



LimeSuite and LimeSDR

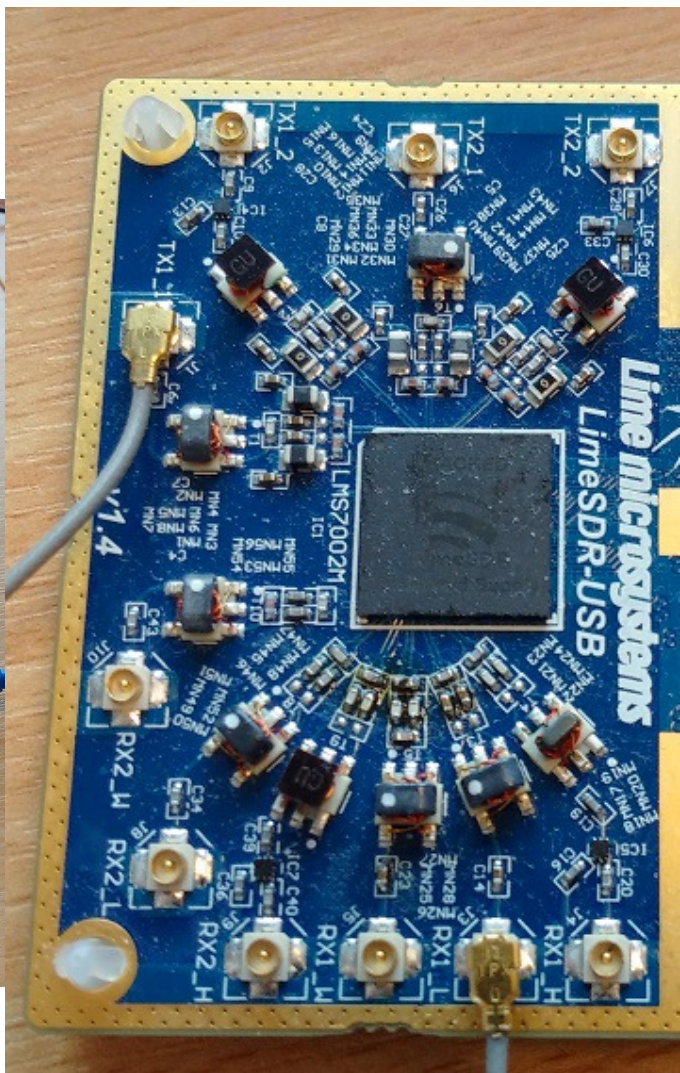
Danny Webster



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1. Introduction
2. Operating LimeSuite software
3. Examples FSK/ASK/PSK
4. Calibration
5. Changing gain, frequency and sample rate
6. Other settings

Suggested Connections for Examples



Use external RF loop back
To avoid interference.
E.g. SMA adapter

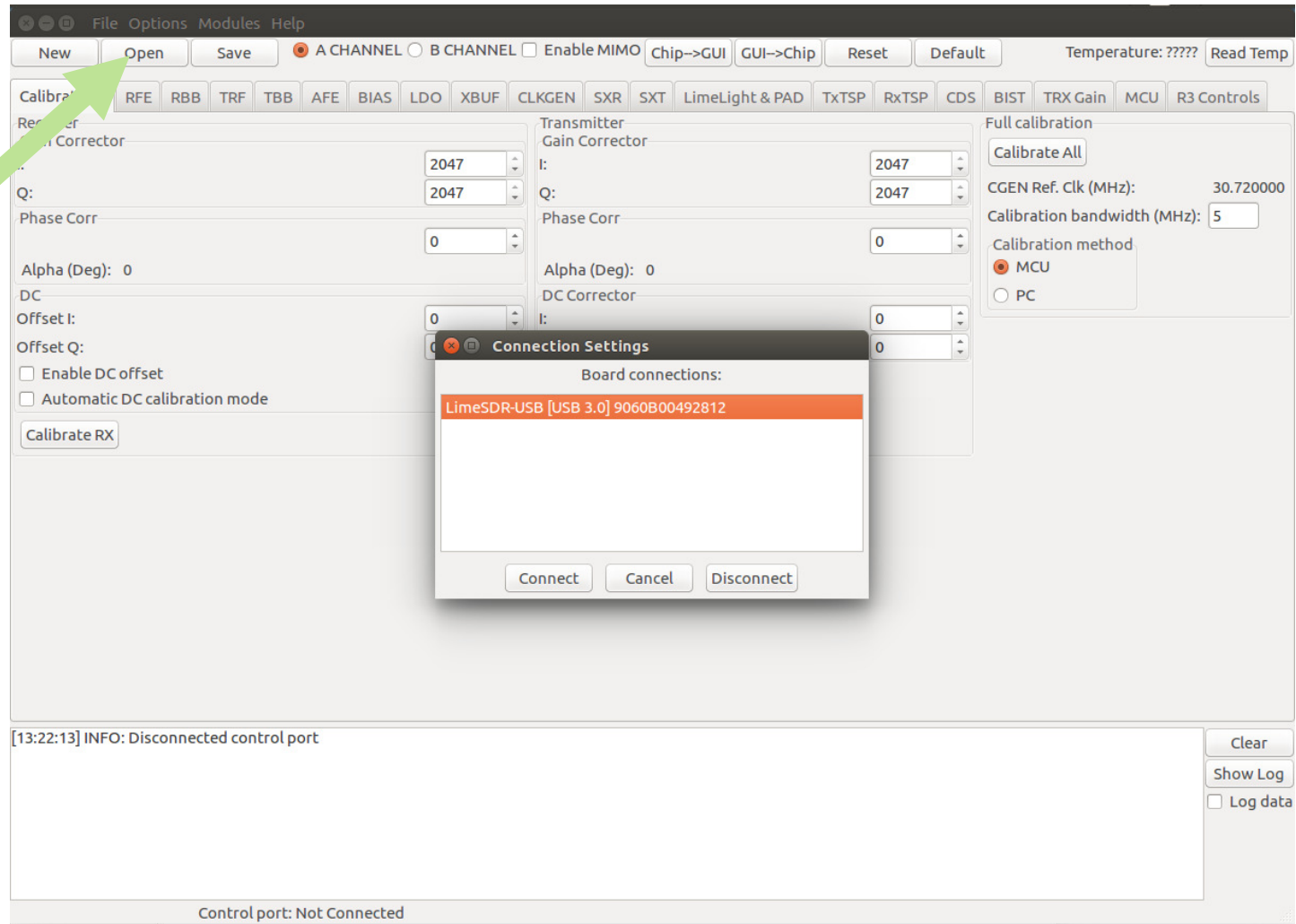
Connect to TX1_1 and RX1_L
For compatibility with
Code examples.

