



Test report No:
NIE: 64430RRF.001

PartiaTest report

ETSI EN 300 328 v2.2.2 (2019-07)

| | |
|---|--|
| (*) Identification of item tested | ISM band radio transceiver |
| (*) Trademark | N53 Series |
| (*) Model and /or type reference | nRF5340 |
| Other identification of the product | Hw version: N5340 QKAA, nRF53 DK v0.9 Sw version: nRF Connect SDK v1.3.0 4c0d3be2ed4ade4dc3e614e95e6f8e4330d663b4 FCC ID: Not Applicable IC: Not Applicable |
| (*) Features | Bluetooth LE, IEEE 802.15.4 |
| Manufacturer | NORDIC SEMICONDUCTOR ASA Otto Nielsens veg 12, N-7052 Trondheim, Norway |
| Test method requested, standard | ETSI EN 300 328 v2.2.2 (2019-07): Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz band; Harmonised Standard for access to radio spectrum |
| Summary | IN COMPLIANCE |
| Approved by (name / position & signature) | Jose Carlos Luque RF Lab. Supervisor |
| Date of issue | 2020-11-09 |
| Report template No | FDT08_22 (*) "Data provided by the client" |

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Uncertainty

Uncertainty (factor $k=2$) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample of the nRF5340 is an ISM band radio transceiver.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of result.

Usage of samples

Samples undergoing test have been selected by: The client.

- Sample S/01 is composed of the following elements:

| Control Nº | Description | Model | Serial Nº | Date of reception |
|------------|----------------------------|---------|-----------|-------------------|
| 64430/005 | ISM band radio transceiver | nRF5340 | 01 | 2020/06/15 |
| 64430/004 | Antenna | -- | -- | 2020/06/15 |

Sample S/01 has undergone the test(s): All tests indicated in Appendixes B, D and F, except the Receiver Blocking tests.

- Sample S/02 is composed of the following elements:

| Control Nº | Description | Model | Serial Nº | Date of reception |
|------------|----------------------------|---------|-----------|-------------------|
| 64430/003 | ISM band radio transceiver | nRF5340 | -- | 2020/06/15 |

Sample S/02 has undergone the test(s): Receiver blocking tests indicated in Appendixes B, D and F.

Test sample description

| | | | | | |
|---|--|--------------------------|--------------------------|--------------------------|-----------------------------------|
| Ports..... : | Port name and description | Cable | | | |
| | | Specified max length [m] | Attached during test | Shielded | Coupled to patient ⁽³⁾ |
| | | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Supplementary information to the ports..... : | -- | | | | |
| Rated power supply | Voltage and Frequency | | | | |
| | <input checked="" type="checkbox"/> | DC: 5V USB powered | | | |
| Rated Power | -- | | | | |
| Clock frequencies..... : | -- | | | | |
| Other parameters | -- | | | | |
| Software version | nRF Connect SDK v1.3.0 4c0d3be2ed4ade4dc3e614e95e6f8e4330d663b4 | | | | |
| Hardware version | N5340 QKAA, nRF53 DK v0.9 | | | | |
| Dimensions in cm (W x H x D) | 135mm x 20mm x 65mm | | | | |
| Mounting position | <input checked="" type="checkbox"/> | Table top equipment | | | |
| Modules/parts..... : | Module/parts of test item | | Type | Manufacturer | |
| | | | | | |
| Accessories (not part of the test item) | Description | | Type | Manufacturer | |
| | | | | | |
| Documents as provided by the applicant | Description | | File name | Issue date | |
| | | | | | |

Identification of the client

NORDIC SEMICONDUCTOR ASA

Otto Nielsens veg 12, N-7052 Trondheim, Norway

Testing period and place

| | |
|---------------|--|
| Test Location | DEKRA Testing and Certification S.A.U. |
| Date (start) | 2020-06-17 |
| Date (finish) | 2020-09-02 |

Document history

| Report number | Date | Description |
|---------------|------------|---------------|
| 64430RRF.001 | 2020-11-09 | First release |

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

| | |
|-------------------|------------------------------|
| Temperature | Min. = 15 °C Max. = 35 °C |
| Relative humidity | Min. = 20 % Max. = 75 % |

In the semianechoic chamber, the following limits were not exceeded during the test.

| | |
|-------------------|------------------------------|
| Temperature | Min. = 15 °C Max. = 35 °C |
| Relative humidity | Min. = 20 % Max. = 75 % |

In the chamber for conducted measurements, the following limits were not exceeded during the test:

| | |
|-------------------|------------------------------|
| Temperature | Min. = 15 °C Max. = 35 °C |
| Relative humidity | Min. = 20 % Max. = 75 % |

Remarks and comments

The tests have been performed by the technical personnel: Jaime Barranquero, José Manuel Jiménez, Cristina Calle, José Gabriel Pendón, Óscar San José and Raúl Ramos.

Used instrumentation:

Conducted Measurements:

| | | Last Calibration | Due Calibration |
|----|---|------------------|-----------------|
| 1. | Climatic chamber BINDER MK 56 | 2020/03 | 2021/03 |
| 2. | Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV 40 | 2019/09 | 2021/09 |
| 3. | Signal Generator 8 KHz-6 GHz, ROHDE AND SCHWARZ SMB100B | 2019/10 | 2021/10 |
| 4. | OPEN SWITCH UNIT UP TO 18 GHz OSP150 ROHDE AND SCHWARZ | 2019/09 | 2021/09 |
| 5. | Vector Signal Generator 8 kHz-6GHz ROHDE AND SCHWARZ SMBV100B | 2019/10 | 2020/10 |

Test system for Receiver Blocking test (Bluetooth Low Energy):

| Test System | TACS4 BEST RF Bluetooth Test System | | | | |
|-------------|-------------------------------------|--------------------------------|------------|-------------------------|-----------------------|
| Control No. | 5852 | | | | |
| Hardware: | Control No. | Equipment | Serial No. | Latest Calibration Date | Next Calibration Date |
| | 5767 | LAN/GPIB/USB E5810B | MY56030024 | N/A | N/A |
| | 5399 | Sweep Generator AGILENT E8257D | MY53401729 | 2019-11-25 | 2020-11-25 |
| | 5749 | R&S® CMW270 | 100651 | 2020-06-08 | 2021-10-08 |
| | 5853 | COMBINER UNIT T4BCU100A | 000001 | N/A | N/A |

Test system for Receiver Blocking test (IEEE 802.15.4 Zigbee):

| Test System | Zigbee Blocking Testbench | | | | |
|-------------|---------------------------|---|------------|-------------------------|-----------------------|
| Control No. | 7062 | | | | |
| Hardware: | Control No. | Equipment | Serial No. | Latest Calibration Date | Next Calibration Date |
| | 5400 | RF Signal Generator KEYSIGHT TECHNOLOGIES E4438C | MY49074245 | 2020-07-16 | 2021-07-16 |
| | 4741 | RF Signal Generator AGILENT TECHNOLOGIES E4438C | MY49073010 | 2020-07-15 | 2021-07-15 |

Radiated Measurements:

| | | Last Calibration | Due Calibration |
|----|--|------------------|-----------------|
| 1. | Semianechoic Absorber Lined Chamber ALBATROSS P29419 | 2020/01 | 2023/01 |
| 2. | Ultralog Antenna 30MHz-6GHz, ROHDE AND SCHWARZ HL562E_UPG | 2019/10 | 2022/10 |
| 3. | Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D | 2019/11 | 2022/11 |
| 4. | EMI Test Receiver 2Hz-44GHz, ROHDE AND SCHWARZ ESW44 | 2019/10 | 2021/10 |
| 5. | Pre-amplifier 30dB 500MHz-18GHz, SCHWARZBECK BBV 9718 C | 2020/01 | 2021/01 |

Testing verdicts

| | |
|-----------------|-----|
| Not applicable: | N/A |
| Pass: | P |
| Fail: | F |
| Not measured: | N/M |

Summary

1. Bluetooth Low Energy 5.0 (2M, 1M)

| ETSI EN 300 328 | | | |
|--|---|---------|--------|
| Requirement – Test case | | Verdict | Remark |
| 4.3.2.2 | Transmitter. RF Output Power | P | (3) |
| 4.3.2.3 | Transmitter. Power Spectral Density | P | (3) |
| 4.3.2.4 | Transmitter. Duty cycle, Tx-Sequence, Tx-gap | N/A | (1) |
| 4.3.2.5 | Medium Utilisation | N/A | (1) |
| 4.3.2.6 | Adaptivity | N/A | (1) |
| 4.3.2.7 | Occupied Channel Bandwidth | P | (3) |
| 4.3.2.8 | Transmitter unwanted emissions in the out-of-band domain | P | (3) |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (conducted) | N/A | |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (radiated) | P | (3) |
| 4.3.2.10 | Receiver spurious emissions (conducted) | N/A | |
| 4.3.2.10 | Receiver spurious emissions (radiated) | P | (3) |
| 4.3.2.11 | Receiver blocking | P | (3) |
| 4.3.2.12 | Geo-location capability | N/A | (2) |
| <u>Supplementary information and remarks:</u> (1) The equipment is declared as non-adaptive equipment using non-FHSS modulation. The maximum declared RF Output power level is less than 10 dBm e.i.r.p. (2) The equipment does not implement geo-location capability as defined in clauses 4.3.2.12.2. (3) Test for only 2M operating mode was requested | | | |

2. IEEE 802.15.4 Zigbee

| ETSI EN 300 328 | | | |
|---|---|---------|--------|
| Requirement – Test case | | Verdict | Remark |
| 4.3.2.2 | Transmitter. RF Output Power | P | |
| 4.3.2.3 | Transmitter. Power Spectral Density | P | |
| 4.3.2.4 | Transmitter. Duty cycle, Tx-Sequence, Tx-gap | N/A | (1) |
| 4.3.2.5 | Medium Utilisation | N/A | (1) |
| 4.3.2.6 | Adaptivity | N/A | (1) |
| 4.3.2.7 | Occupied Channel Bandwidth | P | |
| 4.3.2.8 | Transmitter unwanted emissions in the out-of-band domain | P | |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (conducted) | N/A | |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (radiated) | P | |
| 4.3.2.10 | Receiver spurious emissions (conducted) | N/A | |
| 4.3.2.10 | Receiver spurious emissions (radiated) | P | |
| 4.3.2.11 | Receiver blocking | P | |
| 4.3.2.12 | Geo-location capability | N/A | (2) |
| <u>Supplementary information and remarks:</u> (1) The equipment is declared as non-adaptive equipment using non-FHSS modulation. The maximum declared RF Output power level is less than 10 dBm e.i.r.p. (2) The equipment does not implement geo-location capability as defined in clauses 4.3.2.12.2. | | | |

3. Proprietary protocol: Long Range

| ETSI EN 300 328 | | | |
|---|---|---------|--------|
| Requirement – Test case | | Verdict | Remark |
| 4.3.2.2 | Transmitter. RF Output Power | P | |
| 4.3.2.3 | Transmitter. Power Spectral Density | P | |
| 4.3.2.4 | Transmitter. Duty cycle, Tx-Sequence, Tx-gap | N/A | (1) |
| 4.3.2.5 | Medium Utilisation | N/A | (1) |
| 4.3.2.6 | Adaptivity | N/A | (1) |
| 4.3.2.7 | Occupied Channel Bandwidth | P | |
| 4.3.2.8 | Transmitter unwanted emissions in the out-of-band domain | P | |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (conducted) | N/A | |
| 4.3.2.9 | Transmitter unwanted emissions in the spurious domain (radiated) | P | |
| 4.3.2.10 | Receiver spurious emissions (conducted) | N/A | |
| 4.3.2.10 | Receiver spurious emissions (radiated) | P | |
| 4.3.2.11 | Receiver blocking | P | |
| 4.3.2.12 | Geo-location capability | N/A | (2) |
| <u>Supplementary information and remarks:</u> (1) The equipment is declared as non-adaptive equipment using non-FHSS modulation. The maximum declared RF Output power level is less than 10 dBm e.i.r.p. (2) The equipment does not implement geo-location capability as defined in clauses 4.3.2.12.2. | | | |

Appendix A: Application form for testing. Bluetooth Low Energy 5.0 (2M, 1M)

Information as required by EN 300 328 V2.2.2, clause 5.4.1

In accordance with ETSI EN 300 328, clause 5.4.1, the following information is provided by the manufacturer.

a) The type of wideband data transmission equipment:

- ☐ FHSS
- ☒ other forms of modulation

b) In case of FHSS:

- In case of non-Adaptive FHSS equipment:
The number of Hopping Frequencies:
- In case of Adaptive FHSS equipment:
The maximum number of Hopping Frequencies:
The minimum number of Hopping Frequencies:- The (average) dwell time:

c) Adaptive/non-adaptive equipment:

- ☒ non-adaptive Equipment
- ☐ adaptive Equipment without the possibility to switch to a non-adaptive mode
- ☐ adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The maximum Channel Occupancy Time implemented by the equipment: ms

☐ The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:
 - ☐ The equipment is Frame Based equipment
 - ☐ The equipment is Load Based equipment
 - ☐ The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: µs

- ☐ The equipment has implemented a non-LBT based DAA mechanism
- ☐ The equipment can operate in more than one adaptive mode
- ☐ The equipment has implemented Short Control Signalling Transmissions

e) In case of non-adaptive Equipment:

The maximum RF Output Power: 5.5 dBm

The maximum RF Output Power (e.i.r.p.): 6.5 dBm

The maximum (corresponding) Duty Cycle:

Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

.....

