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TEST REPORT

FCC/IC SIGFOX Test for SRM100A

Certification

APPLICANT

SEONG JI INDUSTRIAL CO.,LTD

REPORT NO.

HCT-RF-1911-FI014-R1

DATE OF ISSUE

December 16, 2019

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FCC ID/IC
2AS8LSRM100A / 25119-SRM100A

Applicant **SEONG JI INDUSTRIAL CO.,LTD**
54-33, DongtanHana 1-gil, Hwaseong-si, Gyeonggi-do, 18423, Korea

Eut Type Model Name	Monarch module SRM100A
Date of Receipt	September 09, 2019
RF Peak Output Power	23.904 dBm (245.70 mW)
FCC Rule Part(s): ISED Rule Part(s):	Part 15.247 RSS-247 Issue 2 (February 2017), RSS-GEN Issue 5 (March 2019)
FCC Classification:	FCC Part 15 Spread Spectrum Transmitter

This test results were applied only to the test methods required by the standard.

Tested by
Se Wook Park

(signature)

Technical Manager
Jong Seok Lee

(signature)

HCT CO., LTD.

Soo Chan Lee
SooChan Lee / CEO

REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	November 13, 2019	Initial Release
1	December 16, 2019	Retested the Conducted Bandedge on Page 37 Added the List Of Test Equipment on Page 81

Engineering Statement:

The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC / IC Rules under normal use and maintenance. measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC / IC Rules under normal use and maintenance.

CONTENTS

1. EUT DESCRIPTION	5
2. Requirements for Bluetooth transmitter(15.247)	6
3. TEST METHODOLOGY	7
EUT CONFIGURATION	7
EUT EXERCISE	7
GENERAL TEST PROCEDURES	7
DESCRIPTION OF TEST MODES	8
4. INSTRUMENT CALIBRATION	8
5. FACILITIES AND ACCREDITATIONS	8
FACILITIES	8
EQUIPMENT	8
6. ANTENNA REQUIREMENTS	9
7. MEASUREMENT UNCERTAINTY	10
8. DESCRIPTION OF TESTS	11
9. SUMMARY OF TEST RESULTS	31
10. TEST RESULT	32
10.1 PEAK POWER	32
10.2 BAND EDGES	37
10.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW)	40
10.4 NUMBER OF HOPPING FREQUENCY	50
10.5 TIME OF OCCUPANCY (DWELL TIME)	53
10.6 SPURIOUS EMISSIONS	59
10.6.1 CONDUCTED SPURIOUS EMISSIONS	59
10.6.2 RADIATED SPURIOUS EMISSIONS	67
10.7 RECEIVER SPURIOUS EMISSIONS	76
10.8 POWERLINE CONDUCTED EMISSIONS	77
11. LIST OF TEST EQUIPMENT	81
12. ANNEX A_ TEST SETUP PHOTO	83

1. EUT DESCRIPTION

Model	SRM100A
EUT Type	Monarch module
Power Supply	DC 3.3 V
Frequency Range	RC2: 902.1375 MHz – 904.6625 MHz RC4: 920.7375 MHz – 923.2625 MHz
Max. RF Output Power	23.904 dBm (245.70 mW)
Modulation Type	DBPSK
Number of Channels	RC2: 54 Channels (9 Macro channels x 6 Micro channels) RC4: 54 Channels (9 Macro channels x 6 Micro channels)
Antenna Specification	Antenna type: Dipole Antenna Peak Gain : 1.98 dBi
Date(s) of Tests	September 09, 2019 ~ November 08, 2019
PMN (Product Marketing Number)	SRM100A
HVIN (Hardware Version Identification Number)	SRM100A
FVIN (Firmware Version Identification Number)	N/A
HMN (Host Marketing Name)	N/A

2. Requirements for Bluetooth transmitter(15.247)

This Sigfox module has been tested by a Sigfox Qualification Lab, and we confirm the following:

- 1) This system is hopping pseudo-randomly.
 - 2) Each frequency is used equally on the average by each transmitter.
 - 3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
 - 4) The receiver shifts frequencies in synchronization with the transmitted signals.
- **15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.**

- **15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.**

The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

- RSS-247 5.1 (a): The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

3. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device (ANSI C63.10-2013, KDB 558074) is used in the measurement of the test device.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C. / RSS-GEN issue 5, RSS-247 issue 2.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3.75 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013). To record the final measurements, the analyzer detector function was set to CISPR quasi-peak mode and the bandwidth of the spectrum analyzer was set to 120 kHz for frequencies below 1 GHz or 1 MHz for frequencies above 1 GHz. For average measurements above 1 GHz, the analyzer was set to peak detector with a reduced VBW setting($RBW = 1 \text{ MHz}$, $VBW = 1/T \text{ Hz}$, where $T = \text{Pulse width}$).

DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

4. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipments, which is traceable to recognized national standards.

Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

5. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA.

The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032).

For ISED, test facility was accepted dated February 14, 2019 (CAB identifier: KR0032).

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements. Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

6. ANTENNA REQUIREMENTS

According to FCC 47 CFR § 15.203:

“An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.”

* The antennas of this E.U.T are permanently attached.

* The E.U.T Complies with the requirement of § 15.203

According to RSS-GEN(Issue 5) Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested..

7. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicate a 95 % level of confidence.

The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	E
Conducted Disturbance (150 kHz ~ 30 MHz)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70
Radiated Disturbance (18 GHz ~ 40 GHz)	5.05

8. DESCRIPTION OF TESTS

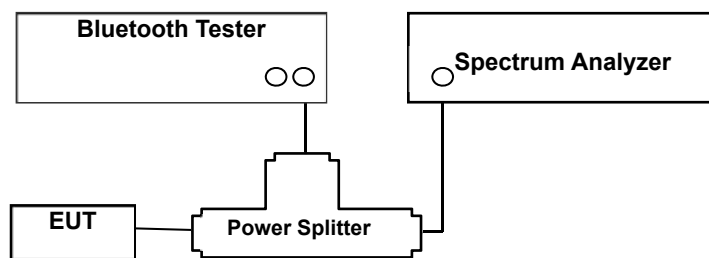
8.1. Conducted Maximum Peak Output Power

Limit

The maximum peak output power of the intentional radiator shall not exceed the following:

1. For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 W.
For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 W.
2. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer. The Spectrum Analyzer is set to the peak detector mode. This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.5 in ANSI 63.10-2013 & Procedure 10(b)(6)(i) in KDB 558074 v05r02)

- 1) Span: approximately 5 times the 20 dB bandwidth, centered on a hopping channel
- 2) RBW > the 20 dB bandwidth of the emission being measured
- 3) VBW ≥ RBW
- 4) Sweep = Auto
- 5) Detector = Peak
- 6) Trace = Max hold

Sample Calculation

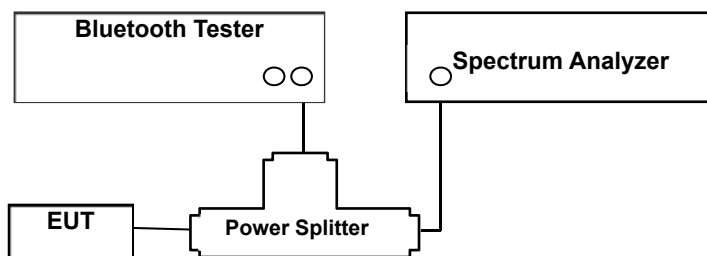
$$\begin{aligned} \text{Output Power} &= \text{Spectrum Reading Power} + \text{Power Splitter loss} + \text{Cable loss(2 ea)} \\ &= 10 \text{ dBm} + 6 \text{ dB} + 1.5 \text{ dB} = 17.5 \text{ dBm} \end{aligned}$$

8.2. Conducted Band Edge(Out of Band Emissions)

Limit

According to § 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.

Test Configuration



Test Procedure

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

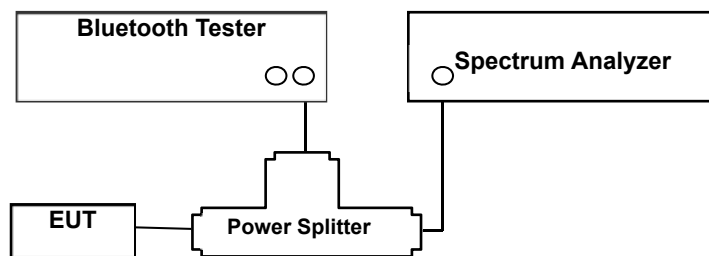
- 1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
- 2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (OBW/RBW)]$ below the reference level.
- 3) Attenuation: Auto (at least 10 dB preferred).
- 4) Sweep time: Coupled.
- 5) RBW: 100 kHz
- 6) VBW: 300 kHz
- 7) Detector: Peak
- 8) Trace: Max hold

8.3. Frequency Separation & 20 dB Bandwidth

Limit

According to § 15.247(a)(1), Frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Configuration



Test Procedure(Frequency Separation)

The Channel Separation test is performed with hopping on.

And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013 & Procedure 10(b)(6)(iii) in KDB 558074 v05r02)

- 1) Span: Wide enough to capture the peaks of two adjacent channels
- 2) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.
- 8) Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

Test Procedure (20 dB Bandwidth)

And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (6.9.2 in ANSI 63.10-2013)

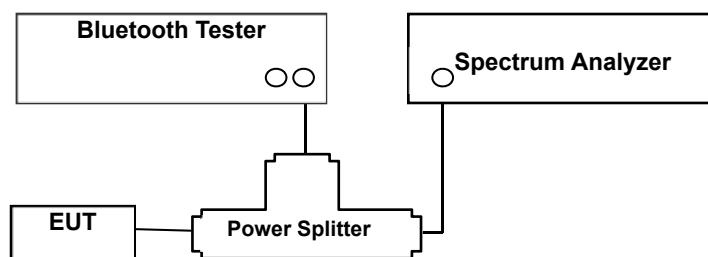
- 1) Span: Set between two times and five times the OBW
- 2) RBW: 1% to 5% of the OBW.
- 3) VBW \geq 3xRBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.

8.4. Number of Hopping Frequencies

Limit

According to § 15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands shall use at least 15 hopping frequencies.

Test Configuration



Test Procedure

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013 & Procedure 10(b)(4) in KDB 558074 v05r02)

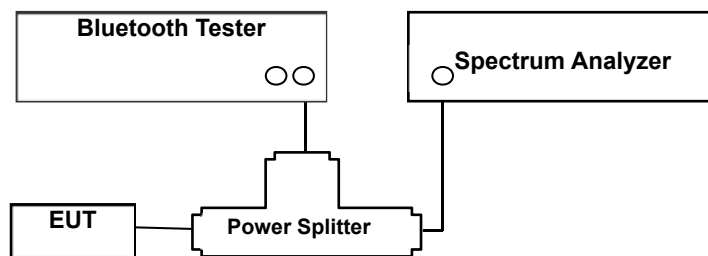
- 1) Span: the frequency band of operation
- 2) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) Allow the trace to stabilize.

8.5. Time of Occupancy

Limit

According to § 15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands. The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

Test Configuration



Test Procedure

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013 & Procedure 10(b)(6)(iv) in KDB 558074 v05r02)

- 1) Span: Zero span, centered on a hopping channel
- 2) RBW shall be \leq channel spacing and where possible RBW should be set $\gg 1 / T$, where T is the expected dwell time per channel.
- 3) Sweep = as necessary to capture the entire dwell time per hopping channel
- 4) Detector: Peak
- 5) Trace: Max hold

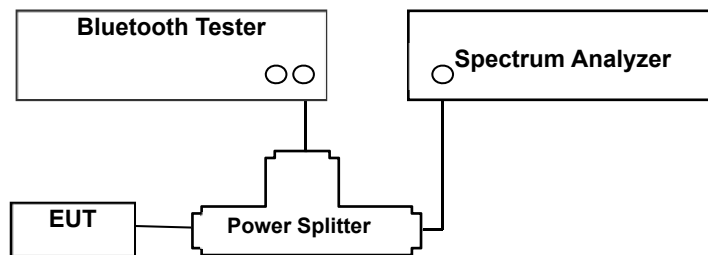
The marker-delta function was used to determine the dwell time.

8.6. Conducted Spurious Emissions

Limit

Conducted > 20 dBc

Test Configuration



Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

- 1) Span: 30 MHz to 10 times the operating frequency in GHz.
- 2) RBW: 100 kHz
- 3) VBW: 300 kHz
- 4) Sweep: Coupled
- 5) Detector: Peak

Measurements are made over the 30 MHz to 25 GHz range with the transmitter set to the lowest, middle, and highest channels.

This test is performed with hopping off.

Factors for frequency

Freq(MHz)	Factor(dB)
30	21.30
100	19.83
200	20.19
300	20.13
400	20.19
500	20.21
600	20.23
700	20.22
800	20.24
900	20.25
1000	20.39
2000	20.44
2400	20.45
2500	20.57
3000	20.68
4000	20.89
5000	21.07
6000	21.06
7000	21.35
8000	21.32
9000	21.48
10000	21.56
11000	21.56
12000	21.68
13000	21.83
14000	21.90
15000	21.98
16000	22.04
17000	22.02
18000	22.08
19000	22.07
20000	22.14
21000	22.17
22000	22.31
23000	22.60
24000	22.34
25000	22.53
26000	21.07

Note : 1. ‘*’ is fundamental frequency range.

2. Factor = Cable loss + Attenuator(20 dB)

8.7. Radiated Test

Limit

FCC

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30

IC

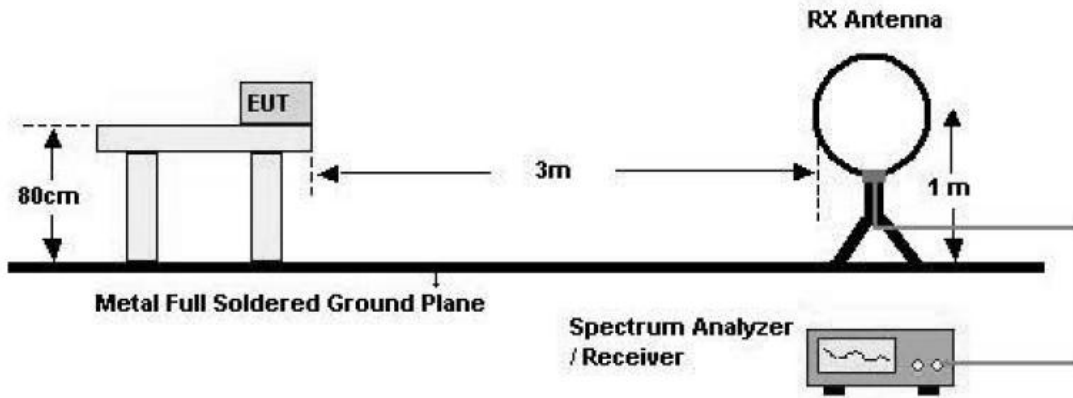
Frequency (MHz)	Field Strength (uA/m)	Measurement Distance (m)
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30

FCC&IC

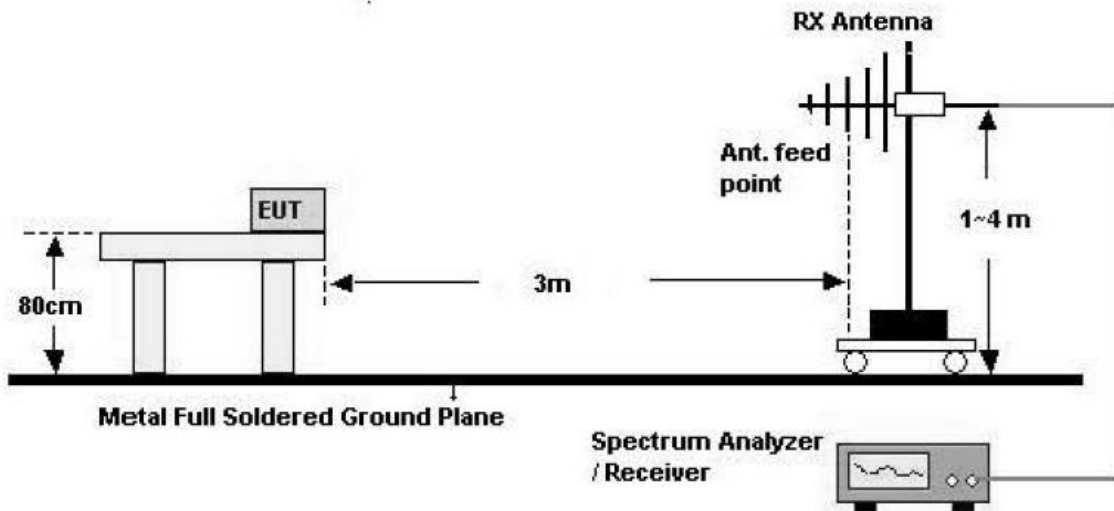
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Test Configuration

