TEST REPORT

Product Name:	LoRa Module
Trademark:	B&T 博安通 , 安信可科技 Ai-Thinker
Model Number:	Ra-01SC
Prepared For:	Shenzhen Ai-Thinker Technology Co., Ltd
Address:	410, Block C, Huafeng Smart Innovation Port. Gushu 2nd Road, Gushu Community, Xixiang Street, Baoan District, Shenzhen, China
Manufacturer:	Shenzhen Ai-Thinker Technology Co., Ltd
Address:	410, Block C, Huafeng Smart Innovation Port. Gushu 2nd Road, Gushu Community, Xixiang Street, Baoan District, Shenzhen, China
Prepared By:	Shenzhen CTB Testing Technology Co., Ltd.
Address:	Floor 1&2, Building A, No. 26 of Xinhe Road, Xinqiao Street, Baoan District, Shenzhen, China
Sample Received Date:	May. 15, 2021
Sample tested Date:	May. 15, 2021 - May. 26, 2021
Issue Date:	Jul. 5, 2021
Report No.:	CTB210527020RFX
Test Standards	ETSI EN 300 220-1 V3.1.1 (2017-02) ETSI EN 300 220-2 V3.2.1 (2018-06)
Test Results	PASS
Remark:	This is SRD-433MHz radio test report.

.

Compiled by:	Reviewed by:	Approved by:
Arron Liu	Bin Mei	Rita Xiao
Arron Liu	Bin Mei	Rita Xiao / Director

TABLE OF CONTENT

(Note: N/A means not applicable)

1. VERSION

Report No.	Issue Date	Description	Approved
CTB210527020RFX	Jul. 5, 2021	Original	Valid

2. TEST SUMMARY

The Product has been tested according to the following specifications:

Test Item	Test Requirement Clause (EN 300 220-2)	Test Method Clause (EN 300 220-1)	Results
Transmitter Parameters			
Operating frequency	Clause 4.2.1	Clause 5.1	PASS
Unwanted emissions in the spurious domain	Clause 4.2.2	Clause 5.9	PASS
TX effective radiated power	Clause 4.3.1	Clause 5.2	PASS
TX Maximum e.r.p. spectral density	Clause 4.3.2	Clause 5.3	N/A[1]
TX Duty cycle	Clause 4.3.3	Clause 5.4	PASS
TX Occupied bandwidth	Clause 4.3.4	Clause 5.6	PASS
TX out of band emissions	Clause 4.3.5	Clause 5.8	PASS
TX Transient	Clause 4.3.6	Clause 5.10	PASS
TX Adjacent channel power	Clause 4.3.7	Clause 5.11	N/A[2]
TX behaviour under low voltage conditions	Clause 4.3.8	Clause 5.12	PASS
TX Adaptive power control	Clause 4.3.9	Clause 5.13	N/A[3]
TX FHSS	Clause 4.3.10	N/A	N/A[4]
TX Short term behaviour	Clause 4.3.11	Clause 5.5	N/A[5]
Receiver Parameters			
RX sensitivity	Clause 4.4.1	Clause 5.14	N/A[6]
RX Blocking	Clause 4.4.2	Clause 5.18	PASS
Polite spectrum access conformance requirement			
Clear channel assessment threshold	Clause 4.5.2	Clause 5.21.2	N/A[7]
Polite spectrum access timing parameters	Clause 4.5.3	Clause 5.21.3	N/A[7]
Adaptive Frequency Agility	Clause 4.5.4	Clause 5.21.4	N/A[8]

N/A[1]: Applies to EUT using annex B band I.

Applies to EUT using DSSS or wideband techniques other than FHSS modulation, using annex C band W, AA or AC.

N/A[2]: Applies to EUT with OCW $\leqslant$ 25 kHz.

N/A[3]: Applies to EUT with adaptive power control using annex C band AF.

N/A[4]: Applies to FHSS EUT using the band 863 MHz to 870 MHz.

N/A[5]: Applies to EUT using annex C bands AD, AE, AF, AG, AH, or AI.

N/A[6]: Applies to EUT employing polite spectrum access.

N/A[7]: Applies to EUT employing polite spectrum access.

N/A[8]: Applies to EUT with AFA.

3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Item	Uncertainty
Occupancy bandwidth	54.3kHz
Conducted output power Above 1G	0.9dB
Conducted output power below 1G	0.9dB
Power Spectral Density , Conduction	0.9dB
Conduction spurious emissions	2.0dB
Out of band emission	2.0dB
3m camber Radiated spurious emission(30MHz-1GHz)	4.6dB
3m chamber Radiated spurious emission(1GHz-18GHz)	5.1dB
3m chamber Radiated spurious emission(18GHz-40GHz)	3.4dB
Receiver Reference Sensitivity level	1.9dB
humidity uncertainty	5.5%
Temperature uncertainty	0.63℃
frequency	1×10^{-7}

4. PRODUCT INFORMATION AND TEST SETUP

4.1 Product Information

Model(s):	Ra-01SC
Model Description:	N/A
SRD:	433.92MHz
Receiver Category:	2
Hardware Version:	V1.1
Software Version:	V1.1
Type of Modulation:	Lora
Antenna installation:	Internal Antenna
Ratings:	DC 5V from PC

4.2 Test Setup Configuration

See test photographs attached in EUT TEST SETUP PHOTOGRAPHS for the actual connections between Product and support equipment.

4.3 Support Equipment

Item	Equipment	Mfr/Brand	Model/Type No.	Series No.	Note
/	/	/	/	/	/

Notes:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

4.4 Channel List

N/A

4.5 Test Mode

All test mode(s) and condition(s) mentioned were considered and evaluated respectively by performing full tests, the worst data were recorded and reported.

Test mode	Low channel	Middle channel	High channel
Transmitting	/	433.925MHz	/
Receiving	/	433.925MHz	/

4.6 Test Environment

Humidity(%):	55
Atmospheric Pressure(kPa):	101.1
Normal Voltage(AC)(V):	230
Normal Temperature(℃) :	25
Low Temperature(℃) :	-10
High Temperature(℃) :	40

5. TEST FACILITY AND TEST INSTRUMENT USED

5.1 Test Facility

All measurement facilities used to collect the measurement data are located at BCTC Building & 1-2F, East of B Building, Pengzhou Industrial, Fuyuan 1st Road, Qiaotou Community, Fuyong Street, Bao'an District, Shenzhen, China. The site and apparatus are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-1 other equivalent standards.