.....

.....

f) The worst case operational mode for each of the following tests:

- RF Output Power
 <6.5 dBm
- Power Spectral Density

- Duty cycle, Tx-Sequence, Tx-gap
 Not applicable
- Accumulated Transmit time, Frequency Occupation & Hopping Sequence (only for FHSS equipment)

- Hopping Frequency Separation (only for FHSS equipment)

- Medium Utilization

- Adaptivity & Receiver Blocking
 According to 4.3.2.11
- Nominal Channel Bandwidth
 1MHz, 2 MHz
- Transmitter unwanted emissions in the OOB domain

- Transmitter unwanted emissions in the spurious domain

- Receiver spurious emissions

g) 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™ 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™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 1: Add more lines if more channel bandwidths are supported.

☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

☐ Single spatial stream/Standard throughput (e.g. IEEE 802.11™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 2: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

• The number of Receive chains:

• The number of Transmit chains:

☐ symmetrical power distribution

☐ asymmetrical power distribution

In case of beam forming, the maximum (additional) beam forming gain: dB

NOTE: The additional beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

• Operating Frequency Range 1: 2400 MHz to 2480 MHz

• Operating Frequency Range 2: MHz to MHz

NOTE: Add more lines if more Frequency Ranges are supported.

j) Nominal Channel Bandwidth(s):

• Nominal Channel Bandwidth 1: 1 MHz

• Nominal Channel Bandwidth 2: 2 MHz

NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

☒ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other

l) The normal and the extreme operating conditions that apply to the equipment:

Normal operating conditions (if applicable):

Operating temperature:

Other (please specify if applicable): 25 ° C

Extreme operating conditions:

Operating temperature range: Minimum -40° C Maximum +85° C

Other (please specify if applicable): Minimum ° C Maximum ° C

Details provided are for the: ☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

m) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:

• Antenna Type:

☒ Integral Antenna

Antenna Gain: 1 dBi

If applicable, additional beamforming gain (excluding basic antenna gain): dB

☐ Temporary RF connector provided

☐ No temporary RF connector provided

☐ Dedicated Antennas (equipment with antenna connector)

☐ Single power level with corresponding antenna(s)

☐ Multiple power settings and corresponding antenna(s)

Number of different Power Levels:

Power Level 1: dBm

Power Level 2: dBm

Power Level 3: dBm

NOTE: These power levels are conducted power levels (at antenna connector).

- For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable

Power Level 1: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|----------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Power Level 2: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|----------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

n) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:

Details provided are for the: ☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

Supply Voltage ☐ AC mains State AC voltage V
☒ DC State DC voltage 5 V

In case of DC, indicate the type of power source

- ☐ Internal Power Supply
☐ External Power Supply or AC/DC adapter
☐ Battery
☒ Other: USB powered

o) Describe the test modes available which can facilitate testing:

.....

p) The equipment type (e.g. Bluetooth[®], IEEE 802.11[™], IEEE 802.15.4[™], proprietary, etc.):

Bluetooth LE 5.2

q) If applicable, the statistical analysis referred to in clause 5.4.1 q)

(to be provided as separate attachment)

r) If applicable, the statistical analysis referred to in clause 5.4.1 r)

(to be provided as separate attachment)

s) Geo-location capability supported by the equipment:

☐ Yes

☐ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.

☒ No

t) Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or clause 4.3.2.11.3):

PER less than or equal to 10 %.

Appendix B: Test results. Bluetooth Low Energy (2M, 1M)

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TEST CONDITIONS

POWER SUPPLY (V):

Vn: 5 Vdc

Type of Power Supply: USB.

ANTENNA:

Maximum Declared Antenna Gain: 1 dBi

TEMPERATURE (°C):

Tn: +15 to +35

Tmin: -40 (*)

Tmax: +85 (*)

The subscripts 'n', 'min' and 'max' indicate test conditions (normal, minimum and maximum respectively).

(*): Declared by applicant.

TEST FREQUENCIES FOR CONDUCTED TESTS:

Low Channel: 2402 MHz

Middle Channel: 2440 MHz

High Channel: 2480 MHz

TEST FREQUENCIES FOR RADIATED TESTS:

Low Channel: 2402 MHz

High Channel: 2480 MHz

(*) Test for only 2M operating mode was requested.

PRODUCT INFORMATION

The following information is provided by the supplier, in accordance with clause 5.4.1:

| Information | Description |
|---|--|
| Modulation: | Non-FHSS: GFSK |
| Adaptivity: | Non-adaptive equipment |
| Maximum RF Output Power (e.i.r.p.): | 6.5 dBm |
| Operation mode 1: Single Antenna Equipment. | Equipment with only one antenna |
| - Operating Frequency Range. | 2400 – 2480 MHz |
| - Nominal Channel Bandwidth. | 2M modulation: 2 MHz. 1M modulation: 1 MHz. |
| Extreme operating conditions: | |
| - Temperature range. | -40 to +85 °C |
| Antenna Type: | Internal (PCB) |
| Antenna Gain: | 1 dBi |
| Nominal Voltage: | |
| - Supply Voltage. | 5 Vdc |
| - Type of Power Supply. | USB powered |
| Type of Equipment: | Bluetooth Low Energy (2M) |
| Geo-location capability: | No |

Test modes available:

- Continuous modulated carrier at 2402 MHz, 2440 MHz and 2480 MHz.
- Continuous reception at 2402 MHz, 2440 MHz and 2480 MHz.

(*) Test for only 2M operating mode was requested.

4.3.2.2: RF output power

LIMITS:

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.

RESULTS:

Type of Equipment: Non-adaptive.

Maximum Declared Assembly Antenna Gain: 1 dBi

Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

- **2M modulation:**

| | | | TRANSMITTER POWER e.i.r.p. (dBm) | | |
|-------------------------|------------------|----------------|----------------------------------|------------------------------|----------------------------|
| Modulation | TEST CONDITIONS | | Low Channel (2402 MHz) | Middle Channel (2440 MHz) | High Channel (2480 MHz) |
| GFSK | T _n | V _n | 5.32 | 5.12 | 5.04 |
| | T _{min} | | 6.42 | 6.23 | 6.15 |
| | T _{max} | | 4.42 | 4.25 | 4.17 |
| Measurement uncertainty | | | <±0.99 dB | | |

Note: P is the e.i.r.p. as defined in clause 5.4.2.2.1.2 step 6.

Verdict: PASS

4.3.2.3: Power Spectral Density

LIMITS:

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

RESULTS:

Type of Equipment: Non-adaptive

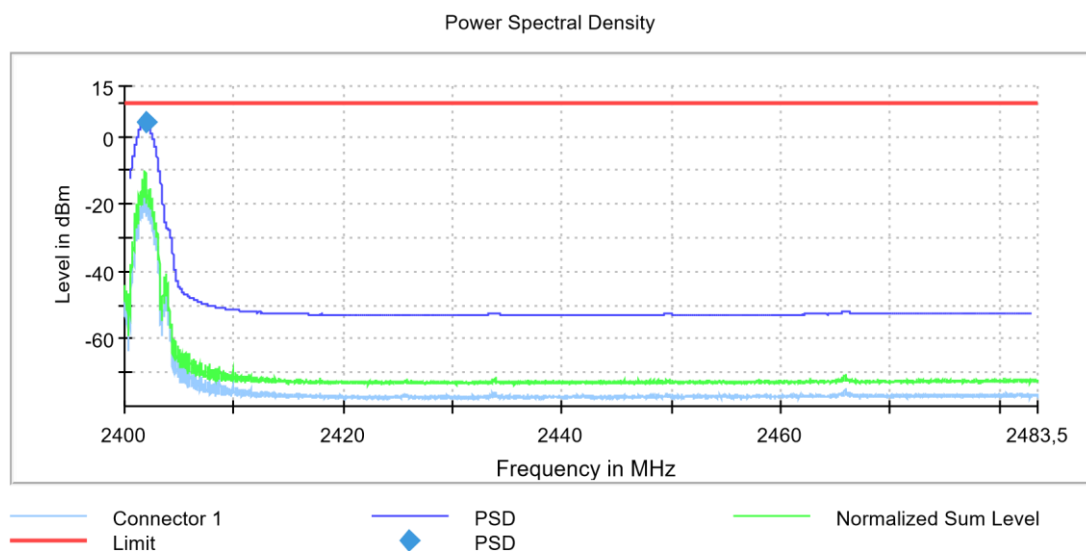
Maximum Declared Assembly Antenna Gain: 1 dBi

Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

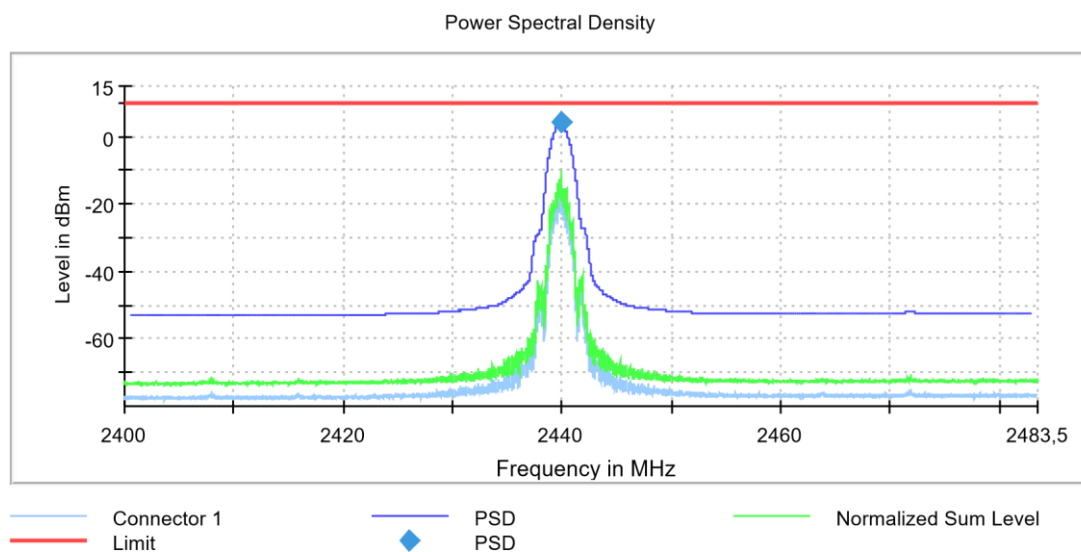
- 2M modulation:**

| | Lowest frequency 2401.914771 MHz | Middle frequency 2439.910220 MHz | Highest frequency 2479.905430 MHz |
|---------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|
| Measured Power Spectral Density | 4.326 dBm/1 MHz | 4.089 dBm/1 MHz | 3.970 dBm/1 MHz |
| Measurement uncertainty | <±0.99 dB | | |

