

**General Purpose Superheterodyne Phase Coherent Ka-Band Receiver
based on the ADMV1014 Downconverter and ETTUS USRP B205mini-I SDR**

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- 1. Superheterodyne Phase Coherent Ka-Band Receiver with Image rejection and IF = 1575 MHz.**
- 2. Bandwidth = 26.5 GHz to 40 GHz.**
- 3. Figure 1 shows a block diagram of the Ka-band receiver.**
- 4. Figure 2 shows a 2-tone RF signal input with 50 KHz separation on a 29 GHz carrier at -115 dBm. The intent of this measurement was to determine the receiver sensitivity.**
- 5. Figure 3 shows the SDR IF input from the ADMV1014 downconverter.**
- 6. Figure 4 shows an output spectral density plot from the SDR with gain = 50, sample rate = 25 Msps, SC12 data format, and low-pass filter set to 12.5 MHz.**
- 7. Figure 5 shows an expanded view of Figure 4 with two-tone response and LO leakage from the RF signal source. Receiver sensitivity is < -115 dBm with C/N >= 32 dB.**
- 8. Figure 6 shows the ADMV1014 downconverter GUI settings with register map shown in Figure 7.**
- 9. Figures 8, 9, and 10 show a custom GUI controlling the SDR. Specifically, SDR gain = 50, downconversion frequency = 1580 MHz, data capture is in the “SC12” mode, sample rate = 25 Msps with low-pass bandwidth = 12.5 MHz.**

Continued Notes

10. **Figure 11 shows a schematic of the ETTUS USRP B205mini-I SDR.**
11. **Figure 12 shows IF Input to SDR with 2 Tone RF Input separated by 50 KHz centered on 29 GHz @ -55 dBm per Tone. This measurement shows the performance with what is considered the maximum RF input. Also shown are the 1st order intermodulation distortion spurs.**
12. **Figure 13 shows the SDR Output Power Spectral Density Plot with 2 Tone RF input separated by 50 KHz centered on 29 GHz @ -55 dBm per Tone.**
13. **Figure 14 shows an expanded view of Figure 13 with 2 tone response, LO leakage from the RF signal source, and 1st order IMD spurs.**
14. **Receiver RF input dynamic range is a conservative 60 dB with lowest RF input sensitivity < -115 dBm and C/N = 32 dB. The maximum signal is considered to be -55 dBm. With a Millimeter Wave 18 inch Ka-band cassegrain parabolic dish antenna, the lowest sensitivity extends down to < -154 dBm. By inserting an attenuator between the ADMV1014 downconverter RF input and LNA, the maximum RF signal can be increased to ~ -49 dBm.**

