

RF TEST REPORT

Client Information:

Applicant: Smithtek PTY LTD
Applicant add.: 12 Daley Court Rockingham 6168 Australia
Manufacturer: Smithtek PTY LTD
Manufacturer add.: 12 Daley Court Rockingham 6168 Australia

Product Information:

Product Name: Mako V2
Model No.: MV2T
Brand Name: Smithtek
FCC ID : 2A9PR-MV2T
Applicable standards: FCC CFR Title 47 Part 15 Subpart C Section 15.249

Prepared By:

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Date of Receipt: 2022.12.08

Date of Test: 2022.12.08-2023.02.13

Date of Issue: 2023.02.13

Test Result: Pass

This device described above has been tested by Dongguan Yaxu (AiT) Technology Limited and the test results show that the equipment under test (EUT) is in compliance with the FCC requirements. And it is applicable only to the tested sample identified in the report.

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Reviewed by:



Simba Huang

Approved by:



Seal.chen

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1. TEST SUMMARY

1.1. TEST STANDARDS

The tests were performed according to following standards:

FCC Rules Part 15.249: Operation within the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5875 MHz, and 24.0-24.25 GHz.

ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.

1.2. REPORT VERSION

Revised No.	Date of issue	Description
01	2023.02.13	Original

1.3. TEST DESCRIPTION

FCC Rules Part 15.249			
Test Item	Section in CFR 47	Result	Test Engineer
	FCC		
Antenna requirement	15.203	Pass	Simba Huang
AC Power Line Conducted Emissions	15.207	Pass	Simba Huang
20dB Bandwidth	Section 15.215(c)	Pass	Simba Huang
Band edge Emissions	Section 15.249(d)	Pass	Simba Huang
Radiated Spurious Emissions	Section 15.205(a),Section 15.209(a), Section 15.249,Section 15.35	Pass	Simba Huang

Note:

1. The measurement uncertainty is not included in the test result.

1.4. TABLE OF CARRIER FREQUENCY

Channel Number	Frequency MHz	Channel Number	Frequency MHz	Channel Number	Frequency MHz
1	902.5	18	910.5	35	919
2	903	19	911	36	919.5
3	903.5	20	911.5	37	920
4	904	21	912	38	920.5
5	904.5	22	912.5	39	921
6	905	23	913	40	921.5
7	905.5	24	913.5	41	922
8	906	25	914	42	922.5
9	906.5	26	914.5	43	923
10	907	27	915	44	923.5
11	907.5	28	915.5	45	924
12	908	29	916	46	924.5
13	908.5	30	916.5	47	925
14	909	31	917	48	925.5
15	909.5	32	917.5	49	926
16	910	33	918	50	926.5
17	902.5	34	918.5	51	927
				52	927.5

1.5. MEASUREMENT UNCERTAINTY

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to TR-100028-01 "Electromagnetic compatibility and Radio spectrum Matters (ERM);Uncertainties in the measurement of mobile radio equipment characteristics; Part 1" and TR-100028-02 "Electromagnetic compatibility and Radio spectrum Matters (ERM);Uncertainties in the measurement of mobile radio equipment characteristics; Part 2 " . system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device. Below is the best Measurement Uncertainty

Test Item	Frequency Range	Measurement Uncertainty	Notes
Radiated Emission	0.009MHz-30MHz	3.10dB	(1)
Radiated Emission	30MHz-1GHz	3.75dB	(1)
Radiated Emission	1GHz-18GHz	3.88dB	(1)
Radiated Emission	18GHz-40GHz	3.88dB	(1)
AC Power Line Conducted Emission	0.15MHz ~ 30MHz	1.20dB	(1)
Note (1): The measurement uncertainty is for coverage factor of k=2 and a level of confidence of 95%.			

1.6. ENVIRONMENTAL CONDITIONS

During the measurement the environmental conditions were within the listed ranges:

Temperature:	15~35°C
Relative Humidity:	30~60 %
Air Pressure:	950~1050mba

2. GENERAL INFORMATION

2.1. GENERAL DESCRIPTION OF EUT

Test Sample Number:	AIT22120707-2(Normal Sample),AIT22120707-1(Engineering Sample)
Product Name:	Mako V2
Trade Mark:	Smithtek
Model/Type reference:	MV2T
Serial model(s):	V2
Difference Description	All the series models are the same as the test model except for the model names.
Power supply	DC 12V
Hardware version:	LoRa_WG_V4.6
Software version:	Pisces Hotspot V0.19
Specification	
Modulation:	Lora
Operation frequency :	902-928MHz
Channel number:	52
Antenna type:	External Antenna
Antenna gain:	Max. 1.0dBi

2.2. MEASUREMENT INSTRUMENTS LIST

No	Test Equipment	Manufacturer	Model No	Serial No	Cal. Date	Cal. Due Date
1	Spectrum Analyzer	R&S	FSV40	101470	2022.09.02	2023.09.01
2	EMI Measuring Receiver	R&S	ESR	101160	2022.09.02	2023.09.01
3	Low Noise Pre Amplifier	HP	HP8447E	AIT-F01319	2022.09.02	2023.09.01
4	Low Noise Pre Amplifier	Tsj	MLA-0120-A02-34	2648A04738	2022.09.02	2023.09.01
5	Passive Loop	ETS	6512	00165355	2022.09.04	2024.09.03
6	TRILOG Super Broadband test Antenna	SCHWARZBECK	VULB9160	9160-3206	2021.08.29	2024.08.28
7	Broadband Horn Antenna	SCHWARZBECK	BBHA9120D	452	2021.08.29	2024.08.28
8	SHF-EHF Horn Antenna 15-40GHz	SCHWARZBECK	BBHA9170	BBHA9170367d	2020.11.24	2023.11.23
9	EMI Test Receiver	R&S	ESCI	100124	2022.09.02	2023.09.01
10	LISN	Kyoritsu	KNW-242	8-837-4	2022.09.02	2023.09.01
11	LISN	R&S	ESH3-Z2	0357.8810.54 - 101161-S2	2022.09.02	2023.09.01
12	Pro.Temp&Humi.chamber	MENTEK	MHP-150-1C	MAA08112501	2022.09.02	2023.09.01
13	RF Automatic Test system	MW	MW100-RFCB	21033016	2022.09.02	2023.09.01
14	Signal Generator	Agilent	N5182A	MY50143009	2022.09.02	2023.09.01
15	Wideband Radio communication tester	R&S	CMW500	1201.0002K50	2022.09.02	2023.09.01
16	RF Automatic Test system	MW	MW100-RFCB	21033016	2022.09.02	2023.09.01
17	DC power supply	ZHAOXIN	RXN-305D-2	28070002559	N/A	N/A
18	RE Software	EZ	EZ-EMC_RE	Ver.AIT-03A	N/A	N/A
19	CE Software	EZ	EZ-EMC_CE	Ver.AIT-03A	N/A	N/A
20	RF Software	MW	MTS 8310	2.0.0.0	N/A	N/A

2.3. DESCRIPTION OF TEST MODES

Operation Frequency List: The EUT has been tested under typical operating condition. The Applicant provides communication tools software to control the EUT for staying in continuous transmitting and receiving mode for testing.

Test Frequency: 902.5MHz, 915MHz, 927.5MHz

Test mode

For RF test items:
The engineering test program was provided and enabled to make EUT continuous transmit.
For Radiated spurious emissions test item:
The engineering test program was provided and enabled to make EUT continuous transmit. The EUT in each of three orthogonal axis emissions had been tested, but only the worst case (X axis) data recorded in the report.

2.4. TEST SOFTWARE

Software name	Model	Version
Conducted emission Measurement Software	EZ-EMC	EMC-Con 3A1.1
Radiated emission Measurement Software	EZ-EMC	FA-03A.2.RE
Bluetooth and WIFI Test System	JS1120-3	2.5.77.0418

3. TEST ITEM AND RESULTS

3.1. ANTENNA REQUIREMENT

Requirement

FCC CFR Title 47 Part 15 Subpart C 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, 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.

FCC CFR Title 47 Part 15 Subpart C Section 15.247(c) (1)(i):

(i) Systems operating in the 902~928 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

Test Result

The directional gain of the antenna less than 6dBi, please refer to the EUT internal photographs antenna photo.

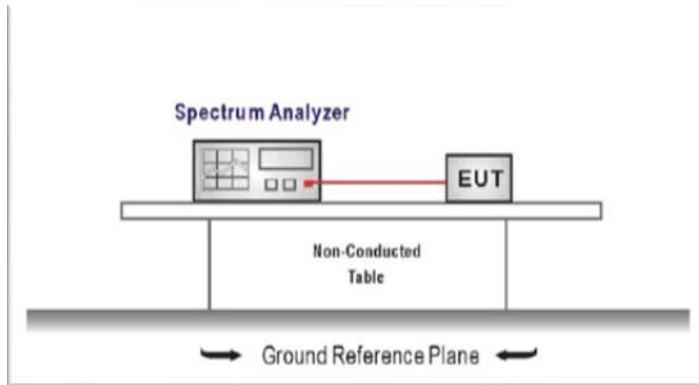
Note: The antenna is permanently fixed to the EUT

3.2. 20DB BANDWIDTH

Limit

Operation Frequency range 902MHz~928MHz.

Test Configuration



Test Procedure

1. The transmitter output was connected to the spectrum analyzer through an attenuator, the path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously
3. Use the following spectrum analyzer settings:
 Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
 RBW $\geq$ 1% of the 20 dB bandwidth, VBW $\geq$ RBW
 Sweep = auto, Detector function = peak, Trace = max hold
4. Measure and record the results in the test report.

Test Mode

Please refer to the clause 2.2.

