



FCC / IC Test Report

FOR:

Telular Corporation.

Model Name:

ST90

Product Description:

Fuel Tank Monitoring

FCC ID: MTFST90

IC ID: 2175D-ST90

Applied Rules and Standards:
47 CFR Part 15.247 (DTS)
RSS-247 Issue 2 (DTSs) & RSS-Gen Issue 5

REPORT #: EMC_TELUL-072-17001_15.247_ISM_DTS

DATE: 2018-07-03



A2LA Accredited

IC recognized #
3462B-2

CETECOM Inc.

411 Dixon Landing Road • Milpitas, CA 95035 • U.S.A.

Phone: + 1 (408) 586 6200 • Fax: + 1 (408) 586 6299 • E-mail: info@cetecom.com • <http://www.cetecom.com>
CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

TABLE OF CONTENTS

1	ASSESSMENT.....	3
2	ADMINISTRATIVE DATA	4
2.1	IDENTIFICATION OF THE TESTING LABORATORY ISSUING THE EMC TEST REPORT	4
2.2	IDENTIFICATION OF THE CLIENT	4
2.3	IDENTIFICATION OF THE MANUFACTURER.....	4
3	EQUIPMENT UNDER TEST (EUT).....	5
3.1	EUT SPECIFICATIONS	5
3.2	EUT SAMPLE DETAILS	6
3.3	ACCESSORY EQUIPMENT (AE) DETAILS.....	6
3.4	TEST SAMPLE CONFIGURATION	6
3.5	JUSTIFICATION FOR WORST CASE MODE OF OPERATION.....	6
4	MEASUREMENT RESULTS SUMMARY	7
5	MEASUREMENT UNCERTAINTY.....	8
5.1	ENVIRONMENTAL CONDITIONS DURING TESTING:.....	8
5.2	DATES OF TESTING:	8
6	MEASUREMENT PROCEDURES.....	9
6.1	RADIATED MEASUREMENT.....	9
6.2	POWER LINE CONDUCTED MEASUREMENT PROCEDURE	12
6.3	RF CONDUCTED MEASUREMENT PROCEDURE	12
7	TEST RESULT DATA	13
7.1	MAXIMUM PEAK CONDUCTED OUTPUT POWER.....	13
7.2	POWER SPECTRAL DENSITY	17
7.3	BAND EDGE COMPLIANCE	21
7.4	EMISSION BANDWIDTH 6dB AND 99% OCCUPIED BANDWIDTH.....	26
7.5	RADIATED TRANSMITTER SPURIOUS EMISSIONS AND RESTRICTED BANDS	33
7.6	AC POWER LINE CONDUCTED EMISSIONS	46
8	TEST SETUP PHOTOS	47
9	TEST EQUIPMENT AND ANCILLARIES USED FOR TESTING	47
10	REVISION HISTORY	48

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 ISED Canada standard RSS-247.

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.

This test report is to support a request for new equipment authorization under the FCC ID: R17LE910NAV2, IC ID: 5131A-LE910NAV2

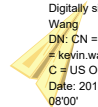
No deviations were ascertained to comply with these requirements.

Company	Description	Model #
Telular Corporation.	Fuel Tank Monitoring	ST90

Responsible for Testing Laboratory:

2018-07-03	Compliance	James Donnellan (EMC Lab Manager)	
Date	Section	Name	Signature

Responsible for the Report:

2018-07-03	Compliance	Kevin Wang (Sr. EMC Engineer)	Kevin Wang 
Date	Section	Name	Signature

Digitally signed by: Kevin Wang
DN: CN = Kevin Wang email
= kevin.wang@cetecom.com
C = US O = Cetecom
Date: 2018.07.03 15:16:25 -
08'00'

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:	James Donnellan
Responsible Project Leader:	Chaman Bhardwaj

2.2 Identification of the Client

Applicant's Name:	Telular Corporation.
Street Address:	3225 Cumberland Blvd. Suite 300
City/Zip Code	Atlanta, GA 30339
Country	USA

2.3 Identification of the Manufacturer

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

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	ST90
HW Version :	Rev B
SW Version :	2.50
FCC-ID :	MTFST90
IC-ID:	2175D-ST90
Product Description:	Fuel Tank Monitoring
Frequency Range / number of channels:	Nominal band: 905 MHz – 925 MHz; Center to center: 905 MHz (ch.0) – 925 MHz (ch.19), 20 channels
Type(s) of Modulation:	2GFSK
Modes of Operation:	ISM Radio in both advertising and connected mode of operation
Antenna Information as declared:	max gain 3.0 dBi
Max. Peak ISM Radio Output Power:	Conducted Power 10.65 dBm
Power Supply/ Rated Operating Voltage Range:	6.3 VDC max, nominal 6 VDC, Low 5 VDC
Operating Temperature Range	- 30 °C to +70°C, nominal 25°C
Other Radios included in the device:	LTE, WCDMA (UMTS),GPS (Quectel, L70)
Sample Revision	☐ Prototype Unit; ☒ Production Unit; Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	613-00031	Rev B	2.50	Radiated Emissions
2	613-00031	Rev B	2.50	Conducted Emissions

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Laptop	Latitude E5430	DELL	BRW1VY1

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	613-00031	Unit was operated in its intended mode of operation by test software in standalone mode either Cellular or ISM
2	613-00031	This Unit was configured for conducted RF power, occupied Bandwidth (OBW), and spurious emissions measurements in ISM mode of operation.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and 100% duty cycle. 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 **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	2GFSK	■	□	□	Complies
§15.247(e) RSS-247 5.2(2)	Power Spectral Density	Nominal	2GFSK	■	□	□	Complies
§15.247(b)(1) RSS-247 5.4(4)	Maximum Conducted Output Power and EIRP	Nominal	2GFSK	■	□	□	Complies
§15.247(d) RSS-247 5.5	Band edge compliance Unrestricted Band Edges	Nominal	2GFSK	■	□	□	Complies
§15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10	Band edge compliance Restricted Band Edges	Nominal	2GFSK	■	□	□	Complies
§15.247(d); §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	2GFSK	■	□	□	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	2GFSK	□	■	□	NA

Note: NA= Not Applicable; NP= Not Performed. There is no AC input

5 **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)
-------------------	---------------------

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 3 dB to the limit.

5.1 **Environmental Conditions During Testing:**

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

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

5.2 **Dates of Testing:**

03/26/2018 – 04/16/2018

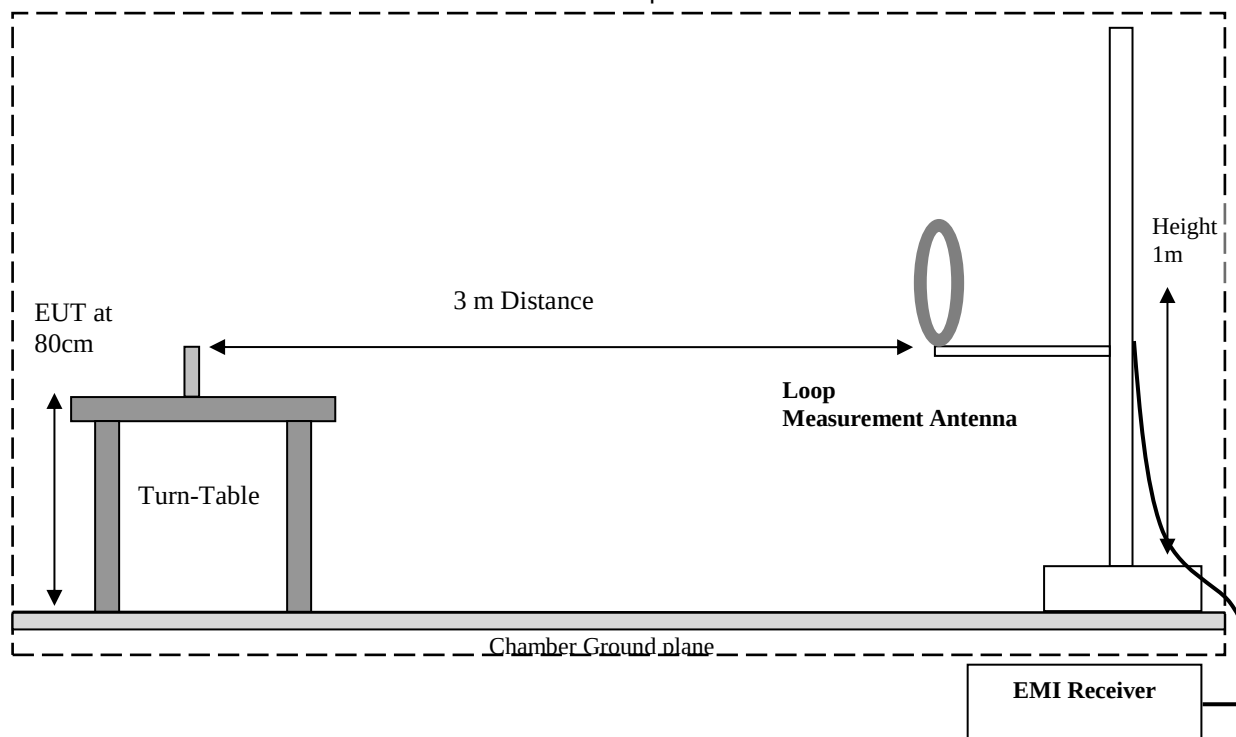
6 Measurement Procedures

6.1 Radiated Measurement

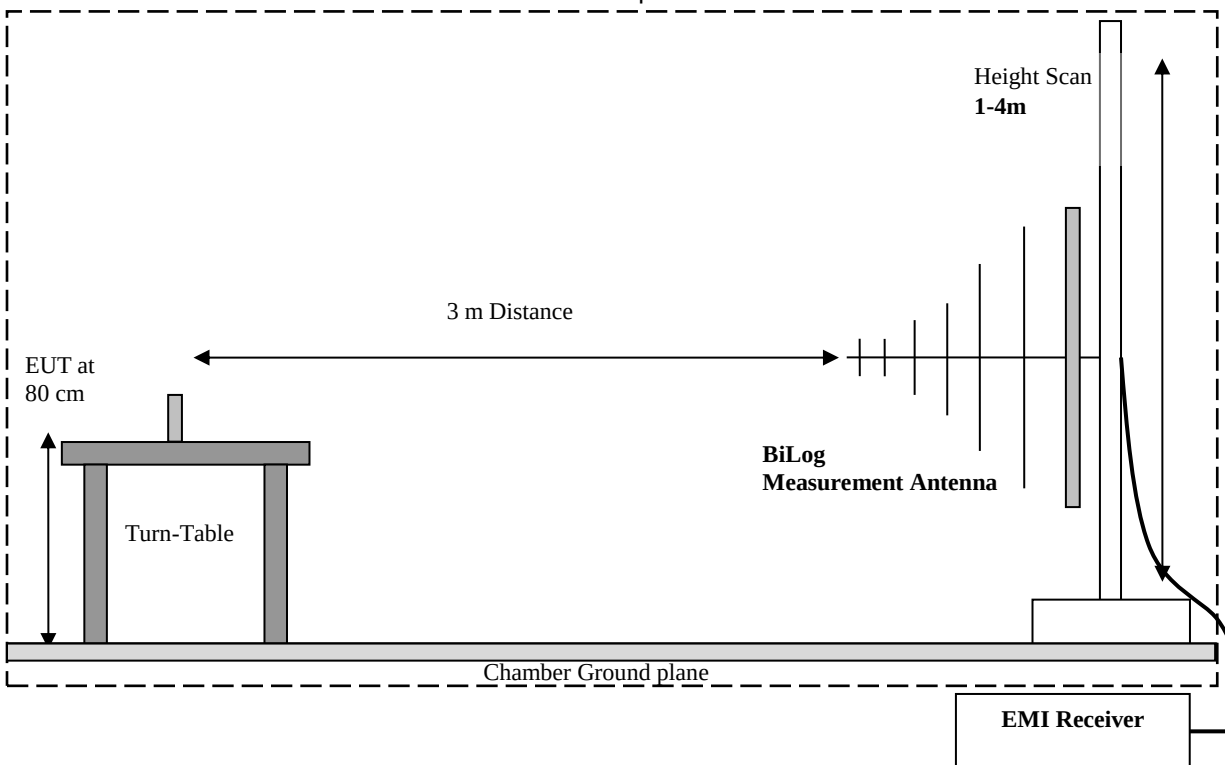
American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services, ANSI C63.26-2015

- 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.

