



FCC / ISSED Test Report

FOR:

Sunsa, Inc

Model Name:

SUNSAW1

Product Description:

IoT wand device to replace wand on horizontal, vertical and miniblinds. BLE/WiFi control of motor to automate home / commercial blinds.

FCC ID: 2AYPZ-SUNSAW1

IC ID: 26999-SUNSAW1

Applied Rules and Standards:

47 CFR Part 15.247 (DTS)

RSS-247 Issue 2 (DTS) & RSS-Gen Issue 5

REPORT #: EMC_SYLER-001-21001_15.247_BT_DTS

DATE: 2021-03-10



A2LA Accredited

IC recognized #
3462B-1

CABID: US0187

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISSED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Sunsa, Inc	IoT wand device to replace wand on horizontal, vertical and miniblinds. BLE/WiFi control of motor to automate home / commercial blinds.	SUNSAW1

Responsible for Testing Laboratory:

2021-03-10	Compliance	Cindy Li (EMC Lab Manager)	
Date	Section	Name	Signature

Responsible for the Report:

2021-03-10	Compliance	Yuchan Lu (Test Engineer)	
Date	Section	Name	Signature

The test results of this test report relate exclusively to the test item specified in Section 3.

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
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Cindy Li
Responsible Project Leader:	Akanksha Baskaran

2.2 Identification of the Client

Client's Name:	Sunsa, Inc
Street Address:	11850 West Market Place, Suite K
City/Zip Code:	Fulton, MD 20759
Country:	USA

2.3 Identification of the Manufacturer

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

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	SUNSAW1
HW Version :	2.0
SW Version :	1.0.0
FCC-ID:	2AYPZ-SUNSAW1
IC-ID:	26999-SUNSAW1
HVIN:	SUNSAW1
PMN:	Sunsa Wand
Product Description:	IoT wand device to replace wand on horizontal, vertical and miniblinds. BLE/WiFi control of motor to automate home / commercial blinds.
Frequency Range / number of channels:	Manufacture: Innophase Module name/number: INP2045 Chip Nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 39), 40 channels
Type(s) of Modulation:	Bluetooth Low Energy, using Dynamic Sequence Spread Spectrum with GFSK modulation.
Modes of Operation:	Bluetooth LE in both advertising and connected mode of operation
Antenna Information as declared:	<ul style="list-style-type: none"> 3.5 dBi
Max. Peak Output Power:	Conducted Power 3.96 dBm
Power Supply/ Rated Operating Voltage Range:	Vmin: 3.1 VDC/ Vnom: 5 VDC / Vmax: 6 VDC
Operating Temperature Range:	Low 0°C, Nominal 21°C, High 70°C
Other Radios included in the device:	❖ <u>WLAN</u> <ul style="list-style-type: none"> Manufacture: Innophase Module name/number: INP2045 Chip
Sample Revision:	<input type="checkbox"/> Prototype Unit; <input type="checkbox"/> Production Unit; <input checked="" type="checkbox"/> Pre-Production

3.2 EUT Sample details

EUT #	Sample Number	HW Version	SW Version	Notes/Comments
1	DUT#6	2.0	1.0.0	Radiated Emissions
2	DUT#2	2.0	1.0.0	Conducted RF

3.3 Accessory Equipment details

AE #	Type	Model	Manufacturer	Serial Number
1	AC/DC Converter	GA - 0502000	-	-
2	Solar Charger	-	-	-

3.4 Support Equipment

SE #	Description
1	Android Tablet, Manufacture: SAMSUNG, Model:SM-T510 , S/N:R52M70B4Y5T

3.5 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1 + AE#1	Special commands through "nRF Connect" app on the Android tablet used to configure the Bluetooth LE radio to low, mid and high channels provided by the client that will not be available to the end user. For radiated measurements, the internal antenna was connected.
2	EUT#2 + AE#1	Special commands through "nRF Connect" app on the Android tablet used to configure the Bluetooth LE radio to low, mid and high channel provided by the client that will not be available to the end user. For conducted measurements, the equipment was connected to 50 ohm RF port of the EUT.

3.6 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels. Based on client declaration, the EUT was configured to the highest duty cycle and 4 dBm output power.

For radiated measurements, all data in this report shows 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 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 of ISED Canada.

Testing procedures are based on 558074 D01 DTS Meas Guidance v05r02 – “GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247” - April 2, 2019, 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
§15.247(a)(1) RSS-247 5.2(1)	Emission Bandwidth	Nominal	BTLE	■	□	□	Complies
§15.247(e) RSS-247 5.2(2)	Power Spectral Density	Nominal	BTLE	■	□	□	Complies
§15.247(b)(1) RSS-247 5.4(4)	Maximum Conducted Output Power and EIRP	Nominal	BTLE	■	□	□	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	BTLE	■	□	□	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	BTLE	■	□	□	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions- Radiated	Nominal	BTLE	■	□	□	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	BTLE	■	□	□	Complies

Note1: 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 $k=1$.

Radiated measurement

9 kHz to 30 MHz	± 2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	± 2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	± 2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	± 0.7 dB (LISN)
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RF conducted measurement	± 0.5 dB
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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 3 dB 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:

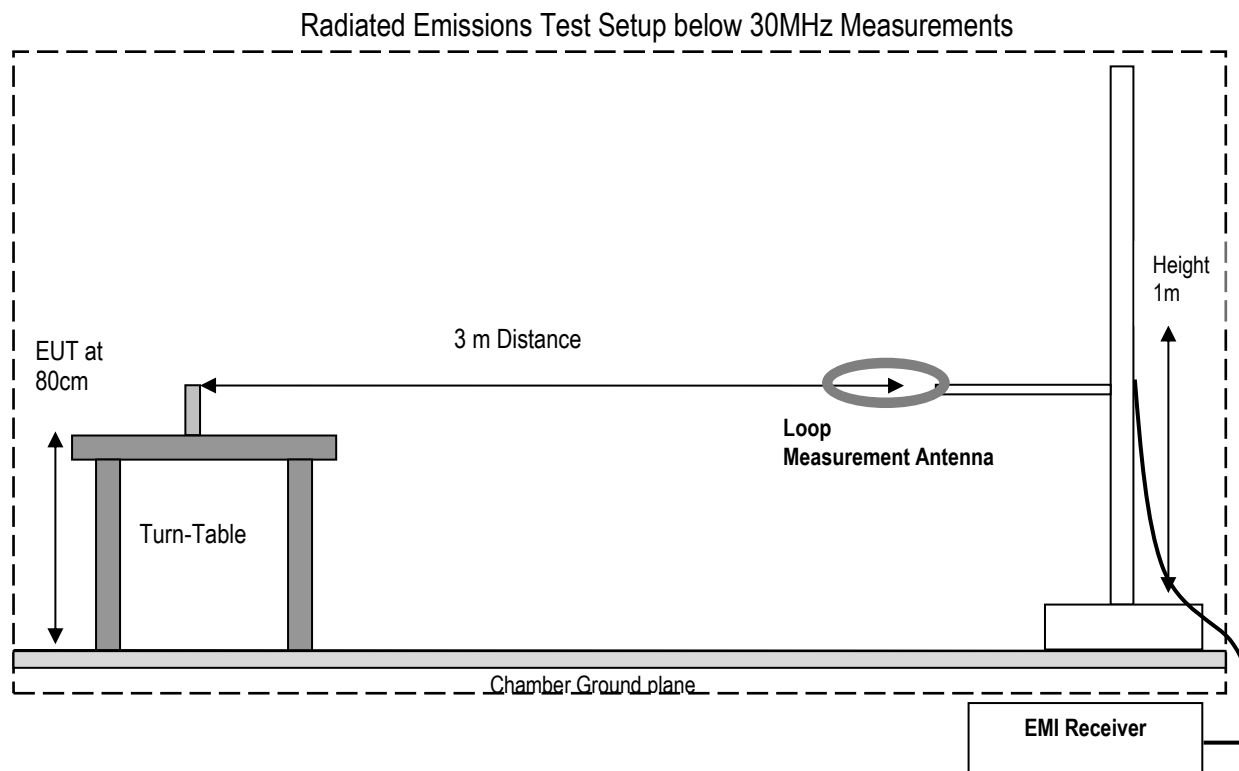
02/18/2021-02/25/2021

7 Measurement Procedures

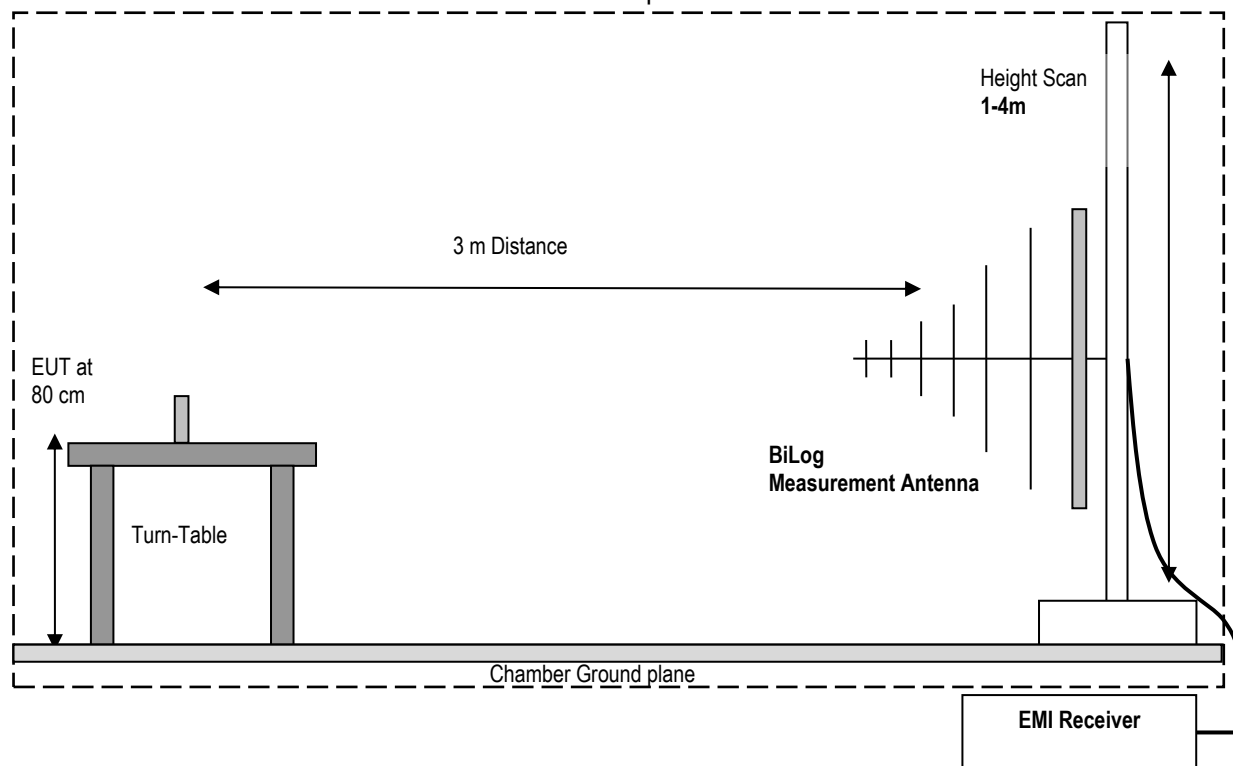
7.1 Radiated Measurement

The radiated measurement is performed according to ANSI C63.10 (2013)

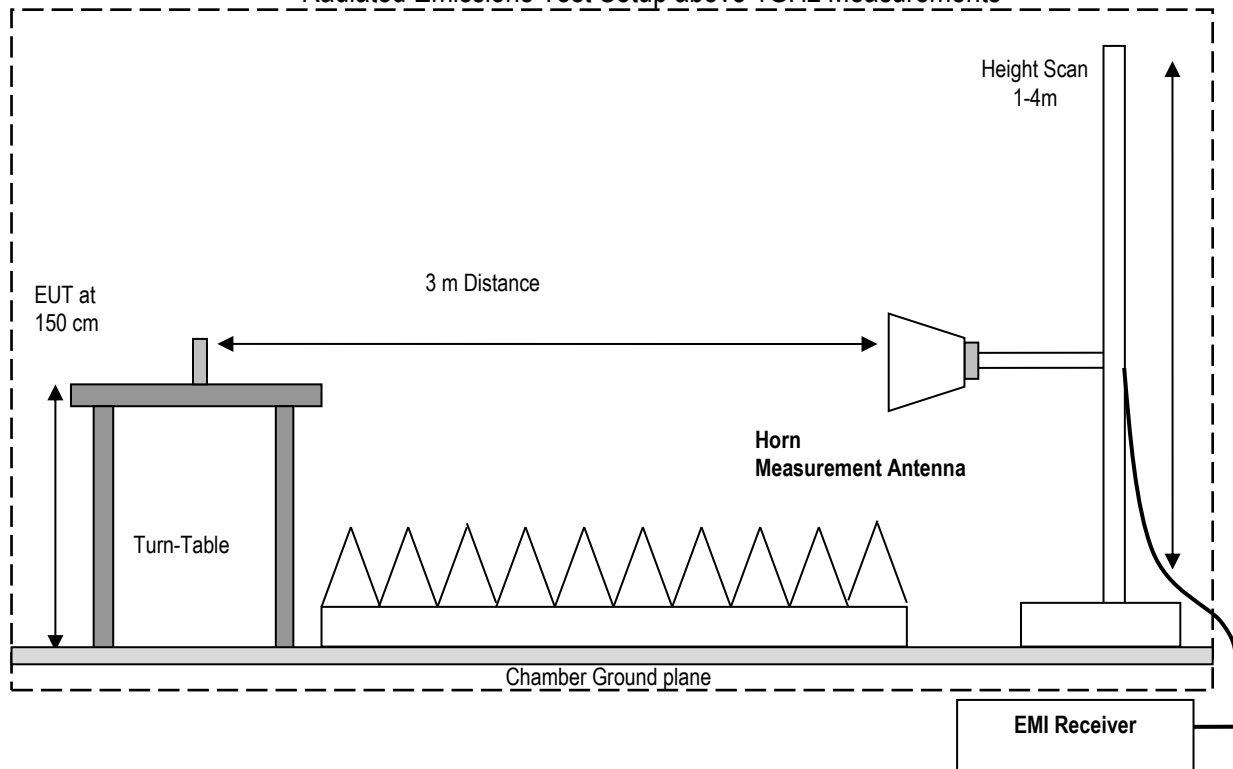
- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to 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 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 dB μ V
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:

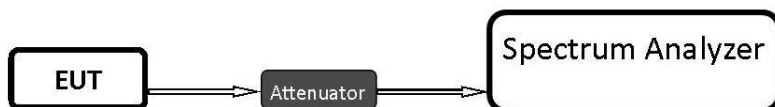
$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} + \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

Example:

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

7.2 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 DTS Meas Guidance v05r02 – “GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247” - April 2, 2019, 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 Maximum Peak Conducted Output Power

8.1.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings:

- RBW \geq DTS bandwidth
- VBW $\geq 3 \times$ RBW
- Span $\geq 3 \times$ RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.1.2 Limits:

Maximum Peak Output Power:

- FCC §15.247 (b)(1): 1 W
- IC RSS-247: 1 W

8.1.3 Test conditions and setup:

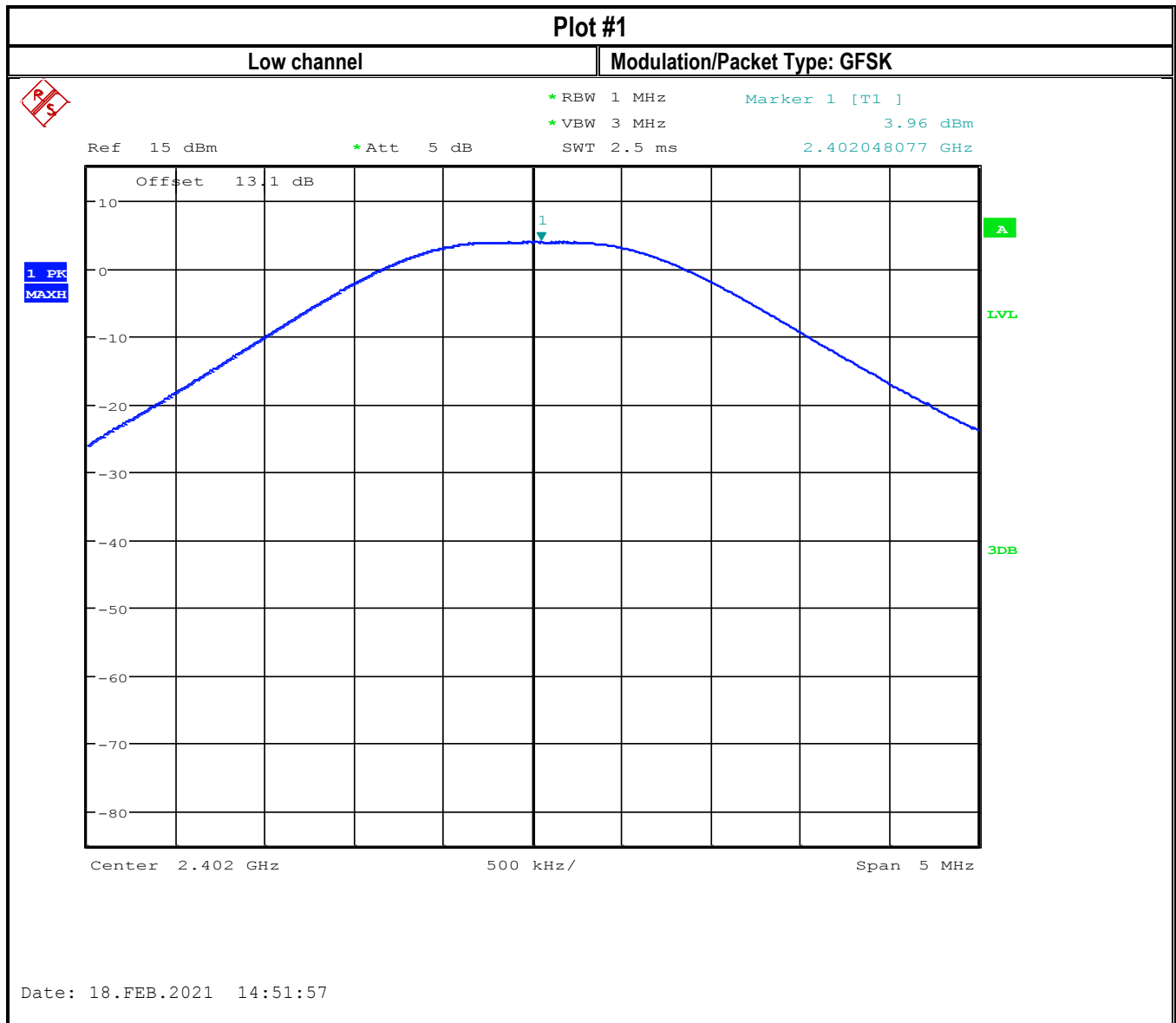
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	2	GFSK continuous fixed channel	5 VDC	3.5 dBi

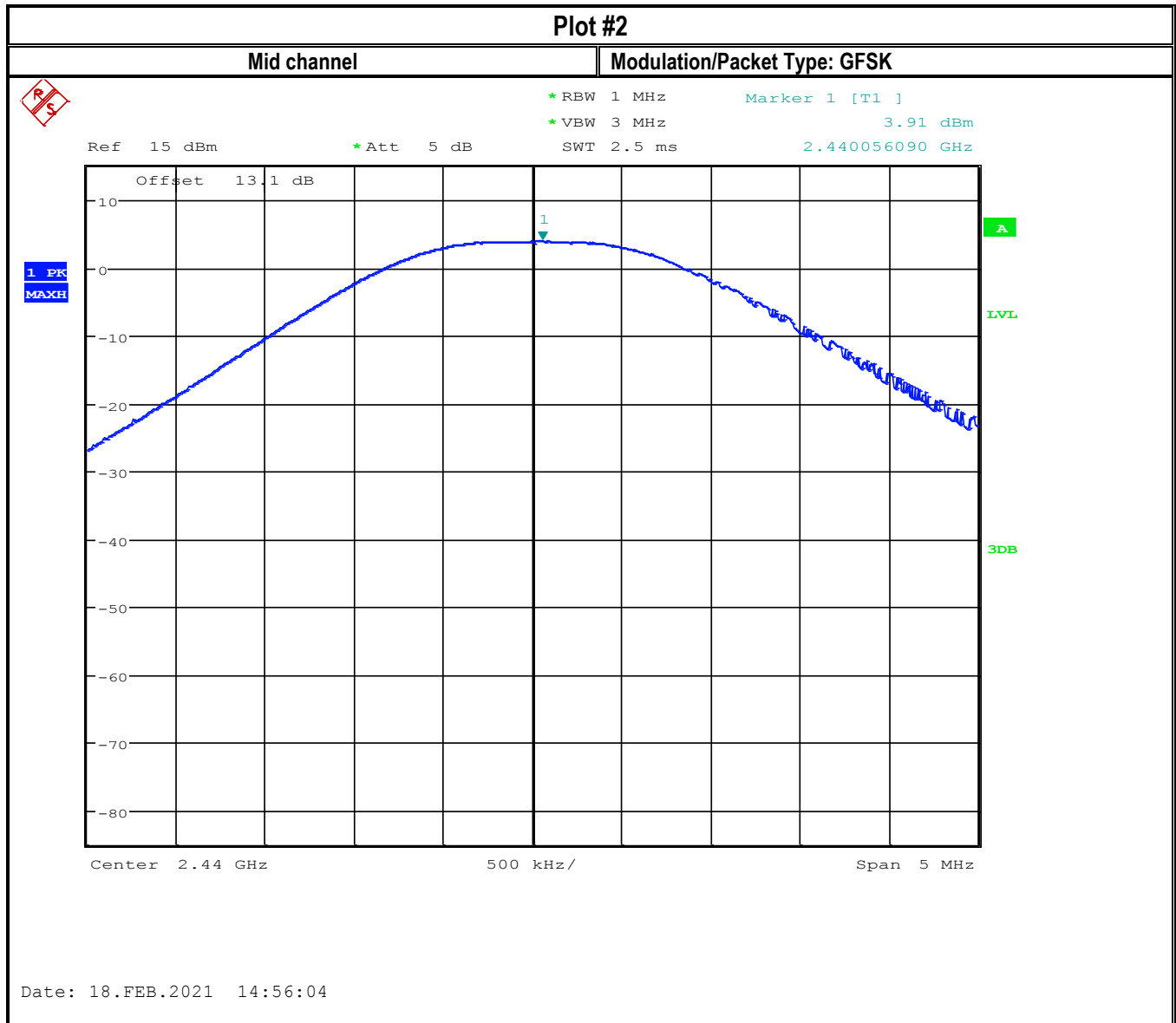
8.1.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 13.2 dB

Plot #	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	3.96	7.46	30 (Pk) / 36 (EIRP)	Pass
2	2442	3.91	7.41	30 (Pk) / 36 (EIRP)	Pass
3	2480	3.70	7.20	30 (Pk) / 36 (EIRP)	Pass

8.1.5 Measurement Plots:





Plot #3

High channel

Modulation/Packet Type: GFSK



* RBW 1 MHz

Marker 1 [T1]

* VBW 3 MHz

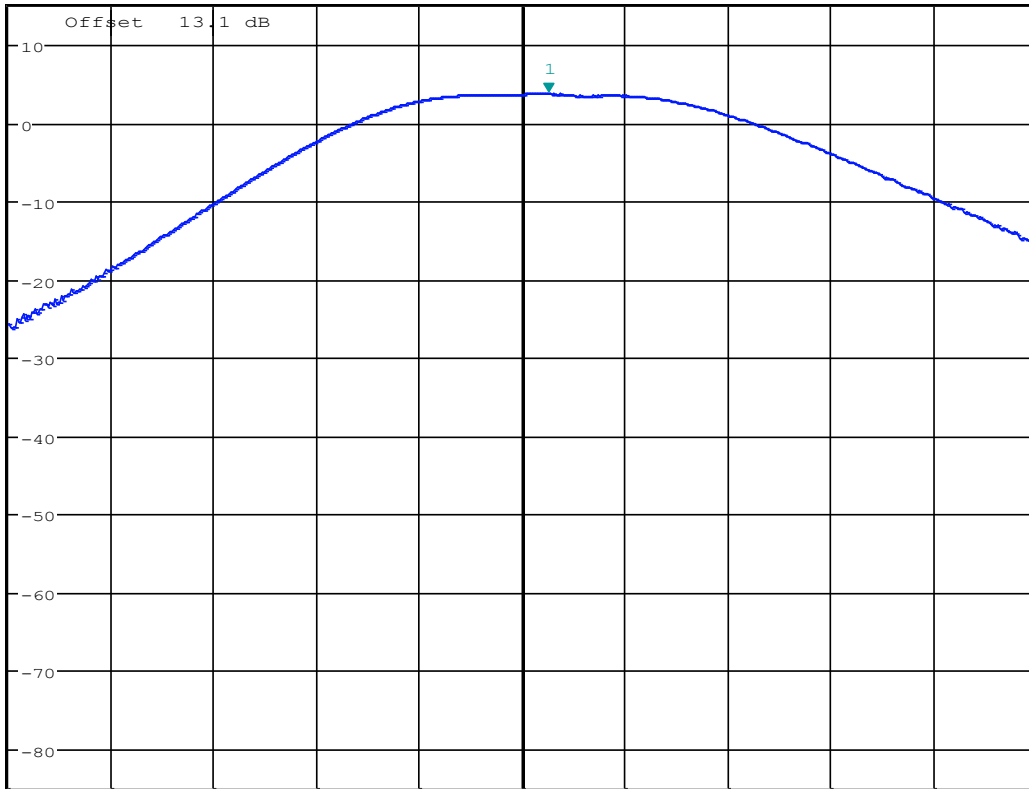
3.70 dBm

Ref 15 dBm

* Att 5 dB

SWT 2.5 ms

2.480128205 GHz

1 PK
MAXH

Date: 18.FEB.2021 14:44:44

8.2 Power Spectral Density

8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings for Peak PSD method:

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 x DTS bandwidth
- Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- Set the VBW $\geq 3 \times \text{RBW}$
- Detector = Peak
- Sweep time = Auto couple
- Trace mode = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level within the RBW
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat

8.2.2 Limits:

FCC§15.247(e) & RSS-247 5.2(2)

- For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

8.2.3 Test conditions and setup:

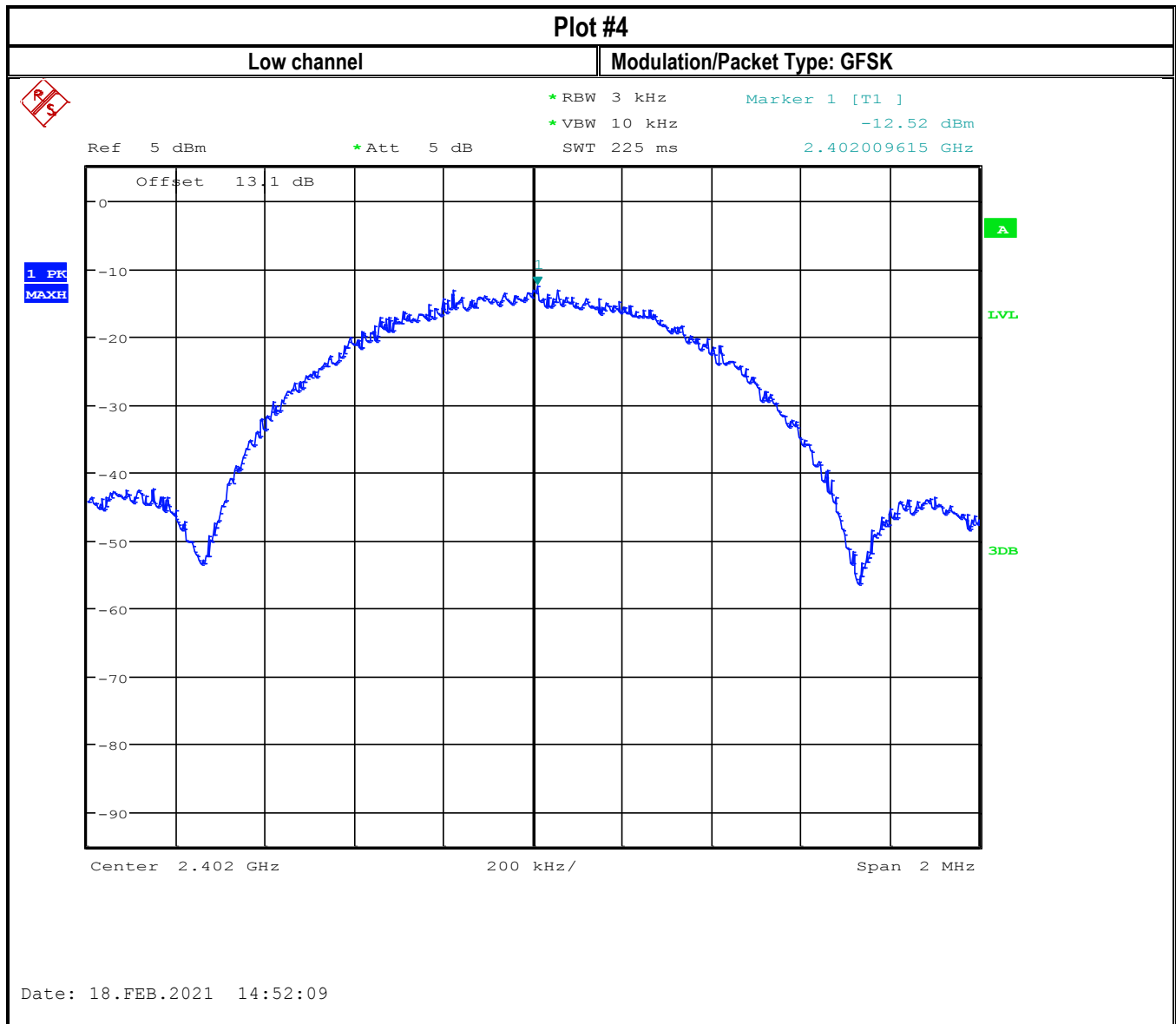
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	2	GFSK continuous fixed channel	5 VDC	3.5 dBi

8.2.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 13.2 dB

Plot #	Frequency (MHz)	Maximum Power Spectral Density (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
4	2402	-12.52	8	Pass
5	2442	-12.74	8	Pass
6	2480	-12.83	8	Pass

8.2.5 Measurement Plots:



Plot #5

Mid channel

Modulation/Packet Type: GFSK



* RBW 3 kHz

Marker 1 [T1]

* VBW 10 kHz

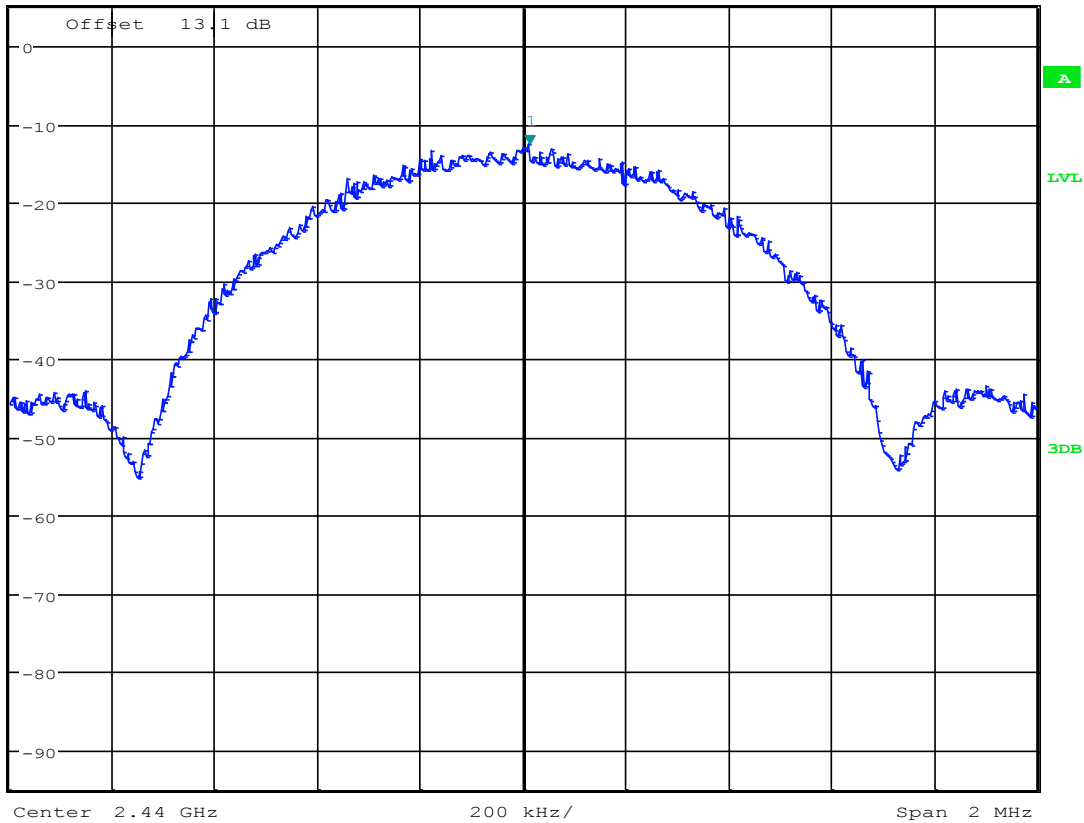
-12.74 dBm

Ref 5 dBm

* Att 5 dB

SWT 225 ms

2.440012821 GHz

1 PK
MAXH

Date: 18.FEB.2021 14:56:41

Plot #6

High channel

Modulation/Packet Type: GFSK



*RBW 3 kHz

Marker 1 [T1]

