TRANSIENT STABILITY ANALYSIS OF THERMAL POWER PLANT JAMSHORO CONNECTED WITH INFINITE BUS BAR SYSTEM

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Abstract: Electrical power system, reliability, stability, security and continuous operation is tremendous in nature, it is partitioned in different classifications however real issue and stress to the transient stability which could be expressed as capacity of power system to maintain synchronization while experiencing basic transient troubles, for example like short circuits faults on main transmission lines, sudden generation jerks , tripping or major load loss. Jamshoro Thermal Power Plant simulation model is set up on MATLAB programming with the assistance of Matlabtool particularly by utilizing Sim-Power System applicationbox and the transient dependability of the power plant has been investigated by applying different electrical troubles on diverse areas of power plant. In this work, achieved effective solution and remedies of various issues which were frequently occurs in the power system related to transient stability the result will enhance the reliability of power system.

Keywords:*Transient stability, fault clearing time(FCT), critical fault clearing time (CFCT), symmetrical and unsymmetrical fault.*

1. Introduction

Stability is a capacity of power system to come back to ordinary or stable working conditions subsequent to having been subjected to some type of unsettling influence or disturbance.Stability of Power system and reliability has been perceived as an essential issue for secure power system operation task. Generally, transient precariousness has been the predominant strength issue on most power system, and has been the focal point of a great part of the industry consideration concerning power system security [1-12, 19-22]. As power system have advanced through proceeding with development in interconnection, utilization of new advances and controls, and the expanded task in profoundly focused on conditions, unique forms of system instability have emerged.Task of maximum reliable energy with attractive plan from power system, requiresan unique understanding of various sorts of insecurity and connection between them is essential [13-18]. Power system stability soundness is the capacity of an electric power framework, for a given beginning working condition, to either recapture another condition of working harmony or come back to the first working condition (if no topo1ogical changes happened in the framework) in the wake of being subjected to a physical fault or aggravation, with most framework factors limited so essentially the whole framework stays in place. For the power system reliable, stable and continuous operation a reasonable comprehension of various kinds of precariousness, faults and connection between them is vital [20-23]. Abapour, M et. al. (2013), worked on the risk assessment of transient instability. It gives an algorithm to assess on-line risk of transient instability. Chang, W.N (2012), uses the electromagnetic transient program, (EMTP) and builds the cogeneration system. Numerous types of symmetrical and unsymmetrical fault including 3Φ-L-Gfault, LLGfault, LL fault, and LGfault occurring in the utility side are assigned for transient stability simulations. Roberts, L (2015), Power System clearing time for analysis of transient stability. The main cause of this metric is to analyze different trends in power system stability with parameter system variation, this system measure stability of new trends in aggregated power grid. Salam, M.A et al (2014), explained carried out transient stability analysis considering a 3-Φ fault at the bus bars and with the effect of different fault-clearing times. Srithorn, P et al (2013), provided method to develop capacity to deal with events of transient by developing capability of STATCOMs transient by developing capability of STATCOMs. Power system security is the capacity of an electric power system, to come back to the initial working reliable and stable condition without jerks.Model of power plant is made by single machine with infinite bus bar [3,14]. Single machine/generator whose rating is 210 MW and coupling transformer whose terminal voltage is 15.75kv and secondary voltage is 220 KV [16].There are four sorts of symmetrical and unsymmetrical fault including 3Φ-L-G fault, LLG fault, LL fault, and LG fault simulated at the diverse locations [24-30].

2. System Parameters & Specification

2.1 Generator Parameters

	Unit # 2 , 3 & 4	Unit # 1
MODEL	Turbine Generator Water Hydrogen Cooled QFSN – 210 - 2	Synchronous GENERATOR FTHRI 562 / 68-2
Phase	3	3
Active power	210 MW	250 MW
Rated current	9056A	10.294 KA
Rated voltage	15.75 KV	16.5 KV
Visual power	247000 KVA	294200 KVA
Power factor	0.85	0.85 (lagging)
Connection	2 – Y	III3~
Speed	3000 RPM	3000 RPM
CRITICAL SPEED 2nd ORDER	3494 RPM	3590 RPM
CRITICAL SPEED 1st ORDER	1263 RPM	1200 RPM
Rated excitation voltage	489 V	370 V
Rated excitation current	1867 A	2020A
Efficiency	98.66 %	99.02 %
Rated pressure of h2 Water flow for stator winding	0.3 MPa 35 m^3/h	3 Kg/Cm^2 --
Insulation class	F	F
Manufactured by	Harbin electric machinery works china	Fuji electric co: Japan

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2.2 Transformer Parameters

	U # 2,3&4	U # 1
MODEL	**SFP7-250000 / 220 TA**	**AD69030T1**
Rated power	250000 KVA	294.2 MVA
Rated current	656.1 / 9164.3 A	772 / 10294 A
Rated voltage	220 ± 4 X 2.5% / 15.75 KV	220 / 16.5 KV
TYPE	Oil Immersed, (ODAF) Cooled	Oil Immersed (OFAF) Cooled
Rated frequency	50 Hz	50 Hz
Number of phases	3	3
Type of cooling	ODAF	OF AF
Temp:classification	A	A
Connection of symbol	YN.d1	YNd1
Noise level	75 dB	90 dB (A)
Temperature rise	60 K	W = 55, O = 50 C
Load loss	609.9 KW	<500 KW
No load loss	613.6 KW	<520 KW
No load current	0.21%	0.2%
Impedance voltage	13.5%	15 % 294.2 MVA base
Weight: 1. Oil	64.49 T	59000 Ltr.
2. Active parts	173.66 T	221000 Kg
Name of manufacturer	Shenyangtransformer works, china	Fuji electric company ltd: Japan