Differences between Linux and Windows

- **Linux (Built from Source)**
 - Copy lms7suite_wfm to
 - ~/LimeSuite/build/lin/bin
- **Linux (Repository)**
 - Copy lms7suite_wfm to
 - ~/
- **Windows**
 - Copy lms7suite_wfm to
 - \Documents or \Desktop

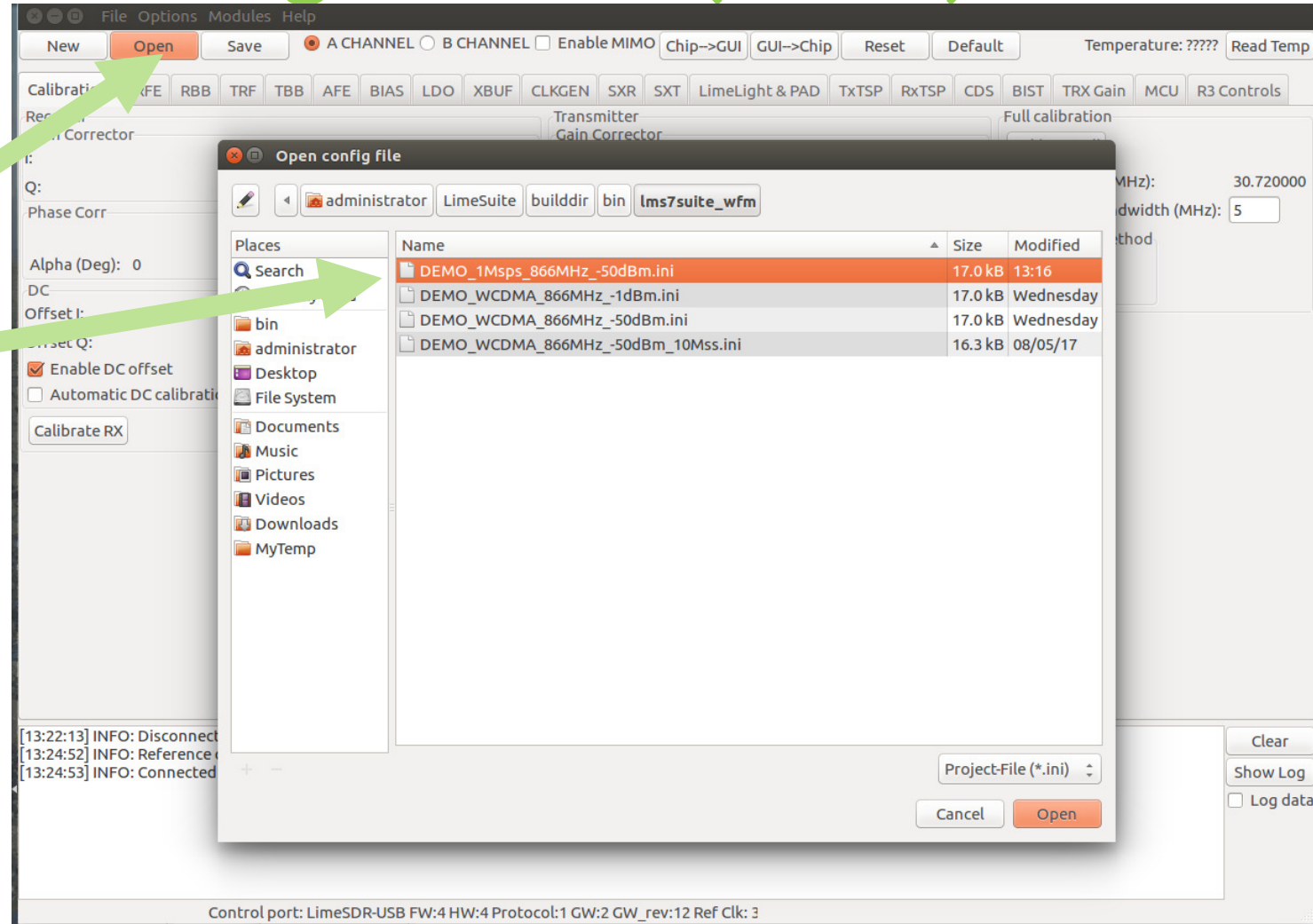
Connecting to LimeSDR

- Connect LimeSDR to USB3
- Start LimeSuite software
- To select LimeSDR
- Top Menubar
 - Options → Connect
- RESET



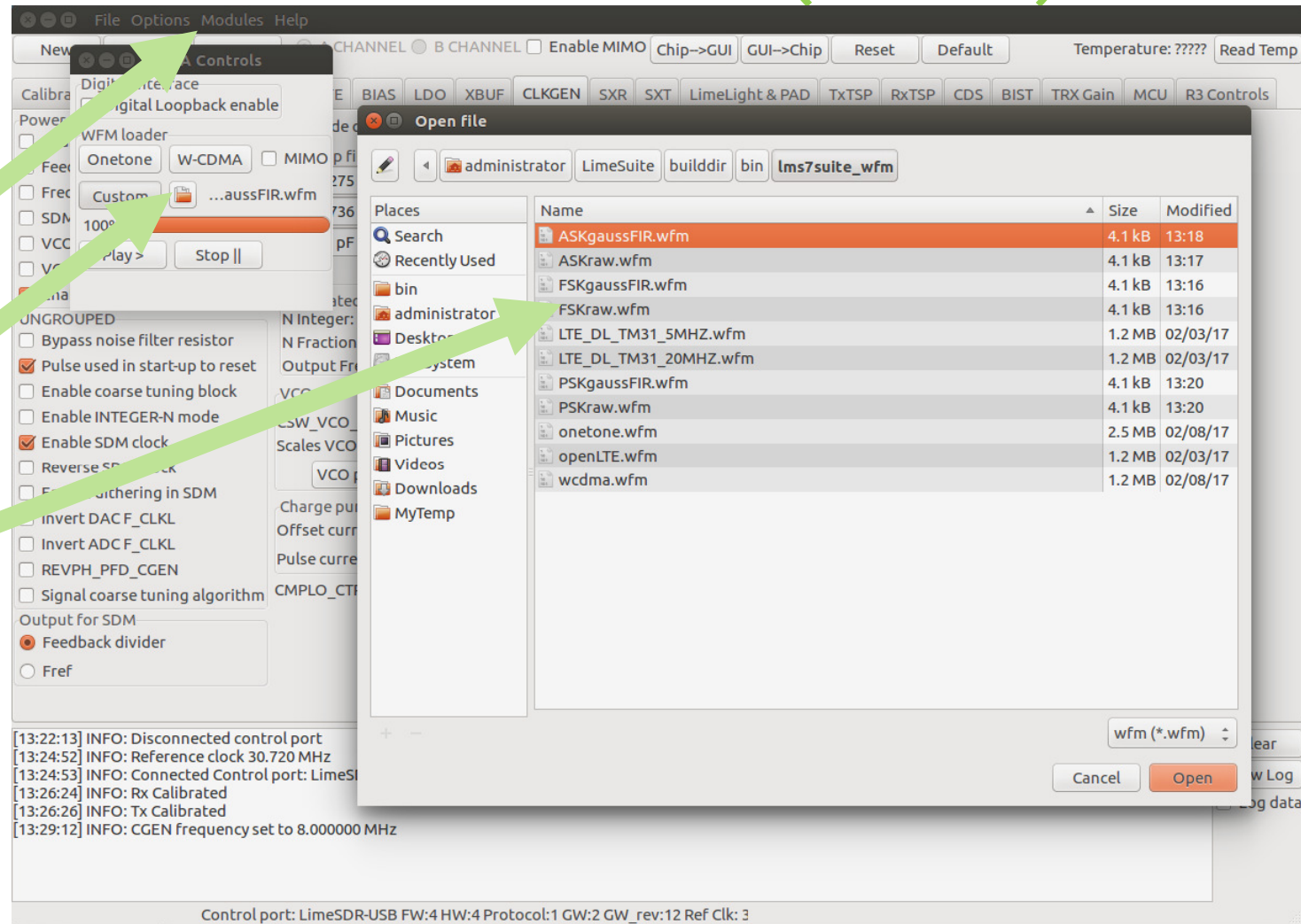
Loading a settings file (.ini)

