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Intro to MATLAB/Simulink Streaming

with ADI's Wideband TRx Eval Boards

Many Thanks to:

Jon Kraft

Travis Collins

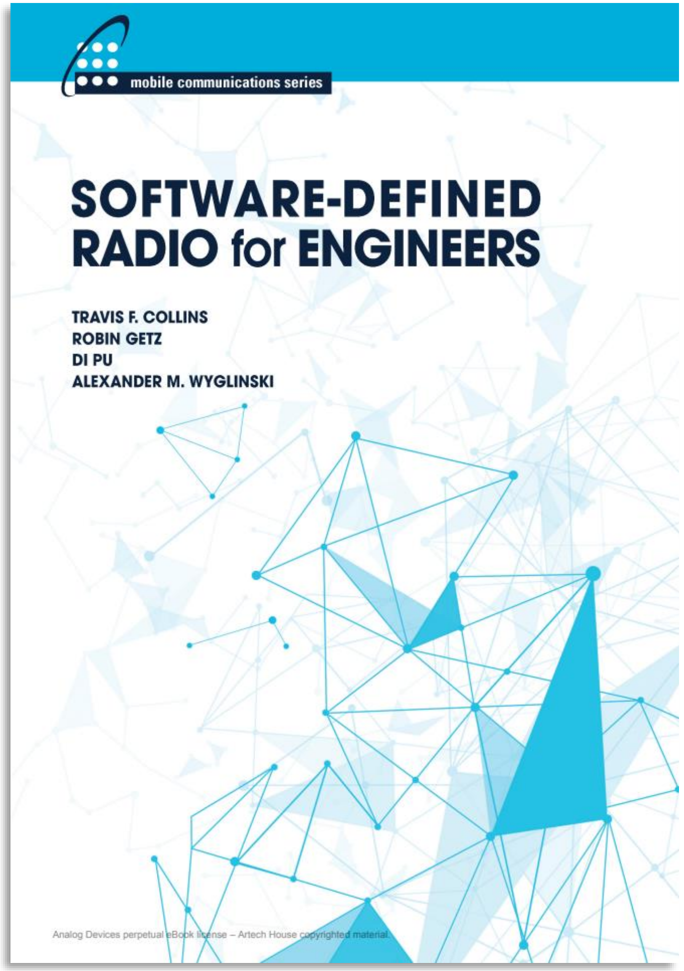
AUGUST 2019

Overview

- What is the Purpose of this Setup Guide?
- What Eval and SOM Hardware is Covered?
- Establish an IP Connection with your TRx Board
- Install the MATLAB Board Support Packages
- Streaming with Simulink
  - Loopback Example using FPGA to generate the TX signal
  - Loopback Example using Simulink Source to generate the TX signal
- Streaming with MATLAB
  - Loopback Example using FPGA to generate the TX signal
  - Loopback Example using MATLAB Source to generate the TX signal
  - Installing Command Line GIT for MATLAB
- EVM Example with MATLAB

Purpose of this Setup Guide

- There is a wiki.analog guide that will always be the most up to date
  - To begin, please review:
    - https://wiki.analog.com/resources/eval/user-guides/MATLAB_bsp
- Also, it is highly recommended to read chapter 5 of “Software Defined Radio for Engineers”
  - https://www.analog.com/en/education/education-library/software-defined-radio-for-engineers.html
- This presentation is only to assist you in getting started by going through the process step by step.
- All this was written around the date located on the title slide. So things may have changed!
  - Please use the above wiki site as the primary reference



mobile communications series

SOFTWARE-DEFINED RADIO for ENGINEERS

TRAVIS F. COLLINS
ROBIN GETZ
DI PU
ALEXANDER M. WYGLINSKI

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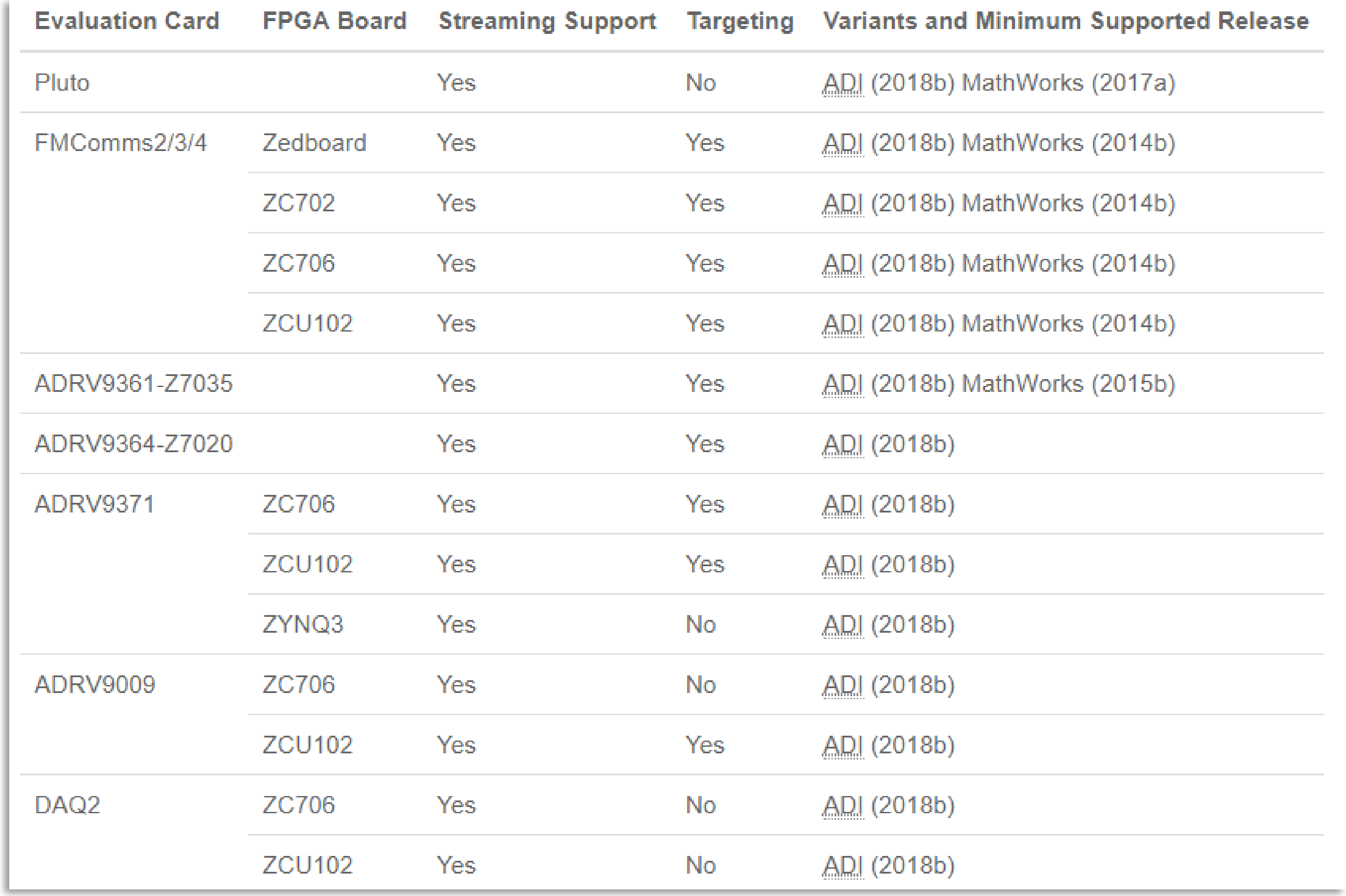
What Hardware is Supported?

- The latest hardware that is supported can be found here:
  - https://wiki.analog.com/resources/eval/user-guides/MATLAB_bsp
- When this document was written, those boards included
- Streaming vs. Targeting:
  - Streaming is just sending info to and from the transceivers.
    - Transceiver parameters (i.e. LO, or gain, filter configuration, sample rate, etc.) can be modified.
    - But no changes to the FPGA.
  - Targeting is changing the FPGA code to implement custom algorithms (i.e. decimation, filtering, carrier recovery, etc.).



Evaluation Card	FPGA Board	Streaming Support	Targeting	Variants and Minimum Supported Release
Pluto		Yes	No	ADI (2018b) MathWorks (2017a)
FMComms2/3/4	Zedboard	Yes	Yes	ADI (2018b) MathWorks (2014b)
	ZC702	Yes	Yes	ADI (2018b) MathWorks (2014b)
	ZC706	Yes	Yes	ADI (2018b) MathWorks (2014b)
	ZCU102	Yes	Yes	ADI (2018b) MathWorks (2014b)
ADRV9361-Z7035		Yes	Yes	ADI (2018b) MathWorks (2015b)
ADRV9364-Z7020		Yes	Yes	ADI (2018b)
ADRV9371	ZC706	Yes	Yes	ADI (2018b)
	ZCU102	Yes	Yes	ADI (2018b)
	ZYNQ3	Yes	No	ADI (2018b)
ADRV9009	ZC706	Yes	No	ADI (2018b)
	ZCU102	Yes	Yes	ADI (2018b)
DAQ2	ZC706	Yes	No	ADI (2018b)
	ZCU102	Yes	No	ADI (2018b)

Establish an IP Connection with Your Board

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Establish an IP Connection with Your Board

- There are many guides and wikis available to establish a connection, via IP address, to your Analog Devices AD936x/AD937x/ADRV900x boards.
  - Best resources are the wiki.analog sites. Such as:
    - ADRV9009: https://wiki.analog.com/resources/eval/user-guides/adrv9009/quickstart/zynqmp
    - AD9371: https://wiki.analog.com/resources/eval/user-guides/mykonos
  - There is also an appendix at the end of this document which explains the process

- Note: the SD card MUST be the prototyping (IIOLIB) software (not the TES SD card)

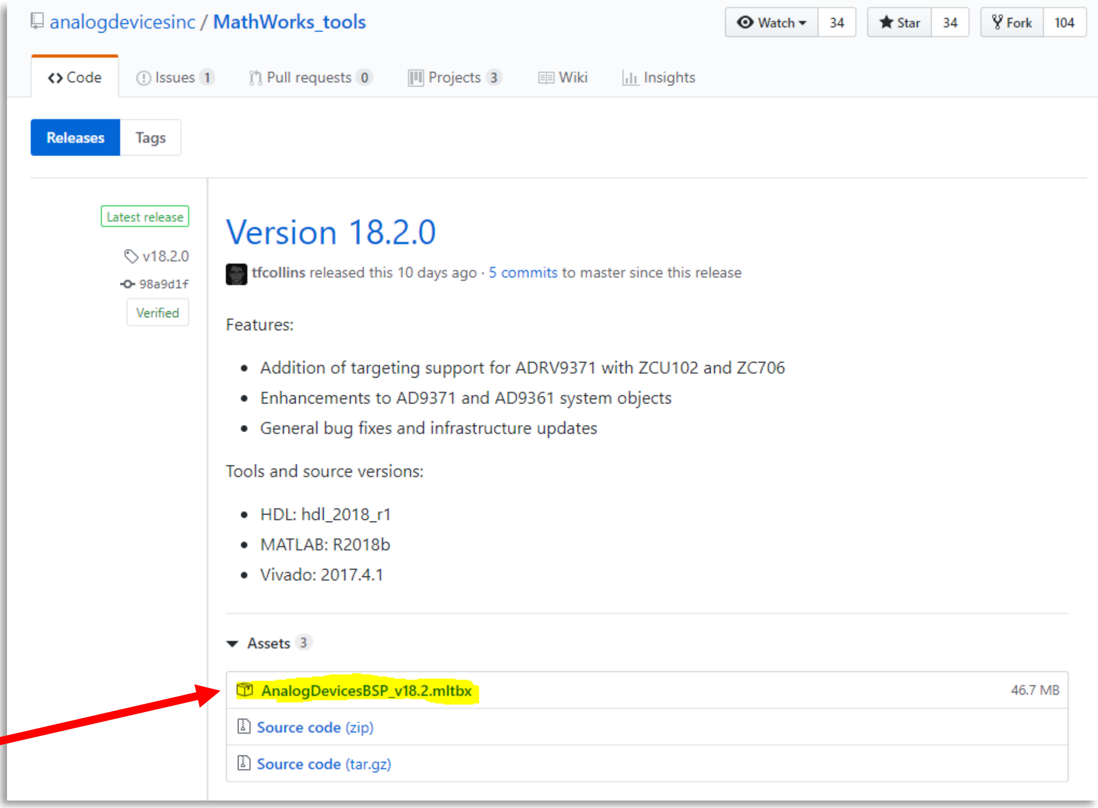
Install the Analog Devices Board Support Package

MATLAB Installation

- First, upgrade to MATLAB 2018b
  - 2018b made a lot of improvements for how to call adons.
  - Some hardware is only supported in MATLAB 2018b (or later)
  - There's other ways to do it with previous revs or MATLAB, but they are more complicated.
  - So it's much easier if you can upgrade to MATLAB 2018b

- Install the LIBIIO drivers (if not done already)
  - https://github.com/analogdevicesinc/libiio/releases
  - These should already be on your computer (if you can run IIOscope, these are on your computer)

- Download the latest Board Support Package (BSP) here:
  - https://github.com/analogdevicesinc/MathWorks_tools/releases
  - This will give you the latest version.



