# TEST REPORT

| | |
|---|---|
| Report No.: | BCTC2206047110-3E |
| Applicant: | Ningbo Jiangbei Runleader Electronics Co., Ltd. |
| Product Name: | Battery indicator & Hour meter |
| Model/Type Reference: | RL-HM027BT |
| Tested Date: | 2022-06-16 to 2022-06-24 |
| Issued Date: | 2022-07-14 |

**Shenzhen BCTC Technology Co., Ltd.**

| | |
|---|---|
| Product Name: | Battery indicator & Hour meter |
| Trademark: | Runleader® |
| Model/Type reference: | RL-HM027BT<br>RL-HM032BT, RL-HM058BT, RL-HM068BT, RL-HM086BT, RL-HM088BT, RL-HM098BT, RL-HM210BT, RL-HM400BT, RL-HM410BT, RL-HM420BT, RL-HM430BT, RL-SM002BT, RL-SM005BT, RL-BI025A-BT, RL-BI025B-BT, RL-BI609BT, RL-BI032BT, RL-BI036BT, RL-BI620BT etc |
| Prepared For: | Ningbo Jiangbei Runleader Electronics Co., Ltd. |
| Address: | 1-2, Sixth Xinheng Road,Cicheng,Jiangbei District,Ningbo City,Zhejiang Province |
| Manufacturer: | Ningbo Jiangbei Runleader Electronics Co., Ltd. |
| Address: | 1-2, Sixth Xinheng Road,Cicheng,Jiangbei District,Ningbo City,Zhejiang Province |
| Prepared By: | Shenzhen BCTC Technology Co., Ltd. |
| Address: | 1 Floor, Building 2, Huayou Industrial, Yousong Road, Fukang Community, Longhua Street, Longhua District, Shenzhen, Guangdong, China |
| Sample Received Date: | 2022-06-16 |
| Sample tested Date: | 2022-06-16 to 2022-06-24 |
| Issue Date: | 2022-07-14 |
| Report No.: | BCTC2206047110-3E |
| Test Standards: | ETSI EN 300 328 V2.2.2 (2019-07) |
| Test Results: | PASS |
| Remark: | This is BLE radio test report. |

Tested by:

SnowZeng/ Project Handler

Approved by:

Carson.zhang/Reviewer

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 BCTC 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.

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## 1. Version

| Report No. | Issue Date | Description | Approved |
|---|---|---|---|
| BCTC2206047110-3E | 2022-07-14 | Original | Valid |
| | | | |

## 2. Test Summary

The Product has been tested according to the following specifications:

| No. | Test Parameter | Clause No. | Results |
|---|---|---|---|
| Transmitter Parameters | | | |
| 1 | RF output power | 4.3.2.2 | PASS |
| 2 | Power Spectral Density | 4.3.2.3 | PASS |
| 3 | Duty Cycle, Tx-sequence, Tx-gap | 4.3.2.4 | N/A |
| 4 | Medium Utilisation (MU) factor | 4.3.2.5 | N/A |
| 5 | Adaptivity (adaptive equipment using modulations other than FHSS) | 4.3.2.6 | N/A |
| 6 | Occupied Channel Bandwidth | 4.3.2.7 | PASS |
| 7 | Transmitter unwanted emissions in the out-of-band domain | 4.3.2.8 | PASS |
| 8 | Transmitter unwanted emissions in the spurious domain | 4.3.2.9 | PASS |
| Receiver Parameters | | | |
| 9 | Receiver spurious emissions | 4.3.2.10 | PASS |
| 10 | Receiver Blocking | 4.3.2.11 | PASS |
| 11 | Geo-location Capability | 4.3.2.12 | N/A |
| Note: N/A is an abbreviation for Not Applicable and means this test item is not applicable for this device according to the technology characteristic of device. | | | |

## 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.

| Test item | uncertainty |
|---|---|
| RF frequency | $1 \times 10^{-7}$ |
| RF power, conducted | 1.38dB |
| Duty Cycle and Tx-Sequence and Tx-Gap | ±0.9 |
| Occupied Channel Bandwidth | ±2.3 |
| Conducted spurious emission (30MHz-1GHz) | 1.28dB |
| Conducted spurious emission (1GHz-18GHz) | 1.576dB |
| Radiated Spurious emission (30MHz-1GHz) | 4.3dB |
| Radiated Spurious emission (1GHz-18GHz) | 4.5dB |
| Temperature | 0.59℃ |
| Humidity | 5.3% |

# 4. Product Information And Test Setup

## 4.1 Product Information

| | |
|---|---|
| Model/Type reference: | RL-HM027BT |
| Model differences: | All the model are the same circuit and RF module, except model names and appearance. |
| Hardware Version: | N/A |
| Software Version: | N/A |
| Operation Frequency: | Bluetooth (BLE): 2402-2480MHz |
| Max. RF output power: | Bluetooth (BLE): -1.14dBm |
| Type of Modulation: | Bluetooth (BLE): GFSK |
| Antenna installation: | PCB antenna |
| Antenna Gain: | 0 dBi |
| Ratings: | DC 3V |

## 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

| No. | Device Type | Brand | Model | Series No. | Note |
|---|---|---|---|---|---|
| 1. | --- | --- | --- | --- | --- |

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 1Mbps) | 2402MHz | 2440MHz | 2480MHz |
| Receiving(GFSK 1Mbps) | 2402MHz | 2440MHz | 2480MHz |

## 4.6 Test Environment

1. Normal Test Conditions:

| | |
|---|---|
| Humidity(%): | 54 |
| Atmospheric Pressure(kPa): | 101 |
| Temperature(℃): | 26 |
| Test Voltage(DC): | 3V |

2.Extreme Test Conditions:

For tests at extreme temperatures, measurements shall be made over the extremes of the operating temperature range as declared by the manufacturer.

For tests at extreme voltages, measurements shall be made over the extremes of the power source voltage range as declared by the manufacturer.

| Test Conditions | LT | HT |
|---|---|---|
| Temperature (℃) | 0 | 35 |

# 5. Test Facility and test Instrument Used

## 5.1 Test Facility

All measurement facilities used to collect the measurement data are located at Shenzhen BCTC Technology Co., Ltd. Address: 1st floor, building 2, Huayou Industrial Zone, Yousong Road, Fukang community, Longhua street, Longhua District, Shenzhen, P. R. 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

| Item | Equipment | Manufacturer | Type No. | Serial No. | Last calibration | Calibrated until |
|---|---|---|---|---|---|---|
| 1 | 966 chamber | ChengYu | 966 Room | 966 | Jun. 06. 2020 | Jun. 05, 2023 |
| 2 | Receiver | R&S | ESR3 | 102075 | May 28, 2021 | May 23, 2023 |
| 3 | Spectrum Analyzer | Agilent | E4407B | MY45109572 | May 28, 2021 | May 23, 2023 |
| 4 | Amplifier | SKET | LAPA_01G18G-45dB | \ | May 28, 2021 | May 23, 2023 |
| 5 | Amplifier | Schwarzbeck | BBV9744 | 9744-0037 | May 28, 2021 | May 23, 2023 |
| 6 | TRILOG Broadband Antenna | Schwarzbeck | VULB 9163 | 942 | Jun. 01, 2021 | May 25, 2023 |
| 7 | Horn Antenna | Schwarzbeck | BBHA9120D | 1541 | Jun. 02, 2021 | May 23, 2023 |
| 8 | band rejection filter | ZBSF | ZBSF-C2441.5 | 1706003606 | May 28, 2021 | Jun. 14, 2022 |
| 9 | Horn antenna | Schwarzbeck | BBHA9170 | 00822 | Jun. 15, 2021 | May 25, 2023 |
| 10 | Loop Antenna | Schwarzbeck | FMZB1519B | 00014 | Jun. 02, 2021 | May 25, 2023 |
| 11 | Spectrum Analyzer | Keysight | N9020A | MY51287403 | Mar.28, 2022 | Jun. 05, 2023 |
| 12 | Signal Generator | Keysight | N5182A | MY50144088 | Mar.28, 2022 | May 23, 2023 |
| 13 | Power Sensor | MWRFtest | MW100-RFCB | \ | Mar.28, 2022 | May 23, 2023 |
| 14 | Radio frequency control box | MWRFtest | MW100-RFCB | \ | \ | \ |
| 15 | Software | Frad | EZ-EMC | FA-03A2 RE | \ | \ |
| 16 | Software | Keysight | Keysight.ETSL Test system | 1.02.05 | \ | \ |
| 17 | D.C. Power Supply | LongWei | TPR-6405D | \ | \ | \ |
| 18 | Communication test set | R&S | CMW500 | 157483 | Mar.28, 2022 | Mar.27, 2023 |
| 19 | Programmable constant temperature and humidity test chamber | Auchno | OJN-9606-408L | 19120183 | Dec. 16, 2021 | Dec. 15, 2022 |