- To select LimeSDR settings
- Open Button
- Select
 - DEMO_1Msps_866Mhz_-50dBm.ini



Selecting a Waveform file (.wfm)

- To select waveform to play back on LimeSDR
- Modules (Top Menubar)
 - FPGA Control
 - Custom Open File
 - (Middle)
 - Custom Button (Left)
 - FSKraw.wfm

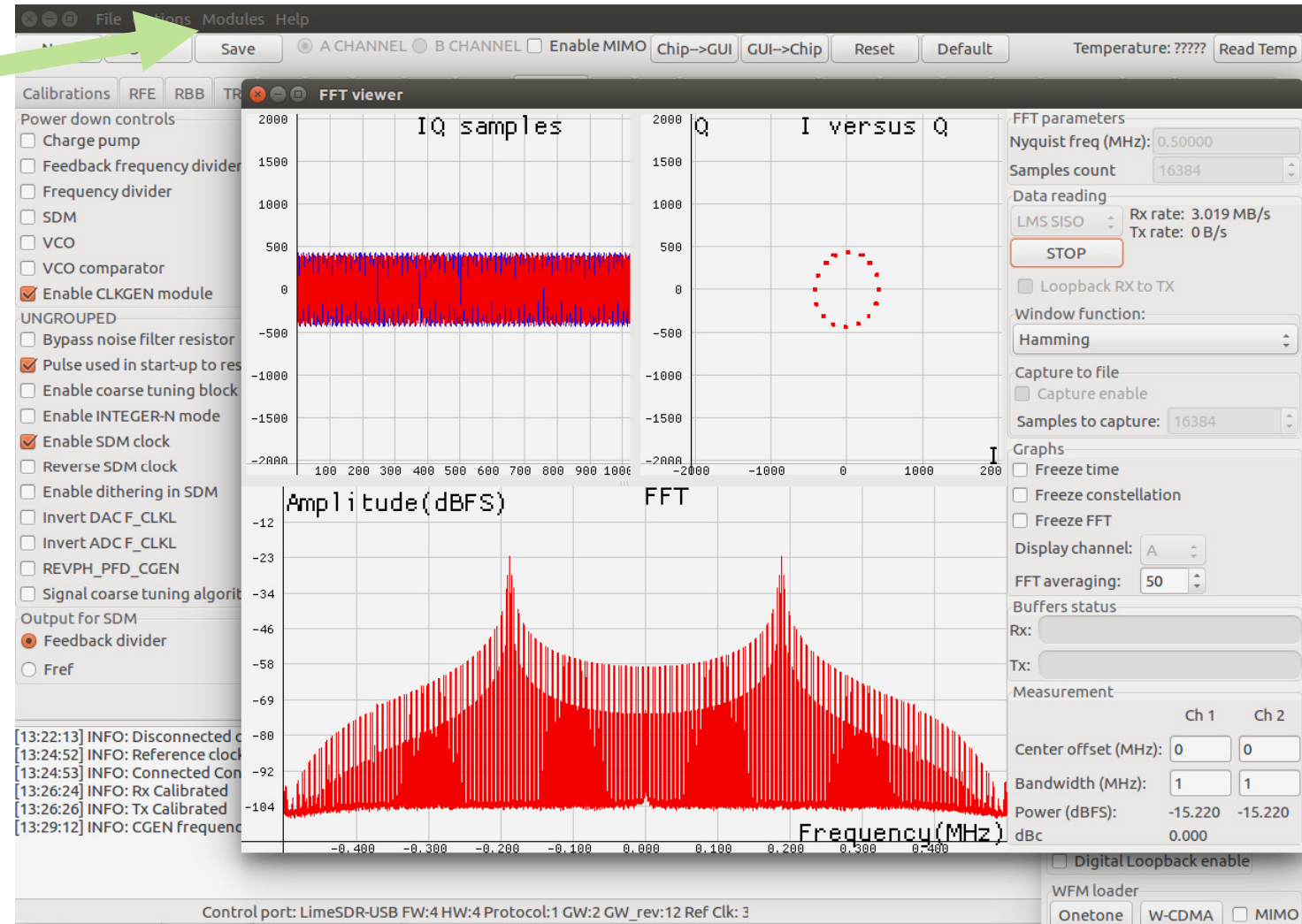


FSK Demo

- **Modules**

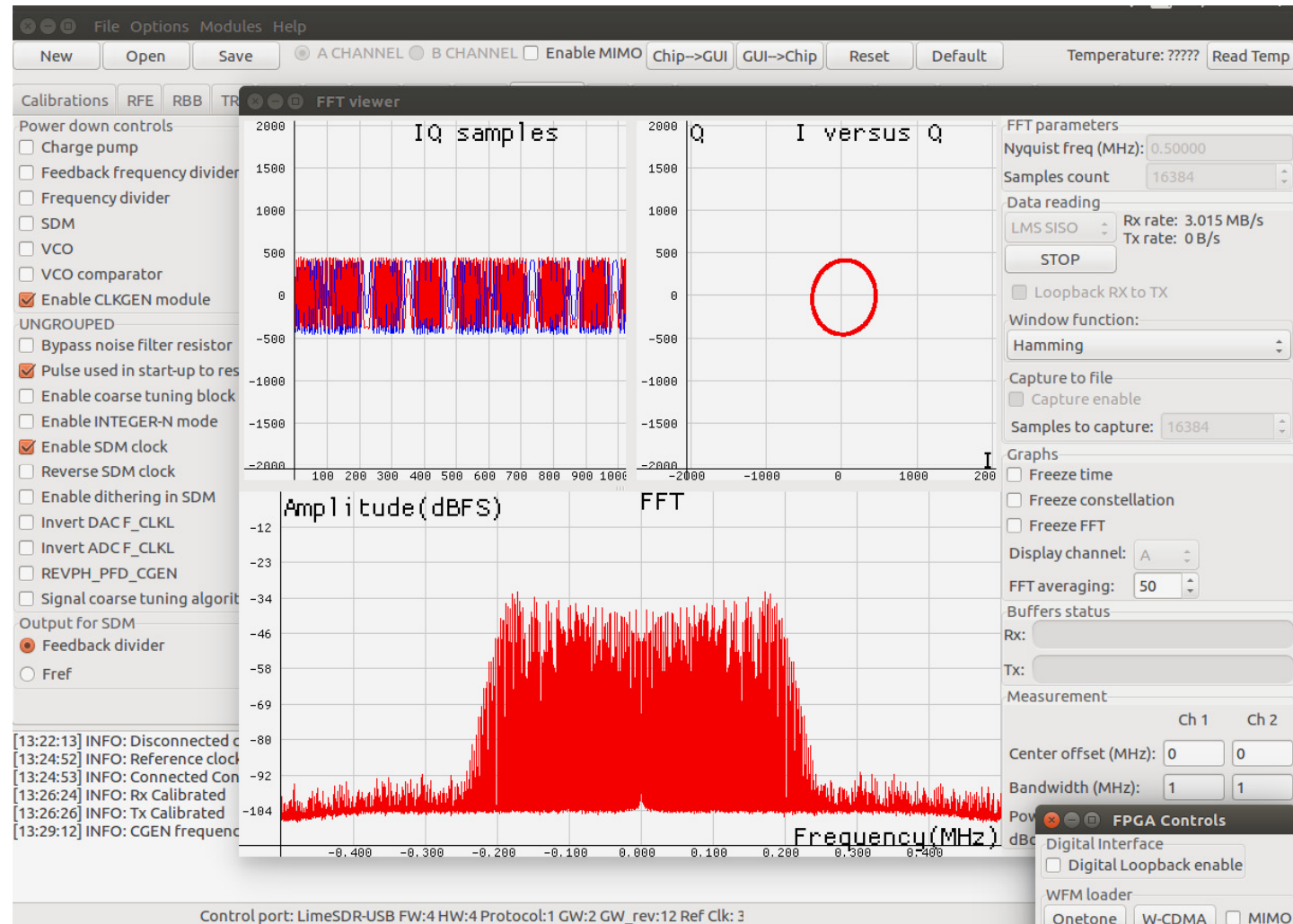
- FFT Viewer
- Hamming or Hanning windows

