TESTING LABORATORY
CERTIFICATE # 4821.01

FCC PART 15.247

TEST REPORT

For

Shenzhen Rakwireless Technology Co., Ltd.

Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street, XiLi town Nanshan District, Shenzhen, China

FCC ID: 2AF6B-RAK7431

Report Type:	**Product Type:**
Original Report	RS485 to LoRaWAN Converter

Report Number:	RSZ200511003-00A
Report Date:	2020-06-17
Reviewed By:	Jacob Kong RF Engineer
Prepared By:	Bay Area Compliance Laboratories Corp. (Shenzhen) 6/F., West Wing, Third Phase of Wanli Industrial Building, Shihua Road, Futian Free Trade Zone, Shenzhen, Guangdong, China Tel: +86-755-33320018 Fax: +86-755-33320008 www.baclcorp.com.cn

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	RS485 to LoRaWAN Converter
Tested Model	RAK7431
Frequency Range	902.3-914.9 MHz
Maximum Conducted Average Output Power	5.38dBm
Technique	Hybrid System
Antenna Specification	3.0dBi
Voltage Range	DC 5V from mirco USB port or DC 8-48V from DC input port
Date of Test	2020-05-20 to 2020-06-03
Sample serial number	RSZ200511003-RF-S1 (Assigned by BACL, Shenzhen)
Received date	2020-05-11
Sample/EUT Status	Good condition
Adapter information	Model: PSY2400300 Input: AC 100-240V, 50/60Hz, 0.6A Max Output: DC 24.0V, 300 mA

Objective

This report is prepared on behalf of *Shenzhen Rakwireless Technology Co., Ltd.* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission's rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, and section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Related Submittal(s)/Grant(s)

Part 15.247 DTS submissions with FCC ID: 2AF6B-RAK7431.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

And KDB 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed at Bay Area Compliance Laboratories Corp. (Shenzhen). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		uncertainty
Occupied Channel Bandwidth		±5%
RF output power, conducted		±0.73dB
Unwanted Emission, conducted		±1.95dB
Radiated Emissions	Below 1GHz	±4.75dB
	Above 1GHz	±4.88dB
Temperature		±1℃
Supply voltages		±0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Shenzhen) to collect test data is located on the 6/F., West Wing, Third Phase of Wanli Industrial Building, Shihua Road, Futian Free Trade Zone, Shenzhen, Guangdong, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No. : 342867, the FCC Designation No. : CN1221.

The test site has been registered with ISED Canada under ISED Canada Registration Number 3062B.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in engineering mode.

No.	Freq.(MHz)	No.	Freq.(MHz)	No.	Freq.(MHz)	No.	Freq.(MHz)
1	902.3	17	905.5	33	908.7	49	911.9
2	902.5	18	905.7	34	908.9	50	912.1
3	902.7	19	905.9	35	909.1	51	912.3
4	902.9	20	906.1	36	909.3	52	912.5
5	903.1	21	906.3	37	909.5	53	912.7
6	903.3	22	906.5	38	909.7	54	912.9
7	903.5	23	906.7	39	909.9	55	913.1
8	903.7	24	906.9	40	910.1	56	913.3
9	903.9	25	907.1	41	910.3	57	913.5
10	904.1	26	907.3	42	910.5	58	913.7
11	904.3	27	907.5	43	910.7	59	913.9
12	904.5	28	907.7	44	910.9	60	914.1
13	904.7	29	907.9	45	911.1	61	914.3
14	904.9	30	908.1	46	911.3	62	914.5
15	905.1	31	908.3	47	911.5	63	914.7
16	905.3	32	908.5	48	911.7	64	914.9

Channel 1, 33 and 64 were tested.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

“UART Assist” was made to the EUT tested and the power level is 20.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

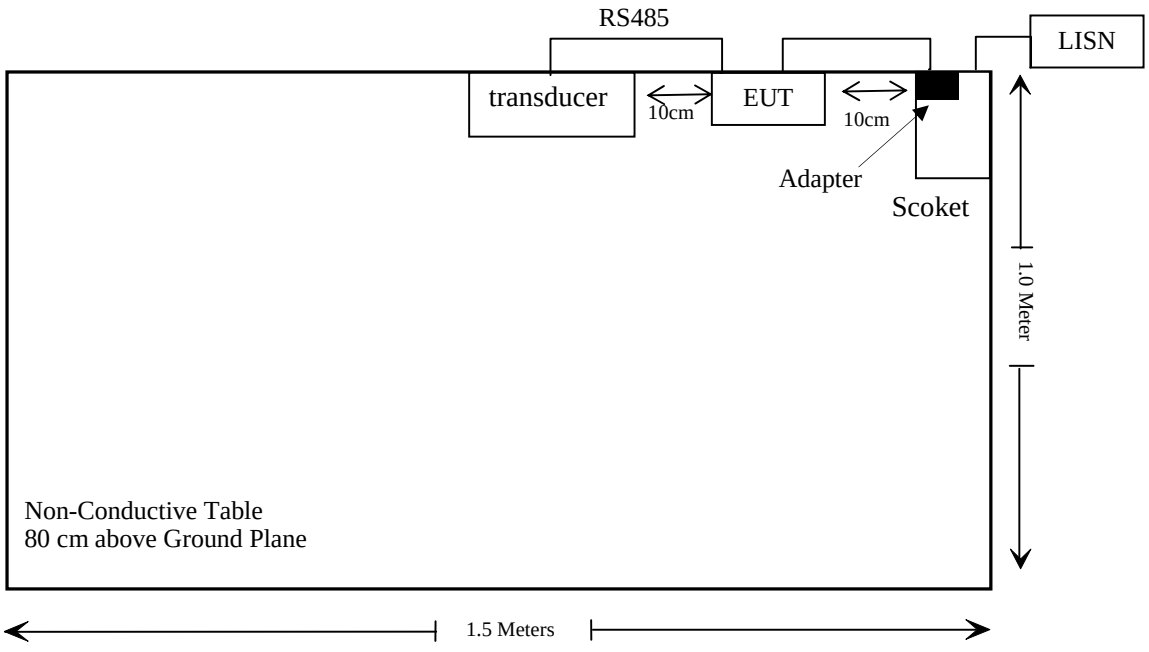
Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
SWITCHING	Adapter	SW-1772	Unknown
BULL	Socket	GN-415K	5503290068073
Guangzhu avvR	transducer	HTS40L	Unknown

