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: **Independent Technologies**

Address: **26 1st Ave SE**
New London, MN 56273

Product: **Enertrac 5922 LoRa Tank Monitor**

Test Report No: **R20200625-20-E1B**

Approved by:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **9 November 2020**

Total Pages: **29**

ilac-MRA A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	30 July 2020	Original – NJohnson Prepared by FLane
A	20 October 2020	Updated band edge tables, added note to Page 4, added additional items to equipment list, deleted note 4 from pg13, updated frequencies in Section 2.2.
B	11 November 2020	

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The intention of this report is to determine if the class II permissive change is possible on the EUT (Enertrac 5922 LoRa Tank Monitor with FCCID: RWB-0005922). The worst-case measurements were reported in this report. Summary of test results presented in this report correspond to the following section

FCC Part 15.247

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

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	NA, Battery Powered Device

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Summary and Operating Condition:

EUT	Enertrac 5922 LoRa Tank Monitor
EUT Received	7 July 2020
EUT Tested	7 July 2020- 8 July 2020
Serial No.	0005922-2002632C (conducted antenna port measurements); 0005922-200296C1, 0005922-200295B4 (radiated measurements);
Operating Band	903.0 – 914.2 MHz (DTS) 902.3 – 914.9 MHz (DSS)
Device Type	LoRa Radio and DTS/FHSS Radio
Power Supply / Voltage	3.6V Battery

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

2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

DTS:

Channel	Frequency
Low	903.0 MHz
High	914.2 MHz

DSS

Channel	Frequency
Low	902.3 MHz
High	914.9 MHz

It operates in either DTS or DSS modes.

These are the only 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.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY AND GENERAL TEST 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
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Nic Johnson	Technical Manager	Review/editing
2	Fox Lane	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	N9038A	MY59050109	April 23, 2019	April 23, 2021
SunAR RF Motion	JB1	A091418	March 6, 2020	March 6, 2021
EMCO Horn Antenna	3115	6415	March 16, 2020	March 16, 2022
Rohde & Schwarz Preamplifier*	TS-PR18	3545700803	April 14, 2020	April 14, 2022
Trilithic High Pass Filter*	6HC330	23042	April 14, 2020	April 14, 2022
MiniCircuits High Pass Filter*	VHF-1320+	15542	April 14, 2020	April 14, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	April 14, 2020	April 14, 2022
RF Cable (antenna to 10m chamber bulkhead)*	FSCM 64639	01E3872	April 14, 2020	April 14, 2022
RF Cable (10m chamber bulkhead to control room bulkhead)*	FSCM 64639	01E3874	April 14, 2020	April 14, 2022
RF Cable (control room bulkhead to test receiver)*	FSCM 64639	01F1206	April 14, 2020	April 14, 2022
N connector bulkhead (10m chamber)*	PE9128	NCEEBH1	April 14, 2020	April 14, 2022
N connector bulkhead (control room)*	PE9128	NCEEBH2	April 14, 2020	April 14, 2022
TDK Emissions Lab Software	V11.25	700307	NA	NA

Notes:
All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

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.

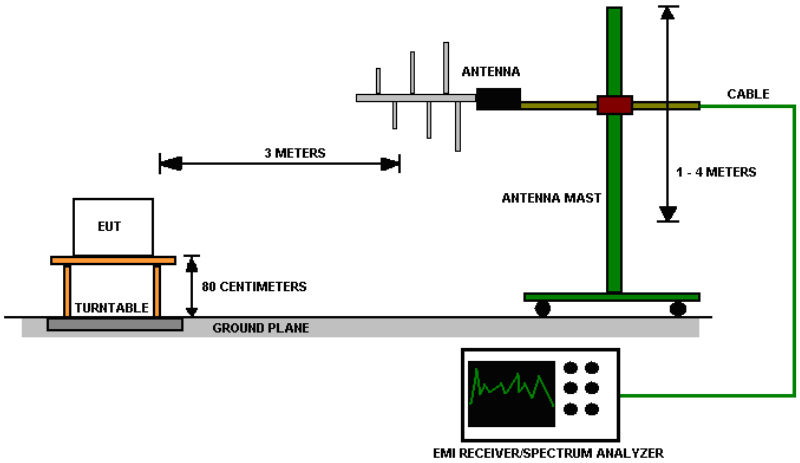


Figure 2 - Radiated Emissions Test Setup

4.0 RESULTS

Important Note: The output power was not intentionally increased from the original. Any deviations of the measured output power values from the values in the original grant of certification are within the laboratory measurement uncertainty as documented in Appendix C of the test report.

DTS Radio Measurements				
CHANNEL	**Transmitter**	**PEAK OUTPUT POWER (dBm)**	**PEAK OUTPUT POWER (mW)**	**RESULT**
Low	LoRa/DTS	16.480	44.463	PASS
High	LoRa/DTS	17.121	51.535	PASS
Low	LoRa/FHSS	18.094	64.476	PASS
High	LoRa/FHSS	18.179	65.751	PASS
Occupied Bandwidth = N/A; 6 dB Bandwidth Limit = N/A			Peak Output Power Limit = 30 dBm; PSD Limit = N/A	

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	LoRa/DTS	900.00	-31.98	16.51	48.49	20.00	PASS
High	LoRa/DTS	928.00	-30.85	17.27	48.13	20.00	PASS

Peak Restricted Band-Edge							
CHANNEL	**Mode**	**Band edge /Measurement Frequency (MHz)**	**Highest out of band level (dBuV/m @ 3m)**	**Detector**	**Limit (dBuV/m @ 3m)**	**Margin**	**Result**
Low	LoRa/DTS	900.00	37.89	Peak	73.98	36.09	PASS
High	LoRa/DTS	928.00	41.78	Peak	73.98	32.20	PASS
*Limit shown is the peak limit taken from FCC Part 15.209							

Class II Permissive change Results: All the measurements were found to be within 2 dB of the values found in the original grant, so class II permissive change is allowed.

