Measurements and Control Laboratory (0908448)

Assignments 2

Problem 1: Vertical Lifting Mechanism

vertical lift conveyors are used to transport unit loads between two levels with speed and care. Whether loads are packaged or unpackaged, soft or rigid, of equal sizes or varied in size.

Figure 1 shows some of machines that use the vertical lifting mechanism.

Figure 1: Machine use vertical lifting mechanism

The model of this mechanism can be illustrate as figure 2

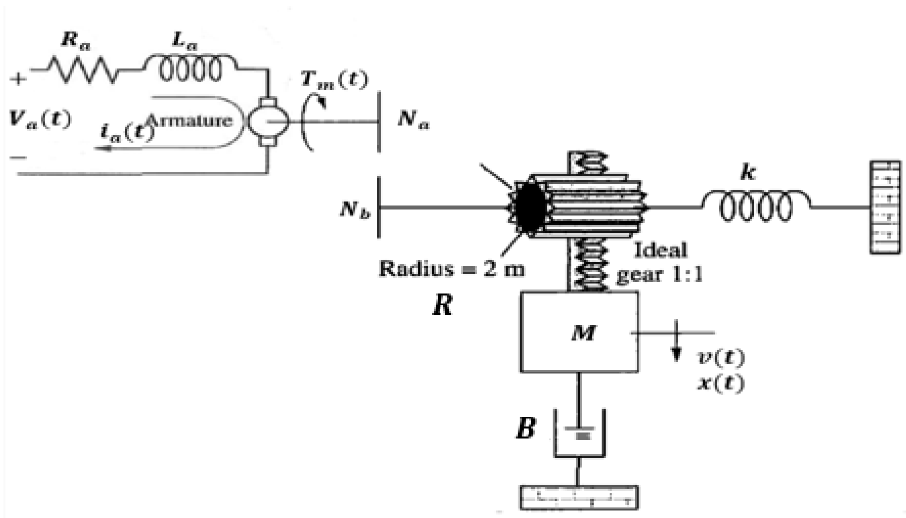
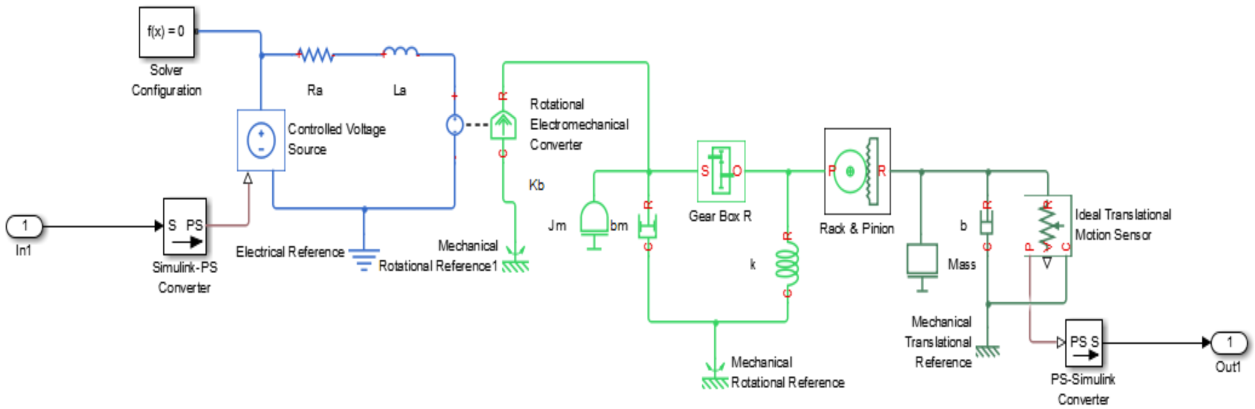


Figure 2: Vertical Lifting Mechanism

The SimScape Model should be like figure 3



Before starting must be run attached file (***Assigment2_problem1.m***) to generate parameter of this system:

1) The Parameters for this system

Parameter	Value
Resistance of Motor (Ra)	
Inductance of Motor (La)	
Damping coefficient of Motor (bm)	
Inertia of Motor (Jm)	
Back emf Constant (Kb)	
Gear Ratio (N)	
Spring Coefficient (k)	
Damping Coefficient (B)	
Pinion Radius (R)	
Load Mass (M)	

