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TEST REPORT

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

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

Product: **011-02883-03**

Test Report No: **R20210524-21-E2A**

Approved By:

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

DATE: **20 September 2021**

Total Pages: **36**

REVISION PAGE

Rev. No.	Date	Description
0	4 August 2021	Original – NJohnson Prepared by KVepuri
A	20 September 2021	Corrected attenuation calculations in Section 4.1. -NJ

CONTENTS

1.0 SUMMARY OF TEST RESULTS

The intention is to see if class II permissive change is possible on the EUT (FCC ID: IPH-0199715). 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 15.2765	Receiver Spurious 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.

Model	011-02883-03
EUT Received	9 July 2021
EUT Tested	9 July 2021- 27 July 2021
Serial No.	Lab assigned SN: 00625
Operating Band	151.820 MHz – 154.600 MHz
Device Type	VHF
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAI05R-050QL6

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 (MHz)
Channel 1	151.820
Channel 2	151.880
Channel 3	151.940
Channel 4	154.570
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

All testing was performed by Karthik Vepuri, and Fox Lane of NCEE Labs. The results were reviewed by Nic Johnson.

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 21, 2021	July 21, 2023
Keysight MXE Signal Analyzer (26.5GHz)	N9038A	MY56400083	May 5, 2020	May 5, 2022
Keysight EXA Signal Analyzer	N9010A	MY56070862	July 20, 2021	July 20, 2023
SunAR RF Motion	JB1	A082918-1	August 17, 2020	August 17, 2021
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	14 April 2020*	14 April 2022*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	14 April 2020*	14 April 2022*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	14 April 2020*	14 April 2022*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	14 April 2020*	14 April 2022*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	14 April 2020*	14 April 2022*
N connector bulkhead (control room)	PE9128	NCEEBH2	14 April 2020*	14 April 2022*

*Internal Characterization

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.

Rated output power of transmitter is 1.97 W thus making the worst-case emissions attenuation 52.94 dB for 151.82 MHz and 45.94 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 form 30MHz-1Ghz and 1.5m 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.

g. During the preview scan, the other 2.4 GHz radios were also operated simultaneously with the VHF radio to investigate for any intermodulation products. If any were detected, they would be shown and noted as such in the data from this section.

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:

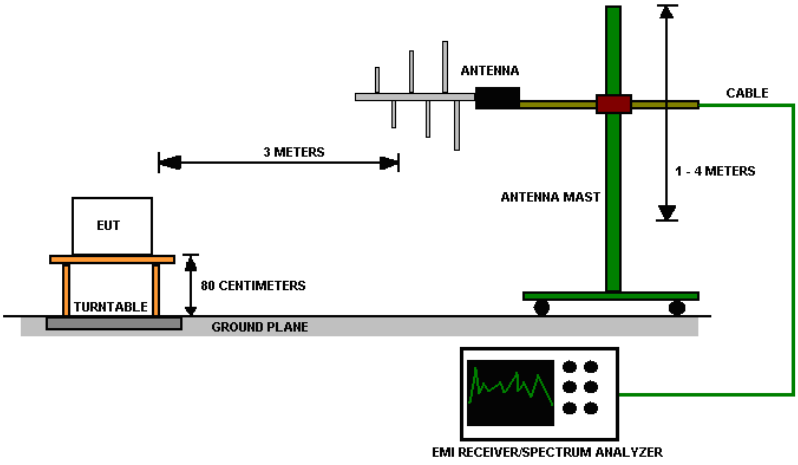


Figure 1 - Radiated Emissions Test Setup

EUT operating conditions

EUT was powered by micro-USB connected to 5V power supply. Device was set to transmit in the mid frequency in its operating range.

Test results:

Radiated Emissions Data				
Frequency	**Level**	**Limit**	**Margin**	**Operating Channel**
MHz	**dBµV/m**	**dBµV/m**	**dB**	
303.893280	43.62	75.23	31.61	151.94 MHz
455.831040	56.92	75.23	18.31	151.94 MHz
607.768320	57.15	75.23	18.08	151.94 MHz
759.691440	61.81	75.23	13.42	151.94 MHz
911.656800	43.81	75.23	31.42	151.94 MHz
303.893280	43.62	75.23	31.61	151.94 MHz

*Worst-case spurious emissions frequency range from the original grant were investigated and compared to the limit.

Note: The EUT contained BLE radio, which were investigated and the worst case radiated spurious were found to be within the permissible tolerance.

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.

4.2 OUTPUT POWER

Test Method: ANSI C63.26:
Section(s) 5.2.3.3 “Measurement of peak power in 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 = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the peak amplitude level.

Deviations from test standard:
No deviation.

Test setup:

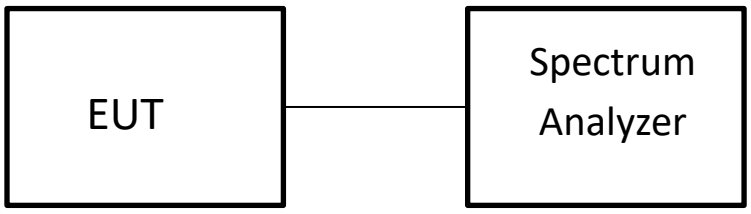


Figure 2 – Peak Output Power Measurements Test Setup

EUT operating conditions:
EUT was connected to a laptop via micro-USB cable. Device was set to transmit in each of its five allocated frequencies.

Test results:

Limit = 33 dBm (2 W)

Output Power

Rated power = 1.55 W = 31.91 dBm

CHANNEL FREQUENCY (MHz)	OUTPUT POWER (dBm)	OUTPUT POWER (W)	Method	RESULT
151.820	29.06	0.80	Conducted	PASS
151.880	28.61	0.73	Conducted	PASS
151.940	30.18	1.04	Conducted	PASS
154.570	28.60	0.72	Conducted	PASS
154.600	28.45	0.70	Conducted	PASS