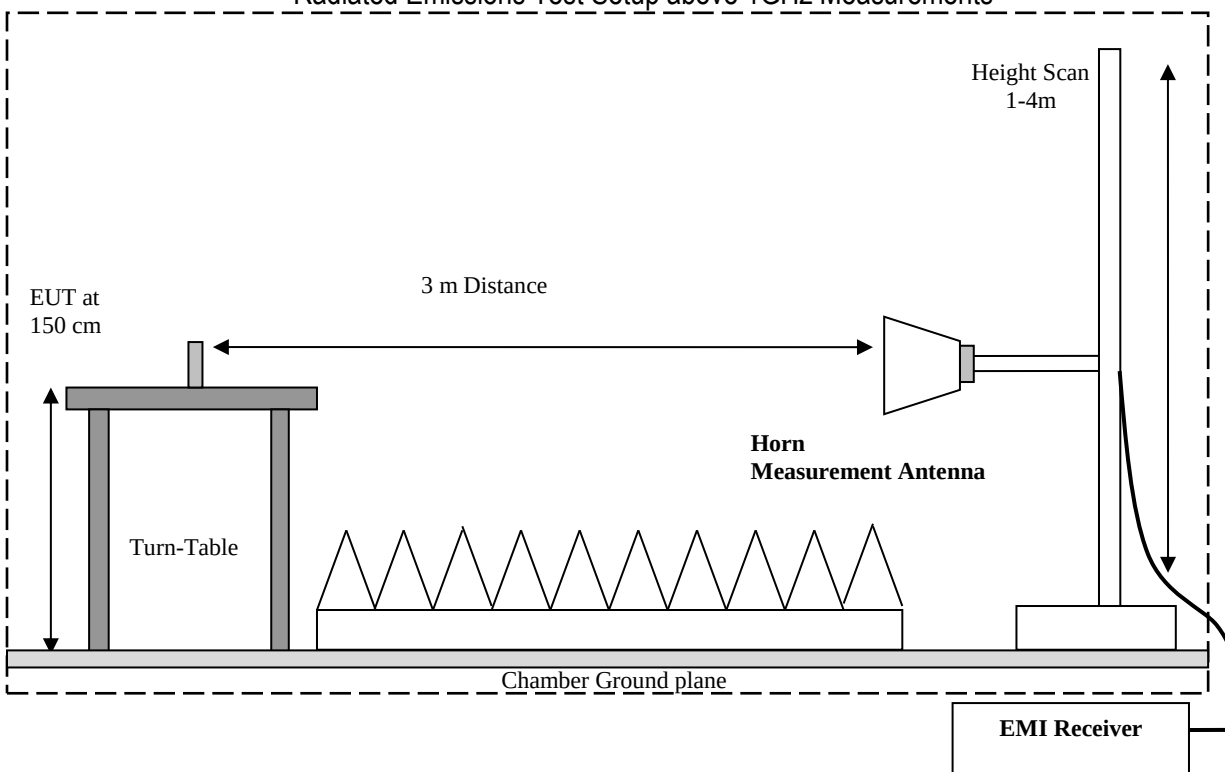
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



6.1.1 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:

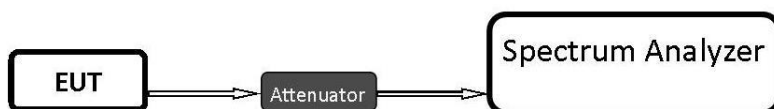
Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/m)
1000	80.5	3.5	14	98.0

6.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.4 (2009). This test requirement is applicable to Li-Ion Battery Charger only.

6.3 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – “GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247” - April 5, 2017, 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.

7 Test Result Data

7.1 Maximum Peak Conducted Output Power

7.1.1 Measurement according to FCC 558074 D01 DTS Measurement Guidance v04

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

7.1.2 Limits:

Maximum Peak Output Power:

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

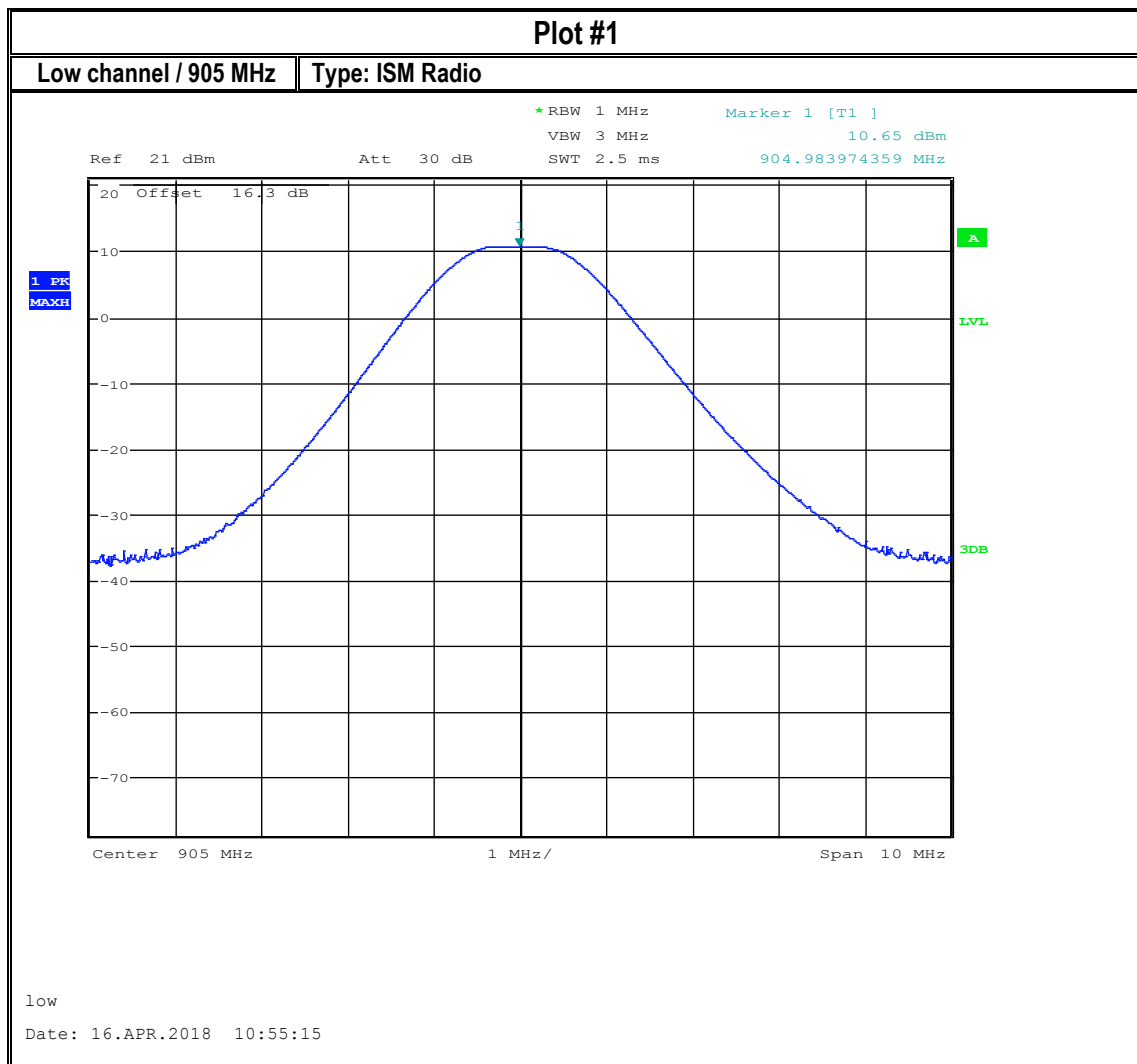
7.1.3 Test conditions and setup:

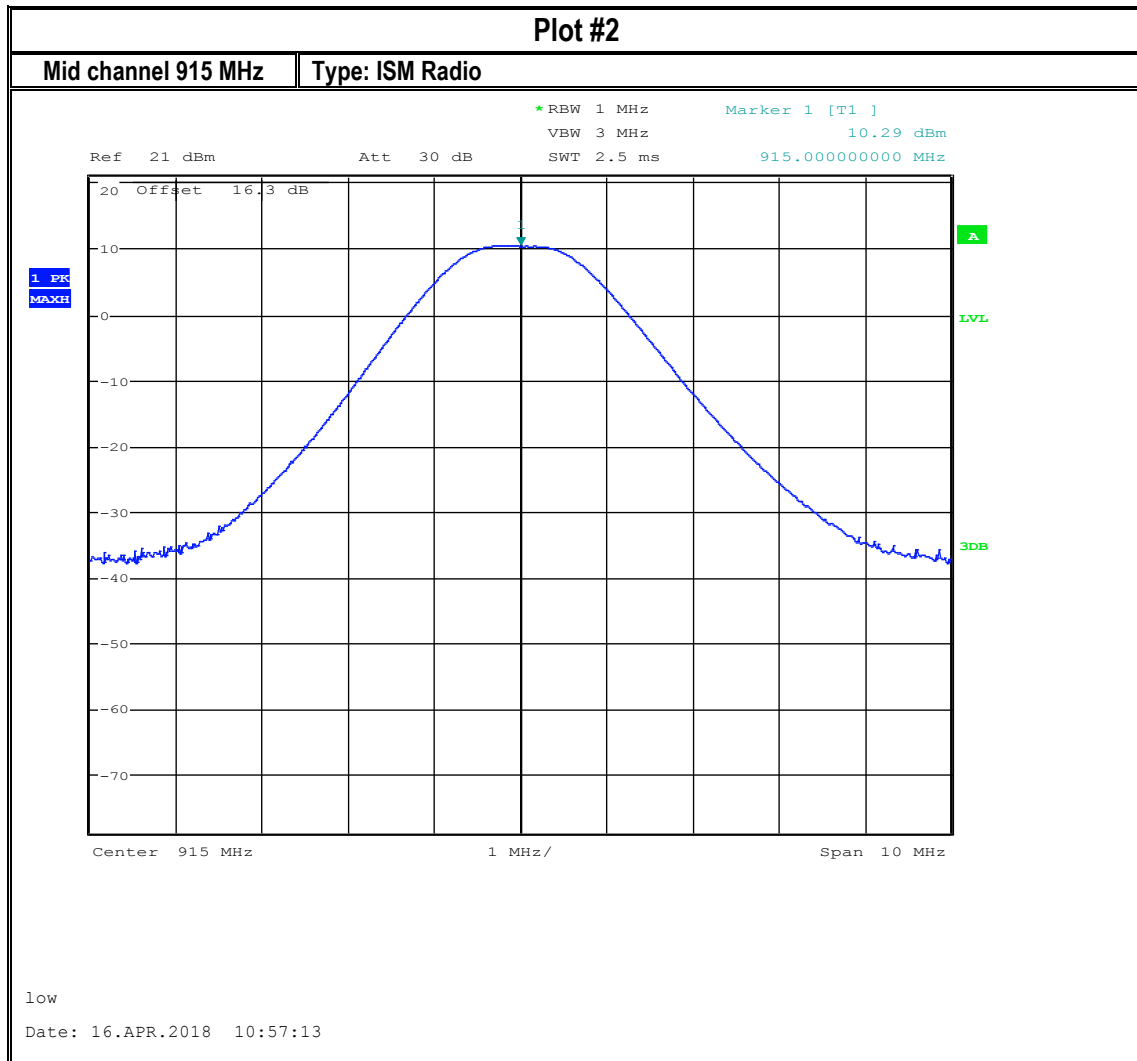
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	2	ISM continuous fixed channel	6.3 VDC max, nominal 6 VDC, Low 5 VDC	3.0 dBi

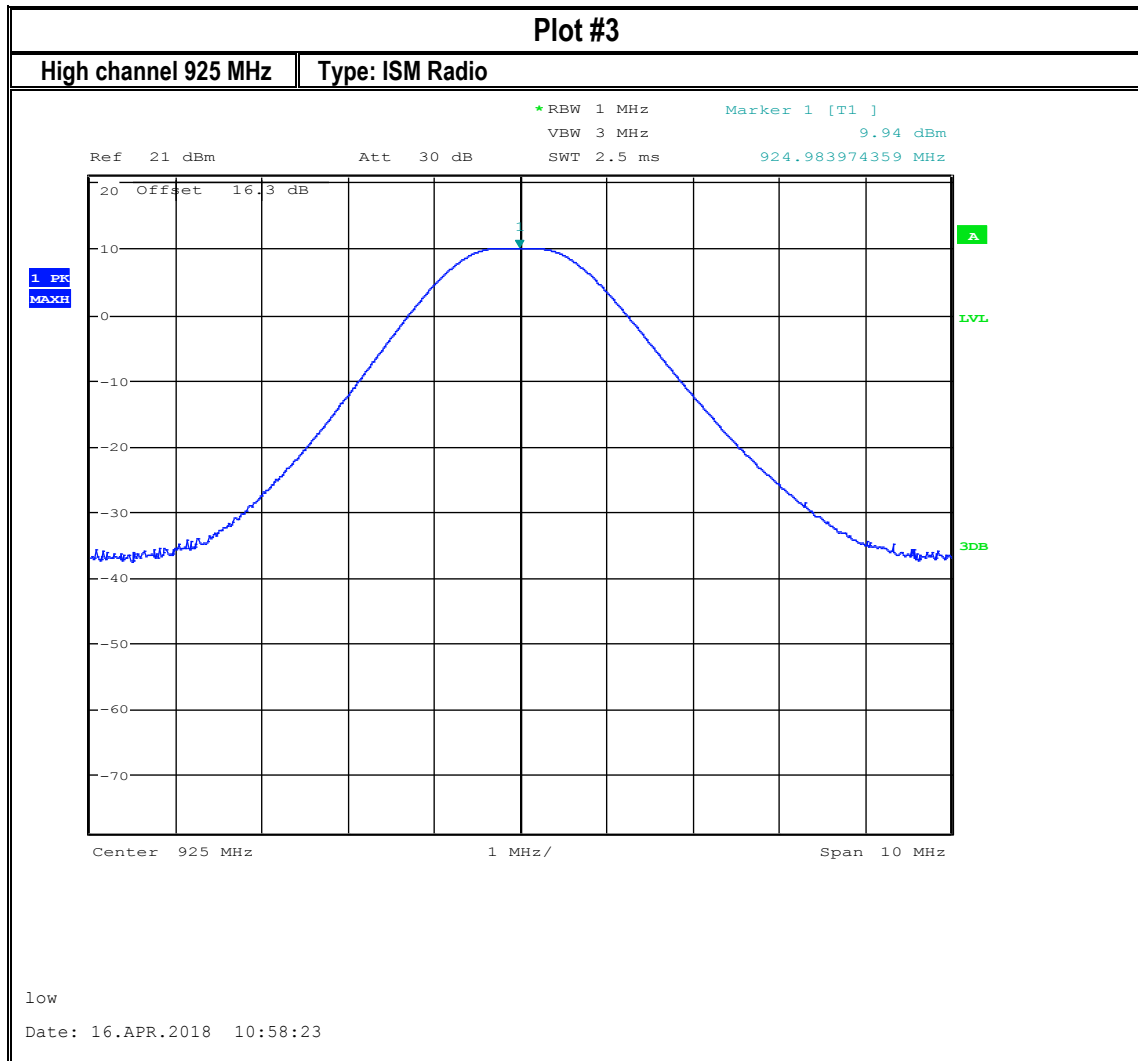
7.1.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	Limit (dBm)	Result
1	905	10.65	30 (Pk)	Pass
2	915	10.29	30 (Pk)	Pass
3	925	9.94	30 (Pk)	Pass

