SAFRAN FEDERAL SYSTEMS

Wf08 Latest

RF Validation Report

January 16, 2024

SFS Proprietary

TABLE OF CONTENTS

1. Introduction

After the Wavefront (WF) system is fully calibrated, the RF Validation procedure is performed. This procedure is a collection of tests that are used to validate different RF characteristics of the WF. For most of the tests, each WF Element is directly connected to an input channel on a Keysight Infiniium EXR-Series Oscilloscope that is equipped with the PathWave Vector Signal Analysis (VSA) software. This software enables the direct measurement of the frequency spectrum as well as broadband phase alignments. For some tests, a Field Fox Spectrum Analyzer is needed. The RF Validation procedure automates control of the WF system, the EXR scope, and the Field Fox. The results of this procedure are saved and this report is automatically generated.

2. Summary

The table below is a high-level overview and statistical summary of some of the RF validation tests performed. Not every RF validation test is represented because a statistical summary does not make sense for some of the tests.

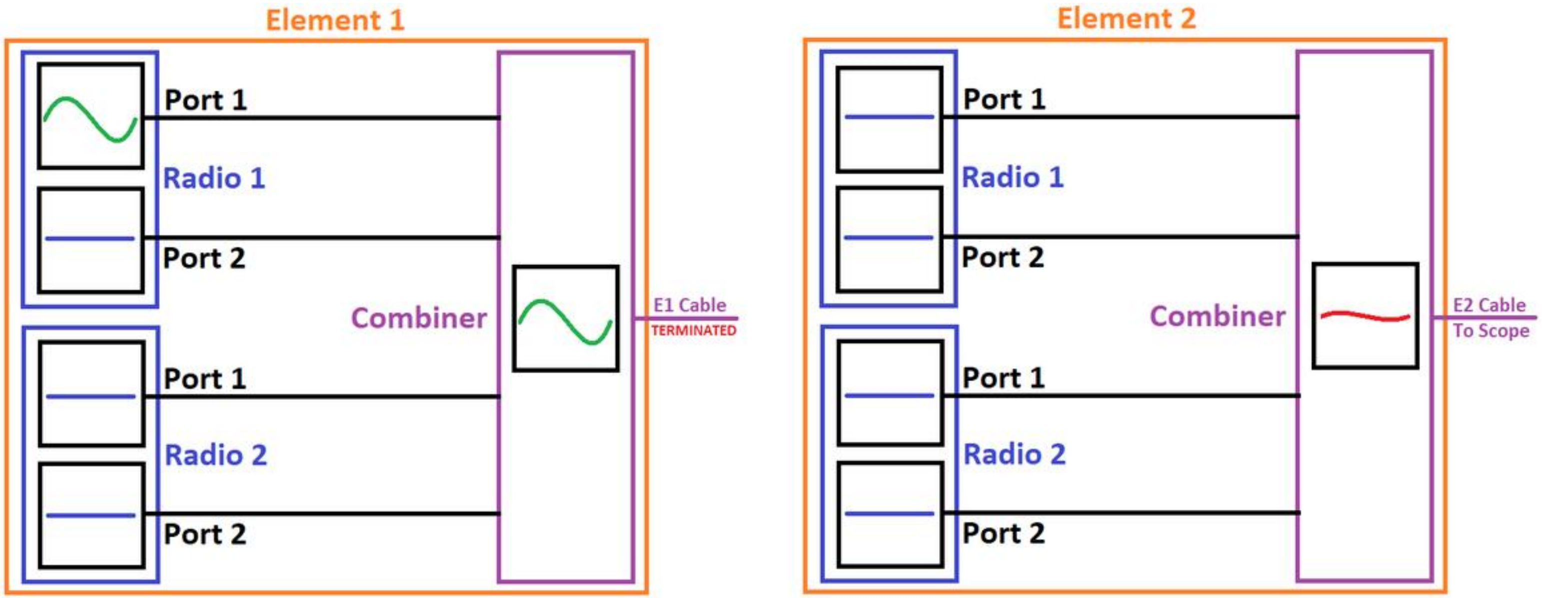
In general, each row in this table represents the statistical analysis across all bands, waveforms, and elements for a specified test. For individual band, waveform, or element data, please refer to the corresponding test section of the report.

	Mean	Std	Min	Max
Isolation [dBc]	-101.64	7.21	-118.71	-85.89
SFDR [dBc]	-74.43	3.32	-78.39	-68.94
LO Leakage [dBc]	-71.16	7.98	-96.95	-59.93
Power Alignment [dB]	0.35	0.22	0.03	1.15
Power Accuracy [dB]	-0.13	0.31	-0.92	0.93
Power Linearity [dB]	0.04	0.27	-0.84	0.74
Time Domain [°]	0.39	0.31	-1.88	2.61
Phase Alignment [°]	0.61	0.41		2.46

3. Isolation

The purpose of this test is to **measure inter-element isolation** of the WF. In other words, this measurement is a **quantification of how much the CW signal on element 1 bleeds through onto the other elements** (see image below for clarification). To do this, all WF elements (except for the first element) are connected to the EXR Scope. The First element is terminated using a 50 Ohm terminator; It cannot be connected to the EXR Scope because neighboring channels of the EXR Scope have less isolation than the WF. This means that the inter-channel isolation of the EXR Scope would be measured and not the inter-element isolation of the WF.

The CW signal on the first WF element is enabled while keeping the other elements disabled. The power of the CW tones found on the disabled channels is measured relative to the set power of the CW signal on element 1. This measurement is the inter-element (M-1) isolation. This measurement is repeated for each L-Band and frequency of the WF. The measurements are tabulated below along with the associated screen captures of the EXR Scope.



Inter-Element Isolation

The isolation measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
Isolation < -110.00 dBc	-110.00 dBc ≥ Isolation ≥ -90.00 dBc	-90.00 dBc ≥ Isolation ≥ -85.00 dBc	Isolation ≥ -85.00 dBc

3.1. Data Table

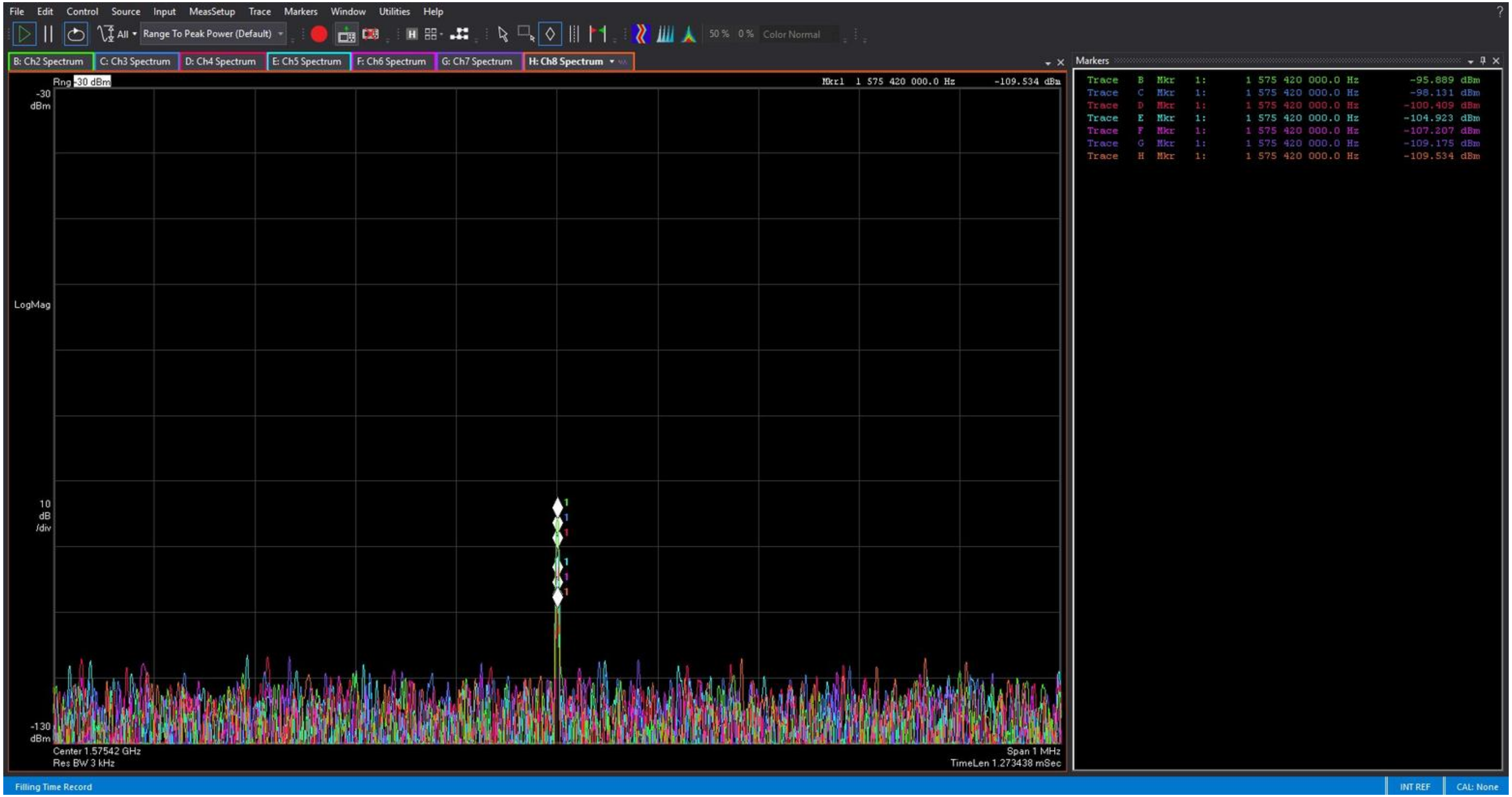
Isolation	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
L1	-85.89	-88.13	-90.41	-94.92	-97.21	-99.18	-99.53
L2	-108.59	-98.22	-96.86	-109.14	-104.82	-102.77	-106.54
L5	-99.80	-104.54	-98.83	-118.71	-106.82	-114.39	-104.71
L6	-99.41	-106.46	-107.82	-99.64	-98.52	-104.06	-99.88

Across all frequency bands and elements, the statistics are:

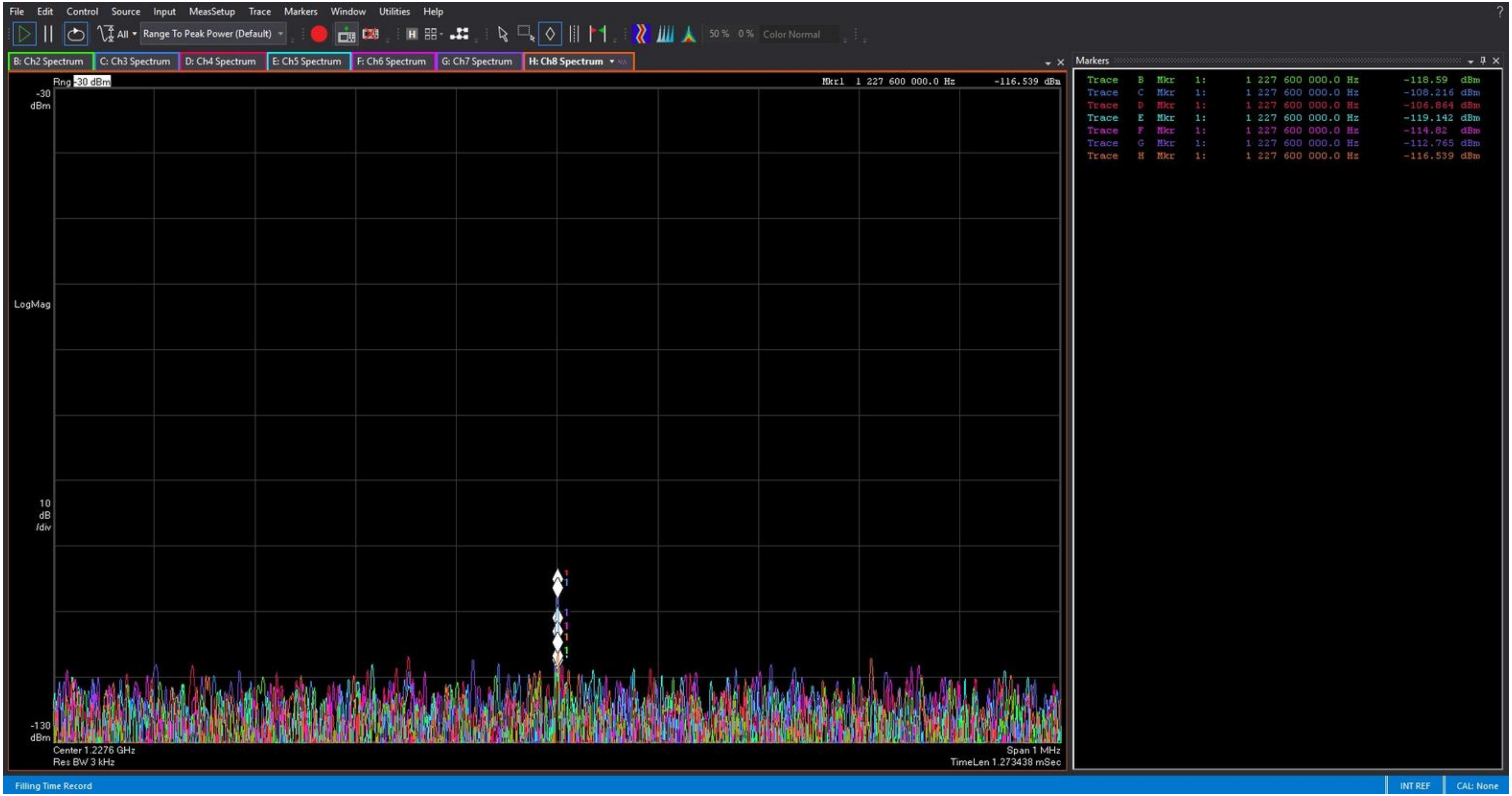
Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-101.64	7.21	-118.71	-85.89

3.2. Scope Captures

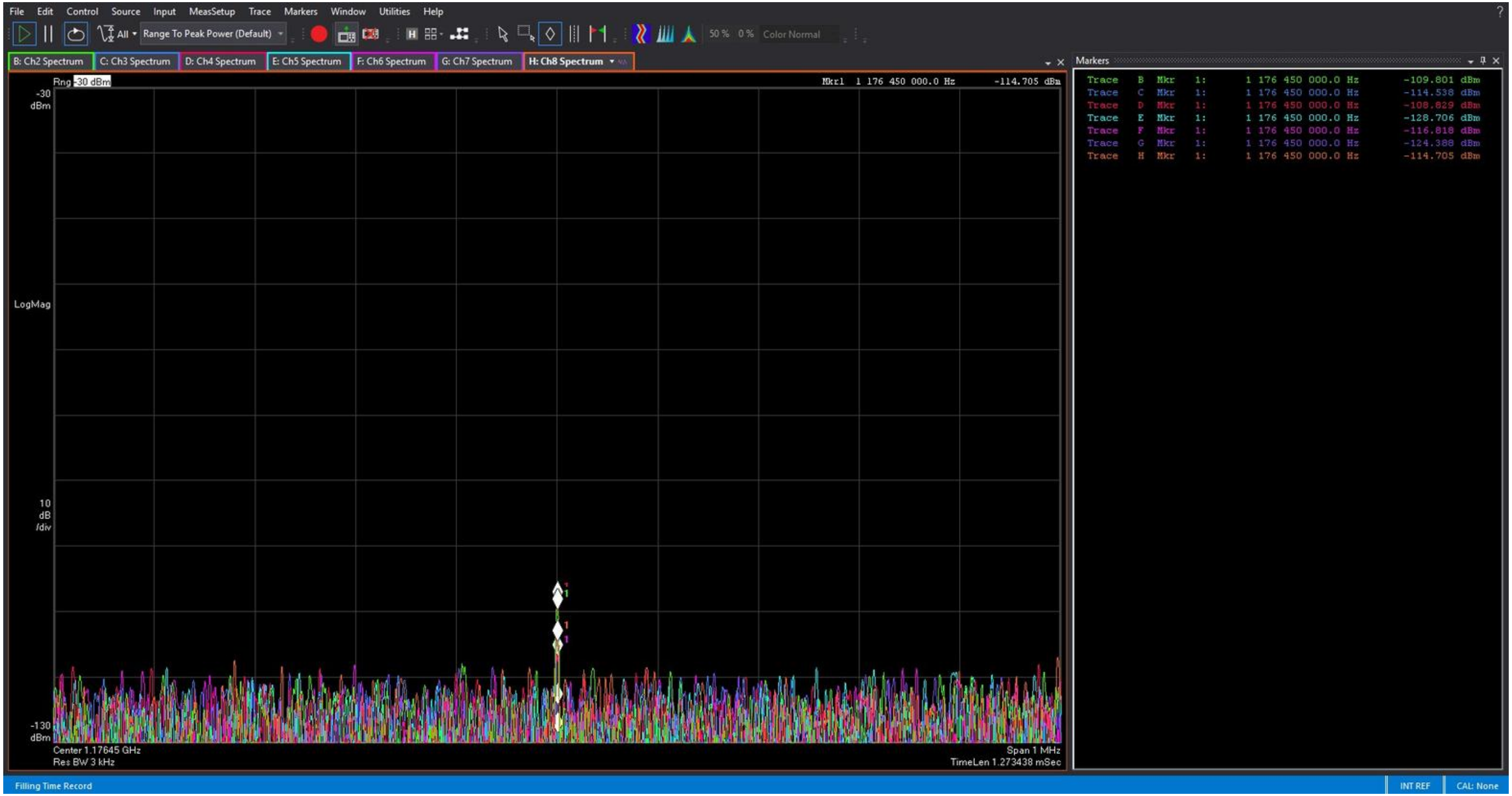
3.2.1. L1



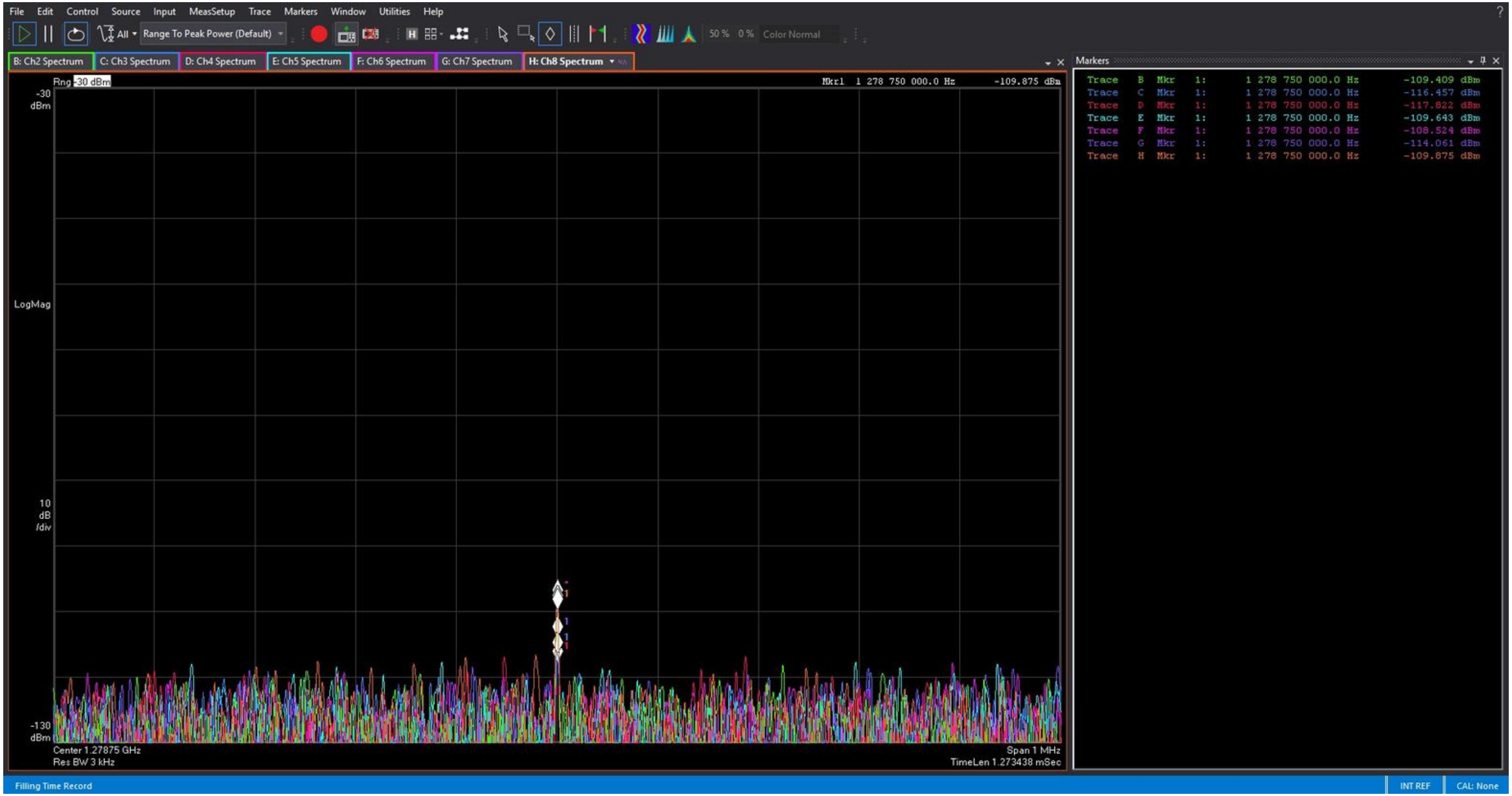
3.2.2. L2


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: Ch5 Spectrum
F: Ch6 Spectrum
G: Ch7 Spectrum
H: Ch8 Spectrum
Rng -30 dBm
Mkr1 1 227 600 000.0 Hz -116.539 dBm
-30 dBm
LogMag
10 dB /div
-130 dBm
Center 1.2276 GHz
Res BW 3 kHz
Span 1 MHz
TimeLen 1.273438 mSec
Markers
Trace B Mkr 1: 1 227 600 000.0 Hz -118.59 dBm
Trace C Mkr 1: 1 227 600 000.0 Hz -108.216 dBm
Trace D Mkr 1: 1 227 600 000.0 Hz -106.864 dBm
Trace E Mkr 1: 1 227 600 000.0 Hz -119.142 dBm
Trace F Mkr 1: 1 227 600 000.0 Hz -114.82 dBm
Trace G Mkr 1: 1 227 600 000.0 Hz -112.765 dBm
Trace H Mkr 1: 1 227 600 000.0 Hz -116.539 dBm
Filling Time Record
INT REF
CAL: None

3.2.3. L5

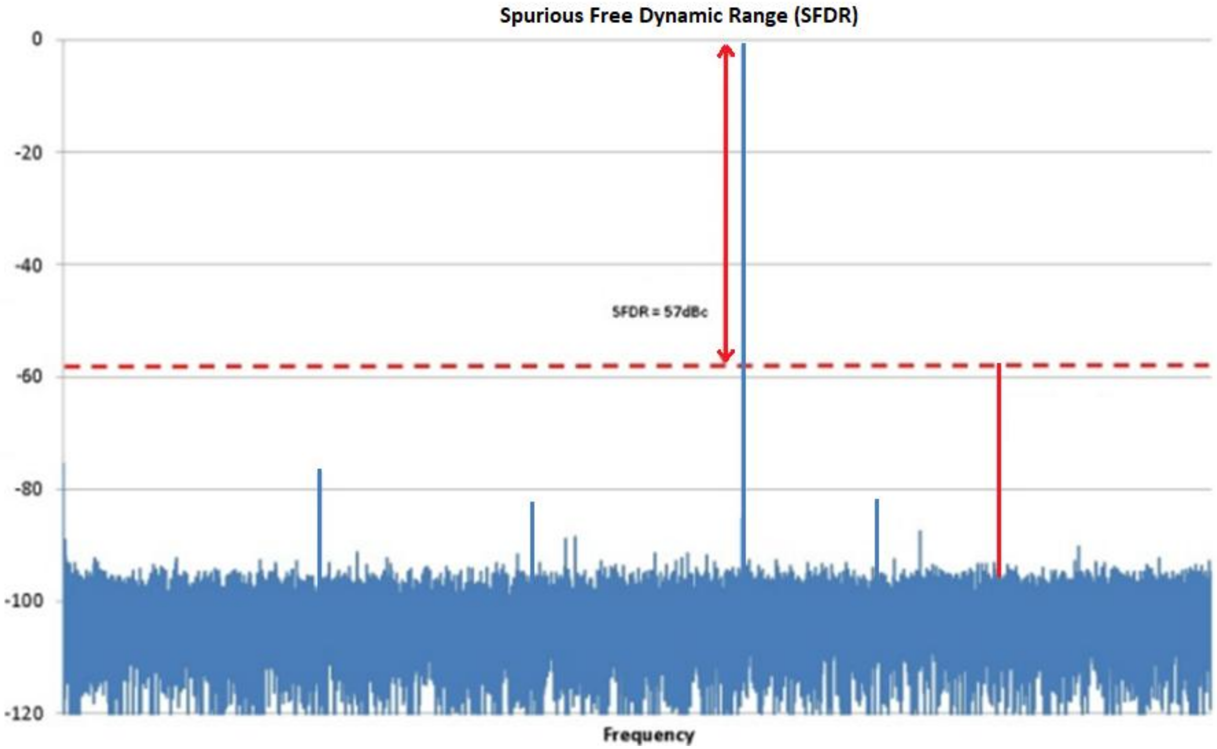

File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: Ch5 Spectrum
F: Ch6 Spectrum
G: Ch7 Spectrum
H: Ch8 Spectrum
Rng -30 dBm
Mkr1 1 176 450 000.0 Hz -114.705 dBm
-30 dBm
LogMag
10 dB /div
-130 dBm
Center 1.17645 GHz
Res BW 3 kHz
Span 1 MHz
TimeLen 1.273438 mSec
Markers
Trace B Mkr 1: 1 176 450 000.0 Hz -109.801 dBm
Trace C Mkr 1: 1 176 450 000.0 Hz -114.538 dBm
Trace D Mkr 1: 1 176 450 000.0 Hz -108.829 dBm
Trace E Mkr 1: 1 176 450 000.0 Hz -128.706 dBm
Trace F Mkr 1: 1 176 450 000.0 Hz -116.818 dBm
Trace G Mkr 1: 1 176 450 000.0 Hz -124.388 dBm
Trace H Mkr 1: 1 176 450 000.0 Hz -114.705 dBm
Filling Time Record
INT REF
CAL: None

3.2.4. L6


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: Ch5 Spectrum
F: Ch6 Spectrum
G: Ch7 Spectrum
H: Ch8 Spectrum
Markers
Rng -30 dBm
Mkr1 1 278 750 000.0 Hz -109.875 dBm
-30 dBm
LogMag
10 dB /div
-130 dBm
Center 1.27875 GHz
Res BW 3 kHz
Span 1 MHz
TimeLen 1.273438 mSec
Trace B Mkr 1: 1 278 750 000.0 Hz -109.409 dBm
Trace C Mkr 1: 1 278 750 000.0 Hz -116.457 dBm
Trace D Mkr 1: 1 278 750 000.0 Hz -117.822 dBm
Trace E Mkr 1: 1 278 750 000.0 Hz -109.643 dBm
Trace F Mkr 1: 1 278 750 000.0 Hz -108.524 dBm
Trace G Mkr 1: 1 278 750 000.0 Hz -114.061 dBm
Trace H Mkr 1: 1 278 750 000.0 Hz -109.875 dBm
Filling Time Record
INT REF
CAL: None

4. SFDR

The purpose of this test is to **measure the relative power and frequency of the largest in-band, un-modulated spur on each element**. To do this, all WF elements are first connected to the EXR Scope and then enabled. A marker is put on the CW tone for each element along with a delta marker on the largest spur found within a 20 MHz span (see image on next page for clarification). The delta marker provides the power and frequency of this spur relative to each elements' CW tone. This measurement is the Spurious Free Dynamic Range (SFDR) and it is repeated for each L-Band and frequency of the WF. The measurements are tabulated below along with the associated screen captures of the EXR Scope.



Depiction of Spurious Free Dynamic Range (SFDR)

This test ignores any spurs found within 500 KHz of each CW tone because a phase noise measurement would be more accurate for this region. This test also ignores the less powerful in-band un-modulated spurs as these are shown in the Unmodulated Spurs section.

The sfdr measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
SFDR < -78.00 dBc	-78.00 dBc ≥ SFDR ≥ -70.00 dBc	-70.00 dBc ≥ SFDR ≥ -65.00 dBc	SFDR ≥ -65.00 dBc

Across all elements and bands, the statistical results of this test are:

Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-74.43	3.32	-78.39	-68.94

4.1. L1

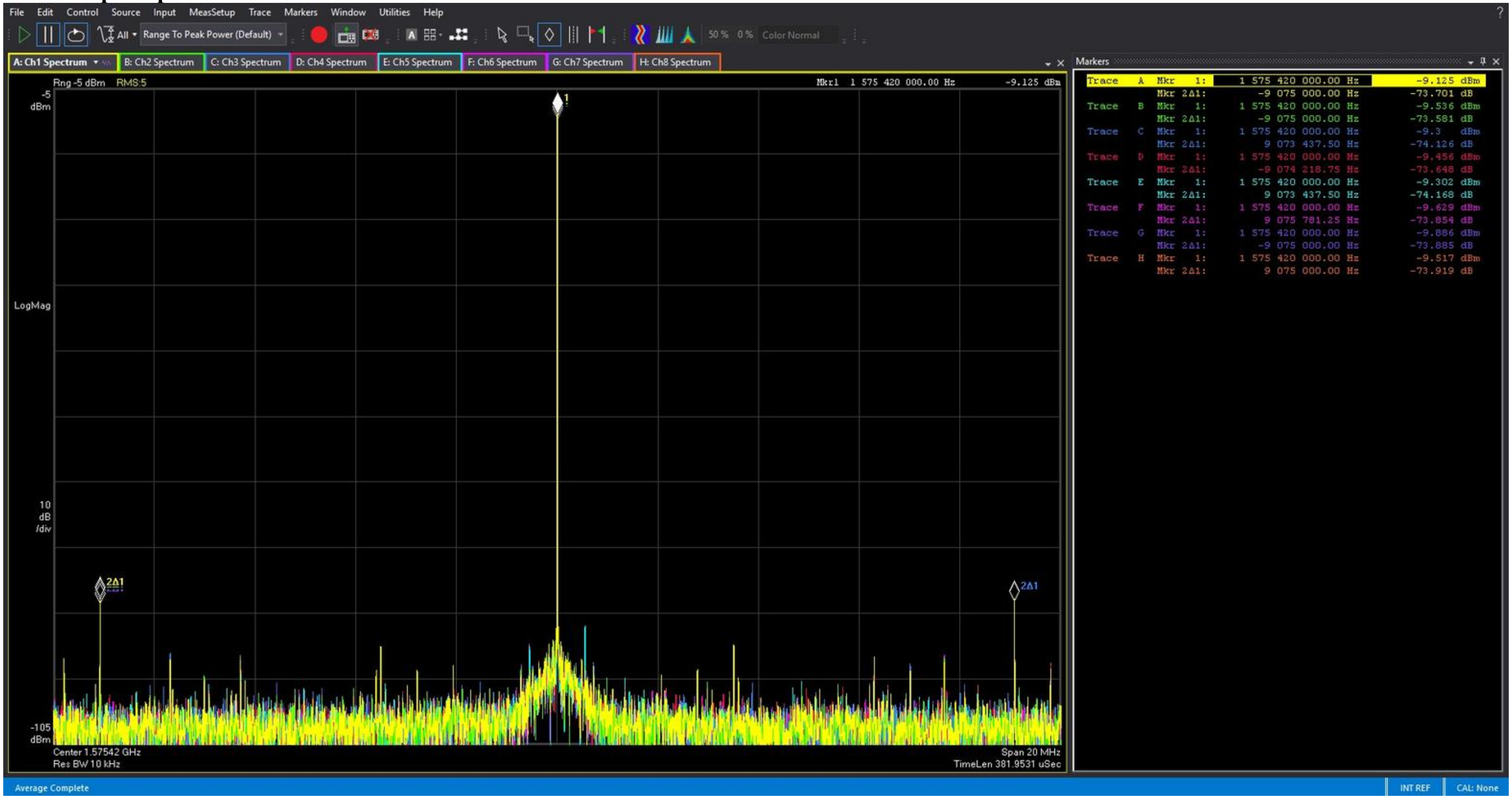
4.1.1. Data Table

SFDR	CW Pwr [dBm]	CW Freq [MHz]	Spur Pwr [dBm]	Spur Offset [MHz]	SFDR [dBc]
E1	-9.13	1575.42	-83.12	-9.07	-73.99
E2	-9.54	1575.42	-82.81	-9.07	-73.27
E3	-9.30	1575.42	-83.07	9.07	-73.77
E4	-9.46	1575.42	-83.36	-9.07	-73.90
E5	-9.30	1575.42	-83.25	9.07	-73.95
E6	-9.63	1575.42	-83.22	9.07	-73.59
E7	-9.89	1575.42	-82.79	-9.07	-72.91
E8	-9.52	1575.42	-82.91	9.07	-73.39

Across all elements for L1, the statistics are:

Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-73.60	0.38	-73.99	-72.91

4.1.2. Scope Capture



4.2. L2

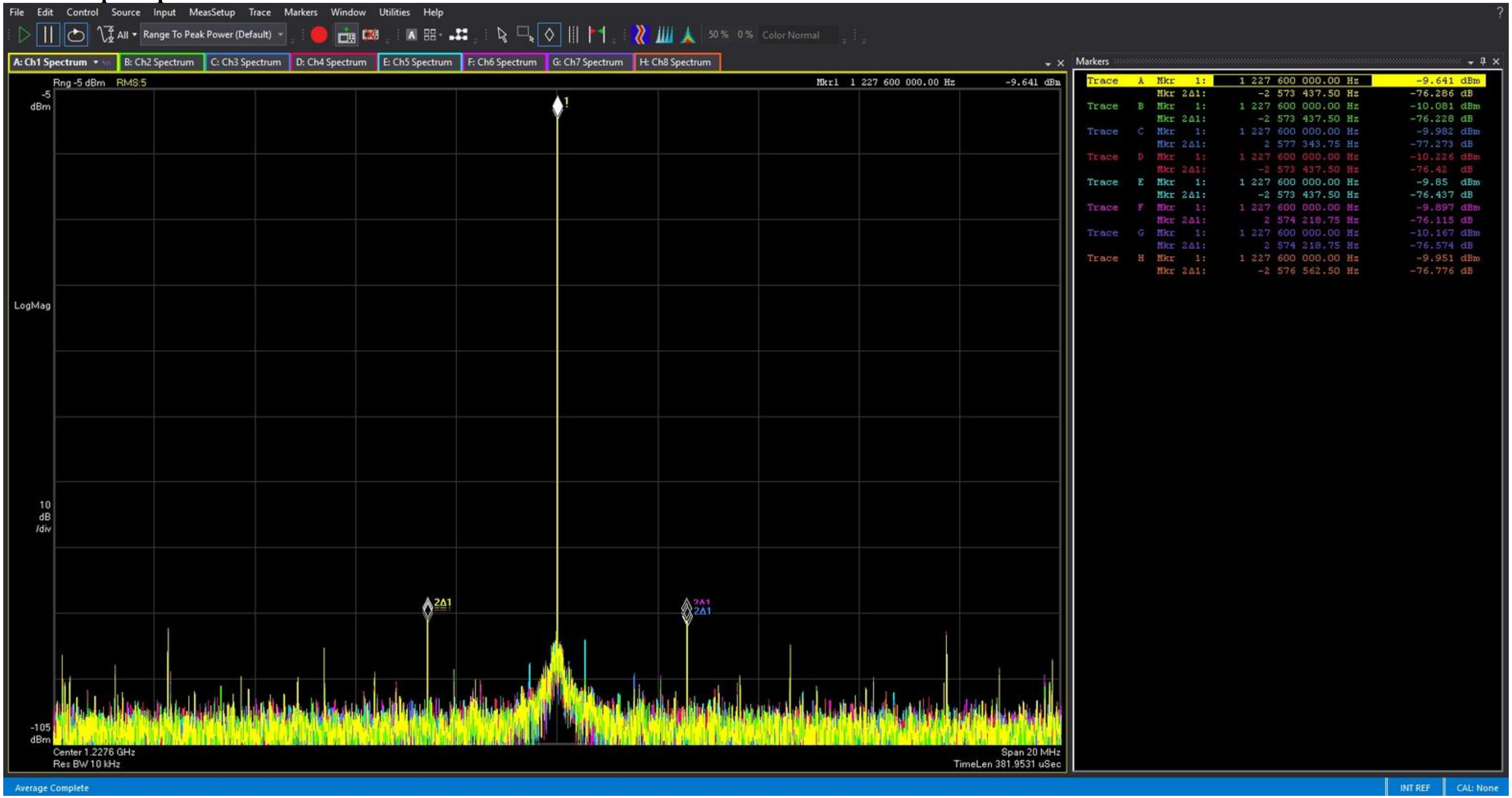
4.2.1. Data Table

SFDR	CW Pwr [dBm]	CW Freq [MHz]	Spur Pwr [dBm]	Spur Offset [MHz]	SFDR [dBc]
E1	-9.64	1227.60	-86.31	-2.57	-76.67
E2	-10.08	1227.60	-86.46	-2.57	-76.38
E3	-9.98	1227.60	-86.56	2.57	-76.58
E4	-10.23	1227.60	-86.29	-2.57	-76.06
E5	-9.85	1227.60	-85.92	-2.57	-76.07
E6	-9.90	1227.60	-86.71	2.57	-76.81
E7	-10.17	1227.60	-86.30	2.57	-76.14
E8	-9.95	1227.60	-87.52	-2.57	-77.57

Across all elements for L2, the statistics are:

Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-76.53	0.50	-77.57	-76.06

4.2.2. Scope Capture



4.3. L5

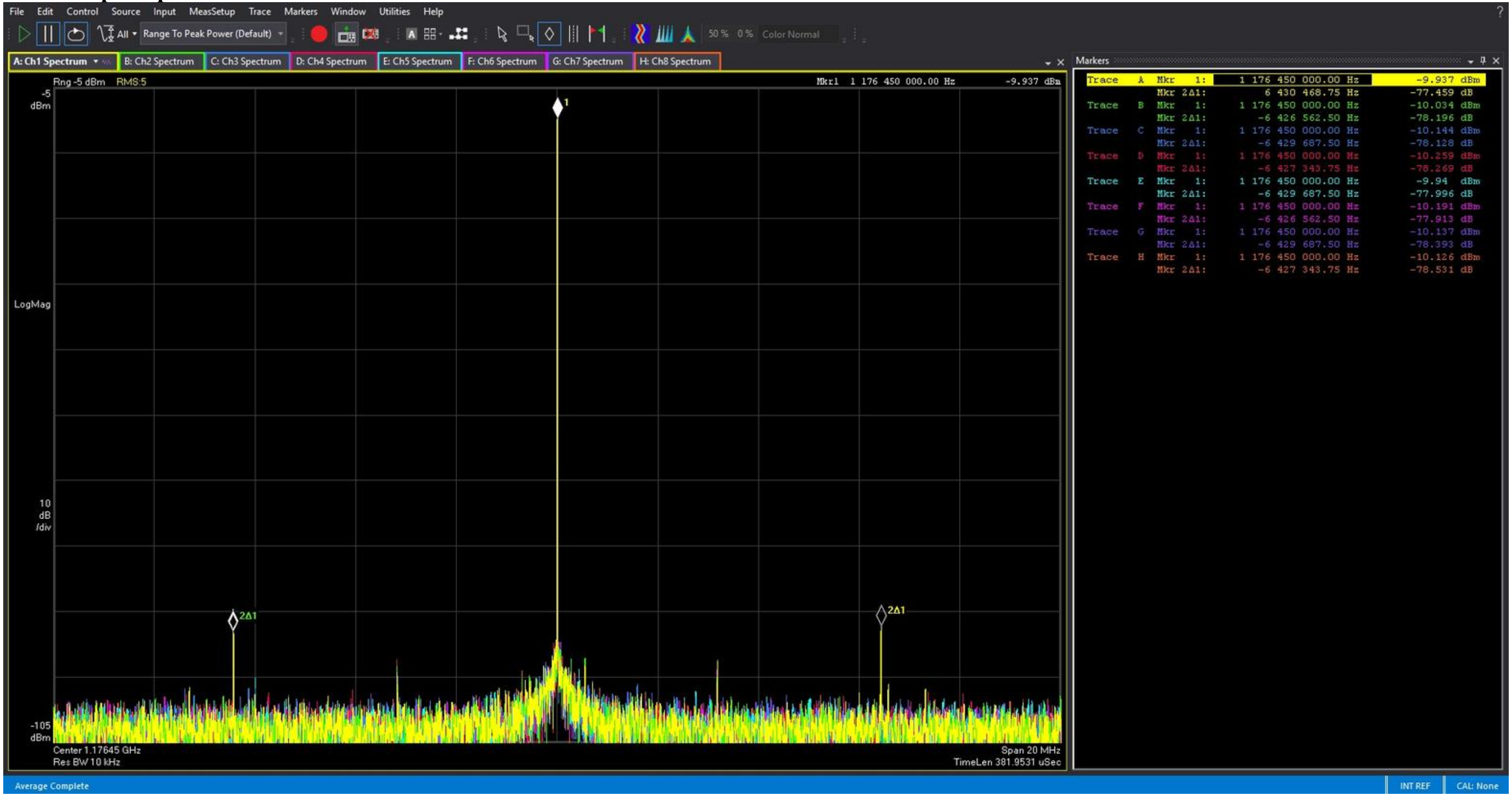
4.3.1. Data Table

SFDR	CW Pwr [dBm]	CW Freq [MHz]	Spur Pwr [dBm]	Spur Offset [MHz]	SFDR [dBc]
E1	-9.94	1176.45	-88.17	6.43	-78.24
E2	-10.03	1176.45	-87.98	-6.42	-77.95
E3	-10.14	1176.45	-88.33	-6.42	-78.19
E4	-10.26	1176.45	-87.89	-6.42	-77.63
E5	-9.94	1176.45	-87.86	-6.42	-77.92
E6	-10.19	1176.45	-88.48	-6.42	-78.29
E7	-10.14	1176.45	-88.53	-6.42	-78.39
E8	-10.13	1176.45	-88.04	-6.42	-77.91

Across all elements for L5, the statistics are:

Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-78.07	0.25	-78.39	-77.63

4.3.2. Scope Capture



4.4. L6

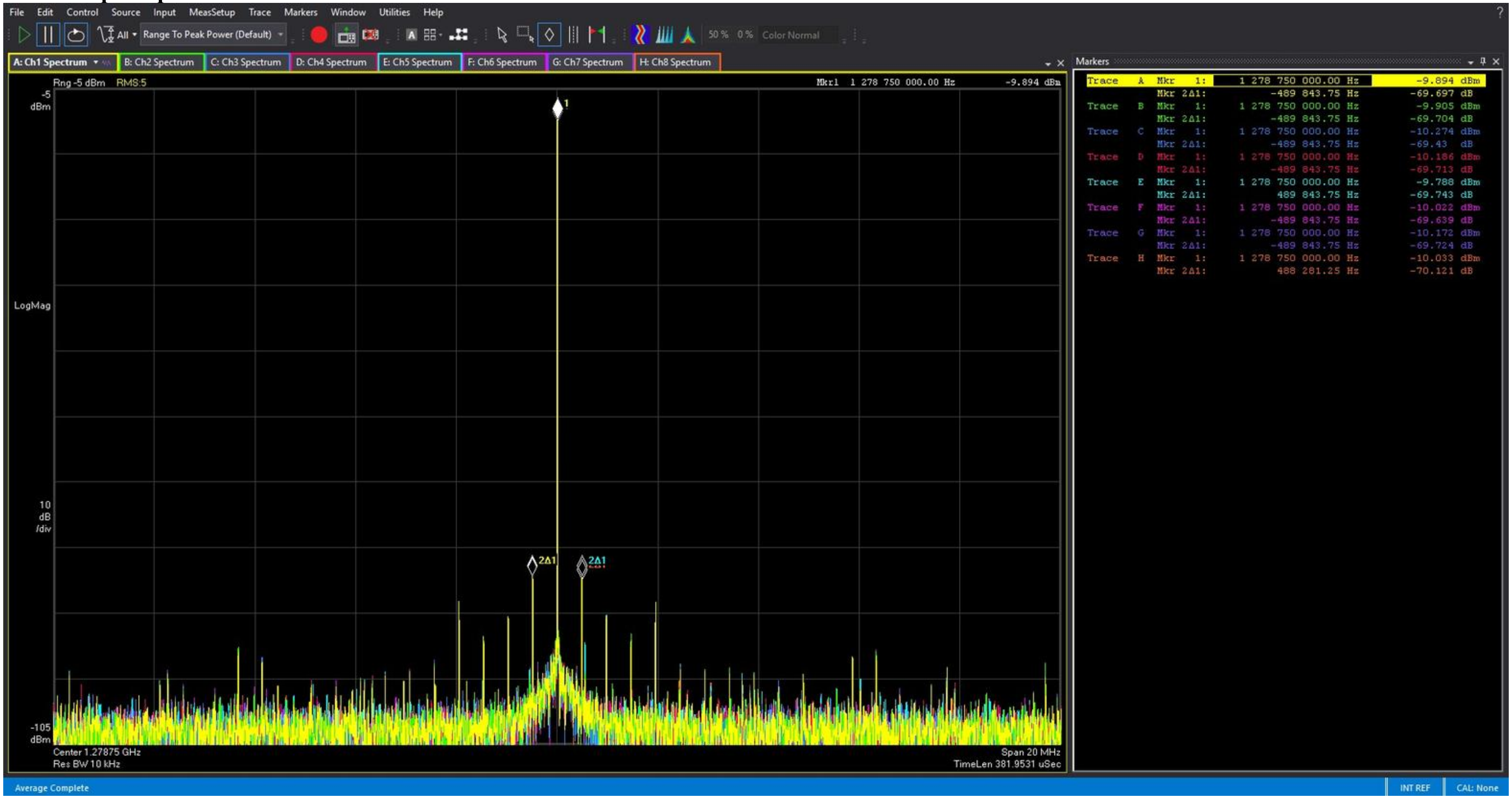
4.4.1. Data Table

SFDR	CW Pwr [dBm]	CW Freq [MHz]	Spur Pwr [dBm]	Spur Offset [MHz]	SFDR [dBc]
E1	-9.89	1278.75	-79.61	-0.48	-69.71
E2	-9.90	1278.75	-79.70	-0.48	-69.80
E3	-10.27	1278.75	-79.90	-0.48	-69.62
E4	-10.19	1278.75	-79.13	-0.48	-68.94
E5	-9.79	1278.75	-79.51	0.49	-69.72
E6	-10.02	1278.75	-79.90	-0.48	-69.87
E7	-10.17	1278.75	-79.49	-0.48	-69.32
E8	-10.03	1278.75	-79.33	0.49	-69.30

Across all elements for L6, the statistics are:

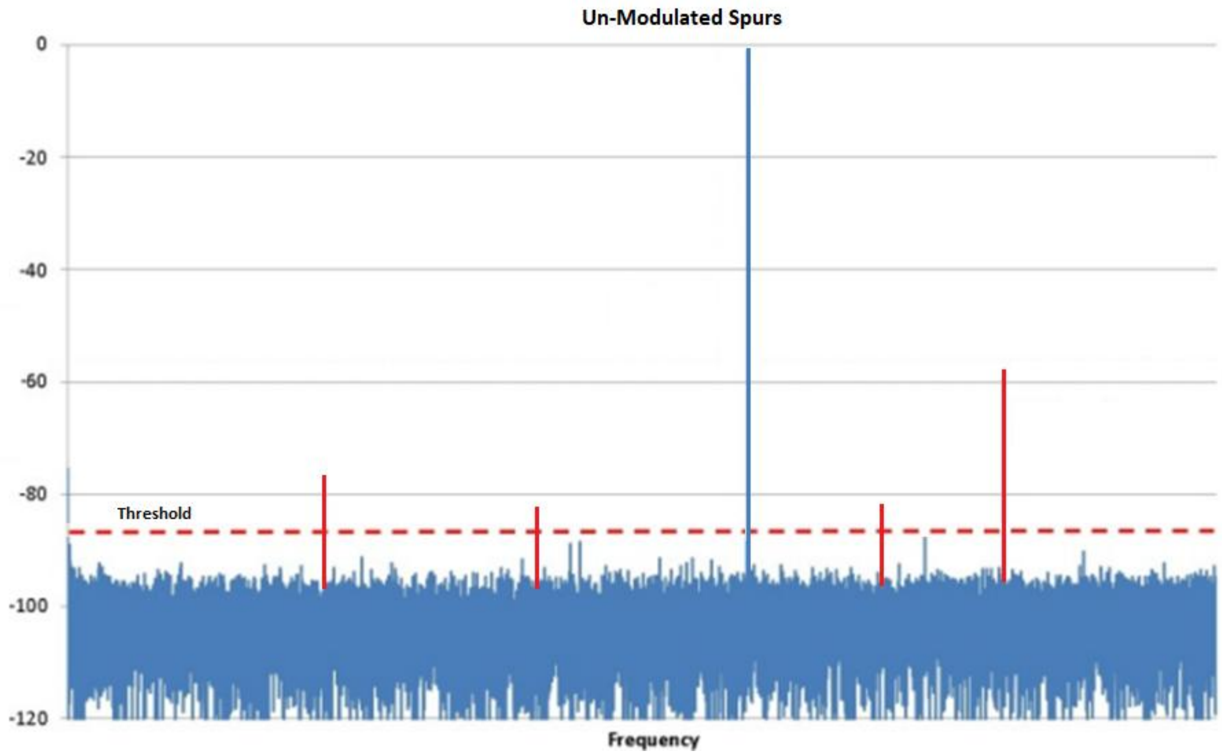
Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-69.54	0.32	-69.87	-68.94

4.4.2. Scope Capture



5. Unmodulated Spurs

The purpose of this test is to **measure the relative power and frequency of up to 10 of the largest in-band, un-modulated spurs on each element**. To do this, all WF elements are first connected to the EXR Scope and then enabled. A marker is put on the CW tone for each element along with delta markers on the spurs with a power above a certain threshold found within a 20 MHz span (see image on next page for clarification). The delta markers provide the power and frequency of these spurs relative to each elements' CW tone. These measurements provide the in-band spectral purity of each element and is repeated for each L-Band and frequency of the WF. These measurements are tabulated below along with the associated screen captures of the EXR Scope.



