

ECE 147C

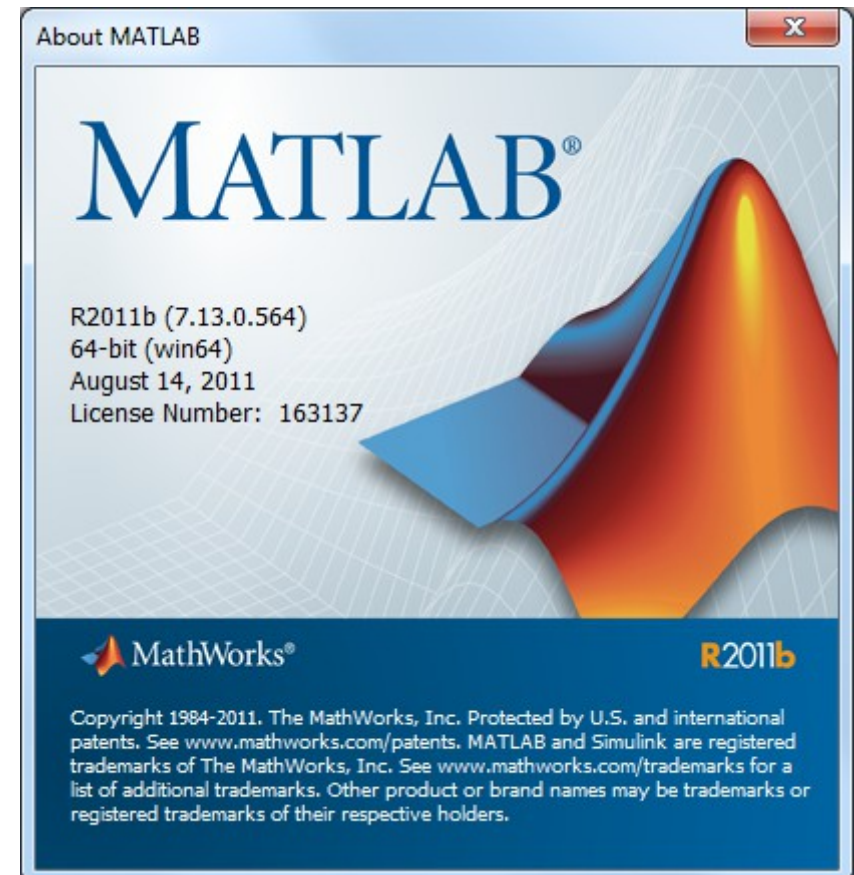
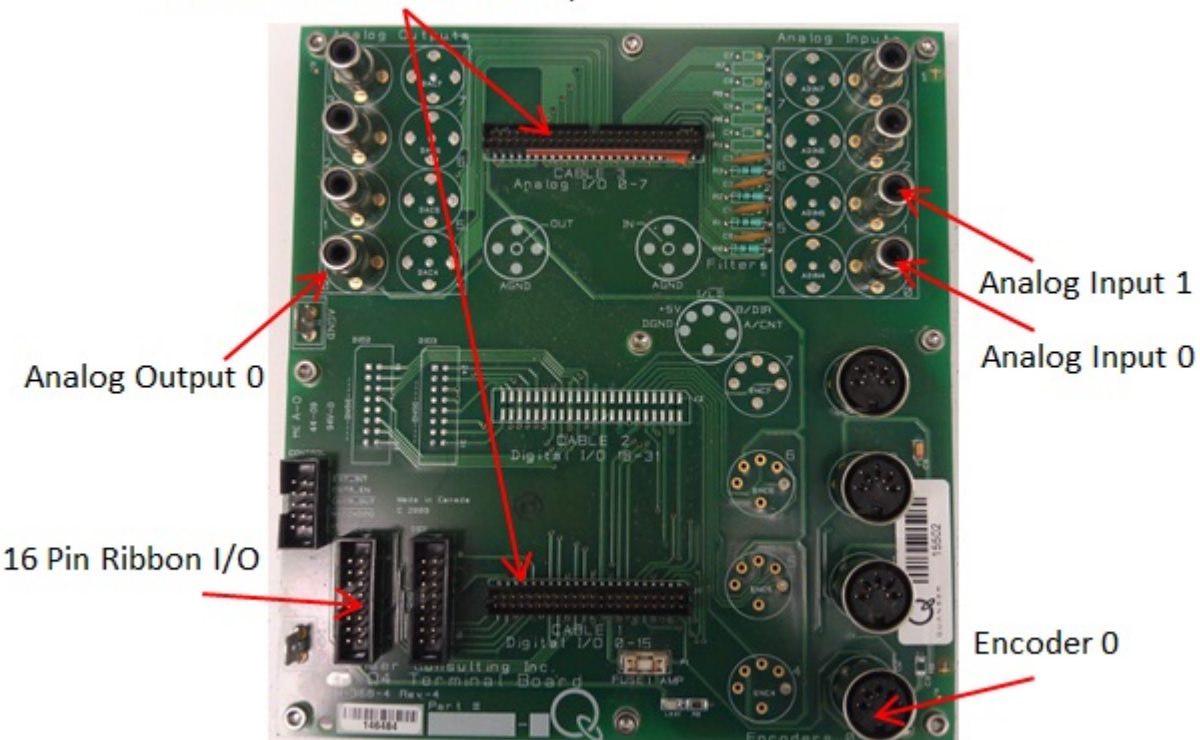
Getting started with the hardware & software

Justin Pearson

2014.04.07

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

Ribbon Connections to DAQ

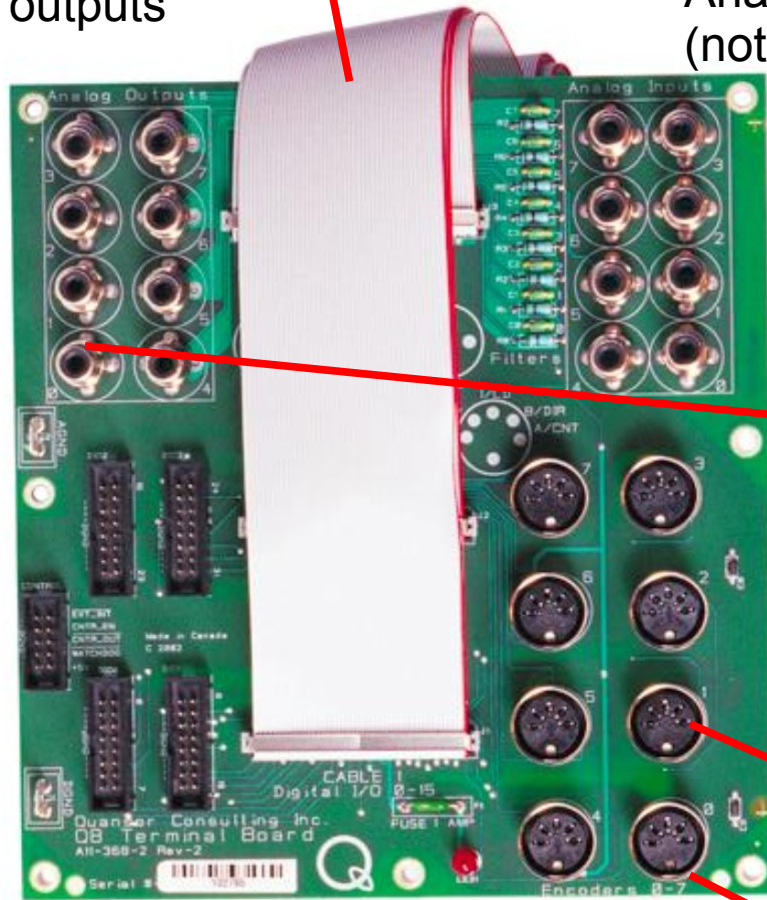


Hardware setup

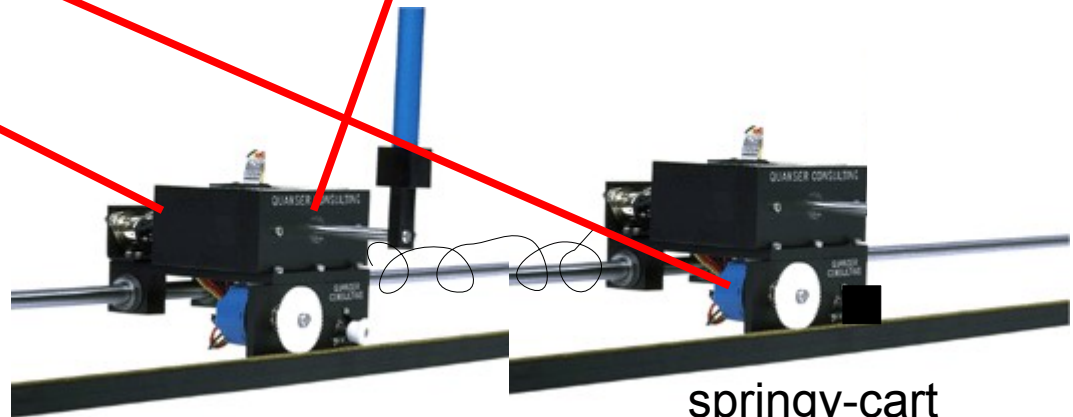
Win 7 computer

Analog outputs

Analog inputs
(not used for us?)



