TEST REPORT

Product Name : GNSS Receiver
Model Number : N5
FCC ID : 2ACHBN5

Prepared for	:	ComNav Technology Ltd.
Address	:	Building 2, No.618 Chengliu Middle Rd.,Shanghai,China
Prepared by	:	EMTEK (SHENZHEN) CO., LTD.
Address	:	Building 69, Majialong Industry Zone, Nanshan District, Shenzhen, Guangdong, China Tel: (0755) 26954280 Fax: (0755) 26954282
Report Number	:	ES200928051W04
Date(s) of Tests	:	October 20, 2020 to March 10, 2021
Date of issue	:	March 11, 2021

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1 TEST RESULT CERTIFICATION

Applicant	:	ComNav Technology Ltd.
Address	:	Building 2, No.618 Chengliu Middle Rd.,Shanghai,China
Manufacturer	:	ComNav Technology Ltd.
Address	:	Building 2, No.618 Chengliu Middle Rd.,Shanghai,China
Trade Mark	:	N/A
EUT	:	GNSS Receiver
Model Number	:	N5

Measurement Procedure Used:

APPLICABLE STANDARDS	
STANDARD	**TEST RESULT**
FCC 47 CFR Part 2 and Part 90	PASS

The above equipment was tested by EMTEK (SHENZHEN) CO., LTD. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.4 (2014) and ANSI/TIA-603-E: 2016 the energy emitted by the sample EUT tested as described in this report is in compliance with the requirements of Part 2 and Part 90

The test results of this report relate only to the tested sample identified in this report

Date of Test : October 20, 2020 to March 10, 2021

Prepared by : Sewen Guo /Editor

Reviewer : Joe Xia/Editor

Approve & Authorized Signer : Lisa Wang/Manager

2 EUT TECHNICAL DESCRIPTION

Product:	GNSS Receiver
Model Number:	N5
Sample number:	2#
Frequency Range:	410.0250MHz to 469.9750MHz
Type of Modulation:	GMSK
Channel Spacing:	12.5 kHz
Rating RF Power:	High: 31.84dBm Low: 28.86dBm
Antenna:	External Rod Antenna Note: Contain three antenna , Each antenna corresponds to a different frequency, and each antenna can only be used alone;
Antenna Gain:	4.0 dBi
Power Supply:	DC14.8V from battery
Battery:	Model:HNB34 2*DC7.4V, 3400mAh,25.1Wh
Adapter:	Model: BI36-120300-I Input:AC100-240V,50/60Hz,1.2A Output:DC12.0V,3.0A
Date of Received:	October 11, 2020
Temperature Range:	-40°C ~ 65°C

Note: *for more details, please refer to the User's manual of the EUT.*

3 SUMMARY OF TEST RESULT

FCC Part Clause	Test Parameter	Verdict	Remark
Part 2.104; Part 22.727; Part 74.461; Part 80.215; Part 90.205	RF Output Power	PASS	
Part 2.1047, Part 90.207	Modulation Characteristic	PASS	
Part 2.1049; Part 22.357; Part 22.731; Part 74.462; Part 80.205; Part 80.207 Part 90.209; Part 90.210	Occupied Bandwidth & Emission Mask	PASS	
Part 2.1051; Part 22.861; Part 74.462; Part 80.211; Part 90.210	Spurious Emission at Antenna Terminal	PASS	
Part 2.1053; Part 22.861; Part 74.462; Part 80.211; Part 90.210	Spurious Radiated Emissions	PASS	
Part 2.1055; Part 22.355; Part 74.464; Part 80.209; Part 90.213	Frequency Stability	PASS	
NOTE1: N/A (Not Applicable)			

RELATED SUBMITTAL(S) / GRANT(S):

This submittal(s) (test report) is intended for FCC ID: 2ACHBN5 filing to comply with of the FCC Part 2 and Part 90

4 TEST METHODOLOGY

4.1 GENERAL DESCRIPTION OF APPLIED STANDARDS

All tests and measurements indicated in this document were performed in accordance with the Code of federal Regulations Title 47 Part 2, Sub-part J as well as the following individual parts:

Part 90 – Private Land Mobile Radio Service

Applicable Standards: ANSI/TIA-603-E: 2016 and ANSI C63.4-2014.

4.2 MEASUREMENT EQUIPMENT USED

4.2.1 Radiated Emission Test Equipment

Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
EMI Test Receiver	Rohde & Schwarz	ESU 26	100154	May 17, 2020	1 Year
Pre-Amplifie	Lunar EM	LNA30M3G-25	J10100000070	May 17, 2020	1 Year
Bilog Antenna	Schwarzbeck	VULB9163	659	Sep 22, 2019	2 Year
Horn antenna	Schwarzbeck	BBHA9120D	9120D-1177	May 17, 2020	2 Year
Pre-Amplifie	SKET	LNPA_0118G-45	SK2019051801	May 17, 2020	1 Year
Loop Antenna	Schwarzbeck	FMZB1519	1519-012	July 14, 2019	2 Year
Spectrum Analyzer	Rohde & Schwarz	FSV40	100967	May 17, 2020	1 Year
Horn antenna	Schwarzbeck	BBHA9120D	9120D-1198	May 17, 2020	2 Year
Bilog Antenna	Schwarzbeck	VULB9163	660	July 16, 2019	2 Year
Cable	H+B	NmSm-05-C15052	N/A	May 17, 2020	1 Year
Cable	H+B	NmSm-2-C15201	N/A	May 17, 2020	1 Year
Cable	H+B	NmNm-7-C15702	N/A	May 17, 2020	1 Year
Cable	H+B	SAC-40G-1	414	May 17, 2020	1 Year
Cable	H+B	SUCOFLEX104	MY14871/4	May 17, 2020	
Cable	H+B	BLU18A-NmSm-6500	D8501	May 17, 2020	1 Year
Band reject Filter(50dB)	WI/DE	WRCGV-2400(2400-2485MHz)	2	May 17, 2020	1 Year

4.2.2 Radio Frequency Test Equipment

Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
Vector Signal Generater	Agilent	N5182B	My53050553	May 19, 2020	1 Year
Analog Signal Generator	Agilent	N5171B	My53050878	May 19, 2020	1 Year
Signal Analyzer	Agilent	N9010A	My53470879	May 19, 2020	1 Year
Power Analyzer	Agilent	PS-X10-200	N/A	May 19, 2020	1 Year
Wideband Radio Communication Tester	R&S	CMW500	1201.0002K50-140822zk	May 19, 2020	1 Year
Test Accessories	Agilent	PS-X10-100	N/A	May 19, 2020	1 Year
Temperature&Humidity test chamber	ESPEC	EL-02KA	12107166	May 19, 2020	1 Year

Blocking Box	Agilent	AD211	N/A	May 19, 2020	1 Year
Spectrum Analyzer	Rohde & Schwarz	FSV40	100967	May 19, 2020	1 Year
Cell site test set	Hewlett packard	8921A	3524A02336	May 19, 2020	1 Year

Remark: *Each piece of equipment is scheduled for calibration once a year.*

4.3 DESCRIPTION OF TEST MODES

The EUT has been tested under its typical operating condition.
The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

The Transmitter was operated in the normal operating mode. The TX frequency was fixed which was for the purpose of the measurements.

Test of channel included the lowest and middle and highest frequency to perform the test, then record on this report.

Test Frequency :

Test Frequency and Channel:

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
410.0250	440.0500	469.9750

Note: In this report
Normal Means Tnorm (℃)=25 and Vnorm=DC 14.8V;
L.V. means Vmin=DC 9V; H.V. means Vmax=DC 36V;
L.T. means Tmin(℃)= -40℃; H.T. means Tmax(℃)= 65℃;

4.4 TEST SOFTWARE

Item		Software
Conducted Emission	:	EMTEK(Ver.CON-03A1)-Shenzhen
Radiated Emission	:	EMTEK(Ver.RA-03A1)-Shenzhen

5 FACILITIES AND ACCREDITATIONS

5.1 FACILITIES

All measurement facilities used to collect the measurement data are located at

Building 69, Majialong Industry Zone District, Nanshan District, Shenzhen, China
The sites are constructed in conformance with the requirements of ANSI C63.7, ANSI C63.10 and CISPR Publication 22.

5.2 LABORATORY ACCREDITATIONS AND LISTINGS

Site Description		
EMC Lab.	:	**Accredited by CNAS** The Certificate Registration Number is L2291. The Laboratory has been assessed and proved to be in compliance with CNAS-CL01 (identical to ISO/IEC 17025:2017) **Accredited by FCC** Designation Number: CN1204 Test Firm Registration Number: 882943 **Accredited by A2LA** The Certificate Number is 4321.01. **Accredited by Industry Canada** The Conformity Assessment Body Identifier is CN0008
Name of Firm	:	EMTEK(SHENZHEN) CO., LTD.
Site Location	:	Building 69, Majialong Industry Zone, Nanshan District, Shenzhen, Guangdong, China

6 TEST SYSTEM UNCERTAINTY

The following measurement uncertainty levels have been estimated for tests performed on the apparatus:

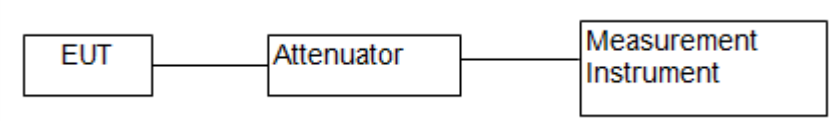
Parameter	Uncertainty
Radio Frequency	±1x10^-5
Maximum Peak Output Power Test	±1.0dB
Conducted Emissions Test	±2.0dB
Radiated Emission Test	±2.0dB
Occupied Bandwidth Test	±1.0dB
Band Edge Test	±3dB
All emission, radiated	±3dB
Antenna Port Emission	±3dB
Temperature	±0.5℃
Humidity	±3%

Measurement Uncertainty for a level of Confidence of 95%

7 SETUP OF EQUIPMENT UNDER TEST

7.1 RADIO FREQUENCY TEST SETUP 1

The component's antenna ports(s) of the EUT are connected to the measurement instrument per an appropriate attenuator. The EUT is controlled by PC/software to emit the specified signals for the purpose of measurements.



7.2 RADIO FREQUENCY TEST SETUP 2

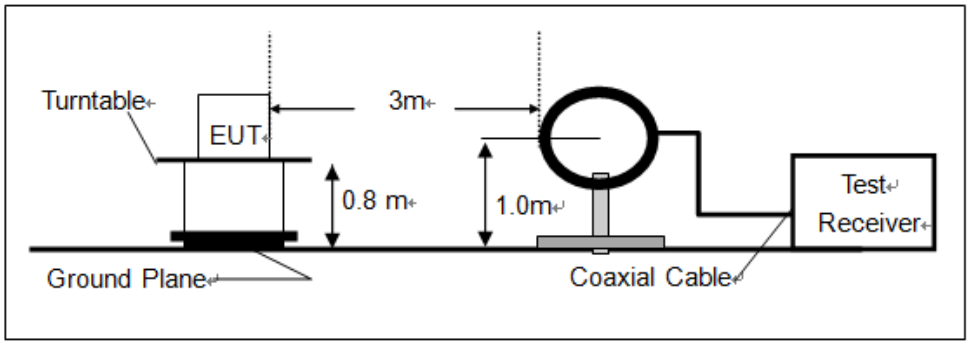
The test site semi-anechoic chamber has met the requirement of NSA tolerance 4 dB according to the standards: ANSI C63.10. The test distance is 3m.The setup is according to the requirements in Section 13.1.4.1 of ANSI C63.10-2013 and CAN/CSA-CEI/IEC CISPR 22.

Below 30MHz：
The EUT is placed on a turntable 0.8meters above the ground in the chamber, 3 meter away from the antenna (loop antenna). The Antenna should be positioned with its plane vertical at the specified distance from the EUT and rotated about its vertical axis for maximum response at each azimuth about the EUT. The center of the loop shall be 1 m above the ground. For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT.