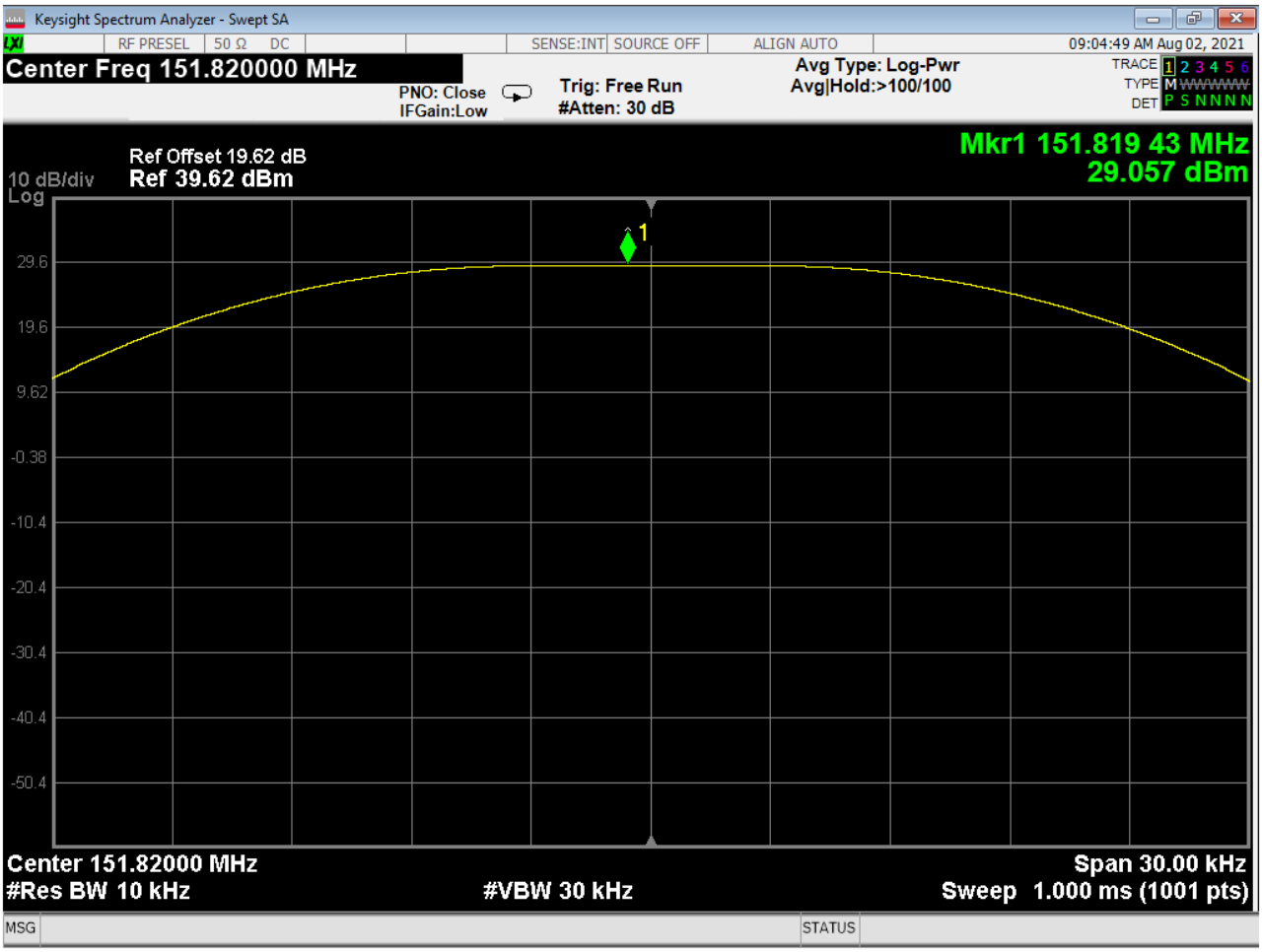


Figure 3 –Output Power, 151.820 MHz

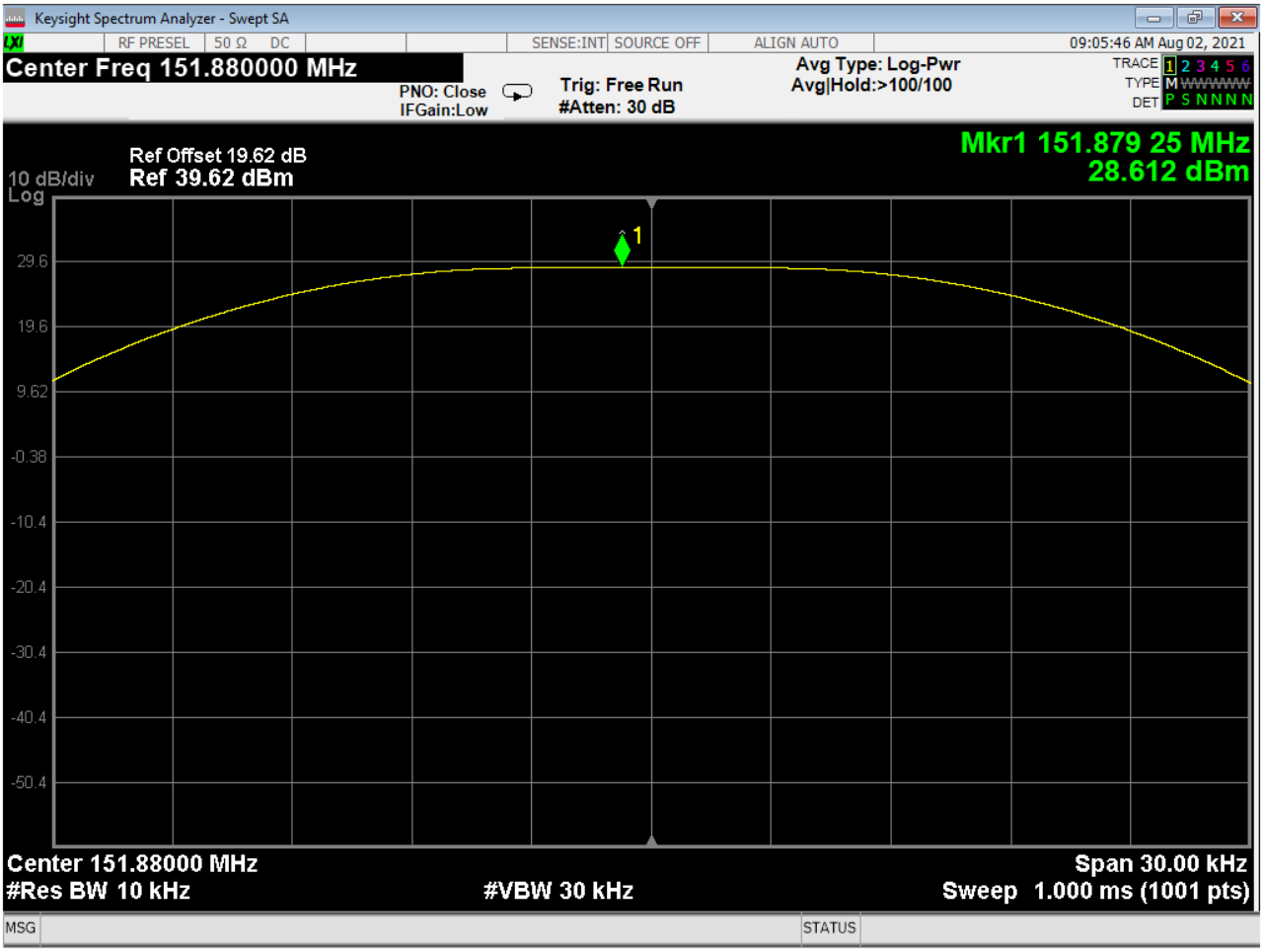


Figure 4 –Output Power, 151.880 MHz

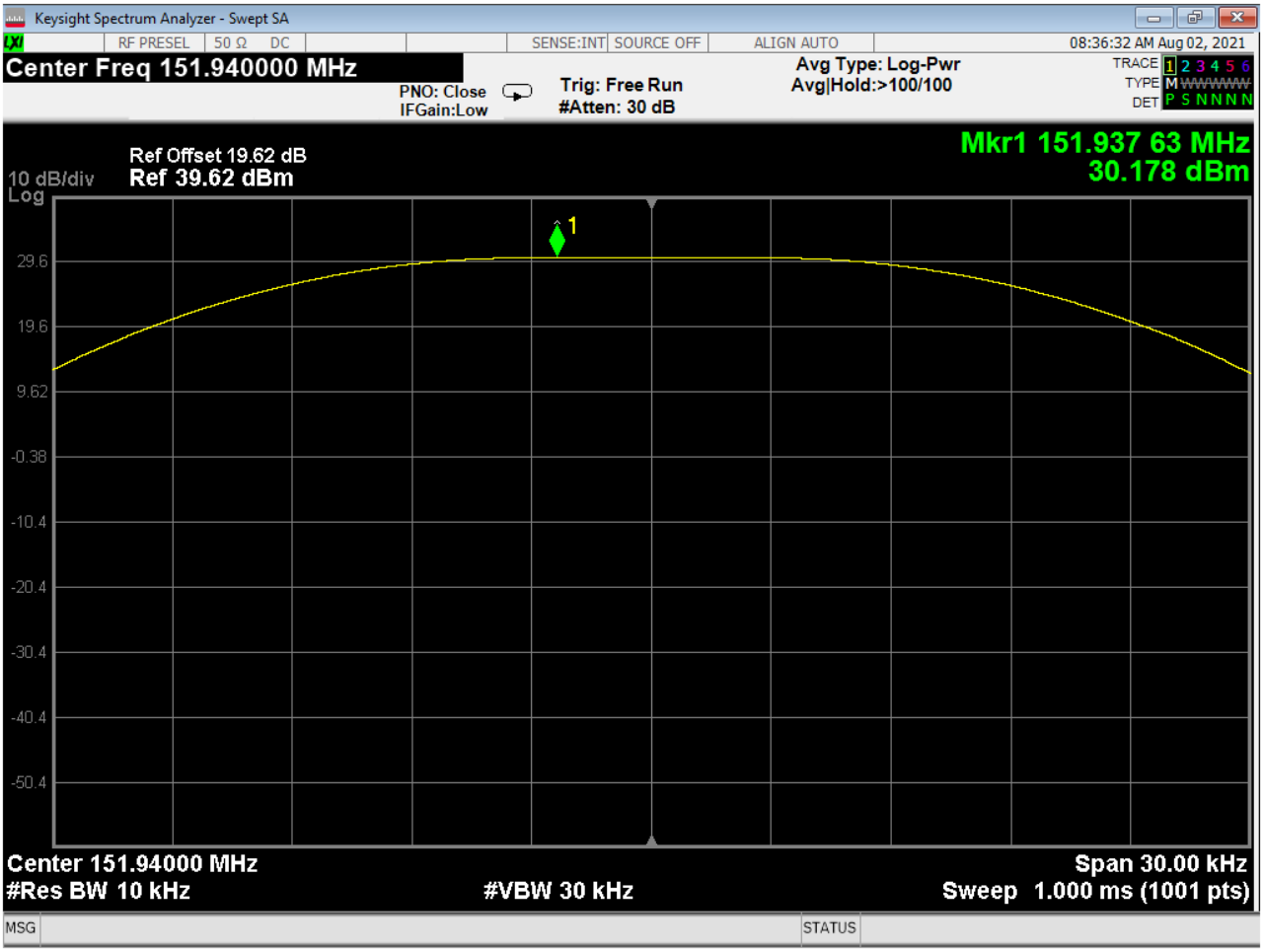


Figure 5 –Output Power, 151.940 MHz

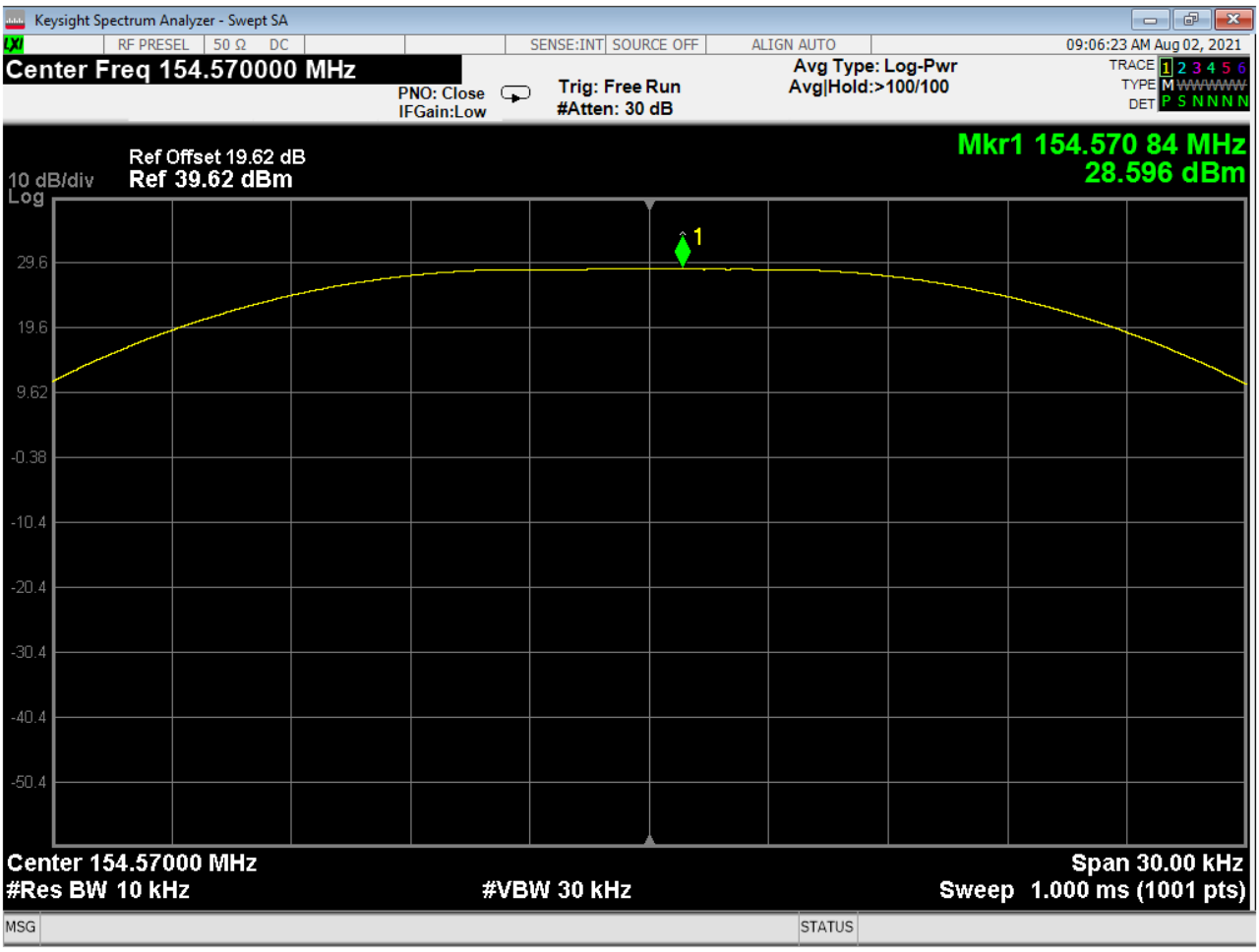


Figure 6 –Output Power, 154.570 MHz

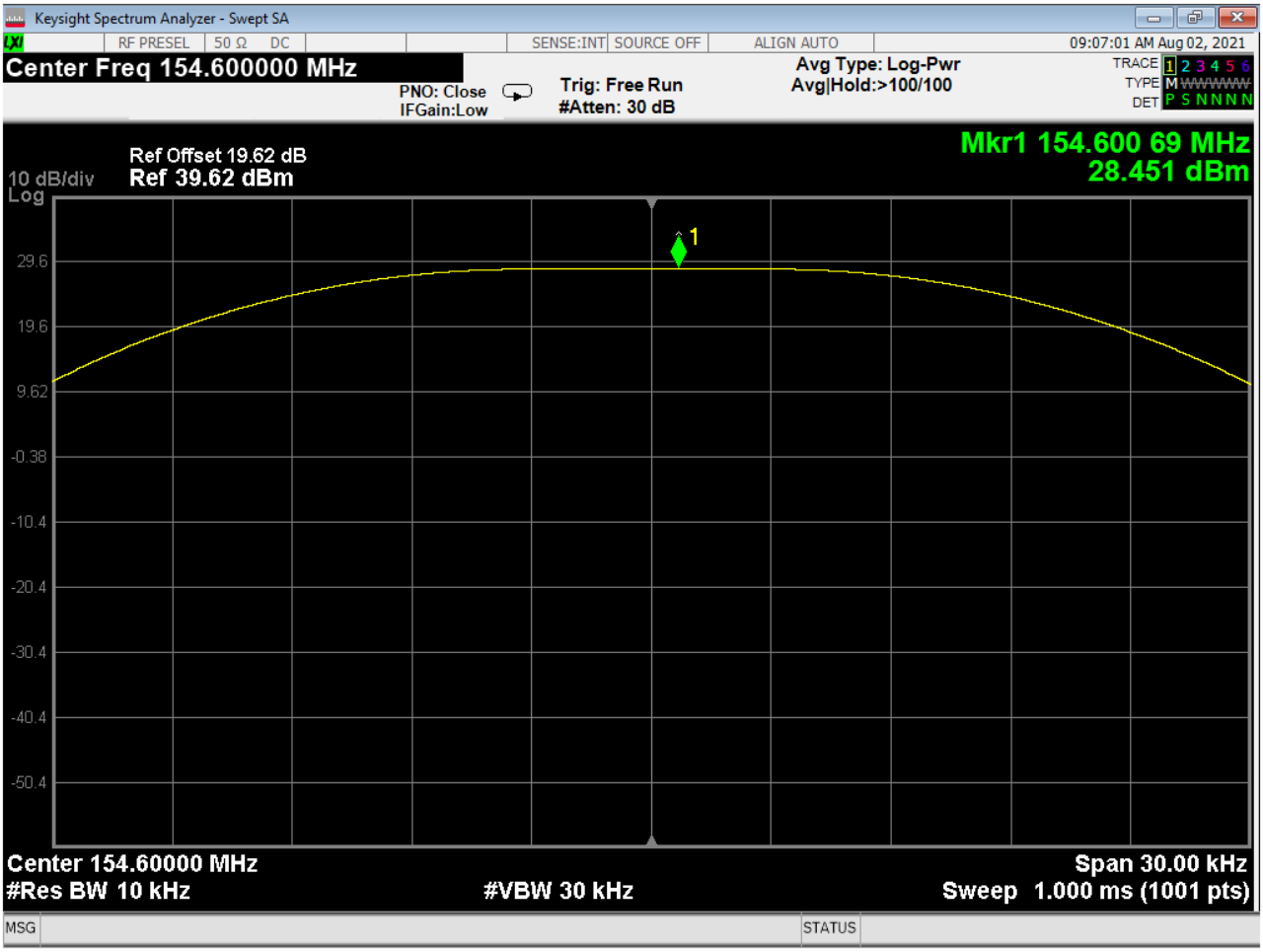


Figure 7 –Output Power, 154.600 MHz

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 = 1 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 = 1 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:

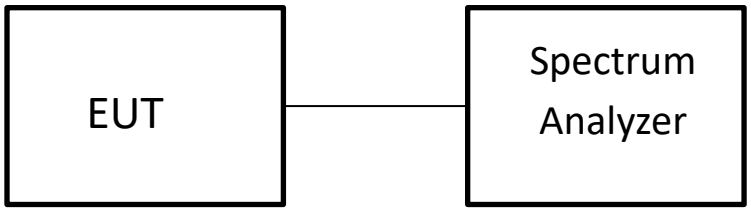


Figure 8 –Measurements Test Setup

EUT operating conditions:
EUT was connected to a laptop via micro-USB cable. Device was set to transmit in each of its five allocated frequencies.

