FCC / ISED Test Report

For:
Geoforce Inc.

Model Name:
Geoforce GT1/GT1s and Geoforce GT0/GT0s

Product Description:
Battery Powered Asset Logistics Device

FCC ID: OWA00GT1X
IC: 10540A-00GT1X

Applied Rules and Standards:
47 CFR Part 25 Satellite Communications
RSS-170 Issue 4 (MESs) & RSS-Gen Issue 5

REPORT #: EMC_GEOFO_038_23001_FCC_25_ISED_RSS_170

DATE: 2024-05-21

A2LA Accredited

IC recognized # 3462B

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Part 25 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-170.

No deviations were ascertained.

Company Name	Product Description	Model No.
Geoforce Inc.	Battery Powered Asset Logistics Device	OWA1S52

Responsible for the Report:

Date	Section	Name	Signature
2024-05-21	Compliance	Chin Ming Lui (EMC Test Engineer)	Chin Ming Lui Digitally signed by: Chin Ming Lui DN: CN = Chin Ming Lui email = ChinMing.Lui@cetecom.com C = US O = CETECOM Inc. OU = OTA Date: 2024.05.22 15:56:09 -07'00'

The test results of this test report relate exclusively to the test item specified in Section3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
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EMC Lab Manager:	Issa Ghanma
Responsible Project Leader:	Sangeetha Sivaraman

2.2 Identification of the Client

Client's Name:	Geoforce Inc.
Street Address:	5830 Granite Parkway, Suite 1200
City/Zip Code	Plano, TX 75024
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as client
Manufacturer's Address:	
City/Zip Code	
Country	

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Product Description:	Battery Powered Asset Logistics Device
Model Name :	Geoforce GT1/GT1s and Geoforce GT0/GT0s
HW Version :	R3
SW Version :	11.X
FCC-ID :	OWA00GT1X
IC :	10540A-00GT1X
Frequency Range / number of channels:	Satcom: 1611.25 – 1618.75 MHz / 4 Channels with 2.5 MHz Spacing
Radio Module(s):	Satcom: Discrete Licensed Geoforce Transmitter (TNB)
Mode(s) of Operation / Modulation:	Satcom: DSSS / BPSK
Antenna Information as declared:	Satcom: Dual Feed Patch Antenna: 5dBi
Max. Output Power (Measured):	Satcom: 19.05 dBm (RMS Conducted)
Max. Output Power (Declared):	Satcom: 23.0 dBm +/- 1.0 dBm
Other Radios included in the device	❖ BLE: • Module: Nordic NRF52840 (DTS) • Frequency Range / Number of Channels: 2402 – 2480 MHz / 39 Channels with 2 MHz Spacing • Mode of Operation: GFSK ❖ GNSS: • Module: uBlox MAX-M10S (RCV Only) • Frequency Range / Number of Channels: 1575.42, 1602, 1561 MHz
Power Supply/ Rated Operating Voltage Range	3.6VDC Nominal, 3.9VDC Maximum
Operating Temperature Range	Low: -40ºC Norm: 25ºC High: 85 ºC
Sample Revision	☐Production ☒ Pre-Production
EUT Dimensions	7.1cm x 7.1cm x 3.2cm
Weight	200 grams
EUT Diameter	☒< 60 cm ☐ Other _____

Note: The information of the EUT specifications in the table above is provided by the client except the specified Max. Output Power (Measured). Refer to following documents:

- **Operational Description:** *GT0-GT1 Theory of Operation Description Document # HW-SP-0-0160*
- **EUT Model Declaration of Similarities:** *Declaration of Product Model Code*

- **Antenna Datasheet – BLE:** *Molex 0479480001, 2.4 GHz SMT MID Chip Antenna*
- **Antenna Datasheet – GPS-SAT:** *Tallysman Wireless TW11-0006-1, Dual Feed Patch Antenna*

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	2-3000101	R3	11.X	Conducted Sample
2	2-3000102	R3	11.X	Radiated Sample

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	N/A	N/A	N/A	N/A

3.4 Support Equipment (SE) details

AE #	Type	Model	Manufacturer	Serial Number
1	DC Power Supply	3003B	Protek	H 001416

3.5 Test Sample Configuration

EUT Set-up #	Combination of SE used for test set up	Comments
1	EUT#1 + SE#1	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle. The RF pigtail cable coming out of the EUT was connected to the 50 ohm RF port of the measurement equipment.
2	EUT#2 + SE#1	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle. The internal antenna was connected.

3.6 Mode of Operation Details

Mode of Operation	Description of Operating Modes	Additional Information
Op. 1	DSSS	To configure the Satcom radio to a fixed channel transmission, the supplied magnet is removed from the device. To toggle between TX channels, the magnet is put back on device and then removed again. • Modulation: BPSK • Operating mode: Fixed Channel • Select TX channel(s) o Ch. A → 1611.25 MHz o Ch. B → 1613.75 MHz o Ch. C → 1616.25 MHz o Ch. D → 1618.75 MHz

3.7 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter set to TX channels A, B, C, and D, and operates at 100% duty cycle. For radiated measurements, all data in this report show the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 25 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-170 of ISED Canada.

This test report is to support a request for new equipment authorization under:

- FCC ID: OWA00GT1XX
- IC: 10540A-00GT1X

Testing procedures are based on guidelines provided in FCC publication (KDB) 971168 D01 v03r01 – "Measurement Guidance for Certification of Licensed Digital Transmitters" and ANSI C63.26-2015 – "American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Devices", by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§2.1046 §25.204(a) RSS-170 5.5	RF Output Power	Nominal	DSSS	■	☐	☐	Complies
§2.1047	Modulation Characteristics	Nominal	DSSS	■	☐	☐	Complies
§2.1049 §25.202(f) RSS-170 5.8	Occupied Bandwidth	Nominal	DSSS	■	☐	☐	Complies
§2.1051 §25.202(f) RSS-170 5.8	Unwanted Emissions at Antenna Terminals	Nominal	DSSS	■	☐	☐	Complies
§2.1053 §25.202(f) RSS-170 5.8	Field Strength of Spurious Radiation	Nominal	DSSS	■	☐	☐	Complies
§2.1055 §25.202(d) RSS-170 5.3	Frequency Stability	Nominal and Extreme	DSSS	■	☐	☐	Complies
§25.216(c)(f)(g)(i)(j) RSS-170 5.9 & 5.10	Emissions from Mobile Earth Stations for Protection of Aeronautical Radionavigation-Satellite Service	Nominal	DSSS	■	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=2.

Radiated measurement

Measurement System		EMC 1	EMC 2
Conducted emissions (mains port)		1.12 dB	0.46 dB
Radiated emissions	(< 30 MHz)	3.66 dB	3.88 dB
	(30 MHz – 1GHz)	3.17 dB	3.34 dB
	(1 GHz – 3 GHz)	5.01 dB	4.45 dB
	(>3 GHz)	4.0 dB	4.79 dB

RF conducted measurement ±0.5 dB

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: http://physics.nist.gov/cuu/Uncertainty/typeb.html. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3dB to the limit.

6.1 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6.2 Dates of Testing:

2024-02-16 – 2024-03-11

6.3 Decision Rule:

Cetecom advanced follows ILAC G8:2019 chapter 4.2.1 (Simple Acceptance Rule).

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3. The measurement uncertainty is mentioned in this test report, See chapter 9, but is not taken into account – neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong.

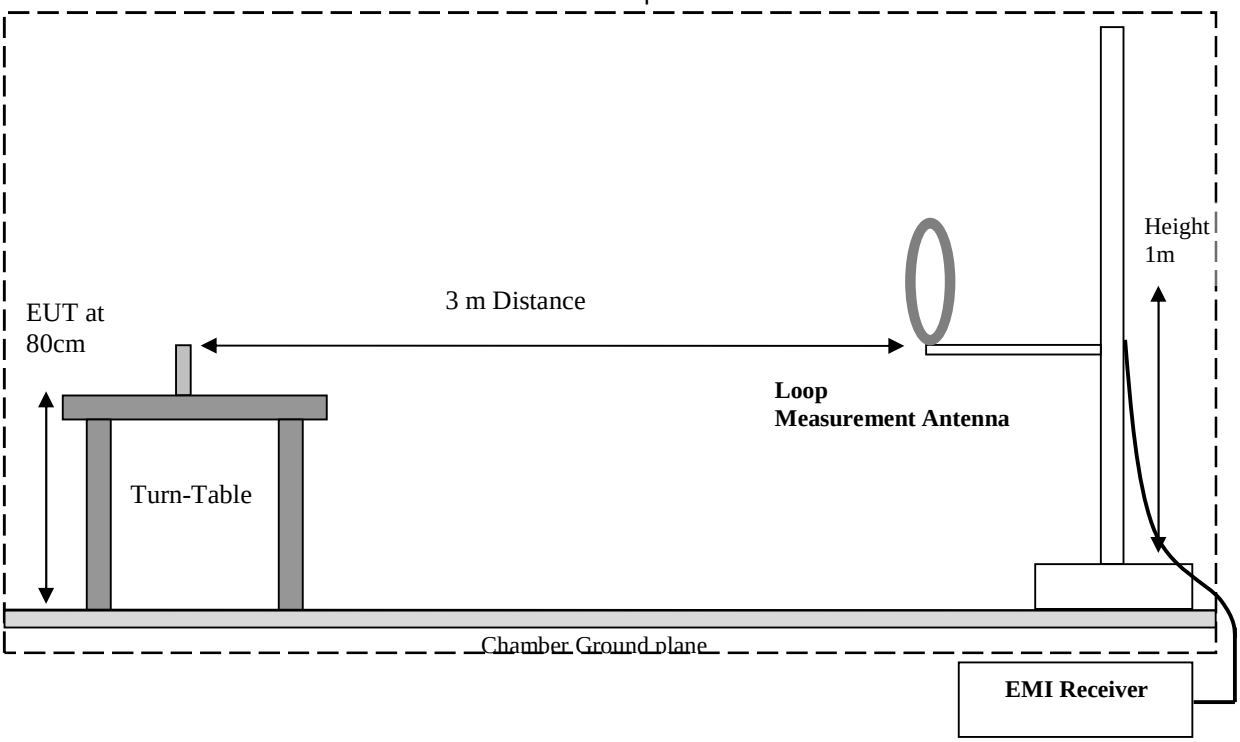
7 Measurement Procedures

7.1 Radiated Measurement

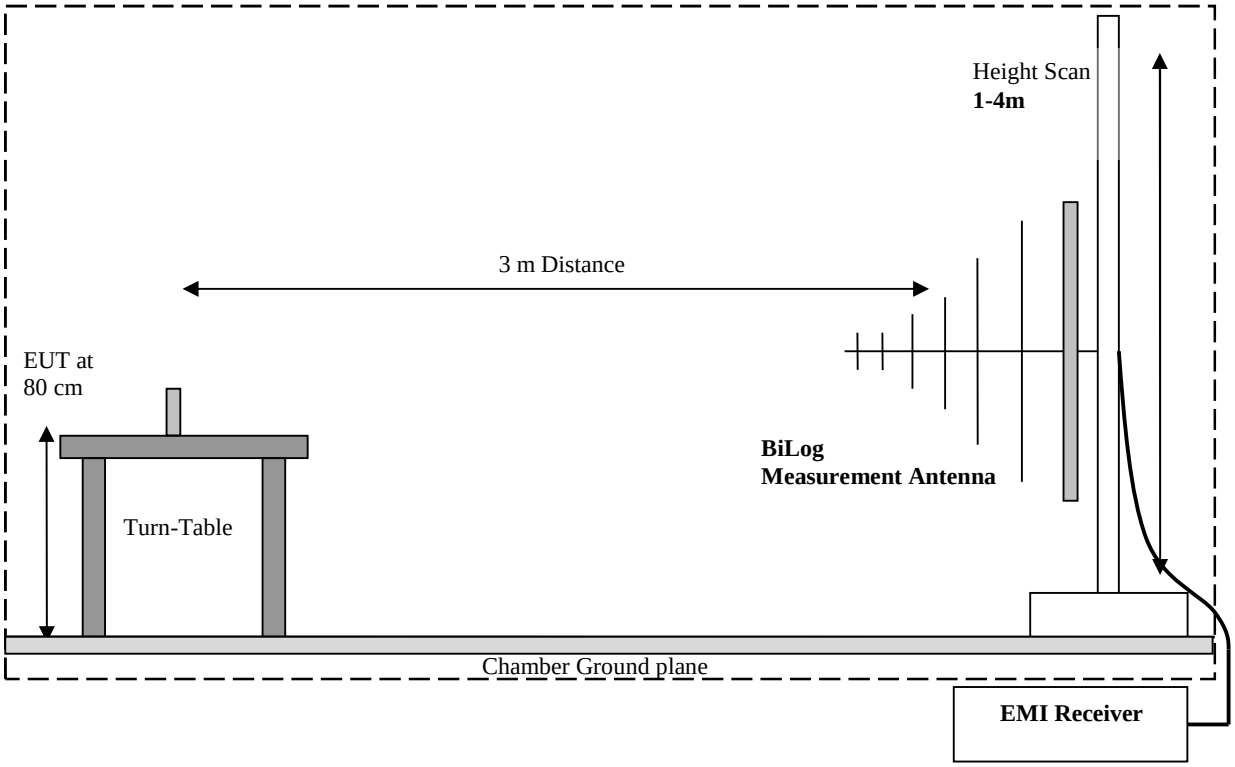
The radiated measurement is performed according to ANSI C63.26 (2015)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

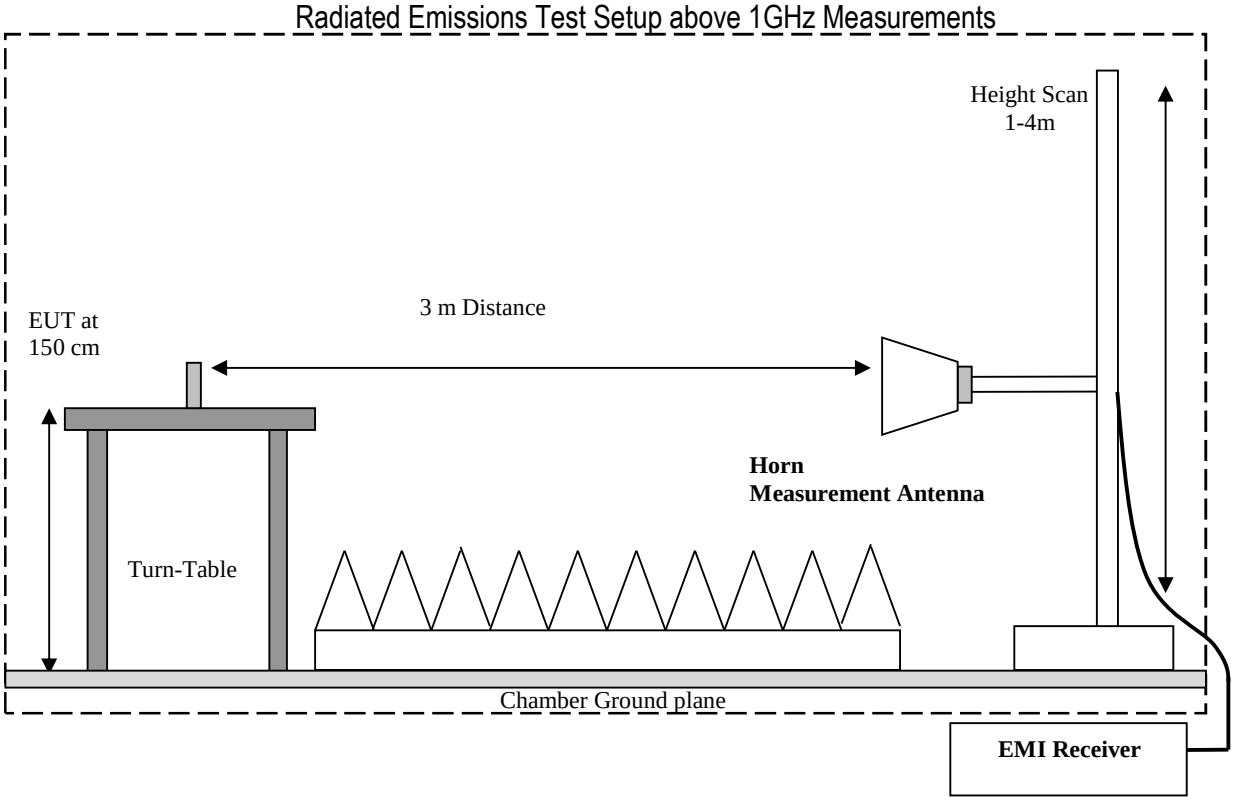
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

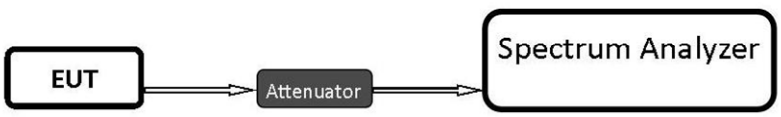
FS (dBµV/m) = Measured Value on SA (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 RF Conducted Measurement Procedure

Testing procedures are based on guidelines provided in FCC publication (KDB) 971168 D01 v03r01 – "Measurement Guidance for Certification of Licensed Digital Transmitters" and ANSI C63.26-2015 – "American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Devices", by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.
- Calculate the conducted power by taking into account attenuation of the cable and the attenuator

8 Test Result Data

8.1 RF Output Power

8.1.1 Measurement according to FCC §2.1046, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.2 RF output power measurement procedures of ANSI C63.26 (2015) for test procedure. The average power using a spectrum/signal analyzer or EMI receiver method was used as described in Section 5.2.4.4.

Spectrum Analyzer Settings:

- Set span to 2 x to 3 x the OBW
- Set RBW = 1% to 5% of the OBW
- Set VBW ≥ 3 x RBW
- Set number of measurement points in sweep ≥ 2 x span / RBW
- Sweep time = auto-couple
- Detector = power averaging (rms)
- Trigger = free run
- Trace average = at least 100 traces
- Compute the power by integrating the spectrum across the OBW of the signal

8.1.2 Limits:

FCC §25.204(a):
In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits except as provided for in paragraph (c) of this section:
+ 40 dBW in any 4 kHz band for θ ≤0°
+ 40 + 3θ dBW in any 4 kHz band for 0° <θ ≤5°
where θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

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The application for MES certification shall state the e.i.r.p. that the MES must have for satisfactory communication. The maximum permissible e.i.r.p. will be the stated e.i.r.p. plus a 2 dB margin. If a detachable antenna is used, the application for certification shall state the recommended antenna type and manufacturer, the antenna gain, and the maximum transmitter output power at the antenna terminal.

