Real-World Wireless Signals in MATLAB

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Agenda

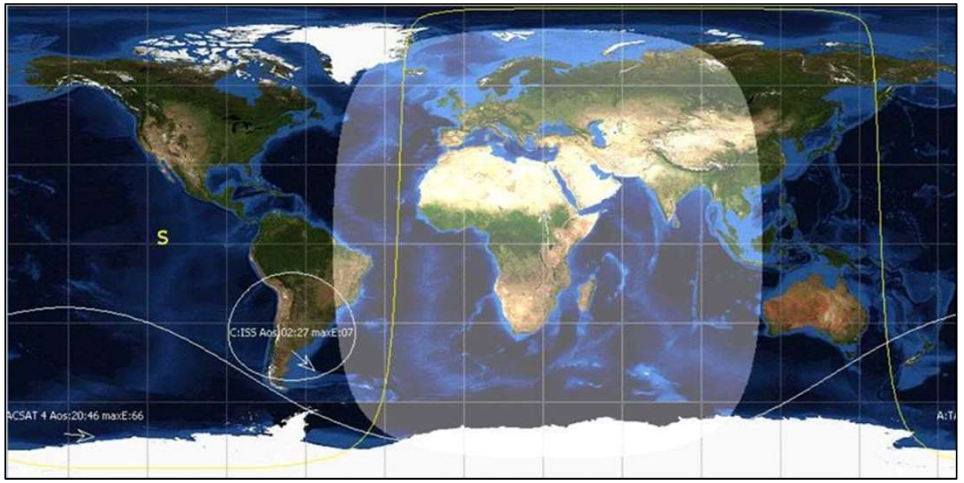
- An example application of SDR and satellites
- Demo – WLAN image transmission
- Software-defined radio with MATLAB and Simulink
- Building a practical digital receiver
- Q&A
- Workshop to install RTL-SDR support package on laptops

Es’hail 2 / QO-100

- The geostationary satellite Es’hail-2 (QO-100) carrying amateur radio transponders is now in a geostationary orbit at 25.9° East.
- These are the first amateur radio transponders to be put into geostationary orbit and they are expected to link radio amateurs from Brazil to Thailand.

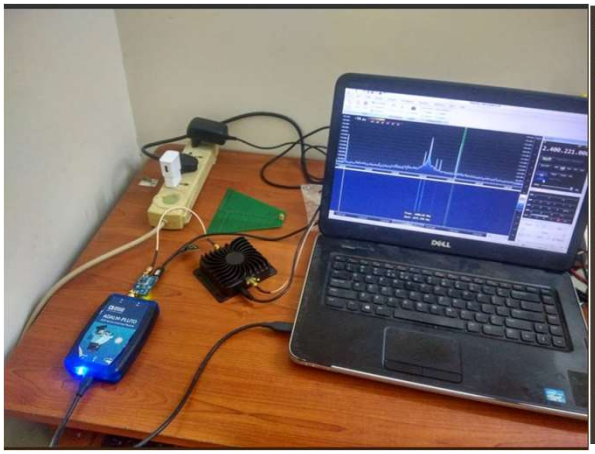
Es’hail-2 carries two “Phase 4” amateur radio transponders :

- 2400 MHz (250 kHz bandwidth for conventional analog operations) and
- 10450 MHz (8 MHz bandwidth transponder for experimental digital modulation schemes and DVB amateur television)



https://amsat-uk.org/2016/05/21/eshail-2-geo-p4a-transponder-freqs/
https://amsat-uk.org/satellites/geo/eshail-2/

Es'hail 2 / QO-100



- Equipment:
  - ADALM-PLUTO
  - CN0417 driver (2.4 GHz)
  - Yosoo- EDUP EP-AB003 8W WiFi Signal Extender
  - Antenna

https://twitter.com/r4d10n/status/1108225024622641152

4

DEMO

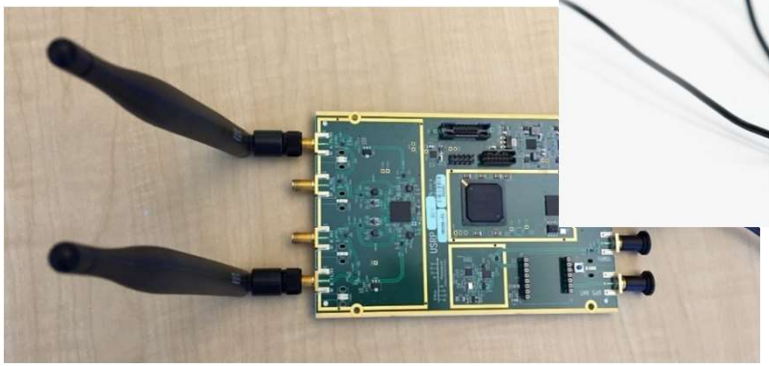
Software-Defined Radio (SDR) with MATLAB and Simulink