Power system ability to retain synchronism when subjected to severe disturbance is called transient stability. kind of disturbance could be sudden increase in load [1-5]. loading takes place in small steps and gradually and the system withstands this change and performs satisfactorily, then power system could be in stady state stability. Schematic Diagram / Simulink Model of Generator Stability Model shown in figure 1a,1b&1c, all paramenters and fault condition setout to find out stability of the system.

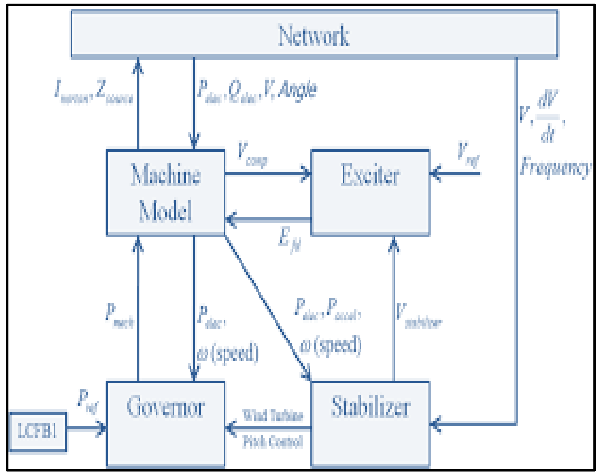

Figure.1a: Schematic Diagram Generator Transient Stability Model.

