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Line Commutated Twelve Pulse Converter For Grid Interfacing of Solar Photovoltaic Panels

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***Abstract*—On account of continuously increasing energy demand, if the dependence is on fossil fuels only then it may lead to energy crises in future. To avoid energy crises, best practical solution is to move towards renewable green energy sources. Solar energy is one way to bridge energy gap. Synchronization of voltage source inverter with grid is crucial issue in interfacing. In the proposed scheme line commutated twelve pulse converter is used to interface solar photovoltaic panels and an ac grid and it does not require any synchronizing circuits.**

***Keywords*—line commutated twelve pulse converter; photovoltaic panels; grid; commutation; synchronization.**

I. INTRODUCTION

The objective of this paper is to come out with a simulated model of line commutated twelve pulse converter and analyse its operation. Nowadays, environmental issues are more of a concern. Renewable green energy is one of the options in reducing pollution and various environmental problems. Also, natural resources used for producing power are dwindling and becoming more and more expensive. So one of the best possible way is to use photovoltaic panels. Photovoltaic cell converts solar energy into electrical energy in the form of dc. The price of photovoltaic modules are expensive for electricity generation, but in recent years, their price has been slowly dropping, and the payback period also reduces, as the technology is developed. For overall efficiency of photovoltaic, losses in the power converter plays a vital role. Grid connected systems use a photovoltaic array to generate electricity, which is then fed to the main grid via a grid interactive power converter [1]. India gets solar energy almost throughout the years, which makes it more convenient to utilize in India [2]. The solar energy cannot be directly interfaced with the utility grid due to some economical issues. Therefore a power electronic interface is developed to interface the solar systems to the utility grid. For high efficiency purpose line commutated converter are used. Main drawback of this is that it produces square wave current output containing harmonics but it can be filtered out by using filters [3]. A power converter technology which uses SCR provides flexibility in interconnection of panels and an ac grid [4]. Photovoltaic is reliable, renewable, clean and inexhaustible technology. Mainly the most important equipment in converting dc of panels into ac is inverter technology [5]. Voltage Source Inverter (VSI) are also used to interface these photovoltaic panels and ac grid [6]. VSI including PWM technique has some limitation of switching frequency to reduce the losses when high power is required [7].

SPWM technique has also its limitations [8]. For the transfer of bulk electricity over long distances to minimize the conduction losses of the transmission lines or connecting electrical networks of different frequencies, High Voltage DC transmission (HVDC) has been increasingly used. One converter is operated in rectifier mode and other is operated in an inverter mode [9].

As compared to any other higher pulse converters, the twelve pulse converter has less complexity in the control and it results in comparable power quality indices if used with an optimally designed passive filter [10]. Solar insolation is the energy radiated for the sun to the surface of the earth measured in J/�^{2}in hourly or daily basis as recommended by World Meteorological Organization. However, in photovoltaic power generation system, solar irradiance is preferred over solar insolation because it is measured in W/�^{2} [11]. In any system, the converters are usually a small component of a overall power system. Twelve pulse converter is significant part of power electronics [12].

In this paper, line commutated twelve pulse converter is used to interface dc of photovoltaic panels and an ac grid and the firing angle is made greater than 90° and without commutation failure it goes to 176°.There is photovoltaic panels on dc side of suitable polarity, and power flow is reversed. The configuration of line commutated twelve pulse converter is shown in Fig. 1.

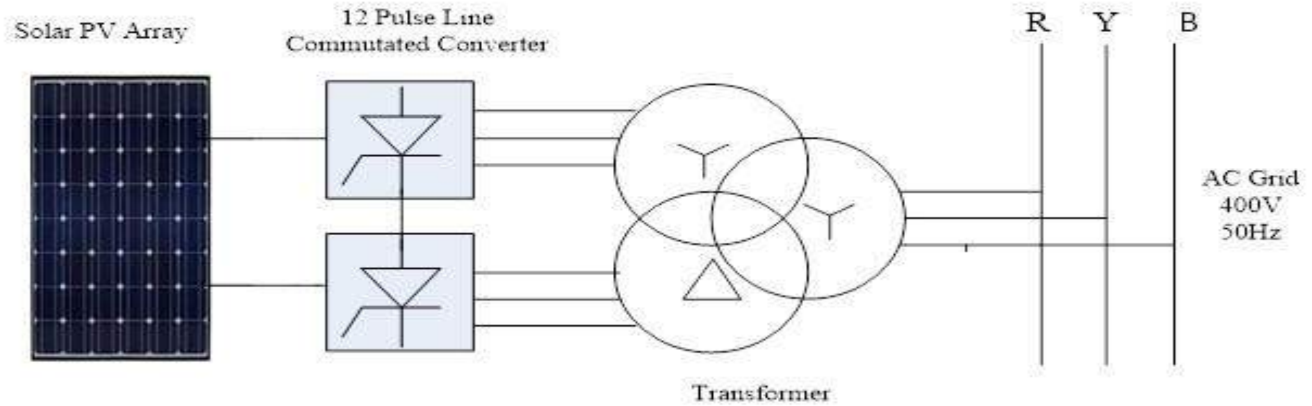

Fig. 1. Configuration of line commutated twelve pulse converter for grid interfacing of solar photovoltaic panels.

II. PROPOSED SCHEME

Circuit for twelve pulse line commutated converter is shown in Fig. 2. This scheme is for delivering 1MW of power to an ac grid.

It consist of two converters. Both the converters are magnetically coupled with one primary and two secondaries. Both converters are six pulse converters. A line commutated twelve pulse converter can be operated in rectification mode for firing angle (α<90°) or an inverter mode for firing angle (α>90°). In the proposed scheme, it is working in an inverter mode for firing angle α=176° and the power flow is reversed as there exists photovoltaic panels in the dc side.

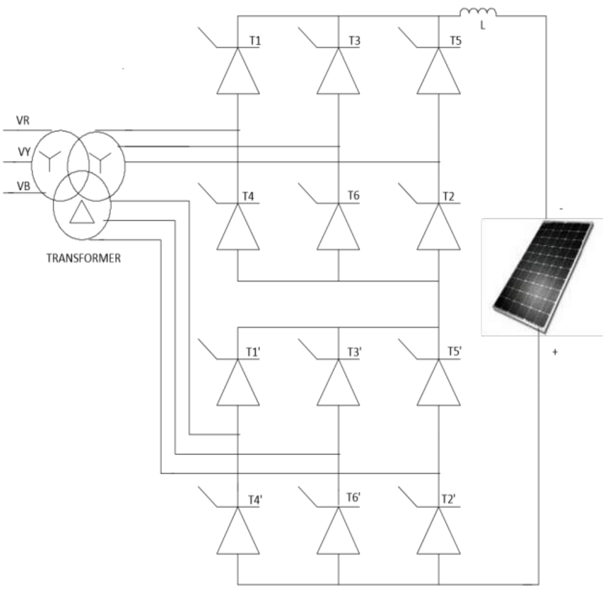

Fig. 2. Line Commutated Twelve Pulse Converter

If dc current Id is assume as constant for both positive half cycle as well as for negative half cycle, the current equation can be written as equation (1). In case of three phase, conduction period of each thyristor is 120°, the current waveform in line as well as secondary of transformer is same (transformer is connected in star) and the equation for this waveform is shown in equation (2). The current flowing through star connected primary of transformer is I_r. The current flowing through two secondaries are I_{r1} and I_{r2}. Here I_{r1} and I_{r2} are in phase but magnitudewise they are different. This current when referred to primary side as I_{r2}' and its magnitude will increase by $\sqrt{3}$ times. I_{r2} referred to primary side can be written by equation (3).

$$i(wt) = \frac{4}{\pi} Id\ [sinwt+\frac{1}{3}sin3wt+\frac{1}{5}sin5wt+\frac{1}{7}sin7wt+\frac{1}{9}sin9wt+\frac{1}{11}sin11wt+\frac{1}{13}sin13wt+\frac{1}{15}sin15wt+\frac{1}{17}sin17wt+\frac{1}{19}sin19wt+\ldots] \quad (1)$$

$$I_{r1}=\frac{2\sqrt{3}}{\pi} Id[sinwt-\frac{1}{5}sin5wt-\frac{1}{7}sin7wt+\frac{1}{11}sin11wt+\frac{1}{13}sin13wt-\frac{1}{17}sin17wt-\frac{1}{19}sin19wt+\frac{1}{23}sin23wt+\frac{1}{25}sin25wt+\ldots] \quad (2)$$

$$I_{r2}'=\frac{2\sqrt{3}}{\pi} Id[sinwt+\frac{1}{5}sin5wt+\frac{1}{7}sin7wt+\frac{1}{11}sin11wt+\frac{1}{13}sin13wt+\frac{1}{17}sin17wt+\frac{1}{19}sin19wt+\frac{1}{23}sin23wt+\frac{1}{25}sin25wt+\ldots] \quad (3)$$

$$I_r=I_{r1}+I_{r2}'$$

$$I_r=\frac{4\sqrt{3}}{\pi}Id\ [sin(wt)+\frac{1}{11}sin11wt+\frac{1}{13}sin13wt+\frac{1}{23}sin23wt+\frac{1}{25}sin25wt-\frac{1}{35}sin35wt+\frac{1}{37}sin37wt+\ldots] \quad (4)$$

From the above equation, the polarity of 5th, 7th, 17th, 19th, 29th and 31st will get cancelled. The equation for Ir is given by equation (4).

The harmonics which appear in twelve pulse converter is given by h=12q±1 where q=1,2,3….and the dc voltage of upper converter is

$$V = \frac{3\sqrt{2}}{\pi} V_L \cos\alpha_1 \quad (5)$$

The dc voltage of lower converter is

$$V = \frac{3\sqrt{2}}{\pi} V_L \cos \quad (6)$$

For delivering, 1MW power to an ac grid, the number of panels required to be connected are calculated. The Table I shows the standard parameters of solar panels which are used in this paper for panels calculation.

A. *Solar Photovoltaic Array*

The I-V characteristics of solar panel SPR-435NE-WHT-D is given in Fig. 3. Without commutation failure, the proposed topology operates when firing angle is 176°.

The atmospheric temperature is assumed to be 45°C and panel temperature to be 75°C. The maximum system voltage is not considered for panels calculation. On the basis of this assumption and paramerters of Table I, 141 panels are required to be connected in parallel and 19 panels are required to be connected in series to transfer 1MW of power to grid.

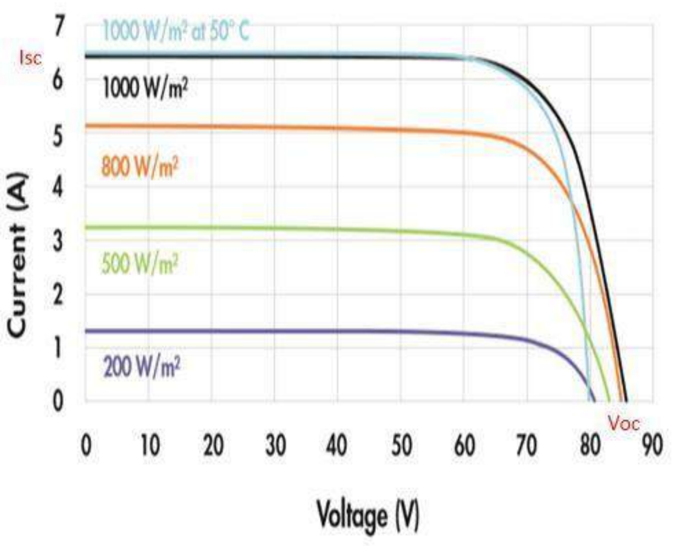

Fig. 3. I-V characteristics of SPR-435NE-WHT-D solar PV panel.

TABLE I. STANDARD PARAMETERS OF SOLAR PANEL

MODEL : SPR-435NE-WHT-D solar PV panel.		
Rated Voltage	Vmpp	72.9 V
Rated Current	Impp	5.97 A
Open Circuit Voltage	Voc	85.6 V
Short Circuit Current	Isc	6.43 A
Maximum system voltage	UI	600V
Temperature Coefficients	Power (P) Voltage (Voc) Current (Isc)	-0.38%/K - 235.5mV/K 3.5ma/K
Assume Atmospheric Temperature	Tatm	45°C
Assume Temperature of Panel	Tp	75°C
No. of panels in parallel	Pparallel	41
No. of panels in series	Pseries	19

III. MATLAB SIMULINK MODEL

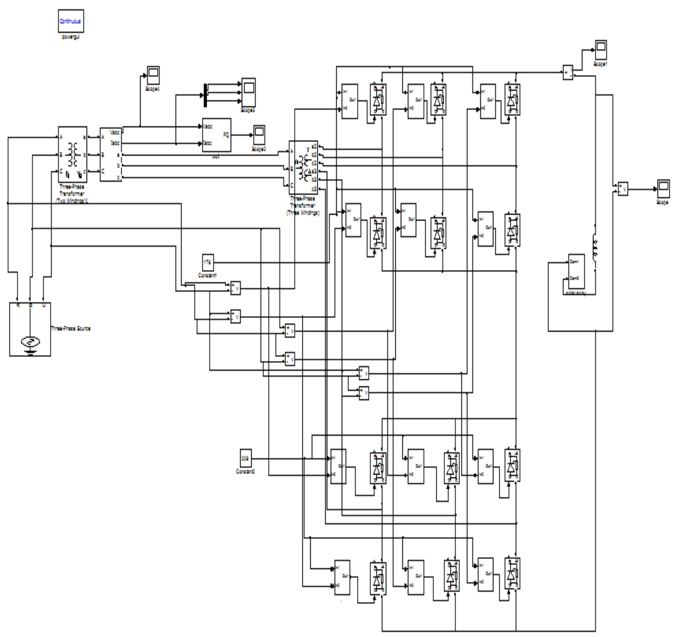
Fig. 4. MATLAB Simulink model of line commutated twelve pulse converter

IV. SIMULATION RESULTS

Without commutation failure, the proposed topology operates when firing angle is 176°. For firing angle α=176°, the simulated results are shown.

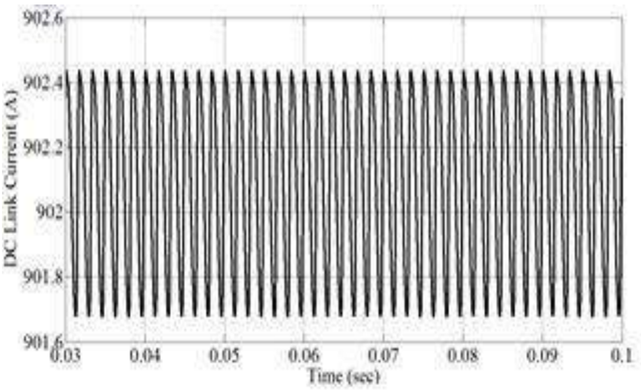

Fig. 5. DC link Current.

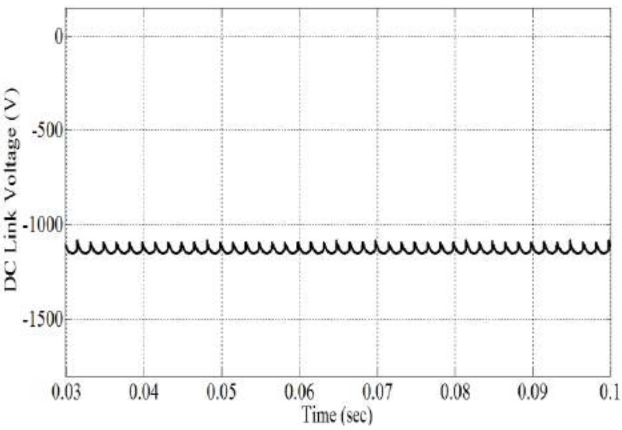

Fig. 6 . DC link Voltage.

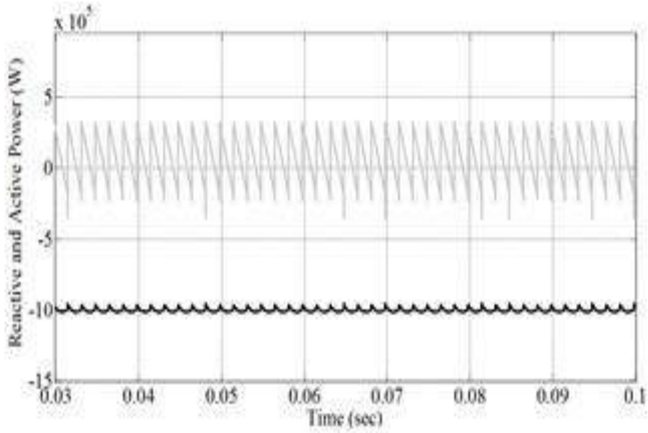

Fig. 7 . Reactive and active power.

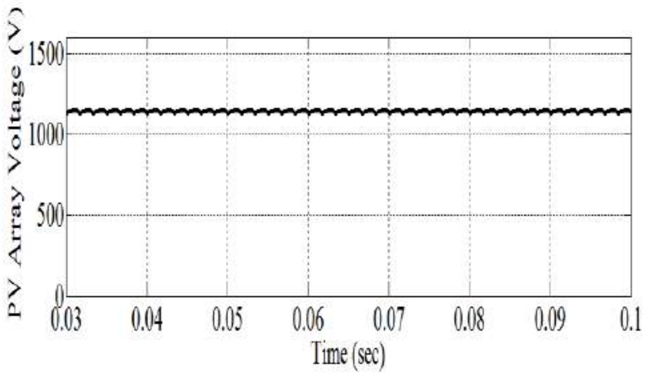

Fig. 8. PV array voltage at 1000 W/m2 irradiance.

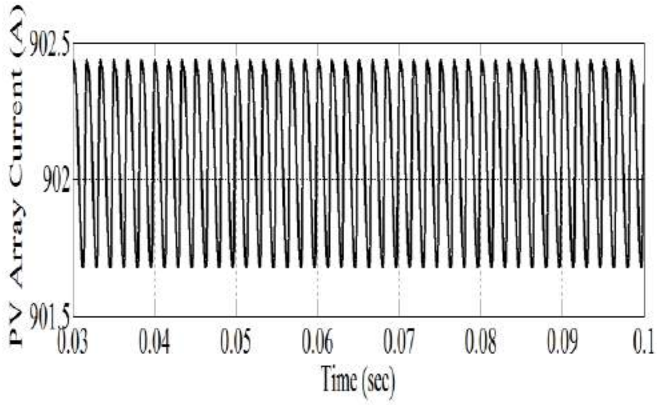

Fig. 9. PV current voltage at 1000 W/m2 irradiance.

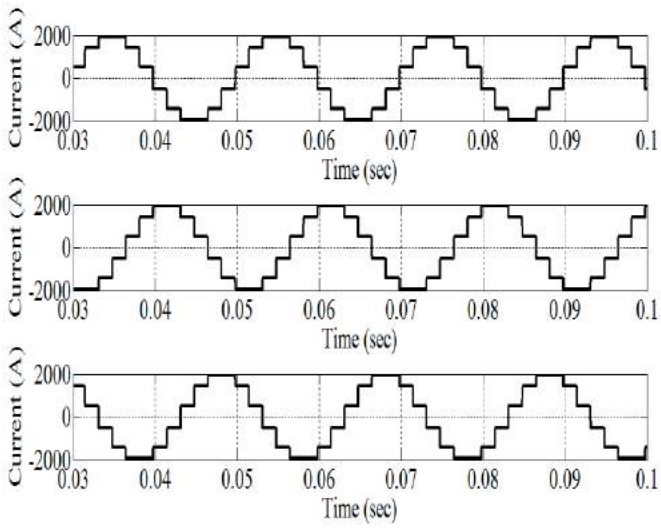

Fig. 10. phase ‘a’ current, (c) phase ‘b’ current, (d) phase ‘c’ current at ac terminal of converter.

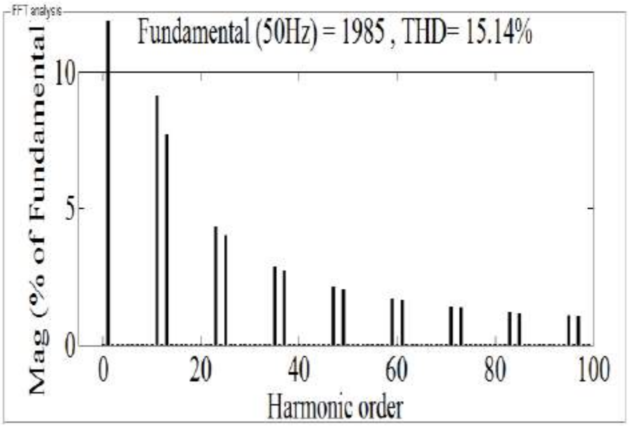

Fig. 11 . FFT Analysis of twelve pulse converter.

V. CONCLUSION

The line commutated twelve pulse converter used has THD of source current half as compared to six pulse converter. The SCR are line commutated and there is no need of synchronization of converter and grid.

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VOLTAGE SAG RIDE THROUGH IMPROVEMENT OF MODERN AC DRIVES

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Abstract- Modern solid -state induction motor drives are highly sensitive to voltage sags. Their nuisance tripping can cause long re-start delays and production losses. Although it is the supply utility's responsibility to maintain a good quality supply system, drives manufacturers also have to take steps to harden the performance so that a drive stays on line as long as possible during a voltage sag provided the resulting performance of the drive can be tolerated. This paper reviews the approaches that can be used to improve the sag behaviour of a drive and presents the results from an experimental study in relation to a modern drive.

1. INTRODUCTION

Many industrial processes are now very much dependant on solid -state AC motor variable speed drives (VSD). Their reliable operation demands an AC supply of high quality. While there is an increasing demand on the electricity supply utilities to improve the supply quality, at the equipment level the drives manufacturers and the application engineers also have to take steps to improve the behaviour of a drive system so that it can ride through short periods during which the supply quality is not adequate. A common and most concerning supply quality situation arises during voltage sags in AC supply systems.

Voltage sags

Voltage sags are short duration reductions in the supplied RMS voltage [1]. They are normally classified as a reduction of the RMS voltage to between 0.1pu and 0.9pu, for a time period of less than 60 seconds. A study of unbalanced fault types has shown that there are seven types of voltage sags for three phase systems [1], however discussions in this paper is limited to balanced three phase voltage sags.

Impact of voltage sags on variable speed drives

With correct application design and parameter settings, damage to equipment from voltage sags is minimised, but can lead to the disruption of continuous production processes. This is a result of not being able to adequately control the process during a voltage sag or a nuisance trip of an inverter. When this occurs, it is often a lengthy task to remove all the damaged process material, and then repair or replace process equipment to allow start -up. This is especially evident in thin strip processing (such as mills producing strip steel or paper) and fibre thread processing.

Voltage sags cause a decrease of the DC Bus voltage in the VSD. During very brief sags it may be possible to supply the energy from the DC Bus capacitor. During longer sag periods, the DC Bus voltage will drop to a lower level. If this falls below the DC Bus trip voltage then the inverter will trip.

There are two standard ways in which a VSD can be configured to function in the case of an under voltage condition as shown in Figure 1. Curve 1 shows the drive tripping and coasting to a stop where manual interaction is required to restart. Curve 2 shows the drive tripping and coasting. The voltage supply then returns to normal and it restarts with auto recovery.

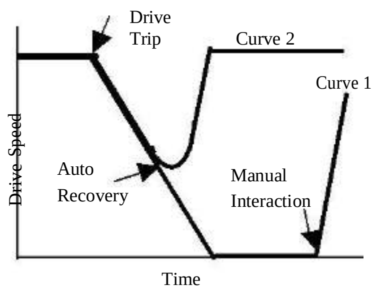

Figure1.Drive recovery from an under voltage trip.

A voltage sag can cause most of its damage to equipment and circuit protection devices when it is cleared. At this point, large voltage and current transients are present, as the system returns to normal. The DC Bus voltage is low (due to the preceding sag), and once full AC voltage is available, the DC Bus capacitor will draw a large currents as it recharges. Pre-charging circuits to reduce initial current when the VSD is first switched on are normally timed out. This recharging current may even be sufficient to burn out the diodes in the rectifier if the incoming circuit protection does not trip first. There are many different types of mitigation techniques available to control or mitigate the effect of a voltage sag on a VSD. They are based around software control (such as kinetic and magnetising energy recovery), hardware (such as increasing the DC bus capacitor size), or a combination (such as a boost converter). In this paper these techniques will be reviewed briefly.

This paper also gives a detailed review of results from a simulation study of a software based mitigation technique utilising both kinetic and magnetising energy recovery, and a detailed account of the effect of balanced voltage sags on a commercially available VSD.

2. MITIGATION TECHNIQUES

2.1 *Software*

Kinetic energy recovery

Sisa examines the kinetic ride through ability of drives in this article [2]. Kinetic ride through is the regeneration of power from the energy stored in the rotating mass of the rotor and load, to keep the DC Bus voltage at a predetermined level. This is done as a coordinated sequence, where the drive (or set of drives if they are on the same DC Bus), act regeneratively by reducing speed and transferring the energy back to the DC Bus. Figure 2 shows curves for kinetic energy assisted ride through versus non -ride-through. The drive system with ride-through ability will be able to withstand much deeper and longer sags than the non-ride-through system, at the expense of drive speed.

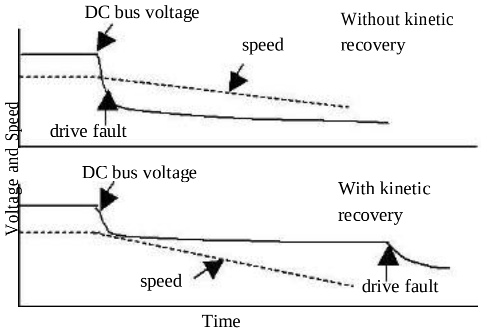

Figure2. Drives with kinetic ride through versus non ride through during a voltage sag.

It is envisaged that by using kinetic ride-through, a controlled stop can be made, reducing down time created by product breaking during a voltage dip, as caused by an uncontrolled stop. Whilst the product during the kinetic ride through may be of low quality, it will prevent the need to re -thread production machines. If there is a common DC Bus in use, it is possible to regenerate from non essential systems first (ie cooling fans, lubrication pumps), in the hope that the voltage sag will be small enough to prevent the production process motors noticing the dip.

2.2Magnetising energy recovery

It is possible to recover a small amount energy from the stored energy due to the magnetising currents (flux) in the motor. Narayanan [3] describes this type of recovery as forcing the inductance of the motor windings to act as a current source, feeding this stored energy back into the DC Bus. The motor requires flux to act in regenerative mode and hence this type of recovery is normally possible only after kinetic energy recovery. There will be a point where it is inefficient for the system to recover kinetic energy, and the control system should then switch to magnetising energy recovery.

2.3 Hardware

Increasing the DC bus capacitor size

The simplest way to improve a VSD's voltage sag ride through ability is to increase the DC Bus capacitor size. Bollen and Zhang have undertaken studies relating to the size of the DC Bus capacitor [1]. They assume a balanced sag on all phases and that the capacitor will supply the energy for as long as possible. Their studies produced a graph as shown in Figure 3. Modern VSDs typically have between 75 and 360 μF of capacitance per kW of drive rating.

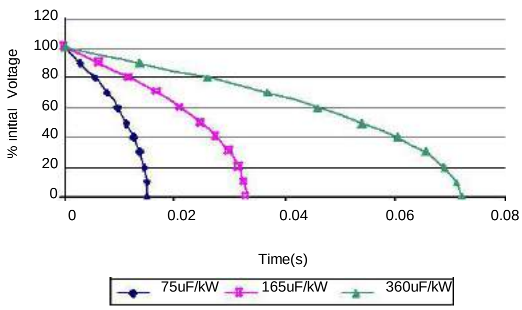

Figure3. Voltage tolerance of an adjustable - speed drive for different capacitor sizes.

The graph in Figure 3 assumes that the voltage level of the incoming supply has dropped to zero. The vertical axis is the undervoltage setting for the DC Bus trip expressed as a percentage of initial Bus voltage. The horizontal axis is the time to trip. If the AC supply voltage does not drop to zero, the DC Bus will fall to a new voltage along the curve, but then be maintained by the supply. This shows that the larger the capacitance per kW rating, the longer the DC Bus capacitors are able to supply the energy during a voltage sag.

Duran-Gomez, Enjeti and Von Jouanne discuss similar methods to the DC Bus capacitor [4]. They discuss the use of batteries to supply the required power during a voltage sag, but noted that "such rapid deep-cycle electric demands is harmful to the battery". The maintenance cost of such a system would be high in order to have a constantly ready system. This is similar to an

Uninterruptable Power Supply (UPS) of the VSD's supply side, however the cost of such a system for the critical drives in a continuous process would be unacceptable. Super capacitors are the emerging technology ready to take over from the normal capacitor on the DC Bus. Super capacitors are high power density capacitors that can store a large charge, however at the moment they are relatively expensive.

There are drawbacks in the use of extra capacitors on the DC bus. Bulkiness and redesign of pre - charging and discharging are some of the concerns in addition to added costs.

2.4Hardware and Software combinations. Boost converters.

There are many types of boost converters that have been experimented with, to varying degrees of success. The boost converter circuits that Gomez and Enjeti [5] describe are designed to improve sag ride through performance with minimal cost. In this approach as shown in Figure 4 there is only the addition of a few extra components (4 diodes and an inductor), utilising the VSD's dynamic braking (DB) semiconductor. The main benefit of such an approach is that there are no additional power semiconductors within the main current path, and the additional components are only rated to a small proportion of the inverter.

During a sag the current is drawn from the rectifier circuit and the boost converter circuit. This helps to limit the tripping due to over currents in the rectifier components. When a sag is detected, the control circuit starts to switch the dynamic braking semiconductor. This is at a constant frequency with a varying duty cycle as determined by the feedback from the DC Bus voltage. During the on-period, current builds up in the inductor, and then during the off-period this current flows to the DC Bus.

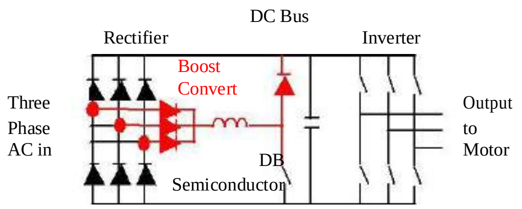

Figure4.Inverter circuit with a 'Boost Converter circuit'.

The boost converter ride through has the extra advantages that it is easy to add to existing variable speed drive units, and si low in cost compared to other improvement possibilities for sag ride through. However, it does require the use of the dynamic braking semiconductor, and source code modifications.

3. MODELLING OF VECTOR DRIVES, AND SIMULATION RESULTS

To investigate the sag behaviour a vector controlled induction motor drive has been modelled using PSCAD/EMTDC™ [6] version 3.0.3.

Figure 5 shows the function blocks of the system simulated.

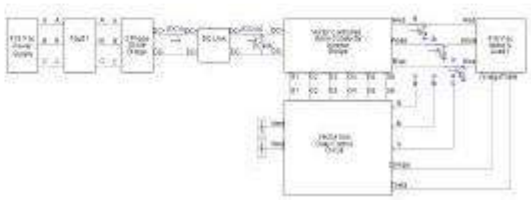

Figure5.Functional blocks of the vector controlled induction motor drive using PSCAD/EMTDC™ .

3.1Simulation results for balanced three phase sags for the drive with no sag mitigation technique in place.

A three phase voltage sag of 0.5 per unit on each phase was applied as shown in Figure 6 (DC Bus voltage, current in and RMS supply voltage) and in Figure 7 (speed, with electrical and load torques).

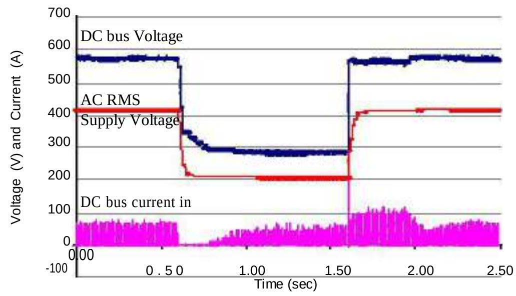

Figure6. Voltages and currents when all three phases drop to 0.5 pu of normal supply voltage for one second.

The drop in the DC bus voltage level would certainly cause a low DC Bus voltage trip. During the initial drop in the voltage, the diodes in the rectifier circuit are reversed biased, thus the capacitor supplies the current to the inverter and there is no current drawn from the AC supply. As the DC Bus voltage level starts to recover, current is again drawn from the AC supply. When the AC supply voltage returns to 1 per unit at 1.6 seconds, a large current transient occurs as the capacitor recharges and the drive accelerates. Figure 6 shows that this inrush current transient is in the range of 200A. This is sufficient to trip circuit protection devices rated for this application.

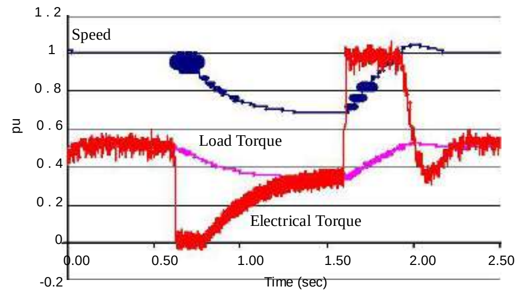

Figure7. Speed and torques when all three phases drop to 0.5 pu of normal supply voltage for one second.

It is clearly evident that the speed drops off as the DC Bus Voltage drops. During this period the electrical torque supplied by the motor is less than the required load torque. An equilibrium speed is reached where the supply voltage can provide the required power to sustain the motor speed. When the sag is cleared the drive quickly accelerates back to set speed.

3.2Simulation results for the balanced three phase sags for the drive with sag mitigation technique in place.

To allow Narayanan's [3] control mitigation techniques to be tested the simulation circuit was modified. The new simulation circuit used for the sag ride through testing has the DC Bus voltage fed into the vector selection block. This reference voltage is used when kinetic energy recovery is implemented.

This circuit confirmed that it is possible to utilise this technique to keep the DC Bus voltage at a nominal level. As shown in Figure 8 the RMS supply voltage sags to 0.5pu on all three phases at the 2 second point. There is a sudden drop in the DC Bus voltage. However unlike in Figure 6 this drop is controlled and it only drops marginally below the setpoint voltage of 520 Volts, before kinetic regeneration takes place and the setpoint voltage is maintained. This voltage level is maintained until the speed reaches 0.10pu, where magnetising energy recovery is used. At this point the DC Bus voltage begins to fall.

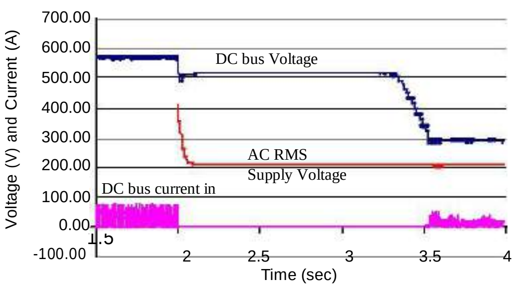

Figure.8 Voltage and current when a three phase sag of 0.5pu is applied with control mitigation in place.

Figure 9 shows additional results of the test above. Comparing this with Figure 7 (where the speed was maintained at a lower value), the speed now continues to falls as regeneration occurs. The electrical torque is driven negative (regenerates) when the mitigation technique is implemented, and as speed is reduced it is driven further negative to maintain the voltage setpoint. Once the speed reaches 0.10pu magnetising energy recovery begins, as observed at approximately 3.4 seconds. The setpoint for the quadrature axis current i_q is given a value of zero, and direct axis current $i_d$setpoint is controlled to regenerate the required energy. As expected, there is very limited energy stored in the form of magnetising energy compared to the kinetic energy component, and the DC Bus voltage begins to fall.

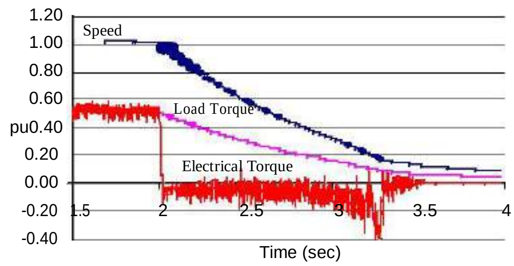

Figure9. Speed and torques when a three phase sag of 0.5pu is applied with control mitigation in place.

In Figure 9 from 2 to 3.4 seconds the system uses kinetic energy recovery. When magnetising current recovery is enabled the voltage level starts to fall from the setpoint of 520Vat the 3.402 second point. By the 3.424 second point the voltage level has dropped to 510V. For that rate of decay of voltage across the capacitor, it must only be supplying approximately 1A of the required 2.6A (known system current draw). Hence we must be recovering magnetising energy. This magnetising energy recovery only lasts for a few cycles, before all the current required is drawn from the capacitor. At this point the DC Bus voltage begins to decrease at a more rapid rate.

4. BEHAVIOUR OF A COMMERIAL

VSD Description of the test equipment

The voltage sags were produced using the University's 20kVA programmable power quality disturbance generator [7]. This supplied a 7.5kW induction motor connected to a load. The load device was a 10kW DC generator connected to a resistor bank. Only balanced three phase sags were used of which the depth and duration can be conveniently controlled.

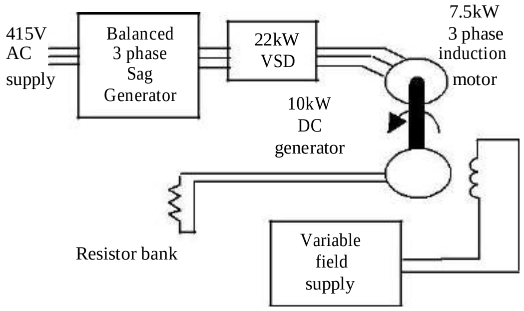

Figure10. Test setup for voltage sag testing.

To avoid damage to the VSD the low DC bus voltage trip was enabled, thus the inverter will shut itself down when it senses a low voltage on the DC bus. This will help prevent damage as a result of the high transient currents when the sag is cleared. As such, the current transients shown in the simulation would not be observed, and the currents were not recorded.

4.1Behaviour of a commercial VSD results during voltage sags

The test VSD was subjected to voltage sags of varying depths for a duration of 10 seconds per test. This allowed both the mmediate and long term effects of the sags to be observed. During this period the motor speed, DC bus voltage, and one phase of the AC voltage waveform were recorded.

These tests were repeated for three different torque loadings.
LOAD 1: A no load test where the only load was the motor and attached generator armature.
LOAD 2: A loaded test with a field current of 0.1A in the field windings of the generator.
LOAD 3: A loaded test with a field current of 0.2A in the field windings of the generator.

The VS D is capable of maintaining set speed for a short period during a voltage sag. As expected, the length and the depth of the voltage sag effect the ride through ability of the drive. A shallow sag can be ridden through for a longer period than a deeper sag. The load inversely affects how long the drive can ride through a voltage sag, (ie the larger the load, the smaller the ride through ability).

Figure 11 shows the natural (without any additional control mitigation) ride through ability of the VSD tested for the test loads. The graph presents the new voltage level during the sag against the ride through period (time that speed remains at approximately 1pu after the voltage sag is applied). The drive is able to ride through a voltage sag provided it remains on the left hand side of the ride through curve. If the length of the sag is sufficient to be on the right hand side of the ride through curve, then the VSD response varies depending on the sag depth.

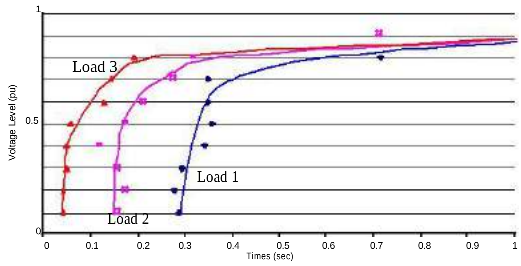

Figure11. Ride through curves for the test VSD with no additional control mitigation.

For deep sags the VSD typically tripped out, and coasted to a stop. It appears that the VSD utilised regenerative braking to provide power back to the DC bus, but the severity of the sag resulted in the inverter tripping nearly instantaneously. It is interesting to note that the DC bus voltage decreases steeply initially as the drive maintains near set speed. There is a slight increase in the DC Bus voltage as what seems to be minimal regeneration occurs before the drive shuts down, and then coasts to a stop. If the voltage returns to normal after the trip, the inverter requires manual interaction before it will start. Figure 12 is representative of this situation.

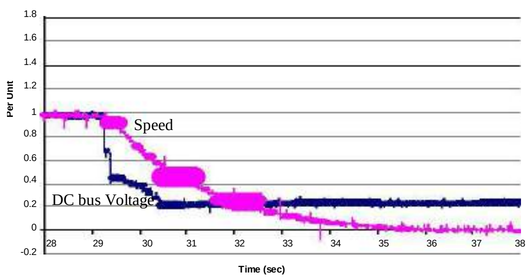

Figure12.A representative curve of the effects of a large depth voltage sag on the test VSD.

For medium depth sags the VSD typically used regenerative braking to near zero speed, and then accelerated back to an equilibrium speed below the set speed. Similar to the previous case, the DC Bus voltage decreased quickly as the drive tried to approximately maintain the set speed. Regeneration again appears to occur as indicated b y the rate of the decrease in speed and the increase in the DC bus voltage. Once the system has regenerated all the energy it can, the DC bus voltage drops again. When the DC bus voltage level has stabilised, the motor then accelerates back to an equilibrium speed. If the voltage level returns to normal the drive will accelerate back to set speed. Figure 13 is representative of this situation.

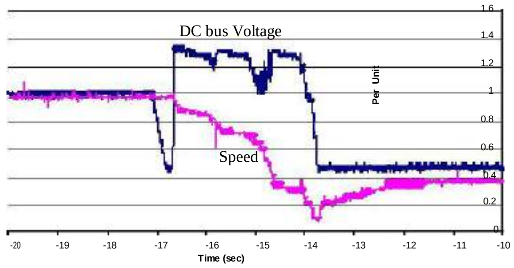

Figure13.A representative curve of the effects of a medium depth voltage sag on the test VSD.

For shallow sags the VSD typically decelerated to the equilibrium speed from the set speed. During this deceleration, regenerative braking appears to be used and results in large fluctuations in the DC bus voltage level. If the voltage level returns to normal the drive will accelerate back to set speed. Figure 14 is representative of this situation.

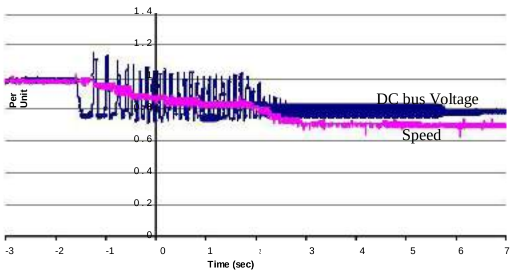

Figure14 A representative curve of the effects of a small depth voltage sag on the test VSD.

For all loading levels the VSD appears to have regenerative abilities, but the control is very coarse and results in a rapid drop in speed, associated with a rise in the DC Bus voltage.

5. CONCLUSIONS

This paper has given a review of methods for voltage sag ride through mitigation techniques. There is no one mitigation technique that will suit every application, and whilst the power supply utilities strive to supply improved power quality, it is up to the applications engineer to minimise power quality issues, with one or a combination of these.

A vector drive simulation during a balanced three phase sag was provided. This demonstrates the danger of large current transients that may be present in the system when a voltage sag is cleared, highlighting the dangers if appropriate actions are not taken to shut the VSD down or somehow maintain the DC Bus voltage level. The simulation is also used to prove that by using the kinetic and magnetising energy of the system it is possible to maintain the DC bus voltage level. This is a trade-off for speed, which for some applications may be acceptable. Recovery of kinetic energy is seen to be worthwhile whilst the recovery of magnetising energy makes only a marginal improvement.

A case study of how a commercially available VSD reacts with balanced three phase sags of different depths with varying loads has been given. The complex sequence of events following a voltage sag were illustrated. The typical outcome is dependant on the depth of the sag. As such it would be particularly difficult for a VSD manufacturer to produce voltage tolerance trip curves for a VSD with a known load. Of course the type of loads used within industry are widely varied and it would be almost impossible for a manufacturer to produce tolerance curves for every possible load, especially given a range of different power quality issues facing today's applications engineers.

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Voltage Source Converter Based HVDC Transmission

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***Abstract* - High Voltage Direct Current system based on Voltage Source Converters (VSC-HVDC) is becoming a more effective, solution for long distance power transmission especially for off-shore wind plants and supplying power to remote regions. Since VSCs do not require commutating voltage from the connected ac grid, they are effective in supplying power to isolated and remote loads. Due to its advantages, it is possible that VSC-HVDC will be one of the most important components of power systems in the future. Power transmission using AC system over the past years has proven to be robust and efficient. One main problem with respect to AC power transmission is the complexities involved in precise power controllability. This problem may be overcome by using VSC based HVDC system of transmission. In the present work, possibility of using VSC based HVDC transmission for evacuating power is explored.**

***Keywords* – Voltage source converter, Control Strategy, HVDC cables, filters, Converters**

I. INTRODUCTION

Conventional HVDC transmission employs line-commutated, current-source converters with Thyristor valves. These converters require a relatively strong synchronous voltage source in order to commutate. The conversion process demands reactive power from filters, shunt banks, or series capacitors, which are an integral part of the converter station. Any surplus or deficit in reactive power must be accommodated by the ac system.

The development of power semiconductors devices, especially IGBT's has led to the transmission of power based on Voltage source converters (VSCs). The VSC based HVDC installation has several advantages compared to conventional HVDC such as, independent control of active and reactive power, dynamic voltage support at the converter bus for enhancing stability possibility to feed to weak AC systems or even passive loads, reversal of power without changing the polarity of dc voltage (advantageous in multi terminal dc system) and no requirements or fast communication between the two converter stations. HVDC light is also called voltage source converter HVDC or VSC HVDC. HVDC light can control both active and reactive power independently without commutation failure in the inverters. Each converter station is composed of a VSC. This difference in reactive power needs to be kept within a given band to keep the ac voltage within the desired tolerance. The weaker the system or the further away from generation, the tighter the reactive power exchange must be to stay within the desired voltage tolerance. HVDC transmission using voltage-source converters (VSC) with pulse-width modulation (PWM) was introduced as HVDC Light in the late 1990s by ABB. These VSC-based systems are force-commutated with insulated-gate bipolar transistor (IGBT) valves and solid-dielectric, extruded HVDC cables HVDC transmission and reactive power compensation with VSC technology has certain attributes which can be beneficial to overall system performance. VSC converter technology can rapidly control both active and reactive power independently of one another. Reactive power can also be controlled at each terminal independent of the dc transmission voltage level. This control capability gives total flexibility to place converters anywhere in the ac network since there is no restriction on minimum network short-circuits capacity. Forced commutation with VSC even permits black start, that is, the converter can be used to synthesize a balanced set of 3-phase voltages like a virtual synchronous generator. The dynamic support of the ac voltage at each converter terminal improves the voltage stability and increases the transfer capability of the sending and receiving end ac systems. In the present work, possibility of using VSC based HVDC transmission for evacuating power is been explored.

II. VSC HVDC SYSTEM

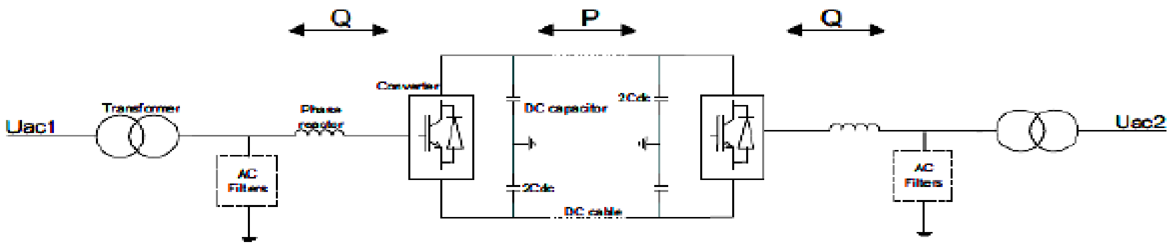

Fig1.Configuration of a VSC-HVDC System

The configuration of a VSC-HVDC system shown in Figure consists of ac filters, transformers, converters, phase reactors, dc capacitors and dc cables.

B. Components of VSC-HVDC System and its operation

VSC-HVDC is a new dc transmission system technology. It is based on the voltage source converter, where the valves are built by IGBTs and PWM is used to create the desired voltage waveform. With PWM, it is possible to create any waveform (up to a certain limit set by the switching frequency), any phase angle and magnitude of the fundamental component. Changes in waveform, phase angle and magnitude can be made by changing the PWM pattern, which can be done almost instantaneously. Thus, the voltage source converter can be considered as a controllable voltage source. This high controllability allows for a wide range of applications. From a system point of view VSC-HVDC acts as a synchronous machine without mass that can control active and reactive power almost instantaneously. In this chapter, the topology of the investigated VSC-HVDC is discussed. Design considerations and modeling aspects of the VSC-HVDC are given. The topology selection for the VSC-HVDC is based on the desired capabilities.

C. Physical Structure

The main function of the VSC-HVDC is to transmit constant DC power from the rectifier to the inverter. As shown in Figure1, it consists of dc-link capacitors c_{dc} two converters, passive high-pass filters, phase reactors, transformers and dc cable. [7]

1. Physical Structure: The main function of the VSC-HVDC is to transmit constant DC power from the rectifier to the inverter. As shown in Figure.1, it consists of dc-link capacitors C_{dc}, two converters, Passive high-pass filters, phase reactors, transformers and dc cable. [7]

2. Converters: The converters are VSCs employing IGBT power semiconductors, one operating as a rectifier and the other as an inverter. The two converters are connected either back-to-back or through a dc cable, depending on the application.

3. Transformers: Normally, the converters are connected to the ac system via transformers. The most important function of the transformers is to transform the voltage of the ac system to a value suitable to the converter. It can use simple connection (two-winding instead of three to eight-winding transformers used for other schemes). The leakage inductance of the transformers is usually in the range 0.1-0.2p.u. [7]

4. Phase Reactors: The phase reactors are used for controlling both the active and the reactive power flow by regulating currents through them. The reactors also function as ac filters to reduce the high frequency harmonic contents of the ac currents which are caused by the switching operation of the VSCs. The reactors are essential for both active and reactive power flow, since these properties are determined by the power frequency voltage across the reactors. The reactors are usually about 0.15p.u. Impedance.

5. AC Filters: The ac voltage output contains harmonic components, derived from the switching of the IGBTs. These harmonics have to be taken care of preventing them from being emitted into the ac system and causing malfunctioning of ac system equipment or radio and telecommunication disturbances. High-pass filter branches are installed to take care of these high order harmonics. With VSC converters there is no need to compensate any reactive power consumed by the converter itself and the current harmonics on the ac side are related directly to the PWM frequency. The amount of low-order harmonics in the current is small. Therefore the amount of filters in this type of converters is reduced

dramatically compared with natural commutated converters. This is described in section 3.6 in detail.
6. Dc Capacitors: On the dc side there are two capacitor stacks of the same size. The size of these capacitors depends on the required dc voltage. The objective for the dc capacitor is primarily to provide a low inductive path for the turned-off current and energy storage to be able to control the power flow. The capacitor also reduces the voltage ripple on the dc side.
7. Dc Cables: The cable used in VSC-HVDC applications is a new developed type, where the insulation is made of an extruded polymer that is particularly resistant to dc voltage. Polymeric cables are the preferred choice for HVDC, mainly because of their mechanical strength, flexibility, and low weight.
8 IGBT Valves: The insulated gate bipolar transistor (IGBT) valves used in VSC converters are comprised of series-connected IGBT positions. The IGBT is a hybrid device exhibiting the low forward drop of a bipolar transistor as a conducting device. Instead of the regular current controlled base, the IGBT has a voltage-controlled capacitive gate, as in the MOSFET device. A complete IGBT position consists of an IGBT, an anti parallel diode, a gate unit, a voltage divider, and a water-cooled heat sink. Each gate unit includes gate-driving circuits, surveillance circuits, and optical interface. The gate-driving electronics control the gate voltage and current at turn-on and turn-off, to achieve optimal turn-on and turn-off processes of the IGBT. To be able to switch voltages higher than the rated voltage of one IGBT, many positions are connected in series in each valve similar to thyristors in conventional HVDC valves. All IGBTs must turn on and off at exactly the same moment, to achieve an evenly distributed voltage across the valve. Higher currents are handled by paralleling IGBT components or press packs.
9 AC Grid**:** Usually a grid model can be developed by using the Thevenin's equivalent circuit. However, for simplicity, the grid was modeled as an ideal symmetrical three-phase voltage source.

D. Converter Topology:

The converters so far employed in actual transmission applications are composed of a number of elementary converters, that is, of three-phase, two-level, six-pulse bridges, as shown in Fig.2, or three phase, three-level, 12-pulse bridges, as shown in Fig

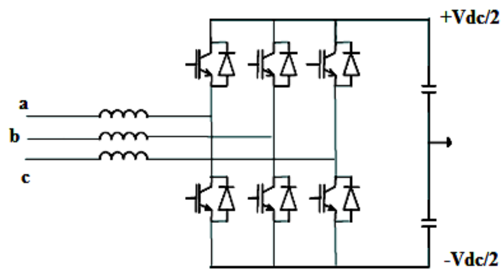

Fig .2 Two level VSC

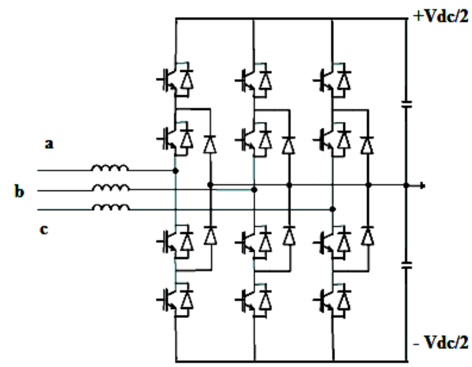

Fig3.Three level VSC

The two-level bridge is the Most Simple circuit Configuration that can be used for building up a three-Phase forced commutated VSC bridge. It has been widely used in many applications at a wide range of power levels. As shown in Figure 2, the two-level converter is capable of generating the two-voltage levels $-0.5\cdot$VdcN and $+0.5\cdot$VdcN. The two-level bridge consists of six valves and each valve consists of an IGBT and an anti-parallel diode. In order to use the two-level bridge in high power applications series connection of devices may be necessary and then each valve will be built up of a number of series connected turn-off devices and anti-parallel diodes. The number of devices required is determined by the rated power of the bridge and the power handling capability of the switching devices. With a present technology of IGBTs a voltage rating of 2.5kV has recently become available in the market and soon higher voltages are expected. The IGBTs can be switched on and off with a constant frequency of about 2 kHz. The IGBT valves can block up to 150kV. A VSC equipped with these valves can carry up to 800A ac line current.

E. Harmonic filtering:

As described above, due to the commutation valve switching process, the currents and the voltages at the inverter and rectifier are not sinusoidal. These non-sinusoidal current and voltage waveforms consist of the fundamental frequency ac component plus higher-order harmonics. Passive high-pass ac filters are essential components of the VSC-HVDC topology to filter the high harmonic components. Hence, sinusoidal line currents and voltages can be obtained from the transformer secondary sides. Furthermore, the reactive power compensation may be accomplished by high-pass filters. When designing the high damping filters the quality factor Q is chosen to obtain the best characteristic over the required frequency band. There is no optimal Q with tuned filters. The typical value of the quality factor Q is between 0.5 and 5.

F.Design of DC Capacitor:

The design of dc side capacitor is an important part for the design of an HVDC system. Due to PWM switching action in VSC-HVDC, the current flowing to the dc side of a converter contains harmonics, which will result in a ripple on the dc side voltage. The magnitude of the ripple depends on the dc side capacitor size and on the switching frequency. The design of the dc capacitor should not only be based on the steady-state operation. During disturbances in the ac system (faults, switching actions) large power oscillations may occur between the ac and the dc side. This in turn will lead to oscillations in the dc voltage and dc over voltages that may stress the valves. It is important to consider the transient voltage variation constraint when the size of the dc capacitors is selected. Here, a small dc capacitor C_{dc} can be used, which should theoretically result in faster converter response and to provide an energy storage to be able to control the power flow. The dc capacitor size is characterized as a time constant τ, defined as the ratio between the stored energy at the rated dc voltage and the nominal apparent power of the converter

Where U_{dcN} denotes the nominal dc voltage and S_N stands for the nominal apparent power of the converter. The time constant is equal to the time needed to charge the capacitor from zero to rated voltage U_{dcN} if the converter is supplied with a constant active power equal to S_N. The time constant τ can be selected less than 5ms to satisfy small ripple and small transient over voltage on the dc voltage, which will be verified in the simulation. This relatively small time constant allows fast control of active and reactive power. Controller speed of less than 5ms is not practical because the connection will not react. This holds for the control of active power, not for the control of reactive power. Reactive power is generated locally and does not require the dc link.

III. CONTROL SYSTEM

The transfer of energy is controlled in the same way as for a classical HVDC connection: the rectifier side controls the dc voltage; the inverter side controls the active power. Like with classical HVDC the power flow can be in either direction. With classic HVDC the reactive power cannot be controlled independently of the active power. With VSC-HVDC there is an additional degree of freedom. VSC-HVDC using PWM technology makes it possible to control the reactive power and the active power independently. The reactive power flow can be controlled separately in each converter by the ac voltage that is requested or set manually without changing the dc voltage. The active power flow can be controlled by dc voltage on the dc side or the variation of frequency of ac side, or set manually. Thus, the active power flow, the reactive power flow, the ac voltage, the dc voltage and the frequency can be controlled when using VSC-HVDC. The control system of the VSC-HVDC is based on a fast inner current control loop controlling the ac current. The ac current references are supplied by the outer controllers. The outer controllers include the dc voltage controller, the ac voltage controller, the active power controller, the reactive power controller or the frequency controller. The reference value of the active current can be derived from the dc voltage controller, the active power controller and the frequency controller, the reference value of the reactive current can be obtained from the ac voltage controller, the reactive power controller. In all these controllers, integrators can be used to eliminate the steady state errors. For example, as shown in Figure 1, either side of the link can choose between ac voltage control and reactive power control. Each of these controllers generates a reference value for the inner current controller. The inner current controller calculates the voltage drop over the converter reactor that will lead to the desired current. Obviously not all controllers can be used at the same time. The choice of different kinds of controllers to calculate the reference values of the converter current will depend on the application and may require some advanced power system study. For example: the active power controller can be used to control the active power to/from the converter; the reactive power controller can be used to control the reactive power; the ac voltage controller which is usually used when the system supplies a passive network can be used to keep the ac voltage. If the load is a passive system, then VSC-HVDC can control frequency and ac voltage. If the load is an established ac system, then the VSC-HVDC can control ac voltage and power flow. But it should be known that because the active power flow into the dc link must be balanced, the dc voltage controller is necessary to achieve power balance. Active power out from the network must equal the active power into the network minus the losses in the system; any difference would mean that the dc voltage in the system will rapidly change. The other converters can set any active power value within the limits for the system. The dc voltage controller will ensure active power balance in all cases.

IV.SIMULATION

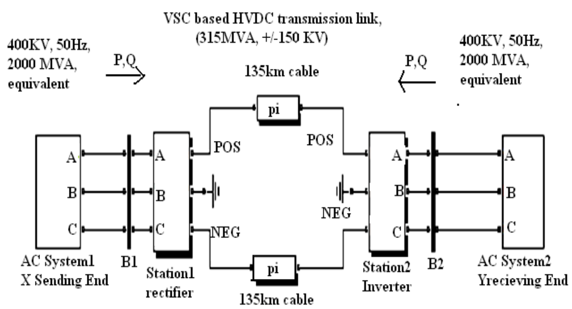

Fig 4 VSC based HVDC transmission link

System Description:

A 300 MW (± 150 kV) forced-commutated voltage-sourced converter (VSC) interconnection is used to transmit DC power from a 400 kV, 2000 MVA, 50 Hz system to another identical AC system [17]. The AC systems (1 and 2) are modelled by damped L-R equivalents with an angle of 80 degrees at fundamental frequency and at the third harmonic. The rectifier and the inverter are three-level Neutral Point Clamped (NPC) VSC converters using close IGBT/Diodes. The rectifier and the inverter are interconnected through a 125 km cable (i.e. 2 pi sections) and two 8 mH smoothing reactors. The sinusoidal pulse width modulation (SPWM) switching uses a single-phase triangular carrier wave with a frequency of 27 time’s fundamental frequency (1350 Hz). A converter transformer (wye grounded /Delta) is used to permit the optimal voltage transformation. The present winding arrangement blocks tripple harmonics produced by the converter. The 0.15 pu phase reactor with the 0.15 pu transformer leakage reactance permits the VSC output voltage to shift in phase and amplitude with respect to the AC system Point of Common Coupling (PCC) and allows control of converter active and reactive power output. The tap position is rather at a fixed position determined by a multiplication factor applied to the primary nominal voltage of the converter transformers. The multiplication factors are chosen to have a modulation index around 0.85 (transformer ratios of 0.915 on the rectifier side and 1.015 on the inverter side). To meet AC system harmonic specifications, AC filters form an essential part of the scheme. They can be connected as shunt elements on the AC system side or the converter side of the converter transformer. Since there are only high frequency harmonics, shunt filtering is therefore relatively small compared to the converter rating. The 78.5 Mvar shunt AC filters are 27th and 54th high-pass tuned around the two dominating harmonics

Simulations Results: The simulation results at the sending end X and receiving end Y are illustrated in the following Figures.

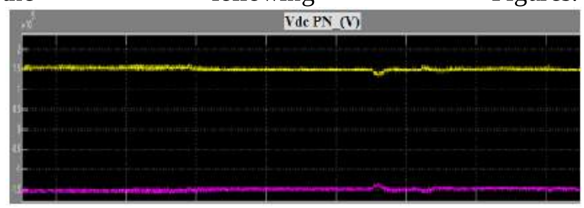

Fig5 .DC Voltage at receiving end

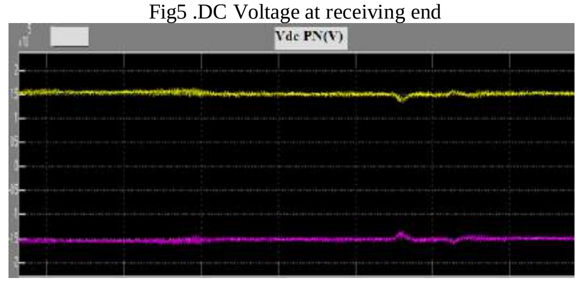

Fig6. DC voltage at sending end

V CONCLUSION

This Paper presents the steady-state performance of AC Transmission System and VSC based HVDC transmission system. The Simulation detail of HVDC system with three levels **VSC** are discussed and simulation diagram is been studied.

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TECH-CHRONICLE
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Study Of PLC & SCADA Controlled Thermal Power Plant

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Abstract— **Thermal power plant consist of many important equipment which is required for the generation such as boiler ,coal conveyer belt ,cooling system ,ash handling plant etc. These equipment requires continuous inspection and monitoring .this paper outlines the automation of boiler &coal conveyer**

.Automation leads to greater efficiency &reliability .The automation is achieved by using PLC&, SCADA. PLC & SCADA is connected through communication cable .This paper focuses on passing the inputs to the equipment so that equipment operation must not get affected .SCADA is used for monitoring the operation of equipment and plc PLC is used to control the operation . The different sensors are used to sense different parameter such as temperature ,pressure ,tearing of belt, overloading, water level etc .If the parameter exceed beyond the predetermined value then it is informed by SCADA system to the operator.in order to automate the boiler and coal conveyer belt the ladder logic is developed. The SCADA screen shows the status of equipment so that operator can take necessary corrective action. In case of emergency different automated check valves are used to release pressure, steam and inform the concerned authority through alarm.

The most common Faults in coal conveyer belt are belt tear up fault, moisture content and overloading fault

Key words **— Communication cables, Programmable Logic Controller (PLC), Power Plant, Supervisory Control and Data Acquisition system (SCADA).**

I. Introduction

In thermal power plant the demand for higher reliability & efficiency is increasing. Power plant requires continuous inspection & monitoring after regular intervals. There may be chances of errors while measuring at various stages by human workers. In order to increase reliability the automation is needed so that overall efficiency of power plant get improved. The automation is developed by using PLC &SCADA which reduces the errors caused by human workers .PLC is programmable logic control. It is used for implementing various function such as sequencing, timing, counting, logic, athematic control through analog and digital input output modules. In order to store the programmed in PLC it must be interfaced to computer via interfacing unit. The programmed can be implemented through various languages. In this paper ladder logic is used for programming .SCADA system is used to supervise a complete process. The output of different sensors is given to the PLC which takes necessary action to control the parameter. SCADA system consist of subsystem such as human machine interface, remote terminal unit, and programmable logic control and communication cable. The alarm system is also provided to inform the operator.SCADA is used to monitor water level, temperature, pressure using different sensors and corresponding output is given to the plc for controlling these parameter. In coal conveyer belt the belt tear up, overloading and moisture content is sense by different sensors. The sensor used are IR sensor, temperature sensor, and humidity sensor.

II. Objective

To develop an programming for automation of boiler and coal conveyer belt by using PLC &SCADA .The automation is achieved by developing a ladder logic for controlling various parameter of boiler and coal conveyer belt.

III.NEED FOR BOILER AUTOMATION

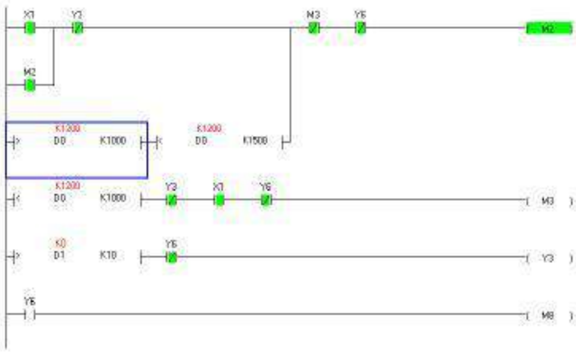
Boiler produces steam at very high temperature. Boiler requires continuous inspection and monitoring at regular interval. Boiler steam temperature in steam power plant is very high .It is difficult to control boiler temperature manually as it may cause serious injury to human workers. The boiler temperature should not be too high or too low. It must be kept within permissible limits. Various mechanism are used to control the temperature of boiler so that boiler works properly. For reliable operation it is necessary to develop automation for boiler. The automation is achieved by using PLC & SCADA

A.BOILER AUTOMATION USING PLC AND SCADA

In boiler the control parameters are temperature control, pressure control, and water level control. These parameter are control by temperature sensor, float switches and pressure sensors .Temperature sensors are used to sense the variation in the temperature. Temperature sensor is passive element. RT pressure sensors are used to sense the variation in pressure inside the boiler. Whereas float switches are used to detect the liquid level float switches are available from low range to high range. Float switch output is given to PLC and necessary corrective action are taken if required.

Ladder Diagram of PLC

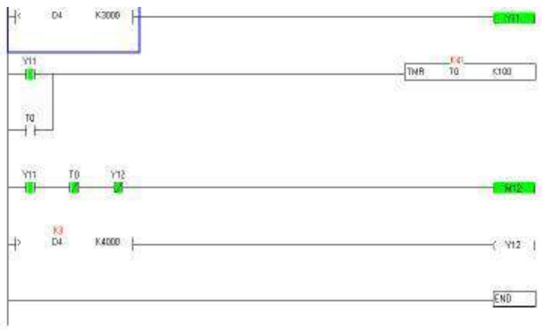
Boiler automation ladder diagram was simulated using WPL soft. For ease of PLC programming ladder diagram is.



Ladder Diagram for Temperature & Pressure Condition

The ladder diagram for controlling Temperature and Pressure. When X1 is switched ON heater 2 will ON. When the temperature exceeds more than 1000_0 C heater 1 will switch ON. If the temperature exceeds 1500_0 C both heaters will switched off.

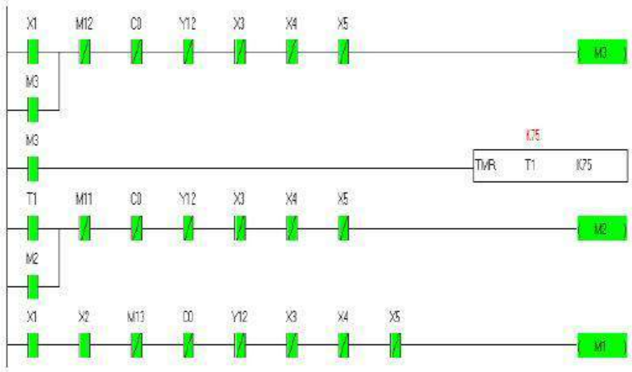
If pressure exceeds 10bar then automated check values switched on to release the steam and pressure and the alarm circuit will be energized. Figure shows the ladder diagram for water level control



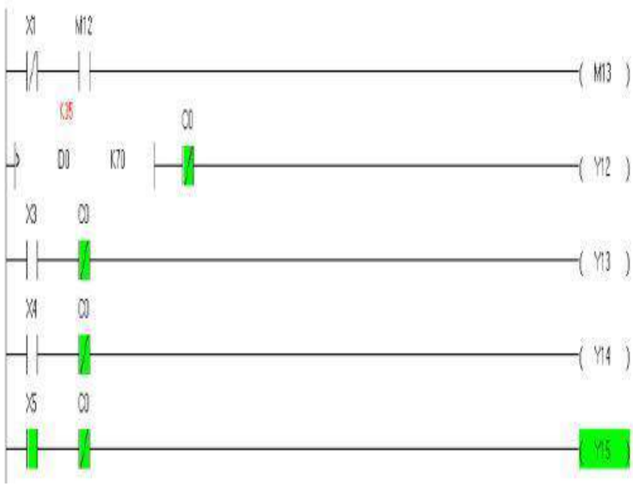
Ladder logic for water level control

IV.COAL HANDLING SYSTEM USING PLC AND SCADA

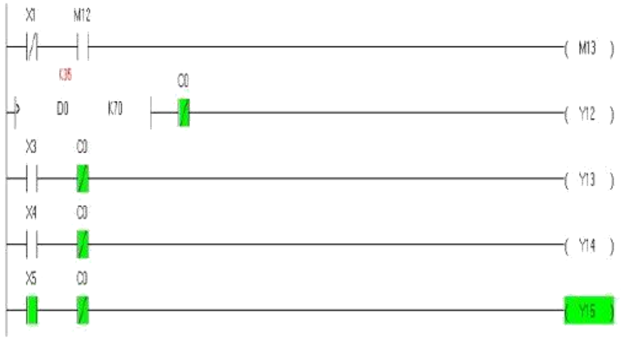
This system will overcome the drawbacks of existing system by detecting faults using different types of sensors such as proximity sensor, temperature sensor, IR sensor, and humidity sensor in the operation. In this method tear up in the conveyor belt is recognize using IR sensor, the increase in temperature is automatically recognize by temperature sensor, the moisture content is measured by using humidity sensor, overloading of the conveyor belt is detected by proximity sensors, thus with the help of these sensor immediate fault detection is possible, so the damage occurring in the belt conveyor can be avoided. Therefore the proposed system gives the efficient way of automating the belt conveyor using delta series PLC along with SCADA for high reliability, accuracy low power consumption and fast operation without delay.



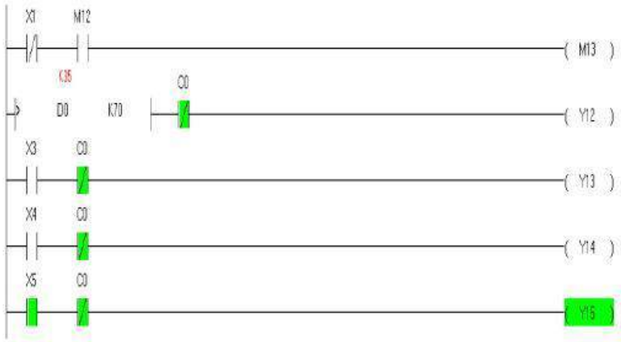
Ladder diagram for startup sequence of the belt conveyor



Ladder diagram for stopping sequence of the belt conveyor



Ladder diagram for high temperature detection



Ladder diagram for conveyor belt tear up detection.

V. CONCLUSIoN

In this paper ladder logic is developed for boiler automation and coal conveyer belt automation. SCADA is used to supervise and monitor operation of the equipment

.Automation system increases reliability, productivity, which in turn brings economic operation the main purpose of using PLC & SCADA is to automate the thermal power plant. The automation increases overall efficiency of power plant get improved. The automation is developed by using PLC &SCADA which reduces the errors caused by human workers.

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TECH-CHRONICLE
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Axial Flux Permanent Magnet BLDC Motor for Electric Vehicles

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***Abstract*— Axial flux permanent magnet (AFPM) brushless direct current (BLDC) motors are an interesting solution, where shape flexibility, compactness, robustness, high efficiency, wide speed range and high torque are required. Different topologies of AFPM BLDC motor are discussed. In most of the applications of AFPM BLDC motors, control over a speed is very important. To achieve accurate speed of a motor, closed loop control using proportional integral (PI) controller is proposed in this paper. Micro controller is used to drive the motor by sensing rotor position using Hall sensor. This paper gives the result of simulation based on AFPM BLDC motor and its various applications.**

Keywords*— *Axial flux machines, permanent magnet motors, BLDC motors, PI controller

I. INTRODUCTION

Axial flux permanent magnet (AFPM) brushless direct current (BLDC) motors have gained much interest in recent years. The search for more efficient and eco-friendly machines makes this an interesting field of research. Investigations in the field of electrical machines have included a wide variety of matters and concepts. The design, control and thermal aspects are some examples of commonly studied issues. From the first DC machines to the current leading induction machines, there is no doubt that high level of technological development has been achieved. Development of new materials and concepts as well as new needs and applications has placed permanent magnet machines in a prominent position. The inherent features of PMSM, such as high efficiency, high compactness and wide operation speed range, make these machines suitable for direct drive applications. In direct drive applications, the shaft of the machine is directly coupled to the shaft of the application, thus avoiding the gearbox, which leads to more efficient and compact solutions. Furthermore, PM machines have a magnetized motor, so that the consumption of electrical energy is decreased. These machines are able to work at low speed, which is very interesting for direct drive low speed applications; however, high speeds are also reachable, giving the PM machine a wide speed range.

For the past two decades, several Asian countries, which have been under pressure for high pressure for high energy prices, have implemented the use of variable speed permanent magnet motor drives for energy saving applications. On the other hand, the United States has kept on using low cost induction motor drives which have around 10 % lower efficiency than adjustable permanent magnet (PM) motor drives for energy saving applications. Therefore, recently the increase in energy prices spurs higher demand of variable speed PM motor drives. Also recent rapid proliferation of motor drives into the automobile industry, based on hybrid drives, generates a serious demand for high efficiency PM motor drive and this was the beginning of interest in BLDC motor.

II. TOPOLOGIES

Constructional wise BLDC motor can be classified into two types, Radial flux motor and Axial Flux Motor. In radial flux motor the magnetic field travels in a radial direction across the air gap between the stator and rotor. When magnetic flux travels in radial direction and interacts with the current flowing in axial direction, torque is produced.

The motor, in which the magnetic field between the rotor and stator travels in axial direction, is called axial flux motor. When the magnet flux travels in axial direction and interacts with radial current it produces torque. Following are the different types of AFPM BLDC motors,

A. Single Side

This is the simplest topology in the axial flux machines range. The stator core may be either slotted or spotless. The axle and the bearings must withstand attraction force, so they have to be properly dimensioned.

B. Double Side

Double side machines consist of three elements in two possible configurations, interior rotor is placed between two stators and the interior stator is placed between two rotors.

C. Multistage

The connection between the winding of different stages could be done in either series or parallel. Furthermore, a connection/disconnection of stages could be done depending on the temporary requirements of the application.

III. PRINCIPLE OF OPERATION

BLDC motor is an electronically switched motor. It requires information about rotor position to generate appropriate gating signal for its power electronic controller. This is as shown in Fig.1. The commutation is done electrically. To know the position of rotor is very important for electrical commutation. Usually the hall sensors are placed in 120 degree in space. When the magnet poles of rotor come to hall sensor, the signal is generated as in Fig.2.

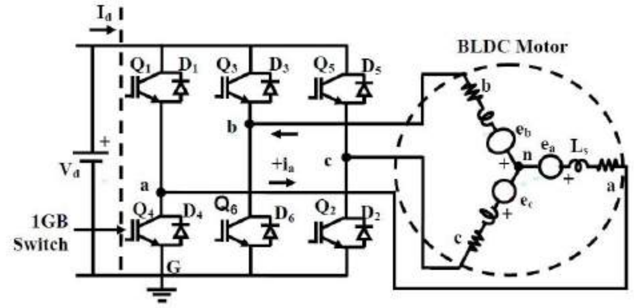

Fig.1. Three-phaseEquivalent Circuit of BLDC motor

According to six steps, the commutation sequence is performed. The motor phases are supposed to conduct for 120 electrical degrees one time per cycle. The two phases are only conducted at one time. The hall sensor signal has the rising edge and the falling edge for each phase. That is, the six trigger signals are generated per cycle. Using these trigger signals, motor control is carried out.

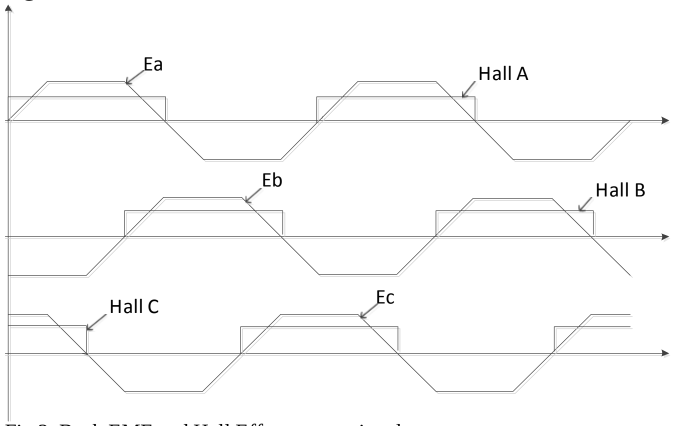

Fig.2. Back EMF and Hall Effect sensor signal

IV. Proposed Closed Loop Controling Technique

Many applications, such as robotics and factory automation, require precise control of speed and position. Speed control systems allow one to easily set and adjust the speed of a motor. The control system consists of a speed feedback system, a motor, an inverter, a controller and a speed setting device. A properly designed feedback controller makes the system insensible to disturbance and changes of the parameters. In closed loop control the speed of BLDC motor can be controlled using proportional integral (PI) controller, PI controller can regulate the duty cycle hence control the voltage applied to BLDC motor. Speed of BLDC motor is directly proportional to applied voltage. Speed of BLDC motor can be set to reference speed. Any diversion from this speed will be given as an error signal to PI controller. PI controller will take appropriate signal on receiving of this error signal and then increase as well as decrease the duty cycle of applied gate signal.

The purpose of a motor speed controller is to take a signal representing the demanded speed and to drive a motor at that speed. Closed loop speed control systems have fast response, but become expensive due to the need of feedback components such as speed sensors. A Hall sensor can also used as a speed sensing device [6]. Speed controller calculates the difference between the reference speed and the actual speed producing an error, which is fed to the PI controller. PI controllers are used widely for motion control systems. They consist of a proportional gain that produces an output proportional to the input error and an integral gain to make the steady state error zero for a step change in the input.

V. Proposed Scheme

Proposed scheme shows that single phase AC supply is converted into DC supply using single phase controlled bridge rectifier. To have a commutation action, three phase bridge inverter is used. DC power from rectifier is supplied to the three phase bridge inverter. Three phase AC supply from inverter is then fed to the AF BLDC motor.