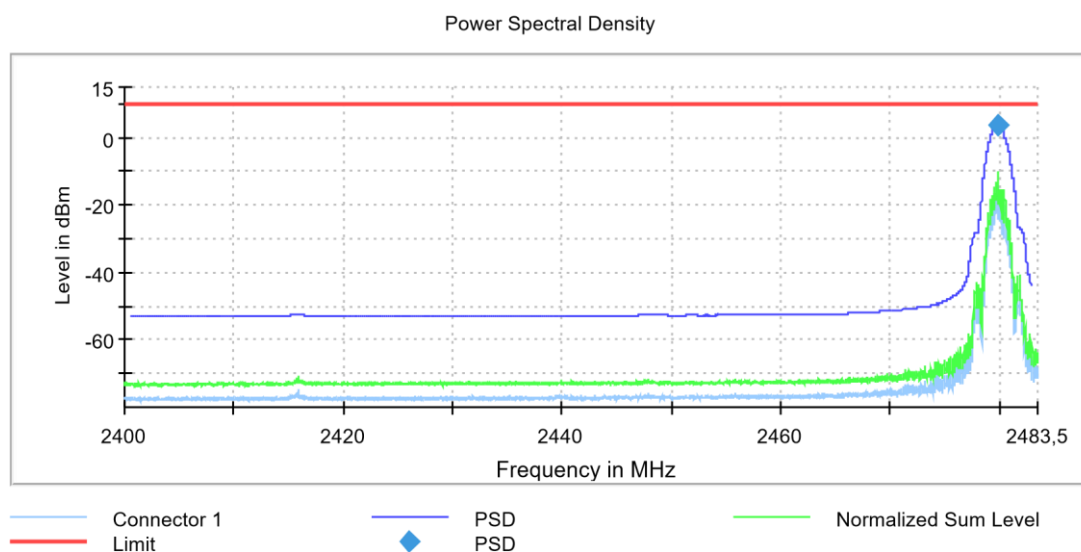
- Low Channel:



- Middle Channel:



- High Channel:



Verdict: PASS

4.3.2.7: Occupied Channel Bandwidth

LIMITS:

The Occupied Channel Bandwidth shall be within the band given in table 1.

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.

Table 1: Service frequency bands

| | Service frequency bands |
|----------|--------------------------|
| Transmit | 2 400 MHz to 2 483,5 MHz |
| Receive | 2 400 MHz to 2 483,5 MHz |

RESULTS:

Type of Equipment: Non-adaptive

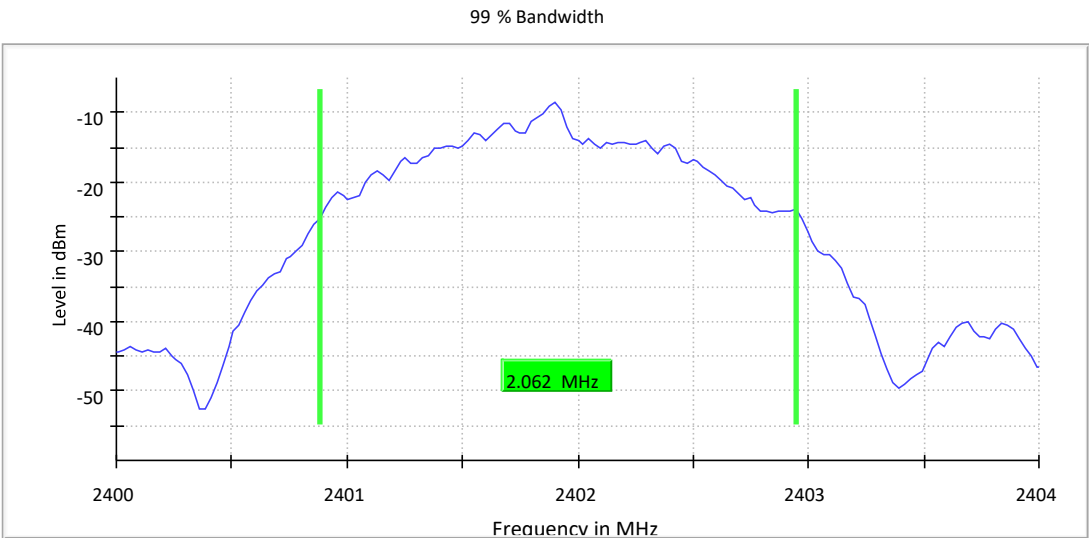
Maximum Declared Assembly Antenna Gain: 1 dBi

Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

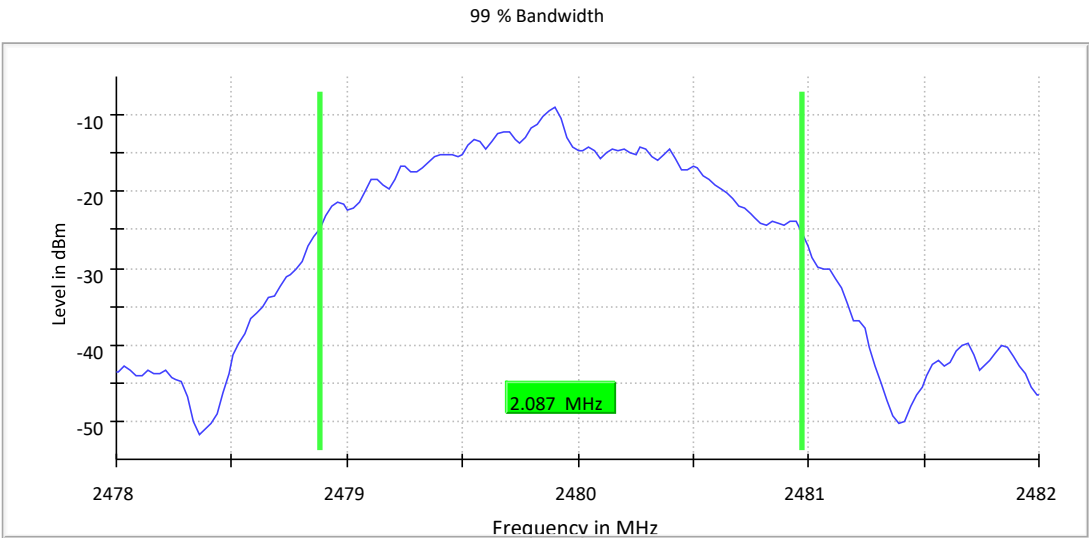
- 2M modulation:**

| Modulation | Channel | Channel Center Frequency (MHz) | Occupied Channel Bandwidth (MHz) | Band Edge (MHz) |
|-----------------------------|---------|--------------------------------|----------------------------------|-----------------|
| GFSK | Low | 2402 | 2.062111 | 2400.881988 |
| | High | 2480 | 2.086956 | 2480.968944 |
| Measurement uncertainty (%) | | <±2.08 | | |

- Low Channel:



- High Channel:



Verdict: PASS

4.3.2.8: Transmitter unwanted emissions in the out-of-band domain

LIMITS:

The transmitter unwanted emissions in the out-of-band domain shall not exceed the values provided by the mask in figure 3.

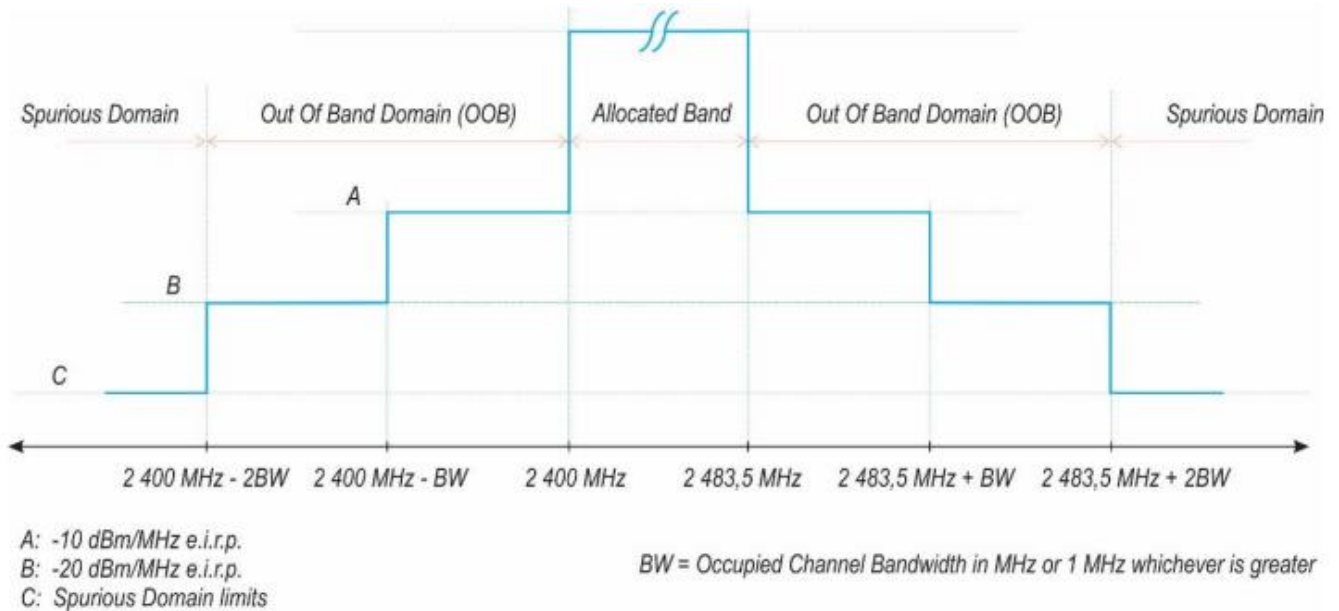


Figure 3: Transmit mask

RESULTS:

- 2M modulation:**

- Low Channel:

| Temperature (°C) | Channel | Frequency (MHz) | Level (dBm) | Limit (dBm) |
|------------------------------|---------|-----------------|-------------|-------------|
| Normal | Low | 2396.375778 | -47.1 | -20.0 |
| Normal | Low | 2396.437889 | -47.3 | -20.0 |
| Normal | Low | 2397.437889 | -45.8 | -20.0 |
| Normal | Low | 2398.437889 | -43.3 | -10.0 |
| Normal | Low | 2398.500000 | -42.9 | -10.0 |
| Normal | Low | 2399.500000 | -29.6 | -10.0 |
| Normal | Low | 2484.000000 | -52.3 | -10.0 |
| Normal | Low | 2485.000000 | -48.5 | -10.0 |
| Normal | Low | 2485.062111 | -50.8 | -10.0 |
| Normal | Low | 2486.062111 | -51.7 | -20.0 |
| Normal | Low | 2487.062111 | -52.2 | -20.0 |
| Normal | Low | 2487.124222 | -49.3 | -20.0 |
| Normal | High | 2396.326088 | -50.5 | -20.0 |
| Normal | High | 2396.413044 | -52.5 | -20.0 |
| Normal | High | 2397.413044 | -52.1 | -20.0 |
| Normal | High | 2398.413044 | -50.1 | -10.0 |
| Normal | High | 2398.500000 | -51.8 | -10.0 |
| Normal | High | 2399.500000 | -53.2 | -10.0 |
| Normal | High | 2484.000000 | -43.4 | -10.0 |
| Normal | High | 2485.000000 | -47.0 | -10.0 |
| Normal | High | 2485.086956 | -44.3 | -10.0 |
| Normal | High | 2486.086956 | -47.8 | -20.0 |
| Normal | High | 2487.086956 | -46.1 | -20.0 |
| Normal | High | 2487.173912 | -47.6 | -20.0 |
| Measurement uncertainty (dB) | | | <±0.89 | |

Verdict: PASS

4.3.2.9: Transmitter unwanted emissions in the spurious domain

LIMITS:

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 12.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and as e.i.r.p. for emissions above 1 GHz.