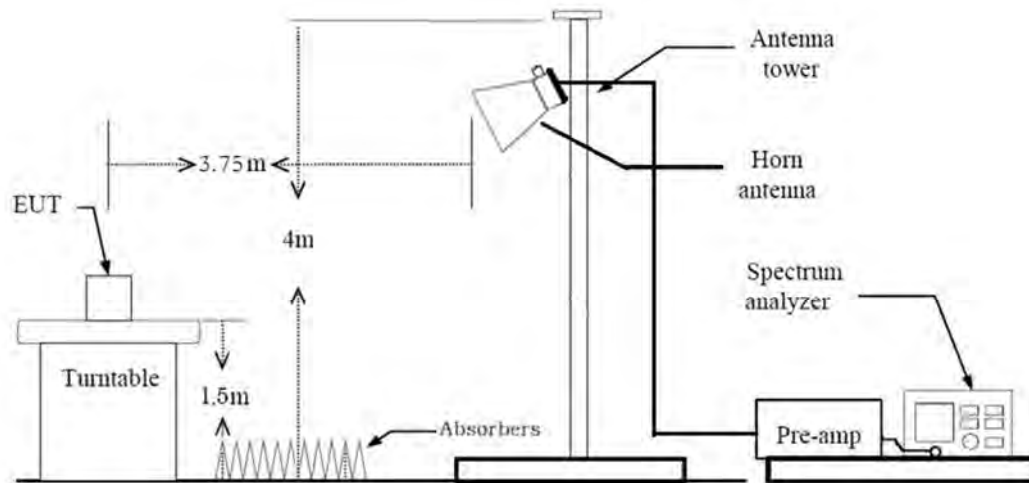
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions(Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3m from the EUT
3. The EUT is placed on a turntable, which is 0.8m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization and Parallel to the ground plane in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor(0.009 MHz – 0.490 MHz) = $40 \times \log(3 \text{ m}/300 \text{ m}) = - 80 \text{ dB}$
Measurement Distance : 3 m
7. Distance Correction Factor(0.490 MHz – 30 MHz) = $40 \times \log(3 \text{ m}/30 \text{ m}) = - 40 \text{ dB}$
Measurement Distance : 3 m
8. Spectrum Setting
 - Frequency Range = 9 kHz ~ 30 MHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 9 kHz
 - VBW \geq 3xRBW
9. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

KDB 414788 OFS and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

(Worst case: semi-anechoic chamber(10 m chamber))

Test Procedure of Radiated spurious emissions(Below 1GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

5. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Peak
- Trace = Maxhold
- RBW = 100 kHz
- VBW \geq 3xRBW

(2) Measurement Type(Quasi-peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Quasi-Peak
- RBW = 120 kHz

*In general, (1) is used mainly

6. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L)

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
*Distance extrapolation factor = $20 \times \log(\text{test distance} / \text{specific distance})$ (dB)
7. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
8. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
9. The unit was tested with its standard battery.
10. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 1 GHz – 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW \geq 3xRBW
 - (2) Measurement Type(Average):
 - We performed using a reduced video BW method was done with the analyzer in linear mode
 - Measured Frequency Range : 1 GHz – 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW \geq $1/\tau$ Hz, where τ = pulse width in seconds
 - The actual setting value of VBW = 1 kHz
11. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
12. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

Test Procedure of Radiated Restricted Band Edge

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
*Distance extrapolation factor = $20 \times \log(\text{test distance} / \text{specific distance})$ (dB)
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. The unit was tested with its standard battery.

9. Spectrum Setting

(1) Measurement Type(Peak):

- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW \geq 3xRBW

(2) Measurement Type(Average):

- Average value of pulsed emissions
- Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission and pulsed operation is employed, the average measurement shall determined from the peak field strength after correcting for the worst-case duty cycle as described in section 9.1.
- DCCF = $20 \times \log_{10}(\text{Pulse width} / \text{Period of the pulse train})$

10. Total(Measurement Type : Peak)

= Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

Total(Measurement Type : Average)

= Peak Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

+ Duty Cycle Correction Factor

11. Duty Cycle Correction Factor (79 channel hopping)

- a. Time to cycle through all channels = $\Delta t = \tau \text{ [ms]} \times 79 \text{ channels} = 229.100 \text{ ms}$, where τ = pulse width
- b. $100 \text{ ms} / \Delta t \text{ [ms]} = H \rightarrow$ Round up to next highest integer, $H' = 1$
- c. Worst Case Dwell Time = $\tau \text{ [ms]} \times H' = 2.9 \text{ ms}$
- d. Duty Cycle Correction = $20 \log (\text{Worst Case Dwell Time} / 100 \text{ms}) \text{ dB} = -30.752 \text{ dB}$

12. Duty Cycle Correction Factor (AFH mode – minimum channel number case - 20 channels)

- a. Time to cycle through all channels = $\Delta t = \tau \text{ [ms]} \times 20 \text{ channels} = 58.00 \text{ ms}$, where τ = pulse width
- b. $100 \text{ ms} / \Delta t \text{ [ms]} = H \rightarrow$ Round up to next highest integer, $H' = 2$
- c. Worst Case Dwell Time = $\tau \text{ [ms]} \times H' = 5.800 \text{ ms}$
- d. Duty Cycle Correction (AFH) = $20 \log (\text{Worst Case Dwell Time} / 100 \text{ms}) \text{ dB} = -24.7314 \text{ dB}$

8.8. AC Power line Conducted Emissions

Limit

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, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dB μ V)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.
5. The EUT is the device operating below 30 MHz.
 - For unterminated the Antenna, the AC line conducted tests are performed with the antenna connected
 - For terminated the Antenna, the AC line conducted tests are performed with a dummy load connected to the EUT antenna output terminal.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

8.9. Receiver Spurious Emissions

Limit

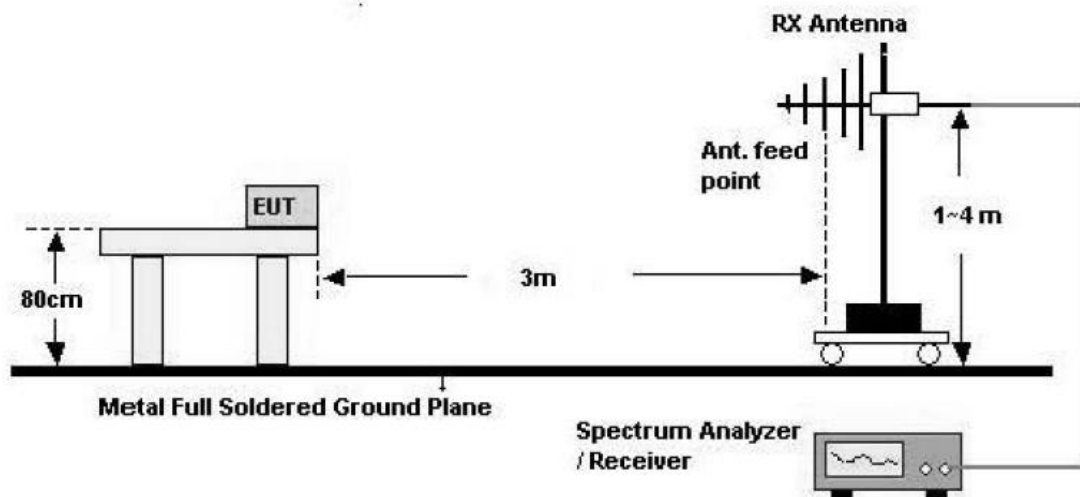
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

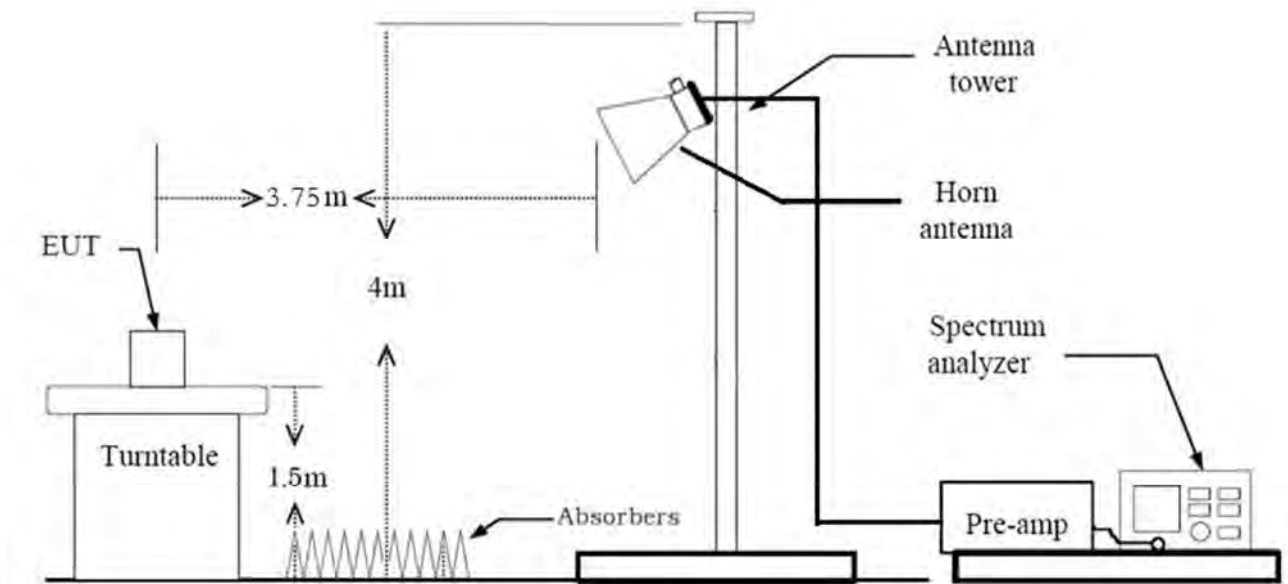
Measurements for compliance with the limits in table may be performed at distances other than 3 metres.

Test Configuration

30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. The unit was tested with its standard battery.
9. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range : 1 GHz – 25 GHz

- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW \geq 3xRBW

(2) Measurement Type(Average):

- We performed using a reduced video BW method was done with the analyzer in linear mode
- Measured Frequency Range : 1 GHz – 25 GHz
- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW \geq $1/\tau$ Hz, where τ = pulse width in seconds

The actual setting value of VBW = 1 kHz

10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

11. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G) + Distance Factor(D.F)

8.10. Worst case configuration and mode

Radiated test

1. All modes of operation were investigated and the worst case configuration results are reported.
 - Mode : Stand alone, Stand alone
2. EUT Axis
 - Radiated Spurious Emissions : X
 - Radiated Restricted Band Edge : X
3. All data rate of operation were investigated and the test results are worst case in highest datarate of each mode.
 - GFSK : DH5
 - $\pi/4$ DQPSK : 2-DH5
 - 8DPSK : 3-DH5
4. All position of loop antenna were investigated and the test result is a no critical peak found at all positions.
 - Position : Horizontal, Vertical, Parallel to the ground plane

Conducted test

1. The EUT was configured with data rate of highest power.
 - GFSK : DH5
 - $\pi/4$ DQPSK : 2-DH5
 - 8DPSK : 3-DH5

9. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	IC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§ 15.247(a)(1)	RSS-247, 5.1	N/A	Conducted	PASS
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A		N/A
Conducted Maximum Peak Output Power	§ 15.247(b)(1)	RSS-247, 5.1 b)	< 0.125 W		PASS
Carrier Frequency Separation	§ 15.247(a)(1)	RSS-247, 5.1 b)	> 25 kHz or >2/3 of the 20dB BW		PASS
Number of Hopping Frequencies	§ 15.247(a)(1)(iii)	RSS-247, 5.1 d)	≥ 15		PASS
Time of Occupancy	§ 15.247(a)(1)(iii)	RSS-247, 5.1 d)	< 400 ms		PASS
Conducted Spurious Emissions	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions		PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§ 15.207(a)	RSS-GEN, 8.8	cf. Section 8.8		N/A
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9	cf. Section 8.7	Radiated	PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9 RSS-GEN, 8.10	cf. Section 8.7		PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7	cf. Section 8.9		PASS

10. TEST RESULT

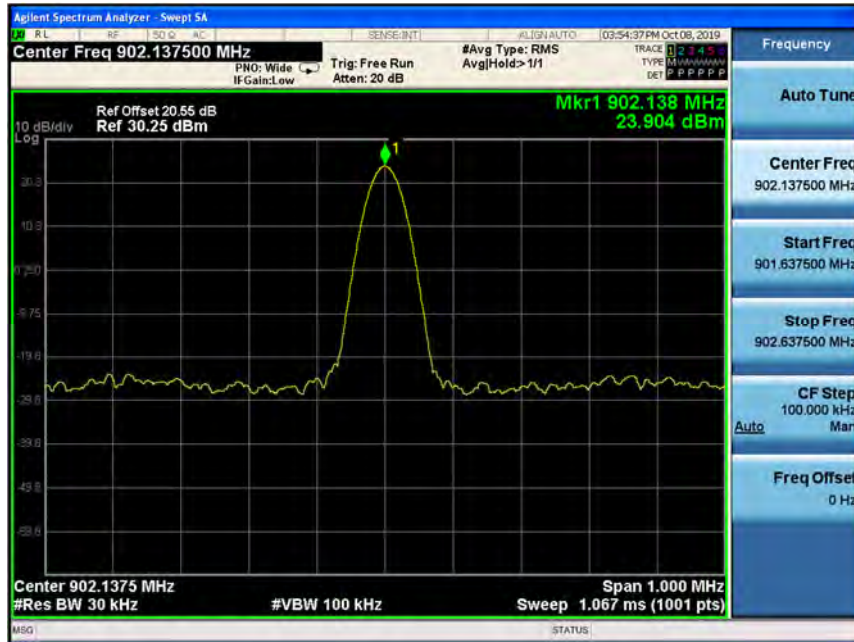
10.1 PEAK POWER

Test Data

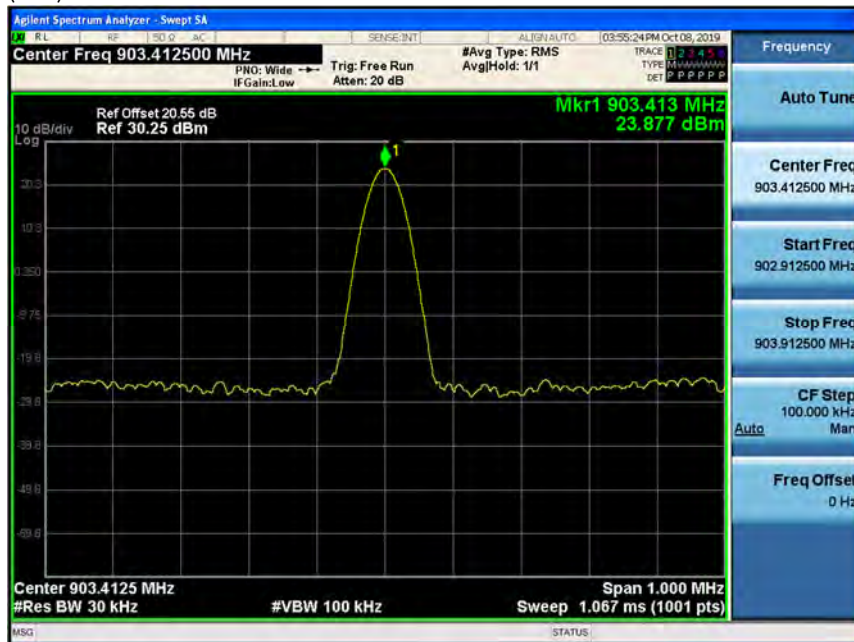
Channel	Frequency (MHz)	Output Power (RC2)		Limit (mW)	Result
		(dBm)	(mW)		
Low	902.1375	23.904	245.70	1000	PASS
Mid	903.4125	23.877	244.17		PASS
High	904.6625	23.839	242.05		PASS

Channel	Frequency (MHz)	Output Power (RC4)		Limit (mW)	Result
		(dBm)	(mW)		
Low	920.7375	23.350	216.27	1000	PASS
Mid	922.0125	23.307	214.14		PASS
High	923.2625	23.266	212.13		PASS

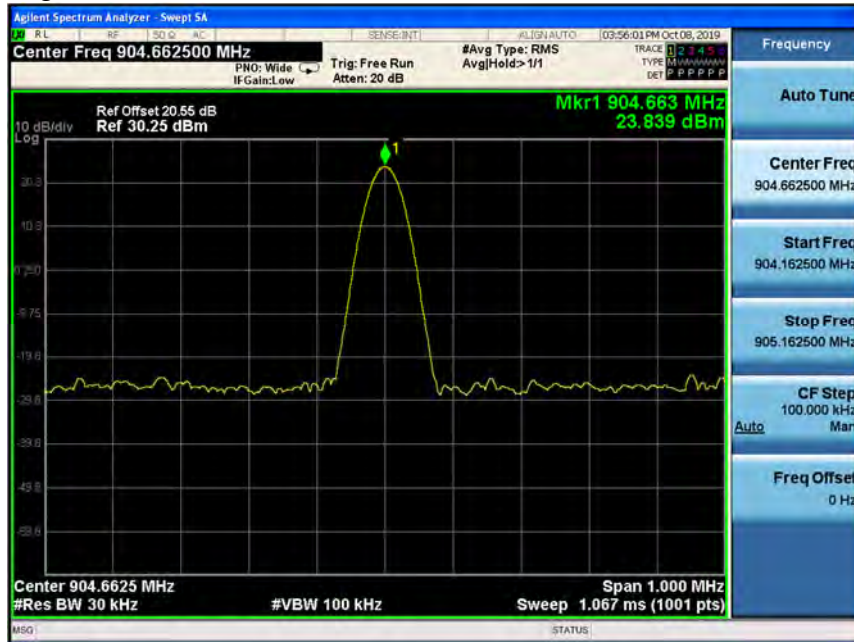
Test Plots (RC2)
Peak Power (Low)



