IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 18, Issue 3, Ver. III (May-Jun. 2016), PP 33-37
www.iosrjournals.org

PIDF Auto Tuning Control System (AVR) In Power System Stability Analysis

Abdal-RazakShehab
Dept. of Electrical engineering, Kufa University,Iraq

Abstract:*This work aims to develop a controller based on auto tuning 0f PIDF to simulate an automatic voltage regulator (AVR) in transient stability power system analysis. AVR is an essential part of the synchronous generator and it is responsible for regulating the reactive power and voltage level under normal operating terms at various load levels. The modeled system consisted of theamplifier, exciter, sensor and proportional-integral-derivative-Filter (PIDF) controller. Simulationof the AVR system is carried out on the interface developed by Matlab GUI and the results are presented and compared with conventional (industrial PID) controller). In an attempt to cover a wide range of operating conditions, PIDF controller has been suggested as a possible solution tooovercome the overshoot and slowly response which coupling design PID under different load condition that could present good performance in all operating points.*

Keywords:*Generator Excitation System, Synchronous Machine Model, Automatic Voltage Regulator (AVR), PID and PIDF Controller, Controller Design.*

I. Introduction

From the power system point of view, the excitation system must contribute for the effective voltage control and enhancement of the system stability [1]. It must be able to respond quickly to a disturbance enhancing the transient stability and the small signalstability.

Synchronous generators have a significant share in providing energy for electrical networks. The effective control of them is conclusive because these importantcomponents are mostly responsible for maintaining stability and security of the power systems. The AVR systems are employed widely in exciter control system. The primary way to control the generator reactive power is the excitation control of generator by AVR. The role of an AVR is keeping the generator terminal voltage level constant under normal operating terms at different load levels [2].In most modern systems the automatic voltage regulator (AVR) is a controller that senses the generator output voltage (and sometimes the current) then initiates corrective action by changing the exciter control in the desired direction. The speed of the AVR is of great interest in studying stability. Because of the high inductance in the generator field winding, it is difficult to make rapid changes in field current. This introduces a considerable lag in the control function and is one of the major obstacles to be overcome in designing a regulating system. The AVR loop of the excitation control system uses terminal voltage error for tuning the field voltage to control the terminal voltage [3]The fundamental components of an exciter control systemcompose of four main components namely amplifier, sensor, exciter and generator [2]. Control principles for the AVR system have been defined in a few publications [4-7].Process control techniques have made major advances during the past decades. Many control methods like adaptive control, neural control, and fuzzy control have been practiced [4-7]. The best known and most widely used among them isthe PID controller because of its simplicity and robustperformance in a wide range of operating conditions. Themost important point to design a PID controller is todetermine the proportional, integral and derivative gains. Inorder to tune the single-input-single-output (SISO) PIDcontrollers, many approaches have been proposed. Comparisons about some well-known PID tuning formulascan be found in the literature [8, 9].In this study a system using PIDF method as an auto tuning method for determining the parameters of PIDF controlfor an AVR system and the AVR system transient stabilityby variation of the PIDF parameters is proposed. Also, AMatlab GUI interface is developed to realize this in easy way.

II. Dynamic Power System Model

2. 1TRANSIENT STABILITY ANALYSIS

The first demand of electrical system trust is to keep the synchronous generators working in parallel and with adequate capacity to satisfy the load demand. If at any time, a generator loses synchronism with the rest of the system, significant voltage and current fluctuation can occur and transmission lines can be automatically worn off from the system by their relays deeply affecting the system configuration.

The second demand is maintaining power system integrity. The high voltage transmission system connects the generation sources to the load centers. Interruption of these nets can obstruct the power flow to the load. This usually requires the power systemtopology study, once almost all electrical systems are connected to each other.When a power system under normal load condition suffers a disturbance there is synchronous machine voltage angles rearrangement. If at each disturbanceoccurrence an unbalance is created between the system generation and load, a new operation point will be established and consequently there will be voltageangles adjustments. The system adjustment to its new operation condition is called "transient period" and the system behavior during this period is called "dynamic performance"[1]. As a primitive definition, it can be said that the systemoscillatory response during the transient period, short after a disturbance, is damped and the system goes in a definite time to a new operating condition, so thesystem is stable. This means that the oscillations are damped, that the system has inherent forces which tend to reduce the oscillations. The instability in a power system can be shown in different ways, according to its configuration and its mode of operation, but it can also be observed without synchronism loss.