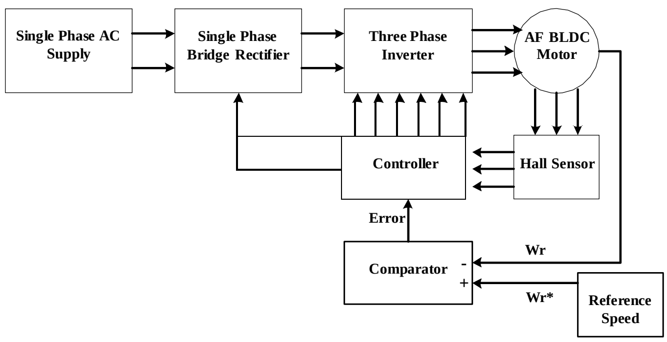

Fig.3. Proposed scheme for closed loop control of AF BLDC motor

Hall sensors detect the rotor position and provide position signal to the controller which energies the appropriate winding of the three phases motor and motor starts running at Wr speed. To have a closed loop control, a reference speed Wr* is fixed at particular value. This value is compared with the actual speed with comparator. Error signal generated by comparator is then given to the controller which takes corrective action and gives the triggering pulses to the rectifier circuit.

VI. Performance Of Motor

Transient period for any machine should be less to have a better transient performance. AF BLDC motor has low inertia, that’s why it has more transient stability. To study the performance of AF BLDC motor, simulation is carried out for different operating conditions. Fig.4 gives the speed characteristic of reference speed Wr* and actual rotor speed Wr with respect to time. The reference speed Wr is set for three thousand rpm. The motor comes to the steady state condition by achieving reference speed near 0.1 second.

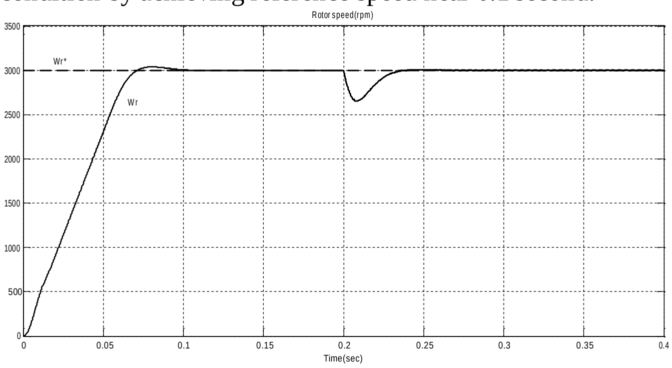

Fig.4. Comparison of reference speed and actual speed

A mechanical load of 7 Nm is connected to the motor at 0.2 sec and due to this load there is a drop in speed. For an equilibrium condition, electromagnetic torque should be equal to mechanical motor and acceleration torque will be zero. To achieve equilibrium condition motor will raise its torque to 7 Nm as shown in Fig.5.

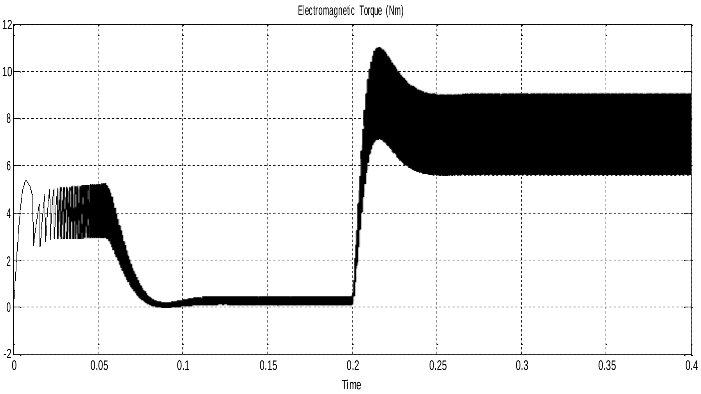

Fig.5. Characteristic of electromagnetic torque of motor

In BLDC motor, back electromotive force (emf) is directly proportional to the speed of the motor. As there is a drop in speed for some certain time, not only the magnitude but also frequency of back electromotive forces (emf) decreases. As seen in Fig.6, there is a decrease in the frequency of back emf near 0.2 second.

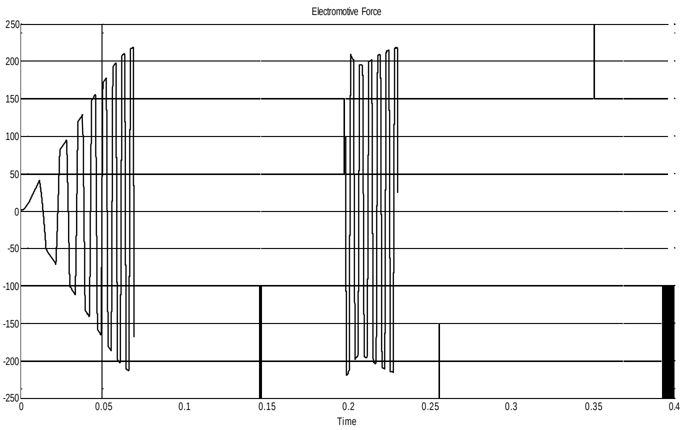

Fig.6. Electromotive force at three thousand rpm speed

Closed loop control will come in action to take care the drop in speed. Error between the actual speed and reference speed is calculated by PI controller and appropriate triggering is given to the six switches to reduce this error. At some particular instant, the error is zero and motor regain its original speed.

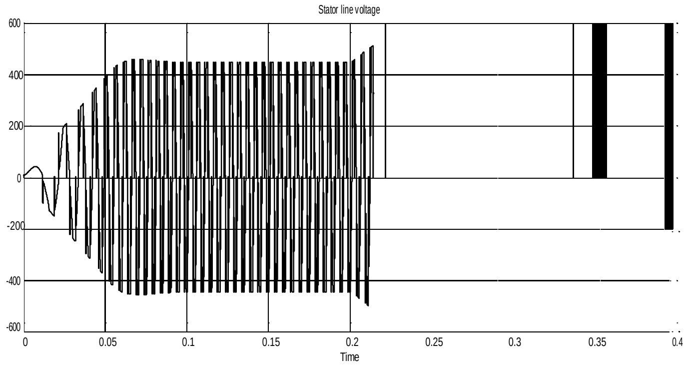

Fig.7. Characteristic of stator line voltage of motor

A characteristic of stator line voltage is shown in above Fig.7. It is clearly seen that after the load is connected to the motor, the stator line voltage is increased. The increased in the stator line voltage is to compensate the error between reference speed and actual speed. The respective stator line current is shown in Fig.8. During transient period, there is a change in stator current and when load is applied to the motor stator current increases to have an electromagnetic torque.

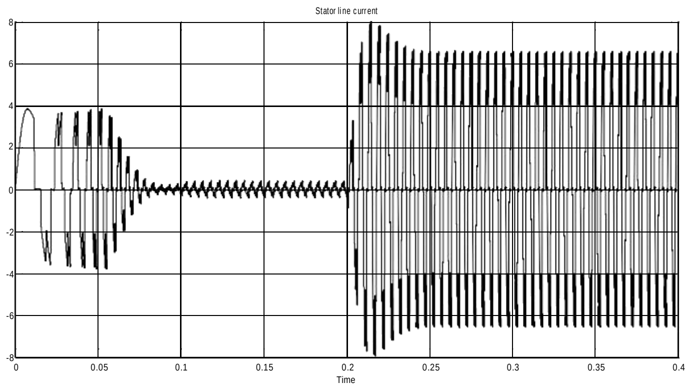

Fig.8. Waveform of stator line current

VII. APPLICATIONS

Throughout the history, induction machines have been the most frequently used topologies in common industries. However, in recent years, because of ecological thinking and the rise low-speed applications, permanent magnet synchronous machines have become more popular. Furthermore, the development of new applications, such as electrical vehicles and renewable energy has pushed the development of high-performance, direct-drive electrical machines.

AFPM BLDC motors can be a good choice because of their disk shape, multi stage capability, and characteristic high torque density. These features make axial flux machines a real alternative to classical radial flux machines. In that sense, it is possible to find companies that commercialize axial machines. Nowadays the majority of applications share the same requirements: high efficiency, saving of space, and economic feasibility, among other characteristics.

However, three applications may be the most relevant due to the numbers of documents and amount of research a review of the literature reveals in the search for information about axial flux machines: wind power, electric vehicles, blowers and elevation.

A. Electric Vehicles

For electric car propulsion systems, the wheel motor is an application that requires the electrical machine has shape flexibility, compactness, robustness, high efficiency, and high torque. Axial flux machines are an interesting solution, where the motor is directly coupled to, or inside, the drive wheels [2]-[6].

B. Wind Power Systems

For low-speed wind turbine applications, AFPM synchronous generator has been studied and designed in [1]. To get low- cost, low weight and simple manufacture, which are highly desirable characteristics of the design, a slotless machine has been designed in order to exploit at the best the mechanical manufacture work reduction allowed by this configuration. Simulation of the system has been carried out into two conditions: steady state wind flow, variable wind speed with the fluctuation assigned by certification standards for wind turbine application.

C. Blowers

In [4], AFPM BLDC motor is fabricated for blowers in vacuum cleaners. Motor design and velocity control of the self-tuning fuzzy proportional-differential-integral (PID) control and a soft-switching mechanism combined with the sensorless drive method have been demonstrated effectively and successfully for the present slim sensorless AFPM BLDC. The system characteristics of the designed slim sensorless AFPM BLDC motors have been enhanced and satisfied the demand of blowers for applying in vacuum cleaners.

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Voltage sag Detection techniques by using wavelet transformation

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ABSTRACT — Voltage sag is one of the most important problem so the power quality which affects the new sensitive equipments. Voltage sags are short duration reductions in rms voltage caused by short circuits, overloads and starting of heavy motors, also the tripping of high-power adjustable-speed drives is probably the main voltage disturbance problem. So Voltage sag is much more of a global problem. Therefore detection methods are needed. For analyzing the effects of voltage sag on these equipments, we need to establish a method for the voltage sags characterization. From the previous studies the magnitude and durations can be the main characteristics of voltage sag.

There are different detection methods for voltage sags such as RMS voltage detection, Fourier transform methods, missing voltage technique, novel detection. The problem with these methods is that they can only analyze either frequency or amplitude at a same time with different graphs but this wavelet transform technique can analyze both frequency and amplitude at a time on the same graph. It may lead to short detection time when voltage sag has occurred compared to other methods. This research paper introduces voltage disturbance detection technique using Wavelet Transform (WT) during system fault using Wavelet Transform (WT) during transient operations. This detection of voltage sag is evaluated on MATLAB software.

KEYWORDS* — *power quality, voltage disturbance, windowing technique, Wavelet Transform, MATLAB.

INTRODUCTION

Voltage sags are related to power quality problems .Voltage sags are short duration reductions in rms voltage caused by short circuits, overloads and starting of large motors. Voltage sag is much more of a global problem. Therefore for proper analysis and mitigation of voltage sag, their characterization is important. Existing methods for sag characterization are inadequate. There are many procedures for characterization of sags but they provide limited information that is insufficient for investigation of impacts on equipment.

In recent 10-15 years, with the rapid development of high and new technology, more and more power electronic devices based on computer and microprocessor control are used in power system. They are more sensitive to system interference than mechanical and electric equipment, so the higher attention to be pay for power quality disturbance .voltage sags are the most serious power-quality problems, as they are frequent causes of malfunctioning electrical equipments of end users [4].

In the IEEE Standard 1159-1995, the term “sag” is defined as a decrease in rms voltage between the values 0.1 to 0.9 p.u., for durations of 0.5cycles to 1 min. Voltage sag is characterized by RMS voltage magnitude, duration, Point on wave and Phase angle jump.

In existing power-quality IEC Standard 60050, 1999 & IEEE Standard 1346, 1998 a voltage sag is defined as a short duration reduction of voltage magnitude in any or all of the phase voltages of a single-phase or a poly phase power supply at a point in the electrical system.

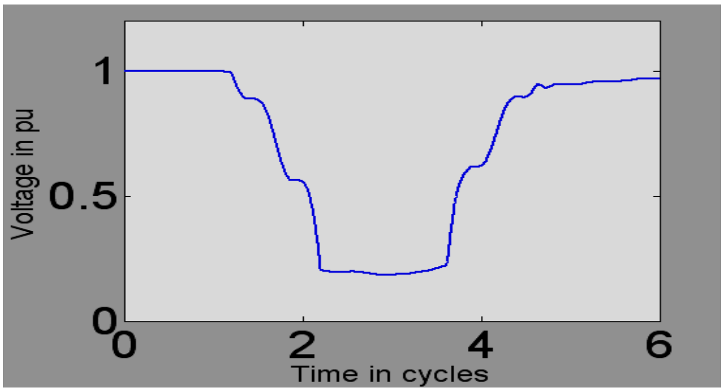

Fig 1.1 Diagram of voltage sag [6]

CHARACTERISTICS OF VOLTAGE SAG:-

Voltage sag is characterized in terms of the following parameters,
1. Magnitude of sag
2. Three phase balance
3. Duration of sag
4. Phase-angle jump.
5. Point on a wave

1. Magnitude of sag:

Generally to characterize the sagmagnitude is through the lowest per unit rms remaining voltage duringthe event of sag . It means a deep sag is the sag with a low magnitude and shallow sag has a large magnitude.[5].

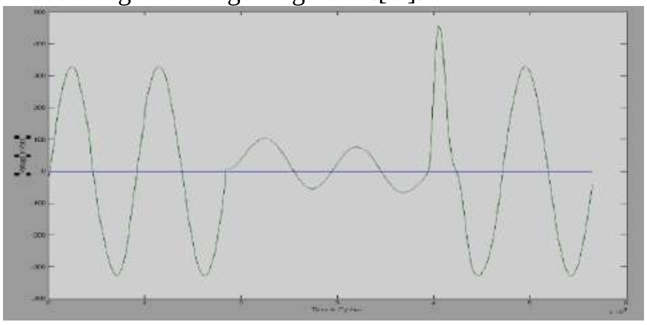

Fig 1.2 Magnitude of voltage sag [6]

3. *Duration of sag:*

The duration of sag is mainly determined by the fault-clearing time. For fast clearing of the fault, duration of sag will be less and vice-versa. The duration of a sag in various standards is defined in the range from 0.5 cycle to one minute. It should be noted that the voltage reduction events shorter than 0.5 cycles influence the sensitivity of some equipment measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings,

4. Phase-angle jump-

The Phase-angle jump manifests itself as a shift in zero crossing of the instantaneous voltage .In three phase faults Phase-angle jumps are due to a difference in the X/R ratio between the source and the feeder. Most of the equipment are not affected by Phase-angle jumps but power electronic converters using phase angle information for their switching may be affected.

5. Point on wave-

To obtain exact value for the sag duration information of "start" and "ending" of the sag is necessary. For this one needs to find the "point-on-wave of sag initiation" and the "point-on-wave of voltage recovery". Both require more advanced analysis techniques, which are still under development.

DETECTION TECHNIQUES OF VOLTAGE SAG

1. *Fourier Transform method-*

The Fourier transform gives information about the presence of different frequency components of the signal. It gives information of different frequency component exists in the signal, but FT do not provide information, on which time these frequency components exist. For stationary signal whose frequency component does not change in time, this information is not required. Time frequency representation of signal is required for non stationary signals. Short Time fourier Transform (STFT) is better than FT but it gives fixed resolution all the times due to fixed window size.Therefore, FT is not a suitable technique for non-stationary signal, with one exception: FT can be used for non-stationary signals, if we are only required in what spectral components exist in the signal, but not required where these occur. However, if this information is needed, i.e., if we want to know, what spectral component occur at what time , then Fourier transform is not the right transform to use. [1]

2. *Wavelet Transform method-*

It gives variable resolution. Translation and scaling is used to generate wavelets from a single basic wavelet. This single basic wavelet is called as mother wavelet. In wavelet analysis, we get details and approximations. The details are the low scale, high frequency components and the approximations are the high-scale, low-frequency components of the signal .The strength of the wavelet analysis is its ability of representing signals in compact from and in many levels of resolutions. [base paper] There are two types of wavelet transforms; one is discrete wavelet transform (DWT) and another is continuous wavelet transform (CWT). The major difference between discrete wavelet transform and continuous wavelet transform is that discrete wavelet transform use a explicit subset of scale and translation values and continuous wavelet transform uses all possible scale and translation.[1]

3. *RMS Value Evaluation Method –*

RMS values, continuously calculated for a moving window of the input voltage samples, provide a convenient measure of the magnitude evolution, because they express the energy content of the signal.

4. *Missing Voltage Technique-*

The RMS value evaluation method is based on the averaging of previously sampled data for one cycle. Therefore, it represents one cycle historical average value, not momentary value. Due to the moving window retaining almost one cycle of "historical" information in the calculation, thus the duration of the sag is in error by almost one cycle if one examines only the RMS plot. Also the point on wave of initiation and recovery of the sag is not clear from this .missing voltage is defined as the difference between the desired instantaneous voltage and the actual instantaneous value [6].

5. *Novel Detection method –*

In the method of missing voltage technique, the missing voltage (MV) can be obtained by subtracting the actual instantaneous value from the desired instantaneous voltage. The start and end of voltage sags can be determined by MV.

SYSTEM DESCRIPTION-

Wavelet Transform Analysis

The wavelet transform is a mathematical tool, much like a Fourier transform in analyzing a stationary signal that decomposes a signal into different scales with different levels of resolution by dilating a single prototype function. Most of the signals in general, are time domain signals in their raw format. That is, whatever that signal is measuring, is a function of time. After plotting time-domain signals, we obtain a time amplitude representation of the signal. This representation is not always the best representation of the signal for most signal processing related applications. In many cases, the most distinguished information is hidden in the frequency content of the signal.

FT and WT is a reversible transform, that is, it allows to go back and forward between the raw and processed (transformed) signals. However, only either of them is available at any given instant. That is, no frequency information is available in the time-domain signal, and no time information is available in the Fourier transformed signal.in some particular application it is necessary to have both the time and the frequency information at the same time.

The FT gives the frequency information of the signal, which means that it tells us how much of each frequency exists in the signal, but it does not tell us when in time these frequency components exist. Therefore, FT is not a suitable technique for non-stationary signal. The wavelet transform is a transform of this type such that it provides the time-frequency representation. Wavelet transform is capable of providing the time and frequency information simultaneously, hence giving a time-frequency representation of the signal [8].

Wavelets are short-duration oscillating waveforms with zero mean and fast decay to zero amplitude, especially suited to analysis of non-stationary signals. Contrary to the use of DFT analysis, the use of wavelets allows the simultaneous evaluation of a signal in the time and frequency domains with different resolutions, making it very attractive for the analysis of electrical power quality disturbances. Wavelets are used in power quality when it is not important to know the exact frequency of a disturbance in voltage or current waveforms, but the time information is important. Wavelet analysis is a technique for carving up function or data into multiple components corresponding to different frequency bands. This allows one to study each component separately.

2.1 Discrete Wavelet Transform (DWT)

The discrete wavelet transform (DWT) is the digital representation of the continuous wavelet transform (CWT).An important property of discrete wavelet transform is the MSD technique which decomposes a signal into scales with different time and frequency resolution. DWT can be implemented using a multi-stage filter bank with the wavelet function as the low-pass filter (LP) and it's dual as the high-pass filter (HP) for two-level decomposition tree-bands of the signal. Down sampling by two at the output of the low-pass and high-pass filters scales the wavelet by two for the next stage. The output coefficients of the low-pass filter (the approximation coefficients) are again decomposed to produce a new representation of the signal and so on, producing a log-arithmic decomposition of the frequency spectra of the input signal for the wavelet decomposition tree. High time resolution is obtained in higher frequency bands whereas low time resolution is provided in the lower frequency band of a signal.

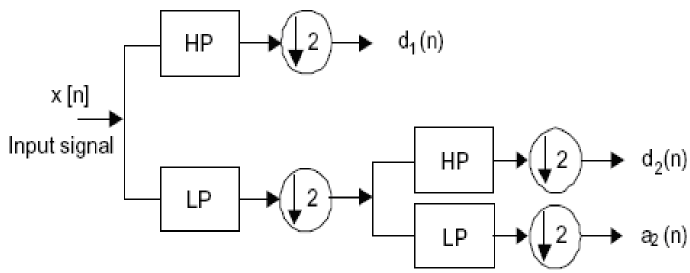

Fig.1.3 Two level wavelet decomposition tree for DWT analysis [7]

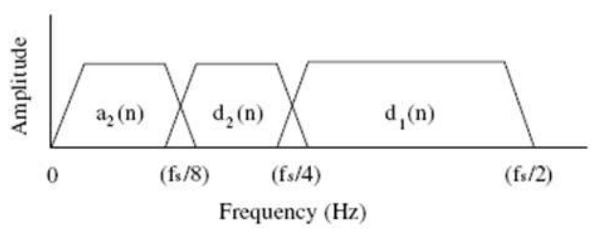

Fig.1.4 Output frequency bands of the wavelet decomposition in fig 1 for f sampling rate [7]

Feature Extraction-

The purpose of feature extraction block is to identify specific signatures of the disturbances in the system. For example, a short circuit and a capacitor-switching incident result in disturbed voltages with different features. The wavelet transform breaks down the error signal into different time-frequency scales. Each scale represents the error signal in the corresponding band. The energy content of the scale signals relative to the error signal changes depending upon the type of disturbance. Therefore, the relative amplitudes of the scale signals with respect to the error signal are selected as the discriminating features. Let f(t) be a signal defined in $L2$ (ˇR) space, which denotes a vector space for finite energy signals, where ˇR is a real continuous number system. The WT of f(t) is then defined as,

$CWT\, f(a, b) = (f,\ \psi a;b) = \int \infty\infty f(t)\psi * a;b(t)dt$ 1

Where,

$\psi a;b(t)=|a|-1=2\psi(t-ba)$ … …….2

ψ(t) is the base function or the mother wavelet, the asterisk denotes a complex conjugate, and a, bϵ, a$\neq$0, are the scale parameter and translation parameter, respectively. Instead of continuous dilation and translation, the mother wavelet maybe dilate and translate discretely by selecting $a = am0$ and $b = nb0am0$,

Where,

$a0$ and $b0$ are fixed values with $a0 > 1$, $b0 > 0$, m, $n\epsilon$Z and Z is the set of positive integers. Then the discretized mother wavelet becomes,

$\psi m;n(t)=a-m=20\psi(t-nb0am0am0)$ ……3

and the corresponding discrete wavelet transform is given by,

$DWTf(m,n)=(f,\psi m;n)=\int\infty\infty f(t)\psi{*}m;n(t)dt$ …….4

Where,

DWT provides a decomposition of a signal into sub bands with a bandwidth that increases linearly with frequency. In the case of dyadic transform ($a0$ = 2 and $b0$ =1), each spectral band is approximately one octave wide.

In this form, DWT can be viewed as a special kind of spectral analyzer. The simplest global features that can be extracted from this type of system are energy estimates in the various bands or other related measures. Spectral features of this type have been used recently to discriminate between various harmonic frequencies. It is possible to obtain a signal f through wavelet series reconstruction by setting

$f=\Sigma m\Sigma nCm;n\psi m;n$ …….5

Where the wavelet coefficients $Cm;\ n$ are obtained by means of the following inner product:

$Cm;n=(f,\Psi m;n)$ ……..6

The function Ψ is the dual analysis wavelet; in the orthogonal case, ψ and Ψ are identical.

CONLUSION-

The simulation diagram of voltage sag detection is shown below. Where the normal sinusoidal signal is compared with a disturbed signal to get the voltage sag and then this output signal is denoised again with the help of wavelet transform so that to get the more correct output waveform of voltage sag.

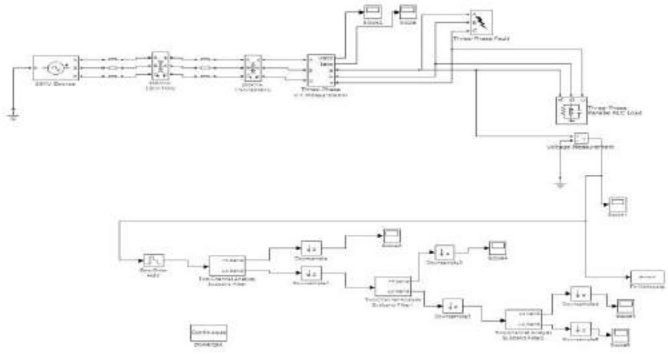

Fig 1.5. simulation diagram of voltage sag detection

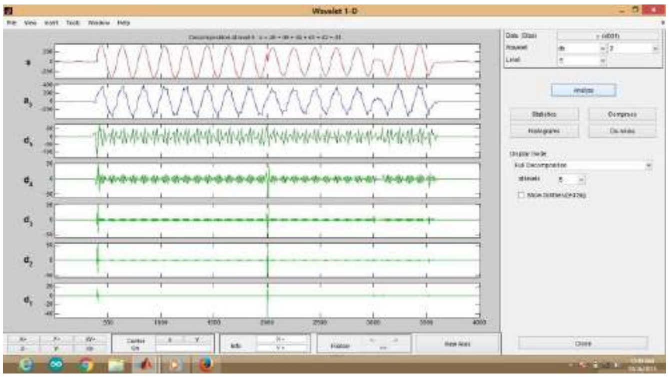

Fig. 1.6 denoised voltage waveform 1

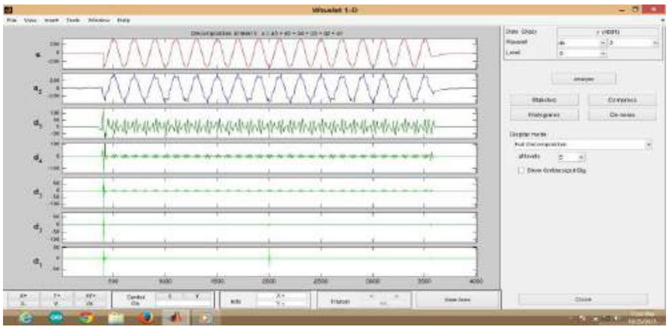

Fig. 1.7 denoised voltage waveform 3

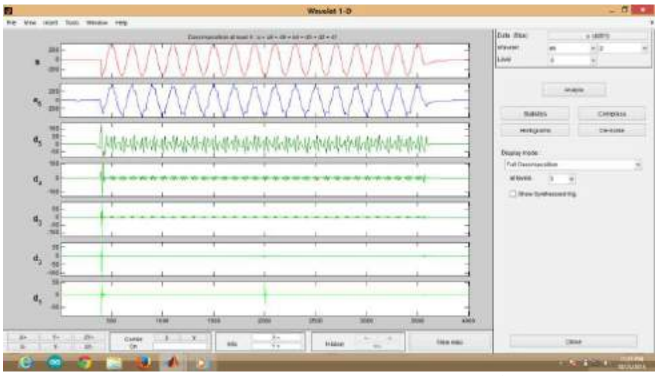

Fig. 1.8 denoised voltage waveform

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TECH-CHRONICLE
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EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

"Design and Development of Fuzzy Lead Lag Controller to Optimize Co- Ordination Control of Flexible AC Transmission System using MATLAB"

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***Abstract*—This paper proposes an evolutionary fuzzy lead-lag control approach for coordinated control of flexible AC transmission system (FACTS) contrivances in a multi-machine power system. The FACTS contrivances used are a thyristor-controlled series capacitor (TCSC) and a static var compensator (SVC), both of which are equipped with a fuzzy lead-lag controller to amend power system dynamic stability. The fuzzy lead-lag controller utilizes a fuzzy controller (FC) to adaptively determine the parameters of two lead-lag controllers at each control step according to the deviations of engenderer rotor speeds. This paper proposes an Advanced Perpetual Ant Colony Optimization (ACACO) algorithm to optimize all of the free parameters in the FC, which eschews the time-consuming task of parameter cull by human experts. The efficacy and efficiency of the proposed evolutionary fuzzy lead-lag controller for oscillation damping control is verified through control of a multi-machine power system and comparisons with other lead-lag controllers.**

Keywords :-Flexible AC transmission system (FACTS), fuzzy control, static VAR compensator (SVC), thyristor controlled series capacitor (TCSC).

I. INTRODUCTION (*Heading 1*)

POWER SYSTEM (PS) stability control is a consequential task in PS operation [1]. Several factors, such as external per disturbances or internal mechanical torques, may facilely affect system stability. With the development of puissance Electronics, the structural control of electric power networks have recently magnetized more attention. In this context, flexible AC transmission system (FACTS) contrivances are becoming more popular. Due to their expeditious replication, these contrivances are acclimated to dynamically adjust the network configuration to enhance steady state Performance as well as dynamic stability [2]–[5]. The availability of FACT contrivances, Such as thyristor controlled series compensators (TCSCs), static var compensators (SVCs), and static synchronous series compensators (SSSCs), can provide variable turn and/or series emolument [3]. Thus, the control of these contrivances is very paramount [4]. TCSCs and SVCs have been widely studied in the technical literature and have been shown to significantly enhance system stability. Therefore, this paper employs these two contrivances and proposes an incipient coordinated control scheme to enhance the dynamic replication of a multi-machine PS. Different FACTS contrivance control methods have been proposed for power oscillation damping and transient stability amelioration [9]. One popular damping control method utilizes a washout filter followed by the order lead-lag controller. This paper proposes a fuzzy lead-lag control scheme for the control and coordination of TCSC and SVC contrivances in a multi-machine PS.

I. EASE OF USE

II. FLEXIBLE AC TRANSMISSION SYSTEMS FACTS is defined as power electronic based system and other static equipment that provide control of one or more AC transmission system parameters to enhance controllability and power transfer capability. The FACTS can be classified broadly into two main types. It is as follows:

A. .Thyristor Controlled Series Capacitor (TCSC)

The basic thyristor controlled series capacitor scheme proposed in 1986 by Vithayathil with others as a method of rapid adjustment of network impedance is shown in Fig 2. It consists of the series compensating capacitor shunted by a thyristor controlled reactor. In a practical TCSC implementation several such basic compensators may be connected in series to obtain the desired voltage rating and operating characteristics. TCSC is a capacitive reactance compensator which consists of a series capacitive bank shunted by a thyristor controlled reactor in order to provide smoothly variable capacitive reactance.

B. Static VAR Compensator (SVC)

The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (SVC capacitive). When system voltage is high, it absorbs reactive power (SVC inductive). An SVC can improve power system transmission and distribution performance in a number of ways. Installing an SVC at one or more suitable points in the network can increase transfer capability and reduce losses while maintaining a smooth voltage profile under different network conditions. The dynamic stability of the grid can also be improved, and active power oscillations mitigated.

II. MODELLING OF TCSC AND SVC

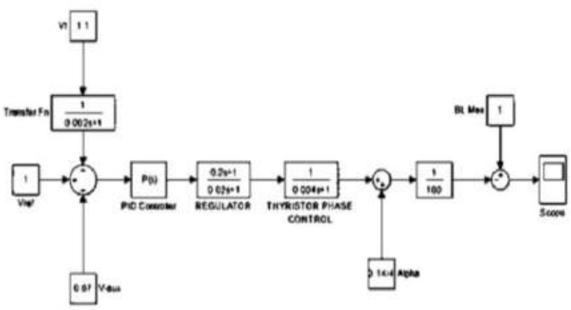
A. Modelling of SVC.

The SVC is a shunt device of the FACTS family using power electronics to control power flow and improve transient stability on power grids. The output of the compensator is controlled in steps by sequentially switching of TCRs and TSCs.By stepwise switching of reactors rather than continuous control, the need for harmonics filtering as part of the compensator scheme is eliminated. SVC application studies require appropriate power system models and study methods covering the particular problems to be solved by the SVC application.

The parameters of the SVC have to be selected to SVC rating and performance criteria taking into account the power system behaviour under various operating conditions.

Simplified Transfer Function of SVC: The system stability studies narrate how to get the substantial results by means of SVC to stabilize system voltages. For this situation the power system is represented by a source voltage in series with an equivalent system reactance Xe in p.u.

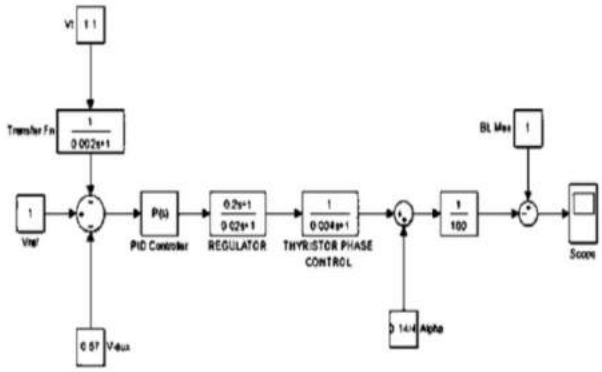
1.Block Diagram of SVC.



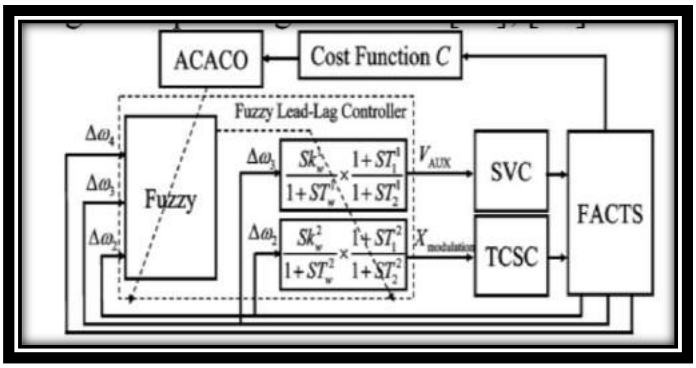
B. Modelling of TCSC

A TCSC involves continuous-time dynamics, relating to voltages and currents in the capacitor and reactor, and nonlinear, discrete switching behaviour of thyristor. Deriving an appropriate model for such a controller is an intricate task. A TCSC model for transient and oscillatory-stability studies, used widely for its simplicity, is the variable-reactance model, the TCSC dynamics during power-swing other dynamics of the TCSC model, the variation of the TCSC response with different firing angles are neglected. It is assumed that the transmission system operates in a sinusoidal steady state, with the only dynamics associated with generators and PSS. This assumption is valid, because the line dynamics are much faster than the generator dynamics in the frequency range of 0.1-2Hz that are associated with angular-stability studies.The variable reactance TCSC model assumes the availability of a continuous-reactance range and is therefore applicable for multi-module TCSC configurations. This model is generally used for inter-area model analysis and provides high accuracy when the reactance-boost factor (XTCSC/Xc) is less than 1.5.

2.Block diagram of TCSC.



Evolutionary fuzzy lead lag controller configuration.



This paper employs two lead-lag controllers to provide congruous control signals to the TCSC and the SVC.

Fuzzy Lead-Lag Controller

In the FC, there are three input variables, and which are speed deviations of the rotors in generatorsG2, G3, and G4, respectively. The outputs of the FC determine the values of the eight parameters in the two lead-lag controllers. The FC is composed of zero-order Takagi-Sugeno (TS)-type fuzzy IF-THEN rules with the following form: Rule I: IF $\Delta\omega 2$ (t) is$A1\ i$ and $\Delta\omega 3$ (t) is$A2\ i$ AND $\Delta\omega 4$ (t) is$A3,\ i$ THEN $T1\ i\ isa1\ i$ (t), $T2\ i\ isa2\ i$ (t), $Tw\ i\ isa3\ i$ (t), $KW\ i\ isa4\ i$ (t), $T1\ 2\ isa5\ i$ (t), $T2\ 2\ isa6\ i$ (t), $TW\ 2\ isa7\ i$ (t), $KW\ 2\ isa8\ i$ (t), i=1,…….R (4 Where, is a crisp value, is the total number of rules, and each fuzzy set utilizes a Gaussian membership function, that is described by $\mu j\ i\ \Delta\omega k$ =Exp $-\Delta\omega k\ -mj\ i\ 2\backslash\ bj\ i\ 2\}$ (5) Represent the center and width of the fuzzy set, respectively.

The firing vigor of the rule is computed by ∅ i (x)= μ1 i Δω2 . μ2 i Δω3 . μ3 i Δω4 .

Conclusion

This paper proposes the simulation of two FACTS contrivances, an SVC and a TCSC, for the stabilization of a multimachine PS. Simulation results in sundry conditions with different torque perturbations verify the Oscillation damping ability of the evolutionary fuzzy lead-lead control approach. In integration, comparison with the traditional lead-lag control approach shows the advantage of introducing the FC to adaptively determine the parameters in lead-lag controllers according to system status. The simulation results show that automatic optimization of the FC through the ACACO algorithm not only simplifies the design effort but additionally ameliorates the system dynamic replication. Comparisons with sundry modified perpetual ACO and PSO algorithms show the advantage of utilizing the ACACO algorithm in the PS stabilization quandary.

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TECH-CHRONICLE
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DERATING OF DISTRIBUTION TRANSFORMER FOR UNBALANCED AND NON LINEAR LOAD

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***Abstract*- Distribution transformer is a very important part with respect to the Power System at consumer level. Distribution transformers are basically built at designed for utilizing at rated frequency and perfect sinusoidal loads. If the load is non-sinusoidal then the losses are more due to thermal stress. Due to nonlinear loads as well as unbalanced load Harmonics are introduced in the power system. This harmonics also disturb the pure sinusoidal waveform. To eliminate this problems rated capacity of the transformer supplying unbalanced as well as nonlinear loads must be reduced. This phenomenon is called de rating of the transformer. In de rating of the transformer "K Factor" is introduced. K factor is a weighting of the harmonic load currents according to their effects on transformer heating.A K factor of 1.0 indicates a linear load (no harmonics). The higher the K factor, the grater harmonic heating effects. So Distribution transformer manufacturers also mentioned the K factor for their products.So in this project by connecting different types of loads in MAT LAB simulation, Calculation of De rating can be done**

***Index terms*- K Factor,de rating of the transformer**

I. INTRODUCTION

Harmonics and distortion in power system current and voltage waveform emerged is a very common phenomenon in the power system. Now a day's harmonic producing devices increasing very fast due to unbalanced and non linear loads. Distribution transformer is a very basic component in a distribution system .Temperature rise of transformer due to non sinusoidal load current was discussed in IEEE transformer committee in March 1980.

This type of harmonics can cause the thermal stress of the transformer. It can reduce the efficiency and life span of the transformer.

De-Rating: The Process of reducing the capacity of the transformer is called De Rating of the transformer. From manufacturer end .

II LITERATURE REVIEW

Mr.S.A.Deokar and Mr.L.Waghmare stated in their paper "Analysis of Distribution performance under non linear balanced load conditions and its remedial in measures" published in IJETAE,Vol.1,Issue 2,December 2011 that the distribution transformers are designed and manufactured for non linear load at rated frequency and balanced supply voltage but due no non linear load or unbalanced loads harmonics are introduced in to the power system, it causes the over heating of the distribution transformer. At manufacturing level the distribution transformer are designed to withstand the Thermal stability for sinusoidal load but in practice non linear load as well as unbalanced loads are present at the consumer ends and it causes Thermal stress to the Distribution Transformer. It causes insulation damage as well as reducing the life span of the Distribution Transformer.So to eliminate this problem estimation of the unbalanced load and non linear loads are to be taken in to the account and a new rating system called K Factor has to be introduced.

The K-factor is an estimate of the ratio of: (a) the heating in a transformer due to winding eddy currents when it is loaded with a given nonsinusoidal current to (b) the winding eddy-current heating caused by a sinusoidal current at the rated line frequency which has the same RMS value as the nonsinusoidal current. For example, if the current in a transformer winding is 100 A, and this current has a K-factor of 10, then the eddy current losses in that winding will be approximately 10 times what they would be for a 100 A sinusoidal current at the rated line frequency. Although the K-factor formula was defined for transformer currents, K-factors of individual load currents are sometimes computed. This practice can be misleading because, in general, K-factors measured at transformers are significantly lower than the relatively high K-factors commonly measured at the input of individual electronic devices. The reduction is primarily due to other sinusoidal load currents, power system impedance and the essentially random phase angles of the harmonic currents produced byTo help get around the problem of successfully applying derating factors to conventional transformers, the K-factor is used by transformer designers to develop transformers made especially for non-linear loads and the extra heating caused by the harmonic currents. Transformers come in basic K-factors such as 4, 9,13,20, 30, 40, and 50.The strategy is to calculate the K-factor for your load and then specify a transformer with a K-factor of anequal or higher value. In this way, the transformer can be sized to the load without derating.The advantage of using a K-factor transformer is that it is usually more economical than using a derated, oversized transformer.

III SIMULATION, OUTPUT WAVEFORMS AND CALCULATION

Case I: For Balanced and Sinusoidal Load

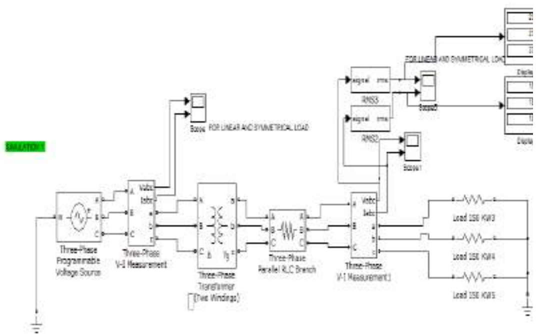

Fig 1: Simulation for Balanced and Linear load

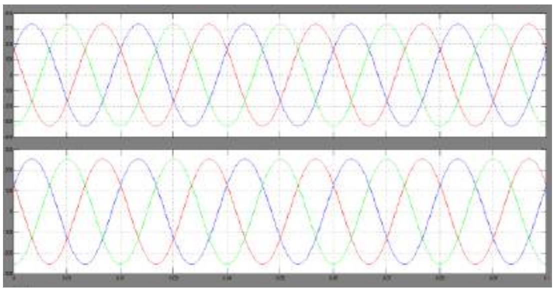

Fig 2: Waveform of Three phase voltage and current

Case 2: When the Load is Unbalanced

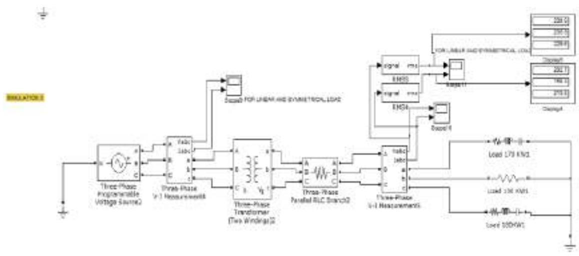

Fig 3: Simulation of Unbalanced Load

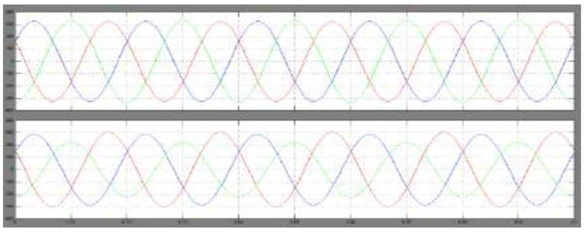

Fig 4: Waveform of Voltage and Current for Three phase Unbalanced Load

Case 3: Simulation for Unbalanced and Non Linear Load

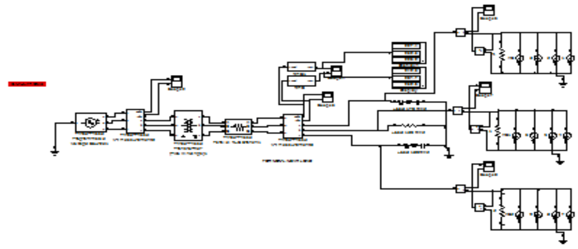

Fig 5: Simulation for Unbalanced and Non Linear Load

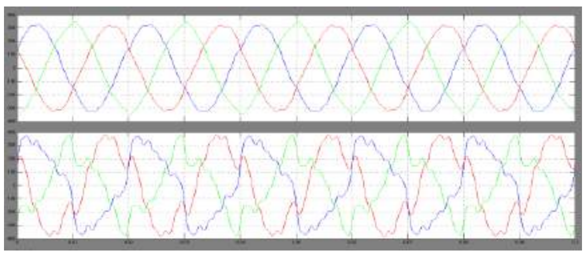

Fig 6: Waveform of Three phase Voltage and Current for Unbalanced and Non Linear Load

RMS values of Voltage and Current and total connected load in Kw:

Phase	Voltage in V	Current in A	Load in Kw
A	227.4	242.5	170
B	232.3	201.7	130
C	262.2	252.6	150

.

Calculation of K factor for Phase A current:

h	% of Harmonic Content	I_h	I^2_h	h^2	$I^2_h{*}h^2$
1	100	1	1	1	1
3	24.62	0.206	0.042	9	0.378
5	12.34	0.1234	0.0152	25	0.38
7	8.77	0.0877	0.0077	49	0.376
13	4.61	0.0461	0.0021	169	0.3591
Total			1.067		2.4931

K factor = 2.4931/1.1067 = 2.33

Calculation of K factor for Phase B current:

h	% of Harmonic Content	I_h	I^2_h	h^2	$I^2_h{*}h^2$
1	100		1	1	1
3	25.79	0.2579	0.0665	9	0.5985
5	15.44	0.1544	0.0238	25	0.5959
7	11	0.11	0.0121	49	0.5929
13	5.83	0.0583	0.00399	169	0.5744
Total			1.10639		3.3617

K factor = 3.3617/1.10639 = 3.04

Calculation of K factor for Phase C current:

h	% of Harmonic Content	I_h	I^2_h	h^2	$I^2_h{*}h^2$
1	100		1	1	1
3	19.64	0.1964	0.0386	9	0.3471
5	11.74	0.1174	0.0138	25	0.3446
7	8.35	0.0835	0.00697	49	0.3416
13	4.38	0.0438	0.00192	169	0.3242
Total			2.3575		1.106

K factor = 2.3575/1.106 = 2.224

IV. RESULT:

The calculated value of K factor is 2.33 for PhaseA,3.04 for Phase B, 2.224 for Phase C.

V CONCLUSION:

As from the calculation of K factor the three different values for three different phases are 2.33,3.04 and 2.224. So in the above selected parameters if a transformer is designed with K factor 4 (Rounding off to next higher integer amongst the biggest value), the heat generation will be minimized and efficiency of the distribution transformer will be increased. In case of already installed distribution transformer we can reduce the number of load connected to it (De rating of Distribution Transformer).

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TECH-CHRONICLE
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Inverter Fed 3-Phase Induction Motor Using Third Harmonic Injection Technique

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Abstract— With a purpose of increasing the amplitude of the voltage fundamental at the AC side of a three-phase inverter controlled by PWM, without reaching the over modulation area, the value of the modulating index (*m*) is increased towards unity. If we consider the inverter input voltage and the modulating index as unity for star connected load, the maximum amplitude of the phase voltage fundamental is half of inverter input voltage. By using a 3rd harmonic injection (THISPWM) sinusoidal wave as a reference wave, the amplitude of the output voltage can be around 15 percent higher than for a sinusoidal reference wave (SPWM).

Keywords—SPWM; THISPWM; THD

I. INTRODUCTION

Now-a-days voltage source inverters (VSI) are widely used with variable voltage and variable frequency in adjustable speed AC drives; uninterruptible power supplies (UPS), frequency changer circuits, solar photovoltaic and wind energy applications etc. The quality of the output on the AC side of inverter depends on the pulse width modulation (PWM) used. In a PWM waveform, the ratio of the output fundamental voltage to the input DC voltage determines the voltage gain. Output fundamental of the conventional sine – triangle PWM is diminished to 0.87 times the input DC voltage. This conventional SPWM method employs a sinusoidal reference and a triangular carrier, and is the most widely used PWM technique in the drives industry.

To overcome this poor utilization of DC voltage, innovative techniques have been presented. It can be seen that an intelligent formation of PWM pulse pattern can enhance the fundamental. Widened pulse width at the middle of the waveform leads to an enhanced fundamental. The third harmonic injection reference functions produce about 15% fortification of the fundamental voltage vis-à-vis the conventional SPWM [1][4].

II. VOLTAGE SOURCE INVERTER

Fig (1) shows the schematic diagram for a three phase Voltage Source Inverter (VSI). A Three phase voltage source inverter circuit changes DC input voltage to a three phase variable frequency, variable voltage output. The input DC voltage can be from a DC source or rectified AC voltage. It consists of six power switches with six associated with freewheeling diodes. The switches are opened and closed periodically in the sequence of their numbering, to produce the desired output waveform.

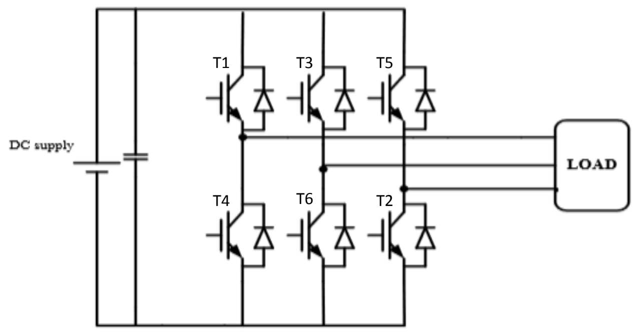

Fig. 1. Circuit diagram for three phase voltage source inverter.

III. SINE WAVE PULSE WIDTH MODULATION

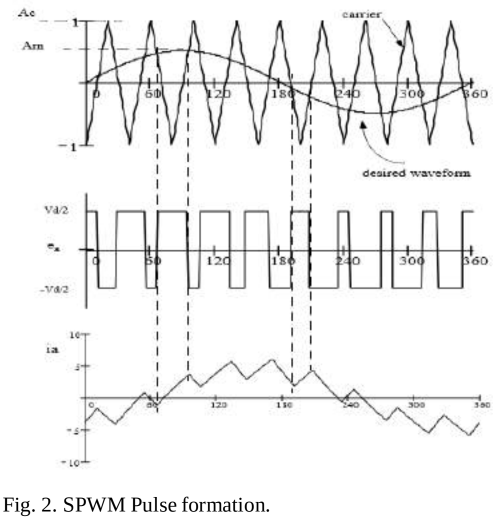

Fig. 2. SPWM Pulse formation.

In the most straightforward implementation, generation of the desired inverter output voltage is achieved by comparing the three phase reference waveform (modulating signal) with the common high frequency triangular carrier wave as depicted schematically in Fig (2) for single phase. Depending on whether the signal voltage is larger or smaller than the carrier waveform, either the positive or negative dc bus voltage is applied at the output. Over the period of one triangle wave, the average voltage applied to the load is proportional to the amplitude to the signal during this period. The resulting chopped square waveform contains a replica of the desired waveform in its low frequency components, with the higher frequency components being at frequencies of close to the carrier frequency [2]. The modulation index m is defined as

$$m = A_m / A_c \qquad (2)$$

where A_m is amplitude of reference waveform and A_c is amplitude of carrier waveform. In simulation program, the amplitude of sine modulating waveform can be adjusted to control the modulation index [1].

IV. THIRD HARMONIC INJECTION SPWM

The output voltage using the SPWM technique is limited to 0.5Vdc. If the SPWM technique is used in motor drive applications, the available voltage may not be sufficient to run the motor at rated condition. In this situation, the machine needs to be de-rated and a reduced torque is produced. To enhance the output voltage from the PWM inverter using carrier-based scheme, third-harmonic injection in the modulating signal is done [2]. The third-harmonic is similar to the selective harmonic injection method and it is implemented in the same manner as sinusoidal PWM. The difference is that the reference AC waveform is not sinusoidal but consists of both a fundamental component and a third harmonic component [3][6].

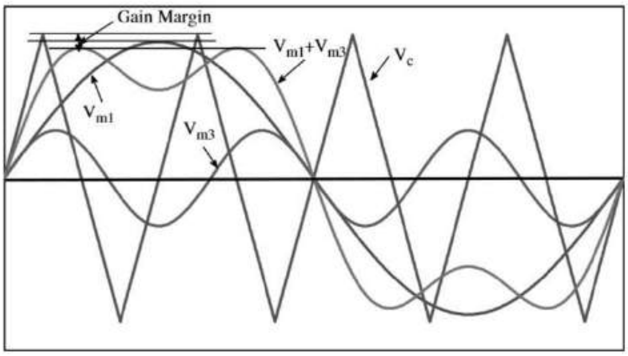

Fig. 3. Circuit diagram for three phase voltage source inverter.

It is shown in Fig (3) that by adding an appropriate third-harmonic component of the modulating signal in the fundamental modulating signal leads to a reduction in the peak of the resultant modulating signal. Hence, the reference value of the resulting modulated signals can be increased beyond 0.5Vdc and that leads to the higher output voltage at the inverter. The injected third-harmonic component in the modulated signal or reference leg voltages cancels out in the legs and does not appear in the output phase voltages. Thus the output voltage does not contain the undesired low-order harmonics. Therefore, the third harmonic PWM provides better utilization of the DC supply voltage than the sinusoidal PWM does. Harmonic elimination techniques which are suitable for fixed output voltage increase the order of harmonics and reduce the size of output filter [2][5].

V. MATLAB SIMULATION AND RESULTS

A. *Parameters considered for simulation*

- Switching frequency -10 KHz
- Modulating Signal Amplitude (Am):
  - I. SPWM - 0.9 V
  - II. THI-SPWM-

  Fundamental Wave - 1.1 V

  Third Harmonic Wave - 0.15 V
- Carrier Signal Amplitude (Ac):
  - – For both the cases -1.0 V
- DC input voltage to Inverter - 725 V
- 3Φ Induction Motor Specification:
  - – 5.4 HP(4KW), 400V, 50Hz, 1430 Rpm
  - – Full load torque - 26.71 N-m

B. *Simulation Model*

Following Fig (4) represents simulation model of inverter fed 3Φ Induction Motor where the switches i.e. IGBTs are controlled by some control technique which is represented by subsystem.

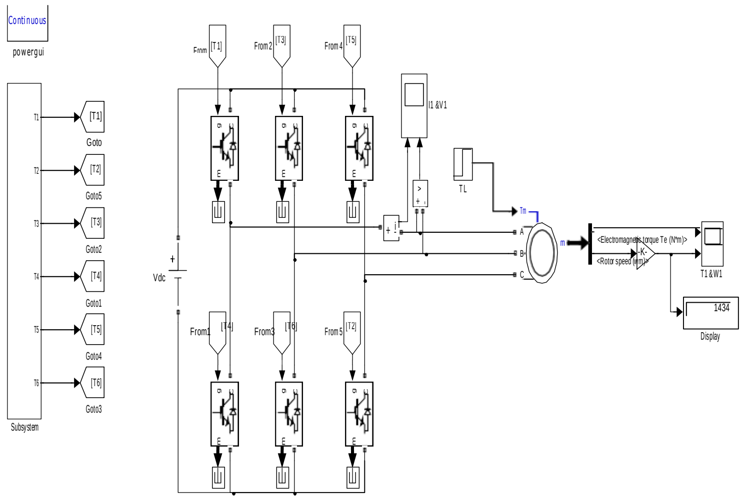

Fig. 4. Simulation Model of 3Φ inverter fed Induction Motor

Here three legs represent 3Φ inverter consisting of two switches per leg. The upper switches are for positive half waves and the lower switches are for negative half waves of 3Φ waveform. At the AC side of this inverter, 3Φ induction motor is connected whose performance we have to analyze. Two measurement blocks, one for voltage and another for current are connect on the AC side of the inverter for line voltage and line current measurement. The nature of speed and electromagnetic torque is analyzed with the help of scope. Here the simulation time is taken as 2 seconds. Initially the load torque applied will be zero. At the time of 1 second the torque applied will be full load torque.

C. *SPWM Control Technique*

When the subsystem shown in Fig (4) consist of control circuit as shown in Fig (5) then that control technique is called as SPWM technique. Here only single sine wave i.e.

fundamental sine wave (50Hz) is compared with high frequency triangular wave for all the three phases with sine wave at 120° apart from each other. Whenever triangular wave is greater than the sine wave, at the point of comparison it gives pulses which are given to the upper switches of inverter legs and the complementary of these pulses are given to the lower switches.

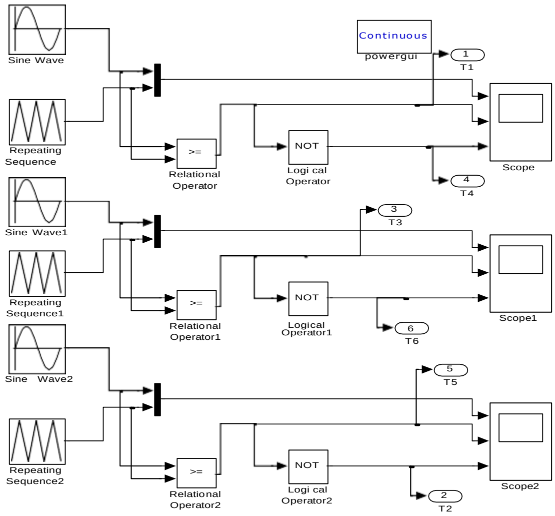

Fig. 5. Subsystem of 3Φ SPWM pulses

Fig (6) shows the simulation results for SPWM control circuit. Here pulses are shown only for the upper and lower switches of the first phase.

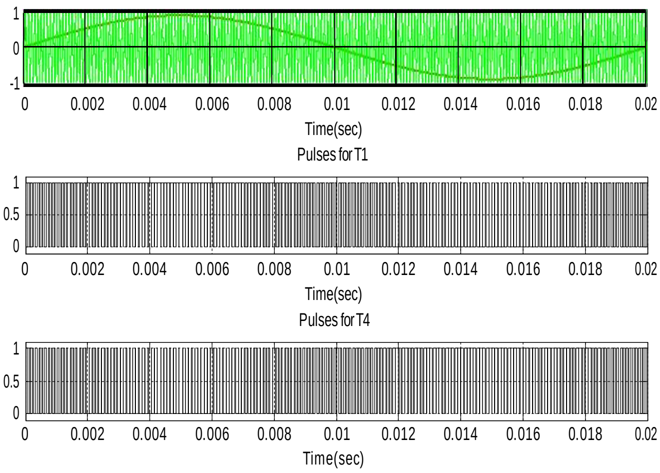

Fig. 6. Simulation results of 3Φ SPWM pulses (1Φ only)

D. THI-SPWM Control Technique

When the subsystem shown in Fig (4) consist of control circuit as shown in Fig (7) then that control technique is called as THI-SPWM technique. Here the resultant of two sine wave i.e. fundamental sine wave (50Hz) as well as third order sine wave (150Hz) is compared with high frequency triangular wave for all the three phases with fundamental sine wave at 120° apart from each other. Whenever triangular wave is greater than resultant wave, at the point of comparison it gives pulses which are given to the upper switches of inverter legs and the complementary of these pulses are given to the lower switches.

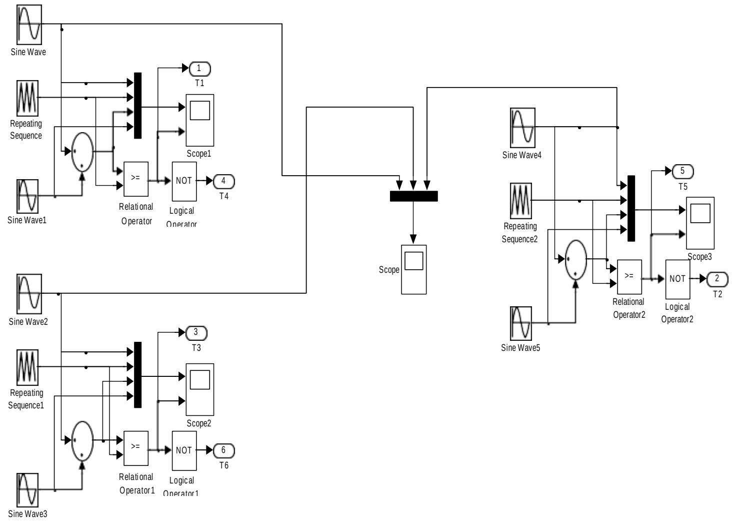

Fig. 7. Subsystem of 3Φ SPWM pulses with Third Harmonic Injection

Fig (8) shows the simulation results for THI-SPWM control circuit. Here pulses are shown only for the upper and lower switches of the first phase.

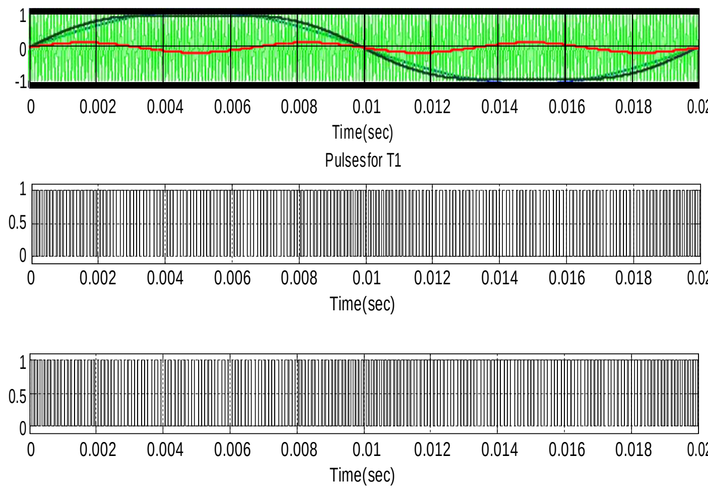

Fig. 8. Simulation results of 3Φ SPWM pulses with Third Harmonic Injection (1Φ only)

E. Inverter- Motor Simulation Results

Simulation of three phase Induction Motor fed with inverter is carried out. The complete simulation time is of 2 seconds. Initially the motor is simulated on no load condition. After time of 1 second the motor is loaded on full load condition. Fig (9) and Fig (10) shows the nature of current and voltage on the AC side of inverter which are fed to the motor for SPWM and THI-SPWM technique respectively.

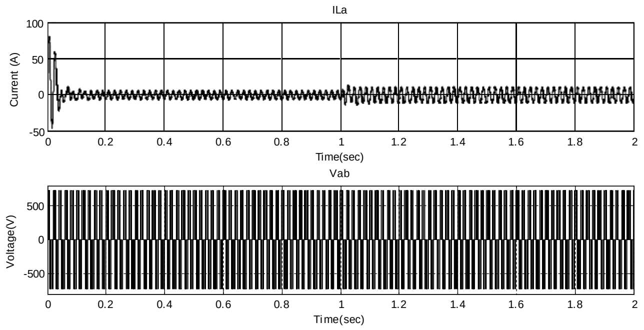

Fig. 9. Simulation results for Line current & Line Voltage on AC side of Inverter for SPWM

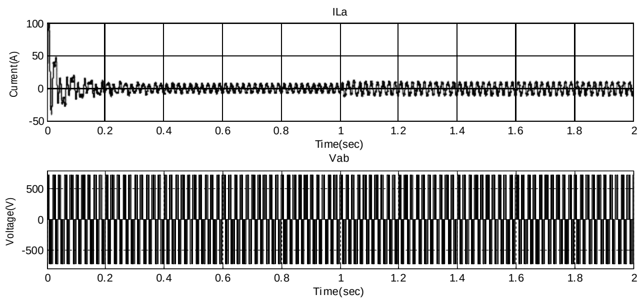

Fig. 10. Simulation results for Line current & Line Voltage on AC side of Inverter for THI-SPWM

Above results are for the input side of the motor. For the analysis output side of the motor we have to analyze the nature of speed and the torque of the motor with the same load condition. Fig (11) shows the nature of torque and speed of the motor for SPWM technique. Fig (12) shows the same result but with enlarged speed scale for analysis. Similarly, Fig (13) shows the nature of torque and speed of the motor for THI-SPWM technique and Fig (14) shows the same result but with enlarged speed scale for analysis.

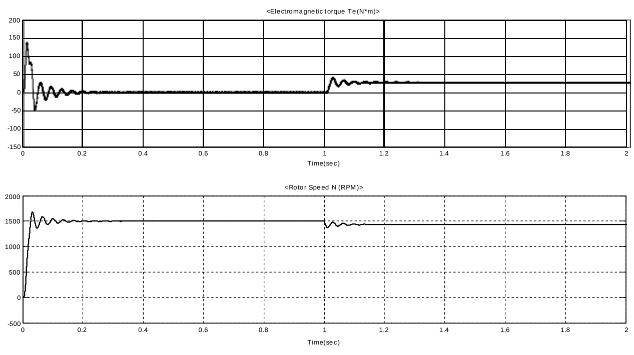

Fig. 11. Simulation results of Torque(N-m) & Speed(RPM) for SPWM

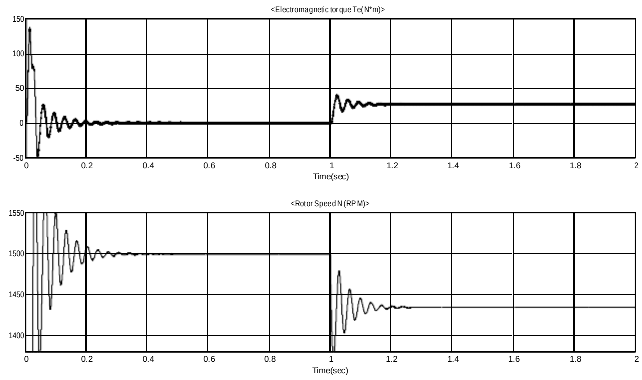

Fig. 12. With enlarged speed range (SPWM)

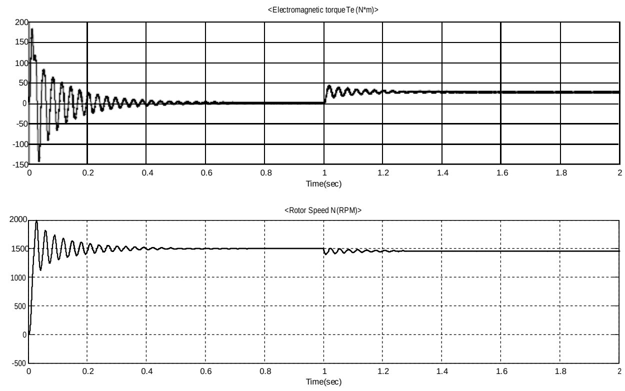

Fig. 13. Simulation results of Torque(N-m) & Speed(RPM) for THISPWM

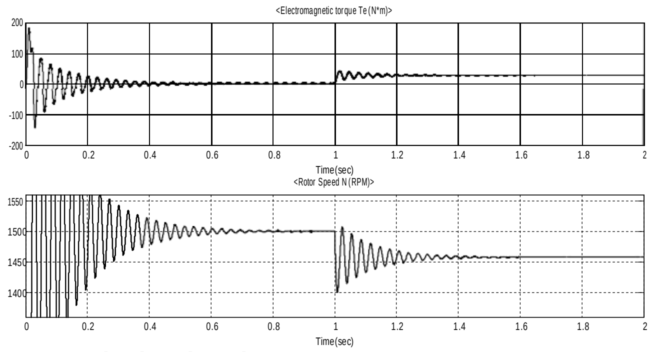

Fig. 14. With enlarged speed range (THISPWM)

From enlarged speed results, it can be observed that the full load speed for SPWM technique is reduced from no load rated speed 1500 rpm to around 1430 rpm-1440 rpm. Whereas for THI-SPWM technique the full load speed reduced to 1460 rpm-1450 rpm. Thus, by using THI-SPWM technique we get increase in speed of motor by approximately 30 rpm- 40 rpm.

F. FFT Analysis

FFT analysis is carried out on line current and line voltage on the AC side of the inverter. Fig (15) and Fig (16) shows FFT of the line current for SPWM and THI-SPWM technique,

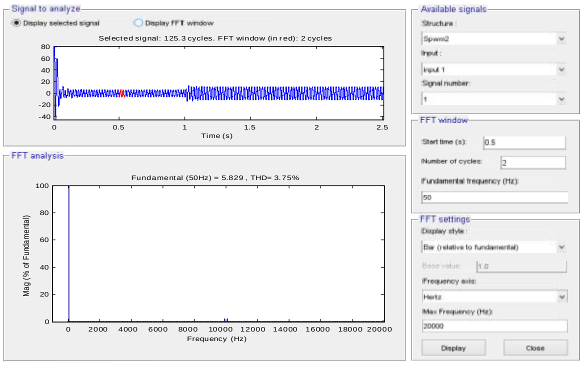

Fig. 15. FFT for line current for SPWM

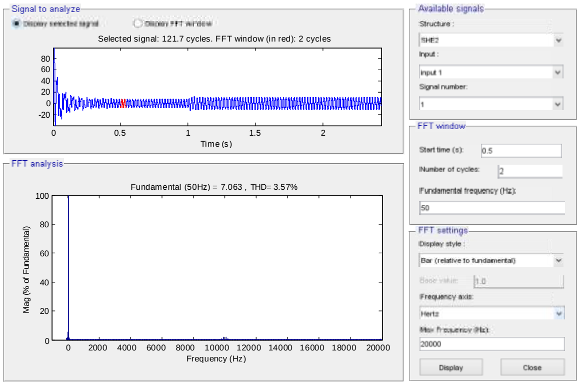

Fig. 16. FFT for line current for THI-SPWM

From the above results, it is observed that the total harmonic distortion (THD) in current for SPWM technique is more a compared to THI-SPWM technique.

Similarly, Fig (17) and Fig (18) shows FFT of the line voltage for SPWM and THI-SPWM technique in bar form.

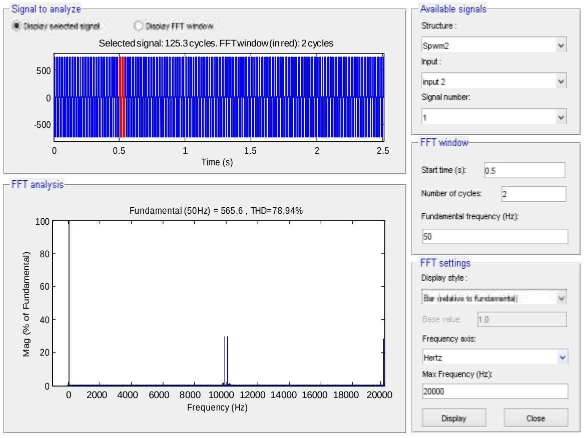

Fig. 17. FFT for line voltage for SPWM (Bar Form)

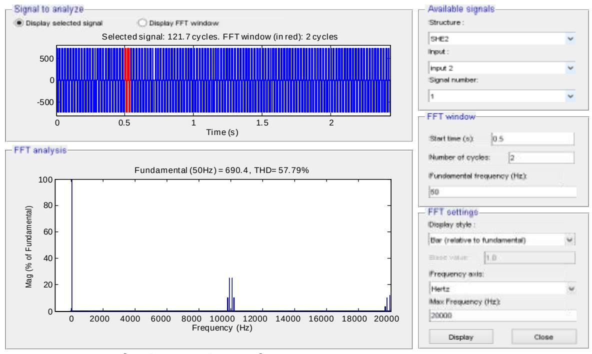

Fig. 18. FFT for line voltage for THISPWM (Bar Form)

Here also it can be observed that the THD in the line voltage on the AC side of inverter for SPWM technique is more as compared to THI-SPWM technique. Now by analyzing the list form of the FFT of line voltage from Fig (19) and Fig (20) for SPWM and THI-SPWM respectively, it can be observed that the fundamental component of the voltage is of greater magnitude in THI-SPWM technique than in SPWM technique. Thus, by using THI-SPWM technique we can be enhanced voltage on AC side of inverter for same switching conditions and load conditions.

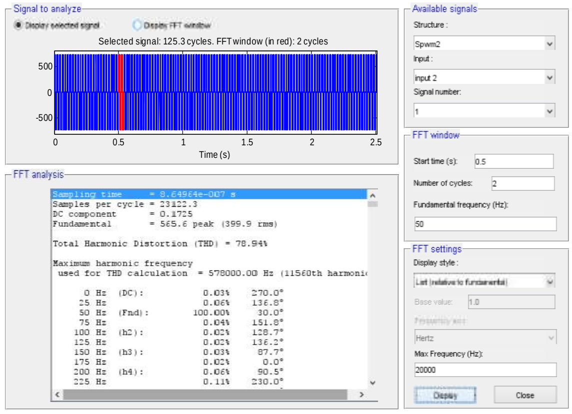

Fig. 19. FFT for line voltage for SPWM (List Form)

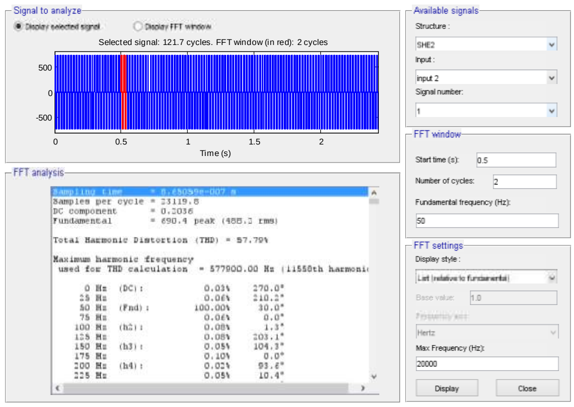

Fig. 20. FFT for line voltage for THI-SPWM (List Form)

VI. Conclusion

The gain margin for increasing the modulating index is more in THI-SPWM and the output voltage on the AC side of the inverter can go beyond 0.5Vdc in THI-SPWM. Motor runs at greater speed for THI-SPWM technique as compared to SPWM technique for same switching and load conditions. The fundamental component of the inverter output voltage is more in THI-SPWM as compared to SPWM for same switching condition. THD in THI-SPWM technique is less than SPWM technique.

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TECH-CHRONICLE
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Design Considerations for Series Connected Distributed FACTS Converters

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Abstract— **The power grid is aging, under-utilized and increasingly congested. Conventional solutions, such as Flexible AC Transmission Systems (FACTS) can be used to control power flow on the grid. However, widespread adoption of this technology has been hampered by high cost and reliability concerns. The concept of Distributed FACTS (D-FACTS) devices, as an alternative approach to realizing cost-effective power flow control, has been recently proposed. This paper discusses the design considerations for implementing distributed power control solutions on the power grid, with specific examples for series VAR compensation, and the significant impact it can have on grid utilization and system reliability. The ability to use mature power conversion techniques demonstrates the potential for low-cost implementation.**

Keywords- FACTS, Distributed FACTS, Active power flow control, Series VAR compensation

I. INTRODUCTION

The power grid in the US and in most other parts of the world, is aging and under increasing stress. The modern industrial infrastructure demands increasing amounts of affordable and reliable electricity. Yet in a semi-regulated utility environment and in the face of increasing public sentiment against locating power lines in their communities, the ability to use the existing asset base more effectively has become a critical issue [1].

The utilities have done a good job in ensuring availability of reliable electricity. An important component of higher reliability is a gradual move from radial power distribution to a system that is increasingly networked. This allows faulted sections of the grid to be rapidly isolated, without sustained interruption of power to the vast majority of customers. The utility cannot effectively control how power flows on such a network. Further, the first line that hits thermal limit constrains the total power transfer capacity of the entire system, even as other lines in the system are only operating at a fraction of their capacity. Finally, the network topology changes continually, as lines, loads and generation are added and dropped. Maintaining system integrity under current conditions, as well as under (N-1) and (N-2) contingency conditions, creates a compelling need for controlling power flow on the network.

The 'conventional' and technically proven approach for controlling power flow on the grid has been through the use of Flexible AC Transmission Systems (FACTS) devices [2]. Shunt VAR compensators such as STATCONs represent the more cost effective technology. Shunt VARs provide grid voltage support, while series VARs are required to control active power flow. Active power flow requires 'series VAR' solutions, that can alter the impedance of the power lines or change the angle of the voltage applied across the line [3]- [4]. Series reactive compensation has rarely been used other than on long transmission lines due to the high cost and complexity of implementation. Finally, one can realize a combination of shunt-series devices such as the universal power flow controller (UPFC) that can provide a myriad of control possibilities, but of course at a higher price.

While FACTS devices have been proven technically and have been available for over a decade, market adoption of the technology has been poor. This seems to be largely due to high cost and reliability/availability levels that may not have met utility expectations. High stresses, particularly under fault conditions, and long mean time to repair are major contributors to the unscheduled downtime experienced by FACTS devices.

The increasing performance and decreasing price of electronics, power electronics and communications technologies have transformed entire industry sectors. It is proposed that a similar approach to the implementation of high power FACTS devices can provide a higher performance and lower cost method for enhancing T&D system reliability and controllability, improving asset utilization and end-user power quality, while minimizing system cost and environmental impact.

The concept of Distributed FACTS devices has recently been proposed as an alternative approach for realizing the functionality of FACTS devices, in particular series FACTS devices, but at lower cost and higher reliability. This paper proposes an approach for classifying D-FACTS devices, and examines the most important design considerations that would guide and limit the application of such devices.

The concept of a Distributed Series Impedance (DSI) that can realize variable line impedance, helping to control active power flow is used to illustrate the feasibility of a Distributed FACTS or D-FACTS approach. The concept can be further extended to realize a Distributed Static Series Compensator or DSSC, using modules of small rated (~10 kVA) single phase inverters and a single turn transformer (STT), along with associated controls, power supply circuits and built-in communications capability. These concepts are discussed in detail, along with the benefits and issues associated with such an application.

II. SERIES D-FACTS DEVICES

Fig. 1 shows a conceptual schematic of D-FACTS devices deployed on a power line so as to alter the power flow by changing the line impedance. Each module is rated at about 10 kVA and is clamped on the line, floating electrically and mechanically on the line. Each module can be controlled so as to increase or decrease the impedance of the line, or to leave it unaltered. With a large number of modules operating together, it is possible to have a significant impact on the overall power flow in the line. The low VA ratings of the modules are in line with mass manufactured power electronics systems in the industrial drives and UPS markets, and suggests that it would be possible to realize extremely low cost. Finally, the use of a large number of modules results in high system reliability, as system operation is not compromised by the failure of a small number of modules.

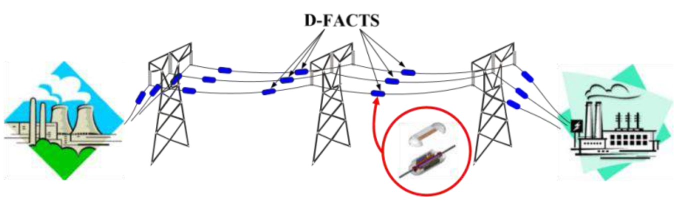

Figure 1. D-FACTS deployed on power line

Equation (1) shows how power flow varies with the line reactance. Control of real power flow on the line thus requires that the angle δ or the line impedance X_L be changed. A phase shifting transformer can be used to control the angle δ. This is an expensive non-scalable solution and provides limited dynamic control capability. Alternatively, a single series compensator can be used to increase or decrease the effective reactive impedance X_L of the line, thus allowing control of real power flow between the two buses. The impedance change can be effected by series injection of a passive capacitive or inductive element in the line. Alternatively, a static inverter can be used to realize a controllable active lossless element such as a negative or positive inductor or a synchronous fundamental voltage that is orthogonal to the line current.

$$P_{12} = \frac{V_1 V_2 2 sin\delta}{X_L} \quad \_\_\_\_\_\_\_\_ \quad (1)$$

where V_1 and V_2 are the bus voltage magnitudes δ is the voltage phase difference and X_L is the line impedance.

The series injection of impedance or voltage at each module can be accomplished using a single turn transformer (STT) and a switch. A typical DSI device implementation is shown in Fig. 2. Switch S_1 can be closed to inject an overall inductance X_L, while S_2 can be closed to inject capacitance X_C. Control power needs to be derived from the line itself or from the voltage generated across the transformer. Further the system requires a cost effective communication infrastructure such as a power line based communication system for it to be able to function in a coordinated manner.