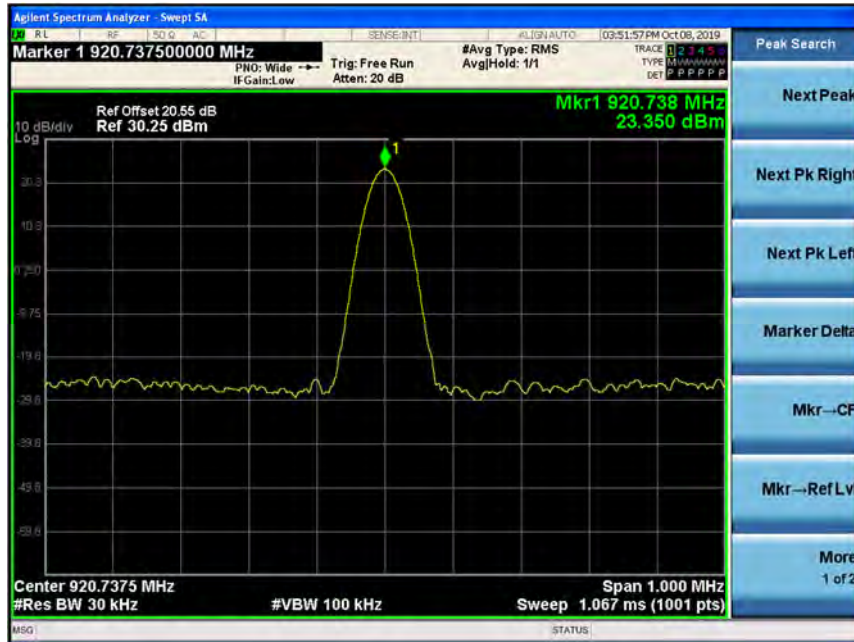
Test Plots (RC2)
Peak Power (Mid)



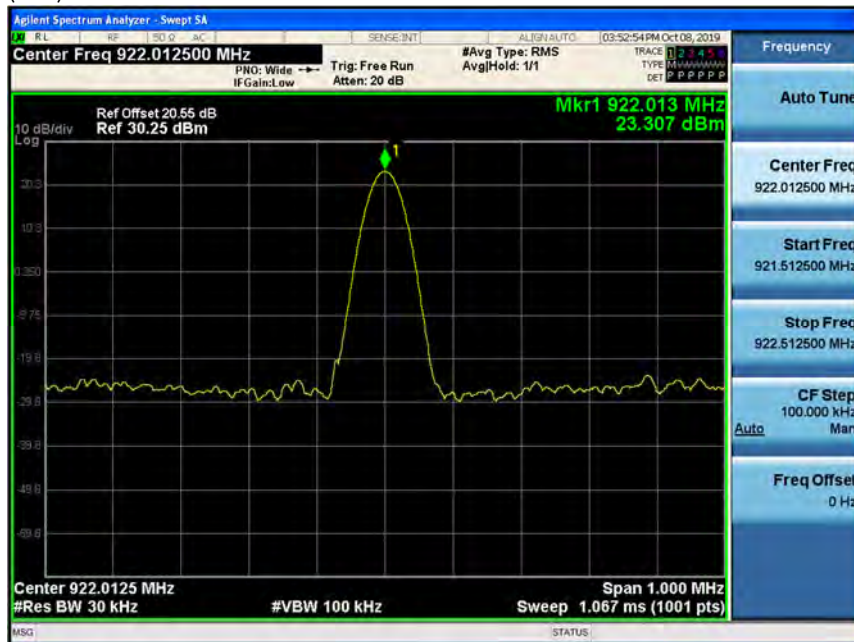
Test Plots (RC2)
Peak Power (High)



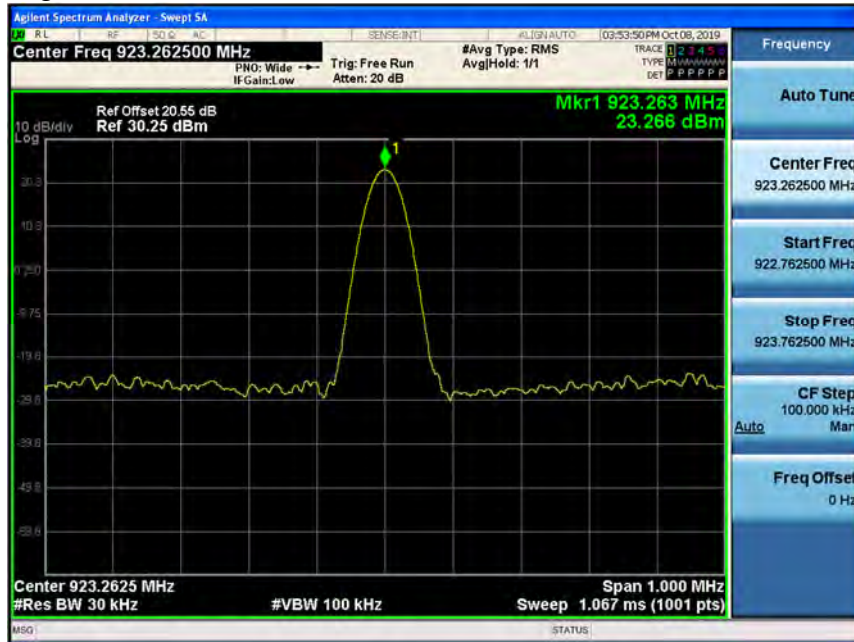
Test Plots (RC4)
Peak Power (Low)



Test Plots (RC4)
Peak Power (Mid)



Test Plots (RC4)
Peak Power (High)



10.2 BAND EDGES

Test Data

- Without hopping

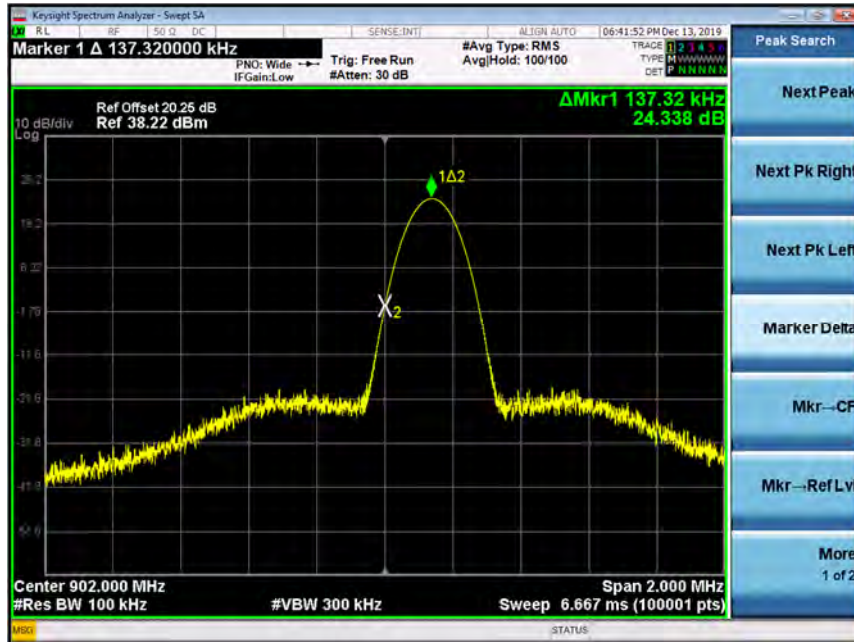
Frequency (MHz)	Channel	Position	sigfox (dB)	Limit	Margin	Result
				(dBc)	GFSK (dBc)	
902.1375	1	Lower	24.338	20	4.34	Pass
923.2625	71	Upper	60.131		40.13	Pass

- With hopping

Frequency (MHz)	Channel No.	Position	sigfox (dB)	Limit	Margin	Result
				(dBc)	GFSK (dBc)	
902.1375	1	Lower	26.761	20	6.76	Pass
923.2625	71	Upper	59.610		39.61	Pass

Test Plots without hopping (RC2)

Band Edges (Low)

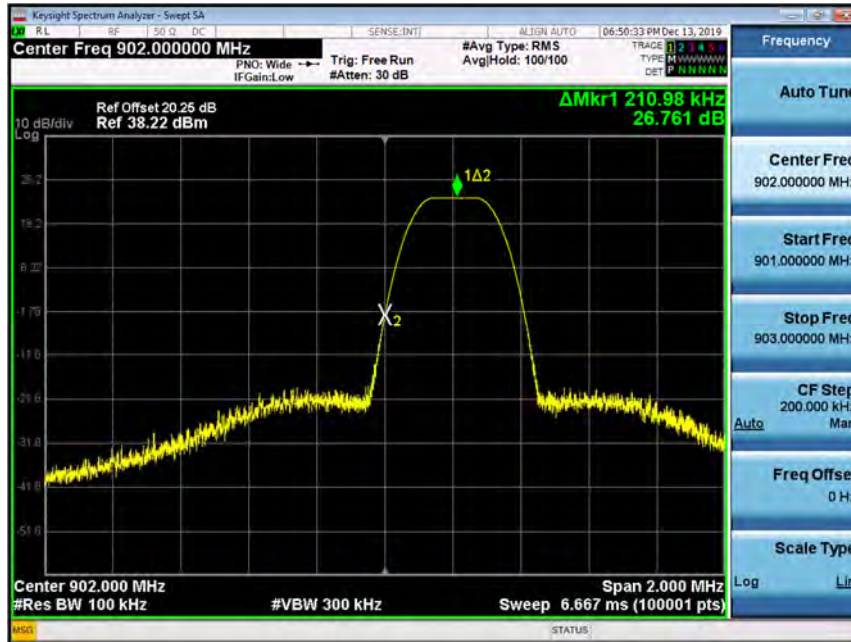


Test Plots without hopping (RC4)

Band Edges (High)



Test Plots with hopping (RC2)
Band Edges (Low)



Test Plots with hopping (RC4)
Band Edges (High)



10.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW)

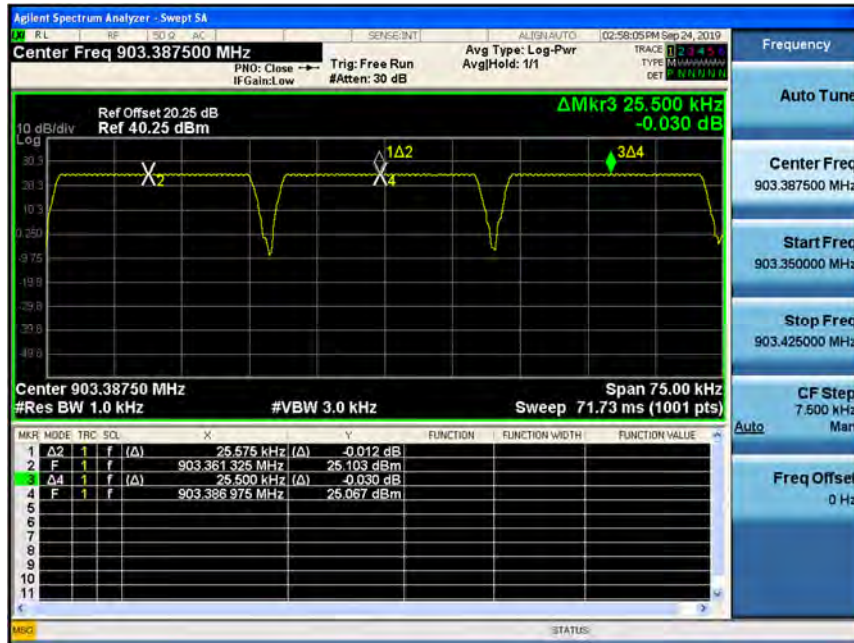
Test Data

Channel Separation (kHz)		20dB Bandwidth (kHz)			Limit (kHz)	Result
RC2	RC4	Channel	RC2	RC4		
25.50	25.05	Low	21.77	21.84	>25 or >20dB BW of hopping channel	Pass
		Mid	21.91	21.84		
		High	21.77	21.60		

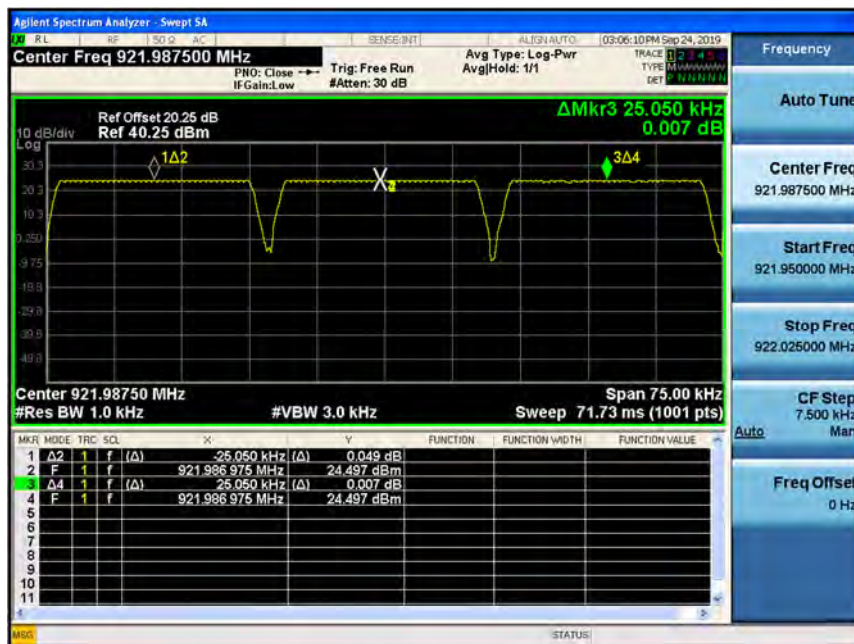
Occupied Bandwidth (99% BW)

99% BW (kHz)				
Channel		Low	Mid	High
	RC2	25.506	25.393	25.388
	RC4	25.318	25.322	25.361

Test Plots (RC2)
Channel Separation

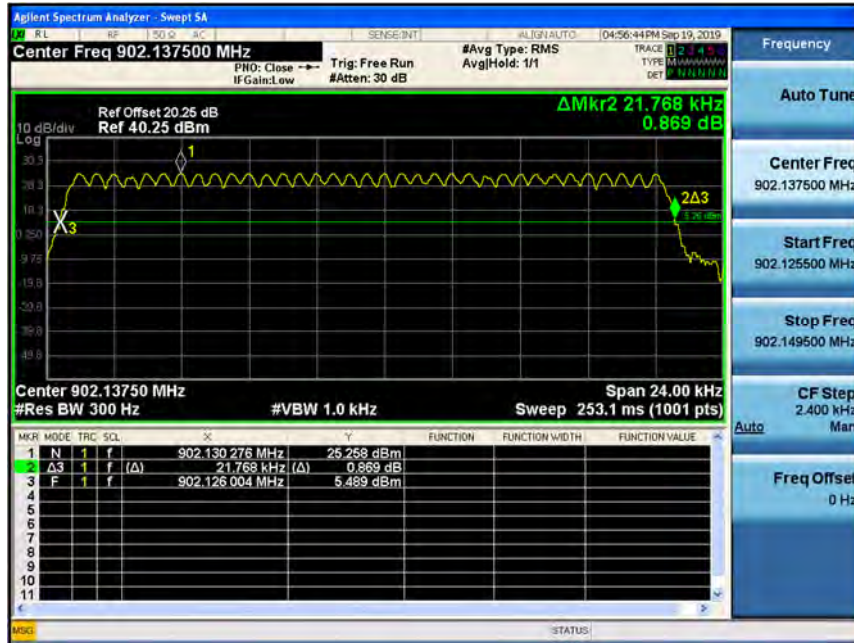


Test Plots (RC4)
Channel Separation



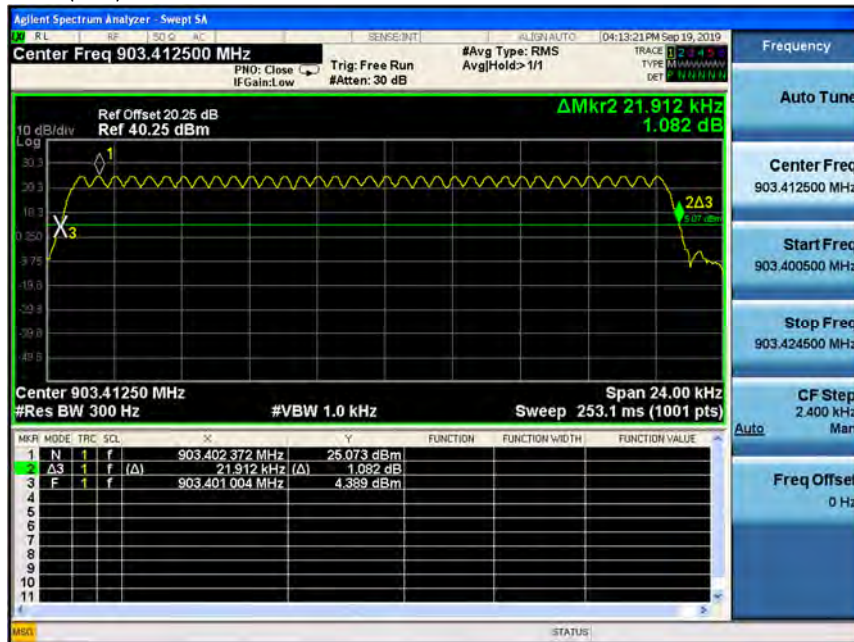
Test Plots (RC2)

