ENGINEERING TEST REPORT

n920T 2020 900MHz OEM Frequency Hopping/DTS Module
Model No.: n920T 2020

FCC ID: NS920N920T
IC: 3143A-20N920T

Applicant:
Microhard Systems Inc.
150 Country Hills Landing NW
Calgary, Alberta
Canada T3K 5P3

In Accordance With

FCC Part 15, Subpart C, Section 15.247
Industry Canada, RSS-247, Issue 2
Frequency Hopping Spread Spectrum (FHSS) / Digital Modulation Systems (DTS)
Operating in 902 - 928 MHz Band

UltraTech's File No.: 20MCRS-113F15CRSS247

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: May 11, 2020	
Report Prepared by: Santhosh Fernandez Issued Date: May 11, 2020	Tested by: Mr. Hung Trinh Test Dates: March 4 – May 6, 2020

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*
- *This test report shall not be reproduced, except in full, without a written approval from UltraTech*

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15
Purpose of Test:	To gain FCC Equipment Authorization for Frequency Hopping Spread Spectrum (FHSS) / Digital Modulation Systems (DTS) Transceiver Operating in the Frequency Band 902 - 928 MHz.
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10 ▪ FCC Public Notice DA 00-705
Environmental Classification:	[x] Commercial, industrial or business environment [x] Residential environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2020	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC Public Notice DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding to Spread Spectrum Devices
FCC Public Notice DA 00-1407	2000	Part 15 Unlicensed Modular Transmitter Approval
KDB Publication No. 558074 D01 V05r02	2019	Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)
RSS-Gen, Issue 5	2019	General Requirements for Compliance of Radio Apparatus
RSS-247, Issue 2	2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
ICES-003, Issue 6	2016	Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248 2762 Email Address: shenouda@microhardcorp.com

MANUFACTURER	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248-2762 Email Address: shenouda@microhardcorp.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Microhard Systems Inc.
Product Name:	n920T 2020 900MHz OEM Frequency Hopping/DTS Module
Model Name or Number:	n920T 2020
Serial Number:	Test Sample
Type of Equipment:	Spread Spectrum Transmitter / Digital Transmission System
Input Power Supply Type:	External Regulated DC Sources
Primary User Functions of EUT:	Wireless data communication Ethernet and serial

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	▪ Mobile ▪ Base Station (fixed use)
Intended Operating Environment:	▪ Commercial, industrial or business environment ▪ Residential environment
Power Supply Requirement:	3.3 VDC
RF Output Power Rating:	0.001 to 1 W
Operating Frequency Range:	FHSS: 902.4 - 927.6 MHz DTS: 903.75 - 926.25 MHz 904 - 926 MHz 905 - 925 MHz 907 - 923 MHz
RF Output Impedance:	50 Ohms
***Channel Spacing:**	400kHz Frequency hopping / DTS mode different Channelization
Duty Cycle:	Continuous
99% dB Bandwidth (FHSS):	411.86 kHz
99% dB Bandwidth (DTS):	1.40 MHz (903.75 - 926.25 MHz) 1.71 MHz (904 – 926 MHz) 2.23MHz (905 – 925 MHz) 2.24 MHz (907 – 923 MHz)
Modulation Type:	2-level FSK
Emission Designation:	412KF1D (FHSS, 902.4 – 927.6 MHz) 1M40F1D (DTS, 903.75 - 926.25 MHz) 1M71F1D (DTS, 904 – 926 MHz) 2M23F1D (DTS, 905 – 925 MHz) 2M24F1D (DTS, 907 – 923 MHz)
Oscillator Frequencies:	See block diagram
Power Spectral Density in 3kHz Band:	7.80 dBm Max.
Antenna Connector Type:	MMCX

* See Operational Description exhibit for details.

RECEIVER	
Equipment Type:	[X] Mobile [X] Base station (fixed use)
Operating Frequency Range:	902 to 928 MHz
RF Input Impedance:	50
Oscillator Frequency(ies):	40.43333MHz

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
Rubber Duck Antenna	3
Puck Antenna	4
Patch Antenna	8
Omni Directional Antenna	8.15
Yagi Antenna	13.15

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF IN/OUT Port	1	PAD	No cable, direct connection
2	DC Supply & I/O Port	1	Pin Header	No cable, direct connection

2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

Ancillary Equipment # 1	
Description:	Test Jig
Brand name:	Microhard Systems Inc.
Model Name or Number:	N/A
Connected to EUT's Port:	I/O Port

Ancillary Equipment # 2	
Description:	AC/DC Adapter(AC100-240V to 12 VDC)
Brand name:	BIRon Switching Power Supply
Model Name or Number:	BI24-120200-AdU
Connected to EUT's Port:	Test Jig of the EUT

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.3 VDC via test jig

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	▪ Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements. ▪ The EUT operates in normal Frequency Hopping mode for occupancy duration, and frequency separation.
Special Test Software & Hardware:	Special software provided by the applicant was installed to allow the EUT to operate in hopping mode or at each channel frequency continuously. For example, the transmitter will be operated at each of lowest, middle and highest frequencies individually continuously during testing.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as a non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	FHSS: 902.4 – 927.6 MHz DTS: 903.75 - 926.25 MHz, 904 -926 MHz 905 - 925 MHz, 907 - 923 MHz
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	FHSS: 902.4, 915 and 927.6 MHz DTS: 903.75, 915 and 926.25 MHz 904, 915 and 926 MHz 905, 915 and 925 MHz 907, 915 and 923 MHz
RF Power Output: (measured maximum output power at antenna terminals)	1 Watt (conducted)
***Normal Test Modulation:**	FHSS: 2-level FSK at data rate 5 DTS: 2-level FSK at data rate 8, 9, 10 and 11
Modulating Signal Source:	Internal

*See Operational Description exhibit supplied by the manufacturer for details of the data rates for FHSS/DTS.

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).

Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203 RSS-Gen, Section 6.8	Antenna requirements	Yes
15.207(a), RSS-Gen, Section 8.8	Power Line Conducted Emissions	Yes
15.247(a)	Provisions for Frequency Hopping Systems	Yes
15.247(a)(2) RSS-247, Section 5.2(a)	6 dB Bandwidth	Yes
15.247(b)(2) RSS-247, Section 5.4	Peak Conducted Output Power - FHSS	Yes
15.247(b)(3) RSS-247, Section 5.4	Peak Conducted Output Power - DTS	Yes
15.247(d) RSS-247, Section 5.5	Band-Edge and RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(d), 15.209 & 15.205 RSS-247, Section 5.5	Transmitter Spurious Radiated Emissions	Yes
15.247(e) RSS-247, Section 5.2(a)	Power Spectral Density	Yes
1.1307, 1.1310, 2.1091 & 2.1093 RSS-Gen, Section 3.4, RSS-102	RF Exposure	Yes
RSS-Gen, Section 7.3	Receiver Spurious Emissions (Radiated)	Yes
RSS-Gen, Section 7.4	Receiver Spurious Emissions (Antenna Conducted)	Yes
ICES-003, Issue 6	Information Technology Equipment (Including Digital Apparatus) - Limits and Methods of Measurement	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 5. TEST DATA

5.1. POWER LINE CONDUCTED EMISSIONS [§15.207(a)]

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

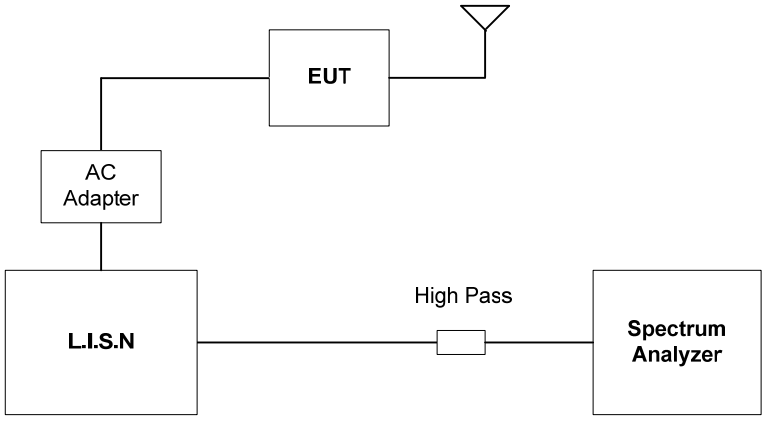
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……..	66 to 56*	56 to 46*
0.5–5 .....……..	56	46
5-30 ……..	60 ..……..	50

*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

ANSI C63.4

5.1.3. Test Arrangement

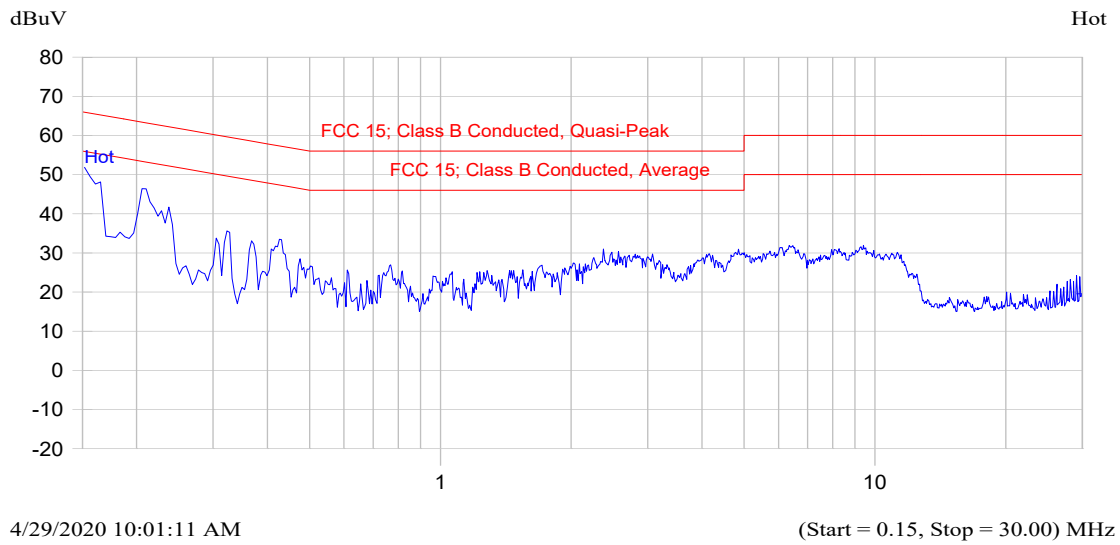


5.1.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3710A00223	9 kHz–22 GHz	May 13, 2020
High Pass filter	Rohde & Schwarz	EZ-25	830164/006	Cut off 150kHz	Jun 7, 2020
LISN Used	EMCO	3825/2	8907-1531	10 kHz–30 MHz	Jan 16, 2021

