TEST REPORT

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Test Report Number: SKT-RFC-220006
Date of issue: October 7, 2022

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:	SMK CONTROLLER UNIT
Model:	**SMK-DWS-00**
FCC ID:	ZE8- SMK-DWS-00
Project number:	SKTEU22-0958
EUT received:	July 6, 2022
Applied standards:	ANSI C63.10-2020 ANSI C63.4-2014 and ANSI C63.4a-2017
Rule parts:	FCC Part 15 Subpart C - Intentional radiators
Equipment Class:	**DCD - Part 15 Low Power Transmitter Below 1705kHz**
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.

Wonsik Ham / **Testing Engineer**

Jongsoo Yoon / **Technical Manager**

Revision History of Test Report

Rev.	Revisions	Effect page	Approved by	Date
-	Initial issue	All	Jongsoo Yoon	Oct. 7, 2022

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1 Summary of test results

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203	Meets the requirements
Radiated Emissions	15.209(a)	Meets the requirements
AC power line Conducted emissions	15.207(a)	N/A

Note: *The EUT is operated from the battery (DC 12 V or DC 24 V) in a vehicle, and therefore the test suites related to AC Mains port were not applicable.*

2 Description of equipment under test (EUT)

Product:	SMK CONTROLLER UNIT
Model:	SMK-DWS-00
Serial number:	None (prototype)

Model differences:

Model name	Difference	Tested (checked)
SMK-DWS-00	fully tested model that was provided by the applicant	☒

Technical data:

Power source	DC 12 V / DC 24 V (powered from the battery in a vehicle)	
Local Oscillator or X-Tal	4 MHz, 8 MHz, 16 MHz, 26 MHz	
Transmit Frequency	433.92 MHz	133 kHz
Antenna Type	Integral chip antenna	Integral loop coil antenna (3 pcs)
Type of Modulation	GFSK	ASK
RF Output power	96.9 dBμV/m (PEAK) (measured @ 3m)	92.1 dBμV/m(AVERAGE) (measured @ 3m)

Note: ** The test report for Equipment Class DSC was issued with other test report number.*
*** The test report for the compliance with FCC Part 15B as a digital device was issued with other test report number.*

I/O port	Type	Q'ty	Remark
CN1	26-pin connector (DC IN, ACC, Actuator, etc.)	1	
CN2	16-pin connector (LF ANT, SSB ANT, CAN. etc.)	1	

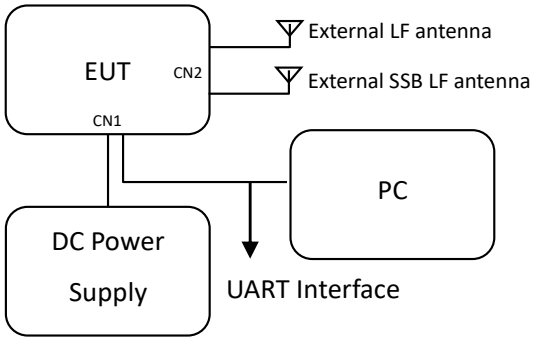
Modification of EUT during the compliance testing:

The firmware of the EUT was modified for the tests in order to select the transmitting LF antenna. The EUT was operated in the test mode by using Tera Term Program to change the operating mode (Internal LF 133 kHz TX, External LF 133 kHz TX, External SSB LF 134 kHz TX and Stand-by).

3 Test and measurement conditions

3.1. Test configuration (arrangement of EUT)

The EUT was operated from DC Power Supply (12 V or 24 V). The measurements were taken while the EUT was transmitting the RF signals. For the radiated measurements, the PC was removed after setting the EUT in transmitting mode.



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	DC Power Supply	HP	6633A	2838A-01000

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)
1	EUT	DC IN	DC Power Supply	DC OUT	2.0	N

3.4. Measurement Uncertainty (*U*)

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = k \times Uc$ (k = 2)
Conducted RF power	±0.64 dB	±1.28 dB
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

3.5. Test date

Date Tested	September 19, 2022 – September 22, 2022

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 FAR used for the radiated spurious emissions fulfills the NSA requirements specified in ETSI TS 102 321 V1.1.1 (2004-05) and ETSI TR 102 273-2 V1.2.1 (2001-12). The measuring apparatus and ancillary equipment conform to CISPR 16-1 series.

4.2. Accreditations

The laboratory has been also notified to FCC and ISED by RRA as a Conformity Assessment Body, and designated to perform compliance testing on equipment subject to Certification under Parts 15, 18, 22, 24, 25, 27, 74, 90, 95, 97 and 101 of the FCC Rules, and RSS-GEN, RSS-170, RSS-210, RSS-247, RSS-248, and RSS-102 (RF Exp.)[MEAS].

Designation No.	KR0007
Company Number (IC)	5429A

4.3. List of test and measurement instruments

No	Description	Model	Manufacturer	Serial No.	Cal. due	Use
1	EMI Test Receiver	ESR26	Rohde&Schwarz	101441	2023.06.29	☒
2	Signal and Spectrum Analyzer	FSW67	Rohde&Schwarz	101371	2023.05.17	
3	Pre-amplifier (30 MHz - 1 GHz)	MLA-10K01-B01-27	TSJ	2005350	2023.05.11	☒
4	Pre-amplifier (1 GHz - 18 GHz)	MLA-0118-J01-40	TSJ	14879	2023.05.09	
5	Attenuator (6dB)	18N5W	API Technology	-	2023.06.08	☒
6	Loop Antenna	HFH2-Z2E	Rohde&Schwarz	100883	2023.12.16	☒
7	BILOG Broadband Antenna	VULB9168	Schwarzbeck	9168-230	2023.06.08	☒
9	DC Power Supply	6633A	HP	2838A-01000	2023.05.09	☒
10	Vector Signal Generator	E4438C	Agilent	MY42080359	2023.02.07	
11	Digital Thermo-Hygrometer	608-H1	Testo	-	2023.05.20	☒

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 three antennas, and meets the requirements of this section.

(a) Internal loop antenna

(b) External LF antenna (loop antenna) connected to CN2 with 2-pin connector

(c) External SSB LF antenna (loop antenna) connected to CN2 with 4-pin connector (with DC power line)

5.2. Radiated emissions

5.2.1 Regulation

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

The EUT repeatedly transmitted RF signals and the following measurement procedure specified in ANSI C63.10-2020 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

5.2.3 Calculation of the field strength limits below 30 MHz

(a) 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.
(b) 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).
(c) All following emission measurements were performed using the test receiver's average, peak, and quasi-peak detector function with specified bandwidth.
(d) 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 Results: PASS

Table 1: Measured values of the Field strength - Internal LF antenna

X-axis is worst-case configuration among 3 axis.

For the measurements under below 30 MHz (DC 12 V)

Freq. (MHz)	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	
0.133	0.2	72.2	71.1	-	20.9	0.1	93.2	92.1	-	125.1	105.1	-	31.9	13.0	-	X-axis
0.267	9	43.9	41.7	-	20.9	0.1	64.9	62.7	-	119.1	99.1	-	54.2	36.4	-	
0.533	9	-	-	31.1	20.9	0.1	-	-	52.1	-	-	73.1	-	-	21.0	

For the measurements under below 30 MHz (DC 24 V)

Freq. (MHz)	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	
0.133	0.2	72.0	71.0	-	20.9	0.1	93.0	92.0	-	125.1	105.1	-	32.1	13.1	-	X-axis
0.267	9	43.6	41.4	-	20.9	0.1	64.6	62.4	-	119.1	99.1	-	54.5	36.7	-	
0.533	9	-	-	30.8	20.9	0.1	-	-	51.8	-	-	73.1	-	-	21.3	

Actual (dBμV/m) = Reading + AF + Cable Loss

Margin (dB) = Limit – Actual

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

Table 2: Measured values of the Field strength - External LF antenna

Z-axis is worst-case configuration among 3 axis.

For the measurements under below 30 MHz (DC 12 V)

Freq. (MHz)	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	
0.133	0.2	69.1	68.0	-	20.9	0.1	90.1	89.0	-	125.1	105.1	-	35.0	16.1	-	Z-axis
0.533	9	-	-	30.9	20.9	0.1	-	-	51.9	-	-	73.1	-	-	21.2	
12.800	9	-	-	27.8	21.5	0.5	-	-	49.8	-	-	69.5	-	-	19.7	

For the measurements under below 30 MHz (DC 24 V)

Freq. (MHz)	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	
0.133	0.2	69.1	68.0	-	20.9	0.1	90.1	89.0	-	125.1	105.1	-	35.0	16.1	-	Z-axis
0.533	9	-	-	30.8	20.9	0.1	-	-	51.8	-	-	73.1	-	-	21.3	
12.800	9	-	-	27.6	21.5	0.5	-	-	49.6	-	-	69.5	-	-	19.9	

Actual (dBμV/m) = Reading + AF + Cable Loss

Margin (dB) = Limit – Actual

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

Table 3: Measured values of the Field strength - External SSB LF antenna

Y-axis is worst-case configuration among 3 axis.

