

Chapter 1

Appendices

1.1 Appendix G - Technical details on jammer equipment

1.1.1 Introduction

The following section provides technical details on the jammer equipment used in the experiments. The jammers are categorized according to the following scheme:

1st Letter (Norwegian / English)	1St digit	2nd digit
S = Sigarett / Cigarette		
H = Håndholdt / Handheld		
U = USB / USB stick		
F = Fastmontert / Permanently installed (Fixed)	Number of antennas	# jammer within same category

Exempli gratia: S1.2, is a cigarette type jammer, that has 1 antenna, and is unit nr.2 in this category.

Additional information:

- Each chapter gives an overview of each jammer brought to Jammertest.
As far as possible, it gives information on
 - Centre frequency [MHz]
 - Bandwidth [MHz]
 - Power Spectral Density (PSD) [dBm/MHz] for the entire bandwidth
 - Total output power (TX total) [dBm] for the entire bandwidth
 - CF max [dBm] (maxhold power at the centre frequency)
 - Sweep rate [μ s] (if applicable)
 - Modulation
- Indicators such as “L1, L2, L5” etc. are used to indicate main bands of attack, used for convenience to distinguish between jammers’ modus operandi

- 2023 measurements

- Technical details on low power jammers given in this appendix are from uncalibrated measurements. They are rough estimates given for both the frequency and time domain. Power levels are not correctly displayed on the chart, because of external attenuators used during measurements with a signal analyser. There may also have been some constraints in the measurement device, causing fast frequency components to not be correctly displayed.

- 2024 measurements

- Measurements done with a R&S FSW. All measurements were performed connected directly to the jammers' antenna port, with the other antennas disconnected and (if applicable) DIP switches for the other antenna ports disabled. Powe levels etc. should be as close to reality as possible for output power at the antenna port.
- Throughout the measurements, bandwidth is defined as 3 dB from local (identifiable) maxima along the maxhold's descent.
- TX power is measured within said bandwidth. Note that TX total is measured over the entire bandwidth, so that peak output power is not equal to TX total.

1.1.2 Technical details on low-power jammer 'S1.1'



The jammer S1.1 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S1.1 is an one-antenna, so-called 'L1-only', jammer, disrupting only the upper L-band.

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Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
1577.40	29.96	7.58	22.34	7.89	37.1	Sawtooth

Table 1.1: Technical characteristics of S1.1 jammer

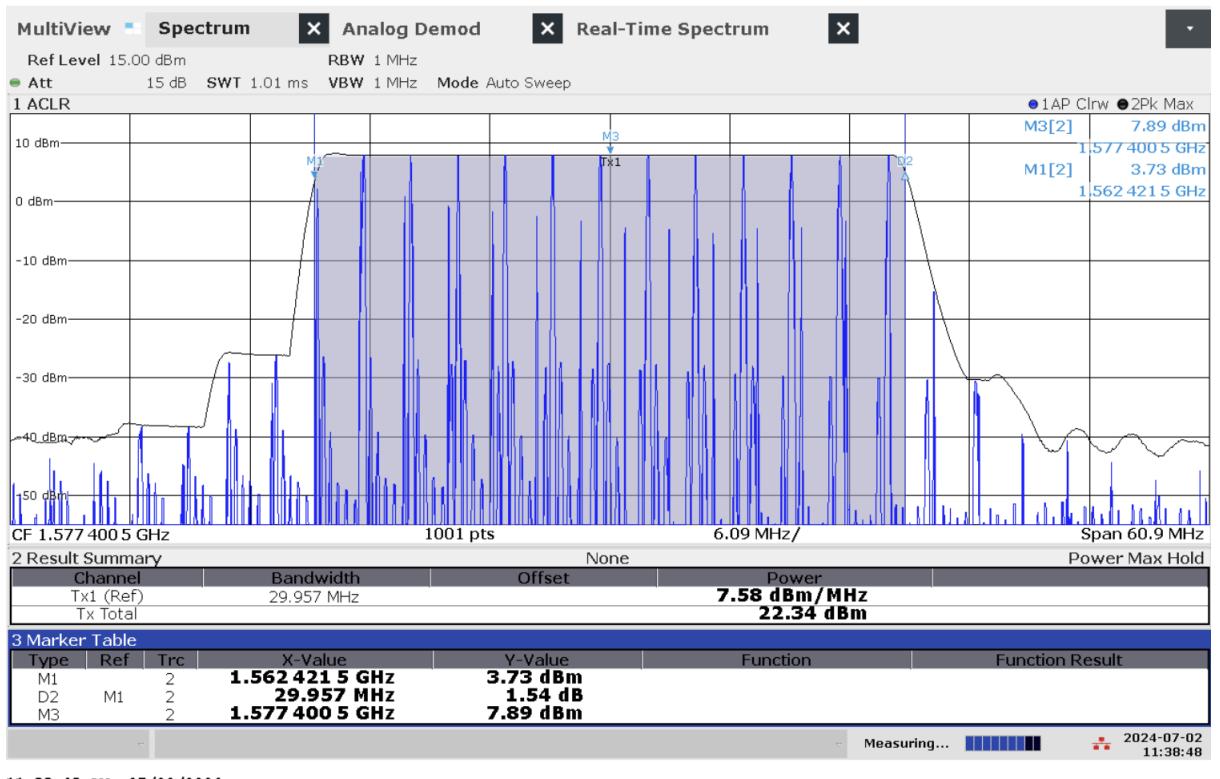


Figure 1.1: Frequency and power measurement of jammer S1.1

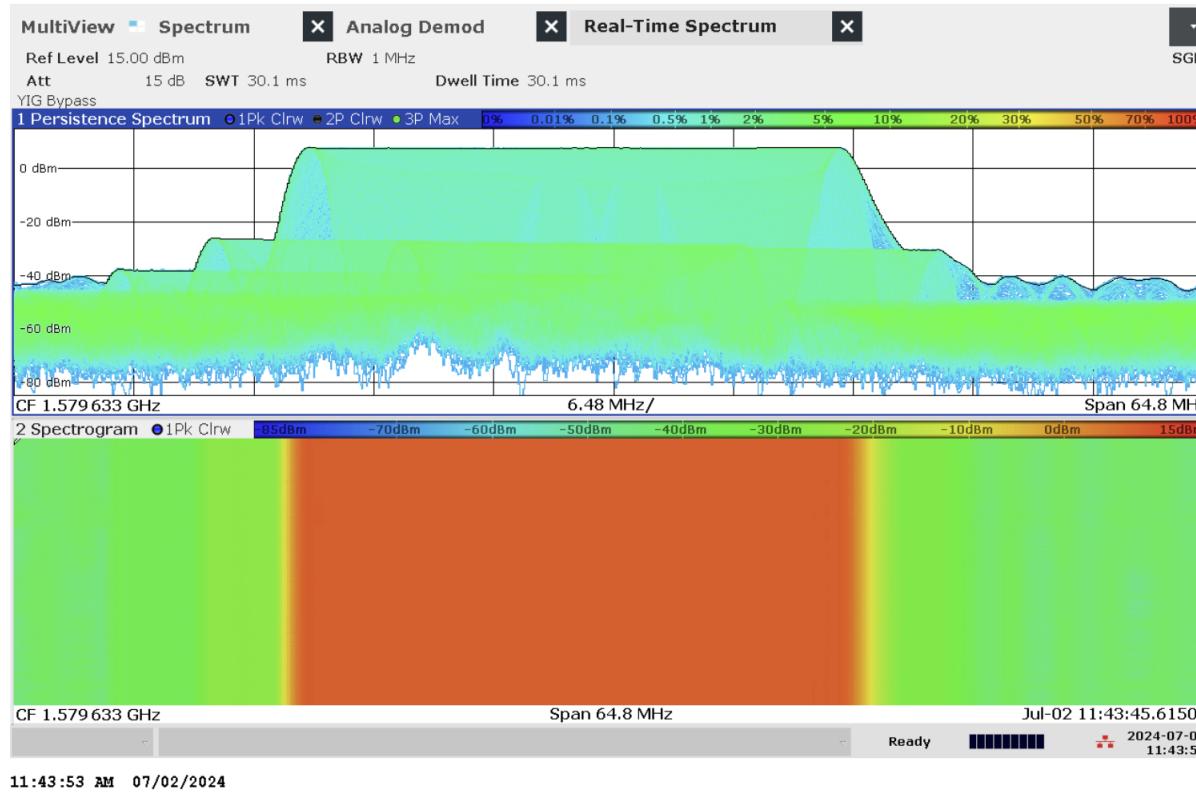


Figure 1.2: Real-time persistence and spectrogram measurement of jammer S1.1

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Figure 1.3: Time domain (analog demod) measurement of jammer S1.1

1.1.3 Technical details on low-power jammer 'S1.2'



The jammer S1.2 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are

intended to cover the car, and a given radius around the car.

S1.2 is an one-antenna, so-called 'L1-only', jammer, disrupting only the upper L-band.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
1582.56	40.03	12.38	29.01	12.61	21.56	Sawtooth

Table 1.2: Technical characteristics of S1.2 jammer

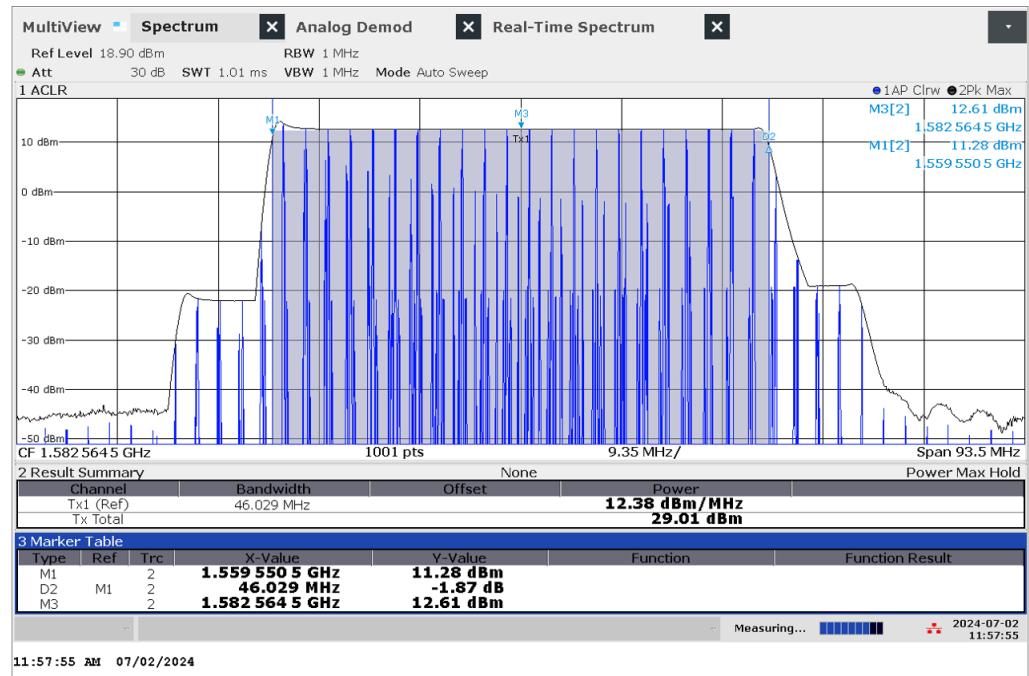


Figure 1.4: Frequency and power measurement of jammer S1.2

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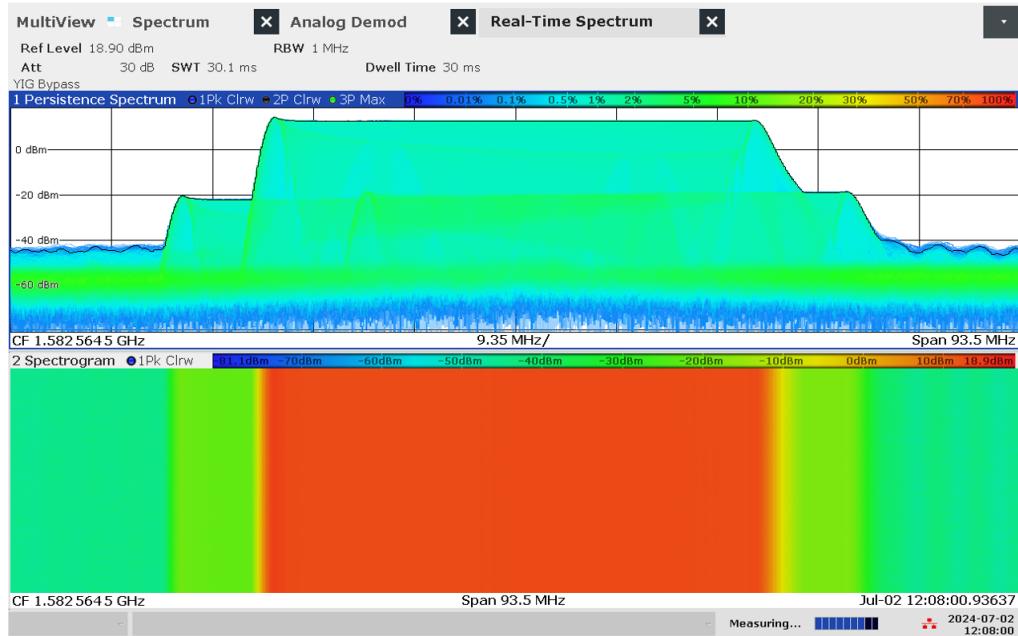


Figure 1.5: Real-time persistence and spectrogram measurement of jammer S1.2

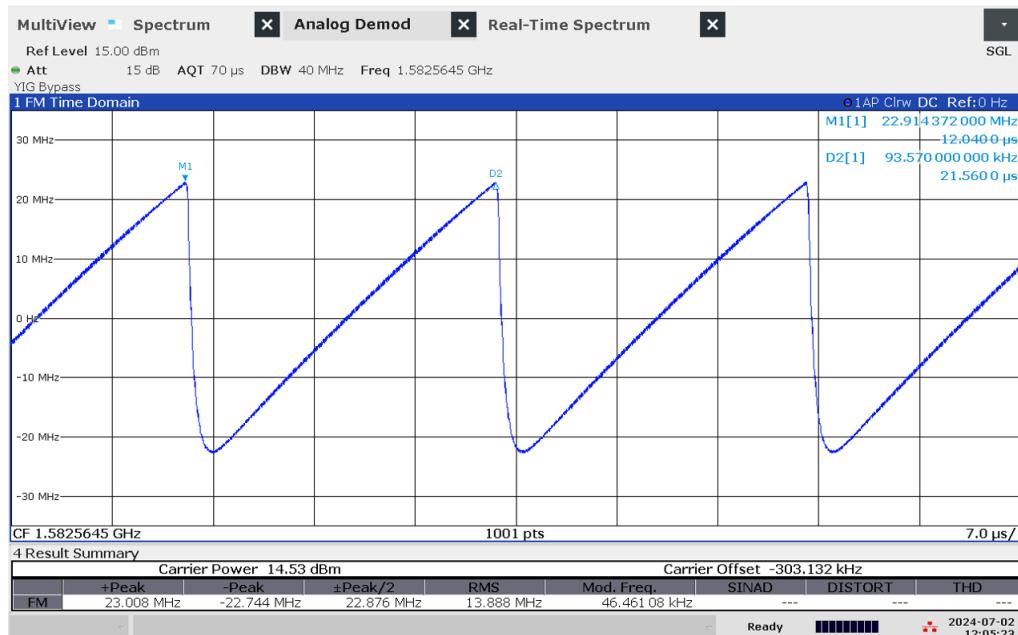


Figure 1.6: Time domain (analog demod) measurement of jammer S1.2

1.1.4 Technical details on low-power jammer 'S1.3'



The jammer S1.3 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car. S1.3 is an one-antenna, so-called 'L1-only', jammer, disrupting only the upper L-band.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
1579.63	31.88	7.56	22.60	7.93	37.5	Sawtooth

Table 1.3: Technical characteristics of S1.3 jammer

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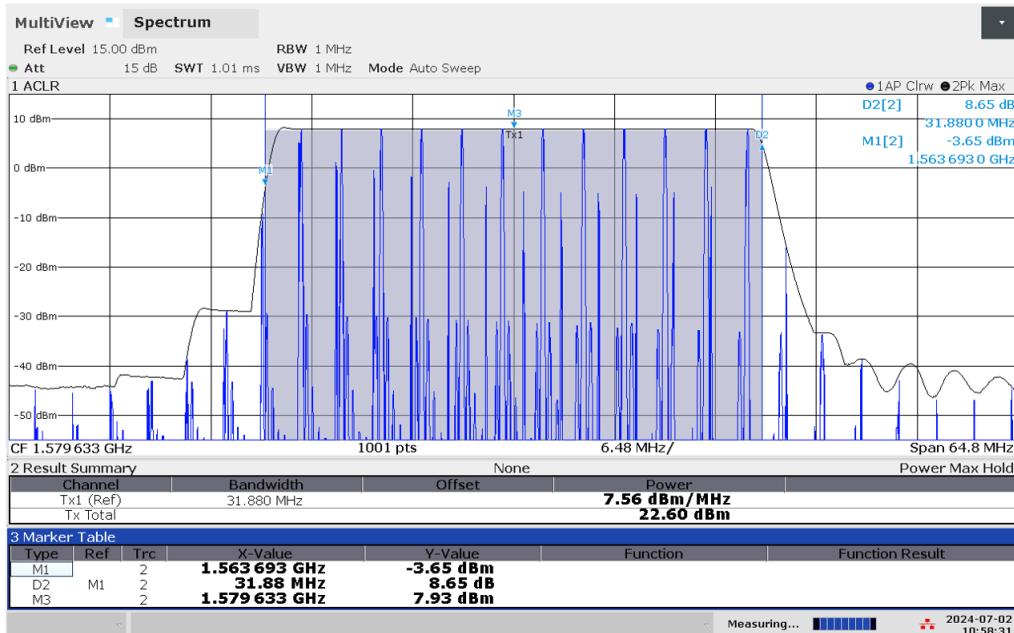


Figure 1.7: Frequency and power measurement of jammer S1.3

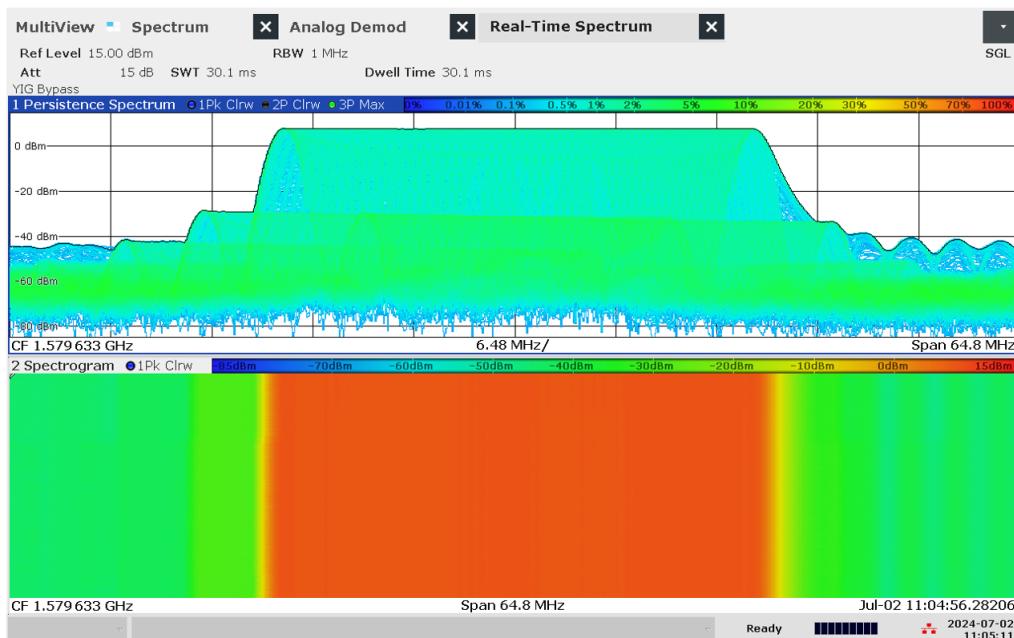


Figure 1.8: Real-time persistence and spectrogram measurement of jammer S1.3



Figure 1.9: Time domain (analog demod) measurement of jammer S1.3

1.1.5 Technical details on low-power jammer 'S2.1'



The jammer S2.1 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car. S2.1 is a two-antenna, so-called 'L1+L2', jammer, disrupting both the upper and lower L-band.