4.1 OUTPUT POWER

Test Method: All the radio measurements were performed using the sections from ANSI C63.10, section 11.9.1.1.

Limits of power measurements:
For FCC Part 15.247 Device:
The maximum allowed peak output power is 30 dBm.

Test procedures:
Details can be found in section 3.4 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 Peak Output Power plots can be found in the Appendix C and tables can be found in the Results section.
2. All the measurements were found to be compliant.

4.2 BANDWIDTH

Test Method: All the radio measurements were performed using the sections from ANSI C63.10 Section 11.8.1.

Limits of bandwidth measurements:

For FCC Part 15.247 Device:
The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

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

Deviations from test standard:
No deviation.

Test setup:
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 and tables can be found in the Results section.
2. All the measurements were found to be compliant.

4.3 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.

Figure 3 - Radiated Emissions Set up, Worst Case Orientation

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 from 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

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. See Figure 3 for worst-case orientation.

Test setup:

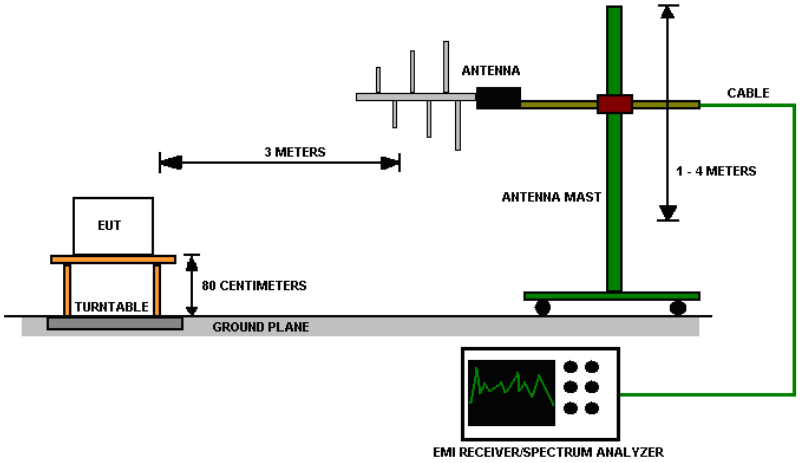


Figure 4 - Radiated Emissions Test Setup

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.

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

Test results:

Radiated Emissions Peak Data Table, Rx Mode					
Freq	(PEAK) EMI (H)	(PEAK) EMI (V)	Limit	(PEAK) Margin (V)	(PEAK) Margin (H)
(MHz)	(dBuV/m)	(dBuV/m)	(dBuV/m)	(dB)	(dB)
30.240000	30.12	32.29	40.00	7.71	9.88
192.720000	22.97	26.19	43.52	17.33	20.55
693.840000	39.01	36.00	46.02	10.02	7.01
955.940000	38.95	41.10	46.02	4.92	7.07

