Advanced
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FCC CFR47 PART 15 SUBPART C & IC RSS-247

TEST REPORT

For

Centrak, Inc.

Clear Repeater
Model Number: IT-105

FCC ID: ST2-IT105
IC: 6012A-IT105

Report Number: 0048-180813-02-FCC-IC

Prepared for
Centrak, Inc.
826 Yardley-Newtown
Newtown, PA 18940, USA

Prepared by
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Date: 10/22/2018

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1. TEST RESULT CERTIFICATION

COMPANY NAME: **Centrak, Inc.**
826 Yardley-Newtown
Newtown, PA 18940, USA

EUT DESCRIPTION: **Clear Repeater**

MODEL: **IT-105**

DATE TESTED: 08/13/2018 to 10/22/2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC Part 15.247 & IC RSS-247:Issue 2 & RSS-GEN: Issue 5	NO NON-COMPLIANCE NOTED

Test Summary

Testing Items Per FCC Part 2/ Part 15.247 & IC RSS-247 /RSS-Gen Standard Requirements for 900MHz band FHS Modulation	**Section**	**Limit**	**Result**
FHS Bandwidth	15.247(a) (1)(i) RSS-247, 5.1(a)	20dB BW<=500KHz	Complies
Peak Power Limit	15.247(b) (2) RSS-247, 5.4(a)	Conducted: 1W (30dBm) for Hopping Channel at least 50 or 0.25W (24dBm) for Hopping Channel less than 50 but at least 25. Max. e.i.r.p. 4W or 1W	Complies
Hopping Channel Separation	15.247(a) (1) RSS-247, 5.1(b)	>=25 kHz or 20 dB BW of Hopping Channel (greater one)	Complies
Number of Hopping Frequency	15.247(a) (1)(i) RSS-247, 5.1(c)	At least 50 if 20dB BW<250KHz; At least 25 if 20dB BW>=250KHz	Complies
Time of Occupancy (Dwell Time)	15.247(a)(1)(i) RSS-247, 5.1(c)	0.4s within 20s if 20dB BW<250KHz; 0.4s within 10s if 20dB BW>=250KHz	Complies
Emissions (Conducted)	15.247(d) RSS-247, 5.5	-20dB (peak, 100KHz RBW)/-30dB(RMS)	Complies
Spurious (Radiated)	15.205(a) RSS-247, 5.5	15.209(a)/RSS-Gen	Complies

FHS Design Requirement	Part 15.247(g) (h)	Provided in Operational Description	Complies
RF Safety*	1.1310/RSS-102	1.0/5.0 mW/cm^2 & RSS-102 Table 1/ Section 2.5	Complies

NOTE: * For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

Advanced Compliance Laboratory, Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: This document reports conditions under which testing was conducted and results of tests performed. This document may not be altered or revised in any way unless done so by Advanced Compliance Laboratory, Inc. (ACL) and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by ACL, Advanced Compliance Laboratory, Inc. will constitute fraud and shall nullify the document.

Approved & Released For ACL By:

Wei Li

Manager
Advanced Compliance Laboratory, Inc.

Tested By:

David Tu

EMC Engineer

2. EUT DESCRIPTION

The EUT for this certification is a low power transmitter, using digital modulation & operating in the 902-928MHz Band.

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Rated Power	Measured Max. Conducted Output Power (dBm/W)	
905.007-918.007	24dBm/0.251W	23.90dBm/ 0.245W	

The EUT can use the following antennas (two identical : one for TRX, other for RX only): Monopole with max 3dBi gain.

With max. 3dBi gain antenna, the max. EIRP =26.9dBm (0.490 W) , which meets this limit.

EUT Specification:

Data Speed (Mbps)	Operation Frequency (MHz)	Modulation Type	Measured Peak Power at Antenna port (dBm/W)	Occupied Bandwidth (KHz)	Emission Designator
1	905.007-918.007	2-GFSK	23.98	88.5	88K5F1D

Power Supply for RF Module: +5VDC

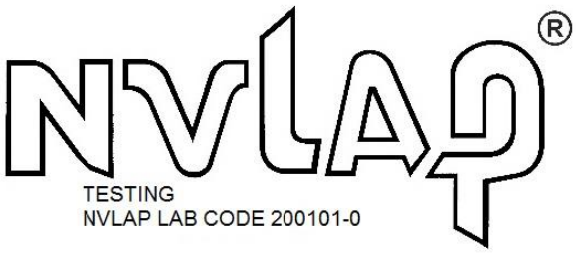
3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4(2014)/C63.10(2013), FCC CFR 47 Part 2 & 15 and IC RSS-247(Issue 2) & RSS-GEN (Issue 5). Test procedure described in FCC Public Notice "KDB 558074 D01 V05 & ANSI C63.10 is used in this report.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at Hillsborough, New Jersey, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods"

ACL site is accepted by FCC to perform measurements under Part 15 or 18 (Designation Number US5347) and also designated by IC as " site IC 3130A". ACL is accredited by NVLAP, Laboratory Code 200101-0. The full accreditation can be viewed at http://www.ac-lab.com



No part of this report may be used to claim or imply product endorsement by NVLAP or any agency of the US Government.

5. CALIBRATION AND UNCERTAINTY

5.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

5.2. MEASUREMENT UNCERTAINTY

The estimated uncertainty of the test result is given as following. The method of uncertainty calculation is provided in Advanced Compliance Lab. Doc. No. 0048-01-01.

	Prob. Dist.	Uncertainty(dB)	Uncertainty(dB)	Uncertainty(dB)
		30-1000MHz	1-6.5GHz	Conducted
Combined Std. Uncertainty u_c	norm.	±2.36	±2.99	±1.83

5.3. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Manufacture	Model	Serial No.	Description	Last Cal dd/mm/yy	Cal Due dd/mm/yy
Hewlett-Packard	HP8546A	3448A00290	EMI Receiver	25/09/17	25/09/19
Agilent	E4440A	US40420700	3Hz-26.5GHz Spectrum Analyzer	17/06/17	17/06/19
EMCO	3104C	9307-4396	20-300MHz Biconical Antenna	12/11/16	12/11/18
EMCO	3146	9008-2860	200-1000MHz Log-Periodic Antenna	13/11/16	13/11/18
ARA	MWH-1826/B	1013	18-26GHZ Horn Antena	10/2/17	10/2/19
EMCO	3115	49225	Double Ridge Guide Horn Antenna	28/11/16	28/11/18
Electro-Meterics	ALR-25M/30	289	10KHz-30MHz Active Loop Antenna	28/05/17	28/05/19
COM-POWER	L1215A	191994	Line Impedance Stabilization Networks	24/03/17	24/03/19
Fischer Custom	LISN-2	900-4-0009	Line Impedance Stabilization Networks	18/03/17	18/03/19
Belden	9913	ACL23	70’ RF cable for Radiated Emission Test	16/03/17	16/03/19
Megaphase	TM8S1S1180	ACL53	18’ RF Cable for Radiated Emission Test	25/9/17	25/09/19
Megaphase	TM8 NKS536	ACL54	3’ RF Cable for Radiated Emission Test	25/09/17	25/09/19
MegaPhase	TM8S1S1240	ACL20	24’ RF Cable for Conducted Emission Test (used with limiter HP 11947A)	25/09/17	25/09/19
R&S	SMH	8942280/010	Signal Generator	15/01/17	15/01/19
Narda	BW-10W5	3037	10dB , 5W in-line Power Attenuator	15/01/17	15/01/19
RES-NET	RFA500NFF30	0108	30dB in-line Power Attenuator	15/01/17	15/01/19
Lorch Microwave	5NF-800/1000-S	AC3	Notch Filter	15/01/17	15/01/19
Lorch Microwave	5NF-1800/2200-S	AE10	Notch Filter	15/01/17	15/01/19
Narda	3022	80986	Directional Coupler	15/01/17	15/01/19
Lorch Microwave	5NF-800/1000-S	AC3	Notch Filter	15/01/17	15/01/19

All Test Equipment Used is Calibrated, Traceable to NIST Standards. Calibration interval: 2 years

6. SETUP OF EQUIPMENT UNDER TEST

SUPPORT EQUIPMENT

None.

TEST SETUP

Testing Frequency/Channel/Port Selection:

- **L**(owest), **M**(iddle), **H**(ighest) Channels of 900MHz Band selected to perform the test
- Conducted measurement performed at EUT's antenna connector.
- Modulation: 2-GFSK
- EUT was set in continuous transmitting mode with modulation (hopping or non-hopping)
- EUT DC voltage provided by external DC power source: AC/DC adaptor or +5V DC. Emission Pre-scans were done for two configurations : EUT powered by AC/DC adaptor & EUT Powered by optional 5V external DC power source. The worse case. EUT powered by AC/DC adaptor was chosen for final data collection.

Frequency settings:

Mode	#1 Tx	#2 Rx1	#3 Rx2
Modulation	2-GFSK		
Lowest Channel (L)	905.007		
Middle Channel (M)	911.507	911.507	911.507
Highest Channel (H)	918.007		

7. APPLICABLE LIMITS AND TEST RESULTS

7.1 20dB &99% BANDWIDTH

LIMIT

§15.247 (a) (1) & RSS-247 Sec. 5.1(a):
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. Alternatively, 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, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. 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.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency 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 frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hop set.

TEST PROCEDURE *per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10*

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1% to 3% of the 99% bandwidth. The VBW/RBW is set to one or three. The sweep time is coupled.

RESULTS

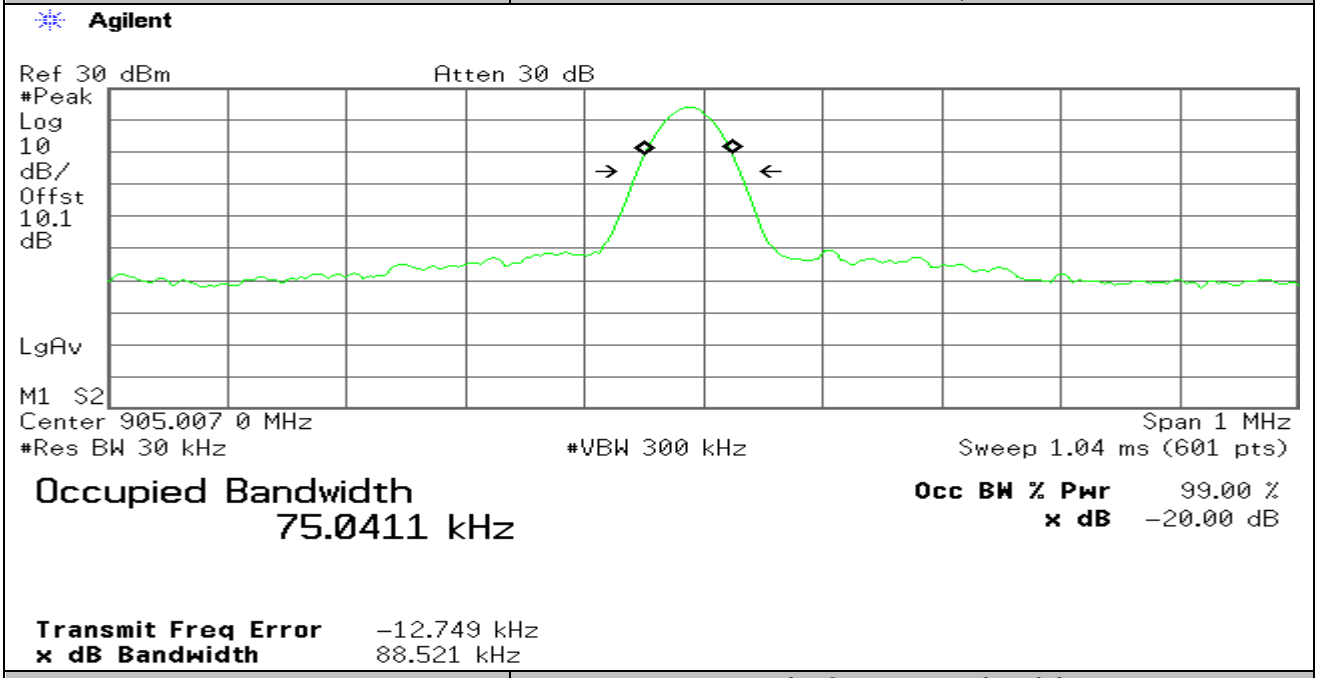
No non-compliance noted.

