Simulation and Analysis of Power Flow and Stability Control Using Stabilizer Multi-Band

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Abstract— The solution of the power flow is one of the most critical problems in electrical power systems. The power demand increases drastically due to industrialization and the electric transportation system. It makes the power system complex which needs to be properly controlled and maintain quality to flow. The effective control and operation of power remain challenging due to the variation in the input and load demand energy and the significantly high peak-to-average power ratio. Therefore, the rated power control is essential for the operating time and power output. The present rated power control method is based on the instantaneous rotational speed of the turbine generator. However, due to practical infrastructure limitations, such as the valve operating time, a more refined rated power control method is required. Flexible ac transmission systems are extensively installed in power systems to maintain a quality power supply. The Stabilizer multi-band has a key role in the improvement and control at the turbine power generating station. This paper presents simulation results of a Synchronous machine, Turbine Excitation Regulator, and Stabilizer multi-band for a 735 kV power line with the help of MATLAB/simulation module.

Keywords: Load Demand, Control and Operation, Synchronous Machine, Turbine Excitation Regulator, Stabilizer Multi-Band, MATLAB/Simulation Module

I. INTRODUCTION

The first three-phase line in North America went into operation in 1893 with a 2300 V, 12 Km line in southern California. In the early period of ac power transmission, different frequencies were in use 25,50,60,125 and 133Hz. In recent years the United State of America uses 60Hz and India. India is having highest 735 Kv 50 Hz electrical infrastructure to transmit power. The major categories of energy for electricity generation are fossil fuels (coal, natural gas, biomass, and petroleum), nuclear energy, and renewable energy sources. Most electricity is generated with steam turbines using fossil fuels and nuclear by the use of turbines and synchronous machines. In India, fossil fuels are contributing 57.9% of total installed capacity, it increased to 62.1% when including nuclear and biomass power. India is the 3rd largest producer of electricity on the earth. The interconnection of different loads and sources makes it complex. The load demand needs to be fulfilled in such a way as to maintain the quality of power. Power quality is important for the industry to produce continuous good products and smooth transportation. There are several main divisions in the study of power system dynamics and stability Electrical machine and system dynamics, System governing and generation control, and Prime-mover energy supply dynamics and control. Improper parameters and equipment of the steam turbine regulating system will not only affect the stability of unit operation but also easily lead to grid frequency oscillation, which can not meet the requirements of the power plant and grid-safe operation. The optimization of primary frequency regulation under the implementation of two detailed rules of power grid the treatment of frequent load fluctuation and slow response of boiler regulating circuit during primary frequency regulation action the realization mode of primary frequency regulation function, frequency signal accuracy, setting of speed unequal rate, valve tube of the digital electro-hydraulic regulation system (DEH) suitable parameters of the power management module, and prevention and cure of power grid oscillation are set to meet the requirements of grid frequency regulation and safe operation of the unit as well as to prevent the swing of the high voltage regulating valve, etc. The Stabilizer multi-band has a key role in the improvement and control at the turbine power generating station.

II. THE SYNCHRONOUS GENERATOR UNIT

Steady-state stability relates to the response of a synchronous generator to a gradually increasing load. It is basically concerned with the determination of the upper limit of machine loading without losing synchronism, provided the loading is increased gradually..

$$\delta = w$$

$$\omega = -\frac{D}{2J}(w - \omega') + \frac{\omega'}{2J}(P_m - P_e)$$

where δ is the turn angle of the generator's rotor, ω is the rotation speed of the rotor with respect to synchronous reference, ω' is the synchronous speed of the generator, J is the moment of inertia of the rotor, P_e is the active power of the generator, P_m is the mechanical input torque to the generator which is equated with the mechanical input power, D is the damping constant of the generator and Te is the electrical torque which is equated with the generated active power. Moreover, the following variables are defined: $\Delta\delta = \delta - \delta'$ and $\Delta\omega = \omega - \omega'$ with ω' to denote the synchronous speed. The generator's electrical dynamics is described as follows

$$E_q = \frac{1}{Td}(E_f - E_q)$$

where E' is the quadrature-axis transient voltage of the generator, E_q is the quadrature axis voltage of the generator, Td is the direct axis open-circuit transient time constant of the generator and E_f is the equivalent voltage in the excitation.

