FCC Test Report

Report No.: RFACXM-WTW-P21060766-5

FCC ID: 2AEUPBHASG001

Test Model: 5F48E9

Received Date: 2021/6/22

Test Date: 2021/7/30 ~ 2021/10/8

Issued Date: 2021/11/3

Applicant: Ring LLC

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Issued By: Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch Hsin Chu Laboratory

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FCC Registration / Designation Number: 723255 / TW2022

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Release Control Record

Issue No.	Description	Date Issued
RFACXM-WTW-P21060766-5	Original release.	2021/11/3

1 Certificate of Conformity

Product: Amazon Sidewalk Bridge Pro by Ring

Brand: Ring LLC

Test Model: 5F48E9

Sample Status: Engineering sample

Applicant: Ring LLC

Test Date: 2021/7/30 ~ 2021/10/8

Standards: 47 CFR FCC Part 15, Subpart C (Section 15.247)
ANSI C63.10: 2013

The above equipment has been tested by **Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's EMC characteristics under the conditions specified in this report.

Prepared by : _____ , **Date:** 2021/11/3
Phoenix Huang / Specialist

Approved by : _____ , **Date:** 2021/11/3
Clark Lin / Technical Manager

2 Summary of Test Results

➢ **Hybrid Mode**

47 CFR FCC Part 15, Subpart C (Section 15.247)			
FCC Clause	Test Item	Result	Remarks
15.207	AC Power Conducted Emission	Pass	Meet the requirement of limit. Minimum passing margin is -5.67 dB at 0.40000 MHz.
15.247(a)(1)(i)	Number of Hopping Frequency Used	NA	Refer to Note
15.247(a)(1)(i)	Dwell Time on Each Channel	Pass	Meet the requirement of limit.
15.247(a)(1)(i)	Hopping Channel Separation	Pass	Meet the requirement of limit.
15.247(b)(2)	Maximum Peak Output Power	Pass	Meet the requirement of limit.
15.205 & 209 & 15.247(d)	Radiated Emissions & Band Edge Measurement	Pass	Meet the requirement of limit. Minimum passing margin is -4.5 dB at 58.29 MHz.
15.247(d)	Antenna Port Emission	Pass	Meet the requirement of limit.
15.247(e)	Power Spectral Density	Pass	Meet the requirement of limit.
15.203	Antenna Requirement	Pass	Antenna connector is R-N type(F) and R-N type(M) not a standard connector.

Note:

1. Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.
2. There is no requirement for this type of hybrid system to comply with the 500 kHz minimum bandwidth normally associated with a DTS transmission; and, there is no minimum number of hopping channels associated with this type of hybrid system.

➢ **DTS Mode**

47 CFR FCC Part 15, Subpart C (Section 15.247)			
FCC Clause	Test Item	Result	Remarks
15.207	AC Power Conducted Emission	Pass	Meet the requirement of limit. Minimum passing margin is -4.95 dB at 0.41172 MHz.
15.205 / 15.209 / 15.247(d)	Radiated Emissions and Band Edge Measurement	Pass	Meet the requirement of limit. Minimum passing margin is -4.4 dB at 58.38 MHz.
15.247(d)	Antenna Port Emission	Pass	Meet the requirement of limit.
15.247(a)(2)	6dB bandwidth	Pass	Meet the requirement of limit.
15.247(b)	Conducted power	Pass	Meet the requirement of limit.
15.247(e)	Power Spectral Density	Pass	Meet the requirement of limit.
15.203	Antenna Requirement	Pass	Antenna connector is R-N type(F) and R-N type(M) not a standard connector.

Note:
1. Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

2.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Measurement	Frequency	Expanded Uncertainty (k=2) (±)
Conducted Emissions at mains ports	150kHz ~ 30MHz	1.9 dB
Conducted emissions	-	2.5 dB
Radiated Emissions up to 1 GHz	9kHz ~ 30MHz	3.1 dB
	30MHz ~ 1GHz	5.5 dB
Radiated Emissions above 1 GHz	1GHz ~ 18GHz	5.1 dB

2.2 Modification Record

There were no modifications required for compliance.

3 General Information

3.1 General Description of EUT

Product	Amazon Sidewalk Bridge Pro by Ring
Brand	Ring LLC
Test Model	5F48E9
Status of EUT	Engineering sample
Power Supply Rating	DC 6V from battery or DC 53V from POE
Modulation Type	FSK
Modulation Technology	**Hybrid Mode:** CSS **DTS Mode:** DTS
Transfer Rate	Refer to Note
Operating Frequency	**Hybrid Mode:** 923.1 ~ 927.7 MHz **DTS Mode:** **Channel Spacing 600 kHz:** 923.3 ~ 927.5 MHz **Channel Spacing 800 kHz:** 902.5 ~ 926.5 MHz
Number of Channel	Refer to Note
Output Power	**Hybrid Mode:** 110.662 mW **DTS Mode:** **Channel Spacing 600 kHz:** 547.016 mW **Channel Spacing 800 kHz:** 587.489 mW
Antenna Type	Refer to Note
Antenna Connector	Refer to Note
Accessory Device	NA
Data Cable Supplied	NA

Note:

1. The LoRa technology information as below table.

Mode	Channel Spacing	Data Rate	Number of Channel	Spec.
Hybrid (Hopping + DTS)	200 kHz	DR1 (SF9): 1.76 kbps	24	1. DR1 (SF9) / BW: 125kHz 2. Group 1: 923.1~924.5 MHz 3. Group 2: 924.7~926.1 MHz 4. Group 3: 926.3~927.7 MHz
DTS	600 kHz	DR13 (SF7): 21.9 kbps DR9 (SF11): 76 kbps	8	DR13 (SF7), DR9 (SF11) / BW: 500kHz
	800 kHz		31	
Note: For DTS channel spacing 600 kHz and 800 kHz modes, the worst Radiated Emissions (below 1GHz) and AC Power Conducted Emission was found in **Channel Spacing 800 kHz.** Therefore only the test data of the mode was recorded in this report.				

2. The EUT contains certified WWAN (LTE) modular which FCC ID: ZMONL668AM00.
3. The EUT has below radios as following table:

Radio 1	Radio 2	Radio 3	Radio 4
WLAN 2.4GHz+ WLAN 5GHz+ Bluetooth	WWAN (LTE)	GPS	LoRa + FSK

4. Simultaneously transmission condition.

Condition	Technology			
1	WLAN (2.4GHz)	LoRa	Bluetooth	-
2	WLAN (5GHz)	LoRa	Bluetooth	-
3	WLAN (2.4GHz)	FSK	Bluetooth	-
4	WLAN (5GHz)	FSK	Bluetooth	-
5	LTE	LoRa	Bluetooth	-
6	LTE	FSK	Bluetooth	-
7	WLAN (2.4GHz)	LoRa	FSK	Bluetooth
8	WLAN (5GHz)	LoRa	FSK	Bluetooth
9	LTE	LoRa	FSK	Bluetooth
Note: The emission of the simultaneous operation has been evaluated and no non-compliance was found.				

5. The EUT must be supplied with a battery and following below table:

Brand	Model No.	Spec.
WELLTECH ENERGY INC.	5F48E9	6 Vdc, 3100 mAh

6. The antennas provided to the EUT, please refer to the following table:

RF Chain No	Brand	Model	Antenna Net Gain (dBi)	Frequency Range	Antenna Type	Connector Type	Cable Length (mm)
WiFi 0	Inpaq	RFPCA520814IMLB301	8.04	2.4~2.4835 GHz	PIFA	i-pex(MHF)	149
			8.81	5.15~5.85 GHz			
WiFi 1	Inpaq	RFPCA501016IMLB301	8.26	2.4~2.4835 GHz	PIFA	i-pex(MHF)	165
			8.64	5.15~5.85 GHz			
BT	Inpaq	RFPCA520815IMAB301	6.88	2.4~2.4835 GHz	PIFA	i-pex(MHF)	210
LoRa/FSK (Outdoor)	Inpaq	RFDPA563600AFRBX01	5.5	902~928 MHz	Dipole	R-N type(F)	1000
LoRa/FSK (Indoor)	Inpaq	FDPA161500AMUB801	2.8	902~928 MHz	Dipole	R-N type(M)	NA
GPS(L1)	Inpaq	RFPCA621512IMTB301	7.26	1575 MHz	PIFA	i-pex(MHF)	NA
GPS(L5)	Inpaq	RFPCA711620IMTB301	6.06	1176 MHz	PIFA	i-pex(MHF)	NA
Note: For LoRa/FSK Radiated Emission test item the max. gain was selected for the final test .							

7. For Radiated Emission test, the EUT was pre-tested under the following modes:

Pre-test Mode	Description
Mode A	**Power from POE**
Mode B	Power from Battery
From the above modes, the worst case was found in **Mode A**. Therefore only the test data of the mode was recorded in this report.	

8. The above EUT information is declared by manufacturer and for more detailed features description, please refer to the manufacturer's specifications or User's Manual.
9. The above Antenna information is declared by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

3.2 Description of Test Modes

Hybrid Mode:

24 channels are provided for Hybrid mode:

Group	Channel	Freq. (MHz)	Group	Channel	Freq. (MHz)	Group	Channel	Freq. (MHz)
Group 1	0	923.1	Group 2	8	924.7	Group 3	16	926.3
	1	923.3		9	924.9		17	926.5
	2	923.5		10	925.1		18	926.7
	3	923.7		11	925.3		19	926.9
	4	923.9		12	925.5		20	927.1
	5	924.1		13	925.7		21	927.3
	6	924.3		14	925.9		22	927.5
	7	924.5		15	926.1		23	927.7

DTS Mode:

8 channels are provided for DTS mode (Channel Spacing: 600 kHz):

Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
0	923.3	3	925.1	6	926.9
1	923.9	4	925.7	7	927.5
2	924.5	5	926.3		

31 channels are provided for DTS mode (Channel Spacing: 800 kHz):

Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
0	902.5	13	912.9	26	923.3
1	903.3	14	913.7	27	924.1
2	904.1	15	914.5	28	924.9
3	904.9	16	915.3	29	925.7
4	905.7	17	916.1	30	926.5
5	906.5	18	916.9		
6	907.3	19	917.7		
7	908.1	20	918.5		
8	908.9	21	919.3		
9	909.7	22	920.1		
10	910.5	23	920.9		
11	911.3	24	921.7		
12	912.1	25	922.5		

3.2.1 Test Mode Applicability and Tested Channel Detail (Hybrid Mode)

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE≥1G	RE<1G	PLC	APCM	
-	√	√	√	√	-

Where **RE≥1G:** Radiated Emission above 1GHz **RE<1G:** Radiated Emission below 1GHz
PLC: Power Line Conducted Emission **APCM:** Antenna Port Conducted Measurement

Radiated Emission Test (Above 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
0 to 23	0, 23	FSK	1.76

Radiated Emission Test (Below 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
0 to 23	0	FSK	1.76

Power Line Conducted Emission Test:

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
0 to 23	0	FSK	1.76

Antenna Port Conducted Measurement:

☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
0 to 23	0, 23	FSK	1.76

Test Condition:

Applicable to	Environmental Conditions	Input Power (System)	Tested by
RE≥1G	25deg. C, 75%RH	120Vac, 60Hz	Nelson Teng
RE<1G	25deg. C, 65~67%RH	120Vac, 60Hz	Sampson Chen, Carter Lin
PLC	26deg. C, 61%RH	120Vac, 60Hz	Sampson Chen
APCM	25deg. C, 60%RH	120Vac, 60Hz	Kevin Ko

3.2.2 Test Mode Applicability and Tested Channel Detail (DTS Mode)

EUT CONFIGURE MODE	APPLICABLE TO				DESCRIPTION
	RE≥1G	RE<1G	PLC	APCM	
1	√	√	√	√	Channel Spacing: 800 kHz
2	√	-	-	√	Channel Spacing: 600kHz

Where **RE≥1G:** Radiated Emission above 1GHz **RE<1G:** Radiated Emission below 1GHz
PLC: Power Line Conducted Emission **APCM:** Antenna Port Conducted Measurement

Radiated Emission Test (Above 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
1	0 to 30	0, 15, 30	FSK	21.9
2	0 to 7	0, 7	FSK	21.9

Radiated Emission Test (Below 1GHz):

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
1	0 to 30	30	FSK	21.9

Power Line Conducted Emission Test:

☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
1	0 to 30	30	FSK	21.9

Antenna Port Conducted Measurement:

☒ This item includes all test value of each mode, but only includes spectrum plot of worst value of each mode.
☒ Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).
☒ Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Channel	Tested Channel	Modulation Type	Data Rate (kbps)
1	0 to 30	0, 15, 30	FSK	21.9
2	0 to 7	0, 7	FSK	21.9

Test Condition:

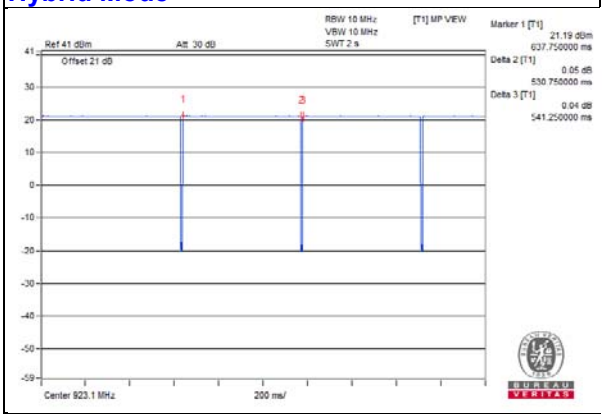
Applicable to	Environmental Conditions	Input Power (System)	Tested by
RE≥1G	23~25deg. C, 71~75%RH	120Vac, 60Hz	Nelson Teng, Tom Yang
RE<1G	23~25deg. C, 67~71%RH	120Vac, 60Hz	Sampson Chen, Carter Lin
PLC	26deg. C, 61%RH	120Vac, 60Hz	Sampson Chen
APCM	25deg. C, 60%RH	120Vac, 60Hz	Kevin Ko, Leon Dai

3.3 Duty Cycle of Test Signal

If duty cycle of test signal is ≥ 98 %, duty factor is not required.
If duty cycle of test signal is < 98%, duty factor shall be considered.

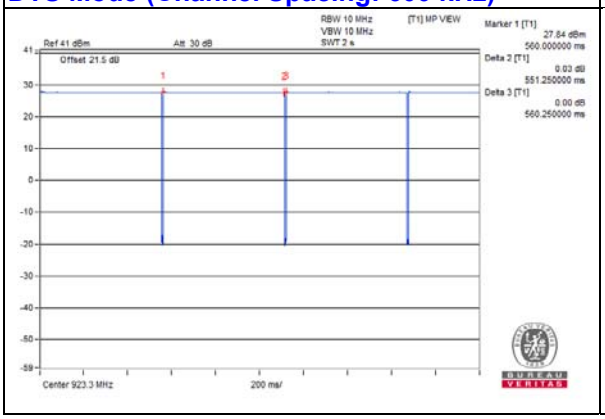
Hybrid Mode: Duty cycle = 530.75 ms/541.25 ms = 0.981

Hybrid Mode

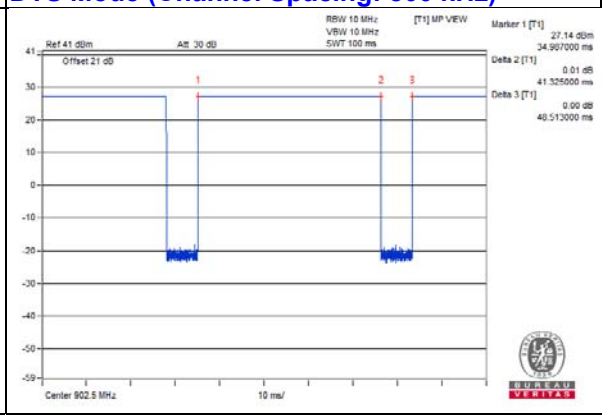


DTS Mode:
Channel Spacing 600 kHz: Duty cycle = 551.25 ms/560.25 ms = 0.984
Channel Spacing 800 kHz: Duty cycle = 41.325 ms/48.513 ms = 0.852, Duty factor = 10 * log(1/Duty cycle) = 0.70 dB

DTS Mode (Channel Spacing: 600 kHz)



DTS Mode (Channel Spacing: 800 kHz)



3.4 Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

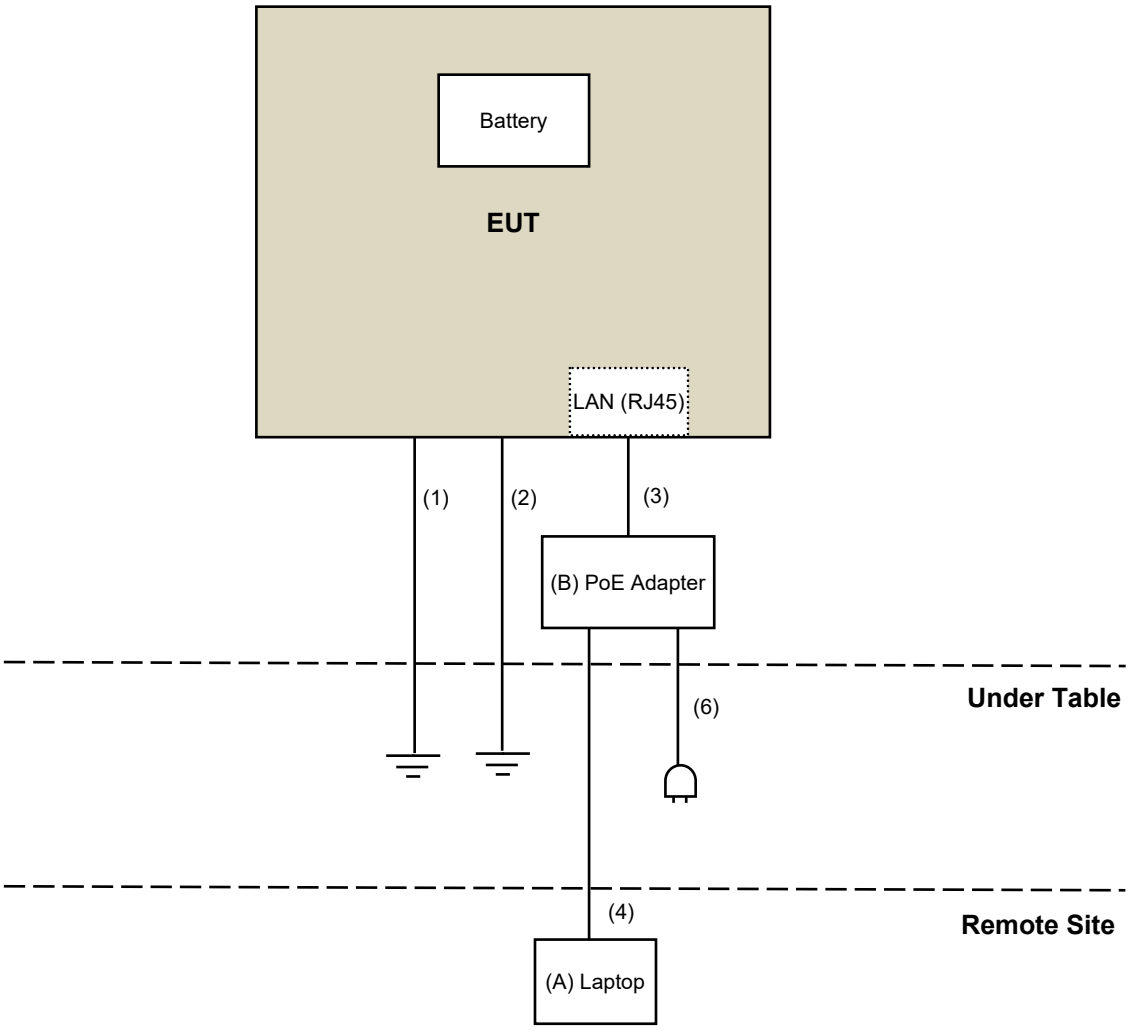
ID	Product	Brand	Model No.	Serial No.	FCC ID	Remarks
A.	Laptop	Lenovo	20U5S01X00 L14	PF-1ANPYA	NA	Provided by Lab
B.	PoE Adapter	Gospower	G0545-530-060-P SE1000	NA	NA	Supplied by client

Note: 1. All power cords of the above support units are non-shielded (1.8m).

