

General Purpose Superheterodyne Phase Coherent X-band Receiver
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1. **Figure 1 shows a block diagram of the superheterodyne phase coherent X-band receiver.**
2. **Figure 2 shows the two-tone RF input with 50 KHz separation centered on 9 GHz at -115 dBm.**
3. **Figure 3 shows the downconverted IF signal between the downconverter and B205mini-I software defined radio centered on 1575 MHz.**
4. **Figure 4 shows an expanded view of the IF signal from 1 MHz to 6 GHz. Improved filtering would be helpful to reduce unwanted spectral noise.**
5. **Figure 5 shows the folded spectral density plot from the SDR with SDR LO = 1580 MHz.**
6. **Figure 6 shows a closer view of the two-tone output from the SDR with SDR LO = 1580 MHz.**
7. **With RF input level at -115 dBm, the C/N is +36 dB. With a C/N of +11 dB, it can be concluded that the minimum RF input signal would be -140 dBm.**
8. **Figures 7 and 8 are included to complete the experiment documentation and show that when the SDR LO (1580 MHz) is above the SDR IF (two tones centered on 1575 MHz), the spectral energy is in the lower, or negative spectrum.**
9. **Figure 9 shows the folded power spectral density plot from SDR with SDR LO = 1570 MHz.**
10. **Figure 10 is an expanded view of Figure 9 showing the two tone SDR output with C/N = +36 dB. Matching the results reported in line 7, if the C/N were reduced to +11 dB the X-band receiver minimum sensitivity would be -140 dBm.**
11. **Figures 11 and 12 are included for report completeness and show that when the SDR LO (1570 MHz) is below the SDR IF (two-tones centered on 1575 MHz), the spectral energy is in the upper, or positive spectrum.**
12. **Figures 13, 14, and 15 are screenshots of the custom B205mini-I GUI controlling the downconversion process.**

