



FCC / ISED Test Report

FOR:
Badger Meter

Model Name:
ORION Cellular INTL

Product Description:

This product reads connected water meters and transmits the readings over the cellular network.
There is a 915 MHz ISM band proprietary XCVR

FCC ID: GIF2017OCEV5INTL
IC ID: 1046A-OCEV5INTL

Applied Rules and Standards:
47 CFR Part 15.247 (DSS)
RSS-247 Issue 2 (FHSs) & RSS-Gen Issue 4

REPORT #: EMC_BADGE_010_17001_15.247_DSS

DATE: 03/08/2018



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	7
4	SUBJECT OF INVESTIGATION	8
5	MEASUREMENT RESULTS SUMMARY	8
6	MEASUREMENTS	9
6.1	MEASUREMENT UNCERTAINTY	9
6.2	ENVIRONMENTAL CONDITIONS DURING TESTING	9
6.3	DATES OF TESTING	9
7	MEASUREMENT PROCEDURES	10
7.1	RADIATED MEASUREMENT	10
7.2	RF CONDUCTED MEASUREMENT PROCEDURE	12
8	TEST RESULT DATA	13
8.1	MAXIMUM PEAK CONDUCTED OUTPUT POWER	13
8.2	BAND EDGE COMPLIANCE	18
8.3	20DB BANDWIDTH	25
8.4	CARRIER FREQUENCY SEPARATION	27
8.5	NUMBER OF HOPPING CHANNELS	29
8.6	TIME OF OCCUPANCY (DWEIL TIME)	31
8.7	TRANSMITTER SPURIOUS EMISSIONS AND RESTRICTED BANDS	34
9	TEST SETUP PHOTOS	46
10	TEST EQUIPMENT AND ANCILLARIES USED FOR TESTING	46
11	REVISION HISTORY	46

1 Assessment

The following device as further described in section 3 of this report 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.

No deviations were ascertained.

Responsible for Testing Laboratory:

03/08/2018	Compliance	James Donnellan (Lab Manager)	
Date	Section	Name	Signature

Responsible for the Report:

03/08/2018	Compliance	Issa Ghanma (EMC 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
Lab Manager:	James Donnellan
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Applicant's Name:	Badger Meter
Street Address:	4545 W. Brown Deer Road
City/Zip Code	Milwaukee, WI 53223
Country	USA
Contact Person:	Randy Schultz
Phone No.	(414) 371-5941
e-mail:	rschultz@badgermeter.com

2.3 Identification of the Manufacturer

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

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	68305
FCC-ID :	GIF2017OCEV5INTL
IC-ID:	1046A-OCEV5INTL
HVIN:	ORION Cellular INTL
PMN:	ORION Cellular INTL
Product Description:	This product reads connected water meters and transmits the readings over the cellular network. There is a 915 MHz ISM band proprietary XCVR.
Frequency Range / number of channels:	Nominal band: 902 MHz – 928MHz Center to center: 904.93 MHz (ch 1) – 923.75 MHz (ch 48), 48 Channels
Type(s) of Modulation:	GFSK
Modes of Operation:	Hopping
Antenna Information as declared:	-SR4L002. No MIMO capability. -Antenna type: Chip -Antenna gain824 – 960 MHz: Peak: 1.00 dBi Average (Linear): -1.5 dBi
Max. measured output Powers:	8.55 dBm
Power Supply/ Rated Operating Voltage Range:	Low: 2.8V / Nominal: 3.6V / High: 3.66V DC
Operating Temperature Range	Low: -20 °C / Nominal: 20 °C / High:40 °C
Other Radios included in the device:	Cellular: Manufacturer: Telite Model: HE910-D FCC ID: RI7HE910 / IC: 5131A-HE910
Sample Revision	<input type="checkbox"/> Prototype Unit; <input checked="" type="checkbox"/> Production Unit; <input type="checkbox"/> Pre-Production
EUT Dimensions	130 X 75 X 60 mm
Weight	383 grams
EUT Diameter	<input type="checkbox"/> < 60 cm <input type="checkbox"/> Other _____

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	94	7	1.5.584	Conducted measurement
2	307	7	1.5.584	Radiated measurement

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	-----	-----	-----	-----

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	The radio of the EUT was configured to a fixed channel using Serial Console tool provided by the client to configure the EUT. The measurement equipment was connected to the 50 ohm RF port of the EUT.
2	EUT#2	The radio of the EUT was configured to a fixed channel using Serial Console tool provided by the client to configure the EUT.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets in test mode on low, mid and high channels, and 100% duty cycle and maximum 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.

For conducted measurements, the highest power and the widest occupied bandwidth mode of operation (GFSK), was used to evaluate the worst case performance of the EUT, including the band edge compliance and TX radiated spurious emissions testing. Maximum peak conducted output power and spectrum bandwidth, were measured in all supported modulation modes for 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 Issue 2 of ISSED Canada.

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

- FCC ID: GIF2017OCEV5INTL
- IC ID: 1046A-OCEV5INTL

Testing procedures are based on ANSI C63.10:2013 including section 7.8 for FHSS systems.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(b)(2) RSS-247 5.1(c)	Maximum Peak Conducted Output Power	Nominal	GFSK	■	□	□	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	GFSK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Spectrum Bandwidth	Nominal	GFSK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(b)	Carrier Frequency Separation	Nominal	GFSK	■	□	□	Complies
§15.247(a)(1) RSS-247 5.1(c)	Number of Hopping Channels	Nominal	GFSK	■	□	□	Complies
§15.247(a)(1)(iii) RSS-247 5.1(c)	Time of occupancy	Nominal	GFSK	■	□	□	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	GFSK	■	□	□	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	-	□	■	□	Note1 Note2 Complies

Note1: NA= Not Applicable; NP= Not Performed.

Note2: The unit does not connect to AC main power.

6 Measurements

6.1 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 30MHz	±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