- Why?
  - Quickly design and build transceivers
  - Work with standards-based signals (FM, ADS-B, WLAN, LTE, etc.)
  - Easily interface with SDR hardware to validate design in a real environment
- How?
  - Design and build transceivers easily with MATLAB and Simulink
  - Validate transceiver designs using simulated channels (AWGN, Multipath Fading, etc.)
  - Send and receive baseband I/Q samples over the air with SDR platforms

Software-defined Radio in MATLAB and Simulink

- With what?

USRP



RTL-SDR

Zynq

ADALM-PLUTO

Software-defined Radio in MATLAB and Simulink

Software-Defined Radio (SDR)

Search MathWorks.com

Trial software | Contact sales

MATLAB and Simulink Hardware Support for SDR

MATLAB and Simulink provides support packages for popular SDR hardware. You can communicate with these SDR platforms directly from MATLAB and Simulink to perform radio-in-the-loop testing, prototyping, and hands-on learning.

USRP® Networked, Bus, and X Series SDRs

Zynq SDR, including PicoZed SOM and ZC706 or ZedBoard with Analog Devices RF FMC card

RTL-SDR Radio

ADALM-PLUTO Radio Support from Communications System Toolbox

USRP® Embedded Series (E310)

Over-the-Air Testing

- 5G/LTE/WLAN: Waveform Generation, Simulation, Measurement and Over-the-Air Testing within MATLAB (46:17) - Video

Prototyping

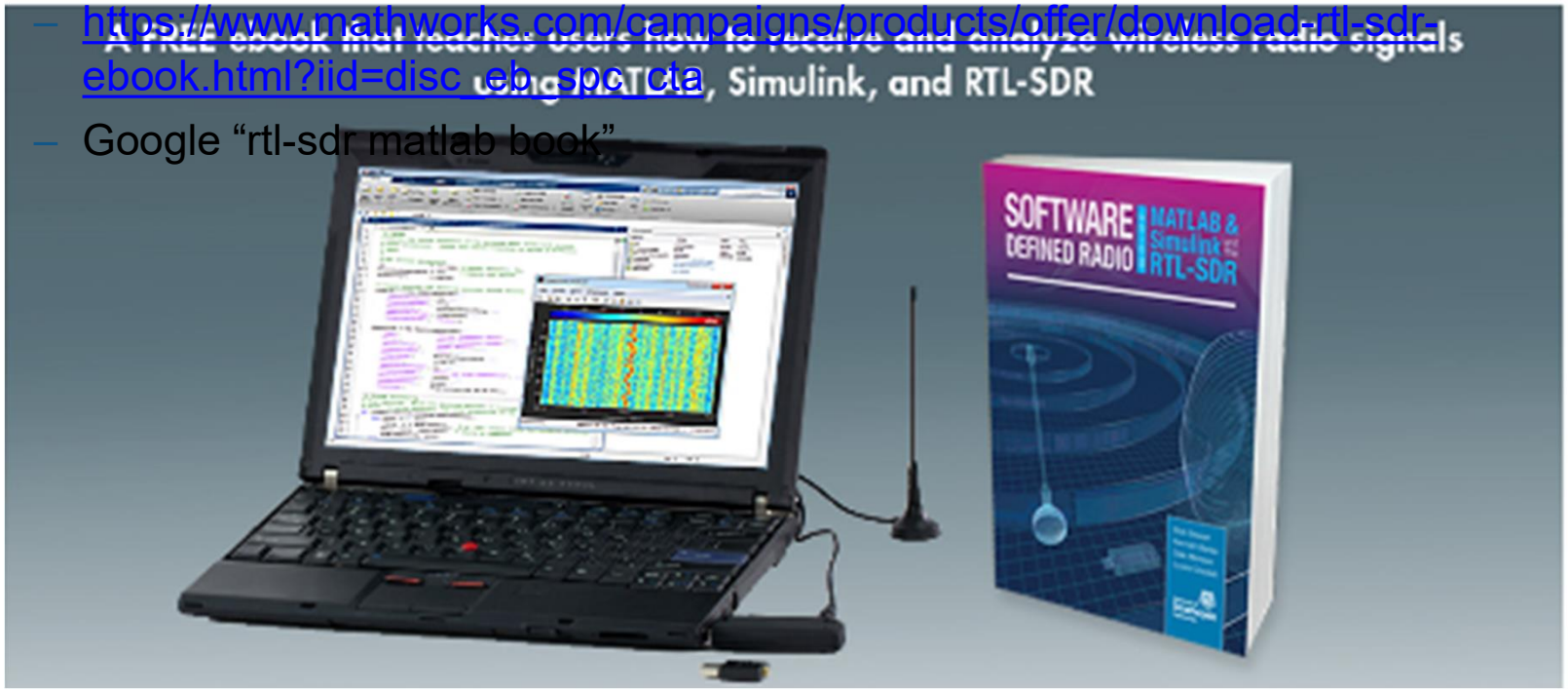
- Getting Started with Software-Defined Radio using MATLAB and Simulink (21:55) - Video
- QPSK Receiver Using Analog Devices

