# 05: SDR Setup

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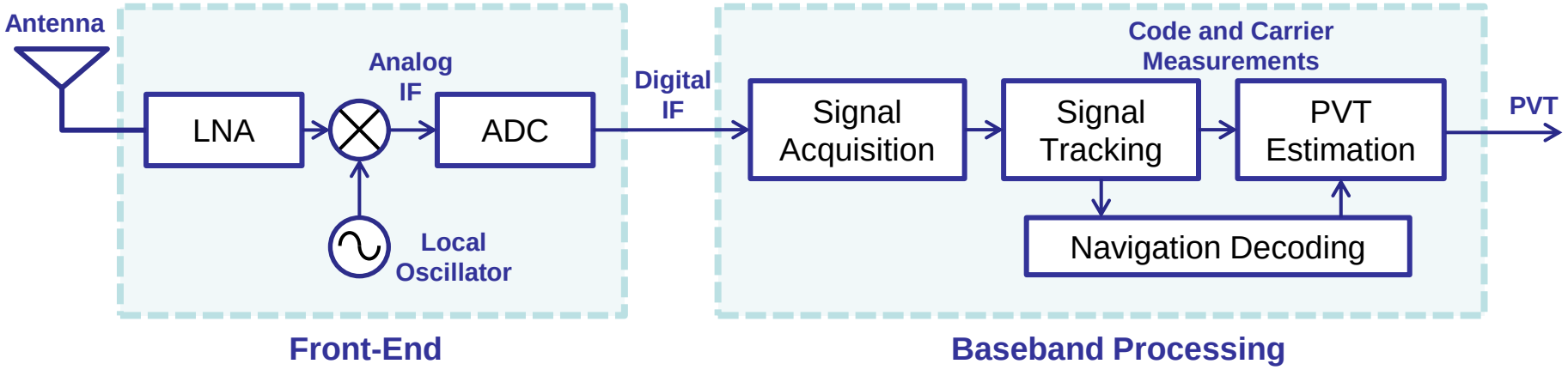
# GNSS Front-end (1)




- What is important to choose front-end?
  - Price
  - How many bands? (How many front-ends?)
  - Sample rate
  - Signal bandwidth
  - Frequency range (Only L1 or not?)
  - Data interface (USB2.0 / USB3.0 / Ethernet…)
  - Sampling bits
  - Oscillator accuracy

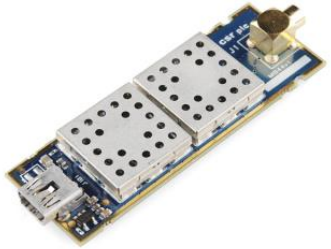
# GNSS Front-end (2)


## DVB-T dongle (RTL-2832U)

- $10, Frequency: 24M-1.7GHz, Sampling: 2.56MHz
- Poor clock accuracy

## Nuand BladeRF (LMS6002D)

- $420, Frequency: 300Hz~3.8GHz, Sampling: ~40Msps
- Tx function (transmitter)



## SiGe GN3S sampler V2/V3 (SiGe4120)

- $450, Frequency: 1575.42MHz, Sampling: 4MHz
- For only GPS L1 signal

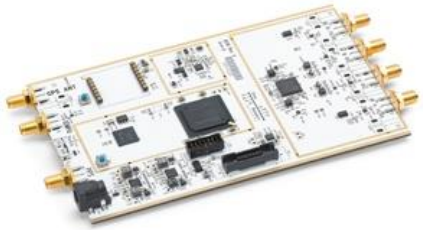

## NSL STEREO (MAX2769b+MAX2112)

- $850, Frequency: 300Hz~3.8GHz, Sampling: ~40MHz
- Two front-ends

# GNSS Front-end (3)

## HackRF (LMS6002D)

- $300, Frequency: 30M-6GHz, Sampling: 20MHz
  - Kick Starter project



## Ettus USRP (AD9361)

- $1100, Frequency: 300~3.8GHz, Sampling: 40Msps
- Tx function (transmitter)

## SwiftNav Piksi (MAX2769)

- $525, Frequency: 1575.42MHz, Sampling: 16Msps
- For only GPS L1 signal
- RTK GPS enable (FPGA based)

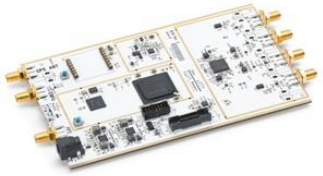

## PocketSDR (MAX2771x2)

- $50, 1.16G~1.61GHz (All GNSS signal frequency)
- Two front-ends
- Open Source Project https://github.com/tomojitakasu/PocketSDR