3. Simulation Model of Proposed System

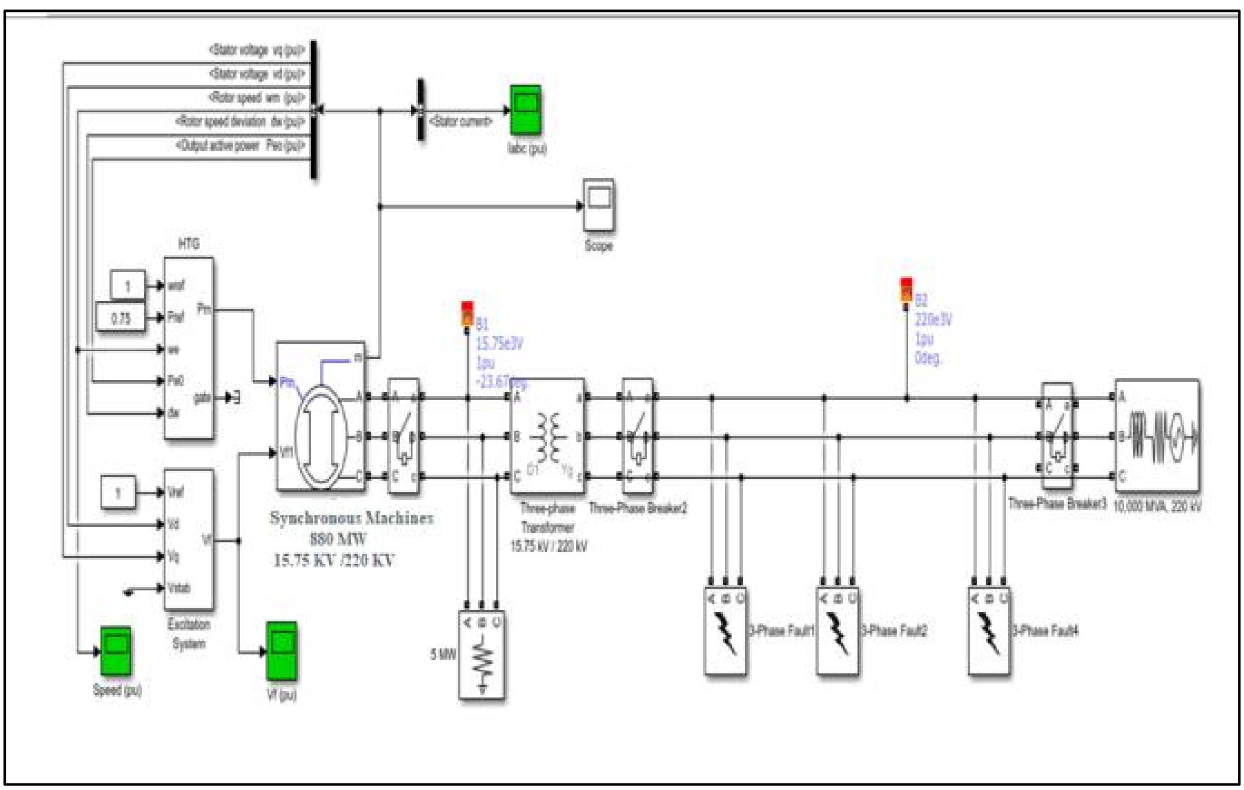

Figure.1b: Simulink Model of power system

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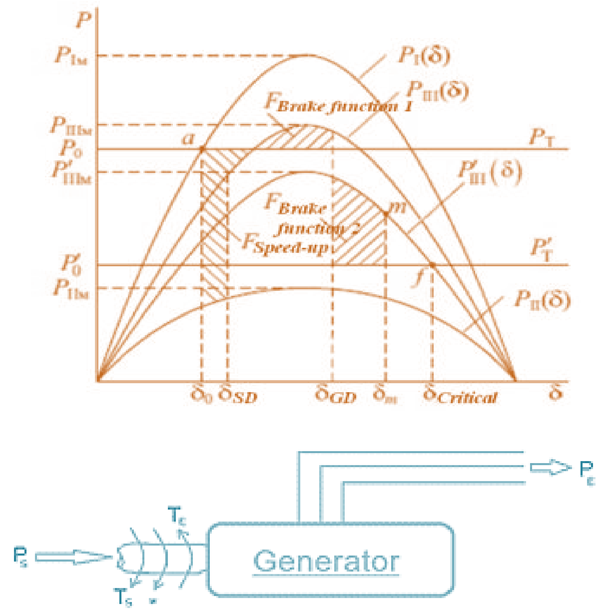

Figure.1c:Power Angle Curves of Generator.

3.1Three Phase Fault Applied On Generator End Applied

Presently in the principal case applied a 3-Φ three phase fault very close to the generator bus as shown in Figure 1&2, all together investigate its effect on transient steadiness [6-8].

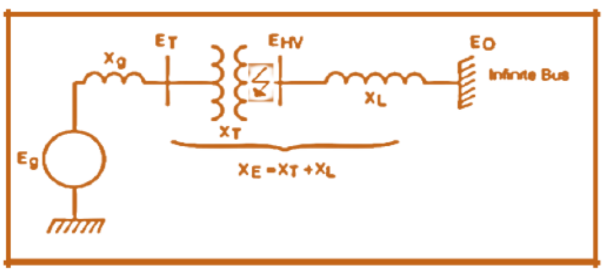

Figure2: Applied 3-Φ fault Generating end side.

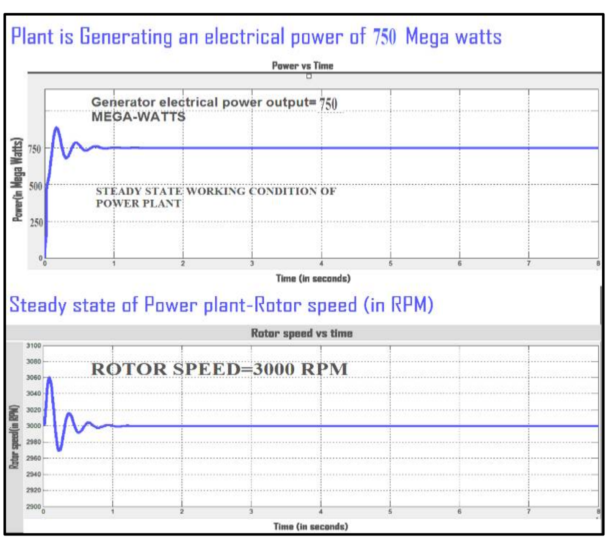

Figure 3: Total output electrical power and rotor speed of plant during Steady state of plant in waveform.

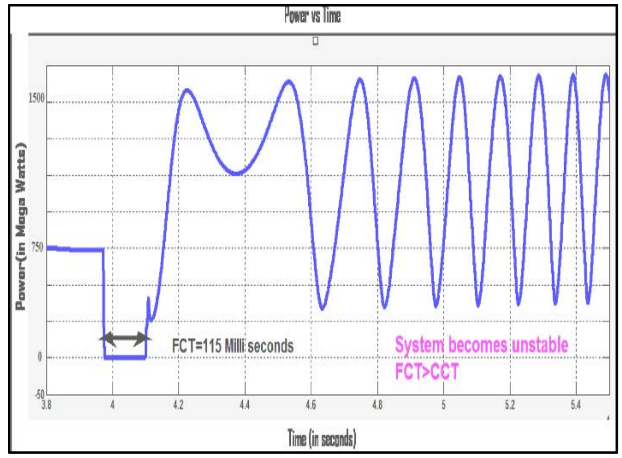

Figure 4: Generating end three phase fault applied, system unstable F.C.T is 115 msec in waveform.

At that point with the assistance of recreation display observed that the F.C.T from 105 - 115 msec and afterward additional to 100 msec as appeared in Figure 3. At 105 msec power system wound up stable however in the wake of experiencing swaying so additionally decreased the fault clearing time FCT to 100 msec then power system turned out to be flawlessly steady [11-14]. It is observed that basic clearing time is 100 msec which implies fault be able to exists securely inside that time and won't undermine transient dependability of power planthowever in the event that existed longer than that power system will remain in unstable condition.

