KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
Electrical Engineering Department

EE 380 - Control Engineering **Experiment # 4**

Servo Motor Speed Control Using a Proportional Controller

OBJECTIVES:

A velocity servo (speed control system) is studied with reference to the effect of loading the output shaft with and without the loop closed. When you have completed the experiment you will know that:

- Velocity feedback can be used to enable the speed of the motor to be regulated.
- The polarity of the feedback is important.
- The effectiveness of the control depends mainly on the gain employed.

APPARATUS:

1. Analogue Unit 33-110
2. Mechanical Unit 33-100
3. Power Supply +/-l 5V dc, 1 .5A, +5V dc, 0.5A

Introduction

An important aspect of closed-loop control is speed control, which has many industrial applications, varying from heavy industrial, such as paper mills or steel rolling mills, to tape or video transport mechanisms.
The block diagram of the closed-loop speed control is shown in Fig. 1. The feedback signal is the output velocity signal v_s, normally from a tachometer, which is compared with a reference voltage v_r to give an error $v_e = v_r - v_s$.

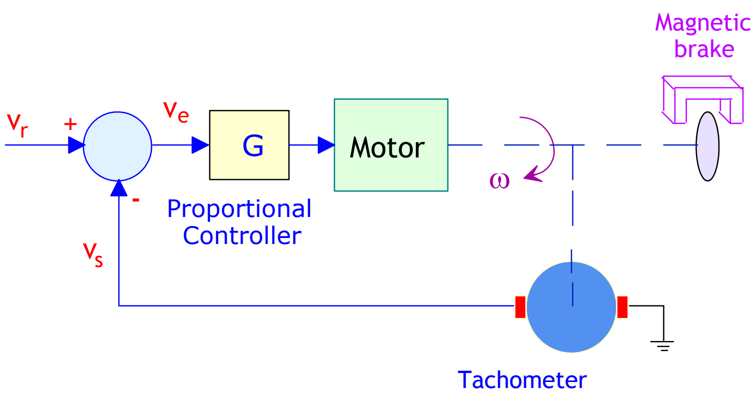

Fig. 1 Closed loop speed control system

In operation the reference is set to a required value, which drives the motor to generate V_s , which reduces the error until the system reaches a steady speed. If the motor is loaded, e.g. with the magnetic brake on the 33-100, the speed falls; this tends to increase the error, increasing the motor drive and thus reducing the speed fall for a given load. Note that this implies negative feedback around the loop. The speed fall with load is a very important characteristic in speed control systems. The rotation direction can be reversed by reversing the reference voltage, though many industrial speed control systems are required to operate in one direction only.

Procedure

Part I: Open-loop Speed Load Test

1) The Analogue Unit and Mechanical Unit should be connected together by the 34-way ribbon cable. The power supply should be connected by 4mm plug leads to the +15V, +5V, OV and -15V sockets at the back of the Mechanical Unit.
2) The connection diagram as in Fig. 2 represents a speed control system which can be made with the 33-002. Set P_2 (tachometer) to zero and set the amplifier feedback resistor to $100\,K\Omega$, this gives the gain (G = 1). Set P_1 to 100. Set SWI up to +10 and adjust P_3 to run the motor at 1000 r/min (31.25 r/min at ou