# Which is Best?


PocketSDR $50

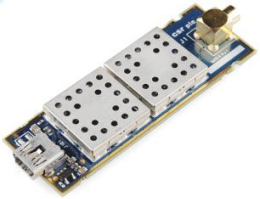

STEREO $850



USRP $1,100

BladeRF $420

HackRF $300



GN3S $450

Piksi $525

RTL-SDR Dongle $10

Performance / Flexibility

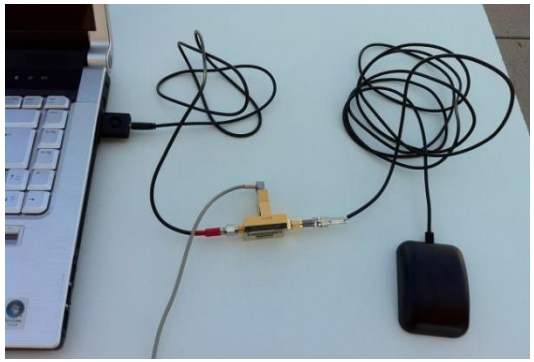
Price

# RTL-SDR

- Most famous SDR front-end device
  - Using Elonics E4000 turner-chip
  - Using Realtek RTL2832U ADC
- Cheap (about $10~$20)
- Large community
  - http://sdr.osmocom.org/trac/wiki/rtl-sdr
- Active antenna cannot be used in default



Using GPS signal splitter and another GPS receiver



Using a bias-T network

# Improved Version of RTL-SDR

**RTL-SDR.com** http://www.rtl-sdr.com/buy-rtl-sdr-dvb-t-dongles


**Price: $19.95**

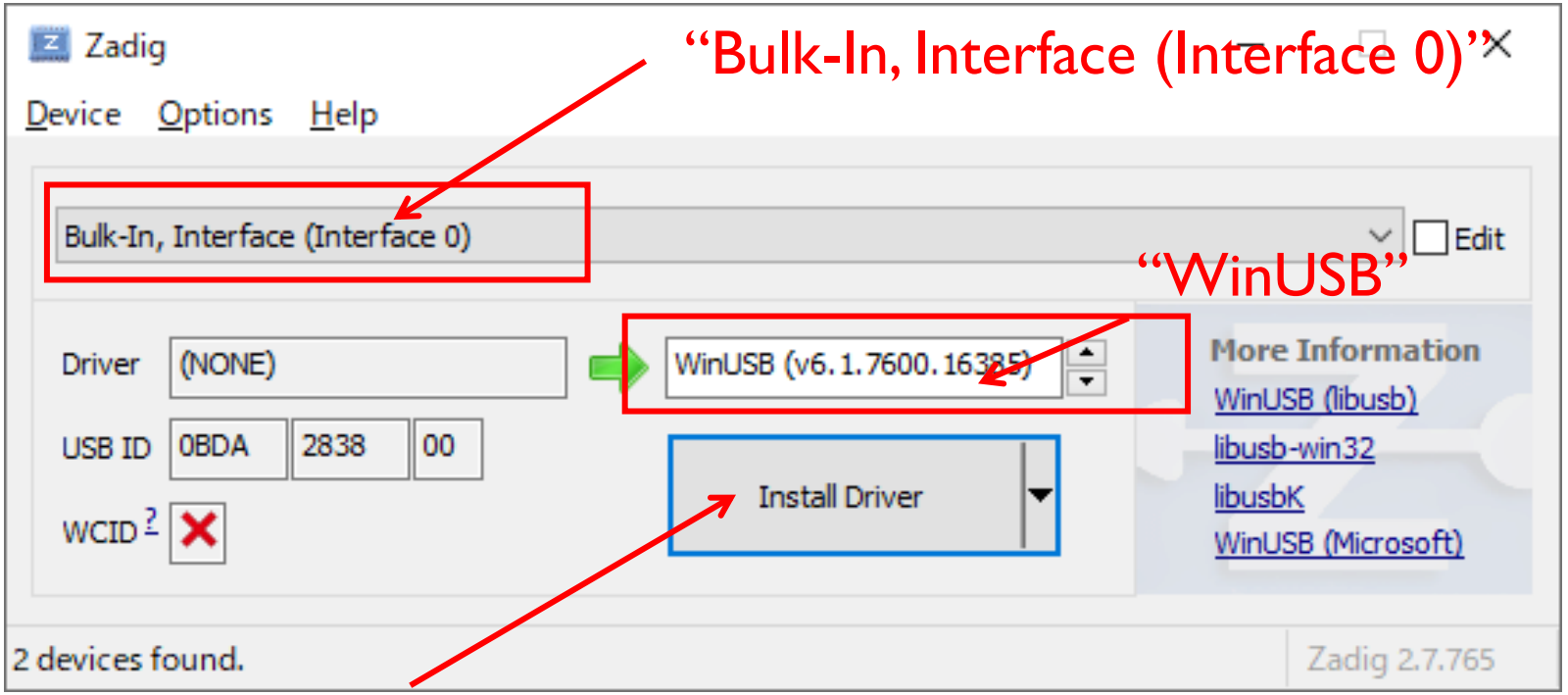
**Improvements:**

- Temperature compensated oscillator (TCXO)
- SMA female antenna port
- Improved component tolerances
- 4.5V USB powered bias tee

