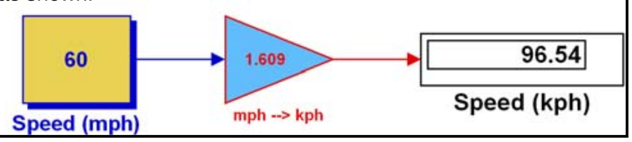
1

Lecture 2 Exercise 1a

- Design a converter that converts a speed of 60 miles per hour to kilometers per hour. Make the following format changes to your blocks:
- All text should be displayed in bold.
- Constant Block Properties:
  – Block text changed to "Speed (mph)"
  – Font: Arial 16.
  – Text and block outline color is blue.
  – The block has a drop shadow.
  – Block fill color is yellow.
- Gain block properties
  – Block text changed to "mph → kph"
  – Font: Arial 12.
  – Text and block outline color is red.
  – Block fill color is light blue.
- Display block properties:
  – Block text changed to "Speed (kph)"
  – Font: Arial 18.
- You solution should look as shown:
-

Demo___________



2

Lecture 2 Exercise 1b

- Use Simulink to calculate how far a vehicle moving at 60 mph would travel in 100 seconds. Provide an answer in both miles and in kilometers.
- Answers: 1.667 miles, 2.682 km.

Demo___________

3

Lecture 2 Exercise 2

Modify the motor model to use the name plate specifications for the motors and generators used in the lab. Use the following items listed on the nameplate:

- Torque constant.
- Rotor Inertia.

- Max motor current is 6.3 amps. (Due to current limits on the DC power supply.)

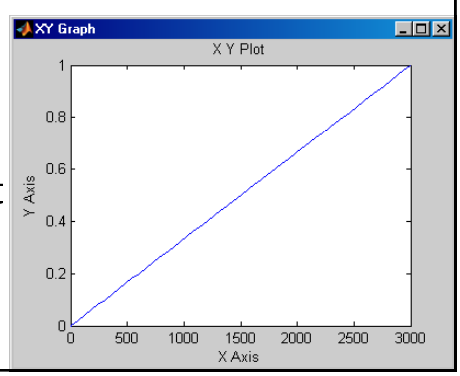
Demo___________

4

Lecture 2 Exercise 3

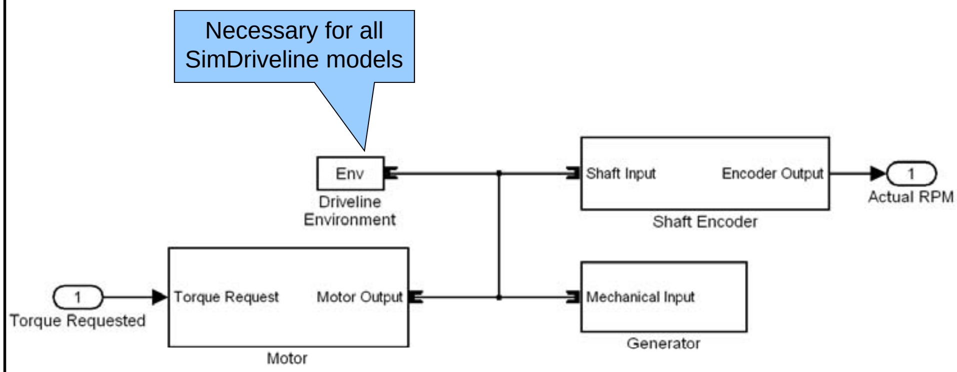
- Verify the operation of your generator model.
- Copy the Generator subsystem to a new model.
- Generate a plot of generator load torque versus shaft rpm.
- You should obtain a plot as shown below:
- You may need to add a part called SimDriveline Env to get your simulation to run.

Demo___________



Lecture 2 Demo

5



Completed Model Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 3 Exercise 1

6

The motor cannot reach the desired speed of 1800 rpm. We would like to find out why.

1. Change the scope y-axis so that the range is 0 to 2000 by default.
2. Modify the scope so that it displays 4 plots in the same window
3. Display following signals:
    1. Desired and actual rpm (already done).
    2. Controller torque requested.
    3. Motor Torque
    4. Generator Torque
4. Determine why the motor cannot reach the desired speed and fix it.

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

7

Lecture 3 Demo 1
Verification – Controller Gain

- Test 3 - Set controller gain to 0.001
  – Steady state error (rpm) ____________________
  – Steady state stability ____________________
- Test 4 – Set controller gain to 0.01
  – Steady state error (rpm) ____________________
  – Steady state stability ____________________
- Test 5 – Set controller gain to 0.1
  – Steady state error (rpm) ____________________
  – Steady state stability ____________________
- Test 6 – Set controller gain to 1
  – Steady state error (rpm) ____________________
  – Steady state stability ____________________

Demo____________

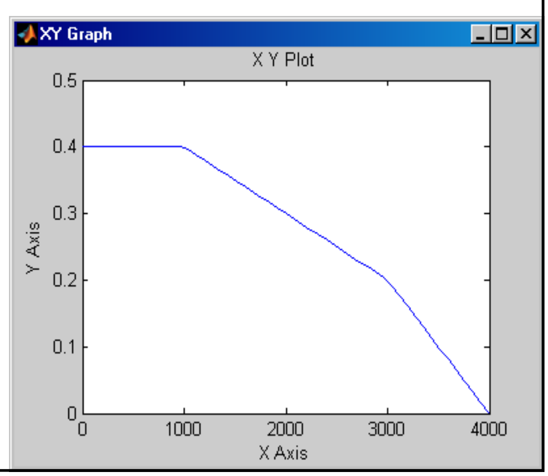
MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

8

Lecture 3 Exercise 2

Demo____________

- Verify the operation of your motor model.
- Copy the Motor subsystem to a new model.
- Generate a plot of motor torque versus shaft rpm.
- You should obtain a plot as shown:
- You may need to add a part called SimDriveline Env to get your simulation to run.



9

Lecture 3 Demo 2
Verification – Feedback Gain

	Old Model	New Model
• Test 4 - Set controller gain to 0.001		
– Steady state error (rpm)	___________	___________
– Torque Signal	___________	___________
– Steady state stability	___________	___________
• Test 5 – Set controller gain to 0.01		
– Steady state error (rpm)	___________	___________
– Torque Signal	___________	___________
– Steady state stability	___________	___________
• Test 6 – Set controller gain to 0.1		
– Steady state error (rpm)	___________	___________
– Torque Signal	___________	___________
– Steady state stability	___________	___________
• Test 7 – Set controller gain to 1		
– Steady state error (rpm)	___________	___________
– Torque Signal	___________	___________
– Steady state stability	___________	___________

Demo___________

10

Lecture 3 Demo 3
Verification – Generator IC

- Test 1 - Set IC to 0 rad/s, all else constant
  - Old Model ______________________________
  - New Model ______________________________
- Test 2 – Set IC to 250 rad/s, all else constant
  - Old Model ______________________________
  - New Model ______________________________
- These results should match our previous simulations since 6 bulbs is equivalent to what we did previously.