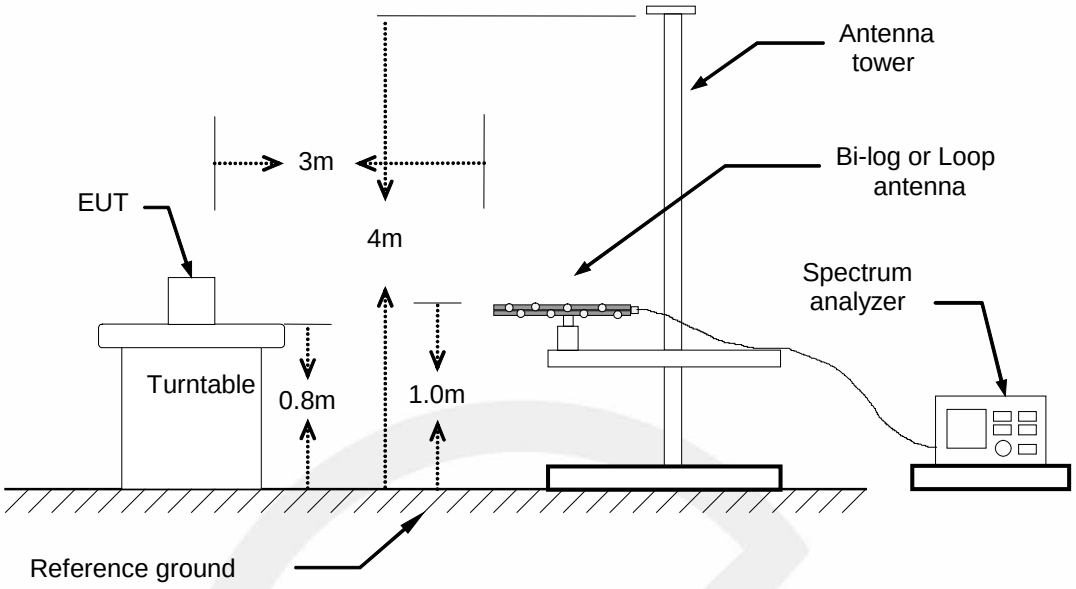
Above 30MHz：
The EUT is placed on a turntable 0.8meters above the ground in the chamber, 3 meter away from the antenna. The maximal emission value is acquired by adjusting the antenna height, polarisation and turntable azimuth. Normally, the height range of antenna is 1 m to 4 m, the azimuth range of turntable is 0° to 360°, and the receive antenna has two polarizations Vertical (V) and Horizontal (H).

Above 1GHz:
(Note: the FCC's permission to use 1.5m as an alternative per TCBC Conf call of Dec. 2, 2014.)
The EUT is placed on a turntable 1.5 meters above the ground in the chamber, 3 meter away from the antenna. The maximal emission value is acquired by adjusting the antenna height, polarisation and turntable azimuth. Normally, the height range of antenna is 1 m to 4 m, the azimuth range of turntable is 0° to 360°, and the receive antenna has two polarizations Vertical (V) and Horizontal (H).

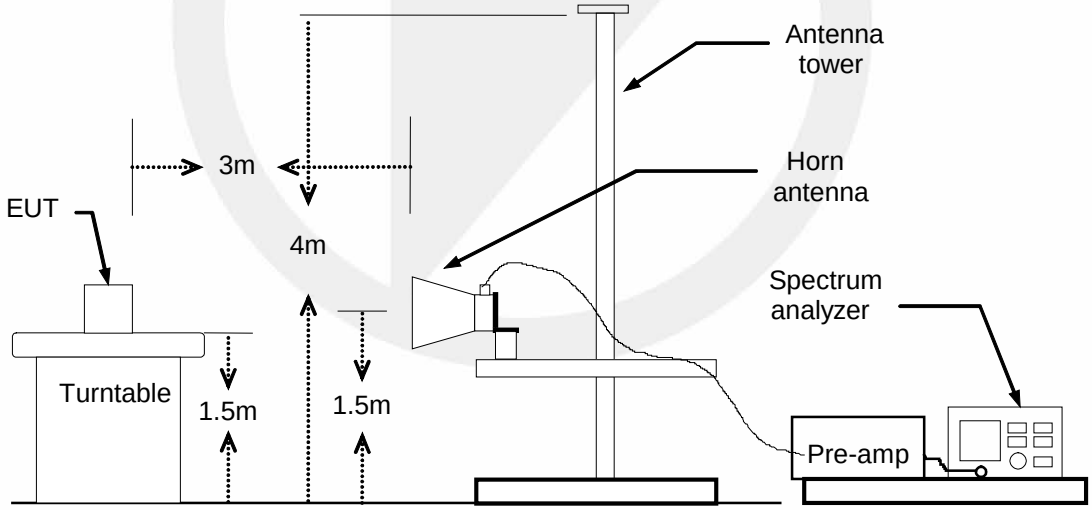
(a) Radiated Emission Test Set-Up, Frequency Below 30MHz



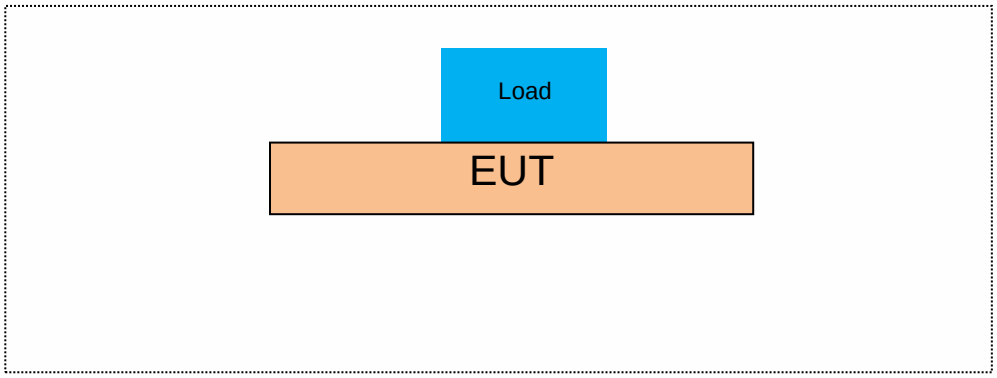
(b) Radiated Emission Test Set-Up, Frequency Below 1000MHz



(c) Radiated Emission Test Set-Up, Frequency above 1000MHz



7.3 BLOCK DIAGRAM CONFIGURATION OF TEST SYSTEM



7.4 SUPPORT EQUIPMENT

EUT Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Auxiliary Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Auxiliary Equipment List and Details			
Description	Manufacturer	Model	Serial Number
/	load	100W/50Ohm	/

Notes:

1. *All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.*
2. *Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.*

8 TEST REQUIREMENTS

8.1 RF OUTPUT POWER

8.1.1 Applicable Standard

According to FCC part 2.1046, part 90.205

8.1.2 Test Configuration

Test according to clause 7.1 radio frequency test setup 1

8.1.3 Test Procedure

1. The maximum peak output power was measured with a Spectrum Analyzer connected to the antenna terminal while EUT was operating in unmodulated situation.

2. Connect a spectrum analyzer, using a quasi peak detector, meeting the requirements of IEC CISPR Publication 16, (through a resistive matching network if required to match the receiver input impedance Rn to the spectrum analyzer) to the receiver antenna terminals.

3. The RF output of the transmitter was connected to the input of the spectrum analyzer through sufficient attenuation
Set to the maximum power setting and enable the EUT transmit continuously
Set RBW = 100 kHz.
Set the video bandwidth (VBW) =300kHz.
Set Span=2 times OBW
Set Detector = Peak.
Set Trace mode = max hold.
Set Sweep = auto couple.
Allow the trace to stabilize.

Measure and record the results in the test report.

8.1.4 Test Results

Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

Modulation Mode	Channel Separation (kHz)	Frequency (MHz)	Power Level	Conducted Output Power (dBm)	Conducted Output Power (W)
Digtal / GMSK	12.5	410.0250	High	31.43	1.39
			Low	28.65	0.73
		440.0500	High	31.35	1.36
			Low	28.86	0.77
		450.0250	High	31.27	1.34
			Low	28.40	0.69
		458.0250	High	31.35	1.36
			Low	28.26	0.67
		469.9750	High	31.84	1.53
			Low	27.89	0.62

Note：The rated high power is 2.0W.
The rated low power is 0.5W.

8.2 OCCUPIED BANDWIDTH & EMISSION MASK

8.2.1 Applicable Standard

According to FCC part 2.1049, part 90.209 and part 90.210

8.2.2 Conformance Limit

(b) Emission Mask B. For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:
(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.
(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

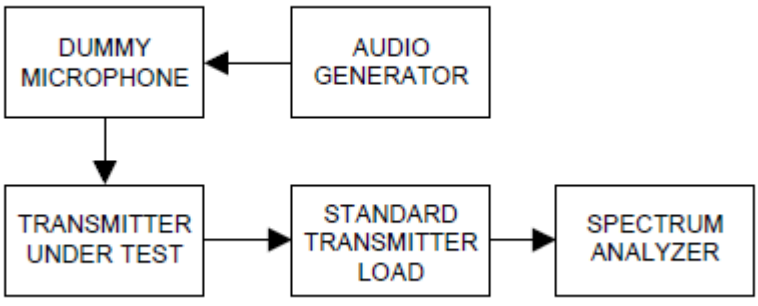
(d) Emission Mask D. channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:
(1) On any frequency from the center of the authorized bandwidth f0 to 5.625 kHz removed from f0: Zero dB.
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(fd−2.88 kHz) dB.
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

8.2.3 Test Configuration

Test according to clause 7.1 radio frequency test setup 1

8.2.4 Test Procedure

Test is carried out under the procedure of ANSI/TIA-603-E: 2016,2.2.11



a) Connect the equipment as illustrated. Use the table 17 to determine the spectrum analyzer resolution bandwidth:

Table 17 - Spectrum Analyzer Resolution Bandwidth

Frequency Band (MHz)	Mask for Equipment with Audio Low Pass Filter	Mask for Equipment without Low Pass Filter	Spectrum Analyzer Resolution Bandwidth (Hz)
25-50	B	C	300
72-76	B	C	300
138-174	NTIA	NTIA	300
150-174	B	C	300
150-174	D or E	D or E	100
380-420	NTIA	NTIA	300
421-512	B	C	300
421-512	D or E	D or E	100
809-824/854-869	B or EA	G or EA	300
806-809/851-854	B	H	300
896-901/935-940	I	J	300

b) Adjust the spectrum analyzer for the following settings:
1) Resolution Bandwidth per the above table.
2) Video Bandwidth at least 10 times the resolution bandwidth.
3) Sweep Speed slow enough to maintain measurement calibration.
4) Detector Mode = Positive Peak.
5) Span that will allow proper viewing of the test bandwidth (see 1.3.4.4).
c) Set the center frequency of the spectrum analyzer to the assigned transmitter frequency. Key the transmitter, and set the level of the unmodulated carrier to a full scale reference line. This is the 0 dB reference for the measurement.
d) Modulate the transmitter with a 2500 Hz sine wave at an input level 16 dB greater than that necessary to produce 50% of rated system deviation. The input level shall be established at the frequency of maximum response of the audio modulating circuit. Transmitters employing digital modulation techniques that bypass the limiter and the audio low-pass filter shall be modulated as specified by the manufacturer.

e) Record the resulting spectrum analyzer presentation of the emission level with an on-line recording evice or in a photograph. It is recommended that the emission limit (as given in 3.2.11) be drawn on the plotted graph or photograph. The spectrum analyzer presentation is the sideband spectrum.