Figure 1. General Purpose Superheterodyne Phase Coherent X-Band Receiver

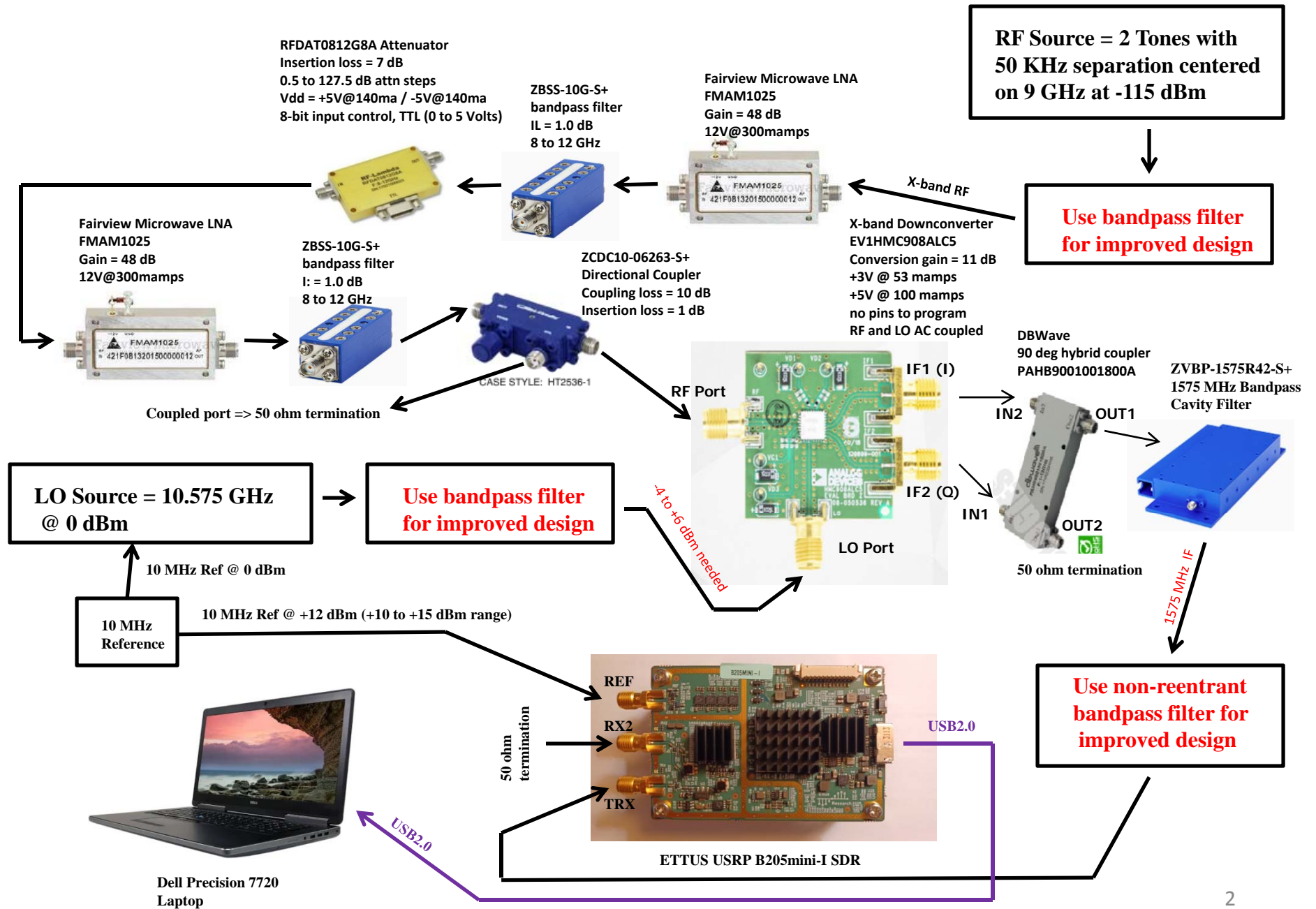
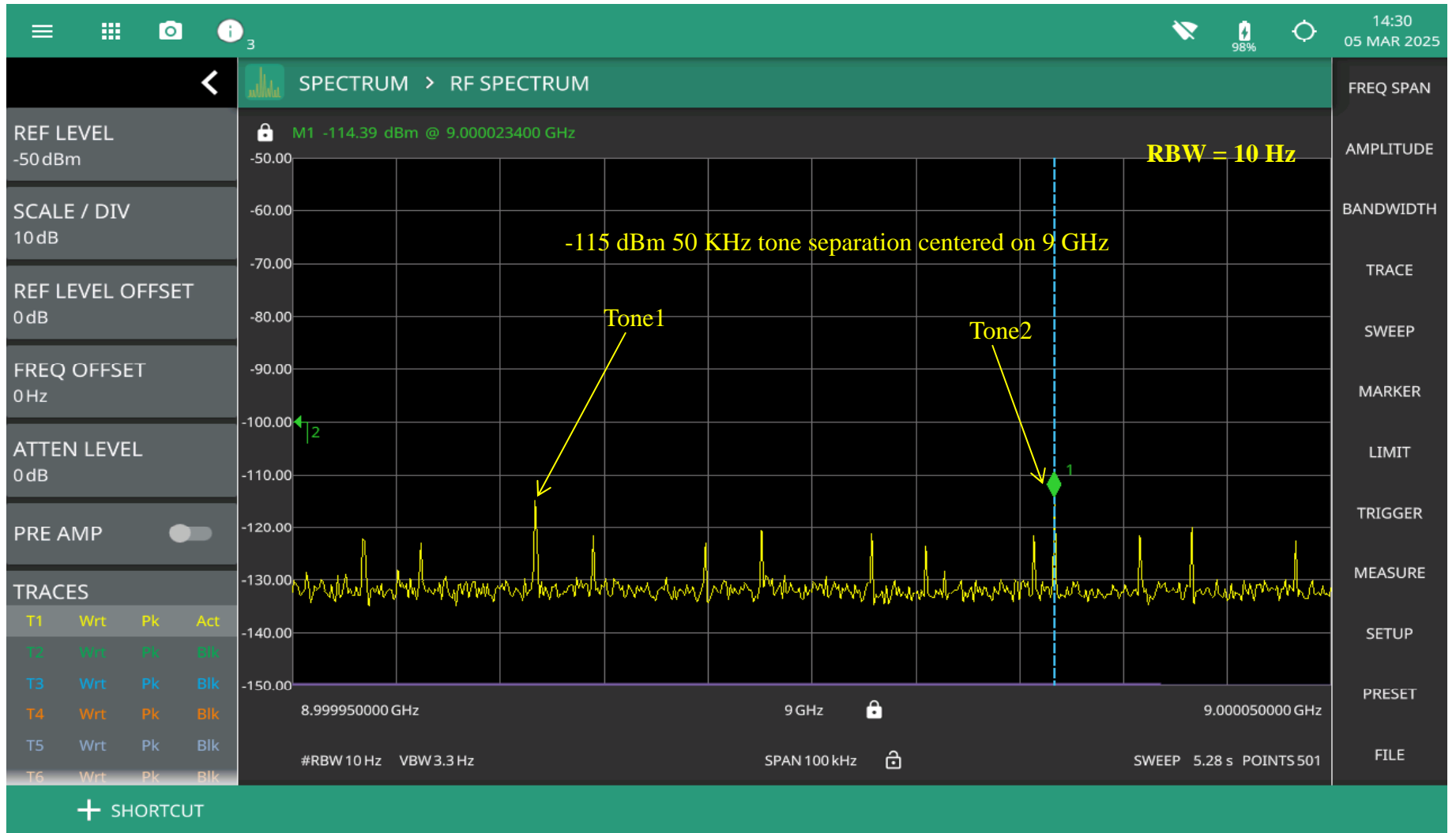
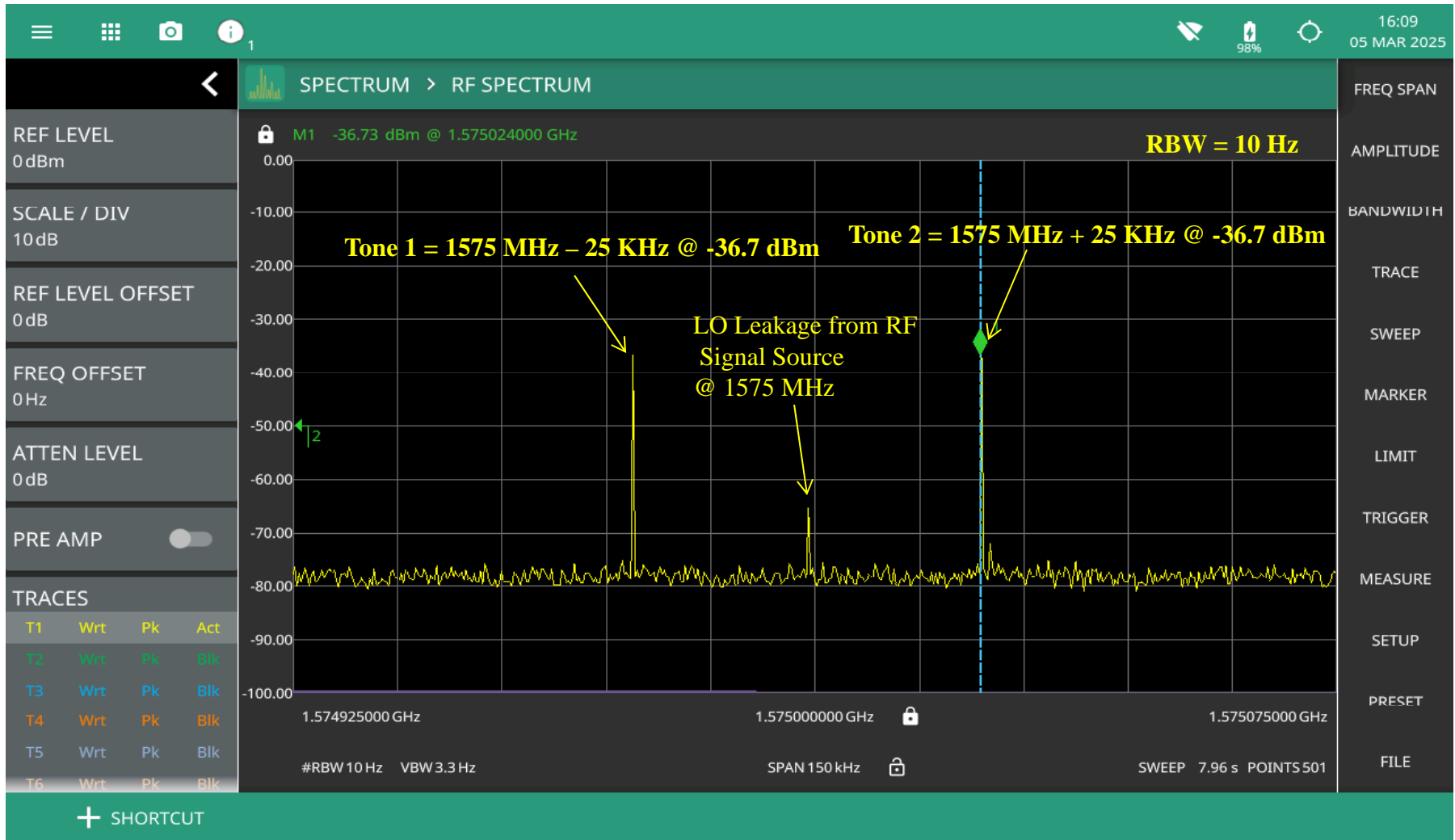


