ncee labs
Product Compliance Solutions

4740 Discovery Drive | Lincoln, NE 68521
tel- 402.323.6233 | tel -888.657.6860 | fax - 402.323.6238
info@nceelabs.com | http://nceelabs.com

Test Report

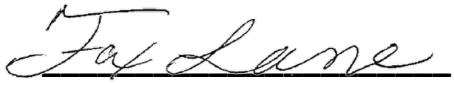
Prepared for: **Inovonics**

Address: **11000 Westmoor Circle**
Building 10, Suite 250
Westminster, CO 80021

Product: **EN 5061**

Test Report No: **R20220503-20-E2C**

Approved by:



Fox Lane,
EMC Test Engineer

DATE: **26 August 2024**

Total Pages: **46**

REVISION PAGE

Rev. No.	Date	Description
Original	21 February 2023	Original – KVepuri Prepared by Flane/KVepuri
A	14 August 2024	Corrected Plot names - FL
B	23 August 2024	Added Manufacturer declared Duty Cycle - FL
C	26 August 2024	Corrected Emissions Table Error - FL

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 5
(3) ISED RSS-247, Issue 2

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	PCB antenna
FCC 15.35 RSS-Gen, 6.10	Duty cycle of pulsed emissions	Pass	Pulsed emissions duty cycle was applied
FCC 15.209 RSS-Gen, 7.1	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a)(1)(i) RSS-247, 5.1(c)	Minimum Bandwidth, Limit: Min. 250kHz, Frequency Separation	Pass	Meets the requirement of the limit.
FCC 15.247(b)(1) RSS-247, 5.1	Maximum Peak Output Power, Limit: Max. 24 dBm	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-247, 5.5	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a) (1) (i) RSS-247, 5.1(c)	Frequency hopping system, Limit: Max. 0.4 Seconds in 10 Second Period	Pass	Meets the requirement of the limit.
FCC 15.209, 15.205,15.247 RSS-Gen, 8.9 RSS-247, 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen. 8.8	Conducted AC Emissions	Pass	Meets the requirement of the limit.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a wireless FHSS transmitter, EN 5061.

EUT	EN 5061
EUT Received	1/18/2023
EUT Tested	1/24/2023- 1/31/2023
Serial No./ Tx ID	010369(NCEE assigned serial number)
Operating Band	902.0 – 928.0 MHz
Device Type	FHSS
Power Supply	12 VAC Power Supply; Part No. W48A-J1000-2T

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low	902.4
Middle	914.8
High	927.6

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

EUT was modified to transmit at the highest practical duty cycle on the lowest, highest and one channel in the middle that was used for all RF tests.

2.3 DESCRIPTION OF SUPPORT UNITS

N/A

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
CAB MRA Recognition Identification No:	US0177

Environmental conditions varied slightly throughout the tests.

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	EMC Test Engineer	Testing, Report and Review
2	Fox Lane	EMC Test Engineer	Testing
3	Blake Winter	EMC Test Engineer	Testing and Report

Notes:
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (44GHz)	N9038A	MY59050109	July 19, 2022	July 19, 2024
SunAR RF Motion***	JB1	A082918-1	July 26, 2022	July 26, 2023
ETS EMCO Red Horn Antenna	3115	00218655	July 21, 2022	July 21, 2023
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	April 4, 2022	April 4, 2024
Trilithic High Pass Filter*	6HC330	23042	April 22, 2022	April 22, 2024
MiniCircuits High Pass Filter*	VHF-1320+	15542	April 4, 2022	April 4, 2024
ETS – Lindgren- VSWR on 10m Chamber	10m Semi-anechoic chamber-VSWR	4740 Discovery Drive	July 30, 2020	July 30, 2023
NCEE Labs-NSA on 10m Chamber	10m Semi-anechoic chamber-NSA	NCEE-001	May 24, 2022	May 24, 2025
TDK Emissions Lab Software	V11.25	700307	NA	NA
Com-Power LISN	LI-220C	20070017	September 22, 2020	September 22, 2022
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 4, 2022	April 4, 2024
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	September 24, 2021	September 24, 2023
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3864	September 24, 2021	September 24, 2023
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	September 24, 2021	September 24, 2023
N connector bulkhead (10m chamber)**	PE9128	NCEEBH1	September 24, 2021	September 24, 2023
N connector bulkhead (control room)**	PE9128	NCEEBH2	September 24, 2021	September 24, 2023

*Internal Characterization

**2 year calibration cycle

*** Extended Cal

Notes:

All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities. All equipment were in Cal during testing. However, latest calibration dates were provided.

3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMENTS

Measurement type presented in this report (Please see the checked box below):

Conducted ☐

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

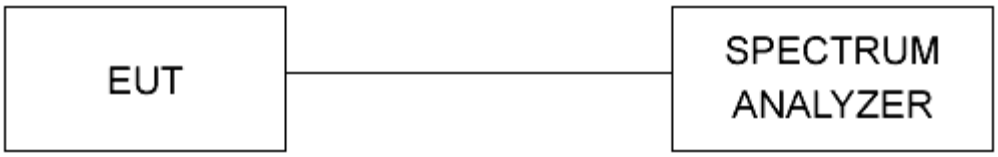


Figure 1 - Bandwidth Measurements Test Setup

Radiated ☒

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

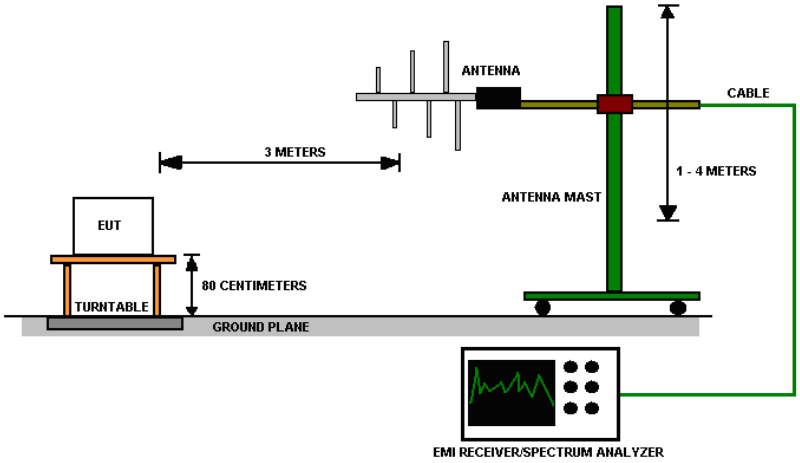


Figure 2 - Radiated Emissions Test Setup

4.0 DETAILED RESULTS

DSS Radiated Radio Measurements								
CHANNEL	**Transmitter**	**99% Occupied Bandwidth (kHz)**	**20 dB Bandwidth (kHz)**	**PEAK Radiated EIRP Power (dBm)**	**PEAK Radiated EIRP Power (mW)**	**RESULT**	No. of Hopping Channels	Time of Occupancy*
							25	**0.0877 S**
Low	Continuous*	250.88	253.6	22.109	162.517	PASS	Min Frequency Separation	Duty Cycle Correction (Emissions)
Mid	Continuous*	251.67	252.8	21.916	155.453	PASS		
High	Continuous*	249.99	253	20.638	115.824	PASS	795 kHz	-8.87 dB
Occupied Bandwidth = N/A; 20 dB Bandwidth Limit 250 kHz ≤ BW ≤ 500 kHz. See tables below for Antenna Factor and Cable Corrections *EUT was hopping in low mid and high channel as provided by the manufacturer				Peak Output Power Limit = 24 dBm; corrections can be found in the last table of this section and in the graphs in Appendix C. Time of Occupancy<0.4 S in 10 S *Manufacturer declares that the worst-case average channel occupancy time is 0.088s within any 10 second period.				

Unrestricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Relative Highest out of band level (dBm)**	**Relative Fundamental (dBm)**	**Delta (dB)**	**Min Delta (dB)**	**Result**
Low*	Continuous*	902.4	-60.725	-21.432	39.293	20	PASS
Low*	Hopping	902.4	-62.486	-21.438	41.048	20	PASS
High*	Continuous*	927.6	-61.736	-23.106	38.63	20	PASS
High*	Hopping	927.6	-61.993	-23.022	38.971	20	PASS
*EUT was hopping in low mid and high channel as provided by the manufacturer							

Peak Restricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)*** **	**Measurement Type**	**Limit (dBuV/m @ 3m)***	**Margin**	**Result**
Low**	Continuous	609.44	31.998	Radiated	46.02	14.022	PASS
Low**	Hopping	608.64	37.829	Radiated	46.02	8.191	PASS
High**	Continuous	966.08	39.162	Radiated	53.98	14.818	PASS
High**	Hopping	970.32	41.283	Radiated	53.98	12.697	PASS
**EUT was hopping in low mid and high channel as provided by the manufacturer ***detector used was peak and compared to Quasi-peak limit from FCC Part 15.209 to show compliance							

Channel	Radiated Power	Antenna Factor	Cable Loss	dBm to dBuV	EIRP conversion
902.3	-21.411	26.6	5.15	107	95.23
914.9	-21.524	26.5	5.17	107	95.23
927.6	-22.812	26.5	5.18	107	95.23

Declaration from manufacturer: The EchoStream protocol defines 64 channels spaced 400 kHz apart. Manufacturer uses only 25 channels from the set of 64. The minimum spacing between channels is ~ 800 kHz with some channels space ~1.2 MHz apart. The entire channel map uses a spacing of 400 kHz, but the used channels are either 800 kHz or 1.2 MHz apart.

4.1 DUTY CYCLE

Manufacturer declared that the maximum on time possible per channel is 26 ms in a given 100 ms period. So, Duty cycle correction factor for spurious emissions related to the transmitter is 20 log(26/100)= -11.70 dB.

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10-2013, Section 6.5, 6.6

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (µV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10-meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1GHz and 1.5m for measurements from 1GHz to 10 GHz.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise, the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

Test setup:

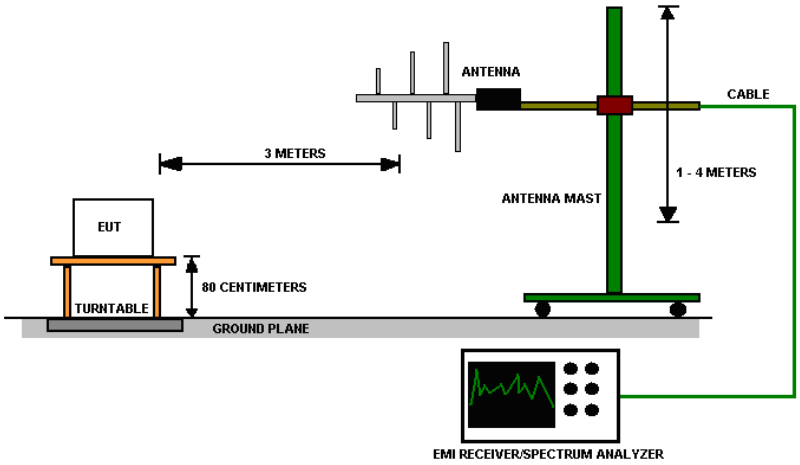


Figure 3 - Radiated Emissions Test Setup

EUT operating conditions
Details can be found in section 2.1 of this report.

Test results:

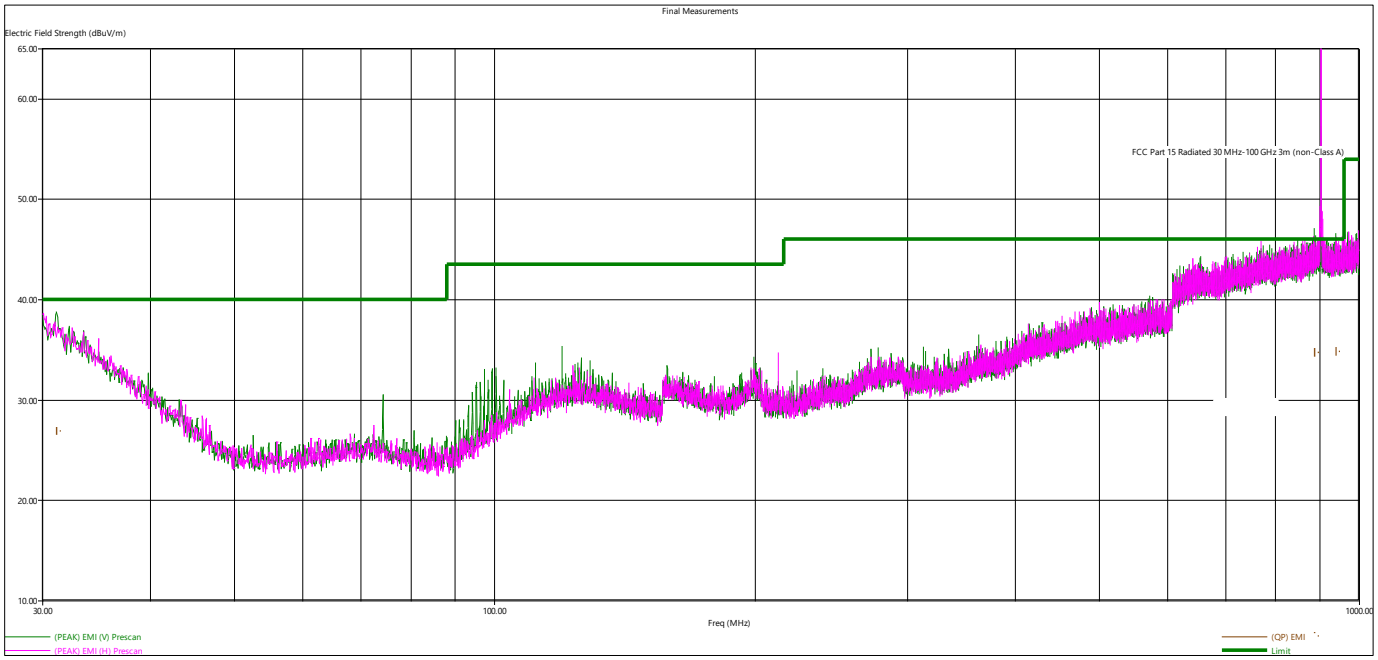


Figure 4 - Radiated Emissions Plot, Low Channel, 30 MHz-1GHz

*Noise floor on this plot looks higher than the other plots because of the receiver settings during the test to avoid saturation. The worst-case measurements are listed in the tables below, all other measurements were found to be at least 6 dB below the limit.

