FCC TEST REPORT

Test Report No. :	DST-RR-17-F001
Applicant :	**DUALi Inc.** 1-309 Innoplex, 552 Woncheon-dong, Yeongtong-gu, Suwon, Gyeonggi-do, Korea
Manufacturer :	**DUALi Inc.** 1-309 Innoplex, 552 Woncheon-dong, Yeongtong-gu, Suwon, Gyeonggi-do, Korea
FCC ID :	SWUDE960
Product name :	SMART CARD Reader
Model name :	**DE-960** (Please see P5 for all the model numbers)
Standard applied :	ANSI C63.10:2013 and ANSI C63.4:2014
Rule parts :	FCC CFR 47, Part 15, Subpart C-15.225
Equipment Class :	DXX - Part 15 Low Power Communication Device Transmitter
Date of receipt :	February 17, 2017
Test Period :	February 28, 2017 ~ March 6, 2017
Date of issue :	March 8, 2017
Test Result :	PASS ☒ FAIL ☐

Tested by : **Jung-tae Kim / testing Engineer**

Reviewed by: **Chang-youl, Kim / Chief Engineer**

DSTech Co.

Revision History

Issue Report No.	Issued Date	Revisions	Effect Section
DST-RR-17-F001	**March 8, 2017**	Initial Release	All

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1 Basic Description of EUT

1.1 Basic Description of EUT

Product name:	SMART CARD Reader
Model name:	DE-960
Serial No:	Fixed
Transmit Frequency:	13.56 MHz
Number of Channels:	1
Type of Modulation	ASK
Local Oscillator or X-Tal	27.12 MHz
Power source	DC 12 V
H/W Version	Ver 1.0
S/W Version	Ver 1.0
Test SW Version	-

1.2 Antenna Description

Type of Antenna	Internal PCB loop antenna
Length(Card RFID)	105 mm × 65 mm, 2-turns

Note : The above EUT information was declared by the manufacturer.

2 Facilities and accreditations

2.1 Address

DSTech Co.

Test Site Location : 80, Jeil-ri, Yangji-myun, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea

TEL : 82-31-336-1798, FAX : 82-31-336-3451

2.2 Certificated

FCC Site Registration No.: 325242

VCCI Site Registration No.: R-3420, C-3794

IC Site Registration No.: 9147A-1

2.3 List of test and measurement instruments

Equipment Type	Model	Manufacture	Serial No	Next Cal. Date	Cal time	Use
EMI TEST RECEIVER	ESCI	R&S	100049	2017.08.01	1 year	☒
Spectrum Analyzer	FSP	R&S	100785	2017.08.01	1 year	☒
Pre-amplifier	8447D	H.P	2727A06183	2017.08.02	1 year	☒
ARTIFICIAL MAIN NETWORK	MN425B	ANRITSU	M05519	2017.08.02	1 year	☒
2-LINE V-NETWORK	ESH3-Z5	R&S	100193	2017.08.02	1 year	☒
Loop Antenna	HFH2-Z2	Schwarzbeck	863048/019	2017.09.18	1 year	☒
TRILOG Broadand Antenna	VULB9168	Schwarzbeck	600	2017.01.16	1 year	☒
Digital Thermo-Hygrometer	PC-5000TRH-II	SATO	15042254-1	2017.07.30	1 year	☒
Tempeature / Humidity Chamber	DS-150SP(T)	DAEWON SCIENCE	150417-01	2017.11.20	1 year	☒
Antenna Mast	EAM 4.0	DAEIL EMC	N/A	N/A	N/A	☒
Antenna Turntable Controller	EMRT2015	HD	N/A	N/A	N/A	☒

3 Summary of test results

3.1 Standards & results

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203	Meets the requirements
Radiated Emissions Field Strength within the band 13.553-13.567 MHz	15.225(a)	Meets the requirements
Field Strength within the bands 13.410-13.553 MHz and 13.567-13.710 MHz 13.110-13.410 MHz and 13.710-14.010 MHz	15.225(b) & (c)	Meets the requirements
Radiated Harmonics and Spurious Emissions Outside of the 13.110 – 14.010 MHz	15.225(d) 15.209(a)	Meets the requirements
Frequency Tolerance of Carrier Signal	15.225(e)	Meets the requirements
AC power line Conducted emissions	15.207(a)	Meets the requirements **

Note: *Battery charging mode.*

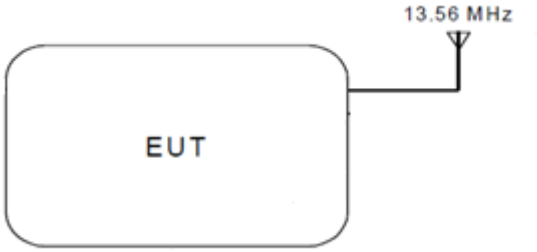
3.2 Uncertainty

Measurement Item	Combined Standard Uncertainty Uc	Expanded Uncertainty U = k × Uc (k = 2)
Conducted RF power	±1.520 dB	±3.04 dB
Radiated disturbance	±2.529 dB	±5.08 dB
Conducted disturbance	±1.950 dB	±3.90 dB

4 Description of Test System

4.1. Test configuration (arrangement of EUT)

The EUT was transmitting RF signals continuously.