Mode No.1: Tx

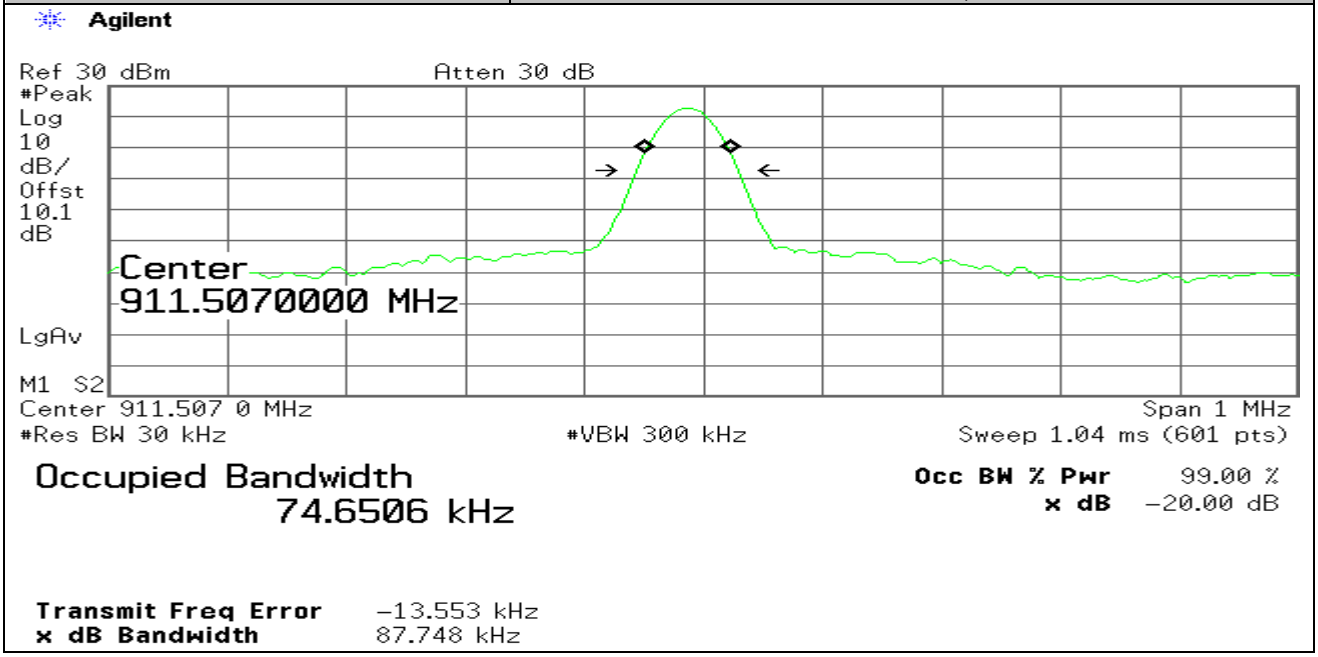
Channel	Frequency (MHz)	20dB Bandwidth (KHz)	99% Bandwidth (KHz)
Low	905.007	88.521	75.041
Middle	911.507	87.748	74.650
High	918.007	87.474	74.396

20dB & 99% BANDWIDTH

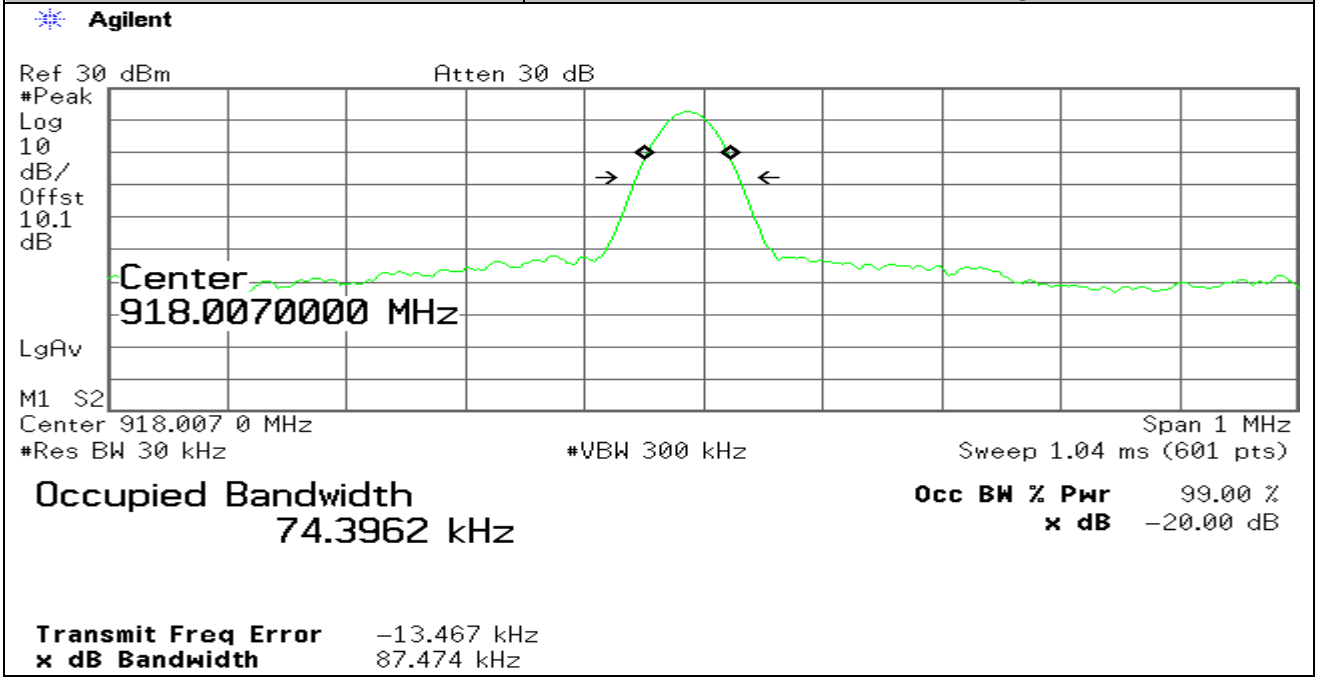
Plot Name:	20dB &99% Bandwidth, Mode No 1. Tx , Low CH



Plot Name:	20dB &99% Bandwidth, Mode No 1. Tx , Mid CH



Plot Name:	20dB & 99% Bandwidth, Mode No 1. Tx , High CH



7.2 MAXIMUM OUTPUT POWER

PEAK POWER LIMIT

§15.247 (b)(2) & RSS-247 Sec. 5.4(a)

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.

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.

b(4) 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. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Therefore, the applicable output power limit shall be calculated as follows:

Pout = 30 -(Gtx-6) for antenna gain ≤6dBi or
Pout = 30 -Floor[(Gtx-6)/3]
G_{Tx} = the maximum transmitting antenna directional gain in dBi.

TEST PROCEDURE *per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10*

The transmitter output is connected to a spectrum analyzer and the analyzer bandwidth is set to a value greater than the 20 dB bandwidth of the EUT.

TEST RESULT

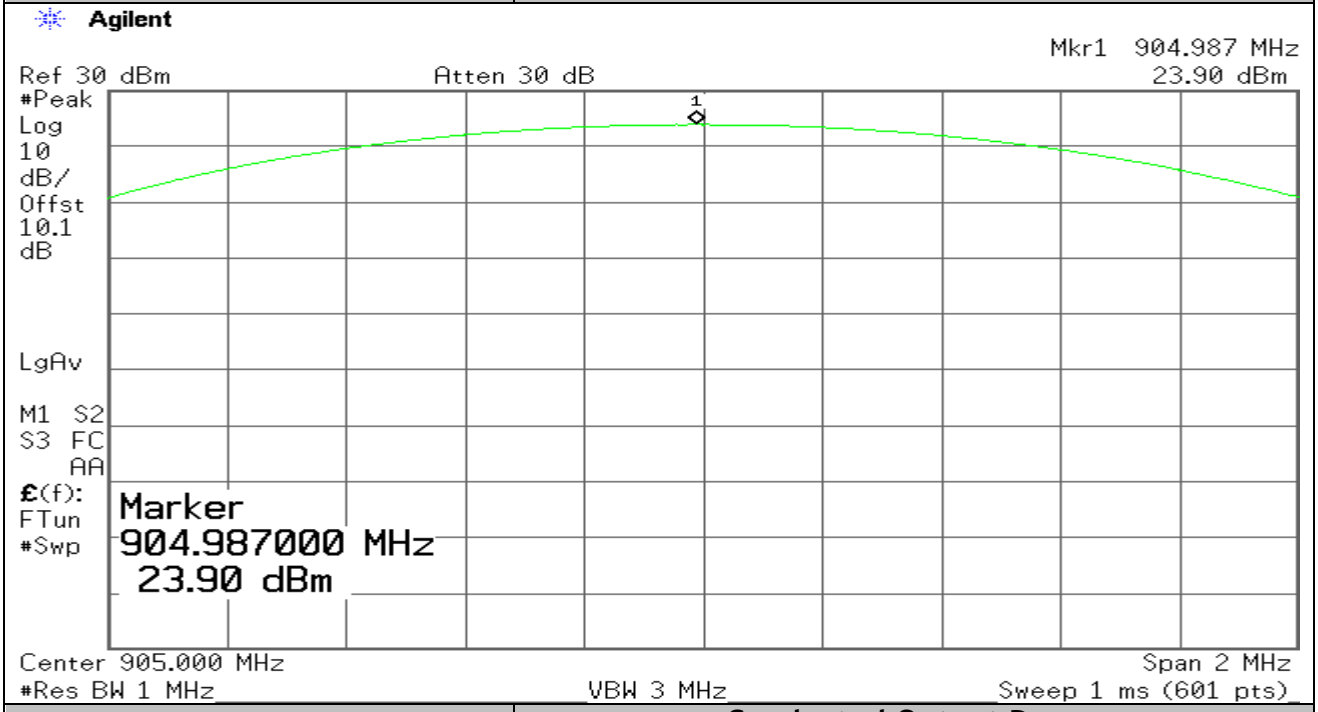
No non-compliance noted.

With max. 3dBi gain Omni antenna, the max. EIRP limit is 26.9dBm/0.490W, which is under 4W/36dBm limit (Frequency Hopping chanel number is 50 for this EUT).

