

ECE 147C

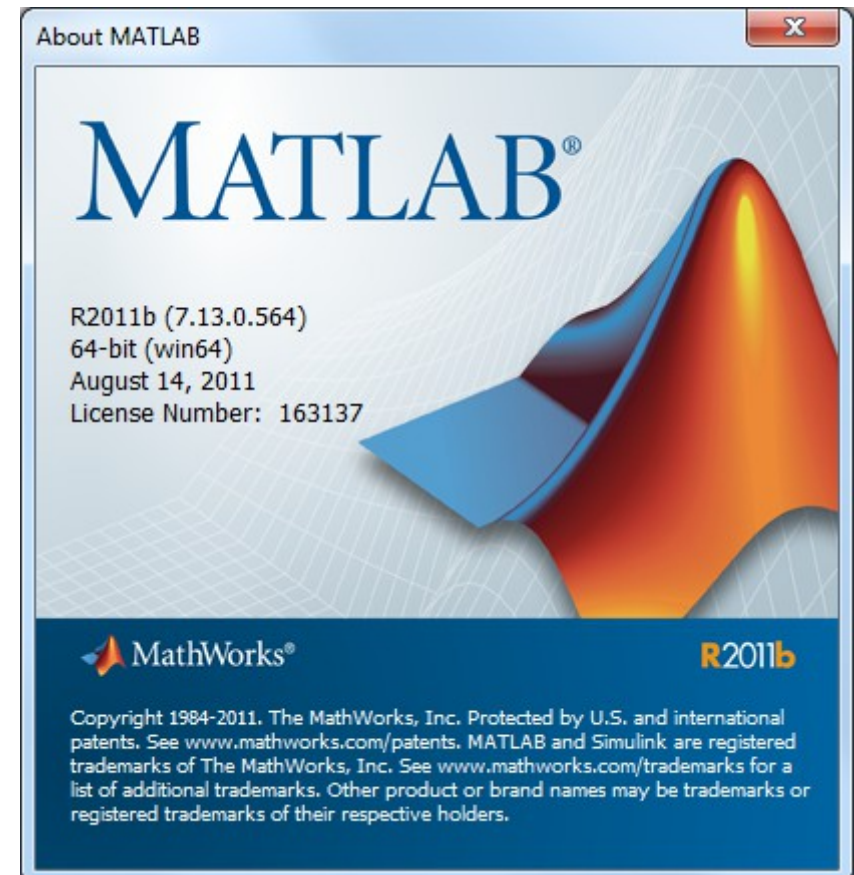
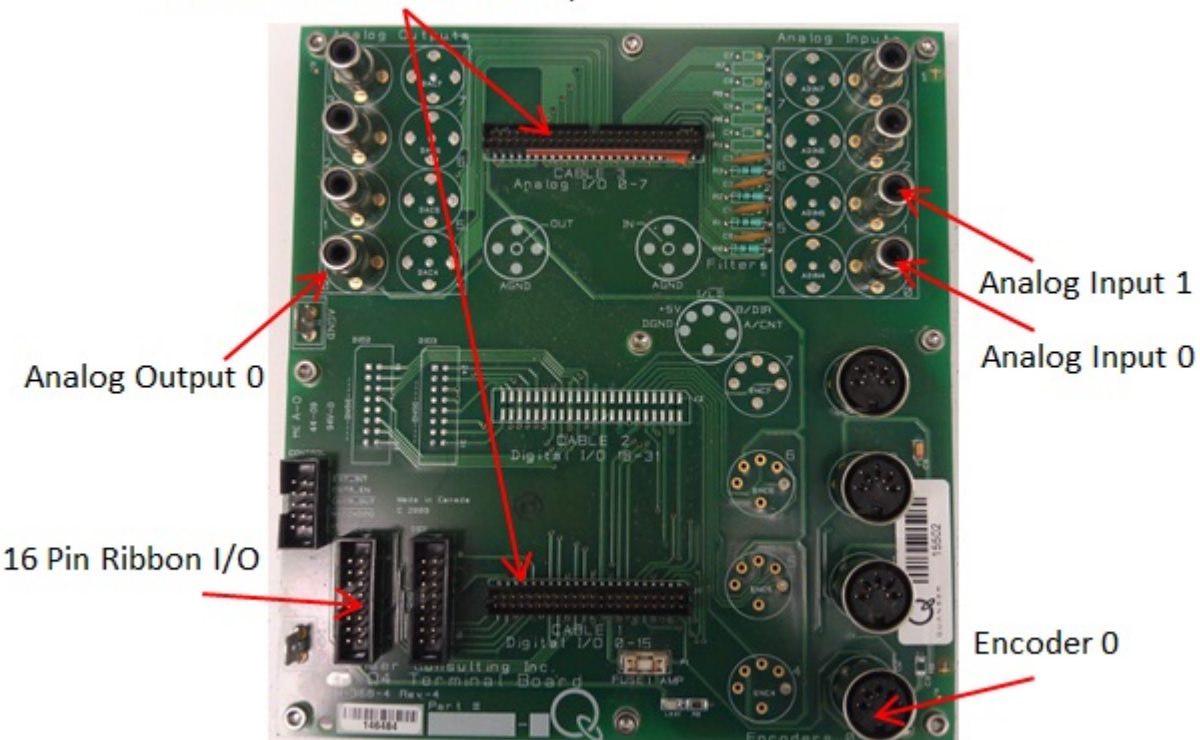
Getting started with the hardware & software

Justin Pearson

2014.04.07

Our current setup: Windows 7,
MATLAB R2011B,
Quanser Q4 terminal board

Ribbon Connections to DAQ

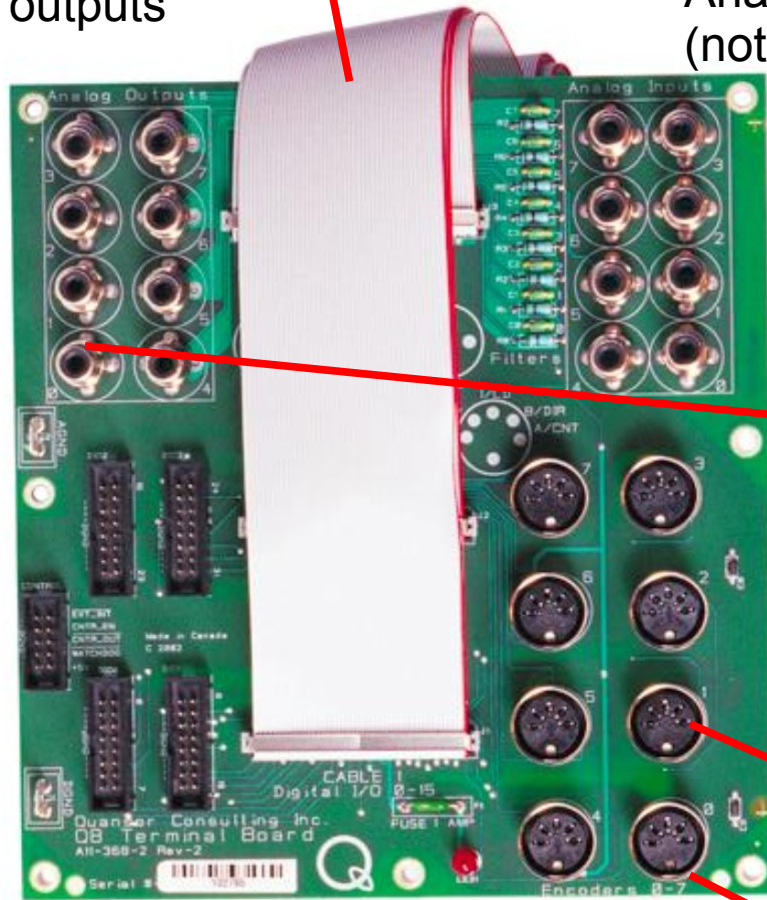


Hardware setup

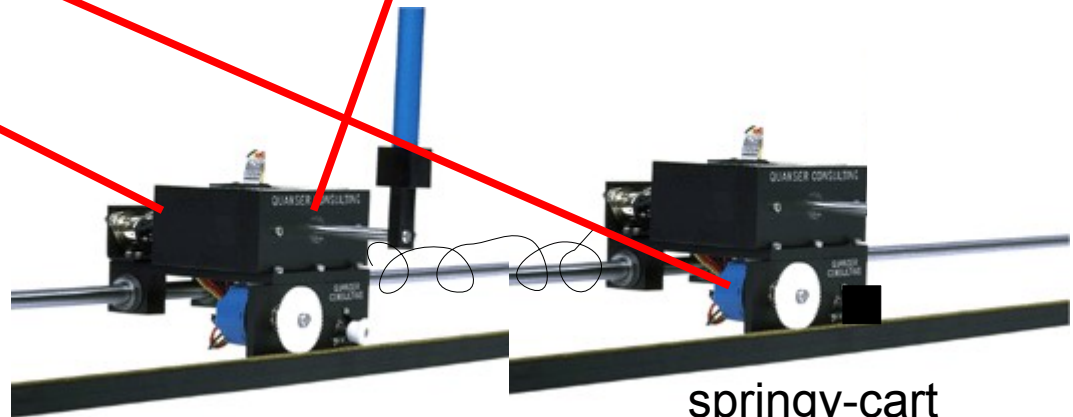
Win 7 computer

Analog outputs

Analog inputs
(not used for us?)