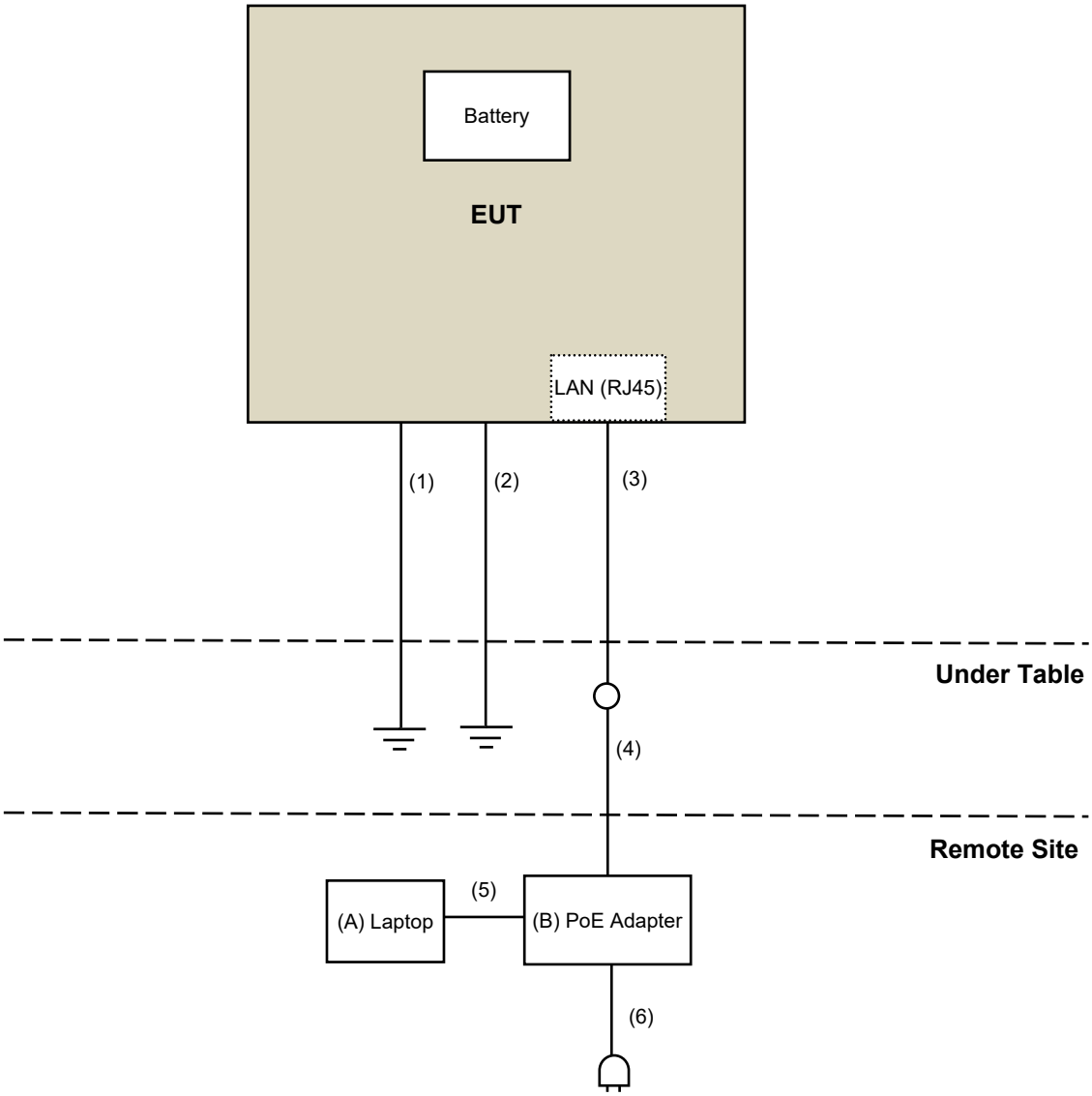
ID	Descriptions	Qty.	Length (m)	Shielding (Yes/No)	Cores (Qty.)	Remarks
1.	GND Cable	1	2	Yes	0	Provided by Lab
2.	GND Cable	1	2	Yes	0	Provided by Lab
3.	RJ-45 Cable	1	1	No	0	Supplied by client
4.	RJ-45 Cable	1	10	No	0	Provided by Lab
5.	RJ-45 Cable	1	1.5	No	0	Provided by Lab
6.	AC Cable	1	1	No	0	Supplied by client

3.4.1 Configuration of System under Test

For AC Power Conducted Emission test:



For Radiated Emission test:



3.5 General Description of Applied Standards and References

The EUT is a RF Product. According to the specifications of the manufacturer, it must comply with the requirements of the following standards and references:

Test standard:
FCC Part 15, Subpart C (15.247)
ANSI C63.10-2013

All test items have been performed and recorded as per the above standards.

References Test Guidance:
KDB 558074 D01 15.247 Meas Guidance v05r02

All test items have been performed as a reference to the above KDB test guidance.

4 Test Types and Results (Hybrid Mode)

4.1 Radiated Emission and Bandedge Measurement

4.1.1 Limits of Radiated Emission and Bandedge Measurement

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 30dB below the highest level of the desired power:

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 ~ 0.490	2400/F(kHz)	300
0.490 ~ 1.705	24000/F(kHz)	30
1.705 ~ 30.0	30	30
30 ~ 88	100	3
88 ~ 216	150	3
216 ~ 960	200	3
Above 960	500	3

Note:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

4.1.2 Test Instruments

For Radiated Emission test:

Description & Manufacturer	Model No.	Serial No.	Calibrated Date	Calibrated Until
Test Receiver Agilent	N9038A	MY51210202	2020/12/1	2021/11/30
Software	ADT_Radiated_V8.7.08	NA	NA	NA
Boresight Antenna Tower & Turn Table Max-Full	MF-7802BS	MF780208530	NA	NA
Pre_Amplifier EMCI	EMC001340	980142	2021/5/24	2022/5/23
LOOP ANTENNA Electro-Metrics	EM-6879	264	2021/3/5	2022/3/4
RF Coaxial Cable JYEBO	5D-FB	LOOPCAB-001	2021/1/7	2022/1/6
RF Coaxial Cable JYEBO	5D-FB	LOOPCAB-002	2021/1/7	2022/1/6
Pre_Amplifier EMCI	EMC330N	980701	2021/3/10	2022/3/9
Trilog Broadband Antenna Schwarzbeck	VULB 9168	9168-406	2020/11/6	2021/11/5
RF Coaxial Cable COMMATE/PEWC	8D	966-4-1	2021/3/17	2022/3/16
RF Coaxial Cable COMMATE/PEWC	8D	966-4-2	2021/3/17	2022/3/16
RF Coaxial Cable COMMATE/PEWC	8D	966-4-3	2021/3/17	2022/3/16
Fixed attenuator Mini-Circuits	UNAT-5+	PAD-ATT5-03	2021/1/11	2022/1/10
Horn Antenna SCHWARZBECK	BBHA 9120D	9120D-783	2020/11/22	2021/11/21
Pre_Amplifier EMCI	EMC 12630 SE	980638	2021/4/7	2022/4/6
RF Cable-Frequency Range : 1-26.5GHz EMCI	EMC104-SM-SM-1200	160922	2020/12/25	2021/12/24
RF Coaxial Cable EMCI	EMC104-SM-SM-2000	180502	2021/4/26	2022/4/25
RF Coaxial Cable EMCI	EMC104-SM-SM-6000	180418	2021/4/26	2022/4/25

Note: 1. The test was performed in 966 Chamber No. 4.
2. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
3. Tested Date: 2021/7/30 ~ 2021/10/8

For other test items:

Description & Manufacturer	Model No.	Serial No.	Calibrated Date	Calibrated Until
Spectrum Analyzer R&S	FSV40	101516	2021/3/8	2022/3/7
Power Meter Anritsu	ML2495A	1529002	2021/6/21	2022/6/20
Pulse Power Sensor Anritsu	MA2411B	1339443	2021/5/31	2022/5/30
Attenuator WOKEN	MDCS18N-10	MDCS18N-10-01	2021/4/13	2022/4/12
Software	ADT_RF Test Software V6.6.5.4	NA	NA	NA

Note: 1. The test was performed in Oven room 2.
2. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
3. Tested Date: 2021/8/26

4.1.3 Test Procedures

For Radiated emission below 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

For Radiated emission above 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.

f. The test-receiver system was set to peak and average detect function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

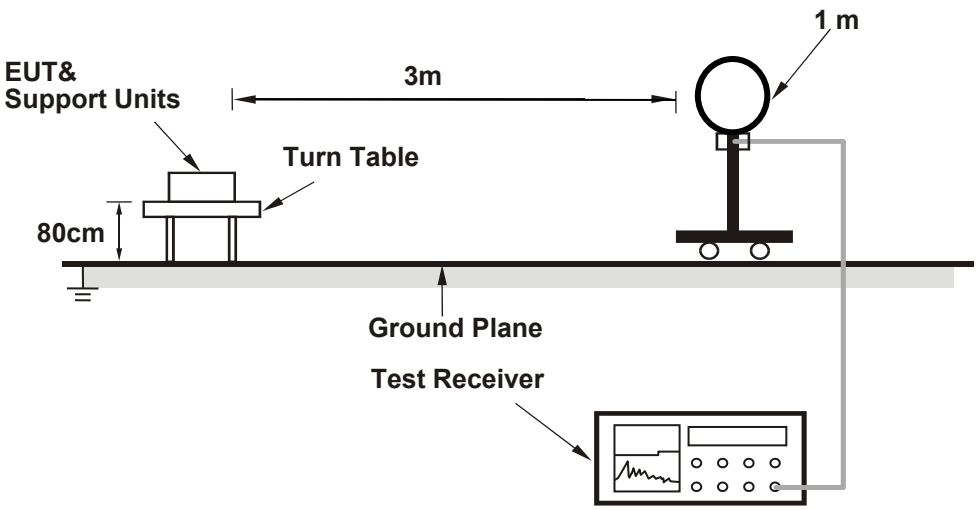
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.
4. All modes of operation were investigated and the worst-case emissions are reported.

4.1.4 Deviation from Test Standard

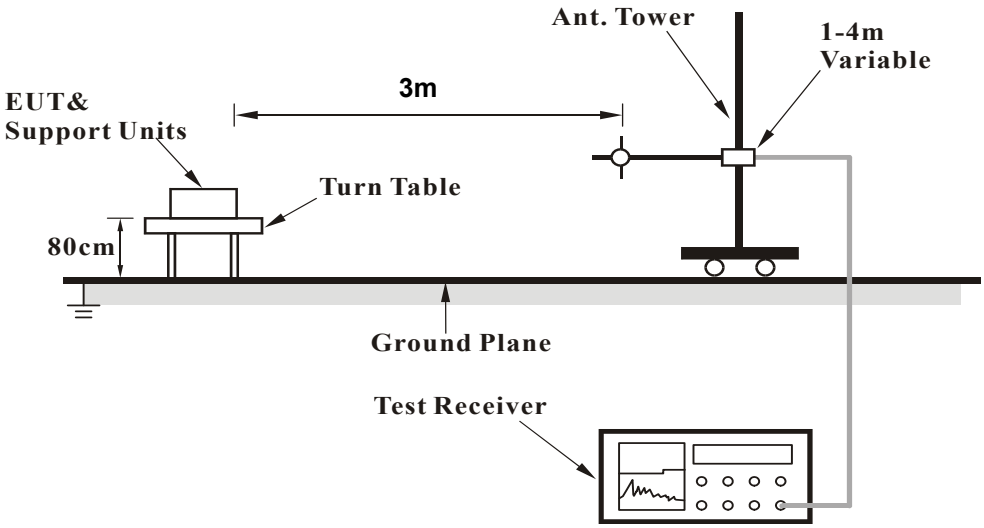
No deviation.

4.1.5 Test Setup

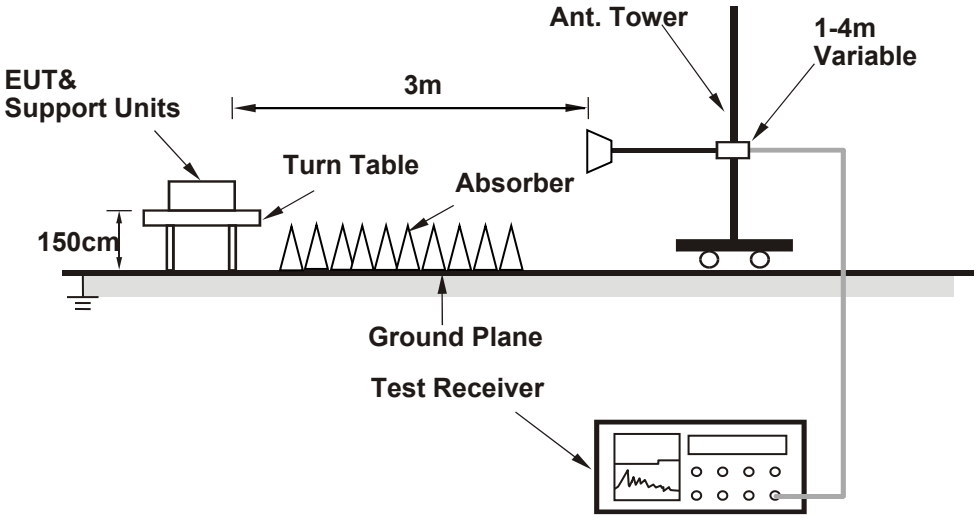
For Radiated emission below 30MHz



For Radiated emission 30MHz to 1GHz



For Radiated emission above 1GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.1.6 EUT Operating Conditions

a. Placed the EUT on the testing table.
b. Controlling software (Run Putty.exe Paste LORA_Test_Command_20210701.txt Command) has been activated to set the EUT under transmission condition continuously at specific channel frequency.

4.1.7 Test Results

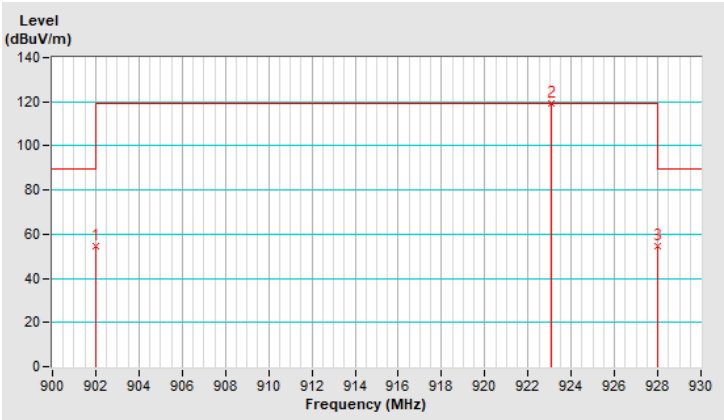
Bandedge Data:

RF Mode	TX LoRa_Hybrid	**Channel**	CH 0：923.1 MHz
Frequency Range	900MHz ~ 930MHz	**Detector Function**	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Antenna Height (m)**	**Table Angle (Degree)**	**Raw Value (dBuV)**	**Correction Factor (dB/m)**
1	902.00	54.7 QP	89.3	-34.6	1.57 H	319	19.7	35.0
2	*923.10	119.3 QP			1.57 H	319	83.8	35.5
3	928.00	54.8 QP	89.3	-34.5	1.57 H	319	19.3	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. " * ": Fundamental frequency.

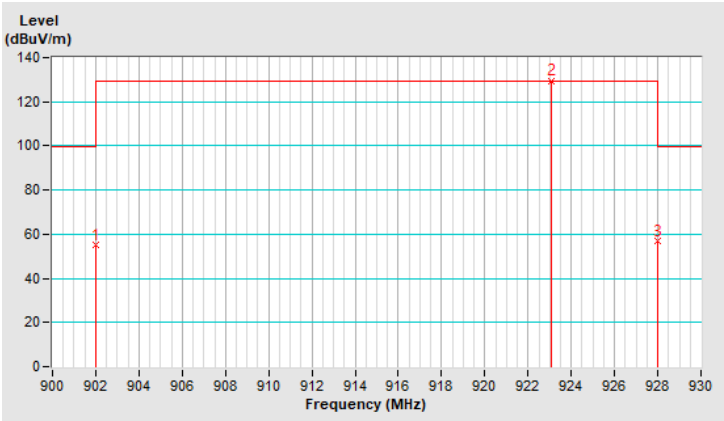


RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	54.9 QP	99.5	-44.6	1.24 V	188	19.9	35.0
2	*923.10	129.5 QP			1.24 V	188	94.0	35.5
3	928.00	56.9 QP	99.5	-42.6	1.24 V	188	21.4	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. " * ": Fundamental frequency.

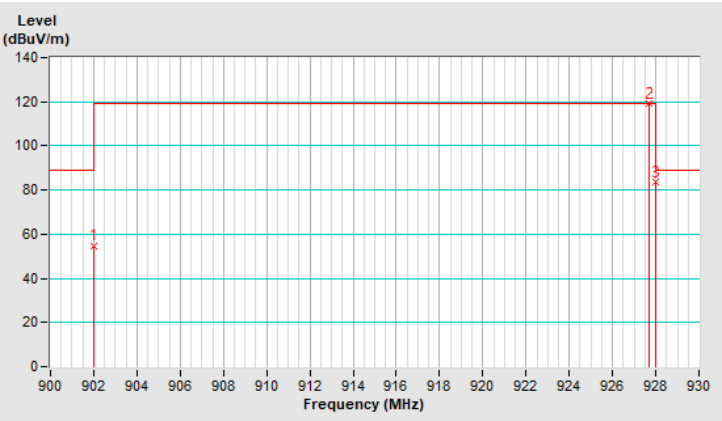


RF Mode	TX LoRa_Hybrid	Channel	CH 23：927.7 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	54.7 QP	89.2	-34.5	1.57 H	319	19.7	35.0
2	*927.70	119.2 QP			1.57 H	319	83.7	35.5
3	928.00	83.4 QP	89.2	-5.8	1.57 H	319	47.9	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. " * ": Fundamental frequency.

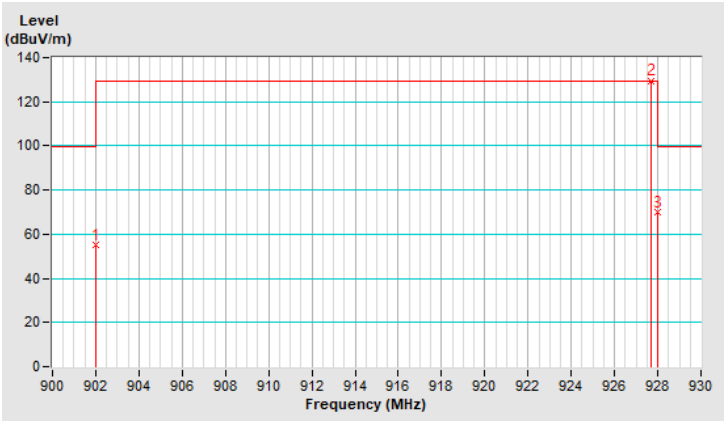


RF Mode	TX LoRa_Hybrid	Channel	CH 23：927.7 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	54.9 QP	99.6	-44.7	1.16 V	191	19.9	35.0
2	*927.70	129.6 QP			1.16 V	191	94.1	35.5
3	928.00	69.8 QP	99.6	-29.8	1.16 V	191	34.3	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. " * ": Fundamental frequency.