Table 12: Transmitter limits for spurious emissions

| Frequency range | Maximum power | Bandwidth |
|---------------------|---------------|-----------|
| 30 MHz to 47 MHz | -36 dBm | 100 kHz |
| 47 MHz to 74 MHz | -54 dBm | 100 kHz |
| 74 MHz to 87,5 MHz | -36 dBm | 100 kHz |
| 87,5 MHz to 118 MHz | -54 dBm | 100 kHz |
| 118 MHz to 174 MHz | -36 dBm | 100 kHz |
| 174 MHz to 230 MHz | -54 dBm | 100 kHz |
| 230 MHz to 470 MHz | -36 dBm | 100 kHz |
| 470 MHz to 694 MHz | -54 dBm | 100 kHz |
| 694 MHz to 1 GHz | -36 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -30 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): ± 4.94

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement uncertainty: 1 to 3 GHz $<\pm 3.98$
 3 to 12.75 GHz $<\pm 4.60$

Verdict: PASS

4.3.2.10: Receiver spurious emissions

LIMITS:

The spurious emissions of the receiver shall not exceed the values given in table 13.

In case of non-FHSS equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or for emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 13: Spurious emission limits for receivers

| Frequency range | Maximum power | Bandwidth |
|--------------------|---------------|-----------|
| 30 MHz to 1 GHz | -57 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -47 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

- LOW CHANNEL: No spurious frequencies detected at less than 6 dB below the limit.
- HIGH CHANNEL: Spurious frequencies detected at less than 6 dB below the limit:

| Spurious frequency (MHz) | E.R.P. (dBm) | Polarization | Detector | Measurement Uncertainty (dB) |
|--------------------------|--------------|--------------|----------|------------------------------|
| 31.8915 | -70.35 | V | RMS | <± 4.94 |

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): <± 4.60

Verdict: PASS

4.3.2.11: Receiver Blocking

LIMITS:

While maintaining the minimum performance criteria as defined in clause 4.3.2.11.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in table 14, table 15 or table 16.

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 + $10 \times \log_{10}(\text{OCBW}) + 10$ 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 + $10 \times \log_{10}(\text{OCBW}) + 20 \text{ dB}$) or (-74 dBm + 20 dB) whichever is less (see note 2) | 2 380 2 504 2 300 2 584 | -34 | CW |
| <p>NOTE 1: OCBW is in Hz.</p> <p>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 $P_{\min} + 30 \text{ dB}$ 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.</p> <p>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.</p> | | | |

RESULTS:

Receiver Category: 2

Maximum Declared Assembly Antenna Gain: 1 dBi

Test Case Results



| | | |
|-----------------------|---|---------------|
| Test Case | TP_5_4_11_RECEIVER_BLOCKING_LE_2M | |
| Verdict | PASS | |
| Date | 2020-09-17 12:52:55 | |
| Comments | Receiver Blocking (Low Energy at 2 Ms/s) | |
| Technology Version | BEST v4.5.0_R1 | |
| Core Version | 5.2 | |
| Test Specs Version | RFTS.p30 / RF-PHY.TS.p15 / ETSI EN 300 328 V2.2.2 | |
| Project | 64430_2MB | |
| Project Creation Date | 2020-09-14 09:28:44 | |
| Sample | DevID:M01 AppID:64430_003 SW:xxxx HW:xxxx | |
| Signature | 1240 17052994 | |
| Parameters | EUT Rx Frequencies | 2402;2480 MHz |
| | EUT Tx Frequencies | 2402;2480 MHz |
| | Type Packet Payload | 4 |
| | Number of Total Packets | 1500 |
| | Receiver Category | 2 |
| | Conformance Test Case Execution | True |

| Time Stamp (ms) | Event | Summary |
|-----------------|------------------|--|
| 55 | Start Test Case: | TP_5_4_11_RECEIVER_BLOCKING_LE_2M |
| 24218 | PARTIAL RESULT: | ===== |
| 24219 | PARTIAL RESULT: | Test Frequency: 2402 MHz |
| 24220 | PARTIAL RESULT: | ===== |
| 24222 | PARTIAL RESULT: | Wanted Signal Power Level: -64.8193666503724 dBm |
| 24223 | PARTIAL RESULT: | Test Interferer Frequency: 2380 MHz |
| 24223 | PARTIAL RESULT: | Blocking Signal Power Level: -33 dBm |
| 24224 | PARTIAL RESULT: | Blocking Signal Shift Required: False |
| 24225 | PARTIAL RESULT: | PER = 0.1 % |
| 24226 | PARTIAL RESULT: | PER Limit: 10 % |
| 24227 | PARTIAL VERDICT: | Partial Verdict: PASS |
| 24228 | PARTIAL RESULT: | ===== |
| 24229 | PARTIAL RESULT: | Test Frequency: 2402 MHz |
| 24230 | PARTIAL RESULT: | ===== |
| 24231 | PARTIAL RESULT: | Wanted Signal Power Level: -64.8193666503724 dBm |
| 24232 | PARTIAL RESULT: | Test Interferer Frequency: 2300 MHz |
| 24232 | PARTIAL RESULT: | Blocking Signal Power Level: -33 dBm |
| 24233 | PARTIAL RESULT: | Blocking Signal Shift Required: False |
| 24234 | PARTIAL RESULT: | PER = 0 % |
| 24235 | PARTIAL RESULT: | PER Limit: 10 % |
| 24236 | PARTIAL VERDICT: | Partial Verdict: PASS |
| 24237 | PARTIAL RESULT: | ===== |
| 24238 | PARTIAL RESULT: | Test Frequency: 2480 MHz |
| 24238 | PARTIAL RESULT: | ===== |
| 24239 | PARTIAL RESULT: | Wanted Signal Power Level: -64.8193666503724 dBm |
| 24240 | PARTIAL RESULT: | Test Interferer Frequency: 2504 MHz |
| 24241 | PARTIAL RESULT: | Blocking Signal Power Level: -33 dBm |
| 24242 | PARTIAL RESULT: | Blocking Signal Shift Required: False |
| 24243 | PARTIAL RESULT: | PER = 0.1 % |
| 24244 | PARTIAL RESULT: | PER Limit: 10 % |
| 24245 | PARTIAL VERDICT: | Partial Verdict: PASS |
| 24247 | PARTIAL RESULT: | ===== |
| 24248 | PARTIAL RESULT: | Test Frequency: 2480 MHz |
| 24249 | PARTIAL RESULT: | ===== |
| 24250 | PARTIAL RESULT: | Wanted Signal Power Level: -64.8193666503724 dBm |
| 24251 | PARTIAL RESULT: | Test Interferer Frequency: 2584 MHz |
| 24252 | PARTIAL RESULT: | Blocking Signal Power Level: -33 dBm |
| 24253 | PARTIAL RESULT: | Blocking Signal Shift Required: False |
| 24253 | PARTIAL RESULT: | PER = 0 % |
| 24255 | PARTIAL RESULT: | PER Limit: 10 % |
| 24256 | PARTIAL VERDICT: | Partial Verdict: PASS |
| 25926 | Test Case Ended: | TP_5_4_11_RECEIVER_BLOCKING_LE_2M |
| 25931 | Final verdict: | Final Verdict: PASS |

Verdict: PASS

Appendix C: Application form for testing. 802.15.4 Zigbee

Information as required by EN 300 328 V2.2.2, clause 5.4.1

In accordance with ETSI EN 300 328, clause 5.4.1, the following information is provided by the manufacturer.

a) The type of wideband data transmission equipment:

- ☐ FHSS
- ☒ other forms of modulation

b) In case of FHSS:

- In case of non-Adaptive FHSS equipment:
The number of Hopping Frequencies:
- In case of Adaptive FHSS equipment:
The maximum number of Hopping Frequencies:
The minimum number of Hopping Frequencies:- The (average) dwell time:

c) Adaptive/non-adaptive equipment:

- ☒ non-adaptive Equipment
- ☐ adaptive Equipment without the possibility to switch to a non-adaptive mode
- ☐ adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The maximum Channel Occupancy Time implemented by the equipment: ms

☐ The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:
 - ☐ The equipment is Frame Based equipment
 - ☐ The equipment is Load Based equipment
 - ☐ The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: µs

- ☐ The equipment has implemented a non-LBT based DAA mechanism
- ☐ The equipment can operate in more than one adaptive mode
- ☐ The equipment has implemented Short Control Signalling Transmissions

e) In case of non-adaptive Equipment:

The maximum RF Output Power: 4 dBm

The maximum RF Output Power (e.i.r.p.): 6.5 dBm

The maximum (corresponding) Duty Cycle:

Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

.....

.....

.....

f) The worst case operational mode for each of the following tests:

- RF Output Power
 <6.5 dBm
- Power Spectral Density

- Duty cycle, Tx-Sequence, Tx-gap
 Not applicable
- Accumulated Transmit time, Frequency Occupation & Hopping Sequence (only for FHSS equipment)

- Hopping Frequency Separation (only for FHSS equipment)

- Medium Utilization

- Adaptivity & Receiver Blocking
 According to 4.3.2.11
- Nominal Channel Bandwidth
 2 MHz
- Transmitter unwanted emissions in the OOB domain

- Transmitter unwanted emissions in the spurious domain

- Receiver spurious emissions

g) 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™ 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™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 1: Add more lines if more channel bandwidths are supported.

☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

☐ Single spatial stream/Standard throughput (e.g. IEEE 802.11™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 2: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

• The number of Receive chains:

• The number of Transmit chains:

☐ symmetrical power distribution

☐ asymmetrical power distribution

In case of beam forming, the maximum (additional) beam forming gain: dB

NOTE: The additional beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

• Operating Frequency Range 1: 2400 MHz to 2480 MHz

• Operating Frequency Range 2: MHz to MHz

NOTE: Add more lines if more Frequency Ranges are supported.

j) Nominal Channel Bandwidth(s):

• Nominal Channel Bandwidth 1: 2 MHz

• Nominal Channel Bandwidth 2:

NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

☒ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other

l) The normal and the extreme operating conditions that apply to the equipment:

Normal operating conditions (if applicable):

Operating temperature:

Other (please specify if applicable): 25 ° C

Extreme operating conditions:

Operating temperature range: Minimum -40° C Maximum +85° C

Other (please specify if applicable): Minimum ° C Maximum ° C

Details provided are for the: ☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

m) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:

• Antenna Type:

☒ Integral Antenna

Antenna Gain: 1 dBi

If applicable, additional beamforming gain (excluding basic antenna gain): dB

☐ Temporary RF connector provided

☐ No temporary RF connector provided

☐ Dedicated Antennas (equipment with antenna connector)

☐ Single power level with corresponding antenna(s)

☐ Multiple power settings and corresponding antenna(s)

Number of different Power Levels:

Power Level 1: dBm

Power Level 2: dBm

Power Level 3: dBm

NOTE: These power levels are conducted power levels (at antenna connector).

- For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable

Power Level 1: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|-------------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Power Level 2: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|-------------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

n) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:

Details provided are for the: ☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

Supply Voltage ☐ AC mains State AC voltage V
☒ DC State DC voltage 5 V

In case of DC, indicate the type of power source

- ☐ Internal Power Supply
☐ External Power Supply or AC/DC adapter
☐ Battery
☒ Other: USB powered

o) Describe the test modes available which can facilitate testing:

.....

p) The equipment type (e.g. Bluetooth[®], IEEE 802.11[™], IEEE 802.15.4[™], proprietary, etc.):

IEEE 802.15.4

q) If applicable, the statistical analysis referred to in clause 5.4.1 q)

(to be provided as separate attachment)

r) If applicable, the statistical analysis referred to in clause 5.4.1 r)

(to be provided as separate attachment)

s) Geo-location capability supported by the equipment:

☐ Yes

☐ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.

☒ No

t) Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or clause 4.3.2.11.3):

PER less than or equal to 10 %.

Appendix D: Test results. 802.15.4 Zigbee

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TEST CONDITIONS

POWER SUPPLY (V):

Vn: 5 Vdc

Type of Power Supply: USB.

ANTENNA:

Maximum Declared Antenna Gain: 1 dBi

TEMPERATURE (°C):

Tn: +15 to +35

Tmin: -40 (*)

Tmax: +85 (*)

The subscripts 'n', 'min' and 'max' indicate test conditions (normal, minimum and maximum respectively).

(*): Declared by applicant.