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Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
L1	1581.59	85.41	13.36	32.68	16.64	40.63	Sawtooth+burst
L2	1198.05	96.58	13.92	33.75	17.30	42.1	Sawtooth+burst

Table 1.4: Technical characteristics of S2.1 jammer

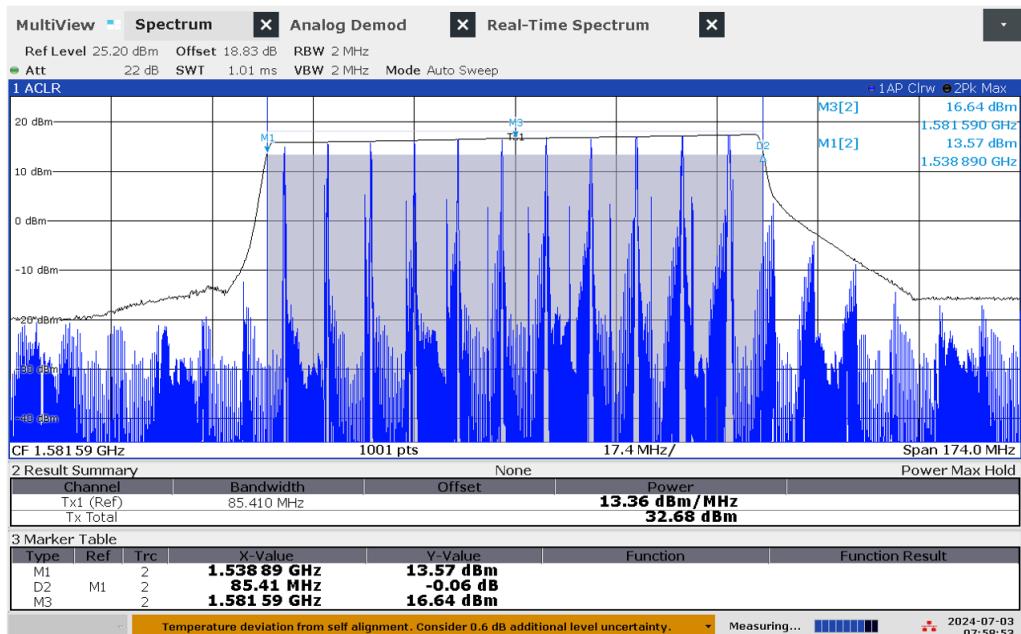


Figure 1.10: Frequency and power measurement of jammer S2.1 on antenna 'L1'

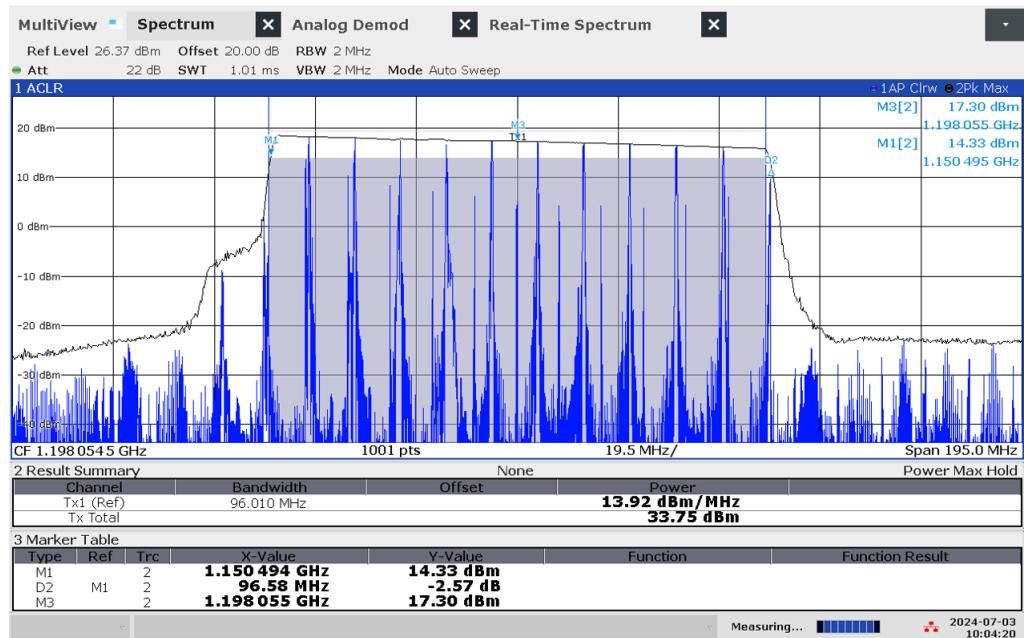


Figure 1.11: Frequency and power measurement of jammer S2.1 on antenna 'L2'



Figure 1.12: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna 'L1'

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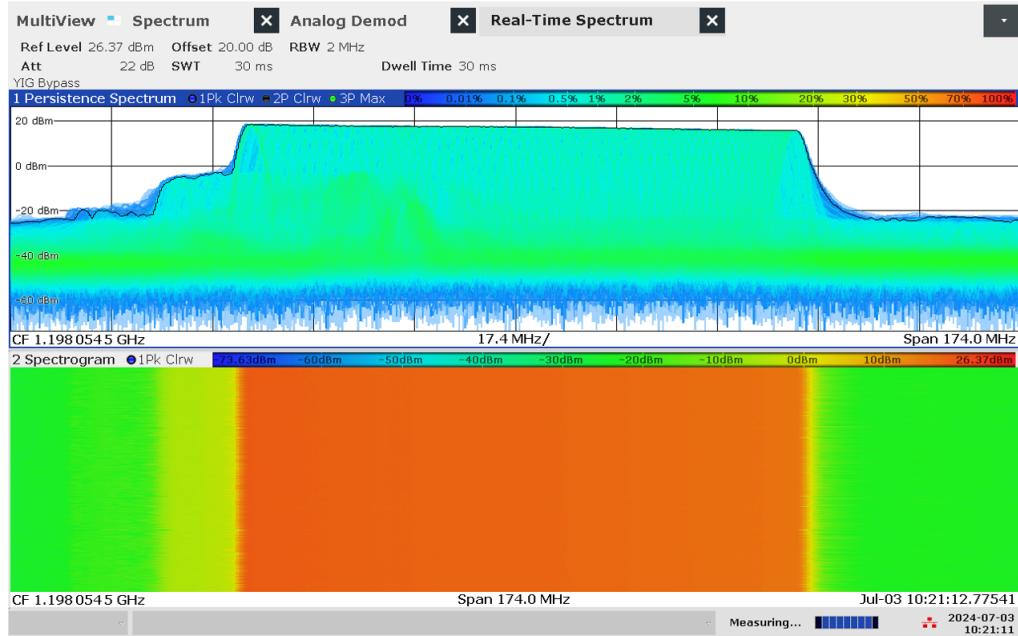


Figure 1.13: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna 'L2'

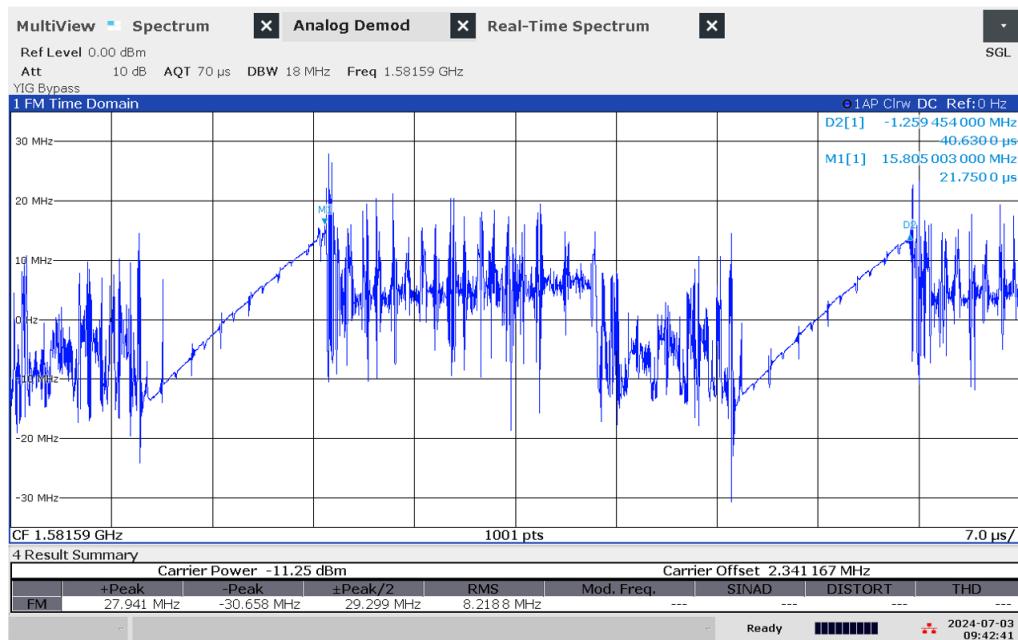


Figure 1.14: Time domain (analog demod) measurement of jammer S2.1 on antenna 'L1'

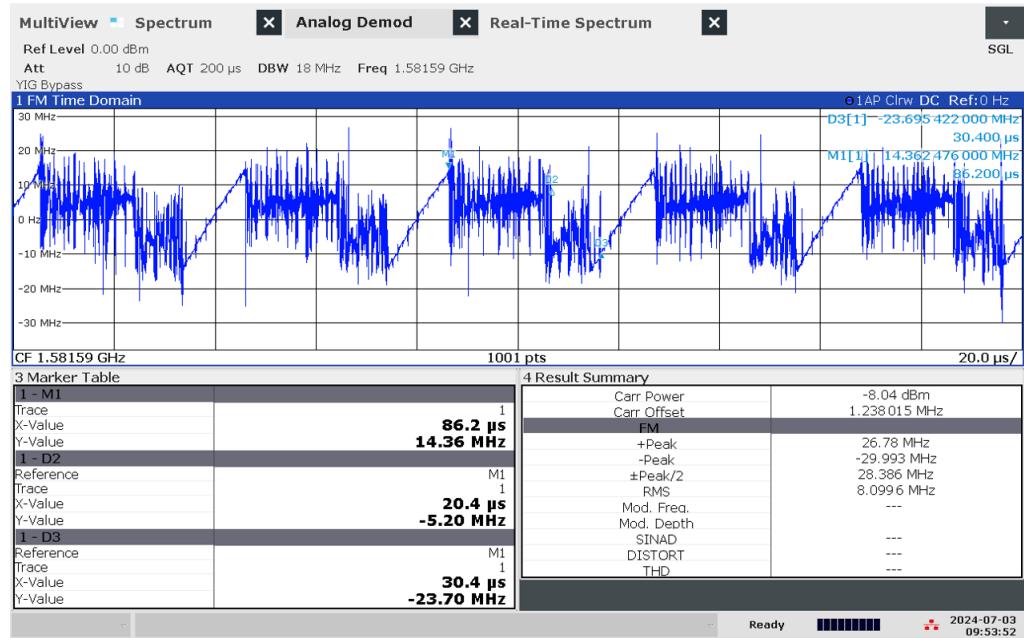


Figure 1.15: Time domain (analog demod) measurement with wider span of jammer S2.1 on antenna 'L1'

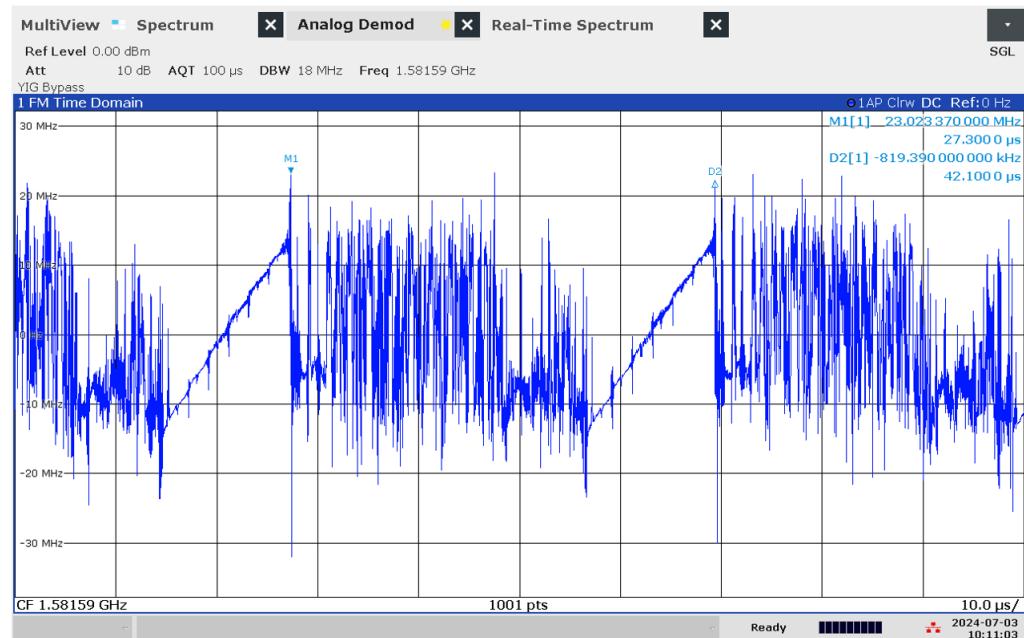


Figure 1.16: Time domain (analog demod) measurement of jammer S2.1 on antenna 'L2'

1.1.6 Technical details on low-power jammer 'S2.2'



The jammer S2.2 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.2 is a two-antenna, so-called 'L1+L2', jammer, disrupting both the upper and lower L-band.

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
L1	1580.86	87.69	12.82	32.25	16.17	40.7	Sawtooth+burst
L2	1207.55	102.04	11.95	32.04	17.02	41.0	Sawtooth+burst

Table 1.5: Technical characteristics of S2.2 jammer

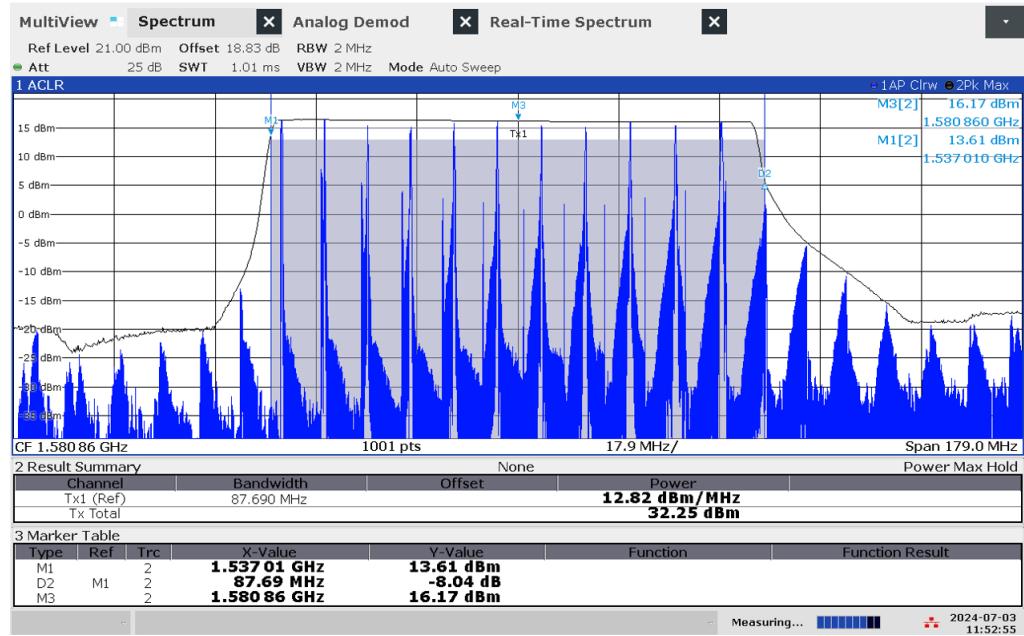


Figure 1.17: Frequency and power measurement of jammer S2.2 on antenna 'L1'

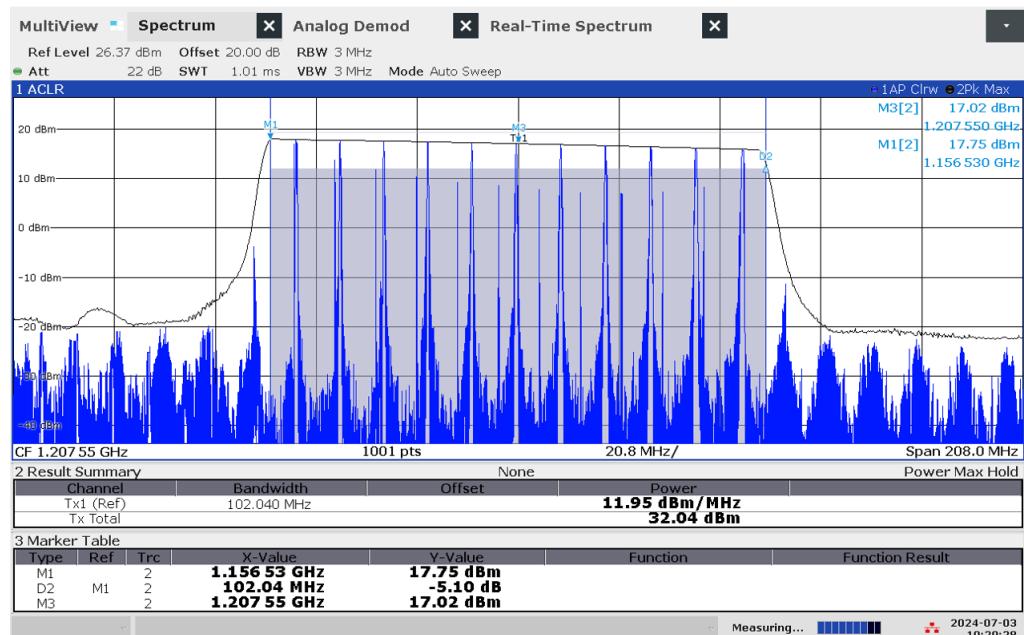


Figure 1.18: Frequency and power measurement of jammer S2.2 on antenna 'L2'

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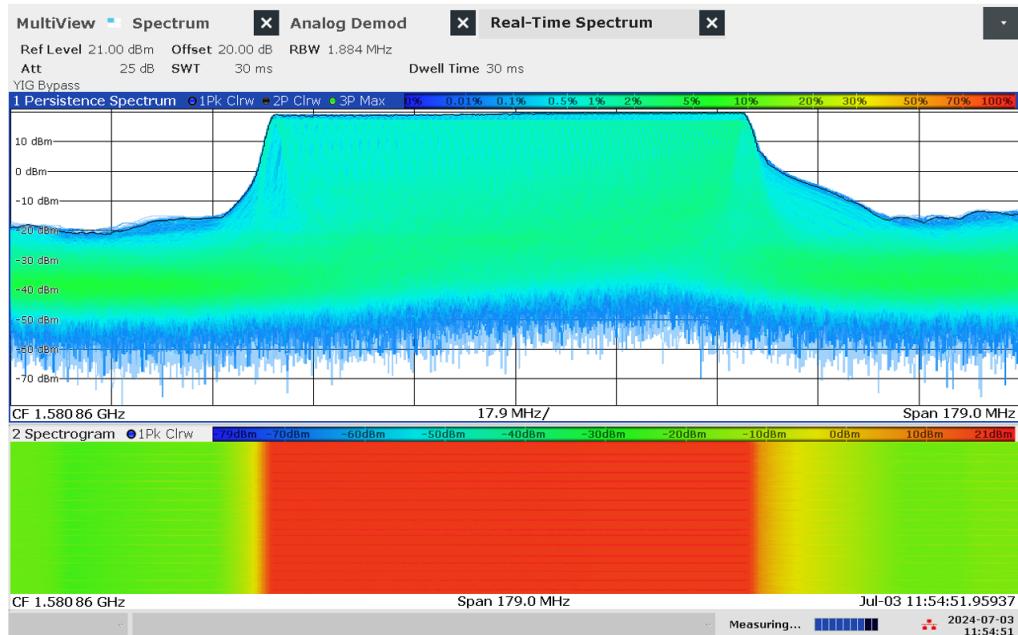


Figure 1.19: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna 'L1'

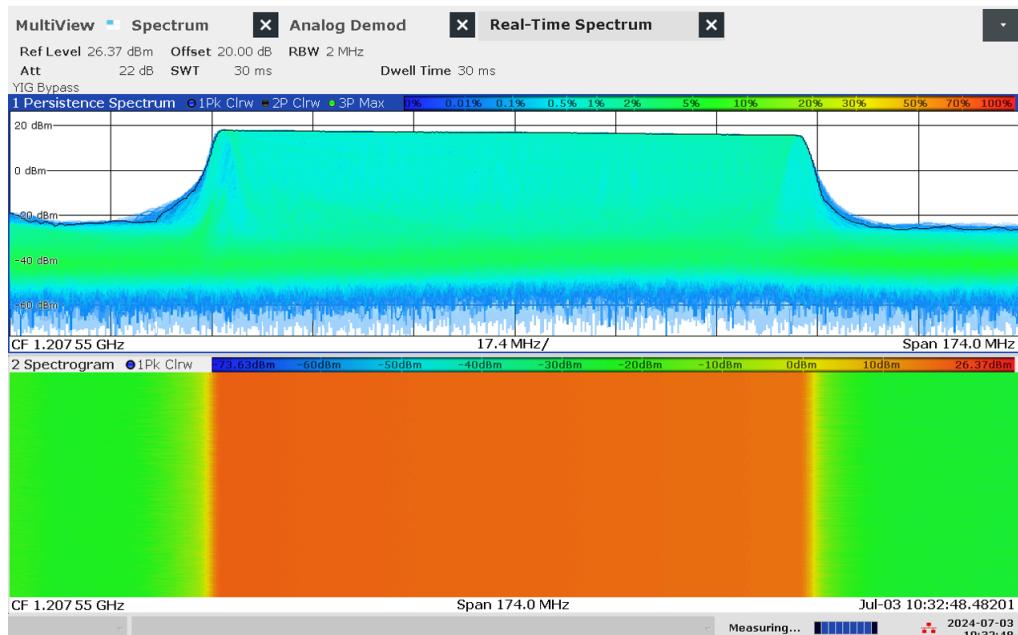


Figure 1.20: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna 'L2'

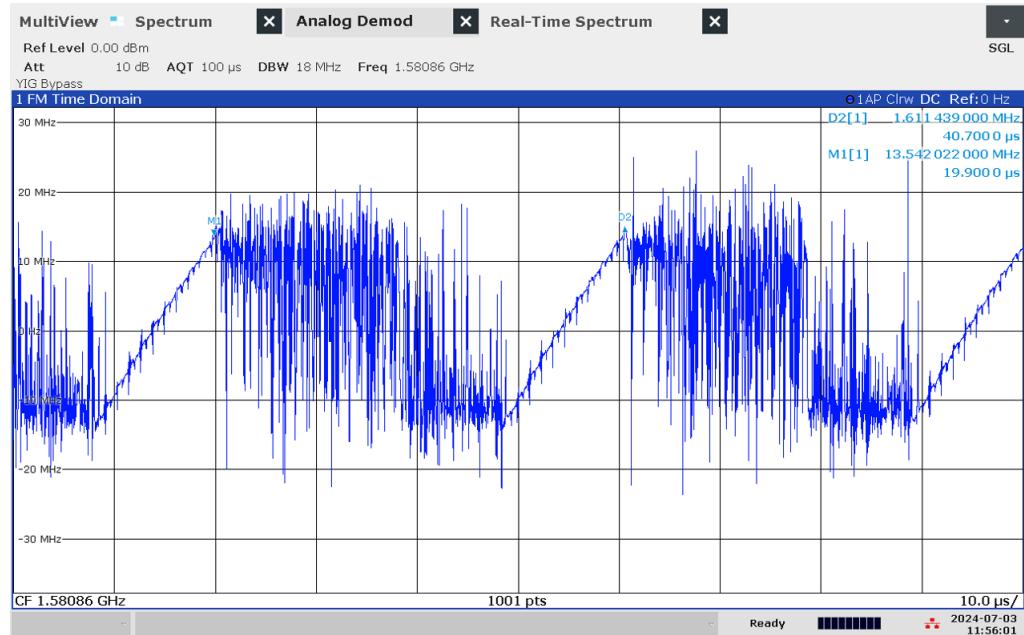


Figure 1.21: Time domain (analog demod) measurement of jammer S2.2 on antenna 'L1'

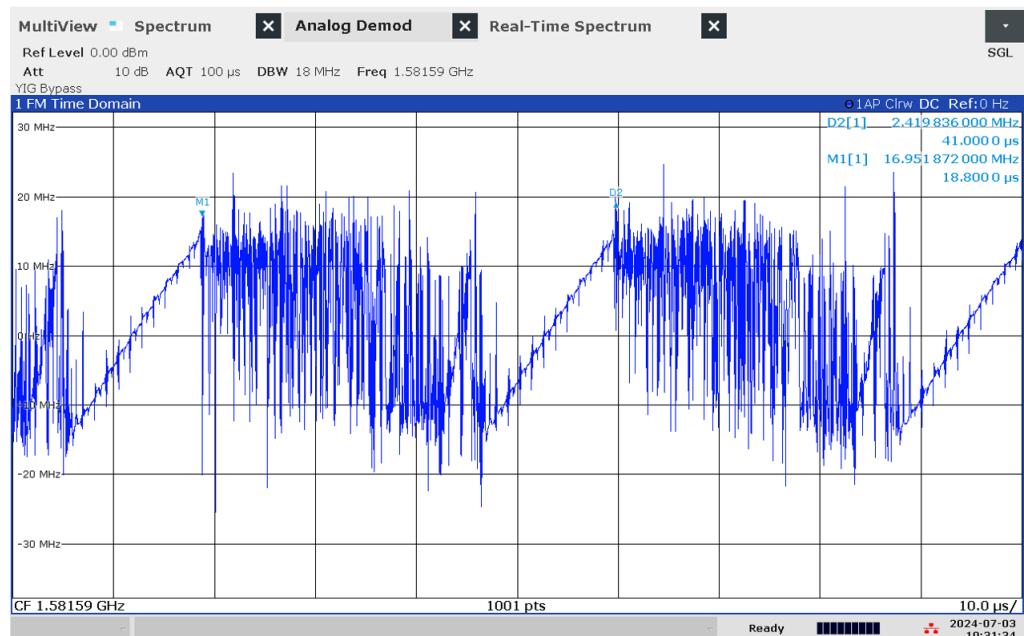


Figure 1.22: Time domain (analog demod) measurement of jammer S2.2 on antenna 'L2'

1.1.7 Technical details on low-power jammer 'S2.3'



The jammer S2.3 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.3 is a two-antenna, so-called 'L1+L2', jammer, disrupting both the upper and lower L-band.