*Peak data is compared to Quasi-Peak Limit, FCC 15.109

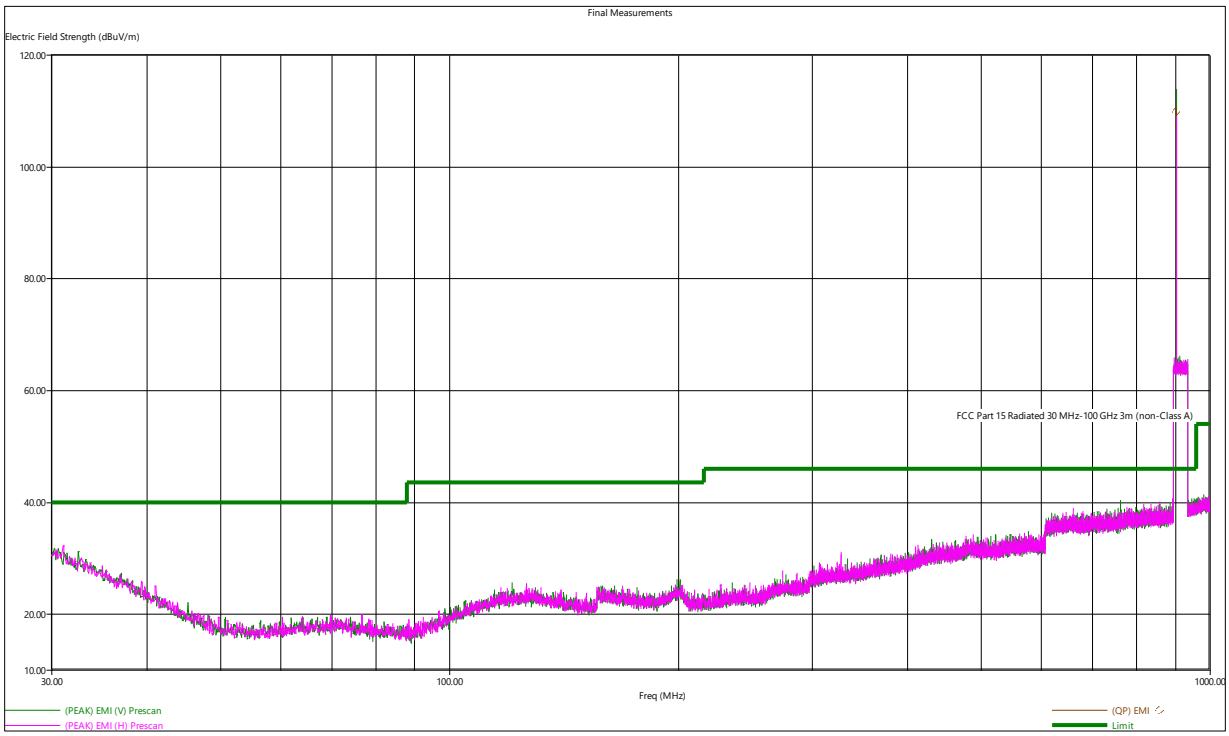


Figure 5 - Radiated Emissions Plot, Low Channel, DTS

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 = Emission level – Limit value

Quasi-Peak Data, DTS						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
903.183040	109.82	NA	NA	123.00	21.00	V

Peak Measurements, DTS						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
2709.57	53.81	73.98	20.17	106	197	H
1805.91*	69.67	89.82	20.15	195	73	V

*unrestricted band

QP was used for fundamental. If peak were used, the limit would either remain the same or increase in relation with the peak measurements in the unrestricted band. Therefore, if the attenuation from the QP fundamental to the peak spurious value is at least 20 dB, it would show compliance.

Average Measurements, DTS						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
2709.57	45.4	53.98	8.58	106	197	H
1805.91*	67.27	89.82	22.55	195	73	V

*unrestricted band

Peak Measurements, FHSS						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
1806.51*	60.08	73.98	29.74	211	293	H
2708.94	49.49	73.98	24.49	225	112	H
3610.86	42.01	73.98	31.97	166	343	H
7231.63	47.14	73.98	42.68	273	277	V
9037.96	49.33	73.98	24.65	156	115	V
9940.53*	50.07	73.98	39.75	107	240	V

*unrestricted band

Limit = fundamental value – 20 dB.
Fundamental value = 109.82 dBuV/m, QP.

Average Measurements, FHSS						
Frequency	**Level**	**Limit**	**Margin**	**Height**	**Angle**	**Pol**
MHz	**dBµV/m**	**dBµV/m**	**dB**	**cm.**	**deg.**	
1806.51	35.82	53.98	18.16	211	293	H
2708.94	45.25	53.98	8.73	225	112	H
3610.86	37.58	53.98	16.4	166	343	H
7231.63	33.89	53.98	20.09	273	277	V
9037.96	36.10	53.98	17.88	156	115	V
9940.53	36.84	53.98	17.14	107	240	V

4.4 BAND EDGES

Test Method: All the radio measurements were performed using the sections from ANSI C63.10 Section 6.10.5 and C63.10 Section 11.13.2.

Limits of band-edge measurements:
For FCC Part 15.247 Device:
For emissions outside of the allowed band of operation (900MHz - 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 highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

Deviations from test standard:
No deviation.

Test setup:
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 and tables can be found in the Results section.
2. 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.
3. 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.