Demo___________

11

Lecture 3 Demo 4 Verification – FeedbackGain

	Old Model	New Model
Test 4 - Set controller gain to 0.001		
– Steady state error (rpm)	____________	____________
– Torque Signal	____________	____________
– Steady state stability	____________	____________
Test 5 – Set controller gain to 0.01		
– Steady state error (rpm)	____________	____________
– Torque Signal	____________	____________
– Steady state stability	____________	____________
Test 6 – Set controller gain to 0.1		
– Steady state error (rpm)	____________	____________
– Torque Signal	____________	____________
– Steady state stability	____________	____________
Test 7 – Set controller gain to 1		
– Steady state error (rpm)	____________	____________
– Torque Signal	____________	____________
– Steady state stability	____________	____________

Demo____________

12

Lecture 3 Demo 5 Verification – Feedback Gain

- Test 1 - Set number of bulbs to 0
  - Steady state error (rpm) ______________________________
  - Torque Signal ______________________________
- Test 2 - Set number of bulbs to 1
  - Steady state error (rpm) ______________________________
  - Torque Signal ______________________________
- Test 3 - Set number of bulbs to 2
  - Steady state error (rpm) ______________________________
  - Torque Signal ______________________________
- Test 4 - Set number of bulbs to 3
  - Steady state error (rpm) ______________________________
  - Torque Signal ______________________________
- Test 5 - Set number of bulbs to 4
  - Steady state error (rpm) ______________________________
  - Torque Signal ______________________________

Demo____________

Lecture 3 Demo 6
Verification – Feedback Gain

- Test 1 - Set number of bulbs to 5
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________
- Test 2 - Set number of bulbs to 6
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________

- The results should show that the steady state error increases as we increase the number of bulbs.
- With no load (0 bulbs) the error should be very close to zero.

Demo___________

Lecture 3 Demo 7
Verification – Feedback Gain

- Test 1 - Set number of bulbs to 0
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________
- Test 2 - Set number of bulbs to 1
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________
- Test 3 - Set number of bulbs to 2
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________
- Test 4 - Set number of bulbs to 3
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________
- Test 5 - Set number of bulbs to 4
  - Steady state error (rpm) ____________________________
  - Torque Signal ____________________________

Demo___________

15

Lecture 3 Demo 8
Verification – Feedback Gain

- Test 1 - Set number of bulbs to 5
  - Steady state error (rpm) ___________________________
  - Torque Signal ___________________________
- Test 2 - Set number of bulbs to 6
  - Steady state error (rpm) ___________________________
  - Torque Signal ___________________________

- The results should show that the steady state error increases as we increase the number of bulbs.
- With no load (0 bulbs) the error should be very close to zero.
- With 6 bulbs, the generator loads down the motor, and then motor cannot achieve the desired speed.

Demo___________

Lecture 3 Problem 2

- Capacitor Car – Description on next page.

Grade___________

Lecture 3A Exercise 1

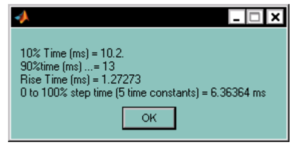
- Use the fixed-step ode3 (Bokacki-Shampine) solver and determine the largest fixed step size that can be used to simulate the system with out yielding an oscillation in the motor torque or plant rpm.
- The desired rpm should be set to 1800, number of bulbs to 3, and the feedback gain to 0.01 (same as used in the previous slides.)
- Note that when we deploy the controller on the MPC555x target, a fixed step size will be used. Thus, this is a good test to determine the required step size needed for our controller.
- Find the max step size to the nearest 100 μs.

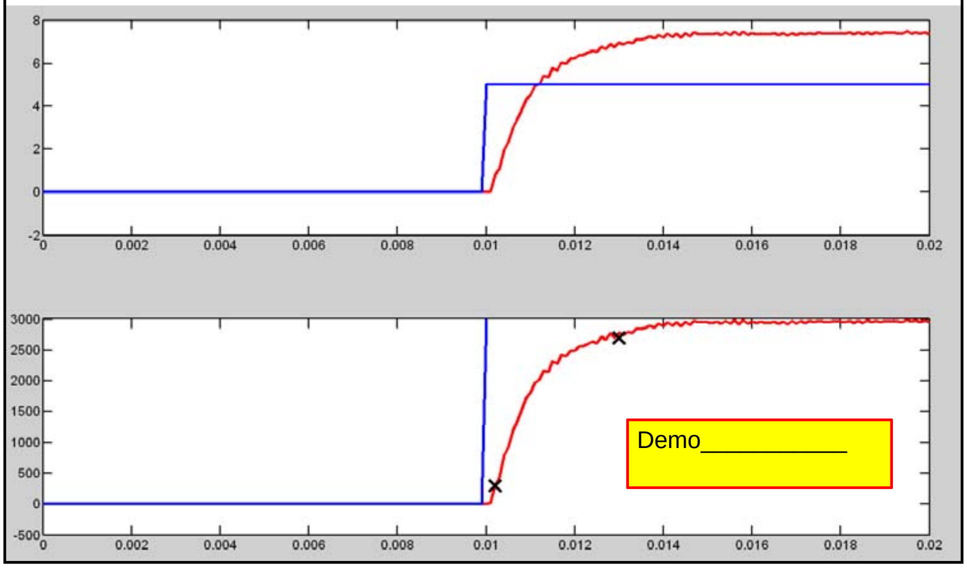
Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

19

Results
Lecture 3A Demo 1





Demo___________

20

Lecture 3A Exercise 2

- Add the flywheel inertia to your system. (Repeat exercise 1 with the added inertia.)
- Use the fixed-step ode3 (Bokacki-Shampine) solver and determine the largest fixed step size that can be used to simulate the system with out yielding an oscillation in the motor torque or plant rpm.
- The desired rpm should be set to 1800, number of bulbs to 3, and the feedback gain to 0.01 (same as used in the previous slides.)
- Note that when we deploy the controller on the MPC555x target, a fixed step size will be used. Thus, this is a good test to determine the required step size needed for our controller.
- Find the max step size to the nearest 1 ms.

