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TEST REPORT

Prepared for: **Garmin International, Inc.**

Address: **1200 E. 151st Street**
Olathe, Kansas, 66062, USA

Product: **A04659**

Test Report No: **R20220628-20-E2A**

Approved By:

Mahendra Karthik Vepuri, NCE
EMC Test Engineer,
iNARTE Certified EMC Engineer #EMC-041453-E

DATE: **22 March 2023**

Total Pages: **28**

REVISION PAGE

Rev. No.	Date	Description
0	19 December 2022	Original – KVepuri Reviewed by KVepuri Prepared by FLane
A	22 March 2023	Section 4.5-conducted Emissions was removed-KV

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 2.1046 FCC Part 95.2767	Output Power	PASS
FCC Part 2.1053 FCC Part 95.2779	Radiated Spurious Emissions	PASS
FCC Part 2.1049 FCC Part 95.2773, 95.2779	Emissions Masks/ Occupied Bandwidth	PASS
FCC Part 2.1055 (a)(1), (b) FCC Part 95.2765	Frequency Stability Under Voltage and Temp Variation	PASS
FCC Part 15.209	Receiver Spurious Emissions	PASS
FCC Part 15.207	Conducted Emissions	PASS

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

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a portable transceiver from Garmin.

EUT	A04659
FCC ID:	IPH-04659
EUT Received	21 July 2022
EUT Tested	21 July 2022 - 20 September 2022
Serial No.	3424308866
Operating Band	151.82-154.60 MHz
Device Type	☐ GMSK ☐ GFSK ☐ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB ☐ 802.11x ☒ VHF
Power Supply / Voltage	Internal Battery/ 5VDC Charger: Garmin (Phi Hong) MN: LACA046 (Representative Power Supply)

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

The EUT was powered by 5 VDC. It was set to transmit continuously on the 3 different channels of its operating range where available. A ferrite was placed on the charging cable adjacent to the USB-C connector FairRite (0431164951). EUT was investigated with a 50 Ohm load where the vhf antenna would be.

2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency (MHz)
Channel 1	151.820
Channel 3	151.940
Channel 5	154.600

These channels are described in FCC Part 95.2763 “MURS Channels”

This EUT was set to transmit in a worse-case scenario with modulation on.

2.3 DESCRIPTION OF SUPPORT UNITS

NA

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
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
3	Blake Winter	Test Engineer	Testing
4	Grace Larsen	Test Engineer	Testing and report

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer (44GHz)**	N9038A	MY59050109	July 19, 2022	July 19, 2024
Keysight MXE Signal Analyzer (26.5GHz)**	N9038A	MY56400083	July 19, 2022	July 19, 2024
Keysight EXA Signal Analyzer**	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A091418-1	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	March 21, 2022	March 21, 2024
8447F POT H64 Preamplifier*	8447F POT H64	3113AD4667	March 21, 2022	March 21, 2024
Trilithic High Pass Filter*	6HC330	23042	March 21, 2022	March 21, 2024
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)*	MFR-57500	01-07-002	March 21, 2022	March 21, 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 Cal cycle

4.0 DETAILED RESULTS

4.1 RADIATED SPURIOUS EMISSIONS

Test Method: ANSI C63.26:2015:

1. Section 5.5, “Radiated Emissions Testing”

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 95.2779 as followed:

Transmitting Frequency (MHz)	Frequency Band	Limit (dB)
151.820 151.880 151.940	≥12.5kHz removed from center frequency	50 + 10log(P)
154.570 154.600	≥50kHz removed from center frequency	43 + 10log(P)

Where P is equal to the output power of the transmitter in Watts.

Maximum measured output power of transmitter is 1.72 W thus making the worst-case emissions attenuation 52.355 dB for 151.82 MHz and 45.355 dB for 154.6 MHz.

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 the EUT was placed on a 1.5m pedestal for measurements from 1GHz to 2 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.

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:

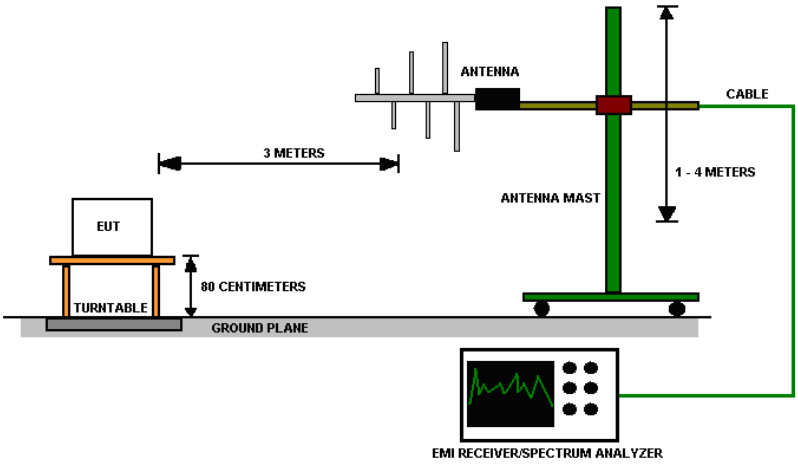

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
EUT was powered by 5V power supply. Device was set to transmit in the Lowest, Mid and Highest frequencies in its operating range.