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

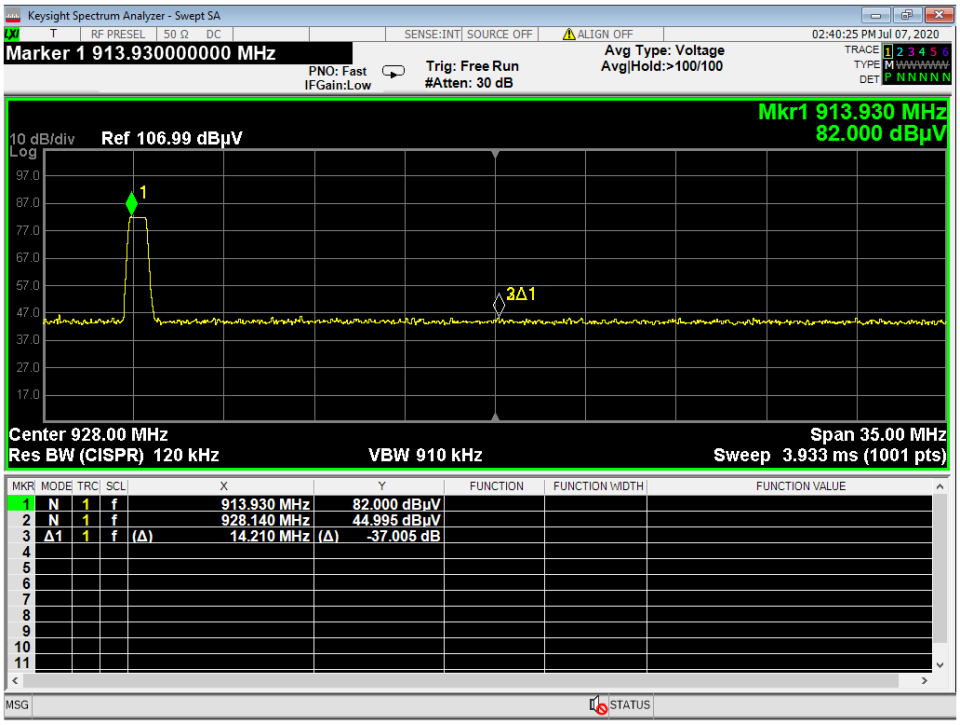
APPENDIX B – MEASUREMENT UNCERTAINTY

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

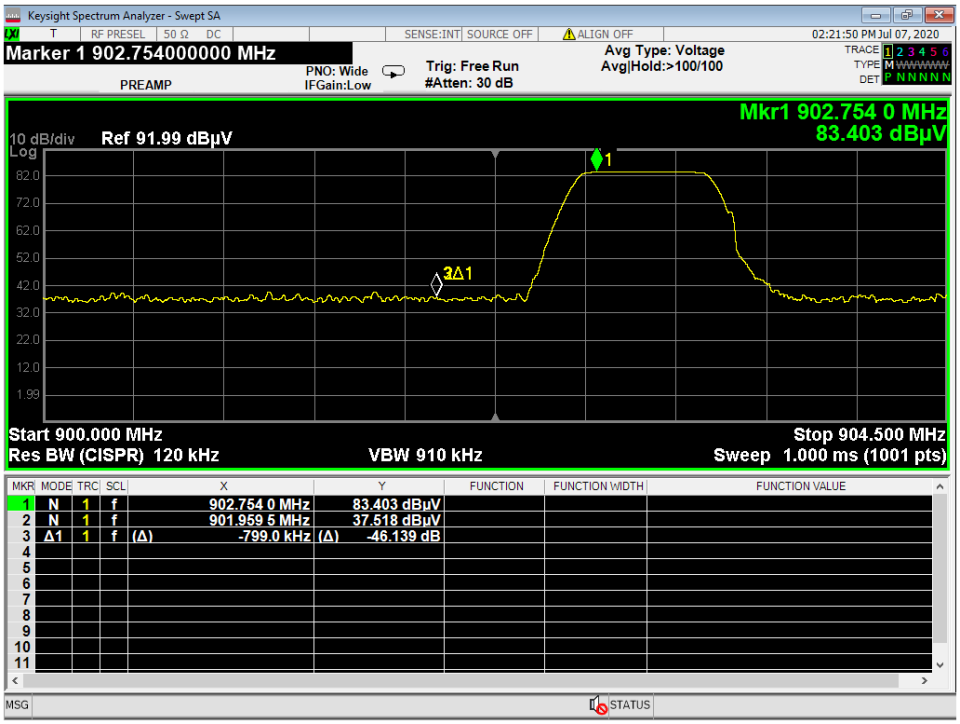
Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