Above 1GHz Data:

RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2769.30	33.0 PK	74.0	-41.0	1.70 H	126	36.8	-3.8
2	2769.30	21.9 AV	54.0	-32.1	1.70 H	126	25.7	-3.8
3	3692.40	32.9 PK	74.0	-41.1	1.25 H	171	34.8	-1.9
4	3692.40	27.1 AV	54.0	-26.9	1.25 H	171	29.0	-1.9
5	4615.50	36.3 PK	74.0	-37.7	1.56 H	132	36.2	0.1
6	4615.50	25.5 AV	54.0	-28.5	1.56 H	132	25.4	0.1
7	7384.80	37.9 PK	74.0	-36.1	3.09 H	113	30.7	7.2
8	7384.80	27.1 AV	54.0	-26.9	3.09 H	113	19.9	7.2
9	8307.90	43.4 PK	74.0	-30.6	1.45 H	21	36.0	7.4
10	8307.90	32.3 AV	54.0	-21.7	1.45 H	21	24.9	7.4
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2769.30	33.4 PK	74.0	-40.6	1.46 V	141	37.2	-3.8
2	2769.30	22.1 AV	54.0	-31.9	1.46 V	141	25.9	-3.8
3	3692.40	34.5 PK	74.0	-39.5	1.61 V	43	36.4	-1.9
4	3692.40	28.4 AV	54.0	-25.6	1.61 V	43	30.3	-1.9
5	4615.50	37.7 PK	74.0	-36.3	1.79 V	33	37.6	0.1
6	4615.50	27.0 AV	54.0	-27.0	1.79 V	33	26.9	0.1
7	7384.80	37.3 PK	74.0	-36.7	1.68 V	44	30.1	7.2
8	7384.80	29.4 AV	54.0	-24.6	1.68 V	44	22.2	7.2
9	8307.90	42.5 PK	74.0	-31.5	1.62 V	119	35.1	7.4
10	8307.90	31.8 AV	54.0	-22.2	1.62 V	119	24.4	7.4

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

RF Mode	TX LoRa_Hybrid	Channel	CH 23：927.7 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2783.10	32.9 PK	74.0	-41.1	1.75 H	119	36.6	-3.7
2	2783.10	21.7 AV	54.0	-32.3	1.75 H	119	25.4	-3.7
3	3710.80	32.6 PK	74.0	-41.4	1.31 H	179	34.4	-1.8
4	3710.80	26.6 AV	54.0	-27.4	1.31 H	179	28.4	-1.8
5	4638.50	36.7 PK	74.0	-37.3	1.58 H	147	36.6	0.1
6	4638.50	25.6 AV	54.0	-28.4	1.58 H	147	25.5	0.1
7	7421.60	37.5 PK	74.0	-36.5	3.14 H	114	30.2	7.3
8	7421.60	26.8 AV	54.0	-27.2	3.14 H	114	19.5	7.3
9	8349.30	43.2 PK	74.0	-30.8	1.50 H	14	35.7	7.5
10	8349.30	31.9 AV	54.0	-22.1	1.50 H	14	24.4	7.5
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2783.10	33.8 PK	74.0	-40.2	1.52 V	134	37.5	-3.7
2	2783.10	22.5 AV	54.0	-31.5	1.52 V	134	26.2	-3.7
3	3710.80	34.4 PK	74.0	-39.6	1.64 V	33	36.2	-1.8
4	3710.80	28.4 AV	54.0	-25.6	1.64 V	33	30.2	-1.8
5	4638.50	37.3 PK	74.0	-36.7	1.73 V	26	37.2	0.1
6	4638.50	26.6 AV	54.0	-27.4	1.73 V	26	26.5	0.1
7	7421.60	37.0 PK	74.0	-37.0	1.73 V	49	29.7	7.3
8	7421.60	29.2 AV	54.0	-24.8	1.73 V	49	21.9	7.3
9	8349.30	42.7 PK	74.0	-31.3	1.56 V	125	35.2	7.5
10	8349.30	31.8 AV	54.0	-22.2	1.56 V	125	24.3	7.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

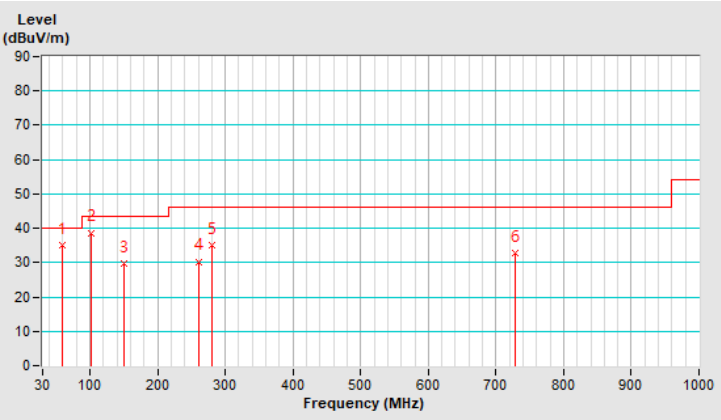
Below 1GHz Data:

RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	9kHz ~ 1GHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	58.32	35.2 QP	40.0	-4.8	3.00 H	175	48.3	-13.1
2	101.94	38.7 QP	43.5	-4.8	2.00 H	46	54.9	-16.2
3	150.79	29.8 QP	43.5	-13.7	2.00 H	46	41.8	-12.0
4	260.81	30.3 QP	46.0	-15.7	1.00 H	112	42.7	-12.4
5	279.90	35.0 QP	46.0	-11.0	1.00 H	225	46.4	-11.4
6	727.47	32.7 QP	46.0	-13.3	3.00 H	59	32.7	0.0

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.

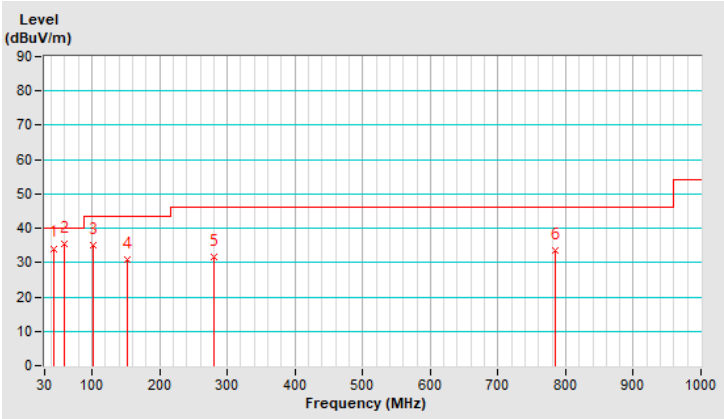


RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	9kHz ~ 1GHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	43.45	34.1 QP	40.0	-5.9	1.00 V	324	46.8	-12.7
2	**58.29**	**35.5 QP**	**40.0**	**-4.5**	**1.00 V**	**264**	**48.6**	**-13.1**
3	101.52	35.0 QP	43.5	-8.5	1.00 V	72	51.3	-16.3
4	152.10	30.8 QP	43.5	-12.7	1.00 V	67	42.8	-12.0
5	280.63	31.5 QP	46.0	-14.5	1.50 V	38	42.9	-11.4
6	784.76	33.7 QP	46.0	-12.3	3.00 V	307	32.4	1.3

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.



4.2 Conducted Emission Measurement

4.2.1 Limits of Conducted Emission Measurement

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

4.2.2 Test Instruments

Description & Manufacturer	Model No.	Serial No.	Calibrated Date	Calibrated Until
Test Receiver R&S	ESCS 30	847124/029	2020/10/20	2021/10/19
LISN R&S	ESH3-Z5	848773/004	2020/10/27	2021/10/26
LISN R & S	ESH3-Z5	835239/001	2021/3/26	2022/3/25
50 ohms Terminator	50	3	2020/10/26	2021/10/25
RF Coaxial Cable JYEBO	5D-FB	COCCAB-001	2020/9/26	2021/9/25
Fixed attenuator STI	STI02-2200-10	005	2020/8/29	2021/8/28
Software BVADT	BVADT_Cond_ V7.3.7.4	NA	NA	NA

Note: 1. The test was performed in Conduction 1.
2. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.
3. Tested Date: 2021/8/26

4.2.3 Test Procedures

a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.

b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

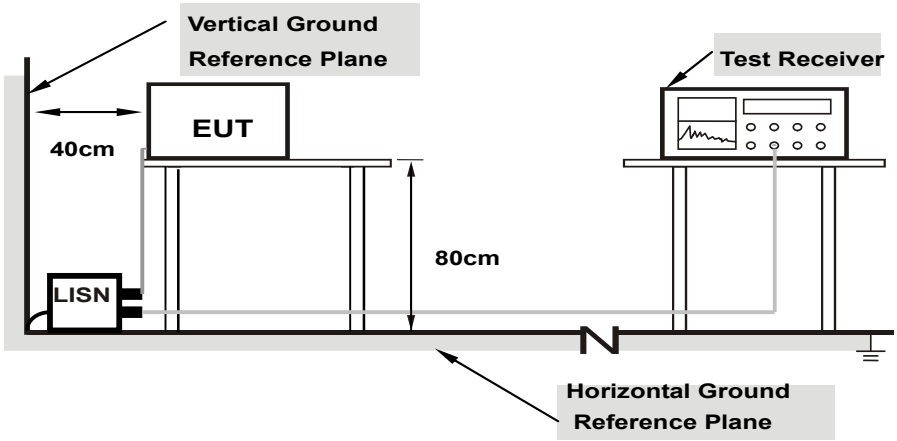
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

Note: The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

4.2.4 Deviation from Test Standard

No deviation.

4.2.5 Test Setup



Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the attached file (Test Setup Photo).

4.2.6 EUT Operating Condition

Same as 4.1.6.

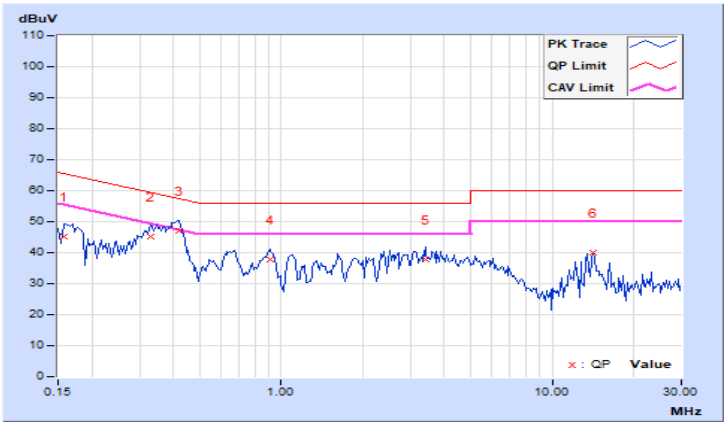
4.2.7 Test Results

RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	150kHz ~ 30MHz	Detector Function & Resolution Bandwidth	Quasi-Peak (QP) / Average (AV), 9kHz

Phase Of Power : Line (L)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.15781	9.95	35.21	24.14	45.16	34.09	65.58	55.58	-20.42	-21.49
2	0.32969	9.98	35.10	28.07	45.08	38.05	59.46	49.46	-14.38	-11.41
3	0.41953	9.99	37.05	31.64	47.04	41.63	57.46	47.46	-10.42	-5.83
4	0.90781	10.02	27.70	22.92	37.72	32.94	56.00	46.00	-18.28	-13.06
5	3.41406	10.14	27.58	20.74	37.72	30.88	56.00	46.00	-18.28	-15.12
6	14.21484	10.78	29.09	25.80	39.87	36.58	60.00	50.00	-20.13	-13.42

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value

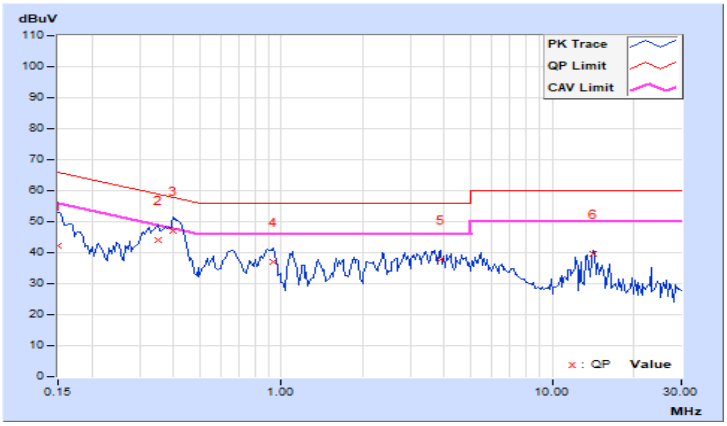


RF Mode	TX LoRa_Hybrid	Channel	CH 0：923.1 MHz
Frequency Range	150kHz ~ 30MHz	Detector Function & Resolution Bandwidth	Quasi-Peak (QP) / Average (AV), 9kHz

Phase Of Power : Neutral (N)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.15000	9.92	32.24	27.50	42.16	37.42	66.00	56.00	-23.84	-18.58
2	0.35313	9.96	34.25	28.61	44.21	38.57	58.89	48.89	-14.68	-10.32
3	**0.40000**	**9.96**	**37.22**	**32.22**	**47.18**	**42.18**	**57.85**	**47.85**	**-10.67**	**-5.67**
4	0.93125	10.00	26.87	21.05	36.87	31.05	56.00	46.00	-19.13	-14.95
5	3.87891	10.12	27.65	21.42	37.77	31.54	56.00	46.00	-18.23	-14.46
6	14.15234	10.60	29.06	25.48	39.66	36.08	60.00	50.00	-20.34	-13.92

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value

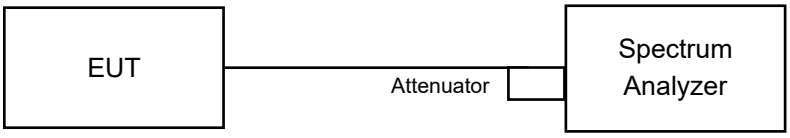


4.3 Number of Hopping Frequency Used

4.3.1 Limits of Hopping Frequency Used Measurement

There is no minimum number of hopping channels associated with this type of hybrid system.

4.3.2 Test Setup



4.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.3.4 Test Procedure

a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.

c. Set the SA on MaxHold Mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.

d. Set the SA on View mode and then plot the result on SA screen.

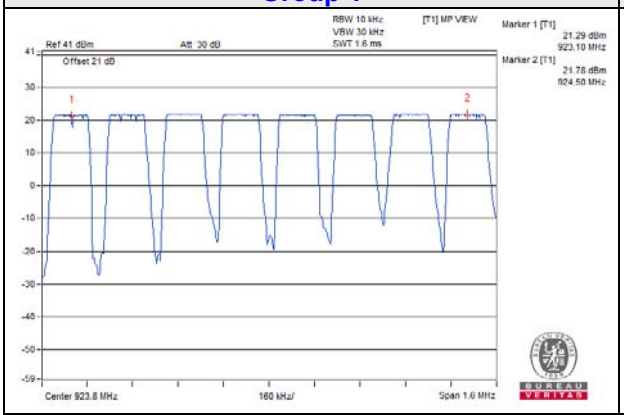
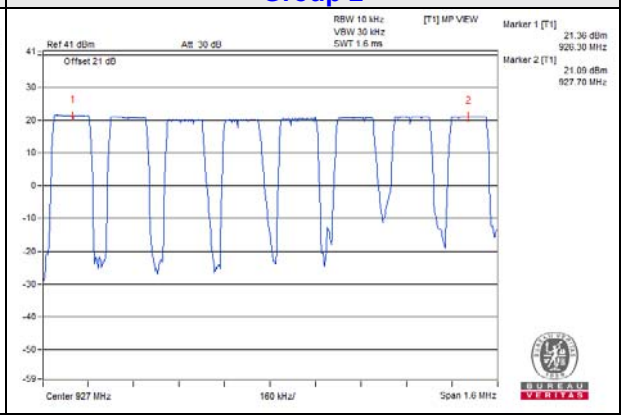
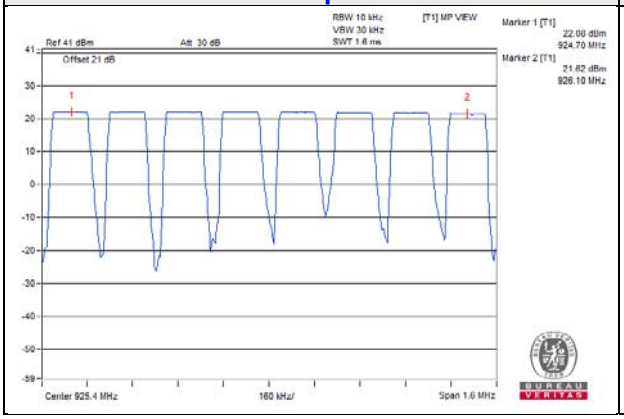
e. Repeat above procedures until all frequencies measured were complete.

4.3.5 Deviation from Test Standard

No deviation.

4.3.6 Test Results

There are 8 hopping frequencies in the hybrid mode of each group.

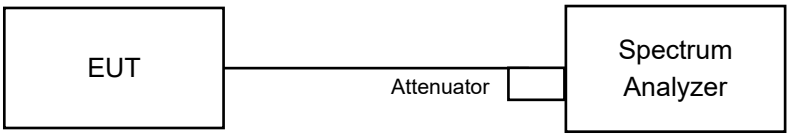
Group 1	Group 2
	
Group 3	
	

4.4 Dwell Time on Each Channel

4.4.1 Limits of Dwell Time on Each Channel Measurement

A hybrid system must comply with a 0.4 second/channel maximum dwell time when the hopping function is turned on.

4.4.2 Test Setup



4.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.4.4 Test Procedures

a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
c. Adjust the center frequency of SA on any frequency be measured and set SA to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
d. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
e. Repeat above procedures until all different time-slot modes have been completed.

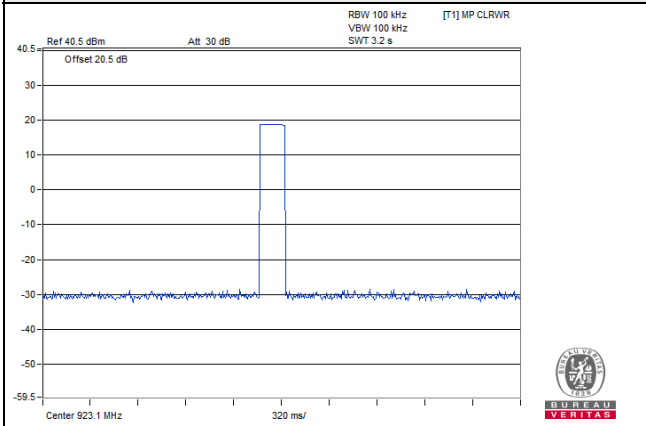
4.4.5 Deviation from Test Standard

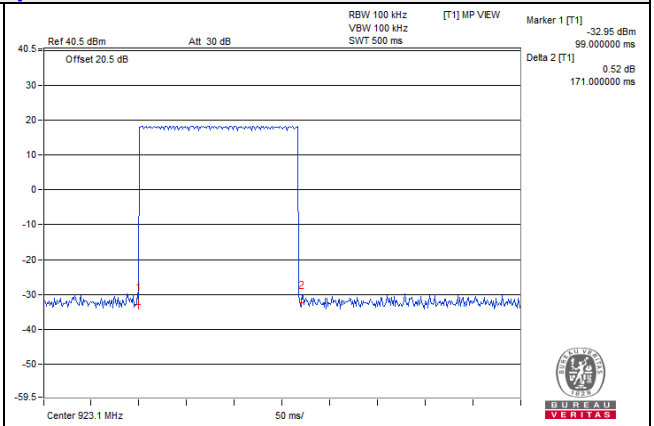
No deviation.