Test results:

Radiated Emissions Data				
Frequency	**Level**	**Limit**	**Margin**	**Operating Channel**
MHz	**dBµV/m**	**dBµV/m**	**dB**	
50.485920	37.08	75.23	38.15	Low
76.081200	28.45	75.23	46.78	Low
133.186319	30.22	75.23	45.01	Low
50.450400	36.57	75.23	38.66	Mid
133.002719	26.18	75.23	49.05	Mid
50.542320	35.05	82.23	47.18	High
133.114800	35.78	82.23	46.45	High

Example of limit calculation:
Limit = 43 + 10log(P) = 45.833; rated power P = 1.92 W
Limit in dBm=P (dBm)-45.833=32.833-45.833=-13 dBm
Limit @ 3 m Test Distance=-13 dBm+95.23=82.23 dBµV/m

*Frequencies with N/A's in their limit and margin columns are transmission frequencies and thus not evaluated.

**All other emissions were found to be at least 20 dB below the limit.

Conducted Spurious Emissions:

No measurements were found within 20 dB of the limit per ANSI C63.26 Part 5.1.1(c).

Receiver Spurious Emissions:

No emissions were found within 10dB of the limit.

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. EUT was investigated for intermodulation. No intermodulation was found above system's noise floor

4.2 OUTPUT POWER

Test Method: ANSI C63.26:
Section(s) 5.2.4.3.1 “General procedure for measuring average power of a narrowband signal with a spectrum/signal analyzer or EMI receiver”

FCC Part 95.2767 MURS transmitting power limit:
Each MURS transmitter type must be designed such that the transmitter power output does not exceed 2 Watts under normal operating conditions.

Test procedures:

a) Set the RBW ≥ OBW.
b) Set VBW ≥ 3 × RBW.
c) Set span ≥ 2 × OBW.
d) Sweep time ≥ 10 × (number of points in sweep) × (transmission symbol period).
e) Detector = Average.
f) Trace mode = Trace Average (Avg|Hold = 100).
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the amplitude level.

Deviations from test standard:
No deviation.

Test setup:

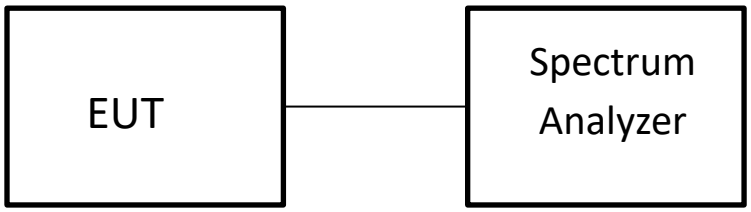

Figure 2 – Peak Output Power Measurements Test Setup

EUT operating conditions:
EUT was connected to a laptop via USB cable. Device was set to transmit in low, mid and high of its allocated frequencies.

Test results:

Limit = 33 dBm (2000 mW)

Output Power

CHANNEL FREQUENCY (MHz)	OUTPUT POWER (dBm)	OUTPUT POWER (mW)	Method	RESULT
151.820	32.355	1719.89	Conducted	PASS
151.940	32.358	1721.08	Conducted	PASS
154.600	32.102	1622.56	Conducted	PASS