For the measurements under below 30 MHz (DC 12 V)

Freq. (MHz)	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	
0.135	0.2	53.0	42.3	-	20.9	0.1	74.0	63.3	-	125.0	105.0	-	51.1	41.7	-	Y-axis
10.764	9	-	-	27.0	21.4	0.4	-	-	48.8	-	-	69.5	-	-	20.7	

For the measurements under below 30 MHz (DC 24 V)

Freq. (MHz)	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	
0.135	0.2	53.0	42.1	-	20.9	0.1	74.0	63.1	-	125.0	105.0	-	51.1	41.9	-	Y-axis
10.765	9	-	-	26.5	21.4	0.4	-	-	48.3	-	-	69.5	-	-	21.2	

Actual (dBμV/m) = Reading + AF + Cable Loss

Margin (dB) = Limit – Actual

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

Table 4: Measured values of the Field strength - Internal LF antenna

X-axis is worst-case configuration among 3 axis.

For the measurements from 30 MHz to 1 GHz (Internal LF antenna, DC 12 V)

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
840.001	H	1.00	31.0	30.4	28.7	3.0	32.3	46.0	13.7	X-axis

For the measurements from 30 MHz to 1 GHz (Internal LF antenna, DC 24 V)

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
320.028	H	1.00	33.5	30.0	19.8	1.8	25.1	46.0	20.9	X-axis
823.982	H	1.01	32.3	30.9	28.6	3.0	33.0	46.0	13.0	

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

Table 5: Measured values of the Field strength - External LF antenna

Z-axis is worst-case configuration among 3 axis.

For the measurements from 30 MHz to 1 GHz (External LF antenna, DC 12 V)

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
46.052	V	1.00	43.3	30.6	19.3	0.7	32.7	40.0	7.3	Z-axis
115.623	H	1.78	41.5	29.9	16.1	1.1	28.8	43.5	14.7	

For the measurements from 30 MHz to 1 GHz (External LF antenna, DC 24 V)

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
45.807	V	1.00	43.7	30.6	19.3	0.7	33.1	40.0	6.9	Z-axis
115.548	H	1.69	41.3	29.9	16.1	1.1	28.6	43.5	14.9	

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

Table 6: Measured values of the Field strength - External SSB LF antenna

Y-axis is worst-case configuration among 3 axis.

For the measurements from 30 MHz to 1 GHz (External SSB LF antenna, DC 12 V)

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
32.433	V	1.00	47.7	30.7	18.2	0.6	35.8	40.0	4.2	Y-axis
208.215	H	1.49	46.1	29.5	16.3	1.5	34.4	43.5	9.1	
268.655	H	1.01	41.7	29.7	18.3	1.7	32.0	46.0	14.0	

For the measurements from 30 MHz to 1 GHz (External SSB LF antenna, DC 24 V)

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
32.433	V	1.09	47.5	30.7	18.2	0.6	35.6	40.0	4.4	Y-axis
208.217	H	1.49	47.0	29.5	16.3	1.5	35.3	43.5	8.2	
267.315	H	1.09	42.0	29.7	18.2	1.7	32.2	46.0	13.8	

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

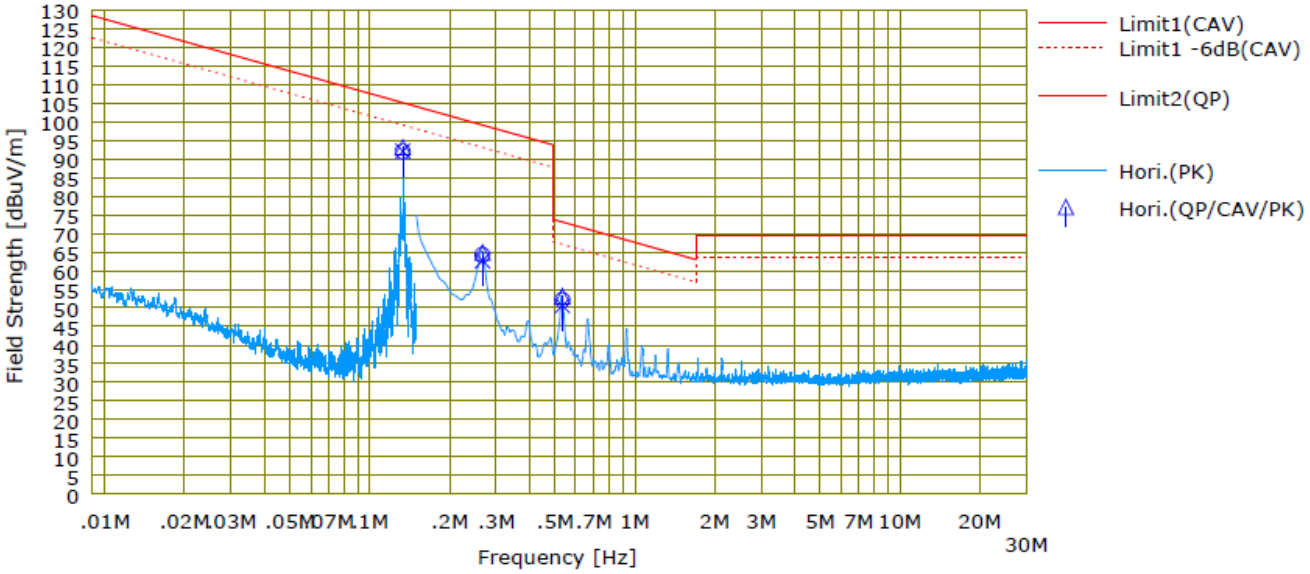
Margin = Limit - Actual

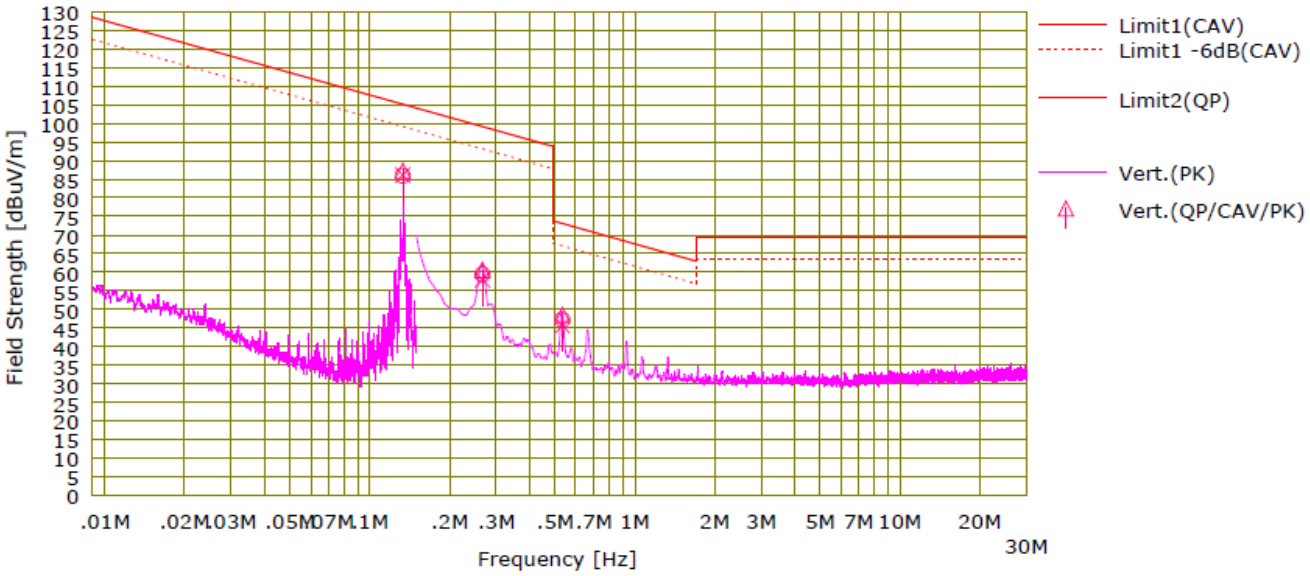
Figure 1. Emission plot for the preliminary radiated measurements

The worst-case plots were attached.

