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Performance Analysis of Transient Stability on a Power System Network

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Abstract— *Three phase fault on a power system network is most severe and uncommon. In order to maintain stability of power system, it is required to adjust the excitation system. A prior study of the effect of disturbance is required for proper designing of power system equipment's. This paper analyses the effect of a three phase fault on a power system 33kV/11kV/3.3kV/0.415kV system. Power flow analysis, transient stability study is presented using ETAP simulations.*

Keywords-**Transient stability analysis, critical clearing time, three phase fault, ETAP.**

1, INTRODUCTION

For the last few years electrical engineers have been focusing on the power system studies using software tools. Recent advances in engineering sciences have brought a revolution in the field of electrical engineering after the development of powerful computer based software. This research work high- lights the effective use of Electrical Transient Analyzer Program (ETAP) software for Transient stability analysis.Transmission networks of present power systems are becoming progressively more stressed because of increasing demand and limitations on building new lines. One of the consequences of such a stressed system is the risk of losing stability following a disturbance. Transients occur due to various disturbances like sudden change in the load, switching of the power electronics devices and capacitor banks, loss of the synchronous generators. Period of duration for the occurrence of this events is very short, even the generators AVR's response time is too large to respond to such an event. If these events are not monitored properly this will result in severe stability problem that may get effect on the system performance and system stability[1-6]. This analysis can be used to determine other things such as nature of the relaying system, critical clearing time of circuit breakers, voltage level and transfer capability between systems [7].

The literature shows an increasing interest in this subject for the last two decades, where the study of transient stability of a power system network carried out to determine the characteristic behaviour of system network subjected to the faults and other disturbances [5-10]. The main objective of this paper is to identify the problems in the power system network due to transient events thataffects the performance and stability of various equipment's which are being used. Refer of these Analysis would help in improving the Power system design and control by adopting differenttechniques.

This paper shows the study of 33kV/11kV/3.3kV/0.415kV utility system. The system of 33kV main bus is fed by power grid source of short circuit 1200MVA .The 33kV main bus is step down to the

11kV,3.3kV,415Vrespective bus comprising of step down transformer of rating 10MVA and three winding transformer of rating 15/10/5MVA respective. Moreover, the conductors/cables, circuit breakers, and rest of power system elements are modelled according to their actual ratings in ETAP. This paper represents a novel approach to analyse the power system network by using ETAP with the help of one line diagram.

The paper is organised as follows: Section I gives the introduction of transient stability in power system network.Section II is the complete single line diagram of the system under consideration; this diagram is implemented based upon practical data in ETAP for simulation purpose system. Section III briefly describes the Load flow analysis. Section IV explains the system modelling. Section V and VI shows the creation of fault event and results of system network, generator behaviour when subjected to fault and cleared. Section VII gives conclusion.

2, SYSTEM STRUCTURE

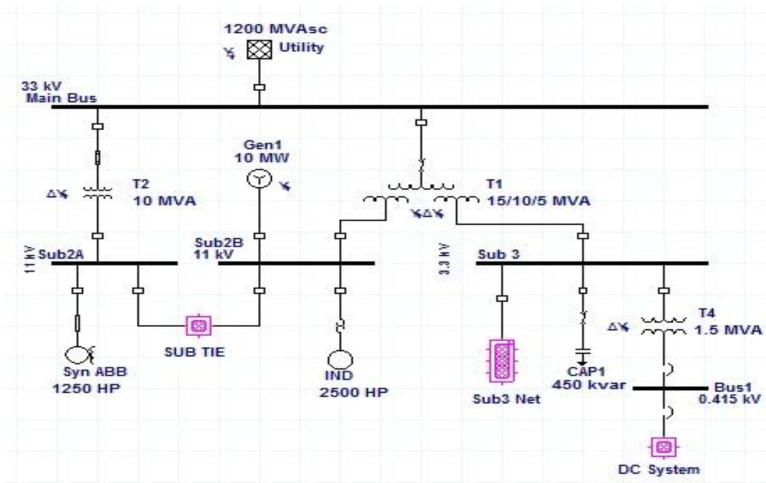

Fig.1. Single line diagram of 33kV/11kV/3.3kV/0.415kV

Single line diagram of the 33kV/11kV/3.3kV/0.415kV utility system is under study. The 11kV bus Sub2A and Sub2B is interconnected which is fed to 1250 HP synchronous motor (Syn ABB) and 2500 HP (IND).Generator (Gen 1) of 10MW supplies at bus Sub2B. Three winding transformer T1 is connected to Sub2B of 11kV and Sub 3 at 3.3kV.Sub 3 supplies to 0.415kV through transformer T4, Capacitor (CAP1) of 450KVAR and Sub 3 Net. Main Bus of 33kV supplies to 11kV bus Sub 2A and 3.3kV bus Sub3. This diagram is implemented in ETAP to perform load flow study and Transients stability analysis.The system is analyse under steady state by using load flow analyses and 3-phase fault at Sub 3 for Transients analysis.