External I/O Cable

Cable Description	Length (m)	From/Port	To
Un-shielding Detachable USB Cable	1.0	EUT	Adapter
Un-shielding Detachable DC Cable	1.0	EUT	Adapter
Un-shielding Detachable RS485 Cable	1.0	EUT	transducer

Block Diagram of Test Setup



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §2.1091	Maximum Permissible Exposure(MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliance
§15.247(a)(1)	20 dB Emission Bandwidth	Compliance*
§15.247(a)(1)(i)	Channel Separation Test	Compliance*
§15.247(f)	Time of Occupancy (Dwell Time)	Compliance*
§15.247(b)(3)	Peak Output Power Measurement	Compliance*
§15.247(d)	Band edges	Compliance*
§15.247(f)	Power Spectral Density	Compliance*

Compliance*: This device contains a certified module (model No.: RAK4200(H), FCC ID: 2AF6B-RAK4200H), please refer to the module test report No. RGMA190904002-00A which was tested by Bay Area Compliance Laboratories Corp. (Shenzhen).

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2019/7/9	2020/7/8
Rohde & Schwarz	LISN	ENV216	101613	2020/1/22	2021/1/21
Rohde & Schwarz	Transient Limiter	ESH3Z2	DE25985	2019/11/29	2020/11/28
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2019/11/29	2020/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2019/7/9	2020/7/8
Sonoma instrument	Pre-amplifier	310 N	186238	2020/4/20	2021/4/20
Sunol Sciences	Broadband Antenna	JB1	A040904-1	2017/12/22	2020/12/21
Unknown	Cable 2	RF Cable 2	F-03-EM197	2019/11/29	2020/11/28
Unknown	Cable 1	Chamber Cable 1	F-03-EM236	2019/11/29	2020/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2019/7/22	2020/07/21
COM-POWER	Pre-amplifier	PA-122	181919	2019/11/29	2020/11/28
Sunol Sciences	Horn Antenna	DRH-118	A052604	2017/12/22	2020/12/21
Insulted Wire Inc.	RF Cable	SPS-2503-3150	02222010	2019/11/29	2020/11/28
Unknown	RF Cable	W1101-EQ1 OUT	F-19-EM005	2019/11/29	2020/11/28
SNSD	Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2020/4/20	2021/4/20
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2019/11/29	2020/11/28
Ducommun Technolagies	Horn antenna	ARH-4223-02	1007726-021304	2017/12/6	2020/12/5

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Shenzhen) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (Minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm2)
P = power input to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Frequency (MHz)	**Antenna Gain**		**Tune up conducted power**		**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**MPE Limit (mW/cm^2)**
	(dBi)	**(numeric)**	**(dBm)**	**(mW)**			
902.3-914.9	3.0	2.0	6.0	3.98	20	0.0016	0.60

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliance

FCC §15.203 - ANTENNA REQUIREMENT

Applicable Standard

According to § 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 this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the user of a standard antenna jack or electrical connector is prohibited. The structure and application of the EUT were analyzed to determine compliance with section §15.203 of the rules. §15.203 state that the subject device must meet the following criteria:

a. Antenna must be permanently attached to the unit.
b. Antenna must use a unique type of connector to attach to the EUT.

Unit must be professionally installed, and installer shall be responsible for verifying that the correct antenna is employed with the unit.
And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Antenna Connector Construction

The EUT has an external antenna with unique antenna connector and the antenna gain is 3.0dBi, fulfill the requirement of this section. Please refer to the EUT photos.

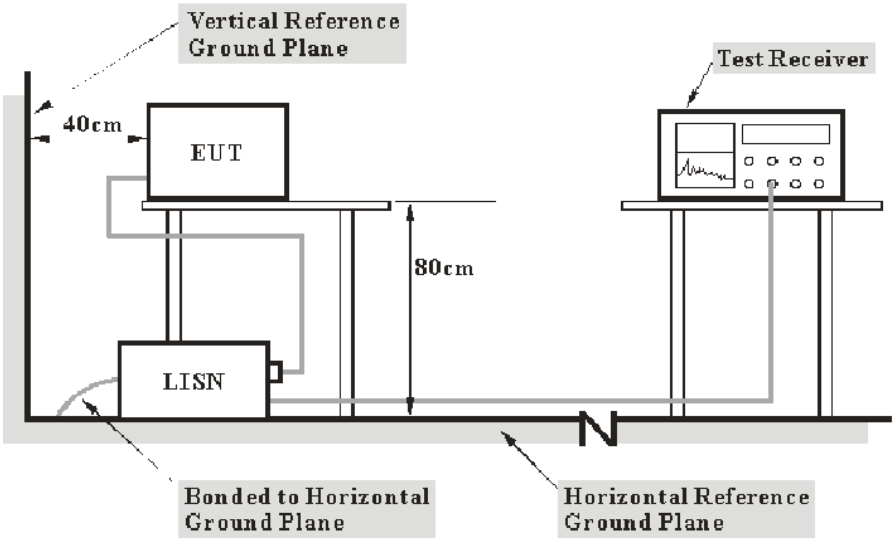
Result: Compliance.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Results Summary

