TEST REPORT

Product Name:	Wi-Fi & BT Module
Trademark:	B&T 博安通 / Ai 安信可科技 Ai-Thinker
Model Number:	Ai-WB3-12F, Ai-WB3-01C, Ai-WB3-07S, Ai-WB3-32S, Ai-WB3-01M, Ai-WB3-13, Ai-WB3-13U, Ai-WB3-12S, Ai-WB3-M1, Ai-WB3-M1-I, Ai-WB3-01S, Ai-WB3-05W, Ai-WB3-01N, Ai-WB3-01F
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:	1&2/F., Building A, No.26, Xinhe Road, Xinqiao, Xinqiao Street, Bao'an District, Shenzhen, Guangdong, China
Sample Received Date:	May. 08, 2023
Sample tested Date:	May. 08, 2023 to May. 25, 2023
Issue Date:	May. 25, 2023
Report No.:	CTB230518006RFX
Test Standards	ETSI EN 300 328 V2.2.2 (2019-07)
Test Results	PASS
Remark:	This is Bluetooth BLE radio test report.

Compiled by:	Reviewed by:	Approved by:
Chen Zheng	Arron Liu	Bin Mei / Director

Note: If there is any objection to the inspection results in this report, please submit a written report to the company within 15 days from the date of receiving the report. The test report is effective only with both signature and specialized stamp. This result(s) shown in this report refer only to the sample(s) tested. Without written approval of Shenzhen CTB Testing Technology Co., Ltd. this report can't be reproduced except in full. The tested sample(s) and the sample information are provided by the client. "*" indicates the testing items were fulfilled by subcontracted lab. "#" indicates the items are not in CNAS accreditation scope.

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(Note: N/A means not applicable)

1. VERSION

Report No.	Issue Date	Description	Approved
CTB230518006RFX	May. 25, 2023	Original	Valid

2. TEST SUMMARY

The Product has been tested according to the following specifications:

Standard	ETSI EN 300 328 V2.2.2		
Test Item	**Test Requirement**	**Test Method**	**Results**
Transmitter Parameters			
RF Output Power	Clause 4.3.2.2	Clause 5.4.2	PASS
Power Spectral Density	Clause 4.3.2.3	Clause 5.4.3	PASS
Duty cycle, Tx-Sequence, Tx-gap	Clause 4.3.2.4	Clause 5.4.4	N/A[1]
Medium Utilization (MU) factor	Clause 4.3.2.5	Clause 5.4.5	N/A[2]
Adaptivity (adaptive equipment using modulations other than FHSS)	Clause 4.3.2.6	Clause 5.4.6	N/A[3]
Occupied Channel Bandwidth	Clause 4.3.2.7	Clause 5.4.7	PASS
Transmitter unwanted emissions in the out-of-band domain	Clause 4.3.2.8	Clause 5.4.8	PASS
Transmitter unwanted emissions in the spurious domain	Clause 4.3.2.9	Clause 5.4.9	PASS
Receiver Parameters			
Receiver spurious emissions	Clause 4.3.2.10	Clause 5.4.10	PASS
Receiver Blocking	Clause 4.3.2.11	Clause 5.4.11	PASS
Geo-location capability	Clause 4.3.2.12	Clause 5.4.12	N/A[4]

Remark:

N/A[1]: Because these requirements apply to non-adaptive frequency hopping equipment mode and RF output power of greater than or equal to 10 dBm.

N/A[2]: Because these requirements apply to non-adaptive frequency hopping equipment mode and RF output power of greater than or equal to 10 dBm.

N/A[3]: Because these requirements apply to adaptive equipment mode and RF output power of greater than or equal to 10 dBm.

N/A[4]: Only for equipment with geo-location capability

Tx: In this whole report Tx (or tx) means Transmitter.

Rx: In this whole report Rx (or rx) means Receiver.

RF: In this whole report RF means Radiated Frequency.

CH:In this whole report CH means channel.

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):	Ai-WB3-12F, Ai-WB3-01C, Ai-WB3-07S, Ai-WB3-32S, Ai-WB3-01M, Ai-WB3-13, Ai-WB3-13U, Ai-WB3-12S, Ai-WB3-M1, Ai-WB3-M1-I, Ai-WB3-01S, Ai-WB3-05W, Ai-WB3-01N, Ai-WB3-01F
Model Description:	All the model are the same circuit and RF module, only for model name. Test sample model: Ai-WB3-12F
Bluetooth Version:	Bluetooth V5.1
Hardware Version:	V1.1
Software Version:	V1.0
Operation Frequency:	Bluetooth: 2402-2480MHz
Max. RF output power:	Bluetooth: 9.76dBm
Type of Modulation:	Bluetooth: GFSK
Antenna installation:	Bluetooth: PCB antenna
Antenna Gain:	Bluetooth: 1.42dBi
Ratings:	DC 3.3V powering 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
1	Laptop	DELL	Vostro 5490	N/A	N/A

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

CH No.	Frequency (MHz)	CH No.	Frequency (MHz)	CH No.	Frequency (MHz)	CH No.	Frequency (MHz)
0	2402	1	2404	2	2406	3	2408
4	2410	5	2412	6	2414	7	2416
8	2418	9	2420	10	2422	11	2424
12	2426	13	2428	14	2430	15	2432
16	2434	17	2436	18	2438	19	2440
20	2442	21	2444	22	2446	23	2448
24	2450	25	2452	26	2454	27	2456
28	2458	29	2460	30	2462	31	2464
32	2466	33	2468	34	2470	35	2472
36	2474	37	2476	38	2478	39	2480

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(GFSK)	2402MHz	2440MHz	2480MHz
Receiving(GFSK)	2402MHz	2440MHz	2480MHz

4.6 Test Environment

Humidity(%):	54
Atmospheric Pressure(kPa):	101
Normal Voltage(DC)(V):	3.3
Normal Temperature(℃) :	23
Low Temperature(℃) :	0
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 1&2F., Building A, No. 26, Xinhe Road, Xinqiao, Xinqiao Street, Bao'an District, Shenzhen, Guangdong, 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

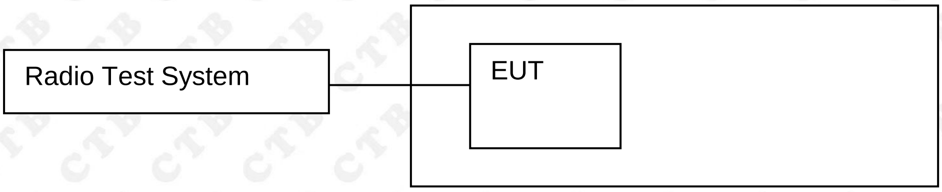
RF conduction and RadiationTest equipment

Item	Equipment	Manufacturer	Type No.	Serial No.	Calibrated until
1	Spectrum Analyzer	Agilent	N9020A	MY52090073	2023.07.19
2	Power Sensor	Agilent	U2021XA	MY56120032	2023.07.19
3	Power Sensor	Agilent	U2021XA	MY56120034	2023.07.19
4	Communication test set	R&S	CMW500	108058	2023.07.19
5	Spectrum Analyzer	KEYSIGHT	N9020A	MY51289897	2023.07.19
6	Signal Generator	Agilent	N5181A	MY50140365	2023.07.19
7	Vector signal generator	Agilent	N5182A	MY47420195	2023.07.19
8	Communication test set	Agilent	E5515C	MY50102567	2023.07.19
9	2.4 GHz Filter	Shenxiang	MSF2400-2483.5MS-1154	20181015001	2023.07.19
10	5 GHz Filter	Shenxiang	MSF5150-5850MS-1155	20181015001	2023.07.19
11	Filter	Xingbo	XBLBQ-DZA120	190821-1-1	2023.07.19
12	BT&WI-FI Automatic test software	Micowave	MTS8000	Ver. 2.0.0.0	/
13	Rohde & Schwarz SFU Broadcast Test System	R&S	SFU	101017	2023.10.30
14	Temperature humidity chamber	Hongjing	TH-80CH	DG-15174	2023.07.19
15	234G Automatic test software	Micowave	MTS8200	Ver. 2.0.0.0	/
16	966 chamber	C.R.T.	966	/	2024.08.11
17	Receiver	R&S	ESPI	100362	2023.07.19
18	Amplifier	HP	8447E	2945A02747	2023.07.19
19	Amplifier	Agilent	8449B	3008A01838	2023.07.19
20	TRILOG Broadband Antenna	Schwarzbeck	VULB 9168	00869	2023.07.22