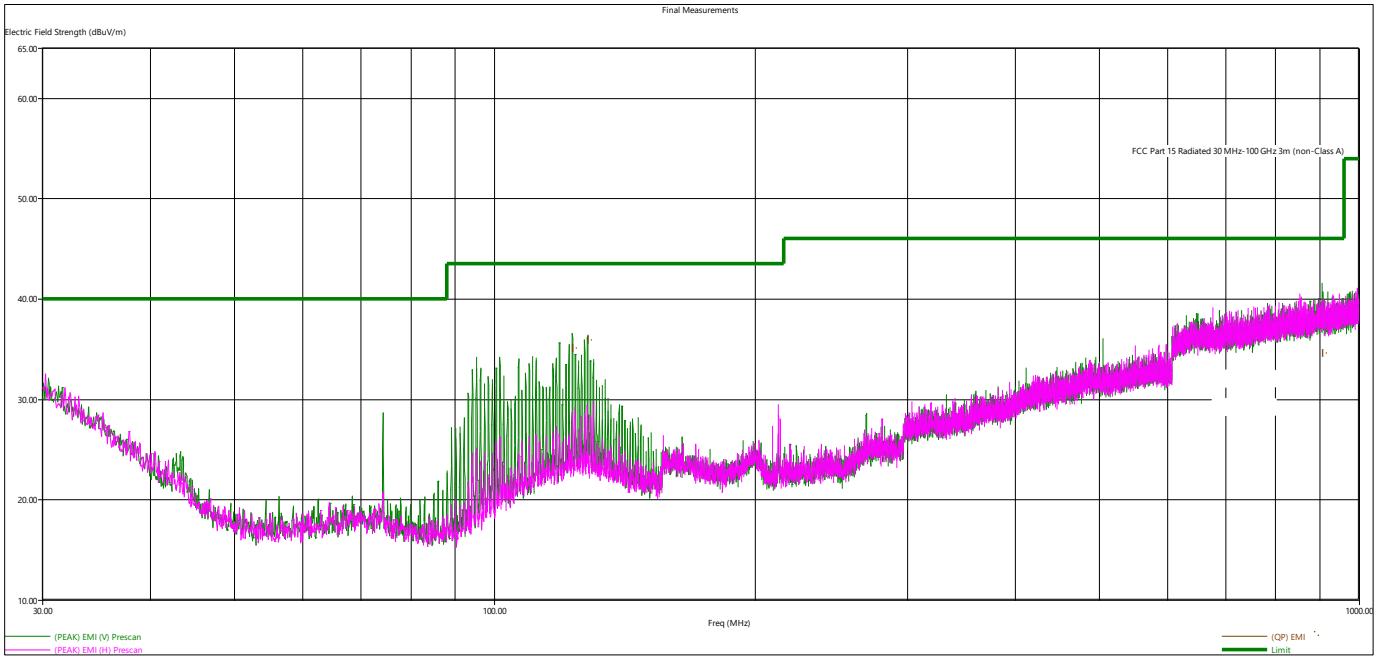


Figure 5 - Radiated Emissions Plot, Transmitter Off, 30 MHz-1GHz

The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions. The worst-case emissions are reported.

No other Quasi-peak measurements were attributable to the EUT in the 30MHz – 1GHz frequencies.

Quasi-Peak Measurements, 900 MHz Radio,								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Radio Band**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			**MHz**
31.222320	26.80	40.00	13.20	388.00	29.00	V	Low	900 -928
887.298960	34.64	46.02	11.38	171.00	59.00	V	Low	900 -928
938.168880	34.75	46.02	11.27	269.00	360.00	V	Low	900 -928
122.744400	35.10	43.52	8.42	106.00	240.00	V	Rx Mode	
128.057040	35.85	43.52	7.67	110.00	288.00	V	Rx Mode	
905.542320	34.60	46.02	11.42	195.00	269.00	V	Rx Mode	
All other measurements were found to be at least 6dB below the limit line.								

Peak Measurements, 900 MHz Radio,								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Radio Band**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			**MHz**
1805.684000	41.54	73.98	32.44	310.00	19.00	H	Low	900 -928
1829.442000	47.68	73.98	26.30	413.00	338.00	H	Mid	900 -928
1856.612000	35.23	73.98	38.75	193.00	0.00	H	High	900 -928
2707.420000	42.68	73.98	31.30	475.00	210.00	H	Low	900 -928
2745.490000	38.42	73.98	35.56	437.00	211.00	H	Mid	900 -928
1805.684000	41.54	73.98	32.44	310.00	19.00	H	High	900 -928
4512.890000	48.37	73.98	25.61	136.00	212.00	H	Low	900 -928
4572.890000	45.58	73.98	28.40	118.00	208.00	H	Mid	900 -928
4638.710000	54.91	73.98	19.07	108.00	196.00	H	High	900 -928
5415.900000	46.30	73.98	27.68	323.00	64.00	V	Low	900 -928
5566.390000	54.27	73.98	19.71	273.00	253.00	H	Mid	900 -928
5487.400000	47.39	73.98	26.59	509.00	125.00	V	High	900 -928
All other measurements were found to be at least 6dB below the limit line.								

Average Measurements, 900 MHz Radio,								
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**	**Channel**	**Radio Band**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**			**MHz**
1805.684000	29.84	53.98	24.14	310	19	H	Low	900 -928
1829.442000	35.98	53.98	18.00	413	338	H	Mid	900 -928
1856.612000	23.53	53.98	30.45	193	0	H	High	900 -928
2707.420000	30.98	53.98	23.00	475	210	H	Low	900 -928
2745.490000	26.72	53.98	27.26	437	211	H	Mid	900 -928
1805.684000	29.84	53.98	24.14	310	19	H	High	900 -928
4512.890000	36.67	53.98	17.31	136	212	H	Low	900 -928
4572.890000	33.88	53.98	20.10	118	208	H	Mid	900 -928
4638.710000	43.21	53.98	10.77	108	196	H	High	900 -928
5415.900000	34.60	53.98	19.38	323	64	V	Low	900 -928
5566.390000	42.57	53.98	11.41	273	253	H	Mid	900 -928
5487.400000	35.69	53.98	18.29	509	125	V	High	900 -928
Average Level is obtained by adding the duty cycle correction factor found in section 4.1 to the peak level. All the measurements were compared to general limits from FCC part 15.209 to show compliance. All other measurements were found to be at least 6dB below the limit line.								

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit Value – Emission Level.
5. The EUT was measured in all 3 orthogonal axes. See the test setup photo exhibit for details on the orientations.

4.3 PEAK OUTPUT POWER

Test Method: ANSI C63.10, Section(s) 7.8.5

Limits of bandwidth measurements:
Per FCC Part 15
For an FHSS system with 25 channels, the output power is required to be less than 250 mW or 24 dBm.

Test procedures:
Spectrum analyzer was set with a resolution bandwidth greater than occupied bandwidth and centered on the operating channel. Output power was measured by radiated method.

Deviations from test standard:
No deviation.

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:
1. All the output power plots can be found in the Appendix C.
2. All data is in the table in results section 4.0.
3. All the measurements were found to be compliant.

4.4 BANDWIDTH

Test Method: ANSI C63.10, Section(s) 6.9.2

Limits of bandwidth measurements:
The allowed 20 dB bandwidth of the hopping channel is 250 kHz ≤ BW ≤ 500 kHz.

Test procedures:
The bandwidth of the fundamental frequency was measured by spectrum analyzer with 3 kHz RBW and 30 kHz VBW.

The 20 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 20dB.
The 99% bandwidth is defined as the bandwidth that contains 99% of the power.

Deviations from test standard:
No deviation.

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.
Test results:

Pass

Comments:
1. All the bandwidth plots can be found in the Appendix C.
2. All data is in the table in results section 4.0.
3. All the measurements were found to be compliant.

4.5 BANDEDGES

Test Method: ANSI C63.10, Section(s) 6.10.6

Limits of band edge measurements:
For emissions outside of the allowed band of operation (902 – 928MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:
The resolution bandwidth was set to 100kHz and the EMI receiver was used to scan from the band edge to the fundamental frequency with a Peak detector. The highest emissions level beyond the band edge was measured and recorded. For restricted band edge measurements, the unit was tested to the same method as section 4.2 of this report.

Deviations from test standard:
No deviation.

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

Test results:

Pass

Comments:

1. All the band edge plots can be found in the Appendix C.
2. All data is in the table in results section 4.0.
3. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
4. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

4.6 CARRIER FREQUENCY SEPARATION, NUMBER OF HOPPING CHANNELS, TIME OF OCCUPANCY

Test Method: ANSI C63.10, Section 7.8.2, 7.8.3, 7.8.4

Limits for Time of Occupancy
Average time of occupancy on any frequency, not to exceed 0.4 seconds within a 10 second period.

Test procedures:
The method from KDB 558074 D01 v05;

Test setup:
Details can be found in section 3.4 of this report.

EUT operating conditions:
Details can be found in section 2.1 of this report.

.

Test results:

Pass

Comments:

1. All the plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are reported on the graph.
4. **Declaration from manufacturer:** The EchoStream protocol defines 64 channels spaced 400 kHz apart. Manufacturer uses only 25 channels from the set of 64. The minimum spacing between channels is ~ 800 kHz with some channels space ~1.2 MHz apart. The entire channel map uses a spacing of 400 kHz, but the used channels are either 800 kHz or 1.2 MHz apart.

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

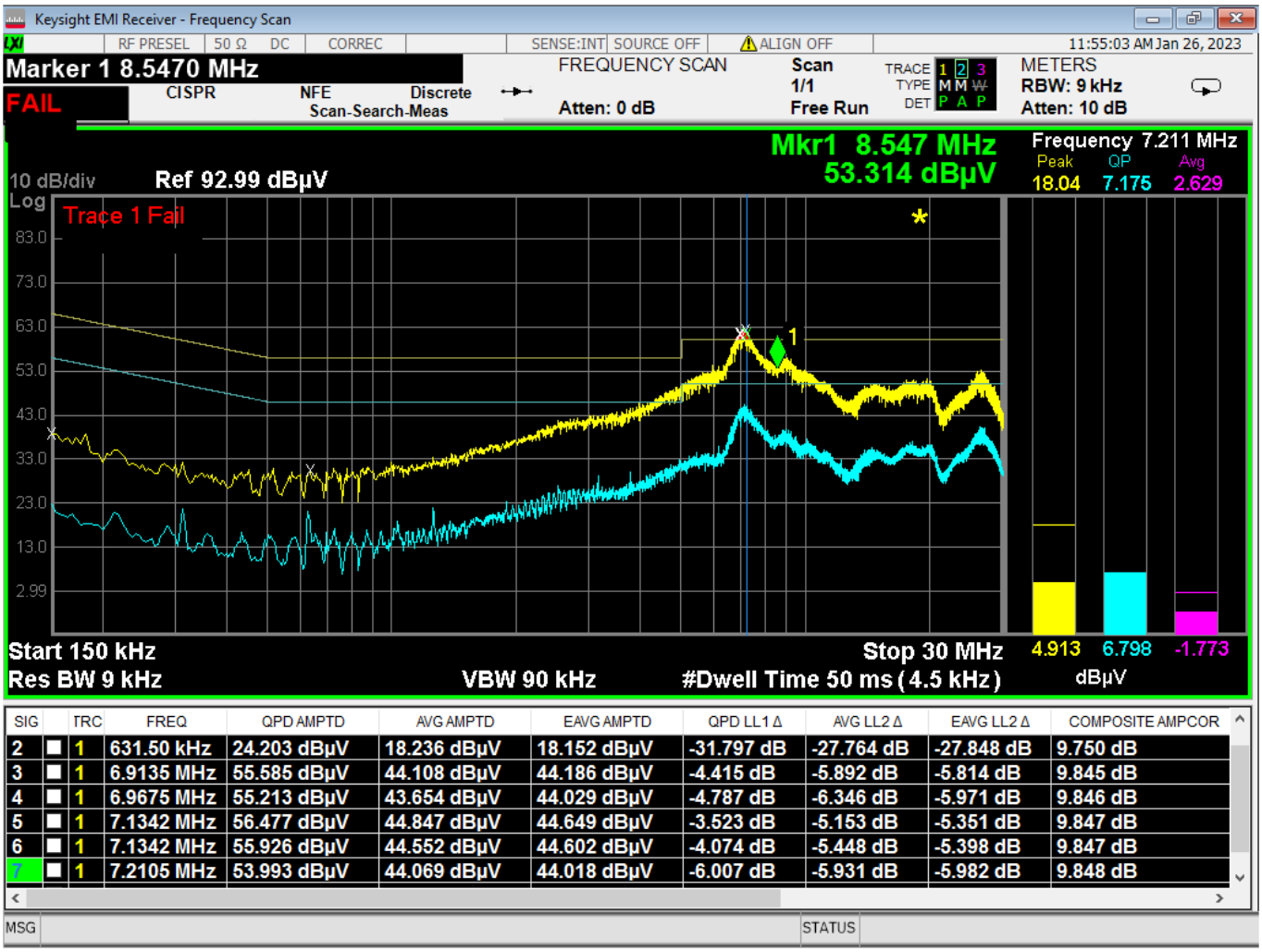
Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room. An iOmega Zip power supply, model SSW5-7630, was connected through a line impedance stabilization network (LISN) to the AC power mains. The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both the Line and Neutral of the AC power connected to the power supply through the LISN were checked for maximum conducted interference.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