2.2. AUTOMATIC VOLTAGE REGULATOR

Automatic devices control generators voltages output and frequency, in order to keep them constant according to pre-established values.

These automatic devices are:

1- Automatic VoltageRegulator

2- Governor

However any governor due to its action loop which control the input mechanical real power, is slower than the AVR. This is associated mainly to itsfinal action in the turbine.The main objective of the automatic voltage regulator– AVR- is to control the terminal voltage by adjustingthe generators exciter voltage. The AVR must keeptrack of the generator terminal voltage all the time andunder any load condition, working in order to keep the voltage within pre-established limits. Based on this, it can be said that the AVR also controls the reactivepower generated and the power factor of the machineonce these variables are related to the generatorexcitation level.

The AVR quality influences the voltage level during steady state operation, and also reduce the voltageoscillations during transient periods, affecting theoverall system stability. Figure 1 illustrates the AVR blocks (regulator, voltage limiter, and exciter and feedback terminal voltage) [10].

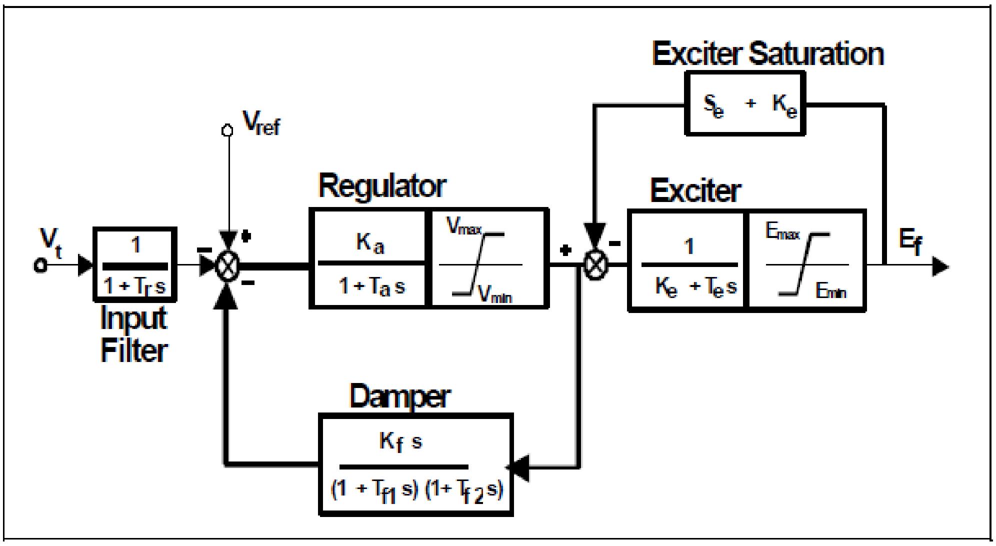


Figure 1- AVR Model Type II of IEEE [10]: RT -IEEE2

III. Auto tuning for PIDF and simulation results

Proportional(P), integral (I), and derivative (D) with first-order filter on derivative term and Time constant of the first-order derivative filter (N), pidstd(Kp,Ti,Td,N) creates a continuous-time PIDF (PID with first-order derivative filter) controller object in standard form. The controller has proportional gain Kp, integral and derivative times Ti and Td, and first-order derivative filter divisor N as shown in the controller transfer function below:

$$C(s) = K_p\left[1 + \frac{1}{T_i} \times \frac{1}{s} + \frac{T_d s}{\frac{T_d}{N} s + 1}\right]$$

Input Arguments

Kp, Proportional gain. Kp must be a real and finite value.

Ti, Integral time. Ti must be a real and positive value. When Ti = Inf, the controller has no integral action. For an array of pidstd controllers, Ti must be an array of real and positive values.
Default: Inf
Td, Derivative time. Td must be a real, finite, and nonnegative value. When Td = 0, the controller has no derivative action.
Default: 0
N, Time constant of the first-order derivative filter.N must be a real and positive value. When N = Inf, the controller has no derivative filter.
For an array of pidstd controllers, N must be an array of real and positive values.
Default:Inf

IV. Designed Interface With MATLAB/GUI

AVR system simulations have performed by using aninterface has developed by MATLAB/GUI. In this paper, the transfer functions proposedfor the components of AVR model in **Fig. 2** are consideredwith different types and gains of the PIDF controller. The block diagram shown in Figure 2 shows a synchronous machine for which output the voltage is controlled by an AVR applied to its excitation system, in the MATLAB simulation. All data were taken from reference [1].