20 dB Bandwidth (Low)



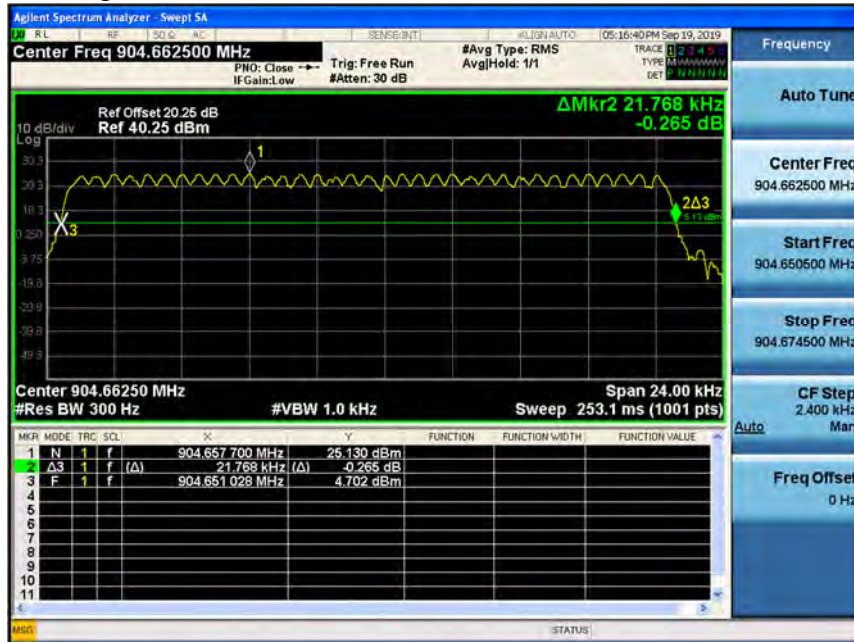
Test Plots (RC2)

20 dB Bandwidth (Mid)



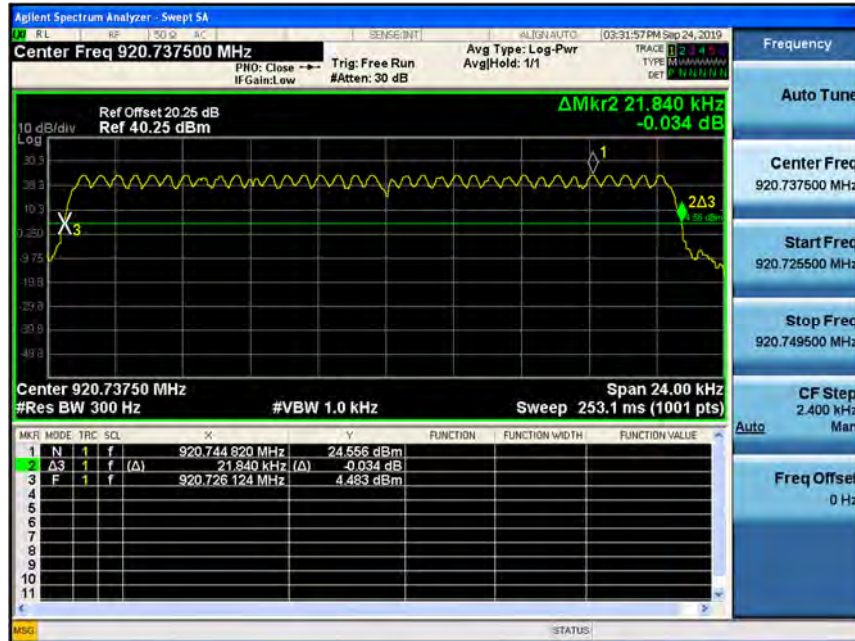
Test Plots (RC2)

20 dB Bandwidth (High)



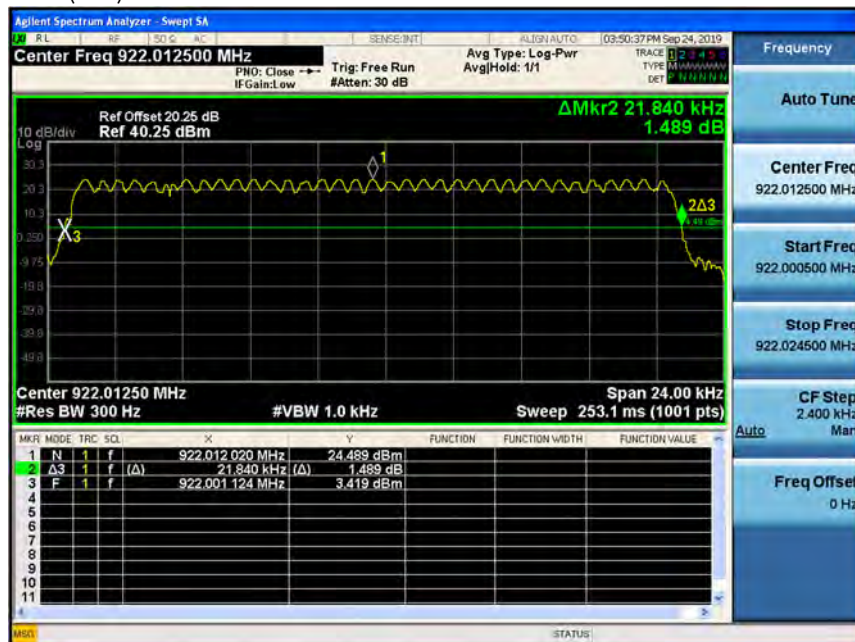
Test Plots (RC4)

20 dB Bandwidth (Low)



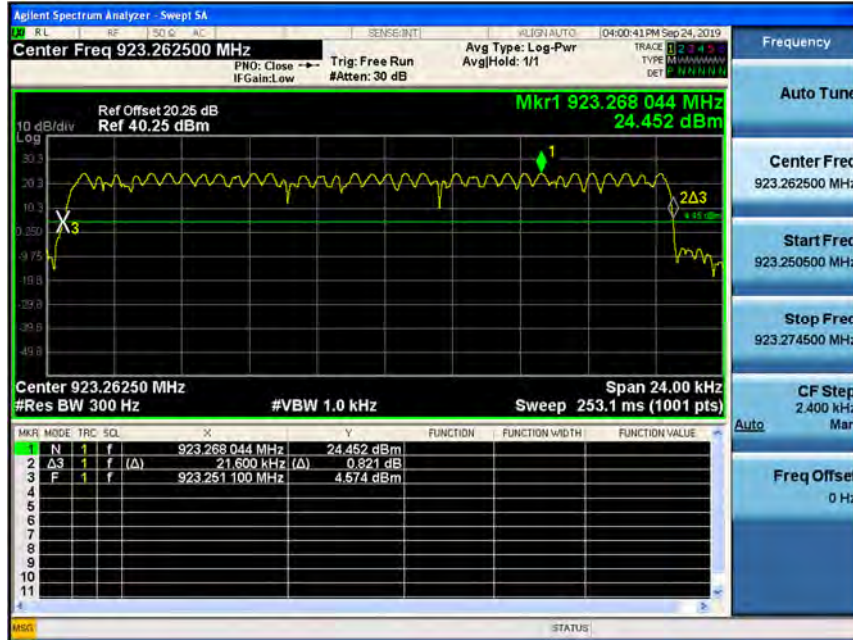
Test Plots (RC4)

20 dB Bandwidth (Mid)



Test Plots (RC4)

20 dB Bandwidth (High)



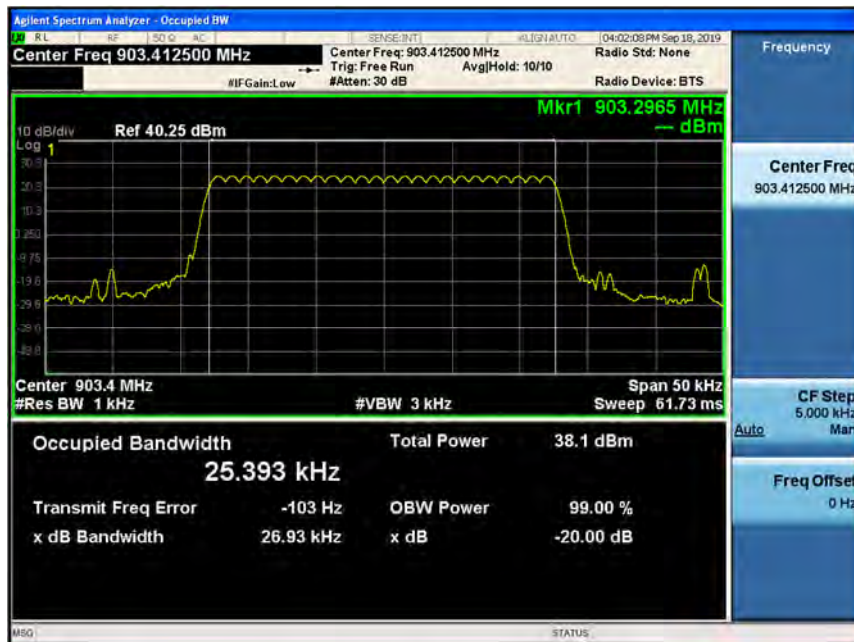
Test Plots (RC2)

Occupied Bandwidth (Low)



Test Plots (RC2)

Occupied Bandwidth (Mid)



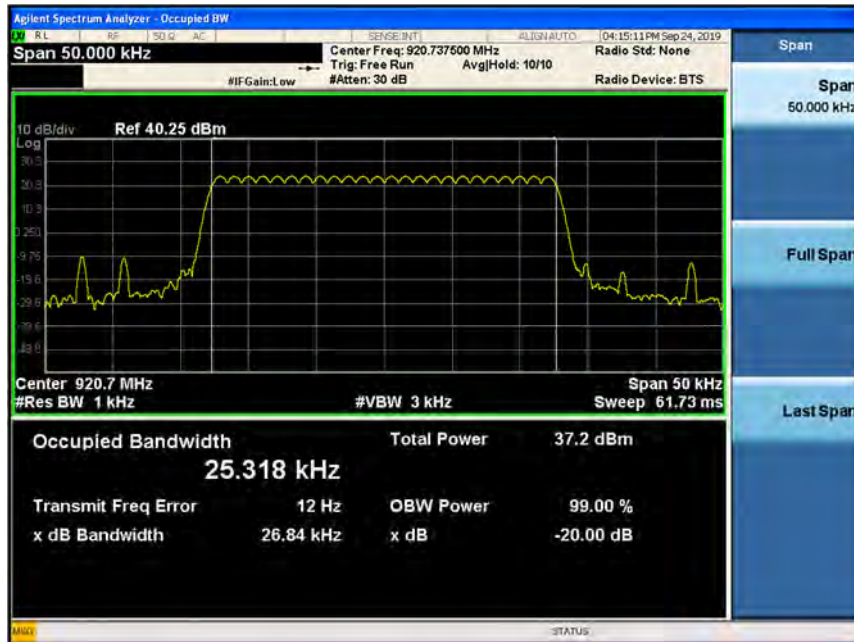
Test Plots (RC2)

Occupied Bandwidth (High)



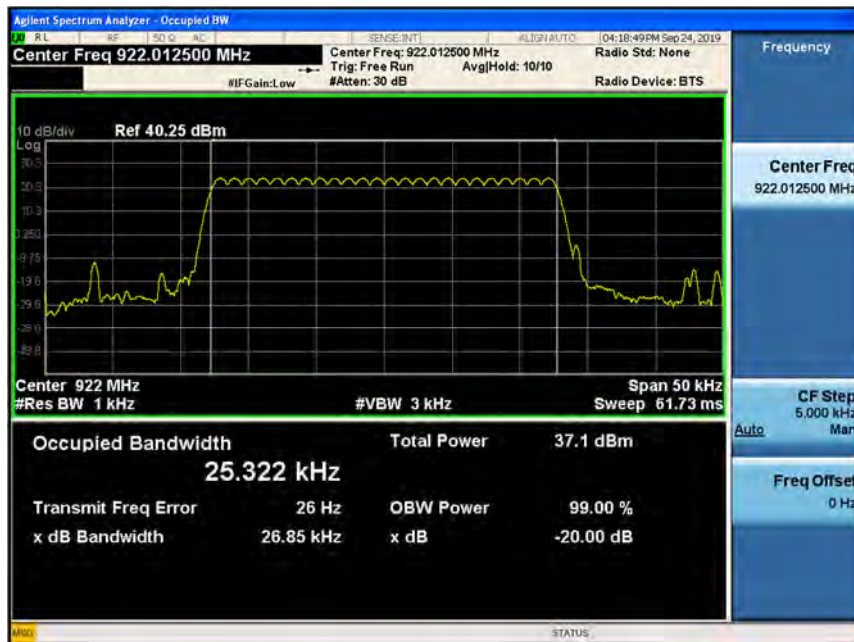
Test Plots (RC4)

Occupied Bandwidth (Low)



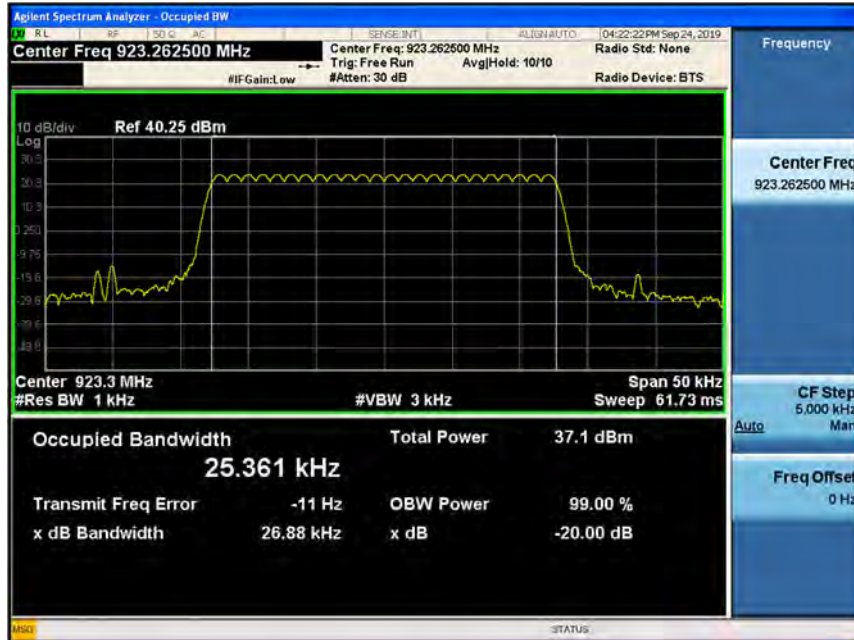
Test Plots (RC4)

Occupied Bandwidth (Mid)



Test Plots (RC4)

Occupied Bandwidth (High)



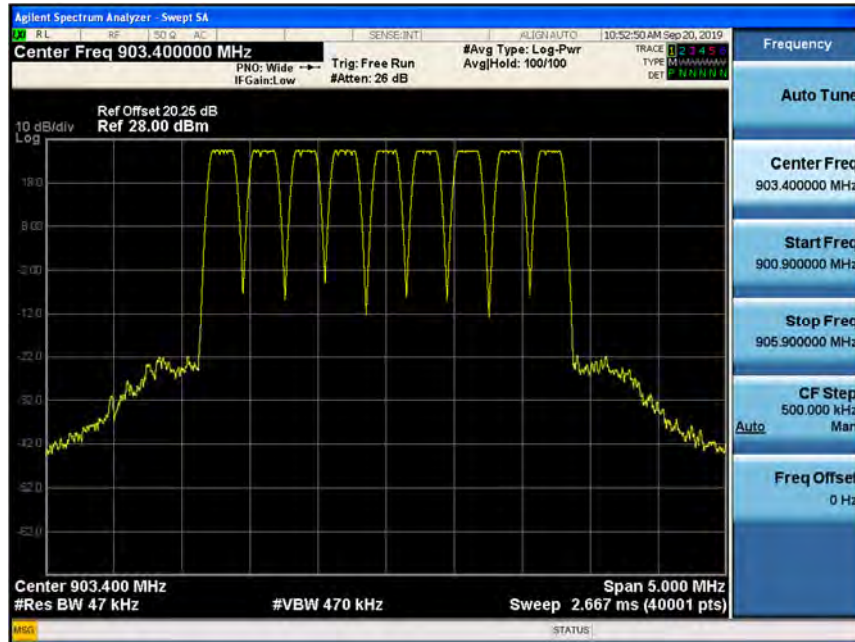
10.4 NUMBER OF HOPPING FREQUENCY

Test Data (Number of Hopping Frequencies : 9 x 6 = 54)

No. of Macro CH		No. of Micro CH		Result (No. of CH)	
RC2	RC4	RC2	RC4	RC2	RC4
9	9	6	6	54	54