Hands-On Learning

- Software-Defined Radio Using MATLAB & Simulink and the RTL-SDR - Ebook
- Digital Communications System Engineering with Software-Defined

Software-defined Radio in MATLAB and Simulink

- With what?
  - https://www.mathworks.com/campaigns/products/offer/download-rtl-sdr-ebook.html?iid=disc_eb_spc_cta
  - Google “rtl-sdr matlab book”



Software-defined Radio in MATLAB and Simulink

MATLAB and Simulink Based Books

Search Books | Books

Digital Communication Systems Engineering with Software-Defined Radio

Written for students, *Digital Communication Systems Engineering with Software-Defined Radio* provides readers with a practical approach to learning software-defined radio concepts.The book helps readers attain a first-hand understanding of critical design trade-offs and issues. Topics include signal and system overview, probability review, digital communications review, and multi-carrier modulation.

An introduction to MATLAB and Simulink is included in an appendix. In addition, a supplemental set of MATLAB code files is available for download.

Get companion software

About This Book

Di Pu, *Worcester Polytechnic Institute*
Alexander M. Wyglinski, *Worcester Polytechnic Institute*

Artech House, 2013

ISBN: 978-1-60807-525-6
Language: English

Buy Now at Amazon.com

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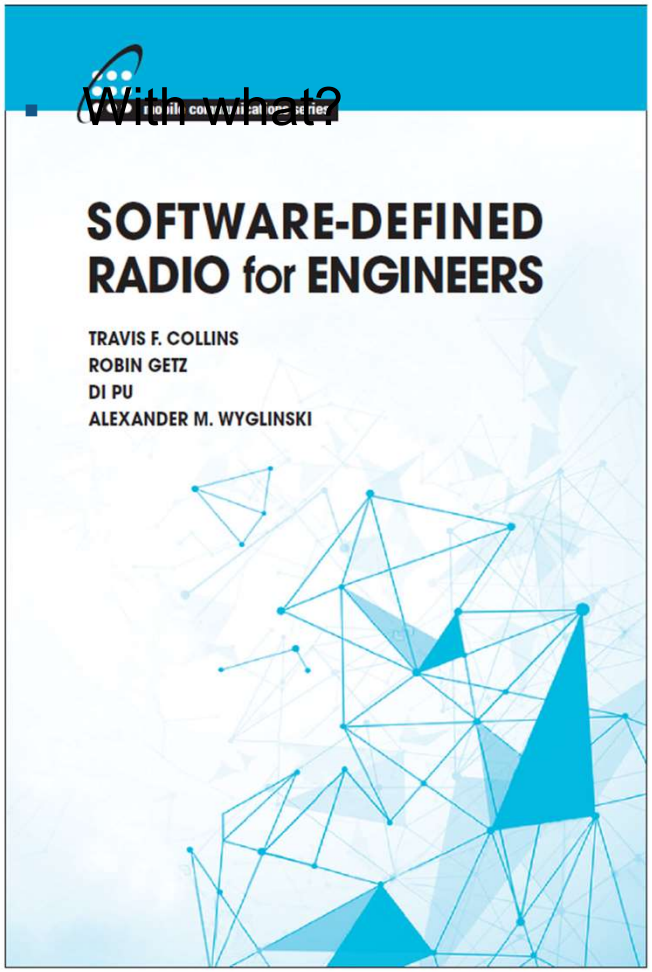
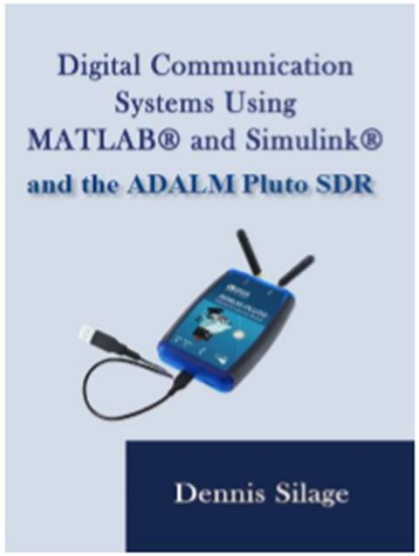


