

King Electrical Manufacturing Company

TEST REPORT

Model:

KRFR-24V

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Radio Spectrum TEST REPORT

Applicant:	King Electrical Manufacturing Company 9131 10th Avenue, South Seattle, WA 98108 USA
Product:	Wireless PTAC controller
Model No.:	KRFR-24V
FCC ID:	2BH5BKRFR-24V
Test Method/ Standard:	47 CFR FCC Part 15.249 & ANSI C63.10 2013
Test By:	Intertek Testing Services Taiwan Ltd., Hsinchu Laboratory No. 17, Ln. 246, Niupu S. Rd., Xiangshan Dist, Hsinchu City 300075, Taiwan



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Revision History

Report No.	Issue Date	Revision Summary
240800011THC-001	Sep. 20, 2024	Original report

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Summary of Tests

Test	Reference	Results
Radiated Emission test	15.249(c), 15.209	Pass
Conducted Emission of AC Power	15.207	Pass
Antenna Requirement	15.203	Pass

Note: Please note that the test results with statement of conformity, the decision rules which are based on: Safety Testing: the specification, standard or IEC Guide 115.

Other Testing: the specification, standard and not taking into account the measurement uncertainty.

1. General Information

1.1 Identification of the EUT

Product:	Wireless PTAC controller
Model No.:	KRFR-24V
Operating Frequency:	915.055MHz
Rating:	1. AC 24V, 50-60Hz 2. DC 24V
Power Cord:	N/A
Sample receiving date:	2024/08/02
Sample condition:	Workable
Test Date(s):	2024/09/10 ~ 2024/09/11

1.2 Antenna description

Antenna Gain : 2.5 dB $\pm$ 2dB
Antenna Type : Monopole Antenna
Connector Type : Fixed

2. Test specifications

2.1 Test standard

The EUT was performed according to the procedures in FCC Part 15 Subpart C Paragraph 15.249 for non-spread spectrum devices.

The test of radiated measurements according to FCC Part15 Section 15.33(a) had been conducted and the field strength of this frequency band were all meet limit requirement, thus we evaluate the EUT pass the specified test.

2.2 Operation mode

TX mode: Power on the EUT and it will transmit continuously.

Mode	Frequency (MHz)	Signal on time (ms)	Signal on & off time (ms)	Duty cycle	Duty Cycle factor
FSK	915.055	9.896	100	9.90%	20.09

The signal is maximized through rotation and placement in the three orthogonal axes.



X axis



Y axis



Z axis

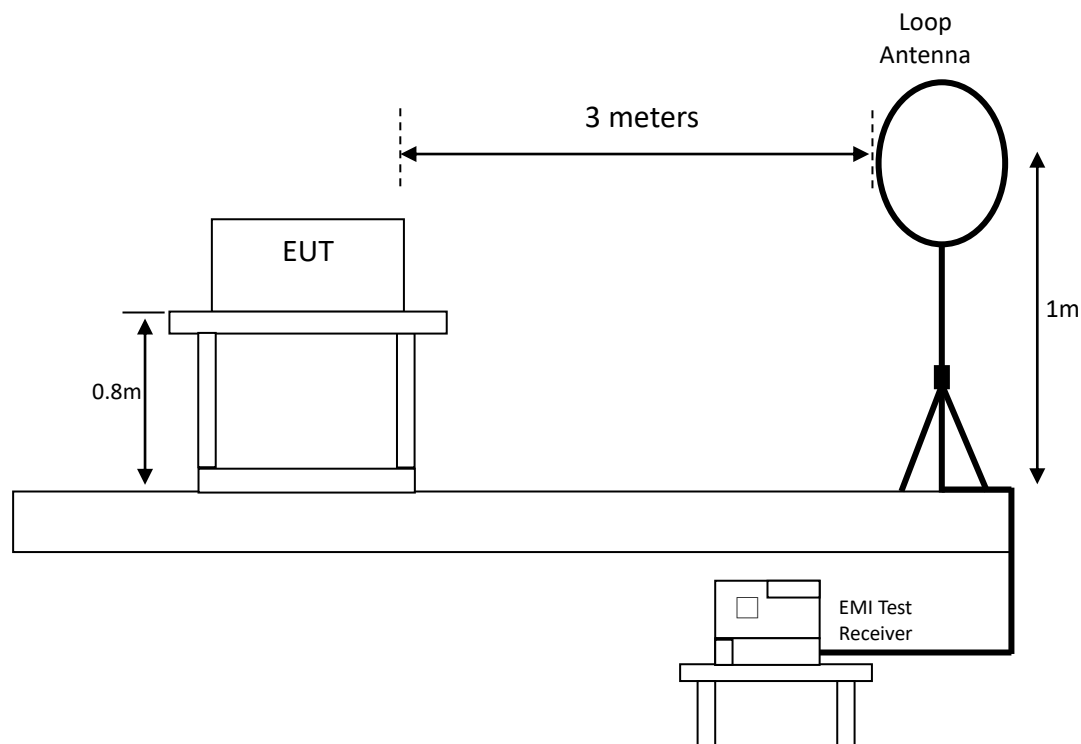
After verifying three axes, we found the maximum electromagnetic field was occurred at Z axis. The final test data was executed under this configuration.