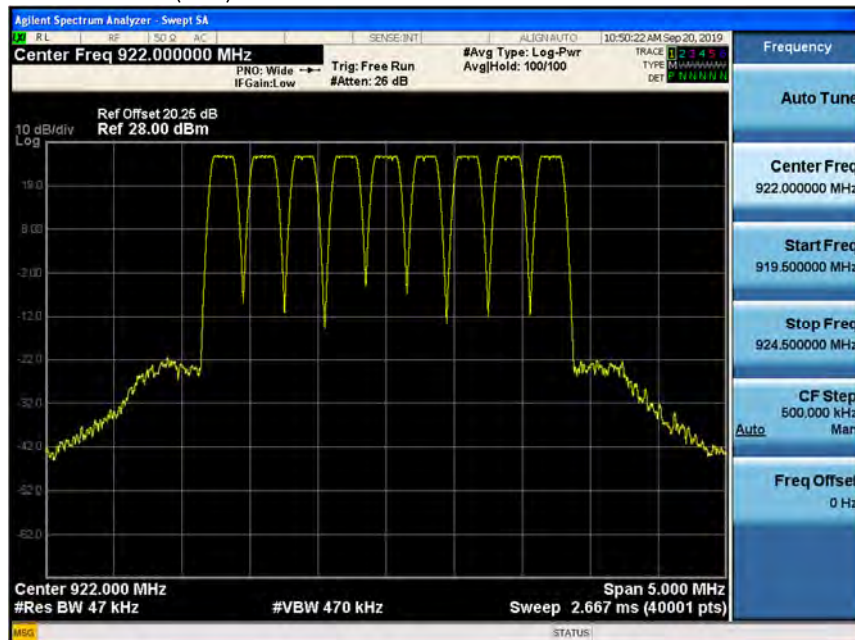
Test Plots

Number of macro channels(RC2)



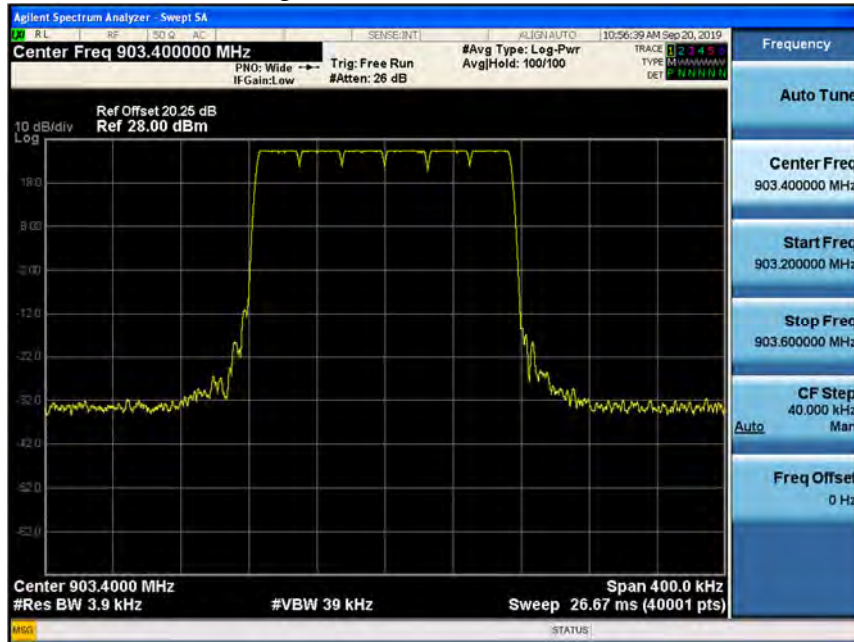
Test Plots

Number of macro channels(RC4)



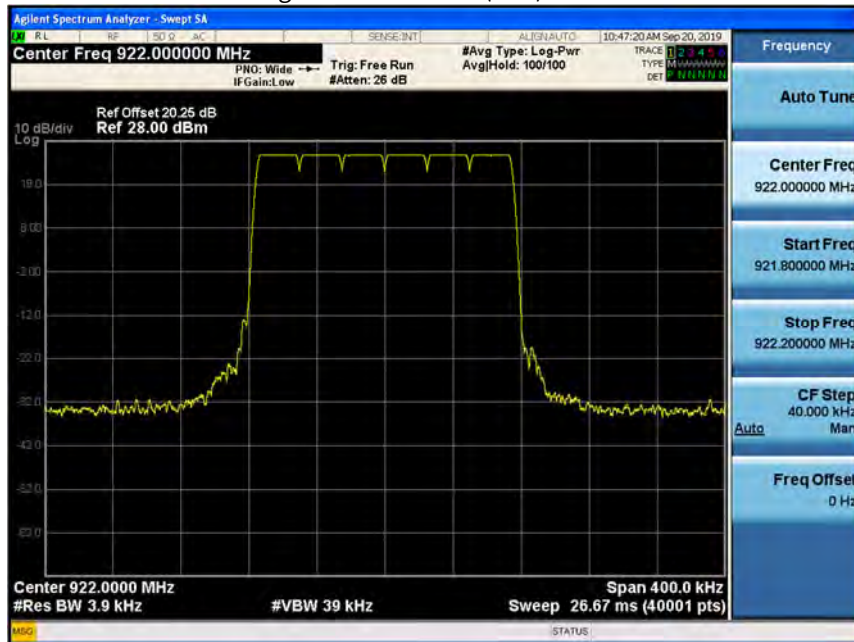
Test Plots

Number of micro channels in one single macro channel(RC2)



Test Plots

Number of micro channels in one single macro channel(RC4)



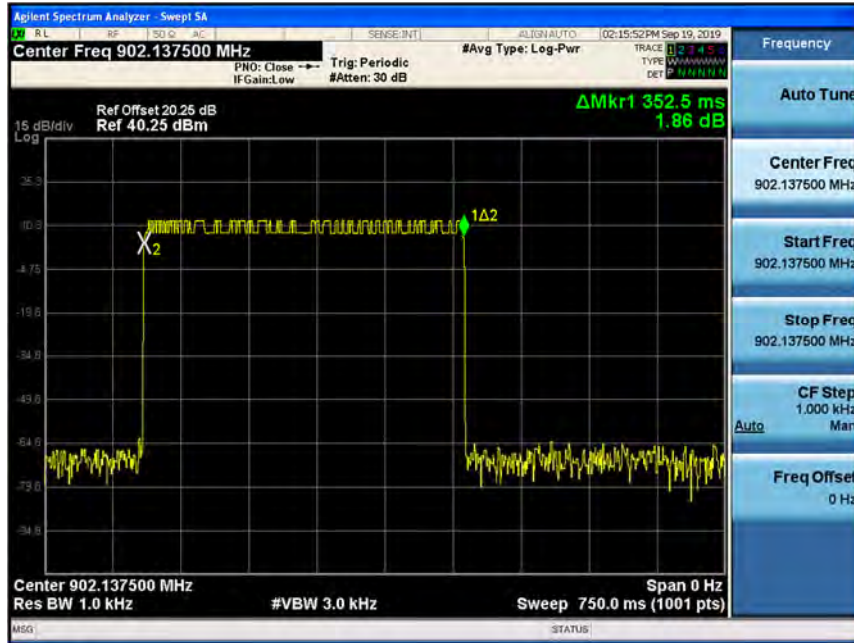
10.5 TIME OF OCCUPANCY (DWELL TIME)**TEST RESULTS**

See the table.

	Channel	RC2	RC4	Limit (ms)	Result
Pulse Time (ms)	Low	352.500	351.800	400	Pass
	Mid	352.500	352.500		Pass
	High	351.800	352.500		Pass

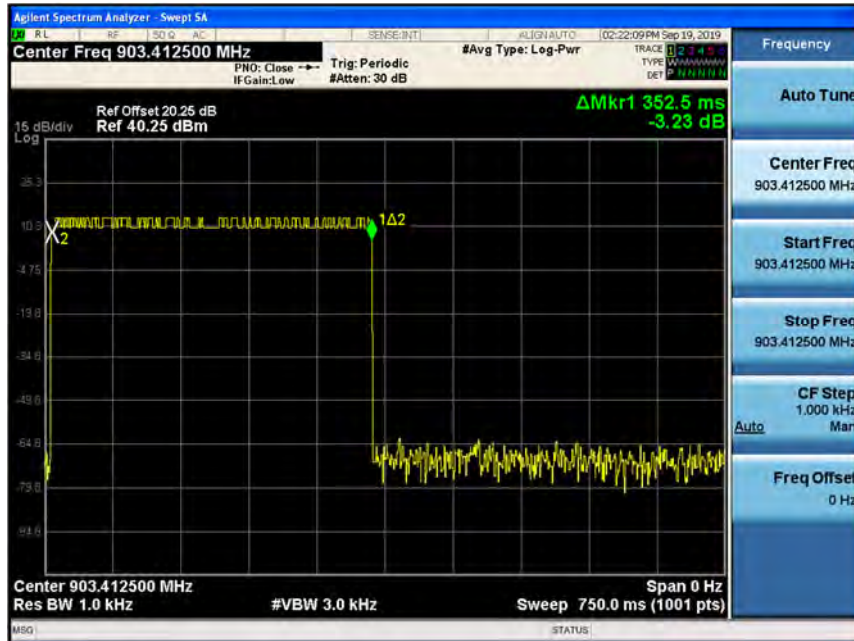
Test Plots (Channel Low_RC2)

Time slot length = 352.5 ms



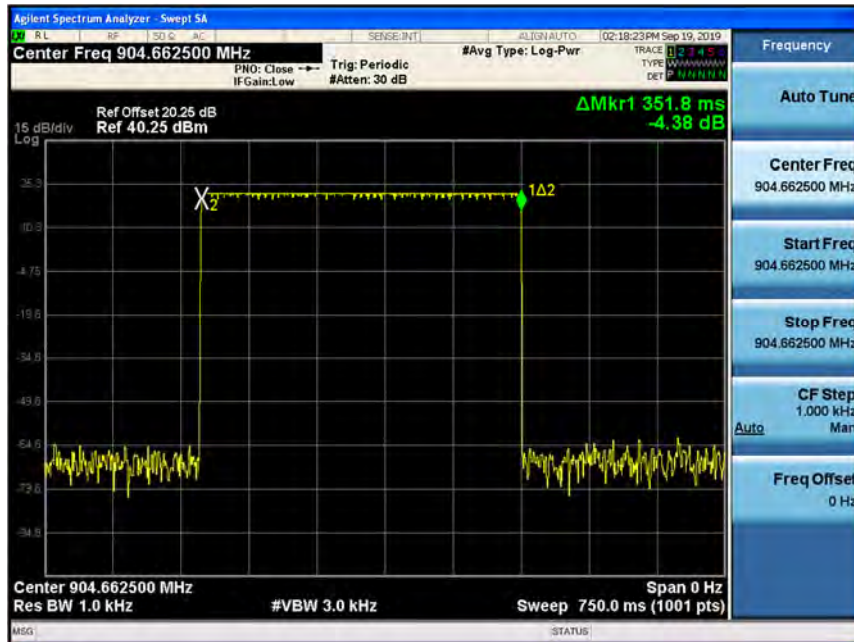
Test Plots (Channel Mid_RC2)

Time slot length = 352.5 ms



Test Plots (Channel High_RC2)

Time slot length = 351.5 ms



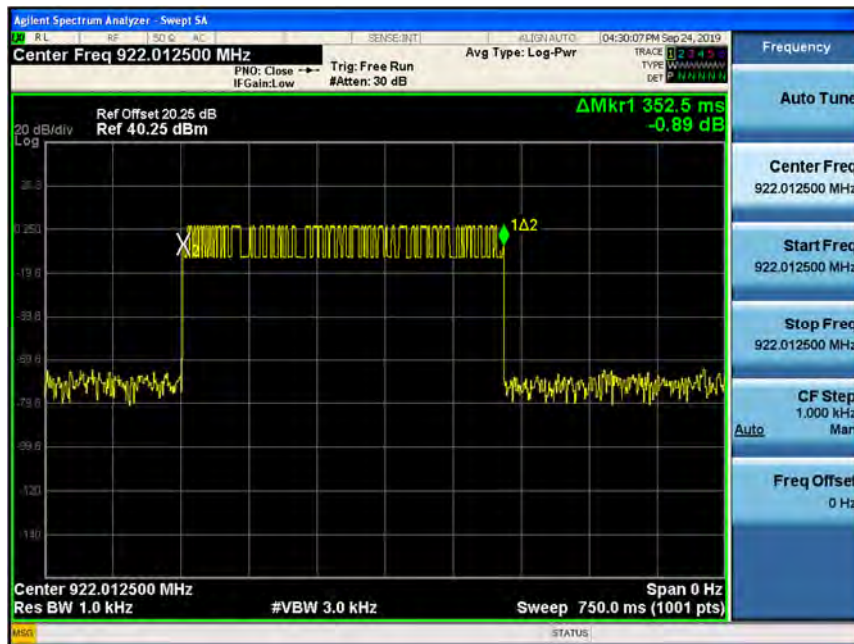
Test Plots (Channel Low_RC4)

Time slot length = 351.8 ms



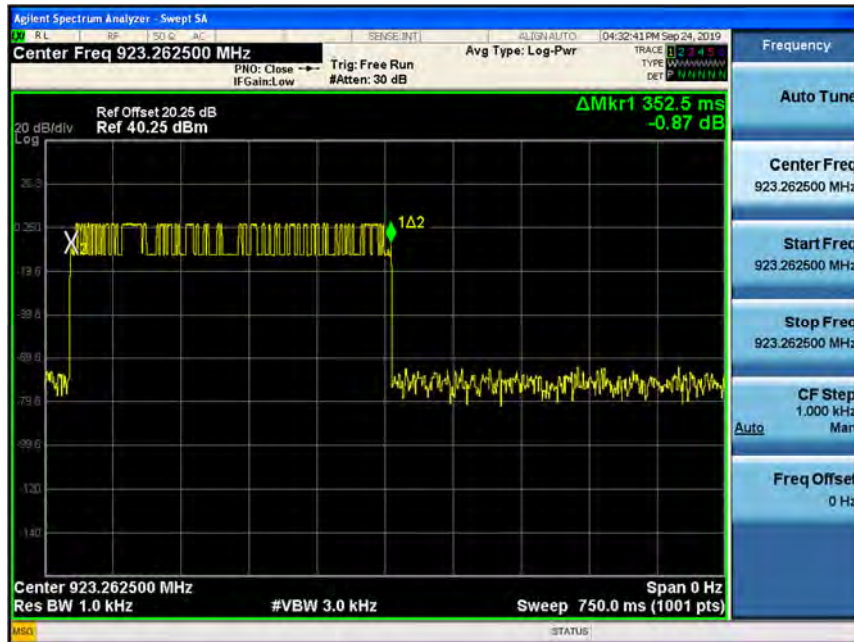
Test Plots (Channel Mid_RC4)

Time slot length = 352.5 ms



Test Plots (Channel High_RC4)

Time slot length = 352.5 ms



Test Plots

Hops / channel @ 20s = 1 (The highest emission is only relevant_RC2)



10.6 SPURIOUS EMISSIONS

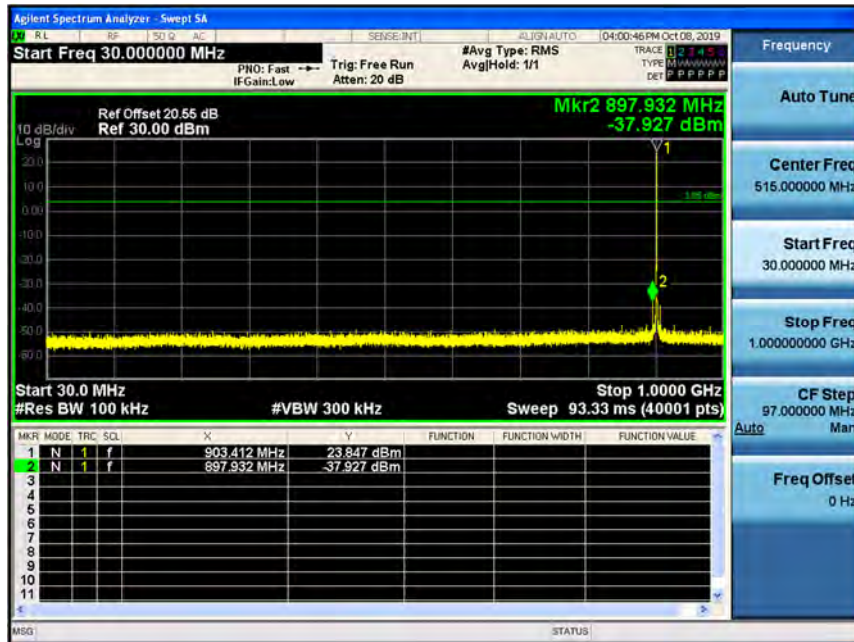
10.6.1 CONDUCTED SPURIOUS EMISSIONS

Test Result : please refer to the plot below.

In order to simplify the report, attached plots were only the worst case channel and data rate.