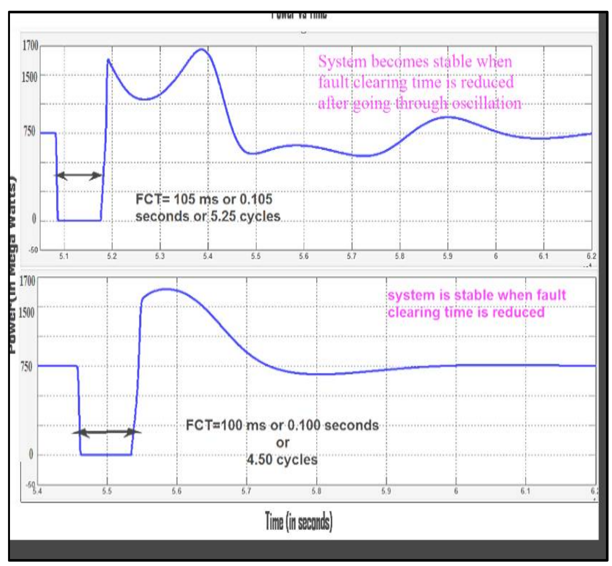

Figure 5: Generating end side three phase fault F.C.T 105-100 msec and output Electrical power waveform.

3.2 Generating side at middle position applied Three phase fault

For such situation, system connected to 3-Φ three phase fault at center, at half away separation creating location as shown in Figure 2. fluctuated the transmission line length shielded a separation of 12 kilo meter from producing side for such situation[15,23].

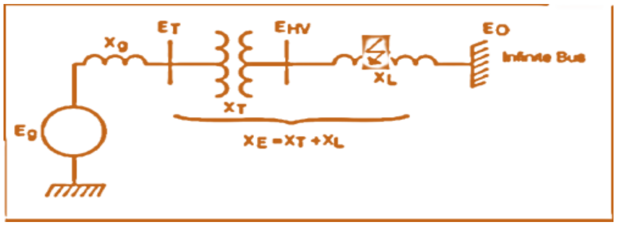

Figure 6: at middle position applied Three phase fault.

The observed basic F.C.Tis 7.25 cycles or 150 msecs as appeared in Figure. 4, that implies fault could persist for longer time when contrasted with past situation where power system and machine stability went unsteady at 5.75 cycles or 115 msecs the fact that fault happened at separation of 12 kilometer far from creating side again with assistance of reenactment display we increment fault persisting time from 160 msecs to 150 msecs power system stability moved toward becoming un-steady as appeared in Figure 5, so constantly operational time of electrical switch intruding on time of the power system and machine ought to be kept below than basic F.C.T so as to work power system temporarily steady [16,19].

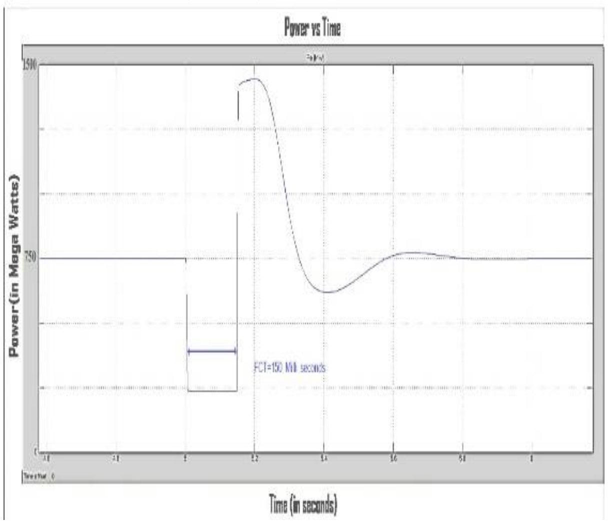

Figure 7: At Generating middle position three phase fault F.C.T 150-100 msec and output Electrical power waveform.

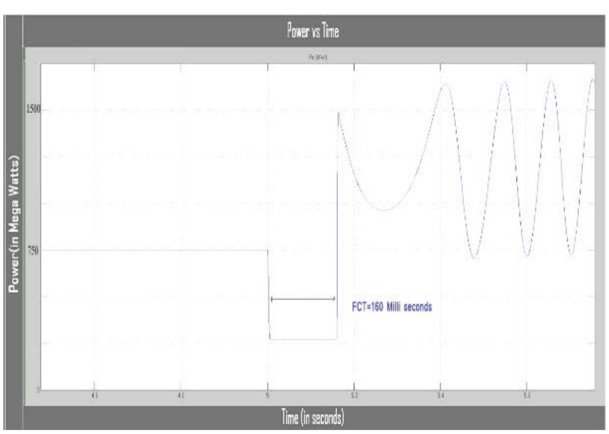

Figure 8: At Generating middle position three phase fault when F.C.T 160msec than C.C.T 150 msec System becomes unstable.

3.3At receiving end side applied Three phase 3- Φ fault

For such situation 3-Φ three phase fault condition is connected at 25 kilometer separate far from generator end as appeared in Figure 3, and for such situation we observed basic clearing time F.C.T of 210 msecs it implies that fault could persist inside this time period exclusive of loss of synchronism causing [20-24].