3. Radiated emission test FCC 15.249 (C)

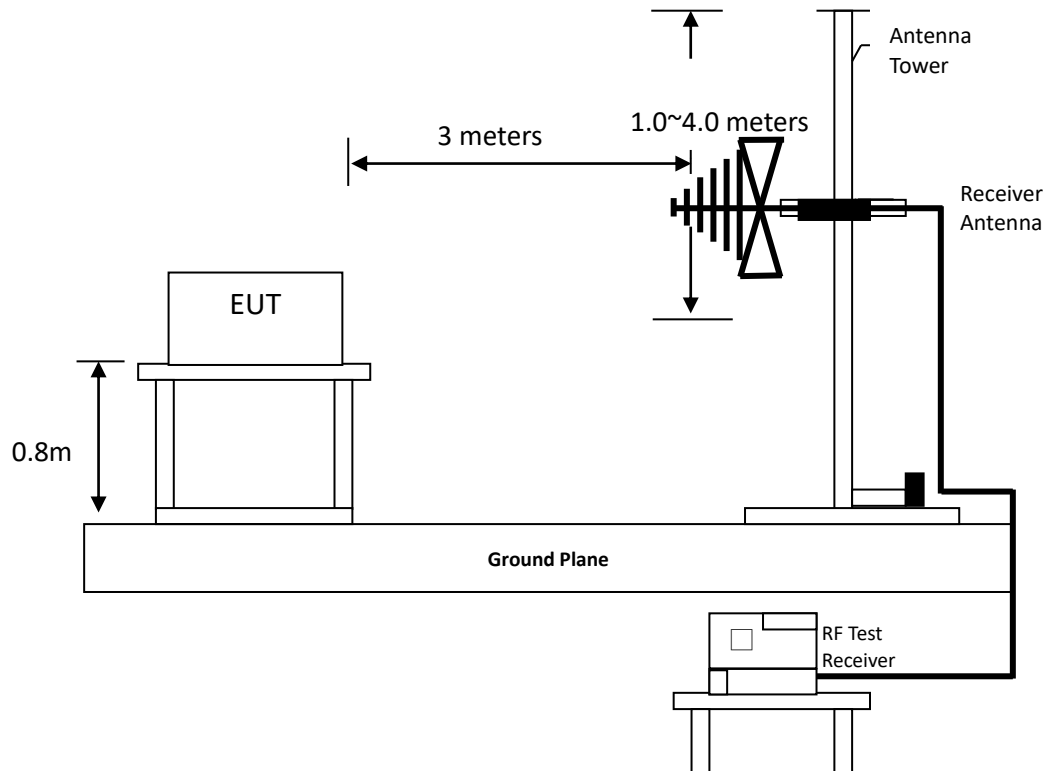
Temperature:	25	°C
Relative Humidity:	71	%
Test Date:	2024/09/10	