Version 18.2.0

tfcollins released this 10 days ago · 5 commits to master since this release

Features:

- Addition of targeting support for ADRV9371 with ZCU102 and ZC706
- Enhancements to AD9371 and AD9361 system objects
- General bug fixes and infrastructure updates

Tools and source versions:

- HDL: hdl_2018_r1
- MATLAB: R2018b
- Vivado: 2017.4.1

Assets 3

AnalogDevicesBSP_v18.2.mltbx	46.7 MB
Source code (zip)	
Source code (tar.gz)	

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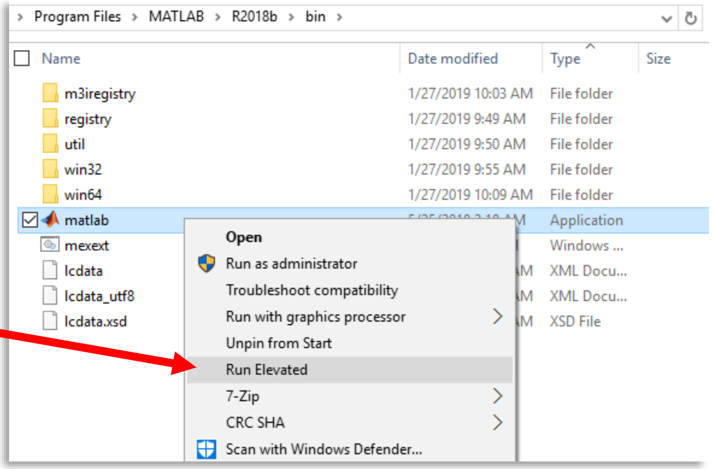
MATLAB Installation

- FIRST, open MATLAB as either:
  - “Run as administrator” or
  - “Run Elevated”
    - For ADI machines, use “Run Elevated”

- THEN, go to MATLAB→Add-Ons→Get Add-Ons
  - Search for “Communications Toolbox Support Package for Xilinx Zynq-Based Radio”
  - Install that add on (it will take several minutes)
  - This might fail if you didn’t “Run Elevated”

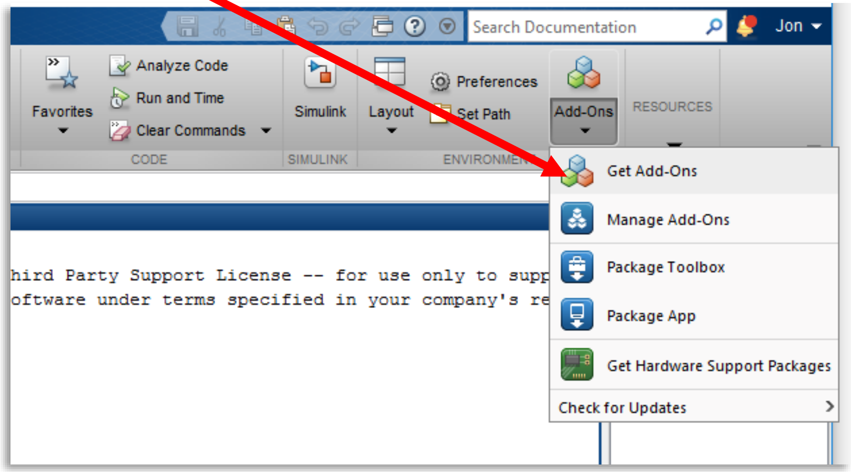
- Finally, double click on Analog Devices BSP file that you downloaded earlier
  - BSP installation will automatically begin



› Program Files › MATLAB › R2018b › bin ›

Name	Date modified	Type	Size
m3iregistry	1/27/2019 10:03 AM	File folder	
registry	1/27/2019 9:49 AM	File folder	
util	1/27/2019 9:50 AM	File folder	
win32	1/27/2019 9:55 AM	File folder	
win64	1/27/2019 10:09 AM	File folder	
☑ matlab	[illegible] M	Application	
mexext		Windows ...	
lcdata	M	XML Docu...	
lcdata_utf8	M	XML Docu...	
lcdata.xsd	M	XSD File	

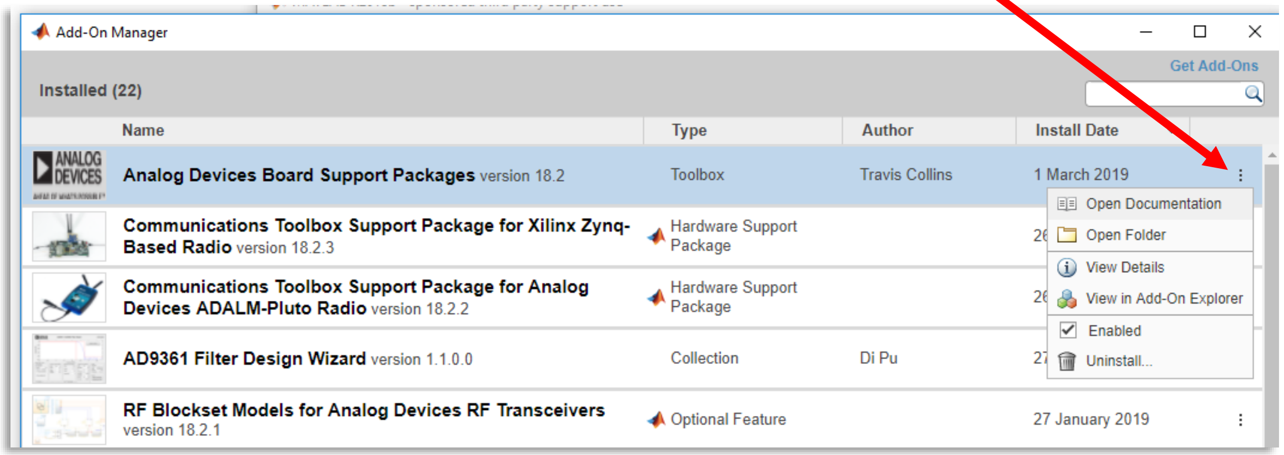
Open
Run as administrator
Troubleshoot compatibility
Run with graphics processor
Unpin from Start
Run Elevated
7-Zip
CRC SHA
Scan with Windows Defender...



```
hird Party Support License -- for use only to supp
oftware under terms specified in your company's re
```

MATLAB Installation

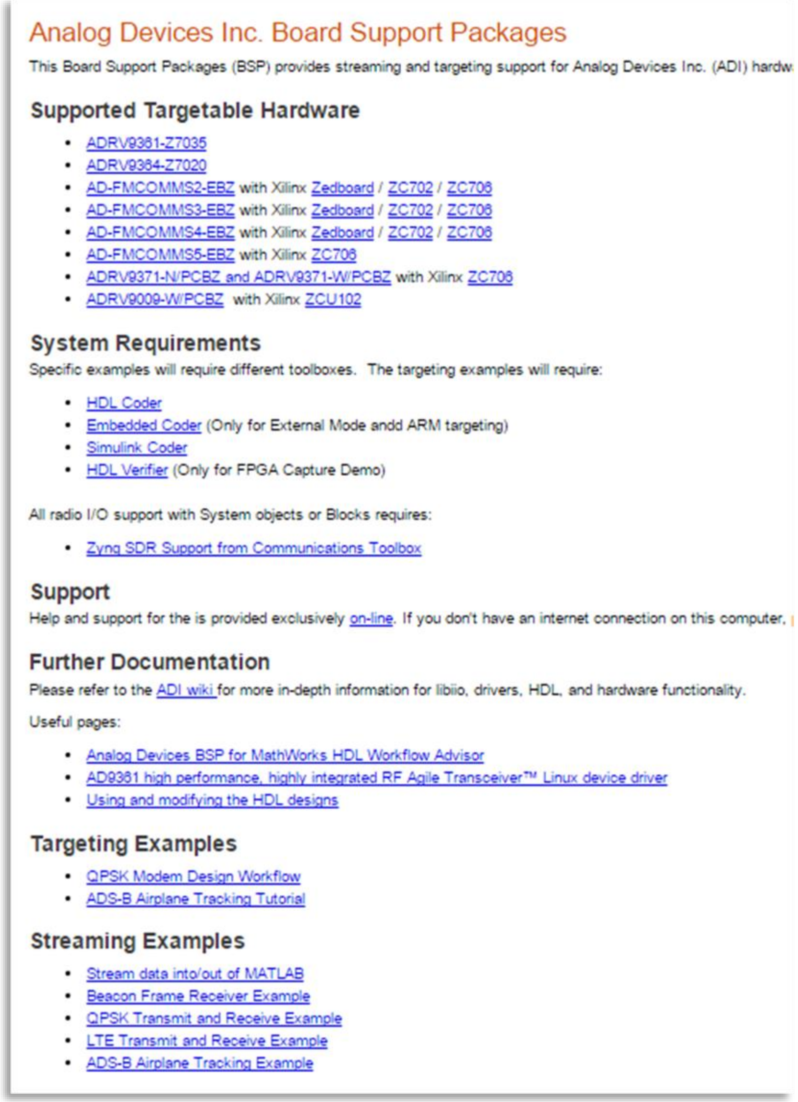
- After installing the Analog Devices BSP, please take a look through the documentation.
  - There’s great (and up to date) stuff in there!
  - You can find that documentation again by going to Add-Ons→Manage Add-Ons→



Add-On Manager

Installed (22)

Name	Type	Author	Install Date
Analog Devices Board Support Packages version 18.2	Toolbox	Travis Collins	1 March 2019
Communications Toolbox Support Package for Xilinx Zynq-Based Radio version 18.2.3	Hardware Support Package		26
Communications Toolbox Support Package for Analog Devices ADALM-Pluto Radio version 18.2.2	Hardware Support Package		26
AD9361 Filter Design Wizard version 1.1.0.0	Collection	Di Pu	27
RF Blockset Models for Analog Devices RF Transceivers version 18.2.1	Optional Feature		27 January 2019



Analog Devices Inc. Board Support Packages

This Board Support Packages (BSP) provides streaming and targeting support for Analog Devices Inc. (ADI) hardw

Supported Targetable Hardware

- ADRV9361-Z7035
- ADRV9364-Z7020
- AD-FMCOMMS2-EBZ with Xilinx Zedboard / ZC702 / ZC706
- AD-FMCOMMS3-EBZ with Xilinx Zedboard / ZC702 / ZC706
- AD-FMCOMMS4-EBZ with Xilinx Zedboard / ZC702 / ZC706
- AD-FMCOMMS5-EBZ with Xilinx ZC706
- ADRV9371-N/PCBZ and ADRV9371-W/PCBZ with Xilinx ZC706
- ADRV9009-W/PCBZ with Xilinx ZCU102

System Requirements

Specific examples will require different toolboxes. The targeting examples will require:

- HDL Coder
- Embedded Coder (Only for External Mode andd ARM targeting)
- Simulink Coder
- HDL Verifier (Only for FPGA Capture Demo)

All radio I/O support with System objects or Blocks requires:

- Zynq SDR Support from Communications Toolbox

Support

Help and support for the is provided exclusively on-line. If you don't have an internet connection on this computer,

Further Documentation

Please refer to the ADI wiki for more in-depth information for libiio, drivers, HDL, and hardware functionality.

Useful pages:

- Analog Devices BSP for MathWorks HDL Workflow Advisor
- AD9361 high performance, highly integrated RF Agile Transceiver™ Linux device driver
- Using and modifying the HDL designs

Targeting Examples

- QPSK Modem Design Workflow
- ADS-B Airplane Tracking Tutorial

Streaming Examples

- Stream data into/out of MATLAB
- Beacon Frame Receiver Example
- QPSK Transmit and Receive Example
- LTE Transmit and Receive Example
- ADS-B Airplane Tracking Example

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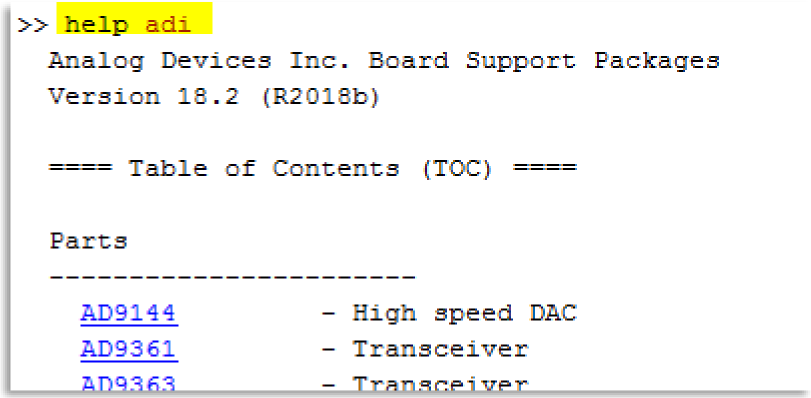
MATLAB Installation

- Now test your installation by going to a MATLAB prompt and typing
  - `help adi`



```
>> help adi
  Analog Devices Inc. Board Support Packages
  Version 18.2 (R2018b)

  ==== Table of Contents (TOC) ====

  Parts
  -----------------------
    AD9144          - High speed DAC
    AD9361          - Transceiver
    AD9363          - Transceiver
```

- You should see the BSP that you just installed and some other helpful resources
  - If you don’t then you did not install the Analog Devices Board Support Package!

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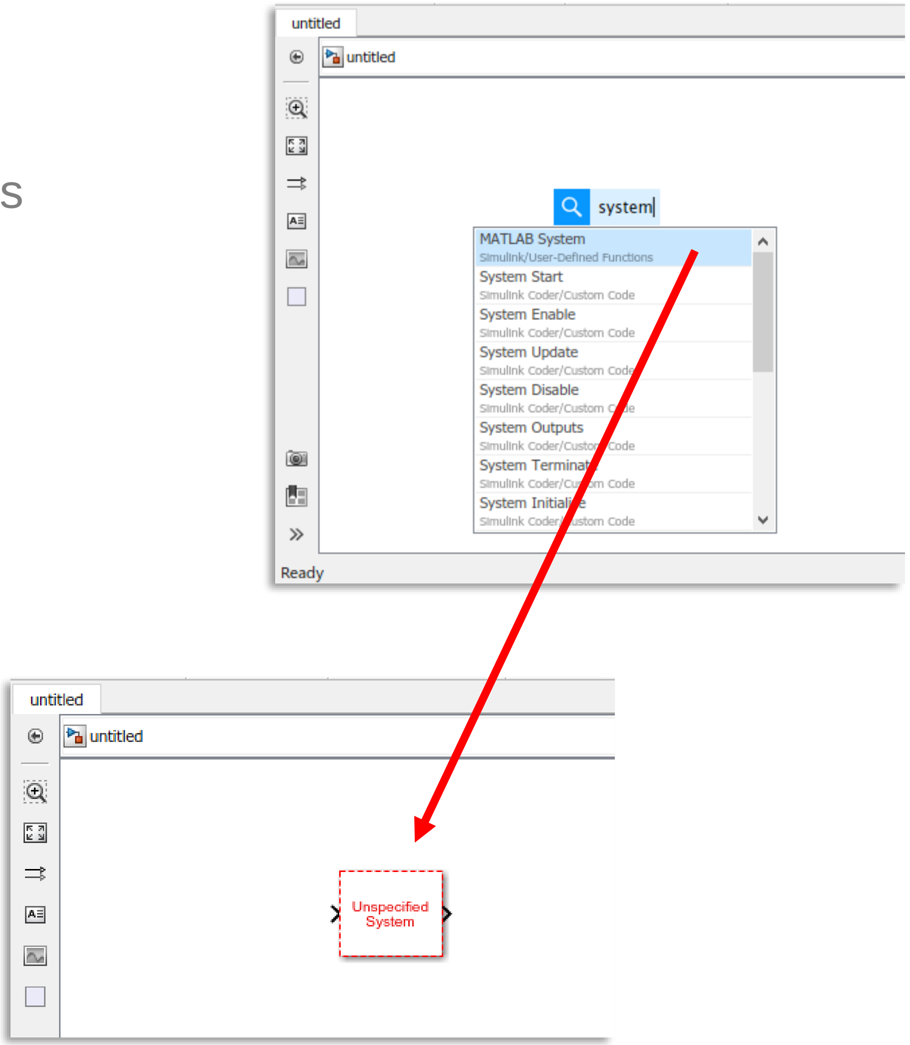
Streaming with Simulink

Streaming with Simulink: Setup

- You can access the eval boards with MATLAB (script) or Simulink
  - Most algorithm development experts prefer MATLAB, and it has many advantages.
  - However, Simulink is fine to get started or for simple setups
- Start Simulink by typing:
  - `simulink`
  - Select Blank Model to start with a clean schematic
  - Double click anywhere on that white space and start typing “system”
  - Then select the “MATLAB System” block when it appears