Frequency Range: 9 kHz ~ 30 MHz

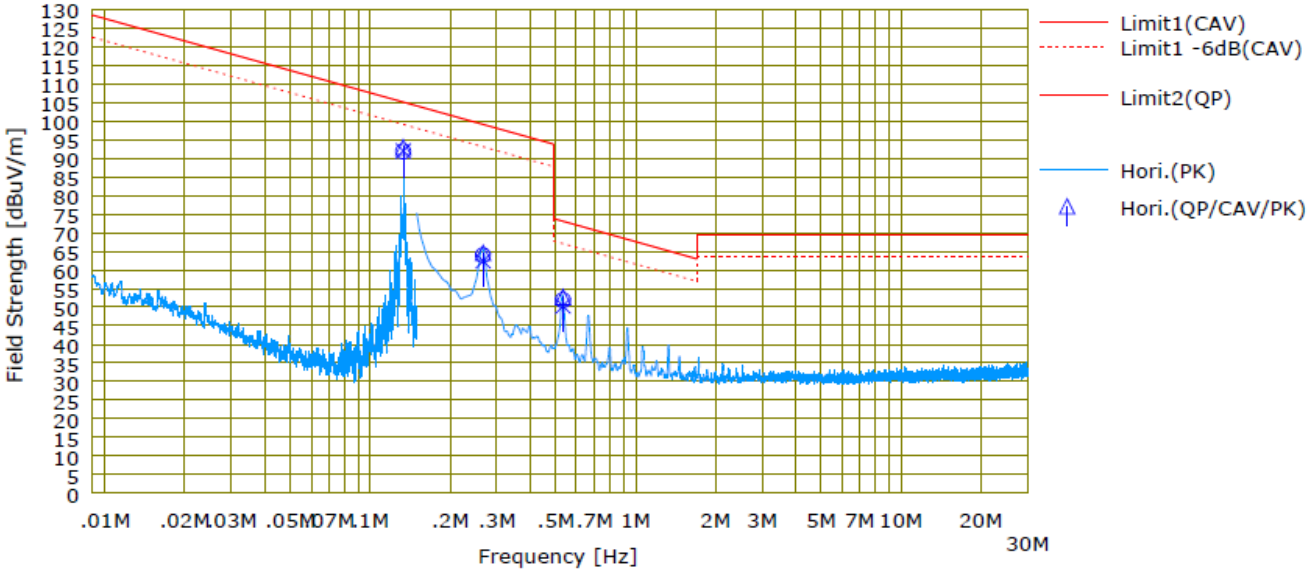
Internal LF antenna (DC 12 V)

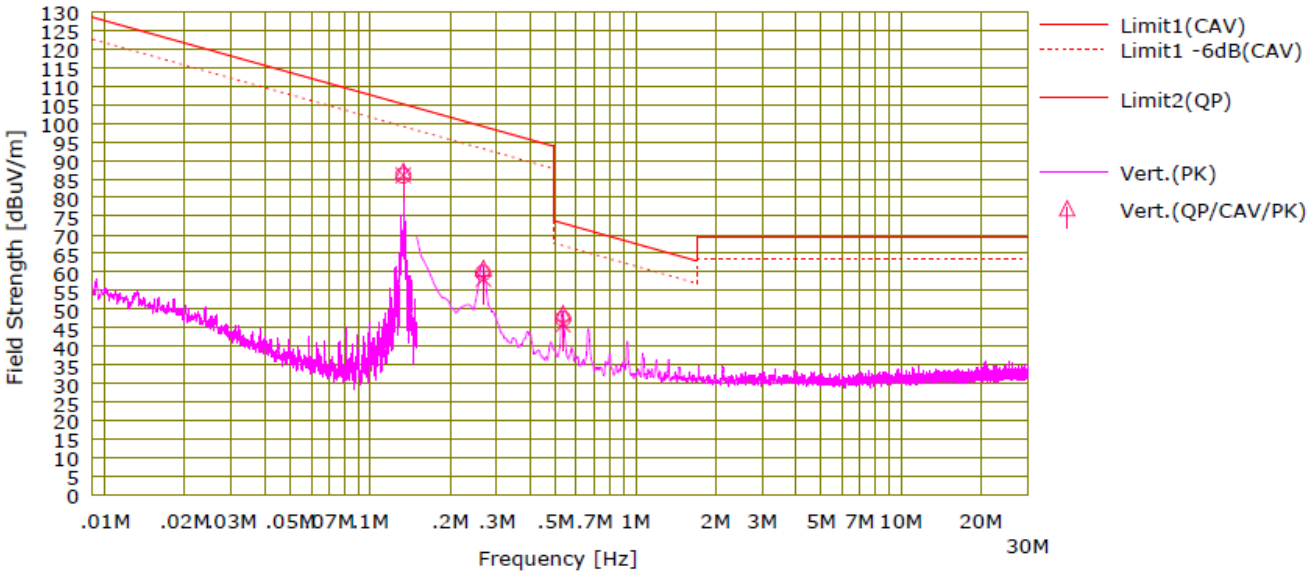




Frequency Range: 9 kHz ~ 30 MHz

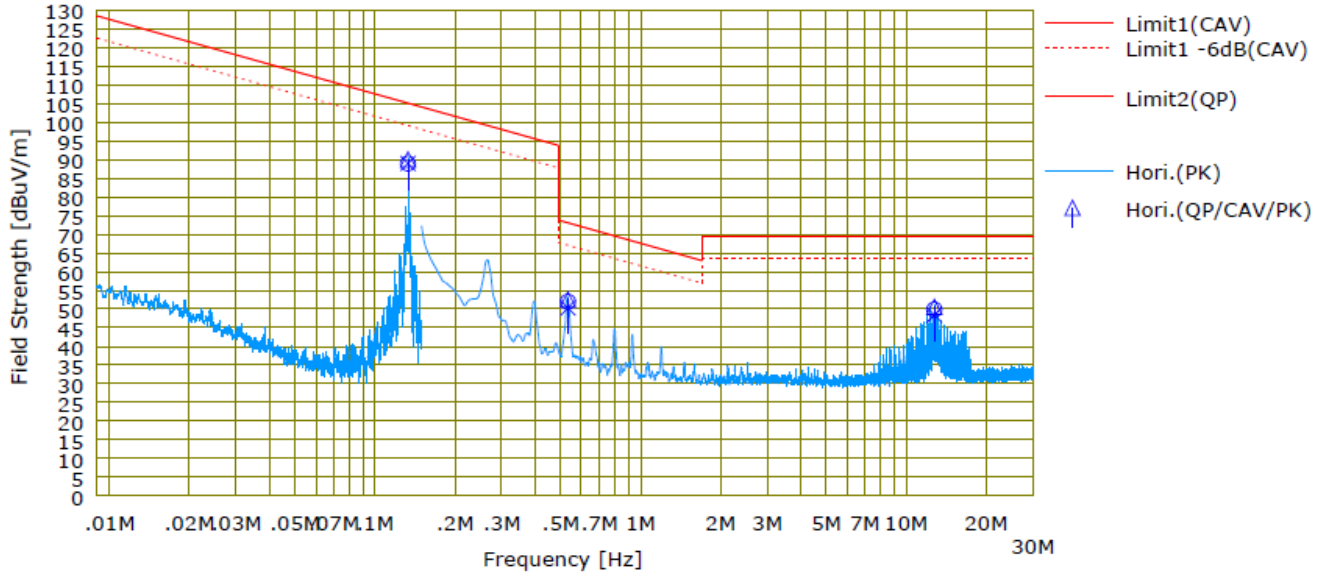
Internal LF antenna (DC 24 V)