## 6. Information As Required

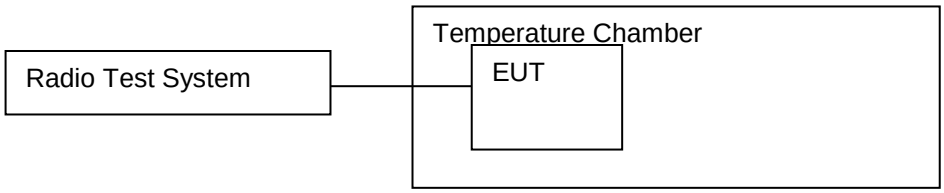
**ETSI EN 300 328 V2.2.2 Annex E**

| | | |
|---|---|---|
| The Type Of Modulation Used By the Equipment | ☐ FHSS<br>☒ other forms of modulation | |
| In Case of FHSS<br><br>Modulation: | ☐ In case of non-Adaptive Frequency Hopping equipment<br>The number of Hopping Frequencies: | |
| | ☐ In case of Adaptive Frequency Hopping Equipment<br>The maximum number of Hopping Frequencies:<br>The minimum number of Hopping Frequencies: | |
| The Worst Case Operational Mode For Each Of The Following Tests: | RF Output Power | -1.14 dBm |
| | Power Spectral Density | -1.23 dBm/MHz |
| | Duty Cycle, Tx-Sequence, Tx-gap. | N/A |
| | Accumulated Transmit time, Frequency Occupation & Hopping Sequence (only for FHSS equipment) | N/A |
| | Hopping Frequency Separation (only for FHSS equipment) | N/A |
| | Adaptivity | N/A |
| | Receiver Blocking. | PASS |
| | Nominal Channel Bandwidth | PASS |
| | Transmitter Unwanted Emissions in the OOB domain. | PASS |
| | Transmitter Unwanted Emissions in the spurious domain | PASS |
| | Receiver spurious emissions | PASS |
| The Different Transmit Operating Modes (Tick All That Apply): | ☒ Operating mode 1: Single Antenna Equipment | |
| | ☒ Equipment with only one antenna | |
| | ☐ Equipment with two diversity antennas but only one antenna active at any moment in time | |
| | ☐ Smart Antenna Systems with two or more antennas, but operating in a (legacy) mode where only One antenna is used (e.g. IEEE 802.11™ [i.3] legacy mode in smart antenna systems) | |
| | ☐ Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming | |
| | ☐ Single spatial stream / Standard throughput / (e.g. IEEE 802.11™ [i.3] legacy mode) | |
| | ☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1 | |
| | ☐ High Throughput (> 1 spatial stream) using Occupied Channel | |

| | | |
|---|---|---|
| | | Bandwidth 2 |
| | ☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming | |
| | | ☐ Single spatial stream / Standard throughput (e.g. IEEE 802.11™ [i.3] legacy mode) |
| | | ☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 1 |
| | | ☐ High Throughput (> 1 spatial stream) using Occupied Channel Bandwidth 2 |
| Operating Frequency Range(S) Of The Equipment: | Operating Frequency Range: 2402 MHz to 2480 MHz | |
| Nominal Channel Bandwidth(s): | Occupied Channel Bandwidth: 1.10 MHz | |
| Type of Equipment (stand-alone, combined, plug-in radio device, etc.): | ☒ Stand-alone<br>☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)<br>☐ Plug-in radio device (Equipment intended for a variety of host systems)<br>☐ Other | |
| Describe the test modes available which can facilitate testing: | Modulation Mode: GFSK<br>Test Frequency: Low Frequency, Middle Frequency, High Frequency | |
| The equipment type (e.g. Bluetooth®, IEEE 802.11™ [i.3], IEEE 802.15.4™ [i.4], proprietary, etc.): | BLE5.1 | |
| NOTE:<br>N/A means not applicable | | |

# 7. RF Output Power

## 7.1 Block Diagram Of Test Setup




## 7.2 Limit

The RF output power for non-FHSS equipment shall be equal to or less than 20 dBm.
NOTE: For Non-adaptive FHSS equipment, the manufacturer may have declared a reduced RF Output Power (see clause 5.4.1 m)) and associated Duty Cycle (see clause 5.4.1 e)) that will ensure that the equipment meets the requirement for the Medium Utilization (MU) factor further described in clause 4.3.2.5. This is verified by the conformance test referred to in clause 4.3.2.5.4.)
For non-adaptive non-FHSS equipment, where the manufacturer has declared an RF output power of less than 20 dBm e.i.r.p., the RF output power shall be equal to or less than that declared value.
This limit shall apply for any combination of power level and intended antenna assembly

| Limit |
|---|
| 20dBm |

## 7.3 Test procedure

**Step 1:**

• Use a fast power sensor with a minimum sensitivity of -40 dBm 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 as the new stored data set..

**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.

In case of insufficient sensitivity of the power sensor (e.g. in case of radiated measurements), 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. The start and stop points shall be included. 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.

• ◦ In case of smart antenna systems operating in mode with beamforming (see clause 5.3.2.2.4), 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 (Pout) shall be calculated using the formula below::

$$P_{out} = A + G + Y$$

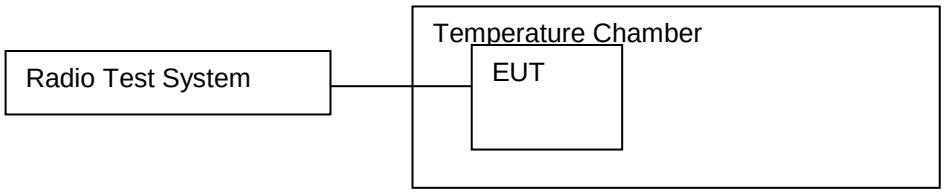
• This value, which shall comply with the limit given in clause 4.3.1.2.3 or clause 4.3.2.2.3, shall be recorded in the test report.

## 7.4 Test Result

| Condition | Mode | Frequency (MHz) | Max RMS Power (dBm) | Limit (dBm) | Verdict |
|---|---|---|---|---|---|
| NVNT | BLE 1M | 2402 | -2.26 | 20 | Pass |
| | | 2440 | -2.26 | 20 | Pass |
| | | 2480 | **-1.14** | 20 | Pass |
| NVLT | BLE 1M | 2402 | -2.14 | 20 | Pass |
| | | 2440 | -2.11 | 20 | Pass |
| | | 2480 | -1.15 | 20 | Pass |
| NVHT | BLE 1M | 2402 | -2.22 | 20 | Pass |
| | | 2440 | -2.14 | 20 | Pass |
| | | 2480 | -1.92 | 20 | Pass |

# 8. Power Spectral Density

## 8.1 Block Diagram Of Test Setup




## 8.2 Limit

The maximum Power Spectral Density for non-FHSS equipment is 10 dBm per MHz

| Limit |
|---|
| 10dBm/MHz |

## 8.3 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 ; for spectrum analysers not supporting this number of sweep points, the frequency band may be segmented
- Detector: RMS
- Trace Mode: Max Hold
- Sweep time: For non-continuous transmissions: 2 × Channel Occupancy Time × number of sweep points

For non-adaptive equipment use the maximum TX-sequence time in the formula above instead of the Channel Occupancy Time

For continuous transmissions: 10 s; the sweep time may be increased further until a value where the sweep time has no further impact anymore 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.