According to the EUT complied with the FCC Part 15.207,

Test Data

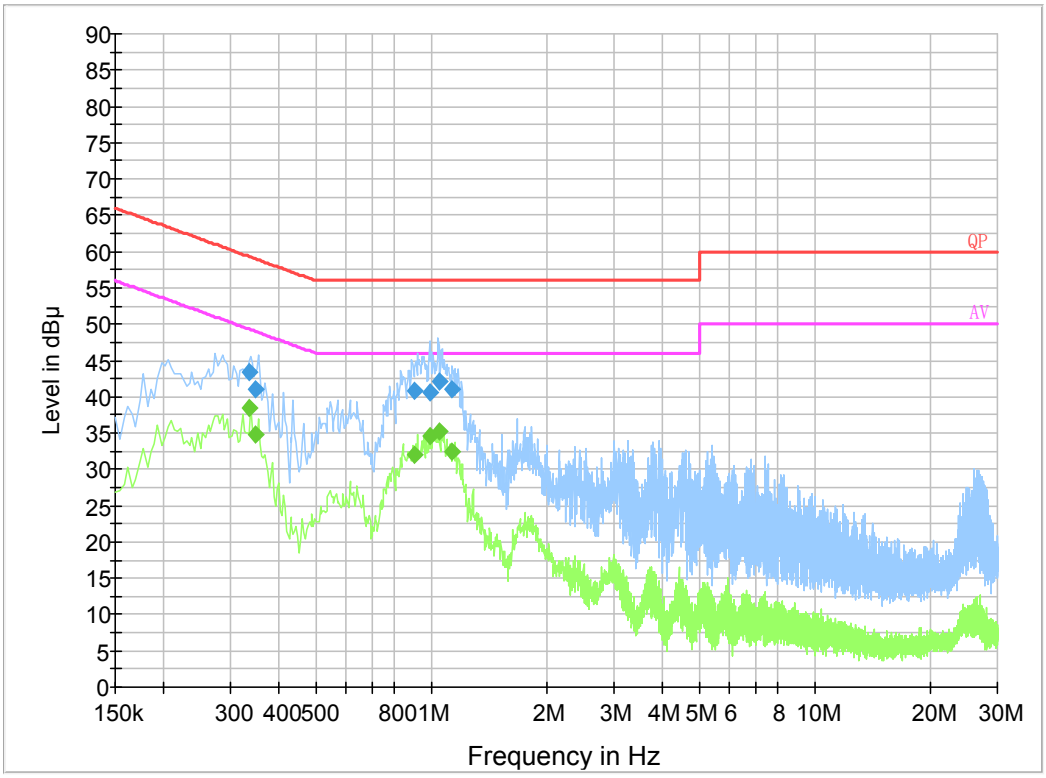
Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	65 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2020-05-21.

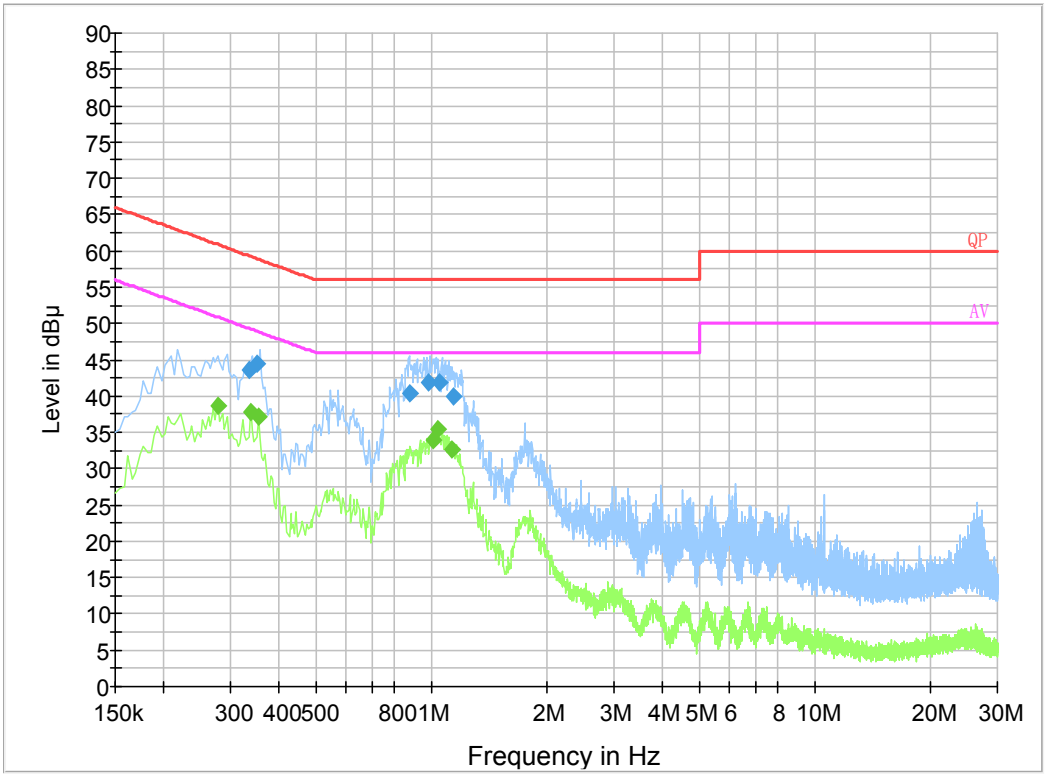
EUT operation mode: Transmitting (the worst case is Middle channel)