# Install RTL-SDR Driver (1)

- Insert the **RTL-SDR** into an available USB port
- If your OS automatically installs a driver, wait until the OS finishes the installation before continuing.
- Run **Zadig**.exe
  - **/05_SDR_Setup/rtlsdr/zadig/zadig-2.7.exe**

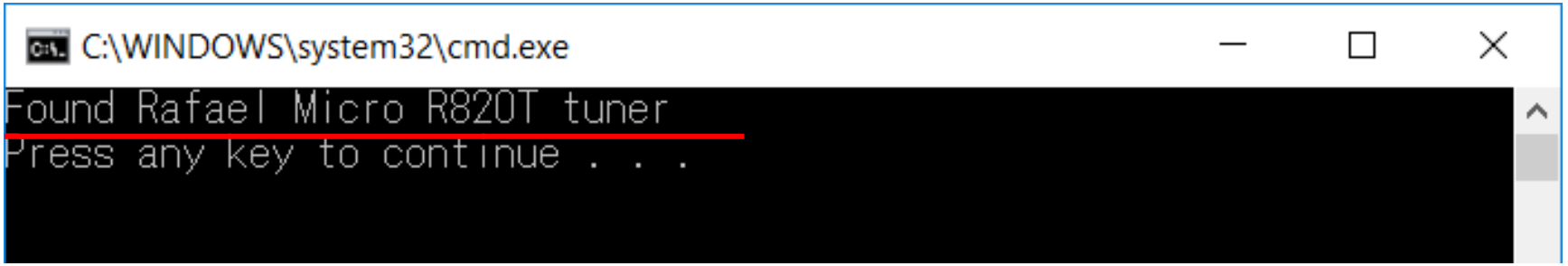
# Install RTL-SDR Driver (2)



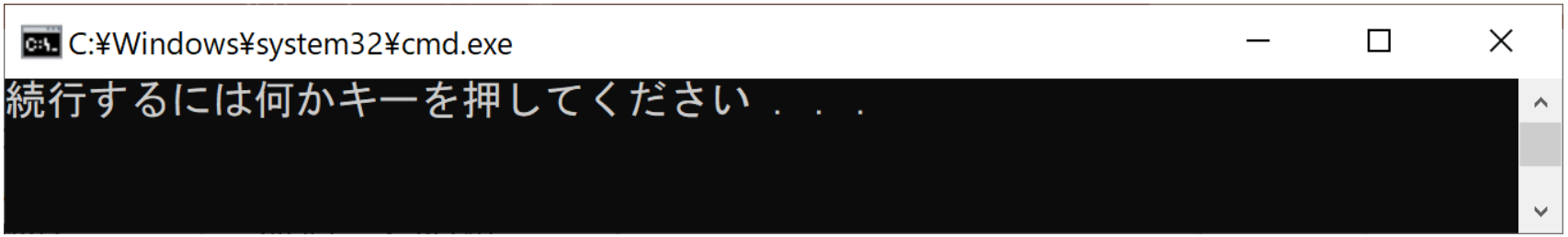

- Click "Install Driver"
- If nothing is displayed…
  - Options -> List All Devices

# Install RTL-SDR Driver (3)

- Enable onboard Bias-T
- Open "rtl-sdr" folder and run "I_bias_tee_on.bat"

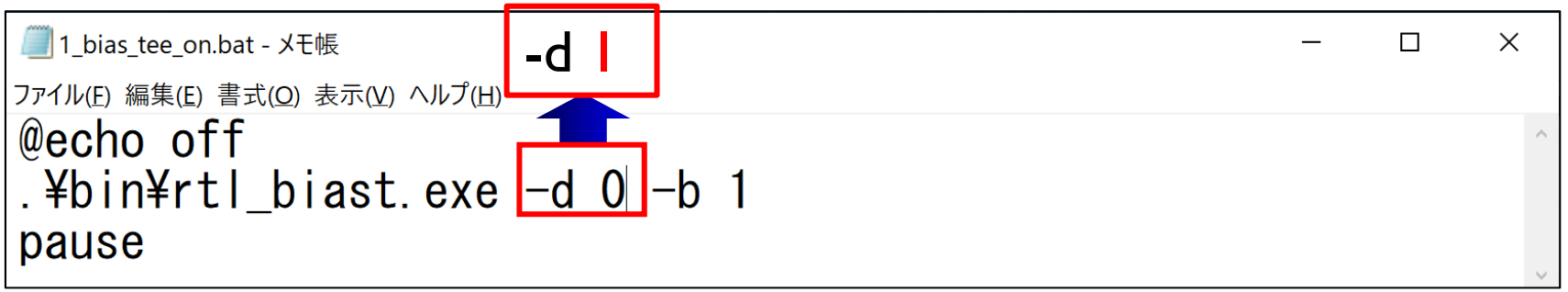



- If nothing is shown as follows, you need to change the device number of RTL-SDR

