TEST REPORT

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Test Report Number: SKT-RFC-200006
Date of issue: December 31, 2020

Applicant:	**KYUNGWOO SYSTECH INC.** #401, Daeryung Post Tower 5, 68, Digital-ro 9, Geumcheon-gu, Seoul, South Korea
Manufacturer:	**KYUNGWOO SYSTECH INC.** #401, Daeryung Post Tower 5, 68, Digital-ro 9, Geumcheon-gu, Seoul, South Korea
Product:	FLIP KEY TAG
Model:	**SMK-HXV-20**
FCC ID:	ZE8-SMK-HXV-20
Project number:	SKTEU20-0472
EUT received:	April 27, 2020
Applied standards:	ANSI C63.10-2013 and ANSI C63.4-2014
Rule parts:	FCC Part 15 Subpart C - Intentional radiators
Equipment Class:	**DSC - Part 15 Security/Remote Control Transmitter**
Remarks to the standards:	None

The above equipment has been tested by SK Tech Co., Ltd., and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product or system, which was tested.

Dowon Ahn / **Testing Engineer**

Jongsoo Yoon / **Technical Manager**

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Revision History of Test Report

Rev.	Revisions	Effect page	Approved by	Date
-	Initial issue	All	Jongsoo Yoon	Dec. 31, 2020

TABLE OF CONTENTS

1 Summary of test results

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203	Meets the requirements
20dB Emission Bandwidth	15.231(c)	Meets the requirements
Transmission Time	15.231(a)	Meets the requirements
Spurious Emission, Band Edge, and Restricted bands	15.231(b), 15.205(a), 15.209(a)	Meets the requirements
AC power line Conducted emissions	15.207(a)	N/A

Note: *The EUT uses a lithium battery with DC 3 V, and therefore the test suites related to AC Mains port were not applicable.*

2 Description of equipment under test (EUT)

Product:	FLIP KEY TAG
Model:	SMK-HXV-20
Serial number:	None (prototype)

Model differences:

Model name	Difference	Tested (checked)
SMK-HXV-20	fully tested model that was provided by the applicant	☒

Technical data:

Power source	DC 3.0 V lithium battery (type CR2032)	
Local Oscillator or X-Tal	32.768 kHz, 26 MHz	
Operating Frequency	433.96 MHz	125 kHz (receive only)
Antenna Type	Integral chip antenna	Resonance coil (2 EA)
Type of Modulation	GFSK	ASK
RF Output power	85.5 dBμV/m (PEAK) (measured @ 3m)	-

I/O port	Type	Q'ty	Remark
–	-	-	

Modification of EUT during the compliance testing:

Two test samples were provided for testing. SAMPLE #1 was firmware modified to transmit RF signal continuously.

3 Test and measurement conditions

3.1. Test configuration (arrangement of EUT)

The EUT was tested as a stand-alone equipment. The EUT was powered from the new battery during the radiated emission measurements. In order to transmit RF signals, the LOCK button on the EUT (SAMPLE #1) was pressed once. The measurements were taken when the EUT (SAMPLE #1) transmitted the RF signals.

NOTE: the Transmission Time was measured in the normal operation for the EUT (SAMPLE #2; without the firmware modification). The RF signals manually transmitted when releasing the button of the EUT or automatically transmitted when being activated during pairing with SMK READER in order for the EUT to be registered to SMK READER or verify the ID code.

3.2. Description of support units (accessory equipment)

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

#	Equipment	Manufacturer	Model No.	Serial No.
1	SMK READER	KYUNGWOO SYSTECH INC.	SMK-HXV-10	N/A

3.3. Interconnection and I/O cables

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)
	-	-	-	-	-	-

3.4. Measurement Uncertainty (*U*)

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = k \times Uc$ ($k = 2$)
Conducted emissions	1.4 ± dB	2.8 ± dB
Radiated emissions (9 kHz to 30 MHz)	1.45 ± dB	2.9 ± dB
Radiated emissions (30 MHz to 1000 MHz)	2.5 ± dB	5.0 ± dB
Radiated emissions (1 GHz to 6 GHz)	2.5 ± dB	5.0 ± dB

3.5. Test date

Date Tested	December 16, 2020 – December 23, 2020

4 Facilities and accreditations

4.1. Facilities

All of the measurements described in this report were performed at SK Tech Co., Ltd
Site I: 88, Geulgaeul-ro 81beon-gil, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea
Site II: 124-8, Geulgaeul-ro, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea

The sites are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-4. The sites comply with the Normalized Site Attenuation requirements given in ANSI C63.4, and site VSWR requirements specified in CISPR 16-1-4. The measuring apparatus and ancillary equipment conform to CISPR 16-1 series.

4.2. Accreditations

The laboratory has been also notified to FCC by RRA as a Conformity Assessment Body, and designated to perform compliance testing on equipment subject to Supplier's Declaration of Conformity (SDoC) and Certification under Parts 15 and 18 of the FCC Rules.

Designation No.	KR0007

4.3. List of test and measurement instruments

No	Description	Model	Manufacturer	Serial No.	Cal. due	Use
1	Signal and Spectrum Analyzer	FSW67	Rohde&Schwarz	101371	2021.06.16	☒
2	EMI Test Receiver	ESR26	Rohde&Schwarz	101441	2021.07.24	☒
3	Pre-amplifier (30 MHz - 1 GHz)	MLA-10K01-B01-27	TSJ	2005350	2021.06.08	☒
4	Pre-amplifier (1 GHz - 18 GHz)	AFS44-00101800-25-10P-44	MITEQ	1116321	2021.06.08	☒
5	Attenuator (6dB)	18N5W	API Technology	-	2021.07.06	☒
6	High Pass Filter	WHKE3-500.2-610-4000-40SS	Wainwright	1	2021.06.09	☒
7	Loop Antenna	HFH2-Z2E	Rohde&Schwarz	100883	2021.12.23	☒
8	BILOG Broadband Antenna	VULB9168	Schwarzbeck	9168-230	2021.07.06	☒
9	Horn Antenna (1 GHz - 18 GHz)	BBHA 9120D	Schwarzbeck	9120D-816	2021.05.22	☒
10	DC Power Supply	6633A	HP	2838A-01000	2021.06.09	☒
11	Signal Generator	SMB100A	R & S	180704	2021.02.25	
12	Digital Thermo-Hygrometer	608-H1	Testo	-	2021.06.11	☒
13	High Pass Filter	WHKX 1.0/15G-12SS	Wainwright	17	2021.06.08	☒

5 Test and measurements

5.1. Antenna requirement

5.1.1 Regulation

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. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. 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 §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 internal chip antenna and meets the requirements of this section.