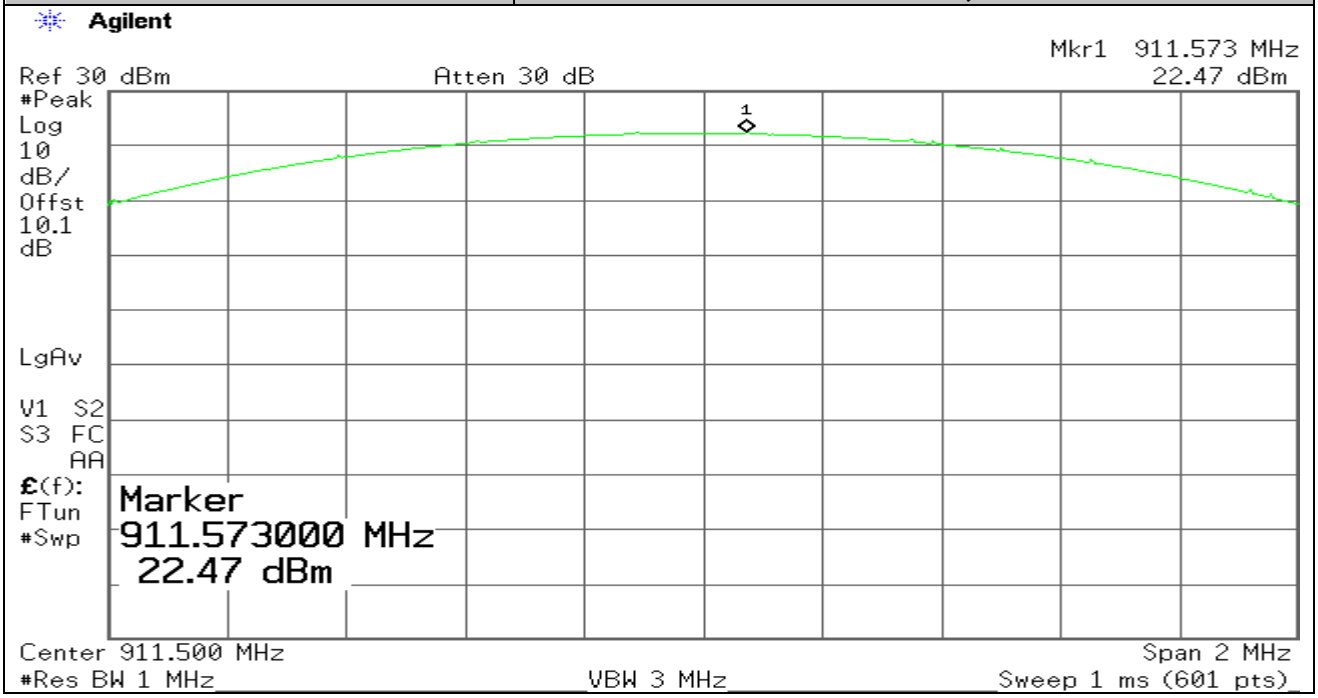
Mode No.1 Tx

Channel	Frequency (MHz)	Output Power* (dBm)	Limit (dBm)	Margin (dB)
Low	905.007	23.90	30	-6.10
Middle	911.507	22.54	30	-7.46
High	918.007	22.26	30	-7.73

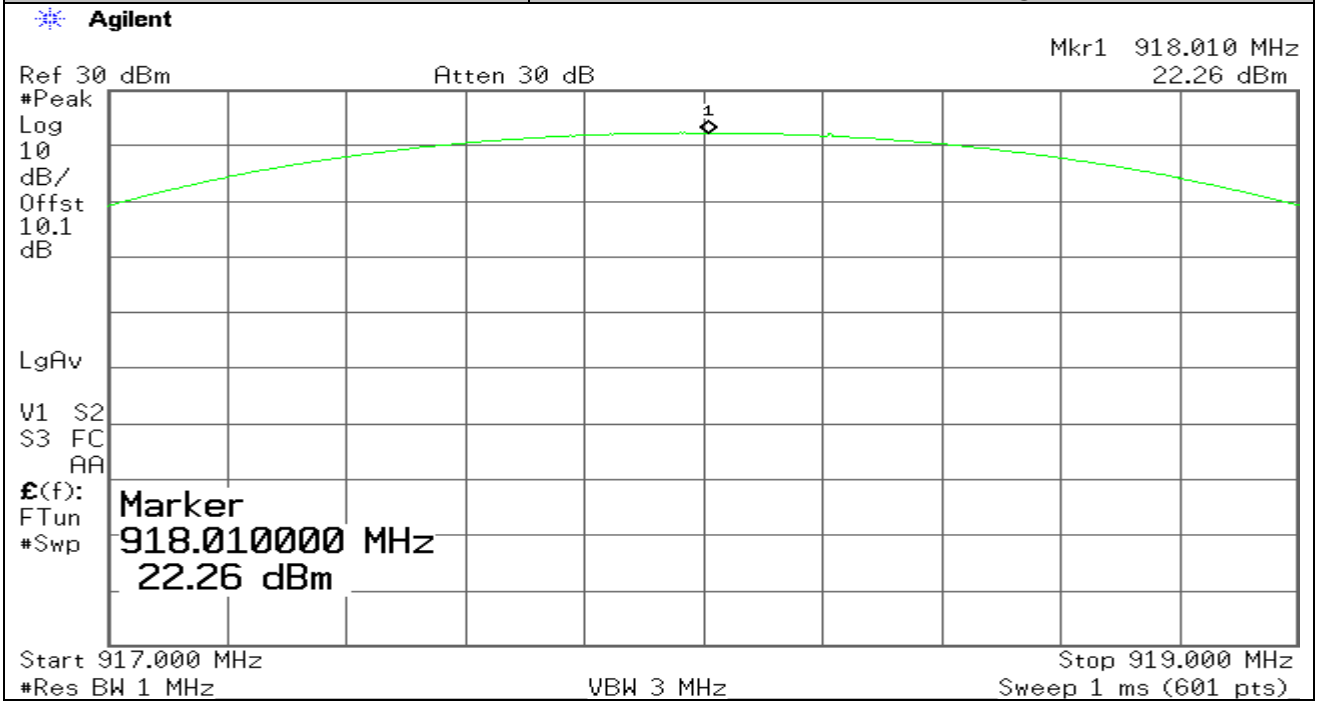
Plot Name:	Conducted Output Power Mode No 1. Tx , Low CH



Plot Name:	Conducted Output Power Mode No 1. Tx , Mid CH



Plot Name:	Conducted Output Power Mode No 1. Tx , High CH



7.3 MAXIMUM PERMISSIBLE EXPOSURE

LIMITS Per FCC Table 1 & Section §1.1310

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f^2)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f^2)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density
NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

LIMITS per RSS-102, Table 1 & Section 2.5

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance[4,5]

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

Per 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:
• below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
• at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
• at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
• at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
• at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

CALCULATIONS

Given

$E = \sqrt{(30 * P * G)} / d$

and

$S = E \wedge 2 / 3770$

where

E = Field Strength in Volts/meter
P = Power in Watts
G = Numeric antenna gain
d = Distance in meters
S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$d = \sqrt{((30 * P * G) / (3770 * S))}$

Changing to units of Power to mW and Distance to cm, using:

P(mW) = P (W) / 1000 and
d (cm) =100 * d (m)

yields

$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$
$d = 0.282 * \sqrt{(P * G / S)}$

where

d = distance in cm
P = Power in mW
G = Numeric antenna gain
S = Power Density in mW/cm^2

Substituting the logarithmic form of power and gain using: P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (dBi) / 10)

yields

$d = 0.282 * 10 \wedge ((P + G) / 20) / \sqrt{S}$ Equation (1)
$S = 0.0795 * 10 \wedge ((P + G)/10)/ d\wedge 2$ Equation (2)

where

d = MPE distance in cm
P = Power in dBm
G = Antenna Gain in dBi
S = Power Density Limit in mW/cm^2

Equation (1) and the measured Output power is used to calculate the MPE distance.
Equation (2) and the measured Output power is used to calculate the Power density.

APPLICABLE LIMITS for separation >= 20cm

FCC: From §1.1310 Table 1 (B), for Public S = 1.0 mW/cm^2 ; for Professional, S = 5.0 mW/cm^2
IC: With formula of 1.31 x 10^{-2} $f^{0.6834}$ W, more restricted EIRP limit value are 1.37W at 902MHz, 2.67W at 2400MHz.

RESULTS

No non-compliance noted.

For this EUT, P+G=23.90+3=26.90 dBm, and d=20cm

A. For FCC, plug all three items into equation (2), yielding,

Power Density Limit (mV/cm^2)	Output Power (dBm)	Antenna] Gain (dBi)	Power Density (mW/ cm$^{2)}$
1.0/5.0	23.90	3	0.1

B. For IC, max. eirp= 0.490W with max. 3dB gain antenna., much less than the limit of 1.37W.

NOTE: For mobile or fixed location transmitters, the minimum separation distance between the antenna & radiating structures of the device and nearby persons is 20 cm, even if calculations indicate that the MPE distance would be less.

7.4. HOPPING FREQUENCY SEPARATION

LIMIT

§15.247 (a)(1) & RSS-247, 5.1(b)

(1) 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. Alternatively, 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, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. 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.

TEST PROCEDURE per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10

The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 /30KHz and the VBW is set to 100/30KHz. The sweep time is coupled.

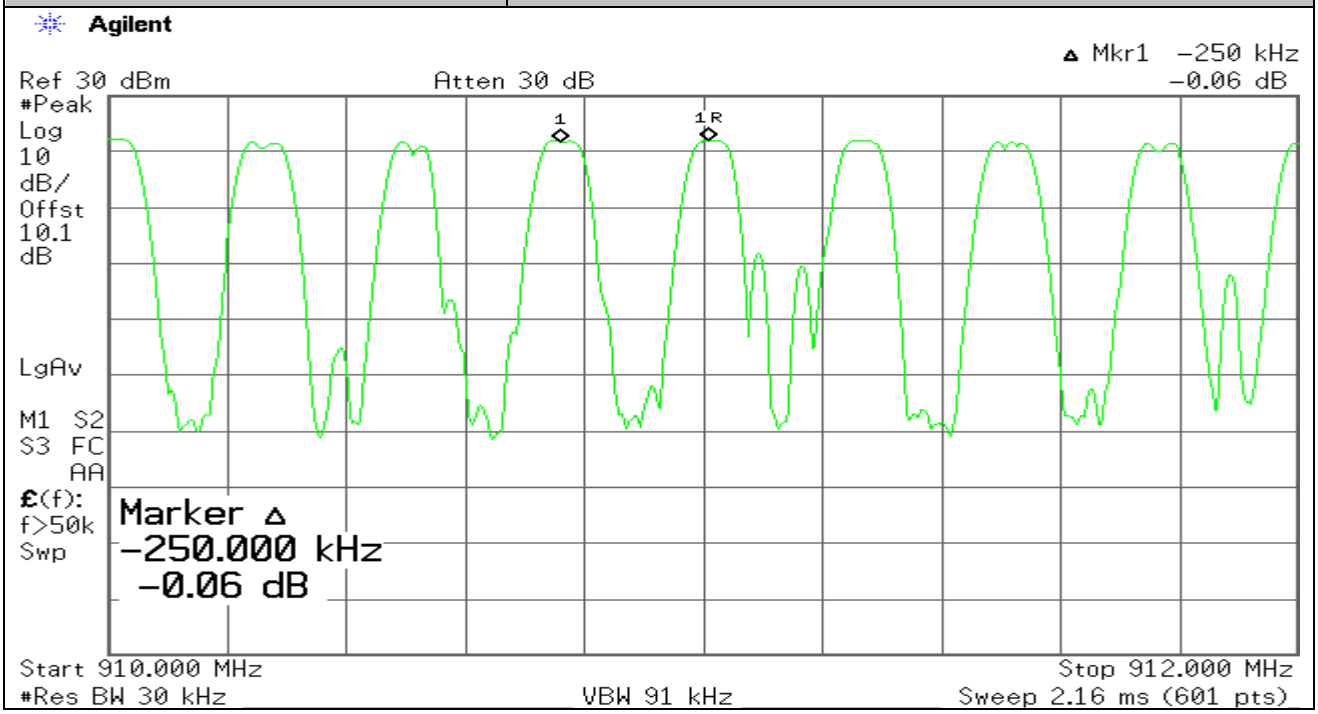
RESULTS

No non-compliance noted.