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

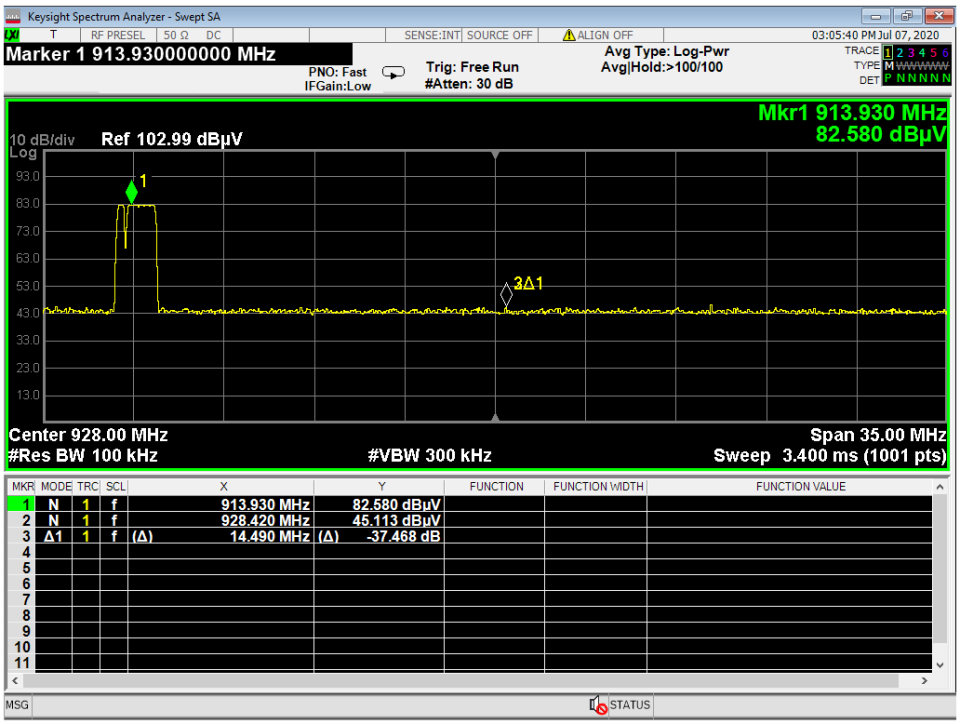
APPENDIX C – GRAPHS AND TABLES



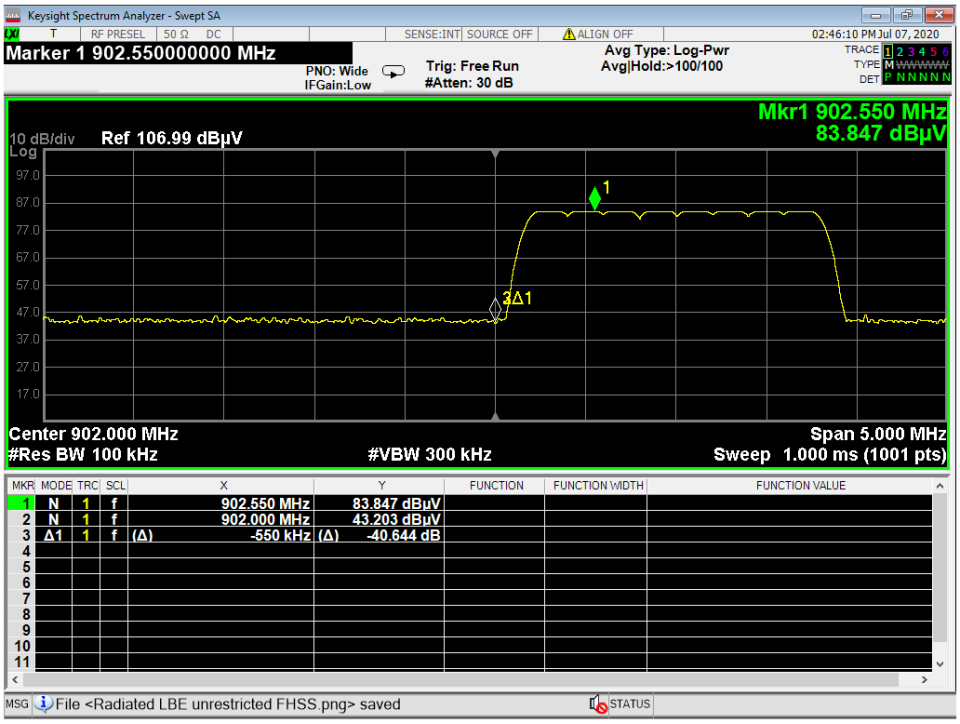
Radiated HBE Unrestricted, DTS