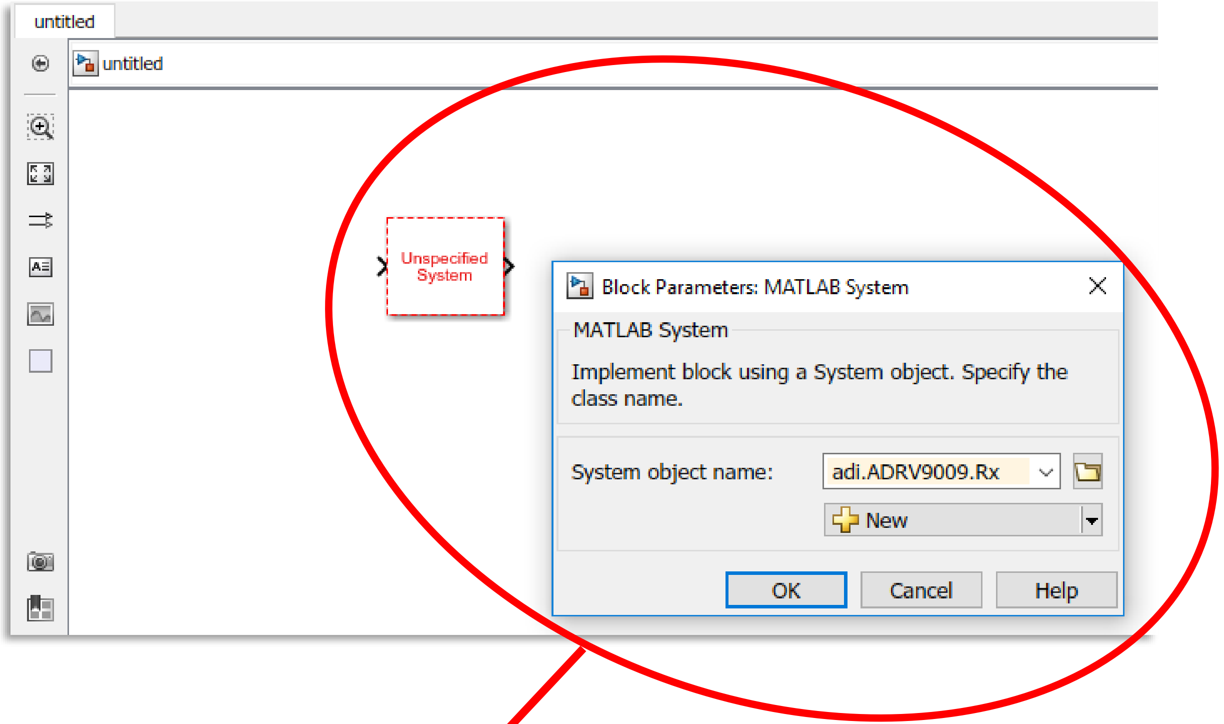

untitled
untitled
system
MATLAB System
Simulink/User-Defined Functions
System Start
Simulink Coder/Custom Code
System Enable
Simulink Coder/Custom Code
System Update
Simulink Coder/Custom Code
System Disable
Simulink Coder/Custom Code
System Outputs
Simulink Coder/Custom Code
System Terminate
Simulink Coder/Custom Code
System Initialize
Simulink Coder/Custom Code
Ready
untitled
untitled
Unspecified System

Streaming with Simulink: Setup Receive Channels

- Double click on that MATLAB System block
- Name the system object
  - The system object name follows the format:

    `adi.<Part or Board Name>.<Tx or Rx>`
  - For example, an ADRV9009 receive block is:

    `adi.ADRV9009.Rx`
  - Note: capitalization matters!



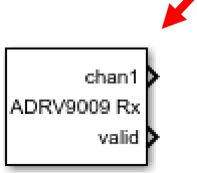
Block Parameters: MATLAB System

MATLAB System

Implement block using a System object. Specify the class name.

System object name: adi.ADRV9009.Rx

  - Pressing OK magically transforms it into a ADRV9009 Rx block!



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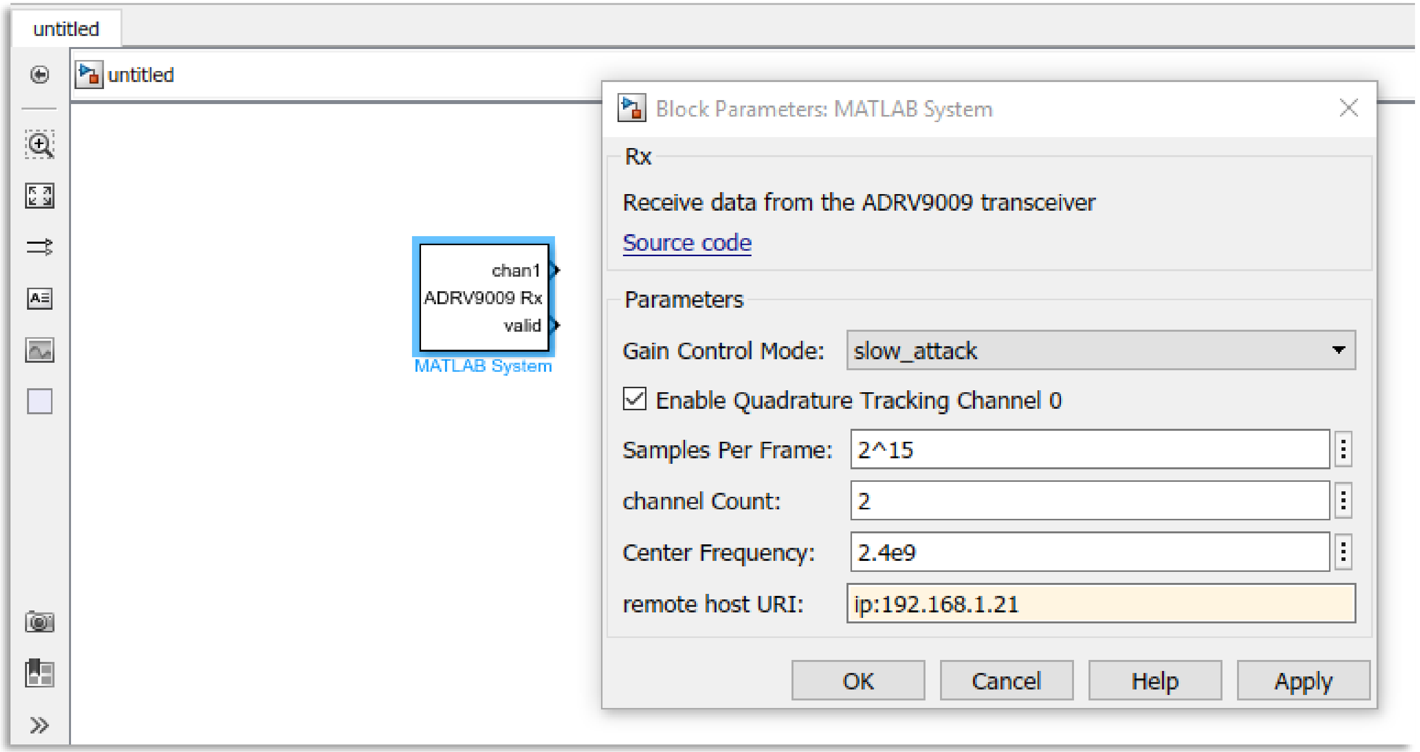
Streaming with Simulink: Setup Receive Channels

- Now double click on that block to reveal its properties
- Change the remote host URI to the static IP address that you gave your eval board (or see the resources mentioned earlier if you haven't done this yet!)



Rx

Receive data from the ADRV9009 transceiver

Source code

Parameters

Gain Control Mode: slow_attack

☑ Enable Quadrature Tracking Channel 0

Samples Per Frame: 2^15

channel Count: 2

Center Frequency: 2.4e9

remote host URI: ip:192.168.1.21

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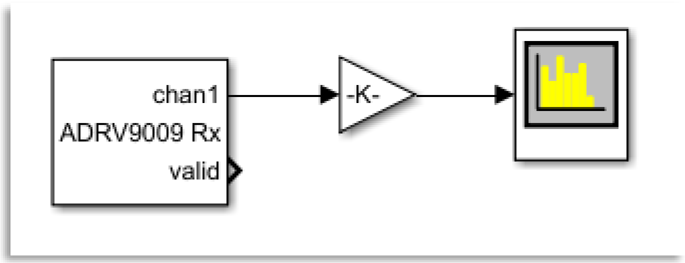
Streaming with Simulink: Setup Receive Channels

- Double click on a blank canvas spot and type “spectrum”
- Select the “Spectrum Analyzer” block
- The output is in ADC codes, scale it to give something meaningful for the gain you are at.
  - In this example, I just divide by 2^15
- Connect that to the ADRV9009 Rx chan1 port



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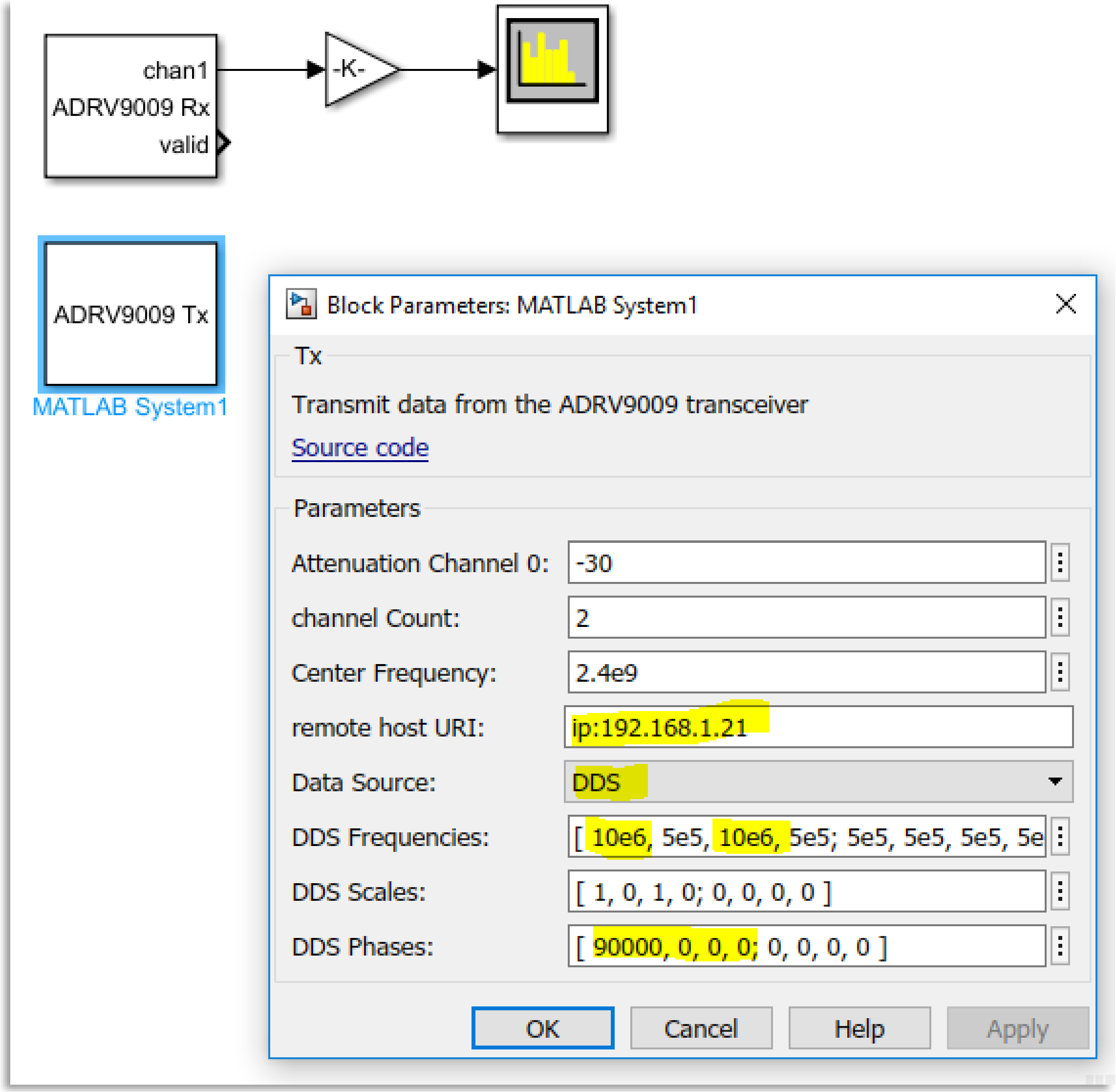
Streaming with Simulink: Setup Transmitter with FPGA DDS Source

- Now add a Transmitter block
  - Start with a MATLAB System block
  - Then rename to adi.ADRV9009.Tx
- Double click on the Tx block to configure
  - Make the changes in highlighted yellow
    - Change the IP address
    - I've also set it to use the FPGA's DDS to generate a single 10MHz tone
      - You could instead leave the Data Source at "DMA" and then connect a MATLAB signal source to the Tx input.



Block Parameters: MATLAB System1

Tx

Transmit data from the ADRV9009 transceiver

Source code

Parameters

Attenuation Channel 0: -30

channel Count: 2

Center Frequency: 2.4e9

remote host URI: ip:192.168.1.21

Data Source: DDS

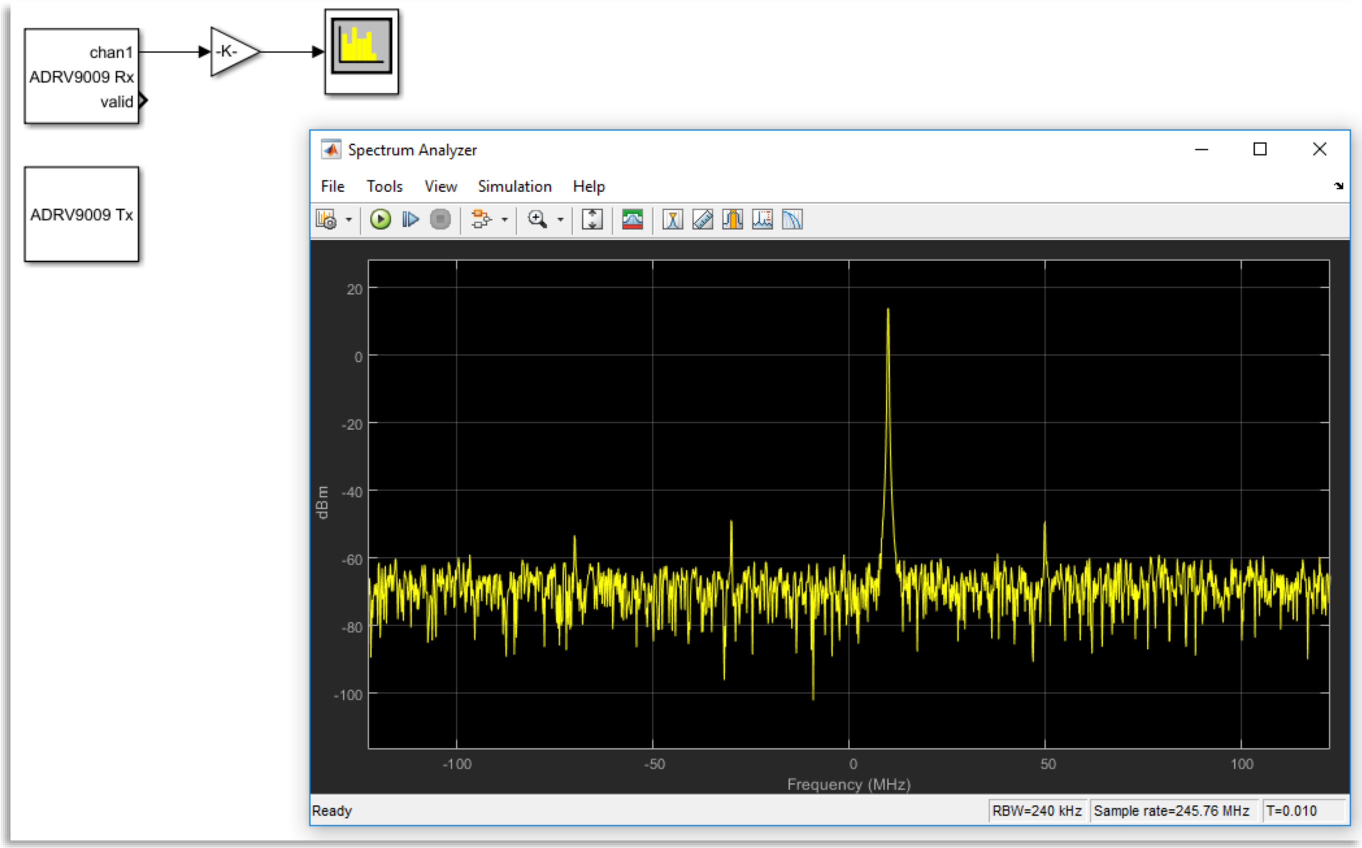
DDS Frequencies: [10e6, 5e5, 10e6, 5e5; 5e5, 5e5, 5e5, 5e