Modulation	Channel Separation (KHz)	Comparison		20dB Bandwidth (KHz)
Tx	250	>	25KHz	88.5

HOPPING FREQUENCY SEPARATION

Plot Name:	FH Channel Separation Mode No 1. Tx



7.5. NUMBER OF HOPPING CHANNELS

LIMIT

§15.247 (a) (1) (i) & RSS-247, 5.1(c)

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency 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 frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

TEST PROCEDURE per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10

The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple contiguous sweeps. The RBW is set to 1 % of the span. The analyzer is set to Max Hold.

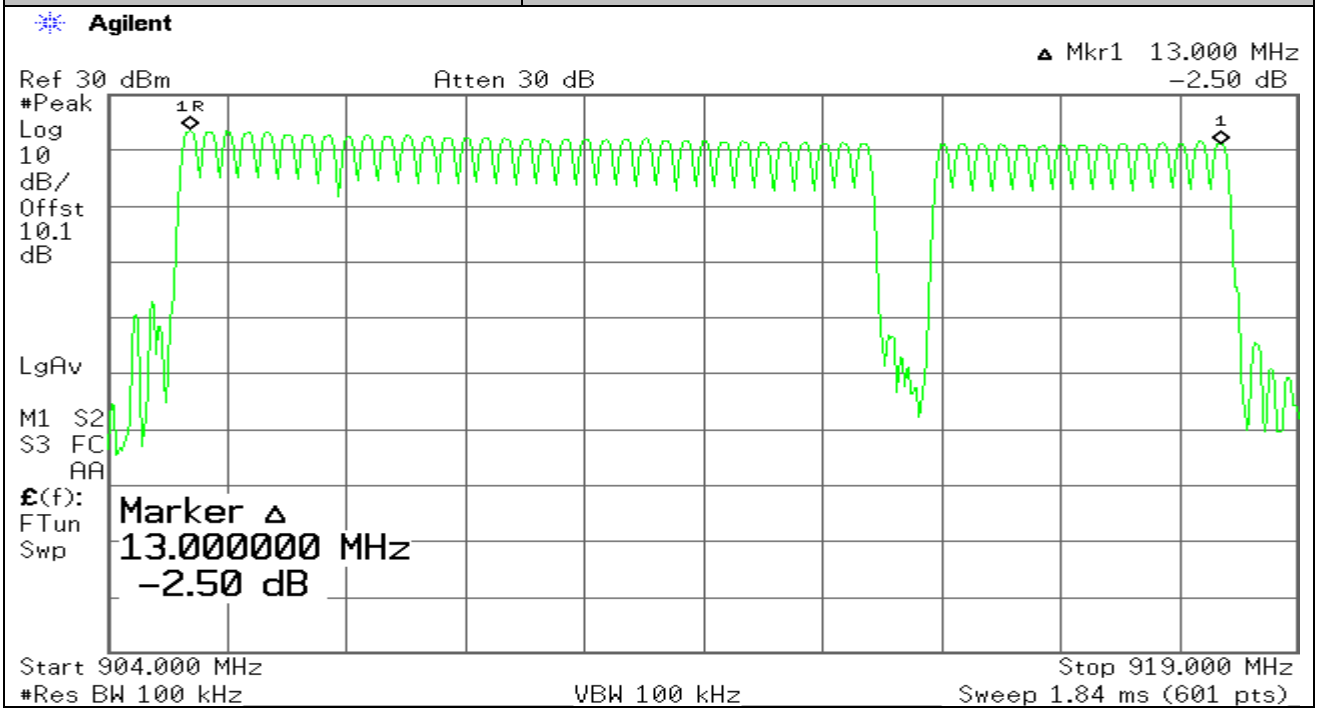
RESULTS

No non-compliance noted

Modulation	Channel Observed	Comparison	limit
Tx	50	=	>=50

NUMBER OF HOPPING CHANNELS

Plot Name:	FH Channel Number Mode No 1. Tx



7.6 TIME OF OCCUPANCY

LIMIT

15.247 (a) (1) (i) & RSS-247, 5.1(d)
(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency 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 frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

TEST PROCEDURE per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. In this case, we selected the mid channel. RBW(IF)=100KHz, VBW=300KHHz. The width of a single pulse (E) was measured and the number of the pulses (D) was measured in the small period of C seconds to enable resolution of each occurrence. The average time of occupancy (ATO) in the specified period (B=total channels (A) * 0.4 s)) is equal to B/C*D*E.

RESULTS

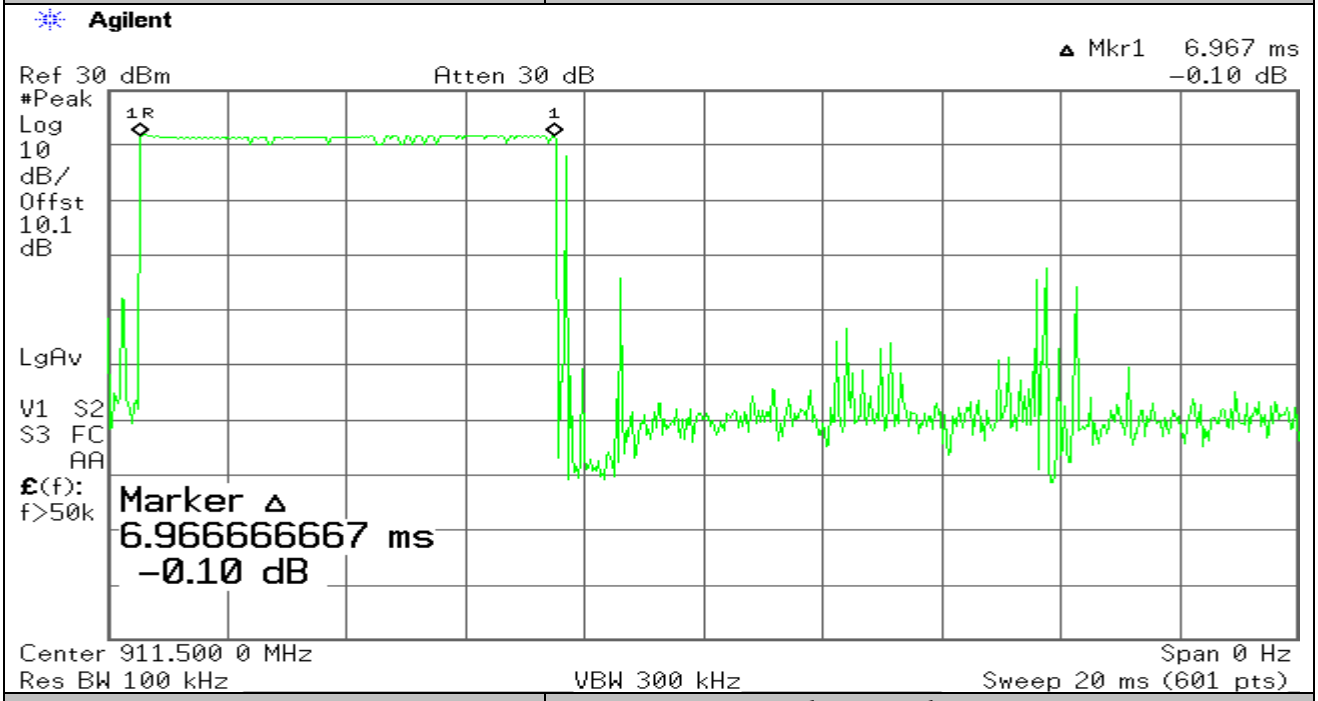
No non-compliance noted.

Average Time of Occupancy (ATO)

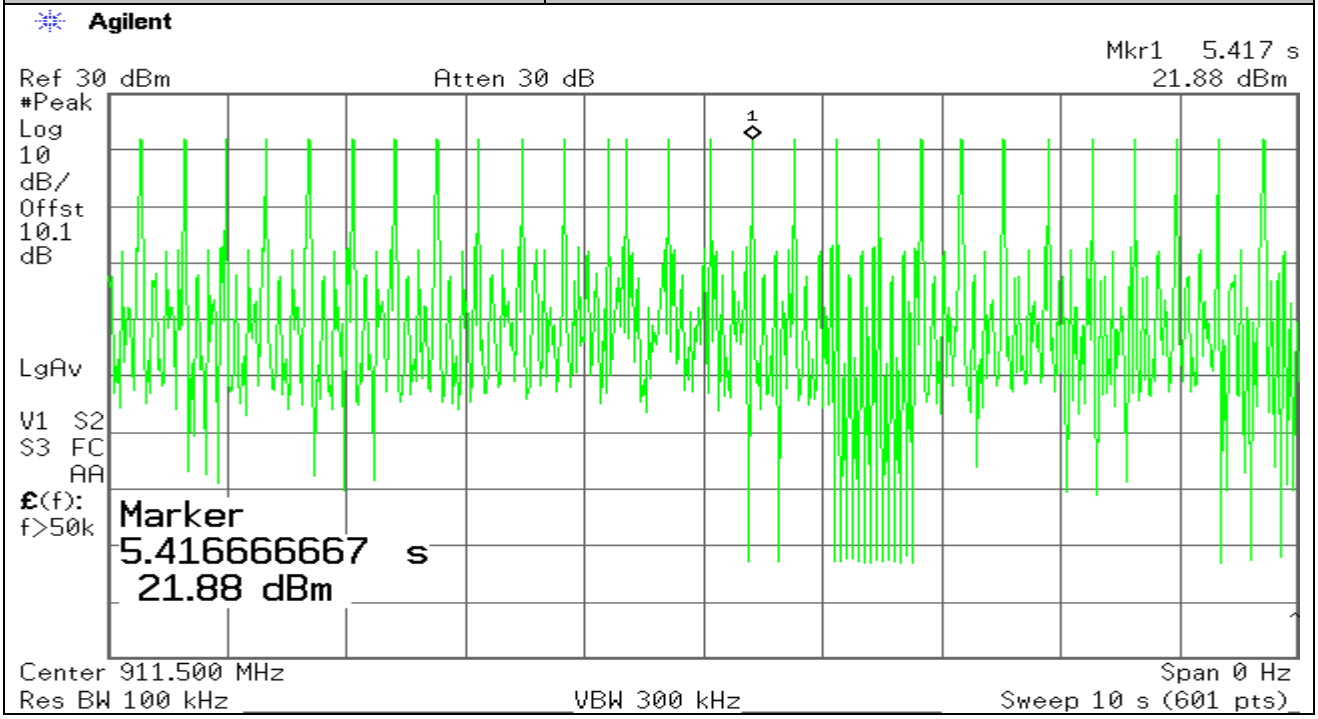
	A	B	C	D	E		
Mod BW	Total Ch #	Total allowed Time (0.4sxCH#)	Small Period (s)	# of Ch in small Period	Each CH Time Occup. (ms)	ATO= B/C*D*E (s)	<limit 0.4s
Tx	50	20s	10s	28	6.967	0.390	Y

Tx

Plot Name:	Pulse Width Mode No 1: Tx



Plot Name:	Pulse Numbers in 10s Mode No 1: Tx



7.7 CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.247 (d) & RSS- 247 Sec. 5.5
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 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)).

TEST PROCEDURE *per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10*

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 100 or 300KHz.

The spectrum from 20 MHz to 10 GHz was investigated with the transmitter set to the lowest, middle, and highest channels with hopping ON or OFF.

RESULTS

Complied with 20dBc attenuation requirement.