Powered from mirco USB port:
AC 120V/60 Hz, Line



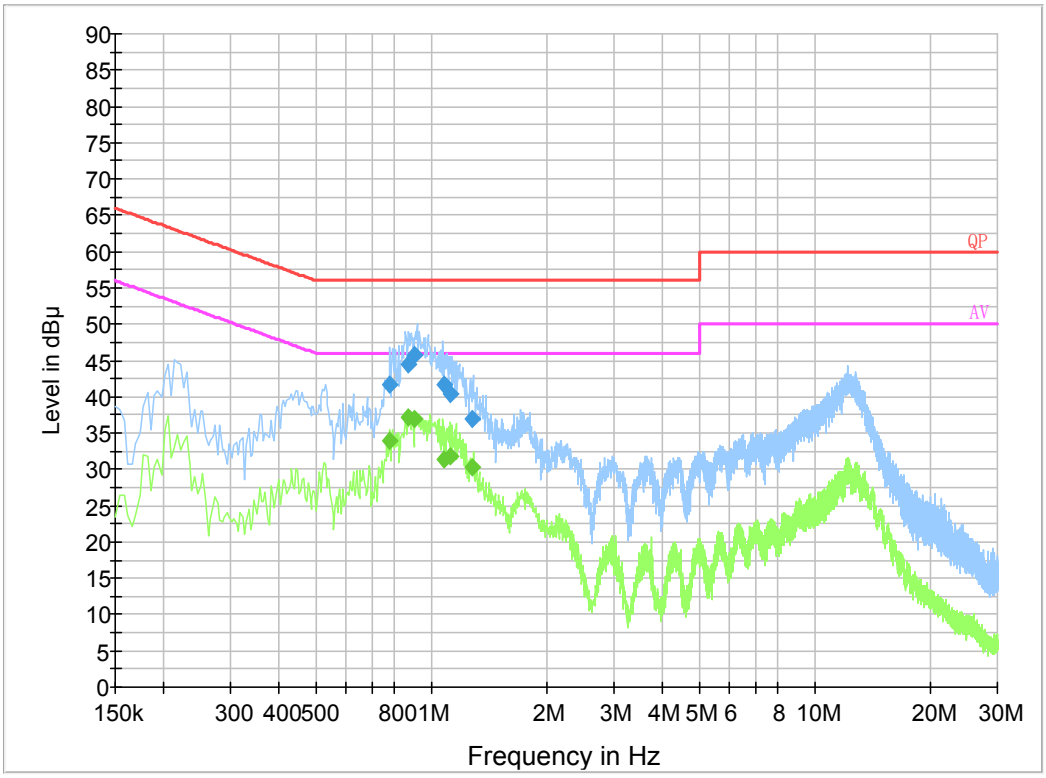
Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.336930	43.3	19.8	59.3	16.0	QP
0.348690	41.1	19.9	59.0	17.9	QP
0.903350	40.9	19.8	56.0	15.1	QP
0.995150	40.6	19.9	56.0	15.4	QP
1.050310	42.0	19.9	56.0	14.0	QP
1.132930	41.1	19.8	56.0	14.9	QP
0.336930	38.5	19.8	49.3	10.8	Ave.
0.348690	34.8	19.9	49.0	14.2	Ave.
0.903350	32.1	19.8	46.0	13.9	Ave.
0.995150	34.7	19.9	46.0	11.3	Ave.
1.050310	35.2	19.9	46.0	10.8	Ave.
1.132930	32.5	19.8	46.0	13.5	Ave.

AC 120V/60 Hz, Neutral



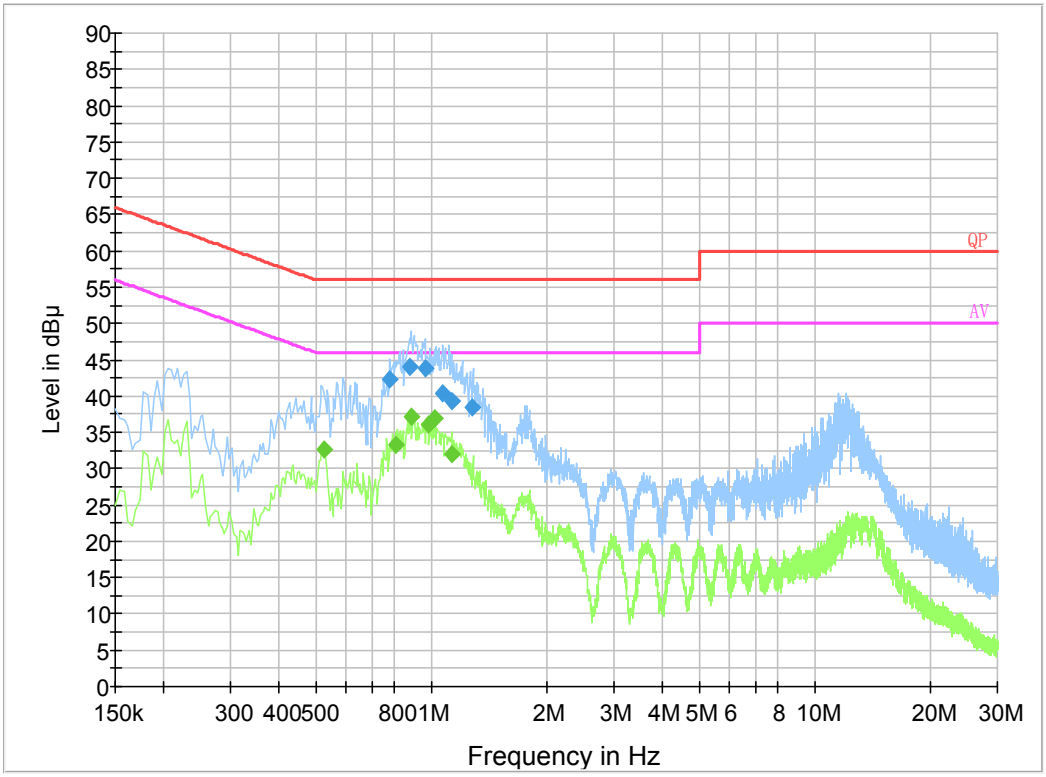
Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.336870	43.6	19.8	59.3	15.7	QP
0.352630	44.4	19.9	58.9	14.5	QP
0.876830	40.4	19.7	56.0	15.6	QP
0.983150	41.8	19.8	56.0	14.2	QP
1.053950	41.8	19.8	56.0	14.2	QP
1.140930	39.9	19.8	56.0	16.1	QP
0.278000	38.7	19.7	50.9	12.2	Ave.
0.338000	37.8	19.8	49.3	11.5	Ave.
0.354000	37.2	19.9	48.9	11.6	Ave.
1.010000	34.0	19.8	46.0	12.0	Ave.
1.046000	35.4	19.8	46.0	10.6	Ave.
1.134000	32.6	19.8	46.0	13.4	Ave.