Depiction of Un-Modulated Spurs

This test ignores any spurs found within 500 KHz of each CW tone because a phase noise measurement would be more accurate for this region. This test does not ignore the SFDR spur found in the previous section.

The unmod spurs measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
Spur < -85.00 dBc	-85.00 dBc ≥ Spur ≥ -70.00 dBc	-70.00 dBc ≥ Spur ≥ -65.00 dBc	Spur ≥ -65.00 dBc

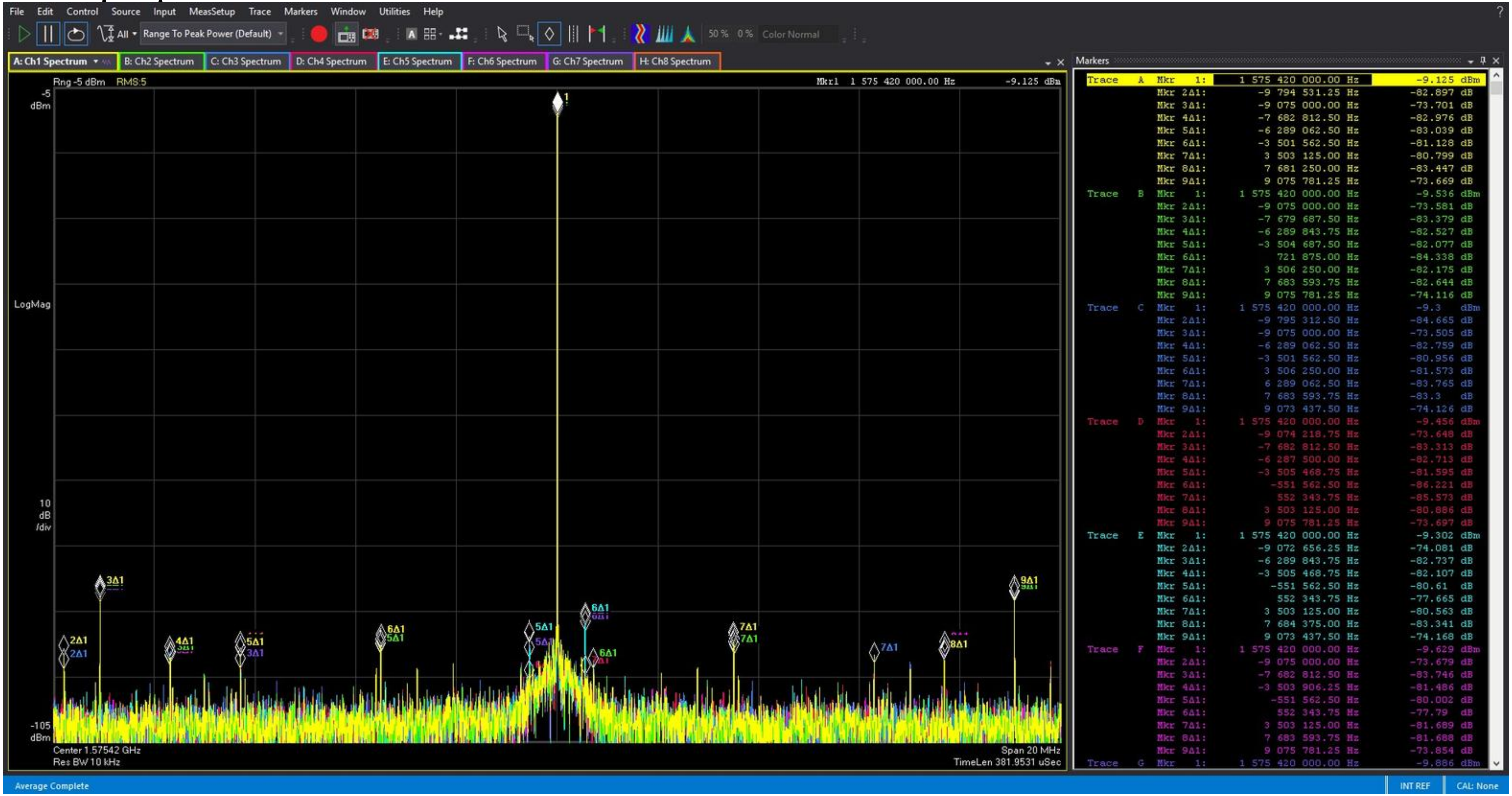
Statistical results do not make sense for this section. The 8 largest spurs were recorded for each element and then the 8 frequencies with the largest spurs were kept. Refer to the SFDR section for the statistics on the largest spurs.

5.1. L1

5.1.1. Data Table

Offset	-9.07 MHz	-7.68 MHz	-6.28 MHz	-3.5 MHz	0.55 MHz	3.5 MHz	7.68 MHz	9.07 MHz
E1 [dBc]	-73.99	-83.23	-82.93	-82.23		-82.32	-82.69	-74.49
E2 [dBc]	-73.27	-81.42	-82.47	-80.55		-81.21	-83.03	-73.86
E3 [dBc]	-73.79		-82.79	-80.99		-80.80	-82.86	-73.77
E4 [dBc]	-73.90	-82.50	-82.32	-81.95	-77.49	-80.36		-73.92
E5 [dBc]	-73.95		-83.08	-81.70	-78.11	-81.98	-82.01	-73.95
E6 [dBc]	-74.14	-82.49		-81.43	-78.22	-81.74	-82.97	-73.59
E7 [dBc]	-72.91		-81.46	-81.01	-77.19	-81.35	-82.57	-73.55
E8 [dBc]	-73.42	-82.16	-82.42	-80.17	-79.54	-80.84	-82.74	-73.39

5.1.2. Scope Capture

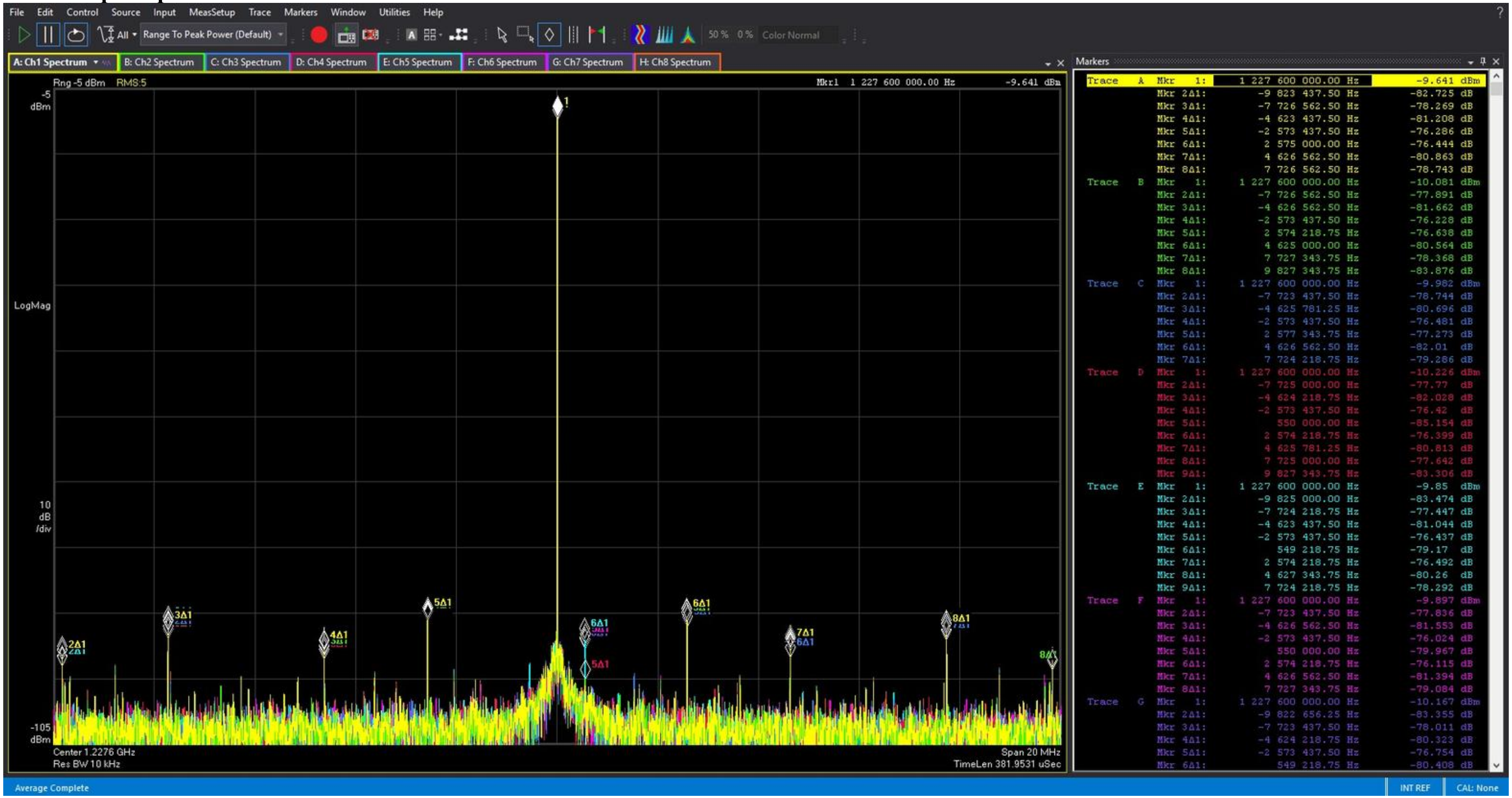


5.2. L2

5.2.1. Data Table

Offset	-9.82 MHz	-7.72 MHz	-4.62 MHz	-2.57 MHz	0.55 MHz	2.57 MHz	4.62 MHz	7.72 MHz
E1 [dBc]	-83.02	-78.33	-81.89	-76.67		-77.08	-80.99	-78.65
E2 [dBc]		-78.57	-80.59	-76.38		-76.89	-81.70	-78.97
E3 [dBc]		-77.88	-82.26	-76.66		-76.58	-81.06	-77.74
E4 [dBc]		-77.06	-80.62	-76.06	-78.79	-76.08	-79.57	-77.92
E5 [dBc]	-82.55	-77.84	-81.21	-76.07	-79.60	-76.11	-81.44	-78.97
E6 [dBc]		-78.28	-80.39	-77.02	-80.68	-76.81	-80.57	-78.20
E7 [dBc]	-81.59	-78.81	-80.89	-76.34	-79.60	-76.14	-81.22	-77.94
E8 [dBc]	-82.60	-78.74	-82.75	-77.57	-80.72	-77.96	-81.56	-78.19

5.2.2. Scope Capture

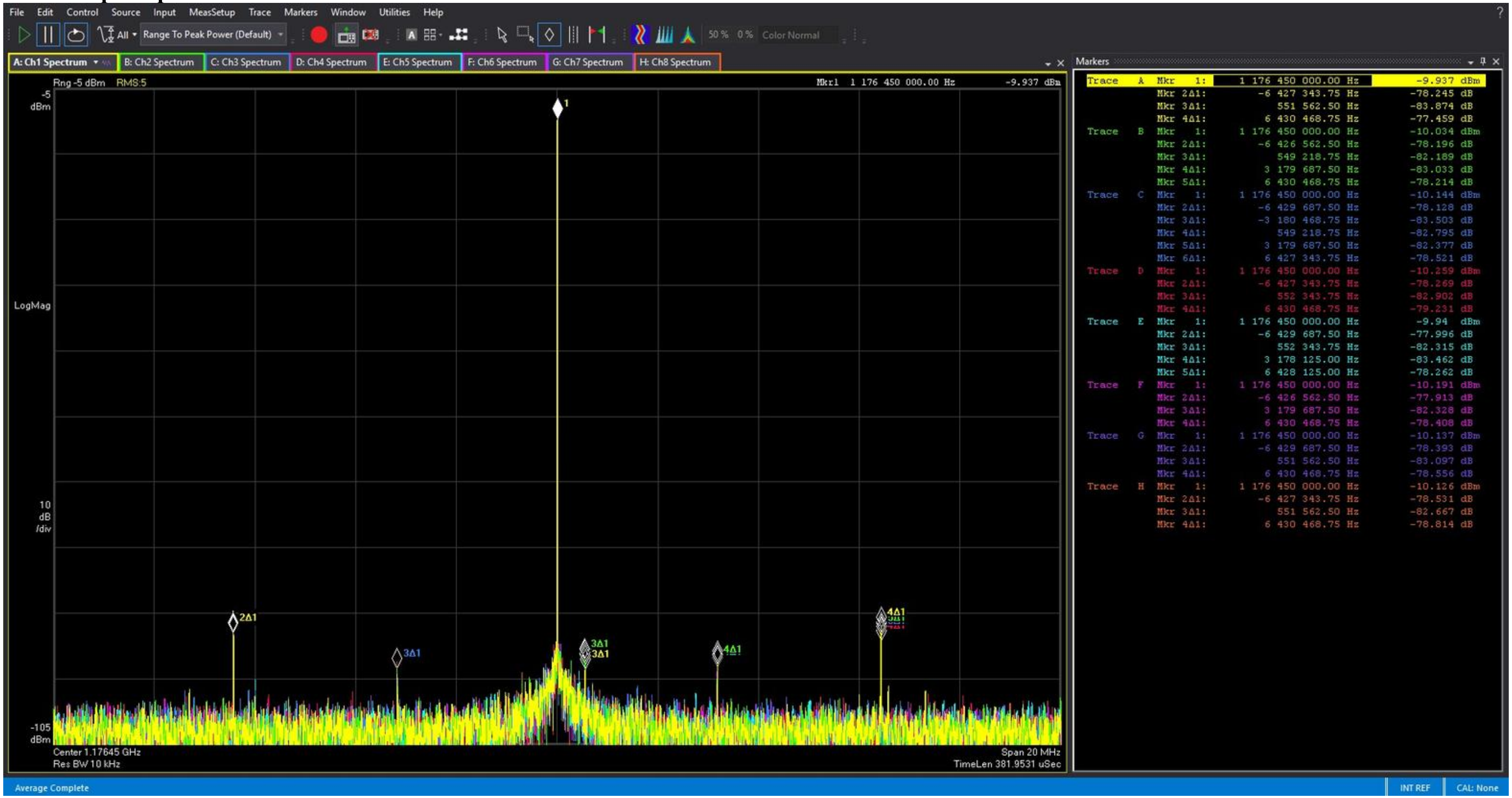


5.3. L5

5.3.1. Data Table

Offset	-6.42 MHz	-3.18 MHz	0.55 MHz	3.17 MHz	6.43 MHz
E1 [dBc]	-78.28		-82.18		-78.24
E2 [dBc]	-77.95		-82.76	-82.48	-78.58
E3 [dBc]	-78.19	-82.18	-82.36	-82.33	-78.49
E4 [dBc]	-77.63		-81.87		-77.73
E5 [dBc]	-77.92		-82.70	-82.40	-78.36
E6 [dBc]	-78.29			-82.52	-78.41
E7 [dBc]	-78.39		-82.58		-78.71
E8 [dBc]	-77.91		-81.93		-78.10

5.3.2. Scope Capture

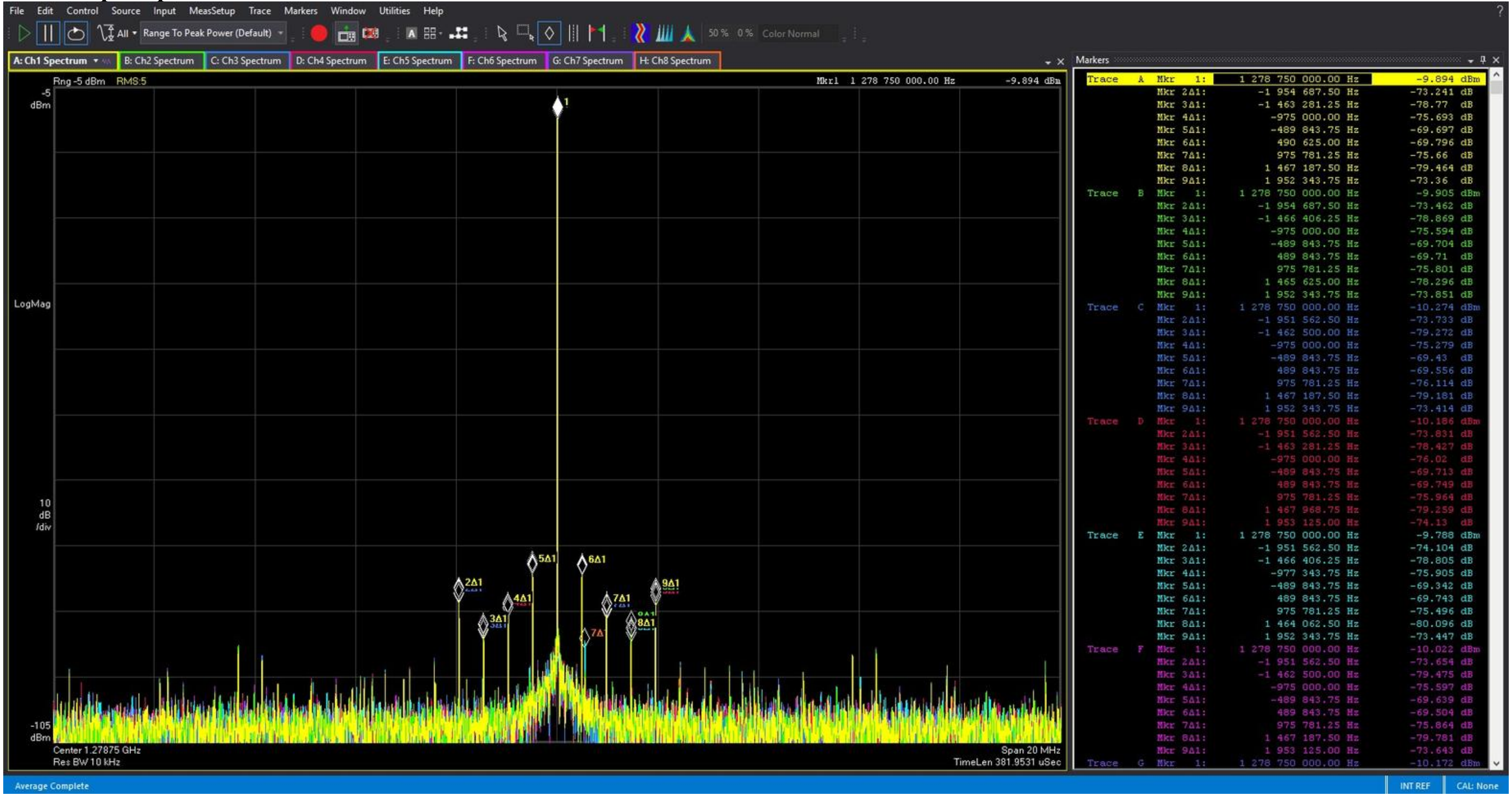


5.4. L6

5.4.1. Data Table

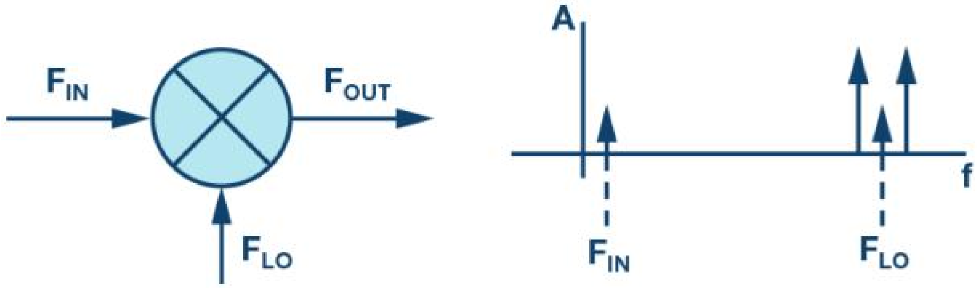
Offset	-1.95 MHz	-1.46 MHz	-0.97 MHz	-0.48 MHz	0.49 MHz	0.54 MHz	0.97 MHz	1.95 MHz
E1 [dBc]	-73.47	-78.56	-75.61	-69.71	-69.72		-75.77	-73.84
E2 [dBc]	-74.00	-78.95	-75.65	-69.80	-69.92		-76.39	-73.74
E3 [dBc]	-73.74	-78.33	-75.93	-69.62	-69.66		-75.81	-73.91
E4 [dBc]	-73.71	-78.27	-75.34	-68.94	-69.33		-75.01	-73.05
E5 [dBc]	-73.89	-79.58	-75.82	-69.87	-69.72		-76.09	-73.73
E6 [dBc]	-73.29	-79.02	-75.47	-69.87	-69.88		-76.04	-73.92
E7 [dBc]	-73.80	-78.84	-75.55	-69.32	-69.96		-75.89	-73.72
E8 [dBc]	-72.80	-79.18	-75.93	-69.42	-69.30	-79.10	-76.06	-72.73

5.4.2. Scope Capture



6. LO Leakage

The purpose of this test is to **measure the isolation between the shared LO and each element**. In other words, this test **quantifies how much the shared LO signal bleeds through onto each of the elements** when the elements' CW tone is offset from its center frequency (see image below for clarification). To do this, all WF elements are first connected to the EXR Scope and then enabled with a 1 MHz offset. A marker is put on the CW tone for each element along with a delta marker on the tone found at the center frequency. The delta marker provides the power of the LO Leakage relative to each elements' CW tone. This test is repeated for each L-Band and frequency of the WF and the measurements are tabulated below along with the associated screen captures of the EXR Scope.



Depiction of LO Leakage

The lo leakage measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
LO Leakage < -80.00 dBc	-80.00 dBc ≥ LO Leakage ≥ -60.00 dBc	-60.00 dBc ≥ LO Leakage ≥ -55.00 dBc	LO Leakage ≥ -55.00 dBc

6.1. Data Table

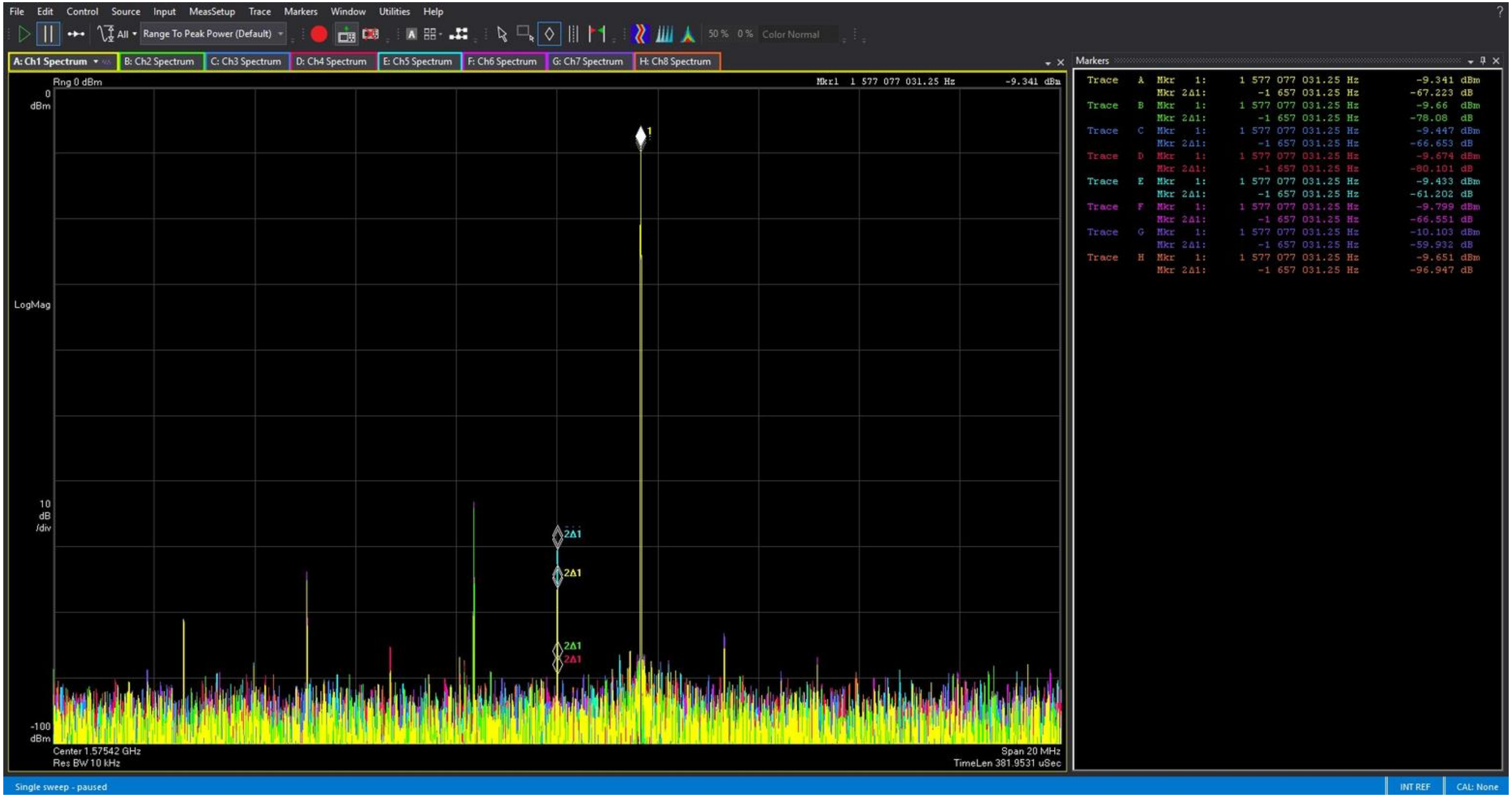
LO Leakage	E1 [dBc]	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
L1	-67.22	-78.08	-66.65	-80.10	-61.20	-66.55	-59.93	-96.95
L2	-69.53	-66.75	-67.89	-67.19	-69.76	-82.47	-68.10	-60.90
L5	-70.28	-77.50	-68.97	-78.97	-64.91	-68.18	-69.31	-65.10
L6	-86.89	-69.25	-65.24	-76.30	-79.60	-72.17	-67.50	-67.78

Across all frequency bands and elements, the statistics are:

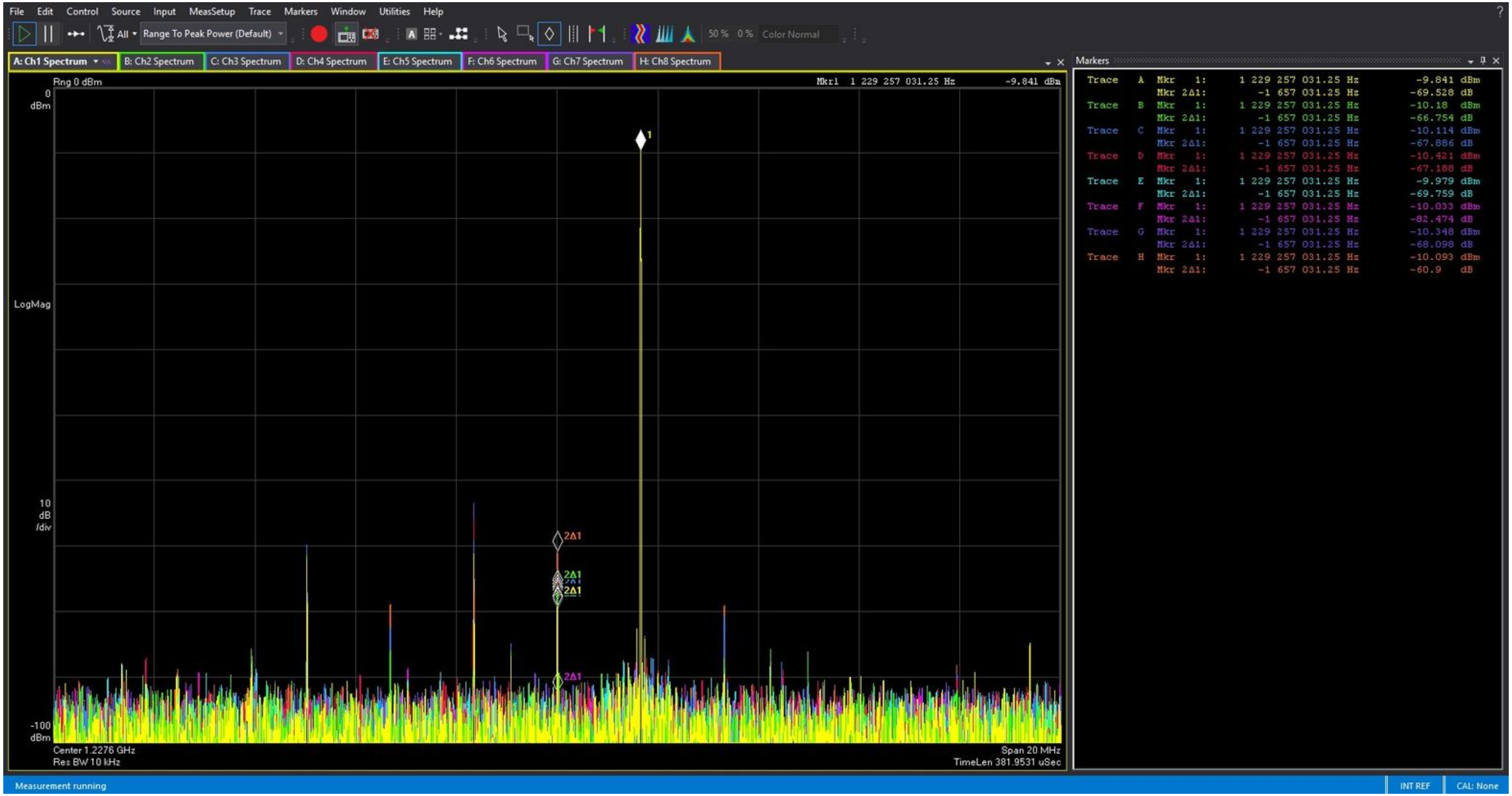
Mean [dBc]	Std [dBc]	Min [dBc]	Max [dBc]
-71.16	7.98	-96.95	-59.93

6.2. Scope Capture

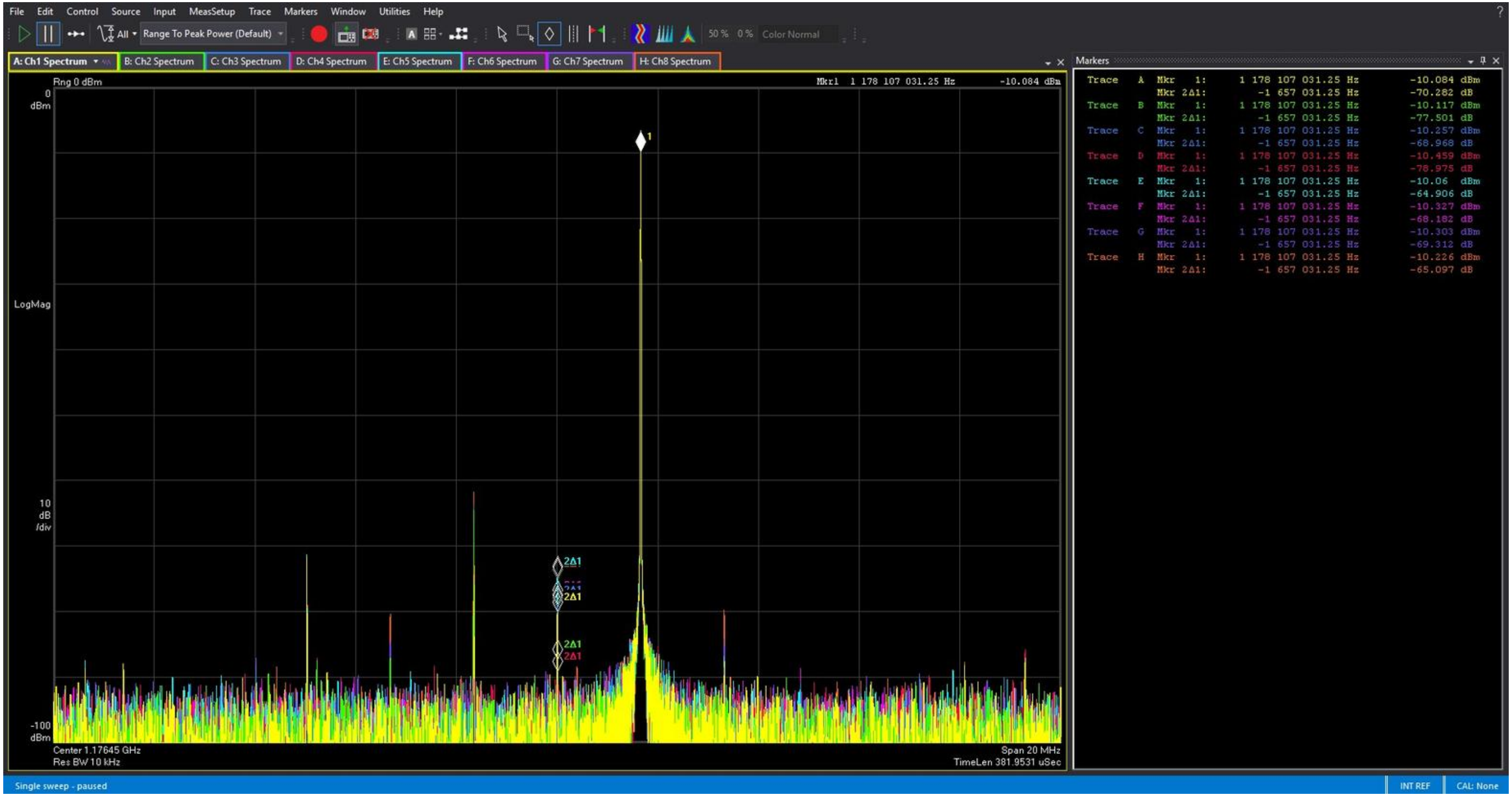
6.2.1. L1 CW



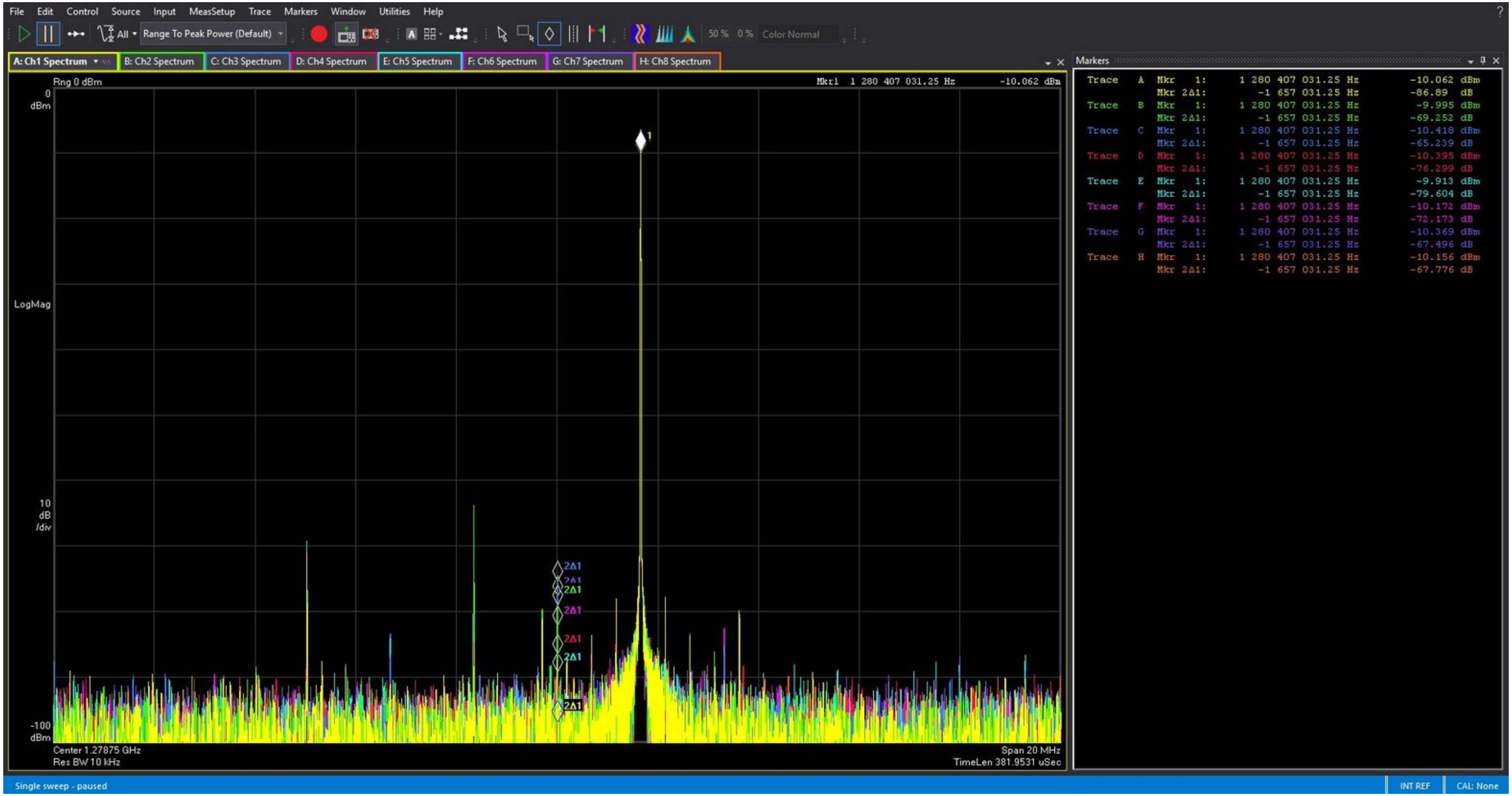
6.2.2. L2 CW


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: Ch5 Spectrum
F: Ch6 Spectrum
G: Ch7 Spectrum
H: Ch8 Spectrum
Rng 0 dBm
Mkr1 1 229 257 031.25 Hz -9.841 dBm
0 dBm
LogMag
10 dB /div
-100 dBm
Center 1.2276 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 229 257 031.25 Hz -9.841 dBm
Mkr 2Δ1: -1 657 031.25 Hz -69.528 dB
Trace B Mkr 1: 1 229 257 031.25 Hz -10.18 dBm
Mkr 2Δ1: -1 657 031.25 Hz -66.754 dB
Trace C Mkr 1: 1 229 257 031.25 Hz -10.114 dBm
Mkr 2Δ1: -1 657 031.25 Hz -67.886 dB
Trace D Mkr 1: 1 229 257 031.25 Hz -10.421 dBm
Mkr 2Δ1: -1 657 031.25 Hz -67.188 dB
Trace E Mkr 1: 1 229 257 031.25 Hz -9.979 dBm
Mkr 2Δ1: -1 657 031.25 Hz -69.759 dB
Trace F Mkr 1: 1 229 257 031.25 Hz -10.033 dBm
Mkr 2Δ1: -1 657 031.25 Hz -82.474 dB
Trace G Mkr 1: 1 229 257 031.25 Hz -10.348 dBm
Mkr 2Δ1: -1 657 031.25 Hz -68.098 dB
Trace H Mkr 1: 1 229 257 031.25 Hz -10.093 dBm
Mkr 2Δ1: -1 657 031.25 Hz -60.9 dB
Measurement running
INT REF
CAL: None

6.2.3. L5 CW

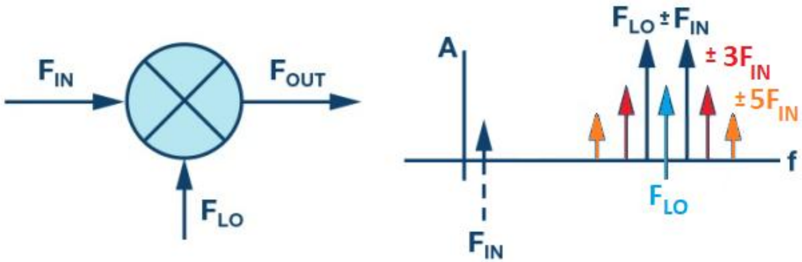

Rng 0 dBm
Mkr1 1 178 107 031.25 Hz -10.084 dBm
LogMag
10 dB /div
Center 1.17645 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 178 107 031.25 Hz -10.084 dBm
Mkr 2Δ1: -1 657 031.25 Hz -70.282 dB
Trace B Mkr 1: 1 178 107 031.25 Hz -10.117 dBm
Mkr 2Δ1: -1 657 031.25 Hz -77.501 dB
Trace C Mkr 1: 1 178 107 031.25 Hz -10.257 dBm
Mkr 2Δ1: -1 657 031.25 Hz -68.968 dB
Trace D Mkr 1: 1 178 107 031.25 Hz -10.459 dBm
Mkr 2Δ1: -1 657 031.25 Hz -78.975 dB
Trace E Mkr 1: 1 178 107 031.25 Hz -10.06 dBm
Mkr 2Δ1: -1 657 031.25 Hz -64.906 dB
Trace F Mkr 1: 1 178 107 031.25 Hz -10.327 dBm
Mkr 2Δ1: -1 657 031.25 Hz -68.182 dB
Trace G Mkr 1: 1 178 107 031.25 Hz -10.303 dBm
Mkr 2Δ1: -1 657 031.25 Hz -69.312 dB
Trace H Mkr 1: 1 178 107 031.25 Hz -10.226 dBm
Mkr 2Δ1: -1 657 031.25 Hz -65.097 dB
Single sweep - paused
INT REF
CAL: None

6.2.4. L6 CW


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: Ch5 Spectrum
F: Ch6 Spectrum
G: Ch7 Spectrum
H: Ch8 Spectrum
Rng 0 dBm
Mkr1 1 280 407 031.25 Hz -10.062 dBm
0 dBm
LogMag
10 dB /div
-100 dBm
Center 1.27875 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 280 407 031.25 Hz -10.062 dBm
Mkr 2Δ1: -1 657 031.25 Hz -86.89 dB
Trace B Mkr 1: 1 280 407 031.25 Hz -9.995 dBm
Mkr 2Δ1: -1 657 031.25 Hz -69.252 dB
Trace C Mkr 1: 1 280 407 031.25 Hz -10.418 dBm
Mkr 2Δ1: -1 657 031.25 Hz -65.239 dB
Trace D Mkr 1: 1 280 407 031.25 Hz -10.395 dBm
Mkr 2Δ1: -1 657 031.25 Hz -76.299 dB
Trace E Mkr 1: 1 280 407 031.25 Hz -9.913 dBm
Mkr 2Δ1: -1 657 031.25 Hz -79.604 dB
Trace F Mkr 1: 1 280 407 031.25 Hz -10.172 dBm
Mkr 2Δ1: -1 657 031.25 Hz -72.173 dB
Trace G Mkr 1: 1 280 407 031.25 Hz -10.369 dBm
Mkr 2Δ1: -1 657 031.25 Hz -67.496 dB
Trace H Mkr 1: 1 280 407 031.25 Hz -10.156 dBm
Mkr 2Δ1: -1 657 031.25 Hz -67.776 dB
Single sweep - paused
INT REF
CAL: None

7. Modulated Spurs

The purpose of this test is to **measure the relative power and frequency of the modulated spurs on each element**. To do this, all WF elements are first connected to the EXR Scope and then enabled. Two CW tones are created at Â± a random offset on each element. A marker is put on one of these CW tones for each element along with delta markers on the modulated spurs. These spurs are found at [M(CWF)] Â± [N(offset)] where CWF is the center frequency of the CW and shared LO. Because we only care about in-band spurs, this simplifies down to down to odd factors of the offset away from the CWF (see image below for clarification).The delta markers provide the relative power and frequency of these spurs. This test is repeated for 3 different random offsets on every L-Band and frequency of the WF. These measurements are tabulated below along with the associated screen captures of the EXR Scope. **This test ignores all un-modulated spurs as they are measured in the modulated spurs section.**



Depiction of Modulated Spurs

The mod spurs measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
9x < -90.00 dBc	-90.00 dBc ≥ 9x ≥ -80.00 dBc	-80.00 dBc ≥ 9x ≥ -75.00 dBc	9x ≥ -75.00 dBc
7x < -85.00 dBc	-85.00 dBc ≥ 7x ≥ -70.00 dBc	-70.00 dBc ≥ 7x ≥ -65.00 dBc	7x ≥ -65.00 dBc
5x < -80.00 dBc	-80.00 dBc ≥ 5x ≥ -60.00 dBc	-60.00 dBc ≥ 5x ≥ -55.00 dBc	5x ≥ -55.00 dBc
3x < -50.00 dBc	-50.00 dBc ≥ 3x ≥ -40.00 dBc	-40.00 dBc ≥ 3x ≥ -35.00 dBc	3x ≥ -35.00 dBc

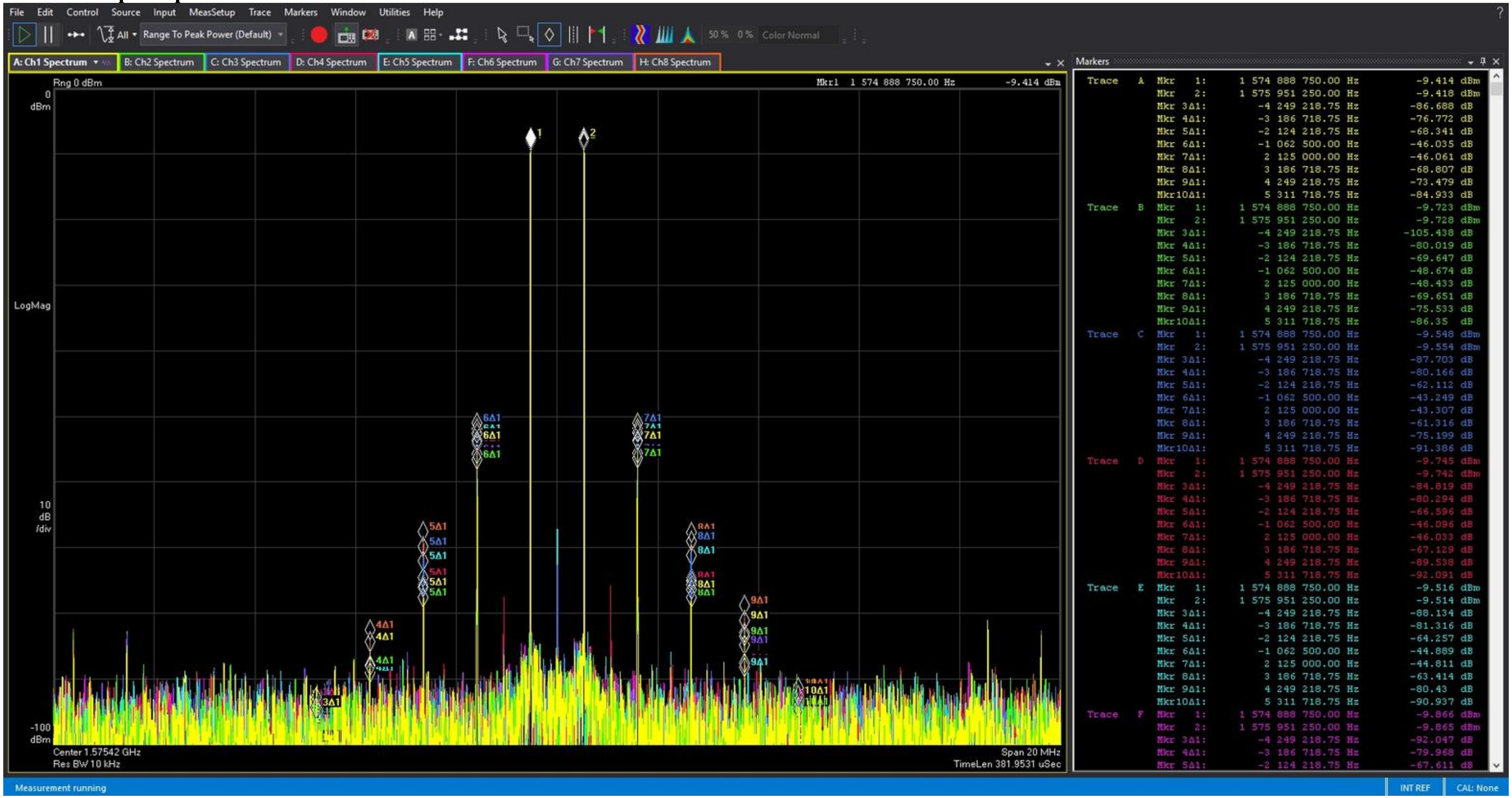
7.1. 0.531 MHz Offset

7.1.1. L1 CW

7.1.1.1. Data Table

Mod Spurs	-9x [dBc]	-7x [dBc]	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]	7x [dBc]	9x [dBc]
E1	-86.69	-76.77	-68.34	-46.03	-9.41	-9.42	-46.06	-68.81	-73.48	-84.93
E2	-105.44	-80.02	-69.65	-48.67	-9.72	-9.73	-48.43	-69.65	-75.53	-86.35
E3	-87.70	-80.17	-62.11	-43.25	-9.55	-9.55	-43.31	-61.32	-75.20	-91.39
E4	-84.82	-80.29	-66.60	-46.10	-9.75	-9.74	-46.03	-67.13	-89.54	-92.09
E5	-88.13	-81.32	-64.26	-44.89	-9.52	-9.51	-44.81	-63.41	-80.43	-90.94
E6	-92.05	-79.97	-67.61	-44.52	-9.87	-9.87	-44.30	-66.61	-79.54	-95.38
E7	-88.74	-91.19	-67.85	-47.30	-10.19	-10.19	-47.18	-67.20	-76.42	-89.57
E8	-89.44	-74.56	-59.62	-43.93	-9.75	-9.75	-43.88	-59.79	-70.86	-83.37

