DESIGN OF Z-N TUNED PID CONTROLLER FOR HIGHER ORDER SYSTEM

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Abstract-*This Paper presents the design of Z-N-Tuned PID Controller, to realize governor action in a power generation plant to improving the dynamic characteristics. Proportional-integral-derivative (PID) controllers are widely used in industrial control system because of the reduced number of parameters to be tuned. The PID control method is most flexible and simple method. This method is more popular among all control methods. The conventional PID controller is replaced by Z-N tuning PID controller, to make them more general and to achieve minimum steady-state error, also to improve the other dynamic behavior (overshoot). The self tuned proportional integral derivative (PID) controllers are designed for applications where large load changes are expected or the need for extreme accuracy and fast response time exists.*

Keyword- *Proportional-Integral-Derivative controls, PID hardware, Ziegler-Nichols Tuning, PID controllers design.*

I INTRODUCTION

The determination of proportional (Kp), derivative (Td) and integral (Ti) constant are known as tuning of PID controller. The most popular tuning technique is the Ziegler-Nichols method. However, besides being suitable only for system with monotonic step response, the compensated system whose controllers are tuned in accordance with the Ziegler-Nichols method have generally a step response with a high- percent overshoot. Ziegler and Nichols proposed the manual tuning of PID controller. The proceeding work is carried out of PID controllers on Z-N tuning that is based on Gain Phase margin tester method. The advantage of Gain Phase margin based-PID controller is that the tuning is also carried out for higher order systems thus the robustness of the system is increased. The performance of this PID controller is examine by MATLAB results.

The proportional integral and derivative (PID) controller is widely used in process industries to control the plant (system) for the desired set point. The PID control method is most flexible and simple method. This method is more popular among all control methods. The determination of proportional (KP), derivative (KD) and integral (KI) constants are known as tuning of PID controller. Ziegler and Nichols give the manual tuning of PID controller. This is off line practical method of PID constants determination. In this method, the system is in open loop configuration. There is chance of system becoming unstable when it is in open loop configuration.

PID control is the proportion of error (P), integral of error (I), differential of error (D) control. In the analog control system, the analog PID control system is shown in Fig.1. The system consists of analog PID controller and the controlled plant.

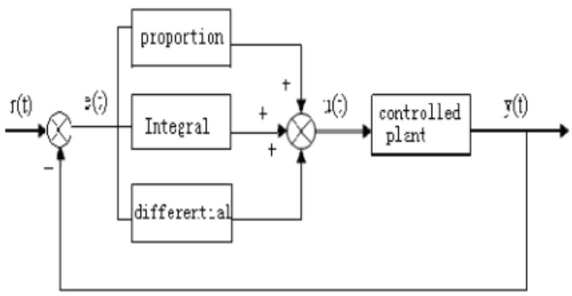

Figure 1: The analog PID Controller

PID controller is a linear controller; the error is given by the given value of r (t) and the actual output y (r).

e (t) =r (t) −y (t)

The control value is gained by composing linearly the proportion , integral and differential of the error, which control the controlled plant, so it is called as PID controller. The deviation of the ratio of integral and differential control, through a linear combination of composition control the amount of control on the plant, it called the PID controller. The control law is as follows. [6]

A PID controller is described by the following transfer function in the continuous s-domain

Gc = P + I + D

Gc= Kp + Ki/S + KdS

Gc = Kp (1 + 1/Ti S + TdS)

Where Kp is the proportional gain, Ki is the integration coefficient and Kd is the derivative coefficient. Ti is the integral action time and Td is referred as derivative action time. These parameters in order to get best performance according to the design of the system. [2]

II TUNING SYSTEM

The proceeding work is carried out of PID controller's on line auto tuning that is based on Ziegler Nichols tuning method. The advantage of Z-N PID controller tuning is also carry out for higher order systems.Z-N PID Controller is controlling the plant or system by continuously monitoring plant output which is known as process value with the desired process value known as set point of the system. The PID controller manipulates on the difference between process value and set point called as error. In the conventional controlling method the transfer function of plant should be calculated in order to find out various parameters and the value of PID constants. But in this method there is no necessary to derive the transfer function of the system. Thus Z-N PID controller is monitoring the plant depending on set point and process value and irrespective of the nature of plant. [3][4]

***Ziegler-Nichols tuning rule*:**

Ziegler-Nichols tuning rule was the first such effort to provide a practical approach to tune a PID controller. According to the rule, a PID controller is tuned by firstly setting it to the P-only mode but Adjusting the gain to make the control system in continuous oscillation. The corresponding gain is referred to as the ultimate gain (Ku) and the oscillation period is termed as the ultimate period (Pu). Then, the PID controller parameters are determined from Ku and Pu the Ziegler-Nichols tuning table.[1]

Type of controller	Parameters		
	K_p	T_i	T_d
P controller	0.5Kcr	∞	0
PI controller	0.45Kcr	$1/1.2P_{cr}$	0
PID controller	0.6Kcr	$1/2\ P_{cr}$	$0.125\ P_{cr}$

Table1: Controller Parameters for Ziegler-Nichols frequency method

The most employed PID design technique used in the industry is the Ziegler–Nichols method, which avoids the need for a model of the plant to be controlled and relies solely on the step response of the plant. The parameter setting, according to the Ziegler–Nichols method, is carried out in four steps.