4.4.6 Test Results

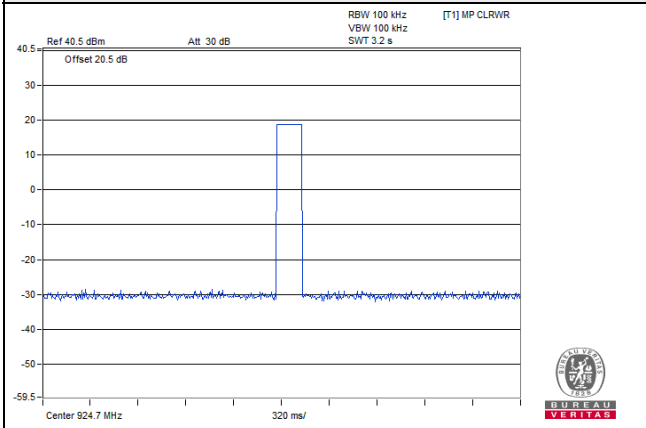
Group	Number of transmission in 3.2 sec (8Hopping*0.4)	Length of transmission time (msec)	Result (msec)	Limit (msec)	Test Result
1	1 times	171	171	400	Pass
2	1 times	168	168	400	Pass
3	1 times	170	170	400	Pass

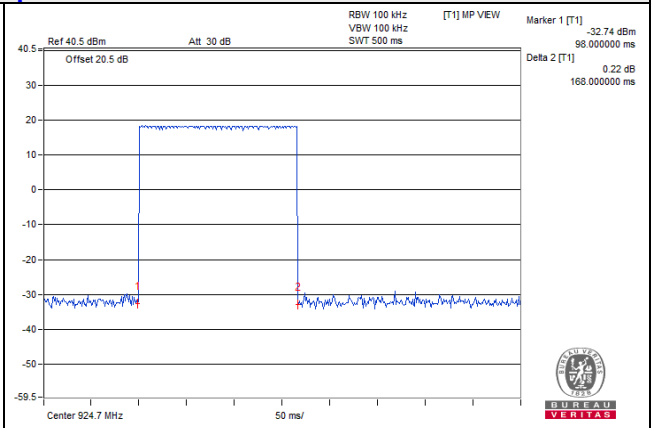
Group 1



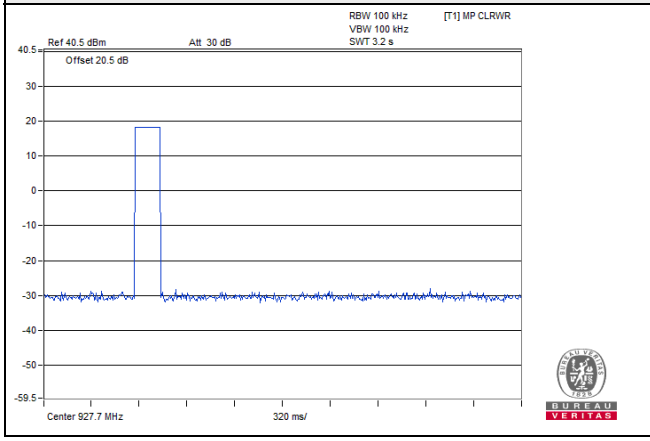


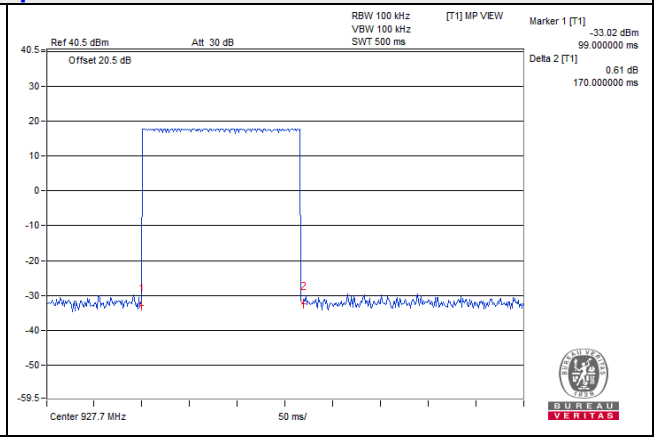
Group 2





Group 3



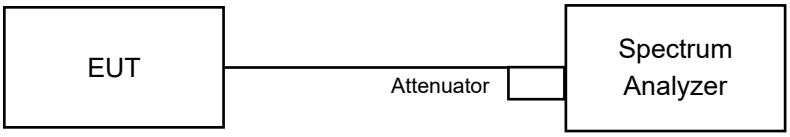


4.5 Channel Bandwidth

4.5.1 Limits of Channel Bandwidth Measurement

For frequency hopping system operating in the 902-928MHz, If the 20dB bandwidth of hopping channel is greater than 25kHz.

4.5.2 Test Setup



4.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.5.4 Test Procedure

a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.

b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.

c. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.

d. Repeat above procedures until all frequencies measured were complete.

4.5.5 Deviation from Test Standard

No deviation.

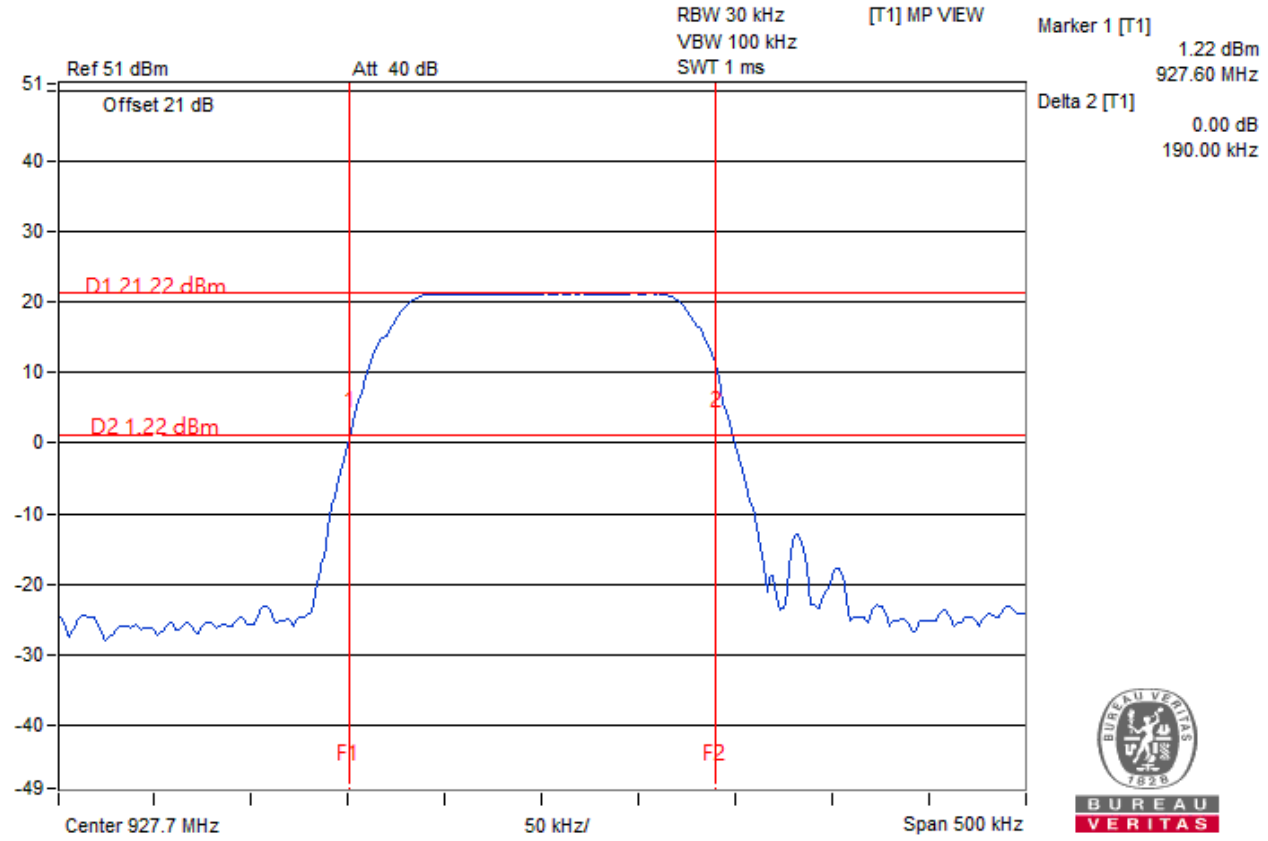
4.5.6 EUT Operating Condition

The software provided by client enabled the EUT to transmit and receive data at lowest and highest channel frequencies individually.

4.5.7 Test Results

Channel	Frequency (MHz)	20dB Bandwidth (MHz)	>= 25kHz
0	923.1	0.2	Yes
23	927.7	0.19	Yes

Spectrum Plot of Min. Value
CH 23

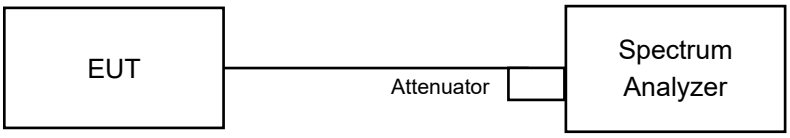


4.6 Hopping Channel Separation

4.6.1 Limits of Hopping Channel Separation Measurement

At least 25kHz or 20dB hopping channel bandwidth (whichever is greater).

4.6.2 Test Setup



4.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.6.4 Test Procedure

Measurement Procedure REF

a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.

b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.

c. By using the MaxHold function record the separation of two adjacent channels.

d. Measure the frequency difference of these two adjacent channels by SA MARK function. And then plot the result on SA screen.

e. Repeat above procedures until all frequencies measured were complete.

4.6.5 Deviation from Test Standard

No deviation.

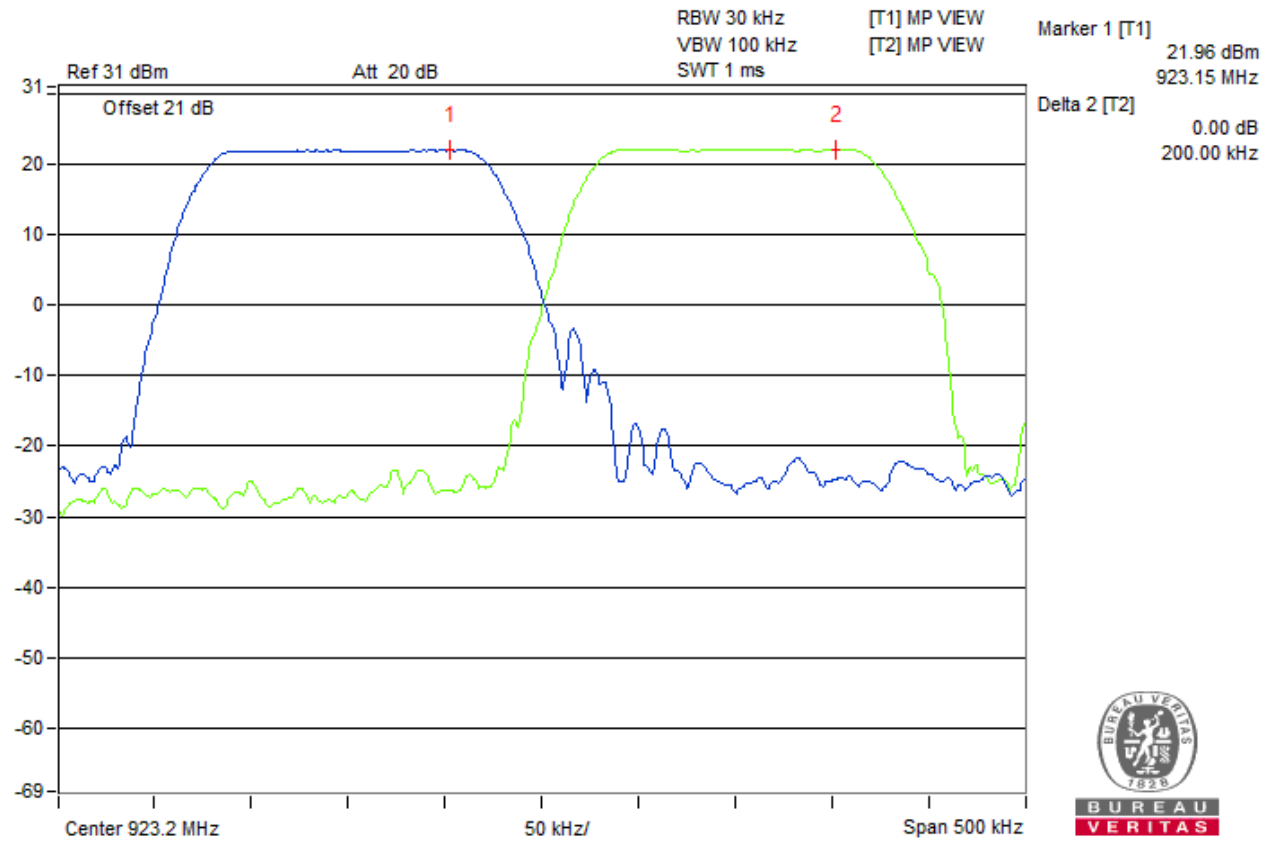
4.6.6 Test Results

Channel	Frequency (MHz)	Adjacent Channel Separation (MHz)	20dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
0	923.1	0.2	0.2	0.2	Pass
23	927.7	0.2	0.19	0.19	Pass

Note: The minimum limit is 20dB bandwidth.

Spectrum Plot of Worst Value

CH 0

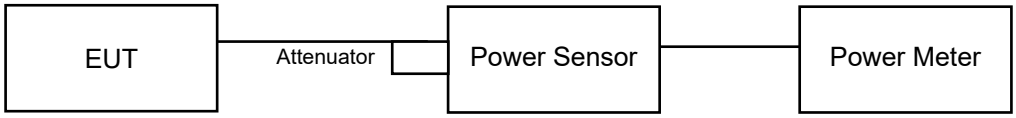


4.7 Maximum Output Power

4.7.1 Limits of Maximum Output Power Measurement

For hybrid system using in the 902-928 MHz bands: 1 Watt (30dBm)

4.7.2 Test Setup



4.7.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.7.4 Test Procedure

Average power sensor was used to perform output power measurement, trigger and gating function of wide band power meter is enabled to measure max output power of TX on burst. Duty factor is not added to measured value.

4.7.5 Deviation from Test Standard

No deviation.

4.7.6 EUT Operating Condition

The software provided by client enabled the EUT to transmit and receive data at lowest and highest channel frequencies individually.

4.7.7 Test Results

Chan.	Chan. Freq. (MHz)	Average Power (mW)	Average Power (dBm)	Limit (dBm)	Pass / Fail
0	923.1	110.662	20.44	30	Pass
23	927.7	104.472	20.19	30	Pass

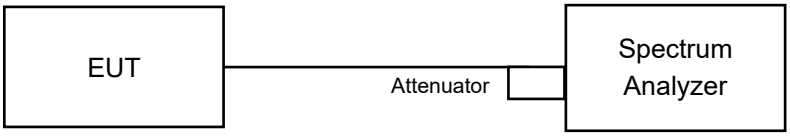
4.8 Power Spectral Density Measurement

4.8.1 Limits of Power Spectral Density Measurement

The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz.

A hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off

4.8.2 Test Setup



4.8.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.8.4 Test Procedure

a. Set analyzer center frequency to DTS channel center frequency.
b. Set the span to 1.5 times the DTS bandwidth.
c. Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d. Set the VBW ≥ 3 × RBW.
e. Detector = peak.
f. Sweep time = auto couple.
g. Trace mode = max hold.
h. Allow trace to fully stabilize.
i. Use the peak marker function to determine the maximum amplitude level within the RBW.

4.8.5 Deviation from Test Standard

No deviation.

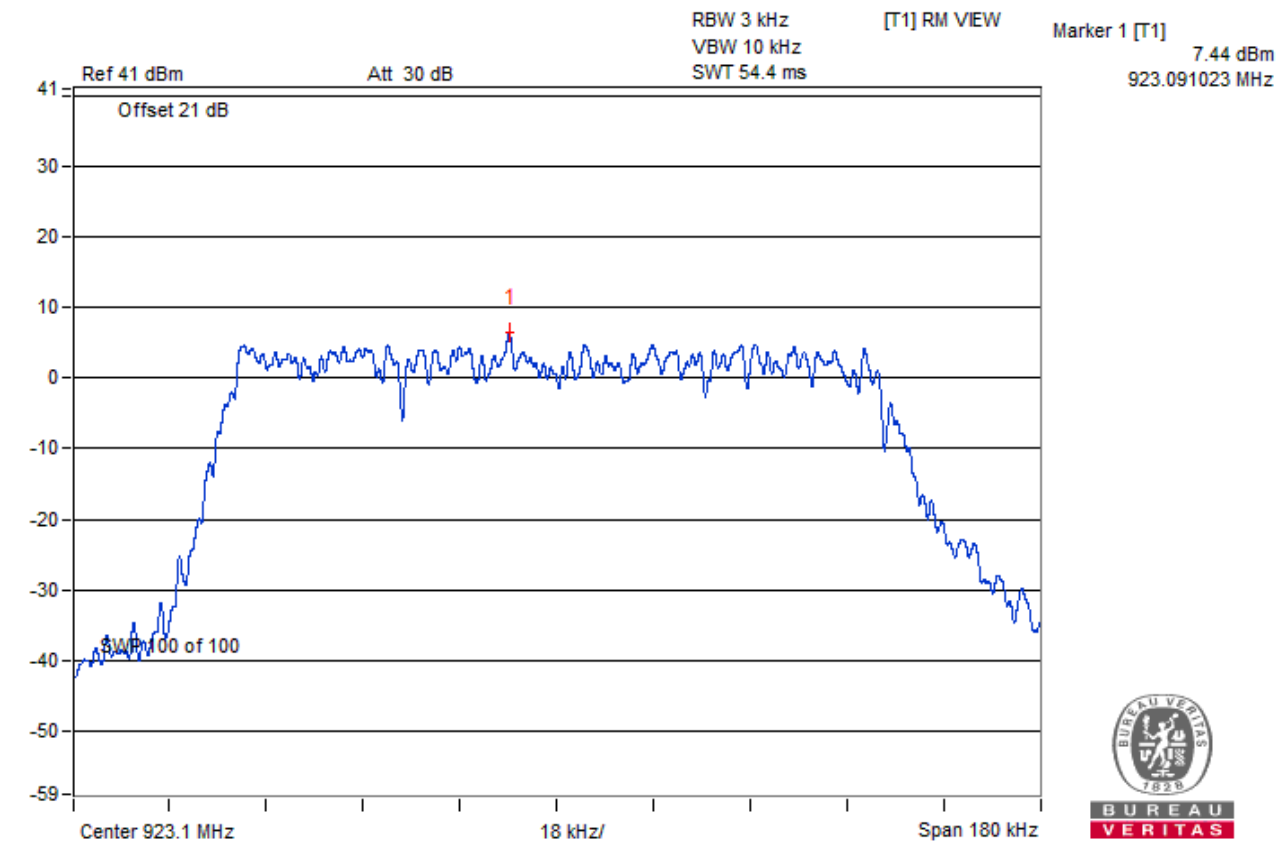
4.8.6 EUT Operating Condition

Same as Item 4.7.6.

4.8.7 Test Results

Chan.	Chan. Freq. (MHz)	PSD (dBm/3kHz)	PSD Limit (dBm/3kHz)	Test Result
0	923.1	7.44	8.00	Pass
23	927.7	7.11	8.00	Pass

Spectrum Plot of Worst Value
CH 0



4.9 Conducted Out of Band Emission Measurement

4.9.1 Limits of Conducted Out of Band Emission Measurement

Below 30dB of the highest emission level of operating band (in 100kHz Resolution Bandwidth).

4.9.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

4.9.3 Test Procedure

The transmitter output was connected to the spectrum analyzer via a low lose cable. Set both RBW and VBW of spectrum analyzer to 100 kHz and 300 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded.