3.1 Test setup & procedure

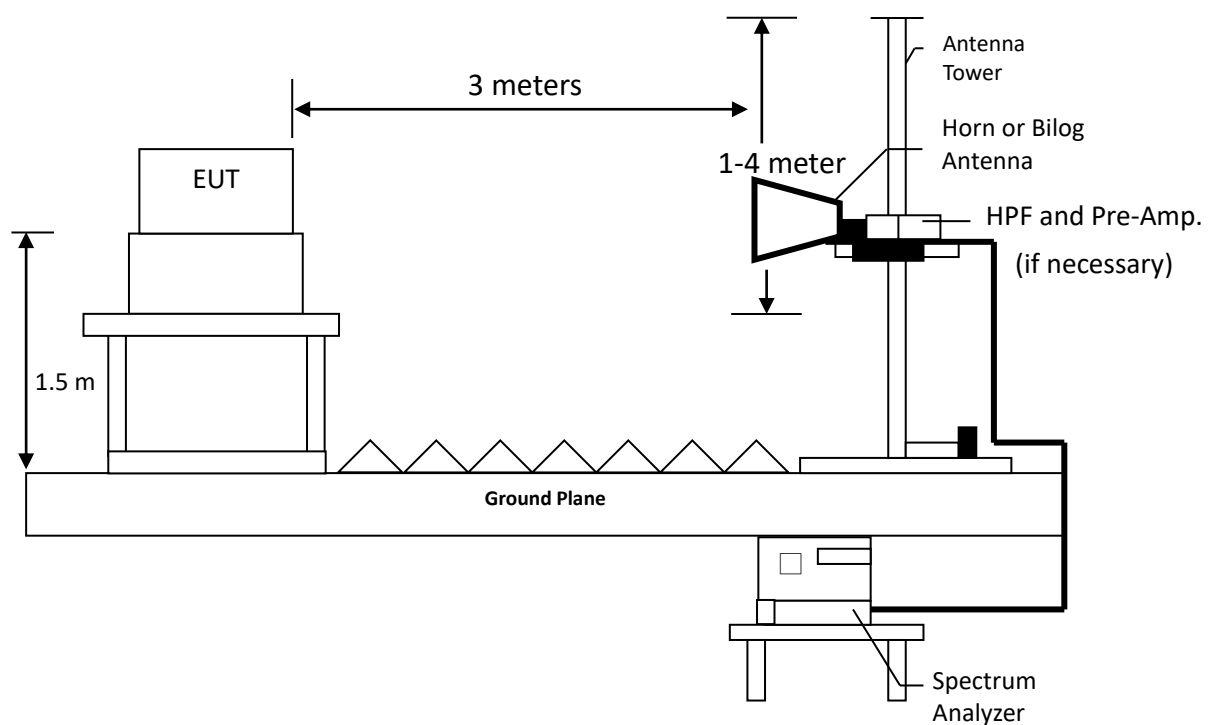
Radiated emission from 9kHz to 30MHz uses Loop Antenna:



Radiated emission below 1GHz using Bilog Antenna



Radiated emission above 1GHz using Horn Antenna



Radiated emissions were investigated cover the frequency range from 30MHz to 1000MHz using a receiver RBW of 120kHz record QP reading, and the frequency over 1GHz using a spectrum analyzer RBW of 1MHz and 10Hz VBW record Average reading. (15.209 paragraph), the Peak reading (1 MHz RBW/ 3 MHz VBW) recorded also on the report.

The EUT for testing is arranged on a turntable. If some peripherals apply to the EUT, the peripherals will be connected to EUT and the whole system. During the test, all cables were arranged to produce worst-case emissions. The signal is maximized through rotation. The height of antenna and polarization is changing constantly for exploring for maximum signal level. The height of antenna can be up to 4 meters and down to 1 meter.

The measurement for radiated emission will be done at the distance of three meters unless the signal level is too low to measure at that distance. In the case of the reading under noise floor, a pre-amplifier is used and/or the test is conducted at a closer distance. And then all readings are extrapolated back to the equivalent three meter reading using inverse scaling with distance.

3.2 Emission limit

3.2.1 Fundamental and harmonics emission limits

Frequency (MHz)	Field Strength of Fundamental		Field Strength of Harmonics	
	(mV/m@3m)	(dBuV/m@3m)	(uV/m@3m)	(dBuV/m@3m)
2400-2483.5	50	94	500	54

3.2.2 General radiated emission limits

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50dB below the level of the fundamental or to the general radiated emission limits in paragraph 15.209, whichever is the lesser attenuation.