Figure 1. Ka-Band Receiver Block Diagram

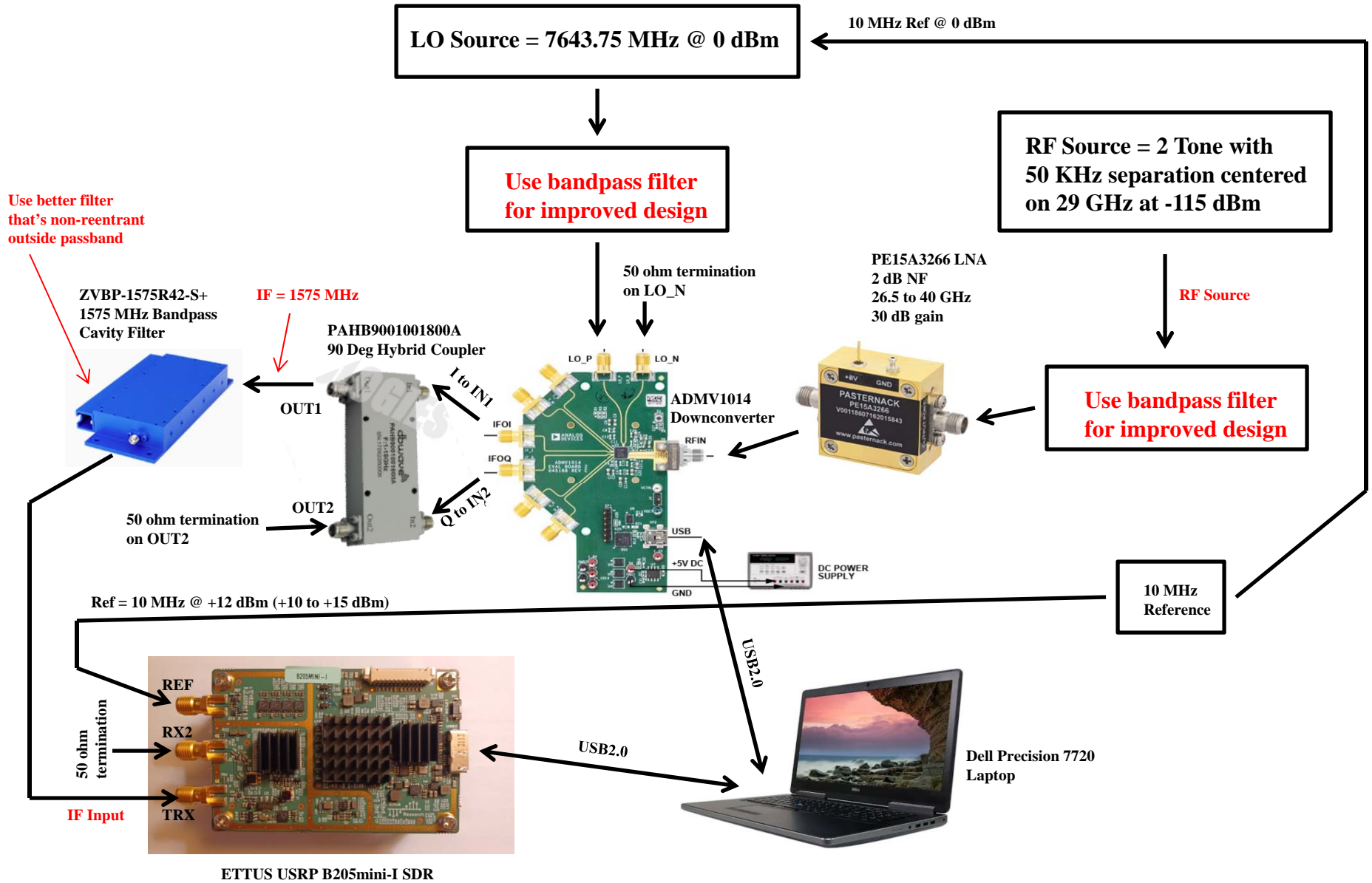