Data Summary:

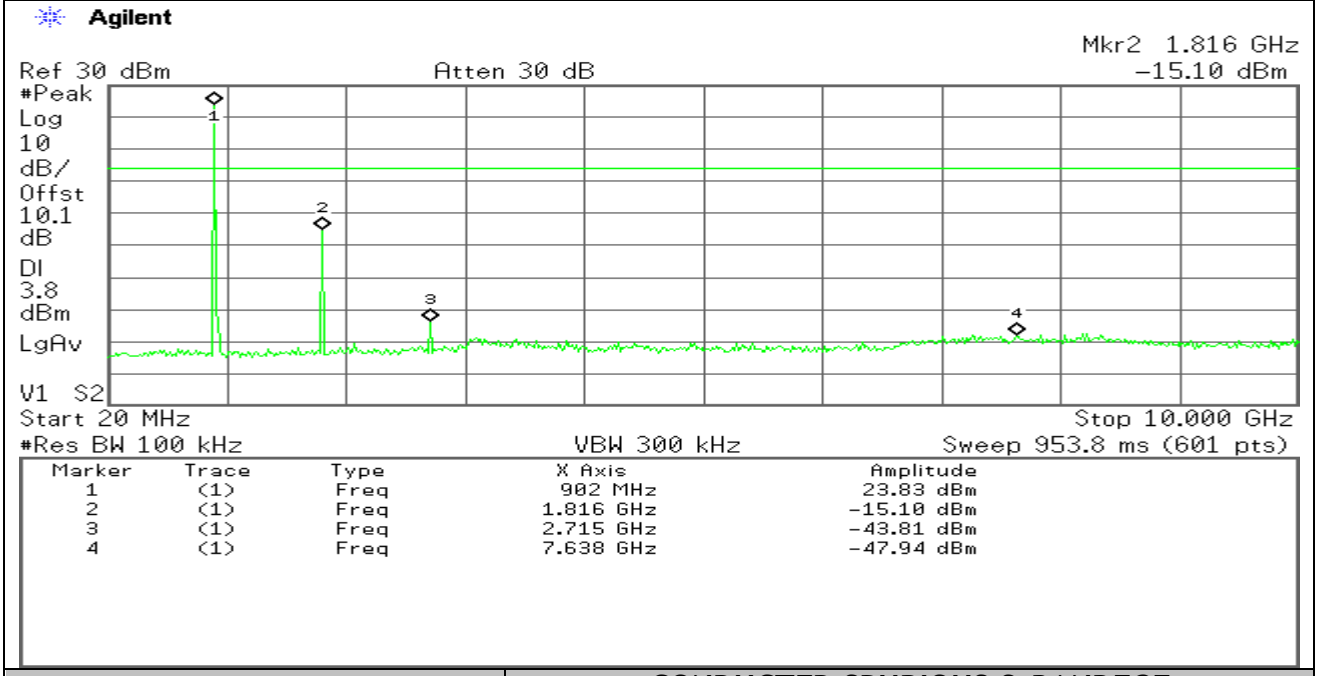
Mode No.1 Tx

Channel	Frequency (MHz)	Hopping	Attenuation (dBc) to max. Spurious Emission Level
Low	905.007	Off./On	>>20dBc
Middle	911.507	Off/On	>>20dBc
High	918.007	Off/On	>>20dBc

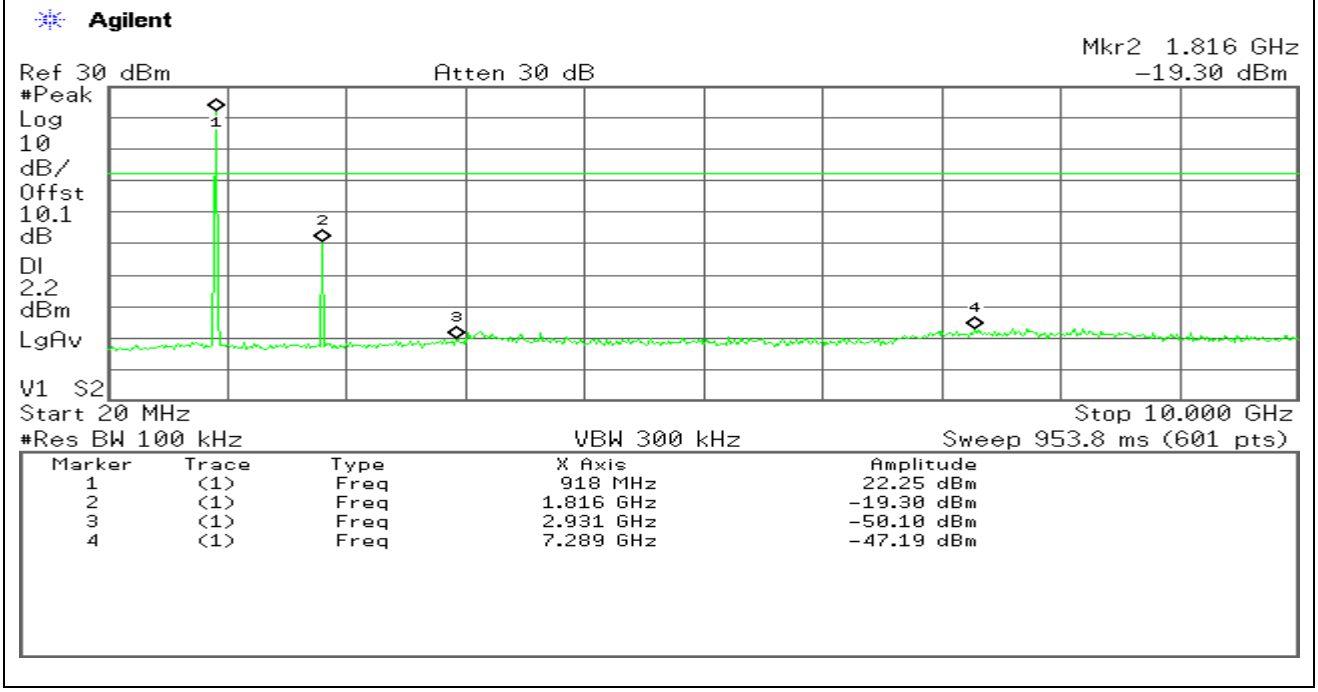
Spurious via Conducted Measurement:

Hopping Off:

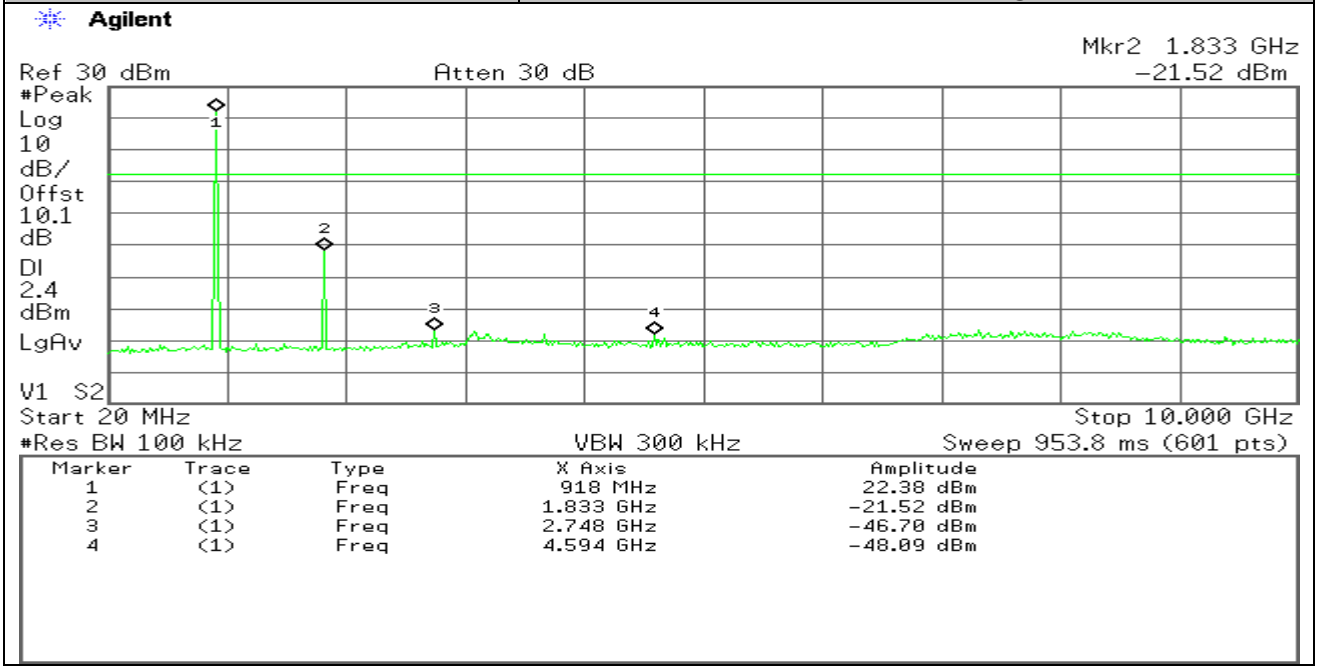
Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , Low CH



Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , Mid CH

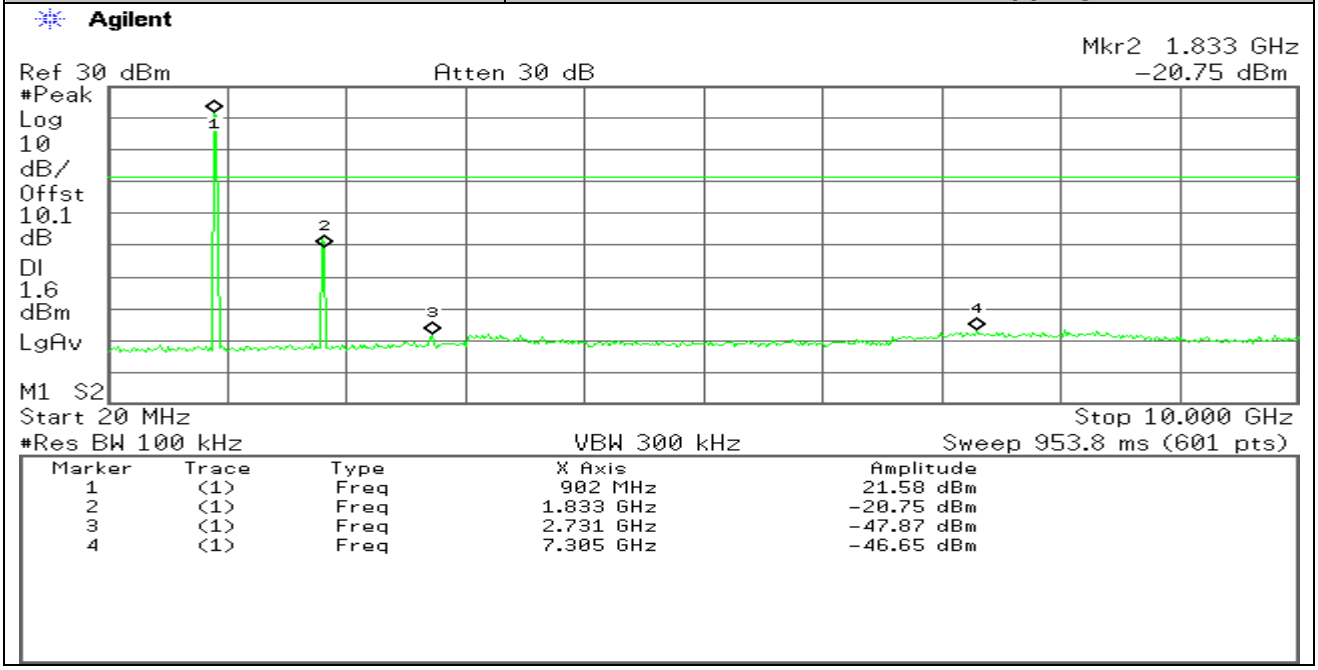


Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , High CH



Hopping On

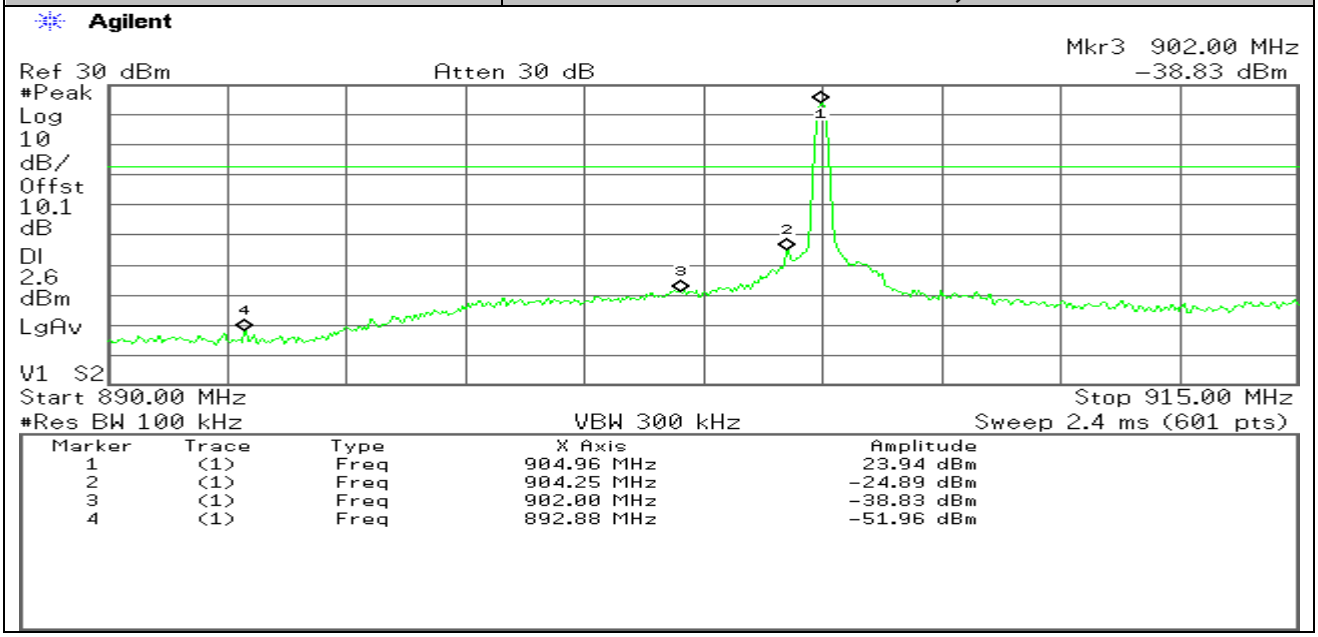
Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , Hopping



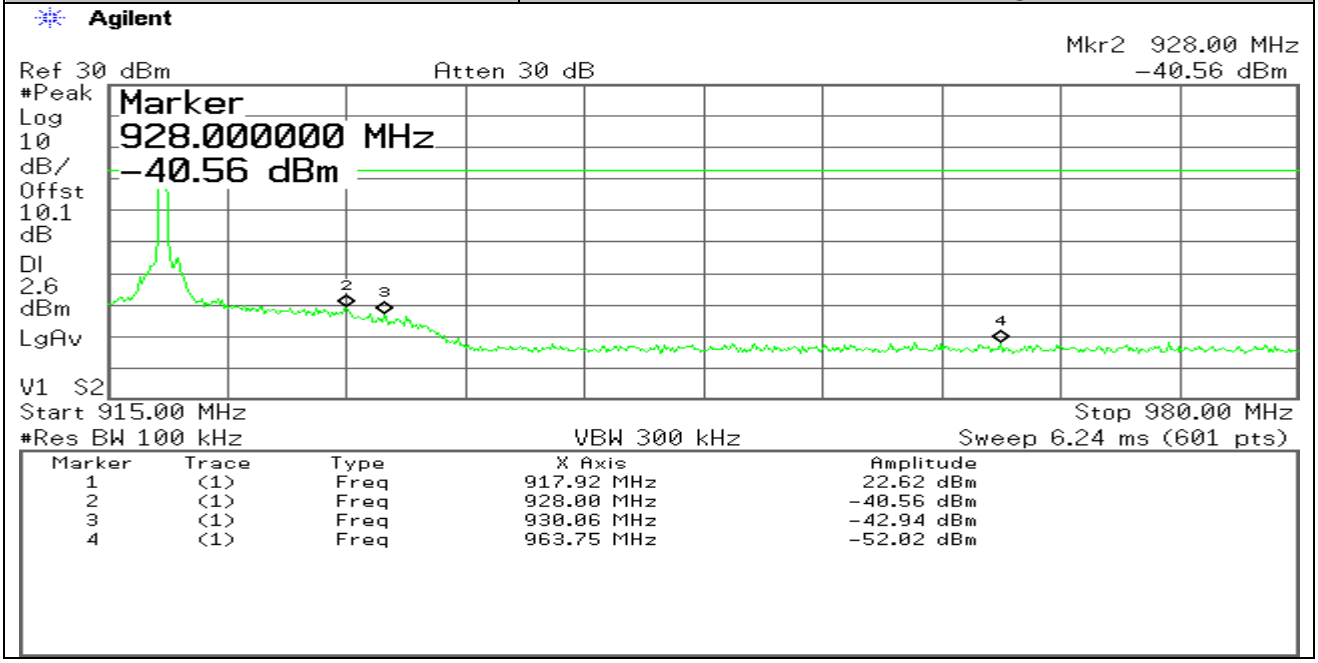
Band-Edge via Conducted Measurement:

Hopping Off:

Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , Low CH

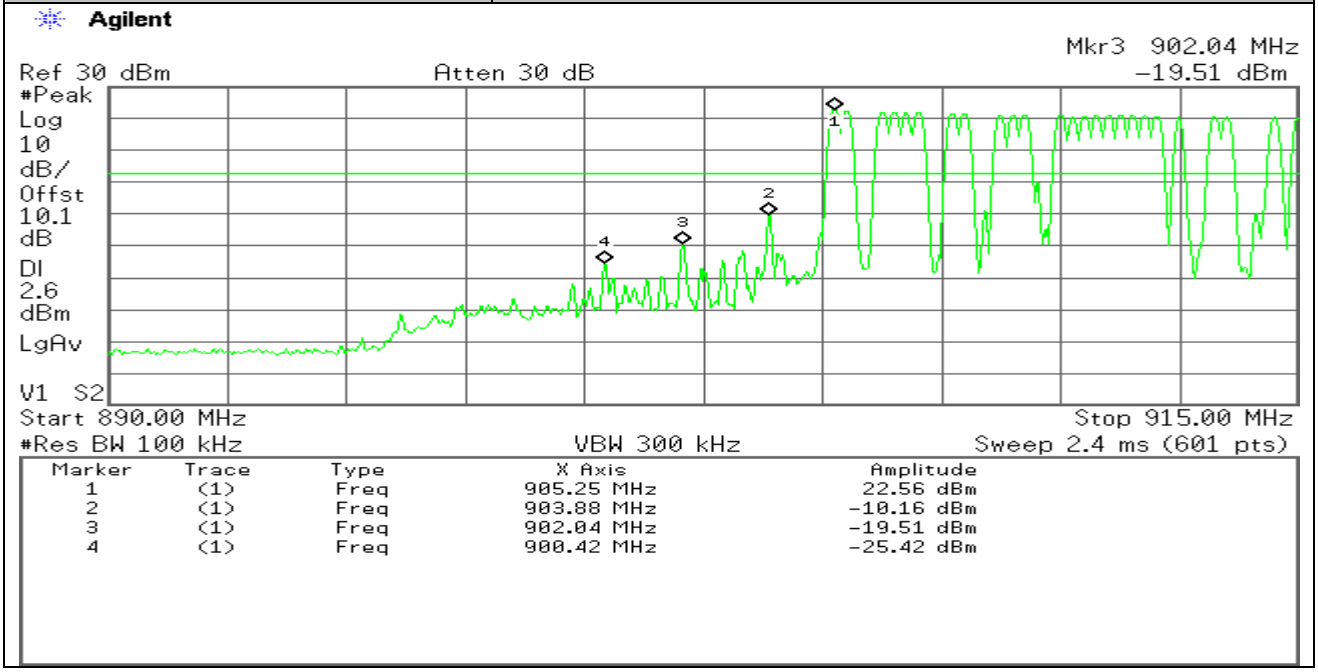


Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , High CH

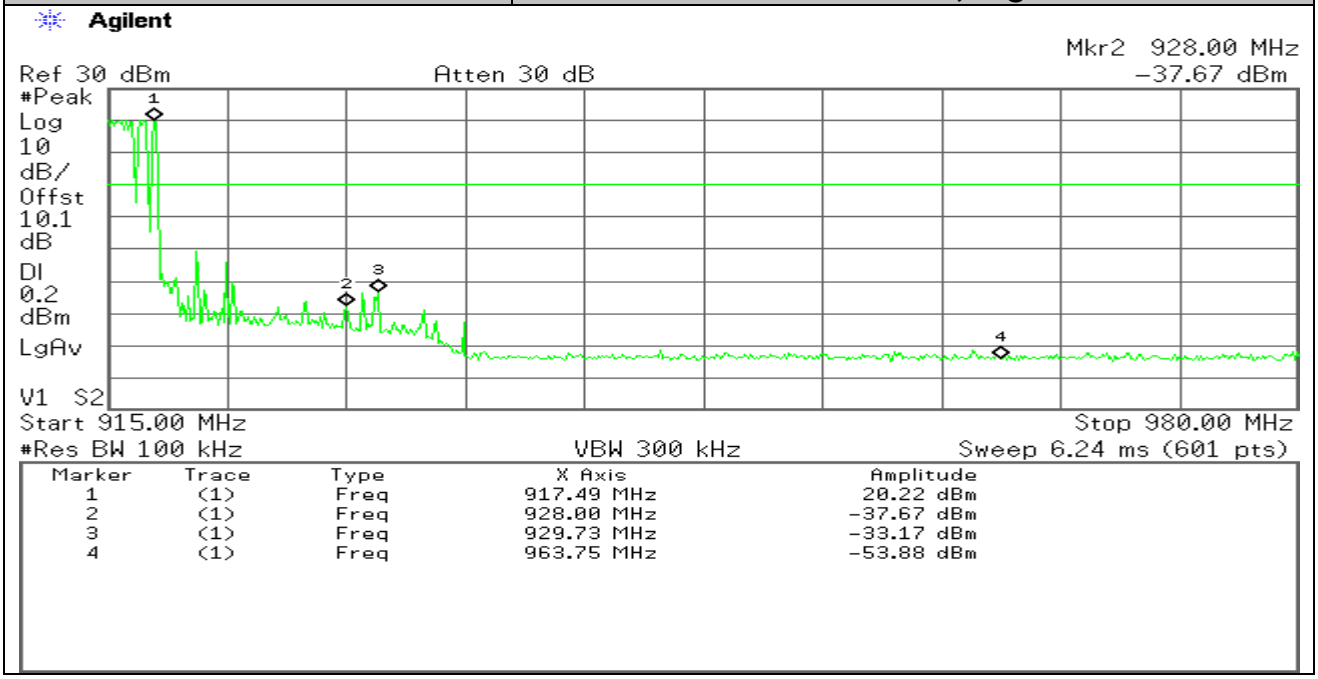


Hopping On

Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , Low CH



Plot Name:	CONDUCTED SPURIOUS & BANDEGE Mode No 1. Tx , High CH



7.8 RADIATED EMISSIONS

7.8.1. TRANSMITTER RADIATED SPURIOUS EMISSIONS

LIMITS

§15.205 (a) RSS-102 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	([2])
13.36-13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

§15.205 (b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (microvolts /meter	Measurement Distance (meters)
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

§15.209 (b) In the emission table above, the tighter limit applies at the band edges.