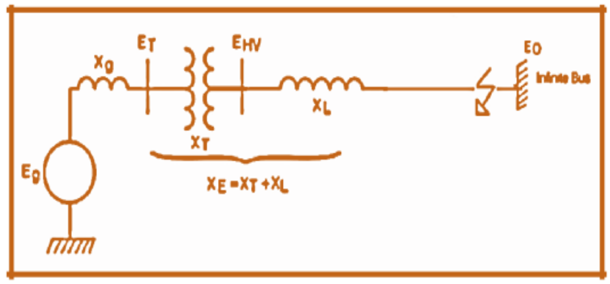

Figure 9: At receiving end side applied Three phase fault

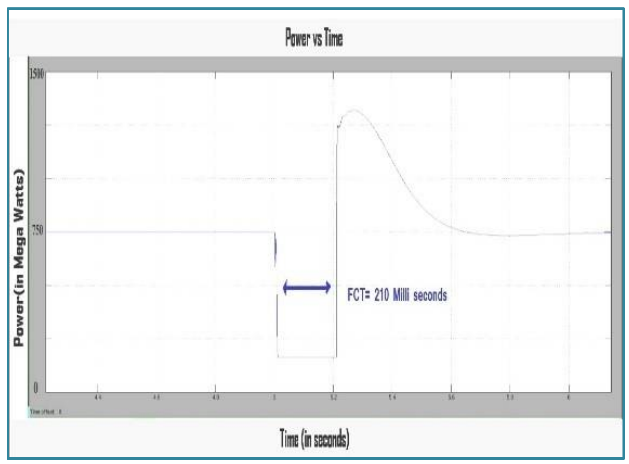

Figure 10: At receiving end side applied 3-Φ Three phase fault, C.C.T found to be 210 msecs in waveform system is stable

As appeared in Figure 5, comparatively when F.C.T expanded from C.C.T, power system under insecure at 220 msecs as indicated in Figure 6, un-stable terminal electrical output waveform.

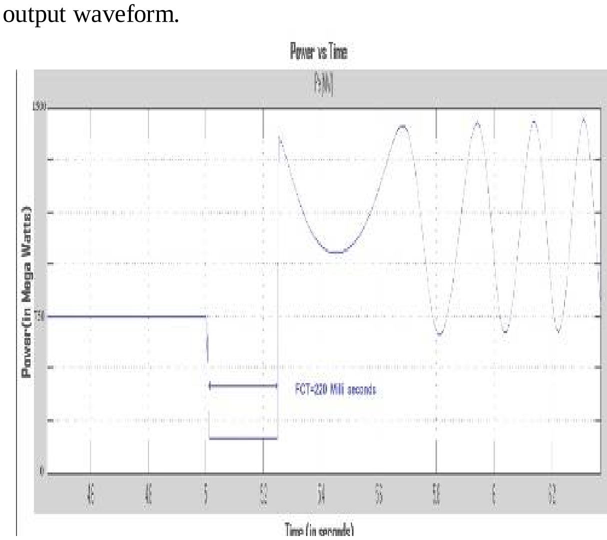

Figure 11: near to receiving end fault applied. F.C.T 220 msecs increase from C.C.T210 msecs value system Un-stable as in waveform.

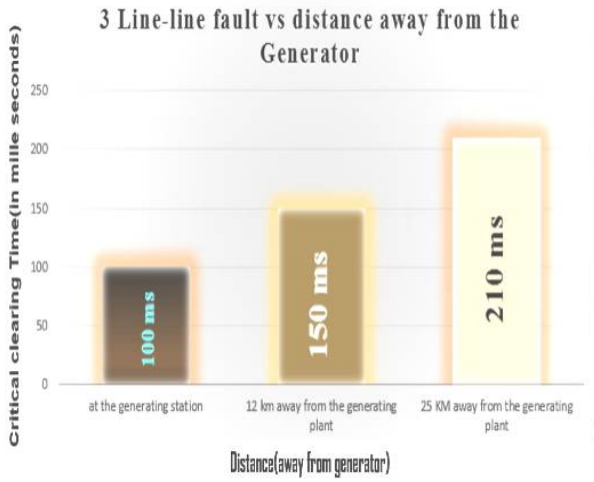

Figure 12: Critical Clearing time during Three Line –Line versus distance away from generator.

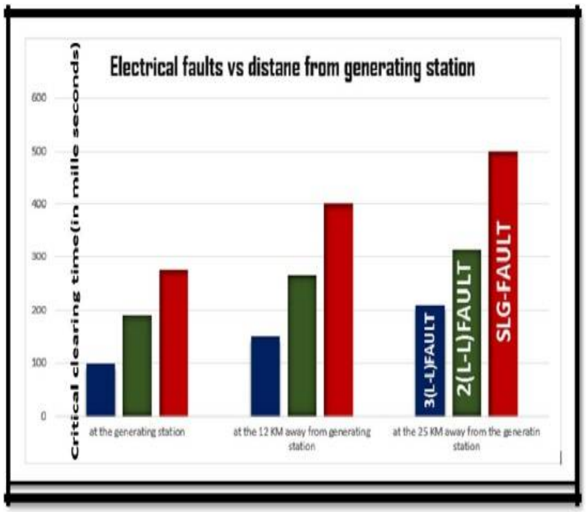

Figure 13: different type of electrical faults and their Critical clearing time against distance away from the generating station.