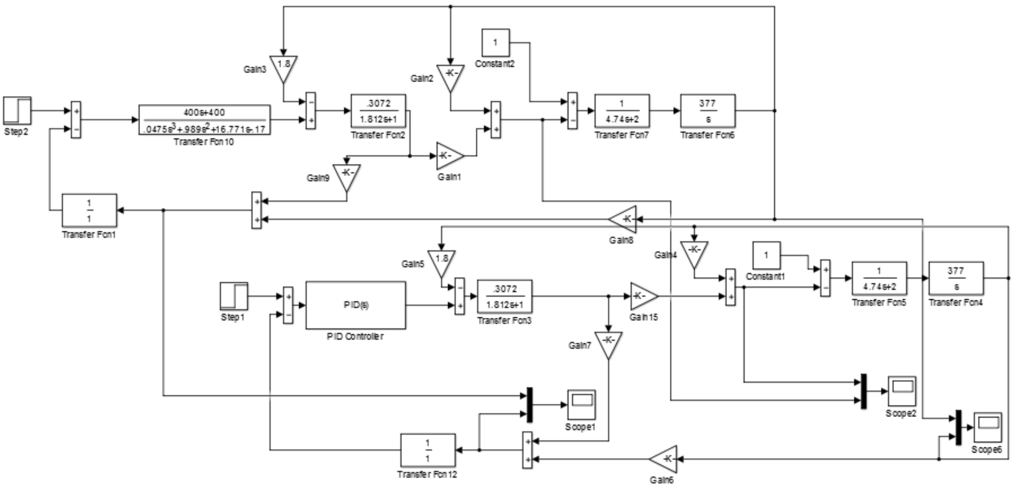
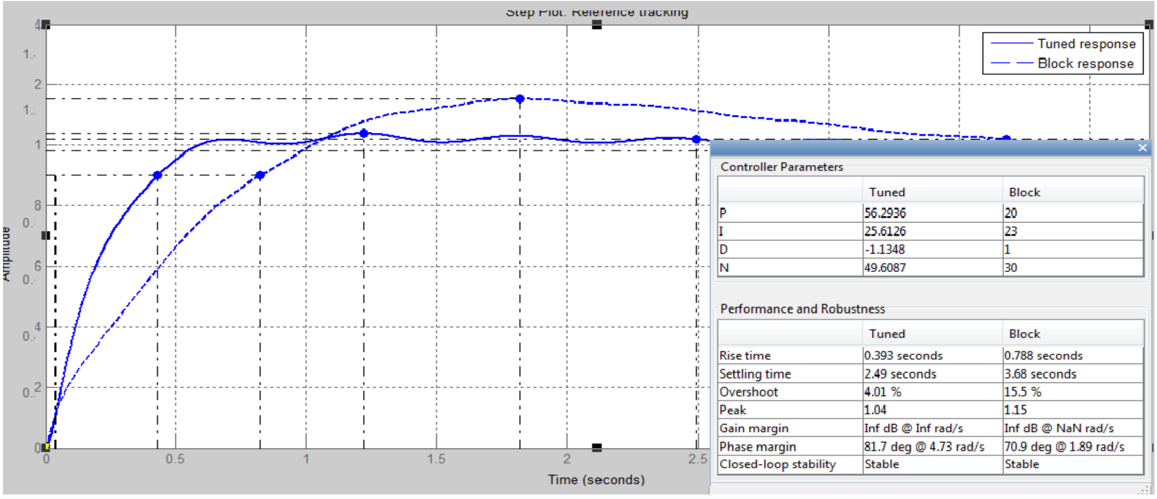


Figure 2 - Block diagram of one synchronous machine with conventional PID and PIDF auto tuning controllers simulated in Matlab.

To select the gains and filter coefficient for PIDF controller, initialized the auto tuning for this purpose , then got the transient response for unit step function(time domain) as shown in **Figure**3, clearly seen that the rise time, overshoot and settling time would be reduced as compared with a conventional PID as shown in **TABLE** 1.