1) Obtain the plant step response.
2) Draw the steepest straight-line tangent to the response.
3) Obtain the measurements
4) Set the parameters according to Table

The main features of PID controllers are the capacity to eliminate steady-state error of the response to a step reference signal because of integral action and the ability to anticipate output changes when derivative action is employed.

III POWER GENERATION PLANT

In a power plant, both active and reactive power demands continually vary the rising or falling trend. Power input must therefore be continuously regulated to match the active power demand; otherwise the machine speed will change with consequent change in frequency, which may be highly undesirable. Also the excitation of generators must be continuously regulated to match the reactive power demand with reactive generation, failing which the voltage at various system buses may go beyond the prescribed limits.

Parameter	Value
Turbine time constant	0.5 s
Governor time constant	0.2 s
Generator Angular Momentum	10Mjrad/s
Governor Speed regulation	0.05
Load change for frequency change of 1%	0.8%
$D= \Delta P/\Delta \omega$	0.8
Turbine rated output	250MW

Table2: Power generation plant parameters [7]

Ziegler Nichols frequency response method or Routh array criterion is used to determine the initial value of Kp, Ki & Kd.
Open loop transfer function (TF) of given plant is

$$\mathbf{G(s) = C(s)/U(s) = 1/\ [(0.2s + 1)(0.5s + 1)(10s + 0.8)]}$$

This TF is third order and has no integral term.
The performance of the Z-N PID controller is shown by MATLAB results.
System Transfer function

$$G(s) = \frac{Kp}{(0.2s+1)(0.5s+1)(10s+0.8)+Kp}$$

The characteristic equation for the closed loop system is

S3 + 7.08S2 + 10.56 + (0.8 + Kp) = 0

By applying Routh Hurwitz criteria, we get

ω = 3.25 rad/sec

Hence the period of sustained oscillation

Pcr = $2\pi/\omega$ = 1.9323

Also we can determine Kp, Ti and Td, using Ziegler Nichols frequency method.
We determine the Kp, Ti & Td, Using Ziegler-Nichols Frequency method

Kp, = 0.6 Kcr = 44.37
Ti = 0.5Pcr = 0.96
Td = 0.125Pcr = 0.24

The Transfer Function of PID controller is then

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$$Gc(s) = \frac{44.93\ (0.23S2 + 0.966S + 1)}{S}$$

IV RESULTS

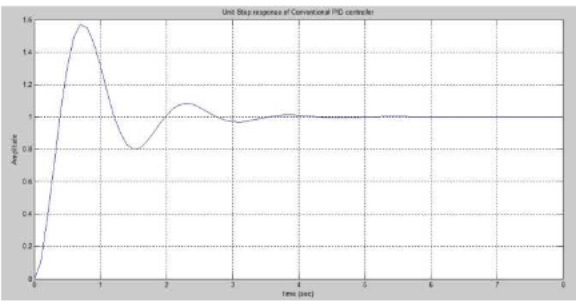

Figure 2: Time Response of Conventional PID Controller

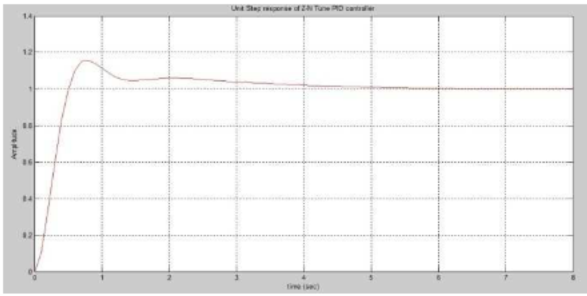

Figure 3: Time Response of Z-N Tuned PID Controller

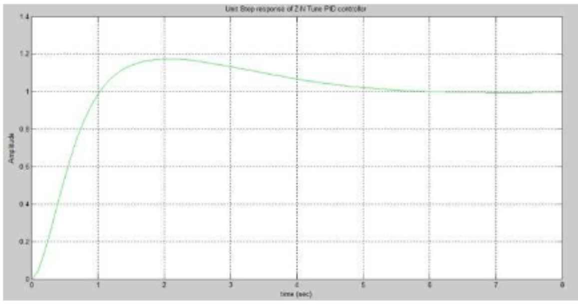

Figure 4: Time Response of Z-N Tuned PID Controller

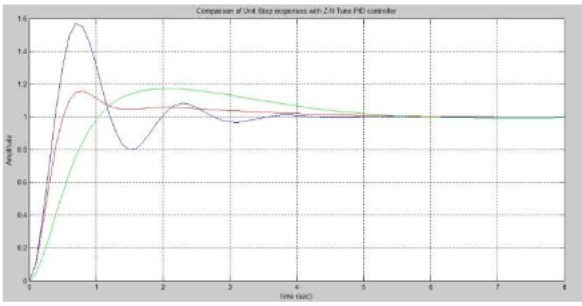

Figure 5: Comparison between PID and Z-N Tuned PID Controller

IV CONCLUSION

The conventional PID controller gives the high overshoot and settling time. In Z-N Tuned PID Controller, Initial controller parameters obtained using Ziegler-Nichols formulas are adjusted by numerical computational technique to get satisfactory performance. Z-N Tuned PID Controller gives zero steady state error and smaller overshoot than conventional PID controller. Z-N Tuned PID controller with simple approach can provide better performance comparing with the conventional PID controller.

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