8.2.5 Test Results

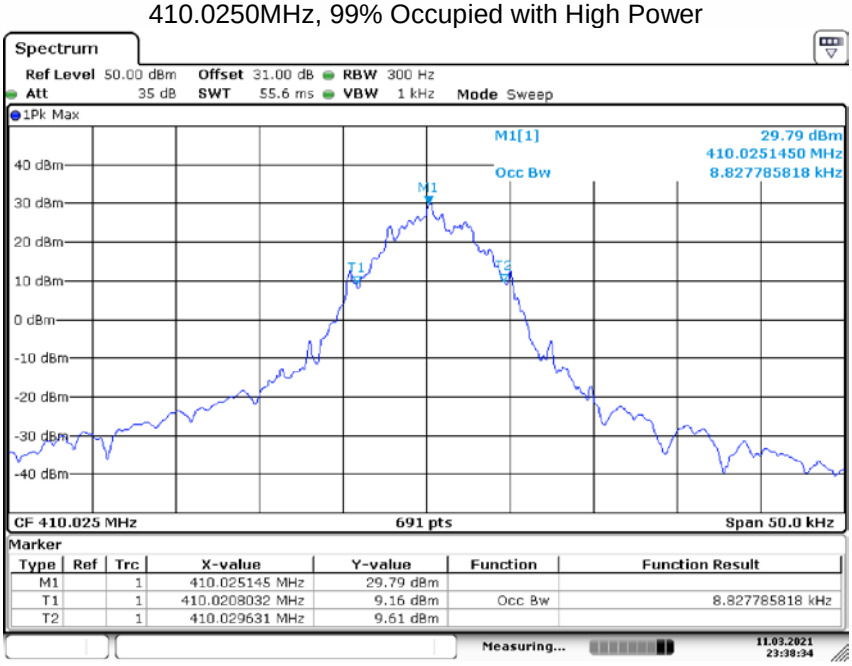
Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

Modulation Mode	Channel Separation (kHz)	Frequency (MHz)	Power Level	99% Occupied Bandwidth (kHz)	26 dB Bandwidth (kHz)
Digtal / GMSK	12.5	410.0250	High	8.827	10.275
			Low	9.406	10.420
		440.0500	High	9.406	10.709
			Low	9.479	10.564
		469.9750	High	9.551	10.781
			Low	9.623	10.709

Note: Emission bandwidth was based on calculation method instead of measurement. Emission Designator
Per CFR 47 §2.201& §2.202, BW = 2M + 2D

For Digital Mode (Channel Spacing: 12.5 kHz)
Emission Designator 9K60F1D and 9K60F1E
The 99% energy rule (title 47CFR 2.1049) was used for digital mode. It basically states that 99% of the modulation energy falls within X kHz, in this case, 9.60 kHz. The emission mask was obtained from 47CFR 90.210(d).
F1D and F1E portion of the designator indicates digital information.
Therefore, the entire designator for 12.5 kHz channel spacing digital mode is 9K60F1D and 9K60F1E.

410.0250MHz, 99% Occupied with High Power



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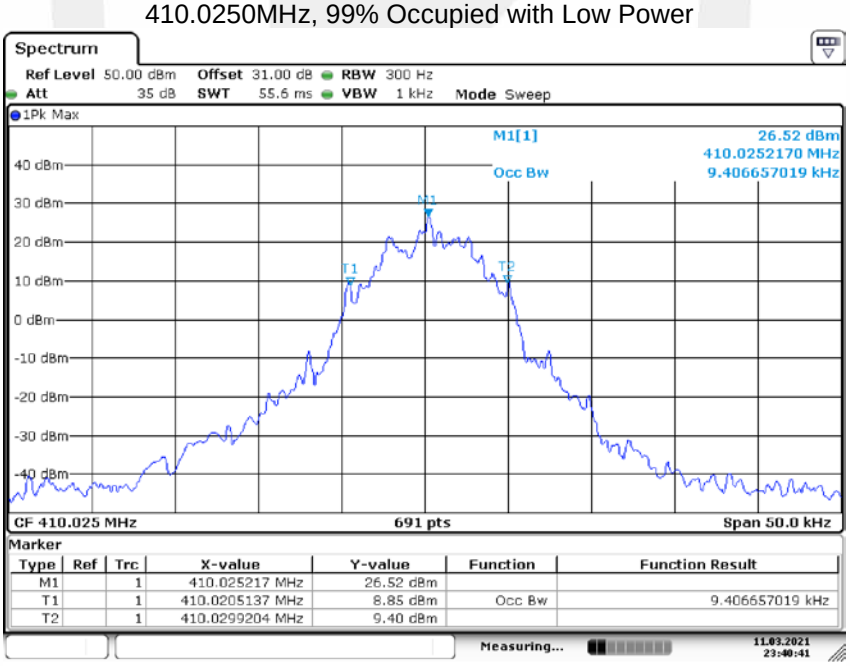
410.0250MHz, 99% Occupied with Low Power



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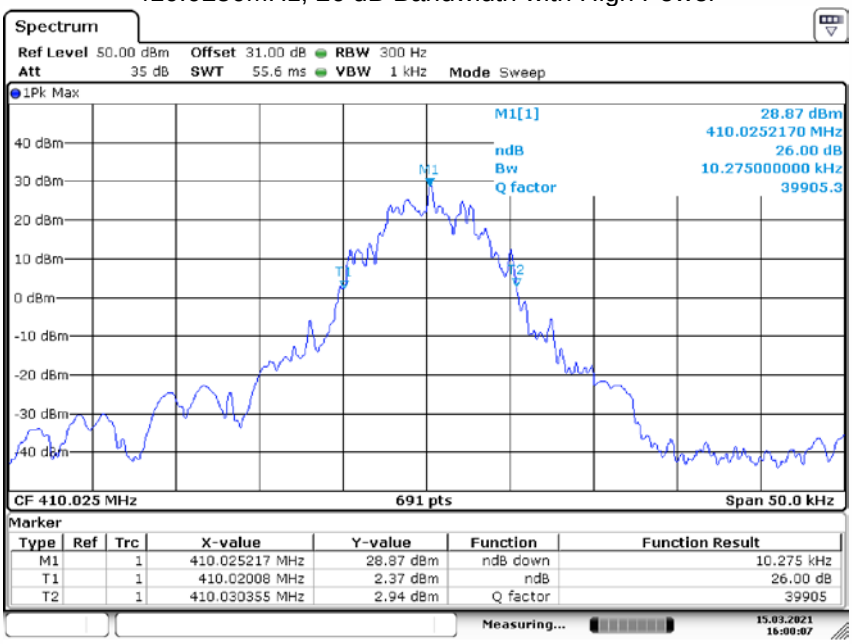
410.0250MHz, 26 dB Bandwidth with High Power



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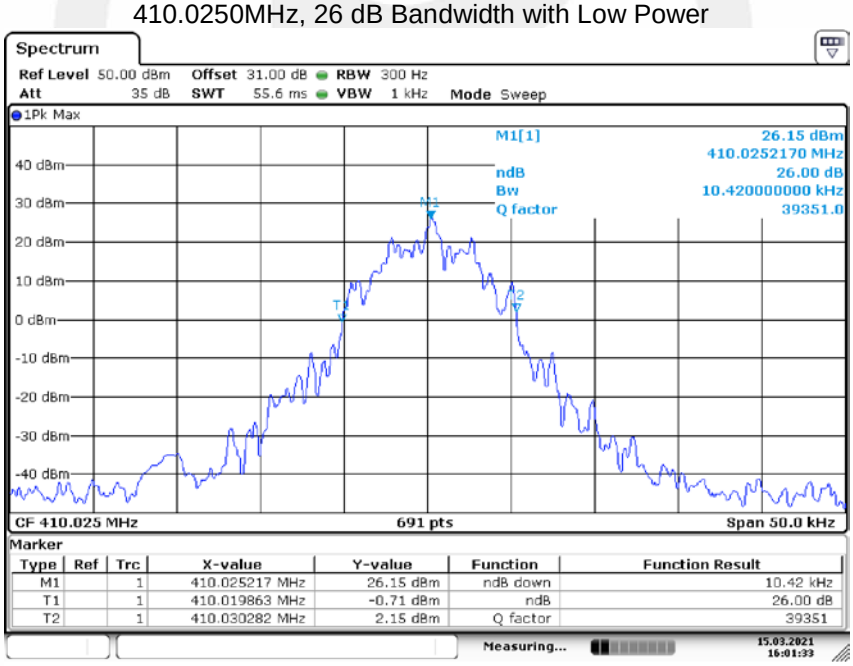
410.0250MHz, 26 dB Bandwidth with Low Power



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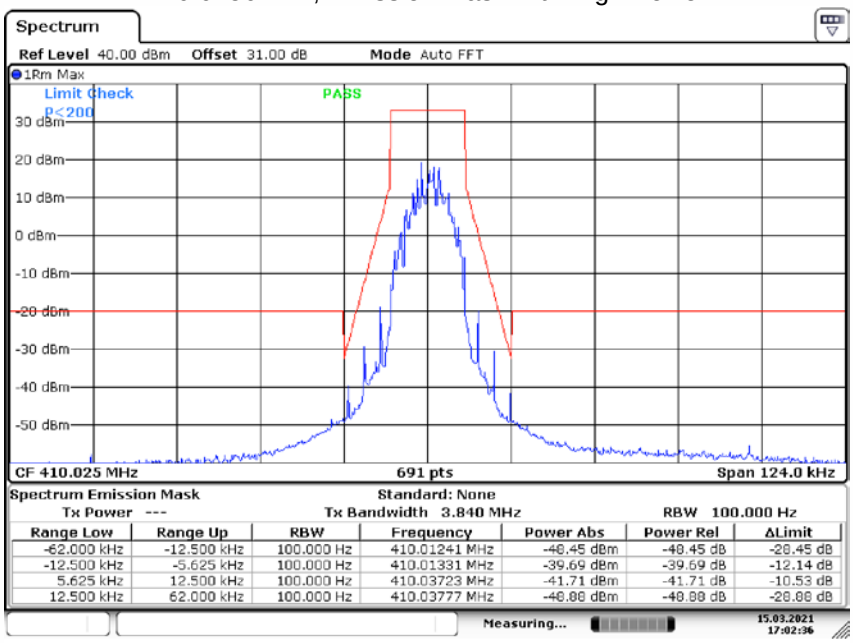
410.0250MHz, Emission Mask with High Power



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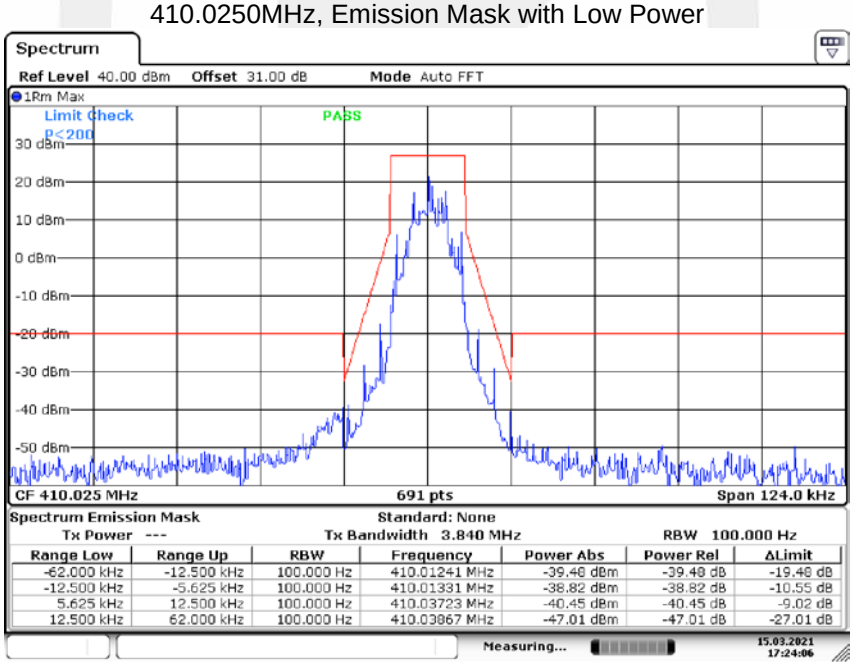
410.0250MHz, Emission Mask with Low Power