5.2. 20 dB Emission Bandwidth

5.2.1 Regulation

According to §15.231(c), The bandwidth of the emission shall be no wider than 0.25 % of the center frequency for devices operating above 70 MHz and below 900 MHz. Bandwidth is determined at the points 20 dB down from the modulated carrier.

5.2.2 Test Procedure

The EUT repeatedly transmitted RF signals and the small antenna, to which the Spectrum Analyzer was connected, placed in the vicinity of the EUT. The Occupied Bandwidth (99 %) and 20 dB emission bandwidth were measured with the following setting according to ANSI C63.10, 12.4.

(a) Set RBW = approximately 1 % of the emission bandwidth
(b) Set the VBW > RBW
(c) Detector = peak
(d) Trace mode = max hold

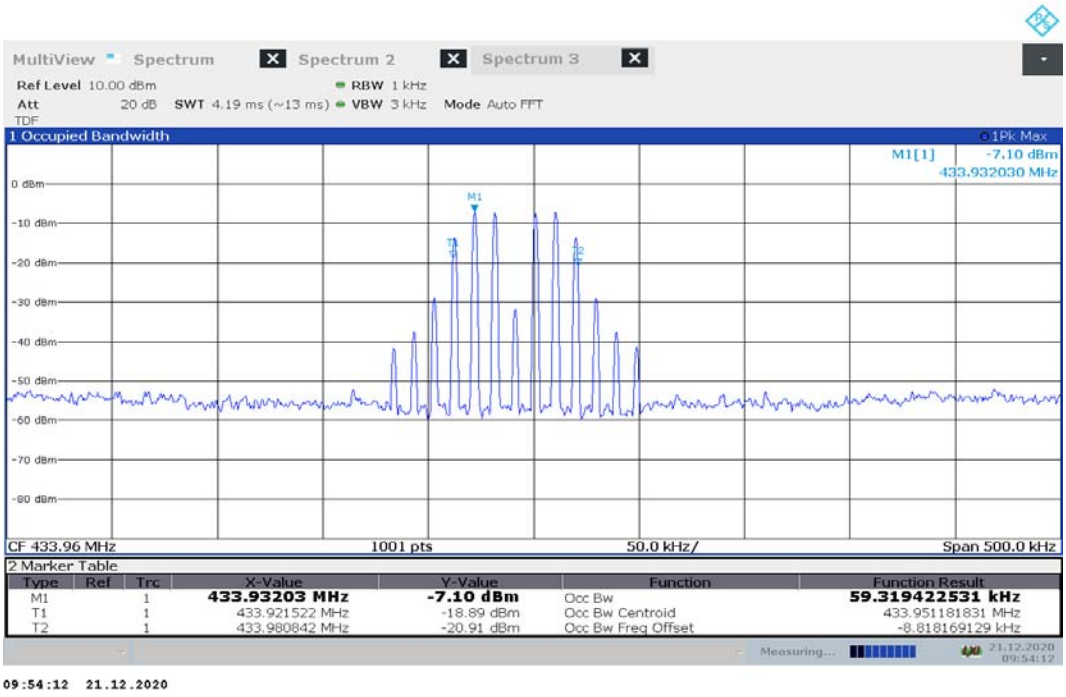
5.2.3 Test Results: PASS

Table 1: Measured values of the 20 dB Emission Bandwidth

Operating frequency	Occupied Bandwidth (99 %)	20 dB Emission Bandwidth	Limit
433.96 MHz	59.3 kHz	59.7 kHz	1084.9 kHz

Figure 1. Plot of the 20 dB Emission Bandwidth & Occupied Bandwidth

Occupied Bandwidth



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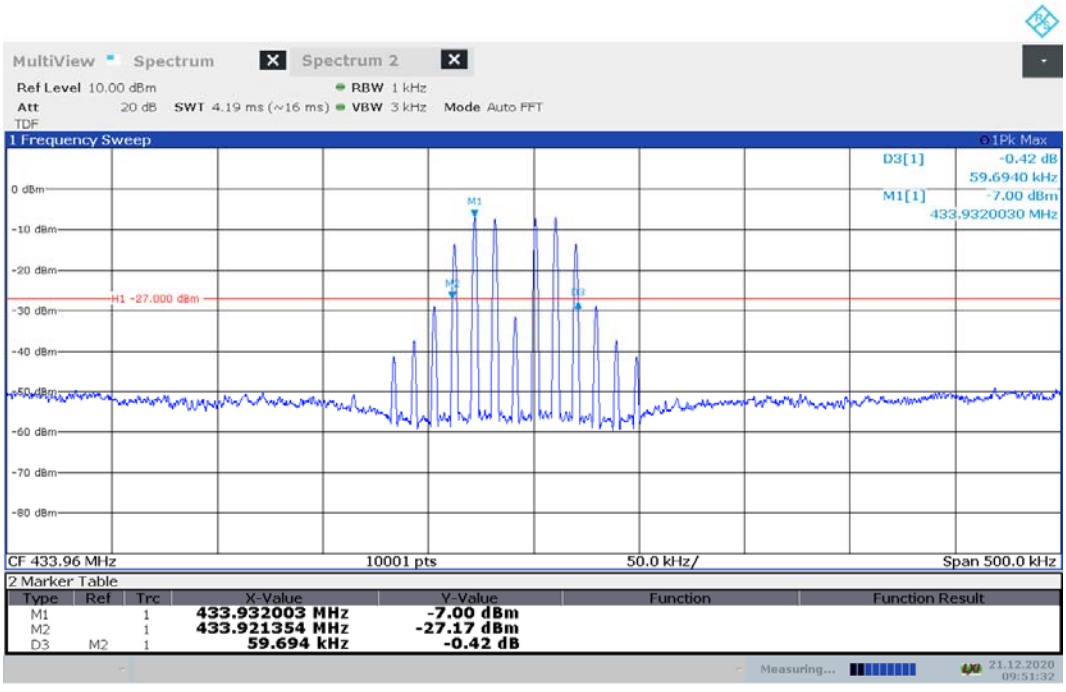
20 dB Emission Bandwidth