Frequency MHz	15.209 Limits (dBμV/m@3m)
30-88	40
88-216	43.5
216-960	46
Above 960	54

Remark:

1. In the above table, the tighter limit applies at the band edges.
2. Distance refers to the distance in meters between the measuring instrument antenna and the closed point of any part of the device or system

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3.3 Radiated spurious emission test data

3.3.1 Measurement results: frequency range from 9 kHz to 30 MHz

Antenna Polarization	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Perpendicular	0.189	PK	17.74	30.27	48.01	102.07	-54.06
Perpendicular	0.519	PK	17.92	23.87	41.79	73.30	-31.51
Perpendicular	1.359	PK	17.96	16.69	34.65	64.94	-30.29
Perpendicular	1.868	PK	17.91	15.77	33.68	69.54	-35.86
Perpendicular	6.877	PK	19.89	10.25	30.14	69.54	-39.40
Perpendicular	15.274	PK	20.25	8.93	29.18	69.54	-40.36

Remark: Corr. Factor = Antenna Factor + Cable Loss

Antenna Polarization	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Parallel	0.189	PK	17.74	28.94	46.68	102.07	-55.39
Parallel	0.519	PK	17.92	23.42	41.34	73.30	-31.96
Parallel	1.449	PK	17.96	17.66	35.62	64.38	-28.76
Parallel	2.108	PK	17.91	16.13	34.04	69.54	-35.50
Parallel	5.257	PK	19.01	10.64	29.65	69.54	-39.89
Parallel	12.695	PK	20.18	7.91	28.09	69.54	-41.45

Remark: Corr. Factor = Antenna Factor + Cable Loss

Antenna Polarization	Frequency (MHz)	Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Ground-parallel	0.219	PK	17.80	27.87	45.67	100.80	-55.13
Ground-parallel	0.519	PK	17.92	22.87	40.79	73.30	-32.51
Ground-parallel	1.389	PK	17.96	18.25	36.21	64.75	-28.54
Ground-parallel	1.868	PK	17.91	16.81	34.72	69.54	-34.82
Ground-parallel	3.848	PK	18.34	11.18	29.52	69.54	-40.02
Ground-parallel	14.225	PK	19.99	9.94	29.93	69.54	-39.61

Remark: Corr. Factor = Antenna Factor + Cable Loss

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3.3.2 Measurement results: frequencies equal to or less than 1 GHz

Antenna Polarization	Frequency (MHz)	Spectrum Analyzer Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Horizontal	47.46	PK	20.48	3.25	23.73	40.00	-16.27
Horizontal	168.71	PK	20.20	2.88	23.08	43.50	-20.42
Horizontal	590.66	PK	28.64	3.03	31.67	46.00	-14.33
Horizontal	635.28	PK	29.59	2.96	32.55	46.00	-13.45
Horizontal	739.07	PK	31.14	3.87	35.01	46.00	-10.99
Horizontal	827.34	PK	32.42	3.87	36.29	46.00	-9.71

Remark: Corr. Factor = Antenna Factor + Cable Loss

Antenna Polarization	Frequency (MHz)	Spectrum Analyzer Detector	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
Vertical	34.85	PK	18.68	9.01	27.69	40.00	-12.31
Vertical	60.07	PK	20.18	7.18	27.36	40.00	-12.64
Vertical	71.71	PK	18.34	10.21	28.55	40.00	-11.45
Vertical	139.61	PK	19.80	3.41	23.21	43.50	-20.29
Vertical	708.03	PK	30.41	2.71	33.12	46.00	-12.88
Vertical	829.28	PK	32.46	3.53	35.99	46.00	-10.01

Remark: Corr. Factor = Antenna Factor + Cable Loss

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3.3.3 Measurement results: frequency above 1GHz

Mode	Frequency (MHz)	Spectrum Analyzer Detector	Ant. Pol. (H/V)	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
TX	1830.11	PK	H	-19.67	84.88	65.21	74.00	-8.79
	1830.11	AV	H	---	---	45.12	54.00	-8.88
	2745.16	PK	H	-15.33	69.16	53.83	74.00	-20.17
	2745.16	AV	H	---	---	33.74	54.00	-20.26
	3660.22	PK	H	-12.86	64.88	52.02	74.00	-21.98
	4575.27	PK	H	-8.81	56.72	47.91	74.00	-26.09
	5490.33	PK	H	-5.78	59.61	53.83	74.00	-20.17
	5490.33	AV	H	---	---	33.74	54.00	-20.26
	1756.00	PK	V	-20.39	72.51	52.12	74.00	-21.88
	1830.11	PK	V	-19.67	82.01	62.34	74.00	-11.66
	1830.11	AV	V	---	---	42.25	54.00	-11.75
	2745.16	PK	V	-15.33	61.14	45.81	74.00	-28.19
	3660.22	PK	V	-12.86	62.04	49.18	74.00	-24.82
	4575.27	PK	V	-8.81	53.38	44.57	74.00	-29.43
	5490.33	PK	V	-5.78	59.94	54.16	74.00	-19.84
	5490.33	AV	V	---	---	34.07	54.00	-19.93