7.1.1.2. Scope Capture

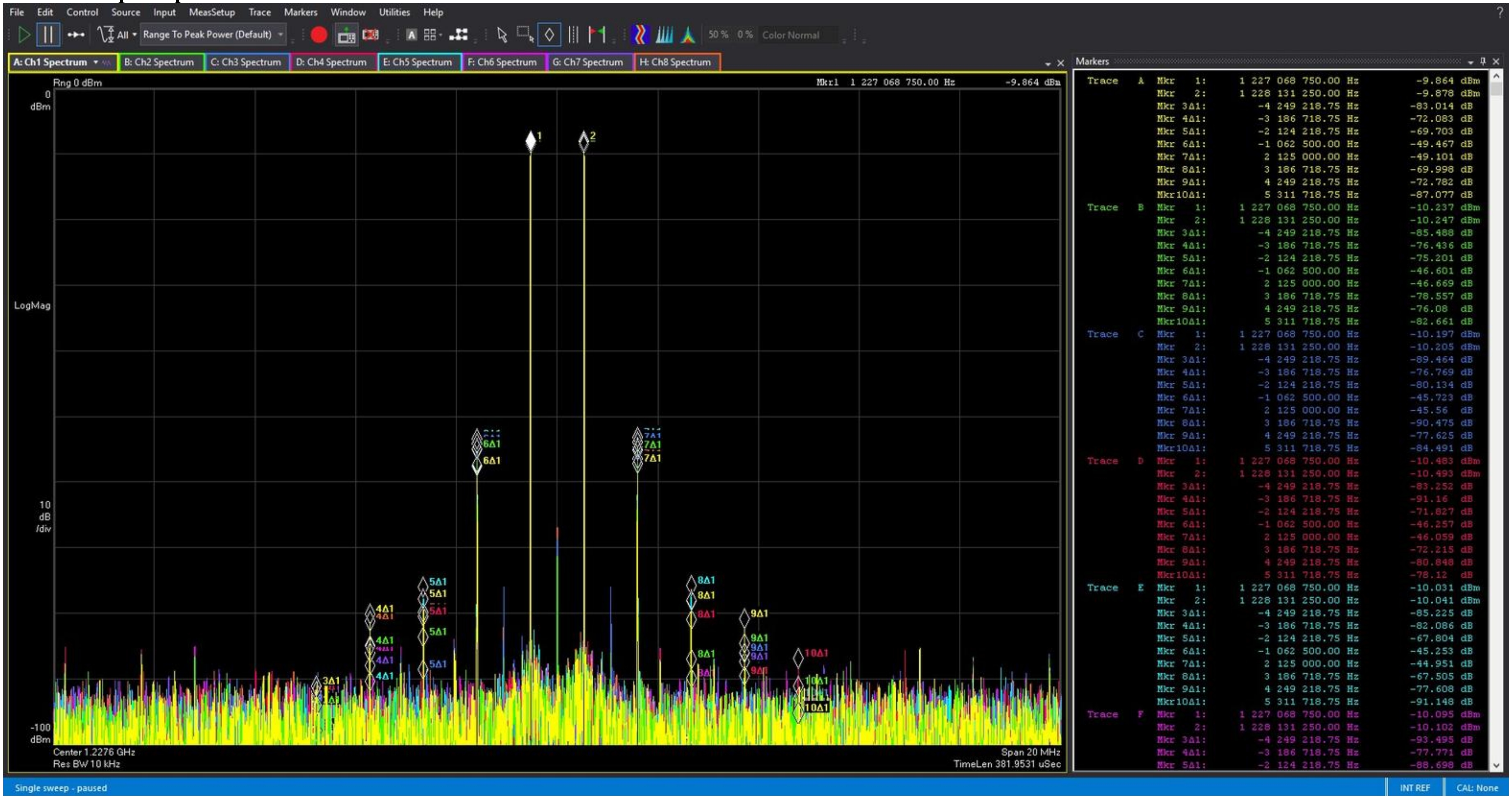


7.1.2. L2 CW

7.1.2.1. Data Table

Mod Spurs	-9x [dBc]	-7x [dBc]	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]	7x [dBc]	9x [dBc]
E1	-81.48	-77.00	-71.22	-45.36	-9.78	-9.80	-45.40	-69.66	-71.99	-84.80
E2	-86.33	-83.14	-74.15	-52.37	-10.05	-10.07	-51.89	-78.77	-77.35	-89.58
E3	-83.41	-85.08	-73.79	-49.54	-9.99	-10.01	-48.85	-75.89	-75.42	-83.01
E4	-86.10	-84.77	-89.07	-48.52	-10.32	-10.34	-48.76	-83.77	-76.91	-77.15
E5	-78.61	-85.17	-84.89	-47.99	-9.89	-9.91	-48.00	-79.62	-84.01	-78.03
E6	-84.97	-77.94	-75.12	-50.10	-9.90	-9.92	-49.73	-79.10	-75.15	-81.32
E7	-85.12	-84.79	-73.46	-47.45	-10.25	-10.27	-47.14	-75.71	-73.69	-91.49
E8	-85.33	-77.53	-72.46	-46.50	-10.03	-10.04	-46.49	-70.28	-72.87	-84.02

7.1.2.2. Scope Capture

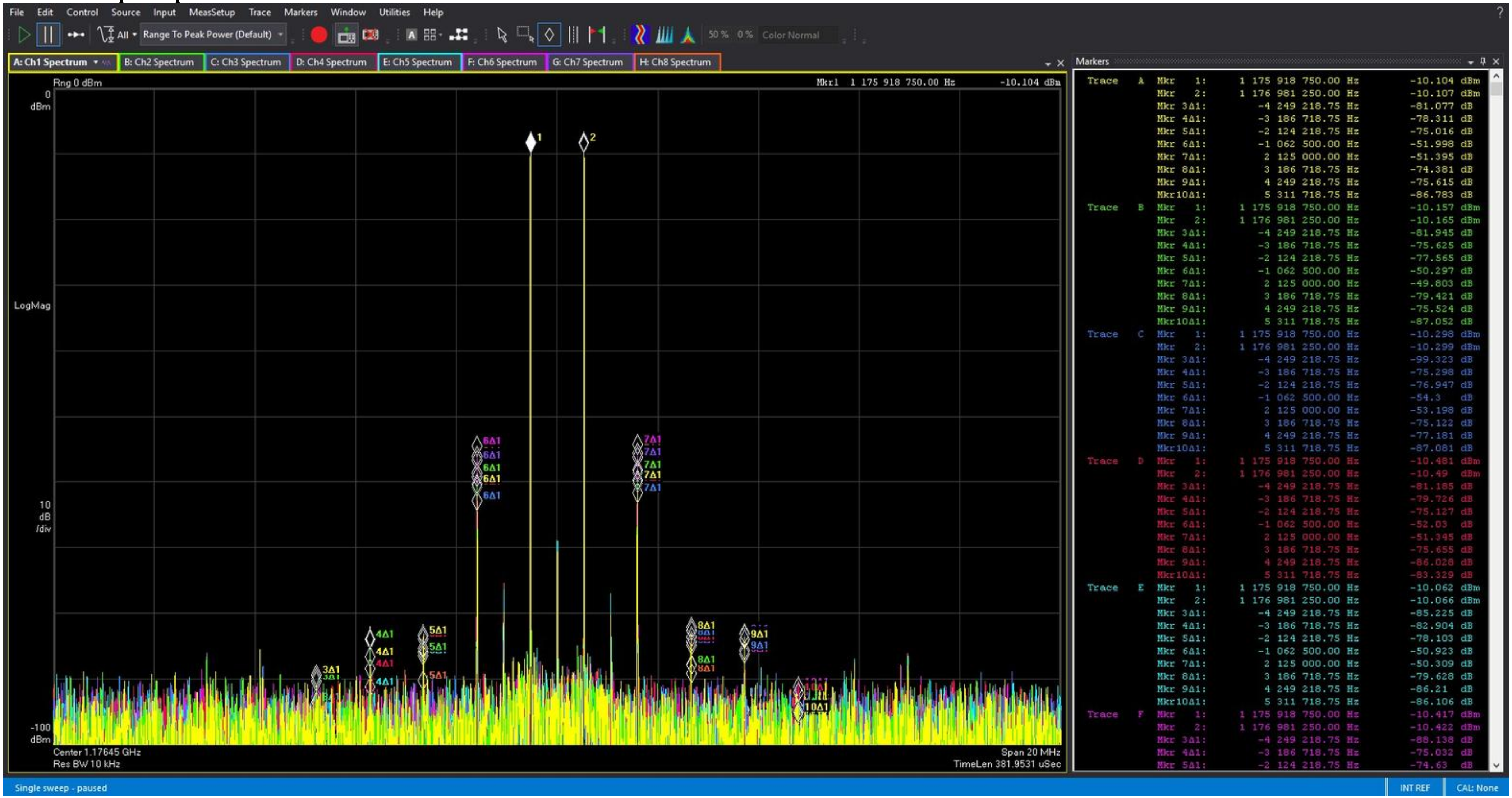


7.1.3. L5 CW

7.1.3.1. Data Table

Mod Spurs	-9x [dBc]	-7x [dBc]	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]	7x [dBc]	9x [dBc]
E1	-93.80	-75.84	-78.41	-46.00	-10.01	-10.03	-45.56	-74.38	-74.09	-89.63
E2	-102.99	-72.30	-73.98	-46.87	-10.06	-10.07	-46.74	-74.04	-72.19	-90.12
E3	-83.80	-71.59	-72.33	-48.08	-10.18	-10.19	-47.52	-71.58	-73.43	-84.40
E4	-90.46	-81.31	-73.16	-47.05	-10.33	-10.35	-46.12	-72.69	-80.59	-83.21
E5	-88.10	-84.37	-73.47	-45.01	-10.00	-10.01	-44.49	-71.36	-83.87	-83.52
E6	-97.60	-77.45	-72.11	-47.47	-10.26	-10.28	-47.53	-75.84	-77.28	-90.10
E7	-83.60	-73.91	-72.84	-48.11	-10.23	-10.25	-47.76	-73.08	-75.14	-94.49
E8	-97.57	-75.89	-77.91	-45.68	-10.17	-10.19	-45.42	-78.60	-74.28	-108.73

7.1.3.2. Scope Capture

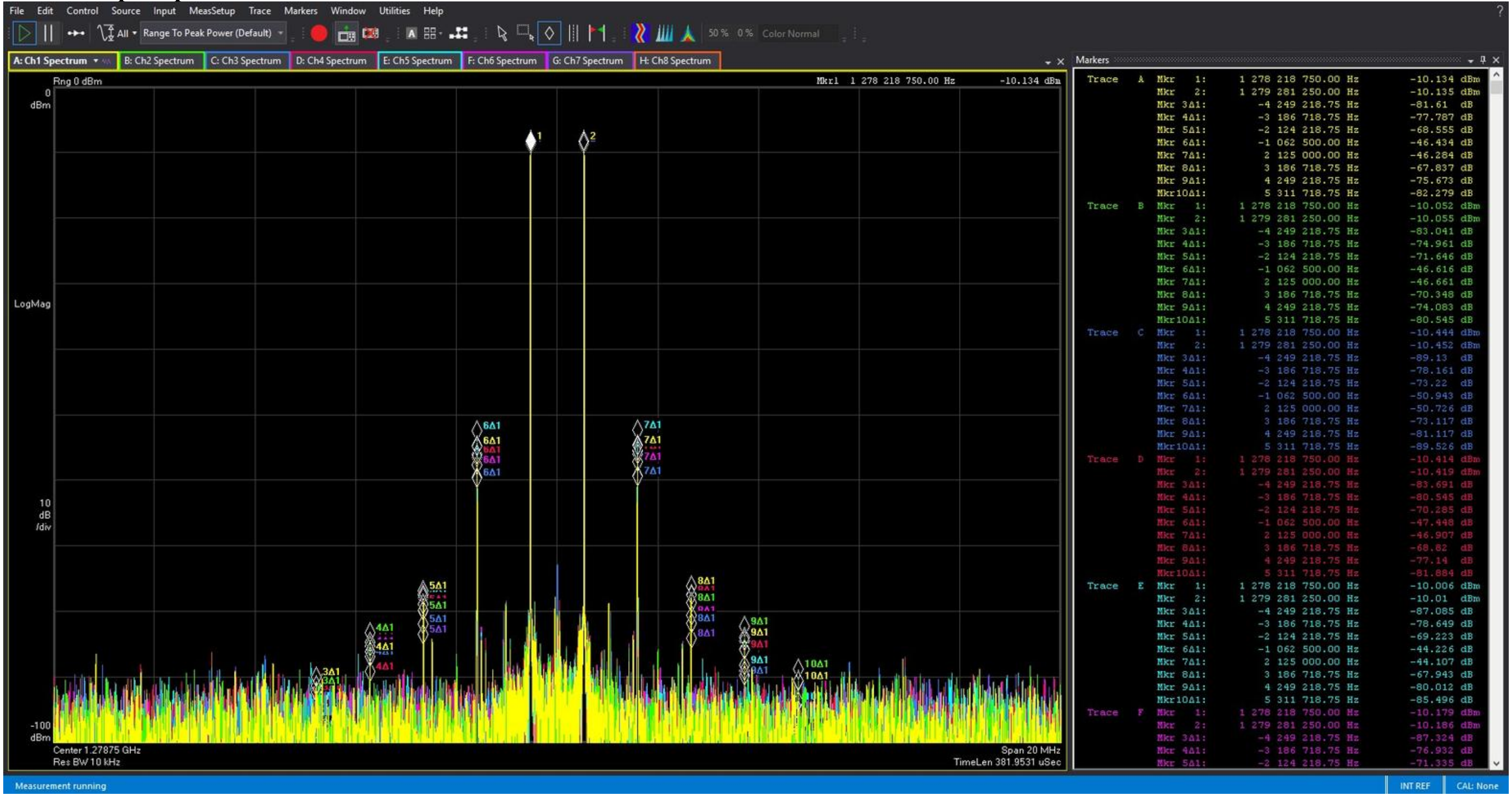


7.1.4. L6 CW

7.1.4.1. Data Table

Mod Spurs	-9x [dBc]	-7x [dBc]	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]	7x [dBc]	9x [dBc]
E1	-81.61	-77.79	-68.56	-46.43	-10.13	-10.14	-46.28	-67.84	-75.67	-82.28
E2	-83.04	-74.96	-71.65	-46.62	-10.05	-10.06	-46.66	-70.35	-74.08	-80.55
E3	-89.13	-78.16	-73.22	-50.94	-10.44	-10.45	-50.73	-73.12	-81.12	-89.53
E4	-83.69	-80.54	-70.29	-47.45	-10.41	-10.42	-46.91	-68.82	-77.14	-81.88
E5	-87.09	-78.65	-69.22	-44.23	-10.01	-10.01	-44.11	-67.94	-80.01	-85.50
E6	-87.32	-76.93	-71.33	-49.27	-10.18	-10.19	-48.84	-72.18	-76.09	-86.72
E7	-88.55	-77.56	-74.91	-51.28	-10.39	-10.39	-50.95	-75.49	-80.48	-85.04
E8	-90.34	-76.25	-69.47	-48.10	-10.19	-10.19	-47.54	-69.23	-77.45	-93.01

7.1.4.2. Scope Capture



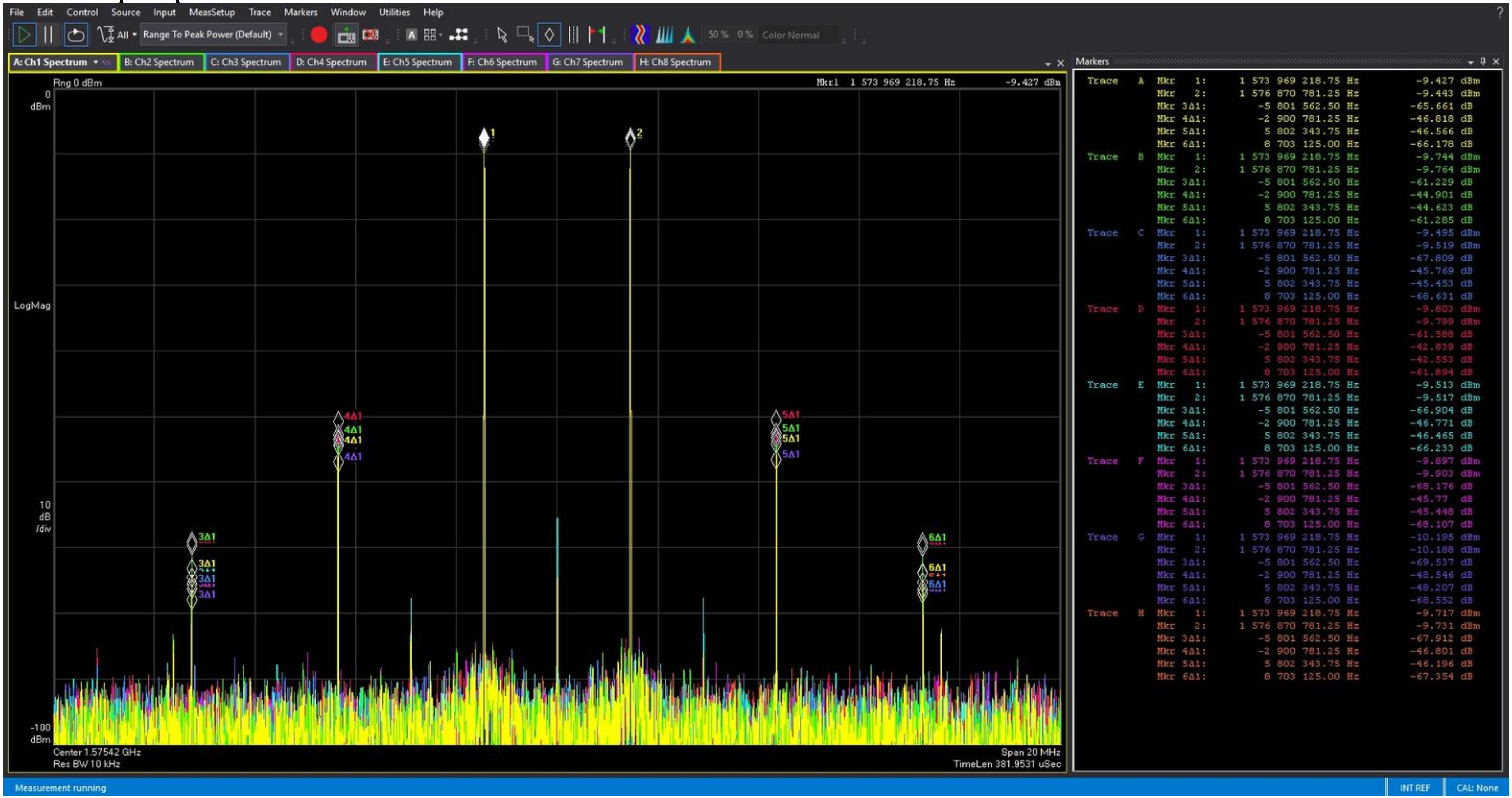
7.2. 1.450 MHz Offset

7.2.1. L1 CW

7.2.1.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-69.13	-47.61	-9.34	-9.36	-47.06	-68.70
E2	-62.78	-46.05	-9.66	-9.68	-45.61	-63.36
E3	-68.90	-45.23	-9.43	-9.45	-44.76	-69.45
E4	-63.11	-43.40	-9.73	-9.73	-43.08	-62.45
E5	-68.76	-47.19	-9.44	-9.44	-46.45	-69.09
E6	-71.02	-46.55	-9.81	-9.82	-45.86	-71.31
E7	-72.13	-48.91	-10.12	-10.11	-48.21	-71.13
E8	-66.04	-45.62	-9.66	-9.68	-45.01	-65.68

7.2.1.2. Scope Capture

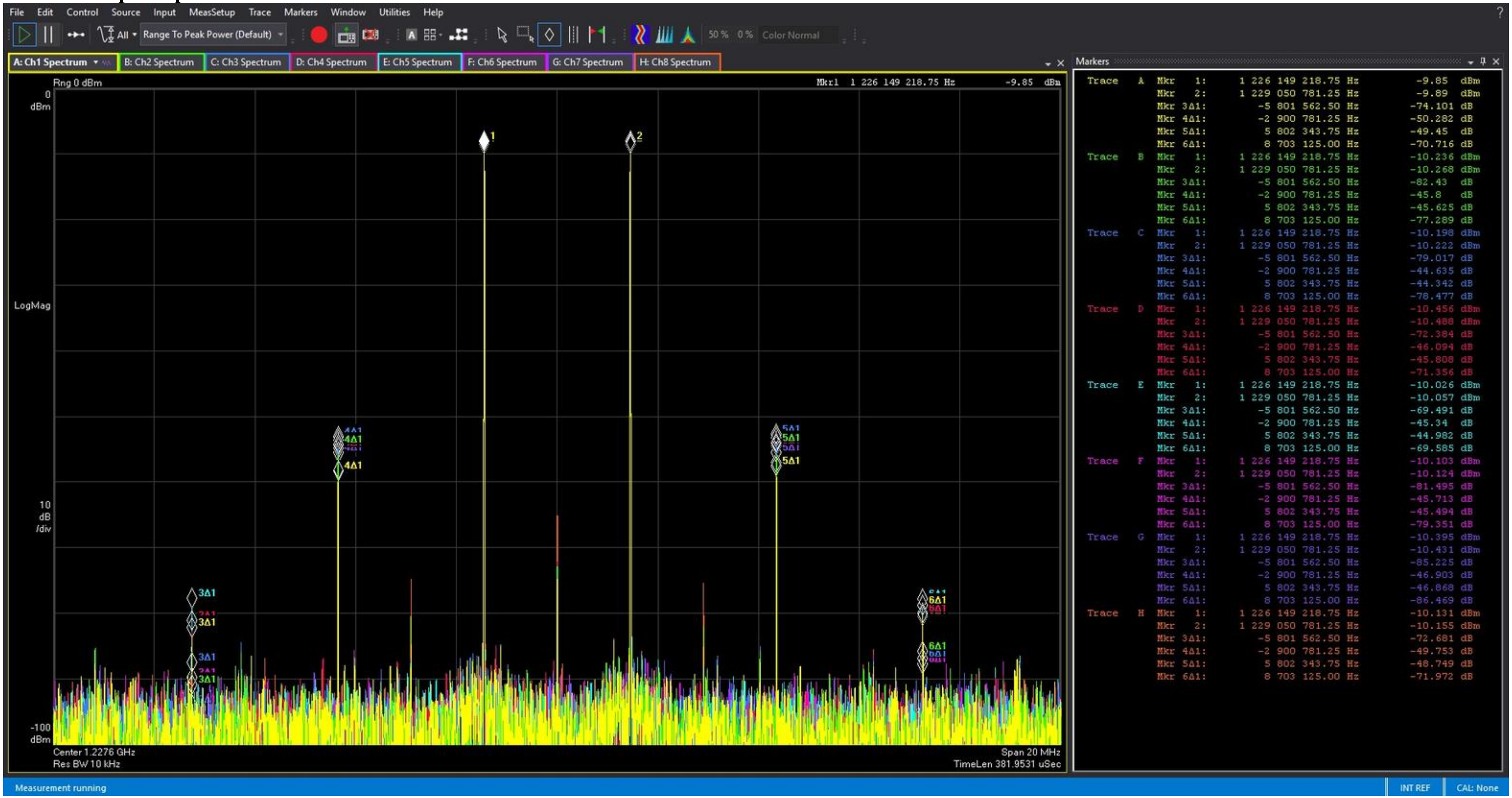


7.2.2. L2 CW

7.2.2.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-74.10	-50.28	-9.85	-9.89	-49.45	-70.72
E2	-82.43	-45.80	-10.24	-10.27	-45.63	-77.29
E3	-79.02	-44.64	-10.20	-10.22	-44.34	-78.48
E4	-72.38	-46.09	-10.46	-10.49	-45.81	-71.36
E5	-69.49	-45.34	-10.03	-10.06	-44.98	-69.59
E6	-81.49	-45.71	-10.10	-10.12	-45.49	-79.35
E7	-85.23	-46.90	-10.39	-10.43	-46.87	-86.47
E8	-72.68	-49.75	-10.13	-10.16	-48.75	-71.97

7.2.2.2. Scope Capture

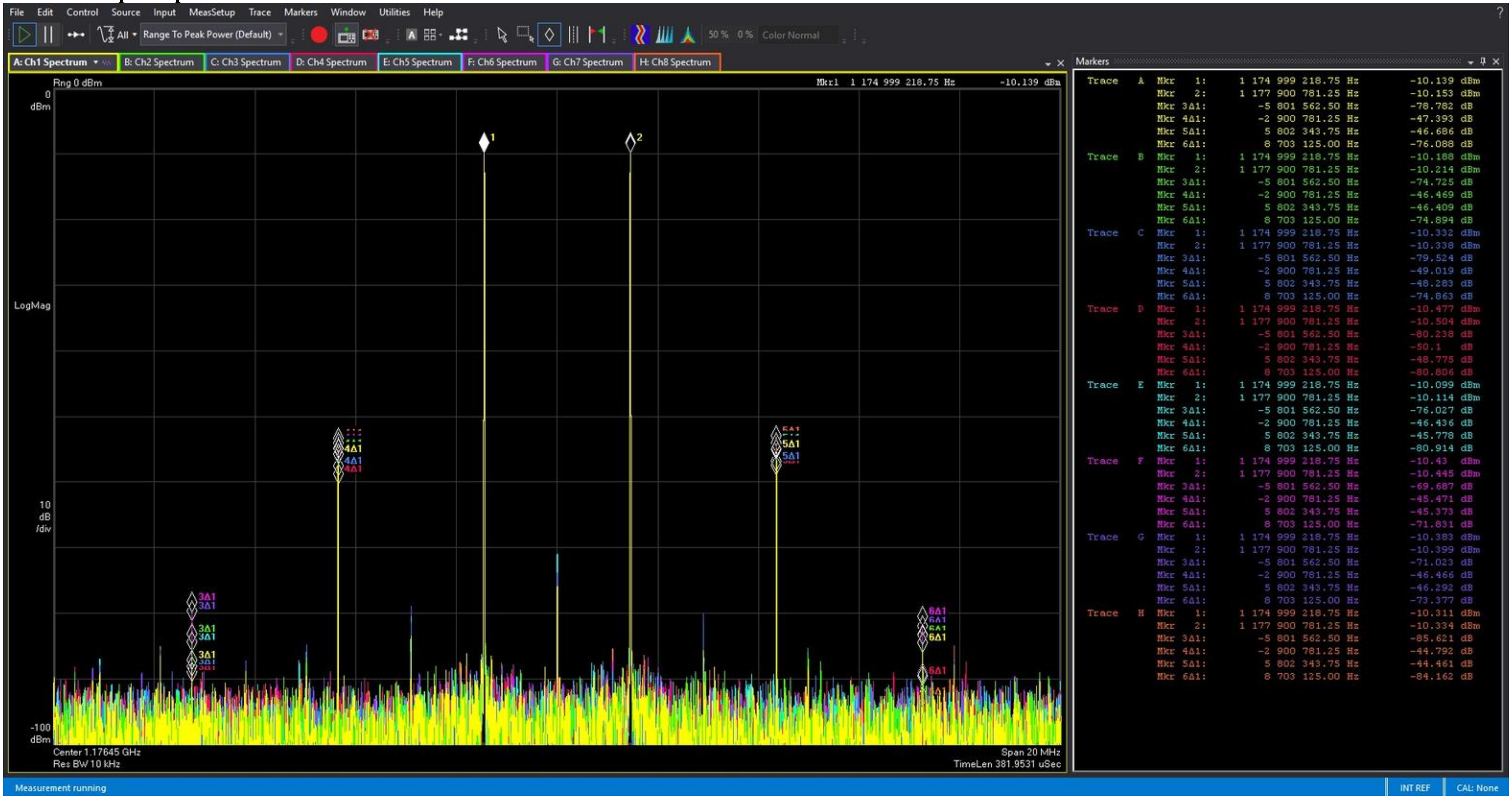


7.2.3. L5 CW

7.2.3.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-78.78	-47.39	-10.14	-10.15	-46.69	-76.09
E2	-74.73	-46.47	-10.19	-10.21	-46.41	-74.89
E3	-79.52	-49.02	-10.33	-10.34	-48.28	-74.86
E4	-80.24	-50.10	-10.48	-10.50	-48.77	-80.81
E5	-76.03	-46.44	-10.10	-10.11	-45.78	-80.91
E6	-69.69	-45.47	-10.43	-10.44	-45.37	-71.83
E7	-71.02	-46.47	-10.38	-10.40	-46.29	-73.38
E8	-85.62	-44.79	-10.31	-10.33	-44.46	-84.16

7.2.3.2. Scope Capture

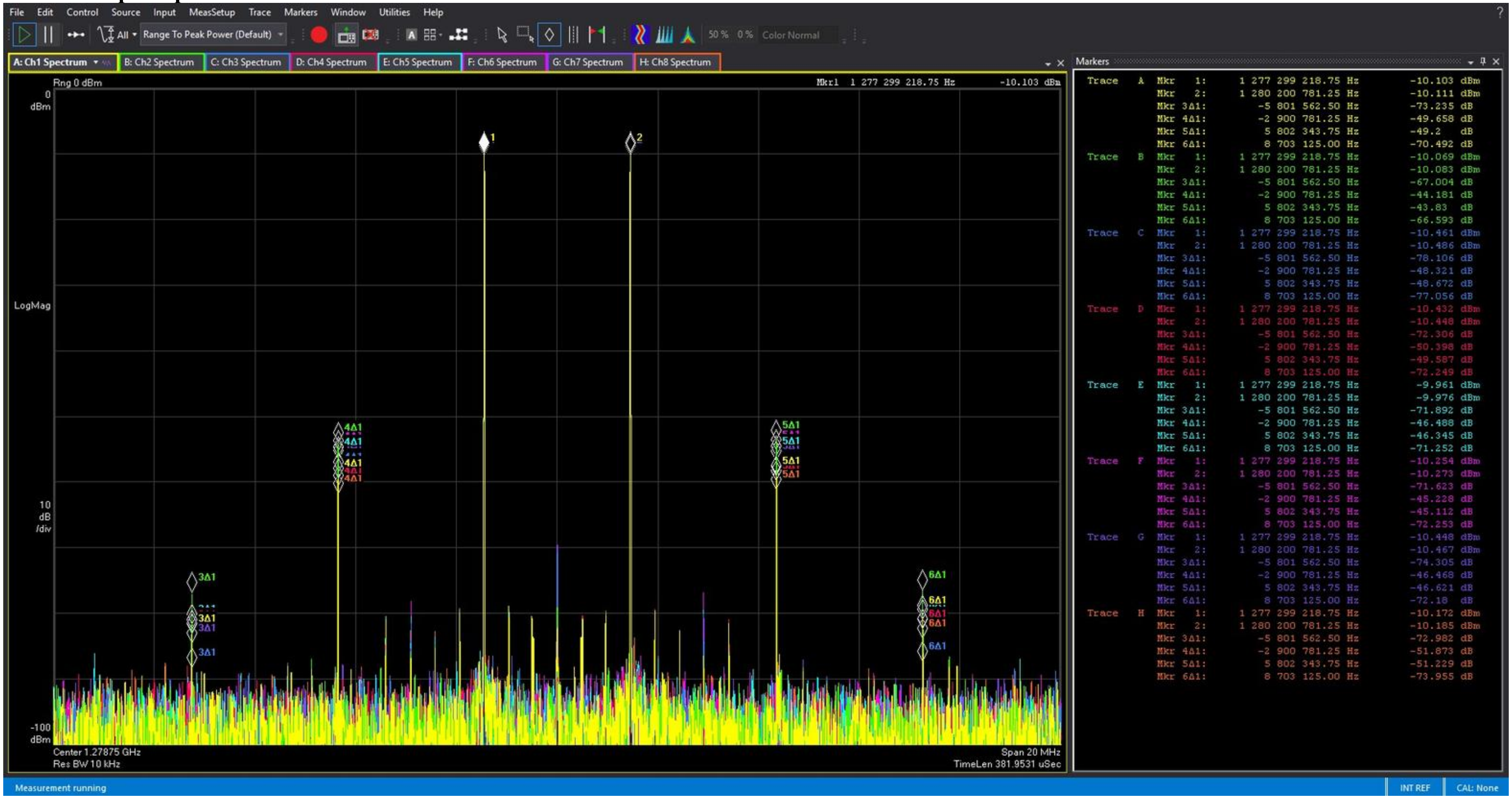


7.2.4. L6 CW

7.2.4.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-73.23	-49.66	-10.10	-10.11	-49.20	-70.49
E2	-67.00	-44.18	-10.07	-10.08	-43.83	-66.59
E3	-78.11	-48.32	-10.46	-10.49	-48.67	-77.06
E4	-72.31	-50.40	-10.43	-10.45	-49.59	-72.25
E5	-71.89	-46.49	-9.96	-9.98	-46.34	-71.25
E6	-71.62	-45.23	-10.25	-10.27	-45.11	-72.25
E7	-74.31	-46.47	-10.45	-10.47	-46.62	-72.18
E8	-72.98	-51.87	-10.17	-10.19	-51.23	-73.96

7.2.4.2. Scope Capture



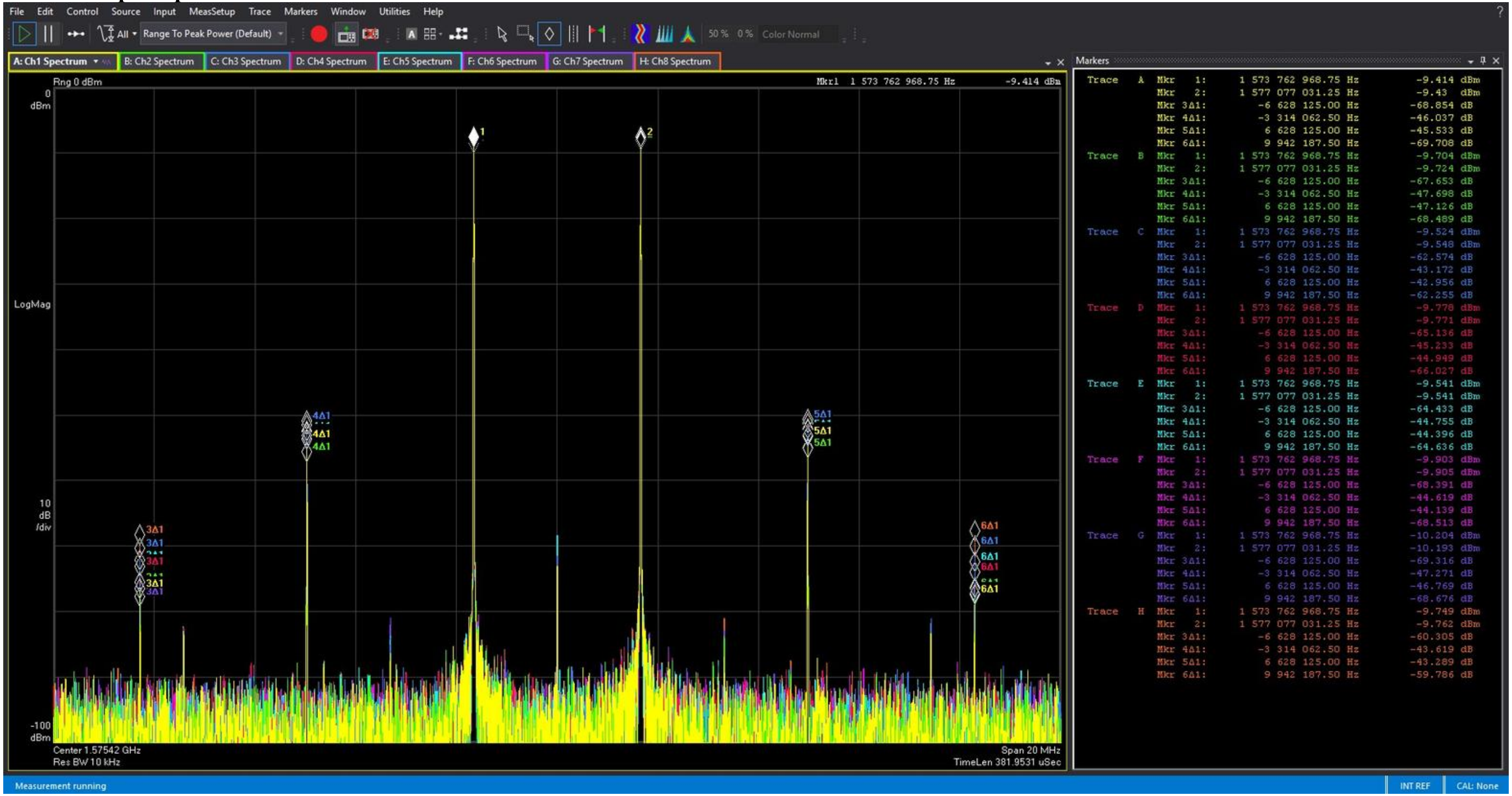
7.3. 1.657 MHz Offset

7.3.1. L1 CW

7.3.1.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-68.85	-46.04	-9.41	-9.43	-45.53	-69.71
E2	-67.65	-47.70	-9.70	-9.72	-47.13	-68.49
E3	-62.57	-43.17	-9.52	-9.55	-42.96	-62.25
E4	-65.14	-45.23	-9.78	-9.77	-44.95	-66.03
E5	-64.43	-44.75	-9.54	-9.54	-44.40	-64.64
E6	-68.39	-44.62	-9.90	-9.91	-44.14	-68.51
E7	-69.32	-47.27	-10.20	-10.19	-46.77	-68.68
E8	-60.30	-43.62	-9.75	-9.76	-43.29	-59.79

7.3.1.2. Scope Capture

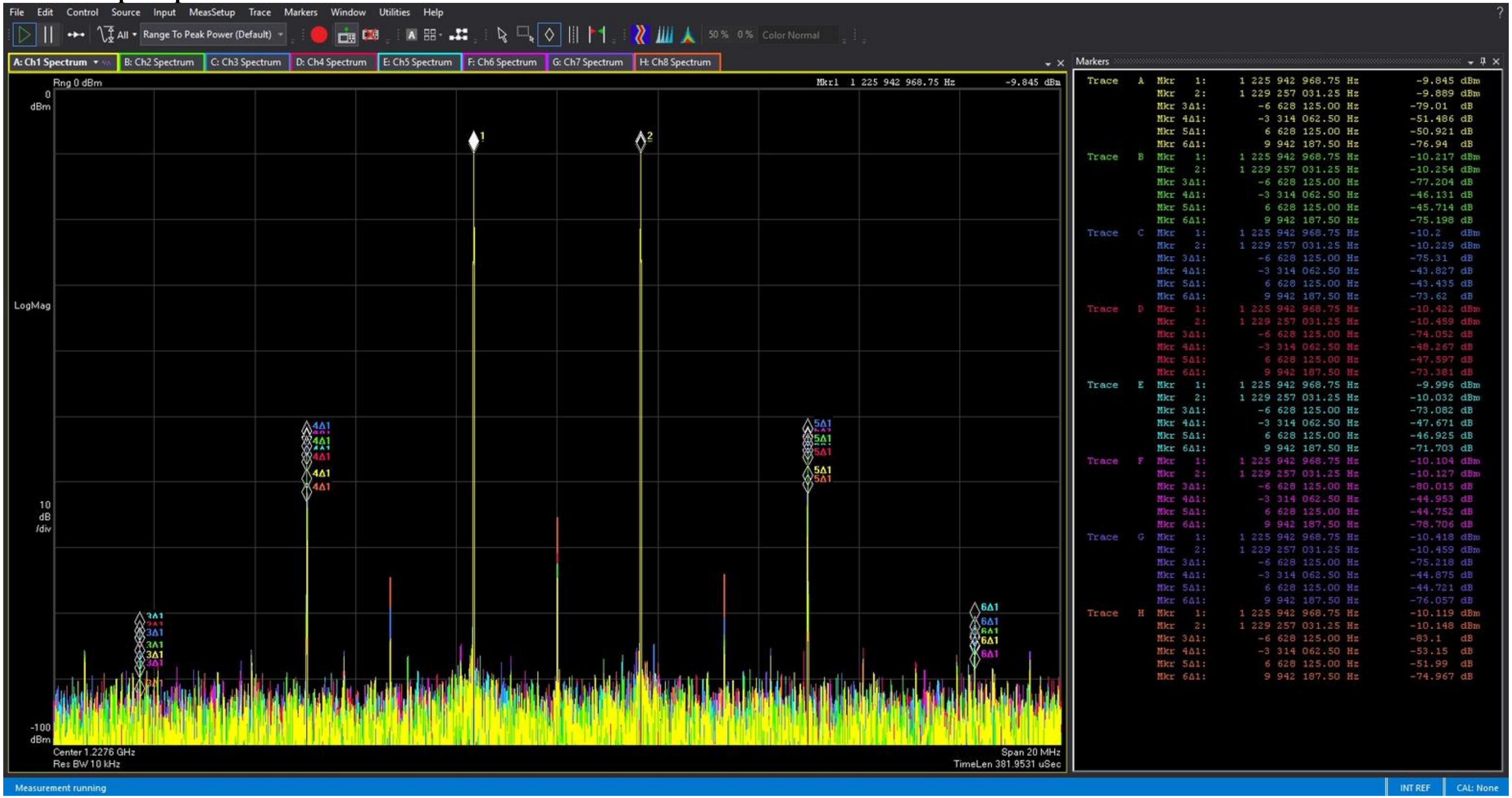


7.3.2. L2 CW

7.3.2.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-79.01	-51.49	-9.84	-9.89	-50.92	-76.94
E2	-77.20	-46.13	-10.22	-10.25	-45.71	-75.20
E3	-75.31	-43.83	-10.20	-10.23	-43.44	-73.62
E4	-74.05	-48.27	-10.42	-10.46	-47.60	-73.38
E5	-73.08	-47.67	-10.00	-10.03	-46.93	-71.70
E6	-80.01	-44.95	-10.10	-10.13	-44.75	-78.71
E7	-75.22	-44.87	-10.42	-10.46	-44.72	-76.06
E8	-83.10	-53.15	-10.12	-10.15	-51.99	-74.97

7.3.2.2. Scope Capture

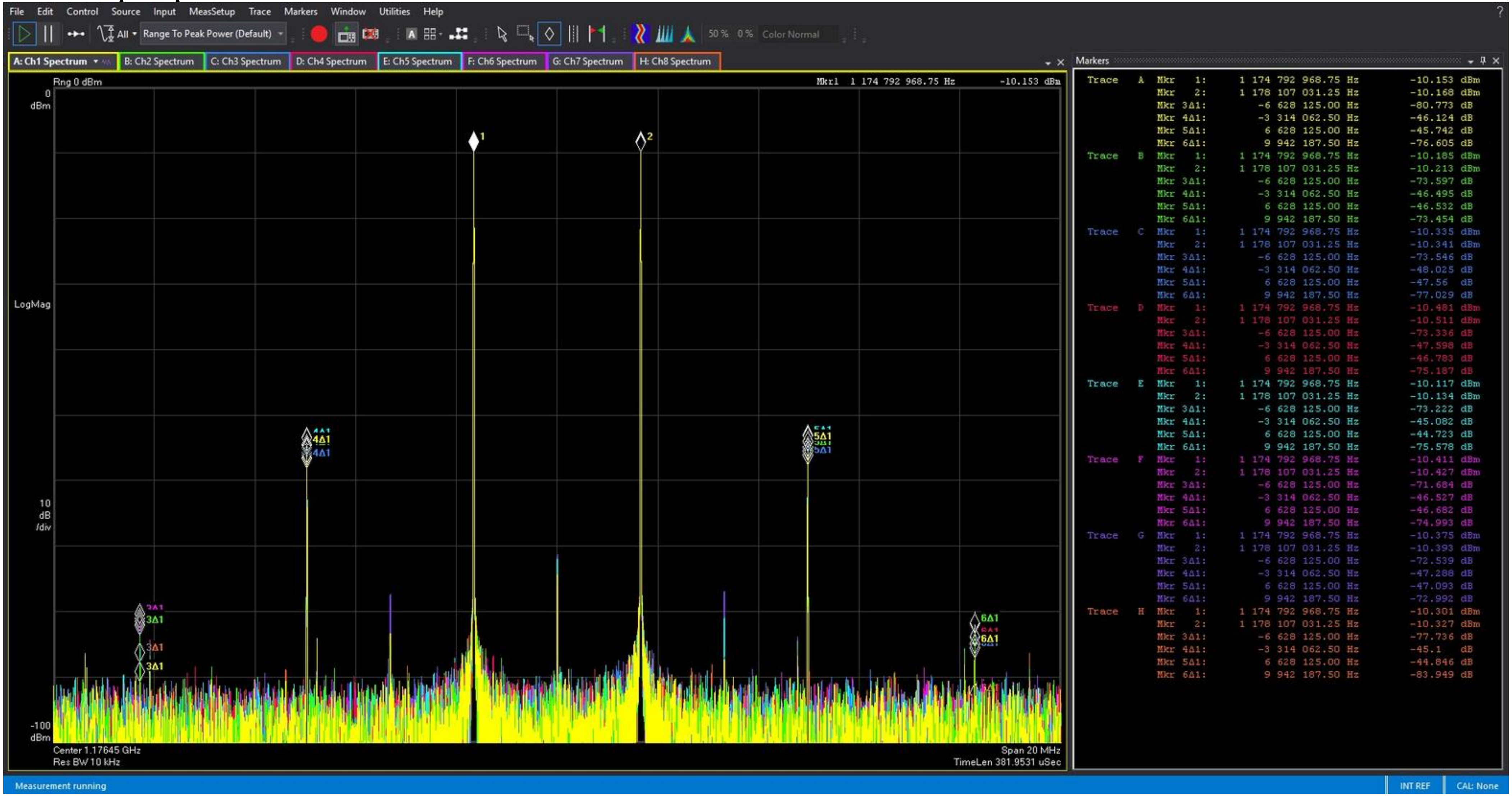


7.3.3. L5 CW

7.3.3.1. Data Table

Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-80.77	-46.12	-10.15	-10.17	-45.74	-76.60
E2	-73.60	-46.49	-10.19	-10.21	-46.53	-73.45
E3	-73.55	-48.02	-10.33	-10.34	-47.56	-77.03
E4	-73.34	-47.60	-10.48	-10.51	-46.78	-75.19
E5	-73.22	-45.08	-10.12	-10.13	-44.72	-75.58
E6	-71.68	-46.53	-10.41	-10.43	-46.68	-74.99
E7	-72.54	-47.29	-10.37	-10.39	-47.09	-72.99
E8	-77.74	-45.10	-10.30	-10.33	-44.85	-83.95

7.3.3.2. Scope Capture

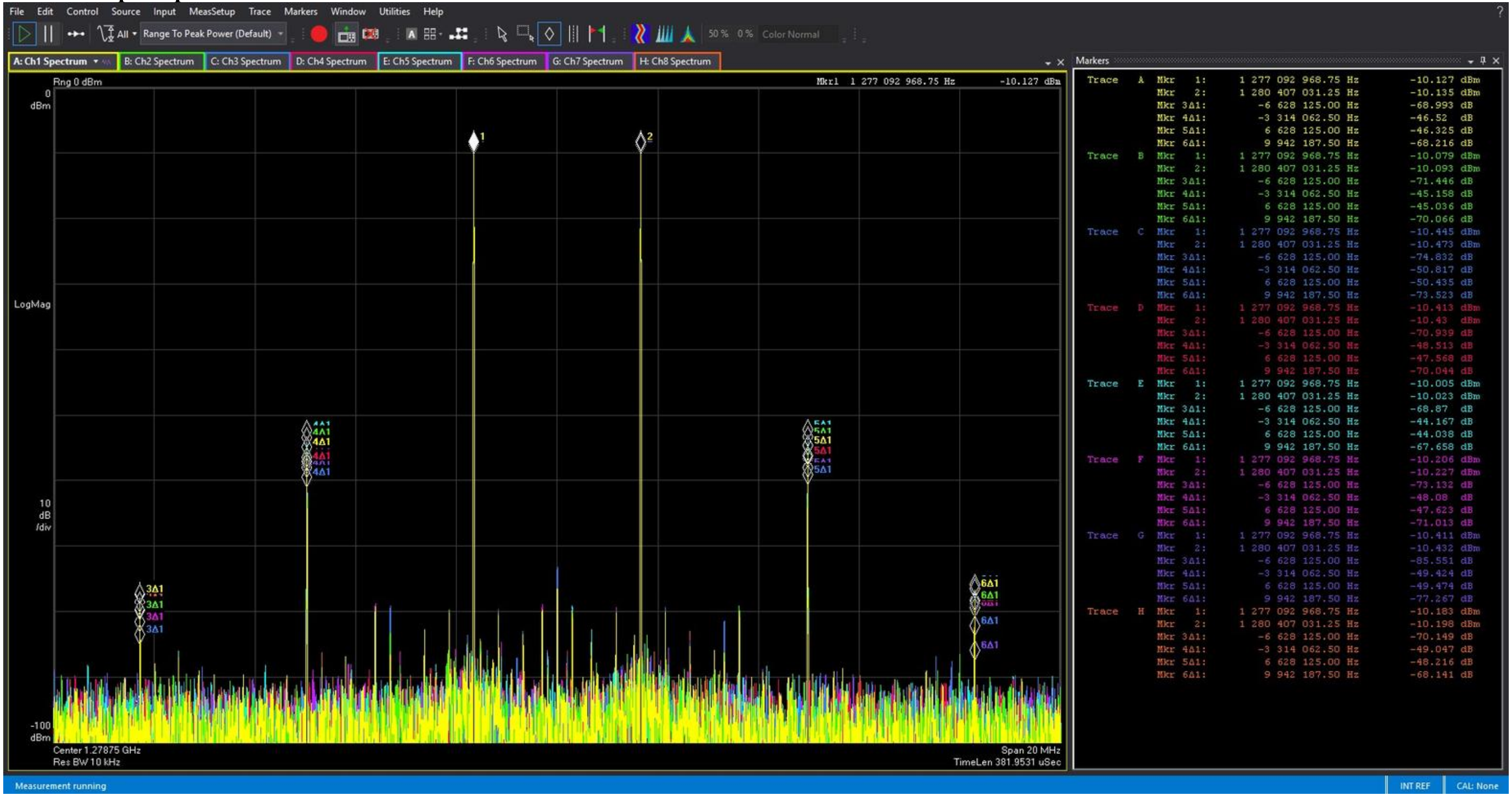


7.3.4. L6 CW

7.3.4.1. Data Table

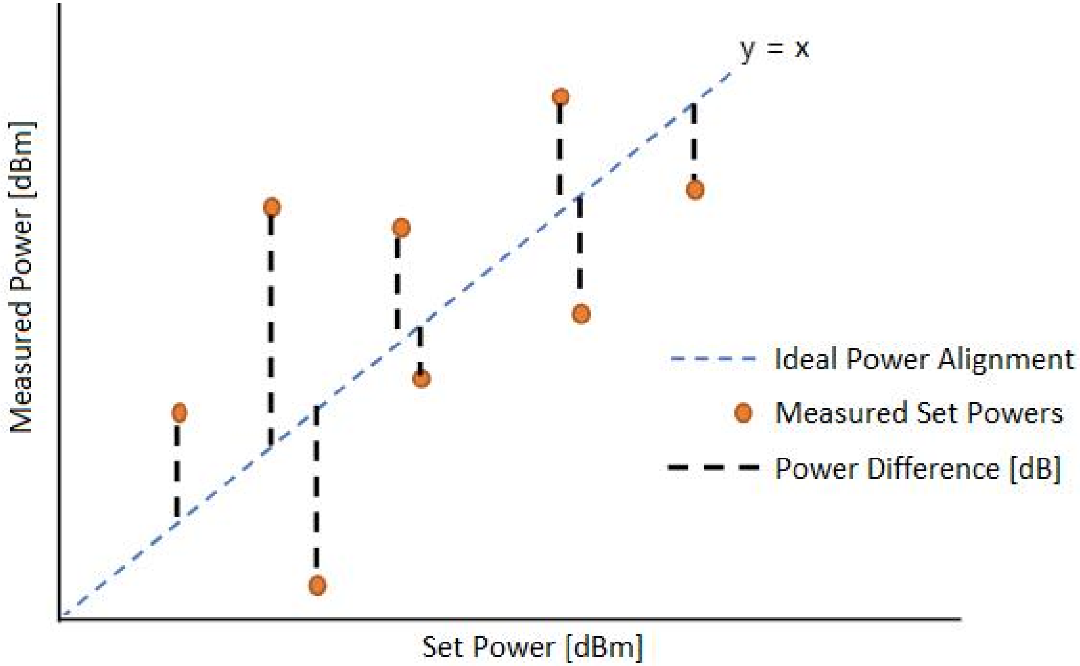
Mod Spurs	-5x [dBc]	-3x [dBc]	-CW [dBm]	+CW [dBm]	3x [dBc]	5x [dBc]
E1	-68.99	-46.52	-10.13	-10.13	-46.33	-68.22
E2	-71.45	-45.16	-10.08	-10.09	-45.04	-70.07
E3	-74.83	-50.82	-10.45	-10.47	-50.43	-73.52
E4	-70.94	-48.51	-10.41	-10.43	-47.57	-70.04
E5	-68.87	-44.17	-10.01	-10.02	-44.04	-67.66
E6	-73.13	-48.08	-10.21	-10.23	-47.62	-71.01
E7	-85.55	-49.42	-10.41	-10.43	-49.47	-77.27
E8	-70.15	-49.05	-10.18	-10.20	-48.22	-68.14

7.3.4.2. Scope Capture



8. Power Alignment

The purpose of this test is to **measure the relative power accuracy of a CW tone on each element as well as the relative power alignment between elements**. To do this, all WF elements are first connected to the EXR Scope and then enabled. A marker is put on the CW tone for each element and the set power of the CW tone is swept. The difference between the set power and measured power is recorded at each set power. This delta is the relative power accuracy of each element. The largest difference between all elements is also recorded as the MxN power alignment. This test is repeated for each L-Band and frequency of the WF. These measurements are tabulated below along with the associated screen captures of the EXR Scope.