TEST FREQUENCIES FOR CONDUCTED TESTS:

Low Channel: 2405 MHz

Middle Channel: 2445 MHz

High Channel: 2480 MHz

TEST FREQUENCIES FOR RADIATED TESTS:

Low Channel: 2405 MHz

High Channel: 2480 MHz

PRODUCT INFORMATION

The following information is provided by the supplier, in accordance with clause 5.4.1:

| Information | Description |
|---|---------------------------------|
| Modulation: | Non-FHSS |
| Adaptivity: | Non-adaptive equipment |
| Maximum RF Output Power (e.i.r.p.): | 6.5 dBm |
| Operation mode 1: Single Antenna Equipment. | Equipment with only one antenna |
| - Operating Frequency Range. | 2400 – 2480 MHz |
| - Nominal Channel Bandwidth. | 2 MHz. |
| Extreme operating conditions: | |
| - Temperature range. | -40 to +85 °C |
| Antenna Type: | Internal (PCB) |
| Antenna Gain: | 1 dBi |
| Nominal Voltage: | |
| - Supply Voltage. | 5 Vdc |
| - Type of Power Supply. | USB powered |
| Type of Equipment: | IEEE 802.15.4 |
| Geo-location capability: | No |

Test modes available:

- Continuous modulated carrier at 2405 MHz, 2445 MHz and 2480 MHz.
- Continuous reception at 2405 MHz, 2445 MHz and 2480 MHz.

4.3.2.2: RF output power

LIMITS:

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.

RESULTS:

Type of Equipment: Non-adaptive.

Maximum Declared Assembly Antenna Gain: 1 dBi

Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| | | TRANSMITTER POWER e.i.r.p. (dBm) | | |
|-------------------------|----------------|----------------------------------|------------------------------|----------------------------|
| TEST CONDITIONS | | Low Channel (2405 MHz) | Middle Channel (2445 MHz) | High Channel (2480 MHz) |
| T _n | V _n | 5.31 | 5.12 | 5.06 |
| T _{min} | | 6.43 | 6.28 | 6.19 |
| T _{max} | | 4.45 | 4.27 | 4.23 |
| Measurement uncertainty | | <±0.99 dB | | |

Note: P is the e.i.r.p. as defined in clause 5.4.2.2.1.2 step 6.

Verdict: PASS

4.3.2.3: Power Spectral Density

LIMITS:

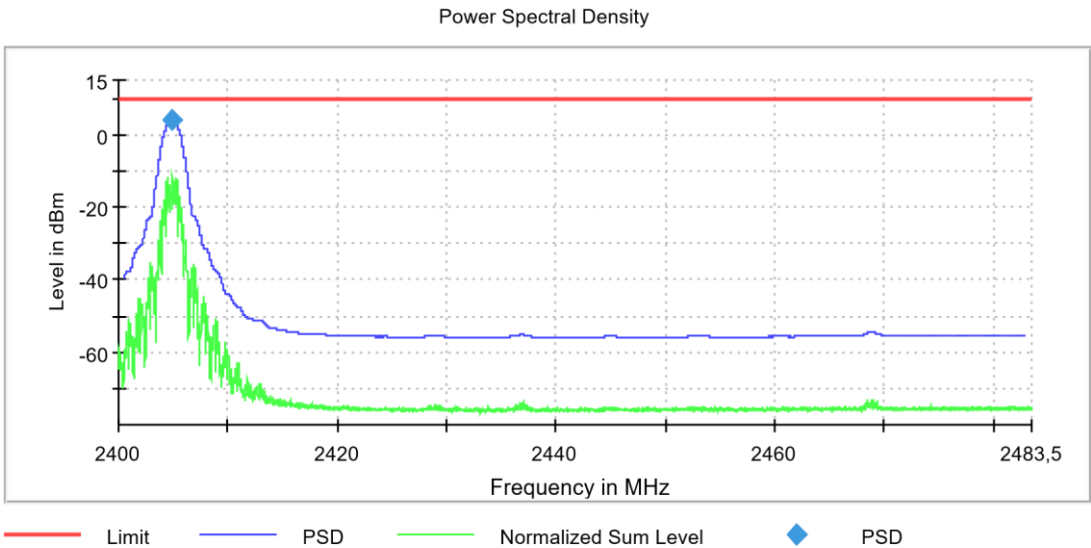
The maximum Power Spectral Density for non-FHSS equipment is 10 dBm per MHz.

RESULTS:

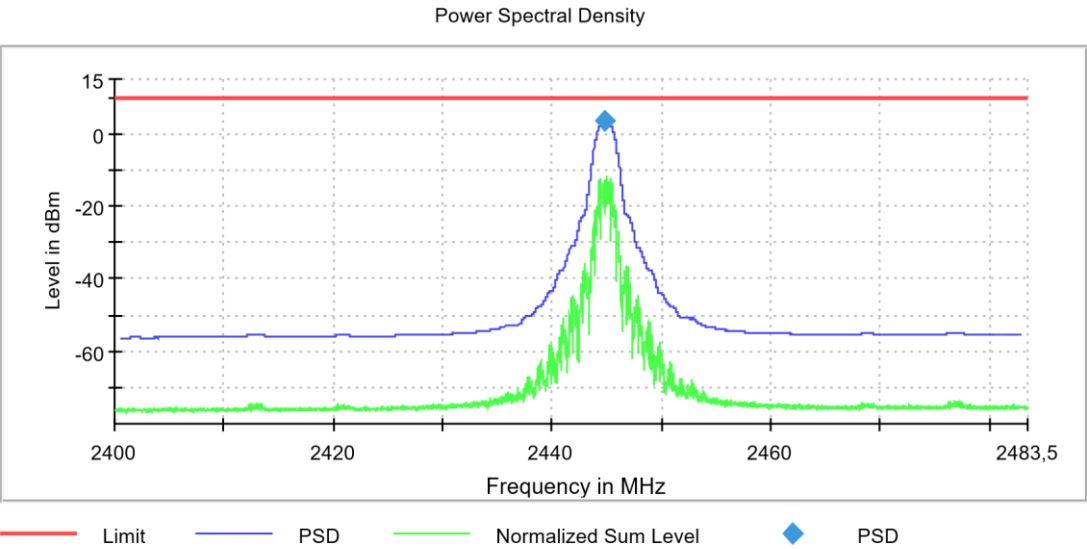
Type of Equipment: Non-adaptive
Maximum Declared Assembly Antenna Gain: 1 dBi
Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| | | | |
|---------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|
| | Lowest frequency 2404.834421 MHz | Middle frequency 2444.829631 MHz | Highest frequency 2479.825440 MHz |
| Measured Power Spectral Density | 3.942 dBm/1 MHz | 3.710 dBm/1 MHz | 3.606 dBm/1 MHz |
| Measurement uncertainty | <±0.99 dB | | |

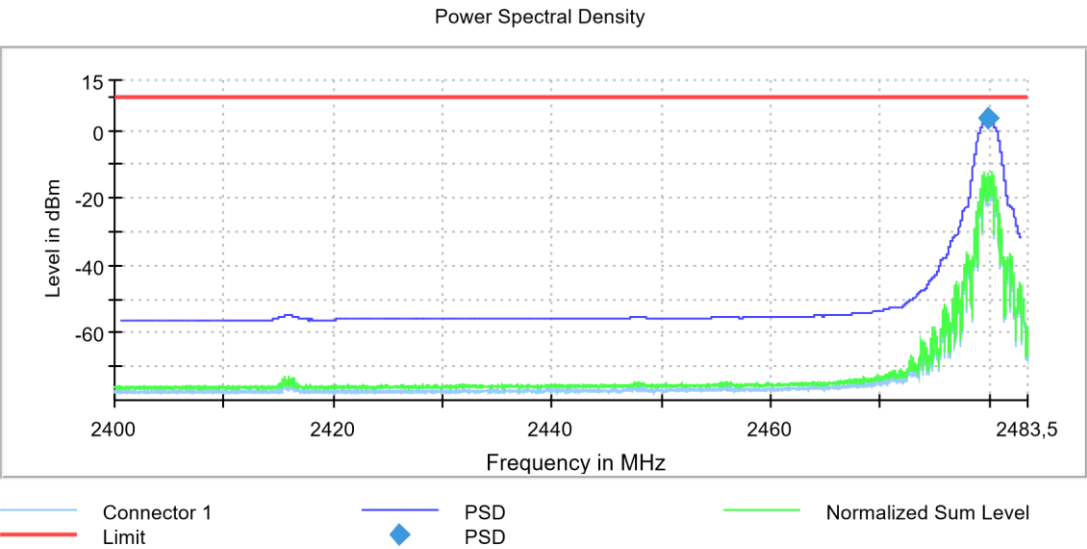
- Low Channel:



- Middle Channel:



- High Channel:



Verdict: PASS

4.3.2.7: Occupied Channel Bandwidth

LIMITS:

The Occupied Channel Bandwidth shall be within the band given in table 1.

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.

Table 1: Service frequency bands

| | Service frequency bands |
|----------|--------------------------|
| Transmit | 2 400 MHz to 2 483,5 MHz |
| Receive | 2 400 MHz to 2 483,5 MHz |

RESULTS:

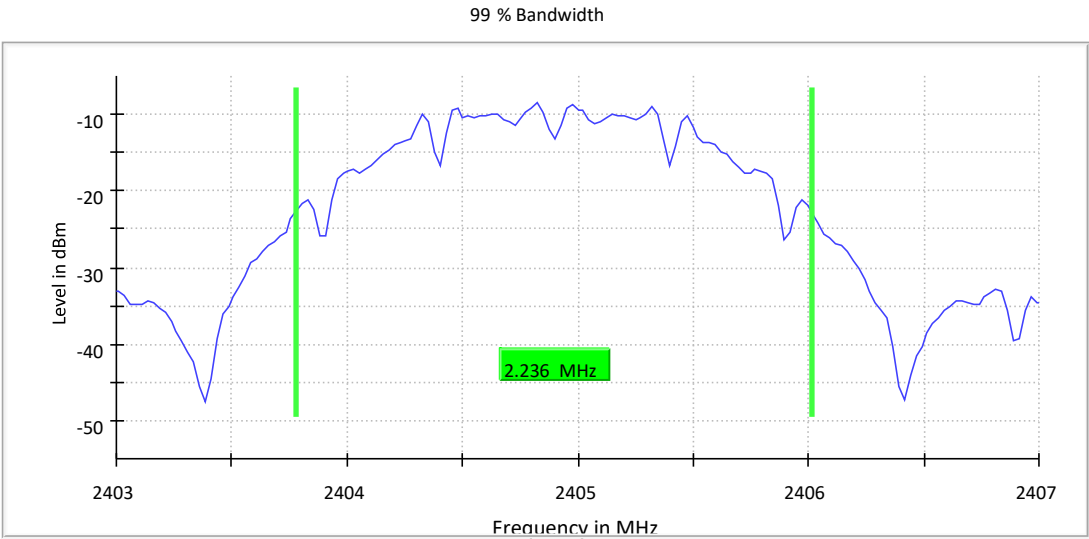
Type of Equipment: Non-adaptive

Maximum Declared Assembly Antenna Gain: 1 dBi

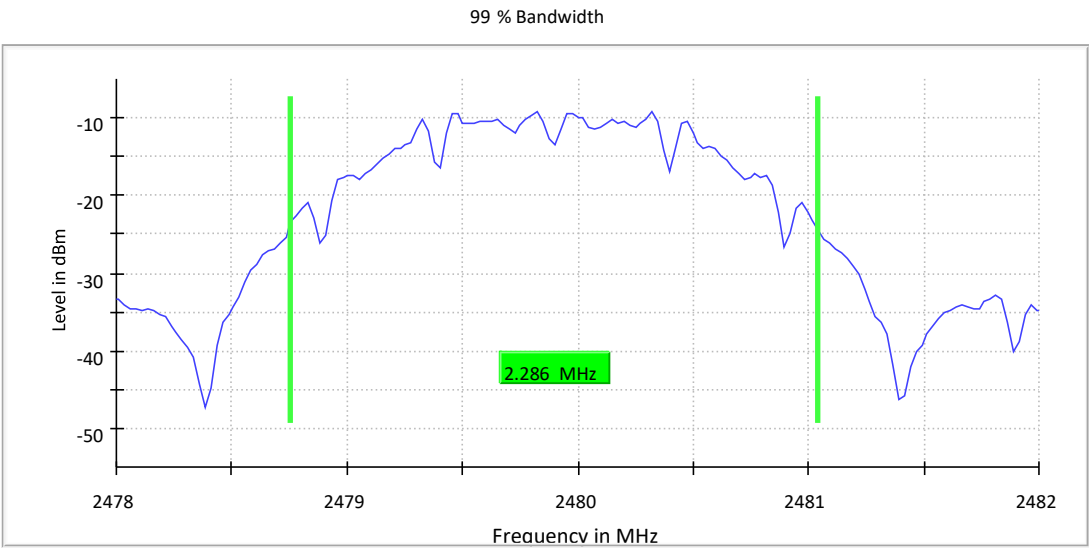
Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| Channel | Channel Center Frequency (MHz) | Occupied Channel Bandwidth (MHz) | Band Edge (MHz) |
|-----------------------------|--------------------------------|----------------------------------|-----------------|
| Low | 2405 | 2.236025 | 2403.782609 |
| High | 2480 | 2.285714 | 2481.043478 |
| Measurement uncertainty (%) | | <±2.08 | |

- Low Channel:



- High Channel:



Verdict: PASS

4.3.2.8: Transmitter unwanted emissions in the out-of-band domain

LIMITS:

The transmitter unwanted emissions in the out-of-band domain shall not exceed the values provided by the mask in figure 3.