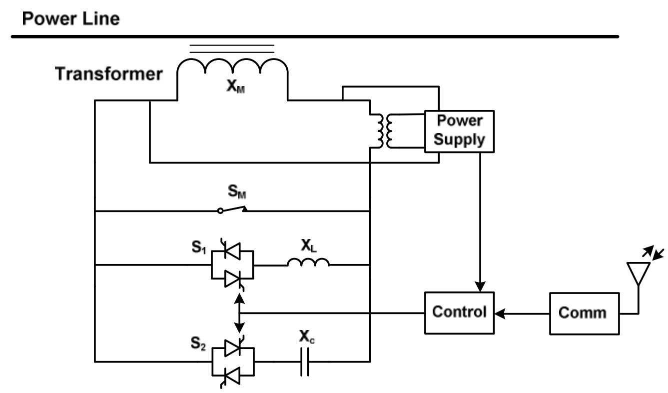

Figure 2. Generic DSI device

A higher level of flexibility and dynamic performance can be obtained if a single phase inverter is used to provide injection of a controllable positive or negative inductance, or for the injection of a desired leading or lagging quadrature voltage. The system schematic, shown in Fig. 3, also utilizes a single-turn-transformer (STT) to reduce the current to levels compatible with existing IGBT devices. For instance, with a 50:1 STT, 1000 Amperes on the power line is reduced to 20 Amperes for the inverter devices. Further, the ability of the inverter to emulate any impedance or voltage clearly provides higher granularity in terms of system control.

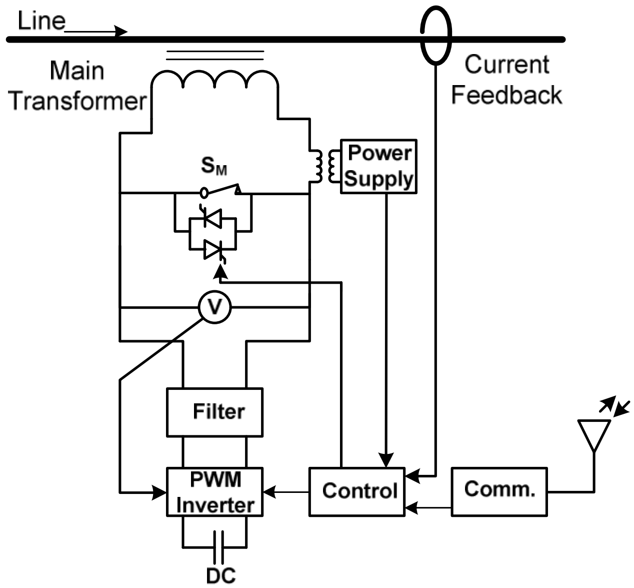

Figure 3. Generic DSSC device

The most important issues concerning the design of such modules are driven by the unique aspects of the application. The issues of mechanical clamping, potential for conductor damage, heat removal, extreme environments, corona discharge, fault currents and lightning strikes are all critical issues to resolve. Of these important issues, the transformer and power supply possibly represent the most critical electrical components that govern the overall design of the device. From a module and system control perspective, there are several key issues to address. Operation of the system under normal and fault conditions, coordinated switching of multiple units to achieve a desired control objective, total system weight and effective heat transfer to the surroundings will determine efficacy of system operation. Some of these important design considerations are addressed in this paper.

III. Transformer Design

The single-turn transformer perhaps represents the most important design issue for series D-FACTS systems. For a typical transmission and distribution line operating at 138 KV level, the line parameters are shown in Table I [5]-[6].

TABLE I. Line Parameters

Operating Line Voltage	Thermal Capacity	Outside radius of conductor	Impedance per mile
138 KV	750 A	0.033 m	0.168+j 0.789

To change the line impedance by 1%, an injection of ~0.00789 Ω/mi (21 μH) is required or an equivalent voltage injection of 7.89 V is required at an operating line current of 1000 A. As an illustrative design example, the rating of the transformer is assumed to be 10 KVA, corresponding to an injection of 10 V at 1000 A.

The transformer operation can be categorized under two different operating conditions: by-pass mode and the injection mode. In the by-pass mode, the output of the transformer is shorted by an electromechanical relay to cancel the power line mmf and therefore to inject only the leakage inductance into the line. In the injection mode, the electromechanical relay is opened and the inductance X_L is injected into the line.

The transformer core consists of two parts that can be physically clamped around a transmission line, forming a complete magnetic circuit as shown in Fig. 4 [7]. The power line itself functions as one of the windings of the transformer. The other winding is wound on the cylindrical core with multiple turns so as to transform the operating line amperes to lower value sustainable for the switches under by-pass mode.

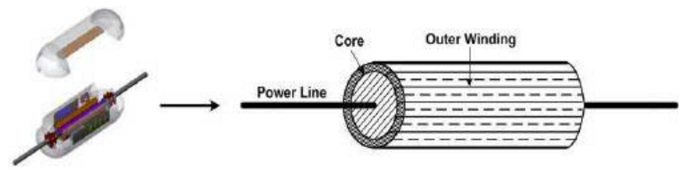

Figure 4. Single Turn Coaxial Transformer

All flux produced by the outer winding links the inner winding completely. The converse is true if the permeability of the magnetic medium is much higher than that of the insulating material between the inner winding and the magnetic core. The leakage inductance is therefore primarily accounted from the leakage flux of the inner winding and from the leakage flux of the end turns of the outer winding.

The weight of the STT is the most critical design consideration and requires use of minimum iron and copper. As the volume of a cylindrical object varies linearly with the length but with the square of the radius, so a lower weight can be obtained if the length is made much longer than the radius for a given volume. For the same reason, gap between the cable and the inner radius of the core must be a minimum so as to just allow for the mechanical clearance and cable deflection under sag conditions.

The current flowing in the power cable produces flux lines tangential to circular paths around the cable. The flux density varies radially as shown in (2), and this results in a non uniform flux density distribution. However for thin cores design computations can be made simpler by assuming magnetic field density to be constant in the core.

For the particular application of coaxial transformers considered here, the magnetic path of the core always will have a small air gap, as a result of the separable cores needed for clamp-on. This results in a decrease in the designed magnetizing inductance of the transformer. Therefore as a design rule, the transformer is designed for a higher value of magnetizing inductance say >3 times the required value. This can be later compensated by introducing the required length of the air gap.

As an example, a design of a transformer with a magnetizing inductance of 50 µH (2 ½ times the nominal value of 21 µH) under nominal operating conditions of 1000 A in the cable, results in a flux of 0.0375 Wb crossing the core cross sectional area. Flux densities of 1.6-1.8 T are common in grain oriented silicon steels at magnetizing field intensities of 2000-5000 A/m. With the operational flux density selected to be at 1.6 T, the physical design of the core is given in Table II.

TABLE II. CORE CONFIGURATION

Mechanical Clearance	Inner Radius	Outside Radius	Length	Weight of iron
0.005 m	0.038 m	0.0573 m	1.15 m	50.4 Kg

The outer winding needs to handle the nominal current of the cable as well as the short time fault current of up to 30,00040,000 A. For the designed length and thickness of the core, copper wire of 10 AWG is selected. The wire can have 9.8 turns per inch giving sufficient space to have 50 turns on the core. Further, a fusing current rating of 667 A allows for short duration fault currents of 33,000 A. The weight of the copper is estimated at 5.6 kg, making the total weight of the transformer approximately 56 Kg.

A.Thermal model for losses

Heat generated in the transformer and the module itself must be transferred to the surroundings effectively so as to maintain safe operation of the windings and the magnetic core. This needs to be done without any fans or moving parts, and the device should be able to withstand climatic extremes and temperatures.

There are three different sources of heat generation in the transformer: (i) copper losses in the inner winding, which are present in the by-pass as well as injection mode, (ii) iron losses in the core which occur only during the injection mode and (iii) copper losses in the outer winding during the by-pass mode. Fig. 5 shows the thermal model of the transformer in the bypass and the normal injection mode. Heat transfer mainly occurs through

inductance with all the DSR modules on the line active, I_0 is the triggering value of current for a module and $I_{thermal}$ is the thermal limit beyond which there is no injection.

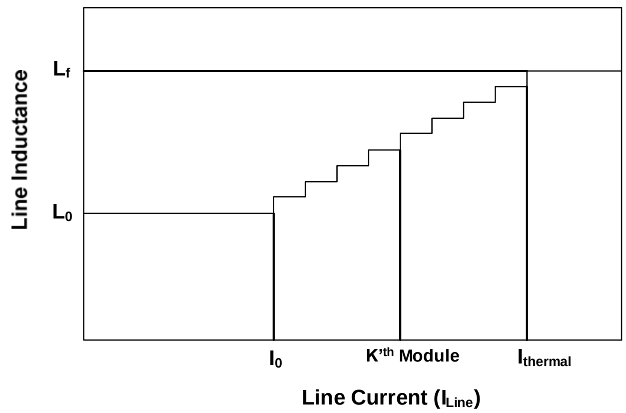

Figure 9. Profile of Injected Impedance

IV SIMULATION RESULTS

As an example illustrating DSI operation in a system, the ability of DSR devices to alleviate line loading and congestion was simulated with the simple four bus system shown in Fig. 10. Each of the lines has a thermal rating of 750 A and an impedance of 0.168+j 0.789.

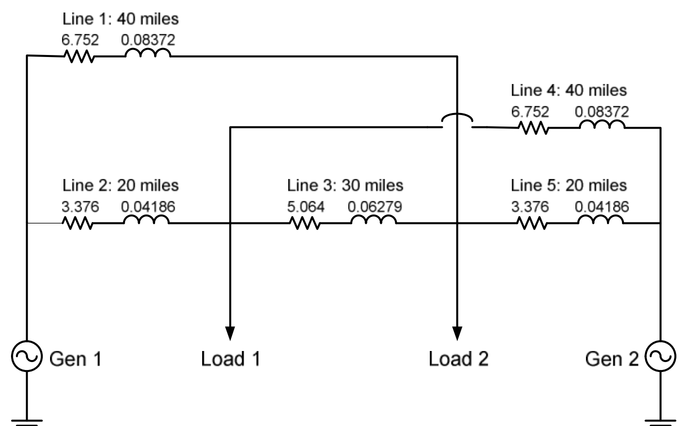

Figure 10. Detailed schematic of the 4 bus system

Line 2 and Line 5 are identified as the most critical line of the network as the maximum transfer capacity of the network is determined by these lines. Fig. 11 shows Line 2 operating at thermal limit, with a rapid reduction in average current as the DSR devices are switched in. The redistribution of the current through the network has a direct impact on the available transfer capacity. The original system ATC is limited by Line 2 or Line 5. Fig. 12 shows the increase in power transfer capacity of the network as a function of injected MVARs.

V EXPERIMENTAL RESULTS

To demonstrate the concept of D-FACTS devices, a DSSC module was built and tested in the laboratory under a project jointly funded by TVA and Soft Switching Technologies [11]. A circuit schematic of the system is shown in Fig. 13. The DSSC system was capable of injecting leading or lagging impedances or quadrature voltages, and could balance the dc bus voltage on the single phase inverter using an 'in-phase' component of the voltage. Successful operation was demonstrated in a laboratory environment. Details of the results have been presented in a previous paper, and are summarized here [8].

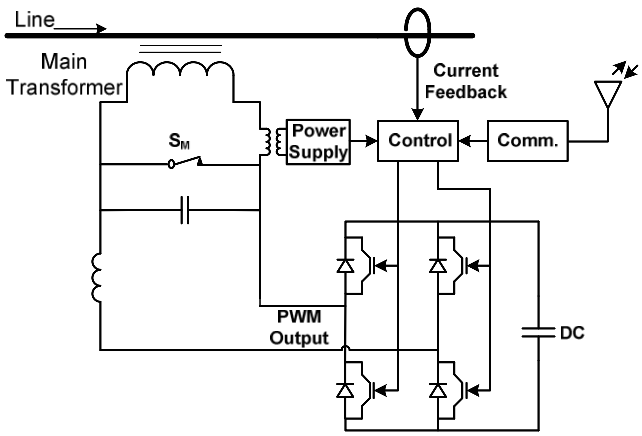

Figure 13. Circuit schematic of DSSC

The unit was designed for line currents of up to 1500 A and fault currents of over 12,000 Amperes. The IGBT inverter was rated at 6.7 kVA and was used to provide the fault current ride-through capability. Based on an STT turns ratio of 90:1, the nominal current in the IGBT inverter at 1500 Amperes was less than 20 Amps. The inverter devices were controlled using sine-triangle PWM at 12 kHz using a PIC microcontroller. DC bus control was realized using a signal in-phase with the line current, while a command reference signal provided the desired quadrature voltage injection. The power supply was designed to operate over a range of 300 – 1500 A in steady state, with ride-through for current surges up to 12,000 A. The module demonstrated injection of positive and negative inductance, quadrature voltage of +/-4.6 volts, and the ability to steer power flow through a desired path in a parallel connection. Fig. 14-15 shows DSSC operation under zero, leading and lagging voltage injection conditions. With zero injection, the voltage impressed across the STT is seen to be in-phase with the current, corresponding to losses in the circuit. The DSSC module was tested under normal and fault currents of up to 12,000 Amperes, and behaved as anticipated. Finally, the DSSC module was used to demonstrate the ability to steer current between two parallel lines as commanded (Fig.).

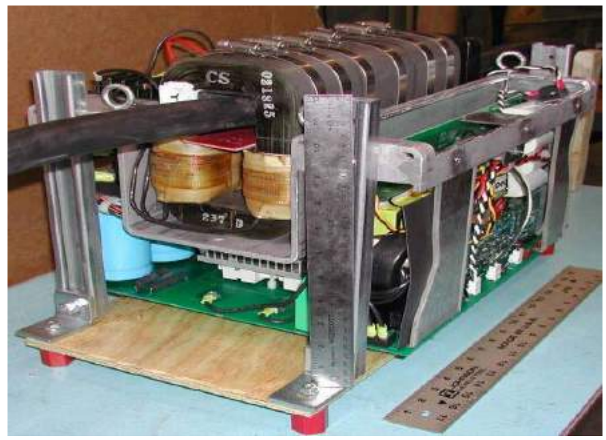

Figure 14. Laboratory prototype of DSSC

VI. CONCLUSIONS

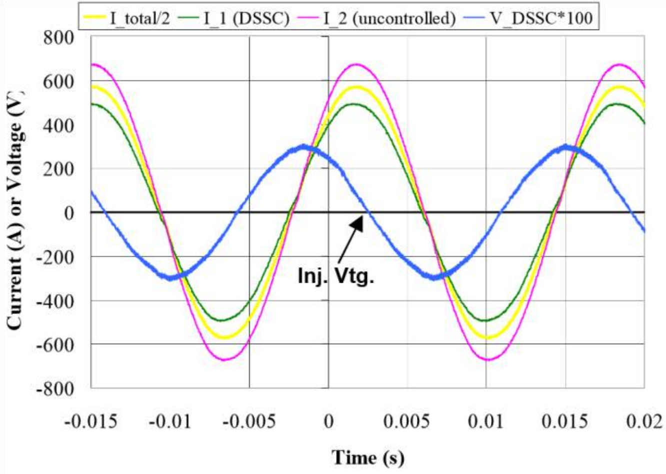

Figure 15. Operation under leading voltage injection

This paper presents a new approach to controlling power flows on the transmission and distribution grid. Distributed FACTS or D-FACTS devices using commercially available low power devices, offer the potential to dramatically reduce the cost of power flow control. Series VAR compensation using D-FACTS would help utilities alleviate grid congestion, defer construction of new transmission lines, and improve system capacity. D-FACTS devices require no change in utility infrastructure and operate autonomously, with or without communications. High reliability, low cost and long life of these devices make them all the more attractive.Widespread adoption of this technology requires in depth analysis of some of the practical limitations. Some of the issues such as operation under normal and fault conditions, coordinated switching, heat transfer and total system weight have been addressed in this paper. Simulations and experimental results demonstrate the potential impact of these devices in terms of better grid utilization and improvement in system reliability.

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Dynamic stability improvement of grid for different types of wind generator connected using STATCOM

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Abstract— **When integrated to the power system, large wind farms are concerned with stability and control issues. A detailed study is needed to recognize the possible problems and to develop methods to alleviate them. Although integration of high levels of wind power into an existing transmission system does not require a major restructure, it inflicts additional control and compensating equipment to enable recovery from severe system disturbances.**

This paper explores the use of a Static Synchronous Compensator (STATCOM) along with wind farms for the purpose of stabilizing the grid voltage after grid-side disturbances such as a three phase short circuit fault, temporary trip of a wind turbine and sudden load changes. The scheme focuses on a essential grid operational requirement to retain proper voltages at the point of common coupling by regulating voltage.

Index Terms— Dynamic Stability, Grid, STATCOM, Wind turbine

INTRODUCTION

The wind power perception has increased intensely in the past few years, hence it has become essential to address problems accompanying with maintaining a stable electric power system. With an increasing share consequent from wind power sources, unceasing connection of wind farms to the system has played an increasing role in assisting uninterrupted power supply to the load, even in the case of insignificant disturbances. The wind farm capacity is being constantly increased through the connection of more and larger wind turbines. Voltage stability and an efficient fault ride through capability are the basic necessities for higher perception. One of the major disputes concerning a wind farm interconnection to a power grid concerns its dynamic stability on the power system. Voltage instability problems occur in a power system that is not able to meet the reactive power demand during faults and heavy loading conditions. Standalone systems are at ease to model, examine, and control than large power systems in simulation studies. A wind farm is usually spread over a widespread area and has various wind generators, which yield different amounts of power as they are exposed to different wind patterns. Flexible AC Transmission Systems (FACTS) such as the Static Synchronous Compensator

(STATCOM) and the Unified Power Flow Controller (UPFC) are being used widely in power systems because of their ability to offer flexible power flow control. The main inspiration for selecting STATCOM in wind farms is its ability to provide bus bar system voltage support either by supplying and/or absorbing reactive power into the system.

I. STATCOM STRUCTURE AND OPERATION

The STATCOM have a solid influence on voltage quality enhancement and show medium performance with respect to complete system stability. The main objective in this paper is to look for results to deliver voltage stability to the system in order to operate wind turbines in accordance with the grid codes. The STATCOM is the best choice available for providing efficient voltage quality in the power system. A STATCOM is a shunt connected reactive power compensation device that is capable of producing and/or absorbing reactive power and in which the output can be varied to control the exact parameters of an electric power system. The STATCOM is a static compensator and is used to regulate voltage and to recover dynamic stability. A STATCOM can supply the essential reactive power under various operating conditions, to control the network voltage dynamically and thus, improve the steady state stability of the network. The STATCOM can be functioned over its full output current range even at very low voltage levels and the maximum var generation or absorption changes linearly with the utility or ac system voltage. Figure 1 and 2 shows the representation of the STATCOM and its VI characteristics. The main role of a STATCOM is to provide reactive power support and thus improve voltage stability.

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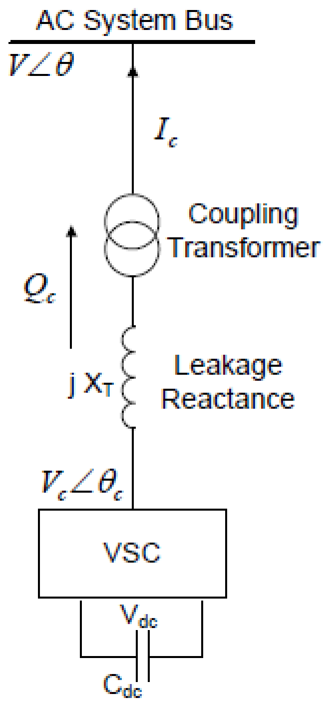


Figure1. Basic model of a STATCOM

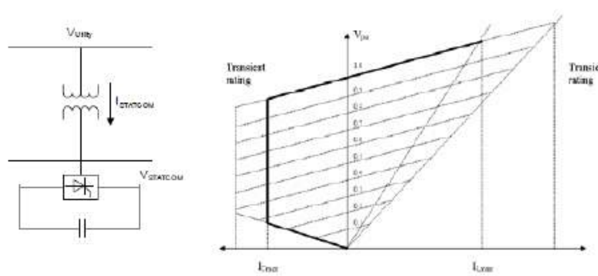


Figure2. STATCOM and its VI characteristics

A. LOCATION OF STATCOM

Simulation results show that STATCOM offers effective voltage support at the bus to which it is connected to. The STATCOM is placed as close as possible to the load bus for numerous reasons. The first reason is that the location of the reactive power support should be as near as possible to the point at which the support is needed. Secondly, in the test system the location of the STATCOM at the load bus is more suitable because the effect of voltage change is the highest at this point.

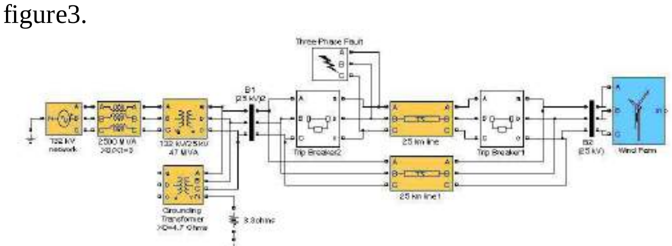
The location of the STATCOM is based on quantitative benefits assessment. The main benefits of using a STATCOM in the system are reduced losses and increased maximum transfer capability. The location of STATCOM is generally chosen to be the location in the system which needs reactive power. To place a STATCOM at any load bus reduces the reactive power flow through the lines, thus, decreasing line current and also the *I* 2*R* losses. Distribution of reactive power at low voltages in a system running close to its stability limit is not very effective. Also, the total amount of reactive power transfer available will be influenced by the transmission line power factor limiting factors. Hence, sources and compensation devices are always kept as near as possible to the load.

B. REACTIVE POWER SUPPORT FROM STATCOM

The quantity of reactive power supplied by any compensating device depends on the voltage drop at the bus and its capabilities. For example, a STATCOM can provide its maximum rated compensating current even at lower voltages. The rating of the STATCOM also decides the maximum reactive power that can be supplied, but usually they have some extra capability called the transient capability which is accessible to the system for a short period of time. The reactive power supplied is also reliant on the immediate reactive power sources in the system. The size of the wind turbine and the synchronous machine also affects the reactive power capability.

II. TEST SYSTEM MODEL

Considered wind farm in this paper has 6, 15 MW turbines. Mentioned units are coupled to grid by a 400/ 20 kV transformer and a 20 kV, 2 lined distribution line with 25 km length and 132/20 kV transformer. Used generators in this model are squirrel cage induction generators and stator windings are directly associated to the grid and at the junction point in order to compensate part of required reactive power, capacitor bank is used. Simulated system model is shown in figure3.



Fg.3. Test Model

In this figure3.system comprising wind farm model and its turbine with other system elements are shown. This grid is used to study and examine machine and wind farm stability. A Short circuit effect closed to the CB on the induction generator stability, that the CB is switched off after 150 ms on each side of line in grid, is considered. Since induction machine electrical torque is in relation with the terminal voltage square then under short circuit conditions its value will decrease significantly according to terminal voltage decrease and so machine slip (rotor speed) increases. According to machine electrical torque changes associated to the slip in short circuit time machine operation point will transfer to new electrical torque curve with low terminal voltage, if the operation point of machine stay at so before its connection and since machine input mechanical torque is constant so machine slip value will increase. If fault is removed according to machine electrical torque, stability conditions are studied. For this purpose modeling are done in 3 parts:

1. Induction generator stability conditions study.
2. Induction generator stability conditions study with using STATCOM.
3. Induction generator stability conditions study with using STATCOM and stabilizer resistance.

In this study, initial conditions are: 1.Units output power in nominal value is stabilized by wind turbines pitch angle control. 2. Part of induction generators required reactive power is considered by capacitor bank connected to 400 V terminals at 400 KVAR rate. In this system it is obvious that for different conditions more reactive power demand is provided by grid. A 3- Phase short circuit is occurred at 15 seconds time and 150 ms later, defected element is deceased. Initially wind farm dynamic conditions in the form of wind turbines direct connection to grid (without STATCOM and stabilizers resistance) is studied.

A- Inductions generator manner and its stability study.

In this condition, units connection to electrical system with constant capacitor connected to generator terminals is studied. Even After system fault elimination, induction generator electrical torque would be less than turbine input mechanical torque so rotor speed will increase till generator protective systems would expel it from the circuit because of high speed. Modeling results and wind farms induction generators output is presented in figure (4). This figure designates the active power of generators and turbines pitch angle controller.

Figure (5) displays the wind farms connection points to grid electrical changes, such as wind farm reactive and active power connection to bus voltage changes. As shown in the figures, as wind speed increases, wind farms pitch angle controller increases and controls the blades angles to keep the output power constant. This topic is shown in figure (4- d) and at 4 seconds time for first turbine. Above situations have been modelled for 2nd and 3rd turbine in 6 seconds and 8 seconds. In the conditions that in 15 seconds a fault has occurred on the first line, after 150 ms mentioned fault will be deceased of electrical system by defected line exit. As it is evident in figures (4) and (5) , when rotor speed increases, units generating power is decreasing and also induction generators required reactive power is increasing. Figure (5- b) shows absorbed reactive power from grid, as units requirement to reactive power increases, bus voltage decreases and ends to voltage instability conditions as shown in figure (5- c), under such conditions wind farm linking to grid is not provided anymore and wind turbine cannot generate active power so units output power will decrease and reaches to zero, and even after fault removed, stability conditions for induction units will not be delivered when rotor speed is increasing. In order to induction generators, generation continues providing their stability, STATCOM using role in condition optimization is studied.

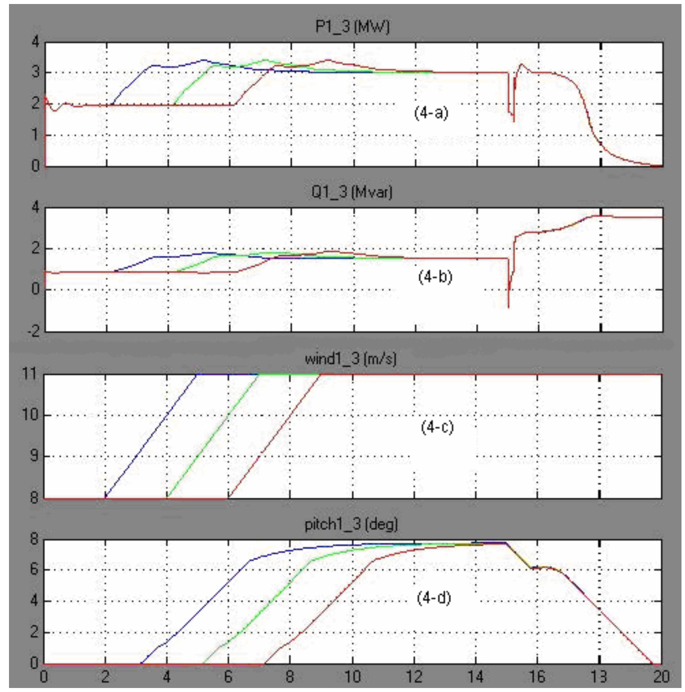


Fig 4. Fig (4-a) and Fig (4-b) show active and reactive power of three wind turbine unit, Fig (4-c) and Fig (4-d) show wind speed and Pitch angel of turbines.

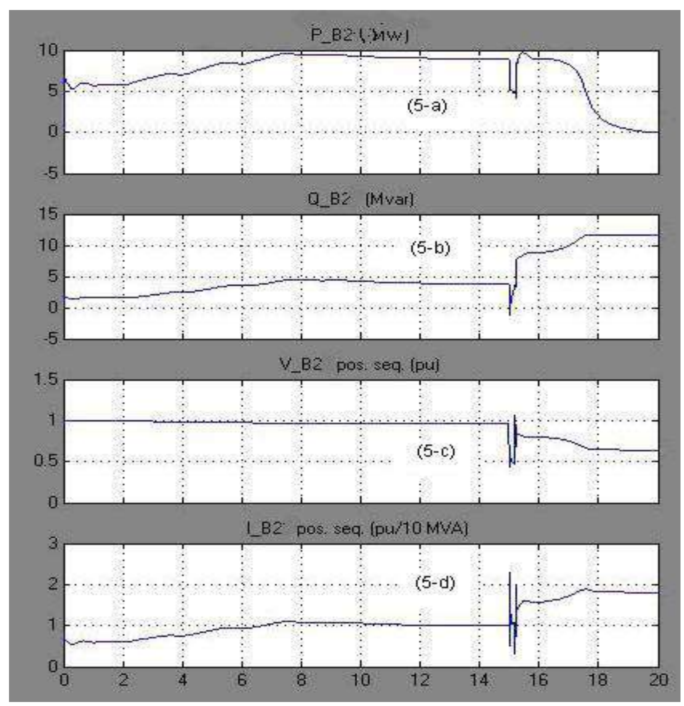


Fig 5. Fig (5-a) and (5-b) show active and reactive power of wind farm bus and Fig (5-c) and (5-d) show voltage and current of wind farm bus.

B. Study system modeling with applying STATCOM.

Test system model with using STATCOM is shown in figure (6). In this model, STATCOM is associated to wind farm bus and its operation in wind farm under the last modelling conditions is analysed and studied. Since STATCOM working acts in the way that with reactive power transformation in its nominal limit, tries to keep and stabilize voltage amplitude in connection point in the determined value, then, provides induction generators stability conditions. Above conditions modeling results are indicated in figures (7) and (8). As it is shown in figure (7) in short circuit time and stability conditions are provided for induction units in the way that rotor speed increase acceleration is controlled and induction generators generated power is kept. Figure (8) shows the wind farms connection parameters conditions. As you see, stable condition for bus voltage is provided by wind units required reactive power proper control possibility and in result, generated power transmission condition to grid is provided by generated electrical torque, created by induction machine, increase possibility.

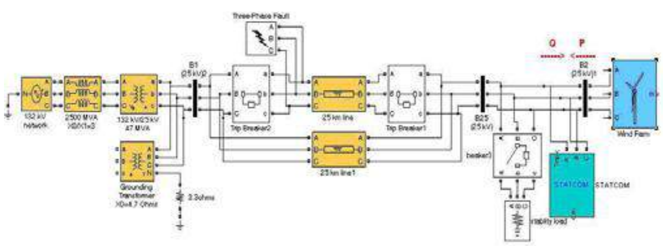


Fig 6. Test system model with STATCOM.

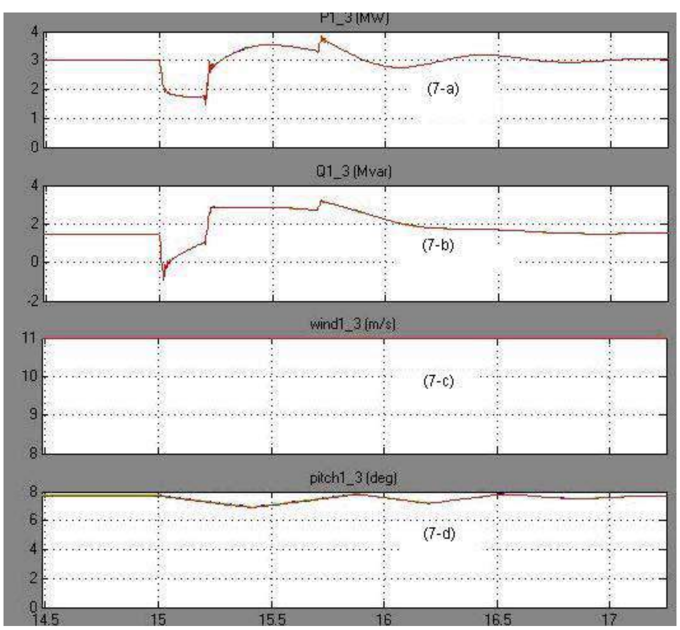


Fig 7. Fig (7-a) and Fig (7-b) show active and reactive power of three wind turbine, Fig (7-c) and (7-d) show wind speed and Pitch angel of them.

Generated power and wind farm reactive power required is presented in figure (8- b). Figure (9) indicates the amplitude vector and STATCOM converter angle that under system conditions is provided in order to keep connection point voltage by controller.

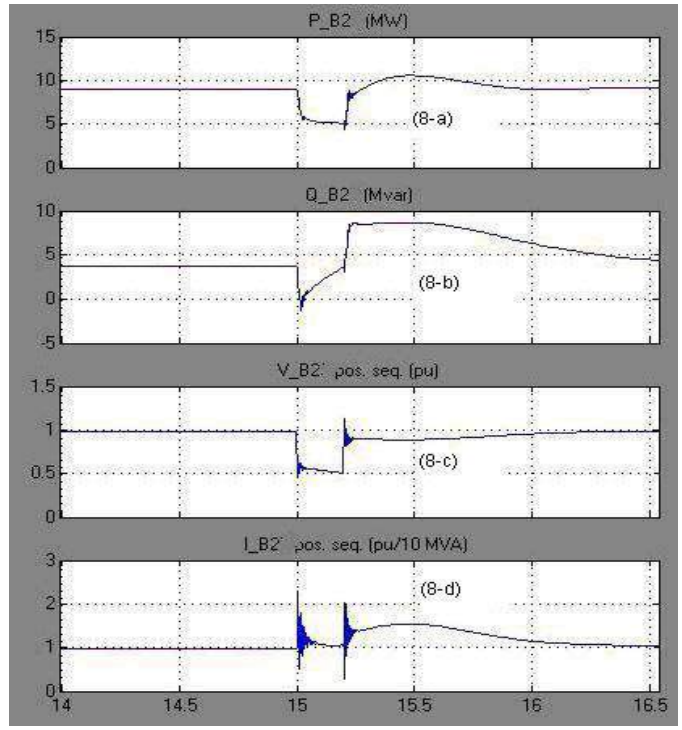


Fig 8. Fig (8-a) and (8-b) show active and reactive power of wind farm bus and Fig (8-c) and (8-d) show voltage and current of wind farm bus.

As you see, after applying STATCOM to system, output voltage increases and in result wind farms stability limit is optimized effectively. In other word in greater slips, machine stable possibility is provided and so machined stability limits slip that can keep it in stable mode, enlarges. In other hand, in order to increase stability limit of induction generators in disturbance conditions, as you see in figure (7), it's obvious that, units generating reactive power increases. The idea that, if we use a local load, we can absorb generated power to use induction machine speed increase acceleration in order to optimize stability conditions exists. So in continuous stabilizer resistances role that is connected to grid as a damper in visual conditions is studied. Its part in induction machine stability increase is effective.

C. Induction generator stability study for active and reactive power compensation.

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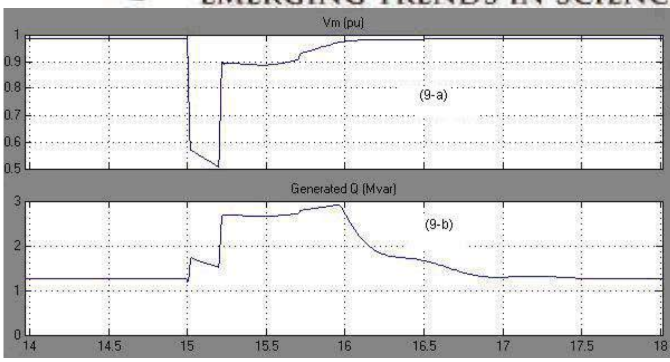

Fig 9. Fig (9-a) shows converter voltage magnitude of STATCOM, Fig (9-b) shows STATCOM generated reactive power.

An induction generator, generating electrical torque changes, in relation to slip is shown in figure (10) for the conditions that a stabilizer load accompanied by reactive power compensators and without stabilizer resistance is used. As you see, in the conditions after fault, the situation reactive and active power compensator is used is in upper stability limit. Using stabilizer resistance beside reactive power compensator conditions is created.

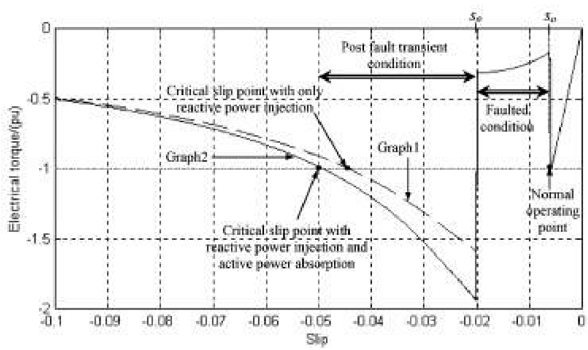

Fig 10 . An induction generator, generating electrical torque changes, in relation to slip.

Conclusion

In current years, wind energy exploitation to electric energy generation has a significant enhancement. Transmission Conditions study and such energy usage in electrical grids is function of system topology and wind farms connection conditions to the grid. Stability conditions and electric units dynamic study is significant in consider to their connection to distribution grids. In this issue, FACTS devices usage in distribution voltage level in order to wind farms stability conditions optimization in system different conditions is considered visually. In this paper STATCOM application role in induction generators stability increase to grid is studied.

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TECH-CHRONICLE
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Study of Five Level Inverter for Harmonic Elimination and PV Application

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***Abstract*—In this paper various PWM techniques are discussed to eliminate harmonic in five level inverter and by the introduction of Multilevel inverter various problems are reduced. Basically the main function of five level inverter is to eliminate harmonic and used for PV application. Various control strategies and improvement is analyzed. Finally the inverter will be modulated using SPWM and SHE techniques to reduced harmonic and PV cell will be used as input to inverter which will be connected to grid so as to feed improve quality power to grid.**

Keywords—Multilevel inverter, PV cell, Harmonic elimination, SPWM and SHE techniques

I INTRODUCTION

A multilevel inverter is more recent and popular type of power electronic converter that synthesizes a desired output voltage from several levels of dc voltages as inputs. If sufficient number of dc sources is used, a nearly sinusoidal voltage waveform can be synthesized. It offers several advantages such as, its capabilities to operate at high voltage with lower dv/dt per switching, high efficiency and low electromagnetic interference [1]-[4]. As the number of level increase, the THD in the inverter output remain less when compared to two level inverters. It is evident that the multilevel concept will be a prominent choice for power electronic systems in future years. Moreover, abundant modulation techniques and control paradigms have been developed for multilevel converters such as sinusoidal pulse width modulation (SPWM), selective harmonic elimination (SHE-PWM), space vector modulation (SVM), and others.

The Demand for renewable energy has increased significantly over the years because of shortage of fossil fuels and greenhouse effect. The definition of renewable energy includes any type of energy generated from natural resources that is infinite or constantly renewed. Examples of renewable energy include solar, wind, and hydropower. Renewable energy, due to its free availability and its clean and renewable character, ranks as the most promising renewable energy resources like Solar energy, Wind energy that could play a key role in solving the worldwide energy crisis. Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronics techniques. Photovoltaic (PV) sources are used today in many applications as they have the advantages of effective maintenance and pollution free. PV inverter, which is the heart of a PV system, is used to convert dc power obtained from PV modules into ac power to be fed into the grid. Improving the output waveform of the inverter reduces its respective harmonic content and, hence, the size of the filter used and the level of Electromagnetic Interference (EMI) generated by switching operation of the inverter[5].

II GENERAL TOPOLOGY OF MULTILEVEL INVERTER

A. MULTILEVEL CONCEPT

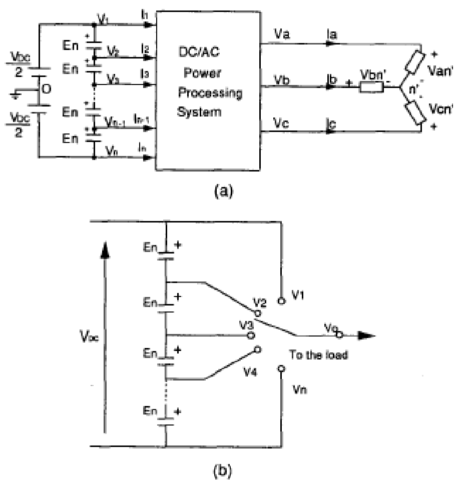

Fig. 1 (a) Three phase multilevel power processing system, (b) *Schematic of single pole of multilevel inverter by a switch.*

Fig. l(a) illustrates a schematic of Dc to AC power conversion system employing three-phase multilevel VSI where *VD*, indicates dc-link voltage obtained from any equipment which can yield stable dc source. Series connected capacitors constitute energy tank for the inverter providing some nodes to which multilevel inverter can be connected. Primarily, the series connected capacitors will be assumed to be any voltage sources of the same value. Each capacitor voltage E_n, is given by

$$E_n = \frac{V_{DC}}{n-1} \tag{1}$$

where *n* denotes the number of levels adopted.
The term so called level in the configuration can be referred to the number of nodes to which the inverter can be accessible as shown in Fig. l(a). Output phase voltages will be defined as voltages across output terminals of the inverter and the ground point denoted by *o* in Fig. l(a). Moreover, input node voltages and currents will be referred to input terminal voltages of the inverter with reference to ground point and the corresponding currents through branches from each nodes of dc-link capacitors to the inverter, respectively. For example, input node voltages are designated by V_1 , V_2 , etc and input node currents by I_1,, I_2, etc as seen in Fig. l(a). Fig. l(b) shows the schematic of a pole in multilevel VSIs where *V*, indicates an output phase voltage. The output phase voltage can assume any voltage level by selection of each node $V_{1,}$ $V_{2,}$ etc. Thus, a pole in multilevel VSI could be regarded as a single-pole-multiple-throw switch. In other words, the topological structure of multilevel inverter suggested must cope with the followingpoints. 1) It should have less switching devices as far as possible. 2) It should be capable of enduring very high input voltage such as HVDC transmission for high power applications. 3) Each switching device should have lower switching frequency owing to multilevel approach.[6].

III Common topologies for multilevel inverters

1) Diode clamped (neutral clamped)

2) Capacitor clamped (flying capacitors)

3) Cascaded H-bridge inverter.

The diode-clamped multilevel inverter employs clamping diodes and cascaded dc capacitors to produce ac voltage waveforms with multiple levels. The inverter can be generally configured as a three-, four-, or five-level topology, but only the three-level inverter, often known as neutral-point clamped (NPC) inverter, has found wide application in high-power medium-voltage (MV) drives [7–9]. The main features of the NPC inverter include reduced *dv*/*dt* and THD in its ac output voltages in comparison to the two-level inverter discussed earlier. More importantly, the inverter can be used in the MV drive to reach a certain voltage level without switching devices in series.
Cascaded H-bridge (CHB) multilevel inverter is one of the popular converter topologies used in high-power medium-voltage (MV) drives [10–12]. It is composed of a multiple units of single-phase H-bridge power cells. The H-bridge cells are normally connected in cascade on their ac side to achieve medium-voltage operation and low harmonic distortion. In practice, the number of power cells in a CHB inverter is mainly determined by its operating voltage and manufacturing cost.
Flying capacitor multilevel inverters uses capacitors to limit the voltage of the power devices. The configuration of the flying capacitor multilevel inverter is like a diode clamped multilevel inverter except that capacitors are used to divide the input DC voltage. The voltage over each capacitor and each switch is *Vdc*.

IV HARMONIC REDUCTION TECHNIQUES

A. Sinusoidal Pulse Width Modulation (SPWM) for multilevel inverter.

SPWM for Multilevel Inverter is based on classic two level. SPWM with triangular carrier and sinusoidal reference waveform.

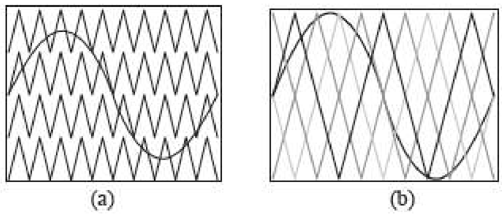

Fig 2 (a) Vertically shifted carriers
(b) Horizontally shifted carriers

Only difference between two level SPWM and multilevel SPWM is, numbers of carriers are used in multilevel SPWM. For '*m*' level inverter '*m*-1' carrier are used. Interaction of particular carrier and reference is used to generate gating signal for particular complementary pair of switches in diodeclamped or capacitor-clamped inverter, or particular cell in multi-cell inverter.Carriers used in multilevel inverter may be vertically shifted or horizontally shifted as shown in Fig 3(a),(b). Advantage of horizontally shifted carriers scheme is that, each modules are switched on and off with a constant number of times by period, independently of magnitude of generated voltage. But vertically shifted carrier scheme can be more easily implemented on any digital controller.

B. Selective Harmonic Elimination

Fig 3 shows a generalized quarter-wave symmetric stepped voltage waveform synthesized by a (2 *m* + 1)-level inverter, where '*m*' is the number of switching angles. By applying

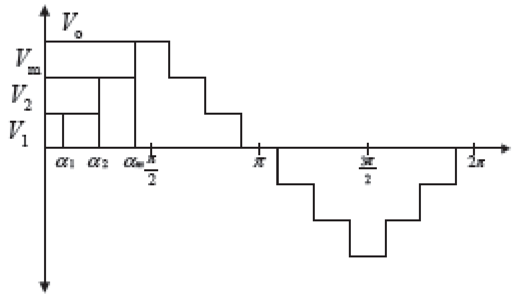

Fig 3. Generalized Stepped-Voltage waveform

Fourier series analysis, the amplitude of any odd 'n^{th} harmonic of the stepped waveform can be expressed as,

$$h_n = \frac{4}{n\pi} \sum_{k=1}^{m} [V_k \cos(n\alpha_k)]$$

whereas the amplitudes of all even harmonics are zero. Where Vk is 'kth' the level of dc voltage, 'n' is an odd harmonic order, 'm' is the number of switching angles, and αk is the 'kth' switching angle. According $\alpha 1$ to αm Fig 2, to must satisfy $\alpha 1 < \alpha 2 \ldots < \alpha m < \pi/2$. To minimize harmonic distortion and to achieve adjustable amplitude of the fundamental component,up to 'm - 1'harmonic contents can be removed from the voltage waveform. In general, the most significant lowfrequency harmonics are chosen for elimination by properly selecting angles among different level inverters, and highfrequency harmonic components can be readily removed by using additional filter circuits.

Advantage of Multilevel Inverter

1. They can generate output voltages with extremely low distortion and lower dv/dt.

2. They draw input current with very low distortion.

3. They generate smaller common-mode (CM) voltage, thus reducing the stress in the motor bearings. In addition, using sophisticated modulation methods, CM voltages can be eliminated [13].

4. They can operate with a lower switching frequency.

Application of five level inverter

1. As conventional system is not possible to available on remote area, a PV application power generating system is proposed in my project so that can be used for remote area.

2. Can be used for Electricity Consumption from utility.

V. CONCLUSION

In this review paper we have analysed and studied various control techniques for harmonic elimination for five level inverter.Further it is said that it can be used for PVapplication. We will be modeling five level inverter for PV application and harmonic elimination with the help of MATLAB.

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TECH-CHRONICLE
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Modeling and Simulation of Two phase Synchronous motor using four-leg Inverter

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***Abstract*- In this paper modeling and simulation of two phase permanent magnet synchronous motor is studied using four-leg inverter. Permanent magnet synchronous motor is proposed which reduces field winding losses and complexities of using slip-rings, brushes and commutators. Four-leg inverter gives most appropriate results as compared to two-leg or three-leg inverter. Unipolar pulse width modulation scheme is implemented for getting more reliable results. Essential equations for modeling of synchronous motor are presented here. The performance of two phase synchronous motor is evaluated and detailed analysis is done using matlab simulation.**

***Index Terms*- Two phase permanent magnet synchronous motor, four-leg inverter, unipolar PWM.**

I. INTRODUCTION

Synchronous motors are widely used in constant speed drives at line frequency as well as in variable speed drive with inverter-fed variable frequency supplies [1]-[3]. For such vehicles high torque densities and efficiencies of the electric drive are needed. The total losses of the electric drive shall be as low as possible. Nowadays, three types of electric machines are commonly used in electric vehicles [4]:

- induction machine with squirrel cage structure
- electrically excited synchronous machine
- permanent magnet (PM) synchronous machine

Typically, asynchronous induction machines are very reliable due to its robust design. However, it needs a magnetizing current component to excite the magnetic field. Electrically excited synchronous machine has a separate field winding in the rotor which is usually supplied through slip rings. For induction and electrically excited synchronous machines, additional copper losses takes place due to the currents required for exciting magnetic field. In permanent magnet synchronous machines, the magnetic field is mainly provided by the permanent magnets. Rare earth magnet has a high energy density and shows a very high torque and power density.

A two-phase synchronous motor presents attractive features such as simple and robust structure, high torque density, and high efficiency [5], [6]. Line-start, two-phase synchronous motors [7] are of special interest because they can operate either in constant speed mode while being supplied by a single phase grid or in variable speed mode while being supplied by a two-phase inverter [8].

The main advantages, as compared with induction motors, are the absence of rotor slip power loss and the natural ability to supply reactive current. Since the magnetic excitation may be provided from the rotor side instead of the stator, the machine can be built with a larger airgap without degraded performance. The ability to supply reactive current also permits the use of natural-commutated dc link converters [9]. These motors also have lower weight, volume, and inertia compared to dc motors for the same ratings.

In certain applications, the field excitation can be provided using permanent magnets, thus dispensing with brushes, slip rings and the dc field winding losses [10], [11]. Applications of these permanently excited synchronous motors are found in various industrial drive systems, such as aerospace, machine tools, robotics, precision textiles, etc. The brushless permanent magnet synchronous motors are simply known as permanent magnet ac motors. These motors are either linestart or inverter-fed types whose polyphase stator windings are simultaneously switched on via balanced polyphase supply voltages [12].

II. PERMANENT MAGNET SYNCHRONOUS MOTOR

In a PMSM, the dc field winding of the rotor is replaced by a permanent magnet material to produce the magnetic flux. Due to absence of components like brushes, slip rings and commutator, the motor becomes lighter, power to weight ratio increases and hence efficiency and reliability gets improved.

PM electric machines are classified into two types: PMDC machines and PMAC machines. PMDC machines are like the DC commutator machines; with the field winding being replaced by the permanent magnets. In PMAC the field is generated by the permanent magnets placed on the rotor. PMAC is simpler to use instead of PMDC. PMAC is divided into two types depending on the nature of the back electromotive force (EMF): Trapezoidal type and Sinusoidal type.

The trapezoidal PMAC machines are also called as Brushless DC motors and build up trapezoidal back EMF waveforms with following characteristics:

1. Rectangular distribution of magnet flux in the air gap
2. Rectangular current waveform
3. Concentrated stator windings.

The sinusoidal PMAC machines are also called as Permanent magnet synchronous machines (PMSM) and build up sinusoidal back EMF waveforms with following characteristics:

1. Sinusoidal current waveforms
2. Sinusoidal distribution of stator conductors.
3. Sinusoidal distribution of magnet flux in the air gap

Based on the rotor design the PM synchronous machine can be classified as:

(a) Surface mounted magnet type (SPMSM):

In this case the magnets are mounted on the surface of the rotor. The magnets can be considered as air because the permeability of the magnets is nearly unity and there is no saliency because of same width of the magnets. Therefore the inductances expressed in the quadrature coordinates are equal (Ld = Lq).

(b) Interior magnet type (IPMSM):

In this case the magnets are place inside the rotor. In this configuration saliency is presented and the d-axis air-gap is greater compared with the q axis air gap for which the q axis inductance is greater in value than the d axis inductance.

The permanent magnet synchronous motor examined is the two phase permanent magnet synchronous motor. Thus armature has only two windings, d axis and q axis winding. If the direct (d) axis winding is ssumed to be centered magnetically in the center of the north pole. Then the quadrature(q) axis winding is 90 electrical degrees ahead of the d-axis. The selection of q-axis as leading to d-axis is purely arbitrary. Alternate option may also be chosen. The machine consists of two essential elements: the field and the armature. Field winding carries direct current and produces a magnetic field which induces alternating current voltages in the armature windings. The armature winding operates at voltage higher than that of the field and hence required more space for insulation. Normal practice is to have the armature on stator. The armature is subjected to a varying magnetic flux, the stator iron is built up of thin laminations to reduce eddy current losses. When carrying balanced two phase currents, the armature will produce a magnetic field in the air gap rotating at synchronous speed. The field produced by the permanent magnet on rotor, on the other hand revolves with the rotor. Here rotor used is of permanent magnet type hence no field windings are considered. For the production of a steady torque, the fields of stator and rotor must rotate at the same speed. Therefore the rotor must run at precisely the synchronous speed. The number of field poles is determined by the equation (1).

$$N_s = \frac{120f}{P} \qquad (1)$$

Where, f= frequency of armature windings and P= number of poles.

Some characteristic features of Synchronous motors are as follows:

- It runs at synchronous speed or not at all i. e. while running it maintains synchronous speed.
- It is capable of being operated under a wide range of power factors, both lagging and leading. Hence it can be used for power correction purpose, in addition to supplying torque to drive.
- As load on motor is increased, rotor progressively tends to fall back in phase but not in speed as in dc motors.
- Permanent magnet synchronous motor has sinusoidal back emf.
- High reliability even at very high achievable speeds due to its brushless structure.
- High efficiency.
- Driven by multi phase inverter controllers.
- Sensor-less speed control is possible.
- Appropriate for position control.

A. *The Mathematical modeling of PMSM*

The model of PMSM without having damper winding is developed on stator reference frame using the following assumptions:

- The induced EMF is sinusoidal.
- Eddy current and hysteresis losses are negligible.
- There are no field current dynamics, are assumed to be constant.
- The stator windings are balanced with sinusoidal;y distributed magneto-motive force.

The PMSM motor equations of stator fluxes, voltages and electromagnetic torque in stator frame of reference are as follows:

$$\lambda_{sd} = L_{sd}\, i_{sd} + \lambda_M \qquad (2)$$

$$\lambda_{sq} = L_{sq}\, i_{sq} \qquad (3)$$

$$v_{sd} = R_s i_{sd} + \frac{d}{dx}\lambda_{sd} - \omega_r \lambda_{sq} \quad (4)$$
$$v_{sq} = R_s i_{sq} + \frac{d}{dx}\lambda_{sq} + \omega_r \lambda_{sd} \quad (5)$$
$$T_e = P(\lambda_{sd}\, i_{sd} - \lambda_{sq}\, i_{sq}) \quad (6)$$
$$T_e - T_l = J\frac{d\omega_r}{dt} \quad (7)$$

Where as,
λ_{sd} = d-axis stator magnetic flux,
λ_{sq} = q-axis stator magnetic flux,
λ_M = rotor magnetic flux,
L_{sd} = d-axis stator leakage inductance,
L_{sq} = q-axis stator leakage inductance,
R_s = stator winding resistance,
T_e = electromagnetic torque,
T_l = motor load torque,
P = number of poles.

Equations (2) and (3) give d-axis and q-axis stator magnetic fluxes respectively. Equations (4) and (5) give direct and quadrature axes voltage equations. In which quadrature axis voltage leads the direct axis voltage by 90° electrical. Electromagnetic torque is calculated using equation (6). Synchronous speed of Synchronous motor is being calculated from Equation (7).

III. FOUR-LEG INVERTER

The operation of two leg inverter is weak, but because of minimum number of switches, it is low cost approach. In the applications in which the middle point of dc voltage is accessible, using a two-leg inverter is an acceptable approach. When the middle point of dc voltage is inaccessible, utilizing this scheme needs not only two capacitors with high capacitances but also a voltage equalizing circuit [5]. Voltage equalization can be done by using resistors in parallel to capacitors. This increases the volume of drive system and power loss [13].

Another approach is utilization of charge-balancing circuits [14] which makes the drive circuit complicated and costly. A noticeable limitation of three-leg inverters in controlling two phase motors is that the RMS value of common leg current is higher than those of other two legs [15], [13] that necessitates utilization of switches with higher current ratings in one leg. When integrated power modules are used, the entire module should be of higher current ratings. This makes the cost enhancement more noticeable. This additional cost as well as better performance of four-leg inverter makes the use of four-leg inverter justifiable in high performance applications [16].

Here four-leg inverter is implemented, containing two series connected Insulated Gate Bipolar Transistor's (IGBT) in one limb respectively. The circuit diagram of four-leg inverter is shown in Fig. 1. Between first two legs, d-axis winding of synchronous motor is connected and between last two legs, q-axis winding of synchronous motor is connected. IGBT's are preferred because it has low switching losses and require no snubber circuits for its operation. Gate signals of IGBT's are controlled using Unipolar Pulse Width Modulation (PWM). The advantages of Unipolar PWM are as follows:

- It has low switching losses.
- Total Harmonic Distortion (THD) of signals is low.
- It also reduces error band width of signals.

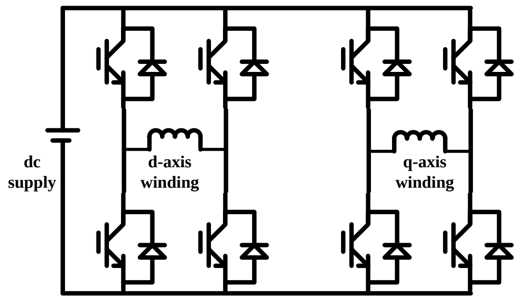


Fig. 1. Two phase two level four leg inverter

IV. IMPLEMENTING MODELLED EQUATION by SIMULINK

Using Equations (2)-(7) modeling of two phase permanent magnet synchronous motor is done. Firstly using Equations (4) and (5), d-axis and q-axis fluxes are calculated in subsystem one as shown in Fig. 2. After using this calculated fluxes and Equations (1) and (2), d-axis and q-axis currents are derived in subsystem two as shown in Fig. 2. Then using all these derived quantities and Equation (5) torque is obtained. From torque value and using speed Equation (7) synchronous speed is calculated. In this way two phase synchronous is modeled.

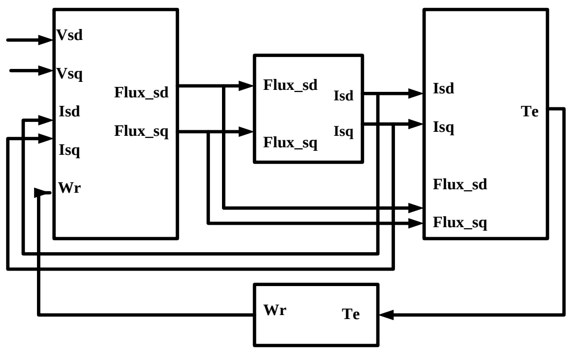


Fig. 2. Model of Two phase synchronous motor

V. RESULTS AND ANALYSIS

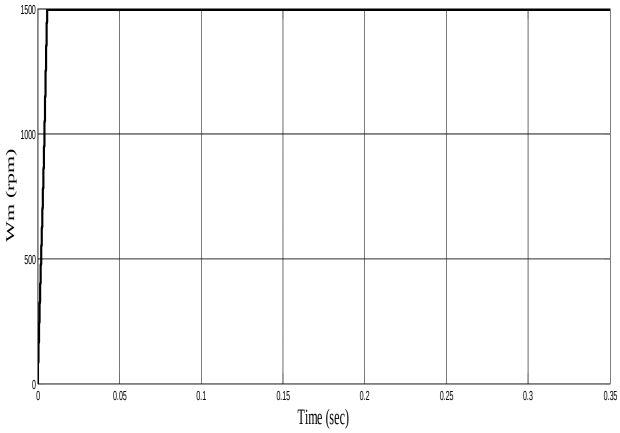
Parameters used for modeling of Synchronous Motor are given in Table I. Using these parameter two phase

Permanent magnet motor is modeled and derived results are given below. Speed of Synchronous motor is constant so kept at 1500 *rpm*. The speed is calculated as shown below. Fig. 3 (a) shows graph of synchronous speed of motor plotted against time. This shows the synchronous speed at 1500 *rpm*. Due to the constant speed, electrical torque required for driving synchronous motor is null. But when load increases, electrical torque tries to catch-up with the load torque so as to keep motor at synchronous speed. Fig. 3 (b) shows electrical torque of PMSM varying with time. Fig. 3 (c) shows direct axis and quadrature axis fluxes of PMSM. The quadrature axis flux leads the direct axis flux by 90 electrical degrees. Stator flux trajectory of direct axis and quadrature axis fluxes are shown in fig. 4. This trajectory is circular to represent the sinusoidal flux PMSM.

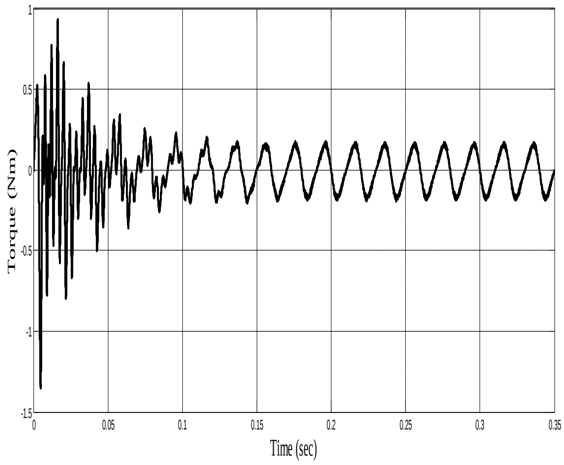
TABLE I
PARAMETERS OF TWO PHASE SYNCHRONOUS MOTOR

Stator Resistance	4.5Ω
d-axis inductance	323mH
q-axis inductance	110mH
Number of poles	4
Rotor flux	1

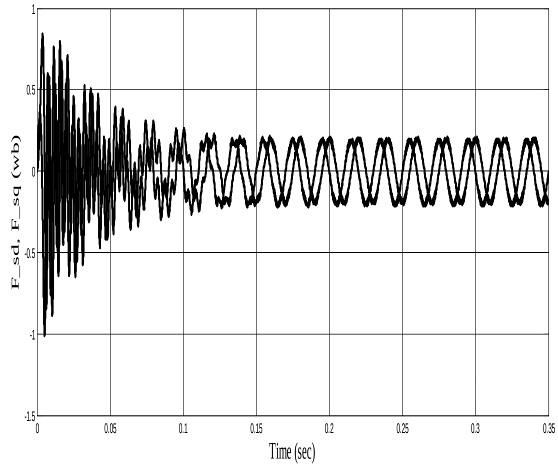
Frequency= 50 *Hz*
No. of poles= 4
From Equation (1), we get
Speed= 120*50/4
= 1500 *rpm*



(a)



(b)



(c)

Fig. 3. Two phase SM's (a) synchronous speed, (b) electromagnetic torque, (c) d-axis and q-axis components of the stator flux.

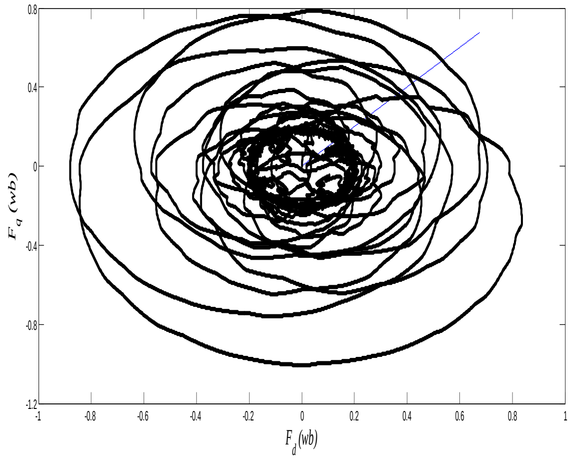


Fig. 4. Stator flux trajectory of two phase SM

VI. ONCLUSION

In this way modeling and simulation of Permanent Magnet Synchronous motor has been done. This shows that PMSM is most reliable in case of constant speed applications. Interior magnet PMSM provides very robust structure and hence can be used in high power and servo applications. PMSM can be used for wide range of varying power factors. PMSM is easy to maintain and hence more efficient than other motors.

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TECH-CHRONICLE
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Implementation of DSTATCOM under Stiff Source Condition in Single Phase and Three Phase Power System

***Abstract* –Loads connected to a stiff source cannot be protected from voltage disturbances using a distribution static compensator (DSTATCOM). In this proposed work, it is intended to provide fast voltage regulation at the load terminal during voltage disturbances and will protect critical loads. In addition, during normal operation, the generated reference load voltages will allow control of the source currents. Consequently, DSTATCOM will inject reactive and harmonic components of load currents to make source power factor unity. Simulation and experimental results will be presented to verify the efficacy of the proposed control algorithm and multifunctional DSTATCOM.**

***Index Terms* – Distribution static compensator (DSTATCOM),multifunctional, power factor, stiff source, voltage regulation.**

I. INTRODUCTION

A distribution static compensator (DSTATCOM) can mitigate several power quality problems. There are two modes of operation. In current control mode (CCM) [2]-[4], it injects harmonic and reactive components of load currents to make source currents balanced, sinusoidal and in phase with load voltages. In voltage control mode (VCM) [5]-[6], it regulates load voltage at a constant value. This protects sensitive loads from voltage disturbances such as swells, sag, fluctuations and transients. These two modes have different objective which cannot be achieved simultaneously.

Based on the distance between source and load, a source is termed as stiff or nonstiff. If the distance is long, then source is termed as non stiff and has high feeder impedance, whereas if the distance is very small, then source is termed as stiff. When a load is connected to nearly a stiff source, feeder impedance will be negligible [2]-[3], [8], [9]. Under these circumstances, DSTATCOM cannot provide sufficient voltage regulation at the load terminal [9].

In present work, this problem is addressed while ensuring that, during normal operation, the advantages of current control mode are retained. A new control-algorithm-based DSTATCOM topology is proposed for voltage regulation even under stiff source.

To achieve this, a suitable external inductor is connected in series between the load and the source point. A DSTATCOM connected at the load terminal provides voltage regulation by indirectly regulating the voltage across the external inductor. This voltage indirectly controls the current drawn from the source. Simulation and experimental results will be presented.

II. LITERATURE REVIEW

Power quality improvement using FACTS devices is the latest area of interest amongst the power system researchers. Some of the research work and literature are as given below:

C. Kumar and M. K. Mishra (2014) proposed a multifunctional DSTATCOM to operate in voltage control mode under stiff source.[1] A. Bhattacharya and C. Chakraborty (2011) proposed an improvement of the dynamic performance of a shunt type active power filter. In proposed topology, the predictive and adaptive properties of artificial neural network (ANNs) are used for the fast estimation of compensating current. [2]

J.Liu, P. Zanchetta,M. Degano, and E. Lavopa (2012) presented the design and implementation of shunt active filter (SAF) for aircraft power networks using an accurate wide- band current control method based on Iterative Learning Control (ILC).This work introduces useful design strategies to increase the error-decay speed and improve the robustness of the SAF control system by using a hybrid P-type ILC controller.[3]

Q.-N. Trinh and H.-H. Lee (2013) proposed an advanced control strategy to enhance performance of shunt active power filter (APF).[4] M. K. Mishra, A. Ghosh and A. Joshi (2003) presented the operating principles of a distribution static com pensator (DSTATCOM) that is used to maintain the voltage of a distribution bus. [5] A. Camacho, M. Castilla, J. Miret, J. Vasquez, and E. Alarcon-Gallo (2013) proposed control scheme which prevents disconnection while achieving the desired voltage support service.[6]M. Moradlou and H.Karshenas (2011) discussed calculation of the optimum rating for two dynamic voltage restorers (DVRs) when used in an interline DVR (IDVR) structure.[7]

S. Srikanthan and M. K. Mishra (2010) proposed a carrier-based pulse width modulation control for an inverter-chopper circuit in order to regulate the capacitor voltages to their reference values.[8] J. Barros and J. Silva (2010) presented an optimal predictive controller for a multilevel converter-based dynamic voltage restorer (DVR), which is able to improve the voltage quality of sensitive loads connected to the electrical power network.[9]

III. DSTATCOM CONFIGURATION

A neutral point-clamped voltage source topology (VSI) topology is chosen which provides independent control of each leg of the VSI [5]. A single-phase equivalent circuit of DSTATCOM in a distribution network is shown in Fig.1. The VSI is represented by μV_{dc}. It is connected to the load terminal through an LC filter (L_f - C_{fc}). The load terminal is connected to the point of common coupling (PCC) through an external series inductor L_{ext}. V_{dc} is the voltage maintained across each dc capacitor, and µ is a control variable. Its value can be +1 or -1, depending upon switching state. Loads have both linear and nonlinear elements with balanced or unbalanced features. Load and source currents are represented by i_l and i_s, respectively. v_s and v_t are source and load voltages, respectively. I_{fi}, i_{ft} and i_{fc} are currents through VSI, DSTATCOM and C_{fc}, respectively.

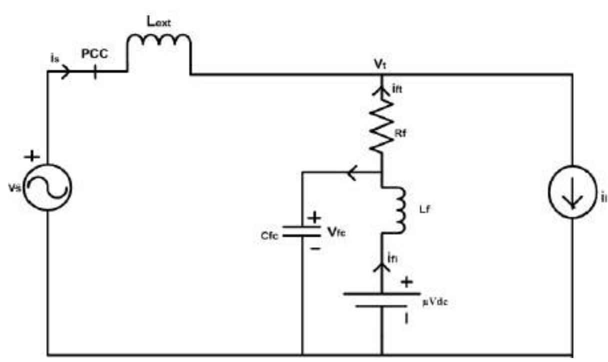

Fig.1 – Single-phase equivalent circuit of DSTATCOM in a distribution network.

IV. SELECTION OF EXTERNAL INDUCTOR

Under normal operation, external impedance (Z_{ext}) does not have much importance, whereas it plays a critical role during voltage disturbances. The value of external impedance is decided by the rating of the DSTATCOM and amount of sag to be mitigated.

V.PROPOSED CONTROL ALGORITHM

The proposed topology aims to provide fast voltage regulation at the load terminal during voltage disturbances, while retaining the advantages of CCM during normal operation. First, the currents that must be drawn from the source to get advantages of CCM will be computed. Using these currents, the magnitude of voltages that need to be maintained at the load terminal will be computed. If this voltage magnitude lies within a permissible range, then the same voltage is used as reference voltage to provide advantages of CCM. If voltage lies outside the permissible range, it is a sign of voltage disturbance, and a fixed voltage magnitude is selected as reference voltage.

A two loop controller, whose output is load angle ɗ, is used to extract load power and VSI losses from the source. Finally, a discrete model is derived to obtain switching pulses.

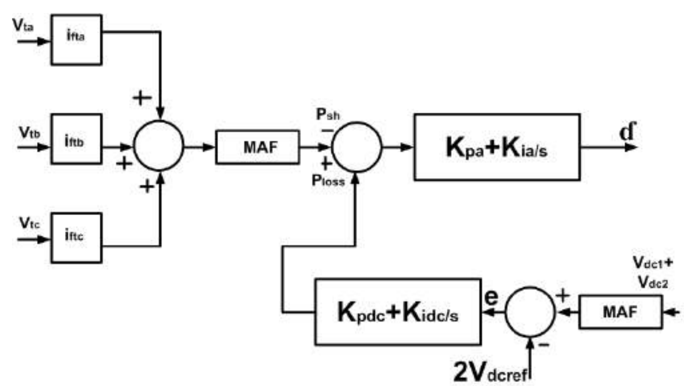

Fig 2 - Controller to calculate ɗ and P_{loss}

VI.CONCLUSION

A new control algorithm based multifunctional DSTATCOM has been proposed to protect the load from voltage disturbances under stiff source. An external series inductance of suitable value can be connected between source and the load to achieve this. In addition, instantaneous reference voltage is controlled in such a way that the source currents are indirectly controlled, and the advantages of CCM operation are achieved while operating in VCM for a permissible range of source voltage.

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I am thankful to my guide Prof. S. S. Mahajan for his guidance and support for this paper. I thank Mr. Irfan Ahmed for sharing his perspective. I owe a great to my parents for their continuous encouragement and moral support

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TECH-CHRONICLE
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Power Quality Enhancing, availability in Distribution Network By using DVR

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Abstract: Power quality problem is one of the major concern in today's era. Power quality problem is an occurrence, manifested as a nonstandard voltage, current or frequency that results in failure of end use equipments. One of the major problems in power quality is power sag. Dynamically changing load and utility side network whole system suffer with this outages and service interruption. Various methods are used to minimize the power quality problem and, custom power devices are used. One of the most powerful FACT devices is DVR (Dynamic Voltage Restorer) using MATLAB, its modeling, analysis and simulation is used here. Here PI controller and PWM pulse controller are for controlling. With the use of various load including induction motors and faults occur at various conditions are considered and DVR compensates load voltage at different fault conditions like line to line, single phase line to ground. In addition with this DVR also compensates the starting voltage dip of induction motor which is again the serious problem.

Key Words—DVR, Power quality, MATLAB/simulink

INTRODUCTION

The IEEE standard dictionary of electrical and electronics defines power quality as "the concept of powering and grounding sensitive electronic equipment in a manner that is suitable to the operation of that equipment". Power quality may also be defined as "the measure, analysis, and improvement of bus voltage, usually a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency". For reliable power system, the generation unit must produce adequate power to meet customer's demand, transmission system must transport bulk power over long distances without overloading or jeopardizing system stability and distribution system must deliver electric power to each customer's premises from bulk power systems. Distribution system locates near end of power system. The reason behind this is that electrical distribution network failures account for about 90% of the average customer interruptions. In the earlier days, the major focus for power system reliability was on generation and transmission only as these more capital cost is involved in these.

CUSTOM POWER DEVICES

Initially for the improvement of power quality or reliability of the system FACTS devices like static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), interline power flow controller (IPFC), and unified power flow controller (UPFC) etc are introduced. These FACTS devices are designed for the transmission system. The main custom power devices which are used in distribution system for power quality improvement are distribution static synchronous compensator (DSTATCOM), dynamic voltage Restorer (DVR), active filter (AF), unified power quality conditioner (UPQC) etc. N.G Hingorani [5] was the first to propose FACTS controllers for improving PQ. He termed them as Custom Power Devices (CPD). These are based on VSC and are of 3 types given below.

1. Shunt connected Distribution STATCOM (DSTATCOM)

2. Series connected Dynamic Voltage Restorer (DVR)

3. Combined shunt and series, Unified Power Quality Conditioner (UPQC).

DYNAMIC VOLTAGE RESTORER

Among the power quality problems like sag, swell, harmonic etc, voltage sag is the most severe disturbances in the distribution system. To overcome these problems the concept of custom power devices is introduced lately. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is generally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like line voltage harmonics compensation, reduction of transients in voltage and fault current limitations

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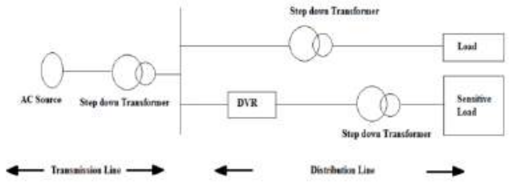
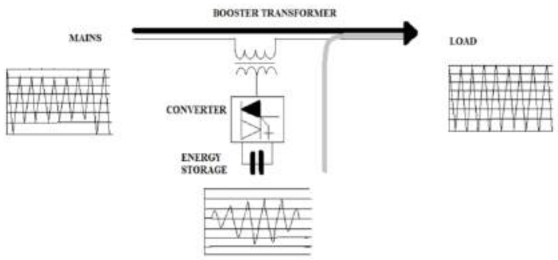


Figure[redacted]Location of DVR

PRINCIPLE OF DVR OPERATION

A DVR is a solid state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers. It is linked in series between a distribution system and a load that shown in Figure.



Figure[redacted] Principle of DVR system

The basic idea of the DVR is to inject a controlled voltage generated by a forced commuted converter in a series to the bus voltage by means of an injecting transformer. A DC to AC inverter regulates this voltage by sinusoidal PWM technique. All through normal operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the DVR control system calculates and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load [18].

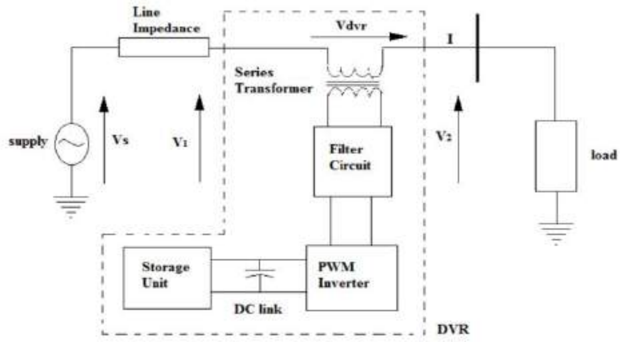


Figure-4.3 Schematic diagram of DVR

Equations related to DVR

Here the impedance ZLINE depends on the fault level of the load. When the system voltage (VSOURCE) drops or reduced from any specific value, the DVR injects a series voltage i.e. VDVR through the injection transformer such that the desired load voltage VLOAD can be maintained. Now the injected voltage of the DVR can be written as

VDVR =VLOAD+ZLINE ILOAD -VSOURCE

Where

VLOAD = desired load voltage

Z LINE = Line impedance

ILOAD = Load current

VSOURCE = system voltage during any fault condition

If we take ILOAD as IL, VSOURCE as VTH, VLOAD as VL, ZLINE as ZTH then, The load current IL is given by,

$$IL=\frac{PL+jQL}{V}$$

When VL is considered as a reference equation can be rewritten as, The load current I_L is given by,

$$I_L = \frac{[P_L + jQ_L]}{V}$$

When V_L is considered as a reference equation can be rewritten as,

$$V_{DVR}\angle 0 = V_L\angle 0 + Z_{TH}\angle(\beta - \theta) - V_{TH}\angle\delta$$

∝, β, δ are angles of V_{DVR}, Z_{TH}, V_{TH} respectively and θ is Load power angle

$$\theta = \tan^{-1}\theta\frac{Q_L}{P_L}$$

The complex power injection of the DVR can be written as,

$$S_{DVR} = V_{DVR}I_L^*$$

It requires the injection of only reactive power and the DVR itself is capable of generating the reactive power.

It requires the injection of only reactive power and the DVR itself is capable of generating the reactive power. In this test system we have a generating unit of 13kv, 50 Hz. The test system employed to carry out the simulations concerning the DVR actuation. The output from generating unit is fed to the primary of the three winding transformer. Further two parallel feeders of 11kv each are drawn. In one of the feeder DVR is connected in series and other feeder is kept as it is. For this system two different loads are considered one by one with different fault conditions. The two loads are linear load and induction motor load. PI controller is used for the control section.

SIMULINK MODEL OF THE TEST SYSTEM WITH LINEAR LOAD

In this simulink model we have a system in which two parallel feeders are shown. In both the feeders further loads are also connected in parallel. In one feeder DVR is connected in series with line and the other feeder is kept as it is. PI controller is used for the control purpose. Here DVR system is connected to the distribution system using a booster transformer.

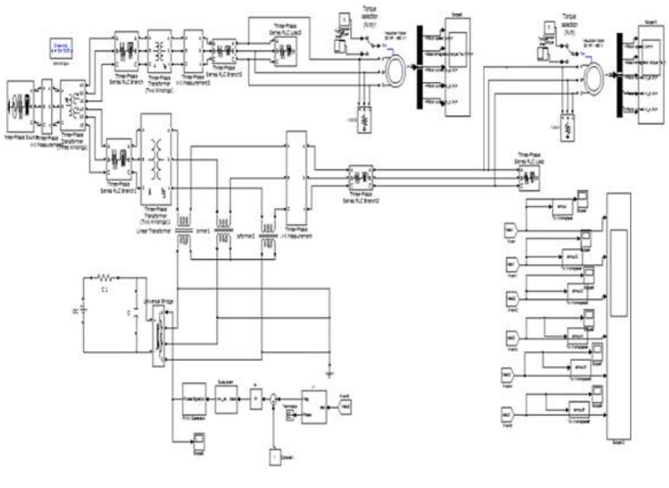


Figure-Simulink model with motor load

Figure-Output result for the starting voltage dip condition

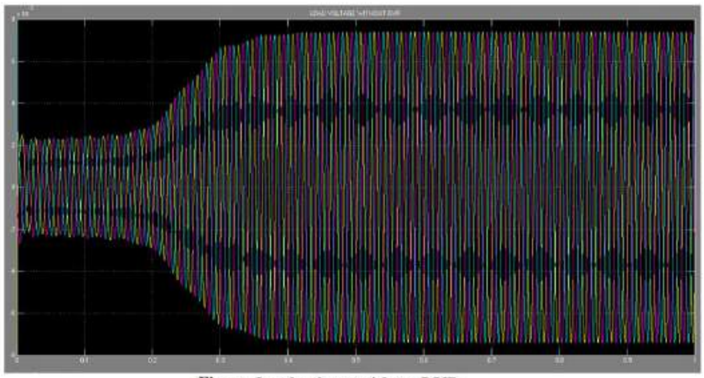


Figure- Load voltage without DVR

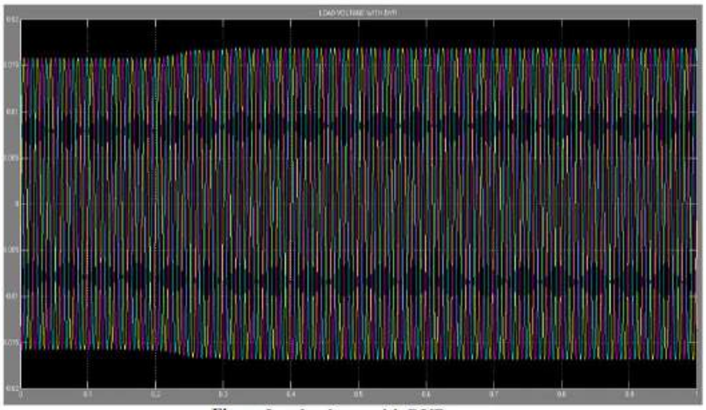


Figure Load voltage with DVR

CONCLUSION AND FUTURE SCOPE OF WORK

CONCLUSION

In this work, a fast and cost effective Dynamic Voltage Restorer (DVR) is proposed for mitigating the problem of voltage sag or dip and other fault conditions in industrial distribution systems, specially consisting of the induction motor load. A controller which is based on feed foreword technique is used which utilizes the error signal which is the difference between the reference voltage and actual measured load voltage to trigger the switches of an inverter using a Pulse Width Modulation (PWM) scheme. Here, investigations were carried out for various cases of load at 11kv feeder. It is clear from the results that the power quality of the system with induction motor as load is increased in the sense that the THD and the amount of unbalance in load voltage are decreased with the application of DVR. The effectiveness of DVR using PI controller is established both for linear static load and induction motor load.