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.4. The EUT is set to transmit in a continuous mode. Established procedures in C63.10 for performing radiated measurements shall be used. For cabinet emission measurements, the EUT transmit antenna may be replaced with a termination matching the nominal impedance of the antenna. EUT was tested with applicable orientations.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak. For measurements above 1 GHz the resolution bandwidth is set to 1 MHz, and then the video bandwidth is set to 1 MHz for peak measurements and 10 Hz for average measurements.

The radio spectrum was investigated from the lowest frequency generated within the device (without going below 9 kHz) up to the 10^{th} harmonic of the rated transmitted emission. The emissions are investigated with the transmitter set to the lowest, middle, and highest channels.

The emissions are investigated with the transmitter set to the lowest, middle, and highest channels, if applicable. The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

RESULTS

No non-compliance noted.

*The duty cycle factor can be applied to the average readings of above 1GHz spurious, if necessary.

During the search process, the 50 frequencies are transmitted . Each with 20 mS transmission and waiting for an ACK for 20 mS. So the maximum duty cycle per frequency is 20% (for 100 mS period), i.e -14dB.

7.8.2. TRANSMITTER RADIATED EMISSIONS DATA

(HARMONICS & SPURIOUS falling in restricted bands listed in Sec.15.205)

Worst Case of Operation Modes: Tx**

Low Channel Harmonics/Spurious

Freq. (MHz)	Worst H/V	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	QP/Avg @3m (dBuV/m)	PK Lim (dBuV/m)	QP /Avg. Lim (dBuV/m)	PK Marg. (dBuV/m)	QP /Avg.Marg* (dBuV/m)
1810***	H	3	-	71.67	56.97				
2715	H	3	-	69.88	48.52	74	54	-4.12	-5.48
3620	H	3	-	58.02	35.81	74	54	-15.98	-18.19
1810**	V	3	-	72.93	57.69				
2715	V	3	-	71.25	51.86	74	54	-2.75	-2.14
3620	V	3	-	60.10	38.40	74	54	-13.9	-15.6

Middle Channel Harmonics/Spurious

Freq. (MHz)	Worst H/V	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	QP/Avg @3m (dBuV/m)	PK Lim (dBuV/m)	QP /Avg. Lim (dBuV/m)	PK Marg. (dBuV/m)	QP /Avg.Marg* (dBuV/m)
1823***	H	3	-	73.79	58.95				
2734.5	H	3	-	70.18	49.84	74	54	-3.82	-4.16
3646	H	3	-	59.93	37.87	74	54	-14.07	-16.13
1823***	V	3	-	75.26	60.82				
2734.5	V	3	-	72.71	52.95	74	54	-1.29	-1.05
3646	V	3	-	59.76	37.50	74	54	-14.24	-16.5

High Channel Harmonics/Spurious

Freq. (MHz)	Worst H/V	Dist. (m)	D Corr (dB)	Peak@3m (dBuV/m)	QP/Avg @3m (dBuV/m)	PK Lim (dBuV/m)	QP /Avg. Lim (dBuV/m)	PK Marg. (dBuV/m)	QP /Avg.Marg* (dBuV/m)
1836***	H	3	-	73.86	58.91				
2754	H	3	-	70.32	50.07	74	54	-3.68	-3.93
3672	H	3	-	60.01	38.06	74	54	-13.99	-15.94
1836***	V	3	-	74.96	59.85				
2754	V	3	-	72.02	52.66	74	54	-1.98	-1.33
3672	V	3	-	60.15	38.38	74	54	-13.85	-15.62

* The duty cycle factor, -14dB was applied to the average readings of above 1GHz spurious for comparing to the final average limit.
* *Data shown above represents the worst case in typical EUT orientation(s). No other significant emissions were found in the rest frequency range. For spurious in restricted band, the limit is per 15.209. For low emission levels, peak readings were used for average limit margin calculation. EUT powered by AC/DC adaptor.
*** Some harmonics are not falling in restricted band and recorded for reference only.

Band Edge Data for EUT

In addition, the band-edge requirements are also verified.

Testing procedure per FCC Public Notice KDB 558074 D01 V05 & ANSI C63.10 / KDB 558074D01:

The measurement of unwanted emissions at the edge of the authorized frequency bands can be complicated by the capture of RF energy from the fundamental emission within the RBW passband. The following techniques are permitted for use in performing a measurement of the unwanted emission level at the band edges.

10.2.5.1 Marker-Delta Method

The marker-delta method, as described in KDB 913591 and in C63.10, can be used to perform measurements of the unwanted emissions level at the band-edges.

10.2.5.2 Integrated Power Measurement

A narrower resolution bandwidth can be used at the band edge to improve the measurement accuracy provided that the measurement is subsequently integrated to the relevant bandwidth specification (e.g., 100 kHz within non-restricted bands and 1 MHz within restricted frequency bands).

Results:

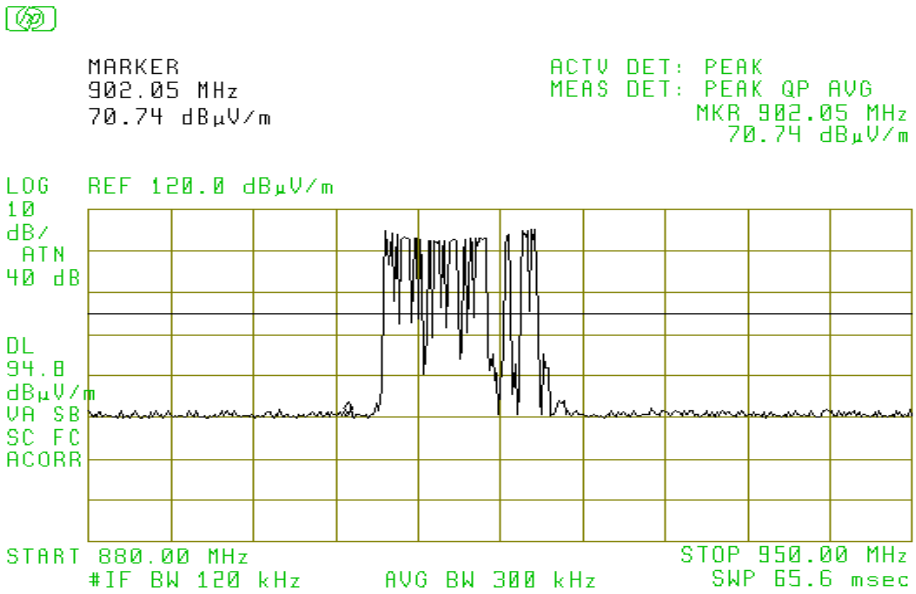
The testing results **for worst case** based on pretesting results are shown as following and comply with the band-edge requirements and restricted band emission requirements (the closest restricted band is =<614MHz & >=960MHz, which is far from 902-928MHz Tx band).

The duty cycle factor can be applied to the average readings of band edge spurious, if necessary.

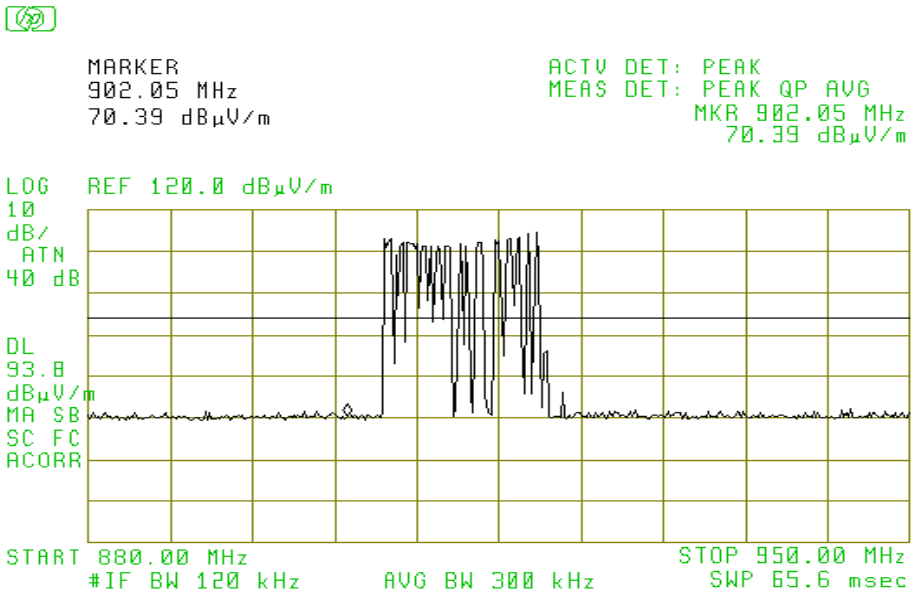
Only the antenna with highest gain in each antenna type (if applicable) was selected for final emission test.

EUT with 3dBi gain Omni Antenna, Hopping On

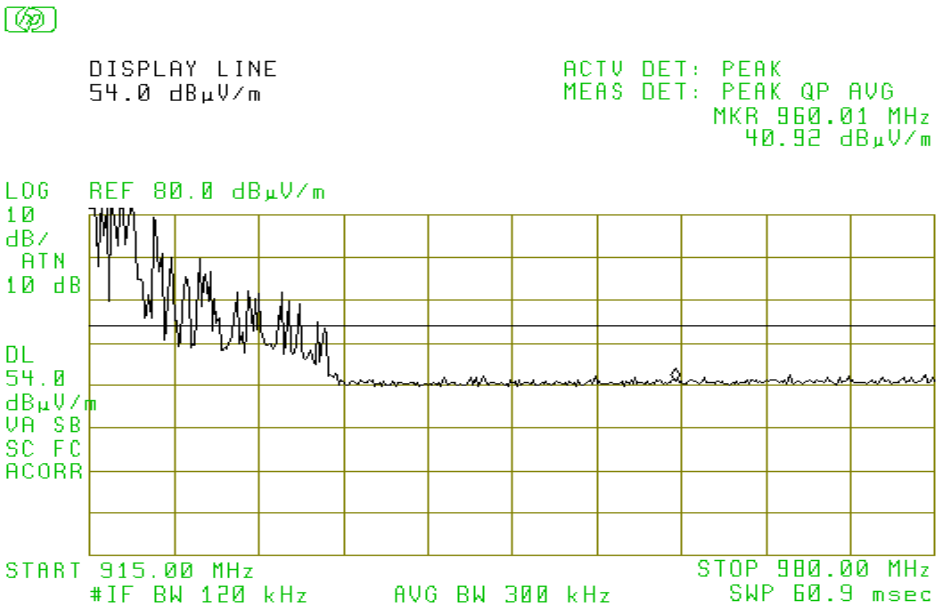
Plot Name:	**Band-Edge Radiated Emissions for Mode 1: Tx @ Low End, V**