- **FSKraw.wfm**



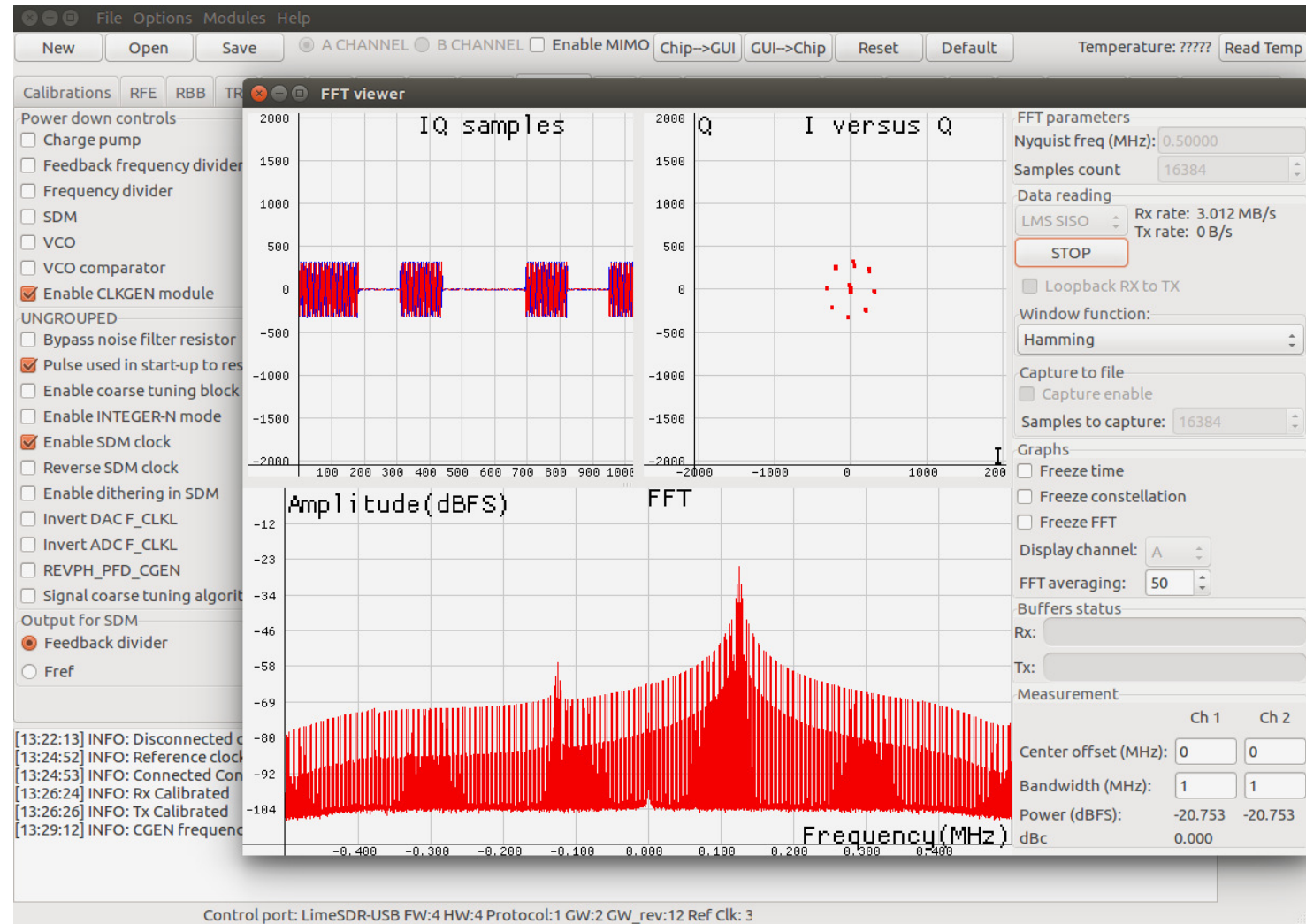
Filtered FSK Demo

- FSKgaussFIR.wfm
- Less interference to adjacent channels.
- FFT Viewer helps you to find optimum radio settings for your signal.
 - Phase Noise
 - Adjacent Channel Interference
 - Avoid Rx overload.