21	Double Ridged Broadband Horn Antenna	Schwarzbeck	BBHA9120D	01911	2023.07.22
22	EMI test software	Fala	EZ-EMC	FA-03A2 RE	/
23	Loop Antenna	Schwarzbeck	FMZB 1519B	1519B-224	2023.07.23
24	loop antenna	ZHINAN	ZN30900A	GTS534	/
25	40G Horn antenna	A/H/System	SAS-574	588	2024.10.30
26	Amplifier	AEROFLEX	Aeroflex	097	2024.10.30

6. RF OUTPUT POWER

6.1 Block Diagram Of Test Setup



6.2 Limit

For adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be 20 dBm.

The maximum RF output power for non-adaptive equipment shall be declared by the supplier and shall not exceed 20 dBm. See clause 5.3.1 m). For non-adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be equal to or less than the value declared by the supplier.

This limit shall apply for any combination of power level and intended antenna assembly.

Limit
20dBm

6.3 Test procedure

Step 1:

• Use a fast power sensor suitable for 2.4 GHz and capable of minimum 1 MS/s.
• Use the following settings:
- Sample speed 1 MS/s or faster.
- The samples shall represent the RMS power of the signal.
- Measurement duration: For non-adaptive equipment: equal to the observation period defined in clause 4.3.1.3.2 or clause 4.3.2.4.2. For adaptive equipment, the measurement duration shall be long enough to ensure a minimum number of bursts (at least 10) are captured.

NOTE 1: For adaptive equipment, to increase the measurement accuracy, a higher number of bursts may be used.

Step 2:

• For conducted measurements on devices with one transmit chain:
- Connect the power sensor to the transmit port, sample the transmit signal and store the raw data. Use these stored samples in all following steps.

• For conducted measurements on devices with multiple transmit chains:
- Connect one power sensor to each transmit port for a synchronous measurement on all transmit ports.
- Trigger the power sensors so that they start sampling at the same time. Make sure the time difference between the samples of all sensors is less than 500 ns.
- For each individual sampling point (time domain), sum the coincident power samples of all ports and store them. Use these summed samples in all following steps.

Step 3:

• Find the start and stop times of each burst in the stored measurement samples.
The start and stop times are defined as the points where the power is at least 30 dB below the highest value of the stored samples in step 2.
NOTE 2: In case of insufficient dynamic range, the value of 30 dB may need to be reduced appropriately.

Step 4:

• Between the start and stop times of each individual burst calculate the RMS power over the burst using the formula below. Save these Pburst values, as well as the start and stop times for each burst.

$$P_{burst} = \frac{1}{k}\sum_{n=1}^{k} P_{sample}(n)$$

with 'k' being the total number of samples and 'n' the actual sample number

Step 5:

• The highest of all Pburst values (value "A" in dBm) will be used for maximum e.i.r.p. calculations.

Step 6:

• Add the (stated) antenna assembly gain "G" in dBi of the individual antenna.

• If applicable, add the additional beamforming gain "Y" in dB.

• If more than one antenna assembly is intended for this power setting, the maximum overall antenna gain (G or G + Y) shall be used.

• The RF Output Power (P) shall be calculated using the formula below:

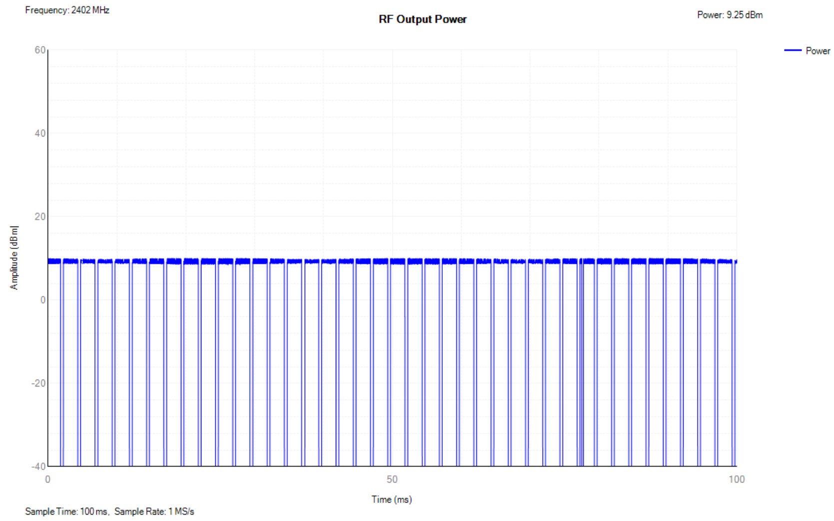
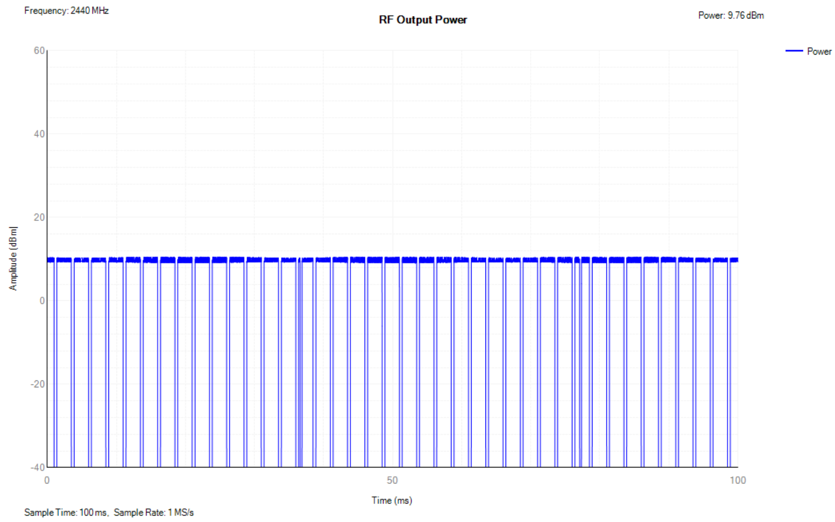
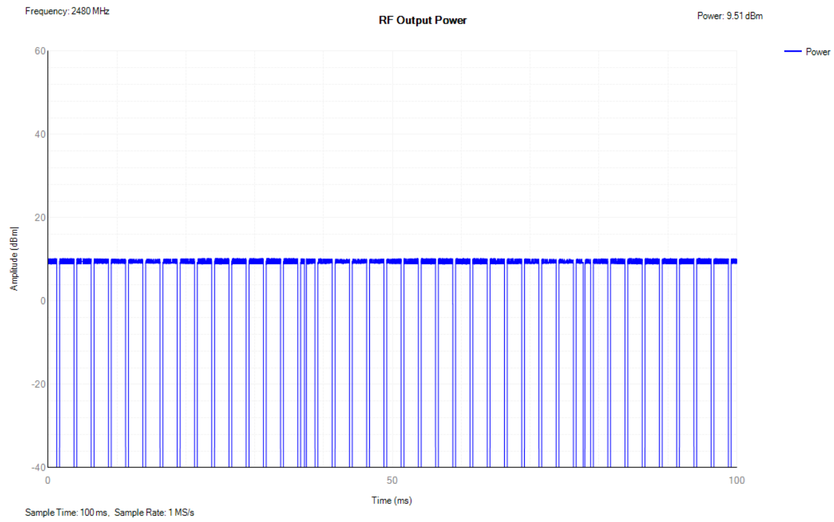
P = A + G + Y

• This value, which shall comply with the limit given in clause 4.3.1.2.3 or clause 4.3.2.2.3, shall be recorded in the test report.