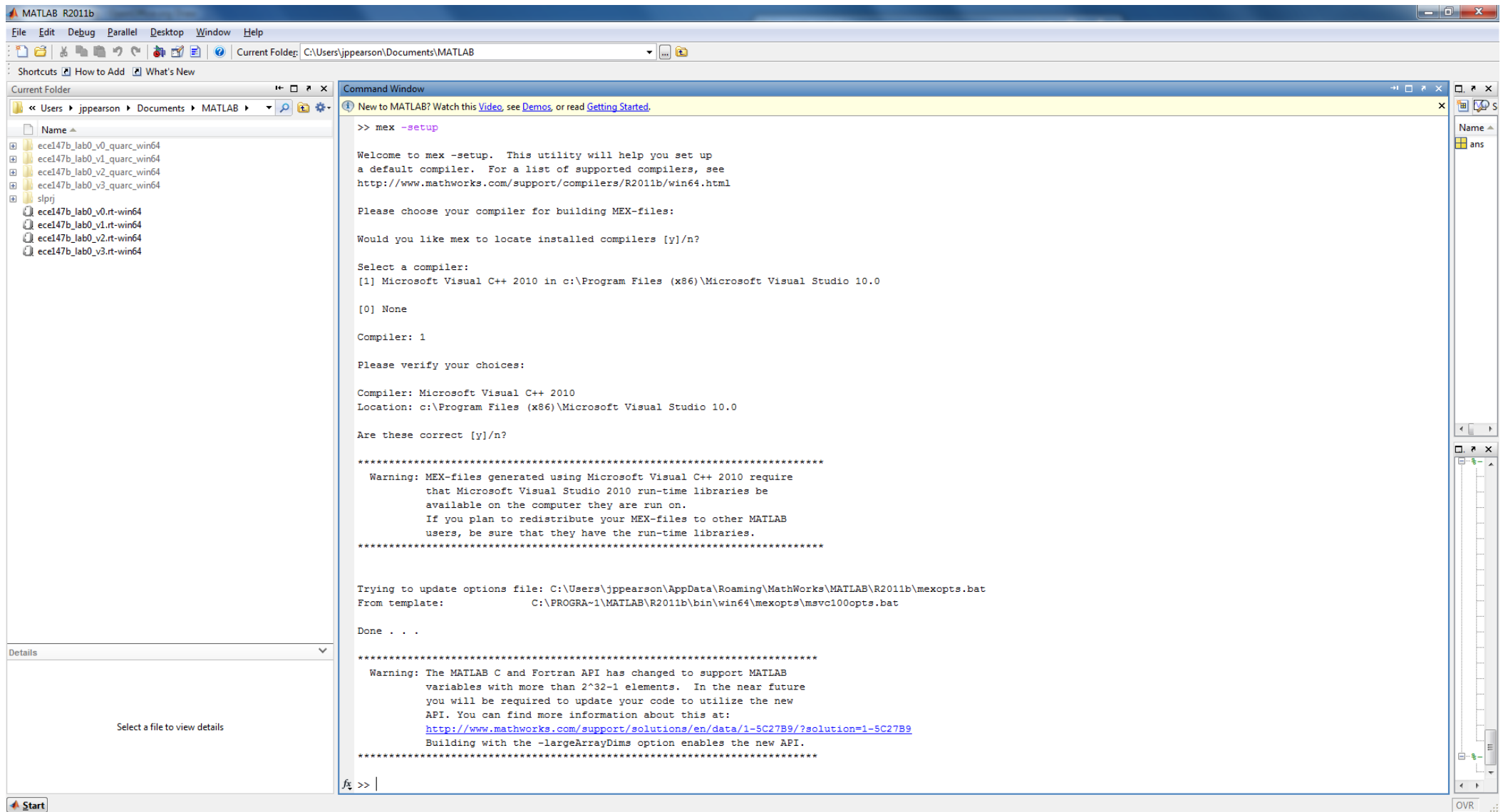
encoders

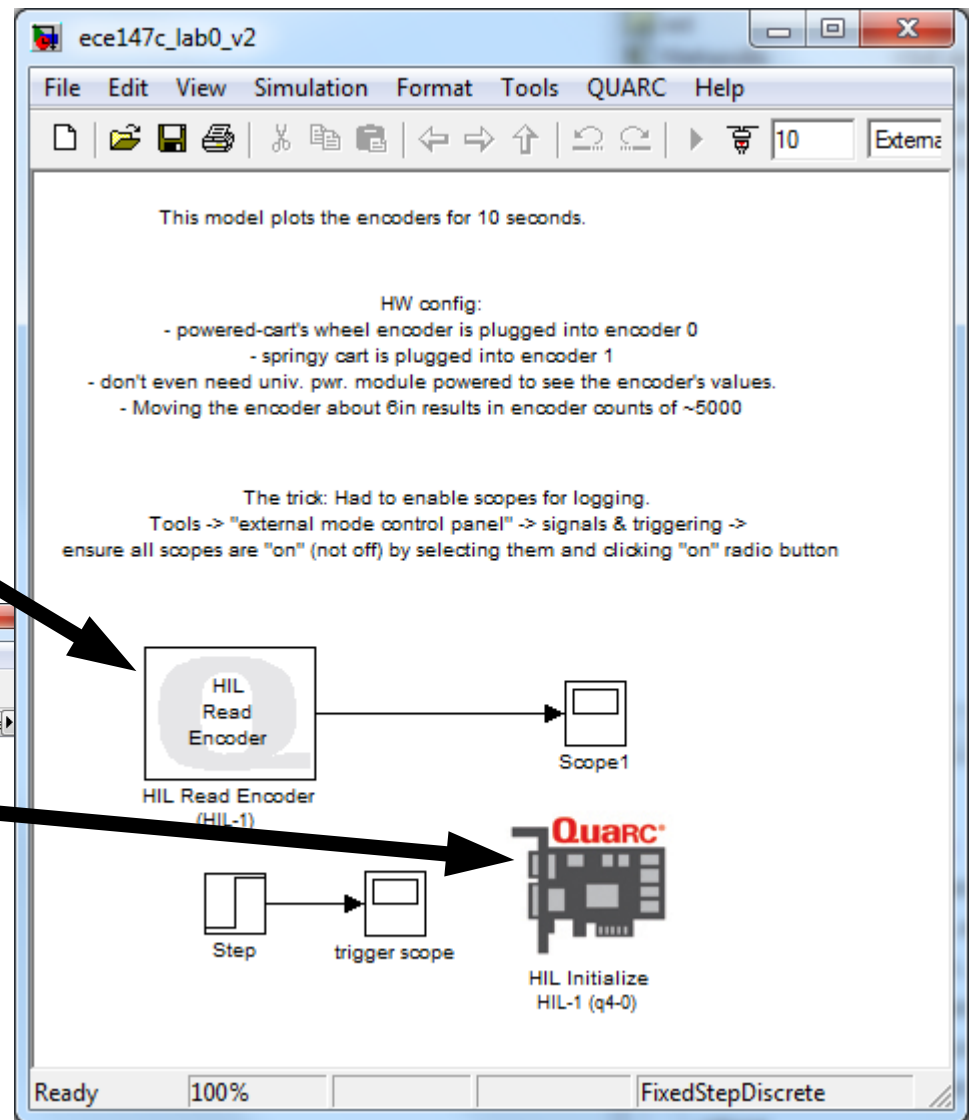
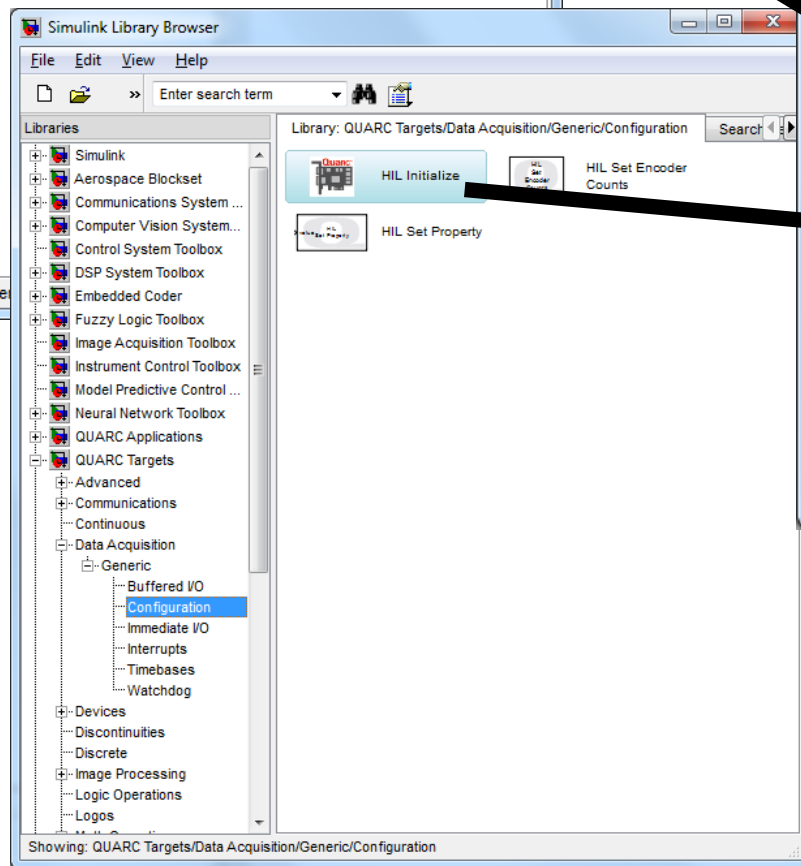
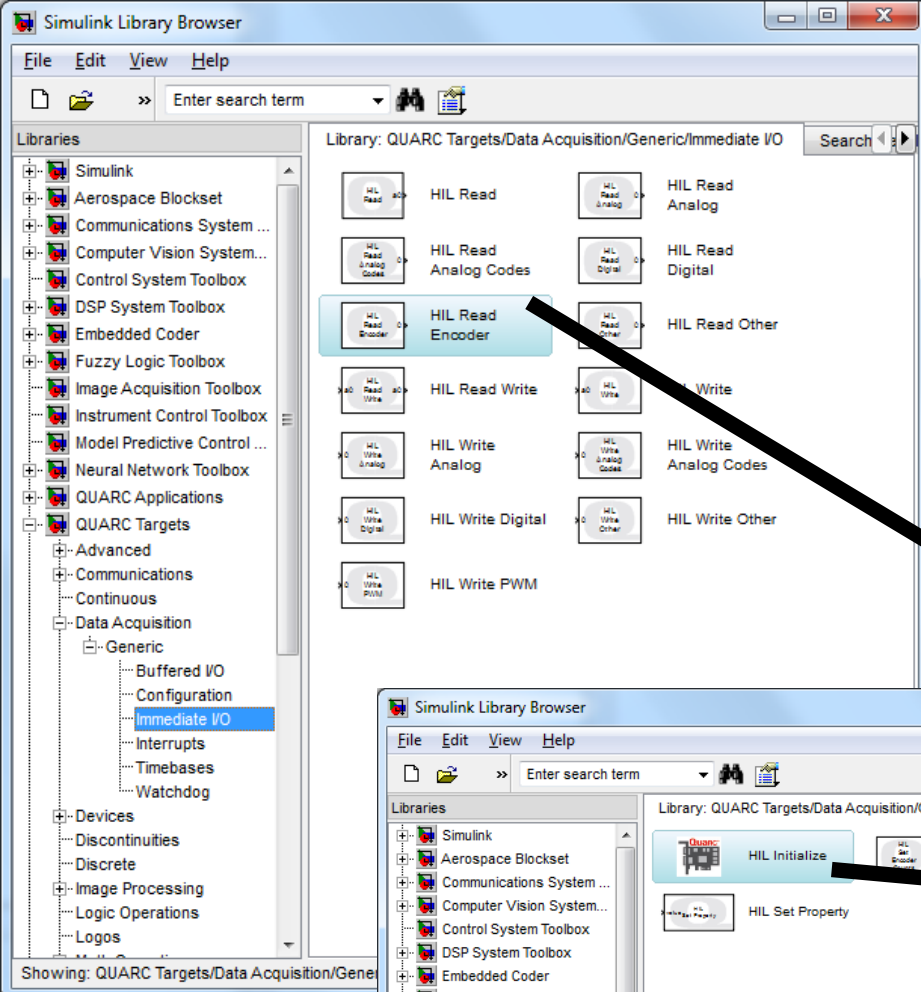