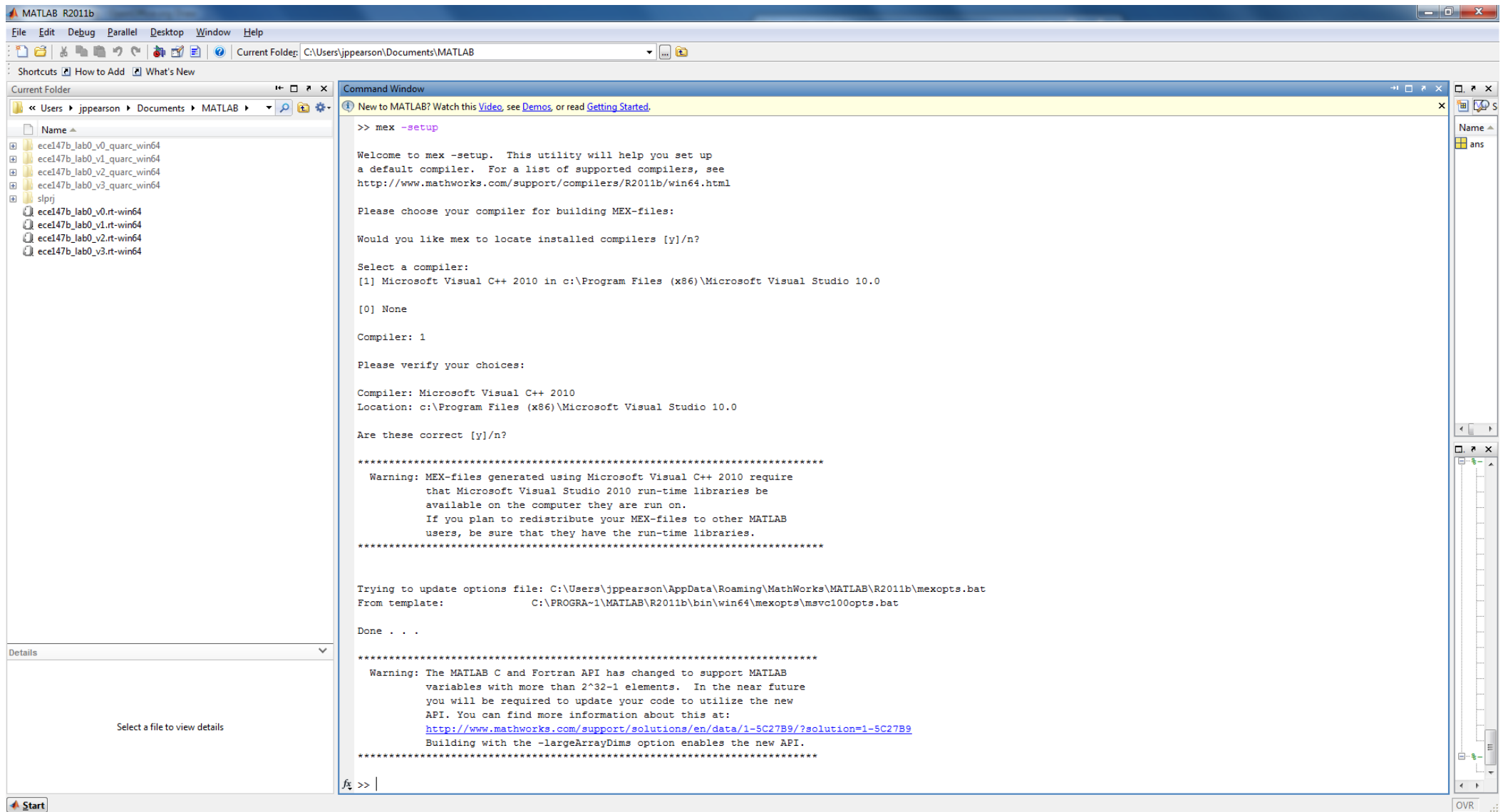
encoders

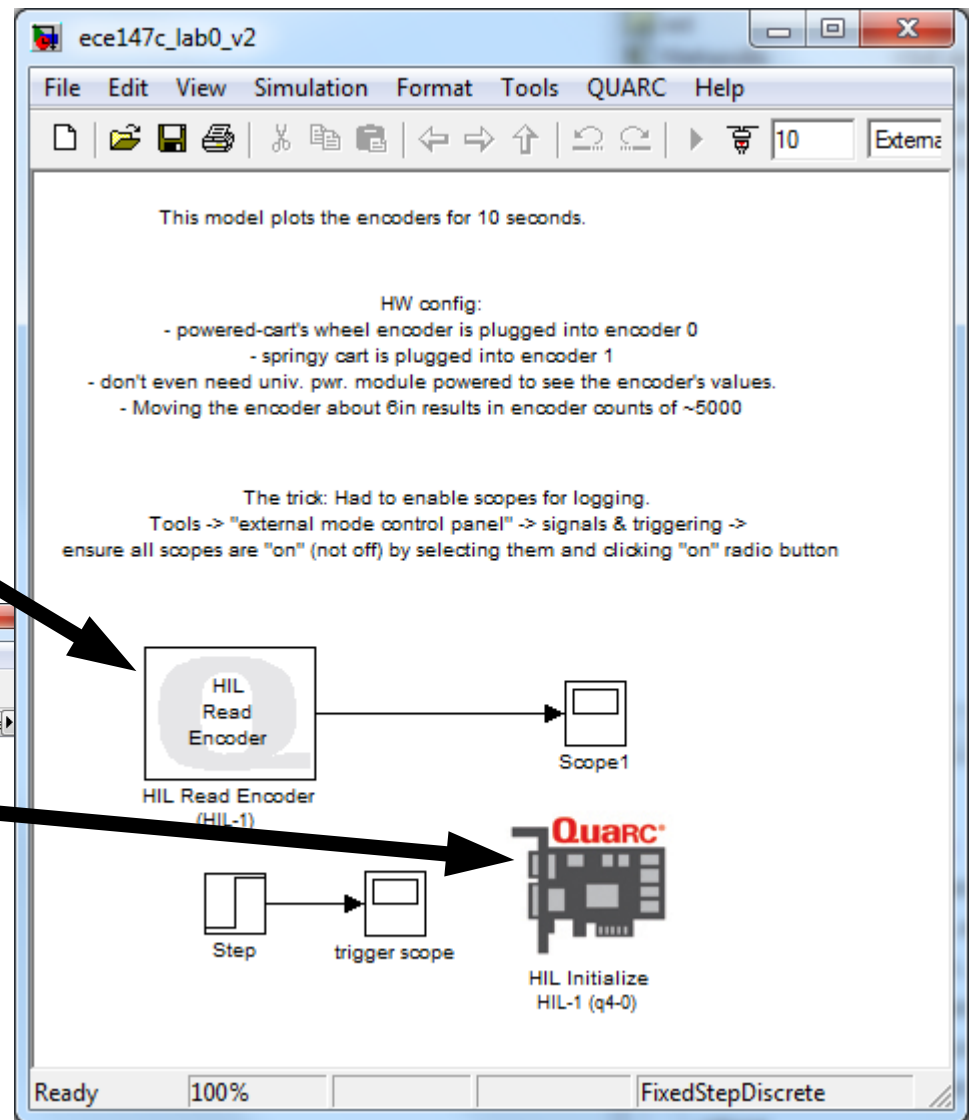
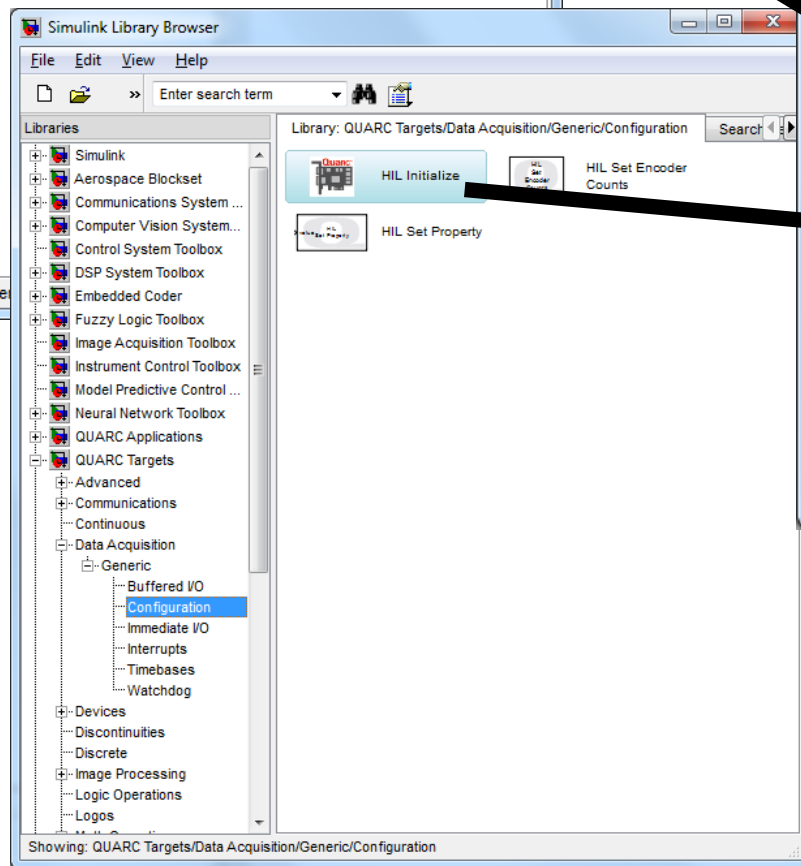
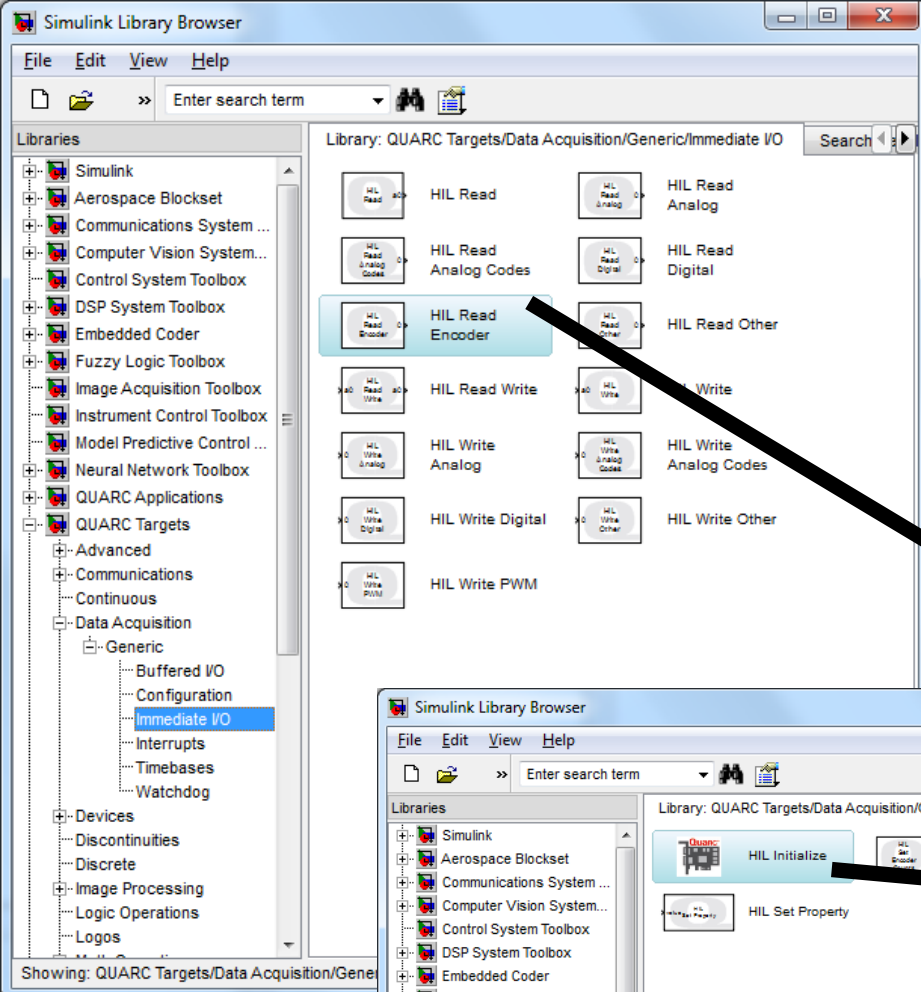


