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TEST REPORT

SCOPE OF WORK
EMC TESTING–DA14531MOD-00F0100

REPORT NUMBER
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TEST REPORT

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Manufacturer	:	Same as applicant
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Intertek Report No:	:	200402059GZU-001

Test standards

EN 300 328 V2.2.2 (2019-07)

Sample Description

Product	:	DA14531 TINY Module
Model No.	:	DA14531MOD-00F0100
Electrical Rating	:	DC 3.3V
Serial No.		Not Labeled
Date Received	:	02 April 2020
Date Test Conducted	:	02 April 2020 to 08 May 2020

Prepared and Checked By	Approved By:
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1.0 TEST RESULT SUMMARY

Radio Spectrum Matter (RSM) Part of Tx				
Test	**Test Requirement**	**Test method**	**Limit/Severity**	**Result**
RF Output Power	EN 300 328: clause 4.3.2.2	EN 300 328: clause 5.4.2	≤20 dBm	PASS
Power Spectral Density	EN 300 328: clause 4.3.2.3	EN 300 328: clause 5.4.3	≤10 dBm/MHz	PASS
Duty cycle, Tx-Sequence, Tx-gap	EN 300 328: clause 4.3.2.4	EN 300 328: clause 5.4.2	EN 300 328: clause 4.3.2.4.3	N/A
Medium Utilisation	EN 300 328: clause 4.3.2.5	EN 300 328: clause 5.4.2	EN 300 328: clause 4.3.2.5.3	N/A
Adaptivity	EN 300 328: clause 4.3.2.6	EN 300 328: clause 5.4.6	EN 300 328: clause 4.3.2.6.3.2	N/A
Occupied Channel Bandwidth	EN 300 328: clause 4.3.2.7	EN 300 328: clause 5.4.7	EN 300 328: clause 4.3.2.7.3	PASS
Transmitter unwanted emissions in the out-of-band domain	EN 300 328: clause 4.3.2.8	EN 300 328: clause 5.4.8	EN 300 328: clause 4.3.2.8.3	PASS
Transmitter unwanted emissions in the spurious domain	EN 300 328: clause 4.3.2.9	EN 300 328: clause 5.4.9	EN 300 328: clause 4.3.2.9.3	PASS
Radio Spectrum Matter (RSM) Part of Rx				
Test	**Test Requirement**	**Test method**	**Limit/Severity**	**Result**
Spurious Emissions (Receiver)	EN 300 328: clause 4.3.2.10	EN 300 328: clause 5.4.10	EN 300 328: 4.3.2.10.3	PASS
Receiver Blocking	EN 300 328: clause 4.3.2.11	EN 300 328: clause 5.4.11	EN 300 328: clause 4.3.2.11.4	PASS

Remark:

N/A: not applicable. Refer to the relevant section for the details.

EN 300 328: the detail version is ETSI EN 300 328 V2.2.2 (2019-07) in the whole report.

Tx: In this whole report Tx (or tx) means Transmitter.
Rx: In this whole report Rx (or rx) means Receiver.
RF: In this whole report RF means Radio Frequency.
When determining the test conclusion, the Measurement Uncertainty of test has been considered.

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2.0 Results Conclusion (with Justification)

RE: Radio Testing Pursuant to Radio Equipment Directive 2014/53/EU, standard ETSI EN 300328 V2.2.2 Performed on the DA14531 TINY Module, Model: DA14531MOD-00F0100.

We tested the DA14531 TINY Module, Model: DA14531MOD-00F0100, to determine if it was in compliance with the relevant standard as marked on the Test Results Summary. We found that the unit met the requirement of ETSI EN 300 328 standard when tested as received. The worst case's test data was presented in this test report.

The production units are required to conform to the initial sample as received when the units are placed on the market.

3.0 LABORATORY MEASUREMENTS

Configuration Information

Operating Frequency:	2402 MHz – 2480MHz
Type of Modulation:	GFSK
Transmit Data Rate:	1Mbps
Number of Channels:	40 Channels
Channel Separation:	2 MHz
Antenna Type:	Integral
Antenna Gain:	-0.5 dBi
Function:	Bluetooth 5.1 with BLE (Bluetooth Low Energy)
Power Supply:	DC 3.3V
Power cord:	N/A

EUT channels and frequencies list:

Test frequencies are lowest channel 0: 2402 MHz, middle channel 19: 2440 MHz and highest channel 39: 2480 MHz.