Remark: 1. Correction Factor = Antenna Factor + Cable Loss - Pre_Amplifier Gain

2. AV Corrected Reading = PK Corrected Reading + Duty cycle correction factor (-20.09)

3.3.4 Measurement results: Fundamental

Frequency (MHz)	Spectrum Analyzer Detector	Ant. Pol. (H/V)	Correction Factor (dB/m)	Reading (dBμV)	Corrected Reading (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)
915	PK	H	33.68	61.06	94.74	114.00	-19.26
	AV	H	---	---	74.65	94.00	-19.35
	PK	V	33.68	59.30	92.98	114.00	-21.02
	AV	V	---	---	72.89	94.00	-21.11

Remark: 1. Correction Factor = Antenna Factor + Cable Loss

2. AV Corrected Reading = PK Corrected Reading + Duty cycle correction factor (-20.09)

4. Conducted emission test FCC 15.207

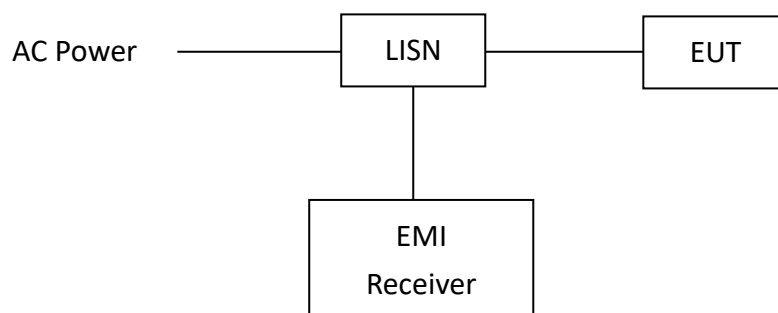
4.1 Measuring instrument setting

Receiver Function	Setting
Detector	QP
Start frequency	0.15MHz
Stop frequency	30MHz
IF bandwidth	9 kHz
Attenuation	10dB

4.2 Test Procedure

Step 1	Configure the EUT according to ANSI C63.10:2013. The EUT or host of EHT has to be placed 0.4 meter far from the conducting wall of the shielding room and at least 80 centimeters from any other grounded conducting surface.
Step 2	Connect EUT or host of EUT to the power mains through a line impedance stabilization network.
Step 3	All the companion devices are connected to the other LISN. The LISN should provide 50Uh/50ohms coupling impedance.
Step 4	The frequency range from 150 kHz to 30MHz was searched.
Step 5	Set the test-receiver system to peak detector and specified bandwidth with maximum hold mode.
Step 6	The measurement has to be done between each power line and ground at the power terminal.