RF conducted measurement	±0.5 dB
--------------------------	---------

6.2 Environmental Conditions During Testing:

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

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

6.3 Dates of Testing:

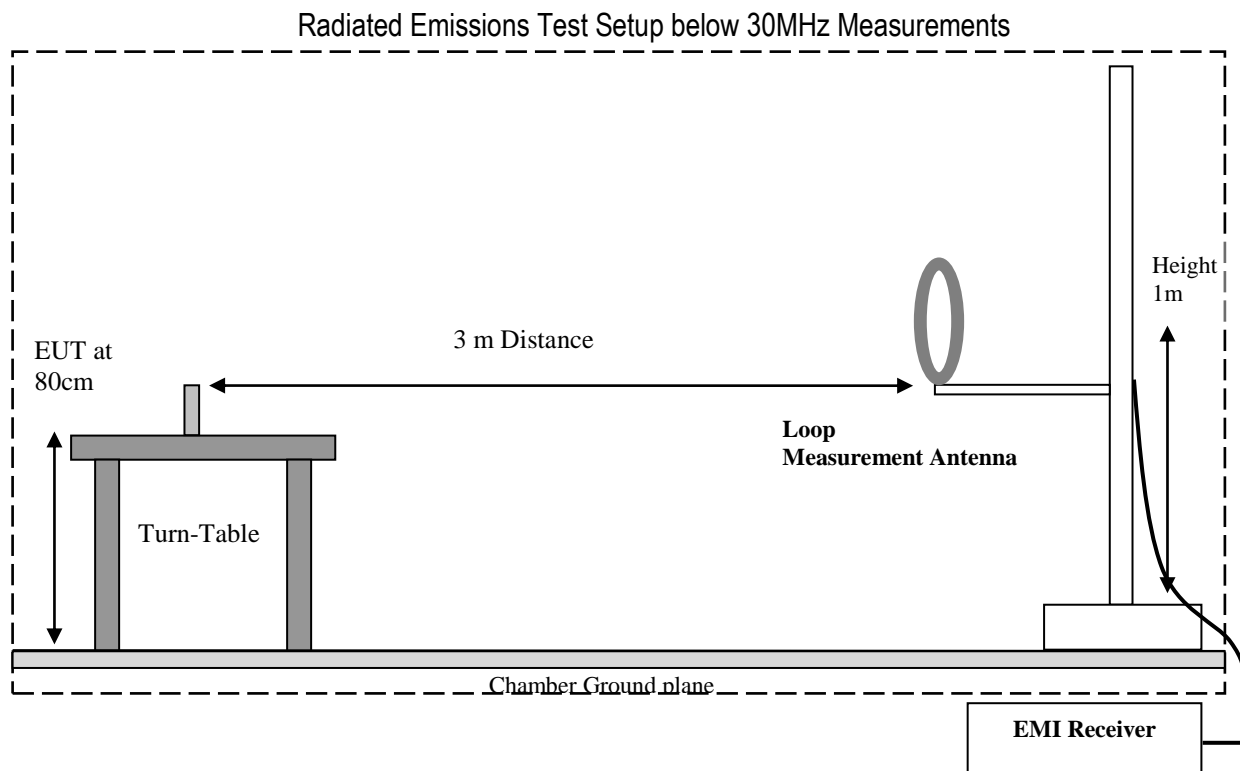
11/28/2017 – 1/24/2017

7 Measurement Procedures

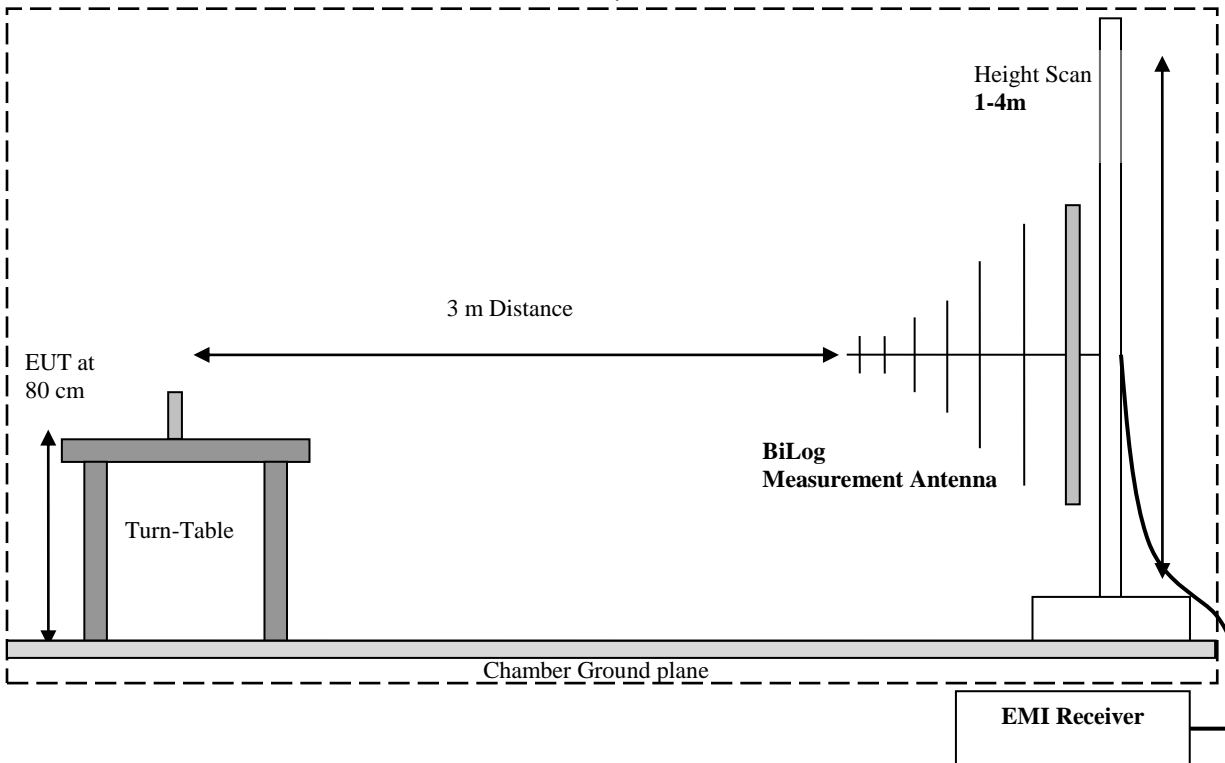
7.1 Radiated Measurement

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

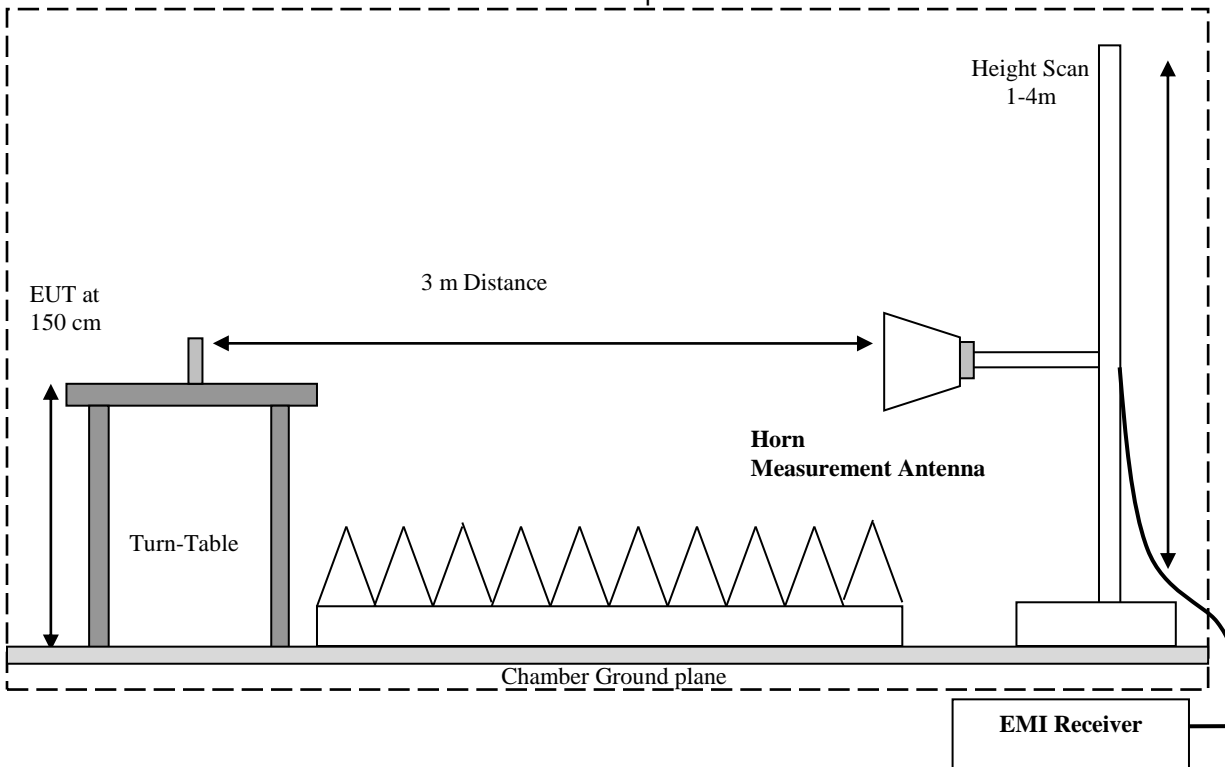
- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to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

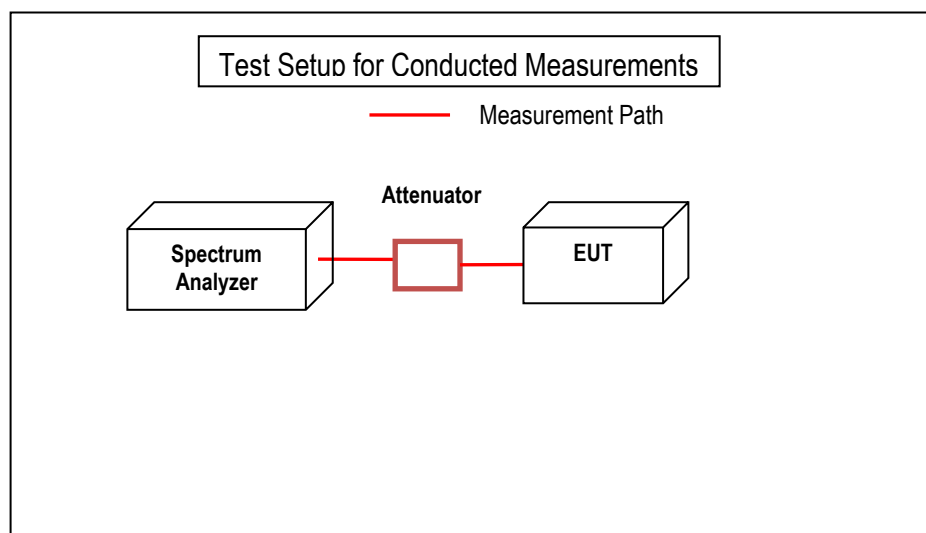
$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} - \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

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

Reference: ANSI C63.10 (2013) Section 6.9, 6.10, and 7.8



- 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.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to ANSI C63.10 Section 7.8.5

Spectrum Analyzer settings:

- Span = approximately 5 times the 20 dB bandwidth
- RBW > the 20 dB bandwidth of the emission being measured
- VBW ≥ RBW
- Sweep = Auto Couple
- Detector function = Peak
- Trace = Max hold
- Use the marker-peak function to set the marker to the peak of the emission.

8.1.2 Limits:

Maximum Peak Output Power:

FCC 15.247: (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

- (2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

RSS-247 5.4:

- a. For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

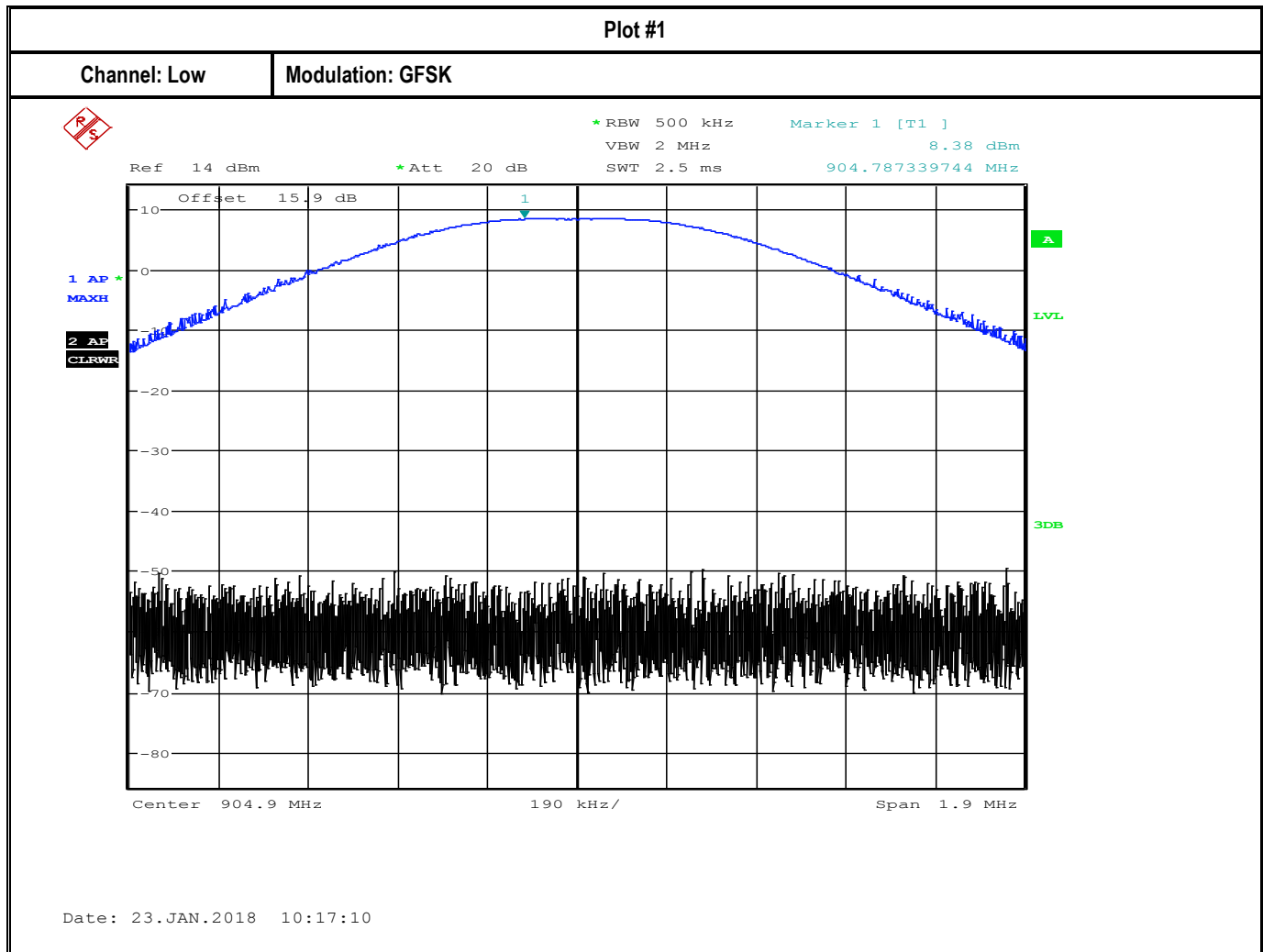
8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	1	GFSK	3.66 VDC	Peak:1.00 dBi Average: -1.5 dBi

8.1.4 Measurement result:

Plot #	Frequency (MHz)	EUT operating mode	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	FCC Limit (dBm)	ISED Limit (dBm)	Result
1	904.9	GFSK	8.38	9.38	23.98	23.98(Pk) / 30(EIRP)	Pass
2	914.1	GFSK	8.47	9.47	23.98	23.98(Pk) / 30(EIRP)	Pass
3	923.7	GFSK	8.55	9.55	23.98	23.98(Pk) / 30(EIRP)	Pass

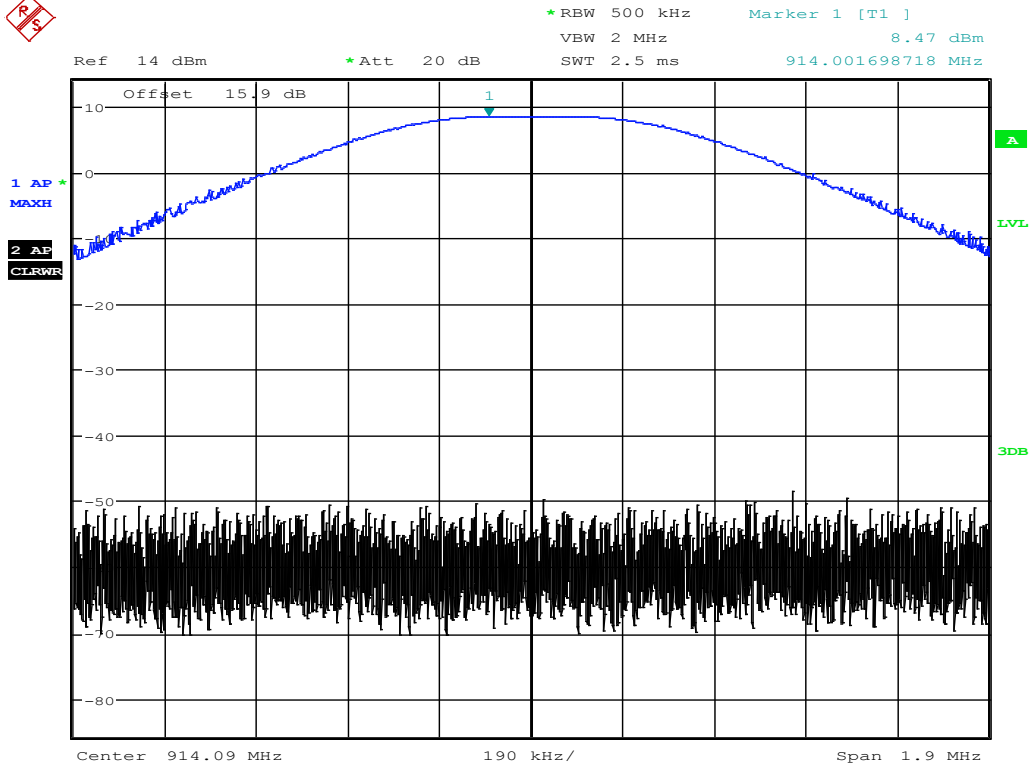
8.1.5 Measurement Plots:



Plot #2

Channel: Mid

Modulation: GFSK



Date: 23.JAN.2018 10:15:55

Plot #3

Channel: High

Modulation: GFSK



* RBW 500 kHz

Marker 1 [T1]

VBW 2 MHz

8.55 dBm

SWT 2.5 ms

923.605608974 MHz

Ref 14 dBm

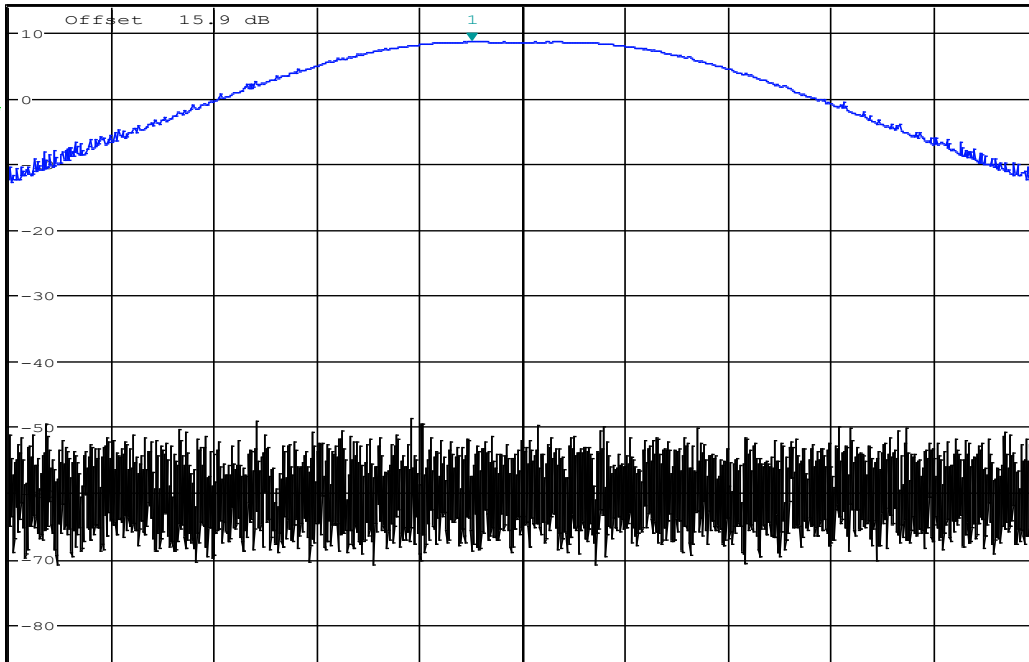
* Att 20 dB

1 AP *

MAXH

2 AP

CLRWR



Center 923.7 MHz

190 kHz/

Span 1.9 MHz

Date: 23.JAN.2018 10:12:26

8.2 Band Edge Compliance

8.2.1 Measurement according to ANSI C63.10 Section 6.10

Spectrum Analyzer settings for non-restricted band edge:

- Span: wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
- RBW \geq 1% of the span
- VBW \geq RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow the trace to stabilize. 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.
- Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
- Now, using the same instrument settings, enable the hopping function of the EUT.
- Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

Spectrum Analyzer settings for restricted band:

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

8.2.2 Limits: Restricted Band FCC 15.209 and RSS-Gen 8.10

- PEAK LIMIT= 74 dB μ V/m @3 m =-21.23 dBm
- AVG. LIMIT= 54 dB μ V/m @3 m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205

Restricted bands of operation:

- Except as shown in CFR 47 Part 15.205 paragraph (d), 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			

8.2.3 Limits: Non-restricted Band §15.247 and RSS-247 5.5

FCC15.247 (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 device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.2.4 Test conditions and setup:

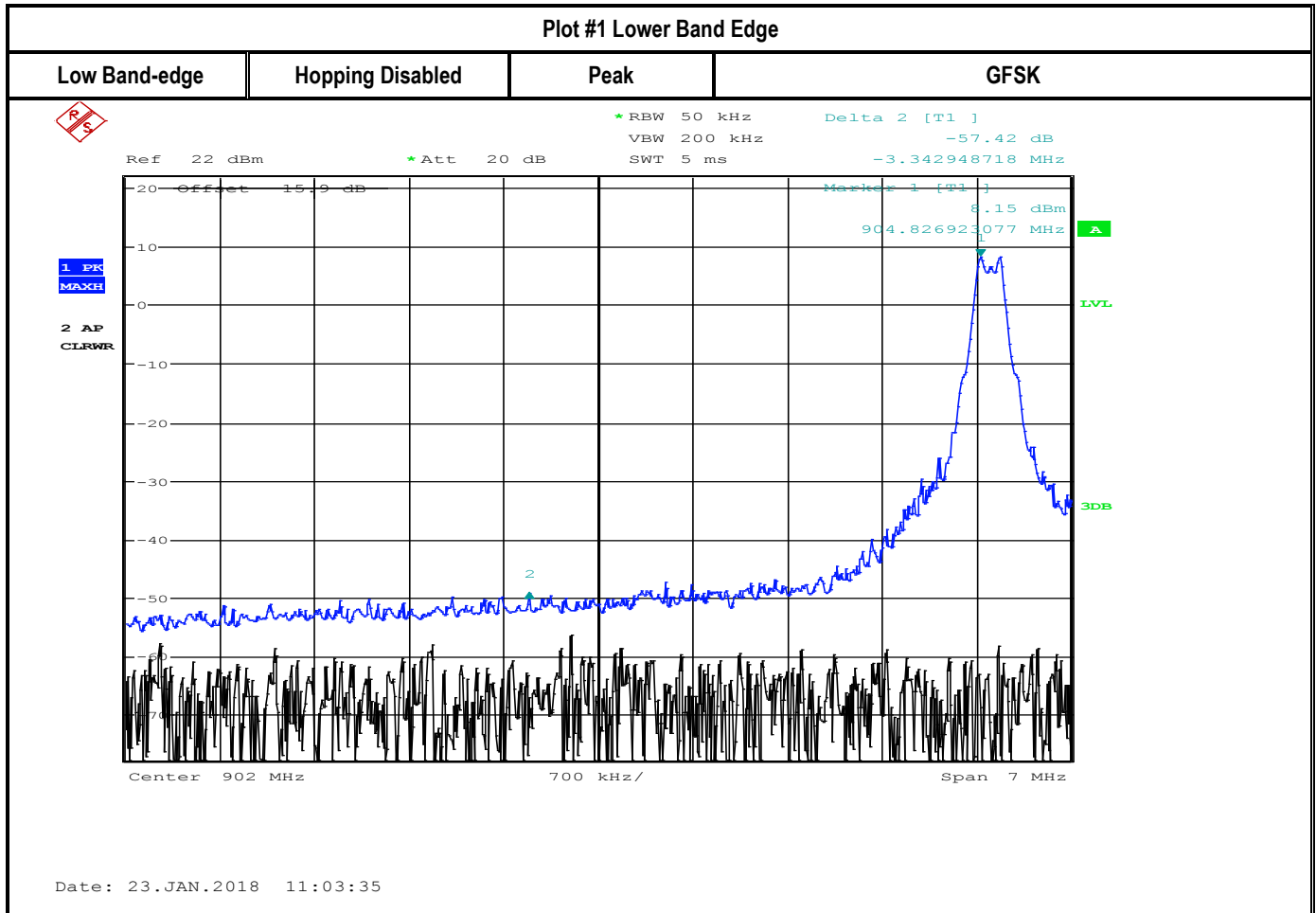
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna gain
22° C	1	GFSK - fixed channel GFSK - hopping	3.66 VDC	Peak: 1.00 dBi Average: -1.5 dBi

8.2.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	GFSK fixed channel	Lower, non-restricted	57.42	> 20	Pass
2	GFSK hopping	Lower, non-restricted	45.32	> 20	Pass

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBm)	Result
3	GFSK fixed channel	Upper, non-restricted peak	59.86	>20	Pass
4	GFSK hopping	Upper, non-restricted peak	54.00	>20	Pass

8.2.6 Measurement Plots:



Plot #2 Lower Band Edge

Low Band-edge

Hopping

Peak

GFSK



Ref 27 dBm

*Att 20 dB

*RBW 50 kHz

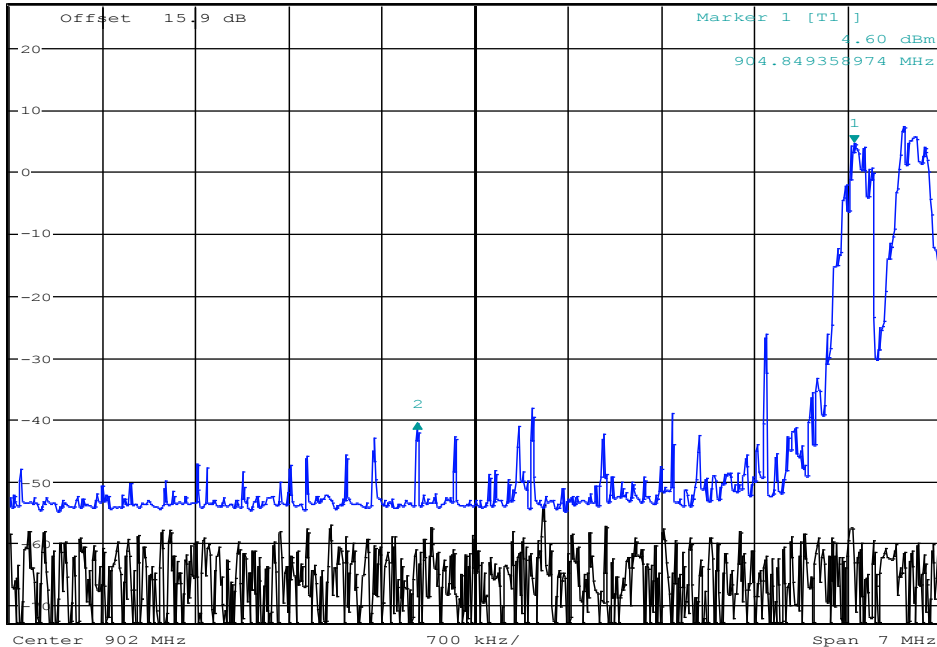
VBW 200 kHz

SWT 5 ms

Delta 2 [T1]

-45.32 dB

-3.286858974 MHz

1 PK
MAXH2 AE
CLRWR

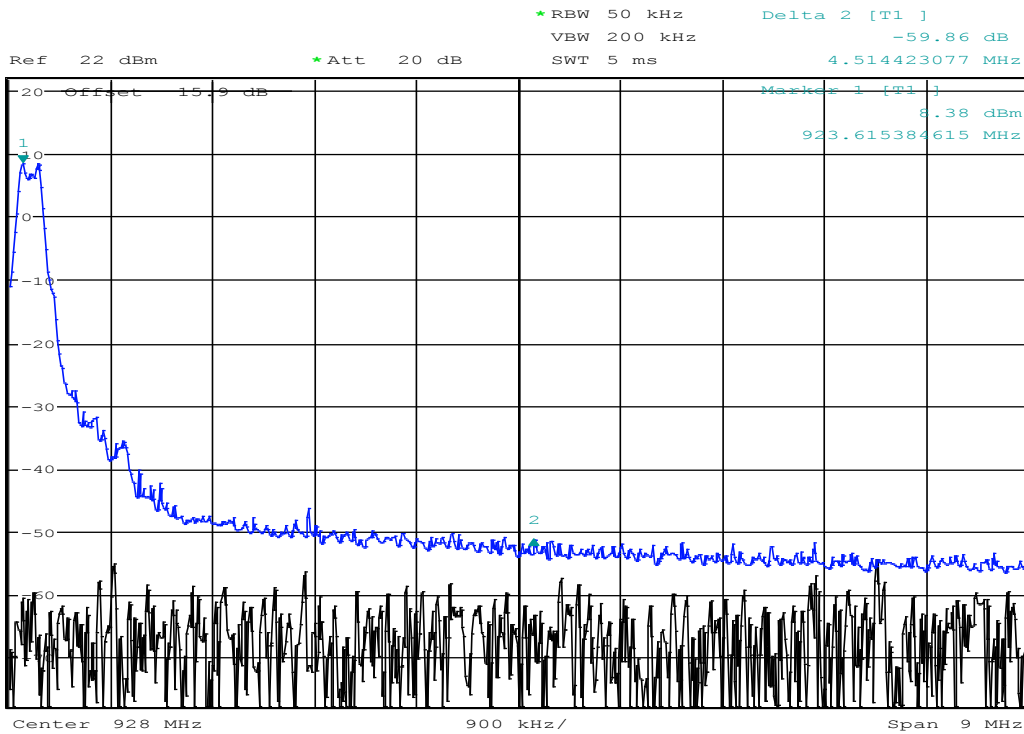
Plot #3 Upper Band Edge

Upper Band-edge

Hopping Disabled

Peak

GFSK

1 PK
MAXH2 AP
CLRWR

Date: 23.JAN.2018 11:06:39

Plot #4 Upper Band Edge

Upper Band-edge

Hopping

Peak

GFSK



Ref 27 dBm

* Att 20 dB

* RBW 50 kHz

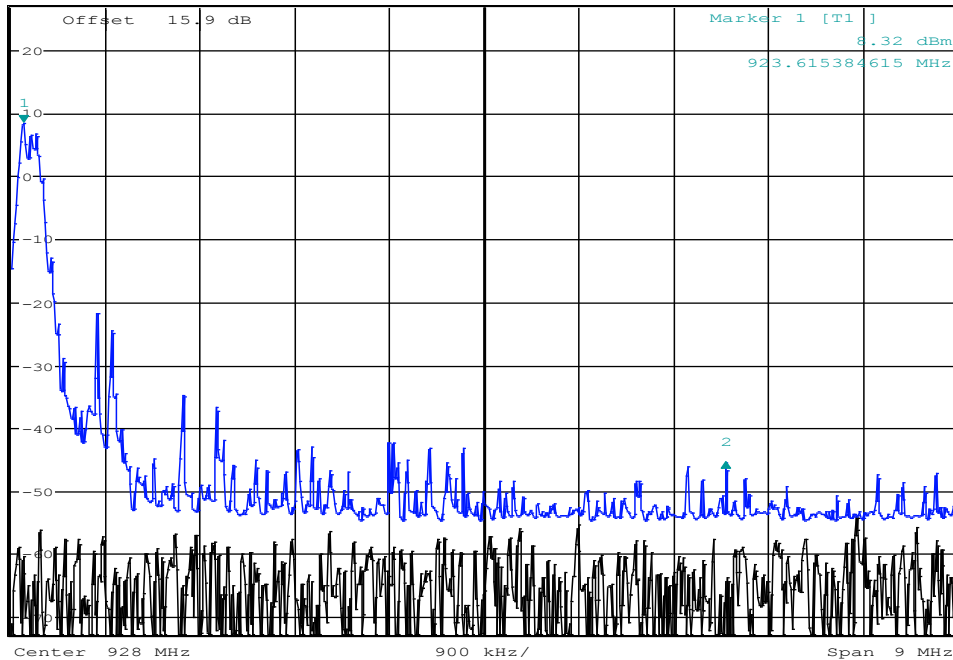
VBW 200 kHz

SWT 5 ms

Delta 2 [T1]