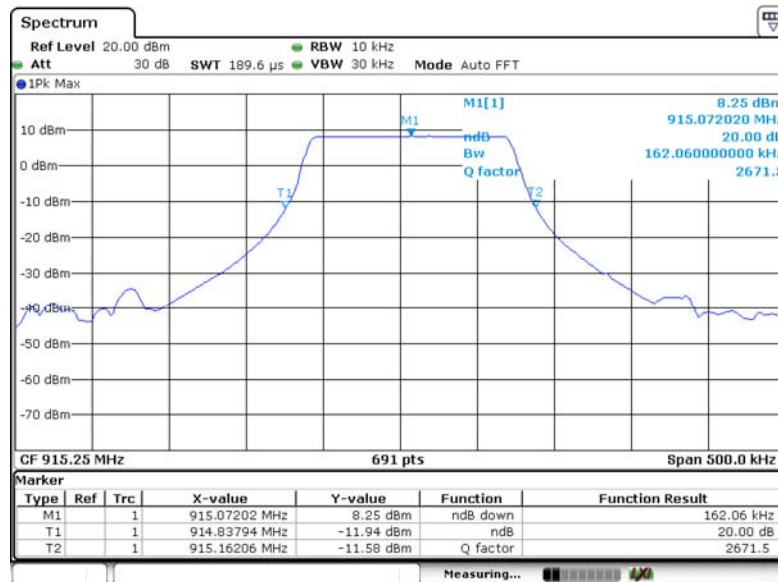
Test Results

Channel frequency (MHz)	20dB Bandwidth [KHz]	Verdict
902.5	162.01	PASS
915	162.06	PASS
927.5	162.03	PASS

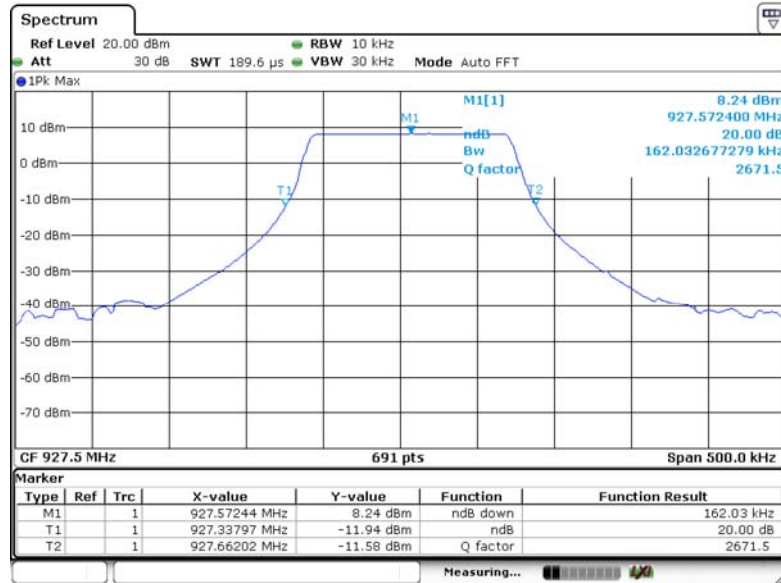
902.5MHz



915MHz



927.5MHz



3.3. CONDUCTED EMISSION

Limit

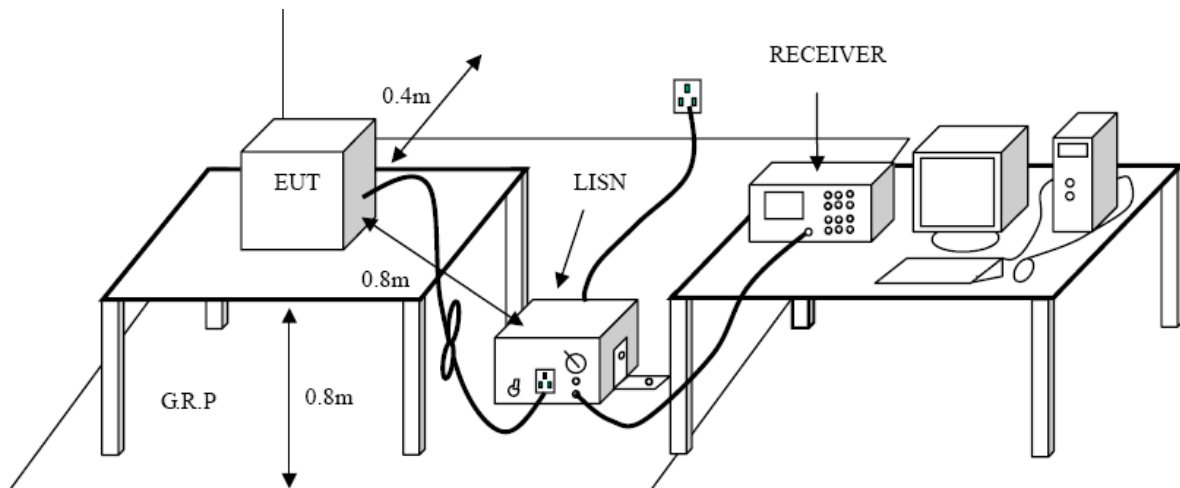
Conducted Emission Test Limit

Frequency	Maximum RF Line Voltage (dB μ V)	
	Quasi-peak Level	Average Level
150kHz~500kHz	66 ~ 56 *	56 ~ 46 *
500kHz~5MHz	56	46
5MHz~30MHz	60	50

Notes:

- (1) *Decreasing linearly with logarithm of the frequency.
- (2) The lower limit shall apply at the transition frequencies.
- (3) The limit decrease in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