A. The Steam Turbine Unit

Steam mills are strength conversion machines. They pull out strength from the water steam and convert it to mechanical torque, which rotates the shaft of the turbine. The turbine protection structures are meant to eliminate/lessen the opportunity of harm to the system or the chance to operators. It protects the turbine from extra speeding, video display units all critical turbine parameters, and journeys the turbine if a circumstance exists that might purpose system harm. The principal protection manage detail on a turbine is the water steam deliver valve. This protection valve may be a separate on/off valve or the shut-off characteristic may be merger into the controls of the water steam deliver valve this is used for pace manage. The water steam turbine is managed via way of means of the governor, which may be mechanical-hydraulic (evolved from James Watt's unique flyball governor) and/or electromechanical. They all encompass a pilot valve, or controller, which modulates the turbine's inlet valve for you to hold the shaft pace on set point. An electro-hydraulic manage device use digital circuits, is greater flexibility, however the average necessities are same. A virtual electro-hydraulic manage device, use a virtual controller and a whole lot of features may be applied via software. Even the superior controls generally function the high-stress and low-stress valves via the prevailing electro-hydraulic controls of the turbine. A usual governor version for water steam mills has principal sections, the governor and water steam manage valve, whose output is critical manage valve place in reaction to hurry deviation of the system, and a phase modelling the turbine, whose enter is steam glide and output is mechanical energy implemented to the rotor. The proper system is shown in fig 1.

