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RF Test Report

Test Report Number	STA-24072635-LC-FCC-IC-NFC
FCC ID	STJ-NFCMF5K
IC	5627A-NFCMF5K
Applicant	ICU Medical, Inc.
Applicant Address 1	951 Calle Amanecer, San Clemente, CA 92673
Applicant Address 2	600 N Field Dr, Lake Forest, IL 60045
Product Name	Medfusion 5000 Wireless Syringe Infusion Pump
Model (s)	Medfusion 5000
Date of Receipt	09/24/2024
Date of Test	10/04/2024-10/22/2024
Report Issue Date	10/29/2024
Test Standards	47CFR Part 15.225 RSS-210 Issue 11, June 2024 RSS-Gen Issue 5 Amd 2 Feb 2021
Test Result	**PASS**

Issued by:

Vista Compliance Laboratories
1261 Puerta Del Sol, San Clemente, CA 92673 USA
www.vista-compliance.com

Minoush Niknam (Test Engineer)

David Zhang (Technical Manager)

REVISION HISTORY

Report Number	Version	Description	Issued Date
STA-24072635-LC-FCC-IC-NFC	01	Initial report	10/29/2024

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1 Test Summary

Test Item	Test Requirement	Test Method	Result
Antenna Requirement	47 CFR Part 15.203	ANSI C63.10: 2013	Pass
Occupied Bandwidth	RSS-Gen Issue 5 Amd 2 Feb 2021	RSS-Gen Issue 5 Amd 2 Feb 2021	Pass
Emission Mask Limit in the band of 13.110 – 14.010 MHz	47 CFR Part 15.225 RSS-210 Issue 11, June 2024	ANSI C63.10: 2013	Pass
Radiated Spurious Emission below 30MHz	47 CFR Part 15.225 RSS-210 Issue 11, June 2024	ANSI C63.10: 2013	Pass
Radiated Spurious Emissions below 1GHz	47 CFR Part 15.225 RSS-210 Issue 11, June 2024	ANSI C63.10: 2013	Pass
AC Power Line Conducted Emissions	47 CFR Part 15.225 RSS-210 Issue 11, June 2024	ANSI C63.10: 2013	Pass
Frequency Stability	47 CFR Part 15.225 RSS-210 Issue 11, June 2024	ANSI C63.10: 2013	Pass

2 General Information

2.1 Applicant

Applicant	ICU Medical, Inc.
Applicant Address 1	951 Calle Amanecer, San Clemente, CA 92673
Applicant Address 2	600 N Field Dr, Lake Forest, IL 60045
Manufacturer	ICU Medical, Inc.
Manufacturer Address 1	951 Calle Amanecer, San Clemente, CA 92673
Manufacturer Address 2	600 N Field Dr, Lake Forest, IL 60045

2.2 Product information

Product Name	Medfusion 5000 Wireless Syringe Infusion Pump
Model Number	Medfusion 5000
Family Models	N/A
Serial Number	G-P3-010
Frequency Band	NFC: 13.56MHz
Type of modulation	NFC: ASK
Equipment Class	DXX
Antenna (S) Information	(NFC) – Rectangular Near Field Communication (NFC) Antenna, Part Number: 1462362131
Clock Frequencies	N/A
Input Power	100-240Vac, 50/60Hz, 160VA (AC) 12.8 VDC Internal Battery (DC)
Power Adapter Manufacturer/Model	Manufacturer: Delta Electronics, Inc., Model: MDS-030BAC15, - Input: 100-240VAC, 0.8-0.6A, 50-60Hz - Output: 15V, 2A
Power Adapter SN	230W6B1000H
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	NFC and integrated 2.4GHz/5GHz module can transmit simultaneously in the host product (co-location). The simultaneous transmission and co-location have been evaluated in the testing.
Additional Info	This device contains a certified 2.4GHz/5GHz WLAN module with Dual band Wi-Fi Antenna, Model: FTW6202, Peak Gain: 2.4GHz, 3.00 dBi; 5GHz: 4.45 dBi. - Brand: Silex - Model: SX-SDMAC-2832S - FCC ID: STJ-SDMAC - ISED ID: 5627A-SDMAC

2.3 Test standard and method

Test standard	47CFR Part 15.225 RSS-210 Issue 11, June 2024
Test method	ANSI C63.10-2013 RSS-Gen Issue 5 Amd 2 Feb 2021

3 Test Site Information

Lab performing tests	Vista Laboratories, Inc.
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www.vista-compliance.com

Test Condition	Temperature	Humidity	Atmospheric Pressure
RF Testing	23.5°C	58.2%	996 mbar
Radiated Emission Testing	23.5°C	58.2%	996 mbar

4 Modification of EUT / Deviations from Standards

N/A

5 Test Configuration and Operation

5.1 EUT Test Configuration

The EUT is an engineering test sample loaded with RF testing firmware specifically designed to support the RF TX/RX measurement in different aspects.

EUT supports a variety of NFC signal types, Types A, B, and F, with different bit rate settings. The RF ON mode is a CW signal that was also used for measuring the fundamental signal strength for comparison. Type A-106 Kbps was determined to be the worst case and used for spurious emission testing.

The following software was used for testing and to monitor EUT performance

Software	Description
EMISoft Vasona	EMC/RF Spurious emission test software used during testing
Tera-Term	Send Command for NFC

5.2 Supporting Equipment

Description	Manufacturer	Model #	Serial #	Remark
AC/DC Adapter	Delta Electronics, Inc.	MDS-030BAC15	230W6B1000H	Provided by client
Test Laptop	Dell	Latitude 5400	37917846974	Provided by client
Access Point	Linksys	EA8300	N/A	Provided by lab
USB to ethernet converter	Plugable	N/A	N/A	Provided by client

6 Uncertainty of Measurement

Test item	Measurement Uncertainty (dB)
RF Output Power (Conducted)	±1.2 dB
Unwanted Emission (conducted)	±2.6 dB
Radiated Emission (9KHz-30MHz)	±3.5 dB
Radiated Emission (30MHz-1GHz)	±4.6 dB

7 Test Results

7.1 Antenna Requirement

7.1.1 Requirement

Per § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

7.1.2 Result

Analysis:

- EUT uses internal Rectangular NFC Antenna that is permanently attached. The integrated Wi-Fi module has internal Dual band Wi-Fi Antenna that is permanently attached. These two antenna co-locate with each other.
-

Conclusion:

- EUT complies with antenna requirement in § 15.203.

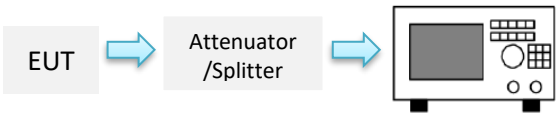
7.2 Occupied Bandwidth (99%)

7.2.1 Requirement

RSS-Gen §6.7

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

7.2.2 Test Setup



7.2.3 Test Procedure

According to section RSS-Gen §6.7

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

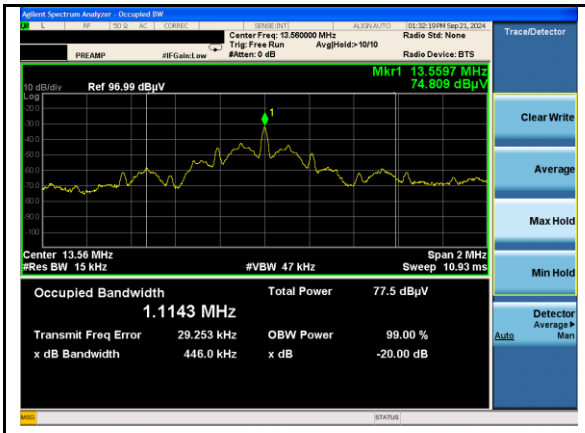
1. Set RBW = 1% to 5% of the actual occupied BW.
2. Set the video bandwidth (VBW) ≥ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Span = large enough to capture all products of the modulation process
7. Allow the trace to stabilize.
8. Use automatic bandwidth measurement capability on instrument to obtain BW result.

7.2.4 Test Result

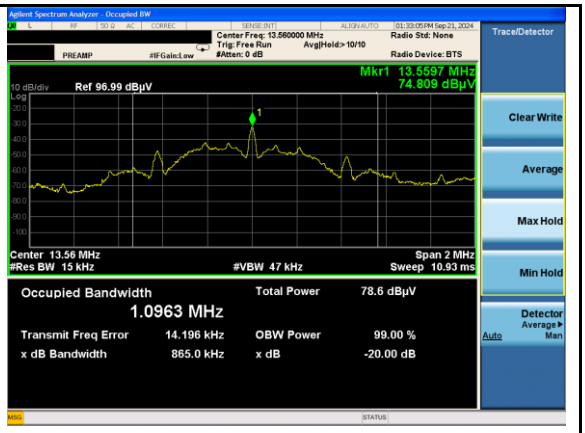
Mode	Mode	Bitrate (kbps)	Frequency (MHz)	Measured 99% OBW (KHz)	Limit (KHz)	Result
NFC	Type A	106	13.56	1114.3	N/A	N/A
NFC	Type A	212	13.56	1096.3	N/A	N/A
NFC	Type A	424	13.56	2105.8	N/A	N/A
NFC	Type A	848	13.56	2082.3	N/A	N/A
NFC	Type B	106	13.56	111.57	N/A	N/A
NFC	Type B	212	13.56	214.76	N/A	N/A
NFC	Type B	424	13.56	581.67	N/A	N/A
NFC	Type B	848	13.56	762.57	N/A	N/A
NFC	Type F	212	13.56	458.15	N/A	N/A
NFC	Type F	424	13.56	845.09	N/A	N/A

Note: the 99% OBW values are for the purpose of reporting the emission bandwidth as required for ISED; therefore; no limitation applies to 99% OBW.

