NEW CONTROL TECHNIQUES FOR HYBRID REGULATOR

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Abstract: The goal of this work is to study the performances of a hybrid controller used to control DC Motor drives. This study is made using computer simulation (MATLAB). In the first part, the basic notions of conventional and fuzzy controller will be presented. The second part is devoted to the control system of the DC Motors. The third part is the design of the hybrid controller. The last parts are devoted to the new control technique for hybrid controllers and to analyze the results of simulation**.**

Keywords: DC Motor, Control System, PI, Fuzzy, Hybrid Controller.

I. INTRODUCTION

The PID conventional regulator is the most frequently control element in the industrial world. If we can get a good model of the process, given by analytic linear equations, direct techniques of control are the simplest and less cost alternatives. The classical PID controller will provide an accurate and efficient solution to lineal control problems.

But, if the process is too complex to achieve a good physical description (time variant, with delays and non-linearity's and, very often, with a poorly-defined dynamics), control strategies (fuzzy logic) have been favored since they are based on the process operator's experience and do not need accurate models.

Each one of these strategies does not exclude the other; they can work together in order to achieve more robust controllers [1].

II. CONTROL SYSTEM FOR DC MOTORS

The control system for DC Motors is based of a cascade structure with two loop controllers. The external loop is the speed control loop. The internal loop is the current control loop. This loop is affected by the most important disturbances and, for this reason, the controller mast have a very speed response time.

A very good choice for DC Motor Drives combine the two control methods for obtains a hybrid current controller who can to be associated with a classical or a fuzzy controller in function of the lineal or the non-lineal controlled process. If the error e between the prescribe and the measured value are smaller that the threshold value e_{th} we use the classical PI (can be a PID) numeric controller, but if the error e between the prescribe and the measured value are bigger that the threshold value e_{th} we use the fuzzy controller (fig.1.) [2].

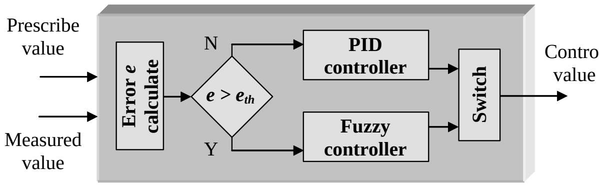

Fig.1. Current Hybrid Controller.

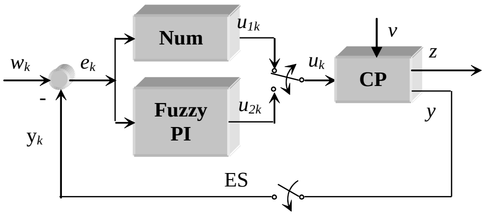

Fig.2. Control System with Hybrid Structure.

III. DESIGN THE HYBRID CONTROLLERS

The control system performance enhancement can be ensured by modifying the controller structure based on using a numeric controller and a PI fuzzy controller in parallel connection, with alternative action on the controlled plant (fig. 2):

- the numeric controller (1) – actuates the controlled plant only in the situations when the absolute value of control error is small ($e_k \le e_{th}$);
- the PI-Fuzzy controller (2) – actuates the controlled plant only in the situations when the absolute value of control error is big ($e_k > e_{th}$) [4].

By considering, for instance, that the hybrid controller consists of a numeric controller and a PI fuzzy controller, the control signal is expressed as:

$$u_k = \begin{cases} u_{1k}, & if\ |e_k| \in [0, \alpha_1 \cdot e_M) \\ u_{1k} + C_1(e_k - \alpha_1 \cdot e_M), & if\ |e_k| \in [0, \alpha_1 \cdot e_M) \\ u_{2k}, & if\ |e_k| \in [\alpha_2 \cdot e_M, e_M) \end{cases} \qquad (1)$$

The parameters $0 < \alpha_1 < \alpha_2 < 1$ and $C_1 > 0$ are chosen by the designer on the basis of his „experience”. The relations (2) ensure a bumpless transfer from one controller to another [3].

The transfer from one controller to another controller must ensure a bumpless control:

$$u_{2k} = u_{1k} = u_k \qquad (2)$$

To switch the control to the controller (2), the new computed value must be [6]:

$$x_{2,k-1}^{(2)}{}_{nec} = x_{1k}^{(2)}{}_{nec} \qquad (3)$$

IV. CONTROL METHODS FOR HYBRID CONTROLLERS

At time *k*, the error *e* is bigger that e_{th}. The value of u_{1k+i} and u_{2k+i} have been computed and the control is translated to the fuzzy controller when:

$$u_{1k+i} - u_{2k+i} = (0{,}1 - 0{,}15) \cdot u_{1k+i} \tag{4}$$

The new proposal control algorithms (fig. 3 and 4.) allows to calculating the values at:

	First control algorithm	Second control algorithm	Third control algorithm
time $k+1$	$u_{1k+1c} = u_{1k+1} - \frac{1}{2}\Delta u_k$ $\Delta u_k = u_{1k} - u_{2k}$	$u_{1k+1c} = u_{1k+1} - \frac{1}{2}\Delta u_k$ $\Delta u_k = u_{1k} - u_{2k}$	$u_{1k+1c} = u_{1k+1} - \frac{1}{2}\Delta u_{k+1}$ $\Delta u_{k+1} = u_{1k+1} - u_{2k+1}$
time $k+2$	$u_{1k+2c} = u_{1k+1c} - \frac{1}{2}\Delta u_{k+1}$ $\Delta u_{k+1} = u_{1k+1c} - u_{2k+1}$	$u_{1k+2c} = u_{1k+2} - \frac{3}{4}\Delta u_{k+1}$ $\Delta u_{k+1} = u_{1k+1} - u_{2k+1}$	$u_{1k+2c} = u_{1k+2} - \frac{3}{4}\Delta u_{k+2}$ $\Delta u_{k+2} = u_{1k+2} - u_{2k+2}$
time $k+3$	$u_{1k+3c} = u_{1k+2c} - \frac{1}{2}\Delta u_{k+2}$ $\Delta u2 = u_{1k+2c} - u_{2k+2}$	$u_{1k+3c} = u_{1k+3} - 0{,}85\Delta u_{k+2}$ $\Delta u_{k+2} = u_{1k+2} - u_{2k+2}$ or: $u_{1k+3c} = u_{2k+3}$ if: $\Delta u_{k+2} \le (0{,}1 - 0{,}15) \cdot u_{2k+2}$	$u_{1k+3c} = u_{1k+3} - 0{,}85\Delta u_{k+3}$ $\Delta u_{k+3} = u_{1k+3} - u_{2k+3}$ or: $u_{1k+3c} = u_{2k+3}$ if: $\Delta u_{k+3} \le (0{,}1 - 0{,}15) \cdot u_{2k+3}$
time $k+r$	$u_{1k+rc} = u_{2k+r}$ if: $\Delta u_{k+r-1} \le (0{,}1 - 0{,}15) \cdot u_{2k+r-1}$ $\Delta u_{k+r} = u_{1k+rc} - u_{2k+r} < 0$	-	-

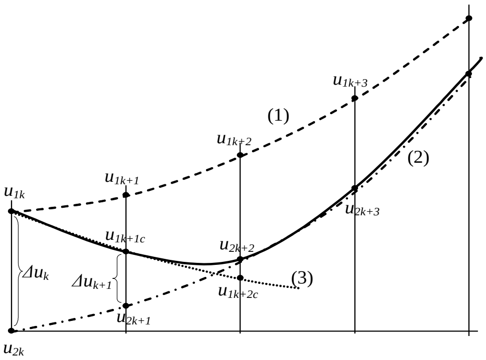

Fig.3.The first proposal control algorithm.

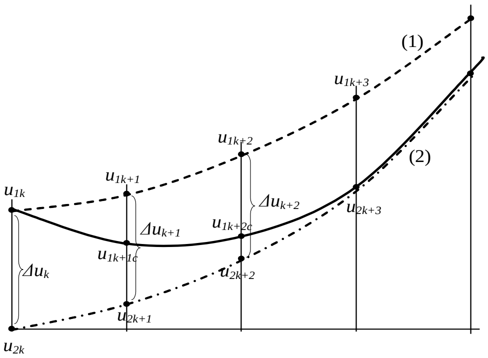

Fig.4.The second and the third proposal control algorithm.

The last algorithm has de advantage that we can get the translation in 2, maxim 3, steps and the transfer is more bumpless.

V. SIMULATION

The Motor used for test is a SMU750 DC Servomotor with characteristics present in [5]. The characteristics of the controllers are shown in [6]. The simulation has a length of 600ms. After 300ms appears a load disturbance. The block diagram of the simulation circuit is present in fig. 6. The simulation result, namely the motor current (*Ia*) and the motor speed (*w*), are present in fig. 5 and fig. 6.

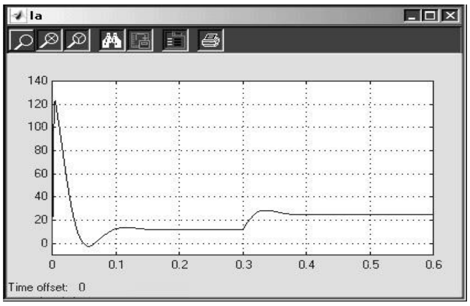

Fig.5. Current Step Response versus Time.

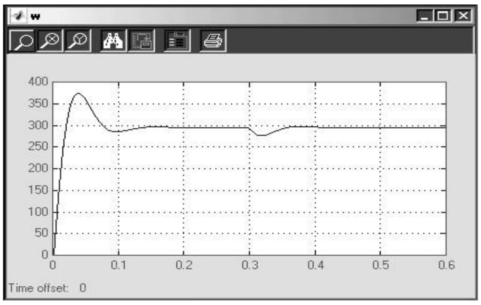

Fig.6. Speed Step Response versus Time.

VI. CONCLUSIONS

The motor reaches the steady state speed in 124ms corresponding to the execution of about 40 fuzzy logic loops. The starting current is 112A (nominal current is 12A for SMU 750). The overshoot of the motor speed is highest 23%. Upon the load variations, the motor recovered the targeted speed in 48,6ms without any speed overshoot. The speed variation due the load variations is highest 7,5%. That's means that a non linear system with a fast change of parameters, like DC Motor drive, can be well controlled by PID which is supervised by a fuzzy system.

VII. REFERENCES

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