motor-cart

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

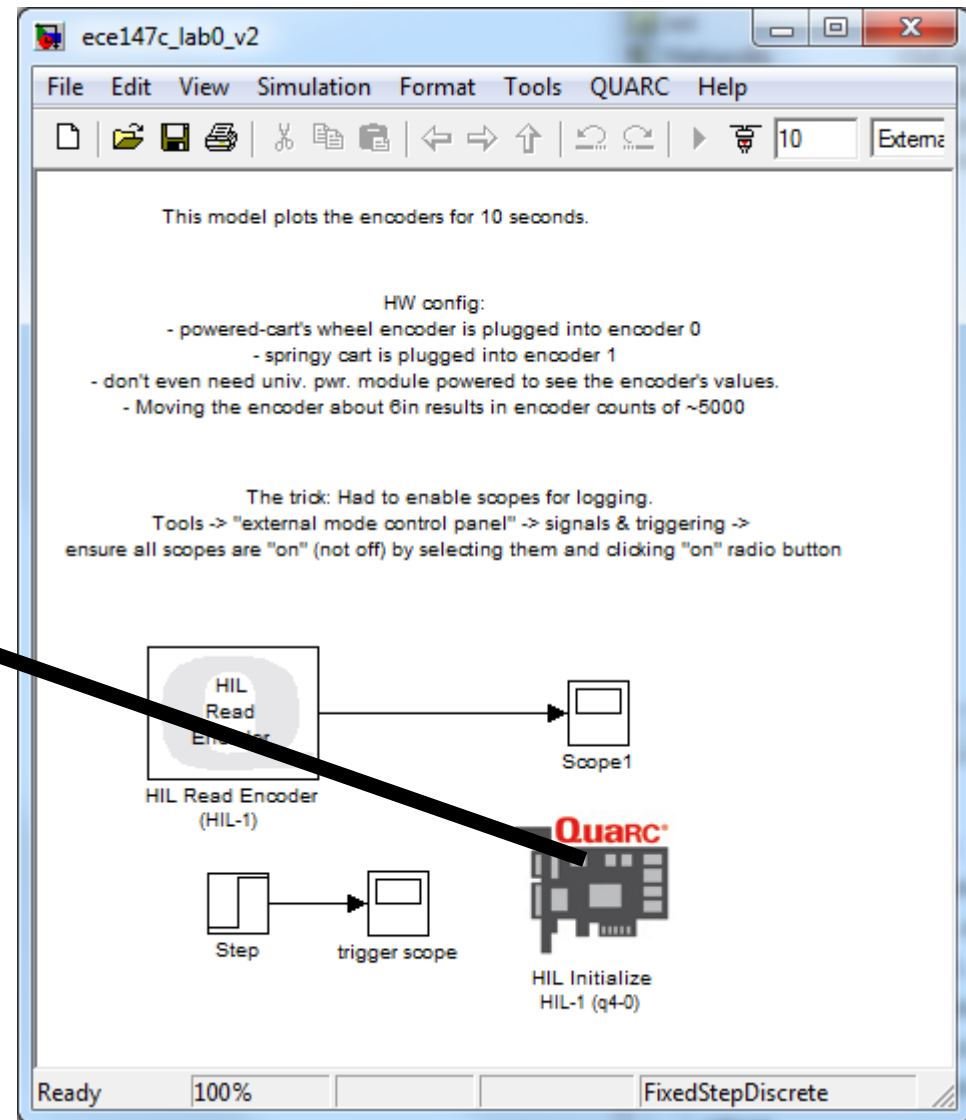
Board name:
HIL-1

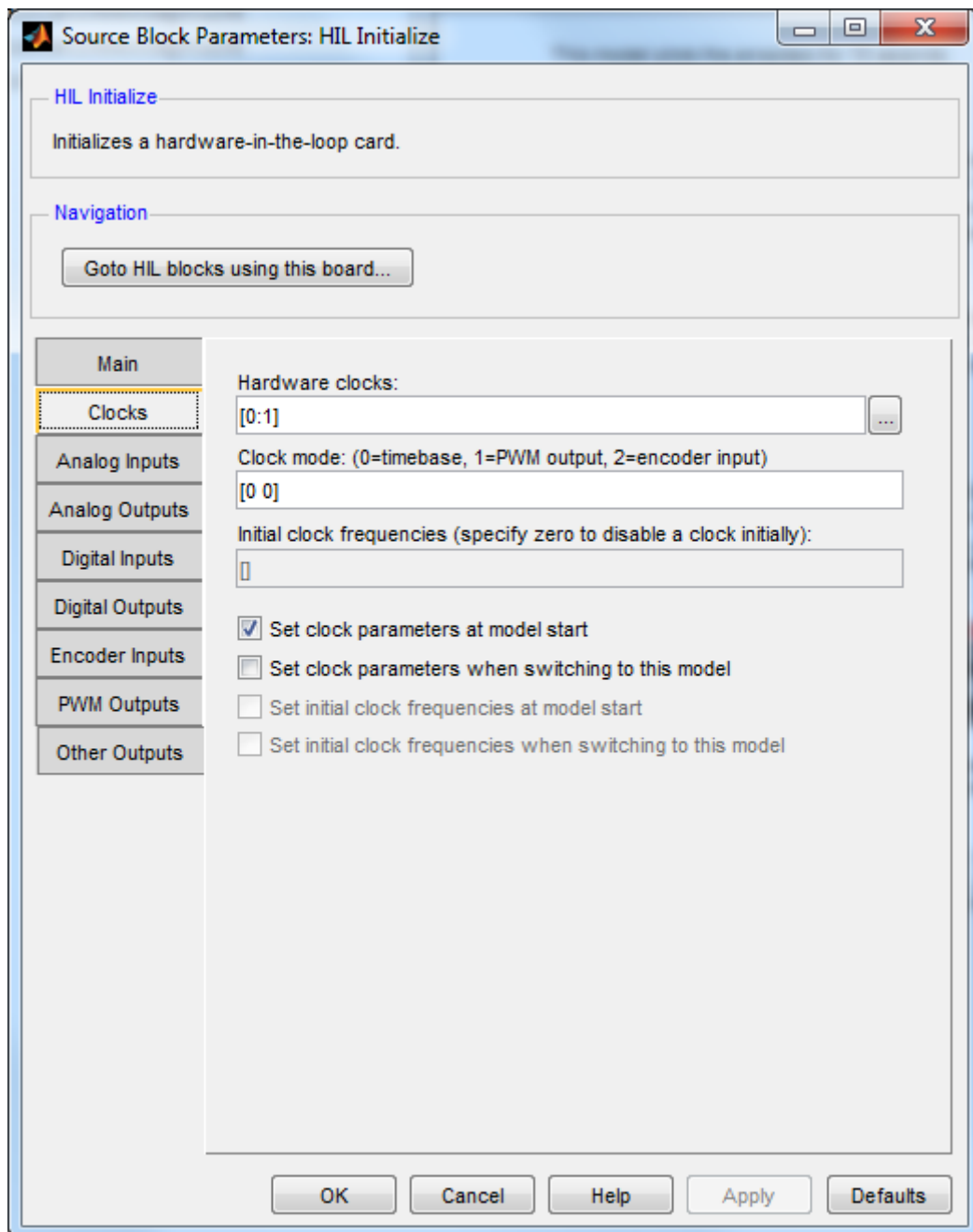
Board type:
q4

Board identifier:
0

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

OK Cancel Help Apply Defaults



The image shows a software window titled "Source Block Parameters: HIL Initialize". It has a standard Windows-style title bar with minimize, maximize, and close buttons. The window is divided into several sections. At the top, there's a description: "HIL Initialize" followed by "Initializes a hardware-in-the-loop card." Below this is a "Navigation" section with a button labeled "Goto HIL blocks using this board...". On the left side, there is a vertical sidebar with a list of tabs: "Main", "Clocks", "Analog Inputs", "Analog Outputs", "Digital Inputs", "Digital Outputs", "Encoder Inputs", "PWM Outputs", and "Other Outputs". The "Clocks" tab is currently selected and highlighted with a dashed border. The main content area of the "Clocks" tab contains the following settings: "Hardware clocks:" with a text input field containing "[0:1]" and a small "..." button to its right; "Clock mode: (0=timebase, 1=PWM output, 2=encoder input)" with a text input field containing "[0 0]"; "Initial clock frequencies (specify zero to disable a clock initially):" with a text input field containing an empty array "[]"; and four checkboxes: "Set clock parameters at model start" (checked), "Set clock parameters when switching to this model" (unchecked), "Set initial clock frequencies at model start" (unchecked), and "Set initial clock frequencies when switching to this model" (unchecked). At the bottom of the window, there are five buttons: "OK", "Cancel", "Help", "Apply", and "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

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):

[]

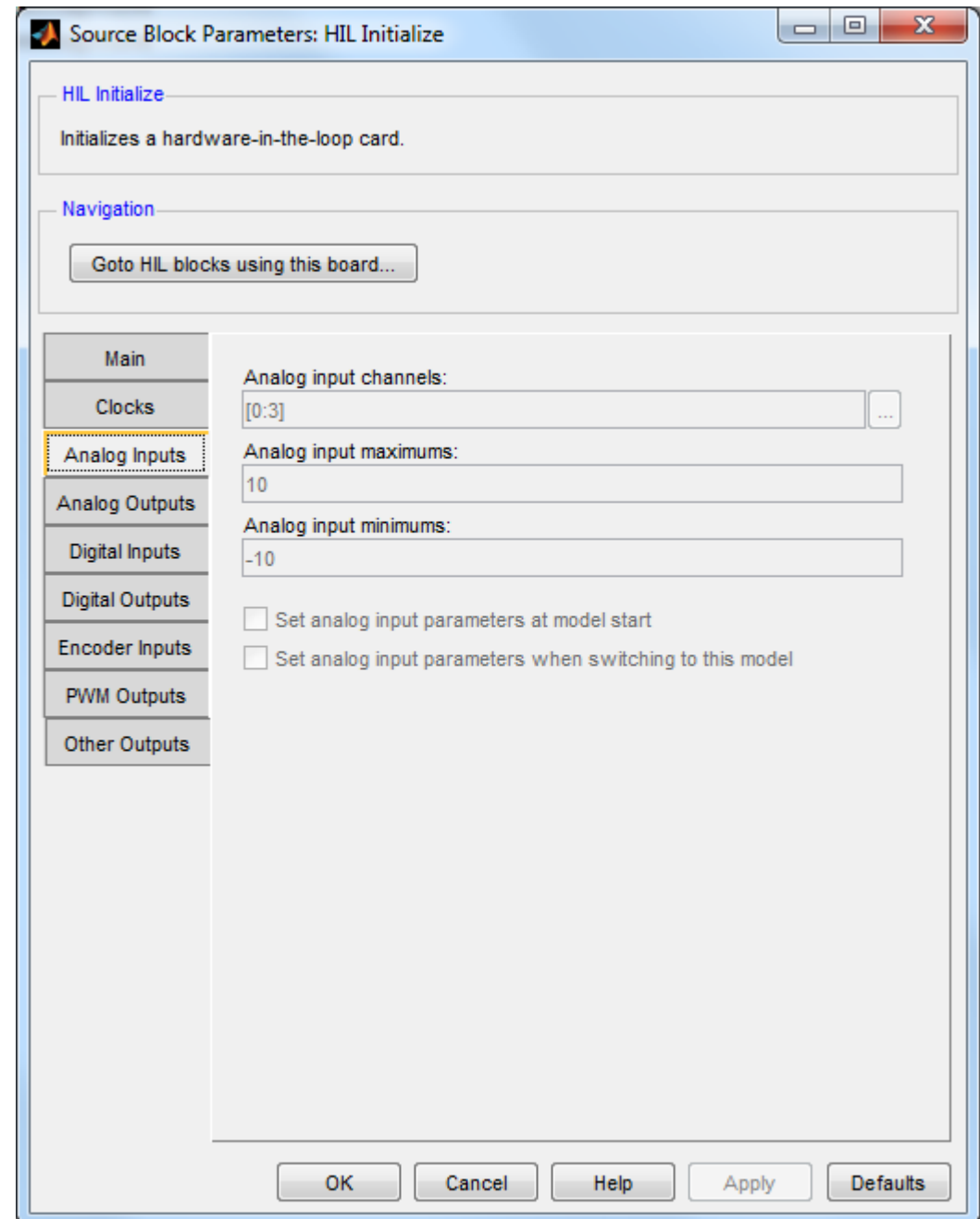
☒ Set clock parameters at model start

☐ 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

The image shows a software window titled "Source Block Parameters: HIL Initialize". It has a standard Windows-style title bar with minimize, maximize, and close buttons. The window is divided into several sections. At the top, there's a description: "HIL Initialize" followed by "Initializes a hardware-in-the-loop card." Below this is a "Navigation" section with a button labeled "Goto HIL blocks using this board...". On the left side, there is a vertical sidebar with a list of tabs: "Main", "Clocks", "Analog Inputs", "Analog Outputs", "Digital Inputs", "Digital Outputs", "Encoder Inputs", "PWM Outputs", and "Other Outputs". The "Analog Inputs" tab is currently selected and highlighted with a dashed border. The main content area of the "Analog Inputs" tab contains the following settings: "Analog input channels:" with a text input field containing "[0:3]" and a small "..." button to its right; "Analog input maximums:" with a text input field containing "10"; "Analog input minimums:" with a text input field containing "-10"; and two checkboxes: "Set analog input parameters at model start" (unchecked) and "Set analog input parameters when switching to this model" (unchecked). At the bottom of the window, there are five buttons: "OK", "Cancel", "Help", "Apply", and "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 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