MotoTron The MathWorks freescale semiconductor

Demo___________

21

Lecture 3A – Problem1 System Rise Time

Demo__________

- We would like to redo our rise time measurement using the motor generator system with the added flywheel.
- A second Speedgoat real-time system has been set up to control and measure data from the motor generator system:
  - The IP address is xxx.xxx.85.112.
  - The rpm signal conversion is 1.25 V per 1000 rpm. (We added a voltage divider to cut the rpm signal in half.)
- Repeat the measurements of Lecture 3A Demo1 for the Motor-Generator system with a flywheel. Note that this system is probably 50 to 100 times slower than the motor itself.
- Generate a plot, calculate the time constant, and calculate the rise time.
- Note that this system is wired differently than the motor.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

22

Lecture 3A – Problem2 Measured Coast Down

Demo__________

- We would like to measure the coast-down response of the motor-generator system used in Problem 1.
- Let the motor speed up to its maximum speed and then allow the motor to coast to a stop.
- For the coast-down, measure:
  - The time constant.
  - The time it takes to reach zero (5 time constants)
  - Generate a plot of the coast-down response showing with the 10% and 90% points marked.
- Save the coast-down data in a file on your computer for use in a later example.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 4 Problem 1

Demo___________

- Repeat the bode plot for our system and include the flywheel inertia of 1.041×10^{-4} kg·m^2.
- Fill in the table below and generate a plot.

Frequency (rad/sec)	Output Amplitude	Gain	Gain (dB)
0.1			
1			
2			
4			
8			
10			
20			
40			
80			
100			
1000			
10000			

Lecture 4 Problem 2

A plant has the following transfer function

$$\frac{1000}{\left(1+{}^{s}\!/_{0.1}\right)\left(1+s\right)\left(1+{}^{s}\!/_{100}\right)}$$

We will use this plant with proportional feedback as shown in class.

a) Use gain and phase plots to find the largest value of the feedback constant F that can be used to have a stable system with zero degrees phase margin.

b) Use Simulink to show that the system is unstable for values of F larger than this value of F.

c) Use Simulink to show that the system is stable for values less than or equal to this value of F.

d) Use gain and phase plots to find the largest value of the feedback constant F that can be used to have a stable system with a 60 degrees phase margin.

Grade___________

Lecture 5 Exercise 1

- Determine the value of the pressure to the friction clutch so that the system coasts down from 2700 rpm to zero in about 130 ms.

Demo___________

Lecture 5 Demo 1
Response Optimization

- Optimum value of Pressure is 0.2224.

Optimization Progress

```
                                  max                    Directional   First-order
 Iter   S-count        f(x)    constraint    Step-size   derivative    optimality   Procedure
    0         1    0.019801            0
    1         7  0.00464494            0         0.02      -0.0303         0.12
    2        11  0.00113933            0         0.01       0.0143         1.47     Hessian modified twice
    3        15 0.000569028            0      0.00243     5.75e-005       0.0119
Optimization terminated due to slow progress in parameter or objective values.
To optimize further, go to Optimization Options and decrease the parameter and/or
function tolerances.

Pressure =

    0.0224
```

Demo___________

27

Lecture 5 Problem 1

- In Lecture 3A problem 2, we measured the coast-down of the motor/generator system with the flywheel.
- Add the flywheel to your model
- Use the measured coast-down data from Lecture 3A as the reference signal.
- Use the Response Optimization Toolbox to determine the optimum value of clutch pressure for the system with the flywheel.

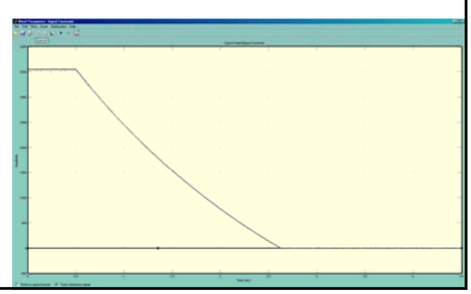
Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

28

Lecture 5 Problem 2

- Use the optimization tool to determine the coefficients for an optimal fit.
- You will need to determine two coefficients.
- An optimal plot is shown below. The fit is so close, you cannot see much difference on the screen capture.
- You may want to change the optimization method to “Simplex search.”
- You may want to increase your max step size so that the simulations take less time.



Demo___________

Lecture 6 Demo 1

29

- Demonstrate the system response for various feedback gains.
- Demonstrate the effect of reducing the simulation maximum step size,

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Init File- Lecture 6 Demo 2

30

- Run your model now

Demo__________

- It works because the Init_File runs before the model runs, and defines all of the constants needed by the mode.
- From now on, we will define all of our data and model constants in the init file.
- The model will reference the variables named in the init file rather than use magic numbers.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 7 Exercise 1

31

Use this waveform as the rpm input for the controller. For this waveform, or a slight modification, observe the system step response for the following conditions:

Number of Bulbs	Proportional Gain	Rise Time	Fall Time
2	10		
2	20		
2	50		
2	100		

Demo___________

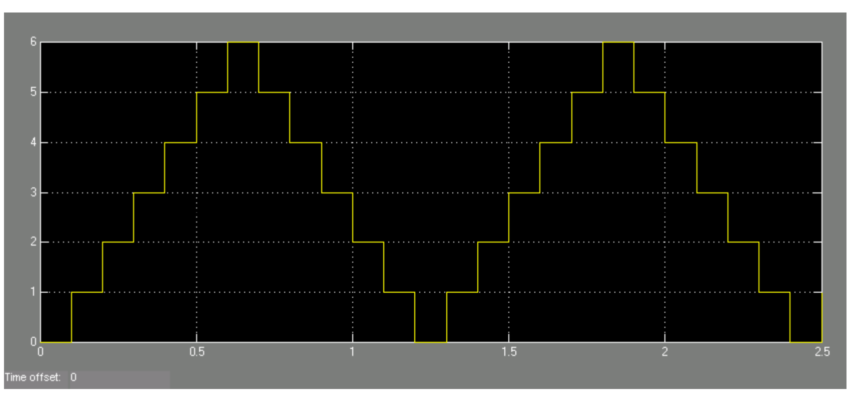
MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 7 Exercise 2

Demo___________

32

Create the following waveforms using one of the Simulink sources. Use this input as the number of bulbs and plot the system response.



Lecture 7 Exercise 3

Demo__________

Determine the maximum value of Sample time that can be used to achieve a stable feedback system using the conditions specified below:

	No Bulbs	1 Bulb	2 Bulbs	3 Bulbs
Gain = 10				
Gain = 20				
Gain = 50				
Gain = 100				

Lecture 7 Demo 1

- Demo your PI controller.
- Show how changing the P and I gains affect the system response.