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5.3. Transmission Time

5.3.1 Regulation

(1) A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.
(2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.
(3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

5.3.2 Test Procedure

The EUT transmitted RF signals and the small antenna, to which the Spectrum Analyzer was connected, placed in the vicinity of the EUT. The Transmission Time was measured in the following operation conditions.
(a) Manual transmission when releasing a button
(b) Automatic transmission when being activated during pairing with SMK READER. The EUT was activated when receiving the commands from SMK READER, and sent a RF signal.

The Spectrum Analyzer was set as below:
(a) Set the center frequency to the operating frequency
(b) Set RBW > 20 dB Emission Bandwidth (or Occupied Bandwidth)
(c) Set Trigger level to start the measurement when the EUT transmitted RF signals
(d) Set Sweep time to capture the pulse trains and/or to capture the burst ON time

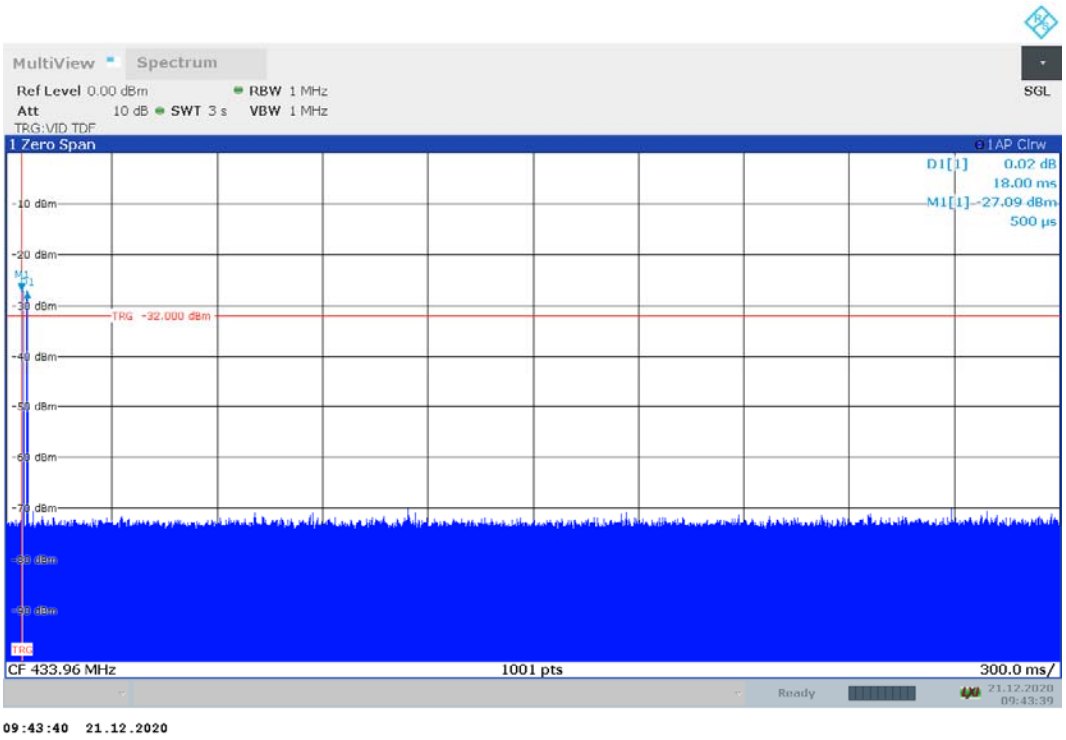
5.3.3 Test Results: PASS

Table 2: Measured values of the Transmission Time

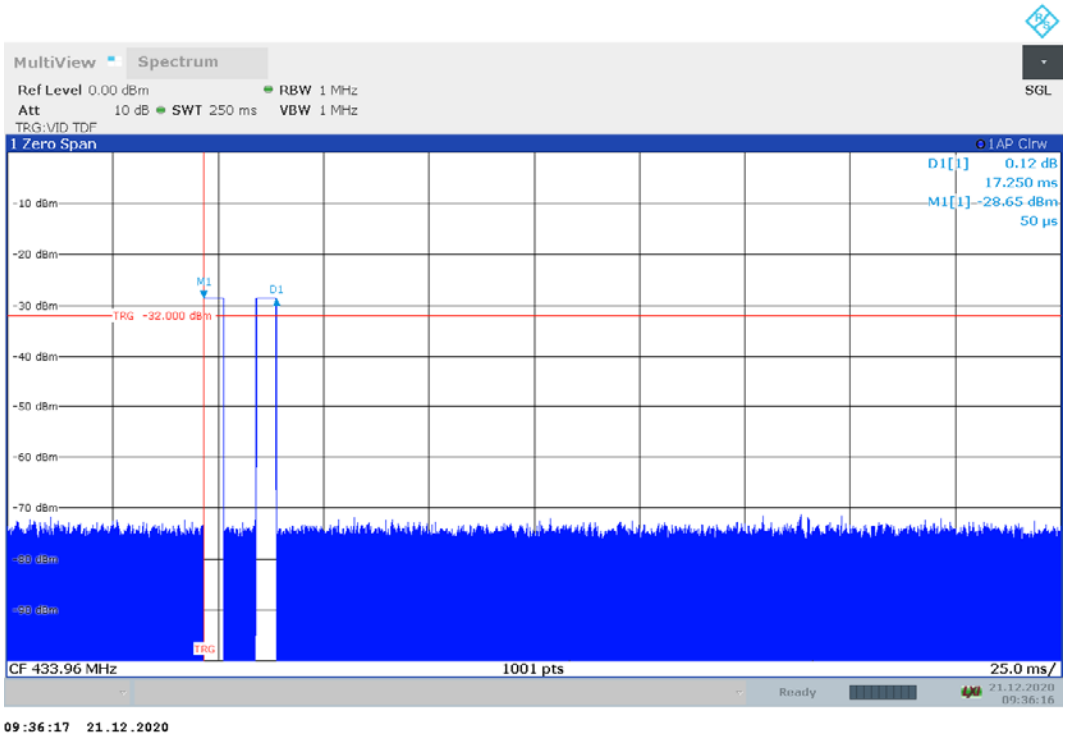
Operating frequency	Transmission Type	Transmission Time	Limit
		[ms]	[s]
433.96 MHz	Manually	17.25	5
433.96 MHz	Automatically	4.80	5