Figure 2. Two Tone RF Input



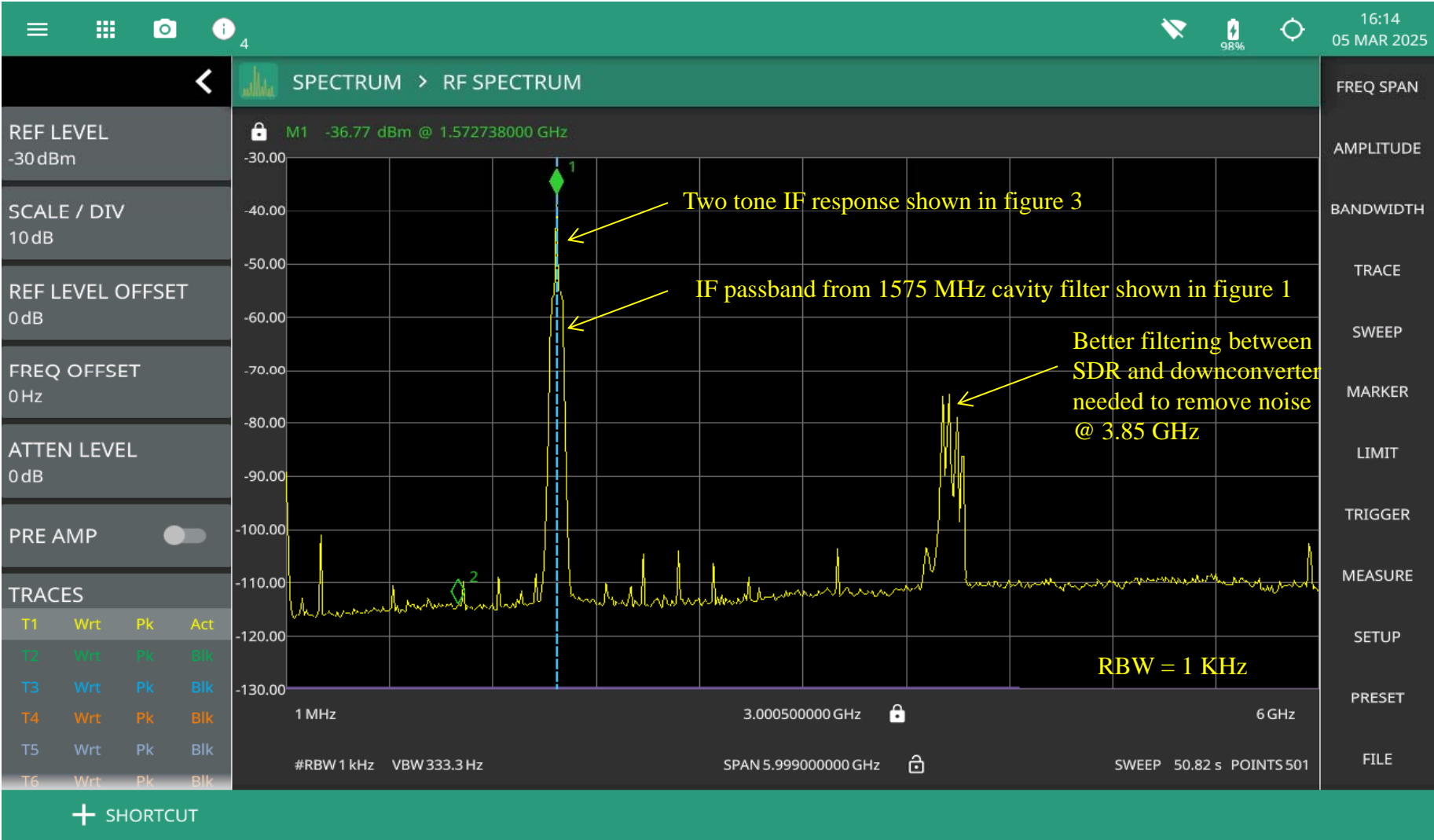
Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
Options: 0031,0104,0124,0125,0128,0199,0743
Date/Time: 05 Mar 2025 14:31:51 CST GPS: ---

Figure 3. IF Input to SDR



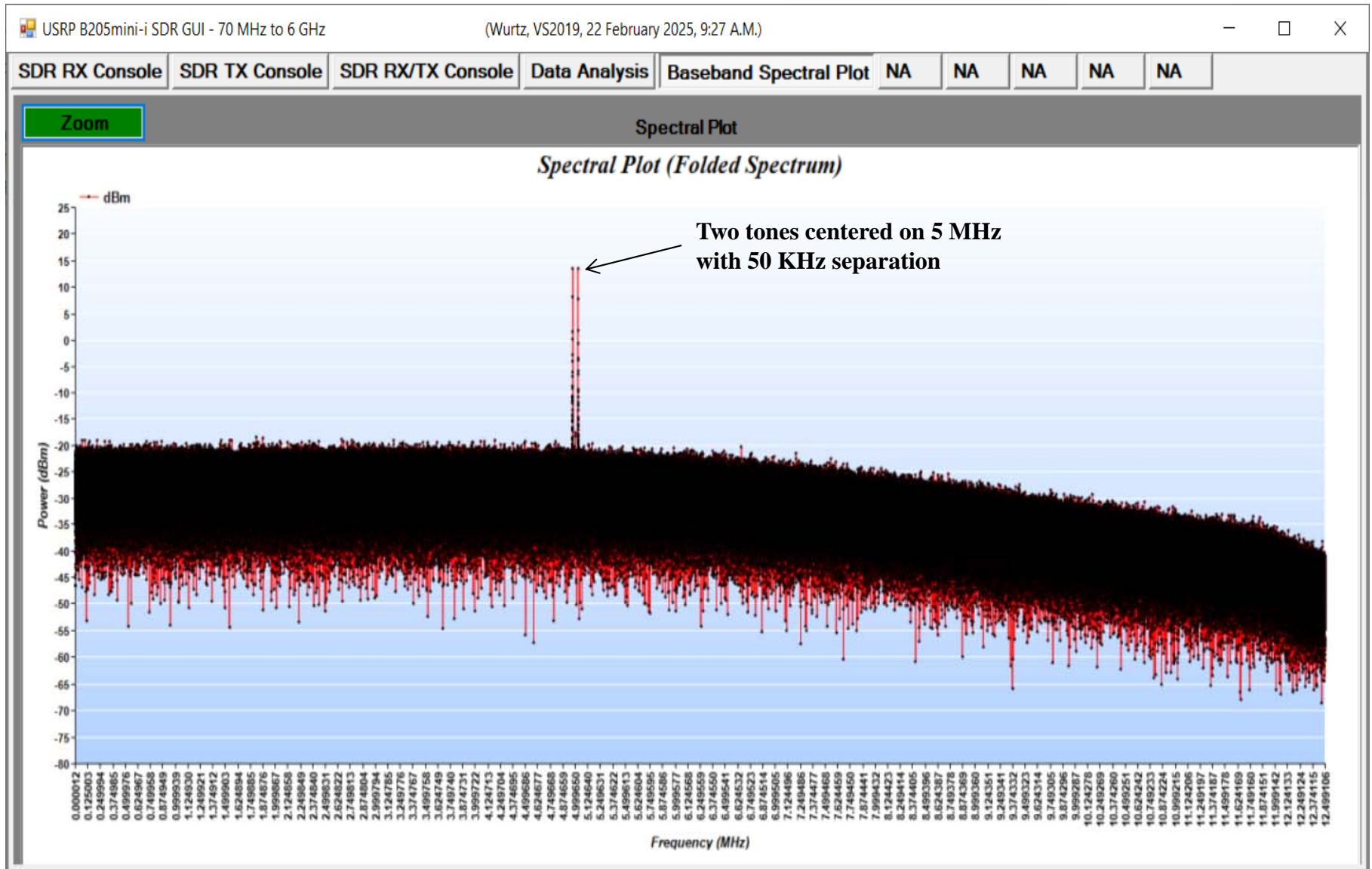
Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
Options: 0031,0104,0124,0125,0128,0199,0743
Date/Time: 05 Mar 2025 16:10:24 CST GPS: ---