Test mode

#	Description	Test case
1	Card RFID	Card type A

Note : The above EUT information was declared by the manufacturer.

4.2. Type of Peripheral Equipment Used:

#	Equipment	Manufacturer	Model No.	Serial No.
1	AC Adapter	FSP GROUP INC.	FSP048-1AD101C	N/A
2	RFID card	N/A	N/A	N/A

4.3. Type of Cables Used:

The following support units or accessories were used to form a representative test configuration during the tests.

#	Start		End		Cable	
	Name	I/O port	Name	I/O port	length (m)	shielded (Y/N)
1	AC Adapter	AC Mains	AC Mains	AC Mains	1.2	N
2	RFID card	-	-	-	-	-

Note: *1) All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.*
2) Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

5 Test and measurements

5.1. Antenna requirement

5.1.1 Regulation

FCC section 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 Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31 (d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

5.1.2 Result: PASS

The EUT has an integral PCB loop antenna, and meets the requirements of this section.

5.2. Radiated emissions

5.2.1 Regulation

FCC 47CFR15 – 15.225

(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.

Frequency (MHz)	Field strength limit (μV/m) @ 30 m	Field strength limit (dBμV/m) @ 30 m	Field strength limit (dBμV/m) @ 3 m
13.110 – 13.410	106	40.5	80.5
13.410 – 13.553	334	50.5	90.5
13.553 – 13.567	15,848	84.0	124.0
13.567 – 13.710	334	50.5	90.5
13.710 – 14.010	106	40.5	80.5

FCC 47CFR15 – 15.209

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

Frequency (MHz)	Field strength limit (μV/m)	Field strength limit (dBμV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F (kHz) = 266.7 – 4.9	48.5 – 13.8	300
0.490 – 1.705	24000/F (kHz) = 49.0 – 14.1	33.8 – 23.0	30
1.705 – 30.0	30	29.5	30
30 – 88	100	40.0	3
88 – 216	150	43.5	3
216 – 960	200	46.0	3
Above 960	500	54.0	3

* The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector. For the frequency bands 9 – 90 kHz, 110 – 490 kHz and above 1000 MHz, the radiated emission limits are based on measurements employing an average detector.

* The lower limit shall apply at the transition frequencies.

5.2.2 Measurement Procedure

Radiated Emissions Test, 9 kHz to 30 MHz (Magnetic Field Test)

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions at a distance of 1 meter or 3 meters according to Section 15.31(f)(2).
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table.
3. Emissions from the EUT are maximized by adjusting the orientation of the Loop antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions if applicable.
4. To obtain the final measurement data, each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

Radiated Emissions Test, above 30 MHz

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the broadband antenna.
4. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
5. The EUT is situated in three orthogonal planes (if appropriate)

5.2.3 Calculation of the field strength limits below 30 MHz

1. No special calculation for obtaining the field strength in dBμV/m is necessary, because the EMI receiver and the active loop antenna operate as a system, where the reading gives directly the field strength result (dBμV/m). The antenna factors and cable losses are already taken into consideration.
2. For test distance other than what is specified, but fulfilling the requirements of section 15.31 (f) (2) the field strength is calculated by adding additionally an extrapolation factor of 40dB/decade (inverse linear distance for field strength measurements).
3. All following emission measurements were performed using the test receiver's average, peak, and quasi-peak detector function with specified bandwidth.
4. The basic equation is as follows;

