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Design of Fuzzy PID controller to control DC motor with zero overshoot

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Abstract:
Most of the real time operation based physical system, digital PID is used in field such as servo-motor/dc motor/temperature control system, robotics, power electronics etc. need to interface with high speed constraints, higher density PLD's such as FPGA used to integrate several logics on single IC. There are some limitations in it to overcome these limitations Fuzzy logic is introduced with PID and Fuzzy PID is formed. This paper explains experimental design of Fuzzy PID controller. We aimed to make controller power efficient, more compact, and zero overshoot. MATLAB is used to design PID controller to calculate and plot the time response of the control system and Simulink to generate a set of coefficients.
Keywords: Fuzzy PID controller, FPGA, MATLAB, Simulink, VHDL.

I. Introduction:

A control system consist of two parts a plant and a controller. A controller can be either digital or analog. Digital controller can be implemented in different hardware platforms, including industrial board based on discrete digital logic, DSP, microprocessor or microcontroller, personal/industrial computer etc. The conventional PID controller doesn't possess the human intelligence; and Digital can but with overshoot in it. To overcome from these limitations some advancement is done by using fuzzy logic both limitations and fuzzy involvement are mention below.

II. Conventional PID controller's limitations:

- A conventional PID cannot be used as the core of smart control system.
- They do not work effectively controlling complex processes that are nonlinear, time-variant, with major disturbances, uncertainties, and large time delays.
- They need to be tuned properly when the plant dynamics change. This is a frustrating and time-consuming experience if the nonlinearities of the plant become more accentuate. There are several algorithms to tune or auto tune PID controllers, but in some situations, when the system becomes too complex, where the conventional PID controller would not work, no matter how it is tuned.

III. Fuzzy PID controller involved:

- FPID uses every day words to establish the Fuzzy Inference System (FIS).
- The linguistic variables error, change of error, and integral of error can be used to handle the same signals than the conventional PID controller uses.
- They can work as a linear or a non linear PID controller.
- They can be smart, working in combination with other soft computing techniques.
- The FPID has more parameters to adjust than conventional PID, but there are several effective methods to tune them.

IV. Advantages:

- Considerable time reduction in the design stage
- Improvements on system reliability and performance
- Elimination of discrete tuning components,
- Possibility of including various performance enhancements

V. Applications:

- FPID controller based on FPGA for process control
- FPID controller for stabilization of power system
- Self-adaptive FPID control in paper tension control
- FPID Controller in Two-Container Water Tank System Control
- FPID application in speed control system of the paper cutter
- FPID control in DC motor of automatic doors

- Self-tuning FPID controller on the AVR system, in soccer robot and to the control of drum water level of a boiler for a power generating plant
- Adaptive FPID Controller in Packing Industry
- Fuzzy logic in the synthesis of controllers for dynamic plants

VI. Simulink model of Fuzzy PID Controller:

By using MATLAB/SIMULINK simulation model is constructed as shown in figure 1 below:

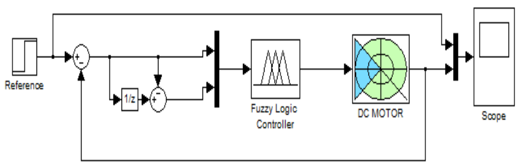

Figure 1: Simulation model of FPID

The very first block is reference or step i.e, input parameters are set as shown in table below:

Table 1: Input Parameters

Parameters	Attributes
Step time	1
Initial value	0
Final value	1
Sample time	1/1000

Unit Delay: sample and hold with one sample period delay.
Sum: Add or subtract inputs. Specify one of the following:

- String containing + or - for each input port, | for spacer between ports (e.g. ++|-|++)
- Scalar, >= 1, specifies the number of input ports to be summed.

MUX: many input and give one output, parameters are depend on designer. Here we use following parameter as shown in Table 2

Table 2: Multiplexer parameters

Parameters	Attributes
Icon shape	Round
List of signs	+,-
MUX	Multiplex vector or scalar signal
No. Of Input	2
output	1

Fuzzy logic controller: Fuzzy Membership function editor, where the number of membership functions and type of membership function is decided.

5 steps to generate fuzzy rules from numerical data:

- Divide the input and output spaces of the given numerical data into fuzzy regions.
- Generate fuzzy rules from the given data.
- Assign a degree of each of the generated rules for the purpose of resolving conflicts among the generated rules.
- Create a combined fuzzy rule base based on both the generated rules and linguistic rules of human experts.
- Determine a mapping from input space to output space based on the combined fuzzy rule base using a defuzzifying procedure.