*VBW 10 kHz

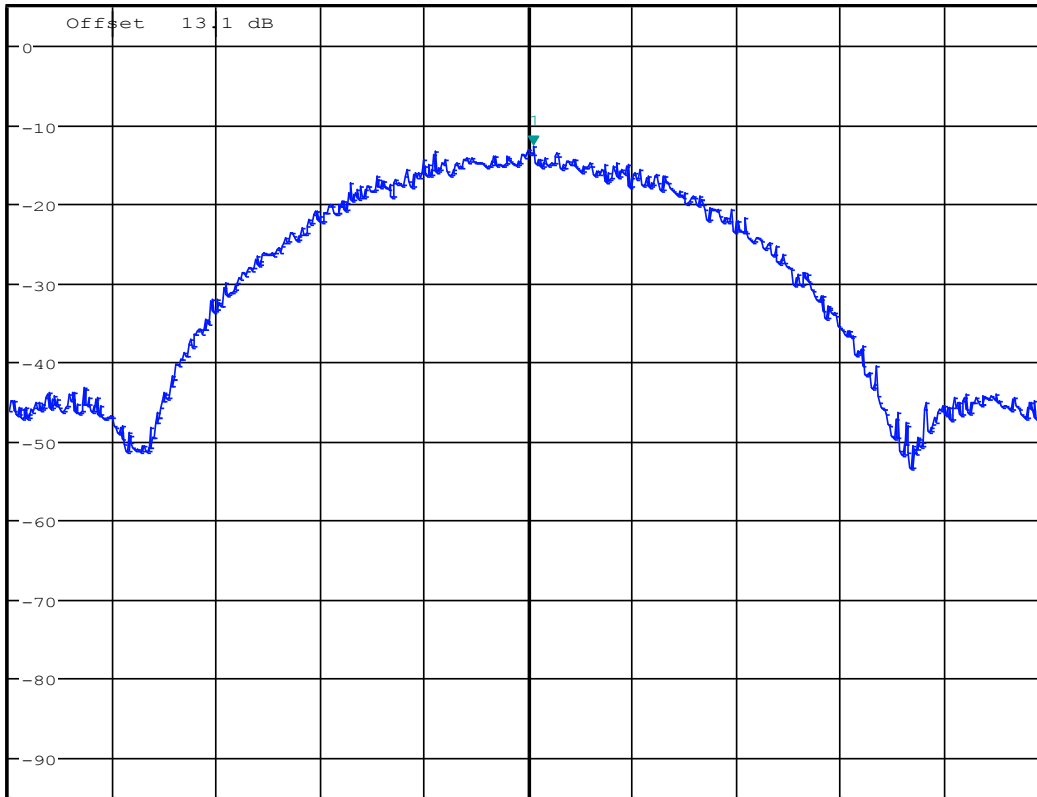
-12.83 dBm

Ref 5 dBm

*Att 5 dB

SWT 225 ms

2.480009615 GHz



Center 2.48 GHz

200 kHz/

Span 2 MHz

Date: 18.FEB.2021 14:44:55

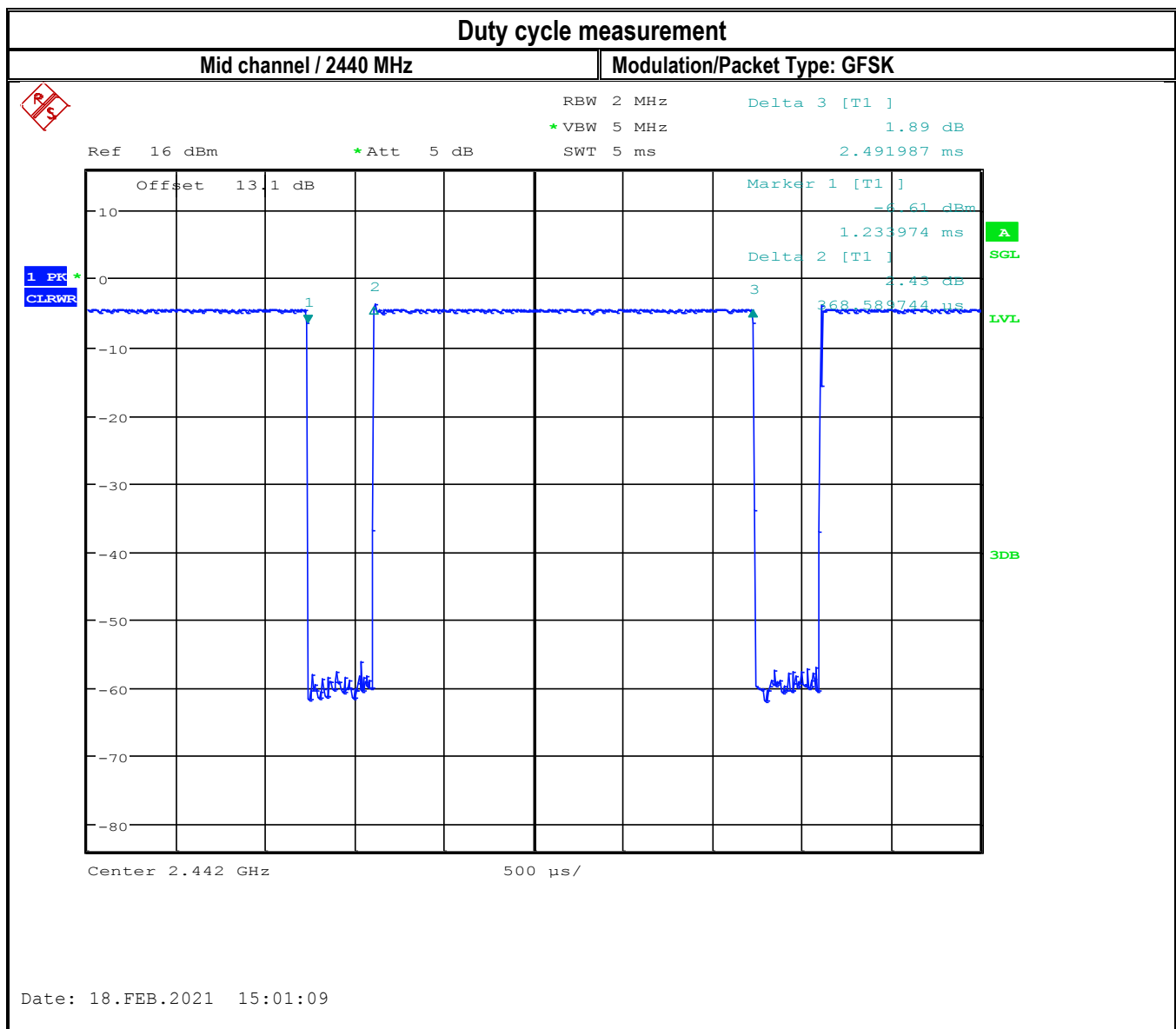
8.3 Duty cycle

8.3.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings:

- Set the center frequency and of the instrument to the center frequency of the transmission
- Zero span
- Set RBW \geq OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.3.2 Measurement result



Duty cycle = 85.21%

Duty cycle correction factor = $10 \cdot \log(1/0.8521) = 0.70$ dB

8.4 Band Edge Compliance

8.4.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings for band edge:

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW $\geq 3 \times$ RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level
- Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge

8.4.2 Limits non restricted band:

FCC§15.247 (d)

- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

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- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30dB instead of 20dB.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.4.3 Limits restricted band §15.247/15.209/15.205 and RSS-Gen 8.9/8.10

- *PEAK LIMIT= 74 dB μ V/m @3m =-21.23 dBm
 - *AVG LIMIT= 54 dB μ V/m @3m =-41.23 dBm
 - Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
 - Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.
- (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

(b)

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

8.4.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
22° C	2	GFSK continuous fixed channel	5 VDC	3.5 dBi

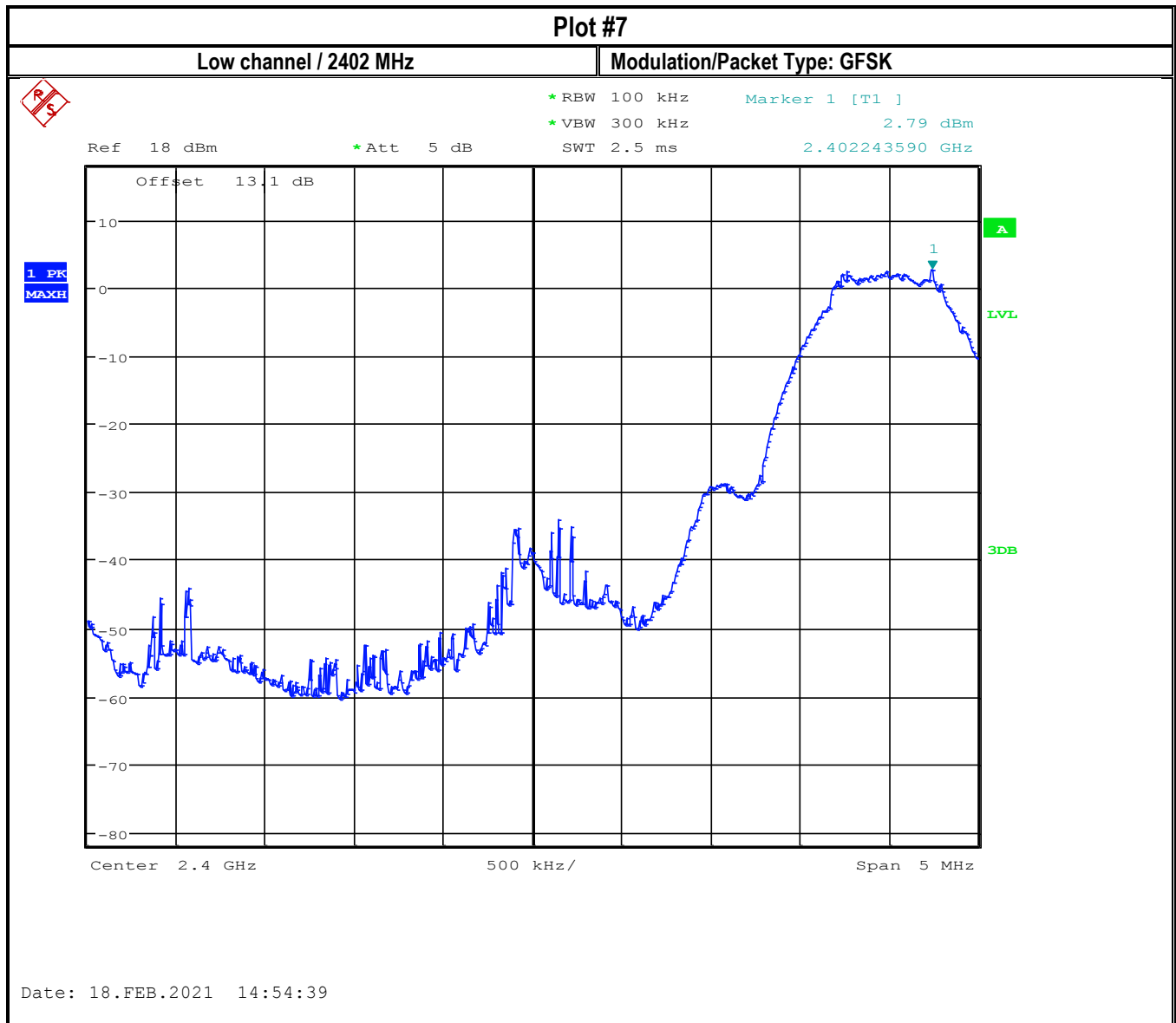
8.4.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
7, 8	GFSK continuous fixed channel	Lower, Non-restricted	-35.11	-20	Pass

Plot #	EUT operating mode	Band Edge	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
9	GFSK continuous fixed channel	Upper Restricted peak	-25.50	NA	-22	-21.23 Peak	Pass
10	GFSK continuous fixed channel	Upper Restricted Average	-51.11	-50.41	-46.91	-41.23 AVG	Pass

Note: According to ANSI C63.10 §11.12.2.6, if Antenna Gain is less than 2 dBi, then 2 dBi should be used to determine the EIRP.

