FCC / ISED Test Report

FOR: BI Incorporated

Model: RF-2021

Product Description:
The HomeGuard 20|20 Transmitter is a waterproof, battery-operated, RF device that is worn around an offender's ankle 24x7.

FCC ID: CSQ-RF2021
IC ID: 1499A-RF2021

Applied Rules and Standards:
47 CFR Part: 15.231
RSS-210 & RSS-Gen Issue 5

REPORT #: EMC_BIINC_004_18001_FCC_15.231_ISED_REV_2

DATE: 07/12/2018

A2LA Accredited

IC recognized # 3462B-2

***CETECOM* Inc.**
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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.231 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-210 & RSS-Gen Issue 5.

No deviations were ascertained.

Responsible for Testing Laboratory:

Date	Section	Name	Signature
07/12/2018	Compliance	James Donnellan (Lab Manager)	

Responsible for the Report:

Date	Section	Name	Signature
07/12/2018	Compliance	Issa Ghanma (EMC Engineer)	Digitally signed by ISSA GHANMA DN: cn=ISSA GHANMA, c=US, o=CETECOM Inc., email=issa.ghanma@cetecom.com Date: 2018.07.12 15:07:15 -07'00'

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
Compliance Manager:	James Donnellan
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Client Firm/Name:	BI Incorporated
Street Address:	6265 Gunbarrel Avenue, Suite B
City/Zip Code	Boulder CO 80301
Country	USA

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

Marketing name:	BI HomeGuard 20|20 Transmitter
PMN:	BI HomeGuard 20|20 Transmitter
Module name:	Blue Gecko
Max. Measured antenna gain (dBi):	-17.35
Type(s) of modulation:	2FSK
Max. Peak output power:	Radiated power: 89.5 dBuV/m
Modes of Operation:	Periodic operation.
Operating voltage range:	Low: 3.0V / High: 3.6V DC
Operating temperature range:	Low: 0˚C / High: 50˚C
Other radios included in the device:	Bluetooth (Disabled)
EUT Dimensions(mm):	52.8 X 73.13 X 23 [L X W X H]
Weight:	93 grams
EUT Diameter:	■< 60 cm ☐Other
Frequency Range / number of channels:	Single channel 318.2 MHz
Sample revision:	☐Prototype Unit; ☐Production Unit; ■Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	Engineering Sample #3	2-10-81870-0 Rev 2	Ver 1.22	Conducted measurement
2	Engineering Sample #1	2-10-81870-0 Rev 2	Ver 1.22	Radiated measurement

3.3 Test Sample Configuration

Set-up #	EUT / AE used for set-up	Comments
1	EUT #1	DC/ Battery
2	EUT #2	DC/ Battery

3.4 Mode of Operation

EUT Set-up #	Combination of AE used for test set up	Comments
1	2FSK	Continuous 2FSK transmission at the maximum output power and duty cycle 318.2 MHz [Radiated and conducted]
2	2FSK	Periodic 2FSK transmission same as the EUT should transmit in realty at 318.2 MHz [conducted]

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on 318.2 channels, and highest possible duty cycle and 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. It was determined during a pretesting that the worst emissions occur with the EUT at vertical orientation.

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 15.231 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-210 & RSS-Gen Issue 5 of ISED Canada.

This test report is to support a request for new equipment authorization under the FCC ID: CSQ-RF2021, and IC ID: 1499A-RF2021

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.231(c) RSS-210 A1.3	Emission Bandwidth	Nominal	2FSK	■	☐	☐	Complies
§15.231(b) RSS-210 A1.2	Field strength	Nominal	2FSK	■	☐	☐	Complies
§15.231(b); §15.205 RSS-210 A1.2	TX Spurious emissions-Radiated	Nominal	2FSK	■	☐	☐	Complies
§15.231(a,3) RSS Gen 210 A1.1.C	Periodic Transmission	Nominal	2FSK	■	☐	☐	Complies
§2.1055; RSS-133 6.3	Frequency Stability	Extreme	-	☐	■	☐	See Note 1
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	-	☐	■	☐	See Note 1 Note 2

Note1: NA= Not Applicable; NP= Not Performed.
Note2: This device does not connect to AC network; hence the test is not applicable.

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)

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:

04/14/2018 - 06/27/2018

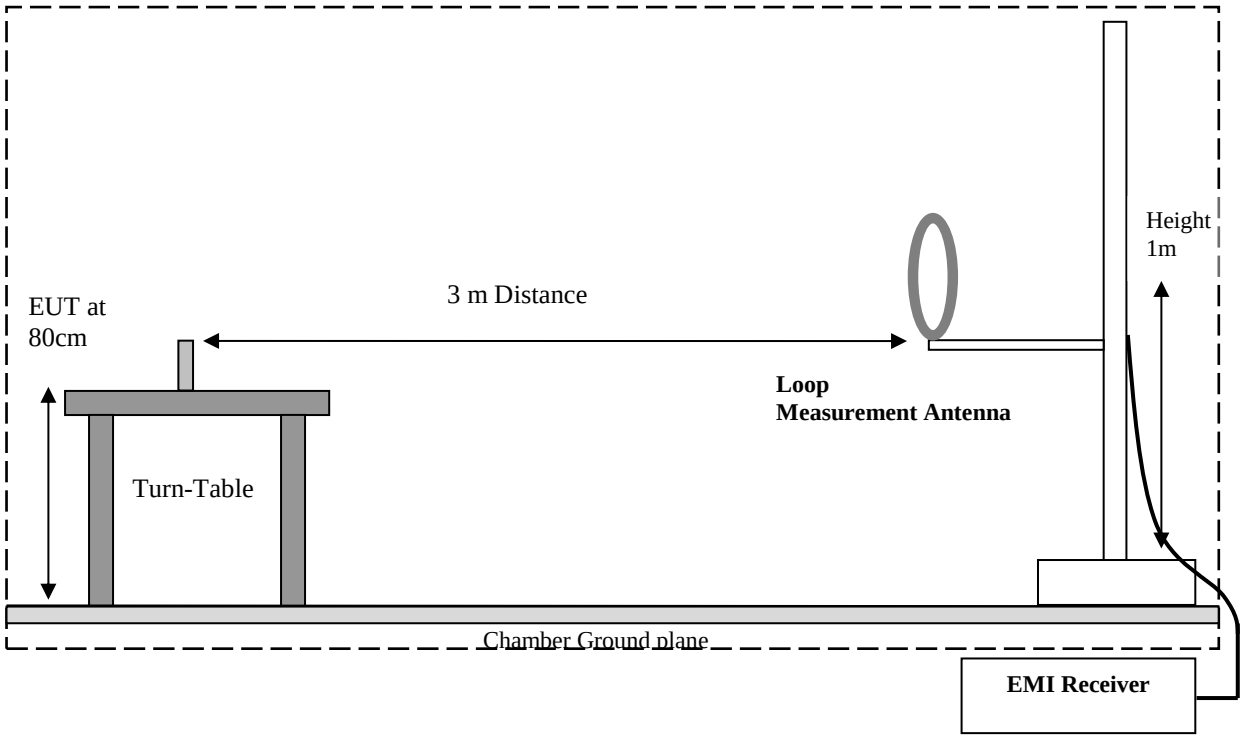
7 Measurement Procedures

7.1 Radiated Measurement

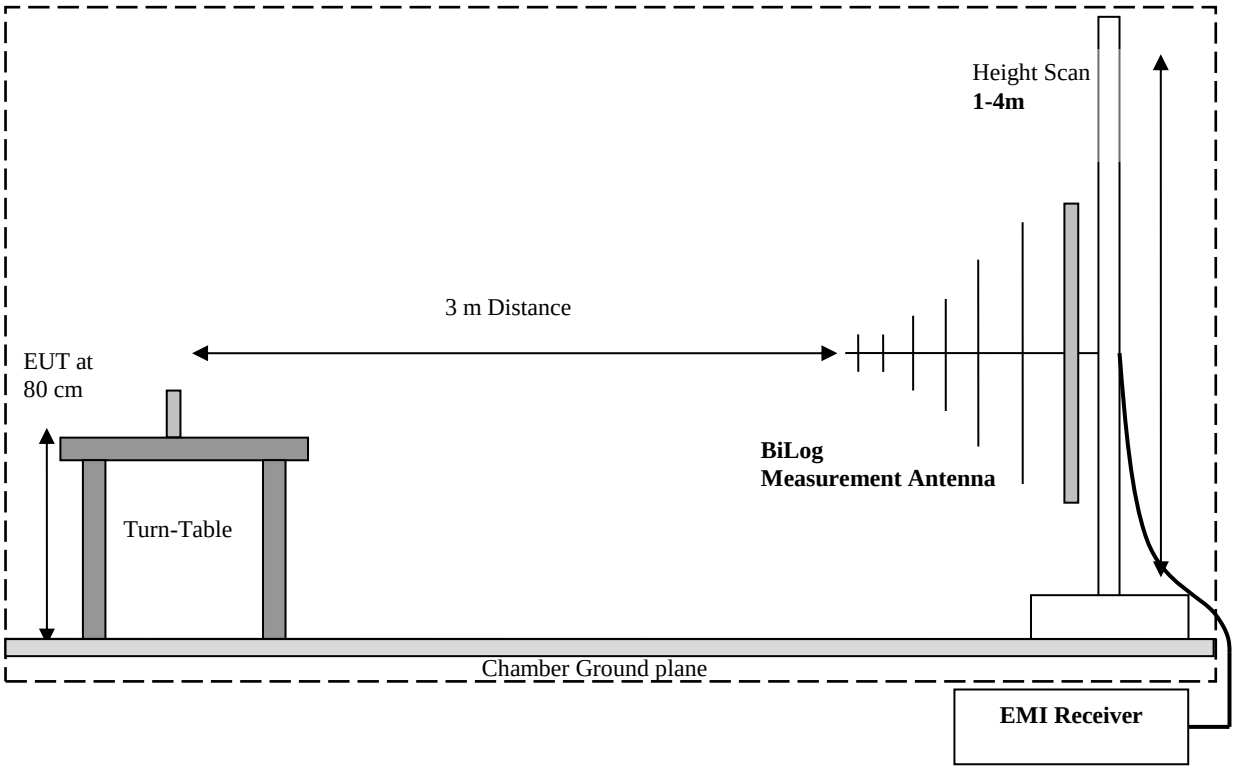
The radiated measurement is performed according to ANSI C63.10 (2013)

- 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.