5.2 Test Instrument Used

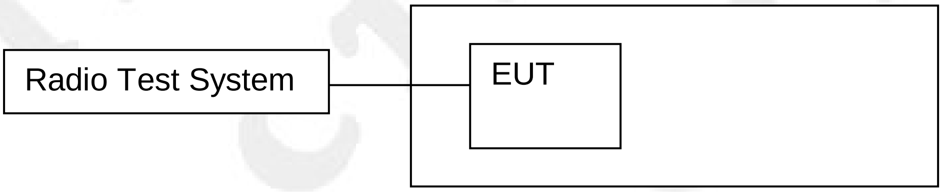
RF conduction and Radiation Test equipment

Item	Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until
1	Spectrum Analyzer	Agilent	N9020A	MY52090073	Sep. 28, 2020	Sep. 28, 2021
2	Power Sensor	Agilent	U2021XA	MY56120032	Sep. 28, 2020	Sep. 28, 2021
3	Power Sensor	Agilent	U2021XA	MY56120034	Sep. 28, 2020	Sep. 28, 2021
4	Communication test set	R&S	CMW500	108058	Sep. 28, 2020	Sep. 28, 2021
5	Spectrum Analyzer	R&S	FSP40	100550	Sep. 28, 2020	Sep. 28, 2021
6	Signal Generator	Agilent	N5181A	MY49060920	Sep. 28, 2020	Sep. 28, 2021
7	Signal Generator	Agilent	N5182A	MY47420195	Sep. 28, 2020	Sep. 28, 2021
8	Communication test set	Agilent	E5515C	MY50102567	Oct. 10, 2020	Oct. 10, 2021
9	band rejection filter	Shenxiang	MSF2400-2483.5MS-1154	20181015001	Sep. 28, 2020	Sep. 28, 2021
10	band rejection filter	Shenxiang	MSF5150-5850MS-1155	20181015001	Sep. 28, 2020	Sep. 28, 2021
11	band rejection filter	Xingbo	XBLBQ-DZA120	190821-1-1	Sep. 28, 2020	Sep. 28, 2021
12	BT&WI-FI Automatic test software	Micowave	MTS8310	Ver. 2.0.0.0	\	\
13	Rohde & Schwarz SFU Broadcast Test System	R&S	SFU	101017	Sep. 28, 2020	Sep. 28, 2021
14	Temperature humidity chamber	Hongjing	TH-80CH	DG-15174	Sep. 28, 2020	Sep. 28, 2021
15	234G Automatic test software	Micowave	MTS8200	Ver. 2.0.0.0	\	\
16	966 chamber	C.R.T.	966 Room	966	Nov. 9, 2019	Nov. 08, 2022

17	Receiver	R&S	ESPI	100362	Sep. 28, 2020	Sep. 28, 2021
18	Amplifier	HP	8447E	2945A02747	Sep. 28, 2020	Sep. 28, 2021
19	Amplifier	Agilent	8449B	3008A01838	Sep. 28, 2020	Sep. 28, 2021
20	TRILOG Broadband Antenna	Schwarzbeck	VULB 9168	00869	Nov. 02, 2020	Nov. 01, 2021
21	Horn Antenna	Schwarzbeck	BBHA9120D	1911	Nov. 02, 2020	Nov. 01, 2021
22	Software	Fala	EZ-EMC	FA-03A2 RE	\	\
23	3-Loop Antenna	Daze	ZN30401	17014	Sep. 28, 2020	Sep. 28, 2021
24	loop antenna	ZHINAN	ZN30900A	/	Sep. 28, 2020	Sep. 28, 2021
25	Horn antenna	A/H/System	SAS-574	588	Sep. 28, 2020	Sep. 28, 2021
26	Amplifier	AEROFLEX	/	S/N/ 097	Sep. 28, 2020	Sep. 28, 2021

6. OPERATING FREQUENCY

6.1 Block Diagram Of Test Setup



6.2 Limit

Short Range Devices frequency ranges :433,040 MHz to 434,790 MHz

6.3 Test procedure

N/A

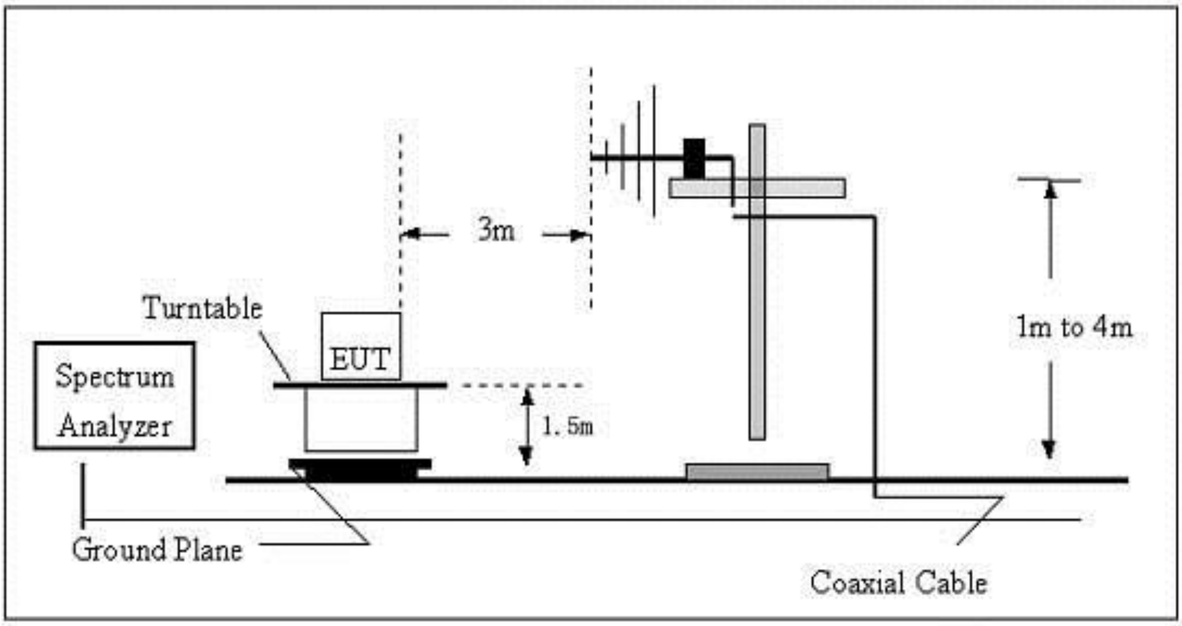
6.4 Test Result

Value	Notes
Operational Frequency band or bands	433.050-434.790 MHz
Nominal Operating Frequency or Frequencies	433.925 MHz
Operating Channel width(s) - OCW	134.47KHz
Note: Declared by the manufacturer	

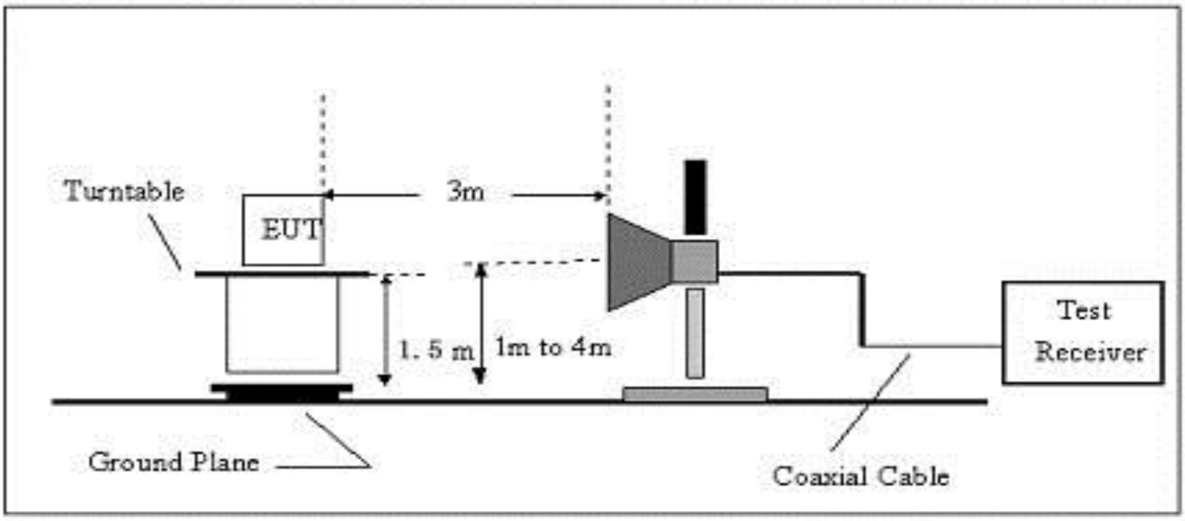
7. UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN

7.1 Block Diagram Of Test Setup

(A) Radiated Emission Test Set-Up, Frequency Below 1000MHz



(B) Radiated Emission Test Set-Up Frequency Above 1 GHz



7.2 Receiver Setup:

Operating Mode	Frequency Range	RBW $_{REF}$ (see note 2)	VBW	Detector mode
Transmit mode	9 kHz ≤ f < 150 kHz	1 kHz	3RBW	Peak
	150 kHz ≤ f < 30 MHz	10 kHz	3RBW	Peak
	30 MHz ≤ f < f_c - m	100 kHz	3RBW	Peak
	f_c - m ≤ f < f_c - n	10 kHz	3RBW	Peak
	f_c - n ≤ f < f_c - p	1 kHz	3RBW	Peak
	f_c + p < f ≤ f_c + n	1 kHz	3RBW	Peak
	f_c + n < f ≤ f_c + m	10 kHz	3RBW	Peak
	f_c + m < f ≤ 1 GHz	100 kHz	3RBW	Peak
	1 GHz < f ≤ 6 GHz	1 MHz	3RBW	Peak

NOTE 1: f is the measurement frequency.
f_c is the Operating Frequency.
m is 10 x OCW or 500 kHz, whichever is the greater.
n is 4 x OCW or 100 kHz, whichever is the greater.
p is 2,5 x OCW.
NOTE 2: If the value of RBW used for measurement is different from RBW $_{REF}$ use bandwidth correction from EN 300 220-1 V3.1.1 (2017-02) clause 4.3.10.1.

7.3 Limits

Frequency range	Maximum power, e.r.p. (≤ 1 GHz) e.i.r.p. (> 1 GHz)	RBW/VBW
30 MHz to 47 MHz	-36 dBm	100 kHz/300KHz
47 MHz to 74 MHz	-54 dBm	100 kHz/300KHz
74 MHz to 87,5 MHz	-36 dBm	100 kHz/300KHz
87,5 MHz to 118 MHz	-54 dBm	100 kHz/300KHz
118 MHz to 174 MHz	-36 dBm	100 kHz/300KHz
174 MHz to 230 MHz	-54 dBm	100 kHz/300KHz
230 MHz to 470 MHz	-36 dBm	100 kHz/300KHz
470 MHz to 862 MHz	-54 dBm	100 kHz/300KHz
862 MHz to 1 GHz	-36 dBm	100 kHz/300KHz
1 GHz to 12,75 GHz	-30 dBm	1 MHz/3MHz

7.5 Test Results

Below 1GHz

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
46.593	-54.67	-12.63	-67.31	-36.00	-31.31	peak	1.1	166	H
66.901	-54.65	-11.98	-66.64	-54.00	-12.64	peak	1.2	26	H
104.168	-55.59	-11.82	-67.40	-54.00	-13.40	peak	1.3	280	H
218.065	-53.41	-11.05	-64.47	-54.00	-10.47	peak	1.1	281	H
326.610	-52.79	-10.30	-63.09	-36.00	-27.09	peak	1.8	110	H
871.782	-51.90	-0.18	-52.08	-36.00	-16.08	peak	1.8	350	H
46.482	-55.20	-11.86	-67.06	-36.00	-31.06	peak	1.5	152	V
101.830	-55.12	-12.61	-67.73	-54.00	-13.73	peak	1.8	292	V
182.759	-55.65	-12.17	-67.82	-54.00	-13.82	peak	1.5	27	V
219.660	-53.03	-10.64	-63.68	-54.00	-9.68	peak	1.5	264	V
327.907	-52.69	-10.07	-62.76	-36.00	-26.76	peak	1.5	265	V
871.434	-52.03	0.03	-52.00	-36.00	-16.00	peak	1.4	282	V

Above 1GHz

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
1302.747	-54.88	-0.49	-55.38	-30.00	-25.38	peak	1.0	19	H
2168.700	-55.28	2.86	-52.42	-30.00	-22.42	peak	1.3	265	H
3636.000	-55.49	5.81	-49.68	-30.00	-19.68	peak	1.6	267	H
4761.964	-53.26	9.11	-44.15	-30.00	-14.15	peak	1.4	284	H
5972.102	-52.92	11.01	-41.90	-30.00	-11.90	peak	1.4	90	H
7248.469	-52.53	13.40	-39.13	-30.00	-9.13	peak	1.1	244	H
1301.104	-54.73	-0.51	-55.24	-30.00	-25.24	peak	1.6	22	V
1736.647	-54.89	-0.38	-55.28	-30.00	-25.28	peak	1.2	266	V
2170.143	-55.91	2.84	-53.07	-30.00	-23.07	peak	1.5	263	V
2900.794	-53.05	4.46	-48.59	-30.00	-18.59	peak	1.7	284	V
4258.238	-53.37	9.52	-43.85	-30.00	-13.85	peak	1.4	88	V
5941.897	-51.95	11.06	-40.89	-30.00	-10.89	peak	1.7	244	V

8. TX EFFECTIVE RADIATED POWER

7.4 Test Procedure

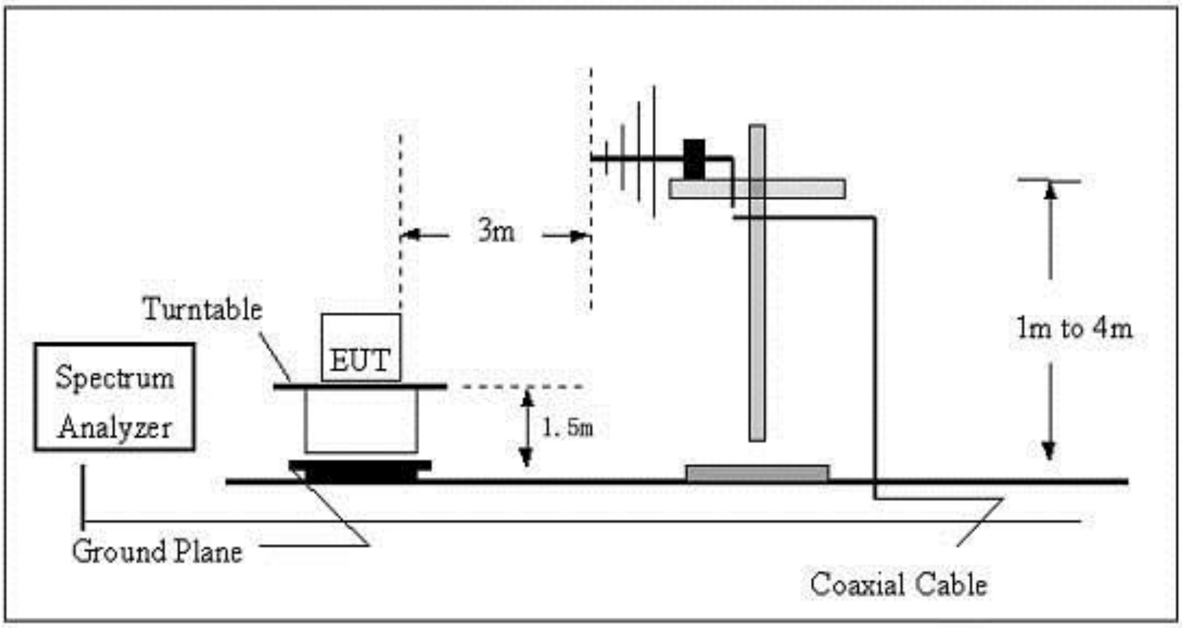
1. Scan from 25MHz to 6GHz, find the maximum radiation frequency to measure.
2. The technique used to find the Spurious Emissions of the transmitter was the antenna substitution method. Substitution method was performed to determine the actual ERP/EIRP emission levels of the EUT.