4.9.4 Deviation from Test Standard

No deviation.

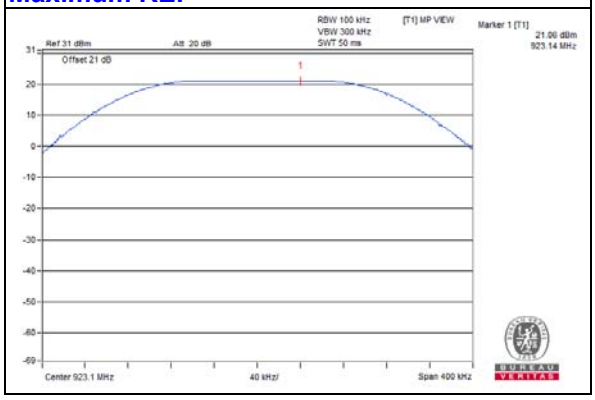
4.9.5 EUT Operating Condition

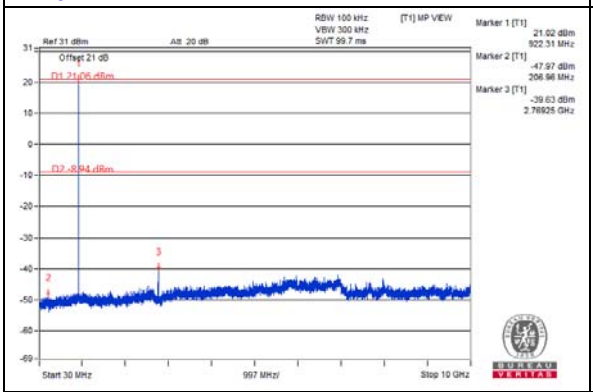
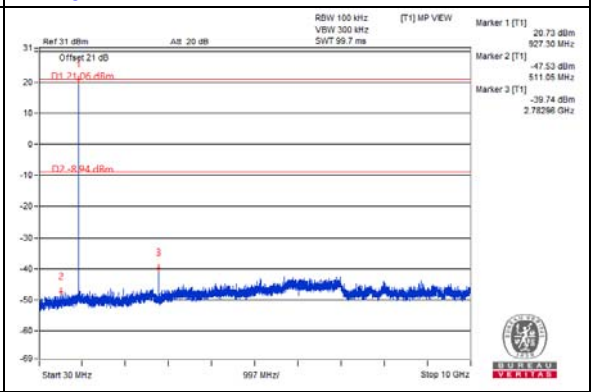
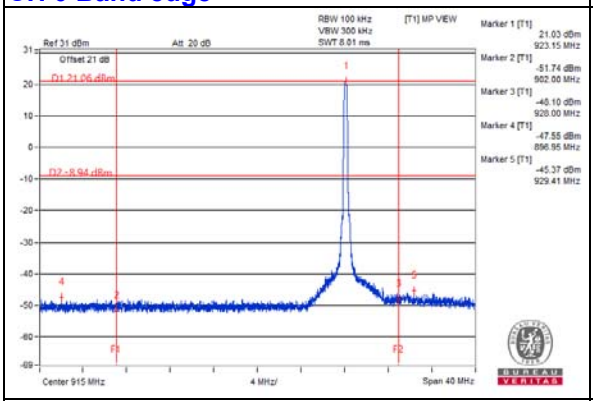
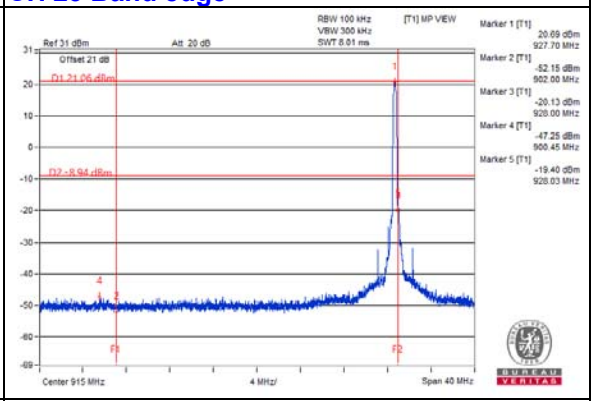
The software provided by client enabled the EUT to transmit and receive data at lowest and highest channel frequencies individually.

4.9.6 Test Results

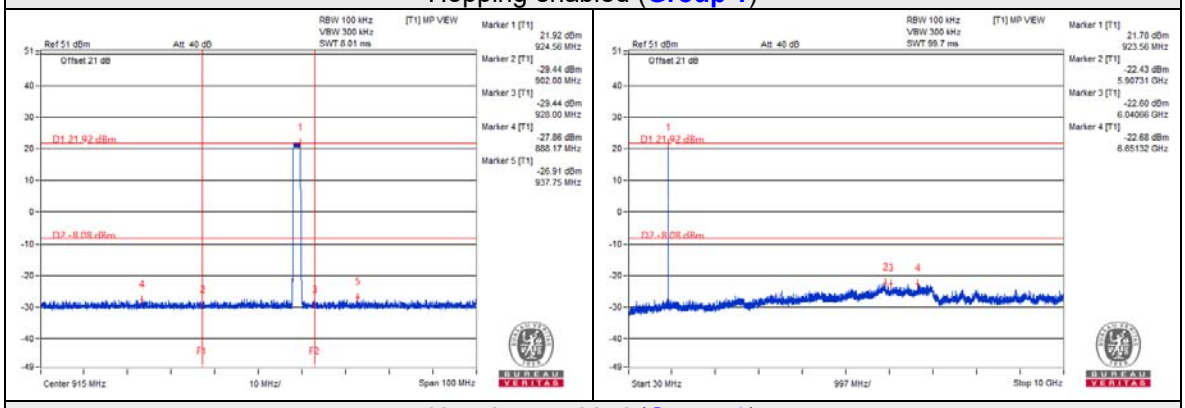
The spectrum plots are attached on the following images. D1 line indicates the highest level, D2 line indicates the 30dB offset below D1. It shows compliance with the requirement.

Maximum REF

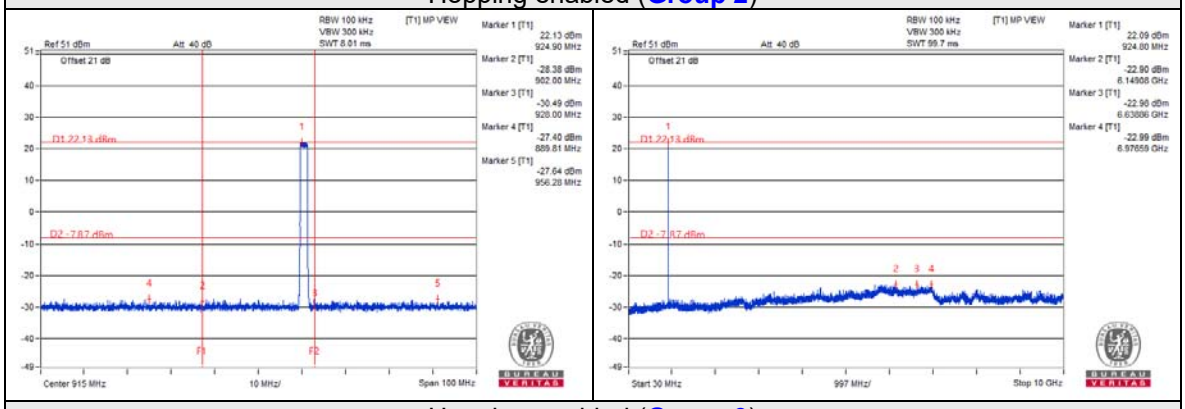


Hopping disabled	
CH 0	**CH 23**
	
CH 0 Band edge	**CH 23 Band edge**
	

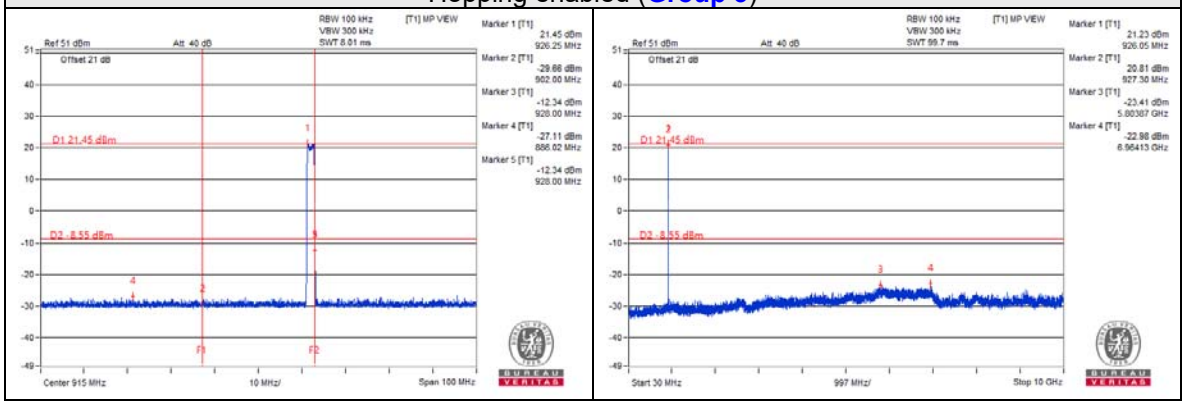
Hopping enabled (**Group 1**)



Hopping enabled (**Group 2**)



Hopping enabled (**Group 3**)



5 Test Types and Results (DTS Mode)

5.1 Radiated Emission and Bandedge Measurement

5.1.1 Limits of Radiated Emission and Bandedge Measurement

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 30dB below the highest level of the desired power:

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 ~ 0.490	2400/F(kHz)	300
0.490 ~ 1.705	24000/F(kHz)	30
1.705 ~ 30.0	30	30
30 ~ 88	100	3
88 ~ 216	150	3
216 ~ 960	200	3
Above 960	500	3

Note:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

5.1.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.1.3 Test Procedures

For Radiated emission below 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

For Radiated emission above 30MHz

a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.

d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.

f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

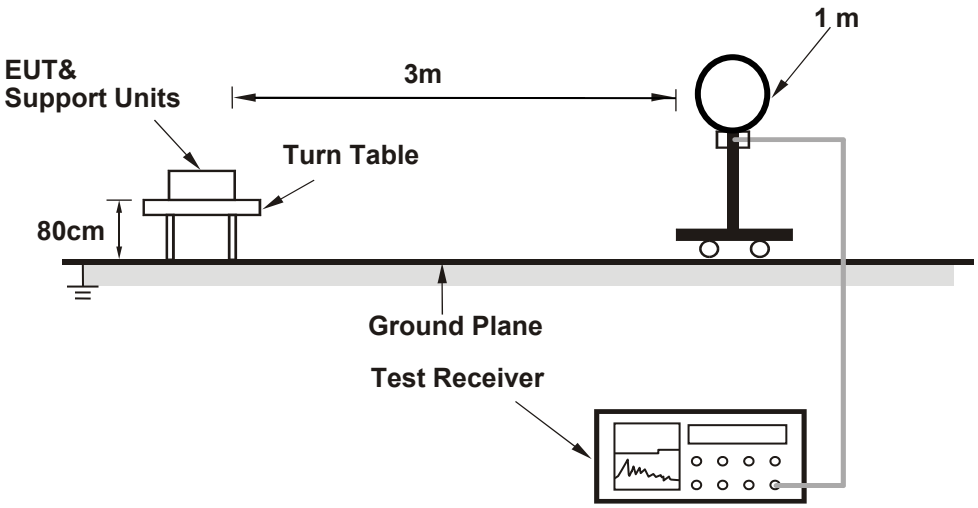
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and the video bandwidth is ≥ 1/T (Duty cycle < 98%) or 10Hz (Duty cycle ≥ 98%) for Average detection (AV) at frequency above 1GHz.
4. All modes of operation were investigated and the worst-case emissions are reported.

5.1.4 Deviation from Test Standard

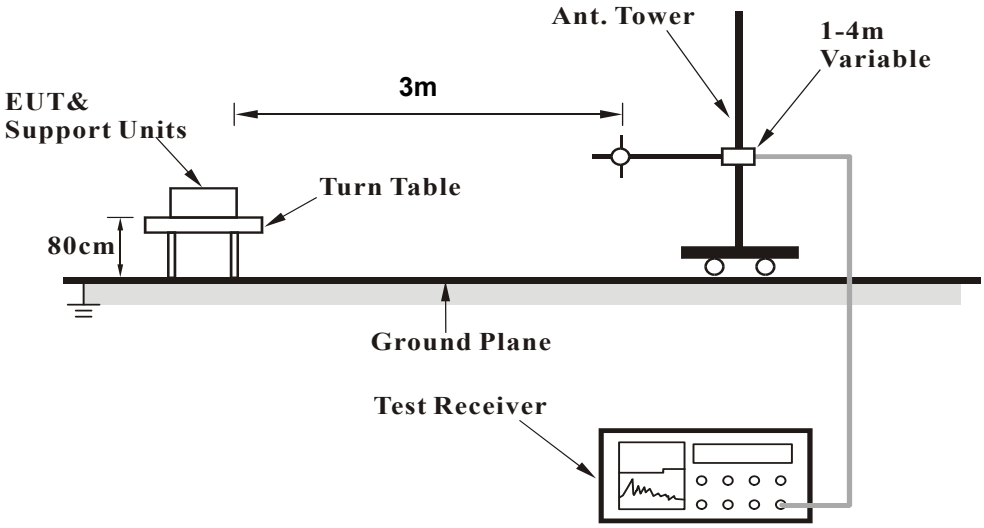
No deviation.

5.1.5 Test Setup

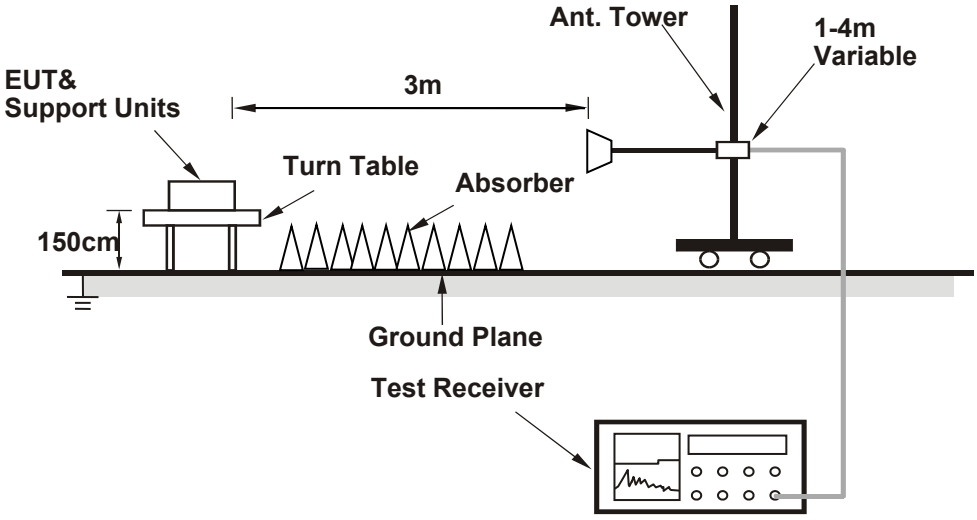
For Radiated emission below 30MHz



For Radiated emission 30MHz to 1GHz



For Radiated emission above 1GHz



For the actual test configuration, please refer to the attached file (Test Setup Photo).

5.1.6 EUT Operating Conditions

a. Placed the EUT on the testing table.
b. Controlling software (Run Putty.exe Paste LORA_Test_Command_20210701.txt Command) has been activated to set the EUT under transmission condition continuously at specific channel frequency.

5.1.7 Test Results (Mode 1)

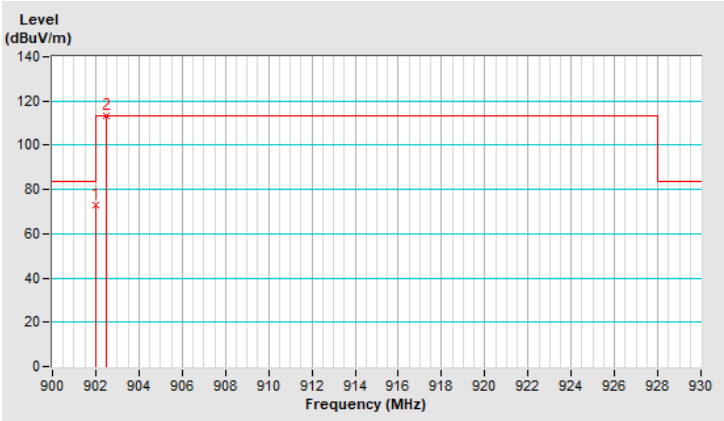
Bandedge Data:

RF Mode	TX LoRa_DTS	**Channel**	CH 0：902.5 MHz
Frequency Range	900MHz ~ 930MHz	**Detector Function**	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Antenna Height (m)**	**Table Angle (Degree)**	**Raw Value (dBuV)**	**Correction Factor (dB/m)**
1	902.00	73.2 QP	83.4	-10.2	1.32 H	354	38.2	35.0
2	*902.50	113.4 QP			1.32 H	354	78.4	35.0

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.

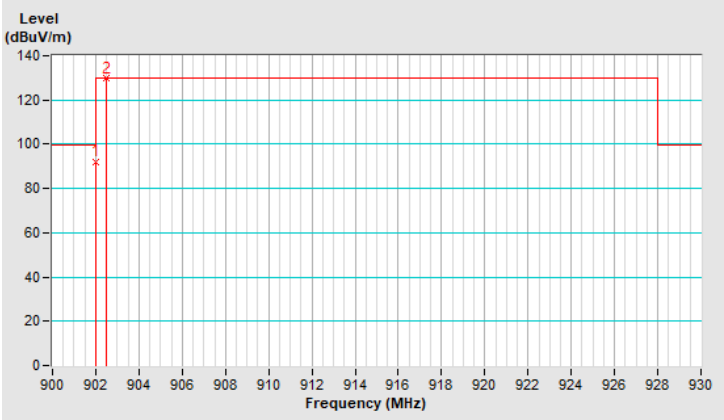


RF Mode	TX LoRa_DTS	Channel	CH 0：902.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	92.2 QP	99.8	-7.6	1.28 V	330	57.2	35.0
2	*902.50	129.8 QP			1.28 V	330	94.8	35.0

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.

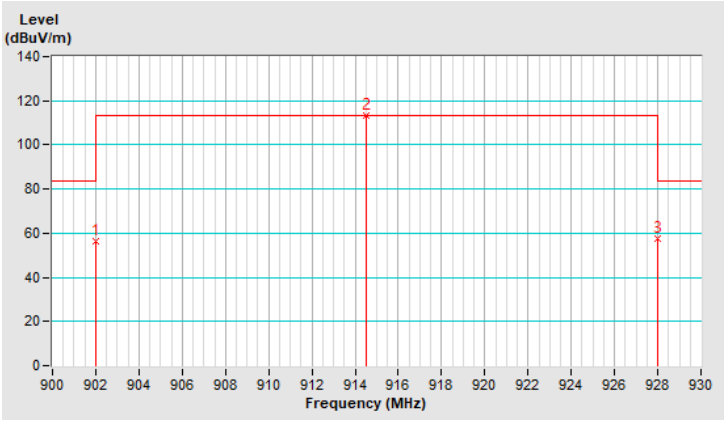


RF Mode	TX LoRa_DTS	Channel	CH 15：914.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	56.5 QP	83.5	-27.0	1.27 H	341	21.5	35.0
2	*914.50	113.5 QP			1.27 H	341	78.2	35.3
3	928.00	57.6 QP	83.5	-25.9	1.27 H	341	22.1	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.

