POSITION CONTROL OF SERVODRIVE USING BLDC-MOTOR

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ABSTRACT

The aim of this investigation is to describe the topic of brushless direct-current (BLDC) motor. Designing and calculation the static and dynamical state of the BLDC-Motor, proposal analyses regulators open loops with-without feed-back, examples for some types of the regulators (P, PD) with some ideas and theoretical part, with simulations performing the function of these regulators in MATLAB-SIMULINK to decide which one of these regulators are suitable, available and reliability with BLDC-Motor and there application in cutting tool machine in general.

1. INTRODUCTION

Brushless direct-current motors (BLDCs) are so named because they have a straight-line speed-torque curve like their mechanically commutated counterparts, permanent-magnet direct-current (PMDC) motors. In PMDC motors, the magnets are stationary and the current-carrying coils rotate. Current direction is changed through the mechanical commutation process. A brushless dc motor has a rotor with permanent magnets and a stator with windings (the magnets rotate and the current-carrying coils are stationary). It is essentially a dc motor turned inside out. The brushes and commutator have been eliminated and the windings are connected to the control electronics. The control electronics replace the function of the commutator and energize the proper winding. The energized stator winding leads the rotor magnet, and switches just as the rotor aligns with the stator [1].

BLDC motor control requires knowledge of the rotor position and mechanism to commutate the motor. To sense the rotor position BLDC motors use Hall Effect sensors to provide absolute position sensing. This results in more wires and higher cost. BLDC motors can be designed into systems that are sensor-based or sensorless. Sensorless BLDC control eliminates the need for Hall effect sensors, using the back-EMF (electromotive force) of the motor instead to estimate the rotor position. Sensorless control is essential for low-cost variable speed applications such as fans and pumps [2].

The Brushless DC (BLDC) motors are popular widely used in industrial applications such as machine tool drives, computer peripherals, robotics and electric propulsion. BLDC motors have many advantages. Much of them due to the BLDC motors reduced maintenance (no brushes), better speed versus torque characteristics, high dynamic response, exhibit a long operating life, noiseless operation, higher speed ranges, their compact size, controllability, high torque to volume ratio, high efficiency and low moment of inertia.

2. DESIGNING FEEDBACK CONTROLLERS FOR MOTOR DRIVES

2.1. CASCADED CONTROL

Feedback is both a mechanical, process and a signal mediated response that is looped back to control the system within itself. This loop is called the feedback loop. A control system usually has input and output to the system, when the output of the system is fed back into the system as part of its input, it is called the "feedback."

Cascade control is used to enable a process having multiple lags to be controlled with the fastest possible response to process disturbances including set point changes. Cascade control is widely used within the industrial processes. Conventional cascade schemes have two distinct features with two nested feedback control loops, there is a secondary control loop located inside a primary control loop. The primary loop controller is used to calculate the setpoint for the inner (secondary) control loop. The inner loop (secondary, slave loop) in a cascade-control strategy should be tuned before the outer look (pimary, master loop). After the inner loop is tuned and closed, the outer loop should be tuned using knowledge of the dynamics of the inner loop. The most common use of cascaded control structure is: Inner current closed loop followed by speed loop and outermost position loop superimposed on the speed loop. The block diagrams of close-loop position control system with P and PD controllers with-without subsidiary speed loop are shown in Fig. 1.and Fig. 2.

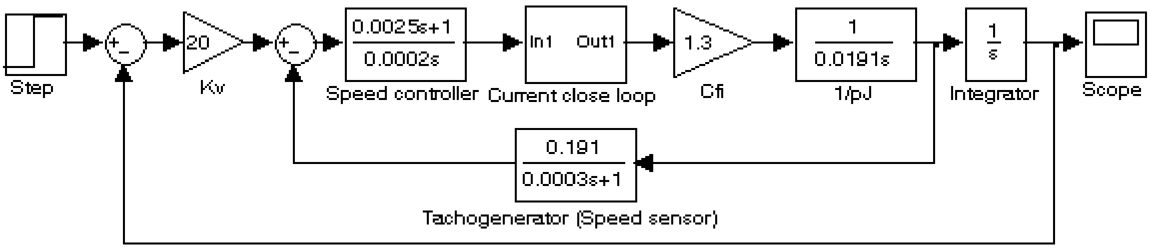


Fig. 1: Block Diagram of P-controller with the subsidiary speed loop.

