

TEST REPORT



Applicant	Ludus Materials Ltd.
Address	Givat brenner, Israel

Manufacturer or Supplier	Qing Yuan Right Source Plastic Company Limited
Address	ZhangWu Village, Yinghua St, Donghua Town, Yingde City, GuangDong Province, PR China, Postal Code 513059
Product	Ludus Paddle
Brand Name	Ludus
Model	LMP01
Additional Model & Model Difference	N/A
Date of tests	Oct. 09, 2024 ~ Oct. 23, 2024

the tests have been carried out according to the requirements of the following standards:

☒ **FCC Part 15, Subpart C, Section 15.225**

CONCLUSION: The submitted sample was found to COMPLY with the test requirement

Prepared by Eric Fang Project Engineer / EMC Department	Approved by Glyn He Assistant Manager / EMC Department
	
	Date: Nov. 28, 2024

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Test Report No.: RF2409WDG0225-2

RELEASE CONTROL RECORD

ISSUE NO.	REASON FOR CHANGE	DATE ISSUED
RF2409WDG0225-2	Original release	Nov. 28, 2024

1 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

APPLIED STANDARD: FCC Part 15, Subpart C			
STANDARD SECTION	TEST TYPE AND LIMIT	RESULT	REMARK
15.207	AC Power Conducted Emission	N/A	Powered from battery
15.225 (a)&(b)&(c)	The field strength of any emissions within the band	PASS	Meet the requirement of limit.
15.225 (d)	The field strength of any emissions appearing outside of the 13.110-14.010 MHz band	PASS	Meet the requirement of limit.
15.225 (e)	Frequency tolerance	PASS	Meet the requirement of limit.
15.215 (c)	20dB Bandwidth	PASS	Meet the requirement of limit.
15.203	Antenna Requirement	PASS	No antenna connector is used.

2 MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

MEASUREMENT	FREQUENCY	UNCERTAINTY
Radiated emissions	9KHz ~ 30MHz	2.80dB
	30MHz ~ 1GMHz	4.65dB

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

3 GENERAL INFORMATION

3.1 GENERAL DESCRIPTION OF EUT

PRODUCT	Ludus Paddle
MODEL NO.	LMP01
ADDITIONAL MODELS	N/A
FCC ID	2BLAR-LMP01
POWER SUPPLY	DC 3.7V from Battery or DC 5V from USB Host Unit
MODULATION TECHNOLOGY	NFC
MODULATION TYPE	ASK
OPERATING FREQUENCY	13.56MHz
NUMBER OF CHANNEL	1
ANTENNA TYPE	PCB antenna
I/O PORTS	Refer to user's manual
CABLE SUPPLIED	See note 5

NOTE:

1. For a more detailed features description, please refer to the manufacturer's specifications or the user's manual.
2. For the test results, the EUT had been tested with all conditions. But only the worst case was shown in test report.
3. Please refer to the EUT photo document (Reference No.: 2409WDG0225) for detailed product photo.
4. When the EUT in charging mode that RF function can't working.
5. Product cable information as follows:

ID	Descriptions	Qty.	Length (m)	Shielding (Y/N)	Cores (Qty.)	Remark
1	USB-A to Microusb cable	1	0.5	N	0	N/A

3.2 DESCRIPTION OF TEST MODES

The EUT only have one channel.

CHANNEL	FREQUENCY (MHz)
1	13.56

3.2.1. CONFIGURATION OF SYSTEM UNDER TEST

Please see section 5 photograph of the test configuration for reference.

3.2.2. TEST MODE APPLICABILITY AND TESTED CHANNEL DETAIL

Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates, XYZ axis and antenna ports. The worst case was found when positioned on X axis for radiated emission. Following channel(s) was (were) selected for the final test as listed below:

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE	FT	PLC	BW	
A	√	√	-	√	Powered by Fully Battery

Where **RE**: Radiated Emission

PLC: Power Line Conducted Emission

FT: Frequency tolerance

BW: 20dB Bandwidth

RADIATED EMISSION TEST:

- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, XYZ axis, antenna ports (if EUT with antenna diversity architecture) and packet type.
- ☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	TESTED CHANNEL	TESTED FREQUENCY (MHZ)	MODULATION TYPE	AXIS
A	1	13.56	ASK	X

FREQUENCY TOLERANCE:

- ☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, antenna ports (if EUT with antenna diversity architecture), and packet types.
- ☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	TESTED CHANNEL	TESTED FREQUENCY (MHZ)	MODULATION TYPE	AXIS
A	1	13.56	ASK	X

20dB BANDWIDTH:

- ☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
- ☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, antenna ports (if EUT with antenna diversity architecture), and packet types.
- ☒ Following channel(s) was (were) selected for the final test as listed below.