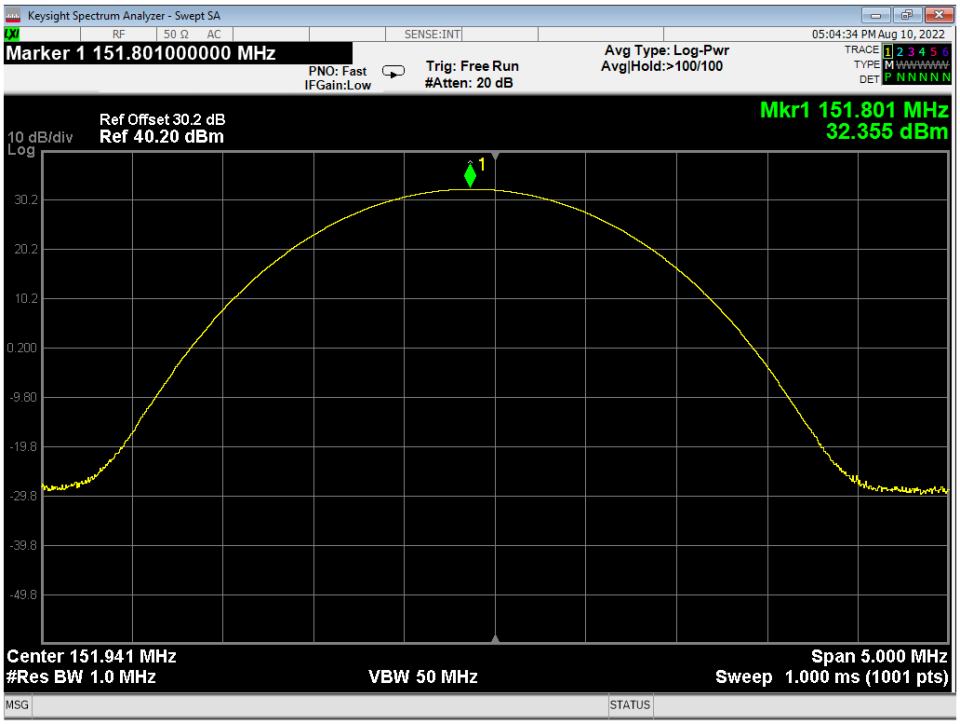

Figure 3 –Output Power, 151.820 MHz

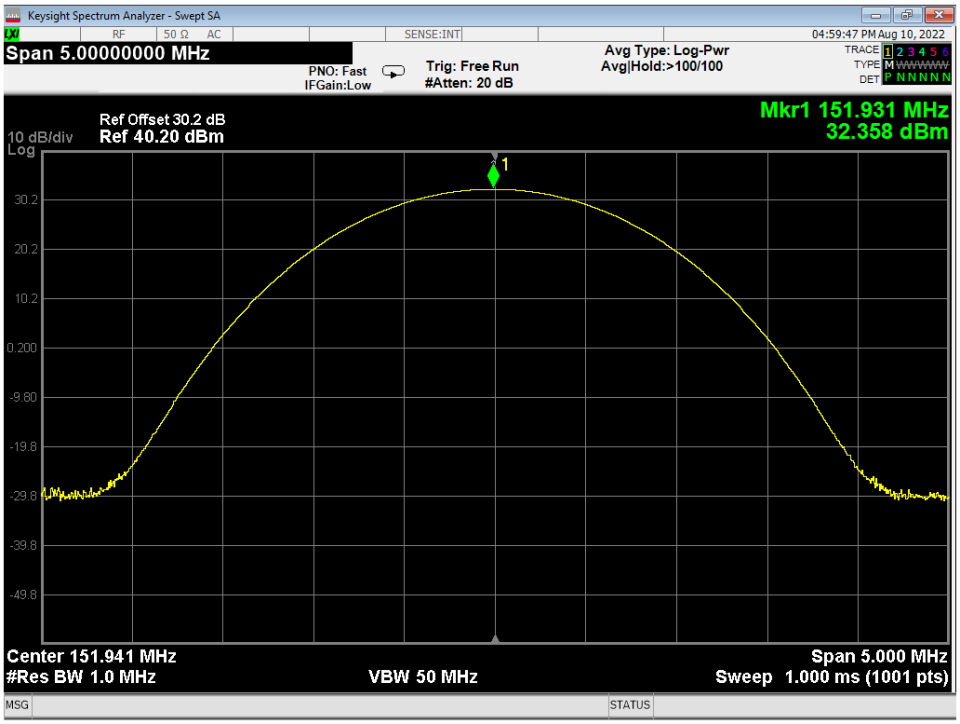

Figure 4 –Output Power, 151.940 MHz

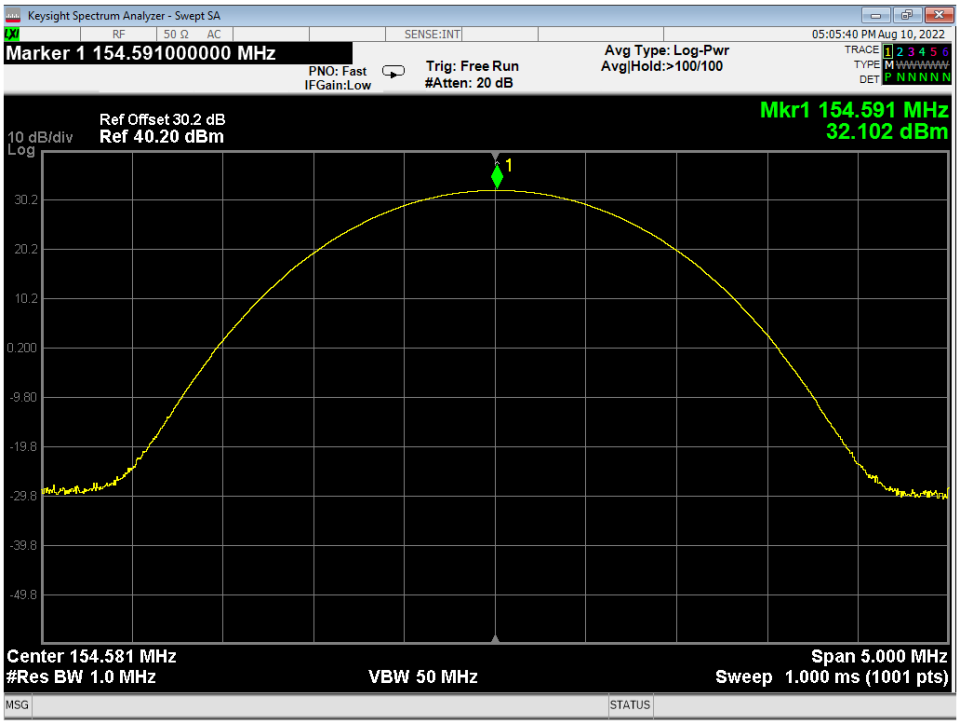

Figure 5 –Output Power, 154.600 MHz

4.3 BANDWIDTH AND EMISSIONS MASK

Test Method: ANSI C63.26,
1. Section(s) 5.4.3, 5.4.4

Limits:

FCC Part 95.2773 MURS authorized bandwidths:

Each MURS transmitter type must be designed to meet the emission bandwidth limitations in this section.

(a) The occupied bandwidth of emissions transmitted on the center frequencies 151.820 MHz, 151.880 MHz, and 151.940 MHz must not exceed 11.25 kHz.

(b) The occupied bandwidth of emissions transmitted on the center frequencies 154.570 MHz and 154.600 MHz must not exceed 20.0 kHz.

FCC Part 95.2773 MURS authorized bandwidths:

Channel Center Frequencies	Paragraphs
151.820, 151.880 and 151.940	(1), (2)
154.570 & 154.600, without audio filter	(5), (6), (7)

(1) 7.27(fd−2.88 kHz) dB on any frequency removed from the channel center frequency by a displacement frequency (fd in kHz) that is more than 5.625 kHz, but not more than 12.5 kHz. RBW = 300 Hz

(2) 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation, on any frequency removed from the channel center frequency by more than 12.5 kHz. RBW = 30 kHz

(3) 25 dB on any frequency removed from the channel center frequency by more than 10 kHz, but not more than 20 kHz. RBW = 300 Hz

(4) 35 dB on any frequency removed from the channel center frequency by more than 20 kHz, but not more than 50 kHz. RBW = 300 Hz

(5) 83 log (fd ÷ 5) dB on any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) that is more than 5 kHz, but not more than 10 kHz. RBW = 300 Hz

(6) 29 log (fd2 ÷ 11) dB or 50 dB, whichever is the lesser attenuation on any frequency removed from the channel center frequency by a displacement frequency (fd in kHz) that is more than 10 kHz, but not more than 50 kHz. RBW = 300 Hz

(7) 43 + 10 log(P) dB on any frequency removed from the channel center frequency by more than 50 kHz. RBW = 30 kHz

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 300 Hz RBW and 910 Hz VBW. The bandwidth measurements were done using the automatic bandwidth measurement.