8.1.3 Test conditions and setup:

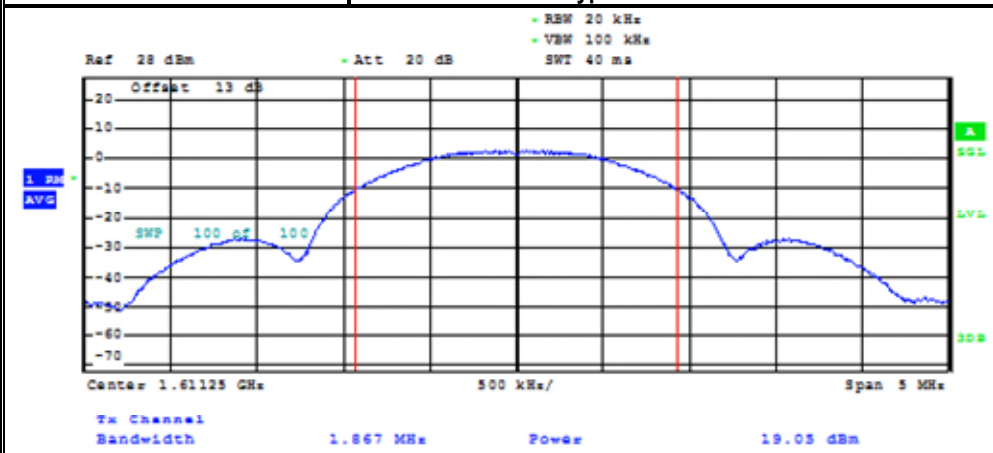
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22.5° C	1	Op. 1	3.6 VDC	5 dBi

8.1.4 Measurement result:

Plot #	Channel	Frequency (MHz)	Maximum Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBW / dBm)	Result
1	A	1611.25	19.05	24.05	40 / 70 (EIRP)	Pass
2	B	1613.75	19.00	24.00		Pass
3	C	1616.25	18.95	23.95		Pass
4	D	1618.75	18.91	23.91		Pass

8.1.5 Measurement Plots:

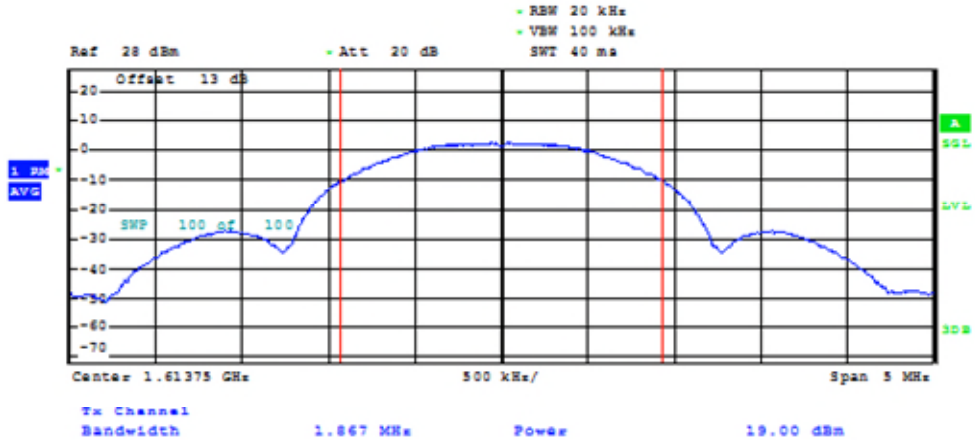
Plot #1	
Channel A / 1611.25 MHz	**Modulation/Packet Type: BPSK**



Date: 21.FEB.2024 16:57:09

Plot #2

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK



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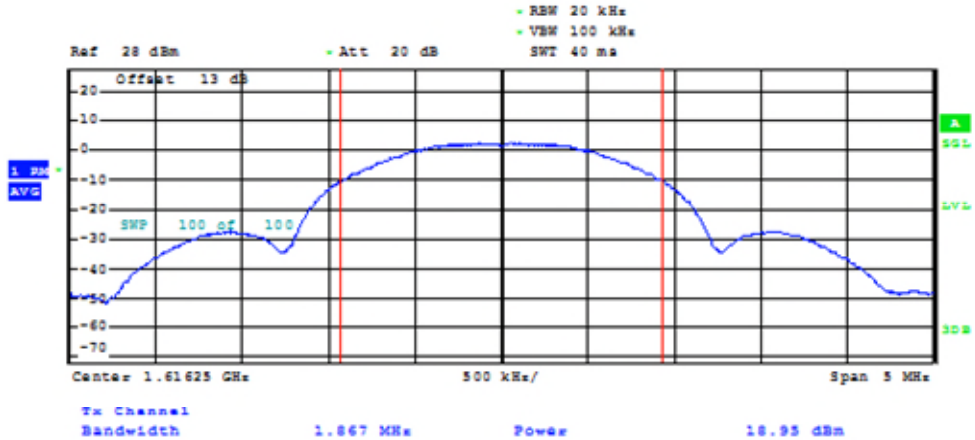
Plot #3

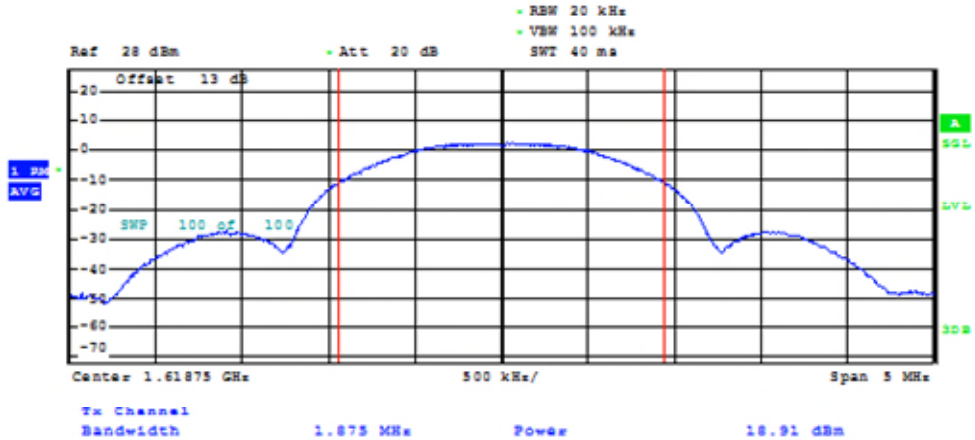
Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 16:55:45

Plot #4

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 16:53:04

8.2 Modulation Characteristics

8.2.1 Measurement according to FCC §2.1047, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.3 Modulation Characteristics of ANSI C63.26 (2015) for test procedure.

Refer to FCC §2.1047:

(a) ***Voice modulated communication equipment.*** A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz shall be submitted. For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter, or of all circuitry installed between the modulation limiter and the modulated stage shall be submitted.

(b) ***Equipment which employs modulation limiting.*** A curve or family of curves showing the percentage of modulation versus the modulation input voltage shall be supplied. The information submitted shall be sufficient to show modulation limiting capability throughout the range of modulating frequencies and input modulating signal levels employed.

(c) ***Single sideband and independent sideband radiotelephone transmitters which employ a device or circuit to limit peak envelope power.*** A curve showing the peak envelope power output versus the modulation input voltage shall be supplied. The modulating signals shall be the same in frequency as specified in paragraph (c) of § 2.1049 for the occupied bandwidth tests.

(d) ***Other types of equipment.*** A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.

8.2.2 Result:

The EUT transmits data using Direct Sequence Spread Spectrum (DSSS) carrier with a Binary Phase Shift Keyed (BPSK) data modulation.

- The DSSS carrier is BPSK modulated at 1.25 MHz.
- The symbol rate is 100.04 sps.
- There is 1 bit per symbol giving a bit rate equal to the symbol rate of 100.04 bps.

8.3 Occupied Bandwidth

8.3.1 Measurement according to FCC §2.1049, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.4.4 Occupied bandwidth – Power bandwidth (99%) measurement procedure of ANSI C63.26 (2015) for test procedure.

Spectrum Analyzer settings:

- Set spectrum analyzer center frequency to nominal EUT channel center frequency
- Set frequency span side enough to capture all modulation products (typically 1.5 x OBW is sufficient)
- Filter = 3 dB
- Set RBW = 1% to 5% of anticipated OBW
- Set VBW ≥ 3 x RBW
- Set reference level as required to prevent signal amplitude from exceeding maximum spectrum analyzer input mixer level
- Use 99% OBW function
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize

8.3.2 Limits:

FCC §25.202(f):

Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

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The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:

a. 25 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater

b. 35 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater
c. 43 + 10 log p (watts) in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

8.3.3 Test conditions and setup:

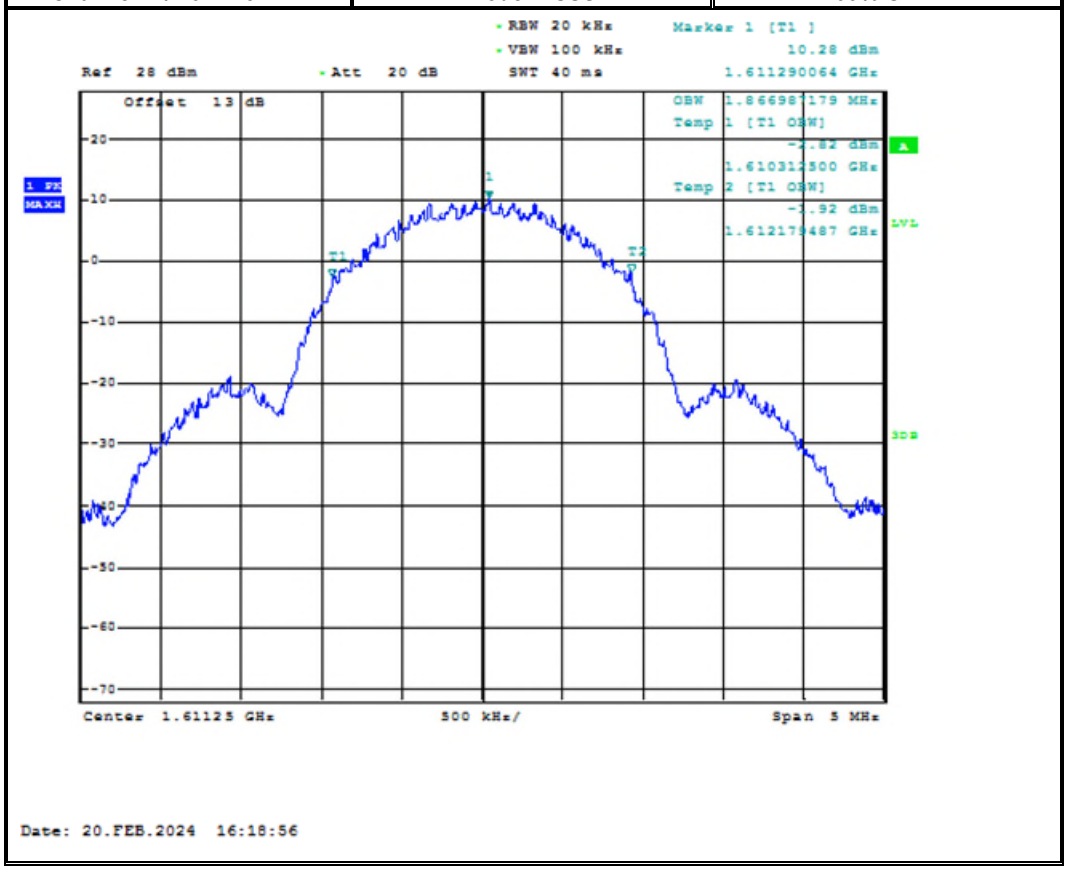
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22.5° C	1	Op. 1	3.6 VDC

8.3.4 Measurement result:

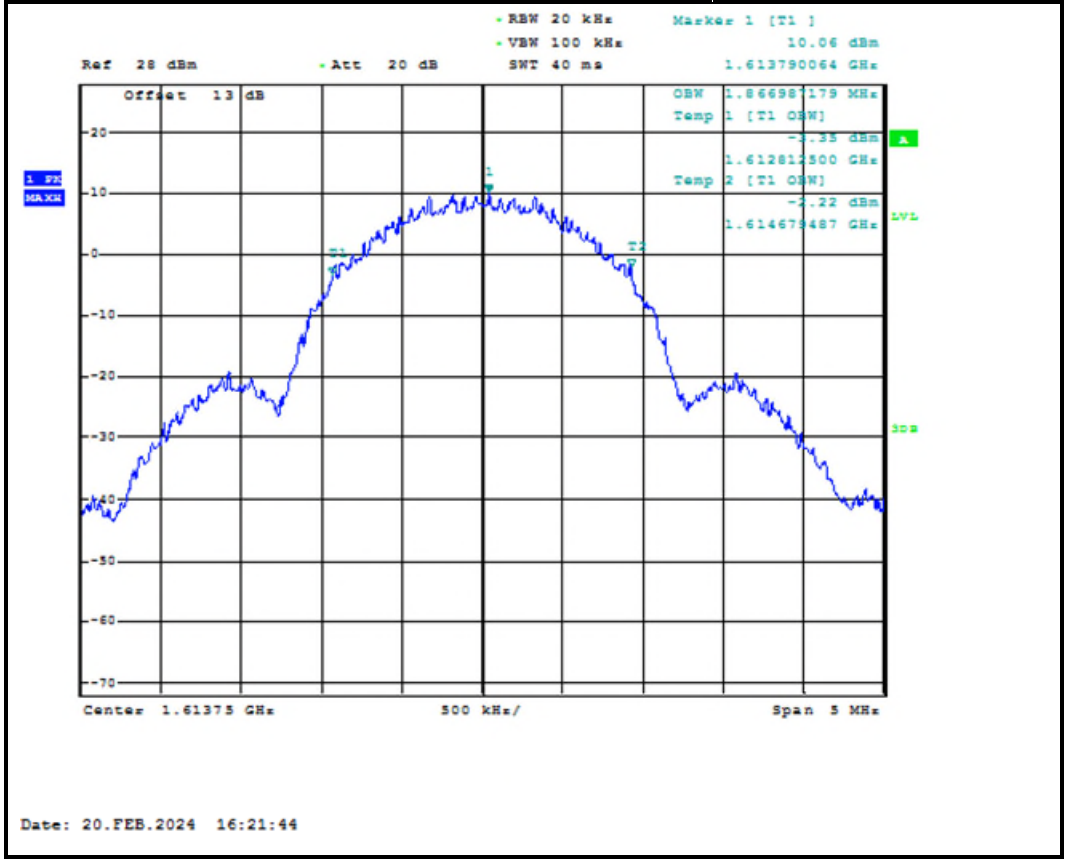
Plot #	Channel	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
1	A	1611.25	1.8670	See Section 8.3.2	Pass
2	B	1613.75	1.8670		Pass
3	C	1616.25	1.8670		Pass
4	D	1618.75	1.8750		Pass

8.3.5 Measurement Plots:

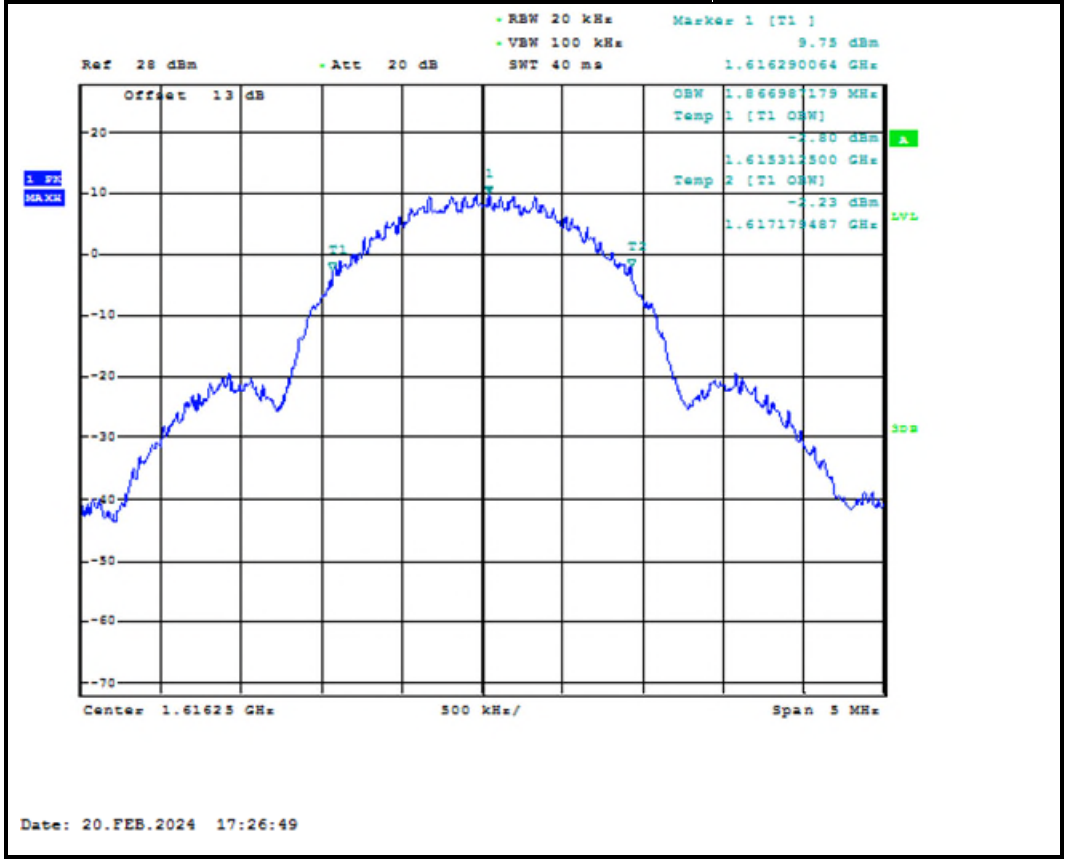
Plot #1		
Channel A / 1611.25 MHz	**Mode: DSSS**	**99% OBW**



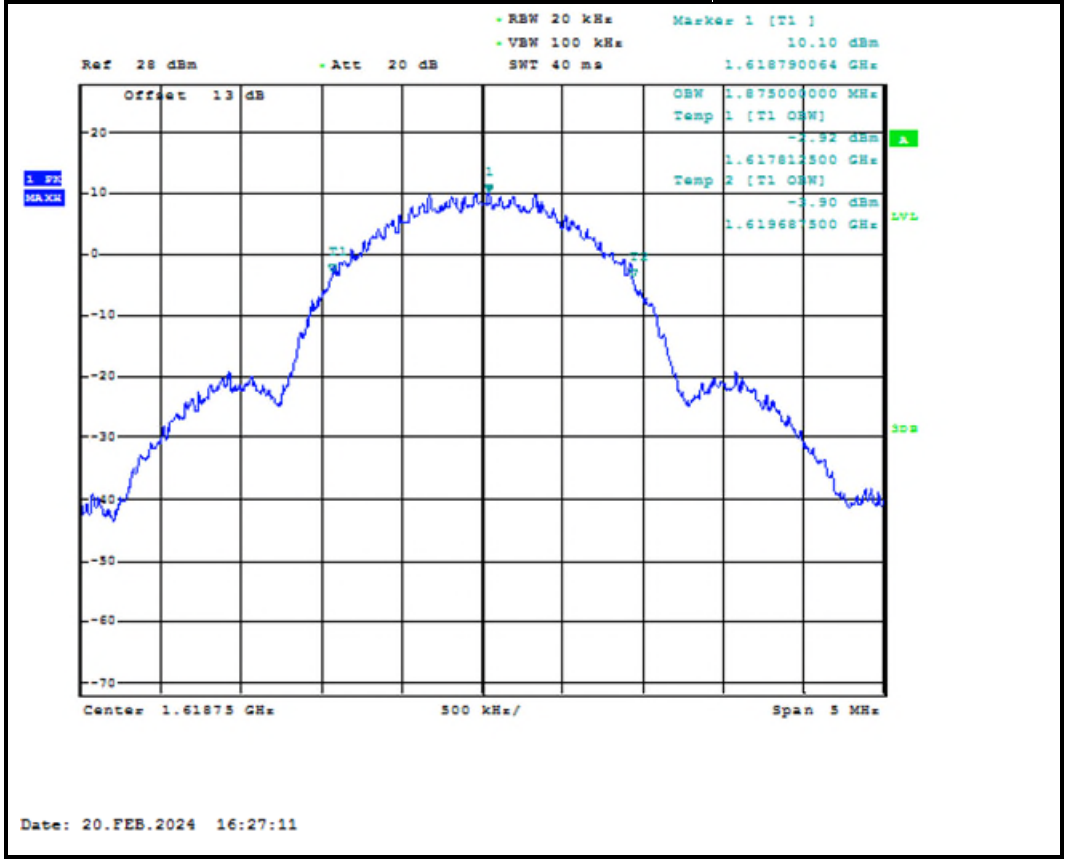
Plot #2		
Channel B / 1613.75 MHz	**Mode: DSSS**	**99% OBW**



Plot #3		
Channel C / 1616.25 MHz	**Mode: DSSS**	**99% OBW**



Plot #4		
Channel D / 1618.75 MHz	**Mode: DSSS**	**99% OBW**



8.4 Unwanted Emissions at Antenna Terminals

8.4.1 Measurement according to FCC §2.1051, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.7.3 Out-of-band unwanted emissions measurements and Section 5.7.4 Spurious unwanted emission measurements of ANSI C63.26 for test procedure.