FS= RA + DF

Where

FS = Field strength in dBμV/m

RA = Receiver Amplitude in dBμV/m

DF = Distance Extrapolation Factor in dB

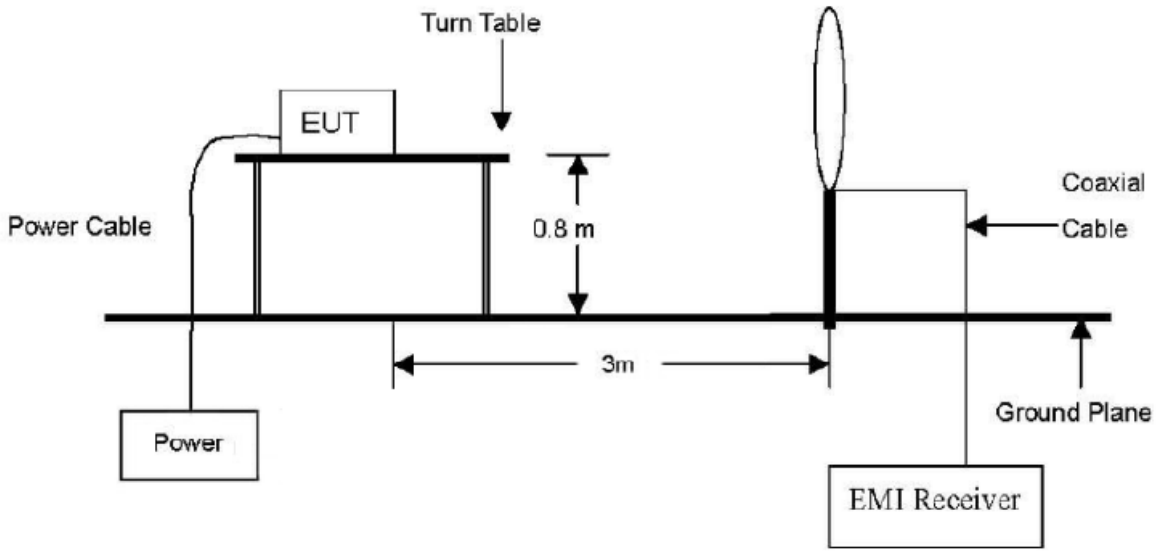
Where $DF = 40\log(D_{TEST} / D_{SPEC})$ where D_{TEST} = Test Distance and D_{SPEC} = Specified Distance

DF = 40log(3m/300m) = -80 dB, for frequency band: 0.009 to 0.490 MHz

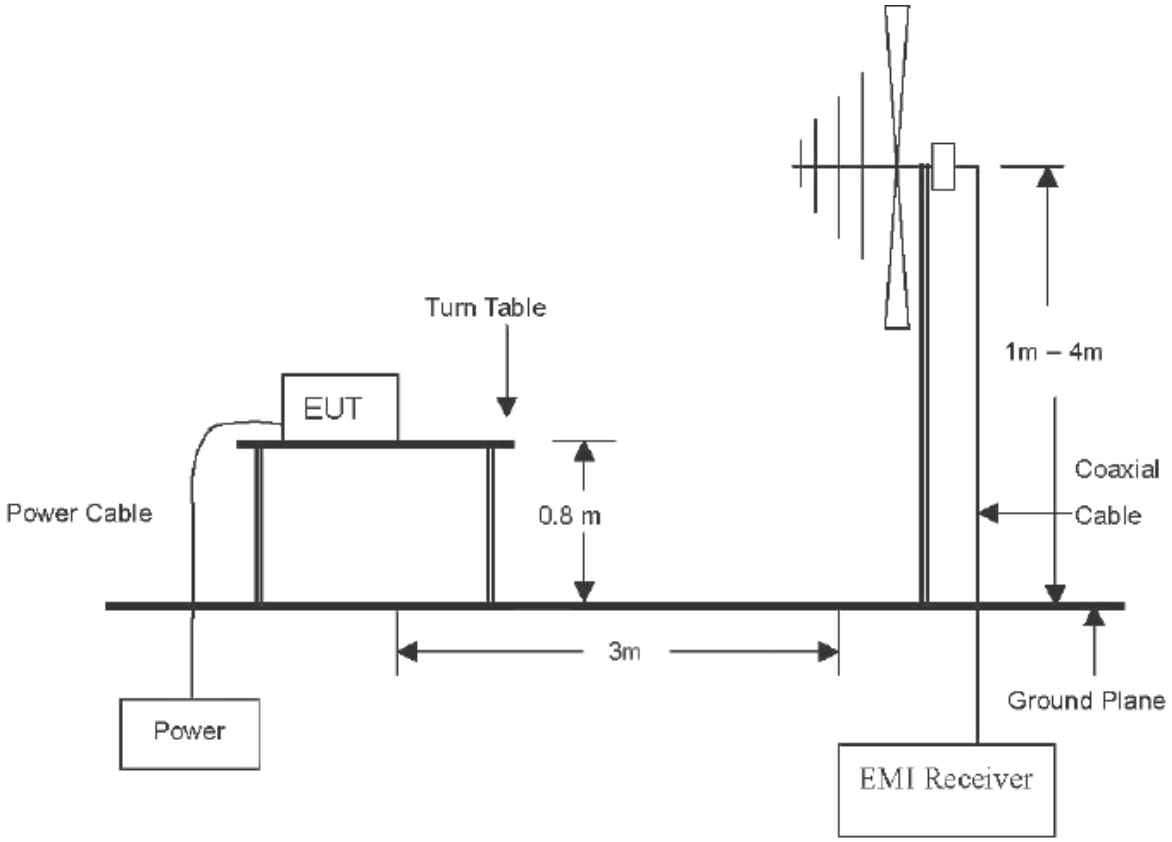
DF = 40log(3m/30m) = -40 dB, for frequency band: 0.490 to 30 MHz