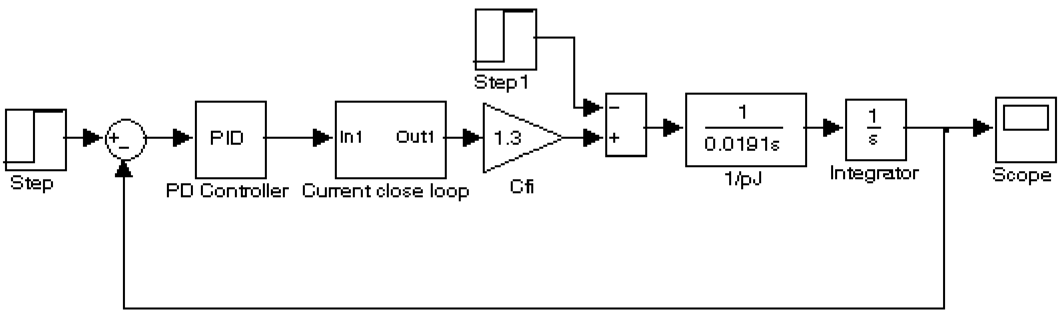


Fig. 2: Block Diagram of PD-controller without the subsidiary speed loop.

3. COMPARISON OF THE P-CONTROLLER WITH PD-CONTROLLER

3.1. PROPORTIONAL CONTROL

Proportional control is denoted by the P-termin the PID controller. It used when the controller action is to be proportional to the size of the process error signal $e(t) = r(t) - y_m(t)$. The time and Laplace domain representations for proportional control are given as [3]:

Time domain
$$u_C(t) = k_v e(t) \quad (1)$$

Laplace Domain
$$U_C(s) = k_v E(s) \quad (2)$$

where the proportional gain is denoted k_v. Fig. 3: shows the block diagrams for proportional control.

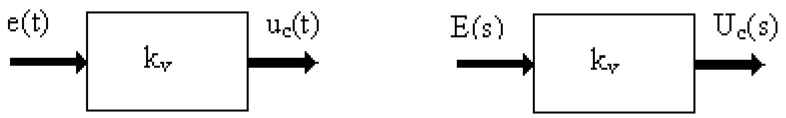


Fig. 3: Block diagrams: proportional control term.

3.2. PROPORTIONAL AND DERIVATIVE CONTROL

A property of derivative control that should be noted arises when the controller input error signal becomes constant but not necessarily zero, as might occur in steady state process conditions. In these circumstances, the derivative of the constant error signal is zero and the derivative controller produces no control signal. Consequently, the controller is taking no action and is unable to correct for steady state offsets, for example.

To avoid the controller settling into a somnambulant state, the derivative control term is always used in combination with a proportional term. This combination is called proportional and derivative, or PD, control. The formulae for simple PD controllers are given as [3]:

Time domain
$$u_C(t) = k_v e(t) + k_D \frac{de}{dt} \quad (1)$$

Laplace Domain
$$U_C(s) = [k_v + k_D s]E(s) \quad (2)$$

where the proportional gain is k_v and the derivative gain is k_D. The block diagrams of P-controller and PD- controller with-without the subsidiary speed loop is given in Fig. 4:

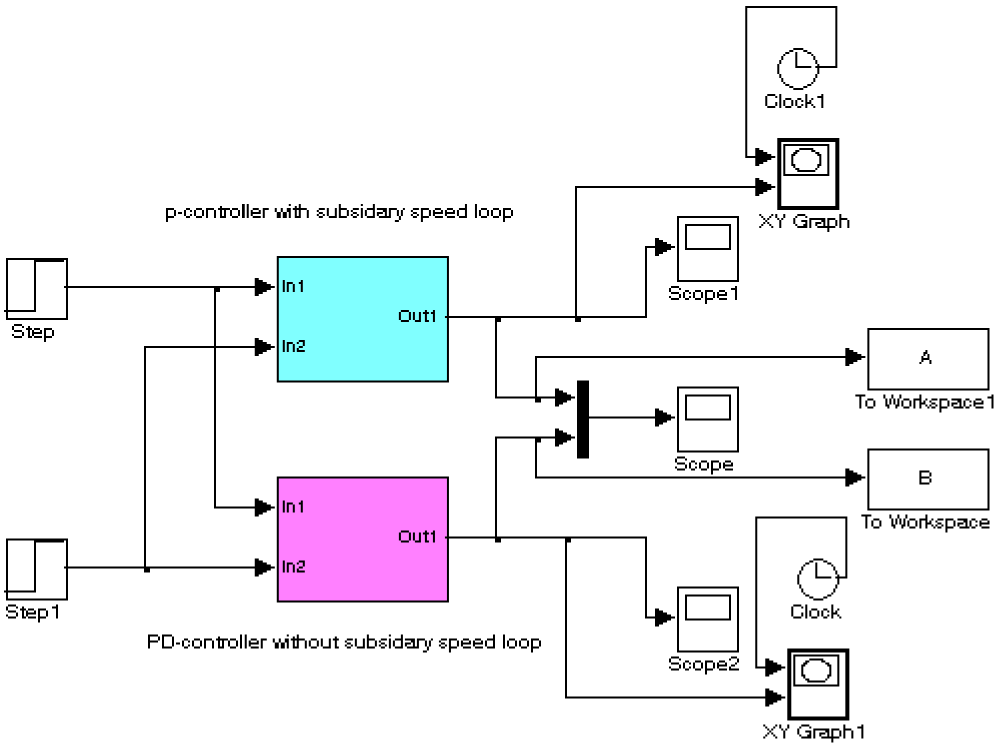
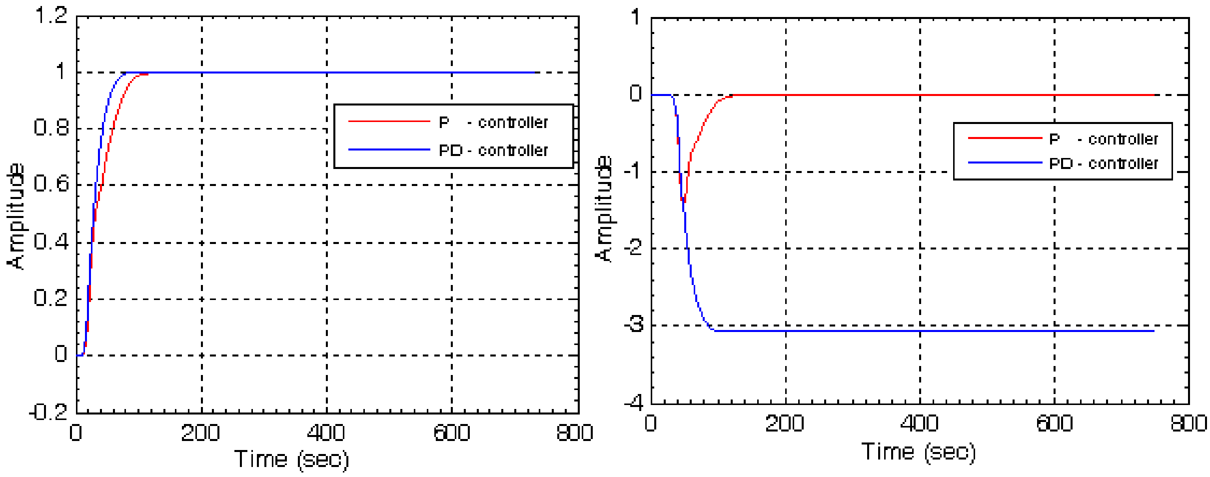


Fig. 4: Block Diagram of P-controller and PD- controller with-without the subsidiary speed loop.



a) b)

Fig. 5: a) Step response of P and PD controllers with-without subsidiary speed loop b) step disturbance response of P and PD controllers with-without subsidiary speed loop.

4. SIMULATION OF THE CIRCLE ROUNDS OF THE TWO REGULATORS IN MATLAB-SIMULINK

To simulate the circle rounds we have two drives. The first one is moving in the X axis and it has a sine signal, the second one is in the Y axis and has cosine signal. If these two drives have the same gain values, then they would have a circular movment or else elliptical. And the two drives should be the same in the same axis X and Y respectively. Block diagram of two drives with P- controller in conjuncion with the subsidiary speed loop is shown in Fig.6:.