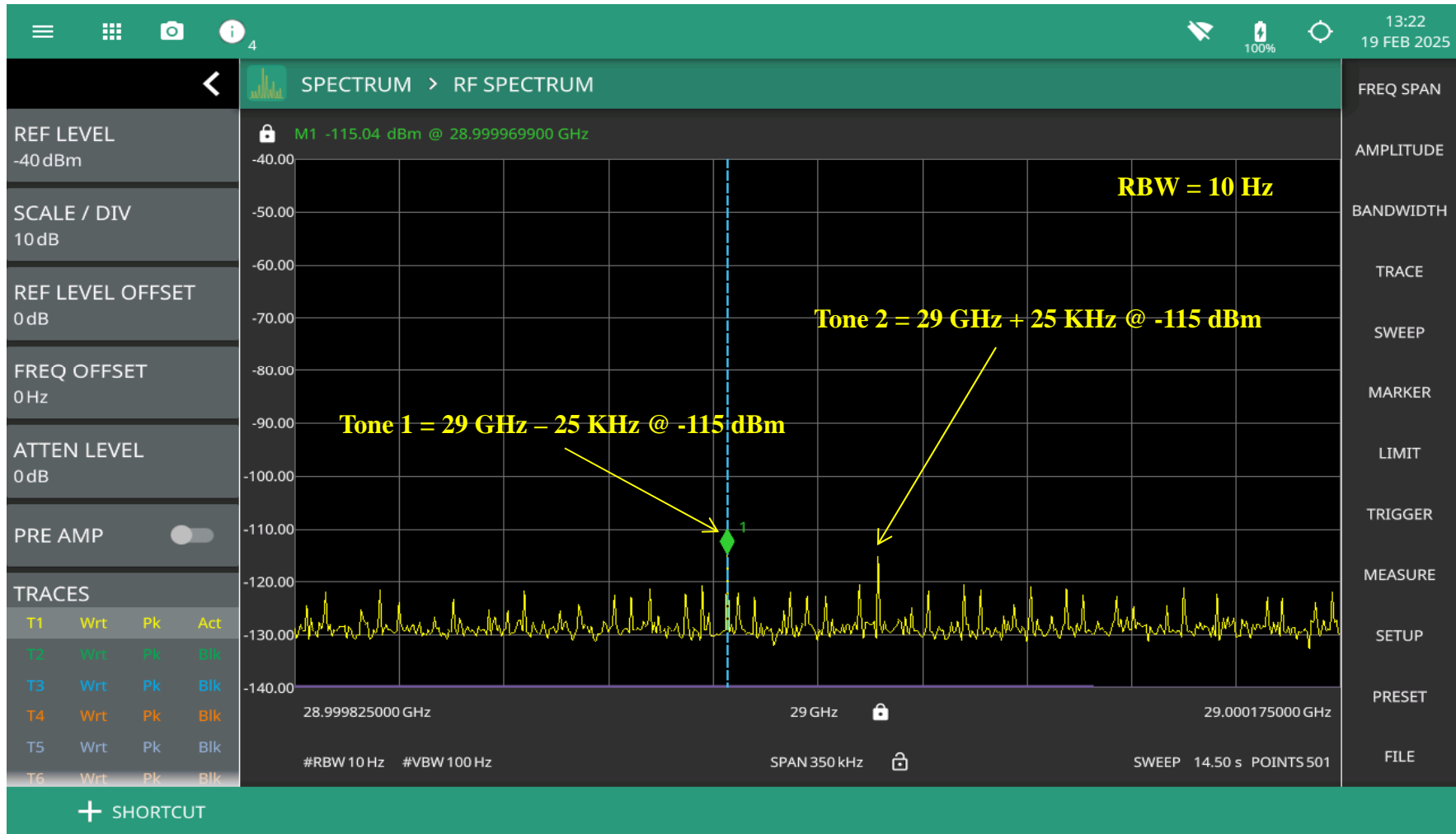
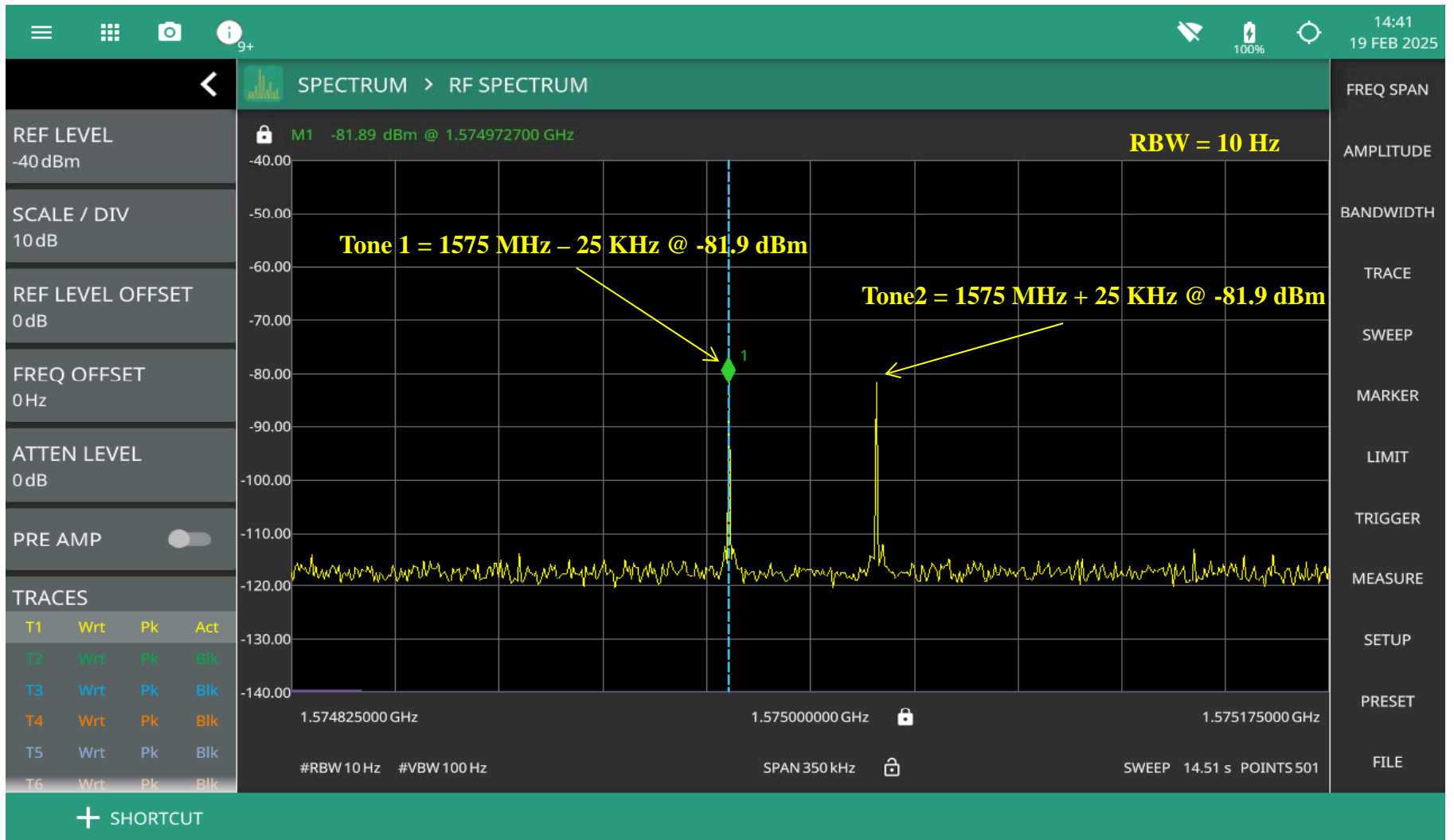