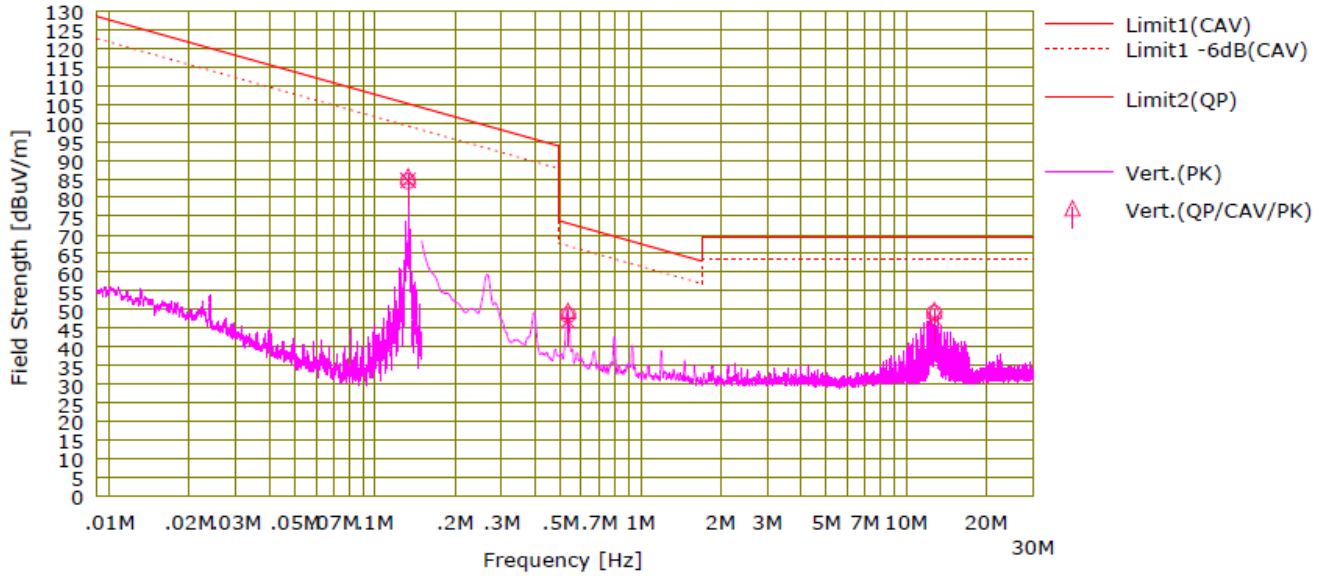




Frequency Range: 9 kHz ~ 30 MHz

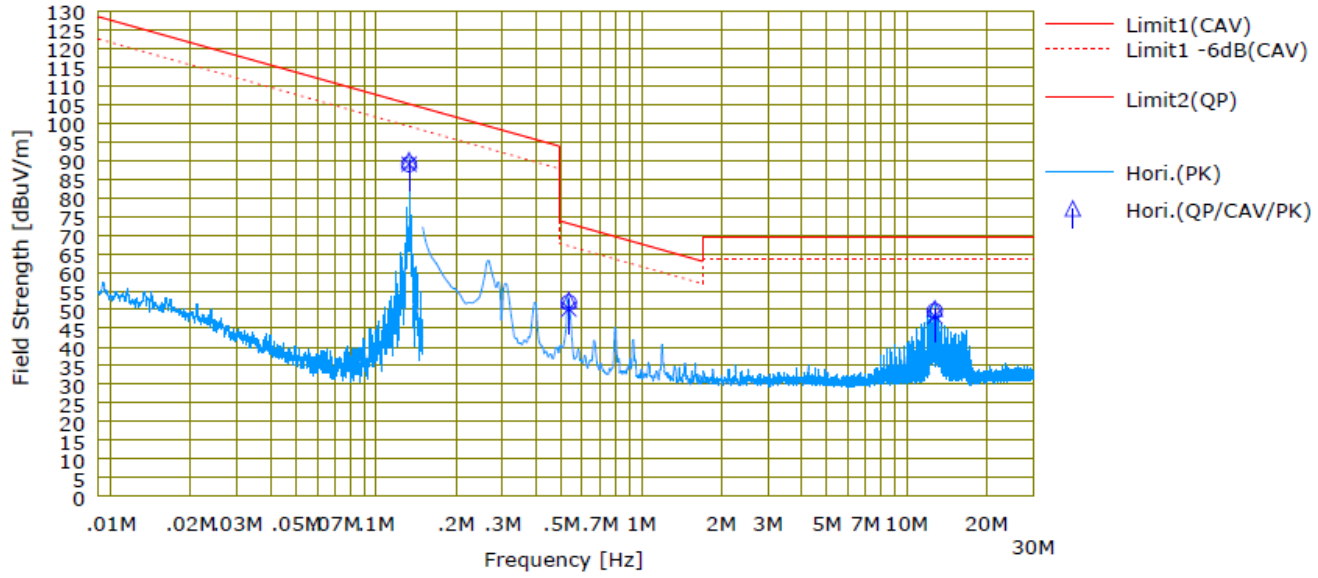
External LF antenna (DC 12 V)

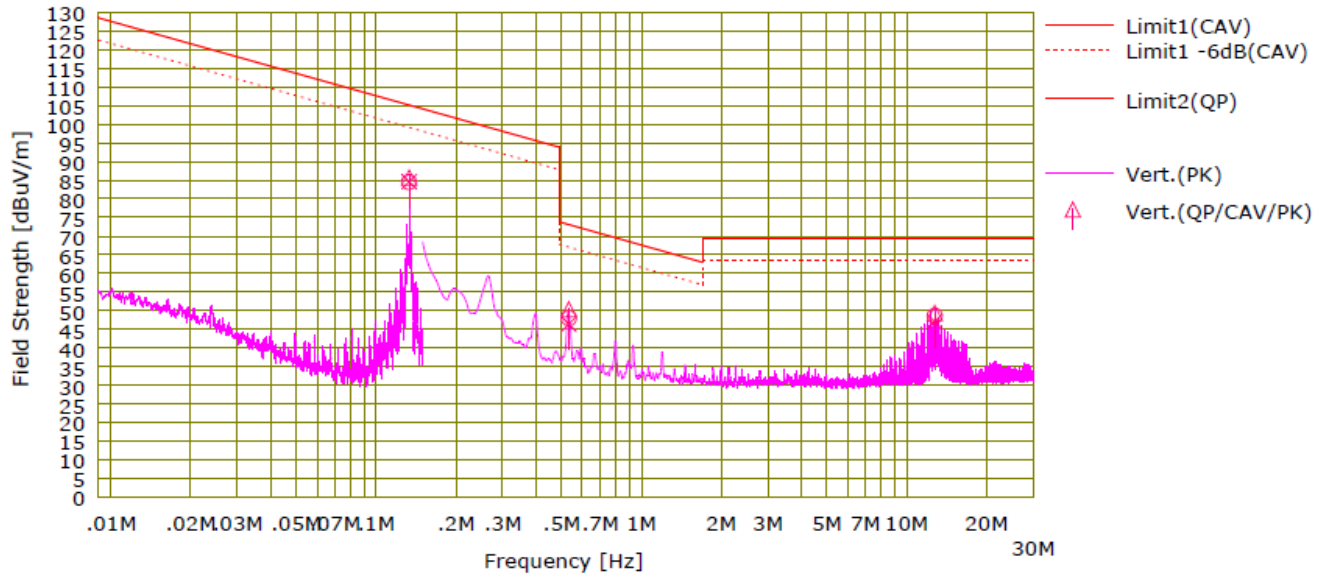




Frequency Range: 9 kHz ~ 30 MHz

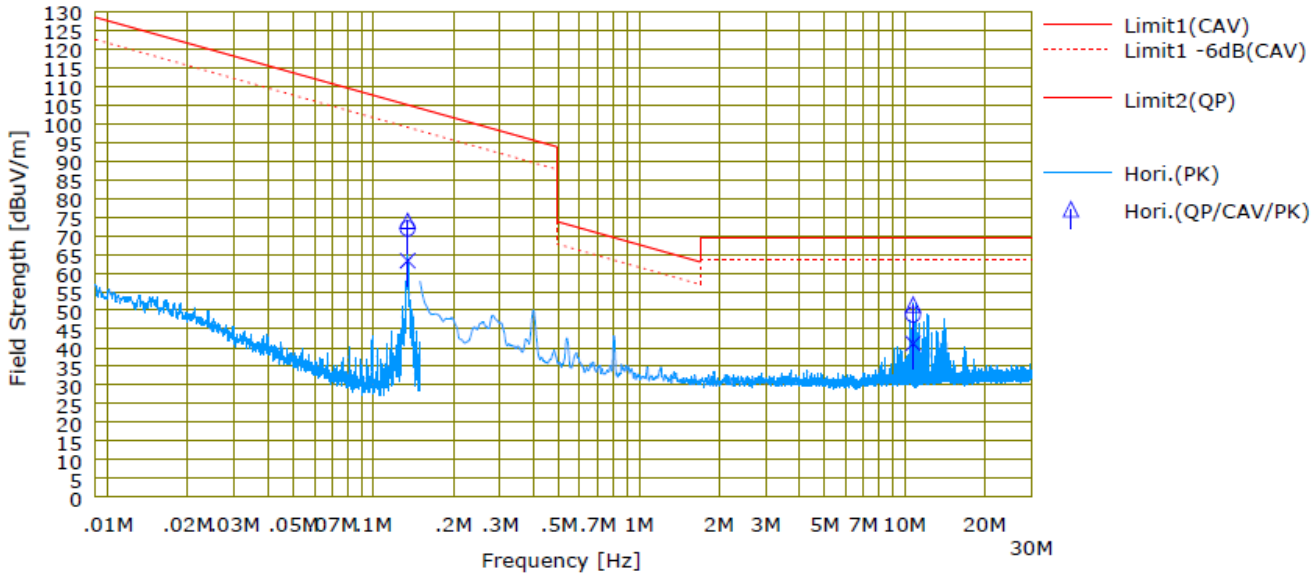
External LF antenna (DC 24 V)