- With what?

- PDF available at http://analog.com for ***FREE***
- Covers the difficult topics (i.e. synchronization) that most other comms books shy away from

Software-defined Radio in MATLAB and Simulink



ANALOG DEVICES ADALM-PLUTO
SDR Active Learning Module

Product Overview

The easy to use ADALM-PLUTO active learning module (PlutoSDR) helps introduce electrical engineering students to the fundamentals of software-defined radio (SDR), radio frequency (RF), and wireless communications. Designed for students at all levels and from all backgrounds, the module can be used for both instructor-led and self-directed learning to help students develop a foundation in real-world RF and communications that they can build on as they pursue science, technology, or engineering degrees.

Connecting RF Theory with RF Practice

The PlutoSDR works as a portable lab that, when used with a host, can augment classroom learning. MATLAB® and Simulink® are two of the many software packages supported by PlutoSDR, and it provides an intuitive graphical user interface (GUI) so students can learn faster, work smarter, and explore more.

Made for Teachers, Students, and Self-Learners

The PlutoSDR features independent receive and transmit channels that can be operated in full duplex. The active learning module can generate or acquire RF analog signals from 325 MHz to 3800 MHz at up to 61.44 megasamples per second (MSPS). Small enough to fit in a shirt pocket, the PlutoSDR is completely self-contained and entirely USB powered with the default firmware. Because PlutoSDR is enabled by libiio drivers, it supports OS X®, Windows®, and Linux®, which allows students to learn and explore on a variety of devices.

With dozens of available online tutorials for SDR-based projects, PlutoSDR boasts labs and teaching material covering topics such as ADS-B aircraft position, receiving NOAA and Meteor-M2 weather satellite imagery, GSM analysis, listening to TETRA signals, pager decoding, and many more!

Visit analog.com

Features

- Portable self-contained RF learning module
- Cost-effective experimentation platform
- RF coverage from 325 MHz to 3.8 GHz
- Flexible rate, 12-bit ADC and DAC
- One transmitter and one receiver (female SMA, 50 Ω)
- Half or full duplex
- MATLAB, Simulink support
- GNU Radio sink and source blocks
- Libiio, a C, C++, C#, and Python API
- USB 2.0 interface
- Plastic enclosure
- USB powered
- Up to 20 MHz of instantaneous bandwidth (complex I/Q)