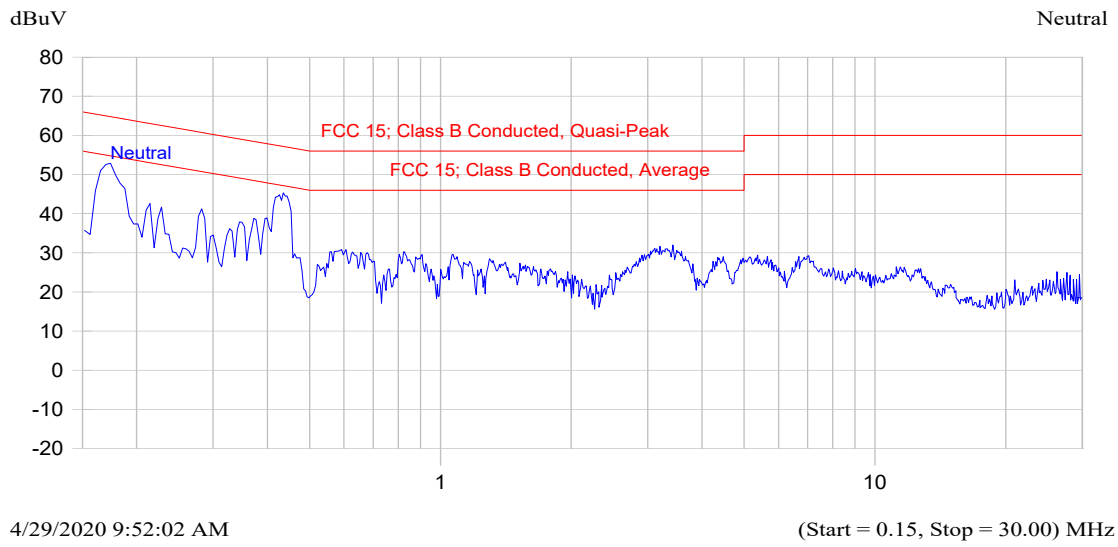
5.1.5. Test Data

Plot 5.1.5.1. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Hot



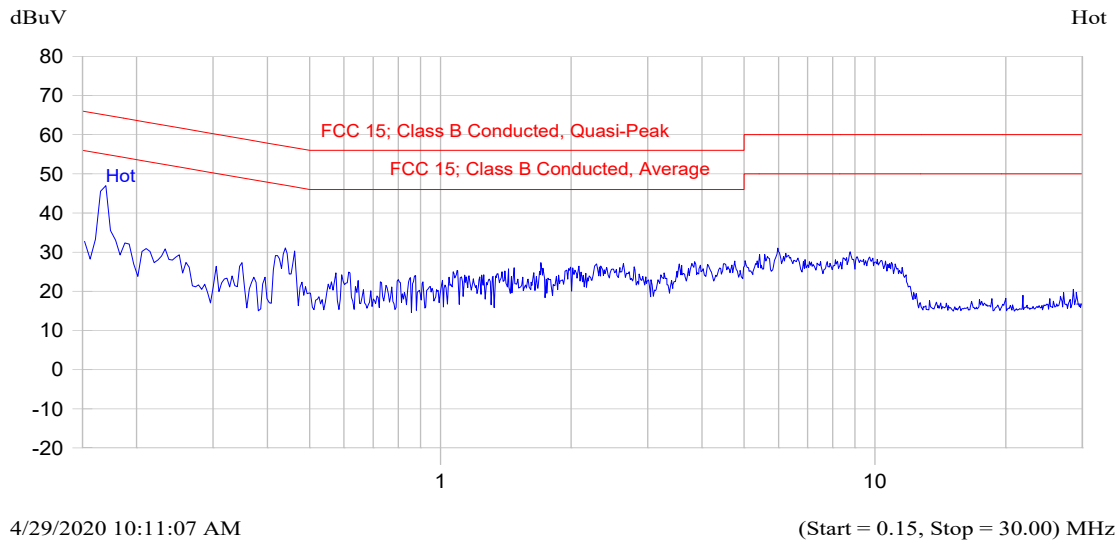
Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.162	50.7	48.2	-17.1	31.9	-23.4	Hot
0.190	48.0	44.6	-19.5	29.4	-24.6	Hot
0.328	37.7	34.0	-25.5	22.2	-27.3	Hot
0.424	40.0	35.1	-22.3	25.3	-22.0	Hot
2.365	31.9	26.8	-29.2	19.2	-26.8	Hot

Plot 5.1.5.2. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral



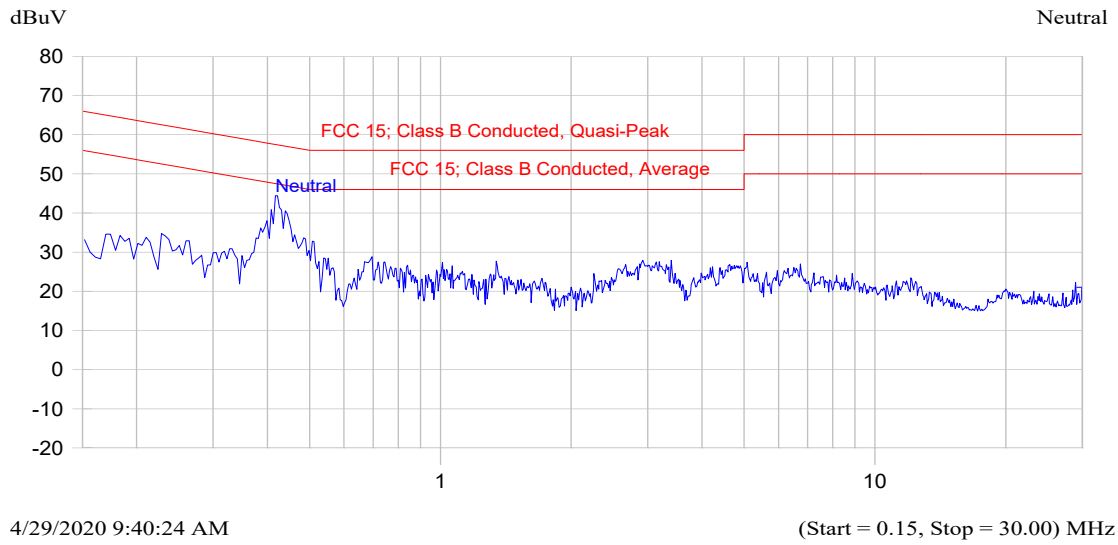
Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.176	52.4	49.4	-15.3	31.2	-23.5	Neutral
0.425	48.0	44.7	-12.6	36.4	-10.9	Neutral
3.168	32.3	28.6	-27.4	21.8	-24.2	Neutral

Plot 5.1.5.3. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Hot



Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.170	48.1	41.7	-23.3	22.4	-32.5	Hot
0.439	36.7	29.9	-27.2	19.6	-27.4	Hot
1.701	29.2	23.1	-32.9	14.2	-31.8	Hot
5.971	30.9	26.1	-33.9	16.3	-33.7	Hot

Plot 5.1.5.4. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral



Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.421	47.1	43.0	-14.4	30.9	-16.6	Neutral
0.693	32.1	25.8	-30.2	17.3	-28.7	Neutral
2.866	30.0	24.7	-31.3	15.6	-30.4	Neutral

5.2. COMPLIANCE WITH FCC PART 15 – GENERAL TECHNICAL REQUIREMENTS

FCC Section	FCC Rules	Manufacturer's Clarification
15.203	Described how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT. The exception is in those cases where EUT must be professionally installed. In order to demonstrate that professional installation is required, the following 3 points must be addressed: ➢ The application (or intended use) of the EUT ➢ The installation requirements of the EUT ➢ The method by which the EUT will be marketed	The antenna employs a unique antenna connector.
15.204	Provided the information for every antenna proposed for use with the EUT: ➢ type (e.g. Yagi, patch, grid, dish, etc…), ➢ manufacturer and model number ➢ gain with reference to an isotropic radiator	See proposed antenna listed in user manual.
15.247(a)	Description of how the EUT meets the definition of a frequency hopping spread spectrum, found in Section 2.1. Based on the technical description.	See Operational Description
15.247(a)	Pseudo Frequency Hopping Sequence: Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, in order to demonstrate that the sequence meets the requirements specified in the definition of a frequency hopping spread spectrum system, found in Section 2.1	See Operational Description
15.247(a)	Equal Hopping Frequency Use: Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g. that each new transmission event begins on the next channel in the hopping sequence after final channel used in the previous transmission events).	See Operational Description
15.247(a)	System Receiver Input Bandwidth: Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.	See Operational Description

FCC Section	FCC Rules	Manufacturer's Clarification
15.247(a)	System Receiver Hopping Capability: Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals	See Operational Description
15.247(g)	Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system	See Operational Description
15.247(h)	Describe how the EUT complies with the requirement that it not have the ability to coordinated with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters	See Operational Description

5.3. PROVISIONS FOR FREQUENCY HOPPING SYSTEMS [§ 15.247(a)(1)]

5.3.1. Limits

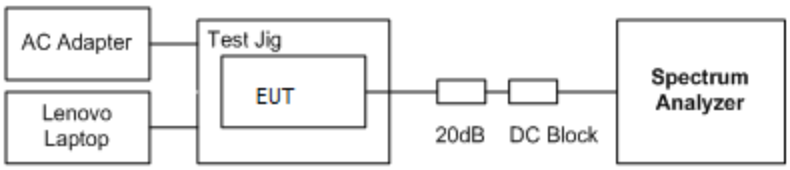
§ 15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier 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 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.

§ 15.247(a)(1)(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.**

5.3.2. Method of Measurements

ANSI C63.10-2013, Sections 6.9.2, 7.8.2, 7.8.3 and 7.8.4

5.3.3. Test Arrangement



5.3.4. Test Equipment list

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---

5.3.5. Test Data

Test Description	FCC Specification	Measured Values	Comments
Frequency Hopping Systems Requirements	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.	--	See Note 1
BW of the hopping channel	The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.	400.64 kHz	See Note 2
Channel Hopping Frequency Separation	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.	400.64 kHz	See Note 2
Number of hopping frequencies	If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies; *if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies*	47 hopping frequencies	See Note 1 and 2
Average Time of Occupancy	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*	**173.1 ms**	See Note 2
Note 1: See operational description exhibit for details. **Note 2**: See the following plots and Annex 1 for details.			

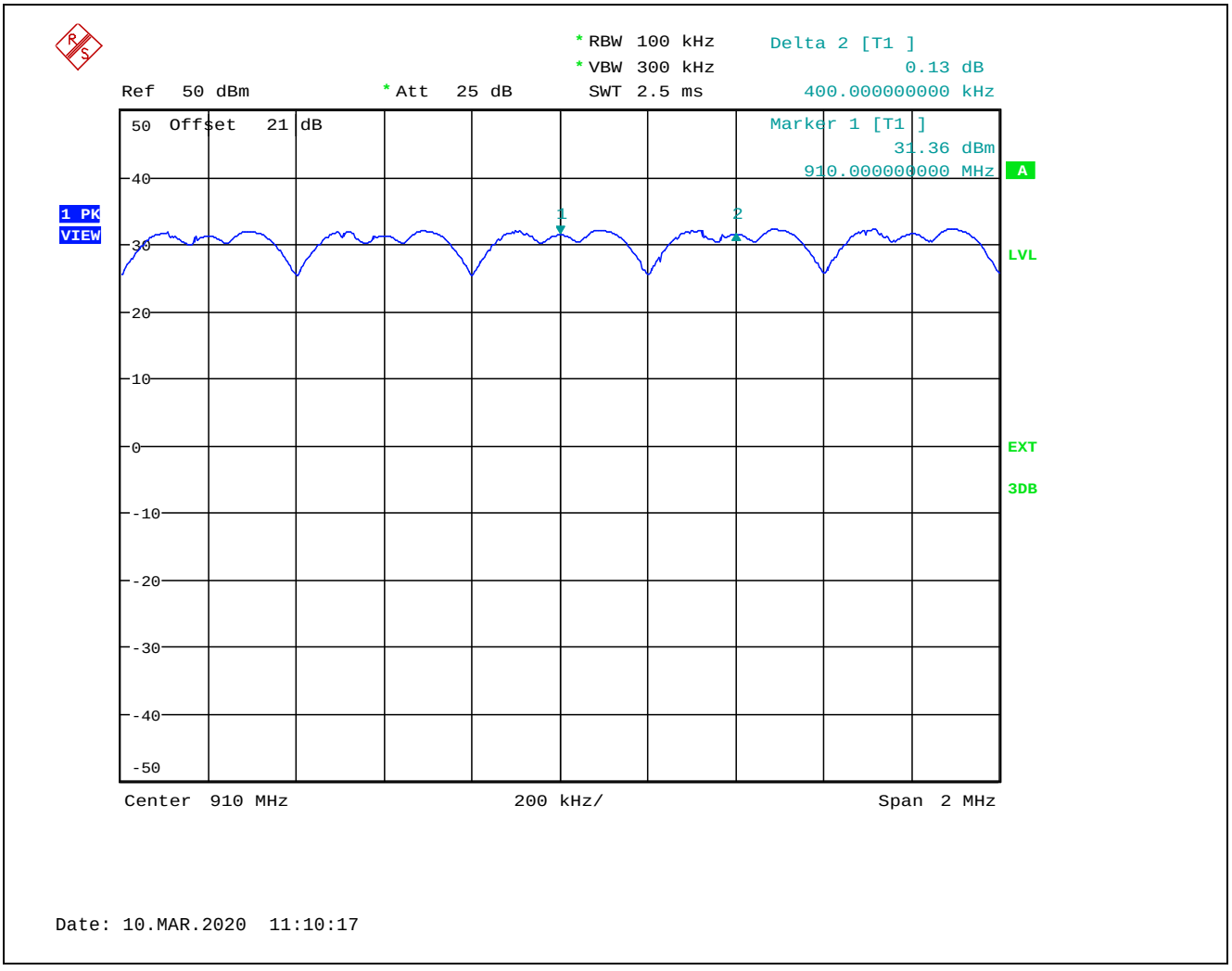
5.3.5.1. BW of the hopping channel

Frequency (MHz)	Data Rate	Power Setting	20dB BW (kHz)	Limit (kHz)
902.4	5	235	392.63	500
915.0	5	200	400.64	500
927.6	5	200	399.04	500