** The small loop antenna with 50 Ω connector was used as a field probe. The small loop antenna was located at the proximity of the EUT, and fixed not to influence the measuring results.

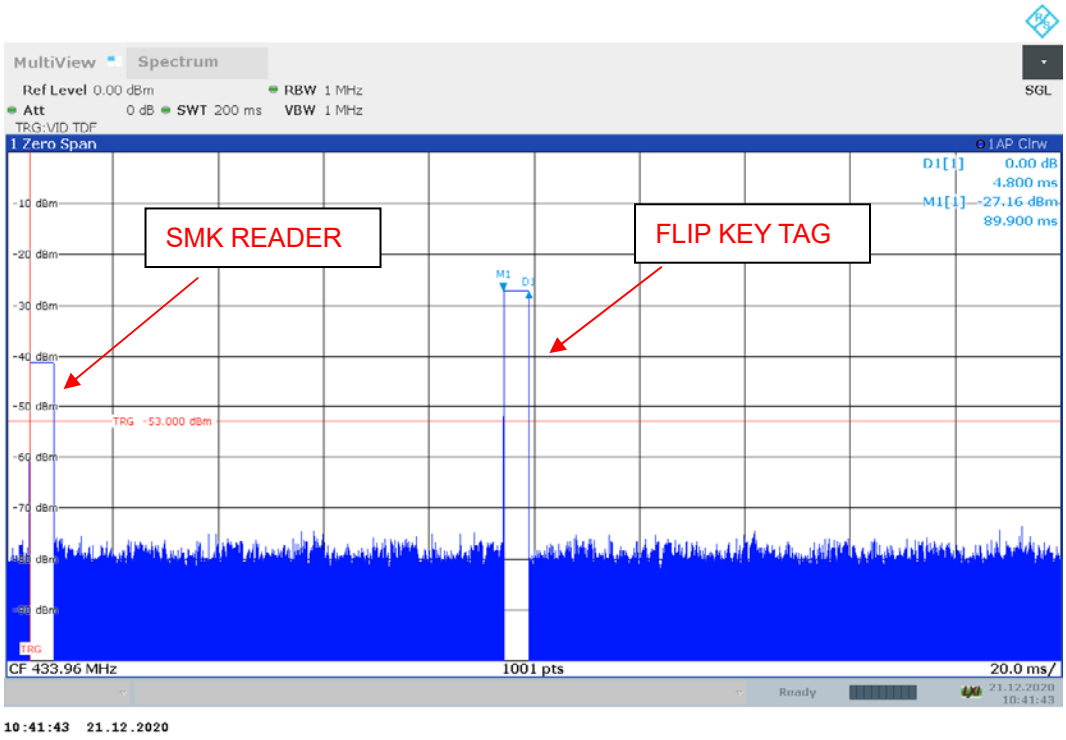
Figure 2. Plot of the Transmission Time



Manual transmission when releasing a button (one time)



Transmission time (duration) for manual operation



Automatic transmission when being activated during pairing with SMK READER

5.4. Radiated emissions

5.4.1 Regulation

FCC 47CFR15 – 15.231

According to §15.231(b), the field strength of emissions from intentional radiators operated under this section shall not exceed the following:

Fundamental frequency (MHz)	Field strength of fundamental (μV/m) @ 3 m	Field strength of spurious emissions (μV/m) @ 3 m
40.66 – 40.70	2,250	225
70 – 130	1,250	125
130 – 174	1,250 to 3,750**	125 to 375**
174 – 260	3,750	375
260 – 470	3,750 to 12,500**	375 to 1,250**
Above 470	12,500	1,250

** linear interpolations

Intentional radiators operating under the provisions of this section shall demonstrate compliance with the limits on the field strength of emissions, as shown in the above table, based on the average value of the measured emissions. As an alternative, compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector. The specific method of measurement employed shall be specified in the application for equipment authorization. If average emission measurements are employed, the provisions in §15.35 for averaging pulsed emissions and for limiting peak emissions apply. Further, compliance with the provisions of §15.205 shall be demonstrated using the measurement instrumentation specified in that section.

The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

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

5.4.2 Measurement Procedure

The EUT repeatedly transmitted RF signals and the following measurement procedure specified in ANSI C63.10-2013 was used.