FUTURE SCOPE

The following points are recommended for future extension of work: Other types of controllers like fuzzy controller and adaptive PI fuzzy controller can be employed in the DVR compensation scheme. Investigation of the effectiveness of multi-level DVR can be investigated. The effectiveness of DVR can be established for active loads like PV source and Wind Turbine.

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TECH-CHRONICLE
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Development of Efficient Controller for LED Lighting Using Microcontroller

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***Abstract*—This study deals with the dimming of light-emitting diode (LED) with a constant current feedback control for lighting applications. A pulse width modulation (PWM) is used for regulating the LED current and brightness. Under proper input voltage operation and high switching frequency, high efficiency can be achieved using synchronous buck converter. The pulses for synchronous buck converter will be given by dsPIC33E series microcontroller (MCU). The operation and design considerations of the proposed work is analyzed and discussed.**

Keywords—synchronous buck converter, constant current feedback control, pulse width modulation, dsPIC33E microcontroller.

I. INTRODUCTION

LEDs are no longer used just as indication purpose for electronic equipment [1]. Developments in technology have allowed LEDs to be used as practical light sources instead of using incandescent bulbs, halogen bulbs and compact fluorescent lamps (CFLs). The advantages of LEDs are long life, durability and efficiency. When driven properly, a high brightness (HB) LED can lasts up to 50,000 hours without a change in light output. The typical efficacy of a power LED measured in lumens per watt is around 40 to 80 [3].

The dimming of lights sources like incandescent bulbs, halogen bulbs and CFLs are easy but they are inefficient, lots of energy got wasted. So another alternative is dimming of LED lights.

The problem with the LED lighting is that they cannot be supplied directly from the DC or AC voltage source. Therefore there should be some kind of device to regulate the power fed to the lighting system which means a power supply should be developed to act as a driver for LED. With the double buck boost converter, two inductors come in the picture, hence increasing the weight of driver. So instead of going for this topology, single converter topology can be opted [4].

With compared with the boost converter topology and two stage power factor correction (PFC) topology, a step down converter has attractive merits. With a buck converter, a low output voltage can be regulated and a relative high efficiency over a wide range of input can be achieved [5].

The dimming will be achieved by PWM using MCU and those pulses will be given to main switch and complementary pulse will be given to freewheeling switch. Using MCU pluses will not have the problem of dead time [6]. Since, synchronous buck converter is used instead of conventional buck converter because of higher efficiency at higher frequency [7]. With proper arrangement of components and proper dimming scope in energy saving is uplifted.

In this proposed work, the design method of synchronous buck converter to regulate the driving current of power LEDs and also design the current controller to adjust the light intensity of illumination of power LEDs. The proposed controller consists of MCU and analog circuits. The purpose of using MCU is to generate the PWM signal for regulating the driving current of power LEDs. Using MCU has some advantage such as simple implementation of PWM dimming control of power LEDs. This paper consists of some sections. In section 2, Architecture and arrangement of components are explained. In section 3, functions of each block of architecture are described. In section 4, future scope is present.

II. RECENT DEVELOPMENTS

The circuit structure of [2] adopts buck converter combined with forward converter. In this work, buck converter is used as a charger and forward converter with active clamp circuit. This arrangement gives moderate efficiency and has problem of energy trapped in leakage inductor and magnetizing inductor of transformer.

The work proposed in [3] opts for PWM instead of linear regulator for dimming purpose. By opting so, the improvement in efficiency of intensity control is achieved. But, using two inductors makes circuit bulky.

The trouble with the LED lighting is that they cannot be supplied directly from the DC or AC voltage source. Therefore, there should be some kind of device to regulate the power fed to the lighting system which means a power supply should be developed to act as a driver for LED. With the double buck boost converter, great efficiency and precise control is obtained. But here again, two inductors come in the picture, hence increasing the weight of driver [4].

The research [5] has given an idea about converter. A buck converter can provide a high efficiency over a wide range of low output voltage. The buck converter operating in critical conduction mode (CRM) can eliminate the reverse recovery loss of diode and achieve zero current switching (ZCS) for the power switch. This paper also describes the necessity of converter to operate under CRM.

Article [6] gives an idea about the implementation of driver of LED using MCU. How pulses using MCU can be generated.

The paper [7] consists of different topologies to implement driver circuit. It has emphasized on using buck converter because of some unbelievable merits.

With the merits of above references more efficient controller can be fabricated and proposed topology is shown in section III.

III. Architecture

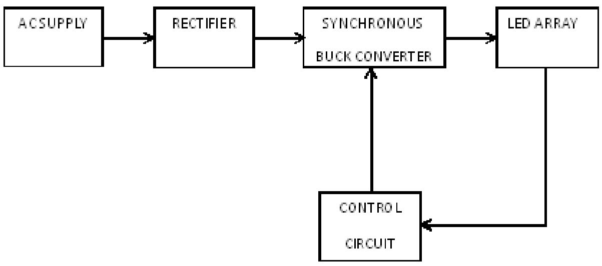

Fig. 1. Functional Block Diagram

The functional block diagram is shown above along with the major components. Single phase AC supply is given to the rectifier for conversion of AC supply to DC supply. The converted DC supply is now provided to synchronous buck converter for stepping the DC voltage as per the requirement of LED array. A constant current feedback is taken from LED array which is given to control block of proposed work. Proportional gate pulses are then given to the switches of buck converter. Hence a proper control over intensity of LED is achieved.

IV. Components

The major components of the proposed work is as follows-

A. Rectification

Rectification is a process of converting AC supply into DC supply. The single phase 230V, 50Hz AC supply is transformed in to 230 V DC supply. The 230 V DC is now processed to synchronous buck converter.

B. Synchronous Buck Converter

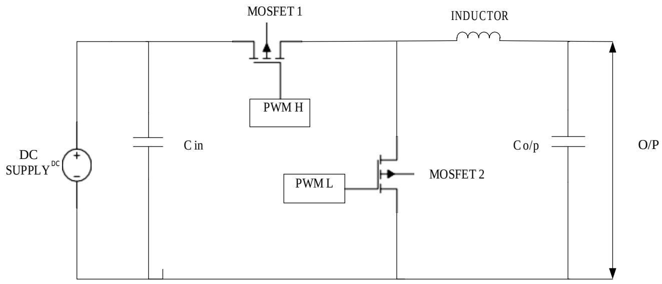

Fig. 2. Synchronous Buck Converter

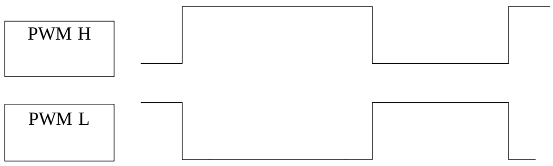

Fig. 3. Pluses for Switches

The synchronous buck converter is a DC-DC converter which is used for purpose of stepping down 230V DC. The synchronous buck converter is shown in fig. 2. It mainly consists of two MOSFETs connected as shown. The pulses of these switches are complementary in nature as shown in fig. 3. The converter also consists of inductor and capacitor which works as output filter. The output voltage of converter is 40V which given to LED array.

C. LED Array

The LED array is a series connection of 10 LED each of rating 4V, 3W, 700 mA. The total voltage across array is 40V, 30W. Since LEDs are connected in series the string current remains same i.e. 700 mA. A constant current feedback of 700 mA is taken from array which is then provided to control circuit of proposed work.

D. Control Circuit

The control circuit of proposed work consists of dsPIC33E series MCU. The pulses shown in fig. 3 are generated by this MCU.

V. Future Scope

The implementation of proposed work will be helpful in intensity control of LED lights and lead us to save energy. Precise control on dimming will give us most efficient operation of synchronous buck converter.

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TECH-CHRONICLE
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A High-Efficiency Bidirectional Interleaved Dc-Dc Converter

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***Abstract* – This paper presents a high-efficiency digital controlled bidirectional interleaved dc-dc converter is design and implemented to provide a regulated high voltage output for high-power proton-exchange-membrane fuel-cell applications. Ripple cancellation on input current and output voltage can be achieved. This interleaved dc-dc converter reduces hysteresis energy losses inside the fuel-cell stacks and meet battery charging consideration on high-voltage dc bus. Here active-clamped circuit is used to reduces voltage spike on power switches for raising the system reliability.**

***Index Terms* – Active-clamped circuit, digital control, fuel-cell, interleaved dc-dc converter, power switches.**

I. INTRODUCTION

Proton exchange membrane (PEM) fuel-cell is a device that converts chemical fuels into electric power, with many advantages such as clean electricity generation, high-current-output ability, high energy density and high efficiency.

The PEM fuel cell presents a low-voltage output with wide range of variations [1]-[3].As shown in fig. 1 a step-up dc-dc converter is always necessary for providing a regulated high-voltage output to the post stage dc-ac inverter in high-power grid –tied applications. For PEM fuel cell system applications, the dc-dc converter must be considered with following design criteria: large step-up ratio, low-input-current ripple and isolation[4]-[6].Input choke with high inductance is needed at low voltage side because high ripple current may cause undesired hysteresis energy losses inside the fuel cell stacks[7]-[10].Increased power loss and component size on input choke are significant to result in poor conversion efficiency and low power density for the step-up dc-dc converter in high power PEM fuel-cell systems.

In this paper, a digital-controlled interleaved dc-dc converter is designed and implemented to achieve low-input-current ripple and high-efficiency power conversion by the developed ripple cancellation characteristics at the high-voltage side. Because the fuel-cell stack lacks storage ability for electric energy. An energy-storage device such as the Li-ion battery is usually used on the high –voltage output dc bus of the power converter in practical high-power applications[11]-[13].

II. LITERATURE REVIEW

Shih-jen Cheng,Yu-Kang Lo(2013) proposes to design and implemented digital controlled interleaved dc-dc converter which provide regulated high voltage output for high-power –proton-exchange-membrane fuel-cell application. Ripple cancellation on input current and output voltage can be achieved by the studied interleaved dc-dc power conversion technique to reduces hysteresis energy losses inside the fuel-cell stacks and meet battery charging consideration on the high-voltage dc bus. An active clamped circuit is also use to reduce the voltage spike on the power switches for raising system reliability[1].

C.A.Ramos-paja,(2009) proposes a proton –exchange membrane fuel-cell control strategy to produce the power requested by an electrical load, minimizing the fuel consumption and also providing a regulated dc bus voltage to the load. the power system consist of hybrid fuel cell capacitor topology, and control objective is to follow the minimum fuel consumption point for given load power profile. This is done by controlling air pump voltage and regulating fuel cell current through dc- dc switching converter.[2] Jung-Min Kwon (2009) proposes a high-efficiency high-step-up current-fed resonant push-pull converter and a full bridge inverter. The converter conserves inherent advantages of a conventional current-fed push-pull converter such as low input-current stress and high-conversion ratio. also, a voltage doubler rectifier employed in order to remove reverse recovery problem of the output rectifying diodes and provide much higher voltage conversion ratio .the proposed system operates in wide input –voltage range with high-efficiency.[3] Morten Nymand (2010) propose a new design approach achieving very high conversion efficiency in low-voltage high-power isolated boost dc–dc converters is presented. The transformer eddy-current and proximity effects are analyzed, demonstrating that an extensive interleaving of primary and secondary windings is needed to avoid high winding losses.[4] Sangwon Lee, Junsung Park and Sewan Choi (2011) propose a new active-clamped three-phase current-fed push-pull dc-dc converter is proposed for high power applications where low-voltage high-current input source such as fuel cells are used. [5] Antonius Yudi Sendjaja and Vinay Kariwala(2011) proposes a simple yet reliable decentralized proportional-integral-derivative(PID) controllers are systematically designed based on a benchmark nonlinear dynamic model of SOFC.[6] Akshay K. Rathore(2012) a wide range zero-voltage switching (ZVS) active clamped L-L type current-fed isolated dc–dc converter is proposed for fuel cells to utility interface application. The proposed converter maintains ZVS of all switches from full load down to very light load condition for wide input voltage variation.[7] Nobuyoshi Mutoh(2012) proposes the failsafe performance of front-and rear- wheel-independent-drive-type electric vehicles (FRID EVs) is clarified from a practical viewpoint through vehicle dynamics analysis under various road conditions and experiments on a running test course. Dynamic analyses at the time of failure were performed under severe road conditions by comparing the vehicle trajectories of FRID EVs with those of conventional EVs, i.e., two- and four-wheel motor drive-type EVs. The analyzed results show that after failure, FRID EVs continue to run safely and stably.[8] Bo Yuan, Xu Yang, Xiangiun Zeng, Jason Duan, Jerry Zhai and Dongho Li (2012) proposed a high efficiency high step-up current-fed multi resonant converter (CFMRC) for interfacing sub stainable power sources, such as PV channel and Fuel cells, which are characterized by low-voltage high-current output and have strict current ripple requirement.[9] Hunter H.Wu*(2012) proposes the design of a 5 kW inductive charging system for electric vehicles(EVs). Over 90% efficiency is maintained from grid to battery across a wide range of coupling conditions at full load. Experimental measurements show that the magnetic field strength meets the stringent International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for human safety.[10]

III. FUEL CELL POWER CONVERTER SYSTEM

As shown in fig.1 step-up dc-dc converter is always necessary for providing regulated high-voltage output to the post stage dc-ac inverter in high-power grid tied application. for the PEM fuel- cell system applications, the dc-dc converter must be concerned with following design criteria: large step-up ratio low-input current ripple, and isolation. Typically input choke with high inductance is needed at low voltage side because high ripple current may cause undesired hysteresis energy losses inside the fuel cell stacks. Increased power loss and component size on the input choke are significant to result in poor conversion efficiency and low power density for step-up dc-dc converters in high power PEM fuel cell system.

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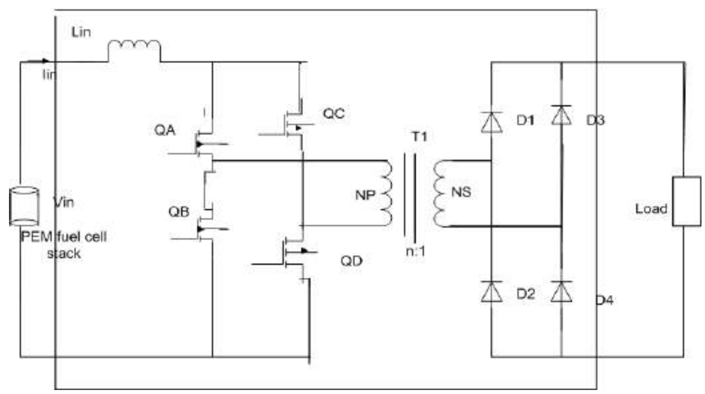

Fig.1 – PEM fuel-cell power converter system

In this paper, a digital controlled interleaved dc-dc converter shown in fig.2 is design and implemented to achieve low-input current-ripple and high-efficiency power conversion by the developed ripple cancellation characteristics at high-current side and voltage -doubler topology at the high voltage side. Because the fuel-cell lacks storage ability for electric energy. An energy-storage device Li-ion battery is usually used on high-voltage output dc-bus of the power converter in high-power applications. A constant-voltage(CV) feedback control with current-limit(CL) protection design is realized to raise reliability of studied fuel-cell power converter. Combined with the studied interleaved operations, output side of current-fed dc-dc converter are connected in parallel to present low-output voltage-ripple that is preferred for battery charging considerations. There is no imbalance problem that exist among the output capacitors of dc-dc converters connected in series. An active- clamped circuit for current-fed dc-dc converter also used to suppress voltage spike on power switches.

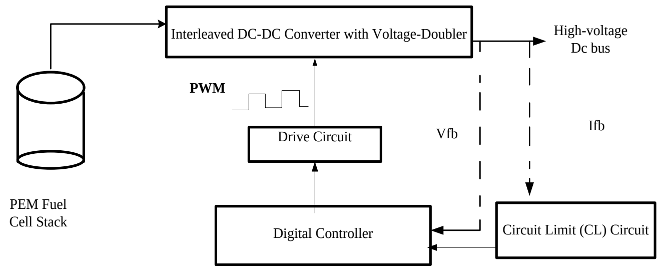

Fig.2 Digital-controlled interleaved dc-dc converter

III. CURRENT-FED FULL-BRIDGE DC-DC CONVERTER WITH VOLTAGE DOUBLER

Fig.3 shows the current-fed full bridge dc-dc converter composed with an input choke Lin, power switches QA ~ QD, a step-up transformer T1, and a secondary voltage doubler. The input choke Lin acts as a boost inductor to store and release the energy from the fuel-cell stack in accordance with the primary switches' operation.

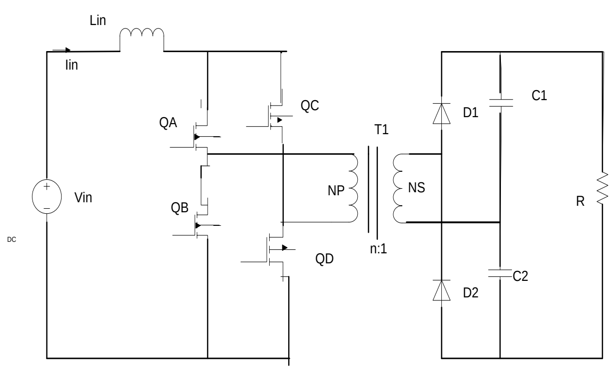

Fig.3- Current-fed full-bridge dc-dc converter

The duty cycle *D* for power switches *QA ~ QD* is always higher than 50% to retain the continuity of the input inductor current *I*Lin. The voltage doubler is added at the transformer secondary side to reduce the voltage stresses of the secondary rectifier diodes for the studied high-voltage output applications. *V*Np and *V*Ns represent the transformer primary and secondary voltages, respectively. According to voltage balance second relationship of the input choke Lin, voltage transfer ratio of the current-fed dc-dc converter with voltage doubler can be derived as

$$Vo/Vin=2/n\,(1-D)$$

`

Where n represents transformer turn ratio.

Table1

CIRCUIT SPECIFICATIONS

Input voltage	37-80V
Output voltage	365V
Rated power	10KW
Maximum Output Current	27.4A
Switching Frequency	30KHZ

IV.CONCLUSION

This paper has presented a digital-controlled dc–dc converter for High-power PEM fuel-cell applications. High-efficiency performance and low-input-current ripple can be achieved by the studied interleaved current-fed full-bridge dc–dc converter with a secondary voltage-doubler topology.

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TECH-CHRONICLE
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A Multilevel PWM Inverter Topology with Reduced Number of Switches

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***Abstract* - As compared to conventional two level inverters, multilevel inverters have been widely accepted for high-power and high voltage applications due to their added advantages of low switching stress and lower total harmonic distortion (THD), hence reducing the size and bulk of the passive filters. In this paper a new five level inverter topology is presented with reduced number of switches as compared to conventional cascaded H-bridge multilevel inverter, and can be extended to any number of levels. The use of the phase carrier disposition multicarrier PWM switching technique for this topology is presented. Control signals are derived.**

Keywords– Multilevel inverter, THD, VSI, SPWM, topology.

I. INTRODUCTION

Among all the modern power converters, the voltage source inverter (VSI) is the simplest and most widely used device with power ratings ranging from fractions of kilowatt to megawatt level. It converts fixed DC voltage to AC voltage with controllable frequency and magnitude. To improve the efficiency, performance and reliability of the system, most of the loads are connected to the AC power line through power converters. In recent years, the multilevel voltage inverter has received wide attention in high-power applications such as large induction motor drives, UPS systems and flexible AC transmission systems [1]-[8]. Multilevel inverter synthesizes a desired stepped output voltage from several input DC voltage sources. With an increasing number of input DC sources, the inverter output voltage waveform approaches nearly sinusoidal waveform. As compared to traditional two-level inverters, the multilevel inverters have more advantages, which include lower semiconductor voltage stress, better harmonic performance, low electromagnetic interference and lower switching losses. A multilevel inverter also enables the use of renewable energy sources. Renewable energy sources such as photovoltaic, wind and fuel cell can be easily interfaced to a multilevel inverter system for high power applications.

The three common topologies for multilevel inverter are: (i) Diode clamped [9] (ii) Flying capacitor [10] and (iii) Cascaded H-bridge inverter. Among them, a cascaded H-bridge inverter is useful because it requires reduced number of components to achieve the same number of output voltage levels among the conventional multilevel inverters[11], [15]. One of the disadvantages of multilevel inverter is the large number of power semiconductor switches required, thus THD and losses increases. Every switch requires a gate driver circuit, therefore increasing the complexity and size of the overall circuit.

This paper presents a new topology of cascaded multilevel inverter that produces the same output as the conventional cascaded multilevel inverter for a given input but has fewer semiconductor switches and gate driver circuits. Its performance is analyzed using different sinusoidal PWM techniques.

This paper proposes an improved topology for cascaded MLI with using less number of switches and thus less gate drive circuits and less circuit layout complexity. Section II explains the principle of operation for the proposed inverter. Then, taking a particular example of single-phase PWM inverter is illustrated in section, details of switching algorithm of the proposed inverter are explained in section III. Section IV shows the result and discussion with the simulation result are included to verifying operating principle of the proposed MLI inverter in section. Finally conclusions are given in section V.

II. OPERATIONAL PRINCIPLE OF THE PROPOSED INVERTER

In order to reduce the overall number of switching devices in conventional cascaded multilevel inverter topologies, a new topology has been presented. The circuit configuration of the new five level inverter is shown in Fig.1.

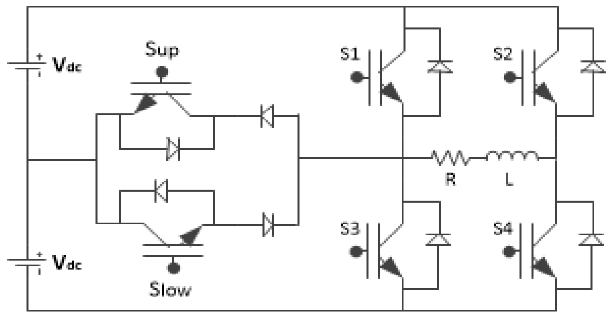

Fig. 1.The power circuit of the multilevel inverter with reduced number of switches.

It is constructed by adding a bi-directional switch to the conventional bridge topology. The bi-direction switch controls current flow to and from the neutral point of the two separate DC voltage sources and is composed of the two switches S_{up} and S_{low}. The inverter power circuit, with the appropriate control used, can apply across the load five different voltage levels, namely $2V_{dc}$,V_{dc}, 0, -V_{dc},-$2V_{dc}$. Switches S_1, S2, S3, S_4 have a voltage rating of $2V_{dc}$ which is the DC bus voltage (Fig. 1). Switches S_{up} and S_{low}, have a voltage rating of V_{dc} which is half the DC bus voltage. As a consequence these two switches would be of a lower cost than switches S, through S4. The antiparallel diodes across, the switches allow continuous current flow and thus help to maintain a sinusoidal output current. Furthermore, the bidirectional switch could be built with the two switches S_{up} and S_{low}, connected simply in series and not in parallel with the extra blocking diodes as shown in Table. 1.

TABLE I. MULTILEVEL INVERTER SWITCH STATES OF THE INVERTER UNFILTERED OUTPUT VOLTAGE SIGNAL ACROSS THE LOAD.

LOAD VOLTAGE	$2V_{dc}$	V_{dc}	*0*	*0**	$-V_{dc}$	$-2V_{dc}$
S_{up}	OFF	OFF	OFF	OFF	ON	OFF
S_{low}	OFF	ON	OFF	OFF	OFF	OFF
S_1	ON	OFF	OFF	ON	OFF	OFF
S_2	OFF	OFF	OFF	ON	ON	ON
S_3	OFF	OFF	ON	OFF	OFF	ON
S_4	ON	ON	ON	OFF	OFF	OFF

III. A MULTILEVEL PWM TECHNIQUE

During One cycle of the output frequency of 50 Hz the inverter operates through four modes. These operational modes are shown in Table I with respect to the per unit (pu) output voltage signal.

Each of these operational modes has a high level and a low level. The five output voltage levels are obtained by the switch combinations shown in Table 1.

From Table I voltage levels "0" and "0*" are the same value. However, for commutation purposes the switch configuration is different for the zero voltage level in the first half cycle of the output voltage to that in the second half cycle.

As can be seen from Fig. 2, the interval of each mode varies with the amplitude of the required sinusoid. The phase angles of mode change ϕ_1, ϕ_2, ϕ_3 and ϕ_4 determine also the time that the inverter operates within a certain mode. For clarity purposes and referring to Fig. 2, the four modes fall within the following boundaries:

Mode I: $\phi_1 < \omega t < \phi_2$ (1)

Mode II: $0 < \omega t \le \phi_2$ and $\phi_2 < \omega t \le \pi$ (2)

Mode III: $\pi < \omega t \le \phi_3$ and $\phi_4 < \omega t \le 2\pi$ (3)

Mode IV: $\phi_3 < \omega t \le \phi_4$ (4)

In order to control the inverter, a multicarrier disposition PWM technique is used. Multicarrier disposition PWM techniques recently presented in [16], [17] entail the natural sampling of a single modulating or reference waveform typically being sinusoidal, through several carrier signals typically being triangular. For an *n*-level system, that is to produce a phase voltage waveform with *n-1* levels plus the zero, *n-1* carrier signals are required. They all have the same frequency and peak-peak amplitude, and each structured such that all carriers are contiguous.

In general, the phase displacement between any two of the contiguous triangular carriers is free, therefore a number of combinations can be studied as follows:

1. The carriers are alternatively in opposition *(AP0* disposition).
2. All the carriers above the zero value reference are in phase but in opposition with those below (PO disposion).
3. All the carriers are in phase (PH disposition).

Additional combinations of carrier phase displacement are possible for the 5-level model, however the minor differences evident between these and the aforementioned techniques selected for investigation would result in similar output waveform characteristics.

The multilevel phase opposition (PO) multicarrier disposition method (Fig. 3**)** was used to derive the switch gating signals for the multilevel inverter under consideration (Fig. 1).

The exchanging phase angles can be shown to be disposition method (Fig. 3**)** was used to derive the switch gating signals for the multilevel inverter under consideration (Fig. 1).

The exchanging phase angles can be shown to be dependent upon the amplitude modulation index or simply modulation index, M_a, as in Fig. 4. For the *n*-level PO disposition PWM technique then, the amplitude modulation index as defined as follows:

$$Ma = \frac{A�}{(�1)c} \quad (5)$$

Where A_c, is the per unit (pu) carrier (triangular) peak-peak value and A_m, is the **(**pu**)** peak value of the modulating (sinusoidal) signal.

Furthermore, the frequency modulation index is defined as:

$$M_f = \frac{fc}{f�} \quad (6)$$

Where f_c, is the frequency of the carrier (triangular) signal and f_m is the frequency of the modulating (sinusoidal) signal.

Whilst $A_C \le A_m$, or equivalently when the amplitude modulation index is greater than 0.5, the exchanging phase angles are defined by:

$$\phi_1 = \sin^{-1}\left(\frac{Ac}{A�}\right) \quad (7)$$

$$\phi_2 = \pi - \phi_1 \quad (8)$$

$$\phi_3 = \quad + \phi_1 \quad (9)$$

$$\phi_4 = 2\pi - \phi_1 \quad (10)$$

For $A_m \le A_c$, or equivalently when the amplitude modulation index is less than 0.5, the exchanging phase angles are equal to

$$\phi_1 = \phi_2 = \frac{\pi}{2} \quad (11)$$

$$\phi_3 = \phi_4 = \frac{3\pi}{4} \quad (12)$$

During the first half cycle of the output voltage and assuming that the modulation index is greater than 0.5, the inverter produces three output levels namely 0, V_{dc} and $2V_{dc}$. During the second half cycle the inverter produces another three voltage levels namely 0*, $-V_{dc}$ and $-2V_{dc}$. As can be seen from Table I. switch S_2 is OFF during the first half cycle and ON for the second half cycle. Conversely switch S_4 is ON for the first half cycle and OFF for the second half cycle. Therefore the switching frequency of switches S_2 and S_4 is equal to the output frequency of 50 Hz and thus low frequency switches such as

BJTs can be used. Also the switching function for S_2 is opposite to that for S_4. Table 2 also shows that the switching function for S_{low} is opposite to that for S_1 and the switching function for S_{up}, is opposite to that for S_3. That is, whenever switch S_{low} is ON, switch S_1 is OFF and whenever switch S_{up}, is ON, switch S_3 is OFF and vice versa.

In order to operate the inverter then, the switch gating signals need to be derived. However due to the above relationships only three gating signals need to be found with these being the ones for switches S_{up}, S_{low}, and S_2. The gating signals for switches S_1, S_3 and S_4 are simply the logical inverse of the gating signals for switches Sup, S_{low}, and S_2 respectively.

III. Control Signals

For illustrative purposes only, the PO carrier disposition PWM technique (Fig. 2) with a carrier frequency f, of 10000 Hz was used. The frequency of the modulating signal was chosen to be 50 Hz. The frequency modulation index is then $M_f = 200$. For this carrier disposition PWM technique as mentioned earlier, the carrier signals above zero are all in phase and out of phase with all carriers below zero this is shown in Fig. 2. The unfiltered output voltage waveform across the load using the multilevel inverter shown in Fig. 1 then regions in that of Fig. 4 when M_a=1.

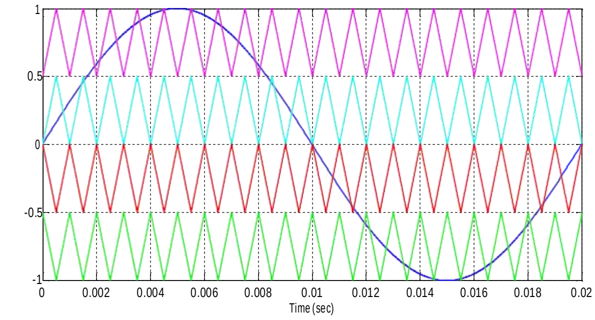

Fig. 2. The multicarrier phase opposition (PO) disposition PWM technique for M_a = 1, M_f =200.

Now that the switching technique and carrier frequency have been set, the derivation of the gating signals in the physical inverter control needs be explained. The gating signals are constructed by adding portions of the PWM decision signals together through appropriate logic gates. The PWM decision signals, as explained in Section II, are derived from the intersections between the carrier signals and the modulating signal. The decision signals for the PO disposition method are given in Fig. 3, and this shows the decision signals only occurring during those time intervals where the modulating signal intersects with the respective carrier signals.

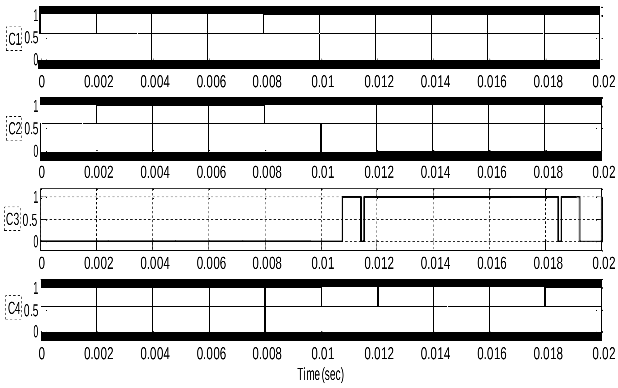

Fig. 3. Decision signals of the multicarrier phase opposition disposition PWM technique and $M_a = 1$, M_f =200.

From Fig. 3 and referring to Fig. 2, *C1* represents carrier 1 and modulating signal intersections; *C2* represents carrier2 and modulating signal intersections; *C3* represents carrier3 and modulating signal intersections and *C4*, represents carrier4 and modulating signal intersections. The switch gating signals are made up of portions of these signals. There are six regions that make up one cycle of the output and these are defined in Fig. 4. The regions are given by the mode exchange phase angles ϕ_1, ϕ_2, ϕ_3 and ϕ_4 defined in section II and Fig. 4. Thus the six regions are as follows:

(i) $0 < \text{time} < \phi_1$
(ii) $\phi_1 < \text{time} < \phi_2$
(iii) $\phi_2 < \text{time} < \pi$
(iv) $\pi < \text{time} < \phi_3$
(v) $\phi_3 < \text{time} < \phi_4$
(vi) $\phi_4 < \text{time} < 2\pi$

as shown in Fig. 4.

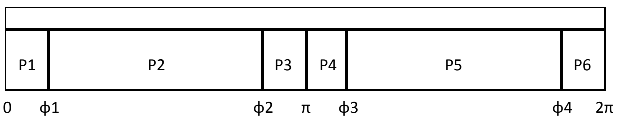

Fig. 4. Output regions for modulation index greater than 0.5.

Having the PWM decision signals of Fig. 4 and the output region pulses of Fig. 3 it is now possible to define the switching signal for each switch. The Boolean expressions that follow would be implement by the use of logical AND and OR gales. The switching functions of Fig. 5 are then given by

$$S_{up} = P1 + P2\cdot C1 + P3 + P4\cdot C3 + P5 + P6\cdot C3 \quad (13)$$

$$S_{low} = P1\cdot C2 + P2 + P3\cdot C2 + P4 + P5\cdot C4 + P6 \quad (14)$$

$$S_1 = \overline{S_{low}} \quad (15)$$

$$S_2 = P4 + P5 + P6 \quad (16)$$

$$S_3 = \overline{S_{up}} \quad (17)$$

$$S_4 = P1 + P2 + P3 \quad (18)$$

Where "+" is a logical OR., "·" is a logical AND and "−" logical inverse or NOT.

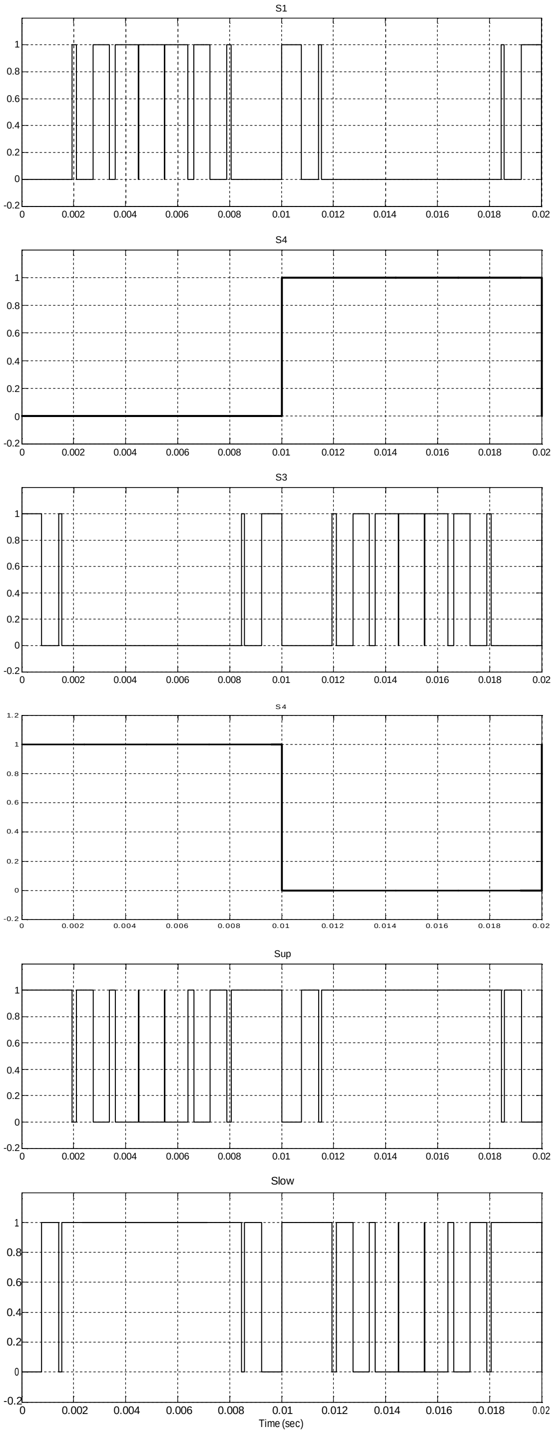

Fig. 5.Inverter switch gating signals for multicarrier phase opposition PWM technique $M_a = 1$, $M_f = 200$.

When constructing the physical circuit the signals *C1*, *C2*, *C3* and *C4* come from comparators which compare the respective carrier signal and the modulating signal; the signals *P1, P2, P3, P4, P5* and *P6* come from a memory device which varies the pulse duration according to eqns. (7), (8), (9) and (10). These signals are then passed through appropriate logic gates as defined by the above equations. The unfiltered output voltage waveform across the load using the multilevel inverter shown in Fig. 1 then results in that of Fig. 6 when M_a=1**.**

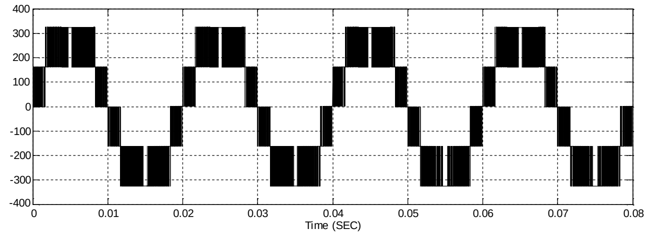

Fig. 6. Inverter output voltage waveform (5-level) with multicarrier phase opposition disposition PWM technique for *Ma* = 1, *Mf*= 200**,** *fo*= ***50*** Hz**.**

IV. SIMULATION RESULTS

The proposed topology has been simulated using MATLAB software to verify the performance of the proposed configuration. A single phase RL load with 8.8Ω resistance, and 12mH inductor was used. Open loop control with wide range of modulation index has been simulated at 10 kHz switching frequency. Two identical power supplies 162.5 V each were used for the dc bus.

The results are presented in Fig. 6 modulation index of 1 respectively. It is revealed that the inverter produces a voltage output signal that has a different number of levels depending upon the modulation index. The performance of the inverter with the multilevel PWM technique used was evaluated for various values of the amplitude modulation index.

V. CONCLUSION

This paper introduces a modular MLI with less number of components. A single phase five level PWM inverter is proposed as a particular. Four carrier signals identical to each other with an offset equivalent to the amplitude of the triangular carrier signals are used to generate PWM strategy, and operational inverter are analysed in detail.

The new proposed inverter cost is less due to the savings from a less number of switches and thus less gate drive circuits and less circuit layout complexity and fewer assembly steps. This leads to a smaller size and volume, less loss and then high efficiency of the inverter.

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POWER UPGRADING OF TRANSMISSION LINE BY USING SIMULTANEOUS AC-DC TRANSMISSION

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ABSTRACT-

Long extra high voltage (EHV) ac lines cannot be loaded to their thermal limits in order to keep sufficient margin against transient instability. With the scheme proposed in this paper, it is possible to load these lines very close to their thermal limits. The conductors are allowed to carry usual ac along with dc superimposed on it. The added dc power flow does not cause any transient instability.

This project presents the feasibility of converting a double circuit ac line into composite ac–dc power transmission line to get the advantages of parallel ac–dc transmission to improve stability and power upgrading. Simulation and experimental studies are carried out for the coordinated control as well as independent control of ac and dc power transmissions. As voltage is kept constant No alterations of conductors, insulator strings, and towers of the original line are needed.

Substantial gain in the load ability of the line is obtained.12 pulse rectifier is used for producing dc as it produces approximately 17% less THD in input line current. By this model we can send extra power in the existing transmission line.

Keyword – Extra High Voltage (EHV) , Total Harmonics Distortion (THD), simultaneous ac–dc power transmission.

INTRODUCTION

In recent years, environmental, right-of-way (Row), and economic concerns have delayed the construction of a new transmission line. The demand of electric power has shown steady growth but geographically it is quite uneven. The power is often not available at the growing load centers but at remote locations. Often the regulatory policies, environmental acceptability, and the economic concerns involving the availability of energy are the factors determining these locations. Now due to stability considerations, the transmission of the available energy through the existing ac lines has an upper limit. Thus, it is difficult to load long extra high voltage (EHV) ac lines to their thermal limits as a sufficient margin is kept against transient instability.

Simultaneous ac–dc power transmission was earlier proposed through a single circuit ac transmission line i.e. uni-polar dc link with ground as return path was used. The limitations of ground as return path is due to the fact that the use of ground may corrode any metallic material if it comes in its path. The instantaneous value of each conductor voltage with respect to ground 3 becomes higher due to addition of dc voltage hence more discs have to be added in each insulator string so that it can withstand this increased voltage. The conductor separation distance was kept constant, as the line-to-line voltage remains unchanged. This thesis gives us the feasibility of converting a double circuit ac line into composite ac–dc power transmission line without altering the original line conductors, insulator strings and tower structures.

CONCEPT OF SIMULTANEOUS AC-DC TRANSMISSION

The circuit diagram in Figure 1. shows the basic scheme for simultaneous ac-dc transmission. The dc power is obtained through the rectifier bridge and injected to the neutral point of the zigzag connected secondary end transformer, and again it is reconverted to ac by the inverter bridge at the receiving end. The inverter bridge is again connected to the neutral of zigzag connected winding of the receiving end transformer. Fig. 1.depicts the basic model for simultaneous ac-dc power flow through a dual circuit ac transmission line. Line commutated 12-pulse rectifier bridge is used in conventional HVDC and the dc power is injected to the neutral point of the zig-zag connected secondary of sending end transformer and is recovered back to ac again by the line commutated 12-pulse bridge inverter at the receiving end side.

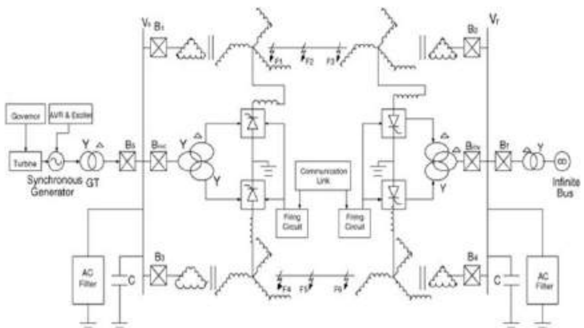


Fig 1. Basic circuit diagram of simultaneous Ac-dc transmission

The inverter bridge is also connected to the neutral of zig-zag connected winding of the receiving end transformer to recover back the dc current to the inverter. The dual circuit ac transmission line carriers both three-phase ac and dc power. Each conductor of each transmission line carries one third of the total dc current with ac current superimposed. Since the resistance is equal in all the three phases of secondary winding of zig-zag transformer and the three conductors of the line, the dc current is equally divided in all the three phases. The conductor of the second transmission line provides return path for the dc current to flow. The saturation of transformer due to dc current can be removed by using zig-zag connected winding at both ends. The fluxes produced by the dc current (Id / 3) flowing through each winding of the core of a zig-zag transformer have equal magnitude and opposite in direction and hence cancel each other. At any instant of time the net dc flux becomes zero.

Thus, the dc saturation of the core is removed. A reactor Xd with higher value is used to reduce harmonics in dc current. In the absence of third order harmonics or its multiple and zero sequence, under normal operating conditions, the ac current flow through each transmission line gets restricted between the zig-zag connected windings and the conductors of the transmission line. The presence of these components may only be able to produce negligible current through the ground due to higher value of Xd.

SIMULATION MODEL

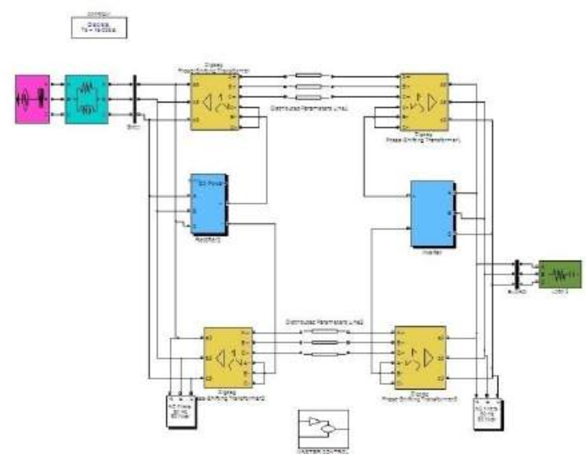


Fig 2. simulation model of existing HVAC model after upgradtion

In this model number of blocks are used such as 500 KV source for the supply, zig-zag transformers at both the ends i.e. sending and receiving end of the transmission line, and 300 Km line is in between two transformer for the transmission purpose and its inductive reactance has a value of 0.9337 mH. And at the receiving end one load is connected which is of 1500 MW to measure the power coming to the receiving side of the system. Rectifier and converter are connected in between to convert some of the ac power to dc so that we can send converted dc current through the neutral of zig-zag transformer to increase the power transfer capability of the system and this dc current again get back through by inverter connected to neutral of receiving end zig-zag transformer. Above model is showing the system after upgradation. The resulting waveforms are shown in the simulation result chapter where all the related waveforms are shown.

The study is based on the comparison between the response between existing EHVAC system and for combined EHV and HVDC transmission (double circuit line) through simulink in

MATLAB. A comparison between the sending end and receiving end voltages and sending end and receiving end current for the two cases have been done. The active and reactive power changes during existing and parallel AC-DC conditions are also observed.

Earlier it was proposed through a single circuit ac transmission line i.e. uni polar dc link with ground as return path was used. The limitations of ground as return path is due to the fact that the use of ground may corrode any metallic material if it comes in its path. The instantaneous value of each conductor voltage with respect to ground becomes higher due to addition of dc voltage, hence more discs have to be added in each insulator string so that it can withstand this increased voltage. This thesis gives us the feasibility of converting a double circuit ac line into composite ac–dc. So we shifted towards a double line transmission with 2 sending end stations and 2 receiving end stations making a more reliable and stronger system capable of overcoming any adversities or shortcomings. It is actually designed for a larger chunk of load transfer. It also guarantees continuous supply if one station is interrupted due to internal or external faults. The voltage, current and power profiles are studied during fault and without fault and it is found to have better transient response than single circuit.

The above fig 2. showing simulation model for simultaneous AC-DC transmission system. In this system we taking transmission line of 500 KV. The part of 500 KV voltage is get converted into DC by using 12 pulse line commutated rectifier and some part i.e approximately 500KV voltage was send through zig-zag transformer. And afterwards 1.3KA dc current is injected to the neutral winding of zig-zag transformer which get further distributed to the three transmission line as (Id/3). And this dc current again recovers back by using inverter which also connected to the receiving end zig-zag transformer. The waveforms for sending and receiving end voltages, current and power are shown in results.

The AC power transmission can be calculated by formula given as,

$Pac=(Va^2*\sin\delta/X)$……..……………………(1)

And dc power can be calculated by formula given as,

$Pdc=Vd*Id$………………………………..……(2)

Power loss of the transmission line is calculated by,

$Ploss=3*Ia^2*R$…………………………………..(3)

SIMULATION RESULTS

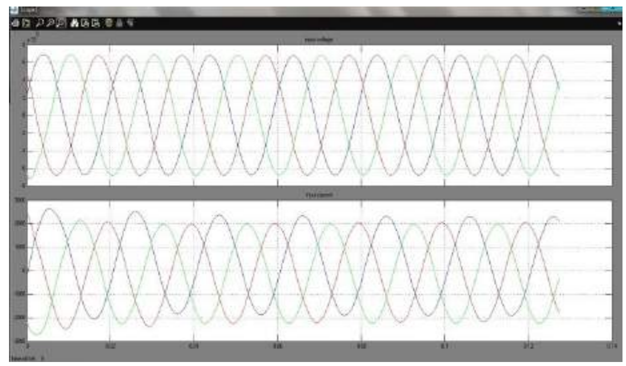


Fig 3. Input Ac voltage and current waveforms

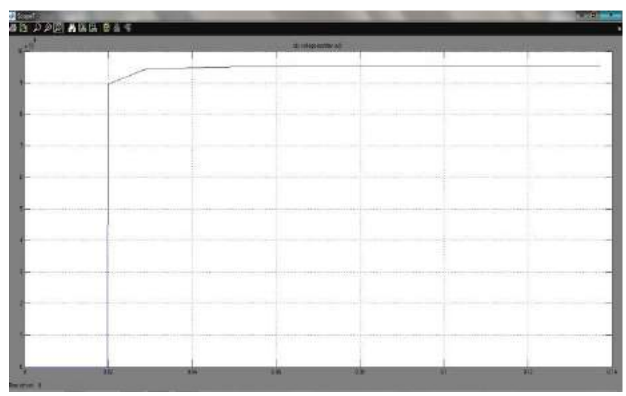
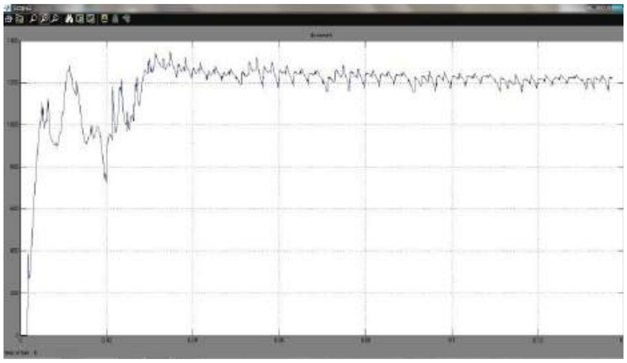


Fig 4. DC voltage waveform across rectifier



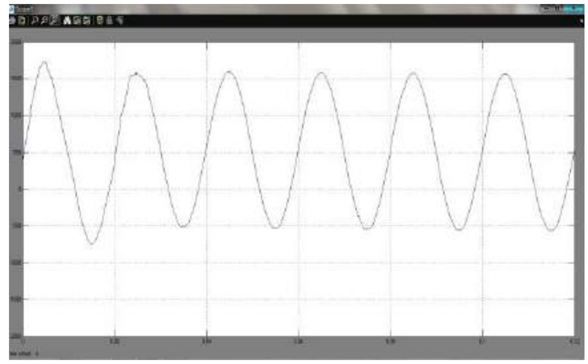


Fig 7. Combined AC-DC current waveform

Fig 5. DC current waveform

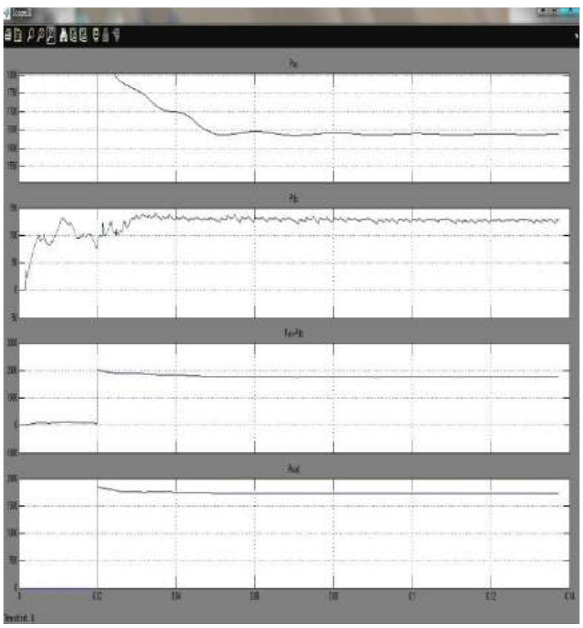


Fig 6. Waveforms of power

1. AC power waveform

2. DC power waveform

3. Combined AC-DC power waveform

4. Load power

PHASE ANGLE δ	AC POWER Pac	DC POWER Pdc	TOTAL POWER (Pac + Pdc)	% INCREASE IN POWER
30	1700	140	1850	8.82
45	1640	135	1770	7.92
60	1637	128	1765	7.82
75	1665	95	1760	5.70
80	1690	93	1785	5.62
90	1690	75	1785	4.01

Table showing percentage increase in power at different power angle

CONCLUSION

Necessity of additional dc power transmission will be experienced maximum during peak load period which is characterized with lower than rate voltage. If dc power is injected during the peak loading period only with V d being in the range of 5% to 10% of E ph, the same transmission line without having any enhanced insulation level can be allowed to be used, 5.1% or 10.2% more power can be transmitted. By adding a few more discs in insulator strings of each phase conductor with appropriate modifications in cross arms of towers insulation level between phase to ground may be increased to a high value, which permits proportional increase in Emax, Therefore higher value of Vd may be used to increase dc and total power flow through the line. This modification in the exiting ac lines is justified due to high cost of a separate HVDC line.

FINDINGS FROM SIMULATION:

1. When simultaneous Ac-Dc power is send & the load requirement is less than or equal to dc power in the line then only dc power flows through the line .

2. If load power requirement is greater than dc power in the line then ac power fulfills the additional power requirement.

3. Simultaneous Ac & Dc power transfer increases the power transfer capability of line.

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Automatic Synchronization of Alternators By Using Microcontroller

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Abstract:-

The manual method of synchronization demands as killed operator and the method is suitable for no load operation or normal frequency condition. Under emergency condition such as lowering of frequency or synchronizing of large machines a very fast action is needed, which may not be possible for a human operator. Thus there is a need of auto synchroniser in a power station or in an industrial establishment where generators are employed. This paper describes a microprocessor based set up for synchronizing a three phase alternator to a busbar . Also existing methods of synchronization are mentioned.

Keywords:-Synchronization, synchronous generators, parallel connection, microcontroller.

I. INTRODUCTION

It is well known that electrical load on a power system an industrial establishment, is never constant but it varies. To meet the requirement of variable load , economically and also for assuring continuity of supply the number of generating units connected to a system busbar are varied suitably . The connection of an incoming alternator to system bus, ie; synchronization requires fulfillment of the condition like the same phase sequence equality of voltages and frequency between the incoming machine and frequency between the in coming machine and busbar. In order to overcome the nine technical drawbacks of the conventional synchronization methods we can introduce a microcontroller based system.

II. NECESSARY CONDITIONS TO BE SATISFIED

a) The terminal voltage of incoming machine must be the same as the busbar voltage.

b) The speed of the incoming machine must be same such that the frequency is equal to the busbar frequency.

c) The phase sequence of the busbar voltage and the incoming machine voltage must in phase.

III. EXISTING METHODS OF SYNCHRONIZATION AND PRINCIPLE

a. Synchronizing Lamp.

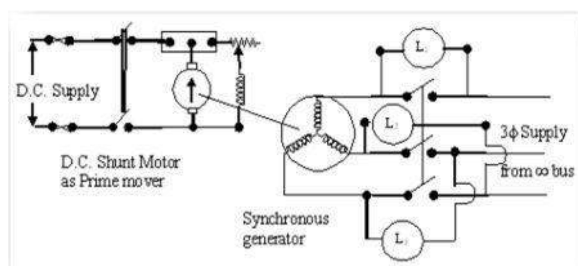

Fig1:- Synchronizing Lamp Method.

The operation of connecting an alternator parallel with another alternator or with a common busbar is known as synchronizing for proper synchronization of alternators the following three conditions must satisfied.

a. The terminal voltage of incoming machine must be the same as the busbar voltage.

b. The speed of the incoming machine must be same such that the frequency is equal to the busbar frequency.

c. The phase of the alternator voltage must be identical to the busbar voltage.

It means that the switch must be closed at the instant the two voltages are in correct phase.
Condition 1 can be checked with the help of voltmeter, frequency is adjusted by varying the prime mover speed. In the dark lamp method the lamps are connected across the alternator and busbar terminal. If the phase sequence is different, the lamps will brighten in a cyclic manner correct phase sequence is indicated by simultaneous darkening brightening of lamps. The switch is closed in the middle of the dark period. Once synchronized properly, the two alternators continues to run in synchronism.

b. Sychroscope

Fig2:- Synchroscope

From fig.2 the armature of the sychroscope will align itself so that the axis of windings are R and F are inclined at an angle equal to phase displacement between V and V'. If there any difference between the frequencies of V and V' a pointer attached to the armature shaft will rotate at slip speed, and the direction of its rotation will indicate whether the incoming machine is running above or below synchronism. At synchronism, the pointer will remain stationary, but it must be brought to the particular position which indicates zero phase displacement between V and V' before the main switch of the incoming generator is closed.

IV. HARDWARE DETAILS

The hardware has been designed to fulfill all the requirements of the synchronizing process.
Block diagram of auto synchronizer setup is shown in fig 3. The auto synchronizer setup consist of
a. Frequency control unit
b. Voltage control unit
c. Potential transformer unit
d. Signal conditioning card
e. Display card and
f. Circuit breaker with the switching circuit.

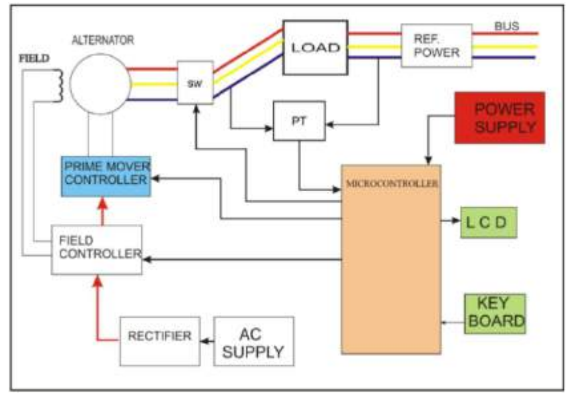

Fig3:-Biock Diagram

a. Frequency Controlling Unit

The frequency of an alternator can be changed by varying the speed of the prime mover which is a DC shunt motor in this case .A rheostat is provided in the field circuit of the motor for this purpose The frequency controlling unit is a lead screw arrangement driven by a stepper motor attached to the variable point on the rheostat the stepper motor is controlled by microcontroller system through a driver circuit.

b. Voltage Controlling Unit

Once frequency of alternator is fixed, or adjusted, its voltage is controlled by variation of excitation current. This excitation current is varied by providing a rheostat in the field circuit of the alternator. The automatic variation of excitation current is obtained by lead screw and stepper motor arrangement similar to the one used for frequency control.

c. Potential Transformer Unit

This unit consists of a bank of four shell type transformer (P.Ts). Out of the four transformers thee are used for stepping down three phase voltages of alternator and the remaining one is used for stepping down the voltage of the phase R of the bus bar. The potential transformers connected to the phase R of the bus bar and the phase R of the alternator are having two secondaries. Hence one secondary is used for voltage measurement and the other is used for frequency measurement .The potential transformers connected to the Y and B phases have only one secondary each.

d. Signal Conditioning Card

It is subdivided into
a) signal conditioning card and
b) ADC subunit.

The signal conditioning subunit consists of for identical circuits each of which comprises of a zero crossing detector (ZSD)(for ralt, yalt, balt and rbus) two rectifier and filter circuits for ralt2 and rbus2 and an in phase sequence detector and an in phase instant detector as shown in fig.3

e. Display Device

Display card has been provided for indication of messages during alternator synchronization process it uses four seven –segment LED displays to represent the three in phase synchronization conditions.

V. CIRCUIT DIAGRAM

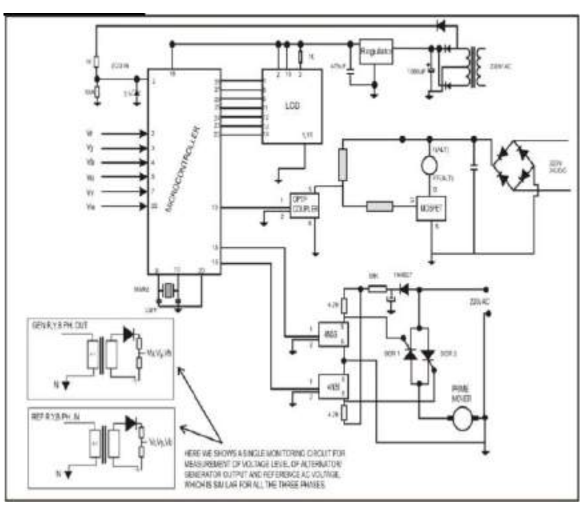

Fig4:- Circuit Diagram

The output voltage both, from the reference & incoming alternator is given to PIC using potential transformer. The PIC has inbuilt ADC (Successive Approximation) which convert this analog signal to digital signals. The PIC compares the incoming voltage to the reference voltage and generate equivalent PWM signal. This PWM signal is a square wave with T_{on}& T_{off} time. It is given to the Opto-coupler. Opto-coupler consist of LED and Photo Diode. This will simultaneously turn on & turn off the LED, which will operate the photo-diode. Now when LED is OFF the resistance of Photo diode will be more and hence the positive current from the 220V dc will gate the MOSFET and this will turn on the MOSFET and thus the negative terminal of field wdg will be connected to negative terminal of dc supply and this will increase the excitation voltage of alternator, thus increasing output voltage of the alternator. The same process repeats if the incoming voltage is more than that of reference voltage , the LED will be On, which will decrease the resistance the 220V will be grounded through photo-diode and the Mosfet will be OFF thus decreasing the excitation of the alternator. For the measurement of frequency a ZCD (Zero Cross Detector) circuit is connected to PIC. The input from incoming alternator is given to ZCD using a Half Wave Rectifier unit. The ZCD counts the no of positive to zero going pulse which is equivalent to the frequency. The ZCD is set at 50 Hz frequency, if the incoming frequency is less it will generate equivalent PWM and the same process repeats as the prime mover used here is field excited. The result is displayed on the 16x4 LCD display. A step down transformer along with full wave rectifier circuit is used to provide 5V dc supply to the PIC &LCD Display. LM 7805 is used as voltage regulator IC to provide constant voltage to the PIC.

VI. CONCLUSION

The microcontroller based system of automatic synchronizer can be used more effectively compared to conventional methods of synchronization such as dark lamp method, bright lamp method and synchronization using sychroscope this because of the fact that the conventional, method calls for of the operator and accuracy is less and it depends on the sense of correct judgment of the operator. Moreover the microprocessor based alternator synchronizer is user friendly and requires less maintenance. It also exploits the advantage of superior performance of the microcontroller like accuracy speed and reliability.

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Efficient and Improved Power Factor Using Combined Extinction and PWM Controlled Three Phase Induction Motor Drive

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***Abstract*- Phase angle controlled technique was used for soft start of induction motor however it suffers from disadvantage of retardation of the firing angle which causes lagging power factor at input side especially at lower speeds. Presently, three phase variable voltage variable frequency drives are widely used for soft start and efficient operation of induction motor. VVVF drive improves power factor (PF) of earlier used phase angle controlled induction motor drive. This paper presents, a new variable voltage control technique which uses four medium frequency PWM controlled AC freewheeling switches instead of six. This method will be suitable for fan, pump or blower load coupled to a three phase induction motor. The advantages of proposed method are its high power factor, high efficiency and ease of control over VVVF method. The paper presents a new technique of three phase AC to AC voltage control using pulse width modulation and extinction angle control. Proposed drive is expected to provide higher efficiency and higher power factor as compared to phase angle controlled and variable voltage variable frequency drive with simplicity and economy.**

Keywords—extinction angle control (EAC), pulse width modulation control (PWM), extinction β), power factor(PF),induction motor (IM), variable voltage and variable frequency drive(VVVF).

I. INTRODUCTION

The proposed project is concerned with the minimum power consumption by improving efficiency and offering AC freewheeling of three phase induction motor (IM) drives which is applicable in industries and power stations for controlled cooling purpose. Three phase induction motor is widely used in industries than other machines due to their advantages such as simplicity in construction, reliability in operation, and cheapness. The speed control of such motors can be achieved by controlling the applied voltage on the motor by the use of power electronic devices [1]. AC phase angle voltage controllers are also used for induction motor soft starter and economic running at reduced speed. But this suffers from several disadvantages such as retardation of power factor due to increase in firing angle at lower speeds, complex control techniques and more number of switches [2-3]. In [5], voltage control strategy for three-phase ac voltage regulator has been studied. This strategy depends on varying the stator ac voltage to control the speed of three phase induction motor. The converter consists of six bidirectional switches. Three switches are connected in series with stator terminals of the motor and another three are used to provide freewheeling path across stator windings. In [7], instead of a using conventional 6-switch, 3-phase inverter for speed control of 3phase induction motor, a 4 switch, 3- phase inverter has been used. This reduces the cost of the inverter, the complexity of the control algorithms and the switching losses. The main drawback of four switch three phase inverter is that it has more harmonics distortion in its output voltage and current as compared to conventional six switch inverter .Variable voltage variable frequency (VVVF) drives are used to minimize the above drawbacks of phase angle controlled drives. With VVVF drive, power factor (PF) and efficiency of induction motor improves as compared to previously used phase angle controlled drive. In order to further improve the efficiency and power factor the proposed drive scheme is presented. The proposed drive can operate induction motor with high PF ranging from lagging to leading or even at near unity for speed range required for fans and blowers. This could have been achieved with the help of combining three phase extinction angle control and medium frequency PWM control with novel AC freewheeling. If number of motors are driven using the proposed drive, plenty of power conservation is possible. The control circuit for the drive is simple and economic. The power circuit of the drive consists of four semiconductor controllable switches, out of which three are main switches and one freewheeling switch. Simulation results of power factor, displacement factor and total harmonic distortion factor are described and discussed.

II. CONTROL TECHNIQUE

Combination of extinction angle and PWM controlled technique

This is a novel technique that is introducing a combination extinction angle (β) control and PWM control for three phase induction motor drive. In this technique both the control technique will be acted simultaneously. In EAC control the conduction is started at zero crossing of the supply voltage, forced commutated at the desired extinction angle and also a freewheeling path is provided for the load current to discharge the stored energy of input voltage. In the conduction period from zero to desired extinction angle, pulse width modulation control is applied. EAC technique is to provide leading power factor. PWM technique is used for better power factor (lagging). By using the combined technique advantages of extinction angle control along with merits of PWM control are employed for controlling induction motor drive, thus results in achieving any power factor from lagging to leading or even at unity pf for any speed and induction motor is expected to draw comparatively less current, thus stator copper losses of three phase induction motor are reduced. If losses are reduced efficiency of motor is improved. In this technique only four semiconductor switches are used instead of six as in phase angle control. So, complexity of circuit is also reduced.

III. POWER CIRCUIT

The power circuit of the proposed technique is shown in Fig.1. In this diagram 3-phase supply is connected to stator winding of 3-phase induction motor through single phase diode bridge along with semiconductor switch(IGBT,GTO etc.) in each phase, whereas instead of three more switches for providing freewheeling path to each phase current only one switch with three phase diode bridge is used. This switch is connected in parallel to the 3-phase stator winding of induction motor. Snubber (R-C) circuit across each of the four switch are connected to provide dead time in between the operation of the main and freewheeling switches. Since the power circuit is employed using four semiconductor switches instead of six thus complexity of the circuit is abridged and cost of the drive is also reduced.

IV. MODES OF OPERATION

The operating modes of proposed drive are divided into four modes

I] Active mode
II] Dead time-I mode
III] Freewheeling mode
IV] Dead time-II mode

I] Active mode (mode-I)

The active mode corresponds to the ON-state period of the main switches S_1 S_2 S_3 and during this mode of operation switch S_4 remains OFF. When switches S_1 S_2 S_3 are made ON, the current flows from the three phase supply to the three phase stator winding through the switches S_1 S_2 S_3 simultaneously along with forward biased diagonally opposite diodes of the bridge as shown in Fig.2. The supply voltage appears across the terminals of star connected stator winding during mode-I.

II] Dead time-I mode (mode-II)

When switch S_1 S_2 S_3 are turned OFF, the stator terminals gets isolated from the AC supply .The stator current flows through parallel snubber circuit (R-C circuit) connected across each switch (S_1 S_2 S_3) for very short time. This short time when three main switches S_1 ,S_2, S_3 are turned OFF and auxiliary switch S_4 is about to turn ON is known as dead time-I (mode-II) as shown in Fig.3.

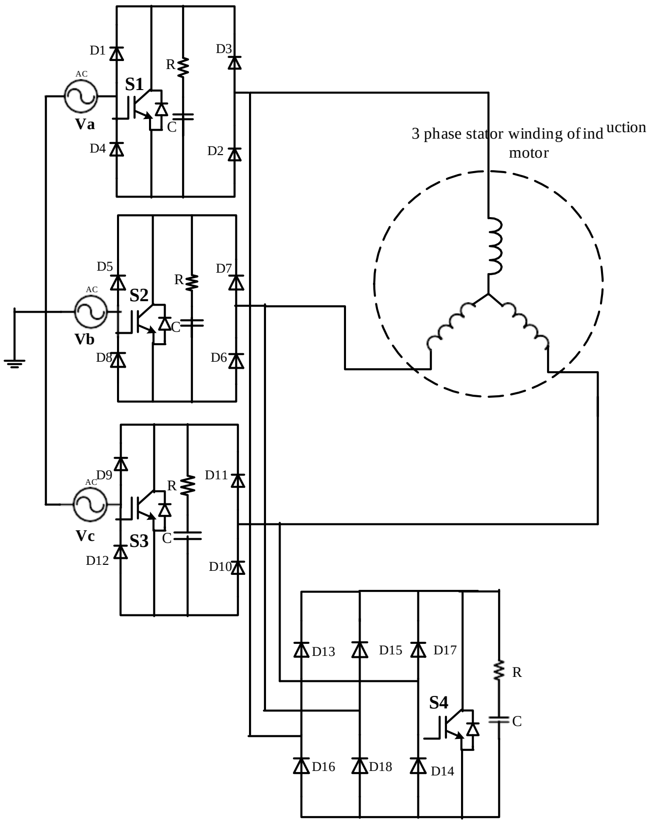

Fig.1.Power circuit of combined extinction angle and PWM controlled three phase induction motor drive

III] Freewheeling mode (mode-III)

The freewheeling auxiliary switch S_4 is turned ON during mode-III. In this mode the three phase stator currents will decay and circulates through three phase diode bridge rectifier. The parallel connected freewheeling switch S_4 as shown in Fig.4.In this mode, three phase load current discharges its stored energy.

IV] Dead time-II mode (mode-VI)

At the end of mode-III, switch S_4 gets turned OFF and main switches S_1 S_2 S_3 are about to turn ON. This short time interval when all the switches are OFF is called Dead time-II (mode-IV) as shown in Fig.5. The input line current during mode-II and mode-IV will be zero, but motor current continues to flow during all the four modes and hence circulates continuously during all the modes. In this mode, snubber across switch S_4 completes the path for the current and dead time is provided before switching on the main swit

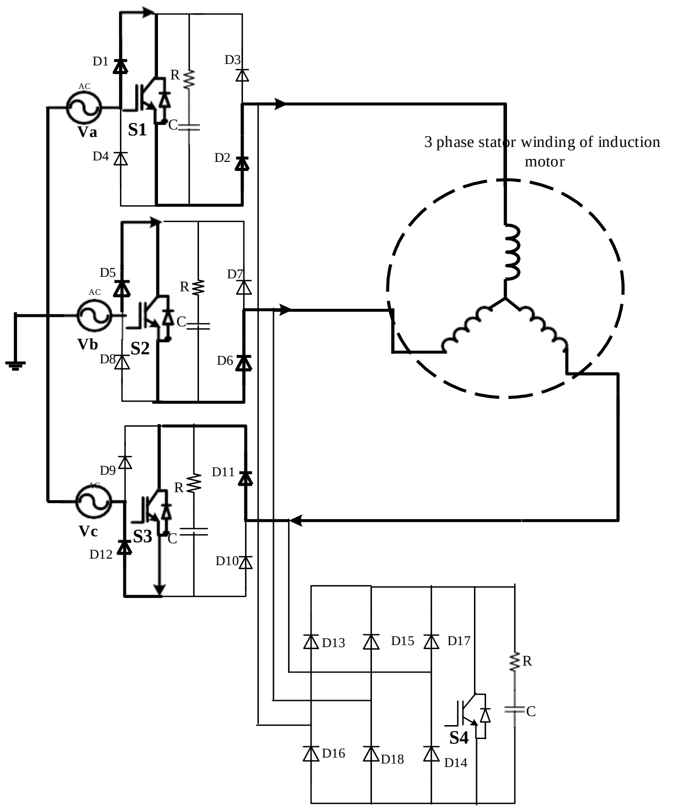

Fig.2.Active mode

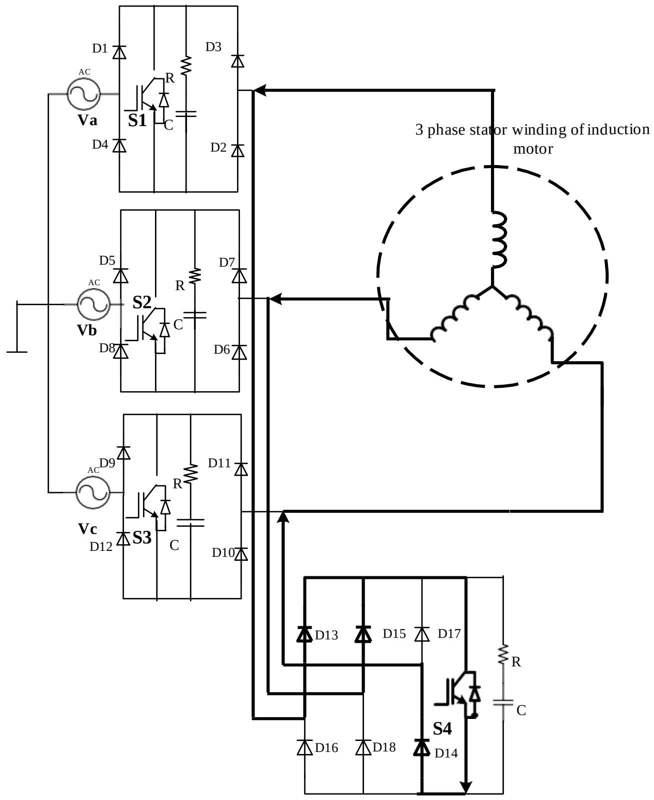

Fig.4.Freewheeling mode

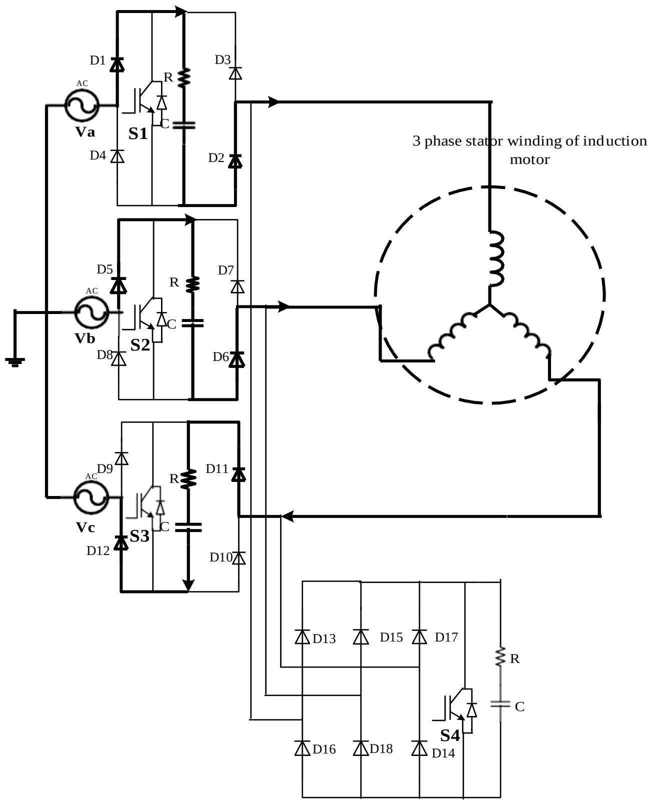

Fig.3.Dead time I mode

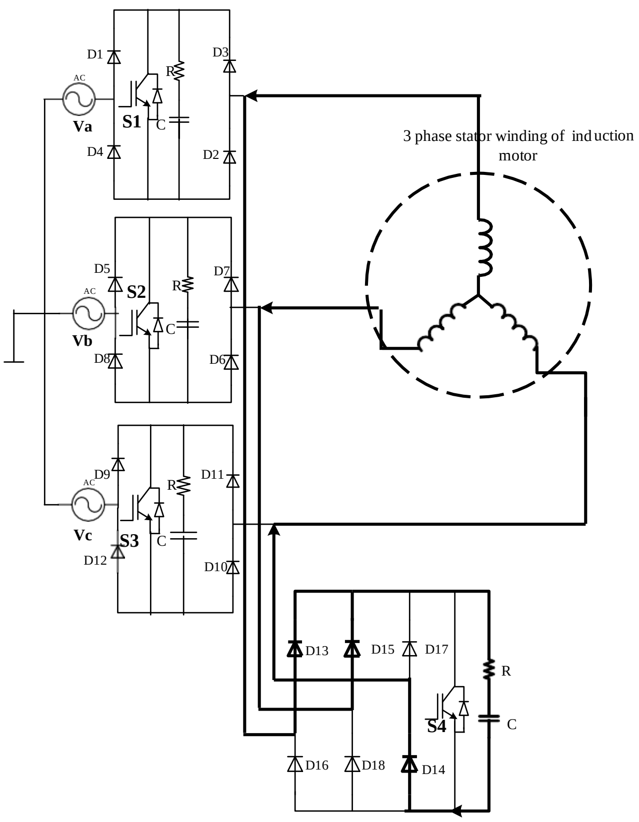

Fig.5.Dead time II mode

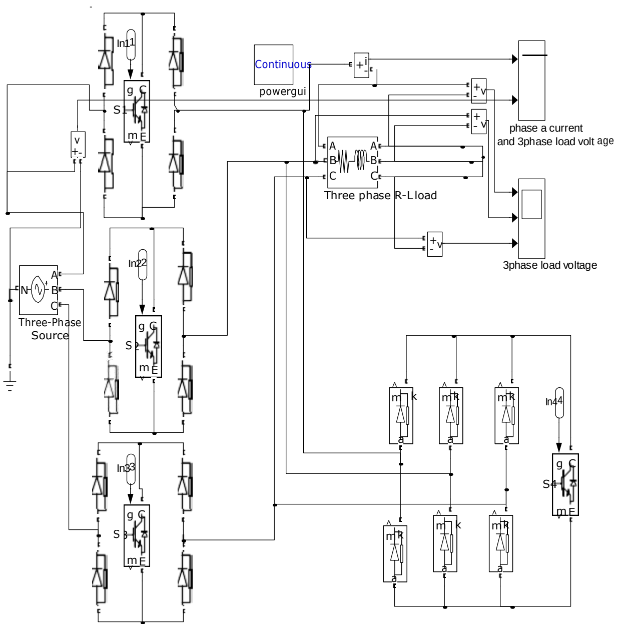

Fig.6.MATLAB circuit of proposed drive

TABLE 1 SIMULATION PARAMETER

Parameter	Value
Maximum supply voltage	400V
Supply frequency	50Hz
Switching frequency	3kHz
Duty cycle	0.4
Load resistance	45Ω
Load inductance	15mH

V. MATLAB CIRCUIT

This section presents the performance evaluation of the proposed scheme with the high frequency PWM technique by simulation using MATLAB Simulink. The complete simulation model for soft starting and speed control of 3 phase induction motor using IGBT is shown in Fig.6.High frequency fixed PWM is generated by comparing triangular wave with dc value. The switching signals have either 0 (turn off) or 1 (turn on). The load is taken as a simple R-L load. The three phase RL load represents three phase stator winding resistance and inductance. Simulation is carried out to determine load voltages of three phases, load current and supply voltage at extinction angle 170 degree. Table.1. represents the values of parameters used for simulation and following results are obtained.