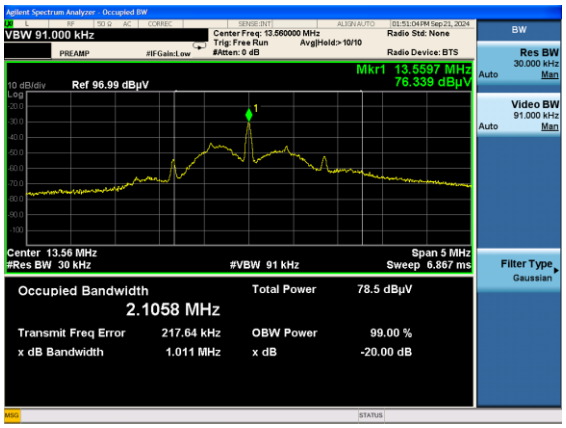
7.2.5 Test Plots



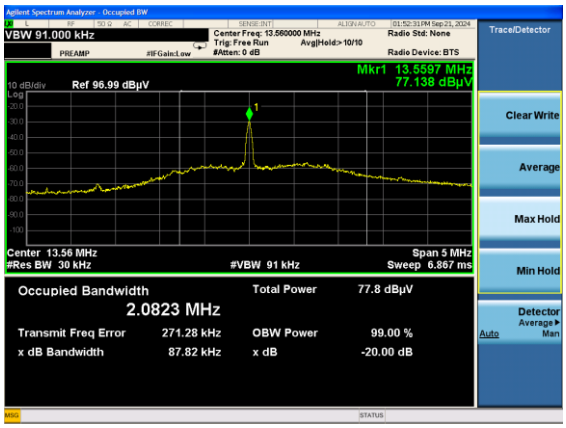
Type A-106Kbps



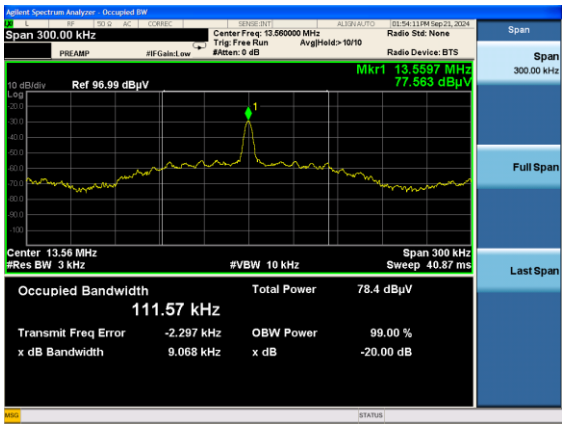
Type A-212Kbps



Type A-424Kbps



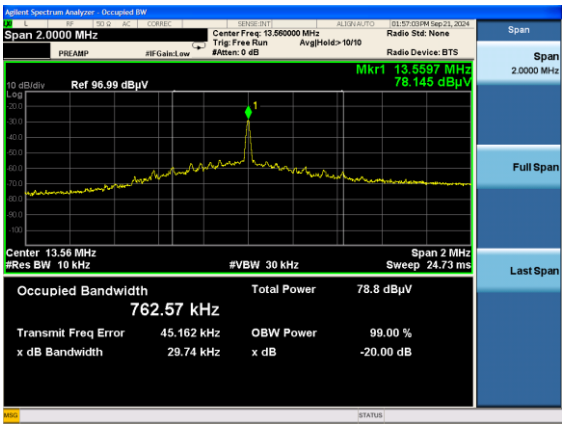
Type A-848Kbps



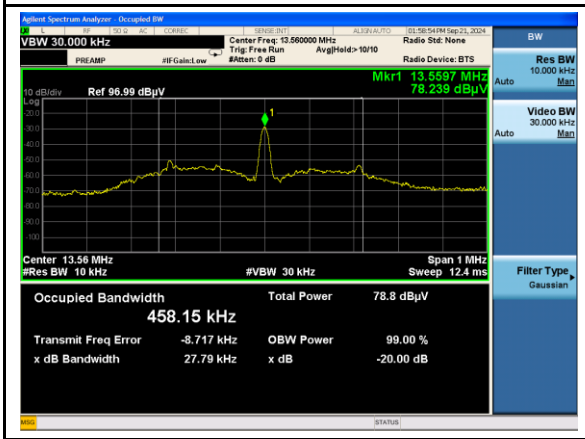
Type B-106Kbps

Type B-212Kbps

Type B-424Kbps



Type B-848Kbps



Type F-212Kbps

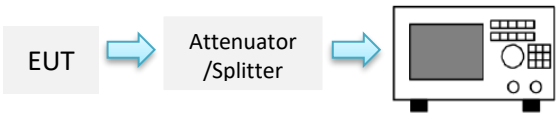
Type A-424Kbps

7.3 20 dB Bandwidth

7.3.1 Requirement

The occupied bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are -6 dB, -20 dB, and -26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this subclause, the ratio is designated by "-xx dB." The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the "-xx dB" bandwidth; other requirements might specify that the "-xx dB" bandwidth be entirely contained within the authorized or designated frequency band.

7.3.2 Test Setup



7.3.3 Test Procedure

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency.

The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Steps a) through c) might require iteration to adjust within the specified tolerances.

e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.

f) Set detection mode to peak and trace mode to max hold.

g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).

h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, this

calculation may be made by using the marker-delta function of the instrument.

i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j.

j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "_xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "_xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

7.3.4 Test Result

Mode	Mode	Bitrate (kbps)	Frequency (MHz)	Measured 20 dB BW (KHz)	Limit (KHz)	Result
NFC	Type A	106	13.56	446	N/A	N/A
NFC	Type A	212	13.56	865	N/A	N/A
NFC	Type A	424	13.56	1011	N/A	N/A
NFC	Type A	848	13.56	87.82	N/A	N/A
NFC	Type B	106	13.56	9.068	N/A	N/A
NFC	Type B	212	13.56	8.893	N/A	N/A
NFC	Type B	424	13.56	30.46	N/A	N/A
NFC	Type B	848	13.56	29.74	N/A	N/A
NFC	Type F	212	13.56	27.79	N/A	N/A
NFC	Type F	424	13.56	28.37	N/A	N/A

7.4 Emission Mask Limit in the band of 13.110 – 14.010 MHz

7.4.1 Requirement

Per §15.225 Operation within the band 13.110–14.010 MHz:

(a) The field strength of any emissions within the band 13.553–13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410–13.553 MHz and 13.567–13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110–13.410 MHz and 13.710–14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110–14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

Per RSS-210, B.6, Band 13.110-14.010 MHz

(a) the field strength of any emission shall not exceed the following limits:

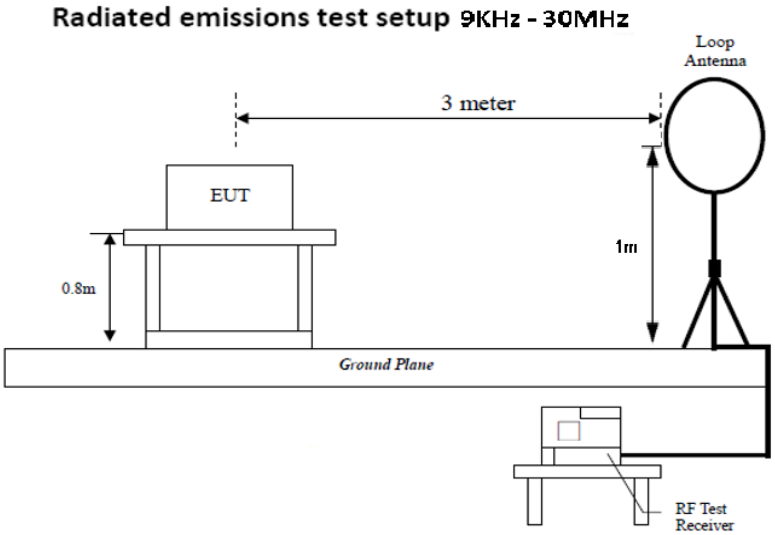
(i) 15.848 mV/m (84 dBµV/m) at 30 m, within the band 13.553-13.567 MHz

(ii) 334 µV/m (50.5 dBµV/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz

(iii) 106 µV/m (40.5 dBµV/m) at 30 m, within the bands 13.110-13.410 MHz and 13.710-14.010 MHz