Powered from DC input port:
AC 120V/60 Hz, Line



Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.782270	41.7	19.8	56.0	14.3	QP
0.869130	44.4	19.8	56.0	11.6	QP
0.908230	45.7	19.8	56.0	10.3	QP
1.081890	41.7	19.9	56.0	14.3	QP
1.120930	40.3	19.8	56.0	15.7	QP
1.278710	36.9	19.8	56.0	19.1	QP
0.782270	33.9	19.8	46.0	12.1	Ave.
0.869130	37.1	19.8	46.0	8.9	Ave.
0.908230	37.0	19.8	46.0	9.0	Ave.
1.081890	31.3	19.9	46.0	14.7	Ave.
1.120930	31.7	19.8	46.0	14.3	Ave.
1.278710	30.4	19.8	46.0	15.6	Ave.

AC 120V/60 Hz, Neutral



Frequency (MHz)	Corrected Amplitude (dBµV)	Correction Factor (dB)	Limit (dBµV)	Margin (dB)	Detector (PK/Ave./QP)
0.782270	42.3	19.8	56.0	13.7	QP
0.876710	44.1	19.7	56.0	11.9	QP
0.963570	43.8	19.8	56.0	12.2	QP
1.069890	40.4	19.8	56.0	15.6	QP
1.133050	39.3	19.8	56.0	16.7	QP
1.278710	38.4	19.8	56.0	17.6	QP
0.526000	32.7	19.8	46.0	13.3	Ave.
0.810000	33.2	19.8	46.0	12.8	Ave.
0.886000	37.1	19.7	46.0	8.9	Ave.
0.982000	36.1	19.8	46.0	9.9	Ave.
1.022000	36.9	19.8	46.0	9.1	Ave.
1.134000	31.9	19.8	46.0	14.1	Ave.

Note:

1) Correction Factor =LISN VDF (Voltage Division Factor) + Cable Loss + Transient Limiter Attenuation
2) Corrected Amplitude = Reading + Correction Factor
3) Margin = Limit – Corrected Amplitude

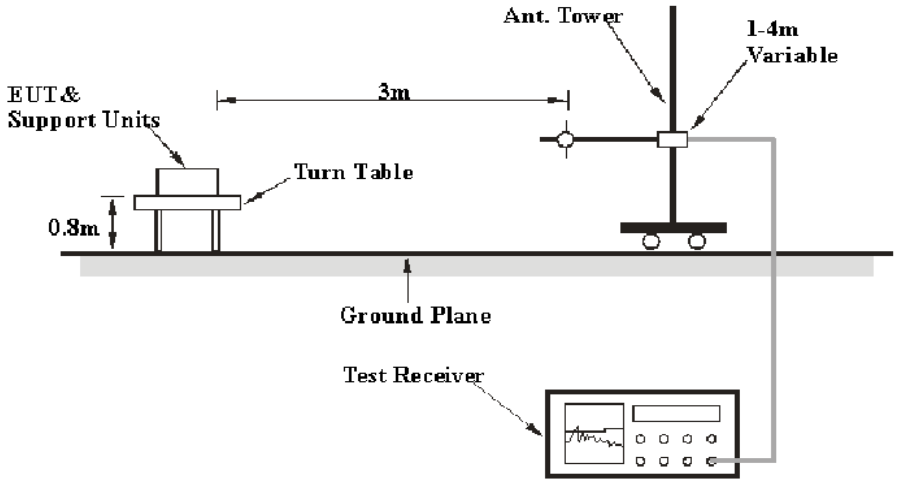
FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS

Applicable Standard

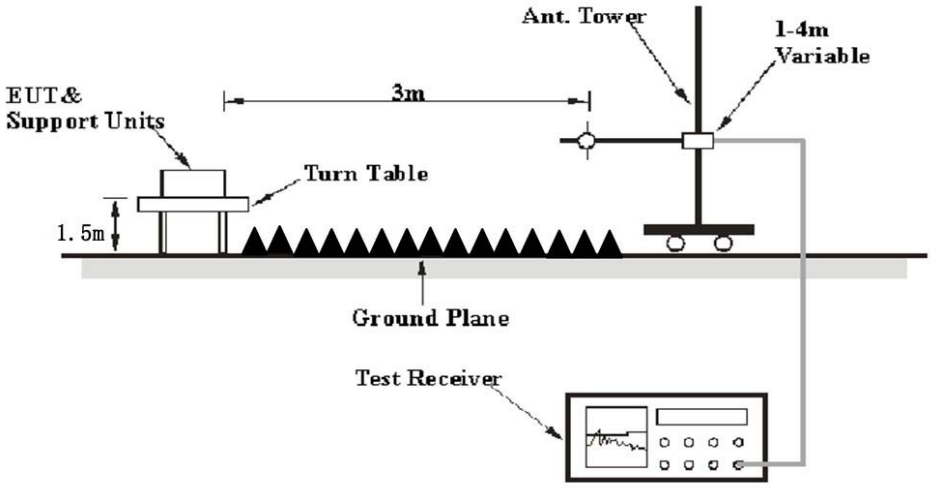
FCC §15.247 (d); §15.209; §15.205;

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209, and FCC 15.247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 10 GHz.

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurements
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz	/	Ave.

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

Data was recorded in Quasi-peak detection mode for frequency range of 30 MHz-1 GHz, peak and Average detection modes for frequencies above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Results Summary