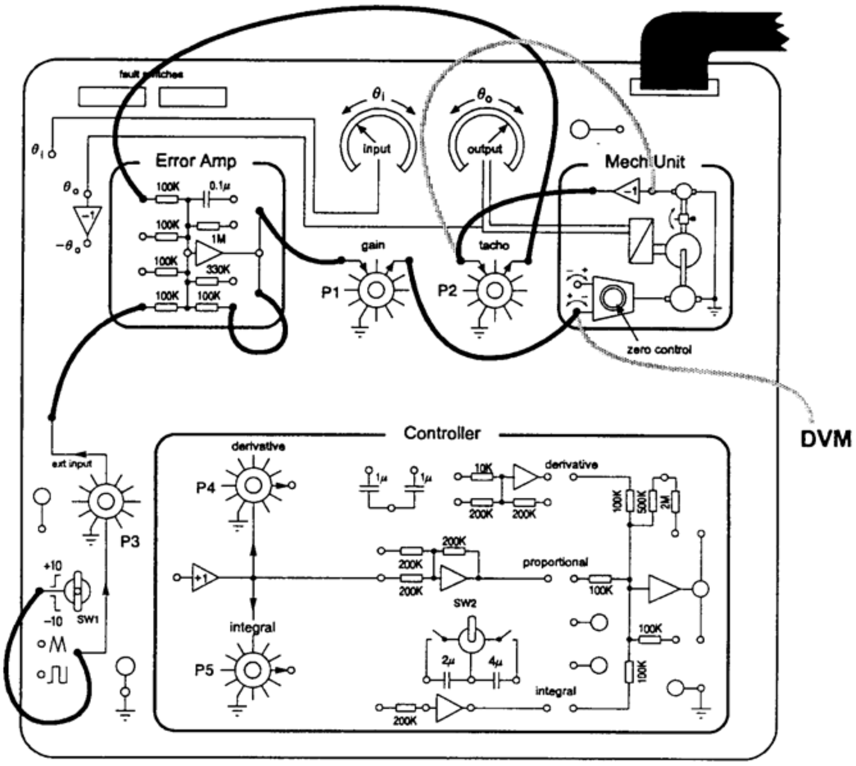

Fig. 2 Connection diagram for speed control system

3) Keep P_2 to zero and plot the speed against brake setting to full brake load.
4) Plot the armature current against brake setting to full brake load. Note that the armature current which increases with loading can be measured by connecting the DVM to the armature current socket on the mechanical unit.

Part 2: Closed-loop Speed Load Test

1) Turn up P_2 slightly, if the speed decreases the loop feedback is negative as required. If the speed increases use the other tachometer polarity. Note that if the system has negative feedback and both the tachometer polarity and the power amplifier input are reversed, the system still has negative feedback, but the motor runs in the opposite direction.
2) Set P_2 to 100 and readjust P_3 to give 1000 r/min with the brake off. Replot the speed characteristic and armature current up to full brake load. Note that G=1.
3) Change the feedback resistor to $330\,K\Omega$ (G = 3.3), adjust P_3 to give 1000 r/min with no load, and replot speed the characteristic and armature current up to full brake load.

Discussions:

1) Compare the open loop and closed loop performance for G=1.
2) What is the effect of increasing the gain from G=1 to G=3.3 on the performance of the closed loop system.
3) Use SIMULINK to simulate the behavior of the motor speed control system shown in Fig. 3 for 10 seconds, and for different controller gains (K=1, K=10, K=20, K=50, K=80, and K=100), using a unit-step reference input and no disturbance. (Assume $K_t = 1$ volt/rad/sec)

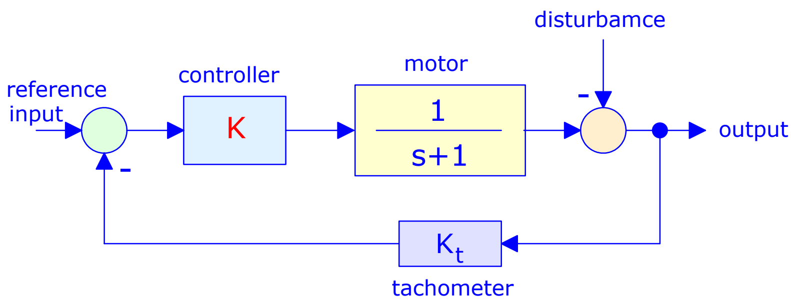

Fig. 3 Block diagram of a speed control system.

a. Explain the effect of increasing the gain on the performance of the system.
b. Plot the steady-state error vs. K.
c. Plot the closed-loop time constant vs. K.
d. What would you recommend as being the best setting for the proportional controller K?
e. Design the controller that will result in a closed-loop time constant of 0.1 sec.
f. Design the controller gain K that will result in a steady-state error of 0.05.
g. Comment on the behavior of the system when a step disturbance is applied after 5 seconds from the start of the simulation (use K=1).