EUT CONFIGURE MODE	TESTED CHANNEL	TESTED FREQUENCY (MHZ)	MODULATION TYPE	AXIS
A	1	13.56	ASK	X

TEST CONDITION:

APPLICABLE TO	ENVIRONMENTAL CONDITIONS	TEST VOLTAGE (SYSTEM)	TESTED BY
RE	21deg. C, 63%RH	DC5V from Host Unit	Roy
FT	25deg. C, 60%RH	DC5V from Host Unit	Vincent
PLC	-	-	-
BW	25deg. C, 60%RH	DC5V from Host Unit	Vincent

3.3 GENERAL DESCRIPTION OF APPLIED STANDARDS

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C. Section 15.225

ANSI C63.10-2013

All test items have been performed and recorded as per the above standards.

3.4 DESCRIPTION OF SUPPORT UNITS

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

NO.	PRODUCT	BRAND	MODEL NO.	SERIAL NO.	FCC ID
1	DC Power Source	APC	ADL-50V-30A	D31907J058	N/A

NO.	SIGNAL CABLE DESCRIPTION OF THE ABOVE SUPPORT UNITS
1	AC Line: unshielded, detachable 1.4m

4 TEST TYPES AND RESULTS

4.1. RADIATED EMISSION AND BANDEDGE MEASUREMENT

4.1.1 LIMITS OF RADIATED EMISSION AND BANDEDGE MEASUREMENT

The field strength of any emissions shall not exceed the following limits:

- (a) 15.848mV/m(84dBuV/m) at 30m, within the band 13.553-13.567 MHz;
- (b) 334uV/m(50.5dBuV/m) at 30m, within the band 13.410-13.553 MHz and 13.567-13.710MHz;
- (c) 106uV/m(40.5dBuV/m) at 30m, within the band 13.110-13.410 MHz and 13.710-14.010MHz;

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.

FREQUENCIES (MHz)	FIELD STRENGTH (microvolts/meter)	MEASUREMENT DISTANCE (meters)
0.009 ~ 0.490	2400/F(kHz)	300
0.490 ~ 1.705	24000/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

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.
4. The measured field strength was extrapolated to distance 30 meters, using the formula that the limit of field strength varies as the inverse distance square (40dB per decade of distance)

Example:

$$\begin{aligned}
 13.56\text{MHz} &= 15848\text{uV/m} & 30\text{m} \\
 &= 84\text{dBuV/m} & 30\text{m} \\
 &= 84+20\log(30/3)^2 & 3\text{m} \\
 &= 124\text{dBuV/m}
 \end{aligned}$$

4.1.2 TEST INSTRUMENTS

9KHz~30MHz

Equipment	Manufacturer	Model No.	Serial No.	Next Cal.
EMI Test Receiver	Rohde&Schwarz	ESR7	101564	Jan. 02, 25
Active Loop Antenna	SCHWARZBECK	FMZB 1519B	1519B-045	Apr. 13, 25
Amplifier	Burgeon	BPA-530	100210	Feb. 21 25
Coaxial RF Cable	/	/	/	Jun. 27, 25
Test Software	ADT	ADT_Radiated_V8.7.07	N/A	N/A

NOTE: 1. Equipment are calibrated by calibration laboratory accredited to ISO/IEC 17025 by a mutually recognized Accreditation and all tests are conducted within a valid calibration cycle.

