A Study on PI and Fuzzy PI Controllers

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Abstract

This paper presents a study on PI and Fuzzy PI Controllers. A controller producing proportional plus integral control action is referred as PI controller. It has only one input and one output. The output value depends upon the input value i.e. if the input is increased, out will also increase. When the PI controller are generalized these are called as Fuzzy PI controllers. The Fuzzy PI controllers use an error signal and its derivative as input signals. Unlike conventional PI controllers, Fuzzy PI controllers have two inputs and one output. The multiple inputs allow for greater control diversity for a fuzzy-PI controller over a conventional PI controller.

Keywords: PI Controller, Fuzzy PI controller, Power Quality

I. INTRODUCTION

The need for simple advanced control alternatives especially arises in the Control Process area, where most of the real processes are generally complex and difficult to model. The application of Fuzzy Logic to a wide range of control applications has made possible the establishment of intelligent control in these areas. Its appeal, from the Process Control Theory point of view, lies in the fact that this technique provides a good support for translating the heuristic knowledge of the skilled operator, expressed in linguistic terms, into computer algorithms. Fuzzy Control solves real problems, previously not tackled due to their complexity or to lack of information.

However, Fuzzy Logic Controllers (FLC) are usually applied with poor analytic knowledge of their behavior and only in simple configurations. In fact, they normally perform like PI or PD. FLC-PI controllers are quite simple, though they are the most widely used in practice and provide similar results to conventional controllers. But in some applications it may be useful to employ more general controllers, which make it easier to reach the system specifications and improve their performance, though they can be also more difficult to tune. The complete study of fuzzy controllers should involve all the terms of conventional controllers. The third control action must be included so as to consider the FLC-PID case. Though the derivative term is not commonly included - neither in the conventional case-, this allows us to complete the development of Fuzzy controllers in a similar way that of the classical ones. It also makes it possible to obtain certain conclusions about their stability and specifications.

II. CONVENTIONAL PI CONTROLLER

A proportional–integral–derivative controller (PID controller or three term controller) is a control loop feedback mechanism widely used in industrial control systems and a variety of other applications requiring continuously modulated control. A PID controller continuously calculates an error value as the difference between a desired setpoint (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively) which give the controller its name.

In practical terms it automatically applies accurate and responsive correction to a control function. An everyday example is the cruise control on a road vehicle; where external influences such as gradients would cause speed changes, and the driver has the ability to alter the desired set speed. The PID algorithm restores the actual speed to the desired speed in the optimum way, without delay or overshoot, by controlling the power output of the vehicle's engine.

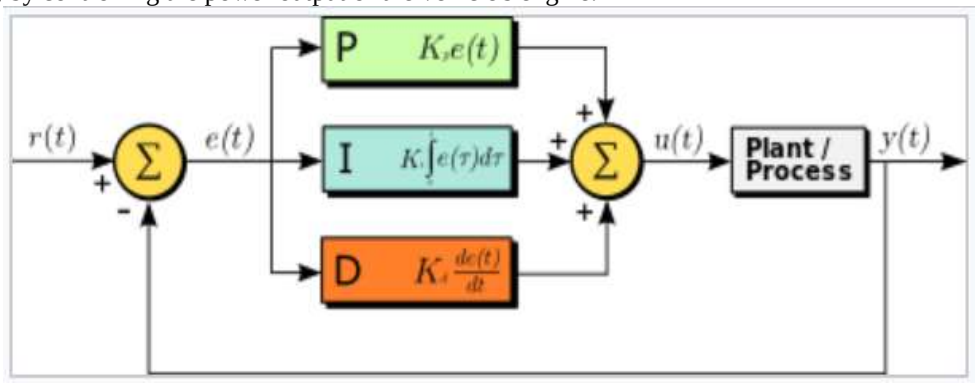

Fig. 1: Block Diagram of a PI Controller

The distinguishing feature of the PID controller is the ability to use the three control terms of proportional, integral and derivative influence on the controller output to apply accurate and optimal control. The block diagram on the right shows the principles of how these terms are generated and applied. It shows a PID controller, which continuously calculates an error value as the difference between a desired setpoint and a measured process variable , and applies a correction based on proportional, integral, and derivative terms. The controller attempts to minimize the error over time by adjustment of a control variable, such as the opening of a control valve, to a new value determined by a weighted sum of the control terms.

