

# Dynamic Behaviour of Hydro Power Plant Using PID Controller

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**Abstract** - Power is a vital infrastructure input for the growth and development of any country. Many development republics began to get rid of conventional energy and towards to use renewable energy like hydropower system, solar cells and wind turbines as soon as possible. Hydropower here plays an important role as renewable and convectional resource. Speed of water is variable, the speed of the system need to controlled to make the system supply frequency constant. This can be done by a properly designed hydraulic governing system. The output response results for hydropower system obviously proved the benefit of using PID controller. PID controller has got properly more rapid output response and minimal overshoot.

**Key Words:** Hydro power plant, PID Governing system, Digital Control Algorithms

## 1. INTRODUCTION

Hydro-electric energy is most important renewable energy in the world. It a pollution free, renewable and environmental friendly source of energy.[1]It provides energy to various loads. User load requires a uniform and uninterrupted supply of input energy. The load demand varies continuously. It affects the terminal voltage and frequency. The objective of the control strategy is to generate and deliver power in an interconnected system as economically and reliably as possible while maintaining the voltage and frequency within permissible limits. Hydro power plant is equipped with hydraulic turbine governor and excitation control. Hydraulic turbine governor control the frequency intern speed of the turbine according to load variation. Reactive power requirement is controlled by Excitation system. The control of Active and Reactive power keeps the system in the steady state. Non-linear model of hydraulic turbine is utilized. To control the Frequency and power and load angle, the controller reads the speed of turbine after every sampling period. MATLAB Simulink is utilized in building system models and simulates their behavior. [2] Therefore, the research on control strategy and transient process of hydro power plants is of great importance [3]. The turbine governor system controls the water inlet into a turbine, which automatically turn the generator rotation for producing electricity. In order to keep a required generated frequency of 50Hz, the rotation speed has to be kept constant. The turbine governor obtains information from the existing velocity of the turbine and then regulates water stream to maintain the turbine speed at the accurate level [4]. In this control structure, the pipes scheme is fixed by servo valve controlled using a servo motor. Actually coding ability of servo schemes performs it additional adjustable for different control requests. Most commonly employed situation control by using a servo motor because of regulation of armature voltage charge the field constantly [5]. Essentially hydro turbine transfer function is not smallest stage since water inertia. Thus, every changing stage of valve situation produces an undesirable response on production turbine power. According to speed governor nominal values, turbine and machine parameter involves into a steady system where the stable regular constant of the speed governor must be 20%. Anyhow, these measurements are typically around 5% and this performs an improvement is undesirable. Thus, the system response, succeeding a slight load adjustment will be unbalanced. A transient droop compensator is properly proposed to be involved in the speed governor to resolve mentioned difficulties [6]. While a Proportional controller can perform a stable state, it is nearly impossible to avoid a continuous error at this state. Typically, the controller should have no error at the stable state. This is wherever the Integral phase comes into play [7].

## 2. SIMULATION:

In this paper various parameters control of a hydro power project is done with the help of a PID controller installed at different location in three different cases which shows the control action of the governor. The various cases are:

1. Excitation system without PID controller.
2. PID controller connected with the exciter.
3. PID controller connected in feedback.

**Case I:** Excitation system without PID

This model is actually designed to see how our systems will response when excitation system is not connected with PID controller. The simulink model showing the excitation system is given below:

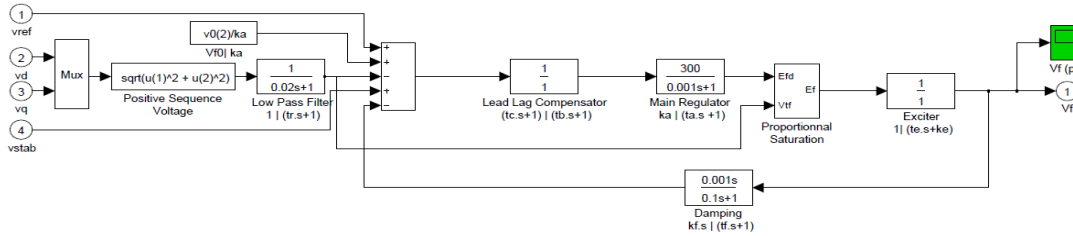
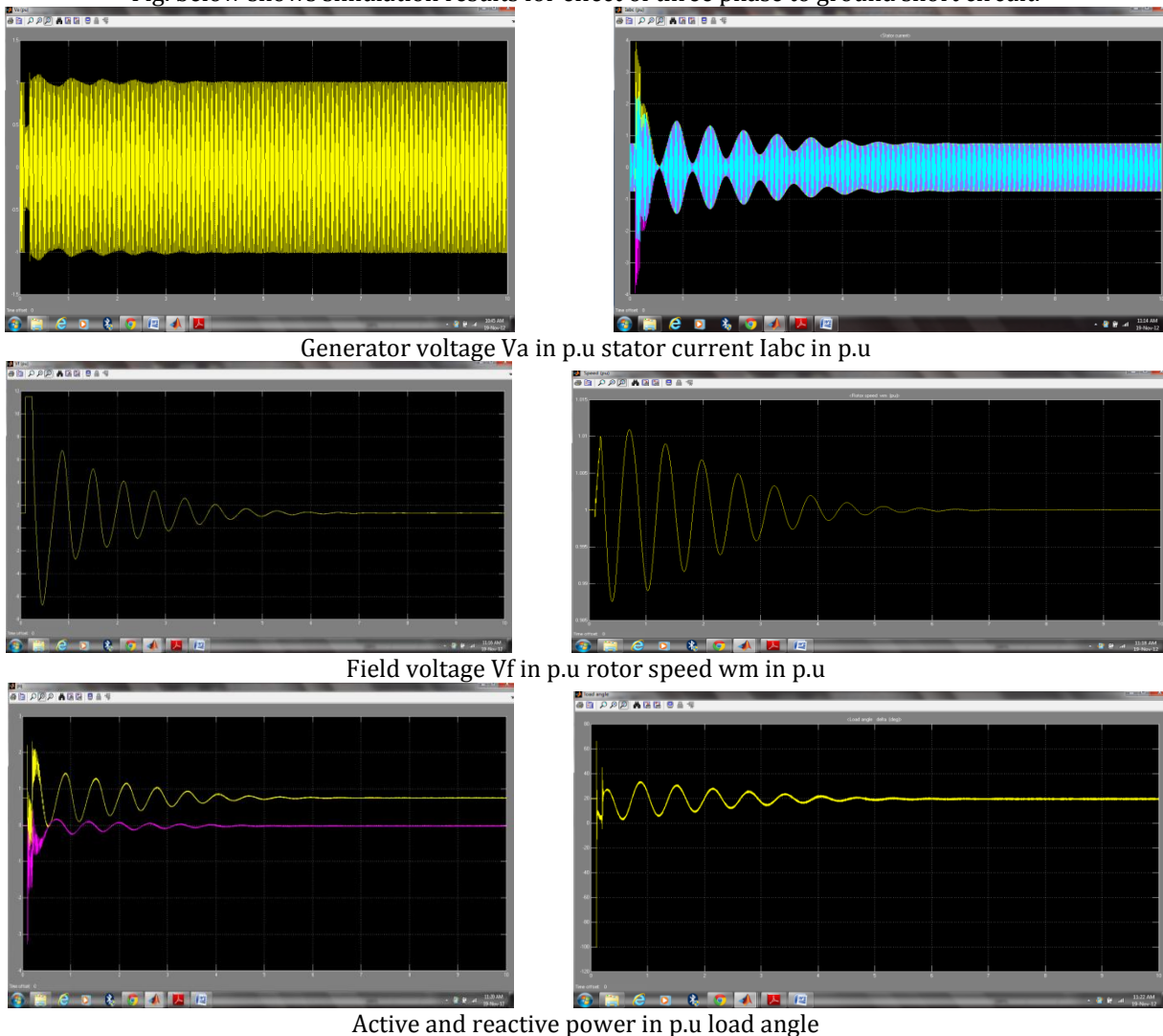