8.4.2 Limits

FCC §25.202(f):
Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
(2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
(3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
(4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

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The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:

a. 25 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater
b. 35 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater
c. 43 + 10 log p (watts) in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna gain
22.5 °C	1	Op. 1	3.6 VDC	5 dBi

8.4.4 Measurement result:

Out-of-Band Emissions:

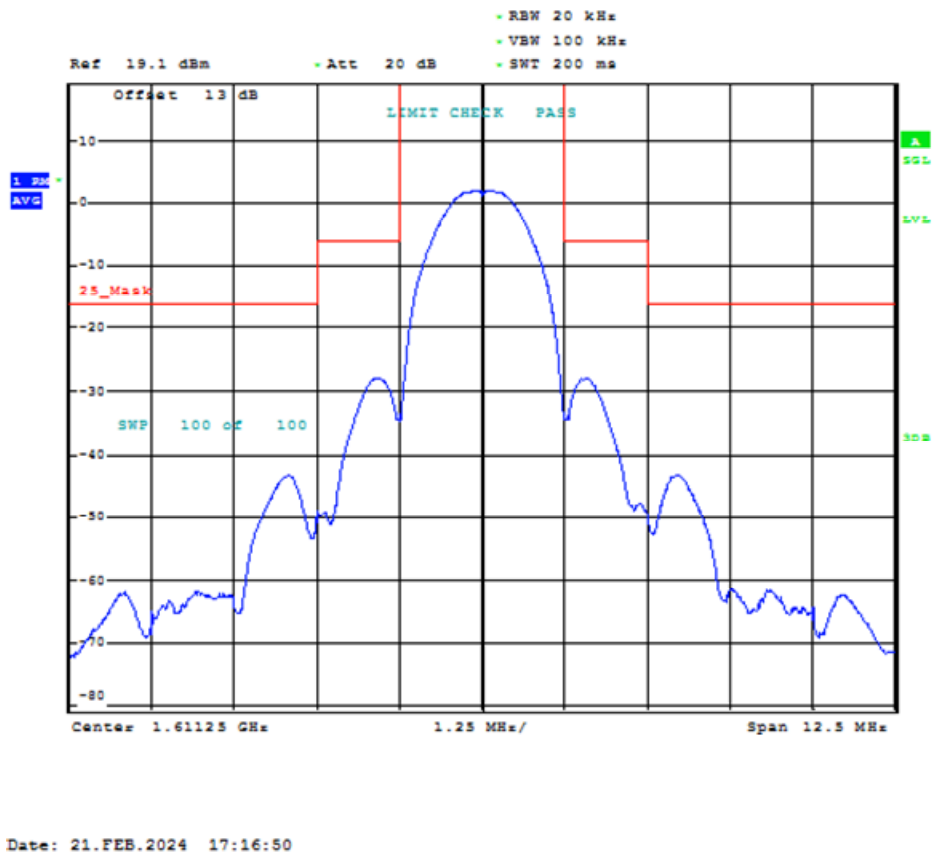
Plot #	Channel	Center Frequency (MHz)	Limit (MHz)	Result
1	A	1611.25	See Section 8.4.2	Pass
2	B	1613.75		Pass
3	C	1616.25		Pass
4	D	1618.75		Pass

Conducted Spurious Emissions:

Plot #	Channel	Center Frequency (MHz)	Frequency Scan Range	Limit	Result
1	A	1611.25	30 MHz – 1 GHz	See Section 8.4.2	Pass
2			1 – 1.605 GHz		Pass
3			1.6175 – 6 GHz		Pass
4			6 – 12 GHz		Pass
5			12 – 17 GHz		Pass
6	B	1613.75	30 MHz – 1 GHz		Pass
7			1 – 1.6075 GHz		Pass
8			1.620 – 6 GHz		Pass
9			12 – 17 GHz		Pass
10			30 MHz – 1 GHz		Pass
11	C	1616.25	30 MHz – 1 GHz		Pass
12			1 – 1.610 GHz		Pass
13			1.6225 – 6 GHz		Pass
14			12 – 17 GHz		Pass
15			30 MHz – 1 GHz		Pass
16	D	1618.75	30 MHz – 1 GHz		Pass
17			1 – 1.6125 GHz		Pass
18			1.625 – 6 GHz		Pass
19			12 – 17 GHz		Pass
20			30 MHz – 1 GHz		Pass

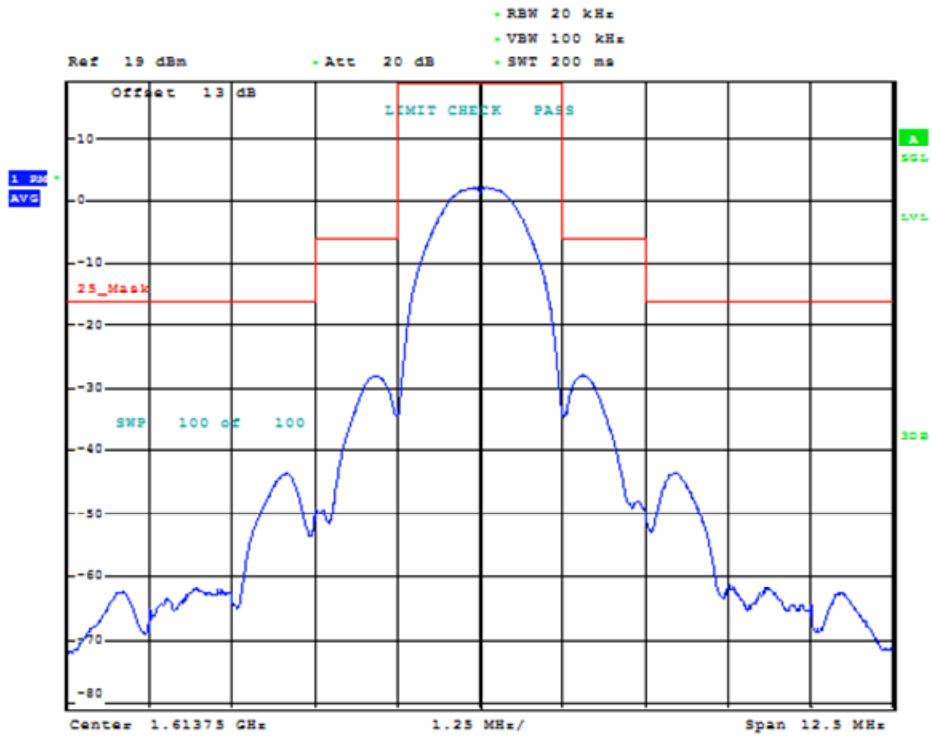
8.4.5 Measurement Plots:

Plot #1 Out-of-Band Emissions	
Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK



Plot #2 Out-of-Band Emissions

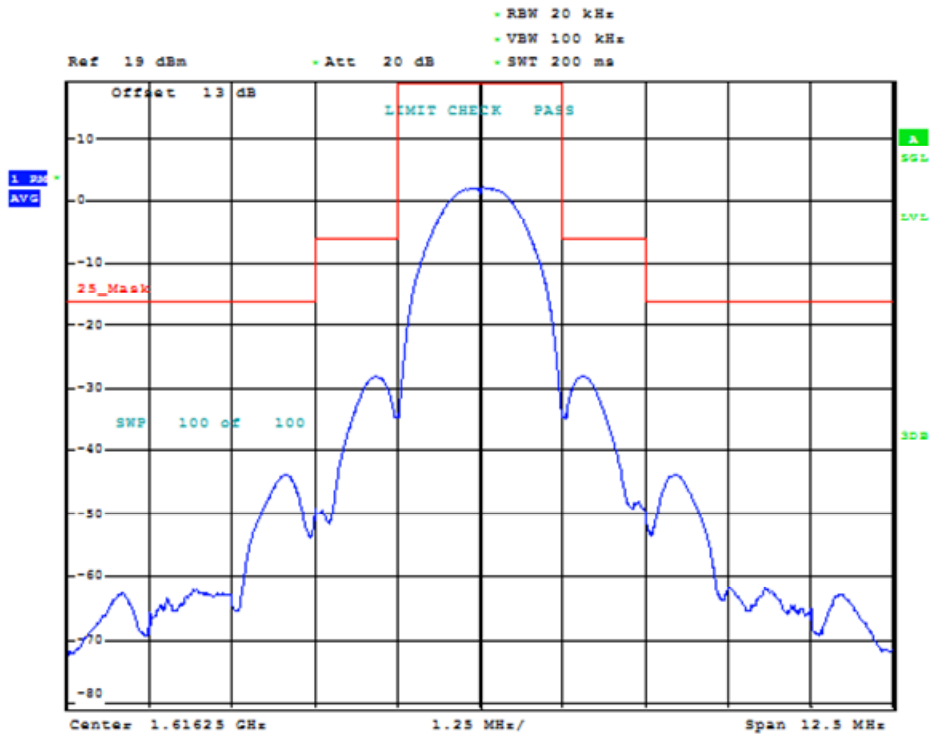
Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 17:15:33

Plot #3 Out-of-Band Emissions

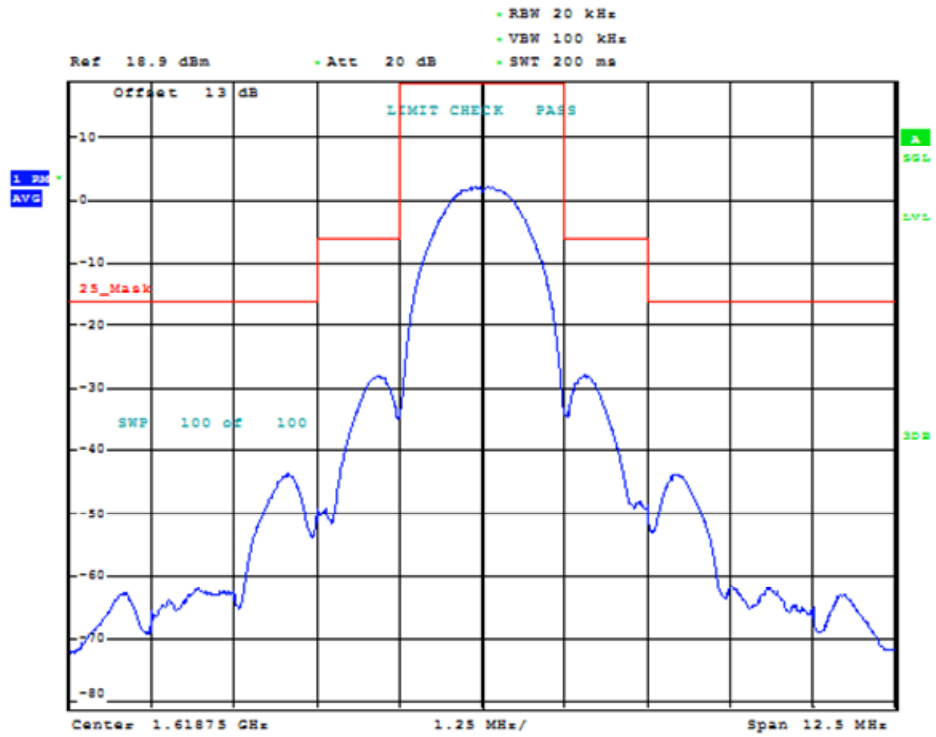
Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 17:14:35

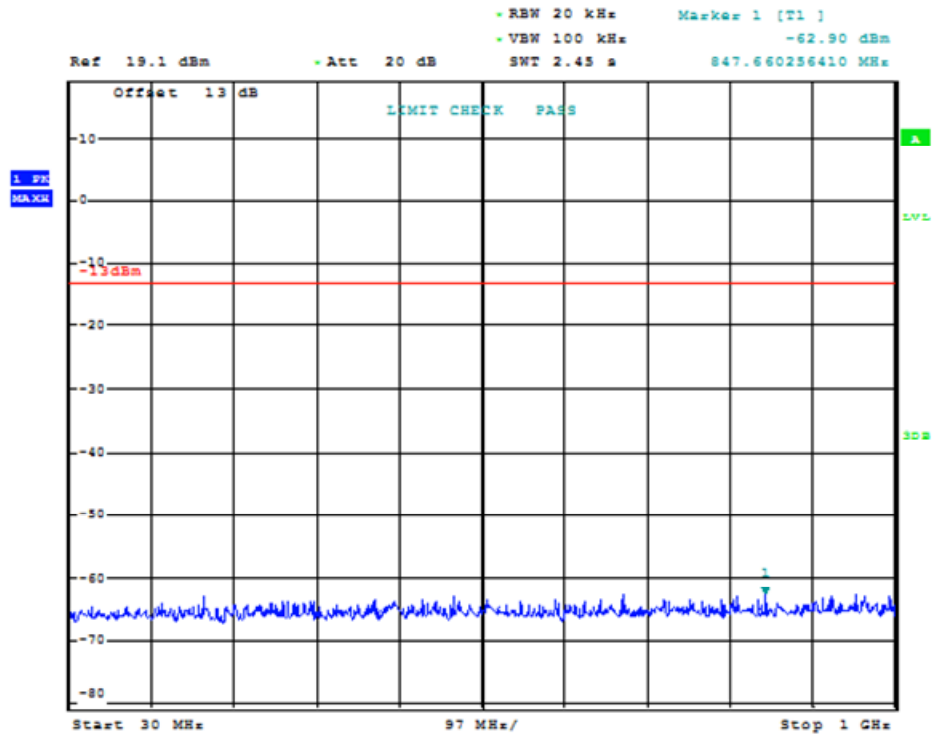
Plot #4 Out-of-Band Emissions

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



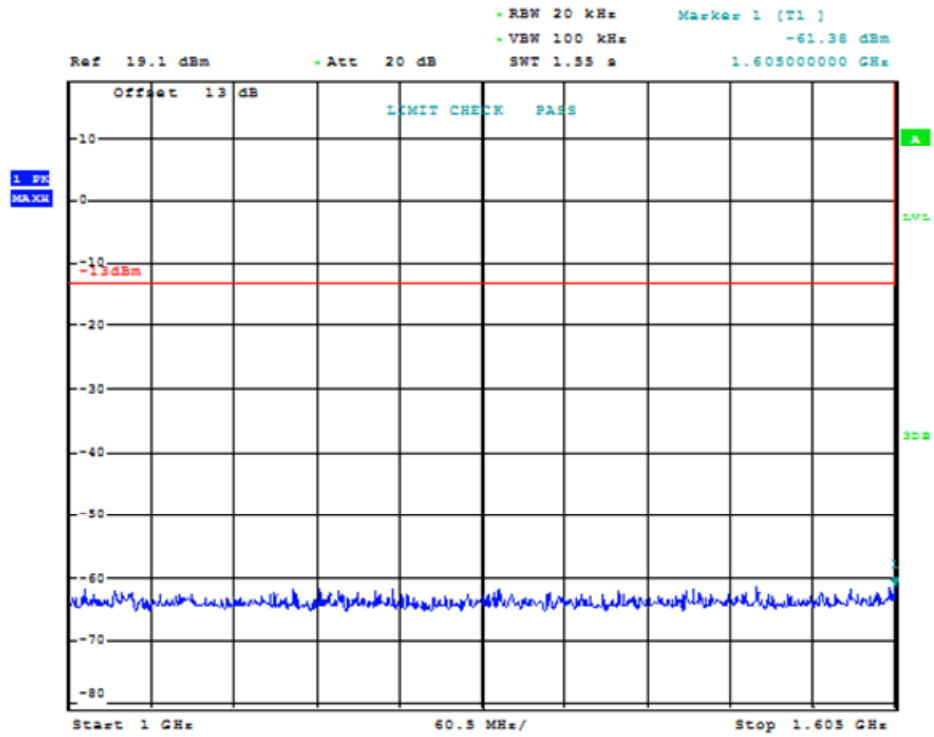
Date: 21.FEB.2024 17:12:38

Plot #5 Conducted Spurious Emissions: 30 MHz – 1 GHz	
Channel A / 1611.25 MHz	**Modulation/Packet Type: BPSK**



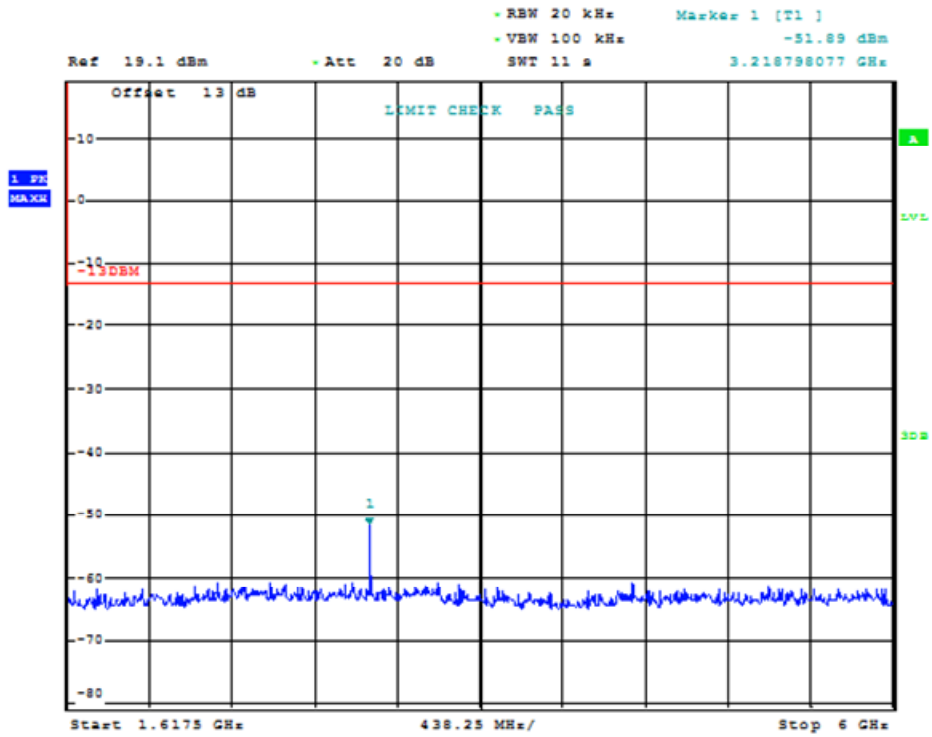
Plot #6 Conducted Spurious Emissions: 1 – 1.605 GHz

Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 17:25:41

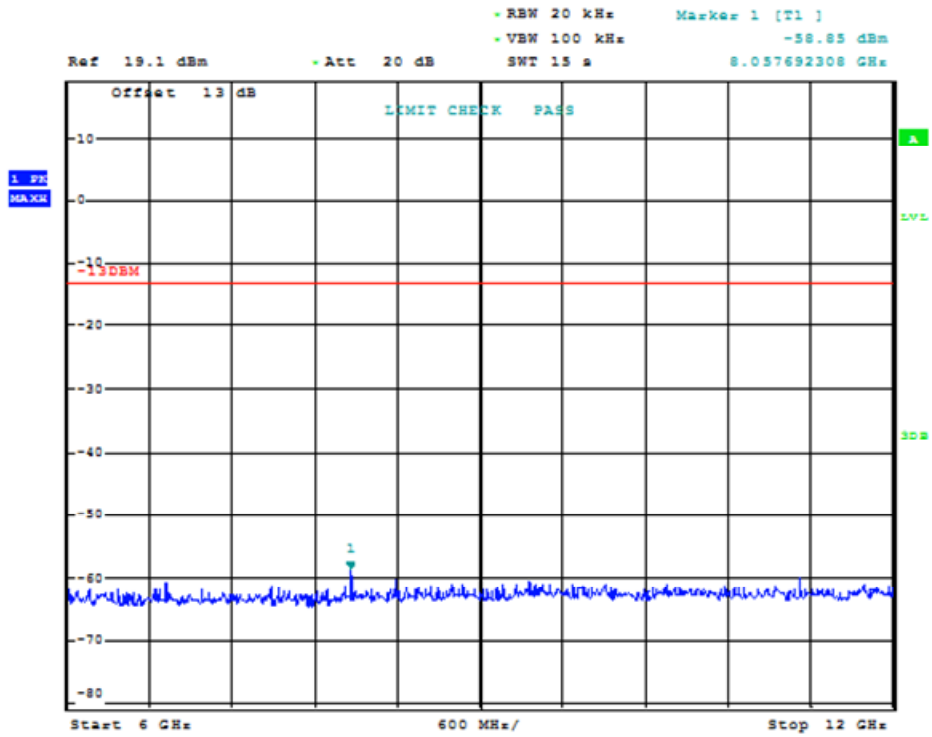
Plot #7 Conducted Spurious Emissions: 1.6175 – 6 GHz	
Channel A / 1611.25 MHz	**Modulation/Packet Type: BPSK**