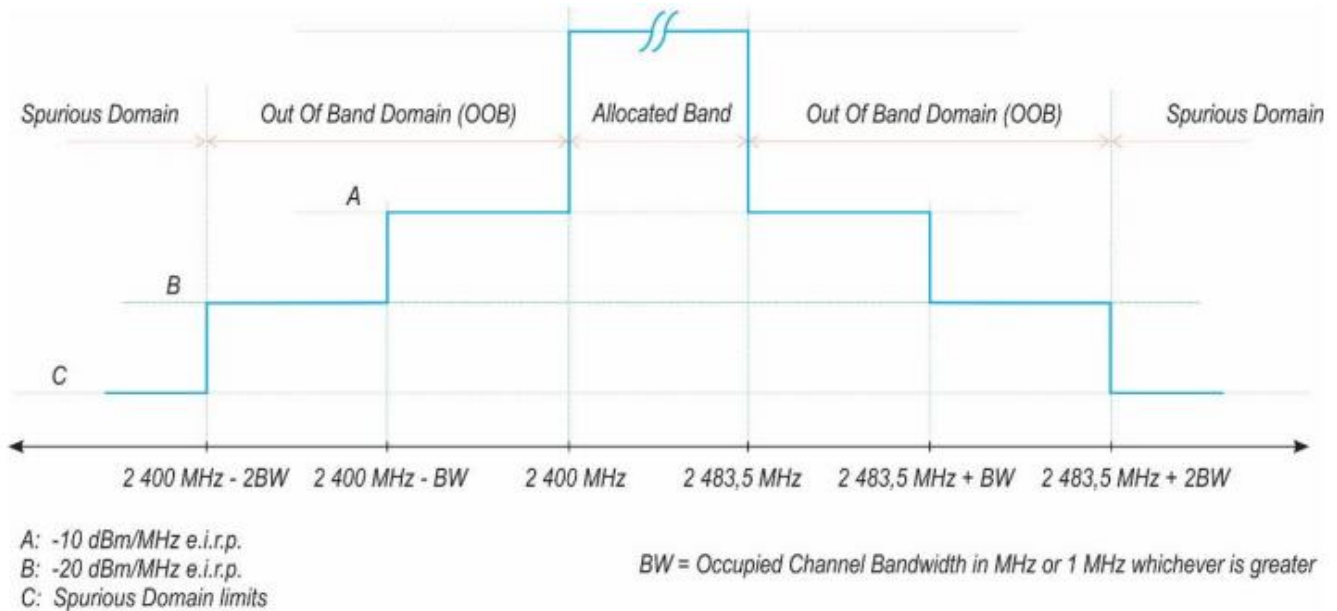


Figure 3: Transmit mask

RESULTS:

| Temperature (°C) | Channel | Frequency (MHz) | Level (dBm) | Limit (dBm) |
|------------------------------|---------|-----------------|-------------|-------------|
| Normal | Low | 2396.027950 | -51.6 | -20.0 |
| Normal | Low | 2396.263975 | -50.7 | -20.0 |
| Normal | Low | 2397.263975 | -50.1 | -20.0 |
| Normal | Low | 2398.263975 | -47.8 | -10.0 |
| Normal | Low | 2398.500000 | -47.2 | -10.0 |
| Normal | Low | 2399.500000 | -44.3 | -10.0 |
| Normal | Low | 2484.000000 | -51.4 | -10.0 |
| Normal | Low | 2485.000000 | -54.3 | -10.0 |
| Normal | Low | 2485.236025 | -53.0 | -10.0 |
| Normal | Low | 2486.236025 | -53.2 | -20.0 |
| Normal | Low | 2487.236025 | -53.1 | -20.0 |
| Normal | Low | 2487.472050 | -52.9 | -20.0 |
| Normal | High | 2395.928572 | -53.2 | -20.0 |
| Normal | High | 2396.214286 | -54.4 | -20.0 |
| Normal | High | 2397.214286 | -54.9 | -20.0 |
| Normal | High | 2398.214286 | -55.0 | -10.0 |
| Normal | High | 2398.500000 | -54.5 | -10.0 |
| Normal | High | 2399.500000 | -52.8 | -10.0 |
| Normal | High | 2484.000000 | -38.3 | -10.0 |
| Normal | High | 2485.000000 | -43.3 | -10.0 |
| Normal | High | 2485.285714 | -45.1 | -10.0 |
| Normal | High | 2486.285714 | -47.2 | -20.0 |
| Normal | High | 2487.285714 | -49.2 | -20.0 |
| Normal | High | 2487.571428 | -49.0 | -20.0 |
| Measurement uncertainty (dB) | | | <±0.89 | |

Verdict: PASS

4.3.2.9: Transmitter unwanted emissions in the spurious domain

LIMITS:

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 12.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and as e.i.r.p. for emissions above 1 GHz.

Table 12: Transmitter limits for spurious emissions

| Frequency range | Maximum power | Bandwidth |
|---------------------|---------------|-----------|
| 30 MHz to 47 MHz | -36 dBm | 100 kHz |
| 47 MHz to 74 MHz | -54 dBm | 100 kHz |
| 74 MHz to 87,5 MHz | -36 dBm | 100 kHz |
| 87,5 MHz to 118 MHz | -54 dBm | 100 kHz |
| 118 MHz to 174 MHz | -36 dBm | 100 kHz |
| 174 MHz to 230 MHz | -54 dBm | 100 kHz |
| 230 MHz to 470 MHz | -36 dBm | 100 kHz |
| 470 MHz to 694 MHz | -54 dBm | 100 kHz |
| 694 MHz to 1 GHz | -36 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -30 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): ± 4.94

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement uncertainty: 1 to 3 GHz $<\pm 3.98$
 3 to 12.75 GHz $<\pm 4.60$

Verdict: PASS

4.3.2.10: Receiver spurious emissions

LIMITS:

The spurious emissions of the receiver shall not exceed the values given in table 13.

In case of non-FHSS equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or for emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 13: Spurious emission limits for receivers

| Frequency range | Maximum power | Bandwidth |
|--------------------|---------------|-----------|
| 30 MHz to 1 GHz | -57 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -47 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): ± 4.94

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): $<\pm 4.60$

Verdict: PASS

4.3.2.11: Receiver Blocking

LIMITS:

While maintaining the minimum performance criteria as defined in clause 4.3.2.11.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in table 14, table 15 or table 16.

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 + $10 \times \log_{10}(\text{OCBW}) + 10$ 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 + $10 \times \log_{10}(\text{OCBW}) + 20 \text{ dB}$) or (-74 dBm + 20 dB) whichever is less (see note 2) | 2 380 2 504 2 300 2 584 | -34 | CW |
| <p>NOTE 1: OCBW is in Hz.</p> <p>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 $P_{\min} + 30 \text{ dB}$ 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.</p> <p>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.</p> | | | |

RESULTS:

Receiver Category: 2

Maximum Declared Assembly Antenna Gain: 1 dBi

- Wanted Signal Power at 2405 MHz: -63.00 dBm

| Low Channel (2405 MHz) | Blocking frequency (MHz) | Blocking Signal Power at DUT Antenna (dBm) | PER (%) | PER Limit (%) | Verdict |
|---------------------------|-----------------------------|---|------------|------------------|---------|
| IEEE 802.15.4 Zigbee | 2300 | -33.0 | 0 | 10 | PASS |
| | 2380 | -33.0 | 0 | 10 | PASS |

- Wanted Signal Power at 2480 MHz: -63.00 dBm

| High Channel (2480 MHz) | Blocking frequency (MHz) | Blocking Signal Power at DUT Antenna (dBm) | PER (%) | PER Limit (%) | Verdict |
|----------------------------|-----------------------------|---|------------|------------------|---------|
| IEEE 802.15.4 Zigbee | 2504 | -33.0 | 0.17 | 10 | PASS |
| | 2584 | -33.0 | 0.17 | 10 | PASS |

Verdict: PASS

Appendix E: Application form for testing. Proprietary protocol: Long Range

Information as required by EN 300 328 V2.2.2, clause 5.4.1

In accordance with ETSI EN 300 328, clause 5.4.1, the following information is provided by the manufacturer.

a) The type of wideband data transmission equipment:

- ☐ FHSS
- ☒ other forms of modulation

b) In case of FHSS:

- In case of non-Adaptive FHSS equipment:
The number of Hopping Frequencies:
- In case of Adaptive FHSS equipment:
The maximum number of Hopping Frequencies:
The minimum number of Hopping Frequencies:- The (average) dwell time:

c) Adaptive/non-adaptive equipment:

- ☒ non-adaptive Equipment
- ☐ adaptive Equipment without the possibility to switch to a non-adaptive mode
- ☐ adaptive Equipment which can also operate in a non-adaptive mode

d) In case of adaptive equipment:

The maximum Channel Occupancy Time implemented by the equipment: ms

☐ The equipment has implemented an LBT based DAA mechanism

- In case of equipment using modulation different from FHSS:
 - ☐ The equipment is Frame Based equipment
 - ☐ The equipment is Load Based equipment
 - ☐ The equipment can switch dynamically between Frame Based and Load Based equipment

The CCA time implemented by the equipment: µs

- ☐ The equipment has implemented a non-LBT based DAA mechanism
- ☐ The equipment can operate in more than one adaptive mode
- ☐ The equipment has implemented Short Control Signalling Transmissions

e) In case of non-adaptive Equipment:

The maximum RF Output Power: 5.5 dBm

The maximum RF Output Power (e.i.r.p.): 6.5 dBm

The maximum (corresponding) Duty Cycle:

Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):

.....

.....

.....

f) The worst case operational mode for each of the following tests:

- RF Output Power
 <6.5 dBm
- Power Spectral Density

- Duty cycle, Tx-Sequence, Tx-gap
 Not applicable
- Accumulated Transmit time, Frequency Occupation & Hopping Sequence (only for FHSS equipment)

- Hopping Frequency Separation (only for FHSS equipment)

- Medium Utilization

- Adaptivity & Receiver Blocking
 According to 4.3.2.11
- Nominal Channel Bandwidth
 2 MHz
- Transmitter unwanted emissions in the OOB domain

- Transmitter unwanted emissions in the spurious domain

- Receiver spurious emissions

g) 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™ 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™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 1: Add more lines if more channel bandwidths are supported.