VI. SIMULATION RESULTS

The simulation result in fig.7. are the gate pulses for all the switches (S_1 S_2 S_3 S_4) at extinction angle 170 degree obtained by comparing triangular wave of 3khz with dc value of 0.4. PWM pulses obtained for switches S_2 and S_3 are phase shifted by the pulses of switch S_1 by 120degree and 240 degree respectively. Switch S_4 operates in complementary to all the three switches, so the pulses obtained for it are complementary to the pulses obtained for the three main switches. Result obtained in fig.8.are the waveform for the three phase load voltage with an extinction angle 170 degree and PWM of 3KHz frequency.

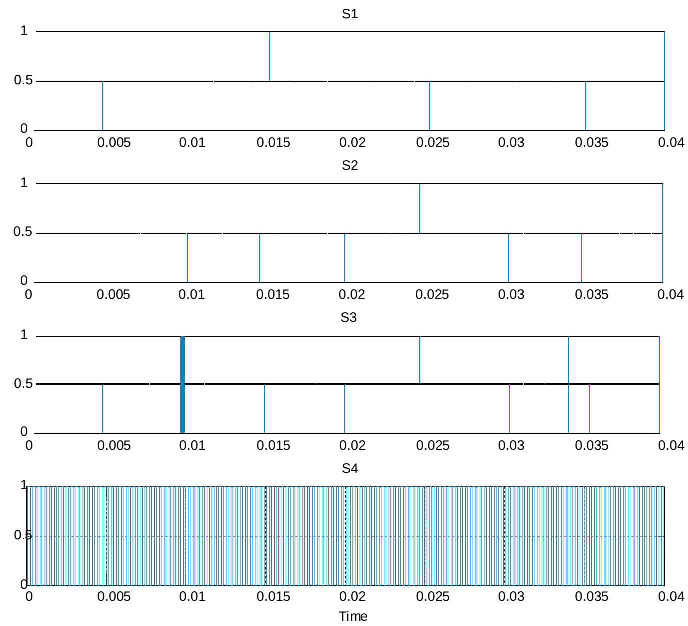

Fig.7.Gate pulses for extinction angle at 170 degree

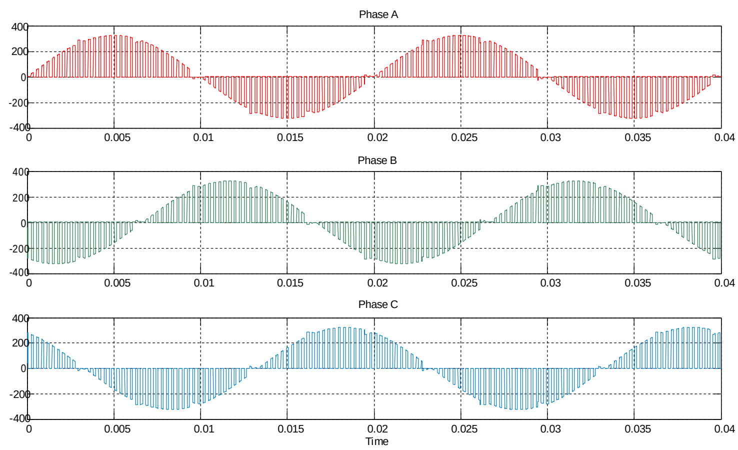

Fig.8.Load voltage waveform for three phases at extinction angle 170degree

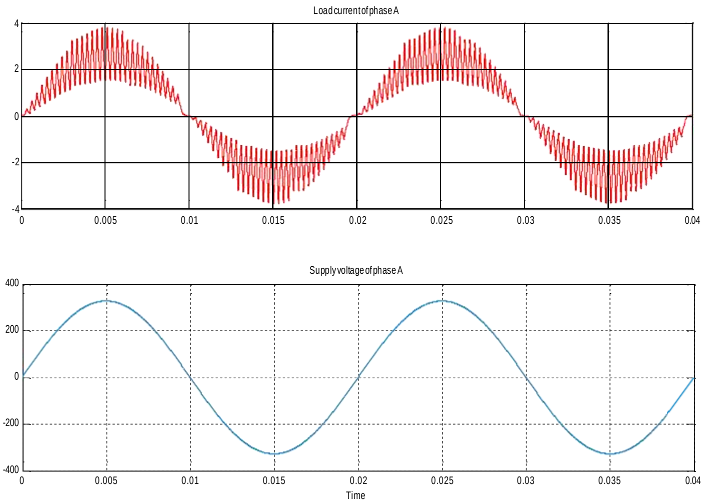

Fig.9.Load current and supply voltage waveform at extinction angle 170 degree

The result obtained in fig.9. shows the waveform of instantaneous load current for phase A, from which fundamental value of load current can be derived and it can be seen that current is leading supply voltage of phase A by a minimum value of phase angle. Thus the obtained power factor will be near unity.

VII. Conclusion

In the proposed drive desired range of voltage and high power factor control are obtainable by controlling the extinction angle and PWM control simultaneously. In the proposed scheme induction motor is expected draw comparatively lesser current than VVVF and conventional phase angle controlled drive. The stator copper losses are expected to reduce due to increase in power factor and reduction in magnitude of stator current.

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TECH-CHRONICLE
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Performance of STATCOM in IG and DFIG wind farms with grid fault analysis

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***Abstract*— Due to the application if renewable sources in the electrical grid system the venerability of the grid is also increasing due to faults. This paper presents the design and analysis of STATCOM connected to a grid interconnected wind farm with IG (Induction Generator) or DFIG (Doubly Fed Induction Generator). The application of STATCOM at specific location, which redefines the system with change in voltage magnitude and reactive power. As advancement in the control technique of the STATCOM, fuzzy logic is introduced to make the response of the device faster.**

Index Terms— Dynamic Stability, Grid, STATCOM, Wind turbine

INTRODUCTION

From the past two decades there is a vast development in renewable resource technology. We are penetrating renewable sources into the grid using photo voltaic and wind energy. With these sources we introduce power electronics devices into the grid. The power electronic switches that are used cause harmonic distortions in the grid system. In the wind generation which may include induction and doubly fed induction generators needs very high reactive power to make these machines generate the power. During the penetration of wind generators due to faults in grid (line to ground or three line faults) the grid system is more vulnerable to the faults occur. We have to provide a support in the grid which regulated the voltage spikes and maintain the voltage at 1pu. STATCOM is a device which can be used as a FACTs device to compensate the reactive power and also reduce the voltage regulation. The STATCOM is a combination of static capacitor and VSI (Voltage source Inverter) which is controlled by PWM technique. The PWM pulses are controlled by a feed back control scheme where it changes the modulation index and phase angles of the PWM signals.

I. STATCOM design

The vital part of the STATCOM is to provide control pulses to the power electronic switches (IGBTs) with changes in the grid system interconnected to the wind farm. The DC voltage of the capacitor is controlled by the modulation index of the feedback control. The control of STATCOM is given as below in fig. 1

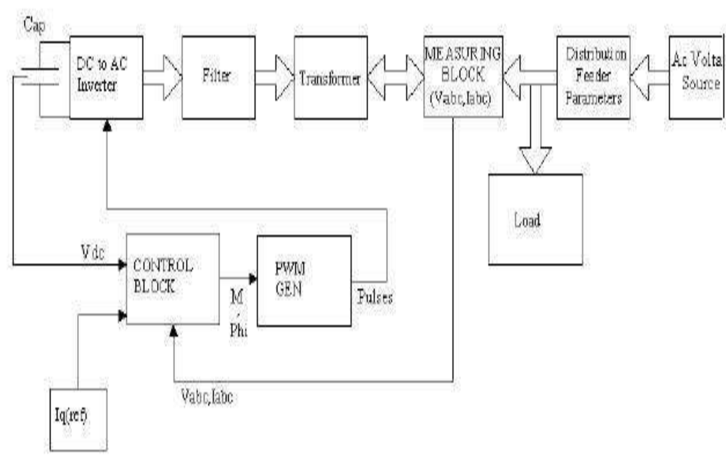

Fig.1: Control of STATCOM

PWM technique:

The pulse width modulation technique is generally used for the conversion of DC to AC waveforms. A full bridge inverter with six IGBTs can be used to convert DC to three phase AC. Each phase has to be phase shifted to each other by 120^0 and has to be in synchronization with the grid to which it is being connected. The pulses that has to be given to the IGBTs are generated with a reference or fundamental waveform compared with a triangular waveform. The fundamental waveform has the frequency of the grid and the triangular or carrier waveform has higher frequency to create a modulation signal. The diagram of the fundamental and the carrier waveform are shown below in fig. 7. Six pulses are formed by applying NOT gates to the three pulses produced by the comparison of the fundamental and carrier waveforms. The generated pulses are fed to the VSI (Voltage source Inverter) with G1 G2 G3 G4 G5 and G6 switches. A simple construction of VSI is shown in fig. 6

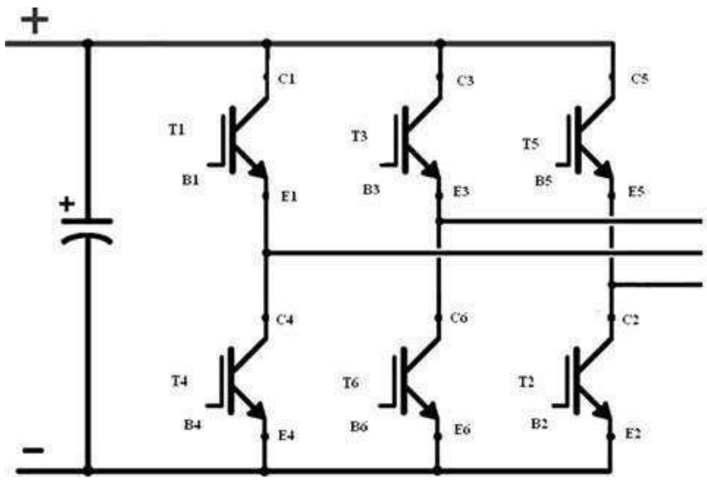

Fig. 2: Voltage source Inverter

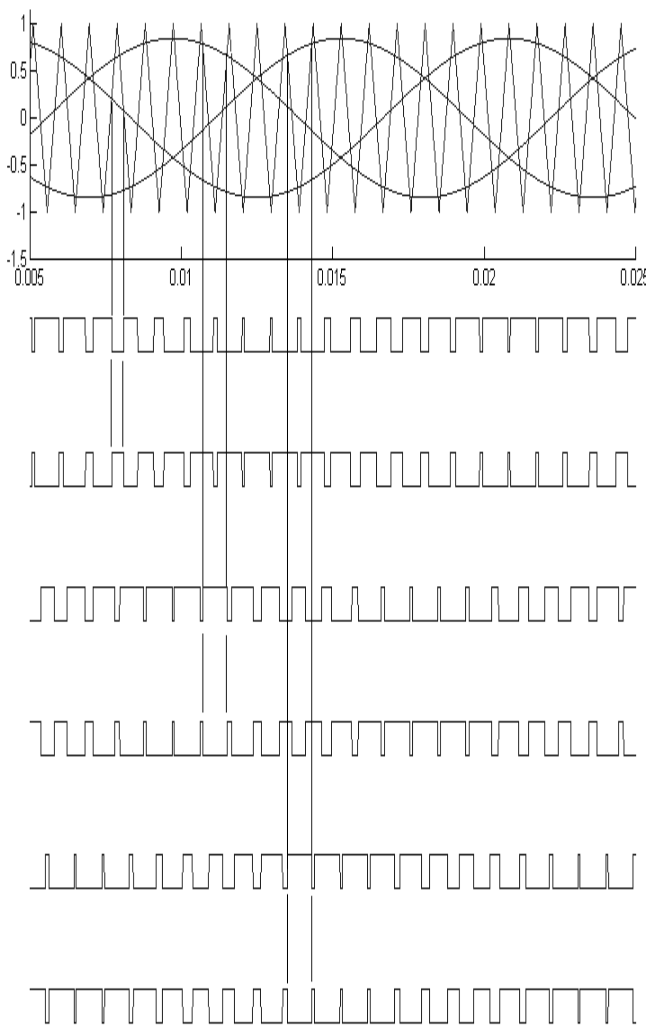

Fig.3: Generation of pulses with respect to reference fundamental waveforms

The higher the carrier frequency the lower the harmonics developed by the inverter. To eliminate the minimum harmonics we also use LC filter to filter the higher order harmonics from the three phase AC voltage waveforms.

I. Wind generation:

The sources which are used in the wind generation to convert mechanical energy to electrical energy through wind turbine are induction generator and doubly fed induction generator. The generator is synchronized to the grid to inject active power into the system. The mechanical power that is required to produce the power is calculated as

$$P_m = \frac{1}{2}\rho\pi R^2 C_p V_\omega^3$$

The power co-efficient is calculated as

$$C_p = \frac{1}{2}\left(\lambda - 0.022\ \beta^2 - 5.6\right)e^{-0.17\lambda}$$

The design and construction of the wind farm with IG is given below

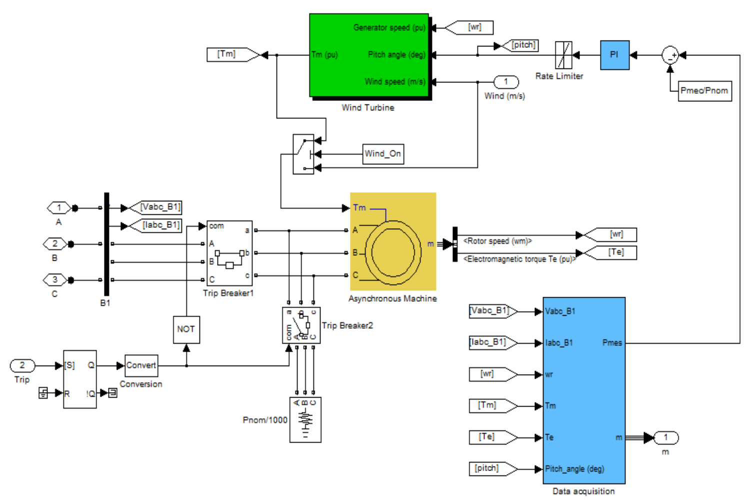

Fig. 4: Induction generator in wind farm

The design and construction of DFIG wind farm is give below in fig. 5

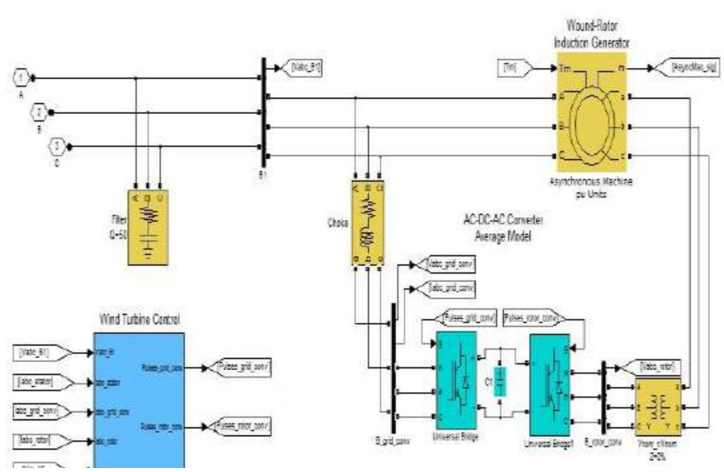

Fig. 5: DFIG wind generation system

I. Simulation and Results:

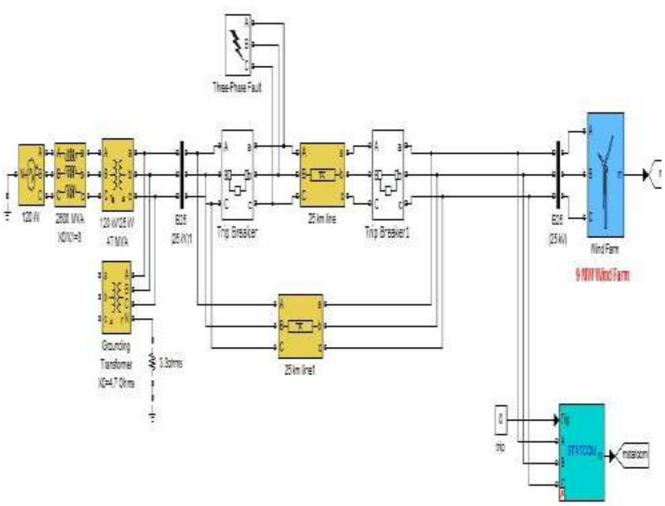

Fig. 1: IG wind farm with grid connected STATCOM

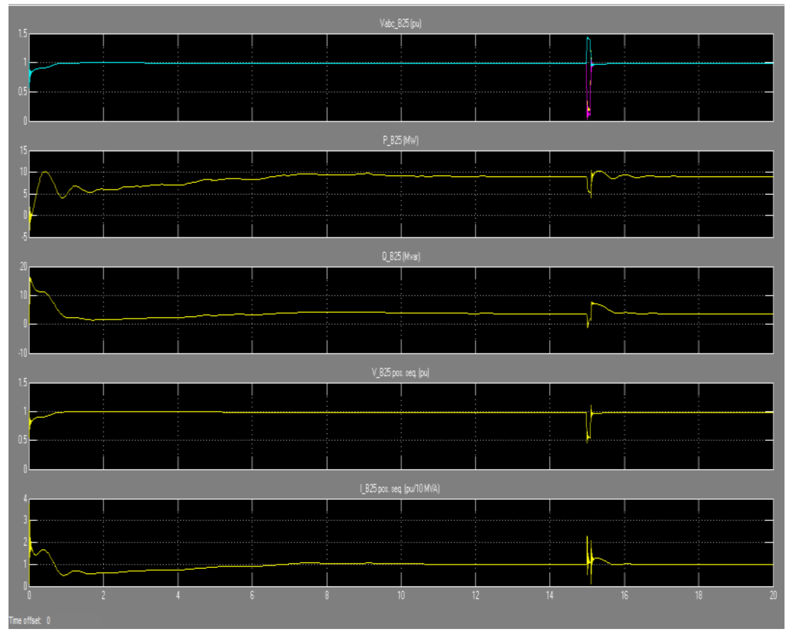

Fig. 4: Change in parameters of grid due to fault

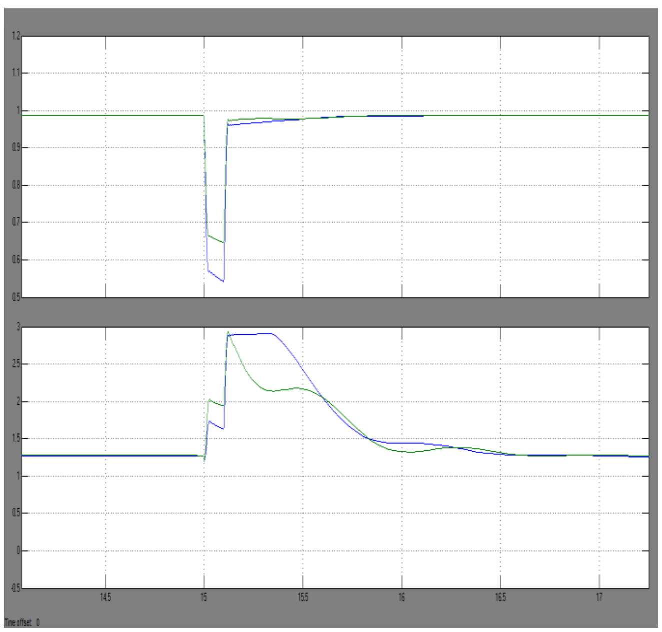

Fig. 3: Voltage regulation and VAR regulation during fault with PI and fuzzy

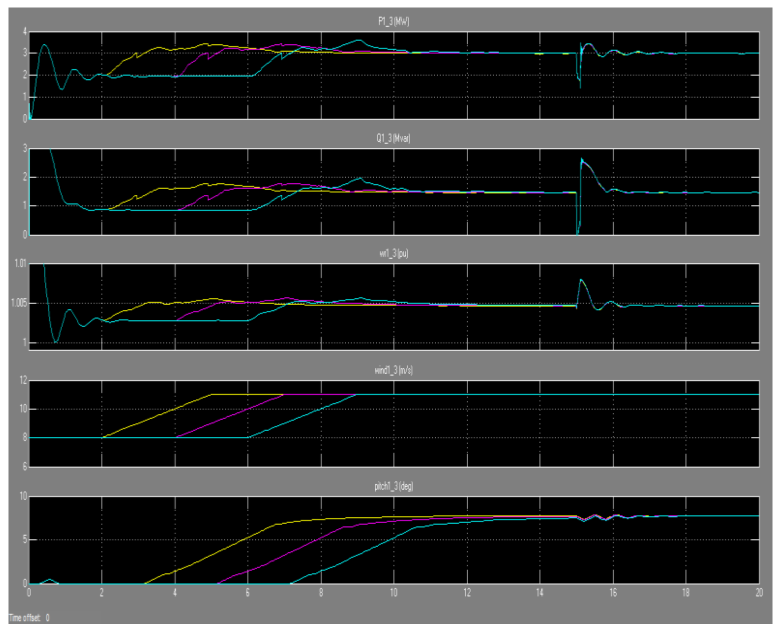

Fig. 4: Change in parameters of wind turbine due to fault

I. CONCLUSION

The outputs are compared with different control topologies of PI and fuzzy and the difference of voltage and VAR regulation is shown with graphical representation using MATLAB simulink software. The parameters like voltage active power and reactive power with change in bus voltage are shown with introducing a fault at the transmission line. The STATCOM supports the grid system by injecting the required reactive power and compensates the VAR required by the wind farm.

Reducing the voltage regulation the system is stable and reliable with the interconnection of STATCOM into the grid with wind farm penetration.

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TECH-CHRONICLE
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Review on A Novel Method of Home Energy Management System Using Microcontroller for Increasing Load Factor

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***Abstract* —Demand side management encourages the users in a smart grid to shift their electricity consumption in response to varying electricity prices. In this paper, we propose a distributed framework for the demand response based on cost minimization. Each user in the system will find an optimal start time and operating mode for the appliances in response to the varying electricity prices. We model the cost function for each user and the constraints for the appliances. We then propose an approximate greedy iterative algorithm that can be employed by each user to schedule appliances. In the proposed algorithm, each user requires only the knowledge of the price of the electricity, which depends on the aggregated load of other users, instead of the load profiles of individual users. In order for the users to coordinate with each other, we introduce a penalty term in the cost function, which penalizes large changes in the scheduling between successive iterations. Numerical simulations show that our optimization method will result in lower cost for the consumers, lower generation costs for the utility companies, lower peak load, and lower load fluctuations.**

Keywords— Advanced metering infrastructure, appliance scheduling, demand response, distributed optimization, time-dependent pricing, Walrasian equilibrium, welfare theorem.

I. INTRODUCTION

In this work, we propose a distributed energy scheduling algorithm as a demand response for the smart grid. We use day ahead pricing scheme, where the price of the electricity for the day is determined on the previous day. We then find optimal operating times for the electric appliances and their corresponding energy consumptions by minimizing the overall cost of operation. Our approach is different from the related work in four main aspects: i) we jointly optimize both the start time and the energy consumption for each appliance of the user; ii) we bill all the users based on their time dependent use of electricity; iii) we enforce realistic constraints on the operation of the appliances by categorizing them into two different classes; iv) we let the energy consumption vary in a discrete manner, which is more realistic. Further, our algorithm is fully distributed, where the only information available to the users is the prices for different time periods. Using this price, each user will find his energy consumption schedule. Since we allow the energy consumption to vary in a discrete fashion, the corresponding optimization problem will be NPhard. Therefore, we employ a greedy iterative algorithm to find the suboptimal energy consumption schedule of each user. In each iteration, all the users will communicate their energy consumption schedule to the utility company. The utility company will then adjust the price depending on the overall system load and broadcast the price to all the users. The users will then update their energy consumption based on the new price. These iterations continue until convergence. We use numerical simulations to show that the proposed algorithm will result in lower cost for the consumers, higher profit for the utility companies, lower peak load, and lower load variance. The rest of this work is organized as follows.

1. Introduce the system model, where we describe the model for the users, model for the appliances, and the pricing strategy. We also formulate the problem of appliance scheduling as a centralized optimization problem.
2. Propose a distributed framework to solve the optimization problem, where each user employs a greedy approach.
3. Provide numerical simulations.
4. Conclude the work efficiency.

II. BRIEF LITERATURE SURVEY

1. In [1], present a systematic review of various home energy management (HEM) schemes. Employment of home energy management programs will make the electricity consumption smarter and more efficient. Advantages of HEM include increased savings for consumers as well as utilities, reduced peak to average ratio (PAR) and peak demand. Where there are numerous applications of smart grid technologies, home energy management is probably the most important one to be addressed. Utilities across the globe have taken various steps for efficient consumption of electricity. New pricing schemes

like, Real Time Pricing (RTP), Time of Use (ToU), Inclining Block Rates (IBR), Critical Peak Pricing (CPP) etc, have been proposed for smart grid. Distributed Energy Resources (DER) (local generation) and/or home appliances coordination along with different tariff schemes lead towards efficient consumption of electricity. This work also discusses a HEM system's general architecture and various challenges in implementation of this architecture in smart grid.

2. In [2], Present a detailed review of various Home Energy Management Schemes (HEM,s). HEM,s will increase savings, reduce peak demand and Pto Average Ratio (PAR). Among various applications of smart grid technologies, home energy management is probably the most important one to be addressed. Various steps have been taken by utilities for efficient energy consumption. New pricing schemes like Time of Use (ToU), Real Time Pricing (RTP), Critical Peak Pricing (CPP), Inclining Block Rates (IBR) etc have been devised for future smart grids. Home appliances and/or distributed energy resources coordination (Local Generation) along with different pricing schemes leads towards efficient energy consumption. This paper addresses various communication and optimization based residential energy management schemes and different communication and networking technologies involved in these schemes.

3. In [3], Energy management system for efficient load management is presented in this paper. Proposed method consists of the two main parts. One is the energy management center (EMC) consisting of graphical user interface. EMC shows the runtime data and also maintains the data log for the user along with control of the appliances. Second part of the Method is load scheduling which is performed using the single knapsack problem. Results of the EMC are shown using LABVIEW while MATLAB simulations are used to show the results of load scheduling. Hardware model is implemented using human machine interface (HMI). HMI consists of PIC18f4520 of microchip family and zigbee transceiver of MC12311 by Free scale. The microcontroller interface with the zigbee transceiver is on standard RS232 interface.

4. In [4], With the exploding power consumption in private households and increasing environmental and regulatory restraints, the need to improve the overall efficiency of electrical networks has never been greater. That being said, the most efficient way to minimize the power consumption is by voluntary mitigation of home electric energy consumption, based on energy-awareness and automatic or manual reduction of standby power of idling home appliances. Deploying bi-directional smart meters and home energy management (HEM) agents that provision real-time usage monitoring and remote control, will enable HEM in "smart households." Furthermore, the traditionally inelastic demand curve has began to change, and these emerging HEM technologies enable consumers (industrial to residential) to respond to the energy market behavior to reduce their consumption at peak prices, to supply reserves on a as-needed basis, and to reduce demand on the electric grid. Because the development of smart grid related activities has resulted in an increased interest in demand response (DR) and demand side management (DSM) programs,

This paper presents some popular DR and DSM initiatives that include planning, implementation and evaluation techniques for reducing energy consumption and peak electricity demand. The paper then focuses on reviewing and distinguishing the various state-of-the-art HEM control and networking technologies, and outlines directions for promoting the shift towards a society with low energy demand and low greenhouse gas emissions. The paper also surveys the existing software and hardware tools, platforms, and test beds for evaluating the performance of the information and communications technologies that are at the core of future smart grids. It is envisioned that this paper will inspire future research and design efforts in developing standardized and user-friendly smart energy monitoring systems that are suitable for wide scale deployment in homes.

III. PROBLEM FORMULATION

Installation of new generating units, especially thermal power plants, to meet ever increasing demand of electricity has threatened our environmental sustainability along with the increasing cost of electricity. This steep increase in demand of electricity has posed a serious challenge to electricity distribution systems and most of utility companies have to follow a trend of load shedding; is the art of managing the load demand by shedding it in critical situations where demand is increased than total generation to avoid system failure or major breakdown. Common practice is to trip feeders originating from a substation. Integration of renewable energy resources and application of efficient load management schemes will avoid the blackout caused by the conventional load shedding. Load management.

IV. OBJECTIVES

The primary objectives of this study can be summarized as follows.

1. Jointly optimize both the start time and the energy consumption for each appliance of the user.
2. Bill all the users based on their time dependent use of electricity.
3. Enforce realistic constraints on the operation of the appliances by categorizing them into two different classes.
4. The energy consumption vary in a discrete manner, which is more realistic. Further, our algorithm is fully distributed, where the only information available to the users is the prices for different time periods.

RESEARCH AND OBJECTIVE

1. Programming of microcontroller and system design using software.
2. Design of Transmission control.
3. Design of Receiver control.

4. Connection establishment between Transmitter and Receiver section.
5. Observing the performance of system for Home Energy Management System.

V. BLOCK DIAGRAM

A. Transmitter Block Diagram for Home Energy Management System

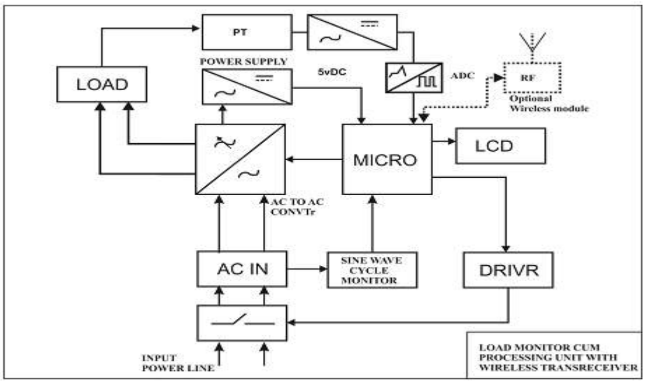

Fig. 1. Transmitter Block for Home Energy Management System.

B. Receiver Block Diagram for Home Energy Management System

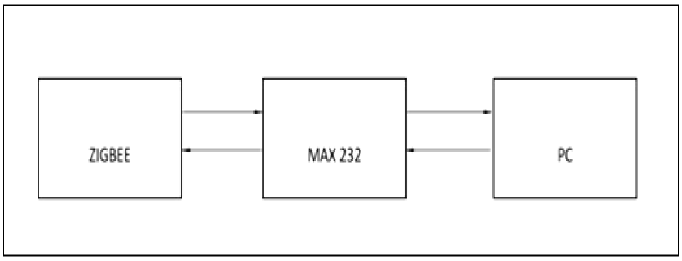

Fig.2. Receiver Block for Home Energy Management System.

VI. PROBABLE OUTCOME

By using this scheme, less power consumption and increase Load factor. Power scheduling and monitoring also result to take decision to control and manage the power. Load Protection against ambiguity in power line.

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TECH-CHRONICLE
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Automated Demand Side Management Based On Load Prediction And Load Scheduling

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Abstract— **The need for demand-side management is apparent within a grid that makes extensive use of intermittent renewable generation. There is a high likelihood that there will be periods when there is insufficient generation.DG (Distributed generation) accommodates in designing automation technologies for heterogeneous devices that learn to adapt their energy consumption against real-time price signals. It also keeps the means by which the automated decisions of these systems can be effectively communicated to, and controlled by, their human owners, whilst allowing a varying range of autonomous behaviors. A key requirement for a safe and efficient electricity grid is that supply and demand are always in perfect balance. Now, in the day to day running of the today's electricity grid, this is achieved by varying the supply-side in real-time to match demand. In this paper, the robustness, sustainability and reliability of DG has been discussed with various aspects and different extensive conditions. The main objective of this task is to study how to achieve a better integration of flexible demand as demand response, DSM with DGs, energy storages and Smart Grids. This would lead to an increase of the value of demand response, DSM and DG based on renewable energy sources in the substantial electricity systems and at the electricity market.**

Keywords- DSM,DG etc.

I. INTRODUCTION

Electricity is the commodity that plays vital role in social and economical development of the nation. With ever increasing growth of industrial area, the need of electricity is increasing everywhere. If India's electricity sector is focused, it faces many issues regarding grid operation, management, control and protection. For example, a system of cross-subsidization is practiced based on the principle of the consumer's ability to pay. In general, the industrial and commercial consumers subsidize the domestic and agricultural consumers. Further, Government give ways such as free electricity for farmers, partly to curry political favor, have depleted the cash reserves of state-run electricity-distribution system. This has financially crippled the distribution network, and its ability to pay for power to meet the demand. This situation has been worsened by government departments of India that do not pay their bills. The collective effect of all above issues is considerable gap between demand and supply of electricity [1]. For efficient and stable operation of electrical grid, electrical supply and demand must remain in balance in real time. Therefore, as an electrical engineer, it is essential to search for novel ways to cope up with increasing need of energy and to reduce gap between demand and supply which includes addition in generation capacity, improvements in system efficiency, enhanced stability and flexibility, integration of renewable resources to grid, supply or demand side management etc. The most favourable and efficient way to tackle the major problems is demand side management which covers major benefits of all above techniques. The key ingredients of this technology consist of many components that play major role in making grid 'Smart', for eg. smart generation, smart transmission and distribution system, smart loads and appliances, smart measurement systems, smart substations, integration of renewable energy resources etc. Some of above components participate in management of load profile, i.e. successful demand side management projects. 'Smart Meter' is an integral part of the project planning, deployment and maintenance of the systems of such DSM projects.

II. MAJOR PROBLEMS IN INDIAN POWER SECTOR

The statistics of Indian power sector is as follows. The electricity sector in India had an installed capacity of 267.637 GW as of end March 2015 and generated around 1048.5 BU for the period April 2014 - March 2015. India became the world's third largest producer of electricity in the year 2013 with 4.8% global share in electricity generation surpassing Japan and Russia. Renewable Power plants constituted 27.25% of total installed capacity and Non-Renewable Power Plants constituted the remaining 72.75%. India generated around 967 TWh (967,150.32 GWh) of electricity (excluding electricity generated from renewable and captive power plants) during the 2013–14 fiscal. The total annual generation of electricity from all types of sources was 1102.9 Tera Watthours (TWh) in 2013. As of March 2013, the per capita total electricity consumption in India was 917.2 kWh. The per capita average annual domestic electricity consumption in India in 2009 was 96 kWh in rural areas and 288 kWh in urban areas for those with access to electricity in contrast to the worldwide per capita annual average of 2,600 kWh and 6,200 kWh in the European Union. Electric energy consumption in agriculture was recorded highest (28.2%) in 1991-92. Per capita electricity consumption is lower compared to many countries despite cheaper electricity tariff in India.

III. AIMS AND OBJECTIVES

The aim of automated demand side management is to encourage the consumer to use optimal energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. Peak demand management does not necessarily decrease total energy consumption, but could be expected to reduce the need for investments in networks and/or power plants for meeting peak demands. An example is the use of energy storage units to store energy during off-peak hours and discharge them during peak hours. For successful DSM projects, the study and analysis of consumer's energy usage habits is necessary. This analysis offers the ideas to shift the load of consumer from peaks to valleys i.e. to even out the load curve.

From the problem formulation statement and the aim, the basic objective of dissertation is to achieve effective DSM. This can be achieved by using historical data sets of consumer energy usage at particular conditions of weather, time and other factors; the short term load prediction of user is done. The predicted load profile for a day or more helps user to manage its own usage to reduce energy bills. It is beneficial for utility to know about manners of energy usage for different classes of users. It helps to design time varying energy tariff [ToD/ToU Tariff] which encourages consumers for local energy management. Further, with designed cost function, it is used for load scheduling which is first and most important objective of significant DSM projects. The objective of load scheduling is to manage the load distribution for an area such that the load demand on system for a day is smoothly flattened.

IV. DEMAND SIDE MANAGEMENT

The 'Demand Side Management' is the Energy demand management, also known as integrated resource management (IRM), is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education. The main objective of DSM is to shift loads from Region-I to Region II or III as shown in Fig 1. Power system distribution networks are designed for peak loads. For optimum utilization of network capacity, utilities employ DSM with objective of minimum possible peak load. DSM ensures maximum load factor and thus maximizing total profit of utilities[1].

Importance of Smart Grid Components in DSM

The smart grid provides scale and ability to resize the system according requirements of economic and convenient DSM projects. Some tiny but important components of smart grid like 'Smart Meter' allow users to connect to data communication network and to gain the benefits of real time [ToD] tariff [3]. The smart grid also gives ease of real time supply and demand balancing for utility which reduces demand supply gap and improves system load factor. These technologies give the DSM programs a number of advantages over conventional DSM techniques.

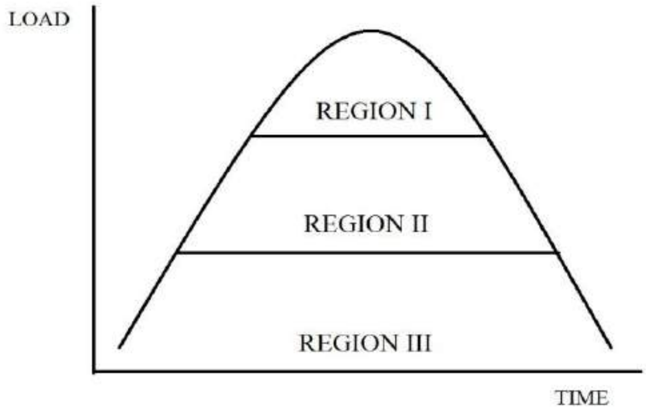

Fig..1 Representation of Typical Load Profile.

The characteristics of smart grid cause successful and efficient DSM projects. Some of them are listed as follows-

a. *Real time information*- The smart meter allow utility to collect and analyze the information at narrow interval of few minutes to some hour instead of relying on manual monthly readings. The data can be shared to consumer via HAN (Home Area Network).

b. *Two way networks*- Smart meter allows collection of real time usage data and send time of day [ToD] tariff and other information to the consumer. The consumer can conserve energy by optimizing usage or submit the feedback on consumption. The network costs are low which allows utility to communicate its consumer base.

c. *Integration of utility information systems*- Smart grid allows utility to take the benefit of many IT solutions as efficient decision engines for management and control aspects of grid.

d. *Shifts in consumer behavior*- The ability of real time data on energy costs and consumption makes consumer aware of cost and environmental impact of their energy usage and related price fluctuations. While smart grid technologies will result in benefits listed above, utilities have to build some characteristics that will help to capture the potential benefits fully. The important characteristics are explored below:

a. Increase in number of managing devices and control programs;

b. Manage the partner ecosystem and improve pace of testing;

c. Built automatic account management capabilities;

d. Educate residential customers for advantages of DSM and other management aspects For successful planning, implementation and operation of any technology or system, study of previous work is very essential. The DSM is combination of many major and minor ideas.

V. APROACH TOWARDS IMPLEMENTATION

Different program approaches those can be used for implementation of DSM are listed below;

1. General information programmes to inform customers about generic energy efficiency options.
2. Site-specific information programmes that provide information about specific DSM measures appropriate for a particular enterprise or home.
3. Financing programmes to assist customers with paying for DSM measures, including loan, rebate, and shared-savings programmes.
4. Direct installation programmes that provide complete services to design, finance, and install a package of efficiency measures.
5. Alternative rate programmes including time-of-use rates, and load shifting rates. These programmes generally do not save energy, but they can be effective ways to shift loads to off-peak periods.
6. Bidding programmes in which a utility solicits bids from customers and energy service companies to promote energy savings in the utility's service area.
7. Market transformation programmes that seek to change the market for a particular technology or service so that the efficient technology is in widespread use without continued utility intervention.The process to plan and implement DSM programmes generally consists of above steps defined as in Fig. given below

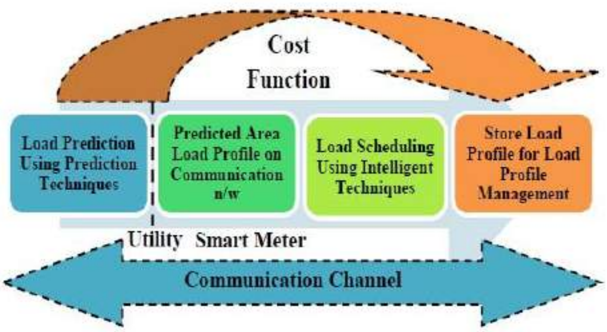

Fig. 2 Communication between Smart Meter and Utility Server.

VI. ELECTRICAL LOAD PREDICTION

Load prediction is vitally important for the electric industry in the deregulated economy. It has many applications including energy purchasing and generation, load switching, contract evaluation, and infrastructure development. A large variety of mathematical methods have been developed for load prediction. There is a growing tendency towards unbundling the electricity system. This is continually confronting the different sectors of the industry (generation, transmission, and distribution) with increasing demand on planning management and operations of the network. The operation and planning of a power utility company requires an adequate model for electric power load prediction.

A. Classification of Prediction Methods

The methods of load prediction are classified according to their base of operation.

1. Qualitative methods: These types of prediction methods are based on judgments, opinions, intuition, emotions, or personal experiences and are subjective in nature. They do not rely on any rigorous mathematical computations.

2. Quantitative methods: These types of prediction methods are based on mathematical (quantitative) models, and are objective in nature. They rely heavily on mathematical computations.

The Qualitative methods are further classified as,

1. Executive Opinion: Approach in which a group of managers meet and collectively develop a forecast.

2. Market Survey: Approach that uses interviews and surveys to judge preferences of customer and to assess demand.

3. Sales Force: Composite Approach in which each salesperson estimates sales in his or her region.

4. Delphi Method: Approach in which consensus agreement is reached among a group of experts.

The quantitative models are further classified as,

1. Time series models- Time series models look at past patterns of data and attempt to predict the future based upon the underlying patterns contained within those data eg. ARIMA [Auto Regressive Integrated Moving Average].

2. Associative models – Associative methods (often called causal models) assume that the variable being forecasted is related to other variables in the environment. They try to project based upon those associations. In its simplest form, linear regression is used to fit a line to the data. That line is then used to forecast the development variable for some selected value of the independent variable. Fuzzy logic is one of the associative models of prediction. Some advanced methods are used for short term load prediction like Fuzzy logic, ANN etc.

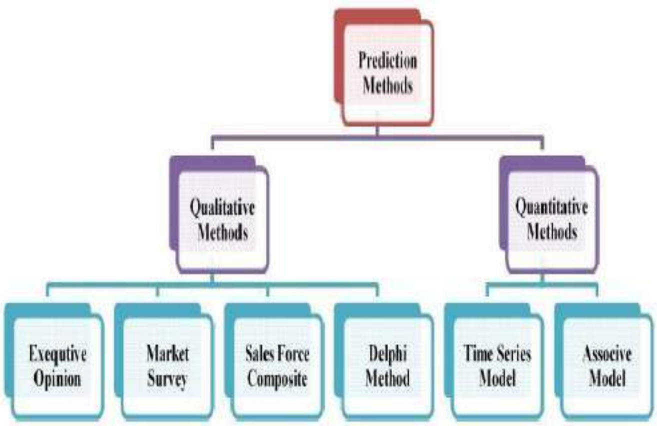

Fig. 3 Classification of Prediction Methods

VII. ELECTRIC LOAD SCHEDULING

The ‘Load Scheduling’ is the process of load balancing by shifting/clipping the electric load with respect to the time of usage. While scheduling the load, the factors to be considered are listed as follows.

a. Load Rating and Total Load Connected In Respected Premises

b. Time of Usage Per Day in Hours

c. Priority of Load [Low/Medium/High]

d. Possibility of Load Clipping Without Affecting Comfort Level

e. Possibility of Load Shifting Without Affecting Comfort Level

The ‘Electrical Load Schedule’ is an estimate of the instantaneous electrical loads operating in a facility, in terms of active, reactive and apparent power (measured in kW, kVAR and kVA respectively). The load schedule is usually categorised by switchboard or occasionally by sub-facility / area.

A. Need of Load Scheduling

Preparing the load schedule is one of the earliest tasks that need to be done as it is essentially a pre-requisite for some of the key electrical design activities (such as equipment sizing and power system studies). While considering the new installations, the load schedule is necessary to know about load characteristics and habits of different user categories. In case of smart grid management and control, the load scheduling plays a vital role in automated load management. It supports the time varying tariffs and helps to enhance the success of DSM projects. The electrical load schedule can typically be started with a preliminary key single line diagram (or at least an idea of the main voltage levels in the system) and any preliminary details of process / building / facility loads. It is recommended that the load schedule is started as soon as practically possible. There are no standards governing load schedules and therefore this calculation is based on generally accepted industry practice. The following methodology assumes that the load schedule is being created for the first time and is also biased towards industrial plants.

B. Basics of Load Scheduling

The basic steps for creating a load schedule are:

i. Step 1: Collect a list of the expected electrical loads in the facility

ii. Step 2: For each load, collect the electrical parameters, e.g. nominal / absorbed ratings, power factor, efficiency, etc

iii. Step 3: Classify each of the loads in terms of switchboard location, Duty Cycle and load criticality

iv. Step 4: For each load, calculate the expected consumed load

v. Step 5: For each switchboard and the overall system, calculate operating, peak and design load

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TECH-CHRONICLE
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DISTRIBUTION POINT FAULT DETECTOR BY USING GSM MODULE

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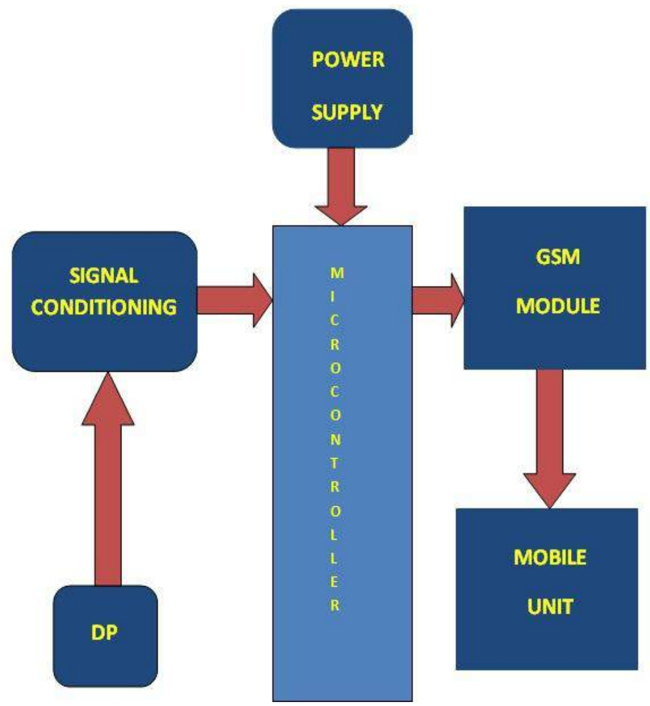
ABSTRACT: **Here we have design the GSM based distribution point fault detection system and to design this system we have considered three phase signals from distribution point DP and for interfacing microcontroller IC 89C51 is used to interface input from distribution point and GSM module to communicate between distribution point & mobile unit. So this system will be beneficial for fault detection in distribution point using GSM module. By this system we can easily detect the faults in distribution point sing GSM system which will reduce the maintenance delay for the fault detection & clearance.**

Key words: GSM, Distribution Point.

1. INTRODUCTION

As we know electricity is very important aspect in our life as food cloth and shelf are the basic things which are needed for human being but now days we cannot imagine our life without electricity so electricity is very important in our life. And we know flow of electricity is from main substation to distribution line and from distribution line to the customer. And large amount of fault is occurs in the distribution line so, we have to get knowledge about the faults in the distribution line there are so many research engineers are working on the fault occurs in the distribution system and if fault is occurs in the distribution system then whole circuitry will get fails but using this system we can easily get information about faults in the distribution system.

Daily works are totally depends on the electricity so without electricity we cannot do our daily works properly. Means without electricity we cannot imagine our life



BLOCK DIAGRAM-

2. COMPONENT DESCRIPTION

MICROCONTROLLER IC-89C51

The MCS 51 controller are optimize for control applications. It is low power, high performance HMOS 8bit microcomputer with 8k bytes of flash programmable and erasable read only memory (EPROM). The on chip flash allows the program memory to be reprogrammed in system or by a conventional non-volatile memory programmer. Operating frequency is from 1 to 16MHz. the 8052AH is an enhanced version of the 8051AH.

- **Port 0**

It is an 8-bit open drain bi-directional input port. When 1s are written to port 0 pins can be used as high impedance inputs. It can also be configured to be the multiplexed low order address/data bus during accesses to external program and data memory. In this application it uses strong internal pull-ups when emitting 1's. It also receives the programming and outputs the code bytes during program verification.

- **Port 1**

It is an 8-bit bi-directional input port with internal pull-ups. The port1 output buffers can sink/source four TTL inputs. When 1s are written to port1 pins. They are pulled high by the internal and can be used as inputs. As inputs, port 1 pins that are externally being pulled low will source current because of the internal pull-ups. In addition it can be configured to be the timer/counter to external count port (P.0/T2) and the timer/counter (P1.1/T2EX), respectively, refer the following table 2-triggered input

Port Pins	Alternate Functions
P1.0	T2 (External count inputs to timer/counter), Clock out
P1.1	T2EX (Timer/counter 2 capture/reload trigger and direction control)

- **Port 2**

It is an 8-bit bi-directional input port with internal pull-ups. The port 2 output buffers can sink/source four TTL inputs. When 1s are written to the port then they are pulled high by the internal pull-ups and can be used as inputs. It emits high order address byte during fetches from external program memory and during accesses to the external data memory that use 16-bit address (MOVX @ DPTR). In this application port 2 uses strong internal pull-ups when emitting 1s. Port2 also receives the high order address bits and some control signals during flash programming and verifications.

- **Port 3**

Port 3 is an 8-bit bi-directional port with internal pull-ups. The port 3 output buffers can sink/source four TTL inputs. When 1s are written to the port then they are pulled high by the internal pull-ups and can be used as inputs. It also serves the function of special features of the AT8951. As shown in following table. It also receives the high order address bits and some control signals during flash programming and verifications.

Port Pins	Alternate Functions
P3.0	R x D (Series input port)
P3.1	T x D (Series output port)
P3.2	(External interrupt 0)
P3.3	(External interrupt 1)
P3.4	T0 (Timer 0 external)
P3.5	T1 (Timer 1 external input)
P3.6	(External data memory write strobe)
P3.7	(External data memory read strobe)

Table No.3.2- Alternate Functions

- **RST**

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

- **ALE/PROG**

Address latch enable is an output pulse for latching the low byte of the address during accesses to the external memory. This pin is also the program pulse input during flash programming. In normal operation ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing and clocking purpose.

- **PSEN**

Program store enable is the read strobe to external program memory. When the AT89c52 is executing code from external program memory, this pin is activated twice

- **EA/VPP**

External access enables. It must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. It should be strapped to Vcc fir internal program executions.

- **XTAL1**

Input to the inverting oscillator amplifier and input internal clock operating circuit.

- **XTAL2**

It gives output from inverting oscillator amplifier.

3. Equipment Used

Resistors-

Resistors are components that have a predetermined resistance. Resistance determines how much current will flow through a component. Resistors are used to control voltages and currents. A very high resistance allows very little current to flow. Air has very high resistance. Current almost never flows through air. (Sparks and lightning are brief displays of current flow through air. The light is created as the current burns parts of the air.) A low resistance allows a large amount of current to flow. Metals have very low resistance. That is why wires are made of metal. They allow current to flow from one point to another point without any resistance. Wires are usually covered with rubber or plastic. This keeps the wires from coming in contact with other wires and creating short circuits. High voltage power lines are covered with thick layers of plastic to make them safe, but they become very dangerous when the line breaks and the wire is exposed and is no longer separated from other things by insulation. Resistance is given in units of ohms. (Ohms are named after Mho Ohms who played with electricity as a young boy in Germany.) Common resistor values are from 100 ohms to 100,000 ohms. Each resistor is marked with colored stripes to indicate it's resistance. To learn how to calculate the value of a resistor by looking at the stripes on the resistor, go to resistor value which includes more information about resistors.

Variable Resistors -

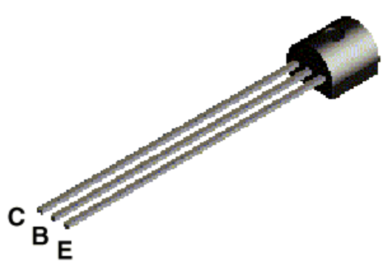
Range the resistance. This is very useful for many situations. Volume controls are variable resistors. When you change the volume you are changing the resistance which changes the current. Making the resistance higher will let less current flow so the volume goes down. Making the resistance lower will let more current flow so the volume goes up. The value of a variable resistor is given as it's highest resistance value. For example, a 500 ohm variable resistor can have a resistVariable resistors are also common components. They have a dial or a knob that allows you to chance of anywhere between 0 ohms and 500 ohms. A variable resistor may also be called a potentiometer.

Switches -

Switches are devices that create a short circuit or an open circuit depending on the position of the switch. For a light switch, ON means short circuit (current flows through the switch, lights light up and people dance.) When the switch is OFF, that means there is an open circuit (no current flows, lights go out and people settle down. This effect on people is used by some teachers to gain control of loud classes.) When the switch is ON it looks and acts like a wire. When the switch is OFF there is no connection.

Transistor -

Transistors are basic components in all of today's electronics. They are just simple switches that we can use to turn things on and off. Even though they are simple, they are the most important electrical component. For example, transistors are almost the only components used to build a Pentium processor. A single Pentium chip has about 3.5 million transistors. The ones in the Pentium are smaller than the ones we will use but they work the same way.Transistors that we will use in projects look like this:

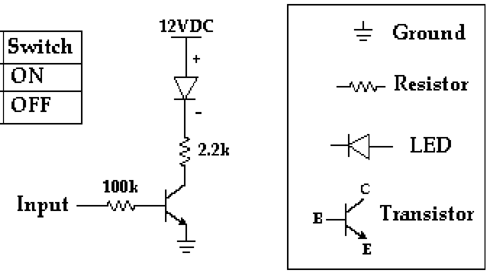


The transistor has three legs, the Collector (C), Base (B), and Emitter (E). Sometimes they are labeled on the flat side of the transistor. Transistors always have one round side and one flat side. If the round side is facing you, the Collector leg is on the left, the Base leg is in the middle, and the Emitter leg is on the right.

Basic Circuit -

The Base (B) is the On/Off switch for the transistor. If a current is flowing to the Base, there will be a path from the Collector (C) to the Emitter (E) where current can flow (The Switch is On.) If there is no current flowing to the Base, then no current can flow from the Collector to the Emitter. (The Switch is Off.)Below is the basic circuit we will use for all of our transistors.To build this circuit we only need to add the transistor and another resistor to the circuit we built above for the LED. Unplug the power supply from the power supply adapter before making any changes on the breadboard. To put the transistor in the breadboard, separate the legs slightly and place it on the breadboard so each leg is in a different row. The collector leg should be in the same row as the leg of the resistor that is connected to ground (with the black jumper wire). Next move the jumper wire going from ground to the 2.2k ohm resistor to the Emitter of the transistor.

Input	Switch
12V	ON
0V	OFF



with this kit because our power supply can only put out 12 volts.

4. GSM MODULE

GSM Interfacing Board

Introduction-

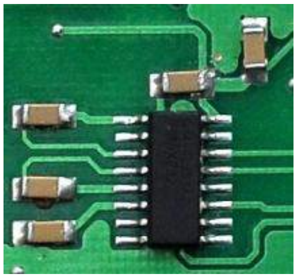
GSM (Global System for Mobile) / GPRS (General Packet Radio Service) TTL Modem is SIM900 Quad-band GSM / GPRS device, works on frequencies 850 MHZ, 900 MHZ, 1800 MHZ and 1900 MHZ. It is very compact in size and easy to use as plug in GSM Modem. The Modem is designed with 3V3 and 5V DC TTL interfacing circuitry, which allows User to directly interface with 5V Microcontrollers (PIC, AVR, Adriano, 8051, etc.) as well as 3V3 Microcontrollers (ARM, ARM Cortex XX, etc.). The baud rate can be configurable from 9600- 115200 bps through AT (Attention) commands. This GSM/GPRS TTL Modem has internal TCP/IP stack to enable User to connect with internet through GPRS feature. It is suitable for SMS as well as DATA transfer application in mobile phone to mobile phone interface. The modem can be interfaced with a Microcontroller using USART (Universal Synchronous Asynchronous Receiver and Transmitter) feature (serial communication).

SIM Com SIM900A GSM Module:

This is actual SIM900 GSM module which is manufactured by SIM Com. Designed for global market, SIM900 is a quad-band GSM/GPRS engine that works on frequencies GSM 850MHz, EGSM 900MHz, DCS 1800MHz and PCS 1900MHz. SIM900 features GPRS multi slot class 10/ class 8 (optional) and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. With a tiny configuration of 24mm x 24mm x 3mm, SIM900 can meet almost all the space requirements in User's applications, such as M2M, smart phone, PDA and other mobile devices.

MAX232 IC-

The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits, so that devices works on TTL logic can share the data with devices connected through Serial port (DB9 Connector).



Serial port / DB9 connector-

User just needs to attach RS232 cable here so that it can be connected to devices which has Serial port / DB9 Connector.

Pin 01-DCD(DATA Carrier detect)

Pin02-RXD (Receive Data)

Pin03-TXD (Transmit Data)

Pin04-DTR (Data Terminal Ready)

Pin05-Signal Ground (SG)

Pin06-Data set Ready (DSR)

Pin07-Request to Send (RTS)

Pin08-Clear to Send (CTS)

Pin09-Ring Indicator (RI)

Indicator LEDs-

Indicator LEDs just used to indicate status accordingly. These are three LEDs represents Power On/Off Status, Network Status and Module On/Off Status respectively. Power LED will keep on until the power supply is enable to this board by using *push-on push-off* switch. Network Status LED will show whether inserted SIM card successfully connected to service provider's Network or not, in short signal strength. Module On/Off indicator LED will show status of GSM

module's power on/off.

Rectifier Units

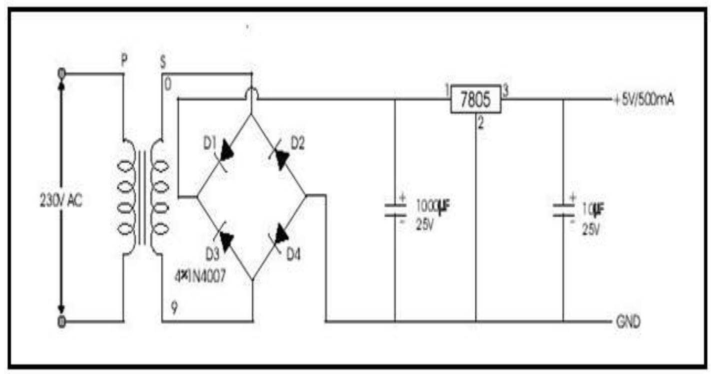
Rectifier unit is a circuit which converts A.C. into pulsating D.C. generally semi-conducting diode is used as rectifying element due to its property of conducting current in one direction only. Generally there are two types of rectifier.

1. Half wave rectifier.
2. Full wave rectifier.

In half wave rectifier only half cycle of mains A.C. is rectified so its efficiency is very poor. So we use full wave bridge type rectifier. In which four diodes are used. In each half cycle. Two diodes conduct at a time and we get maximum efficiency at output.

Advantages

1. The output is twice that of center tap circuit for the same secondary voltage.
2. The need of center tapped transformer is eliminated.
3. PIV rating of diode is half of the centers tap circuit.



Power Supply Design

5. PROJECT PROGRAMING-

```
        MOV SP,#60H
        ///////////
        ORG 070H
        MOV P0,#0FFH
        MOV P1,#0FFH
        MOV P2,#0FFH
        MOV P3,#0FFH
START:  ACALL DELAY1
        ACALL DELAY1
        ACALL DELAY1
        ACALL DELAY1
        CLR A
        MOV R1,#00H
        MOV R2,#2
        MOV DPTR,#500H
```

```
BACK:       CLR A
            MOV A,R1
            MOVC A,@ A+DPTR
            ACALL TRANSFER
            INC R1
            DJNZ R2,BACK

//////////////////////////////////////////////////////
          MOV R2,#4
BACK1:        CLR A
            MOV A,R1
            MOVC A,@ A+DPTR
            ACALL TRANSFER
            INC R1
            DJNZ R2,BACK1
//////////////////////////////////////////////////////
          MOV R2,#9
BACK2:          CLR A
            MOV A,R1
            MOVC A,@ A+DPTR
            ACALL TRANSFER
            INC R1
            DJNZ R2,BACK2
////////////////////////////////////////////////////////////////////
AGAINCHECK:

            JB P1.0,NEXT
            ACALL NUMBER1
            ACALL MSG1
            JNB P1.0, $
            AJMP START
NEXT:     JB P1.1,NEXT1
            ACALL NUMBER1
            ACALL MSG2
            JNB P1.1, $
            AJMP START
NEXT1:      JB P1.2,NEXT2
            ACALL NUMBER1
            ACALL MSG3
            JNB P1.2, $
            AJMP START
NEXT2:      JB P1.3,NEXT3
            ACALL NUMBER1
            ACALL MSG4
            JNB P1.3, $
            AJMP START
NEXT3:      AJMP AGAINCHECK
            AJMP  START

NUMBER1:
            MOV A,#'A'
            ACALL TRANSFER
            MOV A,#'T'
            ACALL TRANSFER
            MOV A,#'+'
            ACALL TRANSFER
            MOV A,#'C'
            ACALL TRANSFER
            MOV A,#'M'
            ACALL TRANSFER
            MOV A,#'G'
            ACALL TRANSFER
            MOV A,#'S'
            ACALL TRANSFER
            MOV A,#''''
            ACALL TRANSFER
            MOV A,#'9'
            ACALL TRANSFER
            MOV A,#'8'
            ACALL TRANSFER
            MOV A,#'6'
            ACALL TRANSFER
            MOV A,#'0'
            ACALL TRANSFER
            MOV A,#'1'
            ACALL TRANSFER
            MOV A,#'7'
            ACALL TRANSFER
            MOV A,#'3'
            ACALL TRANSFER
            MOV A,#'8'
            ACALL TRANSFER
            MOV A,#'1'
            ACALL TRANSFER
            MOV A,#'8'
            ACALL TRANSFER
            MOV A,#''''
            ACALL TRANSFER
```

```
        RET
MSG1:   CLR A
        MOV R1,#00H
        MOV R2,#29
        MOV DPTR,#540H
BACK3:  CLR A
        MOV A,R1
        MOVC A,@ A+DPTR
        ACALL TRANSFER
        INC R1
        DJNZ R2,BACK3
        RET
MSG2:   CLR A
        MOV R1,#00H
        MOV R2,#29
        MOV DPTR,#580H
BACK4:  CLR A
        MOV A,R1
        MOVC A,@ A+DPTR
        ACALL TRANSFER
        INC R1
        DJNZ R2,BACK4
        RET
MSG3:   CLR A
        MOV R1,#00H
        MOV R2,#29
        MOV DPTR,#620H
BACK5:  CLR A
        MOV A,R1
        MOVC A,@ A+DPTR
        ACALL TRANSFER
        INC R1
        DJNZ R2,BACK5
        RET
MSG4:   CLR A
        MOV R1,#00H
        MOV R2,#29
        MOV DPTR,#660H
BACK6:  CLR A
        MOV A,R1
        MOVC A,@ A+DPTR
        ACALL TRANSFER
        INC R1
```

```
        DJNZ R2,BACK6
        RET

TRANSFER:
        MOV TMOD,#20H
;TIMER1,MODE2
        MOV TH1,#-3
;4800 BAUD RATE
        MOV SCON,#50H
;8 BIT,1 STOP,REN
        SETB TR1
;START TIMER
        JNB TI,$
        CLR TI
        RET
ORG 500H
LOOCK_UPTABAL1:
DB "AT"
DB "ATE0"
DB "AT+CMGF 1"
ORG 540H
LOOCK_UPTABAL2:
DB "R PHASE FAULT ACCURE FOR DP 1"
ORG 580H
LOOCK_UPTABAL3:
DB "Y PHASE FAULT ACCURE FOR DP 1"
ORG 620H
LOOCK_UPTABAL4:
DB "B PHASE FAULT ACCURE FOR DP 1"
ORG 660H
LOOCK_UPTABAL5:
DB "FAULT ACCURE AT DP 2         "

        MSG FIELD

        AJMP  START
TRANSFER:

        MOV SBUF,A
        JNB TI,$
        CLR TI
        RET

ORG 500H
```

```
LOOCK_UPTABAL1:
DB "AT",
DB "ATE0",
DB "",
DB """,
ORG 540H
LOOCK_UPTABAL2:
DB "MSG",
ORG 550H
LOOCK_UPTABAL3:
DB "MSG",
ORG 560H
LOOCK_UPTABAL4:
DB "MSG",
/
DELAY1:     MOV 42H,#1
LOOPA2:   MOV 40H,#255
LOOPA1:   MOV 41H,#255
LOOPA:    DJNZ 41H,LOOPA
                    DJNZ 40H,LOOPA1
                    DJNZ 42H,LOOPA2
                    RET

END
```

7. **Conclusion**

From this project we can conclude that this system is used for the detection of fault in the distribution point using GSM module. And by this project we can avoid the losses like financial losses & avoid the time delay

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TECH-CHRONICLE
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A Novel Method to Convert Power from Single Phase to Three Phase using PWM Technique

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***Abstract*—This paper presents a simple converter topology for driving a three-phase induction motor with a single-phase ac supply. This abstract describes the theory of 1 phase to 3 phase and the project shall be made using a programmed microcontroller of 8051 family duly interfaced to 3 phase inverter with 6 numbers MOSFET or IGBTs from DC derived from a single phase or 3 phase, 50 Hz supply. The load shall be a star connected three phase 50 Hz, 440volt,0.5 to 1 HP motor. Alternatively a star lamp load can be used to view the waveform only. The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using a Bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of the microcontroller and other components.**

Keywords- PWM, microcontroller, multilevel inverter, induction motor.

I. INTRODUCTION

Pulse Width Modulated (PWM) inverter systems are used in a wide variety of applications as a front-end power-conditioning unit in electric drives, uninterruptible power supplies, high voltage DC transmission, Active power filters, reactive power compensators in power systems, Electric vehicles, Alternate energy systems and Industrial processes. The inverters realize dc-to-ac power conversion andin the most commonly used voltage source inverter configuration. The dc-input voltage can be obtained from a diode rectifier or from another dc source such as a battery. A typical voltage source PWM inverter system consists of rectifier, DC-link, PWM inverter along with associated controlcircuit and the load. Most modern voltage source inverters are controlled using a wide variety of pulse width modulation schemes, to obtain output ac voltages of the desired magnitude and frequency shaped as closely as possible to a since wave. Analysis of PWM inverter system is required to determine the input-output characteristics for an application specific design, which is used in the development and implementation of the appropriate control algorithm.

In a typical situation, the load is a three-phase induction motor and the conversion is made using some kind of pulsewidth mod-ulation (PWM) converterThis paper presents a single-phase to three-phase conversion system that improves the local power quality for linear and non-linear loads, and guarantees unity power factor at the single-phase feeder.

II. MULTILEVEL PWM INVERTER

The multilevel PWM inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages in stepped waveform. The commutation of the switches allows the addition of the capacitor voltages which reaches the high voltage level at the output, while the power semiconductors withstand only with reduced voltage. A five-level PWM inverter generates an output voltage with five values (levels) with respect to the negative terminal of the capacitor. By considering that ‘n’ is the number of steps of the phase voltage with respect to the negative terminal of the inverter, then the number of steps in the voltage between two phases of the load ‘K’ is defined by:

$$K = 2m + 1 \quad \ldots(1)$$

The number of steps p in the phase voltage of a single-phase load in wyes connection is given by:

$$p = 2k+1 \quad \ldots (2)$$

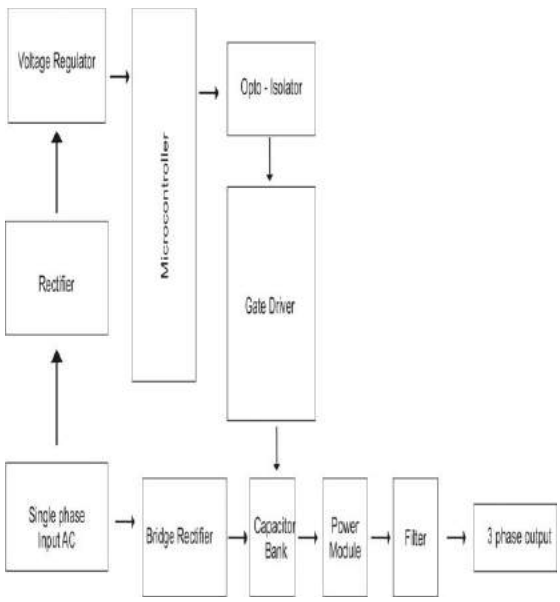
The term multilevel starts with the three-level inverter. By increasing the number of levels in the inverter, the output voltages have more steps generating a staircase waveforms, it results to reduction in harmonic distortion. However, a high number of levels results in increasing the complexity and also introduce voltage imbalance problems

Three different topologies have been proposed for multilevel inverters as diode-clamped (neutral-clamped), capacitor Clamped (flying capacitors) and cascaded multicell with separate dc sources. In addition, several modulation and control strategies have been developed or adopted for multilevel inverters including the following: multilevel sinusoidal pulse width modulation (PWM), multilevel selective harmonic elimination and space-vector modulation (SVM).

The most attractive features of multilevel inverters are as follows:

[1] It can generate output voltage with extremely low distortion.
[2] It draws input current with very low distortion.
[3] Itgenerates smaller common-mode (CM) voltage, thus reducing the stress in the motor bearings. In addition, by using sophisticated modulation methods, CM voltages can be eliminated .
[4] They can operate with a lower switching frequency.

III. BLOCK DIAGRAM



IV. PULSE WIDTH MODULATION

The other common method of generating AC power in electronic power converters i*n pulse width modulation* (PWM). PWM is used extensively as a means of powering AC devices with a DC power source. A DC voltage source can be made to look like an AC signal across a load by altering the duty cycle of the PWM signal. The pattern at which the duty cycle of thePWM signal varies can be generated through simple analog components, a digital microcontroller, or specific PWM integrated circuits. In analog circuitry, a PWM signal is generated by feeding a reference and a carrier signal through a comparator which creates the output signal based on the difference between the two inputs. The reference is a sinusoidal wave at the frequency of the desired output signal. The carrier wave is a triangle or 'sawtooth' wave which operates at a frequency significantly greater than the reference wave. When the carrier signal exceeds the reference the output is at one state.

V. MOSFET DRIVER

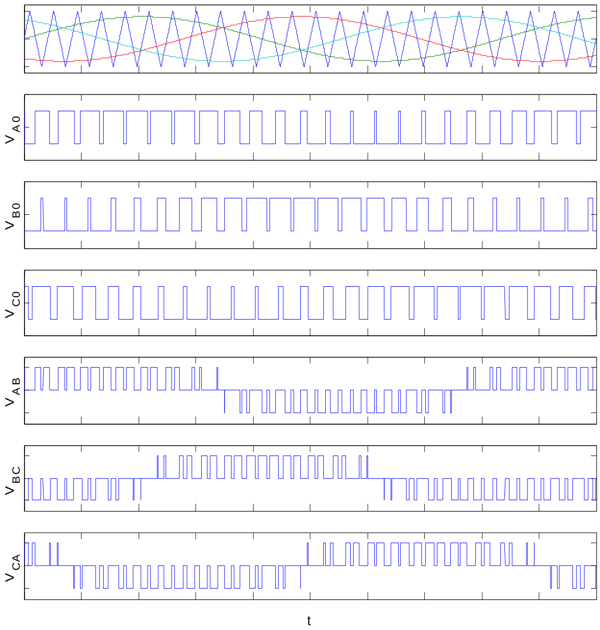
it is beneficial to use N-channel MOSFETs as the high side switches as well as the low side switches because they have a lower 'ON' resistance and therefore less power loss. However, to do so, the drain of the high side device is connected to the 170V DC power which is to be inverted into the 120 AC power. This is a problem because the 170V is the highest voltage in the system and in order for the switch to be turned on the voltage at the gate terminal must be 10V higher than the drain terminal voltage. In order to achieve the extra voltage necessary to switch on the device, a MOSFET driver is used with a bootstrap capacitor.

The MOSFET driver operates from a signal input given from the microcontroller and takes its power from the battery voltage supply that the system uses. The driver is capable of operating both the high side and low side devices, but in order to get the extra 10V for the high side device, an external bootstrap capacitor is charged through a diode from the 12V power supply when the device is off. Because the power for the driver is supplied from the low voltage source, the power consumed to drive the gate is small. When the driver is given the signal to turn on the high side device, the gate of the MOSFET has an extra boost in charge from the bootstrap capacitor, surpassing the needed 10V to activate the device and turning the switch on.

VI. MICROCONTROLLER

In order to use the H-bridge properly, there are four MOSFETs that need to be controlled. This can be done either with analog circuits or a microcontroller. In this case, we chose the microcontroller over the analog system for several reasons. First, it would be simpler to adapt. With an analog system, it would be difficult to make changes for the desired output. In many cases, this is a desired trait, as it would be designed for a single purpose and therefore a single output. However, as this is something that is designed to be available all over the world, it needs to be adjustable to different standards of frequency and voltage. With an analog circuit, this would require a different circuit that it would have to switch over to, while with a micro-controller, it merely requires a change in the program's code. The second advantage of using a microcontroller is that it can allow for easy feedback to control the power flowing through the load. One of the problems that can occur with systems likethis is that the variances in load can cause variances in the supplied current and voltage. With a microcontroller, it is possible to have it "look" at the power output and change the duty cycle based on whether or not the load requires additional power or is being oversupplied.

Necessary waveforms generated by the microcontroller v_{ao}, v_{bo}, v_{co} and the ouput v_{ab}, v_{bc}, v_{ca}.



VIII . CONCLUSION

Three phase asynchronous induction motors are widely used in industrial applications due to their features of low cost, high reliability and less maintenance. Due to the need for three-phase electricity in today's remote areas for agriculture work where three phase power is not available easily, in those areas these single phase to three phase converters are use full.

Operating a three phase induction motor using single phase supply has been presented. The developed single to three phase conversion hardware setup is tested on a three phase 1.5hp, 415V, 50Hz induction motor with loading in power electronics laboratory. From the experimental setup and results chapter it is clear that the developed hardware satisfactory converts from single phase power to three phase power The developed system is useful in remote areas where three phase supply is not available easily.

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Boost Controller using Supercapacitor for Electric Vehicle

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Abstract— **Electric vehicle is a fuel free form of transport which is cheap and 100% environment friendly. Electric vehicles are very cost effective. These vehicles are also low maintenance. These advantages are increasing the popularity of electric vehicle. Normally, electric vehicle runs on battery. This gives electric vehicle some disadvantages. There are not many charging points available along the road. Battery takes a long time to charge. This takes a large amount of current. Battery discharges fast which gives electric vehicle short driving and speed ranges. Battery takes longer time to recharge. Supercapacitors have an edge over battery.**

Keywords—***Supercapacitor, DC-DC Converter, Energy storage system***

I. INTRODUCTION

Batteries are used as an energy storage device to exchange real power. But batteries have limitations in power exchanging capability because of slow chemical process require to release energy. The recent trend is to use the supercapacitor energy storage system (SCESS). Supercapacitors have high power exchanging capability as compared to batteries. The objective of this research is to design a system to maintain the desired the voltage across the load.

Battery energy storage is used in many locations but its disadvantages are the limited discharge rate and the degradation with time. The advantage of supercapacitor energy storage system over the superconducting magnetic energy storage system is that it does not need the cooling and the sophisticated structure which is required by them superconducting magnetic energy storage system [1]. Ultracapacitors can be found in wind power stations (Abbey, Joos, 2007), where they stabilize the power supplied to the grid. They are charged during the period of strong wind and discharge during calm periods. They can also be applied as energy saving subsystems in underground energy supply system. They are placed along the tracks and they collect the energy during braking and give it back during start-up [2]. Also some back-up systems in electronics use ultracapacitors like computer memory back-up. An embedded energy share method between the high energy storage system (battery) and the auxiliary energy storage system such as supercapacitors (SC) is discussed by using polynomial control in [3]. The proposed method is applied to two topologies of dc/dc converters to ensure the load's current sharing between the SC and the battery. The main focus is on the control methods of the dc-bus voltage and currents with adjustable polynomial controllers. Ultra-capacitors are used as an energy storage buffer by simultaneously charging and discharging them by paralleling them to an energy source like a battery, fuel cell, DC-DC converter, etc. and a load. The voltage and current ripple caused by the charging converter can often cause over charging or temperature rise of the capacitor [4]-[7].

Supercapacitor combines the properties of ordinary capacitors and battery into one device. It is available in the range of 10-3400 F. It can provide voltage up to 2.7V/cell. Energy storage technology is becoming more and more important in today's environmentally conscious society. To increase the supercapacitor voltage, it is connected in series and boost converter is applied with PI controller to maintain the voltage constant across the electric vehicle to improve the performance. At present we have consider DC motor as a load. In this paper, supercapacitor with boost convertor is designed in MATLAB SIMULINK software. Using dsPIC33EP256MC202 Microcontroller, hardware is implemented for generating pulses to maintain desired output DC link voltage.

A. Supercapacitor

Supercapacitors were introduced in 1960s, but the interest in it has grown recently. Supercapacitors, as implied by their name, are capable of storing huge amounts of charge. They are typically used in applications where batteries have a short fall when it comes to high power and life, and conventional capacitors cannot be used because of a lack of energy. It is also known as electric double-layer capacitor (EDLC). Compared to normal capacitors of low farad value, the energy density of supercapacitors is typically thousand times greater. In comparison with conventional batteries or fuel cells, EDLCs have a much higher pulse power density. Capacitance of Supercapacitor is as high as 3400 F. The maximum charge voltage of a Supercapacitor lies around 2.7 V. Since supercapacitor have typical voltage of 2.7 V, to raise the voltage they are connected in series. Voltage Balancing circuits are required to connect three or more supercapacitors in series. Supercapacitors (SC) represent one of the innovative solutions in the field of energy storage technologies and have found their place in many today's high-power applications, like traction drives of electric vehicles [1], energy storage systems for elevators [2], integrated active filters, energy buffers for fuel cell powered systems [3].

B. DC-DC convertor

The DC-DC converter is commonly used for charging and discharging of supercapacitor and also for maintaining a desired voltage. It is well known that a DC-DC converter generates voltage according to its duty ratio (the ratio of time with a power supply voltage as a fraction of the total time) and that the energy dissipation is small because of its small currents. There are a number of different topologies which convert dc-voltage to different levels and control the power flow. The simplest ones are the Buck and the Boost converters; they are of a unidirectional type and can therefore only send power into one direction. The boost converter topology is used here.

