Application of Soft Computing Techniques in Process Control System

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ABSTRACT: The objective of this paper is to demonstrate a controller for seed control for an electric drive system by using various "Evolutionary Techniques" based PID Controller. The model of an electric drive is reflected as a second order arrangement for speed control. Here, there is an assessment between various optimization techniques of tuning the parameters for PID controller.

Introduction

A typical conventional electric drive system for variable speed application employing multi machine system is shown in Fig. 1. The system is obviously bulky, expensive, and inflexible and requires regular maintenance. In the past, induction and synchronous machines were used for constant speed applications – this was mainly because of the unavailability of variable frequency supply.Electric Drives are employed for arrangements that involve motion mechanism like machine tools, transportation system, robots, pumps, fans, etc.

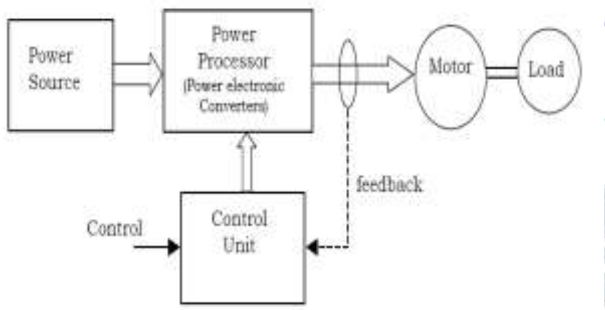

Fig. 1 Electric drive system

PID is the utmost communal and most widespread feedback controller used in Industrial Process control system now a days. A PID controller calculates an "error" value as the difference between a measured process variable and a desired 'set-point'. PID controller is also termed as cumulative effect of three term control: the proportional (P), integral (I) and derivative (D).

If the loop is critical, then this test could be hazardous. Indeed if the process is open-loop unstable, then we will be in trouble before we begin. Notwithstanding for many process control applications, open loop type experiments are usually quick to perform, and deliver informative results. If the system is steady at set point, and remains so, then we have no information about how the process behaves. There are various tuning strategies based on an open-loop step response. While they all follow the same basic idea, they differ in slightly in how they extract the model parameters from the recorded response, and also differ slightly as to relate appropriate tuning constants to the model parameters. There are four different methods, the classic Ziegler-Nichols open loop test, the Cohen-Coon test, Internal Model Control (IMC) and Approximate M-constrained Integral Gain Optimization (AMIGO). Naturally if the response is not sigmoidal or 'S' shaped and exhibits overshoot, or an integrator, then this tuning method is not applicable.

Modelling of separately excited dc motor

The dc motor is the observable ascertaining ground for advanced control algorithms in electric drives due to the stable and straight forward characteristics associated with it.

The armature voltage equation is given by:

$$V_a = E_b + I_a R_a + L_a (dI_a/dt) \quad (1.1)$$

For normal operation, the developed torque must be equal to the load torque plus the friction and inertia, i.e.:

$$T_m = J_m d\omega/dt + B_m \omega + T_L \quad (1.2)$$

Where: TL is load torque in Nm.

Friction in rotor of motor is very small (can be neglected), so $B_m=0$

Therefore, new torque balance equation will be given by:

$$T_m = J_m d\omega/dt + T_L \quad (1.2a)$$

Taking field flux as Φ and Back EMF Constant as K. Equation for back emf of motor will be:

$$E_b = K\,\Phi\,\omega \quad (2)$$

$$T_m = K\,\Phi\,I_a \quad (3)$$

Taking laplace transform of the motor's armature voltage equation we get

$$I_a(S) = (V_a - E_b)/(R_a + L_a S) \quad (4)$$

Put E_b in equation (4) now equation become

$$I_a(S) = (V_a - K\,\Phi\,\omega)/(R_a + L_a S) \quad (5)$$

$$\omega(s) = (T_m - T_L)/JS = (K\Phi I_a - T_L)/J_m S$$

(Armature Time Constant) $T_a = L_a/R_a$ (6)

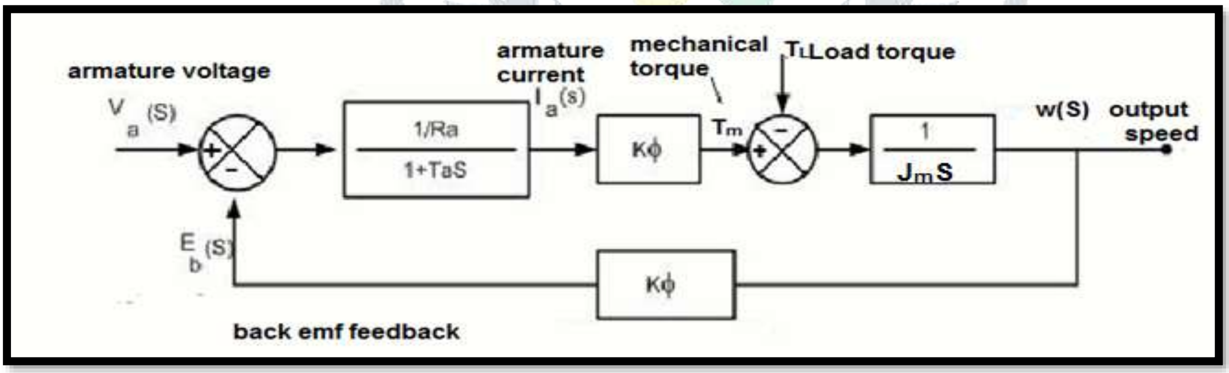

Fig. 2: Block Model of Separately Excited DC Motor

After abridging the above motor model, the overall transfer function will be

$$\omega(s)/V_a(s) = [K\Phi/R_a]/J_m S(1+T_a S)/[1 + (K^2\Phi^2/R_a)/J_m S(1+T_a S)] \quad (7)$$

Review of existing literature

In 2011, Chun-Fei Hsu [9] described an adaptive PID (APID) controller which was composed of a PID controller and a fuzzy compensator which was applied to a DC motor driver and implemented on a field-programmable gate array chip and high-performance industrial applications. In the paper [1], author declared a drive system with resonant loads are carried out to control the speed of dc motor which were conventional proportional-integral (PI) control, PI-based state space control, and model-based predictive control. In paper [valenti 2012] the author continued the design considerations of a novel type of passive filter which was aimed at significant reduction in high-frequency differential mode (DM) and common mode (CM) currents in speed-controlled ac drives. The behavior of HLCF was analyzed in frequency domain in which comparison of the measured, simulated, and calculated results infrequency domain was presented. In the paper [2013], a model of predictive controller for the position control of an electrical drive with an elastic connection was offered. The control methodology enabled the drive's safety. The paper [2014] presented the design and digital implementation of a fuzzy controller to achieve improved performance of servomotor drive in which performance of fuzzy and PID controller-based servomotor drives was inspected under different operating conditions such as change in reference speed, parameter variations, load disturbance, etc. Conventional controllers like P, PI, and PID were being used with servomotor drive control systems to accomplish reasonable transient and steady-state responses.

Conclusion of the study:

Above literature survey has initiated the basic idea for the present work. It has been observed that one of the major challenges in speed control of dc motor is to reduce rise time as well as peak overshoot**.**

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