According to the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

Test Data

Environmental Conditions

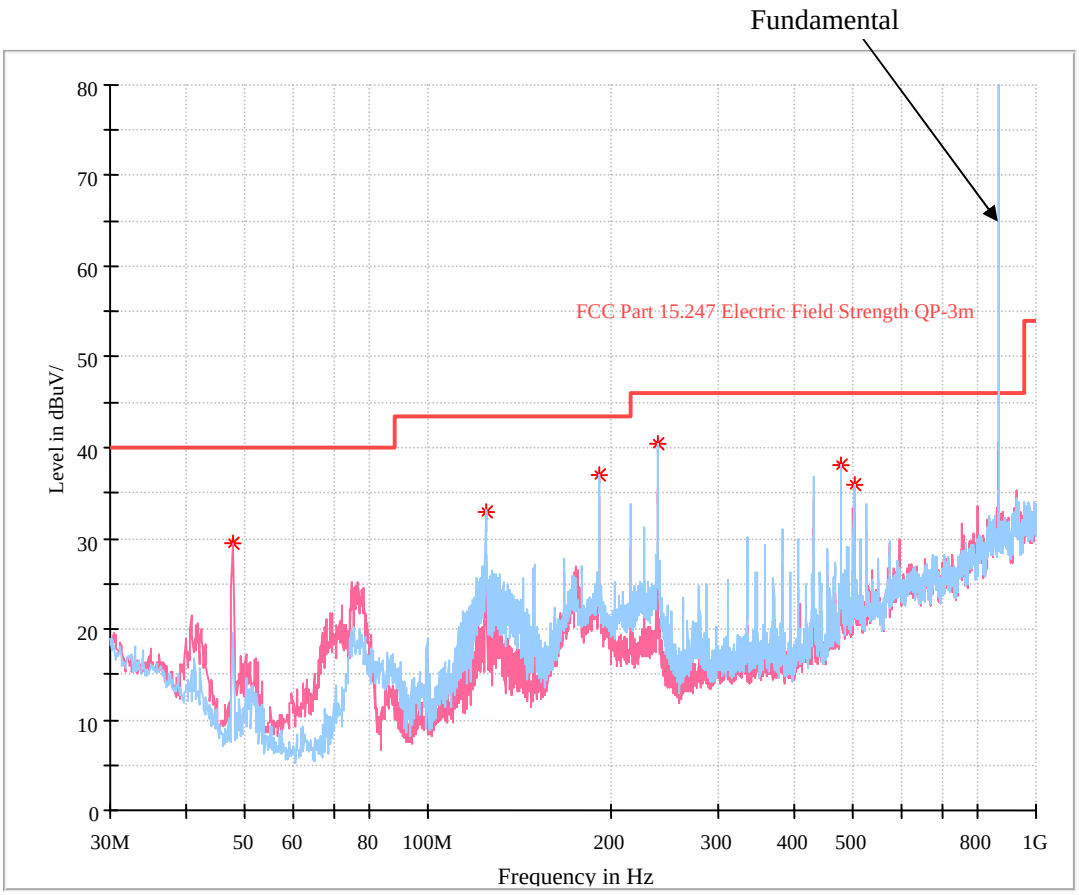
Temperature:	26 ℃
Relative Humidity:	65 %
ATM Pressure:	101.0 kPa

The testing was performed by Hams He from 2020-05-29 to 2020-06-03 for below 1GHz and Leo Huang on 2020-05-20 for above 1GHz.

EUT operation mode: Transmitting (worst case)

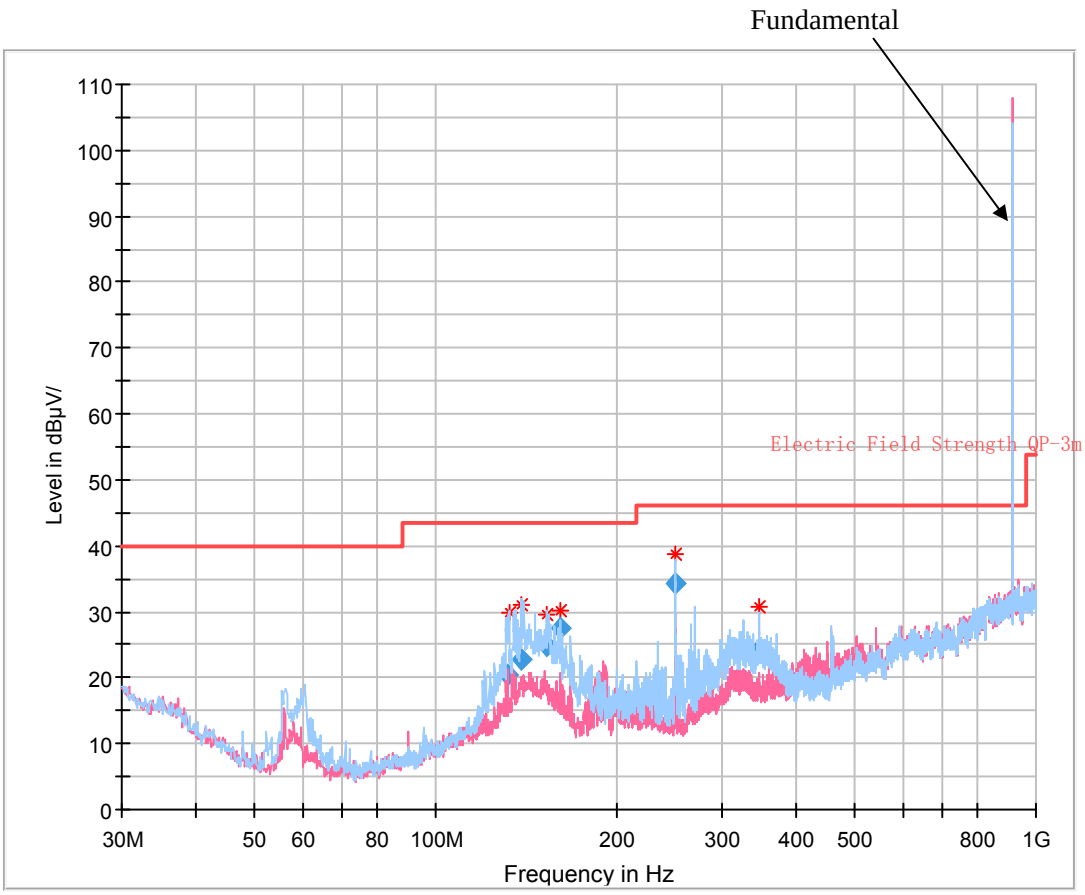
30 MHz~1 GHz:

Powered from mirco USB port:



Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
47.702500	29.46	105.0	V	119.0	-18.6	40.00	10.54
124.332500	32.95	205.0	H	0.0	-14.0	43.50	10.55
191.141250	37.01	205.0	H	305.0	-15.0	43.50	6.49
239.156250	40.37	105.0	H	101.0	-14.1	46.00	5.63
478.261250	38.04	105.0	H	179.0	-6.5	46.00	7.96
501.783750	35.99	205.0	V	222.0	-5.2	46.00	10.01

Powered from DC input port:



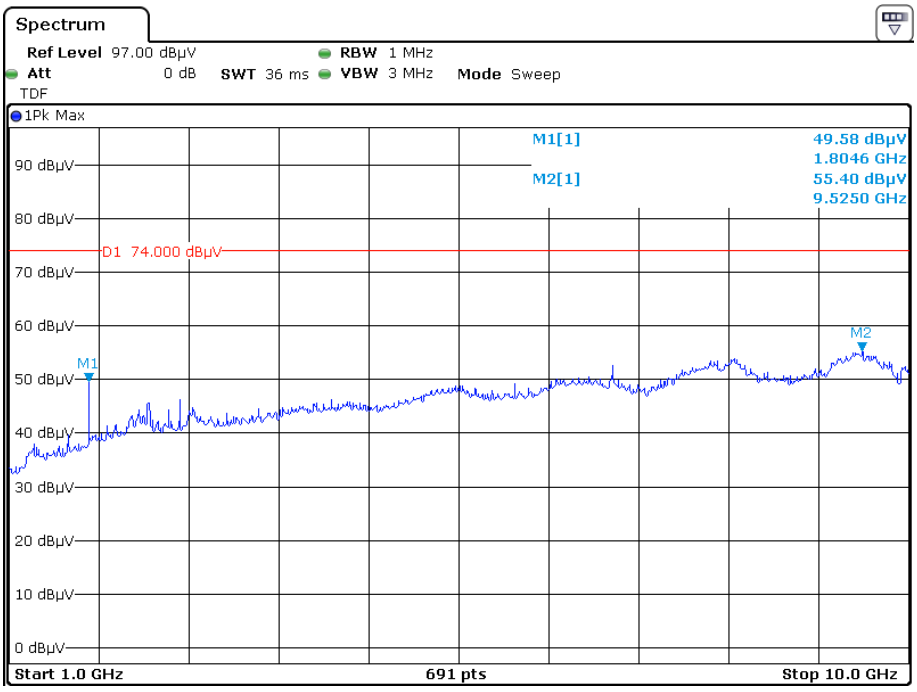
Frequency (MHz)	Corrected Amplitude (dBµV/m)	Antenna height (cm)	Antenna Polarity	Turntable position (degree)	Correction Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
131.785125	20.32	331.0	H	130.0	-13.8	43.50	23.18
138.680000	22.91	200.0	H	312.0	-14.2	43.50	20.59
153.395375	24.77	196.0	H	257.0	-14.3	43.50	18.73
161.130125	27.45	153.0	H	111.0	-14.5	43.50	16.05
251.374000	34.37	111.0	H	316.0	-14.0	46.00	11.63
345.094250	24.26	149.0	H	272.0	-10.8	46.00	21.74

1 GHz - 10 GHz:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247/205/209	
	Reading (dBμV)	Detector (PK/QP/Ave.)		Height (m)	Polar (H/V)			Limit (dBμV/m)	Margin (dB)
902.3MHz									
1804.60	55.47	PK	252	1.3	H	-1.65	53.82	74	20.18
1804.60	42.52	Ave.	252	1.3	H	-1.65	40.87	54	13.13
1804.60	54.19	PK	46	1.5	V	-1.65	52.54	74	21.46
1804.60	47.88	Ave.	46	1.5	V	-1.65	46.23	54	7.77
2706.90	50.14	PK	248	2.5	H	1.09	51.23	74	22.77
2706.90	33.00	Ave.	248	2.5	H	1.09	34.09	54	19.91
2706.90	46.97	PK	340	1.7	V	1.09	48.06	74	25.94
2706.90	31.45	Ave.	340	1.7	V	1.09	32.54	54	21.46
908.7MHz									
1817.40	54.77	PK	344	1.0	H	-1.55	53.22	74	20.78
1817.40	42.78	Ave.	344	1.0	H	-1.55	41.23	54	12.77
1817.40	54.18	PK	124	1.2	V	-1.55	52.63	74	21.37
1817.40	44.16	Ave.	124	1.2	V	-1.55	42.61	54	11.39
2726.10	50.26	PK	216	1.8	H	1.19	51.45	74	22.55
2726.10	33.82	Ave.	216	1.8	H	1.19	35.01	54	18.99
2726.10	46.95	PK	302	2.2	V	1.19	48.14	74	25.86
2726.10	31.42	Ave.	302	2.2	V	1.19	32.61	54	21.39
914.9MHz									
1829.80	52.76	PK	83	2.0	H	-1.55	51.21	74	22.79
1829.80	42.24	Ave.	83	2.0	H	-1.55	40.69	54	13.31
1829.80	53.87	PK	292	2.2	V	-1.55	52.32	74	21.68
1829.80	43.70	Ave.	292	2.2	V	-1.55	42.15	54	11.85
2744.70	49.74	PK	88	2.2	H	1.19	50.93	74	23.07
2744.70	36.61	Ave.	88	2.2	H	1.19	37.80	54	16.20
2744.70	46.52	PK	179	1.1	V	1.19	47.71	74	26.29
2744.70	30.49	Ave.	179	1.1	V	1.19	31.68	54	22.32