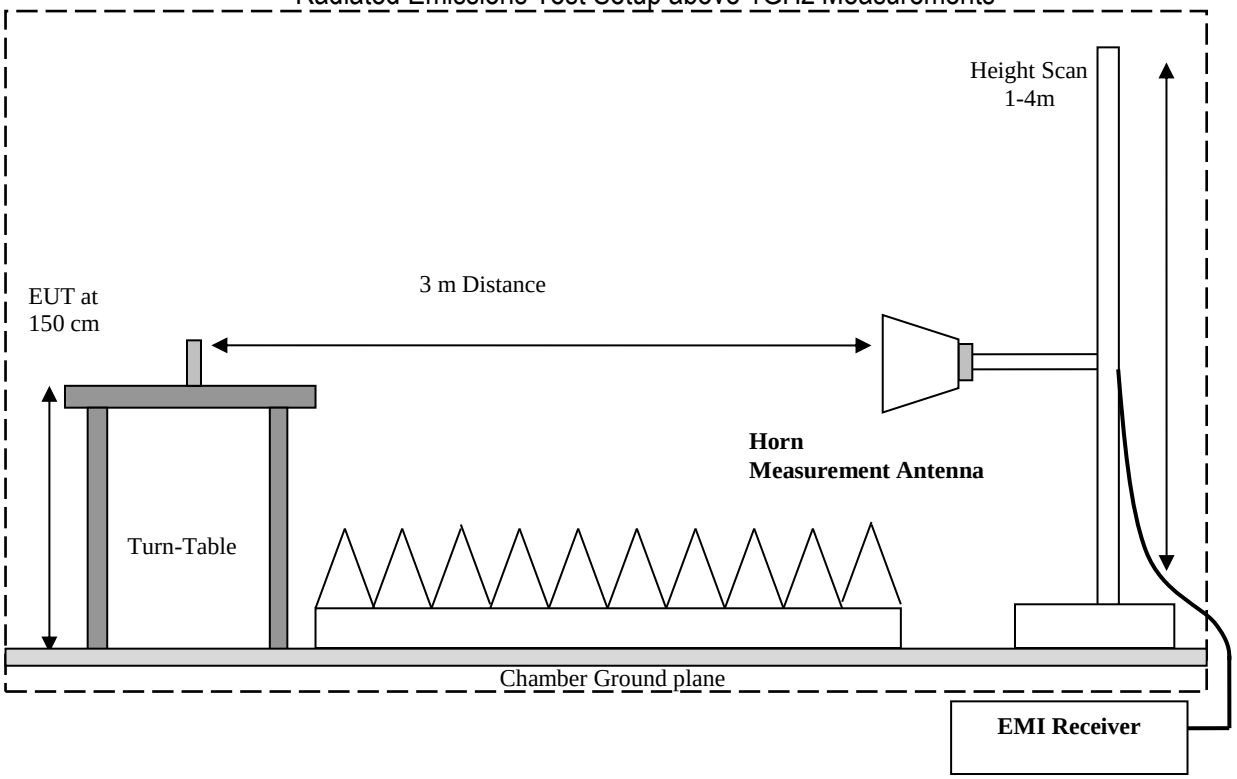
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

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

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

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

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

Example:

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

8 Test Result Data

8.1 Field strength

8.1.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer settings:

- RBW ≥ DTS bandwidth
- VBW ≥ 3 x RBW
- Span ≥ 3 x RBW
- Sweep = Auto couple
- Detector function = RMS
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.1.2 Limits:

Maximum Peak Output Power:

- §15.231(b) and RSS 210 A1.1: In addition to the provisions of §15.205, the field strength of emissions from intentional radiators operated under this section shall not exceed the following:

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)
260-470	3,750 to 12,500 Linear interpolations

8.1.3 Test conditions and setup:

Ambient Temperature	EUT operating mode	Power Input
23° C	318.2 MHz	3.3 V Battery

8.1.4 Measurement result:

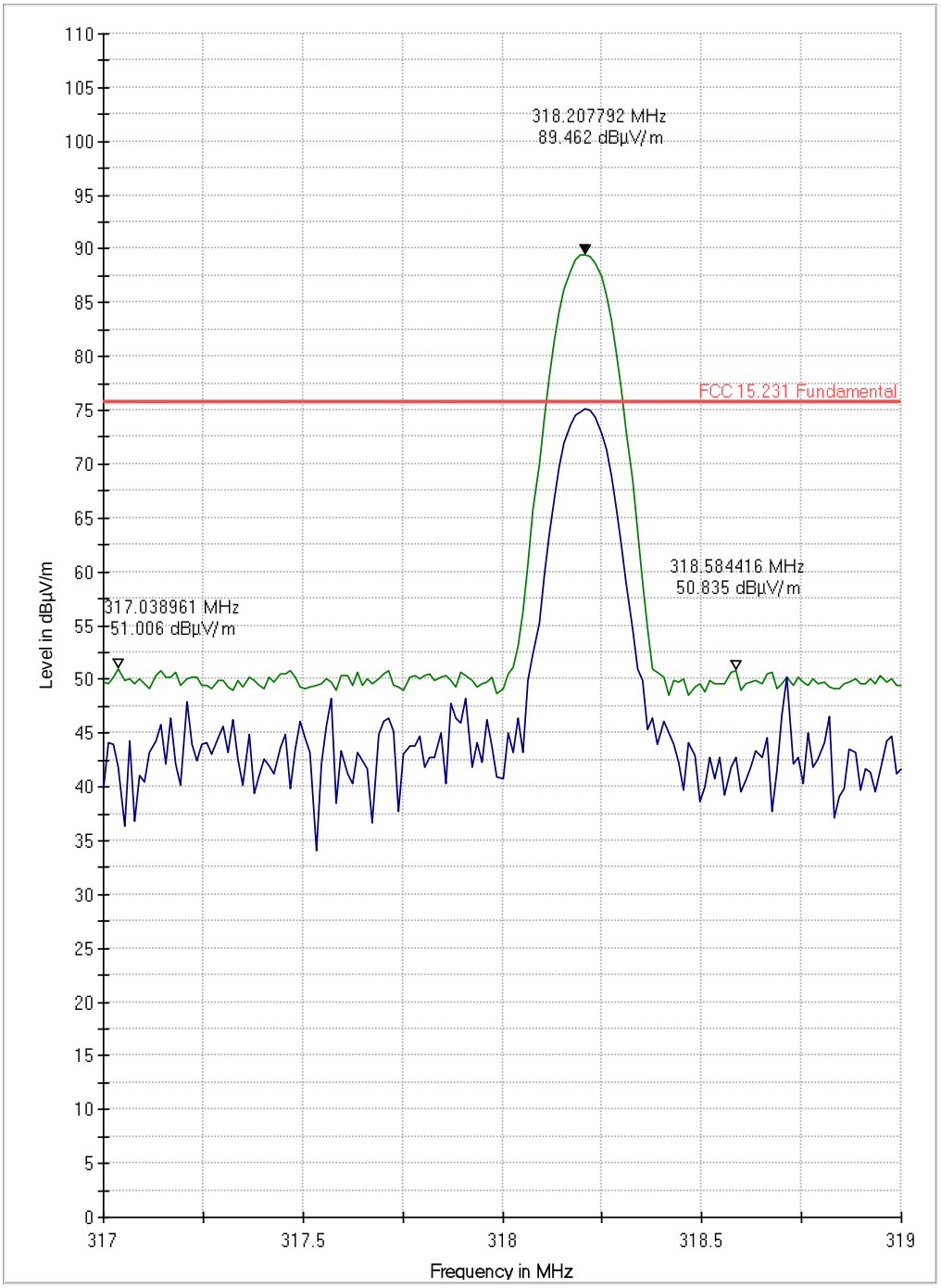
Plot #	EUT Set-Up #	Fundamental frequency (MHz)	Modulation	Fundamental Field Strength (dBµV/m)	Corrected For Duty Cycle* (dBµV/m)	Limit (dBµV/m)	Result
1	2	318.2	2FSK	89.46	67.86	75.8	Pass