Test procedure as below:

1) The EUT was powered ON and placed on a 1.5m high table at a 3 meter fully Anechoic Chamber. The antenna of the transmitter was extended to its maximum length. modulation mode and the measuring receiver shall be tuned to the frequency of the transmitter under test.
2) The EUT was set 3 meters (above 18GHz the distance is 1 meter) away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
3) The disturbance of the transmitter was maximized on the test receiver display by raising and lowering from 1m to 4m the receive antenna and by rotating through 360° the turntable. After the fundamental emission was maximized, a field strength measurement was made.
4) Steps 1) to 3) were performed with the EUT and the receive antenna in both vertical and horizontal polarization.
5) The transmitter was then removed and replaced with another antenna. The center of the antenna was approximately at the same location as the center of the transmitter.
6) A signal at the disturbance was fed to the substitution antenna by means of a non-radiating cable. With both the substitution and the receive antennas horizontally polarized, the receive antenna was raised and lowered to obtain a maximum reading at the test receiver. The level of the signal generator was adjusted until the measured field strength level in step 3) is obtained for this set of conditions.
7) The output power into the substitution antenna was then measured.
8) Steps 6) and 7)were repeated with both antennas polarized.
9) Calculate power in dBm by the following formula:
   $ERP(dBm) = P_{SG}(dBm) – cable\ loss\ (dB) + antenna\ gain\ (dBd)$
   $EIRP(dBm) = P_{SG}(dBm) – cable\ loss\ (dB) + antenna\ gain\ (dBi)$
   $EIRP=ERP+2dB$
   where: Pg is the generator output power into the substitution antenna.
10) Test the EUT in the lowest channel ,middle channel, the Highest channel
    Repeat above procedures until all frequencies measured was complete..

8.1 Block Diagram Of Test Setup

(A) Radiated Emission Test Set-Up, Frequency Below 1000MHz



8.2 Limits

Frequency(MHz)	Limit(ERP,mW)
433.92	10
868.40	25

8.3 Test Procedure

1) The EUT was powered ON and placed on a 1.5m high table at a 3 meter fully Anechoic Chamber. The antenna of the transmitter was extended to its maximum length. Modulation mode and the measuring receiver shall be tuned to the frequency of the transmitter under test.
2) The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
3) The disturbance of the transmitter was maximized on the test receiver display by raising and lowering from 1m to 4m the receive antenna and by rotating through 360° the turntable. After the fundamental emission was maximized, a field strength measurement was made.
4) Steps 1) to 3) were performed with the EUT and the receive antenna in both vertical and horizontal polarization.
5) The transmitter was then removed and replaced with another antenna. The center of the antenna was approximately at the same location as the center of the transmitter.
6) A signal at the disturbance was fed to the substitution antenna by means of a non-radiating cable. With both the substitution and the receive antennas horizontally polarized, the receive antenna was raised and lowered to obtain a maximum reading at the test receiver. The level of the signal generator was adjusted until the measured field strength level in step 3) is obtained for this set of conditions.
7) The output power into the substitution antenna was then measured.
8) Steps 6) and 7) were repeated with both antennas polarized.
9) Calculate power in dBm by the following formula:

   ERP(dBm) = P_{SG} (dBm) – cable loss (dB) + antenna gain (dBd)

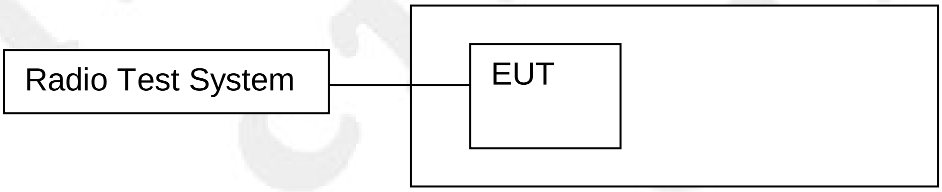
   Where: P_{SG} is the generator output power into the substitution antenna.
10) Test the EUT in the lowest channel ,middle channel, the Highest channel
11) Repeat above procedures until all frequencies measured was complete.

8.4 Test Results

Measurement Conditions		Operation Frequency (MHz)	ERP (dBm)	Limit (dBm)	Result
Temperature	**Voltage**				
Normal	Normal	433.925	4.526	10	PASS
High	High	433.925	4.521	10	PASS
	Low	433.925	4.481	10	PASS
Low	High	433.925	4.482	10	PASS
	Low	433.925	4.522	10	PASS

9. TX DUTY CYCLE

9.1 Block Diagram Of Test Setup



9.2 Limit

Limit: 10%

9.3 Test procedure

Duty cycle is the ratio expressed as a percentage, of the cumulative duration of transmissions Ton_cum within an observation interval $T_{obs.}$ DC=(T_{on_cum}/T_{obs})F_{obs}.

on an observation bandwidth Fobs.

Unless otherwise specified, T_{obs} is 1 hour and the observation bandwidth F_{obs} is the operational frequency band.

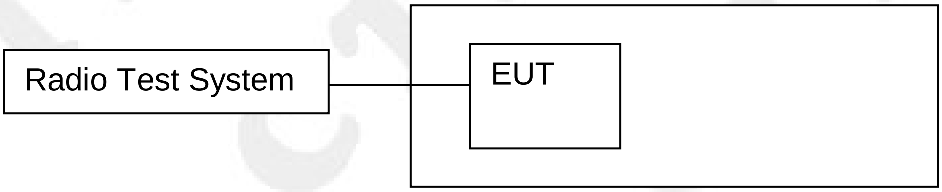
Each transmission consists of an RF emission, or sequence of RF emissions separated by intervals < T_{Dis}.

9.4 Test Result

The duty cycle was not exceeded 10% in a period of 1 hour, which was declared by the manufacturer

10. TX OCCUPIED BANDWIDTH

10.1 Block Diagram Of Test Setup



10.2 Limit

The Operating Channel shall be declared and shall reside entirely within the Operational Frequency Band.
The Maximum Occupied Bandwidth at 99 % shall reside entirely within the Operating Channel defined by F_{low} and F_{high}.