8.4.6 Measurement Plots:



Plot #8

Low channel / 2402 MHz

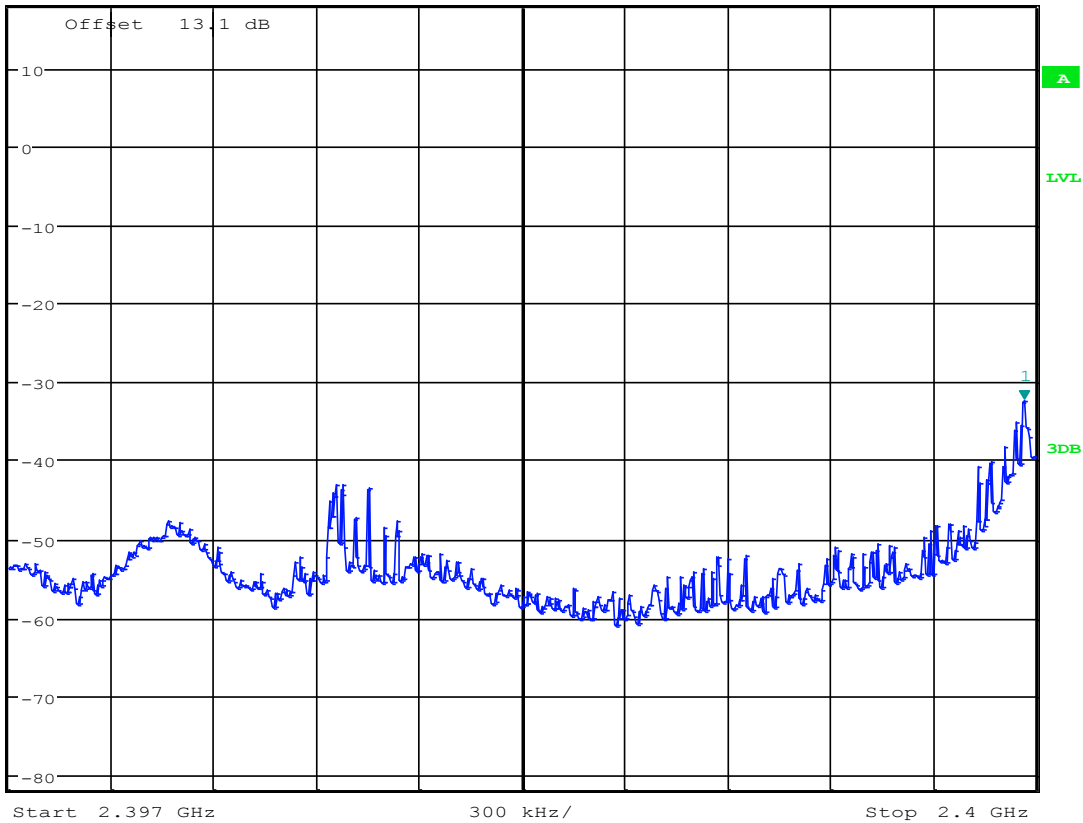
Modulation/Packet Type: GFSK



*RBW 100 kHz Marker 1 [T1]
*VBW 300 kHz -32.32 dBm
SWT 2.5 ms 2.399966346 GHz

Ref 18 dBm

*Att 5 dB

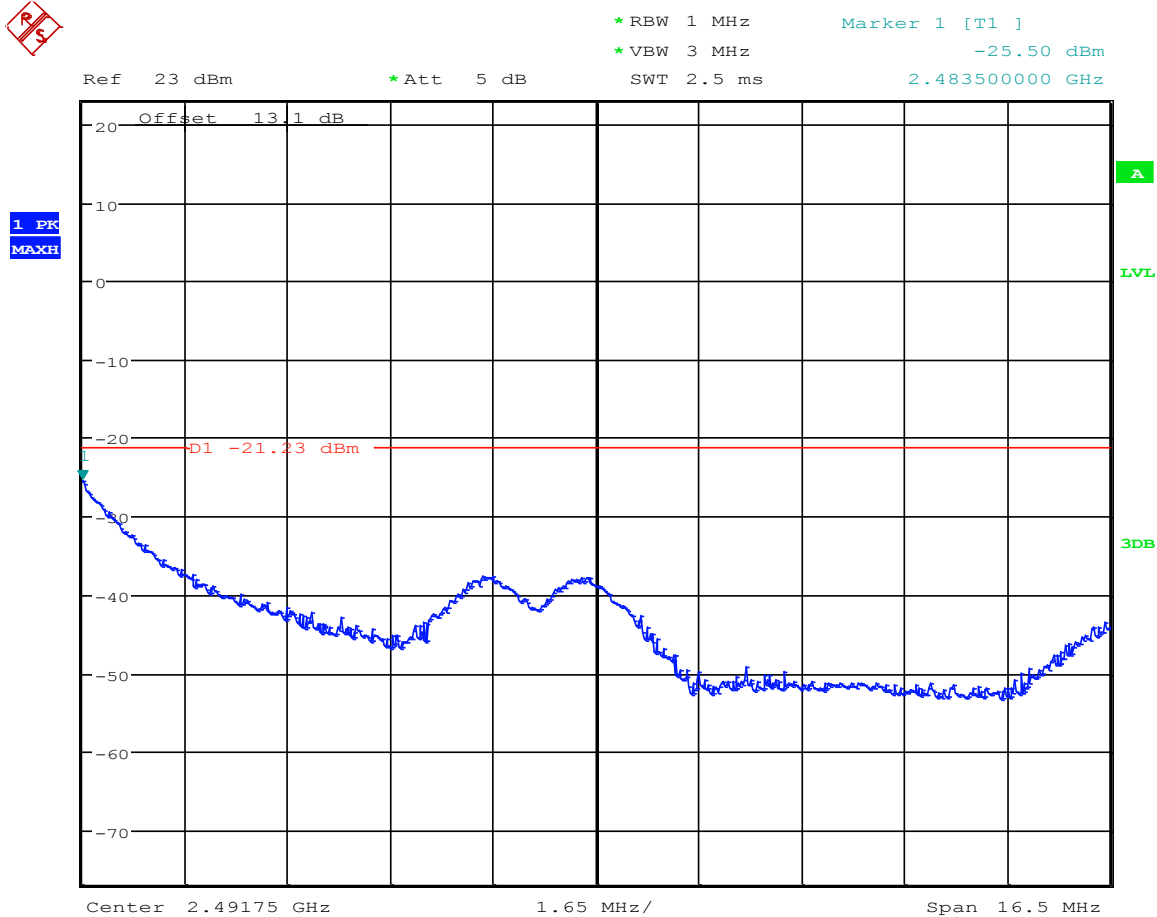
1 PK
MAXH

Date: 18.FEB.2021 14:54:42

Plot #9

High channel 2480 MHz

Modulation/Packet Type: GFSK



Date: 18.FEB.2021 14:42:14

8.5 Emission Bandwidth 6 dB and 99% Occupied Bandwidth

8.5.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

8.5.2 Limits:

FCC §15.247(a)(1) and RSS-247 5.2(1)

- Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

8.5.3 Test conditions and setup:

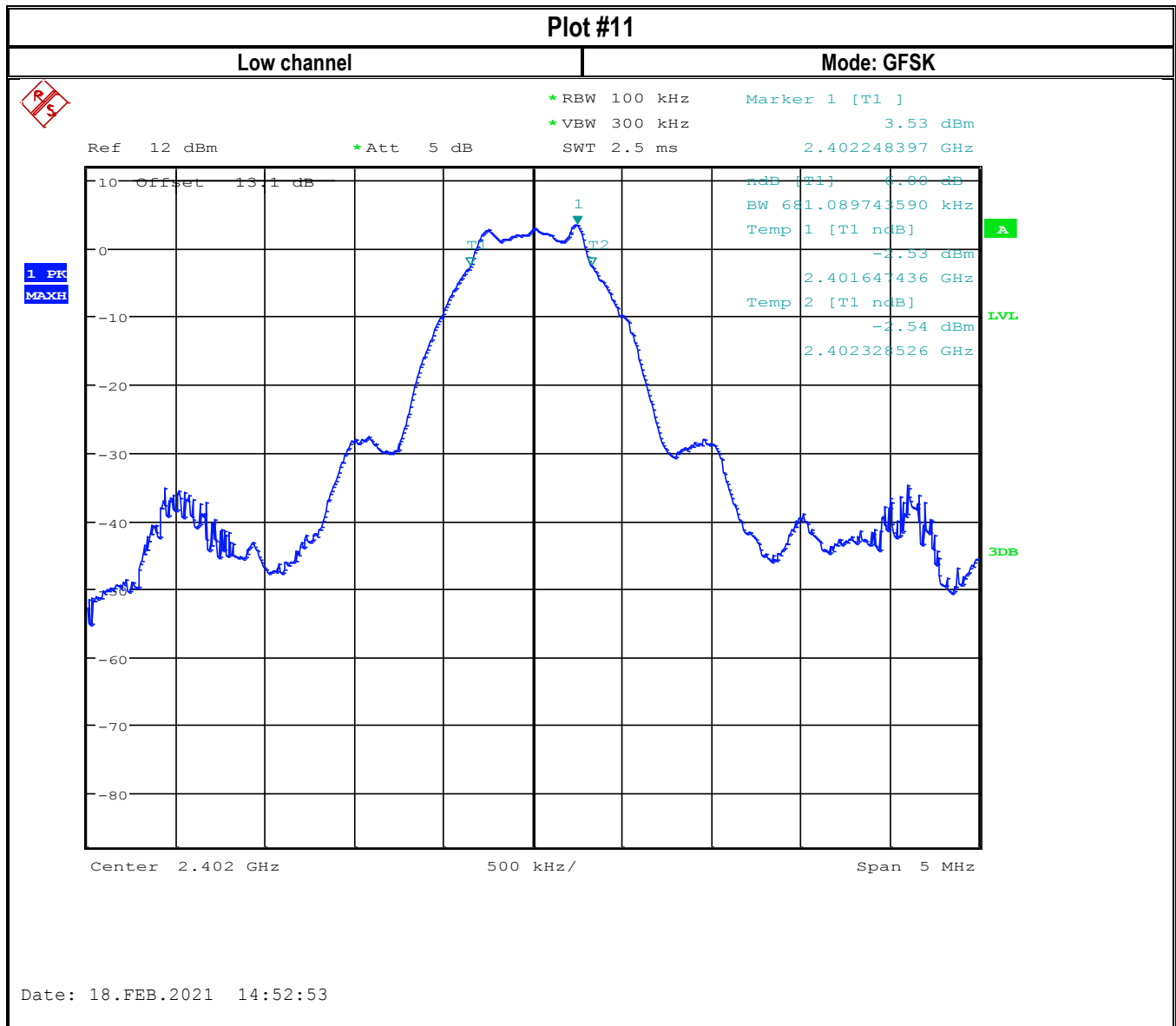
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	2	GFSK continuous fixed channel	5 VDC

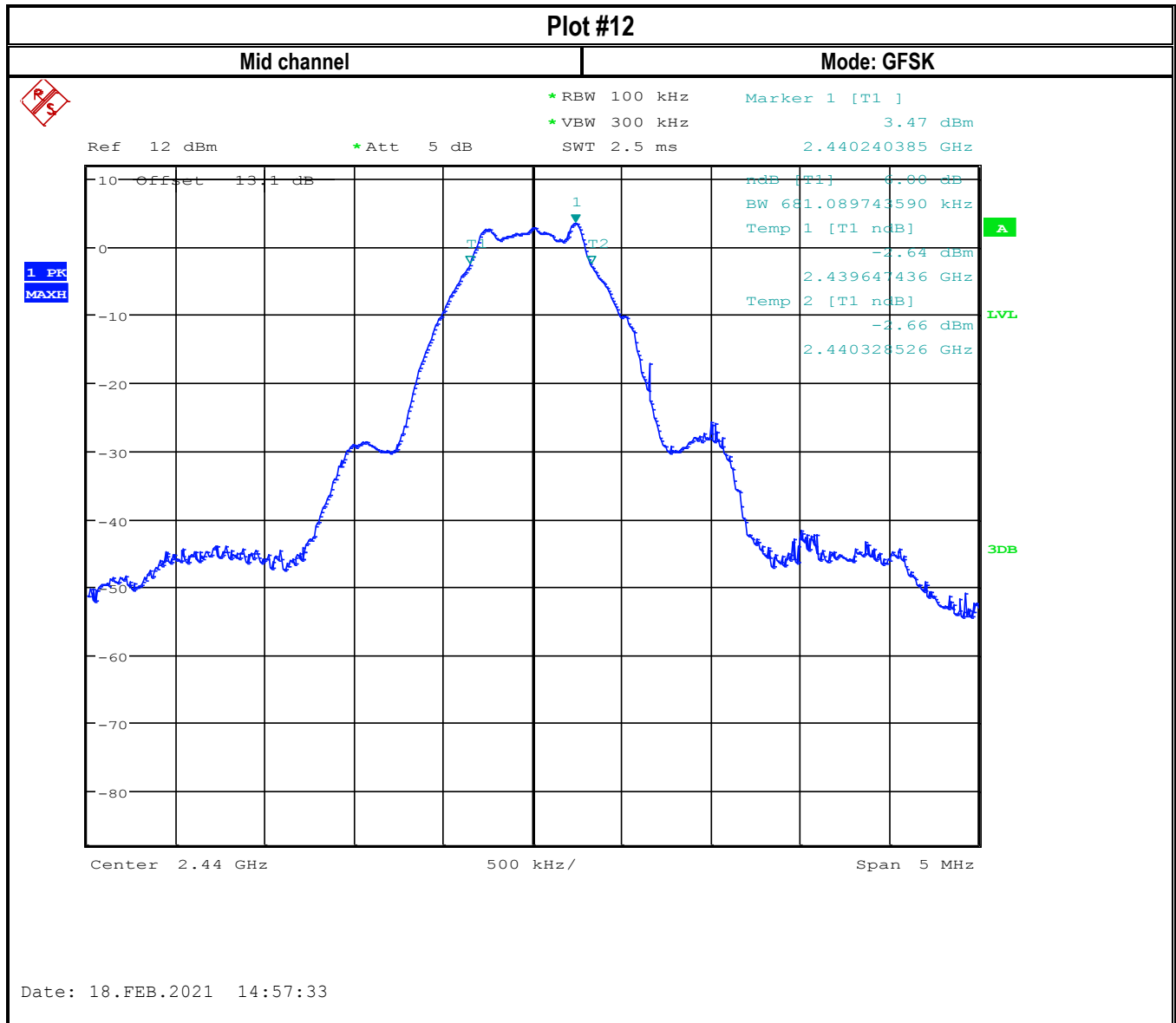
8.5.4 Measurement result:

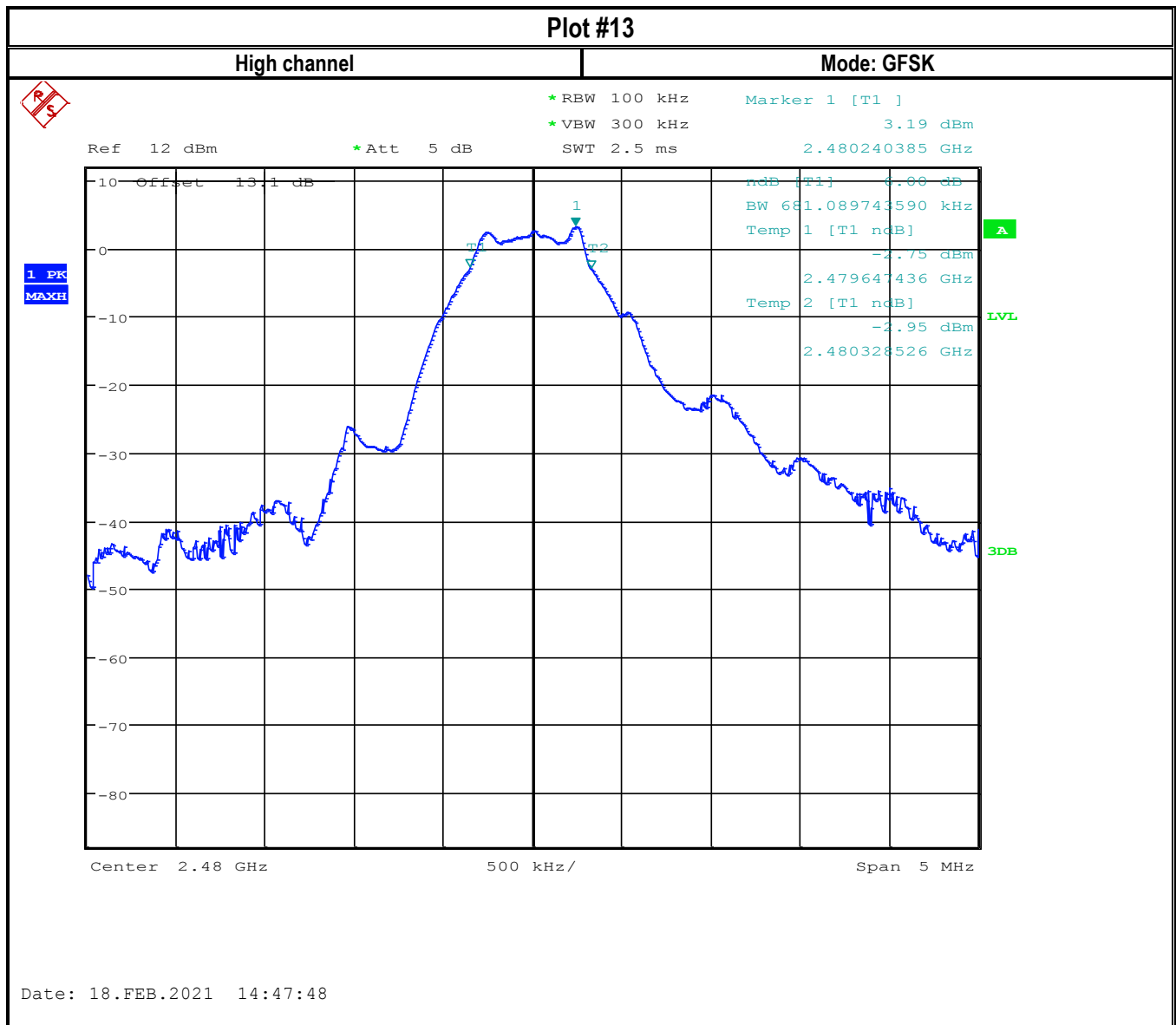
Plot #	Frequency (MHz)	6 dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
11	2402	0.681	> 0.5	Pass
12	2440	0.681	> 0.5	Pass
13	2480	0.681	> 0.5	Pass

Plot #	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
14	2402	1.06	> 0.5	Pass
15	2440	1.06	> 0.5	Pass
16	2480	1.15	> 0.5	Pass