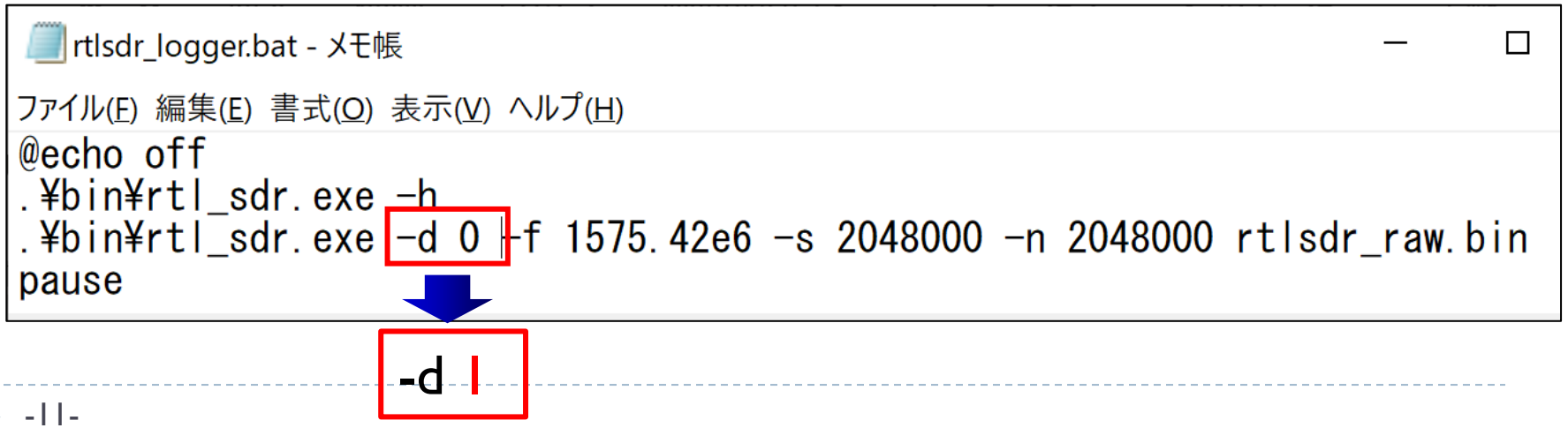


# Install RTL-SDR Driver (4)

- If nothing is shown …
- Edit "1_bias_tee_on.bat"