4, LOAD FLOW ANALYSIS

Load flow studies have been performed at various monitoring points using ETAP, in which Newton–Raphson (NR) method is used. Here number of iterations used is 99.

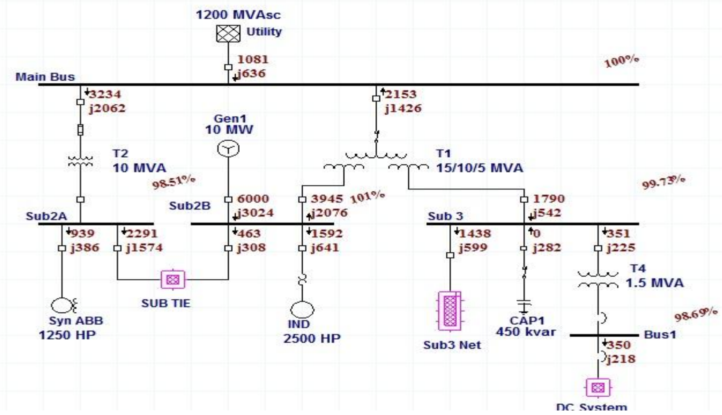

Fig.2. Load Flow Analysis of 33kV/11kV/3.3kV/0.415kV of Power System Network

Equipment	Loading	Size
Generator	100	10MW
Transformer T1	100	15/10/5MVA
Transformer T2	100	10MVA
Transformer T4	100	1.5MVA
Synchronous Motor	100	1250HP
Induction Motor	100	2500HP
Capacitor	3x150	450KVAR

Table 1. Loading of Equipment's

Fig.2 describes percentage of the bus loading as the number transmission stages goes on increasing with the drop across the line increases. Table 1.describes the loading of equipment's. Three winding transformer used with 15/10/5MVA with the Base MVA of 15 MVA and the generator of 10MW is loaded with 7MW as a design criteria and 6MW with normal operation.Table-2 provides the power flow report for the various monitoring points.

From	To	Active Power	Reactive Power	Bus Loading

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		(MW)	(KVAR)	(Percent)
Utility 1250MVA	Main 33KVBus	1081	636	100
Main Bus	Sub2A	3234	2062	98.5
Gen 1	Sub2B	6000	3024	101
Sub2A Sub2B	Sub Tie	2754	1882	101
T1	Sub3	1790	542	99.73
With Cap 450Kvar	Sub3	-	282	99.73
Without Cap 450Kvar	Sub3	1790	823	99.59

Table 2. Power flow report.

5, SYSTEM MODELLING

The 33kV/11kV/3.3kV/0.415kV utility system consists of generator, exciter, governor, load and other equipment's. In this study we would like to establish the mathematical models of these components first. We will now illustrate the equivalent models of the important components for this system below.

a. Excitation System:

The response of the excitation also depends upon its parameters like maximum ceiling voltage, current and insulation factor for rotor to withstand the required temperature. The Fig 3 shows fixed excitation of a generator at excitation voltage 1.36 per unit.The Excitation system used in Fig 3.0 is Fixed Excitation purely because system has only one generator with less load requirement and also short-circuit level of this system is very high so better is the voltage regulation and hence very less amount of voltage will be require to drive the current in order to meet the load requirement.

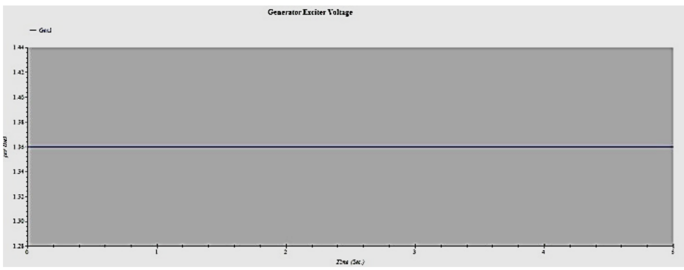

Fig.3. Fixed Excitation of a Generator(Excitation voltage vs Time)

b. GovernorModel:

The primary objective of a governor is to control the speed of the turbine so as to match the change in the electrical power output by adjusting the gate valve position in case of the hydro turbines

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and reheat in case of steam turbine. This is achieved by the load frequency control of the system.Isochronous governor work satisfactorily when the generator is supplying to an isolated load or when only one generator in a multi generator system is required to respond to changes in load but they cannot be used when two or more units are connected to same system. Governoroperation is in isochronous mode.