Figure 2. 2-Tone RF Input



Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
Options: 0031,0104,0124,0125,0128,0199,0743
Date/Time: 19 Feb 2025 13:23:29 CST GPS: ---

Figure 3. IF to SDR



Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
Options: 0031,0104,0124,0125,0128,0199,0743
Date/Time: 19 Feb 2025 14:42:19 CST GPS: ---

Figure 4. SDR Output Power Spectral Density Plot

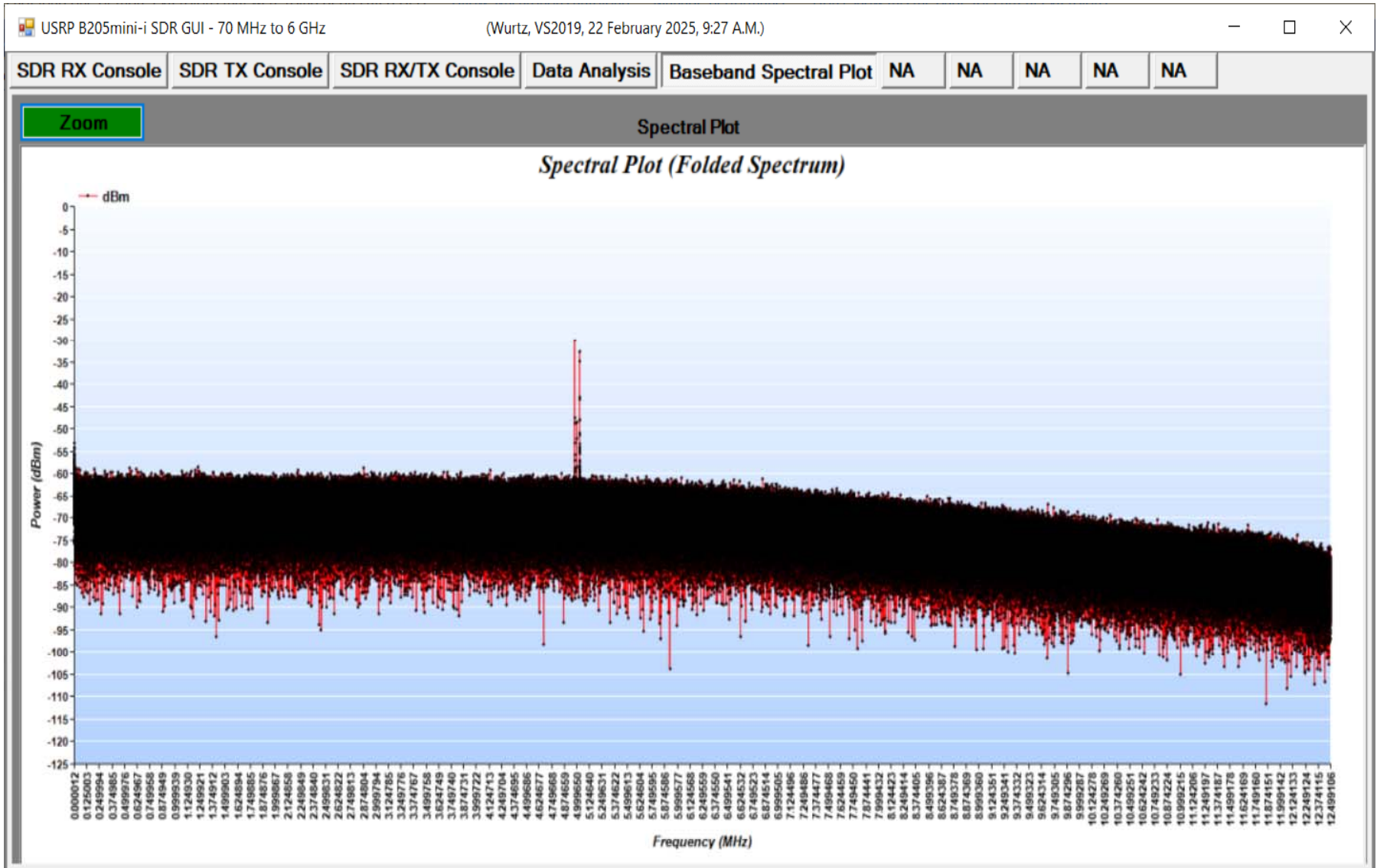


Figure 5. SDR Output Spectral Density Plot (Expanded View)