7.1.5 Measurement Plots:







7.2 Power Spectral Density

7.2.1 Measurement according to FCC 558074 D01 DTS Measurements Guidance v04

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

7.2.2 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.

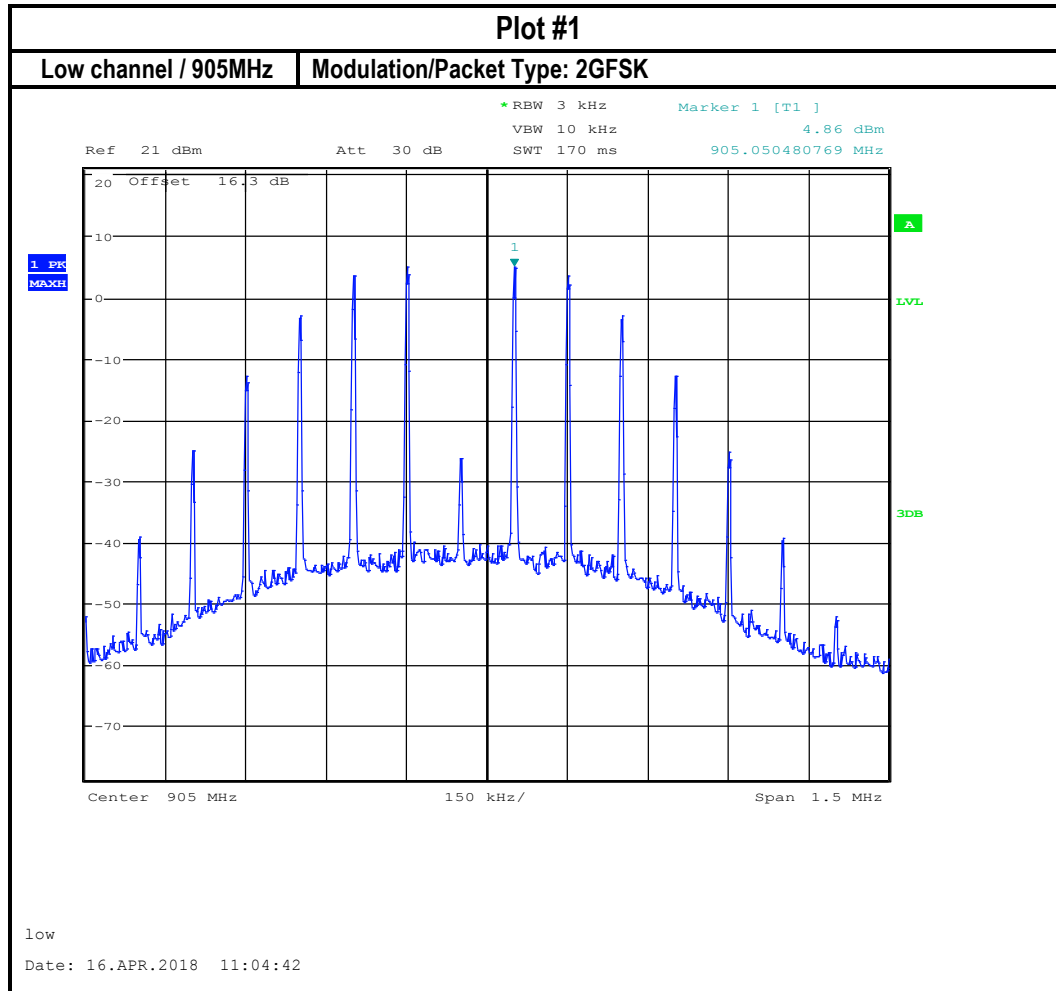
7.2.3 Test conditions and setup:

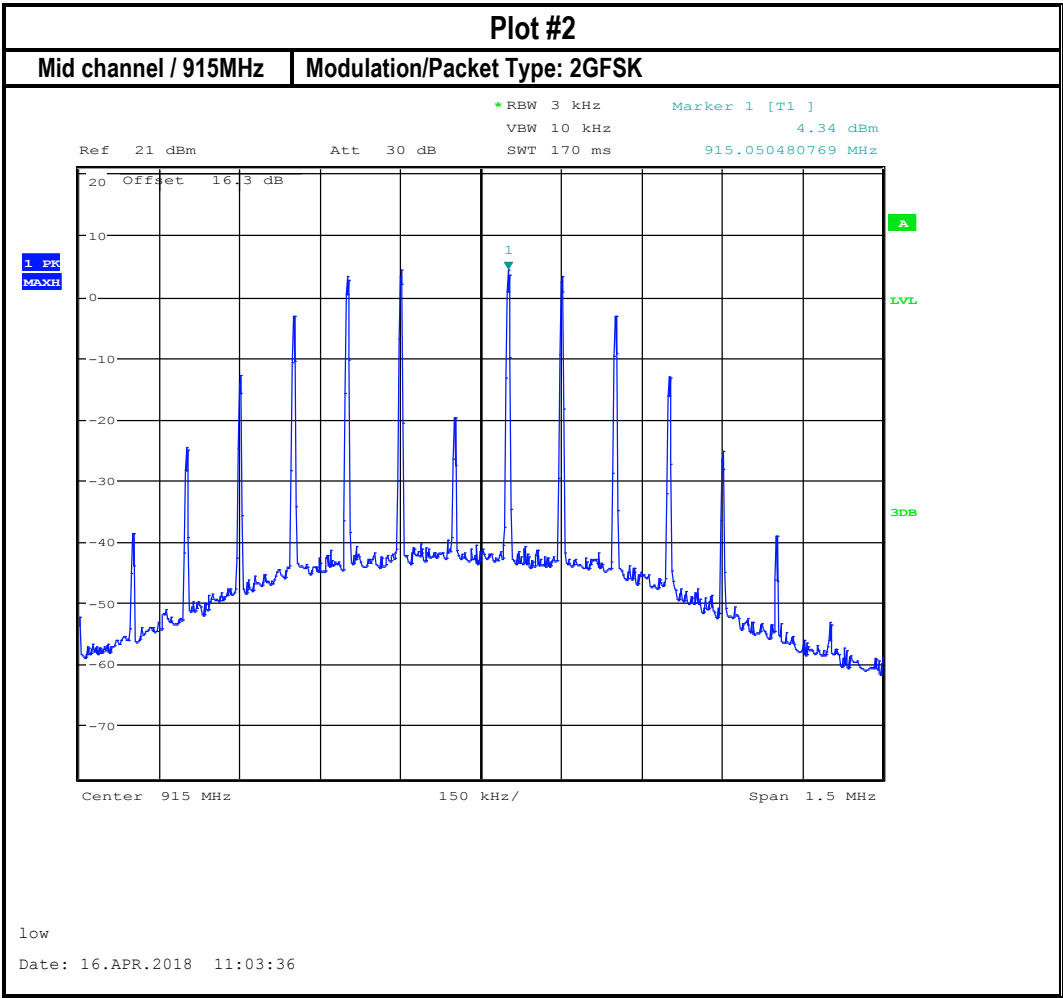
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	1	2GFSK continuous fixed channel	6.3 VDC max, nominal 6 VDC, Low 5 VDC	3.0 dBi

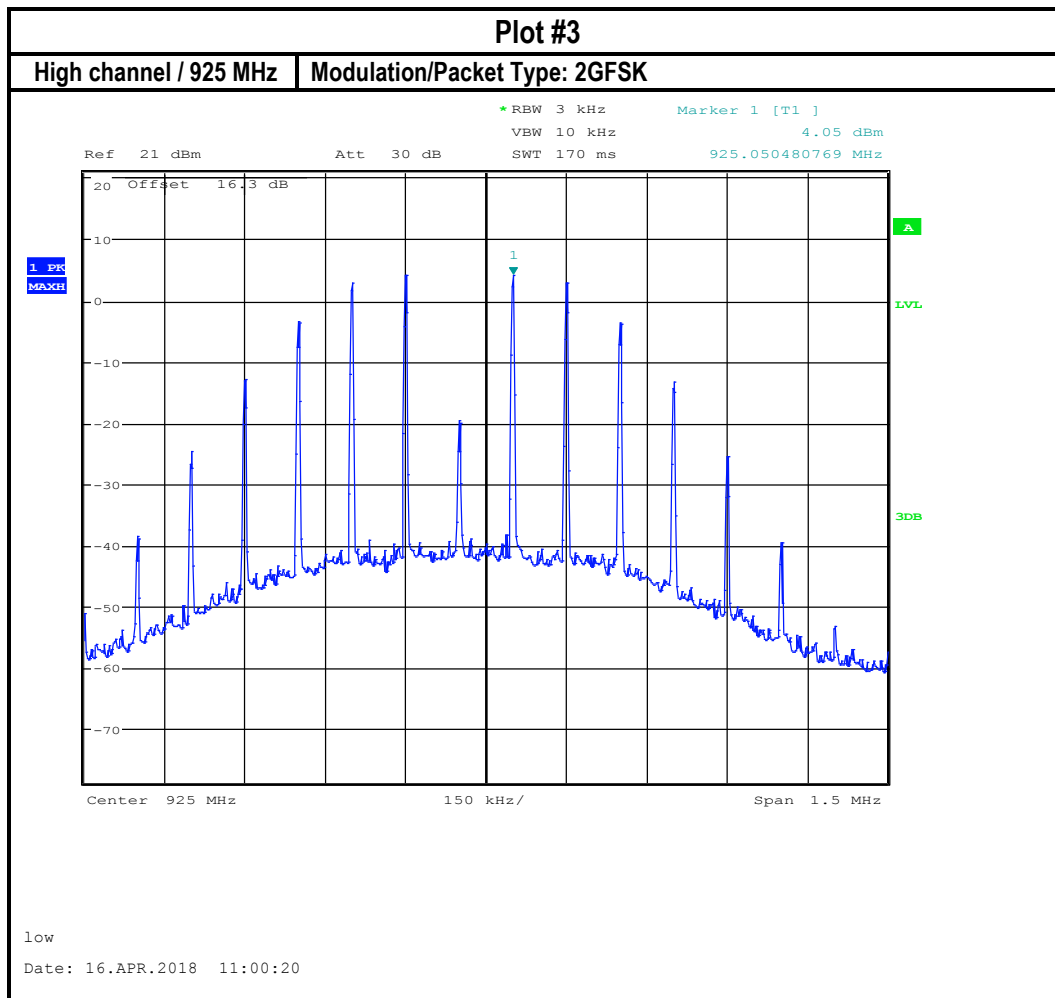
7.2.4 Measurement result:

Plot #	Frequency (MHz)	Maximum Power Spectral Density (dBm/3 kHz)	Limit (dBm / 3 kHz)	Result
1	905	4.86	8	PASS
2	915	4.34	8	PASS
3	925	4.05	8	PASS

7.2.5 Measurement Plots:







7.3 Band Edge Compliance

7.3.1 Measurement according to FCC 558074 D01 DTS Measurement Guidance v04

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

7.3.2 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)).