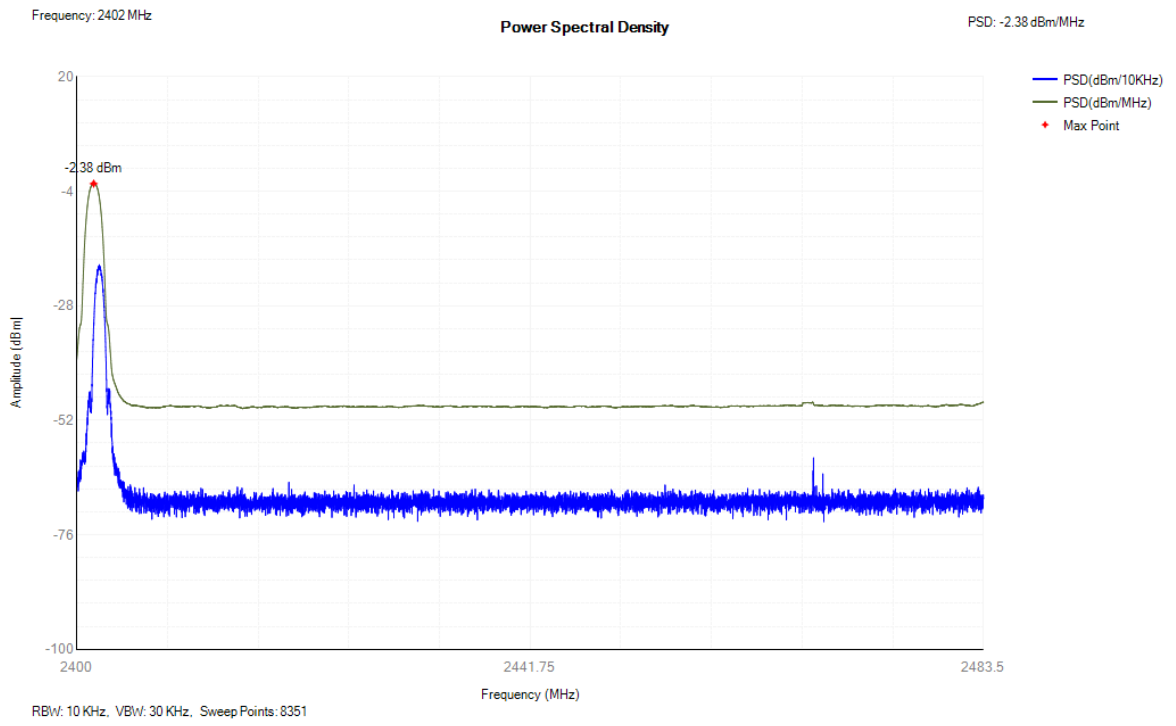
From all the recorded results, the highest value is the maximum Power Spectral Density for the UUT. This value, which shall comply with the limit given in clause 4.3.2.3.3, shall be recorded in the test report.

## 8.4 Test Result

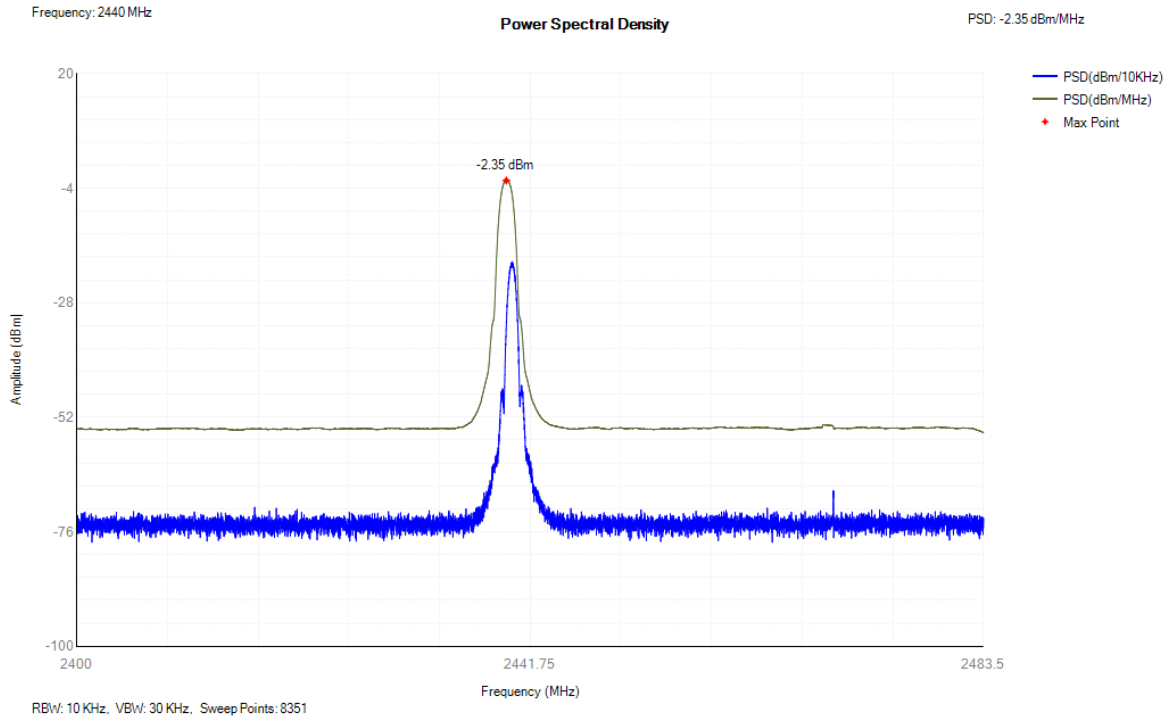
| Condition | Mode | Frequency (MHz) | Max PSD (dBm/MHz) | Limit (dBm) | Verdict |
|---|---|---|---|---|---|
| NVNT | BLE 1M | 2402 | -2.38 | 10 | Pass |
| | | 2440 | -2.35 | 10 | Pass |
| | | 2480 | -1.23 | 10 | Pass |