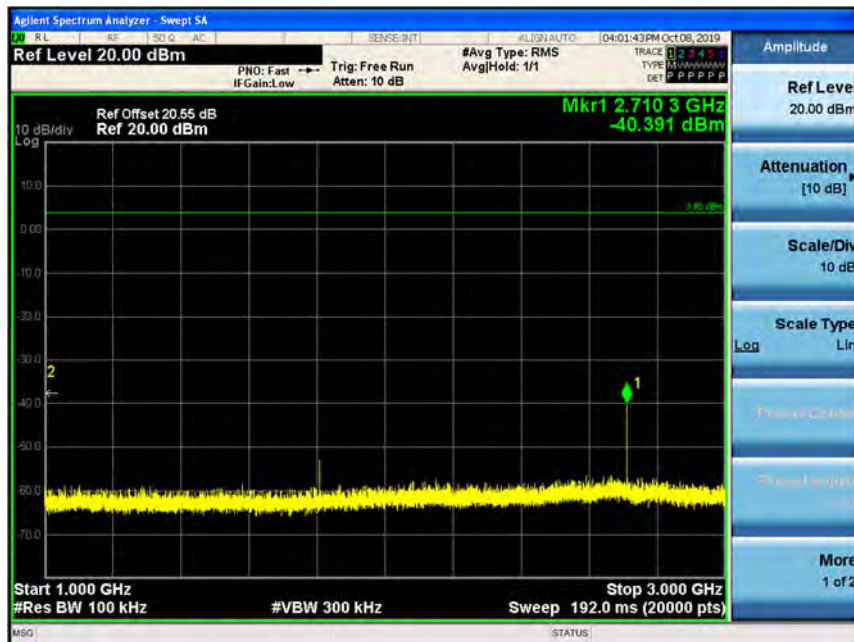
Test Plots (RC2)- 30 MHz - 1 GHz

Spurious Emission



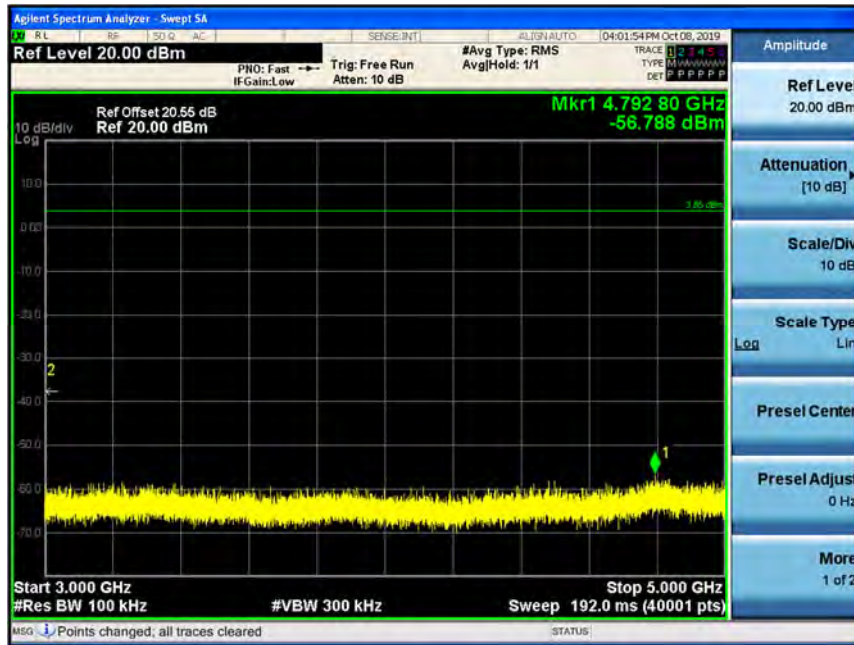
Test Plots (RC2)- 1 GHz – 3 GHz

Spurious Emission



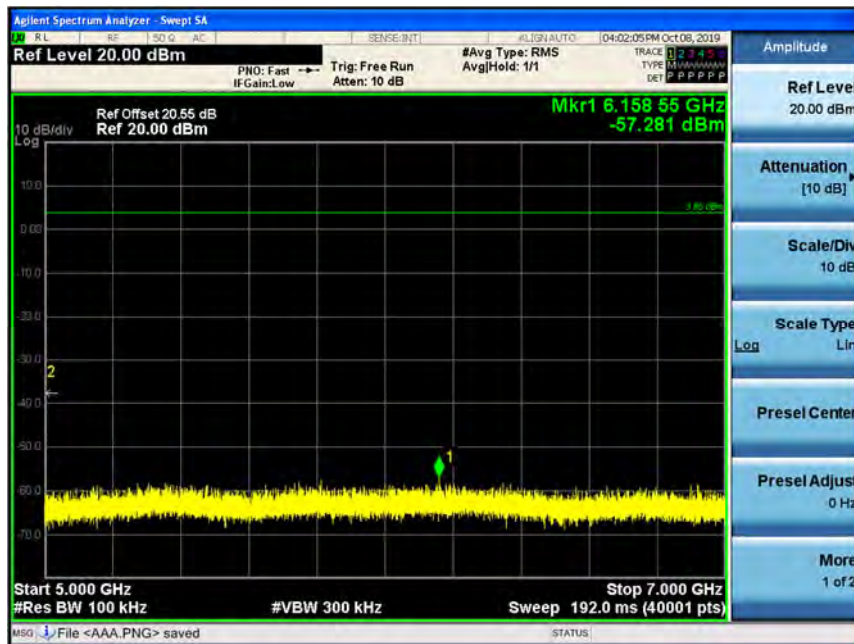
Test Plots (RC2)- 3 GHz – 5 GHz

Spurious Emission



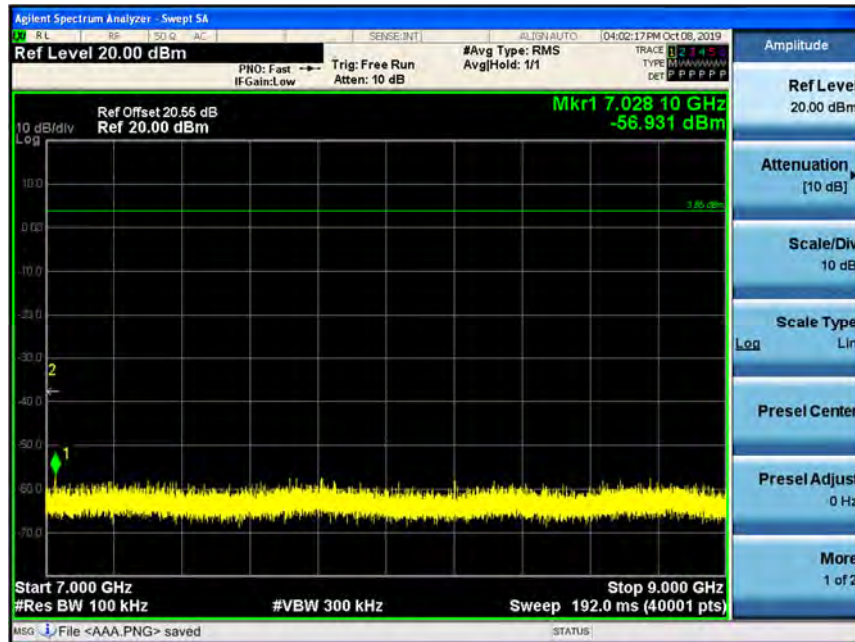
Test Plots (RC2)- 5 GHz - 7 GHz

Spurious Emission



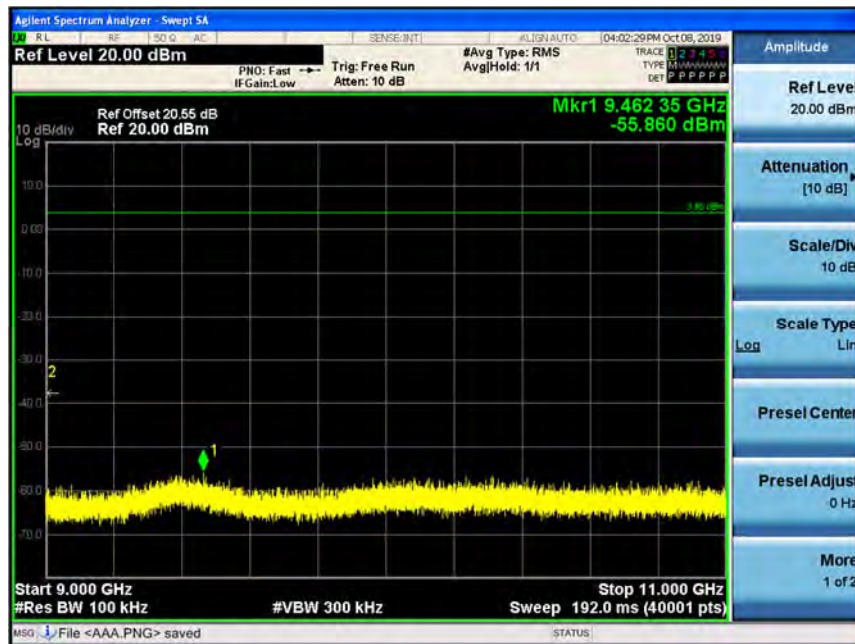
Test Plots (RC2)- 7 GHz - 9 GHz

Spurious Emission



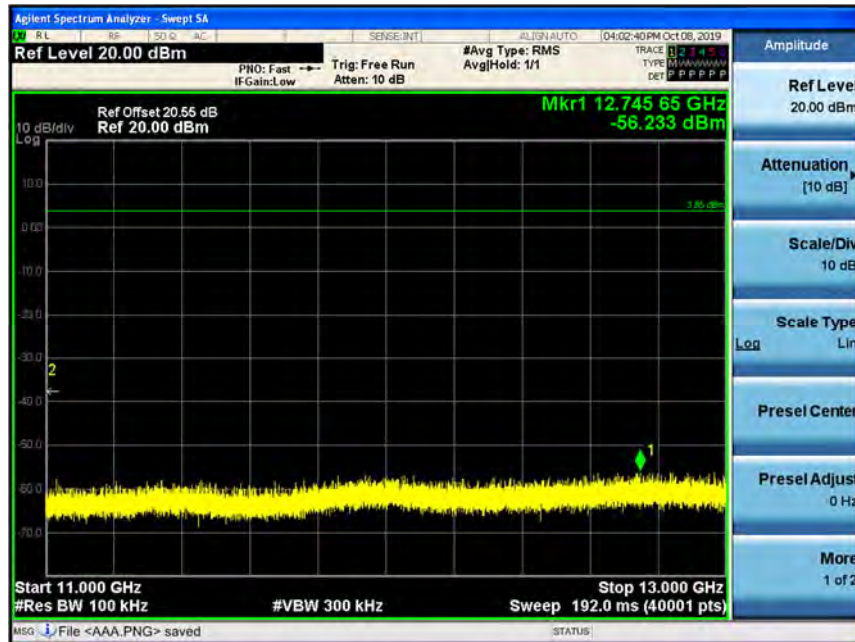
Test Plots (RC2)- 9 GHz - 11 GHz

Spurious Emission



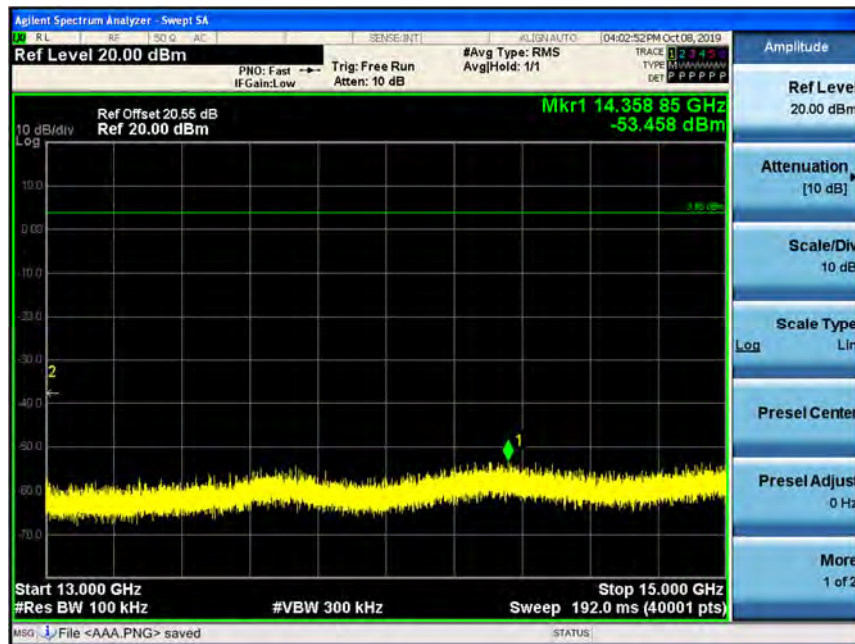
Test Plots (RC2)- 11 GHz - 13 GHz

Spurious Emission



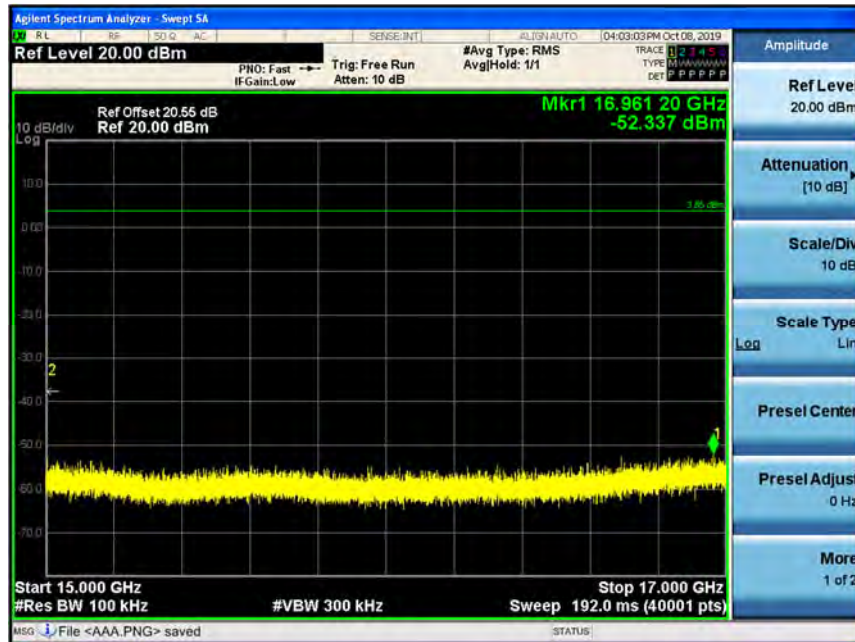
Test Plots (RC2)- 13 GHz - 15 GHz

Spurious Emission



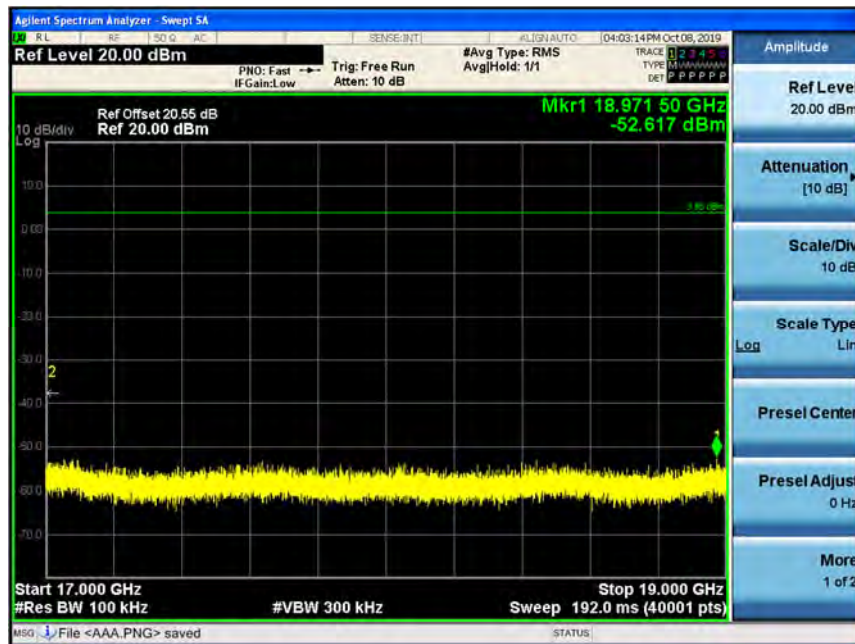
Test Plots (RC2)- 15 GHz - 17 GHz

Spurious Emission



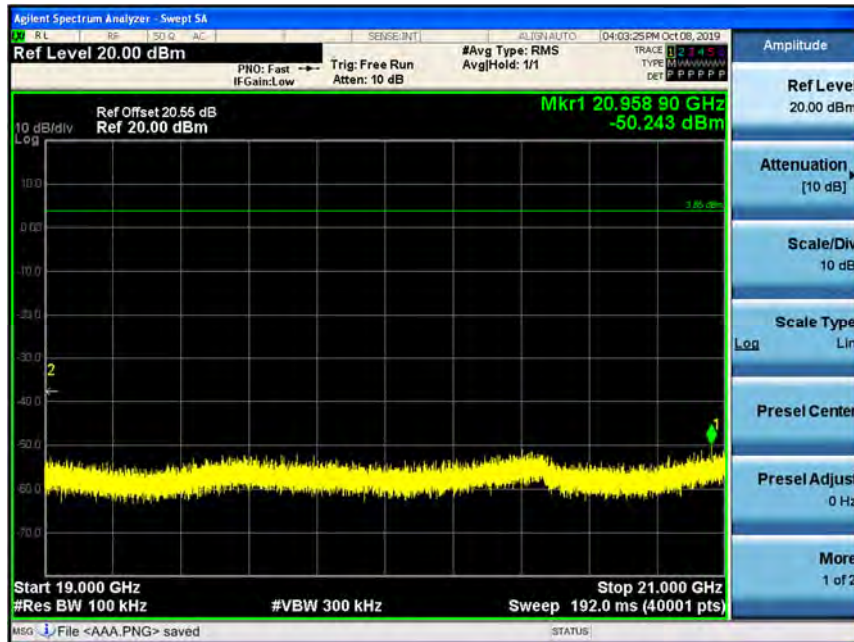
Test Plots (RC2)- 17 GHz - 19 GHz

Spurious Emission



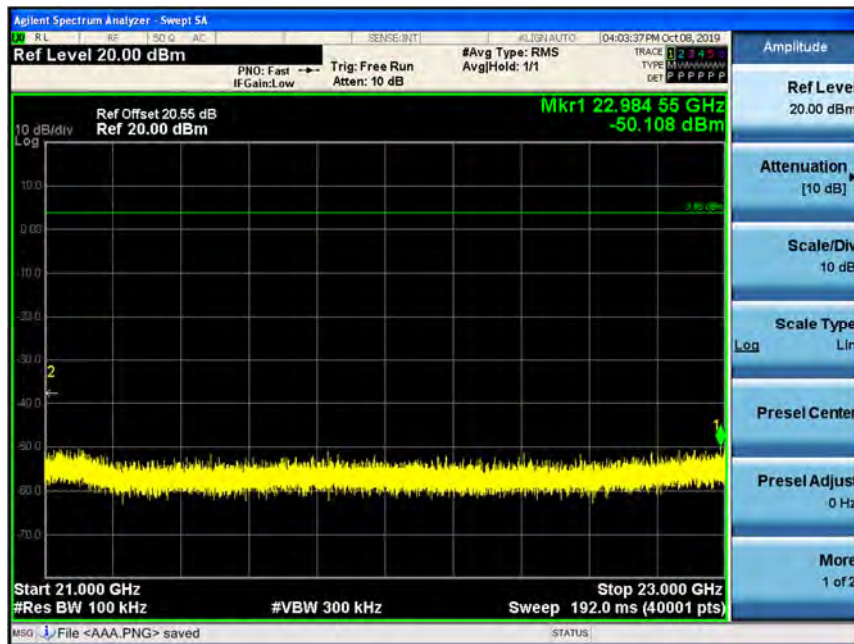
Test Plots (RC2)- 19 GHz - 21 GHz

Spurious Emission



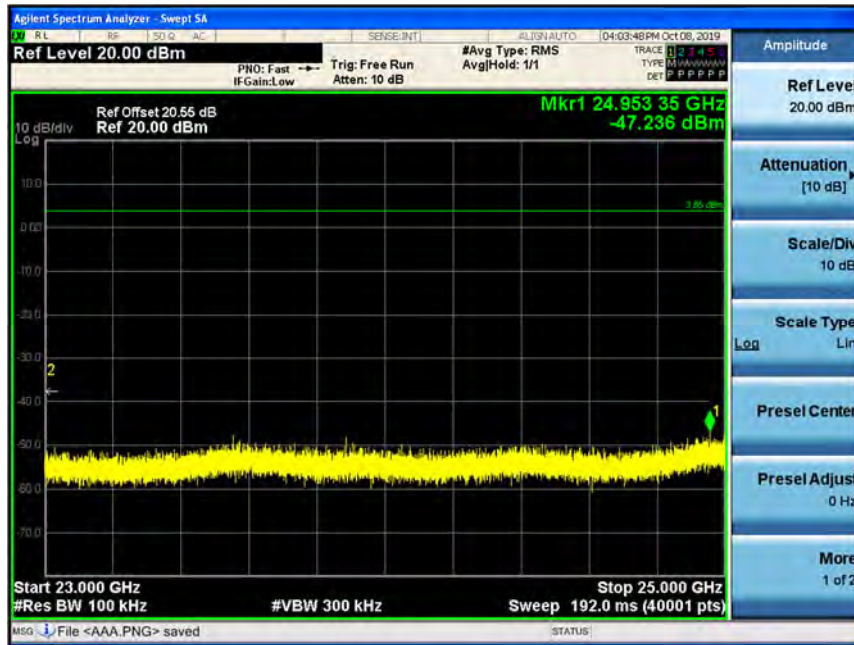
Test Plots (RC2)- 21 GHz - 23 GHz

Spurious Emission



Test Plots (RC2)- 23 GHz - 25 GHz

Spurious Emission



10.6.2 RADIATED SPURIOUS EMISSIONS

Frequency Range : 9 kHz – 30MHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Note:

1. The reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
2. Distance extrapolation factor = $40 \times \log(\text{specific distance} / \text{test distance})$ (dB)
3. Limit line = specific Limits (dBuV) + Distance extrapolation factor
4. Radiated test is performed with hopping off.
5. The test results for below 30 MHz is correlated to an open site.
The result on OFS is about 2 dB higher than semi-anechoic chamber(10 m chamber)

Frequency Range : Below 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.
2. Radiated test is performed with hopping off.

TEST RESULTS
Frequency Range : Above 1 GHz
Channel : RC2_Low

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2706.41	50.65	1.75	V	52.40	73.98	21.58	PK
2706.41	40.99	1.75	V	42.74	53.98	11.24	AV
3608.55	46.27	5.98	V	52.25	73.98	21.73	PK
3608.55	33.12	5.98	V	39.10	53.98	14.88	AV
4510.69	44.84	9.36	V	54.20	73.98	19.78	PK
4510.69	32.13	9.36	V	41.49	53.98	12.49	AV
2706.41	52.80	1.75	H	54.55	73.98	19.43	PK
2706.41	45.82	1.75	H	47.57	53.98	6.41	AV
3608.55	46.29	5.98	H	52.27	73.98	21.71	PK
3608.55	33.13	5.98	H	39.11	53.98	14.87	AV
4510.69	44.87	9.36	H	54.23	73.98	19.75	PK
4510.69	32.53	9.36	H	41.89	53.98	12.09	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
5412.83	42.69	12.01	V	54.70	73.98	19.28	PK
5412.83	31.02	12.01	V	43.03	53.98	10.95	AV
8119.24	41.27	19.29	V	60.56	73.98	13.42	PK
8119.24	28.49	19.29	V	47.78	53.98	6.20	AV
9021.38	40.01	21.01	V	61.02	73.98	12.96	PK
9021.38	27.55	21.01	V	48.56	53.98	5.42	AV
5412.83	43.26	12.01	H	55.27	73.98	18.71	PK
5412.83	31.19	12.01	H	43.20	53.98	10.78	AV
8119.24	41.29	19.29	H	60.58	73.98	13.40	PK
8119.24	28.54	19.29	H	47.83	53.98	6.15	AV
9021.38	40.05	21.01	H	61.06	73.98	12.92	PK
9021.38	27.56	21.01	H	48.57	53.98	5.41	AV

Channel : RC4_Low

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2762.21	47.07	2.30	V	49.37	73.98	24.61	PK
2762.21	34.42	2.30	V	36.72	53.98	17.26	AV
3682.95	46.48	6.23	V	52.71	73.98	21.27	PK
3682.95	33.57	6.23	V	39.80	53.98	14.18	AV
4603.69	44.99	9.46	V	54.45	73.98	19.53	PK
4603.69	32.22	9.46	V	41.68	53.98	12.30	AV
2762.21	48.74	2.30	H	51.04	73.98	22.94	PK
2762.21	38.45	2.30	H	40.75	53.98	13.23	AV
3682.95	46.50	6.23	H	52.73	73.98	21.25	PK
3682.95	33.71	6.23	H	39.94	53.98	14.04	AV
4603.69	45.07	9.46	H	54.53	73.98	19.45	PK
4603.69	32.28	9.46	H	41.74	53.98	12.24	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
7365.90	42.98	18.46	V	61.44	73.98	12.54	PK
7365.90	33.65	18.46	V	52.11	53.98	1.87	AV
8286.64	41.85	19.08	V	60.93	73.98	13.05	PK
8286.64	29.22	19.08	V	48.30	53.98	5.68	AV
7365.90	43.87	18.46	H	62.33	73.98	11.65	PK
7365.90	34.09	18.46	H	52.55	53.98	1.43	AV
8286.64	41.83	19.08	H	60.91	73.98	13.07	PK
8286.64	29.25	19.08	H	48.33	53.98	5.65	AV

TEST RESULTS
Frequency Range : Above 1 GHz
Channel : RC2_Mid

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2710.24	47.88	1.85	V	49.73	73.98	24.25	PK