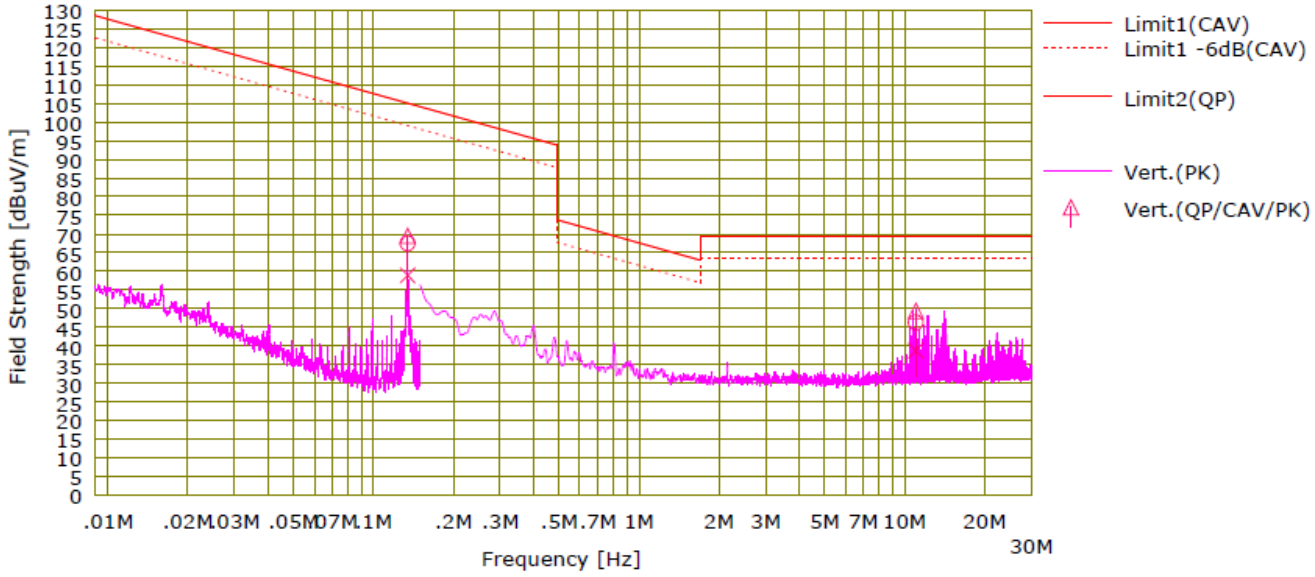




Frequency Range: 9 kHz ~ 30 MHz

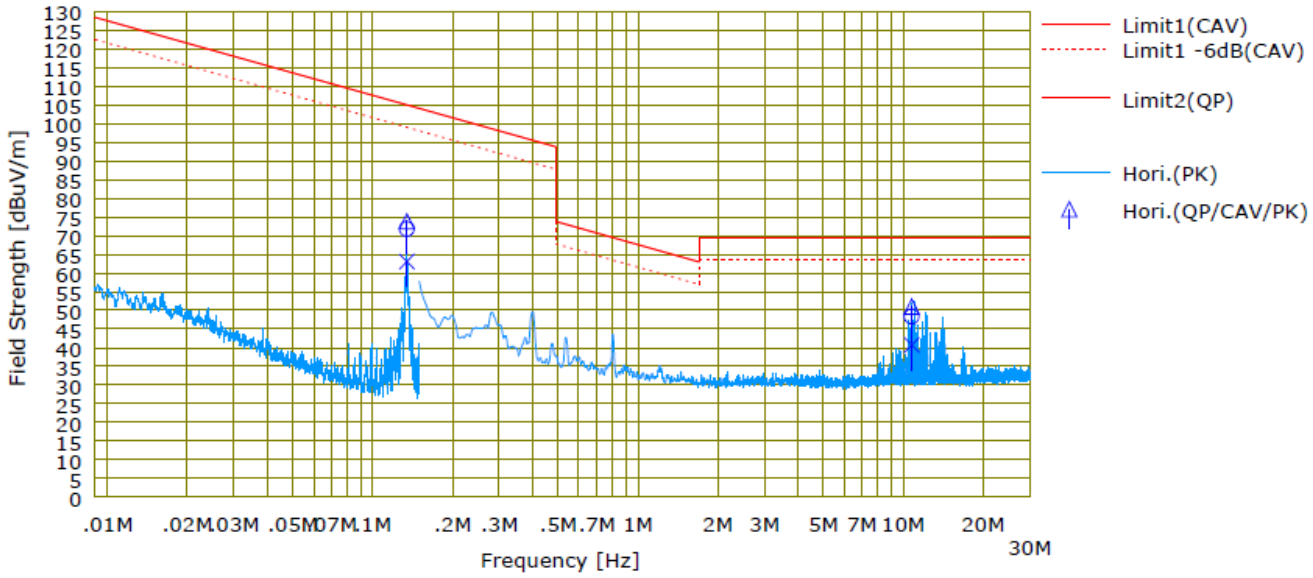
External SSB LF antenna (DC 12 V)