6.4 Test Result

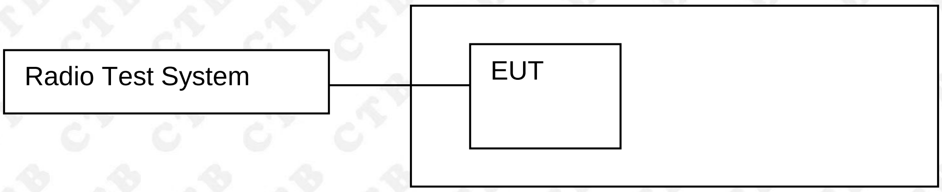
Modulation	Test conditions (Temperature)	EIRP (dBm)		
		Low Channel	Middle Channel	High Channel
GFSK	Normal	9.25	9.76	9.51
	Low	9.09	9.69	9.35
	High	9.07	9.74	9.50
Limit		≤100mW (20dBm)		
Remark: P = A + G + Y,G=1.42dBi,x=100%				

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

Low Channel	
Mid Channel	
High Channel	

7. POWER SPECTRAL DENSITY

7.1 Block Diagram Of Test Setup



7.2 Limit

For equipment using wide band modulations other than FHSS, the maximum Power Spectral Density is limited to 10 dBm per MHz.

Limit
10dBm/MHz

7.3 Test procedure

Step 1:

Connect the UUT to the spectrum analyser and use the following settings:

• Start Frequency: 2 400 MHz

• Stop Frequency: 2 483,5 MHz

• Resolution BW: 10 kHz

• Video BW: 30 kHz

• Sweep Points: > 8 350

NOTE: For spectrum analysers not supporting this number of sweep points, the frequency band may be segmented.

• Detector: RMS

• Trace Mode: Max Hold

• Sweep time: 10 s; the sweep time may be increased further until a value where the sweep time has no impact on the RMS value of the signal

For non-continuous signals, wait for the trace to stabilize.

Save the data (trace data) set to a file.

Step 2:

For conducted measurements on smart antenna systems using either operating mode 2 or operating mode 3 (see clause 5.1.3.2), repeat the measurement for each of the transmit ports. For each sampling point (frequency domain), add up the coincident power values (in mW) for the different transmit chains and use this as the new data set.

Step 3:

Add up the values for power for all the samples in the file using the formula below.

$$P_{Sum} = \sum_{n=1}^{k} P_{sample}(n)$$

with 'k' being the total number of samples and 'n' the actual sample number

Step 4:

Normalize the individual values for power (in dBm) so that the sum is equal to the RF Output Power (e.i.r.p.) measured in clause 5.3.2 and save the corrected data. The following formulas can be used:

$$C_{Corr} = P_{Sum} - P_{e.i.r.p.}$$

$$P_{Samplecorr}(n) = P_{Sample}(n) - C_{Corr}$$

with 'n' being the actual sample number

Step 5:

Starting from the first sample PSamplecorr(n) (lowest frequency), add up the power (in mW) of the following samples representing a 1 MHz segment and record the results for power and position (i.e. sample #1 to sample #100). This is the Power Spectral Density (e.i.r.p.) for the first 1 MHz segment which shall be recorded.

Step 6:

Shift the start point of the samples added up in step 5 by one sample and repeat the procedure in step 5 (i.e. sample #2 to sample #101).

Step 7:

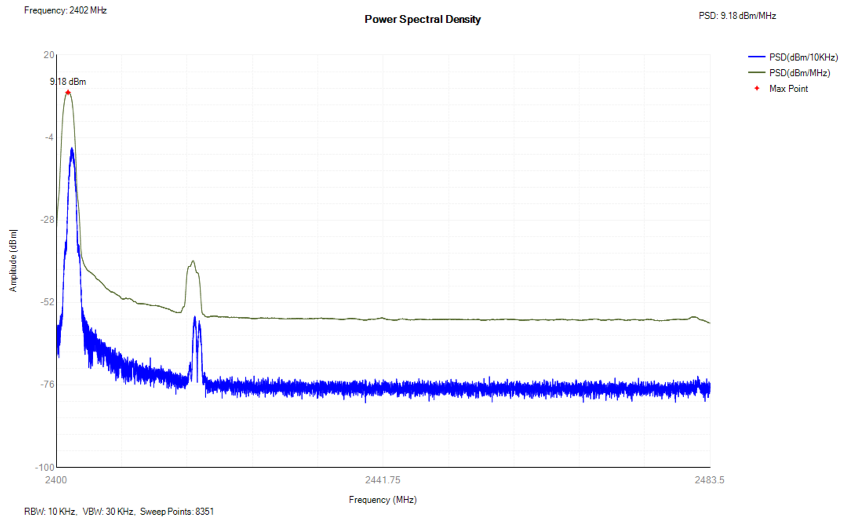
Repeat step 6 until the end of the data set and record the Power Spectral Density values for each of the 1 MHz segments.

From all the recorded results, the highest value is the maximum Power Spectral Density for the UUT. This value, which shall comply with the limit given in clause 4.3.2.3.3, shall be recorded in the test report.

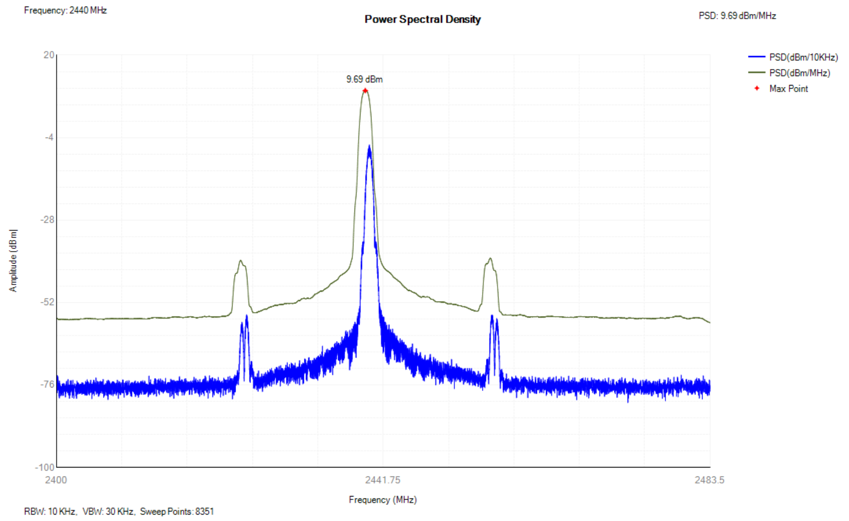
7.4 Test Result

Modulation	Test conditions	Maximum e.i.r.p. Spectral Density (dBm/MHz)		
		Low Channel	Middle Channel	High Channel
GFSK	Normal	9.18	9.69	9.44
Limit		≤10dBm/MHz		