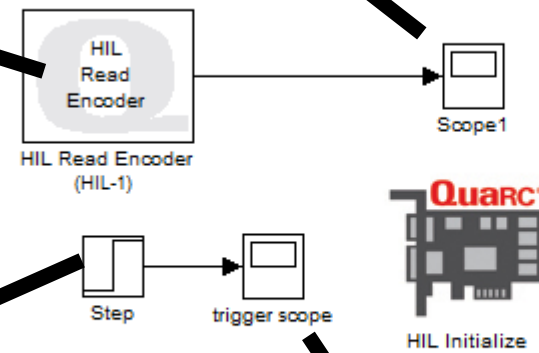
☒ Save data to workspace

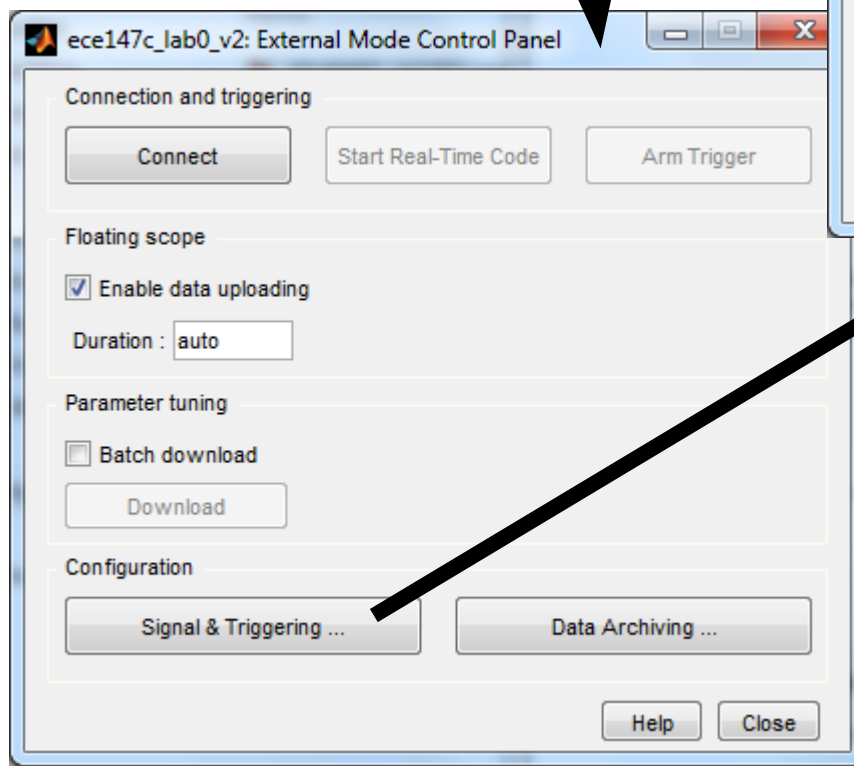
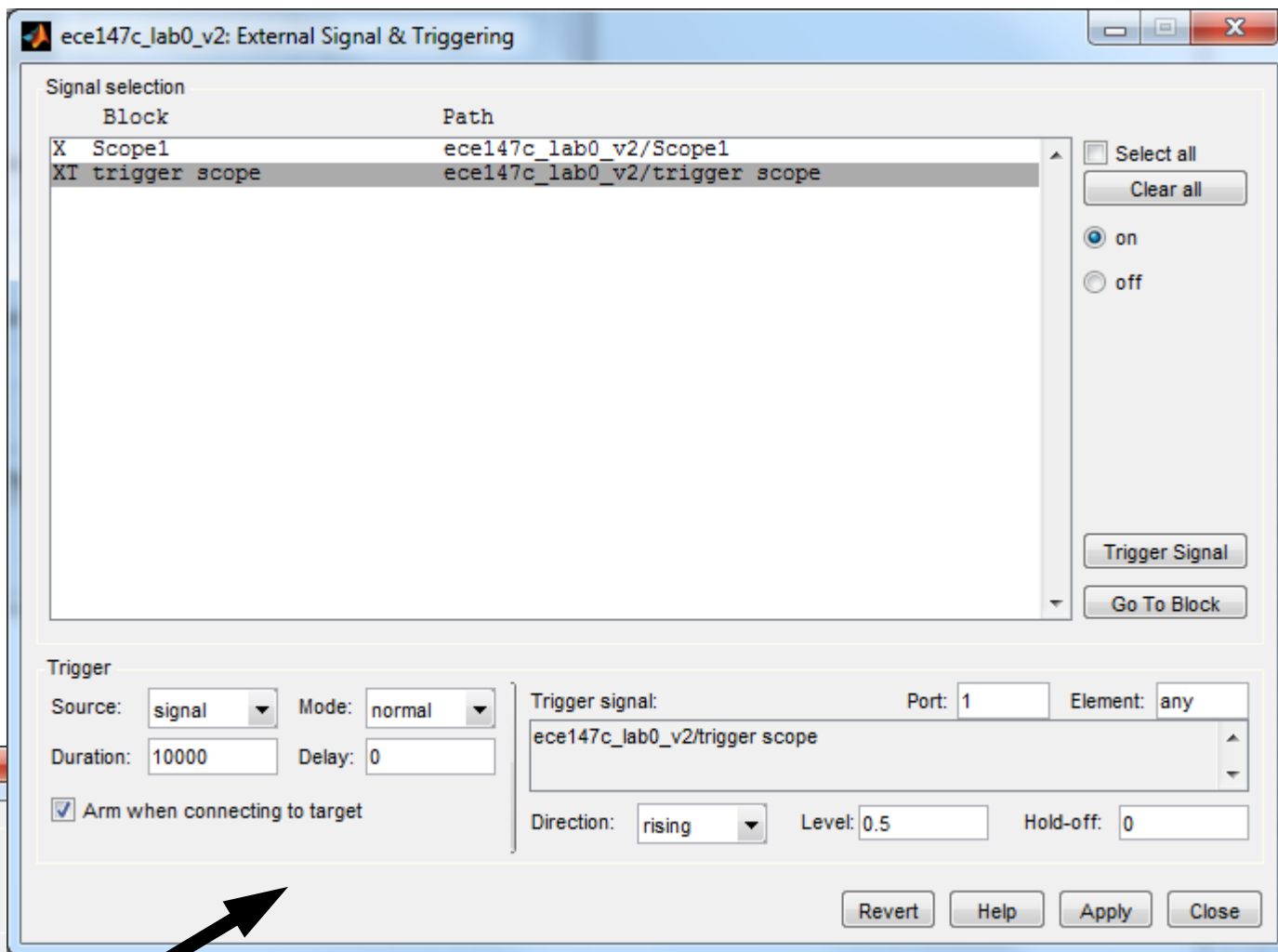