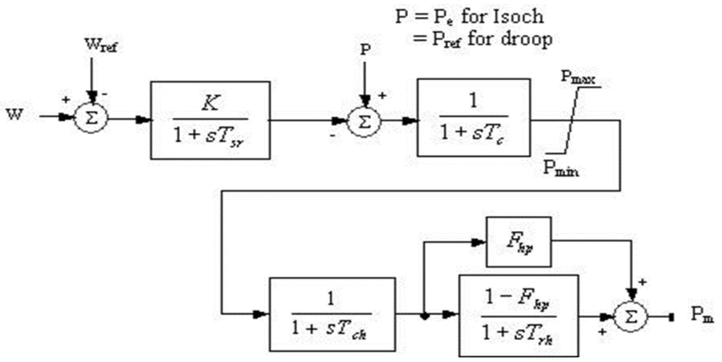


Fig.4. Block diagram of Single Reheat Steam Turbine (ST1)

6, TRANSIENT STABILITY ANALYSIS

The 33kV Main Bus which is considered to be a swing bus feeding to 11kV, 3.3kV and 0.415kV bus. Creating an Event in ETAP at fault t=0.5sec and fault cleared at t=0.7 sec using Newton-Raphson method with 99 iterations. The study of generator characteristics prior with response to the fault occurs and clears at Sub 3 also to study the impact on the bus voltage magnitude and angle at Sub 3 when the capacitor bank is on when subjected to these disturbances. Fault applied is a 3-phase fault at Sub 3.

7, SIMULATION RESULTS OF SYSTEM IN ETAP

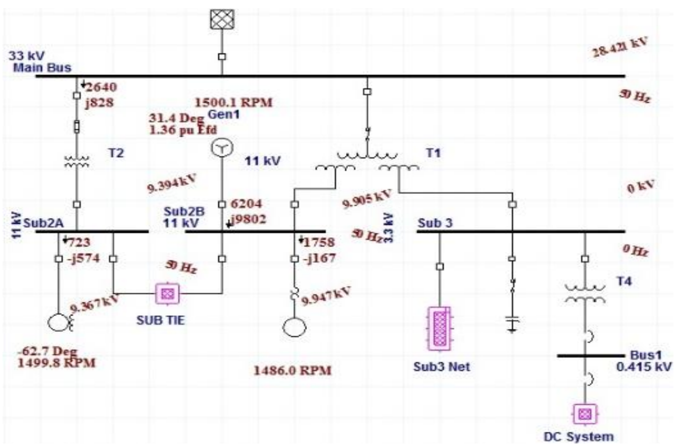


Fig.5.Simulated diagram for 3-phase fault applied at Sub3

Fig.5.describes 3-phase fault at Sub 3 resulting in drop in bus voltage and bus frequency to zero at=0.5sec

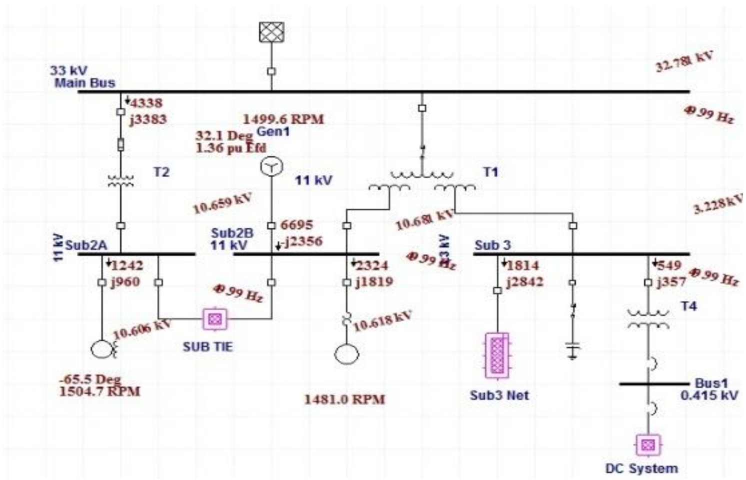


Fig.6. Simulated diagram after 3-phase fault cleared at Sub 3

Fig.6. describes 3-phase fault cleared at Sub 3 resulting in regaining normal voltage and frequency at t=0.7sec.The different plot for generator Gen 1 when fault on Sub 3 at0.5sec and cleared at 0.7sec are shown below in Fig.7,Fig.8,Fig.9,Fig.10,Fig.11,Fig.12,Fig.13.