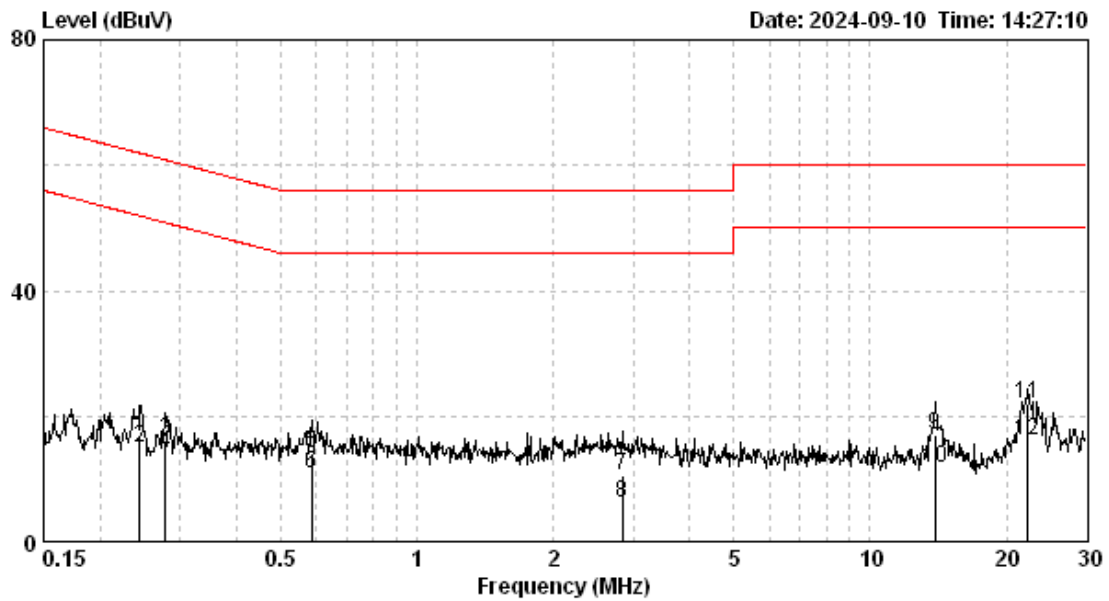
4.3 Test Diagram



4.4 Limit

Frequency (MHz)	Conducted Limit (dBuV)	
	Q.P.	Ave.
0.15~0.50	66 – 56	56 – 46
0.50~5.00	56	46
5.00~30.0	60	50

4.5 Conducted emission data FCC 15.207

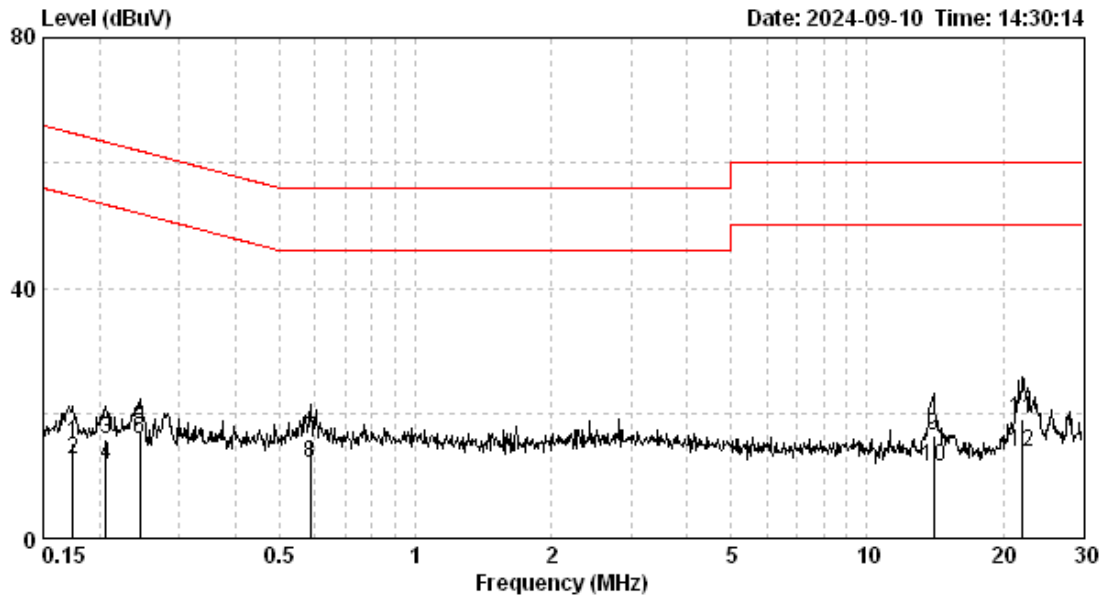


Test voltage :24Vac / 60Hz
Temp. / R.H. :25°C / 68%RH
Atmospheric pressure :1009hPa

Phase	Frequency (MHz)	Corr. Factor (dB)	Reading QP (dBuV)	Level QP (dBuV)	Limit QP (dBuV)	Reading AV (dBuV)	Level AV (dBuV)	Limit AV (dBuV)	Margin (dB)	
									QP	AV
LINE	0.244	9.58	7.11	16.69	61.95	5.24	14.81	51.95	-45.26	-37.14
LINE	0.279	9.57	6.51	16.08	60.85	4.52	14.09	50.85	-44.77	-36.76
LINE	0.585	9.58	4.47	14.05	56.00	1.39	10.97	46.00	-41.95	-35.03
LINE	2.839	9.61	0.93	10.54	56.00	-3.35	6.26	46.00	-45.46	-39.74
LINE	13.915	9.76	7.28	17.04	60.00	2.10	11.86	50.00	-42.96	-38.14
LINE	22.298	9.85	12.13	21.98	60.00	6.13	15.98	50.00	-38.02	-34.02

Remark:

1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Level (dBuV) = Corr. Factor (dB) + Reading (dBuV)
3. Margin (dB) = Level (dBuV) – Limit (dBuV)



