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Comparison of Theoretical and Practical Value Transient Stability Substance

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***Abstract*— It is necessary to design the system as a whole and choose its parts so that they give the required technical performance and are also economically justified. In such a situation, the whole system should be economical and not just one part of the system such as generation, transmission or distribution. The requirement of the power system performance should be considered and fulfilled as a basis of suitability of parts in the system. While laying out the equipment, the necessary clearance between the lines and earth or between lines and section should be maintained and provided for safety. Bus voltages, line flows and performance of protection systems are of interest in addition to the basic information related to the stability. In this paper detailed transient stability analysis is done whereby the classical model is slightly improved upon by taking into account the effect of damping towards transient stability response. The transient stability studies play a vital role in providing secured operating configurations in power systems. From this analysis, we can conclude the importance of these different parameters on power system transient stability studies. The model is simulated on MATLAB software and result is outputted in the form of waveform.**

Keyword*s:- *Power System Stability, Transient analysis, Load flow, Simulink, MATLAB

I.INTRODUCTION

Power systems transient stability phenomena are associated with the operation of synchronous machines in parallel, and become important with long distance heavy power transmissions[1].A power system consists of a few generating plants situated close to resources, supplying electric power to various types of loads spread out over large area, through large complex transmission and distribution network. Thus a power system compose of

1. Generation system
2. Transmission system
3. Distribution system
4. Loads

Depending on the fuel used we have hydro-electric power plants, thermal power plants and nuclear power plants. Generated supply will be of 11 kV. To have greater efficiency, transmission is carried out at high voltages of order 230 kV or 400 kV. Power transformers are used to setup the voltage levels. Transmission system consists of transformers, transmission towers and transmission lines. Thereafter, voltage levels are reduced in stages. Power system analysis deals with analysis problems associated with power network. Power Flow Analysis, Short Circuit Analysis and Transient Stability Study are the main Power System Analysis Problems [2]

A. *Important Terminology*

Tripping TIME = As per In IEEE report, the critical tripping time is defined as "The maximum power goes due to over load such that the power system is transiently stable [3].
Shut Down= Power is cut due to maintenance in progress. It is done manually.
Break Down =Power goes due to any fault in the line. When fault is removed, power is back.
Roasting = power is cut deliberately on order of higher authority due to shortage of power [26].

B. *Power System Stability*

The term stability, maintenance of synchronism and power limit are frequently used interchangeably though interpretation is made many times erroneously [23]. The disturbance may be small or big and the system may become unstable in either event depending on the operating condition at $t=t_0$. The study of stability in the presence of small disturbance constitutes what is known as "stability stability" analysis in the literature [19]. The mathematical model for such a study is a set of linear time-invariant differential equations. When the disturbance is large, the non-linearity inherent in the power system can no longer be ignored and the study of stability under such circumstances constitutes what is known as "transient stability" analysis [21-23-24].

C. *Techniques For Stability Improvement*

Transient stability is a very important aspect of modern multimedia power system. When a multi machine system becomes unstable it is split into two groups of machines which go out of synchronism with each other while the machine within each groups maintain synchronism.The $Pm = \frac{|E||V|}{X}$ is large because for any load, $\delta 1 - \delta o$ is small. The technique for improving stability can be classified into traditional technique and new approaches. [18].Traditional Techniques:

- Effect of generator design
- Increase of voltage
- Reduction in transfer reactance
- Rapid fault clearing
- Automatic reclosing
- ii] New Approaches :
- Quick valve opening action
- Application of breaking resistor
- Single pole switching
- Fast acting automatic voltage regulator
- Quick valve opening action
- Application of breaking resistor
- Fast acting automatic voltage regulator

The above mentioned methods of stability improvement have been in use. With the continued growth of power system, new approaches are needed [18-25]

Fig.1 shows the effect of the voltage regulator on the transient Stability. Along with the useful pre fault, during fault and post fault curves, the post fault power angle curve when the generator has an automatic voltage has an automatic voltage regulator (AVR) is shown. Under pre fault condition the generator is opening at point 1. When a fault occurs the operating point of the operation shifts to point 2 and the rotor accelerates. With no excitation control the operating point will return to point 3 on the post fault curve after the fault is cleared[18][30][10].