Test Graphs

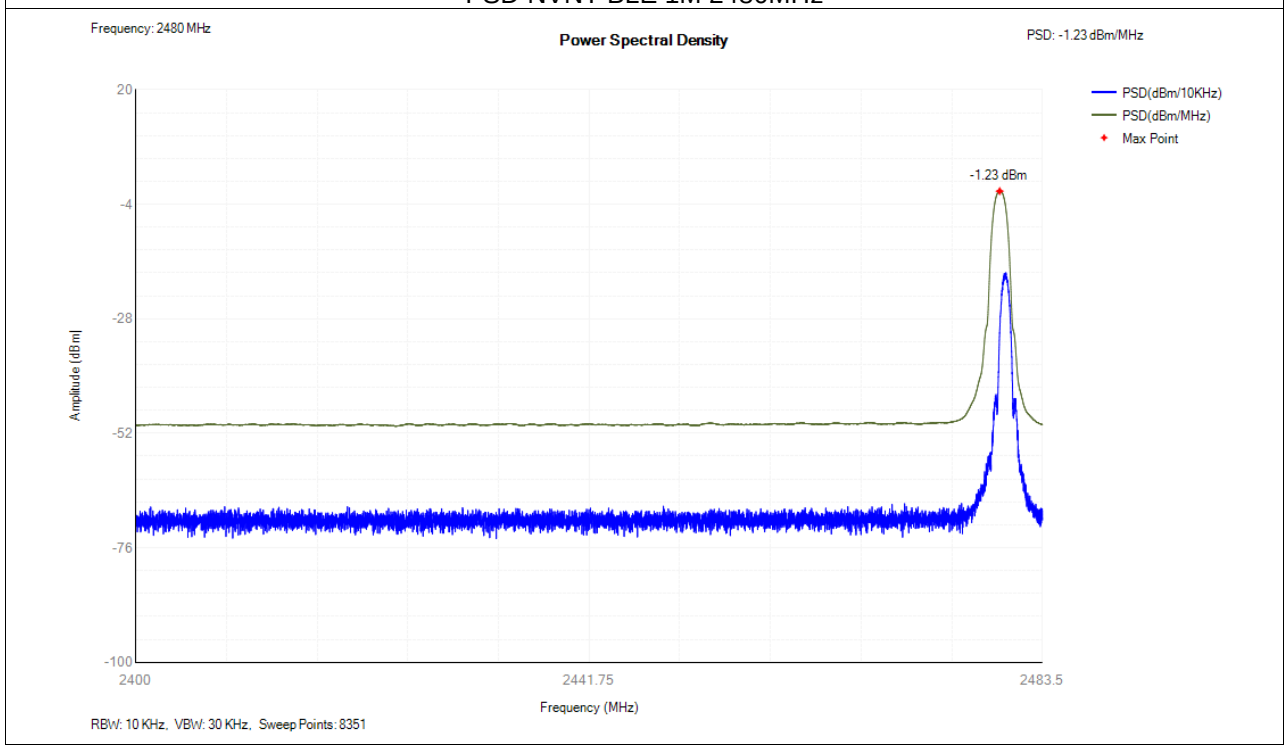
PSD NVNT BLE 1M 2402MHz




PSD NVNT BLE 1M 2440MHz

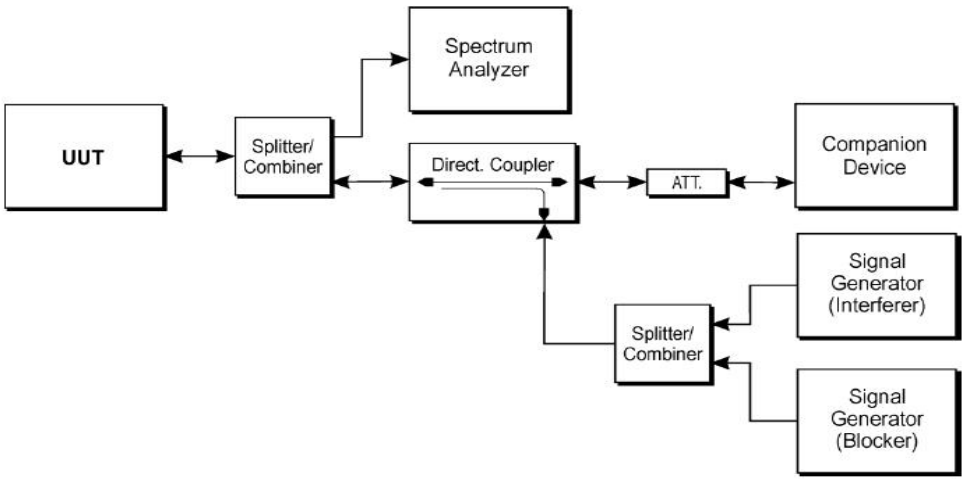


PSD NVNT BLE 1M 2480MHz



# 9. Adaptivity

## 9.1 Block Diagram Of Test Setup




## 9.2 Limit

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

| |
|---|
| Non-LBT based Detect a nd Avoid:<br>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;<br>2 COT ≤ 40 ms;<br>3 Idle Period = 5% of COT;<br>4 Detection threshold level = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.) |
| LBT based Detect and Avoid (Frame Based Equipment):<br>1 Minimum Clear Channel Assessment (CCA) time ⩾ 18 us;<br>2 CCA observation time declared by the supplier;<br>3 COT = 1~10 ms;<br>4 Idle Period = 5% of COT;<br>5 Detection threshold level = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.) |
| LBT based Detect and Avoid (Load Based Equipment):<br>1 Minimum Clear Channel Assessment (CCA) time ⩾ 18 us;<br>2 CCA declared by the manufacturer;<br>3 COT ≤ (13 / 32) * q ms; q = [4~32]; 1.625ms~13ms;<br>4 Detection threshold level = -70 dBm/MHz + 10 × log10 (100 mW / Pout) (Pout in mW e.i.r.p.) |
| Short Control Signalling Transmissions:<br>Short Control Signalling Transmissions shall have a maximum duty cycle of 10% within an observation period of 50ms. |

## 9.3 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:**

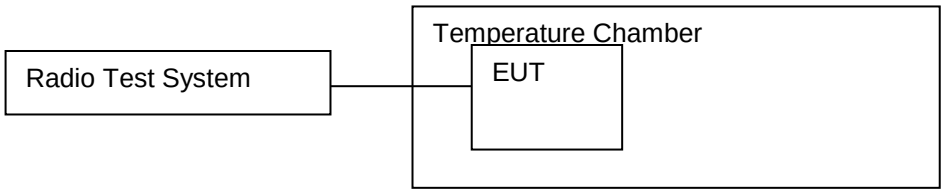
The steps 2 to 6 shall be repeated for each of the frequencies to be tested.

## 9.4 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.

# 10. Occupied Channel Bandwidth

## 10.1 Block Diagram Of Test Setup




## 10.2 Limit

The Occupied Channel Bandwidth shall fall completely within the band given in 2.4GHz to 2.4835GHz.
In addition, for non-adaptive non-FHSS equipment with e.i.r.p. greater than 10 dBm, the Occupied Channel Bandwidth shall be equal to or less than 20 MHz.

## 10.3 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:**

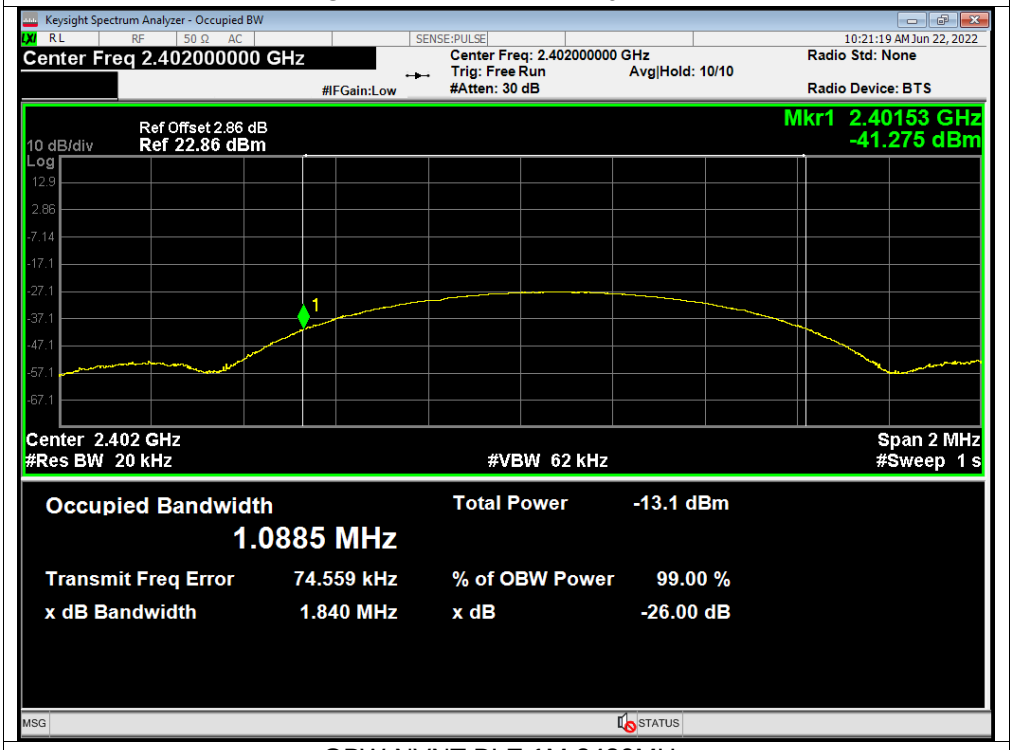
Use the 99 % bandwidth function of the spectrum analyser to measure the Occupied Channel Bandwidth of the UUT.
This value shall be recorded.
NOTE: Make sure that the power envelope is sufficiently above the noise floor of the analyser to avoid the noise signals left and right from the power envelope being taken into account by this measurement.