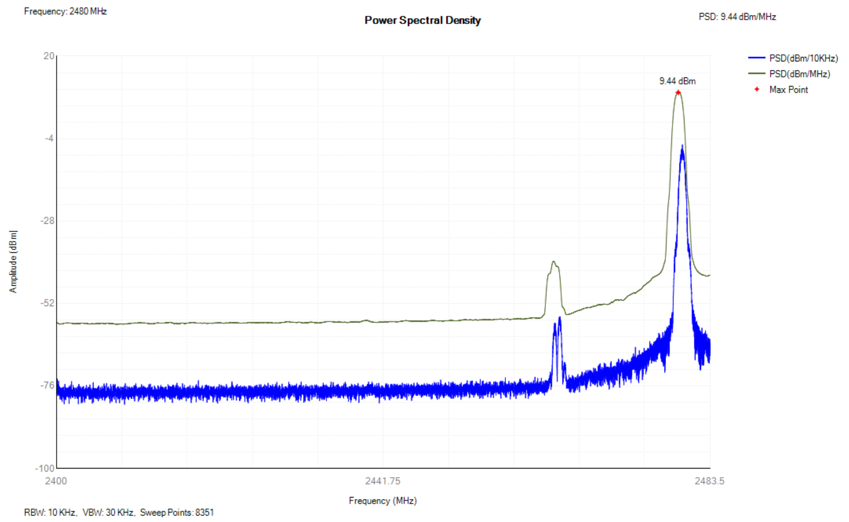
Low Channel



Mid Channel

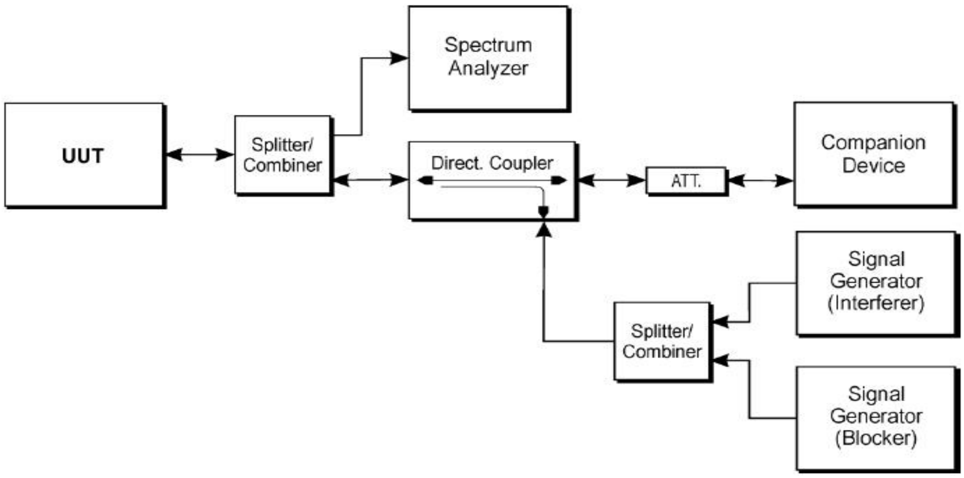


High Channel



8. ADAPTIVITY

8.1 Block Diagram Of Test Setup



8.2 Limit

The frequency range of the equipment is determined by the lowest and highest

Non-LBT based Detect and Avoid: 1 The frequency shall remain unavailable for a minimum time equal to 1 second after which the channel maybe considered again as an 'available' channel; 2 COT ≤ 40 ms; 3 Idle Period = 5% of COT; 4 Detection threshold level = -70dBm/MHz + 20 – Pout E.I.R.P (Pout in dBm);
LBT based Detect and Avoid (Frame Based Equipment): 1 Minimum Clear Channel Assessment (CCA) time = 20 us; 2 CCA observation time declared by the supplier; 3 COT = 1~10 ms; 4 Idle Period = 5% of COT; 5 Detection threshold level = -70dBm/MHz + 20 – Pout E.I.R.P (Pout in dBm);
LBT based Detect and Avoid (Load Based Equipment): 1 Minimum Clear Channel Assessment (CCA) time = 20 us; 2 CCA declared by the manufacturer; 3 COT ≤ (13 / 32) * q ms; q = [4~32]; 1.625ms~13ms; 4 Detection threshold level = -73dBm/MHz + 20 – Pout E.I.R.P (dBm);
Short Control Signalling Transmissions: Short Control Signalling Transmissions shall have a maximum duty cycle of 10% within an observation period of 50ms.

8.3 Test procedure

Step 1:

The UUT may connect to a companion device during the test. The interference signal generator, the blocking signal generator, the spectrum analyser, the UUT and the companion device are connected using a set-up equivalent to the example given by figure 5 although the interference and blocking signal generator do not generate any signals at this point in time. The spectrum analyser is used to monitor the transmissions of the UUT in response to the interfering and the blocking signals.

Adjust the received signal level (wanted signal from the companion device) at the UUT to the value defined in table 6

The analyzer shall be set as follows:

- RBW: ≥ Occupied Channel Bandwidth (if the analyser does not support this setting, the highest available setting shall be used)
- VBW: 3 × RBW (if the analyser does not support this setting, the highest available setting shall be used)
- Detector Mode: RMS
- Centre Frequency: Equal to the centre frequency of the operating channel
- Span: 0 Hz
- Sweep time: > Channel Occupancy Time of the UUT
- Trace Mode: Clear/Write
- Trigger Mode: Video

Step 2:

Configure the UUT for normal transmissions with a sufficiently high payload to allow demonstration of compliance of the adaptive mechanism on the channel being tested

Using the procedure defined in clause 5.3.7.2.1.4, it shall be verified that the UUT complies with the maximum Channel Occupancy Time and minimum Idle Period

Step 3: Adding the interference signal

A 100 % duty cycle interference signal is injected on the current operating channel of the UUT. This interference signal shall be a band limited noise signal which has a flat power spectral density, and shall have a bandwidth greater than the Occupied Channel Bandwidth of the UUT. The maximum ripple of this interfering signal shall be ±1,5 dB within the Occupied Channel Bandwidth and the power spectral density.

Step 4: Verification of reaction to the interference signal

The spectrum analyser shall be used to monitor the transmissions of the UUT on the selected operating channel with the interfering signal injected. This may require the spectrum analyser sweep to be triggered by the start of the interfering signal.

Using the procedure defined in clause 5.3.7.2.1.4, it shall be verified that:

The UUT shall stop transmissions on the current operating channel being tested.

Apart from Short Control Signalling Transmissions (see iii) below), there shall be no subsequent transmissions on this operating channel for a (silent) period defined in clause 4.3.2.5.1.2 step 2. After that, the UUT may have normal transmissions again for the duration of a single Channel Occupancy Time period. Because the interference signal is still present, another silent period as defined in clause 4.3.2.5.1.2 step 2 needs to be included. This sequence is repeated as long as the interfering signal is present.

The UUT may continue to have Short Control Signalling Transmissions on the operating channel while the interference signal is present. These transmissions shall comply with the limits

Alternatively, the equipment may switch to a non-adaptive mode

Step 5: Adding the blocking signal

With the interfering signal present, a 100 % duty cycle CW signal is inserted as the blocking signal

Repeat step 4 to verify that the UUT does not resume any normal transmissions

Step 6: Removing the interference and blocking signal

On removal of the interference and blocking signal the UUT is allowed to start transmissions again on this channel however, it shall be verified that this shall only be done after the period defined in clause 4.3.2.5.1.2 step 2.

Step 7:

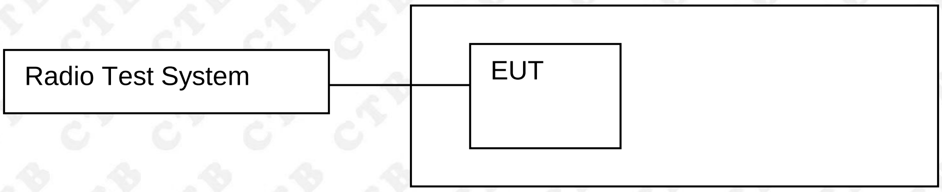
The steps 2 to 6 shall be repeated for each of the frequencies to be tested.

8.4 Test Result

Remark: this requirement does not apply for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

9. OCCUPIED CHANNEL BANDWIDTH

9.1 Block Diagram Of Test Setup



9.2 Limit

The Occupied Channel Bandwidth shall fall completely within the band given in 2.4GHz to 2.4835GHz.
In addition, for non-adaptive systems using wide band modulations other than FHSS and with e.i.r.p greater than 10 dBm, the occupied channel bandwidth shall be less than 20 MHz.

9.3 Test procedure

Step 1:

Connect the UUT to the spectrum analyser and use the following settings:

- Centre Frequency: The centre frequency of the channel under test
- Resolution BW: ~ 1 % of the span without going below 1 %
- Video BW: 3 × RBW
- Frequency Span: 2 × Nominal Channel Bandwidth
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep time: 1 s

Step 2:

Wait for the trace to stabilize.