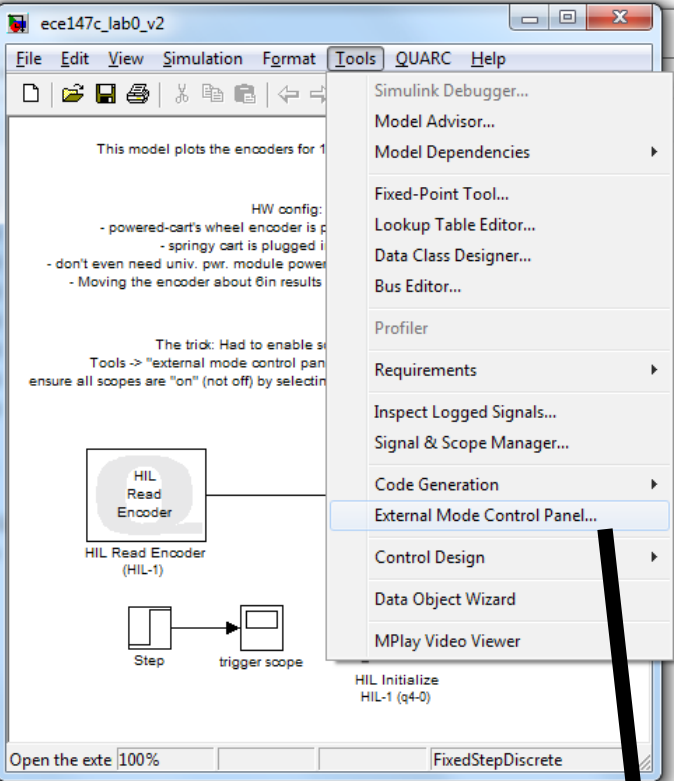
Variable name: ScopeData

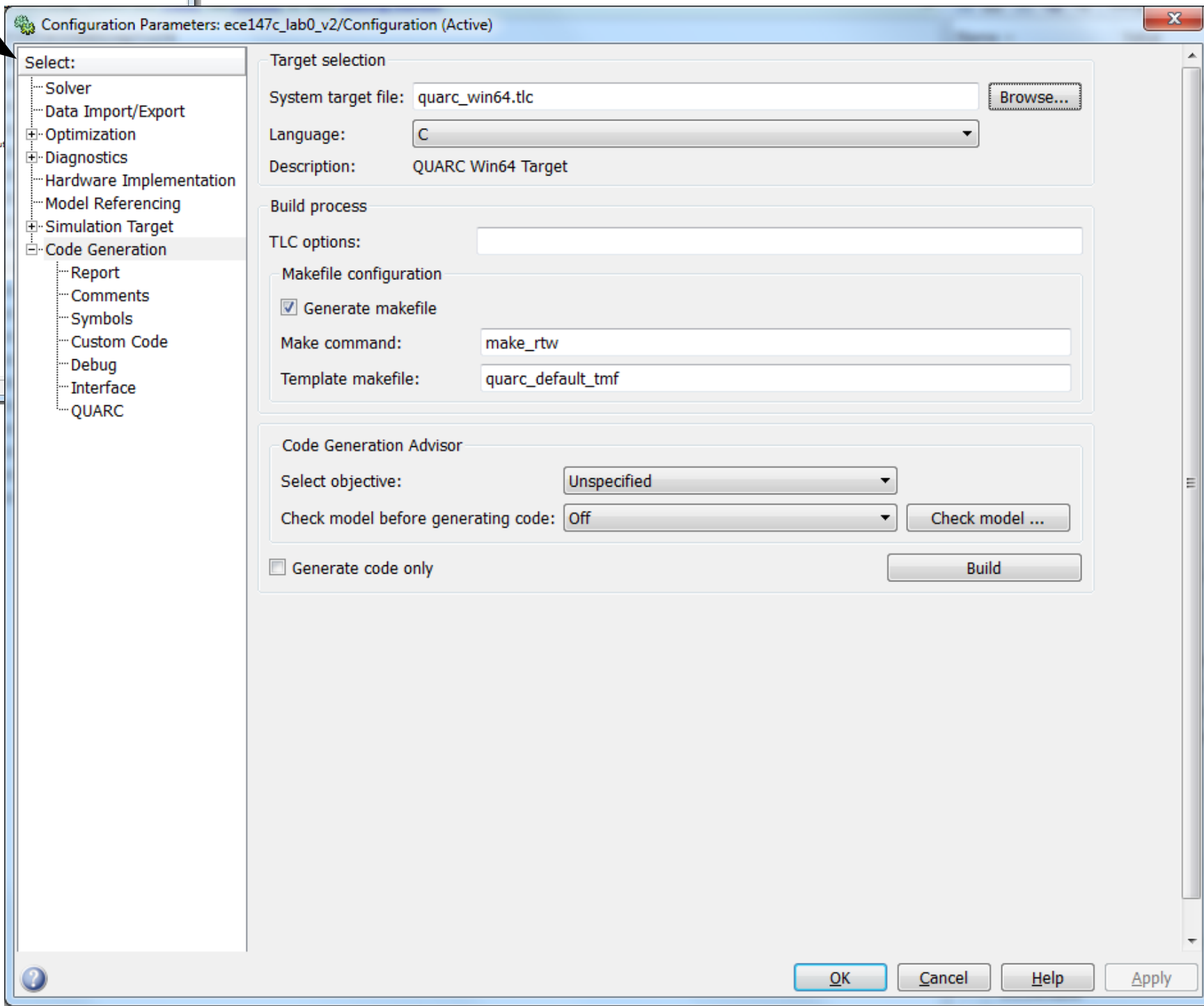
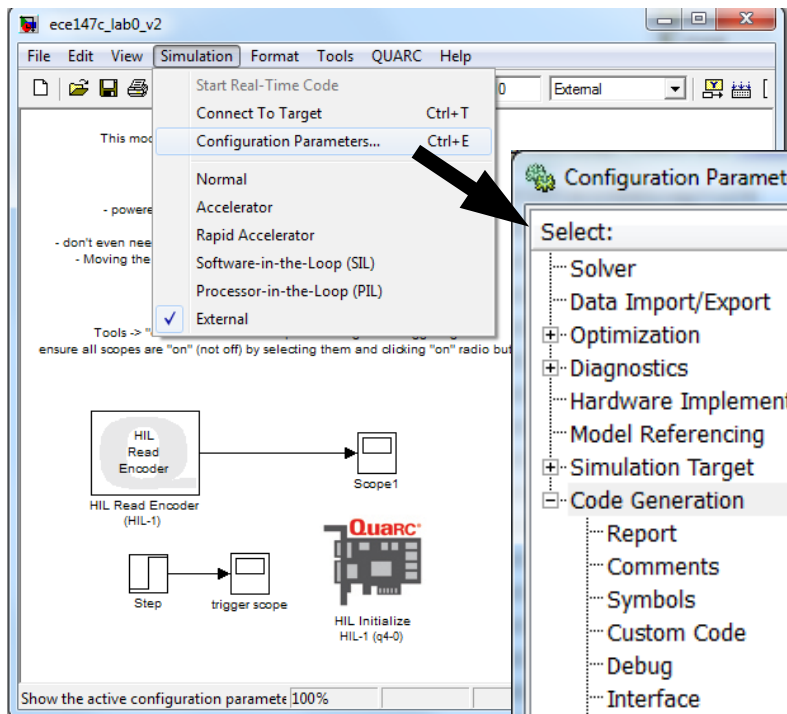
Format: Array