2. The test was performed in 10m Chamber

3. The FCC Site Registration No. is 749762.

30MHz~1GHz

Equipment	Manufacturer	Model No.	Serial No.	Next Cal.
EMI Test Receiver	Rohde&Schwarz	ESU40	100449	Jan. 02, 25
Trilog-Broadband Antenna	SCHWARZBECK	VULB 9168	9168-554	Dec. 25, 25
Pre-Amplifier	Burgeon	BPA-530	100220	Feb. 21, 25
3m Semi-anechoic Chamber	Burgeon	9m*6m*6m	NSEMC003	May. 20, 25
Coaxial RF Cable(3m Below 1G)	/	/	/	Jun. 23, 25
Test software	ADT	ADT_Radiated_V 7.6.15.9.2	N/A	N/A

NOTE:

1. The test was performed in 966 Chamber (a 3m Semi-anechoic chamber).
2. Equipment are calibrated by calibration laboratory accredited to ISO/IEC 17025 by a mutually recognized Accreditation and all tests are conducted within a valid calibration cycle.
3. The horn antenna is used only for the measurement of emission frequency above 1GHz if tested.
4. The FCC Site Registration No. is 749762.

4.1.3 TEST PROCEDURES

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3&10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. 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.
- f. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, For battery operated equipment, the equipment tests shall be perform using fresh batteries. The turntable was rotated to maximize the emission level.
- g. For below 30MHz, a loop antenna with its vertical plane is place 3m from the EUT and rotated about its vertical axis for maximum response at each azimuth about the EUT. And the centre of the loop shall be 1.3m above the ground.

NOTE:

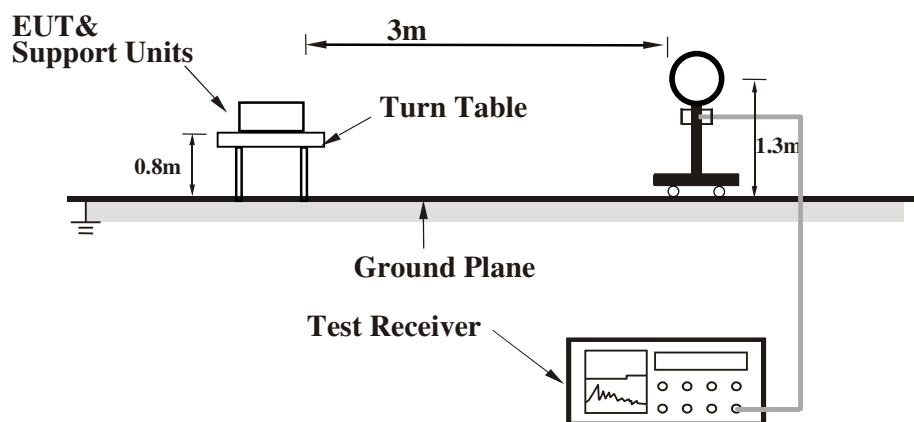
1. The resolution bandwidth of test receiver/spectrum analyzer is 100kHz for peak detection (PK) at fundamental frequency below 1GHz; The resolution bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at radiated spurious emission frequency below 1GHz.
2. $\text{Emission level(dBuV/m)} = \text{Raw Value(dBuV)} + \text{Correction Factor(dB/m)}$
3. $\text{Correction Factor(dB/m)} = \text{Antenna Factor (dB/m)} + \text{Cable Factor (dB)}$
4. $\text{Margin value} = \text{Emission level} - \text{Limit value}$.

4.1.4 DEVIATION FROM TEST STANDARD

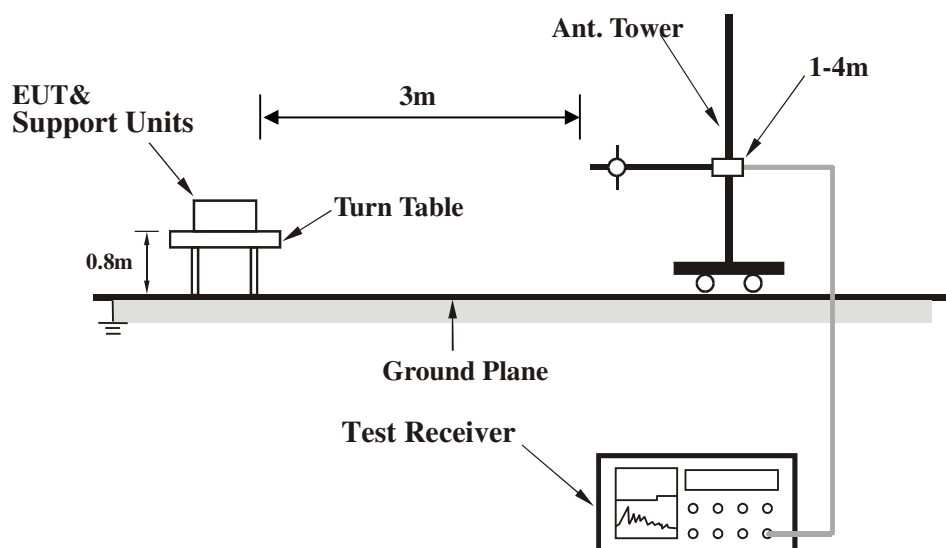
No deviation.

