LAB SESSION 3

Transfer Function Through Block Reduction and Analysis of Feedback on the System Output

Objective:

In the first part of this lab we will learn the commands to find the transfer function of the system by block reduction method and plotting its output against the different inputs. In the second part we will explore the behavior of the dc motor with fixed field and deriving its mathematical expression for the speed as output and the voltage as an input. The effect of the disturbance adding in the plant during operation will be examined and deriving its general expression. In the last unity feedback and proportional controller will be applied to see the effects on the output of the system and results will be plotted.

Equipment Required:

PC and MATLAB® R2017b

Procedure:

Consider the following diagram and reduce it to a single input output relation of $\frac{Y_m(s)}{R(s)}$ by writing a MATLAB program in M-File and explore the sumblk function.

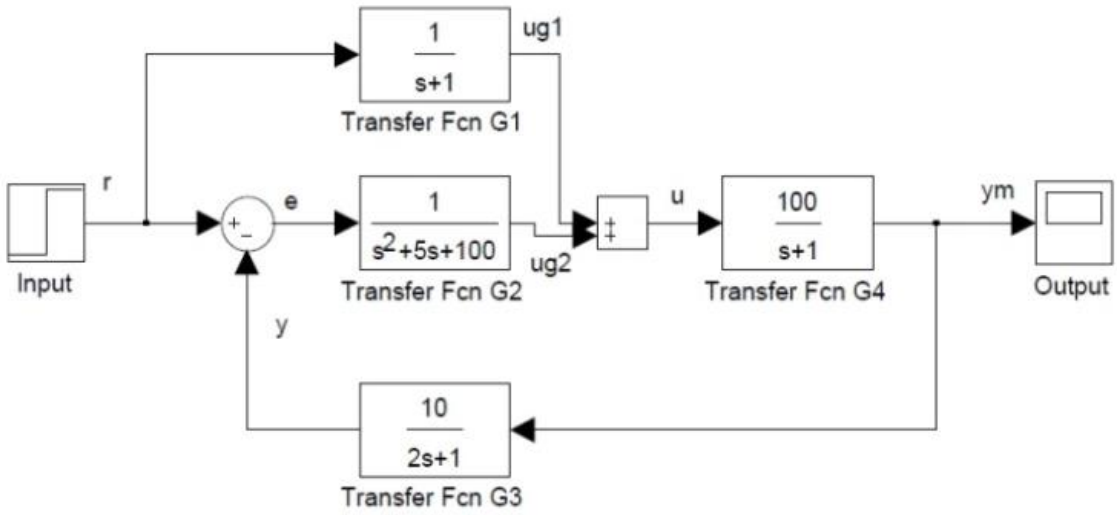

Figure 3.1: A simple feed-back control system

EXERCISE 1:

Explore the **'sumblk'** command in the MATLAB and write down its function.

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EXERCISE 2:

Write the code to find the transfer function $\frac{Y_m(s)}{R(s)}$ for the system given in fig 3.1.

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EXERCISE 3:

Plot the step response of the system shown in the fig 3.1 by using the ***step(sys)*** command. Where $\boldsymbol{sys} = \boldsymbol{tf}(\boldsymbol{num}, \boldsymbol{den})$.

Figure 3.2 Step response of the system

Consider an open-loop speed control of a separately excited DC motor is shown below:

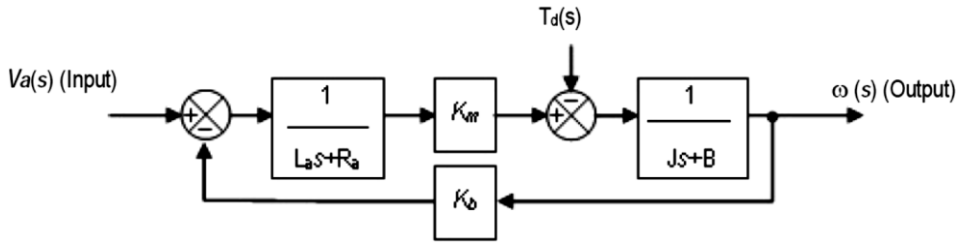

Figure 3.3: An open-loop speed control of a separately excited DC motor

EXERCISE 4:

Find the transfer function $\omega(s)/V_a(s)$.

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Consider the following system parameters as,

R_a	L_a	K_m	J	B	K_b
1	0.005	15	2	0.5	0.5

For the open-loop speed control system of a dc motor (shown above), the transfer function ω(s)/Td(s) with Td(s) = 0 using the given system parameters can be determined by using the following commands.