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

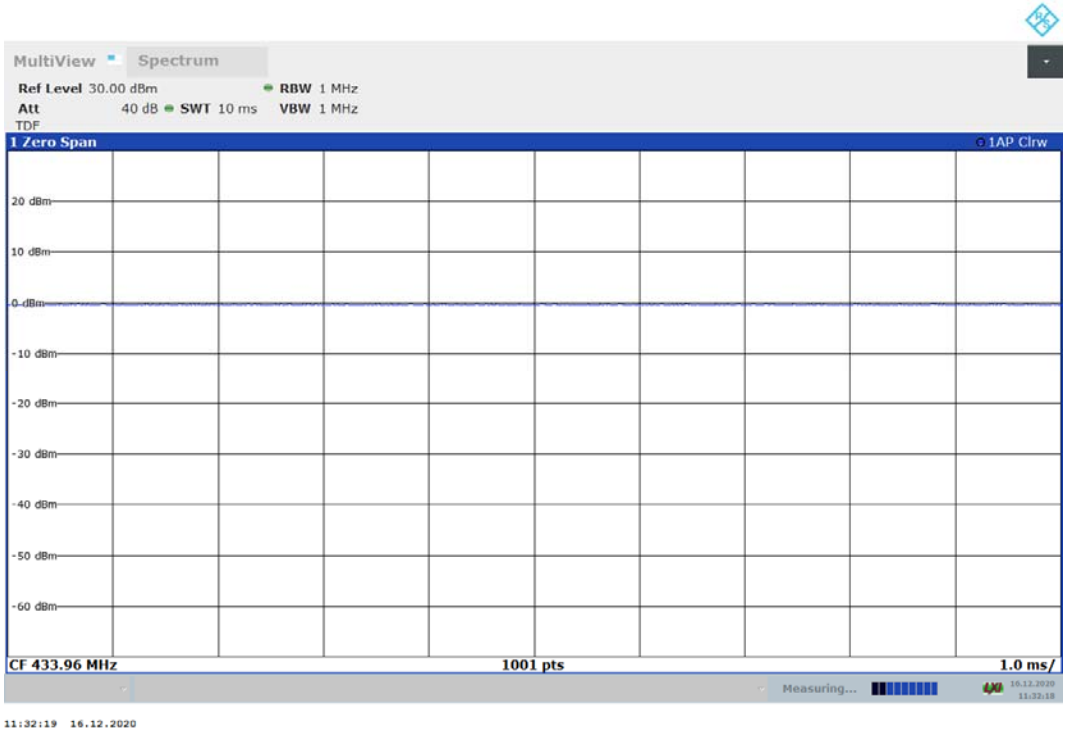
(a) The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions at a distance of 3 meters according to Section 15.31(f)(2).
(b) The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table.
(c) Emissions from the EUT are maximized 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.
(d) 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.
(e) The EUT was situated in three orthogonal planes (if appropriate).

Radiated Emissions Test, above 30 MHz

(a) The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
(b) The EUT was placed on the top of the 0.8-meter height (or 1.5 meter height for above 1 GHz), 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˚.
(c) The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the Bilog broadband antenna, and from 1 GHz to tenth harmonic of the highest fundamental frequency using the horn antenna.
(d) 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.
(e) The EUT was situated in three orthogonal planes (if appropriate).

Measurement software: TEPTO-DV/RE_Version: 3.1.0044

Figure 3. RF signals during the measurements achieved by the modification of firmware
EUT (SAMPLE#1) firmware modification transmits a signal when the button is released RF signal has been modified to transmit continuously



Duration of the RF signals

According to §ANSI 63.10 (7.5 Procedure for determining the average value of pulsed emissions)

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval.64 The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in Equation
$\delta(dB) = 20\log(\Delta)$

δ is the duty cycle correction factor (dB)
Δ is the duty cycle (dimensionless)

5.4.3 Test Results: PASS

Table 3: Measured values of the Field strength

For the measurements under below 30 MHz

Freq. (kHz)	RBW (kHz)	Reading (dBµV)			AF (dB/m)	Cable Loss (dB)	Actual (dBµV/m)			Limit (at 3m) (dBµV/m)			Margin (dB)			Remark
		PK	AV	QP			PK	AV	QP	PK	AV	QP	PK	AV	QP	

No Radiated Spurious Emissions Found

Actual (dBµV/m) = Reading + AF + Cable Loss
Margin (dB) = Limit – Actual
Note: These test results were measured at the 3 m distance.

For the measurements from 30 MHz to 1 GHz (for X-axis)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBµV)	AMP (dB)	AF (dB/m)	CL (dB)	DCCF (dB)	Actual (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			PK					PK	AV	PK	AV	PK	AV
433.962	H	1.00	88.5	30.3	22.3	2.8	-20.4	83.3	62.9	100.8	80.8	17.5	17.9
433.962	V	2.00	84.4	30.3	22.3	2.8	-20.4	79.2	58.8	100.8	80.8	21.6	22.0
867.964	H	2.00	29.2	30.0	28.9	4.1	-20.4	32.2	11.8	80.8	60.8	48.6	49.0
867.964	V	1.00	27.8	30.0	28.9	4.1	-20.4	30.8	10.4	80.8	60.8	50.0	50.4

For the measurements from 30 MHz to 1 GHz (for Y-axis)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBµV)	AMP (dB)	AF (dB/m)	CL (dB)	DCCF (dB)	Actual (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			PK					PK	AV	PK	AV	PK	AV
433.960	H	1.00	89.2	30.3	22.3	2.8	-20.4	84.0	63.6	100.8	80.8	16.8	17.2
433.960	V	2.00	85.0	30.3	22.3	2.8	-20.4	79.8	59.4	100.8	80.8	21.0	21.4
867.945	H	1.00	29.5	30.0	28.9	4.1	-20.4	32.5	12.1	80.8	60.8	48.3	48.7
867.945	V	1.00	26.7	30.0	26.7	4.1	-20.4	27.5	7.1	80.8	60.8	53.3	53.7

V/H: Vertical / Horizontal polarization
AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss including an attenuator/filter if used
Peak Actual = Peak Reading - AMP + AF + CL
AV Actual = Peak Reading - AMP + AF + CL+ DCCF
DCCF = 20*LOG(Transmission On-time/100 ms)
Margin = Limit – Actual

