

FCC Test Report

Report No: WD-RF-R-230400-D0

Product Name : Reader
Model Name : DR20
FCC ID : 2AZ3JDR20
Applicant : Rhombus Systems, Inc.
Received Date : Nov. 17, 2023
Tested Date : Dec. 18, 2023 ~ Dec. 25, 2023
Applicable Standard : 47 CFR FCC Part 15, Subpart C (Section 15.31)
47 CFR FCC Part 2, Subpart J (Section 2.947(f))
ANSI C63.10 : 2013



Wendell Industrial Co., Ltd
Wendell EMC & RF Laboratory

Caution:

This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted.

The test results shown in the test report are traceable to the national/international standard through the calibration report of the equipment.

Please note that the measurement uncertainty are provided for informational purpose only and are not used in determining the Pass/Fail results.

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Test Report

Issued Date: December 25, 2023

Project No.: 23Q110607

Product Name	Reader
Trade Name	rhombus
Brand Trademark	 rhombus
Model Name	DR20
FCC ID	2AZ3JDR20
Applicant	Rhombus Systems, Inc.
Manufacturer	Rhombus Systems, Inc.
EUT Rated Voltage	DC 8V ~ 28V
EUT Test Voltage	DC 28V
EUT Supports Radios Application	Bluetooth BR/EDR/LE NFC 13.56M
Applicable Standard	47 CFR FCC Part 15, Subpart C (Section 15.31) 47 CFR FCC Part 2, Subpart J (Section 2.947(f)) ANSI C63.10 : 2013
Test Result	Complied

Documented :



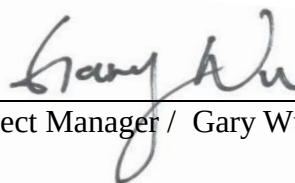
(Specialist / Emma Lu)

Technical Engineer :



(Section Manager / Jack Chang)

Approved :



(Project Manager / Gary Wu)

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Document Revision History

Report No.	Issue date	Description
WD-RF-R-230280-D0	September 14, 2023	Initial report
WD-RF-R-230400-D0	December 25, 2023	This is to request a Class II permissive change for FCC ID: 2AZ3JDR20, originally granted on 10/26/2023. The modification is concerned with following: 1. Adding new PCB board, change non-RF related layout. 2. The power layouts are moved to the shielding case, away from the antenna. 3. Replace component for L3. 4. Back cover adding heat sink. Therefore only radiated emission below 1G has been evaluated for this C2PC. Adding internal photographs for new PCB.

Summary of Test Result

Ref. Std. Clause	Test Items	Result
15.247(d)	Radiated Spurious Emission	Pass
15.207	AC Conducted Emission	Pass

1 Generation Information

1.1 Applicant

Rhombus Systems, Inc.
1920 20th St, Sacramento, CA 95811

1.2 Manufacturer

Rhombus Systems, Inc.
1920 20th St, Sacramento, CA 95811

1.3 Description of Equipment under Test

Product Name	Reader
Model No.	DR20
FCC ID	2AZ3JDR20
Frequency Range	Bluetooth: 2402~2480MHz NFC: 13.56 MHz
Type of Modulation	Bluetooth: GFSK(1Mbps) / $\pi/4$ DQPSK(2Mbps) / 8DPSK(3Mbps) NFC: ASK
Antenna Information	Refer to the table “Antenna List”
EUT Supports Radios Application	Bluetooth BR/EDR/LE NFC 13.56M
EUT Rated Voltage	DC 8V ~ 28V
EUT Test Voltage	DC 28V

Antenna List

No.	Manufacturer	Model No.	Antenna Type	Peak Gain
1	INPAQ Technology Co	RFFPA332305IMAB304	FPCB Antenna	1.97 dBi for 2.4GHz
2	INPAQ Technology Co	RFNFC363005IMFB301	PCB Antenna	N/A