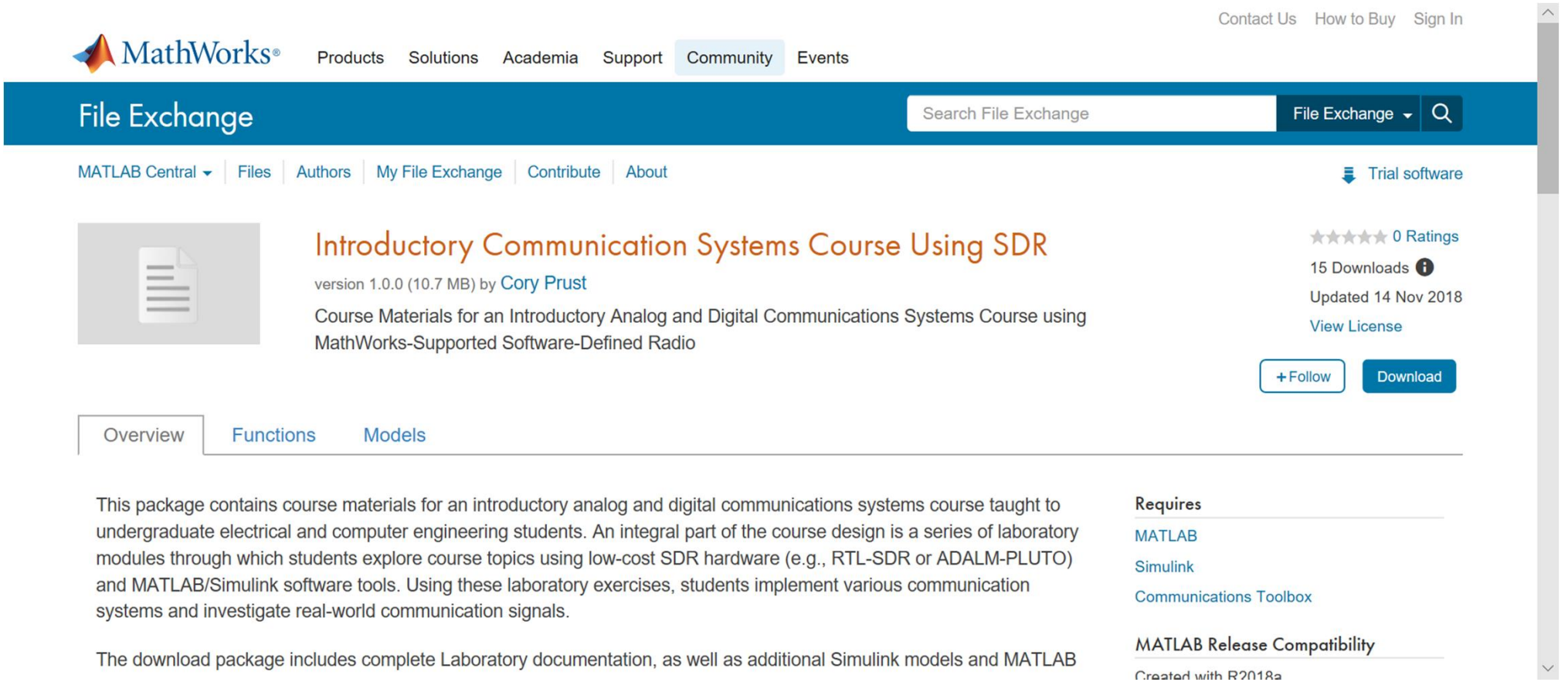
FC CE

Kit Includes

- Analog Devices PlutoSDR active learning module
- Two antennas (824 MHz to ~894 MHz/ 1710 MHz to ~2170 MHz)
- One 15 cm SMA cable
- One USB cable

To purchase this active learning module, visit analog.com/plutosdr.