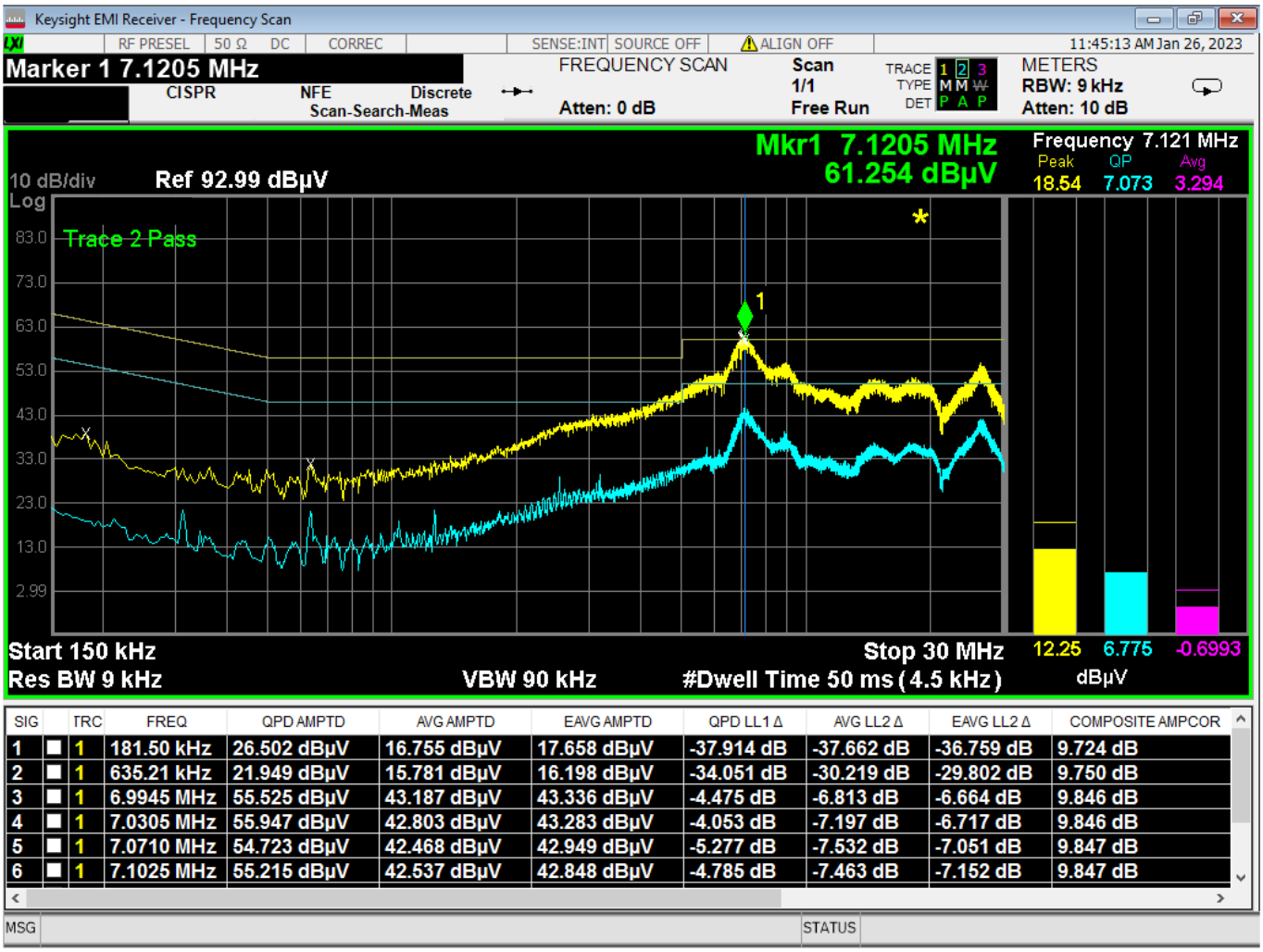
EUT operating conditions:
The battery was removed and power supply was connected with wires to the EUT battery terminals.

Test Results: PASS



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
2	1	631.50 kHz	24.203 dBµV	18.236 dBµV	18.152 dBµV	-31.797 dB	-27.764 dB	-27.848 dB	9.750 dB
3	1	6.9135 MHz	55.585 dBµV	44.108 dBµV	44.186 dBµV	-4.415 dB	-5.892 dB	-5.814 dB	9.845 dB
4	1	6.9675 MHz	55.213 dBµV	43.654 dBµV	44.029 dBµV	-4.787 dB	-6.346 dB	-5.971 dB	9.846 dB
5	1	7.1342 MHz	56.477 dBµV	44.847 dBµV	44.649 dBµV	-3.523 dB	-5.153 dB	-5.351 dB	9.847 dB
6	1	7.1342 MHz	55.926 dBµV	44.552 dBµV	44.602 dBµV	-4.074 dB	-5.448 dB	-5.398 dB	9.847 dB
7	1	7.2105 MHz	53.993 dBµV	44.069 dBµV	44.018 dBµV	-6.007 dB	-5.931 dB	-5.982 dB	9.848 dB

Figure 6 - Conducted Emissions Plot, Line



SIG	TRC	FREQ	QPD AMPTD	AVG AMPTD	EAVG AMPTD	QPD LL1 Δ	AVG LL2 Δ	EAVG LL2 Δ	COMPOSITE AMPCOR
1	1	181.50 kHz	26.502 dBµV	16.755 dBµV	17.658 dBµV	-37.914 dB	-37.662 dB	-36.759 dB	9.724 dB
2	1	635.21 kHz	21.949 dBµV	15.781 dBµV	16.198 dBµV	-34.051 dB	-30.219 dB	-29.802 dB	9.750 dB
3	1	6.9945 MHz	55.525 dBµV	43.187 dBµV	43.336 dBµV	-4.475 dB	-6.813 dB	-6.664 dB	9.846 dB
4	1	7.0305 MHz	55.947 dBµV	42.803 dBµV	43.283 dBµV	-4.053 dB	-7.197 dB	-6.717 dB	9.846 dB
5	1	7.0710 MHz	54.723 dBµV	42.468 dBµV	42.949 dBµV	-5.277 dB	-7.532 dB	-7.051 dB	9.847 dB
6	1	7.1025 MHz	55.215 dBµV	42.537 dBµV	42.848 dBµV	-4.785 dB	-7.463 dB	-7.152 dB	9.847 dB

Figure 7 - Conducted Emissions Plot, Neutral

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30
Power (watts) = 10^[Power (dBm)/10] / 1000
Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)
Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6
Gain = 1 (numeric gain for isotropic radiator)
Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

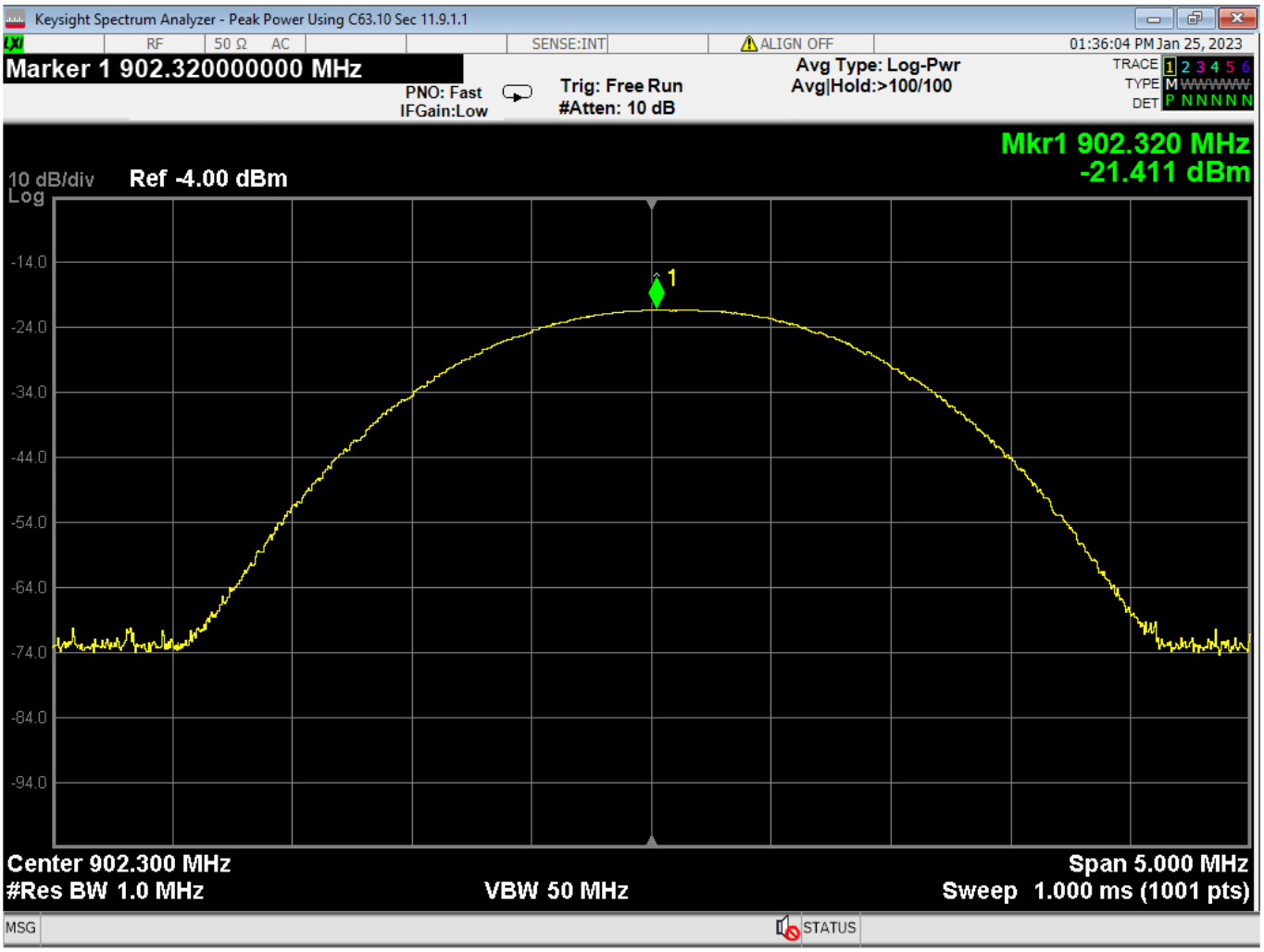
APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±4.31
Radiated Emissions, 3m	1GHz - 18GHz	±5.08
Emissions limits, conducted	30MHz – 18GHz	±3.03 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