Power Linearity: Regression Analysis Process

The power alignment measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
l Alignment l < 0.01 dB	0.01 dB ≥ l Alignment l ≥ 1.00 dB	1.00 dB ≥ l Alignment l ≥ 1.25 dB	l Alignment l ≥ 1.25 dB

The power accuracy measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
l Accuracy l < 0.01 dB	0.01 dB ≥ l Accuracy l ≥ 0.75 dB	0.75 dB ≥ l Accuracy l ≥ 1.00 dB	l Accuracy l ≥ 1.00 dB

Across all elements and bands, the statistical results of this test are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.13	0.31	-0.92	0.93
Alignment	0.35	0.22	0.03	1.15

8.1. L1

8.1.1. AWGN

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	0.02	-0.01	0.06	0.08	0.06	0.06	0.01	0.03	0.09
-65	0.08	0.05	0.10	0.10	0.11	0.10	0.06	0.07	0.05
-60	0.02	-0.02	0.04	0.03	0.05	0.01	-0.05	-0.01	0.10
-55	-0.15	-0.23	-0.14	-0.17	-0.14	-0.20	-0.25	-0.19	0.12
-50	0.03	-0.08	0.22	-0.01	0.04	-0.02	-0.16	0.14	0.39
-45	-0.02	-0.11	-0.02	-0.08	-0.04	-0.20	-0.30	-0.07	0.28
-40	0.01	-0.07	0.03	-0.02	-0.00	-0.18	-0.31	-0.05	0.34
-35	-0.43	-0.60	-0.49	-0.52	-0.46	-0.60	-0.78	-0.52	0.35
-30	-0.31	-0.46	-0.34	-0.35	-0.31	-0.16	-0.65	-0.37	0.49
-25	0.12	-0.26	-0.08	-0.14	-0.06	-0.31	-0.45	-0.22	0.57
-20	0.16	-0.23	-0.06	-0.12	-0.00	-0.29	-0.42	-0.19	0.58
-19	0.21	-0.15	0.00	-0.07	0.05	-0.22	-0.35	-0.12	0.56
-18	0.22	-0.14	0.03	-0.05	0.06	-0.21	-0.35	-0.11	0.58
-17	0.17	-0.19	-0.02	-0.10	0.03	-0.25	-0.39	-0.16	0.57
-16	0.23	-0.13	0.04	-0.05	0.08	-0.20	-0.34	-0.10	0.57
-15	0.32	-0.03	0.14	0.04	0.16	-0.10	-0.25	-0.01	0.57

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-14	0.13	-0.24	-0.03	-0.11	-0.03	-0.25	-0.47	-0.17	0.59
-13	0.17	-0.19	0.01	-0.09	-0.00	-0.21	-0.42	-0.13	0.59
-12	0.12	-0.22	-0.04	-0.13	-0.05	-0.25	-0.49	-0.17	0.61
-11	0.09	-0.26	-0.07	-0.14	-0.03	-0.30	-0.50	-0.21	0.59
-10	0.07	-0.27	-0.09	-0.21	-0.05	-0.32	-0.51	-0.23	0.58

Across all set powers for L1 AWGN, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.12	0.20	-0.78	0.32
Alignment	0.44	0.20	0.05	0.61

8.1.2. CW

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	0.11	0.09	0.14	0.16	0.10	0.11	0.13	0.13	0.07
-65	0.11	0.10	0.15	0.13	0.13	0.14	0.11	0.10	0.05
-60	0.12	0.10	0.12	0.12	0.13	0.11	0.10	0.10	0.03
-55	0.11	0.10	0.11	0.11	0.15	0.12	0.07	0.08	0.08
-50	0.10	0.09	0.03	0.04	0.14	0.10	0.03	0.07	0.11
-45	0.03	-0.02	-0.01	-0.00	0.04	-0.00	-0.08	-0.03	0.13
-40	-0.07	-0.13	-0.08	-0.10	-0.05	-0.12	-0.26	-0.13	0.21
-35	-0.00	-0.03	0.01	0.01	0.01	-0.14	-0.26	-0.06	0.27
-30	0.11	0.06	0.16	0.14	0.15	-0.03	-0.19	0.09	0.34
-25	0.16	0.03	0.10	0.11	0.15	-0.03	-0.25	0.05	0.41
-20	0.12	-0.08	0.59	0.07	0.14	-0.08	-0.29	0.03	0.87
-19	0.11	0.39	0.57	0.49	0.11	-0.10	-0.30	0.00	0.87
-18	0.85	0.43	0.61	0.49	0.14	-0.08	-0.30	0.03	1.15
-17	0.86	0.42	0.59	0.51	0.66	0.32	0.13	0.40	0.73
-16	0.88	0.45	0.65	0.52	0.69	0.34	0.18	0.42	0.70
-15	0.93	0.47	0.67	0.57	0.70	0.35	0.21	0.47	0.72
-14	0.82	0.34	0.60	0.52	0.61	0.34	0.08	0.42	0.75

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-13	0.82	0.36	0.60	0.49	0.56	0.31	0.07	0.41	0.76
-12	0.80	0.36	0.58	0.49	0.60	0.30	0.04	0.41	0.77
-11	0.77	0.31	0.55	0.41	0.57	0.23	-0.01	0.35	0.78
-10	0.76	0.31	0.53	0.44	0.59	0.26	-0.01	0.35	0.77

Across all set powers for L1 CW, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	0.22	0.27	-0.30	0.93
Alignment	0.50	0.35	0.03	1.15

8.2. L2

8.2.1. AWGN

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	-0.05	-0.08	-0.04	-0.03	-0.02	-0.04	-0.03	-0.05	0.06
-65	0.04	0.04	0.05	0.04	0.07	0.04	0.07	0.05	0.03
-60	-0.09	-0.09	-0.10	-0.10	-0.05	-0.10	-0.09	-0.09	0.05
-55	-0.14	-0.23	-0.20	-0.29	-0.15	-0.20	-0.20	-0.19	0.15
-50	-0.23	-0.29	-0.31	-0.40	-0.23	-0.26	-0.31	-0.28	0.18
-45	-0.02	-0.15	-0.09	-0.27	-0.08	-0.13	-0.13	-0.09	0.24
-40	-0.19	-0.34	-0.27	-0.49	-0.25	-0.31	-0.31	-0.24	0.29
-35	-0.41	-0.55	-0.50	-0.68	-0.46	-0.52	-0.56	-0.45	0.26
-30	-0.29	-0.41	-0.41	-0.51	-0.27	-0.35	-0.45	-0.27	0.24
-25	0.03	-0.34	-0.30	-0.46	-0.20	-0.22	-0.32	-0.35	0.48
-20	-0.04	-0.43	-0.38	-0.56	-0.28	-0.31	-0.45	-0.36	0.52
-19	0.01	-0.36	-0.32	-0.49	-0.22	-0.25	-0.38	-0.30	0.50
-18	0.02	-0.36	-0.31	-0.49	-0.21	-0.24	-0.38	-0.29	0.50
-17	-0.01	-0.39	-0.34	-0.53	-0.23	-0.27	-0.41	-0.33	0.52
-16	0.04	-0.34	-0.28	-0.47	-0.18	-0.22	-0.36	-0.28	0.51
-15	-0.02	-0.40	-0.35	-0.53	-0.24	-0.27	-0.42	-0.34	0.51

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-14	-0.16	-0.54	-0.45	-0.64	-0.38	-0.36	-0.59	-0.44	0.48
-13	-0.17	-0.53	-0.46	-0.64	-0.40	-0.36	-0.60	-0.44	0.47
-12	-0.23	-0.58	-0.52	-0.70	-0.43	-0.42	-0.65	-0.50	0.47
-11	-0.22	-0.57	-0.50	-0.69	-0.40	-0.41	-0.64	-0.50	0.47
-10	-0.20	-0.52	-0.46	-0.65	-0.37	-0.37	-0.60	-0.45	0.45

Across all set powers for L2 AWGN, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.30	0.19	-0.70	0.07
Alignment	0.35	0.18	0.03	0.52

8.2.2. CW

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	0.06	0.05	0.08	0.08	0.11	0.07	0.11	0.09	0.06
-65	0.07	0.06	0.07	0.08	0.10	0.08	0.10	0.09	0.04
-60	0.08	0.06	0.07	0.06	0.11	0.07	0.08	0.09	0.05
-55	0.08	0.08	0.06	0.04	0.11	0.06	0.06	0.07	0.06
-50	0.06	0.07	0.04	0.01	0.10	0.04	0.04	0.06	0.09
-45	-0.01	-0.07	-0.08	-0.16	-0.02	-0.07	-0.08	-0.03	0.15
-40	-0.08	-0.17	-0.19	-0.28	-0.14	-0.14	-0.19	-0.14	0.20
-35	-0.08	-0.18	-0.11	-0.32	-0.13	-0.16	-0.15	-0.13	0.24
-30	0.03	-0.10	-0.03	-0.21	-0.03	-0.06	-0.10	-0.01	0.24
-25	0.14	0.00	0.05	-0.12	0.15	0.04	-0.04	0.15	0.27
-20	0.29	0.12	0.14	-0.02	0.33	0.19	0.08	0.29	0.35
-19	0.26	0.11	0.11	-0.02	0.30	0.18	0.06	0.27	0.32
-18	0.74	0.13	0.14	-0.01	0.33	0.19	0.31	0.47	0.75
-17	0.75	0.33	0.35	0.14	0.52	0.18	0.32	0.46	0.61
-16	0.78	0.35	0.38	0.17	0.54	0.43	0.33	0.49	0.60
-15	0.80	0.38	0.41	0.20	0.57	0.47	0.38	0.51	0.60
-14	0.54	0.13	0.20	-0.00	0.31	0.29	0.08	0.31	0.54

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-13	0.42	0.13	0.19	-0.02	0.15	0.28	-0.08	0.14	0.50
-12	0.43	-0.09	-0.02	-0.23	0.17	0.08	-0.07	0.13	0.65
-11	0.39	-0.13	-0.04	-0.28	0.16	0.03	-0.11	0.11	0.67
-10	0.26	-0.11	-0.03	-0.27	0.01	0.04	-0.27	-0.09	0.53

Across all set powers for L2 CW, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	0.11	0.21	-0.32	0.80
Alignment	0.36	0.24	0.04	0.75

8.3. L5

8.3.1. AWGN

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	-0.32	-0.33	-0.32	-0.36	-0.34	-0.34	-0.29	-0.34	0.08
-65	-0.20	-0.20	-0.20	-0.24	-0.23	-0.21	-0.19	-0.22	0.05
-60	-0.31	-0.31	-0.33	-0.37	-0.33	-0.34	-0.31	-0.34	0.06
-55	-0.33	-0.35	-0.40	-0.49	-0.40	-0.39	-0.35	-0.40	0.17
-50	-0.42	-0.41	-0.49	-0.62	-0.46	-0.46	-0.43	-0.50	0.21
-45	-0.30	-0.34	-0.40	-0.52	-0.34	-0.40	-0.31	-0.42	0.22
-40	-0.45	-0.49	-0.57	-0.74	-0.49	-0.56	-0.48	-0.58	0.29
-35	-0.64	-0.71	-0.76	-0.92	-0.73	-0.74	-0.71	-0.76	0.29
-30	-0.49	-0.61	-0.62	-0.80	-0.60	-0.60	-0.64	-0.63	0.31
-25	-0.19	-0.40	-0.46	-0.58	-0.38	-0.52	-0.44	-0.47	0.39
-20	-0.28	-0.45	-0.55	-0.66	-0.39	-0.59	-0.47	-0.54	0.37
-19	-0.31	-0.46	-0.57	-0.67	-0.42	-0.61	-0.49	-0.56	0.36
-18	-0.30	-0.45	-0.54	-0.66	-0.40	-0.59	-0.48	-0.55	0.36
-17	-0.21	-0.36	-0.45	-0.57	-0.30	-0.51	-0.39	-0.46	0.36
-16	-0.26	-0.41	-0.50	-0.62	-0.36	-0.56	-0.44	-0.51	0.36
-15	-0.18	-0.34	-0.41	-0.53	-0.27	-0.47	-0.35	-0.43	0.35

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-14	-0.46	-0.58	-0.63	-0.74	-0.51	-0.68	-0.64	-0.62	0.28
-13	-0.42	-0.53	-0.59	-0.69	-0.49	-0.63	-0.60	-0.59	0.27
-12	-0.50	-0.60	-0.68	-0.77	-0.54	-0.72	-0.67	-0.66	0.26
-11	-0.48	-0.58	-0.64	-0.75	-0.50	-0.70	-0.65	-0.64	0.27
-10	-0.59	-0.69	-0.76	-0.87	-0.61	-0.82	-0.76	-0.76	0.28

Across all set powers for L5 AWGN, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.49	0.16	-0.92	-0.18
Alignment	0.27	0.10	0.05	0.39

8.3.2. CW

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	-0.23	-0.24	-0.24	-0.27	-0.25	-0.25	-0.20	-0.25	0.07
-65	-0.24	-0.24	-0.23	-0.26	-0.25	-0.24	-0.21	-0.25	0.05
-60	-0.23	-0.24	-0.24	-0.28	-0.26	-0.25	-0.22	-0.26	0.06
-55	-0.22	-0.22	-0.24	-0.30	-0.25	-0.26	-0.25	-0.25	0.08
-50	-0.23	-0.23	-0.27	-0.34	-0.26	-0.28	-0.27	-0.27	0.11
-45	-0.29	-0.30	-0.37	-0.41	-0.31	-0.35	-0.32	-0.35	0.12
-40	-0.36	-0.33	-0.43	-0.56	-0.40	-0.41	-0.38	-0.44	0.23
-35	-0.34	-0.37	-0.45	-0.56	-0.38	-0.45	-0.36	-0.43	0.21
-30	-0.23	-0.26	-0.35	-0.50	-0.26	-0.35	-0.25	-0.33	0.27
-25	-0.13	-0.21	-0.25	-0.42	-0.20	-0.27	-0.19	-0.27	0.29
-20	0.04	-0.12	-0.13	-0.35	-0.08	-0.13	-0.15	-0.15	0.39
-19	0.03	-0.12	-0.15	-0.35	-0.10	-0.14	-0.17	-0.16	0.38
-18	0.03	-0.11	-0.11	-0.34	-0.09	-0.14	0.13	0.17	0.52
-17	0.42	-0.12	0.12	0.04	0.25	-0.15	0.14	0.17	0.57
-16	0.45	-0.10	0.16	0.08	0.28	-0.15	0.16	0.20	0.59
-15	0.47	0.20	0.18	0.10	0.32	0.06	0.20	0.21	0.41
-14	0.18	-0.02	-0.02	-0.08	0.10	-0.10	-0.08	0.05	0.29

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-13	0.17	-0.03	-0.04	-0.08	0.06	-0.11	-0.15	-0.09	0.32
-12	0.09	-0.01	-0.20	-0.21	0.03	-0.12	-0.13	-0.08	0.30
-11	0.06	-0.05	-0.22	-0.25	0.01	-0.16	-0.17	-0.12	0.30
-10	0.06	-0.15	-0.21	-0.24	0.03	-0.29	-0.23	-0.25	0.36

Across all set powers for L5 CW, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.15	0.20	-0.56	0.47
Alignment	0.28	0.16	0.05	0.59

8.4. L6

8.4.1. AWGN

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	-0.20	-0.19	-0.20	-0.21	-0.21	-0.22	-0.17	-0.20	0.05
-65	-0.08	-0.08	-0.09	-0.09	-0.11	-0.10	-0.07	-0.08	0.04
-60	-0.07	-0.06	-0.09	-0.10	-0.09	-0.10	-0.07	-0.07	0.04
-55	-0.07	-0.08	-0.09	-0.14	-0.06	-0.10	-0.10	-0.08	0.08
-50	-0.26	-0.29	-0.37	-0.44	-0.30	-0.38	-0.35	-0.34	0.18
-45	-0.03	-0.14	-0.20	-0.29	-0.06	-0.15	-0.15	-0.12	0.26
-40	-0.14	-0.19	-0.26	-0.37	-0.15	-0.23	-0.23	-0.25	0.23
-35	-0.27	-0.27	-0.32	-0.50	-0.26	-0.33	-0.33	-0.41	0.24
-30	-0.18	-0.16	-0.23	-0.41	-0.17	-0.23	-0.22	-0.33	0.25
-25	-0.11	-0.15	-0.43	-0.35	-0.09	-0.26	-0.38	-0.26	0.34
-20	-0.13	-0.19	-0.50	-0.42	-0.09	-0.30	-0.34	-0.31	0.41
-19	-0.21	-0.26	-0.58	-0.49	-0.18	-0.37	-0.41	-0.39	0.40
-18	-0.33	-0.38	-0.69	-0.62	-0.29	-0.49	-0.53	-0.51	0.40
-17	-0.31	-0.35	-0.67	-0.61	-0.26	-0.47	-0.52	-0.49	0.41
-16	-0.29	-0.34	-0.65	-0.59	-0.25	-0.46	-0.50	-0.47	0.40
-15	-0.25	-0.30	-0.60	-0.54	-0.21	-0.41	-0.45	-0.43	0.39

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-14	-0.46	-0.49	-0.77	-0.69	-0.40	-0.55	-0.70	-0.57	0.37
-13	-0.37	-0.39	-0.68	-0.60	-0.33	-0.45	-0.60	-0.48	0.35
-12	-0.40	-0.40	-0.71	-0.62	-0.34	-0.49	-0.62	-0.51	0.38
-11	-0.40	-0.40	-0.70	-0.63	-0.32	-0.49	-0.63	-0.51	0.38
-10	-0.47	-0.47	-0.77	-0.70	-0.38	-0.56	-0.70	-0.58	0.39

Across all set powers for L6 AWGN, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	-0.34	0.19	-0.77	-0.03
Alignment	0.29	0.14	0.04	0.41

8.4.2. CW

Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-70	-0.10	-0.09	-0.08	-0.09	-0.11	-0.09	-0.06	-0.08	0.05
-65	-0.09	-0.09	-0.08	-0.10	-0.11	-0.10	-0.05	-0.07	0.05
-60	-0.08	-0.08	-0.10	-0.10	-0.11	-0.10	-0.07	-0.08	0.05
-55	-0.07	-0.07	-0.10	-0.13	-0.11	-0.11	-0.09	-0.09	0.06
-50	-0.08	-0.07	-0.14	-0.16	-0.10	-0.14	-0.12	-0.10	0.10
-45	-0.10	-0.16	-0.21	-0.25	-0.14	-0.21	-0.21	-0.18	0.14
-40	-0.19	-0.25	-0.29	-0.34	-0.21	-0.31	-0.27	-0.21	0.15
-35	-0.07	-0.15	-0.25	-0.31	-0.09	-0.21	-0.21	-0.15	0.24
-30	0.02	-0.02	-0.09	-0.20	0.01	-0.06	-0.06	-0.05	0.22
-25	0.19	0.11	0.08	-0.09	0.20	0.01	0.08	0.03	0.29
-20	0.29	0.28	0.20	-0.04	0.32	0.18	0.21	0.07	0.37
-19	0.27	0.28	0.18	-0.05	0.30	0.16	0.19	0.06	0.35
-18	0.27	0.31	0.20	-0.06	0.50	0.28	0.21	0.05	0.56
-17	0.44	0.40	0.08	0.14	0.51	0.29	0.25	0.26	0.43
-16	0.47	0.43	0.11	0.17	0.53	0.31	0.27	0.29	0.42
-15	0.49	0.46	0.14	0.19	0.55	0.34	0.31	0.30	0.41
-14	0.27	0.27	-0.03	0.05	0.37	0.21	0.05	0.17	0.40

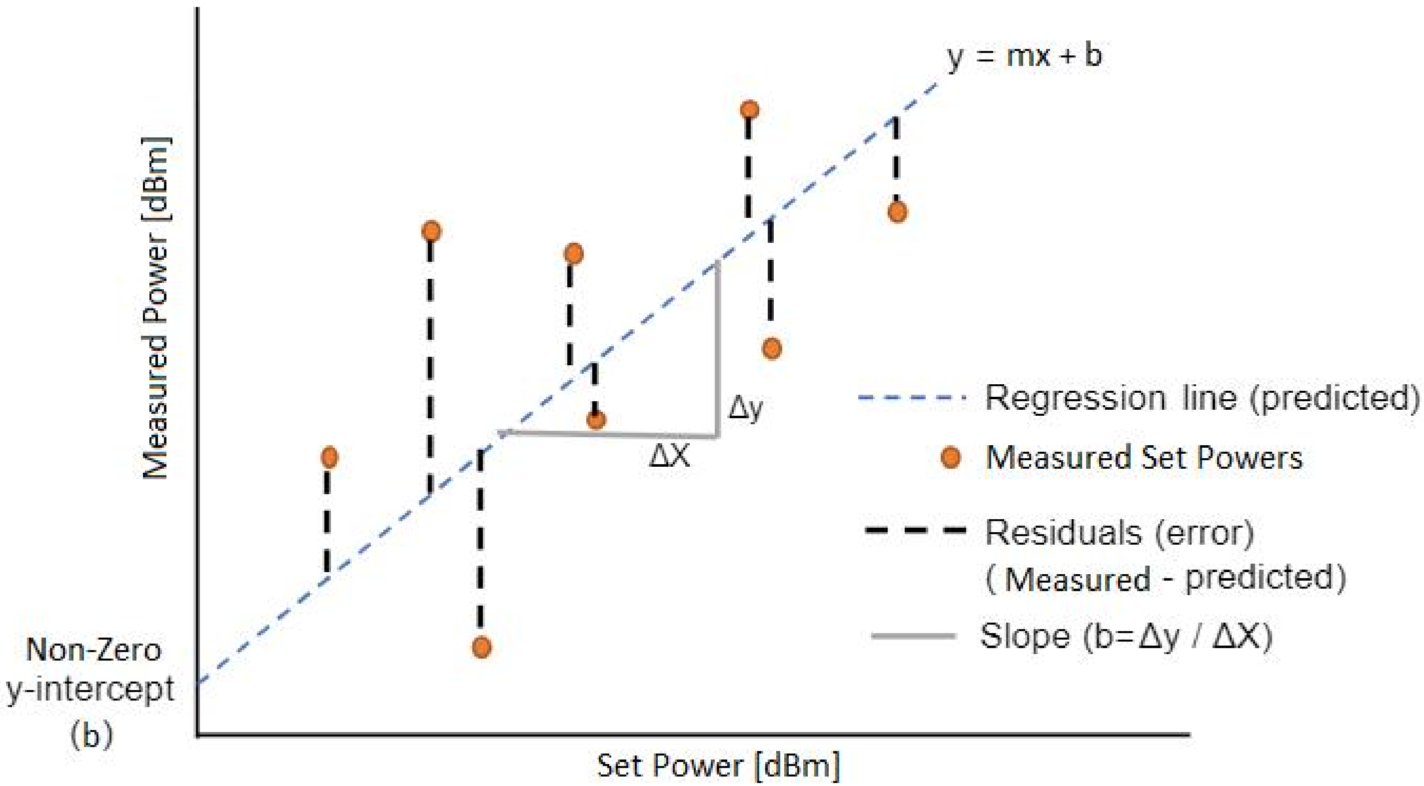
Power [dBm]	E1 [dB]	E2 [dB]	E3 [dB]	E4 [dB]	E5 [dB]	E6 [dB]	E7 [dB]	E8 [dB]	MxN [dB]
-13	0.26	0.27	-0.06	0.04	0.25	0.08	0.03	0.15	0.33
-12	0.07	0.07	-0.30	-0.18	0.28	0.08	-0.18	-0.08	0.58
-11	0.02	0.03	-0.34	-0.24	0.25	0.04	-0.22	-0.12	0.59
-10	0.03	0.04	-0.33	-0.24	0.12	-0.13	-0.21	-0.11	0.45

Across all set powers for L6 CW, the statistics are:

Power	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
Accuracy	0.03	0.21	-0.34	0.55
Alignment	0.30	0.18	0.05	0.59

9. Power Linearity

The purpose of this test is to **measure the linearity of each elements' power setting capability**. To do this, a linear fit is applied to the measured powers from the Power Alignment test for each element. The linear fit and measured data are plotted together alongside the residuals of these linear fits (see image below for clarification). The larger the residuals, the worse the power linearity is. This test is repeated for each L-Band and frequency of the WF.



Power Linearity: Regression Analysis Process

The power linearity measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
ǀ Mean ǀ < 0.01 dB	0.01 dB ≥ ǀ Mean ǀ ≥ 0.75 dB	0.75 dB ≥ ǀ Mean ǀ ≥ 1.00 dB	ǀ Mean ǀ ≥ 1.00 dB
Min > -0.15 dBc	-0.15 dBc ≤ Min ≤ -0.75 dBc	-0.75 dBc ≤ Min ≤ -1.00 dBc	Min ≤ -1.00 dBc
Max < 0.15 dBc	0.15 dBc ≥ Max ≥ 0.75 dBc	0.75 dBc ≥ Max ≥ 1.00 dBc	Max ≥ 1.00 dBc
Std < 0.15 dBc	0.15 dBc ≥ Std ≥ 0.40 dBc	0.40 dBc ≥ Std ≥ 0.50 dBc	Std ≥ 0.50 dBc

Across all elements and bands, the statistical results of this test are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
0.04	0.27	-0.84	0.74

9.1. L1

9.1.1. AWGN

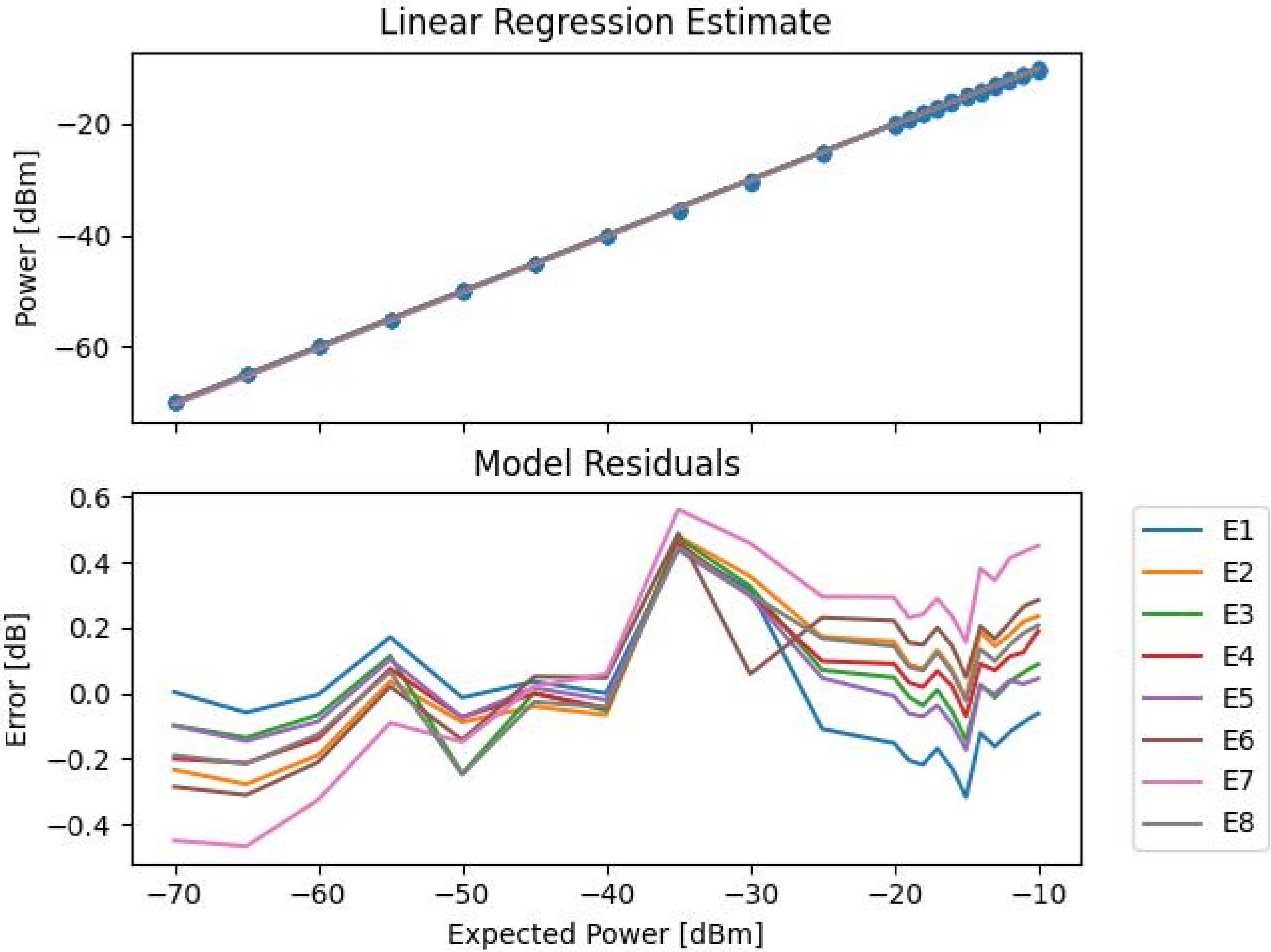
9.1.1.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	-0.05	0.18	-0.32	0.44
E2	0.08	0.19	-0.28	0.48
E3	0.02	0.15	-0.24	0.47
E4	0.05	0.15	-0.21	0.46
E5	0.01	0.14	-0.17	0.44
E6	0.10	0.20	-0.31	0.49
E7	0.16	0.30	-0.47	0.56
E8	0.07	0.17	-0.25	0.45

Across all elements for L1 AWGN, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
0.05	0.20	-0.47	0.56

9.1.1.2. Data Plot



9.1.2. CW

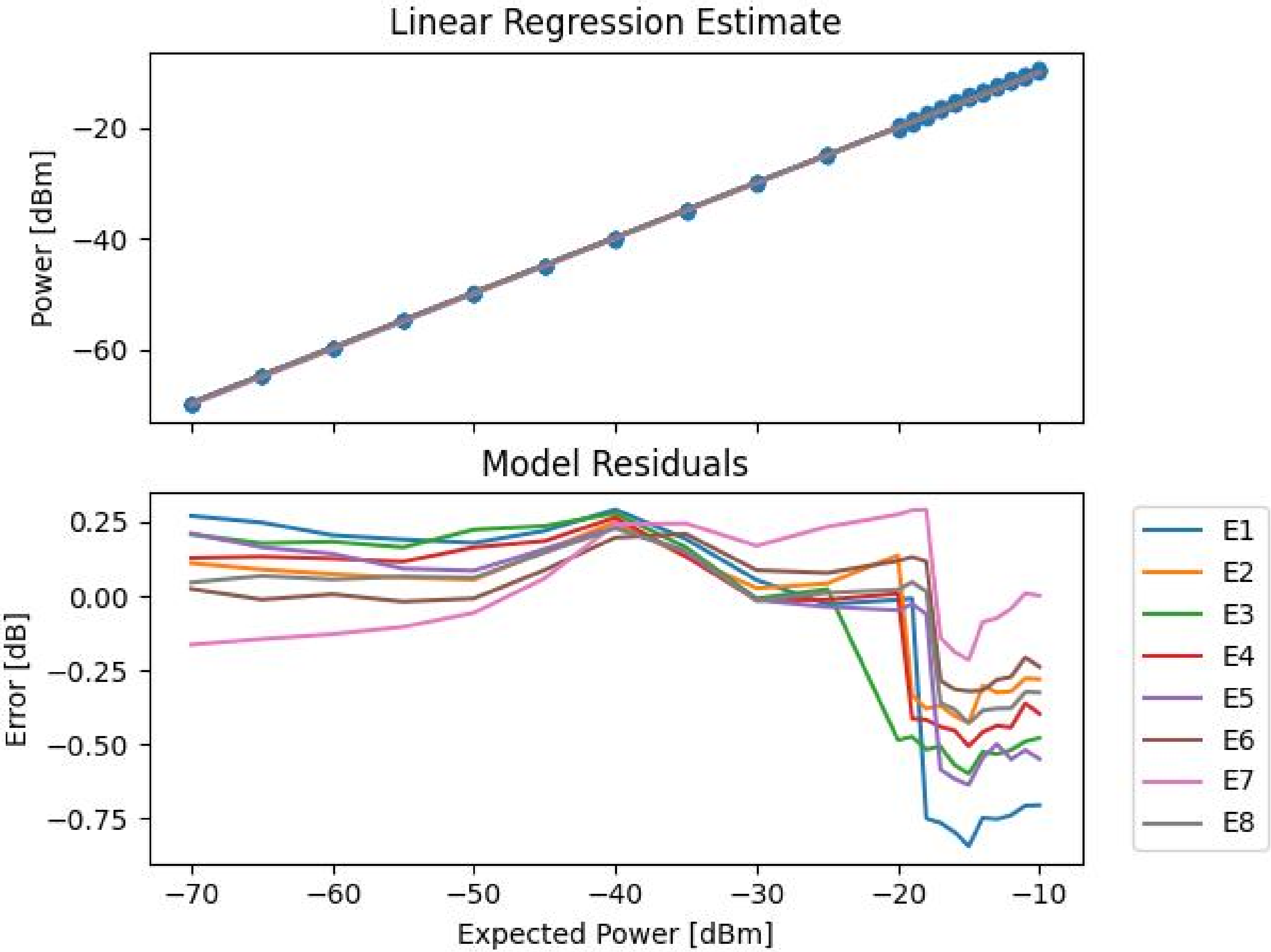
9.1.2.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	-0.24	0.47	-0.84	0.29
E2	-0.11	0.23	-0.43	0.25
E3	-0.19	0.36	-0.60	0.28
E4	-0.15	0.29	-0.51	0.27
E5	-0.16	0.33	-0.64	0.23
E6	-0.06	0.19	-0.32	0.21
E7	0.02	0.18	-0.22	0.29
E8	-0.10	0.23	-0.43	0.23

Across all elements for L1 CW, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
-0.12	0.30	-0.84	0.29

9.1.2.2. Data Plot



9.2. L2

9.2.1. AWGN

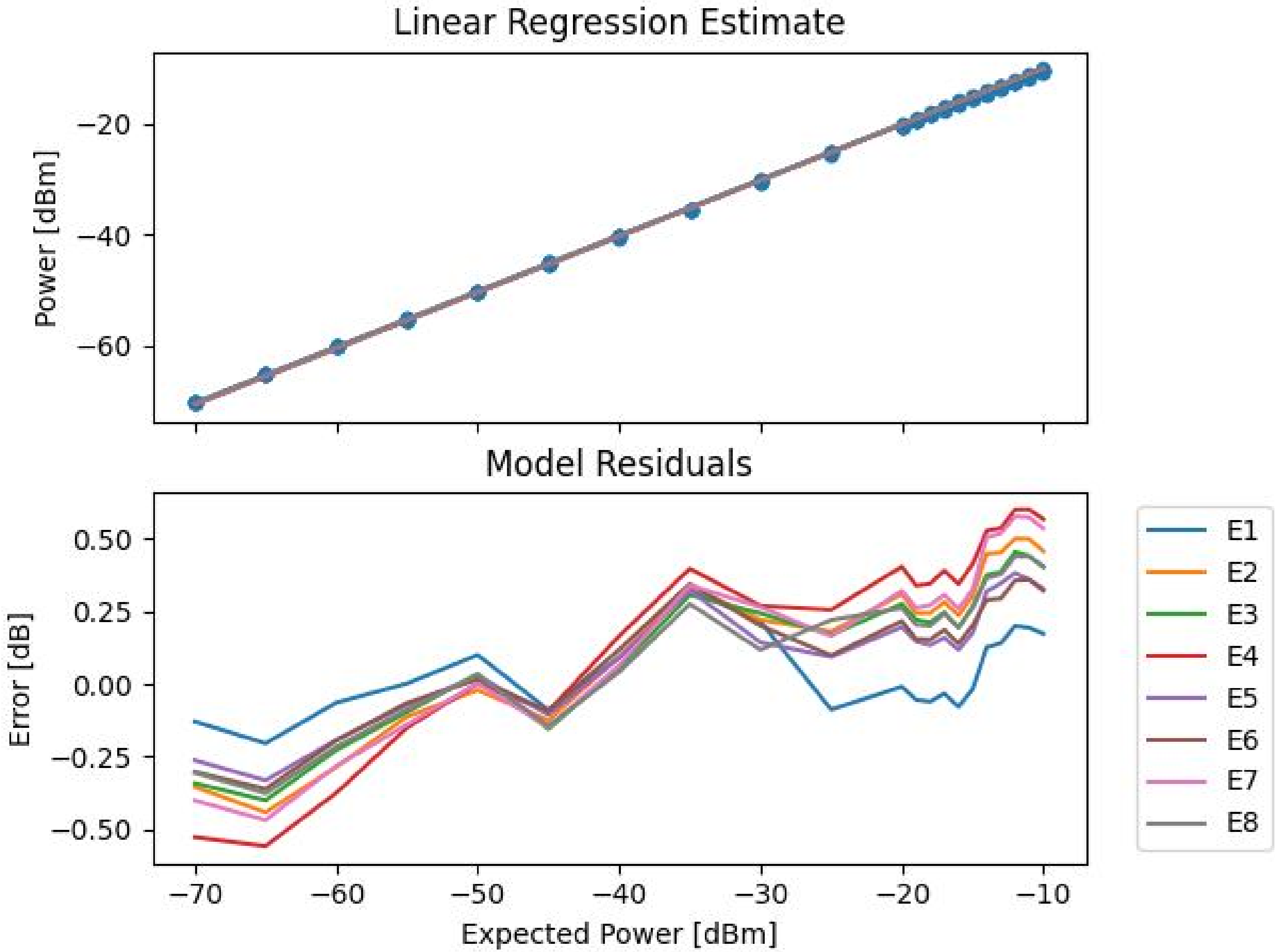
9.2.1.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	0.04	0.14	-0.20	0.33
E2	0.17	0.28	-0.44	0.50
E3	0.15	0.25	-0.40	0.46
E4	0.21	0.36	-0.56	0.60
E5	0.11	0.21	-0.33	0.38
E6	0.12	0.21	-0.36	0.36
E7	0.18	0.32	-0.47	0.58
E8	0.14	0.24	-0.38	0.44

Across all elements for L2 AWGN, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
0.14	0.26	-0.56	0.60

9.2.1.2. Data Plot



9.2.2. CW

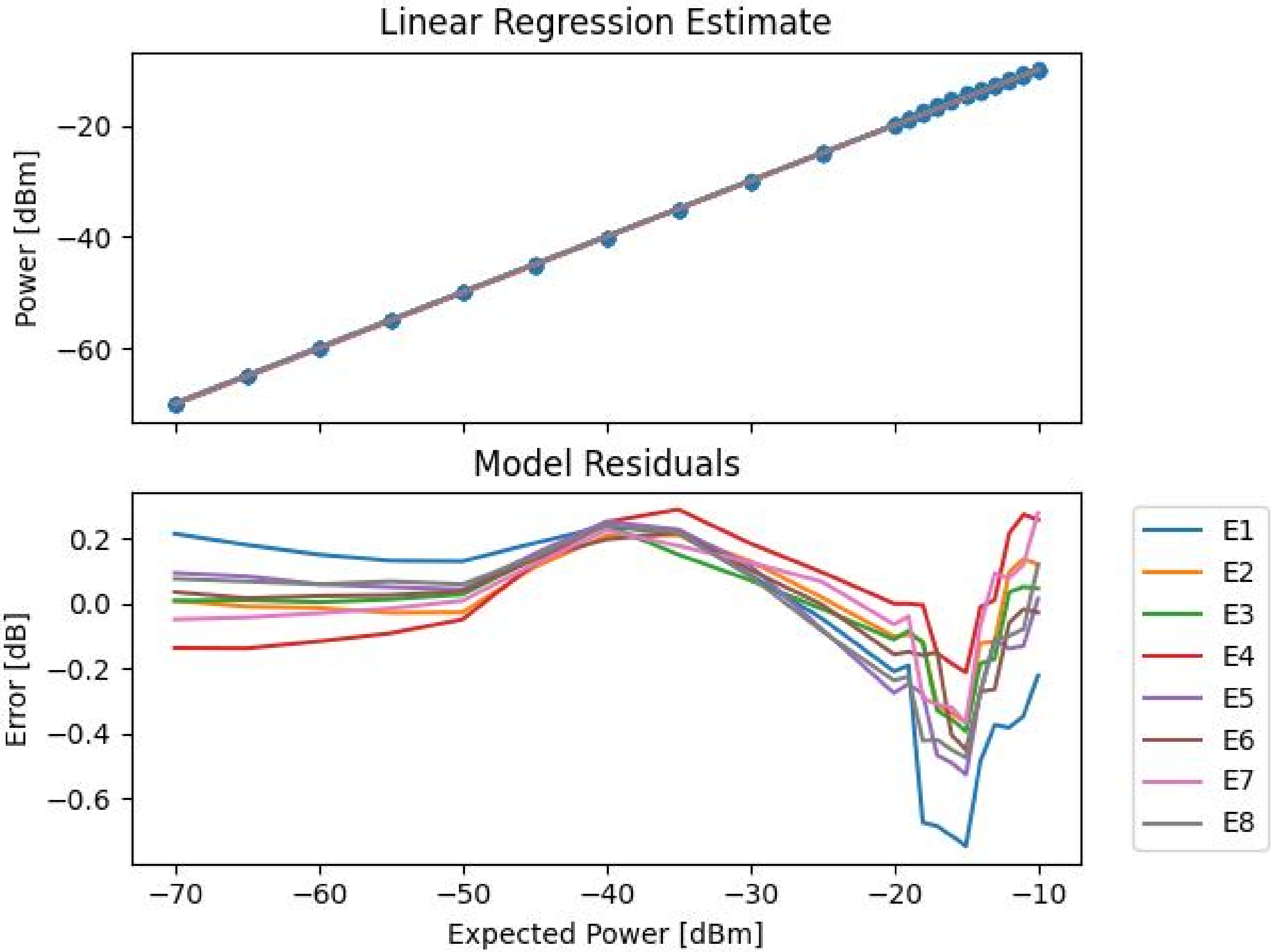
9.2.2.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	-0.17	0.35	-0.75	0.24
E2	-0.03	0.17	-0.37	0.21
E3	-0.05	0.17	-0.39	0.24
E4	0.03	0.16	-0.21	0.29
E5	-0.09	0.23	-0.53	0.25
E6	-0.06	0.18	-0.45	0.22
E7	-0.01	0.18	-0.37	0.28
E8	-0.08	0.23	-0.47	0.24

