LECTURE 27 – SERVO VALVES

SELF EVALUATION QUESTIONS AND ANSWERS

1 A torque motor is connected in a push-pull circuit. Each coil has a resistance of 30 ohms and is rated at 100 mA.

Find:

a. **The voltage of each coil when the armature is centered.**
b. **The maximum value of ΔI**
c. **The maximum control power for the torque motor.**

2 A torque motor is connected in a parallel circuit. Each coil has a resistance of 30 ohms and is rated at 100 mA.

3 A torque motor is connected in a series circuit. Each coil has a resistance of 30 ohms and is rated at 100 mA.

4: A servo valve is flow rated at 80 LPM at 90 bar differential. It is to be operated in a 150 bar system. What will its adjusted flow rate be at the optimum power transfer Δp?

5 : For the servo valve of previous problem, determine the power loss, heat generation rate, and the temperature rise across the valve. The specific heat of the oil is 1.8 kJ/kg c and specific gravity of oil is .895

6:In the given servo system, suppose the forward loop contains a hydraulic motor. The forward loop gain is 200rpm/V and that the feedback loop consists of a tacho generator that has a gain of 0.1V/rpm. What will be the speed of the hydraulic motor for an input of 4V?

Q1Solution:

a. The maximum voltage for the coil is E = IR

$E = 100\text{ mA} \times 30\Omega = 3V$

The armature is centered when

$E = E_{max}/2 = 1.5\text{ V}$

b. The differential current is $I = I_{AD} - I_{BC}$

The maximum value will occur when the maximum voltage is applied to one coil, so that zero voltage is applied to the other. In this case

$\Delta I = I_{AD} - I_{BC} = E_{max}/R - 0 = 3V / 30\Omega = 100\text{ mA}$

c. The maximum control power is then to each

$P = (\Delta I^2)R = (100\text{ mA})^2(30\ \Omega) = 0.3\text{ W}$

Q2 Solution: the voltage to each coil will remain the same (3 V); however, the current through the circuit will increase because of the lower resistance. For a parallel circuit made up of two equal resistors, the equivalence resistance is R/2; in this case, 15 ohms.

The value of I is the total current, which we find from

$I_P = E/R = 3V/15\Omega = 0.2\text{ A} = 200\text{ mA}$

Control power, $P = (I_P)^2(R/2) = (200\text{ mA})^2(30\Omega/2) = 0.6\text{ W}$

Q3 Solution: here, the total resistance is 2R, or 60 ohms. The maximum current will be 100 mA because of the series connection. The maximum voltage, then, is

$E = IR = (100\text{ mA})(60\ \Omega) = 6\text{ V}$

The control power , $P = (I_s)^2\ (2R) = (100\text{ mA})^2(2)(30\ \Omega) = 0.6\text{ W}$

Q4 Solution: For optimum power transfer, the pressure drop across the valve should be $\frac{130}{3}$ = 50 bar

From equation we have

$$Q = Q_R \sqrt{\frac{\Delta p}{\Delta p_R}} = 80\sqrt{\frac{50}{90}} = 59.63 \text{ LPM}$$

Q5 Solution

The power loss is

HP = $\Delta p \times Q = 50\times10^5\times(59.63/1000)\times(1/60)$

= 4.97 kW

The resultant heat generation rate is found fro equation to be

The increase in the fluid temperature is

$$\Delta T = HGR/CpW$$

The weight flow rate is

$$W(oil\ flow\ rate\ in \frac{kg}{s}) = \gamma Q(\ oil\ flow\ rate\ in \frac{m^3}{s} = 895 \times 59.63 \times \frac{10^{-3}}{60} = 0.889$$

Therefore,

$$\Delta T = HGR/CpW$$

$$\Delta T = \frac{4.97}{1.8 \times 0.889} = 3.104\ °C$$

This is the temperature rise experienced by every drop of oil that flows through the valve. The rise occurs in the time required for the fluid to flow through the portion of the valve where the pressure drop occurs.

Although the weight flow rate appears in the equation, the temperature rise is actually independent of flow rate. So the temperature rise for any fluid is a function of pressure drop only.

Q6 Solution:

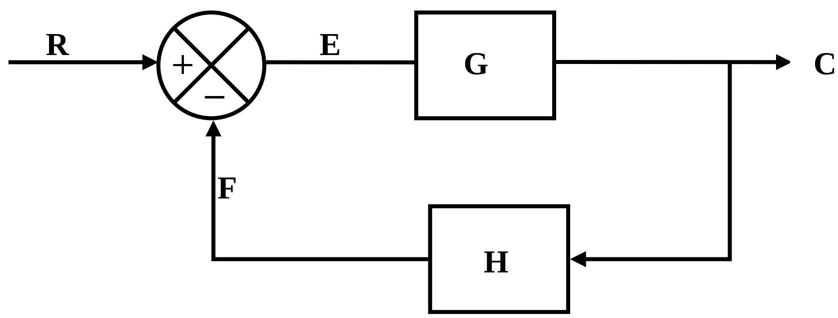

Figure for problem 6

Reference input, R = 3.5V.

Forward loop gain, G = 200 rpm/V

Feedback loop gain, H = 0.1V/rpm

The equation of closed loop transfer is given by,

$$C/R = G/(1 + GH)$$

$$=> C = [G/(1 + GH)].R$$

$$=> C = [200/(1 + 200 \times 0.1)] \times 3.5$$

$$=> C = 38.09\ rpm$$