Demo__________

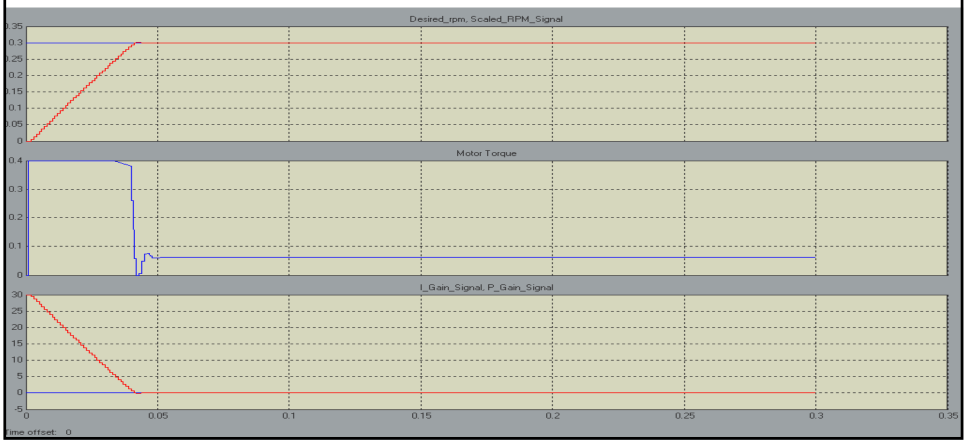
MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 7 Exercise 4

Demo__________

35

- Repeat the previous procedure for different values of proportional gain.
- Determine the proportional and integral gains to achieve a plot close to the one below.



Lecture 7 Demo 2

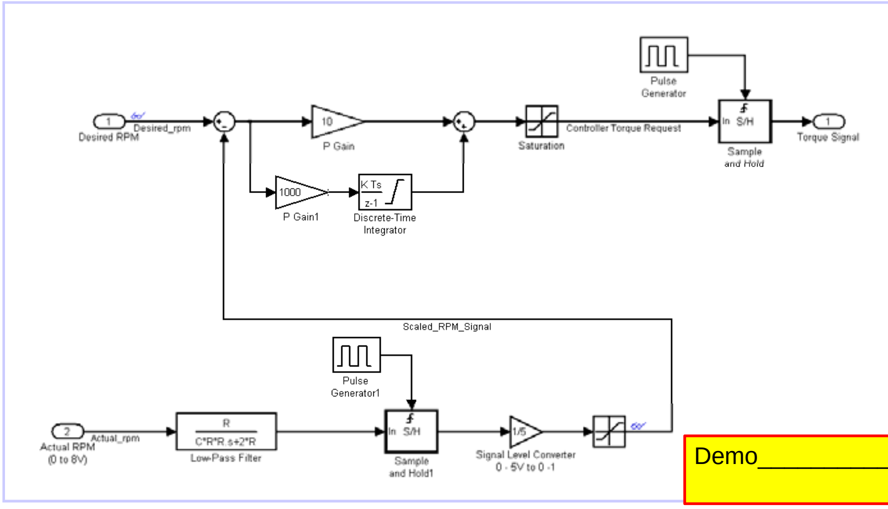
36

- Demo your PI controller with 1 bulb load.
- Show how changing the P and I gains affect the system response.
- Determine values of P and I gains for optimum response.

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 7 Exercise 5



Demo___________

Investigate the difference in these two methods for:

1. The affect of the placement on overshoot at high gain.
2. The affect of the placement on changing the integral gain while the system is running.

Lecture 8 Demo 1

- Initial xPC real-time system response.

Demo___________

Lecture 8 Demo 2

- Constant speed, variable load testing.

Demo__________

Lecture 8 Demo 3

- System response for constant load, constant speed, variable feedback gain.

Demo__________

Lecture 9 Problem 1

- The plots demonstrated in this lecture were for our motor-generator system **without the flywheel**.
- For the problems in this section, we would like to use the transfer function from the system with the flywheel.
- In lecture 4 problem 1, we measured the frequency response plot of the motor-generator system including the flywheel.
- Determine the transfer function of this system from the measured frequency plot.
- Show the magnitude frequency plot whence your transfer function was generated.

Answer___________

Lecture 9 Problem 2

- For a feedback gain of 1, determine the largest fixed time step where the system will be stable (0.1, 0.01, 0.001, 0.0001)
- Show gain and phase plots using Matlab.
- The plots should be displayed in the same manner as shown in the notes for lecture 9.

Gain and plots___________

Lecture 9 Problem 3

- For a feedback gain of 10, determine the largest fixed time step where the system will be stable (0.1, 0.01, 0.001, 0.0001)
- Show gain and phase plots using Matlab.
- The plots should be displayed in the same manner as shown in the notes for lecture 9.

Gain and plots___________

Lecture 9 Problem 4

- For a feedback gain of 100, determine the largest fixed time step where the system will be stable (0.1, 0.01, 0.001, 0.0001)
- Show gain and phase plots using Matlab.
- The plots should be displayed in the same manner as shown in the notes for lecture 9.

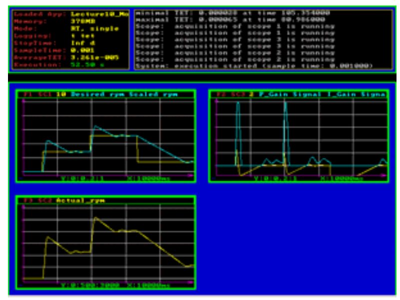
Gain and plots___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 10 xPC 1

- Obtain a copy of the next screen using the xpctargetspy command.

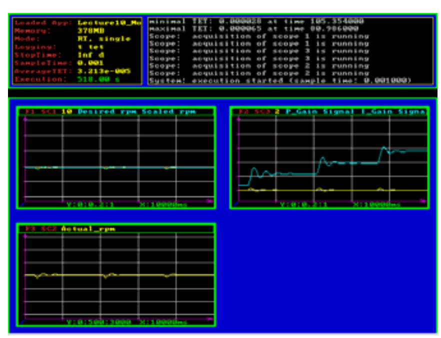
XPCTARGETSPY



Lecture 10 xPC 2

- Obtain a copy of the next screen using the xpctargetspy command.

XPCTARGETSPY

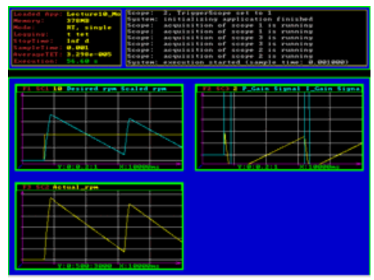


47

Lecture 10 xPC 3

- Obtain a copy of the next screen using the xpctargetspy command.

XPCTARGETSPY



MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

48

Lecture 10 Gauges - Demo

- Demonstrate your working model to me.
  - Front Panel Display
  - xPC Real-Time Display

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

49

Lecture 10A Demo 1

- Demonstrate the controller as an atomic subsystem with sample times of 0.1, 0.01, and 0.001 seconds.

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

50

Lecture 10A Demo 2

Demo___________

Lecture 11 Exercise 1

- Change the LED flasher frequency to 2 Hz and demonstrate your working system.