By using these rules we made nine rules shown in figure below:

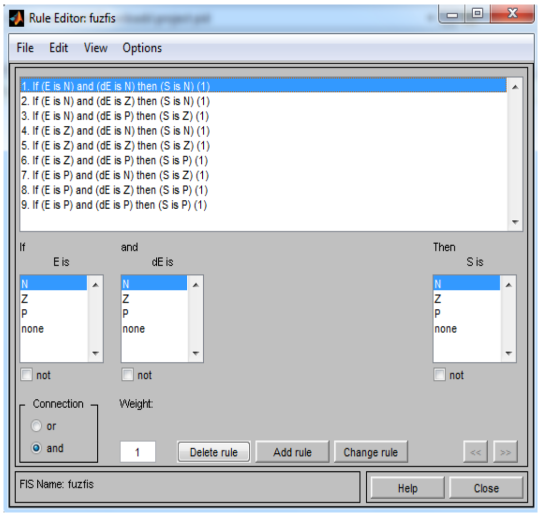

Figure 2: Rule editor

Last block of simulation model is DC motor, which is in terms of transfer function and to construct it following parameter shown in table 3 are set:

Table 3: DC motor parameter

Prompt	Unit	Variable
Armature Resistance	Ohms	Ra
Armature Induction	H	La
Back E.M.F	Volt/(rad/sec)	Kb
Moment of Inertia	Kg-m^2/rad	J
Frictional Constant	N-m/(rad/sec)	B
Armature current	Ampere	i
Armature voltage	Volts	V
Back EMF voltage	Volts	eb
Torque constant	N.m/Ampere	KT
Torque	N.m	Tm
Angular displacement	radians	θ (t)

Transfer function of DC motor:

$$\frac{\omega(s)}{V(s)} = \frac{Kb}{(J+B)(La+Ra)+Kb^2+BR}$$

The values of individual parameter are set by using functional block parameter of DC motor in SIMULINK as shown in figure 3 below:

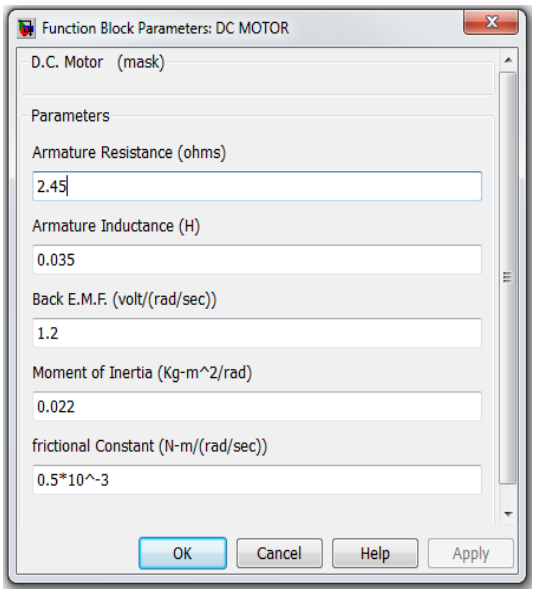

Figure 3: DC motor parameter

Results

Figure 4 shows simulation result of Fuzzy PID controller which control DC motor. From figure it is clearly visible that reference or ideal response not exceed by actual output on behalf of which we can say that there is no overshoot or zero overshoot.

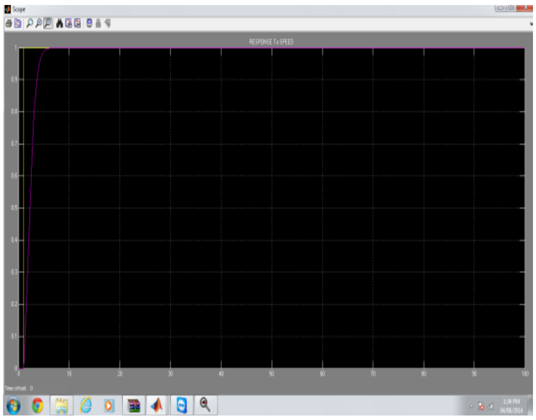

Figure 4: simulation result of Fuzzy PID with zero overshoot

Figure 5 shows rise time (represented by t_r) of the output response is 3.655 this is enlarge view of above result.

Settling time represented by t_s. Figure 6 shows settling time of the output response.