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
 - Report
 - Comments
 - 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

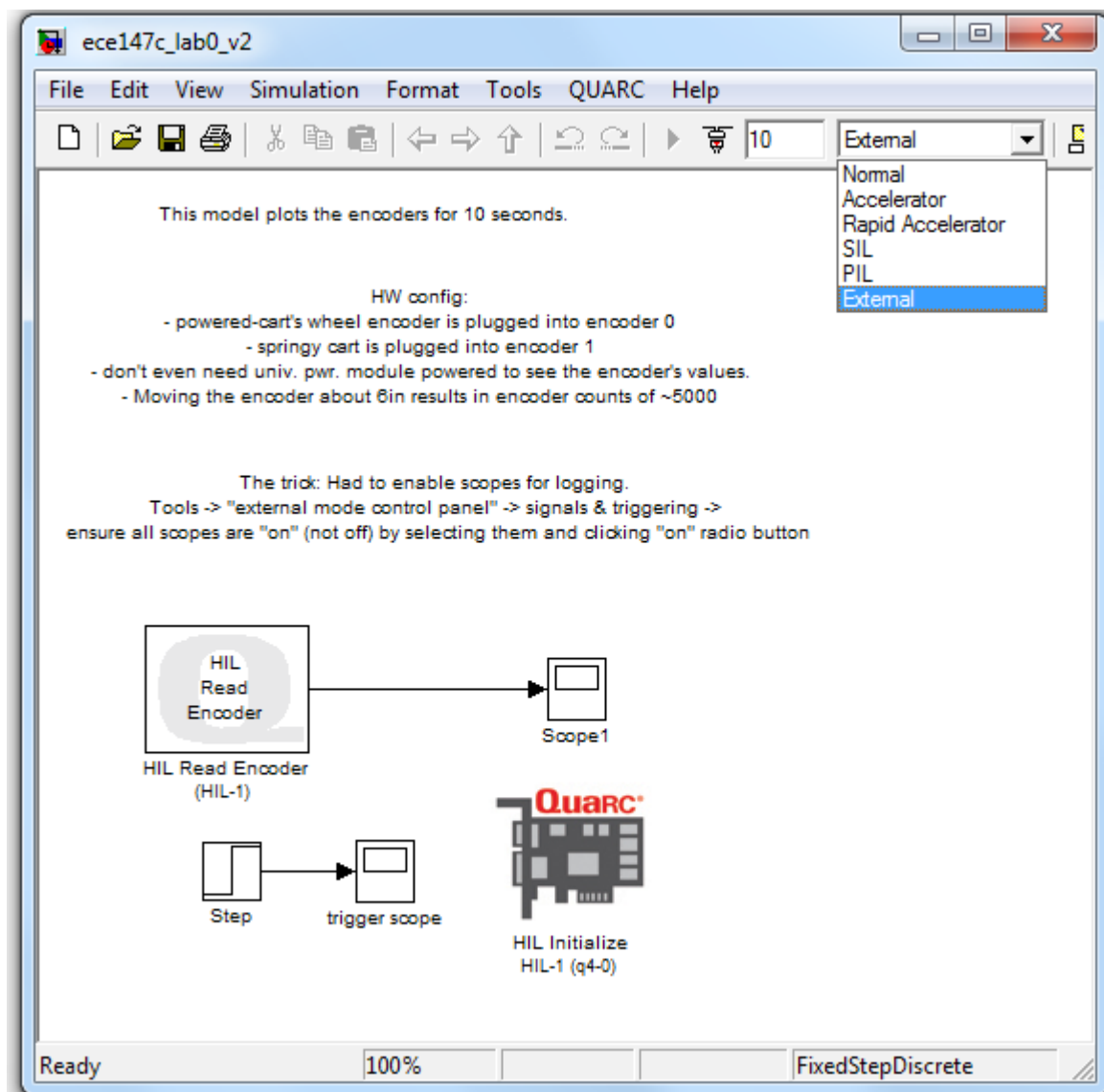
Byte ordering: Unspecified Signed integer division rounds to: Undefined

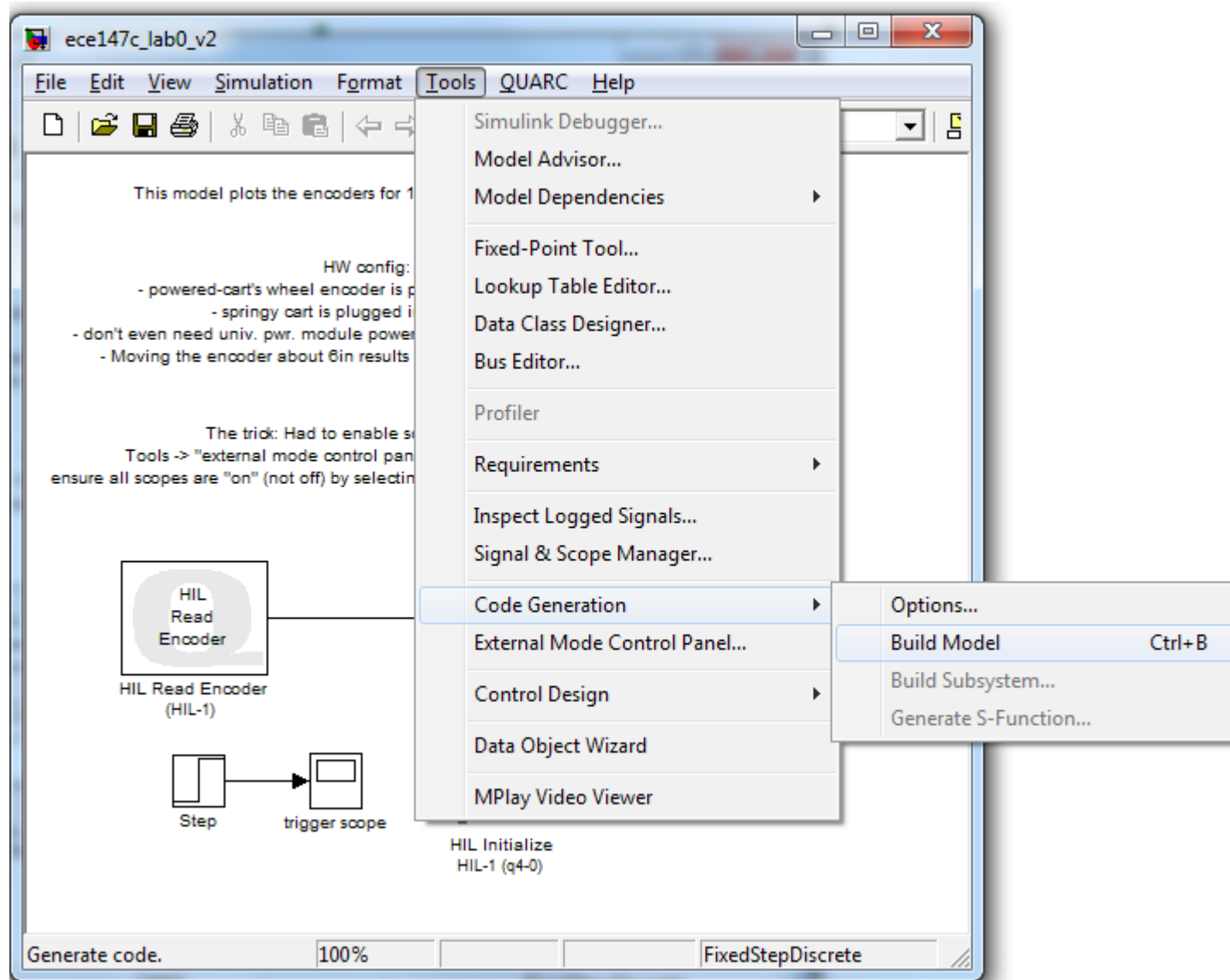
☒ Shift right on a signed integer as arithmetic shift

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](#).