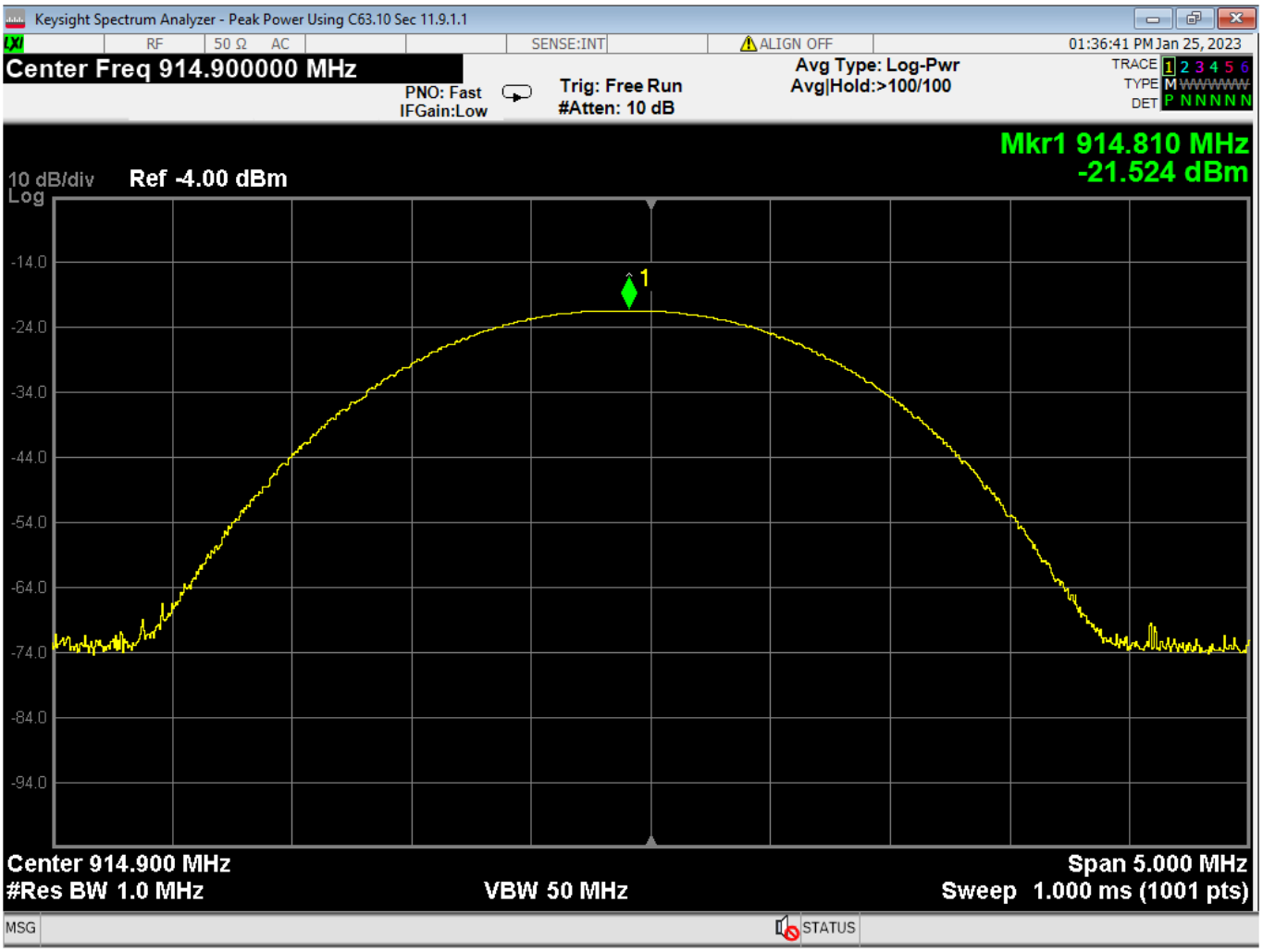
APPENDIX C – GRAPHS AND TABLES



01 Uncorrected Field Strength, Low Channel

Peak radiated EIRP Power = Uncorrected Field Strength + Antenna Factor +Cable Loss+107-95.23 (see Section 4 for antenna factor and cable loss)

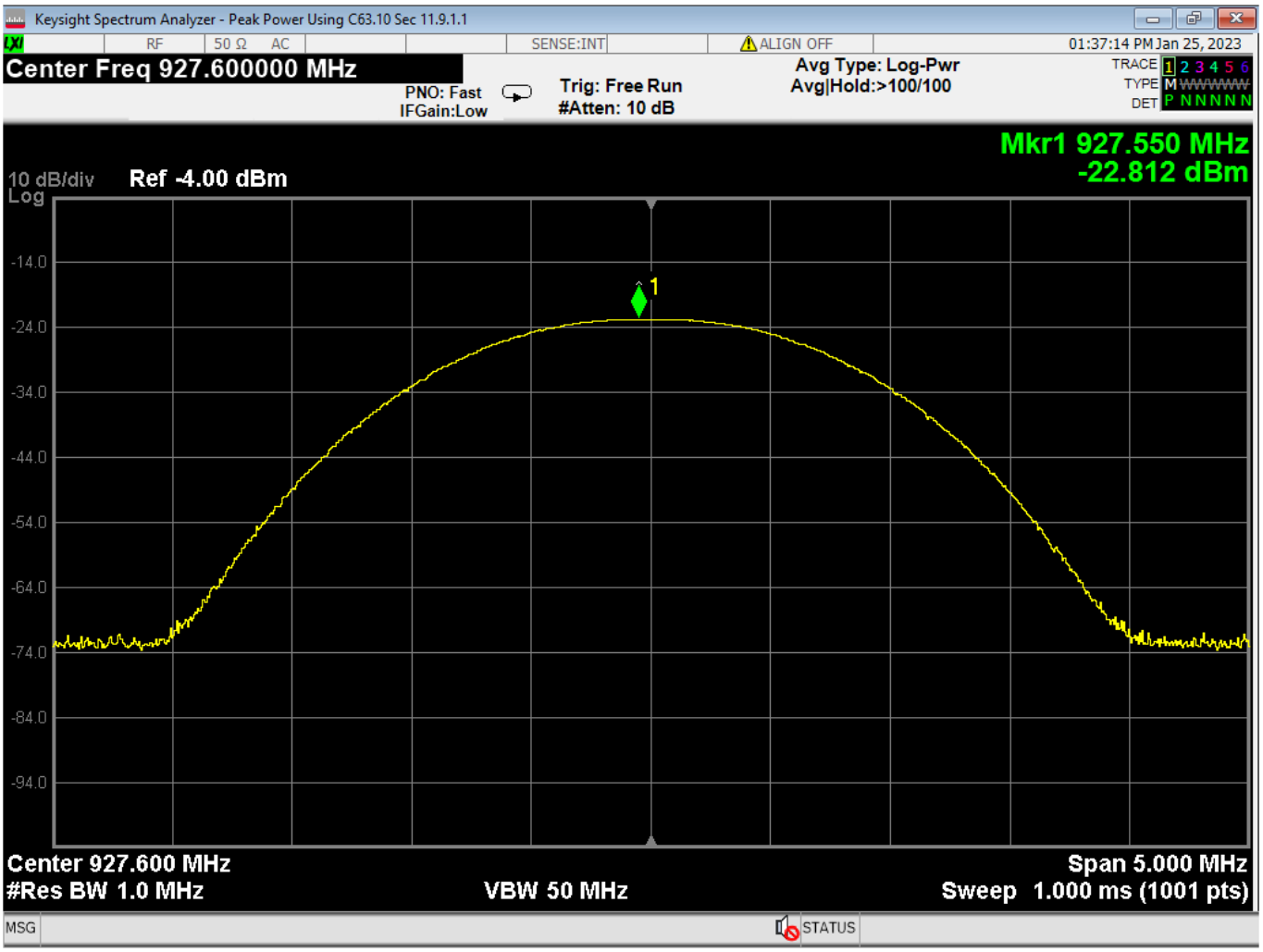
Channel,	Uncorrected Field Strength	Antenna Factor	Cable Loss	dBm to dBuV	EIRP conversion	PEAK Radiated EIRP Power (dBm)
902.3	-21.411	26.6	5.15	107	95.23	22.109



02. Uncorrected Field Strength, Mid Channel

Peak radiated EIRP Power = Uncorrected Field Strength + Antenna Factor +Cable Loss+107-95.23 (see Section 4 for antenna factor and cable loss)

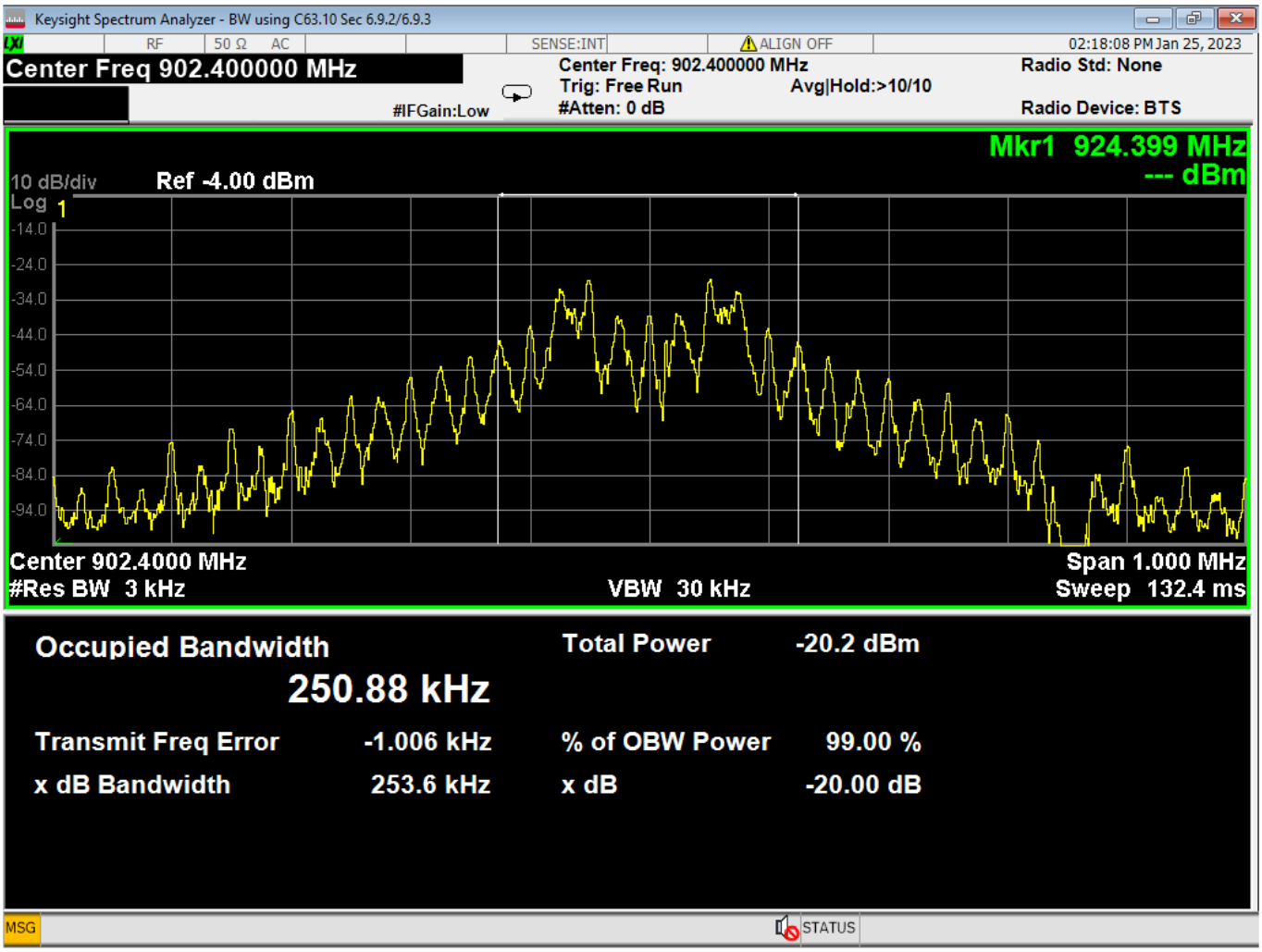
Channel,	Uncorrected Field Strength	Antenna Factor	Cable Loss	dBm to dBuV	EIRP conversion	PEAK Radiated EIRP Power (dBm)
914.9	-21.524	26.5	5.17	107	95.23	21.916



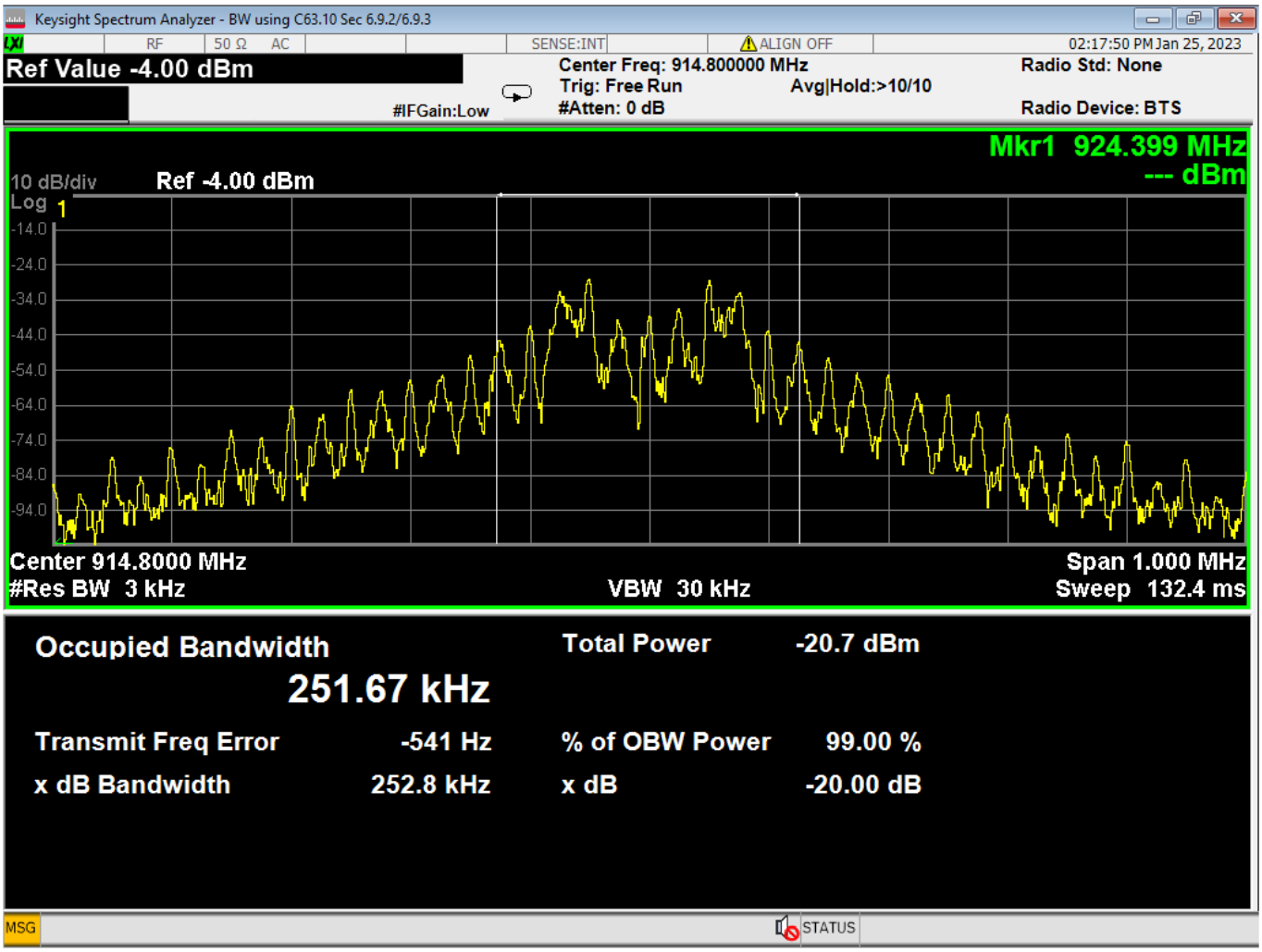
03 Uncorrected Field Strength, High Channel