Plot #	EUT Set-Up #	Fundamental frequency (MHz)	Modulation	Maximum peak output power (dBm)	Corrected For Duty Cycle* (dBm)
2	1	318.2	2FSK	11.58	-10.02

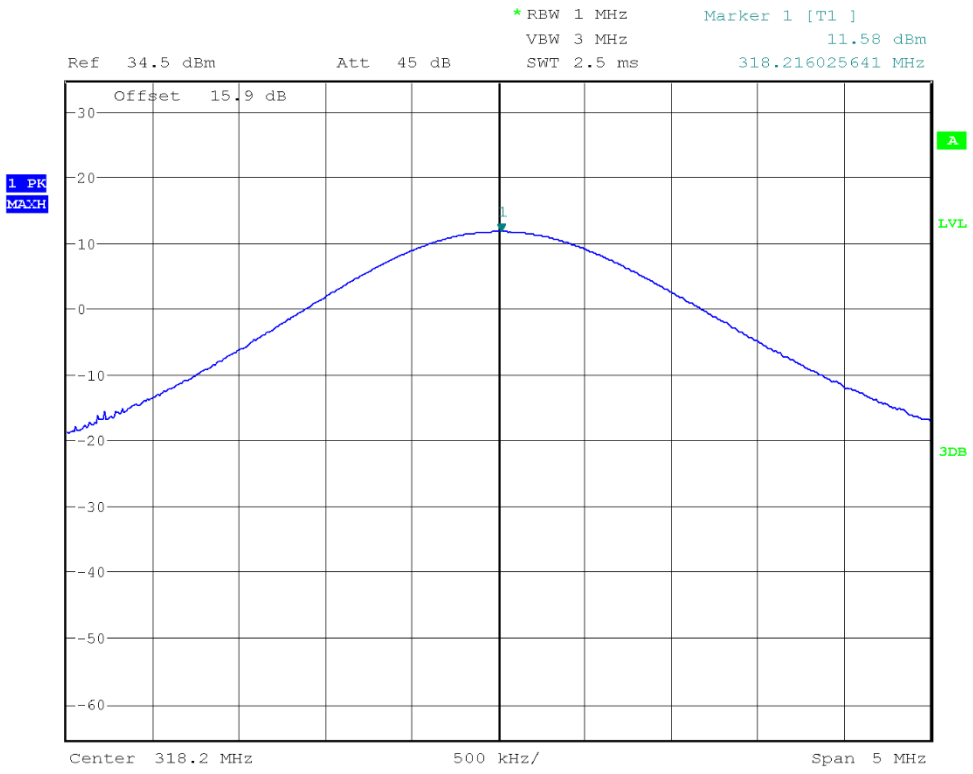
* The field strength results were corrected for the maximum for the device 0.083 duty cycle, by applying an offset of -21.6 dB calculated using the following formula: 20 * log (Duty Cycle) = 20 * log 0.083 = (-21.6 dB)

8.1.5 Measurement Plots:

Plot # 1



Plot # 2


*RBW 1 MHz
VBW 3 MHz
SWT 2.5 ms
Marker 1 [T1]
11.58 dBm
318.216025641 MHz
Ref 34.5 dBm
Att 45 dB
Offset 15.9 dB
1 PK
MAXH
A
LVL
3DB
30
20
10
0
-10
-20
-30
-40
-50
-60
Center 318.2 MHz
500 kHz/
Span 5 MHz
Date: 5.JUN.2018 08:16:37

8.2 Emission Bandwidth

8.2.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer settings:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) ≥ 3 x 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.

8.2.2 Limits:

- FCC §15.231(c): The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. Bandwidth is determined at the points 20 dB down from the modulated carrier.
- RSS-210 A1.1.3: The 99% bandwidth shall be no wider than 0.25% of the center frequency for devices operating between 70 MHz and 900 MHz.

8.2.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	318.2 MHz	3.3 V Battery