Software-defined Radio in MATLAB and Simulink



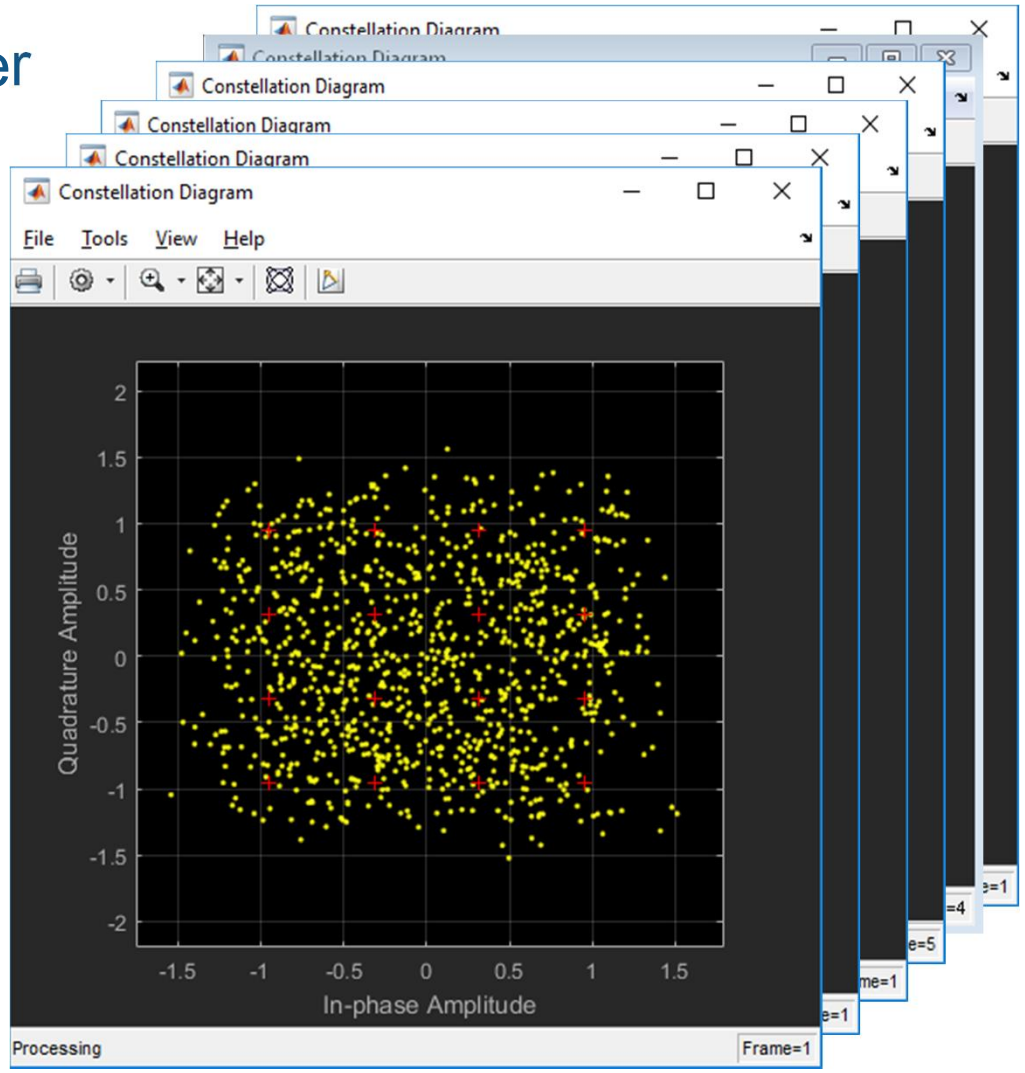
Building a Practical Digital Receiver

My system works perfectly under simulated multipath fading and AWGN!

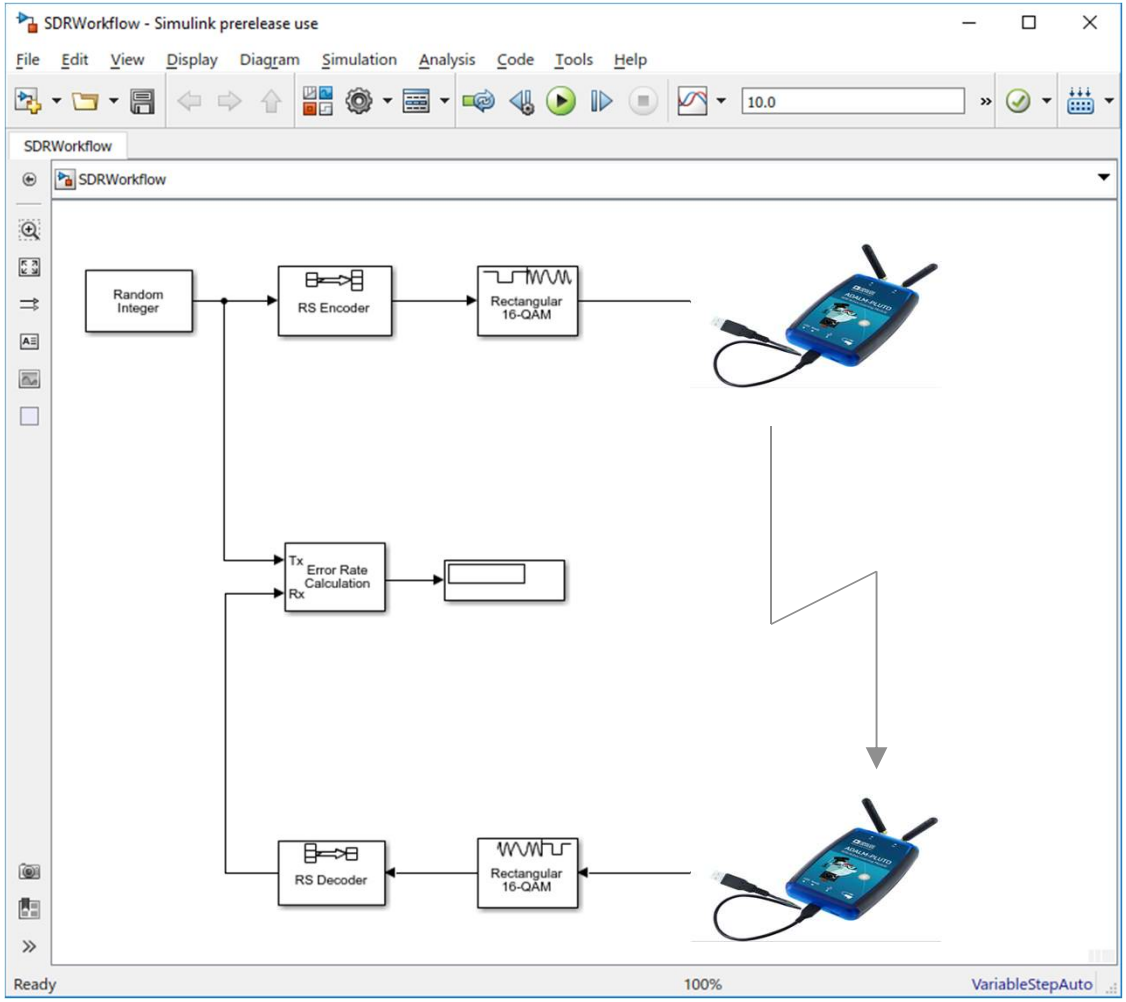
Why does my receiver get 50% BER when I use SDR radios?