The basic boost converter is shown in Fig. 1

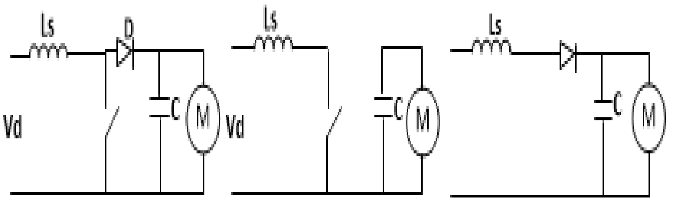


Fig.1. Basic boost convertor

As the name implies, the output voltage is greater than the input voltage. When the switch is on, the diode is reversed biased thus isolating the output stage. The input source supplies the energy to the inductor .When the switch is off, the output stage receives energy from inductor as well as from input source. The boost controller is used in this scheme to increase the supercapacitor voltage to supply to the load as well as to maintain the desired voltage across the load.

The scheme for the SCESS system is shown in Fig.2. It consists of the supercapacitor, the DC/DC converter dc link capacitor, electric vehicle as dc motor load with rating of 12V, 40 watt 1000 rpm and PI controller. The DC/DC converter used here is boost converter. The main aim is to maintain the desired output voltage across the dc link.

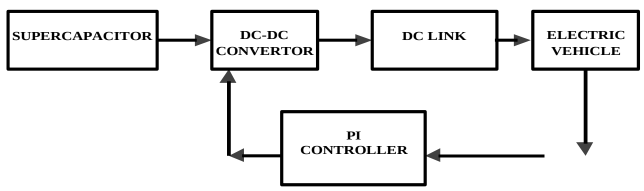


Fig. 2. Proposed Scheme

Duty cycle (D), Inductor (L), output capacitor (C) and energy (E) is calculated by (1), (2), (3) and (4) respectively. Vin is the voltage delivered by supercapacitor and Vout is output voltage across motor. Fs is minimum switching frequency of convertor.

$$D = 1 - \left\{\frac{V_{in(min)}\times \eta}{V_{out}}\right\} = 0.82 \qquad (1)$$

$$L = \frac{V_{in}\times(V_{out}-V_{in})}{\Delta I_L \times F_s \times V_{out}} = 0.841 \mu H \qquad (2)$$

$$C_{out(min)} = \frac{I_{out(max)}\times D}{F_s \times \Delta V_{out}} = 0.001F \qquad (3)$$

$$E = \int_0^{q} V\,dw \qquad (4)$$

$$E = \frac{1}{2} C V^2 \qquad (5)$$

II. SIMULINK MODEL OF OPEN LOOP CONTROL

The model is designed and simulated in the MATLAB/SIMULINK software. IGBT is used as a switch. The switching frequency of the IGBT is kept as 10kHz.This switching frequency is set by pulse width modulation technique.

Four supercapacitors of 100F, 2.7V are connected in series which gives equivalent capacitance and voltage of 25F and 10.8V respectively. Boost controller is used to increase and maintain a constant output dc voltage at motor side.

Two topologies, open loop and close loop methods are used in proposed scheme. In open loop condition, voltage is boost up but it does not maintain constant which reduces the performance and efficiency. To maintain constant voltage across the motor, a closed loop using PI controller is used. The voltage across the load remains constant up to 50% discharge of Supercapacitor.

SIMULINK model of open loop controller is shown in Fig. 3 as below.

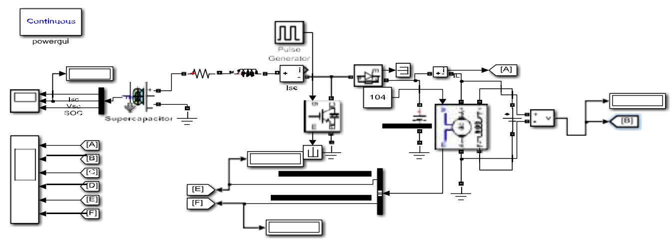
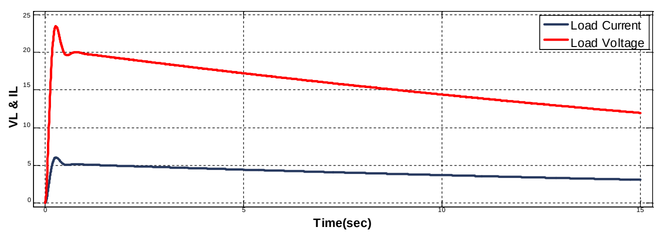


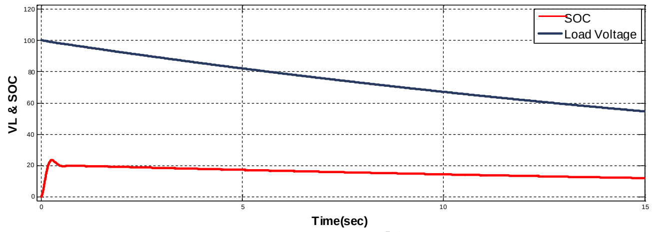
Fig. 3. SIMULINK model of open loop controller.

III. SIMULATION RESULTS OF OPEN LOOP CONTROL

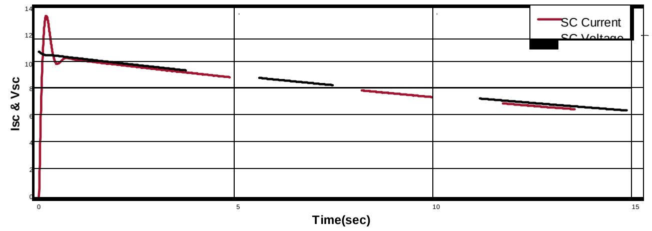
Fig. 4(a) shows the simulation output results of voltage and current across motor. As the time progresses, discharging of the supercapacitor takes place. Due to this, voltage and current gets boost up but does not remain constant and decreases. Both the characteristics are drooping in nature. Fig 4(b) shows the relation between state of charge (SOC) and voltage across motor. SOC shows the state of discharging of supercapacitor. This waveform shows relationship between discharge of supercapacitor and drooping voltage with respect to time. Fig.4(c) shows the comparison between supercapacitor current and voltage. As voltage decreases, current also decreases.



(a)



(b)



(c)

Fig.4 Open loop control waveform (a) Output voltage and current across motor (b) State of charge (SOC) and voltage across motor (c) Supercapacitor voltage and current.

IV. SIMULINK MODEL OF CLOSED LOOP CONTROL

SIMULINK model for closed loop controller is designed as shown in Fig.5. In open loop condition the drooping characteristic was occurred. Due to this, efficiency of appliances was reduced. To avoid such condition, closed loop method is used.

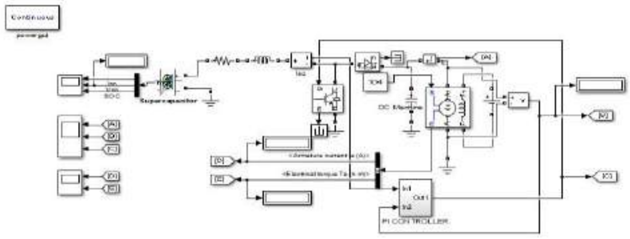
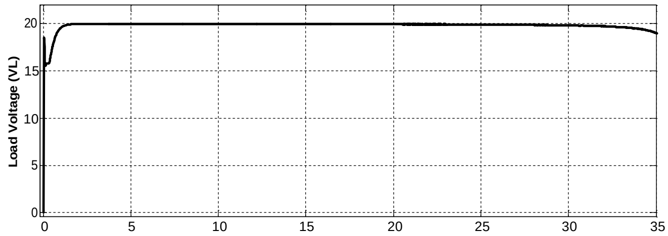


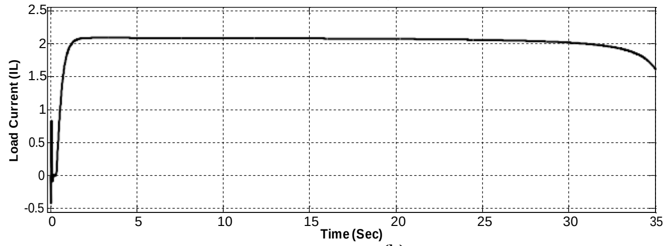
Fig. 5. SIMULINK model of closed loop controller

V. SIMULATION RESULTS OF CLOSED LOOP CONTROL

Fig 6(a) and 6(b), shows voltage and current across motor with respect to time. In open loop condition, as time progresses there was drooping characteristic in output voltage and current. But by using PI controller in closed loop system, the voltage and current maintained constant at desired value till 50% discharge of supercapacitor. Fig 6(c), shows waveform of supercapacitor voltage and current during discharging. Voltage decreases and current increases with respect to discharge time. Fig 6(d) Shows relationship between state of charge (SOC) and load voltage with respect to time. As supercapacitor discharges load voltage boost up and remains constant by closed loop DC-DC convertor. Fig 6(e), shows waveform of electrical torque with respect to time. They have drooping characteristics after 25 sec i.e. 50% discharge of supercapacitor. As per rating of motor, torque is maintained at 0.32N-m. The require current to maintain desired torque is 2.1 Amp as shown in Fig.6 (b). Fig 6(f), shows waveform of energy consumed by motor with respect to time. As time progresses the energy consumed increases. Fig 6(g), shows waveform of boosted voltage with respect to time which is calculated using by (5). As per analysis between open loop voltage and closed voltage, it is observed that in closed loop condition the voltage is boosted up to maintain the constant voltage across the motor load.



(a)



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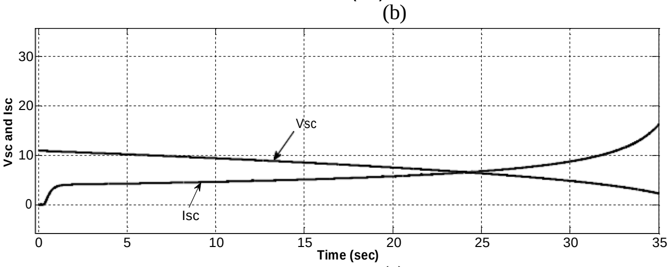
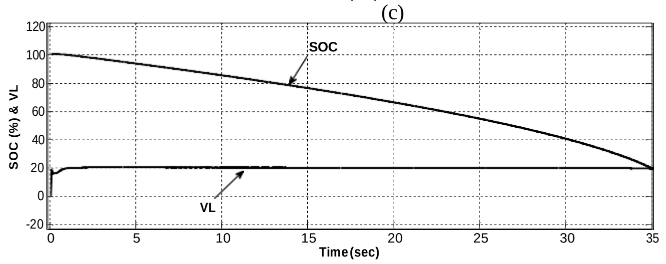
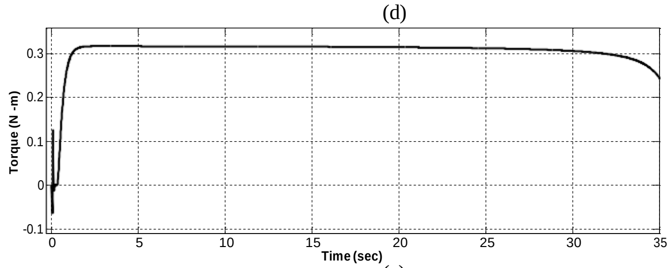


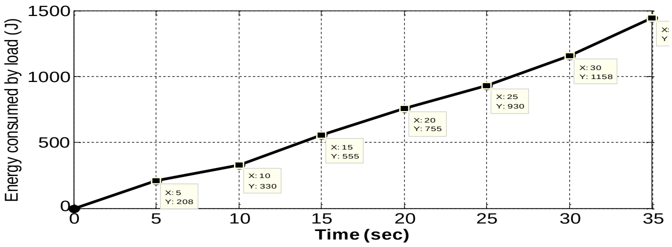
(c)



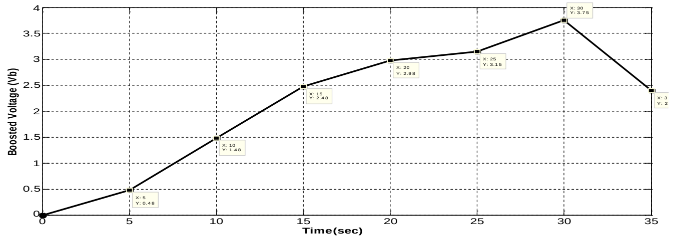
(d)



(e)



(f)



(g)

Fig.6. Closed loop control waveform (a) Voltage across motor, (b) Current across motor, (c) supercapacitor voltage and current during discharging, (d) between state of charge (SOC) and voltage across motor, (e) Electrical torque,
(f) Energy consumed by motor, (g) Boosted voltage

VI. CONCLUSION

In this paper, simulation of open loop and closed loop control is performed using MATLAB/SIMULINK software. Output voltage and current continuously decreases as supercapacitor discharges in open loop control. To maintain motor voltage constant, closed loop control is used by applying PI control.

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Improving Ride- Through Capability Of DC-Link Voltage in Multilevel Unified Power Flow Controllers.

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***Abstract* - The three-level neutral-point-clamped (NPC) converter allows back-to-back connection as the UPFC shunt and series converters. As well the pulse width-modulated (PWM) multilevel control plans, UPFCs need constant dc-link voltage and balanced voltages in the NPC multilevel dc capacitors. This paper proposes three main contributions to increase the dc-link voltage steadiness of multilevel UPFCs under line faults: 1) decoupled active and reactive linear power controllers; 2) real-time PWM generation; and 3) double balancing of dc capacitor voltages. The results show the effectiveness of the real-time PWM generation and dc-link capacitor voltages balancing included in NPC series and shunt converters to stay the dc-link voltage steadiness under line faults, generally enhancing the UPFC ride-through capability**.

Index Terms – **Decoupled power controller, flexible ac transmission system (FACTS), power flow control, Uniffed powerflow controller.**

I INTRODUCTION

Environmental and economical constraints affect the building of electric power stations and transmission lines, While power demand continues to grow. Thus, increasing power controllability and optimize existing power system capacities by suitable control of the power flow (PF) during steady state as well as in transient conditions is needed. The flexible ac transmission systems (FACTS) concept namely, the unified power-flow controller

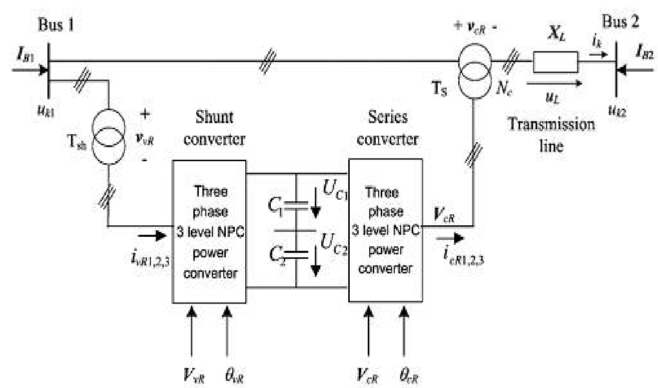

Fig. 1 Typical diagram configuration of the UPFC

(UPFC), can provide the necessary PF optimization in transmission lines while improving power oscillation damping and, thus, is able to enforce active and reactive powers in a transmission line. Multilevel converters present attractive

active and reactive power responses. Decoupled cascaded PI voltage and current controllers

features, such as high-voltage (HV) capability and low harmonic content voltage waveforms, with the NPC multilevel converter being advantageous for UPFCs, since it needs capacitor bank on the dc bus to produce voltage levels. Fig. 1 shows the typical diagram configuration of the UPFC two high-power back-to-back NPC multilevel voltage-source inverters connected through a smoothing capacitor bank dc-link voltage. oscillation damping [2]–[4].The UPFC can control line parameters, such as bus voltage, voltage angle, and line impedance, and, thus, is able to enforce active and reactive powers in a transmission line [5]–[7]. Multilevel converters present attractive features, such as high-voltage (HV) capability and low harmonic content voltage waveforms, with the NPC multilevel converter being advantageous for UPFCs [8], [9], since it needs capacitor banks on the dc bus to produce voltage levels. Fig. 1 shows the typical diagram configuration of the UPFC two high-power back-to-back NPC multilevel voltage-source inverters connected through a smoothing capacitor bank dc-link voltage. Oscillation damping control uses UPFC nonlinear control schemes [10] although a simplified power injection model was employed to obtain the UPFC behavior and the UPFC dc-link ride-through capability was not investigated. In [11], dynamic control and performance evaluation of a UPFC is presented.

UPFC with multilevel converters has been partially addressed in [15] studying the frequency-response characteristics of the UPFC and in [16], the balancing of the voltage capacitors has been proposed using an extra chopper converter and, therefore, requires extra converters. Proportional-integral (PI) power-controlled UPFCs [16] show strong cross-coupling between

II. LITERATURE REVIEW

B.Fardanesh (2004) proposed method for optimal dimensioning of multiconverter converter-based FACTS controllers. This general method allows comparisons of the steady-state performance and effectiveness of all single, two, and three-converter controllers in achieving specific power system operating objectives. The effects of various shunt and series converter size modularizations in multiconverter FACTS controllers are demonstrated. Realistic constraints representing various converter limits have been implemented. MATLAB optimization routines are utilized.

N.G Hingorani, L.Gyugyi (2000) proposed various aspects of unified power flow controller (UPFC) control modes have been discussed and it describes its settings and evaluates their impacts on the power system reliability.

UPFC is the most versatile flexible ac transmission system device ever applied to improve the power system operation and delivery. It can control various power system parameters, such as bus voltages and line flows. A power injection model is used to represent UPFC and a comprehensive method is proposed to select the optimal UPFC control mode and settings. The proposed method applies the results of a contingency screening study to estimate the remedial action cost (RAC) associated with control modes and settings and finds the optimal control for improving the system reliability by solving a mixed-integer nonlinear optimization problem. The proposed method is applied to a test system in this paper and the UPFC performance is analyzed in detail.

S.JIANG, U.D.Annakage, A.M.Gole(2006) proposed a platform system for the incorporation of flexible ac transmiss

transmission systems (FACTS) devices has been presented. The platform permits detailed electromagnetic transients simulation as it is of manageable size. It manifests some of the common problems for which FACTS devices are used such as congestion management, stability improvement, and voltage support. D. E. Soto-Sanchez, T. C. Green (2001) proposed a UPFC using three converters is proposed. Two phase-shifted converters are required to provide a full range of voltage control of the series connection while ensuring low distortion and a balanced DC link. A single shunt converter is used. S. Mehraeen, S. Jagannathan, M. L. Crow (2010) proposed the determination of most unstable bus of system using P-V curve and Eigen value analysis and the critical line using the stability indices has been presented. Voltage collapse indicators indices give exact information about the stability condition of a system and also determine the most in secure bus of the system. The line indices are evaluated for IEEE 14 bus system and critical line is found where the index reaches its maximum value. PSAT (power System Analysis Toolbox) software is used for Continuation Power Flow (CPF)) and the results shows that optimal placement of Unified Power Flow Controller (UPFC) significantly increase the load ability margin and stability of system.

J Guo, M. L, Crow,J. Sarangapani (2009) proposed the DVR multilevel topology is suitable for medium-voltage applications and operated by the control scheme developed in this paper. It is able to mitigate power-quality disturbances, such as voltage sags, harmonic voltages, and voltage imbalances simultaneously within a bandwidth.

H. Fujita, H. Akagi, Y. Watanabe (2006) proposed a control scheme and comprehensive analysis for a unified power flow controller (UPFC) on the basis of theory,

computer simulation and experiment has been presented. This developed theoretical analysis reveals that conventional power feedback control scheme makes the UPFC induce power fluctuation in transient states. This paper proposes an advanced control scheme which has the function of successfully damping out the power fluctuation. Experimental results agree well with both analytical and simulated results and show viability and effectiveness of the proposed

.

III. UPFC DECOUPLED POWER CONTROL

In this work decoupled linear UPFC power controllers are to be introduced to obtain the reference ac voltages (VcRref) and currents (IvRref) for the two back-to-back-connected three phase three-level converters that enforce active and reactive power in the transmission line, with cross-coupling suppression. The converters share common dc-link capacitors C1, C2 and rely on real-time PWM generators to enforce the shunt converter ac input currents (IvR = IvRref) and series converter line-to-neutral voltages (VcR=VcRref). The dc-link voltage will be regulated by the shunt converter, while shunt and series converters will balance the dc voltages of the dc-link capacitors. Real-time PWM generation and the double balance of the two dc capacitor dc voltages are intended to show that it enhances the voltage ride-through capability. Simulation results will be presented to show the ride-through performance under line faults. The effectiveness of the proposed methods will be compared to controllers without real-time PWM generation and decoupled active and reactive power control.

IV. NPC MULTILEVEL CONVERTER

The power electronics device which converts DC power to AC power at required output voltage and frequency level is known as inverter.

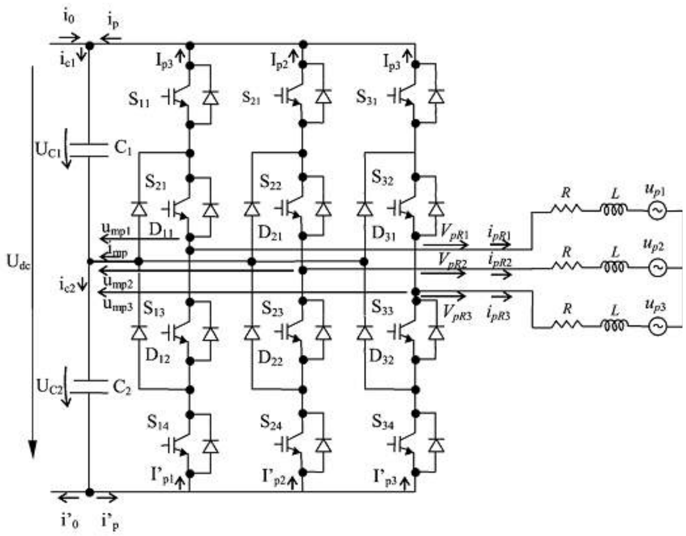

Fig.4.Three-phase three level NPC power converter

In this work it is expected that Active and reactive PF control in the transmission line is accomplished by using a decoupled power controller, nearly enabling cross-coupling suppression. It is expected that PWM generation helps in eliminating errors due to dc capacitor voltage variations. The dc-link capacitor voltages, which are usually balanced using only one of the multilevel converters, will be balanced using both series and shunt multilevel converters. It is expected that the decoupled active and reactive power controllers remain insensitive to the non modeled dynamics and parameter variation, since active and reactive powers are to be enforced, despite network configuration being changed due to fault clearing.

VI. CONCLUSION

It will concludes that a voltage ride-through enhancement strategy for multilevel UPFCs can be realized and the proposed UPFC control strategy will include A) Decoupled active and reactive linear power control. B) Real-time PWM generation in both UPFC multilevel converters, dc-link voltage gains With low sensitivity to dc link current C) The balancing of the dc-link capacitor voltages using both multilevel converters. It will concluded that the decoupled active and reactive power controllers remain insensitive to the no modeled dynamics and parameter variation, since active and reactive powers are to be enforced, despite network configuration being changed due to fault clearing

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A Nine Level Converter Topology for single-Phase Transformerless PV System

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***Abstract* – This paper presents a single-phase transformerless load connected photovoltaic converter based on two cascaded full bridges with different dc-link voltages. The converter can synthesize upto nine voltage levels with a single dc bus, since one of the full bridges is supplied by a flying capacitor. The multilevel output reduces harmonic distortion and electromagnetic interference. A suitable switching strategy is employed to regulate the flying-capacitor voltage, improve the efficiency and minimize the common-mode leakage current with the help of a novel dedicated circuit (transient circuit).**

***Index Terms* - Leakage current, multilevel Inverter, photovoltaic(PV) systems, pulsewidth modulation (PWM) inverter, power switches.**

I. INTRODUCTION

Load connected photovoltaic (PV) converters represent the most widespread solution for residential renewable energy generation. While classical designs of PV converters feature a load frequency transformer, which is a typically heavy and costly component, at the interface between the converter and the electrical Load, researchers are now considering transformerless architectures in order to reduce costs and weight and improve efficiency. Removing the load frequency transformer entails all the benefits above but worsens the output power quality, allowing the injection of dc current into the load and giving rise to the problem of ground leakage current [4].

Although the active parts of PV modules might be electrically insulated from the ground-connected mounting frame, a path for ac ground leakage currents generally exists due to a parasitic capacitance between the modules and the frame and to the connection between the neutral wire and the ground, usually realized at the low-voltage/medium-voltage (LV/MV) transformer [4]. In addition to deteriorating power quality, the ground leakage current increases the generation of electromagnetic interference and can represent a safety hazard, so that international regulations pose strict limits to its magnitude. This issue must be confronted in all transformerless PV converters, regardless of architecture. In particular, in full-bridge-based topologies, the ground leakage current is mainly due to highfrequency variations of the common-mode voltage at the output of the power converter [5].

Once the load frequency transformer is removed from a PV converter, the bulkiest wound and reactive components that remain are those that form the output filter used to clean the output voltage and current from high frequency switching components. Further reduction in cost and weight and improvement in efficiency can be achieved by reducing the filter size, and this is the goal of multilevel converters.

Multilevel converters have been investigated for years but only recently have the results of such researches found their way to commercial PV converters. Since they can synthesize the output voltages using more levels, multilevel converters outperform conventional two- and three-level converters in terms of harmonic distortion. Moreover, multilevel converters subdivide the input voltage among several power devices, allowing for the use of more efficient devices. Multilevel converters were initially employed in high-voltage industrial and power train applications. They were first introduced in renewable energy converters inside utility-scale plants, in which they are still largely employed. Recently, they have found their way to residential-scale single-phase PV converters, where they currently represent a hot research topic [11].

CFBs give developers many degrees of freedom for the control strategy. A CFB made up of n full bridges (and at least $4n$ power switches) can synthesize $2n + 1$ voltage levels when the supply voltage is the same for each full bridge. Reduction in the switches-per-output voltage-level ratio can be achieved in CFB structures if different supply voltages are chosen for each full bridge (asymmetrical CFBs).

The topology proposed in this paper consists of two asymmetrical CFBs, generating nine output voltage levels. In the proposed converter, the dc voltage source supplies one of the full bridges, whereas a flying capacitor supplies the other one. By suitably controlling the ratio between the two voltages, different sets of output levels can be obtained.

Moreover, the flying capacitor used as a secondary energy source allows for limited voltage boosting. The number of output levels per switch (eight switches, nine levels) is comparable to what can be achieved using custom architectures. In final topology two additional very low power switches and a line frequency switching device [transient circuit (TC)] were included in order to reduce the ground leakage current. Finally, it is important to put in evidence that the proposed converter can work at any power factor as reported in Section III.

This paper is organized as follows: Section II presents the power converter topology and the PWM control strategy chosen in order to maximize the performance with the use of a low-cost digital signal processor (DSP). Section III describes the regulation of the flying capacitor used to supply the second full bridge of the CFB topology. Section IV describes the principle of operation of the additional components able to reduce the ground leakage current. Sections V reports the concluding remarks.

II. NINE-LEVEL CONVERTER AND PWM CONTROL STRATEGY

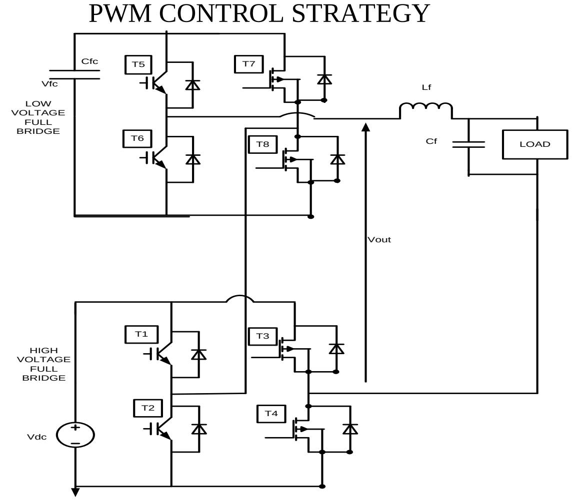

Fig. 1. CFB with a flying capacitor.

The proposed converter is composed of two CFBs, one of which is supplied by a flying capacitor (Fig. 1). The PWM strategy alone is not sufficient to maintain a low ground leakage current, other components were added as described in Section IV. The proposed PWM strategy stretches the efficiency by using the two legs where PWM frequency switching does not occur, devices with extremely low voltage drop, such as MOSFETs lacking a fast recovery diode. In fact, the low commutation frequency of those two legs allows, even in a reverse conduction state, the conduction in the channel instead of the body diode (i.e., active rectification). Insulated-gate bipolar transistors (IGBTs) with fast antiparallel diodes are required in the legs where high-frequency hard-switching commutations occur. In load-connected operation, one full-bridge leg is directly connected to the load neutral wire, whereas the phase wire is connected to the converter through an *LC* filter. As it will be described and justified in the following section, flying-capacitor voltage V_{fc} is kept lower, at steady state, than dc-link voltage V_{DC}. Accordingly, the full bridge supplied by the dc link is called the high-voltage full bridge (HVFB), whereas the one with the flying capacitor is the low-voltage full-bridge (LVFB).

The CFB topology allows certain degrees of freedom in the control, so that different PWM schemes can be considered; however, the chosen solution needs to satisfy the following requirements.

1) Most commutations must take place in the LVFB to limit the switching losses.

2) The neutral-connected leg of the HVFB needs to switch at load frequency to reduce the ground leakage current.

3) The redundant states of the converter must be properly used to control the flying-capacitor voltage.

4) The driving signals must be obtained from a single carrier for a low-cost DSP to be used as a controller.

TABLE I
DESCRIPTION OF THE CONVERTER OPERATING ZONES

Zone	Output Voltage	On Devices	Off Devices	Switching Devices
Zone3B	$-V_{DC} - V_{fc} = -V_{DC}$	T2, T3,T7	T1, T4, T8	T5, T6
Zone3A	$-V_{DC} = -V_{DC} + V_{fc}$	T2, T3,T8	T1, T4, T7	T5, T6
Zone2A	$-V_{DC} + V_{fc} = 0$	T3, T7	T4, T8	T1, T2, T5,T6
Zone2B	$-V_{DC} = -V_{fc}$	T3, T7	T4, T8	T1, T2, T5,T6
Zone1B	$-V_{fc} = 0$	T1, T3,T7	T2, T4, T8	T5, T6
Zone1A	$0 = V_{fc}$	T2, T4,T8	T1, T3, T7	T5, T6
Zone2A	$V_{fc} = V_{DC}$	T4, T8	T3, T7	T1, T2, T5,T6
Zone2B	$0 = V_{DC} - V_{fc}$	T4, T7	T3, T7	T1, T2, T5,T6
Zone3B	$V_{DC} - V_{fc} = V_{DC}$	T1, T4,T7	T2, T3, T8	T5, T6
Zone3A	$V_{DC} = V_{DC} + V_{fc}$	T1, T4,T8	T2, T3, T7	T5, T6

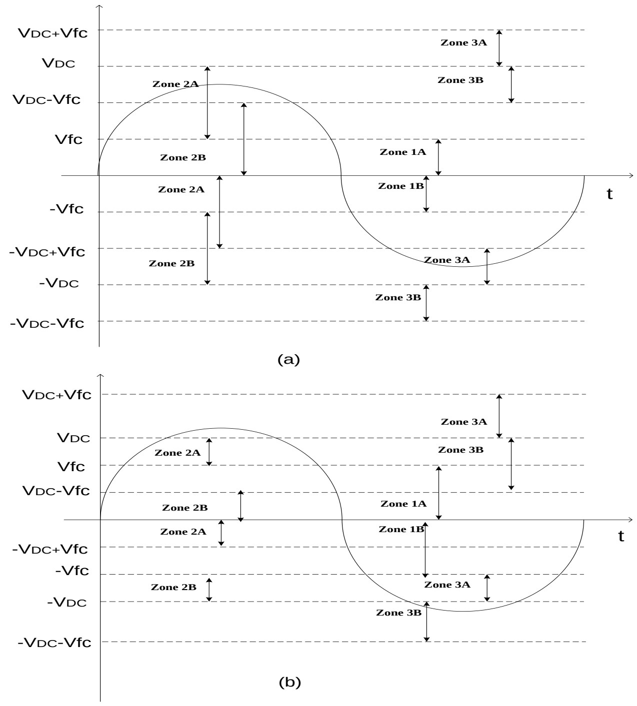

Fig. 2. Operating zones under different Vfc ranges. (a) Vfc < 0.5VDC. (b) Vfc > 0.5VDC.

The switching pattern described in Table I was developed starting from the above requirements. Capacitive coupling renders the common-mode current inversely proportional to the switching frequency of the neutral-connected leg.

The converter can operate in different output voltage zones, where the output voltage switches between two specific levels. The operating zone boundaries vary according to the dc-link and flying-capacitor voltages, and adjacent zones can overlap (Fig. 2).

In zones labeled A, the contribution of the flying-capacitor voltage to the converter output voltage is positive, whereas it is negative in B zones. Constructive cascading of the two full bridges can, therefore, result in limited output voltage boosting. Depending on the Vfc/V_{DC} ratio, one of the (a) or (b) situations in Fig. 2 can ensue; nevertheless, the operation of the converter does not differ much in the two cases. If two overlapping operating zones can supply the same output voltage, the operating zone to be used is determined taking into account the regulation of Vfc, as will be described in Section III.

The switching pattern depends on the instantaneous fundamental component of output voltage V_{out} and on the measured values of Vfc and V_{DC}. If Vfc = V_{DC}/3, the converter can synthesize nine equally spaced output voltage levels. One leg of the HVFB operates at load frequency and one leg of the LVFB at five times the load frequency.

Moreover, apart from zone 2, no high-frequency commutations occur in the whole HVFB (Fig. 2). Since the voltage regulation of the flying capacitor takes place in zone 2, the zone-2 behavior is more articulated and will be described in detail in the following section.

III. FLYING-CAPACITOR VOLTAGE REGULATION

Since the main task facing a load-connected PV converter is the transfer of active power to the electrical load, controlling the voltage of the flying capacitor is critical.

Flying-capacitor voltage Vfc is regulated by suitably choosing the operating zone of the converter depending on the instantaneous output voltage request. Depending on the operating zone of the converter (Fig. 2), Vfc can be added to (A zones) or subtracted from (B zones) the HVFB output voltage, charging or discharging the flying capacitor. In particular, considering a positive value of the current injected into the load, the flying capacitor is discharged in A zones and charged in B zones. Since a number of redundant switch configurations can be used to synthesize the same output voltage waveform, it is possible to control the voltage of the flying capacitor, forcing the converter to operate more in A zones when the flying-capacitor voltage is higher than a reference value or more in B zones when it is lower than a reference value. Similar considerations hold in case of a negative injected current.

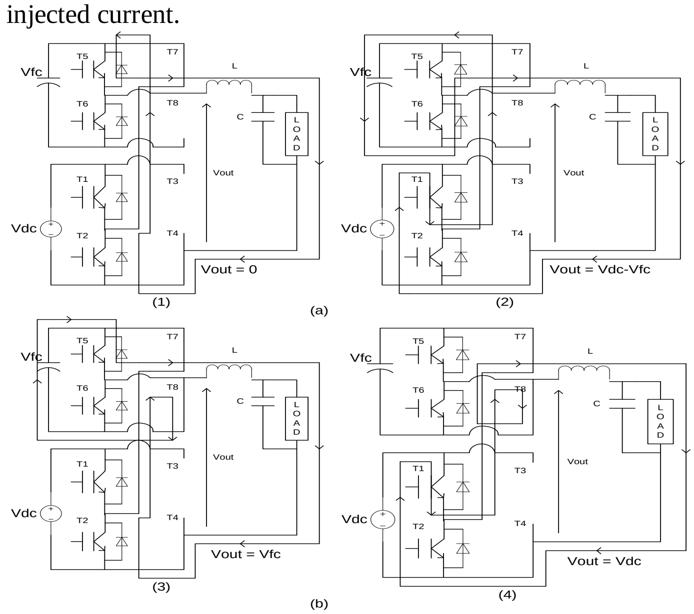

Fig. 3. Converter configurations for the regulation of the flying capacitor. (a) Flying-capacitor charge. (b) Flying-capacitor discharge.

In each case, some commutations between nonadjacent output levels must inevitably occur (level skipping), with the drawback of a certain increase in the output current ripple. The voltage control of the flying capacitor (which determines the zone-A or zone-B operation) is realized by a simple hysteresis control.

Fig.3. illustrates the regulation of V_{fc} supposing a positive current with $V_{out} > 0$ and $V_{fc} < 0.5V_{DC}$. If V_{fc} is too low, output level V_{fc} can be replaced by $V_{DC} - V_{fc}$, thus switching between the 0 and $V_{DC} - V_{fc}$ output levels [zone 2B, Fig. 3(a)]. Similarly, if V_{fc} is too high, $V_{DC} - V_{fc}$ can be replaced with V_{fc}, causing the converter to switch between the V_{fc} and V_{DC} output levels [zone 2A, Fig. 4(b)]. In Fig. 4, the devices switching at low frequency are short circuited when on and not shown when off. Similar V_{fc} regulation strategies can be likewise developed for the case when $V_{fc} > 0.5V_{DC}$.

If $V_{fc} < 0.5V_{DC}$, in order to minimize the current ripple, zone 2 is chosen only when $V_{fc} < V_{out} < V_{DC} - V_{fc}$ (zones 3 are otherwise chosen), limiting level skipping. Level skipping always occurs if $V_{fc} > 0.5V_{DC}$; hence, any A or B zone can be chosen according to the voltage regulation algorithm.

Since the dc-link voltage can go through sudden variations due to the MPPT strategy, it is important that the converter is able to work in any [V_{DC}, V_{fc}] condition. While the distortion of the output voltage is minimized through the on-line dutycycle computation, it is important to assess the capability of the converter to regulate the flying-capacitor voltage under different operating conditions.

IV. APPLICATION TO TRANSFORMERLESS PV CONVERTERS—TC

A particular feature of the commutation pattern of Table I is that T3 and T4 switch at load frequency, commutating at every zero crossing of V_{load}. If the zero crossing with a negative derivative is considered, T4 opens and T3 closes, changing the neutral wire voltage (and thus the voltage across the parasitic capacitance of the PV field) from zero to V_{DC}. For this reason, the commutation can cause a large surge of leakage current that can decrease the power quality and damage the PV modules. A proper TC was designed to decrease these surge currents.

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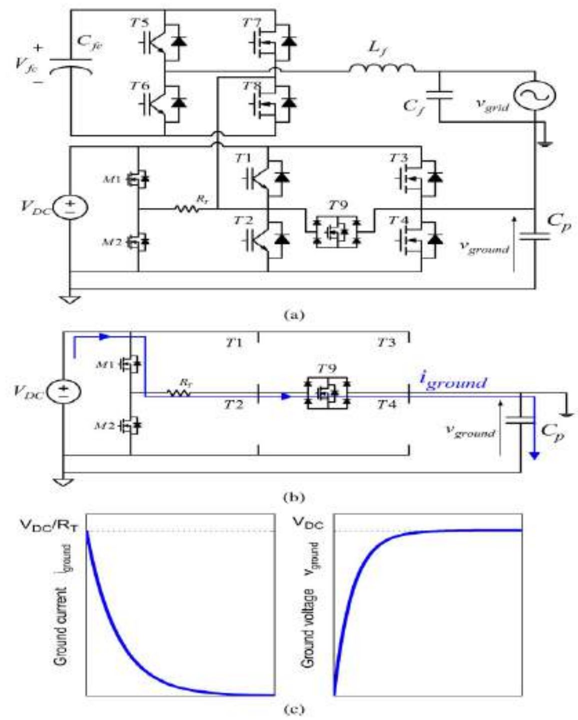

Fig. 4. Ground leakage current limitation circuit topology and behavior. (a) TC topology. (b) TC operation. (c) TC waveforms.

Fig. 4(a) shows the proposed converter topology; it is constituted of the two-cell CFB described in Fig. 1 with the addition of the TC components. In order to better understand the behavior of the TC, the distributed parasitic capacitance of the PV source was modeled with a simple equivalent parasitic capacitance, i.e., C_p, connected between the negative pole of the dc link and the ground.

The TC consists of two low-power MOSFETs M1 and M2, bidirectional switch T9, and resistor R_T . When the converter enters operating zone 1, the HVFB output voltage must be zero, obtained by switching T1 and T3 or T2 and T4 on. Nevertheless, to operate the TC, when entering zone 1, T1, T2, T3, and T4 are all kept off, while T9 is on. This keeps the neutral potential floating, so that the voltage on the parasitic capacitor Vground stays constant [see Fig. 4(b)]. At this point, one of M1 and M2 is turned on (M1 if the slope of the zero crossing is negative and M2 if positive). So doing, C_p is charged through R_T with a first-order transient [see Fig. 4(c)], limiting the current surge.

Whereas the TC introduces additional components, they can be selected with current ratings much lower than the devices of the CFB. Moreover, the power loss due to the added resistor is negligible. Estimating the energy lost charging and discharging a capacitor C_p to V_{DC} averaged over a line period T by $P_{tc} = C_p V^2_{DC}/T$, with $C_p = 200$ nF and $V_{DC} = 300$ V, a dissipation of about 1W is obtained. The operation of the TC is not affected by the power factor because in Load-connected operation, the output voltage is always very close to the Load voltage. The correct operation of the TC requires the Load voltage instantaneous angle that can be obtained with a phase-locked loop (PLL) fed by the load voltage.

V. CONCLUSION

This paper has proposed a novel nine-level converter topology for transformerless PV converter based on a CFB topology with two full bridges, one of which is supplied by a floating capacitor.

A suitable PWM strategy was developed in order to improve efficiency and with the help of a specific TC, minimize the ground leakage current.

The proposed PWM strategy can regulate the voltage across the flying capacitor.

The proposed converter can continuously operate at arbitrary power factors, has limited boosting capability, and can produce nine output voltage levels with 11 power switches, of which three are low power switches for the TC and only four need to be controlled by PWM.

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Study of UPQC using Fuzzy Logic Controller

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***Abstract* –A Unified Power Quality Conditioner (UPQC) using Fuzzy Logic Controller (FLC) is proposed. Since FLC is based on linguistic variable theory and does not require any mathematical model, the results obtained through are good in terms of dynamic response. Tuning of PI Controller is not required in case of FLC. Simulation is carried out using MATLAB/Simulink to validate the results.**

***Index Terms* – UPQC, Fuzzy Logic Controller, PI controller, reactive power, harmonic distortion.**

I. INTRODUCTION

Now a days, power electronics devices has brought about great technological improvements. However, the increasing number of power electronics driven loads used generally in the industry has brought about uncommon power quality problems. These devices are mostly responsible for generating harmonics. Hence the devices that can mitigate these drawbacks are developed one of which is-UPQC. The basic requirements for compensation process involve precise and continuous VAR control with fast dynamic response and on line elimination of load harmonics. Hence Active power filters (APF) has been used. The APFs are of two types; the shunt APF and the series APF. The shunt APFs are used to compensate current related problems, such as reactive power compensation, current harmonic filtering, load unbalance compensation, etc. The series APFs are used to compensate voltage related problems, such as voltage harmonics, voltage sag, voltage swell, voltage flicker, etc. The UPQC is formed by integrating both these APFs.

The UPQC controls the flow of power at fundamental frequency. Also it controls distortion due to harmonics and unbalance in voltage in addition with control of flow of power at fundamental frequency.

The schematic diagram of UPQC is shown in fig 1. It consists of two voltage source inverters (VSIs) connected back to back, sharing a common DC link in between. One of the VSI acts as shunt APF, whereas the other act as series APF. The performance of UPQC is based on how quickly and accurately compensation signals are derived. The Control scheme of UPQC using pi controller is tedious and is prone to severe dynamic interaction between active and reactive power flow.

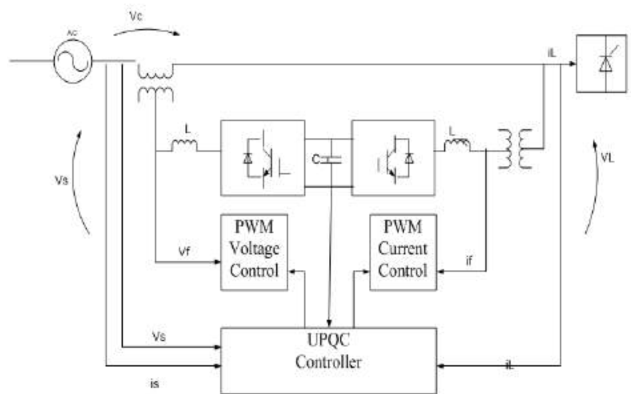

Fig 1.Schematic diagram of UPQC

In this paper, a Fuzzy logic Controller based UPQC is proposed. The dynamic response of FLC based UPQC is better in dynamic response and THD values can also be kept within limits.

II. LITERATURE REVIEW

Possible methods of VAR generation and control by static thyristor circuits are reviewed, and new approaches are described in which power frequency changers (cycloconverters) are employed. Oscillographic recordings illustrate the operation and performance of practical systems, including a 35-Mvar arc furnace compensator. [1]

A quasi-passive filter (QPF) has been proposed to overcome the limitations of conventional shunt passive filters, which are invariably used for harmonic filtering. With certain modifications in the QPF, a modified quasi-passive filter

(MQPF) has been proposed, which can be used for reactive power compensation in addition to harmonic filtering. The proposed QPF and MQPF have been verified through analysis and simulation. Experiments are carried out to verify the validity of the QPF. [2]

A shunt active power filter (APF) based on unified constant frequency integration or one-cycle control for compensating unbalanced loads in a three-phase four-wire system is explored. The scheme neither requires the service of a phase-locked loop nor requires to sense the utility voltages. This makes the scheme insensitive to the distortions that are generally present in the utility voltages. First, the one-cycle control technique is applied to a topology involving a four-leg converter for the proof of concept. Then it is utilized to control a conventional three-leg converter having a split-capacitor dc link. The effectiveness and the viability of the schemes are demonstrated through detailed simulation and experimental verification. [3]

The possible calculation methodologies when designing a selective shunt active filter are presented. To accomplish selective extraction of harmonic sequences, the modulation-filter-demodulation technique is used. The fundamental equations of this method are based on pq theory. Its equivalence with the SRF (synchronous reference frame) method is shown. In order to validate the proposed calculation methods, measured currents from an arc furnace, showing high harmonic distortion, are used. The obtained results show the effectiveness of the proposed method for selective filtering of the undesired current harmonics in a controlled way. [4]

Two control scheme models for UPQC, for enhancing PQ of sensitive non-linear loads has been described. Based on two different kinds of voltage compensation strategy, two control schemes have been designed, which are termed as UPQC-Q and UPQC-P. A comparative loading analysis has developed useful insight in finding the typical application of the two different control schemes. The effectiveness of the two control schemes is verified through extensive simulation using the software SABER. As the power circuit configuration of UPQC remains same for both the models, with modification of control scheme only, the utility of UPQC can be optimized depending upon the application requirement. [6]

III.FUZZY LOGIC CONTROLLER

FLC, basic control action is determined by a set of linguistic rules. These rules are determined by the system. Since the numerical variables are converted into linguistic variables, mathematical modeling of the system is not required in FC. The FLC comprises of three parts: fuzzification, interference engine and defuzzification. The FC is characterized as; i. seven fuzzy sets for each input and output. ii. Triangular membership functions for simplicity. iii. Fuzzification using continuous universe of discourse. iv. Implication using Mamdani‟s „min‟ operator. v. Defuzzification using the „height‟ method.

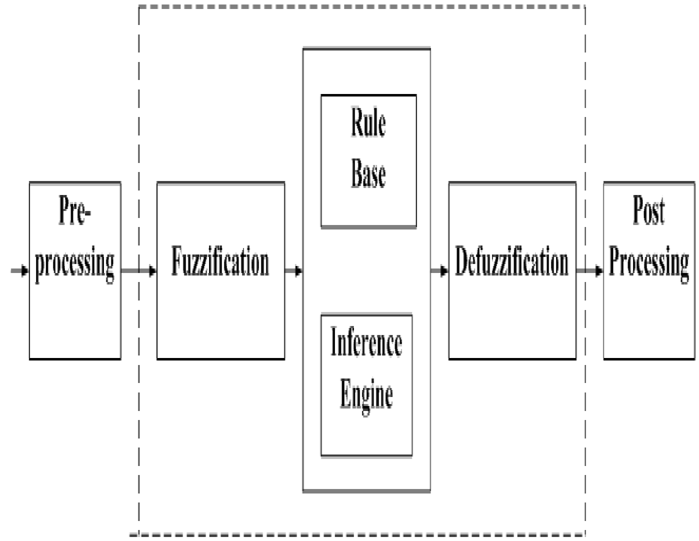

Fig 2.Fuzzy Logic Controller

Fuzzification:

Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB (Negative Big), NM (Negative Medium), NS (Negative Small), ZE (Zero), PS (Positive Small), PM (Positive Medium), and PB (Positive Big). The partition of fuzzy subsets and the shape of membership function adapt the shape up to appropriate system. The value of input error E(k) and change in error CE(k) are normalized by an input scaling factor shown in Fig 2

CHANGE IN ERROR	ERROR						
	NB	**NM**	**NS**	**Z**	**PS**	**PM**	**PB**
NB	PB	PB	PB	PM	PM	PS	Z
NM	PB	PB	PM	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NM	NB
Z	PB	PM	PS	Z	NS	NM	NB
PS	PM	PS	Z	NS	NM	NB	NB
PM	PS	Z	NS	NM	NM	NB	NB
PB	Z	NS	NM	NM	NB	NB	NB

TABLE 1: Fuzzy rules

Interference Method:

Several composition methods such as Max–Min and Max-Dot have been proposed in the literature. In this paper Min method is used. The output membership function of each rule is given by the minimum operator and maximum operator. Table 1 shows rule base of the FLC.

Defuzzification:

As a plant usually requires a non-fuzzy value of control, a defuzzification stage is needed. To compute the output of the FLC, „height" method is used and the FLC output modifies the control output. Further, the output of FLC controls the switch in the inverter. In UPQC, the active power, reactive power, terminal voltage of the line and capacitor voltage are required to be maintained. In order to control these parameters, they are sensed and compared with the reference values. To achieve this, the membership functions of FC are: error, change in error and output. In the present work, for fuzzification, non-uniform fuzzifier has been used. If the exact values of error and change in error are small, they are divided conversely and if the values are large, they are divided coarsely. The set of FC rules are derived from (1).

$$u=-[\alpha E + (1-\alpha)*C] \qquad (1)$$

Where α is self-adjustable factor which can regulate the whole operation. E is the error of the system, C is the change in error and u is the control variable. A large value of error E indicates that given system is not in the balanced state. If the system is unbalanced, the controller should enlarge its control variables to balance the system as early as possible.During the process, it is assumed that neither the UPQC absorbs active power nor it supplies active power during normal conditions. So the active power flowing through the UPQC is assumed to be constant.

IV. CONCLUSION

It is concluded that a UPQC using Fuzzy Logic Controller can be investigated for compensating reactive power and harmonics and that the UPQC so designed will be simple and will be based on sensing the line currents only.It is to ensure that the fuzzy logic controller limits the THD of the source current well below 5% which is the harmonic limit imposed by IEEE-519 standard.

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TECH-CHRONICLE
AN INTERNATIONAL E-JOURNAL ON
EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

"DC-DC CONVERTER FOR INTEGRATION OF SOURCES"

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***Abstract* – This paper presents a multilevel with separate dc sources and solar dc source balancing the power with SPWM technique. The deals simulation and hardware design of single phase multi level inverter with separate two dc sources using conventional method and multicarrier pulse width modulation technique and the output results of both methods are compared and multilevel inverter is designed. Multilevel inverters include an arrangement of semiconductors and dc voltage sources required to generate a stepped output voltage waveform. The number of input DC voltages depends on the number of inverter output voltage levels and as the levels are increased the harmonics are reduced.**

Keywords–: 5-level inverter, PV Cell, DC supply, SPWM Technique, THD.

I. INTRODUCTION

The multilevel concept is used to decrease the harmonic distortion in the output waveform without decreasing the inverter power output. This project presents the most important topologies like diode-clamped inverter (neutral- point clamped), capacitor-clamped (flying capacitor), and cascaded multilevel with separate dc sources and solar dc source balancing the power with SPWM technique. The deals simulation and hardware design of single phase multi level inverter with separate two dc sources using conventional method and multicarrier pulse width modulation technique and the output results of both methods are compared and multilevel inverter is designed. Multilevel inverters include an arrangement of semiconductors and dc voltage sources required to generate a stepped output voltage waveform. The number of input DC voltages depends on the number of inverter output voltage levels and as the levels are increased the harmonics are reduced. Pulse width modulation is the main control strategy implemented in the power electronics. This is the best way of driving modern power electronic devices. Most of the power electronic circuits are controlled by PWM signals of various forms such as multi carrier PWM. Multilevel inverter structures are becoming increasingly popular for high power applications, their switched output voltage harmonics can be reduced since semiconductors are connected in series for multilevel inverter structures the number of levels increases, the synthesized output waveform has more steps, producing a very fine stair case wave and approaching very closely to the desired sine wave. It can be easily understood that as motor steps are included in the waveform the harmonic distortion of the output wave decrease, approaching zero as the number of levels approaches infinity.

II. LITERATURE REVIEW

Multilevel inverter of new approach with two sources is the latest area of interest amongst the power electronic researchers. Some of the research work and literature work are given below.

Naresh Kumar Varathe, Ketan Mishra, Shubham Shivhare (2014) proposes that inverter is used for maximum control techniques of output voltage and current. That power semiconductor device able to reduces the harmonics and provide the high o/p voltage. Result is compared with the conventional single phase seven level inverter grid connected PV inverter. THD and EMI result also in this paper with reduce the losses [1]. Nurul Aisyah Yusof, Norazliani Md Sapari, Hazlie Mokhlis, Jeyraj Selvaraj (2012) proposed that Power electronic converters were developed for integrating the photovoltaic (PV) arrays and utility grid. Inverters are needed to convert the direct current electricity produced by the PV array into alternating current electricity required for loads [2].

Kapil Jain, Pradyumn Chaturvedi (2012) suggested the elementary concept of multilevel converter to achieve higher power to use a series of power semiconductor switches with several lower voltage dc source to perform the power conversion by synthesizing a staircase voltage waveform [3].

Nasrudin A. Rahim, Krismadinata Chaniago, JeyrajSelvaraj (2011) proposed that a novel power conversion structure for grid-connected photovoltaic applications is presented [4].

Divya Subramanian, Rebiya Rasheed (2013) suggested that multilevel inverters include an array of power semiconductors and capacitor voltage sources, the output of which generate voltages with stepped waveforms. The commutation of the switches permits the addition of the capacitor voltages, which reach high voltage at the output, while the power semiconductors must withstand only reduced voltages [5].

K.Surya Suresh and M.Vishnu Prasad investigates the performance of a PV cell connected Multi Level Inverter topology. These MLI's are suitable in high voltage & high power application due to their ability to synthesize waveforms with better harmonic spectrum. The MCPWM Cascaded Multilevel inverter strategy enhances the fundamental output voltage and reduced Total harmonic distortion [6]. Thanuj kumar jala and G. Srinivasa rao (2012) suggested that a single-phase sevenlevel inverter for grid-connected photovoltaic systems, with a novel pulse width-modulated (PWM) control scheme. Three reference signals that are identical to each other with an offset that is equivalent to the amplitude of the triangular carrier signal were used to generate the PWM signals [7]. Chetanya Gupta, Devbrat Kuanr, Abhishek Varshney, Tahir Khurshaid, Kapil Dev Singh (2014) the effectiveness of the proposed strategy in terms of computational efficiency as well as the capability of the inverter to produce very low distorted voltage with low-switching losses. This research aims to extend the knowledge about the performance of different clamped multilevel inverter through harmonic analysis [8].

Loganathan., Prabhakaran, Indhumathy (2015) proposed that the solar fed cascaded multilevel inverter produces AC output voltage of desired magnitude and frequency. Since the inverter is used in a PV system, a optimization technique is used to obtain the switching angles to reduce the harmonic content [9]. Neelashetty Kashappa, Ramesh Reddy (2012) in the proposed scheme, control circuit is designed using 89C51 microcontroller to produce sinusoidal pulse width modulation(SPWM).The developed system can be operated at very high modulation frequencies of upto 200 KHz producing sustained output [10].

III. THEORY

Several multilevel topologies:-

1] Multilevel Diode Clamped/Neutral Point Inverter

Multilevel inverter (MLI) cascade inverter (cascaded inverters will be presented in a later chapter) with diodes blocking the source. This inverter was later derived into the Diode Clamped Multilevel Inverter; also called Neutral-Point Clamped Inverter (NPC) the NPCMLI topology the use of voltage clamping diodes is essential. A common DC-bus is divided by an even number, depending on the number of voltage levels in the inverter, of bulk capacitors in series with a neutral point in the middle of the line.

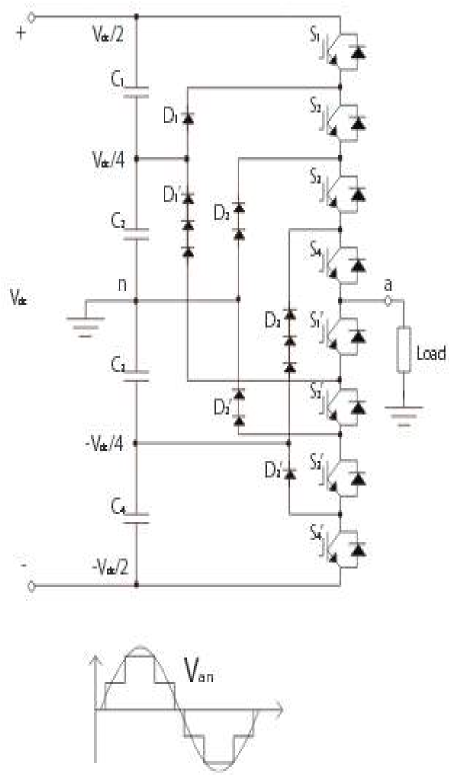

Fig.1 One phase-leg for a two-level NPC Inverter

Diode clamped multilevel inverters use clamping diodes in order to limit the voltage stress of power devices. It was first proposed in 1981 by Nabae, Takashi and Akagi and it is also known as neutral point converter. A k level diode clamped inverter needs ($2k$ – 2) switching devices, (k – 1) input voltage source and (k – 1) (k – 2) diodes in order to operate. *Vdc* is the voltage present across each diode and the switch.

<u>Advantages of Diode Clamped Multilevel Inverters</u>

- Capacitance of the capacitors used is low.
- Back to back inverters can be used.
- Capacitors are pre charged.
- At fundamental frequency, efficiency is high.

<u>Applications of Diode Clamped Multilevel Inverters</u>

- It is used when a high voltage Dc and Ac transmission lines are interfaced.
- For variable speed control of high power drives.
- Static variable compensation.

2] Multilevel Capacitor Clamped/Flying Capacitor Inverter, CCMLI
3] Cascaded Multicell Inverter, CMC
4] Generalized P2-cell Multilevel Inverter, GML
5] Reversing Voltage Multilevel Inverter, RVMLI
6] Modular Multilevel Inverter, M2I
7] Generalized Multilevel Current Source Inverter, GMCS

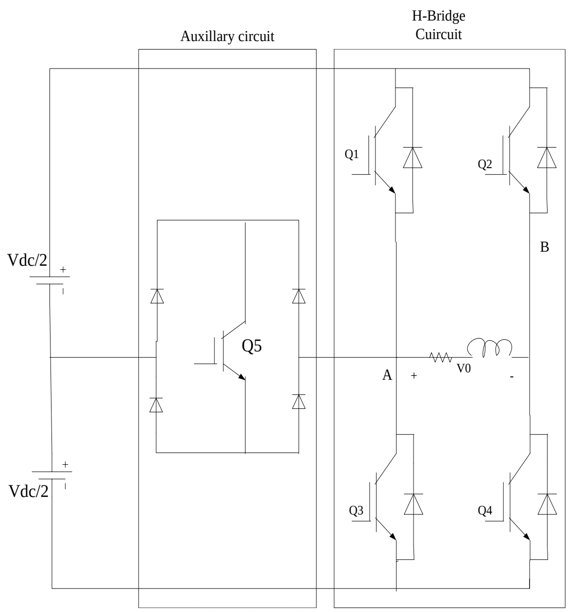

Figure 2. Topology of 5-level multilevel inverter.

TABLE I. THE SWITCHES ON-OFF CONDITION FOR 5-LEVEL MULTILEVEL INVERTER

Output Voltage	Q1	Q2	Q3	Q4	Q5
+Vdc	1	0	0	0	1
+Vdc/2	0	0	0	1	1
0	0	0	1	1	0
-Vdc	0	1	0	0	1
-Vdc/2	1	0	0	1	0

Note: “1” for ON. “0” for OFF

III. MODULATION TECHNIQUE

A. PWM Modulation Technique for 5-level Multilevel Inverter

The modulation technique used in this inverter topology is sinusoidal pulse width modulation (SPWM) technique. The principle is to generate gate signal by comparing a triangular carrier signal with two reference (sinusoidal) signals, which having same frequency and in phase, but different offset voltages as shown in Figure 1[2].

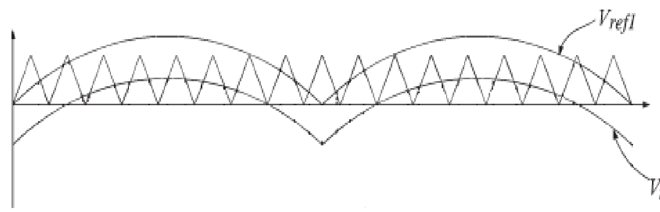

Figure 3. PWM switching signal generation for 5-level multilevel inverter.

According to the amplitude of the voltage reference, V*ref*, the operational interval of each mode varies within a certain period. The modes are separated as

Mode 1: $0 < \omega t \leq \Theta_1 \,\&\, \Theta_2 < \omega t \leq \pi$
Mode 2: $\Theta_1 < \omega t \leq \Theta_2$
Mode 3: $\pi < \omega t \leq \Theta_3 \,\&\, \Theta_4 < \omega t \leq 2\pi$
Mode 4: $\Theta_3 < \omega t \leq \Theta_4$

The phase depends on the modulation index. The modulation index of the proposed five-level PWM inverter is defined as

$$M = \frac{Am}{2Ac}$$

where A_M is the peak value of reference voltage and A_C is the peak value of carrier wave.

IV. Real Time Hardware Implantation been Tested in Simulation

The general block diagram of a multilevel inverter fed by pulse generator is shown in Figure. The ac supply is fed to rectifier which converts alternating current (AC) and additional source of solar for bleaching. The dc supply sends the gate pulses to the driver circuit through pulse generator. The battery source is fed to cascaded multilevel inverter and load and various preface result analyzing.

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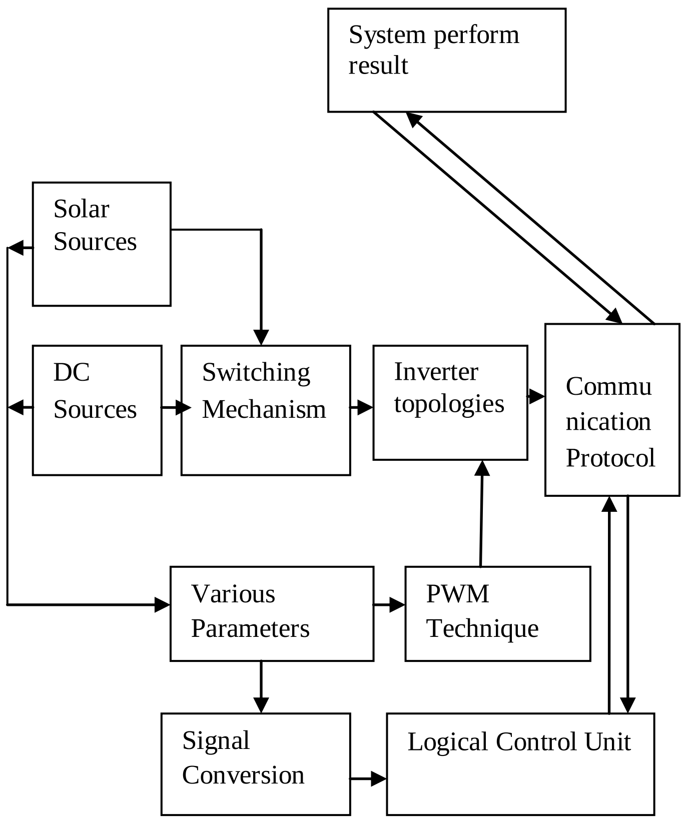

Fig.4 Simple hardware construction diagram

V. FFT ANALYSIS FOR THD

- The harmonics distortion principally comes from Nonlinear-Type Loads.
- The application of power electronics is causing increased level of harmonics due to switching.
- Harmonic distortion can cause serious failure/damage problem.
- Harmonics are important aspect of power operation that requires Mitigation.
- Over-Sizing and power filtering methods are commonly used to limit overheating effects of sustained harmonics.

VI.CONCLUSION

The use of multilevel inverter in PV system was accepted in power system since it gave a lot of advantages. More number of levels of multilevel inverter will give better performance in the system. In this paper, from the simulations and the results, 5-level multilevel inverter had given more efficient performance in terms of the power factor, THD and its efficiency. It also is more suitable for the purpose of integrating PV arrays and grid system. By controlling the modulation index, the desired number of level of the inverter output voltage can be achieved. Multilevel inverter offers improved output voltage and lower THD. It is also more suitable for the purpose of integrating PV arrays and grid system.

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I would like to express my gratitude towards all the people who have contributed precious time and efforts for helping me in my project. I am thankful to my guide Prof. M.J. Katira for his guidance and support for this paper. I owe a great to my parents for their continuous encouragement and moral support.

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TECH-CHRONICLE
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Power System Stability Enhancement Of Various IEEE Bus System Using SSSC

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***Abstract* – In this paper we investigate the controlling and enhancing power flow in a transmission line using a Static Synchronous Series Compensator (SSSC). The Static Synchronous Series Compensator is used to investigate the device in controlling active and reactive power as well as damping power system oscillations in transient mode. The SSSC device is equipped with a SOURCE ENERGY to absorb or supply the active and reactive power to or from the line. Various IEEE bus system have been stabilized using this FACTS device. The results are obtained by simulating the various power system in MATLAB/SIMULINK.**

***Keywords*– static synchronous series compensator(SSSC), FACTS, active and reactive power, IEEE bus system, Voltage Source Converter(VSC).**

I. INTRODUCTION

Generally, nowadays a greater demand has been placed on the transmission network. The increase in demands will rise because of increasing number of non utility generators and heightened competition utilities. These utilities needs to use their power transmission system more effectively to improve utilization degree. To reduce the effective reactance of lines by series compensation is a direct approach to improve transmission capability. For long transmission line the power transfer capability is limited because of stability consideration.

In this article for stability improvement we investigate the Static Synchronous Series Compensator (SSSC), FACTS device controller for its performance. FACTS devices contain a solid state voltage source converter (VSC) it will generate the control to alter the current at fundamental frequency. When the injected voltage is kept in quadrature with the line current, to emulate the inductive or capacitive reactance so as to influence the power flow through transmission lines. The primary purpose of a SSSC is to control the power flow in steady state, and it can also improve the stability of the power.

II. LITERATURE REVIEW

Successful operation of a power system depends largely on the ability to provide reliable and uninterruptible service to the load. The continuous demand in electric power system network has caused the system to be heavily loaded leading to voltage instability. The project describe the active approach series line compensation, in which static voltage sourced converter, is used to provide controllable series compensation, in which static voltage sourced converter, is used to provide controllable series compensation. This compensator is called as Static Synchronous Series Compensator (SSSC). Some of the research work and literature are as given below.

S Arun Kumar, C Easwarlal, M Senthil Kumar (2012) proposes the enhancement of voltage stability using Static Synchronous Series Compensator (SSSC). The continuous demand in electric power system network has caused the system to be heavily loaded leading to voltage instability. Under heavy loaded conditions there may be insufficient reactive power causing the voltages to drop. This drop may lead to drops in voltage at various buses. The result would be the occurrence of voltage collapse which leads to total blackout of the whole system. Flexible AC transmission systems (FACTS) controllers have been mainly used for solving various power system stability control problems. In this study, a Static Synchronous Series Compensator (SSSC) is used to investigate the effect of this device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The PI controller is used to tune the circuit and to provide the zero signal error. The dynamic performance of SSSC is presented by real time voltage and current waveforms using MATLAB software for IEEE 4 bus system[1].

M. Faridi, H. Maeiiat, M. Karimi, P. Farhadi and H. Moseleh (2011) proposed a Static Synchronous Series Compensator (SSSC) is used to investigate the effect of the device in controlling active and reactive powers as well as damping power system oscillations in transient mode. The SSSC equipped with a source of energy in the DC link can supply or absorb the reactive and active power to or from the line[2].

Abido M. A. (2009), proposed power demand has increased substantially while the expansion of power generation and transmission has been severely limited due to limited resources and environmental restrictions. As a consequence, some transmission lines are heavily loaded and the system stability becomes power transfer limiting factor. Flexible AC transmission systems (FACTS) controllers have been used for solving various power system steady state control problems. However, latest studies shows that FACTS controllers could be employed to enhance power system stability in addition to their main function of power flow control[3].

L. Gyugyi (1994), proposed a novel approach in which solid state synchronous voltage sources are employed for the dynamic compensation an real time control of power flow in the transmission system[4].

L. Gyugyi, C. D. Schauder and K. K. Sen (1997), proposed an active approach to series line compensation in which a synchronous voltage source implemented by a gate turn off thyristor based voltage source inverter is used to provide controllable series compensation. This compensator called Static Synchronous Series Compensator (SSSC) can provide controllable compensating voltage over an identical capacitive and inductive range independently of the magnitude of the line current. It is immune to classical network resonances. In addition to reactive compensation with an external DC power supply it can also compensate the voltage drop across the resistive component of line impedance [5].

Kalyan K. Sen (1998), describes the theory and the modeling of the flexible alternating current transmission systems (FACTS) device, namely, Static Synchronous Series Compensator (SSSC) using an Electromagnetic Transient Program (EMTP) simulation package. The SSSC a solid state voltage source inverter coupled with a transformer, is connected in series with a transmission line. An SSSC injects an almost sinusoidal voltage of variable magnitude in series with a transmission line. This injected voltage is in quadrature with line current, thereby emulating an inductive or a capacitive reactance in series with transmission line. The emulated variable reactance influences the electric power flow in the transmission line [6].

Sandeep Gupta, R. K. Tripathi (2010), proposed a review on the research and developments in voltage stability improvement by using FACTS controller [7].

H. Taheri, S. Shahabi, Sh. Taheri and A. Gholam (2009), proposed the problem of controlling and modulating power flow in transmission line using a SSSC [8].

Laszlo Gyugyi and Narain G. Hingorani, provides the detail study of the flexible AC transmission system (FACTS) devices and also comparison of each device [9].

Muhammad Harunur Rashid, provides detail study of electronic devices for our study we will refer to PI controller and various PWM techniques [10].

III. STRUCTURE OF SSSC

Basically the SSSC consisting of the converter with a semiconductor devices having turn off capability to couple with transformer and capacitor. The converters are connected to a power system through a coupling transformer. In that the DC capacitor deliver or provides a DC voltage support for the converter to function and operate as energy storage element. SSSC injects a voltage in series with transmission lines through the series transformer. It is connected in series with the transmission line.

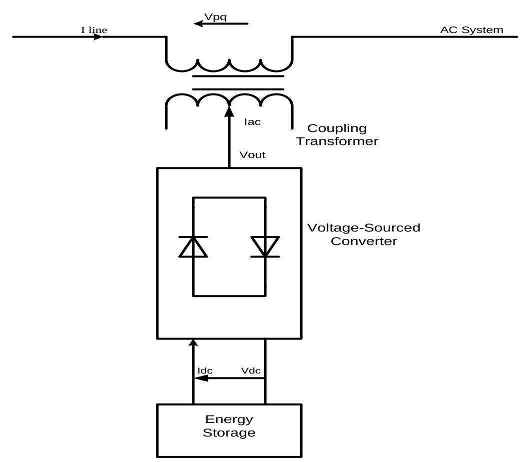

*Fig.1.*Functional Model of SSSC.

The Fig.1 shows the functional model of SSSC where the dc capacitor has been replaced by an energy storage device such as a high energy battery installation to allow active as well as reactive power exchanges with the AC system. The SSSC output voltage phase displacement of the inserted voltage Vpq, with respect to the transmission line current Iline, to determines the exchange of the real and reactive power with AC system.

IV. CONTROL SYSTEM OF SSSC

Fig.2 shows single line diagram of a simple transmission system with an inductive reactance, XL, connecting sending end voltage, VS, and a receiving end voltage, Vr respectively.

SSSC is similar to the variable reactance because the injected voltage and current to the model circuit by this devices are changing depending upon system condition. To respond to the dynamic and transient modifications created in design, SSSC utilizes the series converter.

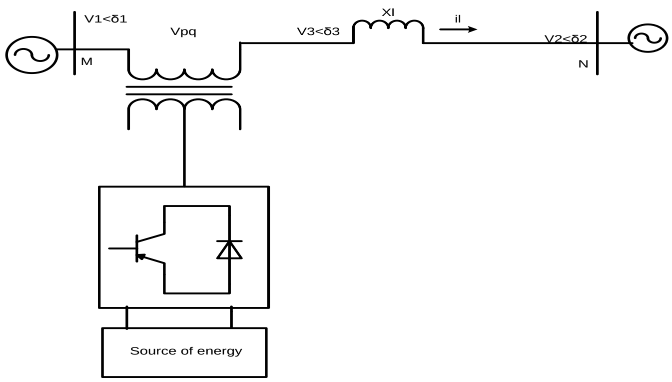

Fig.2. Simple Transmission Line with SSSC

One of the port is connected to the AC system and the other port is connected to a capacitor and battery within the system. We make a assumption that DC source is acting like battery.

If any dynamic changes occur in the system[3], SSSC circuit work according to the control model circuit, the energy of the battery will be converted to AC by converter and then the voltage is injected to the circuit to damp the changes appropriately.

The active and reactive power of the bus is calculated using their voltage and current in dq0 references and compared with the determined reference and the produced error signal is given to the PI controllers. We adjust the parameters of PI controller, trying to achieve zero signal error, so that power can follow through the reference powers precisely. Then the output of the controllers are transformed to abc reference voltage and given to the PWM.

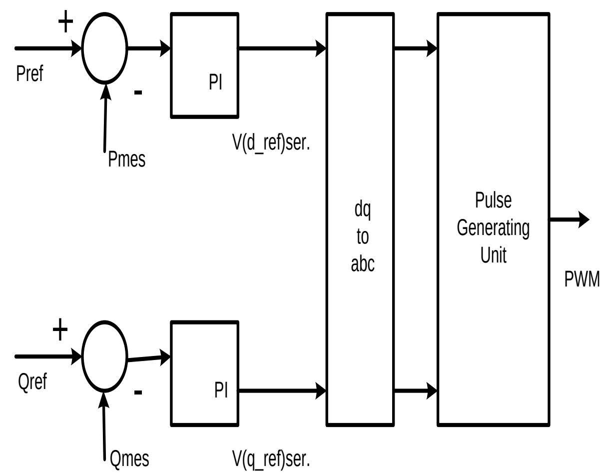

*Fig.3.*Control Scheme of SSSC

V. ADVANTAGES

The various advantages of Flexible AC Transmission Systems (FACTS) devices are:

a. Better utilization of existing transmission systems assets.

b. Increased transmission system reliability and availability.

c. Increased dynamics and transient grid stability and reduced of loop flows.

d. Increased quality of supply for sensitive industries.

VI. APPLICATION

The application of Static Synchronous Series Compensator (SSSC) is as follows:

i. Power flow control.

ii. Series compensation.

iii. Voltage Regulation for long transmission line.

iv. Economic operation.

v. Voltage stability.

VII. CONCLUSION

In our proposed method the SSSC is capable of controlling the flow of power at a particular point in the transmission line. Also it is observed that the SSSC to inject a fast changing active voltage in series with the line irrespective of the phase and magnitude of the line current. In this research SSSC is used to damp power oscillation on a grid power system. Comparison of various IEEE bus system with and without SSSC is been processed in this paper using MATLAB/SIMULINK environment.

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TECH-CHRONICLE
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Design and development of vertical axis wind turbine for micro-generation

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Abstract— ***In this paper we describes the micro power generation using vertical axis wind turbine. This paper describes briefly the design consideration of vertical axis wind turbine using magnetic levitation with the aim to start or work in very low speed of wind. The model has been develop and fabricated in this project. The aim is to make micro vertical axis wind turbine which can be installed at rural areas where the main problem is electricity crises. The effort has been taken to design the VAWT which can work at very low wind speed of 2 m/s.***

Keywords: Rooftop Turbine Ventilator (RTV), Wind Micro-Generation System, Magnetic Levitation, Low Self-Starting Speed.

I. INTRODUCTION

Renewable energy is generally electricity supplied from sources, such as wind power, solar power, geothermal energy, hydropower and various forms of biomass. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. This popularity has been bolstered by cutting edge research and ground breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Facts from the World Wind Energy Association estimates that by 2010, 160GW of wind power capacity is expected to be installed worldwide which implies an anticipated net growth rate of more than 21% per year.

This project focuses on the utilization of wind energy as a renewable source. In the United States alone, wind capacity has grown about 45% to 16.7GW and it continues to grow with the facilitation of new wind projects. The aim of this major qualifying project is to design and implement a magnetically levitated vertical axis wind turbine system that has the ability to operate in both high and low wind speed conditions. Our choice for this model is to showcase its efficiency in varying wind conditions as compared to the traditional horizontal axis wind turbine and contribute to its steady growing popularity for the purpose of mass utilization in the near future as a reliable source of power generation.

II. BACKGROUND KNOWLEDGE

As ongoing research and development of low-speed VAWT struggle to achieve greater efficiency. Several researchers suggest VAWT has advantages over HAWT in terms of omni-direction of kinetic-energy harnessing [4], [5], [9], [11], [12], [17], as it can collect concentration of wind-flow from any direction. Eriksson et al. suggest VAWT works better than HAWT for such rooftop positions and easier generator arrangement, where it can be arranged underneath its rotor [5]. Mertens recommends that VAWT is suitable and appropriate for roof-mounting upon buildings [14]. As Riegler suggests to use existing elevated structures to mount up the VAWT [12], then this can be retrofitted [18] onto existing instant rooftop structures. Ahmed states that VAWT can be linked to a rooftop ventilator in terms of rotor configuration and capability to accepting wind directly towards its rotation [13]. As Mertens remarks on alternative to produce wind energy close to points of uses [14]. Bhutta et al. suggest VAWT can be economical viable for remote zones away from grid transmission lines [4]. Allen et al. remark that micro-generation is a solution to transmission and distribution losses [1]. And Mithraratne suggests that distributed micro-generation systems can provide generation at the point of uses and lower major investments for grid transmissions [10]. Westerholm recommends power storage and distribution systems to provide wind power on demand for economic benefit, particularly in the absence of wind [9]. Even that, Khan et al. illustrate the use of motor-driven to keep rooftop ventilator rotating in the absence of wind [16]. Therefore, for the design of the turbine rotor, as to enable and prolong the turbine to turning as much hours for all year long. Nayar et al. point out that an ability to extract more power, is an ability to respond to wind perturbations [17]. Fernandes et al. site that it is downtime of wind turbines' gearbox failures that present a problem, this causes excessive repair and adds up operational costs [19]. Since, main causes of power loss in the gearbox indicate rotational friction loss in the gearing and bearing mechanisms [19]. To minimize that friction loss is to simplify the design of the direct-drive rotor. This may be improved by low friction and torque properties from magnetic bearing [2]. With various research and development being focused on, these must be coupled along with current wind generation situation in country. First, the country's average wind speed is under 4 m/s, whereas current installed HAWT capacity operates at beyond 8 m/s [8]. Secondly, wind intermittent resource in country causes HAWT to be unable to reach its designated performance and barely generate electricity for some hours in a year [8].