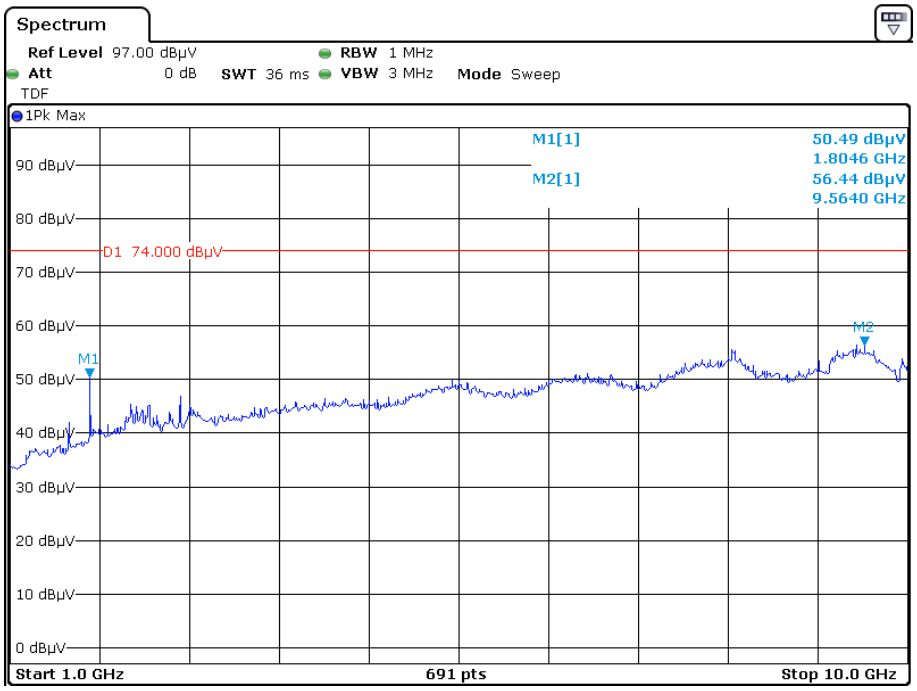
Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude
The other spurious emission which is 20dB to the limit was not recorded.

Pre-scan with low channel Peak
Horizontal



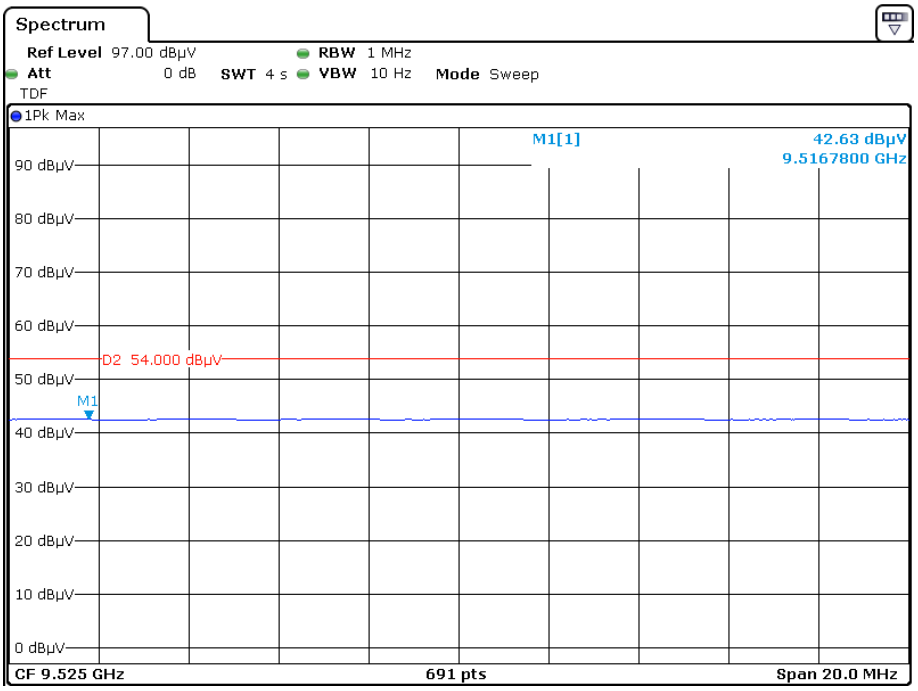
Date: 20.MAY.2020 19:53:09

Vertical



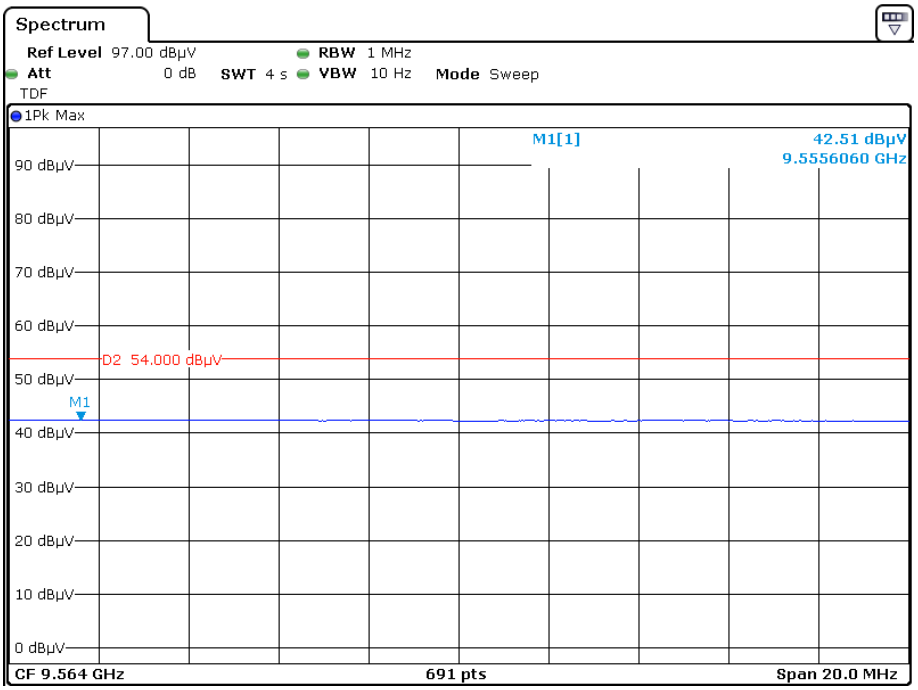
Date: 20.MAY.2020 20:09:25

Pre-scan for Average
Horizontal



Date: 20.MAY.2020 19:59:46

Vertical



Date: 20.MAY.2020 20:12:07

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