Plots: See Annex1

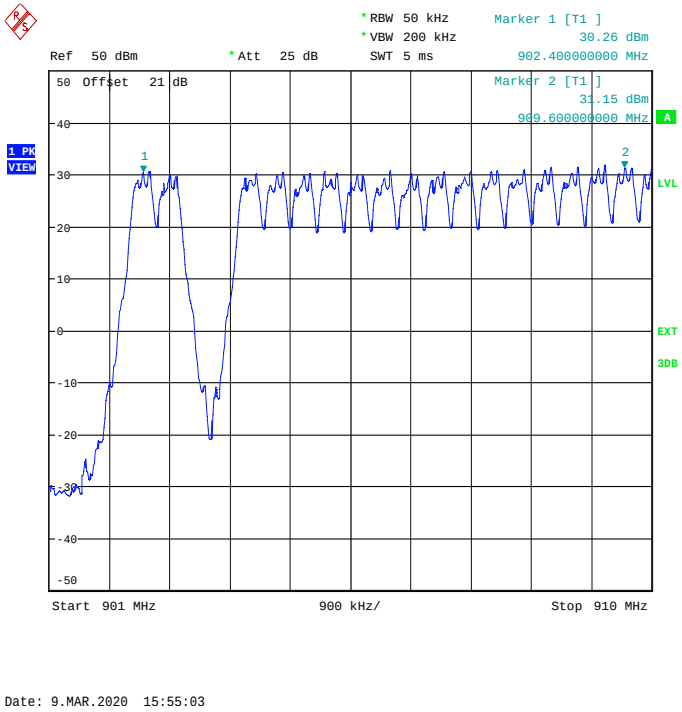
5.3.5.2. Channel Hopping Frequency Separation

Plot 5.3.5.3. Carrier Frequency Separation, 400 kHz

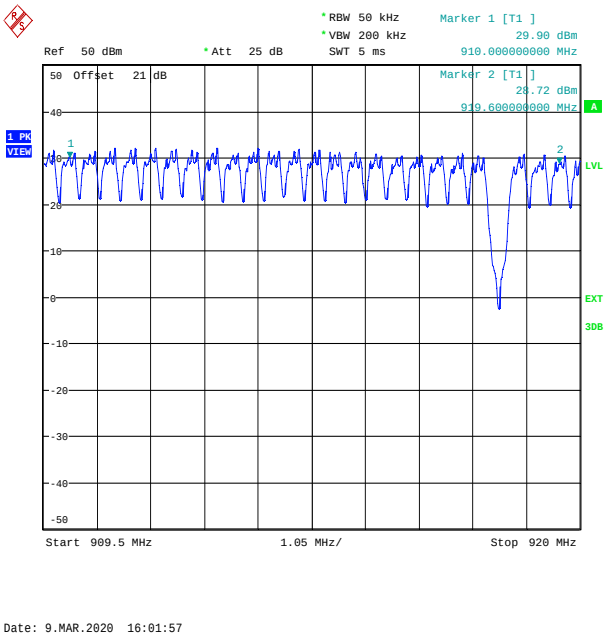


5.3.5.4. Number of hopping frequencies

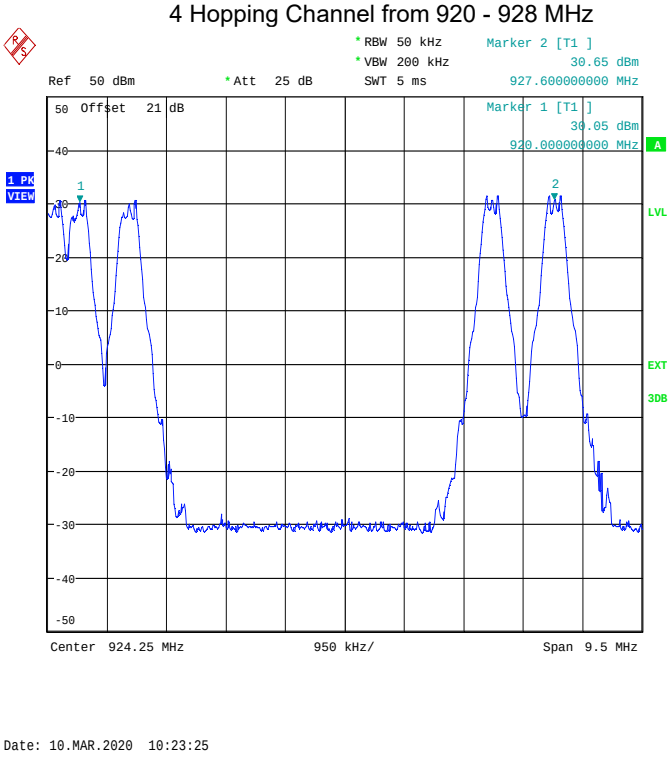
Plot 5.3.5.5. Number of Hopping Frequencies, FHSS Data Rate 5, High Power, Raw Power setting 235 (0-255)
17 Hopping Channel from 902 - 910 MHz



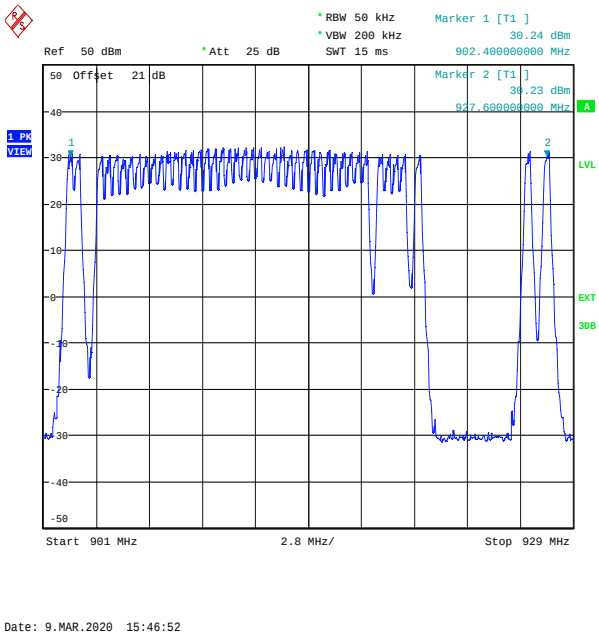
Plot 5.3.5.6. Number of Hopping Frequencies, FHSS Data Rate 5, High Power, Raw Power setting 235 (0-255)
24 Hopping Channel from 910 - 920 MHz



Plot 5.3.5.7. Number of Hopping Frequencies, FHSS Data Rate 5, High Power, Raw Power setting 235 (0-255)
4 Hopping Channel from 920 - 928 MHz

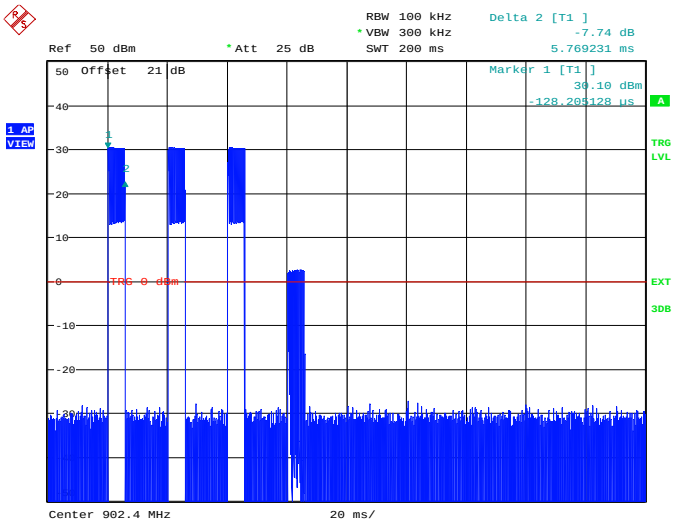


Plot 5.3.5.8. Number of Hopping Frequencies, FHSS Data Rate 5, High Power, Raw Power setting 235 (0-255)
The Total Number of Hopping Channel in 902 – 928 MHz Band is 45 (17 + 24 + 4)

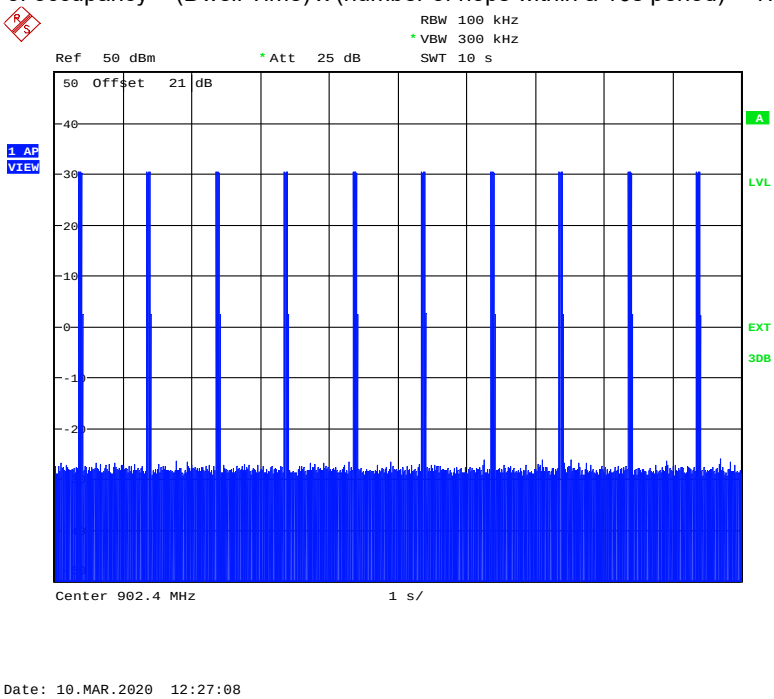


5.3.5.9. Average Time of Occupancy

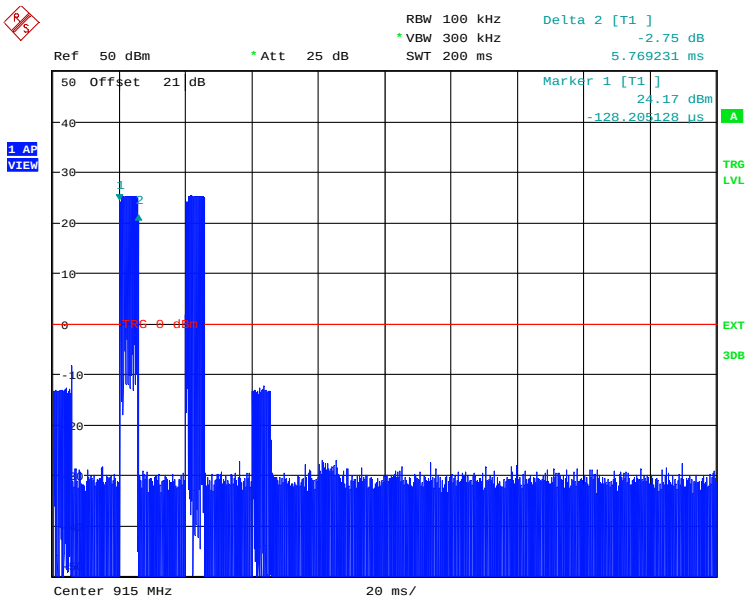
Plot 5.3.5.10. Time of Occupancy, 902.4 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Dwell Time at 902.4 MHz = 5.77x3=17.31 ms



Plot 5.3.5.11. Time of Occupancy, 902.4 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 17.31 ms x10 = 173.1 ms

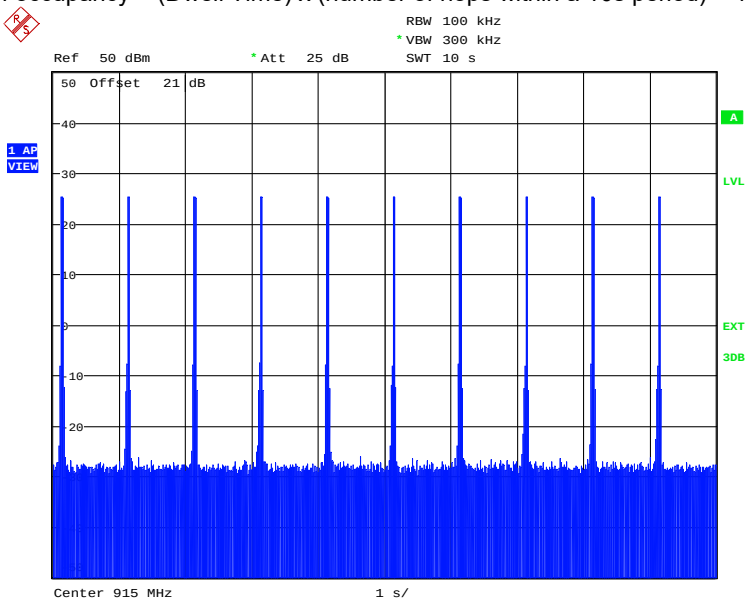


Plot 5.3.5.12. Time of Occupancy, 915.0 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Dwell Time at 915.0 MHz = 5.77x2=11.54 ms