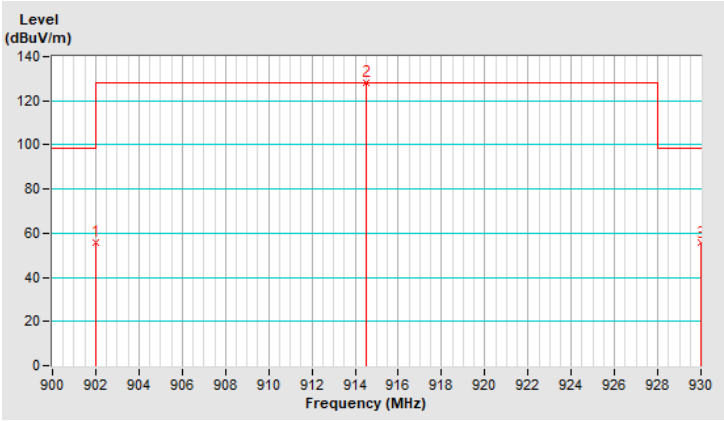


RF Mode	TX LoRa_DTS	Channel	CH 15：914.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	56.0 QP	98.2	-42.2	1.30 V	324	21.0	35.0
2	*914.50	128.2 QP			1.30 V	324	92.9	35.3
3	930.00	55.6 QP	98.2	-42.6	1.30 V	324	20.1	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.

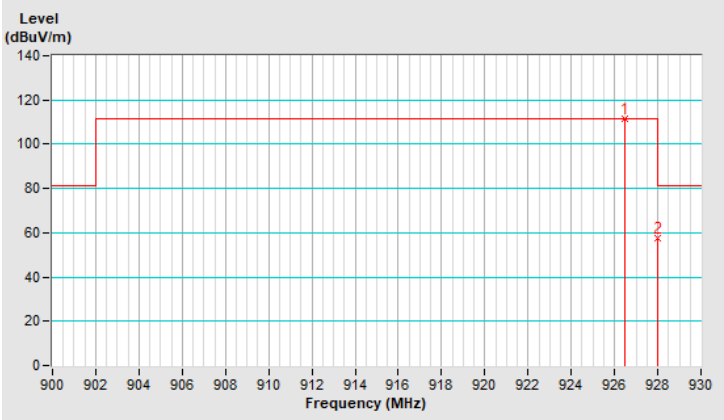


RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	*926.50	111.5 QP			1.30 H	322	76.0	35.5
2	928.00	57.5 QP	81.5	-24.0	1.30 H	322	22.0	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.

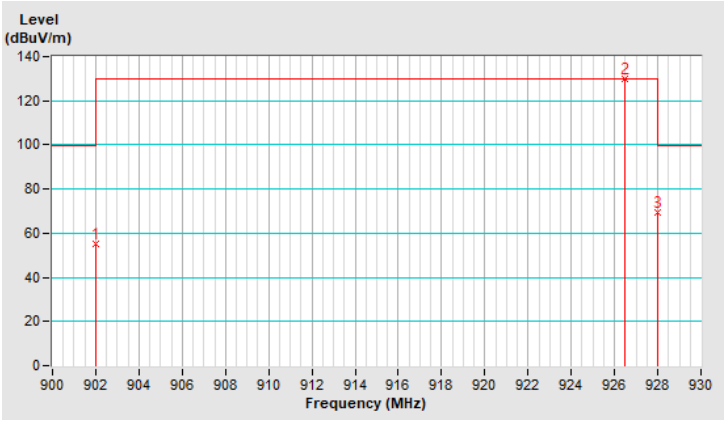


RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	55.0 QP	99.8	-44.8	1.31 V	326	20.0	35.0
2	*926.50	129.8 QP			1.31 V	326	94.3	35.5
3	928.00	69.2 QP	99.8	-30.6	1.31 V	326	33.7	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. “ * “: Fundamental frequency.



Above 1GHz Data:

RF Mode	TX LoRa_DTS	Channel	CH 0：902.5 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2707.50	33.3 PK	74.0	-40.7	1.69 H	145	37.1	-3.8
2	2707.50	21.8 AV	54.0	-32.2	1.69 H	145	25.6	-3.8
3	3610.00	33.6 PK	74.0	-40.4	1.49 H	185	35.9	-2.3
4	3610.00	27.1 AV	54.0	-26.9	1.49 H	185	29.4	-2.3
5	4512.50	36.5 PK	74.0	-37.5	1.72 H	137	36.6	-0.1
6	4512.50	25.6 AV	54.0	-28.4	1.72 H	137	25.7	-0.1
7	5415.00	38.3 PK	74.0	-35.7	3.21 H	121	37.0	1.3
8	5415.00	27.7 AV	54.0	-26.3	3.21 H	121	26.4	1.3
9	8122.50	43.8 PK	74.0	-30.2	1.49 H	15	35.5	8.3
10	8122.50	32.2 AV	54.0	-21.8	1.49 H	15	23.9	8.3
11	9025.00	42.0 PK	74.0	-32.0	1.16 H	22	34.3	7.7
12	9025.00	31.5 AV	54.0	-22.5	1.16 H	22	23.8	7.7
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2707.50	34.0 PK	74.0	-40.0	1.59 V	153	37.8	-3.8
2	2707.50	22.0 AV	54.0	-32.0	1.59 V	153	25.8	-3.8
3	3610.00	34.9 PK	74.0	-39.1	1.55 V	35	37.2	-2.3
4	3610.00	28.8 AV	54.0	-25.2	1.55 V	35	31.1	-2.3
5	4512.50	36.7 PK	74.0	-37.3	1.65 V	29	36.8	-0.1
6	4512.50	26.9 AV	54.0	-27.1	1.65 V	29	27.0	-0.1
7	5415.00	37.9 PK	74.0	-36.1	1.80 V	68	36.6	1.3
8	5415.00	29.6 AV	54.0	-24.4	1.80 V	68	28.3	1.3
9	8122.50	43.4 PK	74.0	-30.6	1.47 V	151	35.1	8.3
10	8122.50	31.8 AV	54.0	-22.2	1.47 V	151	23.5	8.3
11	9025.00	41.3 PK	74.0	-32.7	1.45 V	166	33.6	7.7
12	9025.00	31.0 AV	54.0	-23.0	1.45 V	166	23.3	7.7

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

RF Mode	TX LoRa_DTS	Channel	CH 15：913.7 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2743.50	32.6 PK	74.0	-41.4	1.71 H	128	36.4	-3.8
2	2743.50	21.6 AV	54.0	-32.4	1.71 H	128	25.4	-3.8
3	3658.00	32.8 PK	74.0	-41.2	1.33 H	179	34.8	-2.0
4	3658.00	26.7 AV	54.0	-27.3	1.33 H	179	28.7	-2.0
5	4572.50	37.1 PK	74.0	-36.9	1.59 H	140	37.2	-0.1
6	4572.50	26.0 AV	54.0	-28.0	1.59 H	140	26.1	-0.1
7	7316.00	37.8 PK	74.0	-36.2	3.13 H	122	31.0	6.8
8	7316.00	27.0 AV	54.0	-27.0	3.13 H	122	20.2	6.8
9	8230.50	43.1 PK	74.0	-30.9	1.46 H	10	35.4	7.7
10	8230.50	31.9 AV	54.0	-22.1	1.46 H	10	24.2	7.7
11	9145.00	41.6 PK	74.0	-32.4	1.12 H	27	33.5	8.1
12	9145.00	31.2 AV	54.0	-22.8	1.12 H	27	23.1	8.1
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2743.50	34.2 PK	74.0	-39.8	1.55 V	148	38.0	-3.8
2	2743.50	22.7 AV	54.0	-31.3	1.55 V	148	26.5	-3.8
3	3658.00	34.8 PK	74.0	-39.2	1.59 V	18	36.8	-2.0
4	3658.00	28.6 AV	54.0	-25.4	1.59 V	18	30.6	-2.0
5	4572.50	37.1 PK	74.0	-36.9	1.68 V	21	37.2	-0.1
6	4572.50	26.7 AV	54.0	-27.3	1.68 V	21	26.8	-0.1
7	7316.00	37.4 PK	74.0	-36.6	1.77 V	50	30.6	6.8
8	7316.00	29.5 AV	54.0	-24.5	1.77 V	50	22.7	6.8
9	8230.50	43.0 PK	74.0	-31.0	1.54 V	134	35.3	7.7
10	8230.50	31.8 AV	54.0	-22.2	1.54 V	134	24.1	7.7
11	9145.00	41.6 PK	74.0	-32.4	1.43 V	138	33.5	8.1
12	9145.00	31.1 AV	54.0	-22.9	1.43 V	138	23.0	8.1

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2779.50	33.4 PK	74.0	-40.6	1.70 H	116	37.1	-3.7
2	2779.50	22.1 AV	54.0	-31.9	1.70 H	116	25.8	-3.7
3	3706.00	32.6 PK	74.0	-41.4	1.35 H	190	34.5	-1.9
4	3706.00	26.4 AV	54.0	-27.6	1.35 H	190	28.3	-1.9
5	4632.50	37.2 PK	74.0	-36.8	1.64 H	113	37.1	0.1
6	4632.50	26.3 AV	54.0	-27.7	1.64 H	113	26.2	0.1
7	7412.00	37.1 PK	74.0	-36.9	3.16 H	136	29.8	7.3
8	7412.00	26.3 AV	54.0	-27.7	3.16 H	136	19.0	7.3
9	8338.50	43.7 PK	74.0	-30.3	1.46 H	25	36.2	7.5
10	8338.50	32.6 AV	54.0	-21.4	1.46 H	25	25.1	7.5
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2779.50	34.6 PK	74.0	-39.4	1.56 V	160	38.3	-3.7
2	2779.50	22.5 AV	54.0	-31.5	1.56 V	160	26.2	-3.7
3	3706.00	34.2 PK	74.0	-39.8	1.50 V	50	36.1	-1.9
4	3706.00	28.7 AV	54.0	-25.3	1.50 V	50	30.6	-1.9
5	4632.50	37.3 PK	74.0	-36.7	1.77 V	25	37.2	0.1
6	4632.50	27.4 AV	54.0	-26.6	1.77 V	25	27.3	0.1
7	7412.00	38.0 PK	74.0	-36.0	1.74 V	47	30.7	7.3
8	7412.00	30.2 AV	54.0	-23.8	1.74 V	47	22.9	7.3
9	8338.50	44.4 PK	74.0	-29.6	1.52 V	139	36.9	7.5
10	8338.50	32.4 AV	54.0	-21.6	1.52 V	139	24.9	7.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

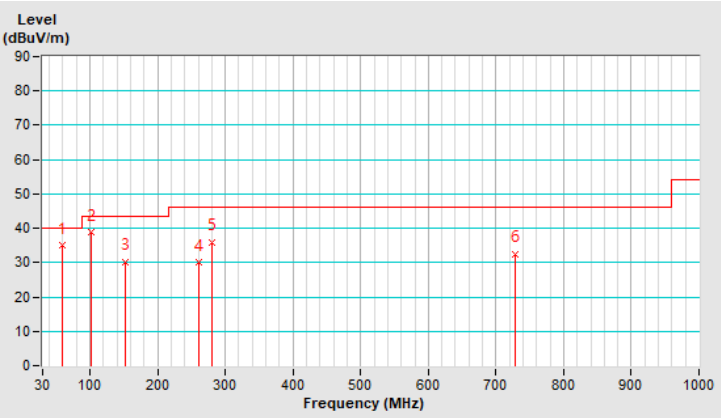
Below 1GHz Data:

RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	9kHz ~ 1GHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	58.58	35.2 QP	40.0	-4.8	3.00 H	179	48.3	-13.1
2	102.36	39.0 QP	43.5	-4.5	2.00 H	55	55.2	-16.2
3	151.59	30.3 QP	43.5	-13.2	2.00 H	67	42.3	-12.0
4	260.96	30.1 QP	46.0	-15.9	1.00 H	102	42.5	-12.4
5	280.97	36.0 QP	46.0	-10.0	1.00 H	233	47.3	-11.3
6	727.87	32.6 QP	46.0	-13.4	3.00 H	50	32.5	0.1

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.

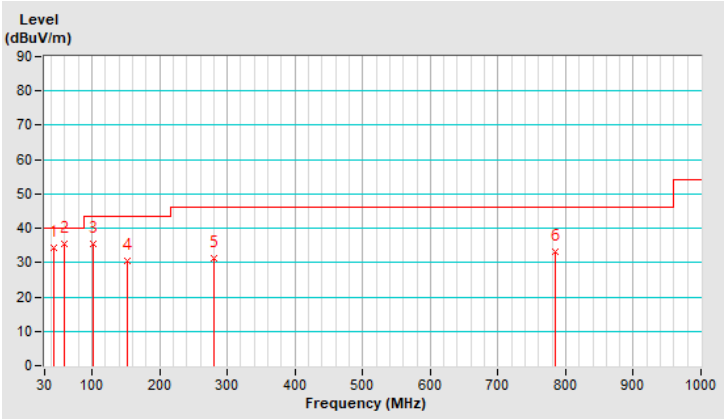


RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	9kHz ~ 1GHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	43.99	34.4 QP	40.0	-5.6	1.00 V	333	47.0	-12.6
2	**58.38**	**35.6 QP**	**40.0**	**-4.4**	**1.00 V**	**257**	**48.7**	**-13.1**
3	102.24	35.3 QP	43.5	-8.2	1.00 V	84	51.5	-16.2
4	152.17	30.6 QP	43.5	-12.9	1.00 V	53	42.6	-12.0
5	280.41	31.3 QP	46.0	-14.7	1.50 V	43	42.7	-11.4
6	784.58	33.2 QP	46.0	-12.8	3.00 V	296	31.9	1.3

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.



5.1.8 Test Results (Mode 2)

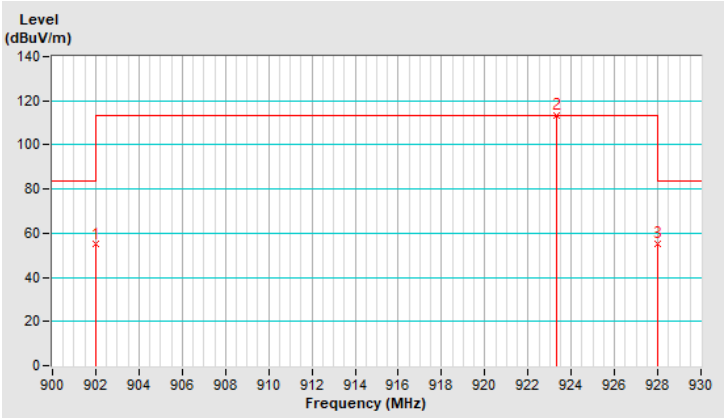
Bandedge Data:

RF Mode	TX LoRa_DTS	**Channel**	CH 0：923.3 MHz
Frequency Range	900MHz ~ 930MHz	**Detector Function**	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	**Frequency (MHz)**	**Emission Level (dBuV/m)**	**Limit (dBuV/m)**	**Margin (dB)**	**Antenna Height (m)**	**Table Angle (Degree)**	**Raw Value (dBuV)**	**Correction Factor (dB/m)**
1	902.00	55.1 QP	83.6	-28.5	1.00 H	32	20.1	35.0
2	*923.30	113.6 QP			1.00 H	32	78.1	35.5
3	928.00	55.3 QP	83.6	-28.3	1.00 H	32	19.8	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.
5. " * ": Fundamental frequency.

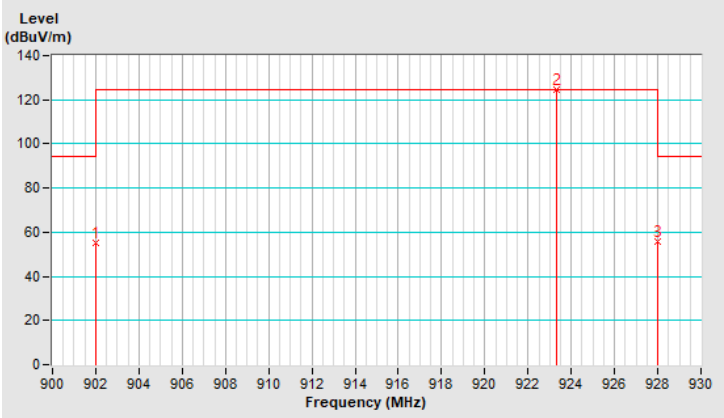


RF Mode	TX LoRa_DTS	Channel	CH 0：923.3 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	902.00	55.0 QP	94.4	-39.4	1.62 V	202	20.0	35.0
2	*923.30	124.4 QP			1.62 V	202	88.9	35.5
3	928.00	55.8 QP	94.4	-38.6	1.62 V	202	20.3	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.
5. " * ": Fundamental frequency.

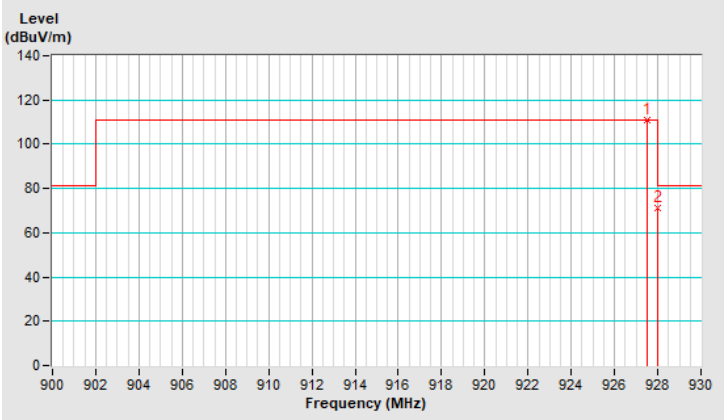


RF Mode	TX LoRa_DTS	Channel	CH 7：927.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	*927.50	111.1 QP			1.00 H	32	75.6	35.5
2	928.00	71.5 QP	81.1	-9.6	1.00 H	32	36.0	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.
5. " * ": Fundamental frequency.

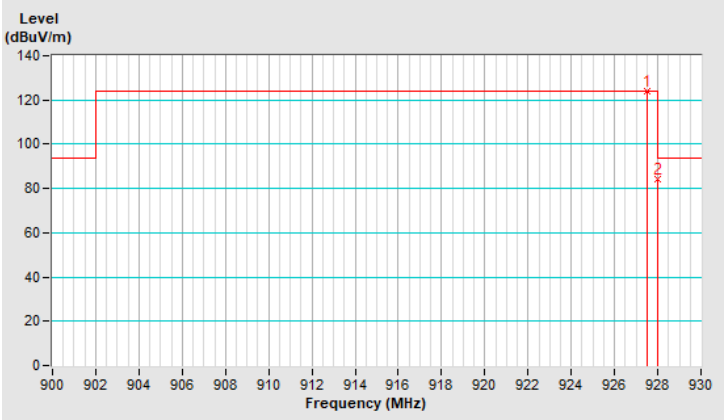


RF Mode	TX LoRa_DTS	Channel	CH 7：927.5 MHz
Frequency Range	900MHz ~ 930MHz	Detector Function	Quasi-Peak (QP)

Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	*927.50	124.0 QP			1.54 V	340	88.5	35.5
2	928.00	83.9 QP	94.0	-10.1	1.54 V	340	48.4	35.5

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit of frequency range 30MHz~1000MHz.
5. The emission levels were very low against the limit of frequency range 9kHz~30MHz: the amplitude of spurious emissions attenuated more than 20 dB below the permissible value to be report.
5. " * ": Fundamental frequency.