motor-cart

springy-cart

How to build a simple Simulink model to read the encoders





Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main

Clocks

Analog Inputs

Analog Outputs

Digital Inputs

Digital Outputs

Encoder Inputs

PWM Outputs

Other Outputs

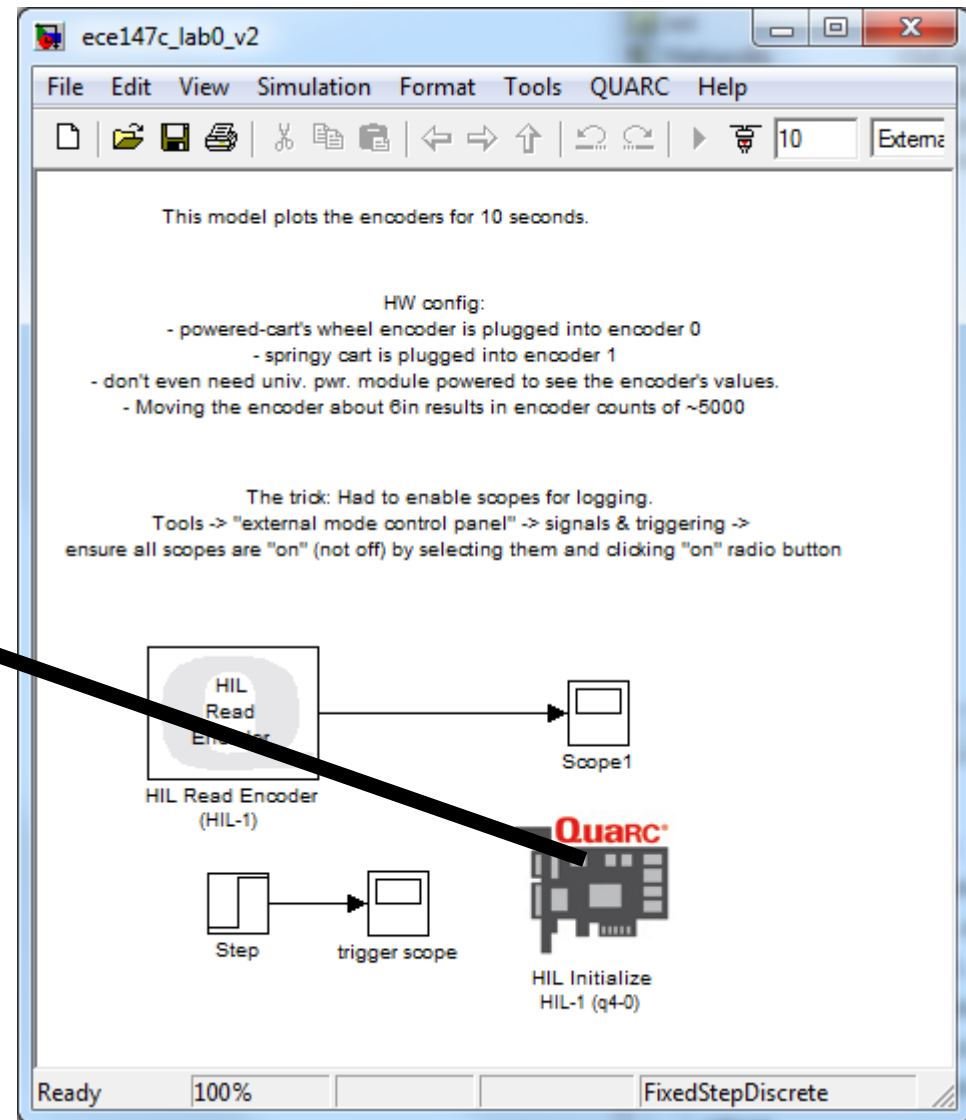
Board name:
HIL-1

Board type:
q4

Board identifier:
0

Board-specific options:
☐ Assume exclusive access to the board

OK Cancel Help Apply Defaults



Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main

Clocks

Hardware clocks:
[0:1] ...

Clock mode: (0=timebase, 1=PWM output, 2=encoder input)
[0 0]

Initial clock frequencies (specify zero to disable a clock initially):
[]

☒ Set clock parameters at model start
☐ Set clock parameters when switching to this model
☐ Set initial clock frequencies at model start
☐ Set initial clock frequencies when switching to this model

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main

Clocks

Analog Inputs

Analog input channels:
[0:3] ...

Analog input maximums:
10

Analog input minimums:
-10

☐ Set analog input parameters at model start
☐ Set analog input parameters when switching to this model

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main
Clocks
Analog Inputs
Analog Outputs
Digital Inputs
Digital Outputs
Encoder Inputs
PWM Outputs
Other Outputs

Analog output channels:
[0:3] ...

Analog output maximums:
[10]

Analog output minimums:
[-10]

Initial analog outputs:
[0]

Final analog outputs:
[0]

Analog outputs on watchdog expiry:
0

☒ Set analog output parameters at model start
☐ Set analog output parameters when switching to this model
☒ Set initial analog outputs at model start
☐ Set initial analog outputs when switching to this model
☒ Set final analog outputs at model termination
☐ Set final analog outputs when switching from this model
☐ Set the analog outputs when a watchdog timer expires

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main
Clocks
Analog Inputs
Analog Outputs
Digital Inputs
Digital Outputs
Encoder Inputs
PWM Outputs
Other Outputs

Digital input channels:
[] ...

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main
Clocks
Analog Inputs
Analog Outputs
Digital Inputs
Digital Outputs
Encoder Inputs
PWM Outputs
Other Outputs

Digital output channels:
[]

Digital output configuration (0=open-collector, 1=totem-pole):
[]

Initial digital outputs:
[1]

Final digital outputs:
[1]

Digital outputs on watchdog expiry (0=low, 1=high, 2=tristate, 3=same):
[2]

☐ Set digital output parameters at model start
☐ Set digital output parameters when switching to this model
☒ Set initial digital outputs at model start
☐ Set initial digital outputs when switching to this model
☒ Set final digital outputs at model termination
☐ Set final digital outputs when switching from this model
☐ Set the digital outputs when a watchdog timer expires

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main
Clocks
Analog Inputs
Analog Outputs
Digital Inputs
Digital Outputs
Encoder Inputs
PWM Outputs
Other Outputs

Encoder input channels:
[0:3]

Encoder quadrature: (0=none, 1=1X, 2=2X, 4=4X)
[4]

Encoder filter frequency in Hertz:
(1/60e-9)/1

Initial encoder counts:
[0]

☒ Set encoder input parameters at model start
☐ Set encoder input parameters when switching to this model
☒ Set initial encoder counts at model start
☐ Set initial encoder counts when switching to this model

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main

Clocks

Analog Inputs

Analog Outputs

Digital Inputs

Digital Outputs

Encoder Inputs

PWM Outputs

Other Outputs

PWM output channels:
[] ...

Mode: (0=duty cycle, 1=frequency, 2=period, 3=one-shot, 4=time, 5=encode)
[0] ...

Frequency in Hz (mode 0, 3 and 4) or duty cycle (modes 1 and 2):
(1/60e-9)/1024 ...

Configuration (0=unipolar, 1=bipolar, 2=paired, 3=complementary)
[] ...

Alignment (0=leading-edge, 1=trailing-edge, 2=center-aligned):
[] ...

Polarity (0=active low, 1=active high):
[] ...

Leading-edge deadband (seconds):
[] ...

Trailing-edge deadband (seconds):
[] ...

Initial PWM outputs:
[0]

Final PWM outputs:
[0]

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Initialize

HIL Initialize
Initializes a hardware-in-the-loop card.

Navigation
Goto HIL blocks using this board...

Main

Clocks

Analog Inputs

Analog Outputs

Digital Inputs

Digital Outputs

Encoder Inputs

PWM Outputs

Other Outputs

Other output channels:
[] ...

Initial other outputs:
[]

Final other outputs:
[]

Other outputs on watchdog expiry:
[]

☐ Set initial other outputs at model start

☐ Set initial other outputs when switching to this model

☐ Set final other outputs at model termination

☐ Set final other outputs when switching from this model

☐ Set the other outputs when a watchdog timer expires

OK Cancel Help Apply Defaults

Source Block Parameters: HIL Read Encoder

HIL Read Encoder
Reads encoder input channels of a hardware-in-the-loop card. Outputs the count values read from the encoder counters.

Navigation
Go to HIL blocks using this board...

Main | **Signal Data Types**

Board name: HIL-1

Channels: [0:3]

Sample time (seconds): .001

☒ Vector output

OK Cancel Help Apply

'Scope1' parameters

General | History | Graphics

☐ Limit data points to last: 5000

☒ Save data to workspace

Variable name: ScopeData1

Format: Array

OK Cancel Help Apply

Source Block Parameters: Step

Step
Output a step.