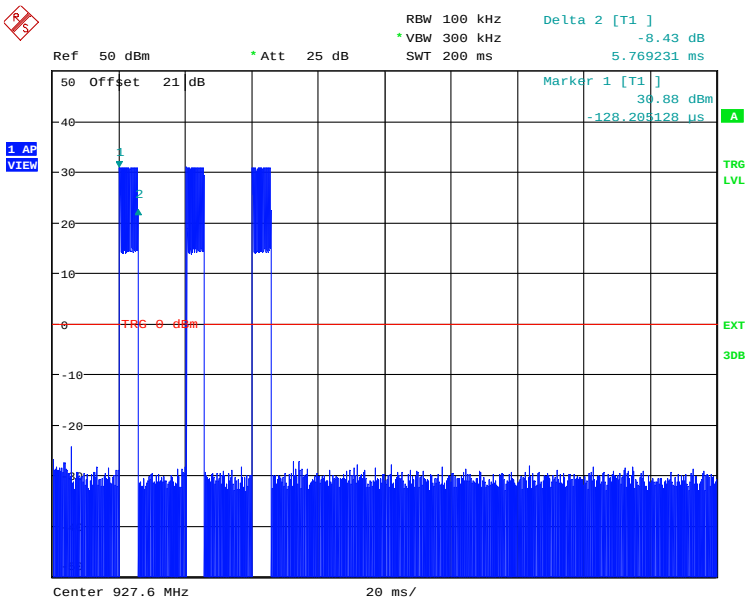
Date: 10.MAR.2020 12:46:05

Plot 5.3.5.13. Time of Occupancy, 915.0 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 11.54 ms x 10 = 115.4 ms

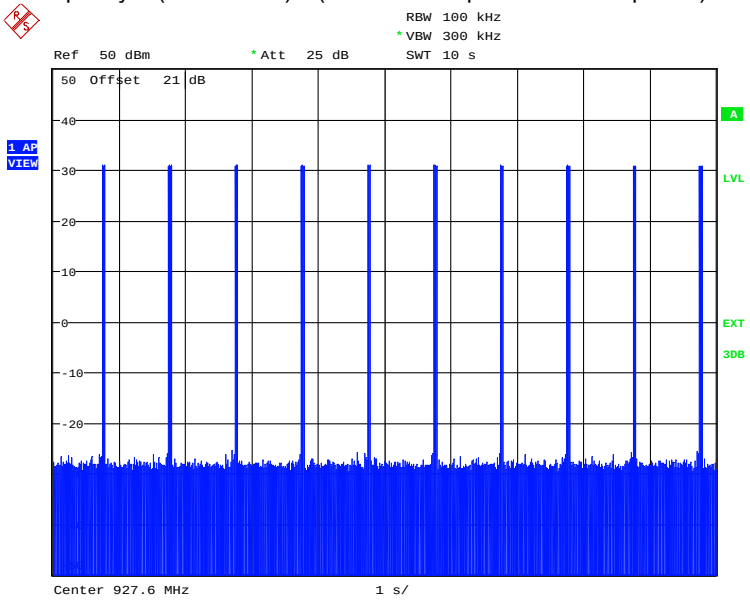


Date: 10.MAR.2020 12:52:52

Plot 5.3.5.14. Time of Occupancy, 927.6 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Dwell Time at 927.6 MHz = 5.77x3=17.31 ms



Plot 5.3.5.15. Time of Occupancy, 927.6 MHz, Data Rate 5, High Power, Raw Power setting 235 (0-255)
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 17.31 ms x 10 = 173.1 ms



5.4. 6dB OCCUPIED BANDWIDTH (DTS) [§ 15.247(a)(2)] [RSS 247-5.2(a)]

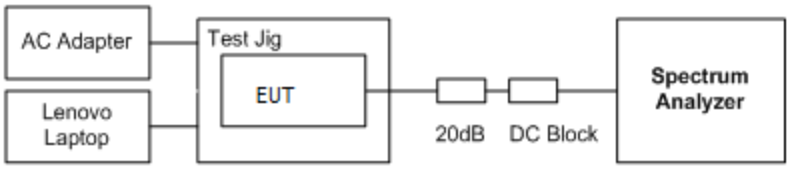
5.4.1. Limit(s)

For a Digital Modulation System, the minimum 6 dB bandwidth shall be at least 500 KHz.

5.4.2. Method of Measurements

KDB 558074 D01 15.247 Meas Guidance v05r02, Section 8.2, Sub clause 11.8 DTS bandwidth Option 2

5.4.3. Test Arrangement



5.4.4. Test Equipment list

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---

5.4.5. Test Data

Frequency (MHz)	Data Rate	Setting (0-255)	6dB BW (MHz)	Min Limit (kHz)
903.75	8	215	1.05	500
915.00	8	225	1.05	500
926.25	8	235	1.05	500
904.00	9	215	1.12	500
915.00	9	225	1.13	500
926.00	9	245	1.13	500
905.00	10	225	1.00	500
915.00	10	235	1.00	500
925.00	10	255	1.00	500
907.00	11	185	0.976	500
915.00	11	200	1.02	500
923.00	11	215	0.962	500

Plots: See Annex 2

5.5. PEAK CONDUCTED OUTPUT POWER- FHSS [§ 15.247(b)(2)] RSS 247-5.4 (a)

5.5.1. Limits

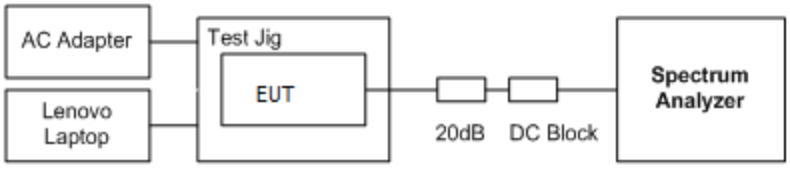
§15.247(b)(2): For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

§15.247(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.

5.5.2. Method of Measurements

ANSI C63.10-2013, section 7.8.5

5.5.3. Test Arrangement



5.5.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---

5.5.5. Test Data

Power Setting 1: High Power Setting for 3 dBi Rubber Duck Antenna with 2.74 dBi Antenna Assembly Gain								
Raw Power Setting (0 – 255)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
235	5	902.40	30.00	1.0000	2.74	32.74	30	36
200	5	915.00	30.00	1.0000	2.74	32.74	30	36
200	5	927.60	30.00	1.0000	2.74	32.74	30	36

Power Setting 2: High Power Setting for 4.0 dBi Puck Antenna with 3.74 dBi Antenna Assembly Gain								
Raw Power Setting (0 – 13)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
235	5	902.40	30.00	1.0000	3.74	33.74	30	36
200	5	915.00	30.00	1.0000	3.74	33.74	30	36
200	5	927.60	30.00	1.0000	3.74	33.74	30	36

Power Setting 3: High Power Setting for 8 dBi Patch Antenna with 7.74 dBi Antenna Assembly Gain								
Raw Power Setting (0 – 255)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
175	5	902.40	26.94	0.4943	7.74	34.68	30	36
170	5	915.00	28.25	0.6683	7.74	35.99	30	36
170	5	927.60	28.22	0.6637	7.74	35.96	30	36

Power Setting 4: High Power Setting for 8.15 dBi Omni Directional Antenna with 7.43 dBi Antenna Assembly Gain								
Raw Power Setting (0 – 255)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
160	5	902.40	24.54	0.2844	7.43	31.97	30	36
170	5	915.00	28.25	0.6683	7.43	35.68	30	36
170	5	927.60	28.22	0.6637	7.43	35.65	30	36

Power Setting 5: High Power Setting for 13.15 dBi Yagi Antenna with 12.43 dBi Antenna Assembly Gain								
Raw Power Setting (0 – 255)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
138	5	902.40	13.09	0.0204	12.43	25.52	30	36
142	5	915.00	23.51	0.2244	12.43	35.94	30	36
145	5	927.60	23.56	0.2270	12.43	35.99	30	36

Power Setting 6: Low Power Setting for All Antenna Types				
Raw Power Setting (0 – 255)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal	
			(dBm)	(W)
140	5	902.40	0.33	1.08
115	5	915.00	0.00	1.00
121	5	927.60	-0.33	0.93

5.6. MAXIMUM CONDUCTED OUTPUT POWER - DTS [§ 15.247(b)(3)] RSS 247-5.4 (d)

5.6.1. Limit(s)

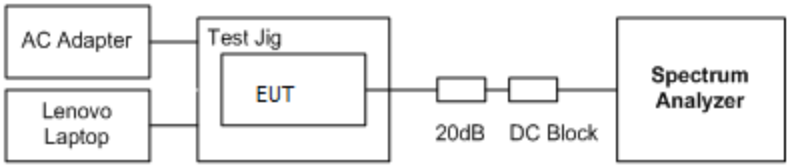
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

§ 15.247(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.

5.6.2. Method of Measurements & Test Arrangement

KDB 558074 D01 15.247 Meas Guidance v05r02, Section 8.3.2, Sub clause 11.9.2.2.2 Method AVGSA-1 of ANSI C63.10

5.6.3. Test Arrangement



5.6.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use

5.6.5. Test Data

Remarks:

1. The EIRP shall be calculated based on the transmitter antenna gain (G_{dBi}), cable loss (CL_{dB}) and peak output power at antenna terminal (P_{dBm}). Calculated EIRP = $P_{dBm} + G_{dBi} - CL_{dB}$

2. EIRP shall not exceed 36 dBm limit (Power Setting = 36 dBm - $G_{dBi} + CL_{dB}$). See Operating Manual for instruction of power setting.

Power Setting 1: High Power Setting for 3 dBi Rubber Duck Antenna with 2.74 dBi (3dBi-0.26dB) Antenna Assembly Gain and 4.0 dBi Puck Antenna with 3.74 dBi (4dBi-0.26dB) Antenna Assembly Gain						
Frequency (MHz)	Data Rate	Setting (0-255)	Channel Power Max. Avg. Conducted (limit 30 dBm) (dBm)	Antenna Assembly Gain (dBm)	EIRP Power (dBm)	EIRP Power Limit (dBm)
903.75	8	215	29.99	2.74/3.74	33.73	36
915.00	8	225	29.99	2.74/3.74	33.73	36
926.25	8	235	29.99	2.74/3.74	33.73	36
904.00	9	215	29.99	2.74/3.74	33.73	36
915.00	9	225	30.00	2.74/3.74	33.74	36
926.00	9	245	30.00	2.74/3.74	33.74	36
905.00	10	225	29.99	2.74/3.74	33.73	36
915.00	10	235	30.00	2.74/3.74	33.74	36
925.00	10	255	29.98	2.74/3.74	33.72	36
907.00	11	185	28.14	2.74/3.74	31.88	36
915.00	11	200	28.16	2.74/3.74	31.90	36
923.00	11	215	28.21	2.74/3.74	31.95	36

Power Setting 2: High Power Setting for 8 dBi Patch Antenna with 7.74 dBi (8dBi-0.26dB) Antenna Assembly Gain and 8.15 dBi Omni Directional Antenna with 7.43 dBi (8.15dBi-0.46dB-0.26dB)Antenna Assembly Gain						
Frequency (MHz)	Data Rate	Setting (0-255)	Channel Power Max. Avg. Conducted (limit 30 dBm) (dBm)	Antenna Assembly Gain (dBm)	EIRP Power (dBm)	EIRP Power Limit (dBm)
903.75	8	185	28.19	7.74/7.43	35.93	36
915.00	8	195	28.21	7.74/7.43	35.95	36
926.25	8	205	28.24	7.74/7.43	35.98	36
904.00	9	185	28.21	7.74/7.43	35.95	36
915.00	9	195	28.23	7.74/7.43	35.97	36
926.00	9	205	28.24	7.74/7.43	35.98	36
905.00	10	185	28.21	7.74/7.43	35.95	36
915.00	10	205	28.23	7.74/7.43	35.97	36
925.00	10	215	28.21	7.74/7.43	35.95	36
907.00	11	185	28.14	7.74/7.43	35.88	36
915.00	11	200	28.16	7.74/7.43	35.90	36
923.00	11	215	28.21	7.74/7.43	35.95	36