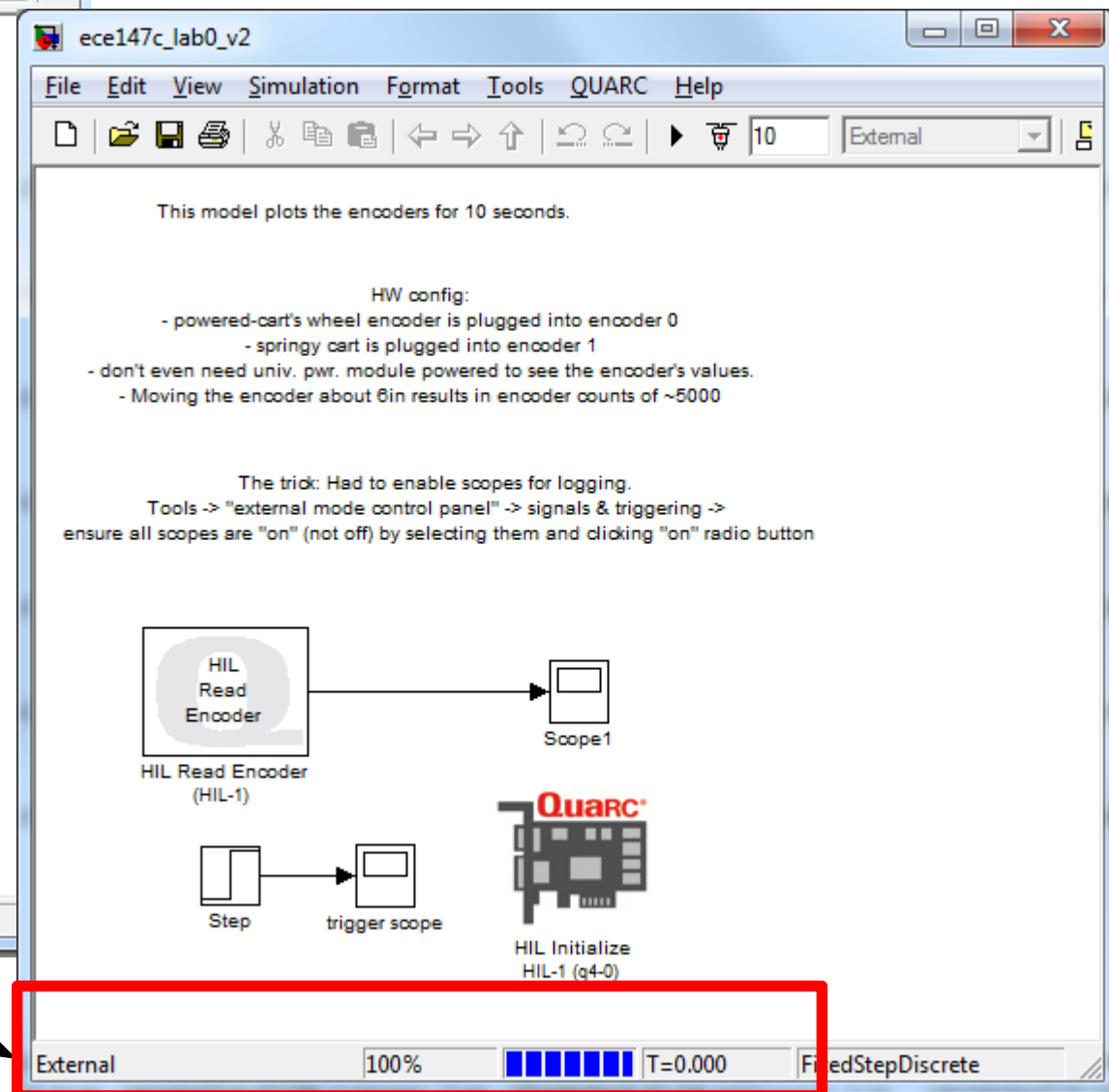
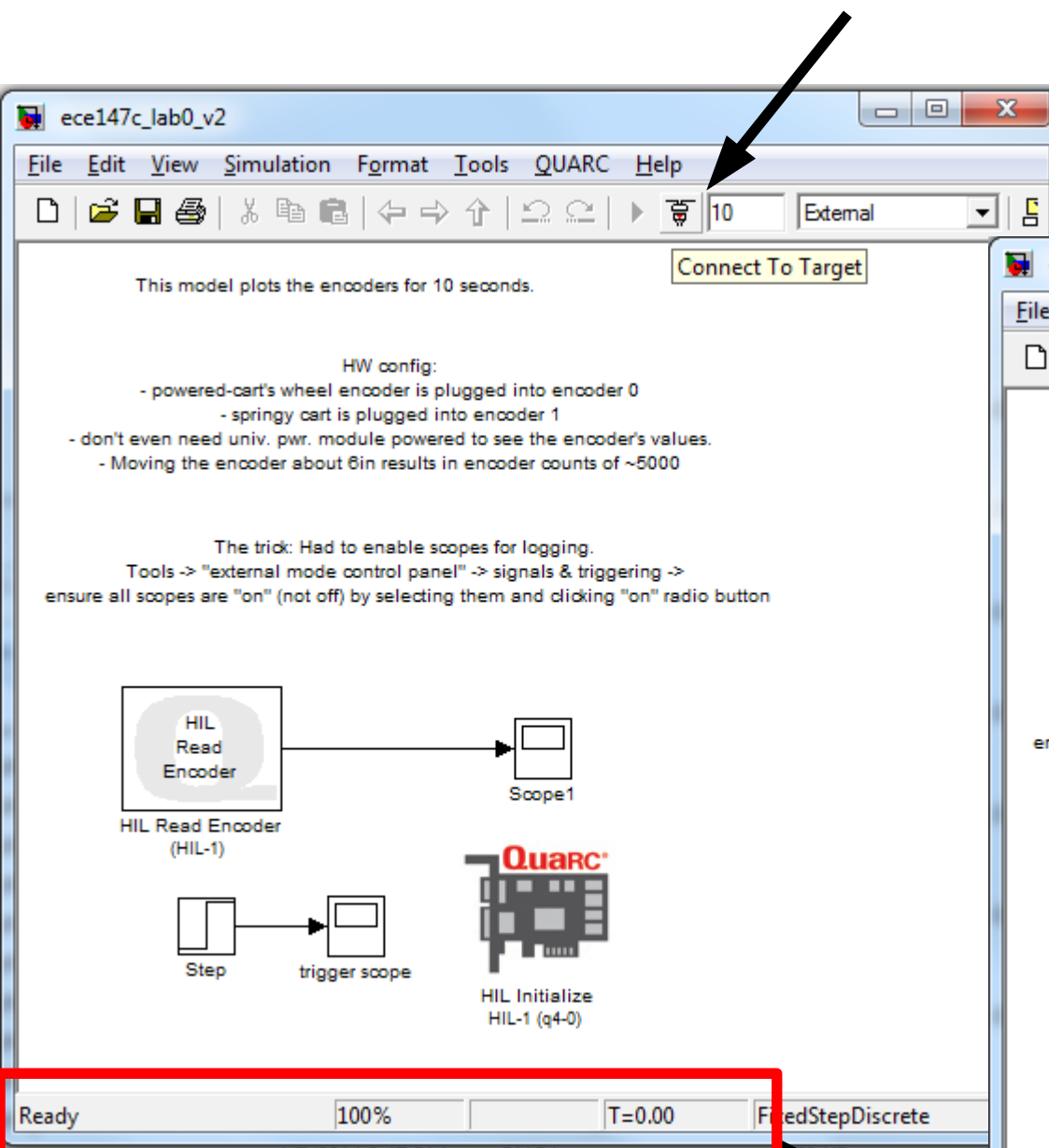
```
*** Generating the interface API.
...
*** Creating data type transition file ece147c_lab0_v2_dt.h
...
*** Creating project marker file: rtw_proj.tmw
...
*** Processing Template Makefile: C:\Program Files\Quanser\QUARC\quarc\R2009a\quarc_win64.tmf
*** Creating ece147c_lab0_v2.mk from C:\Program Files\Quanser\QUARC\quarc\R2009a\quarc_win64.tmf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

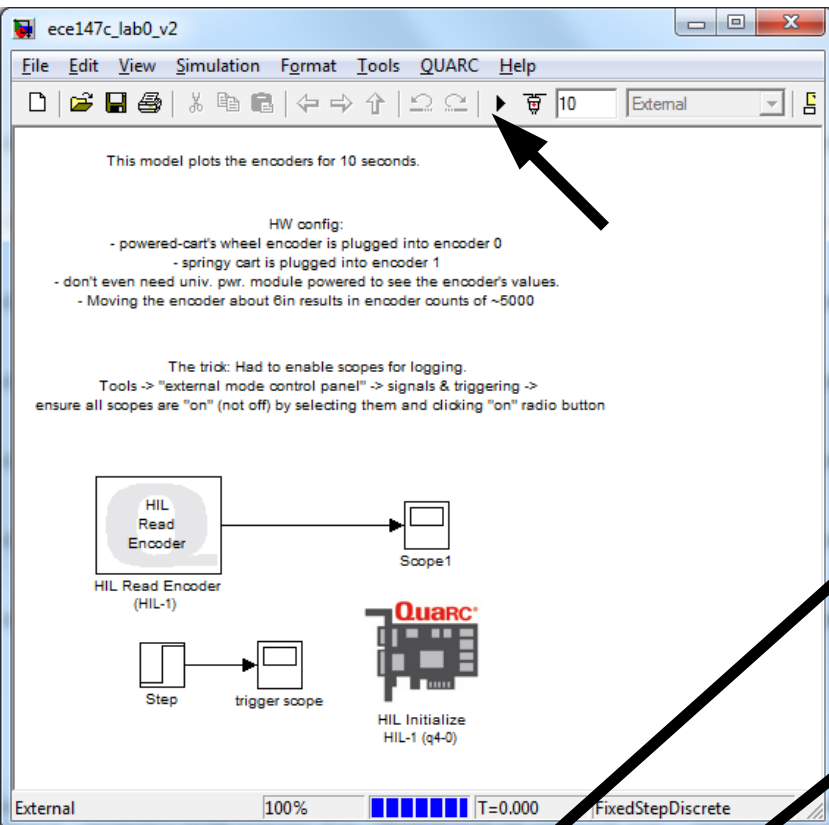
X:\ECE147C_AdvancedDigitalControlLab_Hespanha_Spr2014\Labs\Tools\ece147c_lab0_v2_quarc_win64>call "c:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\vcvarsall.bat" x86_
Setting environment for using Microsoft Visual Studio 2010 x64 cross tools.

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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://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 -DEXI_MODE -DMODEL_URI="shm://ece147c_lab0_v2:1" -DVERBOSE -DUSE_RTMODEL /wd4100 -DMODEL=ece147c_lab0_v2 -DRT -DNUMST=1 -DTID01EQ=0 -DNCSTATES=0 -D
rt_sim.c
rc /r ece147c_lab0_v2.auto.rc
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 'shm://quarc-target:1' ...
*** Model ece147c_lab0_v2 has been downloaded to target 'shm://quarc-target:1' (65536 bytes)
>>
fx >> % yay, no errors :)
```

