DIRECT CURRENT MOTOR CONTROL BASED ON FUZZY LOGIC

Cubilot Martínez, Marta, Álvarez Ruiz de Ojeda, Jacobo

Departamento de Tecnología Electrónica

Universidad de Vigo

Apartado oficial

36200-VIGO (SPAIN)

Tel: 34-86-812143Fax: 34-86-469547

E_mail: jalvarez@uvigo.es

1.- Objectives.

The main objective is to control direct current motor velocity, making use of fuzzy logic advantages.

This control must fix motor velocity to desired value within a velocities range established "a priori". The fuzzy controller must assure that this velocity remain constant through load changes. It must be possible to change desired velocity with the motor performing, too.

Furthermore the obtained results are confronted with the traditional PID control results.

2.- Specifications.

For this study a standard off the self fuzzy processor from American Neuralogix was employed.

The motor has the following characteristics: 0,6 Kw, 220 V, 2A and 1500 rpm (maximum). The input voltage ranges from 0 and 220 volts and the maximum load current is 3 A.

Taking the reference velocity as an input, the controller drives the motor so this velocity is maintained.

3.- Development.

Different solutions were checked to find the best suited one. The first approach took reference (needed) velocity and current velocity as inputs to the controller. The fuzzy controller compared both inputs making use of fuzzy rules and it decided the action value (input voltage to the motor). This solution did not perform good because the action over motor was sudden and it produced instability.

In the final approach, instead of giving the reference velocity value, the inputs of the controller are the "error" or diference between the reference velocity and current velocity of the motor, and the "sign" which indicates what velocity is greater.

The motor velocity depends directly on the input voltage, so an acumulative output of the controller is chosen, that is, the new value will be the sum of last value and the fuzzy rule value. In this way, changes in the output of the controller, this is the input of the motor, are smaller so the motor running is smoother.

Besides, a simplest control program is possible for the motor control. The fuzzy rules must change the input voltage to the motor only when the current velocity does not match the reference velocity. So, the first rule will be:

If error is zero then action is zero.

If the velocities do not match then, when the current velocity exceeds the reference velocity, the input voltage to the motor must be decreased. So, the second rule will be:

If error is not zero and sign is positive then action is -value.

At last, if the reference velocity exceeds the current velocity, then the input voltage must be increased. So, the third rule will be:

If error is not zero and sign is negative then action is +value.

The exact value of the term "value" in the fuzzy rules must be chosen according to the motor characteristics.

This simple rules are not enough to control the motor in an appropriate way. This is because the motors are slow systems that not respond inmediately to the changes in the input voltages. That is the reason why we had to add a synchronization system that considers the motor delay to apply the next control values. So the new values are not applied until the motor velocity is stable.

This control program is valid with some modifications and it manifests the fuzzy logic powerness in system control.

4.- Results. Comparation with traditional control.

System behaviour was tested with load changes and constant reference velocity (this velocity was given by a potentiometer). The load changes were obtained by another asynchronous motor joint to the motor in study. This asynchronous motor is fixed to the same axis that d.c. motor, and it turns in the opposite direction that the d.c. motor when a load is needed.

The results were very satisfactory. The system maintained the reference velocity without oscillations through load changes. The reference velocity was reached in one second as a maximum. The motor replies properly to positive loads steps, that is, if the load is increased suddenly, oscillation does not appear. In the same way, the motor replies without oscillation when the motor load is shut off suddenly.

The motor was also tested with constant load and reference velocity changes. The results were very satisfactory too. The current motor velocity followed the changes in the reference velocity, with a maximum error of half revolution per minute.

Another important result is that oscillation does not appear on the velocity in permanent running. The fuzzy controller allows a difference between the reference velocity and the current velocity, but we have proved that the difference remains constant while working conditions do not change.

The main advantage compared with the traditional PID control, is that oscillations are reduced when positive or negative steps are applied. Besides, the oscillations disappear once reached the permanent running.

Therefore, the fuzzy controller design is simpler and more intuitive than the PID controller design, because PID controllers are based in mathematical equations and system models, and fuzzy controllers are based in the human experience of the system.