Peak radiated EIRP Power = Uncorrected Field Strength + Antenna Factor +Cable Loss+107-95.23 (see Section 4 for antenna factor and cable loss)

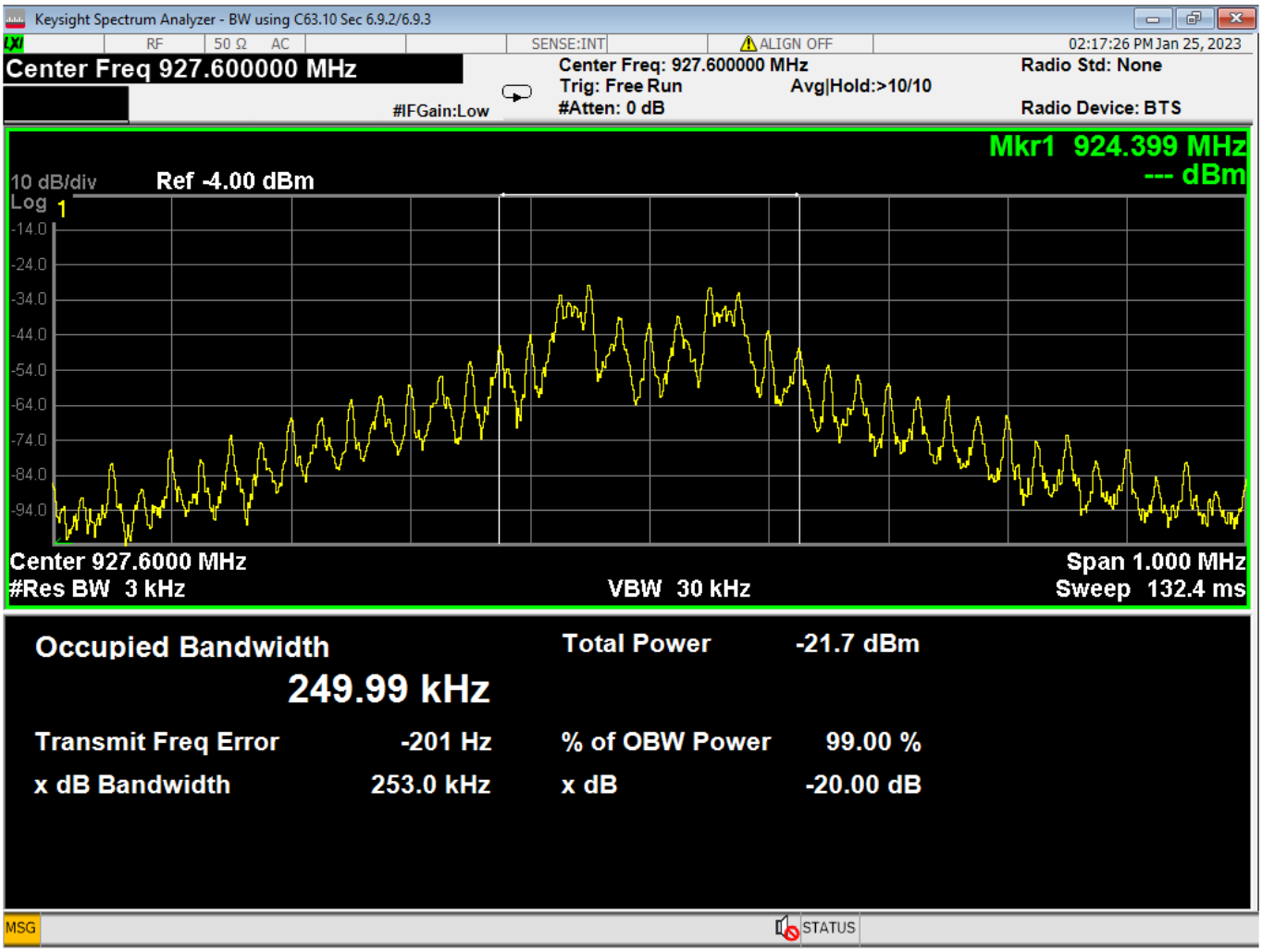
Channel,	Uncorrected Field Strength	Antenna Factor	Cable Loss	dBm to dBuV	EIRP conversion	PEAK Radiated EIRP Power (dBm)
927.6	-22.812	26.5	5.18	107	95.23	20.638