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
L1	1586.65	93.19	14.30	34.0	17.40	46.7	Sawtooth+burst
L2	1204.33	102.05	12.01	32.1	17.06	50.5	Sawtooth+burst

Table 1.6: Technical characteristics of S2.3 jammer

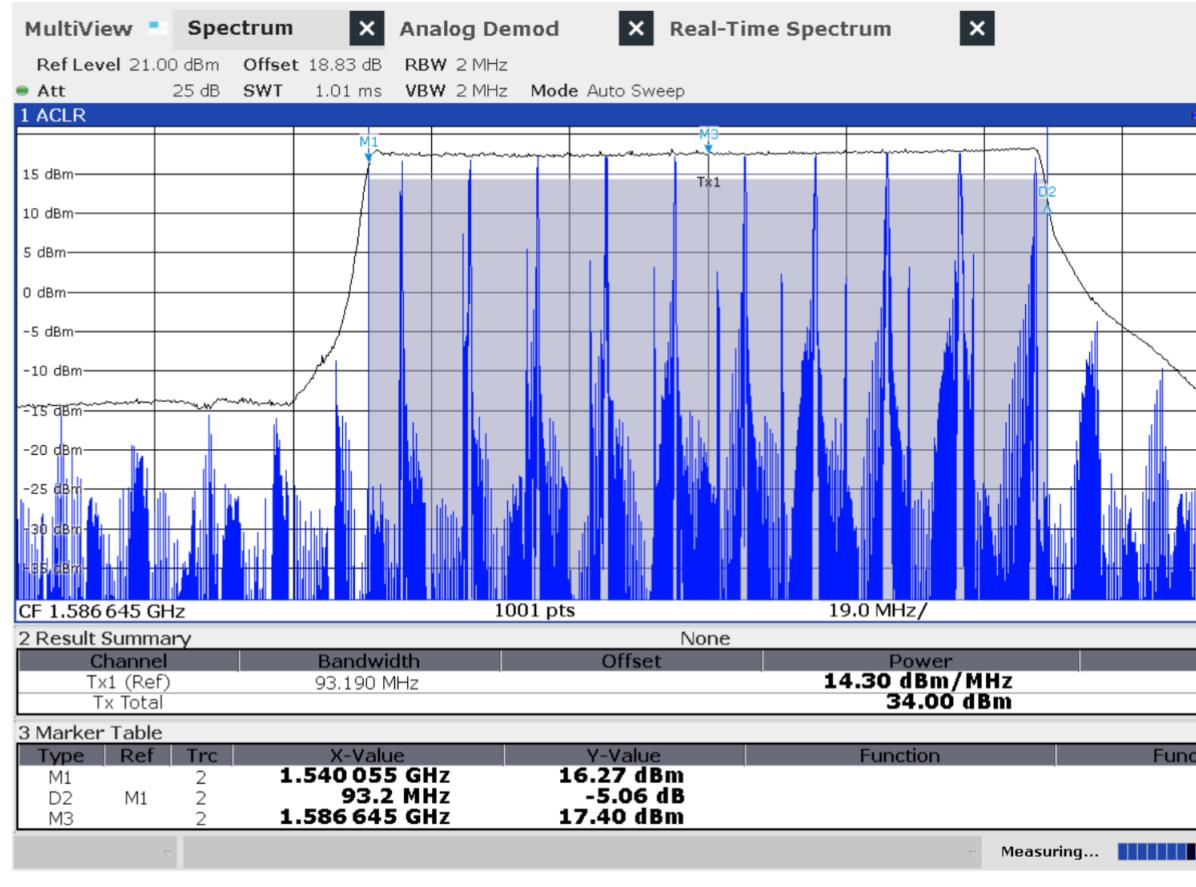


Figure 1.23: Frequency and power measurement of jammer S2.3 on antenna 'L1'

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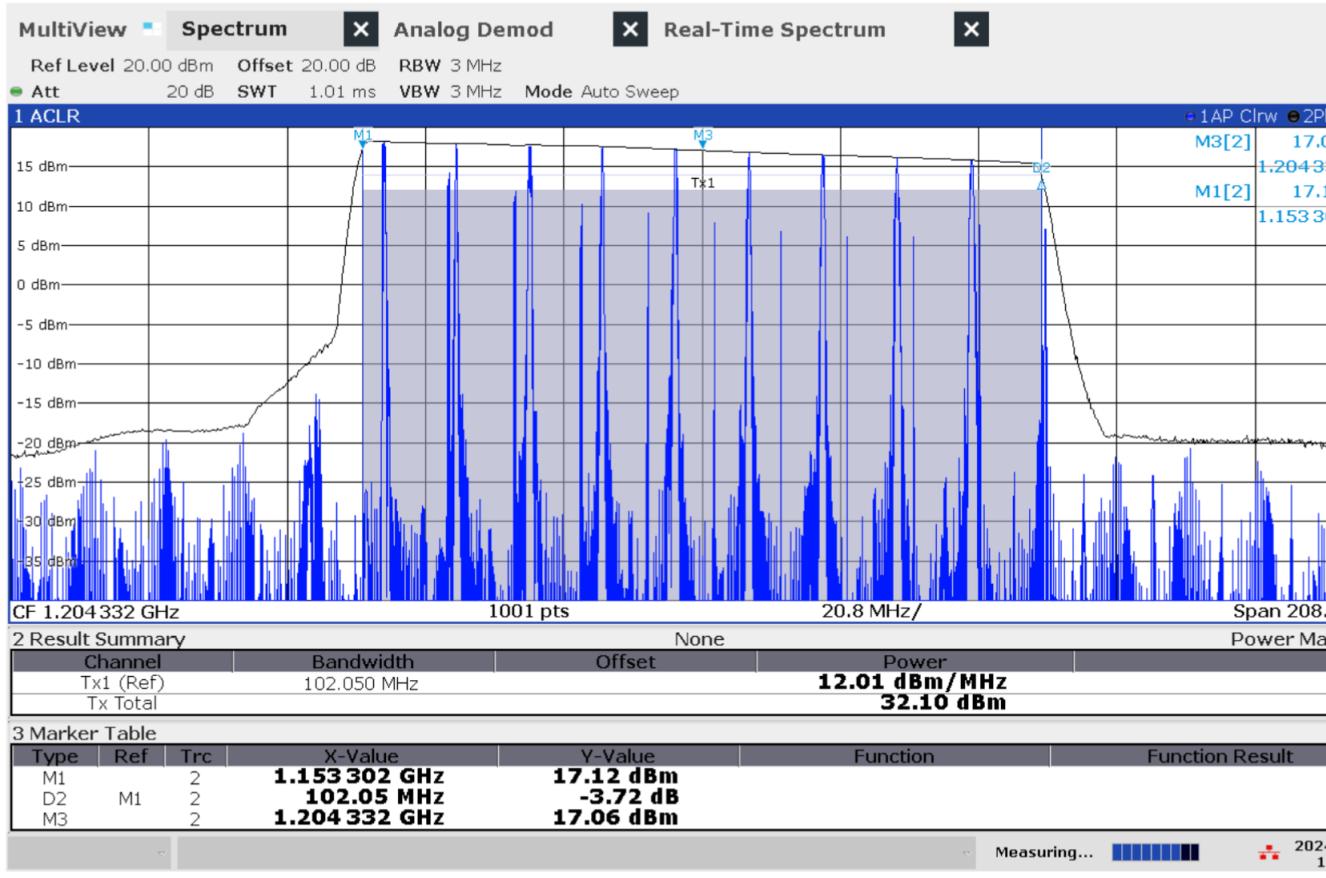


Figure 1.24: Frequency and power measurement of jammer S2.3 on antenna 'L2'

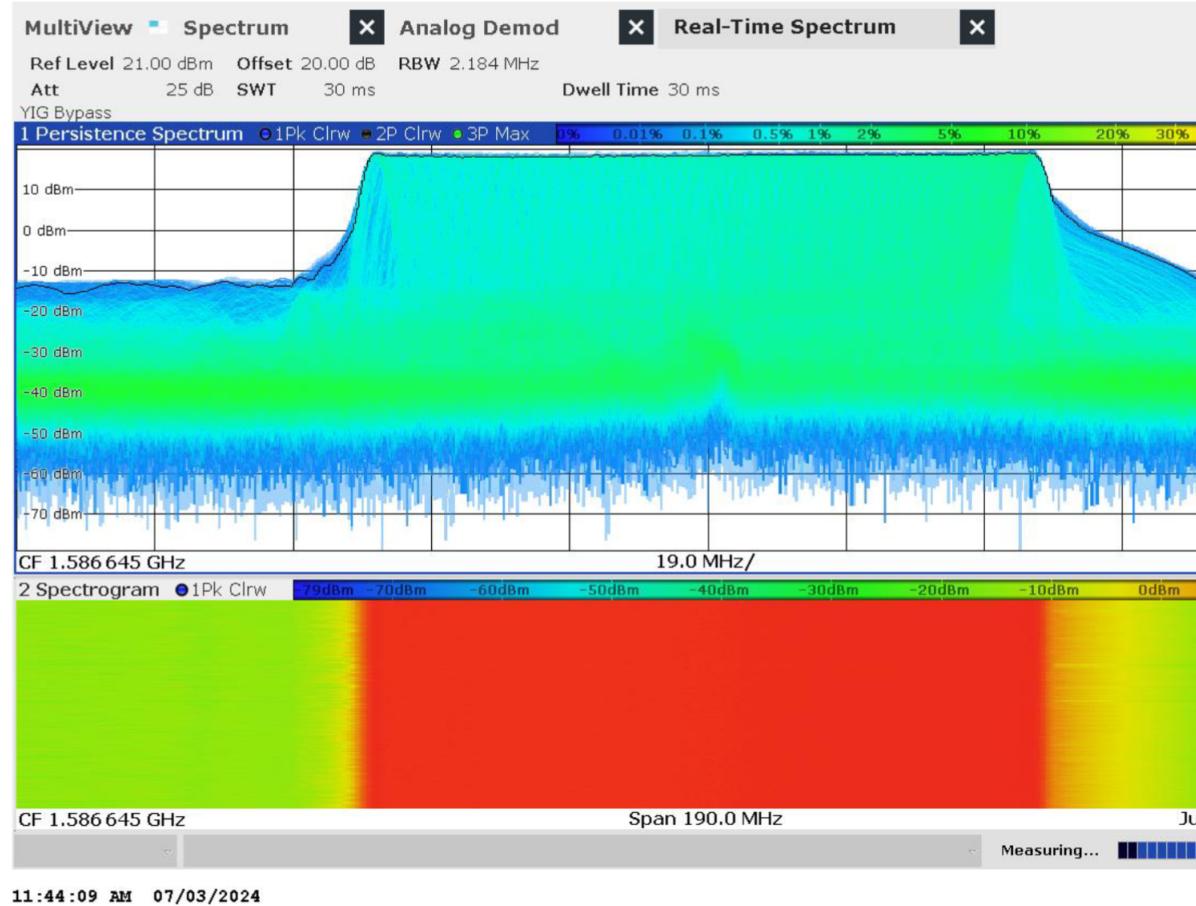


Figure 1.25: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna 'L1'

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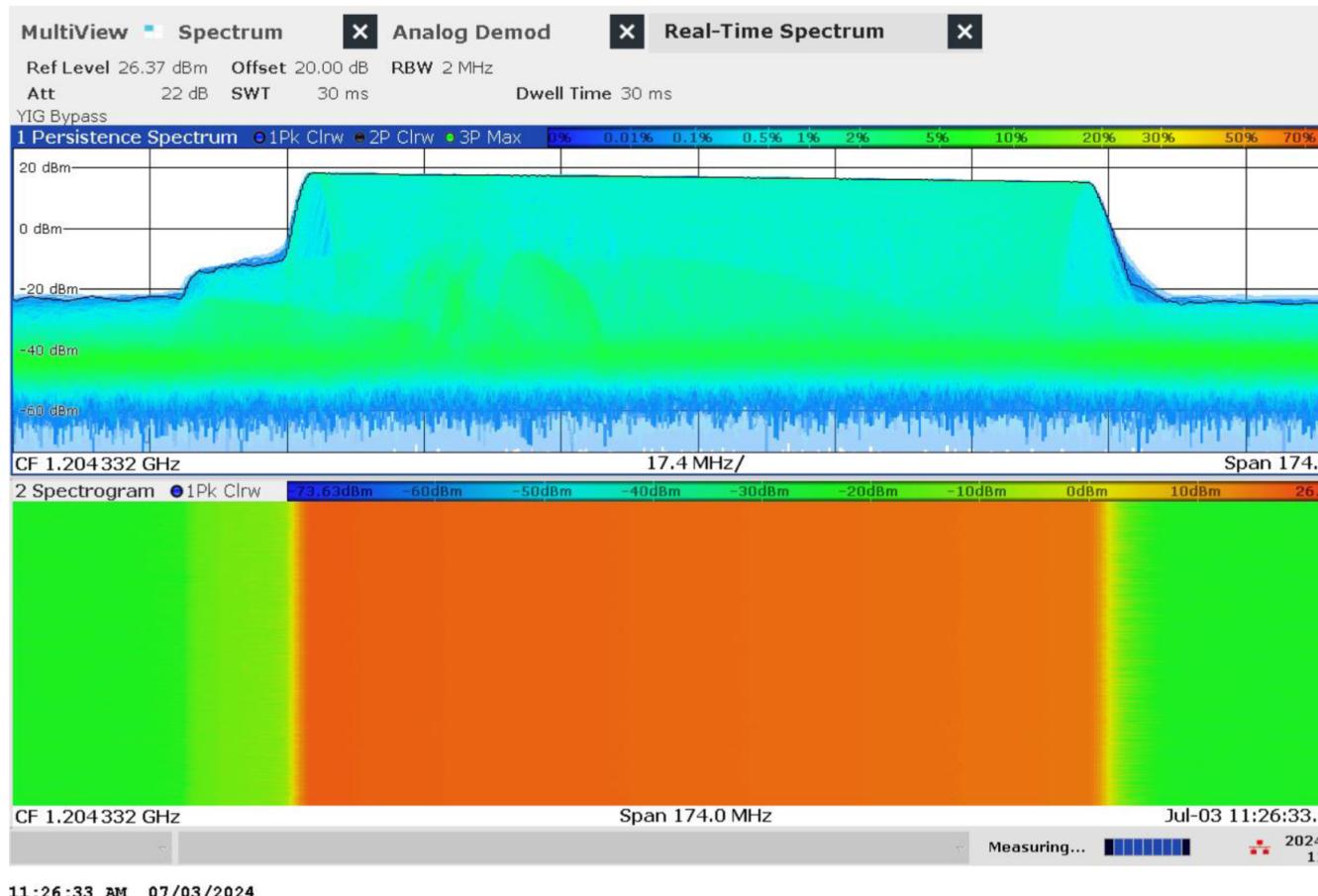


Figure 1.26: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna 'L2'

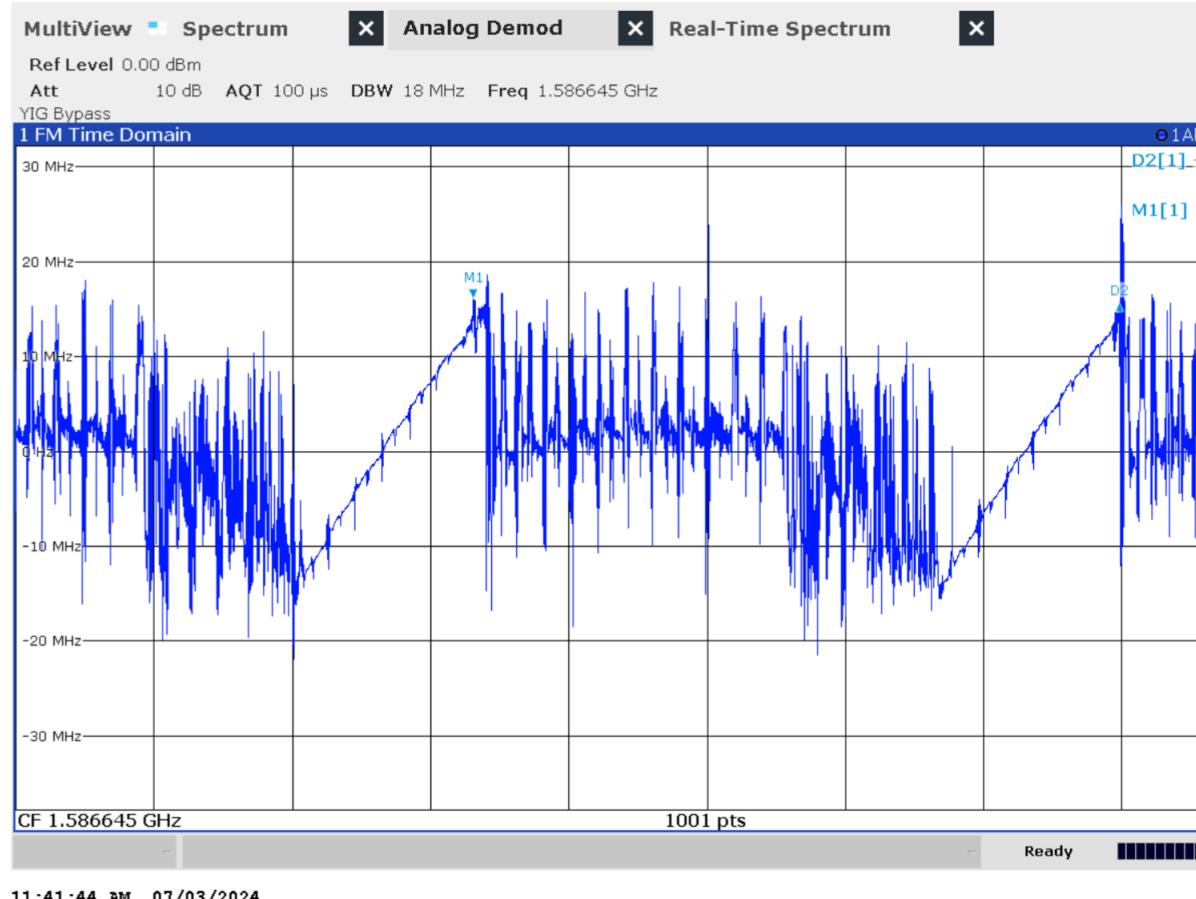
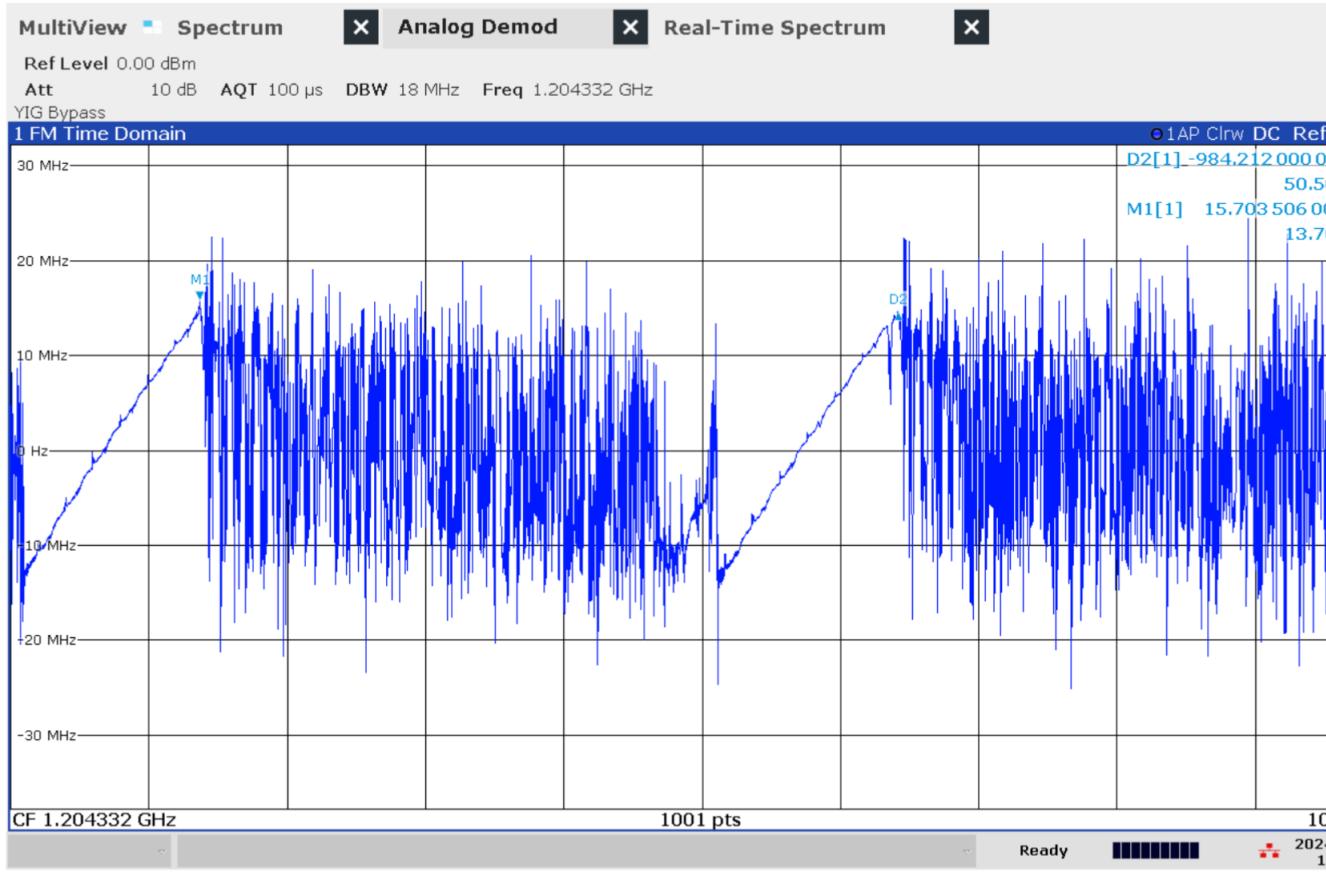


Figure 1.27: Time domain (analog demod) measurement of jammer S2.3 on antenna 'L1'

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Figure 1.28: Time domain (analog demod) measurement of jammer S2.3 on antenna 'L2'

1.1.8 Technical details on low-power jammer 'S2.4'



The jammer S2.4 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.4 is a two-antenna, so-called 'L1+L2', jammer, disrupting both the upper and lower L-band.