2710.24	34.59	1.85	V	36.44	53.98	17.54	AV
3613.65	44.98	6.08	V	51.06	73.98	22.92	PK
3613.65	32.24	6.08	V	38.32	53.98	15.66	AV
4517.06	44.52	9.36	V	53.88	73.98	20.10	PK
4517.06	32.18	9.36	V	41.54	53.98	12.44	AV
2710.24	51.44	1.85	H	53.29	73.98	20.69	PK
2710.24	43.46	1.85	H	45.31	53.98	8.67	AV
3613.65	45.71	6.08	H	51.79	73.98	22.19	PK
3613.65	33.26	6.08	H	39.34	53.98	14.64	AV
4517.06	44.63	9.36	H	53.99	73.98	19.99	PK
4517.06	32.43	9.36	H	41.79	53.98	12.19	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
5420.48	43.11	12.26	V	55.37	73.98	18.61	PK
5420.48	31.19	12.26	V	43.45	53.98	10.53	AV
8130.71	41.00	19.26	V	60.26	73.98	13.72	PK
8130.71	29.29	19.26	V	48.55	53.98	5.43	AV
9034.13	39.55	21.13	V	60.68	73.98	13.30	PK
9034.13	27.38	21.13	V	48.51	53.98	5.47	AV
5420.48	43.36	12.26	H	55.62	73.98	18.36	PK
5420.48	31.27	12.26	H	43.53	53.98	10.45	AV
8130.71	41.06	19.26	H	60.32	73.98	13.66	PK
8130.71	29.33	19.26	H	48.59	53.98	5.39	AV
9034.13	39.56	21.13	H	60.69	73.98	13.29	PK
9034.13	27.40	21.13	H	48.53	53.98	5.45	AV

Channel : RC4_Mid

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2766.04	47.09	2.23	V	49.32	73.98	24.66	PK
2766.04	34.25	2.23	V	36.48	53.98	17.50	AV
3688.05	46.14	6.27	V	52.41	73.98	21.57	PK
3688.05	32.36	6.27	V	38.63	53.98	15.35	AV
4610.06	44.58	9.57	V	54.15	73.98	19.83	PK
4610.06	32.21	9.57	V	41.78	53.98	12.20	AV
2766.04	47.60	2.23	H	49.83	73.98	24.15	PK
2766.04	37.21	2.23	H	39.44	53.98	14.54	AV
3688.05	46.30	6.27	H	52.57	73.98	21.41	PK
3688.05	33.83	6.27	H	40.10	53.98	13.88	AV
4610.06	44.66	9.57	H	54.23	73.98	19.75	PK
4610.06	32.24	9.57	H	41.81	53.98	12.17	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
7376.10	43.08	18.44	V	61.52	73.98	12.46	PK
7376.10	32.99	18.44	V	51.43	53.98	2.55	AV
8298.11	40.90	19.27	V	60.17	73.98	13.81	PK
8298.11	28.93	19.27	V	48.20	53.98	5.78	AV
7376.10	43.34	18.44	H	61.78	73.98	12.20	PK
7376.10	33.69	18.44	H	52.13	53.98	1.85	AV
8298.11	41.36	19.27	H	60.63	73.98	13.35	PK
8298.11	28.96	19.27	H	48.23	53.98	5.75	AV

TEST RESULTS
Frequency Range : Above 1 GHz
Channel : RC2_High

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2713.99	48.67	1.84	V	50.51	73.98	23.47	PK
2713.99	38.58	1.84	V	40.42	53.98	13.56	AV
3618.65	44.98	6.18	V	51.16	73.98	22.82	PK
3618.65	33.54	6.18	V	39.72	53.98	14.26	AV
4523.31	43.91	9.38	V	53.29	73.98	20.69	PK
4523.31	32.41	9.38	V	41.79	53.98	12.19	AV
2713.99	50.77	1.84	H	52.61	73.98	21.37	PK
2713.99	43.55	1.84	H	45.39	53.98	8.59	AV
3618.65	45.60	6.18	H	51.78	73.98	22.20	PK
3618.65	33.61	6.18	H	39.79	53.98	14.19	AV
4523.31	44.02	9.38	H	53.40	73.98	20.58	PK
4523.31	32.44	9.38	H	41.82	53.98	12.16	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
5427.98	43.02	12.30	V	55.32	73.98	18.66	PK
5427.98	31.07	12.30	V	43.37	53.98	10.61	AV
8141.96	41.65	19.41	V	61.06	73.98	12.92	PK
8141.96	29.27	19.41	V	48.68	53.98	5.30	AV
9046.63	39.86	21.19	V	61.05	73.98	12.93	PK
9046.63	27.42	21.19	V	48.61	53.98	5.37	AV
5427.98	43.19	12.30	H	55.49	73.98	18.49	PK
5427.98	31.15	12.30	H	43.45	53.98	10.53	AV
8141.96	41.78	19.41	H	61.19	73.98	12.79	PK
8141.96	29.28	19.41	H	48.69	53.98	5.29	AV
9046.63	39.89	21.19	H	61.08	73.98	12.90	PK
9046.63	27.49	21.19	H	48.68	53.98	5.30	AV

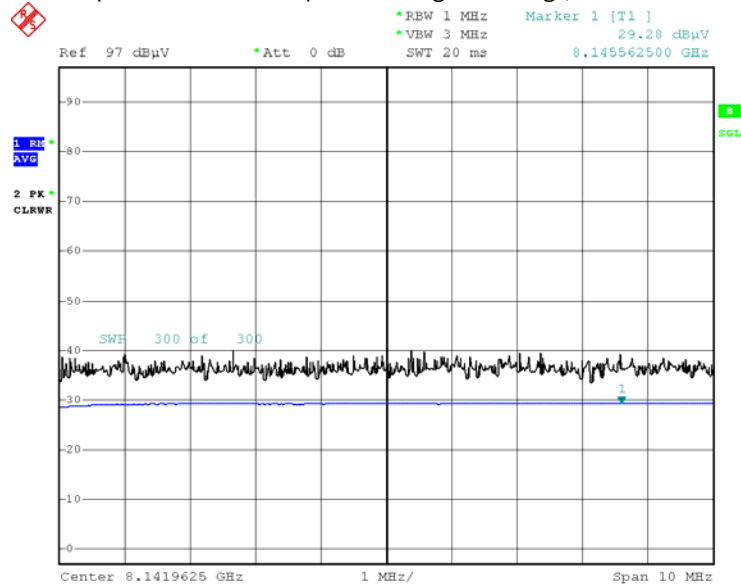
Channel : RC4_High

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2769.79	47.93	2.15	V	50.08	73.98	23.90	PK
2769.79	34.57	2.15	V	36.72	53.98	17.26	AV
3693.05	45.29	6.27	V	51.56	73.98	22.42	PK
3693.05	33.57	6.27	V	39.84	53.98	14.14	AV
4616.31	43.98	9.74	V	53.72	73.98	20.26	PK
4616.31	31.97	9.74	V	41.71	53.98	12.27	AV
2769.79	48.57	2.15	H	50.72	73.98	23.26	PK
2769.79	37.22	2.15	H	39.37	53.98	14.61	AV
3693.05	46.63	6.27	H	52.90	73.98	21.08	PK
3693.05	34.00	6.27	H	40.27	53.98	13.71	AV
4616.31	44.50	9.74	H	54.24	73.98	19.74	PK
4616.31	31.99	9.74	H	41.73	53.98	12.25	AV

Frequency [MHz]	Reading [dBuV]	AN.+CL-AMP G [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
7386.10	44.27	18.46	V	62.73	73.98	11.25	PK
7386.10	34.41	18.46	V	52.87	53.98	1.11	AV
8309.36	41.53	18.91	V	60.44	73.98	13.54	PK
8309.36	29.18	18.91	V	48.09	53.98	5.89	AV
7386.10	43.85	18.46	H	62.31	73.98	11.67	PK
7386.10	33.87	18.46	H	52.33	53.98	1.65	AV
8309.36	41.38	18.91	H	60.29	73.98	13.69	PK
8309.36	29.17	18.91	H	48.08	53.98	5.90	AV