Parameters

Step time: 1

Initial value: 0

Final value: 1

Sample time: .0010

☒ Interpret vector parameters as 1-D

☒ Enable zero-crossing detection

OK Cancel Help Apply

'trigger scope' parameters

General | History | Graphics

☐ Limit data points to last: 5000

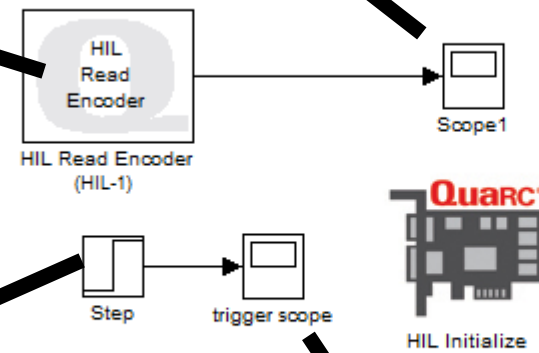
☒ Save data to workspace

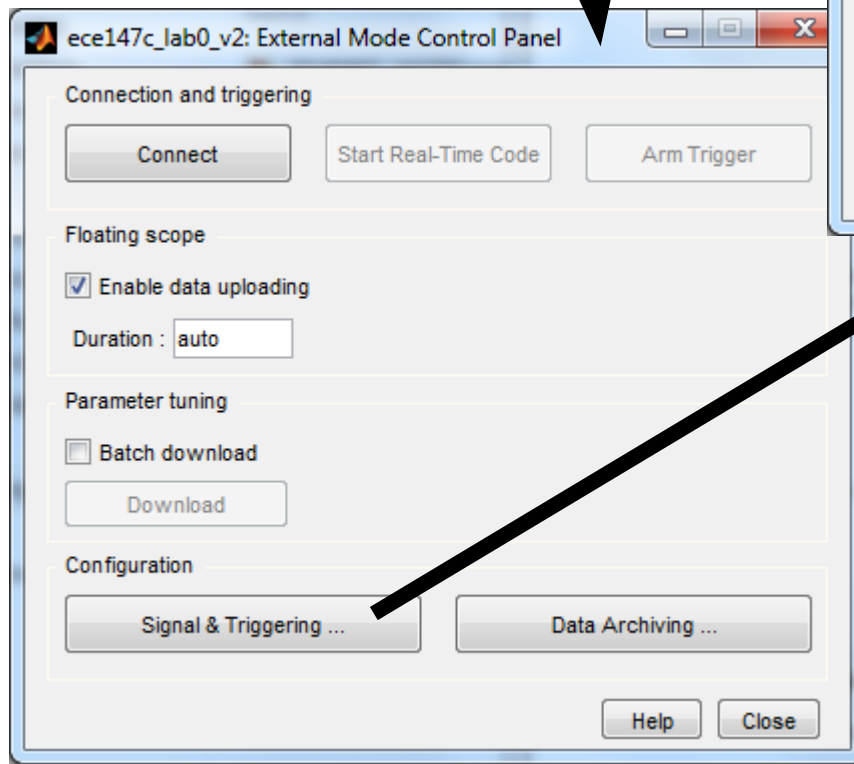
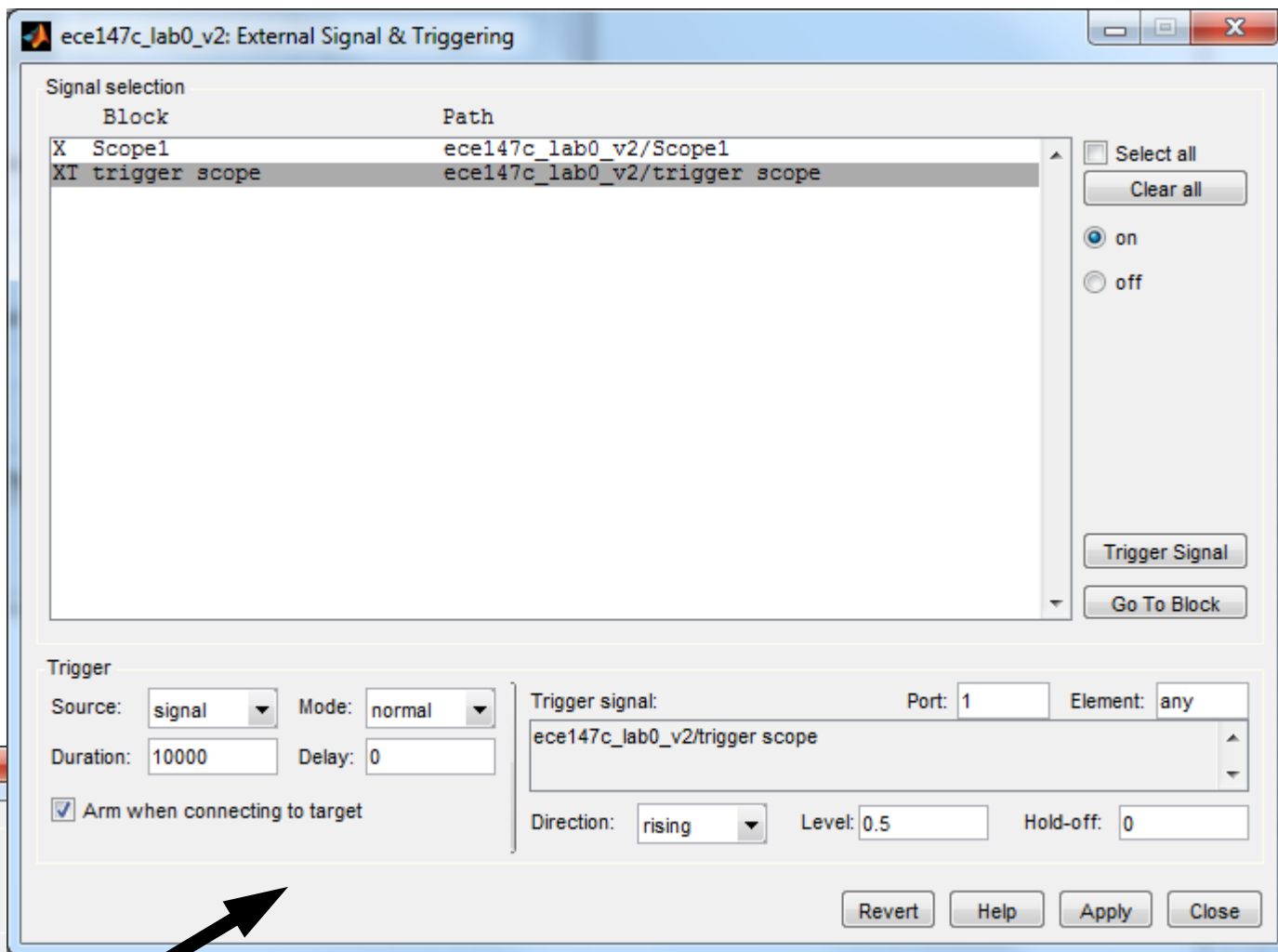
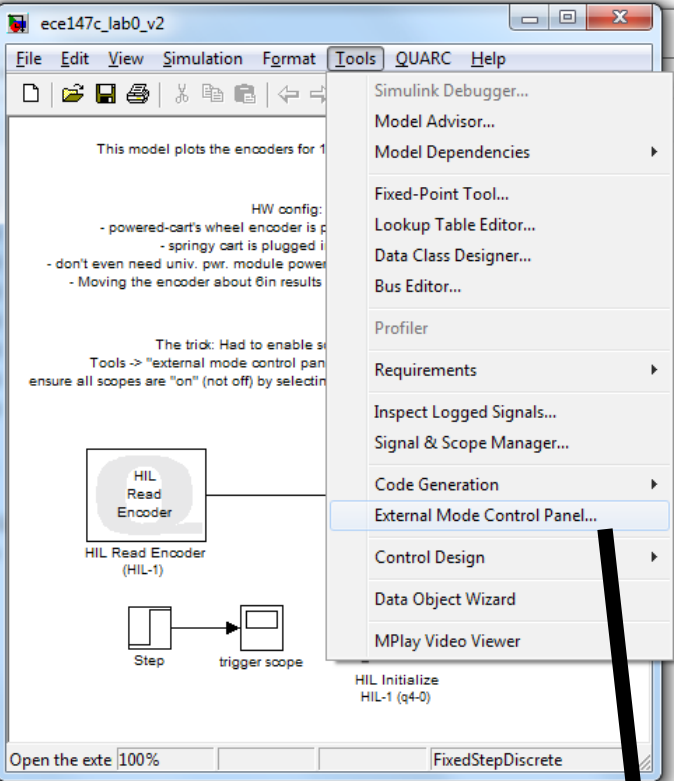
Variable name: ScopeData