Above 1GHz Data:

RF Mode	TX LoRa_DTS	Channel	CH 0：923.3 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2769.90	45.3 PK	74.0	-28.7	1.34 H	301	49.1	-3.8
2	2769.90	41.1 AV	54.0	-12.9	1.34 H	301	44.9	-3.8
3	4616.50	39.2 PK	74.0	-34.8	1.64 H	151	39.1	0.1
4	4616.50	33.2 AV	54.0	-20.8	1.64 H	151	33.1	0.1
5	7386.40	43.2 PK	74.0	-30.8	1.64 H	283	36.0	7.2
6	7386.40	31.7 AV	54.0	-22.3	1.64 H	283	24.5	7.2
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2769.90	50.5 PK	74.0	-23.5	1.54 V	297	54.3	-3.8
2	2769.90	47.7 AV	54.0	-6.3	1.54 V	297	51.5	-3.8
3	4616.50	43.8 PK	74.0	-30.2	1.34 V	157	43.7	0.1
4	4616.50	37.5 AV	54.0	-16.5	1.34 V	157	37.4	0.1
5	7386.40	45.9 PK	74.0	-28.1	1.03 V	89	38.7	7.2
6	7386.40	35.5 AV	54.0	-18.5	1.03 V	89	28.3	7.2

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

RF Mode	TX LoRa_DTS	Channel	CH 7：927.5 MHz
Frequency Range	1GHz ~ 10GHz	Detector Function	Peak (PK) Average (AV)

Antenna Polarity & Test Distance : Horizontal at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2782.50	41.2 PK	74.0	-32.8	1.42 H	297	44.9	-3.7
2	2782.50	36.4 AV	54.0	-17.6	1.42 H	297	40.1	-3.7
3	4637.50	40.5 PK	74.0	-33.5	1.69 H	137	40.4	0.1
4	4637.50	30.0 AV	54.0	-24.0	1.69 H	137	29.9	0.1
5	7420.00	44.3 PK	74.0	-29.7	1.57 H	277	37.0	7.3
6	7420.00	32.1 AV	54.0	-21.9	1.57 H	277	24.8	7.3
Antenna Polarity & Test Distance : Vertical at 3 m								
No	Frequency (MHz)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Correction Factor (dB/m)
1	2782.50	45.6 PK	74.0	-28.4	1.49 V	307	49.3	-3.7
2	2782.50	40.0 AV	54.0	-14.0	1.49 V	307	43.7	-3.7
3	4637.50	45.2 PK	74.0	-28.8	1.31 V	164	45.1	0.1
4	4637.50	36.8 AV	54.0	-17.2	1.31 V	164	36.7	0.1
5	7386.40	44.7 PK	74.0	-29.3	1.09 V	64	37.5	7.2
6	7386.40	33.8 AV	54.0	-20.2	1.09 V	64	26.6	7.2

Remarks:

1. Emission Level(dBuV/m) = Raw Value(dBuV) + Correction Factor(dB/m)
2. Correction Factor(dB/m) = Antenna Factor(dB/m) + Cable Factor(dB) – Pre-Amplifier Factor(dB)
3. Margin value = Emission Level – Limit value
4. The other emission levels were very low against the limit.

5.2 Conducted Emission Measurement

5.2.1 Limits of Conducted Emission Measurement

Frequency (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30.0	60	50

Note: 1.The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

5.2.2 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.2.3 Test Procedures

a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.

b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.

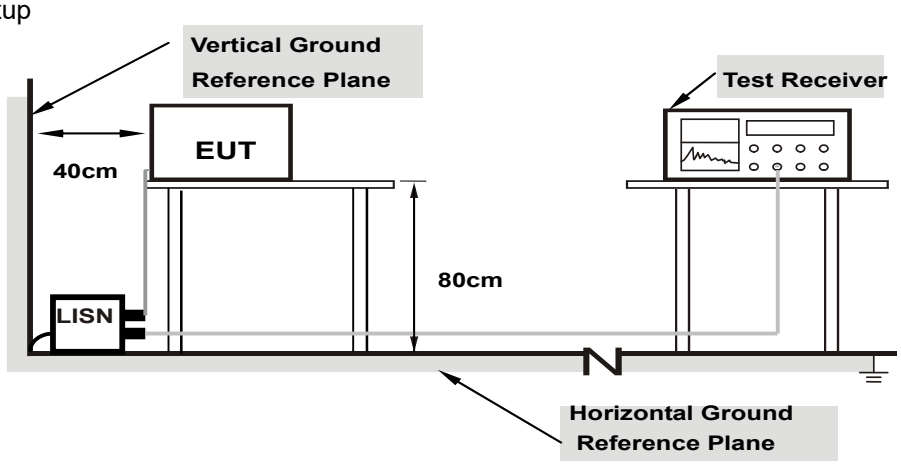
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

Note: The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.

5.2.4 Deviation from Test Standard

No deviation.

5.2.5 Test Setup



Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the attached file (Test Setup Photo).

5.2.6 EUT Operating Conditions

Same as 4.1.6.

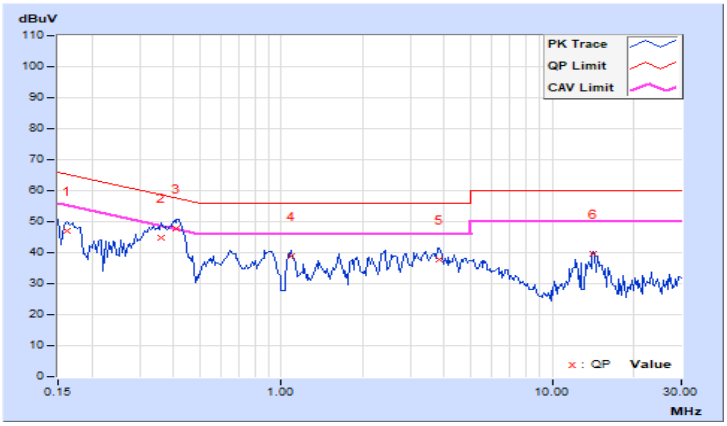
5.2.7 Test Results

RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	150kHz ~ 30MHz	Detector Function & Resolution Bandwidth	Quasi-Peak (QP) / Average (AV), 9kHz

Phase Of Power : Line (L)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.16172	9.95	37.09	28.43	47.04	38.38	65.38	55.38	-18.34	-17.00
2	0.36094	9.99	34.77	30.10	44.76	40.09	58.71	48.71	-13.95	-8.62
3	**0.41172**	**9.99**	**37.67**	**32.67**	**47.66**	**42.66**	**57.61**	**47.61**	**-9.95**	**-4.95**
4	1.08984	10.03	28.96	24.34	38.99	34.37	56.00	46.00	-17.01	-11.63
5	3.82422	10.16	27.77	20.43	37.93	30.59	56.00	46.00	-18.07	-15.41
6	14.15234	10.78	29.00	25.69	39.78	36.47	60.00	50.00	-20.22	-13.53

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value

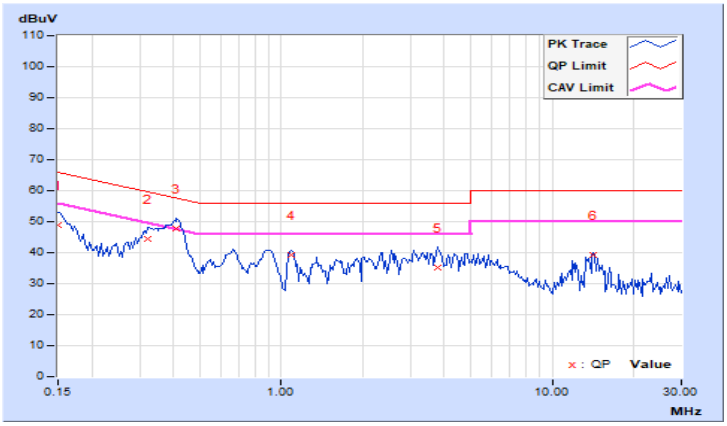


RF Mode	TX LoRa_DTS	Channel	CH 30：926.5 MHz
Frequency Range	150kHz ~ 30MHz	Detector Function & Resolution Bandwidth	Quasi-Peak (QP) / Average (AV), 9kHz

Phase Of Power : Neutral (N)										
No	Frequency (MHz)	Correction Factor (dB)	Reading Value (dBuV)		Emission Level (dBuV)		Limit (dBuV)		Margin (dB)	
			Q.P.	AV.	Q.P.	AV.	Q.P.	AV.	Q.P.	AV.
1	0.15000	9.92	38.83	20.23	48.75	30.15	66.00	56.00	-17.25	-25.85
2	0.32188	9.96	34.50	29.19	44.46	39.15	59.66	49.66	-15.20	-10.51
3	0.41172	9.96	38.00	32.45	47.96	42.41	57.61	47.61	-9.65	-5.20
4	1.08984	10.00	29.33	24.33	39.33	34.33	56.00	46.00	-16.67	-11.67
5	3.77734	10.11	25.24	20.50	35.35	30.61	56.00	46.00	-20.65	-15.39
6	14.21094	10.60	28.72	25.23	39.32	35.83	60.00	50.00	-20.68	-14.17

Remarks:

1. Q.P. and AV. are abbreviations of quasi-peak and average individually.
2. The emission levels of other frequencies were very low against the limit.
3. Margin value = Emission level – Limit value
4. Correction factor = Insertion loss + Cable loss
5. Emission Level = Correction Factor + Reading Value

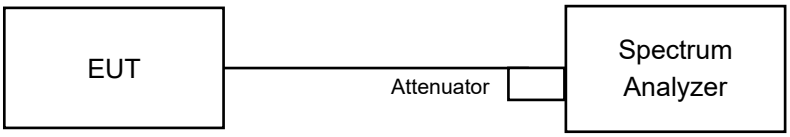


5.3 6dB Bandwidth Measurement

5.3.1 Limits of 6dB Bandwidth Measurement

The minimum of 6dB Bandwidth Measurement is 0.5 MHz.

5.3.2 Test Setup



5.3.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.3.4 Test Procedure

a. Set resolution bandwidth (RBW) = 100kHz
b. Set the video bandwidth (VBW) ≥ 3 x RBW, Detector = Peak.
c. Trace mode = max hold.
d. Sweep = auto couple.
e. Measure the maximum width of the emission that is constrained by the frequencies associated with the two amplitude points (upper and lower) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission

5.3.5 Deviation from Test Standard

No deviation.

5.3.6 EUT Operating Conditions

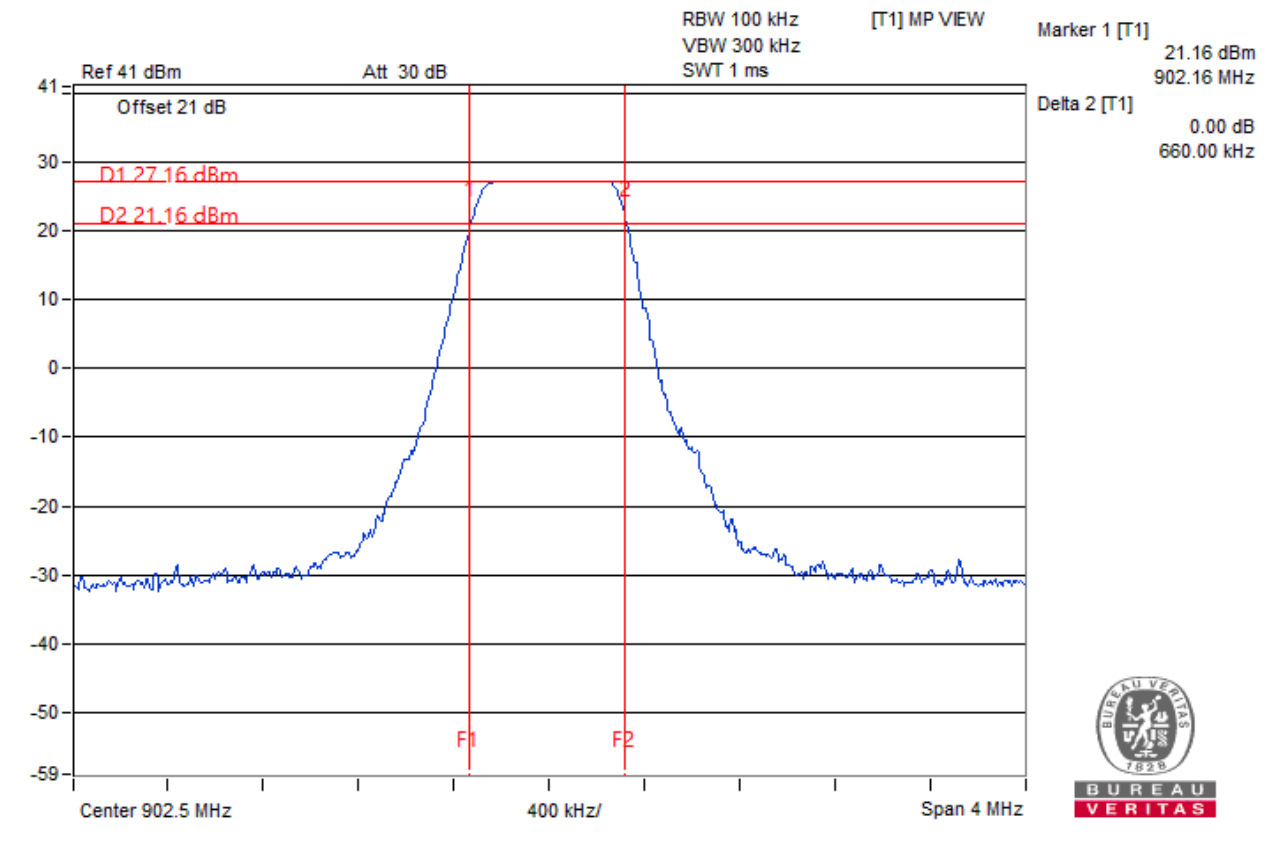
The software provided by client to enable the EUT under transmission condition continuously at lowest, middle and highest channel frequencies individually.

5.3.7 Test Results (Mode 1)

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
0	902.5	0.66	0.5	Pass
15	914.5	0.68	0.5	Pass
30	926.5	0.66	0.5	Pass

Spectrum Plot of Worst Value

CH 0

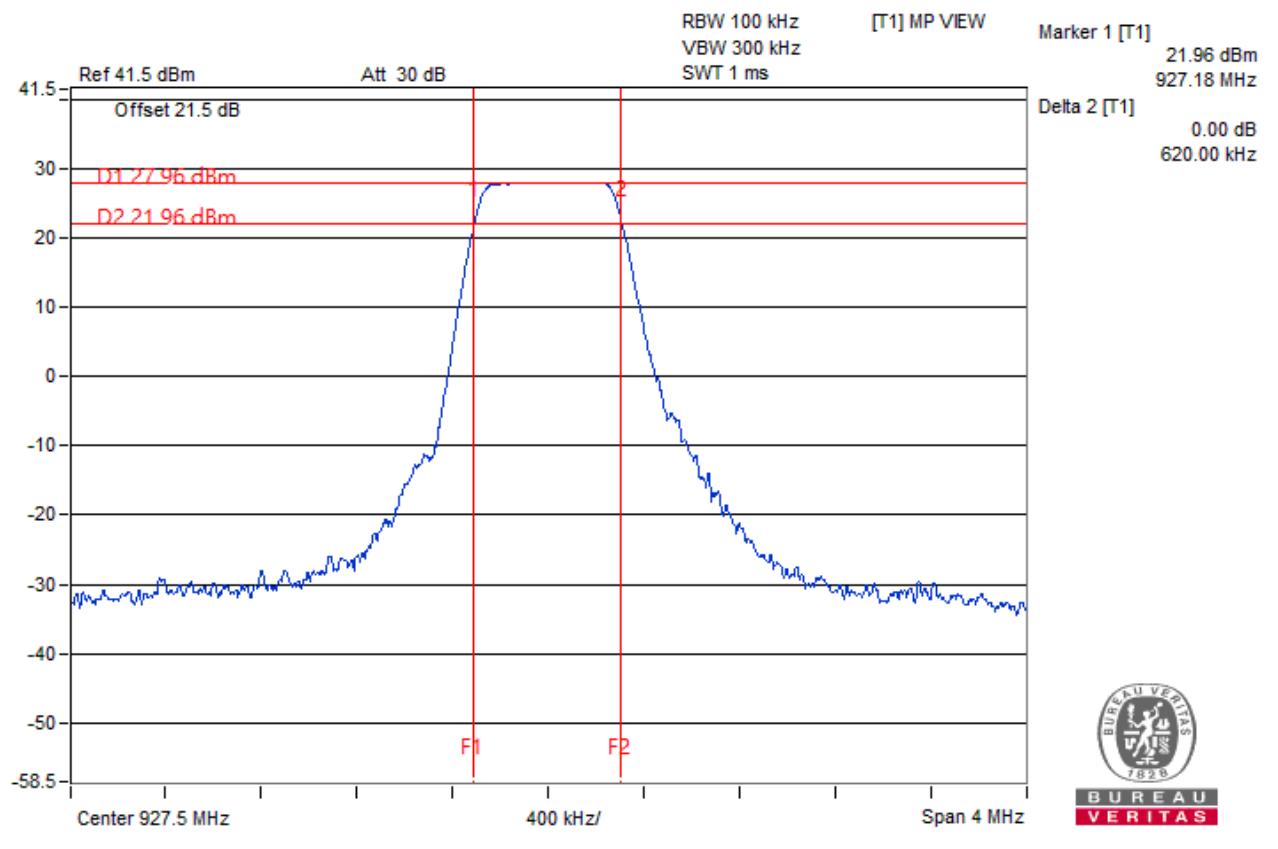


5.3.8 Test Results (Mode 2)

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass / Fail
0	923.3	0.63	0.5	Pass
7	927.5	0.62	0.5	Pass

Spectrum Plot of Worst Value

CH 7

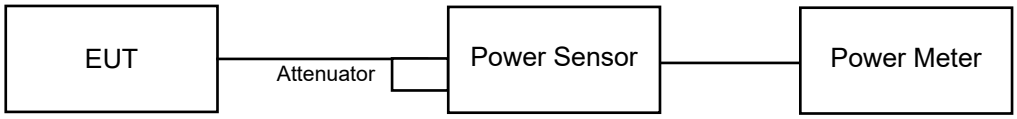


5.4 Conducted Output Power Measurement

5.4.1 Limits of Conducted Output Power Measurement

For systems using digital modulation in the 902-928 MHz bands: 1 Watt (30dBm)

5.4.2 Test Setup



5.4.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.4.4 Test Procedures

Average power sensor was used to perform output power measurement, trigger and gating function of wide band power meter is enabled to measure max output power of TX on burst. Duty factor is not added to measured value.

5.4.5 Deviation from Test Standard

No deviation.

5.4.6 EUT Operating Conditions

Same as Item 5.3.6.

5.4.7 Test Results (Mode 1)

Channel	Frequency (MHz)	Average Power (mW)	Average Power (dBm)	Limit (dBm)	Pass/Fail
0	902.5	554.626	27.44	30	Pass
15	914.5	566.239	27.53	30	Pass
30	926.5	587.489	27.69	30	Pass

5.4.8 Test Results (Mode 2)

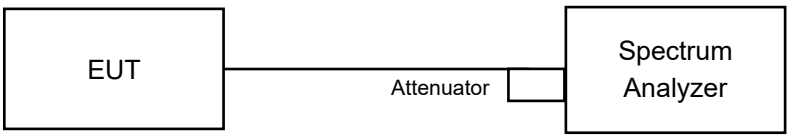
Channel	Frequency (MHz)	Average Power (mW)	Average Power (dBm)	Limit (dBm)	Pass/Fail
0	923.3	543.25	27.35	30	Pass
7	927.5	547.016	27.38	30	Pass

5.5 Power Spectral Density Measurement

5.5.1 Limits of Power Spectral Density Measurement

The Maximum of Power Spectral Density Measurement is 8dBm in any 3 kHz.

5.5.2 Test Setup



5.5.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.5.4 Test Procedure

DTS Mode (Channel Spacing: 600 kHz):

a. Set instrument center frequency to DTS channel center frequency.
b. Set span to at least 1.5 times the OBW.
c. Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz. .
d. Set VBW ≥3 x RBW.
e. Detector = power averaging (RMS) or sample detector (when RMS not available).
f. Ensure that the number of measurement points in the sweep ≥ 2 x span/RBW.
g. Sweep time = auto couple.
h. Employ trace averaging (RMS) mode over a minimum of 100 traces.
i. Use the peak marker function to determine the maximum amplitude level.