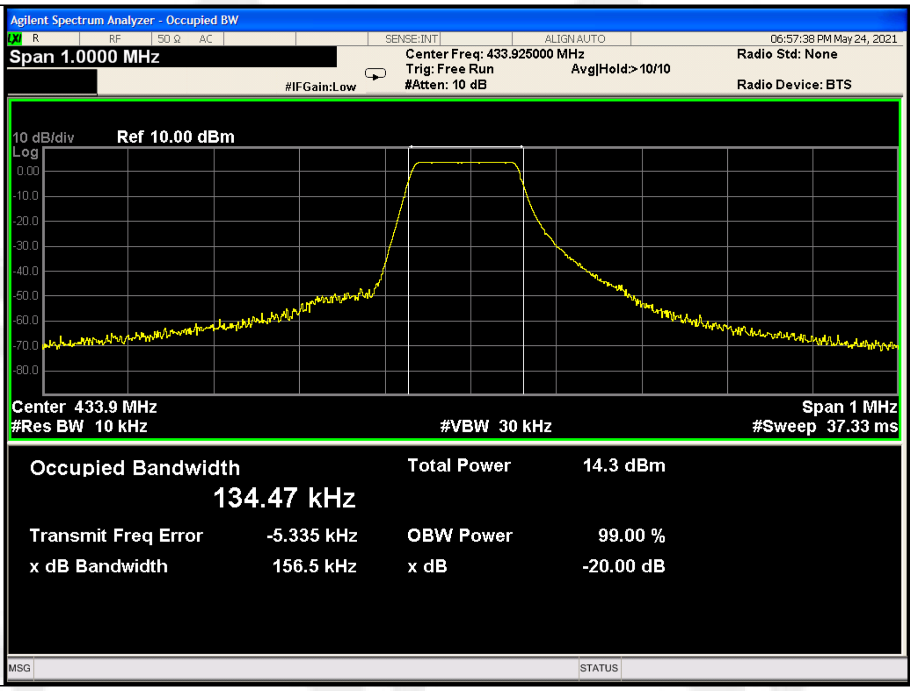
10.3 Test procedure

Setting	Value	Notes
Centre frequency	The nominal Operating Frequency	The highest or lowest Operating Frequency as declared by the manufacturer
RBW	1 % to 3 % of OCW without being below 100 Hz	
VBW	3 x RBW	Nearest available analyser setting to 3 x RBW
Span	At least 2 x Operating Channel width	Span should be large enough to include all major components of the signal and its side bands
Detector Mode	RMS	
Trace	Max hold	

Step 1:
Operation of the EUT shall be started, on the highest operating frequency as declared by the manufacturer, with the appropriate test signal.
The signal attenuation shall be adjusted to ensure that the signal power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals on either side of the power envelope being included in the measurement.
Step 2:
When the trace is completed the peak value of the trace shall be located and the analyser marker placed on this peak.
Step 3:
The 99 % occupied bandwidth function of the spectrum analyser shall be used to measure the occupied bandwidth of the signal.

10.4 Test Result

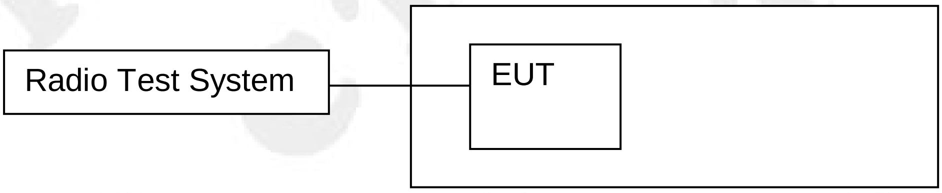
Measurement Conditions		Operation Frequency (MHz)	OBW (KHz)	Result
Temperature	**Voltage**			
Normal	Normal	433.925	134.47	PASS
High	High	433.925	134.40	PASS
	Low	433.925	133.49	PASS
Low	High	433.925	133.50	PASS
	Low	433.925	133.51	PASS

Normal Temperature& Normal Voltage		

Remark: This Report only show the test plots of the worst case.

11. TX OUT OF BAND EMISSIONS

11.1 Block Diagram Of Test Setup



11.2 Limit

Domain	Frequency Range	RBW_{REF}	Max power limit
OOB limits applicable to Operational Frequency Band (See Figure 6)	$f \le f_{low\_OFB}$ - 400 kHz	10 kHz	-36 dBm
	F_{low_OFB} - 400 kHz $\le f \le f_{low\_OFB}$ - 200 kHz	1 kHz	-36 dBm
	f_{low} - 200 kHz $\le f < f_{low\_OFB}$	1 kHz	See Figure 6
	$f = f_{low\_OFB}$	1 kHz	0 dBm
	$f = f_{high\_OFB}$	1 kHz	0 dBm
	$F_{high\_OFB} < f \le f_{high\_OFB}$ + 200 kHz	1 kHz	See Figure 6
	F_{high_OFB} + 200 kHz $\le f \le f_{high\_OFB}$ + 400 kHz	1 kHz	-36 dBm
	F_{high_OFB} + 400 kHz $\le f$	10 kHz	-36 dBm
OOB limits applicable to Operating Channel (See Figure 5)	$f = f_c$- 2.5 x OCW	1 kHz	-36 dBm
	f_c - 2,5 x OCW $\le f \le f_c$ - 0,5 x OCW	1 kHz	See Figure 5
	$f = f_c$ - 0,5 x OCW	1 kHz	0 dBm
	$f = f_c$ + 0,5 x OCW	1 kHz	0 dBm
	f_c + 0,5 x OCW $\le f \le f_c$ + 2,5 x OCW	1 kHz	See Figure 5
	$f = f_c$+ 2,5 x OCW	1 kHz	-36 dBm

NOTE: f is the measurement frequency.
f_c is the Operating Frequency.
F_{low_OFB} is the lower edge of the Operational Frequency Band.
F_{high_OFB} is the upper edge of the Operational Frequency Band.
OCW is the operating channel bandwidth.