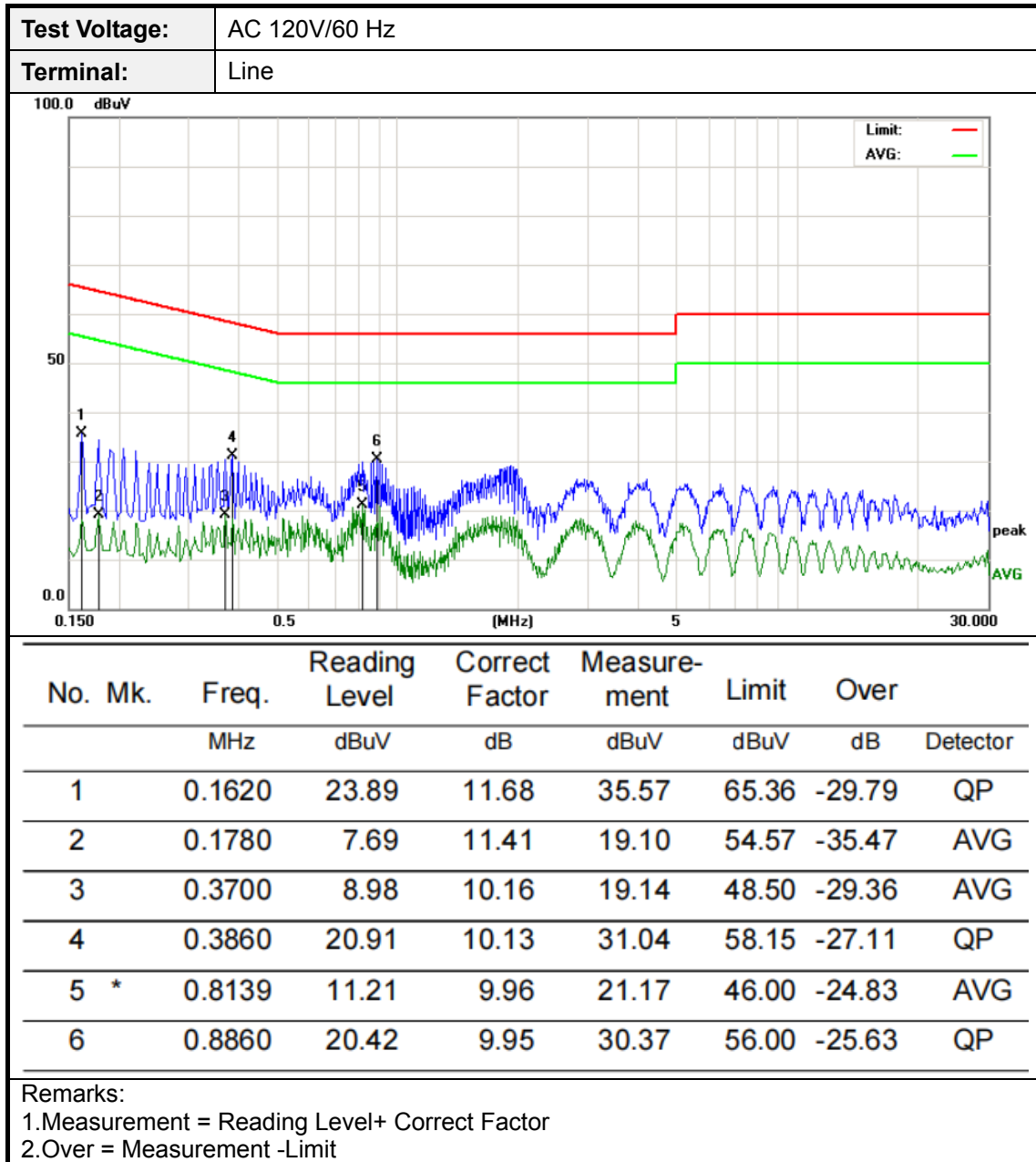
Test Configuration

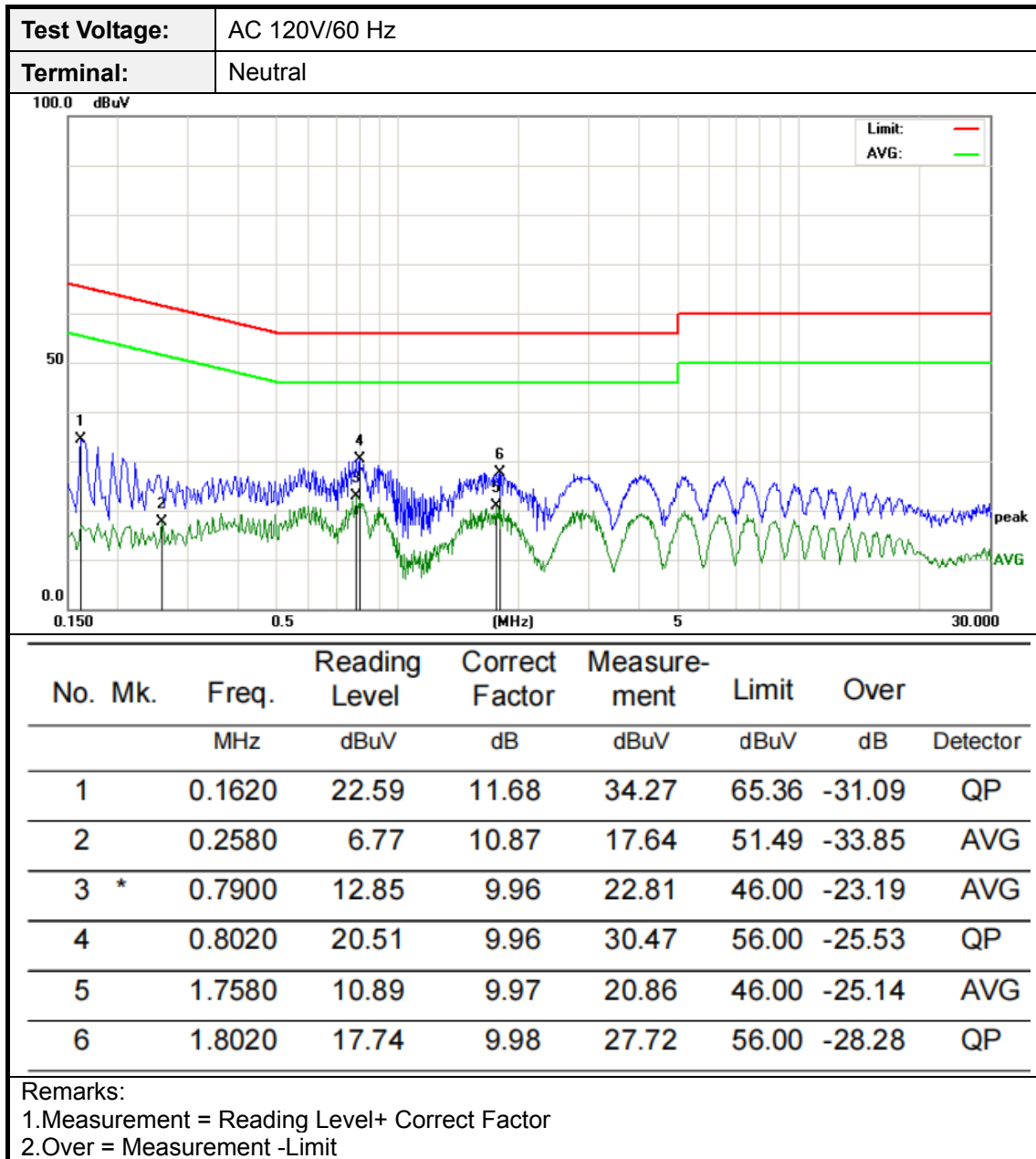


Test Procedure

1. The EUT was setup according to ANSI C63.10:2013 requirements.
2. The EUT was placed on a platform of nominal size, 1 m by 1.5 m, raised 80 cm above the conducting ground plane. The vertical conducting plane was located 40 cm to the rear of the EUT. All other surfaces of EUT were at least 80 cm from any other grounded conducting surface.
3. The EUT and simulators are connected to the main power through a line impedances stabilization network (LISN). The LISN provides a 50ohm /50uH coupling impedance for the measuring equipment.
The peripheral devices are also connected to the main power through a LISN. (Please refer to the block diagram of the test setup and photographs)
4. Each current-carrying conductor of the EUT power cord, except the ground (safety) conductor, was individually connected through a LISN to the input power source.
5. The excess length of the power cord between the EUT and the LISN receptacle were folded back and forth at the center of the lead to form a bundle not exceeding 40 cm in length.
6. Conducted Emissions were investigated over the frequency range from 0.15MHz to 30MHz using a receiver bandwidth of 9 kHz.
7. During the above scans, the emissions were maximized by cable manipulation.

Test Results





Note:

All test modes had been tested. The TX 915MHz is the worst case and recorded in the report.

3.4. RADIATED SPURIOUS EMISSIONS

LIMIT

FCC CFR Title 47 Part 15 Subpart C Section 15.209(a) and 15.205(a)

Standard FCC15.249

Fundamental Frequency	Field Strength of Fundamental (millivolts/meter)	Field Strength of Harmonics (microvolts/meter)
900-928MHz	50 (94dBuV/m @3m)	500 (54dBuV/m @3m)
2400-2483.5MHz	50 (94dBuV/m @3m)	500 (54dBuV/m @3m)
5725-5875MHz	50 (94dBuV/m @3m)	500 (54dBuV/m @3m)
24.0-24.25GHz	250 (108dBuV/m @3m)	2500 (68dBuV/m @3m)

Standard FCC 15.209

Frequency (MHz)	Distance Meters	Field Strengths Limit	
		μ V/m	dB(μV)/m
0.009 ~ 0.490	300	2400/F(kHz)	---
0.490 ~ 1.705	30	24000/F(kHz)	---
1.705 ~ 30	30	30	---
30 ~ 88	3	100	40.0
88 ~ 216	3	150	43.5
216 ~ 960	3	200	46.0
960 ~ 1000	3	500	54.0
Above 1000	3	Other:74.0dB(μV)/m(Peak) 54.0dB(μV)/m (Average)	
Remark: (1) Emission level dB μ V = 20 log Emission level μ V/m (2) The smaller limit shall apply at the cross point between two frequency bands. (3) Distance is the distance in meters between the measuring instrument, antenna and the closest point of any part of the device or system.			

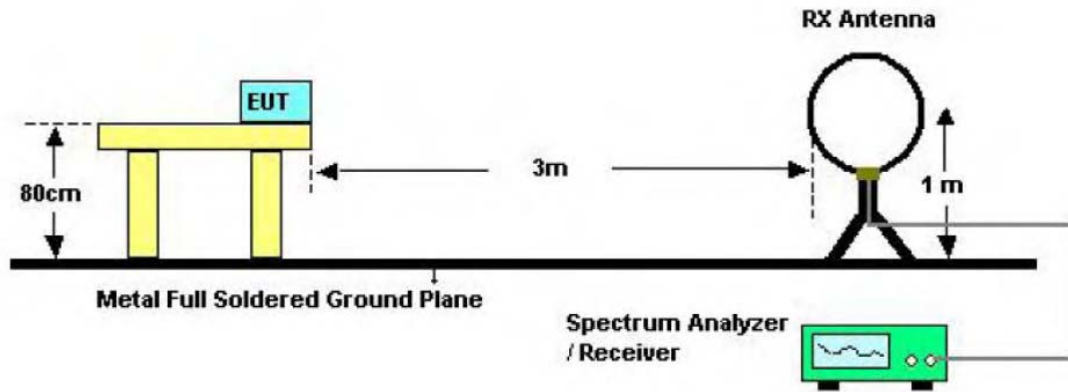
FREQUENCY RANGE OF RADIATED MEASUREMENT

Spectrum Parameter	Setting
Start ~Stop Frequency	9KHz~150KHz/RB 200Hz for QP
Start ~Stop Frequency	150KHz~30MHz/RB 9KHz for QP
Start ~Stop Frequency	30MHz~1000MHz/RB 120KHz for QP
Start ~Stop Frequency	1GHz~26.5GHz RBW 1MHz/ VBW 1MHz for Peak, RBW 1MHz/ VBW 10Hz for Average

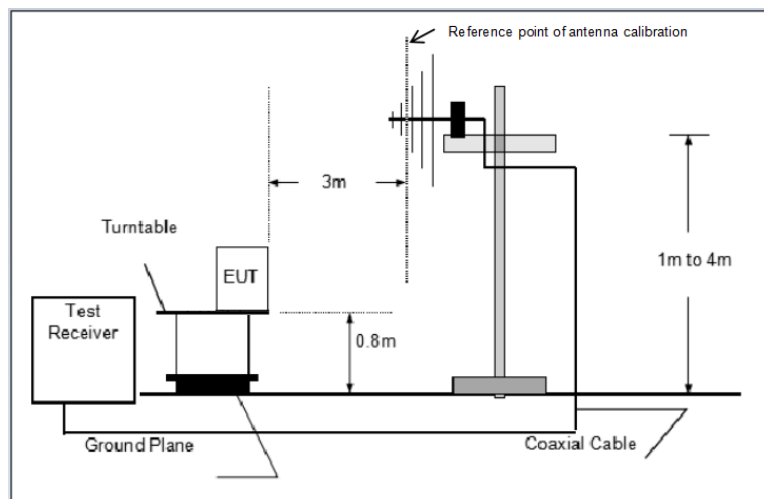
Receiver Parameter	Setting
Start ~Stop Frequency	9KHz~150KHz/RB 200Hz for QP
Start ~Stop Frequency	150KHz~30MHz/RB 9KHz for QP

Start ~Stop Frequency	30MHz~1000MHz/RB 120KHz for QP
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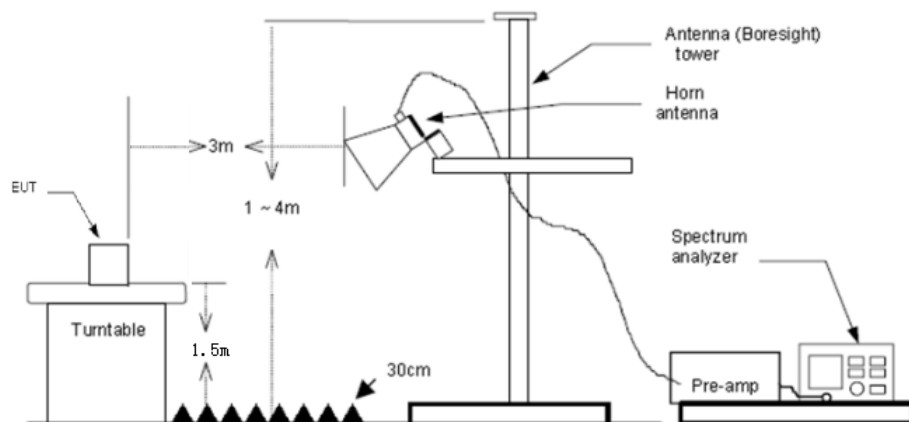
Test Configuration



Below 30MHz Test Setup



Below 1000MHz Test Setup



Above 1GHz Test Setup

Test Procedure

1. The EUT was setup and tested according to ANSI C63.10:2013
2. The EUT is placed on a turn table which is 0.8 meter above ground for below 1 GHz, and 1.5 m for above 1 GHz. The turn table is rotated 360 degrees to determine the position of the maximum emission level.
3. The EUT was set 3 meters from the receiving antenna, which was mounted on the top of a variable height antenna tower.
4. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
5. Set to the maximum power setting and enable the EUT transmit continuously.
6. Use the following spectrum analyzer settings
 - (1) Span shall wide enough to fully capture the emission being measured;
 - (2) Below 1 GHz:
RBW=120 kHz, VBW=300 kHz, Sweep=auto, Detector function=peak, Trace=max hold;
If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.
 - (3) From 1 GHz to 10th harmonic:
RBW=1MHz, VBW=3MHz Peak detector for Peak value.
RBW=1MHz, VBW=10HzPeak detector for Average value.