4.1.5 TEST SETUP

Below 30MHz test setup



Below 1GHz test setup



Note: For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.1.6 EUT OPERATING CONDITIONS

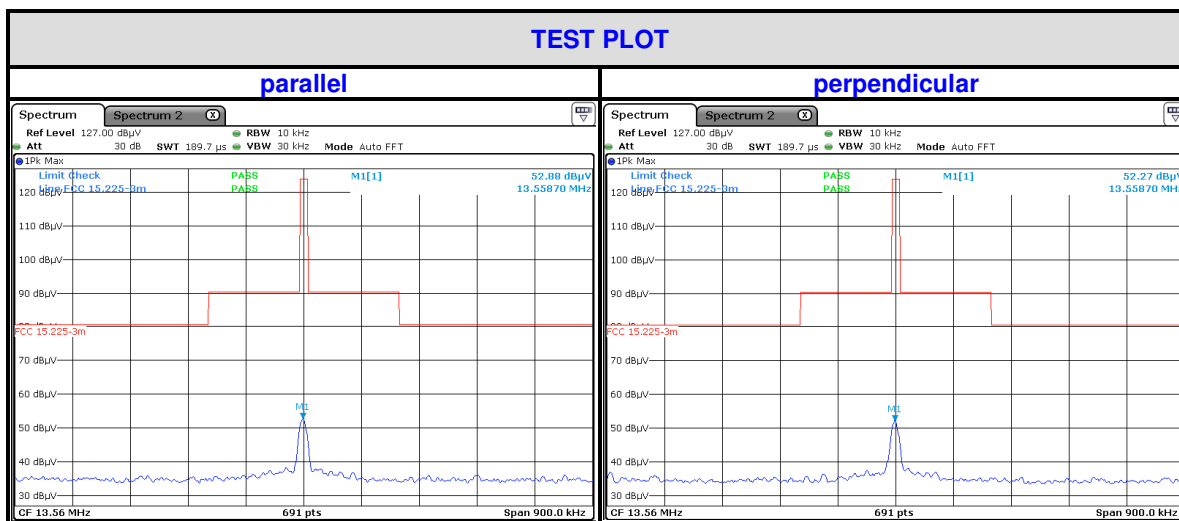
Set the EUT under transmission condition continuously at specific channel frequency.

4.1.7 TEST RESULTS

FIELD STRENGTH (BELOW 30MHZ AT 3M)

No.	Freq. (MHz)	Correction Factor (dB/m)	Raw Value (dBuV)	Emission Level (dBuV/m)	Polarity	Limit (dBuV/m)	Margin (dB)
1	*13.56(QP)	-10.71	63.59	52.88	parallel	124.0	-71.12
2	*13.56(QP)	-10.71	62.98	52.27	perpendicular	124.0	-71.73

- REMARKS:**
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB/m).
 2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB).
 3. The other emission levels were very low against the limit.
 4. Margin value = Emission level – Limit value.
 5. " * ": Fundamental frequency.
 6. All three antenna orientations(parallel, perpendicular, and ground-parallel) testing. But the worst orientation showed in report only.