8.5.5 Measurement Plots:







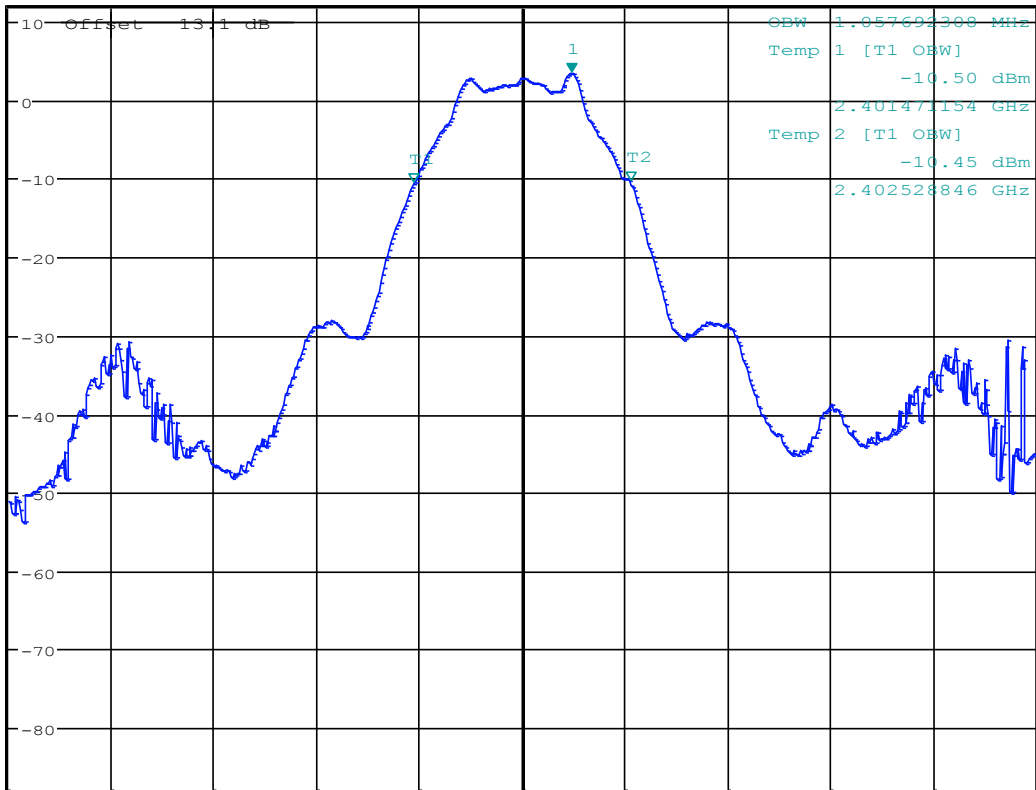
Plot #14

Low channel

Mode: GFSK



Ref 12 dBm *Att 5 dB SWT 2.5 ms Marker 1 [T1] 3.55 dBm
*RBW 100 kHz *VBW 300 kHz 2.402240385 GHz

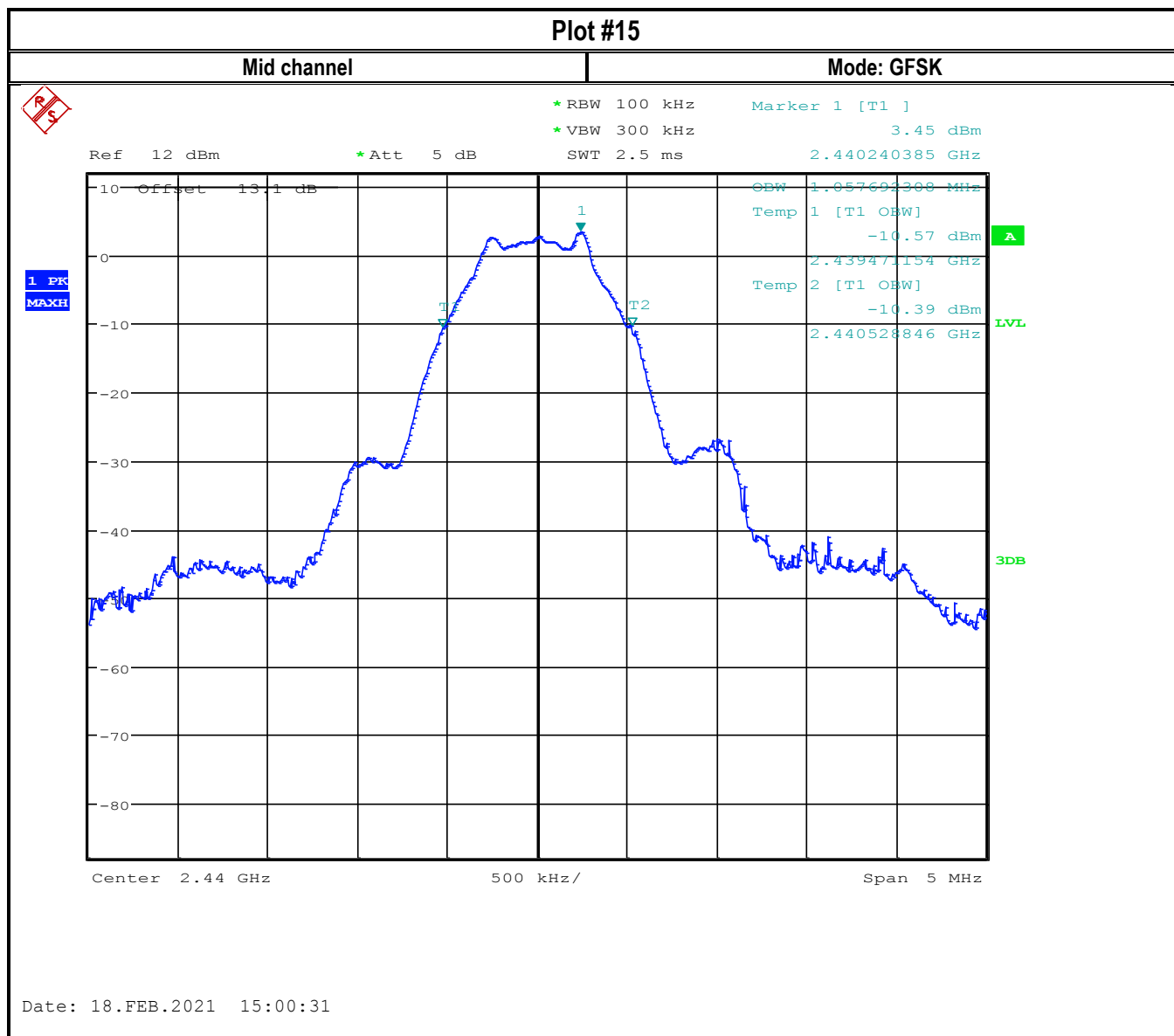


Center 2.402 GHz

500 kHz/

Span 5 MHz

Date: 18.FEB.2021 14:54:23



Plot #16

High channel

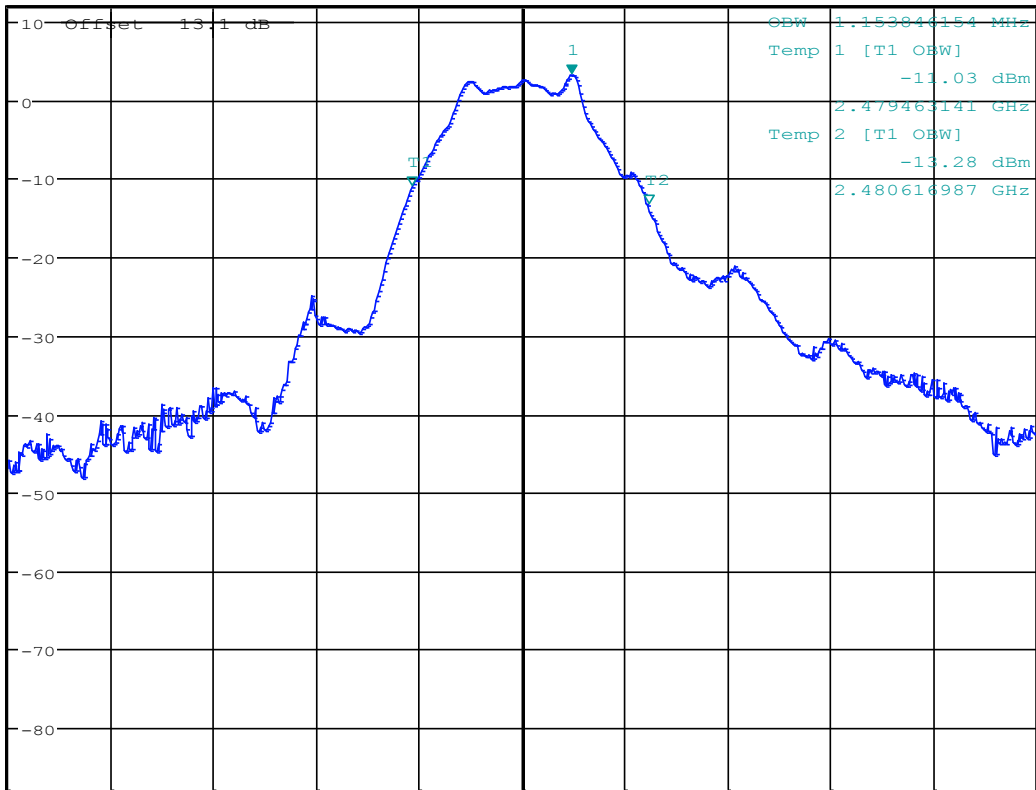
Mode: GFSK



Ref 12 dBm *Att 5 dB SWT 2.5 ms

*RBW 100 kHz Marker 1 [T1] 3.25 dBm

*VBW 300 kHz 2.480240385 GHz



Center 2.48 GHz

500 kHz/

Span 5 MHz

Date: 18.FEB.2021 15:05:33

8.6 Transmitter Frequency Stability

8.6.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

Spectrum Analyzer settings:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

8.6.2 Limits:

FCC §15.215(c)

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

RSS Gen 6.11

When the measurement method of transmitter frequency stability is not stated in the applicable RSS or reference standards, the following conditions apply:

The reference temperature for radio transmitters is +20°C (+68°F).

A hand-held device that is only capable of operating using internal batteries shall be tested at the battery's nominal voltage, and again at the battery's operating end-point voltage, which shall be specified by the equipment manufacturer. For this test, either a battery or an external power supply can be used.

The operating carrier frequency shall be set up in accordance with the manufacturer's published operation and instruction manual prior to the commencement of these tests. No adjustment of any frequency-determining circuit element shall be made subsequent to this initial set-up.

For licence-exempt devices, the following conditions apply:

At the temperatures of -20°C (-4°F), +20°C (+68°F) and +50°C (+122°F), and at the manufacturer's rated supply voltage.

At the temperature of +20°C (+68°F) and at $\pm 15\%$ of the manufacturer's rated supply voltage.

Plot	Temperature(° c)	Calculated Center Frequency(MHz)	Variation	PPM
17	-20	2.43999	0	0
18	20	2.43999	0	0
19	50	2.43999	0	0

Plot	Voltage(V)	Calculated Center Frequency(MHz)	Variation	PPM
20	4.25	2.44000	0.000005	-2.04918
18	5	2.43999	0.000000	0
21	5.75	2.44000	0.000005	-2.04918

Plot #17

Mid channel

Mode: GFSK



*RBW 100 kHz

Marker 3 [T1]

*VBW 300 kHz

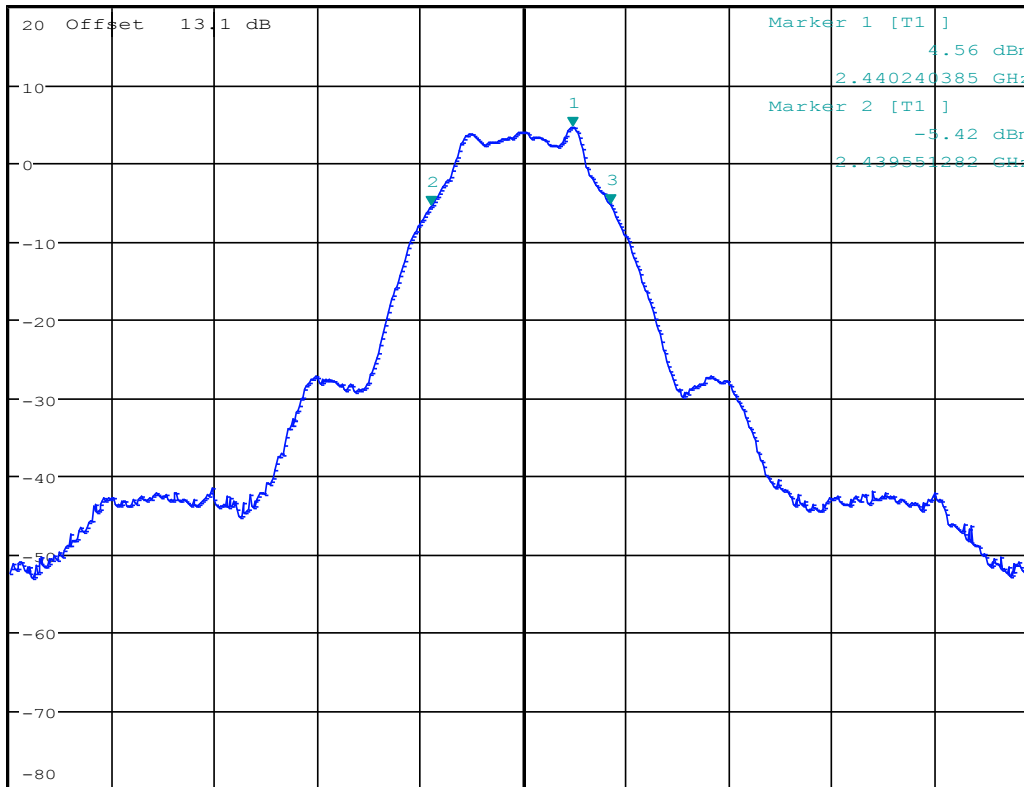
-5.30 dBm

Ref 20 dBm

*Att 5 dB

SWT 2.5 ms

2.440424679 GHz

1 PK
MAXH

Center 2.44 GHz

500 kHz/

Span 5 MHz

Date: 19.FEB.2021 12:33:00

Plot #18

Mid channel

Mode: GFSK



*RBW 100 kHz

Marker 1 [T1]

*VBW 300 kHz

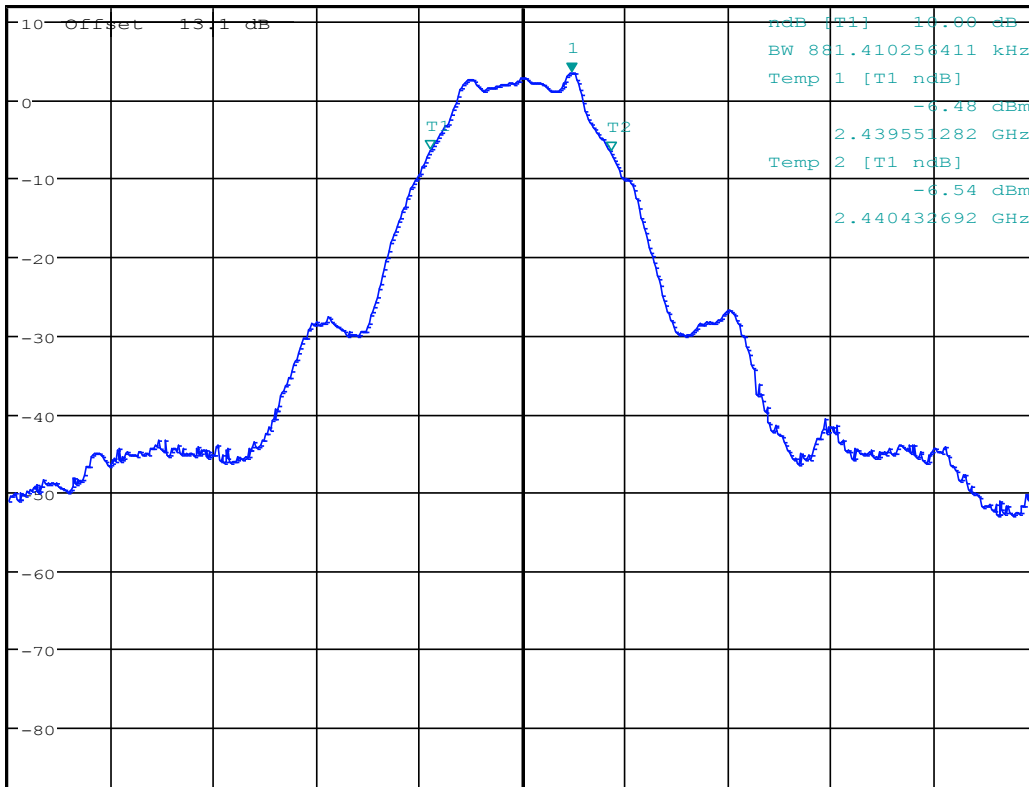
3.54 dBm

Ref 12 dBm

*Att 5 dB

SWT 2.5 ms

2.440240385 GHz



Center 2.44 GHz

500 kHz/

Span 5 MHz

Date: 18.FEB.2021 15:14:14

Plot #19

Mid channel

Mode: GFSK



*RBW 100 kHz

Marker 2 [T1]