III. DESIGN PARAMETERS OF MICRO VERTICAL AXIS WIND TURBINE

A. Swept area

The swept area is the section of air that encloses the turbine in its movement, the shape of the swept area depends on the rotor configuration, this way the swept area of an HAWT is circular shaped while for a straight-bladed vertical axis wind turbine the swept area has a rectangular shape and is calculated using:

$$S = 2\ RL$$

Considering R as 310mm and length of blade as 300mm we get

$$S = 2x0.155x0.300$$

$$S = 0.093m2$$

where S is the swept area [m2], R is the rotor radius [m], and L is the blade length [m]. The swept area limits the volume of air passing by the turbine. The rotor converts the energy contained in the wind in rotational movement so as bigger the area, bigger power output in the same wind conditions.

B. Power and power coefficient

The power available from wind for a vertical axis wind turbine can be found from the following formula:

$$Pw= \tfrac{1}{2}\ \rho\ S\ Vo3$$

Where, Vo is the velocity of the wind [m/s] and ρ is the air density [kg/m3], the reference density used its standard sea level value (1.225 kg/m^3 at 15ºC), for other values the source (Aerospaceweb.org, 2005) can be consulted. Note that available power is dependent on the cube of the airspeed. The power the turbine takes from wind is calculated using the power coefficient:

Cp =Captured mechanical power by blade

Available power in wind Cp value represents the part of the total available power that is actually taken from wind, which can be understood as its efficiency. This project has been carried out to produce the output of 15watt power maximum

The theoretical calculation for 6m/s wind is as follows

$$Pw = \tfrac{1}{2}\ \rho\ S\ Vo3$$

$$= 1/2x1.225x0.093x63$$

$$Pw = 12.25\ watt$$

Hence from above Power available (Pw) at 6m/s we get the output of 12.25 watt. Considering the efficiency of 20% we get power captured as 2.70 watt 20m/s.

$$Pw = \tfrac{1}{2}\ \rho\ S\ Vo3$$

$$= 1/2x\ 1.225X0.093x\ 123$$

$$Pw = 98.43$$

Again considering efficiency of 15-20% we get power captured as 15 watt appx.

C. Tip Speed Ratio

The power coefficient is strongly dependent on tip speed ratio, defined as the ratio between the tangential speed at blade tip and the actual wind speed.

TSR = Tangential speed at blade speed = Rw

Actual wind speed Vo

where ω is the angular speed [rad/s], R the rotor radius [m] and Vo the ambient wind speed [m/s]. Each rotor design has an optimal tip speed ratio at which the maximum power extraction is achieved.

where ω is the angular speed [rad/s], R the rotor radius [m] and Vo the ambient wind speed [m/s]. Each rotor design has an optimal tip speed ratio at which the maximum power extraction is achieved.

D. Blade chord

The chord is the length between leading edge and trailing edge of the blade profile. The blade thickness and shape is determined by the airfoil used, in this case it will be a NACA airfoil, where the blade curvature and maximum thickness are defined as percentage of the chord.

Chord length 4.5 cm.

E. Number of blades

The number of blades has a direct effect in the smoothness of rotor operation as they can compensate cycled aerodynamic loads. For easiness of building, five blades have been contemplated. The solidity σ is defined as the ratio between the total blade area and the projected turbine area. It is an important nondimensional parameter which affects self-starting capabilities and for straight bladed VAWTs is calculated

$$\sigma = N c$$

$$R = 5x45$$

$$\sigma = 1.45$$

Where, N is the number of blades, c is the blade chord, L is the blade length and S is the swept area, it is considered that each blade sweeps the area twice. Solidity determines when the assumptions of the momentum models are applicable, and only when using high $\sigma \geq 0.4$ a self starting turbine is achieved. In this project with contemplating five blades solidity of 1.45 has been considered for self starting property of the project.

IV. MATERIAL SELECTION

SR.NO	Component	Material
1.	Blade	Aluminum Alloy
2.	Flange	Mild Steel
3.	Stand	Mild Steel
4.	Rotor	Mild Steel

Also, the material selection of very light material has been worked out for self starting consideration in turbine.

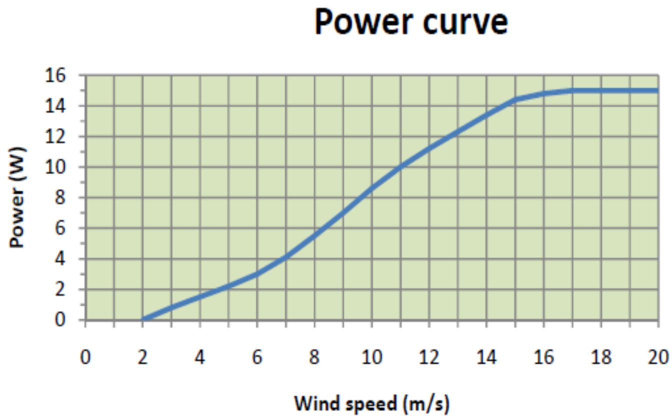
V. PERFORMANCE AND BASIC DESIGN PARAMETER OF VERTICAL AXIS WIND TURBINE.

Performance	
Rated power	10W @10m/s
Peak power	15W
Start-up wind speed	2m/s
Working wind speed	2-20m/s
Survival wind speed	35m/s
Rotor	
Rotor diameter	310mm
Swept area	0.1m2
Blade	5pcs alumimium alloy
Blade length	300mm
Shell material	Erosion resistant aluminum
Rated RPM	400

VI. TESTING RESULT

The designed model has been tested at different speed of wind. During the testing model was loaded to output of 12V. Power generated at different wind speed has been noted during the testing of the model and following results has been achieved.

In testing of the model rotation at different speed of wind was also noted.



VII. CONCLUSION

The design and development of micro vertical axis wind turbine has been carried by considering basic design consideration like solidity, number of blade, chord length of blade etc. After the input design parameters decided conceptual model has been designed based on design parameters and CAD model were developed. The all emphasis during the development was to develop the model which can generate the output even at low wind speed. Towards this aim parts were developed and fabricated with very light material.

Testing of the model was the main area towards the success of project and outcome of the progress of input decided while designing and development of the product.

In This Project We Succeed To Achieve The Best Result Of 12v And 14 Watt Power Output At 15 M/S Speed Of Wind. Also, The Product Start Rotating At Speed Of 2 M/S And Produced 2 Watt Power At Speed Of 4 M/S. Output Was Given Low Energy Led Panel Light And Given Satisfactory Output.

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TECH-CHRONICLE
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Mitigation Measures in Order to Minimize the Impact of Solar Storms on Power Grid

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Abstract- Solar storms generally produce disturbances that affects on Earth and environmental like electrical power blackouts, communication outages, rerouting, loss of a few satellites in the nights sky from a large solar storm. Solar flares can also cause damage and disturbances to satellites & power grids. Warning of solar storms is provide 30 minutes ago to satellite operators, power industry operator, and communications operator that solar storms can cause damage.

Keywords: Solar flare, solar storms, GIC, power grids

I) **Introduction:**

Imagine world without electricity. Everything from communication, banking, transactions to basic necessities like food and water needs and depends on electricity.

Another threat to electric power is geomagnetic storms disturbances caused by solar storms in upper layers of atmosphere that induces currents in conductors on the Earth’s surface, such as transmission lines. Thus this current can cause overload the grid to have voltage collapse, extra-high voltage on transformers. The repairing cost of this is very much and time required for replacement and repair of equipments require week or month thus blackout will be for long period.

Solar flares generally originate from solar regions which are associated with sunspots. Geomagnetic effects occurs when the radiations and flare into interplanetary space away from the sun and toward the earth.

The earth's magnetic field then undergoes fluctuations. These fluctuations can induce currents within conductive material on earth or near the earth's surface like soil, transmission lines, and ocean water. These disturbances are known as geomagnetic disturbances. The difference in time between the flare and disturbance can be one to four days.
Recent information about solar storm producing Geomagnetically-Induced Currents (GIC). Scientists warned that the GIC from sunspots and solar flares could cause significant damage to the power grid, telecommunication system, satellites and other devices.

Solar Storms:

Solar flares are caused by Solar Storms and Coronal Mass Ejections (CME). The source of solar flares are sun, sunspots where large amounts of energy are released in the form of X-ray radiation and fast travelling plasma particles like electrons and protons. Solar flares can trigger coronal mass ejections (CME) where plasma particles escape the sun’s atmosphere and it reach Earth in less than two days. CME distorts the magnetic field and plasma particles penetrate the upper layer of the atmosphere near the geomagnetic North and South Poles which creates geomagnetic storms.

II) Space Weather:

Space weather storms is caused by the activity of Sun that effect on Earth. Solar storms can impact the technology like satellites, electric power grids, Transmission lines. Space weather is a caused by the behavior of Sun, magnetic field and atmospheric. Various phenomena originate from the Sun that result in space weather storms.

Explosions on the Sun are
1) Solar Particles
2) Solar Flares
3) Coronal Mass Ejections (CME)
Sun also emits continuous radiation in the form of charged particles that make plasma of the solar wind.

a) Solar Particle

Solar particle release charged particles like protons, electrons which accelerate to large fractions of the speed of light.

b) Solar Flare :

Solar Flare are explosions on Sun. A flare appears like sudden and intense brightening on Sun. Electromagnetic emission produced during flares travels at speed of light.

C) **Coronal Mass Ejections:**
Coronal Mass Ejections are explosive outbursts of plasma from the Sun. CME contains particle radiation and powerful magnetic fields. In opposition to solar flares, CME are not bright and it takes hours to erupt from the Sun, and takes 1-4 days to travel to Earth.

Space Weather & Solar Cycle:
The number of sunspots on the surface of the Sun increases and decreases in solar cycles. Solar Minimum is when number of sunspots are less while solar maximum occurs when number of sunspots are more. When sunspots are in more than. Thus this energy creates changes in Earth's atmosphere.

Sunspots:
Sunspots are dark. A sunspot size is many times larger than the size of the Earth. Sunspots can persist for weeks and even months before erupting or dissipating. Sunspots occur when strong magnetic fields emerge through the solar surface. This sunspots appears as a dark spot on the Sun. As Sun rotates, Sunspots on its surface appear to move from left to right. One complete rotation of Sun is completed in 27 days.

IMPACT OF SPACE WEATHER:

Space Weather impact is on following

1) **Electric Power:**
Currents are induced in power lines or transmission lines. Damage is caused by these induced current on power grid or transmission lines.

2) **Aviation:**
Space Weather Storms can cause damage to tele-communications, hazards to passengers, satellites and other electronic systems.

3) **Human Space Exploration:**
Energetic particles present can cause health hazard to astronauts as well as threats to electronic systems.

4) **Satellite Operations:**
Energetic particles penetrates electronic components, can cause disturbances in data, signals and command to system.

5) **Surveying:**
Magnetic field changes associated with geomagnetic storms directly affect operations that use the Earth's magnetic field for guidance, such as magnetic surveys.

6) **Tele-Communications:**
Tele-Communications system is affected by space weather. High frequency radio communications are more affected because frequency band depends on reflection.

Impact of Solar Storms on Electrical Power Transmission Grids & Transformers:

The root cause of this phenomenon is not fully understood there has been a significant research on the effects that geoelectric fields and geomagnetically-induced currents have on transformers and high voltage power lines. Some of the possible transmission lines related risk factors may include directional orientation of transmission grid lines.

Space Weather Prediction:

A space weather forecast is done with analysis of the Sun. Sunspot groups can be many times the size of Earth and contain magnetic structures. Forecasters will predict the probability of a solar flare. Forecasters use a number of computer models to determine effects of solar events on Earth's atmosphere. Based on a thorough analysis of current conditions, compared to past conditions, forecasters use numerical models to predict space weather on times scales ranging from hours to weeks.

Solar radiation storms can last from a few hours to days, depending on the magnitude of the eruption. Solar radiation storms can occur at any time during the solar cycle.

Geomagnetic Storms
Geomagnetic storms, strong disturbances to Earth's magnetic field, pose problems for many activities, technological systems, and critical infrastructure. The Earth's magnetic field changes in the course of a storm as the near-Earth system attempts to adjust to the jolt of energy from the Sun carried in the solar wind. CMEs and their effects can disturb the geomagnetic field for days at a time. The most visible attribute of a geomagnetic storm is the aurora, which becomes brighter and moves closer to the equator. This heightened aurora signals the vigorous electrodynamic processes at play as they respond to the burst of energy.

Geomagnetic storms usually last a few hours to days. The strongest storms may persist for up to a week. A string of CMEs may cause prolonged disturbed periods related to the additional energy being pumped into Earth's magnetic field.

The frequency of geomagnetic storms, in general, depends on where we are in the solar cycle–with most storms occurring near solar maximum; however, these storms are also common in the declining phase due to high speed solar wind streams.

Geomagnetic storms induce currents that can have significant impact on electrical transmission equipment. Electric power companies have procedures in place to mitigate the impact of geomagnetic storms.

Solar storm impact on Electric Power Supply System:

Geomagnetic storm can trigger geomagnetically induced currents (GIC) which enter the power grid through grounding cables. If a GIC is strong enough, it can cause damage to important utility components such as high-voltage transformers. The strength of a GIC is not only determined by the amplitude of the geomagnetic storm and the geomagnetic latitude of the region under consideration. GIC strength depends on the power line's length, resistance. Important is to note the between a normal power outage caused and a GIC-induced outage. Replacing high-voltage transformers is a costly and time-consuming task. The typical production time of a customized high-voltage transformer is one year.

Mitigation Measures:

There are two strategies for mitigating impacts of solar storms on power grids, Effective and efficient mitigation would require both strategies. Currently, warning times for geomagnetic storms are approximately one hour, but the forecasting of regional strength and duration of impact is only in its beginnings.

The Electrical grid is interconnected for transmission of power over a large network. Geomagnetically Induced Currents from solar storms is classified as duration of greater than 1 second and is capable of causing damage to large transformers. Operational and grid management mitigation strategies may include disconnecting of power generating capacity from the grid to reduce the risk.

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TECH-CHRONICLE
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Performance Evaluation of STATCOM Connected to Renewable Energy Source

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Abstract— **A Power quality problem is an occurrence of nonstandard voltage, current or frequency that results in a failure or a misoperation of end user equipments. Utility distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and service interruptions which can cost significant financial losses. With the increase in load demand, the Renewable Energy Sources (RES) are increasingly connected in the distribution systems which utilizes power electronic Converters/Inverters. This paper presents a novel control strategy for achieving maximum benefits from these grid-interfacing inverters using the closed loop fuzzy logic control, when installed in 3-phase 4-wire distribution systems. The inverter is controlled to perform as a multi-function device by incorporating active power filter functionality. The inverter can thus be utilized as: 1) power converter to inject power generated from RES to the grid, and 2) shunt APF to compensate current unbalance, load current harmonics, load reactive power demand and load neutral current. All of these functions may be accomplished either individually or simultaneously. This new control concept is demonstrated with extensive MATLAB/Simulink.**

Index Terms—Active power filter (APF), distributed generation (DG), distribution system, grid interconnection, power quality (PQ), renewable energy, Photo Voltaic (PV) System.

I.INTRODUCTION

Renewable energy systems such as PV, solar thermal electricity such as dish-stirling systems, and WT are appropriate solar and wind technologies that can be considered for electric power generation at the distribution system level. Other renewable energy technologies, such as the solar central receiver, hydro-electric generation, geothermal, and large wind farms are normally connected to the grid at the sub-transmission or transmission level because of the higher power capacities of these types of systems. Due to increasing air pollution, global warming concerns, diminishing fossil fuels and their increasing cost have made it necessary to look towards Renewable Energy Sources (RES) as a future energy solution. Renewable Energy Sources are increasingly integrated at the distribution level due to increase in load demand which utilize power electronic converters. Due to the extensive use of power electronic devices, disturbances occur on the electrical supply network. These disturbances are due to the use of non-linear devices. These will introduce harmonics in the power system thereby causing equipment overheating, damage devices, EMI related problems etc. Active Power Filters (APF) is extensively used to compensate the current harmonics and load unbalance. Power quality is one of the most important topics that

electrical engineers have been noticed in recent years. Voltage sag is one of the problems related to power quality. This phenomenon happens continuously in transmission and distribution systems. During a voltage sag event, amplitude of the effective load voltage decrease from 0.9 of the nominal load voltage to 0.1 in very short time (less than one minute). Short circuit, transformer energizing, capacitor bank charging etc are causes of voltage sag. Voltage sag has been classified in 7 groups of A-G [1]. According to this classification most of voltage sags are companion with a phase angle jump (types C, D, F and G). Phase angle jump for power electronics systems such as ac-ac and ac-dc converters, motor drives etc is harmful [2]. Therefore, phase angle jump compensation is one of the voltage sag mitigation goals.

Generally, current controlled voltage source inverters are used to interface the intermittent RES in distributed system. Recently, a few control strategies for grid connected inverters incorporating PQ solution have been proposed. In [3] an inverter operates as active inductor at a certain frequency to absorb the harmonic current. But the exact calculation of network inductance in real-time is difficult and may deteriorate the control performance. A similar approach in which a shunt active filter acts as active conductance to damp out the harmonics in distribution network is proposed in [4]. In [5], a control strategy for renewable interfacing inverter based on – theory is proposed. In this strategy both load and inverter current sensing is required to compensate the load current harmonics. Here, the main idea is the maximum utilization of inverter rating which is most of the time underutilized due to intermittent nature of RES. It is shown in this paper that the grid-interfacing inverter can effectively be utilized to perform following important functions: 1) transfer of active power harvested from the renewable resources (wind, solar, etc.); 2) load reactive power demand support; 3) current harmonics compensation at PCC; and 4) current unbalance and neutral current compensation in case of 3-phase 4-wire system. Moreover, with adequate control of grid-interfacing inverter, all the four objectives can be accomplished either individually or simultaneously. The

PQ constraints at the PCC can therefore be strictly maintained within the utility standards without additional hardware cost.

Approximately 70 to 80% of all power quality related problems can be attributed to fault connections and/or wiring [2]. Power frequency disturbances, electromagnetic interference, transients, harmonics and low power factor are the other categories of PQ problems (shown in table 1) that are related to the supply and types of load [3].

Among these events, harmonics are the most dominant one. The effects of harmonics on PQ are specially described in [4]. According to the IEEE standard, harmonics in th epower system should be limited by two different methods; one is the limit of harmonic current that a user can inject into the utility system at the point of common coupling(PCC) and the other is the limit of harmonic voltage that the can supply to any customer at the PCC. DG interconnection standards are to be followed considering PQ, protection and stability issues [6].

II. SYSTEM DESCRIPTION

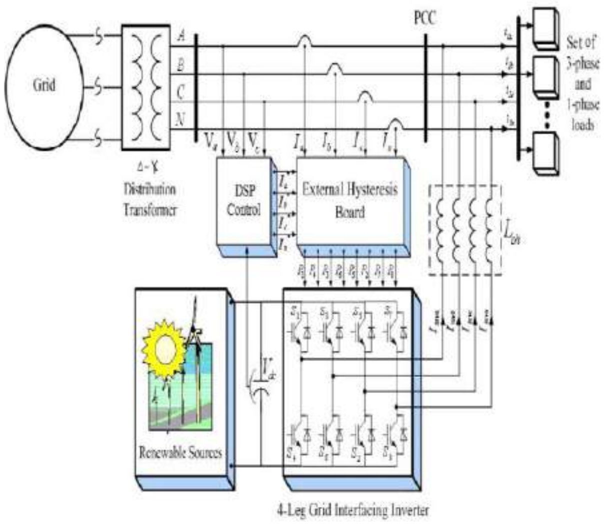

Fig. 1. Schematic of proposed renewable based distributed generation system.

The proposed system consists of RES connected to the dc-link of a grid-interfacing inverter as shown in Fig. 1. The voltage source inverter is a key element of a DG system as it interfaces the renewable energy source to the grid and delivers the generated power. The RES may be a DC source or an A source with rectifier coupled to dc-link. Usually, the fuel cell and photovoltaic energy sources generate power at variable low dc voltage, while the variable speed wind turbines generate power at variable ac voltage. Thus, the power generated from these renewable sources needs power conditioning (i.e., dc/dc or ac/dc) before connecting on dc-link [6]–[8]. The dc-capacitor decouples the RES from grid and also allows independent control of converters on either side of dc-link.

A. DC-Link Voltage and Power Control Operation

Due to the intermittent nature of RES, the generated power is of variable nature. The dc-link plays an important role in transferring this variable power from renewable energy source to the grid. RES are represented as current sources connected to the dc-link of a grid-interfacing inverter. Fig. 2 shows the systematic representation of power transfer from the renewable energy resources to the grid via the dc-link. The current injected by renewable into dc-link at voltage level Vdc can be given as

$$I_{\mathrm{dc1}} = \frac{P_{\mathrm{RES}}}{V_{\mathrm{dc}}} \tag{1}$$

Where PRES is the power generated from RES.

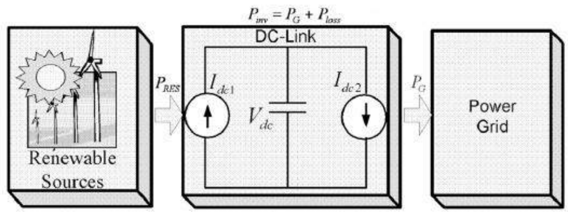

Fig. 2. DC-Link equivalent diagram.

The current flow on the other side of dc-link can be represented as,

$$I_{\mathrm{dc2}} = \frac{P_{\mathrm{inv}}}{V_{\mathrm{dc}}} = \frac{P_G + P_{\mathrm{Loss}}}{V_{\mathrm{dc}}} \tag{2}$$

Where P_{inv}, P_G and P_{Loss} are total power available at grid-interfacing inverter side, active power supplied to the grid and inverter losses, respectively. If inverter losses are negligible then $P_{RES} = P_G$.

B. Control of Grid Interfacing Inverter

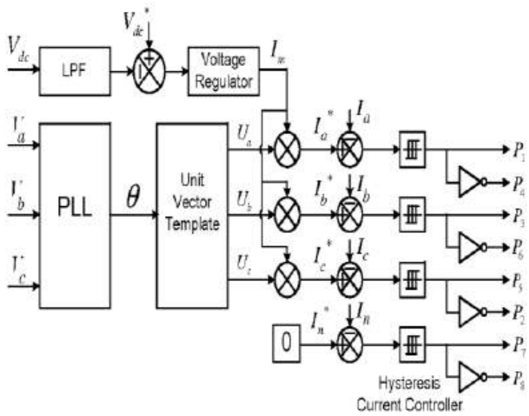

Fig. 3. Block diagram representation of grid-interfacing inverter control.

The control diagram of grid- interfacing inverter for a 3-phase 4-wire system is shown in Fig. 3. The fourth leg of inverter is used to compensate the neutral current of load. The main aim of proposed approach is to regulate the power at PCC during:

1) $P_{RES} = 0$; 2) $P_{RES} <$ Total load power (P_L) ; and 3) $P_{RES} > P_L$. While performing the power management operation, the inverter is actively controlled in such a way that it

always draws/ supplies fundamental active power from/ to the grid. If the load connected to the PCC is non-linear or unbalanced or the combination of both, the given control approach also compensates the harmonics, unbalance, and neutral current. The duty ratio of inverter switches are varied in a power cycle such that the combination of load and inverter injected power appears as balanced resistive load to the grid. The regulation of dc-link voltage carries the information regarding the exchange of active power in between renewable source and grid. Thus the output of dc-link voltage regulator results in an active current (Im). The multiplication of active current component (Im). With unity grid voltage vector templates (U_a,U_b, and U_c) generates the reference grid currents $(I_a^*, I_b^*, \text{and } I_c^*)$. The reference grid neutral current (I^*n) is set to zero, being the instantaneous sum of balanced grid currents. The grid synchronizing angle (θ) obtained from phase locked loop (PLL) is used to generate unity vector template as [9]–[11]

$$U_a = \mathrm{Sin}(\theta) \tag{3}$$

$$U_b = \mathrm{Sin}(\theta - \frac{2\pi}{3}) \tag{4}$$

$$U_c = \mathrm{Sin}(\theta + \frac{2\pi}{3}) \tag{5}$$

The actual dc-link voltage (V_{dc}) is sensed and passed through a first-order *low pass filter* (LPF) to eliminate the presence of switching ripples on the dc-link voltage and in the generated reference current signals. The difference of this filtered dc-link voltage and reference dc-link voltage (V^*_{dc}) is given to a discrete- PI regulator to maintain a constant dc-link voltage under varying generation and load conditions. The dc-link voltage error V_{dceer}(n) at nth sampling instant is given as:

$$V_{\mathrm{dcerr}(n)} = V^*_{\mathrm{dc}(n)} - V_{\mathrm{dc}(n)}. \tag{6}$$

The output of discrete-PI regulator at th sampling instant is expressed as

$$I_{m(n)} = I_{m(n-1)} + K_{PV_{\mathrm{dc}}}(V_{\mathrm{dcerr}(n)} - V_{\mathrm{dcerr}(n-1)}) + K_{IV_{\mathrm{dc}}} V_{\mathrm{dcerr}(n)} \tag{7}$$

Where K_{PVdc} = 10 and K_{IVdc} = 0.05 are proportional and integral gains of dc-voltage regulator. The instantaneous values of reference three phase grid currents are computed as

$$I_a^* = I_m \cdot U_a \tag{8}$$

$$I_b^* = I_m \cdot U_b \tag{9}$$

$$I_c^* = I_m \cdot U_c. \tag{10}$$

The neutral current, present if any, due to the loads connected to the neutral conductor should be compensated by forth leg of grid-interfacing inverter and thus should not be drawn from the grid. In other words, the reference current for the grid neutral current is considered as zero and can be expressed as

$$I_n^* = 0. \tag{11}$$

The reference grid currents (I^*a, I^*b,I^*c and I^*n) are compared with actual grid currents (Ia, Ib,Ic and In) to compute the current errors as

$$I_{\mathrm{aerr}} = I_a^* - I_a \tag{12}$$

$$I_{\mathrm{berr}} = I_b^* - I_b \tag{13}$$

$$I_{\mathrm{cerr}} = I_c^* - I_c \tag{14}$$

$$I_{\mathrm{nerr}} = I_n^* - I_n. \tag{15}$$

These current errors are given to hysteresis current controller. The hysteresis controller then generates the switching pulses (P_1 *to* P_8) for the gate drives of grid-interfacing inverter. The average model of 4-leg inverter can be obtained by the following state space equations

$$\frac{dI_{\mathrm{Inva}}}{dt} = \frac{(V_{\mathrm{Inva}} - V_a)}{L_{\mathrm{sh}}} \tag{16}$$

$$\frac{dI_{\mathrm{Invb}}}{dt} = \frac{(V_{\mathrm{Invb}} - V_b)}{L_{\mathrm{sh}}} \tag{17}$$

$$\frac{dI_{\mathrm{Invc}}}{dt} = \frac{(V_{\mathrm{Invc}} - V_c)}{L_{\mathrm{sh}}} \tag{18}$$

$$\frac{dI_{\mathrm{Invn}}}{dt} = \frac{(V_{\mathrm{Invn}} - V_n)}{L_{\mathrm{sh}}} \tag{19}$$

$$\frac{dV_{\mathrm{dc}}}{dt} = \frac{(I_{\mathrm{Invad}} + I_{\mathrm{Invbd}} + I_{\mathrm{Invcd}} + I_{\mathrm{Invnd}})}{C_{\mathrm{dc}}} \tag{20}$$

Where V_{Inva}, V_{Invb}, V_{Invc} and V_{Invn} are the three-phase ac switching voltages generated on the output terminal of inverter.

These inverter output voltages can be modeled in terms of instantaneous dc bus voltage and switching pulses of the inverter as

$$V_{\mathrm{Inva}} = \frac{(P_1 - P_4)}{2} V_{\mathrm{dc}} \tag{21}$$

$$V_{\mathrm{Inva}} = \frac{(P_3 - P_6)}{2} V_{\mathrm{dc}} \tag{22}$$

$$V_{\mathrm{Inva}} = \frac{(P_5 - P_2)}{2} V_{\mathrm{dc}} \tag{23}$$

$$V_{\text{Inva}} = \frac{(P_7 - P_8)}{2} V_{\text{dc}} \tag{24}$$

Similarly the charging currents V_{Invad}, V_{Invbd}, V_{Invcd} and V_{invnd} on dc bus due to the each leg of inverter can be expressed as

$$I_{\text{Invad}} = I_{\text{Inva}}(P_1 - P_4) \tag{25}$$

$$I_{\text{Invbd}} = I_{\text{Invb}}(P_3 - P_6) \tag{26}$$

$$I_{\text{Invcd}} = I_{\text{Invc}}(P_5 - P_2) \tag{27}$$

$$I_{\text{Invad}} = I_{\text{Inva}}(P_7 - P_8) \tag{28}$$

The switching pattern of each IGBT inside inverter can be formulated on the basis of error between actual and reference current of inverter, which can be explained as:

If $I_{Inva} < (I^*_{Inva} - h_b)$, then upper switch S_1will be OFF (P_1 =0) and lower switch S_4 will be ON (P_4=1) in the phase "a" leg of inverter.
If $I_{Inva} > (I^*_{Inva} - h_b)$, then upper switch S_1 will be ON (P_1 =1) and lower switch S_4 will be OFF (P_4=0) in the phase "a" leg of inverter Where h_b is the width of hysteresis band. On the same principle, the switching pulses for the other remaining three legs can be derived.

III.RENEWABLE ENERGY RESOURCES

Renewable energy resources are the ones that are persistently available and renewing itself with the time. Industrialization and increasing world population has remarked the use of renewable energy resources. Solar power, wind power, biomass, tide power, wave power, geothermal power is known ones.

A) Solar Power

Solar panels are the medium to convert solar power into the electrical power. Solar panels can convert the energy directly or heat the water with the induced energy. PV (Photo-voltaic) cells are made up from semiconductor structures as in the computer technologies. Sun beam is absorbed with this material and electrons are emitted from the atoms that they are bounded. This release activates a current. Photovoltaic is known as the process between beam absorbed and the electricity induced. With a common principle and individual components, solar power is converted into the electric power. Solar batteries are produced by waffling p-n semiconductors. A current-volt characteristic of the PV in the darkness is very similar to that of diot. Under beam, electron flow and current occurs. In closed-loop, PV current passes through the external load. While in open-loop, the current completes the circuit through the p-n diode structure [4]. Solar batteries can be represented with an equivalent circuit of a current source, a resistor and a diot in parallel, and an external load-resistor [5], as seen in Figure 4.

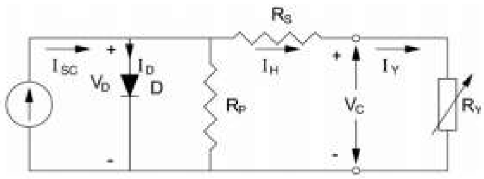

Fig. 4. Equivalent circuit of solar battery

It is possible to insert AC-DC converter, charger, accumulator, extra power source, and controller depending on the design differences in operational and functional specifications [6]. Solar system could be categorized into two types: Line-independent systems: These are established in absence of line electricity to provide electricity. Since the current in these systems are DC and it must be also available overnight, energy is stored in accumulators, DC-Batteries. In case of AC Supply requirements for the appliances, it is possible to use DC-AC inverter [6]. Line-dependent systems: These systems do not need DC Batteries, since the energy is served to the demand with the help of an inverter. Line electricity is being switched in use in case of insufficient sun beam [6].

B) Wind Power

Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 2-3 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is used to feed both energy production and consumption demand, and transmission lines in the rural areas. Wind turbines can be classified with respect to the physical features (dimensions, axes, number of blade), generated power and so on. For example, wind turbines with respect to axis structure: horizontal rotor plane located turbines, turbines with vertical or horizontal spinning directions with respect to the wind. Turbines with blade numbers: 3-blade, 2-blade and 1- blade turbines.
On the other hand, power production capacity based classification has four subclasses [7].

- Small Power Systems
- Moderate Power Systems
- Big Power Systems
- Megawatt Turbines

C) Design and Implementation of Domestic Solar-Wind Hybrid Energy System

Hybrid systems are the ones that use more than one energy resources. Integration of systems (wind and solar) has more influence in terms of electric power production. Such systems are called as "hybrid systems". Hybrid solar-wind applications are implemented in the field, where all-year energy is to be consumed without any chance for an interrupt. It is possible to have any combination of energy resources to supply the energy demand in the hybrid systems, Such as oil, solar and wind. This project is similar with solar power panel and wind turbine power. Differently, it is only an add-on in the system.

Photovoltaic solar panels and small wind turbines depend on climate and weather conditions. Therefore, neither solar nor wind power is sufficient alone. A number of renewable energy expert claims to have a satisfactory hybrid energy resource if both wind and solar power are integrated within a unique body. In the summer time, when sun beams are strong enough, wind velocity is relatively small. In the winter time, when sunny days are relatively shorter, wind velocity is high on the contrast. Efficiency of these renewable systems show also differences through the year. In other words, it is needed to support these two systems with each other to sustain the continuity of the energy production in the system.

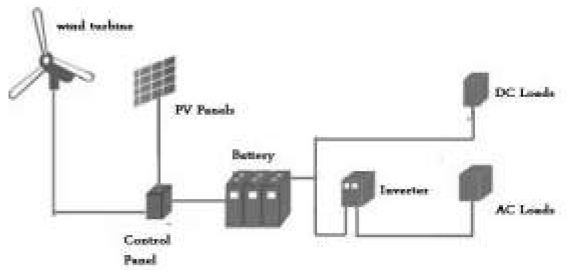

Fig. 5. Hybrid system

In the realized system, a portion of the required energy for an ordinary home has been obtained from electricity that is obtained from the wind and solar power. Experimental setup for the domestic hybrid system consists of a low power wind turbine and two PV panel. Depending on the environmental conditions, required energy for the system can be supplied either separately from the wind or solar systems or using these two resources at the same time is in show Fig 5. Control unit decides which source to use for charging the battery with respect to condition of the incoming energy as seen in Figure 6.

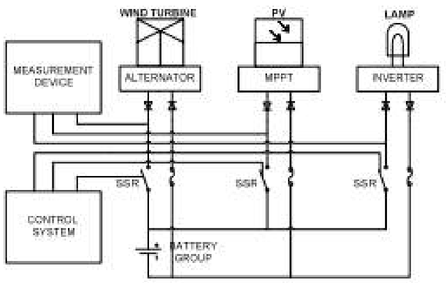

Fig. 6. System block diagram

Wind turbine first converts the kinetic energy to mechanical energy and then converts it to the electricity. The wind turbine in the system consists of tower, alternator, and speed converters (gear box), and propeller. And a picture of the constructed hybrid system is The kinetic energy of the wind is converted to the mechanical energy in the rotor. The rotor shaft speed, 1/18, is accelerated in the reduction gear and then transmitted to alternator. The electricity that comes from the alternator can be directly transmitted to DC receivers as well as it can be stored in the batteries.

IV. ABOUT FUZZY CONTROLLER

Fig. 7 shows the internal structure of the control circuit. The control scheme consists of Fuzzy controller, limiter, and three phase sine wave generator for reference current generation and generation of switching signals. The peak value of reference currents is estimated by regulating the DC link voltage. The actual capacitor voltage is compared with a set reference value. The error signal is then processed through a Fuzzy controller, which contributes to zero steady error in tracking the reference current signal.

A fuzzy controller converts a linguistic control strategy into an automatic control strategy, and fuzzy rules are constructed by expert experience or knowledge database. Firstly, input voltage V_{dc} and the input reference voltage $V_{dc\text{-}ref}$ have been placed of the angular velocity to be the input variables of the fuzzy logic controller. Then the output variable of the fuzzy logic controller is presented by the control Current I_{max}. To convert these numerical variables into linguistic variables, the following seven fuzzy levels or sets are chosen as: NB (negative big), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), and PB (positive big) as shown in Fig.8.

The fuzzy controller is characterized as follows:
1) Seven fuzzy sets for each input and output;
2) Fuzzification using continuous universe of discourse;
3) Implication using Mamdani's 'min' operator;
4) De-fuzzification using the 'centroid' method.

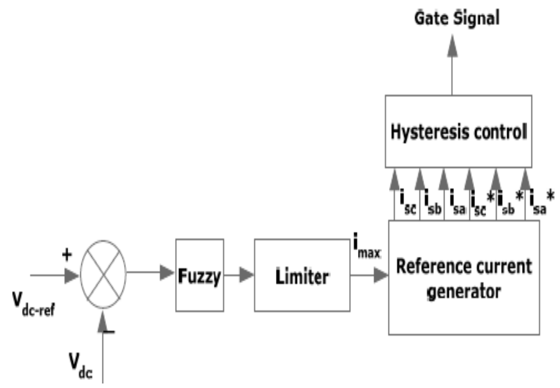

Fig.7.Conventional fuzzy controller

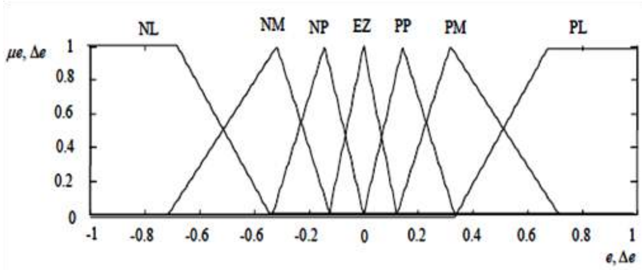

Fig.8. Membership functions for Input, Change in input, Output.

Fuzzification: the process of converting a numerical variable (real number) convert to a linguistic variable (fuzzy number) is called fuzzification.

De-fuzzification: the rules of FLC generate required output in a linguistic variable (Fuzzy Number), according to real world requirements, linguistic variables have to be transformed to crisp output (Real number). Database: the

Database stores the definition of the membership Function required by fuzzyfier and de fuzzyfier.

Rule Base: the elements of this rule base table are determined based on the theory that in the transient state, large errors need coarse control, which requires coarse in-put/output variables; in the steady state, small errors need fine control, which requires fine input/output variables. Based on this the elements of the rule table are obtained as shown in Table 1, with 'V_{dc}' and '$V_{dc\text{-}ref}$' as inputs.

Δe \ e	NL	NM	NS	EZ	PS	PM	PL
NL	NL	NL	NL	NL	NM	NS	EZ
NM	NL	NL	NL	NM	NS	EZ	PS
NS	NL	NL	NM	NS	EZ	PS	PM
EZ	NL	NM	NS	EZ	PS	PM	PL
PS	NM	NS	EZ	PS	PM	PL	PL
PM	NS	EZ	PS	PM	PL	PL	PL
PL	NL	NM	NS	EZ	PS	PM	PL

IV. MATLAB MODELEING AND SIMULATION RESULTS

Here the simulation is carried out in two cases 1.Implementation of proposed converter using conventional PI controller. 2. Implementation of proposed converter using fuzzy logic controller 3. Implementation of proposed converter using hybrid fuzzy logic controller.

Case 1: Implementation of proposed converter using conventional PI controller with PV model.

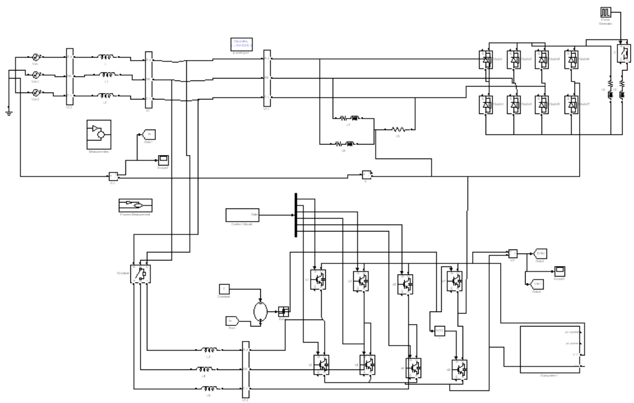

Fig.. 9 Matlab/Simulink Model of Proposed Power Circuit

The power circuit as well as control system are modeled using Power System Block set and Simulink. Performance of proposed converter connected to a weak supply system is shown in

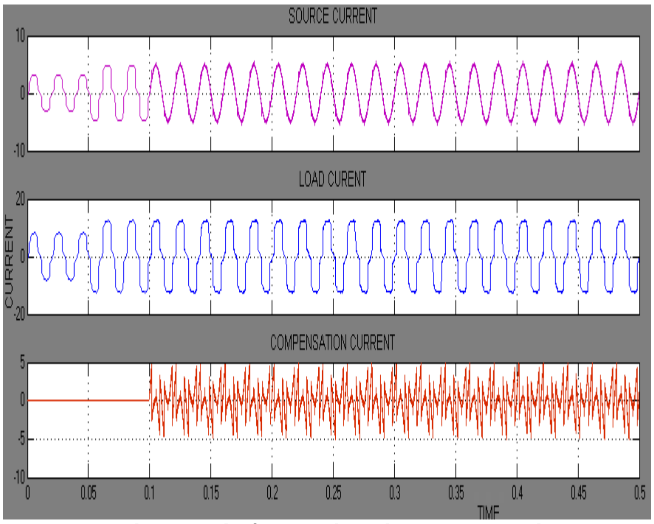

Fig..10. Simulation results for Un Balanced Non Linear Load using PI controller (a) Source current. (b) Load current. (c) Inverter injected current.

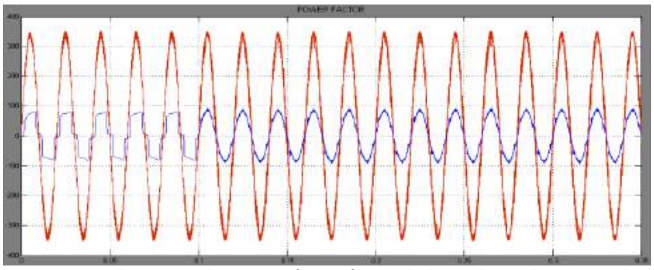

Fig..11. Simulation results power factor for Un balanced Non linear Load

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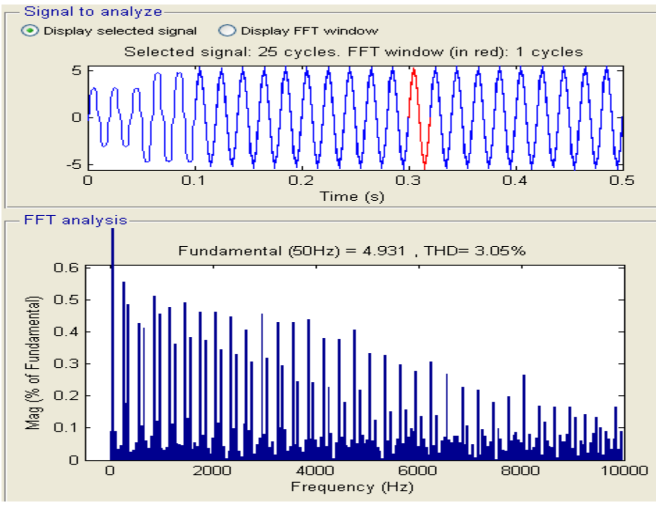

Fig.12. THD for inverter using PI controller

Case 2: Implementation of proposed converter using fuzzy logic controller:

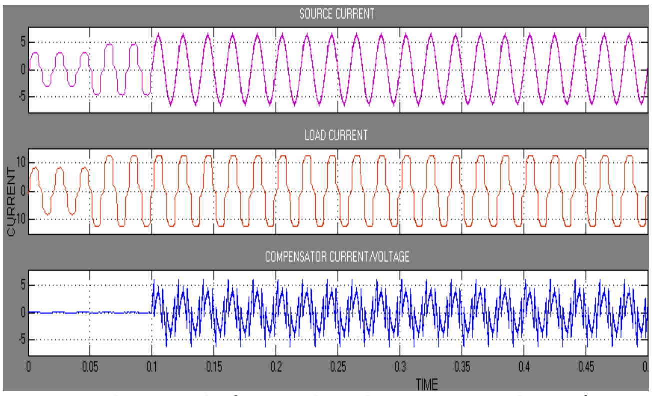

Fig:13 Simulation results for Un Balanced Non Linear Load using fuzzy controller (a) Source current. (b) Load current. (c) Inverter injected current

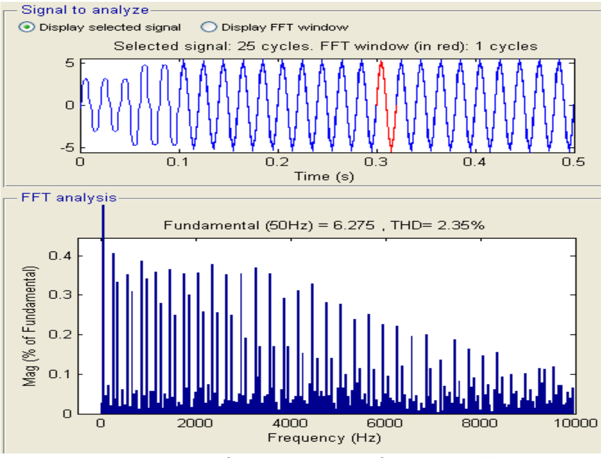

Fig.14 THD for inverter using fuzzy controller

Case 3: Implementation of proposed converter using Hybrid fuzzy logic controller:

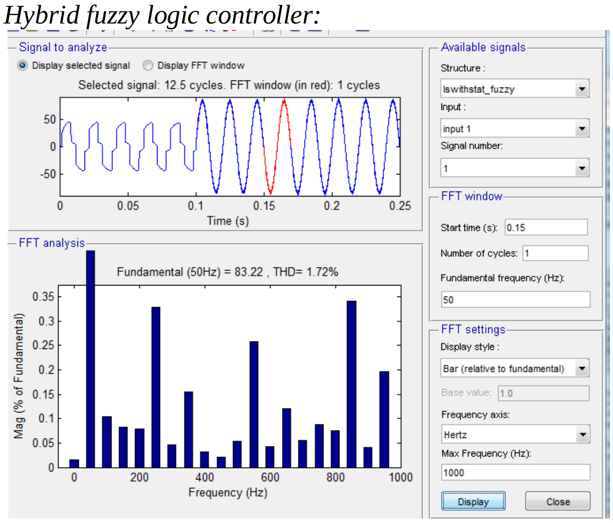

Fig.15 THD for inverter using hybrid fuzzy controller

V. Conclusion

As conventional fossil-fuel energy sources diminish and the world's environmental concern about acid deposition and global warming increases, renewable energy sources (solar, wind, tidal, and geothermal, etc.) are attracting more attention as alternative energy sources. Both PI controllers based and fuzzy logic controller VSI based shunt active power filter are implemented for harmonic and reactive power compensation of the non-linear load. A circuit has been developed to simulate the fuzzy logic based and PI controller based shunt active power filter in MATLAB. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage. The performance of both the controllers has been studied and compared. A model has been developed in MATLAB SIMULINK and simulated to verify the results. The THD of the source current is below 5%, the harmonics limit imposed by IEEE standard. The simulation results show that the performance of converter system has been found to be satisfactory for improving the power quality at the consumer premises. By using conventional controller we get THD value is 3.05%, but using the fuzzy logic controller THD value is 2.35% and using the hybrid fuzzy logic controller THD value is 1.72%. Finally Matlab/Simulink based model is developed and simulation results are presented.

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Self Tuning Filter Method for Real Time Control ofThree-Phase Shunt Active Power Filter (SAPF)

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Abstract—Due to a large amount of non-linear power electronic equipments, impact and fluctuating loads (such as that ofarc furnace, heavy merchant mill and electric locomotive, etc),problems of power quality have become more and more seriouswitheach passing daywhich injects harmonic currents in supply system. These harmonics creates power quality issue. Shunt Active Power Filter (SAPF) is the popular and efficient solution to reduce these harmonics. SAPF can overcome voltage sag, eliminate harmonicsand improves power factor. SAPF reduces total harmonic distortion (THD) to acceptable level. Reference current generation is the heart of APF. Reference current generation using self Tuning Filter (STF) method is presented in this paper. STF method is widely used to control active power filters (APFs).Modeling of this technique is implemented in MATLAB/simulink.

Key Words—SAPF, Power quality, STFmethod, THD, MATLAB/simulink.

I. INTRODUCTION

Power quality issue is becoming very serious now-a-days. This is because nonlinear loads such as electrical machines, static power converters, electric arc furnaces, etc. which mainly lead to harmonic disturbances in power lines. Also power electronic equipments for human comfort plays major role in it. Although these power electronic equipments make our life convenient, it injects lot of harmonic current to the supply system and affects power factor [1].Conventionally, passive LC filters have been used to eliminate line current harmonics and thereby increase the load power factor. Tuned passive filters are very effective for the elimination of specific harmonic components but has some drawbacks, such as

- Fixed Compensation,
- Resonance,
- huge size
- voltage regulation

They may cause series and load resonances in the systemAlso its performance depends on load, it gets affected significantly due to the variation in the filter component values, filter component tolerance, source impedanceand frequency of ac source [1].Shunt Active Power Filter (SAPF) is the effective solution to these problems. Active Filters can be designed to achieve following goals [2]:

- Harmonic Compensation
- Harmonic Isolation
- Reactive power compensation
- Voltage regulation

Out of three system based configurations ofAPF; here we are interested in Shunt Active Power Filter (SAPF). The Active filters overcome the problem occurring in the passive filter. Major Advantage of Active Filter over Passive Filter is that it can be controlled to compensate harmonics such that Total Harmonic Distortion (THD) lower than 5% at the PCC can effectively be achieved. SAPF is shown in fig 1. The reference current generation is like heart for APF.

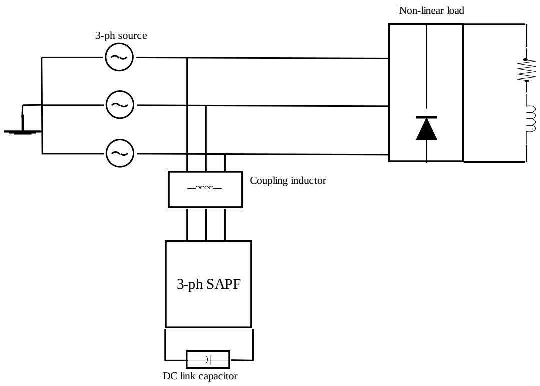


Figure 1. Basic structure of SAPF

In this paper reference current generation using STFmethod is presented. Finally simulation results are presented.

II. CONTROL STRATEGY

Key factor for successful implementation of SAPF is strategy Controls. Block diagram of control strategy is shown in figure 2 below. In this paper SAPF is controlled using Self Tuning Filter (STF) method. Using STF method , reference current will be generated. These reference currents will be further used to generate gate pulses for inverter. The basic principle of reference current generation is shown in figure 3 below.

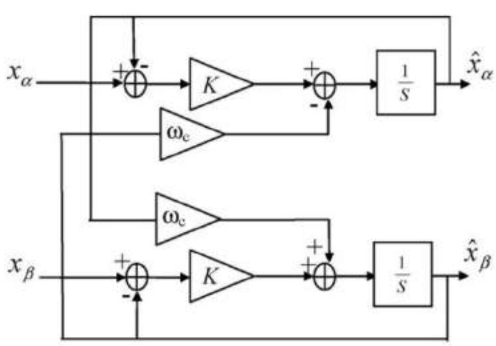


Figure 2. Control strategy of SAPF

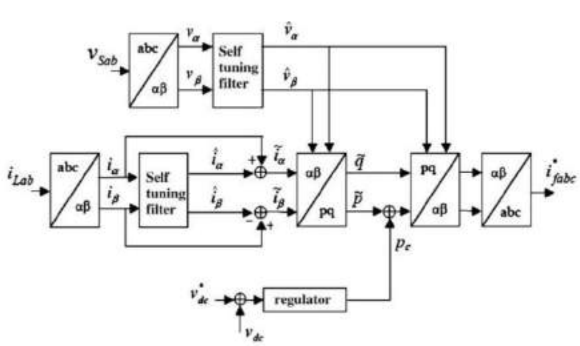


Figure 3. Reference current generation

This theory is useful while working with distorted supply voltage. It is a modified version of the classical p–q theory. The STF is dedicated to extract the fundamental component directly from electrical signals (distorted voltage and current) in α-β referenceframe.

III. HARMONIC ISOLATOR USING STF

The load currents, iLa, iLb and iLc of the three-phase three-wire system are transformed into the αβ axis (see Fig. 3) as follows by using equation

$$\begin{bmatrix} I\alpha \\ I\beta \end{bmatrix} = \sqrt{2/3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \cdot \begin{bmatrix} iLa \\ iLb \\ iLc \end{bmatrix}$$

As known, the currents in the α-β axis can be respectively decomposed into DC and AC components by using equations (1) and (2)

$$i\alpha = \hat{i}\alpha + \tilde{i}\alpha \qquad (1)$$

$$i\beta = \hat{i}\beta + \tilde{i}\beta \qquad (2)$$

Then, the STF extracts the fundamental components at the pulsation ωc directly from the currents in the α-βaxis. After that, theα-β harmonic components of the load currents are computed by subtracting the STF input signals from the corresponding outputs(see Fig. 3). The resulting signals are the AC components ĩαand ĩβ, which correspond to the harmonic components of the load currents iLa, iLb and iLc in the stationary reference frame.For the source voltage, the three voltages Vsa, Vsb and Vsc are transformed to the α-βreference frame as following equation (3):

$$\begin{bmatrix} V\alpha \\ V\beta \end{bmatrix} = \sqrt{2/3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \cdot \begin{bmatrix} Vsa \\ Vsb \\ Vsc \end{bmatrix} \quad (3)$$

Then, we applied self-tuning filtering to these α-β voltage components. This filter allows suppressing of any harmonic componentof the distorted mains voltages and consequently leads to improve the harmonic isolator performance. After computation of the fundamental component $\tilde{v}\alpha\beta$ and the harmonic currents îαβ, we calculate the p and q powers as follows:

$$p = v\alpha \cdot i\alpha + v\beta \cdot i\beta 3. \quad (4) q = v\alpha \cdot i\beta - i\alpha \cdot v\beta 3. \quad (5)$$

Where, p = Instantaneous Active Power = $\hat{p} + \tilde{p}$
q = Instantaneous Reactive Power = $\hat{q} + \tilde{q}$

Where $\hat{p}, \hat{q}$ are fundamental components & $\tilde{p}, \tilde{q}$ are alternative components.The power components $\tilde{p}$ *and* $\tilde{q}$ are related to the same α-β voltages and currents can be written as follows in equation

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} V\alpha & V\beta \\ -V\beta & V\alpha \end{bmatrix} \cdot \begin{bmatrix} i\alpha \\ i\beta \end{bmatrix} \qquad (6)$$

After adding the active power Pc required for regulating DC bus voltage to the alternative component of the instantaneous real power $\tilde{p}$, the current references in the α-β reference frame $i^*_{\alpha\beta}$ are calculated by following equations

$$i^*_\alpha = \tilde{\imath}_\alpha + \frac{\hat{V}_\alpha}{\hat{V}_\alpha^2 + \hat{V}_\beta^2} Pc \qquad (7)$$

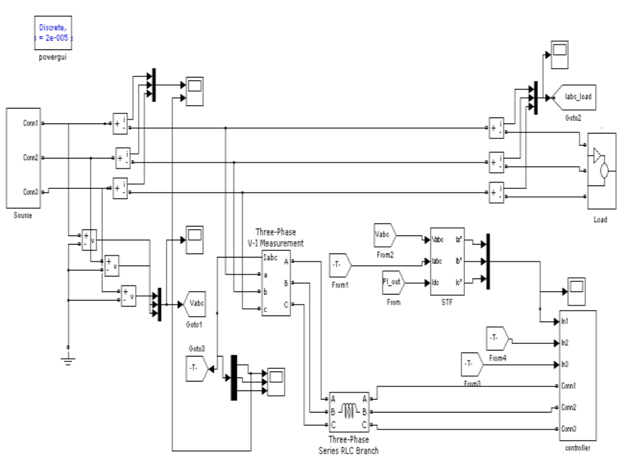
$$i^*_\beta = \tilde{\imath}_\beta + \frac{\hat{V}_\beta}{\hat{V}_\alpha^2 + \hat{V}_\beta^2} Pc \qquad (8)$$

Current references obtained from equations (7) and (8) include two terms, the first term contains the harmonic currentcomponents and thesecond one is a fundamental current component in phasewith thesupply voltage. Consequently, a small amount of activepower is absorbed from or released to the DC capacitor so as to regulate the DC bus voltage. Then, the filter reference currents in the a–b–c coordinates are defined by following equation (9)

$$\begin{bmatrix} i^*_{fa} \\ i^*_{fb} \\ i^*_{fc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ \frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \cdot \begin{bmatrix} i^*_\alpha \\ i^*_\beta \end{bmatrix} \qquad (9)$$

This how reference currents are obtained using Self Tuning Filter Method. These reference currents further used for PWM pulses generation.

IV. SIMULATION BLOCK DIAGRAM FOR STF METHOD



V. SIMULATION RESULTS

The proposed system is simulated in MATLAB/simulink along with the control technique proposed in figure 2 and 3. The system is simulated in MATLAB/ simulinkhaving phase to phase 400v, and frequency of 50 Hz. along with control technique, non linear load and gate pulse generation. SAPF is connected to supply system through very small coupling inductor. The simulation is performed on three phase balanced non linear load; as a result of this following results are obtained.

Following figures5, 6 & 7 shows source voltage of phase A, source current before compensation and source current after compensation respectively.

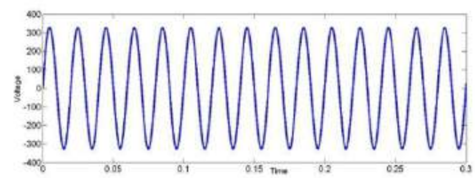


Figure 4. Source voltage of phase A

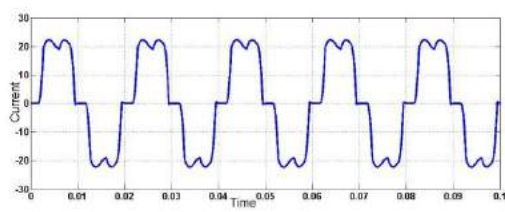


Figure 5. Source current before compensation

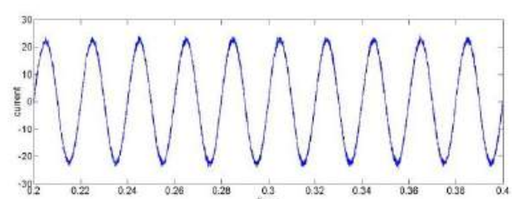


Figure 6. Source current after compensation

The load current for phase A is obtained as fallows in figure 8. Also filter current for phase A is obtained as fallows in figure 10,

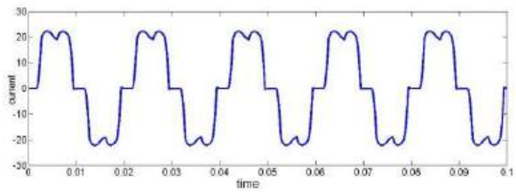


Figure 7. Load Current for phase A

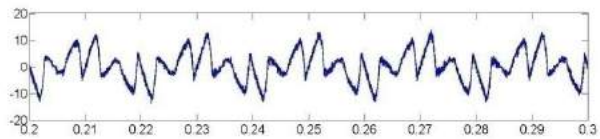
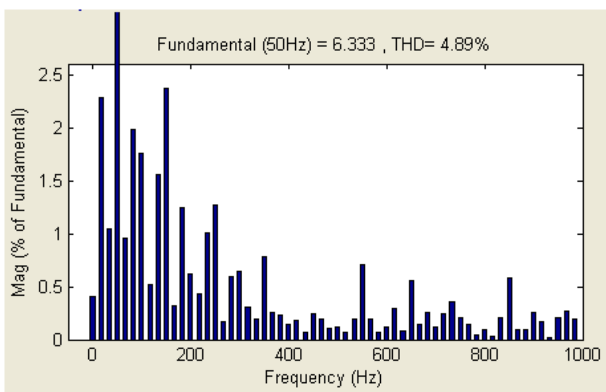


Figure 8. Filter current for phase A

THD of the given system shown in figure 9 below, THD is found to be 4.89%



THD of system

VI. Conclusion

Reference current is the key factor for successful performance of SAPF. The reference current using self tuning filter method is presented in this paper.Further these reference currents are used to generate switching pulses for inverter. THD can be maintained to acceptable level using SAPF. The simulation results using MATLAB/simulink verifies that. The advantages of STF method are that Operating adequately in steady state and transient condition,No phase delay and unity gain at the fundamental frequency, No PLL required, Easy to implement in digital or analogue control system.

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TECH-CHRONICLE
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TO MONITOR THE CONDITION OF TRANSFORMER USING WIRELESS MODULE

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***Abstract*—The demand of electricity goes on increasing day by day because electricity is required everywhere like for the household, commercial and industrial loads. Also the distribution system management is becoming more complex. It has been identified that the major problem in effective monitoring and control is that the full information about the status of transformer are not supplied at the base station. This paper reviews the development of effective monitoring system of distribution transformer using a microcontroller [1]. A wireless network is designed to send data from controller side to a cell phone of monitoring person. In general, the design is develop for the user so that it can be easily recognize that whether the transformer is safe or unsafe. The main objective is to monitor the distribution transformer parameters continuously. If the fault occurs then a message will be sent to the mobile phone of monitoring person.**

***Keywords*— *Microcontroller, Wireless monitoring, Distribution transformer, GSM module* .**

I. INTRODUCTION

In power system, transformer is very expensive and critical electrical equipment which is used to distribute power to the user. If any fault occurs in the distribution transformer then it affects the system reliability. Hence monitoring the status of transformer is very necessary. The life of transformer is long if it is operating under rated condition. However the life is reduced if they are subjected to failure causing loss of supply and thus affecting the system reliability. The major causes of failure in distribution transformer are ineffective cooling and overloading. The reliable operation of power system depends upon its effective functioning. Hence monitoring the status of transformer is very necessary in order to maintain the reliability of power system and also it is helpful to avoid the disruption due to unexpected sudden failure of the system.

Presently the methods used for monitoring the status are having some drawbacks. Few of them are requires a lot of labor work, consume more time in case of equipment failure the operation is done manually.

According to the above requirements, we need a real-time monitoring system in order to detect the status of distribution transformer and send that data to the controlling unit in time. This will help the monitoring person to identify the problem before any serious fault occurs, so that he can take action to prevent the fault which increases the system reliability also the system becomes economical[2], [3]. Widespread use of mobile networks and GSM devices such as GSM modems and their decreasing costs have made them an attractive option not only for voice media but for other wide area network applications.

To monitor the condition of transformer using wireless module is reliable as compare to manual monitoring also it is useful. As it is always not possible to go and check the oil temperature of transformer manually, also it would be difficult to found which transformer is undergoing fault. Using a GSM module we can easily recognize the faulted transformer from the message send to mobile. It is not needed to check all the transformers so in less time we can recover the system.

II. BLOCK DIAGRAM

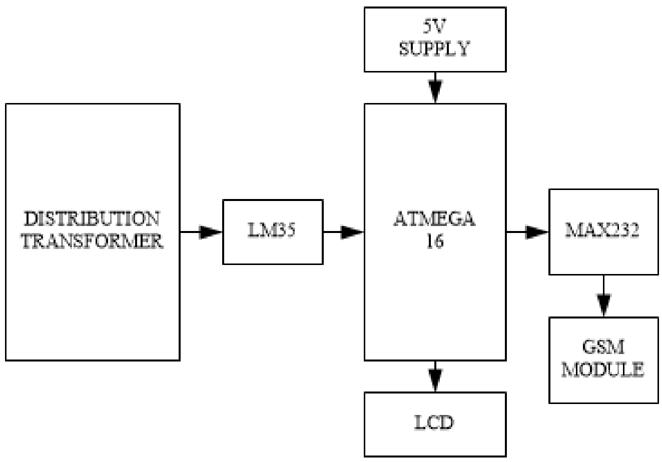

Fig. 1. Block diagram of the monitoring system

The above system is based on microcontroller that monitors the oil temperature of a transformer. The monitored output will be display on LCD. The monitored outputs are compared with the rated values of the transformer and microcontroller will be programmed in such a way that when the monitored values exceed the rated values it displays the value so that it attracts the attention of the monitoring person, also it send a message on a cell phone of a monitoring person through wireless communication network. The time for receiving messages may vary due to the public GSM network traffic but still it is effective than manual monitoring.

The input voltage to the microcontroller is 5V. The temperature of the oil will be sensed by the temperature sensors (LM35) . These values are given as inputs to the microcontroller through the ADC channels and are stored. These data are sent to the GSM modem.

A. Microcontroller

Microcontroller is defined as a system on computer chip which includes number of peripherals like RAM, EEPROM, etc. required to perform some predefined task. There are number of popular families of microcontrollers which are used in different applications as per their capability and feasibility to perform various task, mostly used of these are 8051, AVR and PIC microcontrollers. AVR is an 8-bit microcontroller belonging to the family of Reduced Instruction Set Computer (RISC). In RISC architecture the instruction set of the computer are not only fewer in number but also simpler and faster in operation.

Brain of this project is Atmega16 microcontroller. Its speed is up to 16MIPS throughput at 16MHz. It has 16K bytes of flash and 512 bytes EEPROM. Operating voltage 2.7V-5.5V, in active mode it consumes less than 1µA current.

Fig. 2. Microcontroller ATMEGA16

B. Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to sub-tract a large constant voltage from its output to obtain convenient Centigrade scaling.

Temperature sensor is use to monitor the oil temperature of transformer. LM35 is directly connected to the analog to digital ports of the ATMEGA16 Microcontroller. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range.

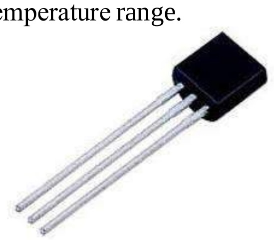

Fig. 3. Temperature sensor (LM35)

C. GSM module (sim300)

A GSM modem is a wireless modem that works with a GSM wireless network[4], [5]. SIM300 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz.

With a tiny configuration of 40mm x 33mm x 2.85 mm, SIM300 can fit almost all the space requirement in your application, such as Smart phone, PDA phone and other mobile device. PIC cannot be connected directly to modem. So MAX 232 is used to interface PIC and the modem. GSM modem.

D. SIM card interface

We can use AT Command for getting information in SIM card. AT commands are the instructions used for controlling a modem. Both the GSM modems and dial-up modems support a fixed set of standard AT commands. GSM modem can be used like a dial-up modem [6]. Apart from the standard AT commands, GSM modems also support an extended set of AT commands. These extended set of AT commands are defined in the GSM standards. With the extended AT commands, several things are done:

- To read, write and delete SMS messages
- To send SMS messages
- To monitor the signal strength. system in less time.

III. SOFTWARE DESIGN

Controller first needs to read the temperature. If temperature exceeds the normal value then trip signal and SMS has to pass. Otherwise if temperature has raised but not exceeds normal value then only the SMS is send to the monitoring person. If after checking, the microcontroller draws the conclusion that the signals are in normal condition then it again reads the input signal and process continues.

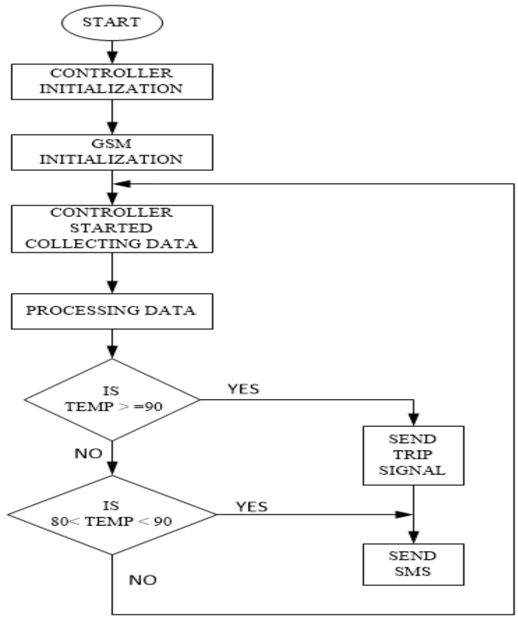

Fig. 4. Software design flow chart

IV. SIMULATION

Simulation of programming is done by using software known as PROTEUS. The program written is dumped in ATMEGA16 chip using a PROTEUS software.

Different simulation results are shown which will justify the program dumped in the controller and prove that it will successfully protect the transformer from overload condition.

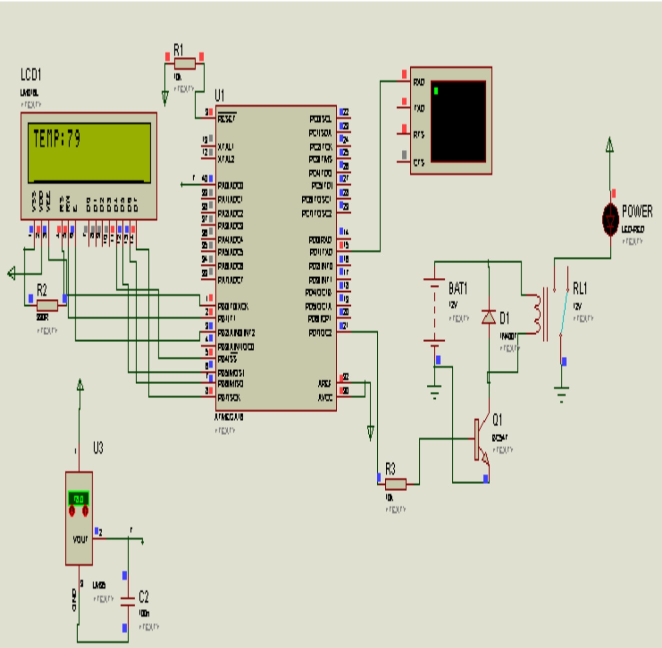

Fig. 5. Simulation under normal condition.

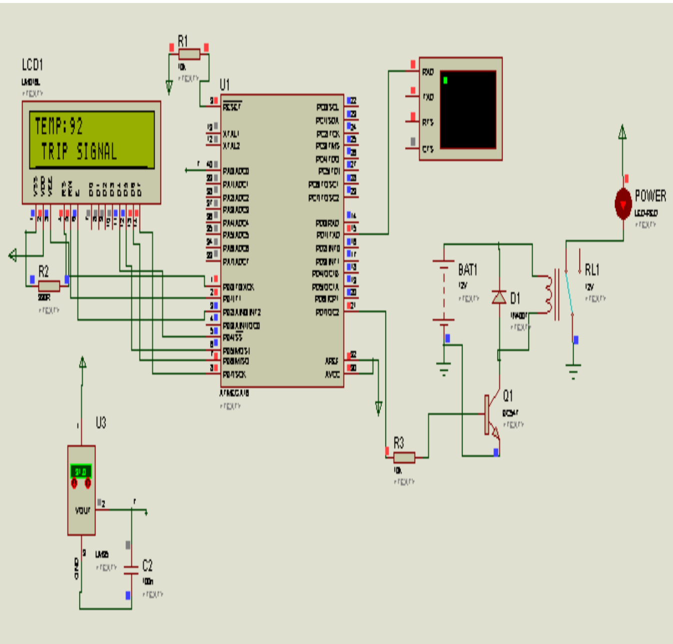

Fig. 6. Simulation under critical condition.

V. FUTURE SCOPE

The simulation is done for sensing the temperature of Transformer, next step can be to do Hardware implementation. Again by using same hardware, distribution transformer over current and overvoltage protection scheme can be thought of.

VI. CONCLUSION

After performing the complete simulation we can conclude that ATMEGA16 is efficient enough to perform the given task and thus can give Transformer protection. It is capable of protecting from overload condition.

As compare to traditional method of protection microcontroller based relay are cheaper. This fact makes the project cost effective. As microcontroller works on logical base not on a mechanical principle thus making it more reliable.

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TECH-CHRONICLE
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Retaining Energy: Regenerative Braking System

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Abstract-**Generally in automobiles wheneverthe brake is applied the vehicle come to a halt and the kineticenergy gets wasted due to friction. This problem has been resolved withthe introduction of regenerative braking. It is an approach torecover or restore the energy lost while braking. In this paper the author gives an overview of what system is preferred where and why.This paper proposes various method of brake with energy regeneration in an electric vehicle (EV). Sincethe braking kinetic energy is converted into the electrical energyand then returns to the battery, the energy regeneration couldincrease the driving range of an EV.**

Key words-Alternator, flywheel;

I. Introduction

A regenerative braking system's purpose is to remove translational kinetic energy from a vehicle, store that energy to be accessed later,to reconvert the stored energy to translational energy (energy of a body moving in a straight line) when required. We now consider some possible methods of regenerative braking.

The standard braking system removes rotational kinetic energy from the vehicle's axles, so it seems most logical to remove energy from the axles in a similar way. As always, a complete, controlled stop requires friction brakes, but a regenerative braking system can retain some energy that is normally lost. The two most promising methods of regenerative braking currently under research are regenerative braking based on kinetic energy storage and electrical energy storage. Each of these systems has its own strengths and weaknesses, but overall, each provides a feasible way to implement regenerative braking, which means that when used efficiently, the range and therefore fuel economy of the automobile will be extended.

II. Faraday's Law of Induction and Electric Regenerative Braking

The first energy storage devices one tends to think of are batteries and capacitors: they can store a large amount of electrical energy and release it on demand [1]. Therefore, a battery or capacitor would serve as an excellent energy storage medium. This battery discharges continually to power the vehicle's systems: a way to recharge it in operation was needed. The solution was to use the engine itself to charge the battery. The device that accomplishes this is the alternator, which is composed of two main components: a set of magnets attached to a rotating shaft and a coil of wire that encloses the travel area of the magnets (figure 1).

When the magnets spin within the coil, a rotating magnetic field is created and an electric current is induced in the coil, which can then be used to power a circuit, or for the purpose of regenerative braking, to charge a batteryorcapacitor[2]. This phenomenon is explained by Faraday's Law of Induction. When applied to this situation, this law states that a magnetic field can induce a current in a wire, and vice versa [1]. This principle is the same one that explains how an electric motor works: the motor operates by passing a current through a coil of wire, which then creates a rotating magnetic field and induces rotational motion in a series of magnets attached to an axis [1].

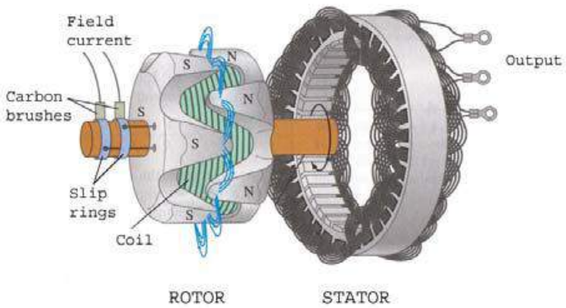

fig. 1.Exploded View of Automotive Alternator

In fact, the motor and the alternator are the same physical device: the specificmotor/alternator behaviors are created by either passing a current through the coil or moving a magnetic field inside the coil [1]. This means that whenever motor runs in onedirection, the electric energy gets converted intomechanical energy, which is then used to acceleratethe vehicle and whenever the motor runs in oppositedirection, it performs functions of a generator, whichthen converts mechanical energy into electricalenergy, which makes it possible to utilize therotational force of the driving axle.The dual uses of this device are the key to electrical regenerative braking technology.

Electric vehicles such as the Chevrolet Volt use a motor and a supply of batteries in place of the conventional ICE and gasoline combination. When running, the motor is powered by current from the batteries. This supply can be switched on and off at will, but the connection to the vehicle’s drive shaft remains; consequently, if the drive shaft turns while the current to the motor is off, current will be induced in the motor. This induced current can be used to charge a capacitor or battery, which can be used as an electrical energy source for the vehicle [3]. The production of current allows regenerative braking action.

For an example of how this system might be useful practically, imagine a conventional vehicle coasting down a hill. The vehicle would naturally pick up speed as it goes further down the hill, necessitating the use of brakes to maintain a constant speed. But in this configuration, kinetic energy is converted to electric current in the motor (which acts as an alternator). This current can be used to recharge the batteries of the car, which results in an increase in stored energy that can be used to drive the vehicle further without recharging the vehicle.

III Inertia and Kinetic Regenerative Braking

The regenerative braking systems described would certainly be useful for smaller vehicles capable of running on an electric motor, but larger vehicles such as vans or trucks require power that current electric motors are incapable of providing, and so would use an ICE. However, an ICE does not have the motor-alternator relationshiptoharness for regenerative braking, and the battery network required for alternator-based regenerative braking adds significant weight, costs and complexity. Therefore, a different method must be used to implement regenerative braking in these vehicles.

Capacitors and batteries are electrical energy storage units appropriate for regenerative braking systems, but their use requires conversion of rotational kinetic energy to electrical energy. This conversion is not strictlynecessary: only a need to remove and store energy from the drive axles exists.

One device capable of storing significant mechanical energy is a flywheel, which is essentially a massive disc. A flywheel is installed on an axis, when spun, or “charged”, has rotational kinetic energy proportional to its mass and angular velocity [1]. As a flywheel can act as an energy storage unit, the remaining question is of how to transfer energy between the main axles of a vehicle and a flywheel.

According to the Law of Conservation of Angular Momentum, the total angular momentum in a closed system is constant [1].The consequence of this law is best explained by example. Imagine a flywheel being spun at a fast speed. If another identical but stationary flywheel were connected to the shaft of the first flywheel, the spinning flywheel would decelerate and the stationary flywheel would accelerate: they would come to an equivalent speed less than that of the original flywheel. The rotational kinetic energy of the first flywheel would be distributed between both flywheels when connected.

The relevance of this law is that the wheels of an automobile are themselves nothing more than flywheels that contact the ground. If the wheels were connected (through the drive axle) to a flywheel, this flywheel could slow the vehicle by charging and could move the vehicle from rest, which is a regenerative braking action.

IV Electric Regenerative Braking in Practice

In an electrical regenerative braking system, there is really only one component to discuss: the alternator/motor's efficiency. As we know from the Second Law of Thermodynamics, the alternator can never retain all rotational energy in the system. To begin, it should be noted that the costs of implementing regenerative braking in electric cars will naturally be minimized. Because the motor can be used as an alternator, implementing a regenerative braking system would simply involve controlling a charging connection to the vehicle's battery packs by computer.

Regenerative braking allows electric vehicles to use the motor as a generator when the brakesare applied, to pump vehicle energy from the brakes into an energy storage device. Regenerativebraking is an effective approach to extend the driving range of EV and can save from8% to as much as 25% of the total energy used by the vehicle, depending on the driving cycleand how it was driven [4]. Generally, the regenerative braking torque cannot be made largeenough to provide all the required braking torque of the vehicle. In addition, the regenerativebraking system may not be used under many conditions, such as with a high state of chargeState of Charge (SOC) or a high temperature of the battery. In these cases, the conventionalhydraulic braking system works to cover the required total braking torque. Thus, cooperationbetween the hydraulic braking system and the regenerative braking system is a main part ofthe design of the EV braking control strategy and is known as torque blending. This torqueblending strategy helps to avoid the driveline disturbances [5].

The two broad classifications of regenerative braking control strategies are as depicted in the(figure2). The yellow region represents regenerative braking and region in red representsfriction braking. The small yellow portion at the bottom which reads compression regen refersto regeneration when accelerator pedal is released and the car coasts in the absence of brakepedal input. Service regen region represents regeneration when brake pedal is applied and itgoes into the red region, when the maximum capacity of generator torque is reached in thecase of serial strategy and simultaneous friction braking activation for parallel strategy.