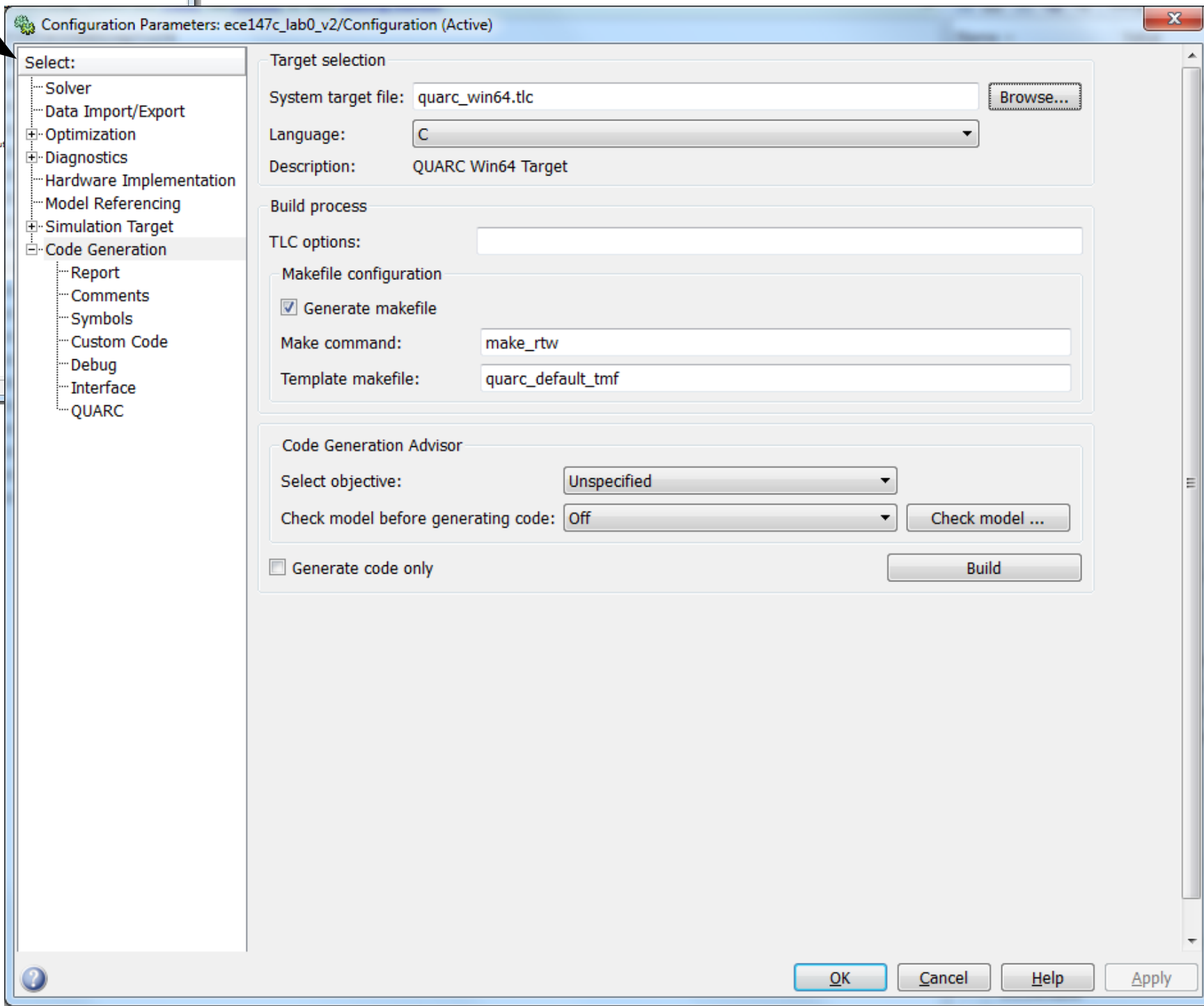
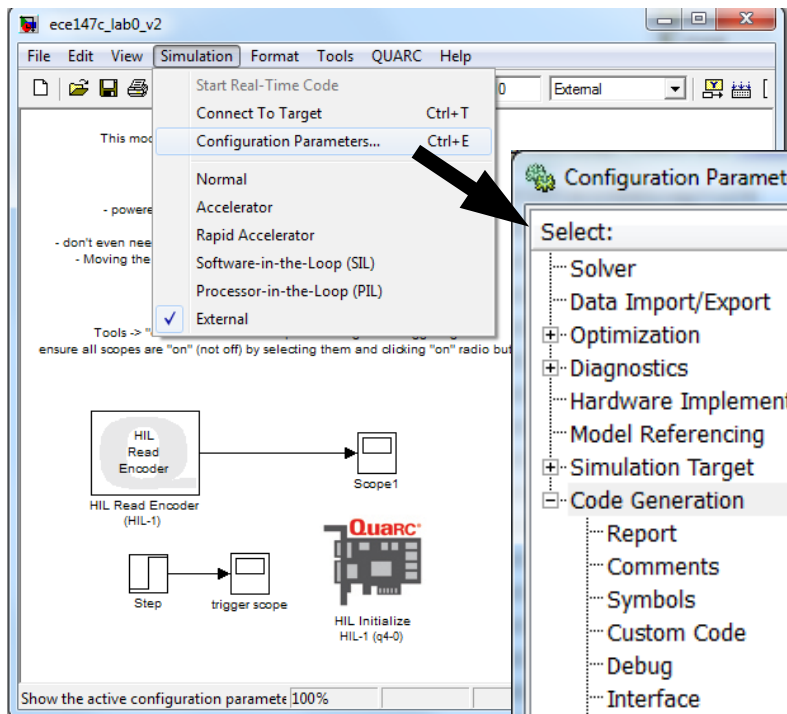
Format: Array

OK Cancel Help Apply

ensure all scopes are "on" (not only selecting them and clicking "on" radio button)







Configuration Parameters: ece147c_lab0_v2/Configuration (Active)

Select:

- Solver
- Data Import/Export
- Optimization
- Diagnostics
- Hardware Implementation
- Model Referencing
- Simulation Target
- Code Generation
 - Report
 - Comments
 - Symbols
 - Custom Code
 - Debug
 - Interface
 - QUARC

Software environment

Target function library: C89/C90 (ANSI)

Shared code placement: Auto

☒ Support non-finite numbers

Data exchange

☐ MAT-file logging

Interface: External mode

Host/Target interface

Transport layer: quarc MEX-file name: quarc_comm

MEX-file arguments: '-w -d %d -uri %u'

Memory management

☐ Static memory allocation

OK Cancel Help Apply

Configuration Parameters: ece147c_lab0_v2/Configuration (Active)

Select:

- Solver
- Data Import/Export
- Optimization
- Diagnostics
- Hardware Implementation
- Model Referencing
- Simulation Target
- Code Generation
 - Report
 - Comments
 - Symbols
 - Custom Code
 - Debug
 - Interface
 - QUARC

☐ MAT-file logging

☐ Stop the model if an overrun occurs

☐ Allow use of fast system timer (experimental)

☒ Allow console output (printing to stdout)

☐ Support dynamic reconfiguration

☐ Show compilation times

☐ Debug version

☐ Enable heap checking (debug version only)

Assertions: Stop model with an error

Minimum thread priority: 2

Stack size: 0

Model affinity: []

OK Cancel Help Apply

Configuration Parameters: ece147c_lab0_v2/Configuration (Active)

Select:

- Solver
- Data Import/Export
- Optimization
- Diagnostics
- Hardware Implementation
- Model Referencing
- Simulation Target
- Code Generation
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 - Symbols
 - Custom Code
 - Debug
 - Interface
 - QUARC

Simulation time

Start time: 0.0 Stop time: 10

Solver options

Type: Fixed-step Solver: discrete (no continuous states)

Fixed-step size (fundamental sample time): 0.001

Tasking and sample time options

Periodic sample time constraint: Unconstrained

Tasking mode for periodic sample times: Auto

☐ Automatically handle rate transition for data transfer

☒ Higher priority value indicates higher task priority

OK Cancel Help Apply

Configuration Parameters: ece147c_lab0_v2/Configuration (Active)

Select:

Solver

Data Import/Export

Optimization

Diagnostics

Hardware Implementation

Model Referencing

Simulation Target

Code Generation

Report

Comments

Symbols

Custom Code

Debug

Interface

QUARC

Embedded hardware (simulation and code generation)

Device vendor: Generic

Device type: Unspecified (assume 32-bit Generic)

Number of bits

char: 8

short: 16

int: 32

long: 32

float: 32

double: 64

native: 32

pointer: 32

Largest atomic size

integer: Char

floating-point: None

Byte ordering: Unspecified

Signed integer division rounds to: Undefined

☒ Shift right on a signed integer as arithmetic shift

Emulation hardware (code generation only)