DDS Scales: [1, 0, 1, 0; 0, 0, 0, 0]

DDS Phases: [90000, 0, 0, 0; 0, 0, 0, 0]

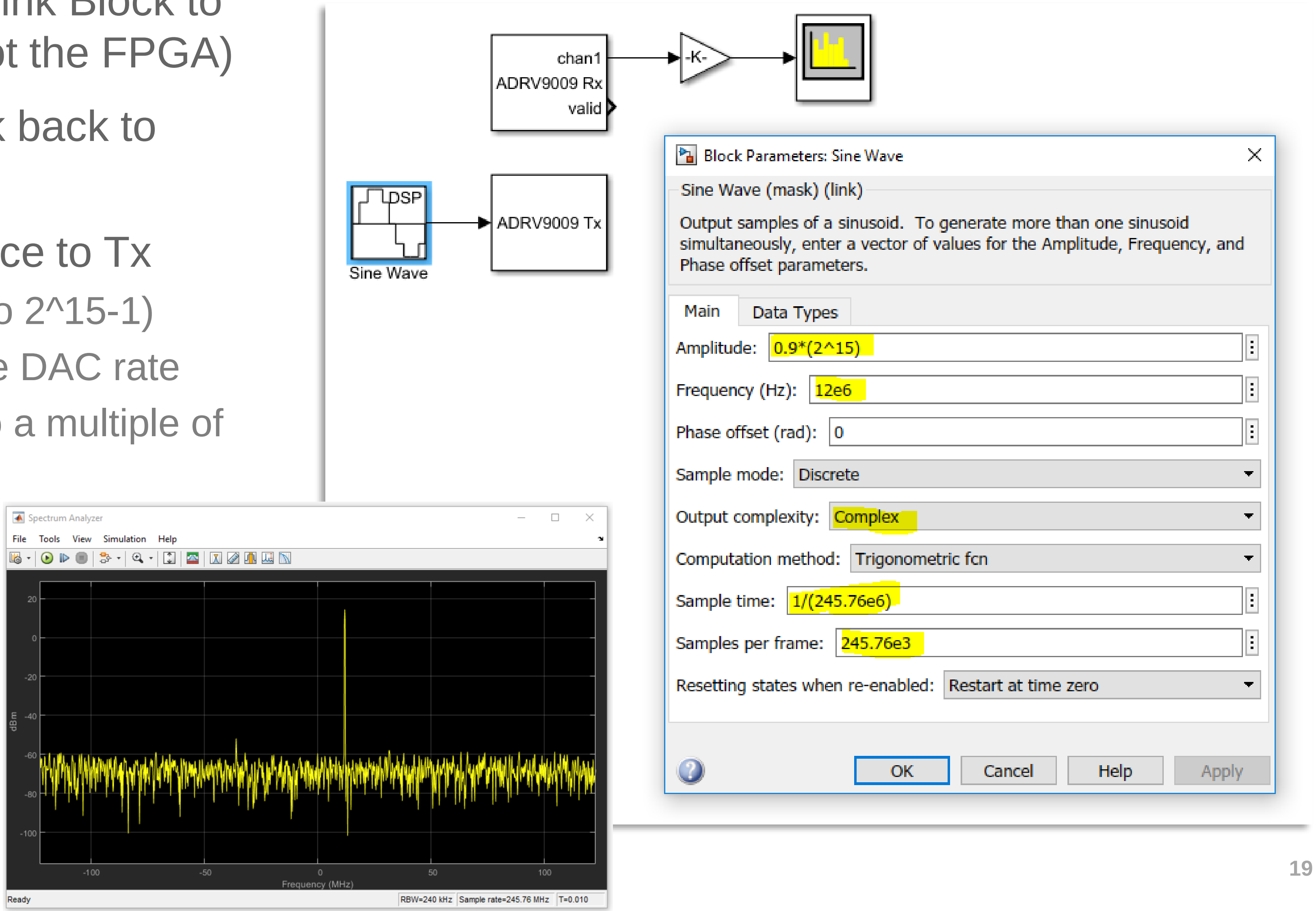
Streaming with Simulink: Run the Loopback DDS Example

- On your TRx Eval board:
  - Use an SMA cable to connect Tx1 to Rx1
- In MATLAB, press the “Play” button
- You should see a tone at 10 MHz



Streaming with Simulink: Setup Transmitter with Simulink Source

- Of course, we also use a Simulink Block to generate the transmit tones (not the FPGA)
- For this, we switch the Tx block back to Data Source = “DMA”
- Then connect a DSP Sine source to Tx
  - Amplitude is in ADC codes (up to 2^15-1)
  - Sample time is the inverse of the DAC rate
  - Samples per frame is best set to a multiple of sample rate. And <1e6.
- Play yields a similar spectrum:



Block Parameters: Sine Wave

Sine Wave (mask) (link)

Output samples of a sinusoid. To generate more than one sinusoid simultaneously, enter a vector of values for the Amplitude, Frequency, and Phase offset parameters.

Main | Data Types

Amplitude: 0.9*(2^15)

Frequency (Hz): 12e6

Phase offset (rad): 0

Sample mode: Discrete

Output complexity: Complex

Computation method: Trigonometric fcn

Sample time: 1/(245.76e6)

Samples per frame: 245.76e3

Resetting states when re-enabled: Restart at time zero

OK | Cancel | Help | Apply

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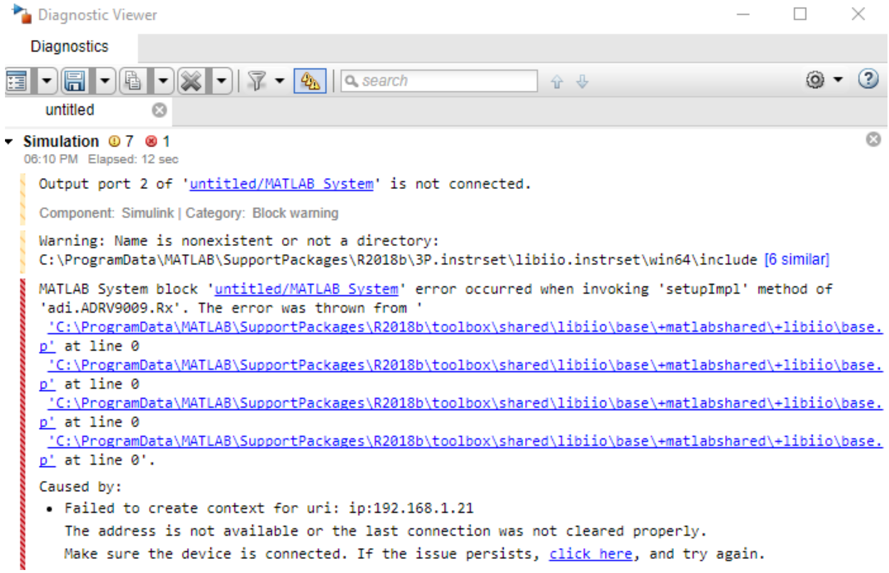
Streaming with Simulink: Troubleshooting

- If you don’t have an eval board configured with the correct IP address, you might see an error like:



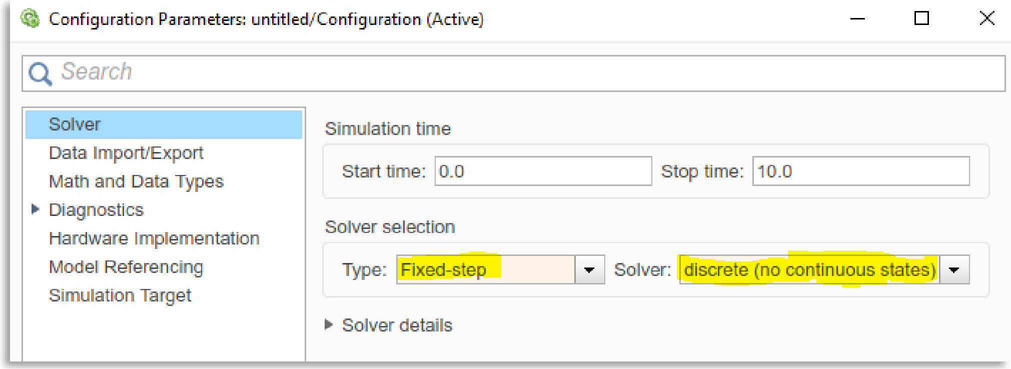
Simulation 7 1
06:10 PM   Elapsed: 12 sec

```
Output port 2 of 'untitled/MATLAB System' is not connected.
```

Component: Simulink | Category: Block warning

```
Warning: Name is nonexistent or not a directory:
C:\ProgramData\MATLAB\SupportPackages\R2018b\3P.instrset\libiio.instrset\win64\include [6 similar]

MATLAB System block 'untitled/MATLAB System' error occurred when invoking 'setupImpl' method of
'adi.ADRV9009.Rx'. The error was thrown from '
 'C:\ProgramData\MATLAB\SupportPackages\R2018b\toolbox\shared\libiio\base\+matlabshared\+libiio\base.
p' at line 0
 'C:\ProgramData\MATLAB\SupportPackages\R2018b\toolbox\shared\libiio\base\+matlabshared\+libiio\base.
p' at line 0
 'C:\ProgramData\MATLAB\SupportPackages\R2018b\toolbox\shared\libiio\base\+matlabshared\+libiio\base.
p' at line 0
 'C:\ProgramData\MATLAB\SupportPackages\R2018b\toolbox\shared\libiio\base\+matlabshared\+libiio\base.
p' at line 0'.

Caused by:
 • Failed to create context for uri: ip:192.168.1.21
   The address is not available or the last connection was not cleared properly.
   Make sure the device is connected. If the issue persists, click here, and try again.
```

- If some scopes are not working then you may need to change some configuration parameters
  - Go to Simulation→Model Configuration Parameters
    - Set Type to “Fixed Step”
    - Set Solver to “Discrete”



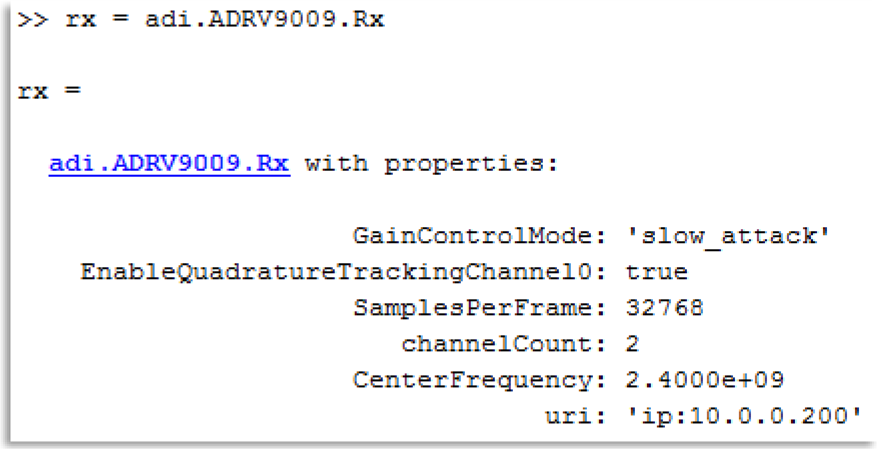
Start time: 0.0   Stop time: 10.0

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

Streaming with MATLAB

Streaming with MATLAB

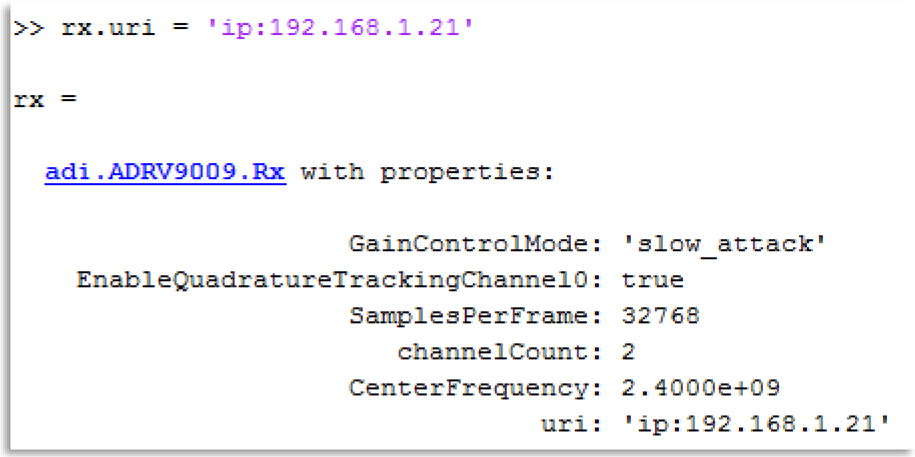
- The same Board Support Package we called from Simulink can be called from MATLAB
- Once again, refer to this site for the latest info:
  - https://wiki.analog.com/resources/eval/user-guides/MATLAB_bsp
- In MATLAB, type “doc adi” to get examples
- Using that help file, we can see how to create a receive object. Let’s do that now!
  - `rx = adi.ADRV9009.Rx`



```
>> rx = adi.ADRV9009.Rx

rx =

  adi.ADRV9009.Rx with properties:

                      GainControlMode: 'slow_attack'
    EnableQuadratureTrackingChannel0: true
                      SamplesPerFrame: 32768
                         channelCount: 2
                      CenterFrequency: 2.4000e+09
                                  uri: 'ip:10.0.0.200'
```

Streaming with MATLAB

- Then change the IP address on the rx object we created:
  - `rx.uri = 'ip:192.168.1.21'`



```
>> rx.uri = 'ip:192.168.1.21'

rx = 

  adi.ADRV9009.Rx with properties:

                      GainControlMode: 'slow_attack'
    EnableQuadratureTrackingChannel0: true
                      SamplesPerFrame: 32768
                         channelCount: 2
                      CenterFrequency: 2.4000e+09
                                  uri: 'ip:192.168.1.21'
```

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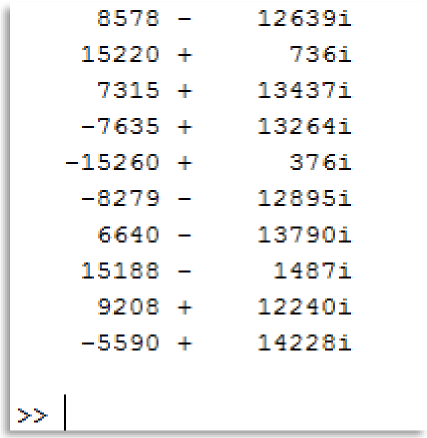
Streaming with MATLAB

- There are a couple of ways to get a buffer of received data from our object:
  - `rx()`

    or
  - `rx.step()`
- Running either of those commands (without the semicolon) will produce a long list of complex data