Power Setting 3: High Power Setting for 13.15 dBi Yagi Antenna with 12.43dBi (13.15dBi-0.46dB-0.26dB) Antenna Assembly Gain						
Frequency (MHz)	Data Rate	Setting (0-255)	Channel Power Max. Avg. Conducted (limit 30 dBm) (dBm)	Antenna Assembly Gain (dBm)	EIRP Power (dBm)	EIRP Power Limit (dBm)
903.75	8	153	23.40	12.43	35.83	36
915.00	8	159	23.44	12.43	35.87	36
926.25	8	164	23.51	12.43	35.94	36
904.00	9	151	23.52	12.43	35.95	36
915.00	9	159	23.40	12.43	35.83	36
926.00	9	165	23.51	12.43	35.94	36
905.00	10	144	23.45	12.43	35.88	36
915.00	10	163	23.54	12.43	35.97	36
925.00	10	168	23.49	12.43	35.92	36
907.00	11	145	23.32	12.43	35.75	36
915.00	11	162	23.22	12.43	35.65	36
923.00	11	168	23.45	12.43	35.88	36

Power Setting 4: Low Power Setting for All Antenna Types			
Frequency (MHz)	Data Rate	Setting (0-255)	Channel Power Max. Avg. Conducted (limit 30 dBm) (dBm)
903.75	8	125	0.03
915.00	8	130	-0.73
926.25	8	132	0.49
904.00	9	123	0.05
915.00	9	130	-0.05
926.00	9	132	-0.53
905.00	10	114	-0.27
915.00	10	130	0.03
925.00	10	133	-0.33
907.00	11	111	-0.43
915.00	11	130	-0.45
923.00	11	130	-0.31

5.7. TRANSMITTER BAND-EDGE & SPURIOUS CONDUCTED EMISSIONS [§ 15.247(d)], RSS 247-5.5

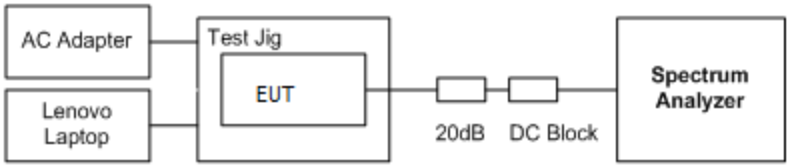
5.7.1. Limit(s)

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

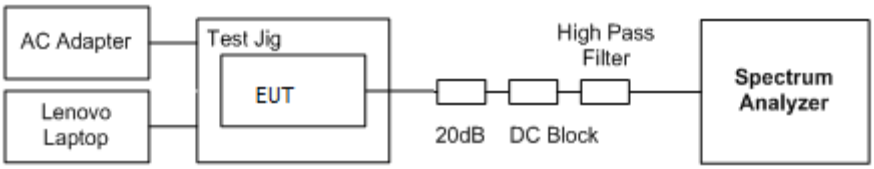
5.7.2. Method of Measurements

ANSI C63.10

5.7.3. Test Arrangement



Band Edge



Conducted Spurious

5.7.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---
High Pass Filter	K & L	11SH10-1500/T8000	2	Cut off 900 MHz	Cal on use

5.7.5. Test Data

5.7.5.1. Conducted Band Edge

FHSS Data Rate 5

Mode	Frequency	Raw Power Setting	Band Edge Compliance
Continuous	902.4	235	Yes
	927.6	200	Yes
Hopping	902.4	235	Yes
	927.6	200	Yes

Refer to Annex 1 for Plots

5.7.5.2. Conducted Spurious

FHSS Data Rate 5 operation and emissions were scanned from 30 MHz- 10 GHz

Frequency	Raw Power Setting	Spurious Compliance
902.4	235	Yes
915.0	200	Yes
927.6	200	Yes

Refer to Annex 1 for Plots

Remarks:
The FHSS mode was chosen for the worst case test configuration for transmitter spurious conducted emissions because both FHSS & DTS modes have approximately the same maximum output power (1W) and the bandwidth of FHSS signal is smaller.

5.8. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205] RSS 247-5.5

5.8.1. Limit

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Section 15.205(a) - Restricted Bands of Operation

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	2655–2900	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

In addition to above for Canada RSS Gen 8.10: the following bands are restricted too. 3.020-3.026 MHz, 5.677-5.683MHz, 121.94-123MHz, 1240-1300MHz, 3500-3600MHz

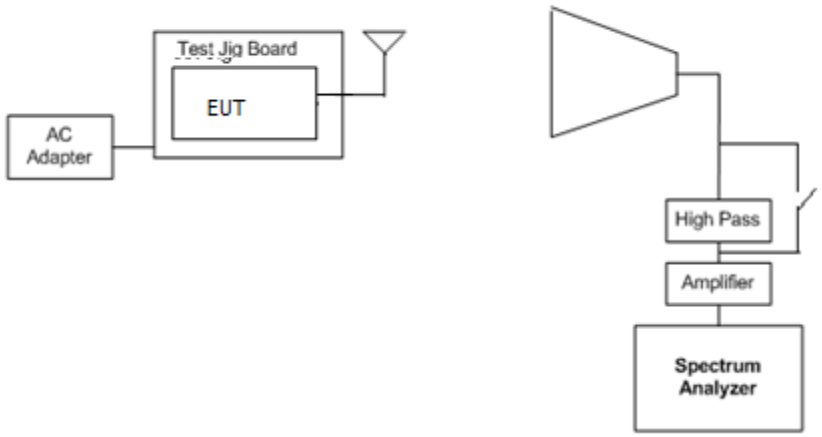
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / F (kHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

5.8.2. Method of Measurements

ANSI C63.10 and ANSI 63.4 procedures.

5.8.3. Test Arrangement



5.8.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	Mar 18, 2021
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	Jun 24, 2020
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	Jan 7, 2021
Biconilog	Emco	3142B	1575	26-2000 MHz	May 10, 2020
Horn Antenna	Emco	3155	6570	1 – 18 GHz	Oct 11, 2020
High Pass Filter	K & L	11SH10-1500/T8000	2	Cut off 900 MHz	Cal on use

5.8.5. Test Data

Remark(s):
The FHSS mode was chosen for the worst case test configuration for transmitter spurious conducted emissions because both FHSS & DTS modes have approximately the same maximum output power (1W) and the bandwidth of FHSS signal is smaller.

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.
- The following test data represent the worst-case derived from exploratory tests.

5.8.5.1. EUT with 3 dBi Rubber Duck Antenna, 2.74 dBi Antenna Assembly Gain

Spurious Radiated Emission

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	235
Measured Conducted Power:	30 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
902.4	128.26	--	V	--	--	--	--
902.4	128.20	--	H	--	--	--	--
2707.2	51.98	47.72	V	54.00	108.26	-6.28	Pass*
2707.2	52.12	46.40	H	54.00	108.26	-7.60	Pass*
3609.6	48.86	37.63	V	54.00	108.26	-16.37	Pass*
3609.6	50.58	41.74	H	54.00	108.26	-12.26	Pass*
4512.0	55.06	46.67	V	54.00	108.26	-7.33	Pass*
4512.0	51.43	40.79	H	54.00	108.26	-13.21	Pass*
5414.4	57.25	48.74	V	54.00	108.26	-5.26	Pass*
5414.4	53.20	42.20	H	54.00	108.26	-11.80	Pass*
9024.0	56.96	43.17	V	54.00	108.26	-10.83	Pass*
9024.0	57.28	43.55	H	54.00	108.26	-10.45	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency: 915 MHz
Raw Power Setting: 200
Measured Conducted Power: 30 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	127.64	--	V	--	--	--	--
915.0	128.82	--	H	--	--	--	--
2745.0	51.74	45.92	V	54.00	108.82	-8.08	Pass*
2745.0	50.93	45.52	H	54.00	108.82	-8.48	Pass*
3660.0	52.58	45.92	V	54.00	108.82	-8.08	Pass*
3660.0	50.91	42.54	H	54.00	108.82	-11.46	Pass*
4575.0	55.59	48.78	V	54.00	108.82	-5.22	Pass*
4575.0	52.59	43.38	H	54.00	108.82	-10.62	Pass*
7320.0	63.60	52.86	V	54.00	108.82	-1.14	Pass*
7320.0	62.22	53.63	H	54.00	108.82	-0.37	Pass*
9150.0	57.57	43.13	V	54.00	108.82	-10.87	Pass*
9150.0	57.79	42.63	H	54.00	108.82	-11.37	Pass*

Fundamental Frequency: 927.6 MHz
Raw Power Setting: 200
Measured Conducted Power: 30 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	127.29	--	V	--	--	--	--
927.6	127.59	--	H	--	--	--	--
2782.8	54.25	50.12	V	54.00	107.59	-3.88	Pass*
2782.8	49.30	43.93	H	54.00	107.59	-10.07	Pass*
3710.4	54.28	46.77	V	54.00	107.59	-7.23	Pass*
3710.4	51.76	44.19	H	54.00	107.59	-9.81	Pass*
4638.0	54.75	47.03	V	54.00	107.59	-6.97	Pass*
4638.0	51.99	42.48	H	54.00	107.59	-11.52	Pass*
7420.8	64.59	53.86	V	54.00	107.59	-0.14	Pass*
7420.8	62.61	53.91	H	54.00	107.59	-0.09	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.8.5.2. EUT with 4 dBi Puck Antenna, 3.74 dBi Antenna Assembly Gain

Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	235
Measured Conducted Power:	30 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
902.4	126.35	--	V	--	--	--	--
902.4	125.05	--	H	--	--	--	--
2707.2	51.20	46.10	V	54.00	106.35	-7.90	Pass*
2707.2	50.14	46.39	H	54.00	106.35	-7.61	Pass*
3609.6	49.52	40.46	V	54.00	106.35	-13.54	Pass*
3609.6	51.79	44.39	H	54.00	106.35	-9.61	Pass*
4512.0	54.34	44.49	V	54.00	106.35	-9.51	Pass*
4512.0	50.53	38.34	H	54.00	106.35	-15.66	Pass*
5414.4	57.87	50.58	V	54.00	106.35	-3.42	Pass*
5414.4	53.15	41.76	H	54.00	106.35	-12.24	Pass*
9024.0	56.77	43.18	V	54.00	106.35	-10.82	Pass*
9024.0	56.59	43.40	H	54.00	106.35	-10.60	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency:	915 MHz
Raw Power Setting:	200
Measured Conducted Power:	30 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	127.08	--	V	--	--	--	--
915.0	120.90	--	H	--	--	--	--
2745.0	50.55	44.21	V	54.00	107.08	-9.79	Pass*
2745.0	52.91	48.04	H	54.00	107.08	-5.96	Pass*
3660.0	50.69	42.25	V	54.00	107.08	-11.75	Pass*
3660.0	51.98	44.32	H	54.00	107.08	-9.68	Pass*
4575.0	53.81	45.01	V	54.00	107.08	-8.99	Pass*
4575.0	53.03	43.73	H	54.00	107.08	-10.27	Pass*
7320.0	62.40	51.82	V	54.00	107.08	-2.18	Pass*
7320.0	60.93	51.05	H	54.00	107.08	-2.95	Pass*
9150.0	57.76	44.43	V	54.00	107.08	-9.57	Pass*
9150.0	56.30	43.26	H	54.00	107.08	-10.74	Pass*

Fundamental Frequency:	927.6 MHz
Raw Power Setting:	200
Measured Conducted Power:	30 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	124.03	--	V	--	--	--	--
927.6	122.82	--	H	--	--	--	--
2782.8	54.22	50.43	V	54.00	104.03	-3.57	Pass*
2782.8	48.58	39.31	H	54.00	104.03	-14.69	Pass*
3710.4	54.77	47.82	V	54.00	104.03	-6.18	Pass*
3710.4	52.93	46.74	H	54.00	104.03	-7.26	Pass*
4638.0	55.98	49.22	V	54.00	104.03	-4.78	Pass*
4638.0	53.20	44.56	H	54.00	104.03	-9.44	Pass*
7420.8	63.16	51.92	V	54.00	104.03	-2.08	Pass*
7420.8	61.71	52.57	H	54.00	104.03	-1.43	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.8.5.3. EUT with 8 dBi Patch Antenna, 7.74 dBi Antenna Assembly Gain

Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	175
Measured Conducted Power:	26.94 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
902.4	128.39	--	V	--	--	--	--
902.4	127.85	--	H	--	--	--	--
2707.2	54.40	50.71	V	54.00	108.39	-3.29	Pass*
2707.2	52.30	47.63	H	54.00	108.39	-6.37	Pass*
3609.6	49.77	41.18	V	54.00	108.39	-12.82	Pass*
3609.6	51.89	44.19	H	54.00	108.39	-9.81	Pass*
4512.0	52.93	43.17	V	54.00	108.39	-10.83	Pass*
4512.0	52.60	42.90	H	54.00	108.39	-11.10	Pass*
5414.4	52.51	40.46	V	54.00	108.39	-13.54	Pass*
5414.4	53.03	41.13	H	54.00	108.39	-12.87	Pass*
9024.0	57.24	43.69	V	54.00	108.39	-10.31	Pass*
9024.0	56.98	43.01	H	54.00	108.39	-10.99	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency:	915 MHz
Raw Power Setting:	170
Measured Conducted Power:	28.25dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	127.74	--	V	--	--	--	--
915.0	128.81	--	H	--	--	--	--
2745.0	53.01	48.16	V	54.00	108.81	-5.84	Pass*
2745.0	50.06	43.48	H	54.00	108.81	-10.52	Pass*
3660.0	51.08	43.50	V	54.00	108.81	-10.50	Pass*
3660.0	54.20	47.97	H	54.00	108.81	-6.03	Pass*
4575.0	58.55	52.30	V	54.00	108.81	-1.70	Pass*
4575.0	56.45	50.66	H	54.00	108.81	-3.34	Pass*
7320.0	58.36	47.08	V	54.00	108.81	-6.92	Pass*
7320.0	59.94	49.50	H	54.00	108.81	-4.50	Pass*
9150.0	57.90	43.83	V	54.00	108.81	-10.17	Pass*
9150.0	56.60	43.47	H	54.00	108.81	-10.53	Pass*

Fundamental Frequency:	927.6 MHz
Raw Power Setting:	170
Measured Conducted Power:	28.22 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	129.46	--	V	--	--	--	--
927.6	129.35	--	H	--	--	--	--
2782.8	53.37	49.03	V	54.00	109.46	-4.97	Pass*
2782.8	50.01	43.49	H	54.00	109.46	-10.51	Pass*
3710.4	52.38	44.09	V	54.00	109.46	-9.91	Pass*
3710.4	53.44	46.8	H	54.00	109.46	-7.20	Pass*
4638.0	55.8	49.17	V	54.00	109.46	-4.83	Pass*
4638.0	55.16	48.26	H	54.00	109.46	-5.74	Pass*
7420.8	59.76	49.43	V	54.00	109.46	-4.57	Pass*
7420.8	60.42	50.69	H	54.00	109.46	-3.31	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.8.5.4. EUT with 8.15 dBi Omni Directional Antenna, 7.43 dBi Antenna Assembly Gain

Spurious Radiated Emissions

Fundamental Frequency: 902.4 MHz

Raw Power Setting: 160
Measured Conducted Power: 24.54 dBm

Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
902.4	126.93	--	V	--	--	--	--
902.4	123.48	--	H	--	--	--	--
2707.2	47.40	38.71	V	54.00	106.93	-15.29	Pass*
2707.2	45.69	35.35	H	54.00	106.93	-18.65	Pass*
3609.6	49.55	40.44	V	54.00	106.93	-13.56	Pass*
3609.6	49.74	40.58	H	54.00	106.93	-13.42	Pass*
4512.0	53.75	45.35	V	54.00	106.93	-8.65	Pass*
4512.0	53.26	43.58	H	54.00	106.93	-10.42	Pass*
5414.4	53.63	41.59	V	54.00	106.93	-12.41	Pass*
5414.4	53.64	42.91	H	54.00	106.93	-11.09	Pass*
9024.0	56.81	43.14	V	54.00	106.93	-10.86	Pass*
9024.0	56.48	42.39	H	54.00	106.93	-11.61	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency: 915 MHz
Raw Power Setting: 170
Measured Conducted Power: 28.25 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	127.58	--	V	--	--	--	--
915.0	128.41	--	H	--	--	--	--
2745.0	50.57	45.11	V	54.00	108.41	-8.89	Pass*
2745.0	49.11	40.80	H	54.00	108.41	-13.20	Pass*
3660.0	53.87	46.90	V	54.00	108.41	-7.10	Pass*
3660.0	52.18	45.30	H	54.00	108.41	-8.70	Pass*
4575.0	51.16	40.11	V	54.00	108.41	-13.89	Pass*
4575.0	64.33	46.71	H	54.00	108.41	-7.29	Pass*
7320.0	59.75	49.01	V	54.00	108.41	-4.99	Pass*
7320.0	57.18	45.83	H	54.00	108.41	-8.17	Pass*
9150.0	57.55	45.07	V	54.00	108.41	-8.93	Pass*
9150.0	57.09	43.45	H	54.00	108.41	-10.55	Pass*

Fundamental Frequency: 927.6 MHz
Raw Power Setting: 170
Measured Conducted Power: 28.22 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	125.97	--	V	--	--	--	--
927.6	124.99	--	H	--	--	--	--
2782.8	50.66	44.31	V	54.00	105.97	-9.69	Pass*
2782.8	49.51	42.31	H	54.00	105.97	-11.69	Pass*
3710.4	51.52	43.31	V	54.00	105.97	-10.69	Pass*
3710.4	52.51	45.05	H	54.00	105.97	-8.95	Pass*
4638.0	52.42	43.05	V	54.00	105.97	-10.95	Pass*
4638.0	52.00	42.71	H	54.00	105.97	-11.29	Pass*
7420.8	58.57	46.57	V	54.00	105.97	-7.43	Pass*
7420.8	57.47	46.19	H	54.00	105.97	-7.81	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.8.5.5. EUT with 13.15 dBi Yagi Antenna, 12.43 dBi Antenna Assembly Gain

Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	138
Measured Conducted Power:	13.09 dBm
Frequency Test Range:	30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
902.4	119.34	--	V	--	--	--	--
902.4	118.57	--	H	--	--	--	--
2707.2	49.75	42.98	V	54.00	99.34	-11.02	Pass*
2707.2	49.46	40.66	H	54.00	99.34	-13.34	Pass*
3609.6	52.01	44.53	V	54.00	99.34	-9.47	Pass*
3609.6	51.49	44.13	H	54.00	99.34	-9.87	Pass*
4512.0	55.05	48.12	V	54.00	99.34	-5.88	Pass*
4512.0	57.83	52.23	H	54.00	99.34	-1.77	Pass*
5414.4	52.85	41.32	V	54.00	99.34	-12.68	Pass*
5414.4	54.33	44.25	H	54.00	99.34	-9.75	Pass*
9024.0	56.94	42.28	V	54.00	99.34	-11.72	Pass*
9024.0	56.47	42.04	H	54.00	99.34	-11.96	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency: 915 MHz

Raw Power Setting: 142
Measured Conducted Power: 23.51 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	122.39	--	V	--	--	--	--
915.0	124.80	--	H	--	--	--	--
2745.0	49.15	41.18	V	54.00	104.80	-12.82	Pass*
2745.0	48.25	40.07	H	54.00	104.80	-13.93	Pass*
3660.0	49.23	38.85	V	54.00	104.80	-15.15	Pass*
3660.0	51.83	43.71	H	54.00	104.80	-10.29	Pass*
4575.0	53.81	46.58	V	54.00	104.80	-7.42	Pass*
4575.0	56.36	50.13	H	54.00	104.80	-3.87	Pass*
7320.0	57.80	46.24	V	54.00	104.80	-7.76	Pass*
7320.0	58.17	47.01	H	54.00	104.80	-6.99	Pass*
9150.0	57.27	43.88	V	54.00	104.80	-10.12	Pass*
9150.0	57.00	42.50	H	54.00	104.80	-11.50	Pass*

Fundamental Frequency: 927.6 MHz
Raw Power Setting: 145

Measured Conducted Power: 23.56 dBm
Frequency Test Range: 30 MHz – 10 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	126.19	--	V	--	--	--	--
927.6	128.24	--	H	--	--	--	--
2782.8	52.37	47.14	V	54.00	108.24	-6.86	Pass*
2782.8	49.23	41.67	H	54.00	108.24	-12.33	Pass*
3710.4	53.78	47.92	V	54.00	108.24	-6.08	Pass*
3710.4	52.42	45.53	H	54.00	108.24	-8.47	Pass*
4638	57.77	52.65	V	54.00	108.24	-1.35	Pass*
4638	58.42	52.83	H	54.00	108.24	-1.17	Pass*
7420.8	58.57	48.24	V	54.00	108.24	-5.76	Pass*
7420.8	59.34	49.10	H	54.00	108.24	-4.90	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.8.6. Band –Edge RF Radiated Emissions for FHSS

Antenna Type	Assembly Gain	Frequency	Raw Power Setting	Band Edge Compliance
3dBi Rubber Duck	2.74	902.4	235	Yes
		927.6	200	Yes
4 dBi Puck	3.74	902.4	235	Yes
		927.6	200	Yes
8 dBi Patch	7.74	902.4	175	Yes
		927.6	170	Yes
8.15 dBi Omni	7.43	902.4	160	Yes
		927.6	170	Yes
13.15 Yagi	12.43	902.4	138	Yes
		927.6	145	Yes

Refer to Annex 1 for Plots

5.8.7. Band –Edge RF Radiated Emissions for DTS

Antenna Type	Antenna Assembly Gain (dBm)	Frequency (MHz)	Data Rate	Raw Power Setting	Band Edge Compliance
3dBi Rubber Duck	2.74	903.75	8	215	Yes
		926.25	8	235	Yes
		904.00	9	215	Yes
		926.00	9	245	Yes
		905.00	10	225	Yes
		925.00	10	255	Yes
		907.00	11	185	Yes
		923.00	11	215	Yes
4dBi Puck	3.74.74	903.75	8	215	Yes
		926.25	8	235	Yes
		904.00	9	215	Yes
		926.00	9	245	Yes
		905.00	10	225	Yes
		925.00	10	255	Yes
		907.00	11	185	Yes
		923.00	11	215	Yes

Antenna Type	Antenna Assembly Gain (dBm)	Frequency (MHz)	Data Rate	Raw Power Setting	Band Edge Compliance
8 dBi Patch	7.74	903.75	8	185	Yes
		926.25	8	205	Yes
		904.00	9	185	Yes
		926.00	9	205	Yes
		905.00	10	185	Yes
		925.00	10	215	Yes
		907.00	11	185	Yes
		923.00	11	215	Yes
8.15 dBi Omni	7.43	903.75	8	185	Yes
		926.25	8	205	Yes
		904.00	9	185	Yes
		926.00	9	205	Yes
		905.00	10	185	Yes
		925.00	10	215	Yes
		907.00	11	185	Yes
		923.00	11	215	Yes
13.15 dBi Yagi	12.43	903.75	8	153	Yes
		926.25	8	164	Yes
		904.00	9	151	Yes
		926.00	9	165	Yes
		905.00	10	144	Yes
		925.00	10	168	Yes
		907.00	11	145	Yes
		923.00	11	168	Yes

Refer to Annex 2 for Plots

5.9. POWER SPECTRAL DENSITY [§ 15.247(e)] RSS 247-5.2 (b)

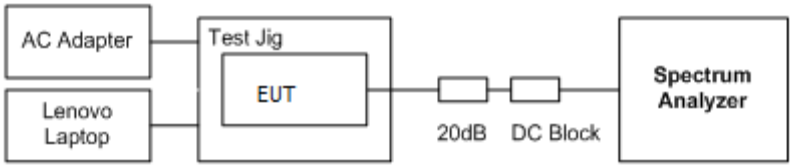
5.9.1. Limit(s)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.9.2. Method of Measurements

KDB 558074D01 DTS Meas Guidance v03r04, Section 10.2 Peak PSD

5.9.3. Test Arrangement



5.9.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---

5.9.5. Test Data

Frequency (MHz)	Data Rate	Setting (0-255)	PSD (dBm)	Limit (dBm)
903.75	8	215	7.28	8
915.00	8	225	7.45	8
926.25	8	235	7.60	8
904.00	9	215	7.66	8
915.00	9	225	7.80	8
926.00	9	245	7.08	8
905.00	10	225	7.68	8
915.00	10	235	7.30	8
925.00	10	255	7.64	8
907.00	11	185	7.48	8
915.00	11	200	7.80	8
923.00	11	215	7.65	8

Refer to Annex 2 for Plots

5.10. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091] RSS Gen 3.4, RSS 102

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

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
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: 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: 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.

(RF) radiation as specified in RSS-102

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
300-6000	$3.142\ f^{0.3417}$	$0.008335\ f^{0.3417}$	$0.02619 f^{0.6834}$	6
Note: f is frequency in MHz.				