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Ra = 1; La = 0.005; Km = 15; J = 2; B = 0.5; Kb = 0.5;
num1= [1]; den1= [La Ra]; num2 = [Km]; den2 = [1]; num3 = [1]; den3 = [J b];
sys1 = tf (num1, den1);
sys2 = tf (num2, den2);
sys3 = tf (num3, den3);
sys4 = series (sys1, sys2);
sys5 = series (sys4, sys3);
sys = feedback (sys5, Kb);
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EXERCISE 5:

Write sys1, sys2, sys3, sys4, sys5 and sys returned by the MATLAB and verify all these transfer functions manually.

sys1 =	sys2 =	sys3 =
sys4 =	sys5 =	sys =

EXERCISE 6:

Explore the **'feedback'** command in the MATLAB and write down its function.

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EXERCISE 7:

Sketch the open-loop step Response. Label the speed and time axes properly.

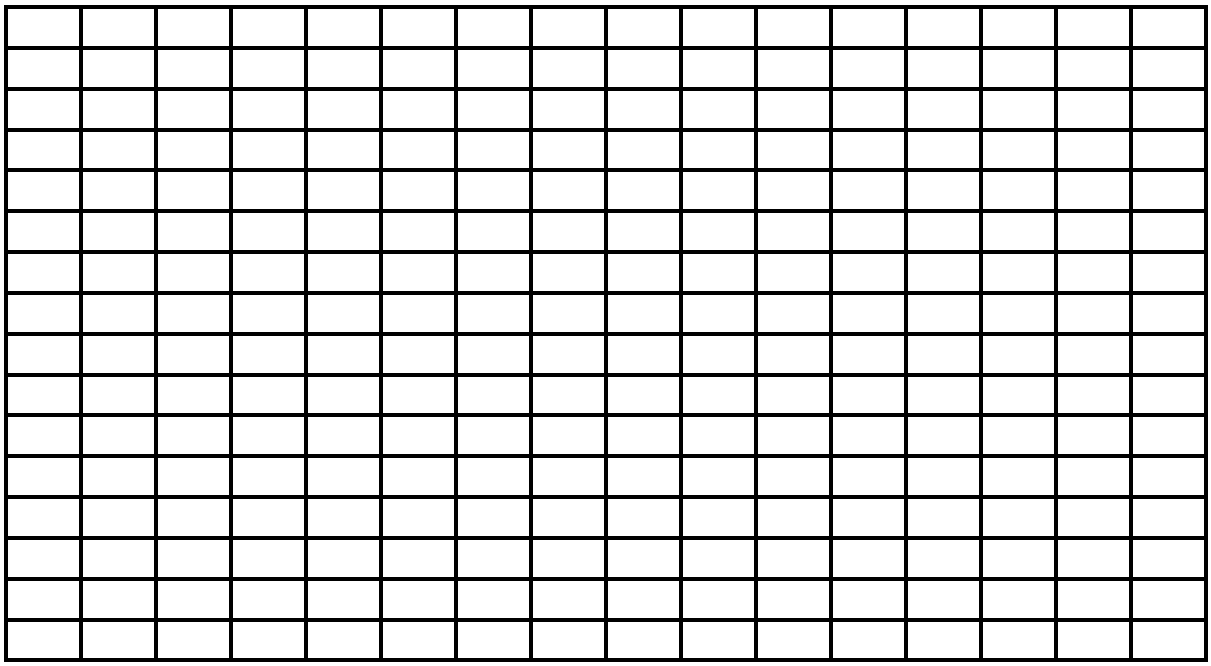

Figure 3.4 Open loop Step Response of the system

EXERCISE 8:

Determine the transfer $T(s)\big|_{Va=0} = \omega(s)/T_d(s)$.

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EXERCISE 9:

Now write MATLAB commands to determine the above-mentioned transfer function.

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EXERCISE 10:

Sketch the open-loop step Response. Label the speed and time axes properly.

Figure 3.5 Open loop Disturbance Step Response of the system

EXERCISE 11:

Write your comments on the step response due to Va (Td=0) and due to Td (Va=0).

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A block diagram model of a closed-loop speed control of a DC motor with unity-feedback is shown below. A proportional controller with gain *K* is used in this system.