DTS Mode (Channel Spacing: 800 kHz):

a. Measure the duty cycle (x).
b. Set instrument center frequency to DTS channel center frequency.
c. Set span to at least 1.5 times the OBW.
d. Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
e. Set VBW ≥3 x RBW.
f. Detector = power averaging (RMS) or sample detector (when RMS not available).
g. Ensure that the number of measurement points in the sweep ≥ 2 x span/RBW.
h. Sweep time = auto couple.
i. Do not use sweep triggering. Allow sweep to “free run”.
j. Employ trace averaging (RMS) mode over a minimum of 100 traces.
k. Use the peak marker function to determine the maximum amplitude level.
l. Add 10 log (1/x), where x is the duty cycle measured in step (a, to the measured PSD to compute the average PSD during the actual transmission time.

5.5.5 Deviation from Test Standard

No deviation.

5.5.6 EUT Operating Condition

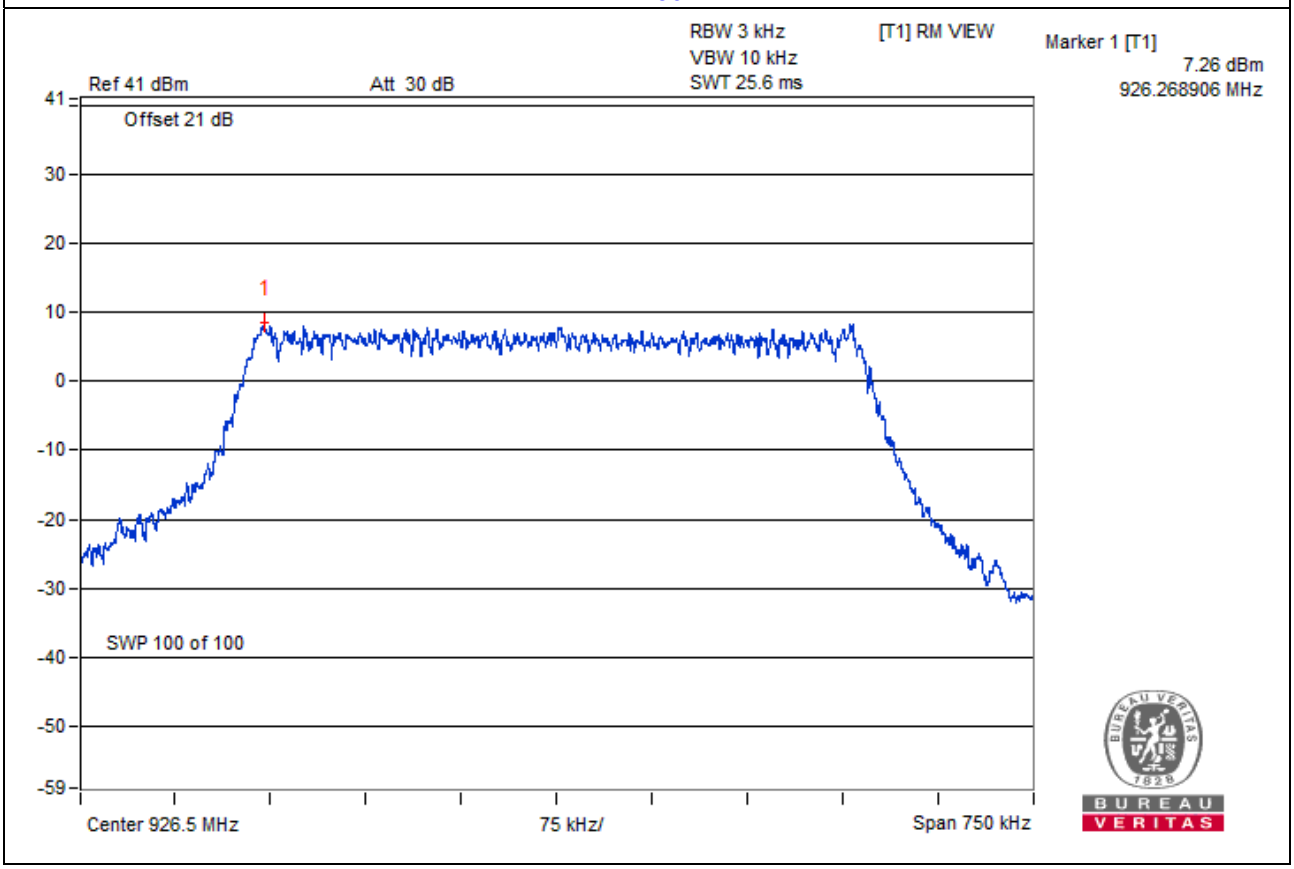
Same as Item 5.3.6.

5.5.7 Test Results (Mode 1)

Chan.	Chan. Freq. (MHz)	PSD w/o Duty Factor (dBm/3kHz)	Duty Factor (dB)	Total PSD (dBm/3kHz)	PSD Limit (dBm/3kHz)	Test Result
0	902.5	6.42	0.70	7.12	8.00	Pass
15	914.5	6.95	0.70	7.65	8.00	Pass
30	926.5	7.26	0.70	7.96	8.00	Pass

Note: Refer to section 3.3 for duty cycle spectrum plot.

Spectrum Plot of Worst Value
CH 30

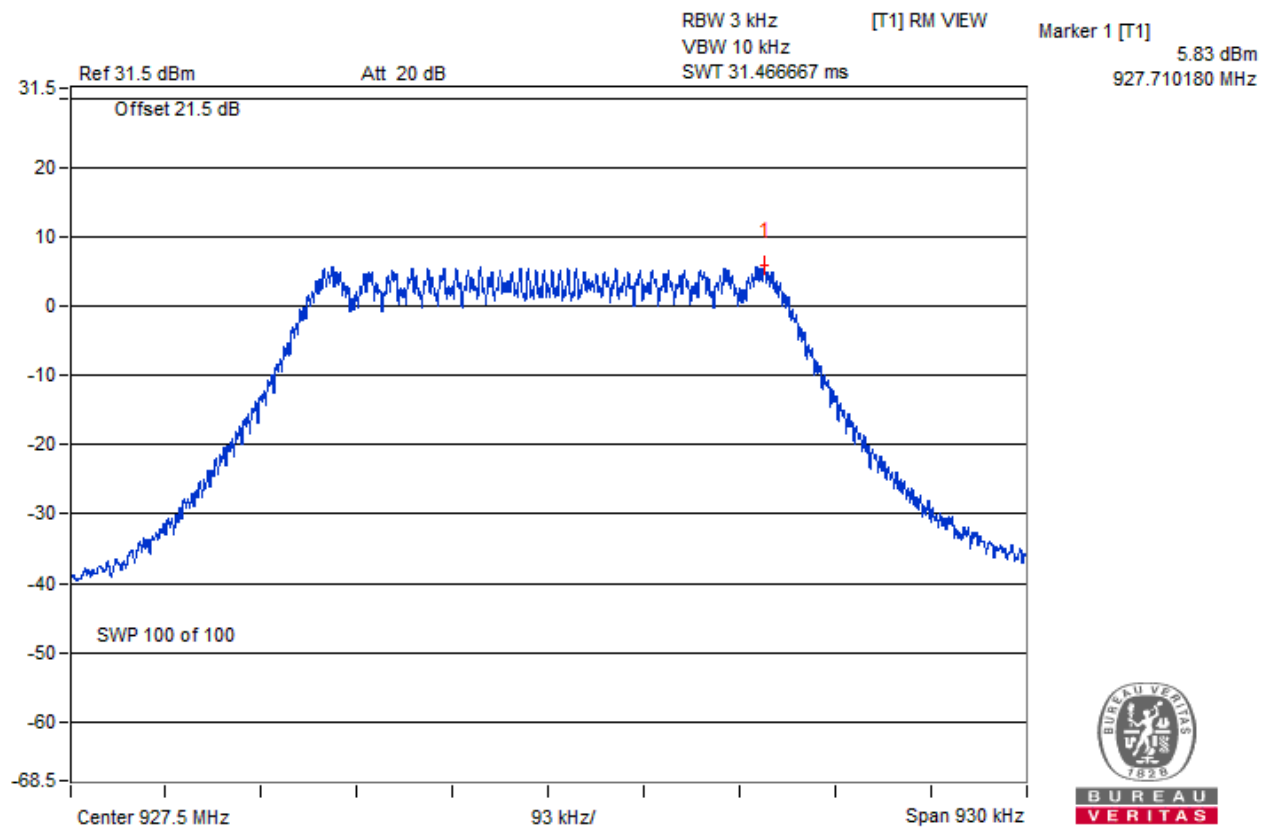


5.5.8 Test Results (Mode 2)

Chan.	Chan. Freq. (MHz)	PSD (dBm/3kHz)	PSD Limit (dBm/3kHz)	Test Result
0	923.3	5.00	8.00	Pass
7	927.5	5.83	8.00	Pass

Spectrum Plot of Worst Value

CH 7

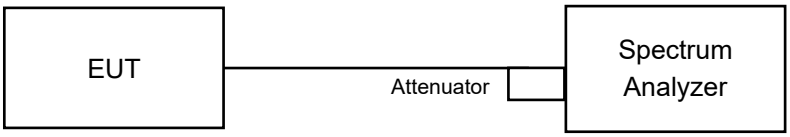


5.6 Conducted Out of Band Emission Measurement

5.6.1 Limits of Conducted Out of Band Emission Measurement

Below 30dB of the highest emission level of operating band (in 100kHz Resolution Bandwidth).

5.6.2 Test Setup



5.6.3 Test Instruments

Refer to section 4.1.2 to get information of above instrument.

5.6.4 Test Procedure

MEASUREMENT PROCEDURE REF

1. Set the RBW = 100 kHz.
2. Set the VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

MEASUREMENT PROCEDURE OOBE

1. Set RBW = 100 kHz.
2. Set VBW ≥ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

5.6.5 Deviation from Test Standard

No deviation.

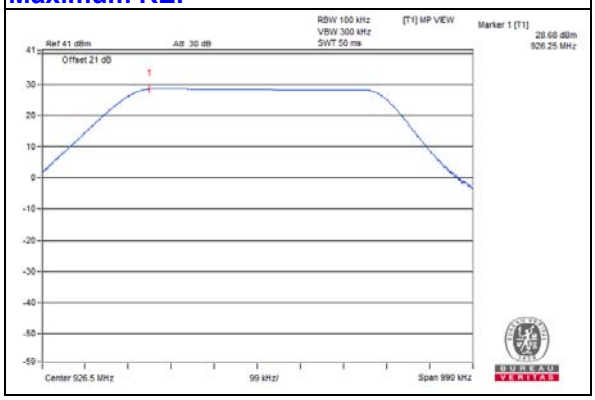
5.6.6 EUT Operating Condition

Same as Item 5.3.6.

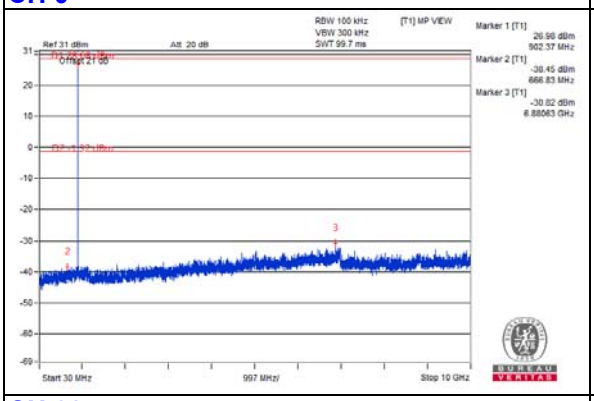
5.6.7 Test Results (Mode 1)

The spectrum plots are attached on the following pages. D1 line indicates the highest level, and D2 line indicates the 30dB offset below D1. It shows compliance with the requirement.

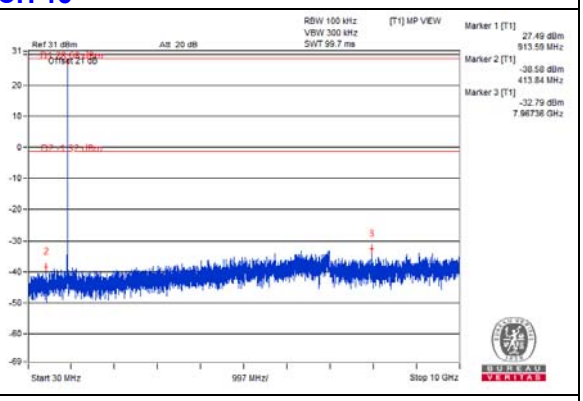
Maximum REF



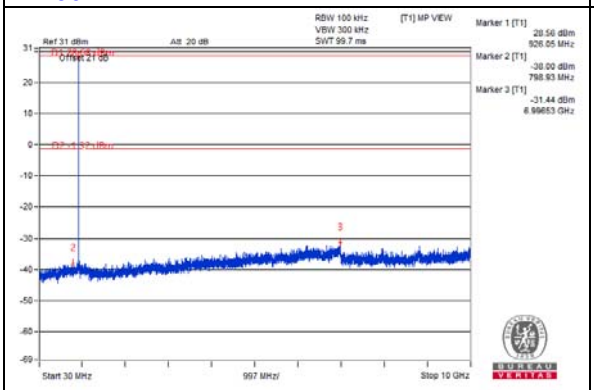
CH 0



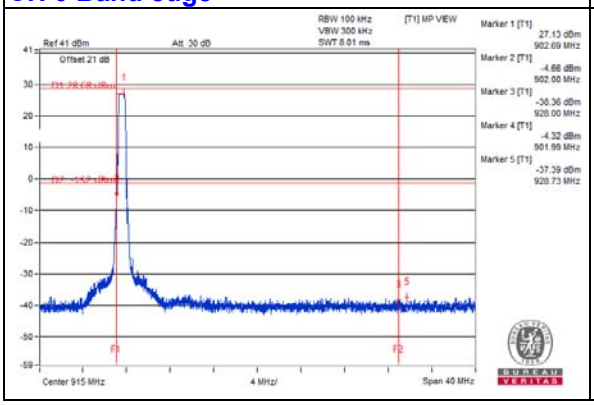
CH 15



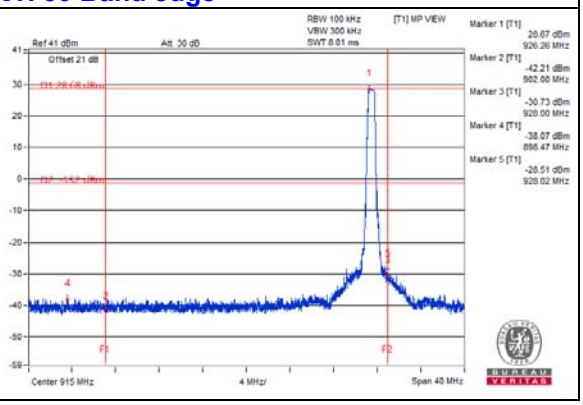
CH 30



CH 0 Band edge



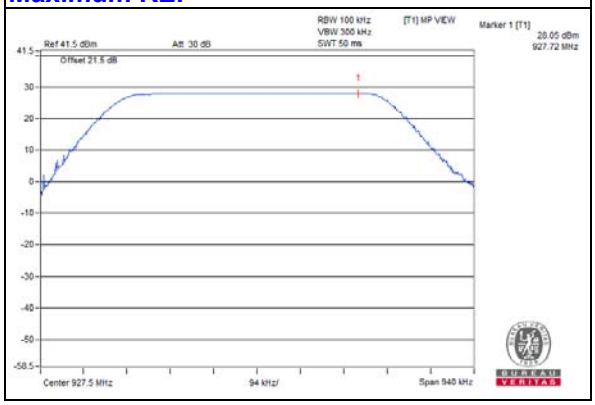
CH 30 Band edge



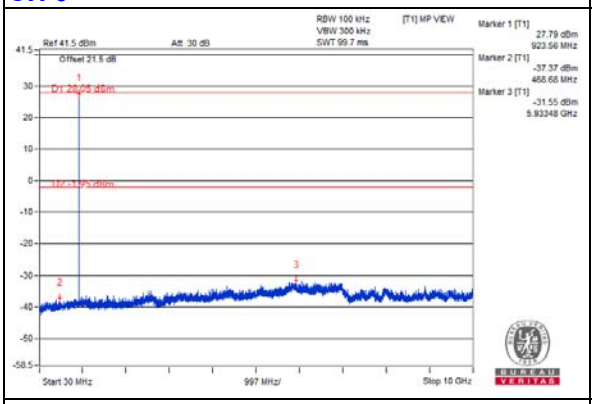
5.6.8 Test Results (Mode 2)

The spectrum plots are attached on the following pages. D1 line indicates the highest level, and D2 line indicates the 30dB offset below D1. It shows compliance with the requirement.

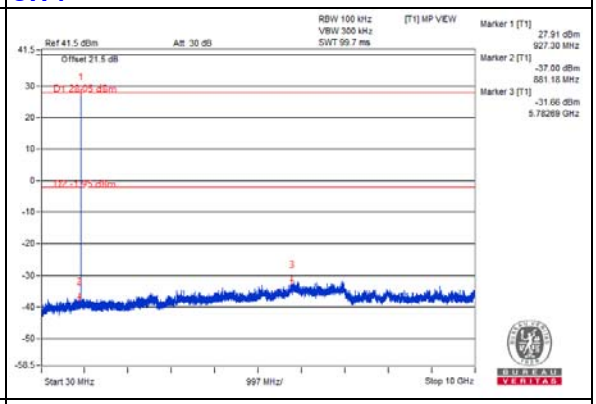
Maximum REF



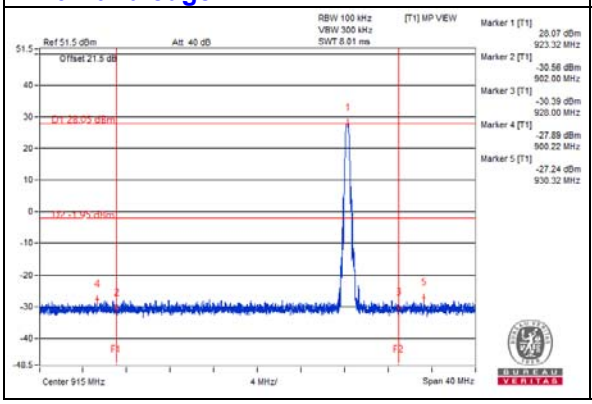
CH 0



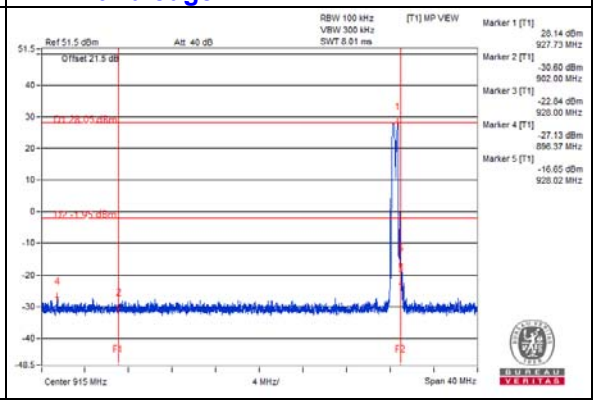
CH 7



CH 0 Band edge



CH 7 Band edge



6 Pictures of Test Arrangements

Please refer to the attached file (Test Setup Photo).

Appendix – Information of the Testing Laboratories

We, Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch, were founded in 1988 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are FCC recognized accredited test firms and accredited according to ISO/IEC 17025.

If you have any comments, please feel free to contact us at the following:

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The address and road map of all our labs can be found in our web site also.

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