TEST MODE:

Please refer to the clause 2.2.

TEST RESULTS

☒ **Passed** ☐ **Not Applicable**

9 KHz~30 MHz and 18GHz~25GHz

From 9 KHz~30 MHz and 18GHz~25GHz: Conclusion: PASS

Note:

- 1) Final level = Reading level + Correct Factor
Correct Factor=Antenna Factor + Cable Loss -Preamplifier Factor
- 2) The emission levels of other frequencies are very lower than the limit and not show in test report.
- 3) The amplitude of spurious emissions which are attenuated by more than 20dB below the permissible value has no need to be reported.
- 4) 18GHz ~ 25GHz
The EUT was pre-scanned the frequency band (18GHz~25GHz), found the radiated level(Background noise) lower than the limit, so don't show on the report. 3

Radiated field strength of the fundamental signal

Frequency (MHz)	Read Level (dBuV)	Correct Factor (dB/m)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dBuV/m)	Polarization	Test value
902.5	78.31	6.70	85.01	94	-8.99	Vertical	QP
902.5	77.11	6.70	83.81	94	-10.19	Horizontal	QP
915	82.93	6.11	89.04	94	-4.96	Vertical	QP
915	80.05	6.11	86.16	94	-7.84	Horizontal	QP
927.5	79.15	5.15	84.30	94	-9.70	Vertical	QP
927.5	77.55	5.15	82.70	94	-11.3	Horizontal	QP

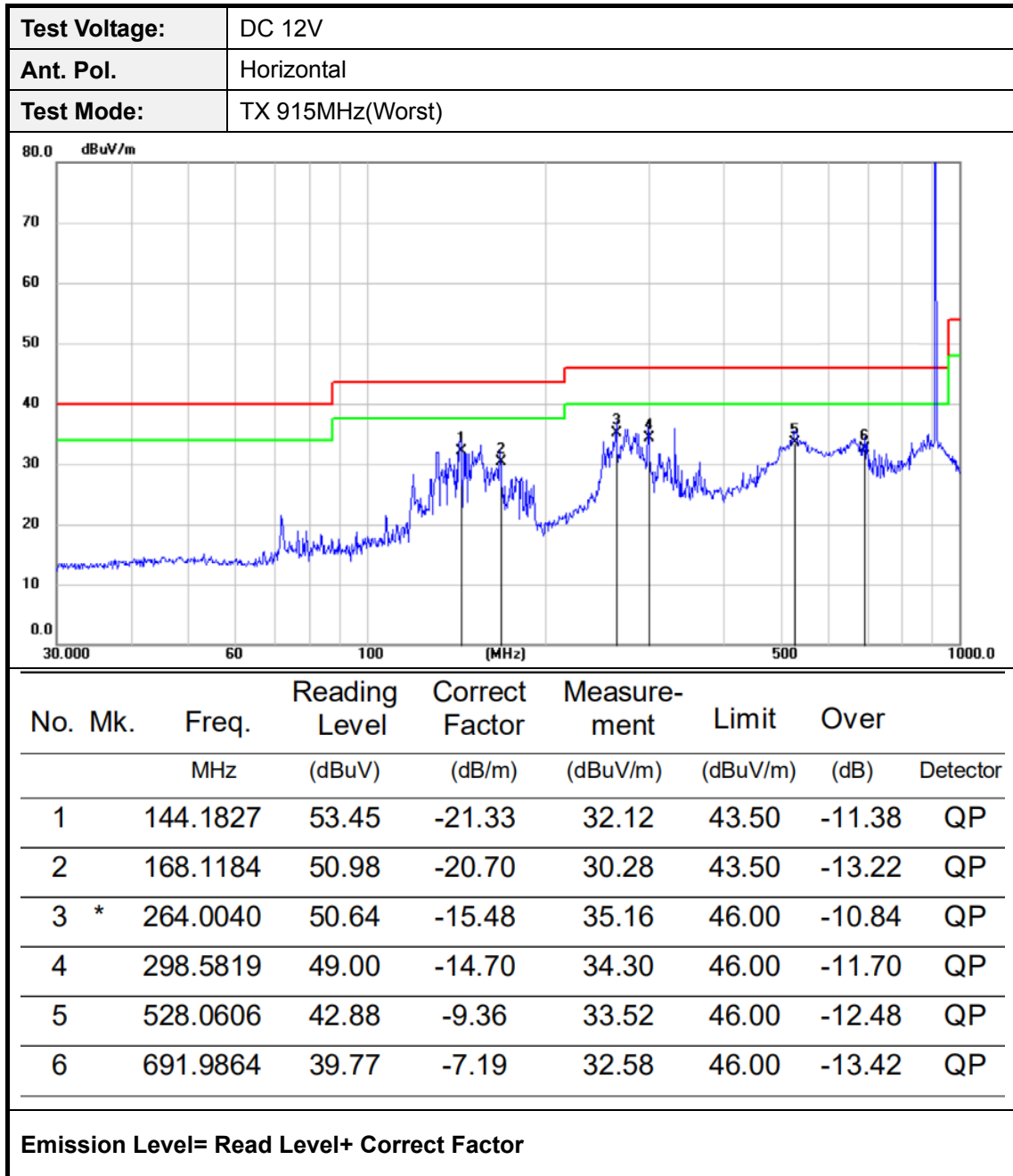
Note:

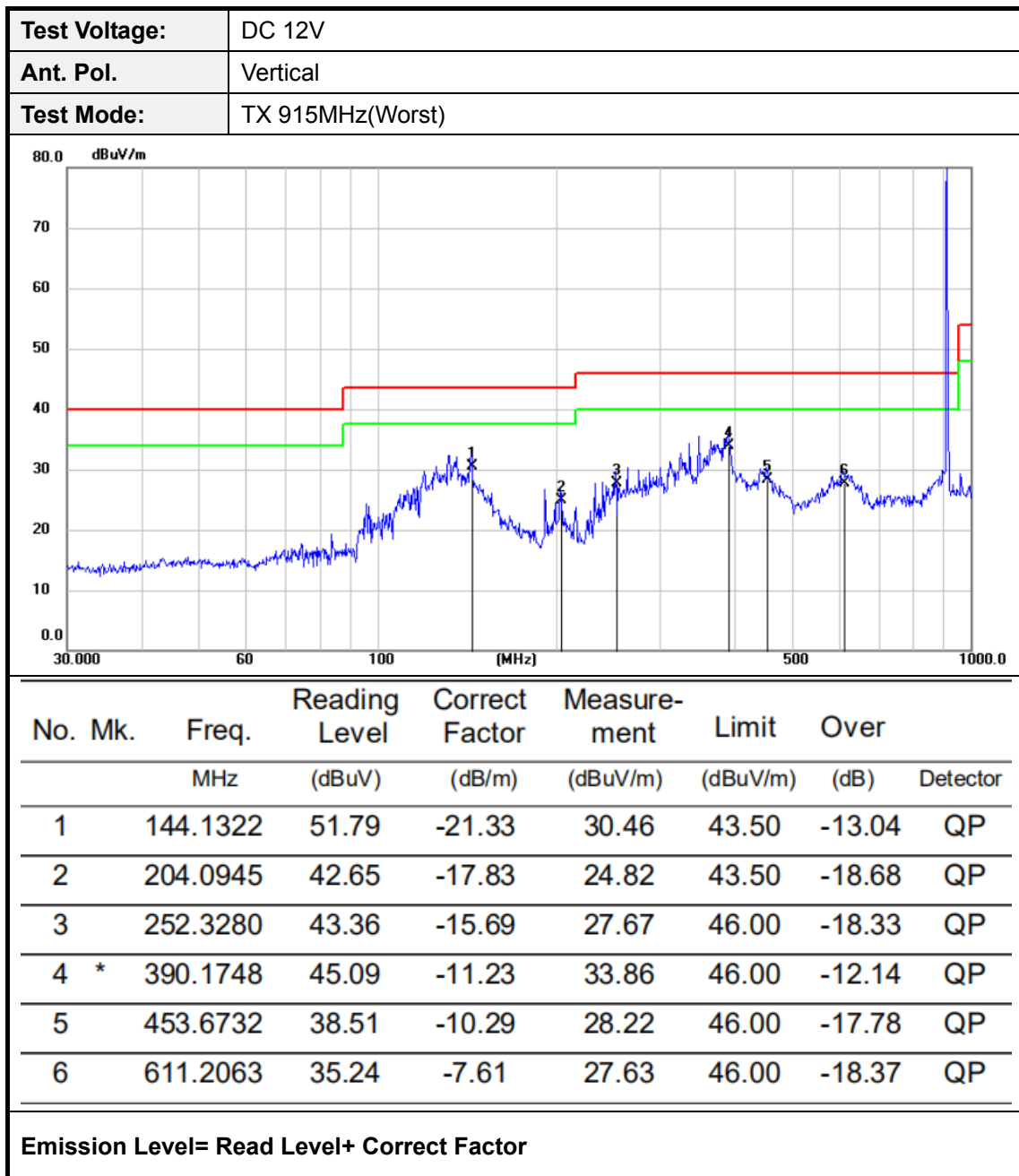
1. Correct Factor=Antenna Factor + Cable Loss -Preamplifier Factor
2. Level = Read Level +Correct Factor

RADIATED EMISSION BELOW 30MHZ

No emission found between lowest internal used/generated frequencies to 30MHz.