Controller Parameters

	Tuned	Block
P	56.2936	20
I	25.6126	23
D	-1.1348	1
N	49.6087	30

Performance and Robustness

	Tuned	Block
Rise time	0.393 seconds	0.788 seconds
Settling time	2.49 seconds	3.68 seconds
Overshoot	4.01 %	15.5 %
Peak	1.04	1.15
Gain margin	Inf dB @ Inf rad/s	Inf dB @ NaN rad/s
Phase margin	81.7 deg @ 4.73 rad/s	70.9 deg @ 1.89 rad/s
Closed-loop stability	Stable	Stable

Figure 3 the step tuned(PIDF) and block(PID) responses for the synchronous machine.

Table.1

Method	RISE TIME (T_r)(sec.)	SETTLING TIME (T_s)(sec.)	PERCENTAGE OVERSHOOT%	PEAKTIME (T_p)(sec.)
Conventional PID	0.78	3.5	12.04	1.4
PIDF	0.398	2.49	3.94	1.04

Graphs are held on the Figure window by this way thegraphs can be compared easily between conventional PID and PIDF response as shown in Figures (4 a, 4 b, 4 c)which shows the time responses of terminal voltage, electric torque and load angle respectively.

V. Results and conclusions

It is clearly that different Kp values will be change the transient response when we tune manually. Due to different position of poles and zeros related to gain value Kp..If the Kp gain is too low, the output signal will bedamped and reach stability eventually after the disturbanceoccurs.CriticalKp gain, at which the output ofthe loop begins to oscillate.

Conversely, if the Kpgain is too high, the system was oscillated andbecome unstable and grow larger over time. With AVR IEEE, the rise time, percentage overshoot and settling time of the step response was acceptedbut not satisfy as seen in **TABLE 1**. On the other hand, the PIDF controller provides the lowestovershoot, little hesitation, lower rise time a good steady state error compared with the AVR IEEE. If we analyze that it comes from the additional pole for the first order filter. So in this way an enhancement would be got to the controller with little addition in electronic components.

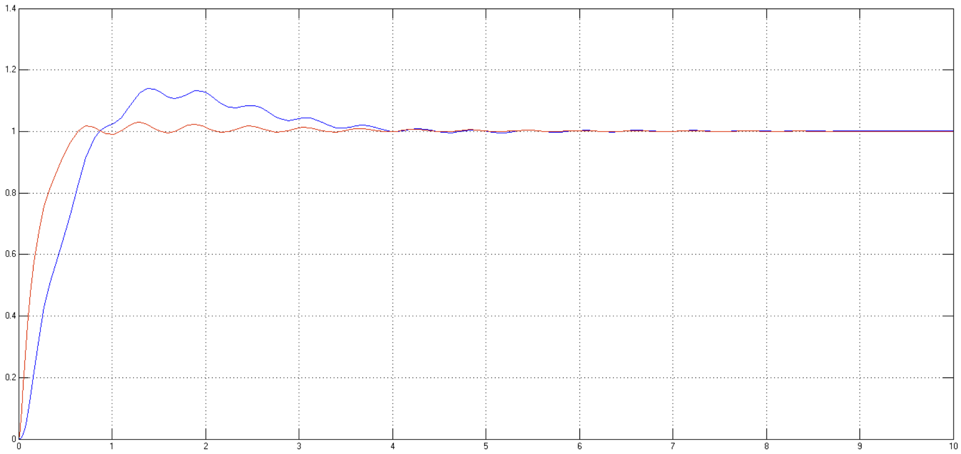


Figure 4 (a) one machine analysis (terminal voltage Vt. Red curve for PIDF and blue curve for conventional PID response)