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	14	2430	28	2458
1	2404	15	2432	29	2460
2	2406	16	2434	30	2462
3	2408	17	2436	31	2464
4	2410	18	2438	32	2466
5	2412	19	2440	33	2468
6	2414	20	2442	34	2470
7	2416	21	2444	35	2472
8	2418	22	2446	36	2474
9	2420	23	2448	37	2476
10	2422	24	2450	38	2478
11	2424	25	2452	39	2480
12	2426	26	2454	/	/
13	2428	27	2456	/	/

Notes:

1. The measurements had been made in the operating mode producing the largest emission in the frequency band being investigated consistent with normal applications. An attempt had been made to maximize the emission by varying the configuration of the EUT.
2. Test Location:
   Intertek Testing Services Shenzhen Ltd. Guangzhou Branch
   All tests were performed at:
   Room102/104, No 203, KeZhu Road, Science City, GETDD Guangzhou, China

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Measurement Uncertainty

No.	Item	Measurement Uncertainty
1	RF output power (conducted)	1.1 dB
2	Occupied Channel Bandwidth	2.3%
3	Power Spectral Density	1.5
4	Spurious Emission (TX)-Radiated	4.7 dB (25 MHz-1 GHz)
		4.8 dB (1 GHz-18 GHz)
5	Spurious Emission (TX)-Conducted	1.5 dB
6	Spurious Emission (RX) -Radiated	4.7 dB (25 MHz-1 GHz)
		4.8 dB (1 GHz-18 GHz)
7	Spurious Emission (RX)-Conducted	1.5 dB
8	Temperature	0.5 °C
9	Humidity	0.4 %
10	Time	1.2%

The measurement uncertainty describes the overall uncertainty of the given measured value during the operation of the EUT.
Measurement uncertainty is calculated in accordance with ETSI TR 100 028-1 V1.4.1 (2001-12) and ETSI TR 100 028-2 V1.4.1 (2001-12).
The measurement uncertainty is given with a confidence of 95%, k=2.

4.0 Test Result of Radio Performance Measurements as Transceiver

4.1 Transmitter Conditions

Item	EUT Type
1	Stand-alone equipment
2	Host connected equipment and plug-in radio equipment
3	Adaptive equipment
4	Non-adaptive equipment

Modulation
Frequency Hopping Spread Spectrum (FHSS) modulation.
DSSS and other forms of modulation

EUT belongs to item 1 & 3 with GFSK modulation.

4.2 Test Conditions

4.2.1 Normal conditions

Ambient:	Temperature:	+15°C to +35°C
	Relative humidity:	20% to 75%
	Press:	1010 mbar

4.2.2 Extreme conditions

Ambient:	Temperature:	Manufacturer’s declared operating temperature: -40℃ to +85℃

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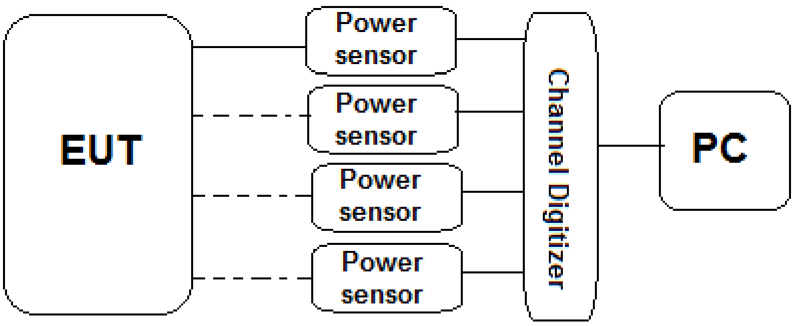
4.3 RF Output Power

Test requirement:	EN 300 328 clause 4.3.2.3 For adaptive equipment using wide band modulations other than FHSS, the maximum RF output power shall be 20 dBm.
Test Method:	EN 300 328 clause 5.4.2
EUT Operation:	
Status:	For systems using wide band modulations other than FHSS, the measurement was performed at the lowest, the middle, and the highest channel on which the equipment could operate. These frequencies were recorded. Entered test mode for the product. Tested in the lowest channel 2402 MHz, middle channel 2440 MHz and the highest channel 2480 MHz kept in continuously transmitting status with normal modulation. Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates. Following channel(s) and data rates were selected for the final test as listed below. These tests were performed at normal environmental conditions and repeated at the extremes of the operating temperature range. Conducted measurement for this kind of product which be used for integral antenna equipment connect to the measuring equipment. Refer to the clause 5.4.2 of standard EN 300 328.