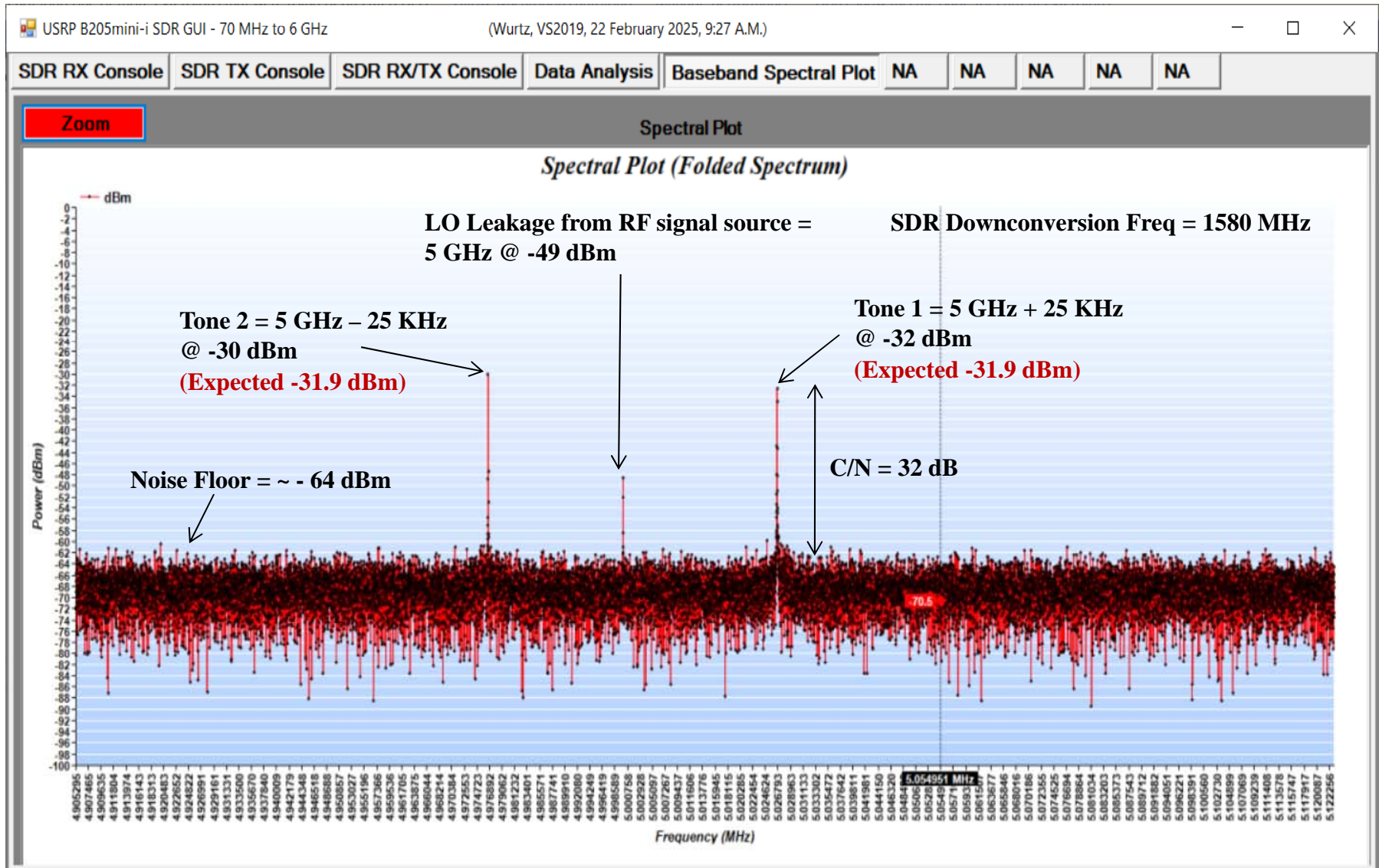


Figure 6. ADMV1014 Downconverter GUI from Analog Devices

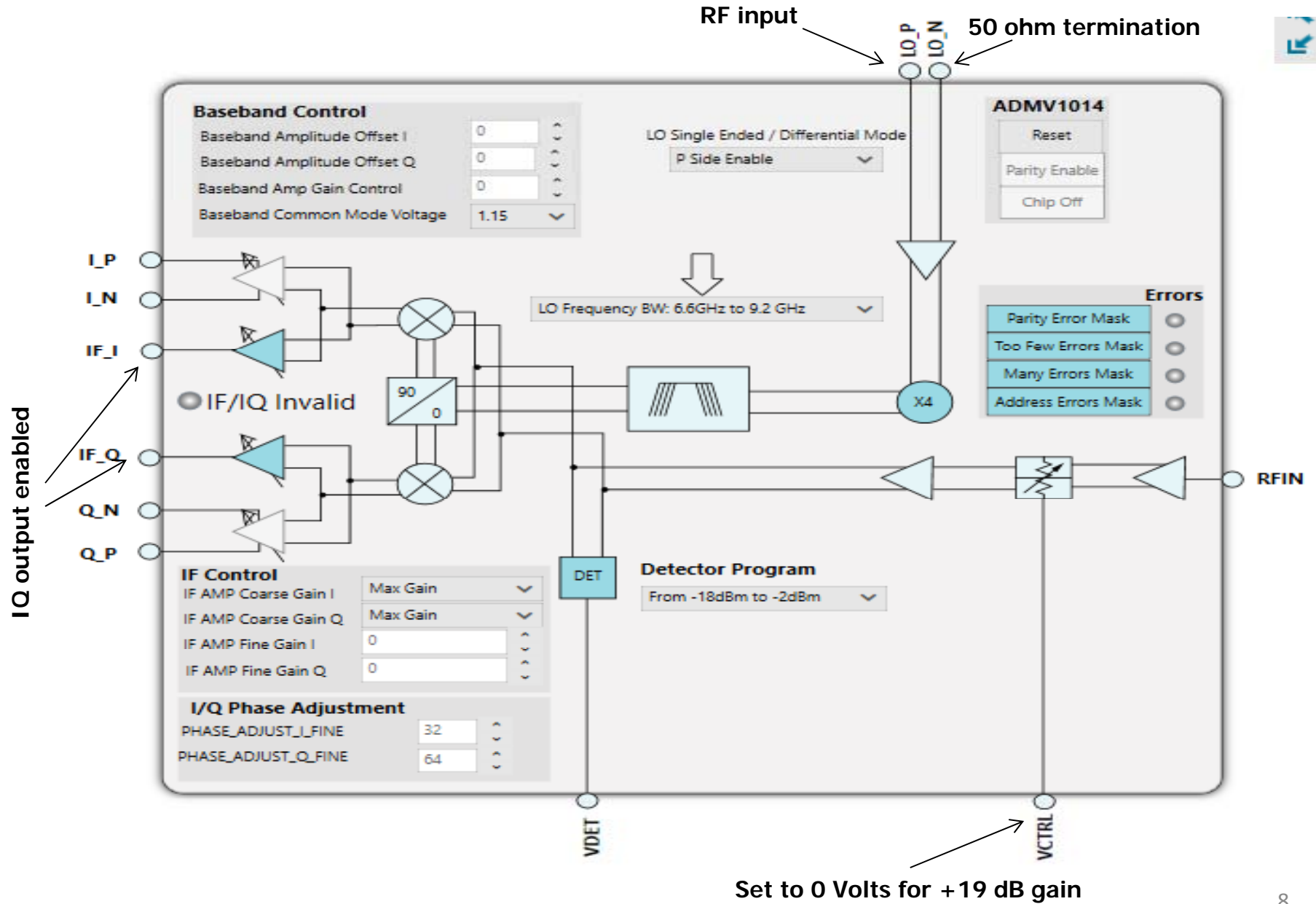


Figure 7. ADMV1014 Downconverter Register Map

Start X Plug-in Manager X System X ADMV1014-045188 RevA X AD5601 X ADMV1014 X ADMV1014 Memory Map X