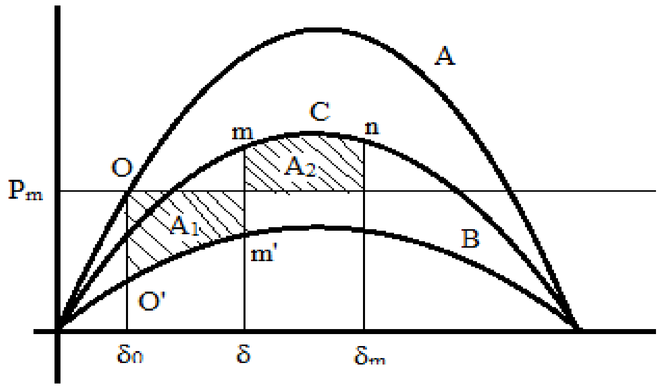


Fig 1. Equal area criterion as applied to the stability study of fault [17]

The initial load angle$\delta$is determined by the intersection of the line and the prefault output curve. When a fault occurs the operating point shifts to δ during fault. The accelerating power causes δ to increases. At angle δ when the operation reaches point during fault circuit breakers open and clear the fault. The operation shifts to point post fault curve. Now the output power is more than the input power and the rotor starts the decelerating. The maximum value of the δ is δ such that the area A_2 equal the area A_1.

Let the amplitudes of pre faults, during faults and post faults curves P_a , P_b and P_c respectively. Applying equal area criterion to fig [31-28]

$$\int_{\delta}^{\delta} (\mathrm{Pi} - \mathrm{P}mbSin\delta)\, d\delta = \int_{\delta}^{\delta} (PmcSin\delta - Pi) d\delta \qquad (1)$$

$$(Pi\delta - PmbCos\delta) \int_{\delta o}^{\delta c} = - \int_{\delta c}^{\delta m} ((Pmccos\delta + Pi\delta) \qquad (2)$$

II. II.CASE STUDIES OF TRANSIENT ANALYSIS

A. *ADVANCED ANALYSIS METHODS*

During the past decades, a number of advanced analysis methods have been developed for TSA (some were especially made for on-line TSA) with mixed success in applications. Here a summary of such methods is given. The principal information of power flow analysis is to find the magnitude and phase angle of voltage at each bus and the real and reactive power flowing in each transmission lines. Power flow analysis is an importance to involving numerical analysis applied to a power system. In this analysis iterative technique can be used due to there no known analytical method to solve the problem[15].

B. *DIRECT METHODS[6]*

Direct methods refer to a class of methods that assess the transient stability of a power system, and also give a measure of degree of stability (“stability margin”), based on partial responses of the system obtained from time-domain simulations[6].

A power distribution network is modeled using a tree topology graph (N, E) with the set of buses (nodes) N :={0, ...,N} and the set of line segments (edges) E := {(i, j)}; for a radial network illustration. At every bus j, let vj denote its voltage magnitude and pj (qj) represent the active (reactive) power injection, respectively[9]. All system quantities are in per unit (p.u.). Bus 0 corresponds to the point of common coupling, assumed to have unity reference voltage; i.e., v0 = 1. For each line (i, j), let rij and xij denote its resistance and reactance and Pij and Qij represent the power flow from i to j, respectively. To tackle the nonlinearity of power flow models, one can assume negligible line losses and almost flat voltage, i.e., vj∼= 1, ∀j[8]. For each (i, j), the liberalized power flow. asserts the bus power balance and line voltage drop under these assumptions, as given.