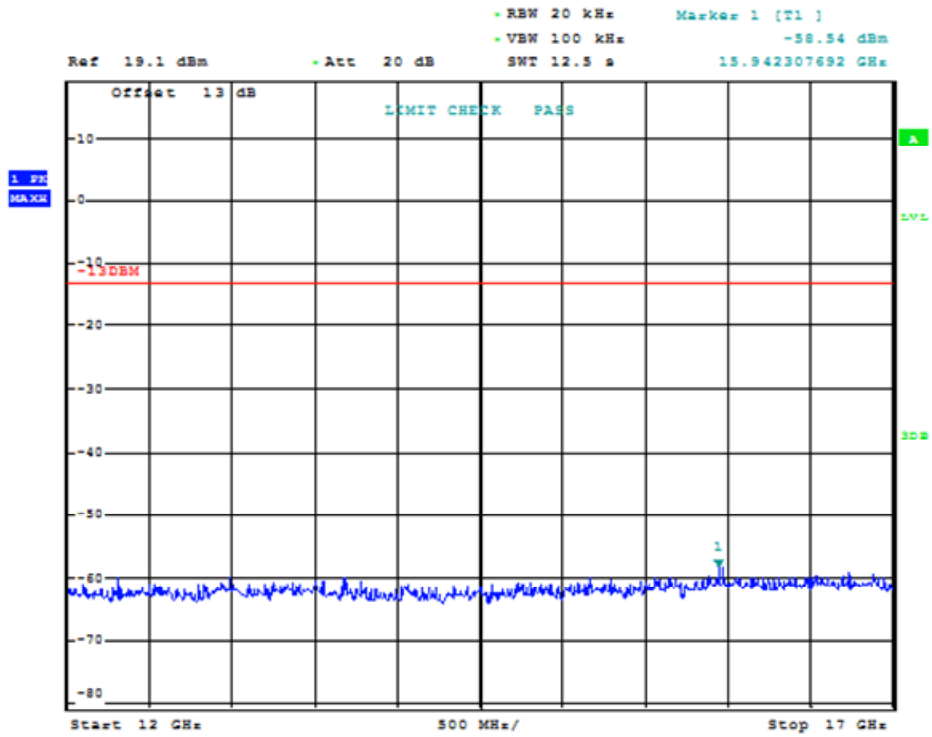
Date: 21.FEB.2024 17:35:19

Plot #8 Conducted Spurious Emissions: 6 – 12 GHz

Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK

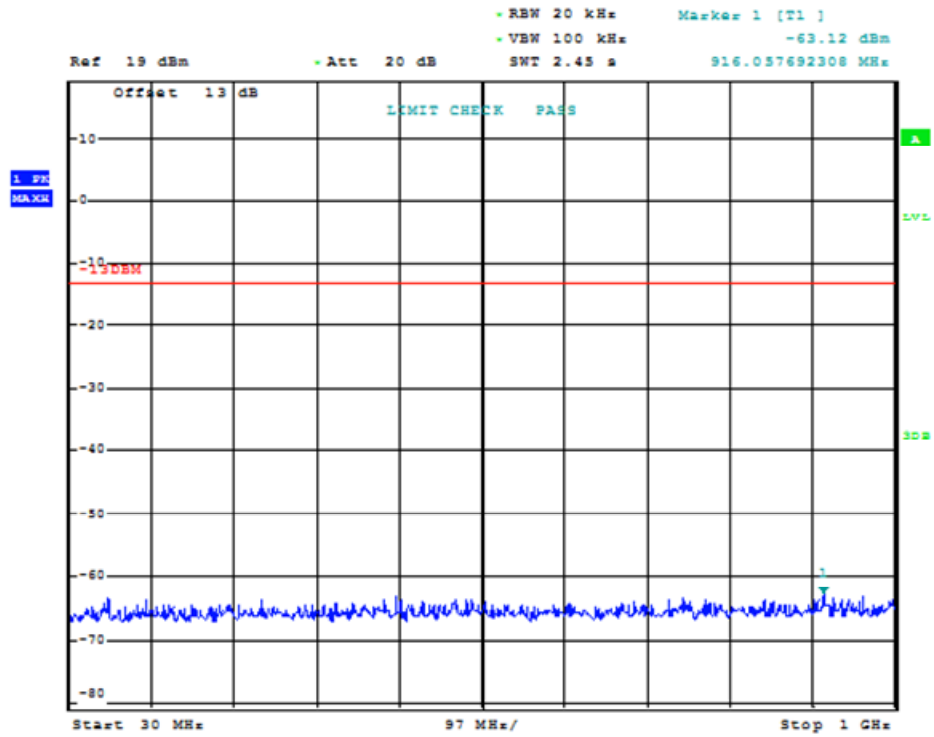


Plot #9 Conducted Spurious Emissions: 12 – 17 GHz	
Channel A / 1611.25 MHz	**Modulation/Packet Type: BPSK**



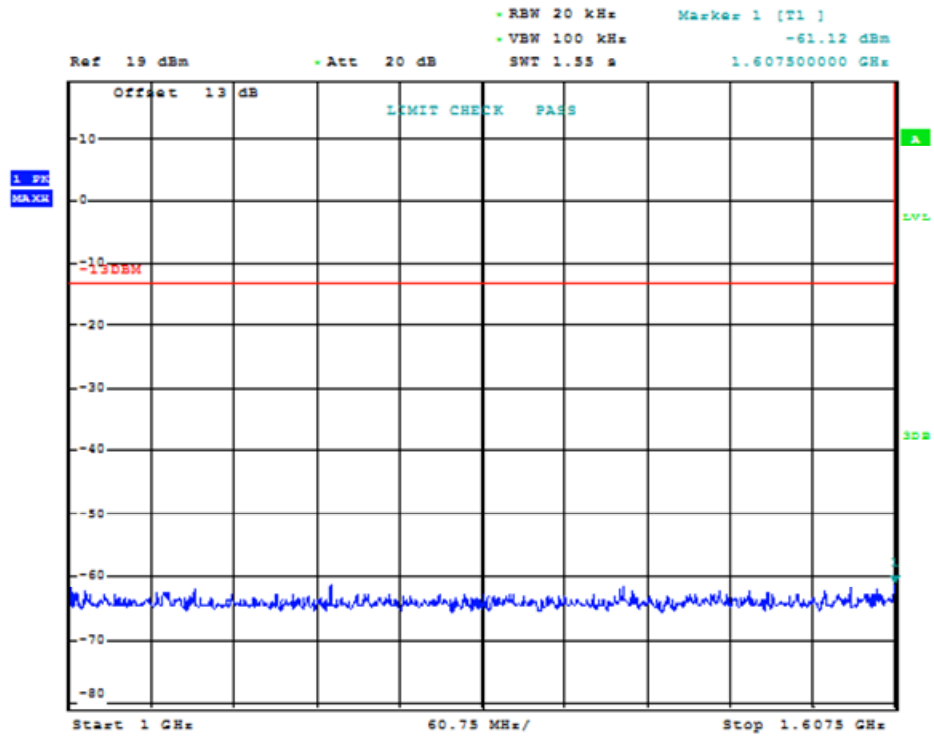
Plot #10 Conducted Spurious Emissions: 30 MHz – 1 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK



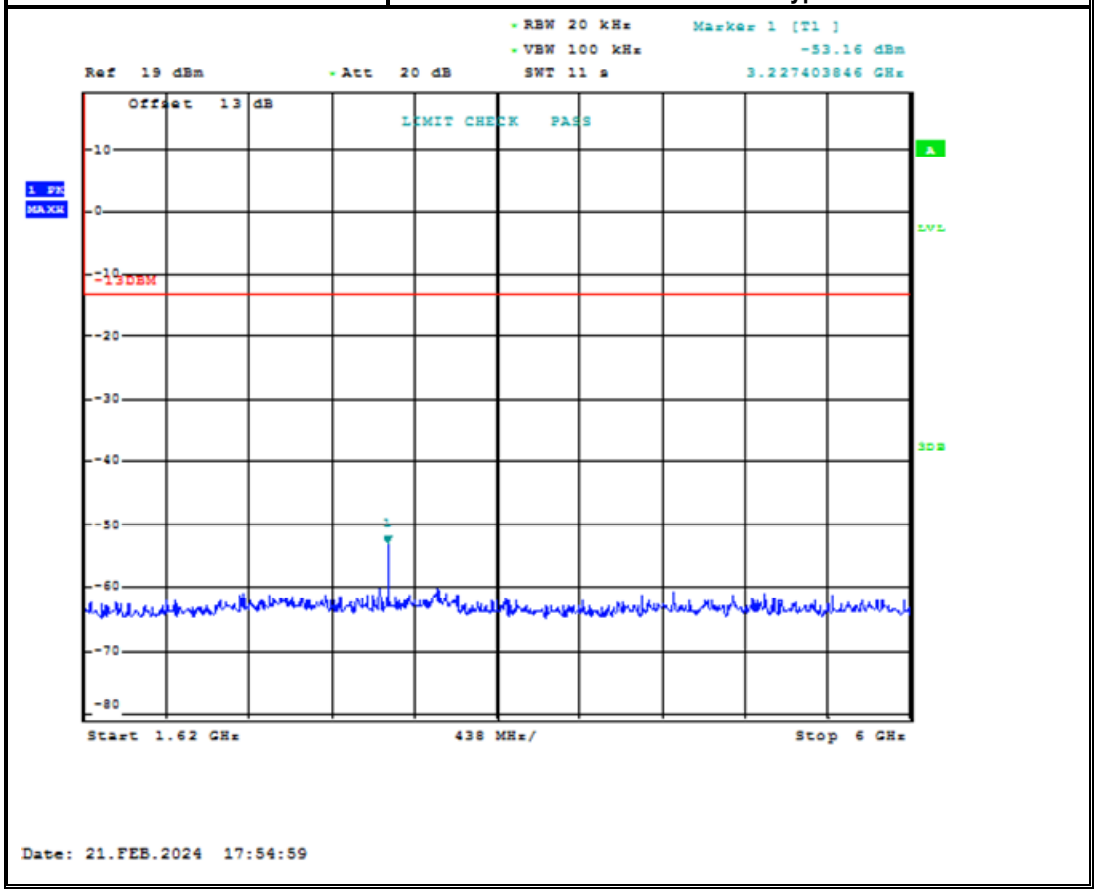
Date: 21.FEB.2024 17:39:11

Plot #11 Conducted Spurious Emissions: 1 – 1.6075 GHz	
Channel B / 1613.75 MHz	**Modulation/Packet Type: BPSK**



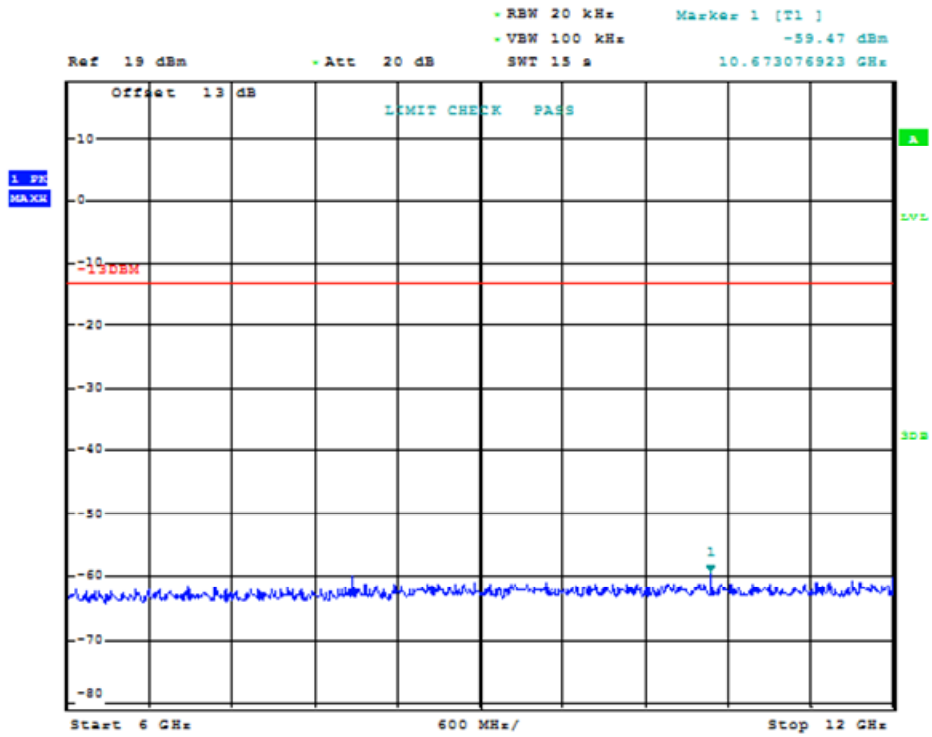
Date: 21.FEB.2024 17:53:12

Plot #12 Conducted Spurious Emissions: 1.620 – 6 GHz	
Channel B / 1613.75 MHz	**Modulation/Packet Type: BPSK**



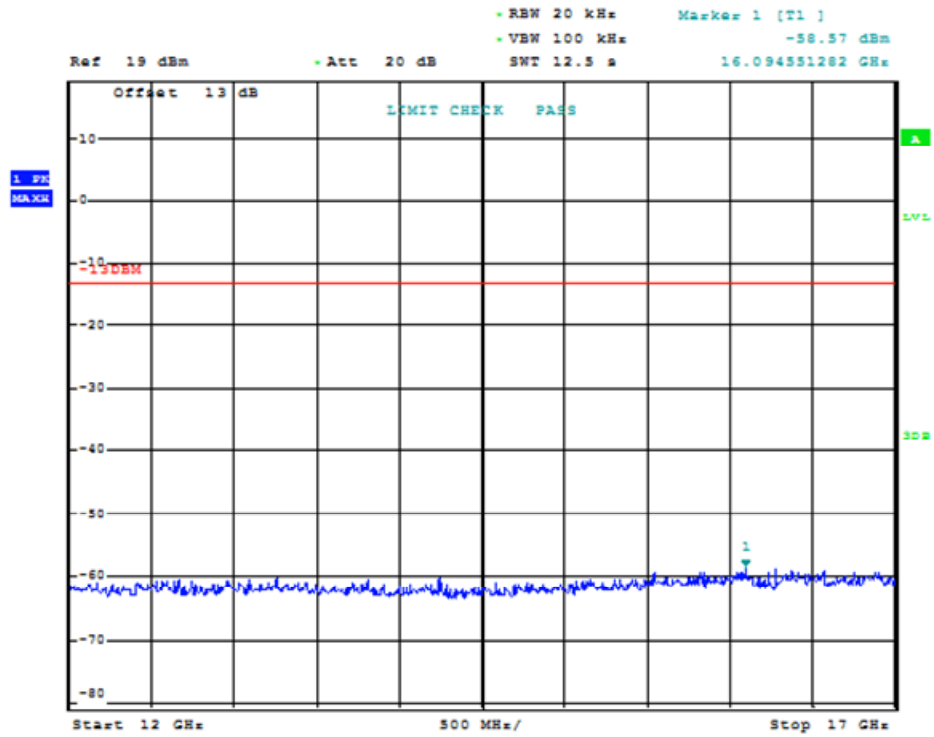
Plot #13 Conducted Spurious Emissions: 6 – 12 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK

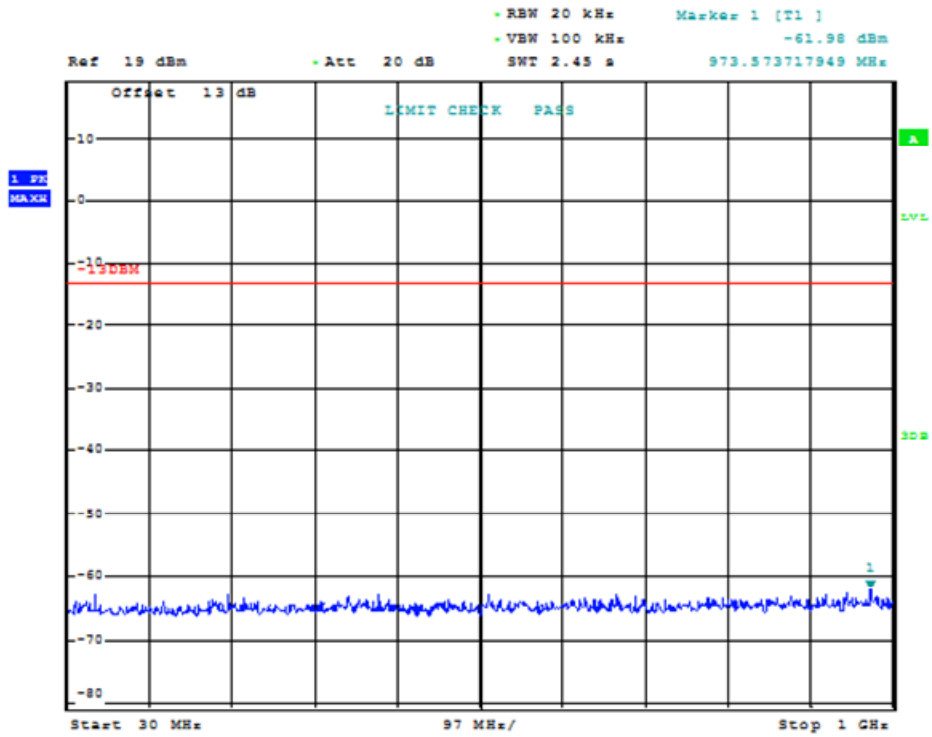


Plot #14 Conducted Spurious Emissions: 12 – 17 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK

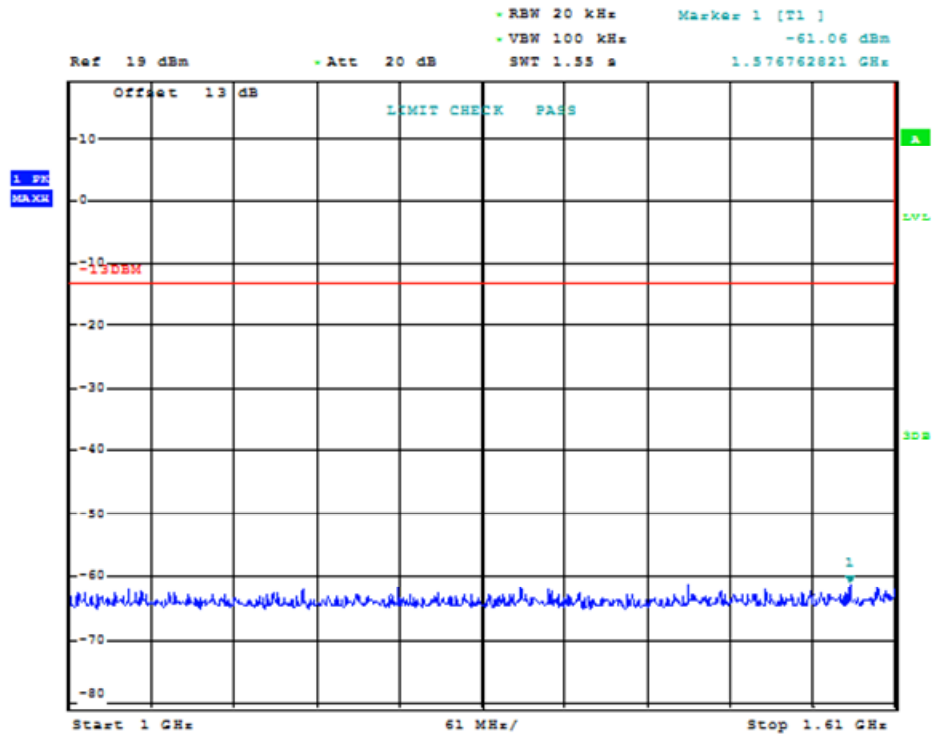


Plot #15 Conducted Spurious Emissions: 30 MHz – 1 GHz	
Channel C / 1616.25 MHz	**Modulation/Packet Type: BPSK**



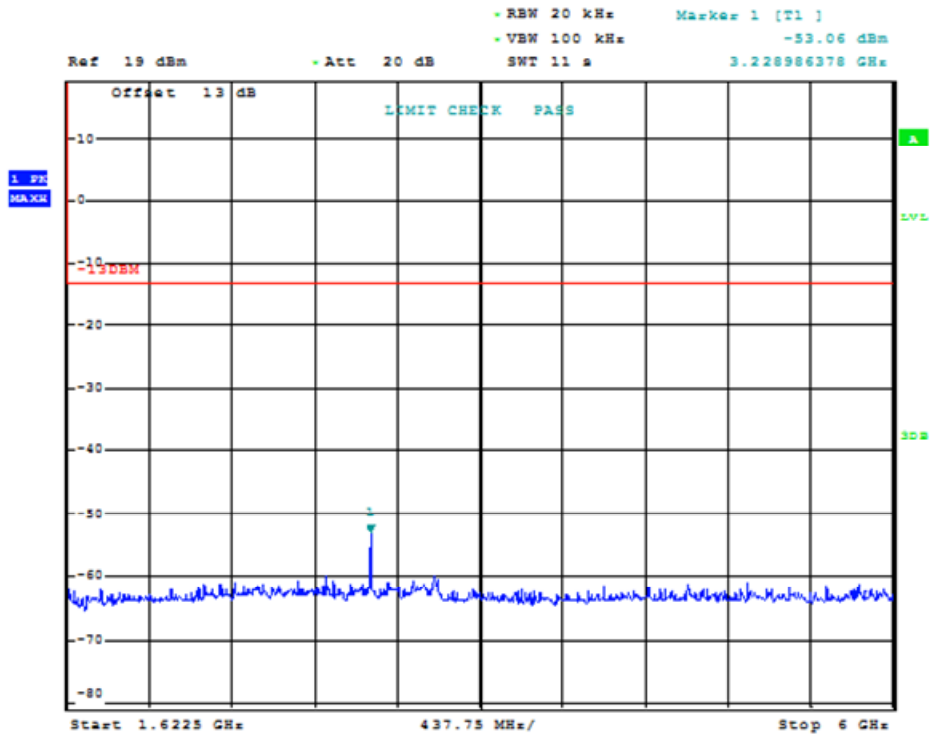
Date: 21.FEB.2024 18:03:53

Plot #16 Conducted Spurious Emissions: 1 – 1.610 GHz	
Channel C / 1616.25 MHz	**Modulation/Packet Type: BPSK**