BELOW 1GHz WORST-CASE DATA:

CHANNEL	Channel 1	DETECTOR FUNCTION	Quasi-Peak (QP)
FREQUENCY RANGE	9KHz ~ 1GHz		

ANTENNA POLARITY & TEST DISTANCE: HORIZONTAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	31.55	16.06 QP	40.00	-23.94	1.90 H	26	35.23	-19.17
2	174.57	14.71 QP	43.50	-28.79	1.74 H	42	32.57	-17.86
3	258.51	28.00 QP	46.00	-18.00	1.57 H	59	44.99	-16.99
4	267.84	27.62 QP	46.00	-18.38	1.07 H	109	44.25	-16.63
5	460.59	21.55 QP	46.00	-24.45	1.23 H	93	32.37	-10.82
6	496.35	23.58 QP	46.00	-22.42	1.38 H	78	33.76	-10.18
ANTENNA POLARITY & TEST DISTANCE: VERTICAL AT 3 M								
NO.	FREQ. (MHz)	EMISSION LEVEL (dBuV/m)	LIMIT (dBuV/m)	MARGIN (dB)	ANTENNA HEIGHT (m)	TABLE ANGLE (Degree)	RAW VALUE (dBuV)	CORRECTION FACTOR (dB/m)
1	34.66	15.40 QP	40.00	-24.60	1.14 V	43	34.49	-19.09
2	151.25	12.72 QP	43.50	-30.78	1.88 V	116	29.34	-16.62
3	264.73	17.22 QP	46.00	-28.78	1.33 V	62	33.97	-16.75
4	328.46	16.42 QP	46.00	-29.58	1.99 V	132	31.14	-14.72
5	451.27	19.67 QP	46.00	-26.33	2.00 V	147	30.66	-10.99
6	620.71	22.80 QP	46.00	-23.20	2.00 V	170	30.44	-7.64

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB/m).
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB).
3. The emission levels of other frequencies were greater than 20dB margin.
4. 9KHz~30MHz have been test and test data more than 20dB margin.
5. Margin value = Emission level – Limit value.

4.2. FREQUENCY TOLERANCE

4.2.1. LIMIT OF FREQUENCY TOLERANCE

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.

4.2.2. TEST INSTRUMENTS

Equipment	Manufacturer	Model No.	Serial No.	Next Cal.
Power Sensor	Keysight	U2021XA	MY57320002	Apr. 07, 25
Digital Multimeter	FLUKE	15B	A1220010DG	N/A
Humid & Temp Programmable Tester	Haida	HD-225T	110807201	Oct. 15, 25
Oscilloscope	Agilent	DSO9254A	MY51260160	Jul. 07, 25
Signal and Spectrum Analyzer	Rohde&Schwarz	FSV40	101094	Jan. 01, 25
Signal Generator	Agilent	N5183A	MY50140980	Jul. 11, 25
MXG-B RF Vector Signal Generator	Keysight	N5182B	MY56200288	Jul. 11, 25
BLUETOOTH TESTER	Rohde&Schwarz	CBT32	100811	N/A
Attenuator	MINI	BW-S10W2+	S130129FGE2	N/A
DC Source	Keysight	E3642A	MY56146098	N/A
Test software	ADT	ADT_RF Test Software V6.6.5.3	N/A	N/A

NOTE:

1. The test was performed in RF Oven room.
2. Equipment are calibrated by calibration laboratory accredited to ISO/IEC 17025 by a mutually recognized Accreditation and all tests are conducted within a valid calibration cycle.