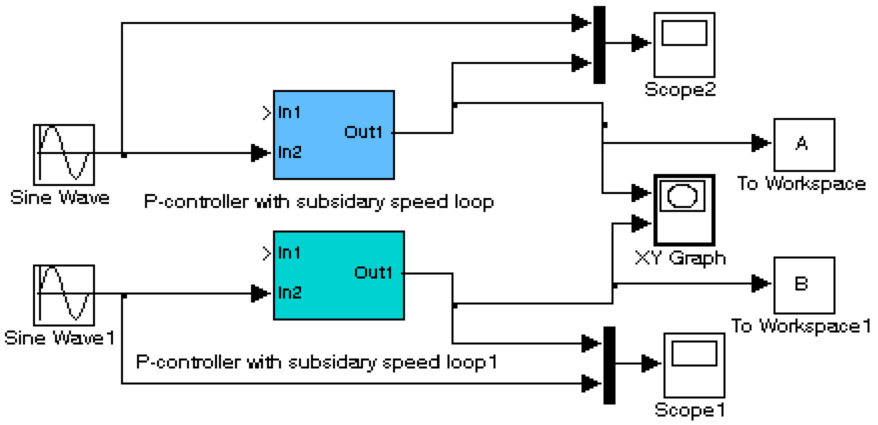
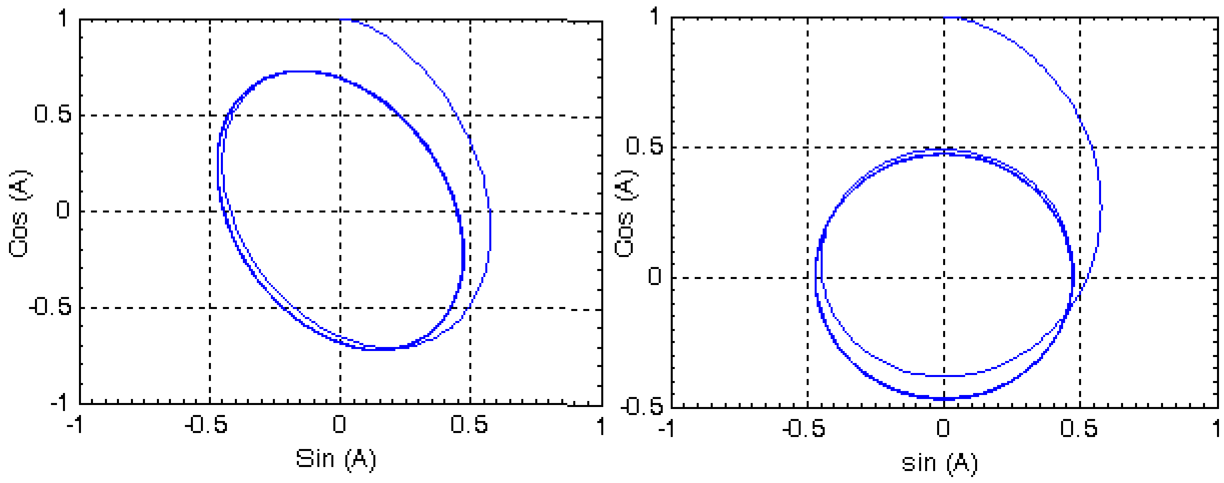


Fig.6: Block diagram of the circle rounds for p-controller with subsidiary speed loop



a) b)

Fig. 7: a) Circle rounds of P controller with different gain values (freq. Sin = 100 rad/s)
b) Circle rounds of P controller with the same gain values (freq. Sin = 100 rad/s)

5. CONCLUSION

The simulation of two drives with the same frequency of 100 rad/s has been configured and initialized in MATLAB-SIMULINK. If these two drives have the same values of the gain Kv so they would have a circular movment, or else elliptical. The increasing or decreasing of the frequency of sine and cosine signal has a profound effect on the radius of the circle, thus the decreasing frequency consequently results in the increasing of the radius circle, because of the frequency bandwidth of the drive. Comparsion (shown in (Fig. 5:)) of P-controller and PD-controller with-without subsidiary speed loop shows that P-controller has a zero error ($y_\infty = w_\infty$) in a steady state, but PD-controller has non-zero error.

REFERENCES

[1] Duane, D., Douglas, W.: Electronically Commutated Motors 2001.

[2] Information on URL: http://robotika.cz/wiki/BldcMotor.

[3] Michael A., Mohammad, H.: PID Control, New Identification and Design Methods 2006.