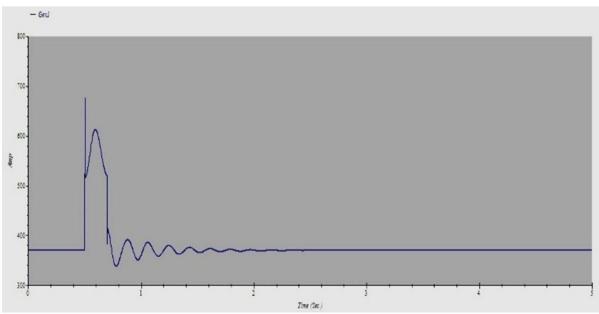


Fig.7.Generator Terminal Current

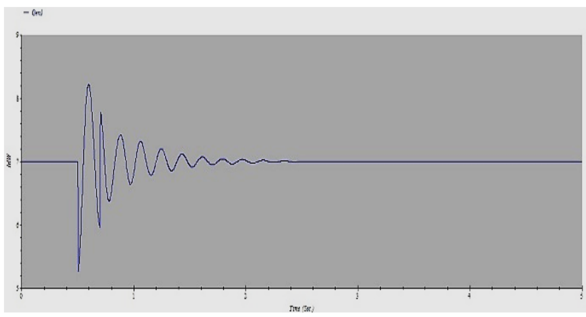
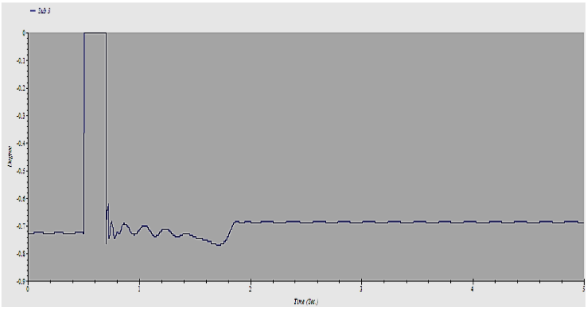


Fig.10. Generator Electrical Power (MW vs Time)



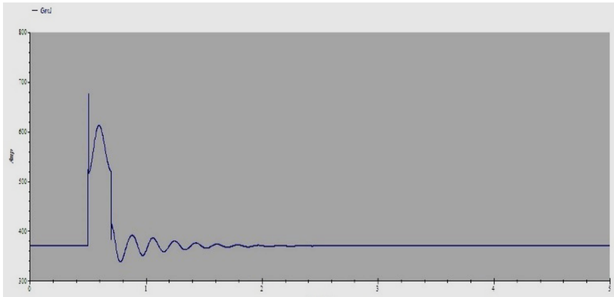
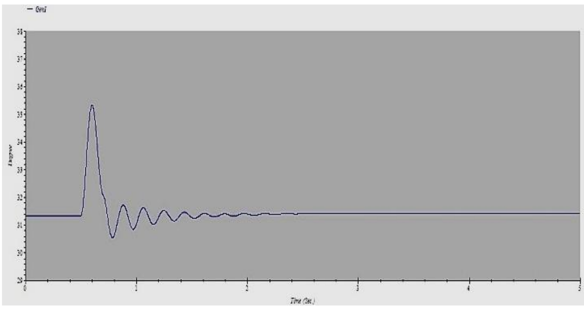


Fig.8. Bus voltage at Sub 3Fig.11.Generator Terminal Current (Current vs Time)



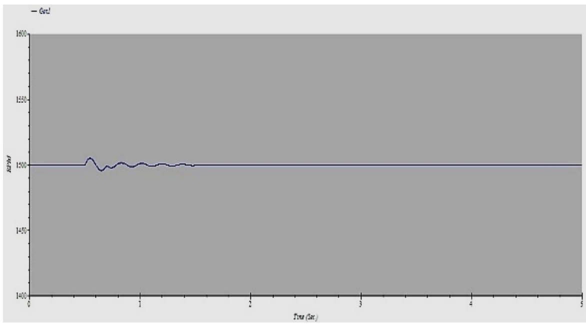


Fig.9.Generator Absolute Angle (Degree vs Time)Fig.12.Generator Speed Variation (RPM vs Time)

8, CONCLUSION AND FUTURE WORK

Dynamic performance of a power system is significant in the design and operation of the system. The transient stability study determines the machine power angles and speed deviations, system electrical frequency, real and reactive power flows of the machines, power flows of lines and transformers, as well as the voltage levels of the buses in the system. These system conditions provide indications for system stability assessment. This paper mainly investigates the power system transient stability of the system 33kV/11kV/3.3Kv/0.415Kv which will be helpful in the power system operation and design of equipment's and also further analysis could be carried out for transient stability enhancement. Transient stability analysis will also be an important factor to be considered in the smart grid for the performance evaluation of equipment's in the power system design, operation, control and protection. This paper also covers an important aspect of maintaining generatorstability by the control of excitation voltage which helps in maintaining the reactive power control.

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