Date: 21.FEB.2024 18:08:03

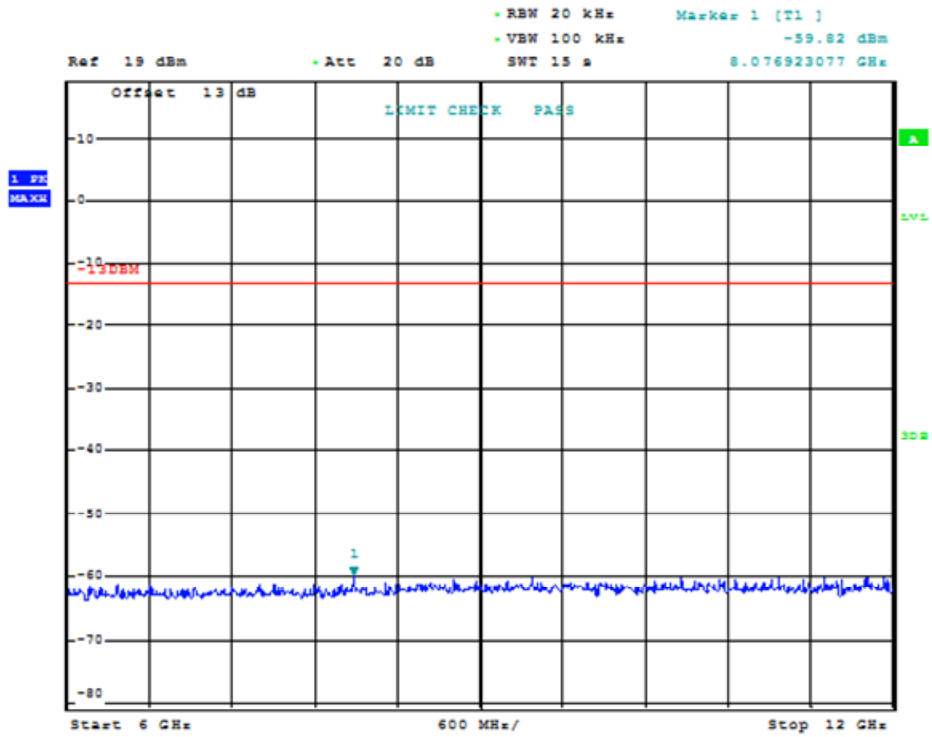
Plot #17 Conducted Spurious Emissions: 1.622.5 – 6 GHz	
Channel C / 1616.25 MHz	**Modulation/Packet Type: BPSK**



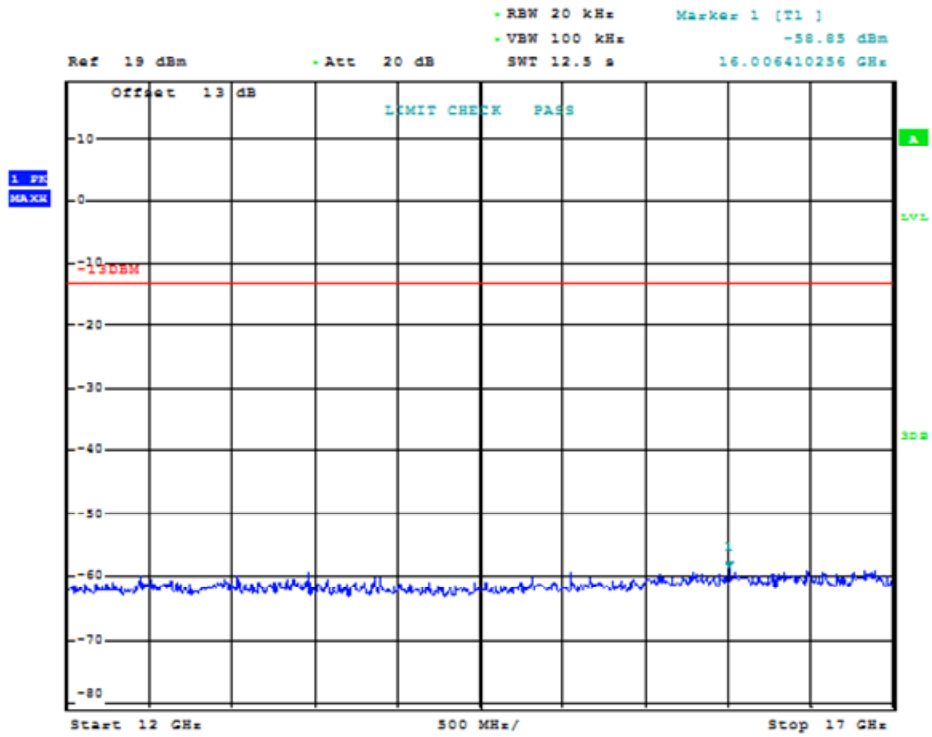
Date: 21.FEB.2024 18:10:13

Plot #18 Conducted Spurious Emissions: 6 – 12 GHz

Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK

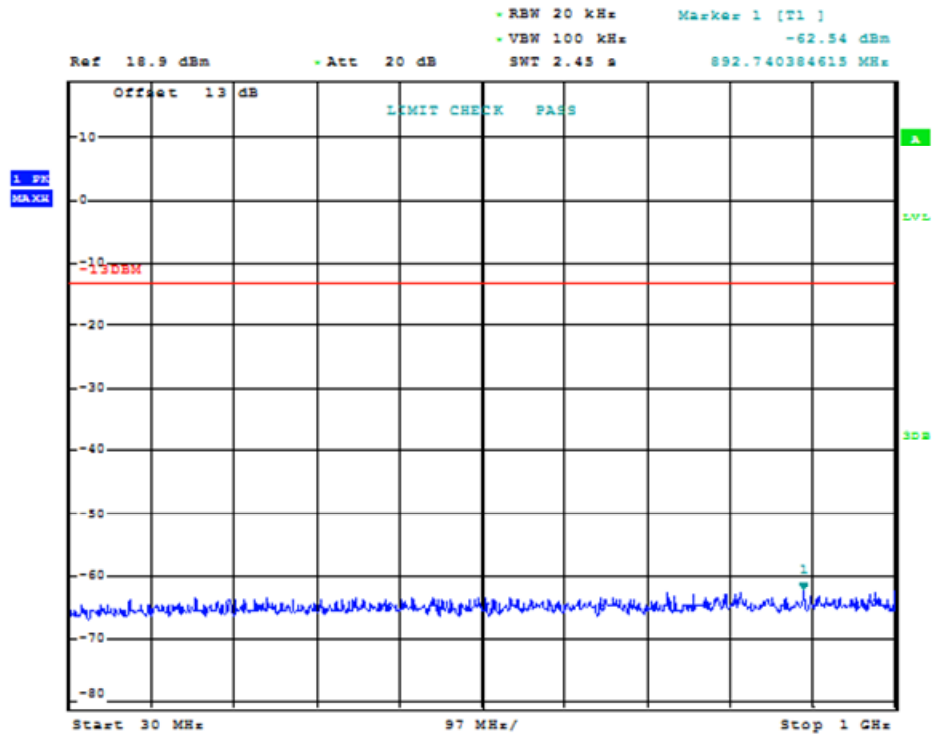


Plot #19 Conducted Spurious Emissions: 12 – 17 GHz	
Channel C / 1616.25 MHz	**Modulation/Packet Type: BPSK**



Plot #20 Conducted Spurious Emissions: 30 MHz – 1 GHz

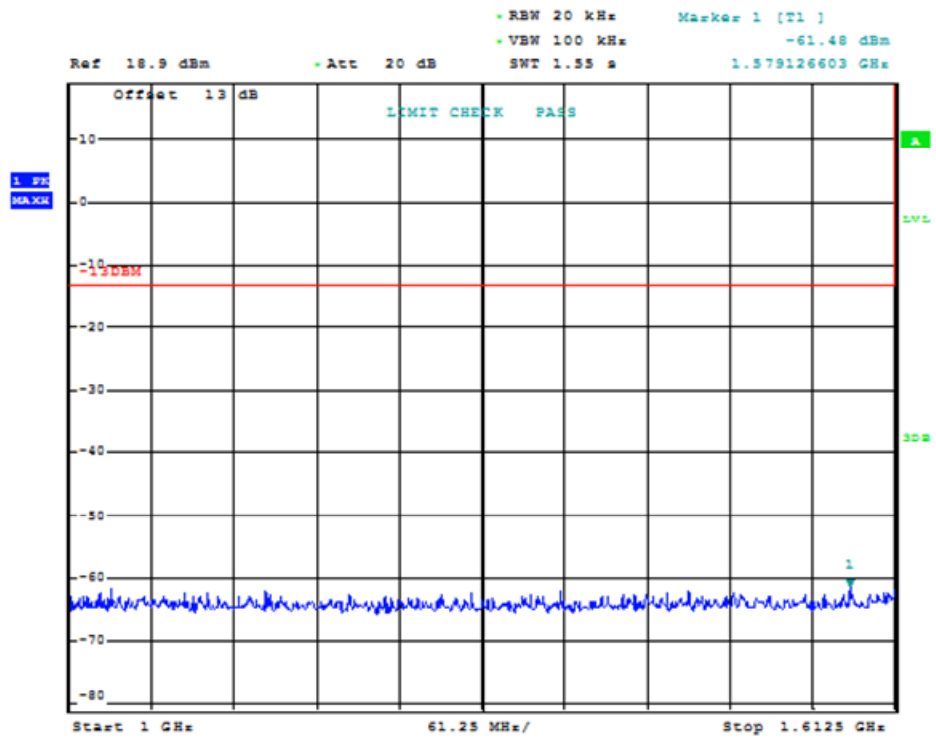
Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 18:19:55

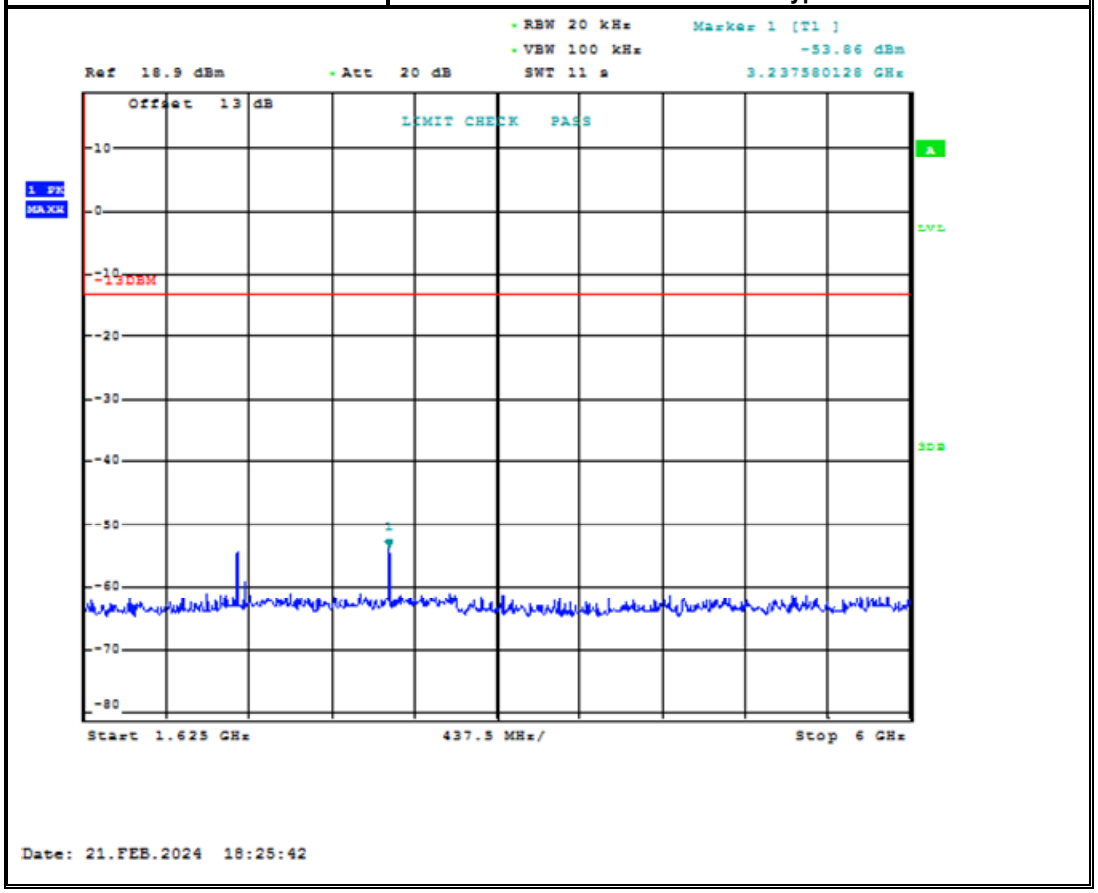
Plot #21 Conducted Spurious Emissions: 1 – 1.6125 GHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



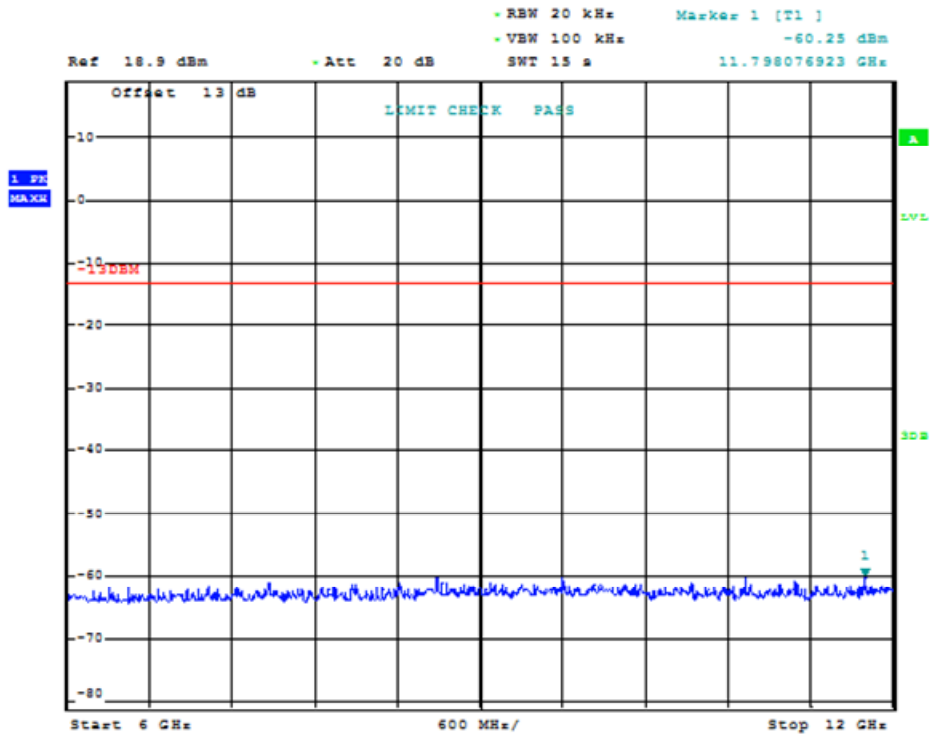
Date: 21.FEB.2024 18:22:51

Plot #22 Conducted Spurious Emissions: 1.625 – 6 GHz	
Channel D / 1618.75 MHz	**Modulation/Packet Type: BPSK**



Plot #23 Conducted Spurious Emissions: 6 – 12 GHz

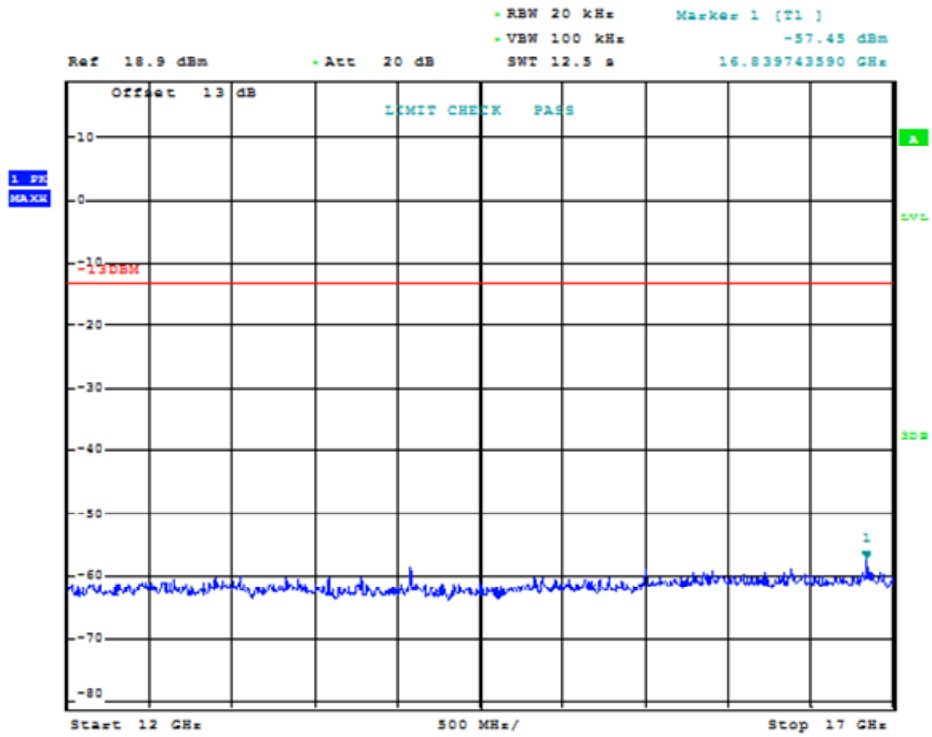
Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 18:26:56

Plot #24 Conducted Spurious Emissions: 12 – 17 GHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Date: 21.FEB.2024 18:28:19

8.5 Field Strength of Spurious Radiation

8.5.1 Measurement according to FCC §2.1053, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.5.4 Radiated measurements using the field strength method of ANSI C63.26 for test procedure.