(c) Measurement bandwidths. The power of unwanted emissions in the frequency bands specified in paragraphs (b)(1) and (3) through (6) of this section is measured with a reference bandwidth of 300 Hz. The power of unwanted emissions in the frequency ranges specified in paragraphs (b)(2) and (7) of this section is measured with a reference bandwidth of at least 30 kHz.

Start Freq	Stop Freq	Integ BW
5.625 kHz	12.50 kHz	300.0 Hz
12.50 kHz	100.0 kHz	300.0 Hz
24.14 kHz	50.00 kHz	300.0 Hz
50.00 kHz	100.0 kHz	30.00 kHz
8.000 MHz	12.50 MHz	1.000 MHz
12.50 MHz	15.00 MHz	1.000 MHz
12.50 MHz	15.00 MHz	1.000 MHz

Deviations from test standard:
No deviation

Test setup:

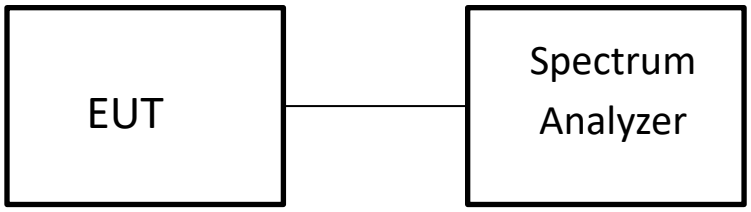

Figure 6 –Measurements Test Setup

EUT operating conditions:
EUT was powered by 5VDC charger. Device was set to transmit in the Lowest, Mid and Highest frequencies in its operating range.

Test results:

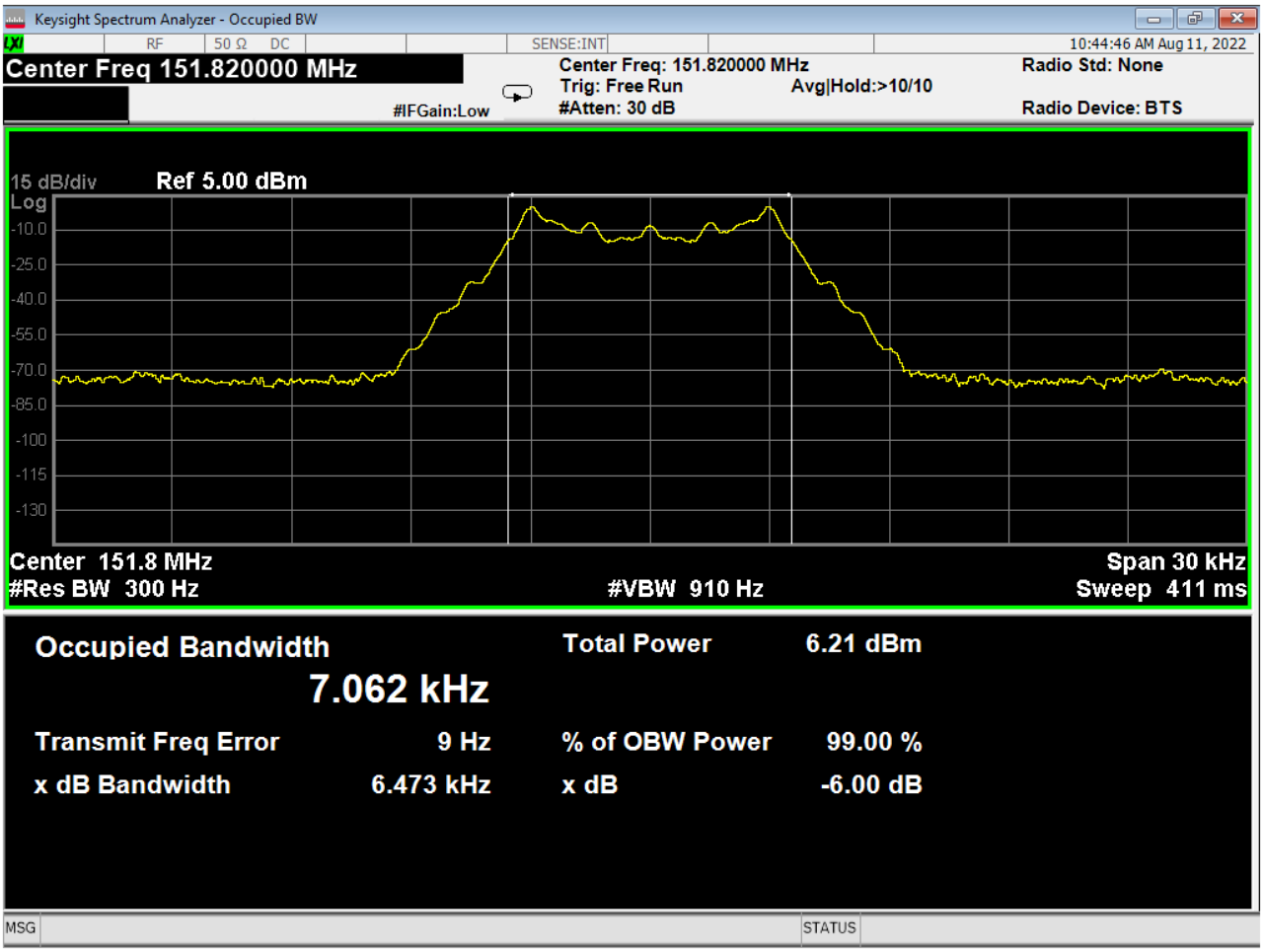

Figure 7 - Bandwidth, 151.820 MHz

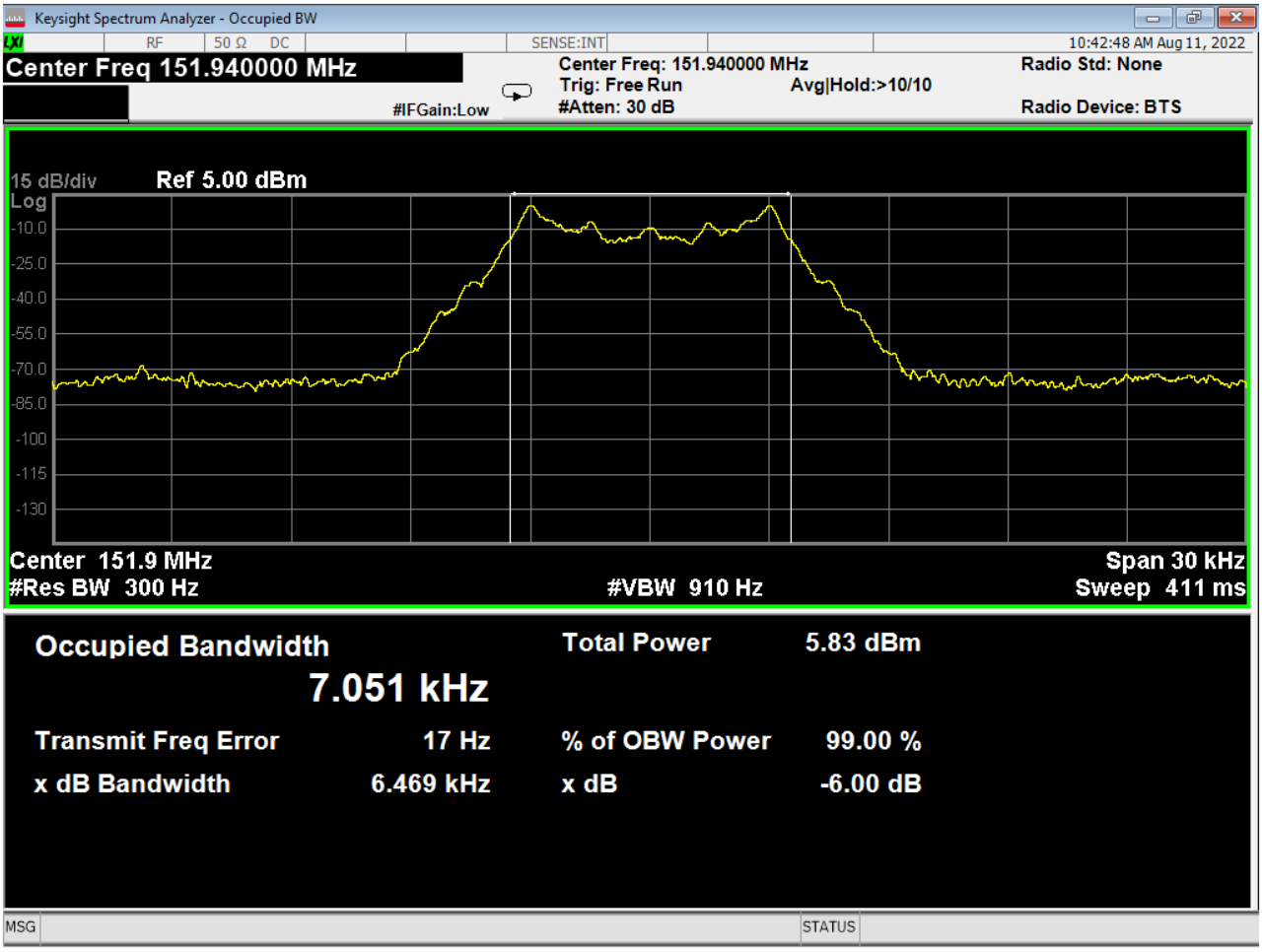

Figure 8 - Bandwidth, 151.940 MHz

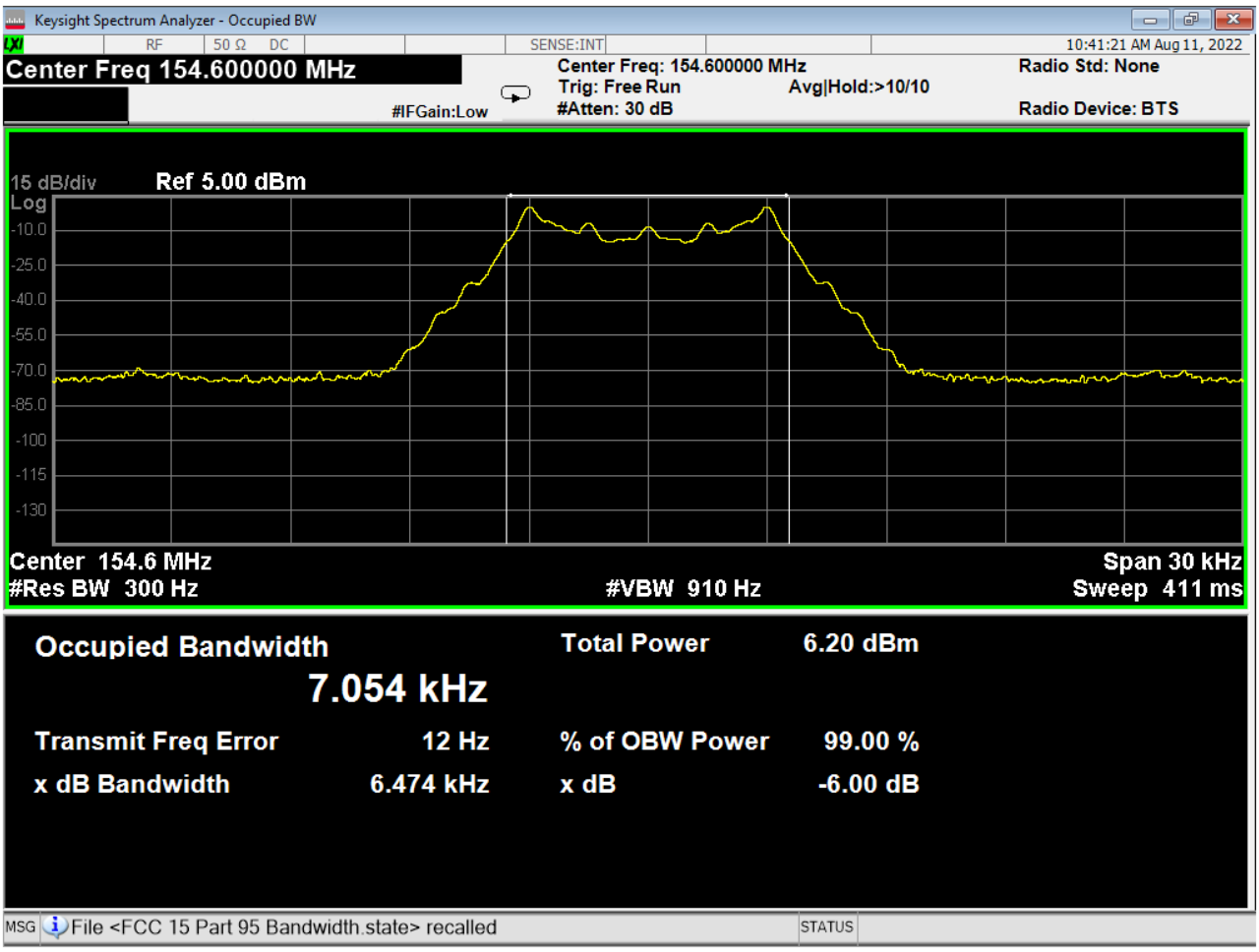

Figure 9 - Bandwidth, 154.600 MHz

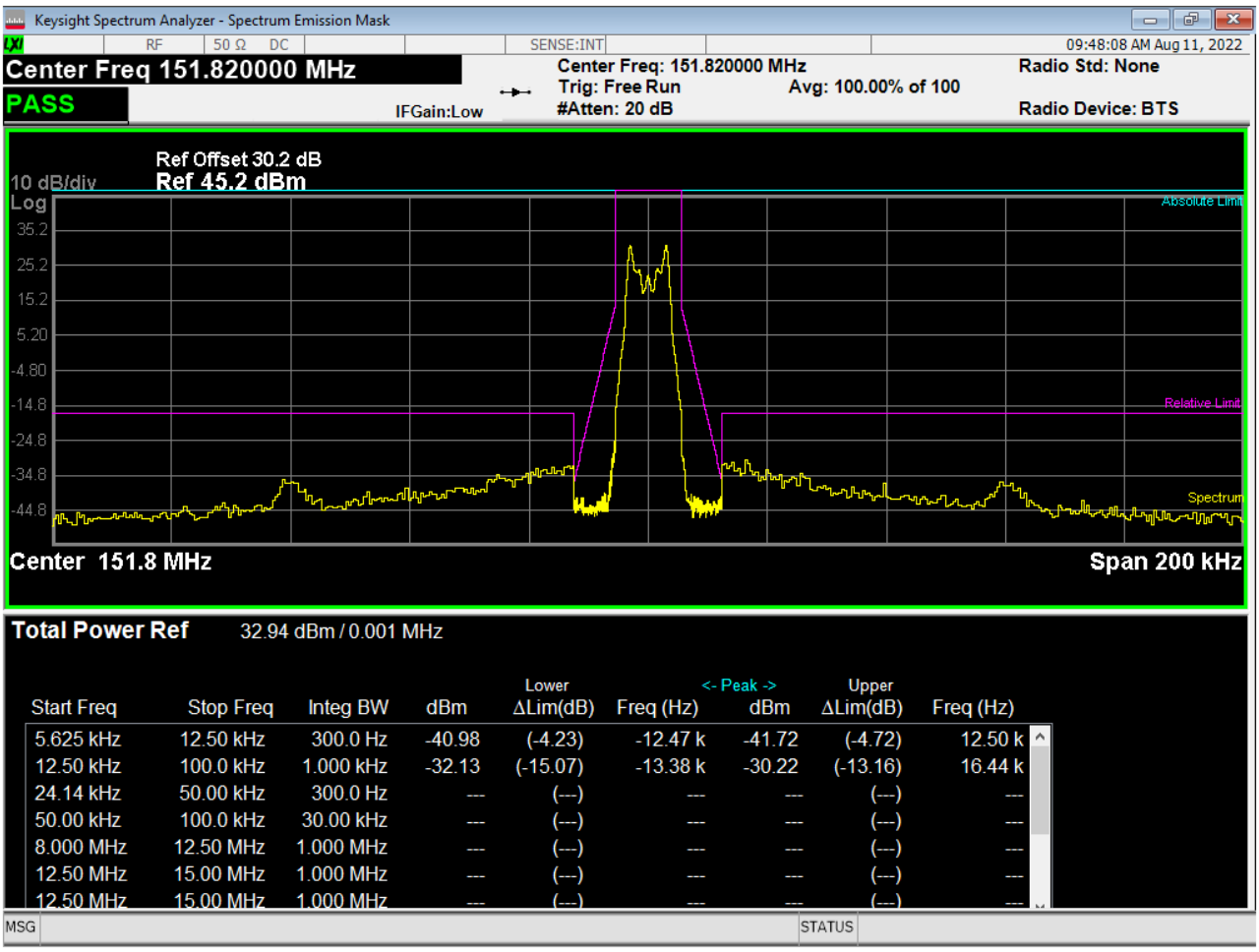

Figure 10 - Emissions Mask, 151.820 MHz

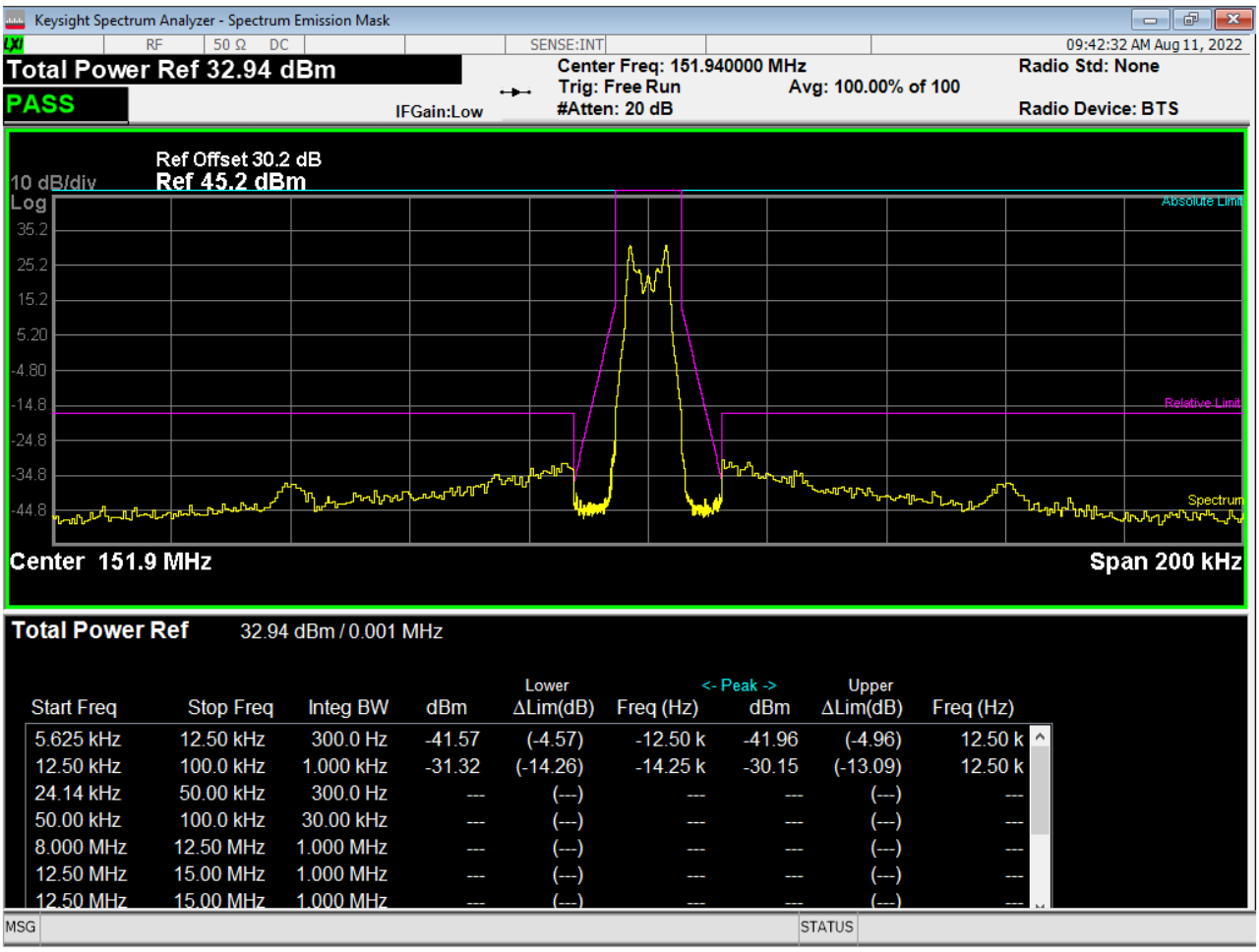

Figure 11 - Emissions Mask, 151.940 MHz

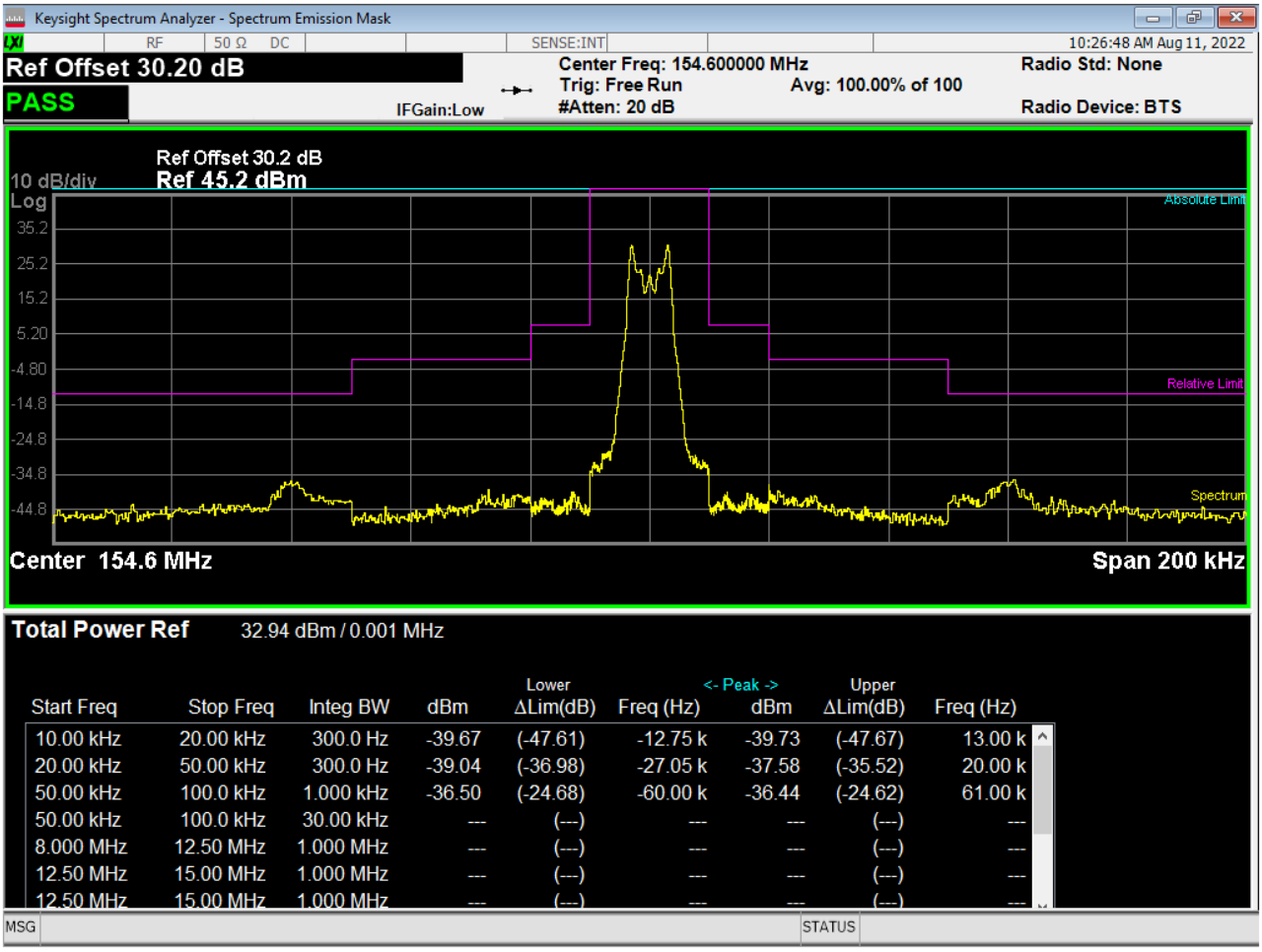

Figure 12 - Emissions Mask, 154.600 MHz

4.4 FREQUENCY STABILITY MEASUREMENTS