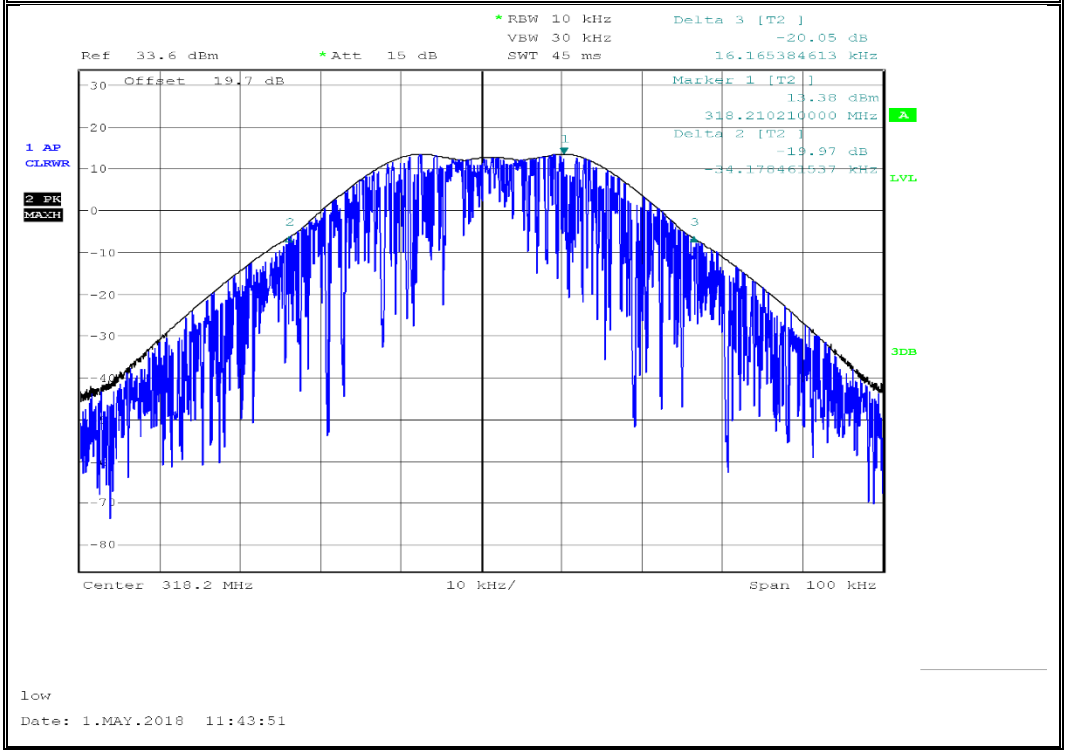
8.2.4 Measurement result:

Plot #	Frequency (MHz)	Modulation	20 dB Bandwidth (KHz)	Limit (KHz)	Result
1	318.2	2FSK	67.16	79.55	Pass

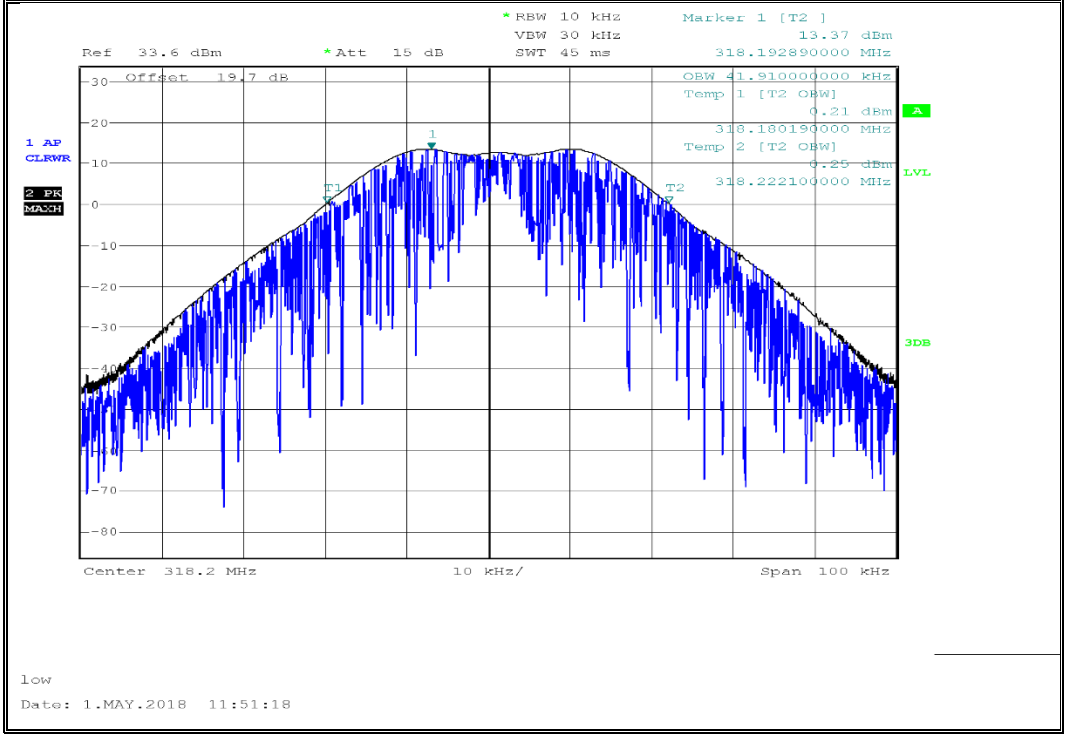
Plot #	Frequency (MHz)	Modulation	99% Emissions Bandwidth (KHz)	Limit (KHz)	Result
2	318.2	2FSK	41.91	79.55	Pass

8.2.5 Measurement Plots:

Plot #1



Plot #2



8.3 Radiated Transmitter Spurious Emissions and Restricted Bands

8.3.1 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

8.3.2 Limits:

- §15.231(b) and RSS 210 A1.1: In addition to the provisions of §15.205, the field strength of emissions from intentional radiators operated under this section shall not exceed the following:

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66-40.70	2,250	225
70-130	1,250	125
130-174	[1]1,250 to 3,750	[1]125 to 375
174-260	3,750	375
260-470	[1]3,750 to 12,500	[1]375 to 1,250
Above 470	12,500	1,250

- 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
[1]0.495-0.505	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 (see §15.205(b)).