For the measurements from 30 MHz to 1 GHz (for Z-axis)

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	DCCF (dB)	Actual (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
			PK					PK	AV	PK	AV	PK	AV
433.960	H	1.00	90.7	30.3	22.3	2.8	-20.4	85.5	65.1	100.8	80.8	15.3	15.7
433.960	V	1.00	86.6	30.3	22.3	2.8	-20.4	81.4	61.0	100.8	80.8	19.4	19.8
867.912	H	1.00	29.7	30.0	28.9	4.1	-20.4	32.7	12.3	80.8	60.8	48.1	48.5
867.912	V	1.00	27.8	30.0	28.9	4.1	-20.4	30.8	10.4	80.8	60.8	50.0	50.4

V/H: Vertical / Horizontal polarization
AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss including an attenuator/filter if used
Peak Actual = Peak Reading - AMP + AF + CL
AV Actual = Peak Reading - AMP + AF + CL+ DCCF
DCCF = 20*LOG(Transmission On-time/100 ms)
Margin = Limit – Actual

For the measurements from 30 MHz to 1 GHz with CISPR quasi-peak detector
(emissions in the restricted bands specified in 15.205)
Z-axis is worst-case configuration among 3 axis.

Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)	AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Remark
40.222	V	1.00	31.9	30.7	19.9	0.8	21.9	40.0	18.1	Z-axis
99.573	V	1.00	32.8	30.2	14.7	1.3	18.6	43.5	24.9	

V/H: Vertical / Horizontal polarization
AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss including an attenuator/filter if used
Actual = Reading - AMP + AF + CL
Margin = Limit - Actual

For the measurements above 1 GHz (for Z-axis)

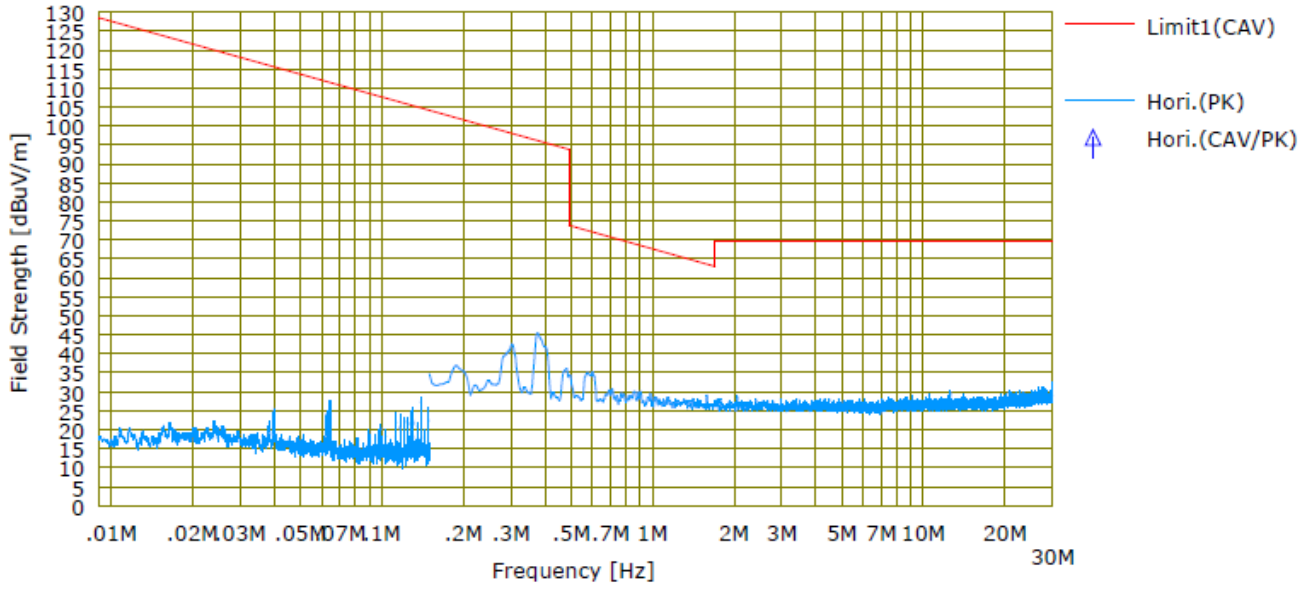
Frequency (MHz)	Pol. (V/H)	Height (m)	Reading (dBμV)		AMP (dB)	AF (dB/m)	CL (dB)	Actual (dBμV/m)		Limit (dBμV/m)		Margin (dB)	
			PK	AV				PK	AV	PK	AV	PK	AV