5.2.4 Test setup

- 9 kHz to 30 MHz Emissions



- 30 MHz to 1000 MHz Emissions



5.2.5 Test Results:

PASS

Frequency [MHz]	RBW [kHz]	Reading [dB(μV/m)]	Cable Loss [dB]	Actual [dB(μV/m)]	Limit (at 3m) [dB(μV/m)]	Margin [dB]
Emissions Quasi-peak DATA under 15.225(a), (b)&(c)						
13.560 0	9	77.11	0.3	77.41	124.0	46.59
13.346 4	9	---	0.3	---	80.5	---
13.472 7	9	---	0.3	---	90.5	---
13.674 3	9	---	0.3	---	90.5	---
13.825 5	9	---	0.3	---	80.5	---
Emissions Quasi-peak DATA under 15.225(d), 15.209						
27.12	9	---	0.	---	69.5	---

Actual (dBμV/m) = Reading + Cable Loss

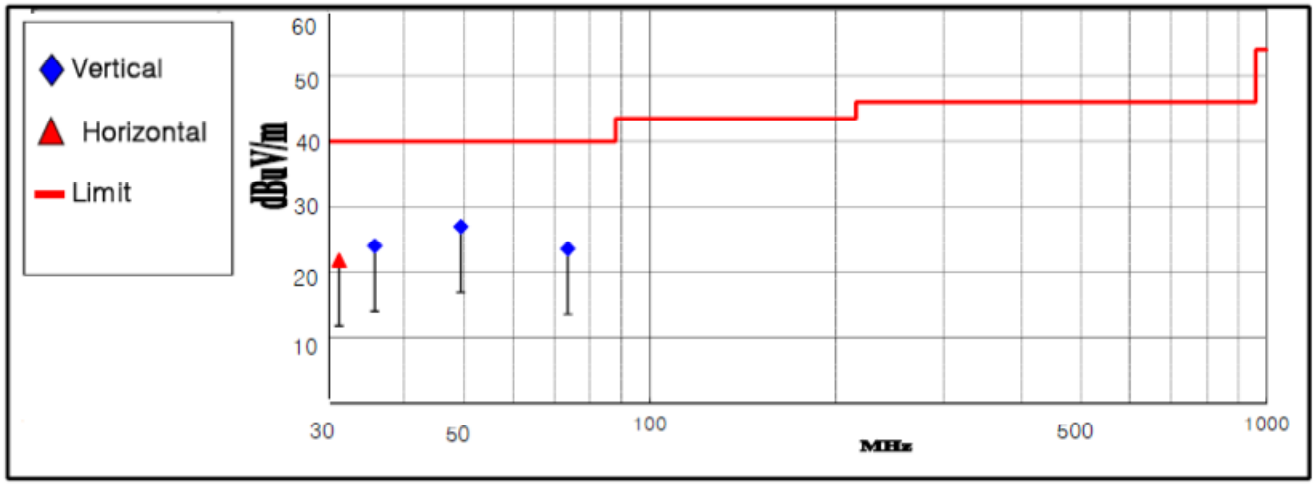
Margin (dB) = Limit – Actual

NOTE: These test results were measured at the 3 m distance.

Remark:"---" means the emission level was too low to be measured or in the noise floor.