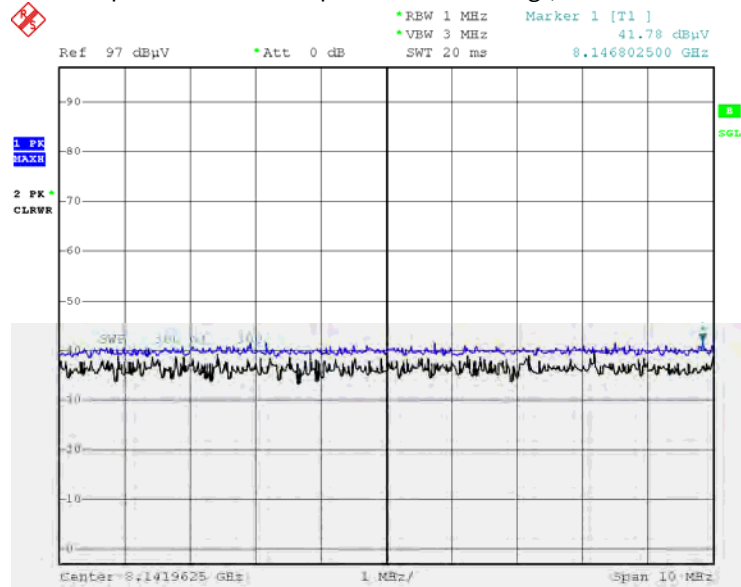
RESULT PLOTS

Radiated Spurious Emissions plot – Average Reading (RC2 9th Harmonic)



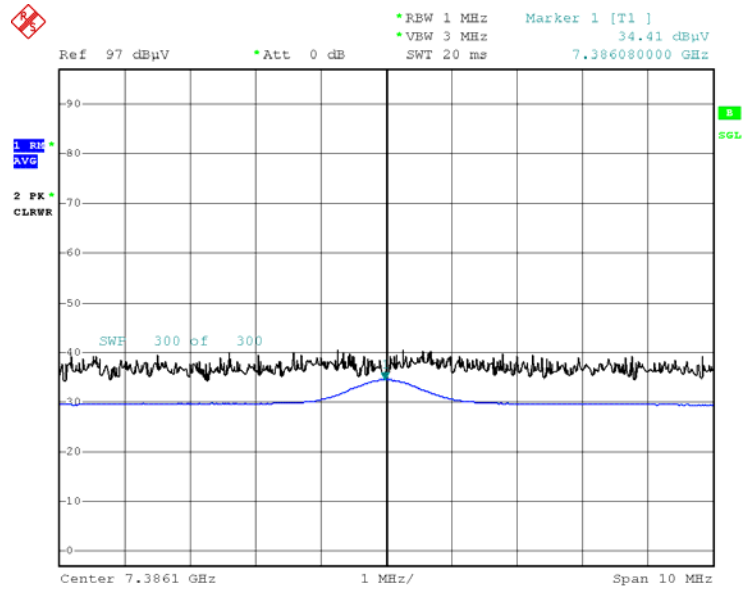
Date: 24.OCT.2019 05:18:03

Radiated Spurious Emissions plot – Peak Reading (RC2 9th Harmonic)



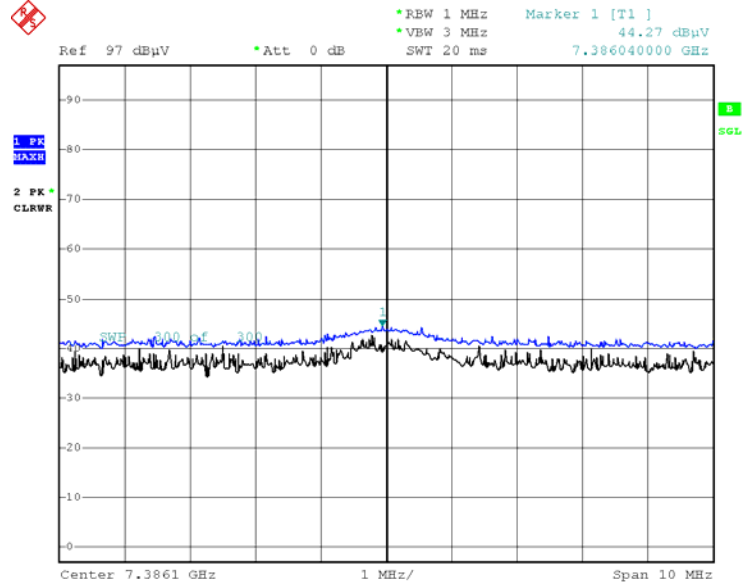
Date: 24.OCT.2019 05:18:17

Radiated Spurious Emissions plot –Average Reading (RC4 8th Harmonic)



Date: 23.OCT.2019 10:48:24

Radiated Spurious Emissions plot – Peak Reading (RC4 8th Harmonic)



Date: 23.OCT.2019 10:50:07

Note : Only the worst case plots for Radiated Spurious Emissions.

10.7 RECEIVER SPURIOUS EMISSIONS

Frequency Range : Below 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.

Frequency Range : Above 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

10.8 POWERLINE CONDUCTED EMISSIONS

Conducted Emissions (Line 1)

Test

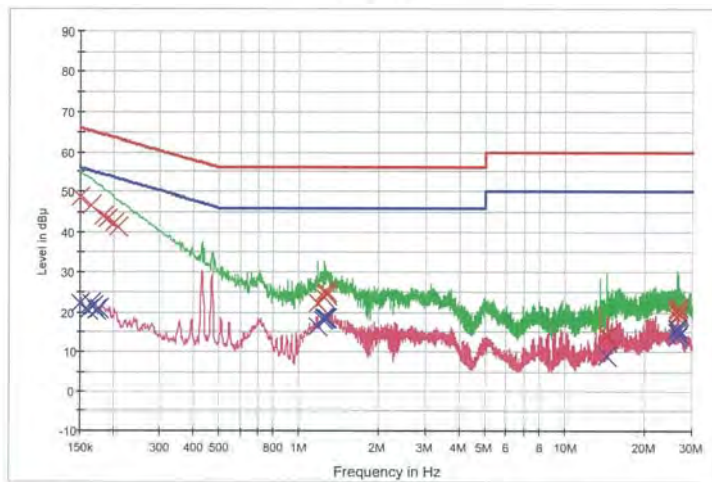
1 / 2

HCT TEST Report

Common Information

EUT: SRM100A
 Manufacturer: SEONG JI INDUSTRIAL CO.,LTD
 Test Site: SHIELD ROOM
 Operating Conditions: SIGFOX_L1

FCC CLASS B



— FCC CLASS B_QP — FCC CLASS B_AV — Preview Result 1-PK+
— Preview Result 2-AVG X Final Result 1-QPK X Final Result 2-CAV

Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	48.6	9.000	Off	L1	9.7	17.4	66.0
0.164000	46.5	9.000	Off	L1	9.7	18.8	65.3
0.184000	44.0	9.000	Off	L1	9.7	20.3	64.3
0.190000	43.3	9.000	Off	L1	9.7	20.7	64.0
0.200000	42.3	9.000	Off	L1	9.7	21.3	63.6
0.208000	41.3	9.000	Off	L1	9.7	22.0	63.3
1.172000	22.3	9.000	Off	L1	9.8	33.7	56.0
1.246000	23.5	9.000	Off	L1	9.6	32.5	56.0
1.250000	24.9	9.000	Off	L1	9.8	31.1	56.0
1.256000	24.7	9.000	Off	L1	9.8	31.3	56.0
1.268000	25.0	9.000	Off	L1	9.8	31.0	56.0
1.282000	24.1	9.000	Off	L1	9.8	31.9	56.0
14.302000	14.2	9.000	Off	L1	10.1	45.8	60.0
26.518000	20.9	9.000	Off	L1	10.2	39.1	60.0
26.524000	20.3	9.000	Off	L1	10.2	39.7	60.0
26.532000	18.9	9.000	Off	L1	10.2	41.1	60.0
26.766000	19.3	9.000	Off	L1	10.2	40.7	60.0
26.798000	21.0	9.000	Off	L1	10.2	39.0	60.0

2019-10-31

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Test

2 / 2

Final Result 2

Frequency (MHz)	CAverage (dBuV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.150000	22.3	9.000	Off	L1	9.7	33.7	56.0
0.160000	20.6	9.000	Off	L1	9.7	34.8	55.5
0.164000	22.1	9.000	Off	L1	9.7	33.2	55.3
0.168000	21.4	9.000	Off	L1	9.7	33.6	55.1
0.172000	20.4	9.000	Off	L1	9.7	34.4	54.9
0.176000	21.0	9.000	Off	L1	9.7	33.7	54.7
1.174000	16.6	9.000	Off	L1	9.8	29.4	46.0
1.230000	18.0	9.000	Off	L1	9.8	28.0	46.0
1.248000	18.5	9.000	Off	L1	9.8	27.5	46.0
1.252000	18.8	9.000	Off	L1	9.8	27.2	46.0
1.256000	10.5	9.000	Off	L1	9.8	27.5	46.0
1.270000	18.6	9.000	Off	L1	9.8	27.4	46.0
14.302000	9.1	9.000	Off	L1	10.1	40.9	50.0
26.516000	15.6	9.000	Off	L1	10.2	34.4	50.0
26.520000	16.1	9.000	Off	L1	10.2	33.9	50.0
26.524000	15.2	9.000	Off	L1	10.2	34.8	50.0
26.532000	13.8	9.000	Off	L1	10.2	36.2	50.0
26.766000	14.6	9.000	Off	L1	10.2	35.4	50.0

2019-10-31

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Conducted Emissions (Line 2)

Test

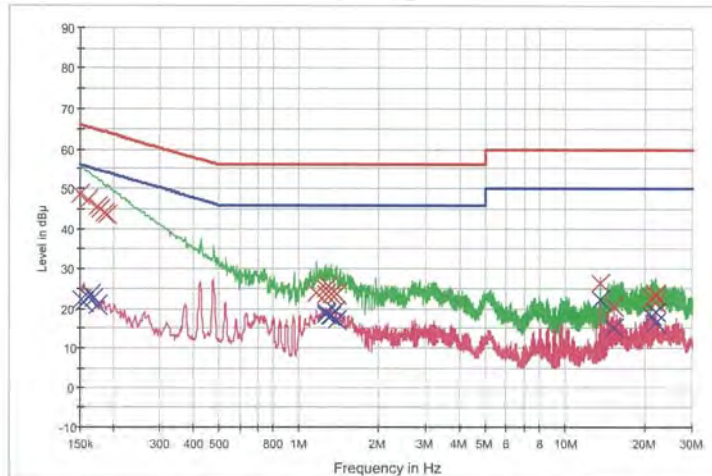
1/2

HCT TEST Report

Common Information

EUT: SRM100A
 Manufacturer: SEONG JI INDUSTRIAL CO.,LTD
 Test Site: SHIELD ROOM
 Operating Conditions: SIGFOX_N

FCC CLASS B



— FCC CLASS B_OP — FCC CLASS B_AV — Preview Result 1-PK+
 — Preview Result 2-AVG X Final Result 1-OPK X Final Result 2-CAV

Final Result 1

Frequency (MHz)	QuasiPeak (dBuV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.150000	48.8	9.000	Off	N	9.7	17.2	66.0
0.160000	47.2	9.000	Off	N	9.7	18.2	65.5
0.174000	45.4	9.000	Off	N	9.7	19.3	64.8
0.178000	44.9	9.000	Off	N	9.7	19.7	64.6
0.188000	43.9	9.000	Off	N	9.7	20.3	64.2
0.190000	43.5	9.000	Off	N	9.7	20.6	64.0
1.168000	23.8	9.000	Off	N	9.8	32.2	56.0
1.254000	25.0	9.000	Off	N	9.8	31.0	56.0
1.264000	23.7	9.000	Off	N	9.8	32.3	56.0
1.288000	25.6	9.000	Off	N	9.8	30.4	56.0
1.316000	23.4	9.000	Off	N	9.8	32.6	56.0
1.382000	23.5	9.000	Off	N	9.8	32.5	56.0
13.562000	26.2	9.000	Off	N	10.1	33.8	60.0
15.306000	20.4	9.000	Off	N	10.1	39.6	60.0
21.240000	22.5	9.000	Off	N	10.2	37.5	60.0
21.800000	23.7	9.000	Off	N	10.2	36.3	60.0
21.840000	23.2	9.000	Off	N	10.2	36.8	60.0
21.998000	21.4	9.000	Off	N	10.2	38.6	60.0

2019-10-31

오전 8:45:20

Test

2 / 2

Final Result 2

Frequency (MHz)	CAverage (dBuV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBuV)
0.152000	22.0	9.000	Off	N	9.7	33.9	55.9
0.156000	21.7	9.000	Off	N	9.7	34.0	55.7
0.160000	22.7	9.000	Off	N	9.7	32.7	55.5
0.164000	23.7	9.000	Off	N	9.7	31.6	55.3
0.168000	22.5	9.000	Off	N	9.7	32.6	55.1
0.174000	20.9	9.000	Off	N	9.7	33.9	54.8
1.254000	19.1	9.000	Off	N	9.8	26.9	46.0
1.266000	18.5	9.000	Off	N	9.8	27.5	46.0
1.312000	18.1	9.000	Off	N	9.8	27.9	46.0
1.316000	18.1	9.000	Off	N	9.8	27.9	46.0
1.374000	19.6	9.000	Off	N	9.8	26.4	46.0
1.392000	17.2	9.000	Off	N	9.8	28.8	46.0
13.562000	22.3	9.000	Off	N	10.1	27.7	50.0
15.306000	15.0	9.000	Off	N	10.1	35.0	50.0
21.240000	18.1	9.000	Off	N	10.2	31.9	50.0
21.800000	19.3	9.000	Off	N	10.2	30.7	50.0
21.840000	19.2	9.000	Off	N	10.2	30.8	50.0
21.998000	16.3	9.000	Off	N	10.2	33.7	50.0

2019-10-31

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11. LIST OF TEST EQUIPMENT

Conducted Test

Manufacturer	Model / Equipment	Calibration Date	Calibration Interval	Serial No.
Rohde & Schwarz	ENV216 / LISN	12/12/2018	Annual	102245
Rohde & Schwarz	ESCI / Test Receiver	06/18/2019	Annual	100033
ESPAC	SU-642 / Temperature Chamber	03/12/2019	Annual	0093008124
Agilent	N9020A / Signal Analyzer	05/23/2019	Annual	MY51110085
Agilent	N9030A / Signal Analyzer	11/20/2018	Annual	MY49431210
Keysight	N9030A / Signal Analyzer	10/23/2019	Annual	MY54170656
Agilent	N1911A / Power Meter	04/10/2019	Annual	MY45100523
Agilent	N1921A / Power Sensor	04/10/2019	Annual	MY52260025
Agilent	87300B / Directional Coupler	11/20/2018	Annual	3116A03621
Hewlett Packard	11667B / Power Splitter	05/24/2019	Annual	5001
Hewlett Packard	E3632A / DC Power Supply	06/18/2019	Annual	KR75303960
Agilent	8493C / Attenuator(10 dB)	07/02/2019	Annual	07560
Rohde & Schwarz	EMC32 / Software	N/A	N/A	N/A
HCT CO., LTD.	FCC WLAN&BT&BLE Conducted Test Software v3.0	N/A	N/A	N/A
Rohde & Schwarz	CBT / Bluetooth Tester	05/16/2019	Annual	100422

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

Radiated Test

Manufacturer	Model / Equipment	Calibration Date	Calibration Interval	Serial No.
Innco system	CO3000 / Controller(Antenna mast)	N/A	N/A	CO3000-4p
Innco system	MA4640/800-XP-EP / Antenna Position Tower	N/A	N/A	N/A
Emco	2090 / Controller	N/A	N/A	060520
Ets	Turn Table	N/A	N/A	N/A
Rohde & Schwarz	Loop Antenna	01/18/2019	Biennial	1513-175
Schwarzbeck	VULB 9160 / Hybrid Antenna	08/09/2019	Biennial	3368
Schwarzbeck	BBHA 9120D / Horn Antenna	11/21/2017	Biennial	9120D-1191
Schwarzbeck	BBHA9170 / Horn Antenna(15 GHz ~ 40 GHz)	12/04/2017	Biennial	BBHA9170541
Rohde & Schwarz	FSP(9 kHz ~ 30 GHz) / Spectrum Analyzer	09/11/2019	Annual	836650/016
Rohde & Schwarz	FSV40-N / Spectrum Analyzer	09/26/2019	Annual	101068-SZ
Wainwright Instruments	WHKX10-2700-3000-18000-40SS / High Pass Filter	01/03/2019	Annual	4
Wainwright Instruments	WHKX8-6090-7000-18000-40SS / High Pass Filter	01/03/2019	Annual	5
Wainwright Instruments	WRCJV2400/2483.5-2370/2520-60/12SS / Band Reject Filter	06/19/2019	Annual	2
Wainwright Instruments	WRCJV5100/5850-40/50-8EEK / Band Reject Filter	01/03/2019	Annual	2
Api tech.	18B-03 / Attenuator (3 dB)	06/04/2019	Annual	2
WEINSCHL	56-10 / Attenuator(10 dB)	10/08/2019	Annual	72316
CERNEX	CBLU1183540B-01/Broadband Bench Top LNA	01/03/2019	Annual	28549
CERNEX	CBL06185030 / Broadband Low Noise Amplifier	01/03/2019	Annual	24615
CERNEX	CBL18265035 / Power Amplifier	01/03/2019	Annual	22966
CERNEX	CBL26405040 / Power Amplifier	06/18/2019	Annual	25956
TESCOM	TC-3000C / Bluetooth Tester	03/26/2019	Annual	3000C000276

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

12. ANNEX A_ TEST SETUP PHOTO

Please refer to test setup photo file no. as follows;

No.	Description
1	HCT-RF-1911-FI014-P