-54.00 dB

6.677884615 MHz

1 PK
MAXH2 AP
CLRWR

Date: 24.JAN.2018 16:13:10

8.3 20dB Bandwidth

8.3.1 Measurement according to ANSI C63.10 Section 6.9.2

Spectrum Analyzer settings:

- Span: approximately 2 to 3 times the 20 dB bandwidth, centered on the hopping channel
- RBW \geq 1% of the 20 dB bandwidth
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max hold

8.3.2 Limits: FCC 15.247 (a) (1) (i), RSS-247 5.1(c)

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

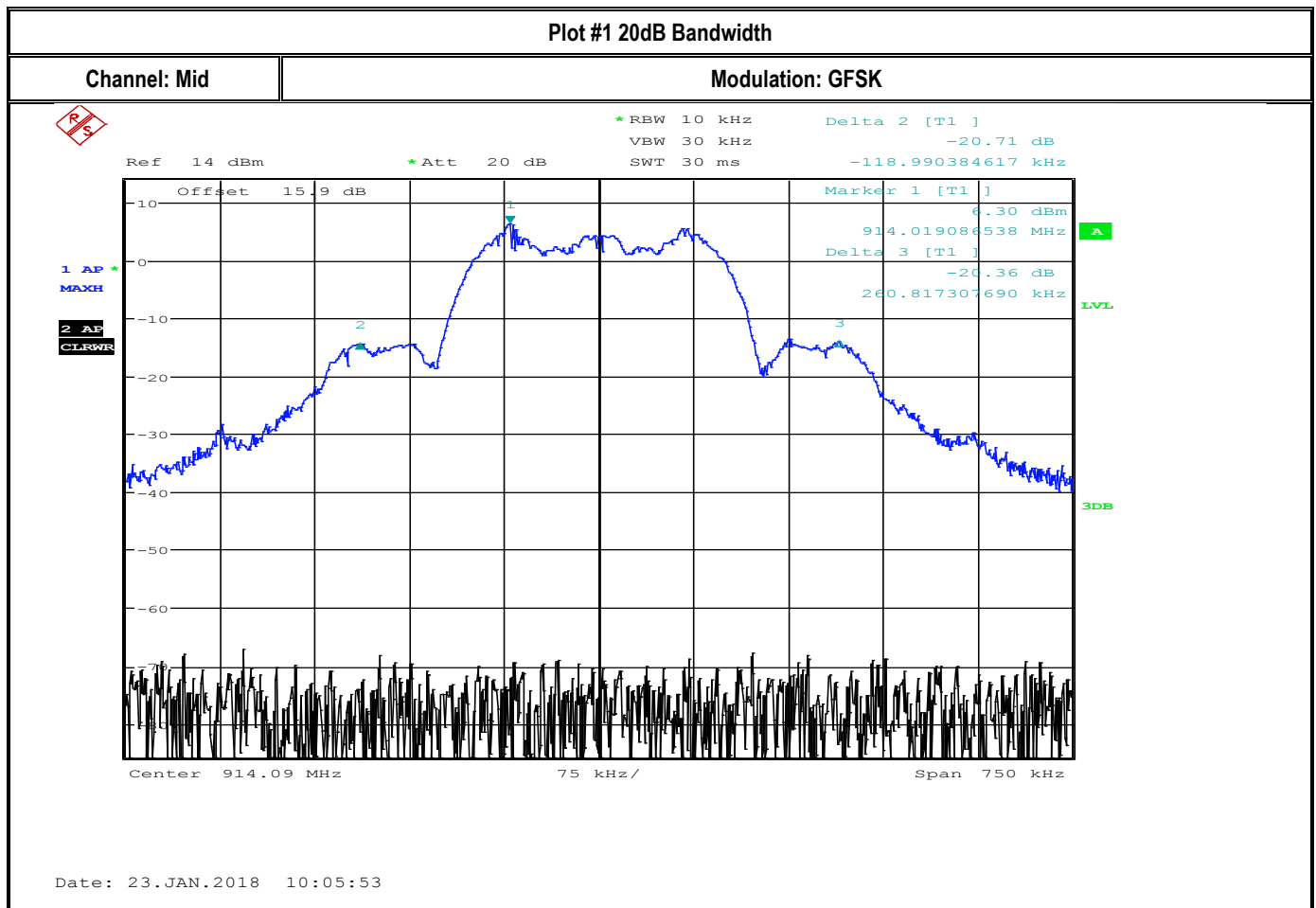
8.3.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK	3.66 VDC

8.3.4 Measurement result:

Plot #	EUT operating mode	20 dB Bandwidth (KHz)
1	GFSK fixed channel	379.8

8.3.5 Measurement Plots:



8.4 Carrier Frequency Separation

8.4.1 Measurement according to ANSI C63.10 Section 7.8.2

Spectrum Analyzer settings:

- Span = Wide enough to capture the peaks of the two adjacent channels
- RBW \geq 1% of the span
- VBW \geq RBW or 3 x
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use marker-delta function to determine the separation between the peaks of the two adjacent channels.

8.4.2 Limits: FCC 15.247 (a) (1) & RSS-247 5.1 (b)

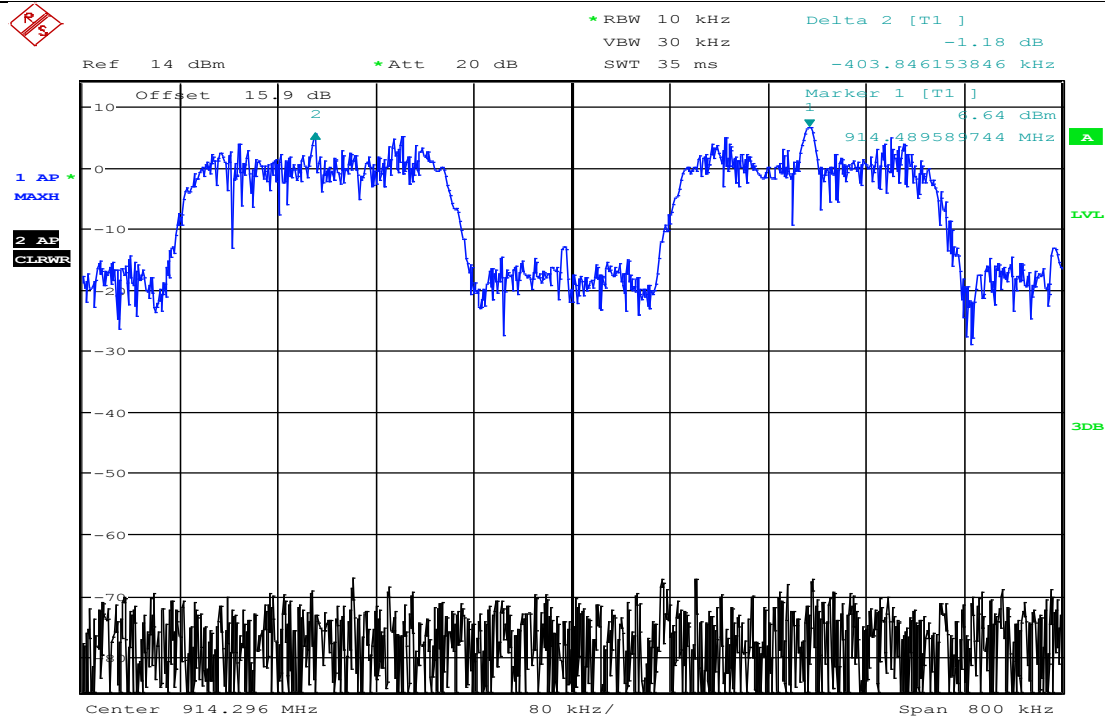
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	GFSK Hopping	3.66VDC

8.4.4 Measurement result:

Plot #	Carrier Frequency Separation (KHz)	Limit (KHz)	Result
1	403.8	> 379.8	Pass

8.4.5 Measurement Plots:**Plot # 1 Carrier Frequency Separation****Modulation: GFSK****Hopping On****Channel 24 & Channel 25**

Date: 23.JAN.2018 10:34:59

8.5 Number of hopping channels

8.5.1 Measurement according to ANSI C63.10 Section 7.8.3

Spectrum Analyzer settings:

- Span = the entire frequency band of operation
- RBW \geq 50 KHz
- VBW \geq RBW or 3X
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold

8.5.2 Limits: FCC 15.247 (a) (1) (i) & RSS-247 5.1 (c)

At least 25 hopping frequencies.

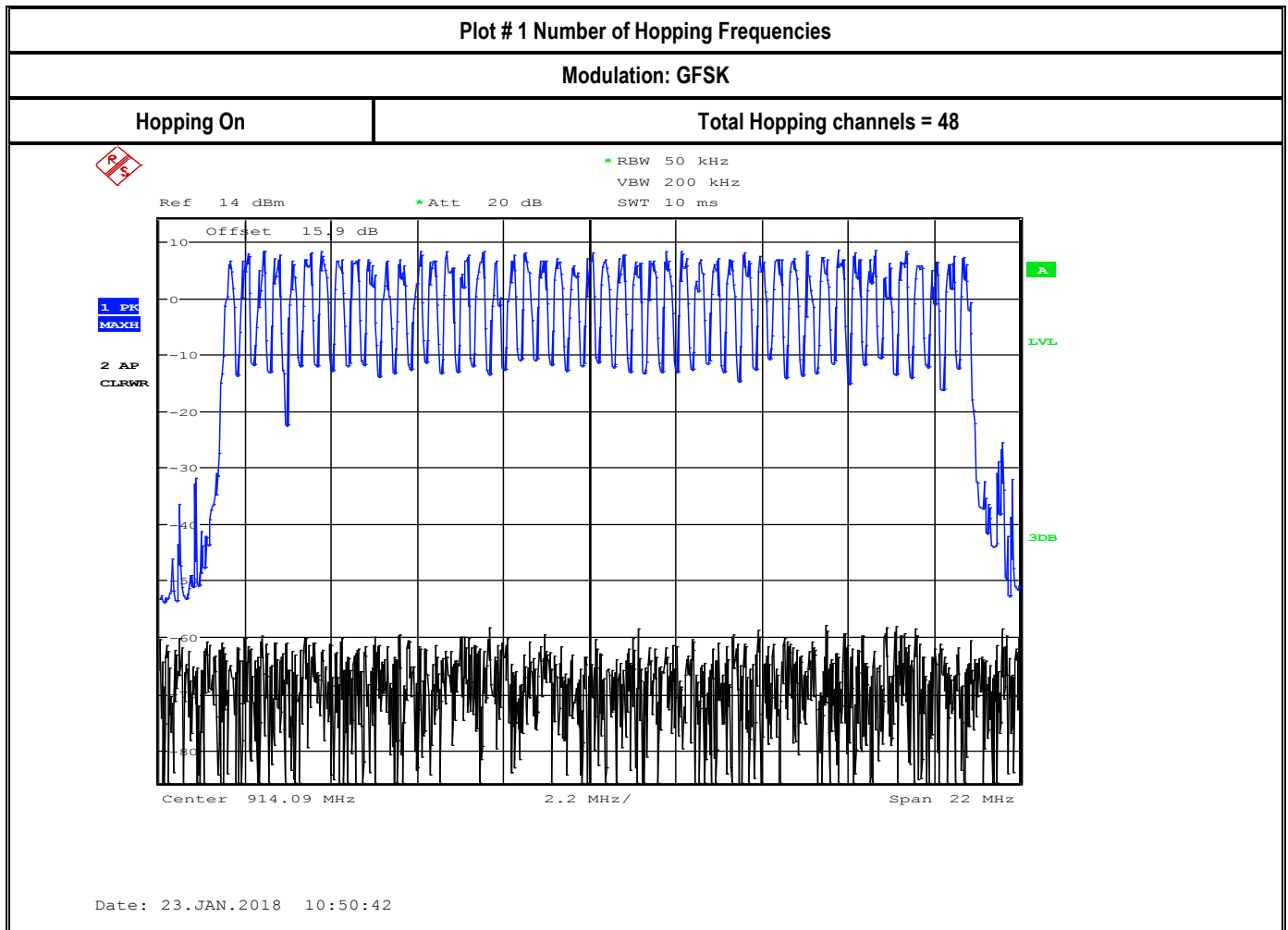
8.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	GFSK hopping	3.66 VDC

8.5.4 Measurement result:

Plot #	Number of Hopping Frequencies	Limit	Result
1	48	>25	Pass

8.5.5 Measurement Plots:



8.6 Time of Occupancy (Dwell Time)

8.6.1 Measurement according to ANSI C63.10 Section 7.8.4

Spectrum Analyzer settings:

Duration of Pulse Measurement

- RBW = 1 MHz
- VBW = 3 MHz
- Span = 0
- Sweep Time = 10 ms
- Sweep Mode = Single
- Detector = Peak
- Trigger = Video

Observation Period

- RBW = 1 MHz
- VBW = 3 MHz
- Span = 0
- Sweep Time = 31.6 s
- Sweep Mode = Single
- Detector = Peak
- Trigger = Free Run