$$Pij - \sum K\epsilon Nj + Pij \qquad (3)$$

$$Qij - \sum K\epsilon Nj + Qj \qquad (4)$$

$$Vi - Vj = RijPij - XijQij \qquad (5)$$

Using the swing equation, we derive the equal area criterion which can be used for stability analysis of the system. The swing equation is

$$M\frac{d\delta m}{dt2} = Pm - Pe \qquad (6)$$

Where, δ_0 is the initial torque angle before any disturbance occurs. When dδ/dt = 0 then the angle δ will stop varying and the machine will be again be operating at synchronous speed post disturbance[29][30]

$$\int 2M\frac{d2\delta}{dt2}.\ \mathrm{dt} = \int 2(Pm - Pe)\frac{\mathrm{d}\delta}{\mathrm{dt}}\mathrm{dt} \qquad (7)$$

$$\mathrm{M}(\frac{\mathrm{d}\delta}{\mathrm{dt}})^2 = 2\int(Pm - Pe) \qquad (8)$$

$$\frac{\mathrm{d}\delta}{\mathrm{dt}} = \sqrt{2/M}\int_{\delta\circ}^{\delta}(Pm - Pe)d\delta + c \qquad (9)$$

Where, δ_0 is the initial torque angle before any disturbance occurs. When dδ/dt = 0 then the angle δ will stop varying and

the machine will be again be operating at synchronous speed post disturbance In fig 2 curve A represents the power angle curve corresponding to healthy condition of the system, curve B represents the fault on the line, and curve C corresponds to the situation when the faulted line is removed. Initially for P_m the torque angle is δ_0[26]. At the instant of fault the output of the generator is given by O. The rotor accelerates along curve 'B' till the faulted line is removed at m`, when the operating point becomes m on curve 'C'. Here the output is more than the input and thus the rotor decelerates till speed becomes equal to the speed of the bus and the torque angle ceases to increase at point n[23][19]. We can conclude that the transient stability depends on the type of disturbance as well as the clearing time of the breaker.

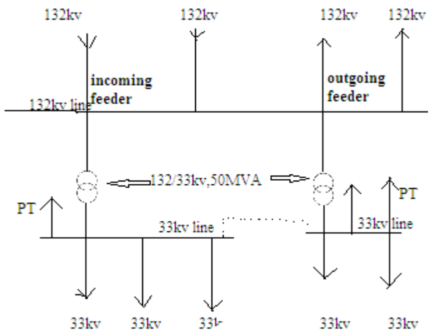


fig. single line diagram of 132kv substation

Fig 2.single line diagram of substation

In direct method , for transient analysis 132/33 kv distribution substation which is located at KARDHA, BHANDARA district has been selected. Substation consists of two transformer, 132/33 kv 50 MVA. It has two incoming feeder and two outgoing feeders of 132 kv and five outgoing feeder of 33 kv. From the observation cum surveying of substation the tripping in transmission line occur when the sudden disturbance comes in system. And if occur vice versa of this situation then the system is not consider as ideal. But it is true that in practical condition this situation is not satisfied the standard rule of power system. After my own observation the system sending voltage is somewhat different from exact receiving output voltage. And this case come due to of instability of power supply.

In the table 2.2 the bus load, voltage, power factor, frequency of the system is changed when tripping occur in substation. Due to tripping the small changes interrupt the system which makes the transmission line unhealthy. In the following table the bus voltage is changed from 134.7 to 134.2, the frequency is from 50hz to 49.97 and the load from 445 to 542 when tripping occur. From below table it is concluded that the parameter reading is become less after the fault clearing.

