LUT School of Engineering Science

BK60A0800 Fluid Power

Fluid Power Report

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Contents

1 Introduction

2 Methods

2.0.1 Control Signal

As specified in the requirements, the control signal is described as follows. Change the 4/3-valve spool voltage U from -10 V to 10 V at time t = 5 s and then back to -10 V at t = 10 s.

2.1 Manufacturer's Data Sheet

For the modeling of the 3/4 Directional Control Valve the inital values from the DCP Parker D3FX data sheet are used. The pump has a signal input of ± 10 V

2.1.1 Dead Band (U_{db})

Figure 1 that there is no flow between 0 and 10 % of the command signal. This means that there is a dead band from -1 V to 1 V so U_{db} = 2 V

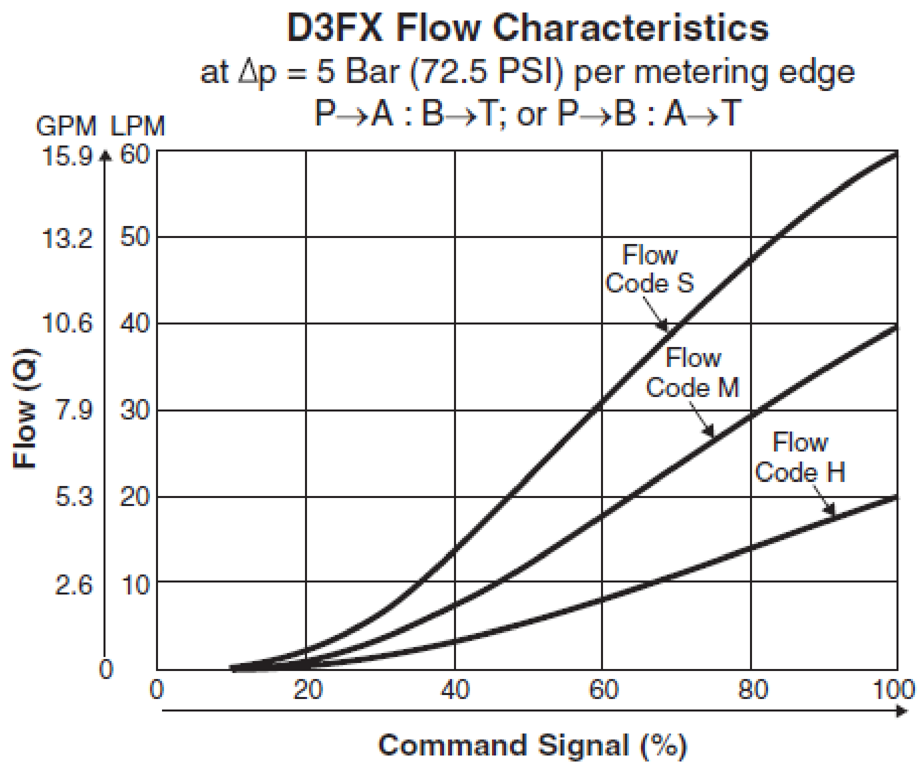

Figure 1: DCV Flow Characteristics

2.1.2 Semi-Empirical Flow Rate Constant (C_v)

Per the data sheet the nominal pressure $Q_{nom} = 20$ l/min when the pressure difference $\Delta p = 10$ bar.

$$C_v = \frac{Q_{nom}}{(U - U_{db}) * \sqrt{\Delta p}} = \frac{20/60000}{(10-2) * \sqrt{10 \times 10^5}} = 4.16 \times 10^{-8} \frac{m^3}{sV\sqrt{Pa}} \tag{1}$$