3.4 Normal working condition of plant

Considering the power system is associated with limitless power system bus as appeared in Figure 10, torque and plant output power as of now is zero and power system is operational in safe and stable condition[25-27].

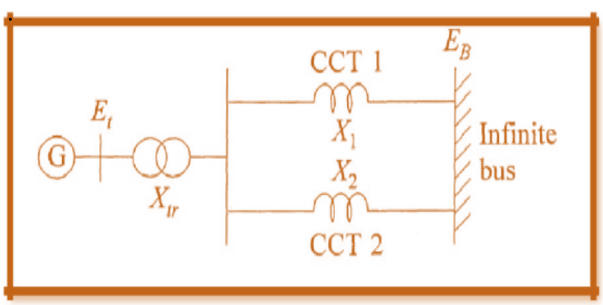

Figure 1: impact on SMIB of Mechanical input

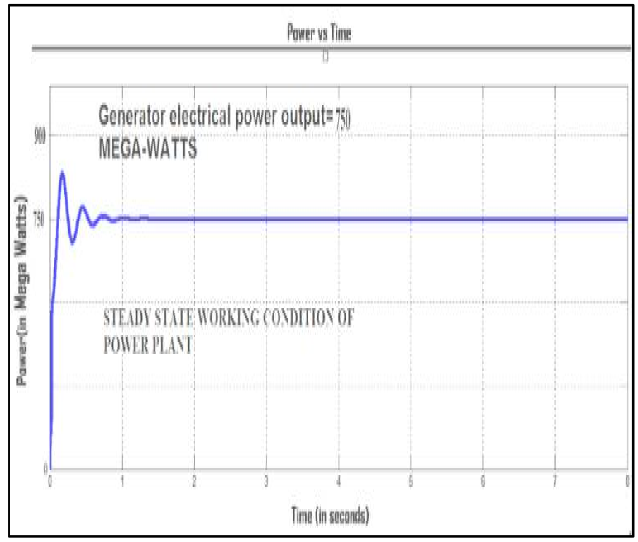

Figure 15: Jamshoro power plant terminal output electrical power.

Figure 15, obtained by running the Simulink model of plant by giving information mechanical power contribution of 750 MW electrical output got is 750 MW.

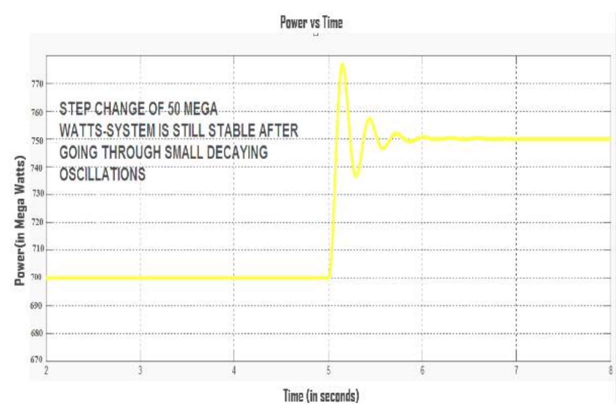

Figure 16: Step change increase in input mechanical power of 50 MW, system became stable after going through oscillations.

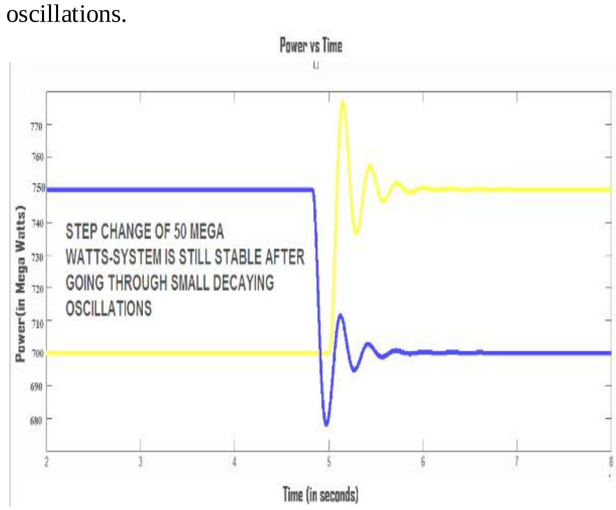

Figure 17: Decrease and increase in input mechanical power of 50 MW, system became stable.

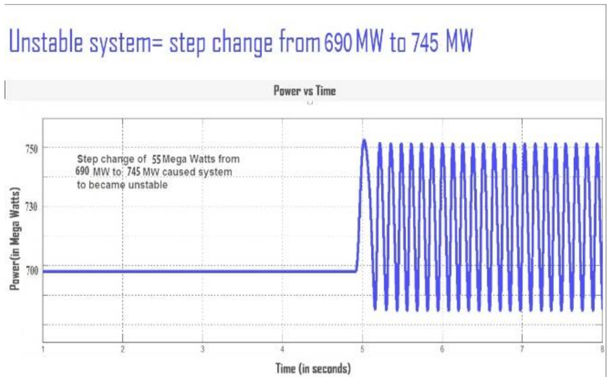

Figure 18: Applied Step change in input mechanical power which is beyond stability limit and Un stable system in waveform

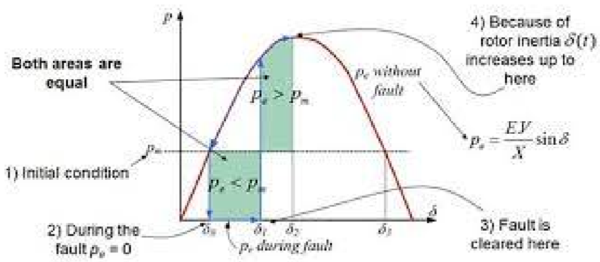

Figure. 19: Power Curve during different four Fault Conditions.