## 10.4 Test Result

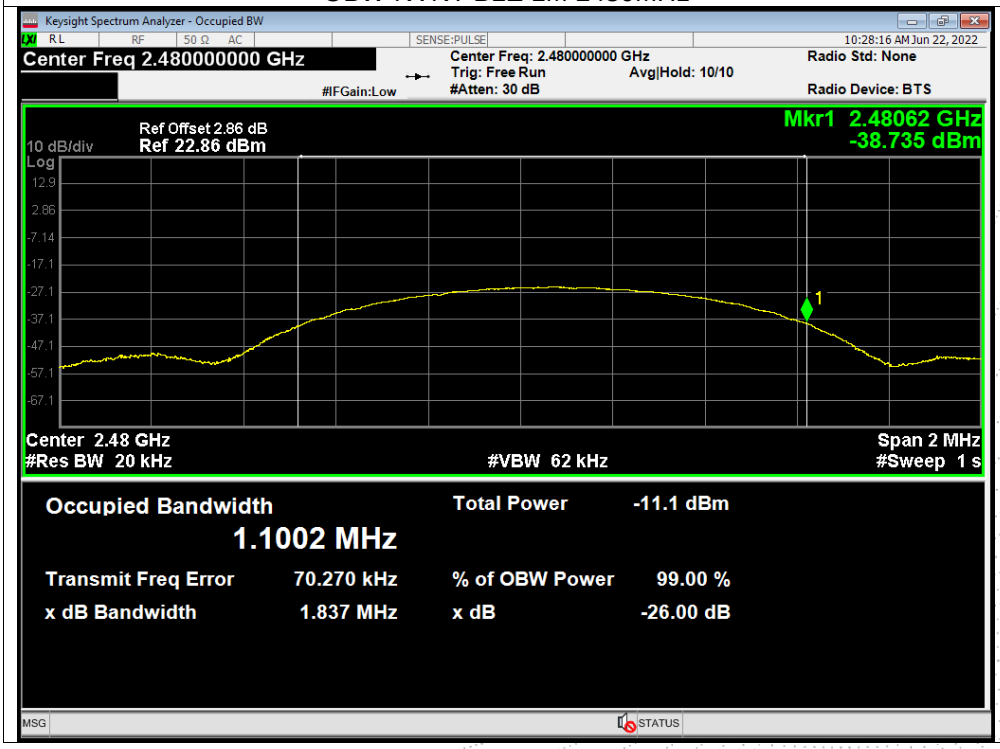
| Condition | Mode | Frequency (MHz) | OBW (MHz) | Lower Edge (MHz) | Upper Edge (MHz) | Limit OBW (MHz) | Verdict |
|---|---|---|---|---|---|---|---|
| NVNT | BLE 1M | 2402 MHz | 1.089 | 2401.53 | 2402.619 | 2400 - 2483.5MHz | Pass |
| | BLE 1M | 2480 MHz | 1.1 | 2479.52 | 2480.62 | | Pass |

Test Graphs

OBW NVNT BLE 1M 2402MHz

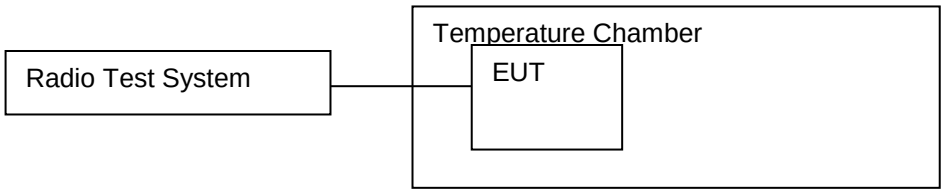



OBW NVNT BLE 1M 2480MHz



# 11. Transmitter Unwanted Emissions In The Out-Of-Band Domain

## 11.1 Block Diagram Of Test Setup




## 11.2 Limit

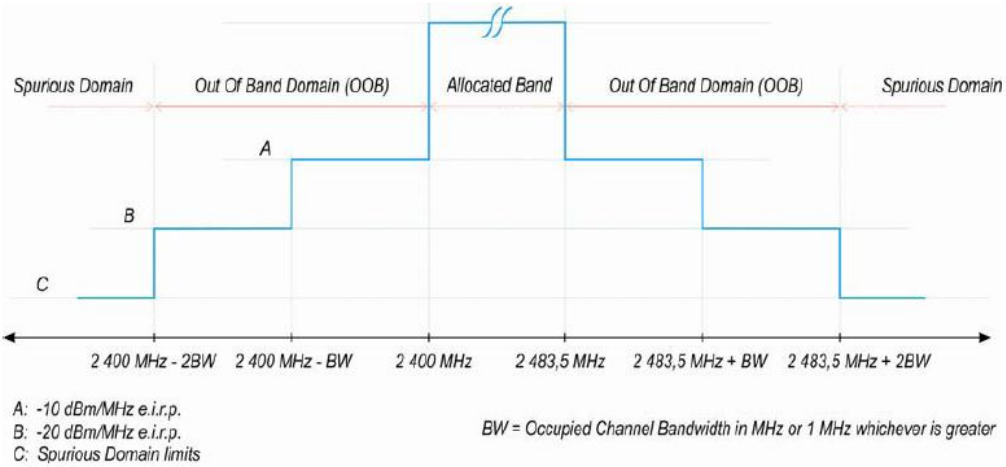



**Figure 3: Transmit mask**

## 11.3 Test procedure

The applicable mask is defined by the measurement results from the tests performed under clause 5.4.7 (Occupied Channel Bandwidth).
The Out-of-band emissions within the different horizontal segments of the mask provided in figure 1 and figure 3 shall be measured using the procedure in step 1 to step 6 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:

-Measurement Mode: Time Domain Power
- Centre Frequency: 2 484 MHz
- Span: Zero Span
- Resolution BW: 1 MHz
- Filter mode: Channel filter
- Video BW: 3 MHz
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep Mode: Single Sweep
- Sweep Points: Sweep time [µs] / (1 µs) with a maximum of 30 000
- Trigger Mode: Video

-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):**

• The measurement shall be performed and repeated while the trigger level is increased until no triggering takes place.

• For FHSS 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.

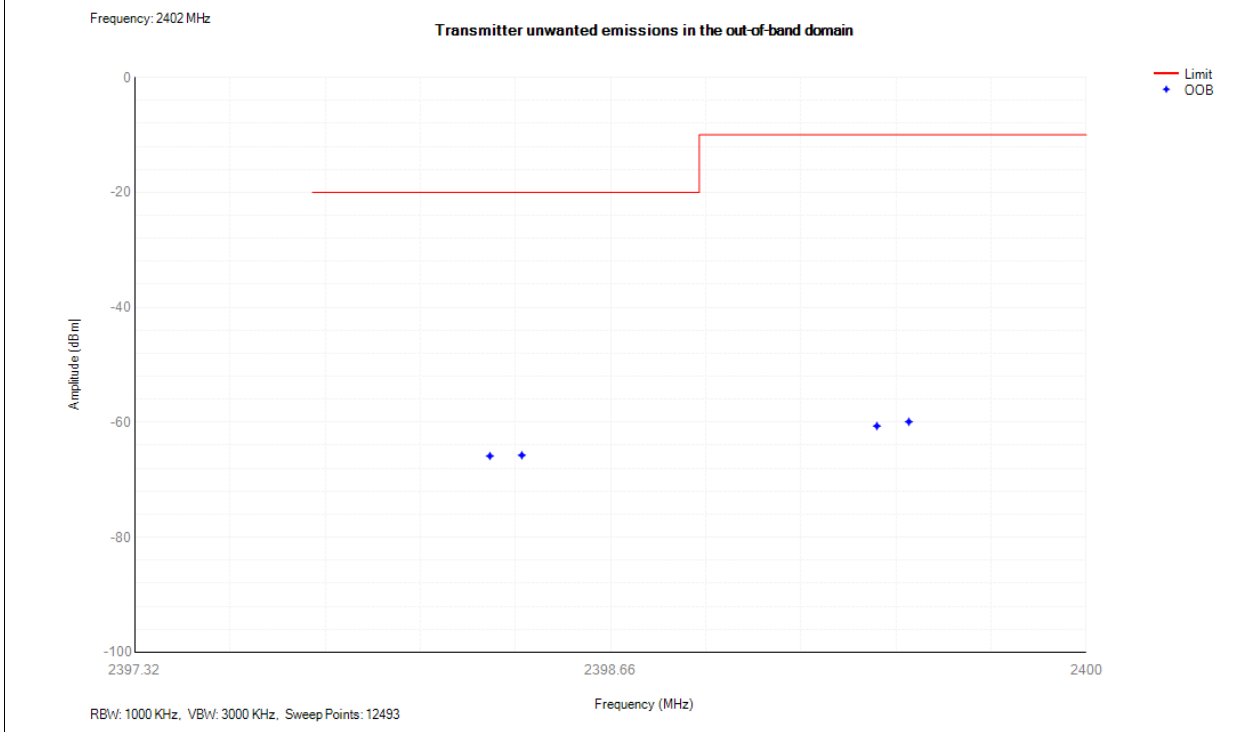
NOTE: Ach refers to the number of active transmit chains.