5.10.1. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.10.2. RF Evaluation

5.10.2.1. Standalone

FCC

Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	FCC MPE Limit (mW/cm^2)	Margin (mW/cm^2)
902.4	36	3981.072	38	0.219	0.602	-0.382

ISED

Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	ISED MPE Limit (mW/cm^2)	Margin (mW/cm^2)
902.4	36	3981.072	38	0.219	0.274	-0.055

5.10.2.2. Co-location

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

FCC

Co-location will only applies to EUT with 3 dBi dipole antenna, used in co-location at the minimum **38 cm** evaluation separation distance required by the operating configurations and exposure conditions of the host device. EIRP is approximately 33 dBm with this antenna.

The maximum calculated MPE ratio of the EUT with 3 dBi dipole antenna (rubber ducky antenna)

Frequency (MHz)	EUT EIRP (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	FCC MPE Limit (mW/cm^2)	MPE Ratio
902.4	33	1995.262	38	0.11	0.602	0.183

The maximum calculated MPE ratio (FCC) for the EUT with 3 dBi dipole antenna is 0.183, this configuration can be co-located with other antennas provided the sum of the MPE ratios for all the other simultaneous transmitting antennas incorporated in a host device is $\leq$ 1.0 - 0.183 $\leq$ 0.817.

The following table addresses the co-location of the EUT with 3 dBi antenna with the specified radio modules.

EUT with 3 dBi dipole antenna co-location with radio module identified in this table

*Radio Module	Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	FCC MPE Limit (mW/cm^2)	MPE Ratio	MPE Ratio of EUT with 3 dBi antenna	Sum of MPE Ratio	Verdict
LTE-A Cat 12 M.2 Module (FCC ID XMR201901EM12G, IC 10224A-201901EM12G)	814.7	30.50	1122.018	38.00	0.062	0.543	0.114	0.183	0.297	Compliant
LTE Module (FCC ID XMR201903EG25G , IC 10224A-201903EG25G	824.2	34.41	2766.942	38.00	0.152	0.549	0.278	0.183	0.461	Compliant
SARA-R410M LTE Cat-M1 Module (FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN)	1850.0	32.12	1629.296	38.00	0.090	1	0.090	0.183	0.273	Compliant
L850 LTE Module (FCC ID: ZMOL850GL, IC: 21374-L850GL)	826.4	--	501.19	38.00	0.028	0.551	0.050	0.183	0.233	Compliant

* The test data of the radio modules represented in this table is the worst-case configuration (maximum MPE ratio) derived from the original radio modules MPE reports. Refer to these reports for detail.

ISED

Co-location will only applies to EUT with 3 dBi dipole antenna, used in co-location at the minimum **38 cm** evaluation separation distance required by the operating configurations and exposure conditions of the host device. EIRP is approximately 33 dBm with this antenna.

The maximum calculated MPE ratio of the EUT with 3 dBi dipole antenna (rubber ducky antenna)

Frequency (MHz)	EUT EIRP* (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	ISED MPE Limit (mW/cm^2)	MPE Ratio
902.4	33	1995.262	38	0.11	0.274	0.401

The maximum calculated MPE ratio for the EUT with 3 dBi dipole antenna is 0.401, this configuration can be co-located with other antennas provided the sum of the MPE ratios for all the other simultaneous transmitting antennas incorporated in a host device is $\leq$ 1.0 - 0.401 $\leq$ 0.599.

The following table addresses the co-location of the EUT with 3 dBi antenna with the specified radio modules.

EUT with 3 dBi dipole antenna co-location with radio module identified in this table

*Radio Module	Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	ISED MPE Limit (mW/cm^2)	MPE Ratio	MPE Ratio of EUT with 3 dBi antenna	Sum of MPE Ratio	Verdict
LTE-A Cat 12 M.2 Module (FCC ID XMR201901EM12G, IC 10224A-201901EM12G)	814.7	30.50	1122.018	38.00	0.062	0.256	0.242	0.401	0.643	Compliant
LTE Module (FCC ID XMR201903EG25G , IC 10224A-201903EG25G	826.4	34.42	2766.942	38.00	0.152	0.258	0.591	0.401	0.992	Compliant
SARA-R410M LTE Cat-M1 Module (FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN)	1850.0	32.12	1629.296	38.00	0.090	0.448	0.200	0.401	0.602	Compliant
L850 LTE Module (FCC ID: ZMOL850GL, IC: 21374-L850GL)	826.4	--	501.19	38.00	0.028	0.258	0.107	0.401	0.508	Compliant

* The test data of the radio modules represented in this table is the worst-case configuration (maximum MPE ratio) derived from the original radio modules MPE reports. Refer to these reports for details.

5.11. RECEIVER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [RSS-Gen §§ RSS-Gen §§ 5.3 & 7]

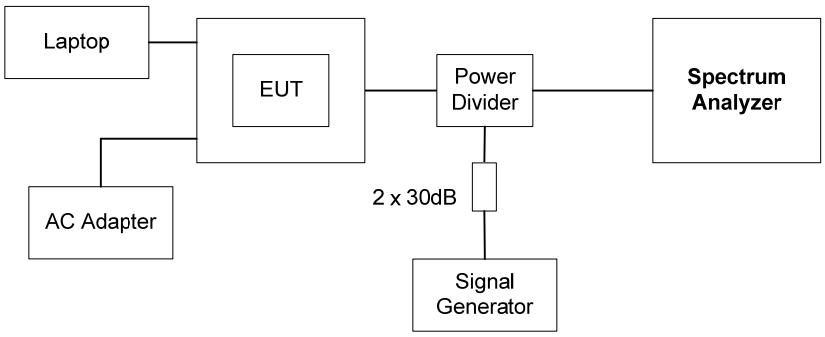
5.11.1. Limits

No spurious output signals appearing at the antenna terminals shall exceed 2 nanowatts per any 4 kHz spurious frequency in the band 30-1000 MHz, or 5 nanowatts above 1 GHz.

5.11.2. Method of Measurements

As per ANSI C63.4.

5.11.3. Test Arrangement



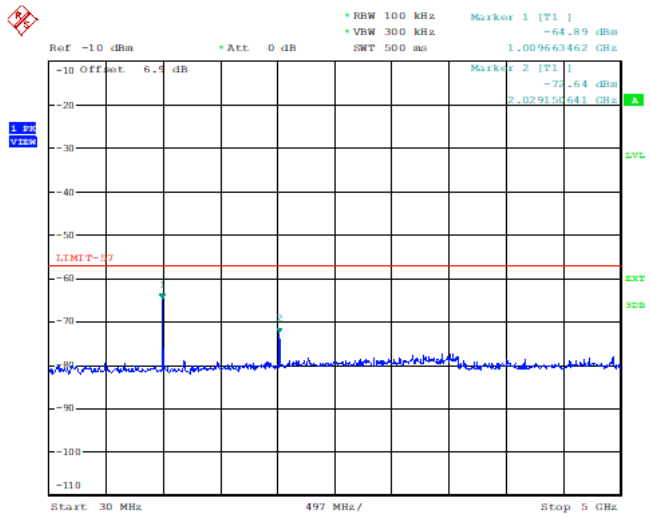
5.11.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
Signal Generator	Agilent	E8241A	US42110625	250 kHz – 20 GHz	Oct 12, 2020
Power Divider	Weinschel	1515	PS134	DC – 18 GHz	Cal on use
Attenuator	Mini Circuits	VAT-30	---	DC–6 GHz	Cal on use
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---

5.11.5. Test Data

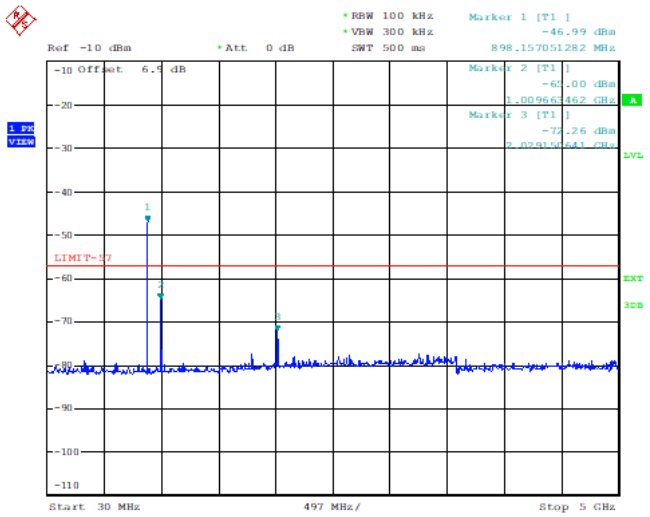
5.11.5.1. Configuration: Rx Conducted, 902.4 MHz

Receiver mode without input signal



Date: 5.MAY.2020 09:38:21

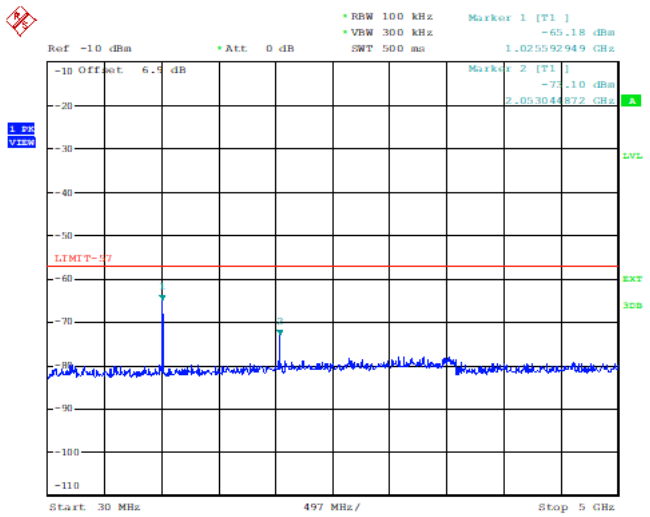
Receiver mode with input signal -47dBm



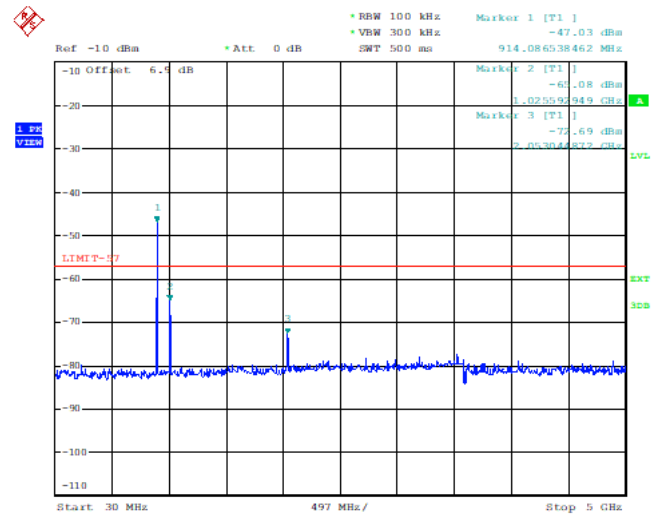
Date: 5.MAY.2020 09:41:38

5.11.5.2. Configuration: Rx Conducted, 915 MHz

Receiver mode without input signal

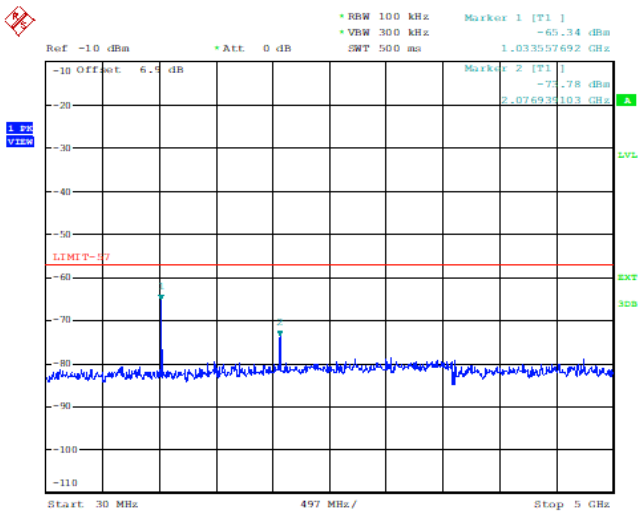


Receiver mode with input signal -47dBm



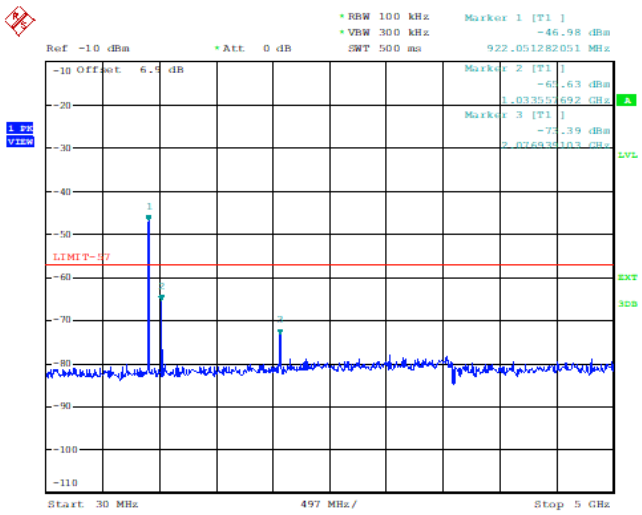
5.11.5.3. Configuration: Rx Conducted, 927.6 MHz