Figure 4. IF Input to SDR (Wider Spectral View)

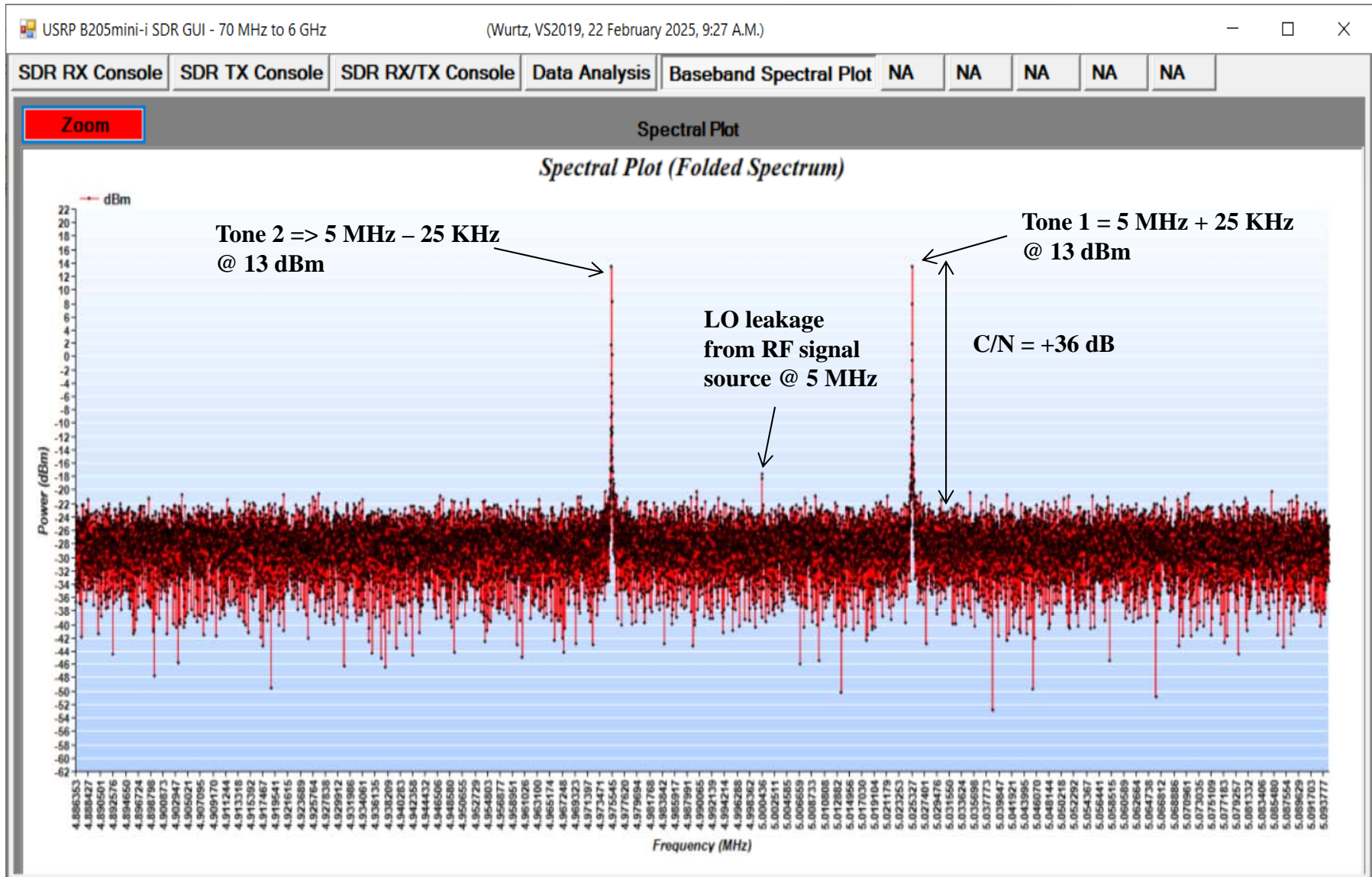


Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
 Options: 0031,0104,0124,0125,0128,0199,0743
 Date/Time: 05 Mar 2025 16:15:21 CST GPS: ---

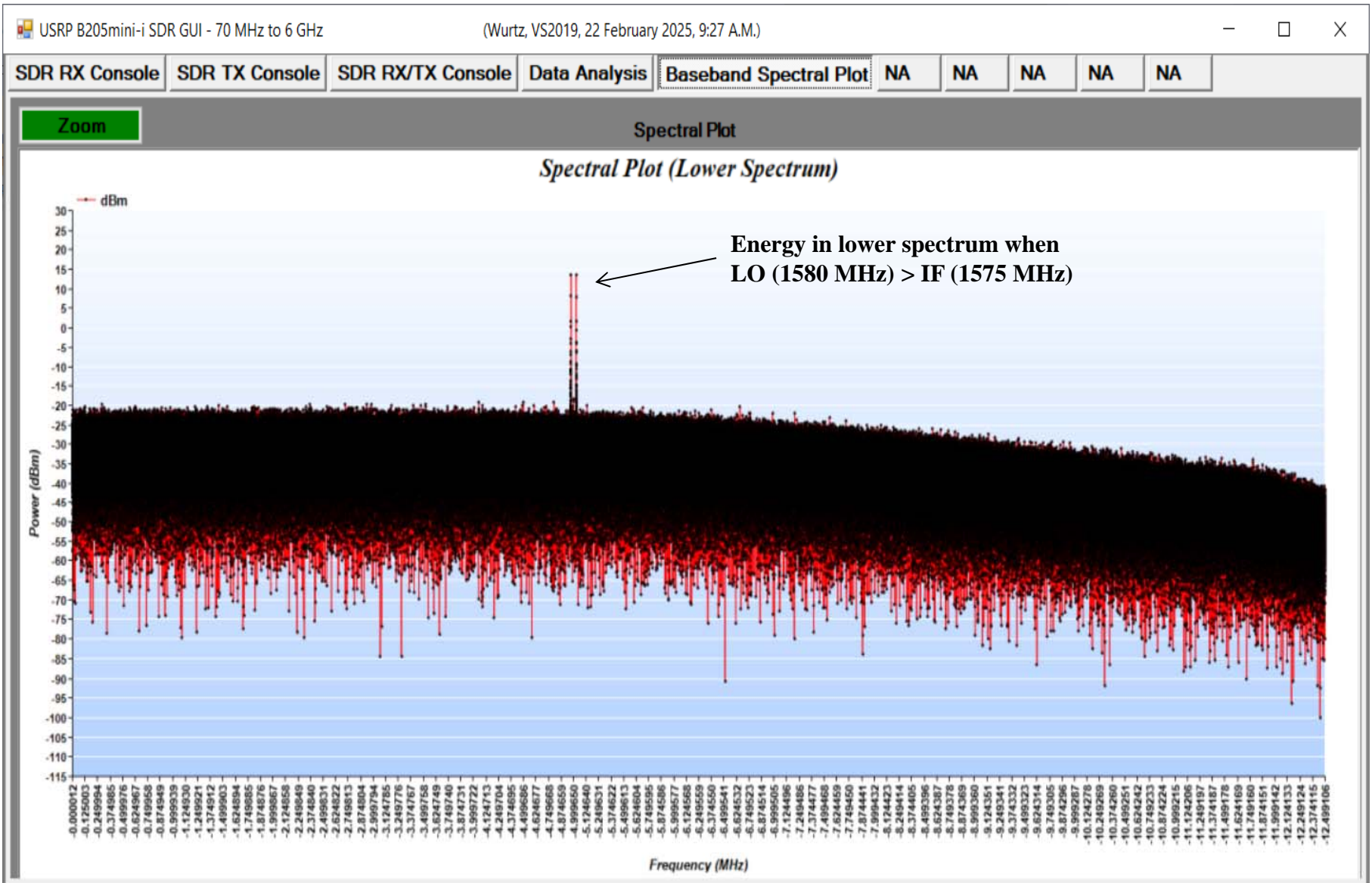
Figure 5. Folded Power Spectral Density Plot from SDR (SDR LO = 1580 MHz)