2) Write the step response specifications of system

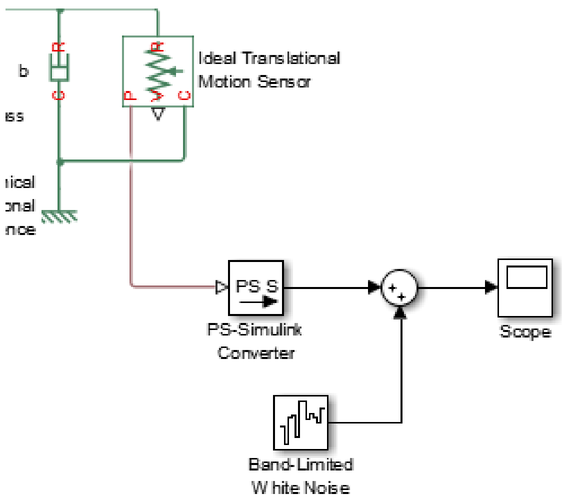
Specification	Value
Overshoot (%)	
Settling Time (sec)	
Rise Time (sec)	
Final Value	
Steady State Error	

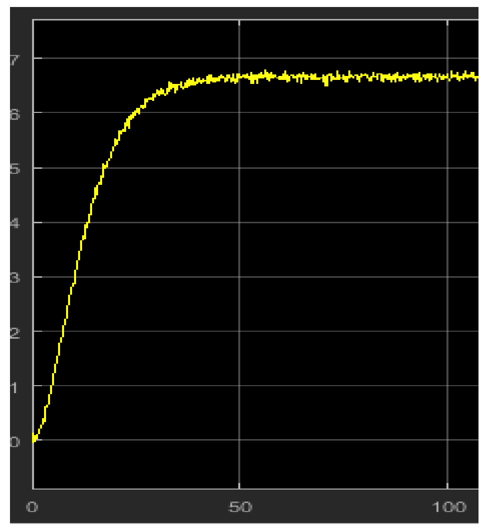
3) Use the **System Identification Toolbo**x to find the **equivalent transfer function**

$$G(s) = \frac{X(s)}{V_a(s)}$$

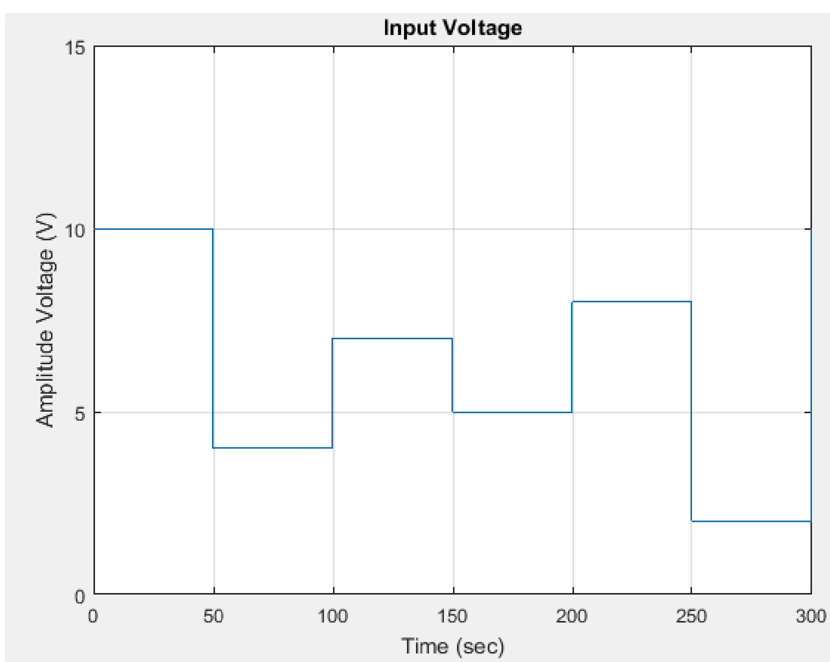
At the following conditions:

a) Add a **Small Value of Noise** using Band-limit noise from source blocks to the output signal, change Noise Power value