PASS

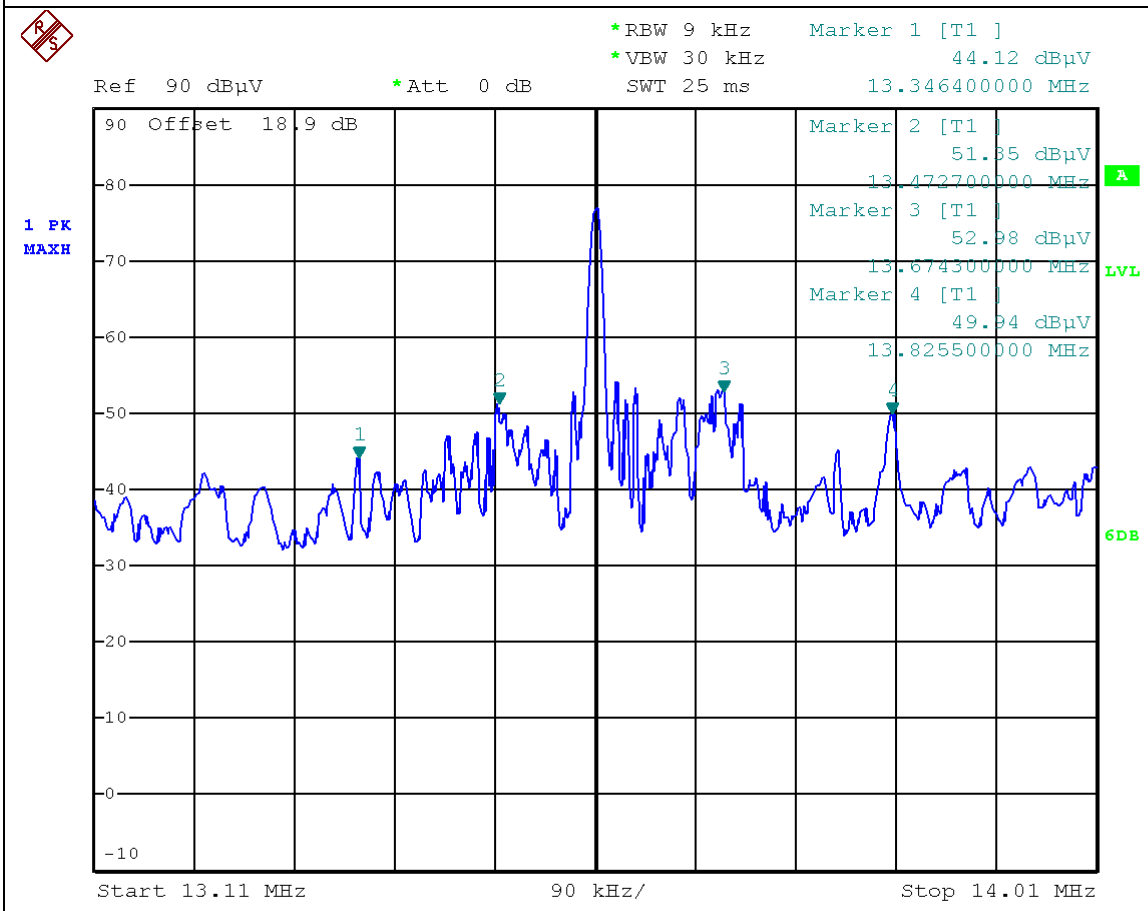
Frequency (MHz)	RBW [kHz]	Actual [dB(μV)/m]	Antenna height (cm)	Pol	Table Angle (Deg)	Corr. (dB)	Margin (dB)	Limits [dB(μV)/m]
31.35	100	21.8	400	H	229	-11.3	18.2	40.0
35.82	100	24.0	280	V	337	-12.3	16.0	40.0
49.40	100	27.0	100	V	359	-14.7	13.0	40.0
73.65	100	23.5	110	V	1	-15.4	16.5	40.0



1. H: Horizontal polarization, V: Vertical polarization
2. Actual = Reading + Corr. (Amp + Antenna factor + Cable loss)
3. Margin value = Limit – Actual

NOTE: 1. All emissions not reported were more than 20 dB below the specified limit or in the noise floor.
2. These test results measured at the 3 m distance.

Plot of the Band edge (Preliminary measurement in the anechoic chamber at 3 m distance to find out the frequencies, at which the spurious emissions occur, with the peak detector function)



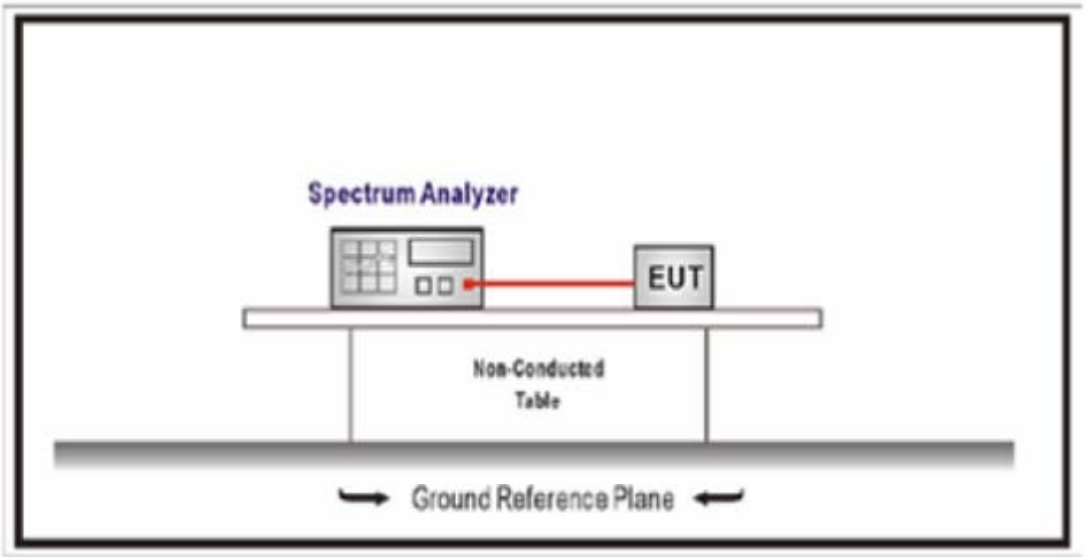
5.3. 20 dB Bandwidth

5.3.1 Regulation

FCC 47CFR15 – 15.225(e)