2.1.3 Time Constant (τ)

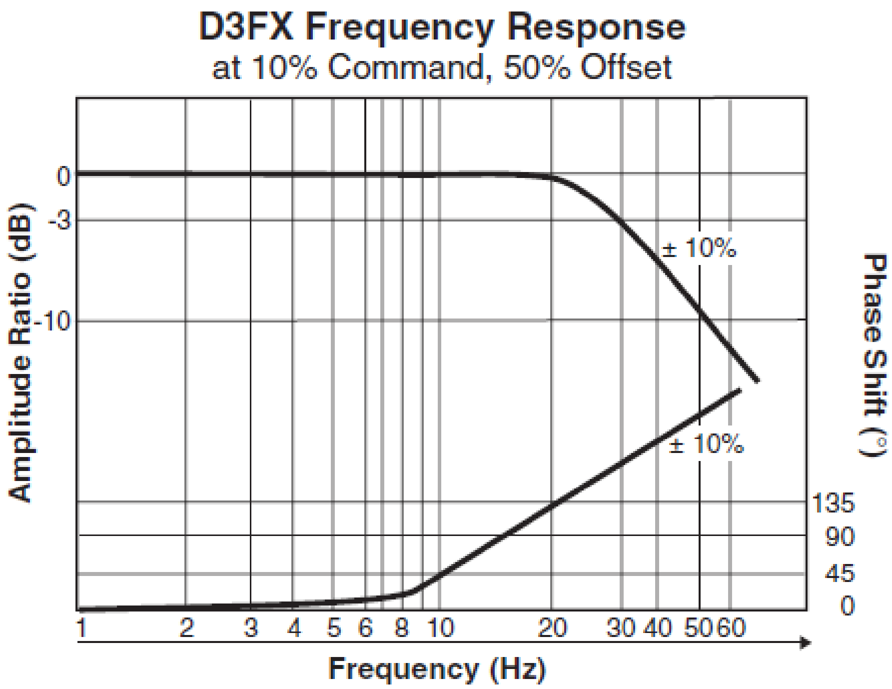

Figure 2: DCV Bode Diagram

From figure 2, the -45 ° phase shift can be calculated:

$$f_{-45^\circ} = 10Hz \tag{2}$$

The time constant can be calculated from the DCV bode diagram shown in figure 2 by substituting the value from equation 2 into equation 3.

$$\tau = \frac{1}{2\pi f_{-45^\circ}} = \frac{1}{2\pi * 10} = 1.59 \times 10^{-2} \tag{3}$$

2.2 Simulation Model

2.3 Model Component Equations

2.3.1 4/3 DCV

The 4/3 Directional Control Valve (DCV) and Double Acting Hydraulic Cylinder were modeled using custom simscape components.

The primary equation governing the DCV is the volume flower rate equation shown by equation 4

$$Q = C_v U * sgn(\Delta p)\sqrt{\frac{2\left|\Delta p\right|}{\rho}} \tag{4}$$

The feedback signal can be modeled using the following first order differential equation:

$$\dot{u} = \frac{u_{in} - u}{\tau_{DCV}} \tag{5}$$

The volume flower rate for each side of the valve is governed by the lumped fluid theory. The continuity equations can be written as in equation 6 and 7.

$$\dot{p_A} = \frac{B_{e_1}}{V_A}(Q_A - Q_{orifice}) \tag{6}$$

$$\dot{p_B} = \frac{B_{e_2}}{V_B}(Q_{orifice} - Q_B) \tag{7}$$

2.3.2 Pump

The pump pressure can be modeled with the following equation is

$$\dot{q_{pump}} = \frac{K_p * (p_{ref} - p_p) - q_{pump}}{\tau_{pump}} \tag{8}$$

The pressure between the pump and DCV can be modeled with the following equation

$$\dot{p_p} = \frac{B_{e_p}}{V_P}(q_{pump} - q_p) \tag{9}$$

2.3.3 One Way Restrictor Valve

Orifice

$$q_{orifice} = sign(p_a - p_b) C_{d_{orifice}} A_{orifice} \sqrt{\frac{2|p_a - p_b|}{\rho}} \tag{10}$$

Check Valve

$$q_{check} = C_{v_{check}} \sqrt{P_1 - P_0 - P_A} \tag{11}$$

2.3.4 Motor

Motor pressure

$$\dot{p_1} = \frac{B_{e_1}}{V_1}(q_B - q_{orifice}) \tag{12}$$

Angular speed

$$\omega = \frac{Q}{V_m}\eta_v \tag{13}$$

$$M_{mreal} = (p_b - p_1) V_m \eta_m \tag{14}$$

$$L = I_m \omega \tag{15}$$

2.3.5 Load

$$F = m_l * g \tag{16}$$

$$\tau_w = (m_w) * g * r_w \tag{17}$$

$$\tau_w = M_{mreal} \tag{18}$$

3 Research

4 Results and Discussion

List of Figures

List of Tables