(iv) RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz

7.4.2 Test Setup



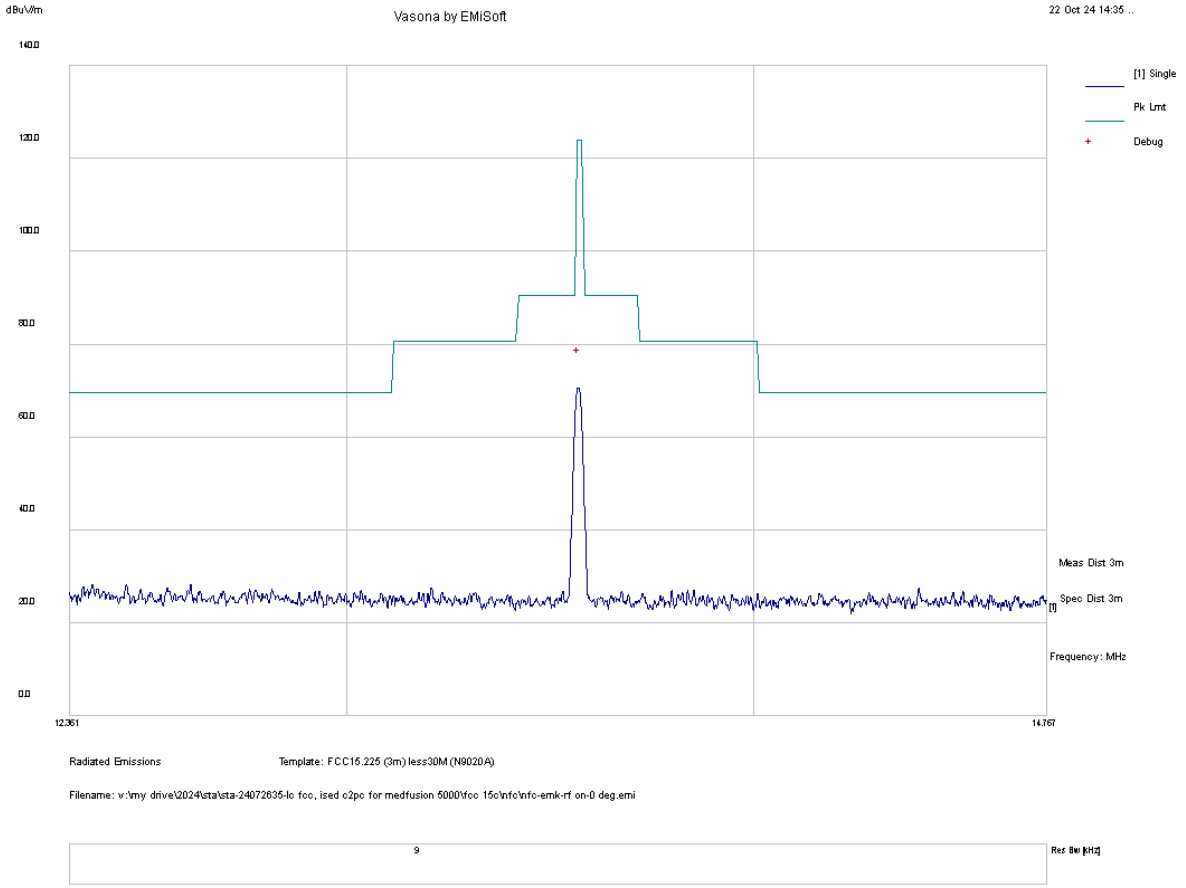
7.4.3 Test Procedure

According to section 6.4 of ANSI C63.10-2013 The process will be repeated in 3 EUT orientations.

1. The EUT was placed on a non-conducting table and switched on and allowed to warm up to its normal operating condition. Measuring loop antenna is placed at 1m height and at 3m distance away from EUT.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna orientation at both 0 deg and 90 deg.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 300 Hz for frequency below 150KHz.
4. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 kHz for frequency between 150KHz – 30MHz.
5. Steps 2 and 4 were repeated for the next frequency point, until all selected frequency points were measured.

7.4.4 Test Result

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 0 deg	Test Engineer:	Minoush Niknam
Remark:	RF on (CW mode)	Test Result:	Pass

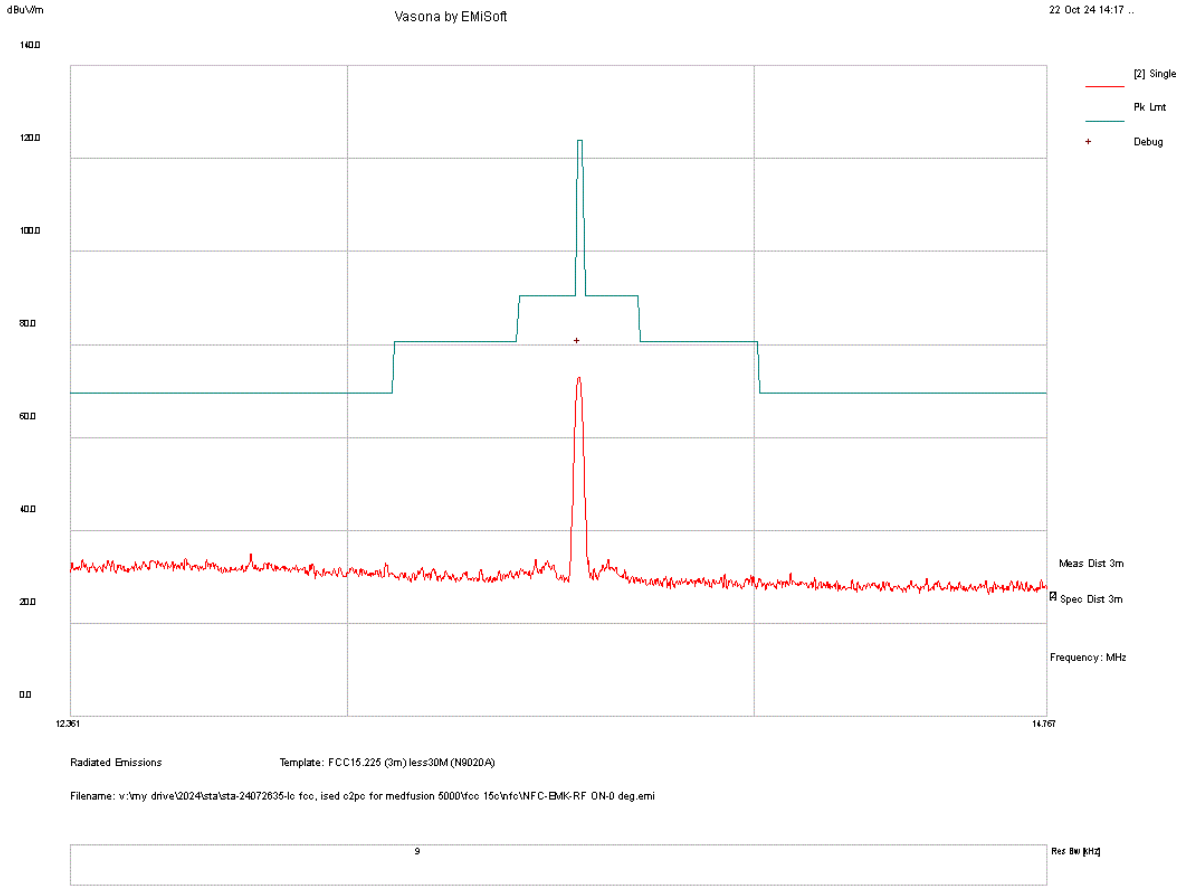


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.561	54.1	1.3	15.1	70.6	Peak Max	0 deg	100	124	-53.4	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 90 deg	Test Engineer:	Minoush Niknam
Remark:	RF on (CW mode)	Test Result:	Pass

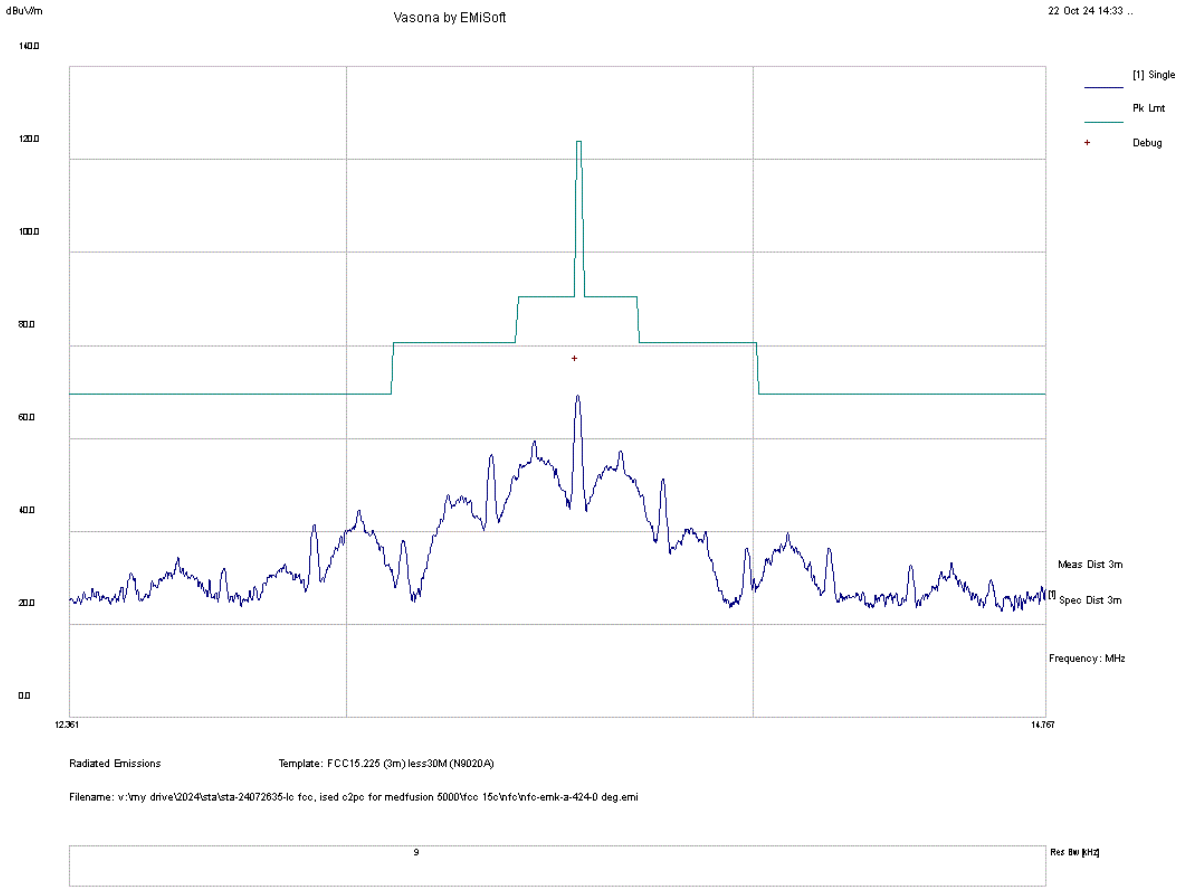


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.560	56.4	1.3	15.1	72.8	Peak Max	90 deg	100	124	-51.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 0 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass

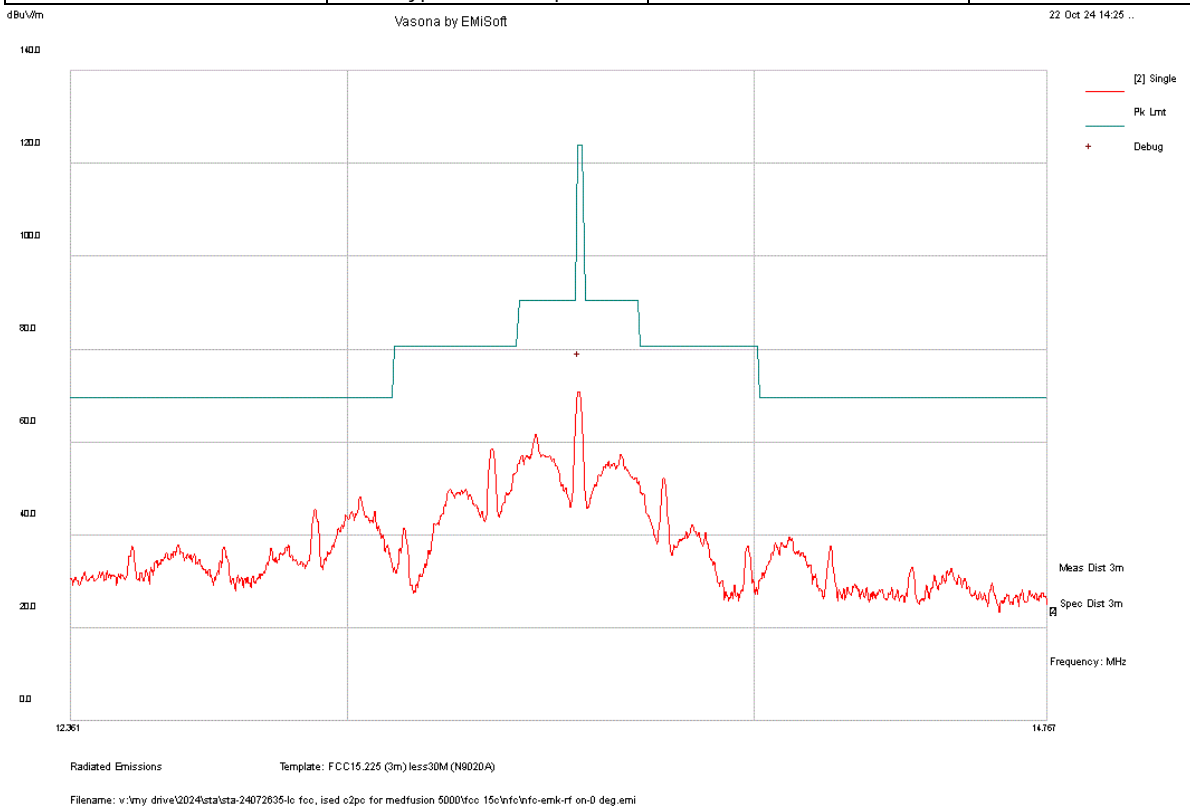


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.559	52.7	1.3	15.1	69.2	Peak Max	0 deg	100	124	-54.8	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 90 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass

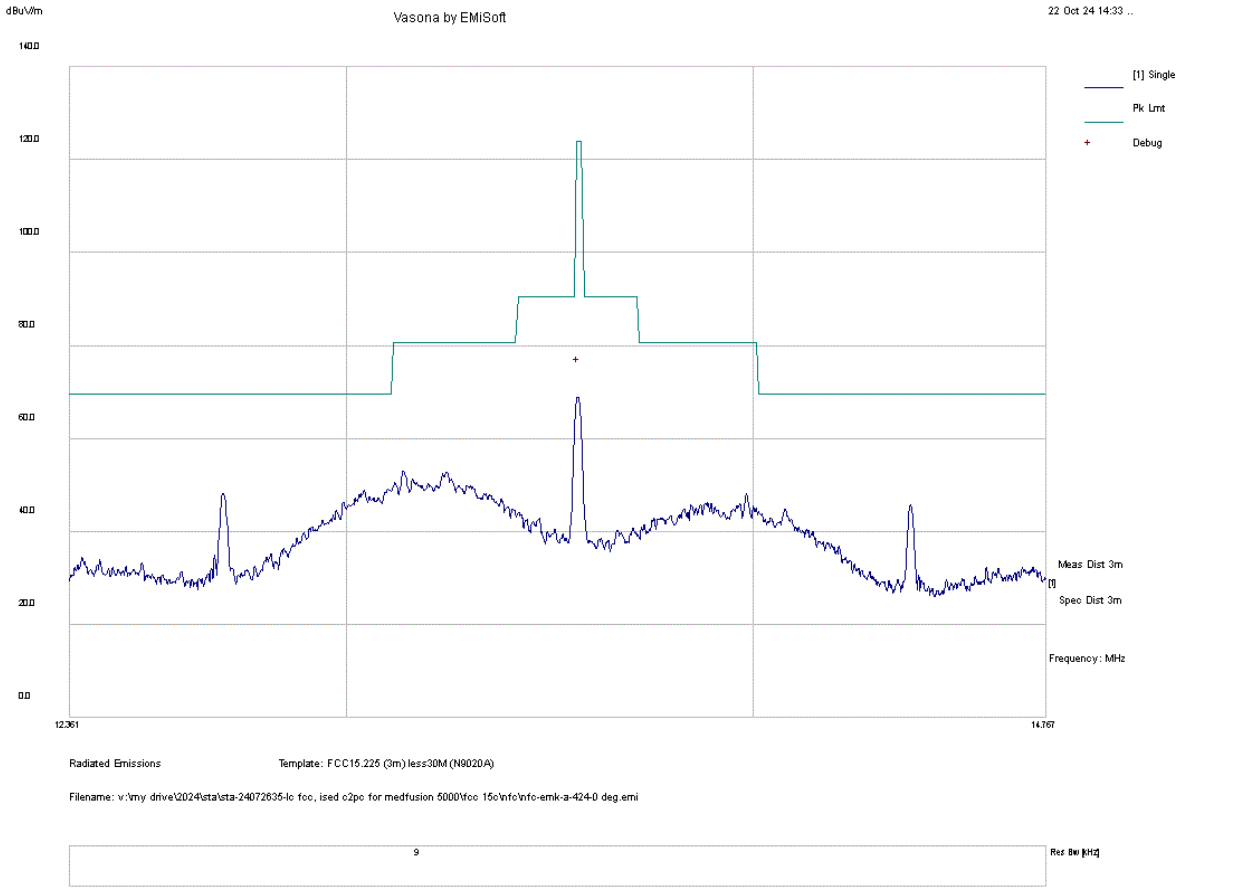


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.560	54.4	1.3	15.1	70.8	Peak Max	90 deg	100	124	-53.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 0 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 424 Kbps	Test Result:	Pass

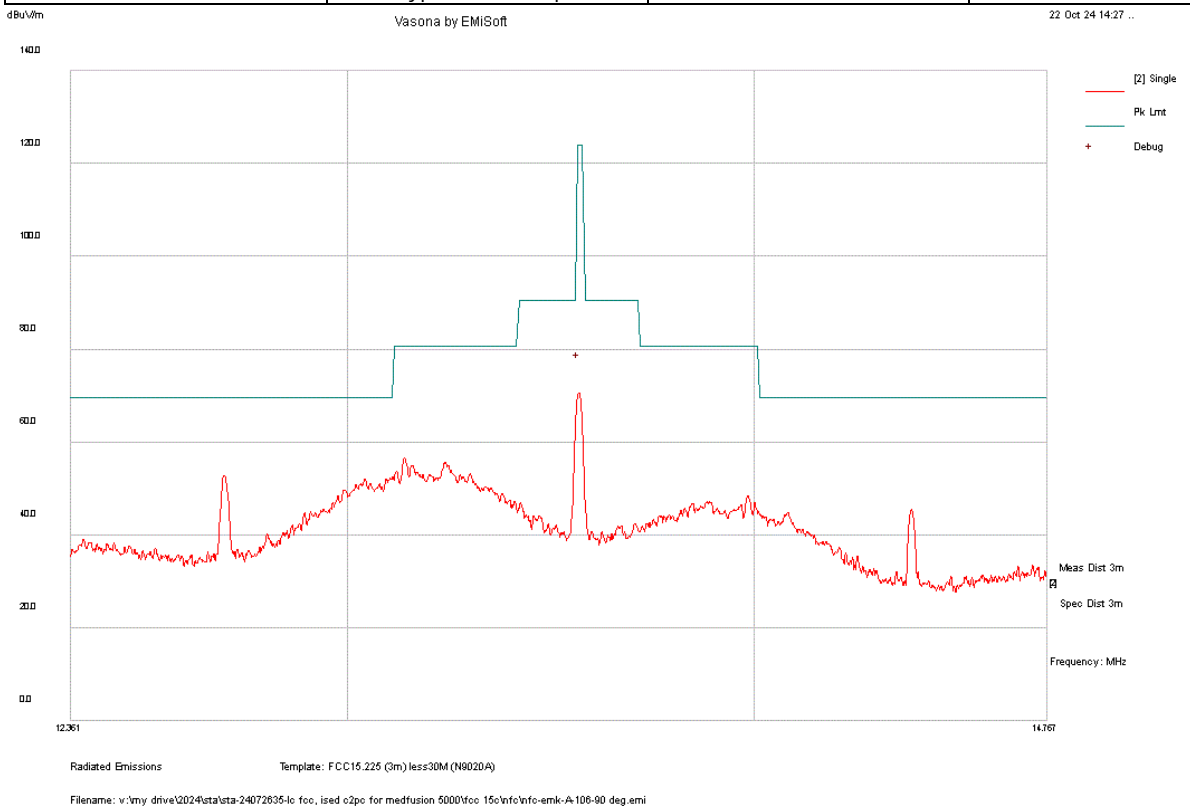


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.561	52.4	1.3	15.1	68.8	Peak Max	0 deg	100	124	-55.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 90 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 424 Kbps	Test Result:	Pass



Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
13.559	54.0	1.3	15.1	70.5	Peak Max	0 deg	100	124	-53.5	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Radiated Spurious Emission below 30MHz

7.4.5 Requirement

Per §15.225 Operation within the band 13.110–14.010 MHz:

(a) The field strength of any emissions within the band 13.553–13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410–13.553 MHz and 13.567–13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110–13.410 MHz and 13.710–14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110–14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

Per RSS-210, B.6, Band 13.110-14.010 MHz

(a) the field strength of any emission shall not exceed the following limits:

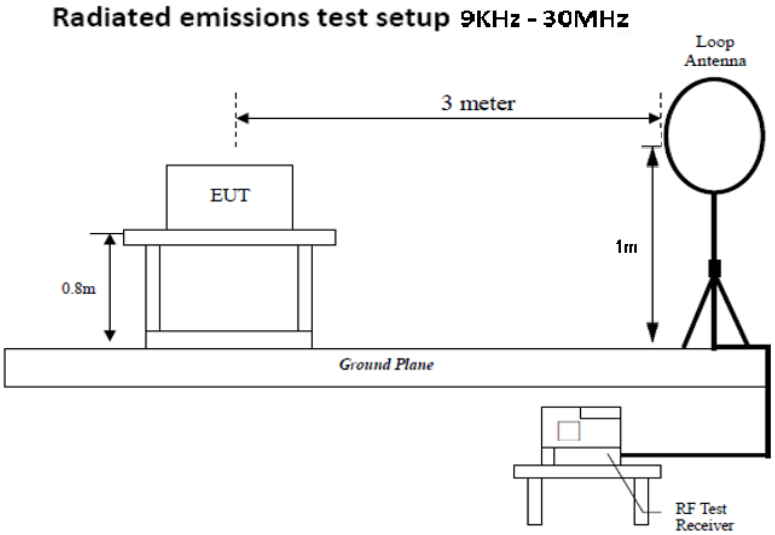
(i) 15.848 mV/m (84 dBµV/m) at 30 m, within the band 13.553-13.567 MHz

(ii) 334 µV/m (50.5 dBµV/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz

(iii) 106 µV/m (40.5 dBµV/m) at 30 m, within the bands 13.110-13.410 MHz and 13.710-14.010 MHz

(iv) RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz

7.4.6 Test Setup



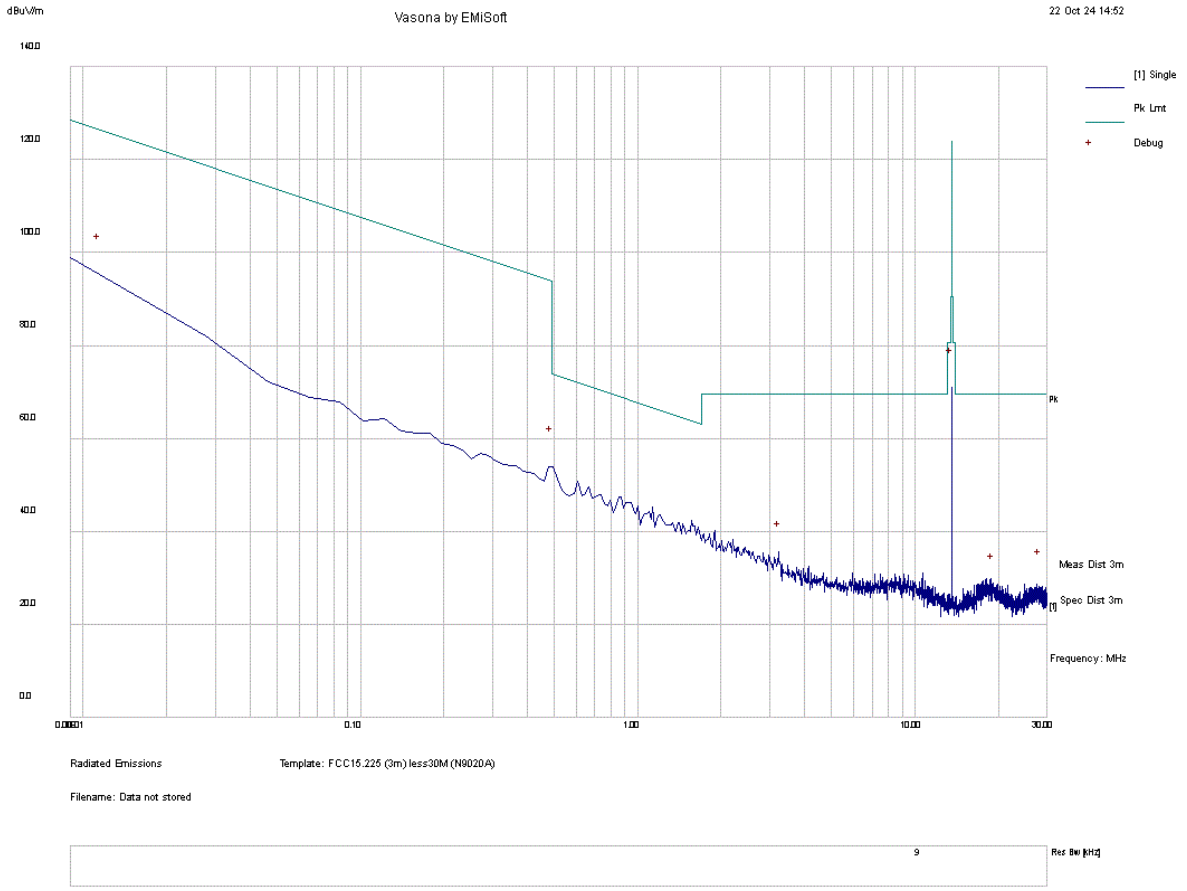
7.4.7 Test Procedure

According to section 6.4 of ANSI C63.10-2013 The process will be repeated in 3 EUT orientations.

1. The EUT was placed on a non-conducting table and switched on and allowed to warm up to its normal operating condition. Measuring loop antenna is placed at 1m height and at 3m distance away from EUT.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna orientation at both 0 deg and 90 deg.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 300 Hz for frequency below 150KHz.
4. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 kHz for frequency between 150KHz – 30MHz.
5. Steps 2 and 4 were repeated for the next frequency point, until all selected frequency points were measured.

7.4.8 Test Result

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 0 deg	Test Engineer:	Minoush Niknam
Remark:	RF on (CW mode)	Test Result:	Pass

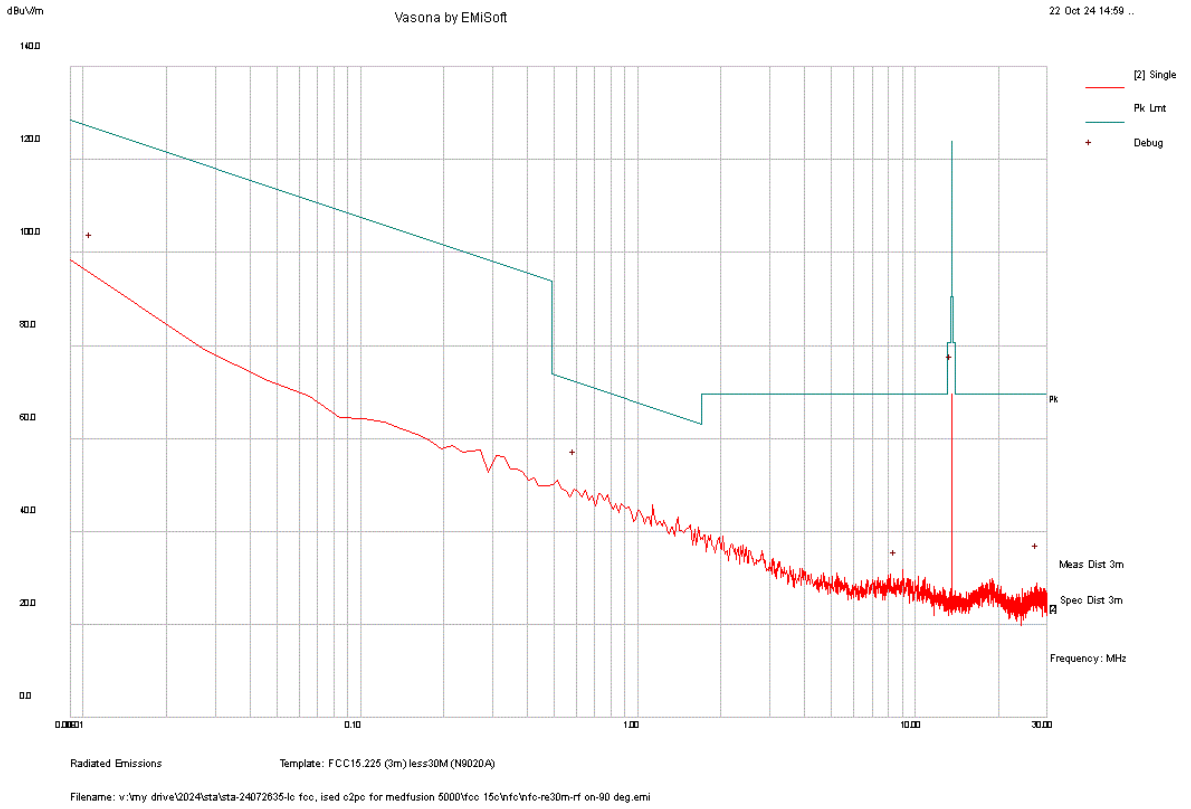


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
0.487	39.0	0.7	14.3	54.0	Peak Max	0 deg	100	93.9	-39.9	Pass
0.011	79.9	0.3	15.0	95.3	Peak Max	0 deg	100	126.4	-31.1	Pass
3.250	17.6	0.9	15.1	33.5	Peak Max	0 deg	100	69.5	-36.0	Pass
18.970	8.7	1.7	16.1	26.4	Peak Max	0 deg	100	69.5	-43.1	Pass
28.001	11.8	2.1	13.7	27.6	Peak Max	0 deg	100	69.5	-41.9	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2023
Antenna Type/Polarity:	Loop / 90 deg	Test Engineer:	Minoush Niknam
Remark:	RF on (CW mode)	Test Result:	Pass