Building a Practical Digital Receiver

- Overcome the hardware!
  - Noisy front end
  - I/Q imbalance
  - Phase noise
  - DC offsets
  - Carrier frequency offsets
  - Timing skew



Building a Practical Digital Receiver



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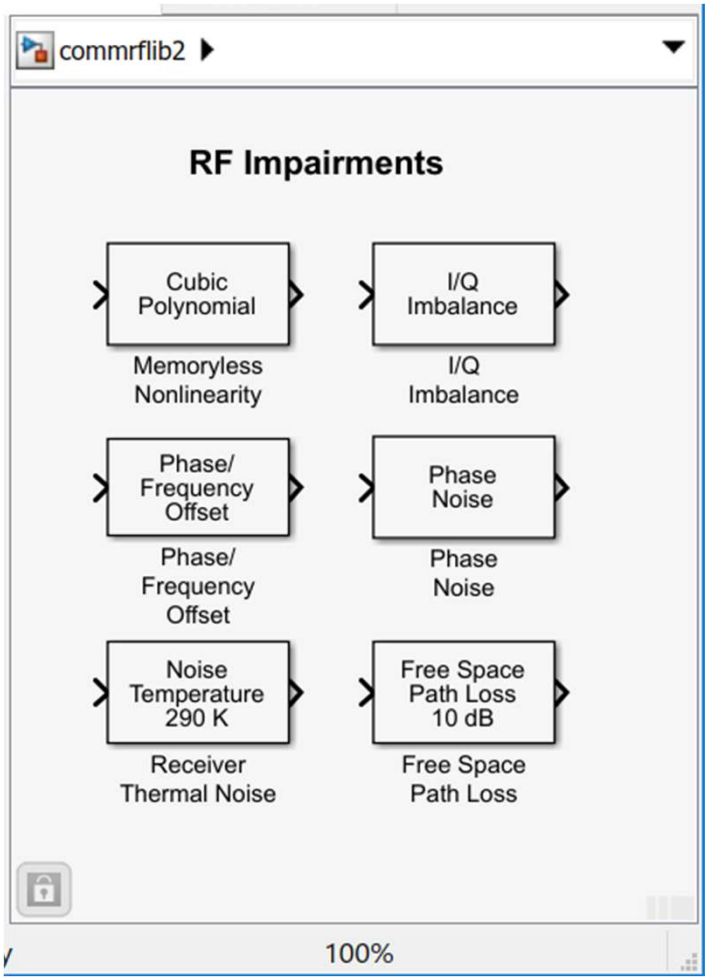