Demo___________

Lecture 11 Exercise 2

- Create an 8-Bit ring counter that changes state every ½ second.
- Do not use Stateflow to do this.
- The LED output sequence is shown below:

1 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0
0 0 1 0 0 0 0 0
0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 0
0 0 0 0 0 1 0 0
0 0 0 0 0 0 1 0
0 0 0 0 0 0 0 1

Demo___________

53

Lecture 11 Exercise 3

- Create an 8-Bit up-down ring counter that changes state every ½ second.
- Do not use Stateflow to do this.
- The LED output sequence is shown below:

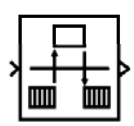
1 0 0 0 0 0 0 0	0 0 0 0 0 0 1 0
0 1 0 0 0 0 0 0	0 0 0 0 0 1 0 0
0 0 1 0 0 0 0 0	0 0 0 0 1 0 0 0
0 0 0 1 0 0 0 0	0 0 0 1 0 0 0 0
0 0 0 0 1 0 0 0	0 0 1 0 0 0 0 0
0 0 0 0 0 1 0 0	0 1 0 0 0 0 0 0
0 0 0 0 0 0 1 0	1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1	0 1 0 0 0 0 0 0

Demo___________

54

Lecture 11 Exercise 4 (Cont)

- You may want to display sample times on the model. Select **Format**, **Port/Signal Displays**, and the **Sample Time Colors** from the Simulink menus.
- You may need to use a **Rate Transition** block located in the **Simulink** / **Signal Attributes** library.



Rate Transition

Demo___________

Lecture 11A Demo 1

Demo__________

55

- Repeat the Procedure to display the values of signals Repeating_Sequence_Fast and Sequence:

algorithm block description

	Name	Value	Unit	
	Repeating_Sequence_Slow	6	unit	0
	Repeating_Sequence_Fast	5	unit	0
	Sequence	5	unit	0

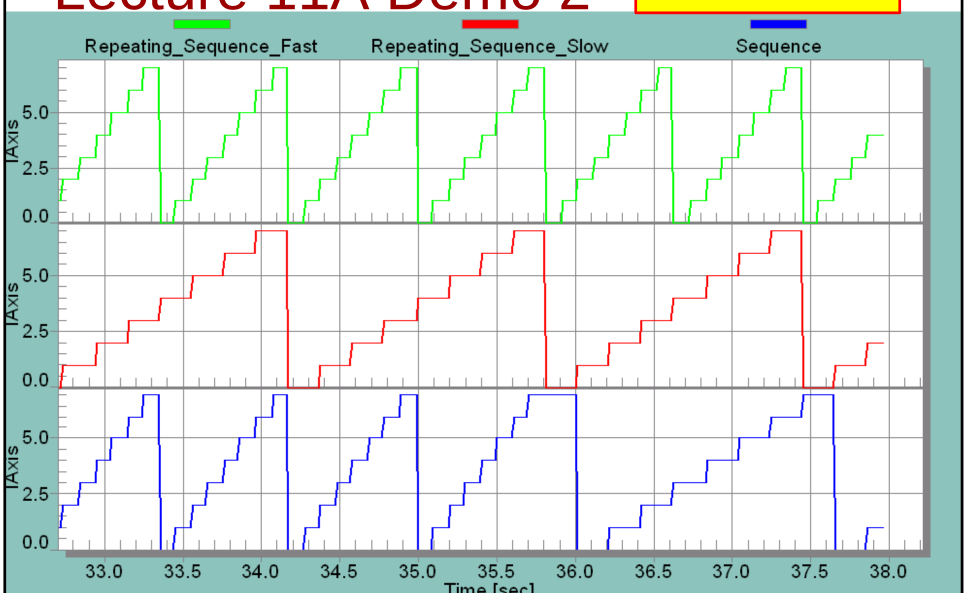
- You should see the fast and slow signals change at different rates, and the Sequence signal should flip-flop between the fast and slow rates.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 11A Demo 2

Demo__________

56



MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 11A Problem 1

Demo__________ 57

- Create the following display of information:

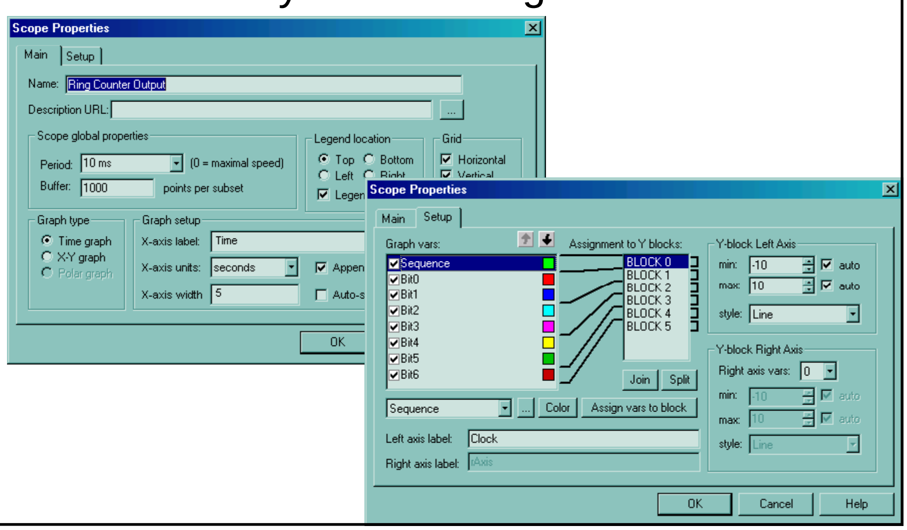
algorithm block description

Name	Value	Unit	
Repeating_Sequence_Slow	5	unit	0
Repeating_Sequence_Fast	3	unit	0
Sequence	4	unit	0
Bit0	0	DEC	100
Bit1	0	DEC	100
Bit2	0	DEC	100
Bit3	0	DEC	100
Bit4	1	DEC	100
Bit5	0	DEC	100
Bit6	0	DEC	100
Bit7	0	DEC	100

Lecture 11A Problem 2

Demo__________ 58

- Create the plot shown on the next page. Note that only bits 0 through 6 are shown.



59

Lecture 12 Problem 1

- Determine the decimal value of the following bit string (it is 32 bits in length.)
- 10011100111011100110111000000011
- Assuming the following data types
  - Uint32 (magnitude)
  - Int32 (2's complement)
  - Sign and magnitude
  - Single precision floating point
- Create an m-file that displays all four results in an mbox.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

60

Lecture 12 Problem 2

- Determine the decimal value of the following bit string (it is 32 bits in length.)
- 01000000111010000110100000000011
- Assuming the following data types
  - Uint32 (magnitude)
  - Int32 (2's complement)
  - Sign and magnitude
  - Single precision floating point
- Create an m-file that displays all four results in an mbox.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

61

Lecture 12 Problem 3

- Create an m-file that defines a arbitrary 32 character text string, the contents of which are zeros and ones. For example, ‘01000000111010000110100000000011’
- The script then displays the value of the bit string in an mbox, assuming the four data types below:
  - Uint32 (magnitude)
  - Int32 (2’s complement)
  - Sign and magnitude
  - Single precision floating point
- Demonstrate your function with a binary value given by your instructor.