Test setup:



Test procedure:

Removed the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the power sensor.
Step 1:
• Used a fast power sensor suitable for 2,4 GHz and capable of minimum 1 MS/s.
• Used the following settings:
- Sample speed 1 MS/s or faster.
- The samples shall represent the RMS power of the signal.
- For adaptive equipment, the measurement duration was long enough to ensure a minimum number of bursts (at least 10) are captured.
For adaptive equipment, to increase the measurement accuracy, a higher number of bursts may be used.

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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. Usethese stored samples in all following steps.
Step 3:
• Find the start and stop times of each burst in the stored measurement samples.
The start and stop times are defined as the points where the power is at least 30 dB below the highest value of the stored samples in step 2.
In case of insufficient dynamic range, the value of 30 dB may need to be reduced appropriately.
Step 4:
• Between the start and stop times of each individual burst calculate the RMS power over the burst using the formula below. 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.
• If applicable, add the additional beamforming gain "Y" in dB.
• If more than one antenna assembly is intended for this power setting, the maximum overall antenna gain (G or G + Y) shall be used.
• The RF Output Power (P) was calculated using the formula below:
P = A + G + Y
• This value, which shall comply with the limit, was recorded in the test report.

4.3.1 Used Test Equipment

Spectrum Analyzer, Broadband power meter
Refer to Clause 5 Test Equipment List for details.

4.3.2 Test Result and Data

Report the worst case:

Measurement Conditions (in Normal & Extreme)	Transmitter e.i.r.p.(dBm), Limit = -10dBW, i.e.20dBm		
Temperature (°C)	Lowest Frequency 2402 MHz (dBm)	Middle Frequency 2440 MHz (dBm)	Highest Frequency 2480 MHz (dBm)
T_{norm} = 25	2.1	2.0	2.1

T_{max} = 85	1.9	1.9	2.0
T_{min} = -40	2.0	2.0	1.9

Remark:

1) Test the EIRP in EUT continuously transmitting mode in the lowest frequency, middle frequency and the highest frequency in normal conditions and in extreme conditions.
2) Antenna gain(G): -0.5 dBi
   Cable loss: -0.3 dB
   P(e.i.r.p)=A(RMS level)+G+Cable loss

TEST RESULTS: The unit does meet the requirements.

4.4 Power Spectral Density

Test requirement: EN 300 328 clause 4.3.2.3

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

Test Method: EN 300 328 clause 5.4.3

EUT Operation:

Status: The measurement was repeated for the equipment being configured to operate at the lowest, the middle, and the highest frequency of the stated frequency range. These frequencies were recorded.

Entered test mode for the product. Tested in the lowest channel 2402 MHz, middle channel 2440 MHz and the highest channel 2480 MHz, kept in continuously transmitting status with normal modulation.

Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates. Following channel(s) and data rates were selected for the final test as listed below.

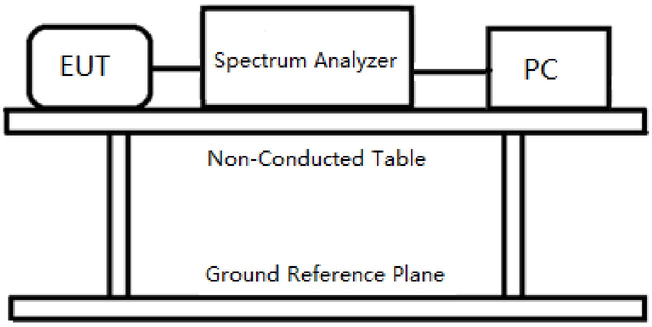
These tests were performed at normal environmental conditions.

Conducted measurement for this kind of products which be used for integral antenna equipment connect to the measuring equipment.

Refer to the clause 5.4.3 of standard EN 300 328.

Test setup:

TEST REPORT



Test procedure:

Removed the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.

Step 1:

- Start Frequency: 2 400 MHz
- Stop Frequency: 2 483,5 MHz
- Resolution BW: 10 kHz
- Video BW: 30 kHz
- Sweep Points: > 8350; 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 x Channel Occupancy Time x number of sweep points

For continuous transmissions: 10 s; the sweep time may be increased further until a value where the sweep time has no 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 3 (multiple antennas, no beamforming or multiple antennas, with beamforming), repeat the measurement for each of the transmit ports. For each frequency 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 amplitude so that the sum was equal to the RF Output Power (e.i.r.p.) measured in clause 5.4.2

Step 5:

Starting from the first sample in the file (lowest frequency), added up the power of the following samples representing a 1 MHz segment and recorded the results for power and position (i.e. sample #1 to #100). This was the Power Spectral Density (e.i.r.p.) for the first 1 MHz segment which was recorded.