Test Method: ANSI C63.26,

1. Section(s) 5.6.3 “Procedure for frequency stability testing”

Limits:
FCC Part 95.2763 MURS frequency accuracy:

Each MURS transmitter type must be designed to meet the applicable frequency tolerance and stability requirements of this section.

(b) MURS transmitters that operate with an emission bandwidth greater than 6.25 kHz must be designed such that the carrier frequencies remain within ±5.0 ppm of the channel center frequencies specified in § 95.2763 during normal operating conditions.

Test procedures:
Radiated power was measured on a spectrum analyzer with resolution bandwidth and video bandwidth set to 500 Hz and 1 kHz respectively. The frequency error functionality on the receiver was used. The temperature was varied from -30°C to +50°C.

Deviations from test standard:
No deviation

Test setup:

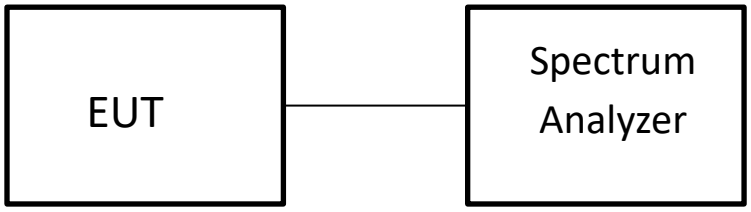

Figure 13 –Measurements Test Setup

EUT operating conditions:
Device was set to transmit in the Lowest, Mid and Highest frequencies in its operating range.

Test results:

Frequency Stability, Temperature Variation

Temp in C°	-30	-20	-10	0	10	20	30	40	50			
Freq (MHz)	Deviation (Hz)									limit (Hz)	limit (ppm)	Result
151.8200	-5	53	17	18	13	45	2	14	47	759.10	5	Pass
151.9400	15	56	12	20	16	45	4	12	49	759.70	5	Pass
154.6000	5	53	22	16	13	42	-5	5	53	773.00	5	Pass

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	150 kHz – 30MHz	±3.03
Antenna port conducted	9 kHz – 25 GHz	±0.50

Values were calculated per CISPR 16-4-2:2011

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

REPORT END