☐ Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming

☐ Single spatial stream/Standard throughput (e.g. IEEE 802.11™ legacy mode)

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1

☐ High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2

NOTE 2: Add more lines if more channel bandwidths are supported.

h) In case of Smart Antenna Systems:

• The number of Receive chains:

• The number of Transmit chains:

☐ symmetrical power distribution

☐ asymmetrical power distribution

In case of beam forming, the maximum (additional) beam forming gain: dB

NOTE: The additional beam forming gain does not include the basic gain of a single antenna.

i) Operating Frequency Range(s) of the equipment:

• Operating Frequency Range 1: 2400 MHz to 2480 MHz

• Operating Frequency Range 2: MHz to MHz

NOTE: Add more lines if more Frequency Ranges are supported.

j) Nominal Channel Bandwidth(s):

• Nominal Channel Bandwidth 1: 1 MHz

• Nominal Channel Bandwidth 2:

NOTE: Add more lines if more channel bandwidths are supported.

k) Type of Equipment (stand-alone, combined, plug-in radio device, etc.):

☒ Stand-alone

☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)

☐ Plug-in radio device (Equipment intended for a variety of host systems)

☐ Other

l) The normal and the extreme operating conditions that apply to the equipment:

Normal operating conditions (if applicable):

Operating temperature:

Other (please specify if applicable): 25 ° C

Extreme operating conditions:

Operating temperature range: Minimum -40° C Maximum +105° C

Other (please specify if applicable): Minimum ° C Maximum ° C

- Details provided are for the:
- ☒ stand-alone equipment
 - ☐ combined (or host) equipment
 - ☐ test jig

m) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:

• Antenna Type:

☒ Integral Antenna

Antenna Gain: 1 dBi

If applicable, additional beamforming gain (excluding basic antenna gain): dB

- ☐ Temporary RF connector provided
- ☐ No temporary RF connector provided
- ☐ Dedicated Antennas (equipment with antenna connector)
 - ☐ Single power level with corresponding antenna(s)
 - ☐ Multiple power settings and corresponding antenna(s)

Number of different Power Levels:

Power Level 1: dBm

Power Level 2: dBm

Power Level 3: dBm

NOTE: These power levels are conducted power levels (at antenna connector).

- For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable

Power Level 1: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|-------------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Power Level 2: dBm

Number of antenna assemblies provided for this power level:

| Assembly # | Gain (dBi) | e.i.r.p. (dBm) | Part number or model name |
|------------|------------|-------------------|---------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

n) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:

Details provided are for the: ☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

Supply Voltage ☐ AC mains State AC voltage V
☒ DC State DC voltage 5 V

In case of DC, indicate the type of power source

- ☐ Internal Power Supply
☐ External Power Supply or AC/DC adapter
☐ Battery
☒ Other: USB powered

o) Describe the test modes available which can facilitate testing:

.....

p) The equipment type (e.g. Bluetooth[®], IEEE 802.11[™], IEEE 802.15.4[™], proprietary, etc.):

Proprietary (Long Range)

q) If applicable, the statistical analysis referred to in clause 5.4.1 q)

(to be provided as separate attachment)

r) If applicable, the statistical analysis referred to in clause 5.4.1 r)

(to be provided as separate attachment)

s) Geo-location capability supported by the equipment:

☐ Yes

☐ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.

☒ No

t) Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or clause 4.3.2.11.3):

PER less than or equal to 10 %.

Appendix F: Test results. Proprietary protocol: Long Range

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TEST CONDITIONS

POWER SUPPLY (V):

Vn: 5 Vdc

Type of Power Supply: USB.

ANTENNA:

Maximum Declared Antenna Gain: 1 dBi

TEMPERATURE (°C):

Tn: +15 to +35

Tmin: -40 (*)

Tmax: +85 (*)

The subscripts 'n', 'min' and 'max' indicate test conditions (normal, minimum and maximum respectively).

(*): Declared by applicant.

TEST FREQUENCIES FOR CONDUCTED TESTS:

Low Channel: 2402 MHz

Middle Channel: 2440 MHz

High Channel: 2480 MHz

TEST FREQUENCIES FOR RADIATED TESTS:

Low Channel: 2402 MHz

High Channel: 2480 MHz

PRODUCT INFORMATION

The following information is provided by the supplier, in accordance with clause 5.4.1:

| Information | Description |
|---|-----------------------------------|
| Modulation: | Non-FHSS: GFSK |
| Adaptivity: | Non-adaptive equipment |
| Maximum RF Output Power (e.i.r.p.): | 6.5 dBm |
| Operation mode 1: Single Antenna Equipment. | Equipment with only one antenna |
| - Operating Frequency Range. | 2400 – 2480 MHz |
| - Nominal Channel Bandwidth. | 1 MHz. |
| Extreme operating conditions: | |
| - Temperature range. | -40 to +85 °C |
| Antenna Type: | Internal (PCB) |
| Antenna Gain: | 1 dBi |
| Nominal Voltage: | |
| - Supply Voltage. | 5 Vdc |
| - Type of Power Supply. | USB powered |
| Type of Equipment: | Proprietary protocol: Longe Range |
| Geo-location capability: | No |

Test modes available:

- Continuous modulated carrier at 2402 MHz, 2440 MHz and 2480 MHz.
- Continuous reception at 2402 MHz, 2440 MHz and 2480 MHz.

4.3.2.2: RF output power

LIMITS:

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.

RESULTS:

Type of Equipment: Non-adaptive.

Maximum Declared Assembly Antenna Gain: 1 dBi

Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| | | TRANSMITTER POWER e.i.r.p. (dBm) | | |
|-------------------------|----------------|----------------------------------|------------------------------|----------------------------|
| TEST CONDITIONS | | Low Channel (2405 MHz) | Middle Channel (2445 MHz) | High Channel (2480 MHz) |
| T _n | V _n | 5.15 | 5.11 | 5.00 |
| T _{min} | | 6.32 | 6.28 | 6.18 |
| T _{max} | | 4.20 | 4.21 | 4.11 |
| Measurement uncertainty | | <±0.99 dB | | |

Note: P is the e.i.r.p. as defined in clause 5.4.2.2.1.2 step 6.

Verdict: PASS

4.3.2.3: Power Spectral Density

LIMITS:

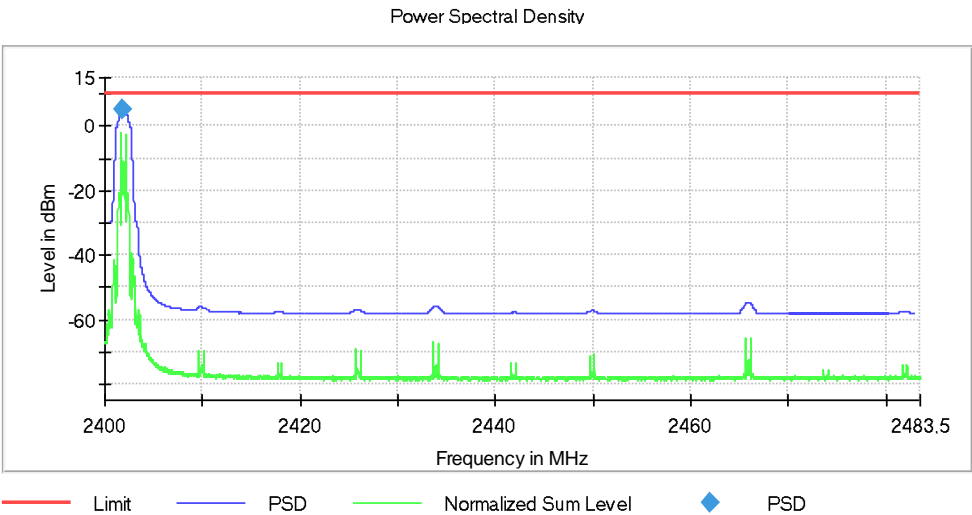
The maximum Power Spectral Density for non-FHSS equipment is 10 dBm per MHz.

RESULTS:

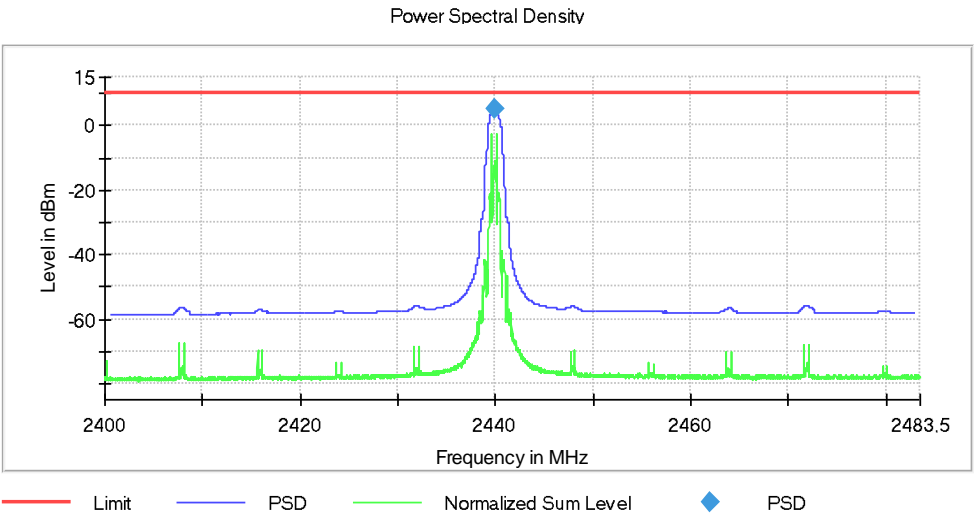
Type of Equipment: Non-adaptive
Maximum Declared Assembly Antenna Gain: 1 dBi
Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| | | | |
|---------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|
| | Lowest frequency 2401.894773 MHz | Middle frequency 2439.890223 MHz | Highest frequency 2479.895432 MHz |
| Measured Power Spectral Density | 5.089 dBm/1 MHz | 5.050 dBm/1 MHz | 4.935 dBm/1 MHz |
| Measurement uncertainty | <±0.99 dB | | |

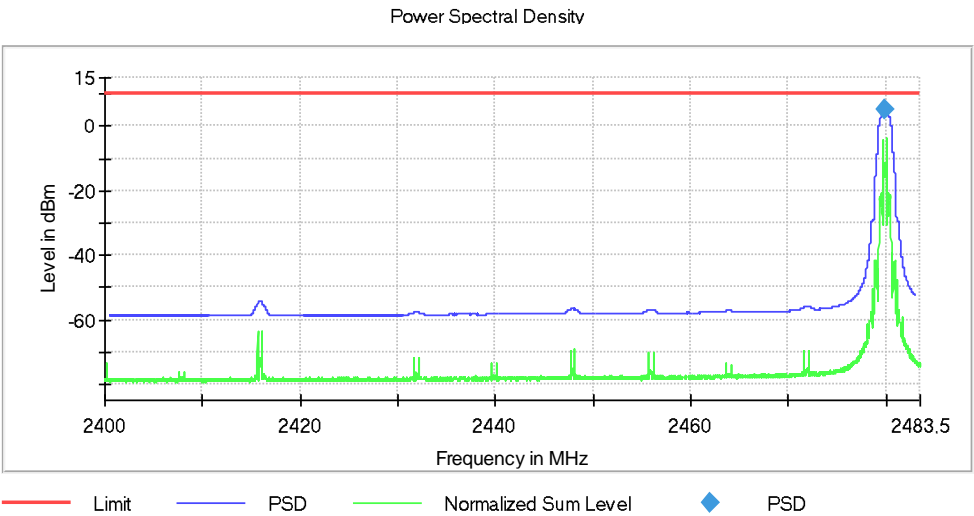
- Low Channel:



- Middle Channel:



- High Channel:



Verdict: PASS

4.3.2.7: Occupied Channel Bandwidth

LIMITS:

The Occupied Channel Bandwidth shall be within the band given in table 1.

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.