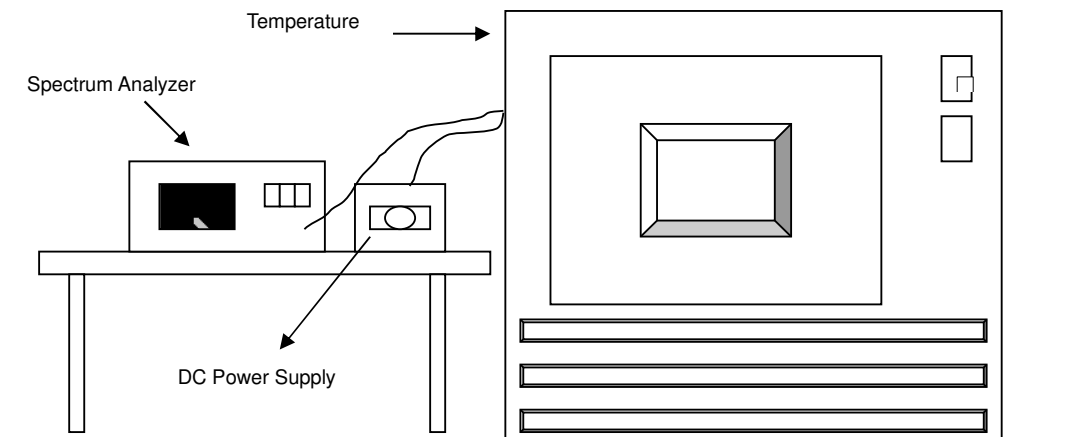
4.2.3. TEST PROCEDURES

- a) The EUT was placed inside the environmental test chamber and powered by nominal DC voltage.
- b) Turn the EUT on and couple its output to a spectrum analyzer.
- c) Turn the EUT off and set the chamber to the highest temperature specified.
- d) Allow sufficient time (approximately 30 min) for the temperature of the chamber to stabilize, turn the EUT on and measure the operating frequency after 2, 5, and 10 minutes.
- e) Repeat step c) and d) with the temperature chamber set to the lowest temperature.
- f) The test chamber was allowed to stabilize at +20 degree C for a minimum of 30 minutes. The supply voltage was then adjusted on the EUT from 85% to 115% and the frequency record.

4.2.4. DEVIATION FROM TEST STANDARD

No deviation.

4.2.5. TEST SETUP



4.2.6. EUT OPERATING CONDITIONS

Set the EUT under transmission condition continuously at specific channel frequency.

4.2.7. TEST RESULTS

FREQUENCY STABILITY VERSUS TEMP.									
TEMP. (°C)	POWER SUPPLY (V)	0 MINUTE		2 MINUTE		5 MINUTE		10 MINUTE	
		Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift
		(MHz)	%	(MHz)	%	(MHz)	%	(MHz)	%
55	3.7Vdc	13.55925	-0.006	13.55993	-0.001	13.55993	-0.001	13.55993	-0.001
50	3.7Vdc	13.55986	-0.001	13.55981	-0.001	13.55979	-0.002	13.55991	-0.001
40	3.7Vdc	13.56035	0.003	13.56075	0.006	13.56063	0.005	13.56029	0.002
30	3.7Vdc	13.55976	-0.002	13.55942	-0.004	13.55974	-0.002	13.55993	-0.001
20	3.7Vdc	13.56073	0.005	13.56013	0.001	13.56039	0.003	13.56008	0.001
10	3.7Vdc	13.55987	-0.001	13.55982	-0.001	13.55991	-0.001	13.55977	-0.002
0	3.7Vdc	13.56035	0.003	13.56015	0.001	13.56014	0.001	13.56016	0.001
-10	3.7Vdc	13.56022	0.002	13.56034	0.003	13.56022	0.002	13.56009	0.001
-20	3.7Vdc	13.56028	0.002	13.56011	0.001	13.56028	0.002	13.56052	0.004

FREQUENCY STABILITY VERSUS VOLTAGE									
TEMP. (°C)	POWER SUPPLY (V)	0 MINUTE		2 MINUTE		5 MINUTE		10 MINUTE	
		Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift	Measured Frequency	Frequency Drift
		(MHz)	%	(MHz)	%	(MHz)	%	(MHz)	%
20	3.7Vdc	13.56073	0.005	13.56013	0.001	13.56039	0.003	13.56008	0.001
	4.255Vdc	13.55991	-0.001	13.55977	-0.002	13.55975	-0.002	13.55991	-0.001
	3.145Vdc	13.55987	-0.001	13.55984	-0.001	13.55991	-0.001	13.55976	-0.002

4.3. 20dB BANDWIDTH

4.3.1 LIMITS OF 20dB BANDWIDTH

The 20dB bandwidth shall be specified in operating frequency band.(13.11MHz – 14.01MHz)

4.3.2 TEST INSTRUMENTS

Equipment	Manufacturer	Model No.	Serial No.	Next Cal.
Power Sensor	Keysight	U2021XA	MY57320002	Apr. 07, 25
Digital Multimeter	FLUKE	15B	A1220010DG	N/A
Humid & Temp Programmable Tester	Haida	HD-225T	110807201	Oct. 15, 25
Oscilloscope	Agilent	DSO9254A	MY51260160	Jul. 07, 25
Signal and Spectrum Analyzer	Rohde&Schwarz	FSV40	101094	Jan. 01, 25
Signal Generator	Agilent	N5183A	MY50140980	Jul. 11, 25
MXG-B RF Vector Signal Generator	Keysight	N5182B	MY56200288	Jul. 11, 25
BLUETOOTH TESTER	Rohde&Schwarz	CBT32	100811	N/A
Attenuator	MINI	BW-S10W2+	S130129FGE2	N/A
DC Source	Keysight	E3642A	MY56146098	N/A
Test software	ADT	ADT_RF Test Software V6.6.5.3	N/A	N/A