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	M
L1	1582.09	86.35	12.42	31.78	15.91	43.5	Saw
L2	1202.90	96.56	13.63	33.48	17.03	47.3	Saw

Table 1.7: Technical characteristics of S2.4 jammer

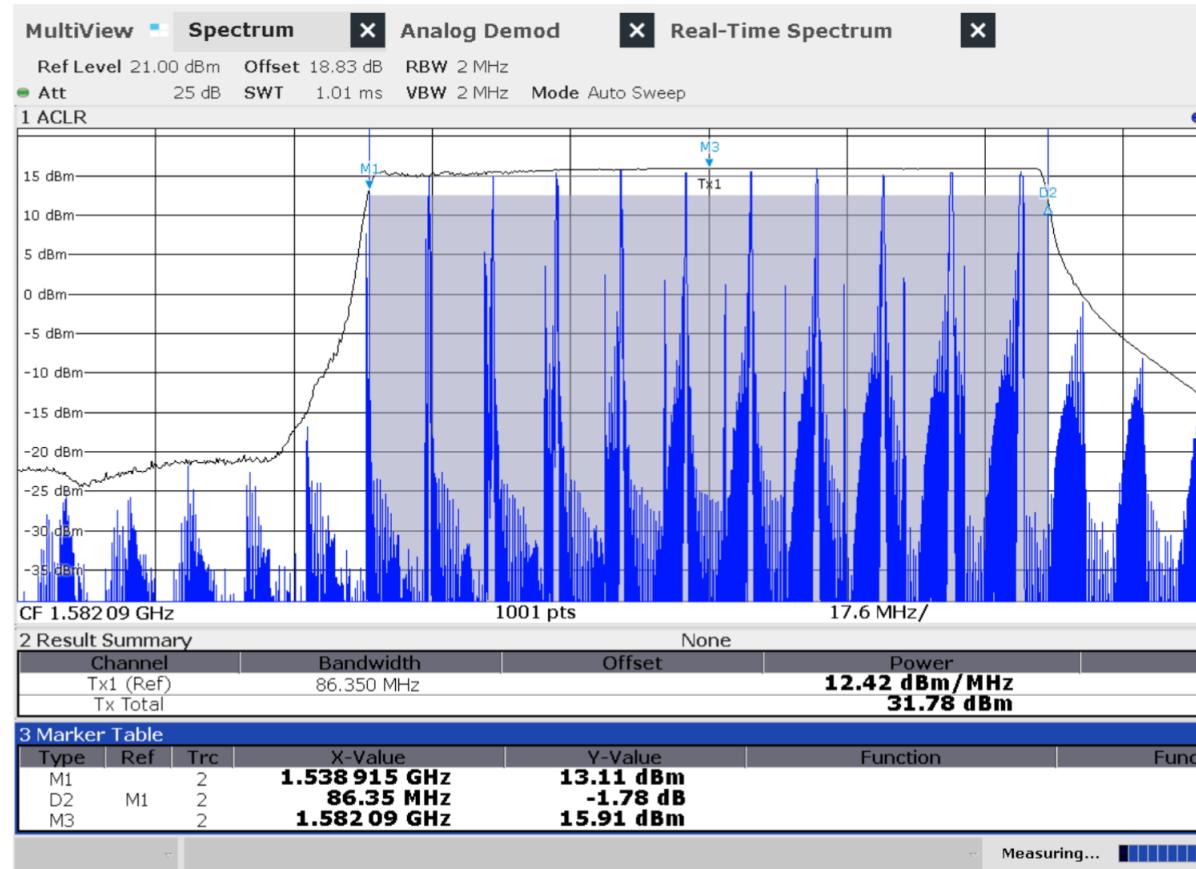


Figure 1.29: Frequency and power measurement of jammer S2.4 on antenna 'L1'

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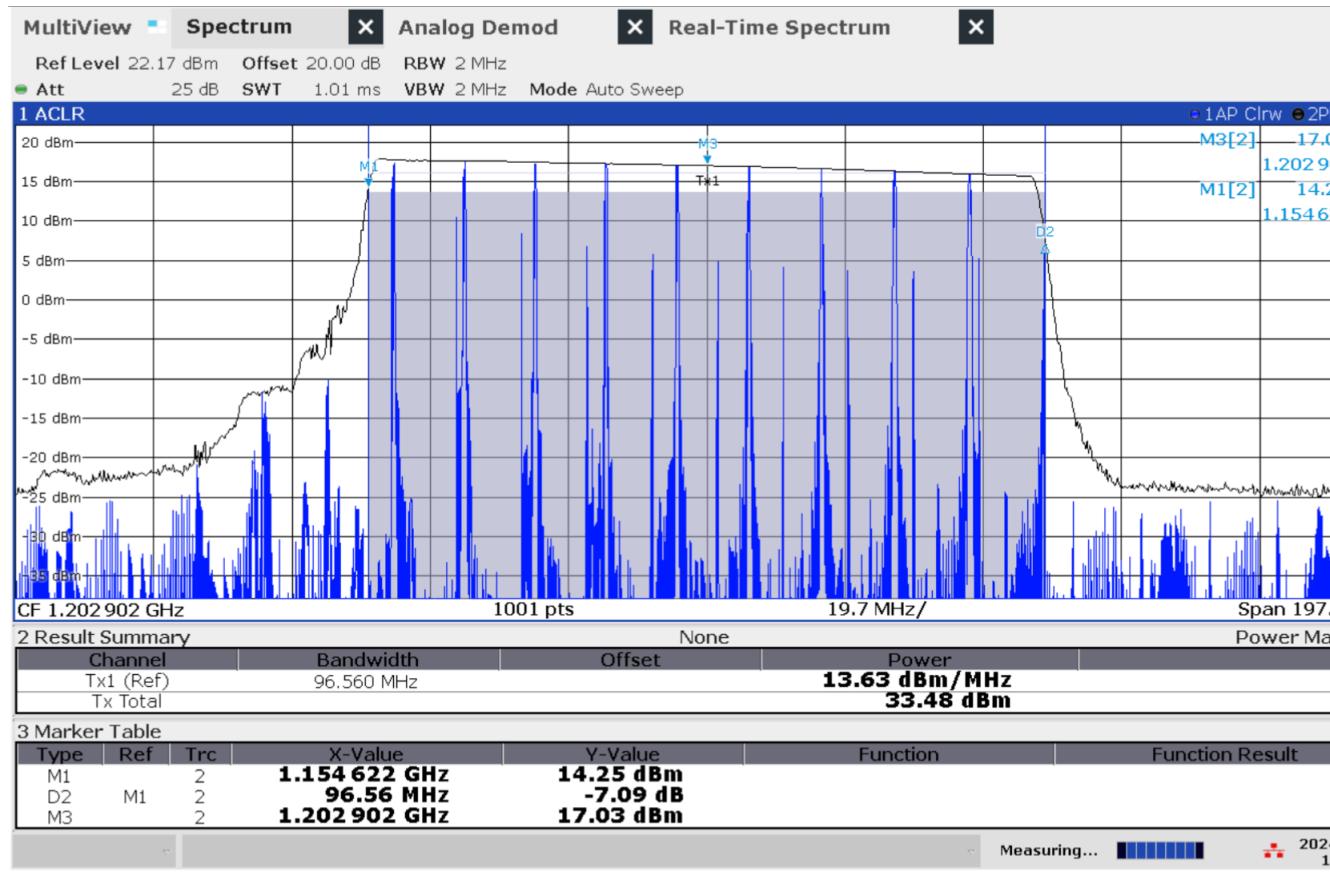


Figure 1.30: Frequency and power measurement of jammer S2.4 on antenna 'L2'

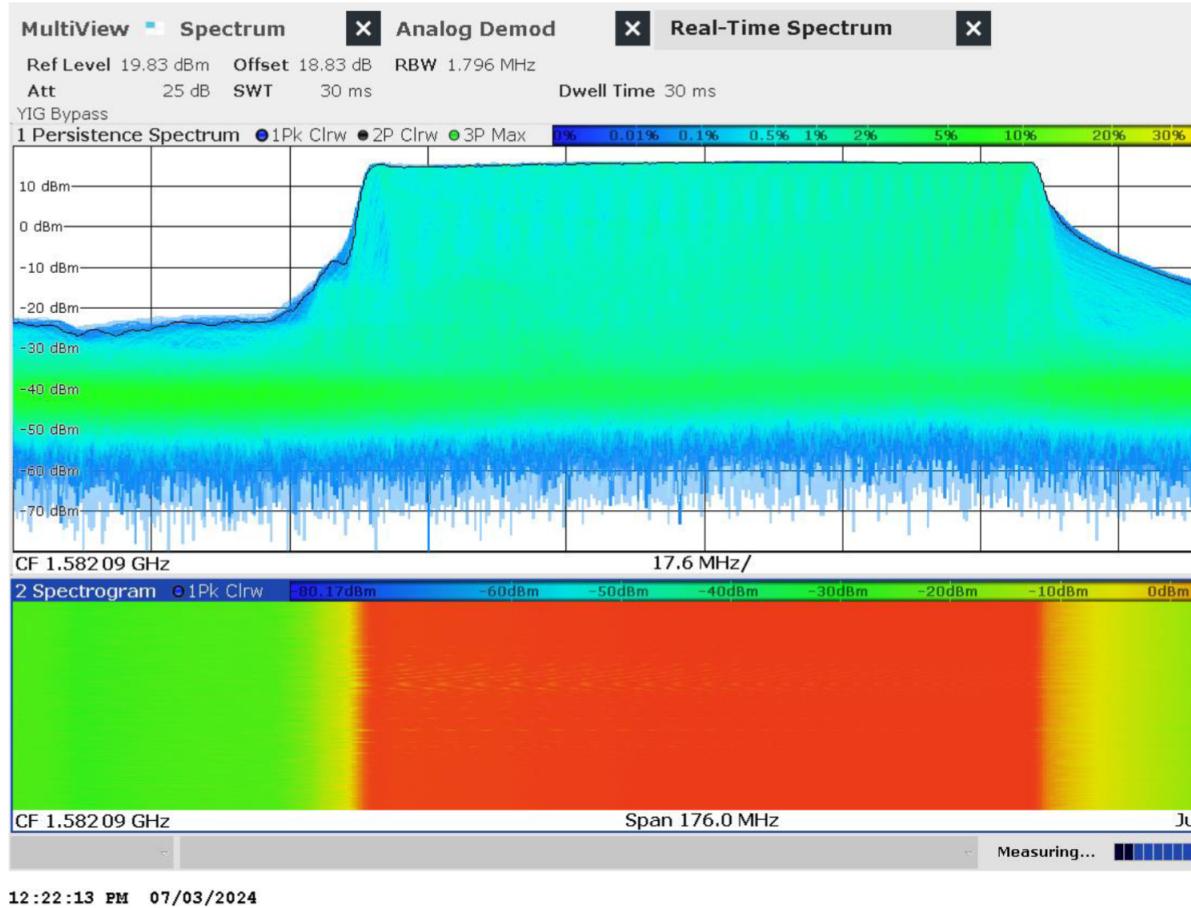


Figure 1.31: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna 'L1'

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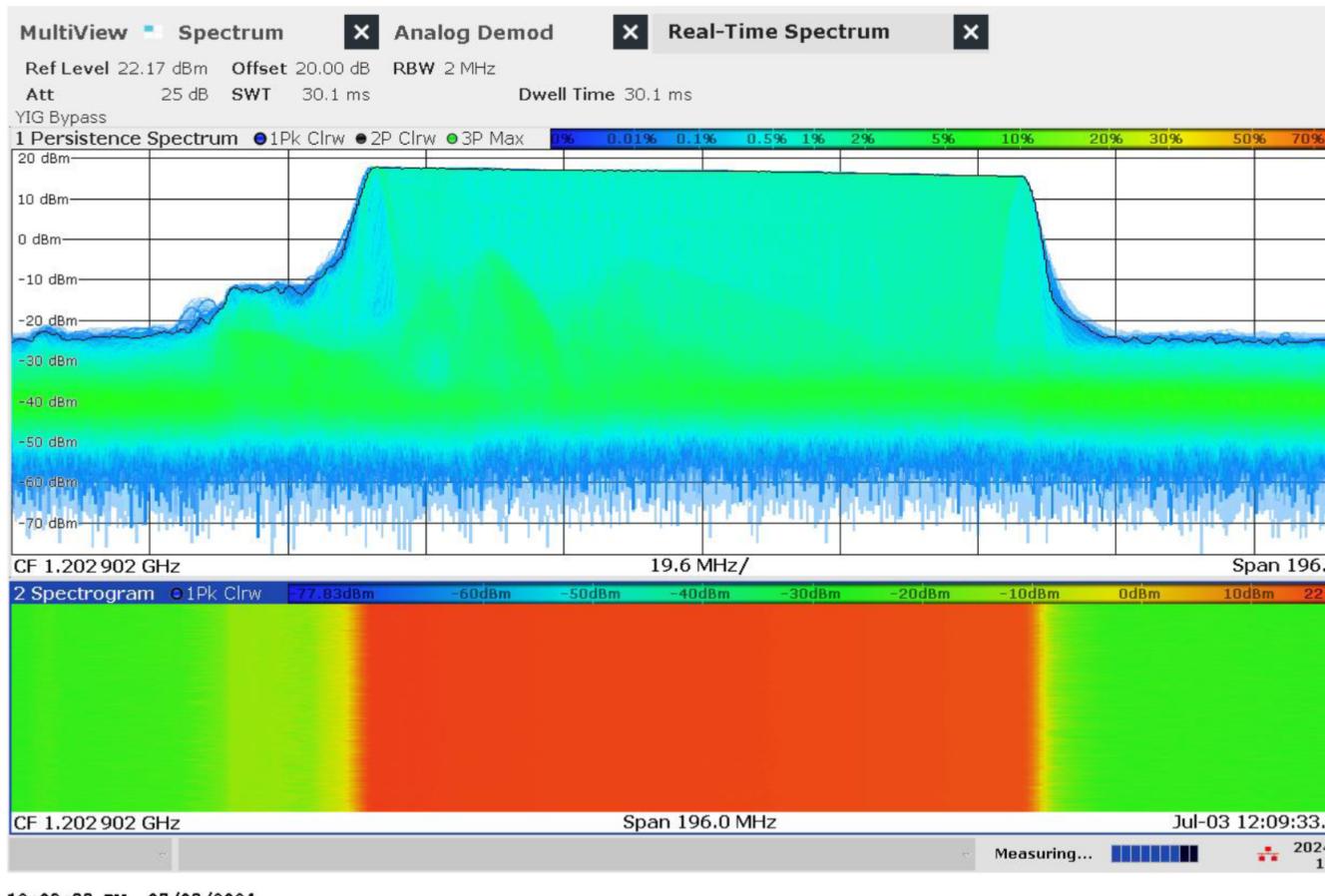


Figure 1.32: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna 'L2'

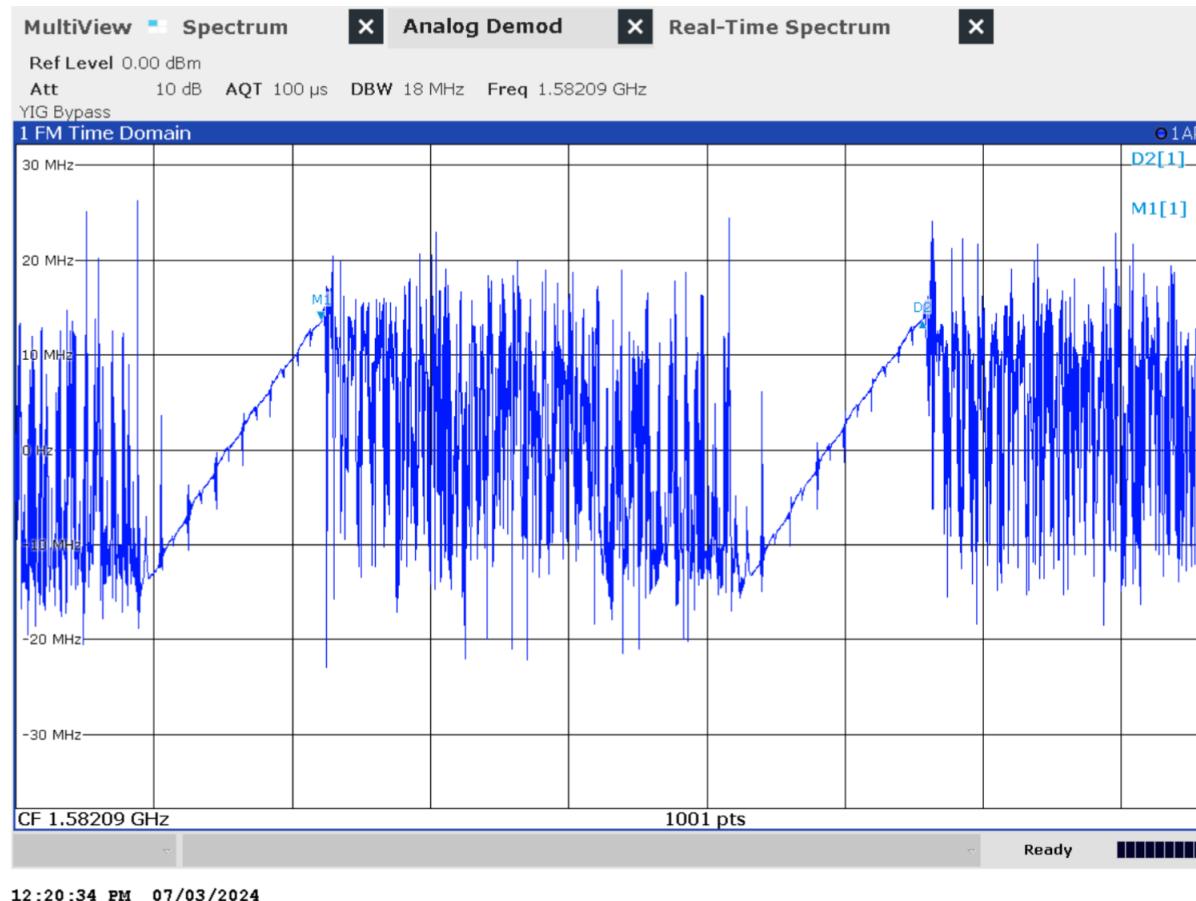


Figure 1.33: Time domain (analog demod) measurement of jammer S2.4 on antenna 'L1'

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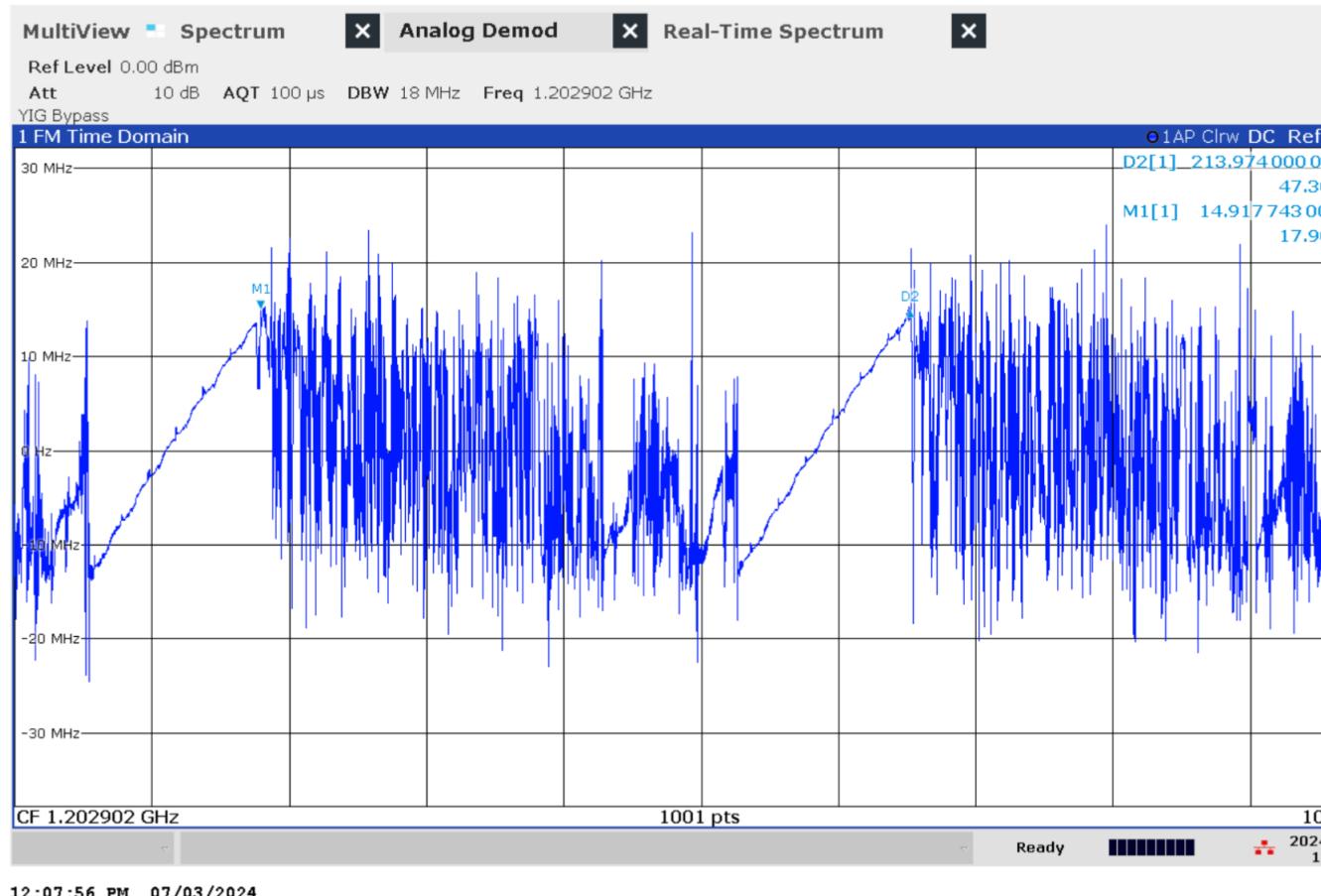


Figure 1.34: Time domain (analog demod) measurement of jammer S2.4 on antenna 'L2'

1.1.9 Technical details on low-power jammer 'U1.1 to U1.4'



USB jammers is category of jammers that is often installed in the USB outlet. They are intended to cover a small radius. These particular jammers suggest in the LED screen that they jam two bands, although this is not the case.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]	Modulation
1590-1600	70-80	N/A	N/A	N/A	5-8	Sawtooth