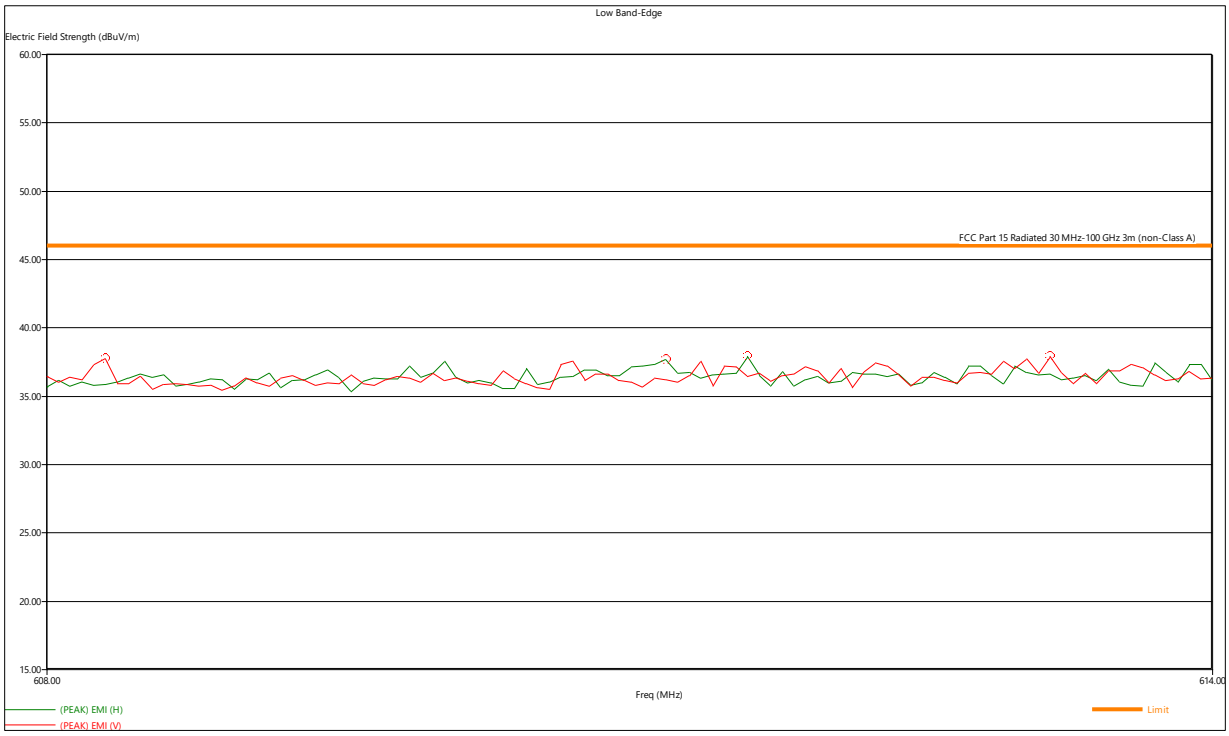
Radiated LBE Unrestricted, DTS



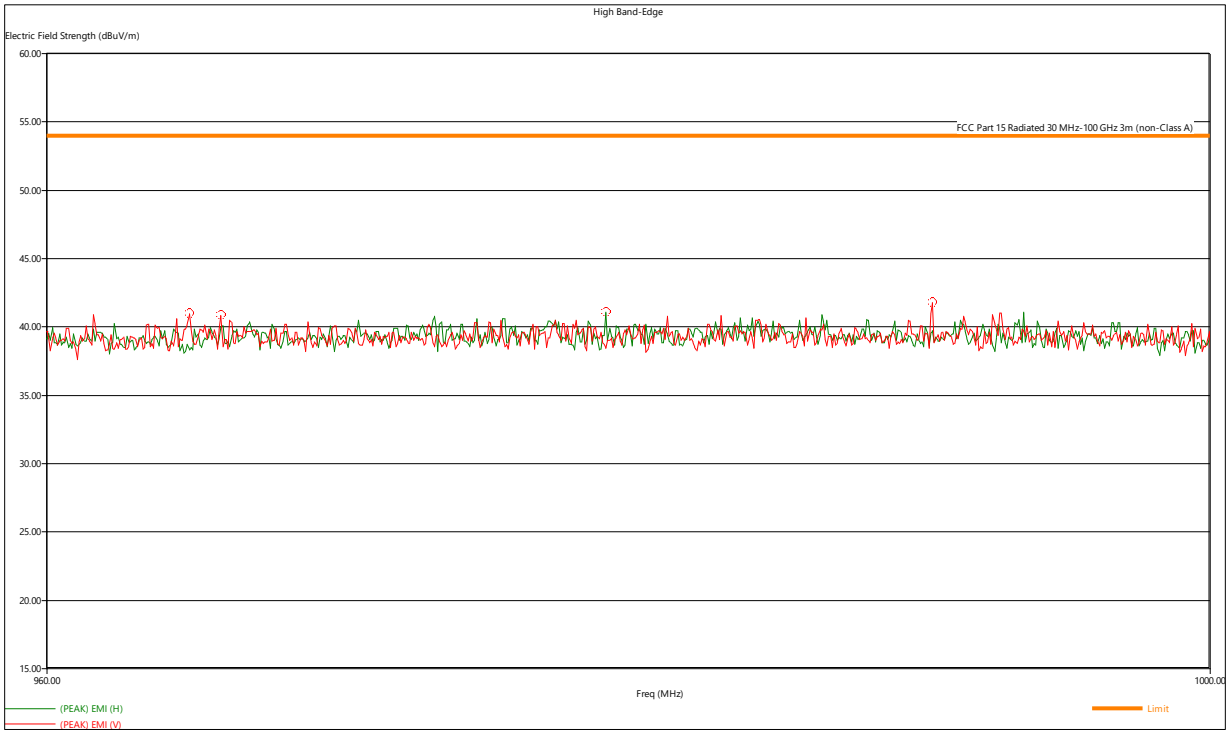
Radiated HBE Unrestricted, FHSS



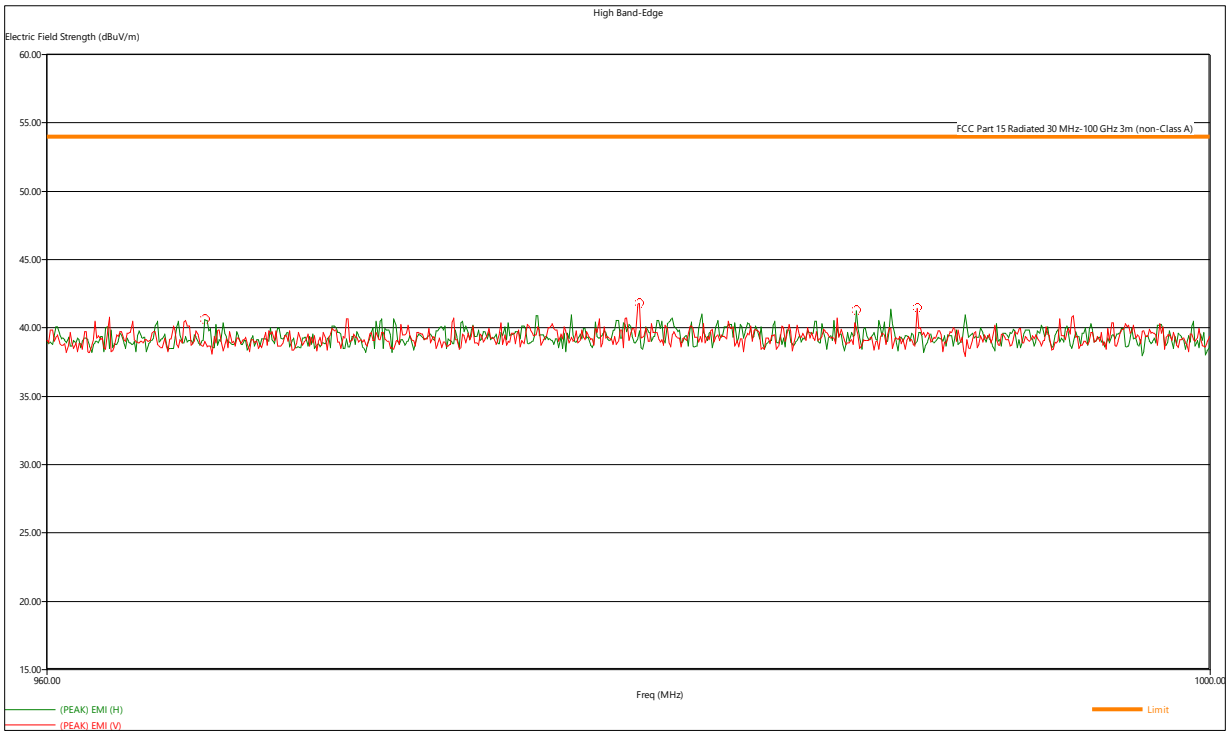
Radiated LBE Unrestricted FHSS