1.4 Test Mode Applicability

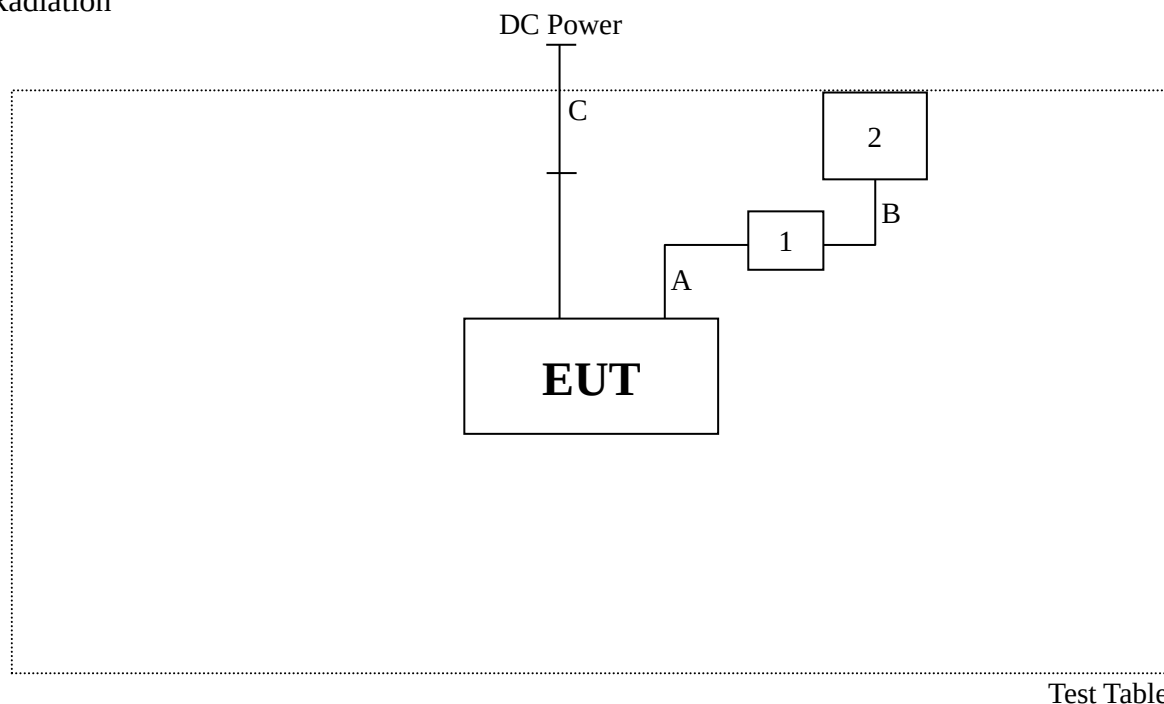
1. These tests were performed on equipment samples to demonstrate compliance with the 15.31(k) chapter simultaneous launch requirements.
2. Select the combination of the highest power transmission mode, only the worst case is shown in the report.
3. The worst case was found when positioned on X axis for radiated emission. Following test modes were selected for the final test, and the final worst case is marked in boldface and recorded in the report.

Test Mode

Mode 1: Bluetooth LE + BT + NFC 13.56MHz
--

1.5 Configuration of Tested System

Radiation



1.6 EUT Exercise Software

1. Setup the EUT as shown in Section 1.6
2. Configure the test mode, the test channel, and the data rate.
3. Press “OK” to start the continuous transmit.
4. Verify that the EUT works properly.

1.7 Tested System Details

The types for all equipment, plus descriptions of all cables used in the tested system (including inserted cards) are:

No.	Product	Manufacturer	Model No.	Serial No.	Power Cord
1	Fixture	Dynacolor	DR test BD	N/A	N/A
2	Notebook PC	acer	N16Q1	NXVF4TA023742254147600	N/A

No.	Signal Cable Type	Signal cable Description
A	Data Cable	Non-shielded, Non-Core, 0.17m
B	USB Cable	Shielded, 1Core, 1.85m
C	DC Power Cable	Non-shielded, Non-Core, 2.5m

1.8 Test Facility

Items	Required (IEC 60068-1)
Temperature (°C)	15-35
Humidity (% RH)	25-75
Barometric pressure (mbar)	860-1060

Description: Accredited by TAF
Accredited Number: 2965

Issued by: Wendell Industrial Co., Ltd

Lab Address: 6F/6F-1, No.188, Baoqiao Rd., Xindian Dist.,
New Taipei City 23145, Taiwan R.O.C

Test Lab: Wendell EMC & RF Laboratory

Test Location: No.67-9, Shimen Rd., Tucheng Dist.,
New Taipei City 236, Taiwan R.O.C

Designation Number: TW0025

Test Firm Registration Number: 665221

1.9 Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence (level based on a coverage factor K=2)

Measurement Project	Condition	Expended Uncertainty
AC Conducted Emission	0.150 ~ 30 MHz	± 2.64 dB
Radiated Emission	0.009 ~ 30 MHz	± 3.7 dB
	30 ~ 1000 MHz	± 3.9 dB
	1000 ~ 18000 MHz	± 4.5 dB
	18000 ~ 40000 MHz	± 4.3 dB
RF Power, Conducted	Conducted Measuring	± 0.75 dB
Occupied Bandwidth	Conducted Measuring	± 2.4 %
Power Density	Conducted Measuring	± 1.2 dB
Duty Cycle and Dwell Time	Conducted Measuring	± 0.9 %
Conducted Unwanted Emission Strength	Conducted Measuring	± 1.4 dB
DC Power Supply	--	± 0.062 ppm
Temperature	--	± 2.0 %
Humidity	--	± 0.55 °C

Note: Please note that the measurement uncertainty are provided for informational purpose only and are not used in determining the Pass/Fail results.

1.10 List of Test Equipment

For AC Conduction measurements / Conducted Room

Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Due Date
EMI Test Receiver	R&S	ESR3	102309	2023/06/19	2024/06/18
2-Line V-Network LISN	R&S	ENV216	101185	2023/06/16	2024/06/15
LISN	SCHWARZBECK	NSLK 8127RC	05028	2023/06/16	2024/06/15
Transient Limiter	EM Electronics Corporation	EM-7600	857	2023/06/17	2024/06/16
50ohm Cable	EMCI	EMCCFD300-BM-BM-5000	170612	2023/06/17	2024/06/16
50 ohm terminal impedance	HUBER+SUHNER	50 ohm terminal impedance	CT-1-109-1	2023/06/16	2024/06/15

Remark:

1. All equipments are calibrated every one year.
2. The test instruments marked with “✓” are used to measure the final test results.
3. Test Software version: FARAD EZ-EMC Ver.EMC-CON 3A1

For Radiated measurements / 9x6x6 Semi Anechoic Room

	Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Due Date
✓	EMI Receiver	Keysight	N9038A	MY51210173	2023/08/18	2024/08/17
✓	Spectrum Analyzer	Keysight	N9010A	MY52220228	2023/08/18	2024/08/17
✓	Active Loop Antenna	Schwarzbeck	FMZB 1513-60B	00033	2023/05/08	2024/05/07
✓	TRILOG super broad Antenna	Schwarzbeck	VULB 9168	VULB 9168-700 & 20E03	2023/07/31	2024/07/30
✓	Horn Antenna	Schwarzbeck	BBHA 9120D	01767	2023/08/17	2024/08/16
✓	Horn Antenna	Schwarzbeck	BBHA 9170	703	2023/08/21	2024/08/20
✓	Pre-Amplifier	EMEC	EMC330	060774	2023/08/22	2024/08/21
✓	Pre-Amplifier	EMEC	EM01G18G	060648	2023/08/22	2024/08/21
✓	Pre-Amplifier	JPT	JPA0118-55-303K	1910001800055003	2023/08/22	2024/08/21
✓	Pre-Amplifier	EMCI	EMC184045SE	980515	2023/08/22	2024/08/21
✓	Cable	EMEC	EM-CB400	105060103	2023/08/22	2024/08/21
✓	Cable	EMEC	EM-CB400	105060102	2023/08/22	2024/08/21
✓	Cable	EMEC	EM-CB400	105060101	2023/08/22	2024/08/21
✓	RF Cable	HUBER+SUHNER	SF102	MY2752/2	2023/08/22	2024/08/21
✓	RF Cable	MVE	280280.LL266.1200	B60028C	2023/08/22	2024/08/21
✓	RF Cable	EMCI	EMC102-KM-KM-600	190646	2023/08/22	2024/08/21
✓	RF Cable	MVE	140140.LL404.700	B90014C	2023/08/22	2024/08/21
✓	RF Cable	MVE	140140.LL404.300	B90006C	2023/08/22	2024/08/21
✓	RF Filter	EMEC	BRF-2400-2500	002	2022/08/17	2024/08/16
✓	RF Filter	EMEC	BRF-5150-5350	104	2022/08/17	2024/08/16
✓	RF Filter	EMEC	BRF-5470-5725	092	2022/08/17	2024/08/16
✓	RF Filter	EMEC	BRF-5725-5875	091	2022/08/17	2024/08/16
✓	RF Filter	EMEC	HPF-2800	002	2022/08/17	2024/08/16
✓	RF Filter	EMEC	HPF-5850	059	2022/08/17	2024/08/16
	SMA Notch Filter	MVE	MFN-902.928.S1	190604001	2022/08/17	2024/08/16

Remark:

1. The equipments are calibrated every one year.
2. The Filter calibrated every two year.
3. The test instruments marked with “✓” are used to measure the final test results.
4. Test Software version: FARAD EZ-EMC Ver.WD-03A1-1

2 Test Result

2.1 Spurious Emission Measurement

2.1.1 Limit

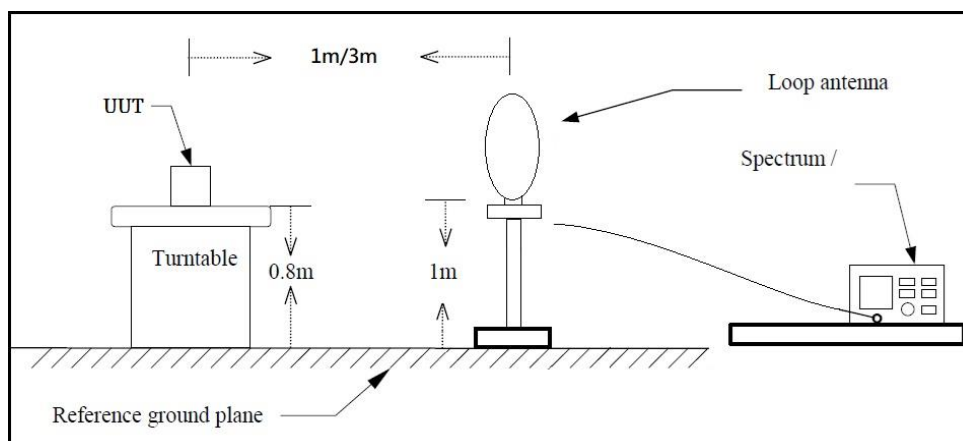
Frequency (MHz)	Field Strength ($\mu\text{V/m}$)	Measurement Distance (m)
0.009 – 0.490	$2400/F(\text{kHz})$	300
0.490 – 1.705	$24000/F(\text{kHz})$	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

Remarks:

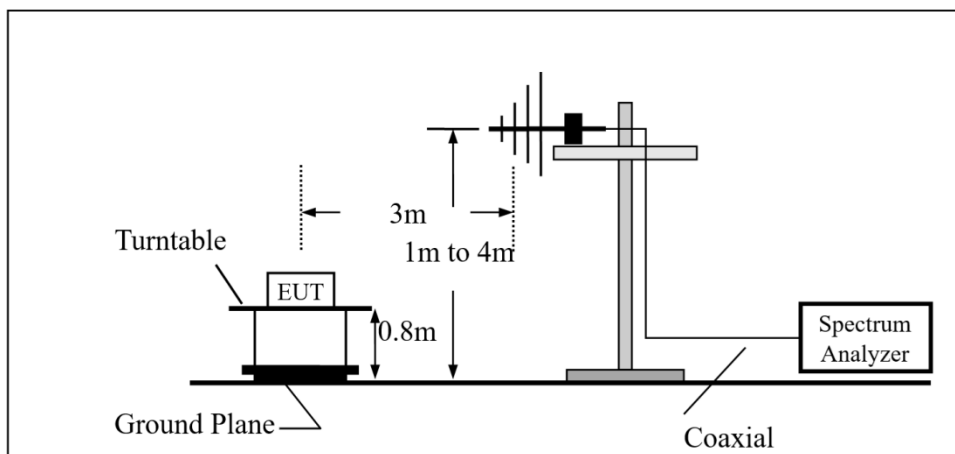
1. RF Voltage (dBuV) = $20 \log \text{RF Voltage}(\mu\text{V})$
2. In the Above Table, the tighter limit applies at the band edges.
3. Distance refers to the distance in meters between the measuring instrument antenna and the closed point of any part of the device or system

2.1.2 Test Setup

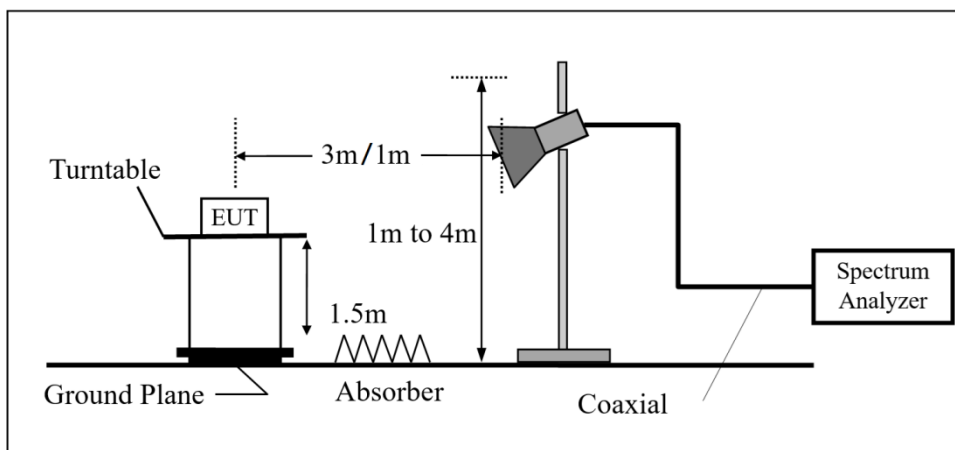
Below 30MHz



30MHz~1GHz



Above 1GHz



2.1.3 Test Procedure

The EUT was setup according to ANSI C63.10, 2013 and tested according test procedure of KDB 558074 for compliance to FCC 47CFR 15.247 requirements.

For Radiated emission below 30MHz

- (1) The EUT was placed on the top of a rotating table 0.8 meters above the ground in a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
- (2) The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- (3) Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- (4) For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- (5) The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

For Radiated emission Above 30MHz

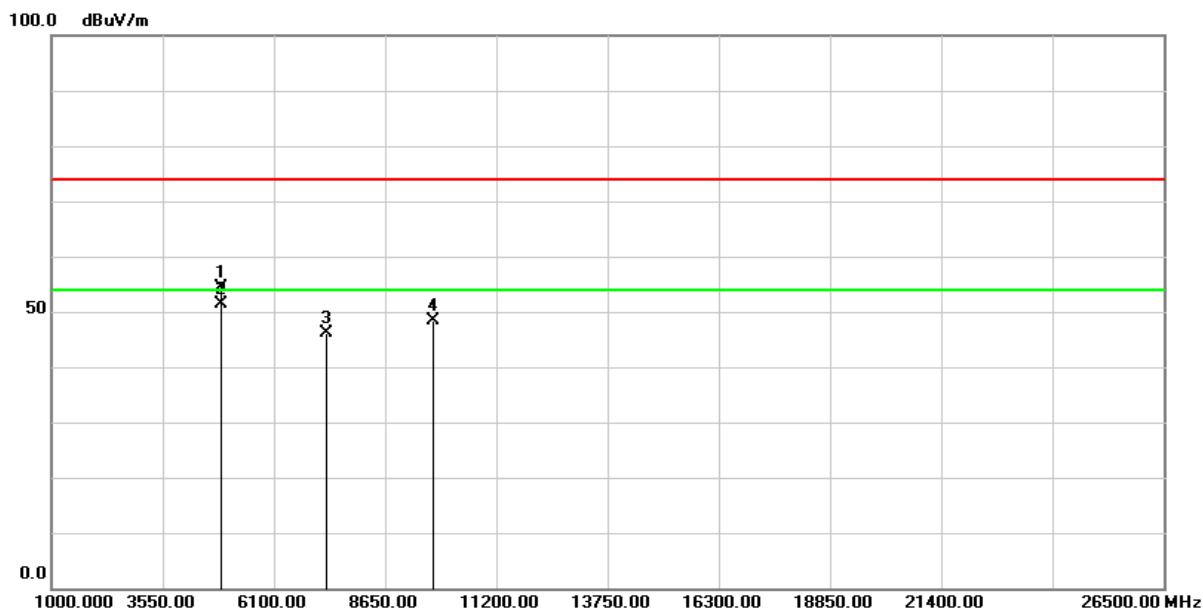
- (1) The EUT was placed on the top of a rotating table 0.8 meters (for below 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for the test. The table was rotated 360 degrees to determine the position of the highest radiation.
- (2) The EUT was set 3 meters away from the interference-receiving antenna, the height of the antenna is varied from 1 meter to 4 meters above the ground to determine the maximum value of the field strength.
- (3) Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
- (4) For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- (5) The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.
- (6) The test-receiver system was set to peak and average detect function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets the average limit, measurement with the average detector is unnecessary.