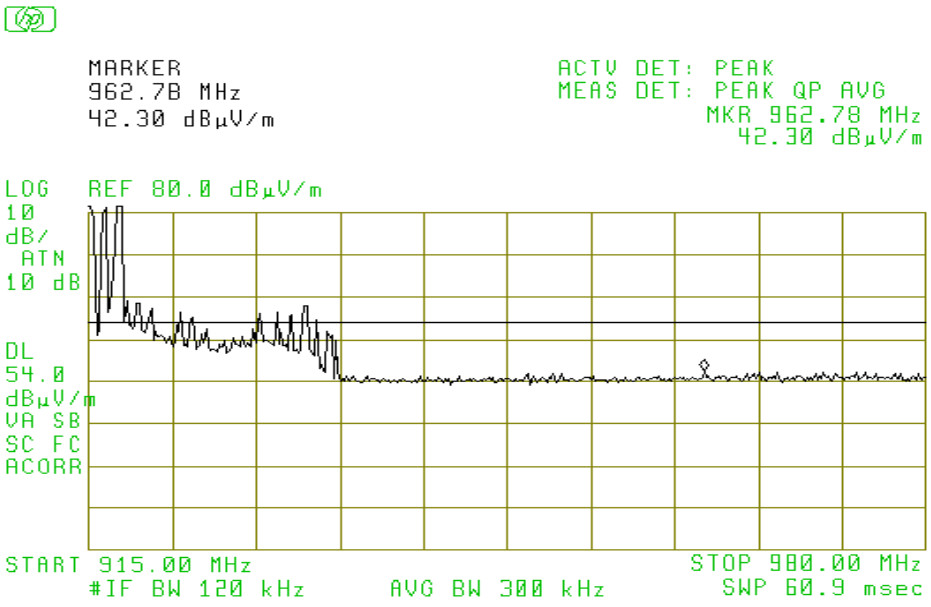
Plot Name:	**Band-Edge Radiated Emissions for Mode 1: Tx @ Low End, H**



Plot Name:	Band-Edge Radiated Emissions for Mode 1: Tx @ High End, V



Plot Name:	Band-Edge Radiated Emissions for Mode 1: Tx @ High End, H



7.9 CONDUCTED EMISSIONS

7.9.1 Test Methods and Conditions

The EUT was under normal operational mode during the conducted emission test. EMI Receiver was scanned from 150KHz to 30MHz with maximum hold mode for maximum emission. Recorded data was sent to the plotter to generate output in linear format. At the input of the spectrum analyzer, a HP transient limiter is inserted for protective purpose. This limiter has a 10 dB attenuation in the range of 150KHZ to 30MHZ. That factor was automatically compensated by the receiver, so the readings are the corrected readings. The reference of the plot is the CISPR 22 Class B limit in following plots.

Conducted Emission Technical Requirements				
	Class A		**Class B**	
Frequency Range	**Quasi-Peak dBuV**	**Average dBuV**	**Quasi-Peak DBuV**	**Average dBuV**
150kHz –0.5MHz	79 (8912uV)	66 (1995uV)	66-56	56-46
0.5MHz-30MHz	73 (4467uV)	60 (1000uV)	---	---
0.5MHz- 5MHz	---	---	56	46 (250uV)
5MHz-30MHz	---	---	60	50

Emissions that have peak values close to the specification limit (if any) are also measured in the quasi-peak/average mode to determine compliance.

7.9.2 Test Data

The following plots show the neutral and line conducted emissions for the standard operation.
(EUT was powered by optional AC/DC adaptor: iMBAPrice, Model # CYSD10-050200. Rated Input: 100-240Vac, 50/60Hz, 0.5A. Output : 5Vdc, 2.0A)

	Highest Data for AC Line Conducted Emissions							
Frequency (MHz)	0.150 (Line)	0.160 (Line)	0.170 (Line)	0.500 (Line)	0.150 (Neutral)	0.160 (Neutral)	0.180 (Neutral)	0.490 (Neutral)
Peak Reading (dBuV)	46.37	45.29	44.64	44.00	44.80	43.83	43.27	39.63
Average Reading (dBuV*)								
Under Limit	Y	Y	Y	Y	Y	Y	Y	Y

* no need to show the average reading if the peak value is under average limit.

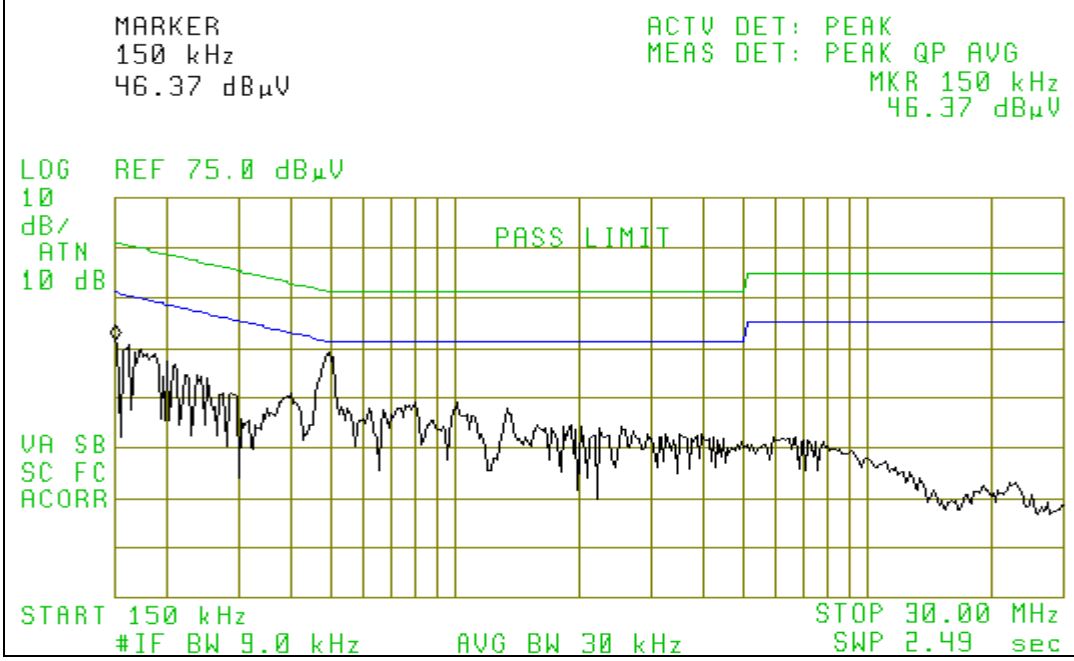
Test Personnel:

David Tu

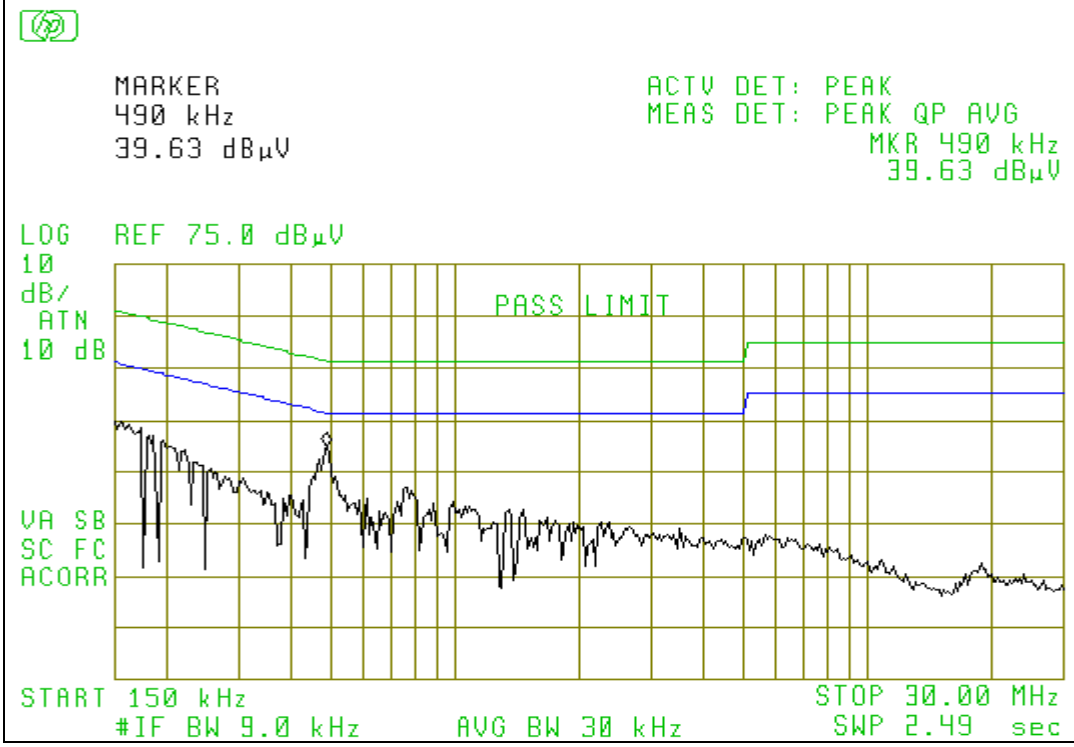
Tester Signature: _____

Typed/Printed Name: ____David Tu_____ Date: _10/22/2018_____

Conducted Emission-Line : 150kHZ- 30 MHz



Conducted Emission-Neutral: 150kHz – 30MHz



7.10 EUT RECEIVING MODE VERIFICATION

Radiated Test Data for Receiving Mode (worst case*) at RX1

Frequency (3) (MHz)	Polarity (H,V))	Antenna Height (m)	Azimuth (Degree)	Peak Reading at 3m (2) (dBuV/m)	Q-Peak/Average Reading (dBuV/m)	FCC/IC 3m Limit (1) (dBuV/m)	Difference (dBuV/m)
38.9	H	1.5	120	30.4		40.0	-9.6
141.4	H	1.4	130	31.9		43.5	-11.6
156.7	H	1.4	160	32.7		43.5	-10.8
490.0	H	1.5	180	36.0		46.5	-10.5
630.0	H	1.3	215	36.5		46.5	-10
878.5	H	1.4	200	39.8		46.5	-6.7
115.9	V	1.1	350	32.1		43.5	-11.4
155.8	V	1.2	340	33.7		43.5	-9.8
192.4	V	1.2	255	35.3		43.5	-8.2
470.0	V	1.1	330	35.8		46.5	-10.7
506.2	V	1.1	340	36.4		46.5	-10.1
726.5	V	1.0	300	39.4		46.5	-7.1
790.1	V	1.0	310	40.6		46.5	-5.9

Radiated Test Data for Receiving Mode (worst case*) at RX2

Frequency (3) (MHz)	Polarity (H,V))	Antenna Height (m)	Azimuth (Degree)	Peak Reading at 3m (2) (dBuV/m)	Q-Peak/Average Reading (dBuV/m)	FCC/IC 3m Limit (1) (dBuV/m)	Difference (dBuV/m)
117.1	H	1.4	140	31.8		43.5	-11.7
153.4	H	1.5	140	31.2		43.5	-12.3
675.0	H	1.5	190	39.1		46.5	-7.4
880.1	H	1.3	190	40.2		46.5	-6.3
150.7	V	1.1	320	32.4		43.5	-11.1
187.1	V	1.1	280	33.6		43.5	-9.9
488.0	V	1.2	320	36.9		46.5	-9.6
725.8	V	1.2	320	38.2		46.5	-8.3
794.6	V	1.1	315	39.6		46.5	-6.9

(1) Receiving mode spurious emissions shall be lower than the limit defined in FCC Sec. 15.209 & IC RSS-GEN.
(2) If the peak reading is less than the FCC/IC quasi-peak or average limit, it'll be not necessary to show the measured/ calculated quasi-peak or average reading.
(3) Emissions from non-EUT accessories shall be excluded.
* EUT powered by AC/DC adaptor