Step 6:

Shifted 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 #101).
Step 7:
Repeated 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 record results, the highest value was the maximum Power Spectral Density for the EUT. This value, which shall comply with the limit given, was recorded in the test report.

4.4.1 Used Test Equipment

Spectrum Analyzer. Refer to Clause 5 Test Equipment List for details.

4.4.2 Test Result and Data

Report the worst case:

Measurement Conditions (in Normal)	Limit = 10dBm/MHz		
Temperature (°C)	Lowest Frequency 2402 MHz (dBm)	Middle Frequency 2440 MHz (dBm)	Highest Frequency 2480 MHz (dBm)
T_{nom} = 25	2	2	2

Remark:

Antenna gain(G): -0.5 dBi

Cable loss: -0.3 dB

P(e.i.r.p)=A(RMS)+G+Cable loss.

4.5 Duty cycle, Tx-Sequence, Tx-gap

N/A: not applicable.
These requirements apply to non-adaptive frequency hopping equipment or to adaptive frequency hopping equipment operating in a non-adaptive mode.

These requirements do not apply for equipment with a maximum declared RF Output power of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The EUT belongs to adaptive equipment.

4.6 Medium Utilisation

N/A: not applicable.
This requirement does not apply to adaptive equipment unless operating in a non-adaptive mode.

In addition, this requirement does not apply for equipment with a maximum declared RF Output power level of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.

The EUT belongs to adaptive equipment.

4.7 Adaptivity (adaptive equipment using modulations other than FHSS)

N/A: not applicable.
This requirement does not apply to non-adaptive equipment or adaptive equipment operating in a non-adaptive mode providing the equipment complies with the requirements and/or restrictions applicable to non-adaptive equipment.
In addition, this requirement does not apply for equipment with a maximum declared RF Output power level of less than 10 dBm e.i.r.p. or for equipment when operating in a mode where the RF Output power is less than 10 dBm e.i.r.p.
For the RF output power, please refer to clause 4.3.2 of the report for details.

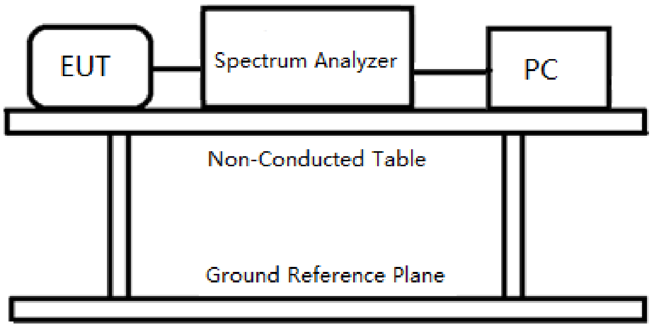
4.8 Occupied Channel Bandwidth

Test requirement:	EN 300 328 clause 4.3.2.7 The Occupied Channel Bandwidth is the bandwidth that contains 99 % of the power of the signal. The Occupied Channel Bandwidth shall fall completely within the band 2,4 GHz to 2,4835 GHz. In addition, for non-adaptive systems using wide band modulations other than FHSS and with e.i.r.p greater than 10 dBm, the occupied channel bandwidth shall be less than 20 MHz.
Test Method:	EN 300 328 clause 5.4.7
EUT Operation:	
Status:	The measurement was performed only on the lowest and the highest frequency within the stated frequency range. Entered test mode for the product. Tested in lowest channel 2402 MHz and highest channel 2480 MHz. Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity

architecture). Following channel(s) and data rates were selected for the final test as listed below.

These tests were performed at normal environmental conditions.

Test setup:



Test Procedure:
Step 1:
Connected the EUT to the spectrum analyzer 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 × Occupied Channel Bandwidth (e.g. 40 MHz for a 20 MHz channel)
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep time: 1s

Step 2:
Waited until the trace was completed.
Found the peak value of the trace and place the analyzer marker on this peak.
Step 3:
Used the 99 % bandwidth function of the spectrum analyzer to measure the Occupied Channel Bandwidth of the EUT.
This value was recorded.

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

4.8.1 Used Test Equipment List

Spectrum Analyzer. Refer to Clause 5 Test Equipment List for details.