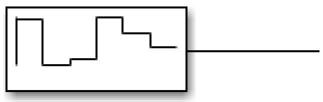




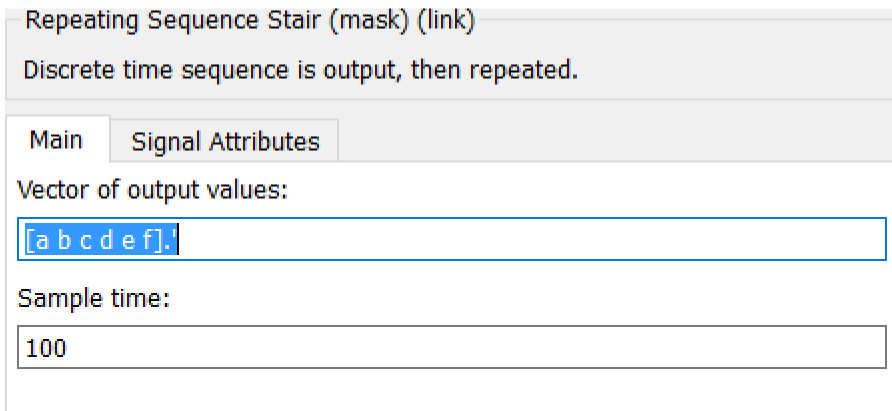
b) The following figure is show the **input voltage,** that was used in identification process



You can generate this signal by using Repeating Sequence Stair from source blocks



The value of (a,b,c,d,e and f) autmatically from **m.file**



Estimated Transfer Function $\frac{X(s)}{V_a(s)}$	

4) Plot the **Input Voltage** and **Output Response**.

5) Plot the estimated response and the original response on the same figure

Problem 2: Two Tank System

The objective is to model the liquid level of the lower tank of a laboratory scale two tank system, schematically shown in Figure 1.

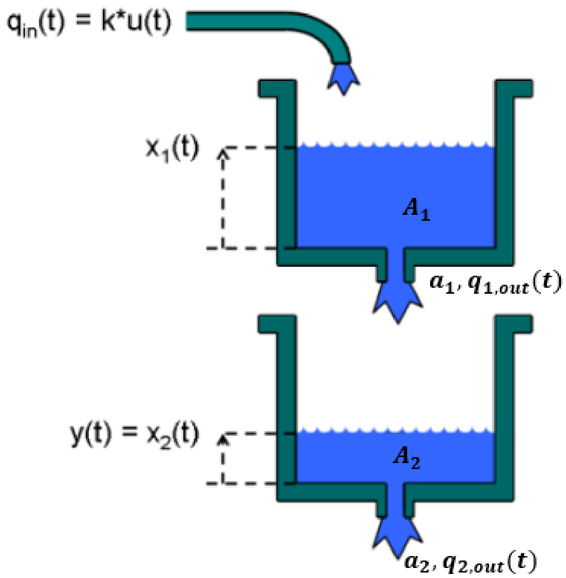


Figure 1: Schematic view of two tank system

Modeling the Two Tank System

To find the mathematical model of two tank system, let
$x_1(t)$: *the wate level in upper tank* and $x_2(t)$: *the wate level in lower tank*

For each tank. fundamental physics (mass balance) states that the change of water volume depends on the difference between in and outflow as $(i = 1, 2)$:

$$\frac{d}{dt}(A_i x_i(t)) = Q_{in}(t) - Q_{out}(t) \qquad (1)$$

Where

$A_i\ (m^2)$: *cross sectional area of tank* (i)
$Q_{in}(t)\ [m^3/s]$: *inflow to tank* (i)

$Q_{out}(t)\ [m^3/s]$: *outflow from tank* (i)

For Upper tank:

the inflow is assumed to be proportional to the voltage applied to the pump, i.e., $Q_{in}1(t) = ku(t)$. Since the outlet hole of the upper tank is small, Bernoulli's law can be applied, stating that the outflow is proportional to the square root of the water level, or more precisely that:

$$Q_{out}1(t) = a_1\sqrt{2gx_1(t)} \tag{2}$$

where a_1 is the cross-sectional area of the outlet hole and g is the gravity constant

For the lower tank,
the inflow equals the outflow from the upper tank, i.e., $Q_{in}2(t) = Q_{out}1(t)$, and the outflow is given by Bernoulli's law:

$$Q_{out}2(t) = a_2\sqrt{2gx_2(t)} \tag{3}$$

where a_2 is the cross-sectional area of the outlet hole.