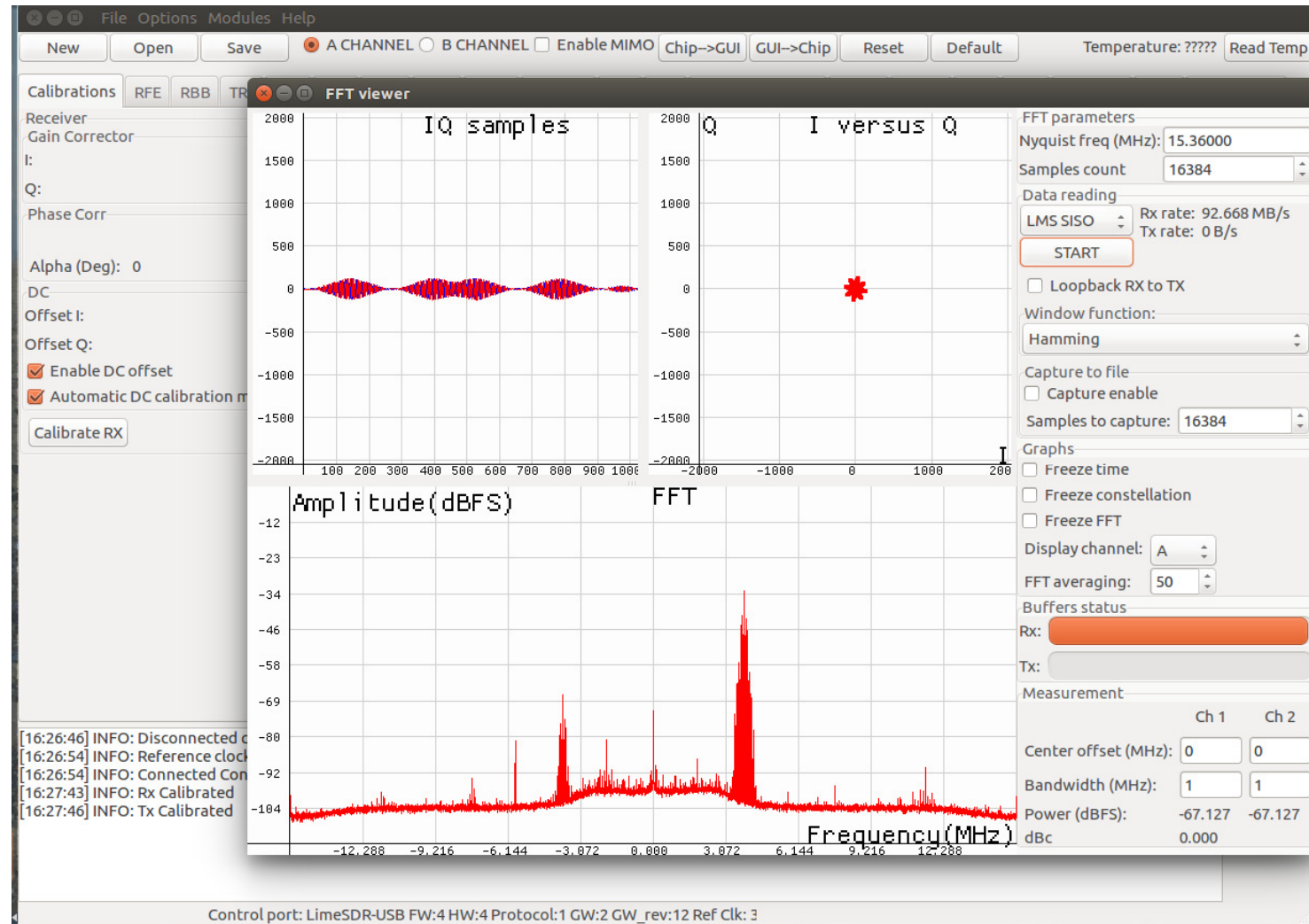
ASK Demo

- ASKraw.wfm



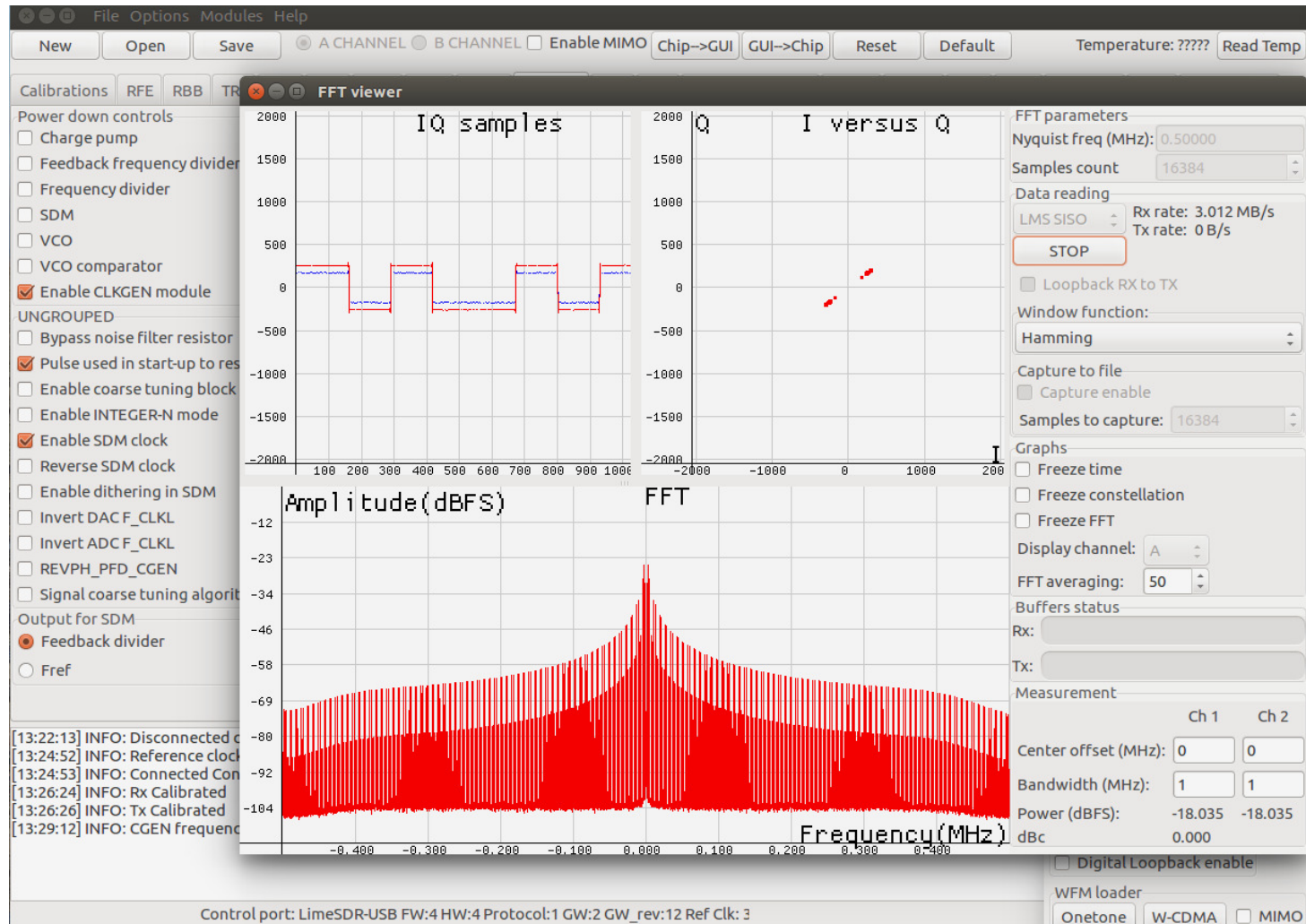
Filtered ASK Demo

- ASKgaussFIR.wfm
- Less interference to adjacent channels.