TABLE 2.1 CHANGE OF CURRENT, POWER OF TWO DIFFERENT FEEDER

Sr.No.	Feeder 1 Bhandara 1			Feeder 2 Bhandara2		
	AMP	MW	MVAR	AMP	MW	MVAR
1	239	53.4	18.53	232	51.1	18.26
2	229	51.7	17.78	222	49.36	17.66
3	225	51	16.53	218	48.67	16.42
4	225	50.8	17.02	217	48.48	16.9
5	226	50.9	17.51	219	48.56	17.36
6	274	57.8	27.2	218	59.52	27.09
7	251	54.6	22.71	240	51.57	22.08
8	257	58.1	21.82	247	52.07	21.22
9	257	54.6	24.7	246	51.7	21.6

TABLE 2.2 CHANGE OF LOAD BUS, FREQUENCY

Sr.No.	Feeder 1 132 KV BUS				Feeder 2 TEMP		
	BUS LOAD	VOLT KV	PF COS	FREQ HZ	WT HV	WT LV	OIL TEMP
1	471	133.4	0.94	50.01	46	46	45
2	451	134.7	0.94	50.03	45	45	44
3	443	134.2	0.94	49.97	45	44	43
4	442	134.5	0.94	50.05	45	44	43
5	445	133.8	0.94	49.97	45	44	43
6	542	131.5	0.94	50	45	44	43
7	491	132.1	0.94	50.03	45	44	43
8	504	131.8	0.94	50.01	45	44	43
9	503	131.4	0.94	50.01	47	47	46

From above observation of 132 kv substation the review comes to finalized that the current, voltage, power factor, load, reactive, active power and all other parameter reading less in post fault. The pre fault reading is higher than the post fault reading. The yellow marking reading is during fault reading and just below yellow marking the post fault reading is available.

C. Load flow analysis[8] :

Power flow analysis is the backbone of power system analysis and design. Power flow analysis is required for many other analyses such as transient stability, optimal power flow and contingency studies. The principal information of power flow analysis is to find the magnitude and phase angle of voltage at each bus and the real and reactive power flowing in each transmission lines[27][30]. In this analysis iterative technique can be used due to there no known analytical method to solve the problem. This resulted nonlinear set of questions or called power flow equations are generate [15]

- Continuation power flow (Bifurcation Analysis);
- Optimal power flow;
- Small signal stability analysis;
- Time domain simulations;
- Phasor measurement unit (PMU) placement [16]

layman's terms, anything that produces power. For a steady state load flow study, parameters that generators are represented as are fixed power and desired voltage magnitude[24][7]. A load in a power system context is defined as devices that consume power in the network. There are three types of loads in power system. They are purely resistive load, purely reactive load and load that consume both type of power. In a steady state load flow study, loads are specified as fixed real and reactive power. Transmission lines are power lines that connect feeder[13]. The main parameters of transmission lines are resistance R, and reactance X. In load flow analysis, parameters of transmission lines are simply represented as the impedance, $Z=R+jX$,

or as the admittance, $Y=\frac{1}{Z}=\frac{1}{R+jx}$ (10)

In a power system network, buses are bound to have individual or mutual admittance, and this increase the complexity to determine the admittance of the bus. However, it is easy to model the admittance of the network into a matrix for any analysis, where the diagonal elements are self-admittance and off-diagonal elements are mutual admittance [12].

- $Ik=\sum_{j=1}^{n} Ykj\, Vj$ *(11)*
- $S^*k=VK^*IK$ *(12)*

The Load flow solution is also known as power flow solution. The load flow solution of an electrical power system provides voltages, current at all the buses, power flows and losses in the lines at specific levels of power generation and loads[18

III. RESULT AND SIMULATION

Fig 3.below shows the single line diagram of substation on MATLAB software

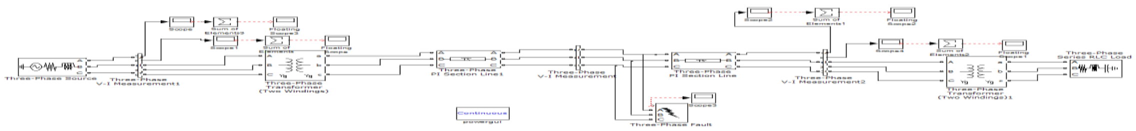


Fig3..Simulation model of transient analysis

Now Figure 4. shown below are for asymmetrical fault Waveform recorded with Fault Current Limiter (FCL) connected to the transmission line and during the fault of Phase A with Ground fault current without FCL as shown in Fig.