RSS-247 5/5

- 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

7.3.3 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:

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			

7.3.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	1	2 GFSK continuous fixed channel	5 VDC	3.0 dBi

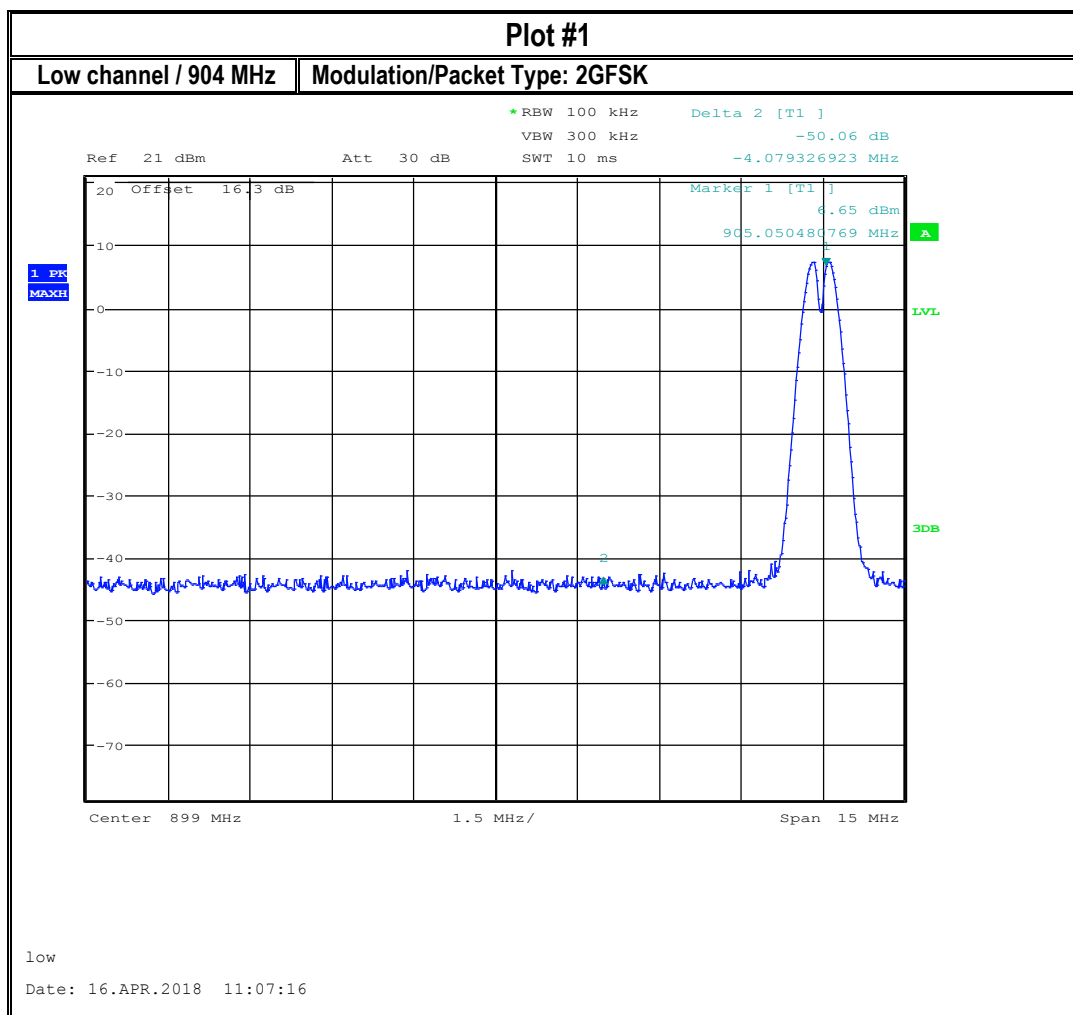
7.3.5 Measurement result:

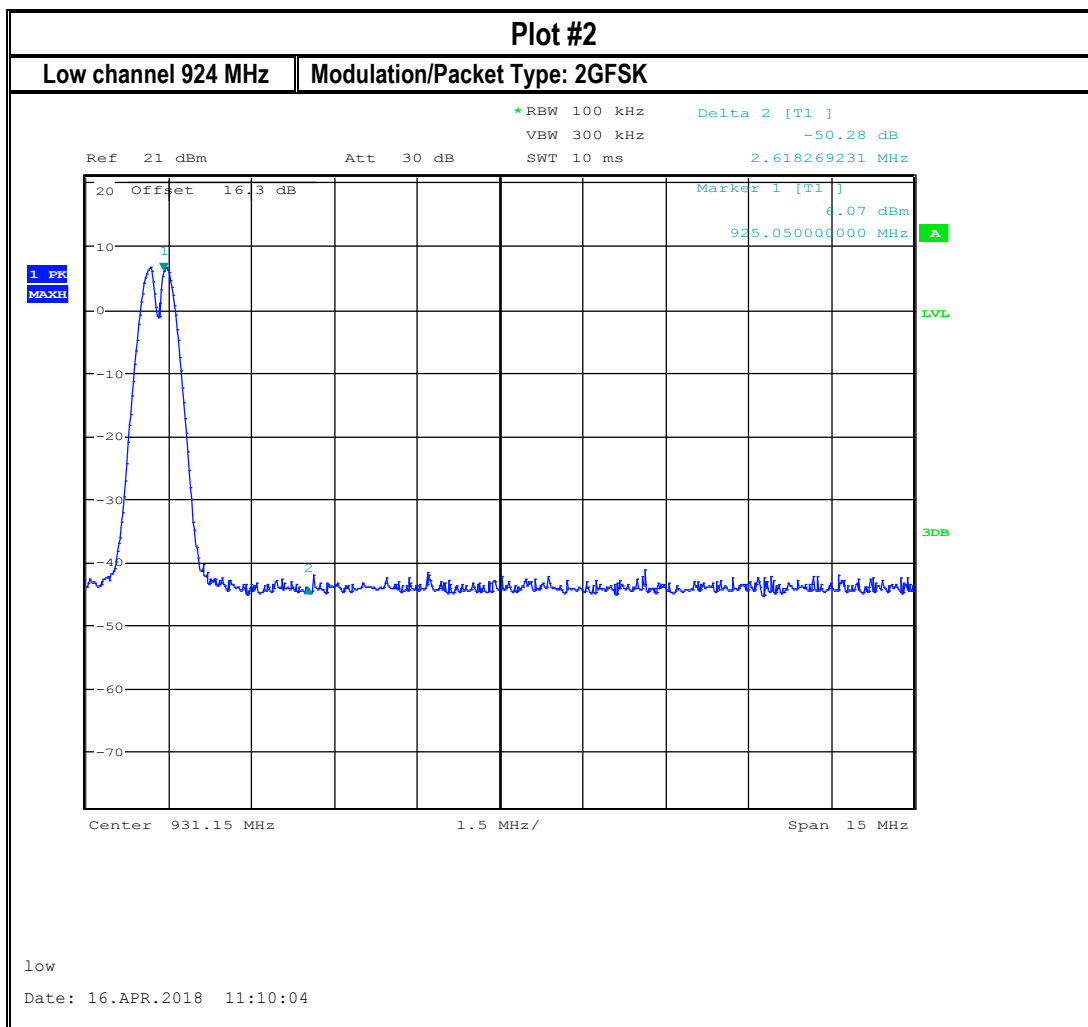
Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	2 GFSK continuous fixed channel	Lower, Non-restricted	-50.06	20	Pass

Plot #	EUT operating mode	Band Edge	Measured Peak Value (dBm)	Corrected by duty cycle	Corrected by Antenna Gain (dBm)	Limit (dBm)	Result
2	2 GFSK continuous fixed channel	Upper Restricted peak	-50.28	NA due to peak detector, 100%DC and max hold	-53.28	-21.23 Peak -41.23 AVG	Pass

Note: The peak measurement passes both peak and average limits.

7.3.6 Measurement Plots:





7.4 Emission Bandwidth 6dB and 99% Occupied Bandwidth

7.4.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

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.

7.4.2 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.

7.4.3 Test conditions and setup:

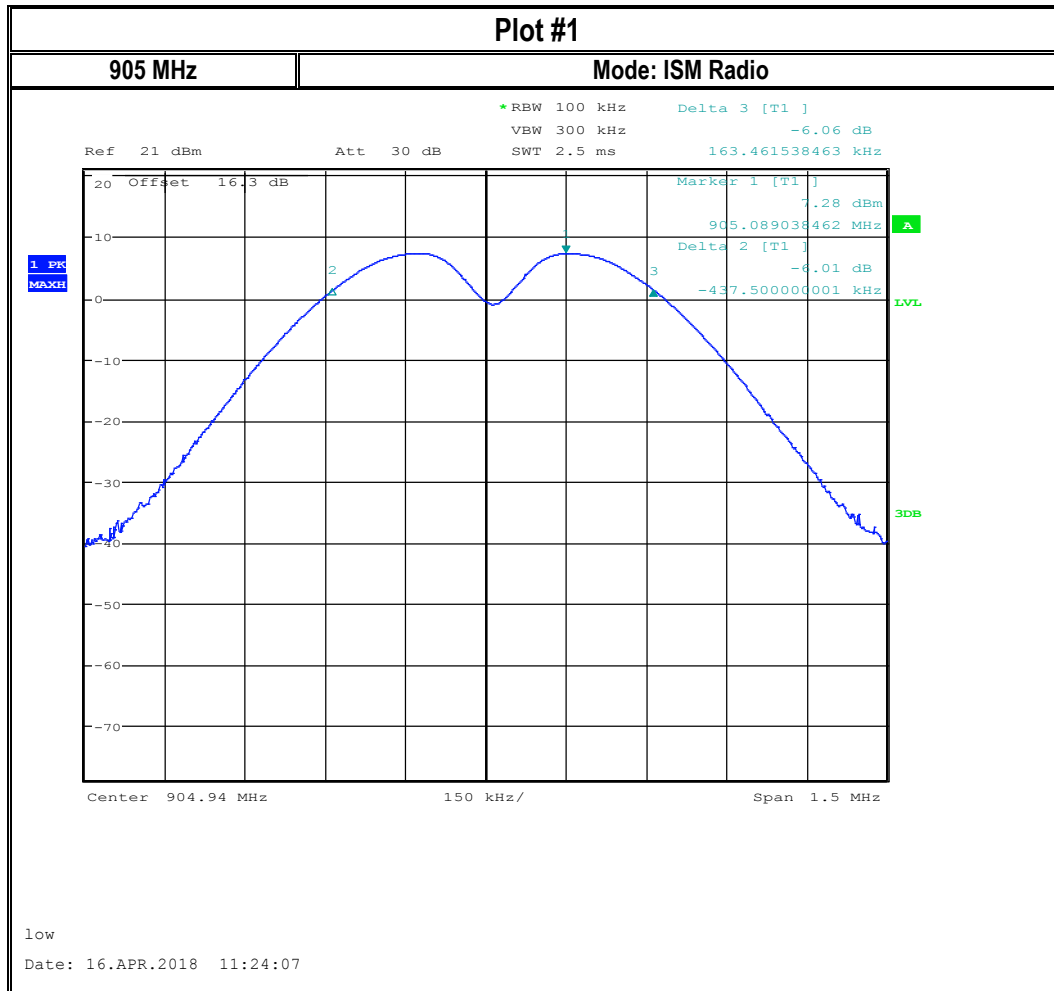
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power or Voltage Input
22° C	2	ISM Radio	6.3 VDC max, nominal 6 VDC, Low 5 VDC