30MHz-1GHz

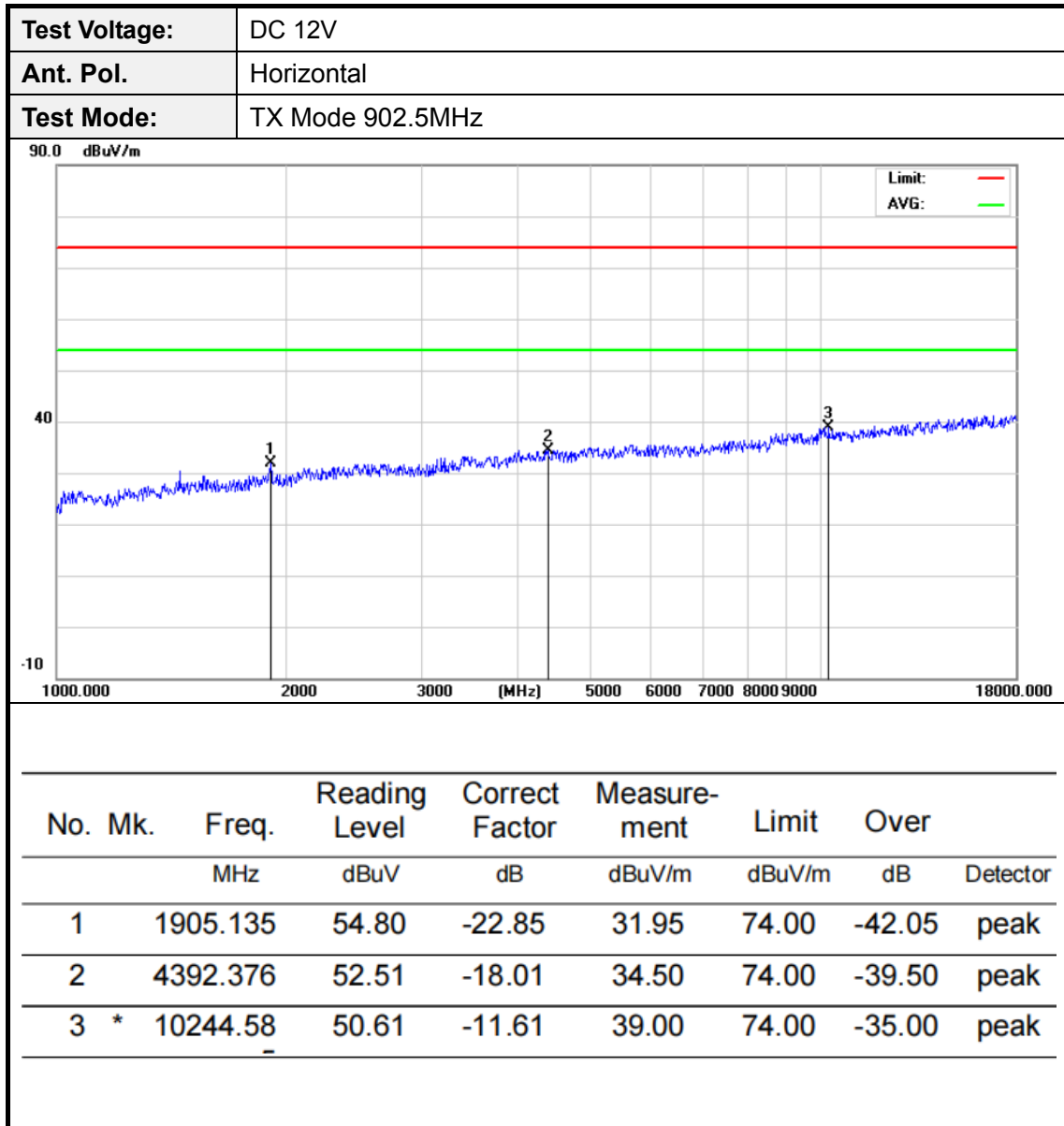


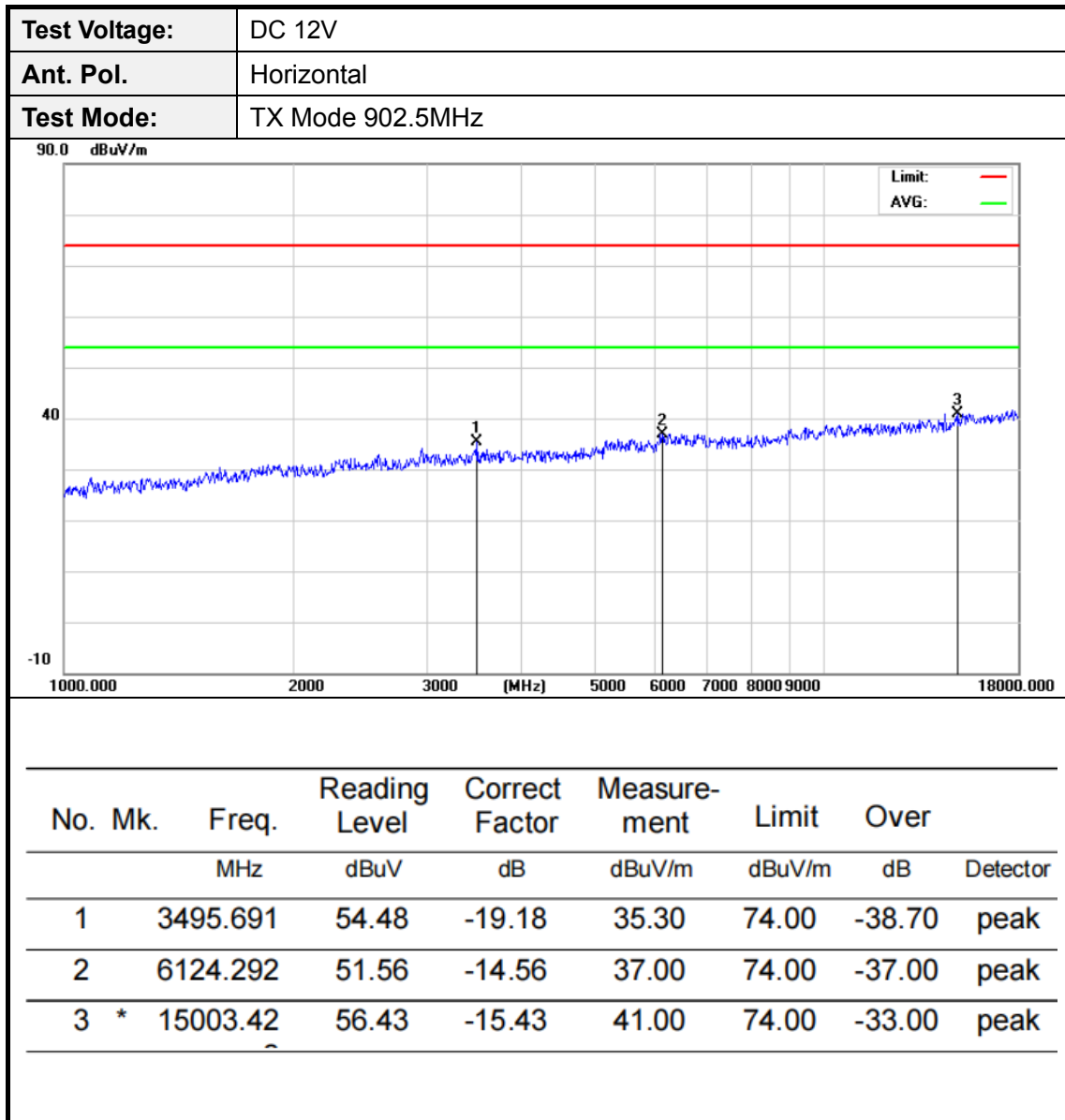


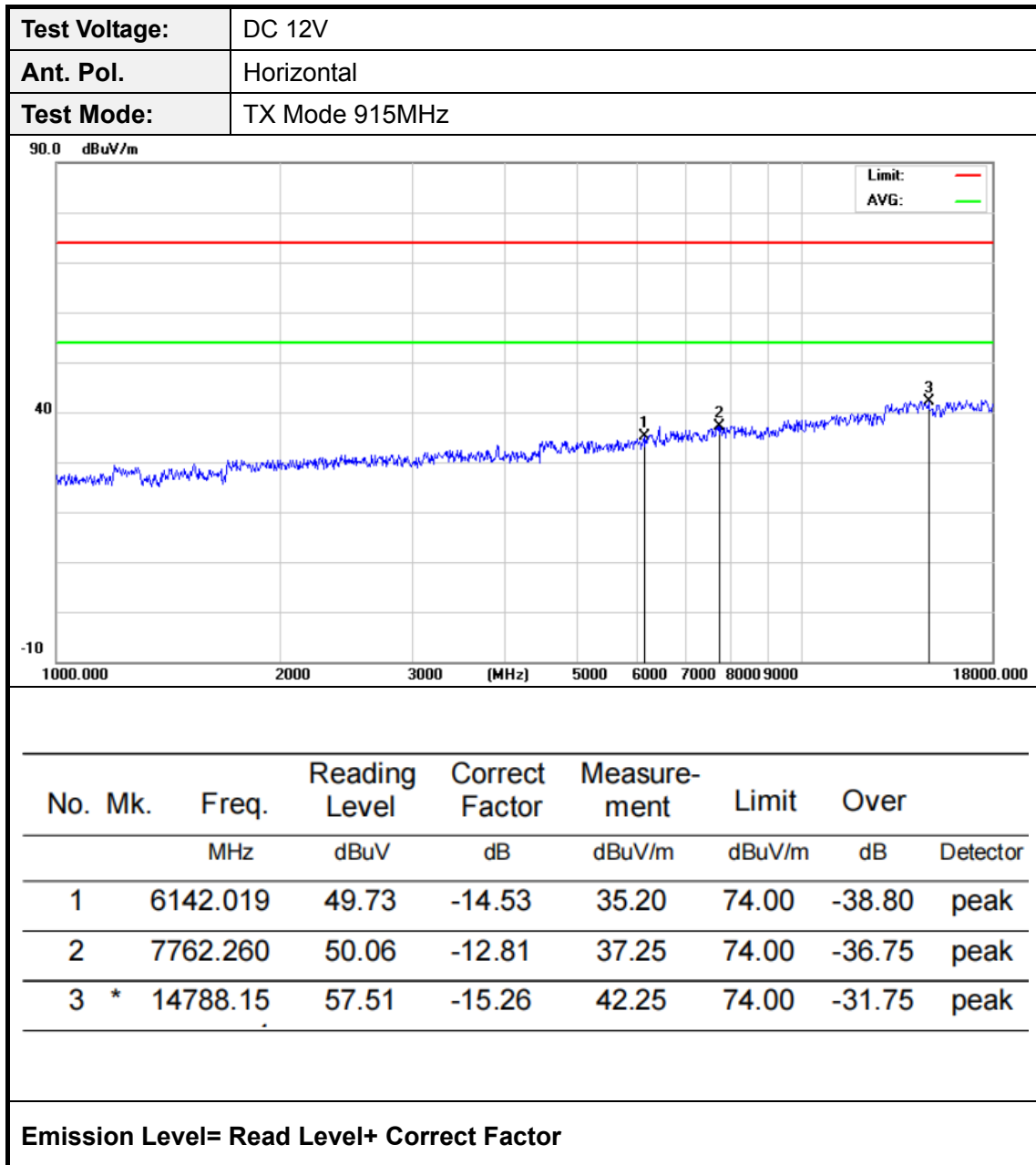
Note:

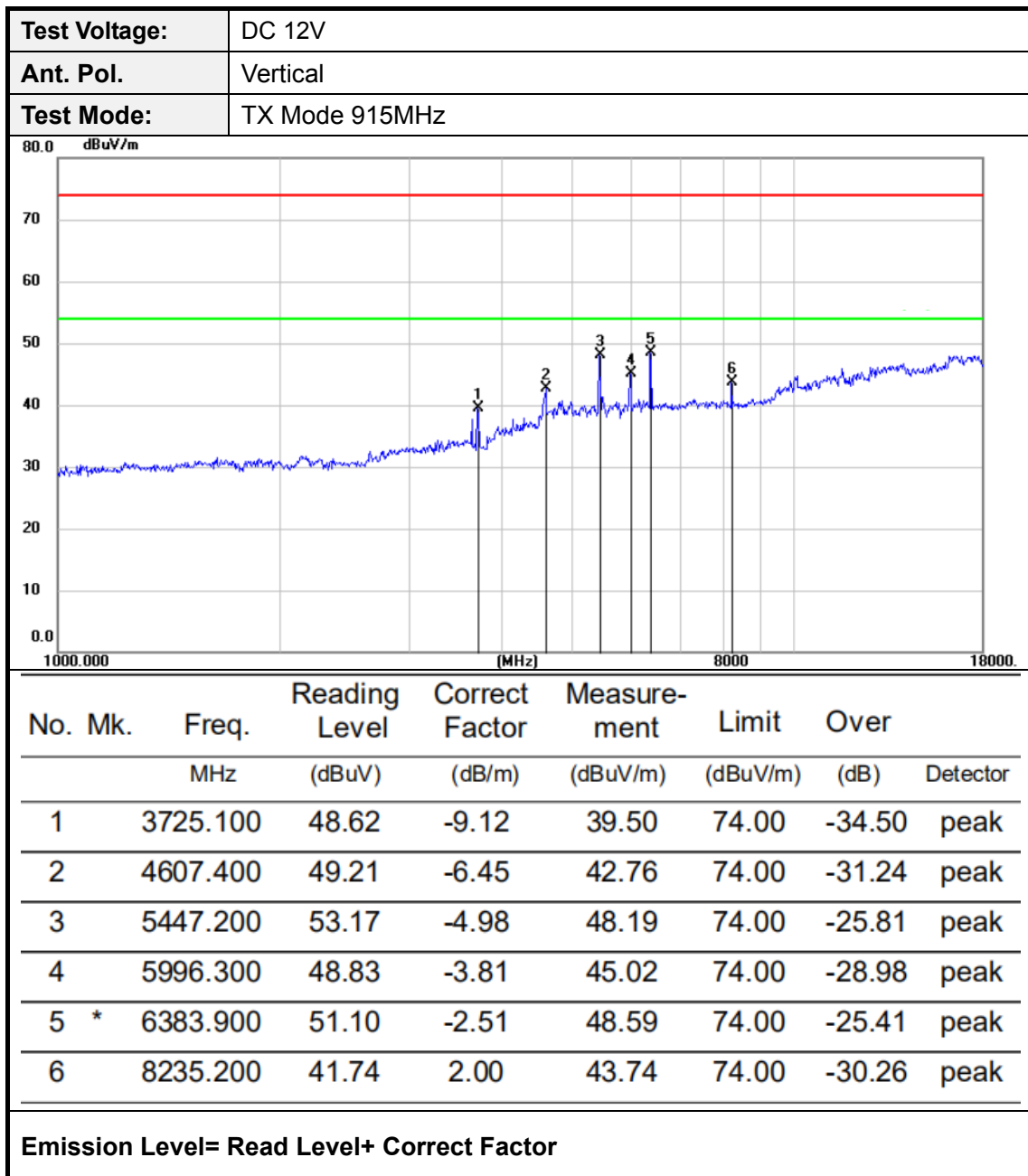
All test modes had been tested. The TX 915MHz is the worst case and recorded in the report.