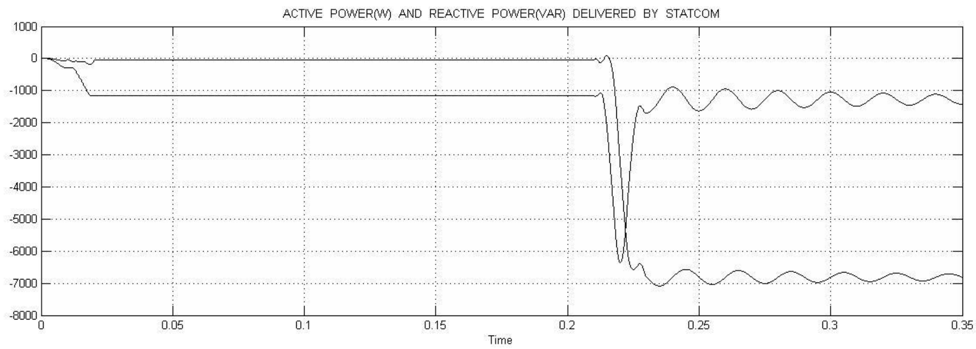
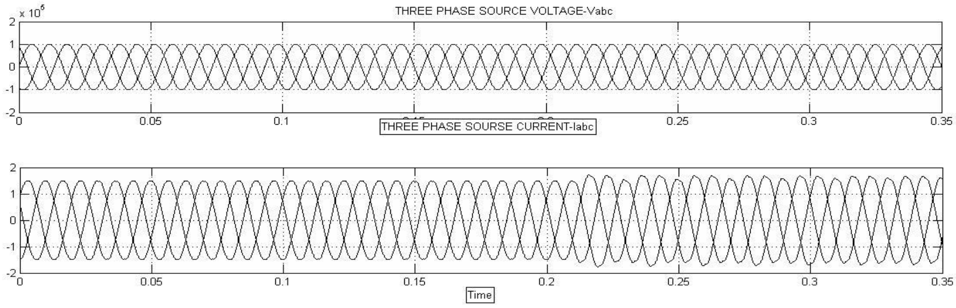


Fig. 5 is the waveform of active and reactive power and it has reduce the fault current to normal value.



IV. Conclusion

This paper discusses methods and techniques for improving computation speed of transient stability analysis with application to the direct method TSA. These methods are summarized with their application potential to on-line TSA [6]. Application examples are presented for some of the methods to show the benefits. Result of transient analysis gives the voltages, current, frequencies and their variation during and after the disturbance at the point of fault so, case study on these parameter is necessary. From this paper we will calculated the parameter reading for pre fault, post faults, transient stability, load flow, tripping time for faults etc[11][31].

It is clear from the above study that Simulink offers a wide perspective for simulation and analysis of various power system networks. The features of a Simulink model are exhaustive and at the same time it is very easy to understand and implement. In the present study, a simple classical model of a multi-machine system was considered [9][19]. However, it explains very well the principles and the scope of the tool, typically for the study of transient stability in a power system. As indicated in the discussions in previous sections, the other factors such as effects of excitation, turbine, speed governor or any control measure, can be easily realized in a Simulink model, especially with the help of readily available and perfectly compatible tools like Power System Block set. It should also be noted that a Simulink model can generate an equivalent C code for embedded applications and for rapid prototyping of control systems. Furthermore, the optimization and application of advanced tools such as ANN and fuzzy logic, is also much easier as there are corresponding toolboxes available within MATLAB. The paper has presented a trial to formulate a model for the 132 kv power system network. The model is based on the latest published data which has been reported for the substation [8].

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