Apply Changes Apply Selected Read All Read Selected Reset Chip Diff Software Defaults Export Import Chip View Side-By-Side Show Bitfields

Registers

🔍

Address (Hex)	Name	Reg	Side Effects	Modified	Data (Hex)	Data (Binary)
+ 0000	SPI_Control	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	0093	0 0 0 0 0 0 0 0 1 0 0 1 0 0 1 1
+ 0001	Alarm	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	0000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
+ 0002	Alarm_masks	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	FFFF	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
+ 0003	Enable	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	3157	0 0 1 1 0 0 0 1 0 1 0 1 0 1 1 1
+ 0004	Quad	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	5645	0 1 0 1 0 1 1 0 0 1 0 0 0 1 0 1
+ 0005	LO_Amp_Phase_Adjust1	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	4101	0 1 0 0 0 0 0 1 0 0 0 0 0 0 0 1
+ 0007	Mixer	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	D840	1 1 0 1 1 0 0 0 0 1 0 0 0 0 0 0
+ 0008	IF_AMP	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	0000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
+ 0009	IF_AMP_BB_AMP	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	0000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
+ 000A	BB_AMP_AGC	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	2391	0 0 1 0 0 0 1 1 1 0 0 1 0 0 0 1
+ 000B	VVA_TEMP_COMP	RegMap'	<input type="checkbox"/>	<input type="checkbox"/>	727C	0 1 1 1 0 0 1 0 0 1 1 1 1 1 0 0

Figure 8. B205mini-I SDR GUI Screenshot 1

USRP B205mini-i SDR GUI - 70 MHz to 6 GHz (Wurtz, VS2019, 17 July 2024, 9:26 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: D:\sc12_sample10_19Feb2025_252PM.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 D:\sc12_sample10_19Feb2025_252PM.dat RX output.
 Entered UHD rx_samples_to_file.exe routine
 RX output file = D:\sc12_sample10_19Feb2025_252PM.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 = -150 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 9. B205mini-I SDR GUI Screenshot 2

USRP B205mini-i SDR GUI - 70 MHz to 6 GHz (Wurtz, VS2019, 17 July 2024, 9:26 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: D:\sc12_sample10_19Feb2025_252PM.dat

Start SDR

Close GUI

Downconversion Freq (MHz)	1580.00	Front-end Analog Bandwidth (MHz)	12.5
Sample Rate (MSPS)	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

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
 TX DSP: 0
 TX Dboard: A
 TX Subdev: FE-TX1

Setting RX Rate: 25.000000 MspS...
 Actual RX Rate: 25.000000 MspS...

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...

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 = -150 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 10. B205mini-I SDR GUI Screenshot 3

USRP B205mini-i SDR GUI - 70 MHz to 6 GHz (Wurtz, VS2019, 17 July 2024, 9:26 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: D:\sc12_sample10_19Feb2025_252PM.dat

Start SDR | Close GUI

Downconversion Freq (MHz)	1580.00	Front-end Analog Bandwidth (MHz)	12.5
Sample Rate (Msps)	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

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.

Press Ctrl + C to stop streaming...

24.539 Msps
25 Msps
24.9842 Msps
24.7187 Msps
24.6504 Msps
24.9987 Msps
24.9997 Msps
22.2662 Msps
24.9973 Msps

Received 246149015 samples in 10.000259 seconds

Done!

UHD rx_samples_to_file.exe completed
Sample Rate = 25 Msps

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 = -150 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