8.3.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	318.2 MHz	3.3 VDC

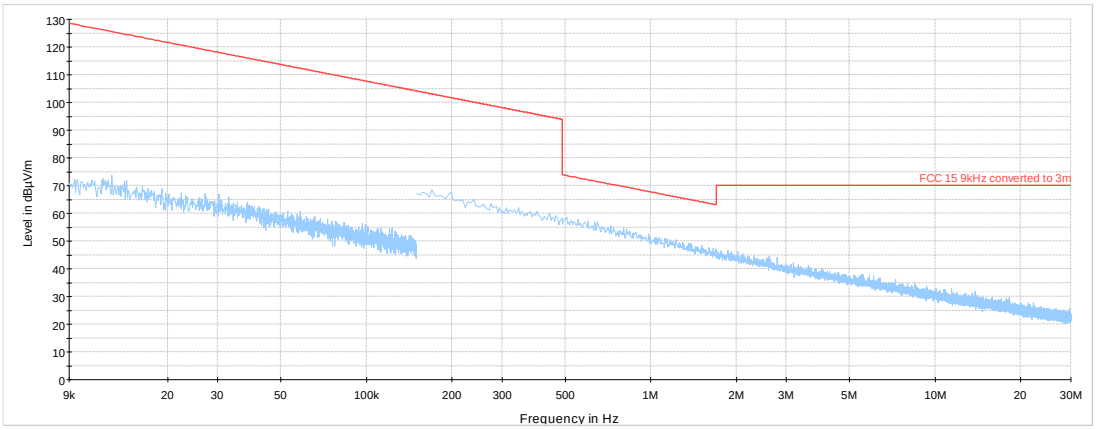
8.3.4 Measurement result:

Plot #	Modulation	Scan Frequency	Limit	Result
1	2FSK	9 kHz – 30 MHz	See section 8.3.2	Pass
2	2FSK	30 MHz – 1 GHz	See section 8.3.2	Pass
3	2FSK	1 GHz – 3 GHz	See section 8.3.2	Pass
4	2FSK	3 GHz – 4.5 GHz	See section 8.3.2	Pass

Note: The field strength results were corrected for the maximum for the device 0.083 duty cycle, by applying an offset of -21.6 dB calculated using the following formula: 20 * log (Duty Cycle) = 20 * log 0.083 = (-21.6 dB)

8.3.5 Measurement Plots:

Plot # 1 Radiated Emissions: 9 KHz – 30 MHz		
Modulation: 2FSK	**Fundamental @ 318.2 MHz**	



Plot # 2 Radiated Emissions: 30 MHz – 1GHz

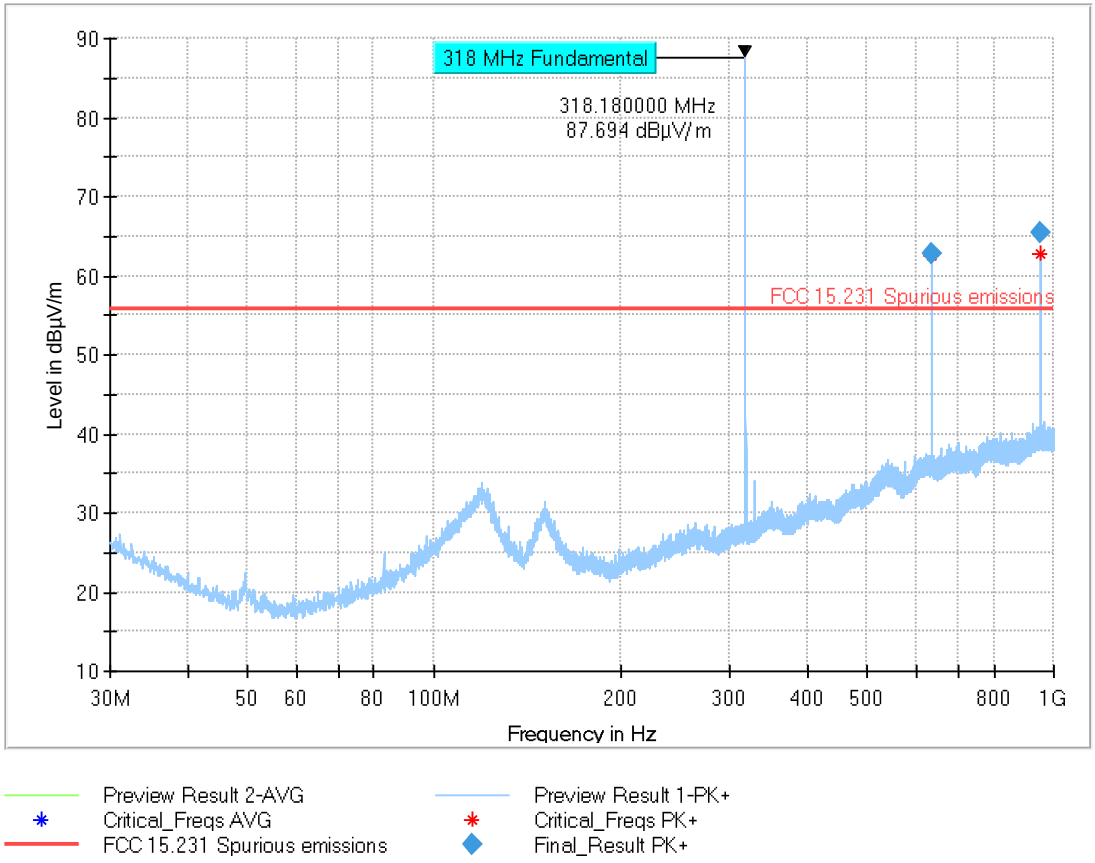
Modulation: 2FSK | **Fundamental @ 318.2 MHz**

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
636.420000	62.78	55.80	-6.98	200.0	120.000	140.0	H	184.0	23.3
954.600000	65.47	55.80	-9.67	200.0	120.000	177.0	V	53.0	26.2