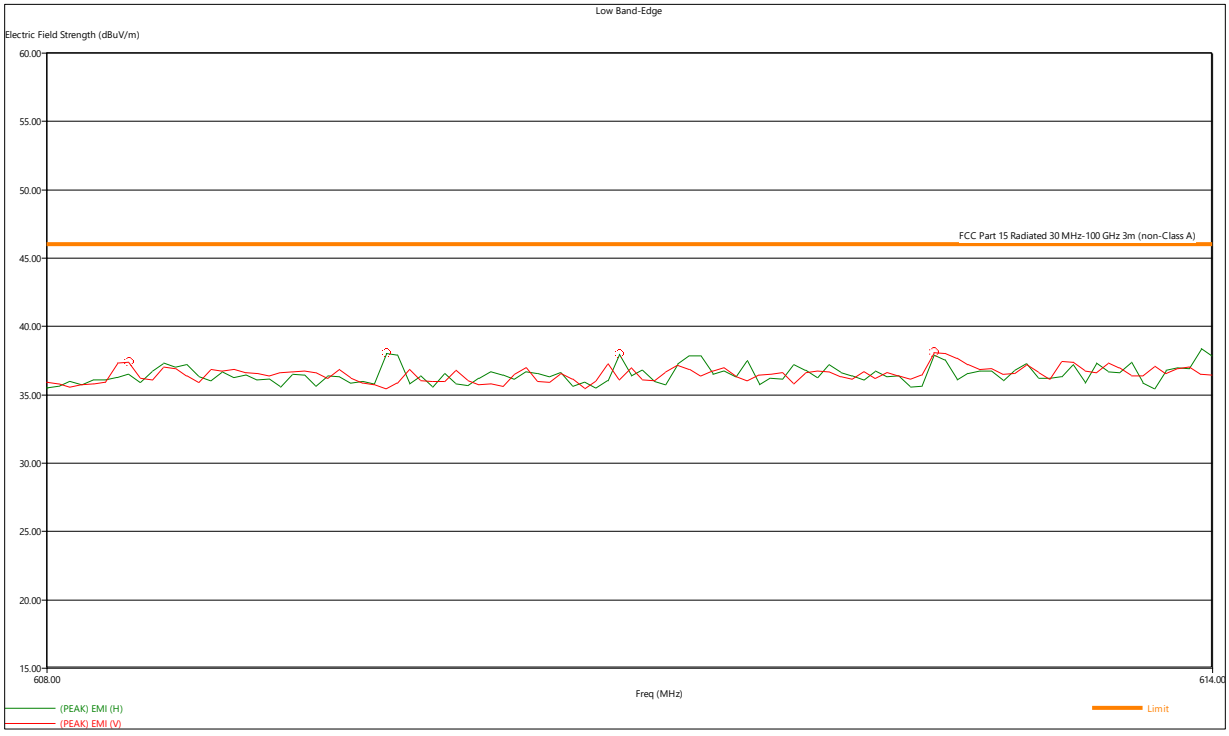
Radiated LBE Restricted, DTS



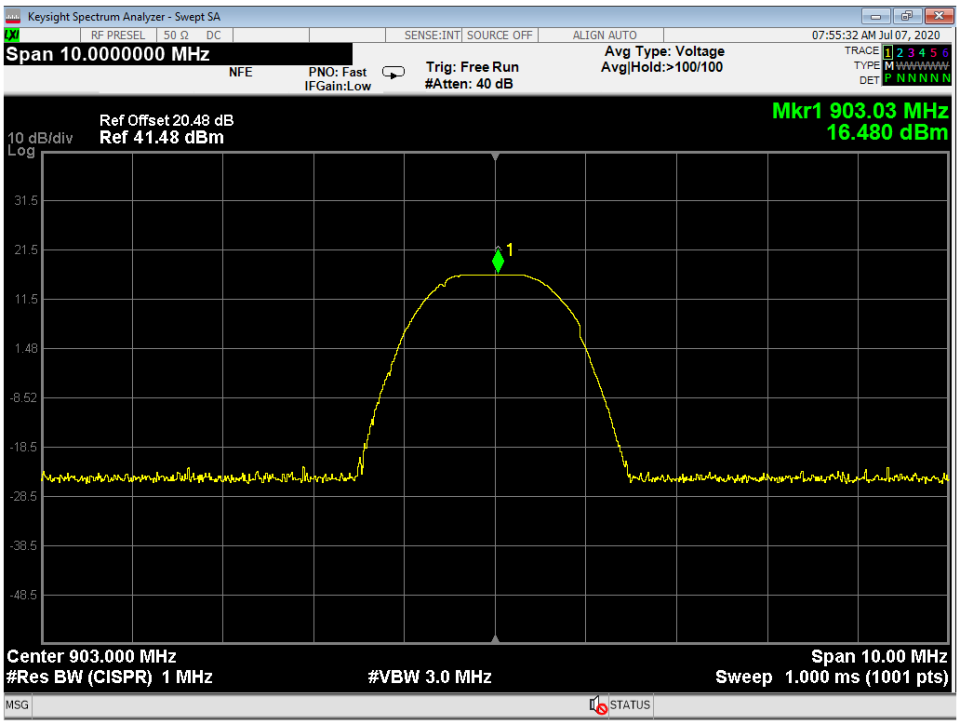
Radiated HBE Restricted, DTS



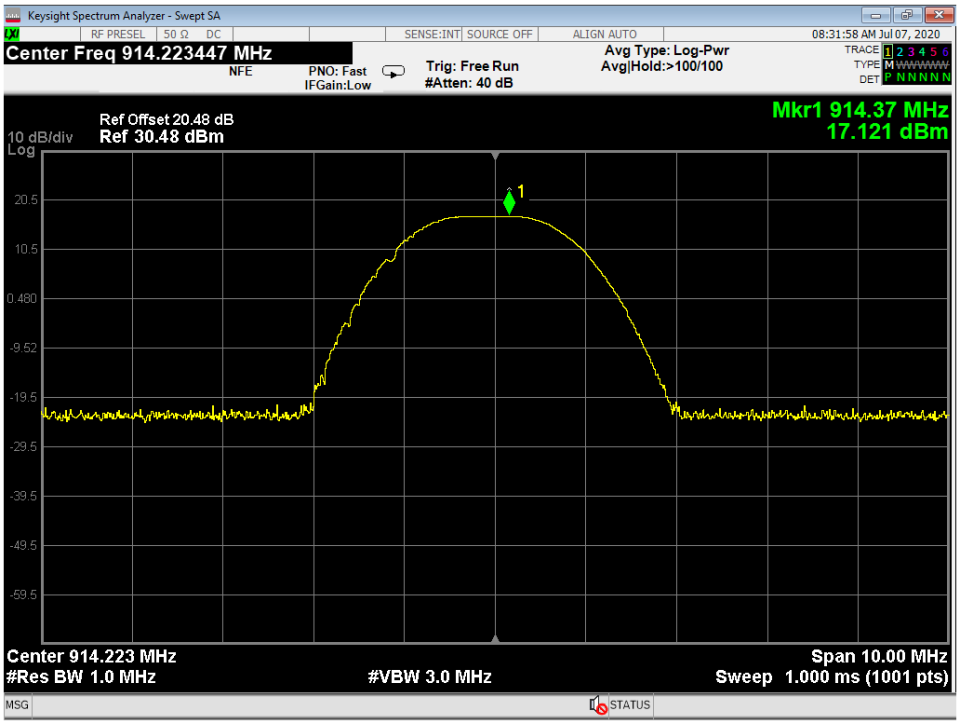
Radiated HBE Restricted, FHSS