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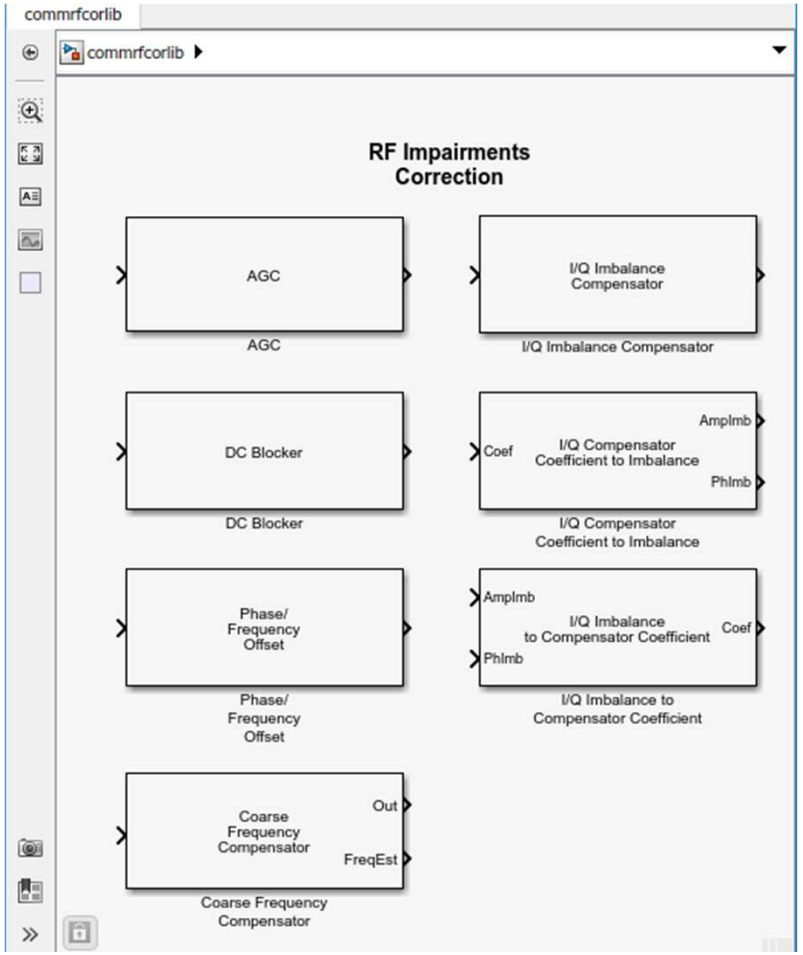

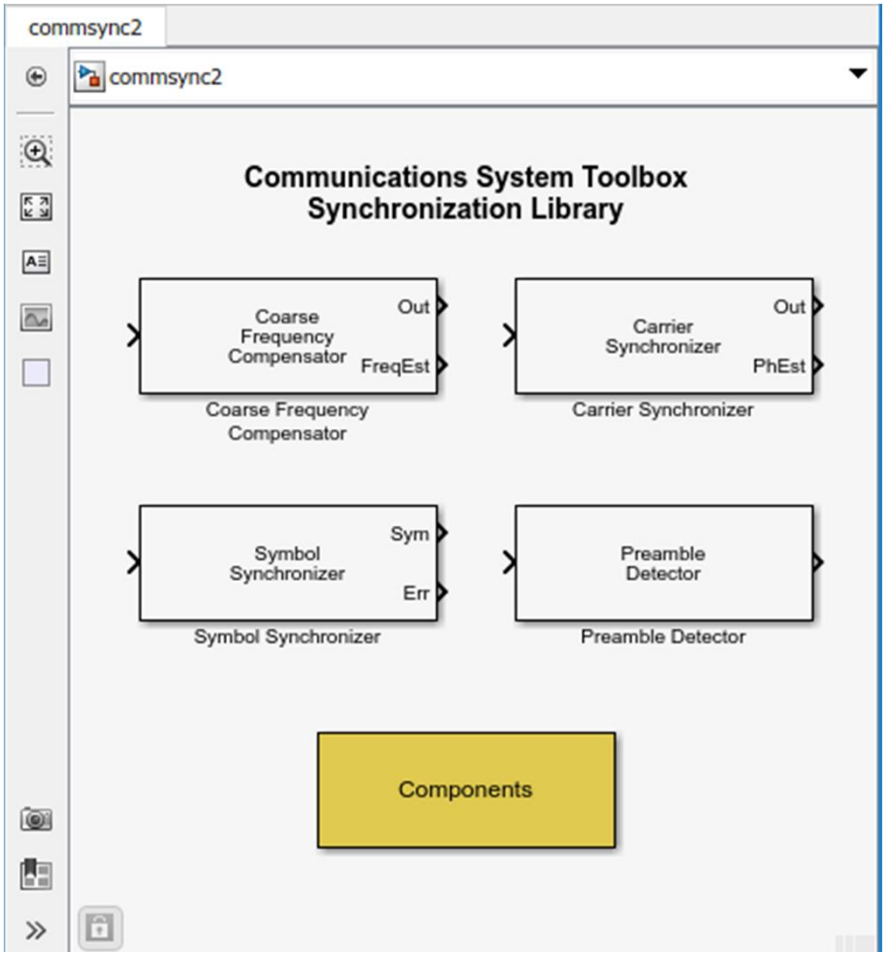

Q&A