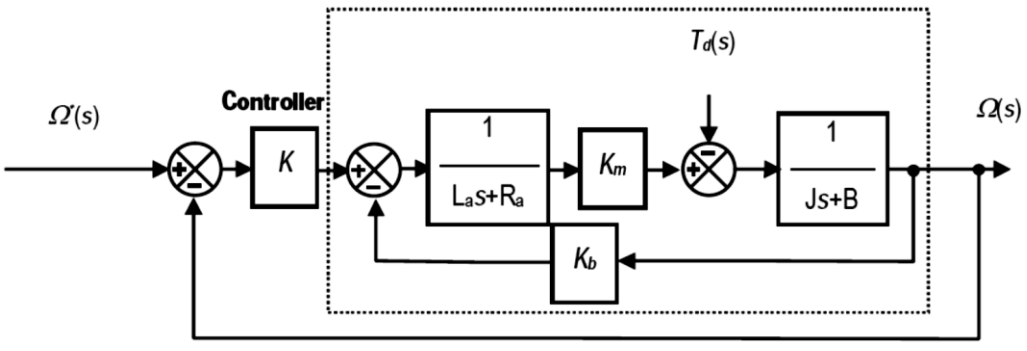

Figure 3.6: Closed-loop speed control of a DC motor with unity-feedback

EXERCISE 12:

Find the transfer function manually with Td(s)=0 $T(s)|_{Td(s)=0} = {\Omega(s)}/{\Omega(s)'}$

EXERCISE 13:

Determine the step response for K=1 and K=30 and K=60 and sketch the step response in each case.