With the assistance of simulation, CFCT basic fault clearing time FCT estimated, the period took into account the fault to exist securely and make no any loss of the plant, for example, loss of synchronism or damage of equipment, by applying diverse faults at different location Also find out impact of changing all of a sudden mechanical power on the transient security of the plant.

Sudden increment or reduction of as given plant will stay stable but after going through small decaying oscillations however in the event additionally expanded from the most extreme point of stability will end up unreliable despite the fact that that farthest point can be enhanced by increment framework damping and field excitation voltage[25-29]. Simulation results help to achieve a conclusion that constantly operational time of electrical switch ought to be kept lower than basic clearing time of the framework keeping in mind the end goal to make the framework briefly steady to make the system transiently stable. Using the fastest circuit breaker to remove the fault as earlier as possible system remains in stable condition, this will be helpful to improve the system efficiency and losses will be minimized [22,30].Stability limit of changing mechanical power ought to dependably be ascertained and measure of progress ought to be kept dependably lower than that value.

4. Conclusion

Power System overloaded due to supply and demand gap of power generation which causes frequent tripping and stability issues. Hence transient stability analysis is important for different power generating stations. In this work by applying distinctive sorts of fault condition on created simulation model to enhance the power system transient stability. effective measures should be taken during planning stage to accomplish specific end goal activity maximum control and proper operation of power plant from NPCC National Power Control System or RCC Regional Control Center such as suitable model of the whole Pakistan electric power system plant should be prepared on technical software such as MATLAB or ETAP, on model system different severe disturbance should be giventoobtain results and solution to overcome those problems. Transmission line and different supplies reactance essentially impact the power exchange capacity, lesser estimations of reactance incredibly upgrade the transient steadiness and stability this area should also be considered. Furthermore during the fault dynamic braking can be investigated suchtechnique effectively reduces rotor acceleration. Critical clearing time CCT of the system should be measured and considered essential indicator for transient stability.

This research promote fast protective relaying that their time for fault clearing should be minimum with improved fast protective relaying such as breaker tripped without cascading tripping by utilizing the quickest electrical switch to expel the fault level as prior as conceivable power system in stable and reliable condition, this simulation work will be useful for enhancing the reliability proficiency, stability of power system and fault could also be isolated without any further cascading tripping.

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References

[1]. Sadhana Singh†*, Savita Vyas†* and Snehesh Banerjee# “2017”Performance Analysis of 210 Mw at NTPC Vindhyachal, Singrauli “ International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161 ©2017 INPRESSCO®,

[2]. S.Arunkumar*, V.Tamilvanan, K.R.Sathishkumar, S.Suresh, K.Tamilselvan “2016”Optimizing the Parameters of 210MW Steam Turbine Operation and Maintenance”Journal of Applied Physics and Engineering Vol.1, No.3 (2016) 1–4 ISSN Number (online): 2455-4650

[3]. Shetye, K. S., Overbye, T. J., Mohapatra, S., Xu, R., Gronquist, J. F., & Doern, T. L. (2016). Systematic determination of discrepancies across transient stability software packages. *IEEE Transactions on Power Systems*, *31*(1), 432-441.

[4]. Baloch, M. H., Wang, J., & Kaloi, G. S. (2016). Stability and nonlinear controller analysis of wind energy conversion system with random wind speed. *International Journal of Electrical Power & Energy Systems*, *79*, 75-83.

[5]. Sarwar Kaloi, G., Wang, J., & Baloch, M. H. (2016). Study of stabilty analysis of a grid connected Doubly fed induction generator based on wind energy Application. *Indonesian Journal of Electrical Engineering and Computer Science*, *3*(2), 305-313.

[6]. Kaloi, G. S., Wang, J., & Baloch, M. H. (2016). Active and reactive power control of the doubly fed induction generator based on wind energy conversion system. *Energy Reports*, *2*, 194-200.

[7]. Baloch, M. H., Wang, J., & Kaloi, G. S. (2016). Dynamic Modeling and Control of Wind Turbine Scheme Based on Cage Generator for Power System Stability Studies. *International Journal of Renewable Energy Research (IJRER)*, *6*(2), 599-606.

[8]. Kaloi, Ghulam Sarwar, and Mazhar Hussain Baloch. "SMART GRID IMPLEMENTATION AND DEVELOPMENT IN PAKISTAN: A POINT OF VIEW." Science International 28.4 (2016).

[9]. Roberts, L. G., Champneys, A. R., Bell, K. R., & di Bernardo, M. (2015). Analytical approximations of critical clearing time for parametric analysis of power system transient stability. *IEEE Journal on Emerging and Selected Topics in Circuits and Systems*, *5*(3), 465-476.