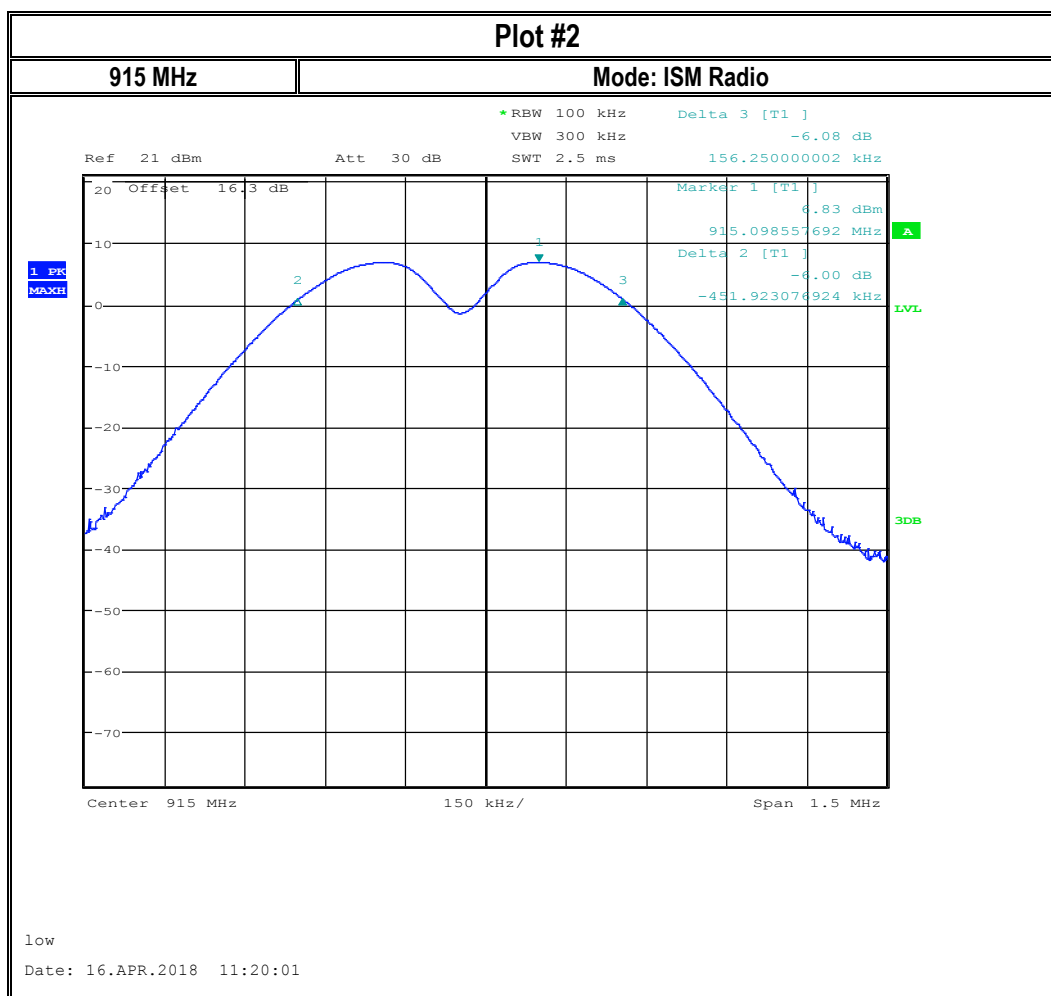
7.4.4 Measurement result:

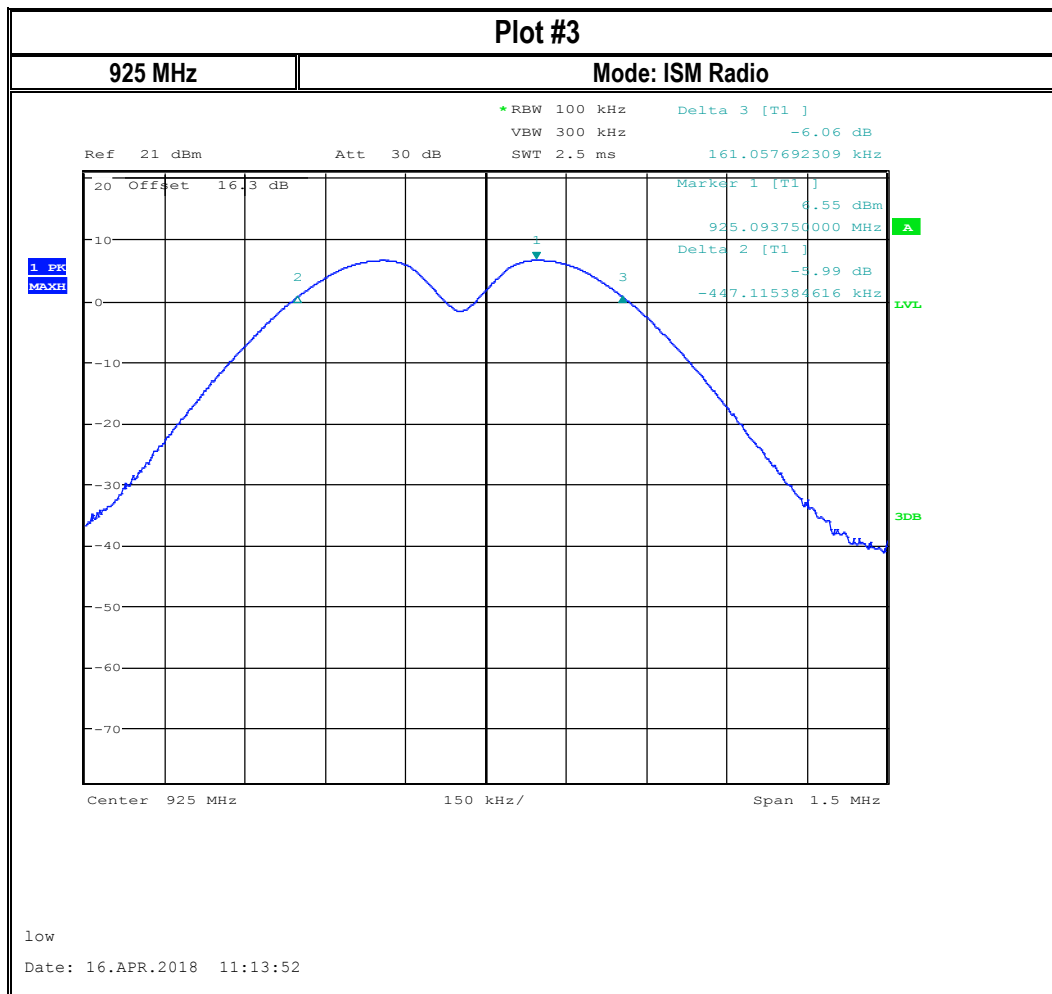
Plot #	Frequency (MHz)	6dB Emissions Bandwidth (MHz)	Limit (MHz)	Result
1	905	0.601	> 0.5	PASS
2	915	0.608	> 0.5	PASS
3	925	0.608	> 0.5	PASS

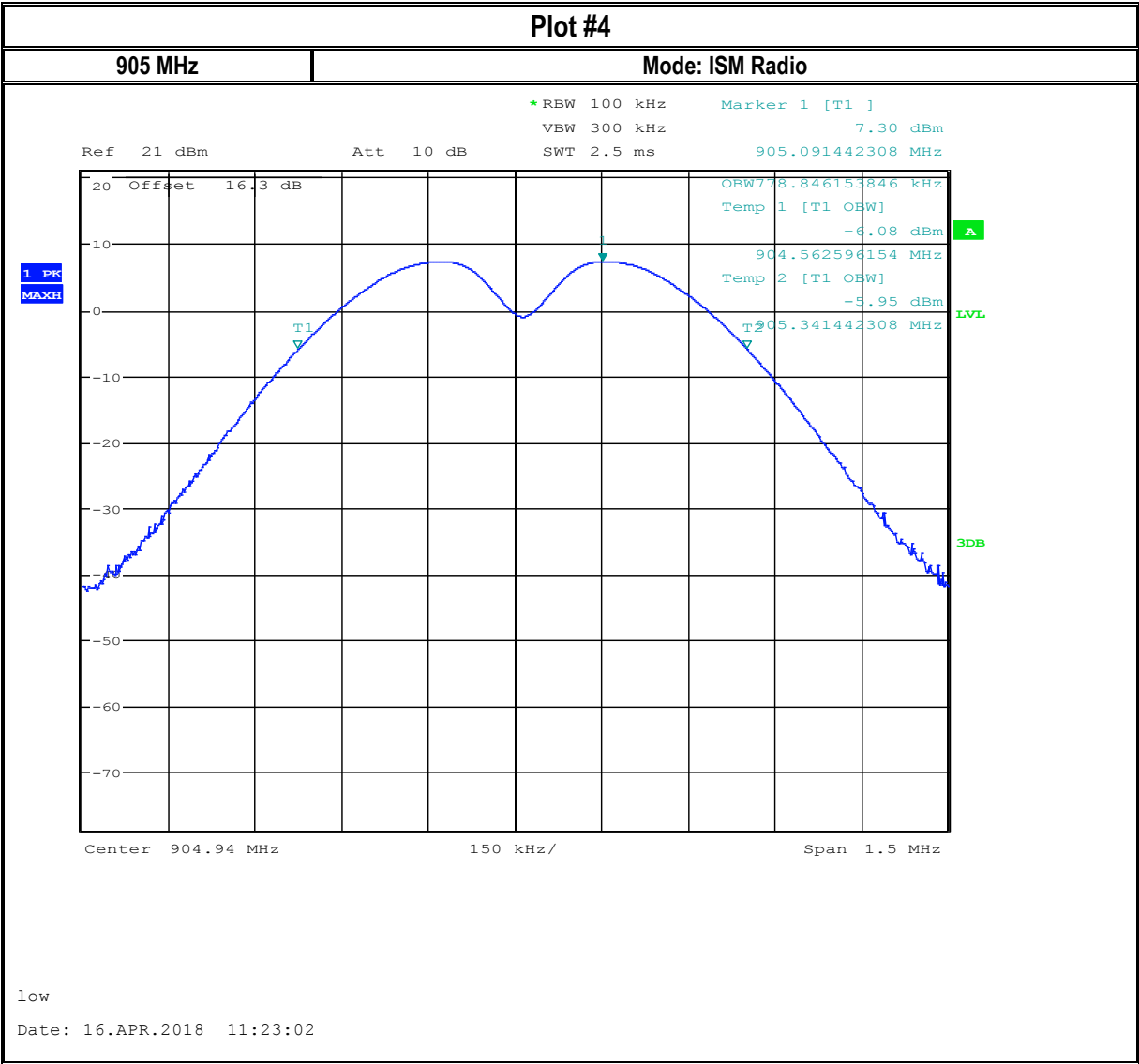
Plot #	Frequency (MHz)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Result
4	905	0.778	> 0.5	PASS
5	915	0.783	> 0.5	PASS
6	925	0.788	> 0.5	PASS

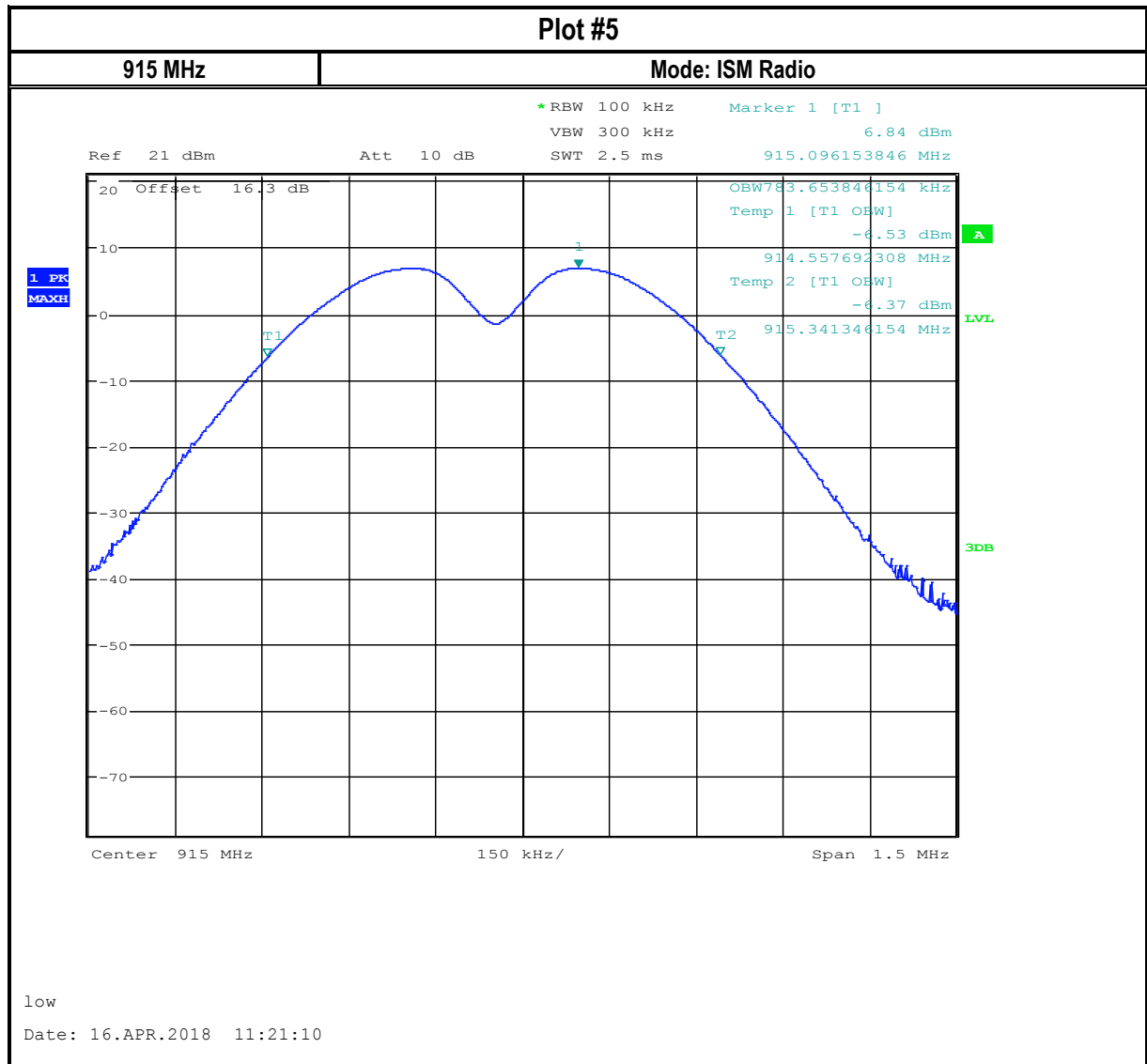
7.4.5 Measurement Plots:

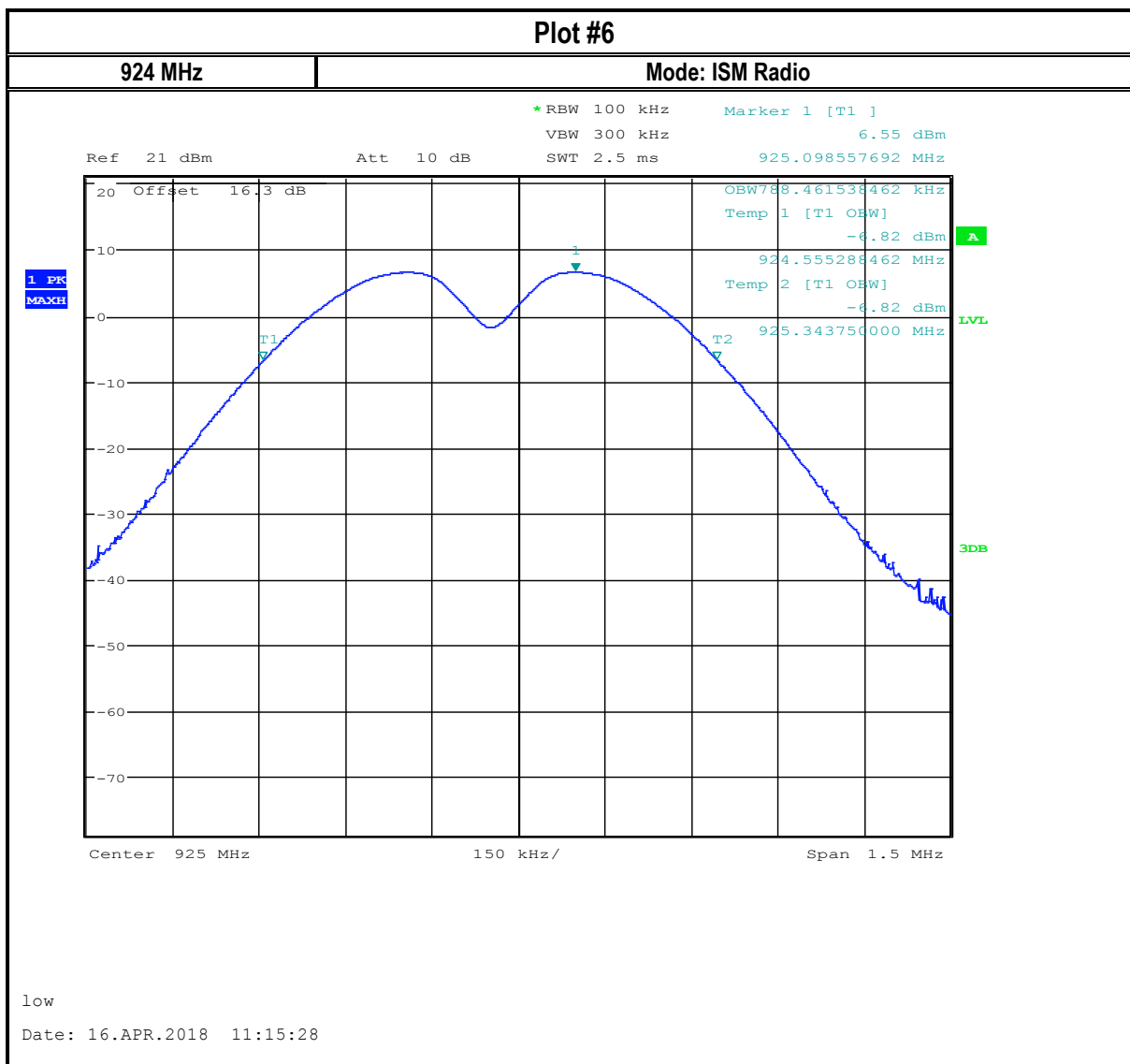












7.5 Radiated Transmitter Spurious Emissions and Restricted Bands

7.5.1 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) = $40 \log (D/d) = 40 \log (300\text{m} / 3\text{m}) = 80\text{dB}$

7.5.2 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

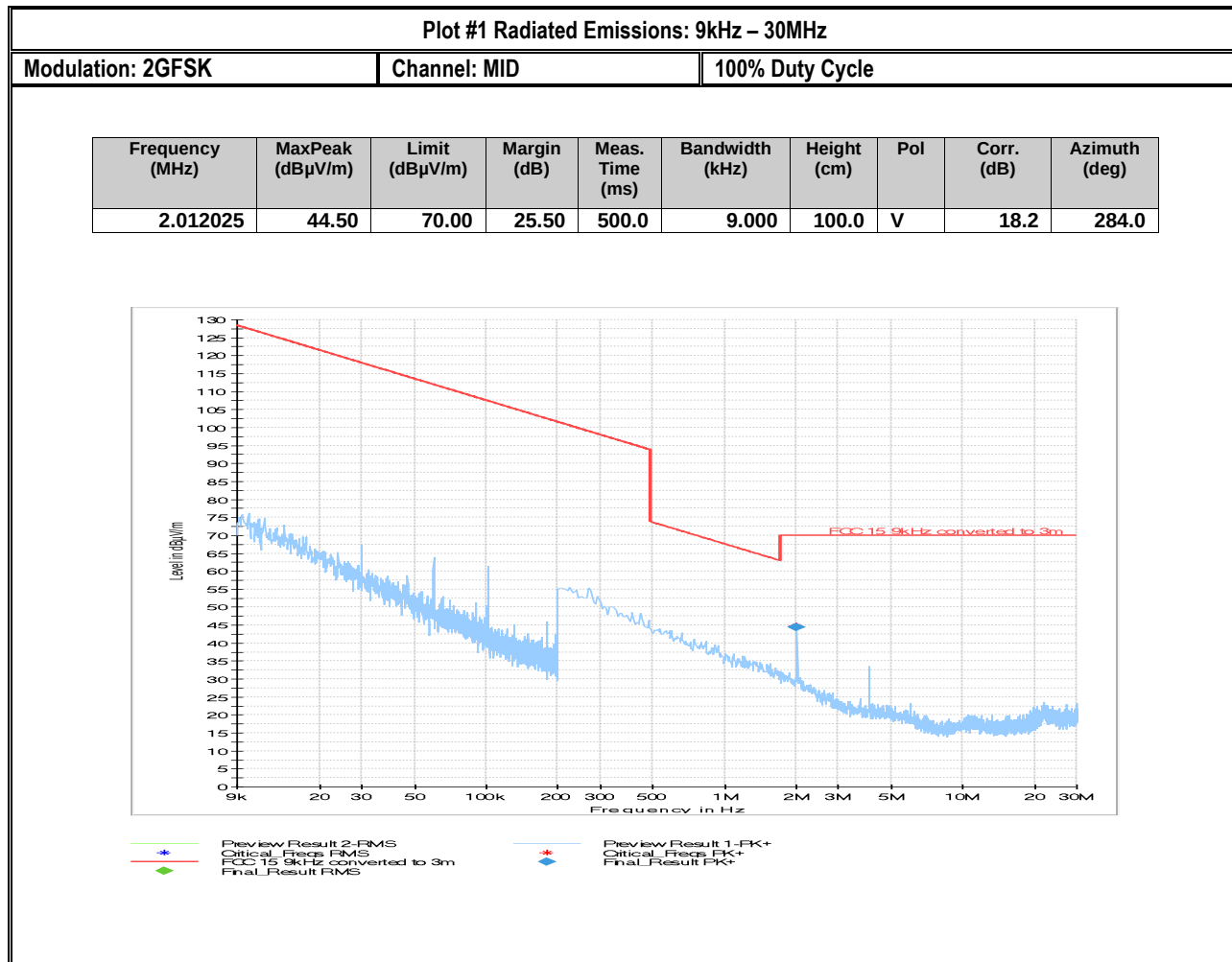
7.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	2 GFSK continuous fixed channel	6.3 VDC max, nominal 6 VDC, Low 5 VDC

7.5.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 7.5.2	Pass
4-8	Mid	30 MHz – 18 GHz	See section 7.5.2	Pass
9-12	High	30 MHz – 18 GHz	See section 7.5.2	Pass

7.5.5 Measurement Plots:



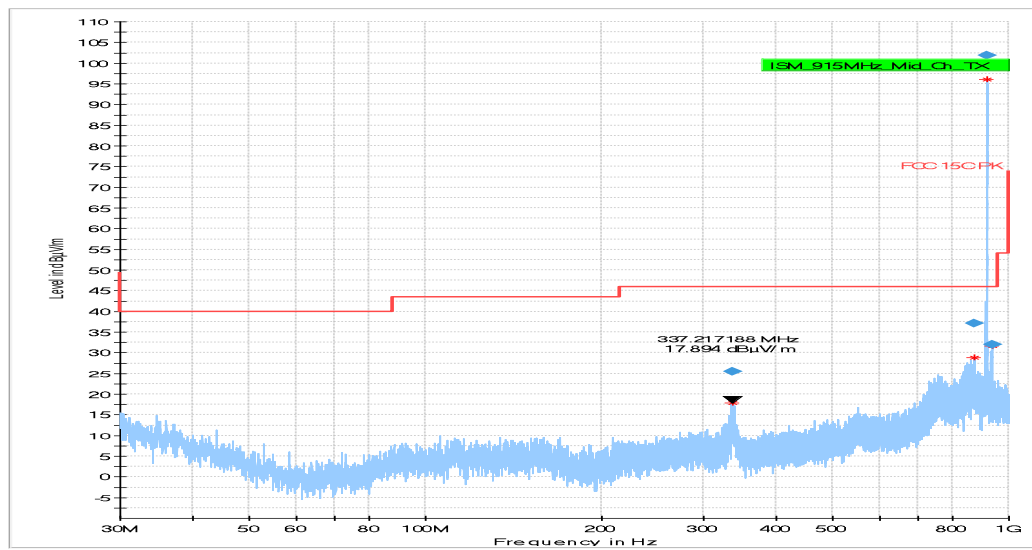
Plot #2 Radiated Emissions: 30MHz – 1000MHz

Modulation: 2GFSK

Channel: MID

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
337.210651	25.40	46.00	20.60	100.0	120.000	100.0	H	-16.6	90.0
875.158191	37.17	46.00	8.83	100.0	120.000	100.0	V	-.63	0.0
915.051422	101.97	46.00	-55.97	100.0	120.000	129.0	H	-6.0	194.0
934.187975	31.97	46.00	14.03	100.0	120.000	100.0	V	-5.4	13.0



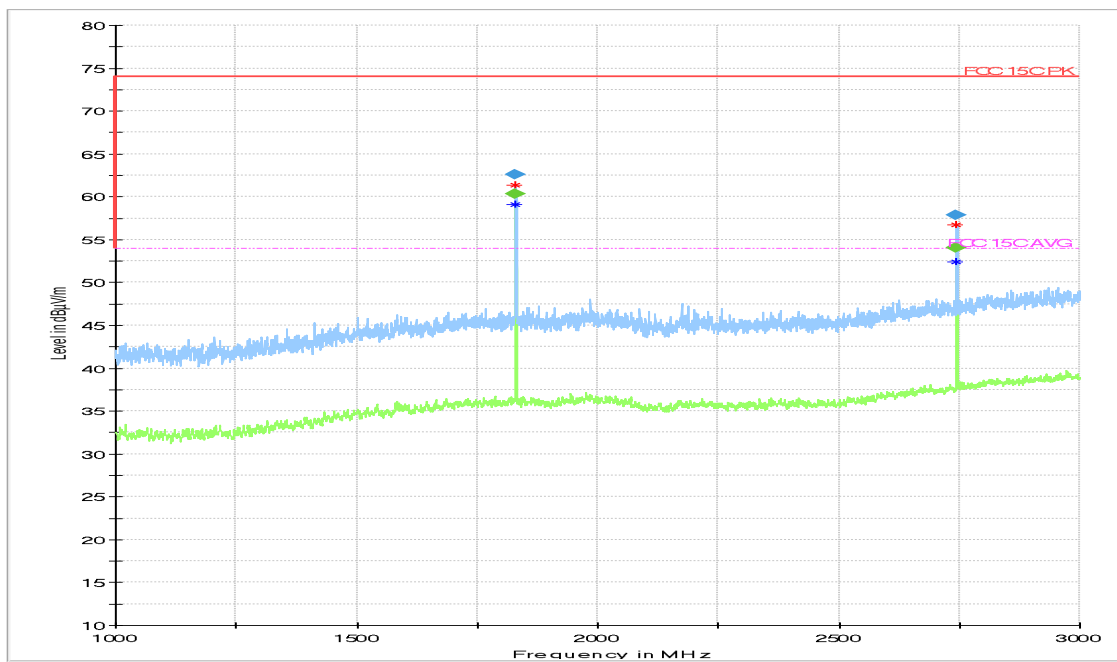
Plot # 3 Radiated Emissions: 1 GHz – 3 GHz