8.6.2 Limits: FCC 15.247 (a) (1) (i) RSS-247 5.1(c)

For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20-second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.6.3 Test conditions and setup:

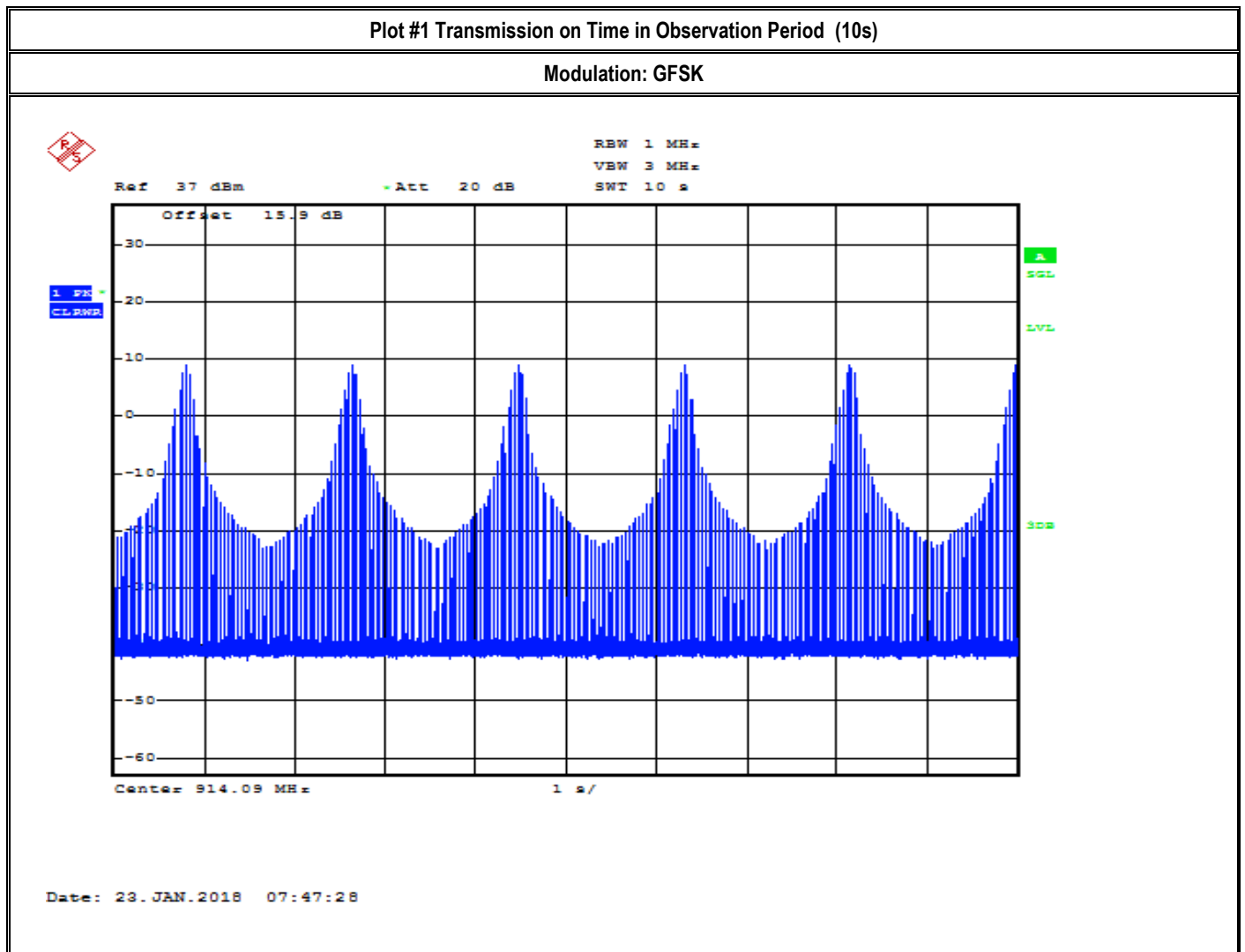
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	GFSK hopping	3.66 VDC

8.6.4 Measurement result:

Plot #	Modulation	Timing	Number of hops 10s	Pulse Width (ms)	Total Dwell Time in 10s (ms)	Limit (ms)	Result
1	GFSK	DH5	6	4.03	24.18	< 400 in 10s	Pass *Note

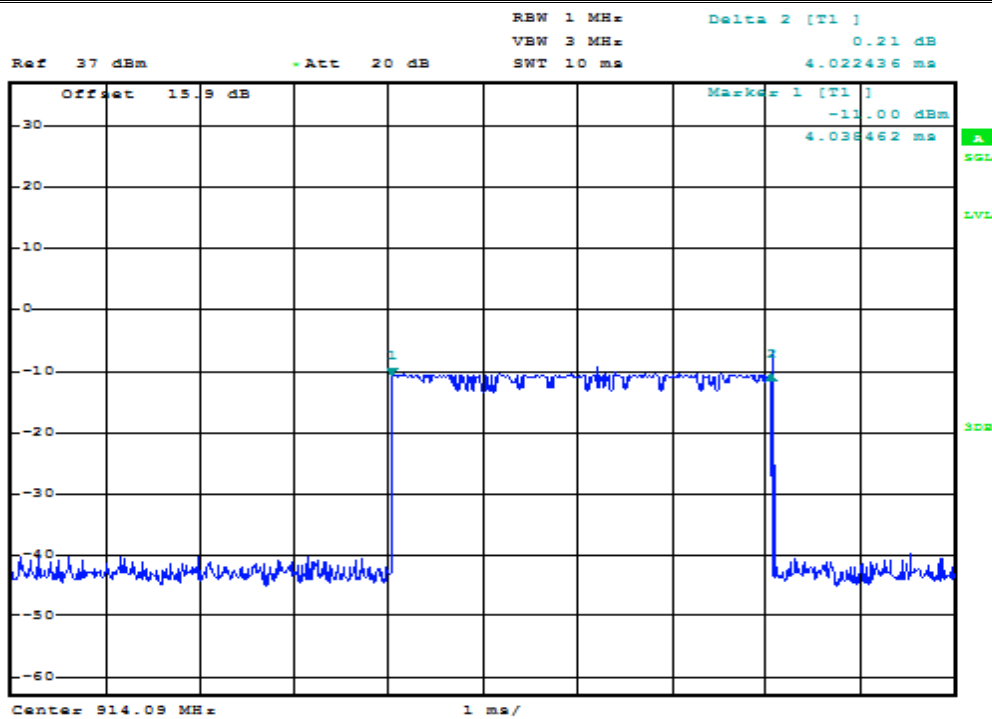
Note: According to the customer declaration the unit was tested in a test mode (worst case) but in Reality, the unit transmit rate is defaulted to once per 15 seconds.

8.6.5 Measurement Plots:



Pulse Duration

Modulation: GFSK



Date: 23.JAN.2018 07:09:50

8.7 Transmitter Spurious Emissions and Restricted Bands

8.7.1 Measurement according to ANSI C63.10

Analyzer Settings:

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

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

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

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

8.7.2 Limits: FCC 15.247(d)/15.209(a) /RSS-Gen 6.13

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= 74dB μ V/m
- AVG. LIMIT= 54dB μ V/m
- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

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 described in 5.4.

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 as follow:

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

8.7.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	GFSK fixed channel	3.8 VDC

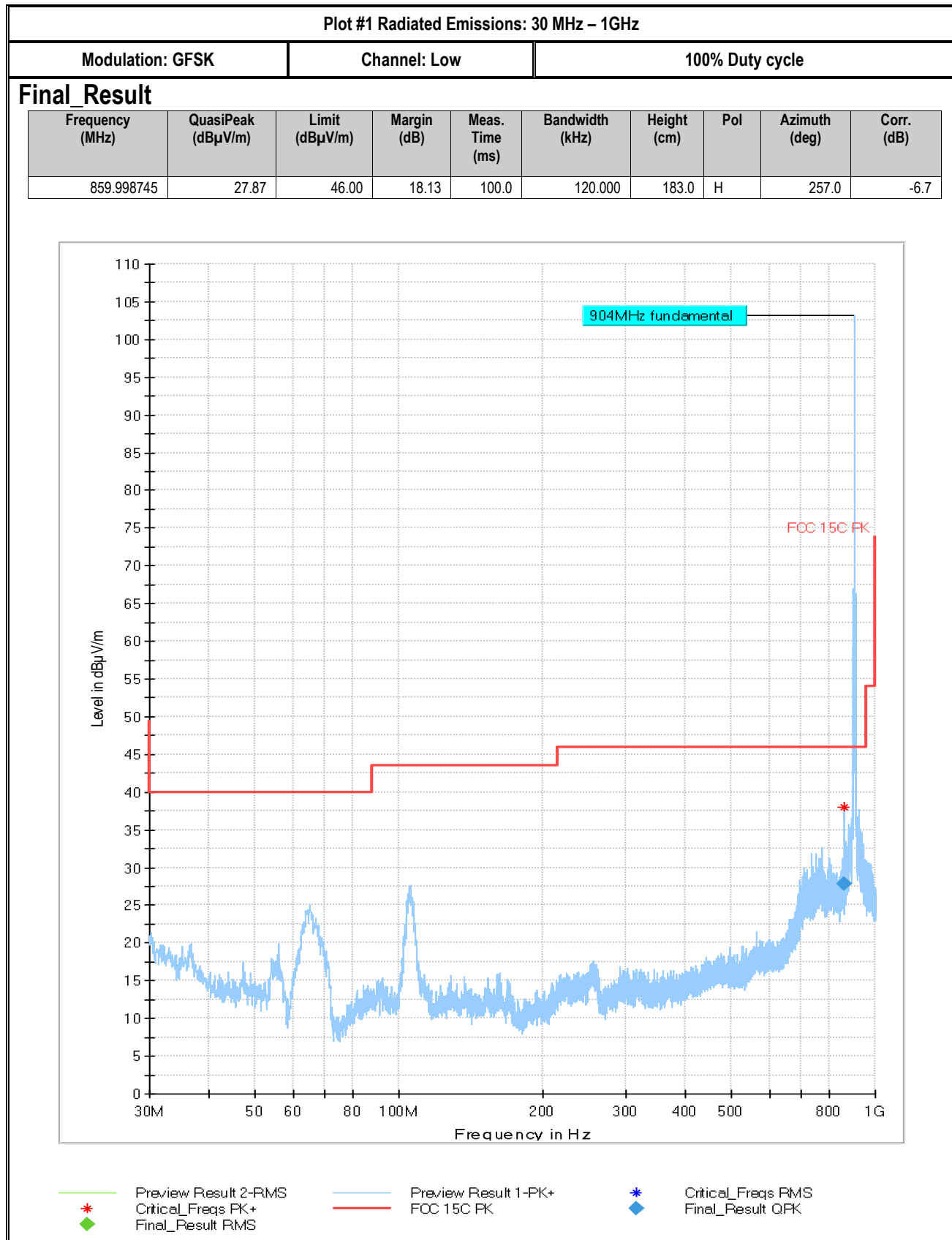
8.7.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.7.2	Pass
4-7	Mid	9 kHz – 26 GHz	See section 8.7.2	Pass
8-10	High	30 MHz – 18 GHz	See section 8.7.2	Pass