62

Lecture 12 Exercise 1

- Create an counter that changes state every ½ second.
- Do not use Stateflow to do this.
- The repeating LED output sequence is shown below:

0 0 0 0 0 0 0 0	1 1 1 1 1 1 1 1
1 0 0 0 0 0 0 0	0 1 1 1 1 1 1 1
1 1 0 0 0 0 0 0	0 0 1 1 1 1 1 1
1 1 1 0 0 0 0 0	0 0 0 1 1 1 1 1
1 1 1 1 0 0 0 0	0 0 0 0 1 1 1 1
1 1 1 1 1 0 0 0	0 0 0 0 0 1 1 1
1 1 1 1 1 1 0 0	0 0 0 0 0 0 1 1
1 1 1 1 1 1 1 0	0 0 0 0 0 0 0 1

Demo___________

63

Lecture 12 Exercise 2

- Create an counter that changes state every ½ second.
- Do not use Stateflow to do this.
- The repeating LED output sequence is shown below:

```
0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0
1 1 0 0 0 0 0 0
1 1 1 0 0 0 0 0
1 1 1 1 0 0 0 0
1 1 1 1 1 0 0 0
1 1 1 1 1 1 0 0
1 1 1 1 1 1 1 0
1 1 1 1 1 1 1 1
1 1 1 1 1 1 0 0
1 1 1 1 1 0 0 0
1 1 1 1 0 0 0 0
1 1 1 0 0 0 0 0
1 1 0 0 0 0 0 0
1 0 0 0 0 0 0 0
```

Demo__________

64

Lecture 13 – Demo 1

- Wire up your circuit.
- Modify the model to display the value of the digital input and the count using the FreeMaster tool.
- Compile and download the model.
- Demo your working system.
  - The ring counter should change direction when the push-button is pressed.

Demo__________

Demo__________ 65

Lecture 13 - Demo 2

Mod 8 counter using a triggered subsystem.

- Wire up your circuit.
- Use the FreeMASTER tool to monitor the following signals for the triggered subsystem:
  - The input.
  - The output
  - The switch output
  - The output of the 1/z block
  - The trigger
  - An example display is shown on the next slide.
- Compile and download the model.
- Demo your working system.
- The counter should hold when you press the pushbutton.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

66

Lecture 13 Exercise 1

- You will notice that the counter does hold when press the bust-button. However, there is a problem:
- When the count reaches 7 and you press the hold push button, all of the LEDs go out and the count holds (actually at -1).
- Fix this problem so that the count always holds when the button is pushed, the counter always remembers the count, and there is one LED on at all times.

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 13 Exercise 2a

Demo__________

67

- Create an up-down ring counter that changes direction when you press a push-button. (A hold button is not required).
  - When the push-button is **not** depressed, the ring counter goes in the "normal" direction.
  - While the push-button is depressed, the ring counter goes in the opposite direction
- The counter should not skip or jump when you press the button (the count should be continuous).
- You are required to use a triggered subsystem to solve this problem.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 13 Exercise 2b

Demo__________

68

- Create an up-down ring counter that changes direction when you press a push-button. (A hold button is not required).
- The push-button has memory (similar to a flip-flop):
  - When the push-button is pressed and released, the counter changes direction.
  - The counter does not change direction until the push-button is pressed and released again.
  - The counter changes direction every time the push-buton is pressed and then released.
- The counter should not skip or jump when you press the button (the count should be continuous).
- You are required to use a triggered subsystem to solve this problem.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 13 Exercise 3

69

- Create an up-down ring counter that changes direction when you press a push-button. (A hold button is not required).
- The counter should not skip or jump when you press the button. (The count should be continuous).
- A second push-button should be used to change the counting frequency. You should be able to change directions and speed simultaneously.

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 13 Exercise 4

70

- Create two 4-bit ring counters with the following properties:
  - One counter shifts to the right, the other shifts to the left.
  - One counter counts at a 1 Hz rate, the other at a 10 Hz rate.
  - Your fixed step size is 1 ms.
  - Two push-buttons are available that hold the individual counters. While holding, the counters cannot lose their count. The hold functions on each counter are independent of the other counter.
- You are required to use triggered subsystem to solve this problem.

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

71

Lecture 14 – Demo 1

- Analog Input – Demo
- Wire up you circuit.
- Compile and download the model.
- Display all signal values using FreeMASTER:
- Demo your working analog voltmeter / bar graph.

algorithm block description

Name	Value	Unit	
Raw_Value	b#10110100	BIN	100
Double_Value	184	unit	100
Scaled_Value	46	unit	100
Bit_0	0	DEC	100
Bit_1	0	DEC	100
Bit_2	0	DEC	100
Bit_3	0	DEC	100
Bit_4	0	DEC	100
Bit_5	0	DEC	100
Bit_6	0	DEC	100
Bit_7	0	DEC	100

Demo___________

72

Lecture 14 – Demo 2

- Wire up you circuit.
- Compile and download the model.
- Demo your working system.
  - Ring counter with embedded Matlab function.

Demo___________

Lecture 14 Exercise 1

Demo__________

- Create an up-down ring counter where the up/down function and the ring counting logic is contained in an Embedded MATLAB Function block.
- As push-button is used to change directions of the counter.
- The counter is allowed to skip positions when you press the push-button.
- You may use a counter external to the embedded Matlab function if you so desire.

Lecture 14 Exercise 2

Demo__________

- Create an up-down ring counter where the up/down function, the ring counting logic, and the stored count is contained in an Embedded MATLAB Function block.
- As push-button is used to change directions of the counter.
- The counter is **not** allowed to skip positions when you press the push-button.
- The embedded function must keep track of the count. You may not use an external counter to keep track of the count. (In essence, the embedded Matlab function has memory.)
  - You may want to use the Matlab persistent and isempty functions.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

75

Lecture 14 Exercise 3

- Create a ring counter using a Truth Table.
- Truth Tables are located in the Stateflow library.

Demo___________

76

Lecture 14 Demo 3

- Wire up you circuit.
- Compile and download the model.
- Demo your working system.
  - Analog voltmeter with ASCII output.