Modulation: 2GFSK

Channel: MID

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
1829.975000	---	60.35	53.98	-6.37	10.0	1000.00	122.0	H	8.5	-4.0
1830.100000	62.63	---	74.00	11.37	10.0	1000.00	127.0	H	8.5	-12.0
2744.290000	57.88	---	73.99	16.11	10.0	1000.00	100.0	H	9.5	336.0
2744.800000	---	54.01	53.98	-0.03	10.0	1000.00	100.0	H	9.6	-28.0



◆ Preview Result 2-RMS
◆ Critical_Freqs PK+
◆ Final Result PK+

◆ Preview Result 1-PK+
◆ FCC 15C PK
◆ Final Result RMS

◆ Critical_Freqs RMS
◆ FCC 15C AVG

Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

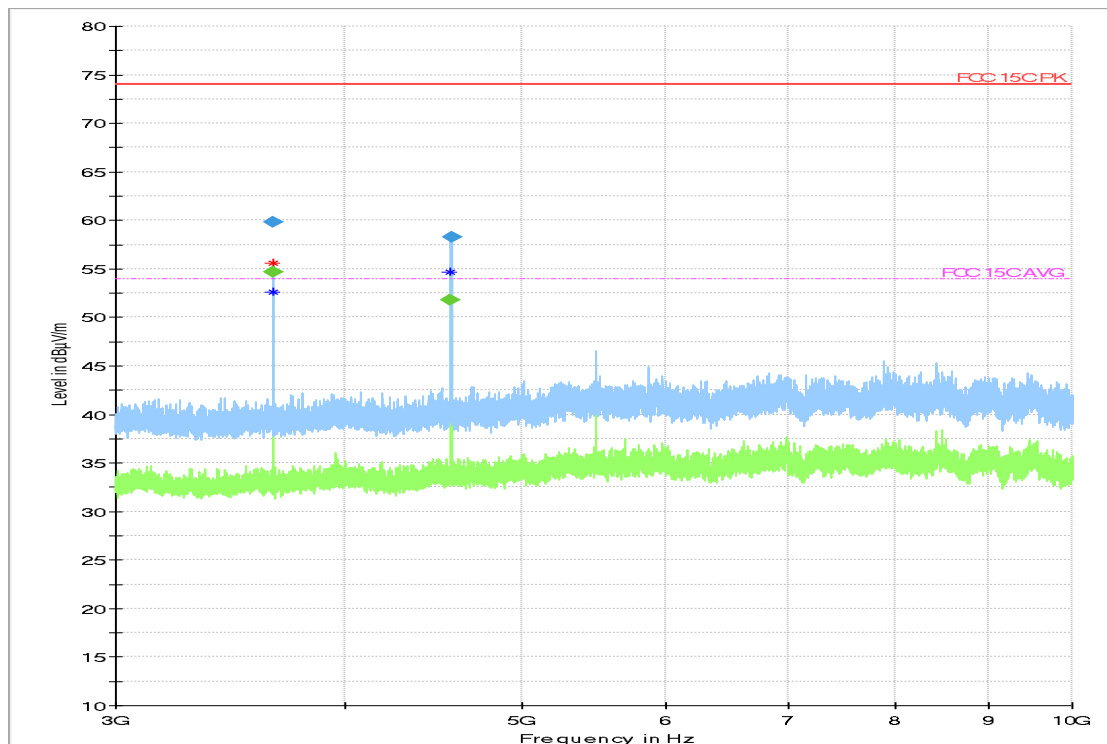
Plot # 4 Radiated Emissions: 3 GHz – 10 GHz

Modulation: 2GFSK

Channel: MID

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
3659.214300	---	54.63	53.9	-0.65	200.0	1000.000	227.0	V	-35.5	252.0
3659.968467	59.81	-----	73.9	14.18	200.0	1000.000	234.0	V	-35.5	255.0
4575.567300	--	51.79	53.9	2.18	200.0	1000.000	118.0	V	-34.0	262.0
4575.880000	58.33	-----	73.9	15.66	200.0	1000.000	146.0	V	-34.0	258.0



◆ Preview Result 2-RMS
◆ Preview Result 1-FK+
◆ Critical_Freqs PK+
◆ Final_Result PK+
◆ FCC 15C PK
◆ Final_Result RMS
◆ Critical_Freqs RMS
◆ FCC 15C AVG

Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

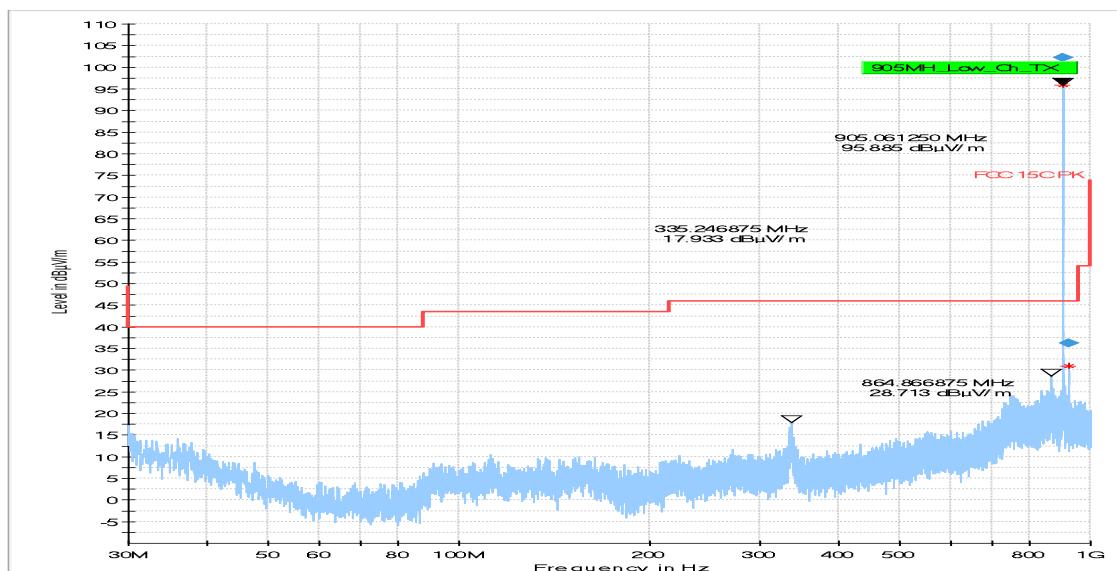
Plot #5 Radiated Emissions: 30 MHz – 1 GHz

Modulation: 2GFSK

Channel: LOW

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
905.051776	102.31	46.00	-56.31	100.0	120.000	133.0	H	-6.4	93.0
923.783099	36.18	46.00	9.82	100.0	120.000	129.0	H	-5.8	102.0



* Preview Result 2-RMS
* Critical_Freqs PK+
* Final_Result RMS

— Preview Result 1-PK+
— FCC 15C PK

* Critical_Freqs RMS
* Final_Result PK+

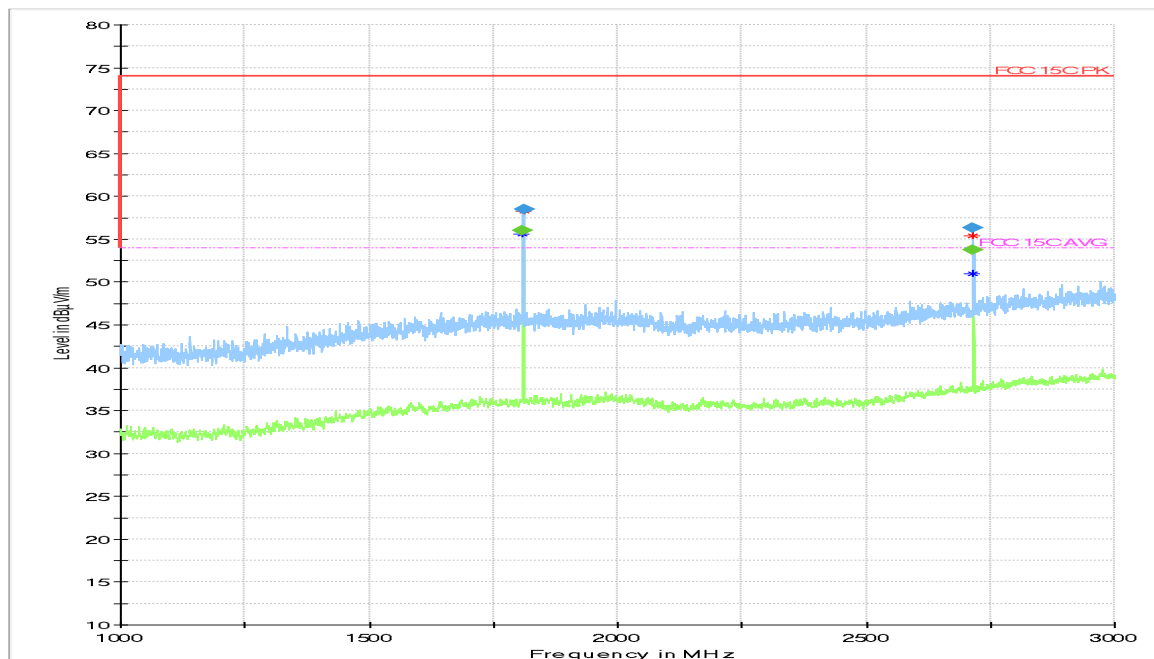
Plot # 6 Radiated Emissions: 1 GHz – 3 GHz

Modulation: 2GFSK

Channel: LOW

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
1809.94000	---	56.04	53.98	-2.06	10.0	1000.000	145.0	V	8.3	109.0
1810.33000	58.49	---	74.00	15.50	10.0	1000.000	145.0	V	8.3	122.0
2714.90500	---	53.76	53.98	0.22	10.0	1000.000	100.0	H	9.4	184.0
2715.34500	56.31	---	73.99	17.68	10.0	1000.000	188.0	V	9.4	340.0



◆ Preview Result 2-RMS
◆ Optical_Freqs PK+
◆ Final_Result PK+

◆ Preview Result 1-PK+
◆ FCC 15C PK
◆ Final_Result RMS

◆ Optical_Freqs RMS
◆ FCC 15C AVG

Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

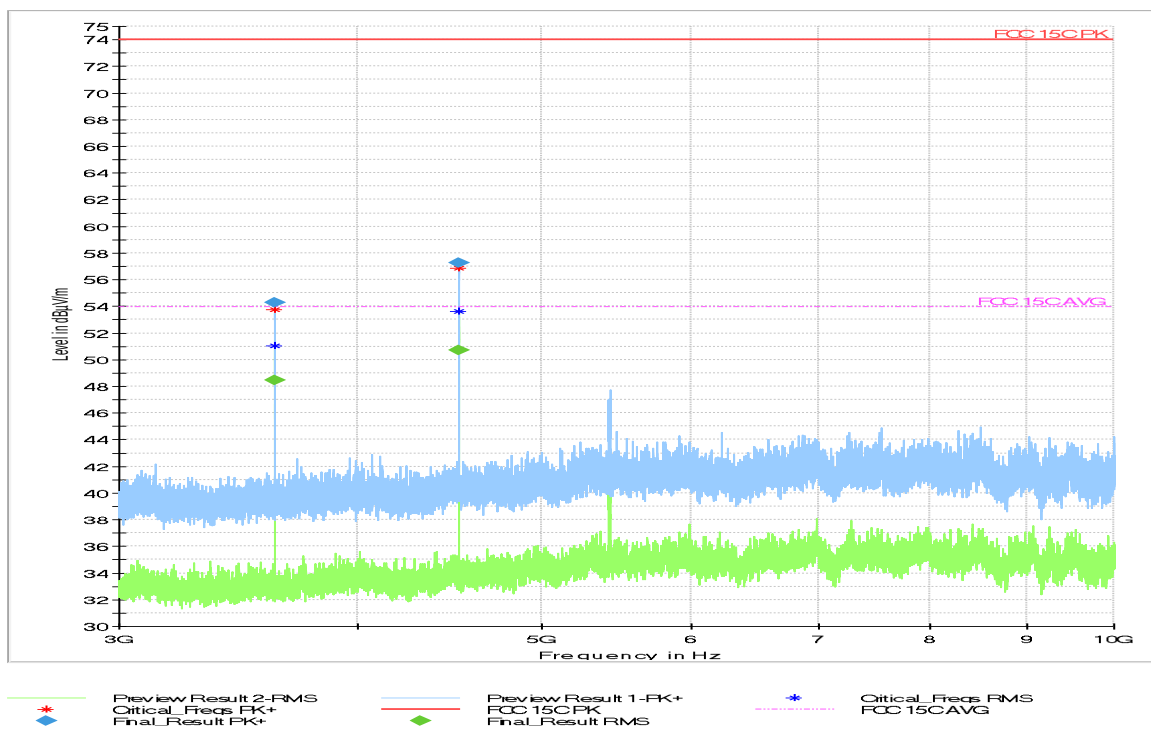
Plot # 7 Radiated Emissions: 3 GHz – 10 GHz