8.5.2 Limits:

FCC §25.202(f):

Emission limitations. Except for SDARS terrestrial repeaters and as provided for in paragraph (i), the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

(5) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
(6) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
(7) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
(8) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

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The average power of unwanted emissions shall be attenuated below the average output power, P (dBW), of the transmitter, as specified below:

d. 25 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater
e. 35 dB in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater
f. 43 + 10 log p (watts) in any 4 kHz, the frequency of which is offset from the channel centre frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater

8.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22.5° C	2	Op. 1	3.6 VDC

8.5.4 Measurement result:

Radiated Spurious Emissions

Plot #	Channel	Scan Frequency	Limit	Result
1 – 3	A	30 MHz – 18 GHz	See section 8.5.2	Pass
4 – 6	B			Pass
7 – 9	C			Pass
10 – 12	D			Pass

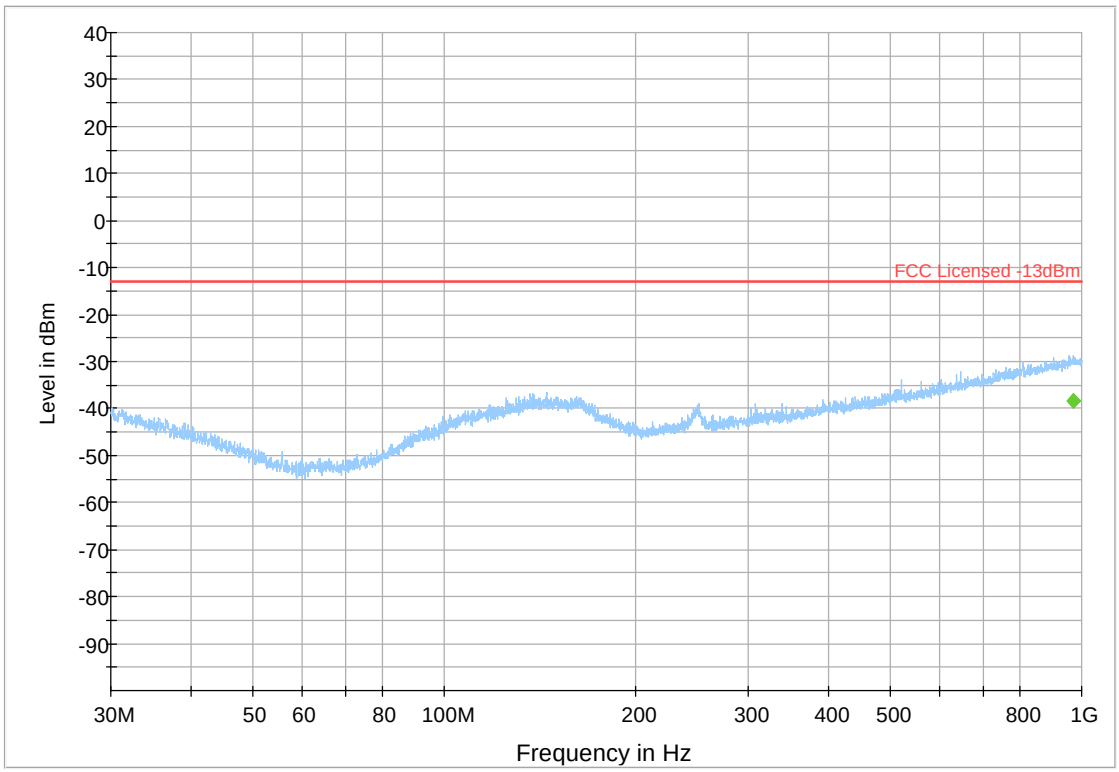
8.5.5 Measurement Plots:

Plot #1 Radiated Emissions: 30 MHz – 1 GHz

Channel A / 1611.25 MHz | **Modulation/Packet Type: BPSK**

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
968.899	---	-38.471	-13.00	25.47	500.0	100.000	243.0	V	186.0	-63.0



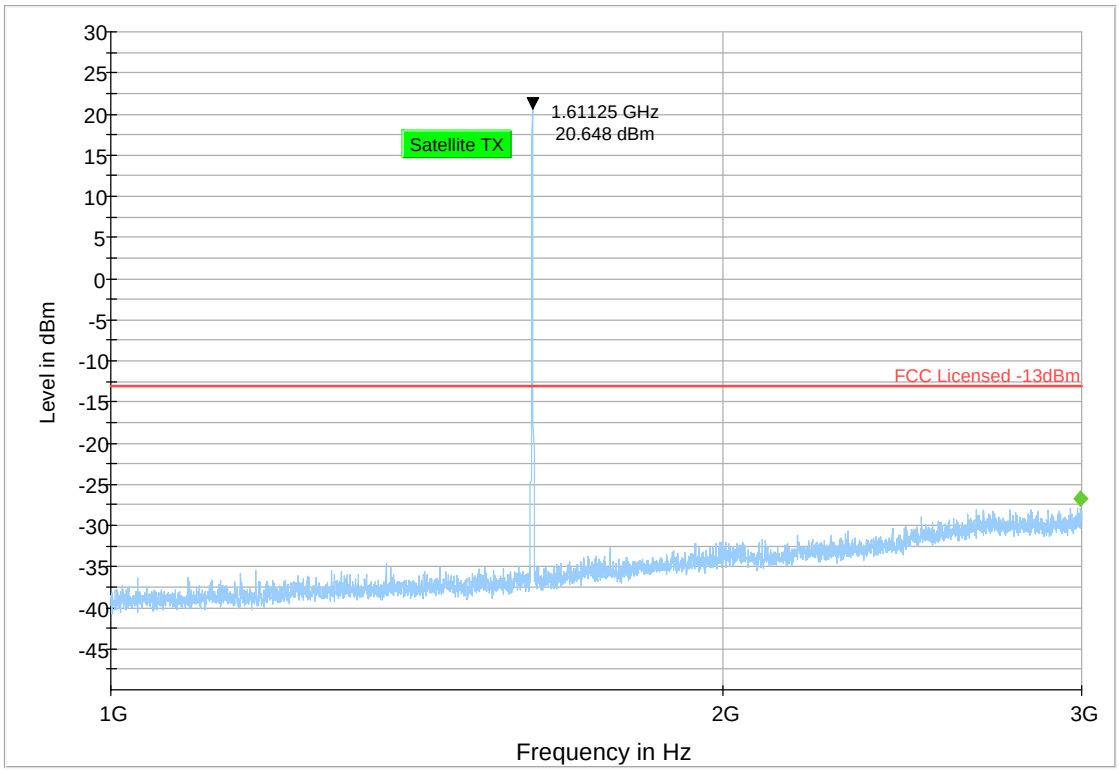
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #2 Radiated Emissions: 1 – 3 GHz

Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
968.899	---	-38.471	-13.00	25.47	500.0	100.000	243.0	V	186.0	-63.0



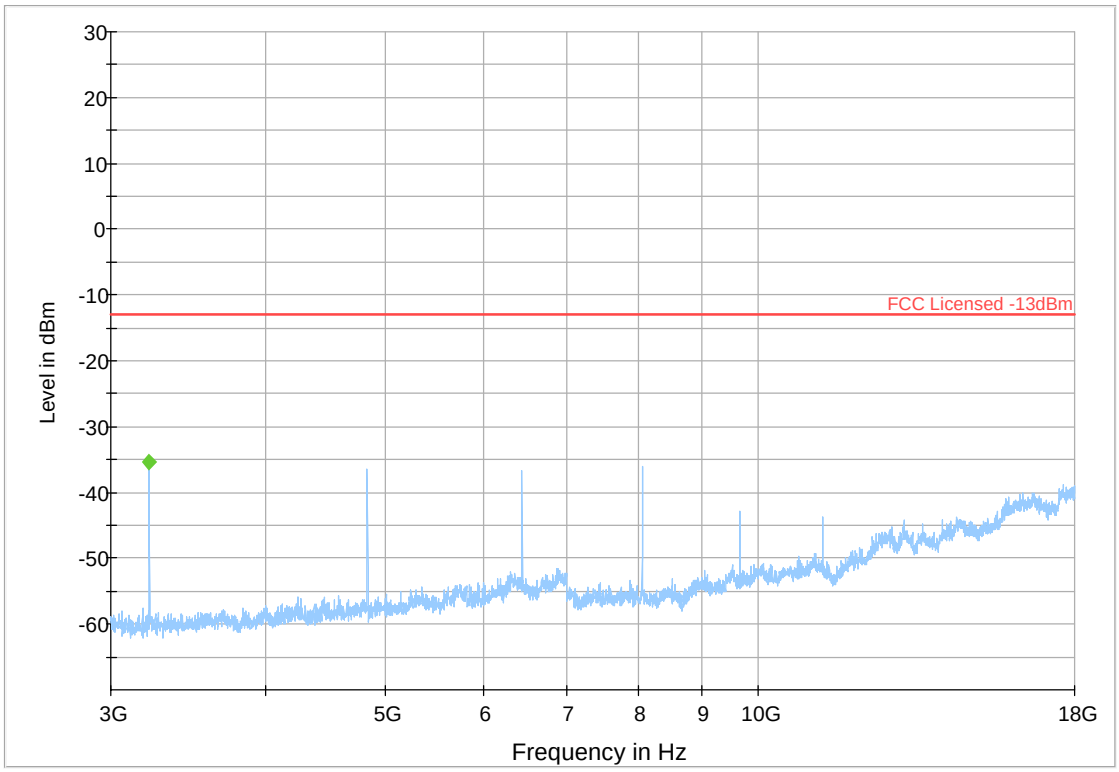
Note: The peak signal above is the transmit channel.

Plot #3 Radiated Emissions: 3 – 18 GHz

Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
3222.656	---	-35.426	-13.00	22.43	500.0	1000.000	302.0	H	347.0	-102.0



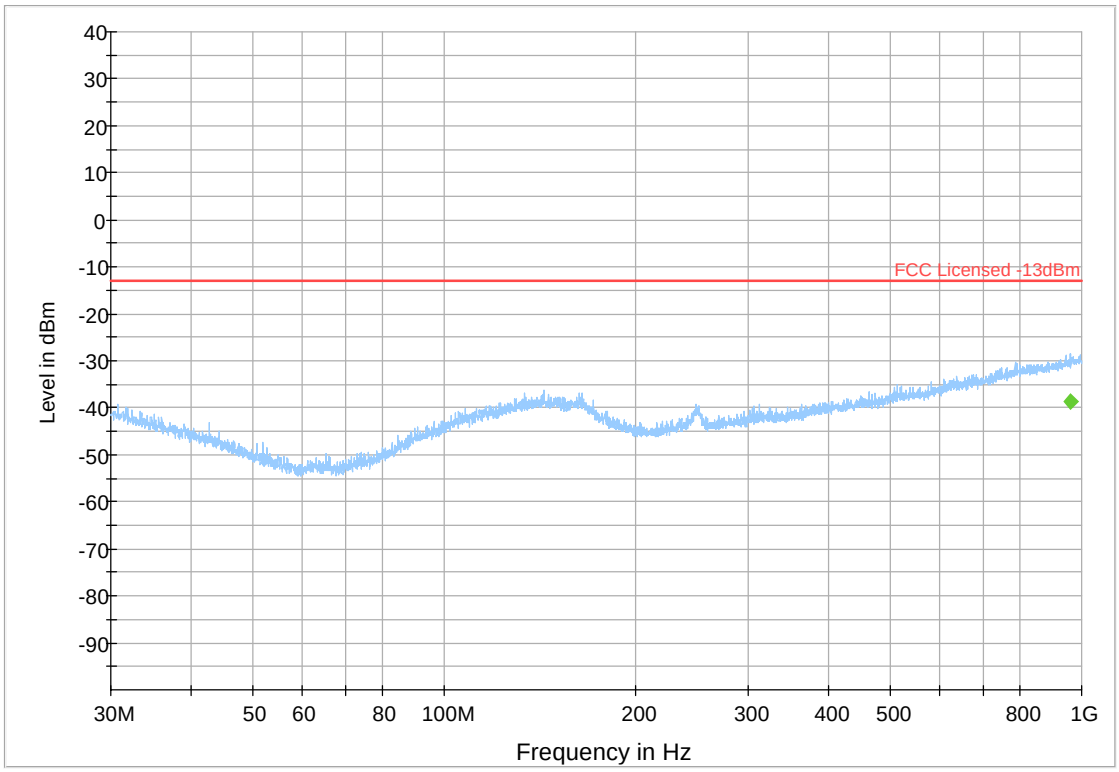
PK+_MAXH FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #4 Radiated Emissions: 30 MHz – 1 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
961.867	---	-38.643	-13.00	25.64	500.0	100.000	292.0	H	229.0	-63.1



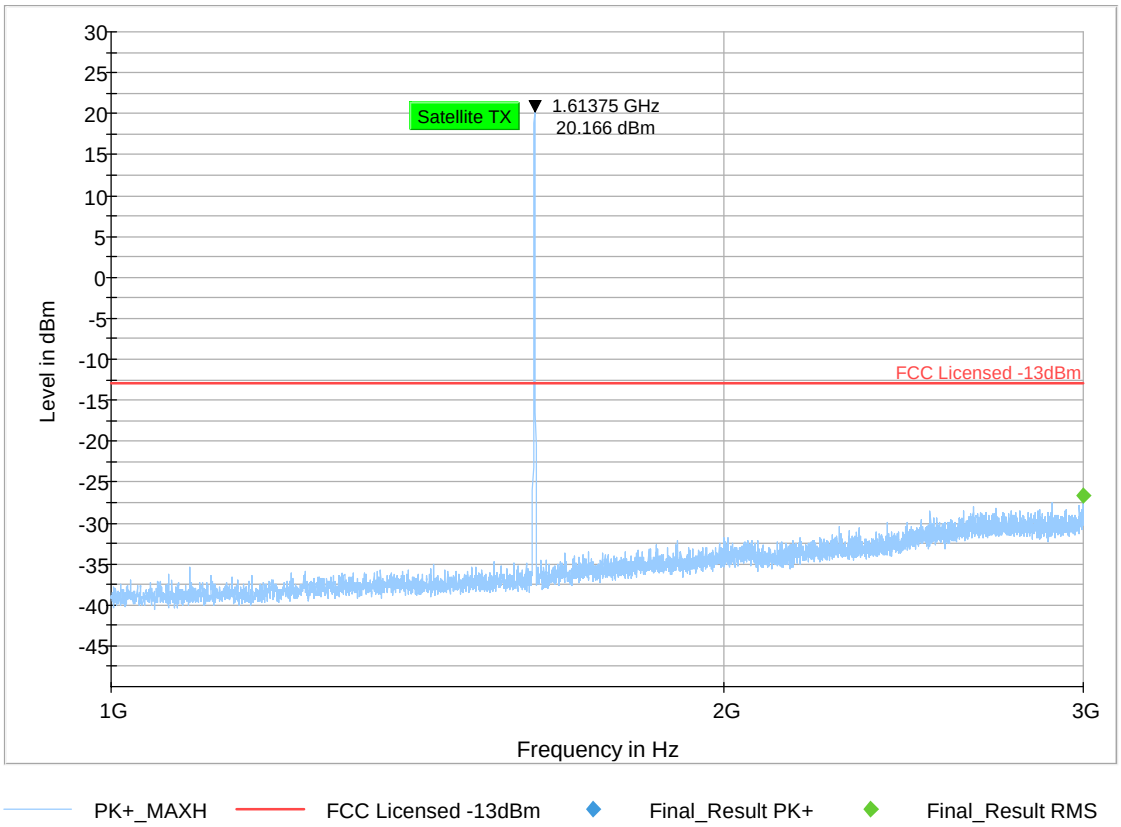
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #5 Radiated Emissions: 1 – 3 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
2999.500	---	-26.665	-13.00	13.66	500.0	1000.000	342.0	V	180.0	-59.4



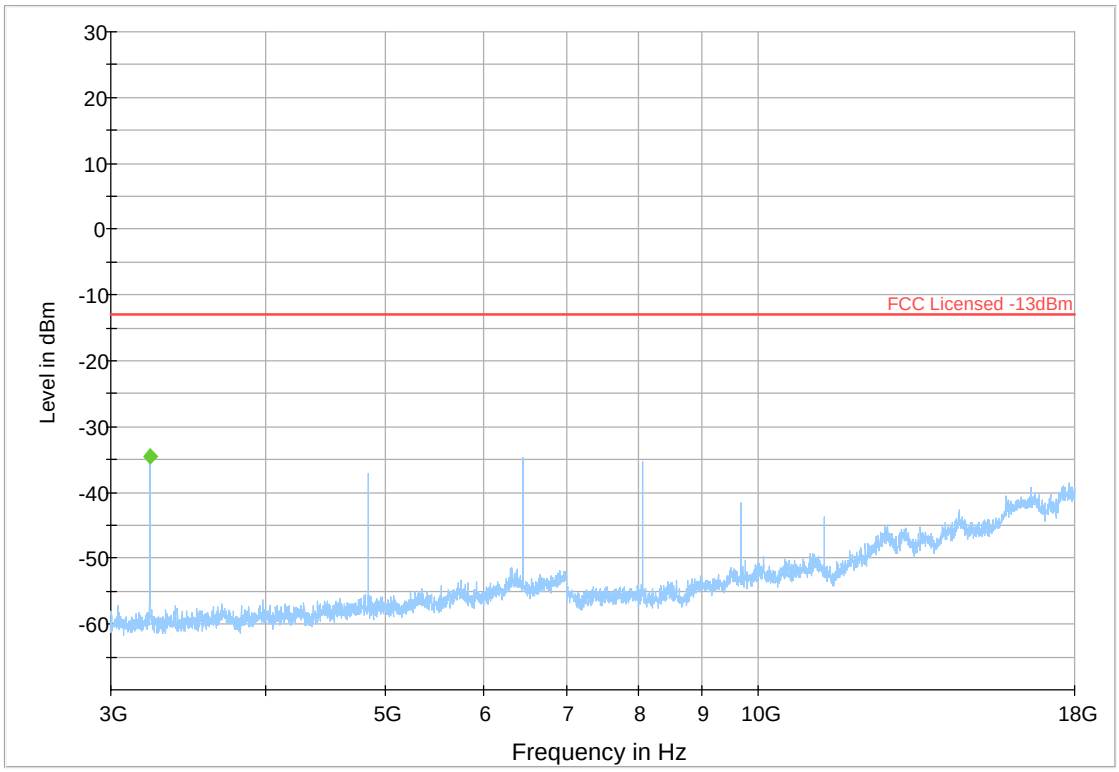
Note: The peak signal above is the transmit channel.

Plot #6 Radiated Emissions: 3 – 18 GHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
3227.344	---	-34.632	-13.00	21.63	500.0	1000.000	304.0	H	351.0	-102.0



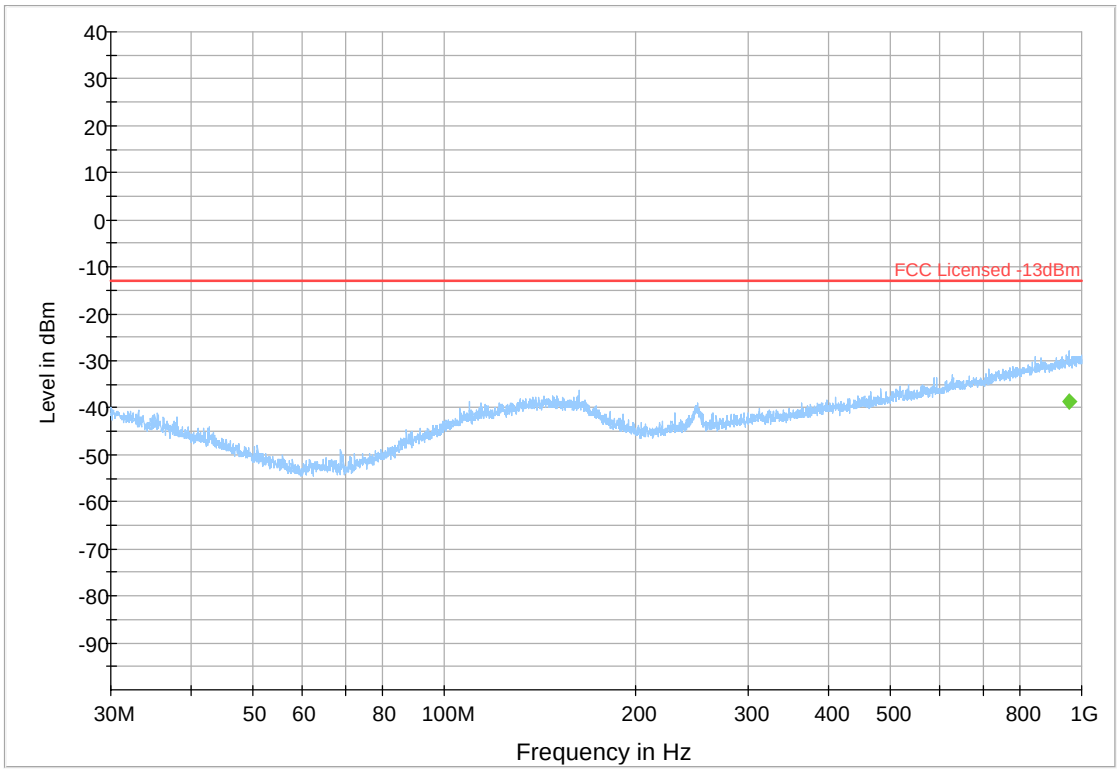
PK+_MAXH FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #7 Radiated Emissions: 30 MHz – 1 GHz

Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
954.956	---	-38.570	-13.00	25.57	500.0	100.000	361.0	H	116.0	-63.1



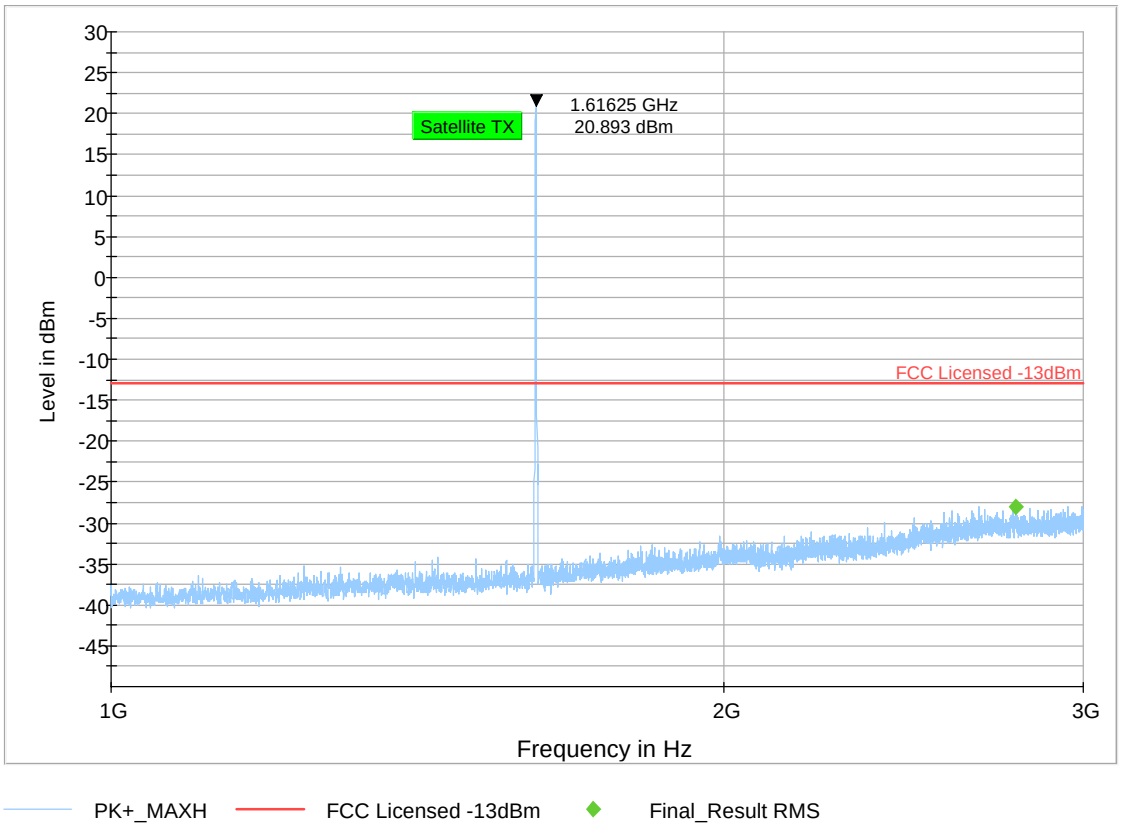
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #8 Radiated Emissions: 1 – 3 GHz

Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
2781.000	---	-27.950	-13.00	14.95	500.0	1000.000	360.0	H	-14.0	-61.4



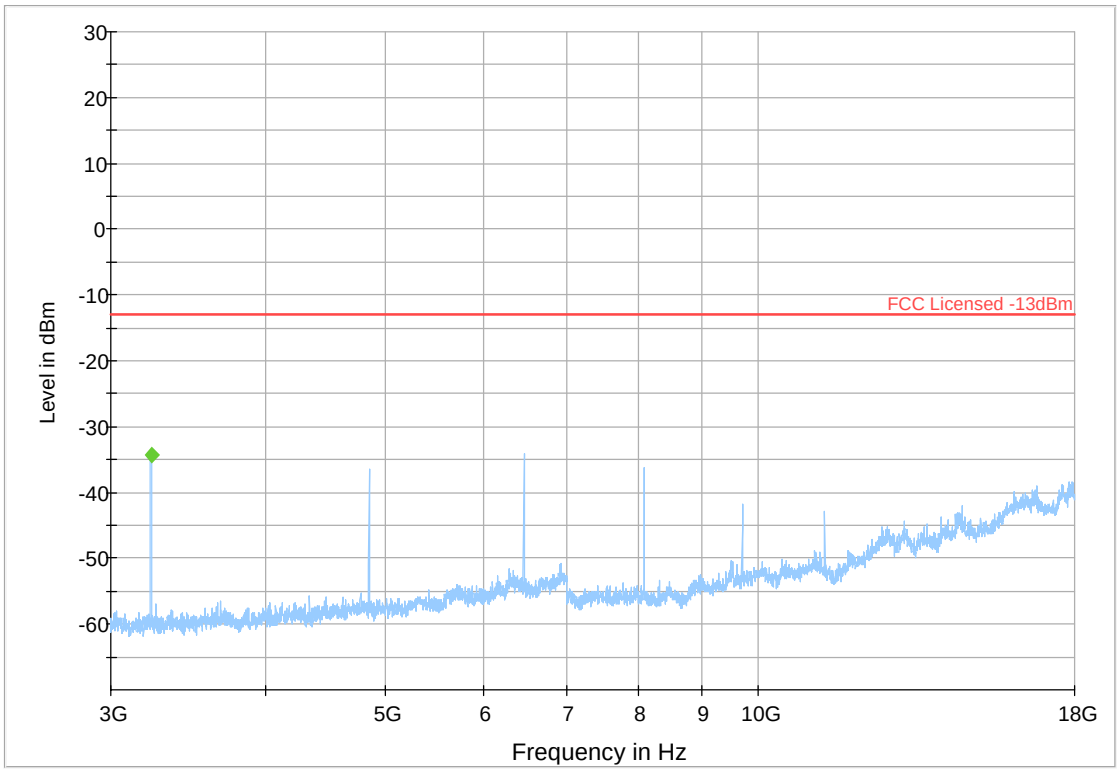
Note: The peak signal above is the transmit channel.

Plot #9 Radiated Emissions: 3 – 18 GHz

Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
3232.500	---	-34.335	-13.00	21.33	500.0	1000.000	271.0	H	351.0	-102.0



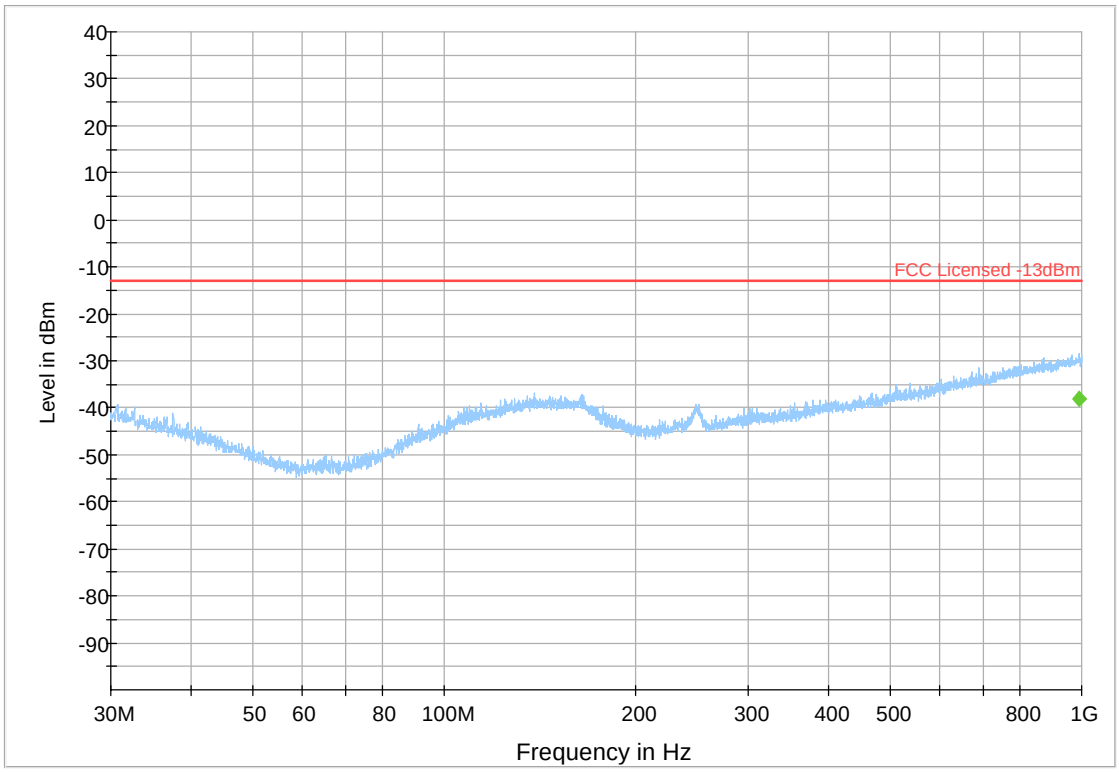
PK+_MAXH FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #10 Radiated Emissions: 30 MHz – 1 GHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
990.300	---	-38.105	-13.00	25.11	500.0	100.000	284.0	H	101.0	-62.7



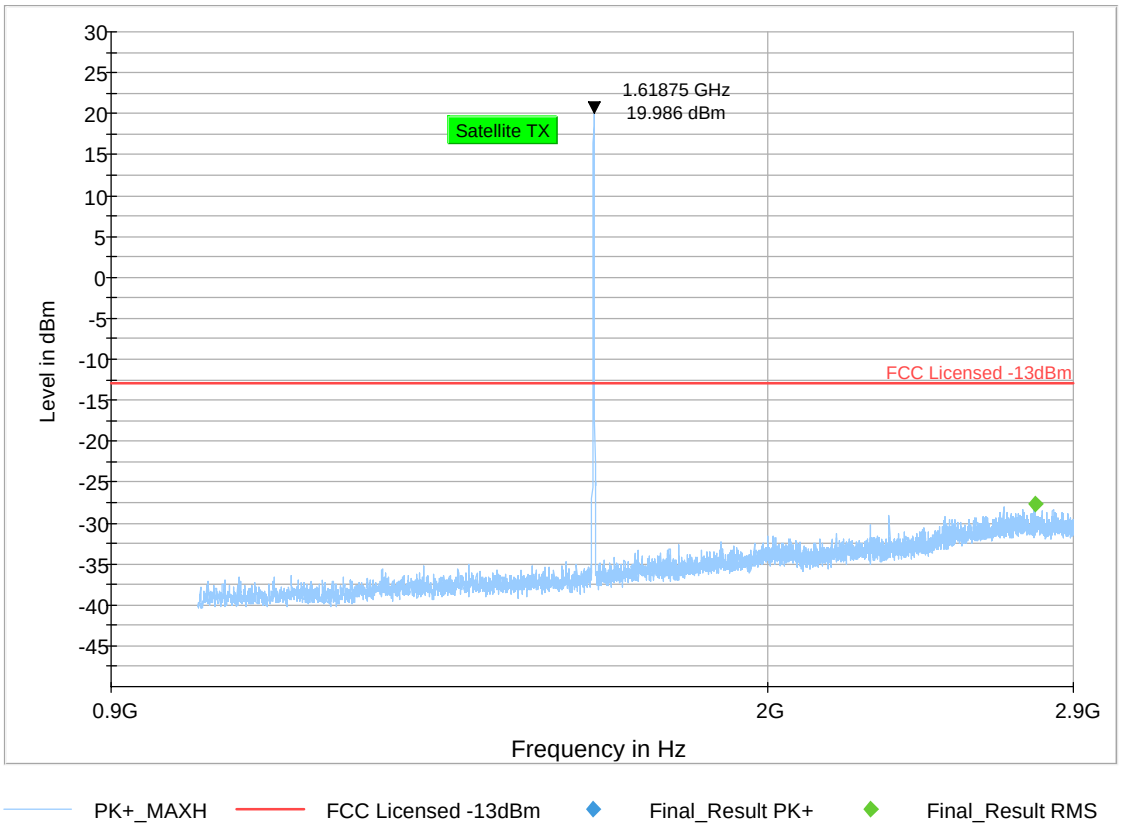
Preview Result 1-PK+ FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

Plot #11 Radiated Emissions: 1 – 3 GHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
2770.250	---	-27.746	-13.00	14.75	500.0	1000.000	265.0	V	2.0	-61.3



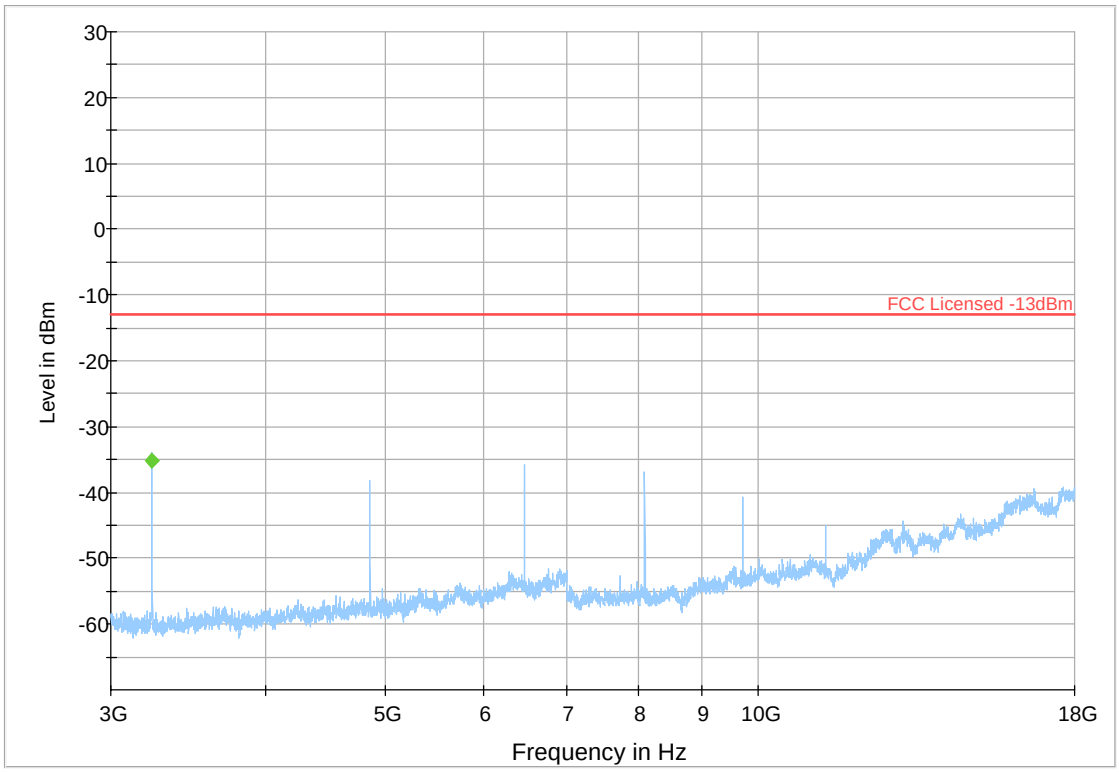
Note: The peak signal above is the transmit channel.

Plot #12 Radiated Emissions: 3 – 18 GHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK

Final_Result

Frequency (MHz)	MaxPeak (dBm)	RMS (dBm)	Limit (dBm)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr (dB)
3237.656	---	-35.181	-13.00	22.18	500.0	1000.000	293.0	H	3.0	-102.0



PK+_MAXH FCC Licensed -13dBm Final_Result PK+ Final_Result RMS

8.6 Frequency Stability

8.6.1 Measurement according to FCC §2.1055, KDB 971168 D01 v03r01 and ANSI C63.26 (2015)

Refer to Section 5.6.3 Procedure for frequency stability testing, Section 5.6.4 Frequency stability over variations in temperature, and 5.6.5 Frequency stability when varying supply voltage of ANSI C63.26 for test procedure.

Refer to FCC §2.1055:
(a) The frequency stability shall be measured with variation of ambient temperature as follows:
(1) From −30° to + 50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:
(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

8.6.2 Limits:

FCC §25.202(d):
Frequency tolerance, Earth stations. The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent of the reference frequency.

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For MES equipment, the carrier frequency shall not drift from the reference frequency by more than ±10 ppm.

8.6.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22.5° C	1	Op. 1	Nominal: 3.6 VDC

8.6.4 Results:

Temperature Variation:

Temperature (°C)	Frequency (MHz)	Measured Frequency (MHz)	Deviation from 20°C Reference (kHz)	Deviation (%)	ppm (%)	Limit (%)	Limit (ppm)
50	1611.25	1611.252797	0.795	0.0000493	0.493	0.001	+/- 10
40		1611.253850	1.848	0.0001147	1.147	0.001	+/- 10
30		1611.253152	1.150	0.0000714	0.714	0.001	+/- 10
20		1611.252002	0	0	0	0.001	+/- 10
10		1611.254143	2.141	0.0001329	1.329	0.001	+/- 10
0		1611.251359	-0.643	-0.0000399	-0.399	0.001	+/- 10
-10		1611.249775	-2.227	-0.0001382	-1.382	0.001	+/- 10
-20		1611.250401	-1.601	-0.0000994	-0.994	0.001	+/- 10
-30		1611.250370	-1.632	-0.0001013	-1.013	0.001	+/- 10

Supply Voltage Variation:

Voltage (Volts DC)	Frequency (MHz)	Measured Frequency (MHz)	Deviation from 20°C Reference (kHz)	Deviation (%)	ppm (%)	Limit (%)	Limit (ppm)
3.1	1611.25	1611.254166	2.164	0.0001343	1.343	0.001	+/- 10
3.6		1611.252002	0	0	0	0.001	+/- 10
3.9 (Max)		1611.254251	2.249	0.0001396	1.396	0.001	+/- 10

8.7 Emissions from Mobile Earth Stations for Protection of Aeronautical Radionavigation-Satellite Service

8.7.1 Limits:

FCC §25.216:

(c) The e.i.r.p. density of emissions from mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed −70 dBW/MHz, averaged over any 2 millisecond active transmission interval, in the band 1559-1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed −80 dBW, averaged over any 2 millisecond active transmission interval, in the 1559-1605 MHz band.

(f) Mobile earth stations placed in service after July 21, 2002 with assigned uplink frequencies in the 1610-1660.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz.

(g) Mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies in the 1610-1626.5 MHz band shall suppress the power density of emissions in the 1605-1610 MHz band-segment to an extent determined by linear interpolation from −70 dBW/MHz at 1605 MHz to −10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from −80 dBW at 1605 MHz to −20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.

(i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after Federal Register publication of the rule changes adopted in FCC 03-283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed −80 dBW/MHz in the 1559-1610 MHz band averaged over any two millisecond interval.

(j) A Root-Mean-Square detector shall be used for all power density measurements.

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MESs with transmitting frequencies in the bands 1610-1626.5 MHz and 1626.5-1660.5 MHz shall comply with the unwanted emission limits specified in this section, where applicable, in addition to the limits in section 5.8.

5.9.1 Band 1610-1626.5

For MESs with transmitting frequencies between 1610 MHz and 1626.5 MHz, the e.i.r.p. density of unwanted emissions shall not exceed the limits shown below, which are the same as those for the band 1605-1610 MHz, averaged over any 2 ms active transmission interval:

a. -70 dBW/MHz at 1605 MHz, linearly interpolated to -10 dBW/MHz at 1610 MHz, for broadband emissions
b. -80 dBW/kHz at 1605 MHz, linearly interpolated to -20 dBW/kHz at 1610 MHz, for discrete emissions

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Carrier-off state emissions

MESs with transmitting frequencies between 1 GHz and 3 GHz shall not exceed -80 dBW/MHz, which is the e.i.r.p. density of carrier-off state emissions in the band 1559-1610 MHz.