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

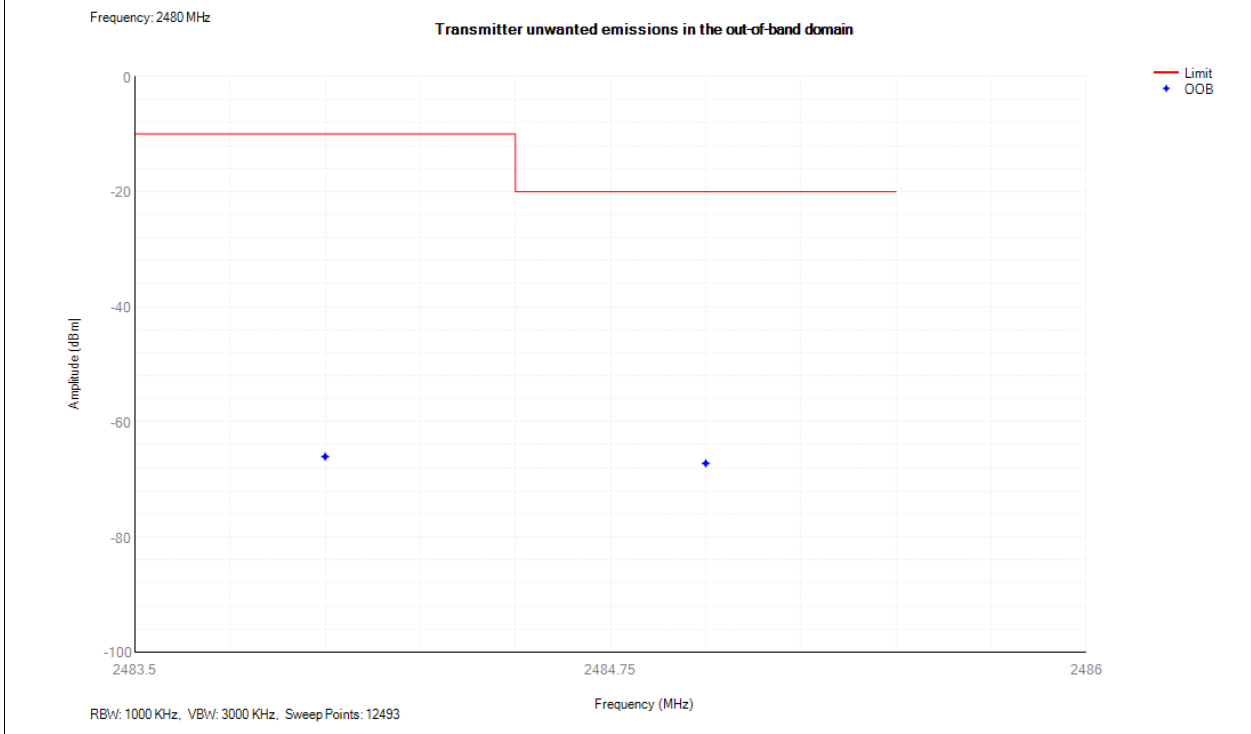
## 11.4 Test Result

| Condition | Mode | Frequency (MHz) | OOB Frequency (MHz) | Level (dBm/MHz) | Limit (dBm/MHz) | Verdict |
|---|---|---|---|---|---|---|
| NVNT | BLE 1M | 2402 | 2399.5 | -59.9 | -10 | Pass |
| | BLE 1M | 2480 | 2485 | -67.2 | -20 | Pass |

| Test Graphs |
| --- |
| Tx. Emissions OOB NVNT BLE 1M 2402MHz |



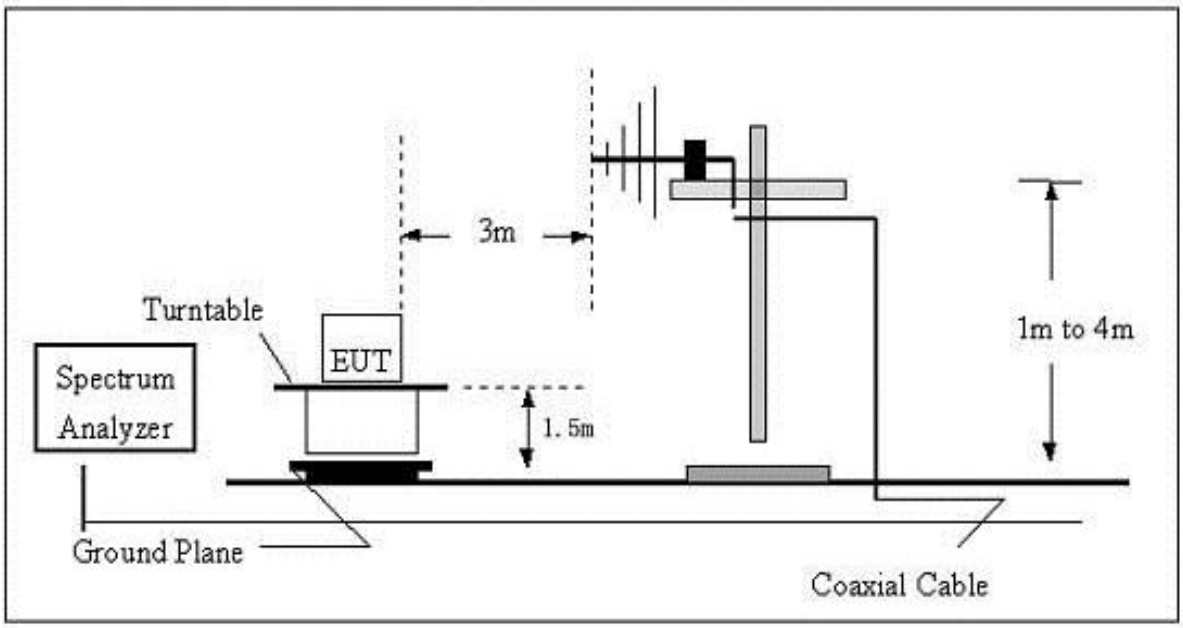

| Tx. Emissions OOB NVNT BLE 1M 2480MHz |
| --- |



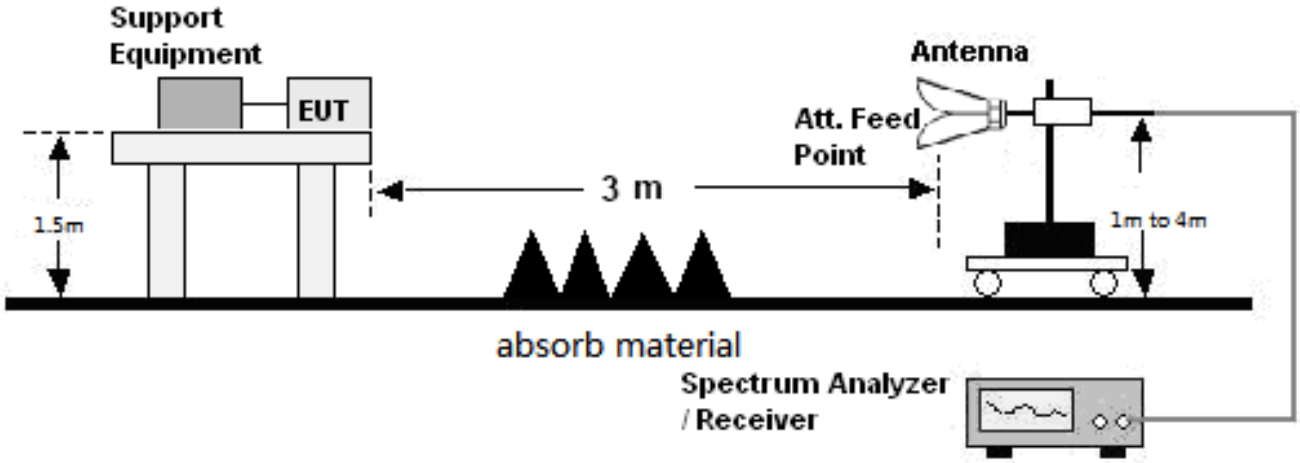
## 12. Transmitter Unwanted Emissions In The Spurious Domain

### 12.1 Block Diagram Of Test Setup

(A)Radiated Emission Test Set-Up Frequency Below 1GHz.