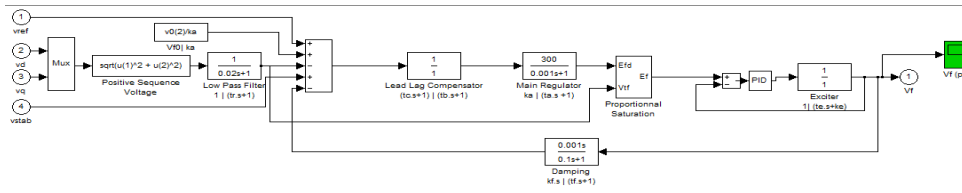
Fig. below shows simulation results for effect of three phase to ground short circuit.



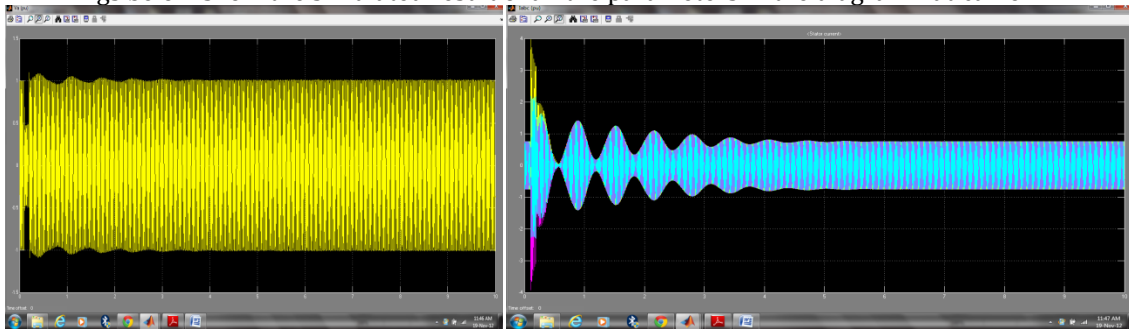
From these simulation result active power stabilizes near 0.745 after fault is cleared and reactive power near -0.02 .All these values are in p.u.

**Case II:** PID connected with the excitor.

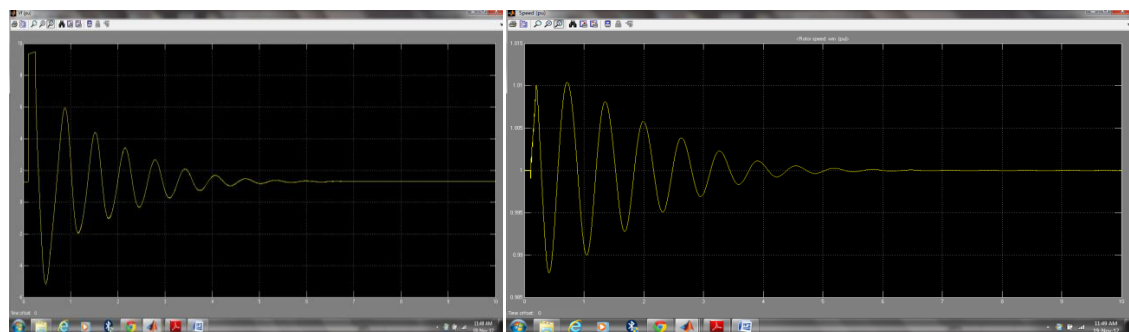
This model is actually designed to see how our system will response when excitation system is connected with PID controller. The simulink model showing the excitation system is given below:



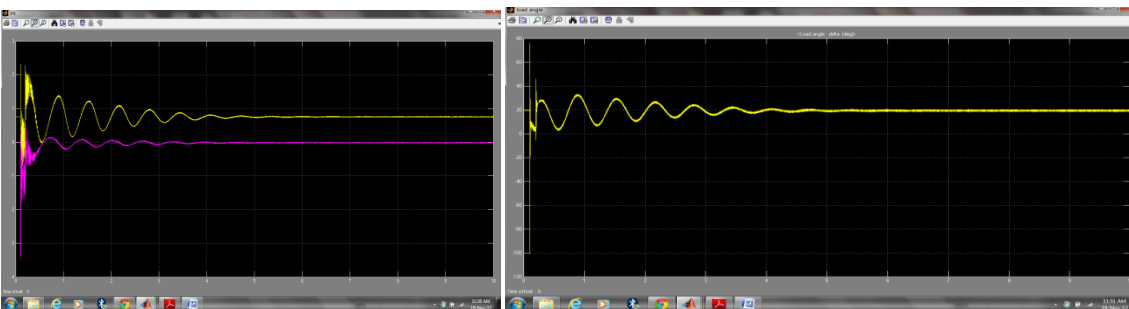
Figs below show the simulated result of all the parameters in the diagrammatical form.