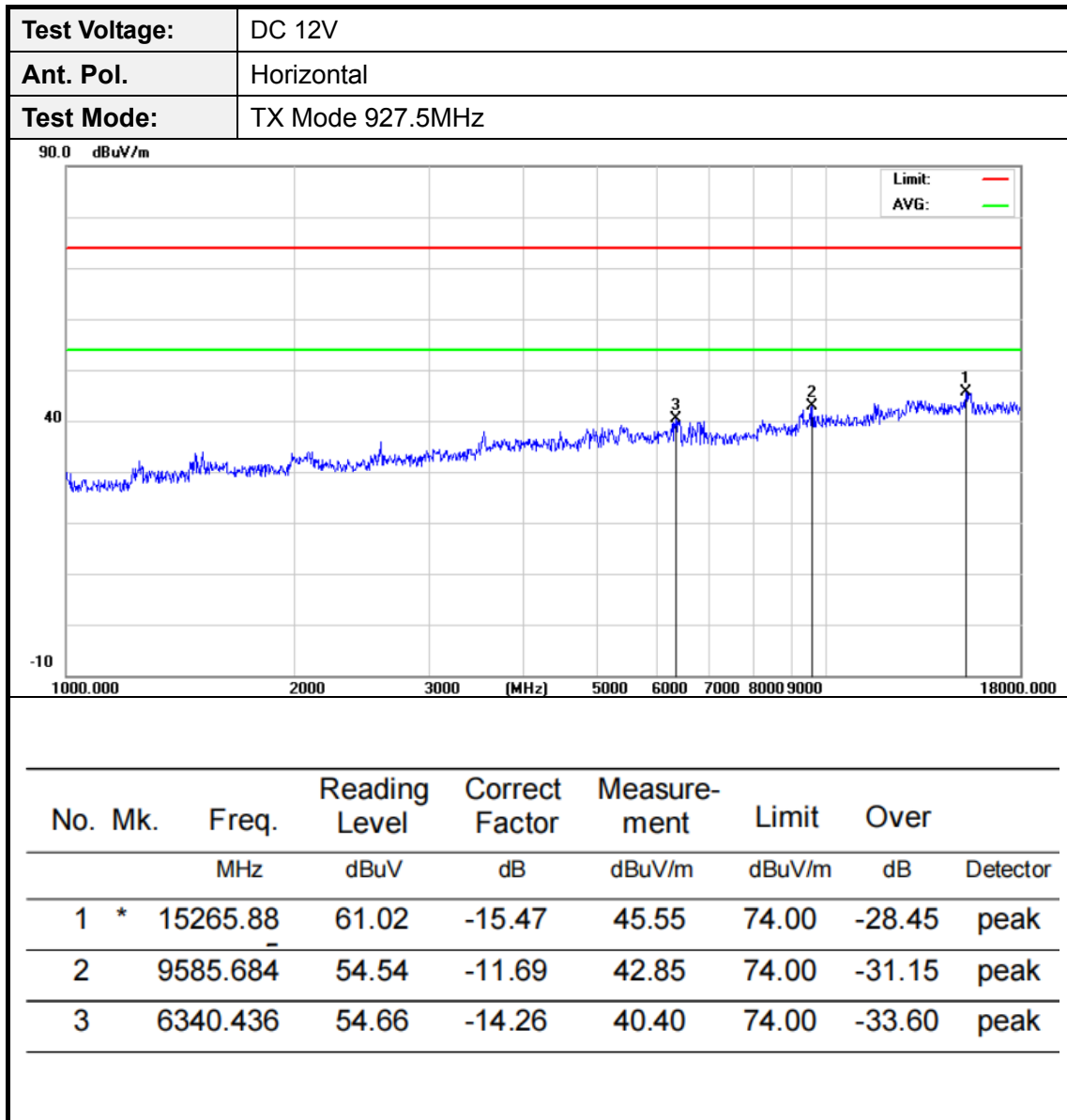
Adobe 1GHz

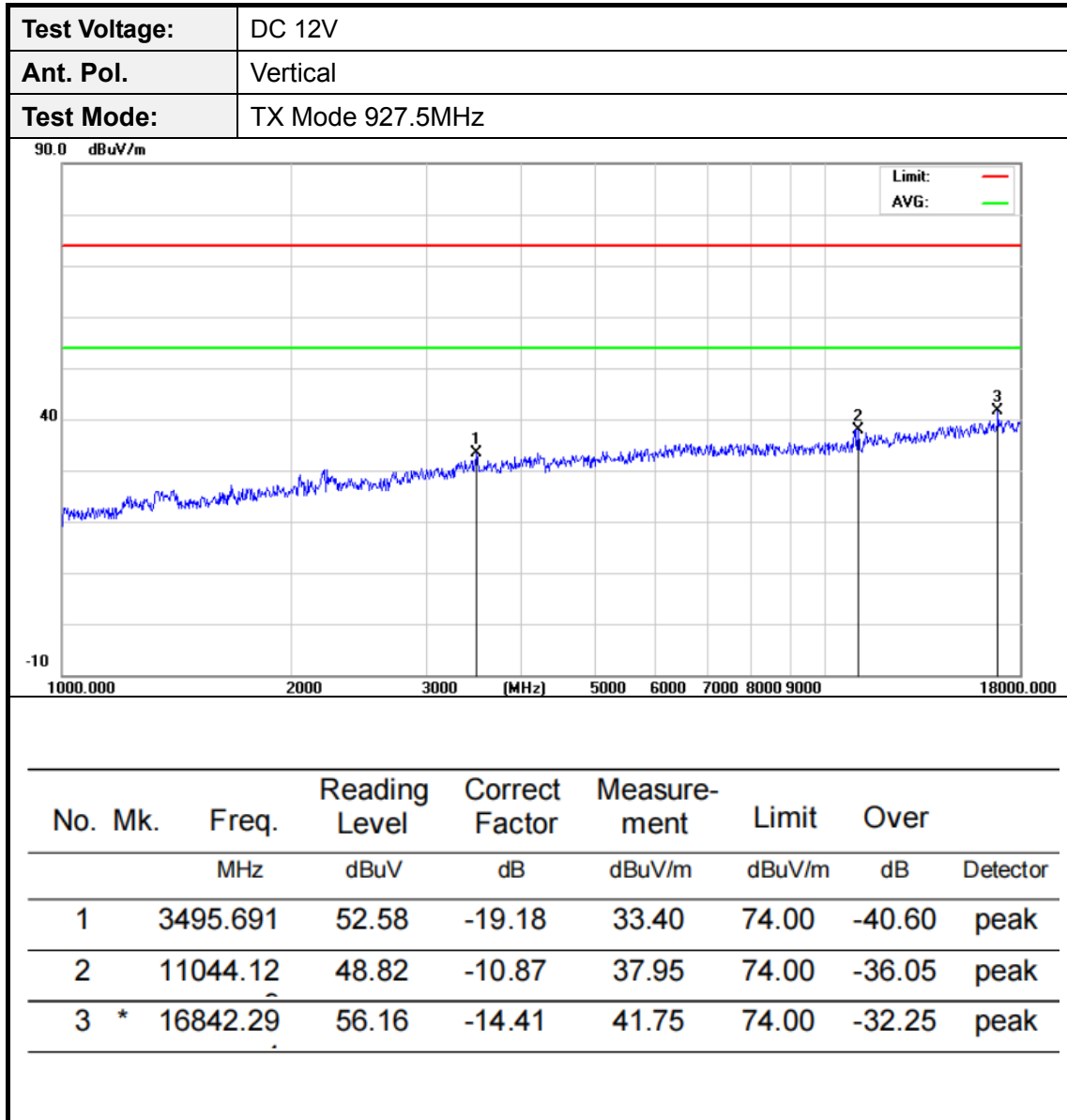






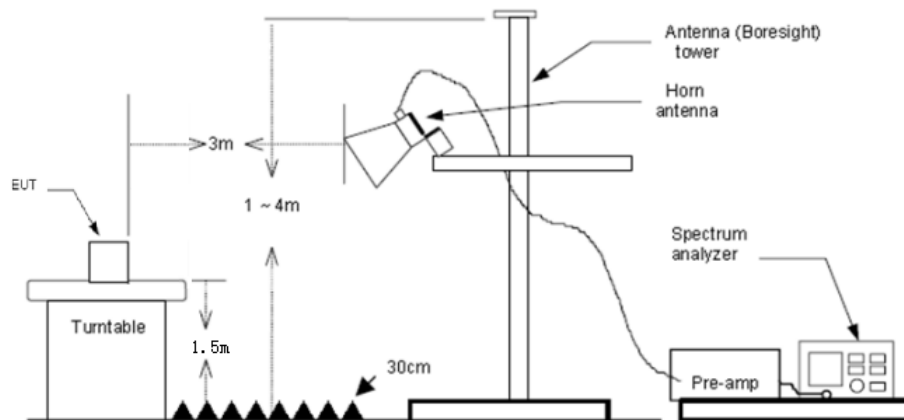






3.5. BAND EDGE EMISSIONS(RADIATED)

Test Configuration



Test Procedure

1. The EUT was setup and tested according to ANSI C63.10:2013
2. The EUT is placed on a turn table which is 0.8 meter above ground for below 1 GHz, and 1.5 m for above 1 GHz. The turn table is rotated 360 degrees to determine the position of the maximum emission level.
3. The EUT was set 3 meters from the receiving antenna, which was mounted on the top of a variable height antenna tower.
4. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
5. Set to the maximum power setting and enable the EUT transmit continuously.
6. Use the following spectrum analyzer settings
 - (1) Span shall wide enough to fully capture the emission being measured;
 - RBW=1MHz, VBW=3MHz PEAK detector for Peak value.
 - RBW=1MHz, VBW=10Hz with PEAK Detector for Average Value.

Test Mode

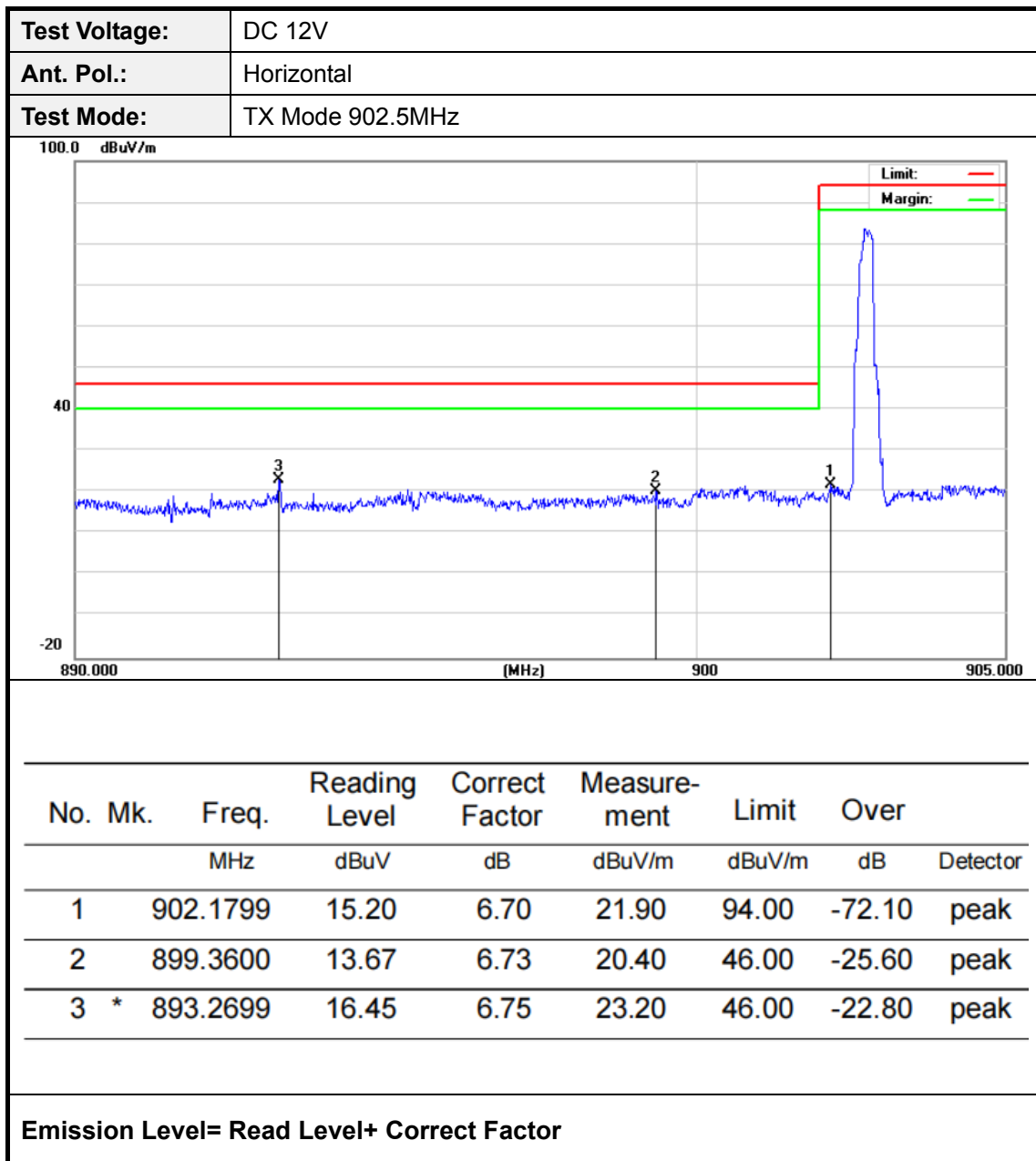
Please refer to the clause 2.2.