Test results:

99% Occupied Bandwidth

CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
151.820	6.890
151.880	6.858
151.940	6.884
154.570	6.865
154.600	6.869

6dB Bandwidth

CHANNEL FREQUENCY (MHz)	6dB Occupied BW (kHz)
151.820	6.490
151.880	6.433
151.940	6.405
154.570	6.478
154.600	6.476

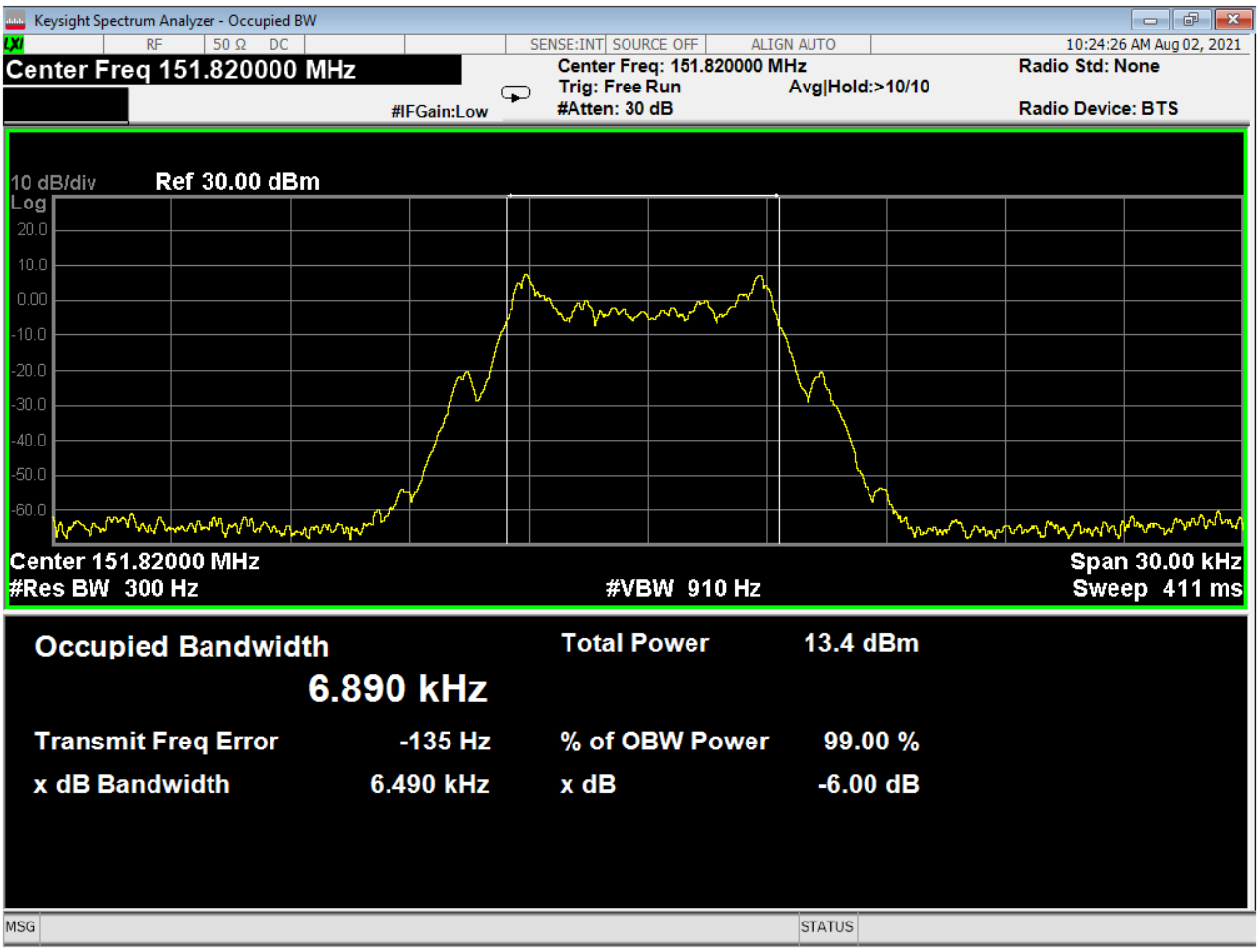


Figure 9 - Bandwidth, 151.820 MHz

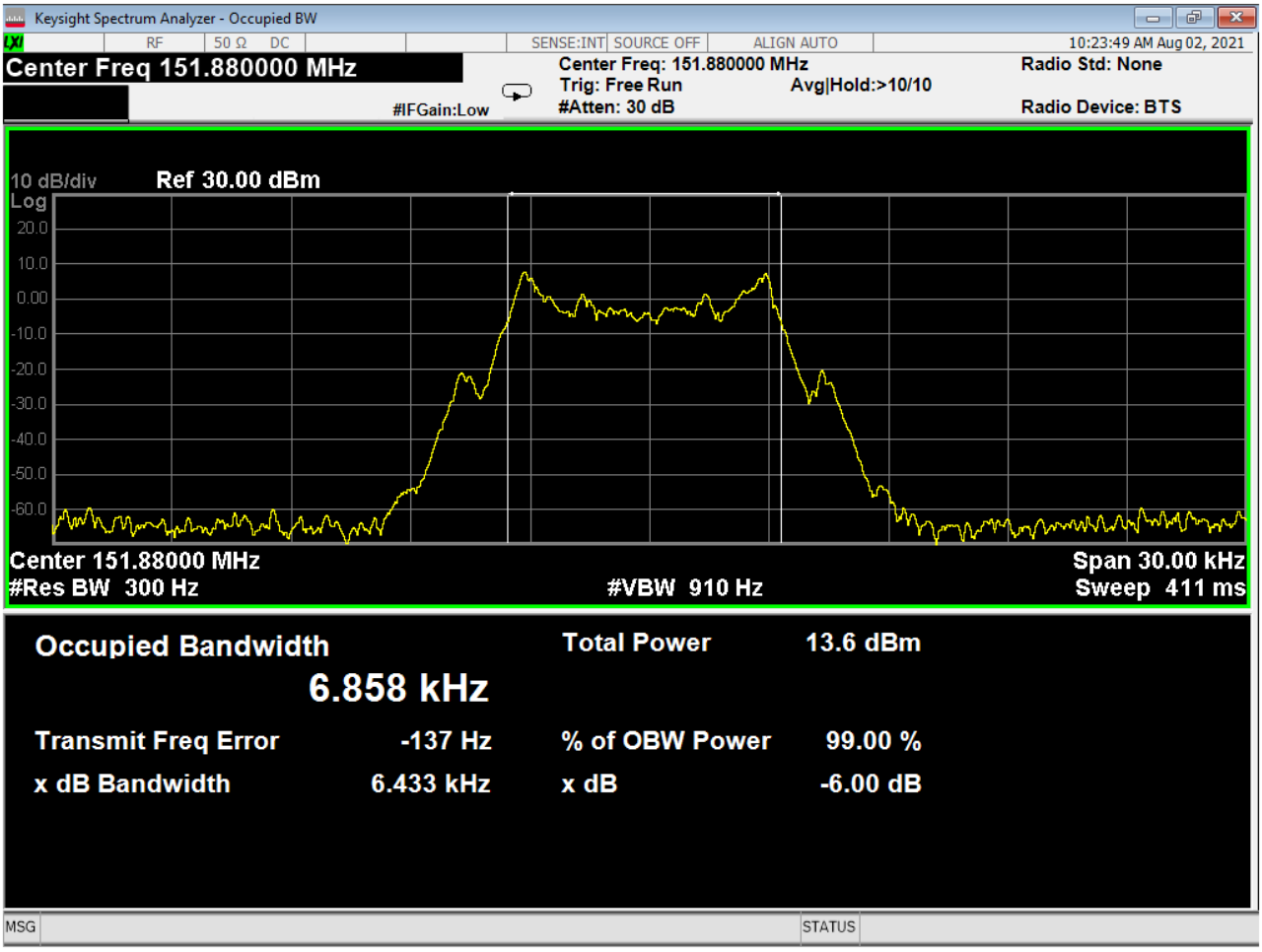


Figure 10 - Bandwidth, 151.880 MHz