NOTE:

1. The test was performed in RF Oven room.
2. Equipment are calibrated by calibration laboratory accredited to ISO/IEC 17025 by a mutually recognized Accreditation and all tests are conducted within a valid calibration cycle.

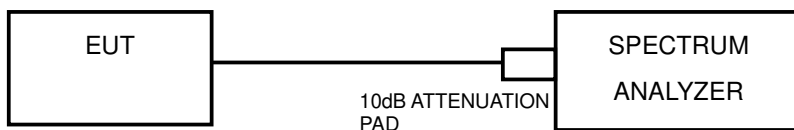
4.3.3 TEST PROCEDURE

- a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
- c. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
- d. Repeat above procedures until all frequencies measured were complete.

4.3.4 DEVIATION FROM TEST STANDARD

No deviation.

4.3.5 TEST SETUP



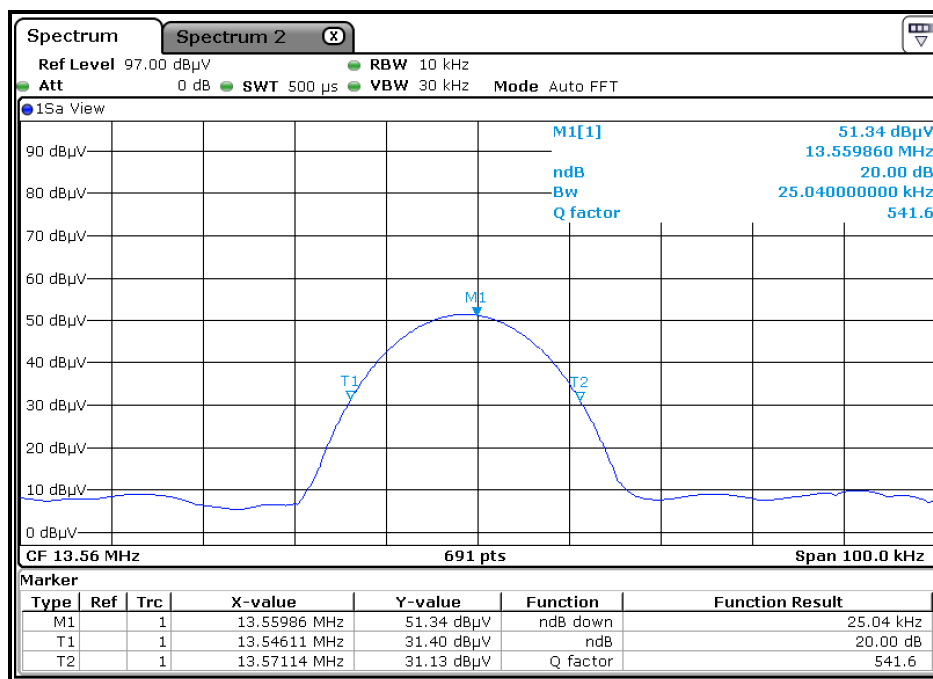
4.3.6 EUT OPERATING CONDITION

The software provided by client to enable the EUT under transmission condition continuously.

4.3.7 TEST RESULTS

CHANNEL	CHANNEL FREQUENCY (MHz)	20dB BANDWIDTH (KHz)
1	13.56	25.040

Lower & Upper Test Frequency Point (MHz)	Test Frequency (MHz)	P/F
Lower	13.5461	PASS
Upper	13.5711	PASS





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5. PHOTOGRAPHS OF THE TEST CONFIGURATION

Please refer to the attached file (Test Setup Photo).



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6. APPENDIX A - MODIFICATIONS RECORDERS FOR ENGINEERING CHANGES TO THE EUT BY THE LAB

No any modifications are made to the EUT by the lab during the test.

---END---