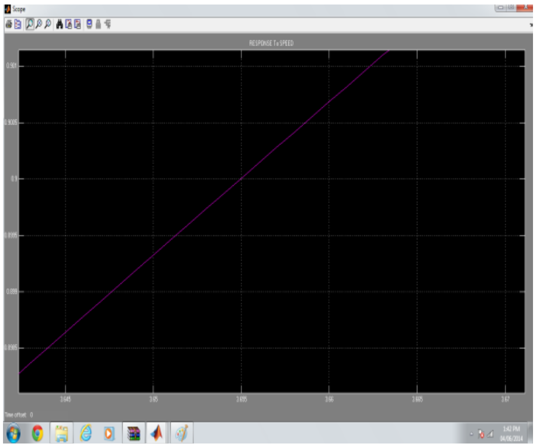

Figure 5:Rise Time

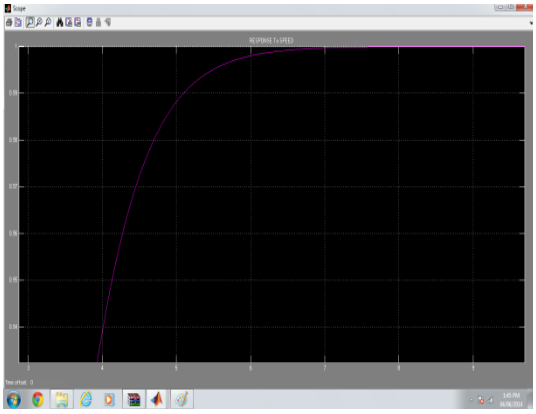

Figure 6: settling time

Table 3:Output response parameter

Controller	Time domain Specification		
	t_r (sec)	t_s (sec)	Over -shoot
FPID	3.655	7	0 %

VII. Future scope

Illustrated PID controller also has developed with all fuzzy rules for designing the hardware PID chip using VHDL. Then, the synthesize tool has used to get the logic gates of hardware PID modules. Numerous PID controllers be capable of realize on a solo FPGA chip together with coefficient calculation and auto tuning.

By reason of the utilization of Arithmetic algorithm, the number of PID controllers on solitary FPGA chip can be increased hugely. The compensation is high processing speed, reduced power consumption and hardware compatibility for implementing on FPGA.

The designed FPID chip can be used to the targeted application. As an example, transportation cruising system. The cruising system based on PID chip can be avoided the collision between vehicles on the road.

References

[1.] Nasri Sulaiman and Zeyad Assi obaid, "FPGA based fuzzy logic: Design and applications-A review", *IACSIT International Journal of engineering and technology. ISSN: 1793-8236 Vol.1, No. 5, Dec-2009*.

[2.] K.S Tang, Kim Fung Man, Gaunrong Chen, Sam Kwong, "An optimal Fuzzy PID Controller" IEEE *Trans. On engineering electronics, volume 48, no.4, Aug 2001, PP 757-765*.

[3.] Sameep singh & Kuldip S. Rattan, "Implementation of a Fuzzy logic Controller on FPGA using VHDL" *pp 110-115, IEEE 2003*.

[4.] V. Tipsuwanporn, T. Runghimmawan, S. Intajag, V. Krongratana, "Fuzzy logic PID Controller based on FPGA for process control", *pp 1495-1500, IEEE 2004*.

[5.] Yamhang Zhang, Zhongqiao Zheng, "Research on the parameter self tuning Fuzzy PID Controller" *Second International symposium on knowledge acquisition & modeling, pp 77-80, 2009 IEEE*.

[6.] Wen Chen, Hui-mei yuan, Yan Wang, "Design and implementation of digital Fuzzy-PID controller based on FPGA", *pp 393-397, IEEE ICIEA 2009*.

[7.] Lijuan Xing, Shizhong yang & Qianqian Lu, "Self tuning Fuzzy PID controller for temperature control in variable air conditioning system", *International conference on information & automation, pp 2117-2120, IEEE June 2010*.

[8.] Essam Natsheh and Khalid A. Buragga, "Comparison between conventional and fuzzy logic PID controllers of controlling DC motor", *IJCSI International Journal of computer science Issues, ISSN: 1697-0814, vol. 7, Issue 5, sep-2010 pp 128-134*.

[9.] Basil Hamed & Moayed at Mobaied, "Fuzzy PID controller using FPGA technique for real time DC motor speed control", *Intelligence control and automation (ICA), pp 233-240, Feb 2011*.

[10.] Shengjiang Chen & Chunfeng Zhang, "Application of Fuzzy self adaptive PID control in paper tension control", *pp170-173, IEEE 2013*.

[11.] Hassan Talebi Abatari and Abdolreza Dehghani Tafti, "Using a Fuzzy PID controller for path following of a car like Mobile Robot", *International conference on Robotics & Mechatronics, pp 189-193, IEEE Feb 2013*.

[12.] O. castilo et al. (Eds): "Design and Implementation of a hybrid Fuzzy controller using VHDL", *soft computing for Hybrid Intel system, SCI 154, pp 437-446, 2008*.

[13.] Opas Raksboon and chaiya Tong chaisuratkul, "Fuzzy PID control compensation system for speed of VVVF motor drive", *International Journal of computer Theory and engineering, vol. 5, No. 6, Dec-2013, pp 900-905*.

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