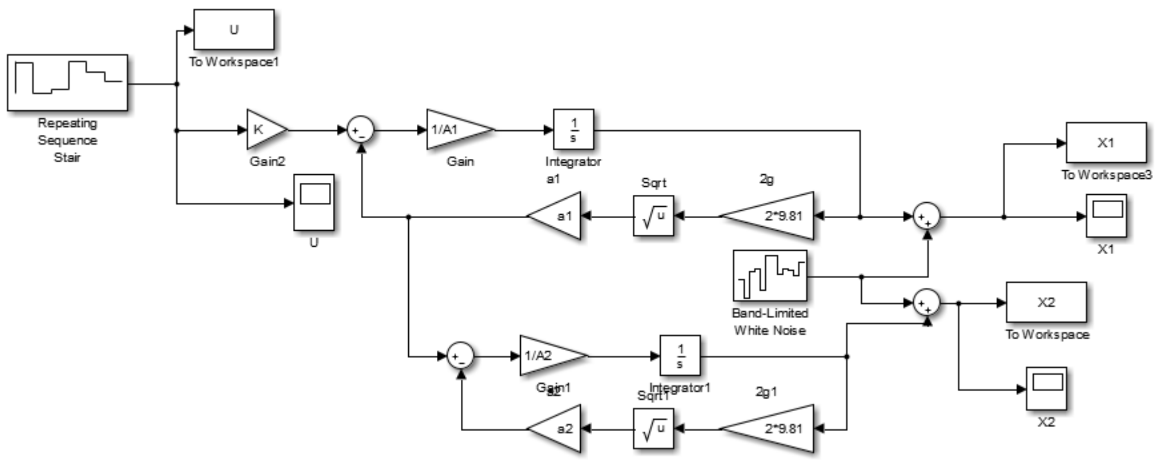
Put equations (1-3) altogether these facts lead to following state-space structure:

$$\dot{x}_1(t) = \frac{1}{A_1}\left(Ku(t) - a_1\sqrt{2gx_1(t)}\right)$$
$$\dot{x}_2(t) = \frac{1}{A_2}\left(a_1\sqrt{2gx_1(t)} - a_2\sqrt{2gx_2(t)}\right)$$

1) Before starting must be run attached file (***Assigment2_problem2.m***) to generate parameter of this system:
2) The Parameters for this system

Parameter	Value
Upper tank Area A_1	
Upper tank outlet area a_1	
Pump Constant (K)	
Lower tank Area A_2	
Lower tank outlet area a_2	
Gravity Constant	9.81 m/s^2

3) Build the Simulink Model of system



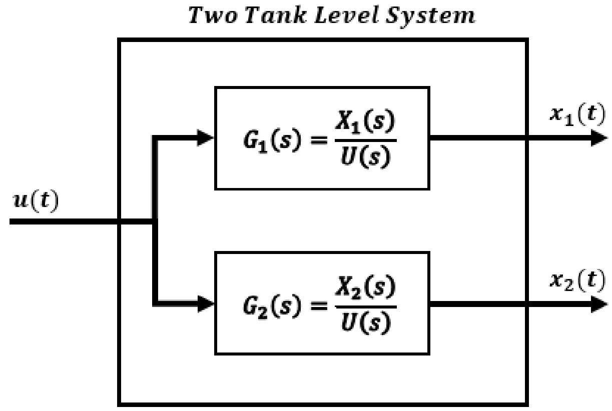
4) Plot the step response for $x_1(t)$ and $x_2(t)$.