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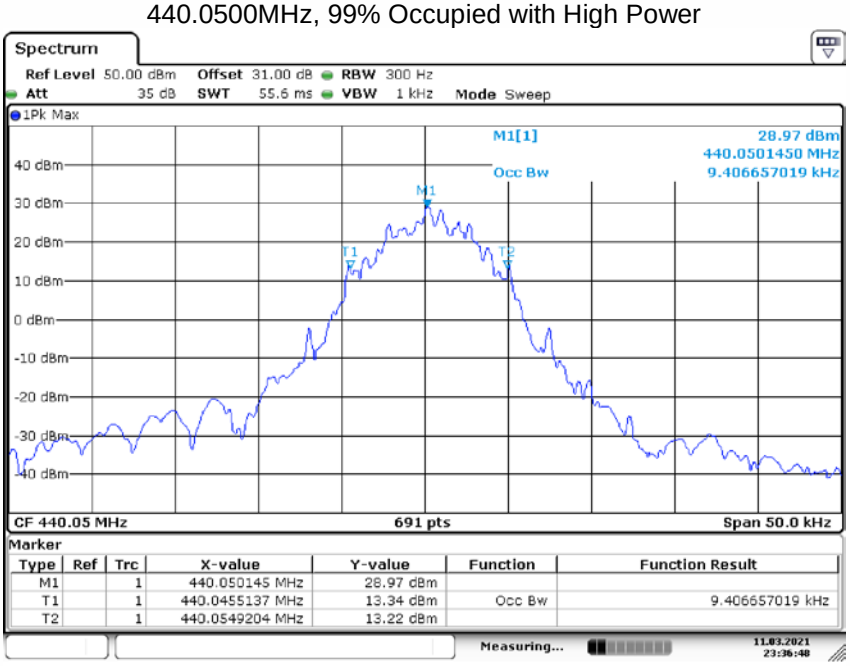
440.0500MHz, 99% Occupied with High Power



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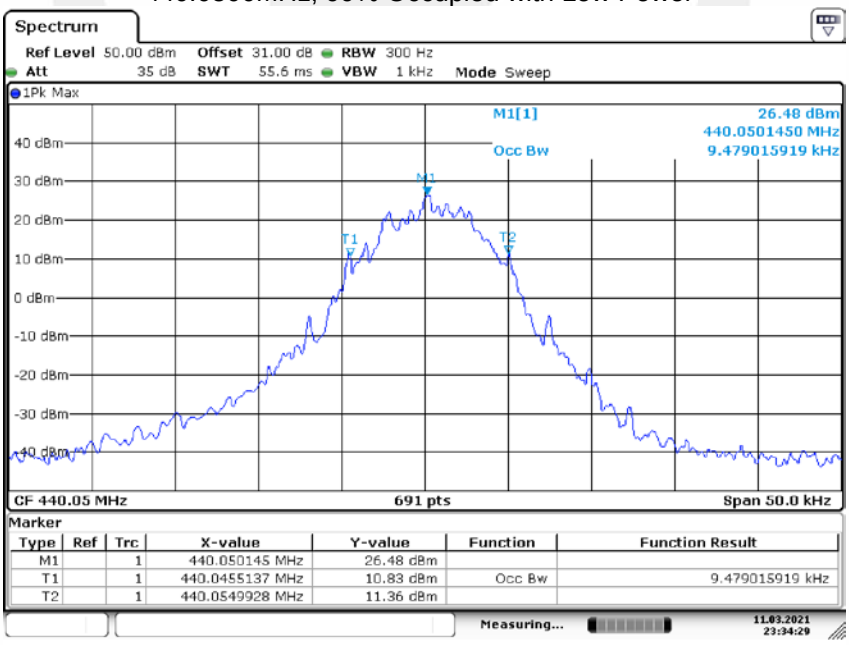
440.0500MHz, 99% Occupied with Low Power



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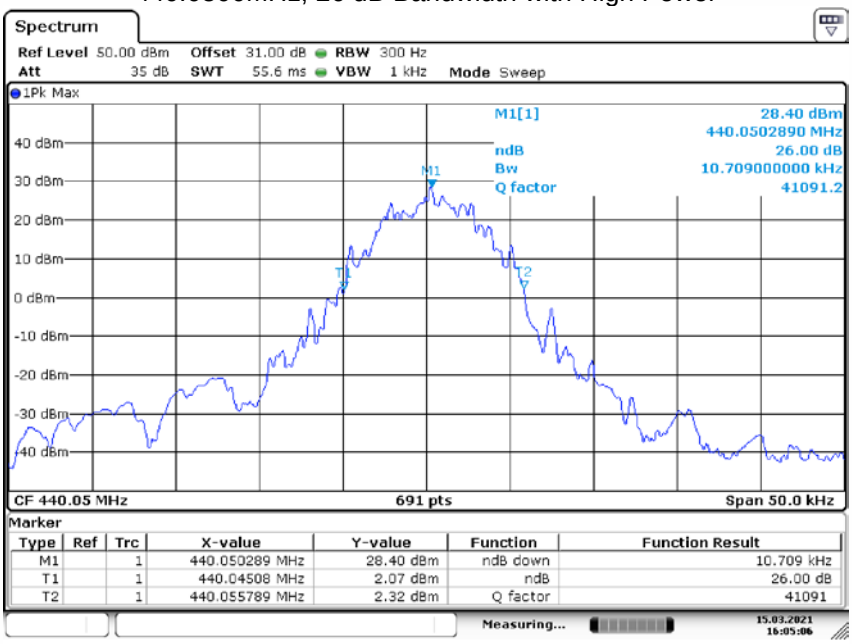
440.0500MHz, 26 dB Bandwidth with High Power



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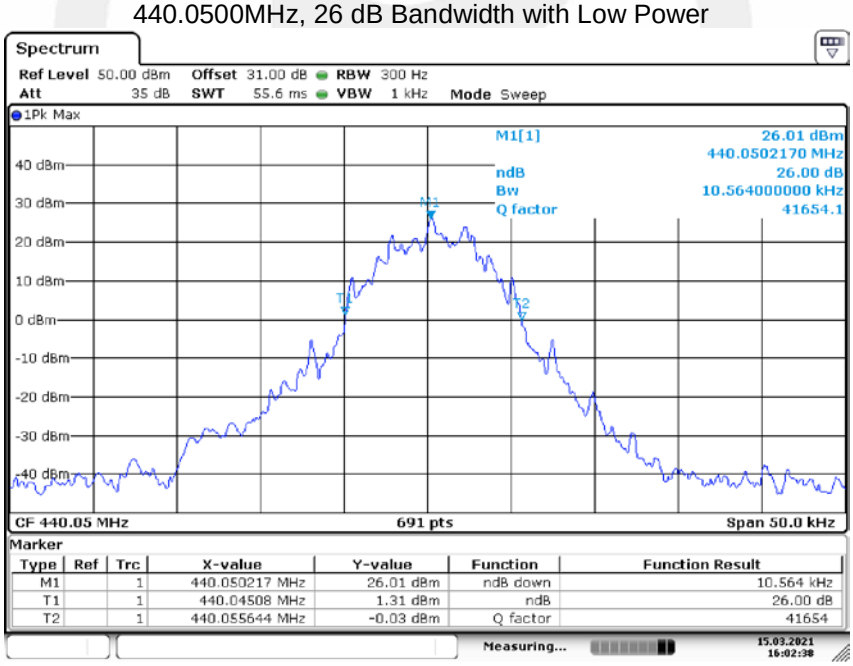

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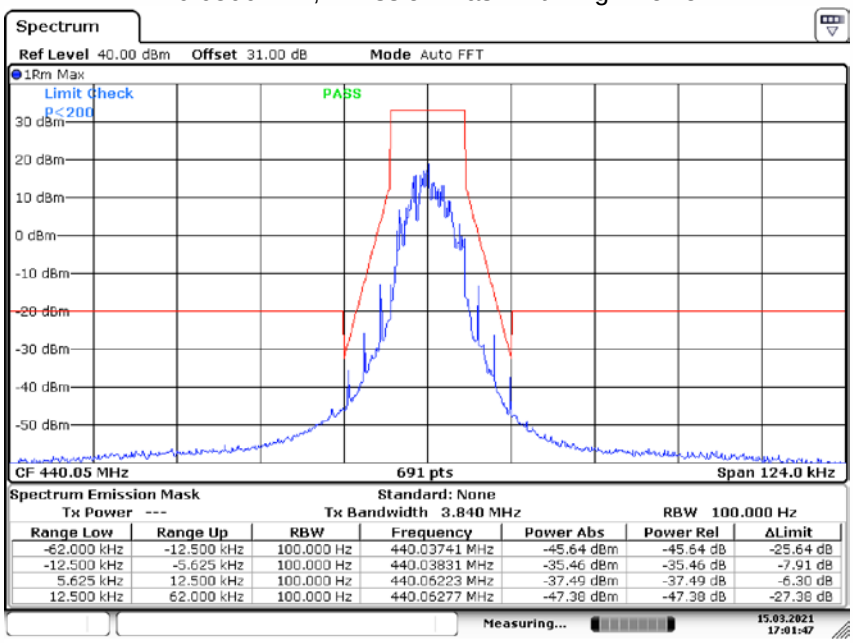
440.0500MHz, Emission Mask with High Power



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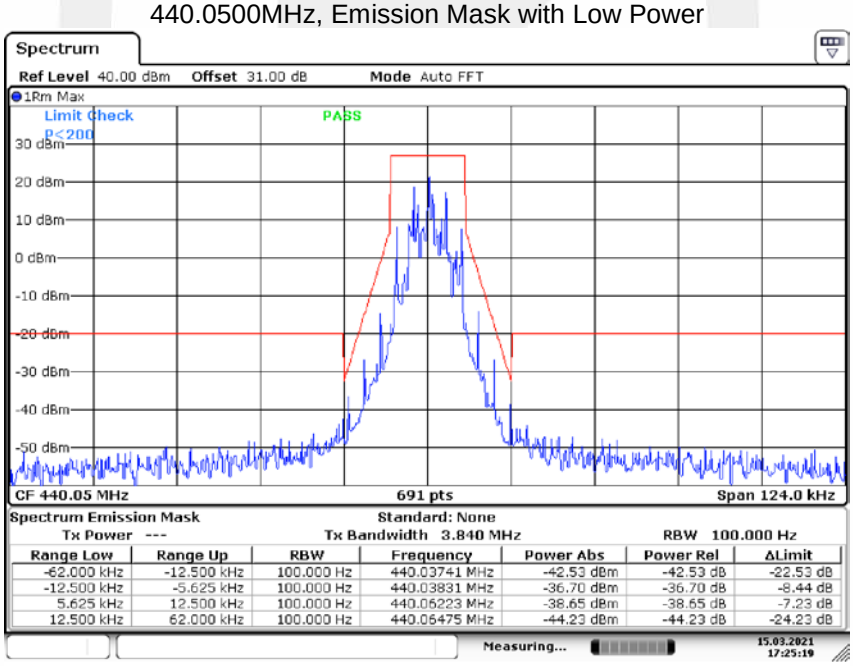
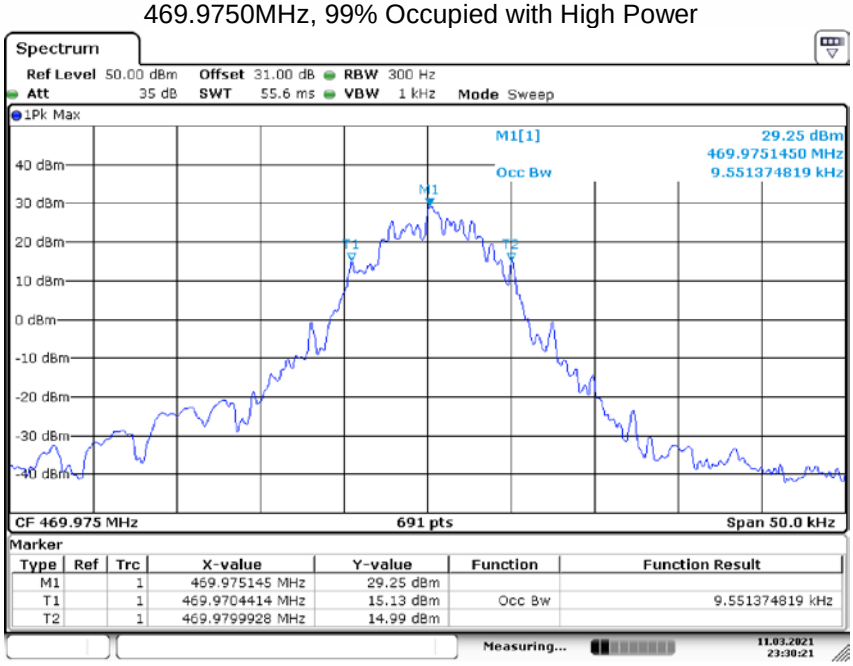
440.0500MHz, Emission Mask with Low Power