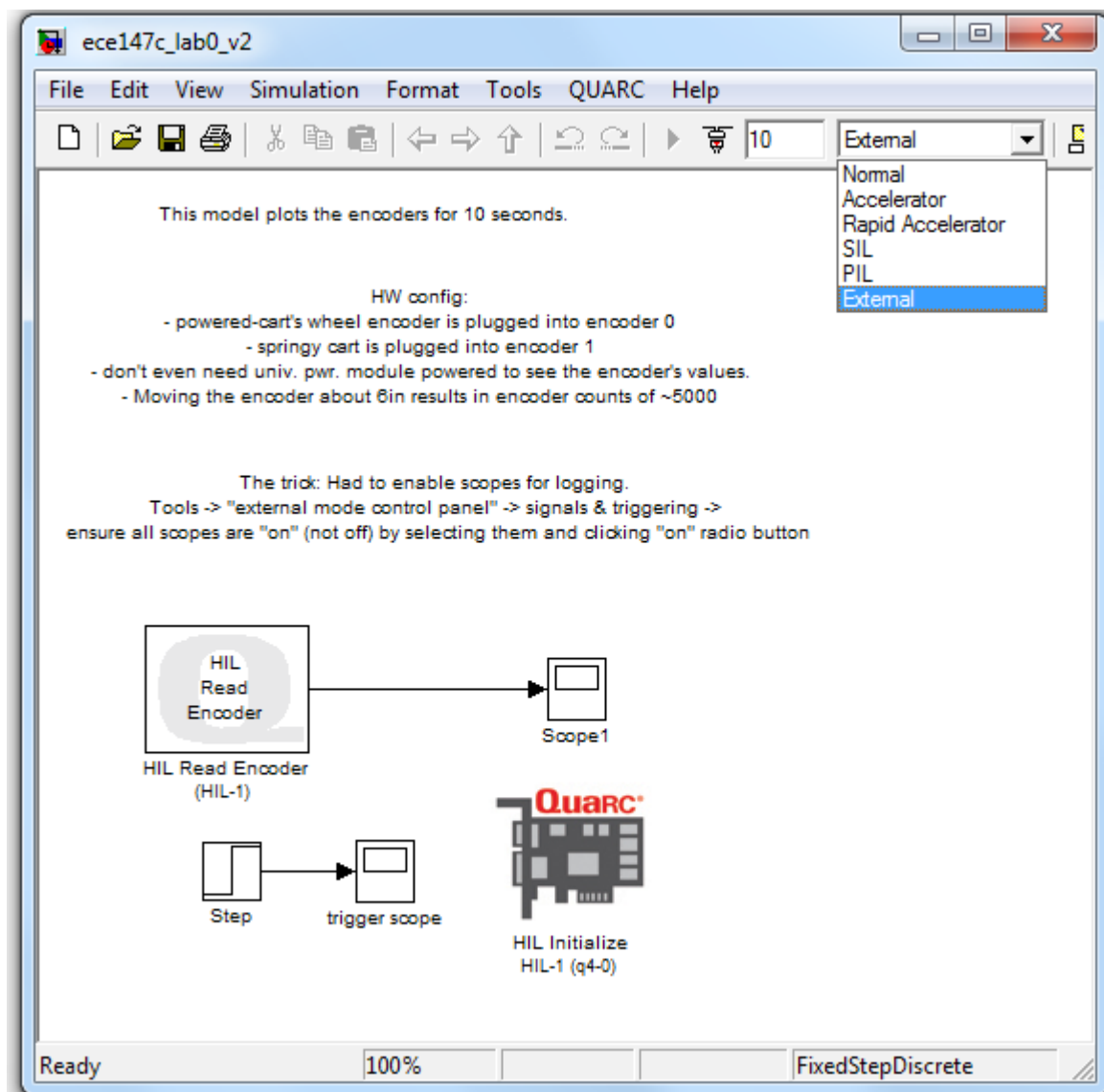
☒ None

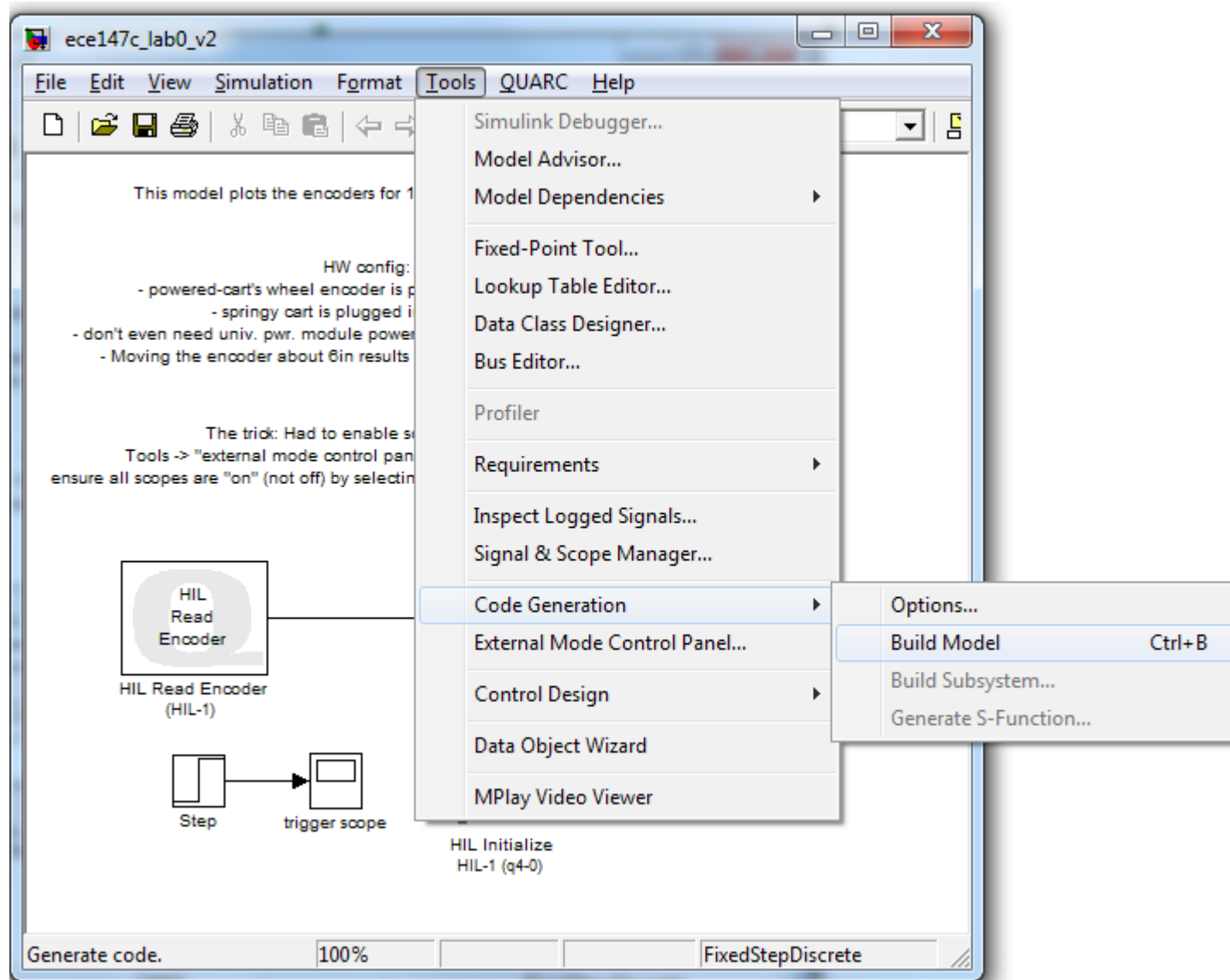
OK

Cancel

Help

Apply





MATLAB R2011b

File Edit Debug Parallel Desktop Window Help

Current Folder: X:\ECE147C_AdvancedDigitalControlLab_Hespanha_Spr2014\Labs\Tools

Shortcuts How to Add What's New

Current Folder

<< Labs >> Tools

Name

- ece147c_lab0_v2_quarc_win64
- slprj
- lock.asdf.odp#
- lock.lab0_v2_setup.odg#
- 20140407_142203.png
- 20140407_142323.png
- 20140407_142353.png
- 20140407_142412.png
- 20140407_142430.png
- 20140407_142501.png
- 20140407_142511.png
- 20140407_142523.png
- 20140407_142655.png
- 20140407_142758.png
- 20140407_142822.png
- 20140407_143557.png
- 20140407_143632.png
- 20140407_143637.png
- 20140407_143646.png
- 20140407_143651.png
- 20140407_143701.png
- 20140407_143704.png
- 20140407_143714.png
- 20140407_143718.png
- 20140407_144614.png
- 20140407_144619.png
- 20140407_144634.png
- 20140407_144641.png
- 20140407_144647.png
- 20140407_144658.png
- 20140407_144852.png
- 20140407_144951.png
- asdf.odp
- bodeomatic.zip
- ece147c_lab0_v2.rt-win64
- lab0_v2_setup.odg
- manipulate_bode.fig
- manipulate_bode.m

Details

Select a file to view details

Command Window

New to MATLAB? Watch this [Video](#), see [Demos](#), or read [Getting Started](#).