[10]. YROWDJH, Y. L. X. Y. R., YROWDJH, K. Y. X., VWURQJO, X., VXUYH, E. W. W., YHU, D. Z. E., UHVHDUFKHUV, P. X. W. W., ... & RI, W. I. (2015). Regular paper Electrical Power Quality Problem: A key Issues, Challenges & Opportunities Bindeshwar Singh1, Pavan Prakash Gupta2, Rajiv Kumar3 and Ashok Kumar4.

[11]. Roberts,Lewis.; Champneys,Alan.; Bell,Keith.; and Bernardo, Mario di.; (2015), " An analytical critical clearing time for parametric analysis of transient stability in power system", IEEE research paper, pp:2-11 2015.

[12]. Selwa, F., &Djamel, L. (2014). Transient Stability Analysis of Synchronous Generator in Electrical Network. *International Journal of Scientific & Engineering Research*, *5*(8), 55-59.

[13]. Hashmani, A. A., Wang, Y., & Lie, T. T. (2002). Enhancement of power system transient stability using a nonlinear coordinated excitation and TCPS controller. International journal of electrical power & energy systems, 24(3), 201-214.

[14]. Selwa, F., &Djamel, L. (2014). Transient Stability Analysis of Synchronous Generator in Electrical Network. *International Journal of Scientific & Engineering Research*, *5*(8), 55-59.

[15]. Salam, M. A., Rashid, M. A., Rahman, Q. M., &Rizon, M. (2014). Transient Stability Analysis of a Three-machine Nine Bus Power System Network. *Engineering Letters*, *22*(1).

[16]. Sharma, C. S. (2014). Transient Stability Analysis of Single Machine Infinite Bus System by Numerical Methods. *International Journal of Electrical and Electronics Research*, *2*(3), 158-166.

[17]. Eleschova, Zaneta,;Belan, Anton.; and Smitkova,Miroslava.; (2014), "What influences length of CCT", Selected topics in power system and remote sensing, pp:189-194 2014.

[18]. Lenga, O. (2014, June). Application of critical clearing time as a transient stability criterion for power system expansion planning. In *Intelligent Energy and Power Systems (IEPS), 2014 IEEE International Conference on* (pp. 215-218). IEEE.

[19]. Abapour, M., &Haghifam, M. R. (2013). On-line assessment of the transient instability risk. *IET Generation, Transmission & Distribution*, *7*(6), 602-612.

[20]. Srithorn, P., &Jamsri, B. (2013, October). Adaptive DC-link STATCOM for power system transient instability damping. In *TENCON 2013-2013 IEEE Region 10 Conference (31194)*(pp. 1-4). IEEE.

[21]. Vaidya, A. P., &Patil, R. V. (2012, March). Comparison of different types of transient stability assessments during congestion. In *Advances in Engineering, Science and Management (ICAESM), 2012 International Conference on*(pp. 232-237). IEEE.

[22]. Xu, Y., Dong, Z. Y., Meng, K., Zhao, J. H., & Wong, K. P. (2012). A hybrid method for transient stability-constrained optimal power flow computation. *IEEE Transactions on Power Systems*, *27*(4), 1769-1777.

[23]. Kalyani, S., Prakash, M., &Ezhilarasi, G. A. (2011, December). Transient stability studies in SMIB system with detailed machine models. In *Recent Advancements in Electrical, Electronics and Control Engineering (ICONRAEeCE), 2011 International Conference on* (pp. 459-464). IEEE.

[24]. Chang, W. N., & Hsu, C. H. (2011, October). Effects of unbalanced faults on transient stability of cogeneration system. In *Proceedings of the 10th WSEAS international conference on System science and simulation in engineering*(pp. 118-123). World Scientific and Engineering Academy and Society (WSEAS).

[25]. Chang, W. N., & Hsu, C. H. (2011, October). Effects of unbalanced faults on transient stability of cogeneration system. In *Proceedings of the 10th WSEAS international conference on System science and simulation in engineering*(pp. 118-123). World Scientific and Engineering Academy and Society (WSEAS).

[26]. Watanabe, M., Mitani, Y., Iki, H., Uriu, Y., &Urano, Y. (2011). Dynamic stability assessment of customer's power systems with detailed models implementation. In *17th Power Systems Computation Conference Stockholm Sweden-August* (pp. 22-26).

[27]. Olulope, P. K., Folly, K. A., Chowdhury, S. P., & Chowdhury, S. (2011, April). Prediction of critical clearing time using artificial neural network. In *Computational Intelligence Applications In Smart Grid (CIASG), 2011 IEEE Symposium on* (pp. 1-5). IEEE.

[28]. Patel, J. S., & Sinha, M. N. (2011, May). Power System Transient Stability Analysis Using ETAP Software. In *National Conference on Recent Trends in Engineering &Technology*(pp. 13-14).

[29]. Hashmani, A. A., &Erlich, I. (2010). Mode selective damping of power system electromechanical oscillations using supplementary remote signals. IET generation, transmission & distribution, 4(10), 1127-1138.

[30]. Morsidi, H.,M. A. Salam and N. Ottman (2009)Transient Stability Analysis of Godong Power Station."(2009) International Conference on IPSA Simulation Software, Godong power station, 8-11, Nov. 2009.

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