Find the peak value of the trace and place the analyser marker on this peak.

Step 3:

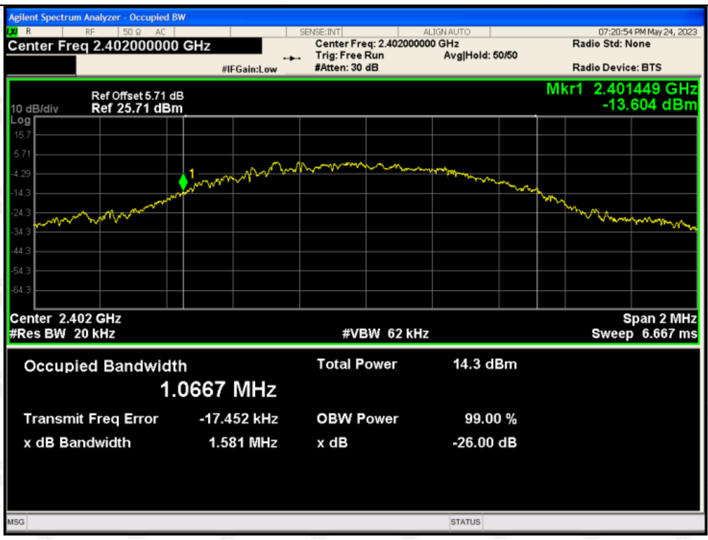
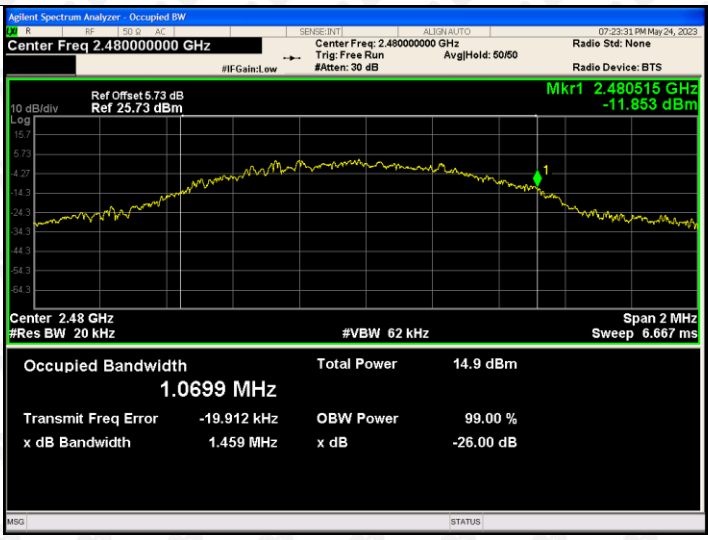
Use the 99 % bandwidth function of the spectrum analyser to measure the Occupied Channel Bandwidth of the UUT.

This value shall be recorded.

NOTE: Make sure that the power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals left and right from the power envelope being taken into account by this measurement.

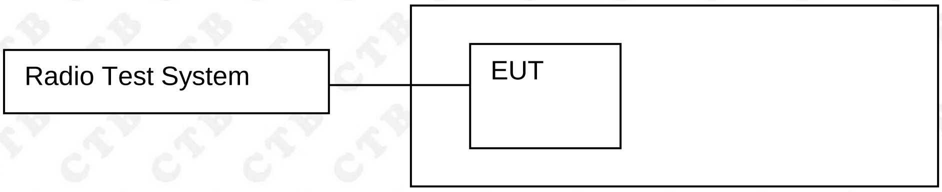
9.4 Test Result

Modulation	Frequency (MHz)	Frequency Range (MHz)		Occupied Channel (MHz)
GFSK	Low	2401.983	/	1.067
	High	/	2479.98	1.07

Low Channel	
High Channel	

10. TRANSMITTER UNWANTED EMISSIONS IN THE OUT-OF-BAND DOMAIN

10.1 Block Diagram Of Test Setup



10.2 Limit

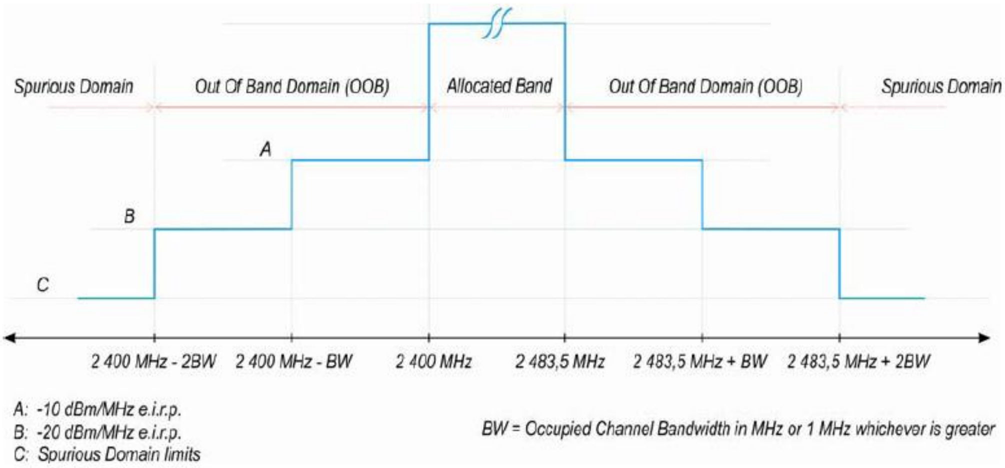


Figure 3: Transmit mask

10.3 Test procedure

The applicable mask is defined by the measurement results from the tests performed under clause 5.3.8 (Occupied Channel Bandwidth).

The test procedure is further as described under clause 5.3.9.2.1.

The Out-of-band emissions within the different horizontal segments of the mask provided in figures 1 and 3 shall be measured using the steps below. This method assumes the spectrum analyser is equipped with the Time Domain Power option.

Step 1:

• Connect the UUT to the spectrum analyser and use the following settings:

- Centre Frequency: 2 484 MHz
- Span: 0 Hz
- Resolution BW: 1 MHz
- Filter mode: Channel filter
- Video BW: 3 MHz
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep Mode: Continuous

- Sweep Points: Sweep Time [s] / (1 μs) or 5 000 whichever is greater

- Trigger Mode: Video trigger

NOTE 1: In case video triggering is not possible, an external trigger source may be used.

- Sweep Time: > 120 % of the duration of the longest burst detected during the measurement of the RF Output Power

Step 2 (segment 2 483,5 MHz to 2 483,5 MHz + BW):

• Adjust the trigger level to select the transmissions with the highest power level.

• For frequency hopping equipment operating in a normal hopping mode, the different hops will result in signal bursts with different power levels. In this case the burst with the highest power level shall be selected.

• Set a window (start and stop lines) to match with the start and end of the burst and in which the RMS power shall be measured using the Time Domain Power function.

• Select RMS power to be measured within the selected window and note the result which is the RMS power within this 1 MHz segment (2 483,5 MHz to 2 484,5 MHz). Compare this value with the applicable limit provided by the mask.

• Increase the centre frequency in steps of 1 MHz and repeat this measurement for every 1 MHz segment within the range 2 483,5 MHz to 2 483,5 MHz + BW. The centre frequency of the last 1 MHz segment shall be set to 2 483,5 MHz + BW - 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 3 (segment 2 483,5 MHz + BW to 2 483,5 MHz + 2BW):

• Change the centre frequency of the analyser to 2 484 MHz + BW and perform the measurement for the first 1 MHz segment within range 2 483,5 MHz + BW to 2 483,5 MHz + 2BW. Increase the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 483,5 MHz + 2 BW - 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 4 (segment 2 400 MHz - BW to 2 400 MHz):

• Change the centre frequency of the analyser to 2 399,5 MHz and perform the measurement for the first 1 MHz segment within range 2 400 MHz - BW to 2 400 MHz Reduce the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 400 MHz - BW + 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 5 (segment 2 400 MHz - 2BW to 2 400 MHz - BW):

• Change the centre frequency of the analyser to 2 399,5 MHz - BW and perform the measurement for the first 1 MHz segment within range 2 400 MHz - 2BW to 2 400 MHz - BW. Reduce the centre frequency in 1 MHz steps and repeat the measurements to cover this whole range. The centre frequency of the last 1 MHz segment shall be set to 2 400 MHz - 2BW + 0,5 MHz (which means this may partly overlap with the previous 1 MHz segment).