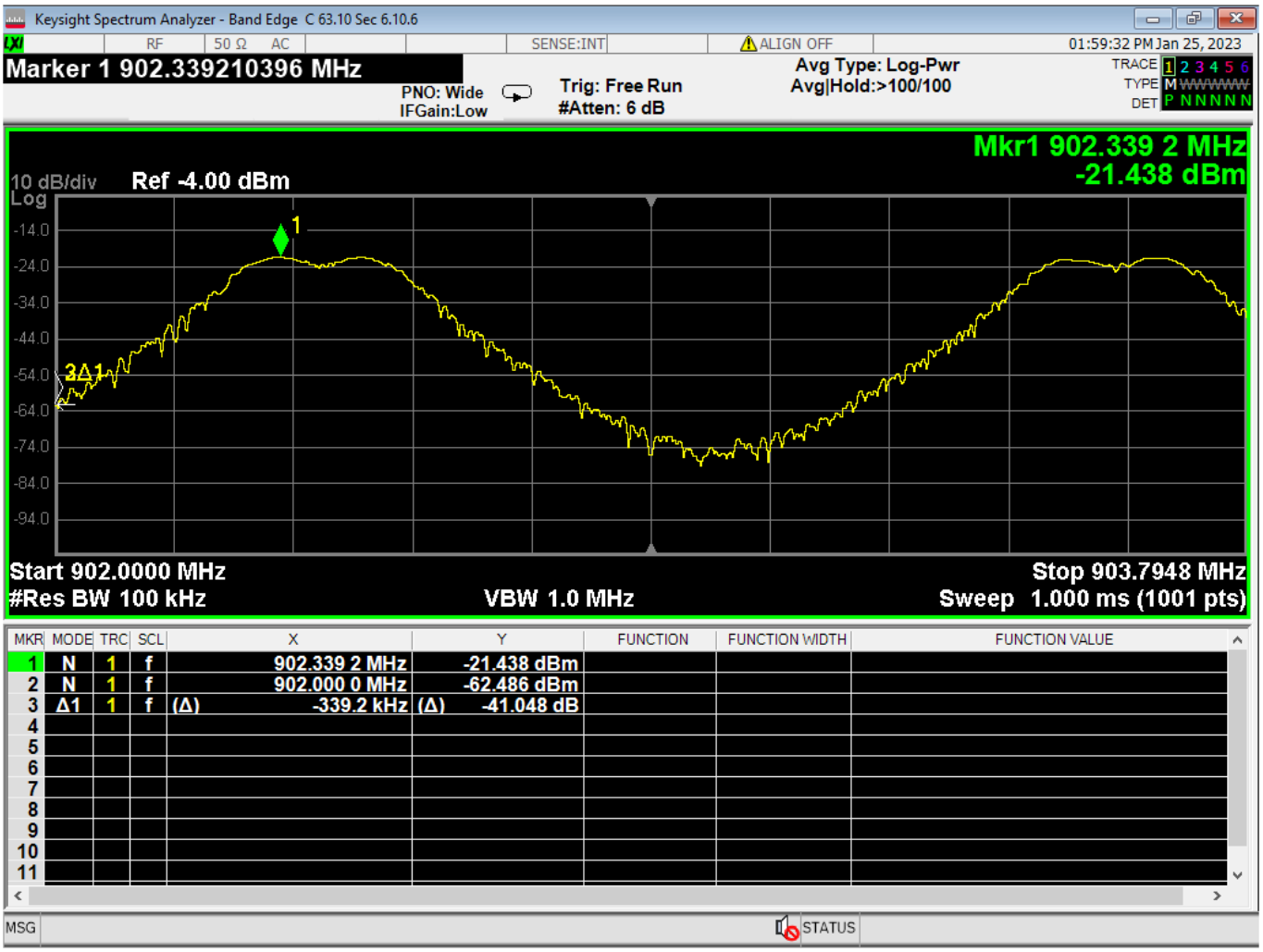
04 Bandwidth Low Channel



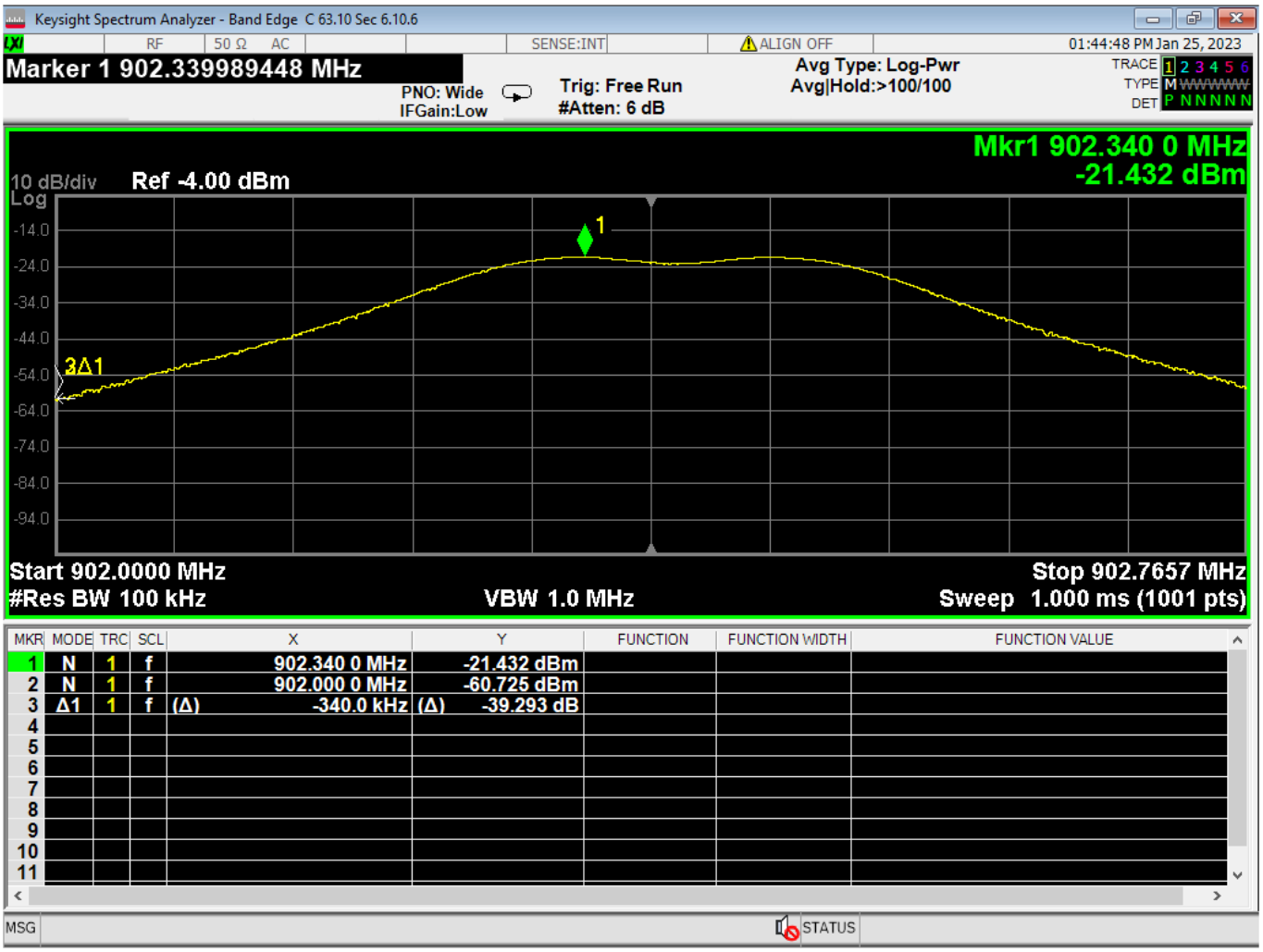
05. Bandwidth Mid Channel



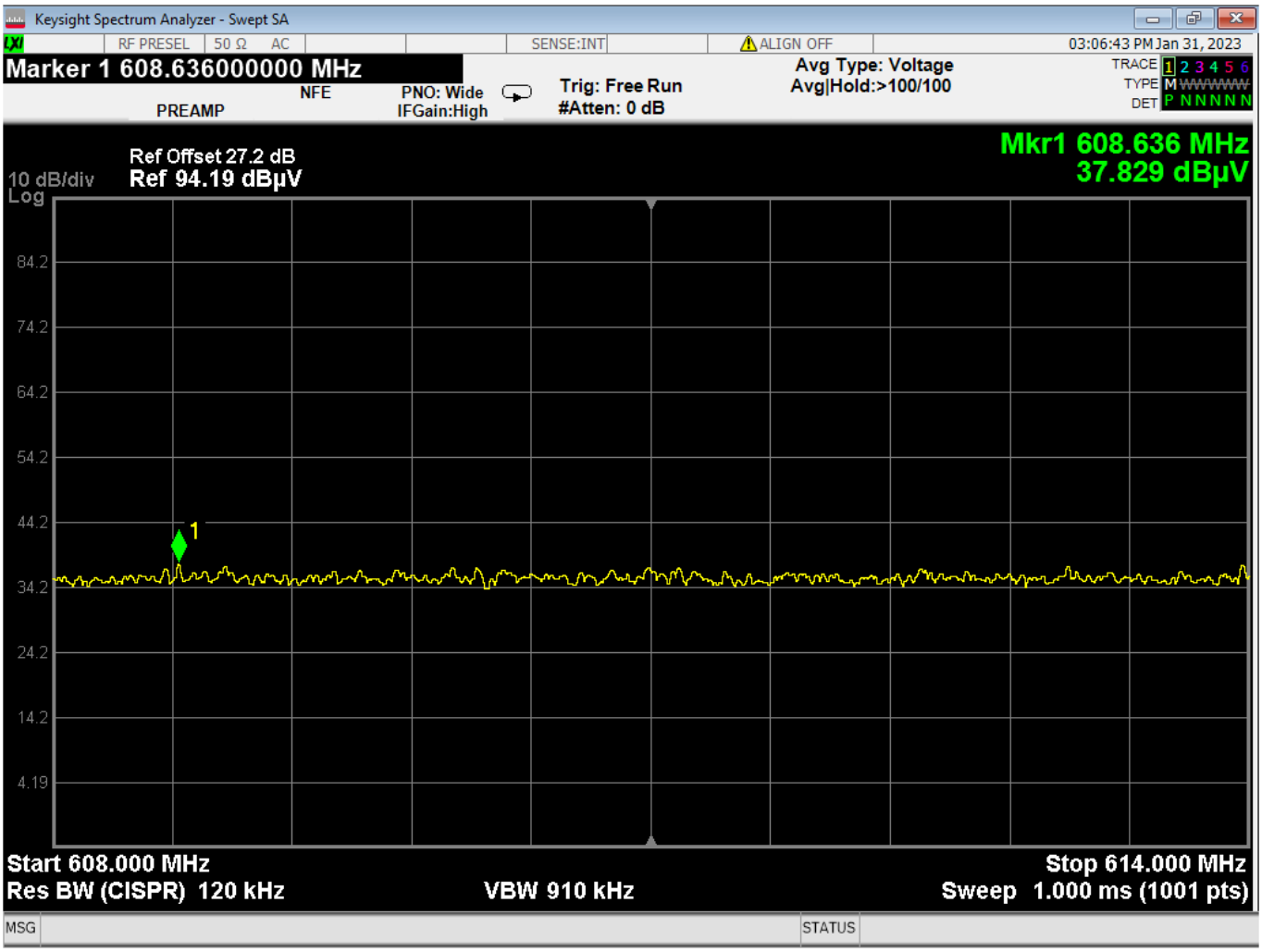
06 Bandwidth High Channel



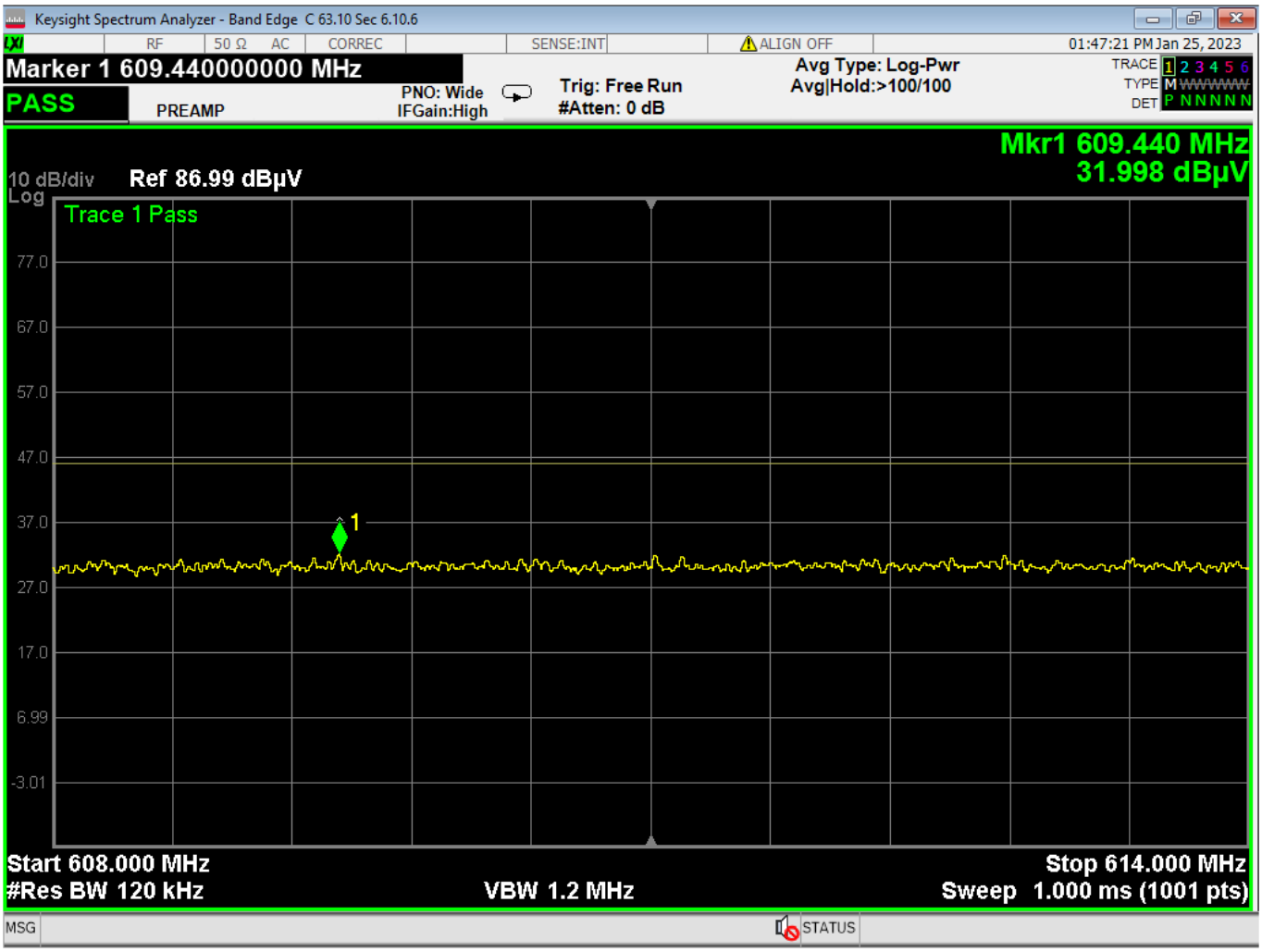
07 Bandedge Unrestricted Low Channel Hopping



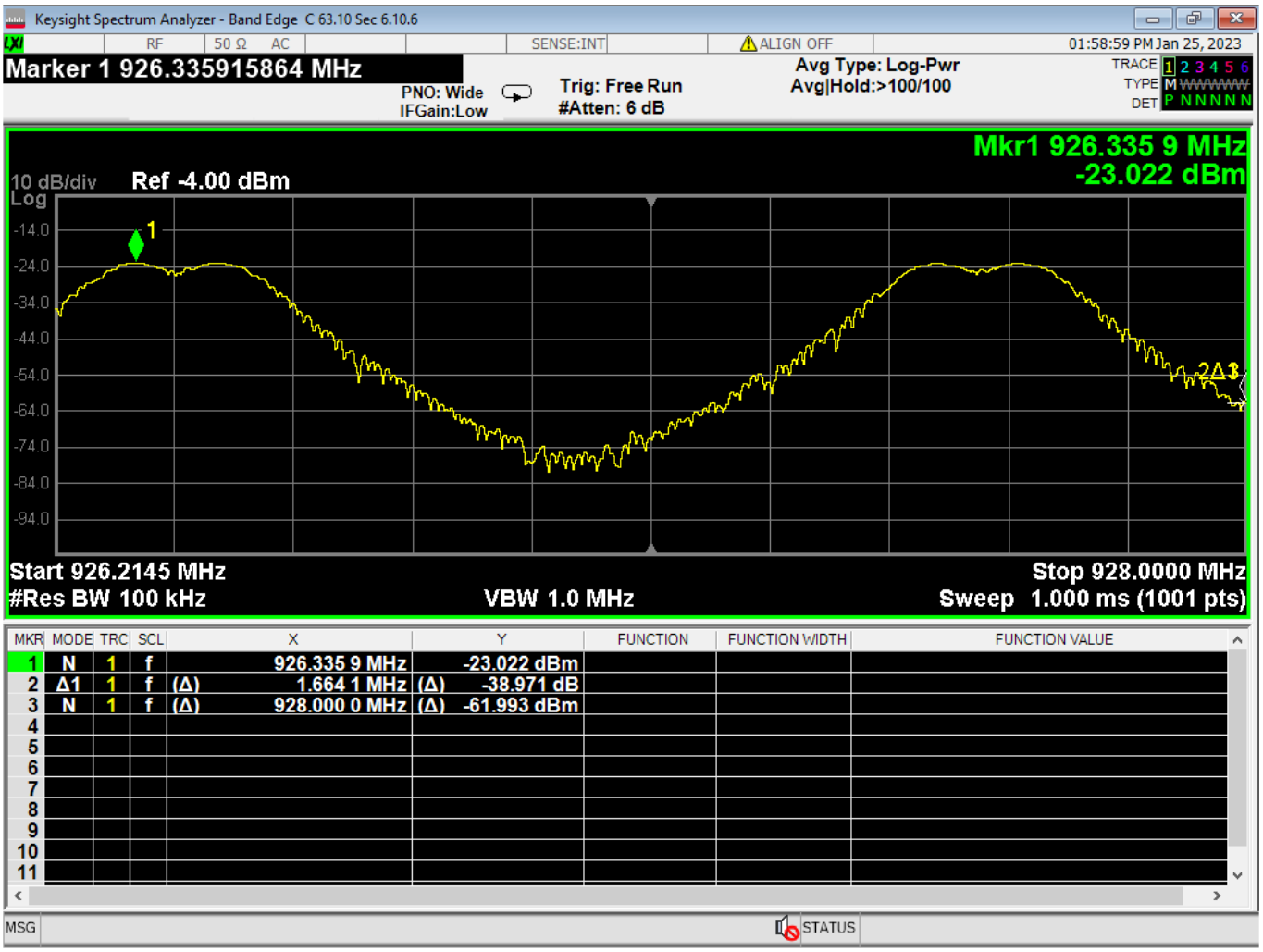
07 Bandedge Unrestricted Low Channel Relative