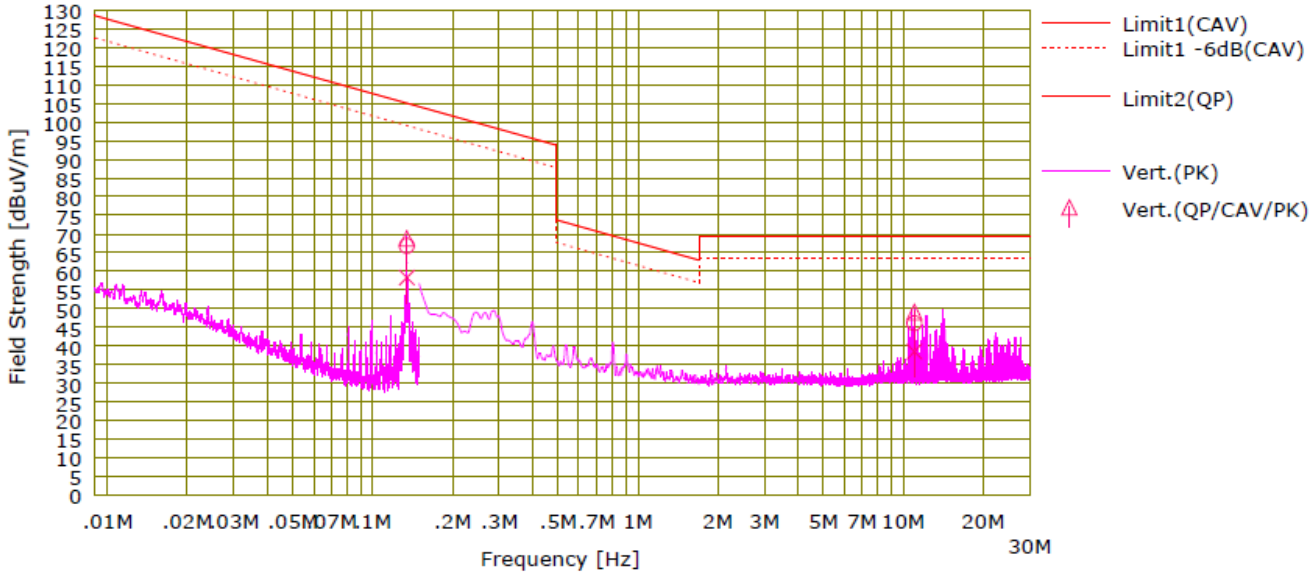




Frequency Range: 9 kHz ~ 30 MHz

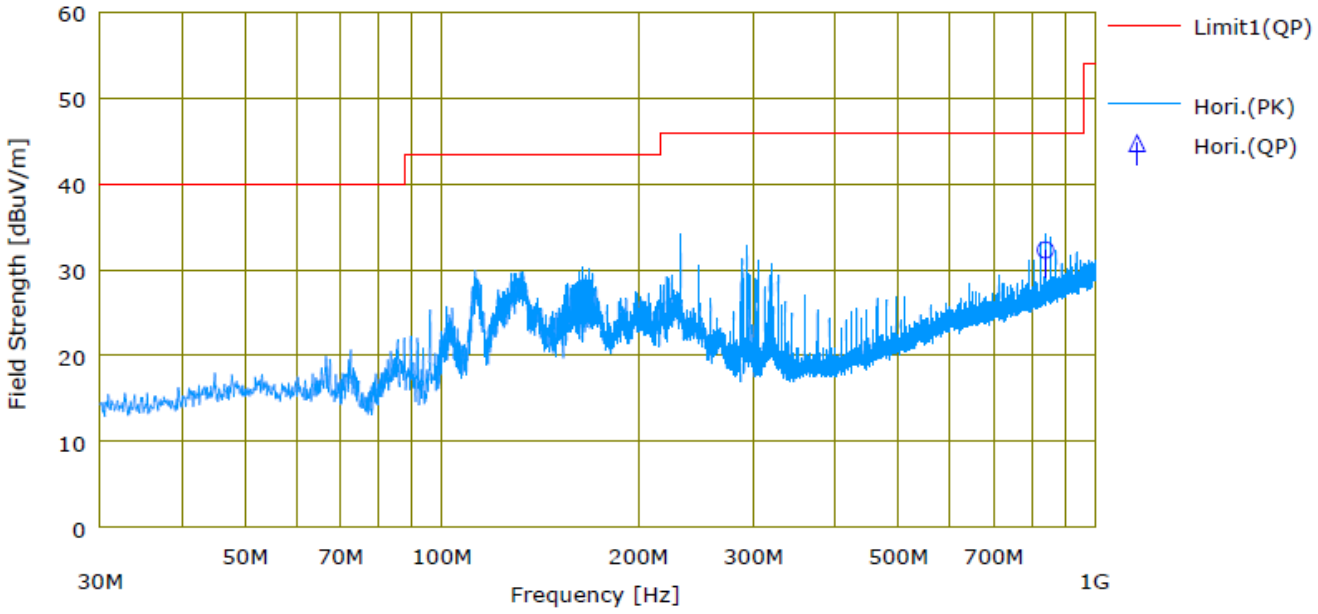
External SSB LF antenna (DC 24 V)

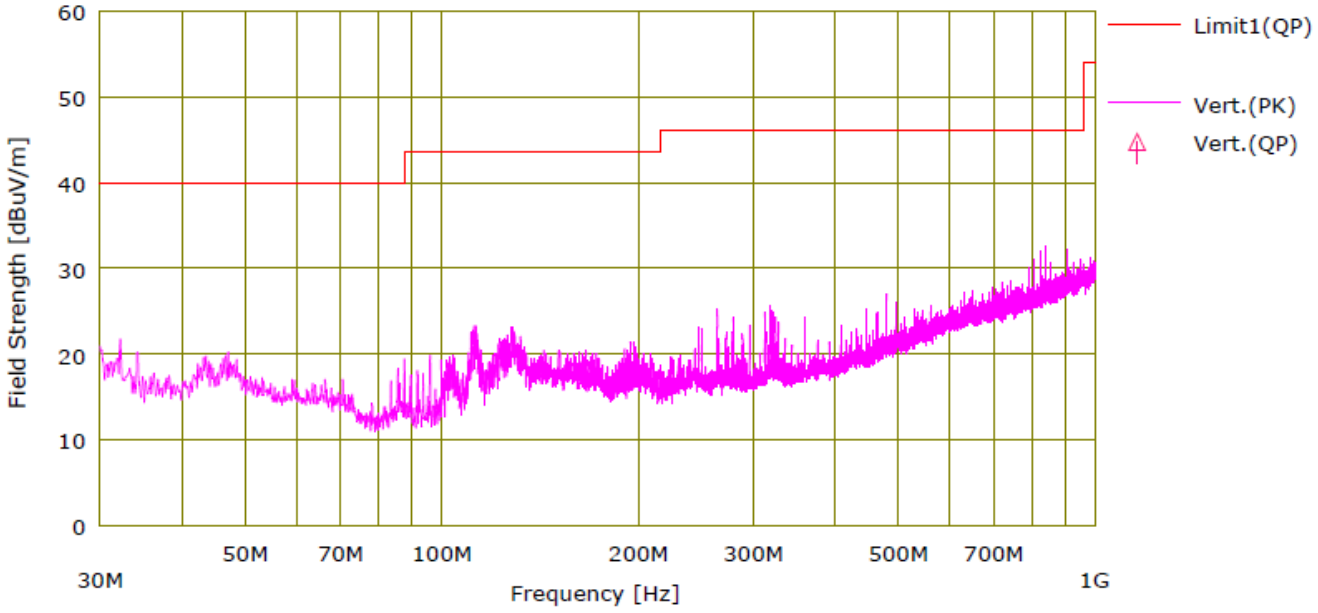




Frequency Range: 30 MHz ~ 1 GHz

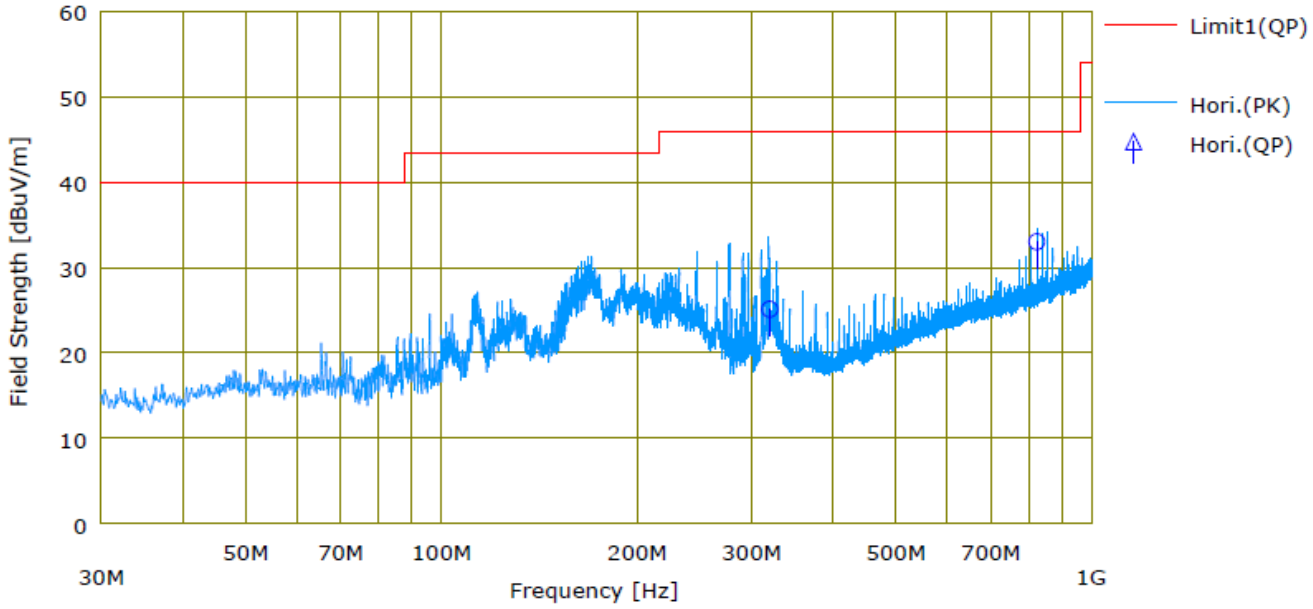
Internal LF antenna (DC 12 V)