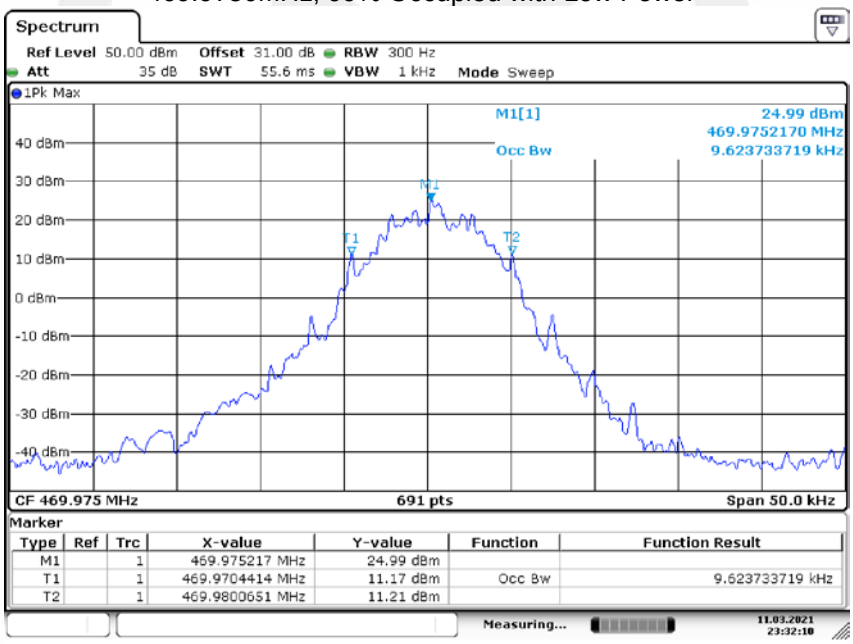
Date: 15.MAR.2021 17:25:18

469.9750MHz, 99% Occupied with High Power



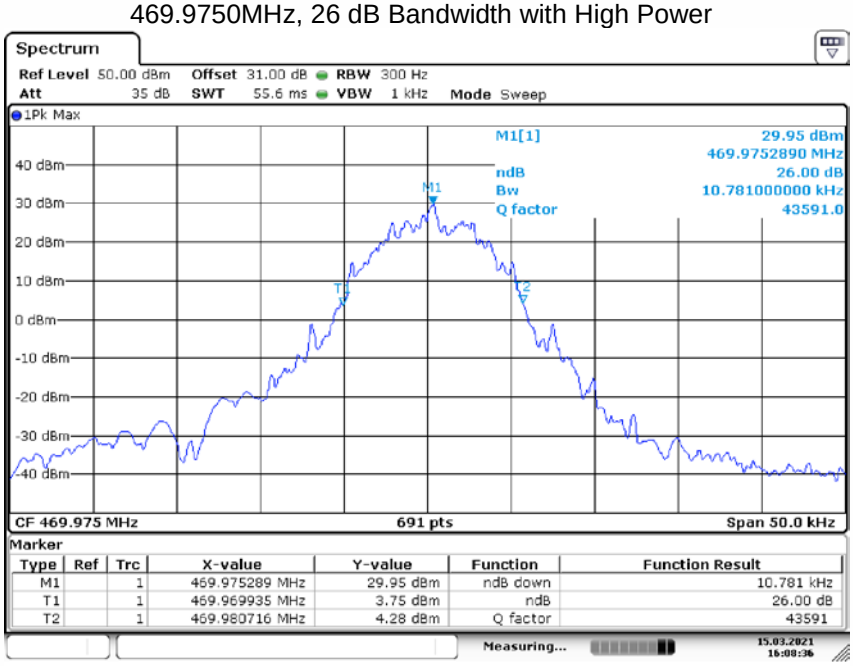
Date: 11.MAR.2021 23:30:21

469.9750MHz, 99% Occupied with Low Power



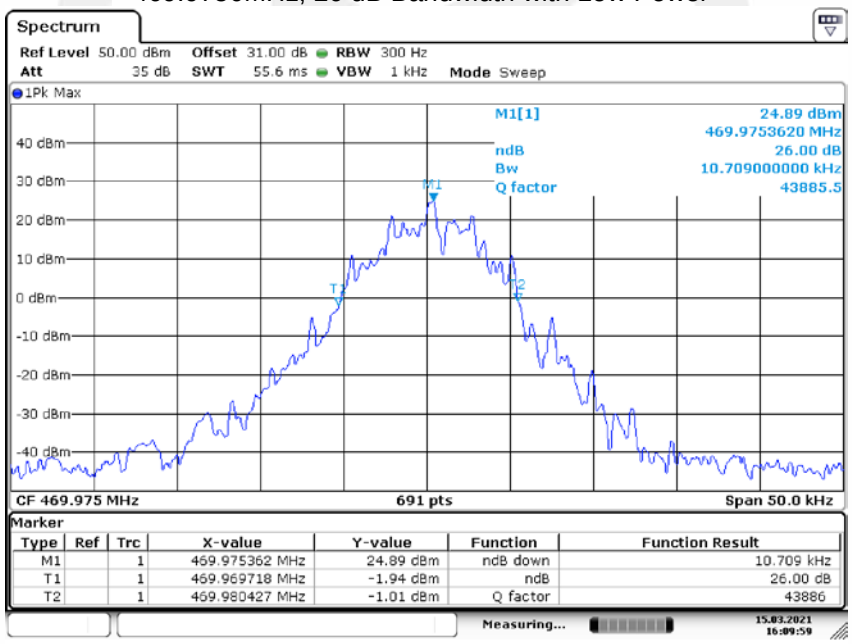
Date: 11.MAR.2021 23:32:10

469.9750MHz, 26 dB Bandwidth with High Power



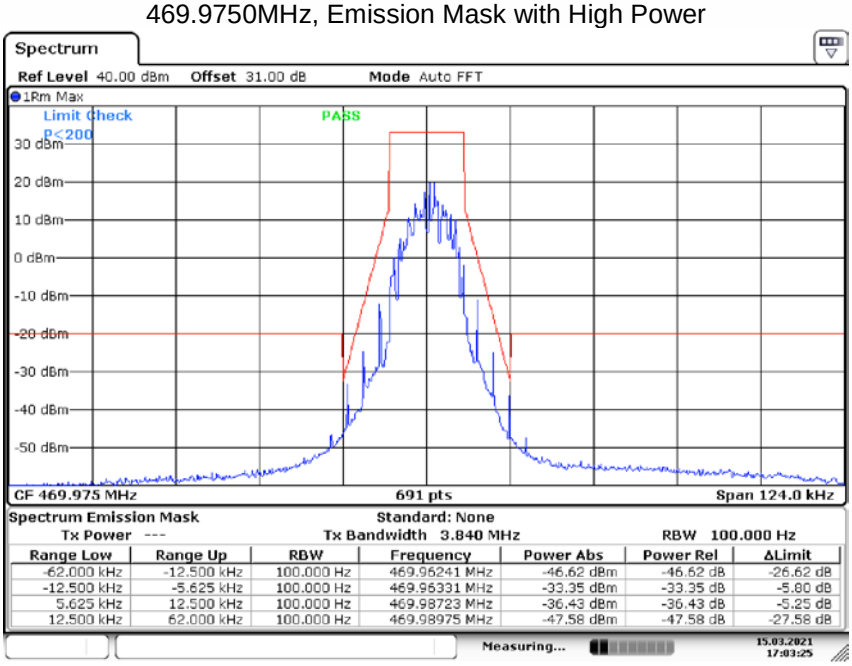
Date: 15.MAR.2021 16:08:36

469.9750MHz, 26 dB Bandwidth with Low Power



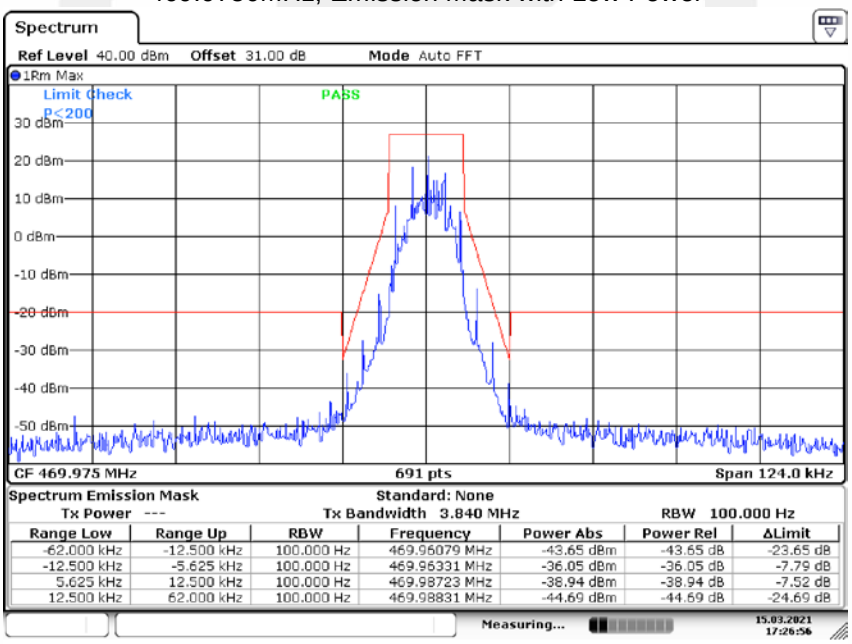
Date: 15.MAR.2021 16:10:00

469.9750MHz, Emission Mask with High Power



Date: 15.MAR.2021 17:03:25

469.9750MHz, Emission Mask with Low Power



Date: 15.MAR.2021 17:26:56

8.3 SPURIOUS EMISSIONS AT ANTENNA TERMINALS

8.3.1 Applicable Standard

According to FCC part 2.1051 and part 90.210

8.3.2 Conformance Limit

(b) Emission Mask B. For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:
(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.
(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

(d) Emission Mask D. channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:
(1) On any frequency from the center of the authorized bandwidth f0 to 5.625 kHz removed from f0: Zero dB.
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(fd−2.88 kHz) dB.
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

8.3.3 Test Configuration

Test according to clause 7.1 radio frequency test setup 1

8.3.4 Test Procedure

The setup of EUT is according with per Standard ANSI/TIA-603-E: 2016 and ANSI C63.4-2014 measurement procedure.
a) Connect the equipment as illustrated, with the notch filter by-passed.
b) Set the center frequency of the spectrum analyzer to the assigned transmitter frequency, key the transmitter, and set the level of the carrier to the full scale reference line.
c) Modulate the transmitter with a 2500 Hz sine wave at an input level 16 dB greater than that necessary to produce 50% of rated system deviation. The input level shall be established at the frequency of maximum response of the audio modulating circuit.
d) Adjust the spectrum analyzer for the following settings:
1) Resolution Bandwidth = 100 kHz for spurious emissions below 1 GHz, and 1 MHz for spurious emissions above 1 GHz.
2) Video Bandwidth ≥3 times the resolution bandwidth.
3) Sweep Speed ≤2000 Hz per second.
4) Detector Mode = mean or average power.
e) Adjust the center frequency of the spectrum analyzer for incremental coverage of the range from:
   1) The lowest radio frequency generated in the equipment to the carrier frequency minus the test bandwidth (see 1.3.4.4).
   2) The carrier frequency plus the test bandwidth to a frequency less than 2 times the carrier frequency.
f) Record the frequencies and levels of spurious emissions from step e).
g) Unkey the transmitter. Replace the transmitter under test with the signal generator and adjust the signal level to reproduce the frequencies and levels of every spurious emission recorded in step f).