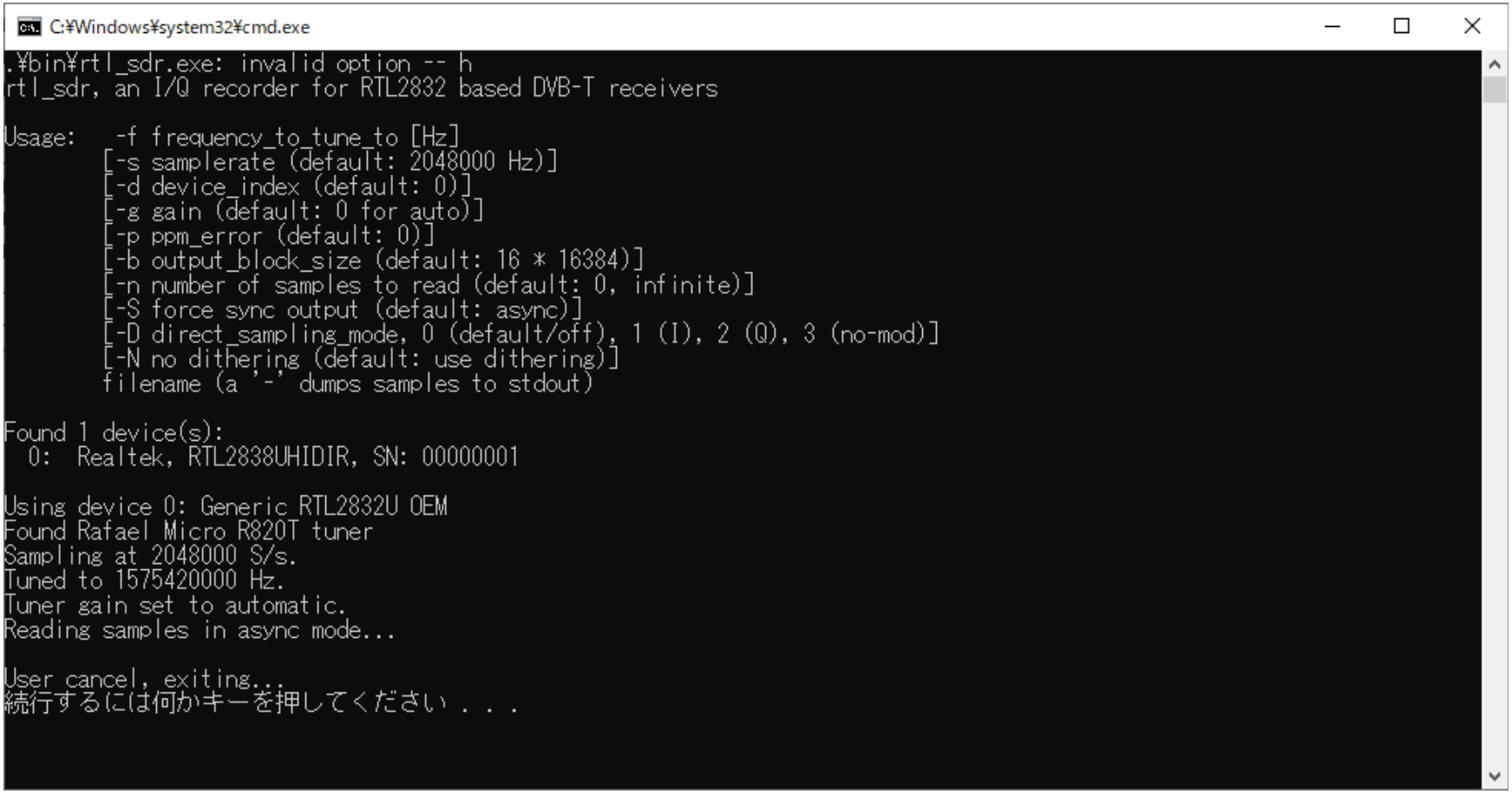



- Edit "2_rtlsdr_logger.bat"



# Install RTL-SDR Driver (5)

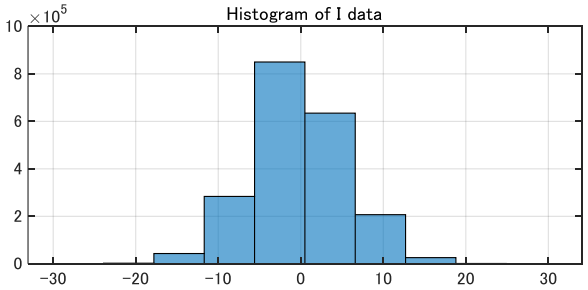
- Open "rtl-sdr" folder and run "2_rtlsdr_logger.bat"

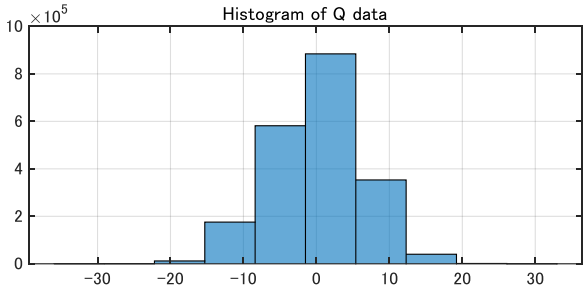


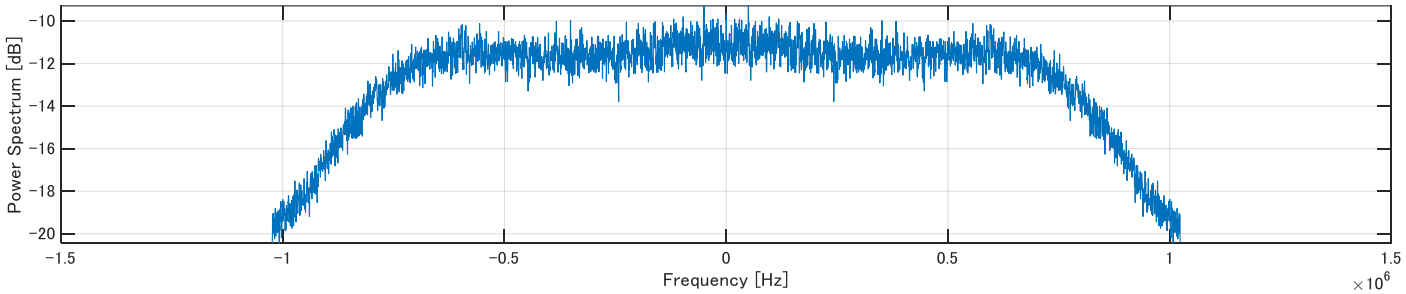
# Exercise 1: Plot Data using MATLAB

- Open "Ex1_run_plot_rfdata.m" and Run 

  - **/05_SDR_Setup/matlab/Ex1_run_plot_rfdata.m**




- Try to plot RF data currently acquired

# RF Data File Format

- rtlsdr_raw
  - RTL-SDR: 8-bit I/Q samples


- int16
  - Generic formats for I/Q samples


- int8
  - PocketSDR: 2-bit I/Q samples


- Baseband File for MATLAB
  - Variable data type


# MATLAB Setup (1)

- Details: https://jp.mathworks.com/help/supportpkg/rtlsdrradio/ug/support-package-hardware-setup.html

- Install addons
  - Click addon in MATLAB menu
  - Search "**rtl-sdr**" in addon explore
  - Install "**Communications Toolbox Support Package for RTL-SDR Radio**"


**Communications Toolbox Support Package for RTL-SDR Radio** 作成者: MathWorks Communications Toolbox Team STAFF

Acquire RF data using **RTL-SDR**.