*VBW 300 kHz

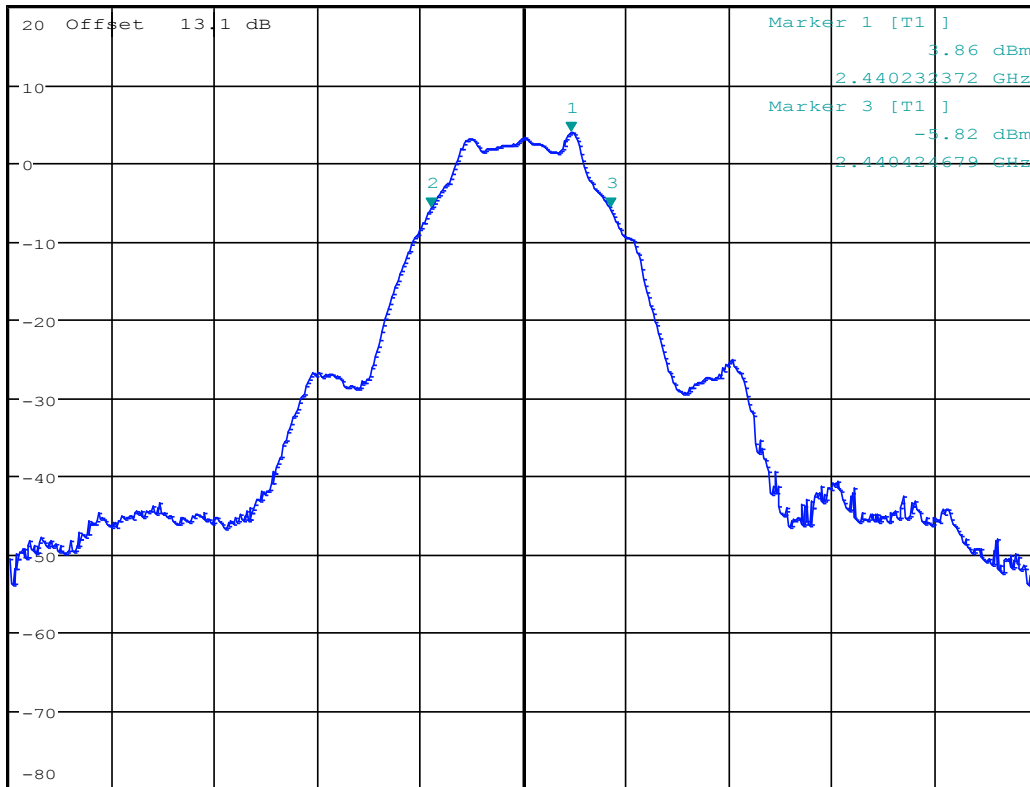
-5.67 dBm

Ref 20 dBm

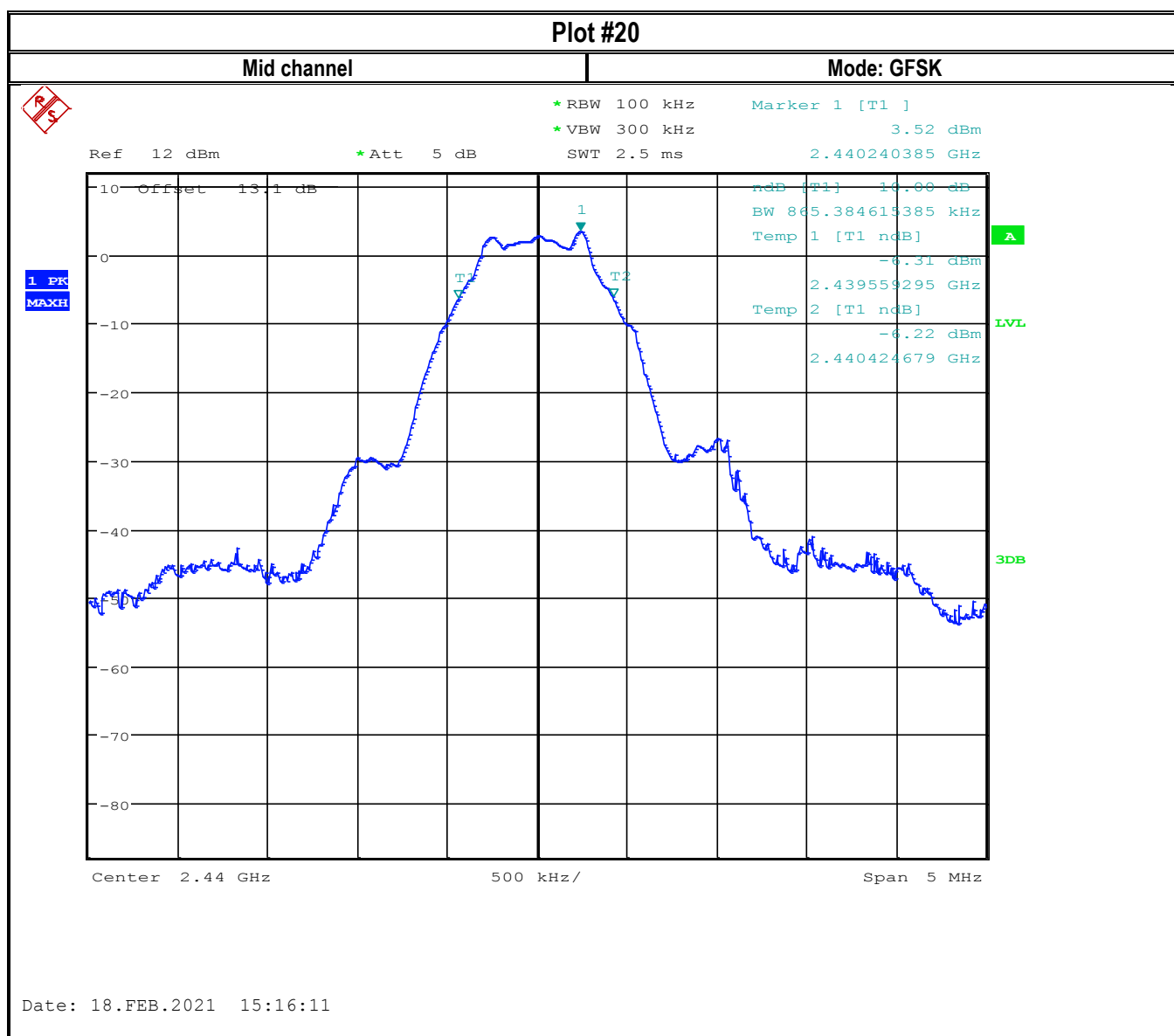
*Att 5 dB

SWT 2.5 ms

2.439551282 GHz

1 PK
MAXH

Date: 19.FEB.2021 14:23:55



Plot #21

Mid channel

Mode: GFSK



*RBW 100 kHz

Marker 1 [T1]

*VBW 300 kHz

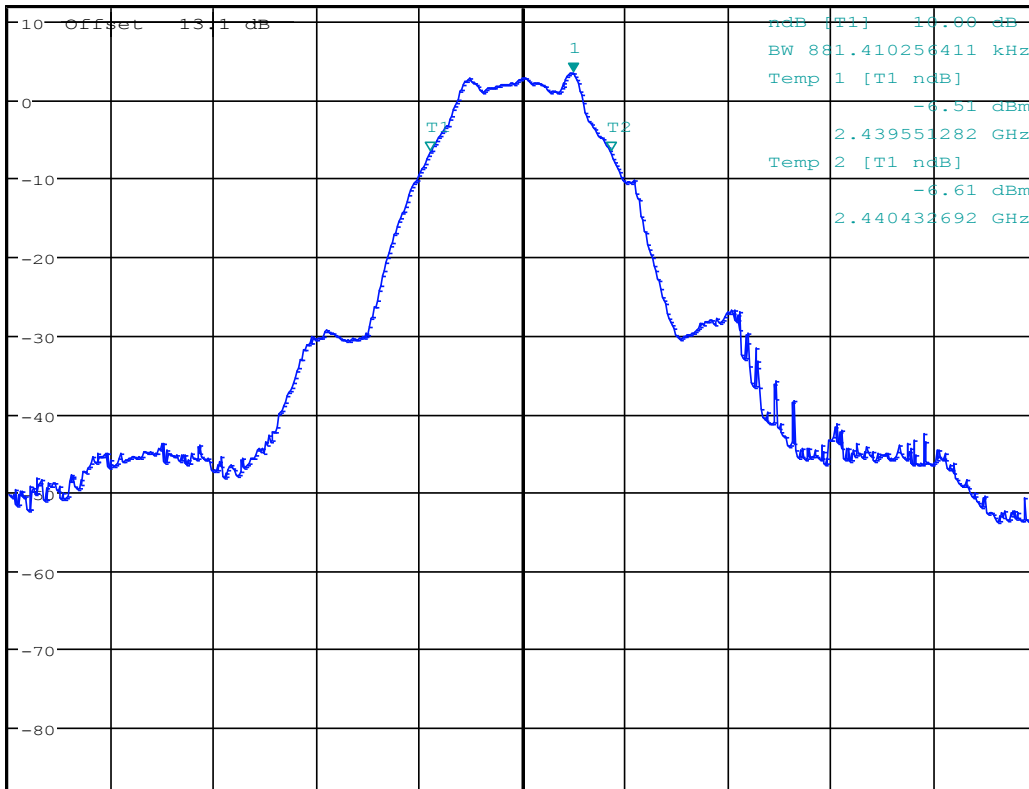
3.48 dBm

Ref 12 dBm

*Att 5 dB

SWT 2.5 ms

2.440248397 GHz



Center 2.44 GHz

500 kHz/

Span 5 MHz

Date: 18.FEB.2021 15:16:48

8.7 Radiated Transmitter Spurious Emissions and Restricted Bands

8.7.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector: Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW= 120 KHz (<1GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1 MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factor as follow: Conversion factor (CF) = $40 \log (D/d) = 40 \log (300m / 3m) = 80dB$

8.7.2 Limits:

FCC §15.247

- In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

FCC §15.209 & RSS-Gen 8.9

- Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency of emission (MHz)	Field strength (μV/m)	Measurement Distance (m)	Field strength @ 3m (dBμV/m)
0.009–0.490	2400/F(kHz) / -----	300	-
0.490–1.705	24000/F(kHz) / -----	30	-
1.705–30.0	30 / (29.5)	30	-
30–88	100	3	40 dBμV/m
88–216	150	3	43.5 dBμV/m
216–960	200	3	46 dBμV/m
Above 960	500	3	54 dBμV/m

FCC §15.205 & RSS-Gen 8.10

- Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

- Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

*PEAK LIMIT= 74 dBμV/m

*AVG. LIMIT= 54 dBμV/m

8.7.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	GFSK continuous fixed channel	110 VAC

8.7.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
22-24	Low	30 MHz – 18 GHz	See section 8.7.2	Pass
25-29	Mid	9 kHz – 26 GHz	See section 8.7.2	Pass
30-32	High	30 MHz – 18 GHz	See section 8.7.2	Pass

8.7.5 Measurement Plots:

Plot #22 Radiated Emissions: 30 MHz – 1GHz

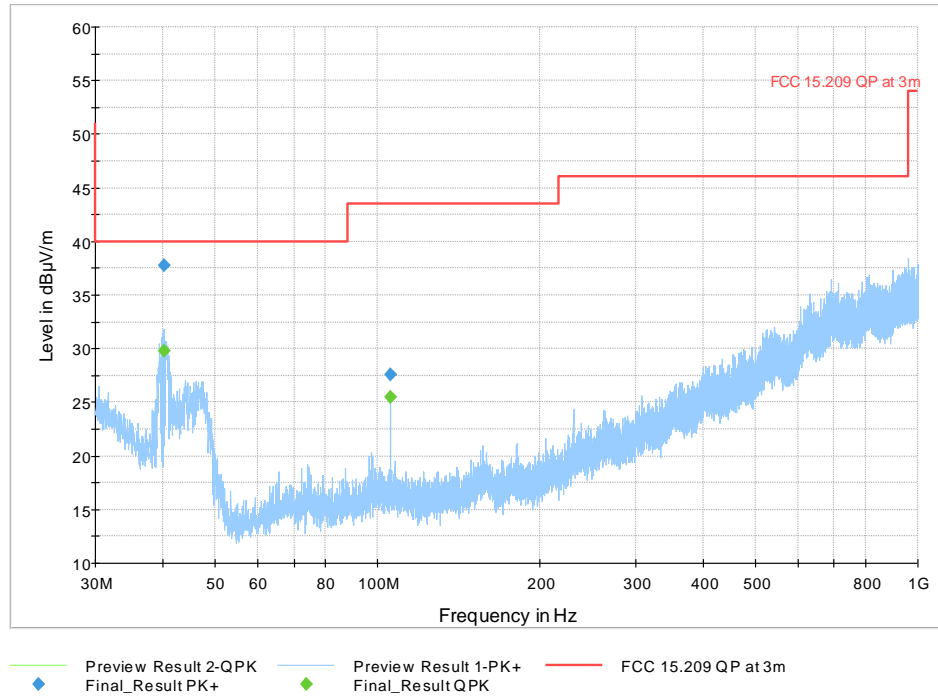
Modulation: GFSK

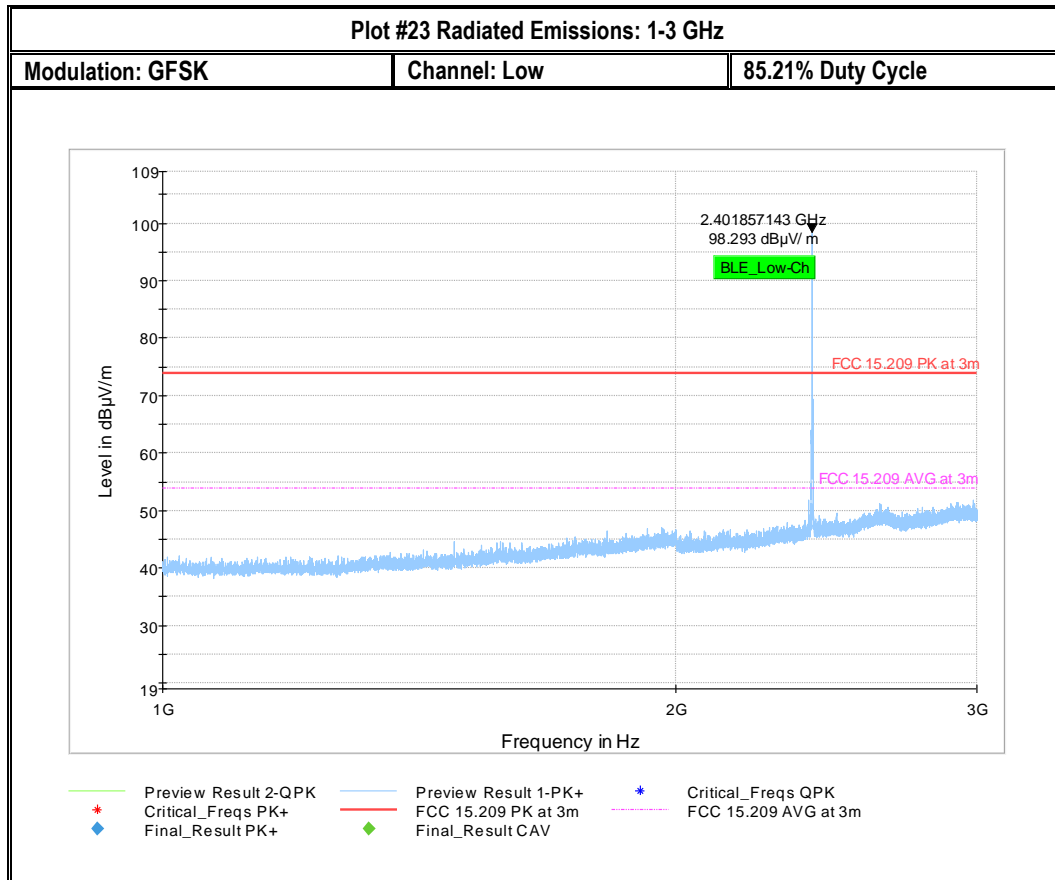
Channel: Low

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
40.250	---	29.77	---	---	500.0	120.000	140.0	V	168.0	14.6	
40.250	37.78	---	40.00	2.22	500.0	120.000	140.0	V	168.0	14.6	
105.660	---	25.49	---	---	500.0	120.000	153.0	V	301.0	13.2	
105.660	27.63	---	43.50	15.87	500.0	120.000	153.0	V	301.0	13.2	