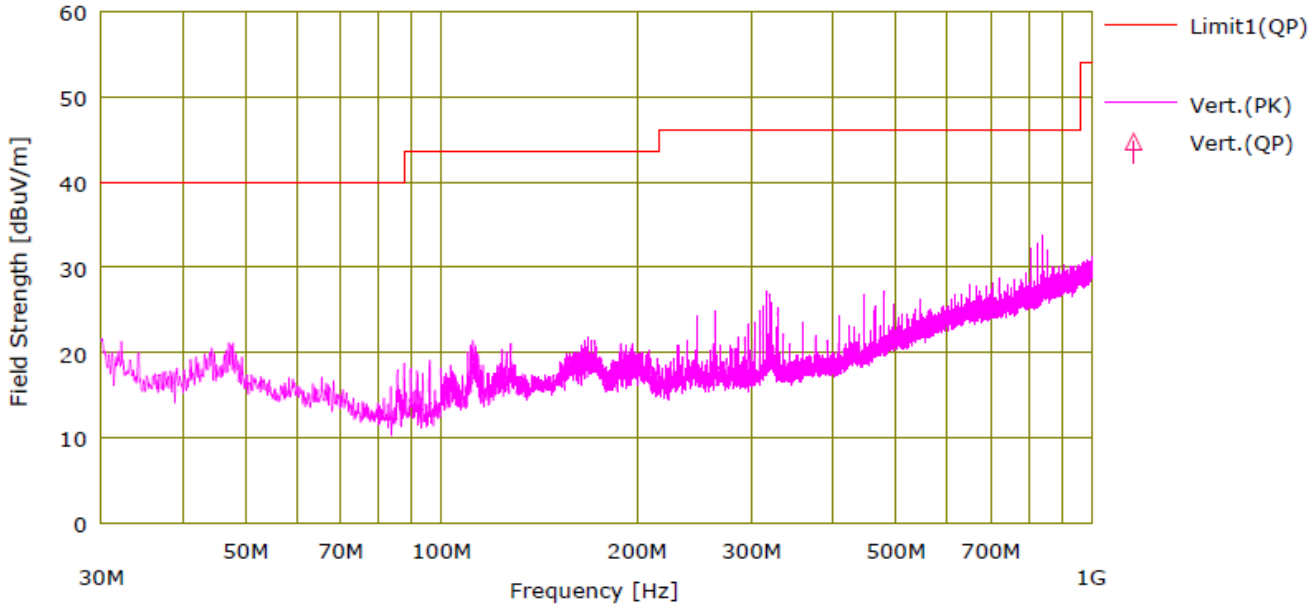




Frequency Range: 30 MHz ~ 1 GHz

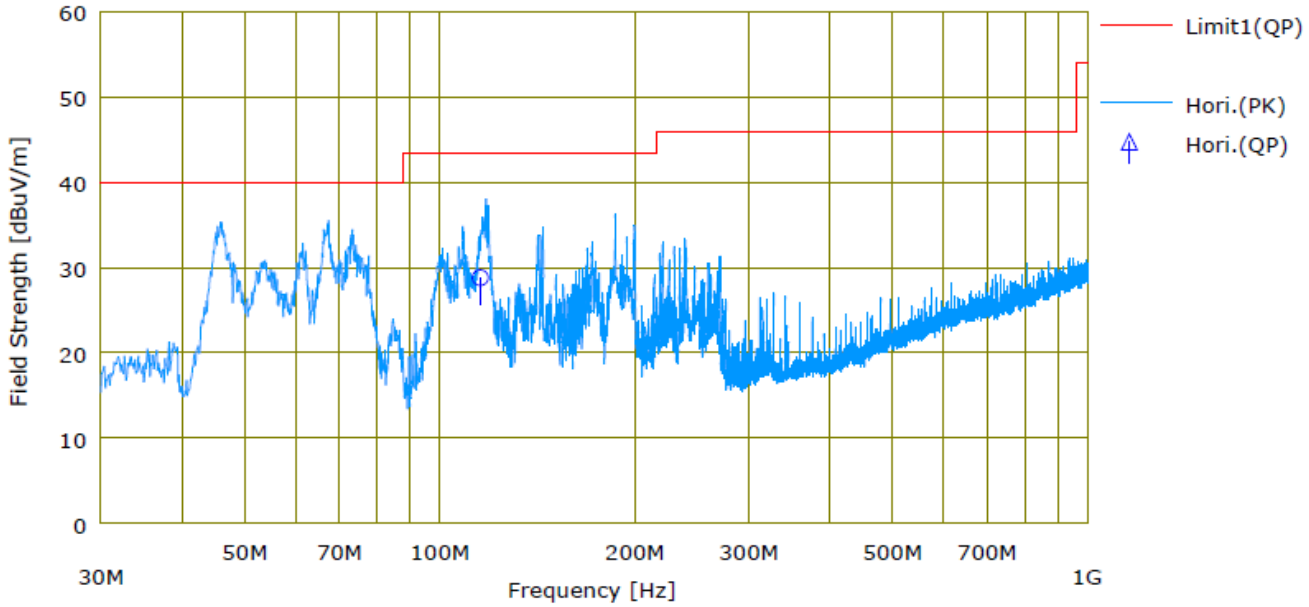
Internal LF antenna (DC 24 V)

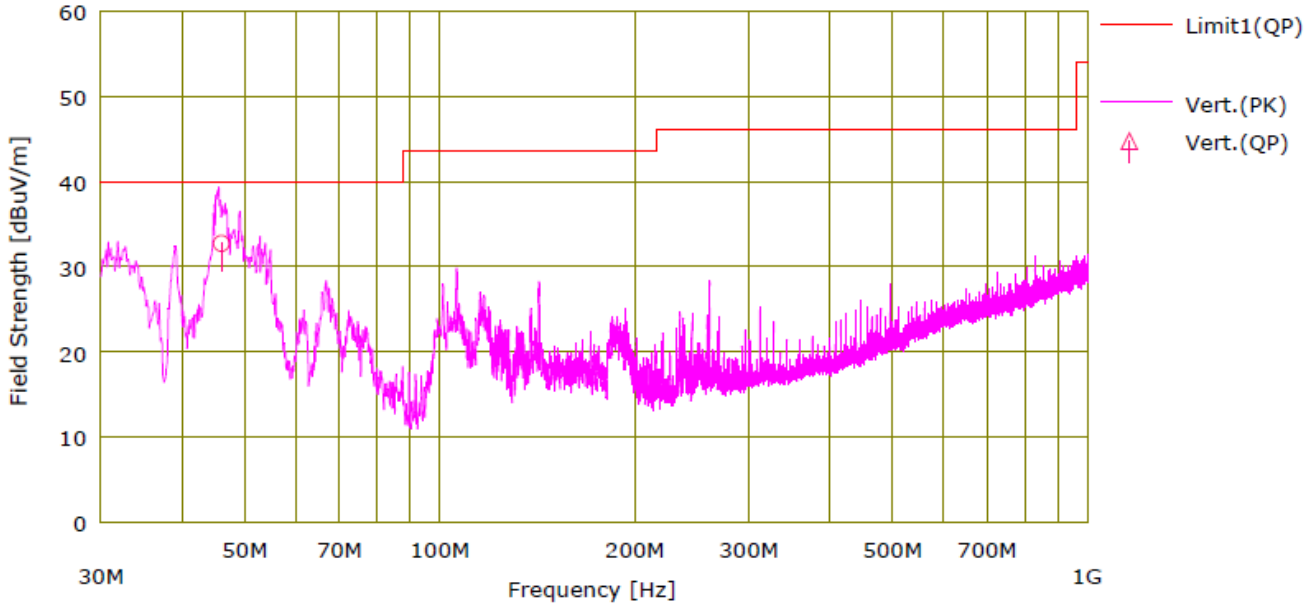




Frequency Range: 30 MHz ~ 1 GHz

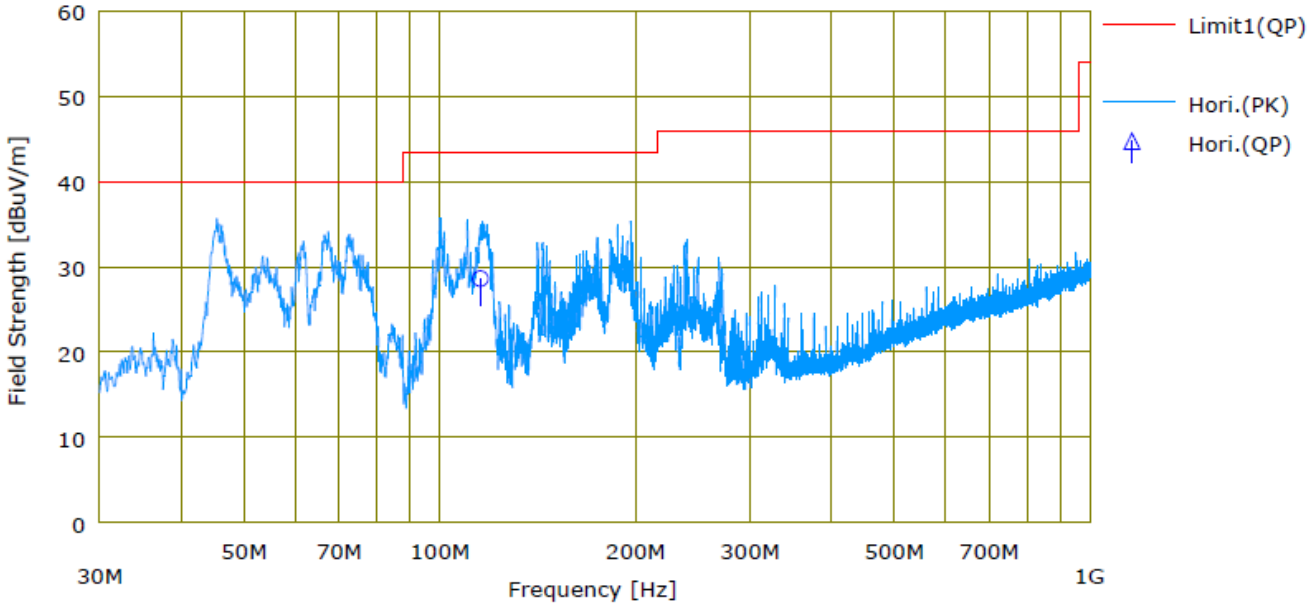
External LF antenna (DC 12 V)