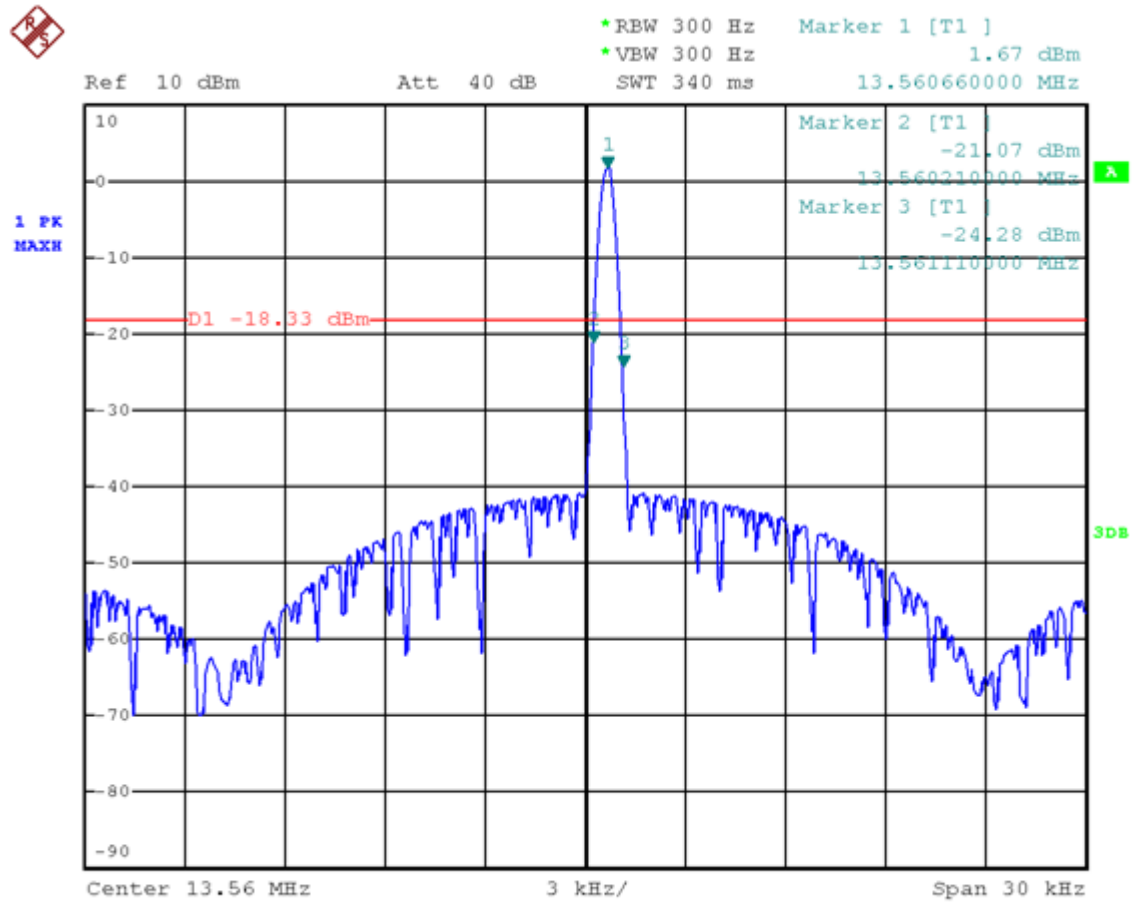
Test setup: The EUT was connected to a spectrum analyzer.
Test procedure: The 20 dB bandwidth was measured by using a spectrum analyzer.