**Figure 6. Folded Power Spectral Density Plot from SDR (SDR LO = 1580 MHz)
Closer View**



**Figure 7. Power Spectral Density Plot from SDR (SDR LO = 1580 MHz)
Lower Spectrum**



**Figure 8. Power Spectral Density Plot from SDR (SDR LO = 1580 MHz)
Upper Spectrum**

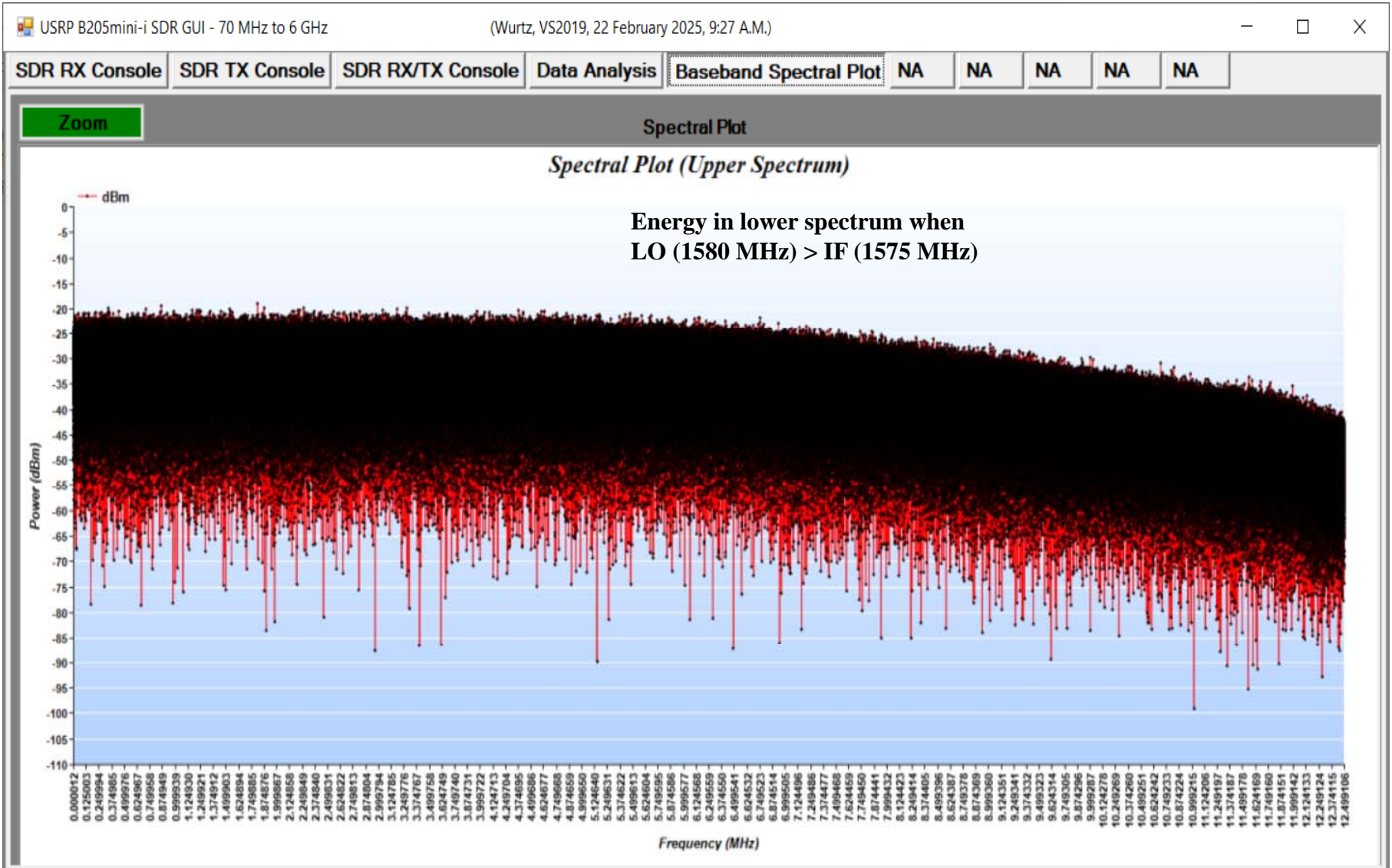
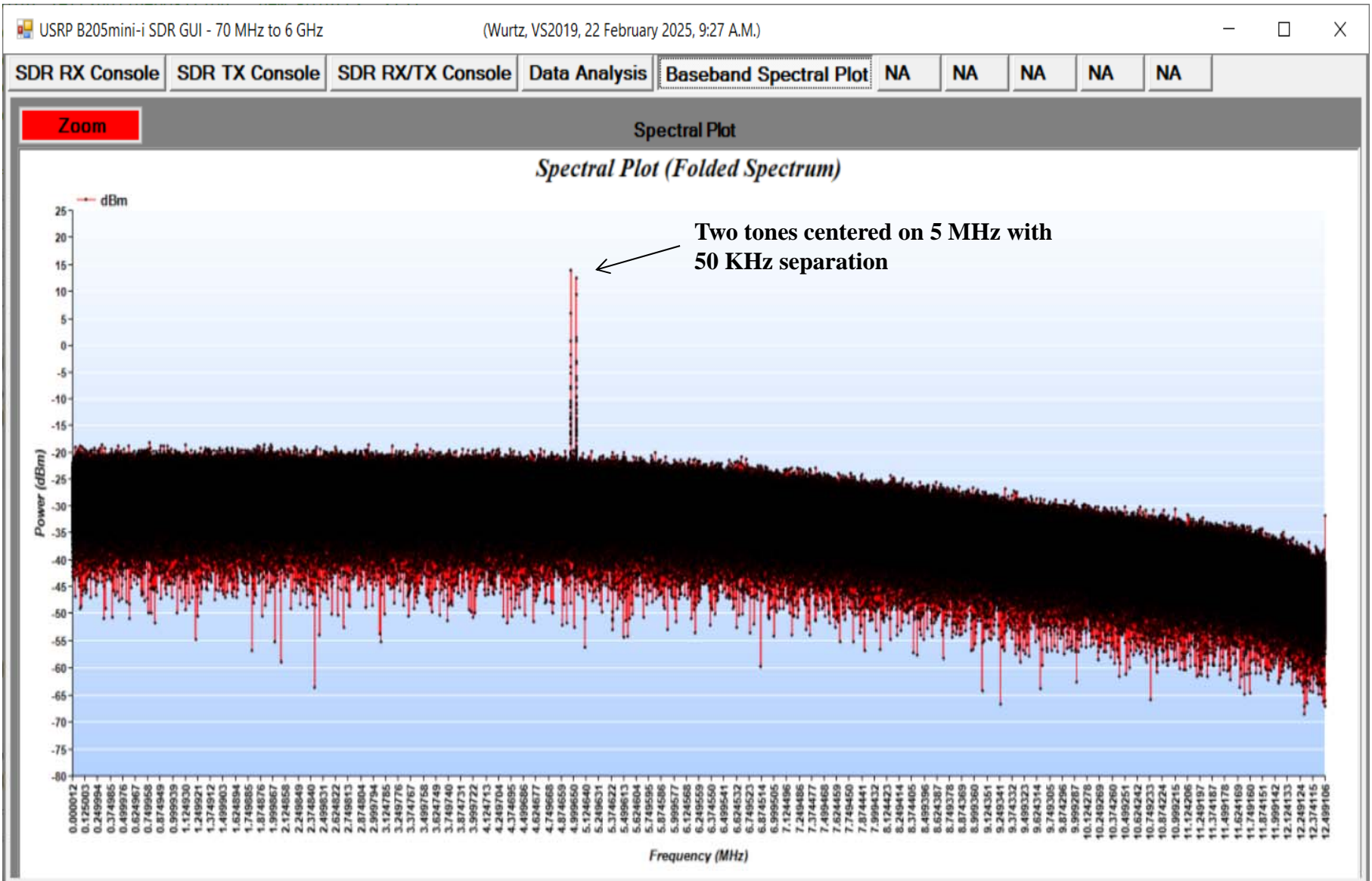
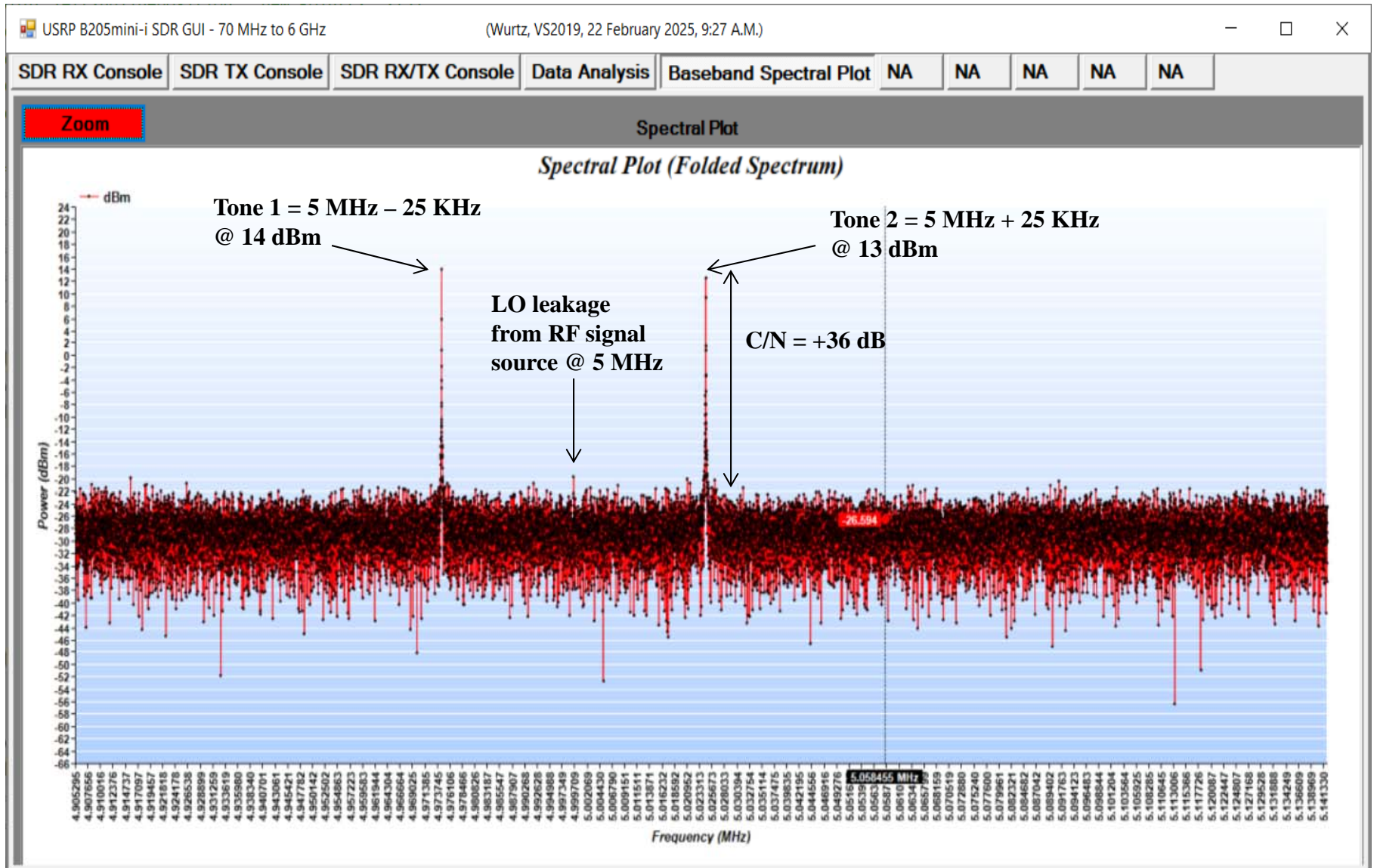