Demo___________

Lecture 14 Demo 4

- Compile and download the model.
- Demo your working system.
- Example output from my model is shown below:

```
Analog Input 1: 5.
Analog Input 1: 5.
Analog Input 1: 113.
Analog Input 1: 302.
Analog Input 1: 65.
Analog Input 1: 228.
Analog Input 1: 234.
Analog Input 1: 202.
```

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 14 Exercise 4

- Read two analog input voltages. Use potentiometers RV1 and RV2 as your inputs.
- Use RV1 to control the output of your LED voltmeter.
- Output the following text strings every second, and in the same order (must be forced in this order using function call triggered subsystems):

Analog Input 1: xxx.

Analog Input 2: yyy.

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

79

Lecture 14 Exercise 5

- Use the analog input and a potentiometer to control the speed at which your ring counter shifts.
- The counter frequency should be continuously variable from 1 Hz to 10 Hz.

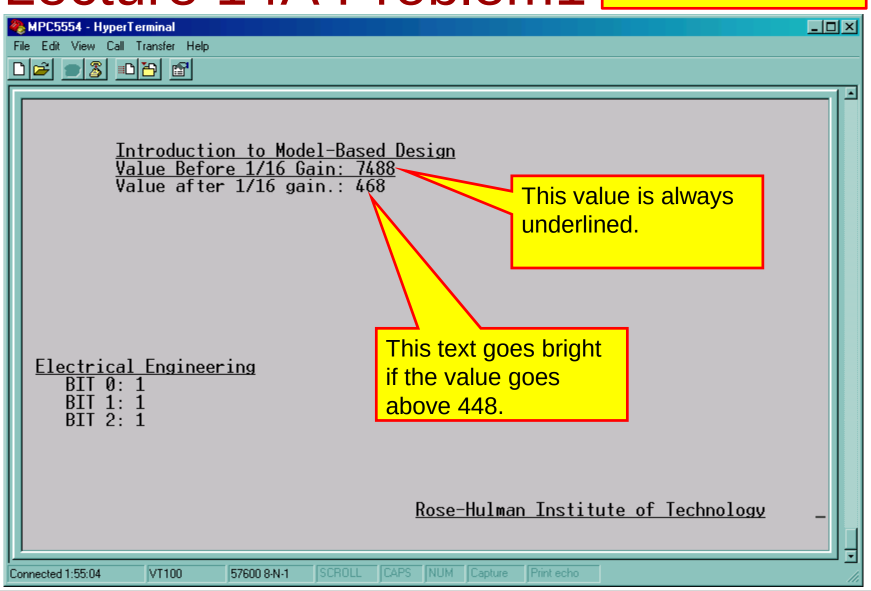
Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Demo___________

80

Lecture 14A Problem1



MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 14A Problem2

Demo__________

81

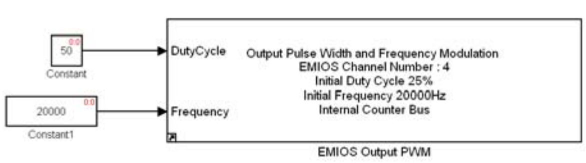
- We would like to create a new subsystem block that displays text with the following characteristics.
- The input to the block is a numerical value of type double.
- The block should be a masked subsystem that specifies:
  - The row and column where the block is placed on the screen.
  - The text displayed on the screen before the numerical value.
  - The period in milliseconds at which the numerical value is refreshed.
  - Two threshold values:
    - When the numerical value is below Threshold1, the text is displayed in black.
    - When the numerical value is between Threshold1 and Threshold2, the text is underlined.
    - When the numerical value is above Threshold2, the text blinks.

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15 Demo 1

82

- MPC555x eMIOS PWM Output
- Verify that the frequency is 20 kHz and that the duty cycle is 50%.
- Display waveforms of the PWM output with the Mobile Studio Desktop Oscilloscope



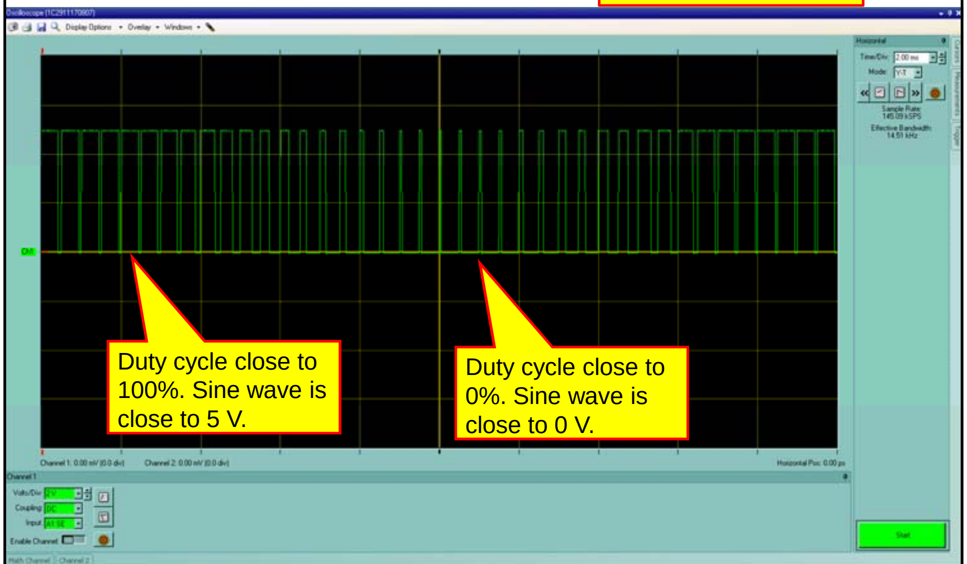
Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 2 Demo 2

83

Demo___________

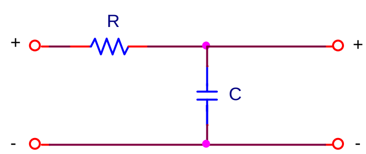


MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15 Demo 3

84

- MPC5554 eMIOS PWM Output
- Add the filter shown below and observe a 60 Hz Sine Wave at the output of the filter.
- Choose the cutoff frequency of the filter to be 600 Hz or higher. (A decade above 60 Hz)
- You may need to increase the PWM frequency to reduce the ripple on the filter output. (20 kHz or higher.)
- Display the Sine wave on Channel 1 of the scope, Display the PWM waveform on Channel 2 of the scope.

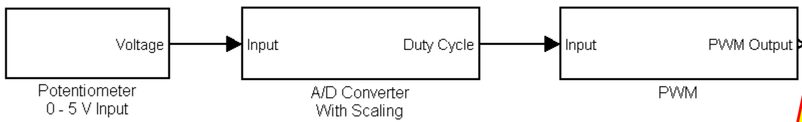


Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15 Demo 4

1) Before connecting the motor, verify that you can use the POT to control the output duty cycle. (Display in the scope)



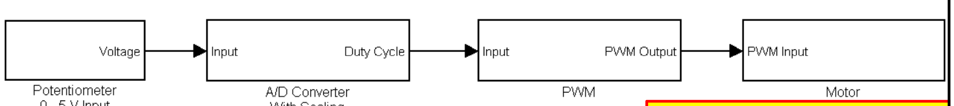
Verify this signal.