Record the signal generator levels in dBm.
h) Insert the notch filter.
i) Adjust the spectrum analyzer for the following settings:
1) Resolution Bandwidth = 100 kHz for spurious emissions below 1 GHz, and 1 MHz for spurious emissions above 1 GHz.
2) Video Bandwidth ≥3 times the resolution bandwidth.
3) Sweep Speed ≤2000 Hz per second.
4) Detector Mode = mean or average power.
j) Key the transmitter. Adjust the center frequency of the spectrum analyzer for incremental coverage of the range from a frequency equal to 2 times the carrier frequency and to the tenth harmonic of the carrier frequency.
k) Record the frequencies and levels of spurious emissions from step j).
l) Unkey the transmitter. Replace the transmitter under test with the signal generator and adjust the signal level to reproduce the frequencies and levels of every spurious emission recorded in step k). Record the signal generator levels in dBm.
m) The levels recorded in steps g) and l) are the absolute levels of conducted spurious emissions in dBm. The conducted spurious attenuation can be calculated by the following:

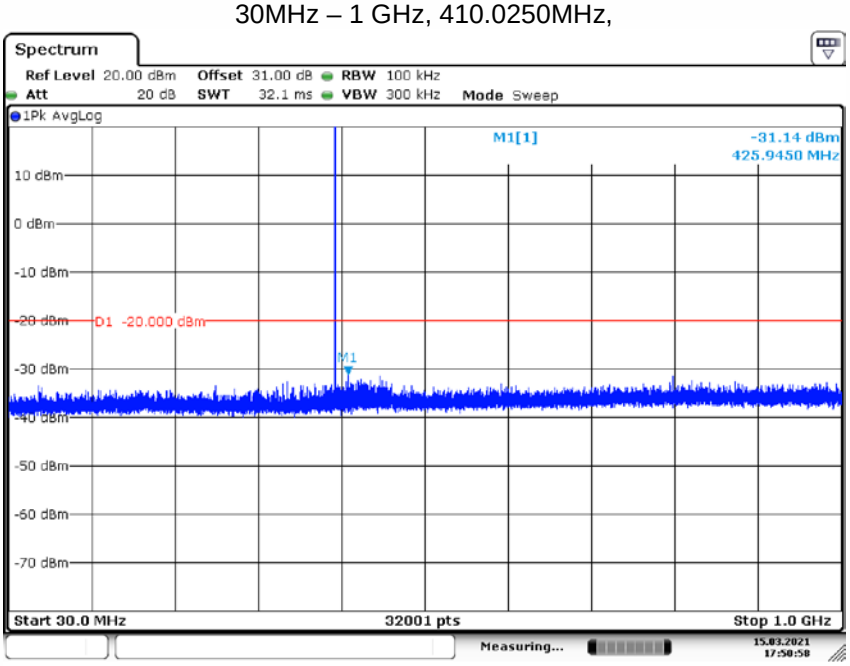
Spurious attenuation (dB) =

$$10\ \log_{10}\left(\frac{TX\ power\ in\ watts}{0.001}\right) - the\ levels\ in\ steps\ g)\ and\ l)$$

8.3.5 Test Results

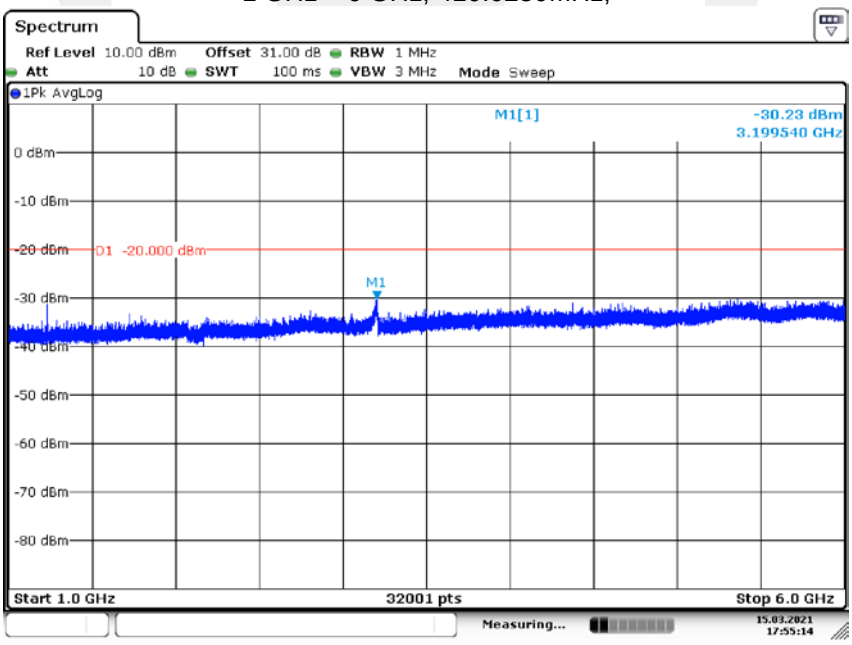
Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