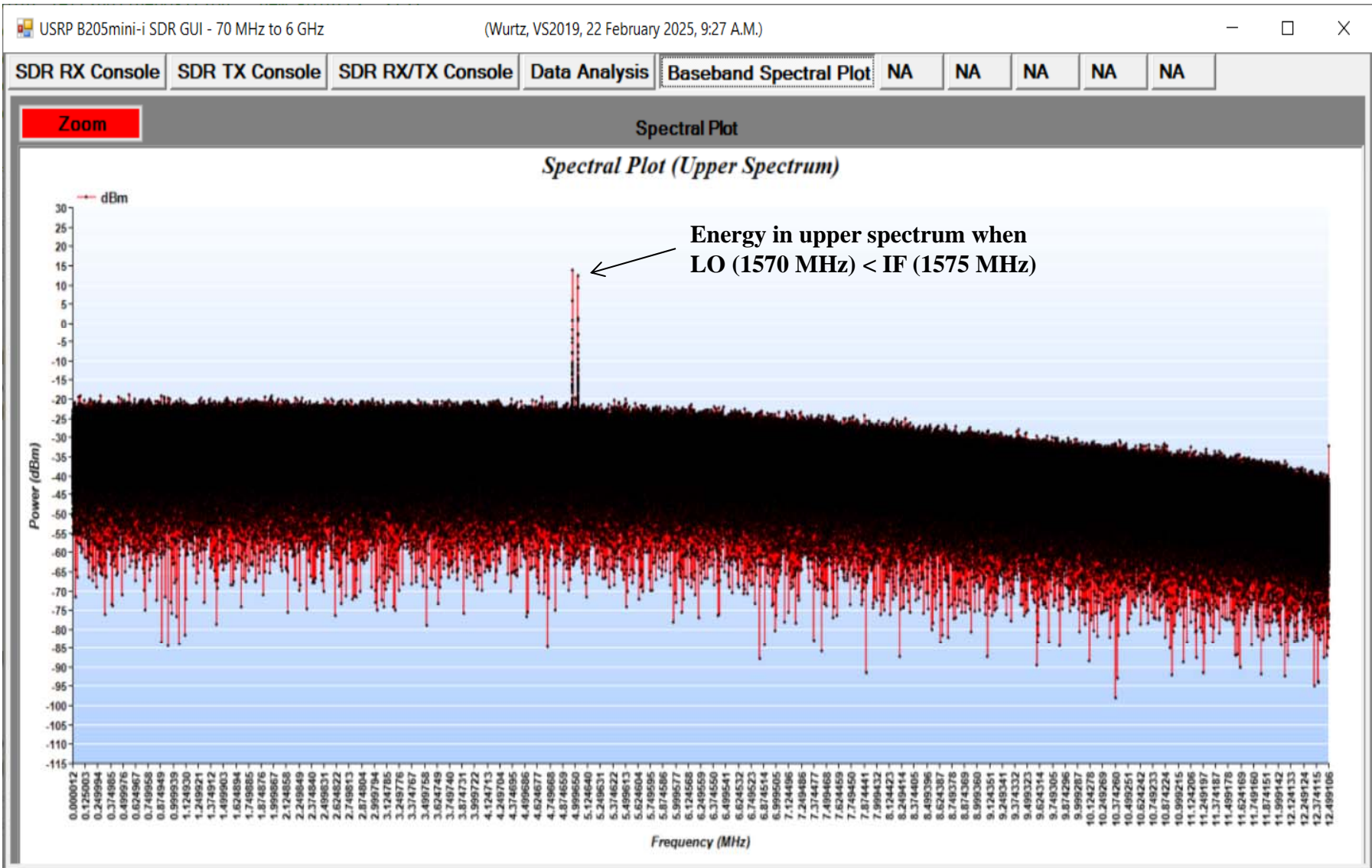
Figure 9. Folded Power Spectral Density Plot from SDR (SDR LO = 1570 MHz)



**Figure 10. Folded Power Spectral Density Plot from SDR (SDR LO = 1570 MHz)
Closer view**



**Figure 11. Power Spectral Density Plot from SDR (SDR LO = 1570 MHz)
Upper Spectrum**



**Figure 12. Power Spectral Density Plot from SDR (SDR LO = 1570 MHz)
Lower Spectrum**

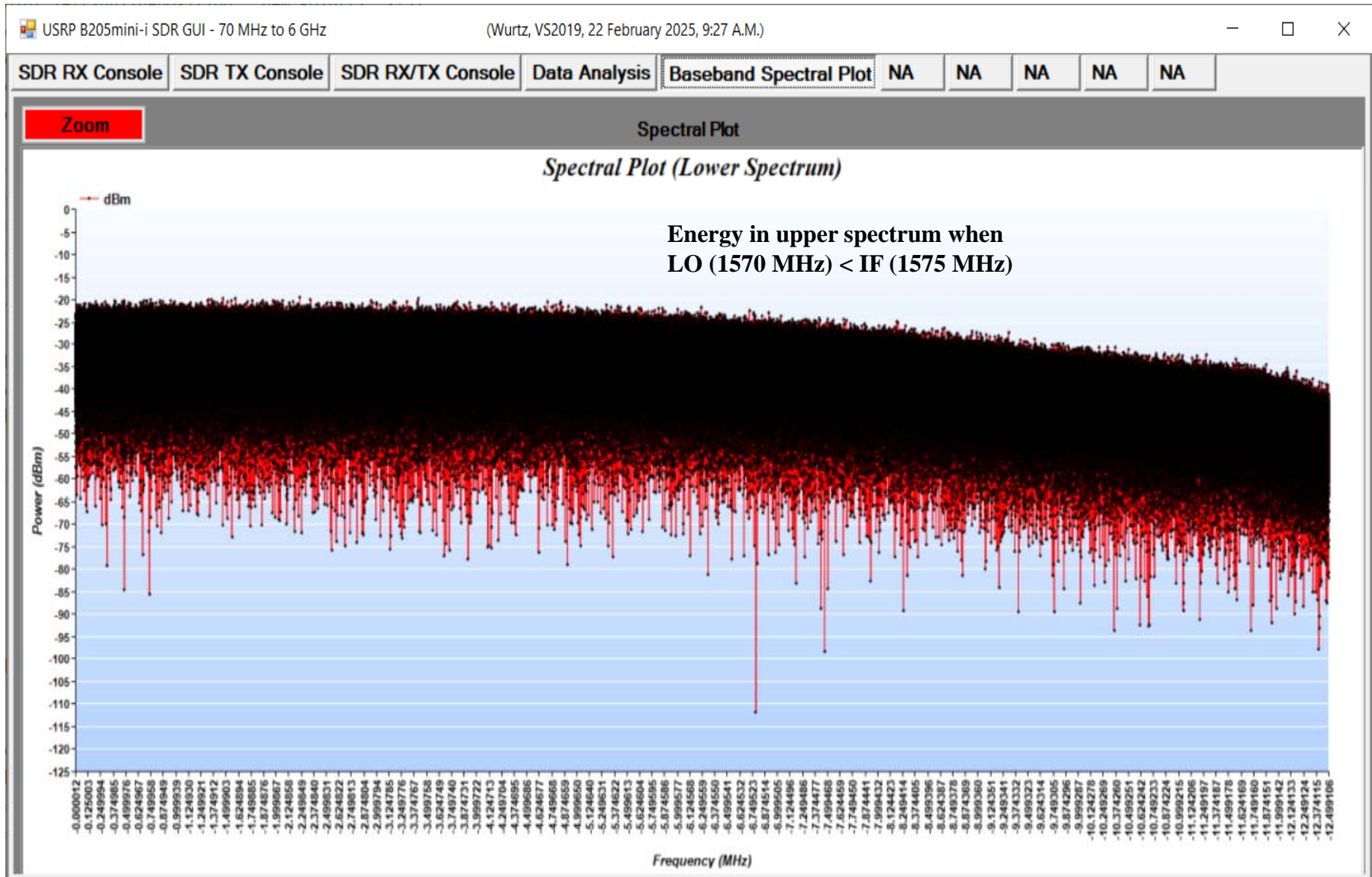


Figure 13. ETTUS USRP B205mini-I GUI Screenshot 1

USRP B205mini-i SDR GUI - 70 MHz to 6 GHz (Wurtz, VS2019, 22 February 2025, 9:27 A.M.)