Across all elements for L2 CW, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
-0.06	0.22	-0.75	0.29

9.2.2.2. Data Plot



9.3. L5

9.3.1. AWGN

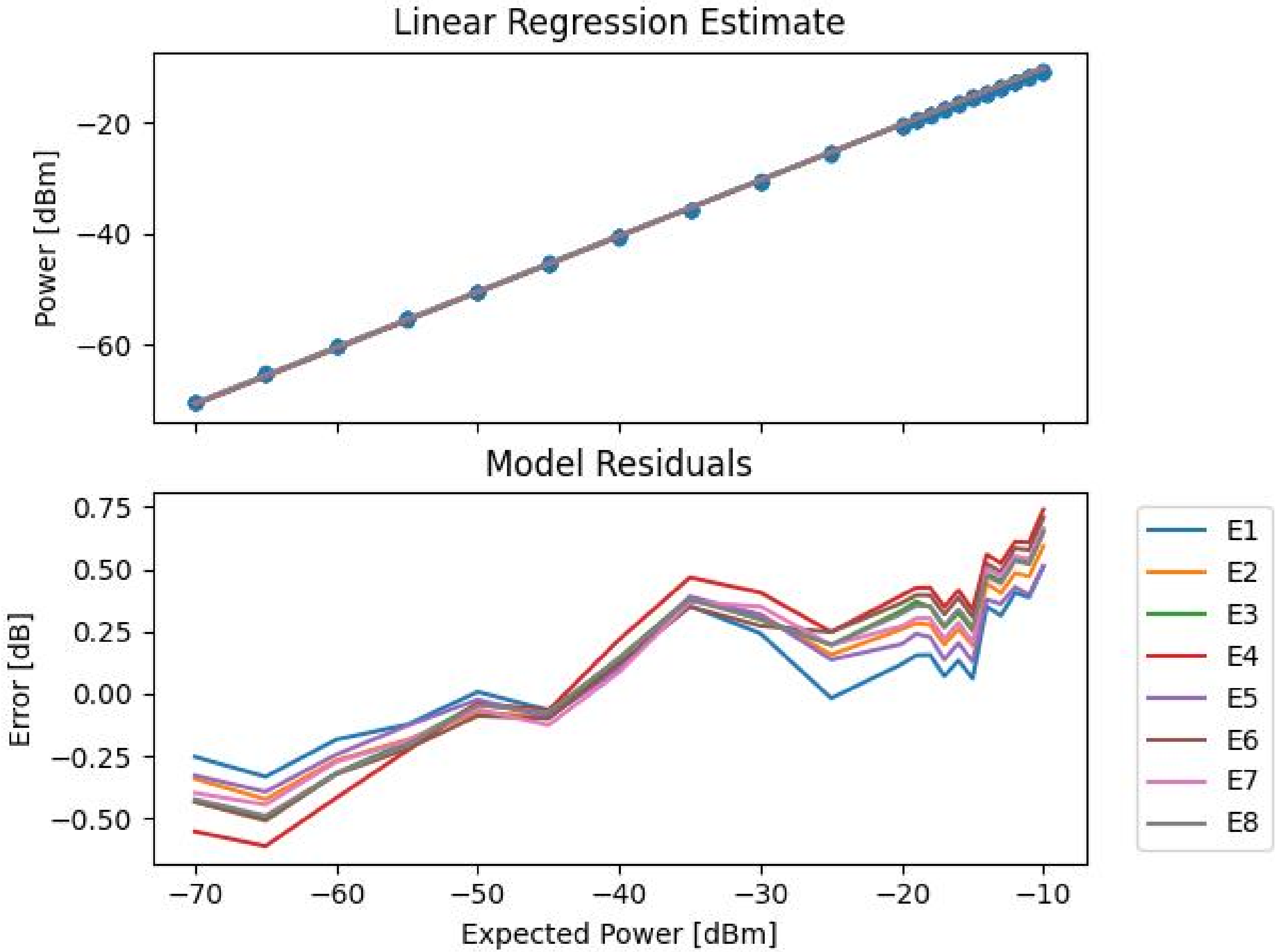
9.3.1.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	0.11	0.23	-0.33	0.51
E2	0.16	0.29	-0.42	0.59
E3	0.19	0.33	-0.50	0.65
E4	0.23	0.39	-0.61	0.74
E5	0.14	0.26	-0.39	0.51
E6	0.21	0.35	-0.51	0.71
E7	0.18	0.32	-0.44	0.67
E8	0.19	0.33	-0.49	0.65

Across all elements for L5 AWGN, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
0.18	0.31	-0.61	0.74

9.3.1.2. Data Plot



9.3.2. CW

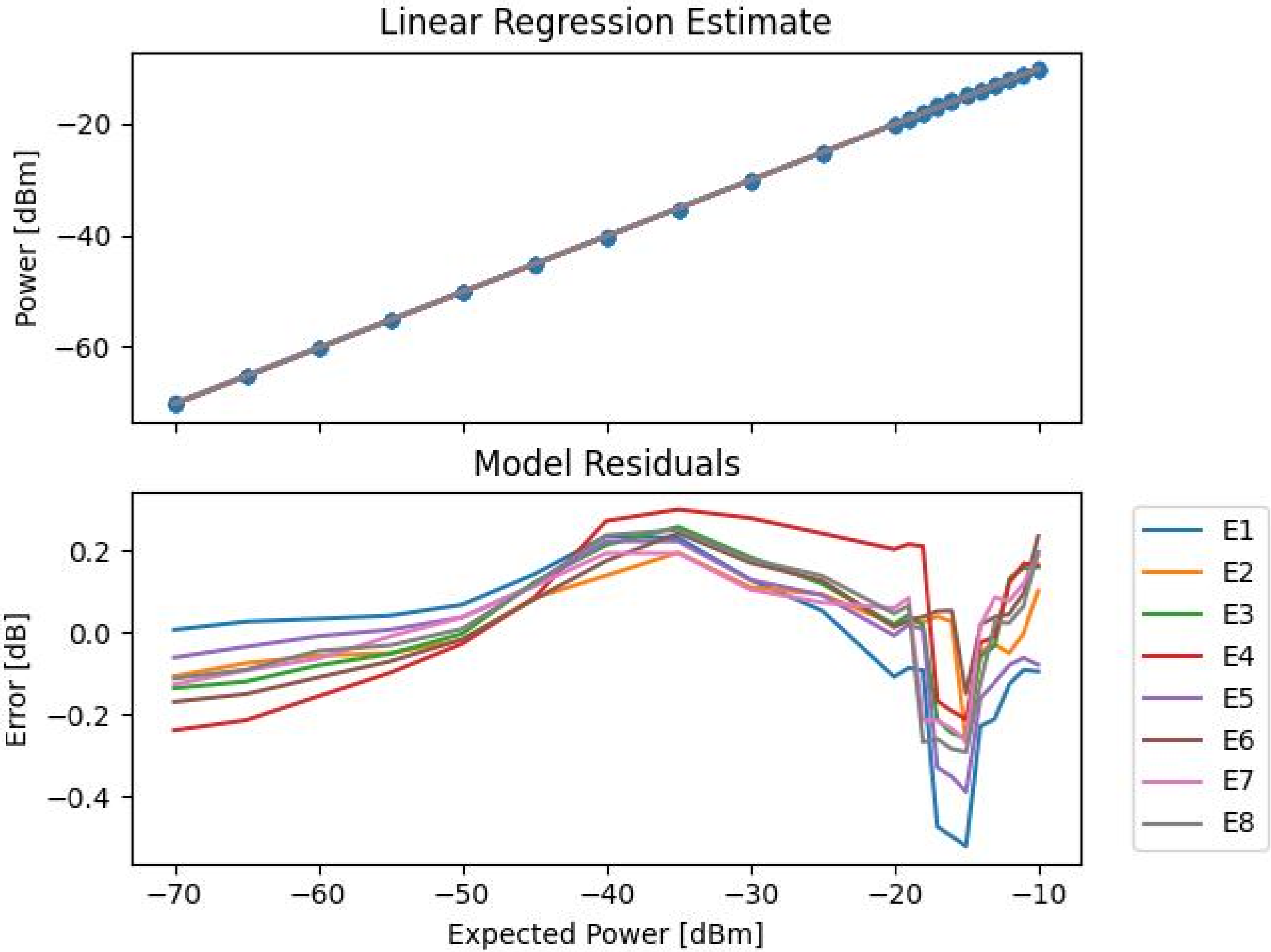
9.3.2.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	-0.07	0.22	-0.52	0.24
E2	0.01	0.10	-0.27	0.19
E3	0.01	0.15	-0.26	0.26
E4	0.04	0.19	-0.24	0.30
E5	-0.04	0.17	-0.39	0.22
E6	0.04	0.12	-0.17	0.24
E7	0.01	0.15	-0.27	0.19
E8	-0.01	0.17	-0.29	0.25

Across all elements for L5 CW, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
-0.00	0.16	-0.52	0.30

9.3.2.2. Data Plot



9.4. L6

9.4.1. AWGN

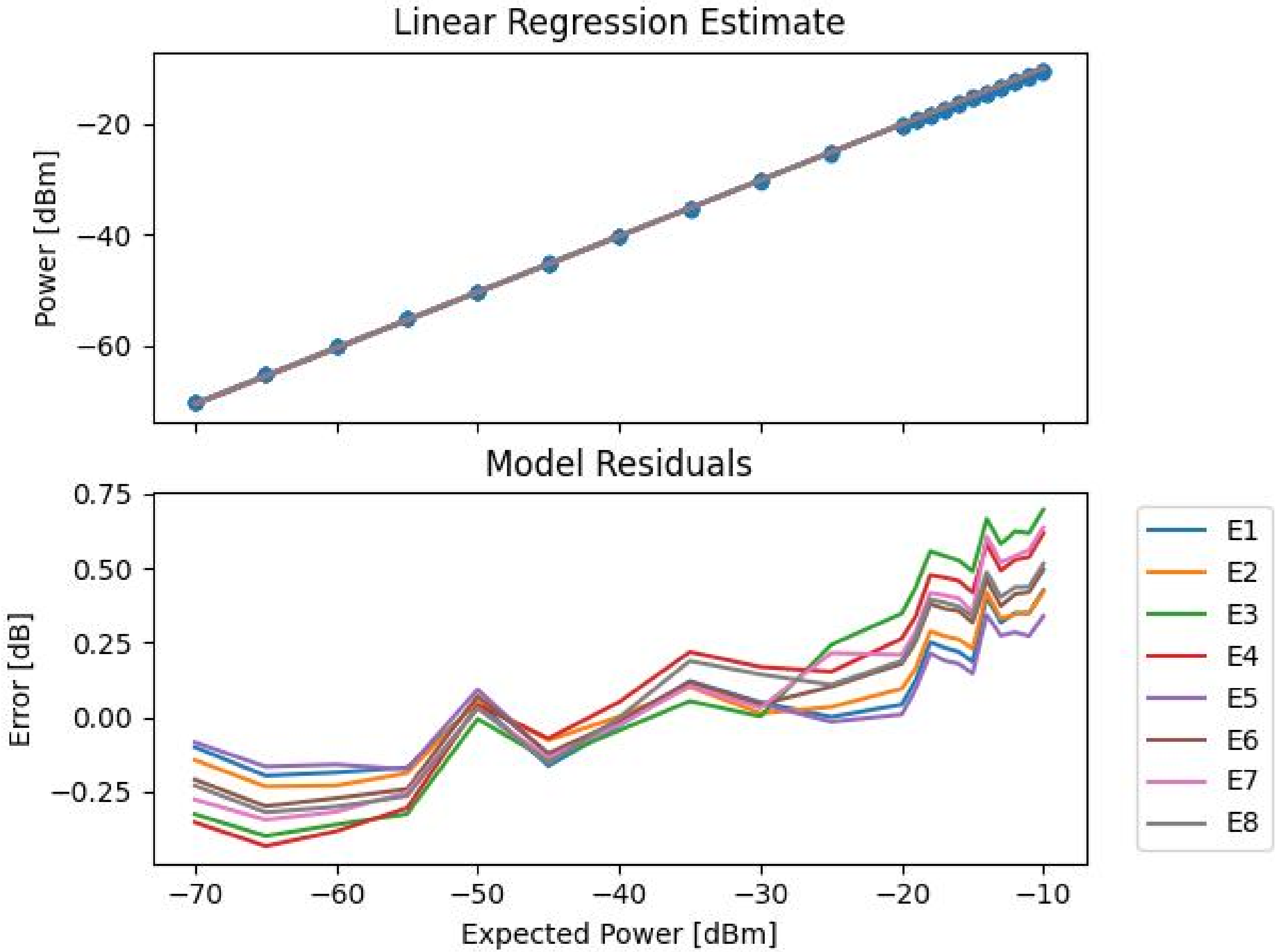
9.4.1.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	0.11	0.20	-0.20	0.43
E2	0.12	0.21	-0.23	0.42
E3	0.23	0.39	-0.40	0.70
E4	0.20	0.34	-0.43	0.62
E5	0.09	0.17	-0.17	0.34
E6	0.15	0.26	-0.30	0.50
E7	0.19	0.32	-0.34	0.64
E8	0.16	0.28	-0.32	0.52

Across all elements for L6 AWGN, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
0.16	0.28	-0.43	0.70

9.4.1.2. Data Plot



9.4.2. CW

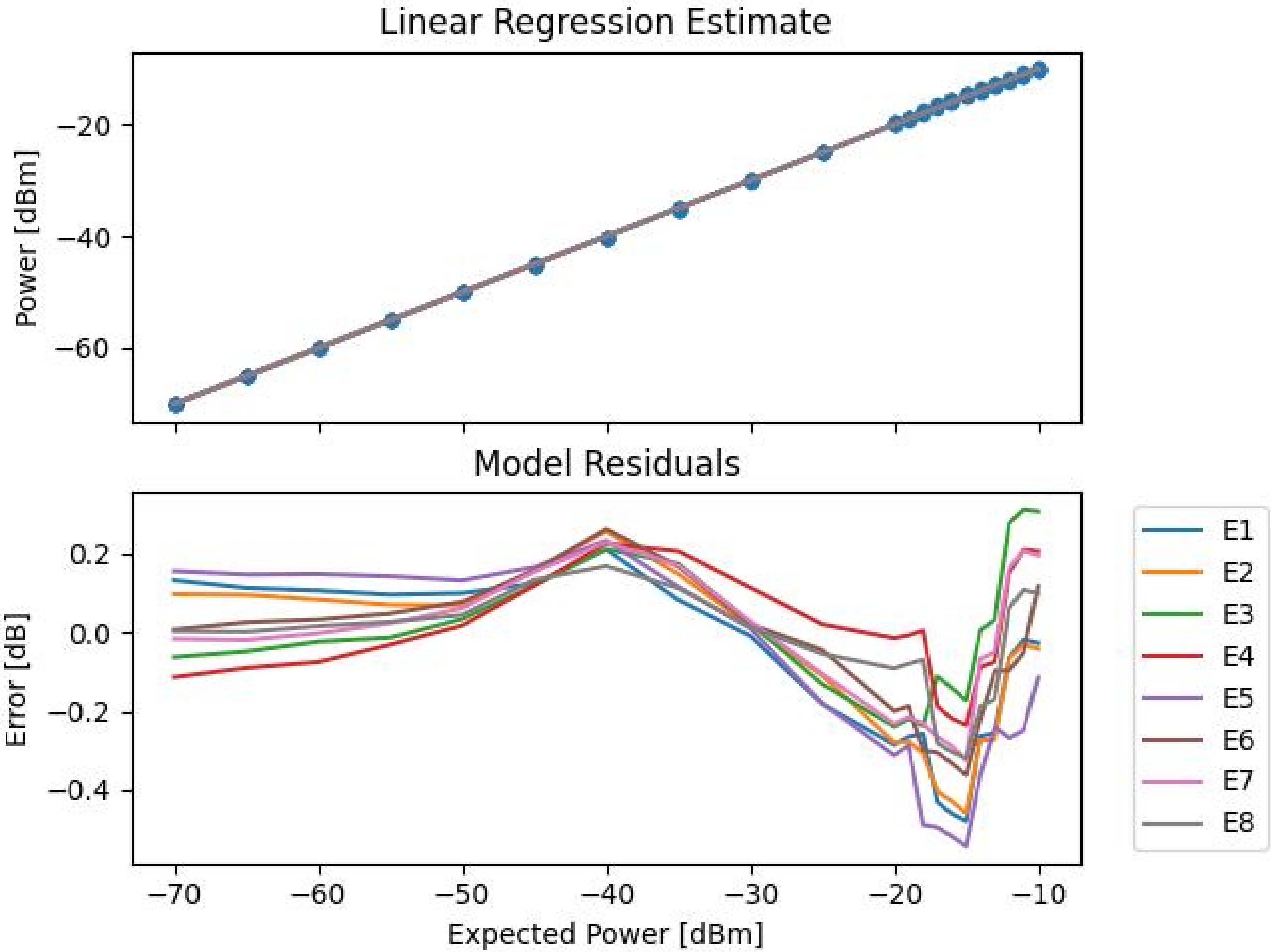
9.4.2.1. Data Table

Power Linearity	Mean [dB]	Std [dB]	Min [dB]	Max [dB]
E1	-0.10	0.22	-0.48	0.21
E2	-0.09	0.22	-0.46	0.26
E3	0.00	0.17	-0.24	0.31
E4	0.01	0.14	-0.24	0.23
E5	-0.13	0.27	-0.54	0.23
E6	-0.06	0.18	-0.36	0.26
E7	-0.03	0.18	-0.32	0.23
E8	-0.04	0.14	-0.32	0.17

Across all elements for L6 CW, the statistics are:

Mean [dB]	Std [dB]	Min [dB]	Max [dB]
-0.05	0.20	-0.54	0.31

9.4.2.2. Data Plot



10. Power Stability

This test is used to **determine the short term power stability of an element**.

The power stability measurements are color coded based on the following acceptance criteria:

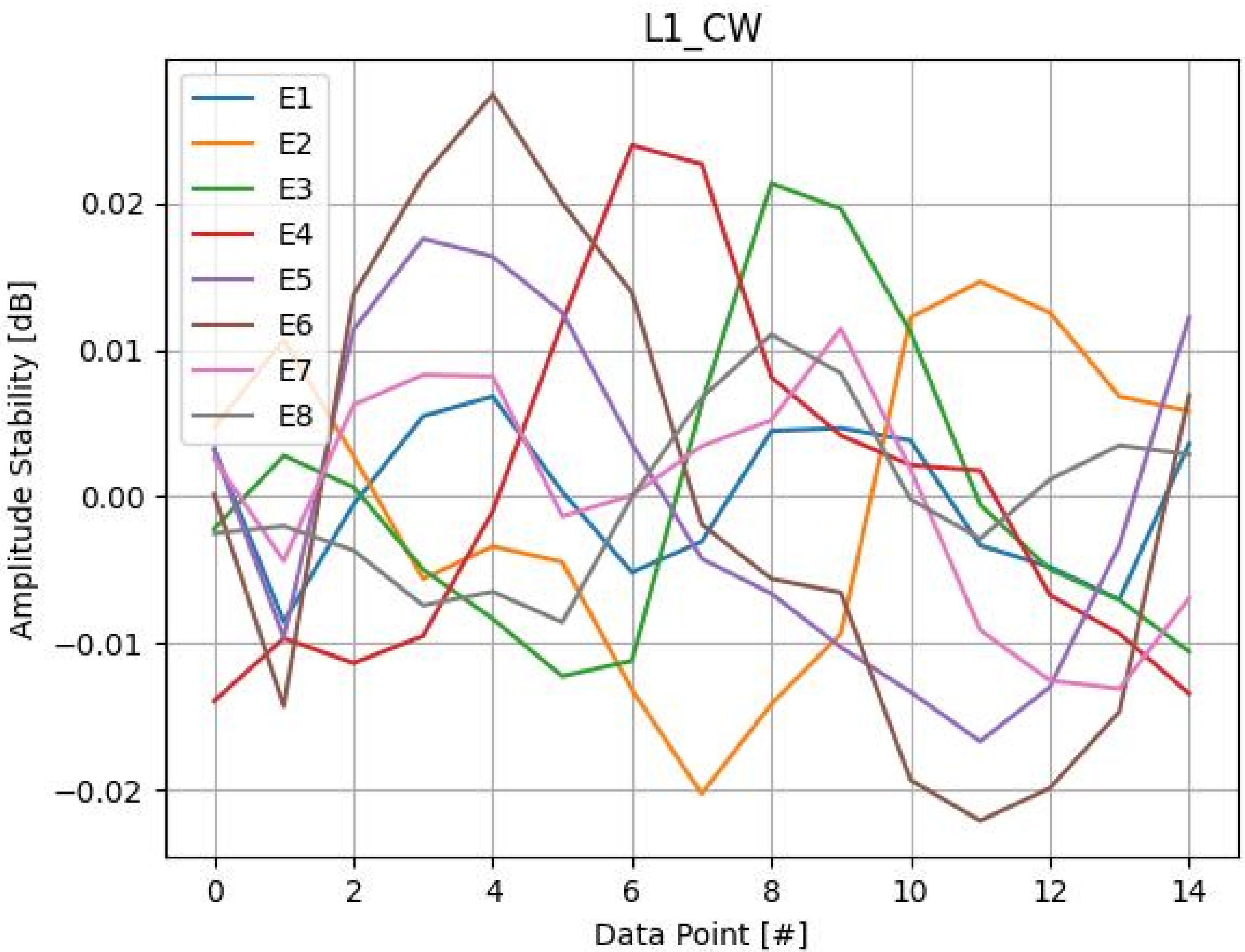
Exceptional	Passing	Borderline	Failing
| Power Stability | < 0.01 dB	0.01 dB ≥ | Power Stability | ≥ 0.05 dB	0.05 dB ≥ | Power Stability | ≥ 0.10 dB	| Power Stability | ≥ 0.10 dB

10.1. L1 CW

10.1.1. Data Table

E1 [dBc]	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
0.00	0.00	-0.00	-0.01	0.00	0.00	0.00	-0.00
-0.01	0.01	0.00	-0.01	-0.01	-0.01	-0.00	-0.00
-0.00	0.00	0.00	-0.01	0.01	0.01	0.01	-0.00
0.01	-0.01	-0.00	-0.01	0.02	0.02	0.01	-0.01
0.01	-0.00	-0.01	-0.00	0.02	0.03	0.01	-0.01
0.00	-0.00	-0.01	0.01	0.01	0.02	-0.00	-0.01
-0.01	-0.01	-0.01	0.02	0.00	0.01	0.00	-0.00
-0.00	-0.02	0.01	0.02	-0.00	-0.00	0.00	0.01
0.00	-0.01	0.02	0.01	-0.01	-0.01	0.01	0.01
0.00	-0.01	0.02	0.00	-0.01	-0.01	0.01	0.01
0.00	0.01	0.01	0.00	-0.01	-0.02	0.00	-0.00
-0.00	0.01	-0.00	0.00	-0.02	-0.02	-0.01	-0.00
-0.00	0.01	-0.00	-0.01	-0.01	-0.02	-0.01	0.00
-0.01	0.01	-0.01	-0.01	-0.00	-0.01	-0.01	0.00
0.00	0.01	-0.01	-0.01	0.01	0.01	-0.01	0.00

10.1.2. Data Plot

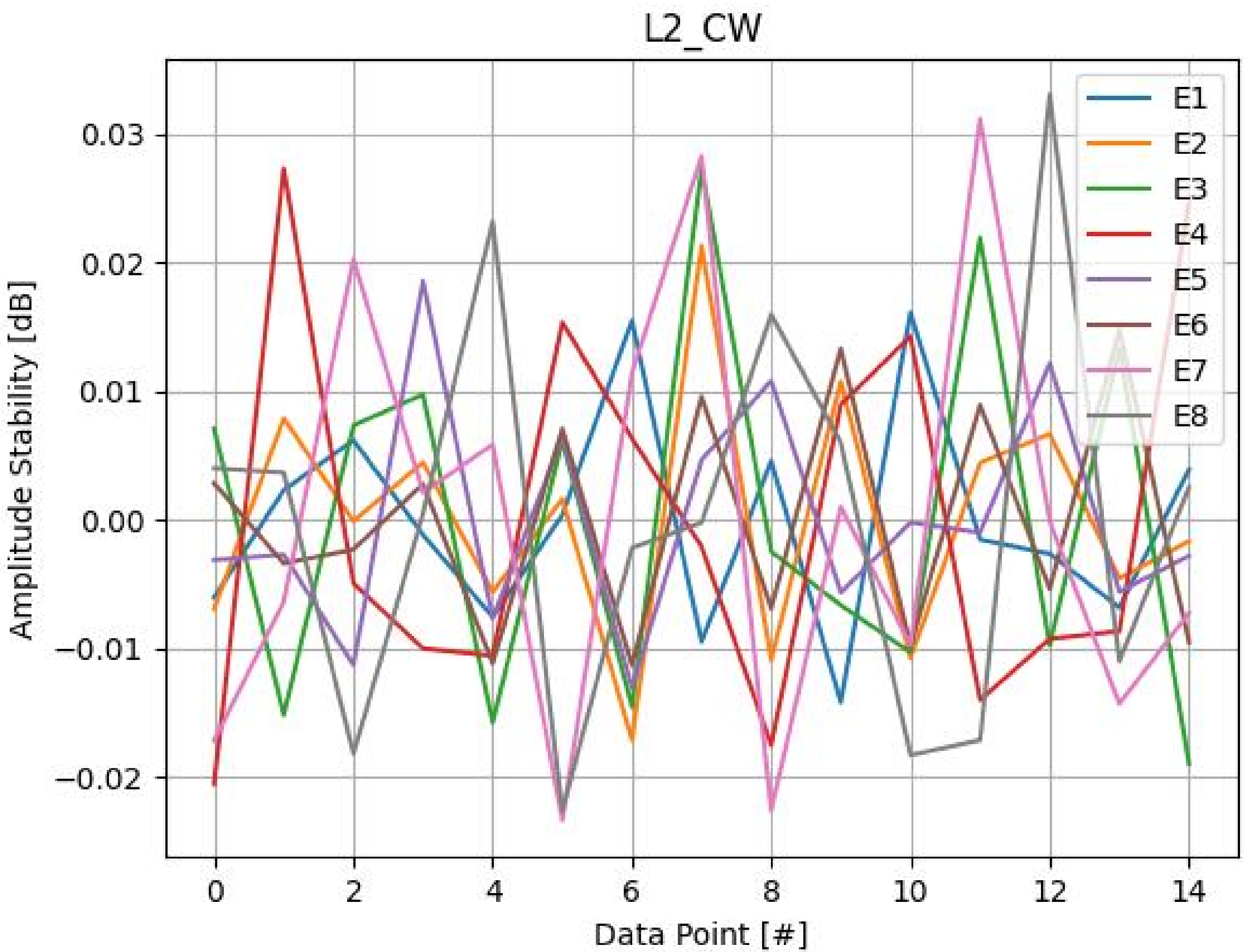


10.2. L2 CW

10.2.1. Data Table

E1 [dBc]	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
-0.01	-0.01	0.01	-0.02	-0.00	0.00	-0.02	0.00
0.00	0.01	-0.02	0.03	-0.00	-0.00	-0.01	0.00
0.01	-0.00	0.01	-0.00	-0.01	-0.00	0.02	-0.02
-0.00	0.00	0.01	-0.01	0.02	0.00	0.00	0.00
-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	0.01	0.02
0.00	0.00	0.01	0.02	0.01	0.01	-0.02	-0.02
0.02	-0.02	-0.01	0.01	-0.01	-0.01	0.01	-0.00
-0.01	0.02	0.03	-0.00	0.00	0.01	0.03	-0.00
0.00	-0.01	-0.00	-0.02	0.01	-0.01	-0.02	0.02
-0.01	0.01	-0.01	0.01	-0.01	0.01	0.00	0.01
0.02	-0.01	-0.01	0.01	-0.00	-0.01	-0.01	-0.02
-0.00	0.00	0.02	-0.01	-0.00	0.01	0.03	-0.02
-0.00	0.01	-0.01	-0.01	0.01	-0.01	-0.00	0.03
-0.01	-0.00	0.01	-0.01	-0.01	0.01	-0.01	-0.01
0.00	-0.00	-0.02	0.02	-0.00	-0.01	-0.01	0.00

10.2.2. Data Plot

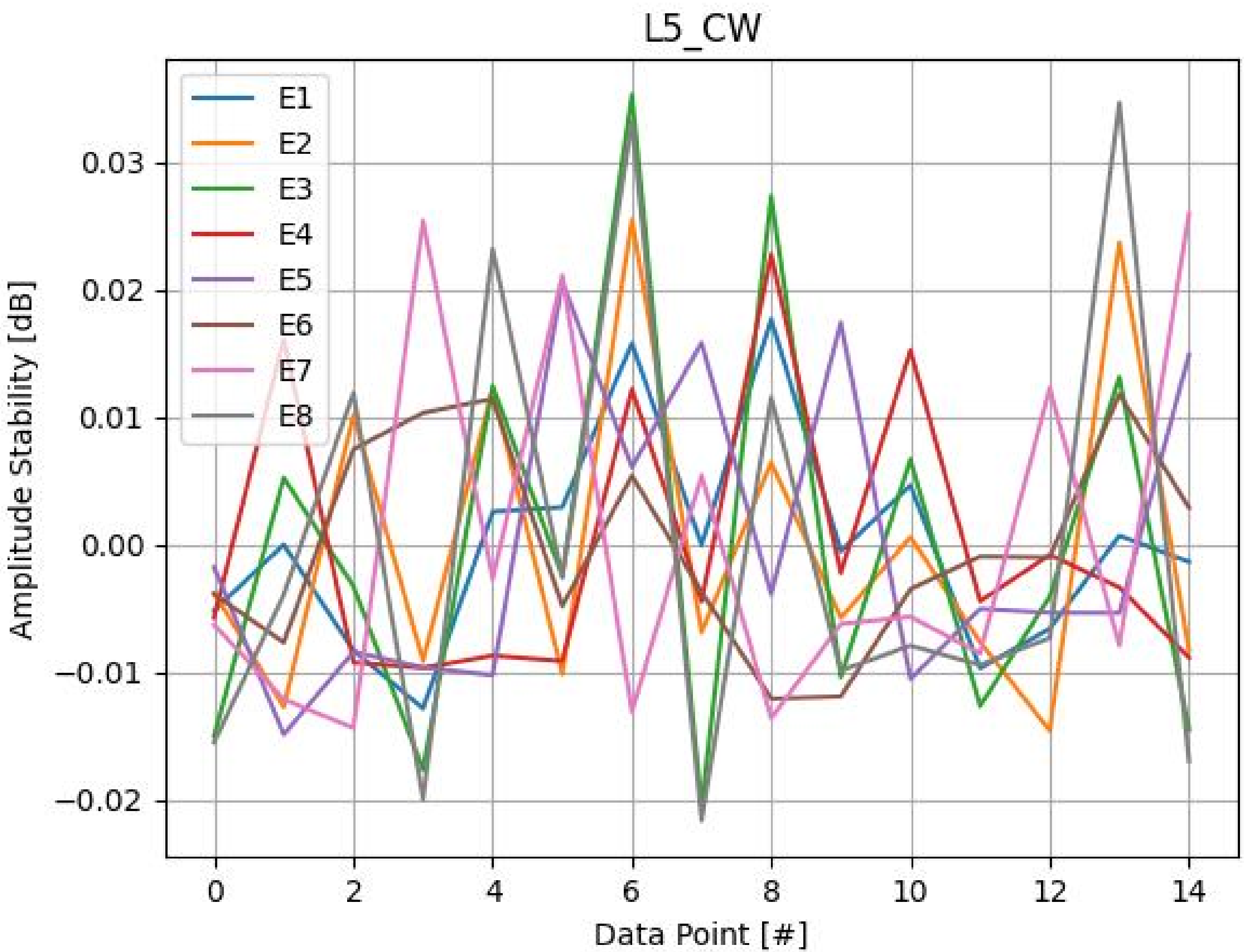


10.3. L5 CW

10.3.1. Data Table

E1 [dBc]	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
-0.01	-0.00	-0.02	-0.01	-0.00	-0.00	-0.01	-0.02
0.00	-0.01	0.01	0.02	-0.01	-0.01	-0.01	-0.00
-0.01	0.01	-0.00	-0.01	-0.01	0.01	-0.01	0.01
-0.01	-0.01	-0.02	-0.01	-0.01	0.01	0.03	-0.02
0.00	0.01	0.01	-0.01	-0.01	0.01	-0.00	0.02
0.00	-0.01	-0.00	-0.01	0.02	-0.00	0.02	-0.00
0.02	0.03	0.04	0.01	0.01	0.01	-0.01	0.03
-0.00	-0.01	-0.02	-0.00	0.02	-0.00	0.01	-0.02
0.02	0.01	0.03	0.02	-0.00	-0.01	-0.01	0.01
-0.00	-0.01	-0.01	-0.00	0.02	-0.01	-0.01	-0.01
0.00	0.00	0.01	0.02	-0.01	-0.00	-0.01	-0.01
-0.01	-0.01	-0.01	-0.00	-0.01	-0.00	-0.01	-0.01
-0.01	-0.01	-0.00	-0.00	-0.01	-0.00	0.01	-0.01
0.00	0.02	0.01	-0.00	-0.01	0.01	-0.01	0.03
-0.00	-0.01	-0.01	-0.01	0.01	0.00	0.03	-0.02

10.3.2. Data Plot

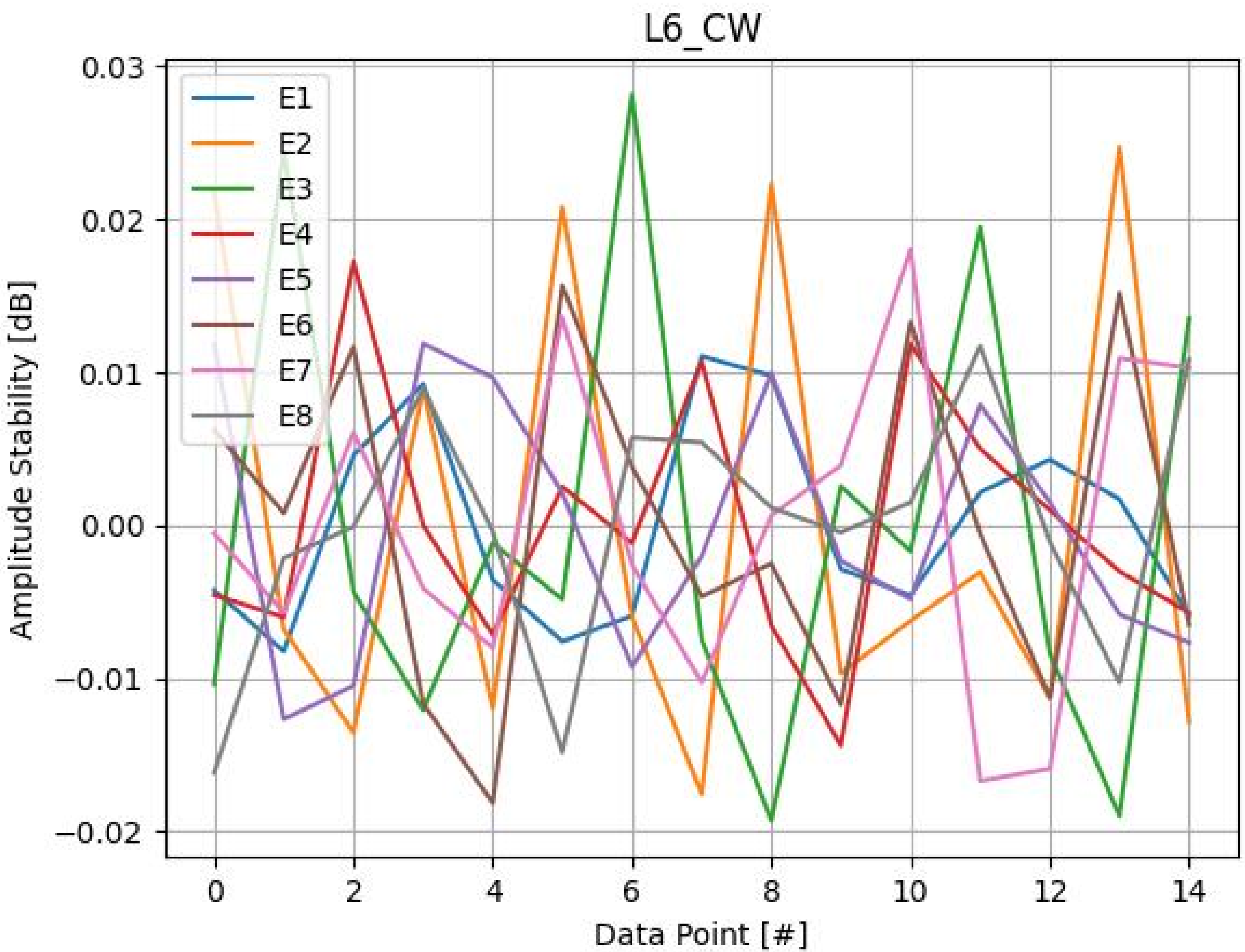


10.4. L6 CW

10.4.1. Data Table

E1 [dBc]	E2 [dBc]	E3 [dBc]	E4 [dBc]	E5 [dBc]	E6 [dBc]	E7 [dBc]	E8 [dBc]
-0.00	0.02	-0.01	-0.00	0.01	0.01	-0.00	-0.02
-0.01	-0.01	0.02	-0.01	-0.01	0.00	-0.01	-0.00
0.00	-0.01	-0.00	0.02	-0.01	0.01	0.01	-0.00
0.01	0.01	-0.01	0.00	0.01	-0.01	-0.00	0.01
-0.00	-0.01	-0.00	-0.01	0.01	-0.02	-0.01	-0.00
-0.01	0.02	-0.00	0.00	0.00	0.02	0.01	-0.01
-0.01	-0.01	0.03	-0.00	-0.01	0.00	-0.00	0.01
0.01	-0.02	-0.01	0.01	-0.00	-0.00	-0.01	0.01
0.01	0.02	-0.02	-0.01	0.01	-0.00	0.00	0.00
-0.00	-0.01	0.00	-0.01	-0.00	-0.01	0.00	-0.00
-0.00	-0.01	-0.00	0.01	-0.00	0.01	0.02	0.00
0.00	-0.00	0.02	0.00	0.01	-0.00	-0.02	0.01
0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.02	-0.00
0.00	0.02	-0.02	-0.00	-0.01	0.02	0.01	-0.01
-0.01	-0.01	0.01	-0.01	-0.01	-0.01	0.01	0.01

10.4.2. Data Plot



11. Time Domain Analysis

The purpose of this test is to visually and statistically investigate the determinism of the Wavefront in the time domain using the EXR Scope.

This test utilizes the Infiniium software on the EXR scope to perform phase measurements in the time-domain. The EXR Scope takes each channel and compares it against channel 1. After a few seconds, the scope accumulates approximately 30,000 samples from which the statistics of these samples are computed by the scope. This test is repeated for each L-Band. These measurements are tabulated below along with the associated screen captures of the EXR Scope.

11.1. CW

The time domain measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
ǀ Mean ǀ < 0.10 °	0.10 ° ≥ ǀ Mean ǀ ≥ 0.75 °	0.75 ° ≥ ǀ Mean ǀ ≥ 1.00 °	ǀ Mean ǀ ≥ 1.00 °
Min > -0.10 °	-0.10 ° ≤ Min ≤ -2.50 °	-2.50 ° ≤ Min ≤ -3.00 °	Min ≤ -3.00 °
Max < 0.10 °	0.10 ° ≥ Max ≥ 2.50 °	2.50 ° ≥ Max ≥ 3.00 °	Max ≥ 3.00 °
Range < 0.50 °	0.50 ° ≥ Range ≥ 4.50 °	4.50 ° ≥ Range ≥ 6.00 °	Range ≥ 6.00 °
Std < 0.15 °	0.15 ° ≥ Std ≥ 0.60 °	0.60 ° ≥ Std ≥ 0.75 °	Std ≥ 0.75 °

Across all Mx1 comparisons for all bands, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
0.39	0.31	-1.88	2.61	4.49

11.1.1. L1

11.1.1.1. Data Table

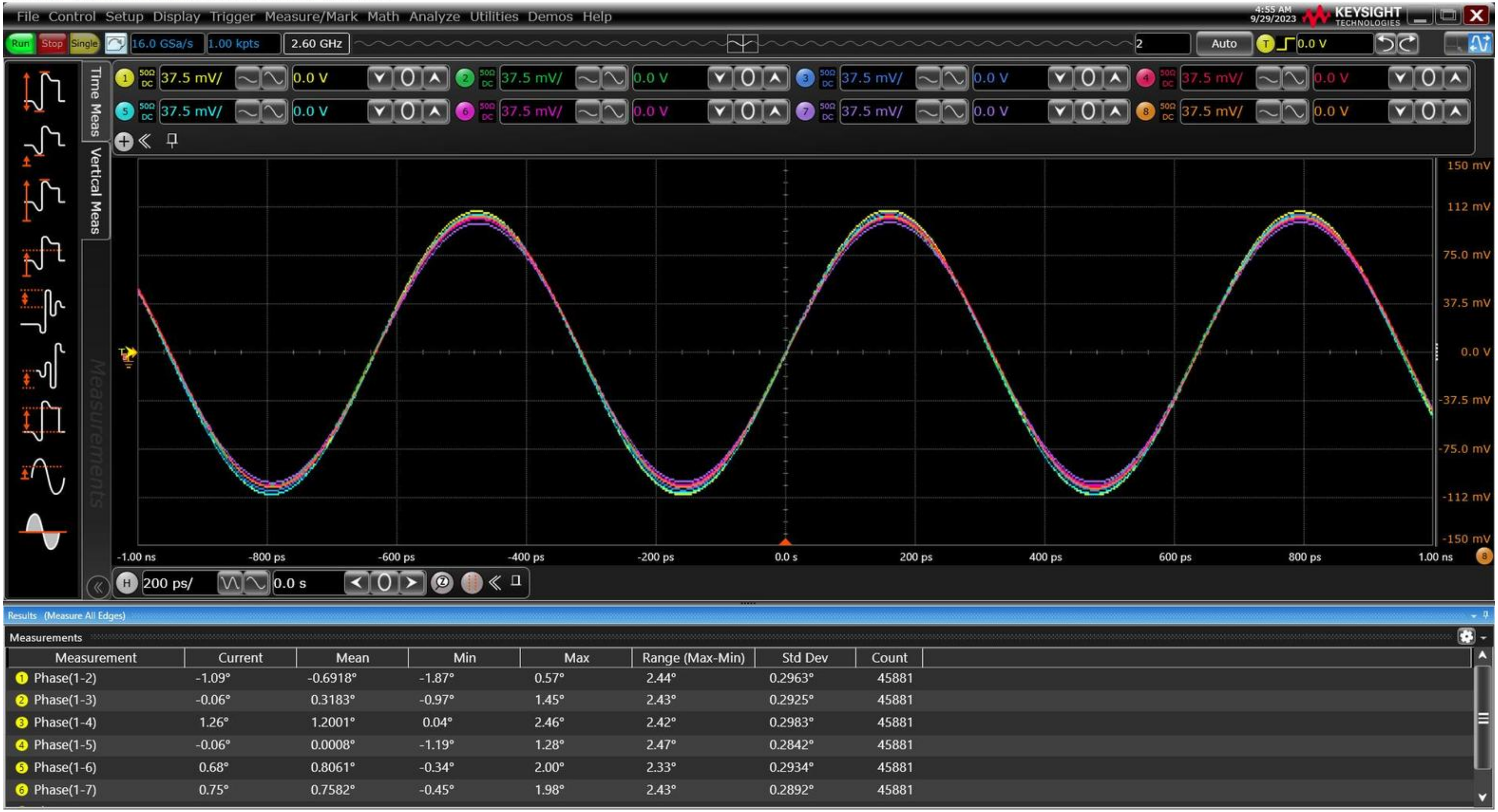
Measurement	Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
Phase(1-2)	-0.69	0.30	-1.87	0.57	2.44
Phase(1-3)	0.32	0.29	-0.97	1.45	2.43
Phase(1-4)	1.20	0.30	0.04	2.46	2.42
Phase(1-5)	0.00	0.28	-1.19	1.28	2.47
Phase(1-6)	0.81	0.29	-0.34	2.00	2.33
Phase(1-7)	0.76	0.29	-0.45	1.98	2.43
Phase(1-8)	0.64	0.29	-0.62	1.77	2.39

Across all Mx1 comparisons for L1, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
0.43	0.29	-1.87	2.46	4.33

11.1.1.1.1. Scope Capture

Keysight Infiniium : Friday, September 29, 2023 4:56:28 AM



Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
Phase(1-2)	-1.09°	-0.6918°	-1.87°	0.57°	2.44°	0.2963°	45881
Phase(1-3)	-0.06°	0.3183°	-0.97°	1.45°	2.43°	0.2925°	45881
Phase(1-4)	1.26°	1.2001°	0.04°	2.46°	2.42°	0.2983°	45881
Phase(1-5)	-0.06°	0.0008°	-1.19°	1.28°	2.47°	0.2842°	45881
Phase(1-6)	0.68°	0.8061°	-0.34°	2.00°	2.33°	0.2934°	45881
Phase(1-7)	0.75°	0.7582°	-0.45°	1.98°	2.43°	0.2892°	45881

11.1.2. L2

11.1.2.1. Data Table

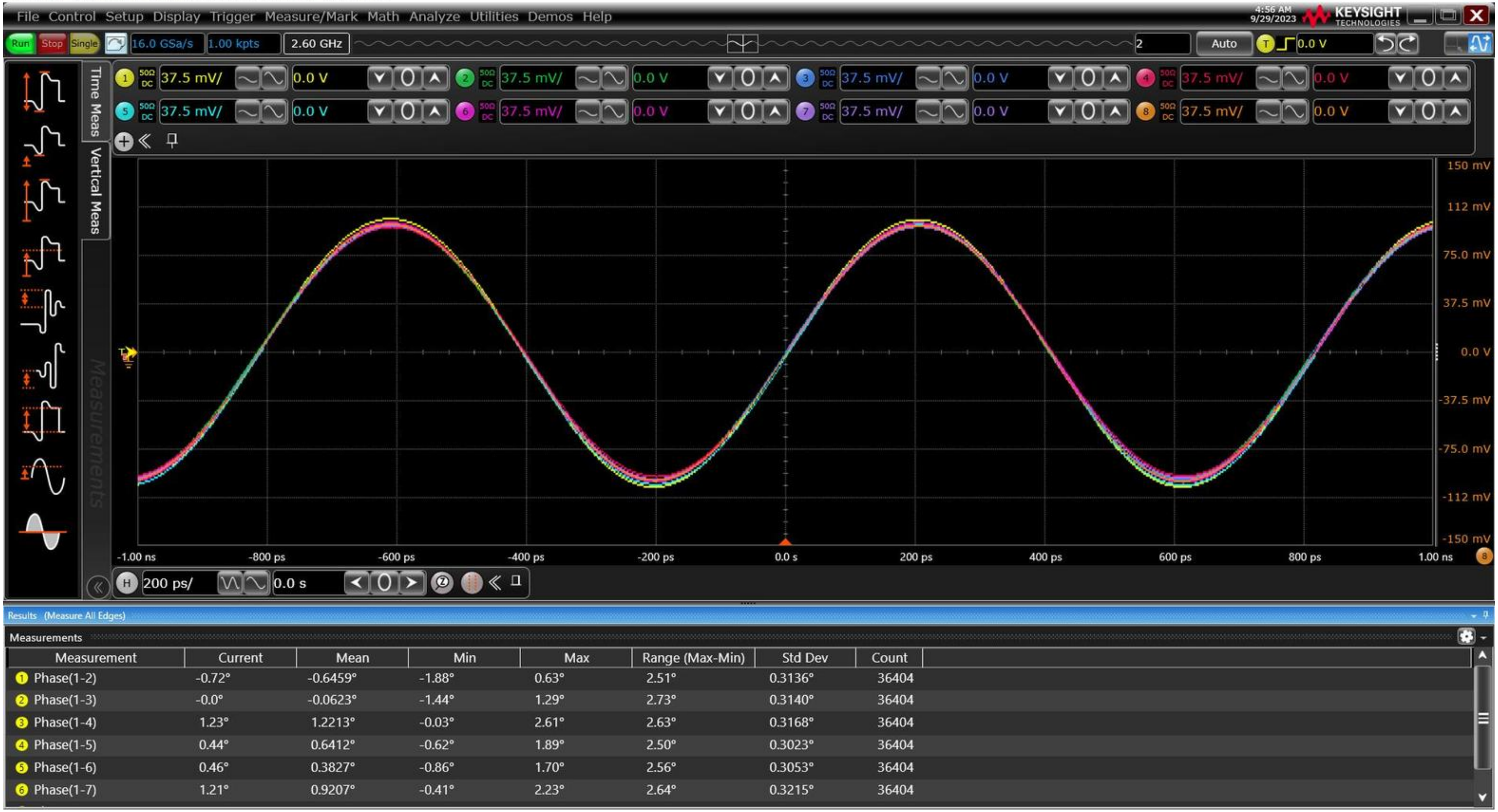
Measurement	Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
Phase(1-2)	-0.65	0.31	-1.88	0.63	2.51
Phase(1-3)	-0.06	0.31	-1.44	1.29	2.73
Phase(1-4)	1.22	0.32	-0.03	2.61	2.63
Phase(1-5)	0.64	0.30	-0.62	1.89	2.50
Phase(1-6)	0.38	0.31	-0.86	1.70	2.56
Phase(1-7)	0.92	0.32	-0.41	2.23	2.64
Phase(1-8)	0.20	0.32	-1.13	1.48	2.61

Across all Mx1 comparisons for L2, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
0.38	0.31	-1.88	2.61	4.49

11.1.2.1.1. Scope Capture

Keysight Infiniium : Friday, September 29, 2023 4:57:25 AM



Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
1 Phase(1-2)	-0.72°	-0.6459°	-1.88°	0.63°	2.51°	0.3136°	36404
2 Phase(1-3)	-0.0°	-0.0623°	-1.44°	1.29°	2.73°	0.3140°	36404
3 Phase(1-4)	1.23°	1.2213°	-0.03°	2.61°	2.63°	0.3168°	36404
4 Phase(1-5)	0.44°	0.6412°	-0.62°	1.89°	2.50°	0.3023°	36404
5 Phase(1-6)	0.46°	0.3827°	-0.86°	1.70°	2.56°	0.3053°	36404
6 Phase(1-7)	1.21°	0.9207°	-0.41°	2.23°	2.64°	0.3215°	36404

11.1.3. L5

11.1.3.1. Data Table

Measurement	Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
Phase(1-2)	-0.32	0.31	-1.64	0.90	2.53
Phase(1-3)	0.16	0.32	-1.12	1.60	2.72
Phase(1-4)	0.65	0.31	-0.59	1.99	2.58
Phase(1-5)	0.70	0.31	-0.53	1.92	2.45
Phase(1-6)	-0.20	0.31	-1.43	1.04	2.47
Phase(1-7)	0.97	0.32	-0.23	2.23	2.46
Phase(1-8)	-0.13	0.32	-1.46	1.13	2.59

Across all Mx1 comparisons for L5, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
0.26	0.31	-1.64	2.23	3.87

11.1.3.1.1. Scope Capture

Keysight Infiniium : Friday, September 29, 2023 4:58:23 AM

Measurement	Current	Mean	Min	Max	Range (Max-Min)	Std Dev	Count
Phase(1-2)	-0.67°	-0.3226°	-1.64°	0.90°	2.53°	0.3084°	34416
Phase(1-3)	-0.28°	0.1608°	-1.12°	1.60°	2.72°	0.3158°	34416
Phase(1-4)	0.64°	0.6472°	-0.59°	1.99°	2.58°	0.3133°	34416
Phase(1-5)	0.31°	0.6989°	-0.53°	1.92°	2.45°	0.3117°	34416
Phase(1-6)	-0.50°	-0.1998°	-1.43°	1.04°	2.47°	0.3073°	34416
Phase(1-7)	0.51°	0.9669°	-0.23°	2.23°	2.46°	0.3209°	34416

11.1.4. L6

11.1.4.1. Data Table

Measurement	Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
Phase(1-2)	-0.11	0.32	-1.35	1.09	2.44
Phase(1-3)	0.10	0.32	-1.26	1.44	2.70
Phase(1-4)	0.54	0.31	-0.66	1.84	2.50
Phase(1-5)	0.65	0.30	-0.55	1.93	2.49
Phase(1-6)	1.04	0.31	-0.17	2.33	2.49
Phase(1-7)	0.35	0.31	-0.86	1.59	2.45
Phase(1-8)	0.87	0.31	-0.34	2.15	2.49

Across all Mx1 comparisons for L6, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]	Range [°]
0.49	0.31	-1.35	2.33	3.68

11.1.4.1.1. Scope Capture

Keysight Infiniium : Friday, September 29, 2023 4:59:20 AM

11.2. AWGN

The purpose of this test is to visually investigate the determinism of the Wavefront. To do this, an AWGN signal with a 50 MHz bandwidth is enabled on each element of wavefront. The timescale on the EXR scope is set to 50ns and a single sweep of all 8 traces is performed before a screenshot of the scope is captured. Following this, the timescale on the EXR scope is decreased by a factor of 10 (5ns) and a single sweep of all 8 traces is performed before another screenshot of the scope is captured. This is repeated for all L-bands.