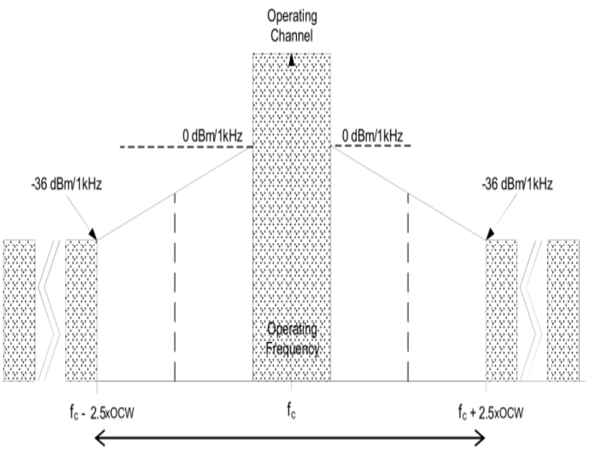


Figure 5: Out Of Band Domain for Operating Channel with reference BW

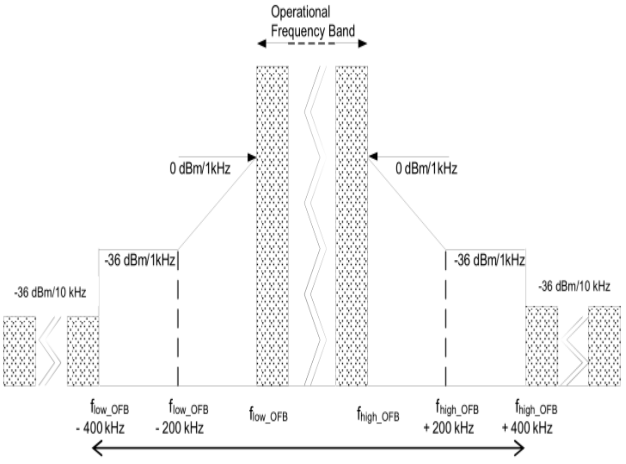


Figure 6: Out Of Band Domain for Operational Frequency Band with reference BW

11.3 Test procedure

Spectrum Analyser Setting	Value	Notes
Centre frequency	Operating Frequency	
Span	6 x Operating Channel width	
RBW	1 kHz (see note)	Resolution bandwidth for Out Of Band domain measurements
Detector Function	RMS	
Trace Mode	Linear AVG	Applies only for EUT generating D-M2 test signal. An appropriate number of samples should be averaged to give a stable reading
	Max Hold	Applies only for EUT generating D-M2a or D-M3 test signal.
NOTE: If the value of RBW used is different from RBW_{REF} in clause 5.8.2, use the bandwidth correction in clause 4.3.10.1.		

Step 1:
Operation of the EUT shall be started, on the highest operating frequency as declared by the manufacturer, with the appropriate test signal.
The signal shape is recorded when stable and shall be below the spectrum mask Out Of Band for operating channel.
Step 2:
The test equipment shall be reconfigured as appropriate for the parameter shown below.

Spectrum Analyser Setting	Value	Notes
Centre frequency	fc_{low}	The lowest Operating Frequency in the band
Span	$2 \times (500 \text{ kHz} + fc_{low} - f_{low\_OFB})$	Ensures that the left most mask specification remains within the span
NOTE: f_{low_OFB} is the lower edge of the Operational Frequency Band.		

Operation of the EUT is restarted, with the appropriate test signal, on the lowest operating frequency as declared by the manufacturer.
If the equipment is using only one operating Frequency in the operational Frequency Band, measurement shall be performed the nominal operating frequency.
The signal shape is recorded when stable; and shall be below the spectrum mask for operating channel and the spectrum mask for operational frequency band.

Step 3:
The test equipment shall be reconfigured as appropriate for the parameter shown below.

Spectrum Analyser Setting	Value	Notes
Centre frequency	fc_{high}	the highest Operating Frequency in the band
Span	$2 \times (500 \text{ kHz} + f_{high\_OFB} - fc_{high})$	Ensures that the rightmost mask specification remains within the span
NOTE: f_{high_OFB} is the higher edge of the operational frequency Band.		

Operation of the EUT is restarted, with the appropriate test signal, on the highest Operating Frequency as declared by the manufacturer.
If the equipment is using only one Operating Frequency in the Operational Frequency Band,

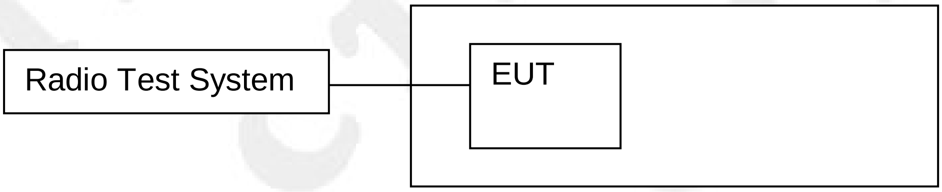
measurement shall be performed at the nominal Operating Frequency
The signal shape is recorded when stable and shall be below the spectrum mask for Out Of Band emissions for operating channel and for operational Frequency Band.
Step 4:
For frequency agile devices, the measurement shall be repeated in each Operational Frequency Band.
Step 5:
Where required (see clause 5.8.3.1 condition 1), the measurements in step 1 to step 5 shall be repeated under extreme test conditions.

11.4 Test Result

Frequency Range	Test Result (dBm)	Max power limit (dBm)
f ≤ flow_OFB - 400 kHz	-45.43	-36
Flow_OFB - 400 kHz ≤ f ≤ flow_OFB - 200 kHz	-41.51	-36
flow - 200 kHz ≤ f < flow_OFB	-26.95	See Figure 6
f = flow_OFB	-5.82	0
f = fhigh_OFB	-6.93	0
Fhigh_OFB < f ≤ fhigh_OFB + 200 kHz	-21.95	See Figure 6
Fhigh_OFB + 200 kHz ≤ f ≤ fhigh_OFB + 400 kHz	-40.53	-36
Fhigh_OFB + 400 kHz ≤ f	-42.69	-36
Remark: The limits decrease linearly with the logarithm .		

12. TX TRANSIENT

12.1 Block Diagram Of Test Setup



12.2 Limit

Absolute offset from centre frequency	RBW_{REF}	Peak power limit applicable at measurement points
≤ 400 kHz	1 kHz	0 dBm
> 400 kHz	1 kHz	-27 dBm

12.3 Test procedure

The output of the EUT shall be connected to a spectrum analyser or equivalent measuring equipment.

The measurement shall be undertaken in zero span mode. The analyser's centre frequency shall be set to an offset from the operating centre frequency. These offset values and their corresponding RBW configurations are listed below.

Table 24: RBW for Transient Measurement

Measurement points: offset from centre frequency	Analyser RBW	RBW_{REF}
-0,5 x OCW - 3 kHz 0,5 x OCW + 3 kHz Not applicable for OCW < 25 kHz	1 kHz	1kHz
±12,5 kHz or ±OCW whichever is the greater	Max (RBW pattern 1, 3, 10 kHz) ≤ Offset frequency/6 (see note)	1 kHz
-0,5 x OCW - 400 kHz 0,5 x OCW + 400 kHz	100 kHz	1 kHz
-0,5 x OCW -1 200 kHz 0,5 x OCW + 1 200 kHz	300 kHz	1 kHz
NOTE: Max (RBW pattern 1, 3, 10 kHz) means the maximum bandwidth that falls into the commonly implemented 1, 3, 10 kHz RBW filter bandwidth incremental pattern of spectrum analysers. EXAMPLE: If OCW is 25 kHz then the RBW value corresponding to one OCW offset frequency is 3 kHz. The rest of the analyser settings are listed in Table 25, and if OCW is 250 kHz then the RBW value corresponding to one OCW offset frequency is 30 kHz.		

Table 25: Parameters for Transient Measurement

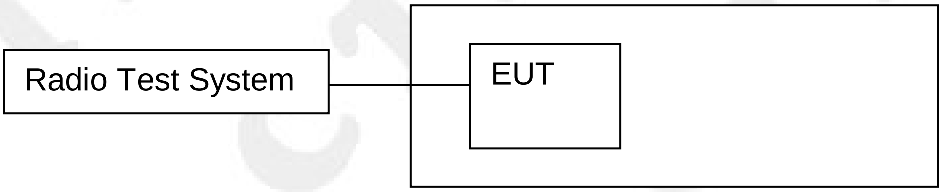
Spectrum Analyser Setting	Value	Notes
VBW/RBW	10	At higher RBW values VBW may be clipped to its maximum value
Sweep time	500 ms	
RBW filter	Gaussian	
Trace Detector Function	RMS	
Trace Mode	Max hold	
Sweep points	501	
Measurement mode	Continuous sweep	
NOTE: The ratio between the number of sweep points and the sweep time shall be the same ratio as above if different number of sweep points is used.		