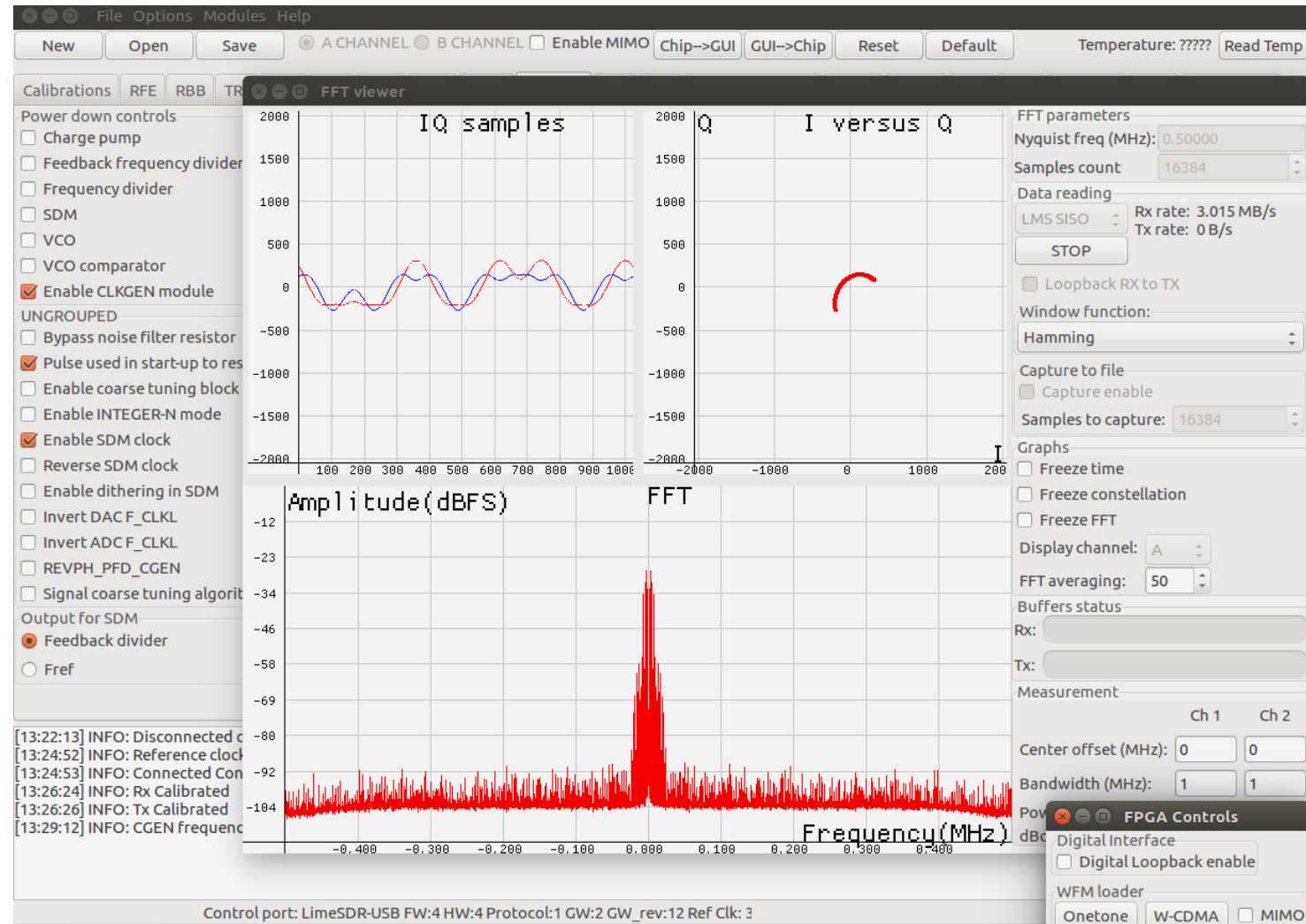
PSK Demo

- PSKraw.wfm



Filtered PSK Demo

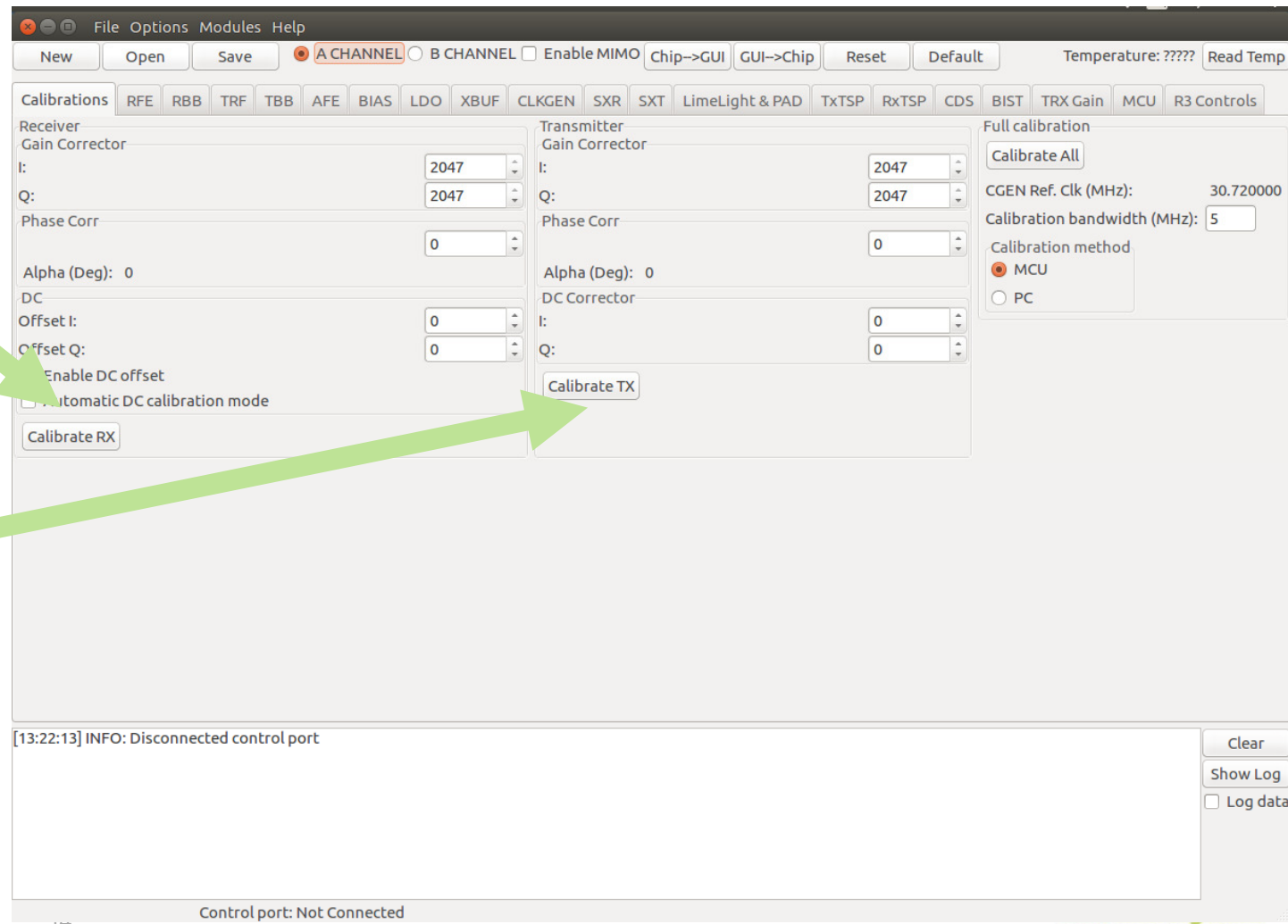
- PSKgaussFIR.wfm
- Less interference to adjacent channels.