Applying duty factor

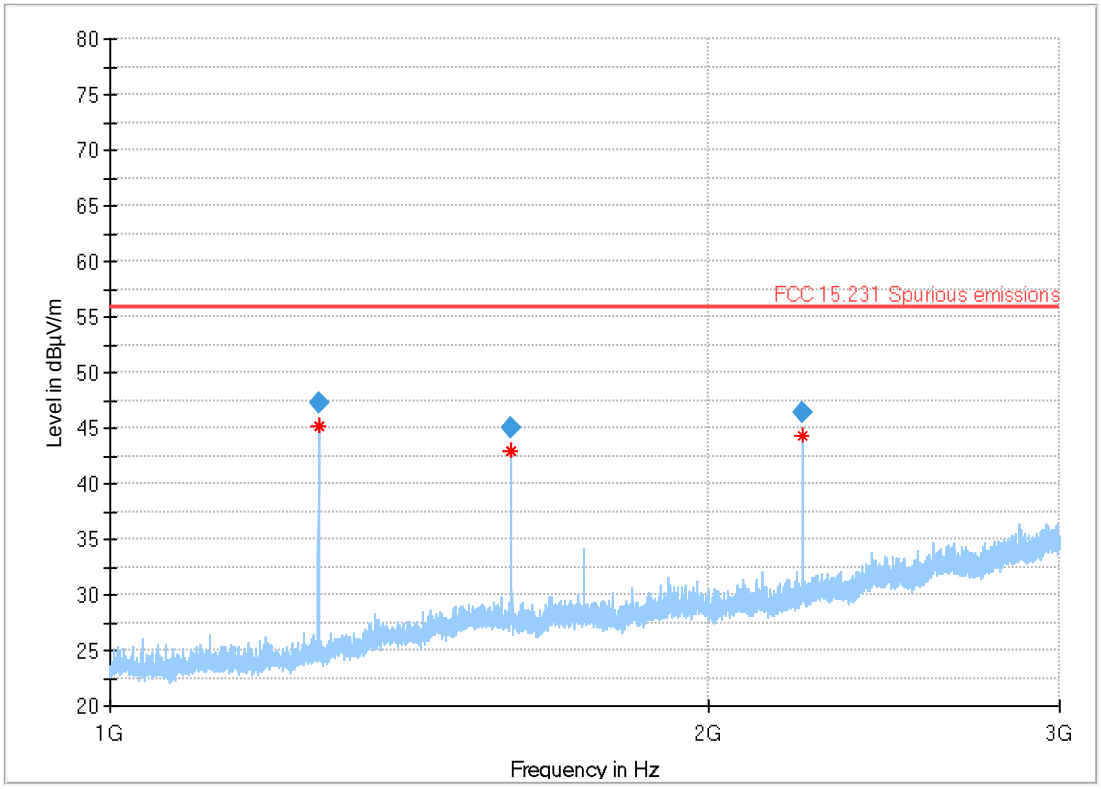
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
636.420000	41.18	55.80	14.62	200.0	120.000	140.0	H	184.0	21.6
954.600000	43.87	55.80	11.93	200.0	120.000	177.0	V	53.0	21.6



Plot # 3 Radiated Emissions: 1GHz - 3 GHz		
Modulation: 2FSK	Fundamental @ 318.2 MHz	

Final_Result

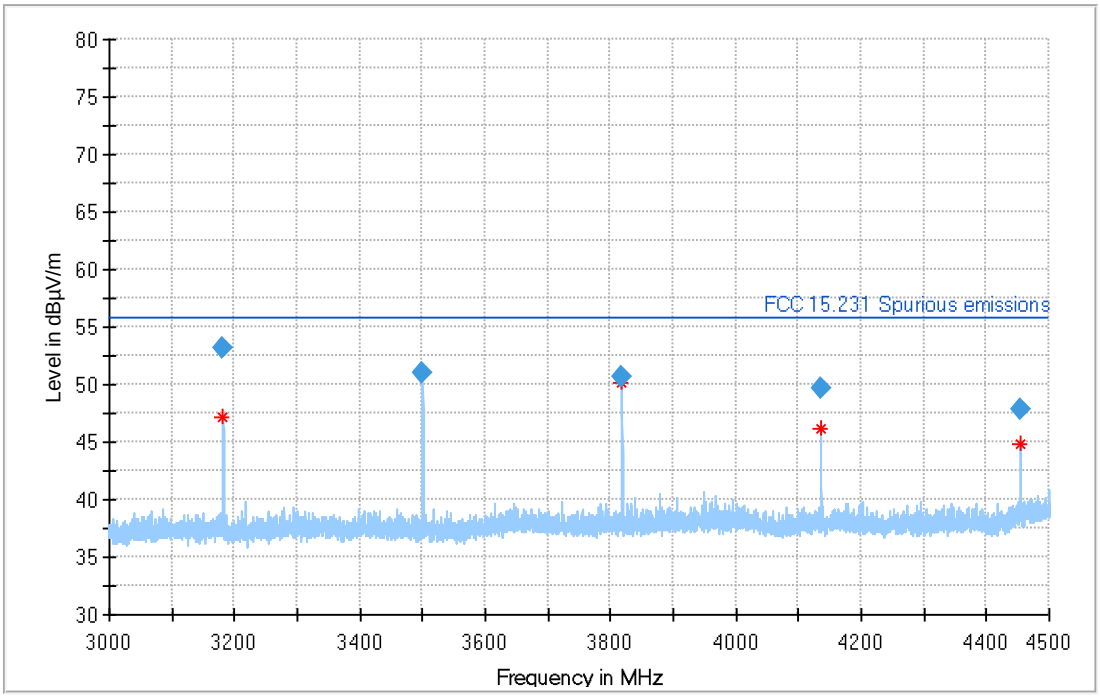
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1272.800000	47.30	55.80	8.50	200.0	1000.000	242.0	V	-20.0	-1.4
1591.100000	44.93	55.80	10.87	200.0	1000.000	156.0	V	33.0	1.5
2227.500000	46.42	55.80	9.38	200.0	1000.000	281.0	V	107.0	3.9



Plot # 4 Radiated Emissions: 3 GHz – 4.5 GHz		
Modulation: 2FSK	**Fundamental @ 318.2 MHz**	

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
3181.900000	53.15	62.00	8.85	200.0	1000.000	161.0	H	300.0	-8.6
3500.400000	50.93	62.00	11.07	200.0	1000.000	195.0	V	273.0	-7.7
3818.600000	50.73	62.00	11.27	200.0	1000.000	157.0	H	89.0	-6.5
4136.500000	49.61	62.00	12.39	200.0	1000.000	300.0	V	-14.0	-5.3
4455.000000	47.89	62.00	14.11	200.0	1000.000	161.0	V	-48.0	-5.1