Plot #24 Radiated Emissions: 3-18 GHz

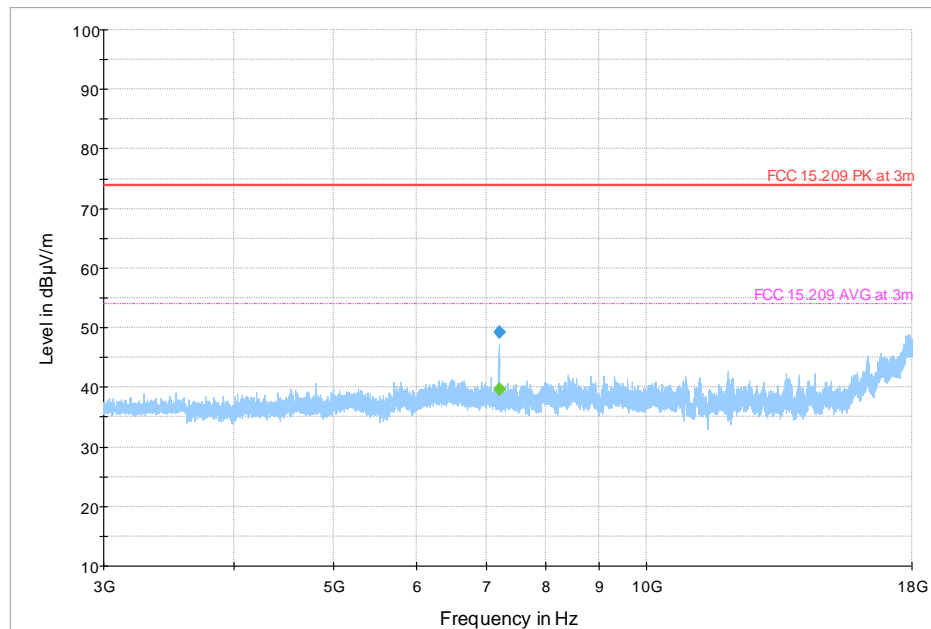
Modulation: GFSK

Channel: Low

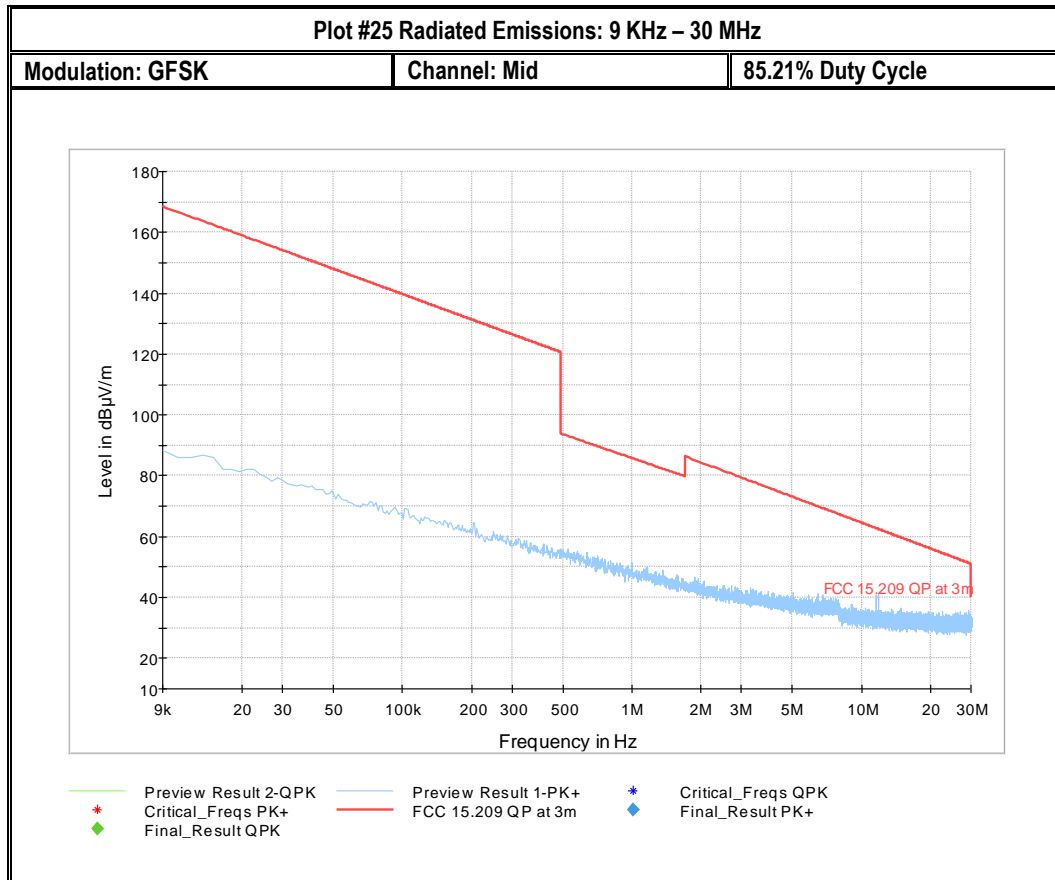
85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
7205.500	---	39.76	53.98	14.21	500.0	1000.000	140.0	H	286.0	-0.6	
7205.500	49.31	---	73.98	24.67	500.0	1000.000	140.0	H	286.0	-0.6	



Preview Result 2-QPK Preview Result 1-PK+ FCC 15.209 PK at 3m
FCC 15.209 AVG at 3m Final_Result PK+ Final_Result CAV



Plot #26 Radiated Emissions: 30 MHz – 1GHz

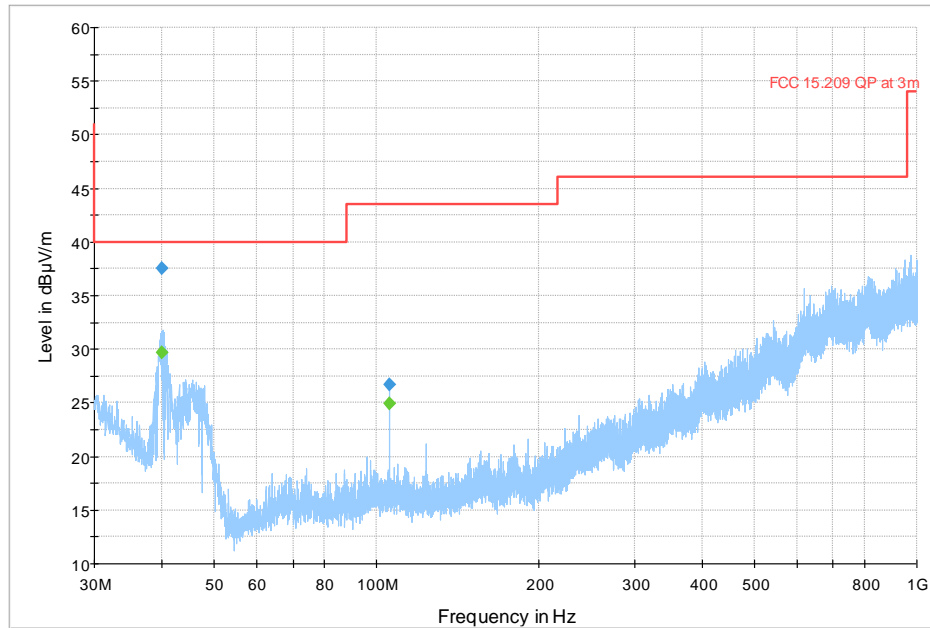
Modulation: GFSK

Channel: Mid

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
39.959	---	29.73	---	---	500.0	120.000	140.0	V	43.0	14.8	
39.959	37.50	---	40.00	2.50	500.0	120.000	140.0	V	43.0	14.8	
105.725	---	24.99	---	---	500.0	120.000	140.0	V	-34.0	13.2	
105.725	26.66	---	43.50	16.84	500.0	120.000	140.0	V	-34.0	13.2	



Preview Result 2-QPK Final_Result PK+ Preview Result 1-PK+ Final_Result QPK FCC 15.209 QP at 3m

Plot #27 Radiated Emissions: 1-3 GHz

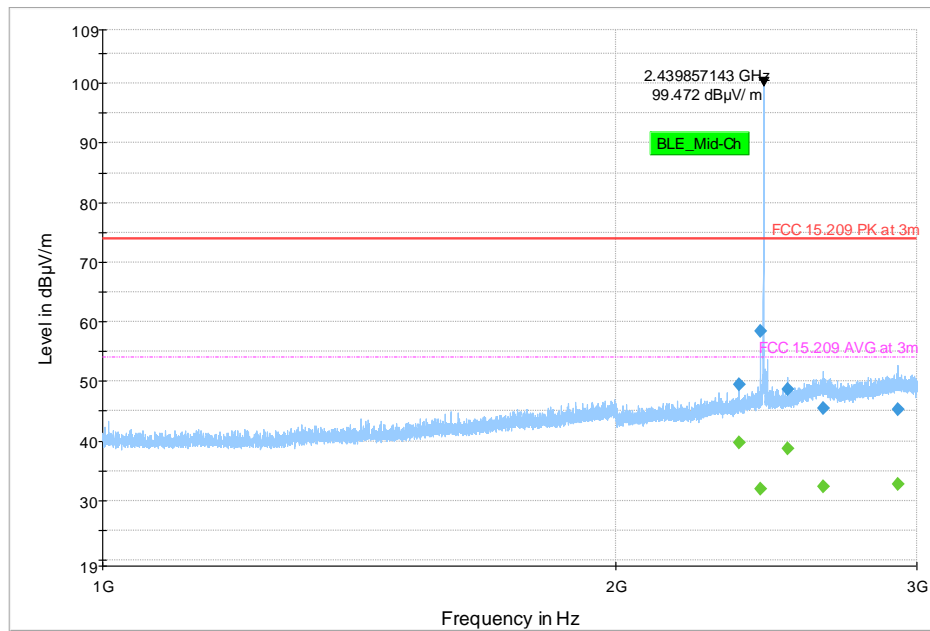
Modulation: GFSK

Channel: Mid

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2359.714	---	39.64	53.98	14.34	500.0	1000.000	163.0	V	326.0	9.2	
2359.714	49.44	---	73.98	24.54	500.0	1000.000	163.0	V	326.0	9.2	
2428.714	---	32.01	53.98	21.97	500.0	1000.000	174.0	V	-44.0	9.4	
2428.714	58.46	---	73.98	15.52	500.0	1000.000	174.0	V	-44.0	9.4	
2519.857	---	38.68	53.98	15.30	500.0	1000.000	140.0	V	9.0	9.9	
2519.857	48.59	---	73.98	25.39	500.0	1000.000	140.0	V	9.0	9.9	
2643.714	45.43	---	73.98	28.55	500.0	1000.000	151.0	V	5.0	10.7	
2643.714	---	32.24	53.98	21.74	500.0	1000.000	151.0	V	5.0	10.7	
2923.000	45.36	---	73.98	28.62	500.0	1000.000	292.0	H	331.0	11.6	
2923.000	---	32.69	53.98	21.28	500.0	1000.000	292.0	H	331.0	11.6	



Preview Result 2-QPK
FCC 15.209 AVG at 3m

Preview Result 1-PK+
Final_Result PK+

FCC 15.209 PK at 3m
Final_Result CAV

Plot #28 Radiated Emissions: 3-18 GHz

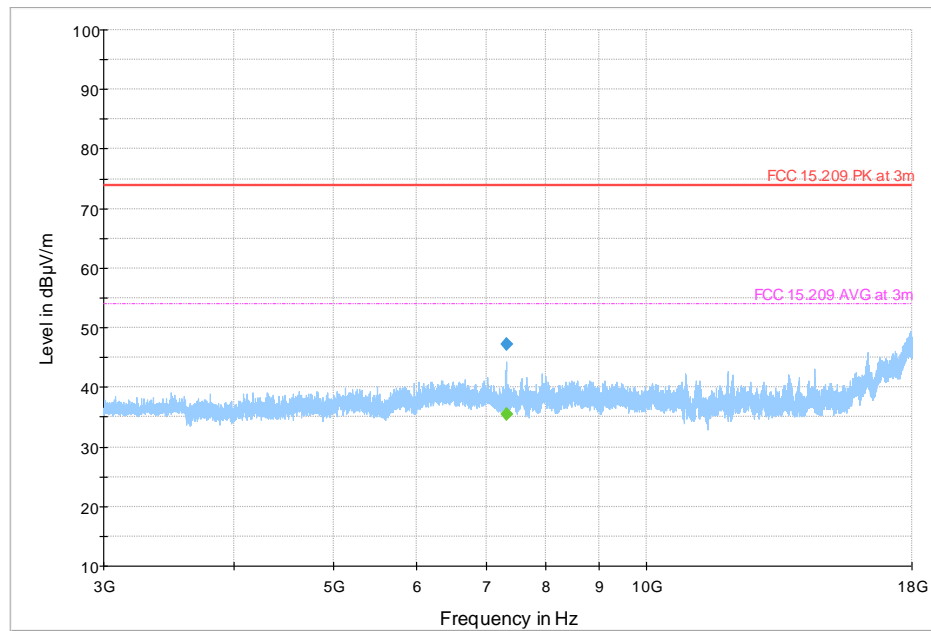
Modulation: GFSK

Channel: Mid

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
7321.000	---	35.43	53.98	18.55	500.0	1000.000	140.0	H	287.0	-0.5	
7321.000	47.14	---	73.98	26.84	500.0	1000.000	140.0	H	287.0	-0.5	

Preview Result 2-QPK
FCC 15.209 AVG at 3mPreview Result 1-PK+
Final_Result PK+FCC 15.209 PK at 3m
Final_Result CAV

Plot #29 Radiated Emissions: 18-26 GHz

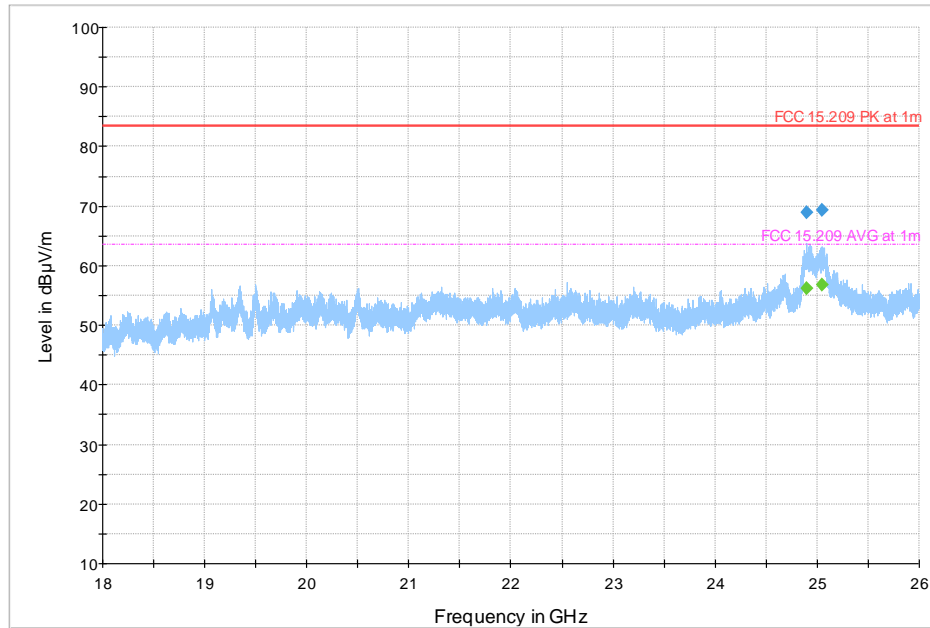
Modulation: GFSK

Channel: Mid

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
24897.000	---	56.18	63.50	7.32	500.0	1000.000	100.0	V	-29.0	30.2	
24897.000	68.92	---	83.50	14.58	500.0	1000.000	100.0	V	-29.0	30.2	
25046.750	---	56.72	63.50	6.78	500.0	1000.000	100.0	V	36.0	30.4	
25046.750	69.41	---	83.50	14.09	500.0	1000.000	100.0	V	36.0	30.4	