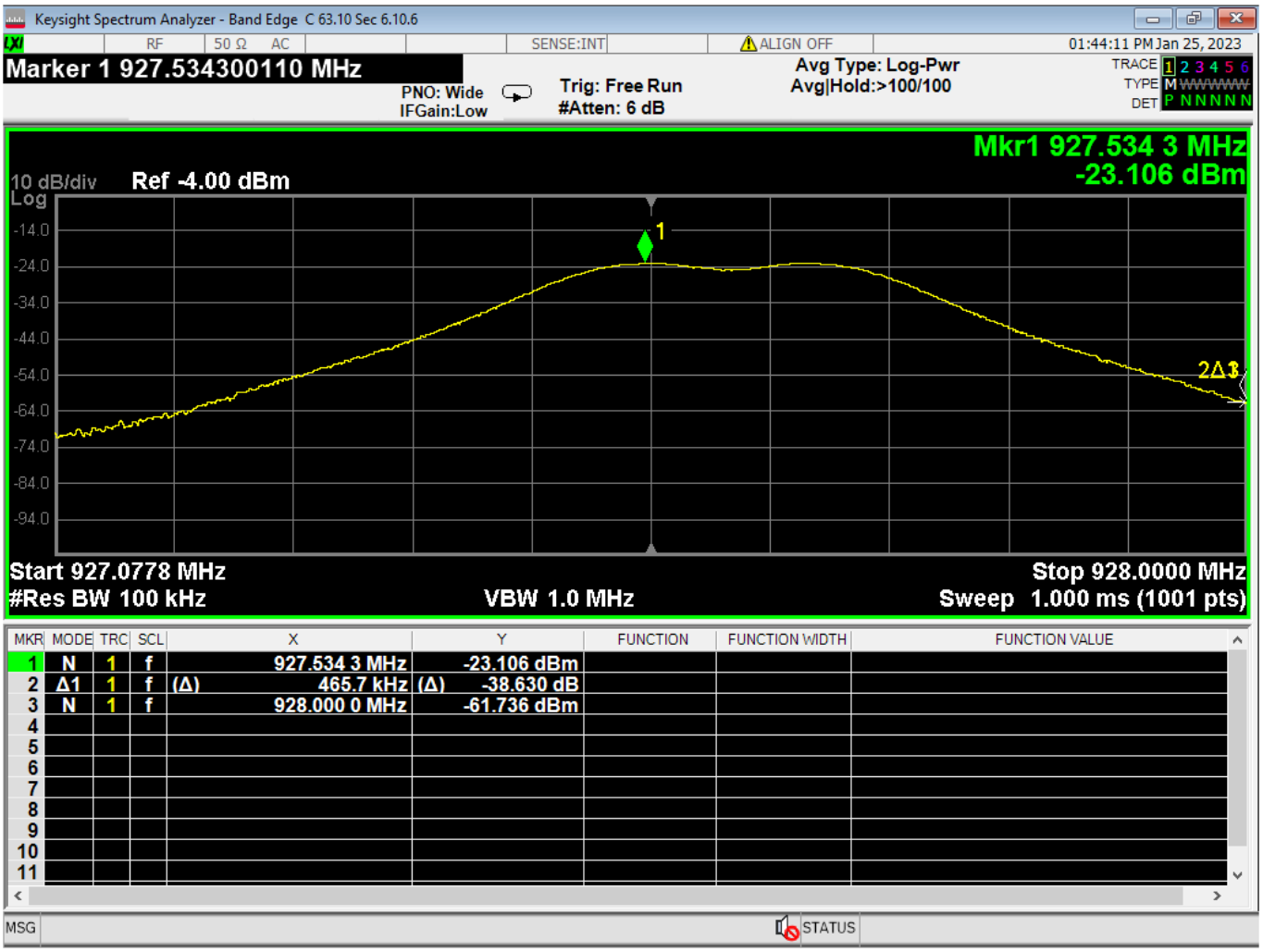
08 Bandedge Restricted Low Channel Hopping



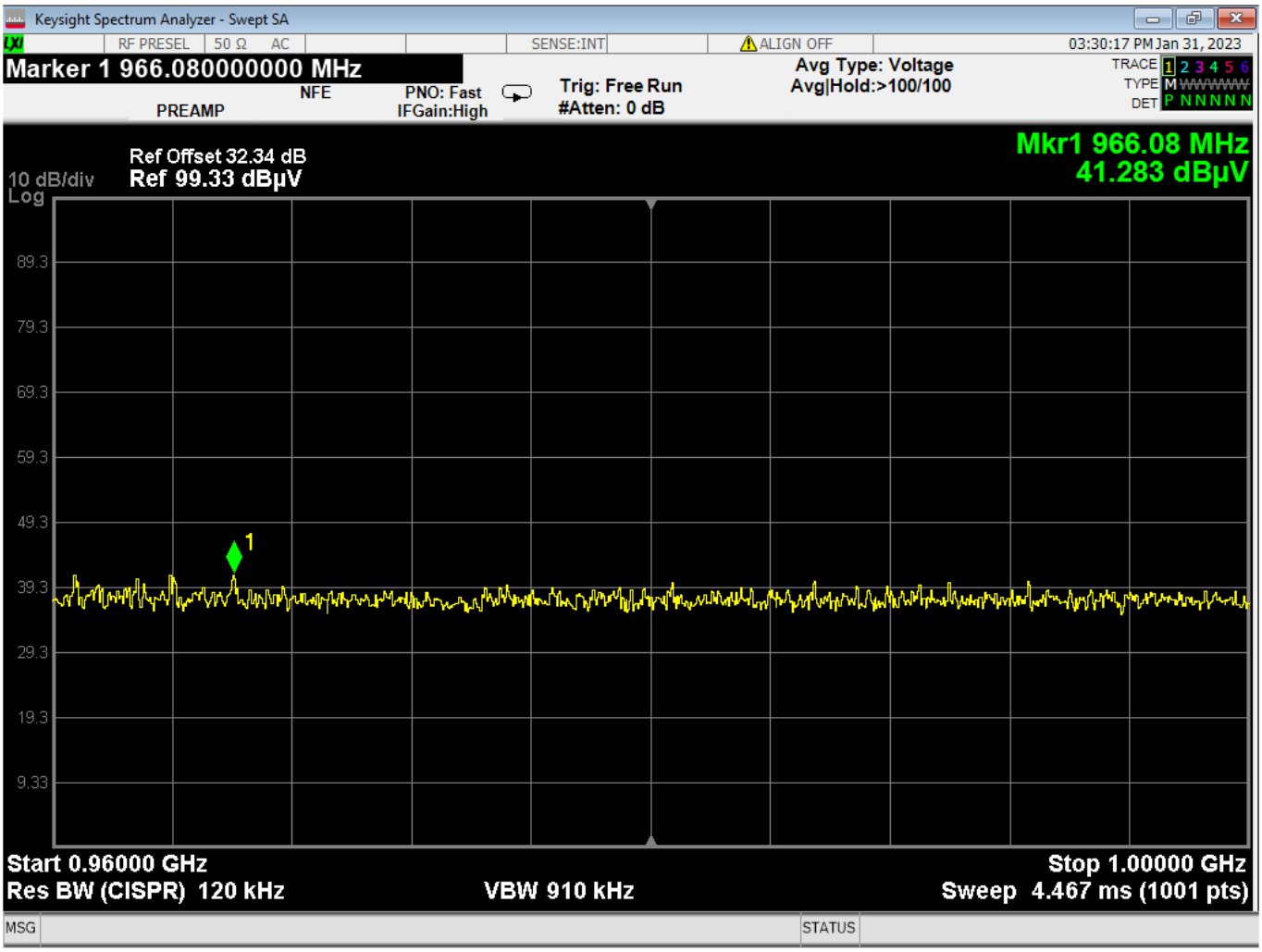
08 Bandedge Restricted Low Channel



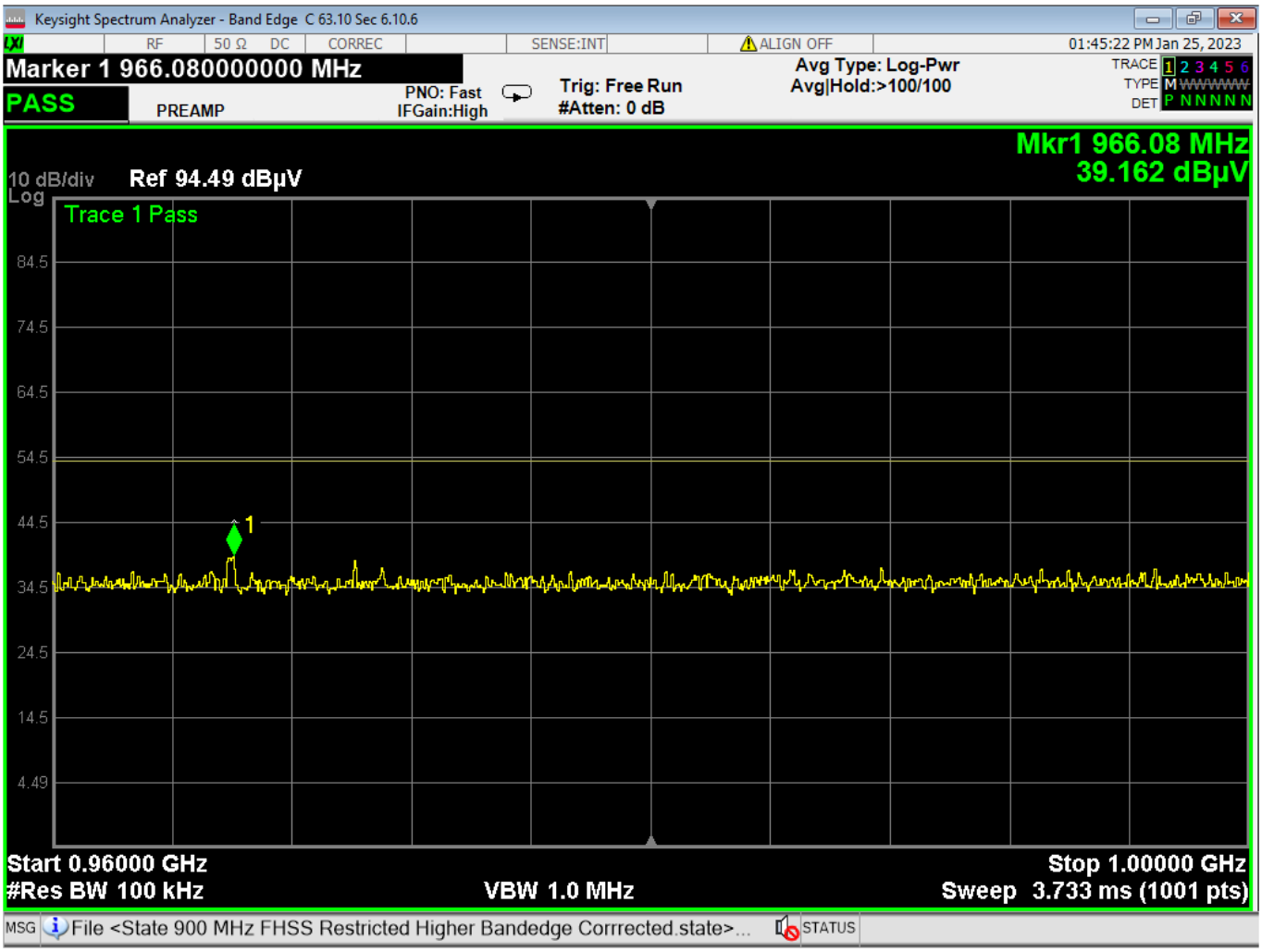
09 Bandedge Unrestricted High Channel Hopping