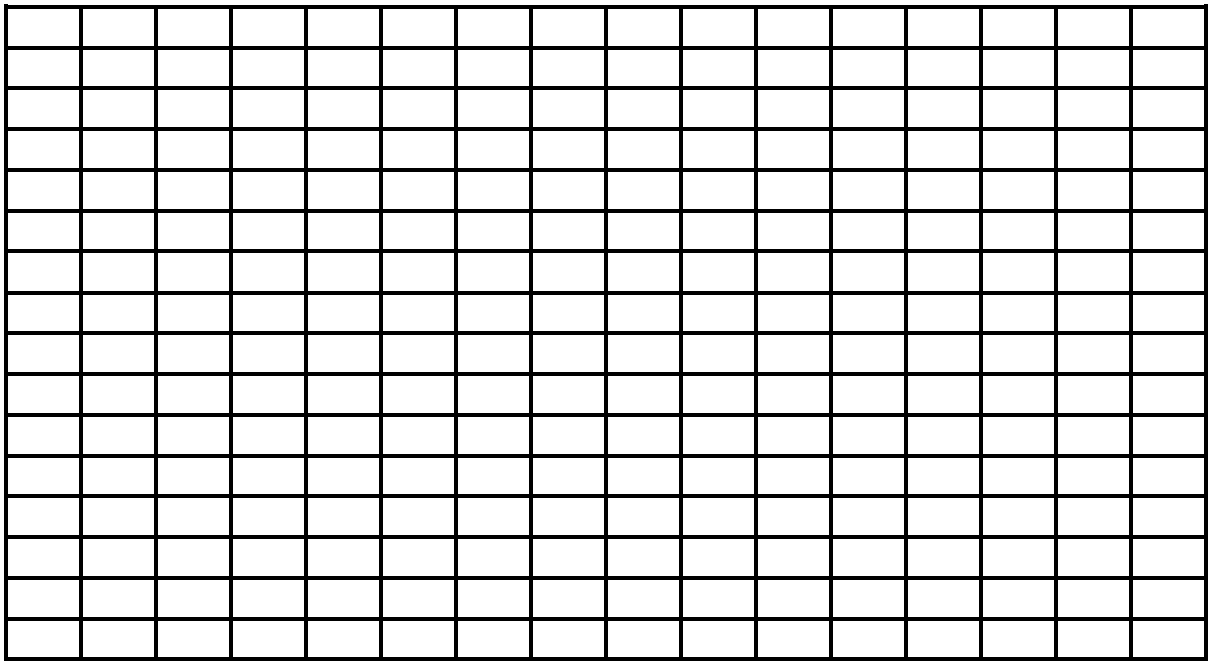

Figure 3.7 Output Response for K=1

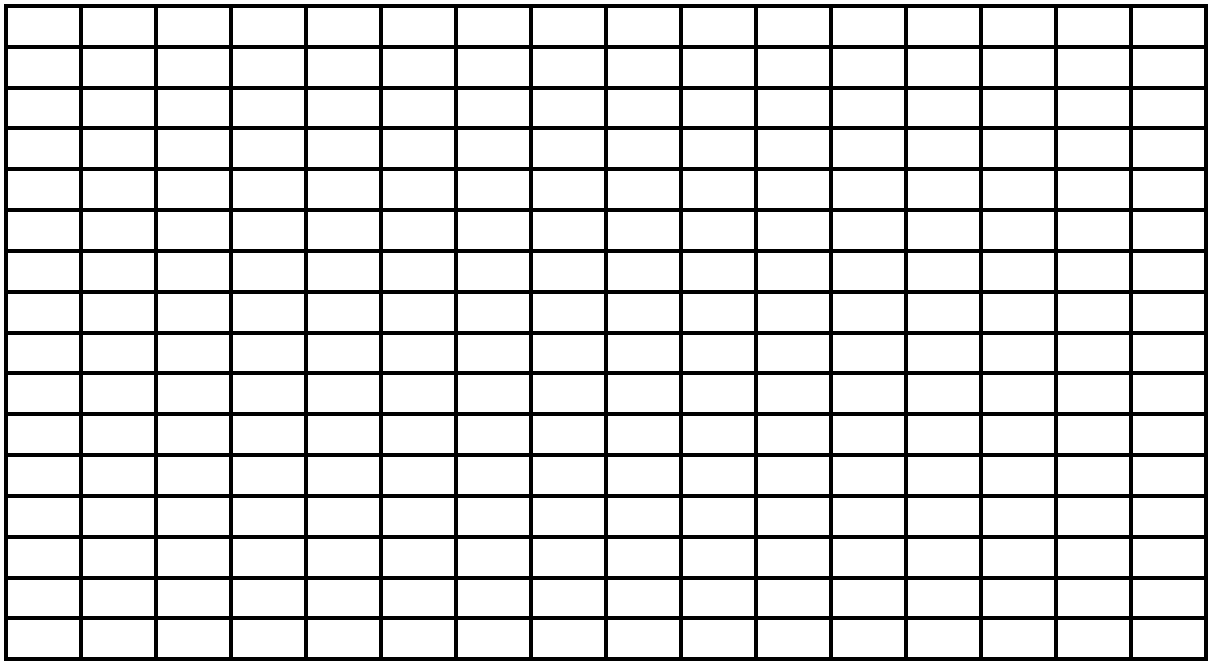

Figure 3.8 Output Response for K=30

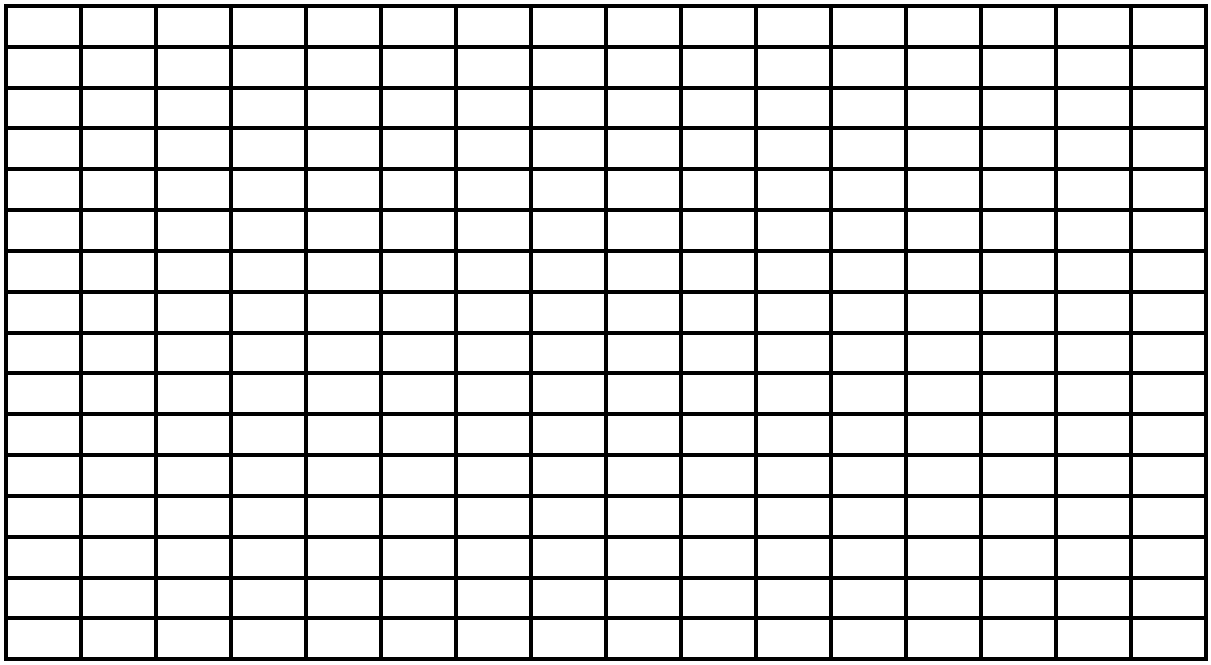

Figure 3.9 Output Response for K=60

EXERCISE 14:

Comment on the effect of *K* on the settling time, peak response and overshoots:

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