- The duty cycle correction factor was calculated using the following formula:

$$20\log(4.09*6/100)=(-12.2\text{dB})$$

8.7.5 Measurement Plots:



Plot # 2 Radiated Emissions: 1-3 GHz

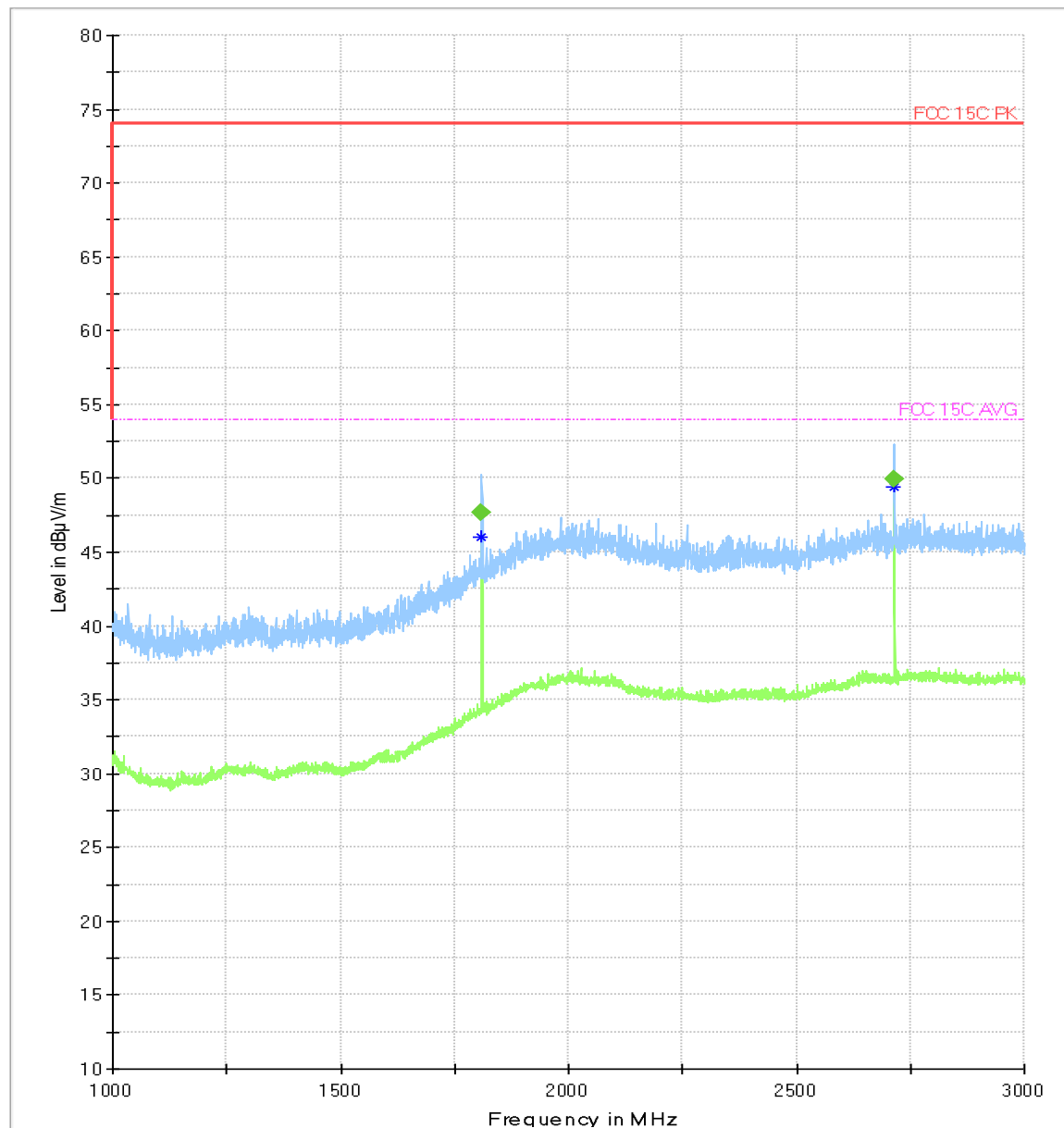
Modulation: GFSK

Channel: Low

100% Duty cycle

Final_Result

Frequency (MHz)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1809.865000	47.72	53.98	6.26	10.0	1000.000	128.0	H	327.0	-10.9
2714.655000	49.97	53.98	4.01	10.0	1000.000	139.0	H	-5.0	-9.8



Preview Result 2-RMS
Critical_Freqs PK+
Final_Result QPK

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

Critical_Freqs RMS
FCC 15C AVG

Plot # 3 Radiated Emissions: 3-18 GHz

Modulation: GFSK

Channel: Low

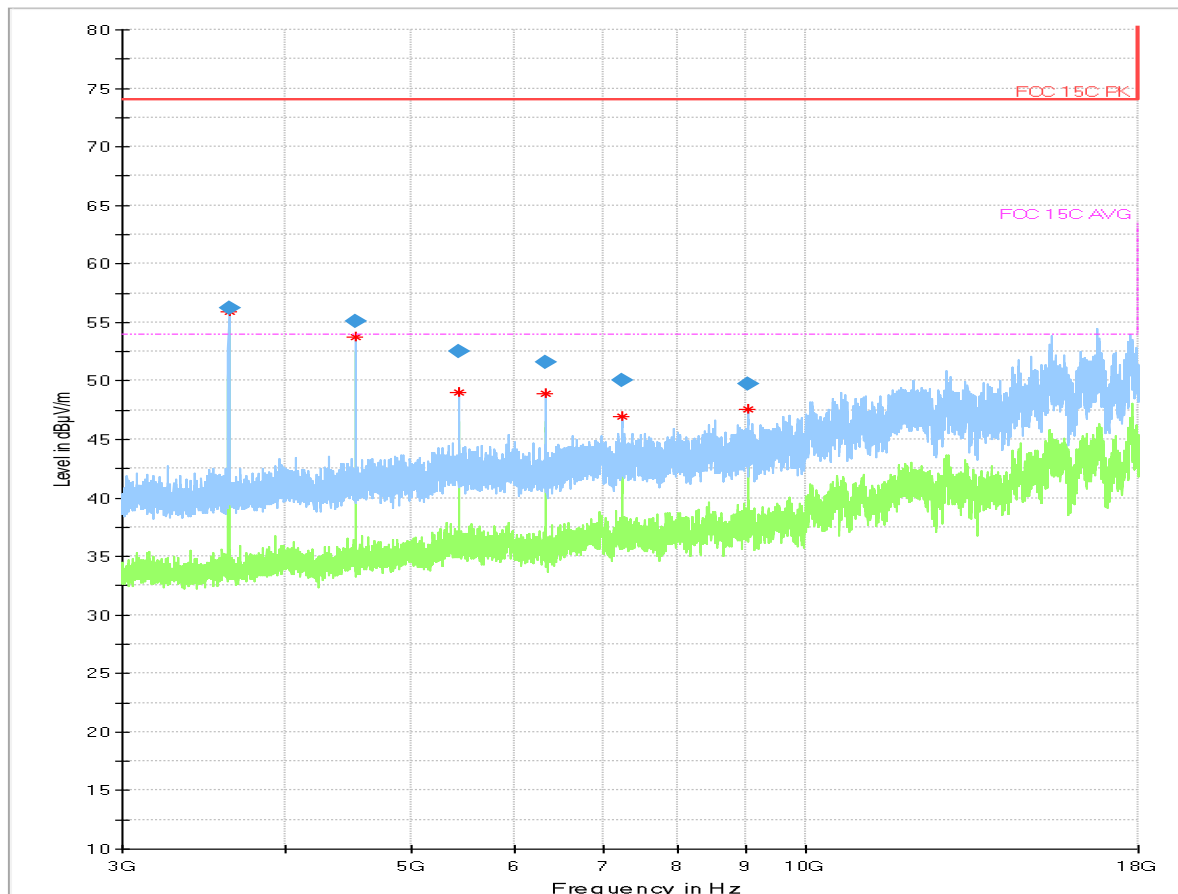
100% Dynamic Duty cycle

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3619.498000	56.25	73.99	17.74	10.0	1000.000	148.0	H	165.0	-34.3
4524.224667	55.06	73.99	18.93	10.0	1000.000	219.0	H	297.0	-32.5
5429.774000	52.51	73.99	21.48	10.0	1000.000	263.0	V	218.0	-29.9
6334.285333	51.62	73.99	22.36	10.0	1000.000	188.0	H	8.0	-29.5
7238.564000	50.08	73.99	23.91	10.0	1000.000	247.0	V	196.0	-28.1
9048.686000	49.69	73.98	24.29	10.0	1000.000	154.0	V	216.0	-24.2

Corrected Final_Result by applying duty cycle factor

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3619.498000	44.05	53.99	9.94	10.0	1000.000	148.0	H	165.0	-12.20
4524.224667	42.86	53.99	11.13	10.0	1000.000	219.0	H	297.0	-12.20
5429.774000	40.31	53.99	13.68	10.0	1000.000	263.0	V	218.0	-12.20
6334.285333	39.42	53.99	14.57	10.0	1000.000	188.0	H	8.0	-12.20
7238.564000	37.88	53.99	16.11	10.0	1000.000	247.0	V	196.0	-12.20
9048.686000	37.49	53.99	16.50	10.0	1000.000	154.0	V	216.0	-12.20



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

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

◆ Critical_Freqs RMS
◆ FOC 15C AVG

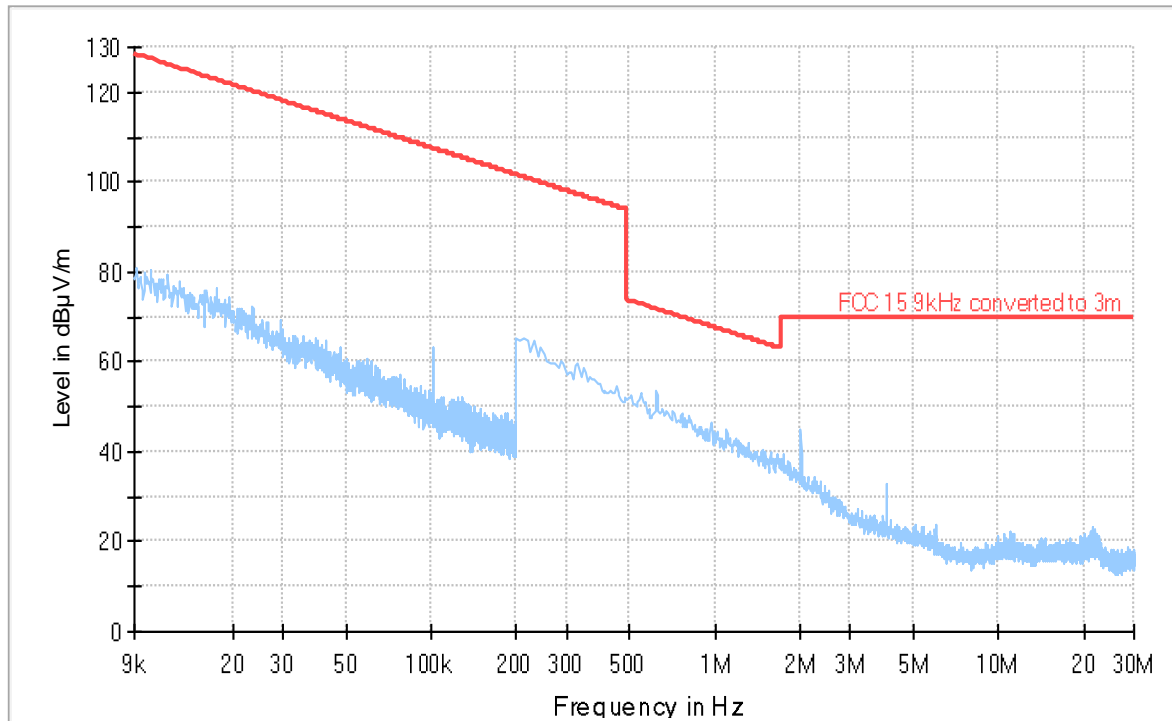
Plot # 4 Radiated Emissions: 9 KHz - 30 MHz

Modulation: GFSK

Channel: Mid

100% Duty cycle

Full Spectrum



Preview Result 2-RMS
* Critical_Freqs RMS
FCC 15.9kHz converted to 3m
◆ Final_Result RMS

Preview Result 1-PK+
* Critical_Freqs PK+
◆ Final_Result QPK

Plot #5 Radiated Emissions: 30 MHz – 1GHz

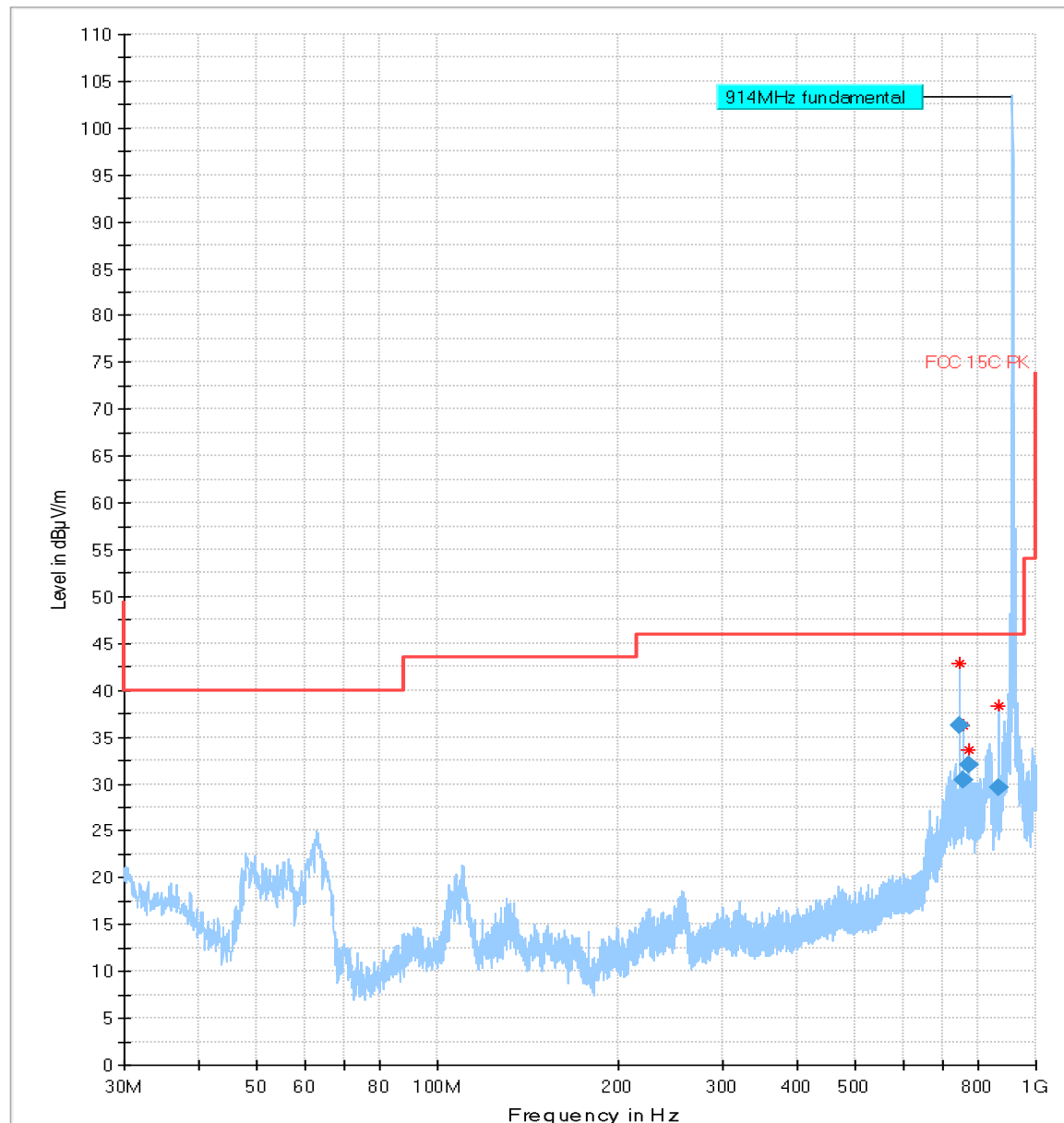
Modulation: GFSK

Channel: Mid

100% Duty cycle

Final_Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
745.009320	36.29	46.00	9.71	100.0	120.000	169.0	H	254.0	-8.0
758.039305	30.44	46.00	15.56	100.0	120.000	166.0	H	253.0	-7.6
771.049000	32.03	46.00	13.97	100.0	120.000	127.0	H	257.0	-7.9
869.101045	29.57	46.00	16.43	100.0	120.000	175.0	H	250.0	-6.3