Table 1.8: Technical characteristics of U1.1-U1.4 jammer

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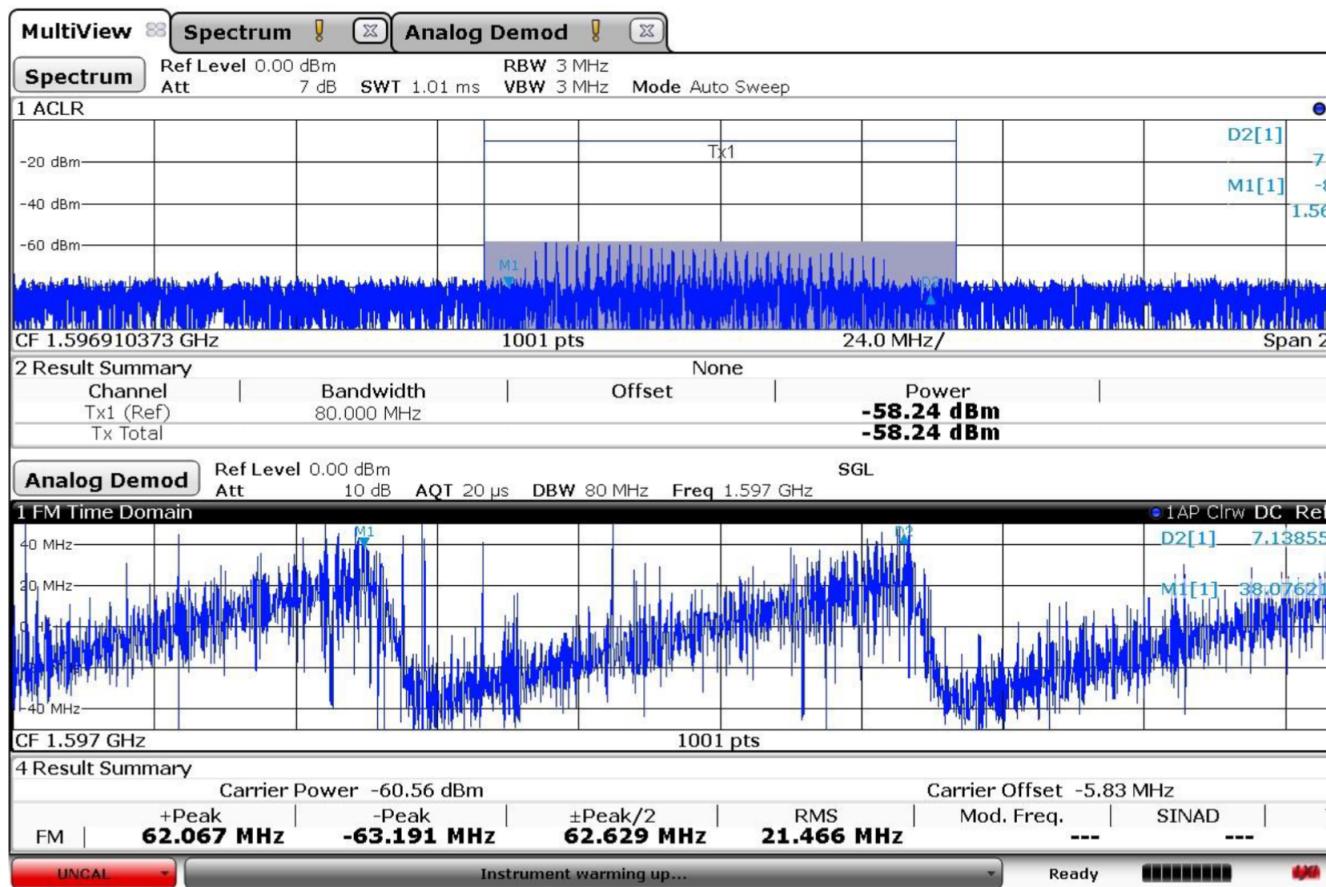


Figure 1.35: Example measurement of a U1.1 - U1.4 jammer

1.1.10 Technical details on low-power jammer 'H1.1'



The jammer H1.1 belongs to the 'Handheld category' of jammers. It is a medium weight battery driven jammer with a configuration panel for operation: multi-frequency and multi-modulation for both low and high output power. Its commercially available for military training purposes as Novatel's NEAT-jammer. Antenna has TNC-connector.

H1.1 is a one-antenna, yet multi-frequency, jammer, therefore a so-called 'L1+L2', disrupting parts of both the upper and lower L-band.

Configuration choices are (as provided by the producer):

- Centre frequency: 1575.42 MHz and 1227.6 MHz
- Estimated output power: low power -5 dBm, high power 20 dBm
- Type of modulation: narrow band (NB), wide band (WB), continuous wave (CW), chirp/sweep and other (optional to program)

In the 2024 measurements below, bandwidth is defined as

- main lobe in PRN signal
- 3 dB from local (identifiable) maxima

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Antenna configuration	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [μs]
L1, NB, HIGH PWR	1575.42	2.05	17.52	20.63	11.07	N/A
L1, WB, HIGH PWR	1575.40	20.03	8.20	21.25	11.43	N/A
L1, CW, HIGH PWR	1575.42	0.103	22.50	12.62	13.67	N/A
L1, CHIRP, HIGH PWR	1575.60	18.75	3.10	15.83	-5.73	10.42
L1, NB, LOW PWR	1575.42	2.05	-12.84	-9.73	-19.35	N/A
L1, WB, LOW PWR	1575.40	19.93	-21.66	-8.66	-17.91	N/A
L1, CW, LOW PWR	1575.42	0.10	-7.55	-17.46	-16.37	N/A
L1, CHIRP, LOW PWR	1575.60	18.75	-27.03	-14.31	-35.65	10.46
L2, NB, HIGH PWR	1227.42	2.049	18.73	21.84	12.17	N/A
L2, WB, HIGH PWR	1227.36	20.30	9.27	22.34	12.09	N/A
L2, CW, HIGH PWR	1227.42	0.10	23.96	14.13	15.17	N/A
L2, CHIRP, HIGH PWR	1227.22	18.79	4.98	17.72	-4.11	10.4
L2, NB, LOW PWR	1227.42	2.05	-11.20	-8.09	-17.79	N/A
L2, WB, LOW PWR	1227.36	20.30	-20.39	-7.32	-17.41	N/A
L2, CW, LOW PWR	1227.42	0.10	-5.98	-15.81	-14.77	N/A
L2, CHIRP, LOW PWR	1227.22	18.76	-24.97	-12.23	-33.98	10.4

Table 1.9: Technical characteristics of H1.1 jammer

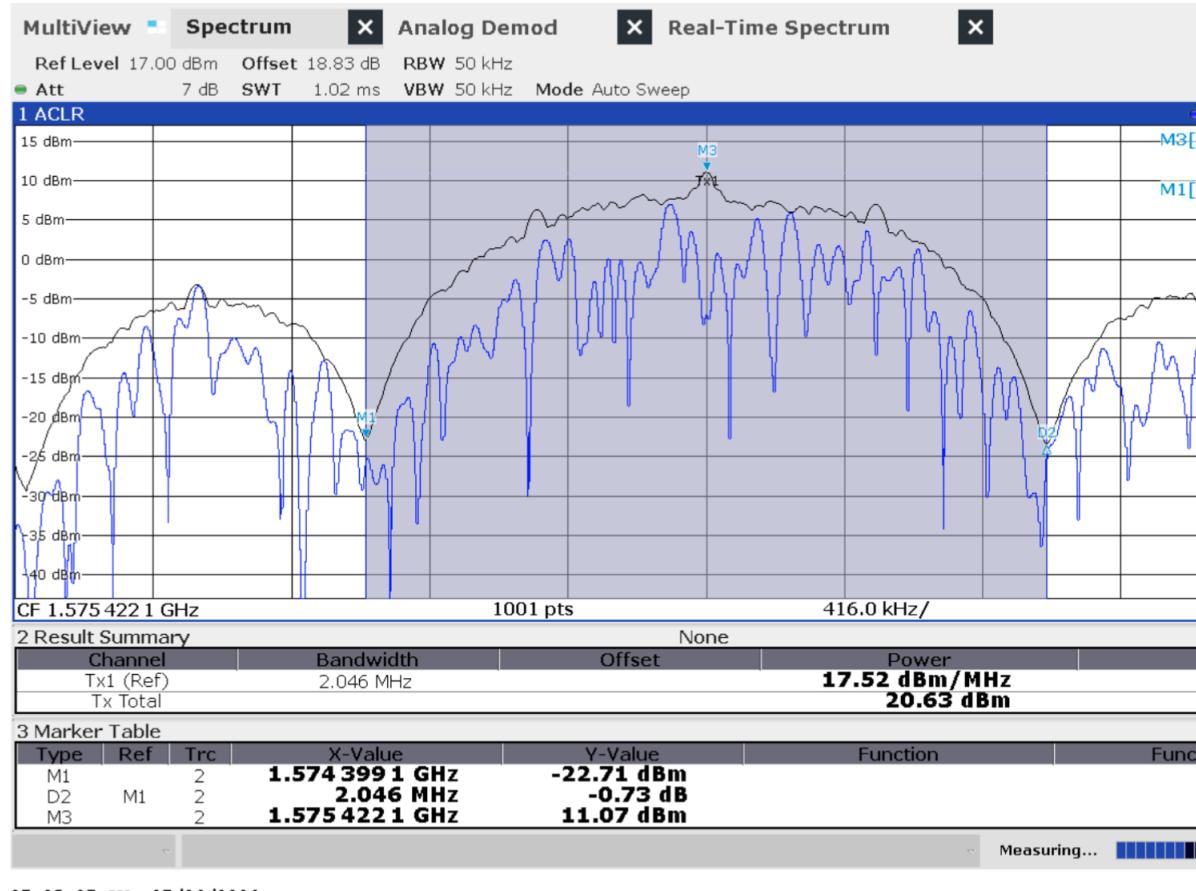


Figure 1.36: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

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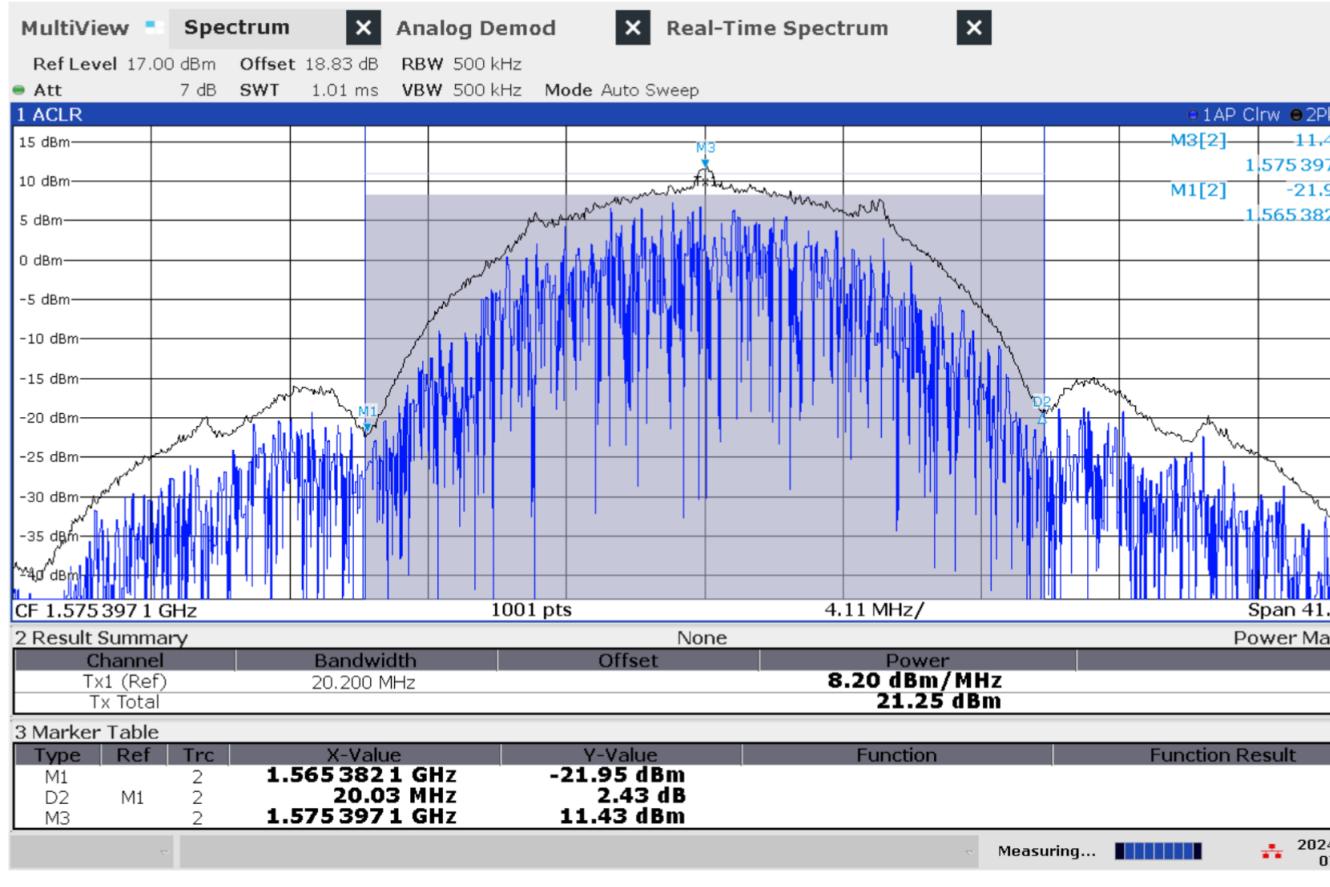


Figure 1.37: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

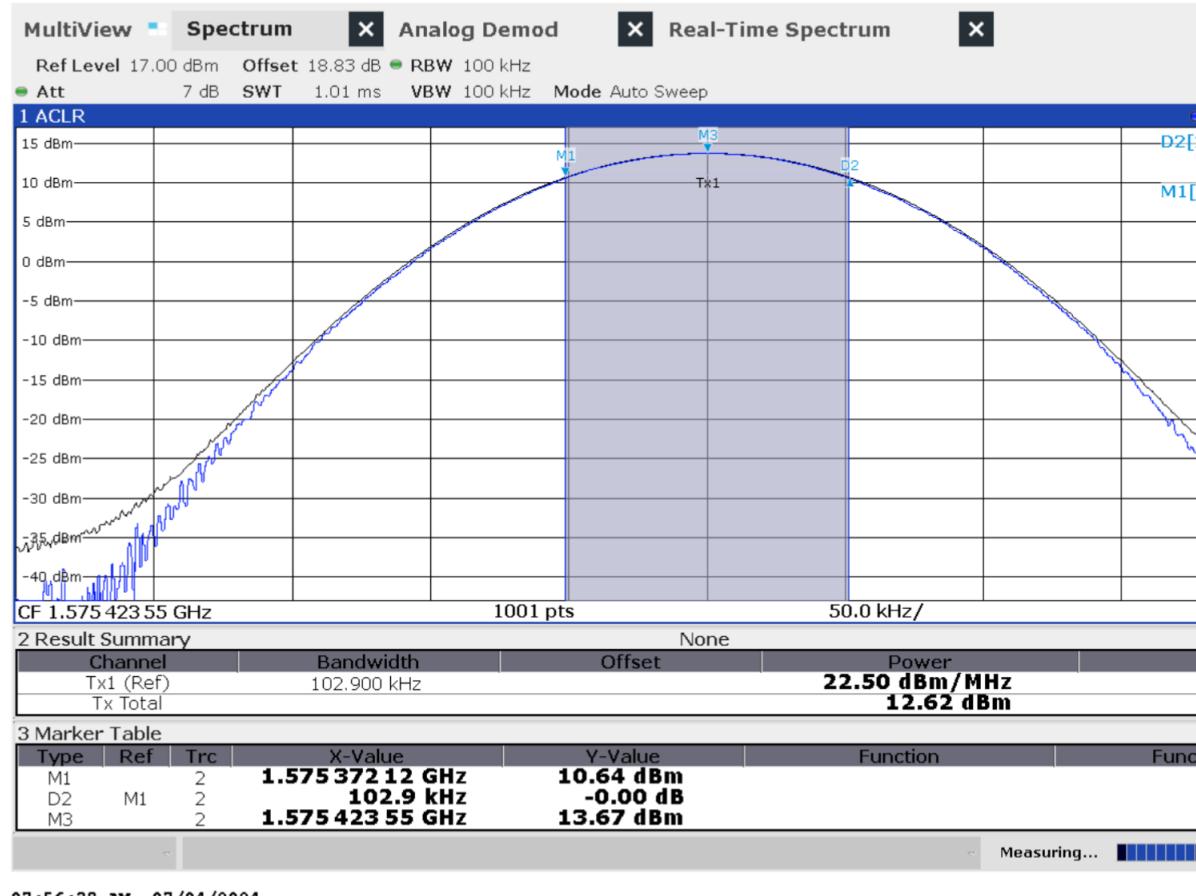


Figure 1.38: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

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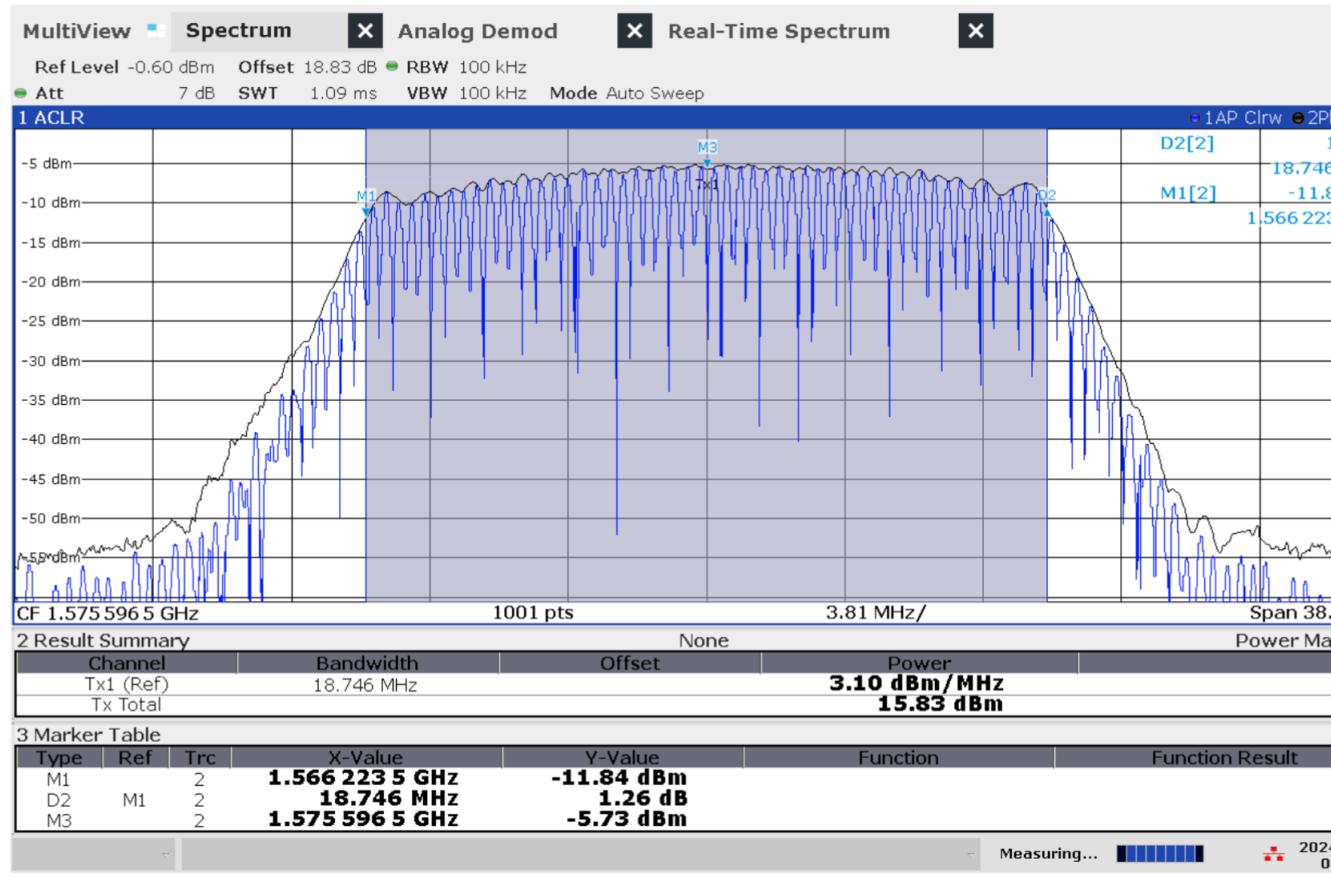