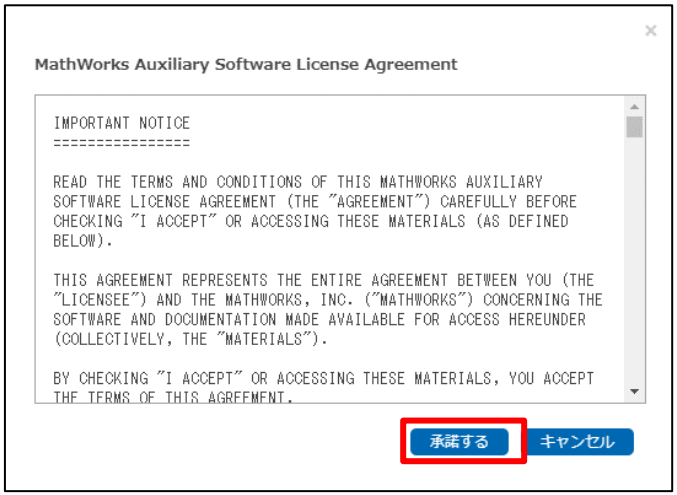
Design and verify practical **SDR** systems using Communications System Toolbox™ Support Package for **RTL-SDR** Radio. Support enables you to use the **RTL-SDR** USB radio as a standalone peripheral for