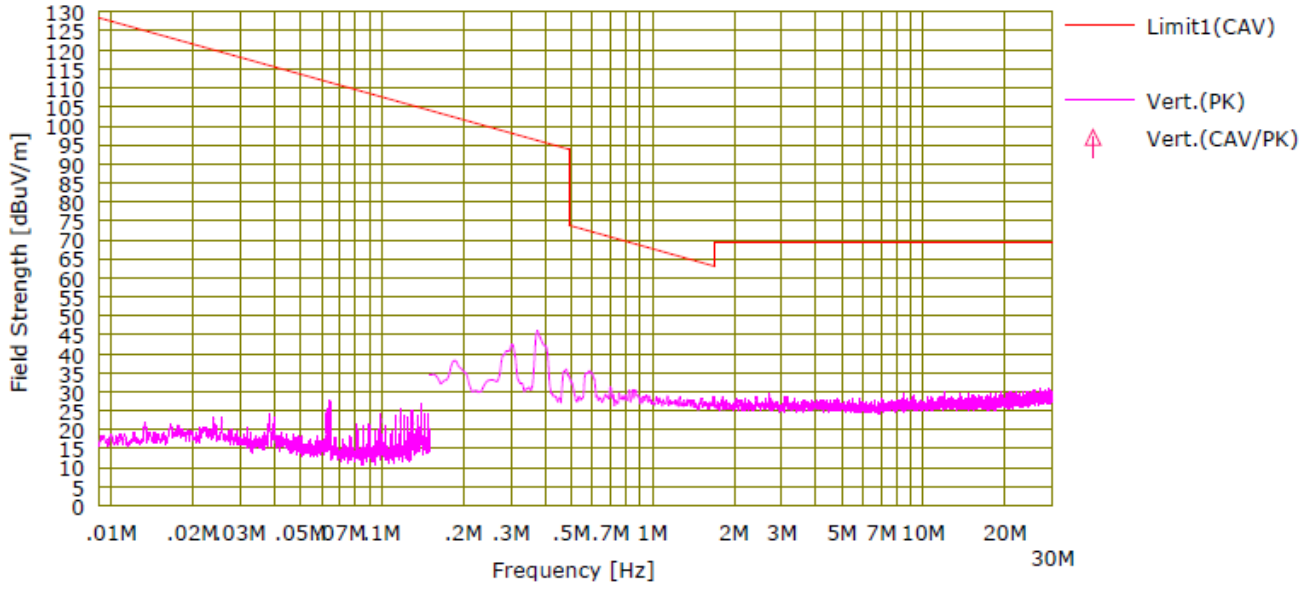
No Radiated Spurious Emissions Found

V/H: Vertical / Horizontal polarization
AMP, AF and CL: pre-amplifier gain, antenna factor and cable loss including an attenuator/filter if used
Actual = Reading - AMP + AF + CL
Margin = Limit - Actual

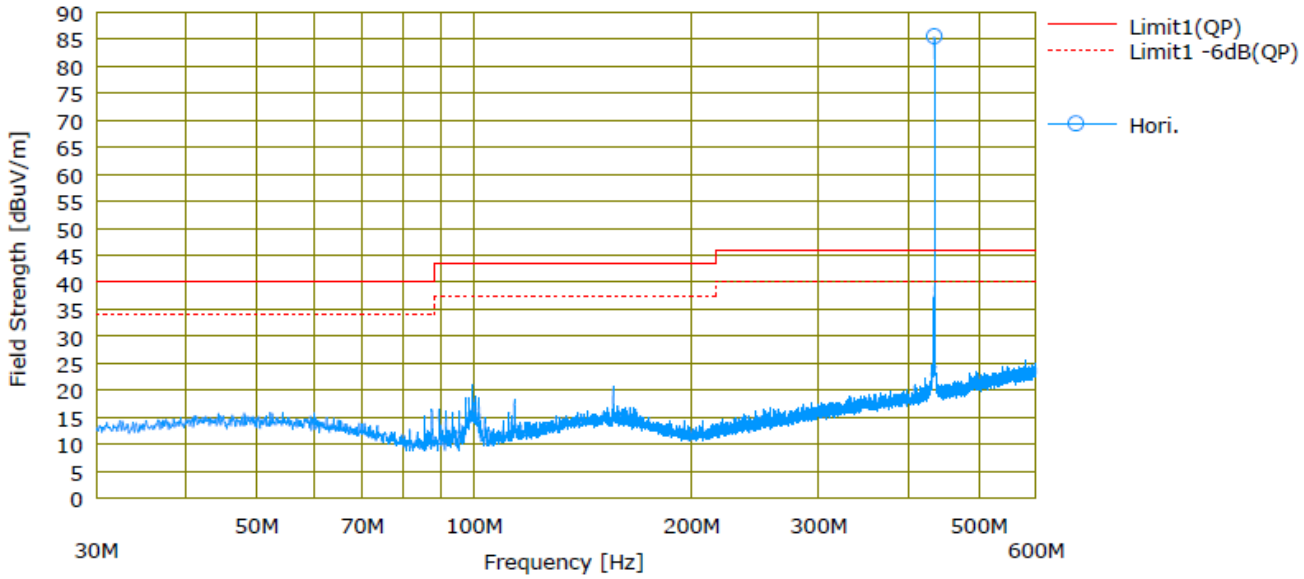
Figure 4. Emission plot for the preliminary radiated measurements
The worst-case plots were attached.(Z-axis)

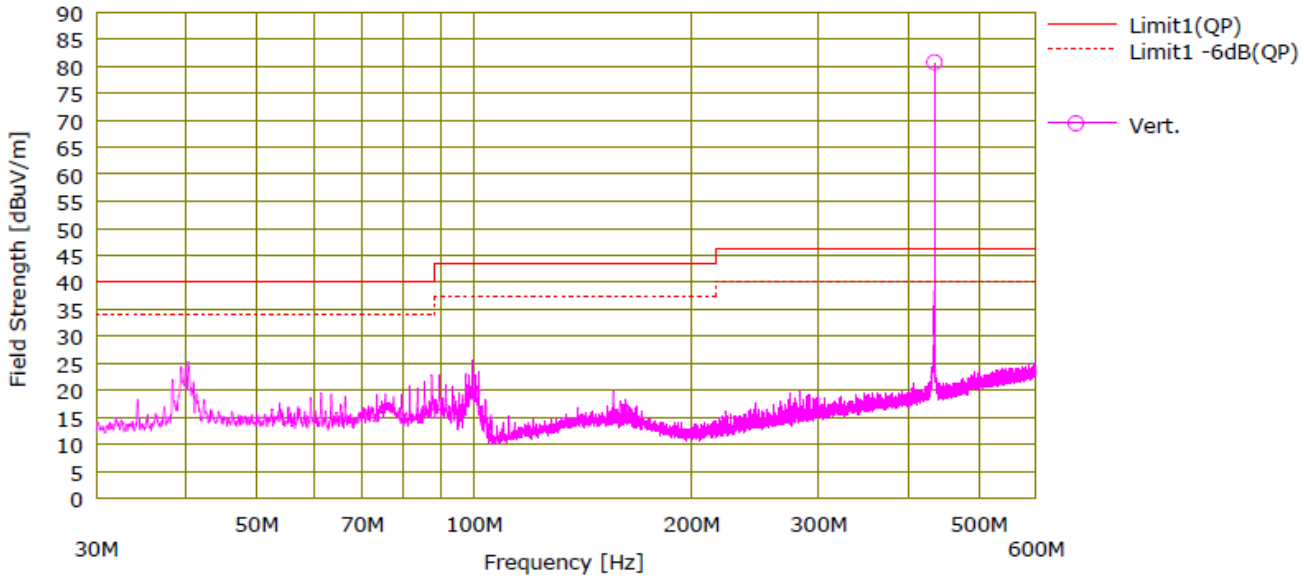
Measurement frequency range: 9 kHz to 30 MHz