2.1.4 Test Result of Radiated Spurious Emission Measurement

- (1) The radiation measurement frequency is 9kHz ~ 30MHz. The interference value of this frequency range is less than the limit value of 20 dB. It is considered that the background noise value is not recorded.
- (2) The following table shows the radiation measurement frequency from 30MHz to 26.5G/40GHz, pre-scanning in the X, Y and Z axes. The worst case (X-axis) is documented in this report.

Above 1GHz Data

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/08/31
Test Voltage :	AC 120V/60Hz	Temperature :	24.1 °C
Polarization :	Horizontal	Relative Humidity :	54.2 %



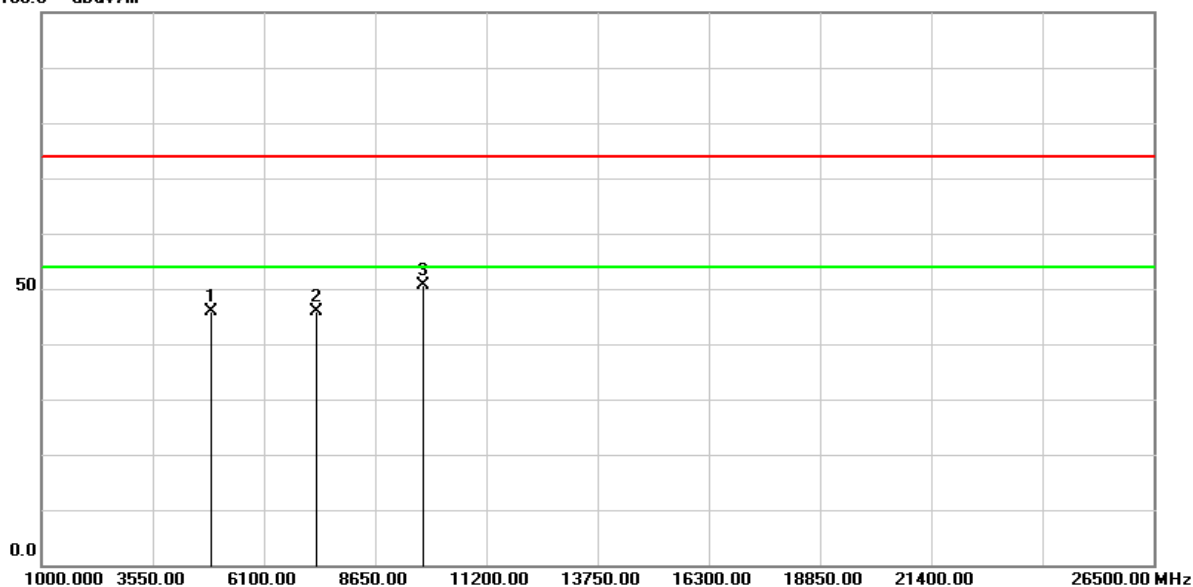
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	4882.000	73.44	-19.01	54.43	74.00	-19.57	peak
2	4882.000	70.35	-19.01	51.34	54.00	-2.66	AVG
3	7323.000	58.71	-12.49	46.22	74.00	-27.78	peak
4	9764.000	57.10	-8.73	48.37	74.00	-25.63	peak

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/08/31
Test Voltage :	AC 120V/60Hz	Temperature :	24.1 °C
Polarization :	Vertical	Relative Humidity :	54.2 %