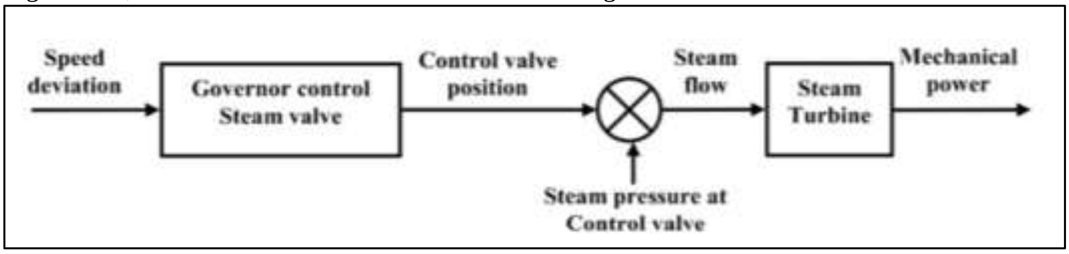

Fig. 1: Typical modal for stream turbine control

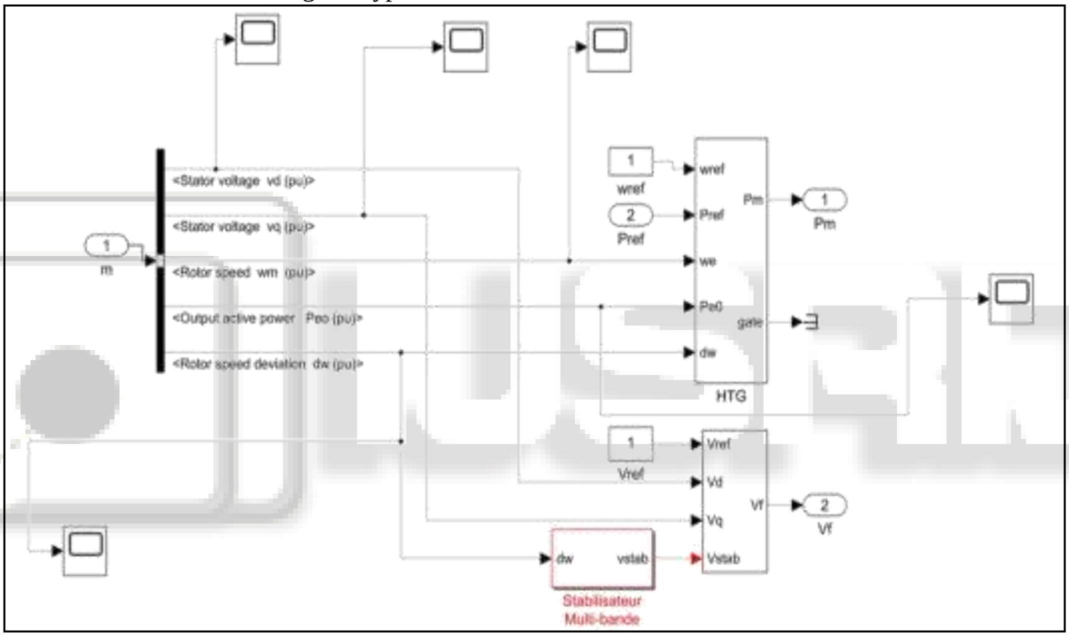

Fig. 2: Turbine Excitation Regulator

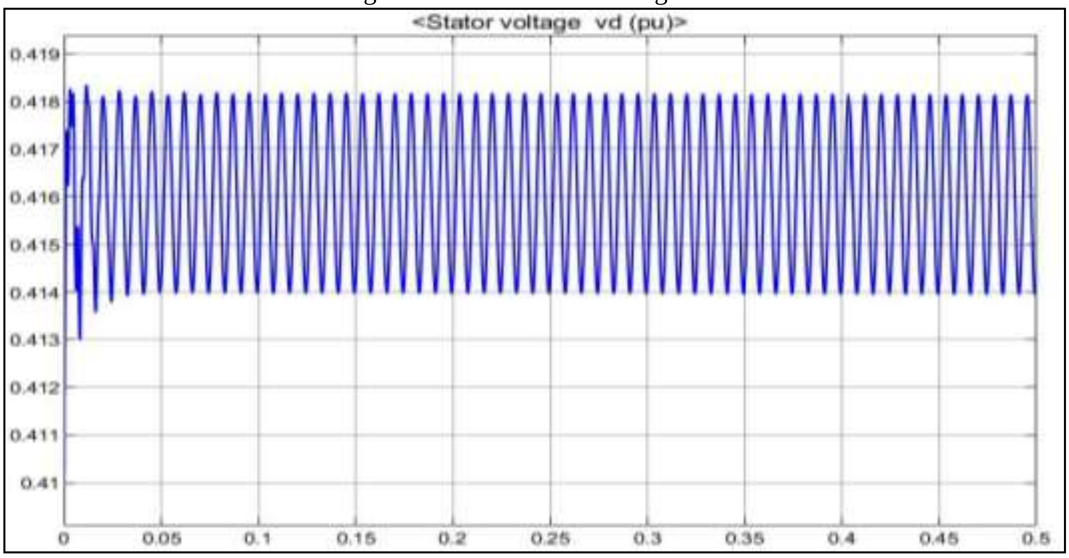

Fig. 3: Regulator stator voltage

Turbine excitation systems are basic to the operation of modern synchronous machines. It is responsible for supplying DC current for the synchronous machine field windings. Well-designed excitation systems provide trustability of operation, stability & fast transient response. For synchronous generators, it is responsible for maintaining a constant terminal voltage and maintaining a constant power factor. Turbine excitation systems use closed-loop or feedback control to regulate the machine's output. It also works as a Limiter – Limiting the synchronous machine to work within the boundary & capacity. In addition, a modern excitation system equipped with the Power System Stabilizer (PSS) function, provides a positive contribution by dampening the electromechanical oscillations arising from the power system or the unit itself.

B. The Stabilizer Multi-Band Unit

The Stabilizer multi-band is consist of different type of controller, such as PID controller shown in fig 4. The control effect of nonlinear Proportional-Integral-Derivative controller is better than that of traditional Proportional-Integral-Derivative controller under disturbance action. The anti-interference of nonlinear PID controller is good which quickly recover steady state. This nonlinear PID controller has better adaptability for various random disturbances. It can improve control precision of generator voltage, thus make the power system performance has been effectively improved. The nonlinear PID controller is practical method for the application. The turbine is connected to prime mover. The prime mover control and voltage regulator control for a single synchronous generator connected to an infinite bus (large utility) and isolated bus. To increase the prime mover input to the machine, (i.e. you add more fuel to the engine or steam to the turbine), generator watts increase. When we increase the prime mover input to the generator, power (kW) produced by the generator will also increase. However, the reactive power (kvars) output will decrease in response to an increase in the bus voltage This extrade in reactive electricity output or bus voltage isn't continually simply observable, for the reason that value of the bus voltage growth relies upon on many factors (i.e., the machine's output with recognize to the weight on the bus).