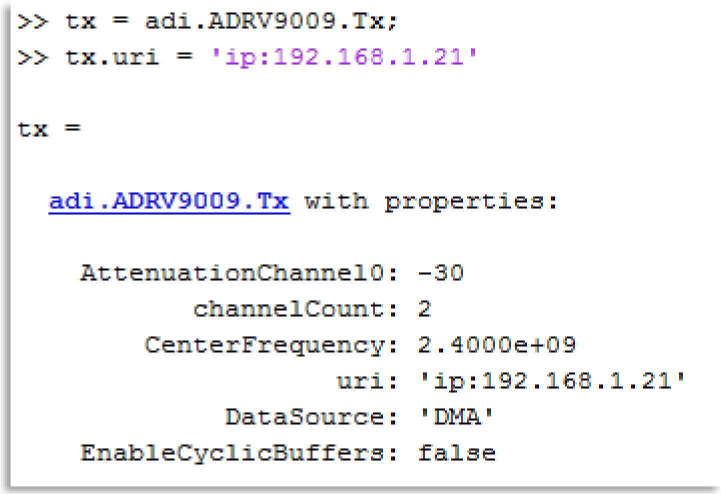
```
    8578 -     12639i
   15220 +       736i
    7315 +     13437i
   -7635 +     13264i
  -15260 +       376i
   -8279 -     12895i
    6640 -     13790i
   15188 -      1487i
    9208 +     12240i
   -5590 +     14228i

>> |
```

Streaming with MATLAB

- To receive both channels of Rx data:
  - First, enable all 4 ADCs (Rx1 I and Q, and Rx2 I and Q):
    - rx.channelCount = 4;
  - `[data0, data1] = rx();`

Streaming with MATLAB: Loopback Example

- Loop back example:
  - Let’s connect Tx1 to Rx1, then generate some Tx1 data, receive the data on Rx1, and plot it.
- So first connect Tx1 to Rx1 with an SMA cable
- Then, generate a Tx object:



```
>> tx = adi.ADRV9009.Tx;
>> tx.uri = 'ip:192.168.1.21'

tx =

  adi.ADRV9009.Tx with properties:

    AttenuationChannel0: -30
           channelCount: 2
        CenterFrequency: 2.4000e+09
                    uri: 'ip:192.168.1.21'
             DataSource: 'DMA'
    EnableCyclicBuffers: false
```

Streaming with MATLAB: Loopback DDS Example

- Configure the FPGA to generate a 10 MHz tone:
  - `tx.DataSource = 'DDS';`
  - `tx.DDSFrequencies = [10e6, 1e6, 10e6, 1e6; 1e6, 1e6, 1e6, 1e6];`
  - `tx.DDSScales = [1, 0, 1, 0; 0, 0, 0, 0];`
  - `tx.DDSPhases = [90000, 0, 0, 0; 0, 0, 0, 0];`
- Connect an SMA cable from Tx1 to Rx1
- Transmit the data:
  - `tx.AttenuationChannel0 = -10;`
  - `tx();`
- Section 5.2 of “Software-Defined Radio for Engineers”, shows how to plot this data:
  - https://www.analog.com/media/en/training-seminars/design-handbooks/Software-Defined-Radio-for-Engineers-2018/SDR4Engineers.pdf#page=208
  - `sa = dsp.SpectrumAnalyzer;`
  - `sa.SampleRate = 245.76e6;`
  - `sa(rx());`

ANALOG DEVICES
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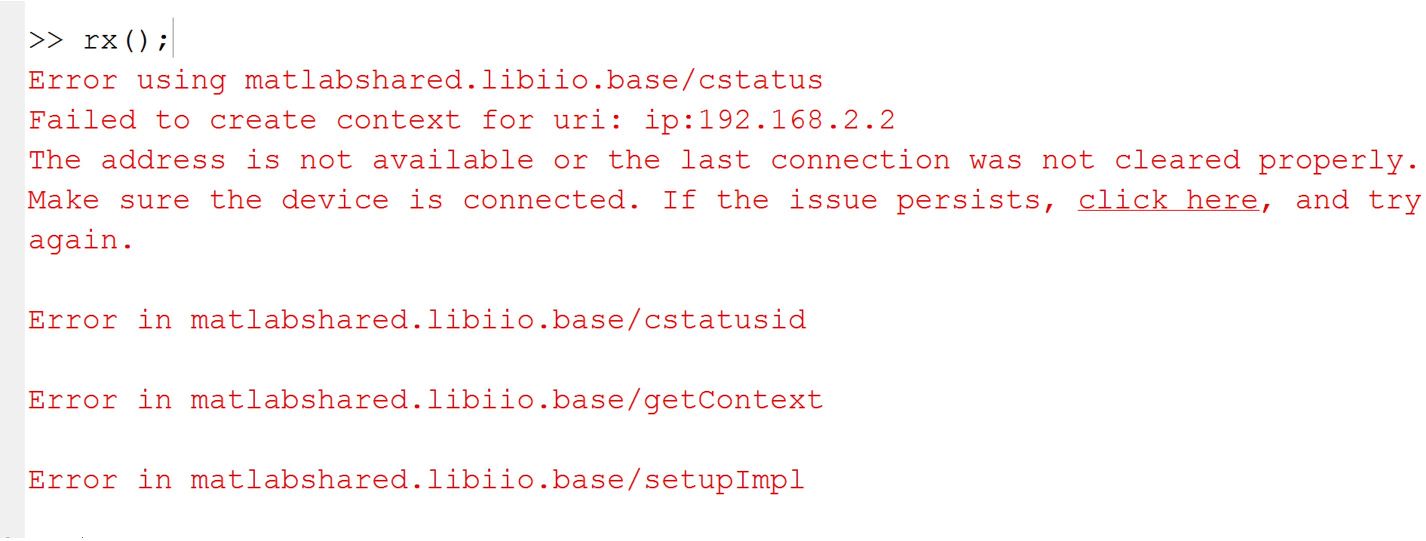
Streaming with MATLAB: Loopback with MATLAB Source Example

- Once again, follow the examples of Section 5.2 of “Software-Defined Radio for Engineers”:
  - https://www.analog.com/media/en/training-seminars/design-handbooks/Software-Defined-Radio-for-Engineers-2018/SDR4Engineers.pdf#page=208
- Excellent examples also found here:
  - https://github.com/analogdevicesinc/MathWorks_tools/tree/master/test

- Change Tx source to DMA and create a sine wave:
  - `tx.DataSource = 'DMA';`
  - `amplitude = 2^15;  frequency = 14e6;`
  - `swv1 = dsp.SineWave(amplitude, frequency);`
  - `swv1.ComplexOutput = true;`
  - `swv1.SamplesPerFrame = 2^20;`
  - `swv1.SampleRate = 245.76e6;`
- Connect an SMA cable from Tx1 to Rx1
- Transmit the data:
  - `tx.AttenuationChannel0 = -10;`
  - `tx(swv1());`
- Plot the output:
  - `sa = dsp.SpectrumAnalyzer;`
  - `sa.SampleRate = 245.76e6;`
  - `sa(rx());`

Streaming with MATLAB or Simulink: Troubleshooting

- If the link between the board is broken or reset without MATLAB's knowledge you can get errors like:



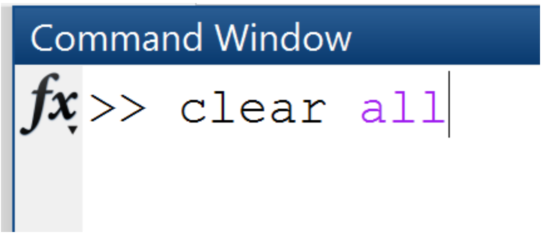
```
>> rx();
Error using matlabshared.libiio.base/cstatus
Failed to create context for uri: ip:192.168.2.2
The address is not available or the last connection was not cleared properly.
Make sure the device is connected. If the issue persists, click here, and try
again.

Error in matlabshared.libiio.base/cstatusid

Error in matlabshared.libiio.base/getContext

Error in matlabshared.libiio.base/setupImpl
```

- You can try:



```
fx >> clear all
```

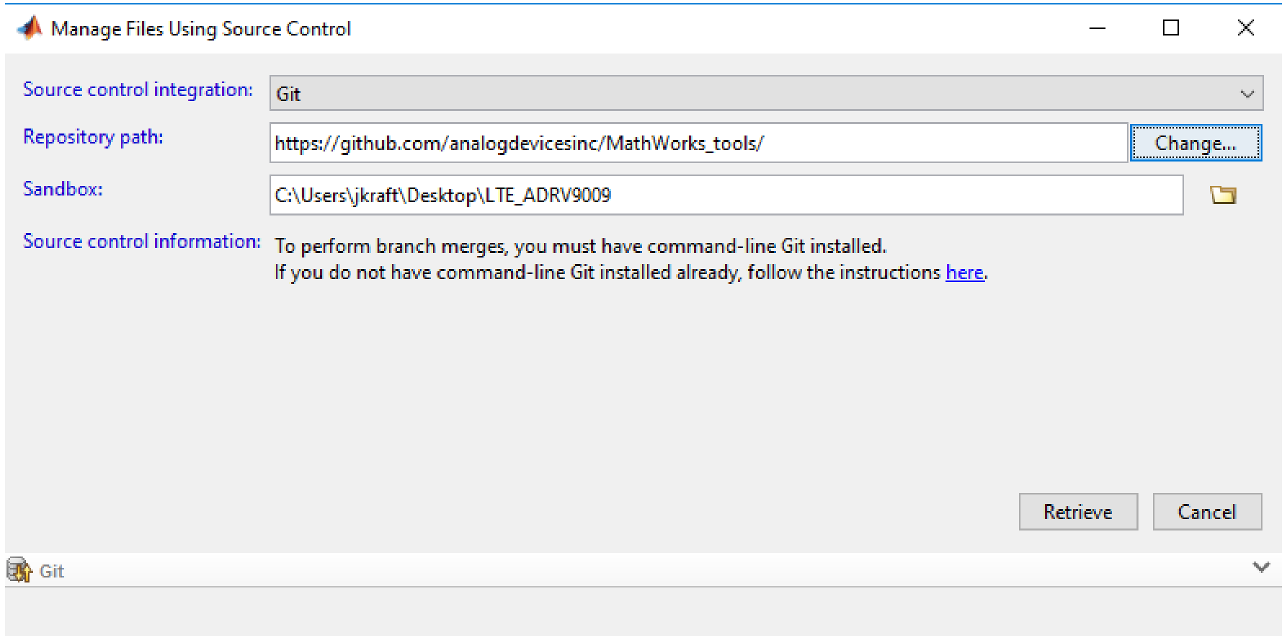
- Otherwise restart MATLAB and restart the board

Installing Command Line GIT for MATLAB

- Many good things are found in ADI's github repository!

- You can download the files individual and run from a folder, or use command line git
  - Download command line git here: https://gitforwindows.org/

- Then right click on a blank space in "Current Folder" explorer, and select Source Control→Manage Files



Manage Files Using Source Control

Source control integration: Git

Repository path: https://github.com/analogdevicesinc/MathWorks_tools/

Sandbox: C:\Users\jkraft\Desktop\LTE_ADRV9009

Source control information: To perform branch merges, you must have command-line Git installed.
If you do not have command-line Git installed already, follow the instructions here.

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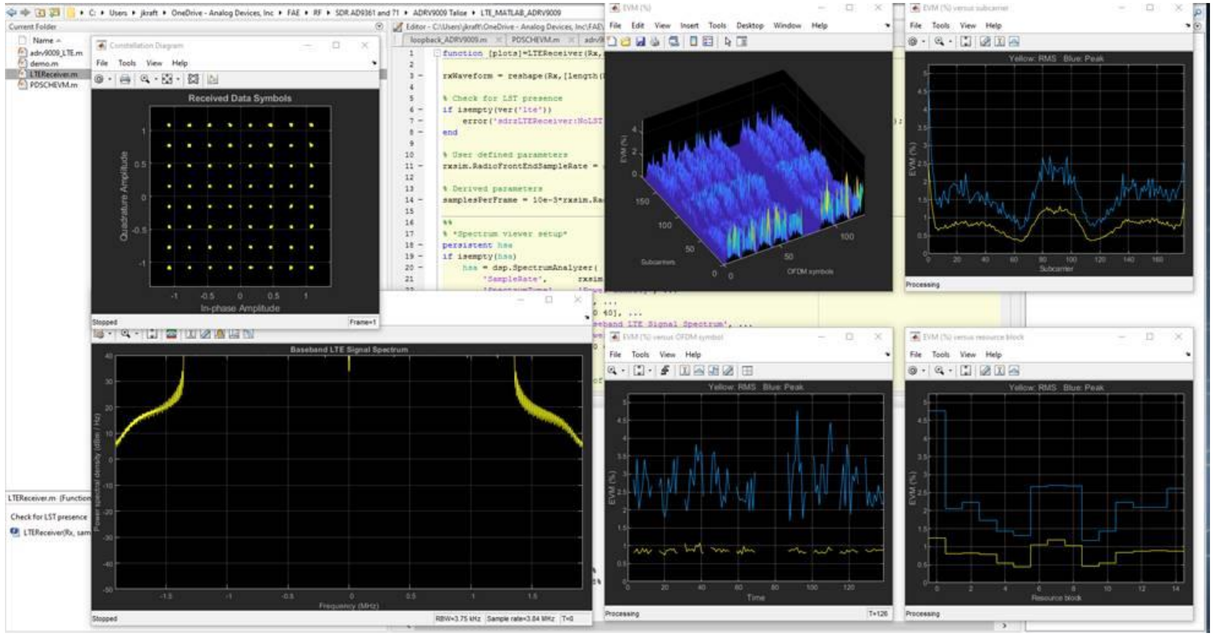
EVM Example in MATLAB

EVM Example in MATLAB

- Example courtesy of Dr. Travis Collins

- The scripts for this example are found here:
  - https://github.com/analogdevicesinc/MathWorks_tools/tree/adrv9009-lte-demo/hil_models/LTE_MATLAB_ADRV9009

- Download and from that folder, run:
  - `demo('ip:192.168.1.21')`


C: ▸ Users ▸ jkraft ▸ OneDrive - Analog Devices, Inc ▸ FAE ▸ RF ▸ SDR AD9361 and 71 ▸ ADRV9009 Talise ▸ LTE_MATLAB_ADRV9009
Current Folder
Name
adrv9009_LTE.m
demo.m
LTEReceiver.m
PDSCHEVM.m
Editor - C:\Users\jkraft\OneDrive - Analog Devices, Inc\FAE\
loopback_ADRV9009.m
PDSCHEVM.m
Constellation Diagram
File Tools View Help
Received Data Symbols
Quadrature Amplitude
In-phase Amplitude
Stopped
Frame=1
Baseband LTE Signal Spectrum
Power spectral density (dBm / Hz)
Frequency (MHz)
RBW=3.75 kHz Sample rate=3.84 MHz T=0
EVM (%)
File Edit View Insert Tools Desktop Window Help
Subcarriers
OFDM symbols
EVM (%) versus subcarrier
Yellow: RMS Blue: Peak
Subcarrier
Processing
EVM (%) versus OFDM symbol
Time
T=126
EVM (%) versus resource block
Resource block

```
function [plots]=LTEReceiver(Rx,

rxWaveform = reshape(Rx,[length(

% Check for LST presence
if isempty(ver('lte'))
    error('sdrzLTEReceiver:NoLST
end

% User defined parameters
rxsim.RadioFrontEndSampleRate =

% Derived parameters
samplesPerFrame = 10e-3*rxsim.Ra

%%
% *Spectrum viewer setup*
persistent hsa
if isempty(hsa)
    hsa = dsp.SpectrumAnalyzer(
        'SampleRate',      rxsim
```