12.4 Test Result

Absolute offset from centre frequency	**Peak power limit applicable at measurement points**	**Test Value**	**Test results**
≤ 400 kHz	0 dBm	-16.39dBm	Pass
> 400 kHz	-27 dBm	-36.35dBm	Pass

13. TX BEHAVIOUR UNDER LOW VOLTAGE CONDITIONS

13.1 Block Diagram Of Test Setup



13.2 Limit

The equipment shall either:
a) remain in the Operating Channel OC without exceeding any applicable limits (e.g. Duty Cycle); or
b) reduce its effective radiated power below the Spurious Emission limits without exceeding any applicable limits (e.g. Duty Cycle); or
c) shut down, (ceasing function);
as the voltage falls below the manufacturers declared operating voltage.

13.3 Test procedure

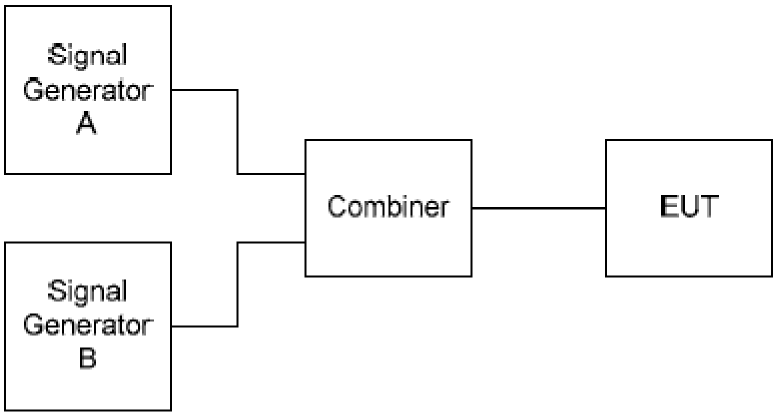
Step 1:
Operation of the EUT shall be started, on Operating Frequency as declared by the manufacturer, with the appropriate test signal and with the EUT operating at nominal operating voltage.
The centre frequency of the transmitted signal shall be measured and noted.
Step 2:
The operating voltage shall be reduced by appropriate steps until the voltage reaches zero.
The centre frequency of the transmitted signal shall be measured and noted.
Any abnormal behaviour shall be noted.

13.4 Test Result

Test Voltage	Test result
DC 3.3V	ok
DC 3V	ok
DC 2.7V	ok
DC 2.4V	Not ok

14. RX BLOCKING

14.1 Block Diagram Of Test Setup



14.2 Limit

RX category 3

Requirement	Limits
	Receiver category 3
Blocking at ±2 MHz from OC edge f_{high} and f_{low}	≥ -80 dBm
Blocking at ±10 MHz from OC edge f_{high} and f_{low}	≥ -60 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -60 dBm

RX category 2

Requirement	Limits
	Receiver category 2
Blocking at ±2 MHz from OC edge f_{high} and f_{low}	≥ -69 dBm
Blocking at ±10 MHz from OC edge f_{high} and f_{low}	≥ -44 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -44 dBm

RX category 1.5

Requirement	Limits
	Receiver category 1.5
Blocking at ±2 MHz from OC edge f_{high} and f_{low}	≥ -43 dBm
Blocking at ±10 MHz from OC edge f_{high} and f_{low}	≥ -33 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -33 dBm

RX category 1

Requirement	Limits
	Receiver category 1
Blocking at ±2 MHz from Centre Frequency	≥ -20 dBm
Blocking at ±10 MHz from Centre Frequency	≥ -20 dBm
Blocking at ±5 % of Centre Frequency or 15 MHz, whichever is the greater	≥ -20 dBm

14.3 Test procedure

Signal generator A shall be set to an appropriate modulated test signal at the operating frequency of the EUT receiver.

Signal generator B shall be unmodulated.

Measurements shall be carried out at frequencies of the unwanted signal at approximately the frequency(ies) offset(s) defined in technical requirement avoiding those frequencies at which spurious responses occur. Additional

measurement points may be requested by technical requirements clause.

If several operational frequency bands are used by the equipment, at least one blocking measurement by bands has to be performed.

Step 1:

Signal generator B shall be powered off. Signal generator A shall be set to the minimum level which gives the wanted performance criterion of EUT or the reference level in Table 32, whichever is the higher The output level of generator A shall then be increased by 3 dB unless otherwise specified in technical requirement.

Step 2:

Signal generator B is powered on and set to operate at the nominal operating frequency - offset frequency.

Signal generator B is then switched on and the signal amplitude is adjusted to the minimum level at which the wanted performance criterion is not achieved.

With signal generator B settings unchanged, the receiver shall be replaced with a suitable RF power measuring equipment. The power into the measuring equipment shall be measured and noted.

The blocking level is then the conducted power received from generator B at the EUT antenna connector.

This can either be measured on the antenna connector for conducted test or be calculated for radiated test (see clause C.5.4).

The blocking level shall be higher or equal to the blocking power level requested in the technical requirement clause.

Step 3:

The measurement in steps 1 to 3 shall be repeated with signal offsets at required frequencies.

Step 4:

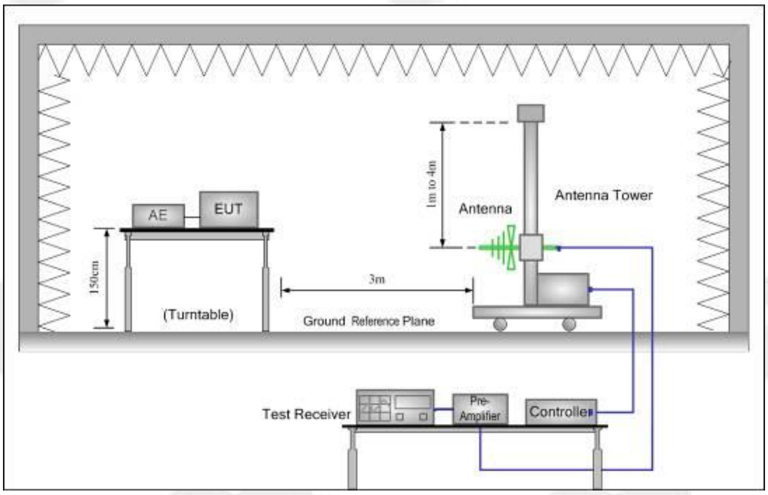
The information shown in below Table shall be recorded in the test report for each measured signal level and unwanted signal offset.