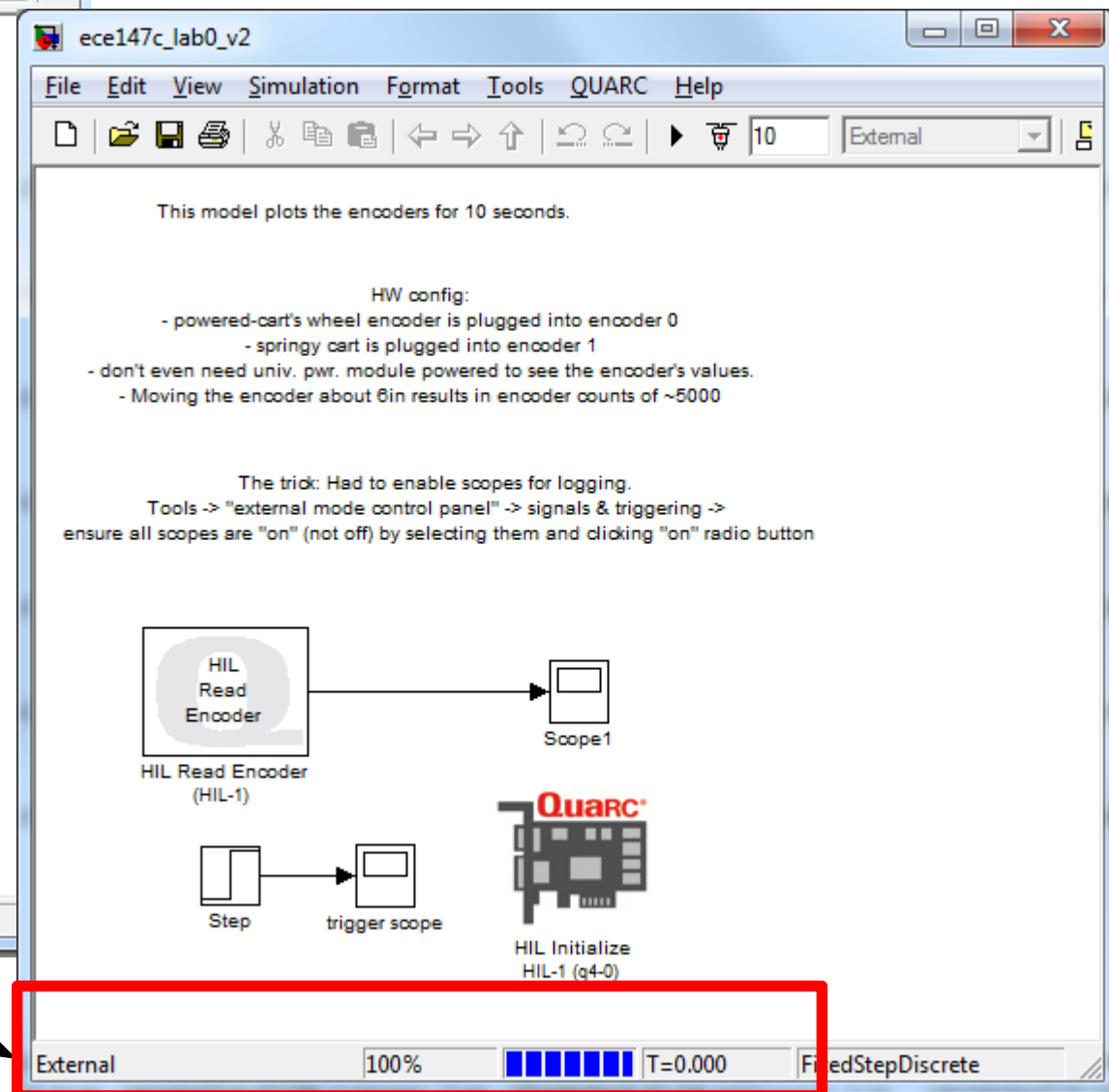
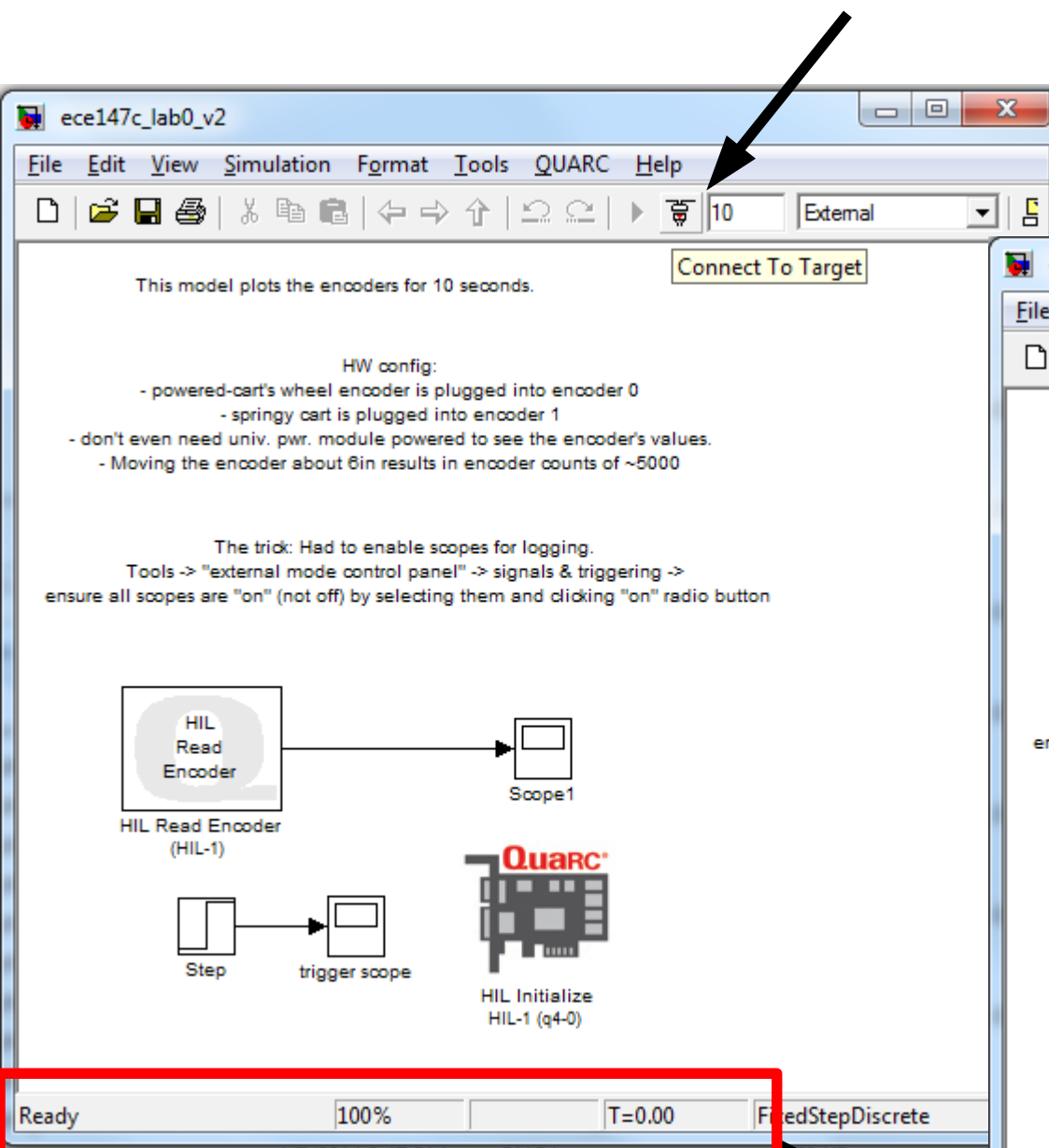
```
*** Generating the interface API.
...
*** Creating data type transition file ece147c_lab0_v2_dt.h
...
*** Creating project marker file: rtw_proj.tmw
...
*** Processing Template Makefile: C:\Program Files\Quanser\QUARC\quarc\R2009a\quarc_win64.tmf
*** Creating ece147c_lab0_v2.mk from C:\Program Files\Quanser\QUARC\quarc\R2009a\quarc_win64.tmf
*** Building ece147c_lab0_v2: .\ece147c_lab0_v2.bat

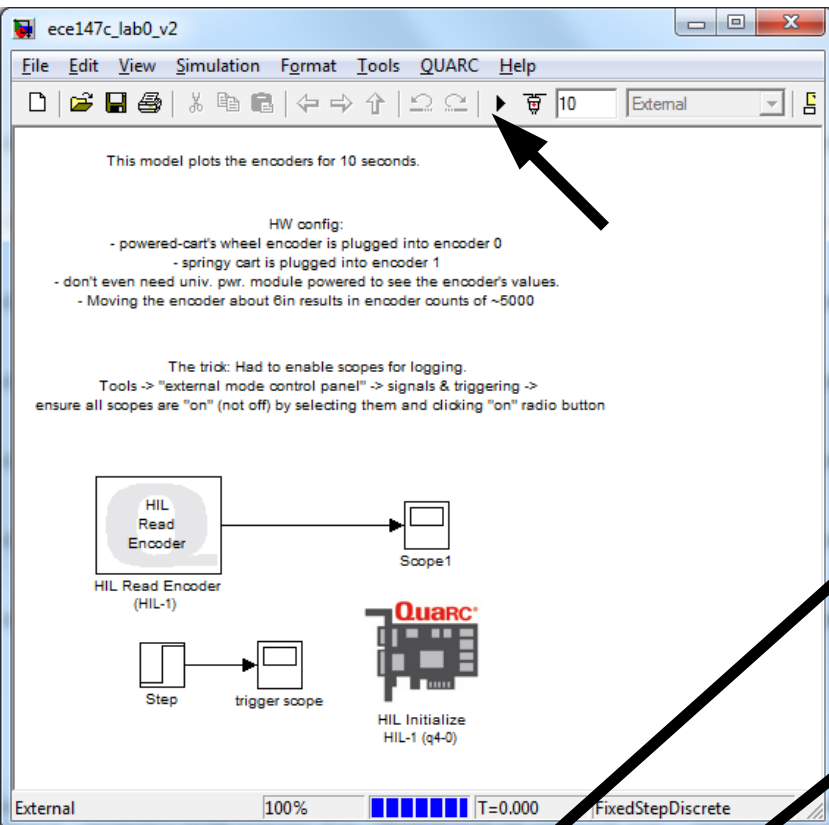
X:\ECE147C_AdvancedDigitalControlLab_Hespanha_Spr2014\Labs\Tools\ece147c_lab0_v2_quarc_win64>call "c:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\vcvarsall.bat" x86_
Setting environment for using Microsoft Visual Studio 2010 x64 cross tools.

Microsoft (R) Program Maintenance Utility Version 10.00.30319.01
Copyright (C) Microsoft Corporation. All rights reserved.

*** Compiling ece147c_lab0_v2.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
ece147c_lab0_v2.c
*** Compiling ece147c_lab0_v2_data.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
ece147c_lab0_v2_data.c
*** Compiling ece147c_lab0_v2_main.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
ece147c_lab0_v2_main.c
*** Compiling rtGetInf.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
rtGetInf.c
*** Compiling rtGetNaN.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
rtGetNaN.c
*** Compiling rt_nonfinite.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
rt_nonfinite.c
*** Compiling C:\PROGRA~1\MATLAB\R2011b\rtw\c\src\rt_sim.c
cl -Ox -DNDEBUG -DEXT_MODE -DMODEL_URI="shmем://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
rt_sim.c
Microsoft (R) Windows (R) Resource Compiler Version 6.1.7600.16385
Copyright (C) Microsoft Corporation. All rights reserved.

*** Linking ...
C:\PROGRA~1\MATLAB\R2011b\sys\perl\win32\bin\perl C:\PROGRA~1\MATLAB\R2011b\rtw\c\tools\mkvc_lnk.pl ece147c_lab0_v2.1k ece147c_lab0_v2.obj ece147c_lab0_v2_data.obj ece14
link /RELEASE /INCREMENTAL:NO /NOLOGO -subsystem:console,5.02 /NODEFAULTLIB:libc.lib /NODEFAULTLIB:libcmtd.lib /NODEFAULTLIB:msvcrt.lib /NODEFAULTLIB:libcd.lib /NODEFA
*** Created executable ece147c_lab0_v2.rt-win64
*** Downloading ece147c_lab0_v2 to target 'shmем://quarc-target:1' ...
*** Model ece147c_lab0_v2 has been downloaded to target 'shmем://quarc-target:1' (65536 bytes)
>>
fx >> % yay, no errors :)
```