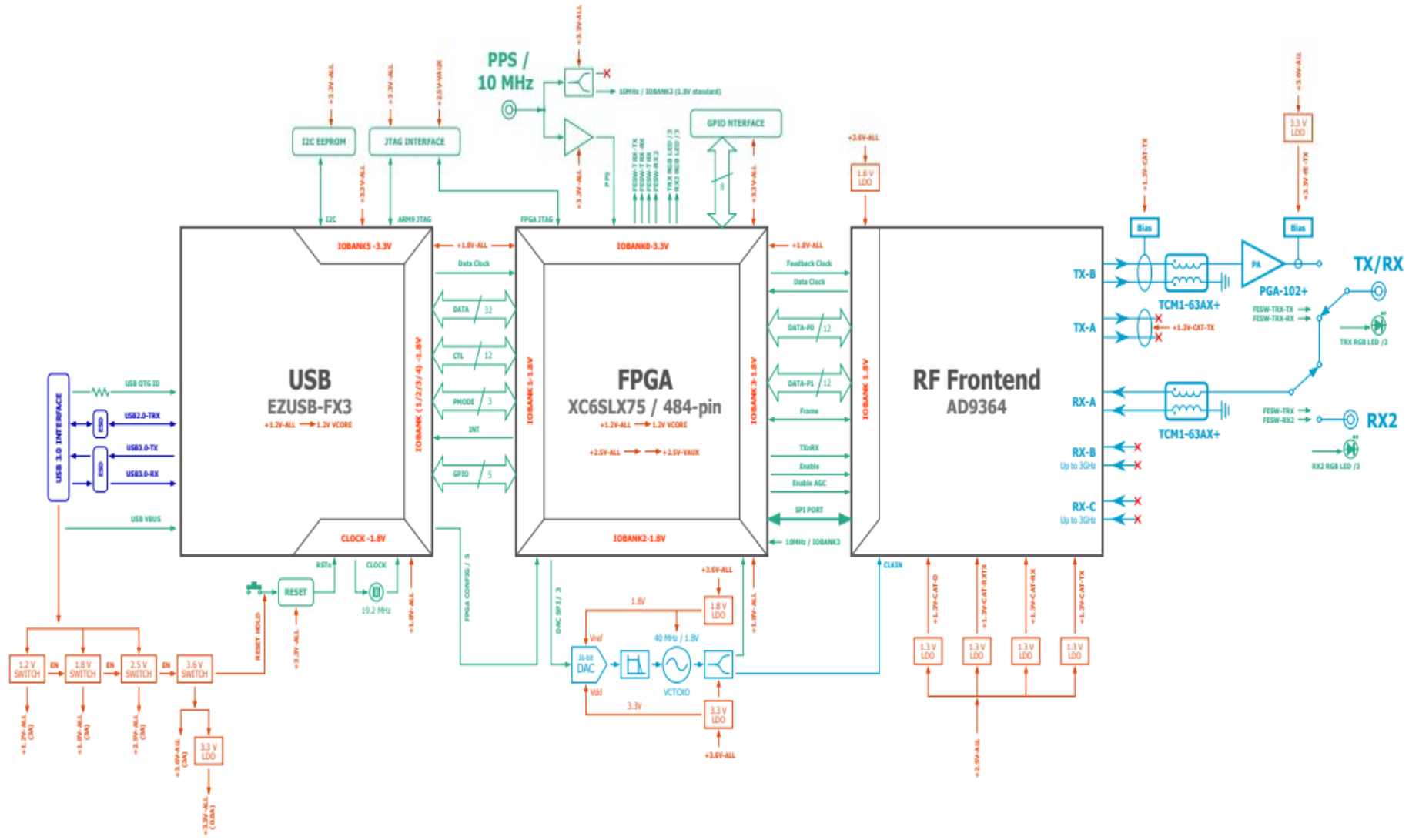
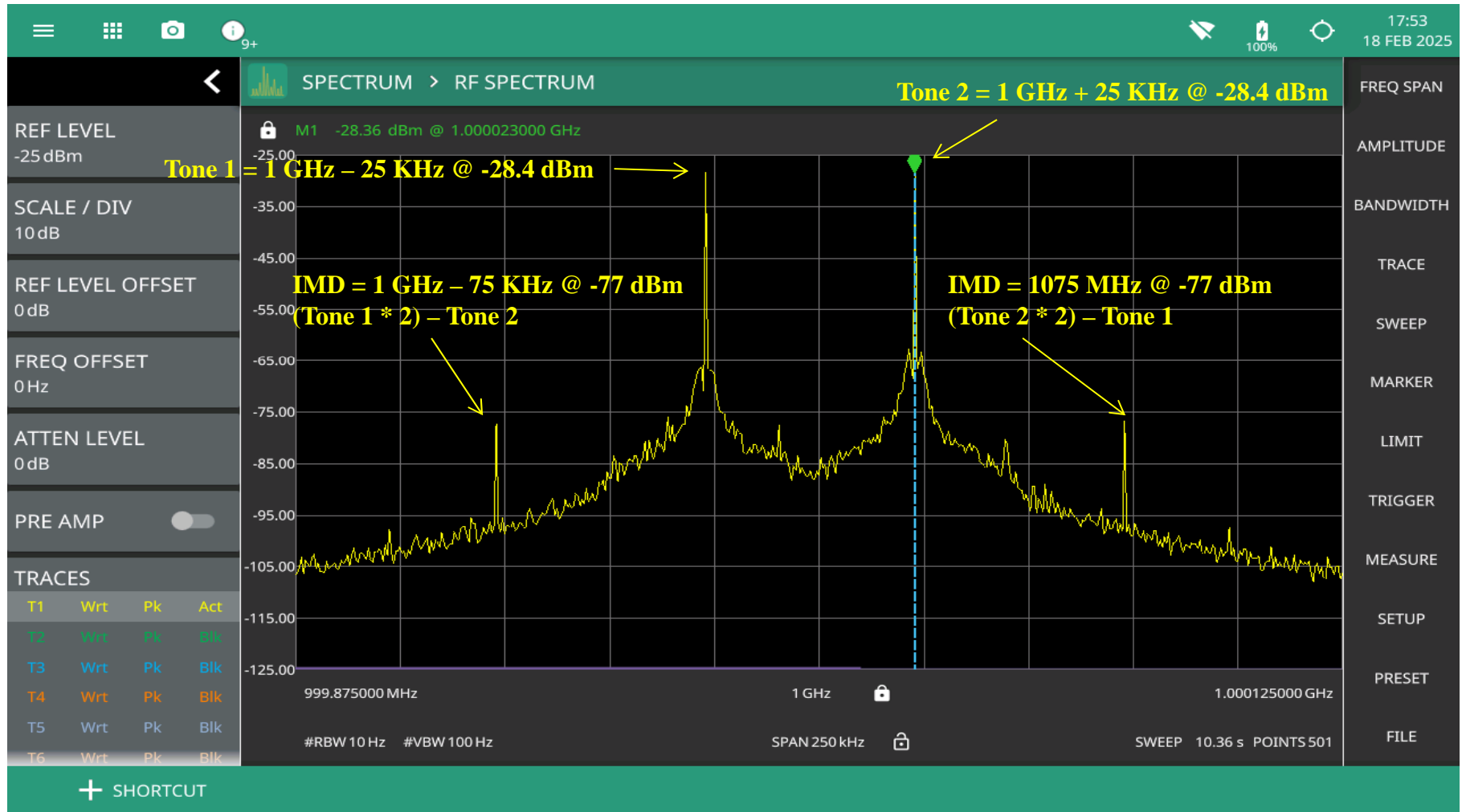