Modulation: 2GFSK

Channel: LOW

100% Duty Cycle

Frequency (MHz)		RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
3619.190500	---	48.44	53.98	5.54	200.0	1000.000	206.0	H	-35.5	45.0
3620.245367	54.30	---	73.99	19.70	200.0	1000.000	204.0	H	-35.5	46.0
4525.667333	---	50.71	53.98	3.27	200.0	1000.000	142.0	V	-33.8	85.0
4525.890100	57.26	---	73.99	16.73	200.0	1000.000	126.0	V	-33.8	99.0



Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

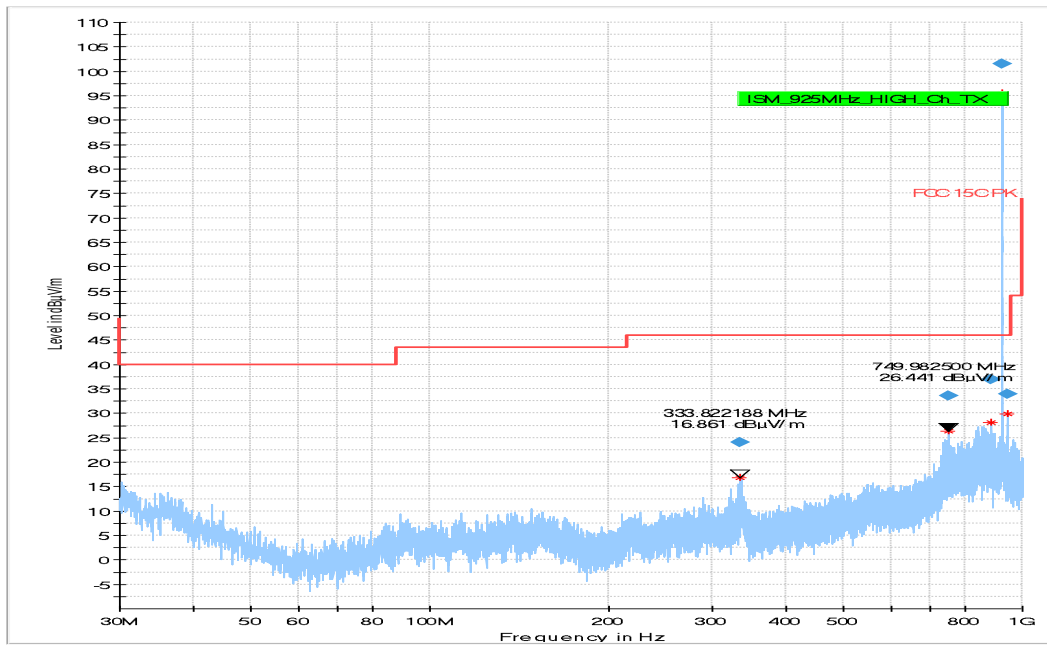
Plot # 8 Radiated Emissions: 30 MHz – 1000 MHz

Modulation: 2GFSK

Channel: HIGH

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
333.830606	24.12	46.00	21.88	100.0	120.000	100.0	H	-16.6	268.0
749.972847	33.66	46.00	12.34	100.0	120.000	217.0	H	-7.8	154.0
884.746392	36.99	46.00	9.01	100.0	120.000	250.0	V	-6.3	279.0
925.052766	101.52	46.00	-55.52	100.0	120.000	131.0	H	-5.7	105.0
944.194940	34.01	46.00	11.99	100.0	120.000	131.0	H	-5.4	100.0



* Preview Result 2-RMS
◆ Critical_Freqs PK+
◆ Final_Result RMS

— Preview Result 1-PK+
— FCC 15C PK

* Critical_Freqs RMS
◆ Final_Result PK+

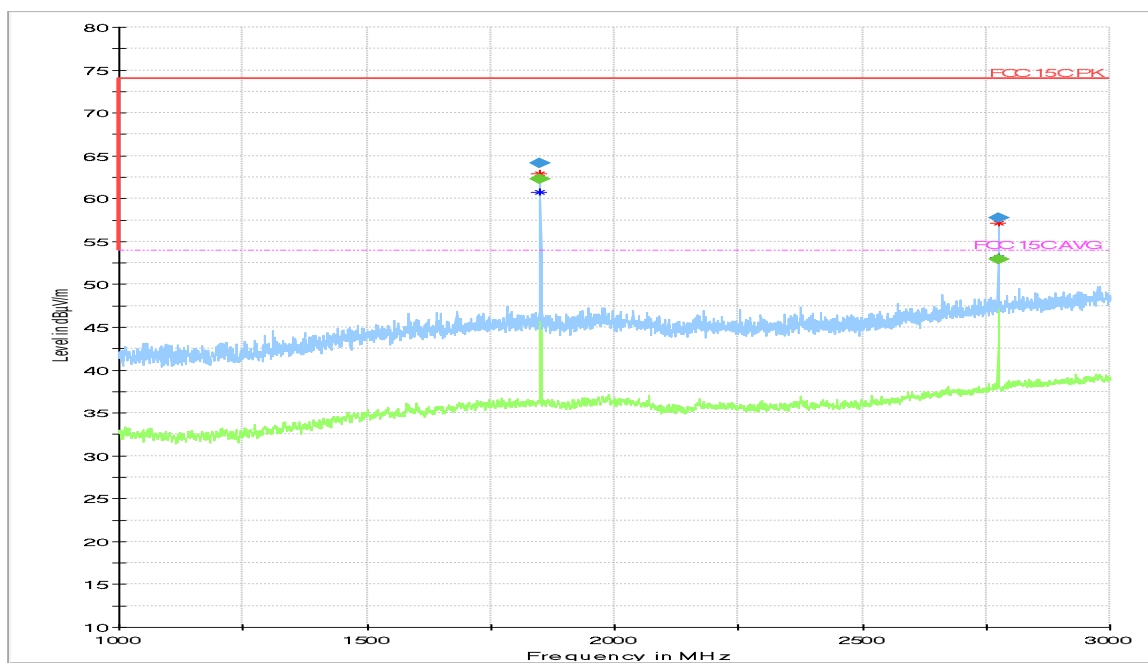
Plot # 9 Radiated Emissions: 1 GHz – 3 GHz

Modulation: 2GFSK

Channel: HIGH

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
1849.88000	---	62.27	53.98	-8.29	10.0	1000.000	100.0	H	8.7	63.0
1850.28000	64.18	---	74.00	9.81	10.0	1000.000	121.0	H	8.7	73.0
2774.36000	57.72	---	73.99	16.27	10.0	1000.000	206.0	V	10.0	69.0
2774.60500	---	52.90	53.98	1.08	10.0	1000.000	200.0	V	10.0	76.0



* Preview Result 2-RMS
* Optcal_Freqs PK+
* Final_Result PK+

Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

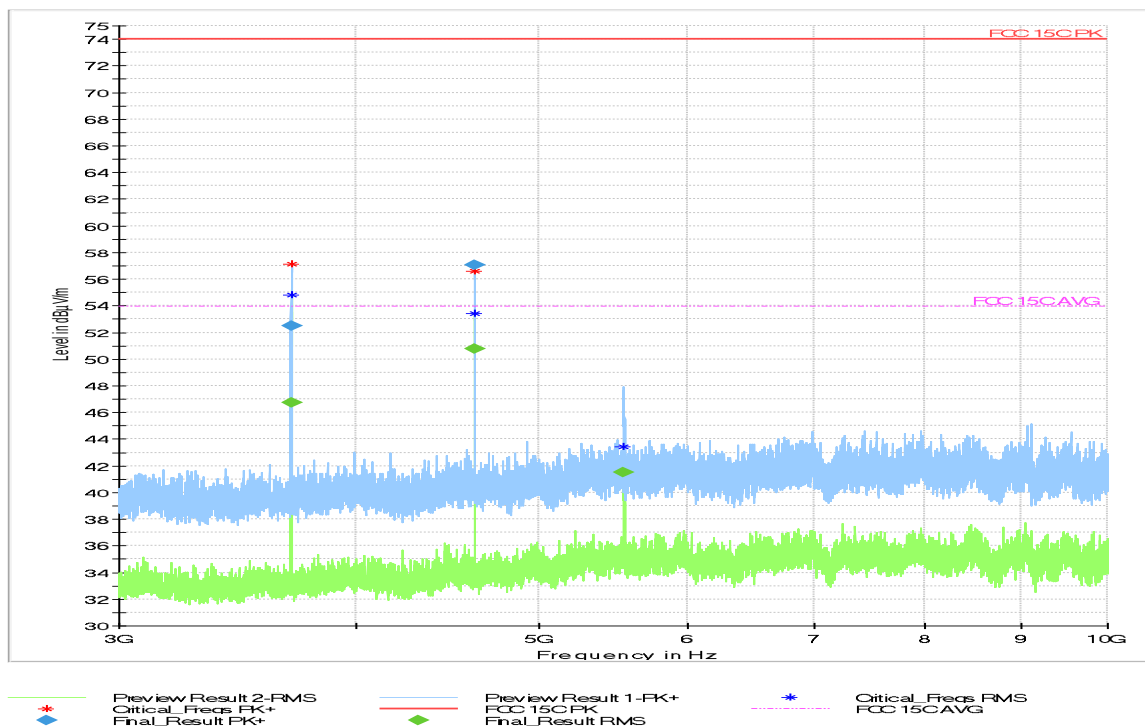
Plot # 10 Radiated Emissions: 3 GHz – 10 GHz

Modulation: 2GFSK

Channel: HIGH

100% Duty Cycle

Frequency (MHz)	MaxPeak (dBμV/)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Corr. (dB)	Azimuth (deg)
3699.193500	---	46.74	53.98	7.24	200.0	1000.000	125.0	H	-35.5	-34.0
3699.499334	52.49	---	73.99	21.50	200.0	1000.000	125.0	H	-35.5	-40.0
4623.513066	57.06	---	73.99	16.93	200.0	1000.000	148.0	V	-33.8	91.0
4625.470467	---	50.77	53.98	3.21	200.0	1000.000	108.0	V	-33.8	97.0
5548.532800	---	41.50	53.98	12.48	200.0	1000.000	108.0	V	-31.4	82.0



Note: These harmonics are not in the restricted bands and these are below ≥ 20 dBc

7.6 AC Power Line Conducted Emissions

7.6.1 Measurement according to ANSI C63.10 (2013)

Analyzer Settings:

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

7.6.2 Limits: §15.207 & RSS-Gen 8.8

FCC §15.207(a) & RSS-Gen 8.8

- 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.

7.6.3 Test conditions and setup:

Ambient Temperature °C	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22	1 and 2	BT LE continuous fixed channel	Line & Neutral	110V / 60Hz

7.6.4 Measurement Result:

Plot #	Port	EUT Set-Up #:	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	1	continuous fixed channel	150 kHz – 30 MHz	See section 7.6.2	NA
2	AC Mains	1	continuous fixed channel	150 kHz – 30 MHz	See section 7.6.2	NA

NOTE: NA -> means not applicable

8 Test setup photos

Setup photos are included in supporting file name: "EMC_TELUL-072-17001_15.247_Setup_Photos.pdf"

9 Test Equipment And Ancillaries Used For Testing

Item Name	Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Antenna Biconilog 3142E	Biconlog Antenna	EMCO	3142E	166067	3 years	6/27/2017
Magnetic Loop Antenna	Loop Antenna	ETS Lindgren	6512	164698	3 years	7/28/2017
Antenna Horn 3115 SN 35111	Horn Antenna	EMCO	3115	35111	3 years	7/24/2015
Antenna Horn 3116	Horn Antenna	ETS Lindgren	3116	70497	3 years	7/22/2015
Antenna Horn CBL6141B	Horn Antenna	Teseq	CBL6141B	41106	3 years	11/01/2017
Digital Radio Comm. Tester	Wideband radio communication receiver	R&S	CMW500	127068	2 years	07/01/2017
Digital Barometer	Compact Digital Barometer	Control Company	35519-055	91119547	2 Years	6/8/2017
FSU26	Spectrum Analyzer	R&S	FSU26	200065	3 years	7/3/2017
LISN	Line Impedance Stabilization Network	FCC	FCC-LISN-50-25-2-08	8014	2 Year	11/10/2016
Thermometer Humidity TM320	Thermometer Humidity	Dickson	TM320	52800633	1 Year	11/2/2017

Note:

1. 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.

10 Revision History

Date	Report Name	Changes to report	Report prepared by
2018-04-16	EMC_TELUL-072-17001_15.247_ISM_DTS_draft	Draft	Chaman Bhardwaj
2018-05-22	EMC_TELUL-072-17001_15.247_ISM_DTS	Initial Release. Updated dates and signature field and RSS-247 reference on cover page	Kevin Wang
2018-07-03	EMC_TELUL-072-17001_15.247_ISM_DTS_Rev1	Update EUT Model number, HW version, SW version, FCC ID and IC ID	Kevin Wang