30MHz – 1 GHz, 410.0250MHz,



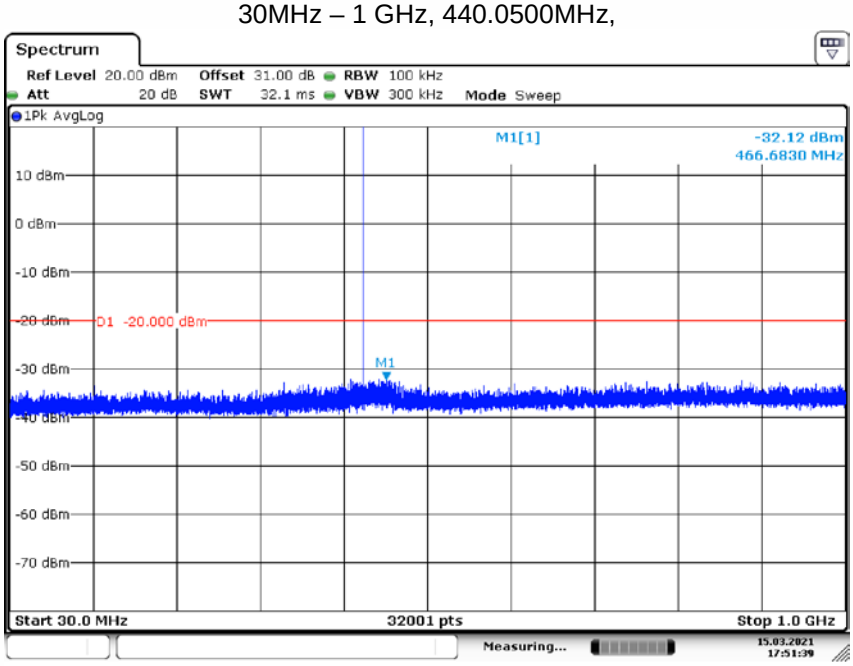
Date: 15.MAR.2021 17:50:58

1 GHz – 6 GHz, 410.0250MHz,



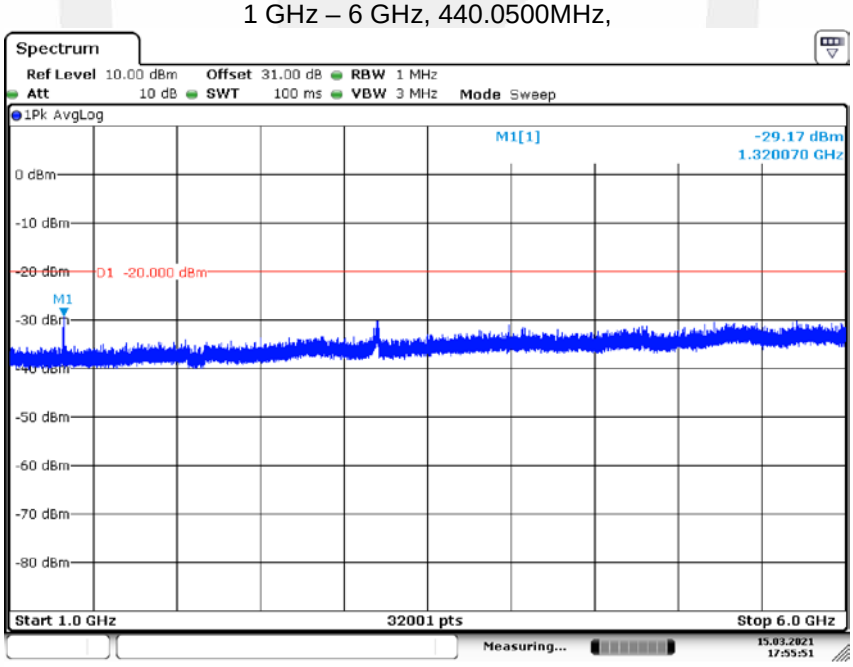
Date: 15.MAR.2021 17:55:14

30MHz – 1 GHz, 440.0500MHz,



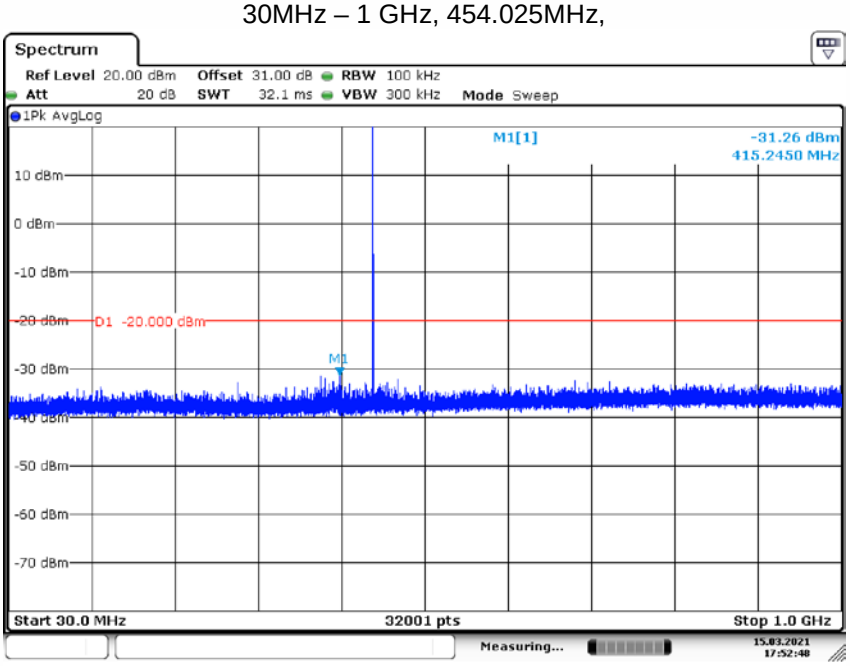
Date: 15.MAR.2021 17:51:38

1 GHz – 6 GHz, 440.0500MHz,



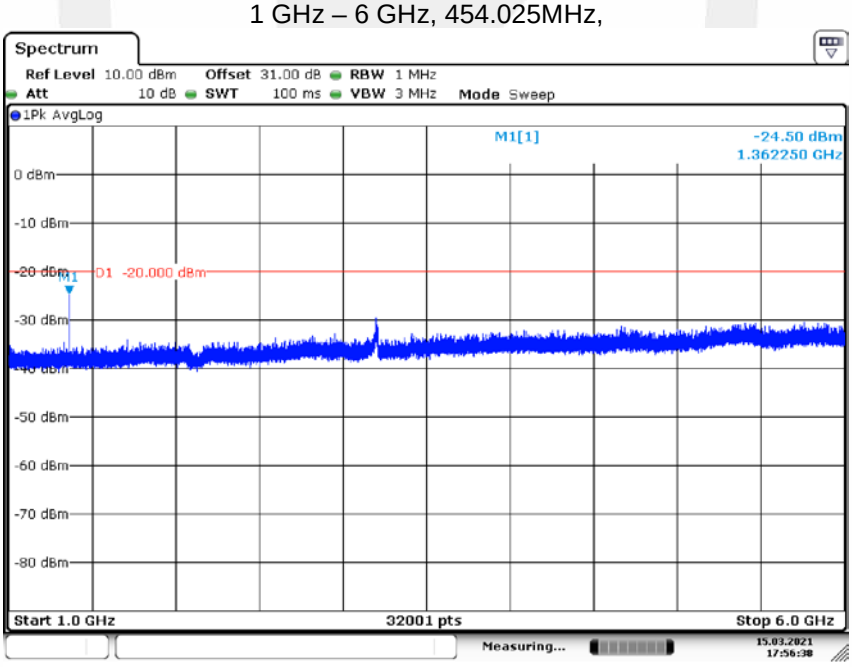
Date: 15.MAR.2021 17:55:52

30MHz – 1 GHz, 454.025MHz,



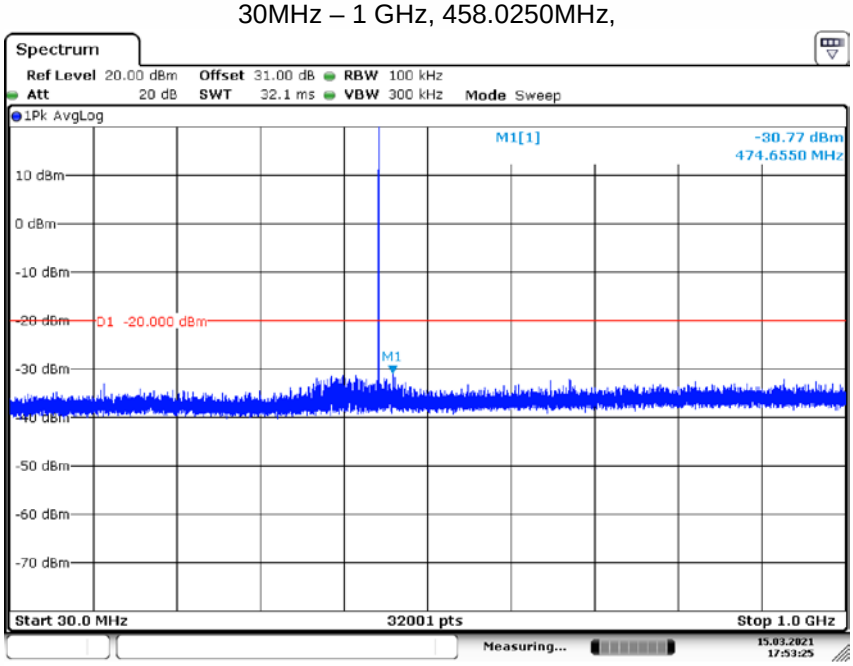
Date: 15.MAR.2021 17:52:48

1 GHz – 6 GHz, 454.025MHz,



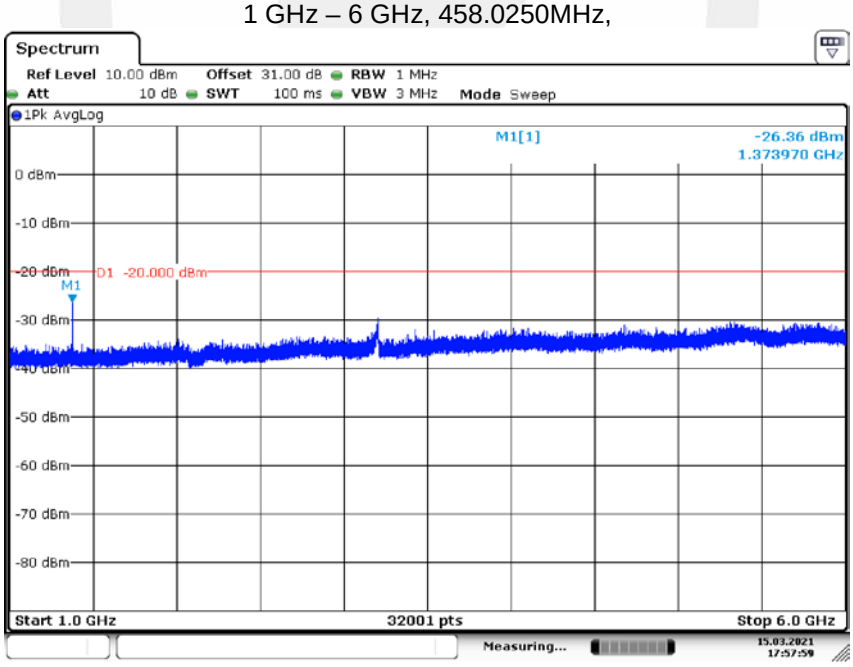
Date: 15.MAR.2021 17:56:38

30MHz – 1 GHz, 458.0250MHz,



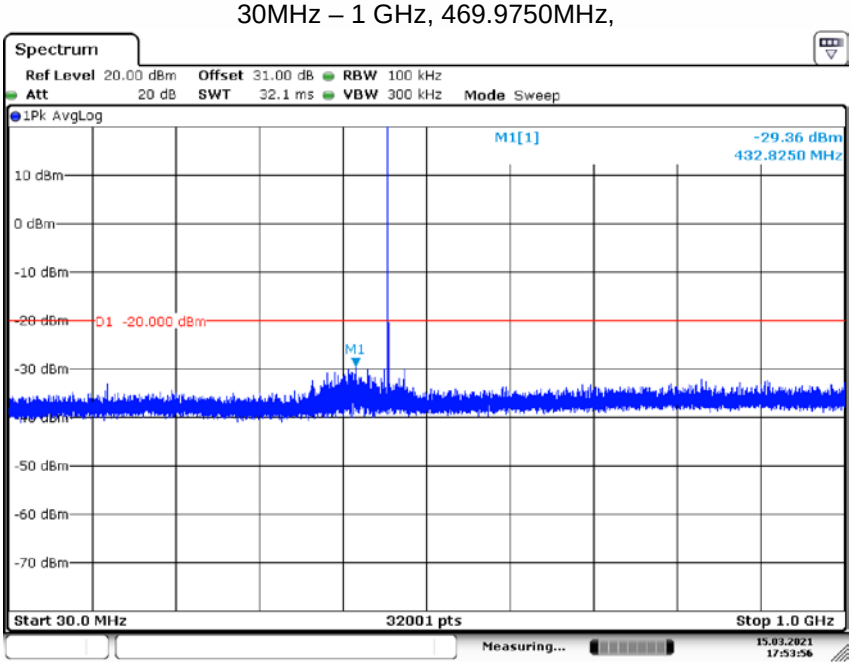
Date: 15.MAR.2021 17:53:25

1 GHz – 6 GHz, 458.0250MHz,



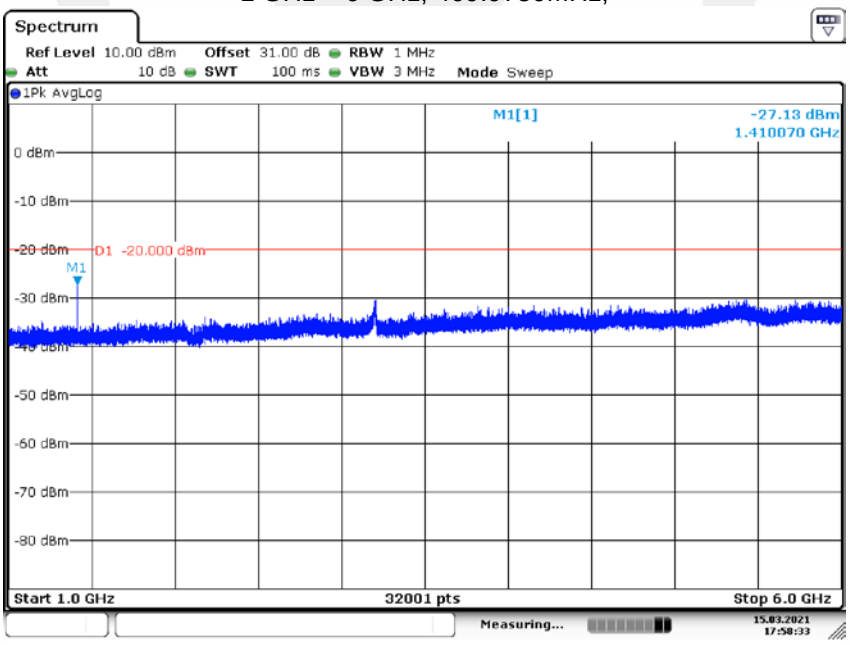
Date: 15.MAR.2021 17:57:59

30MHz – 1 GHz, 469.9750MHz,



Date: 15.MAR.2021 17:53:56

1 GHz – 6 GHz, 469.9750MHz,



Date: 15.MAR.2021 17:58:33

8.4 RADIATED SPURIOUS EMISSIONS

8.4.1 Applicable Standard

According to FCC part 2.1053, part 90.210

8.4.2 Conformance Limit

(b) Emission Mask B. For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:
(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.
(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

(d) Emission Mask D. channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:
(1) On any frequency from the center of the authorized bandwidth f0 to 5.625 kHz removed from f0: Zero dB.
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(fd−2.88 kHz) dB.
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

8.4.3 Test Configuration

Test according to clause 7.1 radio frequency test setup 2

8.4.4 Test Procedure

a) Connect the equipment as illustrated.
b) Adjust the spectrum analyzer for the following settings:
1) Resolution Bandwidth = 10 kHz for spurious emissions below 1 GHz, and 1 MHz for spurious emissions above 1GHz.
2) Video Bandwidth = 300 kHz for spurious emissions below 1 GHz, and 3 MHz for spurious emissions above 1 GHz.
3) Sweep Speed slow enough to maintain measurement calibration.
4) Detector Mode = Positive Peak.
c) Place the transmitter to be tested on the turntable in the standard test site, or an FCC listed site compliant with ANSI C63.4 clause 5.4. The transmitter is transmitting into a nonradiating load that is placed on the turntable. The RF cable to this load should be of minimum length. For transmitters with integral antennas, the tests are to be run with the unit operating into the integral antenna.
d) For each spurious measurement the test antenna should be adjusted to the correct length for the frequency involved. This length may be determined from a calibration ruler supplied with the equipment. Measurements shall be made from the lowest radio frequency generated in the equipment to the tenth harmonic of the carrier, except for the region close to the carrier equal to ± the test bandwidth (see 1.3.4.4).
e) Key the transmitter.
f) For each spurious frequency, raise and lower the test antenna from 1 m to 4 m to obtain a maximum reading on the spectrum analyzer with the test antenna at horizontal polarity. Then the turntable should be rotated 360° to determine the maximum reading. Repeat this procedure to obtain the highest possible reading. Record this maximum reading. g) Repeat step f) for each spurious frequency with the test antenna polarized vertically.