SDR RX Console | SDR TX Console | SDR RX/TX Console | Data Analysis | Baseband Spectral Plot | NA | NA | NA | NA | NA

Select Output File: G:\Qualis_Files\MMRF_PhaseII_receiver\lx_band_parts\lx_band_test\sc12_sample1_5March2025_253PM.dat

Start SDR | Close GUI

Downconversion Freq (MHz)	1580.00	Front-end Analog Bandwidth (MHz)	12.5
Sample Rate (Mpsps)	25.0	Samples per RX Block	10000
RF Front-end Gain (dB)	50	Record Duration (secs)	10
Output Data Format	sc12	RX Input Selection	

Processing Notes

```

Found Monitor DPI = 96
Number of Logical Processors = 8
List of USB COM Ports
***ERROR*** - SeaLINK+422 USB to RS-422 Converter not found
Selected file G:\Qualis_Files\MMRF_PhaseII_receiver\lx_band_parts\lx_band_test\sc12_sample1_5March2025_253PM.dat RX output.
Entered UHD rx_samples_to_file.exe routine
RX output file = G:\Qualis_Files\MMRF_PhaseII_receiver\lx_band_parts\lx_band_test\sc12_sample1_5March2025_253PM.dat
Downconversion Frequency = 1580 MHz
Sample Rate = 25 Mpsps
Front-end Gain = 50 dB
Output format = sc12
Front-end Analog Bandwidth = 12.5 MHz
Record Duration = 10 Seconds
Samples per Block = 10000

Creating the usrp device with: ...
Using Device: Single USRP:
Device: B-Series Device
Mboard 0: B205mini
RX Channel: 0
RX DSP: 0
RX Dboard: A
RX Subdev: FE-RX1
TX Channel: 0
    
```

Clear Display

Note 1: Gain from 0 to 76 dB
 Note 2: Absolute Max RF Input = +25 dBm
 Note 3: Max RF Input before Comp = -15.0 dBm
 Note 4: Front-end Analog Bandwidth 200 KHz to 56 MHz
 Note 5: 10 MHz @ +10 dBm Ref
 Note 6: < 8 dB Noise Figure




Figure 14. ETTUS USRP B205mini-I GUI Screenshot 2

USRP B205mini-i SDR GUI - 70 MHz to 6 GHz (Wurtz, VS2019, 22 February 2025, 9:27 A.M.)

SDR RX Console | SDR TX Console | SDR RX/TX Console | Data Analysis | Baseband Spectral Plot | NA | NA | NA | NA | NA

Select Output File: G:\Qualis_Files\MMRF_PhaseII_receiver\lx_band_parts\lx_band_test\sc12_sample1_5March2025_253PM.dat

Start SDR | Close GUI

Downconversion Freq (MHz)	1580.00	Front-end Analog Bandwidth (MHz)	12.5
Sample Rate (Mpsps)	25.0	Samples per RX Block	10000
RF Front-end Gain (dB)	50	Record Duration (secs)	10
Output Data Format	sc12	RX Input Selection	

Processing Notes

```

RX Channel: 0
RX DSP: 0
RX Dboard: A
RX Subdev: FE-RX1
TX Channel: 0
TX DSP: 0
TX Dboard: A
TX Subdev: FE-TX1

Setting RX Rate: 25.000000 Mpsps...
Actual RX Rate: 25.000000 Mpsps...

Setting RX Freq: 1580.000000 MHz...
Setting RX LO Offset: 0.000000 MHz...
Actual RX Freq: 1580.000000 MHz...


Setting RX Gain: 50.000000 dB...
Actual RX Gain: 50.000000 dB...

Setting RX Bandwidth: 12.500000 MHz...
Actual RX Bandwidth: 12.500000 MHz...

Locking LO on channel 0
Waiting for "lo_locked": ++++++ locked.
    
```

Clear Display

Note 1: Gain from 0 to 76 dB
 Note 2: Absolute Max RF Input = +25 dBm
 Note 3: Max RF Input before Comp = -15.0 dBm
 Note 4: Front-end Analog Bandwidth 200 KHz to 56 MHz
 Note 5: 10 MHz @ +10 dBm Ref
 Note 6: < 8 dB Noise Figure



**Figure 15. ETTUS USRP B205mini-I GUI
Screenshot 3**

The screenshot shows the ETTUS USRP B205mini-I SDR GUI with the following configuration and log data:

Parameter	Value
Downconversion Freq (MHz)	1580.00
Sample Rate (Mpsps)	25.0
RF Front-end Gain (dB)	50
Output Data Format	sc12
Front-end Analog Bandwidth (MHz)	12.5
Samples per RX Block	10000
Record Duration (secs)	10
RX Input Selection	[Dropdown]

Processing Notes:

```

Actual RX Bandwidth: 12.500000 MHz...
Locking LO on channel 0
Waiting for "lo_locked": ++++++ locked.
Press Ctrl + C to stop streaming...
25.0071 Mpsps
24.9995 Mpsps
25.002 Mpsps
24.9985 Mpsps
24.6098 Mpsps
24.9996 Mpsps
24.9999 Mpsps
25.0003 Mpsps
25.0015 Mpsps
Received 249611979 samples in 10.000158 seconds
Done!
UHD rx_samples_to_file.exe completed
Sample Rate = 25 Mpsps
Sample Rate = 25 Mpsps
Sample Rate = 25 Mpsps
Sample Rate = 25 Mpsps
  
```

Notes:

- Note 1: Gain from 0 to 76 dB
- Note 2: Absolute Max RF Input = +25 dBm
- Note 3: Max RF Input before Comp = -15.0 dBm
- Note 4: Front-end Analog Bandwidth 200 kHz to 56 MHz
- Note 5: 10 MHz @ +10 dBm Ref
- Note 6: < 8 dB Noise Figure

Log Analysis: An arrow points to the log entries "24.9985 Mpsps" and "24.6098 Mpsps" with the text "Actual transfer rate in 1 second increments".

Hardware Image: A photograph of the ETTUS USRP B205mini-I SDR hardware is shown in the bottom right corner, featuring three SMA connectors labeled TRX, RXZ, and REF, and a USB 3.0 port.