Preview Result 2-QPK Preview Result 1-PK+ FCC 15.209 PK at 1m
FCC 15.209 AVG at 1m Final_Result PK+ Final_Result CAV

Plot #30 Radiated Emissions: 30 MHz – 1GHz

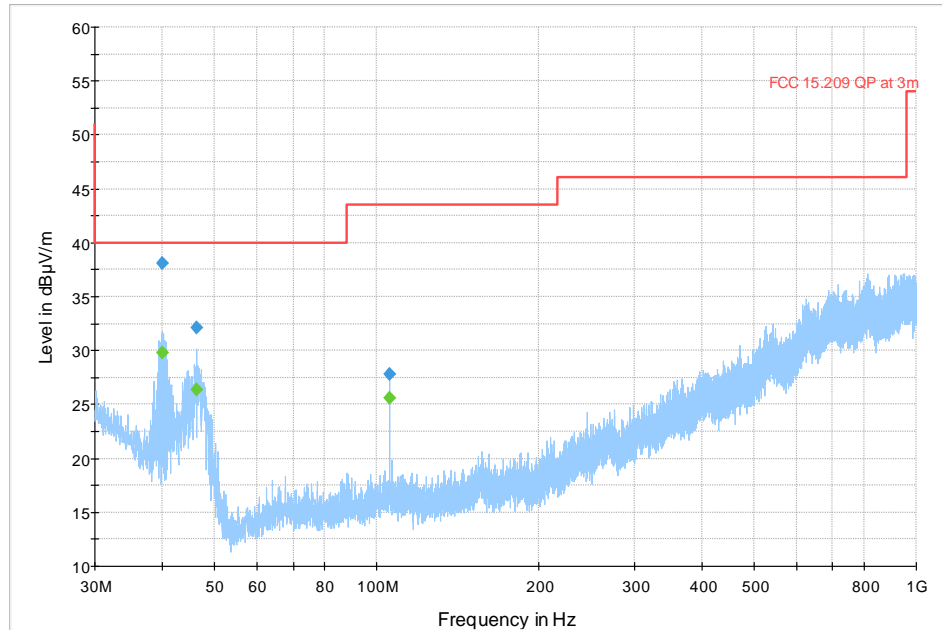
Modulation: GFSK

Channel: High

85.21% Duty Cycle

Final Result

Frequency (MHz)	MaxPeak (dBμV/m)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
39.926	38.14	---	40.00	1.86	500.0	120.000	140.0	V	89.0	14.8	
39.926	---	29.85	---	---	500.0	120.000	140.0	V	89.0	14.8	
46.264	32.09	---	40.00	7.91	500.0	120.000	152.0	V	324.0	11.4	
46.264	---	26.41	---	---	500.0	120.000	152.0	V	324.0	11.4	
105.692	---	25.58	---	---	500.0	120.000	140.0	V	111.0	13.2	
105.692	27.76	---	43.50	15.74	500.0	120.000	140.0	V	111.0	13.2	



Preview Result 2-QPK Final_Result PK+ Preview Result 1-PK+ Final_Result QPK FCC 15.209 QP at 3m

Plot #31 Radiated Emissions: 1-3 GHz

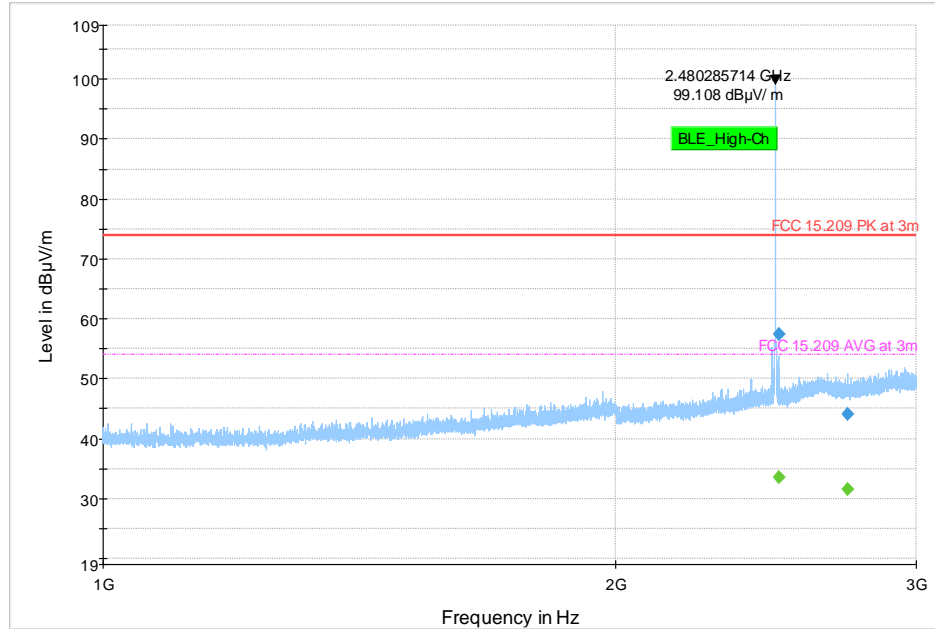
Modulation: GFSK

Channel: High

85.21% Duty Cycle

Final Result

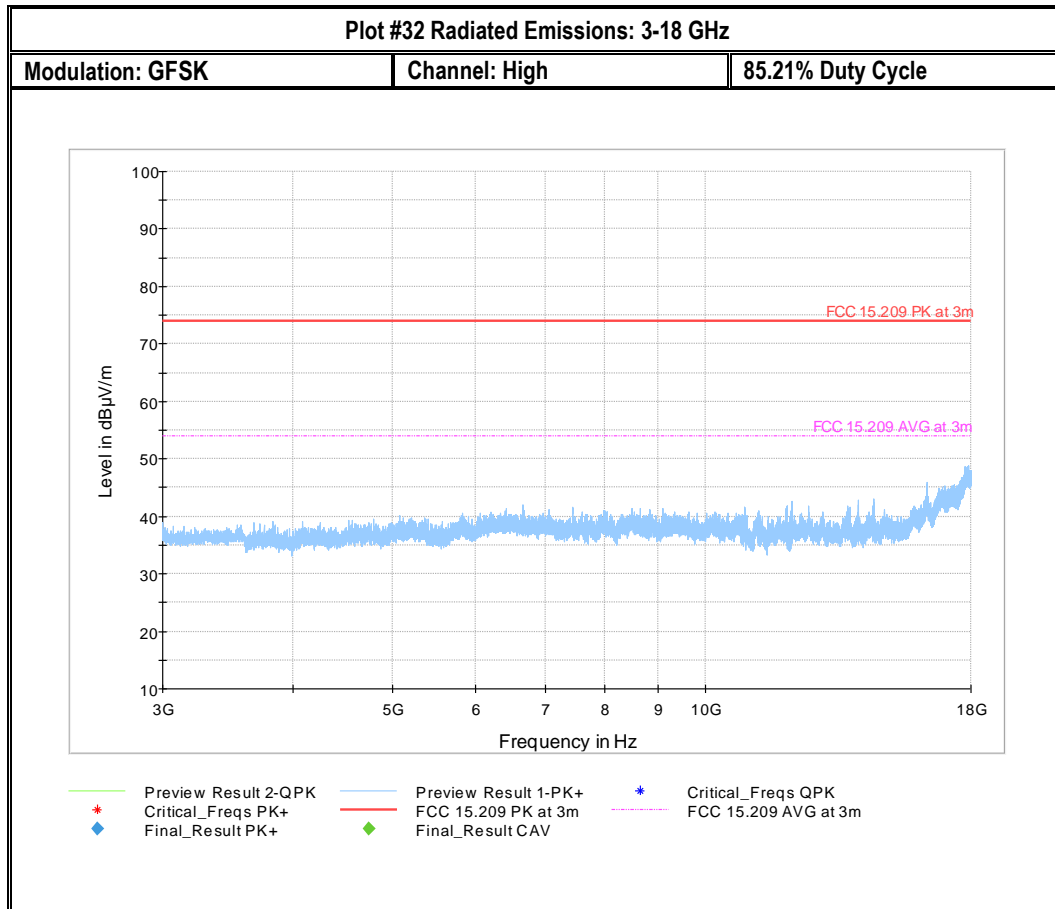
Frequency (MHz)	MaxPeak (dBμV/m)	CAverage (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
2490.143	---	33.57	53.98	20.41	500.0	1000.000	140.0	V	0.0	9.7	
2490.143	57.43	---	73.98	16.55	500.0	1000.000	140.0	V	0.0	9.7	
2732.429	---	31.64	53.98	22.34	500.0	1000.000	266.0	V	349.0	11.0	
2732.429	44.08	---	73.98	29.90	500.0	1000.000	266.0	V	349.0	11.0	



Preview Result 2-QPK
FCC 15.209 AVG at 3m

Preview Result 1-PK+
Final_Result PK+

FCC 15.209 PK at 3m
Final_Result CAV



8.8 AC Power Line Conducted Emissions

8.8.1 Measurement according to ANSI C63.10 (2013)

Analyzer Settings:

- RBW = 9 KHz (CISPR Bandwidth)
- Pre-scan Detector = Peak / Average for
- Final Measurements Detector = Quasi-Peak / Average

8.8.2 Limits: FCC 15.207 & RSS-Gen 8.8

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between frequency ranges.

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

8.8.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22	1	GFSK continuous fixed channel	Line & Neutral	110 V / 60 Hz

8.8.4 Measurement Result:

Plot #	Port	EUT Set-Up #	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	1	GFSK continuous fixed channel	150 kHz – 30 MHz	See section 8.8.2	Pass

8.8.5 Measurement Plots:

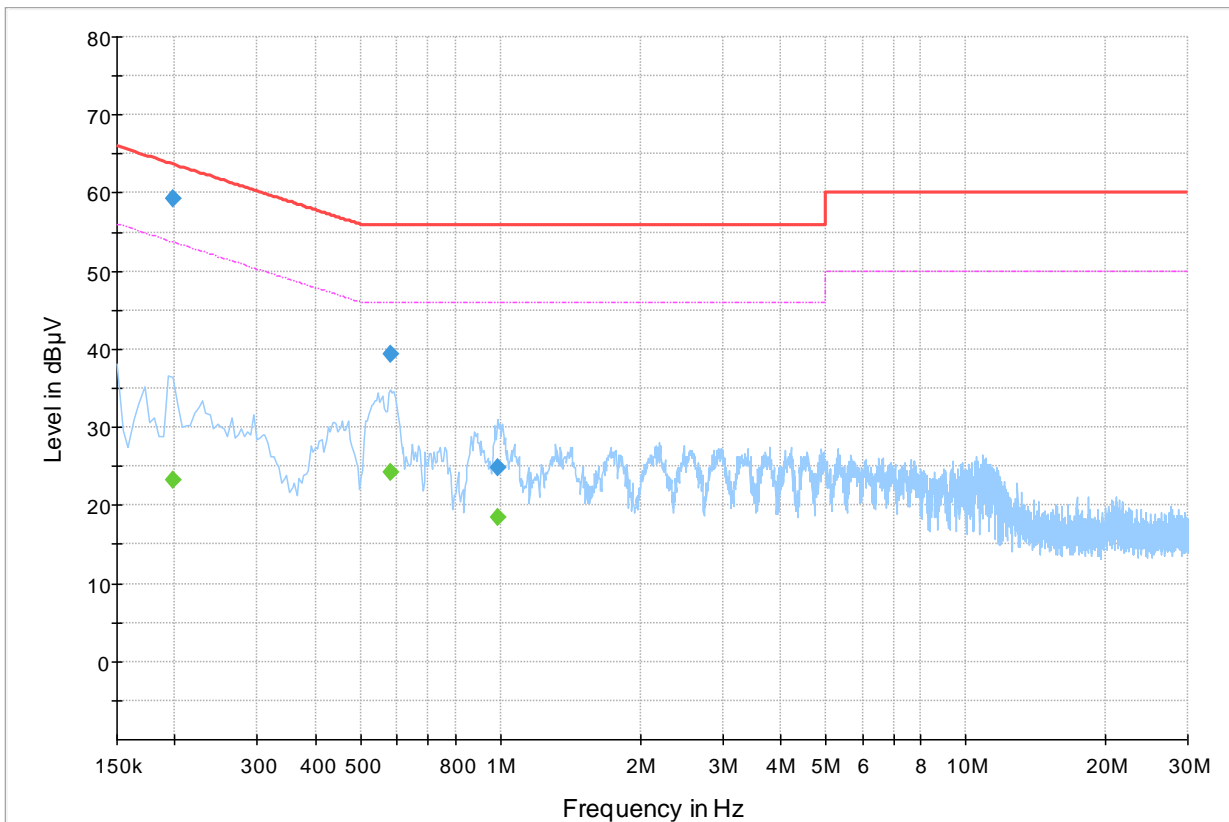
Plot # 1

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Final_Result

Frequency (MHz)	QuasiPeak (dBμV)	CAverage (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)	Comment
0.198	---	23.33	53.68	30.35	500.0	9.000	N	GND	10.2	
0.198	59.25	---	63.68	4.43	500.0	9.000	N	GND	10.2	
0.580	39.43	---	56.00	16.57	500.0	9.000	L1	GND	10.0	
0.580	---	24.25	46.00	21.75	500.0	9.000	L1	GND	10.0	
0.988	24.79	---	56.00	31.21	500.0	9.000	L1	GND	10.1	
0.988	---	18.44	46.00	27.56	500.0	9.000	L1	GND	10.1	



Preview Result 1-PK+
Final_Result QPK

EN 55032 Voltage on Mains QP
Final_Result CAV

EN 55032 Voltage on Mains AV

9 Test setup photos

Setup photos are included in supporting file name: "EMC_SYLER_001_21001_Setup_Photos.pdf"

10 Test Equipment and Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP ANTENNA	ETS LINDGREN	6507	00161344	3 YEARS	10/30/2020
BILOG ANTENNA	ETS.LINDGREN	3142E	00166067	3 YEARS	03/12/2020
HORN ANTENNA	EMCO	3115	00035114	3 YEARS	08/10/2020
HORN ANTENNA	ETS.LINDGREN	3117	00215984	3 YEARS	01/31/2021
HORN ANTENNA	ETS.LINDGREN	3116	00070497	3 YEARS	11/23/2020
SPECTRUM ANALYZER	R&S	FSU26	200065	3 YEARS	07/16/2019
SIGNAL ANALYZER	R&S	FSV 40	101022	3 YEARS	07/15/2019
TEST RECEIVER	R&S	ESU.EMI	100256	3 YEARS	07/16/2019
COMPACT DIGITAL BAROMETER	CONTROL COMPANY	10510-922	200236891	3 YEARS	04/13/2020
DIGITAL THERMOMETER	CONTROL COMPANY	36934-164	181230565	3 YEARS	01/10/2019
LINE IMPEDANCE STABILIZATION NETWORK	FCC	FCC-LISN-50-25-2-08	08014	3 YEARS	07/19/2019

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 Revision History

Date	Report Name	Changes to report	Report prepared by
2021-03-10	EMC_SYLER_001_21001_15.247_BT_DTS	Initial version	Yuchan Lu

<<The End>>