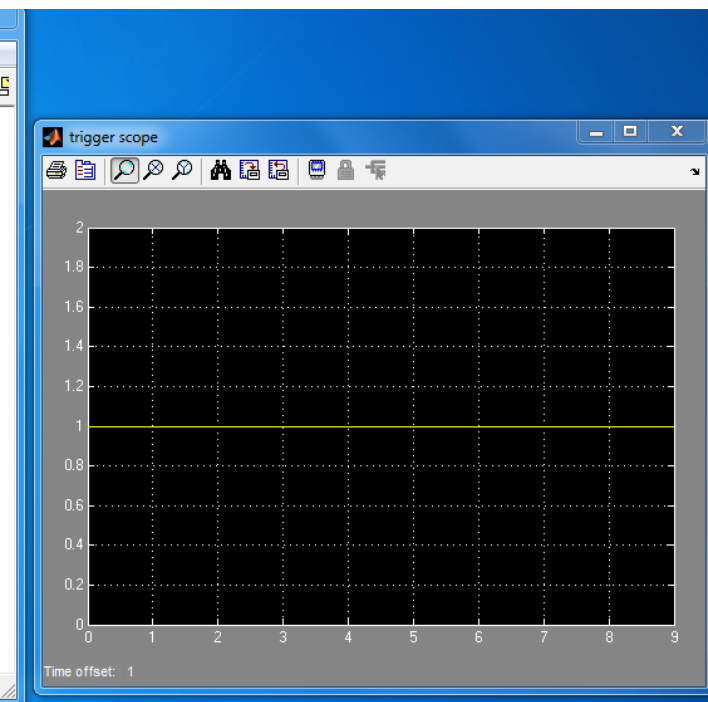
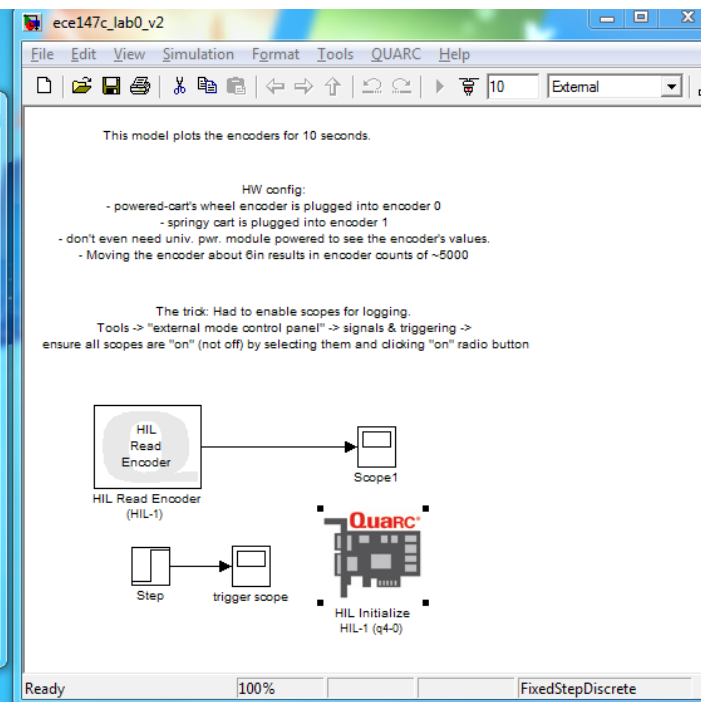
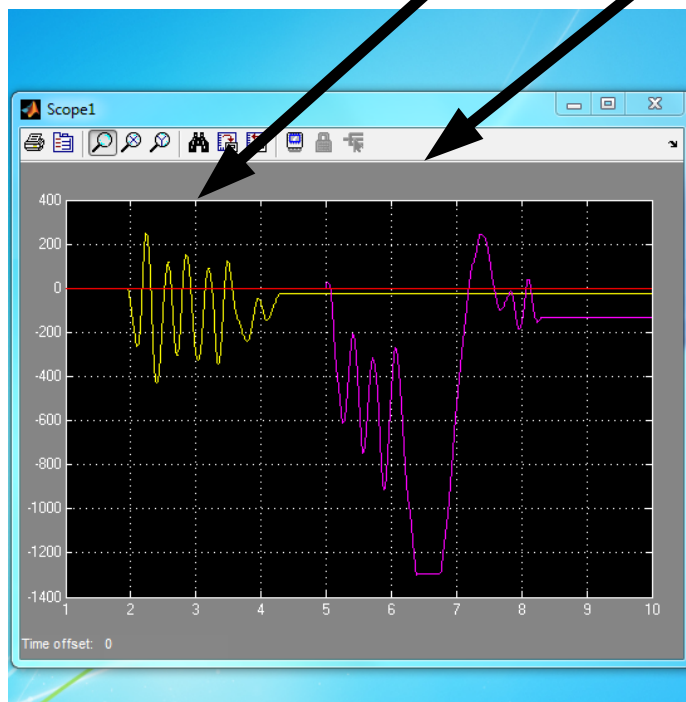




Wiggle motor-cart's wheel encoder

Wiggle springy-cart's wheel encoder

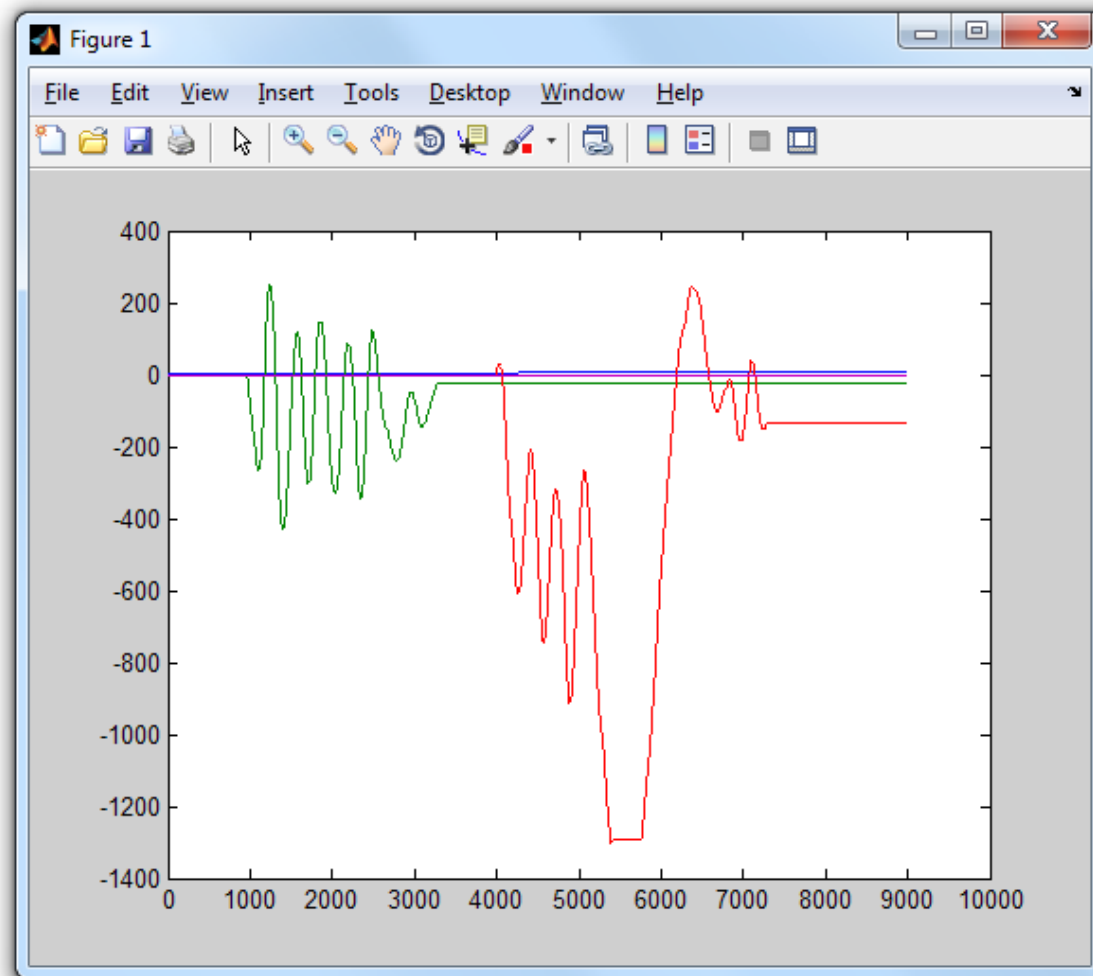
Note: doesn't show 3 encoders??



Command Window

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```
>> whos  
      Name      Size      Bytes  Class  Attributes  
  
ScopeData      9001x2      144016  double  
ScopeData1     9001x5      360040  double  
  
>> plot(ScopeData1)  
fx >>
```



Next: move motor

ece147c_lab0_v3

File Edit View Simulation Format Tools QUARC Help

10 External

Move cart slightly

This model sends a sine wave command to the motor.

HW config:

- powered-cart's wheel encoder is plugged into encoder 0
- springy cart is plugged into encoder 1
- don't even need univ. pwr. module powered to see the encoder's values.
- Moving the encoder about 6in results in encoder counts of ~5000
- Sin amplitude is 2, freq is 2π . Results in very small 3" wiggles

The trick: Had to enable scopes for logging.
Tools -> "external mode control panel" -> signals & triggering -> ensure all scopes are "on" (not off) by selecting them and clicking "on" radio button

Note: this is also reqd to add a new scope

HIL Read Encoder (HIL-1)

Scope1

Step

trigger scope

Sine Wave

HIL Write Analog (HIL-1)

to motor

Quarc

HIL Initialize HIL-1 (q4-0)

Ready 108% FixedStepDiscrete

ece147c_lab0_v3

File Edit View Simulation

Move cart slightly

This model sends a

- powered-cart's
- springy
- don't even need univ. pv
- Moving the encoder
- Sin amplitude is 2,

The trick

Tools -> "external

ensure all scopes are "on" (

Source Block Parameters: HIL Write A

HIL Write Analog

Writes to analog output channels of a har
card. Inputs are the analog output voltage

Navigation

Go to HIL blocks using this board...

Board name: HIL-1

Channels:
0

Sample time (seconds):
0.001

☐ Vector input

OK Cancel Help Apply

Source Block Parameters: Sine Wave

Sine Wave

Output a sine wave:

$$O(t) = \text{Amp} * \sin(\text{Freq} * t + \text{Phase}) + \text{Bias}$$

Sine type determines the computational technique used. The
parameters in the two types are related through:

$$\text{Samples per period} = 2 * \pi / (\text{Frequency} * \text{Sample time})$$
$$\text{Number of offset samples} = \text{Phase} * \text{Samples per period} / (2 * \pi)$$

Use the sample-based sine type if numerical problems due to running
for large times (e.g. overflow in absolute time) occur.

Parameters

Sine type: Time based

Time (t): Use simulation time

Amplitude:
2

Bias:
0

Frequency (rad/sec):
 $2 * \pi$

Phase (rad):
 $\pi / 2$

Sample time:
.001

☒ Interpret vector parameters as 1-D

OK Cancel Help Apply

'to motor' parameters

General History Graphics

☐ Limit data points to last: 5000

☒ Save data to workspace

Variable name: motor_cmd

Format: Structure with time

OK Cancel Help Apply

HIL Read Encoder (HIL-1)

Read Encoder (HIL-1)

step trigger scope

HIL Initialize HIL-1 (q4-0)

Sine Wave

to motor

HIL Write Analog (HIL-1)

108% FixedStepDiscrete

Troubleshooting:

- is Universal power module on?
- Is analog output cable connecting analog output 0 to UPM's "From D/A"?
- Is cable from UPM's "To Load" to motor-cart's motor plug?
- Is simulink "HIL Write Analog" block set to same channel as the board's analog output?