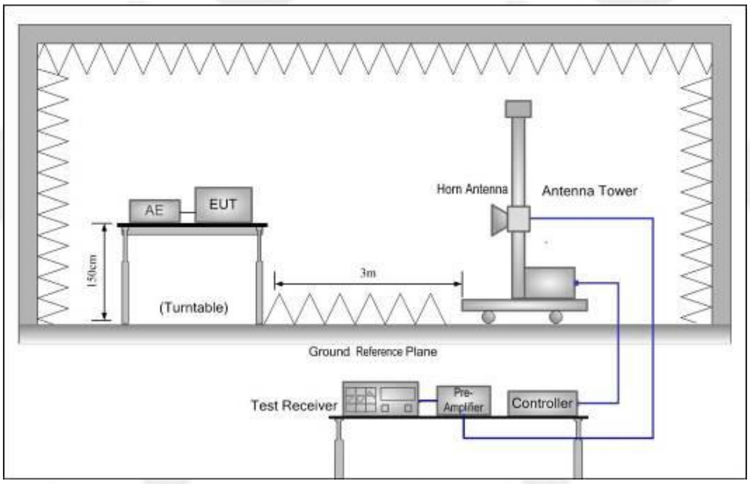
Value	Notes
Operating Frequency	Nominal centre frequency of the receiver
Signal generator A	Power level of signal generator A
Blocking level	Power level of signal generator B

14.4 Test Result

Requirement (MHz)	Result (dBm)	Limit Receiver category 2 (dBm)
Blocking at -2 MHz from OC edge f_{low}	-53.50	⩾ -69
Blocking at +2 MHz from OC edge f_{high}	-55.70	⩾ -69
Blocking at -10 MHz from OC edge f_{low}	-36.95	⩾ -44
Blocking at +10 MHz from OC edge f_{high}	-36.84	⩾ -44
Blocking at -5 % of Centre Frequency edge f_{low}	-33.53	⩾ -44
Blocking at +5 % of Centre Frequency edge f_{high}	-34.32	⩾ -44

15. SPURIOUS EMISSIONS

<table>
<tr><td>Receiver setup:</td><td>RBW=120kHz, VBW=300kHz, Detector= peak</td></tr>
<tr><td>Limit:</td><td>
<table>
<tr><th>Frequency</th><th>Limit(operation)</th><th>Limit(standby)</th></tr>
<tr><td>47 MHz to 74 MHz
87.5 MHz to 118 MHz
174 MHz to 230 MHz
470 MHz to 862 MHz</td><td>4nW(-54dBm)</td><td>2nW(-57dBm)</td></tr>
<tr><td>Other frequencies below 1000 MHz</td><td>250nW(-36dBm)</td><td>2nW(-57dBm)</td></tr>
<tr><td>Above 1000 MHz</td><td>1uW(-30dBm)</td><td>20nW(-47dBm)</td></tr>
</table>
</td></tr>
<tr><td>Test Frequency range:</td><td>25MHz to 4GHz</td></tr>
<tr><td>Test setup:</td><td>Below 1GHz


Above 1GHz

</td></tr>
<tr><td>Test procedure:</td><td>Substitution method was performed to determine the actual ERP emission levels of the EUT.</td></tr>
</table>

	The following test procedure as below: 1>.Below 1GHz test procedure: 1. On the test site as test setup graph above,the EUT shall be placed at the 1.5m support on the turntable and in the position closest to normal use as declared by the provider. 2. The test antenna shall be oriented initially for vertical polarization and shall be chosen to correspond to the frequency of the transmitter.The output of the test antenna shall be connected to the measuring receiver. 3. The transmitter shall be switched on, if possible, without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test. 4. The test antenna shall be raised and lowered from 1m to 4m until a maximum signal level is detected by the measuring receiver. Then the turntable should be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver. 5. Repeat step 4 for test frequency with the test antenna polarized horizontally. 6. Remove the transmitter and replace it with a substitution antenna (the antenna should be half-wavelength for each frequency involved). The center of the substitution antenna should be approximately at the same location as the center of the transmitter. At the lower frequencies, where the substitution antenna is very long, this will be impossible to achieve when the antenna is polarized vertically. In such case the lower end of the antenna should be 0.3 m above the ground. 7. Feed the substitution antenna at the transmitter end with a signal generator connected to the antenna by means of a nonradiating cable. With the antennas at both ends vertically polarized, and with the signal generator tuned to a particular test frequency, raise and lower the test antenna to obtain a maximum reading at the spectrum analyzer. Adjust the level of the signal generator output until the previously recorded maximum reading for this set of conditions is obtained. This should be done carefully repeating the adjustment of the test antenna and generator output. 8. Repeat step 7 with both antennas horizontally polarized for each test frequency. 9. Calculate power in dBm into a reference ideal half-wave dipole antenna by reducing the readings obtained in steps 7 and 8 by the power loss in the cable between the generator and the antenna, and further corrected for the gain of the substitution antenna used relative to an ideal half-wave dipole antenna by the following formula: ERP(dBm) = Pg(dBm) – cable loss (dB) + antenna gain

	(dBd) where: Pg is the generator output power into the substitution antenna. 10. Above 1GHz test procedure: Different between above is the test site, change from Semi-Anechoic Chamber to fully Anechoic Chamber, and the test antenna do not need to raise from 1 to 4m, just test in 1.5m height.
Measurement Record:	Uncertainty: ± 4.5dB
Test Instruments:	Refer to section 2.3 for details
Test mode:	Refer to section 2.2 for details
Test results:	Passed

Measurement Data

Tx in operation mode				
Frequency (MHz)	Spurious Emission		Limit (dBm)	Test Result
	polarization	Level(dBm)		
51.45	Vertical	-70.74	-54.00	Pass
129.70	V	-72.89	-36.00	
189.79	V	-74.90	-54.00	
388.84	V	-76.29	-36.00	
510.58	V	-74.36	-54.00	
677.99	V	-56.77	-54.00	
956.89	V	-52.27	-36.00	
1740.37	V	-40.79	-30.00	
2423.45	V	-43.95	-30.00	
3294.19	V	-42.77	-30.00	
134.11	Horizontal	-70.42	-36.00	
216.11	H	-71.18	-54.00	
360.69	H	-72.63	-36.00	
486.25	H	-73.34	-54.00	
691.75	H	-72.57	-54.00	
871.03	H	-47.98	-36.00	
1739.84	H	-43.67	-30.00	
2426.77	H	-42.37	-30.00	
3293.08	H	-46.28	-30.00	
Tx in standby Mode				
N/A: Not applicable, since the spurious emission of the EUT is too weak to be detected.(≤-80dBm)				

Remark:

Rx in operation mode				
Frequency (MHz)	Spurious Emission		Limit (dBm)	Test Result
	polarization	Level(dBm)		
50.48	Vertical	-69.42	-57.00	Pass
130.06	V	-69.85	-57.00	
189.91	V	-70.97	-57.00	
391.25	V	-68.77	-57.00	
509.13	V	-69.58	-57.00	
678.71	V	-68.76	-57.00	
954.77	V	-68.08	-57.00	
1738.74	V	-66.60	-47.00	
2425.40	V	-67.27	-47.00	
3294.62	V	-67.06	-47.00	
132.95	Horizontal	-69.51	-57.00	
215.83	H	-69.36	-57.00	
358.46	H	-68.84	-57.00	
485.89	H	-68.61	-57.00	
693.10	H	-68.25	-57.00	
868.47	H	-68.51	-57.00	
1738.55	H	-67.49	-47.00	
2426.26	H	-68.03	-47.00	
3292.90	H	-67.84	-47.00	
Rx in standby Mode				
N/A: Not applicable, since the spurious emission of the EUT is too weak to be detected.(≤-80dBm)				

16. EUT PHOTOGRAPHS

Refer to Report No. CTB210527019REX- for EUT external and internal photos.

17. EUT TEST SETUP PHOTOGRAPHS

Spurious emissions

※※※※※ END OF REPORT ※※※※※