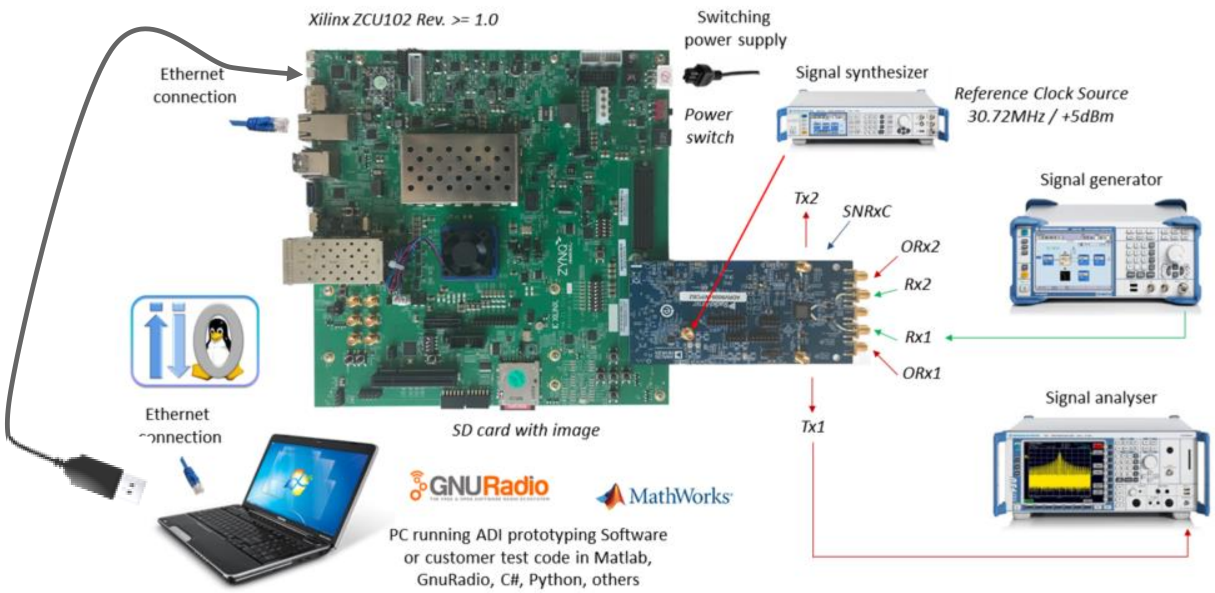
Support and Feature Expansion

- If something is broken, you have an enhancement request for a device, or you have a question about these interfaces please email or ask on EngineerZone:
  - Travis Collins travis.collins@analog.com
  - EZ: https://ez.analog.com/linux-device-drivers/linux-software-drivers

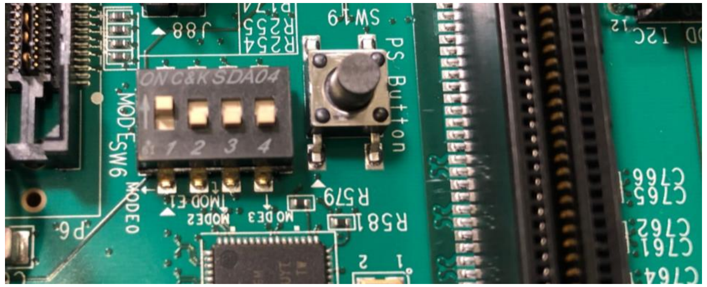
Appendix 1: Setup the Hardware

ZCU102 Hardware Setup

- Need to have:
  - SD Card in place
  - Ethernet cable between laptop & FPGA board
  - USB cable between UART and laptop (J83 on ZCU102)
  - Power cable connected
  - SDR board in the correct HPC slot:
    - AD9371 (or FMCOMMSx or DAQ2) board goes in slot 0
    - ADRV9009 board goes in HPC slot 1 (closest to SD card)
  - 30.72 MHz reference clock connected to SDR board
    - (see next slide for some options on this)



- Don’t bother with HDMI or display port connections. They don’t seem to work on the ZCU102
- DIP switches at SW6 need to be UP DN DN DN (up is toward SD card, DN is away from SD card)



ANALOG DEVICES
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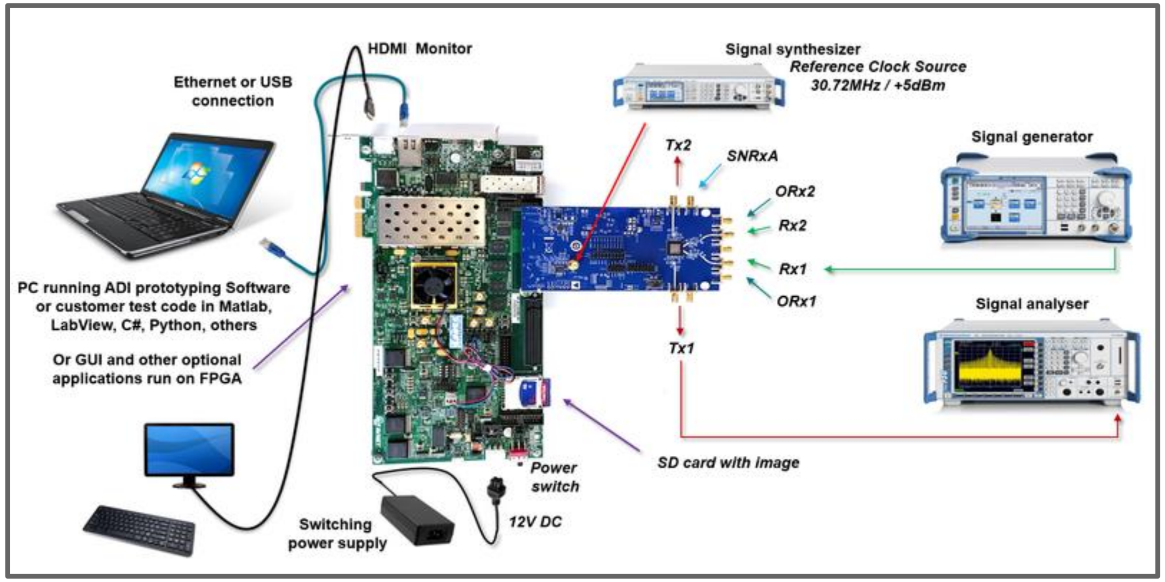
ZYNQ3 (and ZC706) Hardware Setup

- Need to have:
  - SD Card in place
  - Ethernet cable between laptop & FPGA board
  - USB cable between UART and laptop (J21 on ZC706)
  - Power cable connected
  - SDR board in the correct HPC slot:
    - AD936x (i.e. FMCOMMSx) board goes in J5 (LPC) (closest to SD card)
    - AD9371 and ADRV9009 goes in J37 (HPC) (closest to ethernet)
  - 30.72 MHz reference clock connected to SDR board
    - (see next slide for some options on this)



HDMI Monitor

Ethernet or USB connection

Signal synthesizer

Reference Clock Source 30.72MHz / +5dBm

Signal generator

PC running ADI prototyping Software or customer test code in Matlab, LabView, C#, Python, others

Or GUI and other optional applications run on FPGA

Signal analyser

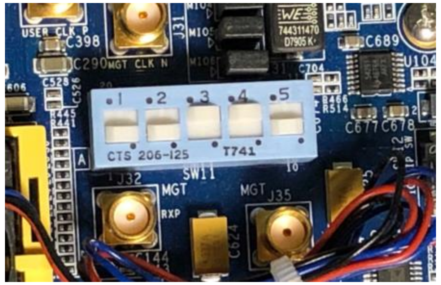
SD card with image

Power switch

12V DC

Switching power supply

- DIP switches at SW11 need to be:



ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

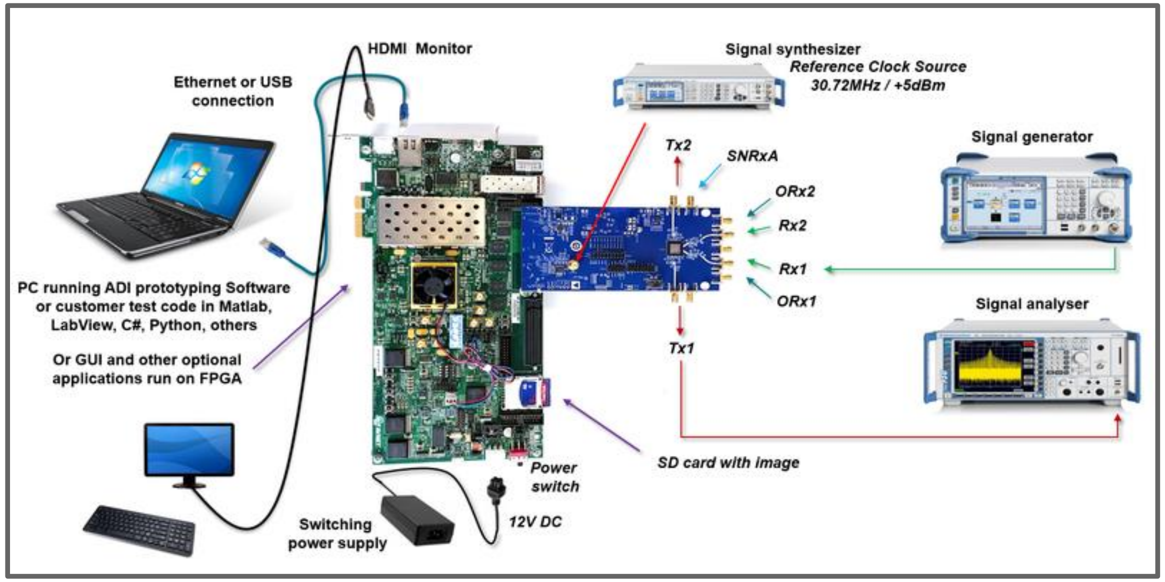
ZYNQ3 (and ZC706) Hardware Setup

- There are two ways to use the ZYNQ3 and ZC706 boards:

1. With an HDMI Monitor Connected.
   - Connect an HDMI Monitor to P1
   - Then use a USB micro to USB OTG adapter on J2. Such as:
     - https://www.amazon.com/gp/product/B00LTHBCNM/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1
   - Connect a USB Keyboard and Mouse to the USB OTG adapter
   - Now, the FPGA board is your computer and you can interact directly with the Linux Software installed on the FPGA.

OR

2. Control via your Laptop.
   - We'll use the UART to assign an IP address to the FPGA board, then open IIOscope on a laptop, add that IP address, and control the radio board from IIOscope on the laptop.
   - The rest of this document explains this procedure.



SDR Board Reference Clock Options

- The ADRV900x boards REQUIRE a reference clock (and AD9371 boards will complain if they don’t get one).
  - 30.72 MHz is the default value, but this could be changed (i.e. 61.44MHz) if required.
- A signal source works great, of course.
- But an easier solution is the Crystek CPRO33-30.72 SMA oscillator.
- These are not expensive, but they are hard to find, so here’s the part’s list for that option:

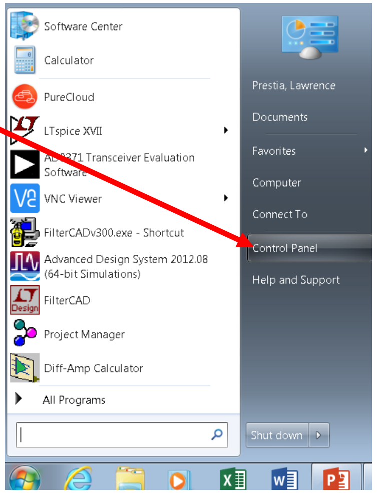
SMA 30.72 MHz clock source for the AD9371 and ADRV9008/9 boards:		
Oscillator	CPRO33-30.72	https://www.digikey.com/products/en?keywords=CPRO33-30.72
SMA to barrel adapter		https://www.digikey.com/products/en?keywords=CCADP-MM-6
3.3V power wall wart	2.1/5.5mm barrel	https://www.digikey.com/product-detail/en/kaga-electronics-usa/KTPS05-03315U-VI-P1/62-1234-ND/5820199

Set a Static IP Address

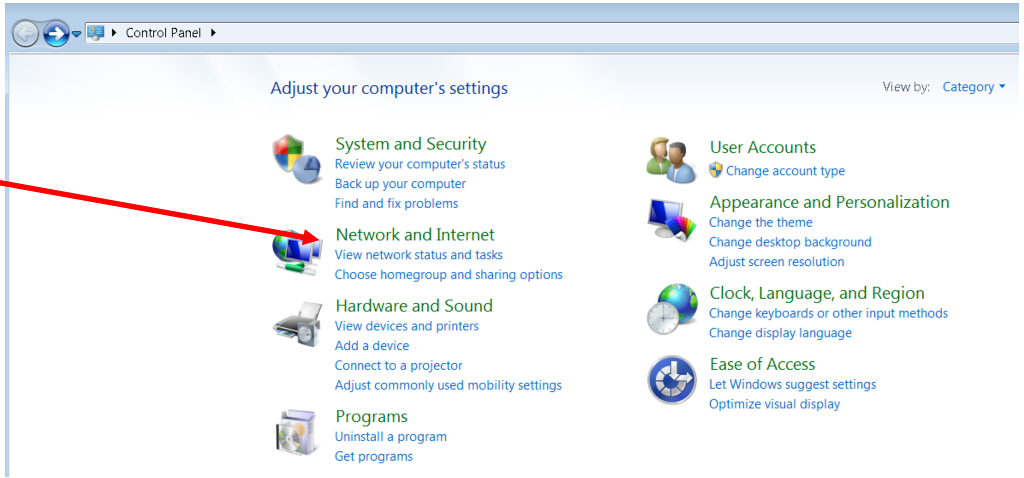
AHEAD OF WHAT'S POSSIBLE™

Set a Static IP Address (1)

1. **Set up LAN laptop settings for communications.**
   a) **Start, Control Panel,**



   b) **Network and Internet**


Control Panel
Adjust your computer's settings
View by: Category
System and Security
Review your computer's status
Back up your computer
Find and fix problems
Network and Internet
View network status and tasks
Choose homegroup and sharing options
Hardware and Sound
View devices and printers
Add a device
Connect to a projector
Adjust commonly used mobility settings
Programs
Uninstall a program
Get programs
User Accounts
Change account type
Appearance and Personalization
Change the theme
Change desktop background
Adjust screen resolution
Clock, Language, and Region
Change keyboards or other input methods
Change display language
Ease of Access
Let Windows suggest settings
Optimize visual display