To visually understand the importance of these scope captures, consider the amplitude in addition to the phase of the AWGN waveforms in the time domain. To have a truly deterministic wavefront, all elements of the wavefront should be capable of producing the exact same AWGN waveform (given the proper seed) at the exact same time. When this is accomplished, the AWGN waveforms on each channel will be indistinguishable from one another in both amplitude and phase.

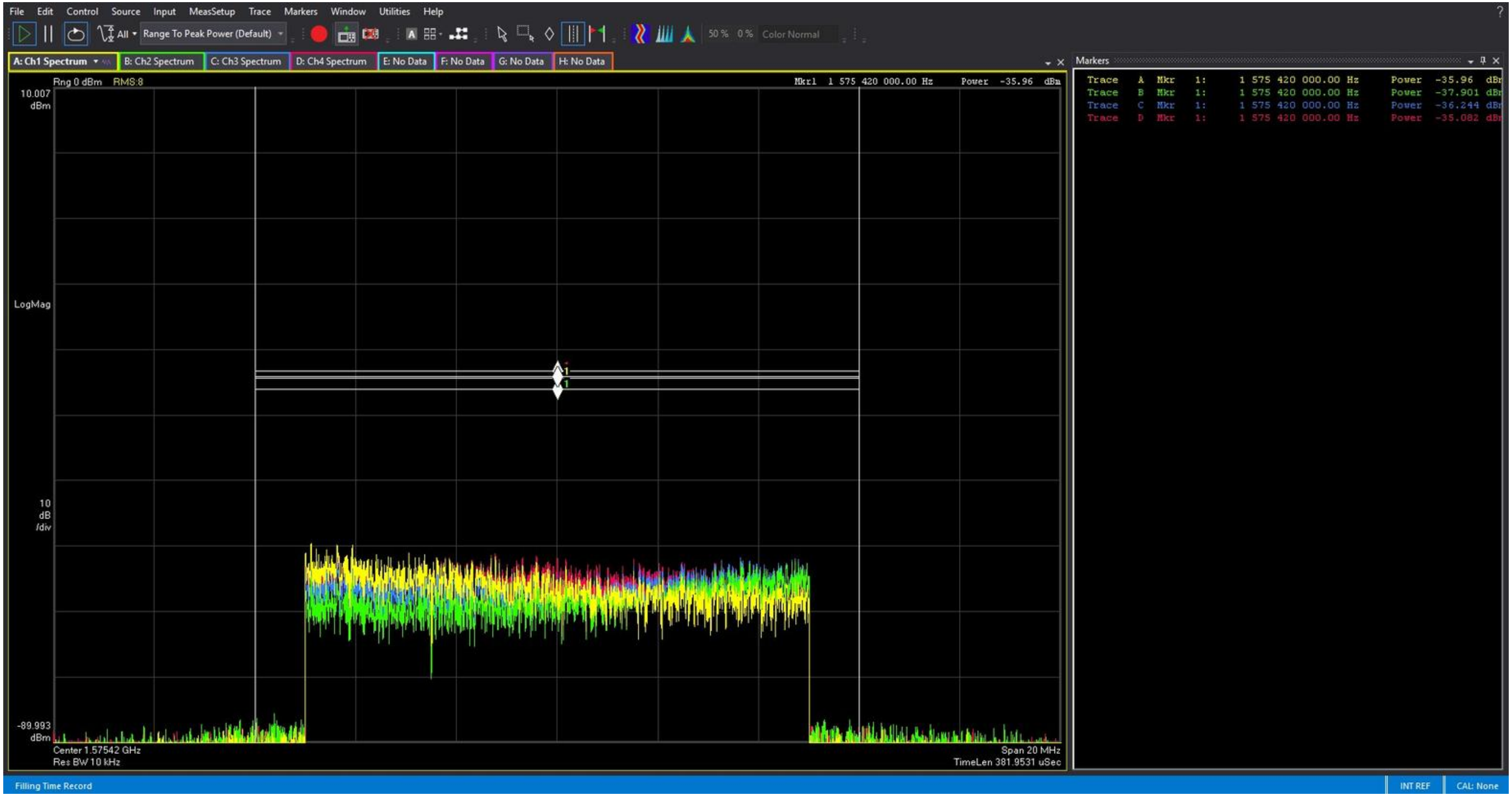
11.2.1. L1

11.2.2. L2

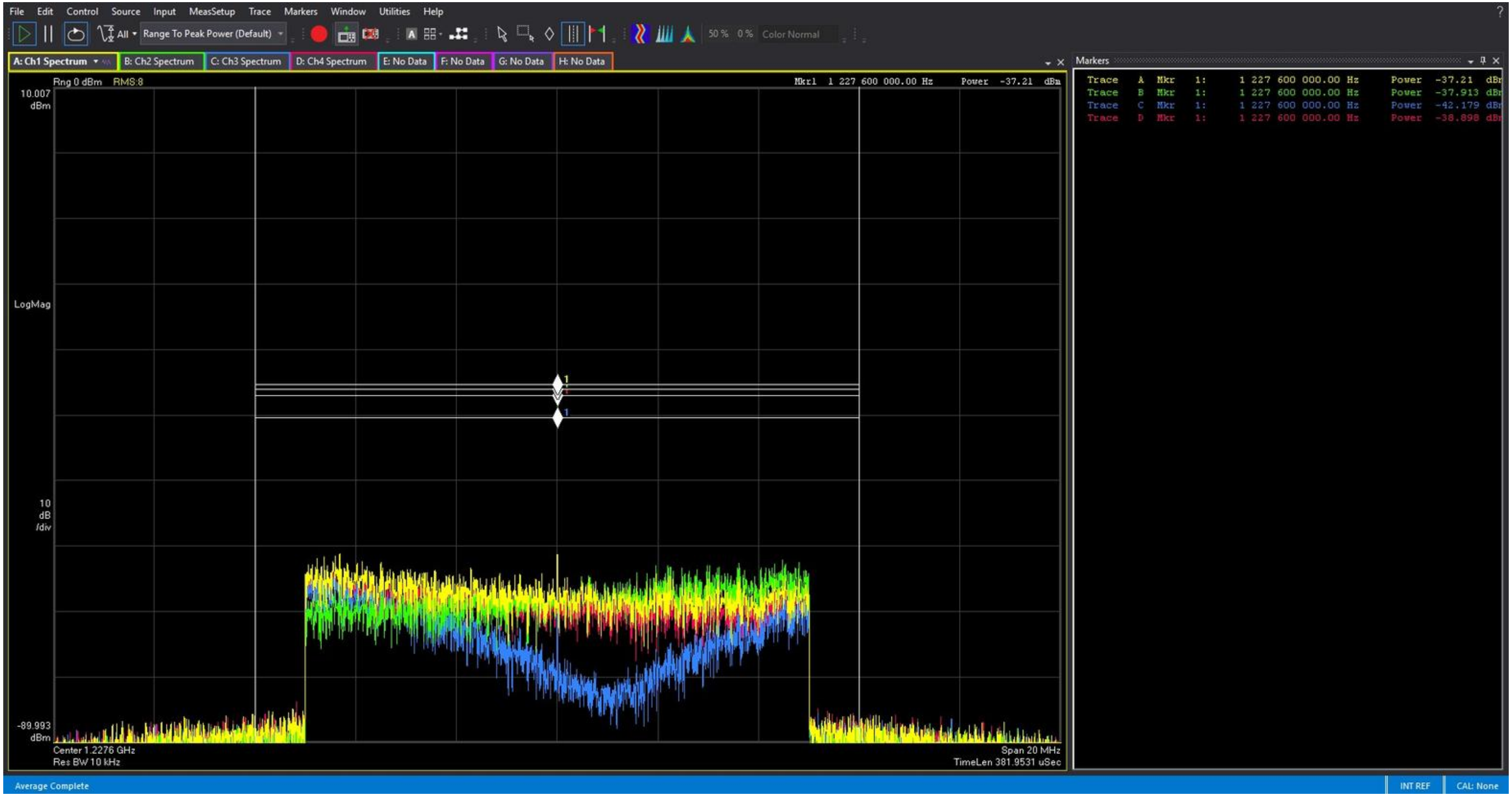
12. Nulling AWGN

The purpose of this test is to **ensure AWGN signals can be nulled**. To do this, every other element is set 180 degrees out of phase with each other. Each pair of 2 signals are then mixed together using the exr scope and the resulting destructive interference (null) is recorded.

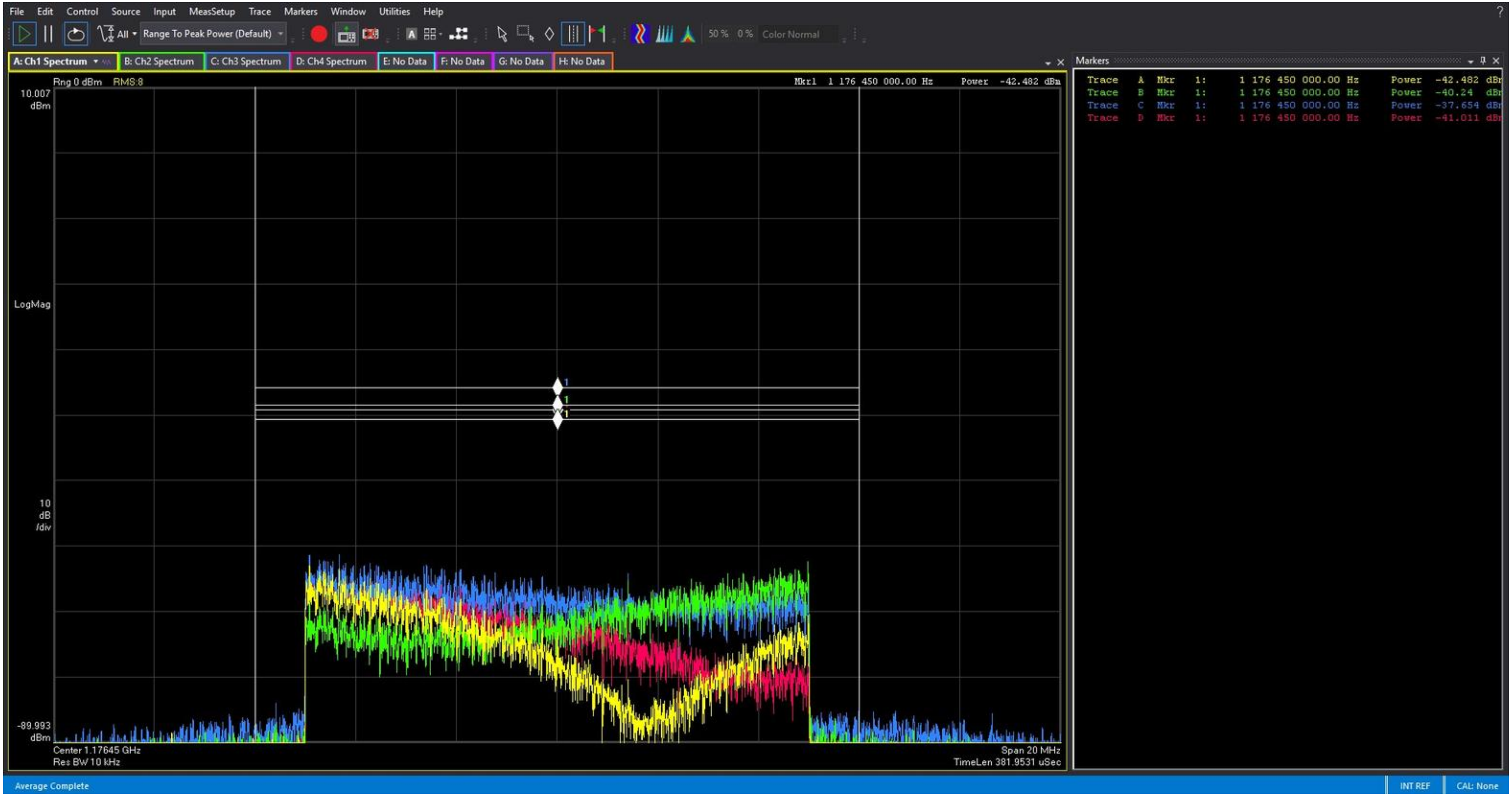
12.1. L1 AWGN


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: No Data
F: No Data
G: No Data
H: No Data
Rng 0 dBm RMS:8
Mkr1 1 575 420 000.00 Hz Power -35.96 dBm
10.007 dBm
LogMag
10 dB /div
-89.993 dBm
Center 1.57542 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 575 420 000.00 Hz Power -35.96 dBm
Trace B Mkr 1: 1 575 420 000.00 Hz Power -37.901 dBm
Trace C Mkr 1: 1 575 420 000.00 Hz Power -36.244 dBm
Trace D Mkr 1: 1 575 420 000.00 Hz Power -35.082 dBm
Filling Time Record
INT REF
CAL: None

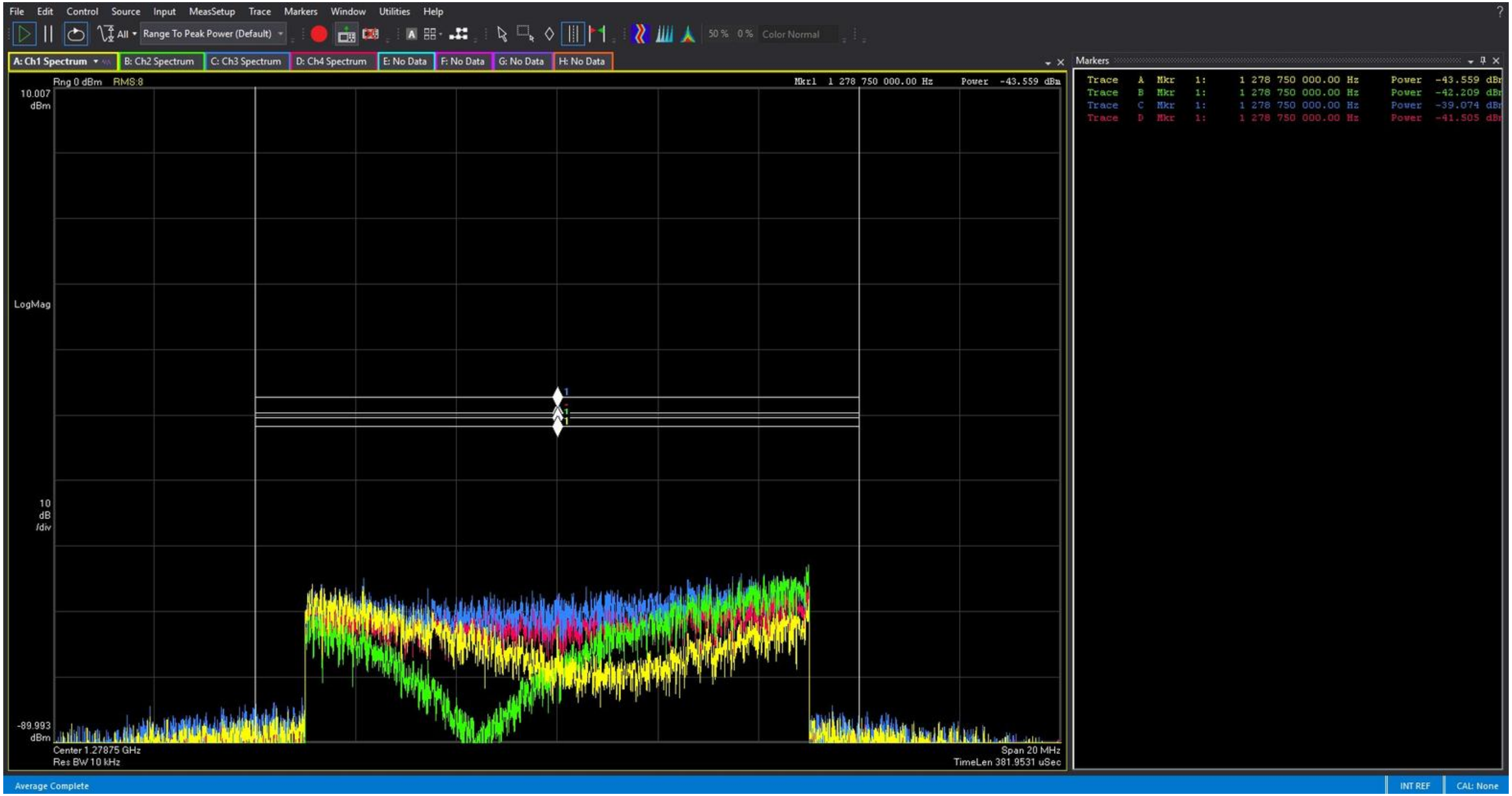
12.2. L2 AWGN


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
All
Range To Peak Power (Default)
50 % 0 % Color Normal
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: No Data
F: No Data
G: No Data
H: No Data
Rng 0 dBm RMS:8
Mkr1 1 227 600 000.00 Hz Power -37.21 dBm
10.007 dBm
LogMag
10 dB /div
-89.993 dBm
Center 1.2276 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 227 600 000.00 Hz Power -37.21 dBm
Trace B Mkr 1: 1 227 600 000.00 Hz Power -37.913 dBm
Trace C Mkr 1: 1 227 600 000.00 Hz Power -42.179 dBm
Trace D Mkr 1: 1 227 600 000.00 Hz Power -38.898 dBm
Average Complete
INT REF
CAL: None

12.3. L5 AWGN


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: No Data
F: No Data
G: No Data
H: No Data
Rng 0 dBm RMS:8
Mkr1 1 176 450 000.00 Hz Power -42.482 dBm
10.007 dBm
LogMag
10 dB /div
-89.993 dBm
Center 1.17645 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 176 450 000.00 Hz Power -42.482 dBm
Trace B Mkr 1: 1 176 450 000.00 Hz Power -40.24 dBm
Trace C Mkr 1: 1 176 450 000.00 Hz Power -37.654 dBm
Trace D Mkr 1: 1 176 450 000.00 Hz Power -41.011 dBm
Average Complete
INT REF
CAL: None

12.4. L6 AWGN


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
A: Ch1 Spectrum
B: Ch2 Spectrum
C: Ch3 Spectrum
D: Ch4 Spectrum
E: No Data
F: No Data
G: No Data
H: No Data
Rng 0 dBm RMS:8
Mkr1 1 278 750 000.00 Hz Power -43.559 dBm
10.007 dBm
LogMag
10 dB /div
-89.993 dBm
Center 1.27875 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace A Mkr 1: 1 278 750 000.00 Hz Power -43.559 dBm
Trace B Mkr 1: 1 278 750 000.00 Hz Power -42.209 dBm
Trace C Mkr 1: 1 278 750 000.00 Hz Power -39.074 dBm
Trace D Mkr 1: 1 278 750 000.00 Hz Power -41.505 dBm
Average Complete
INT REF
CAL: None

13. Phase Alignment

The purpose of this test is to **quantify inter-element phase alignment**. To do this, all WF elements are connected to the EXR Scope. Each WF element is compared against the first element (E1) using the Vector Signal Analysis (VSA) software in phase mode. These comparisons are given the notation Mx1, meaning the phase of element M is being compared against the phase of element 1. 2x1 phase values cannot be measured because the exr scope has insufficient isolation between neighboring channels for this measurement. Each element is stepped over all power levels while the reference (E1) is held at a mid-range power.

The MxN inter-element phase alignments are calculated using the Mx1 measured data. Take for example, at any given power, if we get a phase alignment of -1 deg on 3x1, and a phase alignment of 1 deg on 4x1, then we know that 4x3 is (4x1 - 3x1) = 2 deg. The only values we cannot calculate are 2xN values because we can't measure 2x1. A second run through of this test would be necessary to get all MxN information. The 2xN data however can be validated through the time-domain or phase stability tests. See the following table for a quick overview of the measurements and calculations performed.

Can't Measure								
2x1	3x1	4x1	5x1	6x1	7x1	8x1	Measured Data	Mismatch gain comparison (0-60 vs 0)
	3x1 - 2x1	4x1 - 2x1	5x1 - 2x1	6x1 - 2x1	7x1 - 2x1	8x1 - 2x1	Can't Calculate	
		4x1 - 3x1	5x1 - 3x1	6x1 - 3x1	7x1 - 3x1	8x1 - 3x1		Matched gain comparison (0-60 vs 0-60)
			5x1 - 4x1	6x1 - 4x1	7x1 - 4x1	8x1 - 4x1		
				6x1 - 5x1	7x1 - 5x1	8x1 - 5x1	Calculated Data	
					7x1 - 6x1	8x1 - 6x1		
						8x1 - 7x1		

MxN Phase Alignment Measurements and Calculations

Averaging the phase alignment is acceptable for this test because it will not artificially improve it. This test helps validate the manual calibration routine and the applied LUT's themselves. It also validates the inter-channel phase alignment spec over a large subset of power/element pairings over frequency.

The phase alignment measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
| Mean | < 0.25 °	0.25 ° ≥ | Mean | ≥ 1.00 °	1.00 ° ≥ | Mean | ≥ 1.50 °	| Mean | ≥ 1.50 °
Max < 0.25 °	0.25 ° ≥ Max ≥ 2.50 °	2.50 ° ≥ Max ≥ 3.00 °	Max ≥ 3.00 °
Std < 0.10 °	0.10 ° ≥ Std ≥ 0.60 °	0.60 ° ≥ Std ≥ 0.75 °	Std ≥ 0.75 °

For all MxN phase alignments across all bands, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]
0.61	0.41	0.00	2.46

13.1. L1 CW

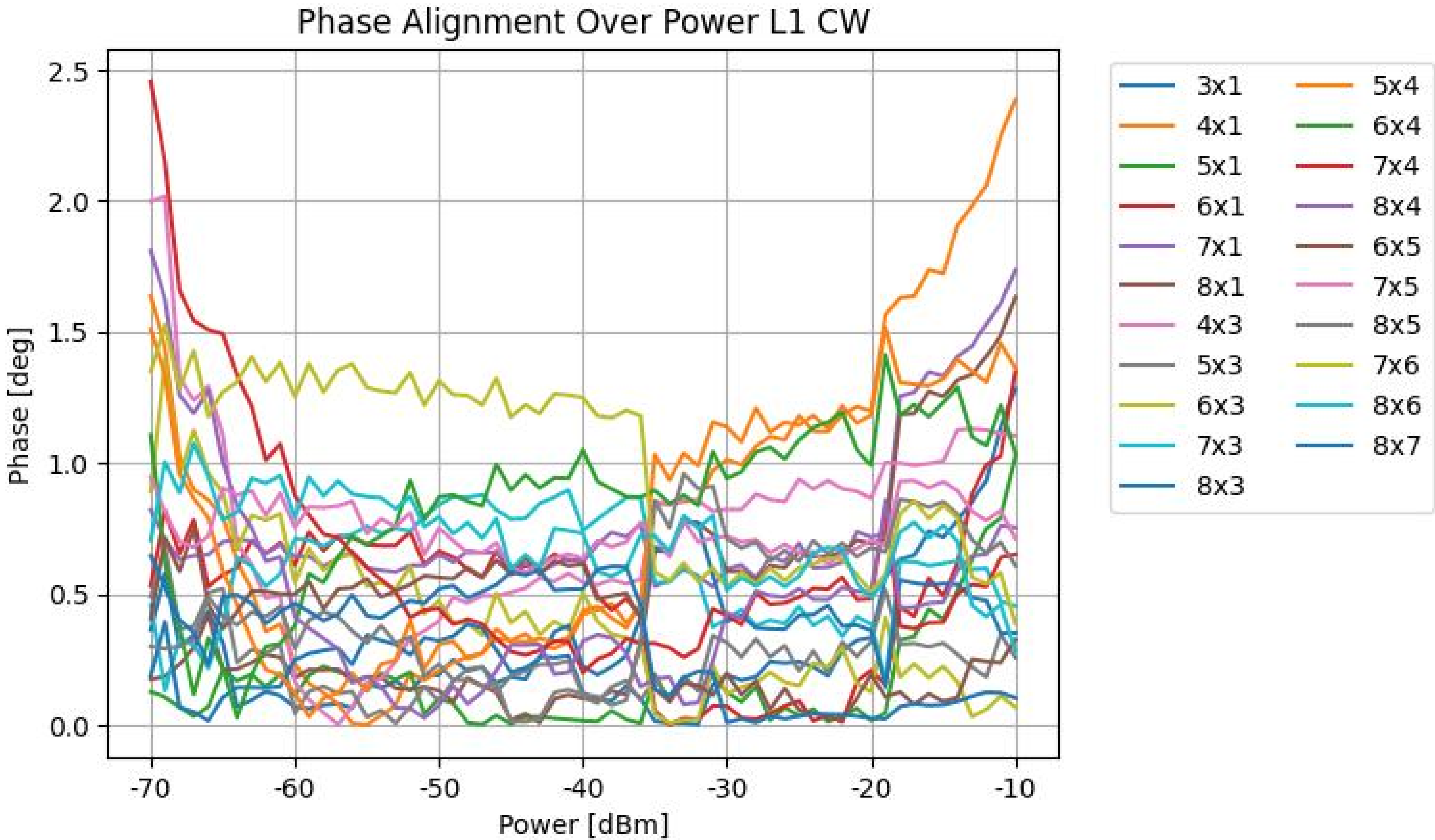
Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
3x1	0.29	0.28	0.00	1.28
4x1	0.82	0.63	0.00	2.39
5x1	0.17	0.21	0.00	1.03
6x1	0.49	0.30	0.00	1.35
7x1	0.76	0.30	0.53	1.74
8x1	0.48	0.43	0.01	1.63
4x3	0.74	0.41	0.00	2.02
5x3	0.24	0.13	0.00	0.68
6x3	0.41	0.30	0.01	1.40
7x3	0.60	0.20	0.13	0.90
8x3	0.34	0.16	0.01	0.78
5x4	0.75	0.48	0.03	1.52
6x4	0.85	0.31	0.03	1.41
7x4	0.63	0.47	0.20	2.46
8x4	0.47	0.37	0.03	1.81
6x5	0.37	0.22	0.02	0.75
7x5	0.75	0.10	0.58	0.95

Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
8x5	0.47	0.27	0.01	0.96
7x6	1.00	0.35	0.39	1.53
8x6	0.72	0.16	0.28	1.07
8x7	0.31	0.22	0.01	0.65

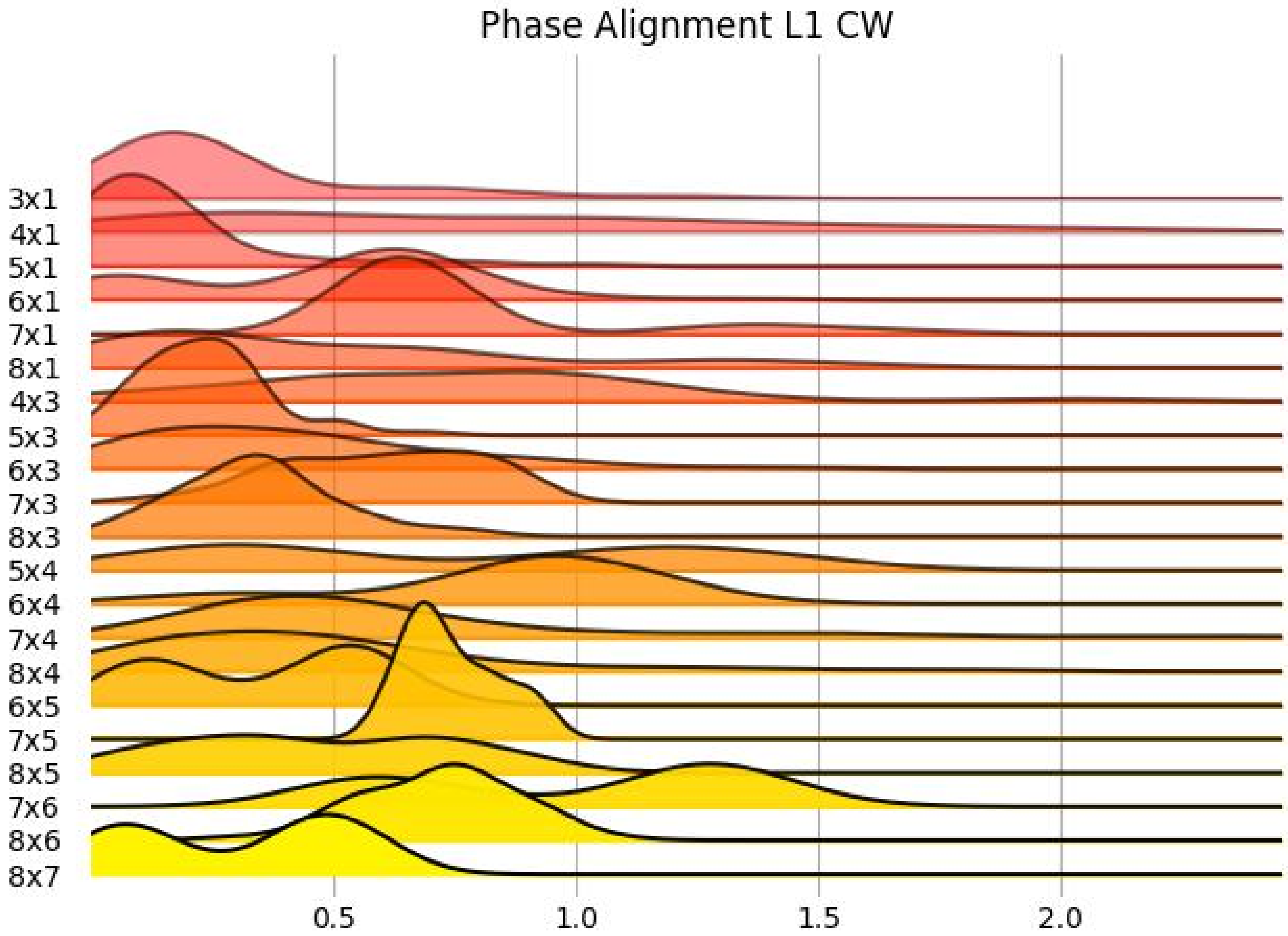
For all MxN phase alignments on L1, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]
0.55	0.39	0.00	2.46

13.1.1. Phase Alignment Over Power



13.1.2. Phase Alignment



13.2. L2 CW

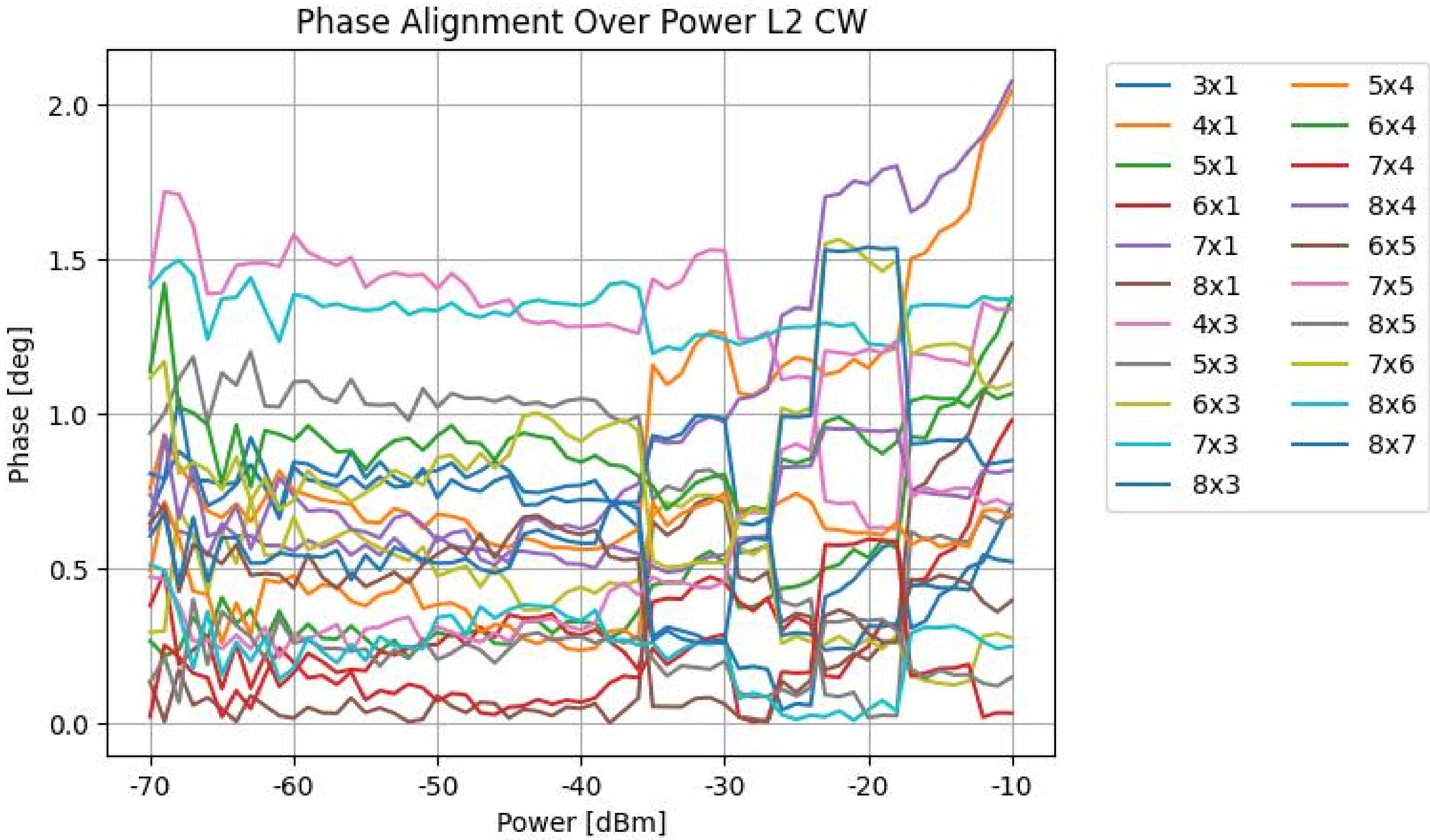
Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
3x1	0.58	0.23	0.04	0.88
4x1	0.95	0.38	0.56	2.04
5x1	0.46	0.28	0.21	1.38
6x1	0.33	0.17	0.11	0.98
7x1	0.97	0.50	0.52	2.08
8x1	0.28	0.34	0.00	1.23
4x3	1.31	0.25	0.63	1.72
5x3	0.81	0.33	0.02	1.20
6x3	0.45	0.17	0.12	0.74
7x3	1.33	0.07	1.20	1.50
8x3	0.69	0.22	0.24	1.05
5x4	0.50	0.17	0.23	0.74
6x4	0.91	0.12	0.67	1.42
7x4	0.17	0.16	0.00	0.59
8x4	0.67	0.14	0.49	0.95
6x5	0.41	0.20	0.00	0.70
7x5	0.52	0.30	0.21	1.24

Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
8x5	0.22	0.08	0.07	0.40
7x6	0.93	0.27	0.50	1.56
8x6	0.24	0.12	0.01	0.51
8x7	0.69	0.33	0.26	1.54

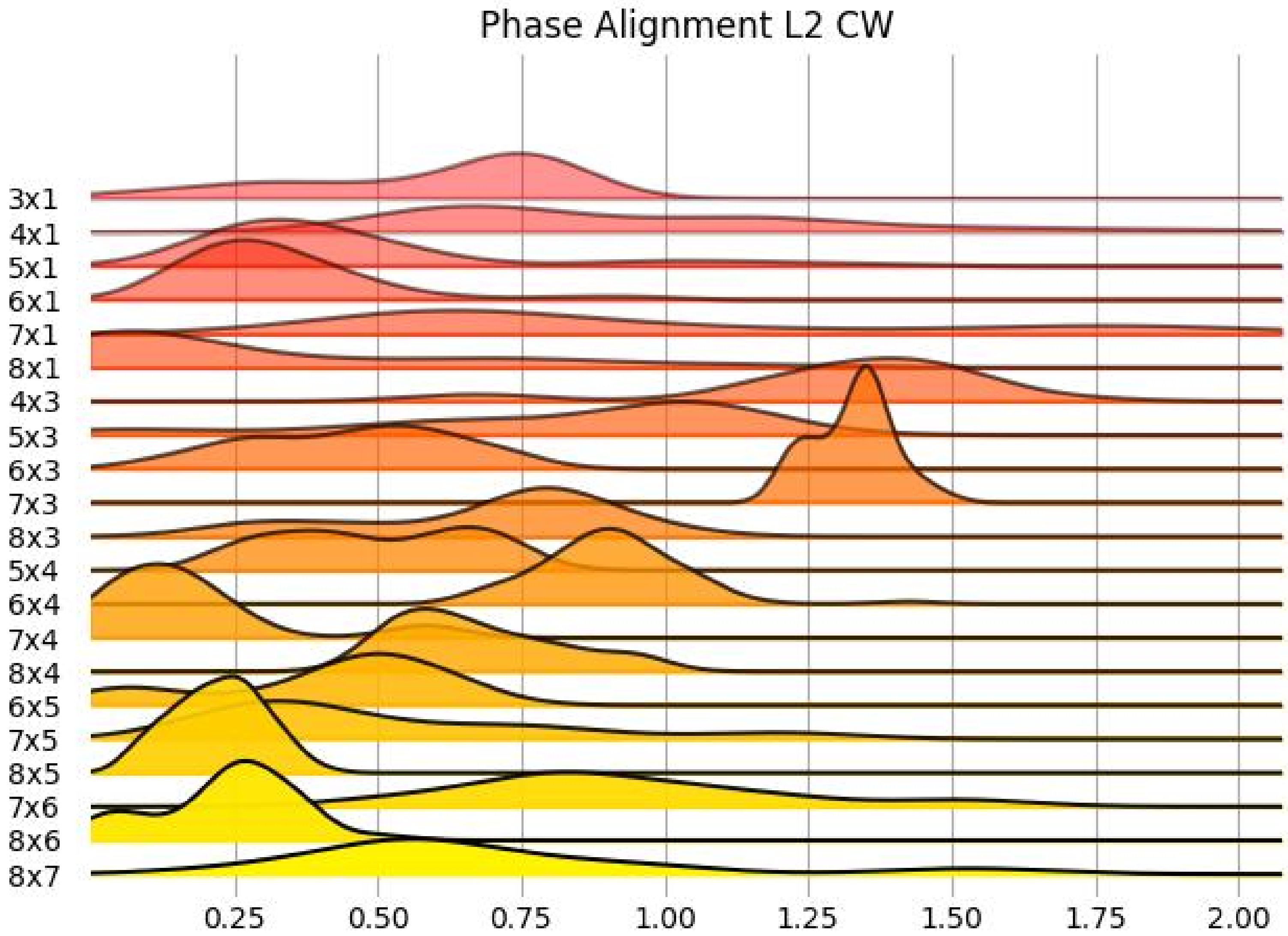
For all MxN phase alignments on L2, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]
0.64	0.41	0.00	2.08

13.2.1. Phase Alignment Over Power



13.2.2. Phase Alignment



13.3. L5 CW

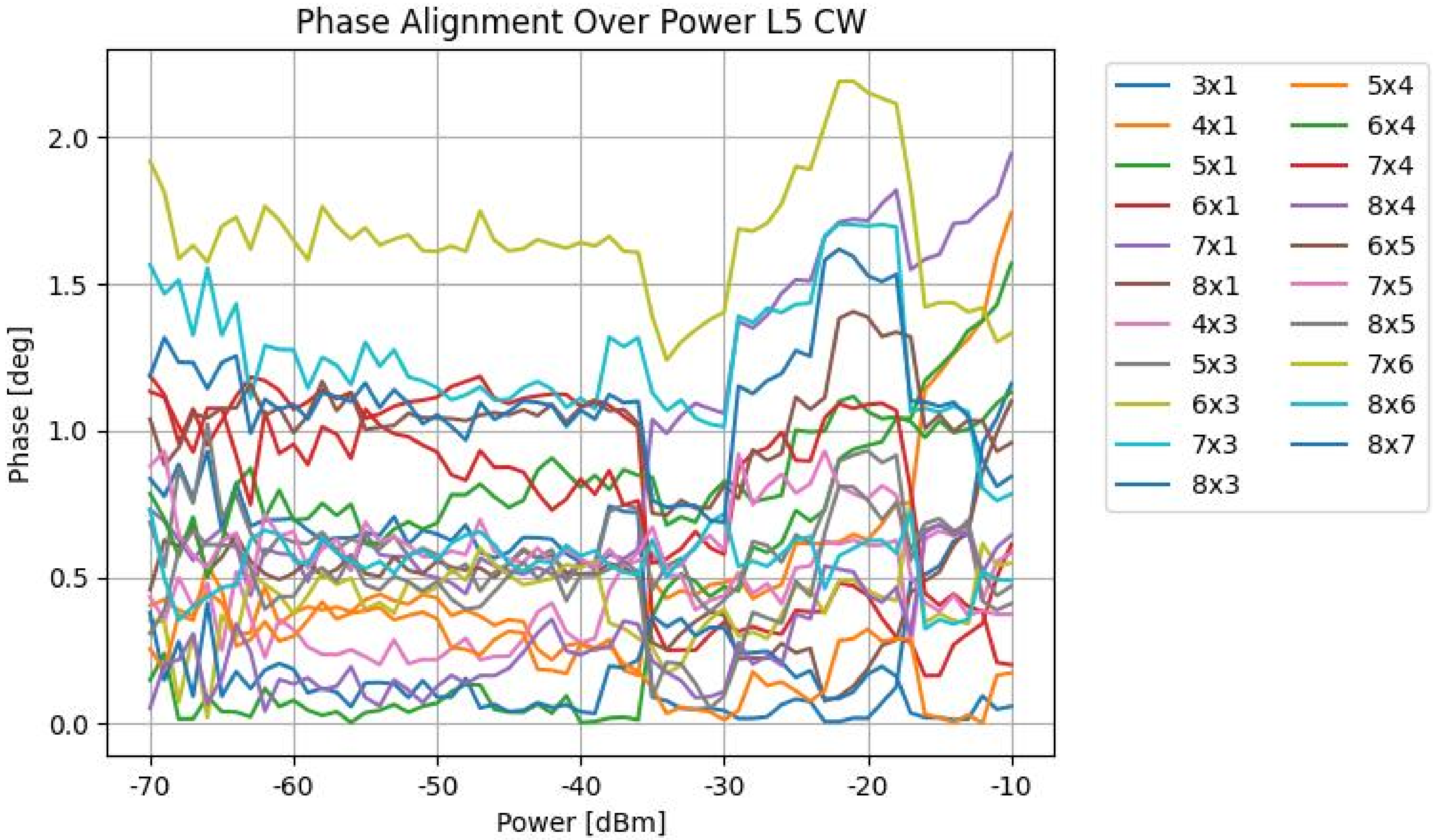
Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
3x1	0.50	0.32	0.01	1.16
4x1	0.53	0.34	0.16	1.74
5x1	0.40	0.46	0.00	1.57
6x1	0.78	0.39	0.16	1.19
7x1	0.96	0.50	0.44	1.94
8x1	0.48	0.19	0.08	1.10
4x3	0.41	0.15	0.20	0.66
5x3	0.62	0.14	0.38	1.02
6x3	0.41	0.13	0.02	0.76
7x3	1.25	0.22	0.76	1.70
8x3	0.15	0.10	0.01	0.41
5x4	0.23	0.13	0.00	0.54
6x4	0.82	0.15	0.50	1.13
7x4	0.83	0.23	0.20	1.13
8x4	0.27	0.18	0.04	0.68
6x5	1.04	0.15	0.71	1.40
7x5	0.62	0.14	0.37	0.93

Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
8x5	0.48	0.17	0.05	0.81
7x6	1.66	0.22	1.24	2.19
8x6	0.55	0.09	0.32	0.73
8x7	1.11	0.21	0.69	1.62