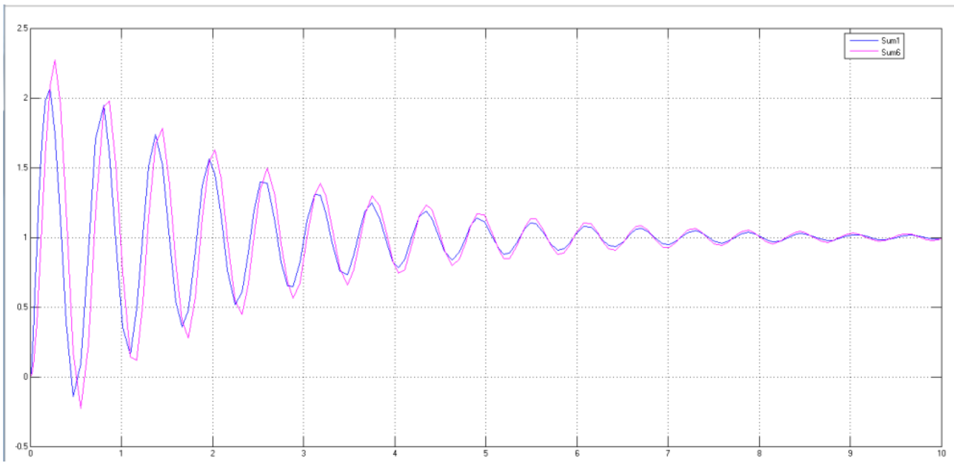


Figure (4b)one machine analysis (electrical torque)

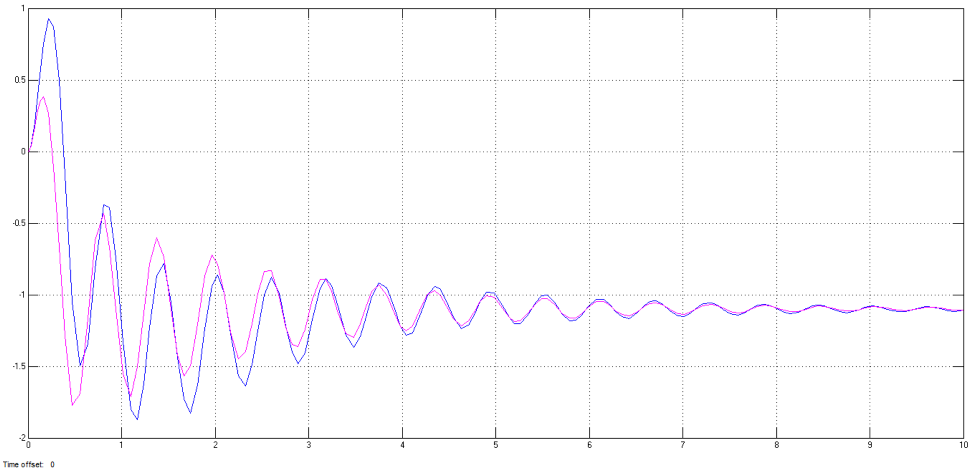


Figure (4c)one machine analysis (load angle)

References

[1]. Anderson, P.M. and Fouad, A. A. - "Power System Control and Stability"- The Iowa State University Press, Ames, Iowa, USA, 1977.
[2]. H. Saadat "Power System Analysis", New York, McGraw-Hill, 1999.
[3]. J. Faiz ,Gh.Shahgholian, M.Arezoomand, “Analysis and Simulation ofthe AVR System and Parameters Variation Effects”, POWERENG 2007, April 12-14, 2007, Setubal, Portugal.
[4]. A.Visioli, “Tuning of PID controllers with fuzzy logic”, IEE Proc. Control Theory Appl., Vol. 148, No. I, pp. 1-8, Jan. 2001.
[5]. T. L. Seng, M. B. Khalid, R. Yusof, “Tuning of a Neuro-Fuzzy Controller by Genetic Algorithm”, IEEE Trans. on Systems, Man, and Cybernetics-Part B: Cybernetics, Vol. 29, No. 2, pp. 226-236, Ap. 1999.
[6]. T. Senjyu, N. Gibo, K. Uezato, “Cooperative Control of AVR and GOV for Improving Transient Stability of Power Systems Using Fuzzy Controller”, IEEE Con., pp. 35-40, 1993.
[7]. G. K. Venayagamoorthy, R. G. Harley, "A Robust Artificial Neural Network Controller for a turbo generator when Line Configuration Changes", IEEE Trans., pp. 917-922, 1999.
[8]. W. Tan, J. Liu, T. Chen, H. J. Marquez, "Comparison of Some Well- Known PID Tuning Formulas", Computers and Chemical Eng., Vol. 30,pp. 1416–1423, 2006.
[9]. W. K. Ho, 0 . P. Gan, E. B. Tay, and E. L. Ang, “Performance and Gain and Phase Margins of Well-Known PID Tuning Formulas”, IEEE Transactions on Control Systems Technology, Vol. 4, No. 4, July 1996.
[10]. IEEE Committee Report- "Computer Representation of Excitation Systems "- IEEE Transactions on Power Apparatus and Systems - Vol. PAS-87, pp. 1460-1464, Jun/1968.