100.0 dBuV/m



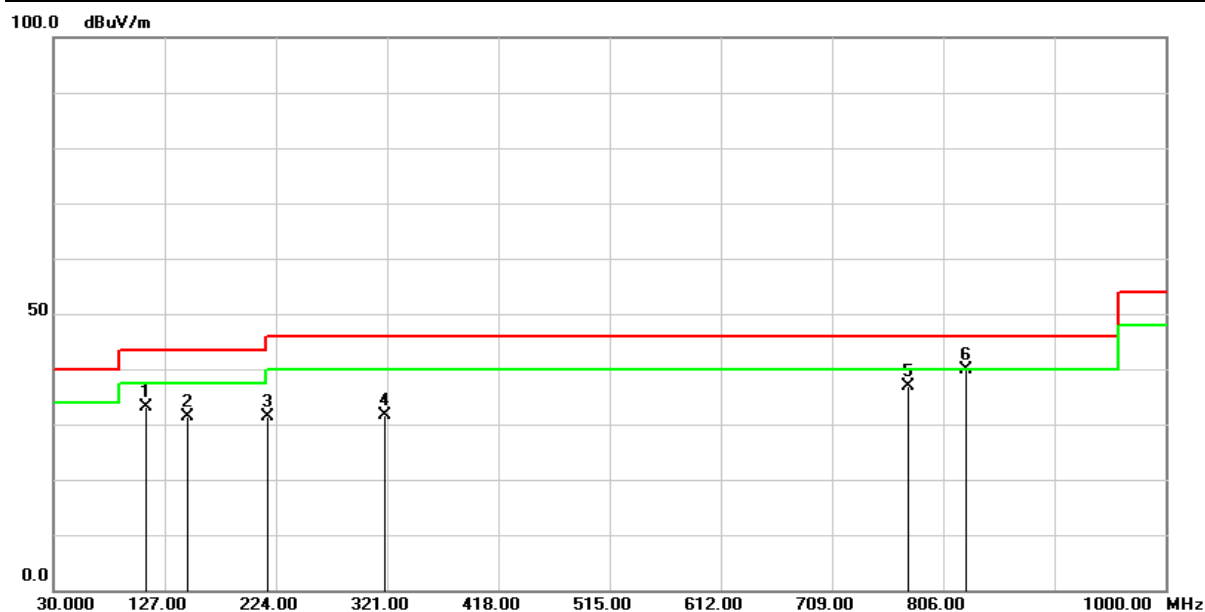
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	4882.000	64.87	-19.01	45.86	74.00	-28.14	peak
2	7323.000	58.37	-12.49	45.88	74.00	-28.12	peak
3	9764.000	59.24	-8.73	50.51	74.00	-23.49	peak

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

Below 1GHz Data (Original PCB)

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/08/30
Test Voltage :	AC 120V/60Hz	Temperature :	24.1 °C
Polarization :	Horizontal	Relative Humidity :	54.2 %

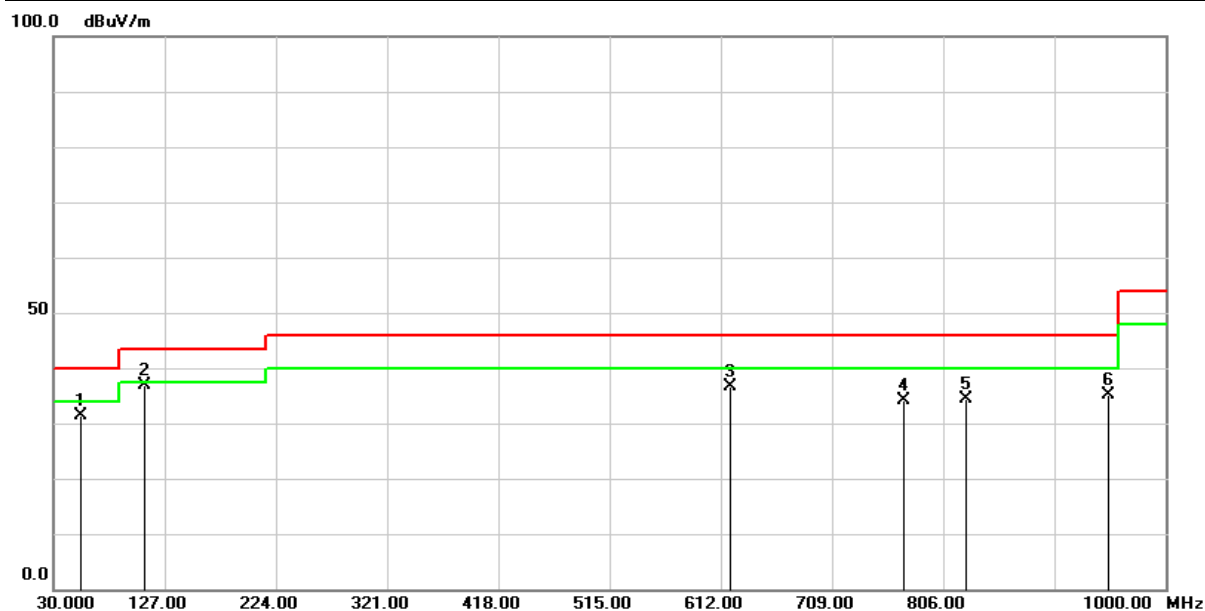


No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	110.5100	47.38	-14.21	33.17	43.50	-10.33	QP
2	147.3700	42.66	-11.20	31.46	43.50	-12.04	QP
3	216.2400	45.84	-14.49	31.35	46.00	-14.65	QP
4	319.0600	41.08	-9.56	31.52	46.00	-14.48	QP
5	774.9600	35.32	1.52	36.84	46.00	-9.16	QP
6	826.3700	37.78	2.08	39.86	46.00	-6.14	QP

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/08/30
Test Voltage :	AC 120V/60Hz	Temperature :	24.1 °C
Polarization :	Vertical	Relative Humidity :	54.2 %