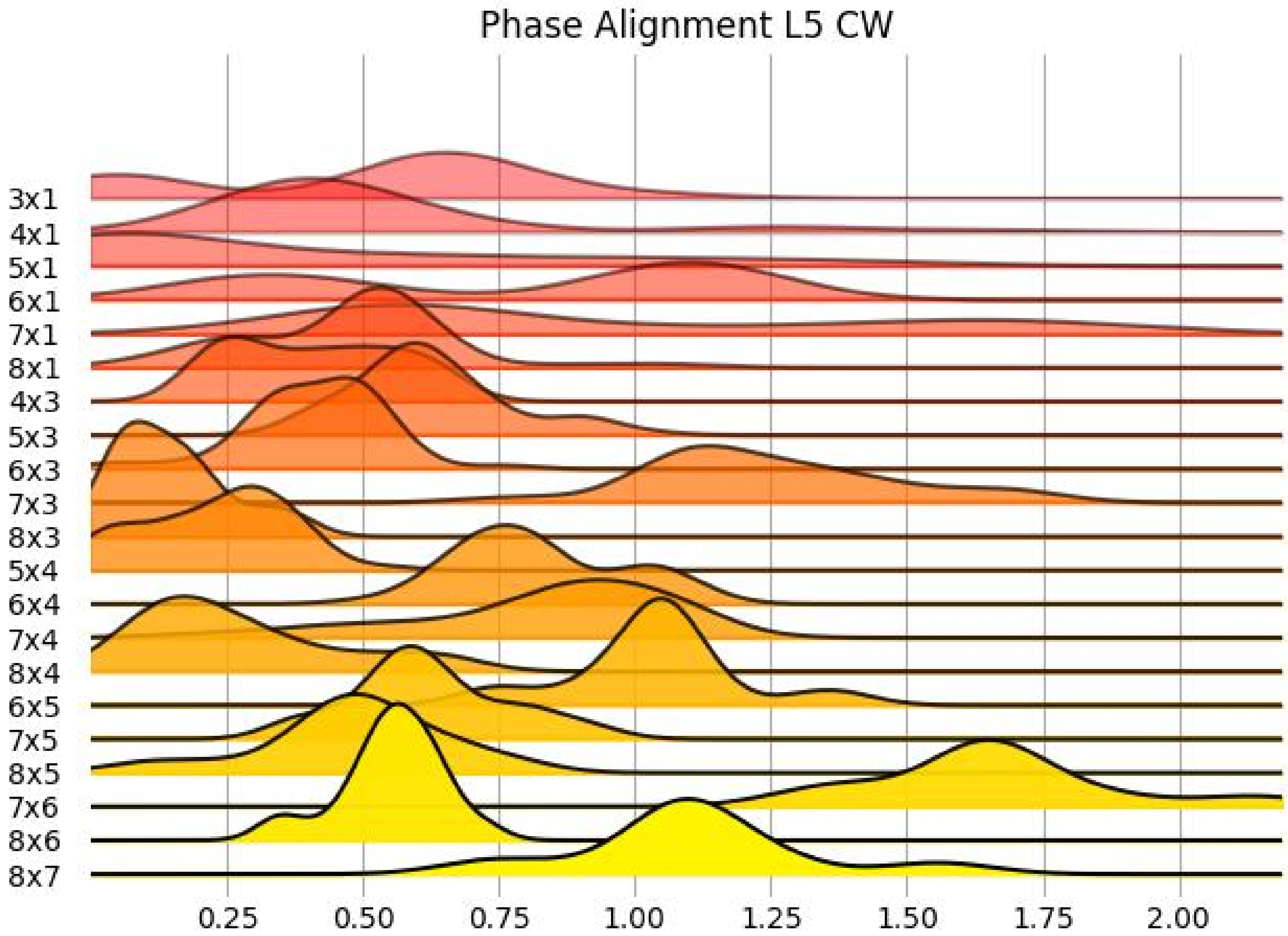
For all MxN phase alignments on L5, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]
0.67	0.44	0.00	2.19

13.3.1. Phase Alignment Over Power



13.3.2. Phase Alignment



13.4. L6 CW

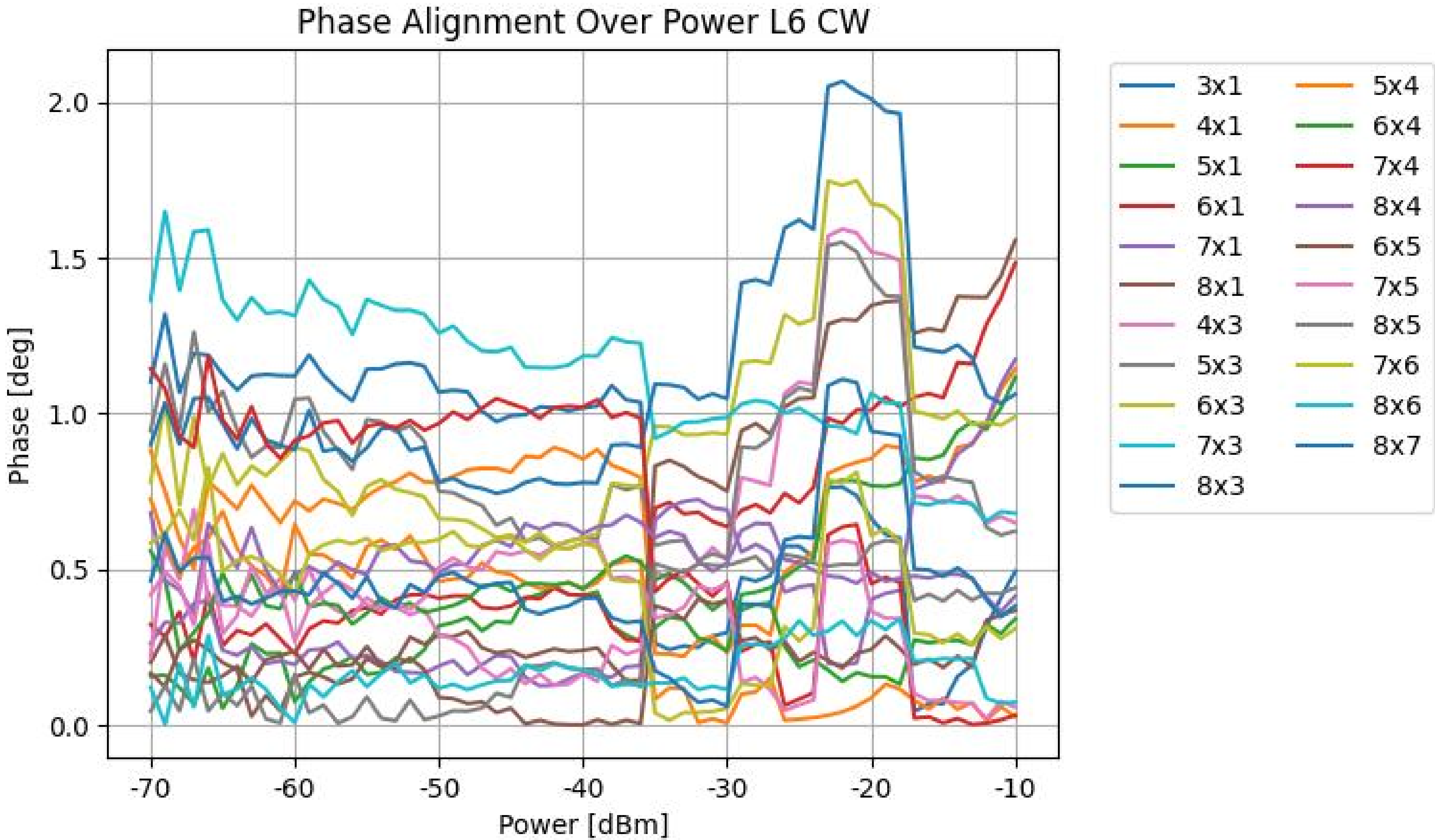
Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
3x1	0.80	0.37	0.04	1.32
4x1	0.71	0.22	0.22	1.14
5x1	0.42	0.28	0.05	1.12
6x1	0.60	0.33	0.20	1.48
7x1	0.39	0.27	0.13	1.17
8x1	0.61	0.49	0.14	1.56
4x3	0.57	0.40	0.13	1.59
5x3	0.88	0.26	0.53	1.55
6x3	0.93	0.31	0.58	1.75
7x3	1.13	0.24	0.65	1.65
8x3	1.10	0.37	0.74	2.07
5x4	0.33	0.24	0.01	0.73
6x4	0.37	0.11	0.13	0.56
7x4	0.68	0.39	0.00	1.18
8x4	0.54	0.08	0.36	0.68
6x5	0.18	0.12	0.00	0.41
7x5	0.37	0.18	0.02	0.59

Phase Alignment	Mean [°]	Std [°]	Min [°]	Max [°]
8x5	0.26	0.21	0.01	0.59
7x6	0.46	0.21	0.02	0.83
8x6	0.17	0.08	0.00	0.34
8x7	0.47	0.22	0.06	1.11

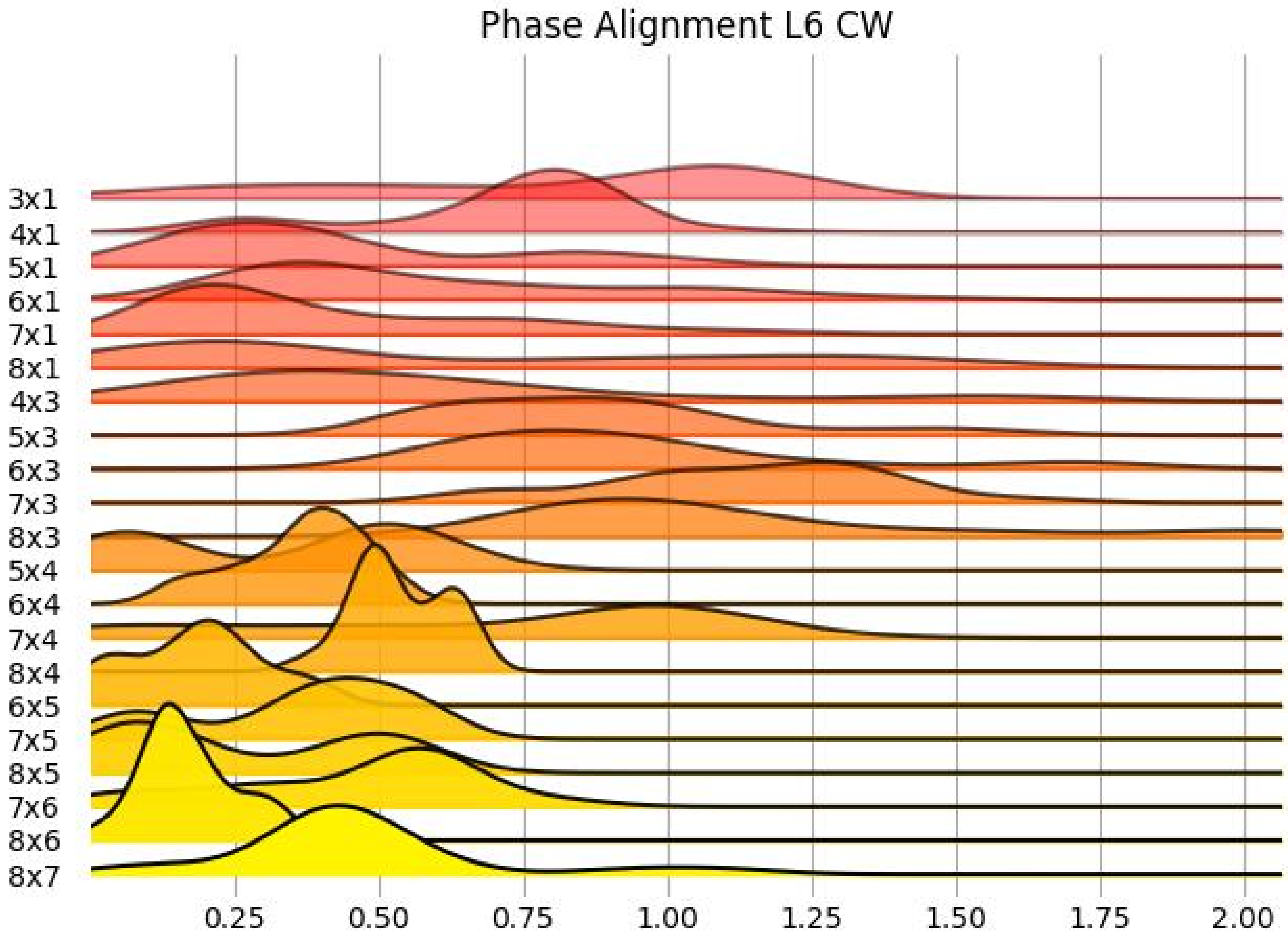
For all MxN phase alignments on L6, the statistics are:

Mean [°]	Std [°]	Min [°]	Max [°]
0.57	0.39	0.00	2.07

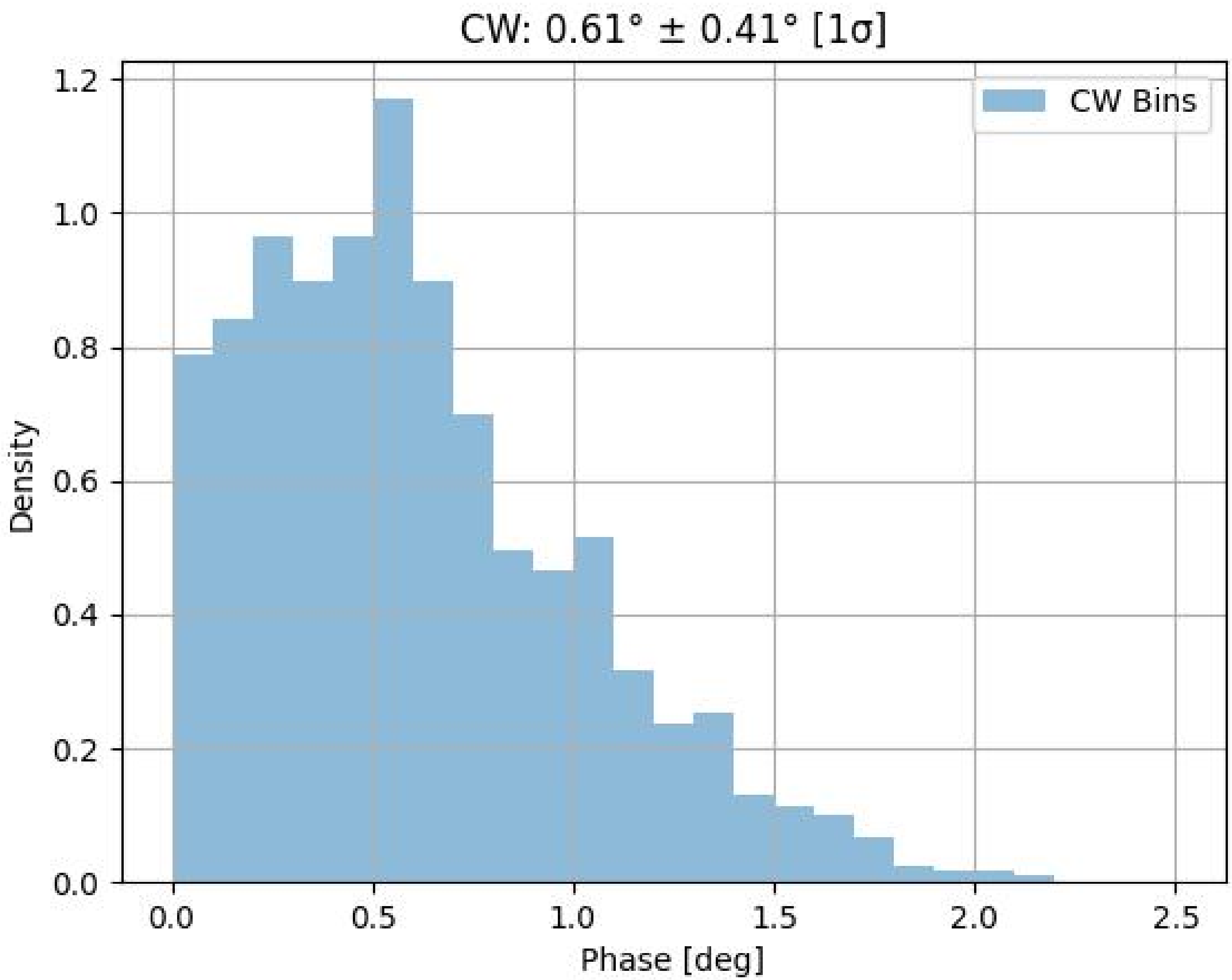
13.4.1. Phase Alignment Over Power



13.4.2. Phase Alignment



13.5. All Bands



14. Group Delay

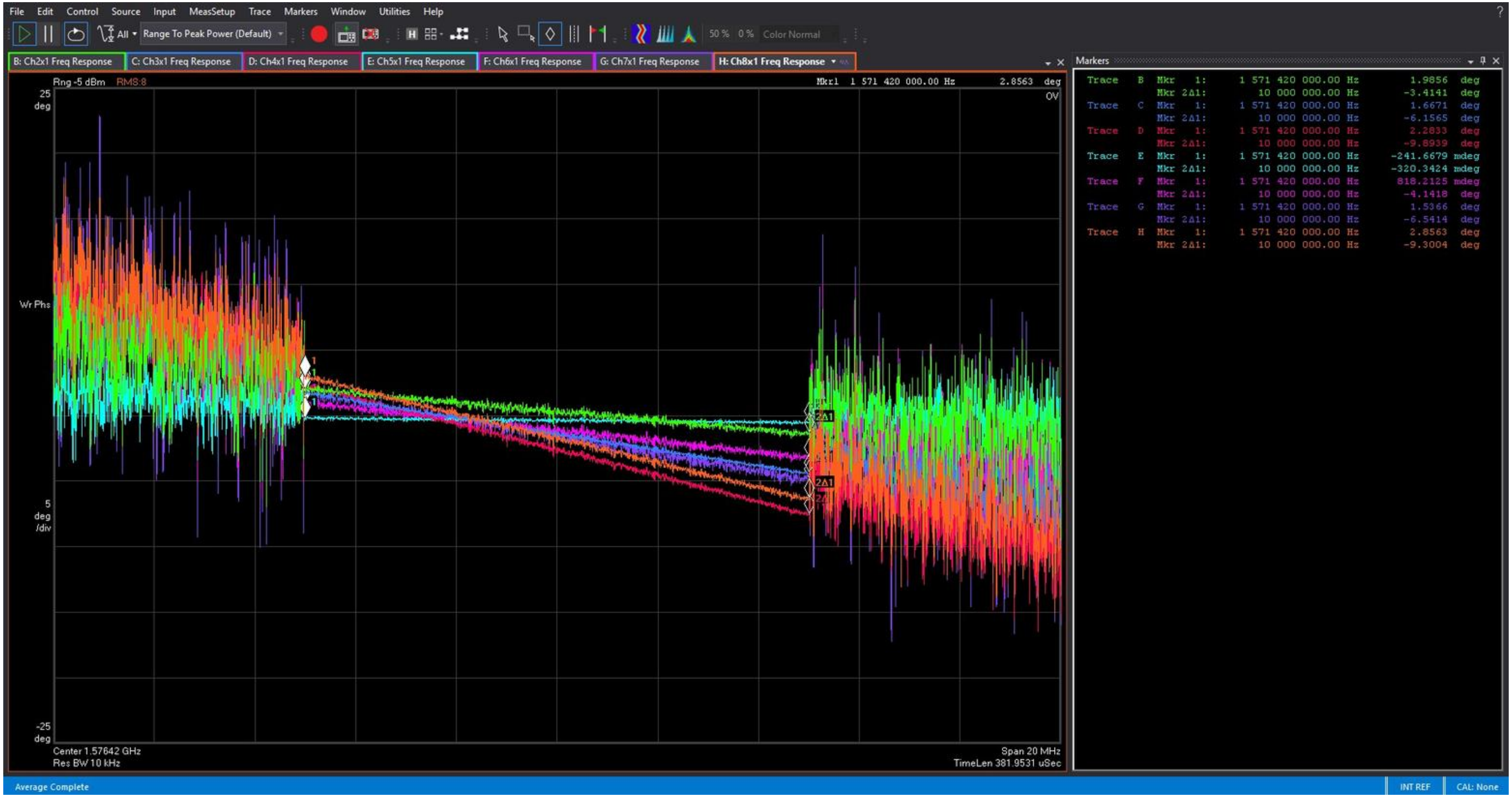
The purpose of this test is to **quantify the inter-element group delay** across a 10 MHz span for AWGN signals. Group delay is characterized as the time it takes different frequency components to travel through a system. The phase vs gain look up tables applied to the radios account for most of the group delay affects for signals at the center frequency of the radio. However, since AWGN signals span multiple frequencies, the LUT applied to the radios only account for group delay affects at the center frequency of the AWGN signals. The following table and scope images highlight this phenomenon across a 10 MHz span for each L band.

14.1. Data Table

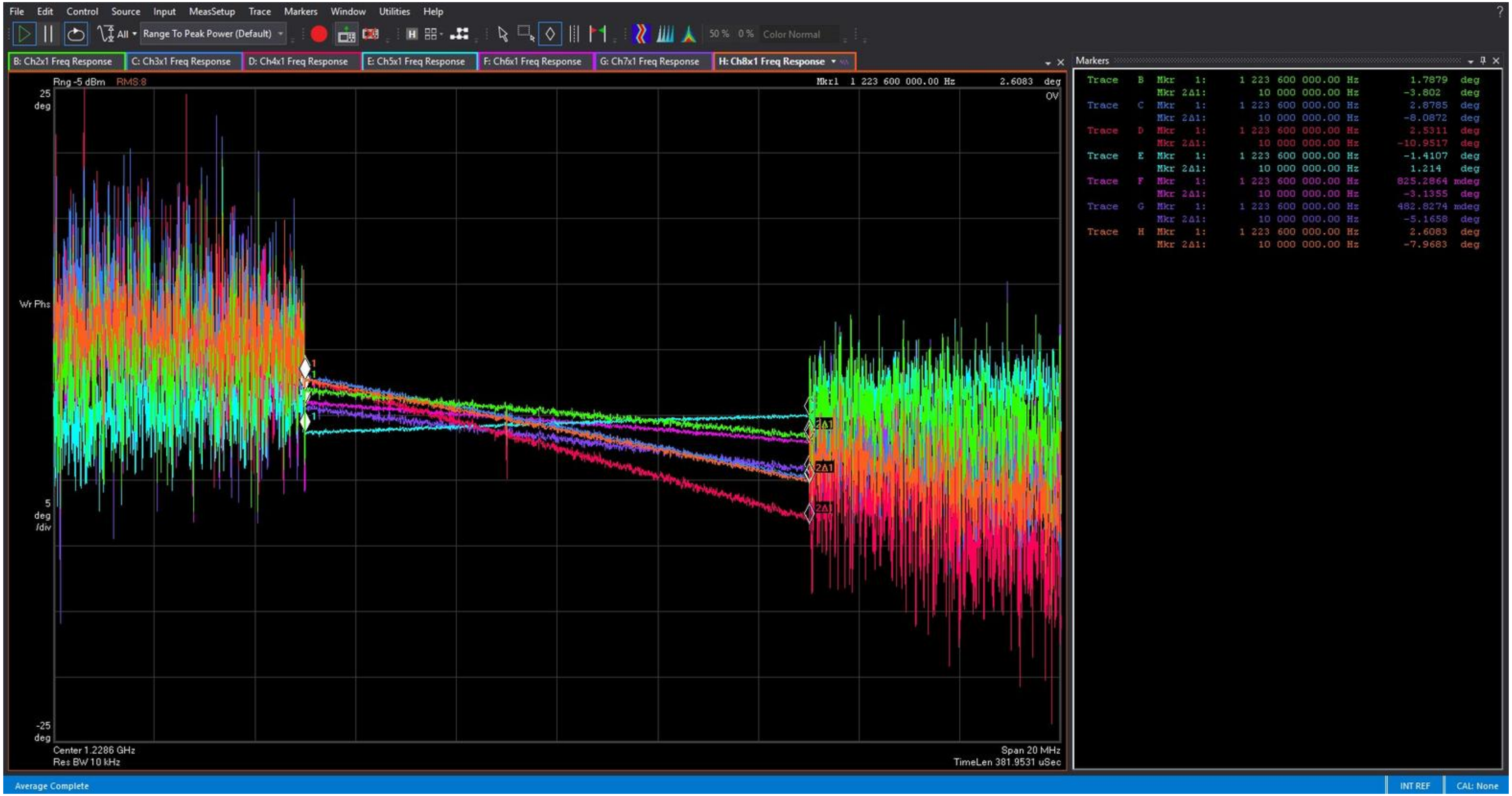
Group Delay	2x1 [°]	3x1 [°]	4x1 [°]	5x1 [°]	6x1 [°]	7x1 [°]	8x1 [°]
L1	-3.41	-6.16	-9.89	-0.32	-4.14	-6.54	-9.30
L2	-3.80	-8.09	-10.95	1.21	-3.14	-5.17	-7.97
L5	-4.06	-8.53	-12.22	-1.86	-5.04	-6.16	-9.52
L6	-3.59	-7.68	-11.99	1.11	-2.48	-4.01	-6.17

14.2. Scope Captures

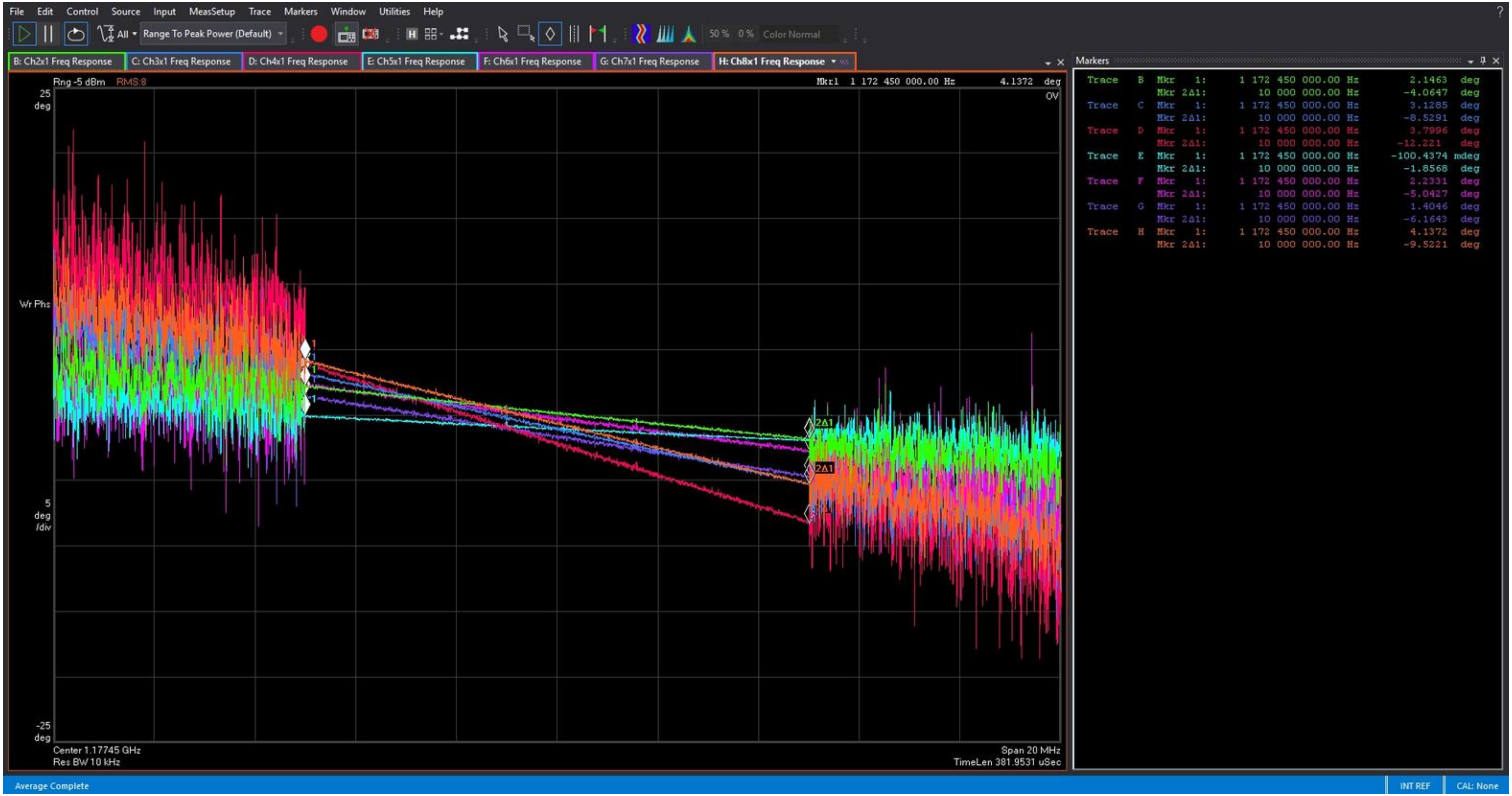
14.2.1. L1



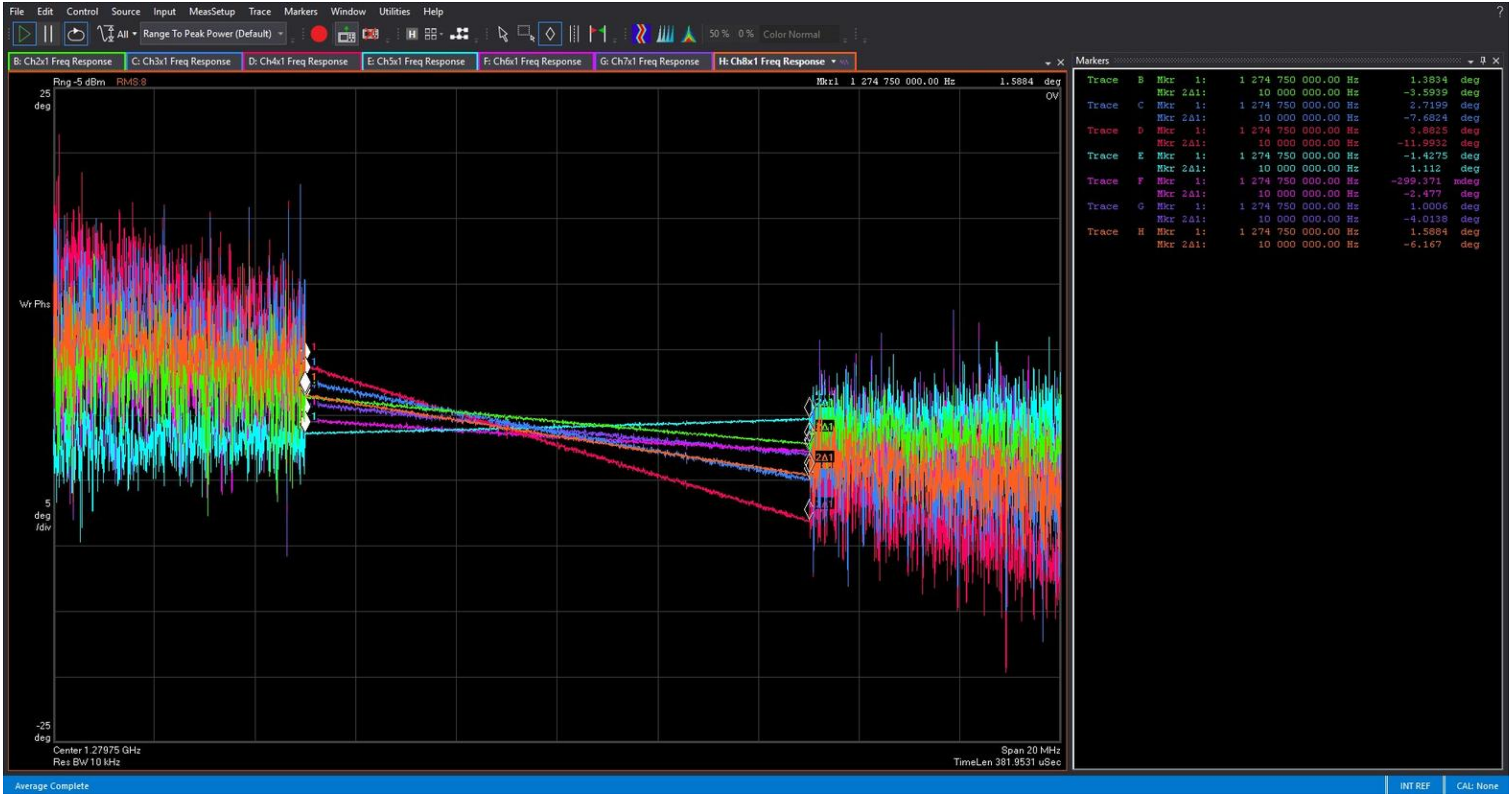
14.2.2. L2


File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
B: Ch2x1 Freq Response
C: Ch3x1 Freq Response
D: Ch4x1 Freq Response
E: Ch5x1 Freq Response
F: Ch6x1 Freq Response
G: Ch7x1 Freq Response
H: Ch8x1 Freq Response
Rng -5 dBm RMS:8
Mkr1 1 223 600 000.00 Hz 2.6083 deg
OV
25 deg
Wr Phs
5 deg /div
-25 deg
Center 1.2286 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace B Mkr 1: 1 223 600 000.00 Hz 1.7879 deg
Mkr 2Δ1: 10 000 000.00 Hz -3.802 deg
Trace C Mkr 1: 1 223 600 000.00 Hz 2.8785 deg
Mkr 2Δ1: 10 000 000.00 Hz -8.0872 deg
Trace D Mkr 1: 1 223 600 000.00 Hz 2.5311 deg
Mkr 2Δ1: 10 000 000.00 Hz -10.9517 deg
Trace E Mkr 1: 1 223 600 000.00 Hz -1.4107 deg
Mkr 2Δ1: 10 000 000.00 Hz 1.214 deg
Trace F Mkr 1: 1 223 600 000.00 Hz 825.2864 mdeg
Mkr 2Δ1: 10 000 000.00 Hz -3.1355 deg
Trace G Mkr 1: 1 223 600 000.00 Hz 482.8274 mdeg
Mkr 2Δ1: 10 000 000.00 Hz -5.1658 deg
Trace H Mkr 1: 1 223 600 000.00 Hz 2.6083 deg
Mkr 2Δ1: 10 000 000.00 Hz -7.9683 deg
Average Complete
INT REF
CAL: None

14.2.3. L5



14.2.4. L6

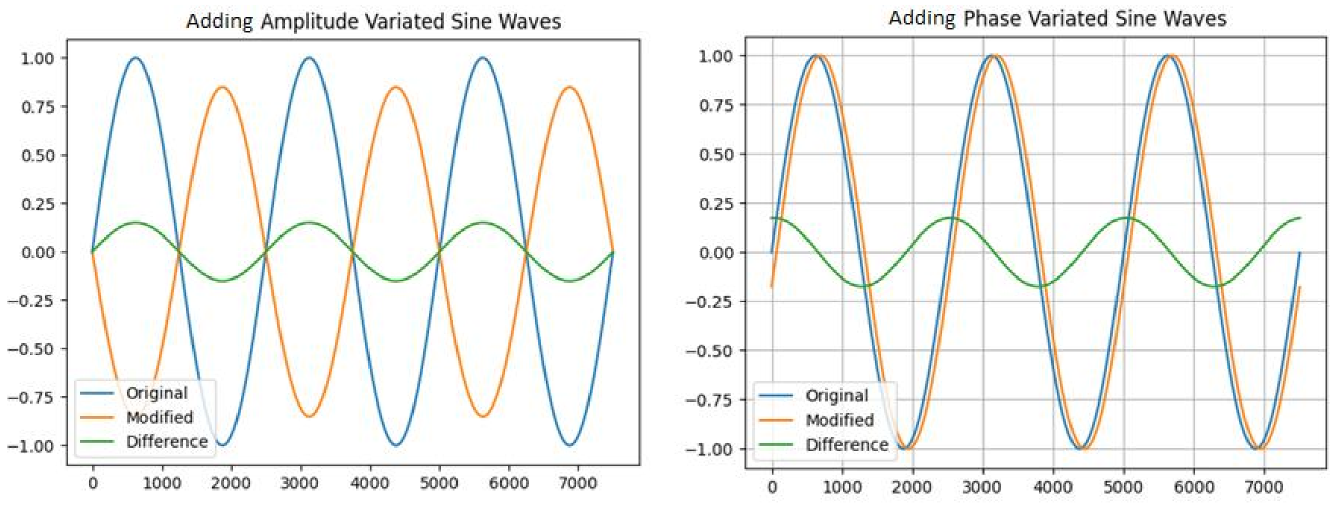

File Edit Control Source Input MeasSetup Trace Markers Window Utilities Help
Range To Peak Power (Default)
Color Normal
B: Ch2x1 Freq Response
C: Ch3x1 Freq Response
D: Ch4x1 Freq Response
E: Ch5x1 Freq Response
F: Ch6x1 Freq Response
G: Ch7x1 Freq Response
H: Ch8x1 Freq Response
Rng -5 dBm RMS:8
Mkr1 1 274 750 000.00 Hz 1.5884 deg
25 deg
Wr Phs
5 deg /div
-25 deg
Center 1.27975 GHz
Res BW 10 kHz
Span 20 MHz
TimeLen 381.9531 uSec
Markers
Trace B Mkr 1: 1 274 750 000.00 Hz 1.3834 deg
Mkr 2Δ1: 10 000 000.00 Hz -3.5939 deg
Trace C Mkr 1: 1 274 750 000.00 Hz 2.7199 deg
Mkr 2Δ1: 10 000 000.00 Hz -7.6824 deg
Trace D Mkr 1: 1 274 750 000.00 Hz 3.8825 deg
Mkr 2Δ1: 10 000 000.00 Hz -11.9932 deg
Trace E Mkr 1: 1 274 750 000.00 Hz -1.4275 deg
Mkr 2Δ1: 10 000 000.00 Hz 1.112 deg
Trace F Mkr 1: 1 274 750 000.00 Hz -299.371 mdeg
Mkr 2Δ1: 10 000 000.00 Hz -2.477 deg
Trace G Mkr 1: 1 274 750 000.00 Hz 1.0006 deg
Mkr 2Δ1: 10 000 000.00 Hz -4.0138 deg
Trace H Mkr 1: 1 274 750 000.00 Hz 1.5884 deg
Mkr 2Δ1: 10 000 000.00 Hz -6.167 deg
Average Complete
INT REF
CAL: None

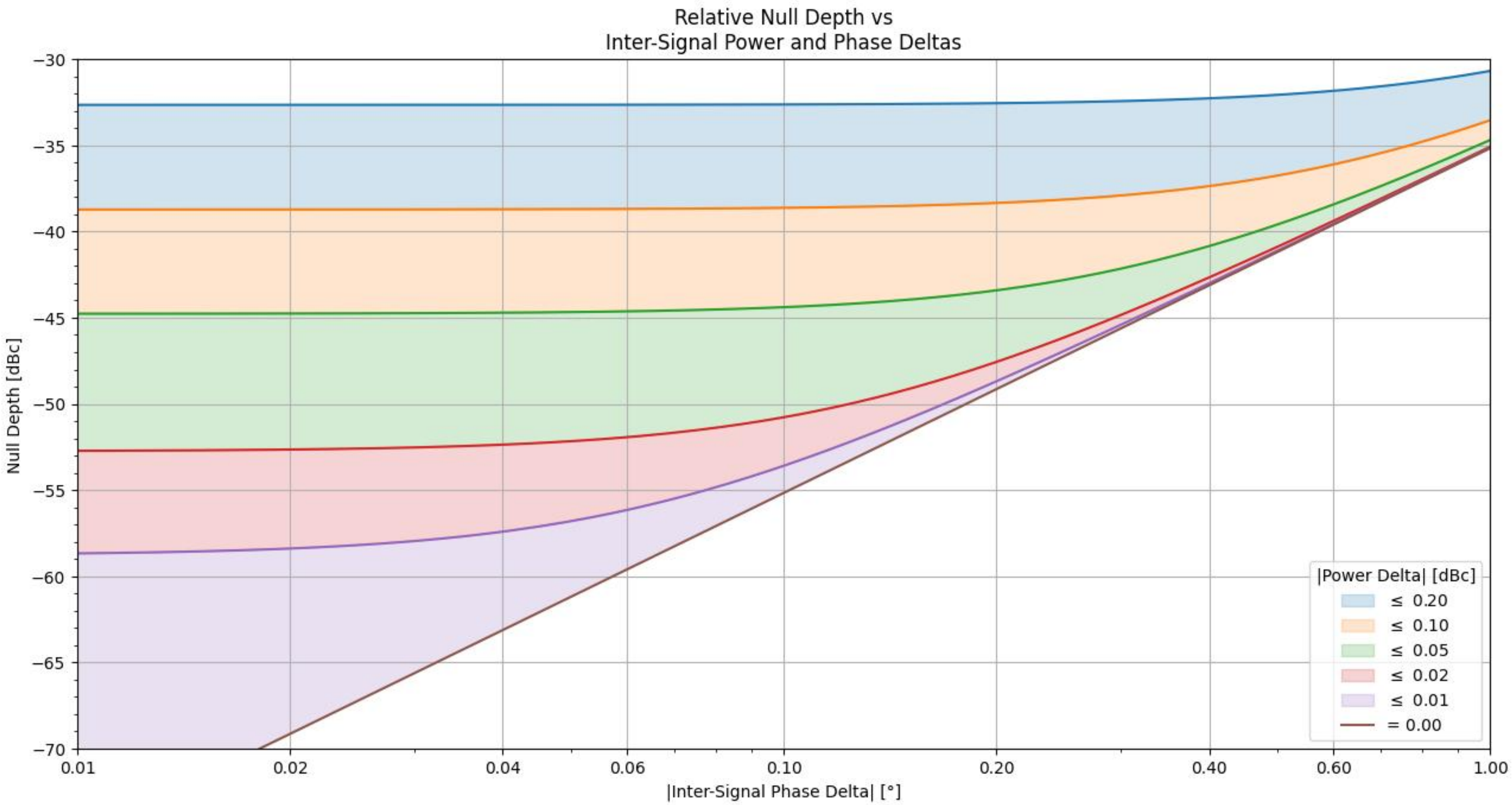
15. Phase Stability

The purpose of this test is to **quantify inter-element phase and amplitude stability**. To do this, two WF elements, each with a CW tone offset 1 MHz from their respective center frequencies (to avoid affects caused by LO Leakage), are connected to a 2:1 power splitter. The output of this splitter is then connected to a Field Fox Spectrum Analyzer (SA). The two CW tones are power matched to within 0.01 dB (ideally to within 0.005 dB) and anti-aligned in phase to within 0.1 degrees. The resulting signal out of the power combiner would ideally be an infinitely small signal/null (perfectly matched, anti-aligned signals will cancel out).

Due to power and phase resolution capabilities along with imperfect amplitude and phase stabilities, the resulting null is non-zero. The relative depth of this null [dBc] provides an **upper bound** to the inter-element amplitude and phase stabilities. **It does not provide an exact measurement because this method cannot decouple phase and power alignment and stability**. In other words, the relative null depth is a function of these 4 variables, of which we have some control over the alignments. This provides us with some information on the stabilities.

The following image may clarify; the blue and orange traces represent the two CW tones that are power matched and anti-aligned. The green trace is the result (null [dBm]) of adding these two traces together. The phase and power mis-alignments between the blue and orange tones is exaggerated to show the affect it has on the amplitude of the null. This amplitude relative to the amplitude of the two tones is the null depth [dBc]. This null depth is what is used to 'work backwards' to quantify the phase and power alignment and stability between elements on the WF (using the Inter-Element Phase Stability plot).





Once the signals have been properly power and phased matched, the stability of the resulting null is observed and measured periodically for 1 minute. Afterwards, the Field Fox is used to generate a Max Hold trace to get the 'worst case' null depth. This way, the instrument and measurement is not subject to variations due to periodic polling. This test is repeated for each L-Band and frequency of the WF. These measurements are tabulated below along with the associated plots and screen captures of the Field Fox SA.

The phase stability measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
I Phase Offset I < 0.10 °	0.10 ° ≥ I Phase Offset I ≥ 1.00 °	1.00 ° ≥ I Phase Offset I ≥ 1.50 °	I Phase Offset I ≥ 1.50 °
Best Null < -90.00 dBc	-90.00 dBc ≥ Best Null ≥ -65.00 dBc	-65.00 dBc ≥ Best Null ≥ -60.00 dBc	Best Null ≥ -60.00 dBc
Worst Null < -65.00 dBc	-65.00 dBc ≥ Worst Null ≥ -55.00 dBc	-55.00 dBc ≥ Worst Null ≥ -50.00 dBc	Worst Null ≥ -50.00 dBc
Avg Null < -65.00 dBc	-65.00 dBc ≥ Avg Null ≥ -60.00 dBc	-60.00 dBc ≥ Avg Null ≥ -55.00 dBc	Avg Null ≥ -55.00 dBc

15.1. Data Table

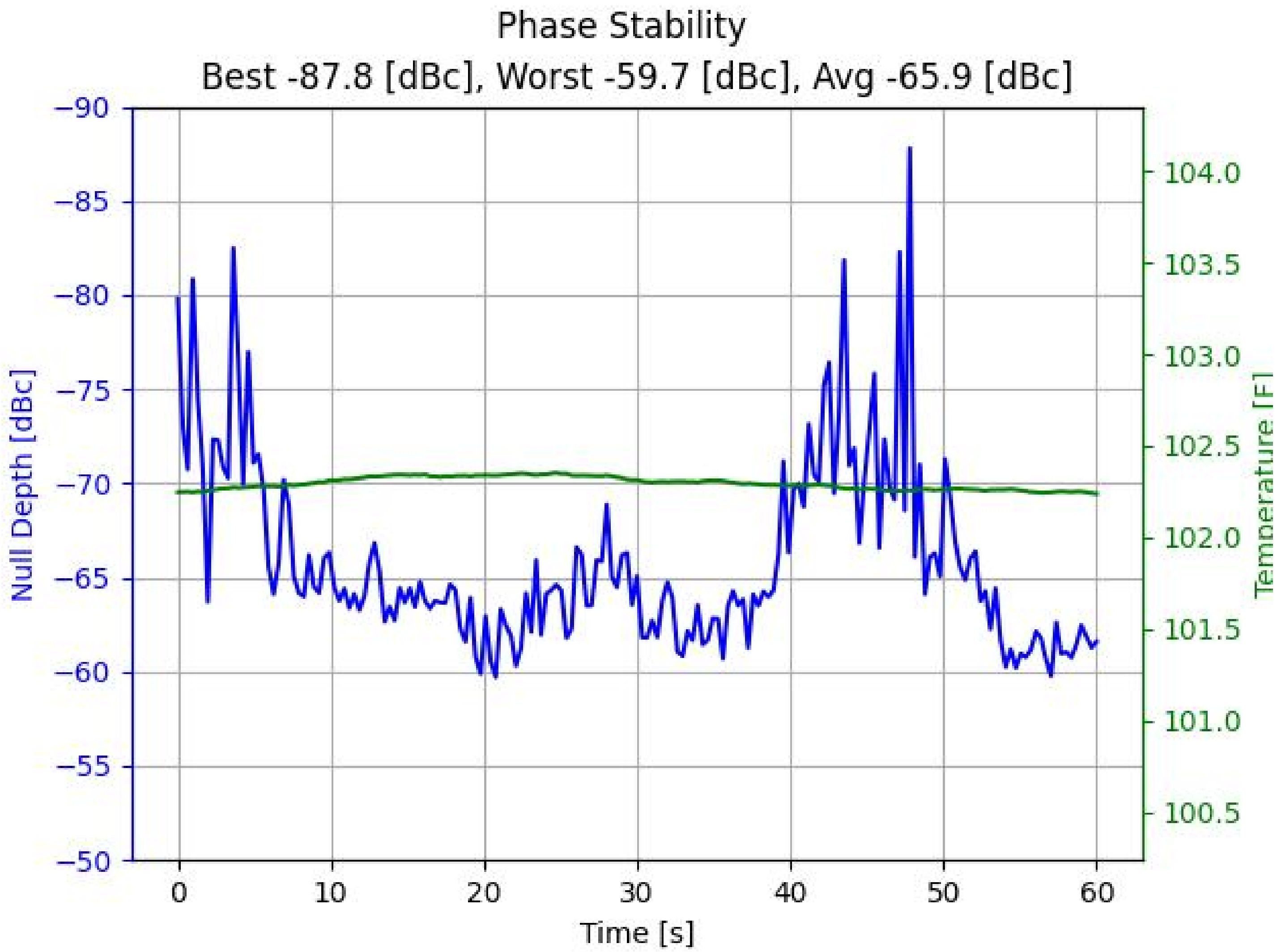
Phase Stability	Power Diff [dB]	Phase Offset [°]	Best Null [dBc]	Worst Null [dBc]
L1	-0.00	0.30	-85.50	-57.63
L2	-0.01	0.40	-95.52	-63.84
L5	-0.01	0.90	-76.67	-56.25
L6	-0.01	0.70	-68.99	-57.31

The 'Worst Null' gives an upper bound of the amplitude and phase stability. A -60 dBc Worst Null is roughly equivalent to saying the amplitude stability is better than 0.01 dB and the phase stability is better than 0.06Â° (see the inter-element phase stability plot above).