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



## 12.2 Limits

| Frequency Range | Maximum power | bandwidth |
|---|---|---|
| 30 MHz to 47 MHz | -36dBm | 100kHz |
| 47 MHz to 74 MHz | -54dBm | 100kHz |
| 74 MHz to 87.5 MHz | -36dBm | 100kHz |
| 87.5MHz to118 MHz | -54dBm | 100kHz |
| 118 MHz to174MHz | -36dBm | 100kHz |
| 174MHz to 230MHz | -54dBm | 100kHz |
| 230 MHz to 470 MHz | -36dBm | 100kHz |
| 470 MHz to 694 MHz | -54dBm | 100kHz |
| 694 MHz to1 GHz | -36dBm | 100kHz |
| 1GHz to12.75 GHz | -30dBm | 1MHz |

## 12.3 Test Procedure

**30MHz ~ 1GHz:**
a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.
b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.
**Above 1GHz:**
a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..
b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.

## 12.4 Test Results

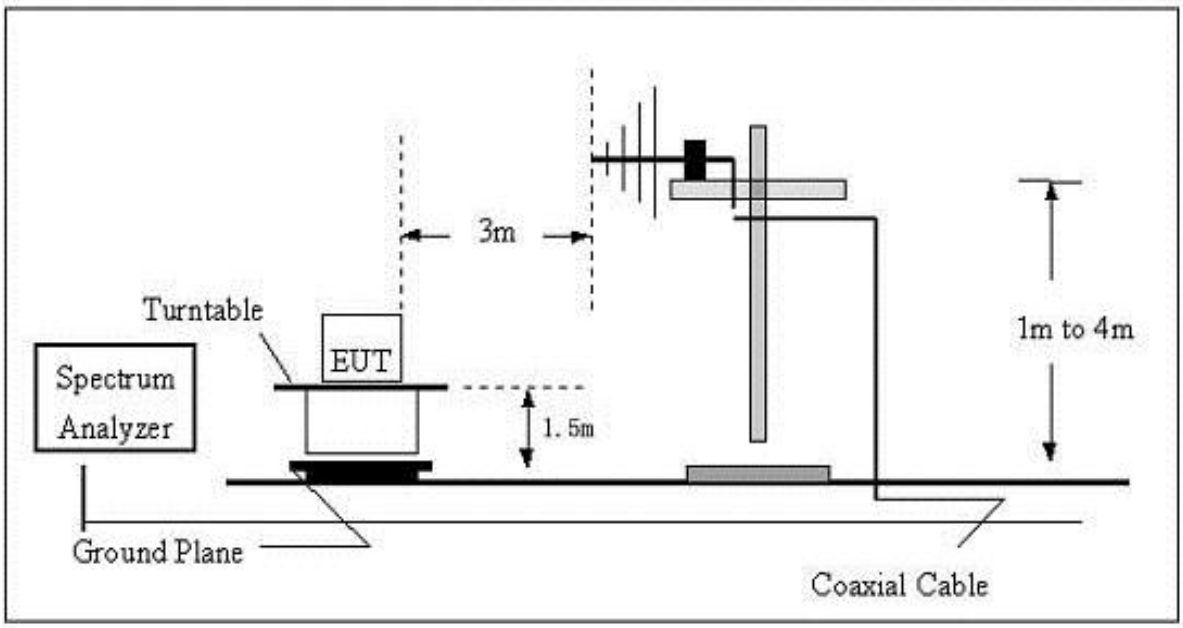
| Frequency | Receiver Reading | Turn table Angle | RX Antenna | | Correct | Absolute Level | Result | |
|---|---|---|---|---|---|---|---|---|
| | | | Height | Polar | Factor | | Limit | Margin |
| (MHz) | (dBm) | Degree | (m) | (H/V) | (dBm) | (dBm) | (dBm) | (dB) |
| GFSK low channel | | | | | | | | |
| 525.61 | -55.55 | 312 | 1.3 | H | -7.68 | -63.23 | -54 | -9.23 |
| 525.61 | -55.44 | 324 | 1.2 | V | -7.68 | -63.12 | -54 | -9.12 |
| 4804.00 | -45.56 | 341 | 1.5 | H | -0.43 | -45.99 | -30 | -15.99 |
| 4804.00 | -43.72 | 35 | 1.9 | V | -0.43 | -44.15 | -30 | -14.15 |
| 7206.00 | -60.41 | 209 | 1.2 | H | 8.31 | -52.10 | -30 | -22.10 |
| 7206.00 | -62.87 | 16 | 1.4 | V | 8.31 | -54.56 | -30 | -24.56 |
| GFSK high channel | | | | | | | | |
| 550.00 | -55.64 | 122 | 1.7 | H | -7.68 | -63.32 | -54 | -9.32 |
| 525.61 | -54.45 | 254 | 1.9 | V | -7.68 | -62.13 | -54 | -8.13 |
| 4960.00 | -46.02 | 289 | 1.5 | H | -0.32 | -46.34 | -30 | -16.34 |
| 4960.00 | -44.61 | 193 | 1.3 | V | -0.32 | -44.93 | -30 | -14.93 |
| 7440.00 | -59.76 | 346 | 1.2 | H | 9.35 | -50.41 | -30 | -20.41 |
| 7440.00 | -62.28 | 335 | 1.9 | V | 9.35 | -52.93 | -30 | -22.93 |

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

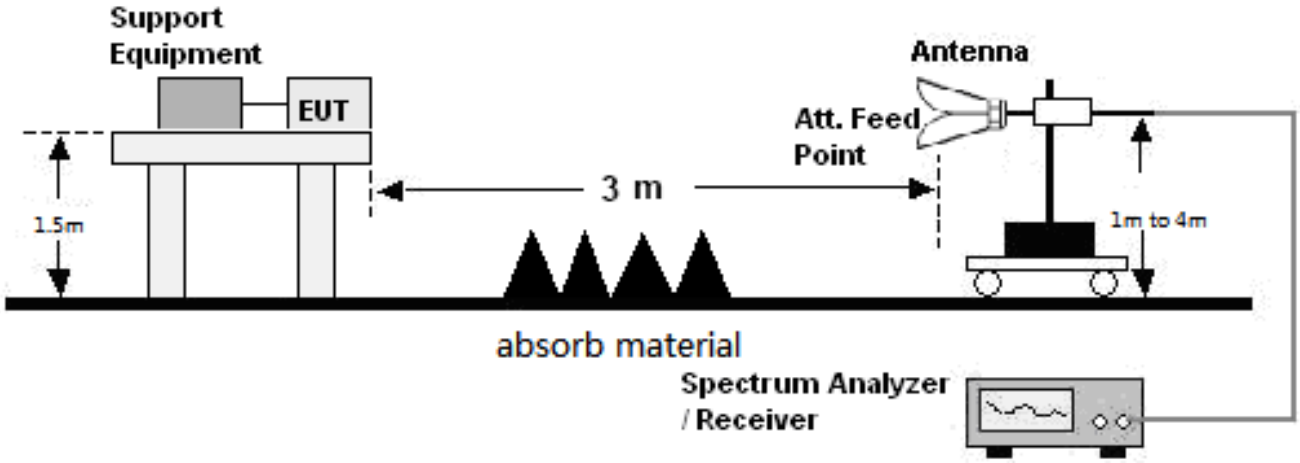
## 13. Receiver Spurious Emissions

### 13.1 Block Diagram Of Test Setup

(A)Radiated Emission Test Set-Up Frequency Below 1GHz.




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



## 13.2 Limits

| Frequency Range | Maximum power | Measurement Width |
|---|---|---|
| 30 MHz to 1 GHz | -57 dBm | 100kHz |
| 1 GHz to 12.75 GHz | -47 dBm | 1MHz |

## 13.3 Test Procedure

**30MHz ~ 1GHz:**
a. The Product was placed on the nonconductive turntable 1.5m above the ground in a full anechoic chamber.
b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 120 kHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied between 1~4 m in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
c. For each frequency whose maximum record was higher or close to limit, measure its QP value: vary the antenna's height and rotate the turntable from 0 to 360 degrees to find the height and degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to QP Detector and specified bandwidth with Maximum Hold Mode, and record the maximum value.
**Above 1GHz:**
a. The Product was placed on the non-conductive turntable 1.5 m above the ground in a full anechoic chamber..
b. Set the spectrum analyzer/receiver in Peak detector, Max Hold mode, and 1MHz RBW. Record the maximum field strength of all the pre-scan process in the full band when the antenna is varied in both horizontal and vertical, and the turntable is rotated from 0 to 360 degrees.
c. For each frequency whose maximum record was higher or close to limit, measure its AV value: rotate the turntable from 0 to 360 degrees to find the degree where Product radiated the maximum emission, then set the test frequency analyzer/receiver to AV value and specified bandwidth with Maximum Hold Mode, and record the maximum value.