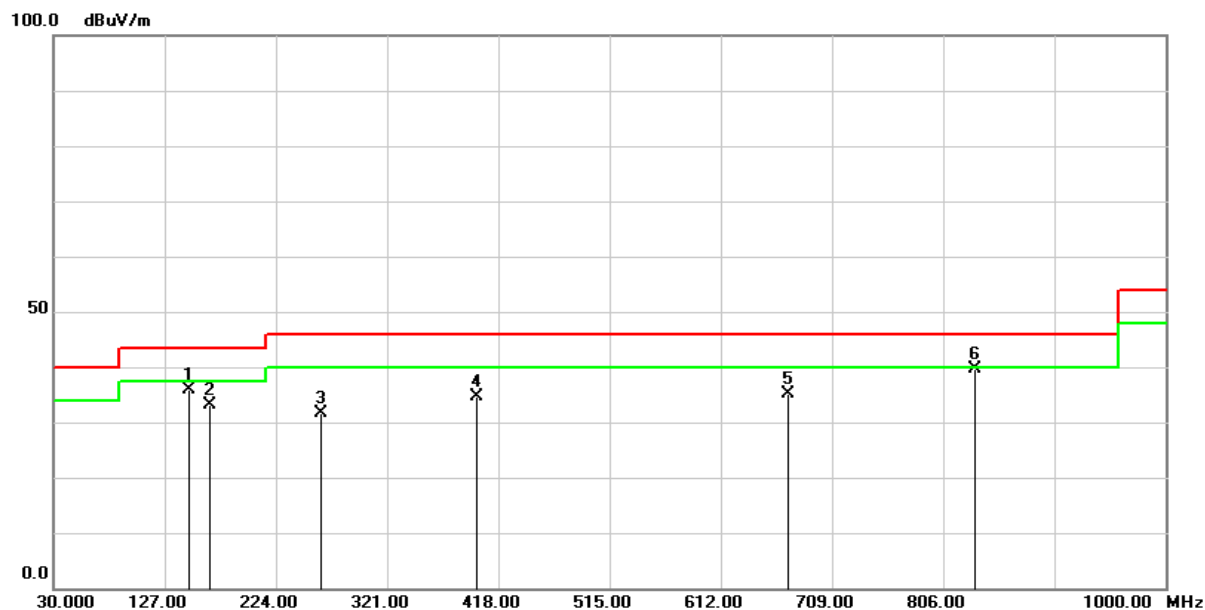
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	53.7950	41.91	-10.46	31.45	40.00	-8.55	QP
2	109.5400	51.13	-14.21	36.92	43.50	-6.58	QP
3	619.7600	38.29	-1.62	36.67	46.00	-9.33	QP
4	771.0800	32.82	1.42	34.24	46.00	-11.76	QP
5	825.4000	32.24	2.08	34.32	46.00	-11.68	QP
6	950.5300	30.44	4.69	35.13	46.00	-10.87	QP

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

Below 1GHz Data (New PCB)

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/12/23
Test Voltage :	AC 120V/60Hz	Temperature :	22.1 °C
Polarization :	Horizontal	Relative Humidity :	42.7 %



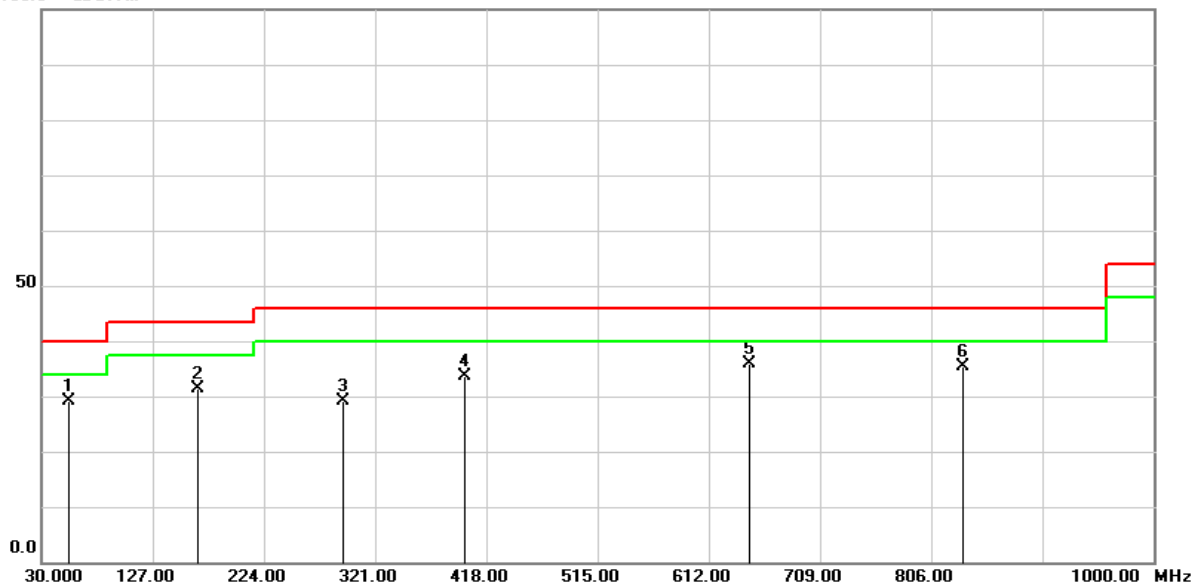
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	148.3400	47.16	-11.19	35.97	43.50	-7.53	QP
2	166.7700	44.30	-11.27	33.03	43.50	-10.47	QP
3	263.7700	43.15	-11.49	31.66	46.00	-14.34	QP
4	399.5700	41.87	-7.25	34.62	46.00	-11.38	QP
5	670.2000	36.14	-0.94	35.20	46.00	-10.80	QP
6	834.1300	37.49	2.22	39.71	46.00	-6.29	QP