ANALOG DEVICES
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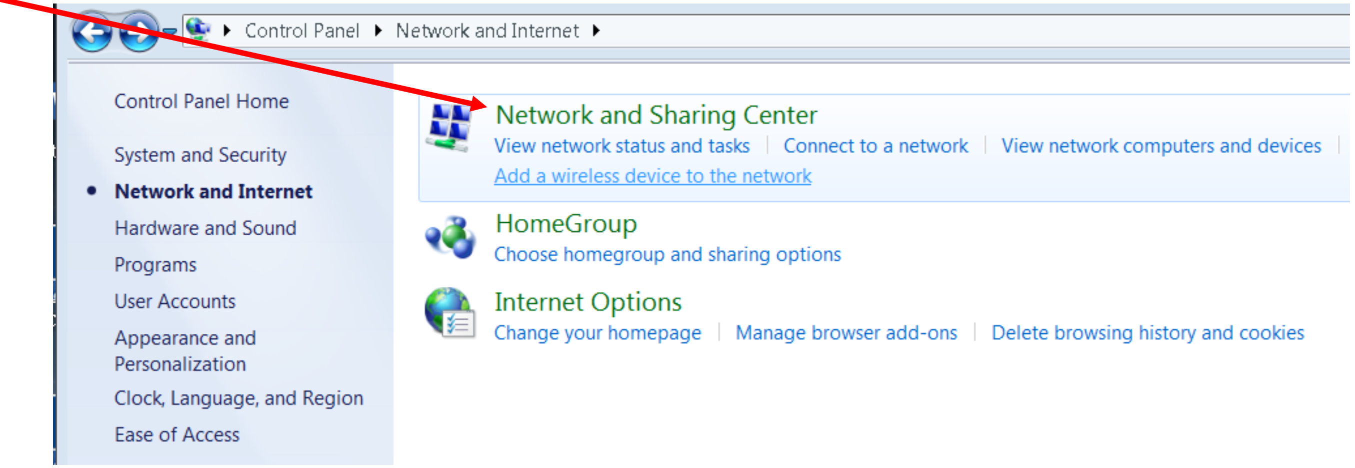
Set a Static IP Address (2)

c) Network and Sharing Center



Control Panel ▸ Network and Internet ▸

Control Panel Home

System and Security

• **Network and Internet**

Hardware and Sound

Programs

User Accounts

Appearance and Personalization

Clock, Language, and Region

Ease of Access

Network and Sharing Center

View network status and tasks | Connect to a network | View network computers and devices | Add a wireless device to the network

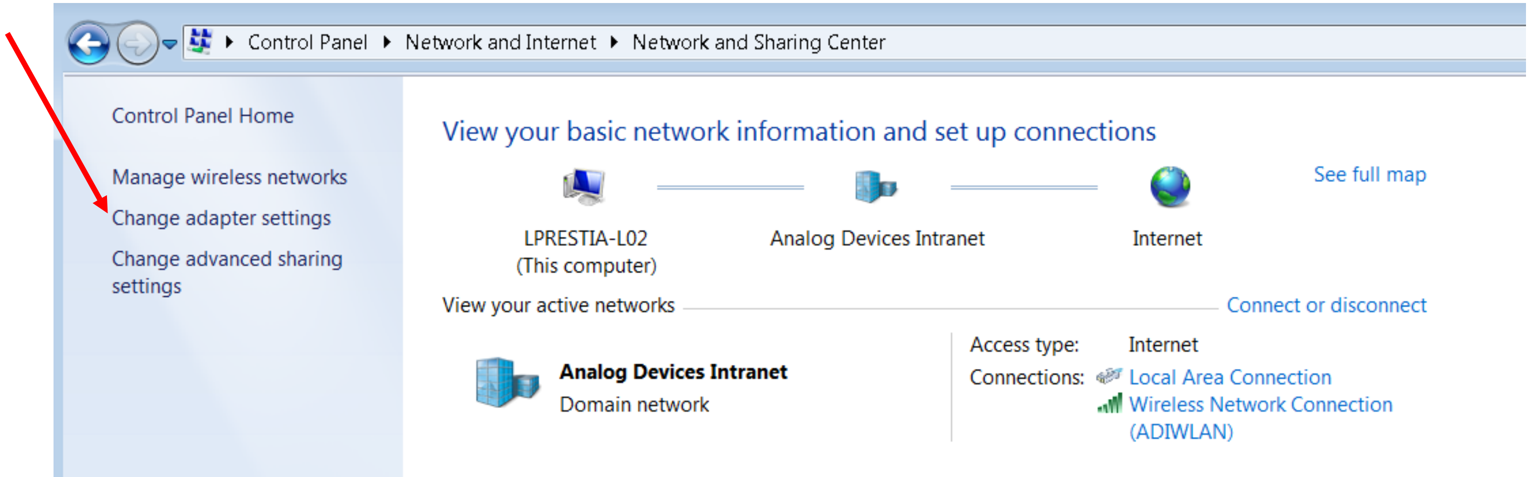
HomeGroup

Choose homegroup and sharing options

Internet Options

Change your homepage | Manage browser add-ons | Delete browsing history and cookies

d) Change adapter settings



Control Panel ▸ Network and Internet ▸ Network and Sharing Center

Control Panel Home

Manage wireless networks

Change adapter settings

Change advanced sharing settings

View your basic network information and set up connections

See full map

LPRESTIA-L02 (This computer)

Analog Devices Intranet

Internet

View your active networks

Connect or disconnect

Analog Devices Intranet

Domain network

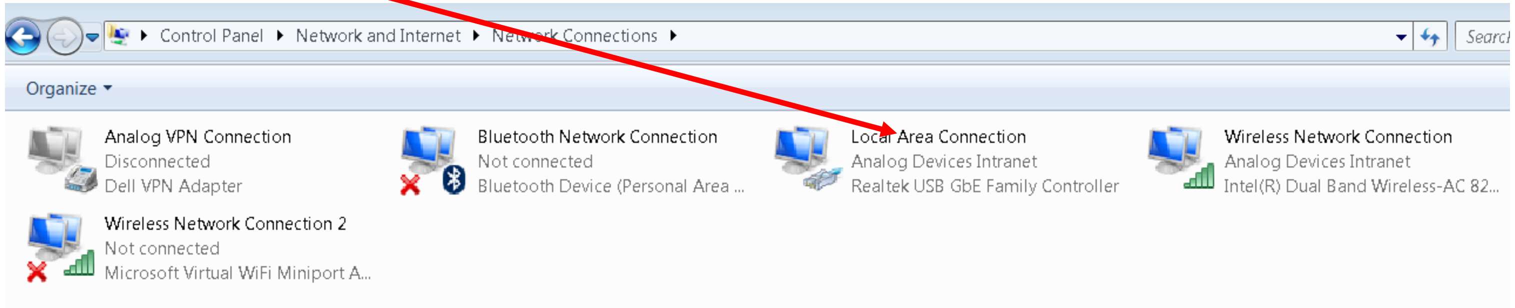
Access type: Internet

Connections: Local Area Connection

Wireless Network Connection (ADIWLAN)

Set a Static IP Address (3)

e) **Local Area Connection or Ethernet**



Control Panel ▸ Network and Internet ▸ Network Connections ▸

Organize ▾

Analog VPN Connection
Disconnected
Dell VPN Adapter

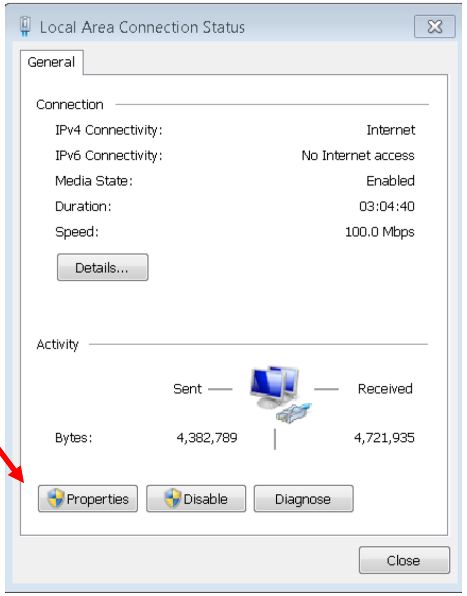
Bluetooth Network Connection
Not connected
Bluetooth Device (Personal Area ...

Local Area Connection
Analog Devices Intranet
Realtek USB GbE Family Controller

Wireless Network Connection
Analog Devices Intranet
Intel(R) Dual Band Wireless-AC 82...

Wireless Network Connection 2
Not connected
Microsoft Virtual WiFi Miniport A...

f) **Properties**



Local Area Connection Status

General

Connection

IPv4 Connectivity:	Internet
IPv6 Connectivity:	No Internet access
Media State:	Enabled
Duration:	03:04:40
Speed:	100.0 Mbps

Details...

Activity

	Sent	Received
Bytes:	4,382,789	4,721,935

Properties Disable Diagnose

Close

ANALOG DEVICES
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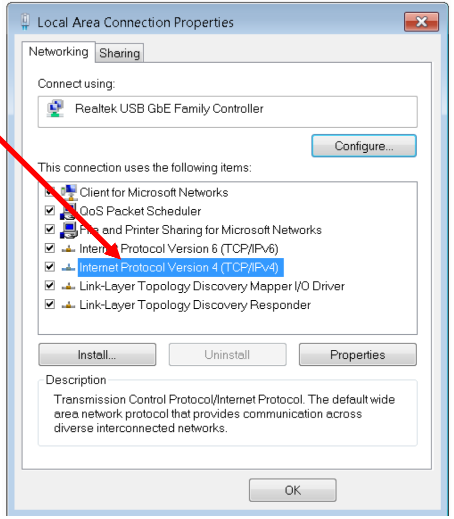
Set a Static IP Address (4)

g) Internet Protocol Version 4 (double-click)



Local Area Connection Properties

Networking | Sharing

Connect using:

Realtek USB GbE Family Controller

Configure...

This connection uses the following items:

- ☑ Client for Microsoft Networks
- ☑ QoS Packet Scheduler
- ☑ File and Printer Sharing for Microsoft Networks
- ☑ Internet Protocol Version 6 (TCP/IPv6)
- ☑ Internet Protocol Version 4 (TCP/IPv4)
- ☑ Link-Layer Topology Discovery Mapper I/O Driver
- ☑ Link-Layer Topology Discovery Responder

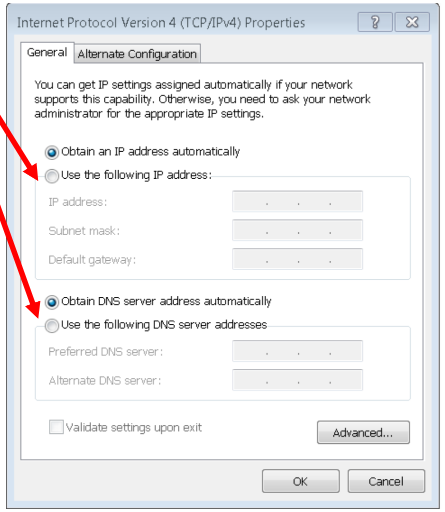
Install... | Uninstall | Properties

Description

Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.

OK

f) Use the following…



Internet Protocol Version 4 (TCP/IPv4) Properties

General | Alternate Configuration

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

- ● Obtain an IP address automatically
- ○ Use the following IP address:

IP address: . . .

Subnet mask: . . .

Default gateway: . . .

- ● Obtain DNS server address automatically
- ○ Use the following DNS server addresses

Preferred DNS server: . . .

Alternate DNS server: . . .

☐ Validate settings upon exit

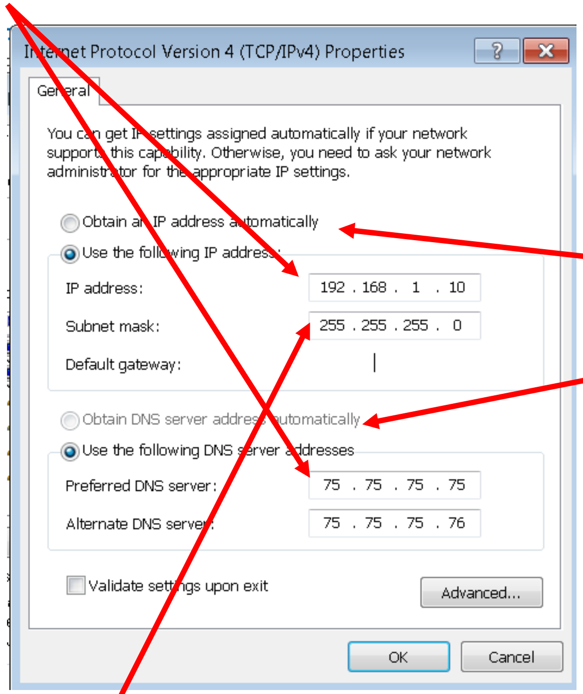
Advanced...

OK | Cancel

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

Set a Static IP Address (5)

g) Fill in IP Address, Preferred DNS, Alternate DNS with values shown



Internet Protocol Version 4 (TCP/IPv4) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically

● Use the following IP address:

IP address: 192 . 168 . 1 . 10

Subnet mask: 255 . 255 . 255 . 0

Default gateway:

○ Obtain DNS server address automatically

● Use the following DNS server addresses:

Preferred DNS server: 75 . 75 . 75 . 75

Alternate DNS server: 75 . 75 . 75 . 76

□ Validate settings upon exit

IMPORTANT – Change back to OBTAIN…AUTOMATICALLY when done

f) Subnet fills in automatic

g) OK, OK

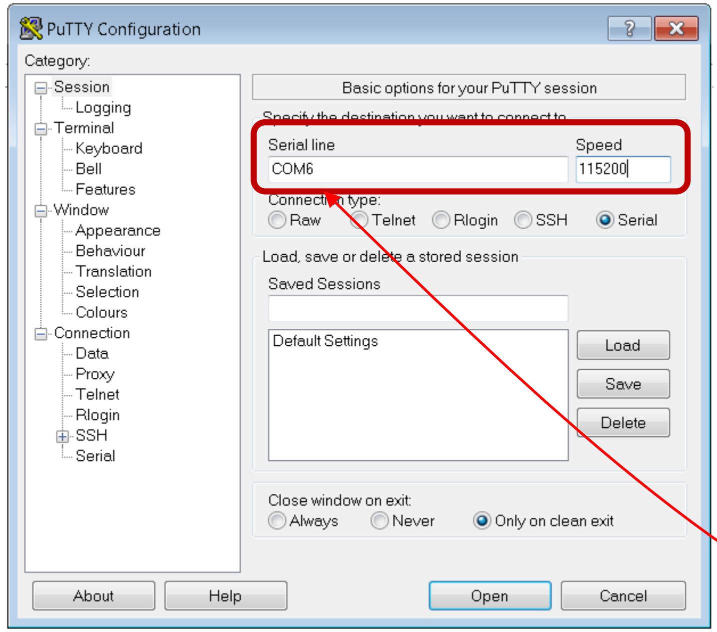
AHEAD OF WHAT'S POSSIBLE™

Connect Via Terminal Program (i.e. Putty or TeraTerm)

Connecting to the FPGA Board

Power Up FPGA Board

- Open Device Manager & find USB to UART Bridge "Interface 0"
  - You may need to download and install the CP2108 drivers from Silicon labs
- Open PuTTY and use Serial Link to connect to that COM port. Baud rate will be 115200.