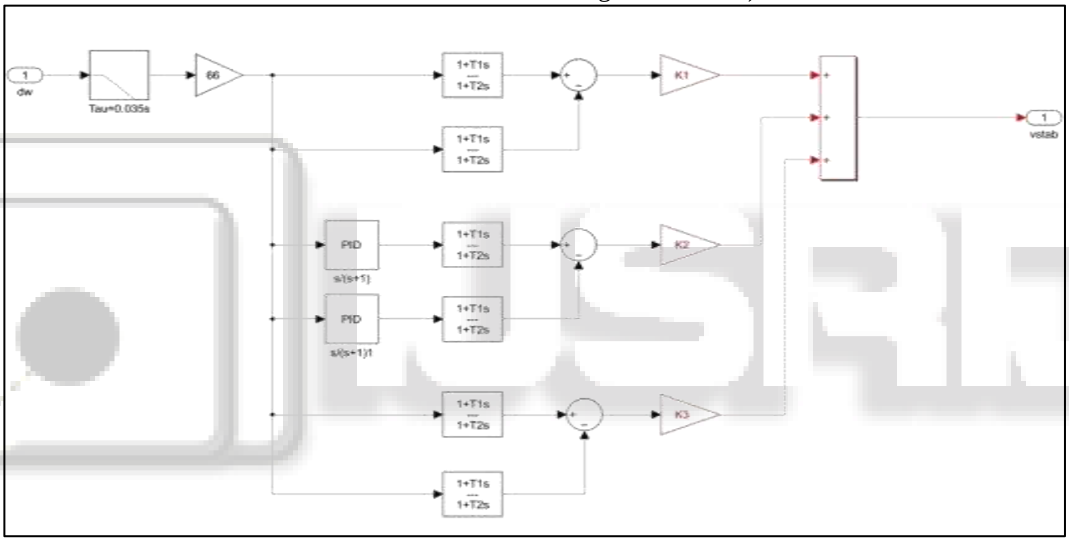

Fig. 4: Overview of Stabilizer multi-band connected in Turbine Excitation Regulator

The controller responds to the mistake through growing the top mover enter to hold the favored pace below given load conditions. An oscillating top mover controller will bring about frequency swings, which bring about a various reactive load. This load reasons generator modern-day swings, which bring about bus voltage fluctuations. The rotor speed Fig.5 and its deviation Fig.6 graph shown below

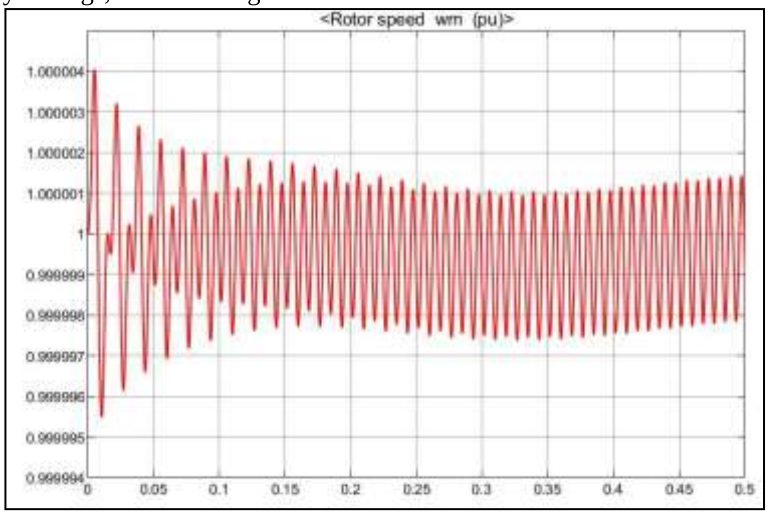

Fig. 5: Waveform of Rotor speed

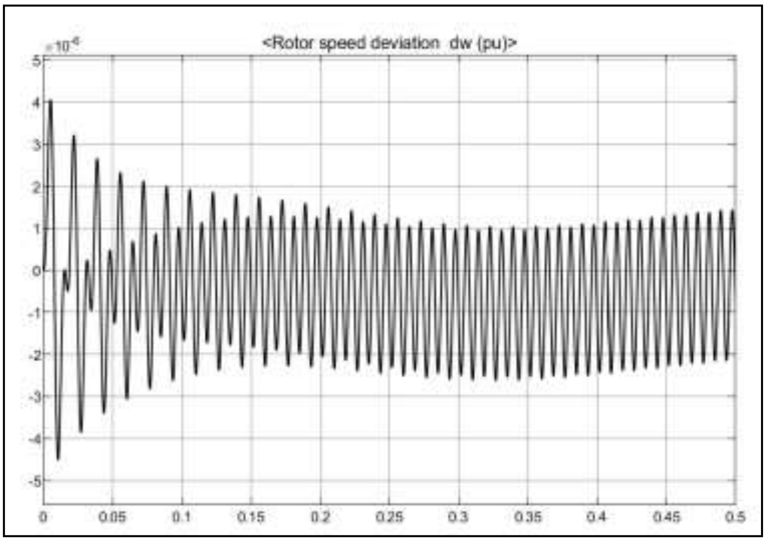

Fig. 6: Waveform of Rotor speed deviation

III. RESULTS

The simulink model of stabilizer multi-band connected in turbine excitation regulator is shown in Fig. 4. Turbine excitation regulator diagram Fig. 1 and model in Fig. 2. are block diagram which gives a better understanding about voltage shown in Fig. 3. The load demand is fulfill by more excitation and prime mover torque. The rotor is having damper bar which balance speed according to load shown in Fig. 6.

IV. CONCLUSION

A detail circuitry modeling of turbine excitation regulator and stabilizer multi-band in simulink is presented. The model is able to operate at 50 Hz and 60 Hz frequency with deviation. The controller PID is helpful in control and stability of the system. It provide better stability to flow quality power.

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