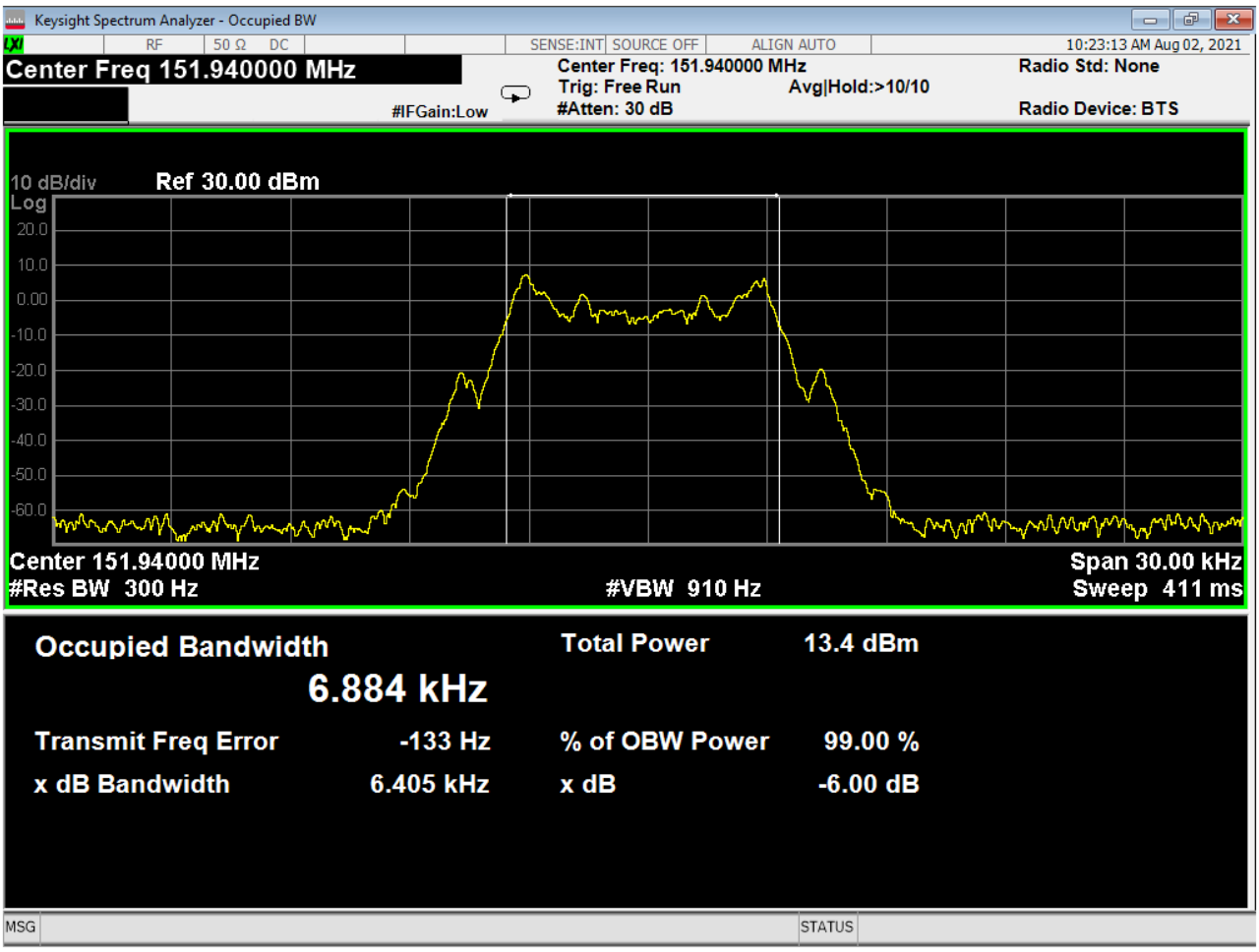


Figure 11 - Bandwidth, 151.940 MHz

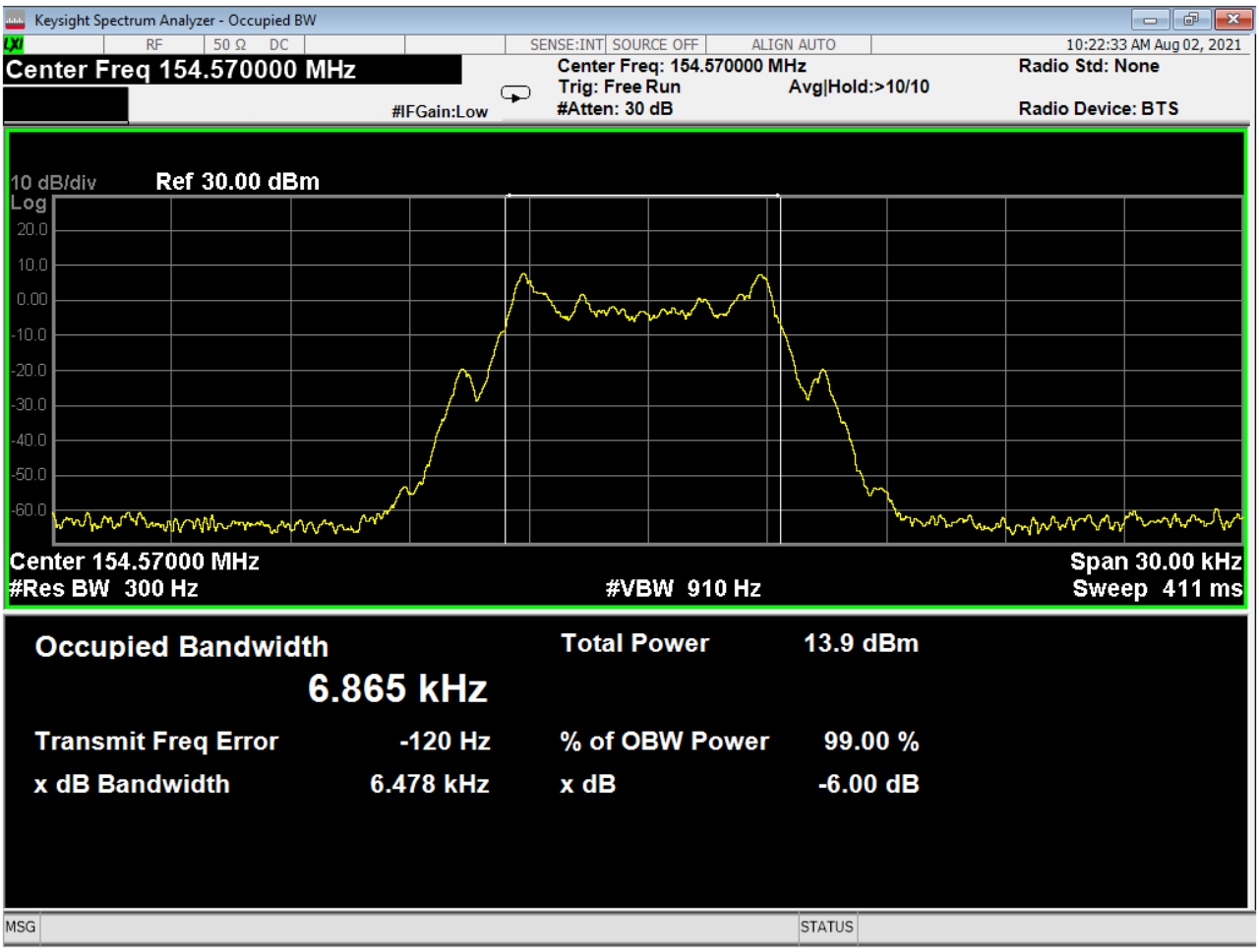


Figure 12 - Bandwidth, 154.570 MHz

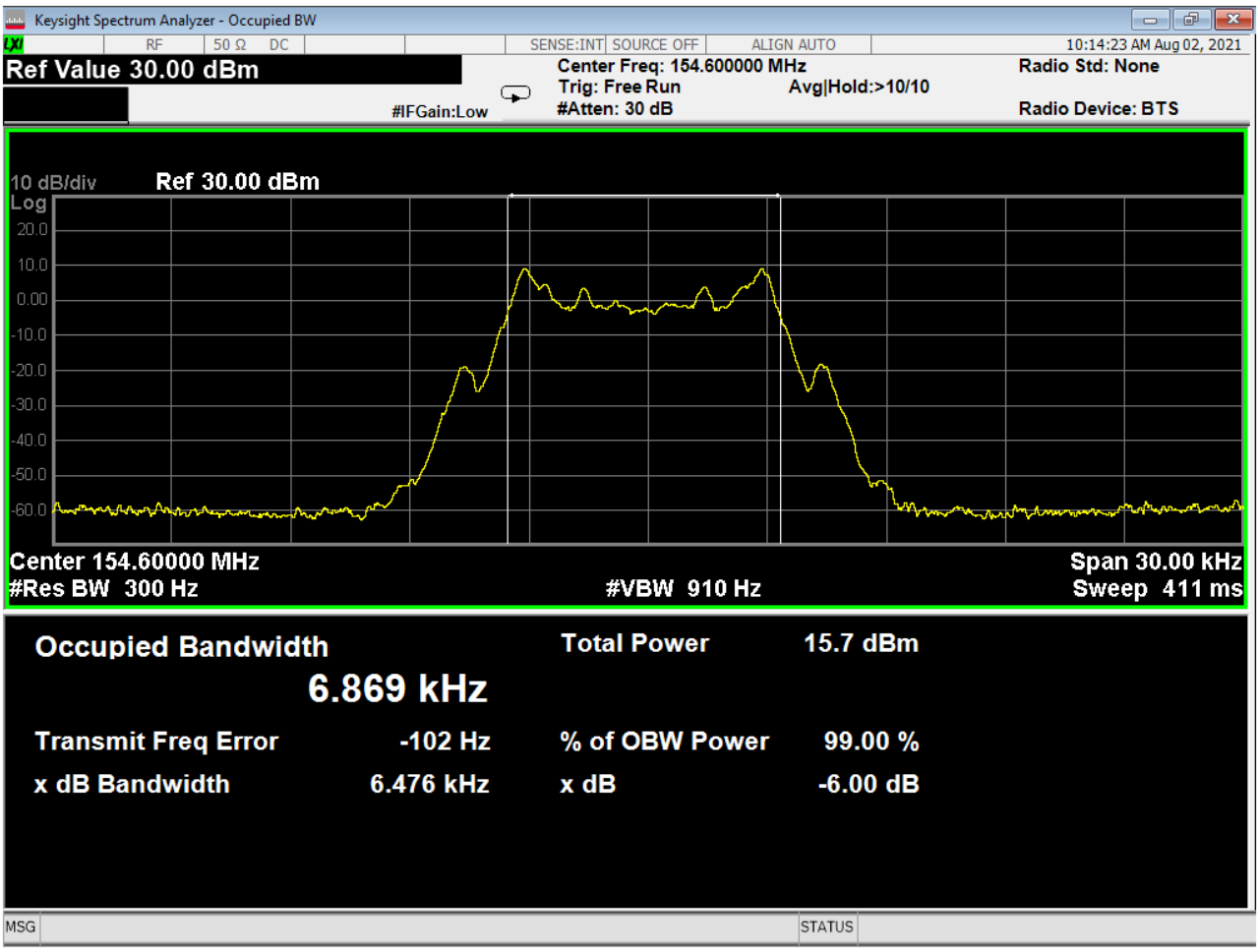


Figure 13 - Bandwidth, 154.600 MHz