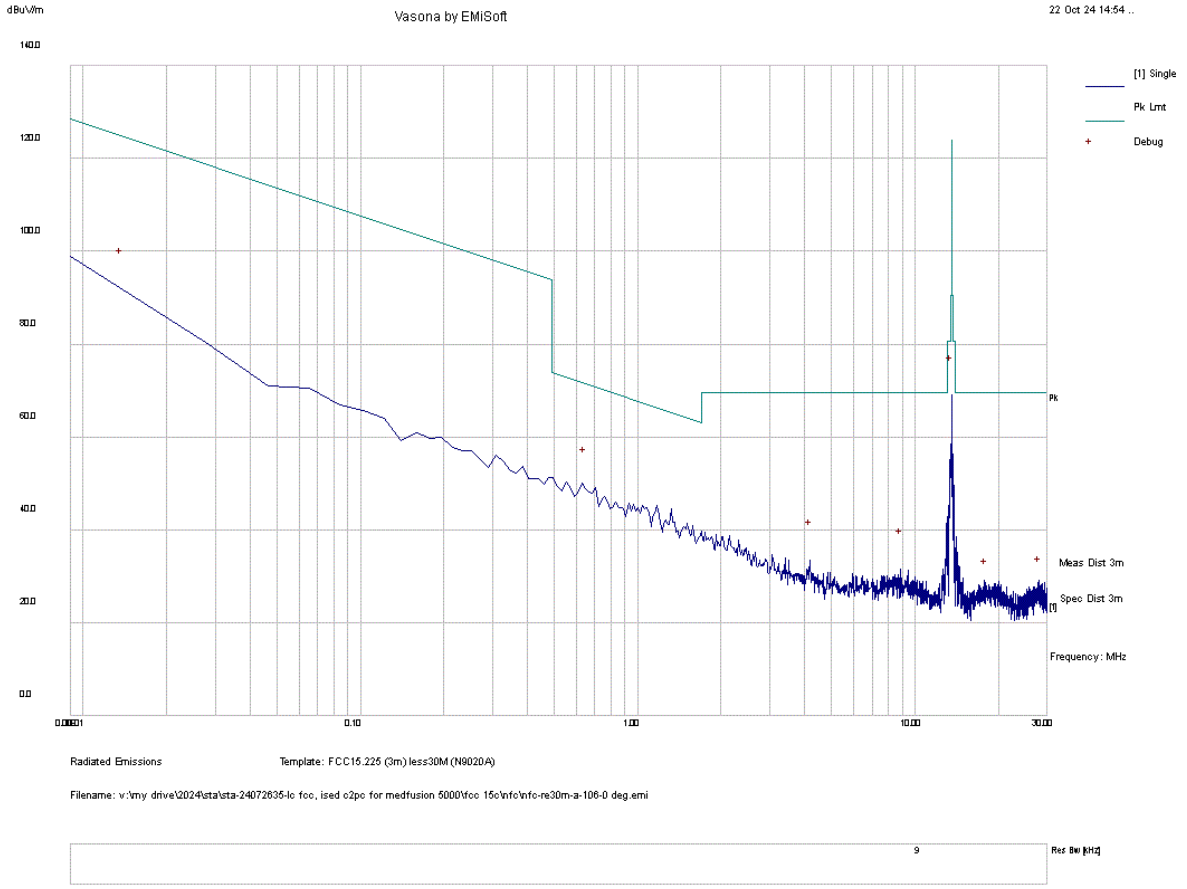


Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
0.011	80.3	0.3	15.0	95.6	Peak Max	90 deg	100	127.1	-31.5	Pass
0.592	33.8	0.7	14.5	49.0	Peak Max	90 deg	100	72.2	-23.2	Pass
8.532	10.9	1.0	15.4	27.3	Peak Max	90 deg	100	69.5	-42.3	Pass
27.597	12.7	2.1	13.8	28.6	Peak Max	90 deg	100	69.5	-40.9	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2024
Antenna Type/Polarity:	Loop / 0 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass

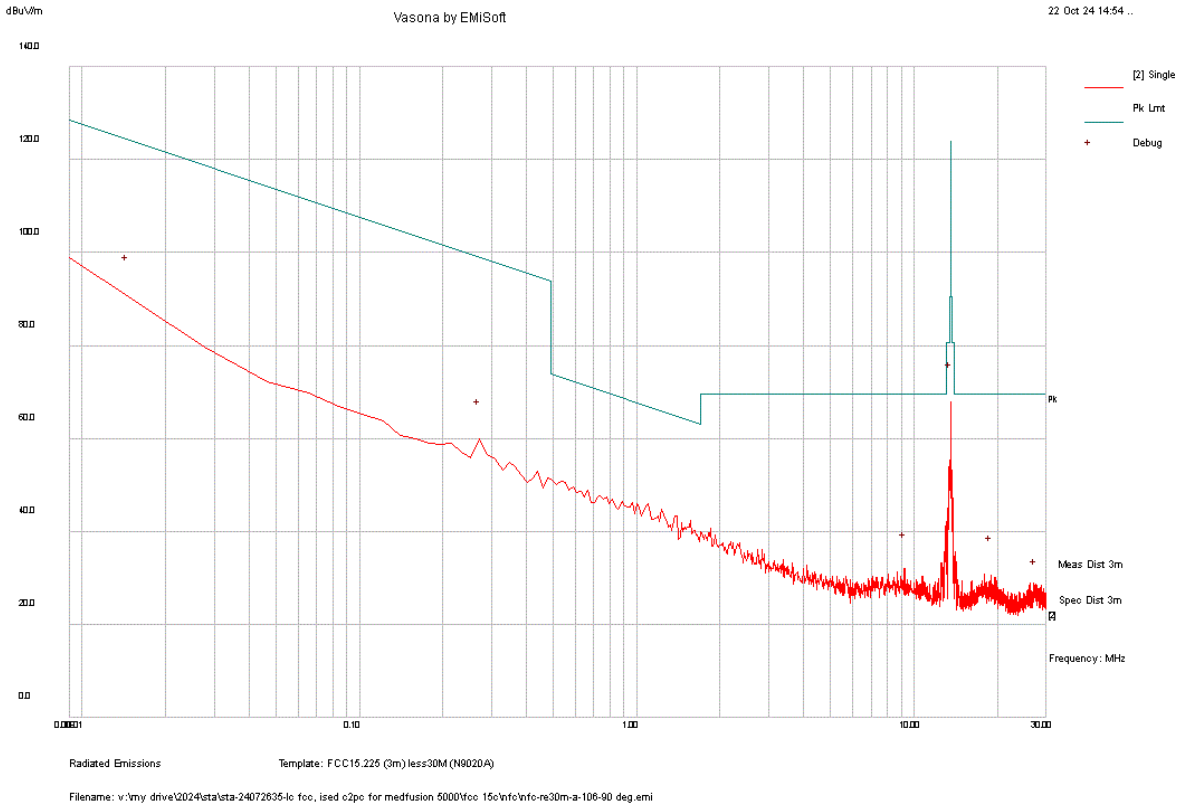


Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
0.014	76.5	0.3	15.2	92.0	Peak Max	0 deg	100	124.9	-32.9	Pass
0.642	34.0	0.7	14.5	49.2	Peak Max	0 deg	100	71.5	-22.2	Pass
4.179	17.5	0.9	15.1	33.4	Peak Max	0 deg	100	69.5	-36.1	Pass
17.923	7.6	1.6	15.8	25.1	Peak Max	0 deg	100	69.5	-44.4	Pass
28.001	9.7	2.1	13.7	25.6	Peak Max	0 deg	100	69.5	-43.9	Pass
8.876	15.2	1	15.4	31.6	Peak Max	0 deg	100	69.5	-37.9	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Test Standard:	15.225, RSS-210	Mode:	RFID TX
Frequency Range:	Below 30MHz	Test Date:	10/22/2023
Antenna Type/Polarity:	Loop / 90 deg	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass



Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Limit dBuV/m	Margin dB	Pass/Fail
0.270	45.0	0.6	14.2	59.8	Peak Max	90 deg	100	99.0	-39.1	Pass
0.014	75.2	0.3	15.3	90.8	Peak Max	90 deg	100	124.4	-33.6	Pass
9.253	14.8	1.0	15.4	31.2	Peak Max	90 deg	100	69.5	-38.3	Pass
18.942	12.6	1.7	16.1	30.4	Peak Max	90 deg	100	69.5	-39.1	Pass
27.439	9.3	2.1	13.8	25.2	Peak Max	90 deg	100	69.5	-44.3	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

7.5 Radiated Spurious Emissions below 1GHz

7.5.1 Requirement

Per §15.225 Operation within the band 13.110–14.010 MHz:

(a) The field strength of any emissions within the band 13.553–13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410–13.553 MHz and 13.567–13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110–13.410 MHz and 13.710–14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110–14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

Per RSS-210, B.6, Band 13.110-14.010 MHz

(a) the field strength of any emission shall not exceed the following limits:

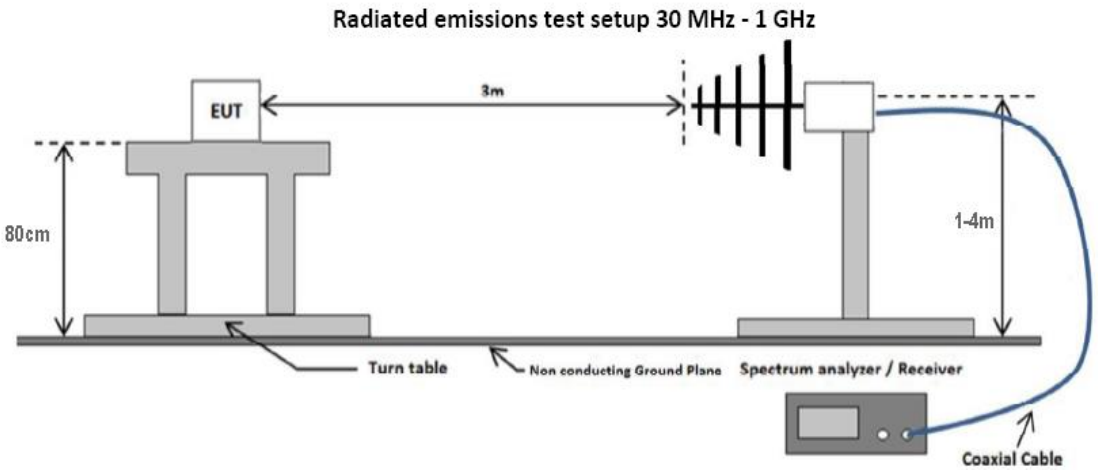
(i) 15.848 mV/m (84 dBµV/m) at 30 m, within the band 13.553-13.567 MHz

(ii) 334 µV/m (50.5 dBµV/m) at 30 m, within the bands 13.410-13.553 MHz and 13.567-13.710 MHz

(iii) 106 µV/m (40.5 dBµV/m) at 30 m, within the bands 13.110-13.410 MHz and 13.710-14.010 MHz

(iv) RSS-Gen general field strength limits for frequencies outside the band 13.110-14.010 MHz

7.5.2 Test Setup



7.5.3 Test Procedure

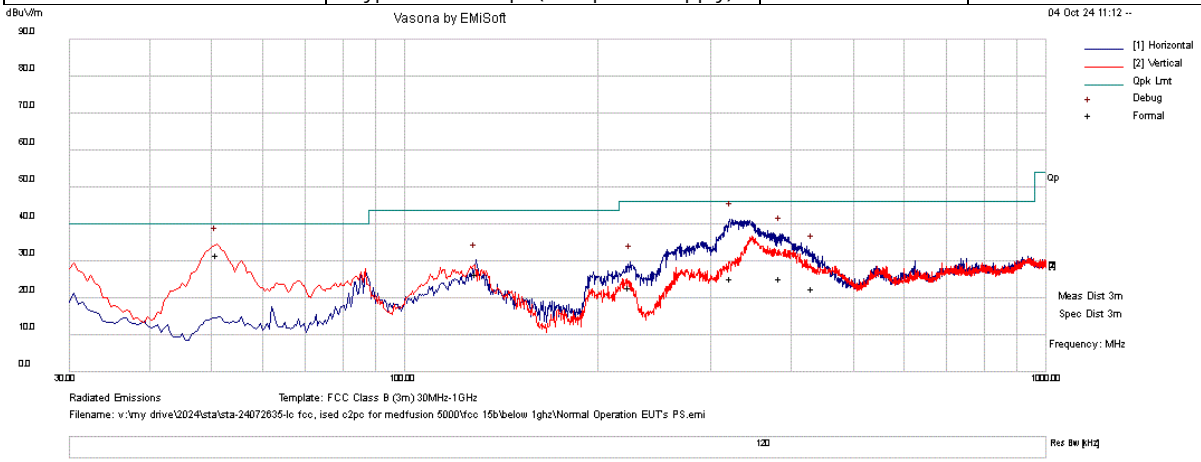
According to section 6.5 of ANSI C63.10-2013 as well as the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was used during the scanning to point to EUT to maximize the emission. The process will be repeated in 3 EUT orientations.

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
   a. Vertical or horizontal polarization (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
   b. The EUT was then rotated to the direction that gave the maximum emission.
   c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 300 Hz for frequency below 150KHz.
4. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 kHz for frequency between 150KHz – 30MHz.
5. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-Peak detection at frequency between 30MHz - 1GHz.
6. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz with Peak detection for Peak and average measurement at frequency above 1GHz.
7. Steps 2 and 3 were repeated for the next frequency point, until all selected frequency points were measured.

7.5.4 Test Result

RADIATED EMISSIONS BELOW 1 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	802.11b Mode
Frequency Range:	30 MHz - 1 GHz	Test Date:	10/04/2024
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps (with power supply)	Test Result:	Pass



No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	124.723	45.3	3.9	-18.4	30.9	Quasi Max	V	0	92	43.5	-12.6	Pass
2	42.002	46.1	2.6	-18.0	30.8	Quasi Max	V	178	0	40.0	-9.2	Pass
3	93.760	54.2	3.5	-19.7	37.9	Quasi Max	V	139	100	43.5	-5.6	Pass
4	141.194	48.9	4.1	-18.0	35.0	Quasi Max	H	161	12	43.5	-8.5	Pass
5	249.952	44.5	5.3	-14.6	35.1	Quasi Max	H	120	65	46.0	-10.9	Pass
6	179.078	42.5	4.5	-17.3	29.7	Quasi Max	H	114	0	43.5	-13.8	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
2. AF (dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Conducted Emissions

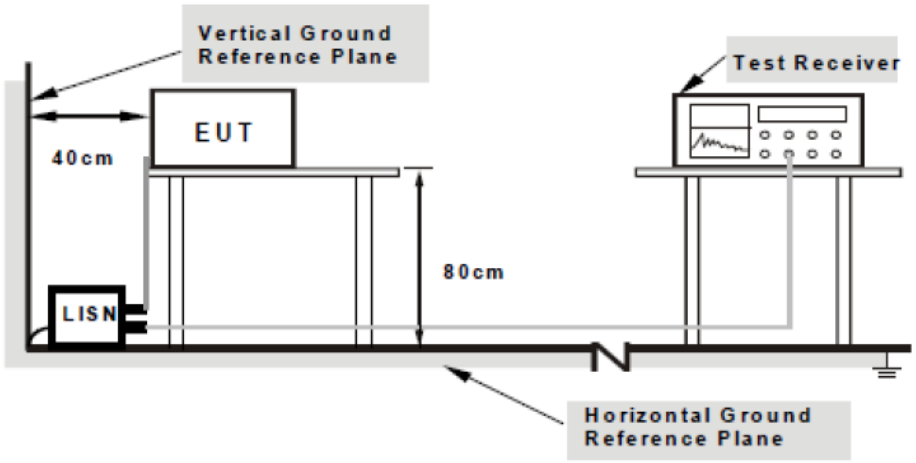
7.5.5 Requirement

Per § 15.207 (a) and RSS-Gen, an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Limits for Conducted Emissions at the Mains Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	66 – 56	56 – 46
	0.5 – 5	56	46
	5 - 30	60	50
NOTE 1 The lower limit shall apply at the transition frequencies.			

7.5.6 Test setup



Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

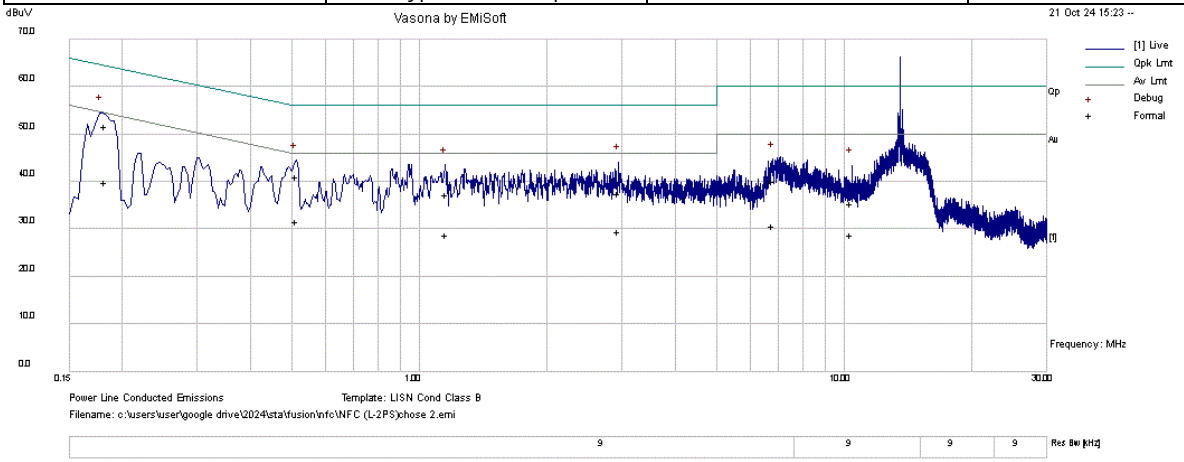
7.5.7 Test Procedure

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50Ω/50μH EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment was powered separately from another main supply.
5. The EUT was switched on and allowed to warm up to its normal operating condition.
6. A scan was made on the NEUTRAL line (for AC mains) or Earth line (for DC power) over the required frequency range using an EMI test receiver.
7. High peaks, relative to the limit line, were then selected.
8. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 10 kHz. For FCC tests, only Quasi-peak measurements were made; while for CISPR/EN tests, both Quasi-peak and Average measurements were made
9. All possible modes of operation were investigated. Only the worst-case emissions were measured and reported. All other emissions were relatively insignificant.