Step 6:

• In case of conducted measurements on equipment with a single transmit chain, the declared antenna assembly gain "G" in dBi shall be added to the results for each of the 1 MHz segments and compared with the limits

provided by the mask given in figure 1 or figure 3. If more than one antenna assembly is intended for this power setting, the antenna with the highest gain shall be considered.

• In case of conducted measurements on smart antenna systems (equipment with multiple transmit chains), the measurements need to be repeated for each of the active transmit chains. The declared antenna assembly gain "G" in dBi for a single antenna shall be added to these results. If more than one antenna assembly is intended for this power setting, the antenna with the highest gain shall be considered. Comparison with the applicable limits shall be done using any of the options given below:

- Option 1: the results for each of the transmit chains for the corresponding 1 MHz segments shall be added. The additional beamforming gain "Y" in dB shall be added as well and the resulting values compared with the limits provided by the mask given in figure 1 or figure 3.

- Option 2: the limits provided by the mask given in figure 1 or figure 3 shall be reduced by

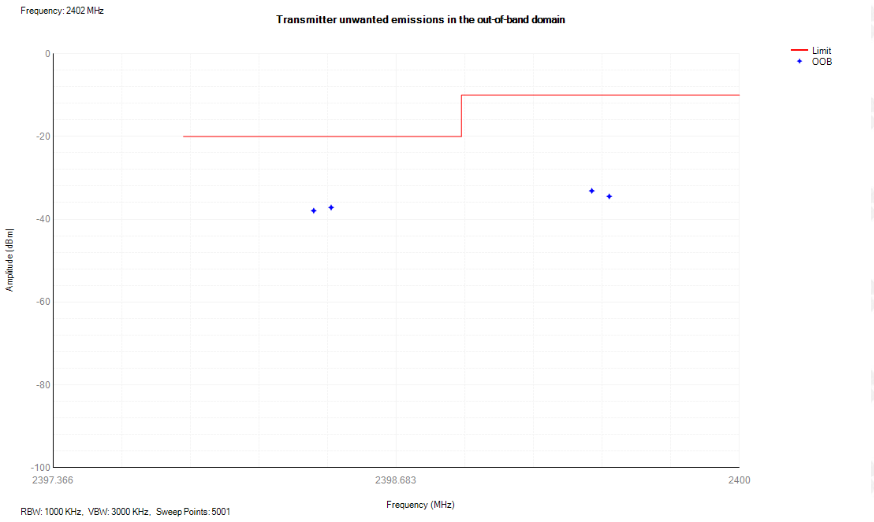
10 × log10(Ach) and the additional beamforming gain "Y" in dB. The results for each of the transmit chains shall be individually compared with these reduced limits.

NOTE 2: Ach refers to the number of active transmit chains.

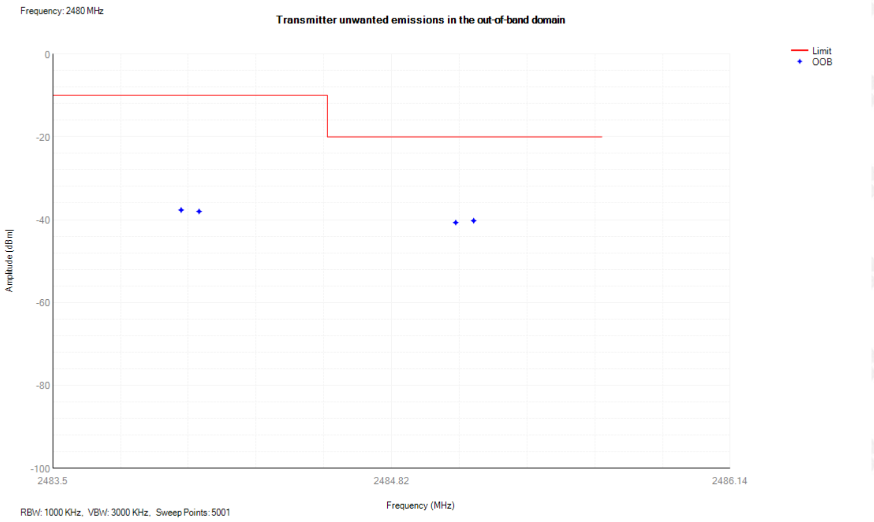
It shall be recorded whether the equipment complies with the mask provided in figure 1 or figure 3.

10.4 Test Result

Low Channel				
Test Freq (MHz)	**Antenna**	**Freq(MHz)**	**Level**	**Limit**
2402	Antenna 1	2399.433	-33.14	-10
2402	Antenna 1	2398.433	-37.16	-20

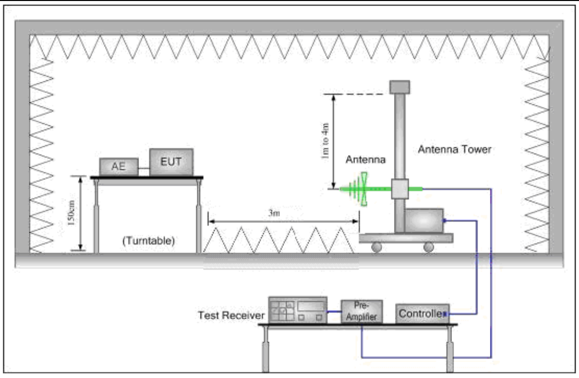


High Channel				
Test Freq (MHz)	**Antenna**	**Freq(MHz)**	**Level**	**Limit**
2480	Antenna 1	2484.07	-38	-10
2480	Antenna 1	2485.07	-40.69	-20

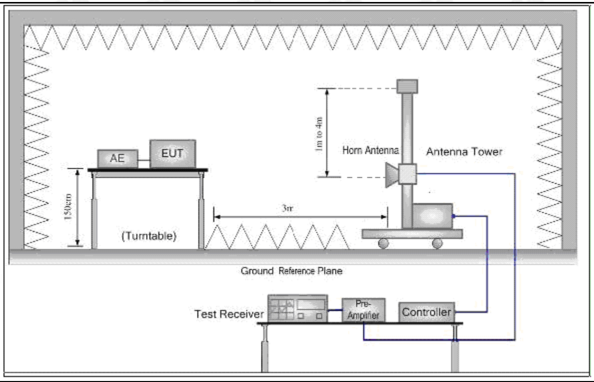


11. TRANSMITTER UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN

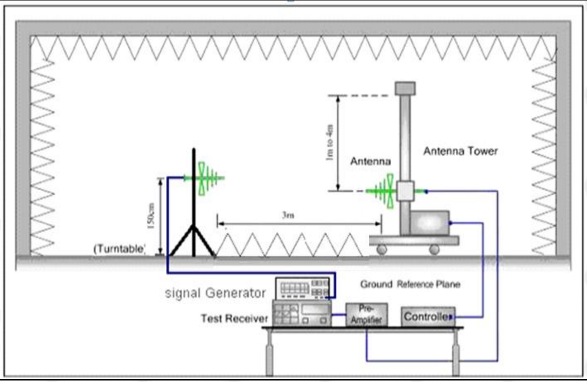
11.1 Block Diagram Of Test Setup



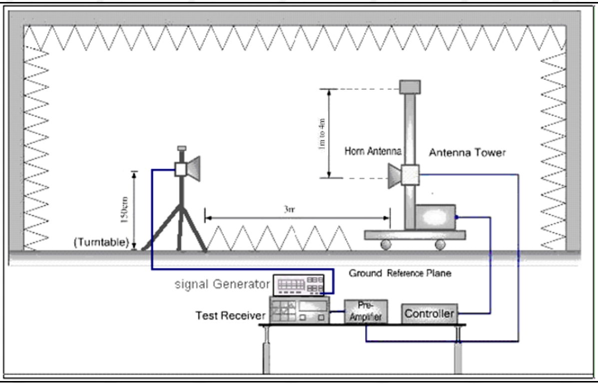
Below 1GHz



Above 1GHz



Below 1GHz



Above 1GHz

11.2 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 694 MHz	-54 dBm	100 kHz/300KHz
694 MHz to 1 GHz	-36 dBm	100 kHz/300KHz
1 GHz to 12,75 GHz	-30 dBm	1 MHz/3MHz

11.3 Test Procedure

1. Scan from 30MHz to 12.75GHz, 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+2.15dB

   where:

   P_{SG} is the generator output power into the substitution antenna.
10) Test the EUT in the lowest channel , the Highest channel

Repeat above procedures until all frequencies measured was complete.