Figure 1.39: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

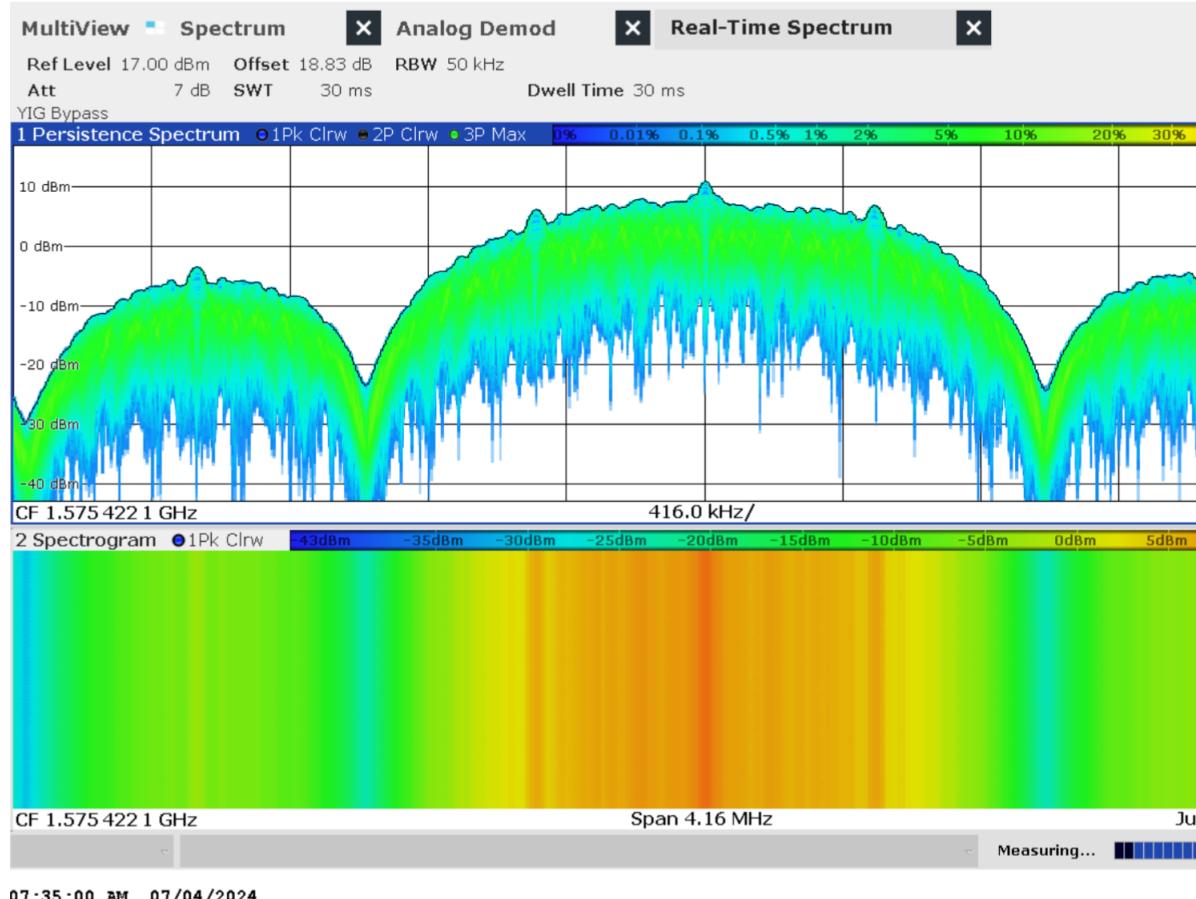


Figure 1.40: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

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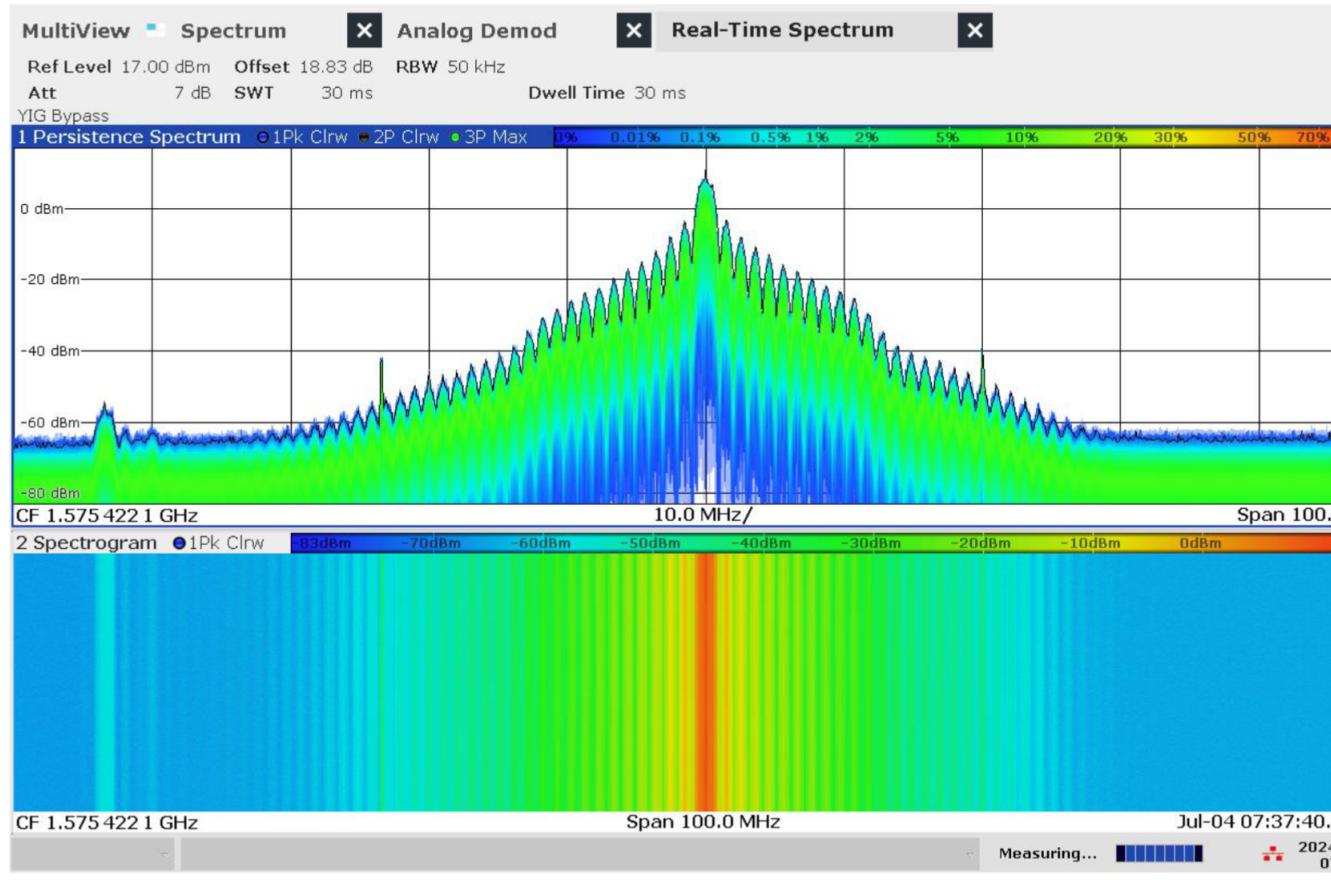


Figure 1.41: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

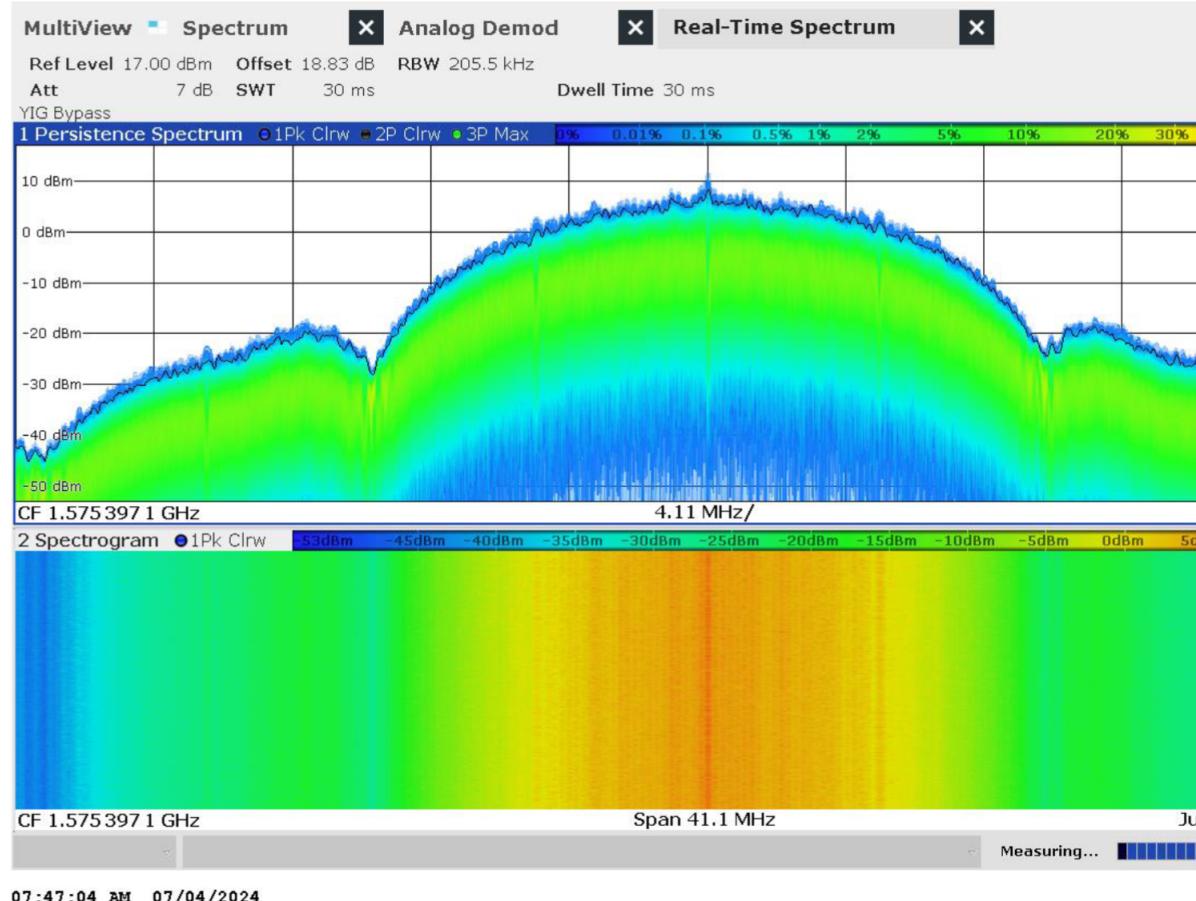


Figure 1.42: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT43

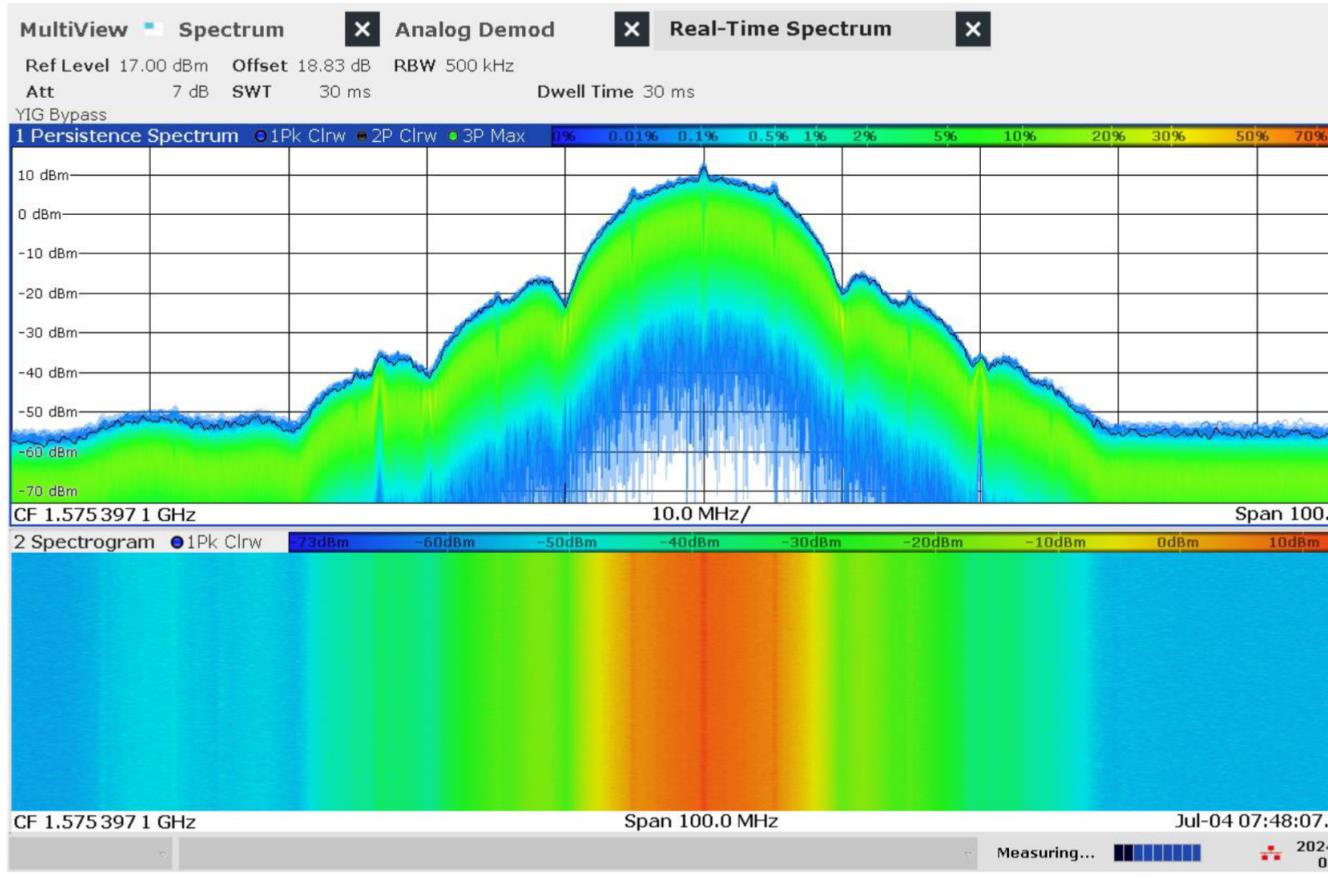


Figure 1.43: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

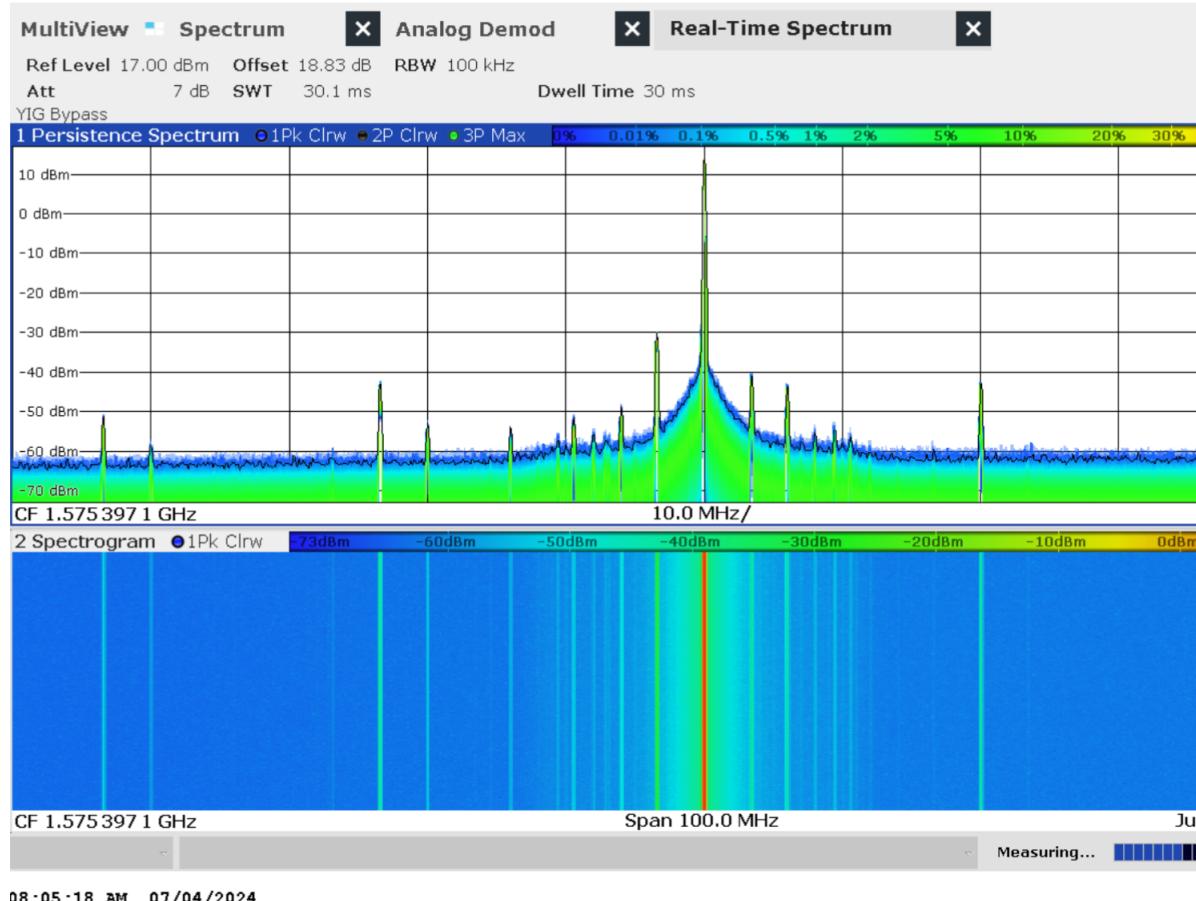


Figure 1.44: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT45

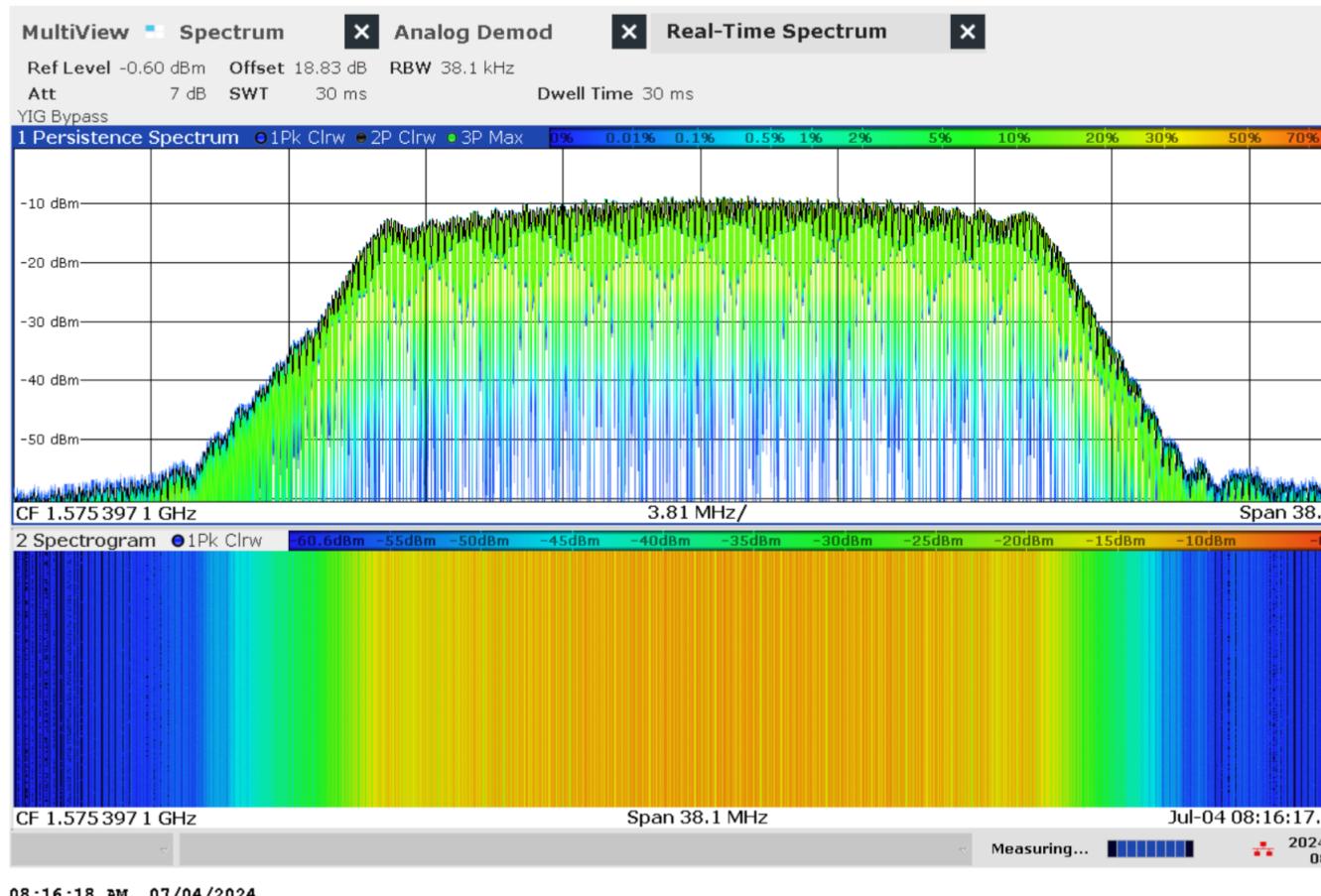


Figure 1.45: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

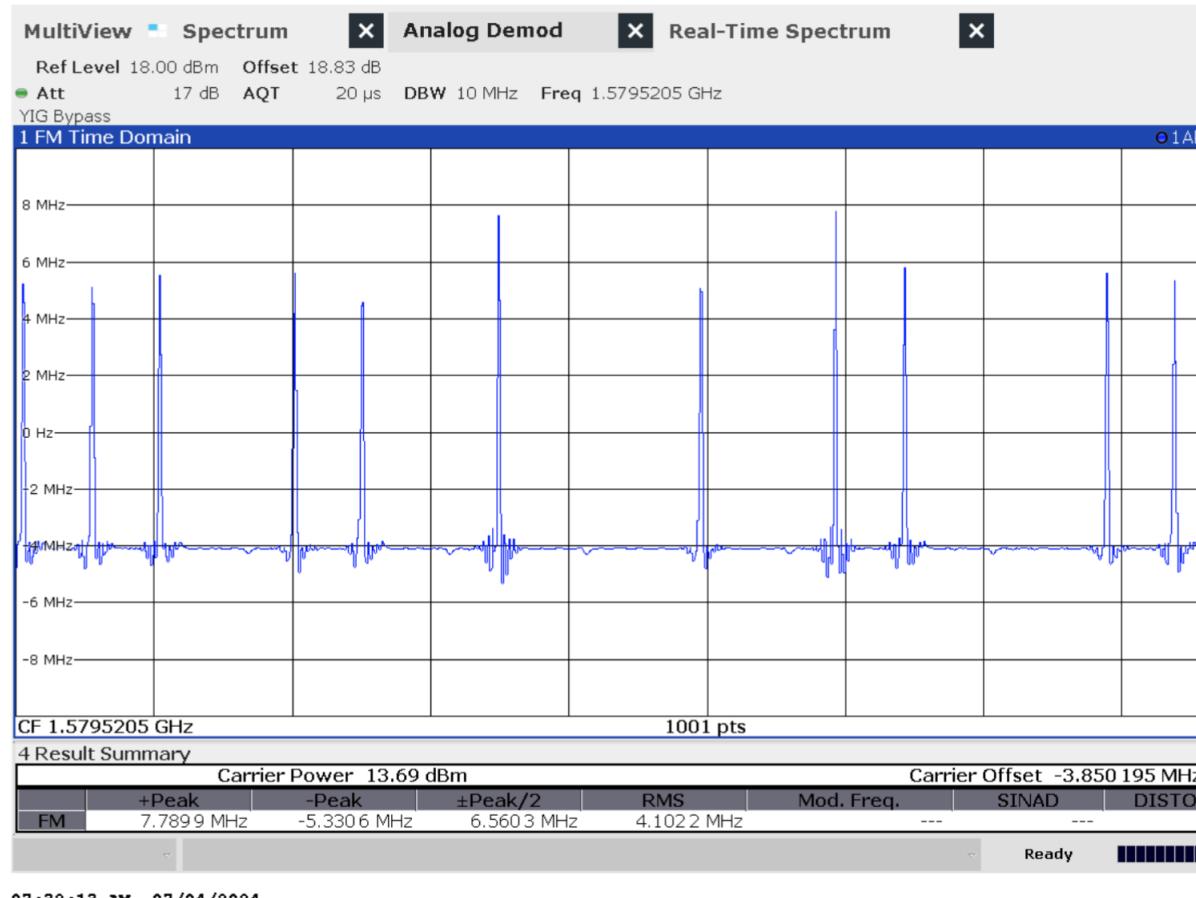


Figure 1.46: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT47

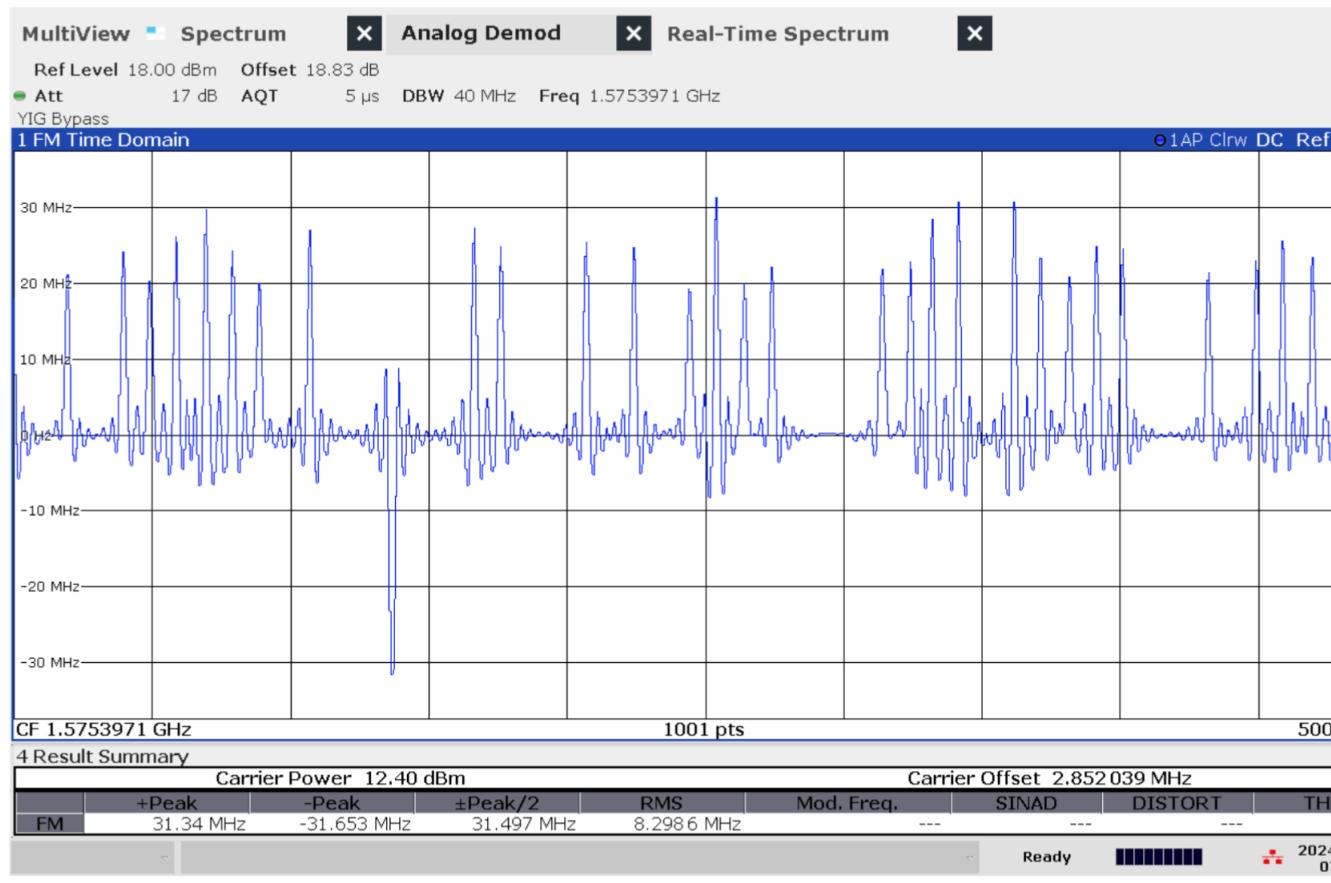


Figure 1.47: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)