h) Reconnect the equipment as illustrated.
i) Keep the spectrum analyzer adjusted as in step b).
j) Remove the transmitter and replace it with a substitution antenna (the antenna should be half-wavelength for each frequency involved). The center of the substitution antenna should be approximately at the same location as the center of the transmitter. At the lower frequencies, where the substitution antenna is very long, this will be impossible to achieve when the antenna is polarized vertically. In such case the lower end of the antenna should be 0.3 m above the ground.
k) Feed the substitution antenna at the transmitter end with a signal generator connected to the antenna by means of a nonradiating cable. With the antennas at both ends horizontally polarized, and with the signal generator tuned to a particular spurious frequency, raise and lower the test antenna to obtain a maximum reading at the spectrum analyzer. Adjust the level of the signal generator output until the previously recorded maximum reading for this set of conditions is obtained. This should be done carefully repeating the adjustment of the test antenna and generator output.
l) Repeat step k) with both antennas vertically polarized for each spurious frequency.
m) Calculate power in dBm into a reference ideal half-wave dipole antenna by reducing the readings obtained in steps k) and l) by the power loss in the cable between the generator and the antenna, and further corrected for the gain of the substitution antenna used relative to an ideal half-wave dipole antenna by the following formula:

$$P_d(\text{dBm}) = P_g(\text{dBm}) - \textit{cable loss}\ (\text{dB}) + \textit{antenna gain}\ (\text{dB})$$

where:

P_d is the dipole equivalent power and

P_g is the generator output power into the substitution antenna.

n) The Pd levels record in step m) are the absolute levels of radiated spurious emissions in dBm. The radiated spurious emissions in dB can be calculated by the following:

Radiated spurious emissions (dB) =

$$10\ \log_{10}\left(\frac{TX\ power\ in\ watts}{0.001}\right) - the\ levels\ in\ step\ m)$$

NOTE: It is permissible to use other antennas provided they can be referenced to a dipole.

by the substitution.
Spurious emissions in dB =10 1g (TXpwr in Watts/0.001)-the absolute level
Spurious attenuation limit in dB =50+10 Log10 (power out in Watts) for EUT with a 12.5 kHz channel bandwidth.

8.4.5 Test Results

■ Radiated measurement

An artificial load was connected to the antenna port for the test.
All the modes were tested; the data of the worst mode are described in the following table

Emissions In the Spurious Domain below 1GHz.

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	410.0250

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
35.69	V	100	-53.68	-20	-33.68	PASS
66.68	V	100	-51.73	-20	-31.73	PASS
158.19	V	100	-51.04	-20	-31.04	PASS
212.83	V	100	-53.71	-20	-33.71	PASS
380.45	V	100	-51.38	-20	-31.38	PASS
713.21	V	100	-53.45	-20	-33.45	PASS
35.64	H	100	-52.45	-20	-32.45	PASS
68.33	H	100	-52.02	-20	-32.02	PASS
151.8	H	100	-53.49	-20	-33.49	PASS
203.46	H	100	-54.94	-20	-34.94	PASS
300.92	H	100	-52.5	-20	-32.5	PASS
754.16	H	100	-51.55	-20	-31.55	PASS

Emissions In the Spurious Domain below 1GHz.

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	440.0500

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
39.98	V	100	-51.61	-20	-31.61	PASS
66.09	V	100	-51.76	-20	-31.76	PASS
158.06	V	100	-53.75	-20	-33.75	PASS
221.08	V	100	-54.98	-20	-34.98	PASS
304.38	V	100	-54.95	-20	-34.95	PASS
730.54	V	100	-52.3	-20	-32.30	PASS
35.76	H	100	-51.38	-20	-31.38	PASS
59.12	H	100	-52.56	-20	-32.56	PASS
151.14	H	100	-53.85	-20	-33.85	PASS
227.76	H	100	-54.26	-20	-34.26	PASS
363.56	H	100	-52.74	-20	-32.74	PASS
729.97	H	100	-51.82	-20	-31.82	PASS

Emissions In the Spurious Domain below 1GHz.

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	469.9750

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
38.27	V	100	-54.73	-20	-34.73	PASS
63.61	V	100	-51.98	-20	-31.98	PASS
155.94	V	100	-53.33	-20	-33.33	PASS
209.08	V	100	-53.85	-20	-33.85	PASS
355.2	V	100	-51.23	-20	-31.23	PASS
680.42	V	100	-51.23	-20	-31.23	PASS
39.92	H	100	-52.95	-20	-32.95	PASS
67.81	H	100	-54.25	-20	-34.25	PASS
153.44	H	100	-53.27	-20	-33.27	PASS
223.22	H	100	-54.43	-20	-34.43	PASS
388.84	H	100	-54.22	-20	-34.22	PASS
700.08	H	100	-52.27	-20	-32.27	PASS

Emissions In the Spurious Domain above 1GHz:

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	410.0250

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
1693.58	V	1000	-37.51	-20	-17.51	PASS
2269.74	V	1000	-41.81	-20	-21.81	PASS
3138.79	V	1000	-42.18	-20	-22.18	PASS
3952.14	V	1000	-43.56	-20	-23.56	PASS
4112.18	V	1000	-45.13	-20	-25.13	PASS
5196.39	V	1000	-46.04	-20	-26.04	PASS
1790.75	H	1000	-42.56	-20	-22.56	PASS
2177.97	H	1000	-40.67	-20	-20.67	PASS
2465.86	H	1000	-43.75	-20	-23.75	PASS
2869.68	H	1000	-43.9	-20	-23.9	PASS
3481.28	H	1000	-47.11	-20	-27.11	PASS
3996.01	H	1000	-42.53	-20	-22.53	PASS

Emissions In the Spurious Domain above 1GHz:

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	440.0500

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
1758.18	V	1000	-42.73	-20	-22.73	PASS
2058.13	V	1000	-43.51	-20	-23.51	PASS
2591.28	V	1000	-37.85	-20	-17.85	PASS
3030.10	V	1000	-48.08	-20	-28.08	PASS
3308.29	V	1000	-46.61	-20	-26.61	PASS
4703.04	V	1000	-43.12	-20	-23.12	PASS
1692.30	H	1000	-37.94	-20	-17.94	PASS
2272.61	H	1000	-44.71	-20	-24.71	PASS
3127.04	H	1000	-40.71	-20	-20.71	PASS
3789.08	H	1000	-45.31	-20	-25.31	PASS
4432.08	H	1000	-47.48	-20	-27.48	PASS
4874.78	H	1000	-43.62	-20	-23.62	PASS

Emissions In the Spurious Domain above 1GHz:

Temperature:	24℃	Channel Spacing	12.5 kHz
Humidity:	53%	Test Mode:	TX
Air Pressure:	106kPa	Traffic Channel:	469.9750

Frequency (MHz)	Antenna Polarization	RBW (kHz)	Emission level (dBm)	Limit (dBm)	Over (dB)	Verdict
1778.92	V	1000	-39.66	-20	-19.66	PASS
2957.64	V	1000	-41.34	-20	-21.34	PASS
3364.75	V	1000	-42.31	-20	-22.31	PASS
3964.35	V	1000	-42.52	-20	-22.52	PASS
4524.06	V	1000	-44.49	-20	-24.49	PASS
4752.11	V	1000	-47.68	-20	-27.68	PASS
1597.41	H	1000	-44.09	-20	-24.09	PASS
2955.12	H	1000	-44.32	-20	-24.32	PASS
3277.43	H	1000	-40.79	-20	-20.79	PASS
3899.95	H	1000	-49.82	-20	-29.82	PASS
4152.54	H	1000	-46.43	-20	-26.43	PASS
5096.75	H	1000	-47.02	-20	-27.02	PASS

Note:
Absolute Level = Substituted Level - Cable loss + Antenna Gain
Margin = Limit- Absolute Level

8.5 FREQUENCY STABILITY

8.5.1 Applicable Standard

According to FCC part 2.1055, part 90.213

8.5.2 Conformance Limit

Stations operating in the 154.45 to 154.49 MHz or the 173.2 to 173.4 MHz bands must have a frequency stability of 5 ppm.

In the 150-174 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

6In the 150-174 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth or designed to operate on a frequency specifically designated for itinerant use or designed for low-power operation of two watts or less, must have a frequency stability of 5.0 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 2.0 ppm.

In the 421-512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

In the 421-512 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

8.5.3 Test Configuration

Test according to clause 7.2 radio frequency test setup 1

8.5.4 Test Procedure

Test method: ANSI/TIA-603-E: 2016, section 2.2.2
Frequency Stability vs. Temperature: The equipment under test was connected to an external DC power supply and the RF output was connected to a frequency counter via feed-through attenuators. The EUT was placed inside the temperature chamber. The DC leads and RF output cable exited the chamber through an opening made for the purpose.

After the temperature stabilized for approximately 20 minutes, the frequency output was recorded from the counter.

8.5.5 Test Results

Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

Frequency: 454.0250MHz, Limit: ±2.5 ppm, 12.5 kHz			
Test Environment		Frequency Measure with Time Elapsed	
Temperature (℃	Power Supplied (VDC)	Measured Frequency (MHz)	Frequency Error (ppm)
Frequency Stability versus Input Temperature			
65	14.8	454.0239	-2.42
50	14.8	454.0247	-0.66
40	14.8	454.0243	-1.54
30	14.8	454.0249	-0.22
20	14.8	454.0250	0.00
10	14.8	454.0250	0.00
0	14.8	454.0249	-0.22
-10	14.8	454.0245	-1.10
-20	14.8	454.0243	-1.54
-30	14.8	454.0240	-2.20
-40	14.8	454.0243	-1.54
Frequency Stability versus Input Voltage			
25	12.58	454.0246	-0.88

Frequency: 458.0250MHz, Limit: ±2.5 ppm, 12.5 kHz			
Test Environment		Frequency Measure with Time Elapsed	
Temperature (℃)	Power Supplied (VDC)	Measured Frequency (MHz)	Frequency Error (ppm)
Frequency Stability versus Input Temperature			
65	14.8	458.0243	-1.53
50	14.8	458.0241	-1.53
40	14.8	458.0247	-1.96
30	14.8	458.0249	-0.65
20	14.8	458.0248	-0.22
10	14.8	458.0245	-0.44
0	14.8	458.0243	-1.09
-10	14.8	458.0241	-1.53
-20	14.8	458.0242	-1.96
-30	14.8	458.0240	-1.75
-40	14.8	458.0239	-2.18
Frequency Stability versus Input Voltage			
25	12.58	458.0247	-1.96

Detail of factor for radiated emission

Frequency(MHz)	Ant_F(dB)	Cab_L(dB)	Preamp(dB)	Correct Factor(dB)
0.009	20.6	0.03	\	20.63
0.15	20.7	0.1	\	20.8
1	20.9	0.15	\	21.05
10	20.1	0.28	\	20.38
30	18.8	0.45	\	19.25
30	11.7	0.62	27.9	-15.58
100	12.5	1.02	27.8	-14.28
300	12.9	1.91	27.5	-12.69
600	19.2	2.92	27	-4.88
800	21.1	3.54	26.6	-1.96
1000	22.3	4.17	26.2	0.27
1000	25.6	1.76	41.4	-14.04
3000	28.9	3.27	43.2	-11.03
5000	31.1	4.2	44.6	-9.3
8000	36.2	5.95	44.7	-2.55
10000	38.4	6.3	43.9	0.8
12000	38.5	7.14	42.3	3.34
15000	40.2	8.15	41.4	6.95
18000	45.4	9.02	41.3	13.12
18000	37.9	1.81	47.9	-8.19
21000	37.9	1.95	48.7	-8.85
25000	39.3	2.01	42.8	-1.49
28000	39.6	2.16	46.0	-4.24
31000	41.2	2.24	44.5	-1.06
34000	41.5	2.29	46.6	-2.81
37000	43.8	2.30	46.4	-0.3
40000	43.2	2.50	42.2	3.5

--------- END OF REPORT --------