III. FUZZY PI CONTROLLER

Fuzzy logic controllers (FLC's) have the following advantages over the conventional controllers: they are cheaper to develop, they cover a wider range of operating conditions, and they are more readily customizable in natural language terms. A self-organizing fuzzy controller can automatically refine an initial approximate set of fuzzy rules. Application of PI-type fuzzy controller increases the quality factor. In this paper, the voltage raising type-pulse controller is considered. Two types of fuzzy controllers used for the control of boost converter are investigated; the simulation results confirm the above mentioned advantages.

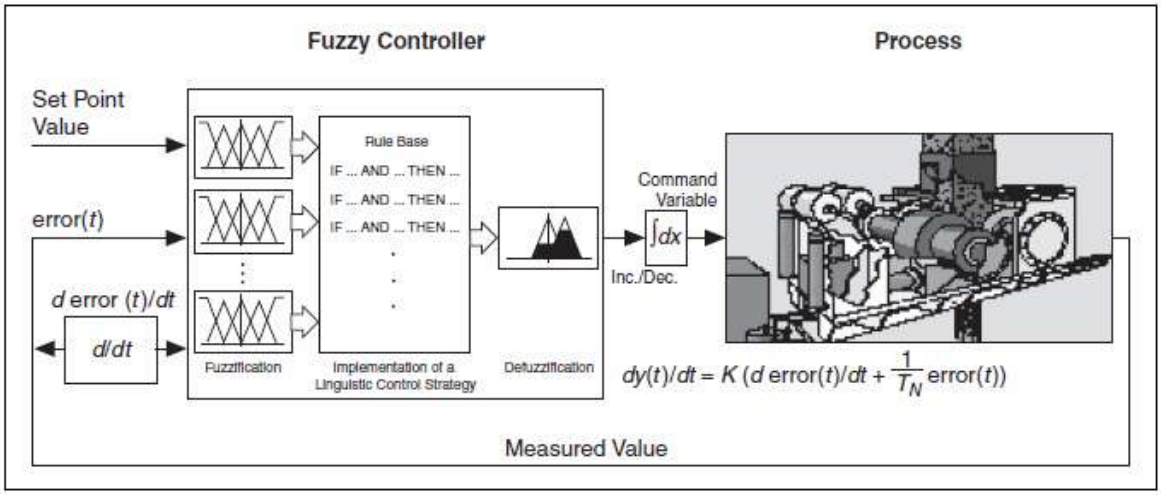

Fig. 2: Fuzzy PI Controller

The fuzzy-PI controller shown in the following image uses the error signal e(t) and its derivative de(t)/dt from the measured data pre-processing step as inputs. If the output signal describes the necessary difference toward the current output value, you need a subsequent integrator device to build up the command variable value.

IV. ADVANTAGES OF FUZZY PI CONTROLLERS

The benefit of the fuzzy-PI controller is that it does not have a special operating point. The rules evaluate the difference between the measured value and the set value, which is the error signal. The rules also evaluate the tendency of the error signal to determine whether to increase or decrease the control variable. The absolute value of the command variable has no influence.
Another advantage of a fuzzy-PI controller over a conventional PI controller is that it can implement nonlinear control strategies and that it uses linguistic rules. With fuzzy-PI controllers, you can consider the error tendency by itself when the error becomes small.

V. CONCLUSION

The advantages of Fuzzy PI controllers have been studied in this paper. The basic block diagrams for the PI and Fuzzy PI controllers have been depicted. The efficient performance of the fuzzy PI controllers make them superior over conventional PI controllers and are applicable to most of the application nowadays.

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