Figure 11. ETTUS USRP B205mini-I Schematic



**Figure 12. IF Input to SDR with
2 Tone RF Input separated by 50 KHz centered on 29 GHz @ -55 dBm per Tone**



Anritsu MS2090A SN: 2303019 SW Package: V2023.3.1
 Options: 0031,0104,0124,0125,0128,0199,0743
 Date/Time: 18 Feb 2025 17:54:40 CST GPS: ---

Figure 13. SDR Output Power Spectral Density Plot with 2 Tone RF input separated by 50 KHz centered on 29 GHz @ -55 dBm per Tone

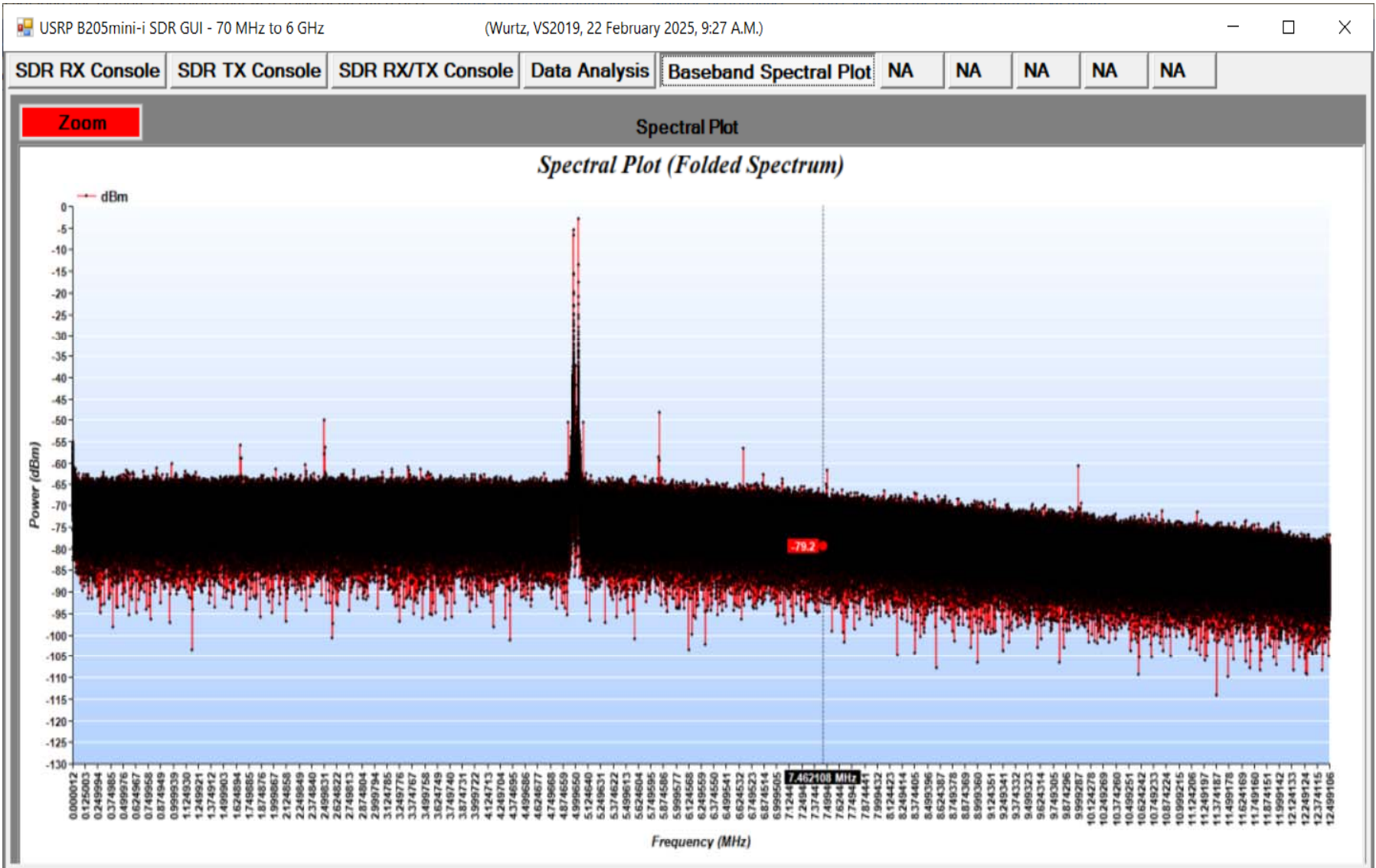


Figure 14. Expanded View of Figure 13