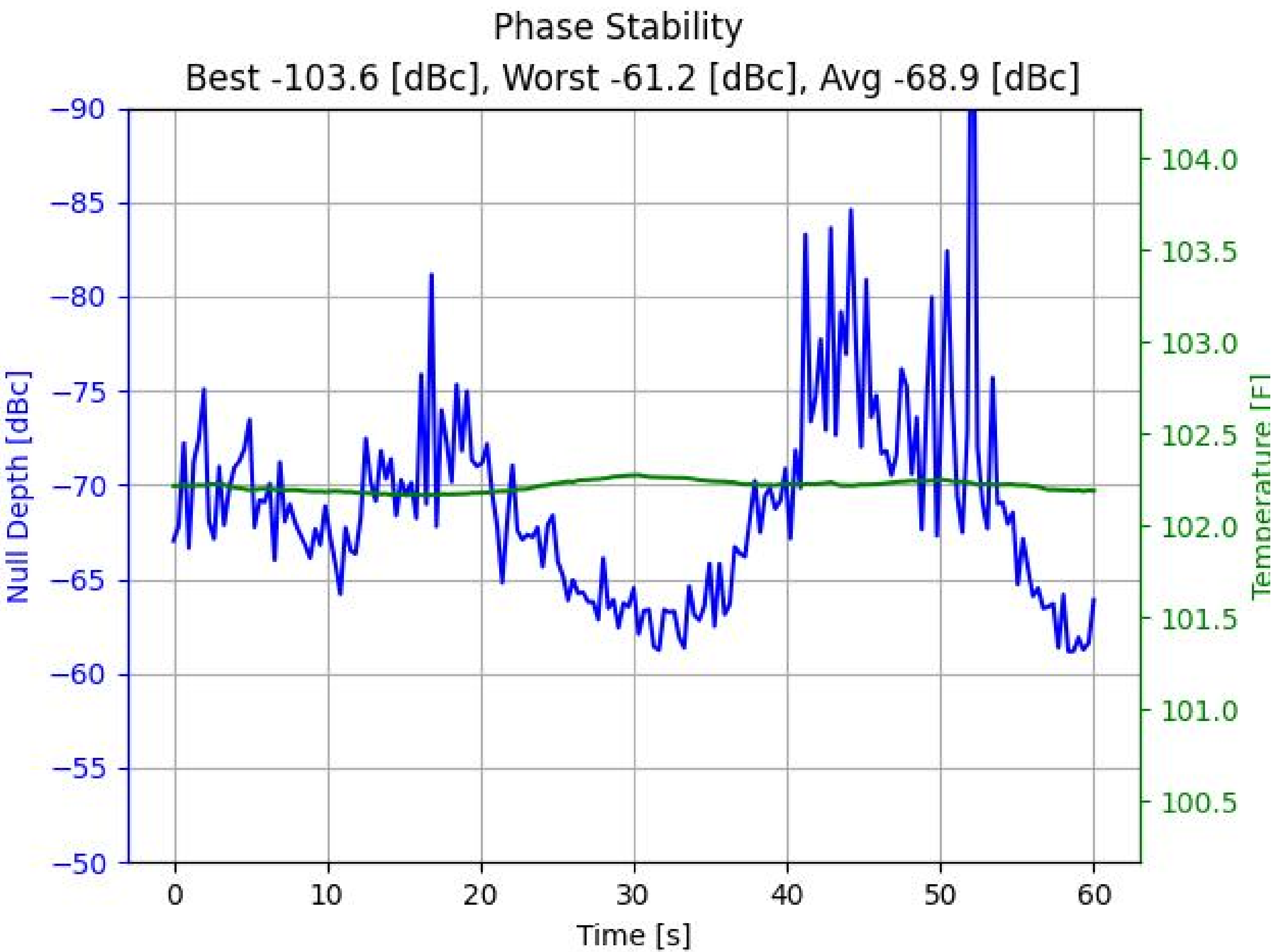
The 'Worst Null' however does not tell the whole story. It can be artificially high due to a poorly matched initial power or phase alignment (caused by the insufficient resolution of setting and measuring these). The actual phase and amplitude stabilities are probably closer to the values you can derive from the 'Average Nulls'.

15.2. Data Plots

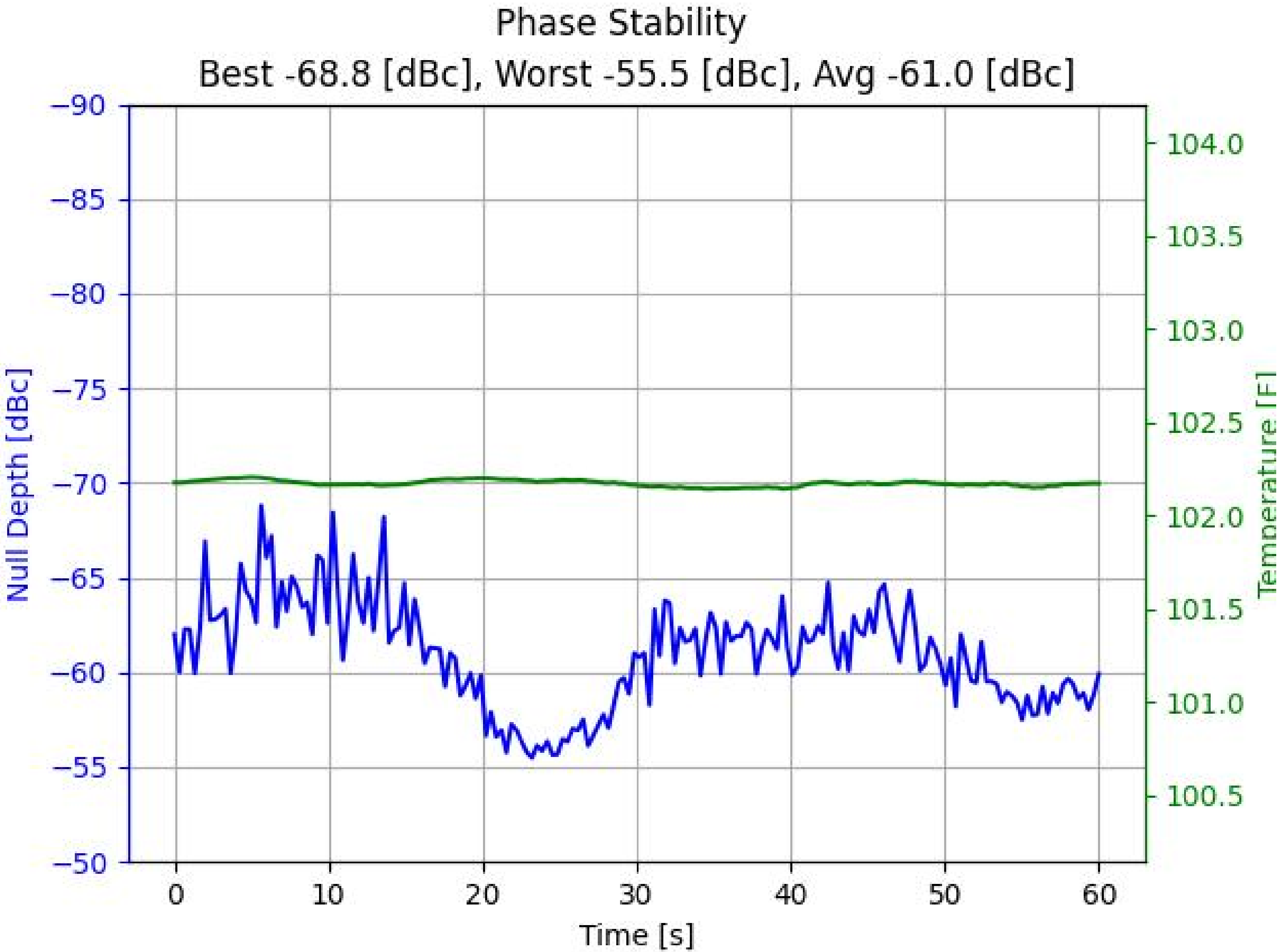
15.2.1. L1



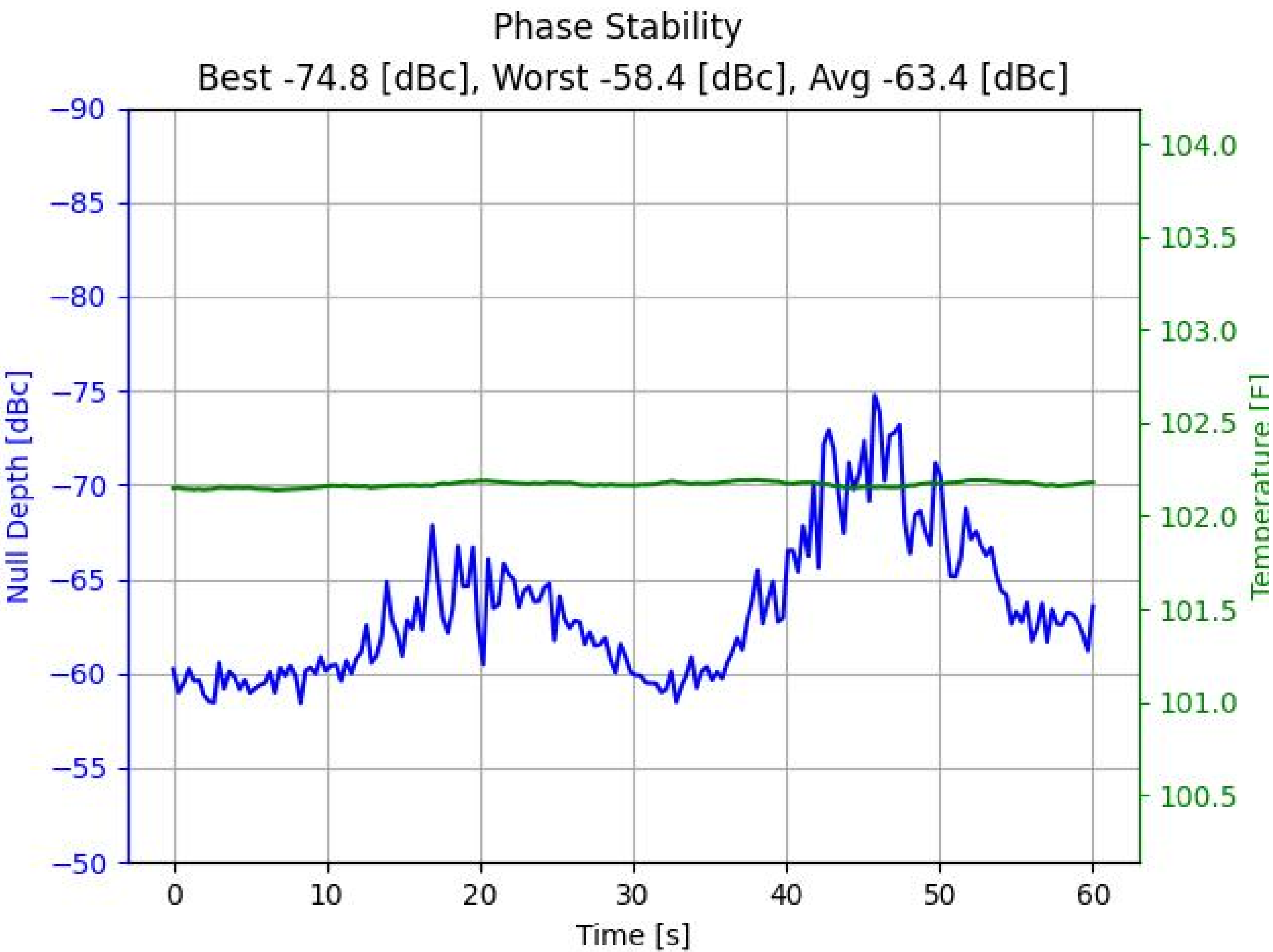
15.2.2. L2


Phase Stability
Best -103.6 [dBc], Worst -61.2 [dBc], Avg -68.9 [dBc]
−90
−85
−80
−75
−70
−65
−60
−55
−50
Null Depth [dBc]
104.0
103.5
103.0
102.5
102.0
101.5
101.0
100.5
Temperature [F]
0
10
20
30
40
50
60
Time [s]

15.2.3. L5

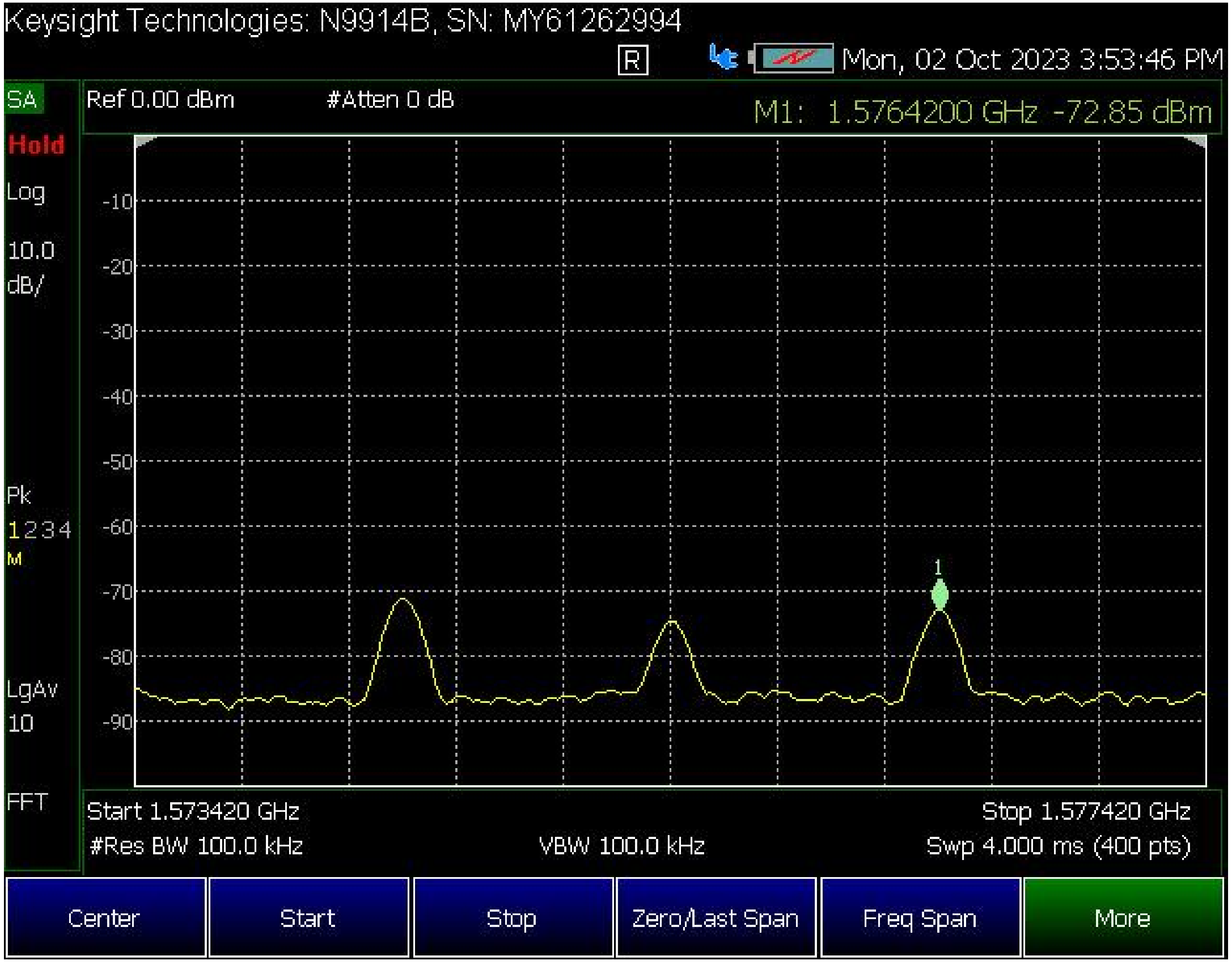

Phase Stability
Best -68.8 [dBc], Worst -55.5 [dBc], Avg -61.0 [dBc]
Null Depth [dBc]
−90
−85
−80
−75
−70
−65
−60
−55
−50
Temperature [F]
104.0
103.5
103.0
102.5
102.0
101.5
101.0
100.5
0
10
20
30
40
50
60
Time [s]

15.2.4. L6

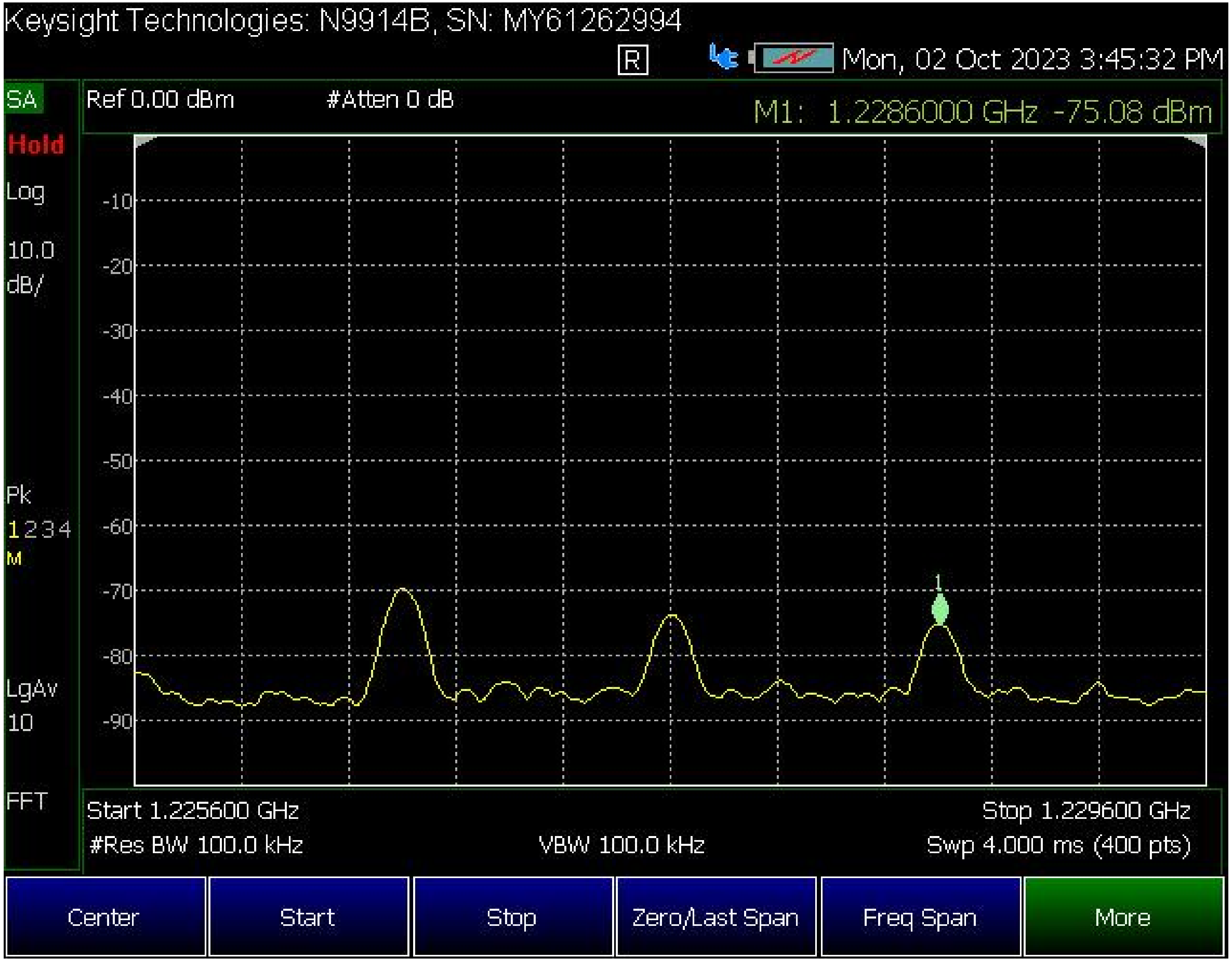

Phase Stability
Best -74.8 [dBc], Worst -58.4 [dBc], Avg -63.4 [dBc]
Null Depth [dBc]
−90
−85
−80
−75
−70
−65
−60
−55
−50
Temperature [F]
104.0
103.5
103.0
102.5
102.0
101.5
101.0
100.5
0
10
20
30
40
50
60
Time [s]

15.3. Scope Captures

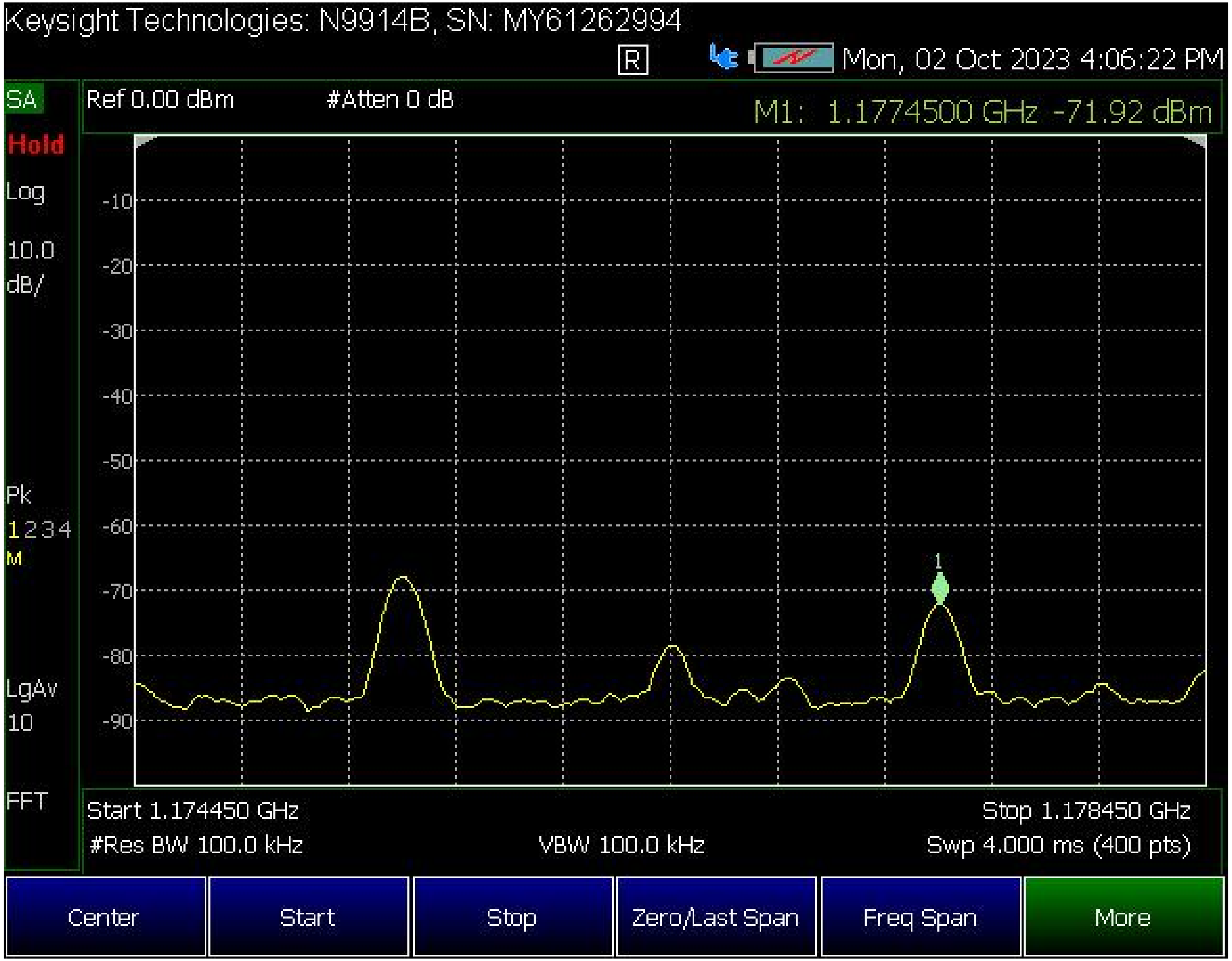
15.3.1. L1



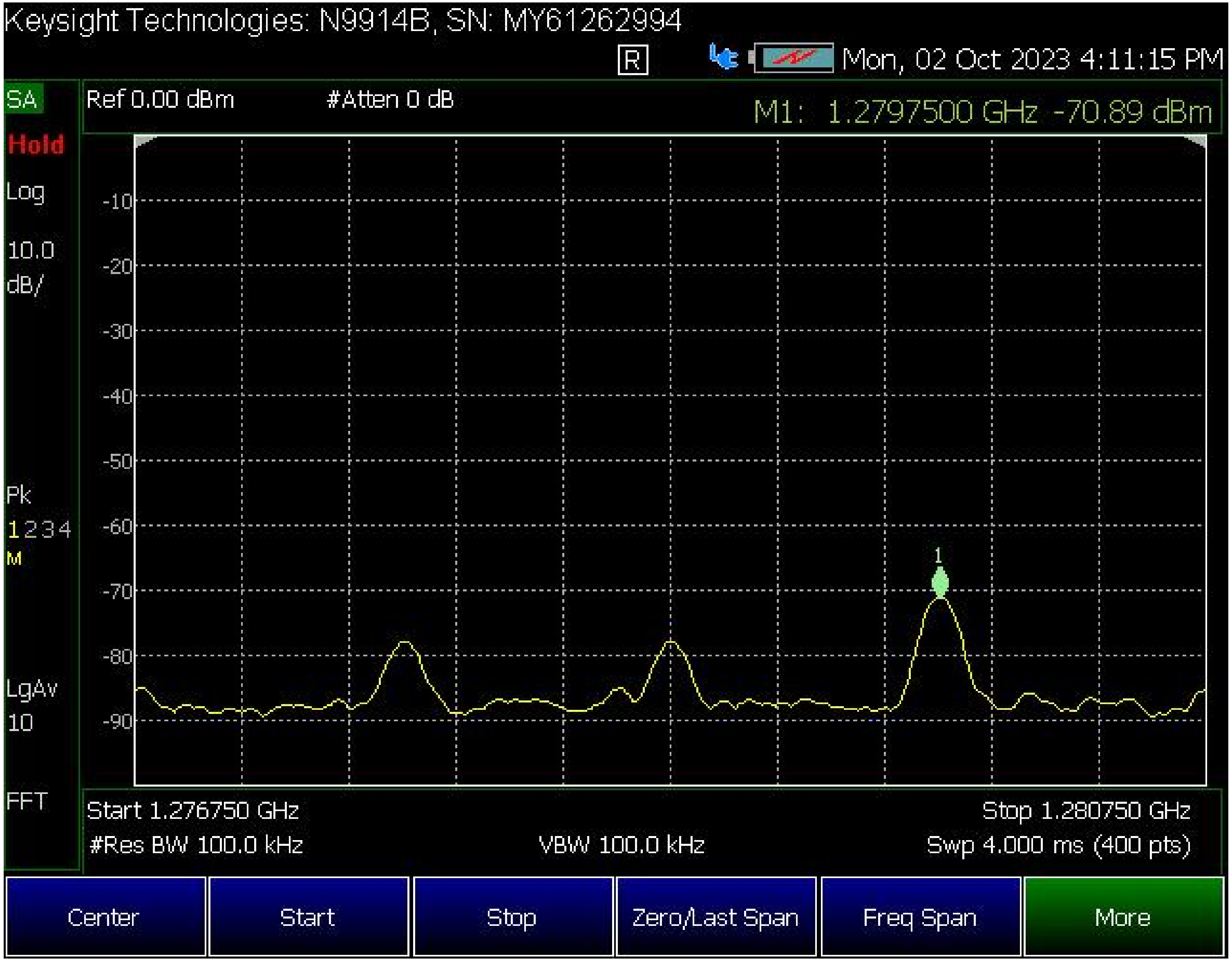
15.3.2. L2


Keysight Technologies: N9914B, SN: MY61262994
R
Mon, 02 Oct 2023 3:45:32 PM
SA
Hold
Log
10.0
dB/
Pk
1234
M
LgAv
10
FFT
Ref 0.00 dBm
#Atten 0 dB
M1: 1.2286000 GHz -75.08 dBm
-10
-20
-30
-40
-50
-60
-70
-80
-90
1
Start 1.225600 GHz
Stop 1.229600 GHz
#Res BW 100.0 kHz
VBW 100.0 kHz
Swp 4.000 ms (400 pts)
Center
Start
Stop
Zero/Last Span
Freq Span
More

15.3.3. L5


Keysight Technologies: N9914B, SN: MY61262994
Mon, 02 Oct 2023 4:06:22 PM
SA
Hold
Log
10.0
dB/
Pk
1 2 3 4
M
LgAv
10
FFT
Ref 0.00 dBm
#Atten 0 dB
M1: 1.1774500 GHz -71.92 dBm
-10
-20
-30
-40
-50
-60
-70
-80
-90
Start 1.174450 GHz
Stop 1.178450 GHz
#Res BW 100.0 kHz
VBW 100.0 kHz
Swp 4.000 ms (400 pts)
Center
Start
Stop
Zero/Last Span
Freq Span
More

15.3.4. L6


Keysight Technologies: N9914B, SN: MY61262994
R
Mon, 02 Oct 2023 4:11:15 PM
SA
Hold
Log
10.0
dB/
Pk
1234
M
LgAv
10
FFT
Ref 0.00 dBm
#Atten 0 dB
M1: 1.2797500 GHz -70.89 dBm
-10
-20
-30
-40
-50
-60
-70
-80
-90
1
Start 1.276750 GHz
Stop 1.280750 GHz
#Res BW 100.0 kHz
VBW 100.0 kHz
Swp 4.000 ms (400 pts)
Center
Start
Stop
Zero/Last Span
Freq Span
More

16. Phase Drift

The purpose of this test is to quantify the phase drift of the WF. **Phase drift is characterized as the long-term phase deviation of an element over time**. To perform this test, all 8 elements of the WF are connected to the EXR scope. Time domain phase measurements between the reference element (E1) and all other elements are performed every 5 seconds, allowing the statistical count to increase to ~70,000 before the mean phase is pulled to ensure minimal error from scope resolution is present in the data. To isolate phase drift from phase alignment, the initial phase of each element is subtracted out from the data, leaving only the phase deviation from any given element to the reference element (E1).

The phase deviation of each WF element is calculated by de-meaning the measured data. The measured data can be thought of as an Nx8 matrix with N time samples for each inter-element phase measurement, (i.e. Phase(1-2), Phase(1-3)... Phase(1-8)) where the first column is an Nx1 zero vector representing the inter-element phase measurement of the reference element (Phase(1-1)). De-meaning the data removes the dependency on the reference element. Therefore, the drift of all elements relative to the mean can be characterized (i.e. Phase(1-M), Phase(2-M)...Phase(8-M)).

The phase drift measurements are color coded based on the following acceptance criteria:

Exceptional	Passing	Borderline	Failing
Range < 0.10 °	0.10 ° ≥ Range ≥ 0.40 °	0.40 ° ≥ Range ≥ 0.50 °	Range ≥ 0.50 °

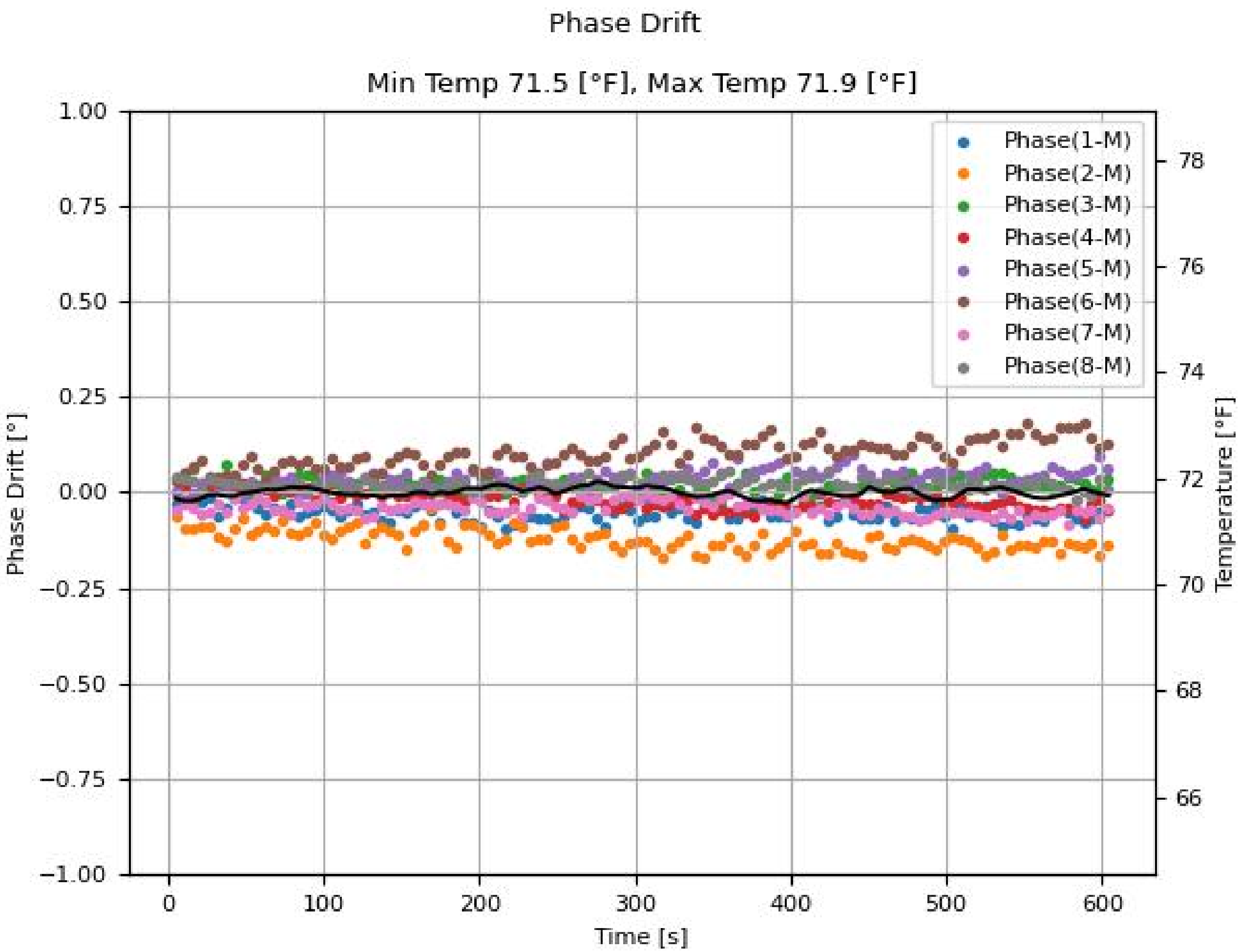
16.1. Temp Dependent

These tests investigate the **impact that ambient temperature changes have on phase drift**. To create repeatable, consistent temperature changes, a custom-built temperature shroud was designed to fit over the WF. A lever mechanism is used to control the ambient temperature around the wavefront by changing the amount of hot air that is funneled from the back of cabinet to the front. In addition to the inter-element time-domain phase measurements, a digital multimeter (DMM) is queried every 5 seconds for the temperature of the air around the WF.

Custom Built PhaseDrift Shroud Over WF Cabinet

16.1.1. Typical

This test depicts the typical phase drift performance of the WF in a temperature controlled room. It serves as a baseline for comparing minute temperature changes to moderate and extreme ones.



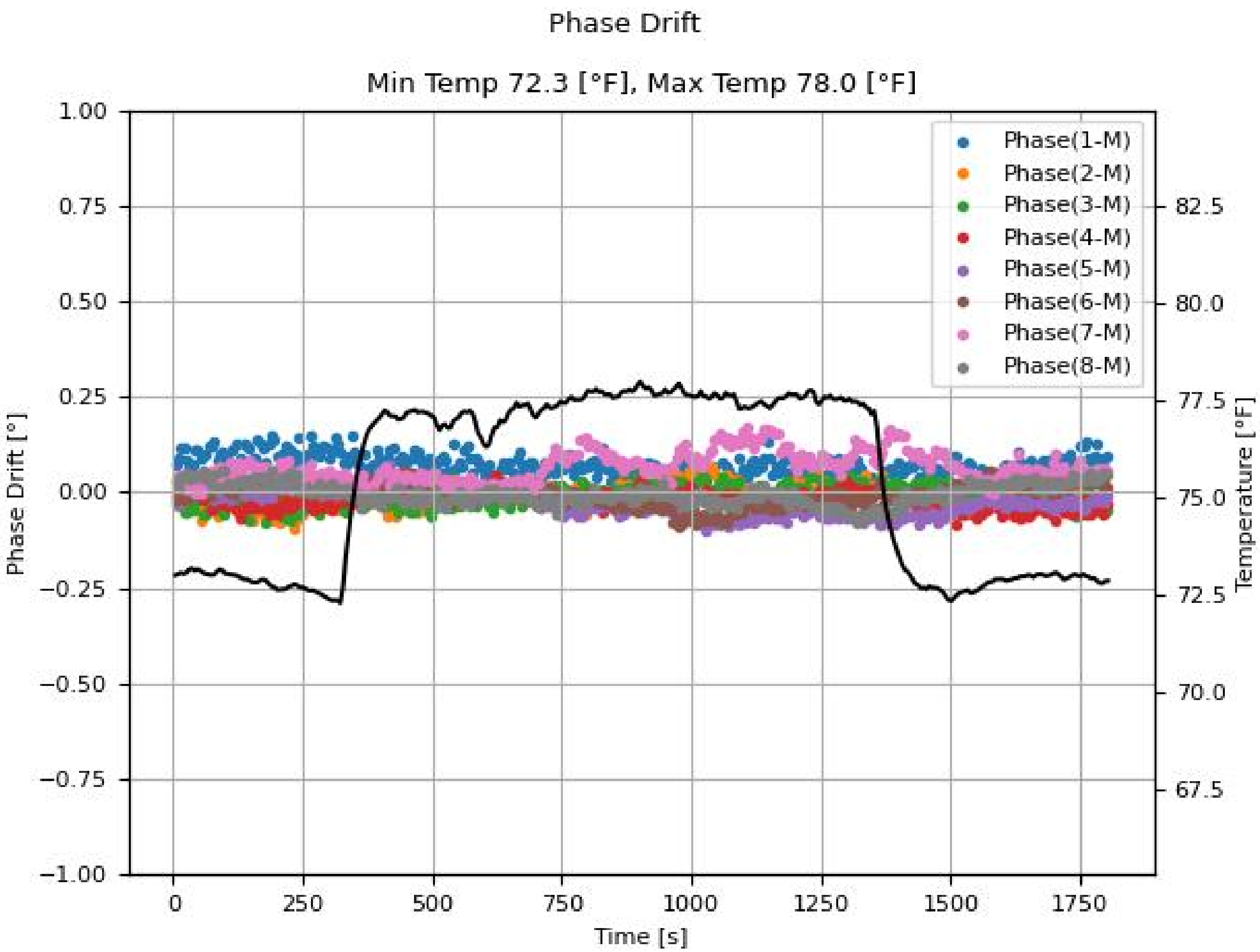
16.1.1.1. Data Table

Phase Drift	Min [°]	Max [°]	Range [°]
1-M	-0.09	-0.01	0.08
2-M	-0.17	-0.04	0.13
3-M	-0.04	0.07	0.11
4-M	-0.07	0.03	0.10
5-M	-0.02	0.10	0.12
6-M	0.03	0.18	0.15
7-M	-0.08	-0.00	0.08
8-M	-0.02	0.06	0.07

These results show that under temperature controlled conditions, the WF elements do not drift from initial alignment.

16.1.2. Moderate

This test depicts an induced temperature change of ~6°F in 120 seconds. Following this, the phase is sampled for 1,000 seconds before the temperature is returned to its initial reading.



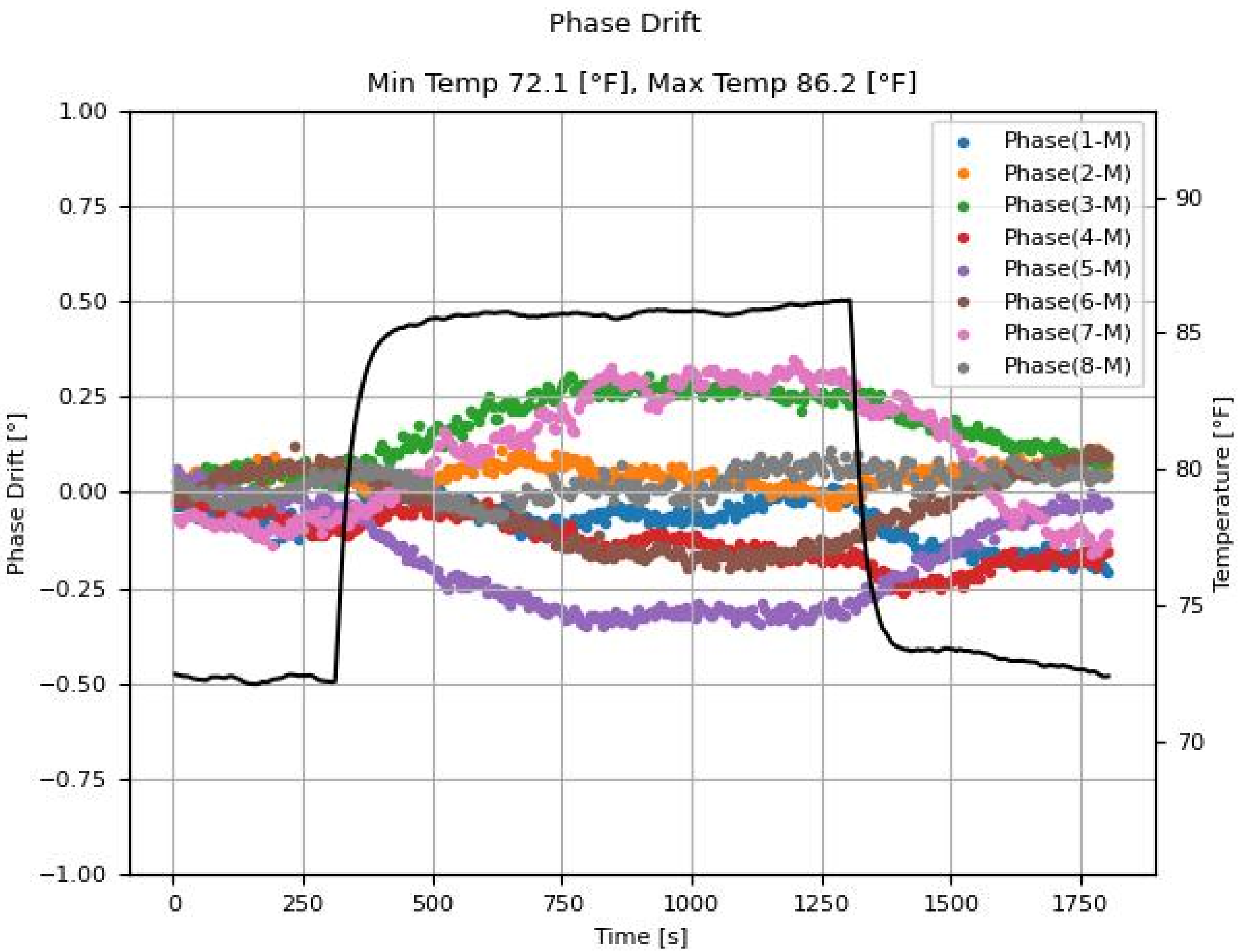
16.1.2.1. Data Table

Phase Drift	Min [°]	Max [°]	Range [°]
1-M	-0.00	0.15	0.15
2-M	-0.10	0.07	0.16
3-M	-0.08	0.05	0.12
4-M	-0.08	0.04	0.12
5-M	-0.10	0.07	0.17
6-M	-0.09	0.06	0.15
7-M	-0.01	0.17	0.18
8-M	-0.08	0.06	0.13

These results highlight the fact that moderate temperature changes (as defined above), have an insignificant impact on the phase drift of the WF elements.

16.1.3. Extreme

This test depicts an induced temperature change of ~14°F in 120 seconds. Following this, the phase is sampled for 1,000 seconds before the temperature is returned to its initial reading.



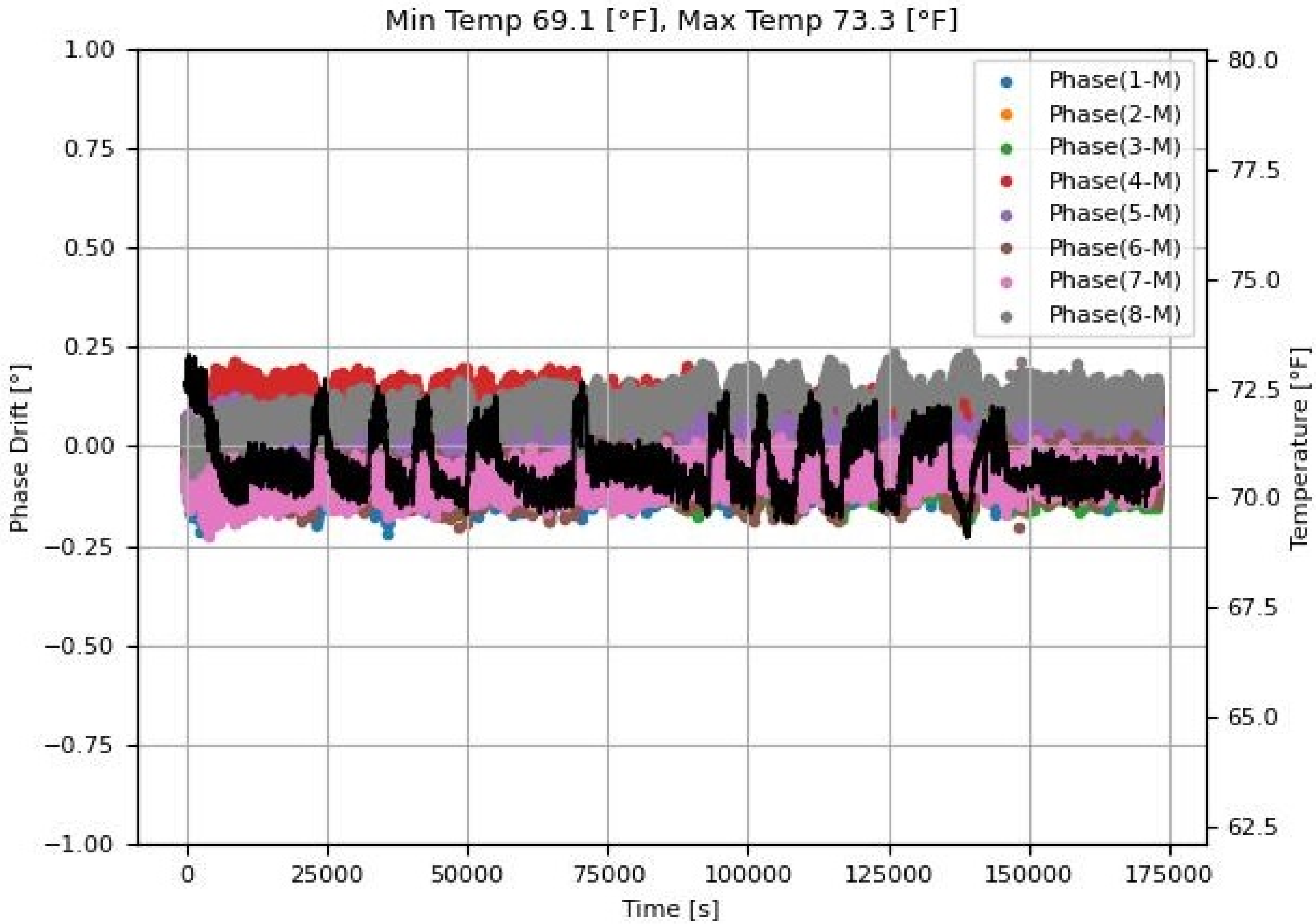
16.1.3.1. Data Table

Phase Drift	Min [°]	Max [°]	Range [°]
1-M	-0.21	0.04	0.24
2-M	-0.03	0.12	0.15
3-M	-0.01	0.31	0.32
4-M	-0.26	-0.01	0.25
5-M	-0.35	0.06	0.41
6-M	-0.20	0.12	0.32
7-M	-0.16	0.35	0.51
8-M	-0.07	0.11	0.18

These results show how extreme temperature changes (as defined above) induce a bounded phase drift of ±0.25°. Therefore, given an extreme temperature change, the user should expect that phase will drift from initial alignment ±0.25°.

16.2. 48-Hours

This test investigates the phase drift of the WF over a 48-hour period in an environment that is temperature controlled within ±2°F.



16.2.1. Data Table

Phase Drift	Min [°]	Max [°]	Range [°]
1-M	-0.22	0.07	0.29
2-M	-0.14	0.11	0.26
3-M	-0.18	0.06	0.25
4-M	-0.04	0.21	0.25
5-M	-0.06	0.13	0.19
6-M	-0.20	0.05	0.26
7-M	-0.23	0.18	0.41
8-M	-0.07	0.24	0.31

These results highlight how the phase of the WF does not experience significant drift when a scenario is running for two consecutive days in temperature controlled rooms to within ±2°F.

End of Report