Table 1: Service frequency bands

| | Service frequency bands |
|----------|--------------------------|
| Transmit | 2 400 MHz to 2 483,5 MHz |
| Receive | 2 400 MHz to 2 483,5 MHz |

RESULTS:

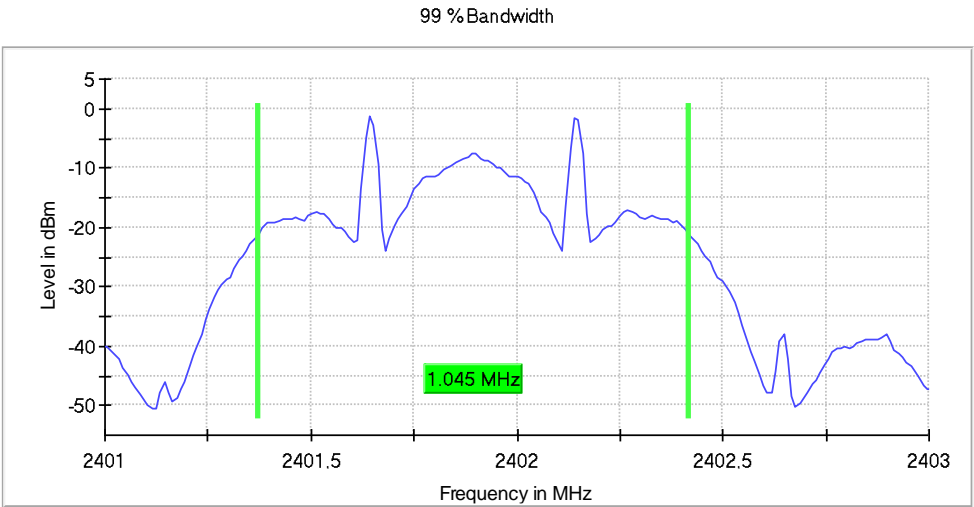
Type of Equipment: Non-adaptive

Maximum Declared Assembly Antenna Gain: 1 dBi

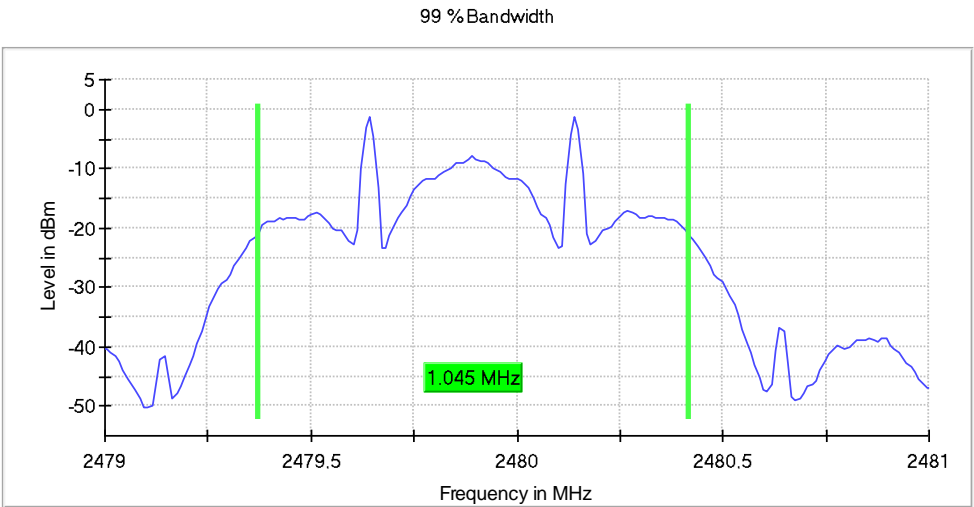
Maximum Declared Output Power (e.i.r.p.): 6.5 dBm

| Channel | Channel Center Frequency (MHz) | Occupied Channel Bandwidth (MHz) | Band Edge (MHz) |
|-----------------------------|--------------------------------|----------------------------------|-----------------|
| Low | 2402 | 1.044776 | 2401.373134 |
| High | 2480 | 1.044776 | 2480.417910 |
| Measurement uncertainty (%) | | <±2.08 | |

- Low Channel:



- High Channel:



Verdict: PASS

4.3.2.8: Transmitter unwanted emissions in the out-of-band domain

LIMITS:

The transmitter unwanted emissions in the out-of-band domain shall not exceed the values provided by the mask in figure 3.

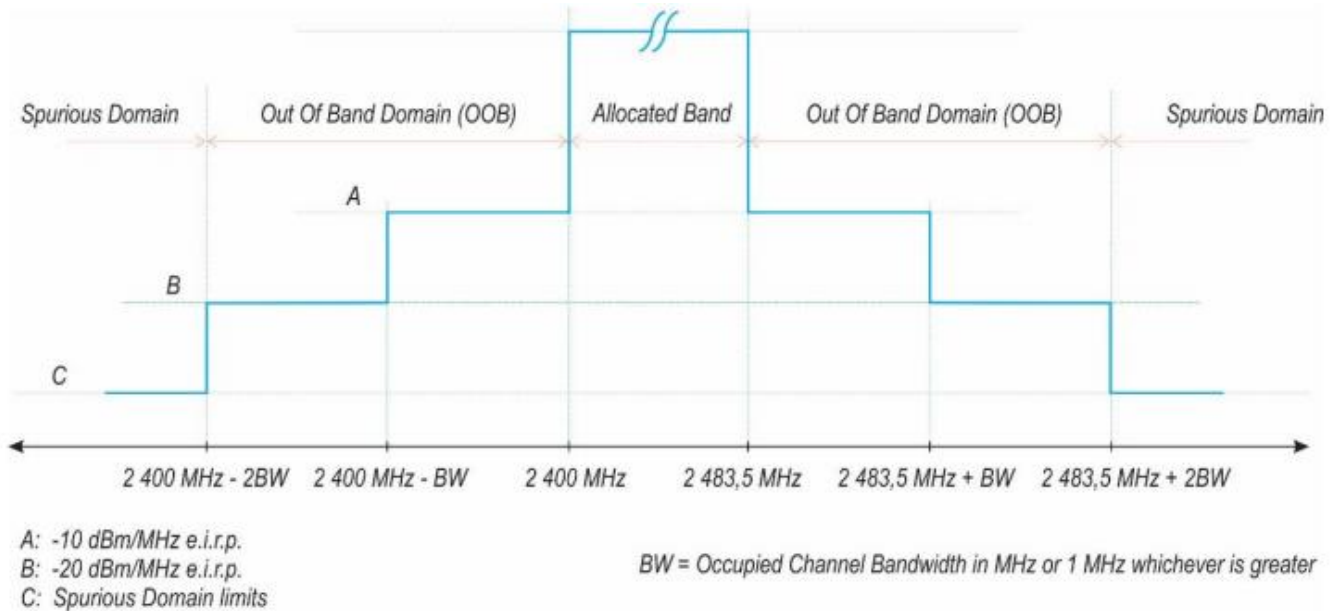


Figure 3: Transmit mask

RESULTS:

| Temperature (°C) | Channel | Frequency (MHz) | Level (dBm) | Limit (dBm) |
|------------------------------|---------|-----------------|-------------|-------------|
| Normal | Low | 2398.410448 | -53.9 | -20.0 |
| Normal | Low | 2398.455224 | -52.2 | -20.0 |
| Normal | Low | 2399.455224 | -50.4 | -10.0 |
| Normal | Low | 2399.500000 | -50.2 | -10.0 |
| Normal | Low | 2484.000000 | -54.9 | -10.0 |
| Normal | Low | 2484.044776 | -55.7 | -10.0 |
| Normal | Low | 2485.044776 | -55.7 | -20.0 |
| Normal | Low | 2485.089552 | -54.3 | -20.0 |
| Normal | High | 2398.410448 | -56.7 | -20.0 |
| Normal | High | 2398.455224 | -58.5 | -20.0 |
| Normal | High | 2399.455224 | -56.9 | -10.0 |
| Normal | High | 2399.500000 | -55.6 | -10.0 |
| Normal | High | 2484.000000 | -53.3 | -10.0 |
| Normal | High | 2484.044776 | -54.5 | -10.0 |
| Normal | High | 2485.044776 | -53.7 | -20.0 |
| Normal | High | 2485.089552 | -53.5 | -20.0 |
| Measurement uncertainty (dB) | | | <±0.89 | |

Verdict: PASS

4.3.2.9: Transmitter unwanted emissions in the spurious domain

LIMITS:

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in table 12.

In case of equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and as e.i.r.p. for emissions above 1 GHz.

Table 12: Transmitter limits for spurious emissions

| Frequency range | Maximum power | Bandwidth |
|---------------------|---------------|-----------|
| 30 MHz to 47 MHz | -36 dBm | 100 kHz |
| 47 MHz to 74 MHz | -54 dBm | 100 kHz |
| 74 MHz to 87,5 MHz | -36 dBm | 100 kHz |
| 87,5 MHz to 118 MHz | -54 dBm | 100 kHz |
| 118 MHz to 174 MHz | -36 dBm | 100 kHz |
| 174 MHz to 230 MHz | -54 dBm | 100 kHz |
| 230 MHz to 470 MHz | -36 dBm | 100 kHz |
| 470 MHz to 694 MHz | -54 dBm | 100 kHz |
| 694 MHz to 1 GHz | -36 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -30 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): ± 4.94

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement uncertainty: 1 to 3 GHz $<\pm 3.98$
 3 to 12.75 GHz $<\pm 4.60$

Verdict: PASS

4.3.2.10: Receiver spurious emissions

LIMITS:

The spurious emissions of the receiver shall not exceed the values given in table 13.

In case of non-FHSS equipment with antenna connectors, these limits apply to emissions at the antenna port (conducted). For emissions radiated by the cabinet or for emissions radiated by integral antenna equipment (without antenna connectors), these limits are e.r.p. for emissions up to 1 GHz and e.i.r.p. for emissions above 1 GHz.

Table 13: Spurious emission limits for receivers

| Frequency range | Maximum power | Bandwidth |
|--------------------|---------------|-----------|
| 30 MHz to 1 GHz | -57 dBm | 100 kHz |
| 1 GHz to 12,75 GHz | -47 dBm | 1 MHz |

RESULTS:

RADIATED:

The level of spurious emissions was measured as their power when radiated by cabinet and antenna.

Frequency range 30 MHz – 1 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): $\leq \pm 4.94$

Frequency range 1 – 12.75 GHz

No radiated spurious frequencies detected at less than 6 dB below the limit for both the Low and High channels.

Measurement Uncertainty (dB): $\leq \pm 4.60$

Verdict: PASS

4.3.2.11: Receiver Blocking

LIMITS:

While maintaining the minimum performance criteria as defined in clause 4.3.2.11.3, the blocking levels at specified frequency offsets shall be equal to or greater than the limits defined for the applicable receiver category provided in table 14, table 15 or table 16.

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 + $10 \times \log_{10}(\text{OCBW}) + 10$ 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 + $10 \times \log_{10}(\text{OCBW}) + 20 \text{ dB}$) or (-74 dBm + 20 dB) whichever is less (see note 2) | 2 380 2 504 2 300 2 584 | -34 | CW |
| <p>NOTE 1: OCBW is in Hz.</p> <p>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 $P_{\min} + 30 \text{ dB}$ 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.</p> <p>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.</p> | | | |

RESULTS:

Receiver Category: 2

Maximum Declared Assembly Antenna Gain: 1 dBi

- Wanted Signal Power at 2405 MHz: -67.69238 dBm

| Low Channel (2405 MHz) | Blocking frequency (MHz) | Blocking Signal Power at DUT Antenna (dBm) | PER (%) | PER Limit (%) | Verdict |
|---------------------------|-----------------------------|---|------------|------------------|---------|
| Longe Range | 2300 | -33.0 | 5.45 | 10.00 | PASS |
| | 2380 | -33.0 | 4.36 | 10.00 | PASS |

- Wanted Signal Power at 2480 MHz: -67.64650 dBm

| High Channel (2480 MHz) | Blocking frequency (MHz) | Blocking Signal Power at DUT Antenna (dBm) | PER (%) | PER Limit (%) | Verdict |
|----------------------------|-----------------------------|---|------------|------------------|---------|
| Longe Range | 2504 | -33.0 | 4.20 | 10.00 | PASS |
| | 2584 | -33.0 | 1.84 | 10.00 | PASS |

Verdict: PASS

Appendix G Photographs

EQUIPMENT FOR RADIATED AND CONDUCTED MEASUREMENTS