5.3.2 Test setup



5.3.3 Test Results:

PASS



5.4. Frequency tolerance of carrier signal

5.4.1 Regulation

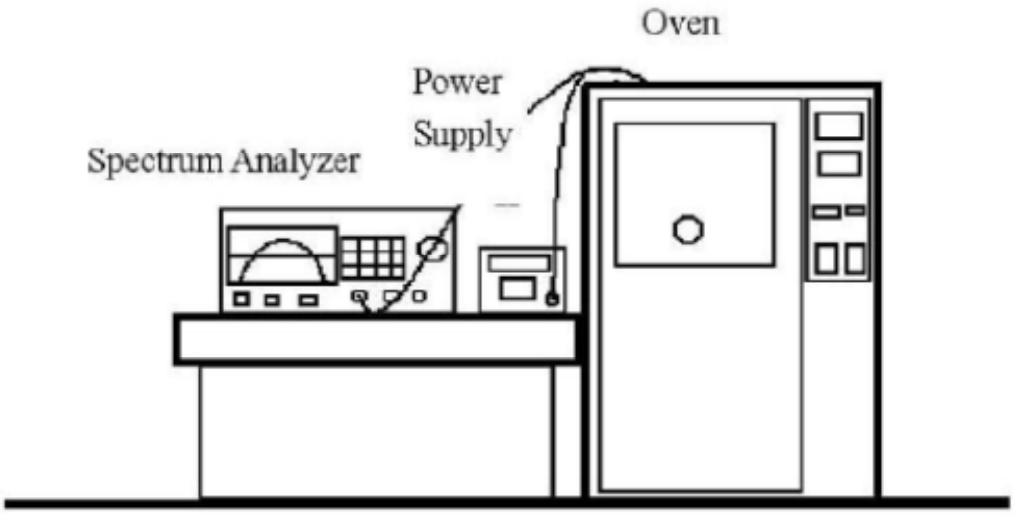
FCC 47CFR15 – 15.225(e)

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.

5.4.2 Measurement Procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator.
2. The transmission time was measured with the spectrum analyzer using RBW=1 ㎑, VBW=1 ㎑.
3. Set the temperature of chamber to -20 . Allow sufficient time ℃ (approximately 30 min) for the temperature of the chamber to stabilize. While maintaining a constant temperature inside the chamber, turn the EUT on and measure the EUT operating frequency.
4. Repeat step 2 with a 10℃ decreased per stage until the highest temperature 50℃ is measured, record all measured frequencies on each temperature step.

5.4.2 Test setup



5.4.3 Test Results:

PASS

Table 5: Frequency Tolerance

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz									
Environment Temperature [°C]	Power Supplied [V_{AC}]	Carrier Frequency Measured with Time Elapsed							
		STARUP		2 minutes		5 minutes		10 minutes	
		[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
+50	120	13.560647	-647	13.560645	-645	13.560645	-645	13.560644	-644
+40	120	13.560650	-650	13.560650	-650	13.560647	-647	13.560647	-647
+30	120	13.560555	-555	13.560655	-655	13.560655	-655	13.560654	-654
+20	120	13.560660	-660	13.560660	-660	13.560661	-661	13.560661	-661
+10	120	13.560668	-668	13.560668	-668	13.560669	-669	13.560670	-670
0	120	13.560670	-670	13.560670	-670	13.560671	-671	13.560671	-671
-10	120	13.560671	-671	13.560671	-671	13.560672	-672	13.560672	-672
-20	120	13.560685	-685	13.560685	-685	13.560688	-688	13.560688	-688

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz								
Power Supplied [V_{AC}]	Carrier Frequency Measured with Time Elapsed							
	STARUP		2 minutes		5 minutes		10 minutes	
	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
85 %	13.560661	-661	13.560661	-661	13.560661	-661	13.560660	-660
100 %	13.560660	-660	13.560660	-660	13.560661	-661	13.560661	-661
115 %	13.560659	-659	13.560659	-659	13.560659	-659	13.560659	-659

Err [Hz] = Measured carrier frequency (MHz) - Reference Frequency (13.56 MHz)

5.5. AC power line Conducted emissions

5.5.1 Regulation

FCC 47CFR15 – 15.207(a)

According to §15.207(a), for 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 50μH/50Ω 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.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Qausi-peak	Average
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency.

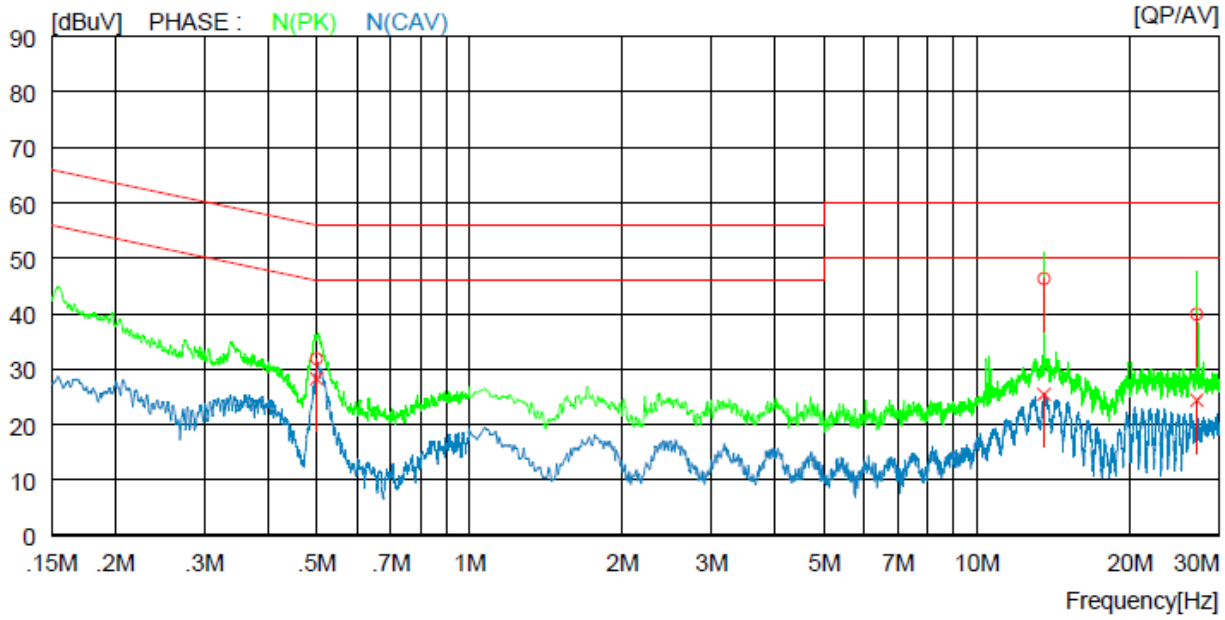
5.5.2 Test Procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