PuTTY Configuration

Category:

- Session
  - Logging
- Terminal
  - Keyboard
  - Bell
  - Features
- Window
  - Appearance
  - Behaviour
  - Translation
  - Selection
  - Colours
- Connection
  - Data
  - Proxy
  - Telnet
  - Rlogin
  - SSH
  - Serial

Basic options for your PuTTY session

Specify the destination you want to connect to

Serial line: COM6

Speed: 115200

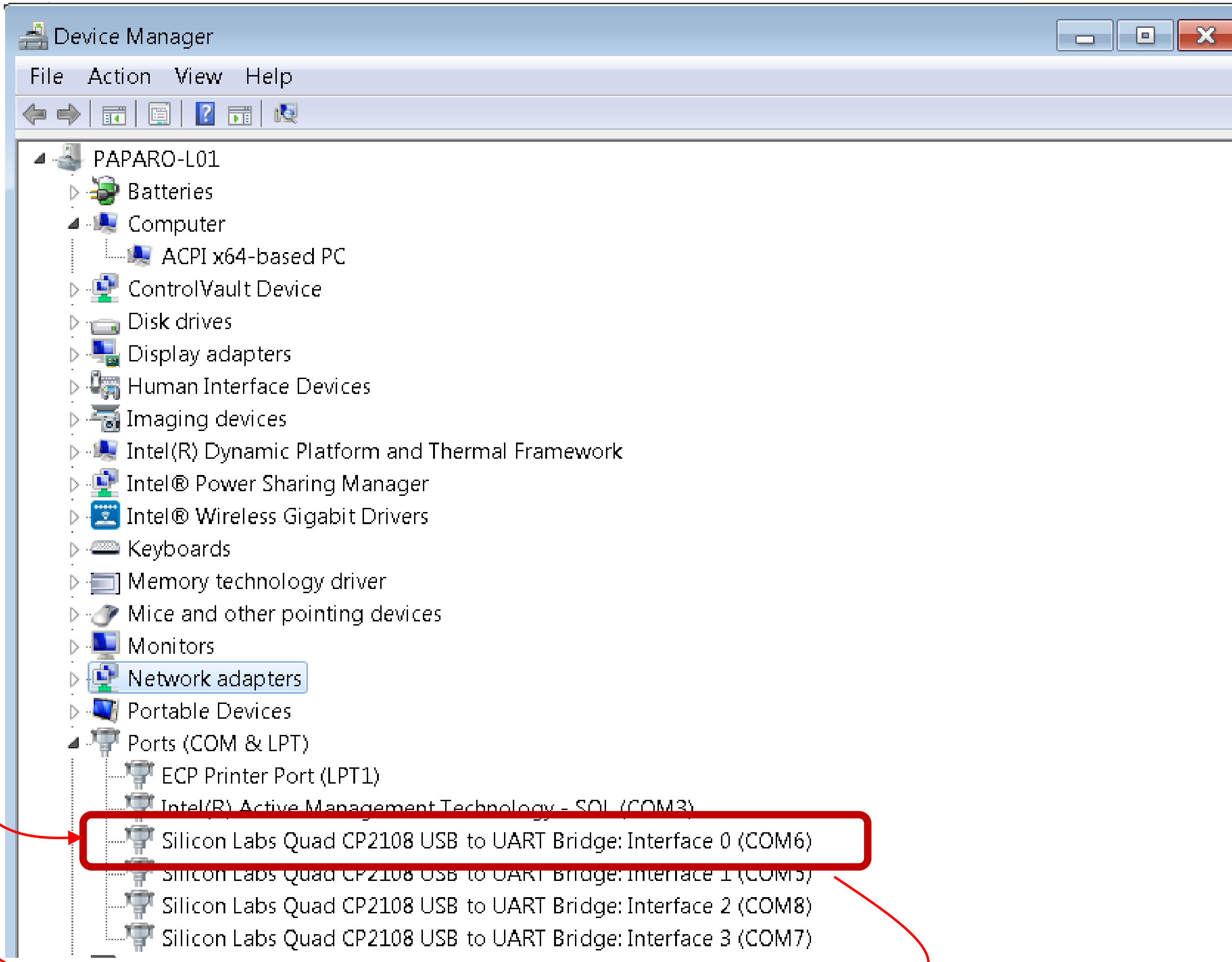
Connection type: ○ Raw ○ Telnet ○ Rlogin ○ SSH ● Serial

Load, save or delete a stored session

Saved Sessions

Default Settings

Close window on exit: ○ Always ○ Never ● Only on clean exit

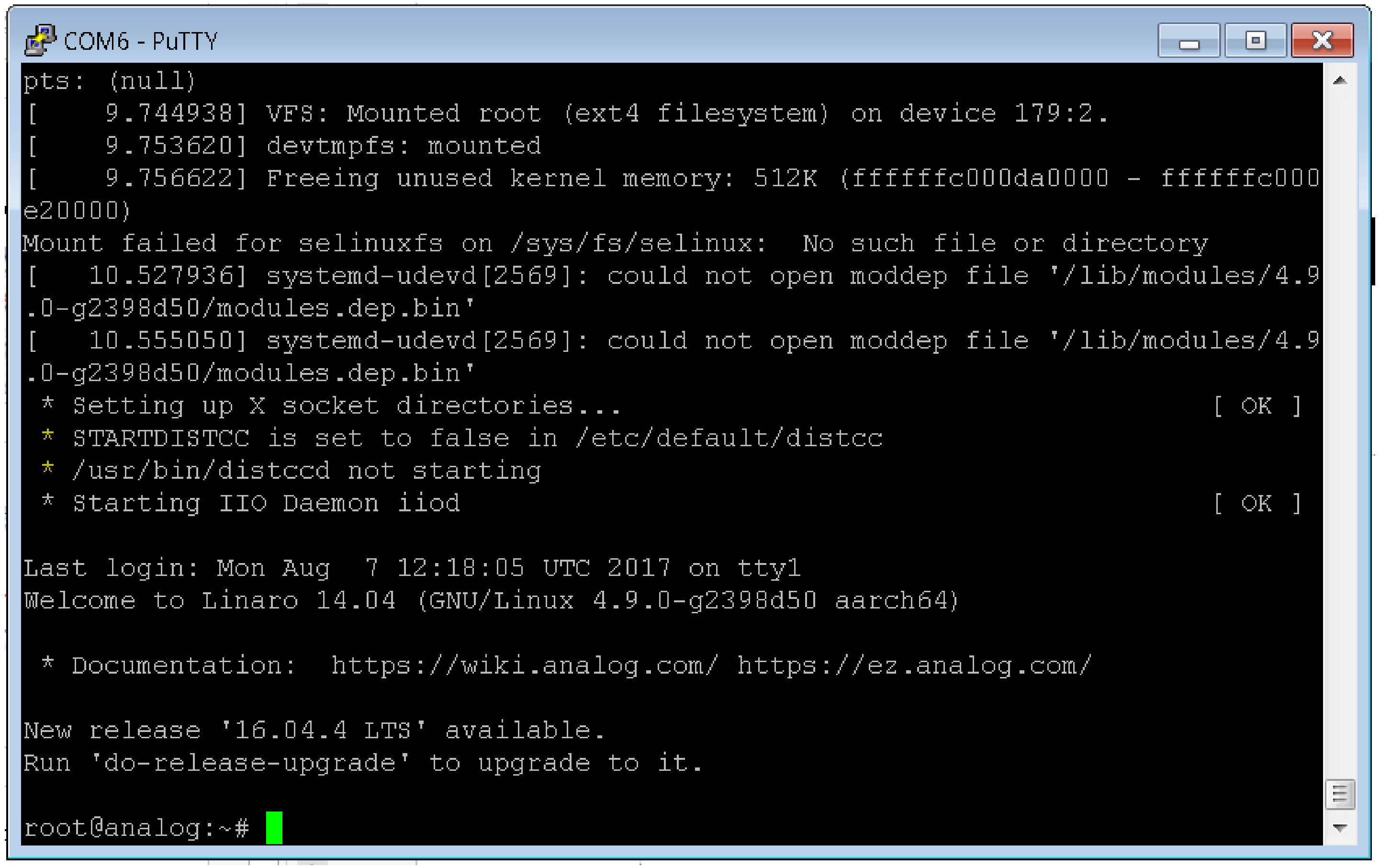


Device Manager

- PAPARO-L01
  - Batteries
  - Computer
    - ACPI x64-based PC
  - ControlVault Device
  - Disk drives
  - Display adapters
  - Human Interface Devices
  - Imaging devices
  - Intel(R) Dynamic Platform and Thermal Framework
  - Intel® Power Sharing Manager
  - Intel® Wireless Gigabit Drivers
  - Keyboards
  - Memory technology driver
  - Mice and other pointing devices
  - Monitors
  - Network adapters
  - Portable Devices
  - Ports (COM & LPT)
    - ECP Printer Port (LPT1)
    - Intel(R) Active Management Technology - SOL (COM3)
    - Silicon Labs Quad CP2108 USB to UART Bridge: Interface 0 (COM6)
    - Silicon Labs Quad CP2108 USB to UART Bridge: Interface 1 (COM5)
    - Silicon Labs Quad CP2108 USB to UART Bridge: Interface 2 (COM8)
    - Silicon Labs Quad CP2108 USB to UART Bridge: Interface 3 (COM7)

Connecting to the FPGA Board

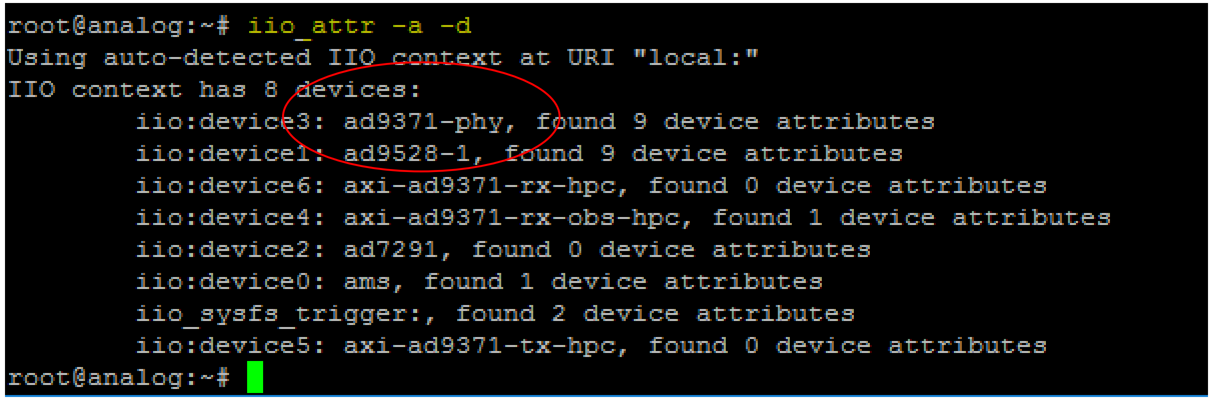
- When board is finished booting, you should see this, ending with the “root@analog:~#” cmd prompt
  - You may have to hit return a few times to get the command prompt



```
pts:  (null)
[    9.744938] VFS: Mounted root (ext4 filesystem) on device 179:2.
[    9.753620] devtmpfs: mounted
[    9.756622] Freeing unused kernel memory: 512K (ffffffc000da0000 - ffffffc000
e20000)
Mount failed for selinuxfs on /sys/fs/selinux:  No such file or directory
[   10.527936] systemd-udevd[2569]: could not open moddep file '/lib/modules/4.9
.0-g2398d50/modules.dep.bin'
[   10.555050] systemd-udevd[2569]: could not open moddep file '/lib/modules/4.9
.0-g2398d50/modules.dep.bin'
 * Setting up X socket directories...                                    [ OK ]
 * STARTDISTCC is set to false in /etc/default/distcc
 * /usr/bin/distccd not starting
 * Starting IIO Daemon iiod                                              [ OK ]

Last login: Mon Aug  7 12:18:05 UTC 2017 on tty1
Welcome to Linaro 14.04 (GNU/Linux 4.9.0-g2398d50 aarch64)

 * Documentation:  https://wiki.analog.com/ https://ez.analog.com/

New release '16.04.4 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

root@analog:~#
```

Setting IP address of FPGA Board

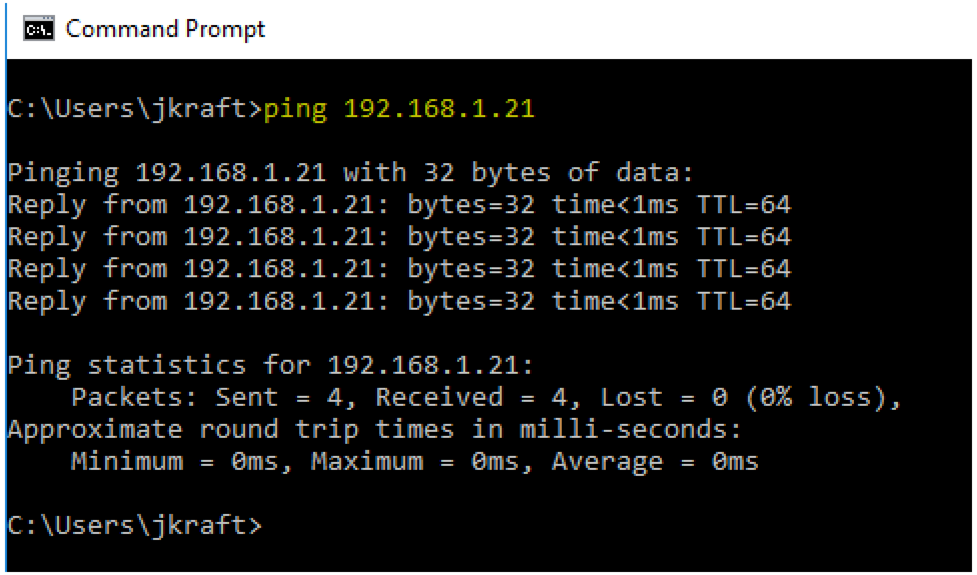
- From PuTTY window, configure the board for a static IP address by typing `enable_static_ip.sh 192.168.1.21`
  - The “1.21” ending could really be anything that doesn’t conflict with something else already connected
- To check ip address, type `ifconfig`
  - You should get back a bunch of info confirming the inet6 addr
- To change ip address (if necessary), type `ifconfig eth0 192.168.1.10`
- To verify the TRx cards connected, type `iio_attr -a -d`



```
root@analog:~# iio_attr -a -d
Using auto-detected IIO context at URI "local:"
IIO context has 8 devices:
        iio:device3: ad9371-phy, found 9 device attributes
        iio:device1: ad9528-1, found 9 device attributes
        iio:device6: axi-ad9371-rx-hpc, found 0 device attributes
        iio:device4: axi-ad9371-rx-obs-hpc, found 1 device attributes
        iio:device2: ad7291, found 0 device attributes
        iio:device0: ams, found 1 device attributes
        iio_sysfs_trigger:, found 2 device attributes
        iio:device5: axi-ad9371-tx-hpc, found 0 device attributes
root@analog:~# 
```

Ensure that your laptop can talk to that address

- Open Command prompt & ping the address.



```
C:\Users\jkraft>ping 192.168.1.21

Pinging 192.168.1.21 with 32 bytes of data:
Reply from 192.168.1.21: bytes=32 time<1ms TTL=64
Reply from 192.168.1.21: bytes=32 time<1ms TTL=64
Reply from 192.168.1.21: bytes=32 time<1ms TTL=64
Reply from 192.168.1.21: bytes=32 time<1ms TTL=64

Ping statistics for 192.168.1.21:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\Users\jkraft>
```

- If no response:
  - check IP address of your laptop (see “Set Static IP Address” instructions above)

Shutdown and Troubleshooting

Safely Shutdown

- To shutdown gracefully (i.e. not corrupt the SD card):
  - `sudo shutdown -h now` command from PUTTY

- Troubleshooting:
  - If unable to see devices in iio-oscilloscope, you could have the wrong HPC spot
  - If unable to boot and FPGA board and you see some red LEDs? Likely a bad SD card or SW06 in wrong position.
  - If unable to boot past first stage boot loader? Likely a bad SD card
  - If unable to connect from laptop, check the network config (see above section on configuring a static IP)

Command Summary

- Terminal Commands:
  - `enable_static_ip.sh 192.168.1.21`
    - Sets IP address (to 192.168.1.21)
  - `ifconfig`
    - Check's IP address
  - `ifconfig eth0 192.168.1.10`
    - Changes IP address (to 192.168.1.10 in this example)
  - `iio_attr -a -d`
    - See what devices are connected
  - `sudo shutdown -h now`
    - Safely shutdown the FPGA

- Matlab Receive Commands:
  - `rx = adi.ADRV9009.Rx`
  - `rx.uri = 'ip:192.168.1.21’`
  - `rx.channelCount = 4`
  - `[data0, data1] = rx();`