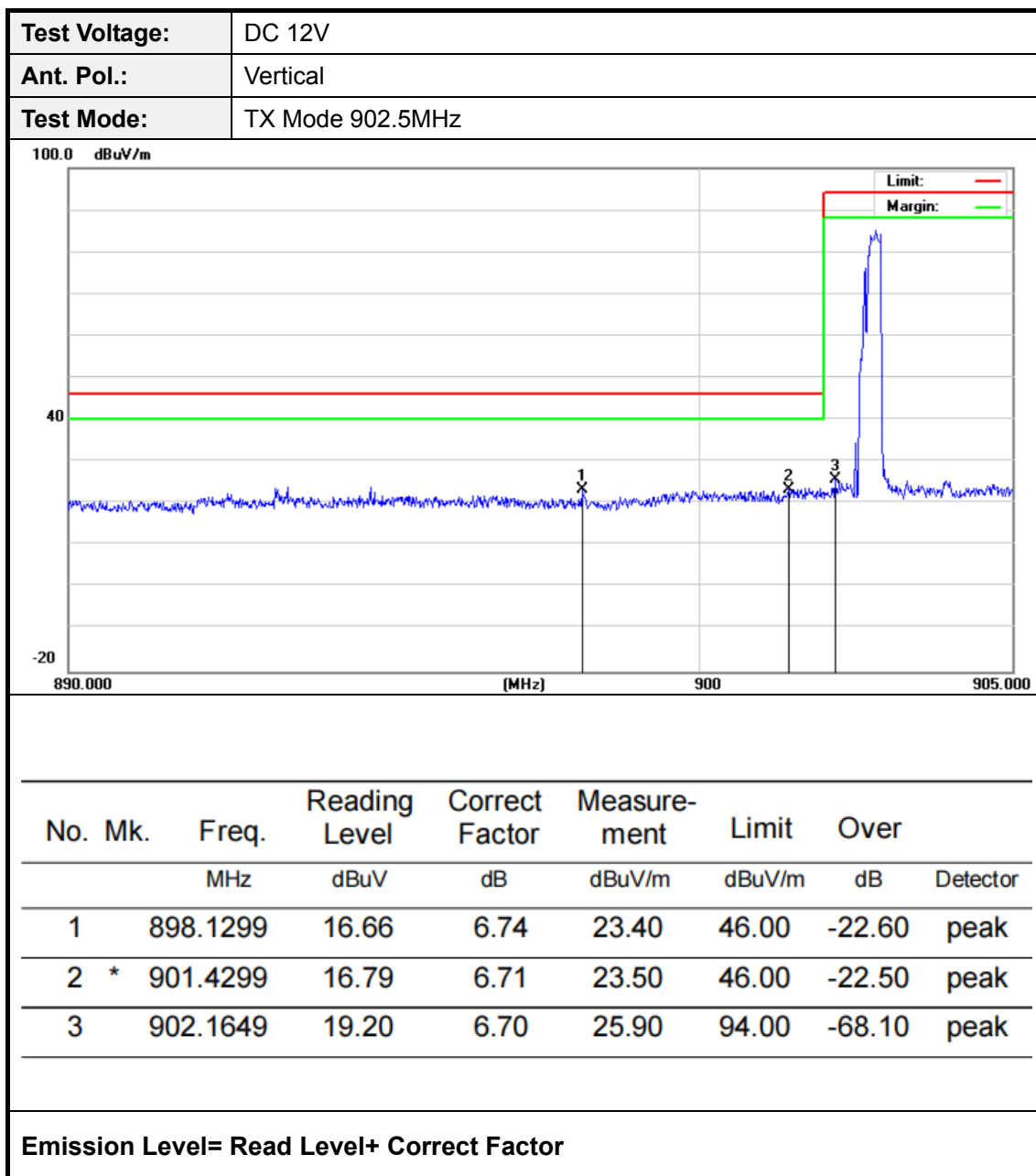
Test Results

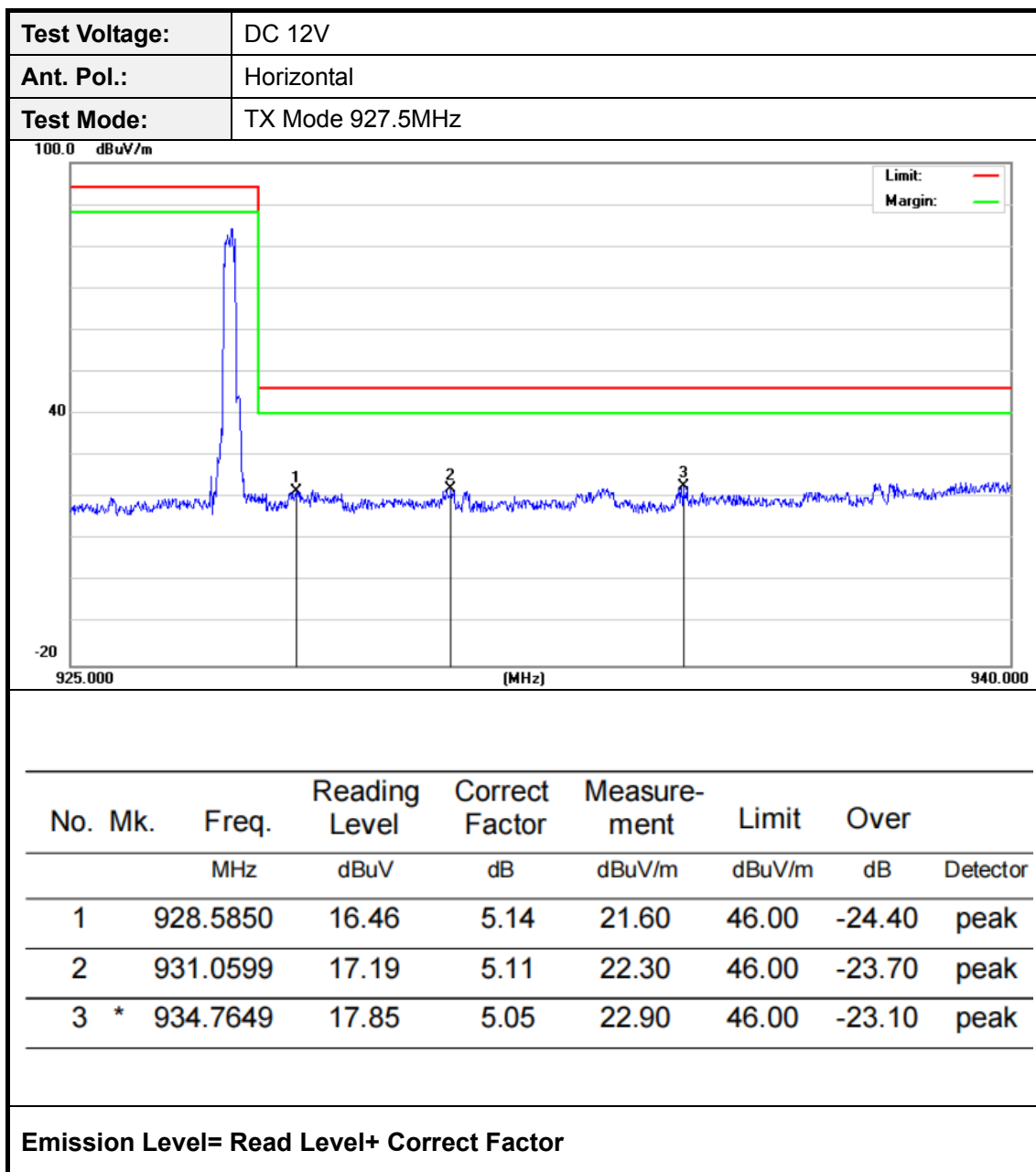
☒ **Passed** ☐ **Not Applicable**

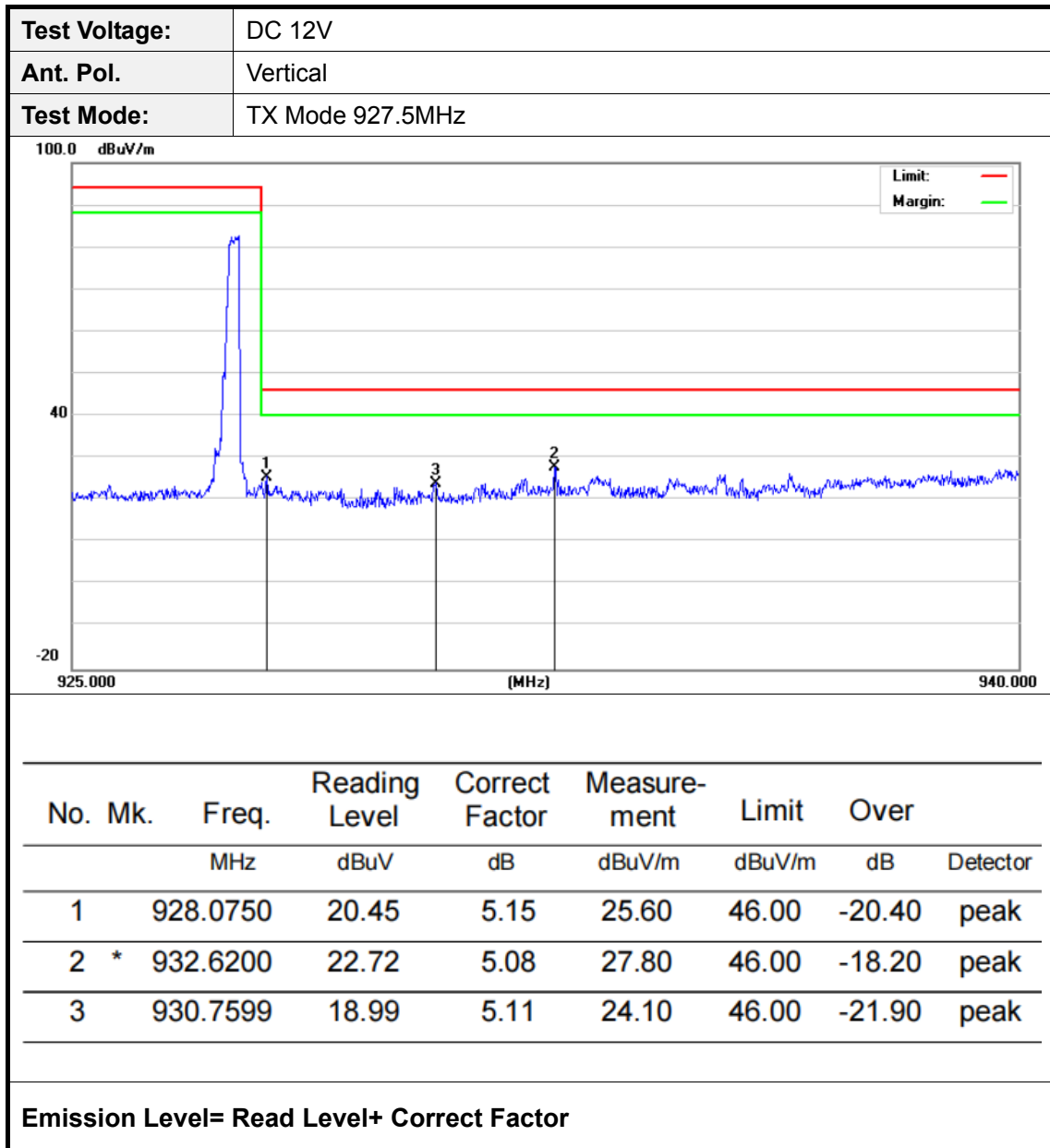
Note:

- 1) Final level= Read level + Antenna Factor + Cable Loss - Preamp Factor
- 2) Correction Factor = Antenna factor + cable loss
- 3) The peak level is lower than average limit(54dBuV/m), this data is the too weak instrument of signal is unable to test.
- 4) The emission levels of other frequencies are very lower than the limit and not show in test report.









4.EUT TEST PHOTOS

Reference attachment Test Setup Photos

*****THE END*****