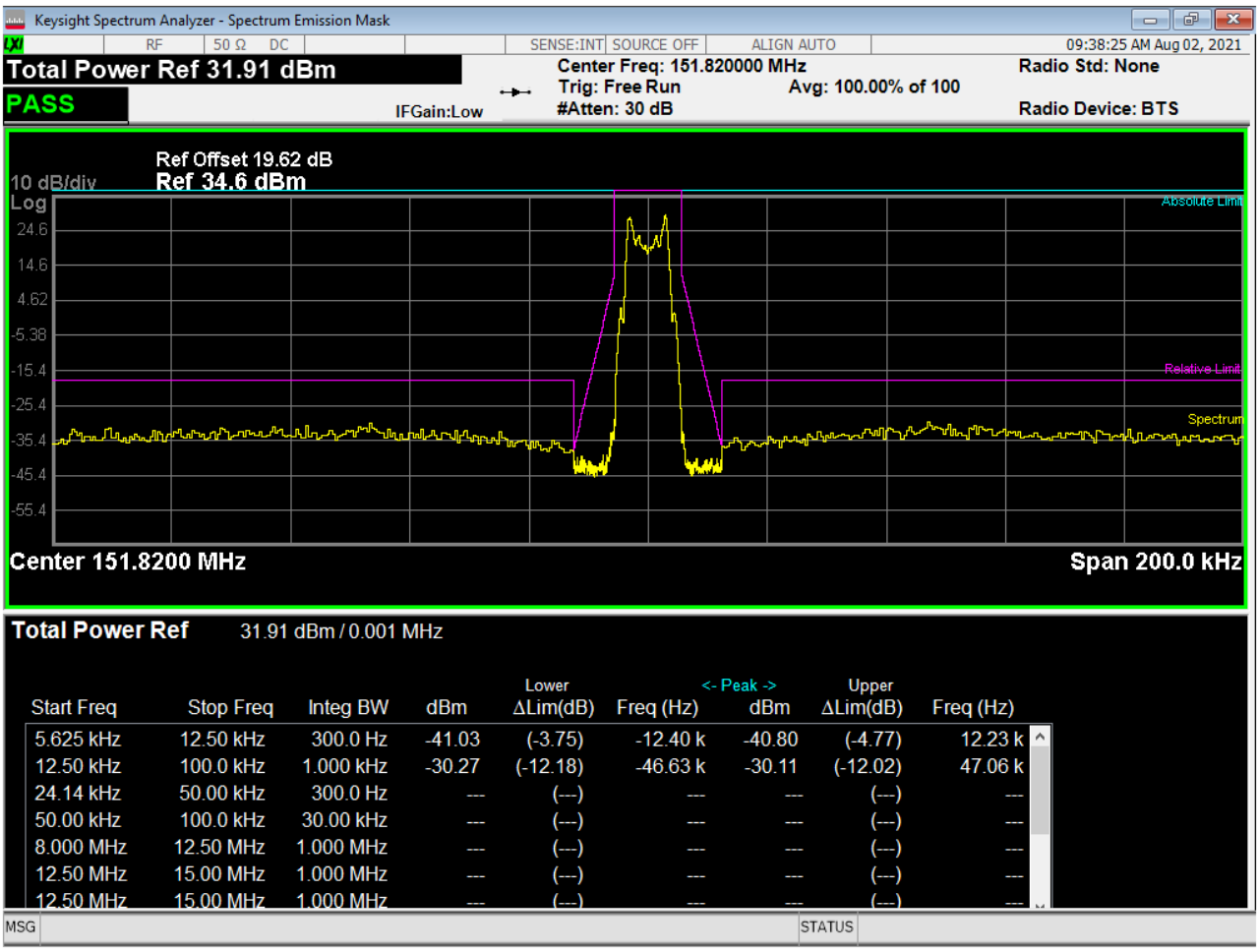


Figure 14 – Emissions Mask, 151.820 MHz

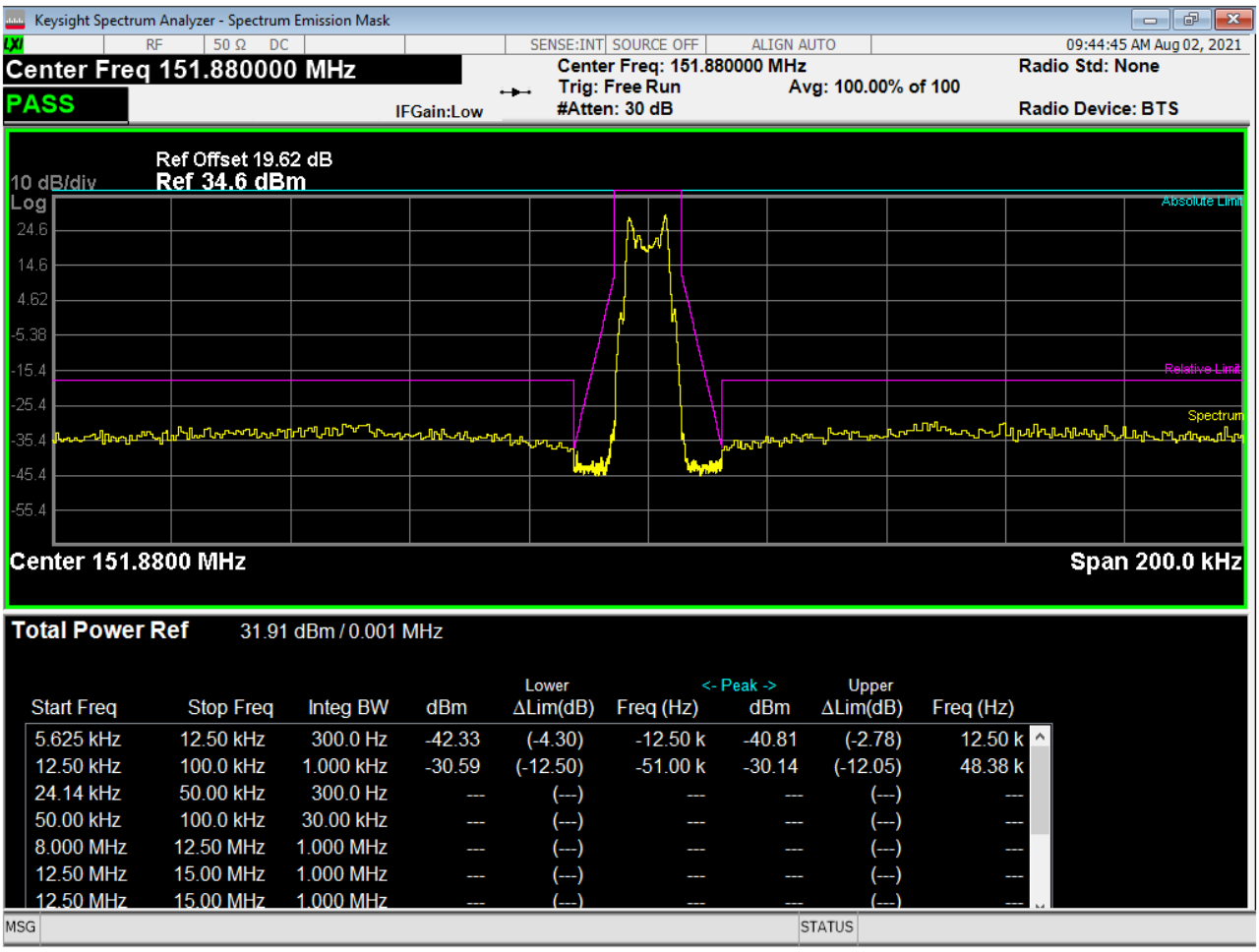


Figure 15 - Emissions Mask, 151.880 MHz

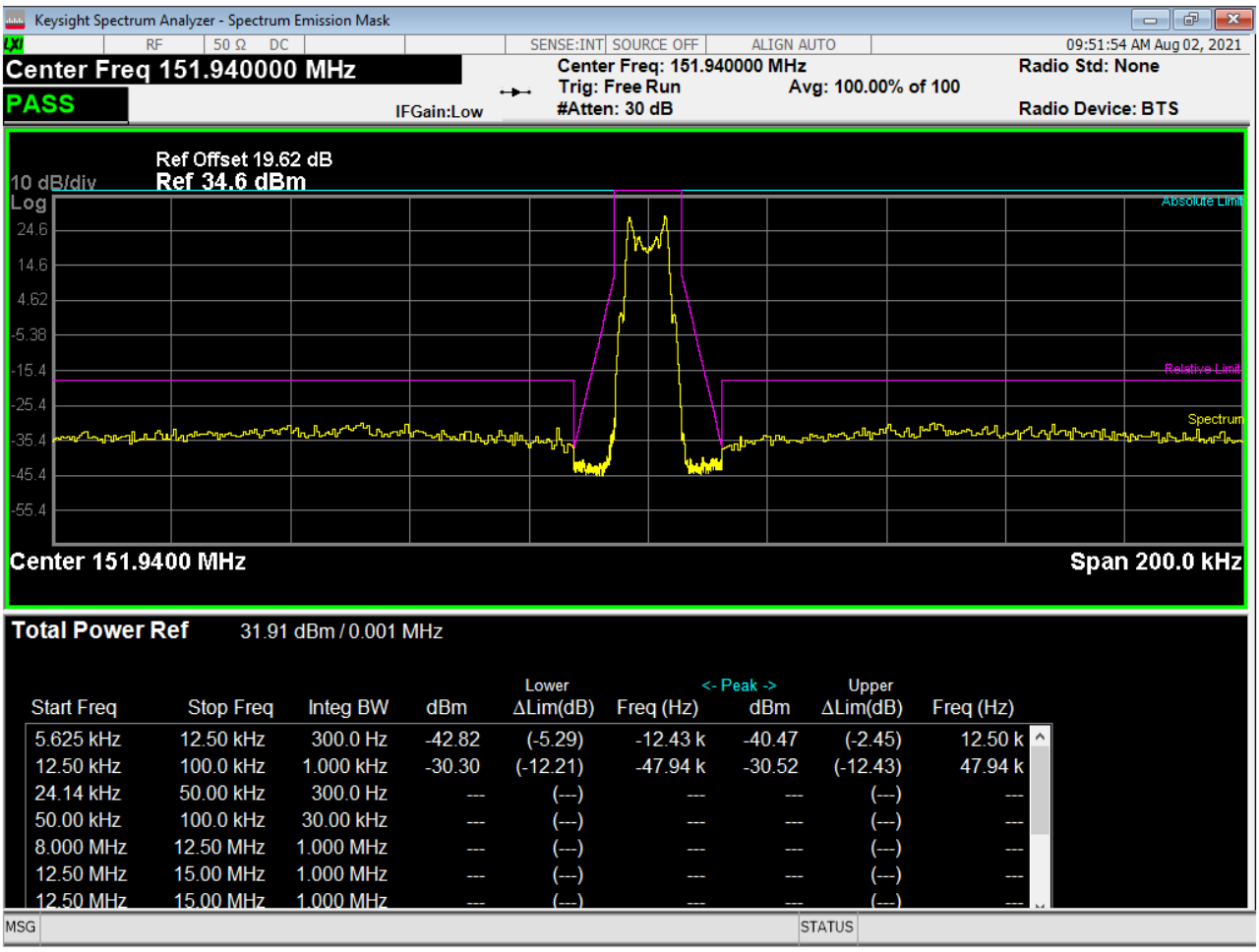
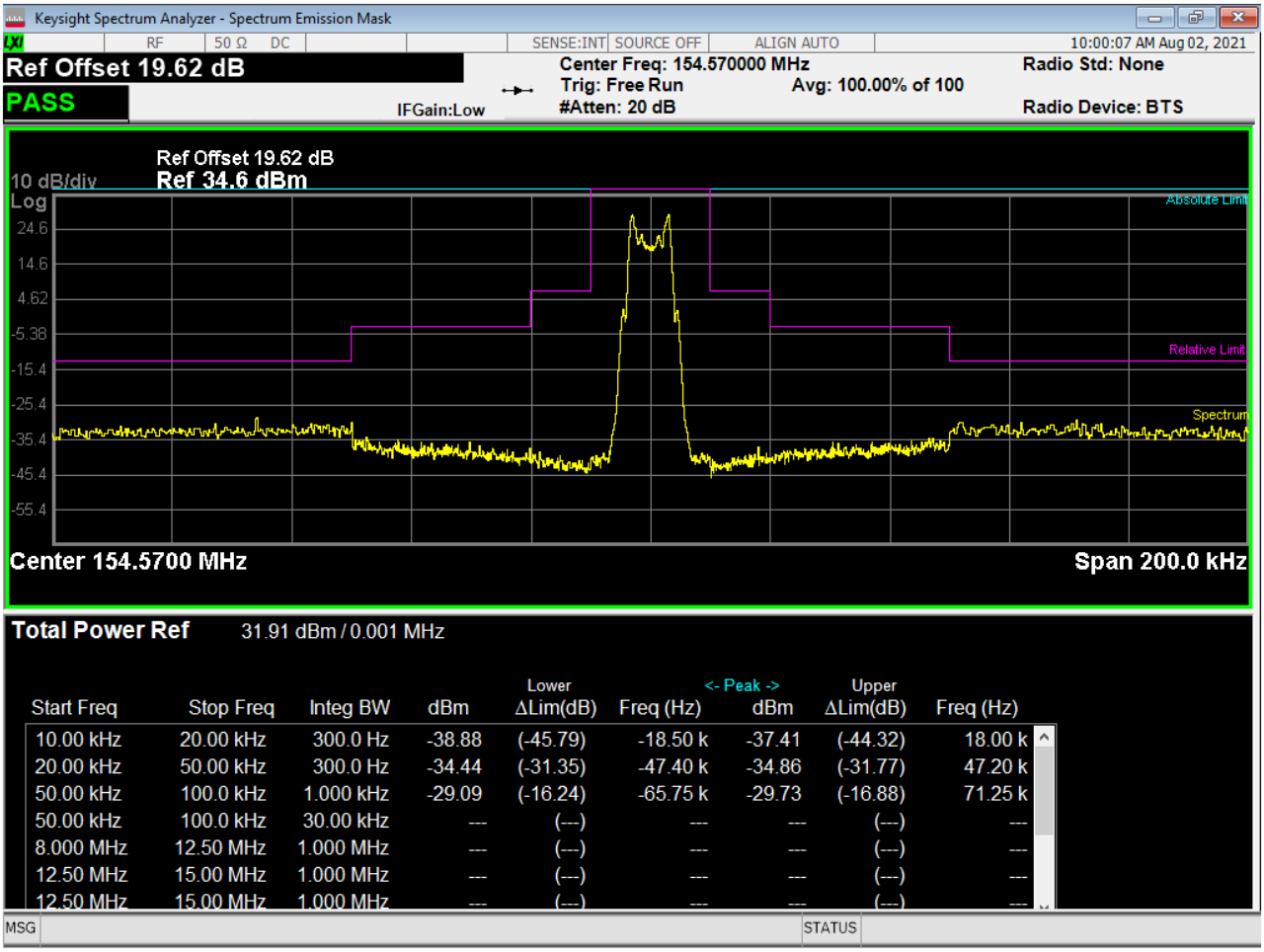