* Preview Result 2-RMS
Critical_Freqs PK+
Final_Result RMS

Preview Result 1-PK+
FCC 15C PK

* Critical_Freqs RMS
Final_Result QPK

Plot #6 Radiated Emissions: 1-3 GHz

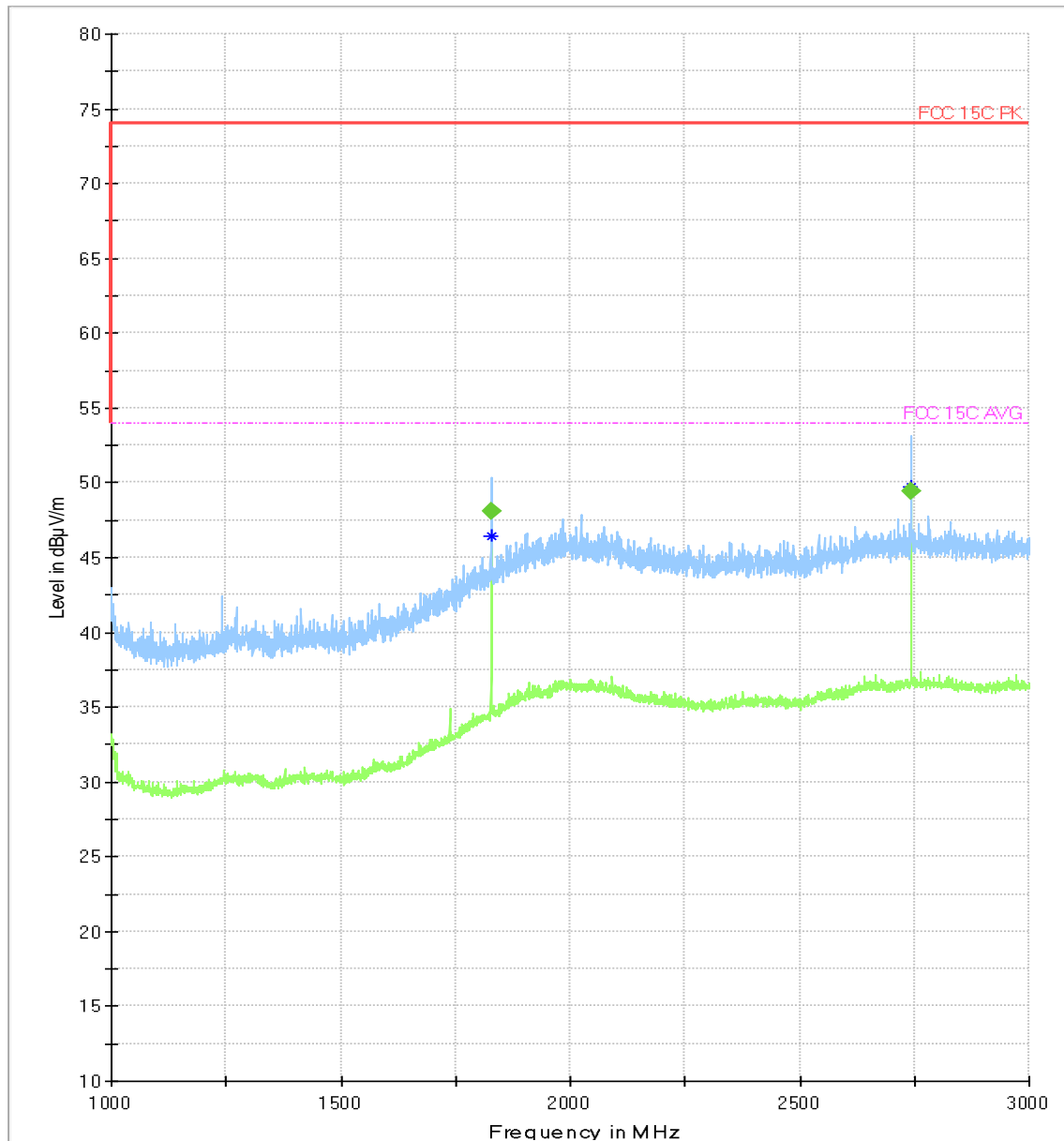
Modulation: GFSK

Channel: Mid

100% Duty cycle

Final Result

Frequency (MHz)	RMS (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1828.250000	48.11	53.98	5.87	10.0	1000.000	133.0	H	314.0	-10.6
2742.190000	49.48	53.98	4.50	10.0	1000.000	146.0	H	280.0	-9.7



Preview Result 2-RMS
Critical_Freqs PK+
Final_Result QPK

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

Critical_Freqs RMS
FCC 15C AVG

Plot #7 Radiated Emissions: 3-18 GHz

Modulation: GFSK

Channel: Mid

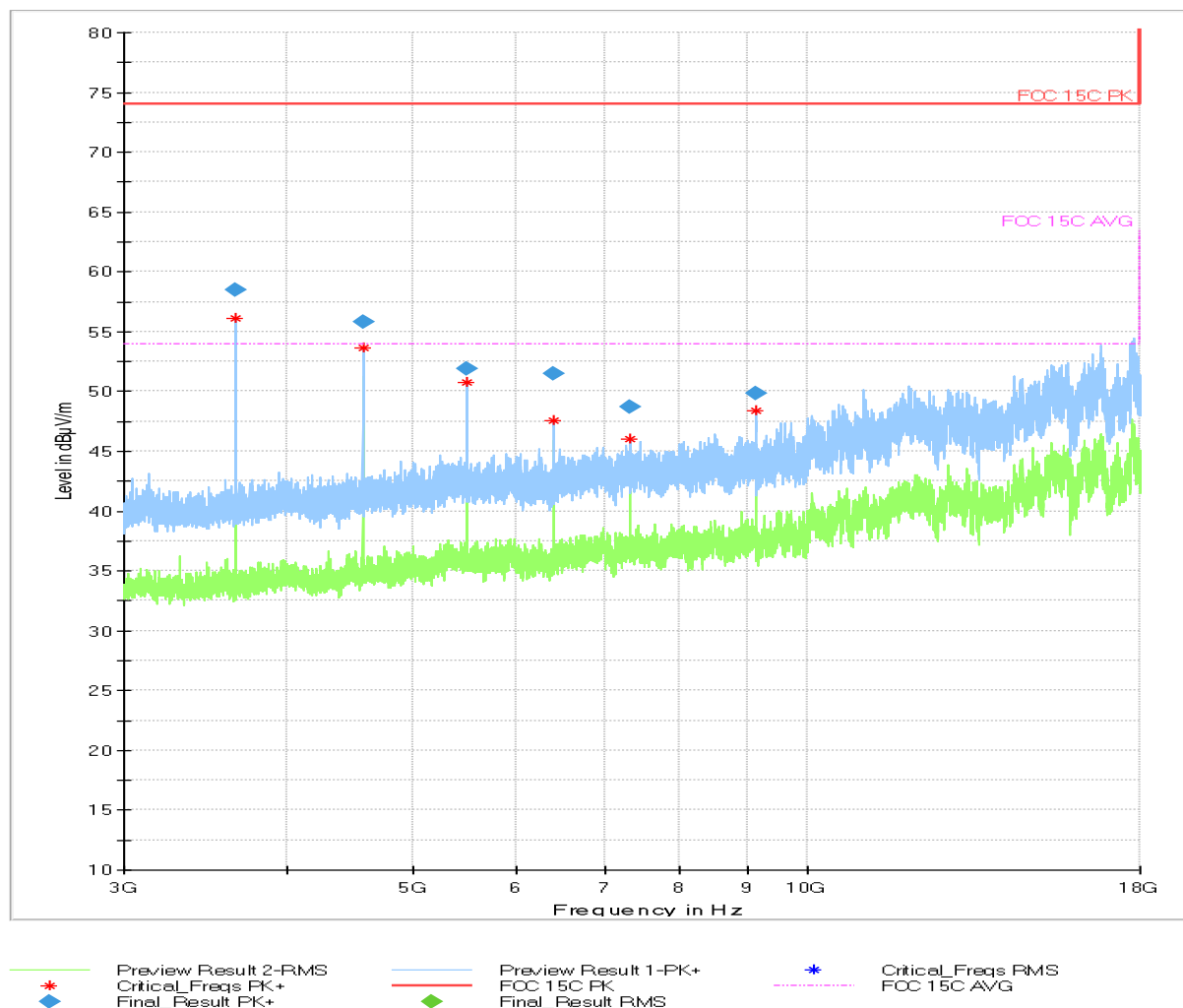
100% Duty cycle

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3656.046667	58.48	73.99	15.51	10.0	1000.000	253.0	H	177.0	-34.3
4570.845333	55.77	73.99	18.22	10.0	1000.000	100.0	H	305.0	-32.7
5484.828000	51.94	73.99	22.05	10.0	1000.000	212.0	V	222.0	-29.9
6399.184000	51.47	73.99	22.52	10.0	1000.000	194.0	H	5.0	-29.4
7312.672667	48.70	73.99	25.28	10.0	1000.000	271.0	V	184.0	-28.3
9141.760000	49.79	73.98	24.19	10.0	1000.000	108.0	V	210.0	-24.3

Corrected Final_Result by applying duty cycle factor

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3656.046667	46.28	53.98	7.70	10.0	1000.000	253.0	H	177.0	-12.20
4570.845333	43.57	53.98	10.41	10.0	1000.000	100.0	H	305.0	-12.20
5484.828000	39.74	53.98	14.24	10.0	1000.000	212.0	V	222.0	-12.20
6399.184000	39.27	53.98	14.71	10.0	1000.000	194.0	H	5.0	-12.20
7312.672667	36.50	53.98	17.48	10.0	1000.000	271.0	V	184.0	-12.20
9141.760000	37.59	53.98	16.39	10.0	1000.000	108.0	V	210.0	-12.20