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

Test Mode :	Mode 1: Bluetooth LE + BT + NFC 13.56MHz	Test Date :	2023/12/23
Test Voltage :	AC 120V/60Hz	Temperature :	22.1 °C
Polarization :	Vertical	Relative Humidity :	42.7 %

100.0 dBuV/m



No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	53.2800	39.60	-10.46	29.14	40.00	-10.86	QP
2	165.8000	42.60	-11.19	31.41	43.50	-12.09	QP
3	292.8700	39.49	-10.39	29.10	46.00	-16.90	QP
4	399.5700	41.00	-7.25	33.75	46.00	-12.25	QP
5	647.8900	37.02	-1.20	35.82	46.00	-10.18	QP
6	833.1600	33.31	2.19	35.50	46.00	-10.50	QP

Remark :

1. Correction Factor = Antenna factor + Cable loss – Amplifier gain
2. Result Value = Reading Level + Correct Factor
3. Margin Level = Result Value – Limit Value
4. The other emission levels were very low against the limit

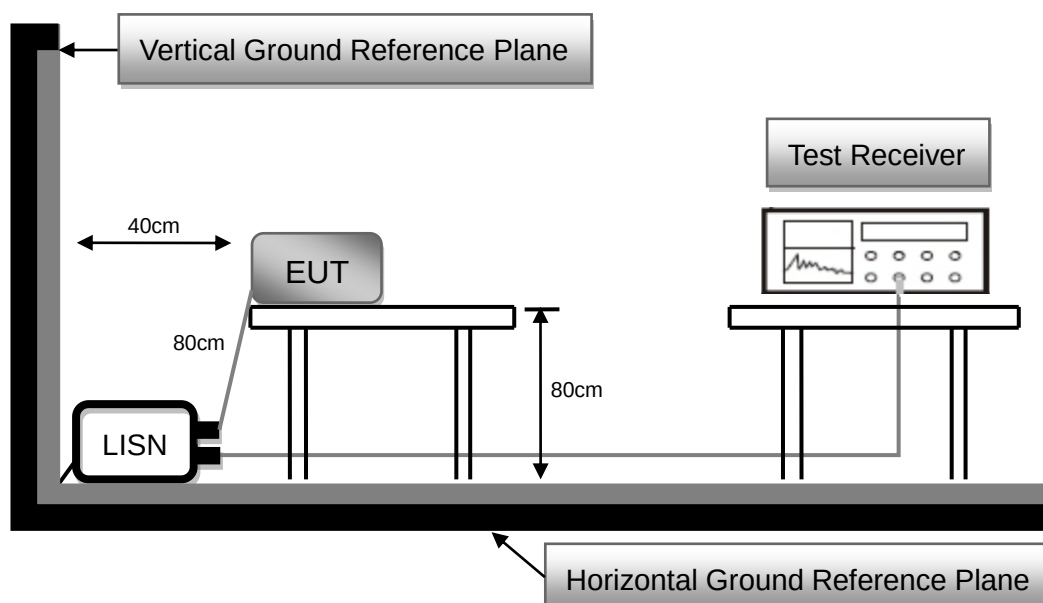
2.2 AC Conducted Emissions Measurement

2.2.1 Limit

Frequency (MHz)	FCC Part 15 Subpart C Paragraph 15.207 (dBμV) Limit	
	Quasi-peak	Average
0.15 to 0.5	66 to 56*	56 to 46*
0.50 to 5.0	56	46
5.0 to 30.0	60	50

*Decreases with the logarithm of the frequency

2.2.2 Test Setup



2.2.3 Test Procedure

1. The EUT was placed 0.8 meter height wooden table from the horizontal ground plane with EUT being connected to power source through a line impedance stabilization network (LISN). The LISN at least be 80 cm from nearest chassis of EUT.
2. The line impedance stabilization network (LISN) provides 50 ohm/50uH of coupling impedance for the measuring instrument. All other support equipments powered from additional LISN(s).
3. Interrelating cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle. All I/O cables were positioned to simulate typical usage.
4. All I/O cables that are not connected to a peripheral shall be bundle in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m.
5. The EMI test receiver connected to LISN powering the EUT. The actual test configuration, please refer to EUT test photos.
6. The receiver scanned from 150kHz to 30MHz for emissions in each of test modes. Conducted emissions were invested over the frequency range from 0.15MHz to 30MHz using a receiver bandwidth of 9kHz. A scan was taken on both power lines, Line and Neutral, recording at least six highest emissions.
7. The EUT and cable configuration of the above highest emission levels were recorded. The test data of the worst case was recorded.

2.2.4 Test Result

Owing to the DC operation of EUT, this test item is not performed.

--- END ---