Test voltage : 24Vac / 60Hz
 Temp. / R.H. : 25°C / 68%RH
 Atmospheric pressure : 1009hPa

Phase	Frequency (MHz)	Corr. Factor (dB)	Reading QP (dBuV)	Level QP (dBuV)	Limit QP (dBuV)	Reading AV (dBuV)	Level AV (dBuV)	Limit AV (dBuV)	Margin (dB)	
									QP	AV
NEUTRAL	0.175	9.58	5.55	15.12	64.72	3.10	12.68	54.72	-49.60	-42.05
NEUTRAL	0.206	9.58	6.11	15.69	63.36	2.22	11.80	53.36	-47.66	-41.56
NEUTRAL	0.246	9.58	7.83	17.41	61.91	6.33	15.91	51.91	-44.49	-36.00
NEUTRAL	0.585	9.59	6.11	15.71	56.00	2.45	12.04	46.00	-40.29	-33.96
NEUTRAL	14.063	9.77	6.66	16.43	60.00	1.60	11.37	50.00	-43.57	-38.63
NEUTRAL	22.063	9.88	9.26	19.14	60.00	3.94	13.81	50.00	-40.86	-36.19

Remark:

1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Level (dBuV) = Corr. Factor (dB) + Reading (dBuV)
3. Margin (dB) = Level (dBuV) – Limit (dBuV)

Appendix A: Test equipment list

Test Equipment	Brand	Model No.	Serial No.	Calibration Date	Next Calibration Date
EMI Test Receiver	KEYSIGHT	N9038B	MY63060107	2024/03/06	2025/03/05
Spectrum analyzer	KEYSIGHT	N9020B	MY63450146	2024/03/05	2025/03/04
Signal Analyzer	R&S	FSV40	101532	2024/07/12	2025/07/11
Active Loop Antenna	SCHWARZBECK	FMZB1519	1519-067	2024/01/16	2025/01/15
Broadband Antenna	SCHWARZBECK	VULB 9168	9168-172	2024/01/02	2025/01/01
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-456	2023/12/27	2024/12/26
Pre-Amplifier	SGH	SGH118(45dB)	20220105-1	2024/01/23	2025/01/22
966-2(A) Cable	SUHNER	SUCOFLEX 104	295105/4	2024/03/02	2025/03/02
966-2(B) Cable	SUHNER	SUCOFLEX 104P	CB0005	2024/03/02	2025/03/02
RF Cable	SUHNER	SUCOFLEX 104P	9403 / 4P	2023/11/24	2024/11/23
Power Meter	Anritsu	ML2495A	0844001	2024/01/08	2025/01/07
Power Sensor	Anritsu	MA2491A	031543	2024/01/08	2025/01/07
20dB Attenuator	PE	PE7001-20	N/A	2024/05/23	2025/05/22
966-2_3m Semi-Anechoic Chamber	CHANCE MOST	CEM-966_2	N/A	2024/07/30	2025/07/29
Test software	Audix	e3	V9	NCR	NCR

Note: No Calibration Required (NCR).

Test Equipment	Brand	Model No.	Serial No.	Calibration Date	Next Calibration Date
EMI Test Receiver	R&S	ESCI	100018	2024/07/23	2025/07/22
LISN	R&S	ENV216	101160	2024/06/26	2025/06/25
Cable	SUHNER	EMCCFD300-BM -NM-6000	170502	2024/06/25	2025/06/24
Test software	Audix	e3	V4.20040112L	NCR	NCR
Test site	Intertek	Con-2	N/A	NCR	NCR

Note: No Calibration Required (NCR).

Appendix B: Measurement Uncertainty

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

Item	Uncertainty
Radiated disturbances from 9kHz~30MHz in a semi-anechoic chamber at a distance of 3m	2.73 dB
Vertically polarized radiated disturbances from 30MHz~1GHz in a semi-anechoic chamber at a distance of 3m	3.91 dB
Horizontally polarized radiated disturbances from 30MHz~1GHz in a semi-anechoic chamber at a distance of 3m	3.49 dB
Vertically polarized Radiated disturbances from 1GHz~18GHz in a semi-anechoic chamber at a distance of 3m	3.71 dB
Horizontally polarized Radiated disturbances from 1GHz~18GHz in a semi-anechoic chamber at a distance of 3m	3.71 dB
Conducted Measurement	0.69 dB
AC Conducted Emission	1.31 dB