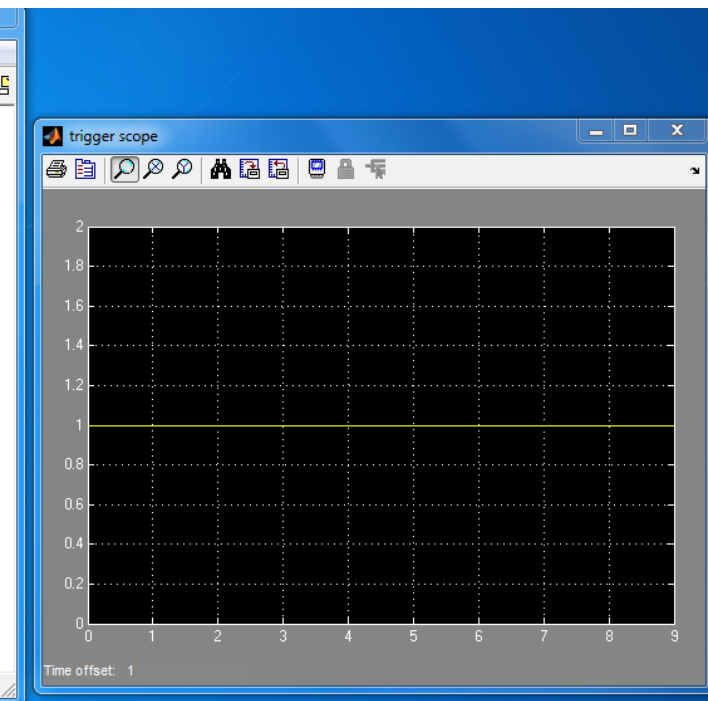
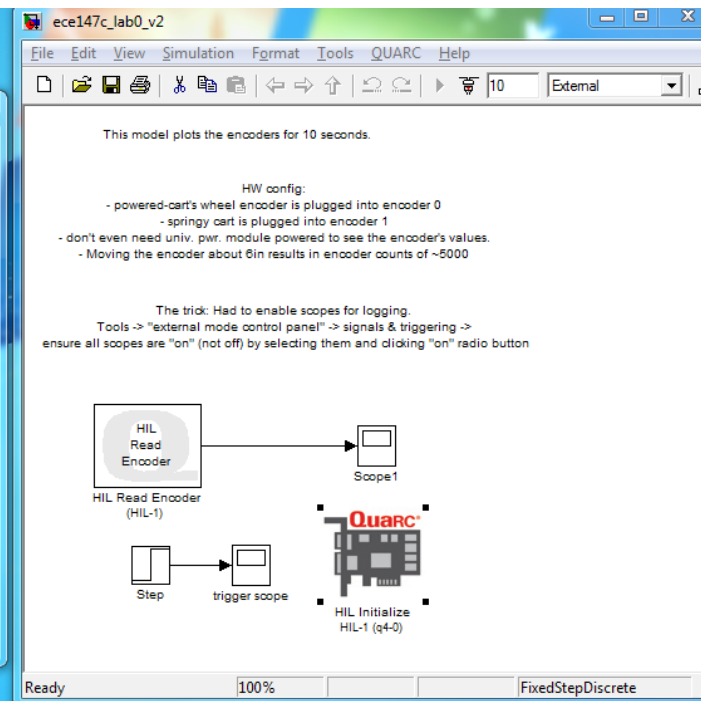
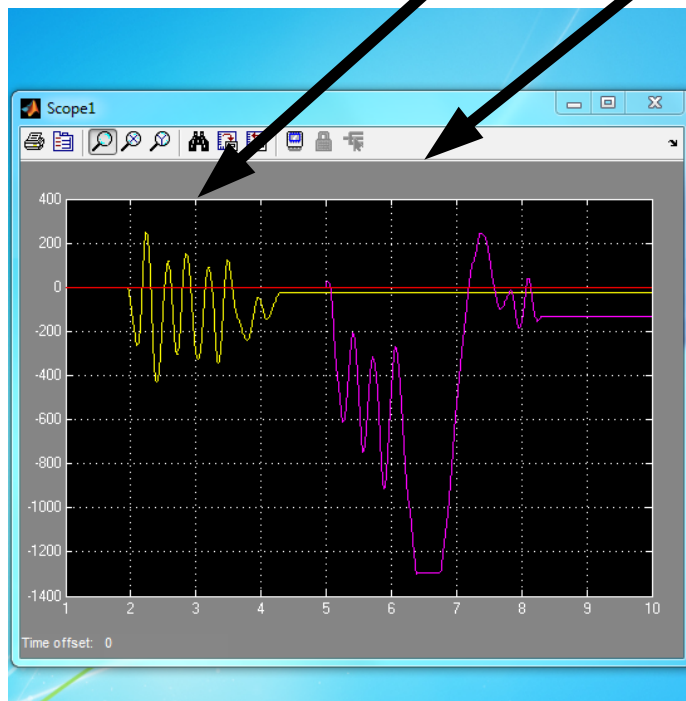




Wiggle motor-cart's wheel encoder

Wiggle springy-cart's wheel encoder

Note: doesn't show 3 encoders??



Command Window

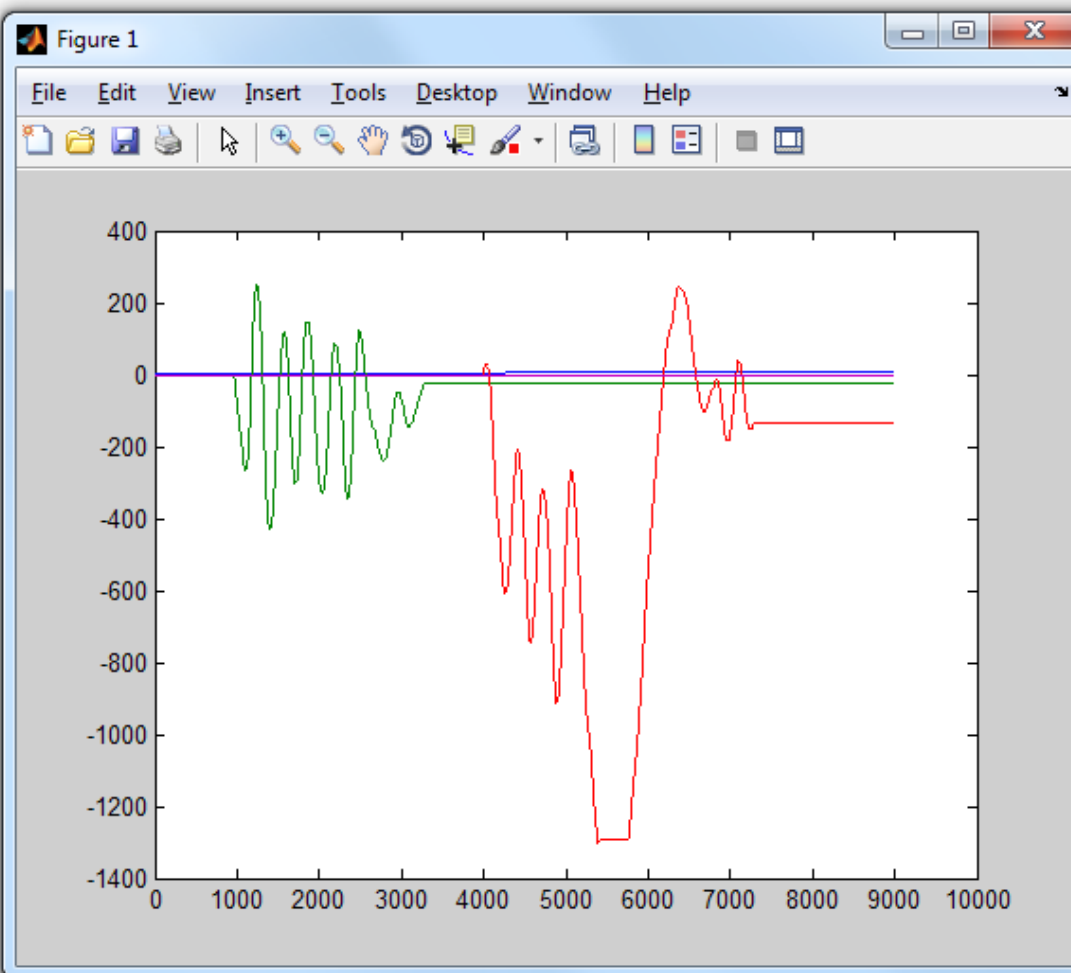
 New to MATLAB? Watch this [Video](#), see [Demos](#), or read [Getting Started](#).

```
>> 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?