11.4 Test Results

Below 1GHz

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
Low Channel									
46.806	-54.66	-12.60	-67.26	-36.00	-31.26	peak	1.7	173	H
67.479	-54.92	-12.23	-67.15	-54.00	-13.15	peak	1.7	155	H
104.141	-55.87	-12.57	-68.44	-54.00	-14.44	peak	1.2	146	H
217.219	-52.86	-11.03	-63.90	-54.00	-9.90	peak	1.2	199	H
327.274	-53.21	-9.87	-63.08	-36.00	-27.08	peak	1.6	202	H
871.016	-51.74	-0.38	-52.11	-36.00	-16.11	peak	1.5	339	H
48.372	-55.41	-12.10	-67.52	-36.00	-31.52	peak	1.7	94	V
100.859	-54.87	-11.87	-66.74	-54.00	-12.74	peak	1.5	134	V
183.093	-55.53	-12.30	-67.83	-54.00	-13.83	peak	1.5	342	V
217.314	-53.57	-10.96	-64.52	-54.00	-10.52	peak	1.6	197	V
325.678	-53.23	-9.67	-62.91	-36.00	-26.91	peak	1.2	101	V
871.707	-52.53	-0.21	-52.74	-36.00	-16.74	peak	1.1	215	V
High Channel									
45.694	-55.16	-12.38	-67.54	-36.00	-31.54	peak	1.4	334	H
68.376	-55.29	-12.51	-67.80	-54.00	-13.80	peak	1.4	344	H
103.607	-55.80	-11.75	-67.55	-54.00	-13.55	peak	1.7	55	H
218.582	-52.91	-10.90	-63.81	-54.00	-9.81	peak	1.4	256	H
327.577	-53.00	-9.63	-62.63	-36.00	-26.63	peak	1.0	332	H
869.700	-52.22	-0.31	-52.53	-36.00	-16.53	peak	1.7	165	H
48.628	-55.54	-12.19	-67.73	-36.00	-31.73	peak	1.5	227	V
100.775	-54.79	-12.48	-67.27	-54.00	-13.27	peak	1.7	262	V
183.647	-55.62	-11.69	-67.31	-54.00	-13.31	peak	1.4	98	V
217.370	-53.00	-10.99	-63.99	-54.00	-9.99	peak	1.0	110	V
327.490	-52.97	-9.47	-62.44	-36.00	-26.44	peak	1.0	31	V
870.384	-52.61	-0.41	-53.03	-36.00	-17.03	peak	1.7	284	V

Remark:
Absolute Level = Receiver Reading + Factor
Factor = Antenna Factor + Cable Loss – Pre-amplifier

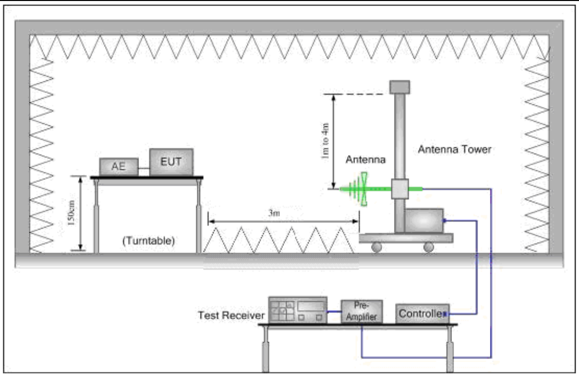
Above 1G:

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
Low Channel									
4804	-54.61	8.41	-46.20	-30.00	-16.20	peak	1.0	12	H
7206	-52.20	12.55	-39.65	-30.00	-9.65	peak	1.5	254	H
4804	-54.04	8.41	-45.63	-30.00	-15.63	peak	1.5	2	V
7206	-51.64	12.55	-39.09	-30.00	-9.09	peak	1.4	236	V
High Channel									
4960	-54.84	8.51	-46.33	-30.00	-16.33	peak	1.8	75	H
7440	-52.70	12.69	-40.01	-30.00	-10.01	peak	1.7	188	H
4960	-54.23	8.51	-45.72	-30.00	-15.72	peak	1.6	263	V
7440	-51.69	12.69	-39.00	-30.00	-9.00	peak	1.9	355	V

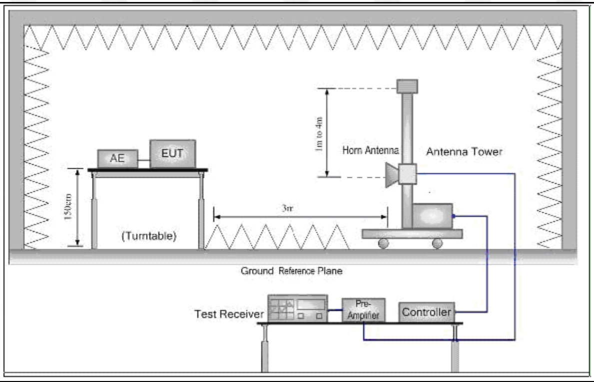
Remark:
Absolute Level = Receiver Reading + Factor
Factor = Antenna Factor + Cable Loss – Pre-amplifier

12. RECEIVER SPURIOUS EMISSIONS

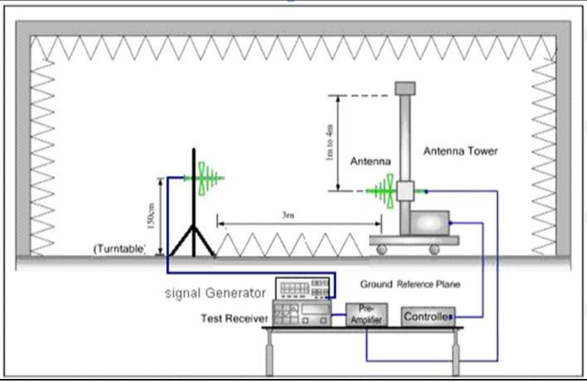
12.1 Block Diagram Of Test Setup



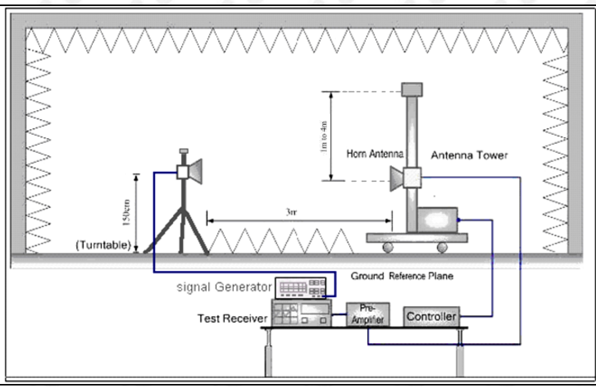
Below 1GHz



Above 1GHz



Below 1GHz



Above 1GHz

12.2 Limits

Frequency(MHz)	Limit
30-1000	-57dBm
1000-12750	-47dBm

12.3 Test Procedure

1. Scan from 30MHz to 12.75GHz, 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 hight 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+2.15dB

where:

P_{SG} is the generator output power into the substitution antenna.