8.4 Periodic Operation

8.4.1 Limits:

- FCC §15.231 (a) The provisions of this section are restricted to periodic operation within the band 40.66-40.70 MHz and above 70 MHz. Except as shown in paragraph (e) of this section, the intentional radiator is restricted to the transmission of a control signal such as those used with alarm systems, door openers, remote switches, etc. Continuous transmissions, voice, video and the radio control of toys are not permitted. Data is permitted to be sent with a control signal. The following conditions shall be met to comply with the provisions for this periodic operation:

    - (3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

- RSS-210 A1.1: Devices shall comply with the following for momentary operation:
    - C. Periodic transmissions at regular, predetermined intervals are not permitted, except as specified in Section A.1.4. However, polling or supervision transmissions that determine system integrity of transmitters used in security or safety applications are permitted, provided the total duration of transmission does not exceed 2 seconds per hour for each transmitter.

8.4.2 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	318.2 MHz	3.3 V Battery

8.4.3 Measurement result:

Plot #	Frequency (MHz)	Number of pulses per hour
1	318.2	163

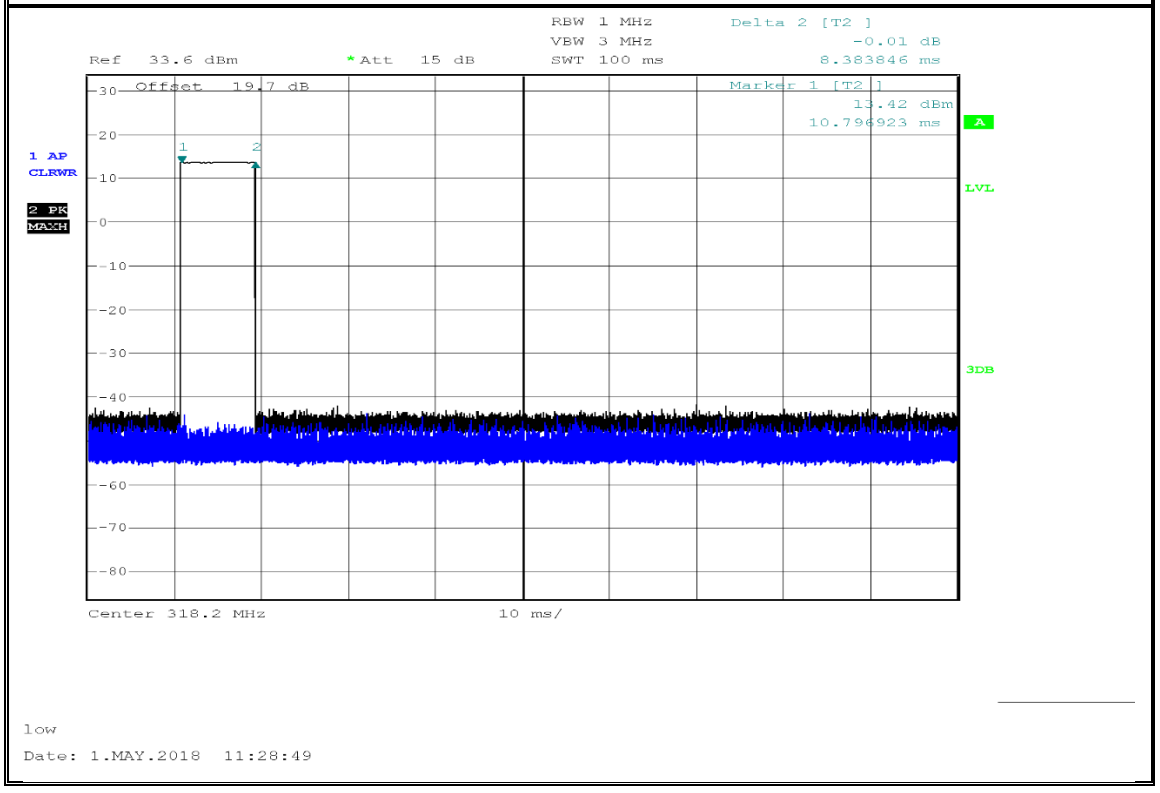
Plot #	Frequency (MHz)	Pulse duration [ms]
2	318.2	8.38

Total duration of transmission = Number of pulses per hour X pulse duration
=1.37 seconds per hour.

8.4.4 Measurement Plots:

Plot #1

Plot #2



9 Test setup photos

Setup photos are included in supporting file name:
"EMC_BIINC_004_18001_FCC_15.231_ISED_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Biconlog Antenna	EMCO	3142E	166067	3 years	6/27/2017
Loop Antenna	ETS Lindgren	6512	164698	3 years	7/8/2017
Horn Antenna	ETS Lindgren	3115	35114	3 years	31/6/2017
HORN ANTENNA	ETS LINDGREN	3117	00167061	3 YEARS	08/08/2017
Compact Digital Barometer	Control Company	35519-055	91119547	2 Years	6/8/2017
Test Receiver	R&S	ESU.EMI	100256	3 years	01/31/2018
Spectrum Analyzer	R&S	FSU26	200302	2 years	7/5/2017
Thermometer Humidity	Dickson	TM320	1625369	1 Year	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 History

Date	Report Name	Changes to report	Report prepared by
06/18/2018	EMC_BIINC-004-18001_FCC_15.231_ISED	Initial Version	Issa Ghanma
06/28/2018	EMC_BIINC_004_18001_FCC_15.231_ISED_REV_1	1- Update the report name. 2- Update testing dates. 3- Update date of report. 4- Applying duty cycle factor to peak rather than quasi peak	Issa Ghanma
07/12/2018	EMC_BIINC_004_18001_FCC_15.231_ISED_REV_2	5- Correct the antenna gain unit [dBm] to [dBi]	Issa Ghanma