Plot #8 Radiated Emissions: 30 MHz – 1GHz

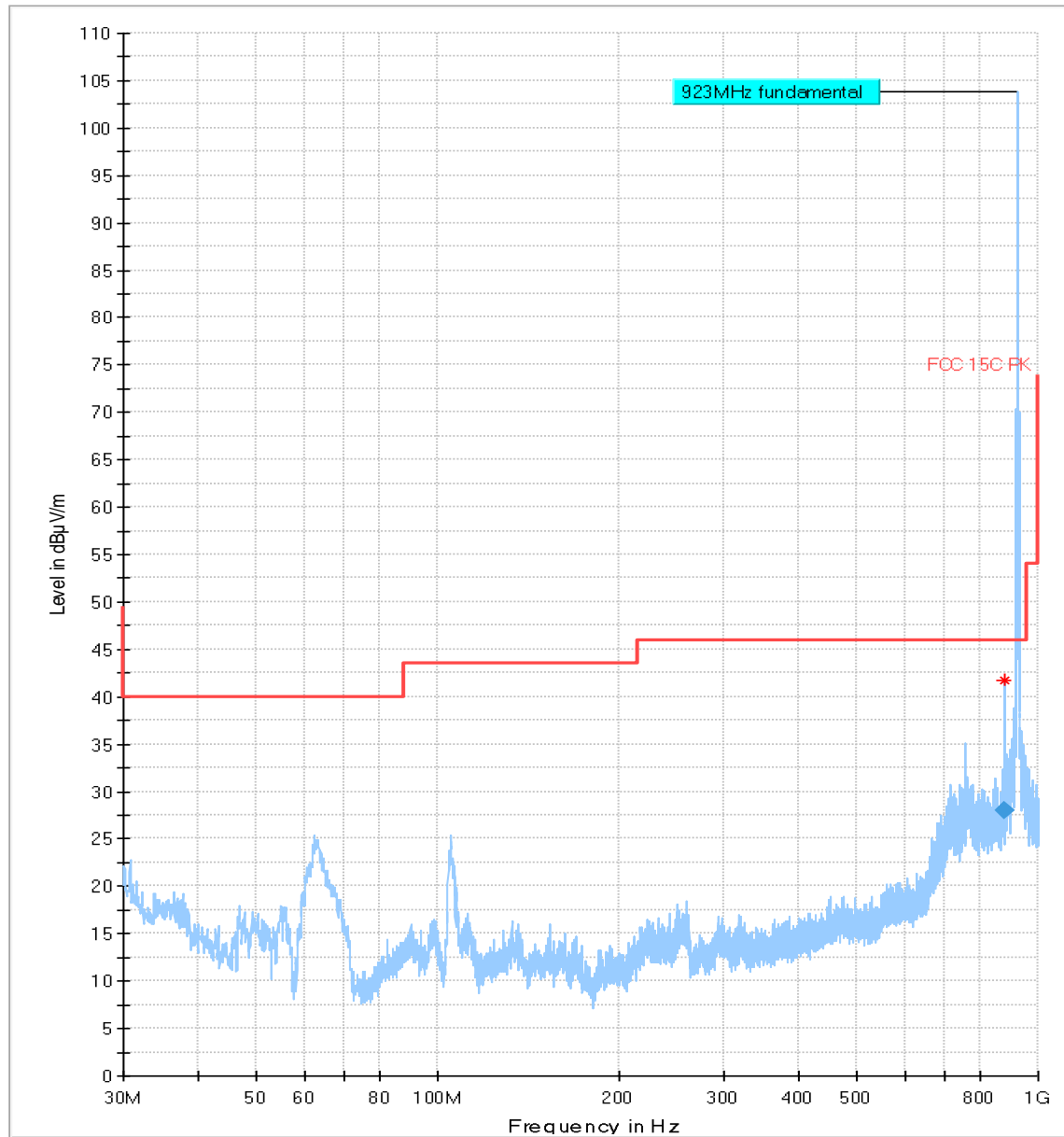
Modulation: GFSK

Channel: High

100% Duty cycle

Final Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
878.770325	28.04	46.00	17.96	100.0	120.000	177.0	H	256.0	-6.1



* Preview Result 2-RMS
Critical_Freqs PK+
Final_Result RMS

Preview Result 1-PK+
FCC 15C FK

* Critical_Freqs RMS
Final_Result QPK

Plot # 9 Radiated Emissions: 1-3 GHz and Restricted Bands

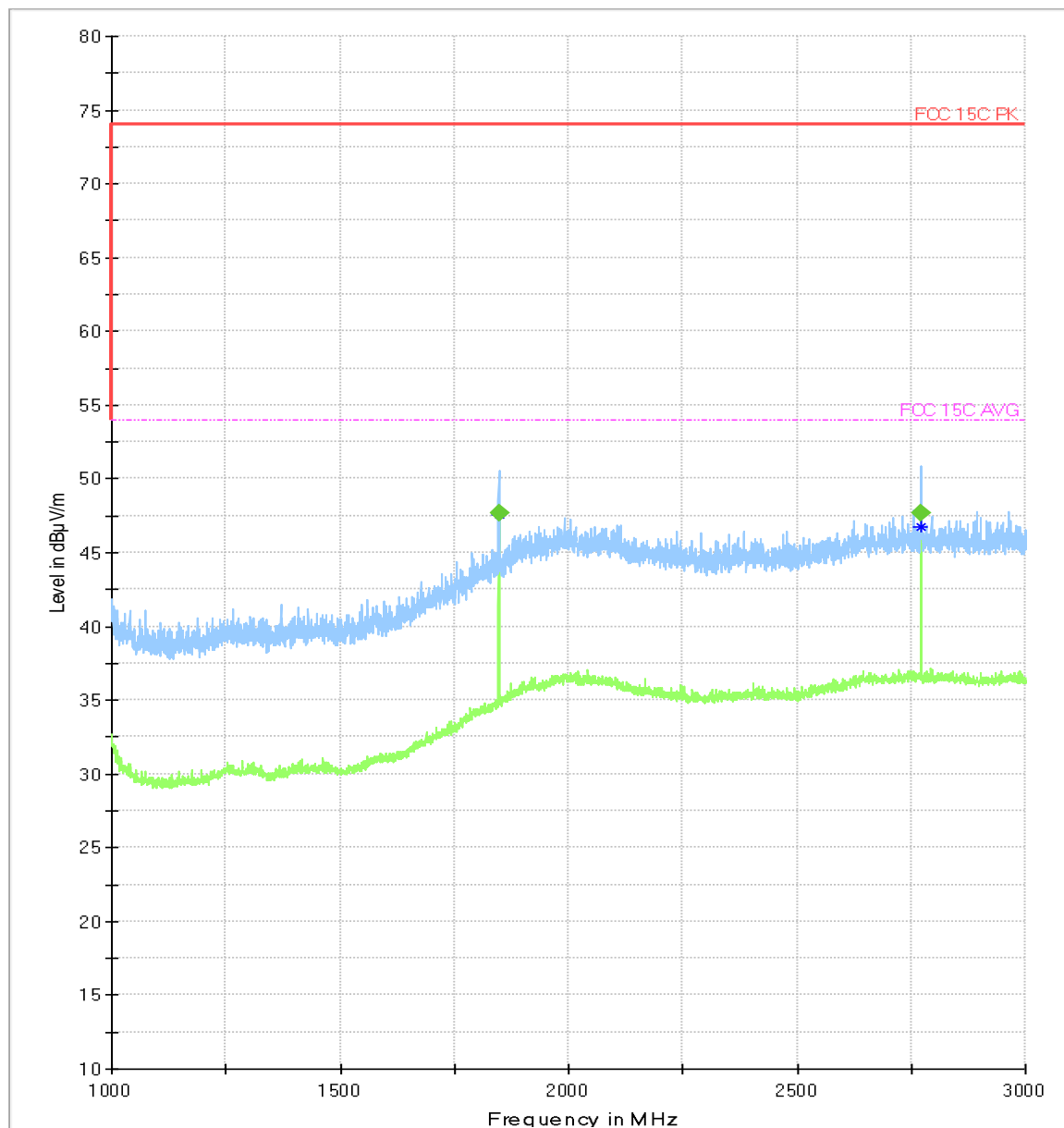
Modulation: GFSK

Channel: High

100% Duty cycle

Final_Result

Frequency (MHz)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1847.145000	47.68	53.98	6.30	10.0	1000.000	151.0	H	321.0	-10.4
2770.905000	47.63	53.98	6.35	10.0	1000.000	164.0	H	48.0	-9.5



Preview Result 2-RMS
Critical_Freqs PK+
Final_Result QPK

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

Critical_Freqs RMS
FCC 15C AVG

Plot #10 Radiated Emissions: 3-18 GHz

Modulation: GFSK

Channel: High

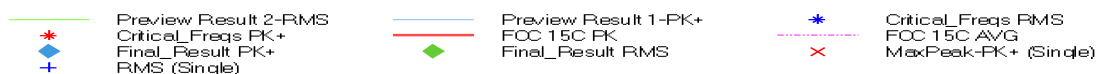
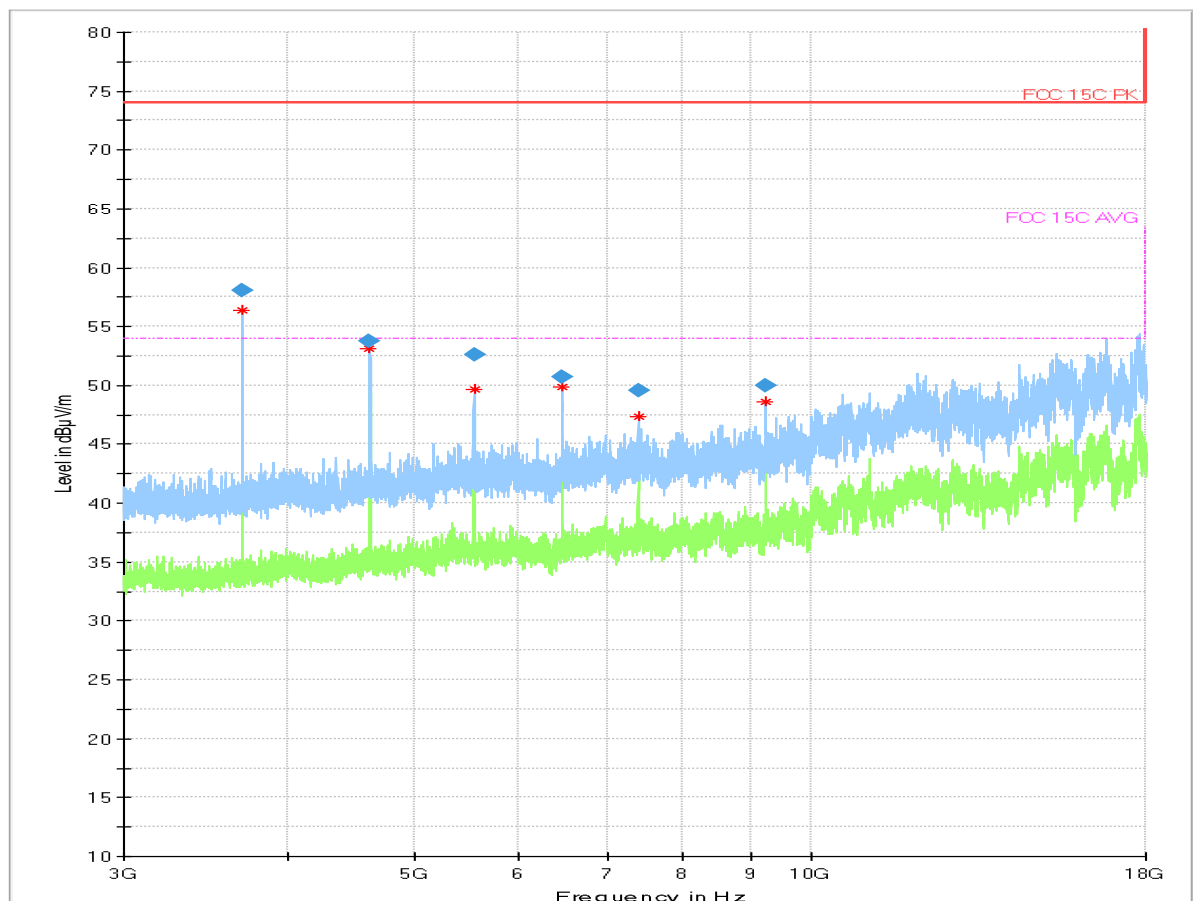
100% Duty cycle

Final_Result

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
6466.150667	50.72	73.99	23.27	10.0	1000.000	231.0	H	4.0	-28.7
7389.068667	49.61	73.99	24.38	10.0	1000.000	284.0	H	132.0	-28.0
3694.498000	58.01	73.99	15.98	10.0	1000.000	187.0	H	163.0	-34.3
9236.484667	49.95	73.98	24.03	10.0	1000.000	116.0	V	209.0	-23.9
4618.772000	53.74	73.99	20.25	10.0	1000.000	215.0	V	137.0	-32.6
5541.737333	52.57	73.99	21.42	10.0	1000.000	268.0	V	210.0	-30.0

Corrected Final_Result by applying duty cycle factor

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
6466.150667	38.52	53.99	15.47	10.0	1000.000	231.0	H	4.0	-12.20
7389.068667	37.41	53.99	16.58	10.0	1000.000	284.0	H	132.0	-12.20
3694.498000	45.81	53.99	8.18	10.0	1000.000	187.0	H	163.0	-12.20
9236.484667	37.75	53.99	16.24	10.0	1000.000	116.0	V	209.0	-12.20
4618.772000	41.54	53.99	12.45	10.0	1000.000	215.0	V	137.0	-12.20
5541.737333	40.37	53.99	13.62	10.0	1000.000	268.0	V	210.0	-12.20



9 Test setup photos

Setup photos are included in supporting file name: "EMC_BADGE_010_17001_15.247_DSS_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
PASSIVE LOOP ANTENNA	ETS LINDGREN	6512	00164698	3 YEARS	08/08/2017
BOLOG ANTENNA	TESEO	CBL 6141B	41106	3 YEARS	11/01/2017
HORN ANTENNA	ETS LINDGREN	3117	00167061	3 YEARS	08/08/2017
SIGNAL ANALYZER	R&S	FSU26	200065	2 YEARS	03/07/2017
SIGNAL ANALYZER	R&S	FSV 40	101022	2 YEARS	07/05/2017
COMPACT DIGITAL BAROMETER	CONTROL COMPANY	35519-055	91119547	1 YEARS	06/05/2017
THRMOMETER HUMIDIY	DICKSON	TM320	16253639	1 YEARS	11/02/2017

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
03/08/2018	EMC_BADGE_010_17001_15.247_DSS	Initial Version	Issa Ghanma