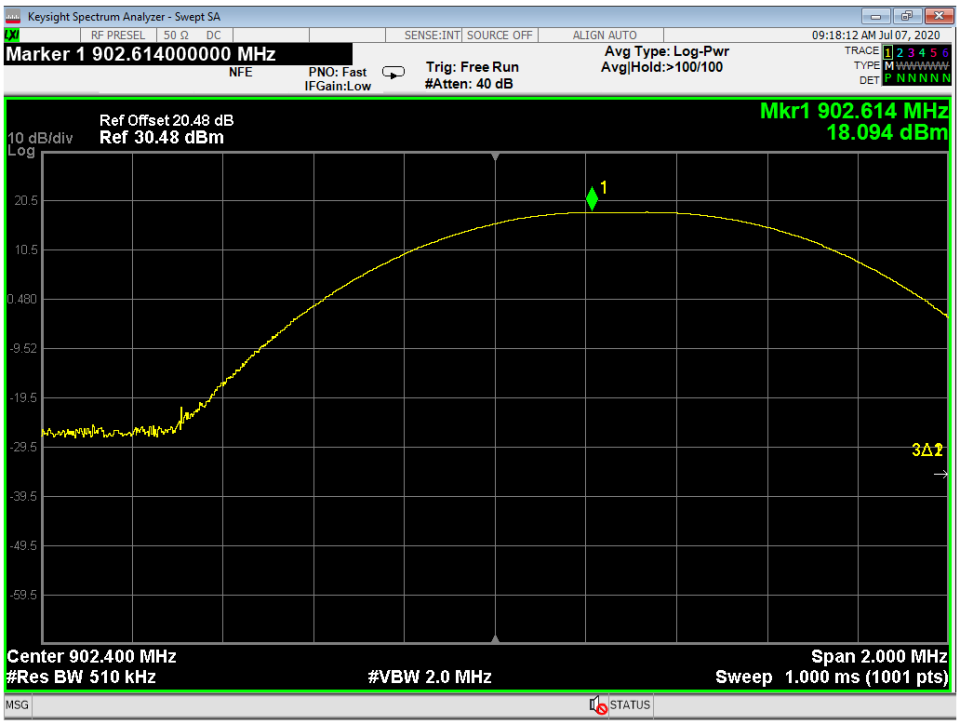
Radiated LBE Restricted FHSS



Peak Output Power, Low Channel DTS



Peak Output Power, High Channel DTS



Peak Output Power, Low Channel FHSS

Peak Output Power, High Channel FHSS

REPORT END