## 13.4 Test Results

| Frequency | Receiver Reading | Turn table Angle | RX Antenna | | Correct | Absolute Level | Result | |
|---|---|---|---|---|---|---|---|---|
| | | | Height | Polar | Factor | | Limit | Margin |
| (MHz) | (dBm) | Degree | (m) | (H/V) | (dBm) | (dBm) | (dBm) | (dB) |
| GFSK low channel | | | | | | | | |
| 366.58 | -54.58 | 266 | 1.4 | H | -11.84 | -66.42 | -57.00 | -9.42 |
| 366.58 | -55.69 | 49 | 1.5 | V | -11.84 | -67.53 | -57.00 | -10.53 |
| 2489.68 | -51.25 | 278 | 1.1 | H | -6.80 | -58.05 | -47.00 | -11.05 |
| 2489.68 | -53.16 | 297 | 1.9 | V | -6.80 | -59.96 | -47.00 | -12.96 |
| GFSK high channel | | | | | | | | |
| 366.58 | -54.76 | 333 | 1.9 | H | -11.84 | -66.60 | -57.00 | -9.60 |
| 366.58 | -54.99 | 258 | 1.3 | V | -11.84 | -66.83 | -57.00 | -9.83 |
| 2489.68 | -50.58 | 254 | 1.9 | H | -6.80 | -57.38 | -47.00 | -10.38 |
| 2489.68 | -52.70 | 165 | 1.4 | V | -6.80 | -59.50 | -47.00 | -12.50 |

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

# 14. Receiver Blocking

## 14.1 Limit

For equipment that supports a PER or FER test to be performed, the minimum performance criterion shall be a PER or FER less than or equal to 10 %.
For equipment that does not support a PER or a FER test to be performed, the minimum performance criterion shall be no loss of the wireless transmission function needed for the intended use of the equipment
■ General
While maintaining the minimum performance criteria as defined in clause 4.3.1.12.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in below.
●Receiver Category 1
Receiver Blocking parameters for Receiver Category 1 equipment

| Wanted signal mean power from companion device (dBm) | Blocking signal frequency (MHz) | Blocking signal power (dBm) (see note 4) | Type of blocking signal |
|---|---|---|---|
| (-133 dBm + 10 × log10(OCBW)) or -68 dBm whichever is less (see note 2) | 2 380<br>2 503,5 | -34 | CW |
| (-139 dBm + 10 × log10(OCBW)) or -74 dBm whichever is less (see note 3) | 2 300<br>2 330<br>2 360<br>2 524<br>2 584<br>2 674 | -34 | CW |
| NOTE 1: OCBW is in Hz.<br>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 Pmin + 26 dB where Pmin 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.<br>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 Pmin + 20 dB where Pmin 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.<br>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. | | | |

●Receiver Category 2

Receiver Blocking parameters receiver category 2 equipment

| Wanted signal mean power from companion device (dBm) | Blocking signal frequency (MHz) | Blocking signal power (dBm) (see note 3) | Type of blocking signal |
|---|---|---|---|
| (-139 dBm + 10 × log10(OCBW) + 10 dB) or (-74 dBm + 10 dB) whichever is less (see note 2) | 2 380<br>2 504<br>2 300<br>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 Pmin + 26 dB where Pmin 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.

●Receiver Category 3

Receiver Blocking parameters receiver category 3 equipment

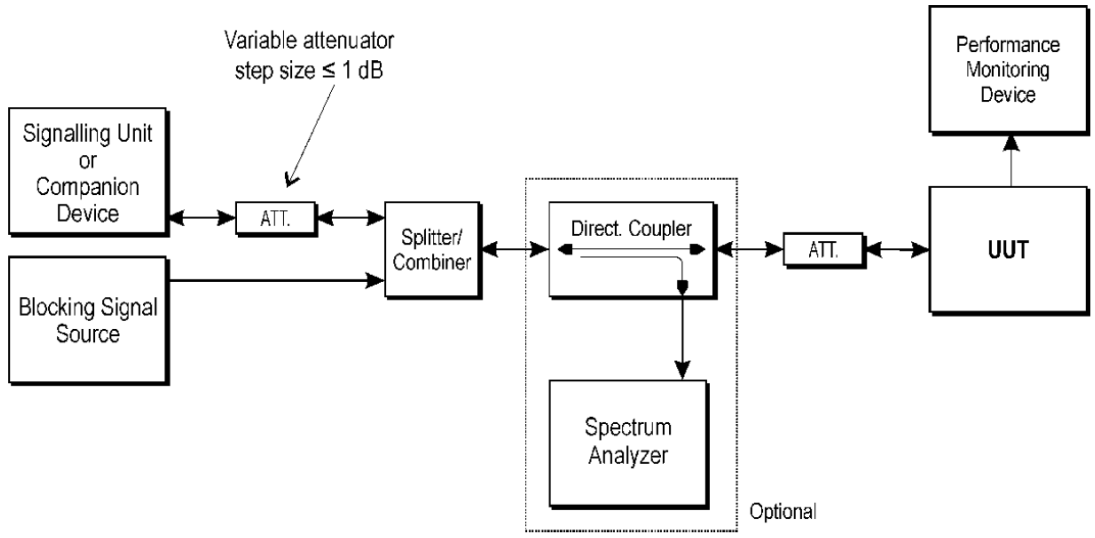
| Wanted signal mean power from companion device (dBm) | Blocking signal frequency (MHz) | Blocking signal power (dBm) (see note 3) | Type of blocking signal |
|---|---|---|---|
| (-139 dBm + 10 × log10(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less (see note 2) | 2 380<br>2 504<br>2 300<br>2 584 | -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 Pmin + 30 dB where Pmin 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.

## 14.2 Block Diagram Of Test Setup




## 14.3 Test procedure

Refer to ETSI EN 300 328 V2.2.2 (2019-07) Clause 5.4.11.2.

## 14.4 Test Result

Receiver category

| | | |
|---|---|---|
| ☐ | Receiver category 1 | Adaptive equipment with a maximum RF output power greater than 10 dBm e.i.r.p. shall be considered as receiver category 1 equipment. |
| ☐ | Receiver category 2 | Non-adaptive equipment with a Medium Utilization (MU) factor greater than 1 % and less than or equal to 10 % or adaptive equipment with a maximum RF output power of 10 dBm e.i.r.p. shall be considered as receiver category 2 equipment. |
| ☒ | Receiver category 3 | Non-adaptive equipment with a maximum Medium Utilization (MU) factor of 1 % or adaptive equipment with a maximum RF output power of 0 dBm e.i.r.p. shall be considered as receiver category 3 equipment. |

| **Receiver Category 3** | | | | | |
|---|---|---|---|---|---|
| **GFSK Transmitting** | **Wanted Signal Power(dBm)** | **Blocking Frequency(MHz)** | **Blocking Power(dB)** | **Measured PER(%)** | **Limit (%)** |
| 2402 | -58.59 | 2380 | -34 | 0 | 10 |
| 2402 | -58.59 | 2300 | -34 | 0 | 10 |
| 2480 | -58.59 | 2504 | -34 | 1.76 | 10 |
| 2480 | -58.59 | 2584 | -34 | 0.1 | 10 |

Note:

1) This report only shows the worst case test data.
   OCBW=1100000Hz
   (-139dBm+10*log10(OCBW)+20dB)=-58.59
   (-74dBm+20dB)=-54dBm
   -58.59dBm≤-54dBm
   Wanted Signal Power=-58.59dBm
2) In case of conducted measurements, the wanted signal and blocking signal level have corrected by the actual antenna gain

## 15. EUT Test Setup Photographs

Spurious Emission Test Setup



# STATEMENT

1.The equipment lists are traceable to the national reference standards.

2.The test report can not be partially copied unless prior written approval is issued from our lab.

3.The test report is invalid without stamp of laboratory.

4.The test report is invalid without signature of person(s) testing and authorizing.

5.The test process and test result is only related to the Unit Under Test.

6.The quality system of our laboratory is in accordance with ISO/IEC17025.

7.If there is any objection to report, the client should inform issuing laboratory within 15 days from the date of receiving test report.

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