Generator voltage  $V_a$  in p.u stator current  $I_{abc}$  in p.u



Field voltage  $V_f$  in p.u rotor speed  $w_m$  in p.u

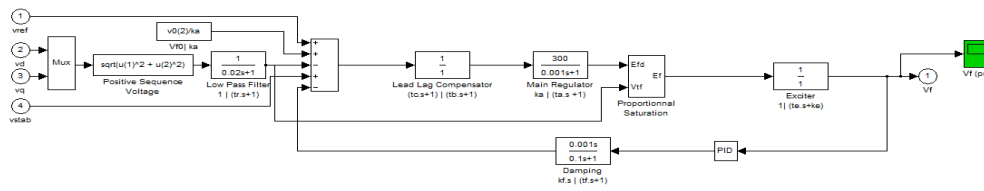


Active and reactive power in p.u load angle

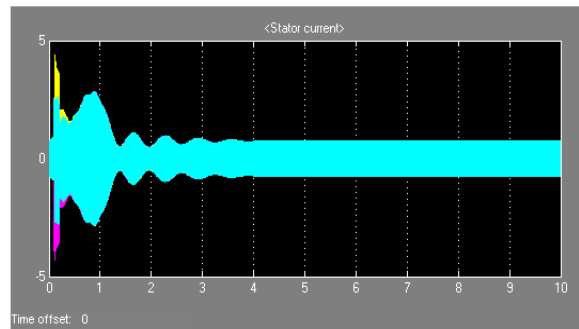
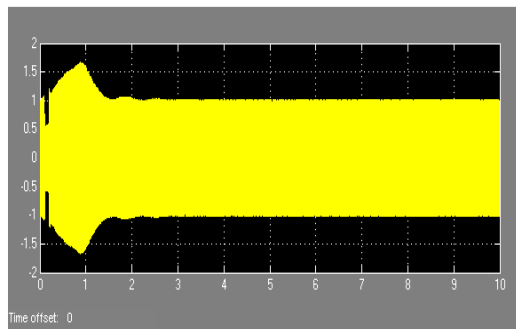
In this control system speed of the rotor reaches upto 1.01 pu when fault occur in the system and after the fault speed settles at time 6.7 sec. Similarly generator output voltage settles at time 2 sec, stator current settles at  $t=6$  sec, load angle settles at  $t=5$  sec, excitation voltage settles at  $t=6.5$  sec.

Case III: PID connected in feedback.

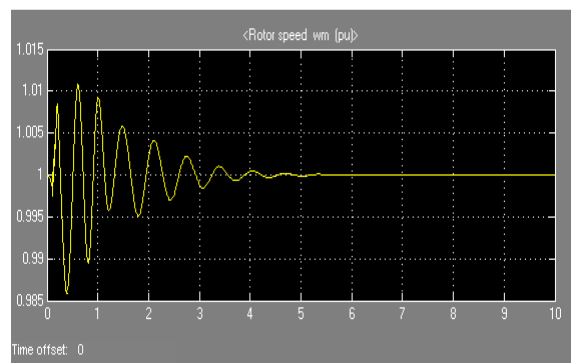
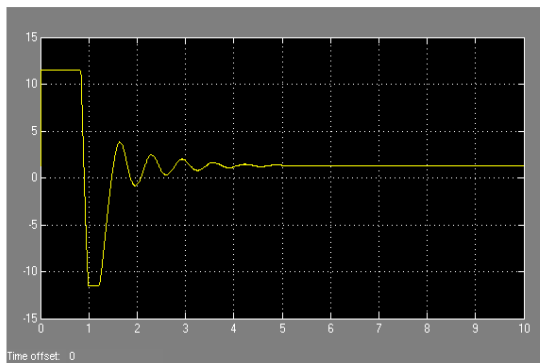
This model is actually designed to see how our system will response when excitor output is feedback with PID to the lead lag compensator. The simulink model showing the excitation system is given below:



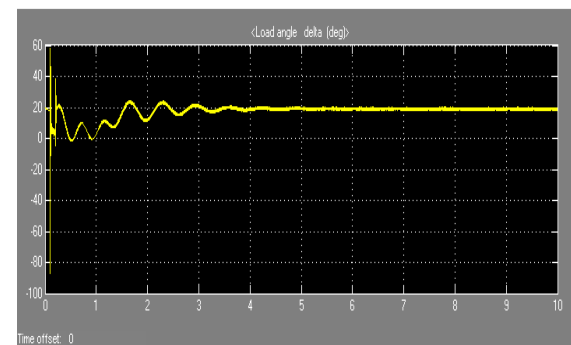
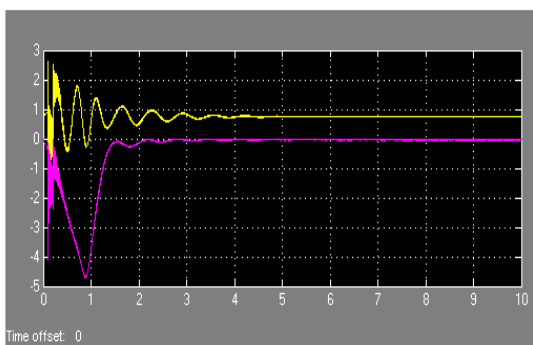
Figs below shows the simulated result:



Generator output voltage (Va) in pu. Stator current (Iabc) in pu



Excitation voltage (Vf) in pu. Rotor speed (Wm) in pu



Active (P) and reactive power (Q) in pu. Load angle delta (deg)

From the above result it becomes clear that this system gives more stable result than the other three cases. In this system the settling time of all the parameters is very less and approaches toward the stability more quickly. In this control system speed of the rotor reaches up to 1.01 pu when fault occur in the system and after the fault speed settles at time 3.5 sec. Similarly generator output voltage settles at time 1.7 sec, stator current settles at t=3.5 sec, load angle settles at t=2.5 sec, Excitation voltage settles at t=4.5 sec. Furthermore parameters after the three phase fault attains its pu value very quickly. Control of these parameters transfer the power in a smooth and better way.

### 3 Simulation results

Data showing magnitude and settling point of different parameters of the hydropower plant under three different cases after the fault:

Magnitude of different parameters of synchronous machine in pu after three phase fault							
Case	Generator o/p (Va)	Stator current (Iabc)	Excitation voltage(vf)	Rotor speed (ws)	Power		Load angle in degree
					P	Q	
I	1	0.76	1.3	1	0.75	-0.03	20
II	1	0.75	1.4	1	0.75	-0.03	19
III	1	0.76	1.3	1	0.75	-0.03	20
IV	1	0.76	1.3	1	0.75	-0.03	19.5

Settling time of different parameters of synchronous machine in seconds.							
Case	Generator o/p (Va)	Stator current (Iabc)	Excitation voltage (vf)	Rotor speed (ws)	Power		Load angle
					P	Q	
I	2	7.5	7	7	6	5	5.5
II	2	5	6	6	5	4	5
III	2	6	6.5	6.7	5	4	5
IV	1.7	3.5	4.5	3.5	2.7	2.7	2.5

### 4. CONCLUSION

From the study of Simulink result it become clear when three phase fault occur on the system, transient occur in the system but with the help of the governor control and excitation control transients can be more quickly overcome and system is made to work smoothly. From these results it becomes clear that magnitude of parameters after the fault is same as before but oscillating in nature around these values and the only difference is in the settling time and the amount of oscillations in the system. From all three cases PID connected in the feedback loop gives us the most convenient results and makes our system stable more quickly.

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