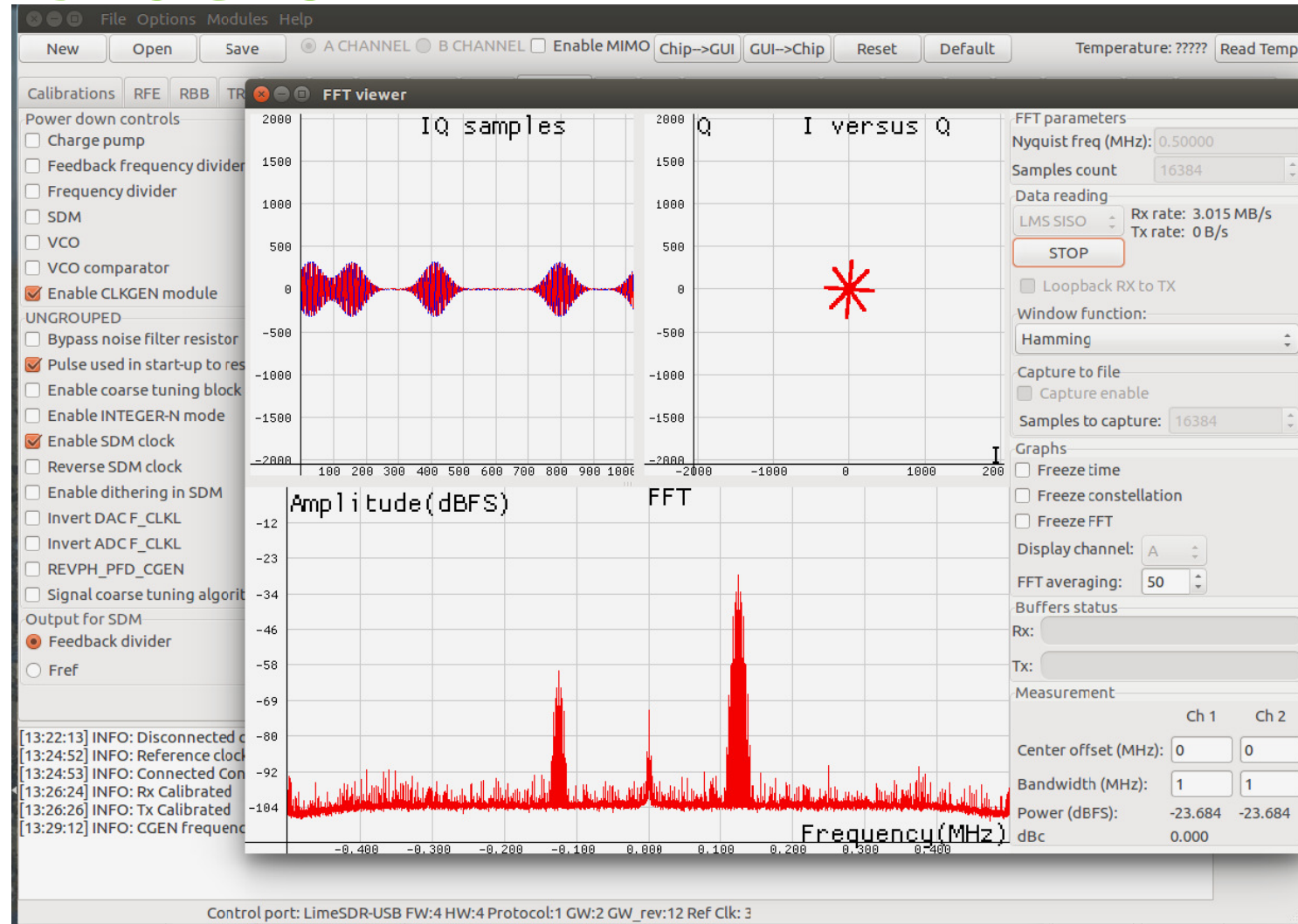
Automatic Calibration

- Calibrate RX

- Calibrate TX



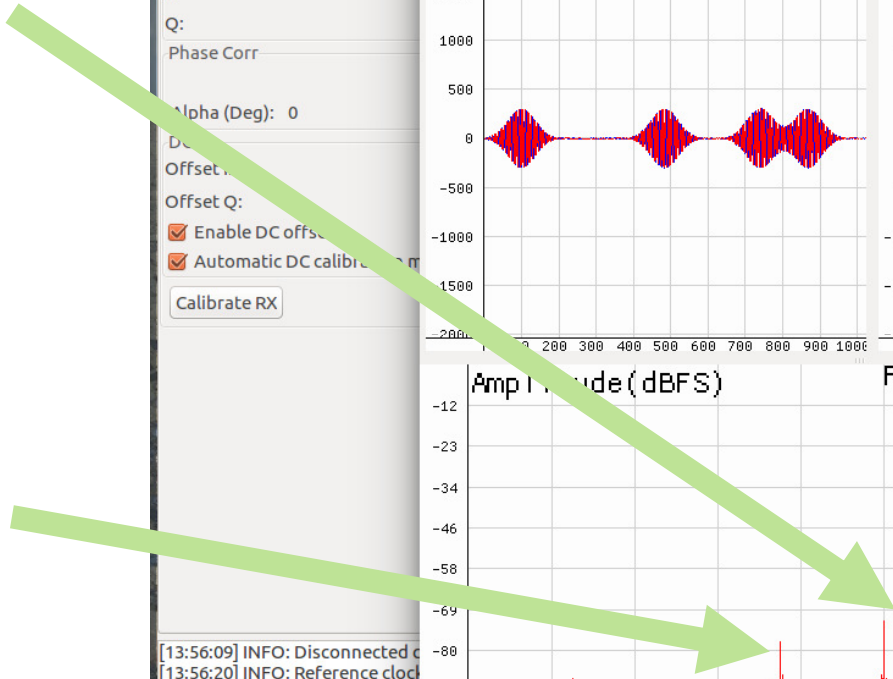
Before Calibration



After Calibration

- DC Leakage reduced in RX

- Unwanted sideband rejection improved



Changing RF gain (Rx RF)

- Change LNA gain to improve signal to noise.
- Too much gain can sometimes overload receiver or make it vulnerable to interference.

The screenshot displays the LimeSDR GUI interface for RF gain control. The 'Gain controls' section is highlighted, showing the 'LNA' dropdown menu set to 'Gmax-9'. A green arrow points from the text 'Change LNA gain to improve signal to noise.' to this dropdown. Other settings in the 'Gain controls' section include 'Loopback' set to 'Gmax-40' and 'TIA' set to 'Gmax'. The 'DC' section shows 'Mixer LO signal' at 0.557 V and 'Enable DC offset' checked. The status bar at the bottom shows 'Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3'.

Changing analogue gain (Rx IF)

- Change PGA gain to optimise level at ADC.
- Too much gain can overload receiver.
- Too little gain can give poor signal to noise ratio.

The screenshot shows the LimeSDR GUI with the RBB module selected. The 'PGA gain' is set to 0 dB. A green arrow points to this setting. The interface includes various control panels for power down, RXLPF, and operational amplifiers.

Power down controls

- LPFL block
- PGA block
- Enable RBB module
- Direct control
 - Direct control of PDs and ENs

RXLPF RC time constant

Resistance: 16

LPFH capacitance value: 128

LPFL capacitance value: 1970

Rx Filters

RF bandwidth (MHz): 10

TUNE

BB loopback to RXLPF: Disabled

PGA input connected to: LPFL_RBB

PGA gain: 0 dB

PGA Feedback capacitor: 2

PGA output connected to: ADC Output pads

Operational amplifier

LPFH stability passive compensation: 1

LPFL stability passive compensation: when 20 MHz

Input stage reference bias current (RBB_LPF): 12

Output stage reference bias current (RBB_LPF): 12

Output stage reference bias current (PGA): 6

Input stage reference bias current (PGA): 6

PGA stability passive compensation: 23

[13:22:13] INFO: Disconnected control port
[13:24:52] INFO: Reference clock 30.720 MHz
[13:24:53] INFO: Connected Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 30.72 MHz
[13:26:24] INFO: Rx Calibrated
[13:26:26] INFO: Tx Calibrated

Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3

Changing RF gain (Tx RF)

- Change TX gain to change output signal level.
- Change both TXPAD gain controls to same value.

The screenshot shows the LimeSDR GUI with the TRF tab selected. The interface includes a menu bar (File, Options, Modules, Help), a toolbar (New, Open, Save), and a status bar (Temperature: ?????, Read Temp). The TRF tab contains several sections of controls:

- Power down controls:** Includes checkboxes for Power detector (checked), TX LO buffer, TXPAD, and Enable TRF module (checked). There are also options for Direct control and Direct control of PDs and ENs.
- Power detector:** Includes a dropdown for Resistive load (R_DIFF 5K|1.25K).
- Bias current:** Includes dropdowns for Linearization section (51.7 uA) and Main gm section (18).
- Trim duty cycle:** Includes dropdowns for I channel (8) and Q channel (8).
- TXPAD cascode transistor gate bias:** Includes radio buttons for VDD (selected) and GNDS.
- Other controls:** Includes checkboxes for Enable Tx MIMO mode and Enable TXPAD loopback path. A list of gain controls includes TXFE output selection (Band1), EN_LOWBWLOMX_TMX_TRF (High band - bias resistor 3K), TXPAD power detector preamplifier gain (25 db), TXPAD linearizing part gain (31), TXPAD gain control (31), Bias voltage at gate of TXPAD cascode (2), Bias at gate of mixer NMOS (21), and Bias at gate of mixer PMOS (31).