ハードウェア サポート

# MATLAB Setup (2)

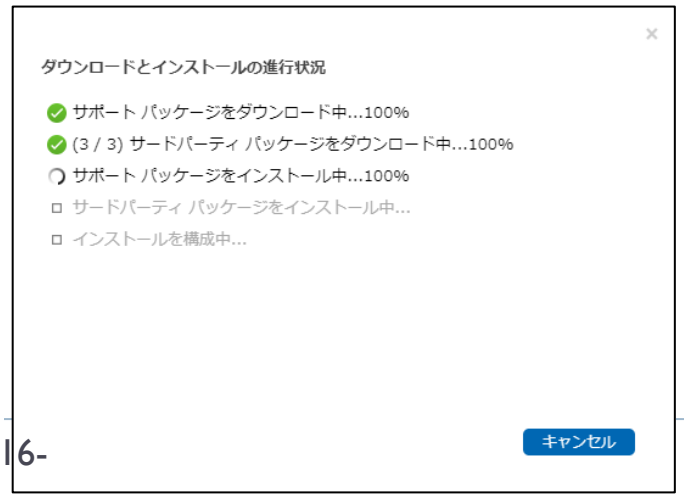
- Accept License and install

1

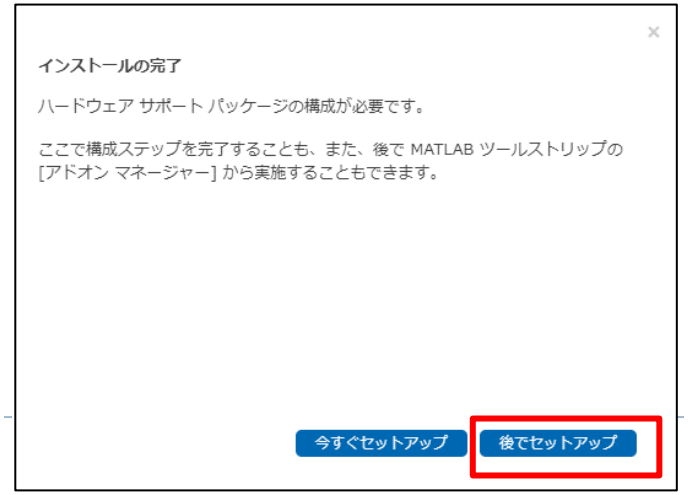



2


3




4



# Exercise 2: Capture using MATLAB

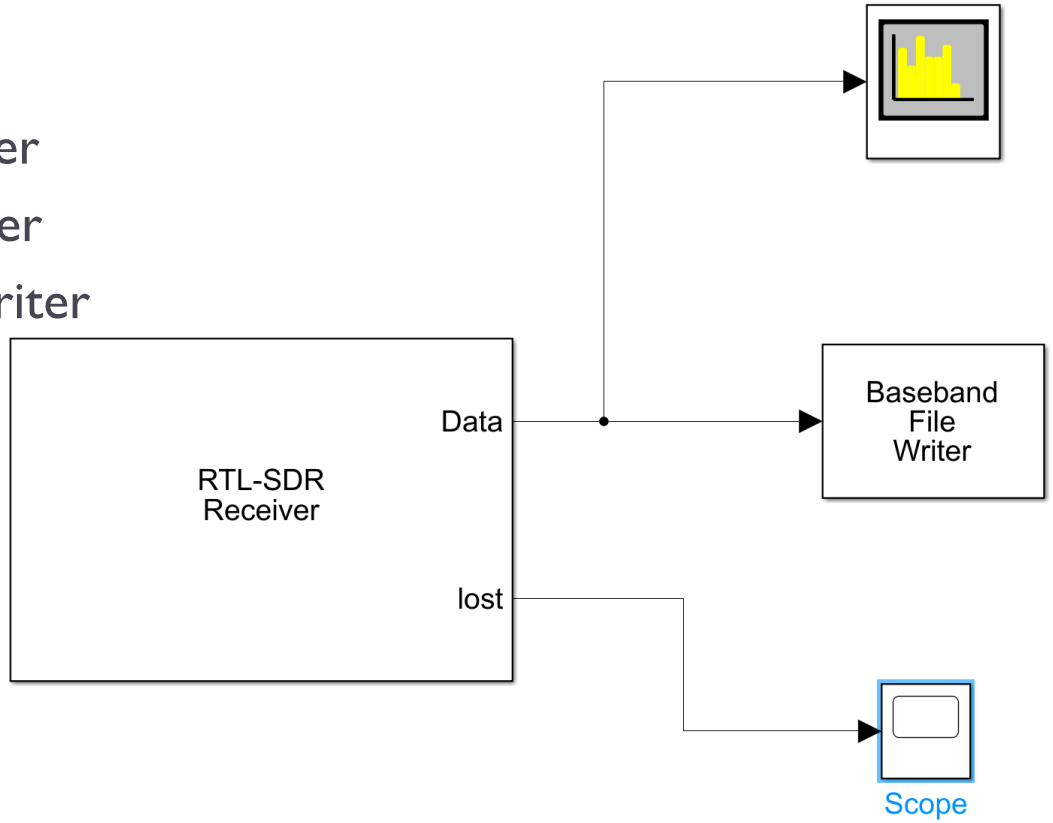
- MATLAB
  - **/05_SDR_Setup/matlab/Ex2_run_rtlsdr_logger.m**
  - **Int16 Binary file** and **Baseband file** are captured
- Baseband file is RF data format for MATLAB
  - Baseband File Reader/Writer Blocks for Simulink
  - BasebandFileReader/Write functions

```
7   %% Setting
8   Fc = 1575.42e6; % Center frequency [Hz]
9   Fs = 2.048e6; % Sampling rate [Hz]
10  nsec = 1; % [sec]
11
12  % Output file name
13  bbfile = 'rtlsdr_matlab.bb';
14  binfile = 'rtlsdr_matlab.bin';
15
```

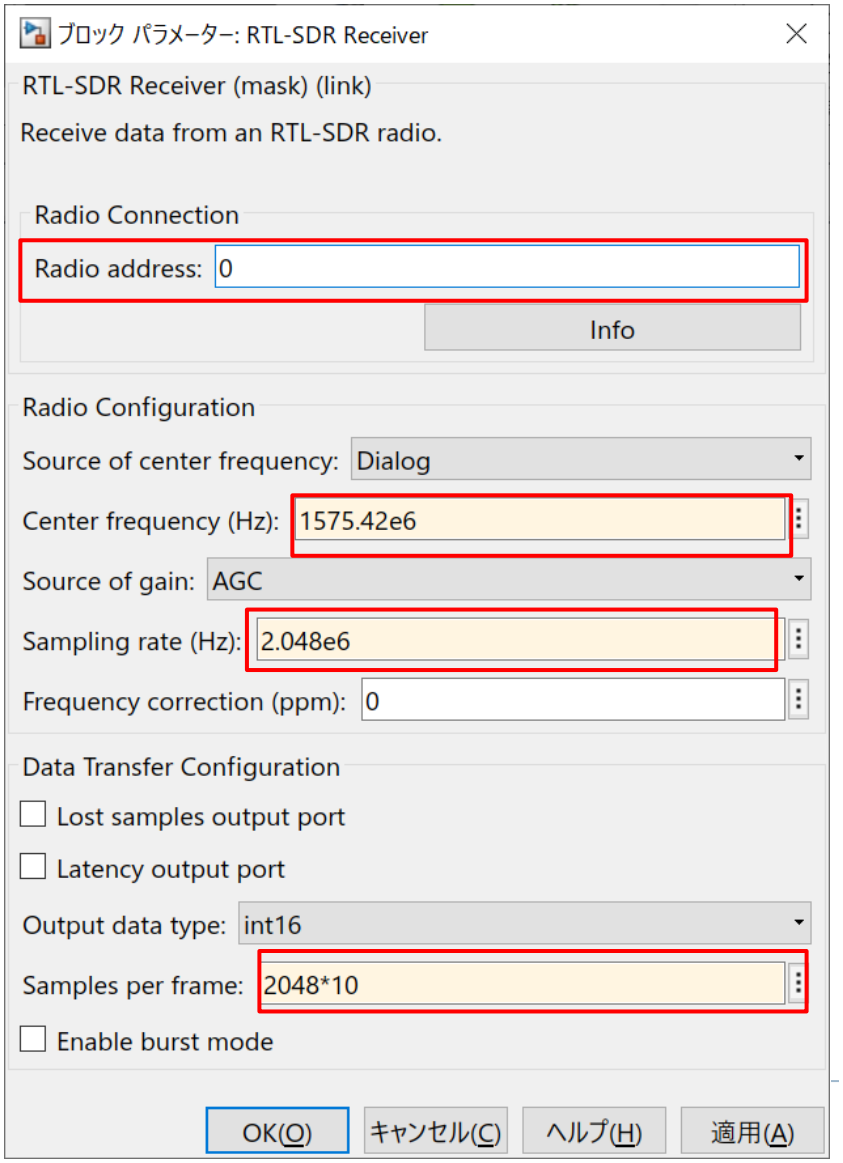
# Exercise 3: Capture using Simulink (1)