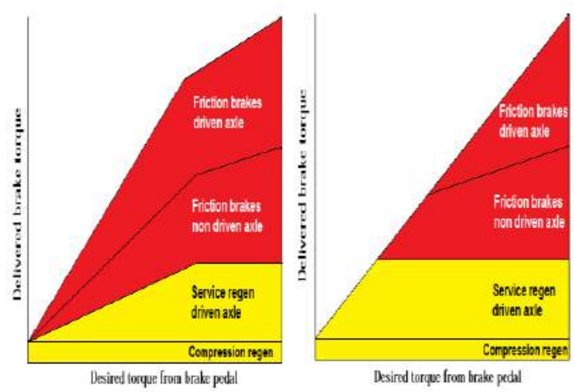

fig. 2.Parallel and Serial regenerative braking control respectively

A. Serial regenerative braking

Serial regenerative braking is based on a combination of friction-based adjustable brakingsystem with a regenerative braking system that transfers energy to the electric motors andbatteries under an integrated control strategy.Serial regenerativebraking could give an increase of 15-30% in fuel efficiency. It requires a brake-by-wire systemand has more consistent pedal feel due to good torque blending capability.

B. Parallel regenerative braking

Parallel braking system is based on a combination of friction-based system and the regenerativebraking system, operated togetherwithout an integrated control. The regenerativebraking force is added to the mechanical braking force which cannot be adjusted. The regenerativebraking force will increase with the mechanical braking force.The beginning pedal travel is used to control the regenerative braking force only; thenormalmechanical braking force is not changed. The regenerativebraking force is calculated from the brake control unit by comparing the demanded braketorque and the motor torque available. The wheelpressure is reduced by the amount of theregenerative braking force. Parallelregenerative braking could give an increase of 9-18% in fuel efficiency. It can be added to conventional braking systems. However it requiresmore work in achieving good torque blending.

VFuture scope

Regenerative braking systems require further researchto develop a better system that captures more energyand stops faster. As the time passes, designers andengineers will perfect regenerative braking systems,so these systems will become more and morecommon. All vehicles in motion can benefit fromthese systems by recapturing energy that would havebeen lost during braking process.Future technologies in regenerative brakes willinclude new types of motors which will be moreefficient as generators, new drive train designs whichwill be built with regenerative braking in mind, andelectric systems which will be less prone to energylosses.

VIConclusion

The regenerative braking system used in the vehiclessatisfies the purpose of saving a part of the energylost during braking. Also it can be operated at hightemperature range and are efficient as compared toconventional braking system. The results from someof the test conducted show that around 30% of theenergy delivered can be recovered by the system.Regenerative braking system has a wide scope forfurther development and the energy savings. The useof more efficient systems could lead to huge savingsin the economy of any country.

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ENGERGY MANAGEMENT OF ENGERGY STORAGE SYSTEMS WITH REFERENCE TO ELECTRIC VEHICLES

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***Abstract* — The problem of managing energy of multiple energy sources for electric vehicle power system is considered. The area of energy management in the application domain of electric vehicles is relatively new and encompasses several different disciplines. Basically, the challenges in electric vehicles having multiple energy storage systems lies in managing the energy expenditure, determining the proportional power splits and establishing methods to interface between the energy systems.**

In this paper, an attempt has been made to provide a new method to the problem of electric vehicle power and energy management. The overall approach to the problem taken from the basic principles found in conventional management methodology. The proposed methodology permits this multidisciplinary problem to be approached systematically.

This paper has given a trace on implementation of a power and energy management system for a dual-source electric vehicle powered by lead acid batteries and supercapacitors.

Keywords- Supercapacitors, energy management, electric vehicle, power, batteries.

I. INTRODUCTION

The primary design challenges in electric vehicles having multiple energy storage systems lies in managing the net energy expenditure, determining the proportional power split and establishing methods to interface between the energy systems so as to meet the demands of the vehicle propulsion and auxiliary load requirements. Combined usage of multiple energy storage systems in a synergistic arrangement permits key attributes of the individual systems to be exploited. However, to obtain high utilization efficiencies, these energy storage systems require an intervention of their natural power sharing. As such, a power and energy management system is required to strategies and arbitrate power sharing between the multiple energy sources and the load.

Electric vehicles (EV)s have been in existence ever since the inception of the automobile [1]. However, in the early race for dominance, the internal combustion engine (ICE) quickly overtook the EV as the prime propulsion power system for road vehicles. Although the electric power train was superior in terms of performance and energy conversion efficiency, the restrictive factor remained the source of electrical energy. Battery powered vehicles simply could not match the high-energy density, abundant supply and logistical attributes of petroleum based propulsion [2]. Even with ICE energy conversion efficiency figures of below 20%, the energy density (Joules/kg) of petroleum far surpasses the energy density of any known battery technology. While economically recoverable petroleum deposits continue to diminish, the automobile population is ever increasing, causing cities to become congested with toxic hydrocarbons by-products. As a result, the ICE is increasingly becoming a target of environmental debates. Assuming that personal transportation continues to be a vital link in the economic chain of modern societies, private automobile appears to be the system of choice. This would provide opportunities to rethink private transportation modes as we now see it. At present, after more than a century since its introduction, and decades since it was forced into near oblivion, EVs have regained a strong global presence [3, 4]. Industry efforts, coupled with paradigm shifts in transportation perspectives provide substantial grounds for continuing EV research contributions. The viability of a purely electric vehicle as a future transportation solution is perhaps arguable. The single limitation of current EVs compared to an ICE Hybrid EV is still the travel range. As a near future target, EVs will find definite niche applications where short commuting distances or predefined routes dictate the vehicles' range requirement [5].

II. SUPERCAPACITOR

Recent concerns of global warming, has led to an international push toward electricity generation from renewable energy sources. In fact, the increasing partition of renewable energy power generation which is an inconsistent generation, have led to a time gap between supply and demand. As result, it appears an increase demand for energy storage.

An supercapacitor cell construction consists of two electrodes, a separator, and an electrolyte. The electrodes consist of two parts, a metallic current collector and a high surface area active material. A membrane called the ‘separator’ separate the two electrodes. The separator permits the mobility of charged ions but prohibits electronic conduction. This composite is subsequently rolled or folded into a cylindrical or rectangular form and stacked in a container. Then the system is impregnated with an electrolyte, which is either a solid state, organic or aqueous type. The decomposition voltage of the electrolyte determines the maximum operating voltage of an supercapacitor. Owing to the very small separation distance between the electrolytes, as well as the large effective surface of the active material, large capacitance magnitudes in terms of Farads are obtainable.

III. THE EMERGING AREA OF VEHICLE POWER AND ENERGY MANAGEMENT

As the future of electric and hybrid electric vehicles is evidently becoming promising [6, 7], significant research efforts worldwide have been directed towards improving propulsion systems and energy storage units [8]. In the course of vehicles becoming “More Electric” [9], with increasing number of onboard electrically powered subsystems for both commercial and military applications, the need to manage the vehicular power system is imperative. Electrical loads for both traction and ancillary loads are expected to increase as the automotive power system architecture shifts towards a more silicon rich environment [10]. The complex demand profiles anticipated by these dynamic loads require accurate and optimized control of power flow and energy storage subsystems within the vehicle, thus presents a technical challenge and opportunity for vehicular power and energy management research.

IV. BACKGROUND ON ELECTRIC VEHICLES

The development process of the Electric Vehicle (EV) is interesting, as the first documented invention of an EV dates back to 1834 [1]. Due to the lack of technology, primarily for electrochemical storage units, the interest in EVs gradually diminished and ceased to receive any attention after 1920. In the early 1970s, circumstances changed in favour of the EV concept due to the dramatic increase in petroleum prices. Compelled by the Arab oil trade embargo of 1973, which resulted in an enormous energy crisis, exploration into alternate energy sources was initiated [3]. This eventually lead to the US Congress formation of the ‘Electric and Hybrid Vehicle Research, Development and Demonstration Act’ of 1976 [2]. Design methods for electric vehicle power systems management incorporating the use of batteries and ultracapacitors in synergistic operations are not well established. However, an increasing community of avid researchers are actively working towards the goal of achieving baseline concepts for vehicular power system architecture. Areas that are currently drawing focus are:

• Sizing of onboard charge sustaining and depleting energy storage units

• Regenerative energy recuperation.

• Peak power alleviation using ultracapacitors.

• Power blending of two or more energy sources of different power/energy specifications

The driveline architecture that will be investigated comprises of the two energy storage systems categorised as Type 1 and Type 2. As depicted in Figure 1, the scope of the power and energy management problem encompasses the energy systems as well as the conversion and distribution of power. The vehicle load demand that is analysed in this dissertation is limited to the propulsion loads. Although the non-propulsion load demands have been investigated as part of this research project, the core of the work presented here will focus on addressing the system encapsulated as power and energy management.

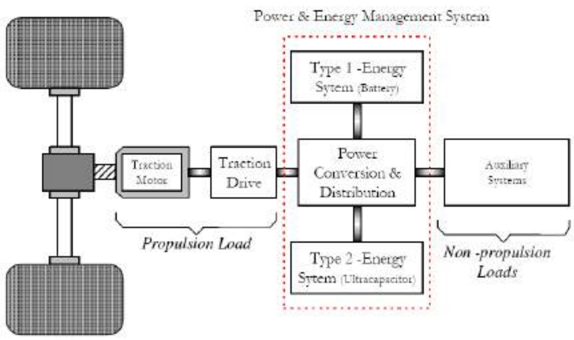

Fig. 1. EV drive train and power system architecture

V. EV BATTERY SYSTEMS

In EV applications, desirable attributes for the battery system are high specific power, high specific energy and a high number of cycle life as well as a long calendar life. Technical challenges exist to meet these performance requirements whilst adhering to the initial and replacement costs constraints. Battery systems for EVs need to be rechargeable and also handle the harsh operating environment that they are subjected to in an EV. There are basically two categories of battery systems that are accordingly termed as primary batteries and secondary batteries. Primary batteries are non-rechargeable and are discarded at the end of a single full discharge. These batteries are commonly found in consumable electronics.

Secondary batteries however are rechargeable with the number charge-discharge cycles varying for different battery technology. It is the secondary battery that finds application in EVs.

A) Basic configuration of secondary batteries

A basic secondary battery cell consists of two electrodes immersed in an electrolyte. The anode is the electrode where oxidation occurs whereby electrons are transported out of the cell to the cathode via the load circuit. The cathode is the electrode where reduction takes place and where electrons from the external load return to the cell. The electrolyte however serves as a path for completing the electrical circuit inside the cell. Electrons are transported via ion migration from one electrode to the other through the electrolyte, thus creating a potential across the cell. During a battery cell charging operation, the process is reversed and the negative electrode becomes the cathode while the positive electrode becomes the anode.

Electrons are externally injected into the negative electrode to perform reduction while oxidation takes place at the positive electrode. The reactions that take place during charge and discharge do not necessary occur at the same reaction rates. The unsymmetrical reaction rates are expressed as the charge acceptance rate during a charging process and a charge release rate during discharge. Generally, the charge release rate of a battery system is higher than the charge acceptance rate, which is why secondary batteries require a longer time to recharge. Figure 2 illustrates the basic battery cell construction and operating principle.

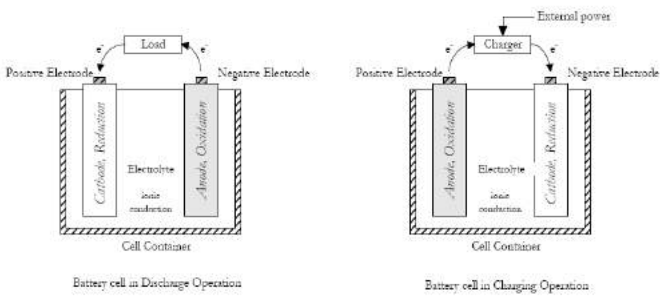

Fig. 2 Operating principle of a secondary type battery cell

Only in an ideal battery cell do electrons only flow when the external circuit is completed. However, in all battery systems, a slow discharge does occur due to diffusion effects. This open circuit discharge is known as the self-discharge of the battery, and is a parameter that is used as one of the long-term performance descriptors of a particular battery type. Figure 3, 4 and 5 illustrates the basic equivalent circuit model (Thevenin model) of a secondary battery, the corresponding voltage characteristic as a function of the battery stored charge capacity and the power characteristics. The battery is represented by an ideal open circuit voltage source (Voc) and a series internal resistance (Ri).

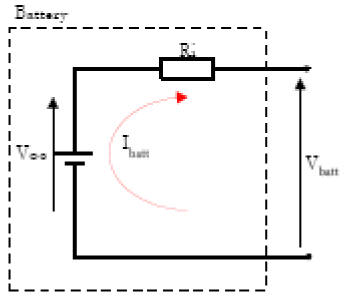

Fig. 3 Basic equivalent circuit

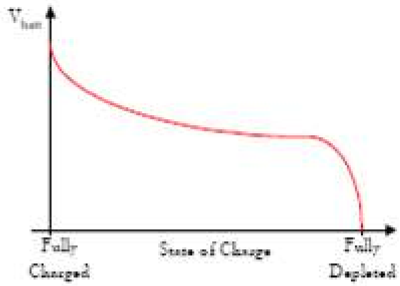

Fig. 4 Thermal voltage supply v/s charge capacity

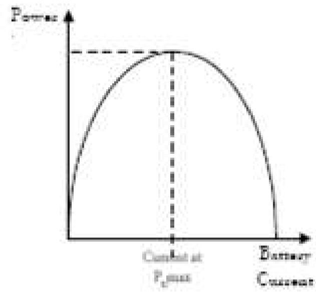

Fig. 5 Battery power characteristics

B) Electrical Energy Storage

Electrical Energy Storage, EES, is one of the key technologies in the areas covered by the IEC. EES techniques have shown unique capabilities in coping with some critical characteristics of electricity, for example hourly variations in demand and price. In the near future EES will become indispensable in emerging IEC-relevant markets in the use of more renewable energy, to achieve CO2 reduction and for Smart Grids. Historically, EES has played three main roles. First, EES reduces electricity costs by storing electricity obtained at off-peak times when its price is lower, for use at peak times instead of electricity bought then at higher prices. Secondly, in order to improve the reliability of the power supply, EES systems support users when power network failures occur due to natural disasters, for example. Their third role is to maintain and improve power quality, frequency and voltage.

Regarding emerging market needs, in on-grid areas, EES is expected to solve problems – such as excessive power fluctuation and undependable power supply – which are associated with the use of large amounts of renewable energy. In the off grid domain, electric vehicles with batteries are the most promising technology to replace fossil fuels by electricity from mostly renewable sources. The Smart Grid has no universally accepted definition, but in general it refers to modernizing the electricity grid. It comprises everything related to the electrical system between any point of electricity production and any point of consumption. Through the addition of Smart Grid technologies the grid becomes more flexible and interactive and can provide real-time feedback. For instance, in a Smart Grid, information regarding the price of electricity and the situation of the power system can be exchanged between electricity production and consumption to realize a more efficient and reliable power supply. EES is one of the key elements in developing a Smart Grid.

VI. CONCLUSION

Findings based on the exhaustive literature survey were presented to state the various methods of addressing power and energy management of batteries and ultracapacitors in EV architectures. The capability and benefit of using ultracapacitors as a battery peak power suppression system was clearly demonstrated. However, it was also shown that although ultracapacitors are able to store and release energy at high rates (high power), extracting the energy for use in a vehicle propulsion system requires a power conversion process in order to fulfill working voltage requirements This is rarely discussed in the open literature. To support a cost analysis of ultracapacitor applications, figures should include the power electronics overhead that is fundamentally required to exploit the use of ultracapacitors in EVs.

Since with practical scenarios, the exact vehicle power demand profiles are not known in advance and are difficult to accurately predict, and since a battery-ultracapacitor system cannot be dimensioned to capture all possible situations, energy management becomes a trade-off between storage system service life and round trip efficiency. An energy management strategy that tries to regulate the energy system state of charge in anticipation of load demand changes can sometimes lead to energy being transferred back and forth between sources. Doing so imposes an energy loss penalty and hence a lower round trip efficiency.

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TECH-CHRONICLE
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Designing of Hybrid Solar PV and Wind Energy Generation System : A Review

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***Abstract:-* Due to the fact that solar and wind power is intermittent and unpredictable in nature, higher penetration of their types in existing power system could cause and create high technical challenges especially to weak grids or stand-alone systems without proper and enough storage capacity. By integrating the two renewable resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. This paper provides a review of challenges and opportunities / solutions of hybrid solar PV and wind energy integration systems. Voltage and frequency fluctuation, and harmonics are major power quality issues for both grid-connected and stand-alone systems with bigger impact in case of weak grid. This can be resolved to a large extent by having proper design, advanced fast response control facilities, and good optimization of the hybrid systems. The paper gives a review of the main research work reported in the literature with regard to optimal sizing design, power electronics topologies and control. The paper presents a review of the state of the art of both grid-connected and stand-alone hybrid solar and wind systems.**

Keywords—Hybrid renewable energy, Photovoltaic, Wind energy, Grid-connected, Stand-alone

INTRODUCTION

The global penetration of renewable energy in power systems is increasing rapidly especially for solar photovoltaic (PV) and wind systems. The renewable energy counted for around 19% of the final energy consumption worldwide in 2012 and continued to rise during the year 2013 as per 2014 renewables global status report [1]. The report highlighted that for the first time the PV installation capacity was more than the wind power capacity worldwide. Table 1 below summarizes some important selected indicators from that report and the previous year report which shows the global rapid increase of renewable energy. Although Europe has dominated the PV market worldwide, the rest of the world starts picking-up with the lead from China and India [2-3].

Table : Important global indicators for renewable energy

		2010	2011	2012	2013
Renewable power installed capacity (with hydro)	GW	1,250	1,355	1,470	1,560
Renewable power installed capacity (without hydro)	GW	315	395	480	560
Solar PV installed capacity	GW	40	71	100	139
Wind power installed capacity	GW	198	238	283	318
Concentrating solar thermal power installed capacity	GW	1.1	1.6	2.5	3.4

Solar and wind power is naturally intermittent and can create technical challenges to the grid power supply especially when the amount of solar and wind power integration increases or the grid is not strong enough to handle rapid changes in generation levels. In addition, if solar or wind are used to supply power to a stand-alone system, energy storage system becomes essential to guarantee continuous supply of power. The size of the energy storage depends on the intermittency level of the solar or wind.

This paper provides a review of challenges and opportunities for hybrid system of solar PV and wind. The paper reviews the main research works related to optimal sizing design, power electronics topologies and control for both grid-connected, stand-alone hybrid solar and wind systems.

I. HYBRID SOLAR PV-WIND SYSTEMS

A Grid -connected system

Maintainin The integration of combined solar and wind power systems into the grid can help in reducing the overall cost and improving reliability of renewable power generation to supply its load. The grid takes excess renewable power from renewable energy site and supplies power to the site' loads when required. Fig. 1 and Fig. 2 show the common DC and common AC bus grid-connected to solar PV and wind hybrid system, respectively.

B Power electronics topologies and control

There are two topologies for grid-connected solar PV and wind hybrid system as can be seen from Fig. 1 and Fig. 2. Fig. 1 shows that the DC outputs' voltages from individual solar PV, wind and battery bank stream, through individual DC/DC and AC/DC units, are integrated on the DC side and go through one common DC/AC inverter which acts as an interface between the power sources and the grid to provide the desired power even with only one source available. Hence, the renewable energy sources act as current sources and can exchange power with the grid and the common DC/AC inverter controls the DC bus voltage. The individual units can be employed for maximum power point tracking (MPPT) systems to have the maximum power from the solar PV and wind systems and the common DC/AC inverter will control the DC bus voltage. The battery bank is charged when there is an extra power and discharged (by supplying power) when there is shortage of power from the renewable energy sources. On the other hand, Fig. 2 shows that renewable energy sources are injecting power directly to the grid through individual DC/AC and AC/DC-DC/AC units.

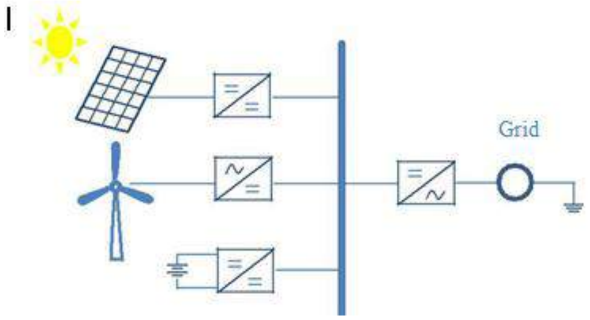


Fig. 1 Grid-connected hybrid system at common DC bus

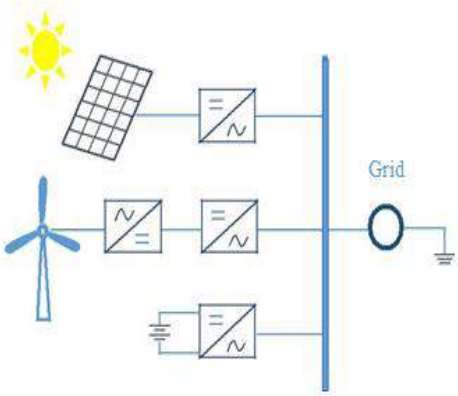


Fig. 2 Grid-connected hybrid system at common AC bus

C Power quality

The increased penetration of grid-connected renewable energy sources has an impact on the grid power quality in particular weak grids. Voltage fluctuation, frequency fluctuation and harmonics are major power quality issues. Furthermore, intermittent energy from solar PV and wind has a huge impact on network reliability. However, accurate forecasting and scheduling systems can minimize the impacts. Various statistical forecasting and regression analysis approaches and algorithms are used to forecast weather pattern, solar radiation and wind speed [41-44].

II. Stand-alone (autonomous) system

The stand-alone or autonomous power system is an excellent solution for remote areas where utilities facilities, in particular transmission lines, are not economical to run or difficult to install due to their high cost and/or difficulties of terrain, etc. The stand-alone systems can be sub-classified into common DC bus or common AC bus. Variable nature of solar and wind resources can be partially overcome by integration of the two resources into an optimum combination and hence the system becomes more reliable. The strength of one source could overcome the weakness of the other during a certain period of time [52-54]. For stand-alone applications, storage cost still represents the major economic issue. Combining both PV solar and wind powers can minimize the storage requirements and ultimately the overall cost of the system [55]. Increasing PV panels and capacity of wind turbines could be a better choice compared to the increasing of batteries since batteries are much more expensive with a shorter lifespan compared to the life time of a PV or WT. However, for high reliability systems too few batteries can't meet the reliability requirements, which will incur more cost since too many PV modules or too large WTs will be required [56]. For a small islanded electricity system in New Zealand, with winter peaking demand, I. G. Mason [57] found that the average storage ratio for solar PV to wind was 1.768:1 in comparison to 0.613:1 (residential) and 0.455:1 (farm dairy) with summer peaking demand. Huang et al. [58] highlighted that when a single 400w wind turbine of a hybrid solar PV-wind power system was replaced by 8 smaller wind turbines with a capacity of 50w each at three different locations in China, the power output of the overall system increased by 18.69% (at Shenyang), 31.24% (at Shanghai) and 53.79% at Guangzhou) due to the fact that small wind turbines can capture wind at a lower speed in comparison to larger ones.

Power electronics topologies and control

There are two main topologies for stand-alone solar PV and wind hybrid system as mentioned before; DC-common bus and AC-Common bus. Fig. 3 below shows a stand-alone solar PV and wind hybrid system with DC common bus. One of its main advantages is to include DC interface bus for coupling different generation sources, which do not have to operate at a constant frequency and in synchronism[17].

The DC bus line output voltage from all streams is set to be fixed and the output current from each source is controlled independently. The DC outputs' voltages from individual solar PV, wind and battery bank stream, through individual DC/DC and AC/DC units, are integrated on the DC side, combined in parallel and go through one common DC/AC inverter which acts as an interface between the power sources and the loads to provide the required power to the load by regulating the AC output voltage. The battery bank is interfaced by a DC/DC converter which regulates the DC-link bus voltage by charging (in case of extra power) or discharging the battery (in case of shortage of power). The renewable energy sources act as current sources and supply directly the loads. The interface common unit regulates the magnitude of the load's voltage. The individual AC/DC and DC/DC units can be employed for MPPT systems to have the maximum power from the solar PV and wind systems and the common DC/AC inverter will control magnitude of the load's voltage. The battery bank acts as a voltage source to control the common DC bus voltage by charging or discharging.

In the conventional way for controlling the complete hybrid system, power electronics converters are used for maximum energy extract from solar and wind energy resources. In addition, advanced controlling techniques can remove the power fluctuations caused by the variability of the renewable energy sources [116-119]. Fig. 4 below shows stand-alone solar PV and wind hybrid system with AC common bus. The form of pure AC bus bar system is widely used worldwide with lot of advantages, such as simple operation, plug and play scenario, low cost and easy extension according to the load's requirement. On the other hand, controlling AC voltage and frequency and energy management are some of the challenges for this type of topology. In this topology, the AC outputs' voltages from individual solar PV, wind and battery bank stream, through individual DC/AC and AC/DC-DC/AC units, are feeding the loads directly. The renewable energy sources can act as current sources provided that the battery bank exists as a voltage source to control the common AC bus voltage by charging or discharging. Hence, the individual units can be employed for MPPT systems to have the maximum power from the solar PV and wind systems provided that the battery bank exists as a voltage source to control the common AC bus voltage by charging or discharging. The battery bank is charged when there is an extra power and discharged and can supply power in case of shortage of power from the renewable energy sources.

Droop control is normally applied to generators for frequency control and sometimes voltage control in order to have load sharing of parallel generators. It can also be used to perform proper current sharing in a microgrid. With droop control, decentralized control for each interfacing converter is achieved. At the same time, no communication or only low bandwidth communication, such as power line communication, can be used in AC systems [120].

A line interactive UPS and its control system were presented by Abusara et al. [121]. Power flow was controlled using frequency and voltage drooping technique in order to ensure seamless transfer between grid-connected and stand-alone parallel modes of operation. A supervisory control strategy was designed in [122] for a DC distributed solar microgrid to have MPPT and decide on power flow direction.

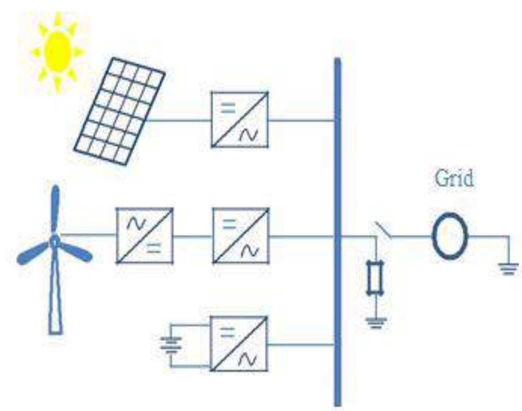
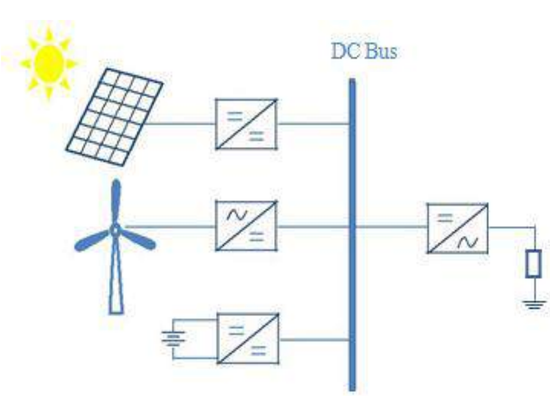


Fig. 5 Hybrid system with AC microgrid

Fig. 3 Stand-alone hybrid system at common DC bus



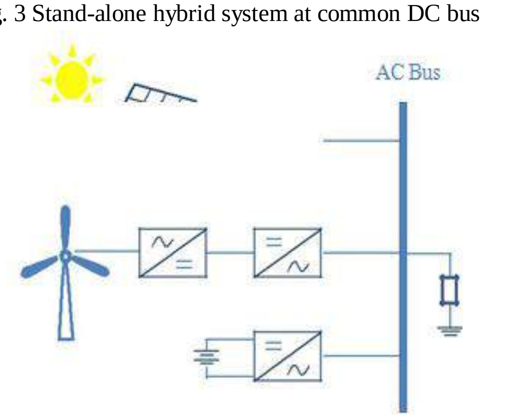


Fig. 4 Stand-alone hybrid system at common AC bus

III. AC Microgrid

Fig. 5 below shows a hybrid solar PV and wind system along with battery bank which is connected to an AC Microgrid. The system can work in grid-connected mode or stand-alone mode. The DC outputs' voltages from individual solar PV and wind stream, through individual DC/AC and AC/DC-DC/AC units, are integrated and combined in parallel on the AC side to provide the power to the grid/loads even with only one source available. Hence, in the grid-connected mode of operation, the renewable energy sources act as current sources and inject power directly into the AC bus. The battery system interfaced by a bi-directional converter and can be charged or discharged depending on the situation of the generation, load and its state of charge.

However, in the stand-alone mode, the renewable energy sources act as current sources feeding directly the loads and the battery bank acts as a voltage source controlling the AC bus voltage by charging or discharging. The battery converter regulates the magnitude and frequency of the load voltage. The individual RES units can be employed for MPPT systems to have the maximum power from the solar PV and wind systems in the grid-connected mode.

The same thing can be applicable in the stand-alone mode provided that the battery bank exists as a voltage source to control the AC bus voltage by charging or discharging.

CONCLUSION

This paper has provided a review of challenges and opportunities on integrating solar PV and wind energy sources for electricity generation. The main challenge for grid-connected system as well as the stand-alone system is the intermittent nature of solar PV and wind sources. By integrating the two resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. This definitely has bigger impact on the stand-alone generation. Integration of renewable energy generation with battery storage and diesel generator back-up systems is becoming a cost-effective solution for stand-alone type. The wind-battery-diesel hybrid configuration can meet the system load including peak times. Energy management strategies should ensure high system efficiency along with high reliability and least cost. Good planning with accurate forecasting of weather pattern, solar radiation and wind speed can help in reducing the impact of intermittent energy.

Voltage and frequency fluctuation, and harmonics are major power quality issues for both grid-connected and stand-alone systems with bigger impact in case of weak grid. This can be resolved to a large extent by having proper design, advanced fast response control facilities, and good optimization of the hybrid systems.

The paper gave an overview of different research works related to optimal sizing design, power electronics topologies and control for grid-connected and stand-alone hybrid solar PV and wind systems. Solar PV and wind hybrid system can be connected in a common DC or common AC bus whether they are working in a grid-connected mode or a stand-alone mode.

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TECH-CHRONICLE
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To Study the Effects of Ultracapacitor (UCAP) as a Conditioner In an Integrated Power System

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***Abstract* – Penetration of various types of distributed energy resources (DERs) like solar, wind, and plug-in hybrid electric vehicles (PHEVs) onto the distribution grid is on the rise. There is a corresponding increase in power quality problems and intermittencies on the distribution grid. In order to reduce the intermittencies and improve the power quality of the distribution grid, an ultracapacitor (UCAP) integrated power conditioner is proposed in this paper. UCAP integration gives the power conditioner active power capability, which is useful in tackling the grid intermittencies and in improving the voltage sag and swell compensation. UCAPs have low energy density, high-power density, and fast charge/discharge rates, which are all ideal characteristics for meeting high-power low-energy events like grid intermittencies, sags/swells. Thesimulationmodeloftheoverall systemisdeveloped and compared with the experimental hardware setup.**

***Index Terms* – Active power filter (APF), dc–dc converter, d–q control, digital signal processor (DSP), dynamic voltage restorer (DVR), energy storage integration, sag/swell, ultracapacitors (UCAP).**

I. INTRODUCTION

POWER QUALITY is major cause of concern in the industry, and it is important to maintain good power quality on the grid. Therefore, there is renewed interest in power quality products like the dynamic voltage restorer (DVR) and active power filter (APF). DVR prevents sensitive loads from experiencing voltage sags/swells and APF prevents the grid from supplying nonsinusoidal currents when the load is nonlinear. The concept of integrating the DVR and APF through a back–back inverter topology was first introduced in and the topology was named as unified power quality conditioner (UPQC). The design goal of the traditional UPQC was limited to improve the power quality of the distribution grid by being able to provide sag, swell, and harmonic current compensation. In this paper, energy storage integration into the power conditioner topology is being proposed, which will allow the integrated system to provide additional functionality. With the increase in penetration of the distribution energy resources (DERs) like wind, solar, and plug-in hybrid electric vehicles (PHEVs), there is a corresponding increase in the power quality problems and intermittencies on the distribution grid in theseconds to minutes time scale . Energy storage integration with DERs is a potential solution, which will increase the reliability of the DERs by reducing the intermittencies and also aid in tackling some of the power quality problems on the distribution grid. Applications where energy storage integration will improve the functionality are being identified, and efforts are being made to make energy storage integration commercially viable on a large scale. Smoothing of DERs is one application where energy storage integration and optimal control play an important role.

Of all the rechargeable energy storage technologies superconducting magnet energy storage (SMES), flywheel energy storage system (FESS), battery energy storage system (BESS), and ultracapacitors (UCAPs), UCAPs are ideal for providing active power support for events on the distribution grid which require active power support in the seconds to minutes time scale like voltage sags/swells, active/reactive power support, and renewable intermittency smoothing.

II. LITERATURE REVIEW

Ultracapacitor as a conditioner in an integrated power system is the latest area of interest amongst the Power Electronics researchers. Some of the research work and literature are as given below.

Deepak Somayajula , and Mariesa L. Crow proposes the concept of integrating UCAP-based rechargeable energy storage to a power conditioner system to improve the power quality of the distribution grid[2].W. Li, G. Joos, and J. Belanger proposes methods to overcome the challenges of real-time simulation of wind systems, characterized by their complexity and high-frequency switching have been discussed.The simulation results of the detailed wind system model show that the hybrid ESS has a lower battery cost, higher battery longevity, and improved overall efficiency over its reference ESS[3].X. Li, D. Hui, and X. Lai proposes results of a wind/photovoltaic (PV)/BESS hybrid power system simulation analysis undertaken to improve the smoothing performance of wind/PV/BESS hybrid power generation and the effectiveness of battery SOC control has been presented [4]. P. Thounthong, A. Luksanasakul, P. Koseeyaporn, and B. Davat proposes mathematical model reduced-order model of the FC, PV, and SC converters is described for the control of the power plant. Using the intelligent fuzzy logic controller based on the flatness property for dc grid voltage regulation, a simple solution to the fast response and stabilization problems in the power system has been proposed[5].J. Tant, F. Geth, D. Six, P. Tant, and J. Driesen proposes the potential of using battery energy storage systems in the public low-voltage distribution grid, to defer upgrades needed to increase the penetration of photovoltaic (PV) has been investigated [6]. Y. Ru, J. Kleissl, and S. Martinez proposes the problem of determining the size of battery storage used in grid-connected photovoltaic (PV) systems . Here the electricity is generated from PV and is used to supply the demand from loads [7]. S. Teleke, M. E. Baran, S. Bhattacharya, and A. Q. Huang proposes a rule-based control scheme, which is the solution of the optimal control problem defined, to incorporate the operating constraints of the BESS, such as state of charge limits, charge/discharge current limits, and lifetime has been discussed.[8] .T. K. A. Brekkenetal. presented sizing and control methodologies for a zinc–bromine flow batterybased energy storage system. The results show that the power flow control strategy does have a significant impact on proper sizing of the rated power and energy of the system[9].

III. THREE-PHASE INVERTERS

The one-line diagram of the system is shown in Fig. 1. The power stage consists of two back-to-back three-phase voltage source inverters connected through a dc-link capacitor. UCAP energy storage is connected to the dc-link capacitor through a bidirectional dc–dc converter. The series inverter is responsible for compensating the voltage sags and swells; and the shunt inverter is responsible for active/reactive power support and renewable intermittency smoothing. The complete circuit diagram of the series DVR, shunt APF, and the bidirectionaldc–dc converter is shown in Fig. 2. Both the inverter systems consist of IGBT module, its gate-driver, LC filter, and an isolation transformer. The dc-link voltage Vdc is regulated at 260 V for optimum voltage and current compensation of the converter and the line–line voltage Vab is 208 V. The goal of this project is to provide the integrated power conditioner and UCAP system with active power capability 1) to compensate temporary voltage sag (0.1–0.9 p.u.) and swell (1.1–1.2 p.u.), which last from 3 s to 1 min [18]; and 2) to provide active/reactive support and renewable intermittency smoothing, which is in the seconds to minutes time scale.

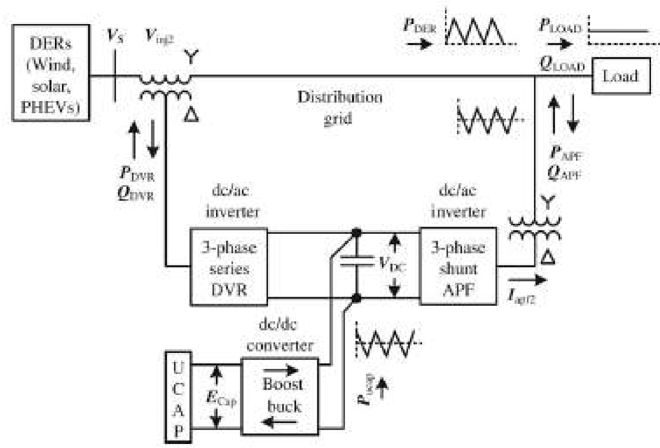

Figure.1 One-line diagram of power conditioner with UCAP energy storage.

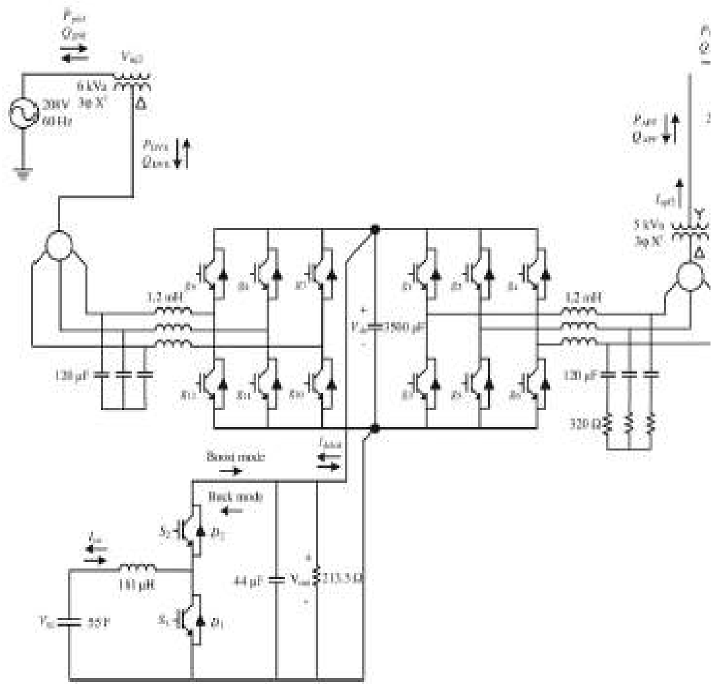

Figure 2.Model of power conditioner with UCAP energy storage

IV. Controller Implementation

Average current mode control is used to regulate the output voltage of the bidirectional dc–dc converter in both Buck and Boost modes, while charging and discharging the UCAP bank. While the UCAP-APF system is discharging power, the dc-link voltage Vout tends to be less than Vref, which causes the reference current Iucref to be positive, thereby operating the dc–dc converter in Boost mode. Along similar lines, when the UCAP-APF system is absorbing power from the grid, the dc-link voltage Vout tends to be greater than Vref, which causes the reference current Iucref to be negative and thereby operating the dc–dc converter in Buck mode. Average current mode control technique was found as the ideal method for UCAP-APF integration as it tends to be more stable when compared with other methods like voltage mode control and peak current mode control. Average current mode controller and the higher level integrated controller are shown in Fig. 3, where the actual output voltage Vout is compared with the reference voltage Vref and the error is passed through the voltage compensator C1 (s), which generates the average reference current Iucref. This is then compared with the actual UCAP current Iuc, and the error is then passed through the current compensator C2 (s). The converter model for average current mode control is based on the following transfer functions developed in :

$$G_{\mathrm{id}}(s) = \frac{V_{\mathrm{out}}\left(sC + \frac{2}{R}\right)}{s^2\mathrm{LC} + s\frac{L}{R} + (1-D)^2}$$

$$G_{\mathrm{vi}}(s) = \frac{(1-D)\left[1 - \frac{sL}{R(1-D)^2}\right]}{\left(sC + \frac{2}{R}\right)}.$$

The model of the dc–dc converter in average current mode control is shown in Fig. 4 that has two loops. The inner current loop Ti (s) has the current compensator C2 (s), voltage modulator gain VM, and the transfer function Gid (s). The outer voltage loop Tv (s) constitutes the voltage compensator C1 (s), current loop Ti (s), and the transfer function Gvi (s). The current compensator design C2 (s) must be carried out initially and the voltage compensator C1 (s) design is based on the design of the current compensator due to the dependency of C1 (s) on C2 (s). The current compensator C2 (s) must be designed in such a way that at the crossover frequency of the current loop there is enough phase-margin to make the current loop Ti (s) stable and it should have a higher bandwidth when compared to the voltage loop Tv (s). Based on these criteria, the transfer functions of the current loop Ti (s) and the current compensator C2 (s) are given by

$$T_i(s) = G_{\mathrm{id}}(s)\,.\frac{C_2(s)}{V_M}$$

$$C_2(s) = 1.67 + \frac{231.81}{s}.$$

The closed-loop transfer function of the current loop is then given by

$$T_1(s) = \frac{T_i(s)}{1 + T_i(s)}.$$

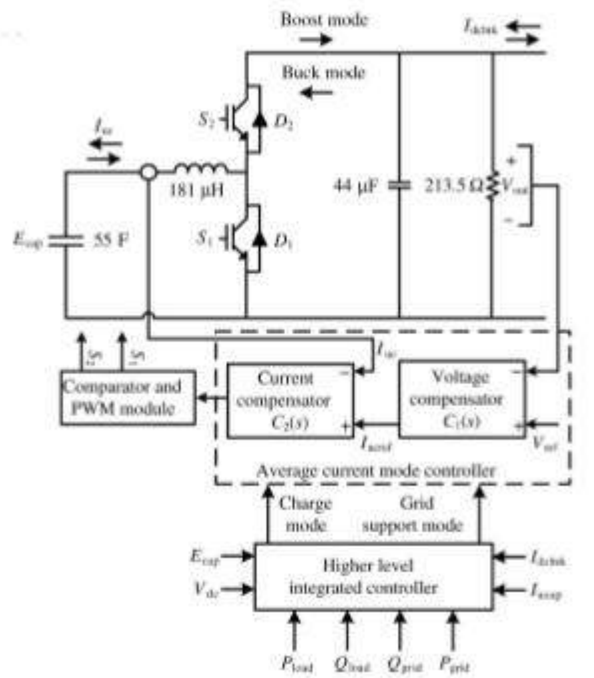

Figure 3 : Average current mode controller and the higher level integrated controller

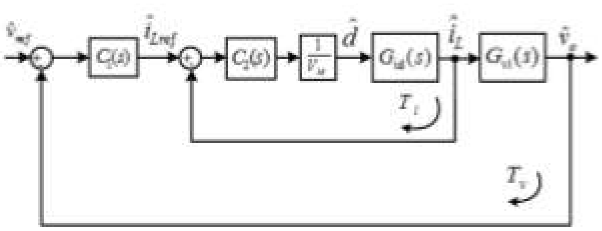

Figure 4 :The model of the dc–dc converter in average current mode control

V.CONCLUSION

In this paper, the concept of integrating UCAP-based rechargeable energy storage to a power conditioner system to improve the power quality of the distribution grid is presented. With this integration, the DVR portion of the power conditioner will be able to independently compensate voltage sags and swells and the APF portion of the power conditioner will be able to provide active/reactive power support and renewable intermittency smoothing to the distribution grid. UCAP integration through a bidirectional dc–dc converter at the dc-link of the power conditioner is proposed. Designs of major components in the power stage of the bidirectional dc–dc converter are discussed. Average current mode control is used to regulate the output voltage of the dc–dc converterdue to its inherently stable characteristic. A higher level integrated controller that takes decisions based on the system parameters provides inputs to the inverters and dc–dc converter controllers to carry out their control actions. The simulation of the UCAP-PC system is carried out using MATLAB. Hardware experimental setup of the integrated system is presented and the ability to provide temporary voltage sag compensation and active/reactive power support and renewable intermittency smoothing to the distribution grid is tested Similar UCAPbased energy storages can be deployed in the future in a microgrid or a low-voltage distribution grid to respond to dynamic changes in the voltage profiles and power profiles on the distribution grid.

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TECH-CHRONICLE
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Comparative Study Of Improvement Of The Electric Power Quality Using FACTS Devices & Series Active and Shunt Passive Filters

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***Abstract* – This paper presents A control algorithm for a three-phase hybrid power filter is proposed. It is constituted by a series active filter and a passive filter connected in parallel with the load. The control strategy is based on the vectorial theory dual formulation of instantaneous reactive power, so that the voltage waveform injected by the active filter is able to compensate the reactive power and the load current harmonics and to balance asymmetrical loads. The proposed algorithm also improves the behavior of the passive filter. Simulations have been carried out on the MATLAB-Simulink platform with different loads and with variation in the source impedance. This analysis allowed an experimental prototype to be developed. Experimental and simulation results are presented.**

***Index Terms* – Active power filter, passive filters, reactive power, hybrid filter, power quality.**

I. INTRODUCTION

The increase of nonlinear loads due to the proliferation of electronic equipment causes power quality in the power system to deteriorate. Harmonic current drawn from a supply by the nonlinear load results in the distortion of the supply voltage waveform at the point of common coupling (PCC) due to the source impedance. Both distorted current and voltage may cause end-user equipment to malfunction, conductors to overheat and may reduce the efficiency and life expectancy of the equipment connected at the PCC. Traditionally, a passive LC power filter is used to eliminate current harmonics when it is connected in parallel with the load. This compensation equipment has some drawbacks, due to which the passive filter cannot provide a complete solution. These disadvantages are mainly the following.

—The compensation characteristics heavily depend on the system impedance because the filter impedance has to be smaller than the source impedance in order to eliminate source current harmonics.

—Overloads can happen in the passive filter due to the circulation of harmonics coming from nonlinear loads connected near the connection point of the passive filter.

—They are not suitable for variable loads, since, on one hand, they are designed for a specific reactive power, and on the other hand, the variation of the load impedance can detune the filter.

—Series and/or parallel resonances with the rest of the system can appear.

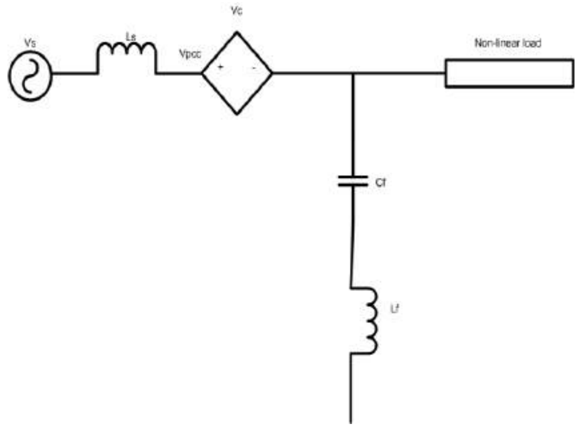

Fig.1. Series active filter and parallel passive filter

An active power filter, APF, typically consists of a threephase pulsewidth modulation (PWM) voltage source inverter. When this equipment is connected in series to the ac source impedance it is possible to improve the compensation characteristics of the passive filters in parallel connection. This topology is shown in Fig. 1, where the active filter is represented by a controlled source, where is the voltage that the inverter should generate to achieve the objective of the proposed control algorithm. Different techniques have been applied to obtain a control signal for the active filter. One such is the generation of a voltage proportional to the source current harmonics .With this control algorithm, the elimination of series and/or parallel resonances with the rest of the system is possible. The active filter can prevent the passive filter becoming a harmonics drain on the close loads. Additionally, it can prevent the compensation features depending on the system impedance. From the theoretical point of view, the ideal situation would be that the proportionality constant, k, between the active filter output voltage and source current harmonics, had a high value. However, at the limit this would be an infinite value and would mean that the control objective was impossible to achieve. The chosen k value is usually small so as to avoid high power active filters and instabilities in the system. However, the choice of the appropriate k value is an unsolved question since it is related to the passive filter and the source impedance values. Besides, this strategy is not suitable for use in systems with variable loads because the passive filter reactive power is constant, and therefore, the set compensation equipment and load has a variable power factor.

In another proposed control technique, the APF generates a voltage waveform similar to the voltage harmonics at the load side but in opposition. This strategy only prevents the parallel passive filter depending on the source impedance; the other limitations of the passive filter nevertheless remain.

II. LITERATURE REVIEW

Power quality problem exists if any voltage, current or frequency deviation results in a faliure or in a bad operation of customer's equipment. One more problem is harmonics. Harmonics are produced due to non linear load. A flexible and versatile solution to power quality problem are offerd by active power filters. Here are various literature review on the the improvement of power quality.

P. Salmeron and S. P. Litran (2010), proposed a control algorithm for three phase hybrid power filter. This is constituted by a series active filter and passive filter connected in parallel with the load. The control stratergy is based on the Vectorial Theory dual formulation of instantaneous reactive power so that the voltage waveform injected by active filter is able to compensate the reactive power and the load current harmonics and to balance a symmetrical load the proposed algorithm also improves the behaviour of passive filter [1].

B. Singh, K. Al-Hadad, and A.Chandra (1999), proposed active filtering of electric power has become a mature technology for harmonic and reactive power compensation in two wire (single phase), three wire (three phase without neutral), and four wire (three phase with neutral) ac power networks with nonlinear load. they proposed a comprehensive review of active filter configurations, control strategy, selection of compontants, other related economic and technical consideration, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues.[2]

J. W. Dixon, G. Venegas, and L. A. Moran (1997), proposed a series active power filter working as a sinusoidal current source, in phase with the mains voltage. The amplitude of the fundamental current in the series filter is controlled through the error signal generated between the load voltage and a pre established reference. The control allows an effective correction of power factor, harmonic distortion, and load voltage regulation. Compared with previous methods of control developed for series active filters, this method is simper to implement, because it is only required to generate a sinusoidal current, in phase with the mains voltage, the amplitude of which is controlled through the error in the load voltage [3].

R. S. Herrera and P. Salmeron (2007)the behavior of different active power filter (APF) control algorithms resulting from five formulations of the instantaneous power theory: – original theory,– transformation, modified or cross product formulation, – – reference frame and vectorial theory are analyzed. A simulation platform with control + APF + load is built to test the different algorithms. The results obtained in an unbalanced and nonsinusoidal three-phase four-wire system are compared. The final analysis shows that from the five formulations, only the vectorial one allows balanced and sinusoidal source currents after compensation.[4]

Darwin Rivas, Luis Moran, Juan W. Dixon and Jose R. Espinoza (2003), proposed the performance analysis of a hybrid filter composed of passive and active filters connected in series. The analysis is done by evaluating the influence of passive filter parameters variations and the effects that different active power filter's gain have in the compensation performance of the hybrid scheme.[5]

J. C. Das (2004), proposed new topologies for harmonic mitigation and active filters have come long way & these address the line harmonic control at the source.[6]

F.Z. Peng and D. J. Adams (1999), proposed 22 configurations of power filters for harmonic compensation of non linear load.[7]

H. Akagi (2005), proposed unlike traditional paassive harmonic filters, modern active harmonic filters have the following multiple function: harmonic filtering, damping, isolation and termination, reactive-power control for power factore correction and voltage regulation, load balancing, voltage flicker reduction, and/or their combination.[8]

J. K. Pomilio and S.M. Deckmann(2007), proposed usage of data obtained from laboratory measurement of typical home application to verify whether these nonlinear loads behave similar to current or voltage type harmonic source [9]. C. Sankaran, provides complete knowledge about quality.[10]

III.SERIES ACTIVE FILTER AND PARALLEL PASSIVE FILTER

The project provides a new control strategy based on the dual formulation of the electric power vectorial theory is proposed. For this, a balanced and resistive load is considered as reference load. The strategy obtains the voltage that the active filter has to generate to attain the objective of achieving ideal behavior for the set hybrid filter-load. When the source voltages are sinusoidal and balanced the power factor is unity, in other words, the load reactive power is compensated and the source current harmonics are eliminated. By this means, it is possible to improve the passive filter compensation characteristics without depending on the system impedance, since the set load-filter would present resistive behavior. It also avoids the danger that the passive filter behaves as a harmonic drain of close loads and likewise the risk of possible series and/or parallel resonances with the rest of the system. In addition, the compensation is also possible with variable loads, not affecting the possible the passive filter detuning.

Although the APF series control based on the instantaneous reactive power theory is not new, in this paper the authors propose a new formulation that has consequences in the control loop design. In fact, the instantaneous reactive power here is defined from a dot product whereas in it is defined as a cross product; this results in a remarkable simplification in the implementation of the reference generation method. The final development allows any compensation strategy to be obtained, among them, unit power factor.

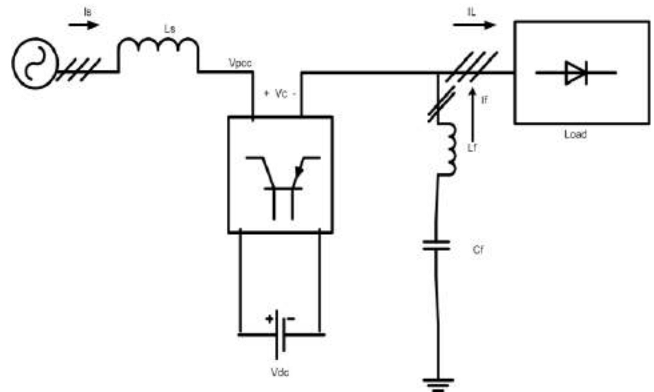

Fig.2. System with compensating equipment

IV. COMPARISON WITH FACTS DEVICE

The series and shunt compensation are able to increase the maximum transfer capabilities of power network .Concerning to voltage stability, such compensation has the purpose of injecting reactive power to maintain the voltage magnitude in the nodes close to the nominal values, besides, to reduce line currents and therefore the total system losses. At the present time, thanks to the development in the power electronics devices, the voltage magnitude in some node of the system can be adjusted through sophisticated and versatile devices named FACTS. One of them is the static synchronous compensator STATCOM.

VI. CONCLUSION

A control algorithm for a hybrid power filter constituted by a series active filter and a passive filter connected in parallel with the load is proposed. The control strategy is based on the dual vectorial theory of electric power. The new control approach achieves the following targets.

—The compensation characteristics of the hybrid compensator do not depend on the system impedance.

—The set hybrid filter and load presents a resistive behavior. This fact eliminates the risk of overload due to the current harmonics of nonlinear loads close to the compensated system.

—This compensator can be applied to loads with random

power variation as it is not affected by changes in the tuning frequency of the passive filter. Furthermore, the reactive power variation is compensated by the active filter.

—Series and/or parallel resonances with the rest of the system are avoided because compensation equipment and load presents resistive behavior.

Therefore, with the proposed control algorithm, the active filter improves the harmonic compensation features of the passive filter and the power factor of the load.

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TECH-CHRONICLE
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EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

High-Performance Multilevel Inverter With Voltage Balance and Minimum Switching Losses

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Abstract—Hybrid cascade multilevel inverters combine semi- conductor devices of different voltage ratings and technologies, which allow better system efficiency to be achieved. The bottlenecks of these topologies are, the need for isolated supplies for the cells and the lack of modularity. This paper focuses on the design and control of high-resolution, high-efficiency multilevel inverters with simplified dc power supplies. It introduces several rules for systematically designing the dc voltages of the cells, for which all unsupplied capacitor voltages can be regulated. Six classes of inverters are obtained covering single- and three- phase, staircase and pulsewidth-modulated (PWM) inverters. New configurations of hybrid cascade multilevel inverters are obtained for each class. A double modulation strategy with two different frequencies is proposed that allows switching losses of PWM inverters to be reduced.

Index Terms—AC-DC power converters, asymmetrical multi- level inverters, cascade multilevel inverters, hybrid multilevel in- verters, multilevel converters, multilevel topologies, pulse width modulation converters, series connected converters.

I. INTRODUCTION

Power electronic converters ,especially dc/ac PWM inverter mostly used in industry because they provide reduced energy consumption better system efficiency, improved quality of product, good maintains. Cascade multilevel inverters are the simplest as they combine standard H-bridge inverters in series to obtain a better inverter by hybridizing the properties of several cells and switches that would features high blocking voltage capabilities and low relative conduction losses with fast switches. Performing PWM by operating the high voltage cell at low switching frequency. By designing and controlling the inverter appropriately, it is possible to modulate all pairs of adjacent levels by switching only the low-voltage cells .As a cost point of view ,multilevel inverters not only offers high power ratings but also enable the use of low power application in renewable energy sources such as photo voltaic ,wind and fuel cell. For this reason two level high voltage and large power inverters has been designed with series connection of switching power devices such as gate turn off thyristers (GTOs) and insulated gate bipolar transistors(IGBTs).

II. LITERATURE REVIEW

In[1] a new multi-level, high power converter topologies have been proposed using a hybrid approach involving integrated Gate Commutated Thyristors (IGCT) and Insulated Gate Bipolar Transistors (IGBT) operating in synergism. Excellent current and voltage waveforms can be achieved even in weak network conditions. Additionally it is shown, that the multi-level conversion system can further be simplified by utilizing series connected H-bridges without the need of supply transformers and rectifiers.

In[2] hybrid asymmetric nine-level inverter has been investigated. It consists of a three-phase three-level integrated gate-commutated thyristor inverter (main inverter), with a two-level insulated-gate bipolar transistor H-bridge (sub inverter) in series with each phase. This paper proposes a control method to stabilize their voltages. Power balancing is guaranteed by varying the common-mode voltage, using an online nonlinear model-predictive controller. The controller predicts the system evolution as a function of the control inputs. A cost function of system and control quantities is iteratively minimized. This paper proposes a start up method that charges them in parallel with the supplied ones, without any additional equipment. Measurements show its successful application in the proposed drive system.

In[3] a cascaded H-bridge multilevel inverter that can be implemented using only a single dc power source and capacitors. Standard cascaded multilevel inverters require n dc sources for 2n + 1 levels. Without requiring transformers, the scheme proposed here allows the use of a single dc power source (e.g., a battery or a fuel cell stack) with the remaining n-1 dc sources being capacitors, which is referred to as hybrid cascaded H-bridge multilevel inverter (HCMLI) in this work. It is shown that the inverter can simultaneously maintain the dc voltage level of the capacitors and choose a fundamental frequency switching pattern to produce a nearly sinusoidal output. This work mainly discusses control of seven-level HCMLI with fundamental frequency switching control and how its modulation index range can be extended using triplen harmonic compensation.

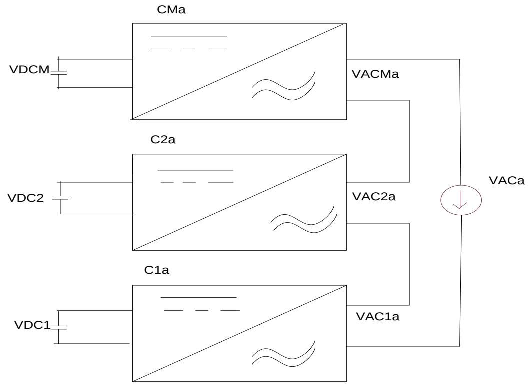
In[4] a method to increase the reliability of modular medium-voltage induction motor drives is discussed, by providing means to bypass a failed module. The impact on reliability is shown. A control, which maximizes the output voltage available after bypass, is described and experimental.

In[5] operation of three-level (3L) ANPC inverters has been analyzed under device failure conditions, and proposes the fault-tolerant strategies to enable continuous operating of the inverters and drive systems under single and multiple device open- and short-failure conditions. Therefore, the reliability and robustness of the electrical drives are greatly improved. Moreover, the proposed solution adds no additional components to standard 3L-ANPC inverters; thus, the cost for robust operation of drives is lower.

III. HYBRID CASCADED MULTILEVEL INVERTER MODEL

A. Investigated Hybrid Cascaded Multilevel Inverter Topologies

This paper investigates the design and control of single- and three-phase hybrid cascaded multilevel inverter topologies for which at least two rows have different voltage ratings and switch technologies and for which only the row with the highest volt- age is supplied. Examples of such topologies are represented in Figs. 1 and 2. For the three-phase topologies, we only con- sider structures that combine a supplied three-phase cell with unsupplied single-phase cells as for the topologies represented in Fig. 2. A



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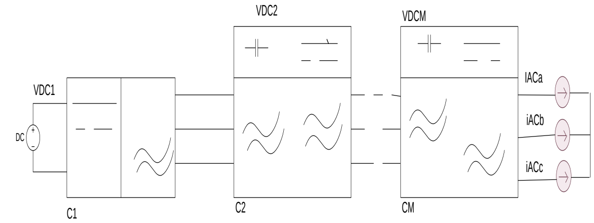

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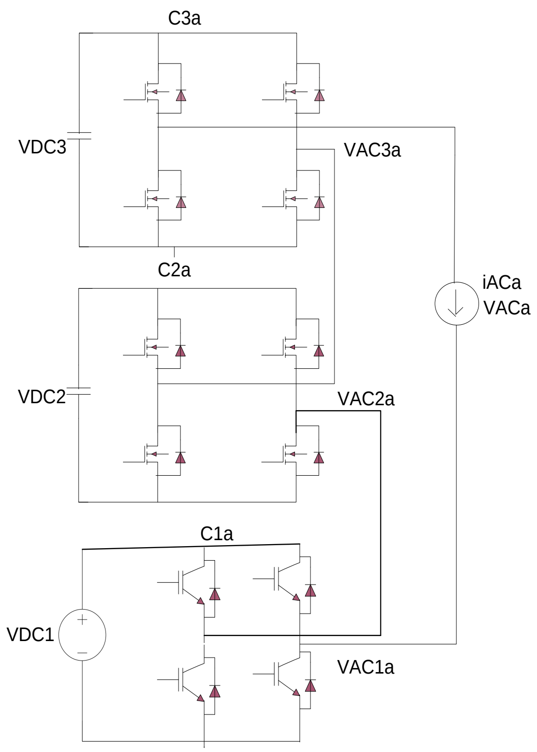
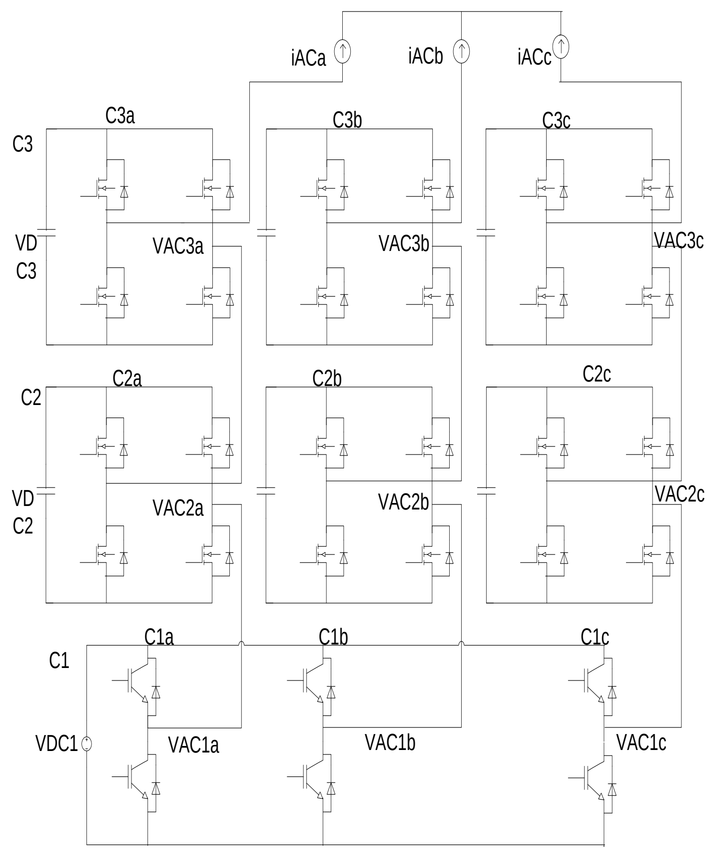


(b)

Figure 1 Investigated single-phase inverter topologies combine cells with different supply voltages and switch devices voltages. (a) General single-phase topology. (b) Asymmetrical cascade inverter.



(b)

Figure 2 Investigated three-phase inverter topologies combine one three-phase cell with single-phase cells and thus feature a single dc supply. (a) General three-phase topology. (b) Hybrid inverter with two-level three-phase inverter and H-bridges.

The regulation of the voltages of all unsupplied capacitors in these topologies is complex for two main reasons: First, the energy is stored in capacitors that are distributed both over the phases of the inverter and over the cells within a phase. Second, due to the asymmetry of the dc-voltages, the cells of different voltage ratings need to be coordinated to generate the desired output voltage. For the analysis, the converter is first split between its supplied subinverter, which is referred to as the high-voltage cell and its unsupplied subinverter, which is referred to as the low-voltage cell. The main difficulty is the energy balance of the low-voltage cell.

IV. CONCLUSION

Six rules for designing hybrid cascaded multilevel inverters with simplified supply and low switching losses have been de- rived. These design rules constrain the ratio between the dc volt- ages of the supplied cells and the dc voltages of the unsupplied cells. They allow one to design single- and three-phase inverters that can be operated either with staircase or with PWM. The proposed modular concepts define new configurations that increase the flexibility for choosing suitable switches.Theconcept of energy balance domain has been introduced to characterize the achievable operating modes and power factor. The proposed supply simplification is best suited for applications that do not require high power factor over the full inverter magnitude. For these,the switching devices can be optimally used,which results in a very high energy efficiency and very high number of levels. The internal balance of the cells over the phases and within the phase can be decoupled from the total energy regulation. The former is best done by controlling the common-mode voltage of the low-voltage cell. Applying the proposed voltage regulation and double modulation concepts,the solution is suitable for high dynamic performance. The effectiveness of the proposed con- cepts has been demonstrated experimentally on an multilevel induction motor drive.

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TECH-CHRONICLE
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Wireless Transmission of Electrical Energy by using Inductive Coupling

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Abstract-*In this paper, we are discussing concept of transmitting power without wires. The various technologies are now evolved for wireless transmission of electricity and the need for a wireless system of energy transmission is being discussed here to find its possibility in actual practices, their advantages, disadvantages and their feasibility. Many theories, research papers, patents are available on wireless transmission of electricity but its practical use is not started yet. The paper briefly explains the possible ways to get useful and practical results out of all research carried out so far elsewhere.*

***Keywords*—Wireless Power Transmission (WPT)**

I.INTRODUCTION

Wireless power transmission (WPT) is the efficient transmission of electric power from one point to another through vacuum or an atmosphere without the use of wire or any other substance. This can be used for applications where either an instantaneous amount or a continuous delivery of energy is needed, but where conventional wires are unaffordable, inconvenient, expensive, hazardous, unwanted or impossible. The power can be transmitted using inductive coupling for short range, resonant induction for mid range and electromagnetic wave power transfer for high range. WPT is a technology that can transport power to locations, which are otherwise not possible or impractical to reach. Wireless power transfer (WPT) or wireless energy transmission is the transmission of electrical power from a power source to a consuming device without using solid wires or conductors. Wireless power system consists of a "transmitter" device connected to a source of power such as mains power lines, which converts the power to a time-varying electromagnetic field, and one or more "receiver" devices which receive the power and convert it back to dc or ac electric power which is consumed by an electrical load. One of the major drawbacks in current power distribution system is the losses during the transmission of electrical energy. As the demands of power are increasing conveniently, power generation also increases and this leads to increase power loss during transmission. Our present transmission system is only 70-74% efficient this means about 1/3 of our generated power is waste in distribution [1]. Now-a-days global scenario has been changed a lot and there is tremendous development in every field. So we have to keep pace for development of new power technology. The transmission of power without wires

2. HISTORY OF WPT

Nikola Tesla conducted the first experiments in wireless power transfer at the turn of the 20th century. From 1891 to 1898 he investigated wireless transmission of electrical energy using his radio frequency resonant transformer called the Tesla coil, which produces high voltage, high frequency alternating currents. The Tesla coil was first developed as a high-voltage radiofrequency power supply for his "System of Electric Lighting" patented in 1891. With this basic resonance transformer design concept he was able to transmit electrical energy over short distances without interconnecting wires by means of resonant magnetic inductive coupling

The transformer's primary LC circuit acted as a transmitter. The transformer's secondary LC circuit was tuned to the primary LC circuit's resonant frequency and acted as a receiver. The Tesla coil transformer itself could be configured as a wireless transmitter and used to transmit energy by capacitive inductive coupling. While demonstrating this technology during lectures before the American Institute of Electrical Engineers in 1891, the Institution of Electrical Engineers in 1892 and at the 1893 Columbian Exposition in Chicago he was able to wirelessly power lamps from across the stage and out into the room.

In 1899 Tesla moved his wireless transmission research to Colorado Springs, Colorado. At the Colorado Springs Experimental Station he assembled an enormous version of his resonance transformer called a Tesla coil magnifying transmitter, capable of producing voltages on the order of 10 megavolts. In one demonstration, using just the primary circuit energized to only one-twentieth of the oscillator's full capacity, he was able to light three incandescent lamps by resonant inductive coupling to an improvised secondary circuit at a distance of about one hundred feet

3. WIRELESS ENERGY TRANSMISSION TECHNOLOGY

3.1. Electromagnetic induction method

The basic concept behind electromagnetic approach of WPT is magnetic induction between two coil say transmitting and receiving coil. When transmitter coil is excited than it generates flux and when receiver coil receives this flux a potential difference is developed across its terminals. The potential difference developed in receivers is directly related to distance between transmitter and receiver coil. Fig.1 shows the basic model for WPT.

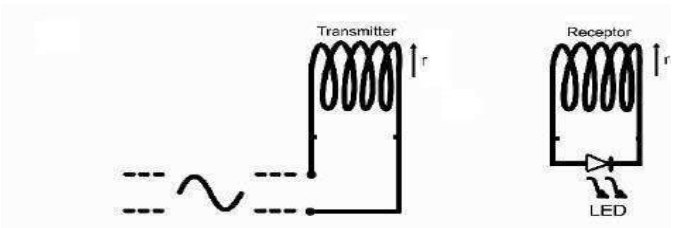

Fig-1: Basic Concept of WPT

This is the basic model and its efficiency is very poor and cannot be used for large distance transmission.

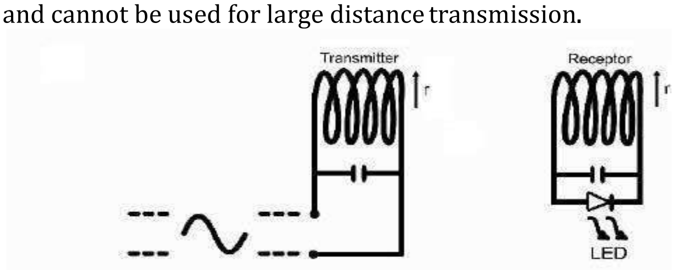

Fig-2: Modification using Coupling

We can enhance its efficiency by inductive coupling as shown in fig.2. But after this also we cannot use it for long distance transmission

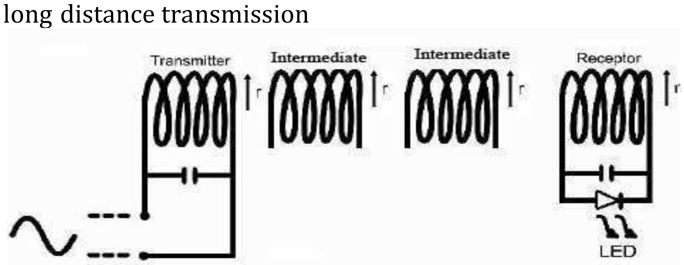

Fig-3: WPT with intermediates

For transmitting power through this method for long distance we have to introduce intermediate coils between transmitter and receiver as shown in fig.3.In general term this intermediate coils is called repeaters These repeaters increase efficiency of transmission. We can also use spiral coil for making transmitter and receivers. Efficiency is improved by using spiral based WPT.

4. BASIC DESIGN AND IMPLEMENTATION OF WIRELESS POWER SYSTEM

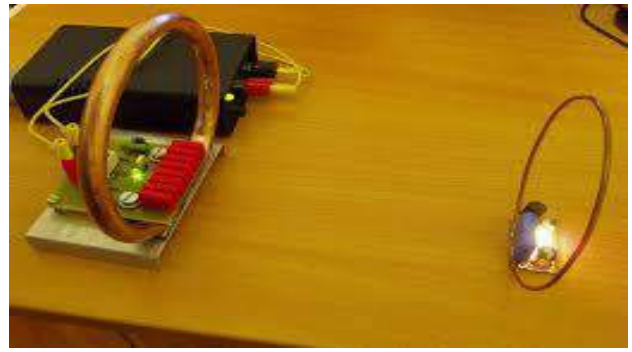

Fig-4.1: Practical Model

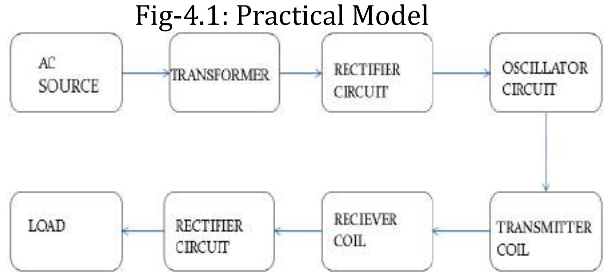

Fig-4.2: Block Diagram of WPT System

4.1 AC Power Source

In the wireless power transmission the 230V AC supply is given. And this AC supply then given to the step down transformer.

4.2 Step Down Transformer

The 230V AC supply is then gives to the transformer which is a step down transformer. As because the transformer only operates on AC supply it is necessary to give the AC supply to the system. This is the step down transformer that steps down the voltage from 230V to 24V with increasing the current.

4.3 Rectifier Circuit

The rectifier is covert the AC signals to DC signals. In this we used the bridge rectifier because the bridge rectifier works in both positive and negative half cycle. That gives full wave rectification. The rectifier is takes the 24VAC supply from transformer and convert it into 24V DC that requires for the circuit.

4.4 Oscillator Circuit

In this project the oscillator circuit is requires for generating the frequency up-to 1MHz. As well as it converts the DC supply return to AC.

4.5 Transmitting Coil

The transmitter coils are made up of copper coils, the supply is given from the oscillator is goes in this coils. Because step of down voltage the current is increases and this current is required for the produce the magnetic field. Due to current the flux are produces surrounding the coils and because of this the magnetic flux is produces between the transmitter and receiver coil.

4.6 Receiver Coil

The receiver coils are also made up of copper, the receiver receives the electric current from the transmitter. There is AC supply is takes place. Then the supply is given to the rectifier circuit that converts the AC signals to DC signals

4.7 LOAD

The 12V DC supply is comes from rectifier which having the wattage of 12 Watts. The load is used are the LED's or the DC Fan.

5. MERITS

1. Wireless Power Transmission system would completely eliminates the existing high-tension power transmission line cables, towers and sub stations between the generating station and consumers and facilitates the interconnection of electrical generation plants on a global scale.

2. The power could be transmitted to the places where the wired transmission is not possible. Loss of transmission is negligible level in the Wireless Power Transmission; therefore, the efficiency of this method is very much higher than the wired transmission.

3. Power is available at the rectenna as long as the WPT is operating. The power failure due to short circuit and fault on cables would never exist in the transmission and power theft would be not possible at all.

4. The main advantage of this technology is it does not require the wire because it wirelesses.

5. As there is no use of wires that means there is no extra wastage of wires.

6. Also due to that the losses that takes place in wired transmission such as copper loss, corona loss etc. are eliminated.

7. The weather does not affect the transmission as there is no wires are used.

6. DEMERITS

1. Capital Cost for practical implementation of WPT to be very high.

2. The other disadvantage of the concept is interference of microwave with present communication systems.

3. Common belief fears the effect of microwave radiation.

4. But the studies in this domain repeatedly proves that

5. the microwave radiation level would be never higher than the dose received while opening the microwave oven door, meaning it is slightly higher than the emissions created by cellular telephones

6. In wireless power transmission distance creates the issue in transmission. Because as increasing the distance of the transmission the strength of the magnetic field getting weak and therefore the efficiency of transmission can be reduce.

7. APPLIATIONS

- It can be used in electronics consumer such as cell phones, laptop etc.

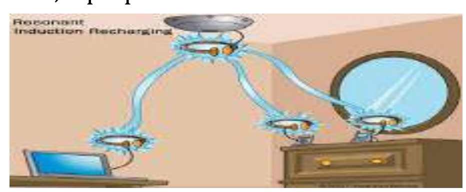

Fig-7.1: Application in Electronics Devices

- It is also used in industrial applications.
- Wireless power transmission used for in electric vehicles.

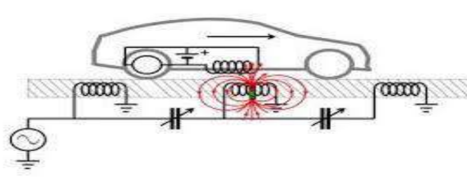

Fig-7.2: Electrical Car Charging

- Other applications such as in medical, military etc.
- This can also used for the charging of artificial hearts.

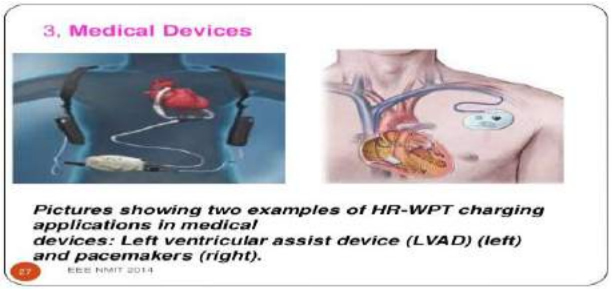

Fig-7.3:.Application in Medical

8. DISCUSSION

In our project the main goal was to design and implement a system that transmits power from one circuit to another circuit without wire. In this purpose, a transmitter circuit was implemented. At the end of the transmitter circuit an antenna was connected, which transmits the power. Another antenna was used to receive the power wirelessly from the transmitter circuit. In this project hollow copper pipes were used as antenna, because it has high Q-factor and high power handling performance. It requires a huge task to implement the whole project. During implementation a number of remarkable problems were faced and were solved as well. Though these implementation sessions require patience, it gives a great pleasure after successful solution.

9. SUGGESTIONS FOR FUTURE WORK

The circuit was just a trivial representation of a wireless power transfer concept. The time and bulk effort needed to take the project to perfection was not manageable.
To transmit the power to a greater distance, a high power radio frequency amplifier connected with an oscillator is needed. But the construction of the bulky RF power amplifier requires much time and patience. High power vacuum tube transistor amplifier with high current will make the system more efficient. A crystal oscillator circuit might be a better option for the transmitter circuit since it can produce a very high frequency A.C. current. Use of resonant inductive coupling instead of inductive coupling will increase the efficiency, power transfer and range to a new level. Further effort on this same project can yield some real solutions that can solve the problems of this project. The knowledge of this project will help those who want to design a wireless transfer system.

10. CONCLUSION

The goal of this project was to design and implement a wireless transfer for low power devices via inductive coupling. After analyzing the whole system step by step for optimization, a system was designed and implemented.
Experimental results showed that significant improvements in terms of power-transfer efficiency have been achieved. Measured results are in good agreement with the theoretical models. It was described and demonstrated that inductive coupling can be used to deliver power wirelessly from a source coil to a load coil and transfer the power wirelessly. This mechanism is a potentially robust means for transmission of power wirelessly. As it was mentioned earlier, wireless power transmission could be the next big thing

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