At the bottom, a log window shows the following messages:

```
[13:22:13] INFO: Disconnected control port  
[13:24:52] INFO: Reference clock 30.720 MHz  
[13:24:53] INFO: Connected Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 30.72 MHz  
[13:26:24] INFO: Rx Calibrated  
[13:26:26] INFO: Tx Calibrated
```

The status bar at the bottom indicates: Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3

Changing analogue gain (Tx IF)

- Change TX IF gain to change to minimise adjacent channel interference.
- (Needed after filter bandwidth changed)
- (Recalibration needed after filter and gain change)

The screenshot displays the LimeSDR GUI's configuration interface for the TBB (Transmit Baseband) section. A green arrow highlights the 'Frontend gain' dropdown menu, which is currently set to 9. The interface includes various control panels for power down, operational amplifier, and Tx filters, along with a log window at the bottom showing system status messages.

Key configuration options visible include:

- Power down controls:** LPPFH_TBB biquad (unchecked), LPFIAMP_TBB front-end current amp (unchecked), LPF55_TBB low pass real-pole filter (checked), Enable TBB module (checked), Direct control (unchecked), Direct control of PDs and ENs (unchecked).
- Operational amplifier:** Output stage bias current low band real pole filter (12), Input stage bias current of low band real pole filter (12), Input stage bias reference current of high band low pass filter (2), Output stage bias reference current of high band low pass filter (12), Output stage bias reference of low band ladder filter (12), Input stage bias reference of low band ladder filter (12).
- Tx Filters:** RF bandwidth (MHz) 56, TUNE, Tune Gain.
- Other controls:** Bypass LPF ladder of TBB (unchecked), Bypass LPF55 filter capacitor banks (unchecked), Tx BB loopback (Disabled), Enable Tx IO analog input (Disabled), Reference bias current (12), IAMP main bias current sources (12), IAMP cascade transistors gate voltage (12), TxLPF resistor banks (0), LPFH equivalent resistance stage (193), LPFLAD equivalent resistance stage (76), LPF55 equivalent resistance stage (24), Common control signal for all TBB filters (24).

The log window at the bottom shows the following messages:

```
[13:22:13] INFO: Disconnected control port
[13:24:52] INFO: Reference clock 30.720 MHz
[13:24:53] INFO: Connected Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 30.72 MHz
[13:26:24] INFO: Rx Calibrated
[13:26:26] INFO: Tx Calibrated
```

Changing RF frequency (SXT and SXR)

- Change Tx and Rx frequency using SXT and SXR.
- Redo calibrations if above 1GHz.
- Advanced settings can be used to optimise phase noise.

The screenshot shows the LimeSDR GUI with the SXT/SXR controls panel. A green arrow points to the 'Frequency, M' field, which is set to 865.928. The 'Enable SXR/SXT module' checkbox is checked. The 'Test mode of SX' is set to 'TST disabled'. The 'Reference clock (MHz)' is 30.720. The 'Output Freq, MHz' is 865.928. The 'PLL LPF zero resistor' is set to 'Rzero = 20 kOhm'. The 'CMPLO_CTRL' is set to 'Low threshold is set to 0.18V'. The 'Log data' checkbox is checked.

```
[13:22:13] INFO: Disconnected control port
[13:24:52] INFO: Reference clock 30.720 MHz
[13:24:53] INFO: Connected Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 30.72 MHz
[13:26:24] INFO: Rx Calibrated
[13:26:26] INFO: Tx Calibrated
```

Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3

Changing sample rate (CLKGEN)

- Change CLKGEN Frequency
- $\text{ADC rate} = \text{CLKGEN}/4$
- $\text{DAC rate} = \text{CLKGEN}/1,2,4$
- Calculate
- Tune

File Options Modules Help

New Open Save A CHANNEL B CHANNEL Enable MIMO Chip->GUI GUI->Chip Reset Default Temperature: ????? Read Temp

Calibrations RFE RBB TRF TBB AFE BIAS LDO XBUF CLKGEN SXR SXT LimeLight & PAD TxTSP RxTSP CDS BIST TRX Gain MCU R3 Controls

Power down controls Test mode of SX TST disabled

Feedback frequency divider
Frequency divider
SDM
VCO
VCO comparator
 Enable CLKGEN module

UNGROUPED
 Bypass noise filter resistor
 Pulse used in start-up

Enable ... block
Enable INTEGE...
... SDM clock
 Reverse SDM clock
 Enable dithering in SDM
 Invert DAC_F_CLKL
 Invert ADC_F_CLKL
 REVPH_PFD_CGEN
 Signal coarse tuning algorithm

Output for SDM
 Feedback divider
 Fref

CP2 2.275 pF
CP3 1.736 pF
CZ 32 pF

FCLKH to
TSP frequency
RxTSP (MHz): 2.000
TxTSP (MHz): 8.000

Frequency controls
CLK_H (MHz): 8.000
CLKH_OV_CLKL 1
CLK_L (MHz): 0
Rx phase 120
Tx phase 120
 Auto phase
Calculate Tune

Calculated Values for Fractional Mod...
N Integer: 78
N Fractional: 131072
Divide...
Output Freq (MHz): 8.000

VCO Com... Compar...
SDM DONE: ???
COMPO: ???
Read Read

CSW_VCO_CGEN 172
Scales VCO bias current 16
VCO params

Charge pump scales
Offset current 20
Pulse current 20
CMPLO_CTRL: Low threshold is set to 0.18V

[13:22:13] INFO: Disconnected control port
[13:24:52] INFO: Reference clock 30.720 MHz
[13:24:53] INFO: Connected Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 30.72 MHz
[13:26:24] INFO: Rx Calibrated
[13:26:26] INFO: Tx Calibrated

Clear
Show Log
 Log data

Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3

Changing signal processing (TSP)

- **Change signal processing option**

- DC Corrector
- Gain/Phase Corrector
- Inverse Sinc
- NCO Frequency/Phase
 - (Enable CMIX)
- Interpolation Ratio
- FIR Filters

The screenshot displays the LimeSDR GUI's TxTSP configuration window. Key settings include:

- Enable TxTSP:** Checked.
- NCO:** FCW (MHz) = 0.200000, PHO (deg) = 0.000.
- Mode:** FCW selected.
- TSG:** TSGFCW = TSP clk/8, TSGMODE = DC source.
- DC Reg:** DC source selected.
- Gain/Phase Corrector:** Gain = 0 dB, HBI ratio = 2³.
- DC Corrector:** I = -4, Q = 12.

The bottom status bar indicates: Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3

Changing signal processing (RSP)

- Change signal processing option
 - Gain/Phase Corrector
 - Auto DC Corrector
 - NCO Frequency/Phase
 - (Enable CMIX)
 - AGC
 - Decimation Ratio
 - FIR Filters

The screenshot displays the LimeSDR GUI's RxTSP configuration page. The 'Enable RxTSP' checkbox is checked. The NCO section is active, showing a frequency of 0.000000 MHz and a phase of 0.000 degrees. The TSG section is also active, showing 'TSP clk/4' selected. The AGC section is active, showing 'AGC' mode and a window size of 2^10. The bottom status bar shows 'Control port: LimeSDR-USB FW:4 HW:4 Protocol:1 GW:2 GW_rev:12 Ref Clk: 3'.