Demo___________

Motor Control Demo 5

2) Once you have verified the PWM signal on the scope, connect the PWM output of the MPC555x to the PWM input of the motor controller demo.

3) Verify the motor speed is controlled by the potentiometer.



Demo___________

Lecture 15A – Demo 1
Plant Test

- From previous simulations, you have a good idea of how the plant should respond to changes in the torque request and bulb load.
- Test your plant for various inputs and verify that it responds correctly.
- If your plant passes all of the above tests, we can now connect the plant to the controller and test our system using a complete HIL setup.

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15A – Demo 2

- Demo of HIL simulation.
  - Proportional Gain = 1
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 20 kHz
- Speed Step Response
- Bulb Step Response

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15A – Demo 3

- Demo of HIL simulation.
  - Proportional Gain = 100
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 20 kHz
- Speed Step Response
- Bulb Step Response

Demo__________

Lecture 15A – Demo 4

- Demo of HIL simulation.
  - Proportional Gain = 10
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 20 kHz
- Speed Step Response
- Bulb Step Response

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15A – Demo 5

- Demo of HIL simulation.
  - Proportional Gain = 10
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 200 kHz
  - Filter Cutoff frequency 2 kHz
- Speed Step Response
- Bulb Step Response

Demo__________

Lecture 15A – Demo 6

- Demo of HIL simulation.
  - Proportional Gain = 1
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 200 kHz
  - Filter Cutoff frequency 200 Hz
- Speed Step Response
- Bulb Step Response

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 15A – Demo 7

- Demo of HIL simulation.
  - Proportional Gain = 1
  - Integral Gain = 10
  - Fixed Step size = 1 ms
  - PWM frequency is set to 200 kHz
  - Filter Cutoff frequency 200 Hz
- Speed Step Response
- Bulb Step Response

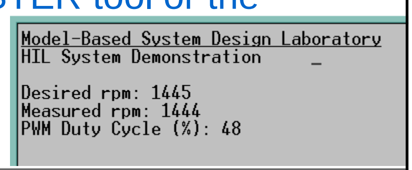
Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 16 Demo 1

Demo__________

- Once you have made all of the connections:
  - Plug in your plant. (Wear safety glasses!)
  - Verify that the motor speed follows the desired speed specified by the POT on the MPC555x demo board.
  - Display the desired speed and actual speed using either the FreeMASTER tool or the RHIT Debug Blocks.



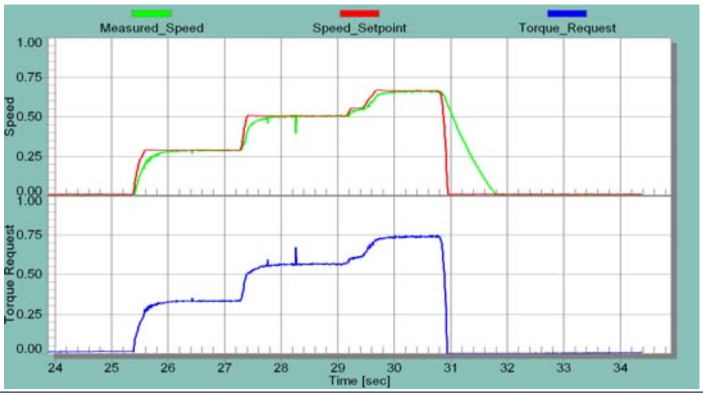
MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 16 Demo 2

Demo__________

95

- Show the step response of your system using the FreeMASTER tool. The screen capture below show the step response with no load:



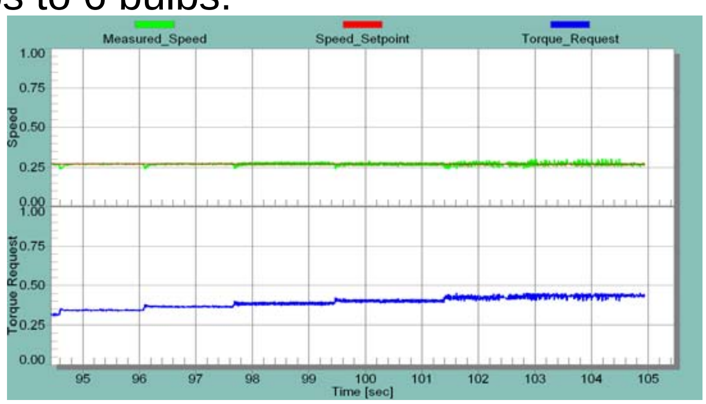
MotoTron | The MathWorks | freescale semiconductor | ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 16 Demo 3

Demo__________

96

- For constant speed request, show the system response as the bulb load is increased from no bulbs to 6 bulbs:

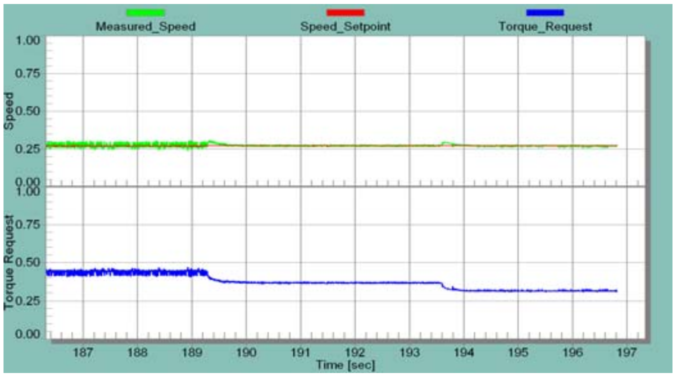


MotoTron | The MathWorks | freescale semiconductor | ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 16 Demo 4

Demo___________

- For constant speed request, show the system response as the bulb load is decreased from 6 bulbs to 2 bulbs, and then from 2 bulbs to no load: (I only have 4 fingers. If you have more fingers, you can go from 6 bulbs to no bulbs in one step.)



MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 17
Generator Model With Bulb

- Demo your working model with the New Bulb Load

Demo___________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Lecture 18 Demo 1

- We notice that we now have overshoot.
- Add a second test that verifies that the overshoot is less than 5%.
- You need to check to see how many tests pass both the rise time specification and the overshoot specification.

Demo__________

Lecture 18 Exercise 1

- Verify summary of results showing that 34 of 35 runs passed the specification.

Demo__________

MotoTron The MathWorks freescale semiconductor ROSE-HULMAN INSTITUTE OF TECHNOLOGY