5.5.3 Test Results:

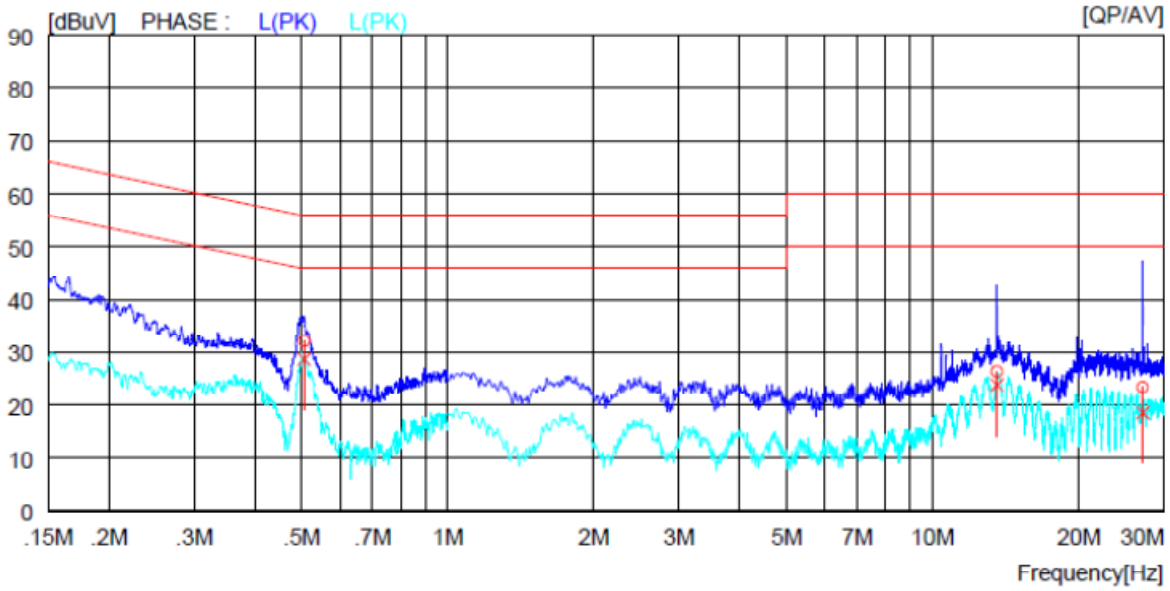
PASS

(Neutral Line)



NO	FREQ [MHz]	READING QP [dBuV]	READING AV [dBuV]	C.FACTOR [dB]	RESULT QP [dBuV]	RESULT AV [dBuV]	LIMIT QP [dBuV]	LIMIT AV [dBuV]	MARGIN QP [dBuV]	MARGIN AV [dBuV]	PHASE
1	0.49955	21.9	18.2	10.0	31.9	28.2	56.0	46.0	24.1	17.8	N(PK)
2	13.56065	35.7	14.8	10.6	46.3	25.4	60.0	50.0	13.7	24.6	N(PK)
3	27.12130	28.8	13.3	11.1	39.9	24.4	60.0	50.0	20.1	25.6	N(PK)

PASS
(Live Line)



NO	FREQ	READING QP	READING AV	C.FACTOR	RESULT QP	RESULT AV	LIMIT QP	LIMIT AV	MARGIN QP	MARGIN AV	PHASE
	[MHz]	[dBuV]	[dBuV]	[dB]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	[dBuV]	
1	0.50615	22.1	18.6	10.0	32.1	28.6	56.0	46.0	23.9	17.4	L(PK)
2	13.58425	15.7	13.1	10.6	26.3	23.7	60.0	50.0	33.7	26.3	L(PK)
3	27.13510	12.3	7.4	11.1	23.4	18.5	60.0	50.0	36.6	31.5	L(PK)