5) Write the step response specifications of system

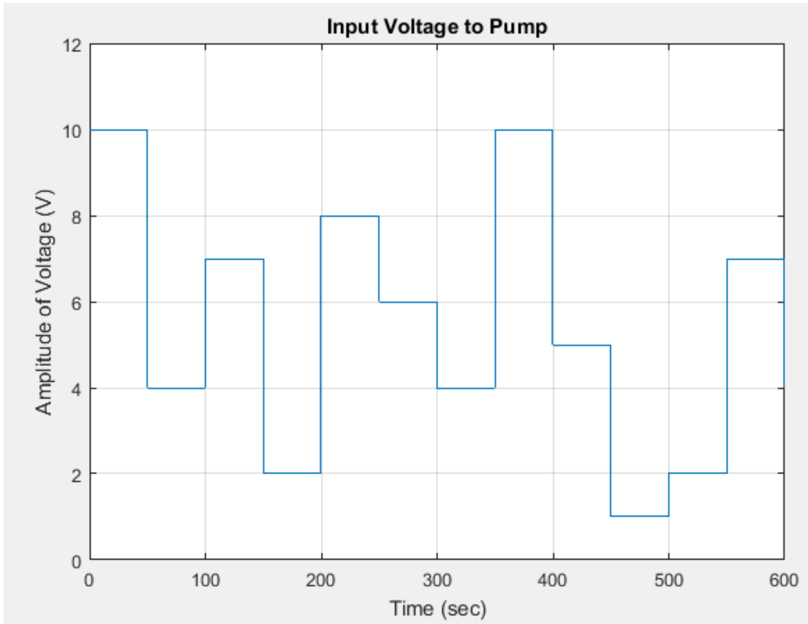
Specification	$x_1(t)$	$x_2(t)$
Overshoot (%)		
Settling Time (sec)		
Rise Time (sec)		
Steady State Value of Response		
Steady State Error		

6) Use the **System Identification Toolbo**x to find the **equivalent transfer function**

Two Tank Level System



a) The following figure is show the **input voltage,** that was used in identification process

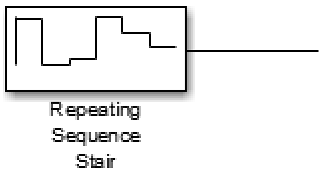


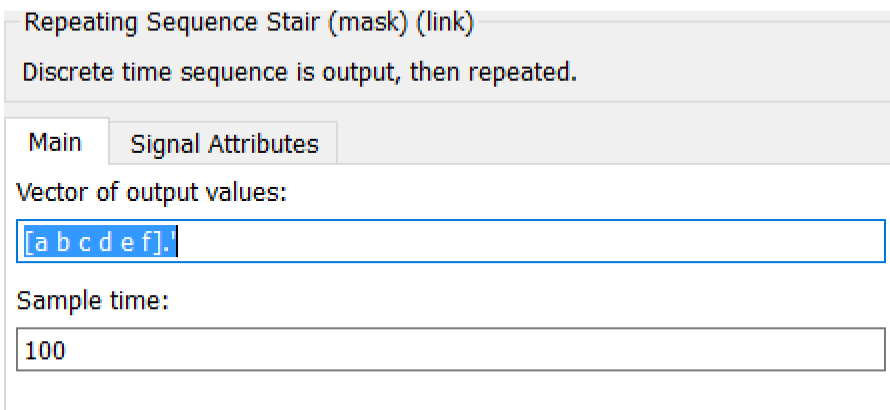
Estimated Transfer Function $\frac{X_1(s)}{U(s)}$ **Best Fit**	
Estimated Transfer Function $\frac{X_2(s)}{U(s)}$ **Best Fit**	

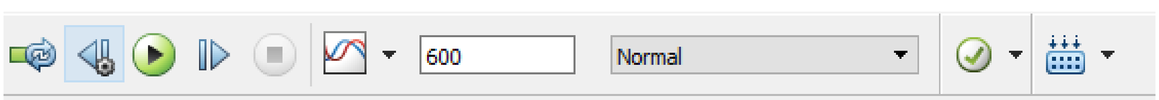
7) Plot the estimated response and the original response on the same figure

Notes:

1) Must be run attached ***m.file*** before starting
2) For your Case you to see the steady state value may need to change the **sample time of block (Repeating Sequence Stair)** and **Simulation time (6*sample time)**, to see the **steady state value**
   The value (a,b,c,d,e,f) will generate automatically form ***m.file***







3) Change the solver to (**ode23t (mod.stiff/trapezoidal))**
4) If obtain high **distortion (noise) in output**, must be **reduce the noise power** in Band-Limited White Noise block