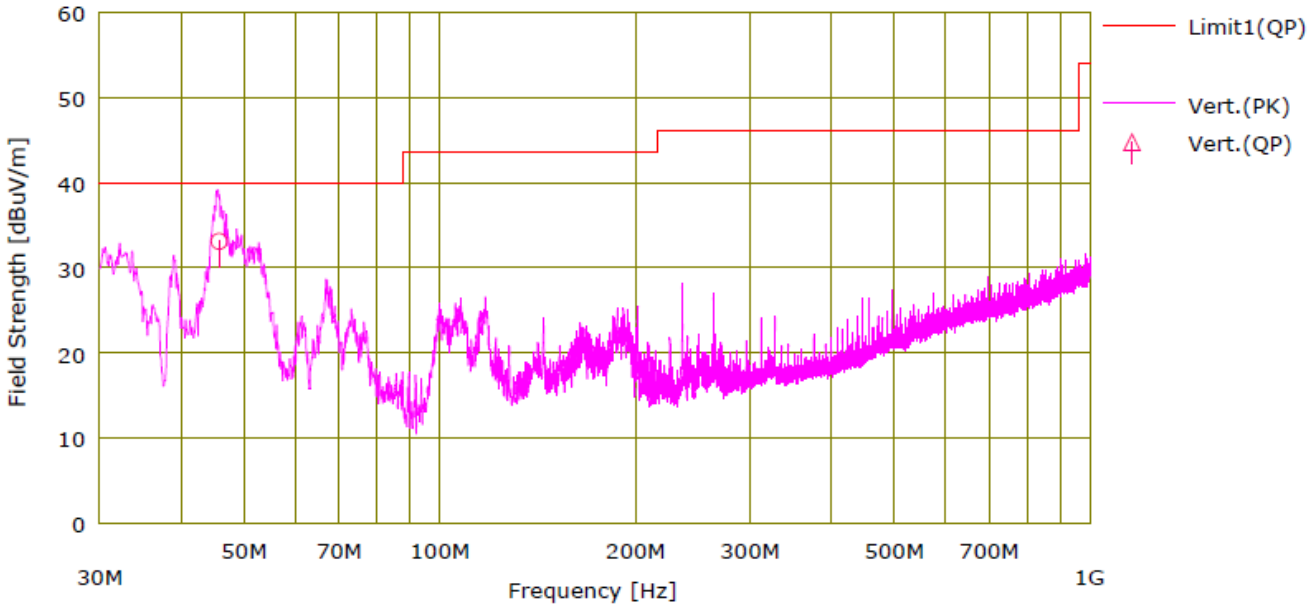




Frequency Range: 30 MHz ~ 1 GHz

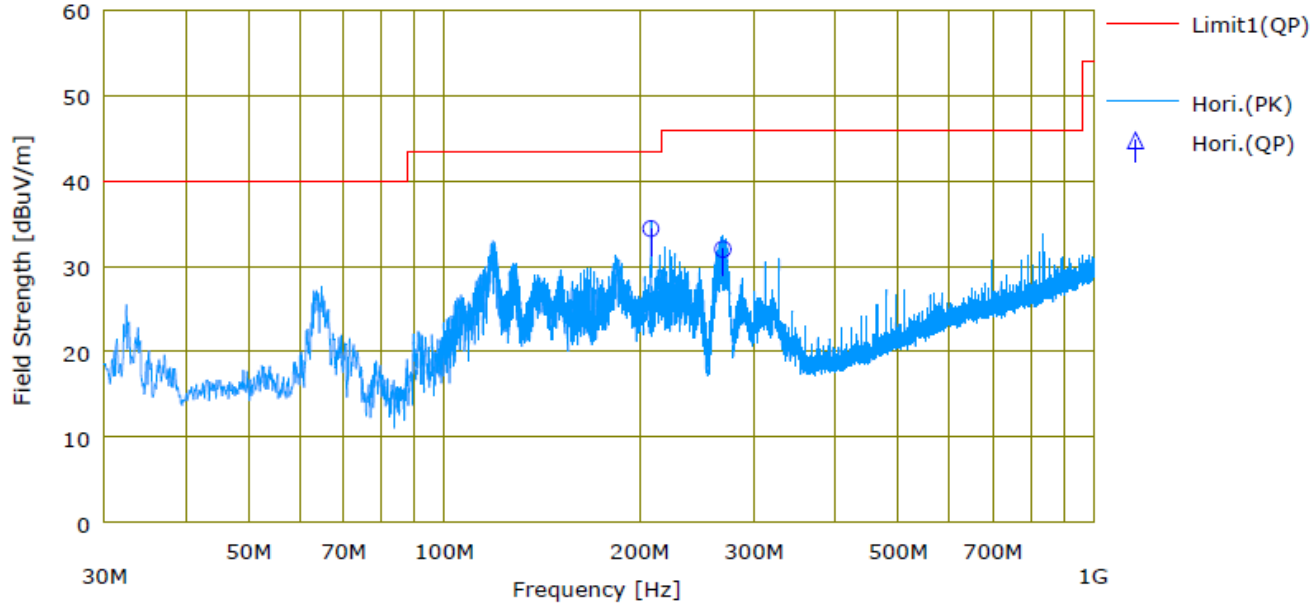
External LF antenna (DC 24 V)

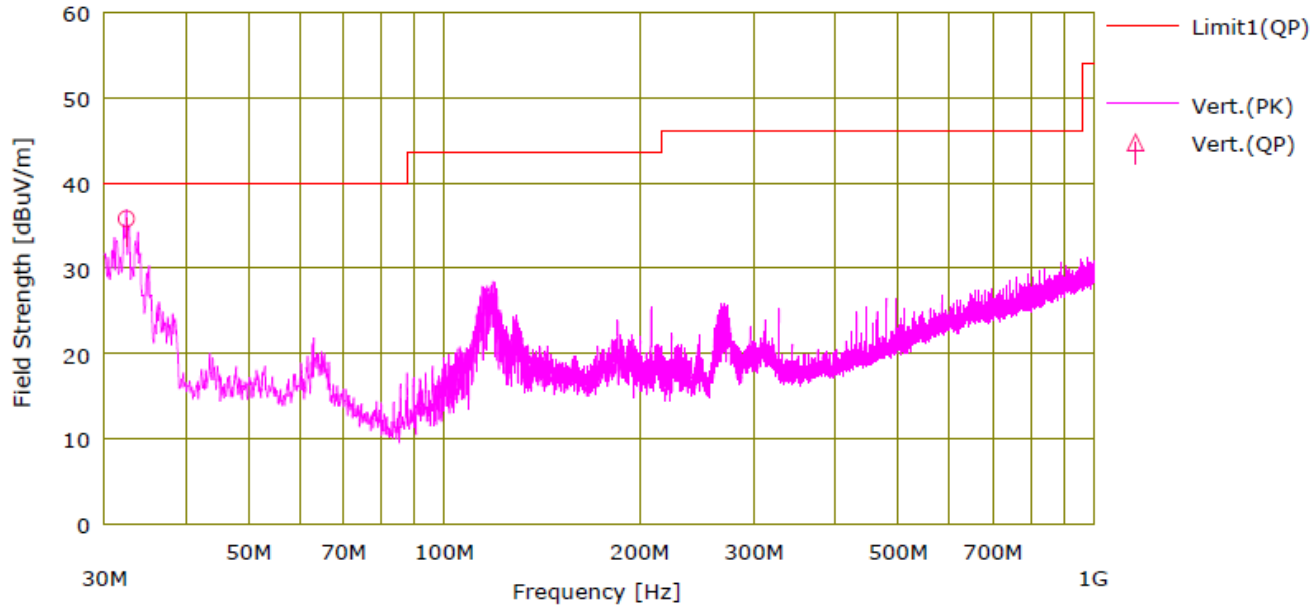




Frequency Range: 30 MHz ~ 1 GHz

External SSB LF antenna (DC 12 V)





Frequency Range: 30 MHz ~ 1 GHz

External SSB LF antenna (DC 24 V)