Figure 1.48: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT49

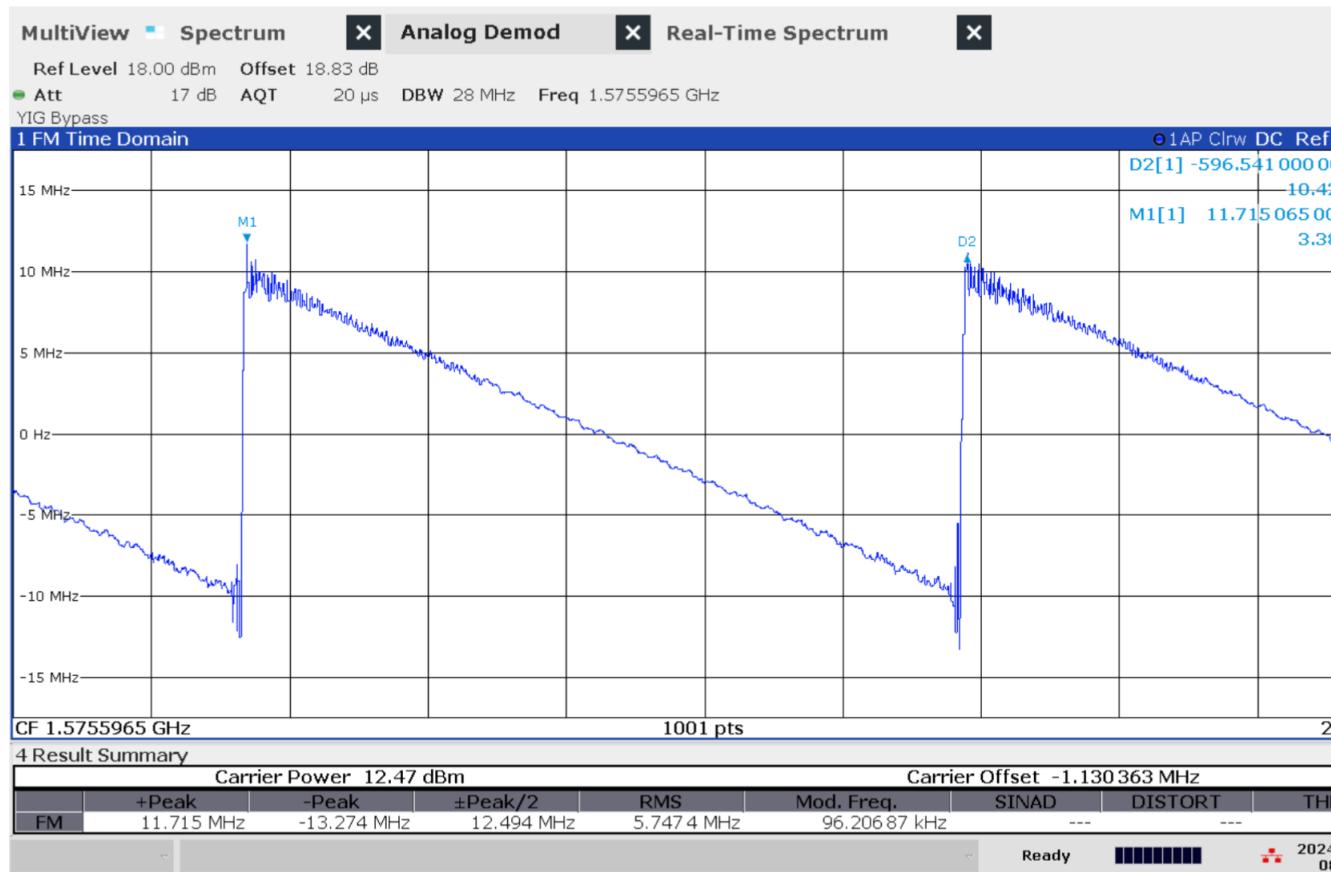


Figure 1.49: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

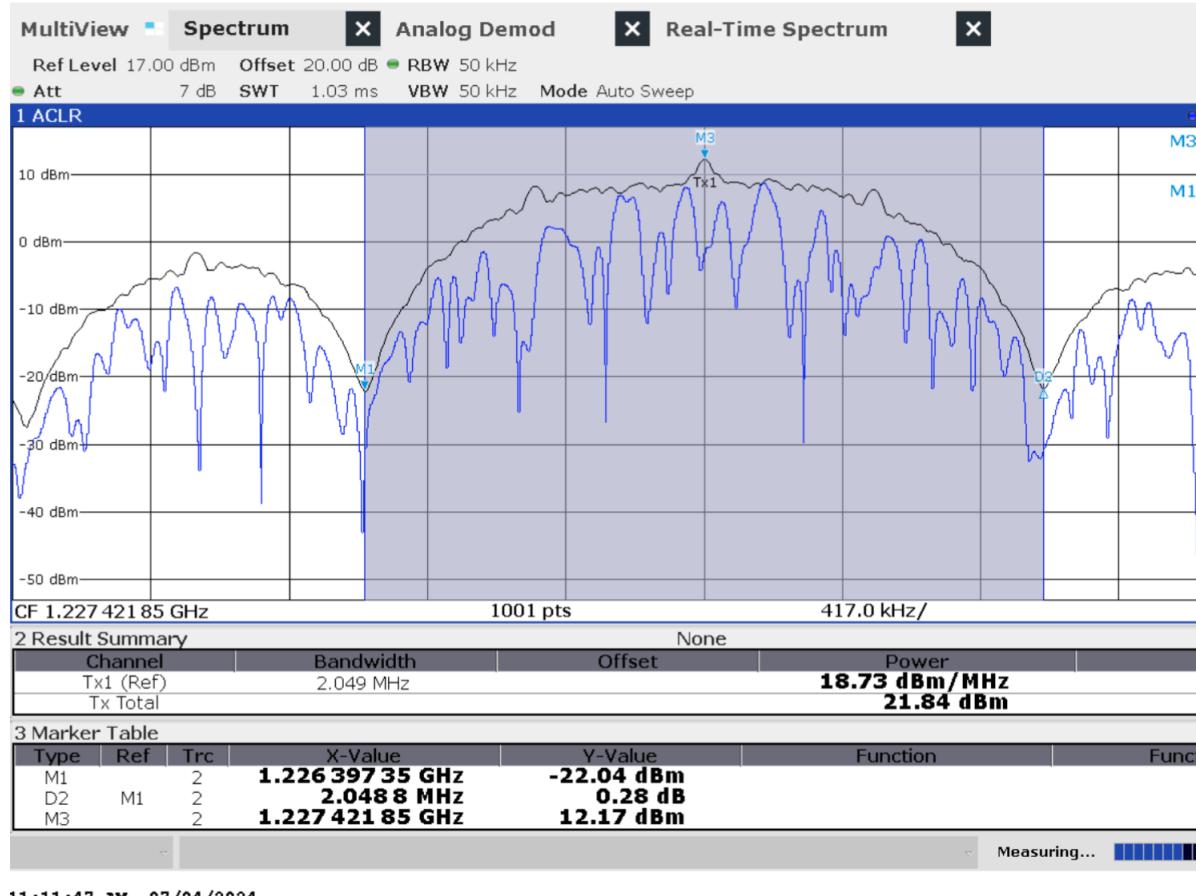


Figure 1.50: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

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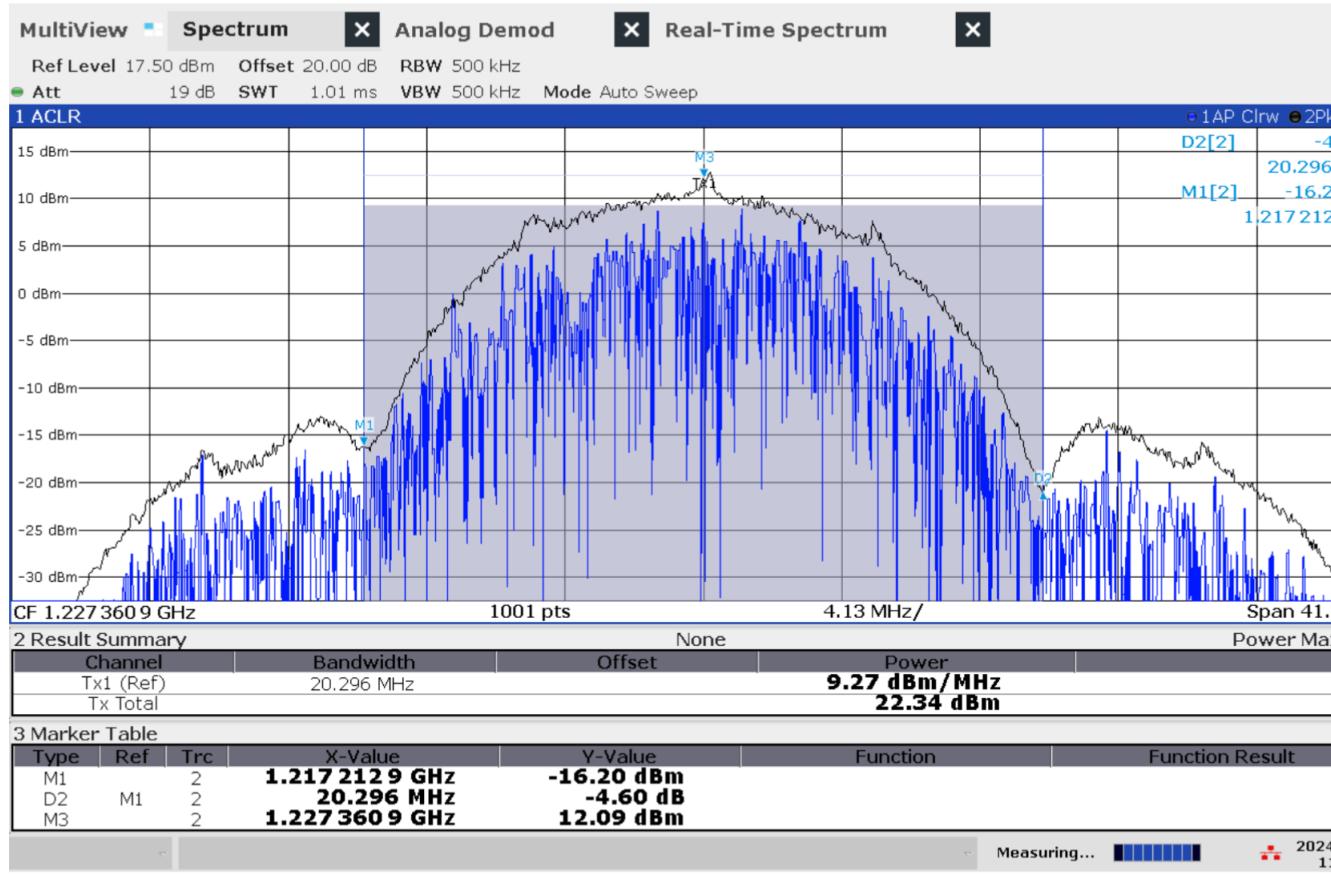


Figure 1.51: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

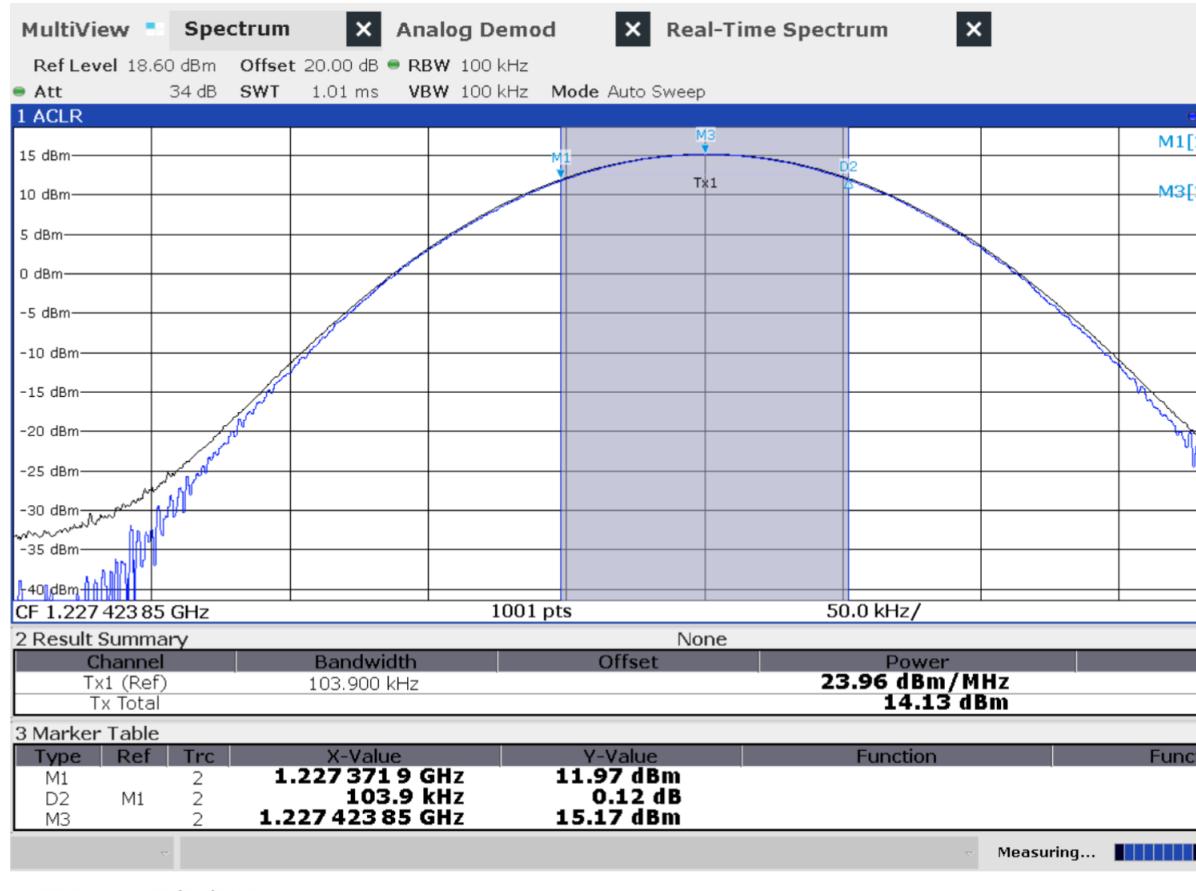


Figure 1.52: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

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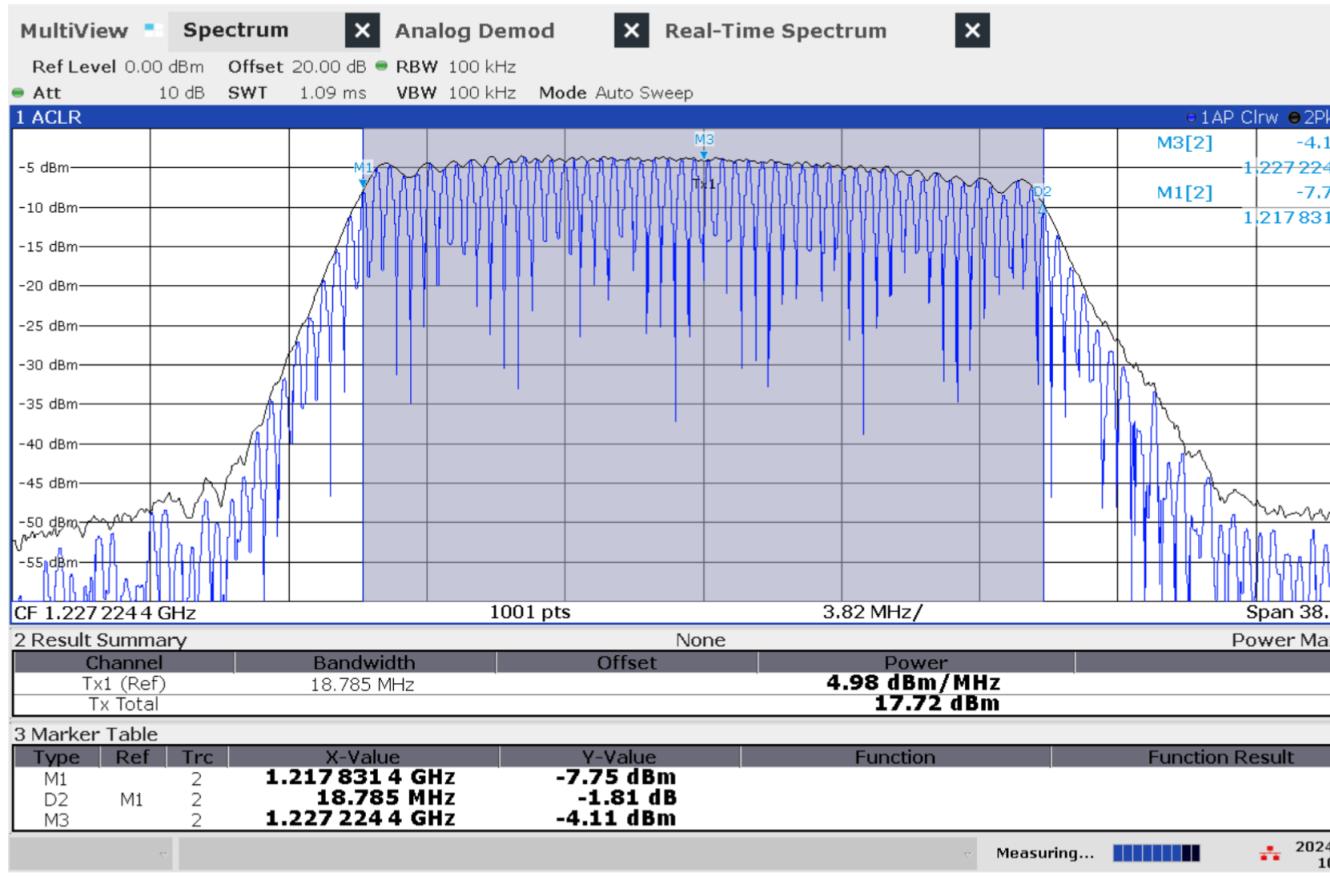


Figure 1.53: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)