8.7.2 Test conditions and setup:

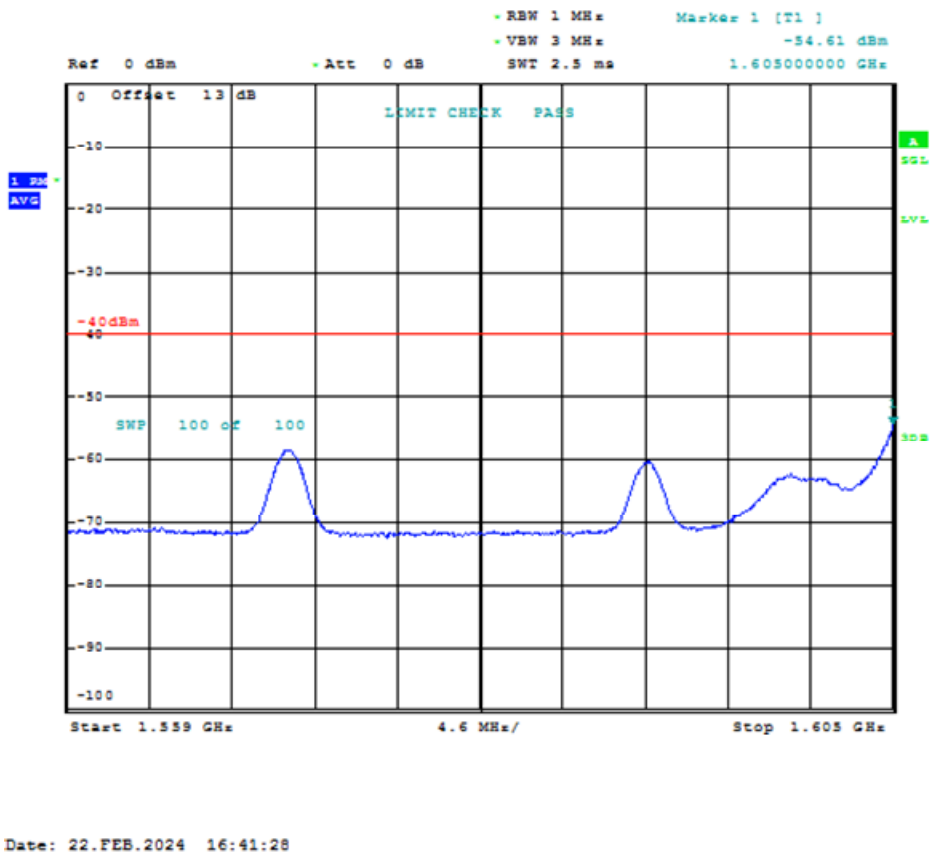
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22.5° C	1	Op. 1	3.6 VDC

8.7.3 Measurement result:

Plot #	Channel	e.i.r.p. Density Frequency Scan Range	Limit	Result
1	A	1559 – 1605 MHz	See section 8.7.1	Pass
2		1605 – 1610 MHz		Pass
3	B	1559 – 1605 MHz		Pass
4		1605 – 1610 MHz		Pass
5	C	1559 – 1605 MHz		Pass
6		1605 – 1610 MHz		Pass
7	D	1559 – 1605 MHz		Pass
8		1605 – 1610 MHz		Pass
9	Carrier Off	1559 – 1610 MHz		Pass

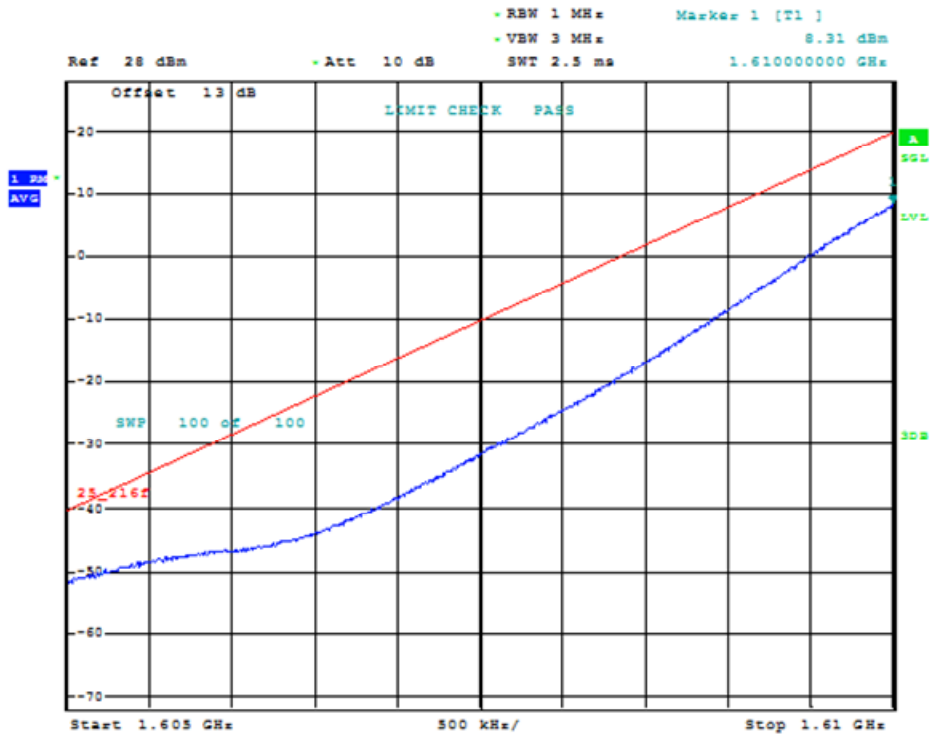
8.7.4 Measurement plots:

Plot #1 e.i.r.p. Density 1559 – 1605 MHz	
Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK



Plot #2 e.i.r.p. Density 1605 – 1610 MHz

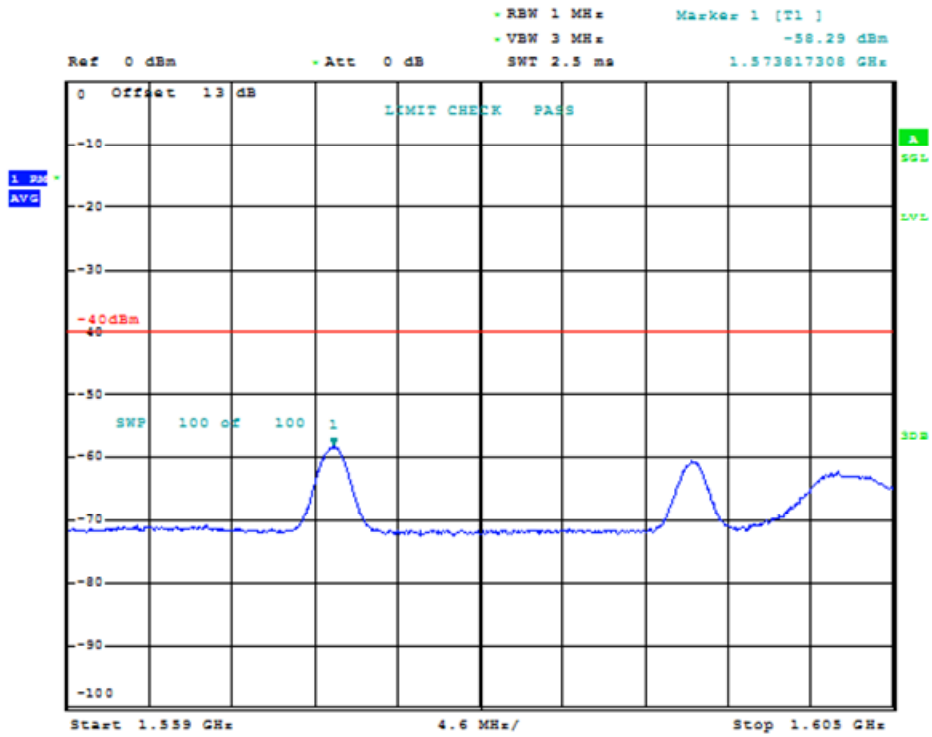
Channel A / 1611.25 MHz	Modulation/Packet Type: BPSK



Date: 22.FEB.2024 17:13:52

Plot #3 e.i.r.p. Density 1559 – 1605 MHz

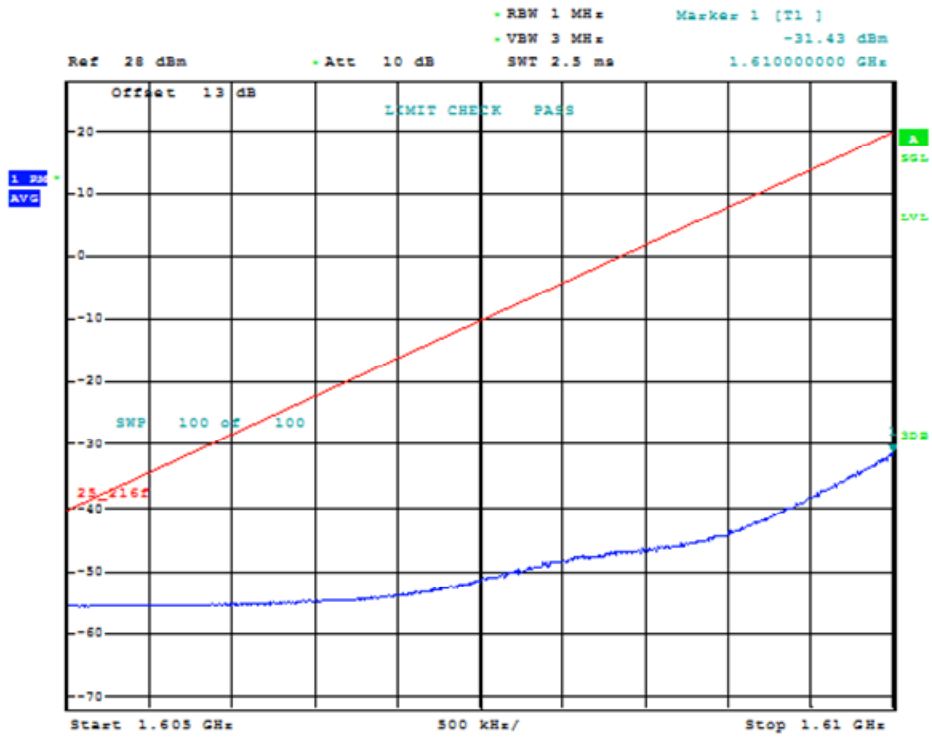
Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK



Date: 22.FEB.2024 17:48:02

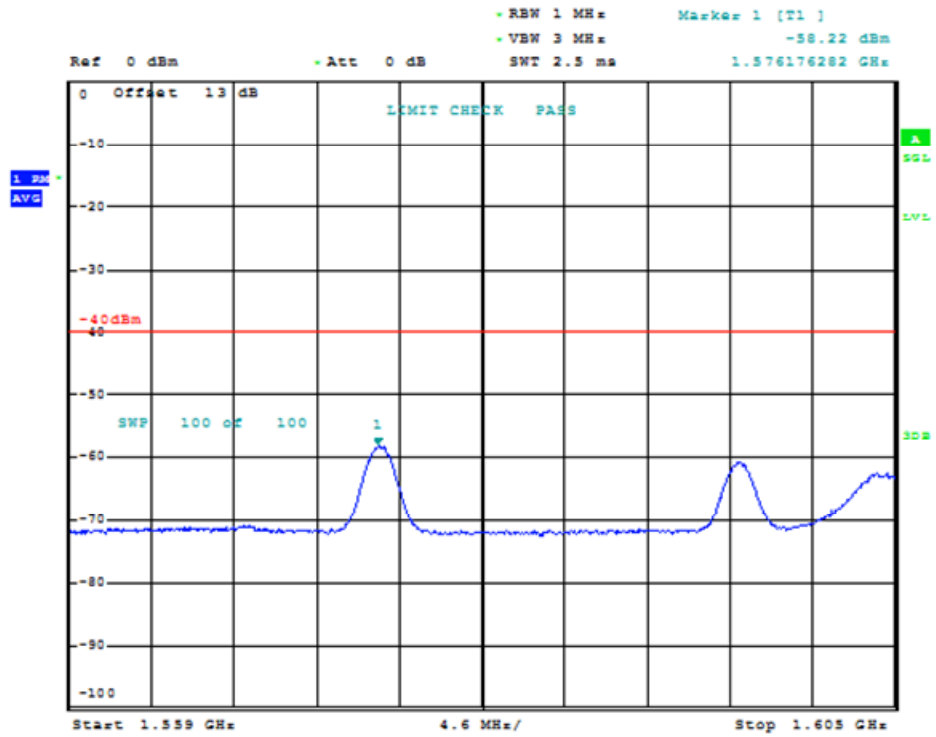
Plot #4 e.i.r.p. Density 1605 – 1610 MHz

Channel B / 1613.75 MHz	Modulation/Packet Type: BPSK



Plot #5 e.i.r.p. Density 1559 – 1605 MHz

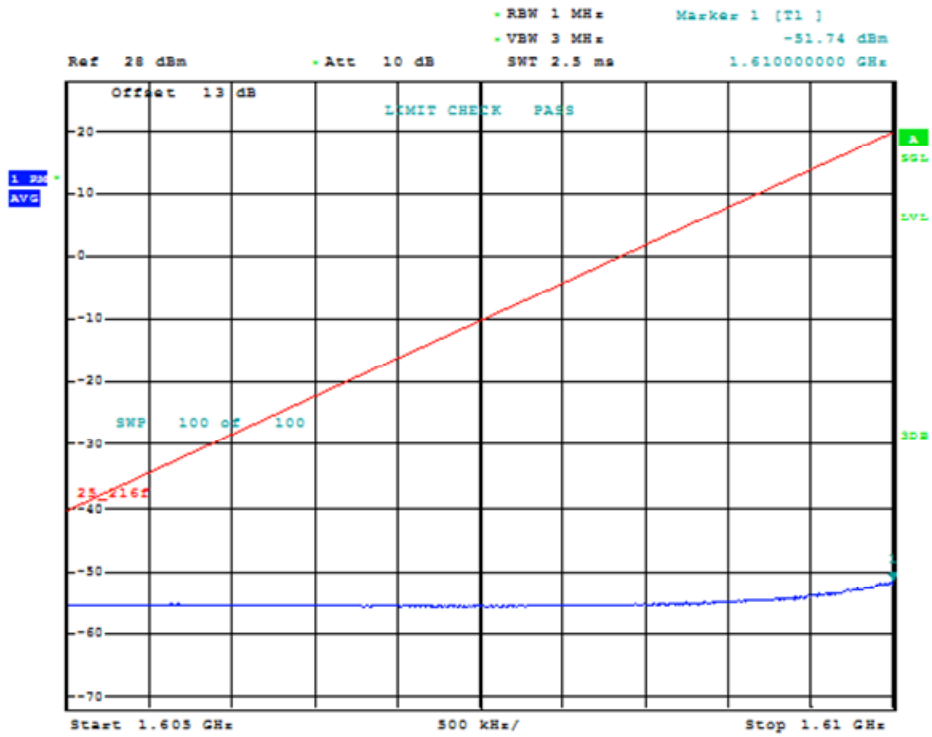
Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK



Date: 22.FEB.2024 17:44:14

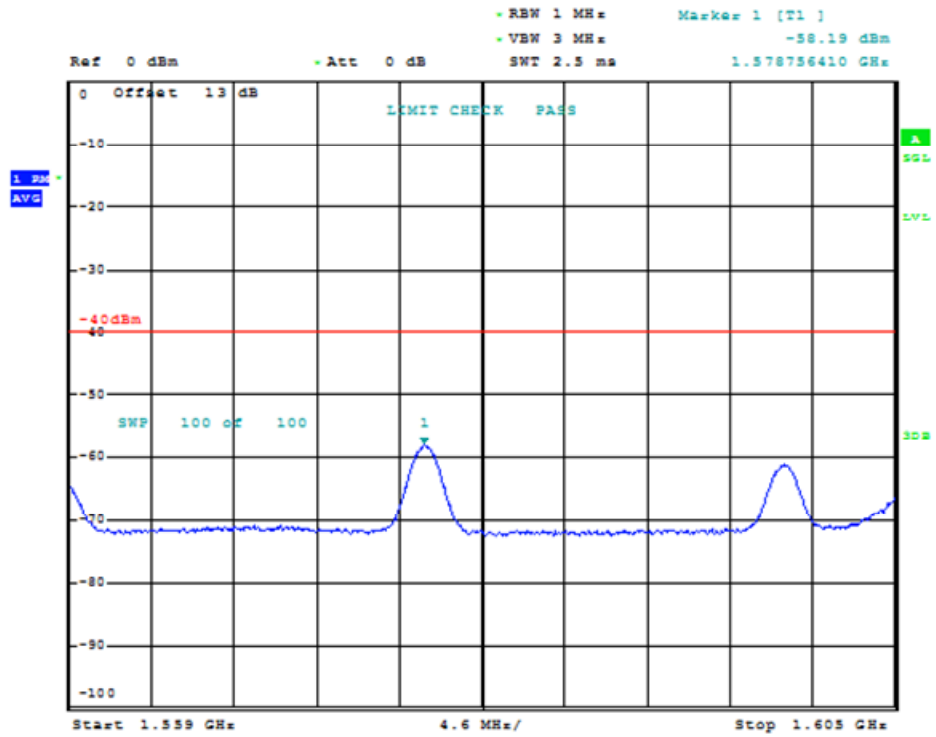
Plot #6 e.i.r.p. Density 1605 – 1610 MHz

Channel C / 1616.25 MHz	Modulation/Packet Type: BPSK



Plot #7 e.i.r.p. Density 1559 – 1605 MHz

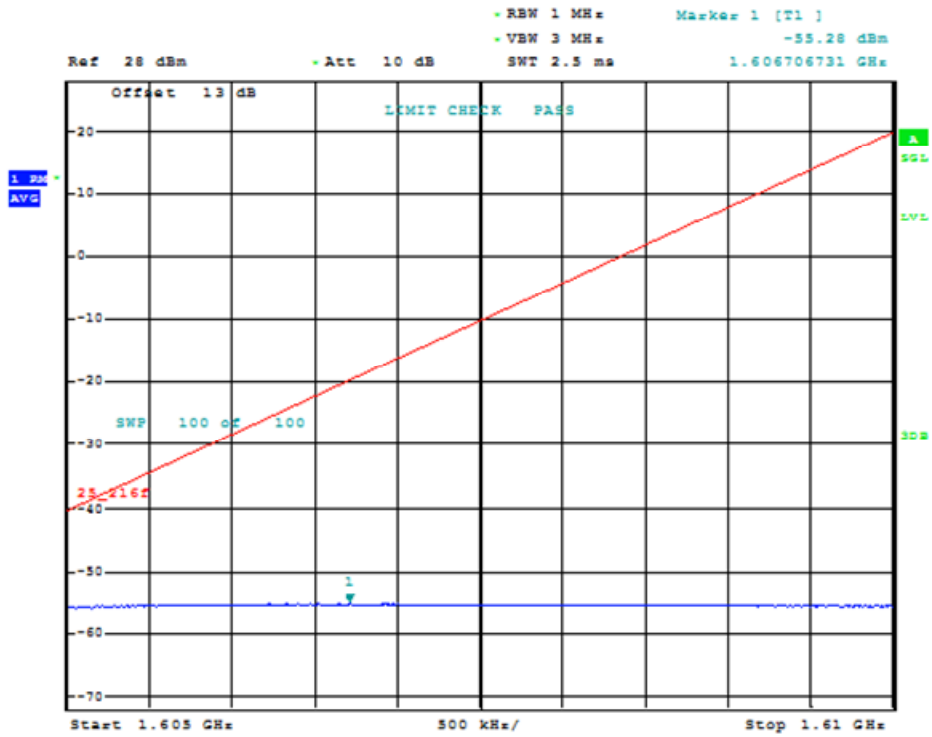
Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Date: 22.FEB.2024 17:39:34

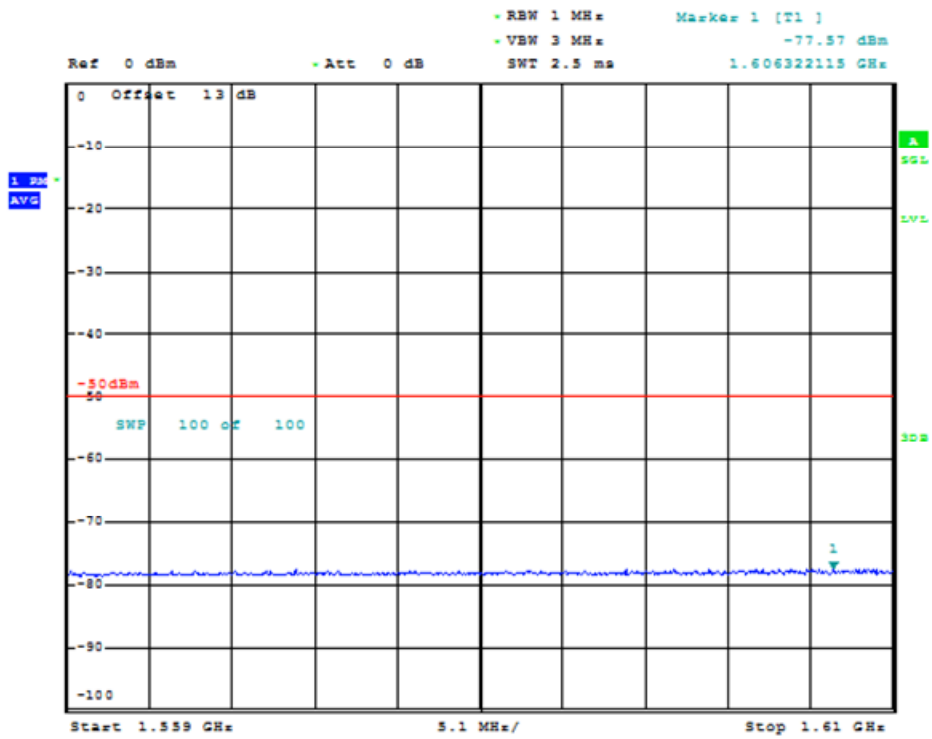
Plot #8 e.i.r.p. Density 1605 – 1610 MHz

Channel D / 1618.75 MHz	Modulation/Packet Type: BPSK



Plot #9 e.i.r.p. Density 1559 – 1610 MHz

Carrier Off	Modulation/Packet Type: BPSK



Date: 22.FEB.2024 17:31:49

9 Test setup photos

Setup photos are included in supporting file name:
"EMC_GEOFO_038_23001_FCC_25_ISED_RSS_170_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Bilog Antenna	A.H. SYSTEMS	BiLA2G	569	2 Years	10/30/2023
Horn Antenna	EMCO	3115	00035111	2 Years	10/26/2023
Horn Antenna	ETS-LINDGREN	3117-PA	00167061	1 Year	9/25/2023
Signal Analyzer	Rohde & Schwarz	FSV40	101022	2 Years	9/25/2023
Spectrum Analyzer	Rohde & Schwarz	FSU26	200302	2 Years	1/24/2024
Thermometer Humidity	Control Company	4410,90080-03	230712972	2 Years	10/18/2023
DC Power Supply	Protek	3003B	H 001416	N/A	N/A
Temperature Humidity Chamber	TESTEQUITY	123H	N/A	N/A	N/A

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.
Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

11 History

Date	Report Name	Changes to report	Prepared by
2024-05-21	EMC_GEOFO_038_23001_FCC_25_ISED_RSS_170	Initial Version	Chin Ming Lui

<<< The End >>>