7.5.8 Test Result

CONDUCTED EMISSIONS

Test Standard:	LISN B Cond Class B	Mode:	Normal operation
Frequency Range:	0.15 - 30MHz	Test Date:	10/21/2024
Line:	Live	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass

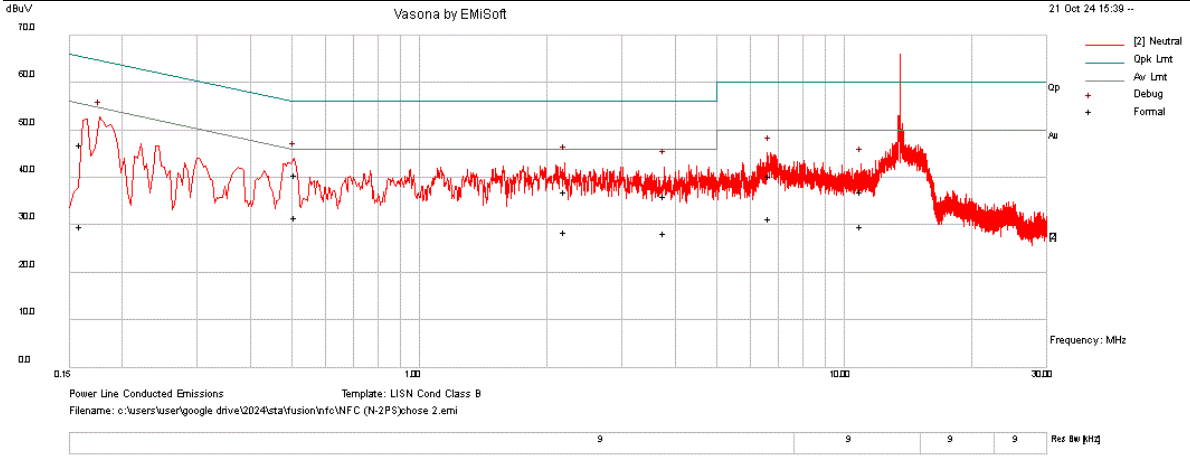


Frequency MHz	Raw dBuV	Cable Loss dB	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass/Fail
0.182	41.5	10.0	0.2	51.8	Quasi Peak	Live	64.4	-12.6	Pass
0.513	31.0	10.0	0.1	41.2	Quasi Peak	Live	56.0	-14.8	Pass
2.940	27.5	10.1	0.1	37.7	Quasi Peak	Live	56.0	-18.3	Pass
1.157	27.1	10.1	0.1	37.2	Quasi Peak	Live	56.0	-18.8	Pass
6.781	29.8	10.1	0.2	40.0	Quasi Peak	Live	60.0	-20.0	Pass
10.413	25.2	10.1	0.2	35.5	Quasi Peak	Live	60.0	-24.5	Pass
0.182	29.8	10.0	0.2	40.0	Average	Live	54.4	-14.3	Pass
0.513	21.5	10.0	0.1	31.7	Average	Live	46.0	-14.3	Pass
2.940	19.4	10.1	0.1	29.5	Average	Live	46.0	-16.5	Pass
1.157	18.7	10.1	0.1	28.9	Average	Live	46.0	-17.1	Pass
6.781	20.5	10.1	0.2	30.8	Average	Live	50.0	-19.2	Pass
10.413	18.5	10.1	0.2	28.8	Average	Live	50.0	-21.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + Factor (dB).
2. Margin = Level (dBuV) - Limit value(dBuV)
3. The 13.56MHz emission is NFC fundamental signal not subject to the limit requirement.

Test Standard:	LISN B Cond Class B	Mode:	Normal operation
Frequency Range:	0.15 - 30MHz	Test Date:	10/21/2024
Line:	Neutral	Test Engineer:	Minoush Niknam
Remark:	Type A – 106 Kbps	Test Result:	Pass



Frequency MHz	Raw dBuV	Cable Loss dB	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass/Fail
0.512	30.5	10.0	0.1	40.7	Quasi Peak	Neutral	56.0	-15.3	Pass
0.159	36.6	10.0	0.2	46.9	Quasi Peak	Neutral	65.5	-18.6	Pass
2.202	27.0	10.1	0.1	37.2	Quasi Peak	Neutral	56.0	-18.8	Pass
3.767	26.0	10.1	0.1	36.2	Quasi Peak	Neutral	56.0	-19.8	Pass
6.678	30.2	10.1	0.2	40.4	Quasi Peak	Neutral	60.0	-19.6	Pass
10.940	26.8	10.1	0.2	37.1	Quasi Peak	Neutral	60.0	-22.9	Pass
0.512	21.6	10.0	0.1	31.7	Average	Neutral	46.0	-14.3	Pass
0.159	19.6	10.0	0.2	29.8	Average	Neutral	55.5	-25.7	Pass
2.202	18.5	10.1	0.1	28.7	Average	Neutral	46.0	-17.3	Pass
3.767	18.2	10.1	0.1	28.4	Average	Neutral	46.0	-17.6	Pass
6.678	21.3	10.1	0.2	31.5	Average	Neutral	50.0	-18.5	Pass
10.940	19.4	10.1	0.2	29.8	Average	Neutral	50.0	-20.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + Factor (dB).
2. Margin = Level (dBuV) - Limit value(dBuV)
3. The 13.56MHz emission is NFC fundamental signal not subject to the limit requirement.

7.6 Frequency Stability

7.6.1 Requirement

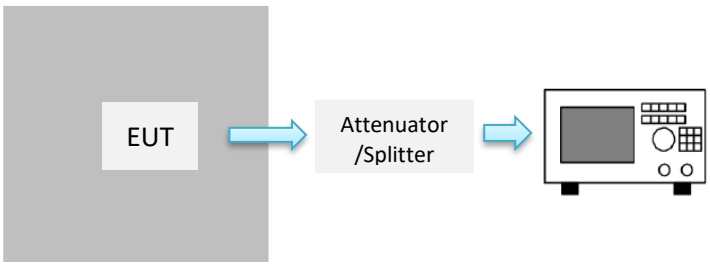
Per §15.225 Operation within the band 13.110–14.010 MHz:

(e) The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of −20 degrees to + 50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

Per RSS-210, B.6, Band 13.110-14.010 MHz

(b) the carrier frequency stability shall not exceed ±100 ppm

7.6.2 Test Setup



7.6.3 Test Procedure

According to section 6.8 of ANSI C63.10-2013

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

1. Set RBW = 1% to 5% of the actual occupied BW.
2. Set the video bandwidth (VBW) ≥ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Span = large enough to capture all products of the modulation process
7. Allow the trace to stabilize.
8. Use automatic bandwidth measurement capability on instrument to obtain BW result.

7.6.4 Test Result

Frequency Stability versus Temperature: The Frequency tolerance of the carrier signal shall be maintained within ± 0.01% of the operating frequency over a temperature variation of -20ºC to +50ºC at normal supply voltage.

Reference Frequency: 13.56MHz at 20°C at 7.2 VDC

Frequency Stability						
Temperature	Test Mode	Frequency (MHz)	Measured Freq.	Freq. Drift (%)	Freq. Deviation (Limit: 0.01%)	Result
50	NFC-CW	13.56	13.559616	-0.0028	<0.01	Pass
40	NFC-CW	13.56	13.559698	-0.0022	<0.01	Pass
30	NFC-CW	13.56	13.559652	-0.0026	<0.01	Pass
20	NFC-CW	13.56	13.559635	-0.0027	<0.01	Pass
10	NFC-CW	13.56	13.559576	-0.0031	<0.01	Pass
0	NFC-CW	13.56	13.559625	-0.0028	<0.01	Pass
-10	NFC-CW	13.56	13.559679	-0.0024	<0.01	Pass
-20	NFC-CW	13.56	13.559673	-0.0024	<0.01	Pass

Frequency Stability versus Input Voltage: The Frequency tolerance of the carrier signal shall be maintained within ± 0.01%, the frequency of the transmitter was measured at 85% and at 115% of the rated power supply voltage at a 20ºC environmental temperature.

Carrier Frequency: 13.56MHz at 20°C at 120VAC

Measured Voltage ±15% of nominal (V)	Measured Freq. (MHz)	Freq. Drift (%)	Freq. Deviation (Limit: 0.01%)	Pass/Fail
8.28 VDC	13.559652	-0.0026	<0.01	Pass
6.12 VDC	13.559652	-0.0026	<0.01	Pass
138 VAC	13.559652	-0.0026	<0.01	Pass
102 VAC	13.559652	-0.0026	<0.01	Pass

8 EUT and Test Setup Photos

See FCC exhibits

9 Test Instrument List

Equipment	Manufacturer	Model	Instrument Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	5/24/2024	5/24/2027
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A1)	N/A1)
Spectrum Analyzer	Keysight	N9020A	MY50110074	5/15/2024	5/15/2026
EMC Test Receiver	R&S	ESL6	100230	5/14/2024	5/14/2025
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	5/28/2024	5/28/2025
Bi-Log Antenna	ETS-Lindgren	3142E	217921	7/25/2024	7/25/2025
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	7/22/2024	7/22/2025
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	7/22/2024	7/22/2025
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/17/2024	5/17/2025
RF Attenuator	Pasternack	PE7005-3	VL061	07/29/2024	07/29/2025
EM Center Control	ETS-Lindgren	7006-001	160136	N/A1)	N/A1)
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A1)	N/A1)
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A1)	N/A1)
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	6/13/2024	6/13/2026
RE test cable (below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	07/29/2024	07/29/2025
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	07/29/2024	07/29/2025
RE test cable (>18GHz)	Sucoflex	104	344903/4	07/29/2024	07/29/2025
Pulse limiter	Com-Power	LIT-930A	531727	07/29/2024	07/29/2025
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	07/29/2024	07/29/2025
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	07/29/2024	07/29/2025
USB RF Power Sensor	ETS-Lindgren	7002-006	SN 00151268	5/14/2024	5/14/2026
Agilent Signal Generator	MXG N5182A	N5182A	US47080548	5/15/2024	5/15/2025
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL052	N/A1)	N/A1)
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL053	N/A1)	N/A1)
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL054	N/A1)	N/A1)
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL055	N/A1)	N/A1)
2.4GHz Notch Filter	Micro-Tronics	BRM50702	VL063	N/A1)	N/A1)
5GHz Notch Filter	Micro-Tronics	BRM50716	VL064	N/A1)	N/A1)

Note:

1) These pieces of equipment are not for measurement purposes and only require functional verification. Calibration is not required.

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