Figure 16 - Emissions Mask, 151.940 MHz



Start Freq	Stop Freq	Integ BW	dBm	Lower ΔLim(dB)	Lower Freq (Hz)	<- Peak -> dBm	Upper ΔLim(dB)	Upper Freq (Hz)
10.00 kHz	20.00 kHz	300.0 Hz	-38.88	(-45.79)	-18.50 k	-37.41	(-44.32)	18.00 k
20.00 kHz	50.00 kHz	300.0 Hz	-34.44	(-31.35)	-47.40 k	-34.86	(-31.77)	47.20 k
50.00 kHz	100.0 kHz	1.000 kHz	-29.09	(-16.24)	-65.75 k	-29.73	(-16.88)	71.25 k
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	---	(---)	---	---	(---)	---

Figure 17 - Emissions Mask, 154.570 MHz

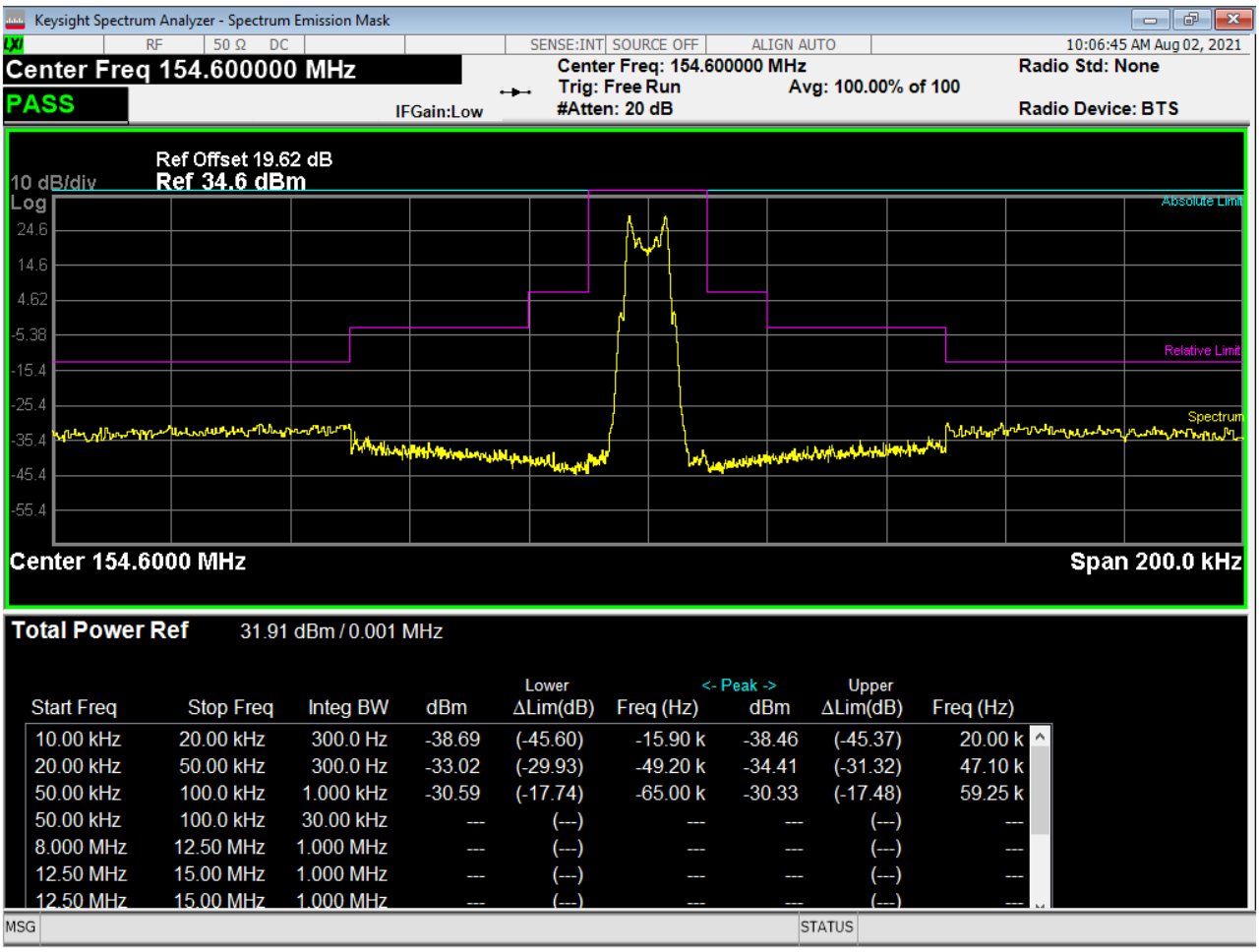


Figure 18 - Emissions Mask, 154.600 MHz

4.4 FREQUENCY STABILITY MEASUREMENTS

Test Method: ANSI C63.26,

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

Limits:
FCC Part 95.2765 MURS frequency accuracy:

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

(a) MURS transmitters that operate with an emission bandwidth of 6.25 kHz or less must be designed such that the carrier frequencies remain within ±2.0 parts-per-million (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 300 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:

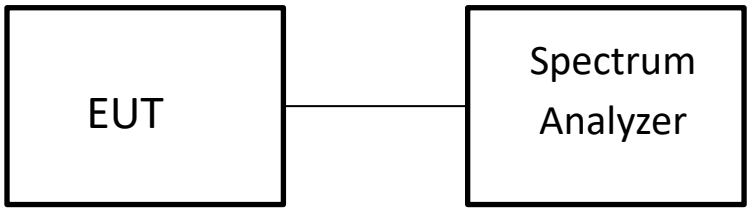


Figure 19 –Measurements Test Setup

EUT operating conditions:
EUT was connected to a laptop via micro-USB cable. Device was set to transmit in each of its five allocated frequencies.

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	81	59	68	43	76	68	93	120	117	303.640	5	Pass
151.9400	57	31	34	41	86	85	95	120	110	303.880	5	Pass
154.6000	24	151	46	55	76	90	94	122	116	309.200	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	±3.82 dB
Radiated Emissions, 3m	1GHz - 18GHz	±4.44 dB
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB
Antenna port conducted	9 kHz – 25 GHz	±0.50 dB

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

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

REPORT END