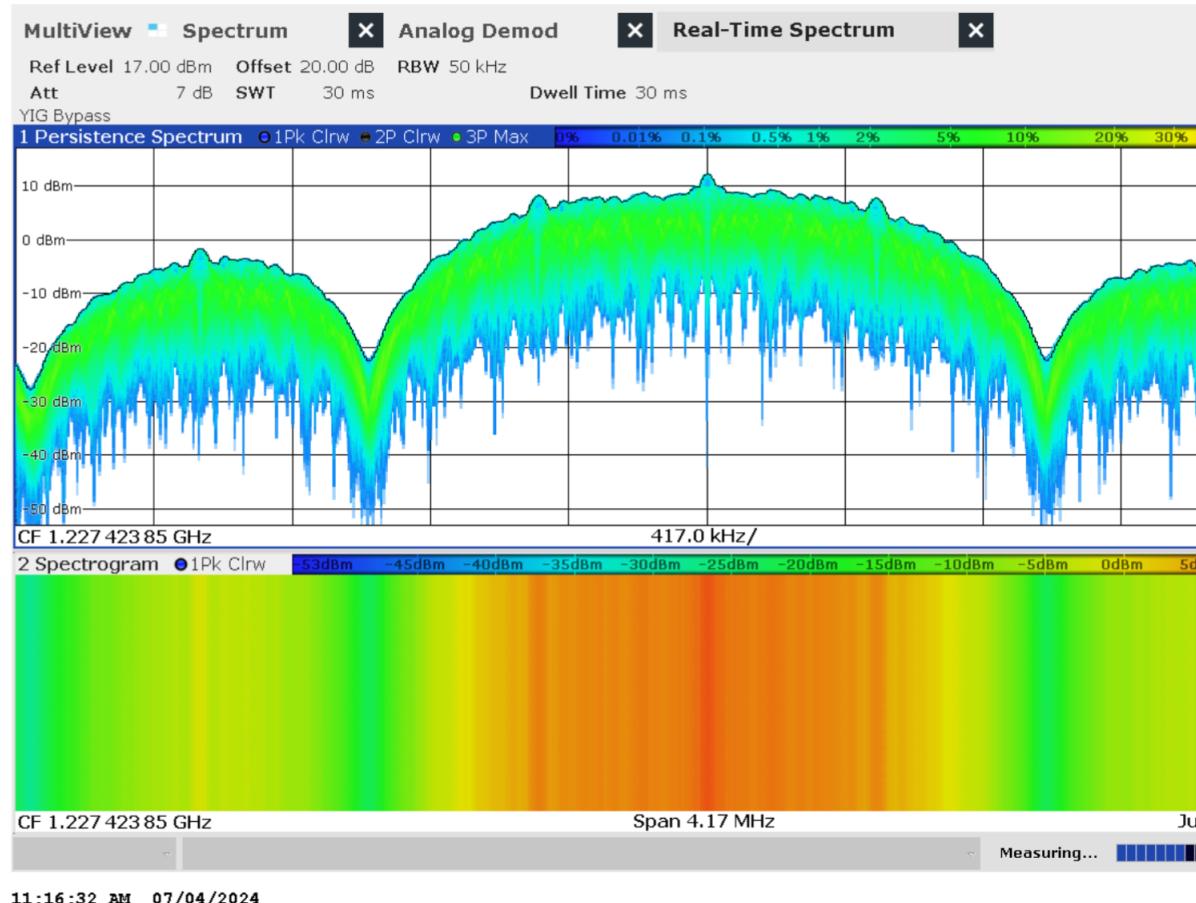


Figure 1.54: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT55

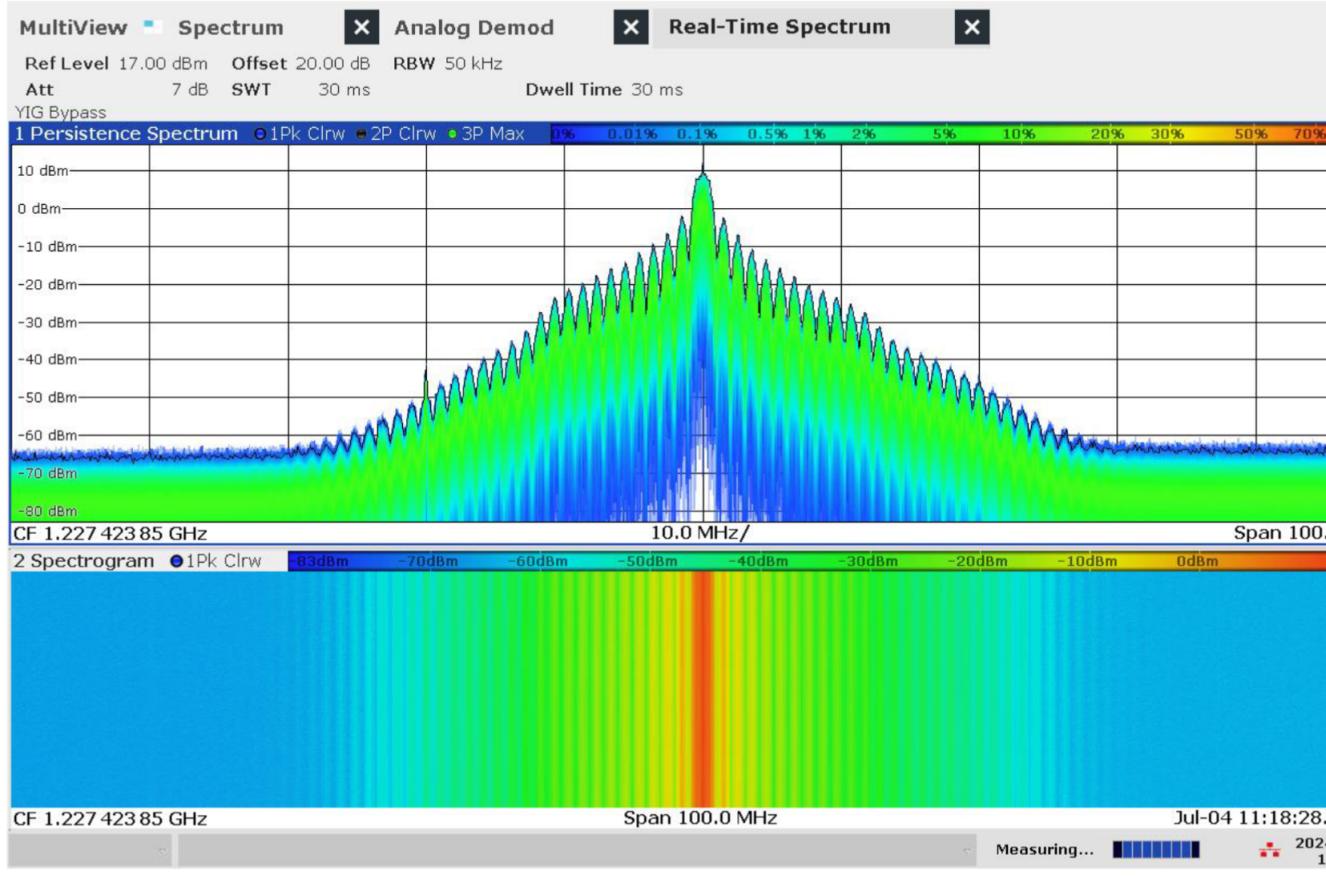


Figure 1.55: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

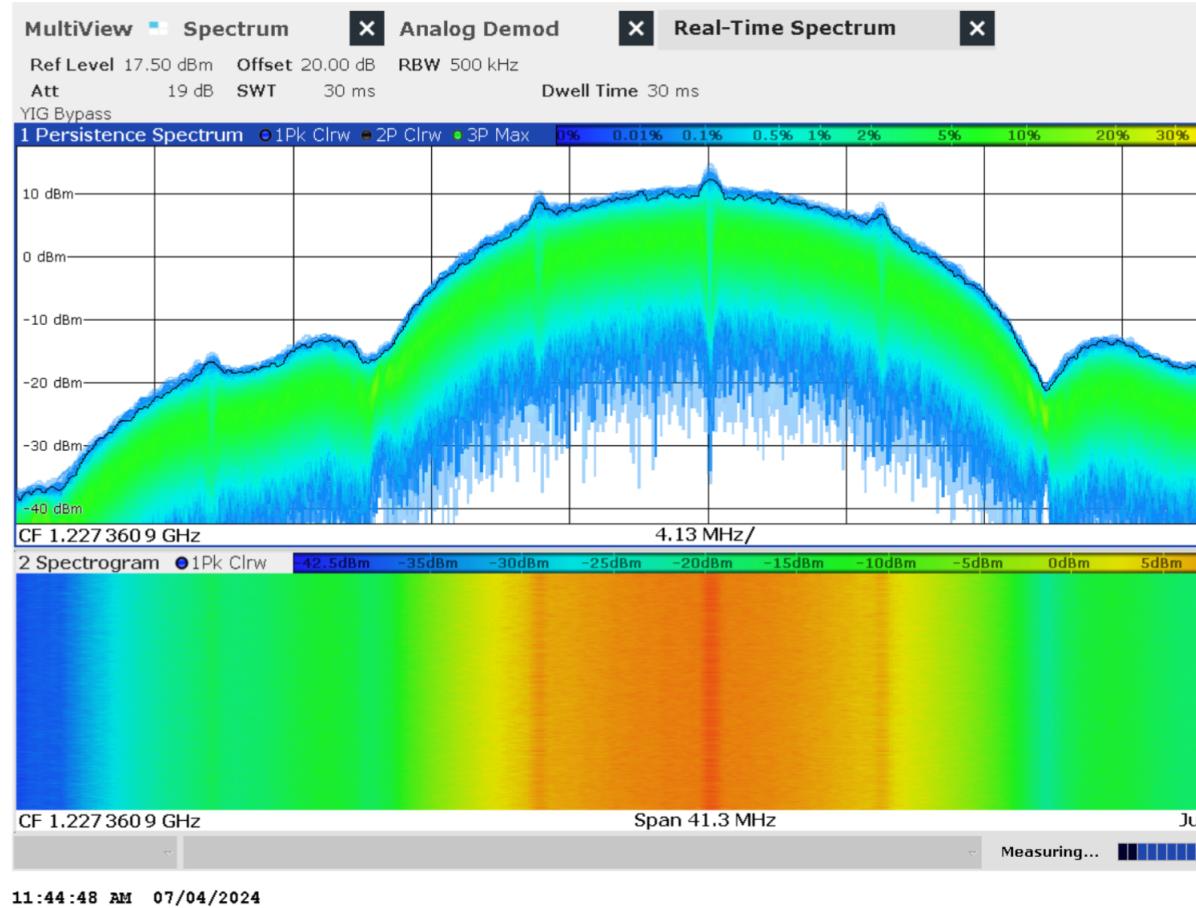


Figure 1.56: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

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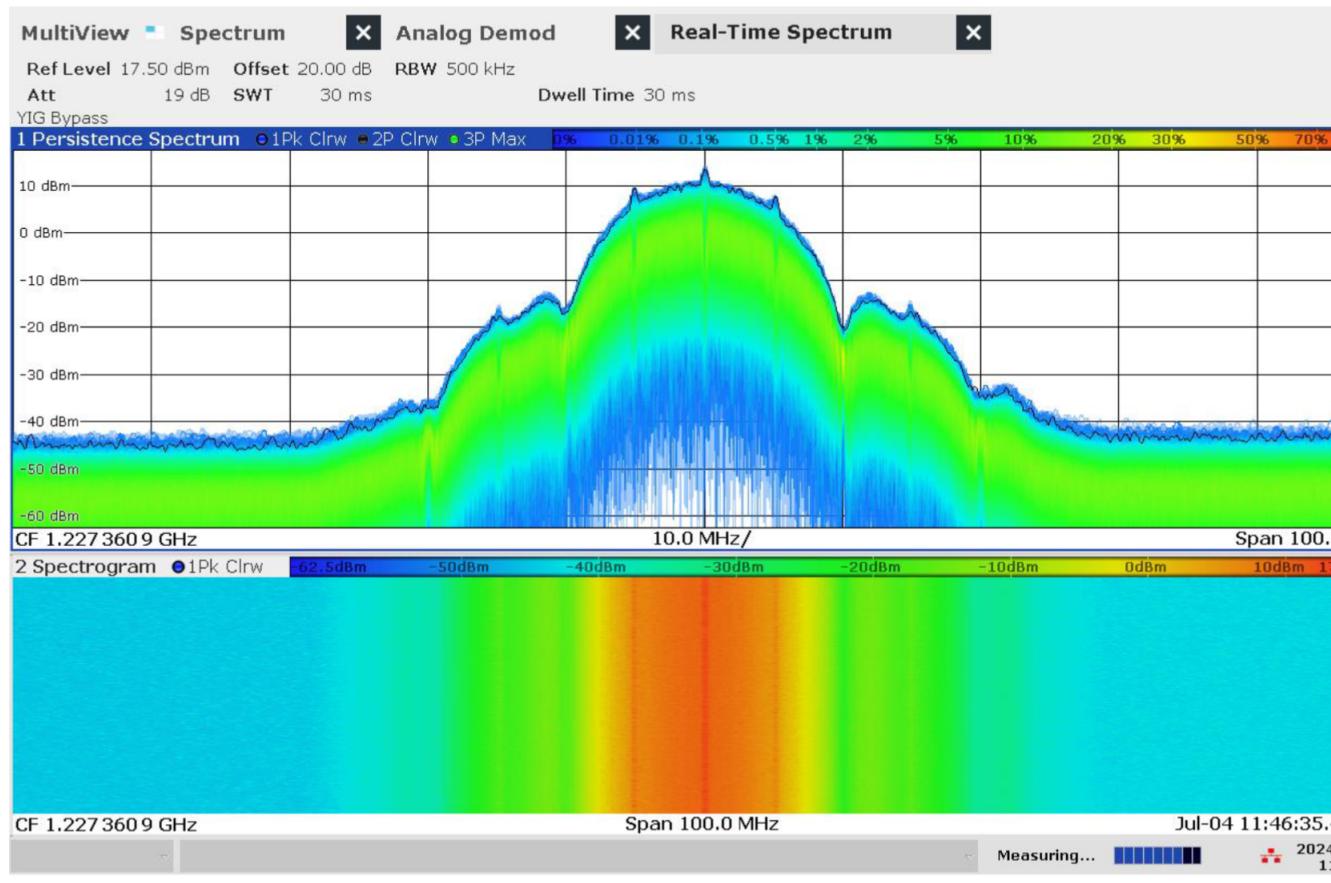


Figure 1.57: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

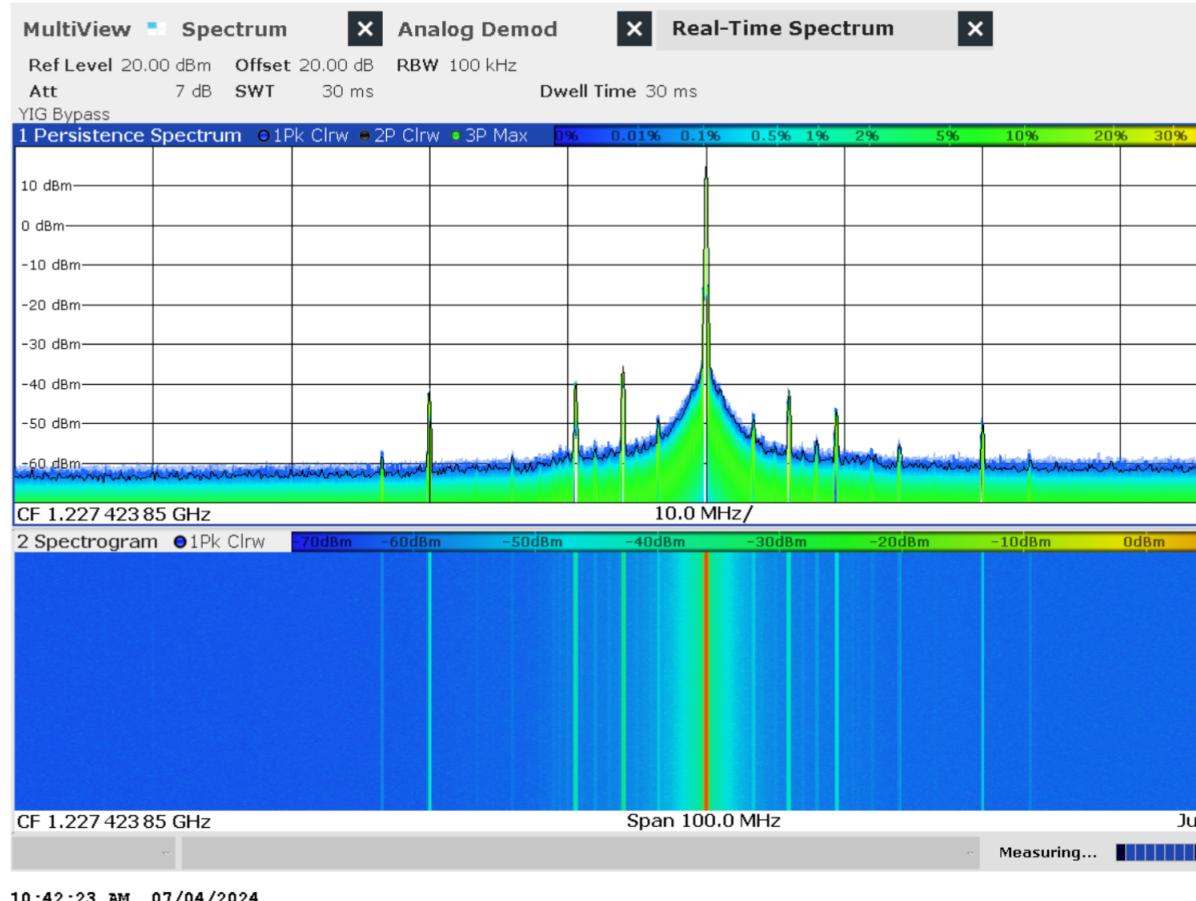


Figure 1.58: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT59

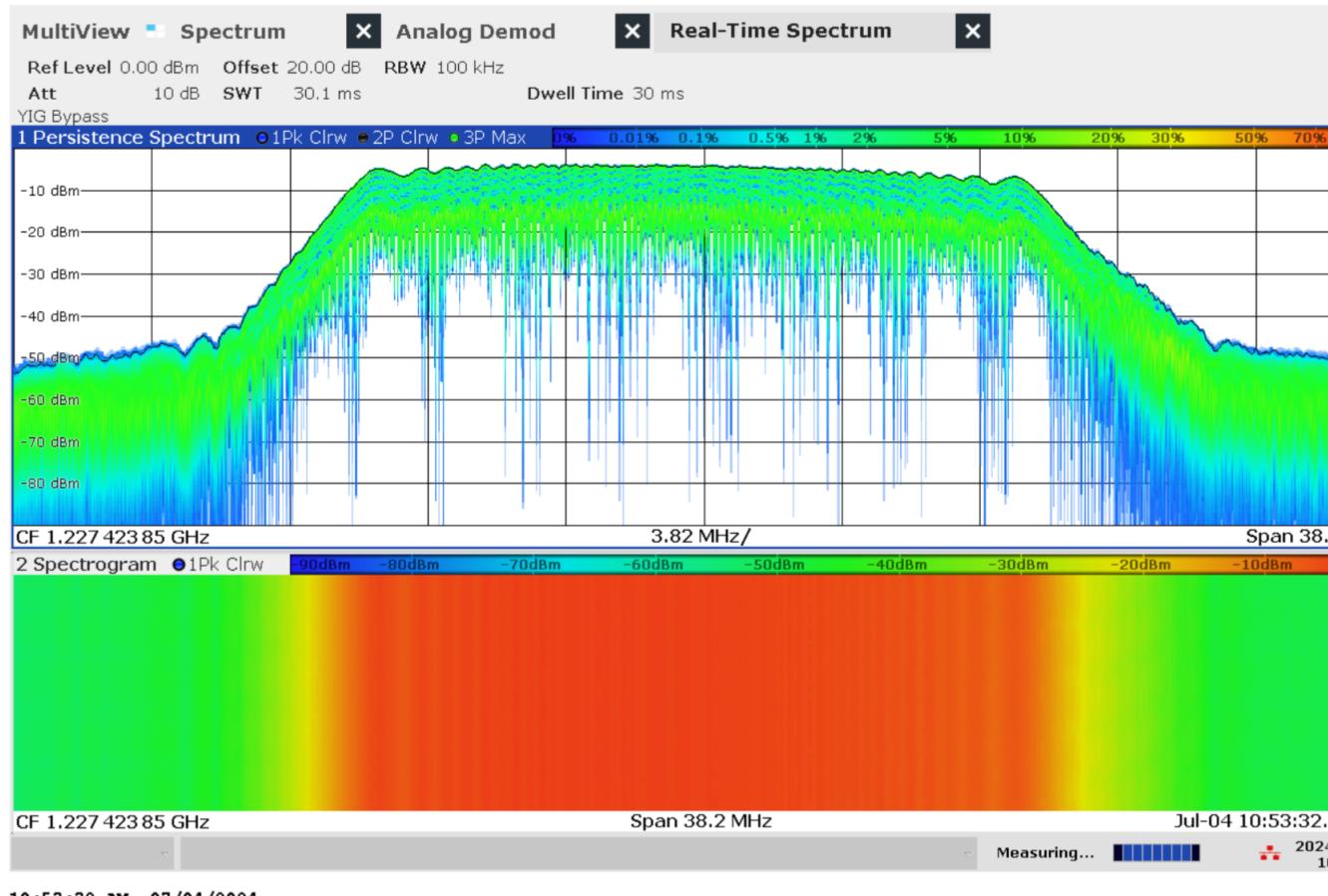


Figure 1.59: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)



Figure 1.60: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

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Figure 1.61: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

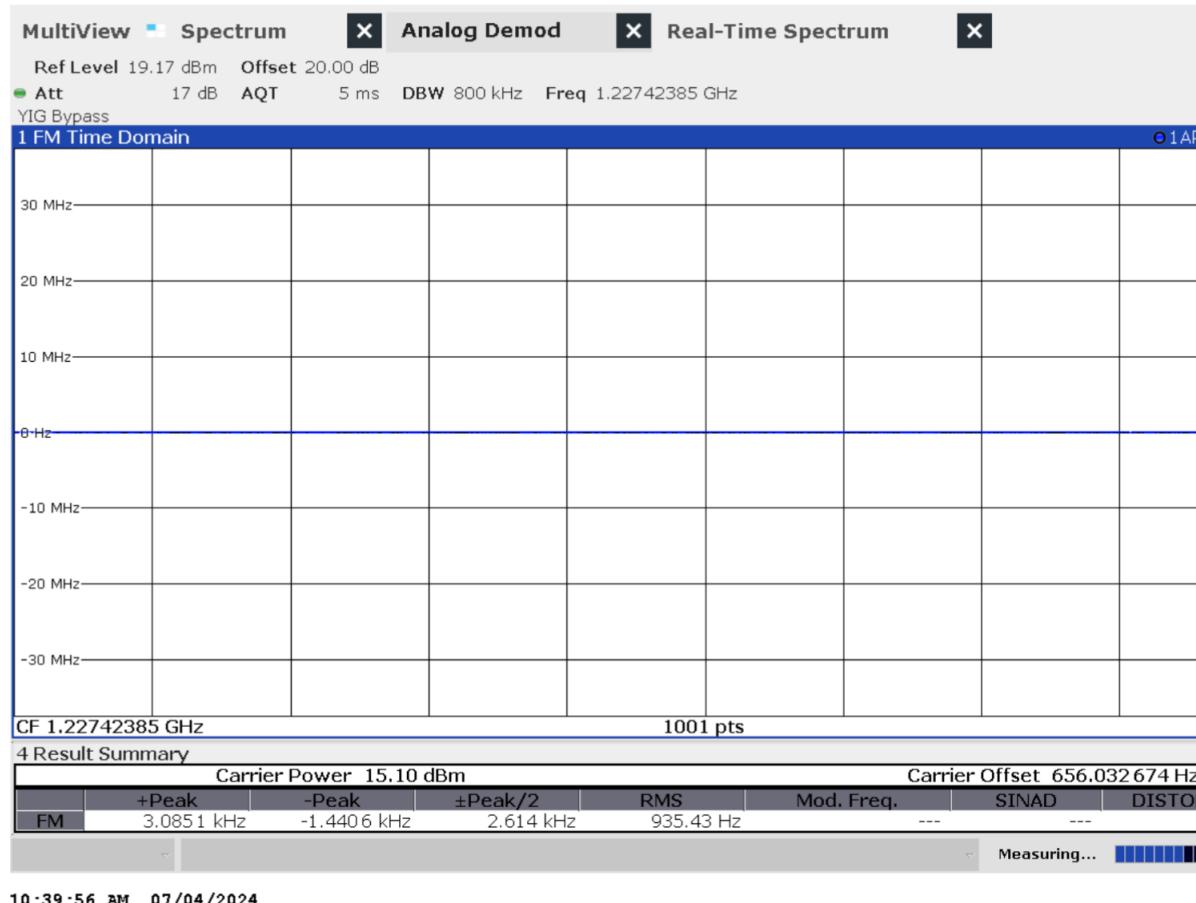


Figure 1.62: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

1.1. APPENDIX G - TECHNICAL DETAILS ON JAMMER EQUIPMENT63



Figure 1.63: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)