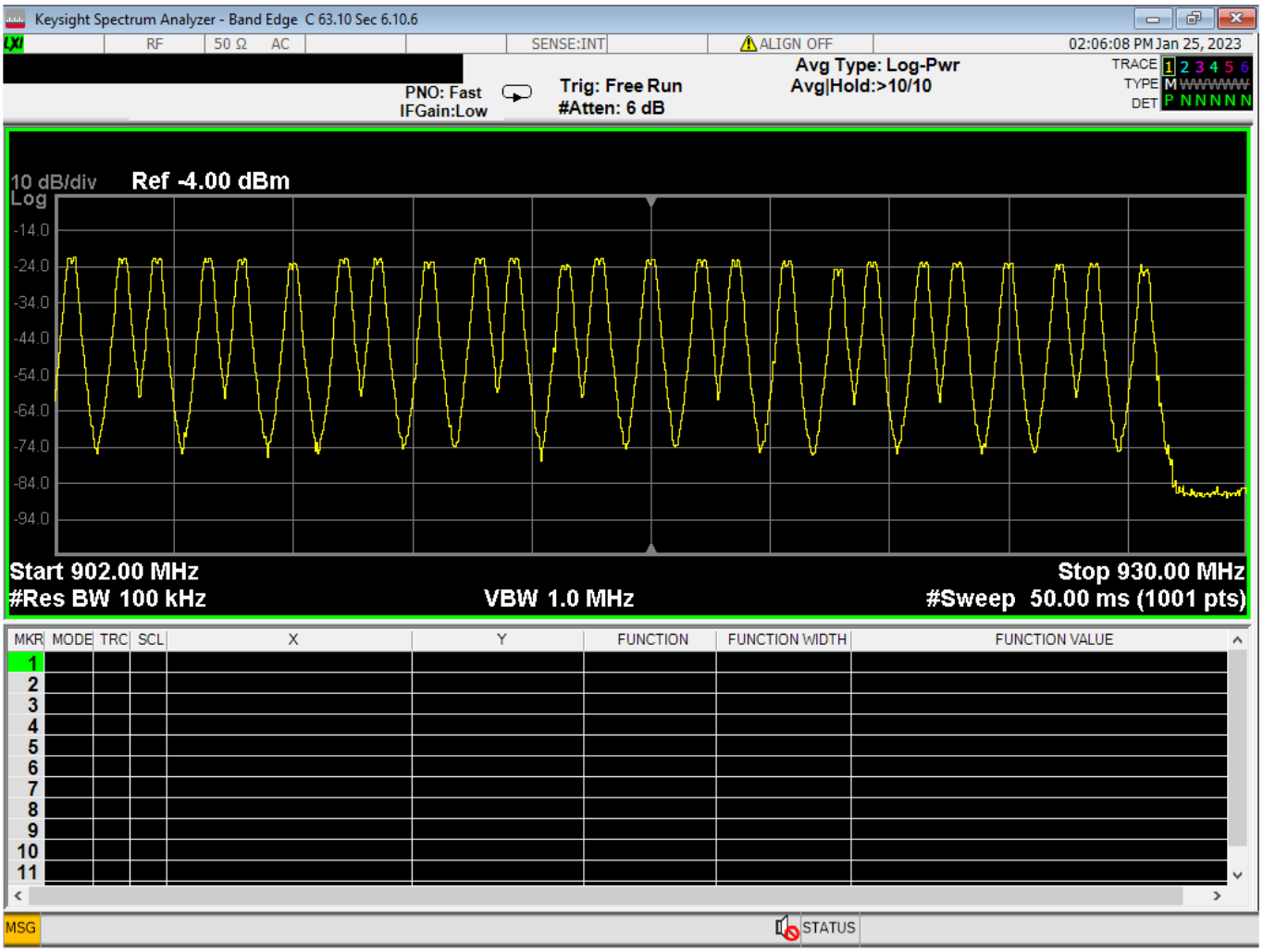
09 Bandedge Unrestricted High Channel



10 Bandedge Restricted High Channel Hopping

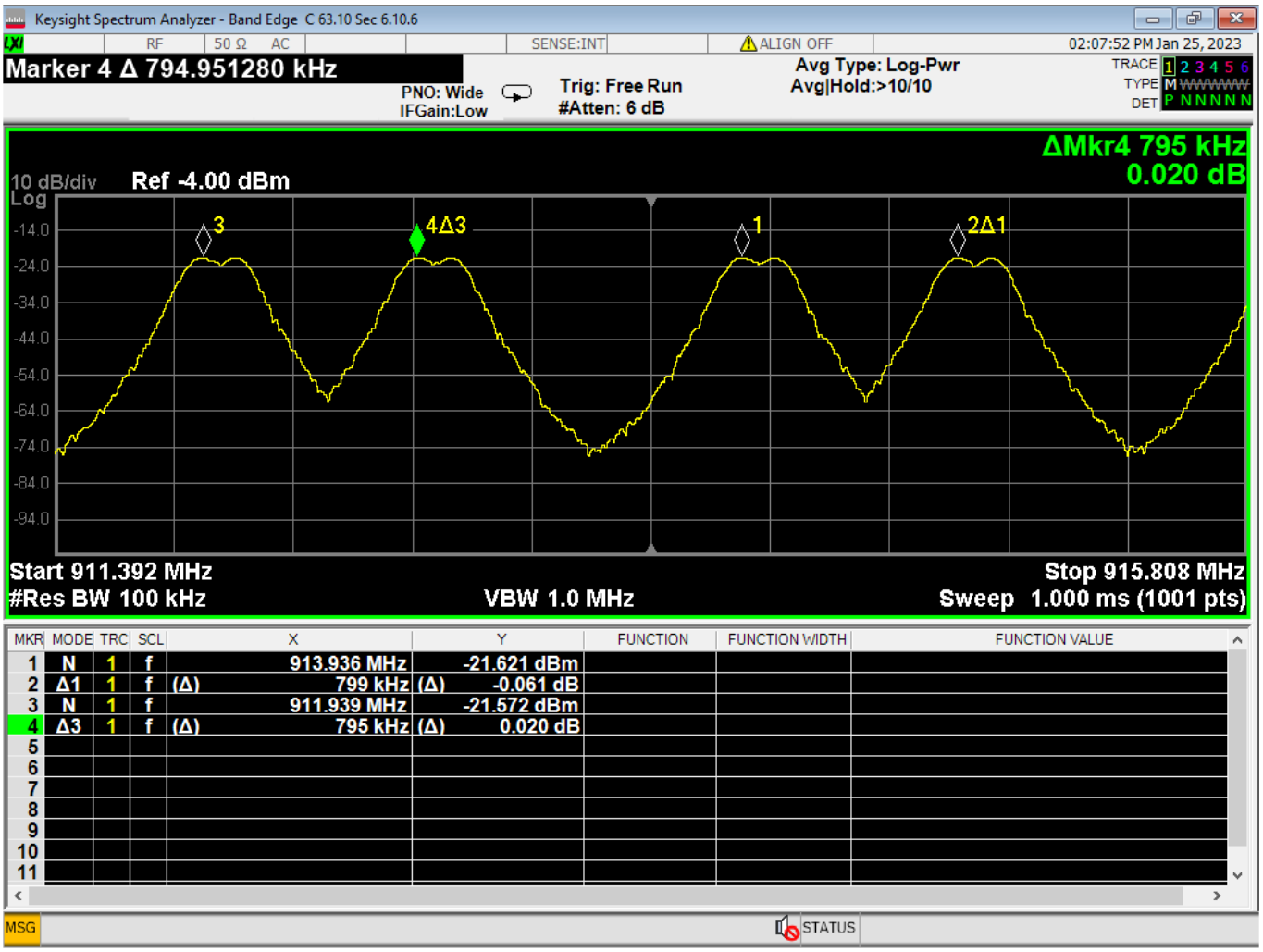


10 Bandedge Restricted High Channel, continuous.



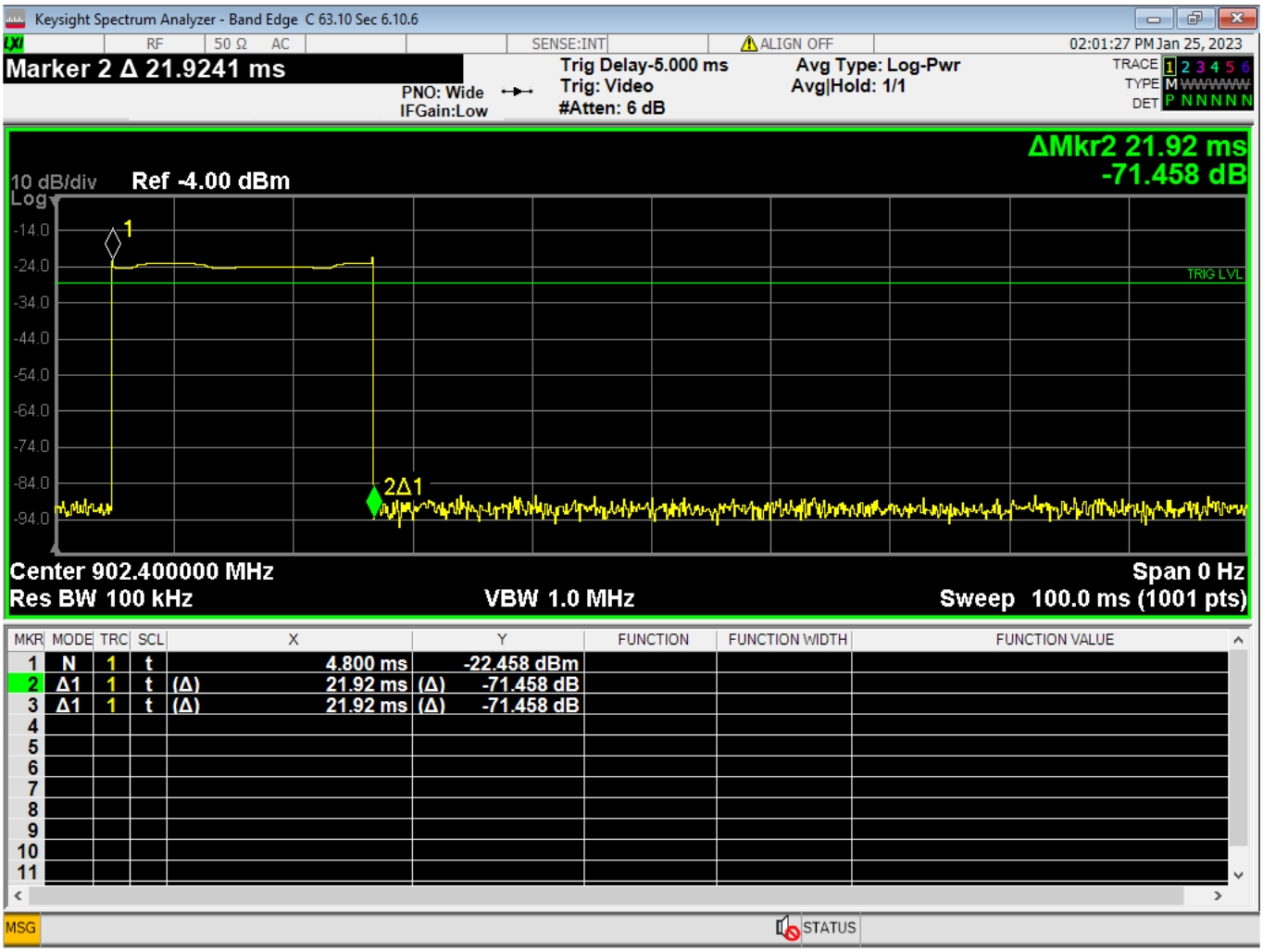
11 Hop Count, 25 Hops

Declaration from manufacturer: The EchoStream protocol defines 64 channels spaced 400 kHz apart. Manufacturer uses only 25 channels from the set of 64. The minimum spacing between channels is ~ 800 kHz with some channels space ~1.2 MHz apart. The entire channel map uses a spacing of 400 kHz, but the used channels are either 800 kHz or 1.2 MHz apart.



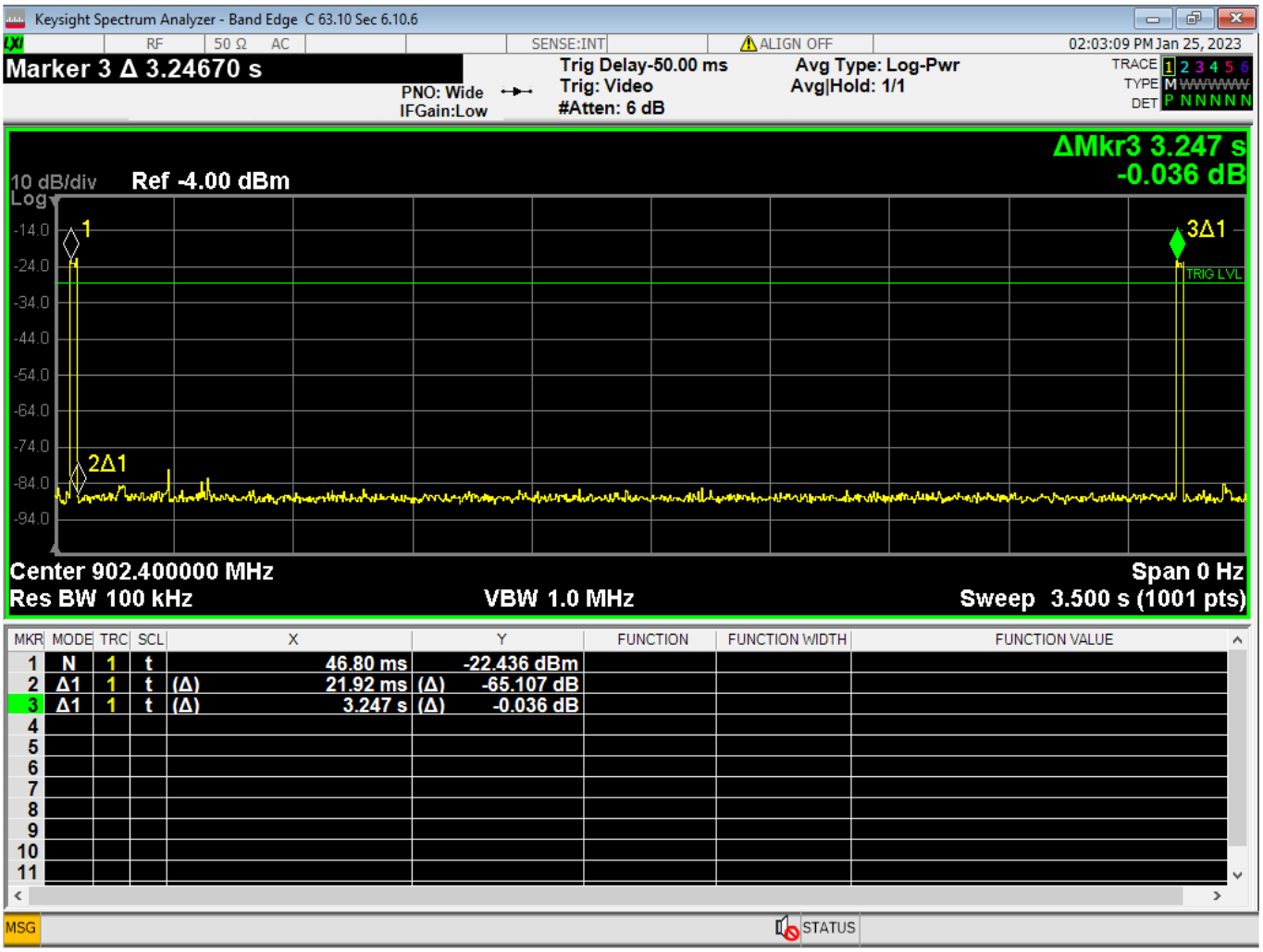
12 Minimum Frequency Separation

Declaration from manufacturer: The EchoStream protocol defines 64 channels spaced 400 kHz apart. Manufacturer uses only 25 channels from the set of 64. The minimum spacing between channels is ~ 800 kHz with some channels space ~1.2 MHz apart. The entire channel map uses a spacing of 400 kHz, but the used channels are either 800 kHz or 1.2 MHz apart.



13 Channel Occupancy, On time*

***Measured in hopping mode provided by the manufacturer.**



14 Channel Occupancy/ Period, Maximum of 4 Hops possible*
***Measured in hopping mode provided by the manufacturer.**

21.92 ms x4= ms=0.0877 s

REPORT END