11) Test the EUT in the lowest channel , the Highest channel
Repeat above procedures until all frequencies measured was complete.

12.4 Test Results

Below 1GHz

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
Low Channel									
44.246	-60.10	-12.31	-72.41	-57.00	-15.41	peak	1.6	116	H
68.957	-60.50	-11.90	-72.41	-57.00	-15.41	peak	1.0	169	H
104.354	-60.12	-11.95	-72.07	-57.00	-15.07	peak	1.7	60	H
218.302	-62.80	-10.78	-73.58	-57.00	-16.58	peak	1.8	25	H
327.919	-61.29	-9.57	-70.86	-57.00	-13.86	peak	1.5	333	H
871.265	-68.67	0.18	-68.48	-57.00	-11.48	peak	1.3	213	H
46.576	-60.83	-12.62	-73.46	-57.00	-16.46	peak	1.1	89	V
102.198	-61.60	-11.91	-73.51	-57.00	-16.51	peak	1.1	170	V
183.917	-62.34	-12.21	-74.56	-57.00	-17.56	peak	1.8	321	V
219.428	-60.98	-10.83	-71.81	-57.00	-14.81	peak	1.3	6	V
326.273	-59.62	-9.63	-69.25	-57.00	-12.25	peak	1.2	346	V
869.248	-69.48	-0.12	-69.60	-57.00	-12.60	peak	1.2	46	V
High Channel									
44.078	-60.23	-12.45	-72.68	-57.00	-15.68	peak	1.7	234	H
67.819	-60.24	-12.49	-72.74	-57.00	-15.74	peak	1.4	150	H
105.162	-60.32	-12.40	-72.72	-57.00	-15.72	peak	1.5	80	H
217.023	-62.07	-10.90	-72.97	-57.00	-15.97	peak	1.2	250	H
326.218	-61.42	-9.78	-71.20	-57.00	-14.20	peak	1.0	307	H
870.791	-69.11	-0.50	-69.61	-57.00	-12.61	peak	1.5	197	H
48.845	-60.27	-12.30	-72.58	-57.00	-15.58	peak	1.2	233	V
101.695	-61.18	-12.10	-73.28	-57.00	-16.28	peak	1.6	299	V
182.368	-62.69	-11.93	-74.62	-57.00	-17.62	peak	1.8	135	V
218.377	-61.16	-10.64	-71.81	-57.00	-14.81	peak	1.5	80	V
327.842	-59.79	-9.48	-69.27	-57.00	-12.27	peak	1.0	127	V
871.686	-69.41	-0.56	-69.97	-57.00	-12.97	peak	1.8	231	V

Remark:
Absolute Level = Receiver Reading + Factor
Factor = Antenna Factor + Cable Loss – Pre-amplifier

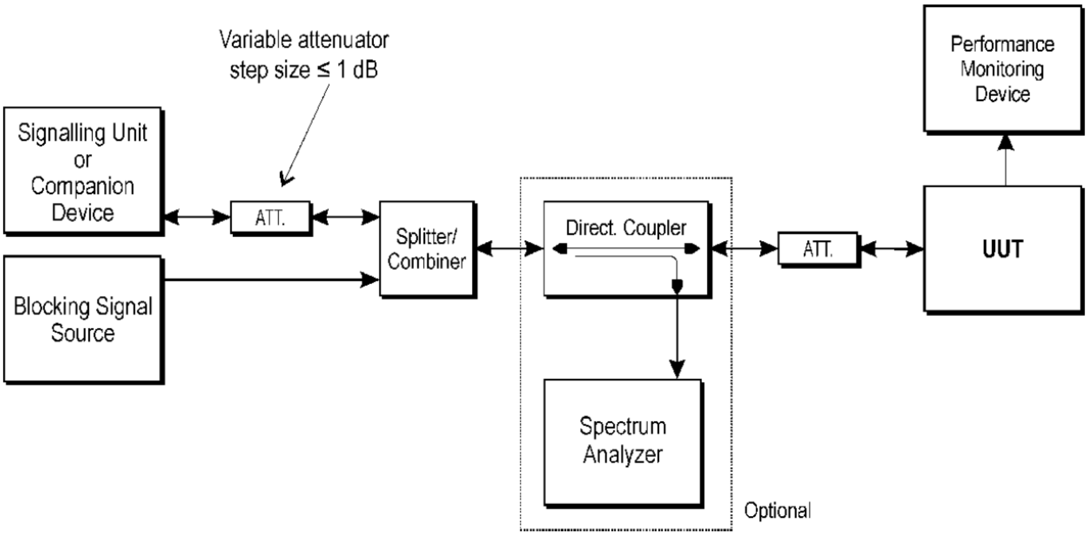
Above 1G:

Freq (MHz)	Rd_level (dBm)	Factor (dB)	Level (dBm)	Limit (dBm)	Over (dB)	detector	Height	Degree	Antenna polarization
Low Channel									
2248.45	-61.33	3.12	-58.21	-47.00	-11.21	peak	1.6	257	H
2248.82	-60.18	3.14	-57.04	-47.00	-10.04	peak	1.6	76	V
High Channel									
2443.42	-59.69	3.52	-56.17	-47.00	-9.17	peak	1.8	9	H
2443.74	-62.41	3.56	-58.85	-47.00	-11.85	peak	1.1	314	V

Remark:
Absolute Level = Receiver Reading + Factor
Factor = Antenna Factor + Cable Loss – Pre-amplifier

13. RECEIVER BLOCKING

13.1 Block Diagram Of Test Setup



13.2 Limit

Table 14: Receiver Blocking parameters for Receiver Category 1 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 4)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 4)	Type of blocking signal
(-133 dBm + 10 × $\log_{10}$(OCBW)) or -68 dBm whichever is less (see note 2)	2 380 2 504	-34	CW
(-139 dBm + 10 × $\log_{10}$(OCBW)) or -74 dBm whichever is less (see note 3)	2 300 2 330 2 360 2 524 2 584 2 674		

NOTE 1: OCBW is in Hz.
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 20 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 4: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

Table 15: Receiver Blocking parameters receiver Category 2 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW
NOTE 1: OCBW is in Hz. NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 26 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal. NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.			

Table 16: Receiver Blocking parameters receiver Category 3 equipment

Wanted signal mean power from companion device (dBm) (see notes 1 and 3)	Blocking signal frequency (MHz)	Blocking signal power (dBm) (see note 3)	Type of blocking signal
(-139 dBm + 10 × $\log_{10}$(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW
NOTE 1: OCBW is in Hz. NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 30 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal. NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.			

13.3 Test procedure

Refer to ETSI EN 300 328 V2.2.2 (2020-07) Clause 5.4.11.2.

13.4 Test Result

Receiver Category 2					
Transmitting	P_{min}(dBm)	Blocking Frequency(MHz)	Blocking Power(dB)	Measured PER(%)	Limit (%)
2402	-69	2380	-32.58	0.58	10
2402	-69	2504	-32.58	0.63	10
2402	-69	2300	-32.58	0.47	10
2402	-69	2584	-32.58	0.26	10
2441	-69	2380	-32.58	0.37	10
2441	-69	2504	-32.58	0.52	10
2441	-69	2300	-32.58	0.48	10
2441	-69	2584	-32.58	0.37	10
2480	-69	2380	-32.58	0.78	10
2480	-69	2504	-32.58	0.71	10
2480	-69	2300	-32.58	0.40	10
2480	-69	2584	-32.58	0.36	10
Note:This report only shows the worst case test data.					

14. EUT PHOTOGRAPHS

Refer to Report No.: CTB230518007REX for EUT external and internal photos.

15. EUT TEST SETUP PHOTOGRAPHS

Spurious emissions

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