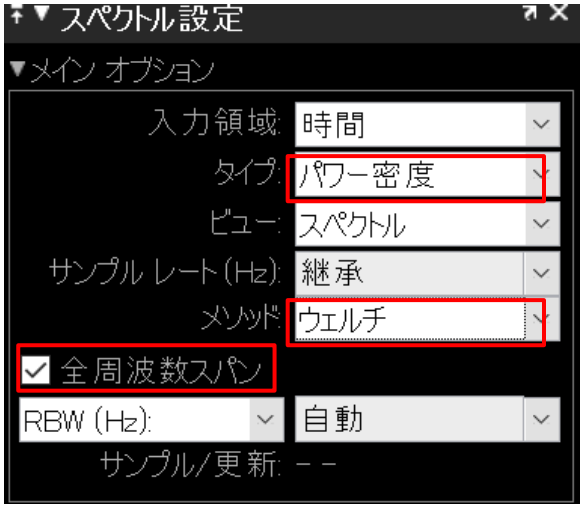
- Simulink
  - **/05_SDR_Setup/simulink/Ex3/rtlsdr_logger.slx**

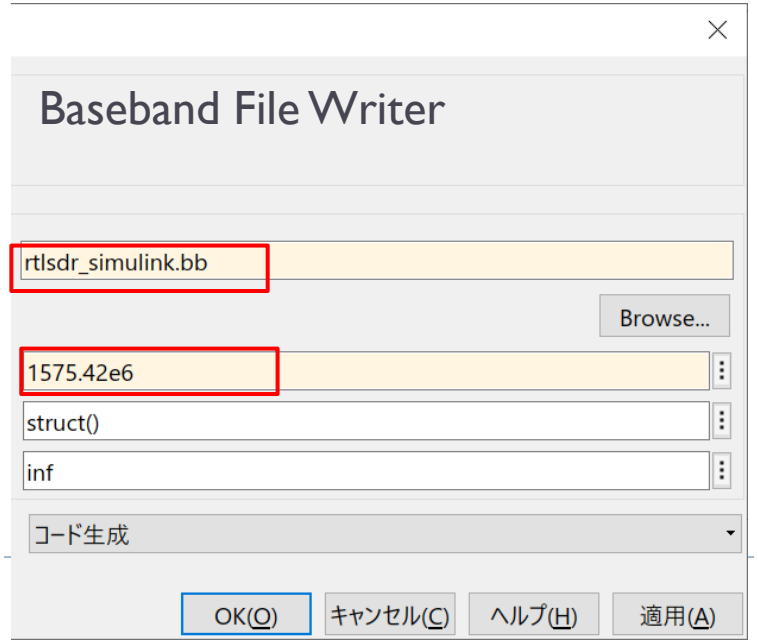
- **Blocks**
  - RTL-SDR Receiver
  - Spectrum Analyzer
  - Baseband File Writer
  - Scope



# Exercise 3: Capture using Simulink (2)

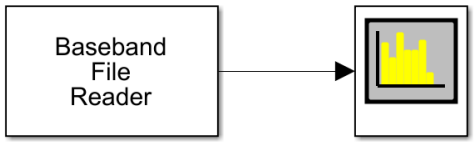


# Exercise 4: Read Baseband File

- Simulink
  - **/05_SDR_Setup/simulink/Ex4/rtlsdr_reader.slx**





- **Advanced Challenge**
  - Visualization raw samples using Array Plot
  - Compute Histogram using Histogram and Display
  - Insert DC Blocker

# Exercise 5: Convert RF file

- MATLAB
  - **/05_SDR_Setup/matlab/Ex5_run_convert_rtlsdr.m**
  - Convert rtl-sdr format (uint8) to int16 binary and Baseband file
  - Plot and check converted data using "Ex1_run_plot_rfdata.m"