Receiver mode without input signal



Date: 5.MAY.2020 10:03:35

Receiver mode with input signal -47dBm



Date: 5.MAY.2020 09:48:49

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.12. RECEIVER SPURIOUS EMISSIONS (RADIATED) [§§ RSS-Gen §§ 5.3 & 7]

5.12.1. Limits

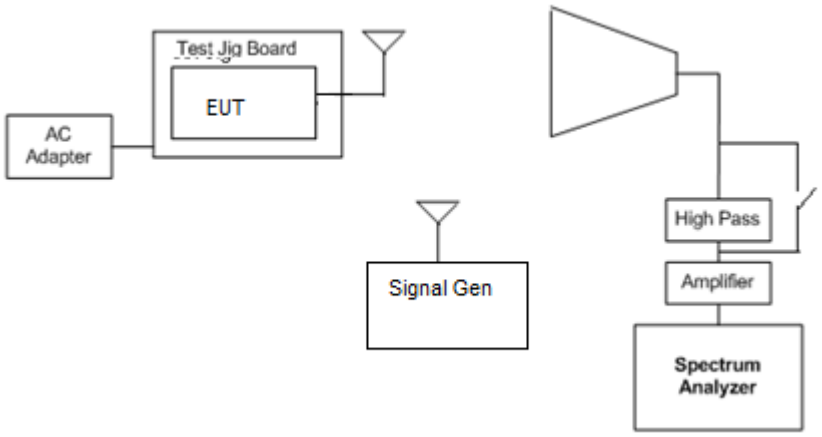
The equipment shall meet the limits of the following table:

Spurious Frequency (MHz)	Field Strength at 3 meters	
	(μV/m)	(dBμV/m)
30 – 88	100	40.0
88 – 216	150	43.5
216 – 960	200	46.0
Above 960	500	54.0

5.12.2. Method of Measurements

RSS-Gen and ANSI C63.4

5.12.3. Test Arrangement



5.12.4. Test Equipment used

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	Mar 18, 2021
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	Jun 24, 2020
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	Jan 7, 2021
Biconilog	Emco	3142B	1575	26-2000 MHz	May 10, 2020
Horn Antenna	Emco	3155	6570	1 – 18 GHz	Oct 11, 2020
AC Adapter	BIRon Switching Power Supply	BI24-120200-AdU	---	AC100-240V to 12 VDC	---
Laptop	Lenovo	ThinkPad Edge 0578	IS057882 ULRBXKBG	---	---
Signal Generator	Agilent	E8241A	US42110625	250 kHz-20 GHz	Oct 12, 2020

5.12.5. Test Data

The emissions were scanned from 30 MHz to 5.0 GHz at 3 Meters distance and all emissions less than 20 dB below the limits were recorded.

5.12.5.1. Near Lowest Frequency (902.4 MHz)

All emissions found were more than 20 dB below the permissible limits.

5.12.5.2. Near Middle Frequency (915 MHz)

All emissions found were more than 20 dB below the permissible limits.

5.12.5.3. Near Highest Frequency (927.6 MHz)

All emissions found were more than 20 dB below the permissible limits.

5.13. Radiated Emissions –Unintentional @ ICES-003

5.13.1. Limits

The equipment shall meet the limits of the following table:

Test Frequency Range (MHz)	Class B Limits (dBμV/m)	EMI Detector Used	Measurement Distance (meters)
30 – 88	40.0	Quasi-Peak	3
88 – 216	43.5	Quasi-Peak	3
216 – 960	46.0	Quasi-Peak	3
960 -1000	54.0	Quasi-Peak	3
Above 1000	54.0 74.0	Average Peak	3

5.13.2. Method of Measurements

Refer to Ultratech Test Procedures ULTR-P001-2004 & ANSI C63.4 for method of measurements.

The spectrum shall be investigated from the lowest radio frequency signal generated or used in the device, without going below the lowest frequency for which a radiated emission limit is specified, up to the frequency 5th harmonic of the highest frequency or 40 GHz, whichever is lower

Calculation of Field Strength:

The field strength is calculated by adding the calibrated antenna factor and cable factor, and subtracting the Amplifier gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

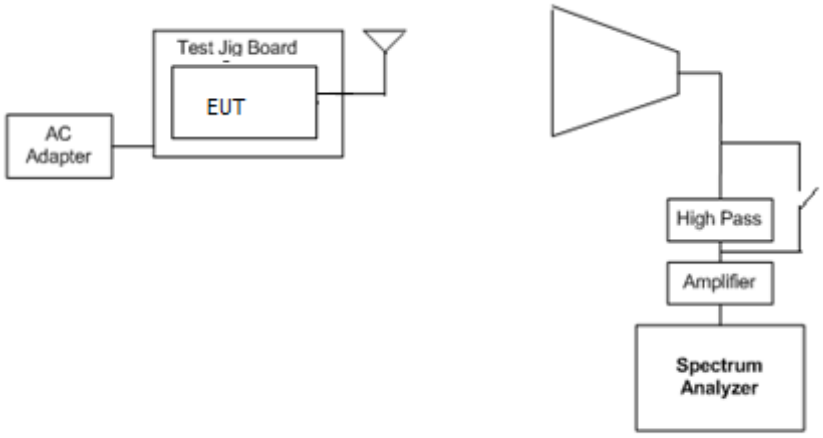
$$FS = RA + AF + CF - AG$$

Where FS = Field Strength
RA = Receiver/Analyzer Reading
AF = Antenna Factor
CF = Cable Attenuation Factor
AG = Amplifier Gain

5.13.3. Test Equipment

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Calibration Due Date
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	Mar 18, 2021
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	Jul 25, 2020
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	Jun 24, 2020
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	Jan 7, 2021
Biconilog	Emco	3142B	1575	26-2000 MHz	May 10, 2020
Horn Antenna	Emco	3155	6570	1 – 18 GHz	Oct 11, 2020

5.13.4. Test Arrangement



5.13.5. Test Data

The emissions were scanned from 30 MHz to12. 5 GHz at 3 meters distance and all emissions in excess of 20 dB below the limits were recorded.

FREQUENCY (MHz)	RF LEVEL (dBuV/m)	DETECTOR USED (PEAK/QP)	ANTENNA PLANE (H/V)	LIMIT (dBuV/m)	MARGIN (dB)
40.35	33.48	PEAK	V	40	-6.52
40.35	26.74	PEAK	H	40	-13.26
80.95	37.39	PEAK	V	40	-2.61
80.95	38.66	PEAK	H	40	-1.34
102.19	36.68	PEAK	V	43.5	-6.82
102.19	42.1	QP	H	43.5	-1.4
146.6	40.88	PEAK	V	43.5	-2.62
146.6	41.45	PEAK	H	43.5	-2.05
161.86	36.65	PEAK	V	43.5	-6.85
161.86	42.5	QP	H	43.5	-1.00
201.92	29.25	PEAK	V	43.5	-14.25
201.92	33.98	PEAK	H	43.5	-9.52
265.38	36.52	PEAK	V	46	-9.48
265.38	35.65	PEAK	H	46	-10.35
276.6	34.12	PEAK	V	46	-11.88
276.6	33.83	PEAK	H	46	-12.17
283.01	39.49	PEAK	V	46	-6.51
283.01	40.54	PEAK	H	46	-5.46
288.46	33.39	PEAK	V	46	-12.61
288.46	34.81	PEAK	H	46	-11.19
298.72	32.31	PEAK	V	46	-13.69
298.72	34.28	PEAK	H	46	-11.72
309.61	30.65	PEAK	V	46	-15.35
309.61	35.16	PEAK	H	46	-10.84
320.83	31.84	PEAK	V	46	-14.16
320.83	38.88	PEAK	H	46	-7.12
331.73	31.84	PEAK	V	46	-14.16
331.73	35.35	PEAK	H	46	-10.65
342.95	31.69	PEAK	V	46	-14.31
342.95	36.46	PEAK	H	46	-9.54

Contd ….

FREQUENCY (MHz)	RF LEVEL (dBuV/m)	DETECTOR USED (PEAK/QP)	ANTENNA PLANE (H/V)	LIMIT (dBuV/m)	MARGIN (dB)
376.28	31.63	PEAK	V	46	-14.37
376.28	37.2	PEAK	H	46	-8.8
387.18	40.04	PEAK	V	46	-5.96
387.18	43.72	PEAK	H	46	-2.28
398.39	36.03	PEAK	V	46	-9.97
398.39	37.79	PEAK	H	46	-8.21
408.97	37.24	PEAK	V	46	-8.76
408.97	39.92	PEAK	H	46	-6.08
420.19	32.11	PEAK	V	46	-13.89
420.19	33.73	PEAK	H	46	-12.27
431.09	37.18	PEAK	V	46	-8.82
431.09	40.37	PEAK	H	46	-5.63
453.2	34.3	PEAK	V	46	-11.7
453.2	36.25	PEAK	H	46	-9.75
464.42	31.72	PEAK	V	46	-14.28
464.42	30.61	PEAK	H	46	-15.39
475.64	36.49	PEAK	V	46	-9.51
475.64	34.31	PEAK	H	46	-11.69
486.53	33.7	PEAK	V	46	-12.3
486.53	31.35	PEAK	H	46	-14.65
497.96	41.27	PEAK	V	46	-4.73
497.96	37.48	PEAK	H	46	-8.52
508.65	35.61	PEAK	V	46	-10.39
508.65	32.81	PEAK	H	46	-13.19
511.21	33.14	PEAK	V	46	-12.86
511.21	30.07	PEAK	H	46	-15.93
519.87	40.96	PEAK	V	46	-5.04
519.87	38.36	PEAK	H	46	-7.64
530.77	33.89	PEAK	V	46	-12.11
530.77	33.75	PEAK	H	46	-12.25
541.98	40.88	PEAK	V	46	-5.12
541.98	39.09	PEAK	H	46	-6.91

Contd ….

FREQUENCY (MHz)	RF LEVEL (dBuV/m)	DETECTOR USED (PEAK/QP)	ANTENNA PLANE (H/V)	LIMIT (dBuV/m)	MARGIN (dB)
553.2	34.47	PEAK	V	46	-11.53
553.2	31.31	PEAK	H	46	-14.69
564.1	39.17	PEAK	V	46	-6.83
564.1	36.5	PEAK	H	46	-9.5
575.32	32.82	PEAK	V	46	-13.18
575.32	32.11	PEAK	H	46	-13.89
586.22	35.52	PEAK	V	46	-10.48
586.22	37.08	PEAK	H	46	-8.92
608.11	33.34	PEAK	V	46	-12.66
608.11	36.91	PEAK	H	46	-9.09
630.12	32.98	PEAK	V	46	-13.02
630.12	37.24	PEAK	H	46	-8.76
696.79	34.47	PEAK	V	46	-11.53
696.79	36.93	PEAK	H	46	-9.07
825.64	35.88	PEAK	V	46	-10.12
825.64	35.9	PEAK	H	46	-10.1
851.92	38.99	PEAK	V	46	-7.01
851.92	39.17	PEAK	H	46	-6.83
865.06	37.06	PEAK	V	46	-8.94
865.06	38.25	PEAK	H	46	-7.75
878.2	40.47	PEAK	V	46	-5.53
878.2	40.23	PEAK	H	46	-5.77
891.35	38.71	PEAK	V	46	-7.29
891.35	37.06	PEAK	H	46	-8.94
904.48	40.04	PEAK	V	46	-5.96
904.48	37.7	PEAK	H	46	-8.3
930.77	37.72	PEAK	V	46	-8.28
930.77	37.43	PEAK	H	46	-8.57
983.33	37.68	PEAK	V	54	-16.32
983.33	38.88	PEAK	H	54	-15.12

EXHIBIT 6. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

6.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	± 1.44	± 1.8
U	Expanded uncertainty U: $U = 2u_c(y)$	± 2.89	± 3.6

6.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	± 2.15	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.30	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	± 2.14	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.29	± 5.2

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	± 1.52	Under consideration
U	Expanded uncertainty U: $U = 2u_c(y)$	± 3.04	Under consideration