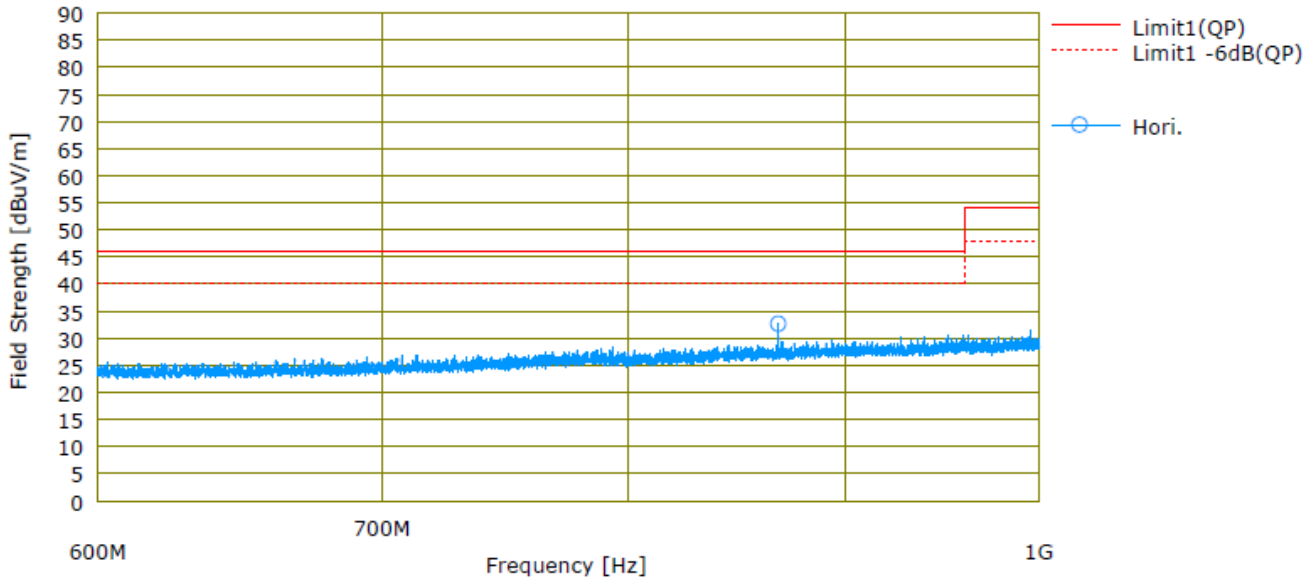


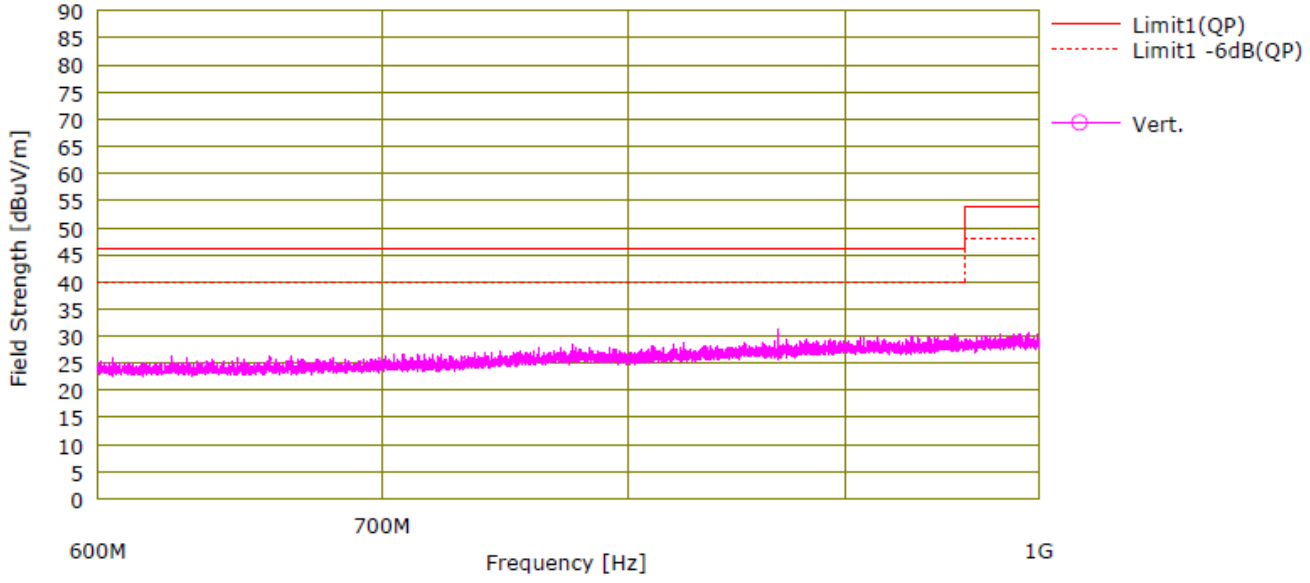
Measurement frequency range: 30 MHz to 600 MHz





Measurement frequency range: 600 MHz to 1 GHz





Measurement frequency range: 1 GHz to 5 GHz