4.8.2 Test result and Data:

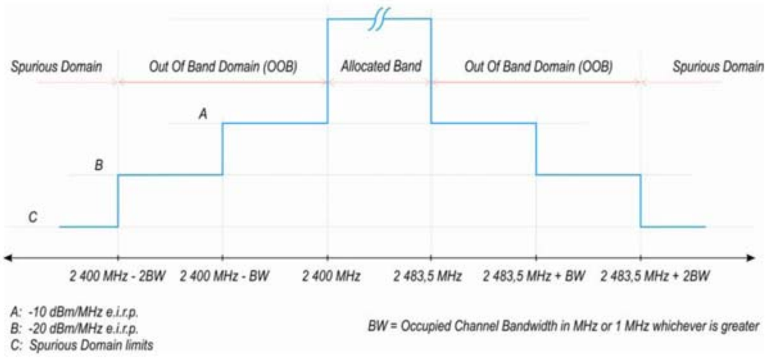
Measurement Conditions (in Normal)	Band edge of 99% Bandwidth (MHz)		Limit (MHz)	
Temperature (°C)	FL	FH	Lower	Higher
T_{norm} = 25	2401.39	2480.53	> 2400.0	< 2483.5

Note:
99% bandwidth of the lowest channel is 1.131109 MHz.
99% bandwidth of the highest channel is 1.074866 MHz.
FL: The Lowest frequency of the power envelope of the lowest channel.
FH: The Highest frequency of the power envelope of the highest channel.

4.9 Transmitter unwanted emissions in the out-of-band domain

Test requirement: EN 300 328 clause 4.3.2.8

The transmitter unwanted emissions in the out-of-band domain but outside the allocated band, shall not exceed the values provided by the mask in figure below.
Note: Within the 2 400 MHz to 2 483.5 MHz band, the Out-of-band emissions are fulfilled by compliance with the Occupied Channel Bandwidth requirement.



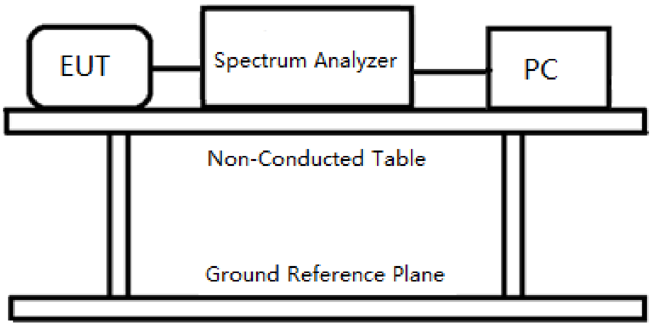
Test Method: EN 300 328 clause 5.4.8

EUT Operation:

Status: Entered test mode for the product. Tested in lowest channel 2402 MHz and highest channel 2480 MHz kept in continuously transmitting status with normal modulation.
Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity

architecture). Following channel(s) and data rates were selected for the final test as listed below.
These tests were performed at normal environmental conditions and repeated at the extremes of the operating temperature range.
Conducted measurement for this kind of products which be used for integral antenna equipment connect to the measuring equipment.
Refer to the clause 5.3.2 of standard EN 300 328.

Test setup:



Test Procedure:

Step 1:
Connect the UUT to the spectrum analyzer and use the following settings:
- Centre Frequency: 2 484 MHz
- Span: 0 Hz
- Resolution BW: 1 MHz
- Filter mode: Channel filter
- Video BW: 3 MHz
- Detector Mode: RMS
- Trace Mode: Max Hold
- Sweep Mode: Continuous
- Sweep Points: Sweep Time [s] / (1 µs) or 5 000 whichever is greater
- Trigger Mode: Video trigger

In case video triggering is not possible, an external trigger source may be used.
- Sweep Time: > 120 % of the duration of the longest burst detected during the measurement of the RF Output Power

Step 2:
Scanned from 2400 MHz-2BW to 2483.5+2BW, found the maximum emission frequency to measure and record.
In case of conducted measurements on equipment with a single transmit chain, the declared antenna assembly gain "G" in dBi was added to the results for each of the 1 MHz segments and compared with the limits provided by the mask.
P(e.i.r.p)=A(RMS level)+G+Cable loss

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4.9.1 Used Test Equipment List

Spectrum Analyzer. Refer to Clause 5 Test Equipment List for details

4.9.2 Test Result and Data

2402MHz:

Measurement Conditions (in Normal & Extreme)	Transmitter e.i.r.p.(dBm/MHz), Limit			
	-20	-10	-10	-20
Temperature (°C)	segment 2 400 MHz - 2BW to 2 400 MHz - BW	segment 2 400 MHz - BW to 2 400 MHz	Segment 2 483,5 MHz to 2 483,5 MHz + BW	segment 2 483,5 MHz + BW to 2 483,5 MHz + 2BW
T_{norm} = 25	-61.5	-56.1	-69.6	-69.6

2480MHz:

Measurement Conditions (in Normal & Extreme)	Transmitter e.i.r.p.(dBm/MHz), Limit			
	-20	-10	-10	-20
Temperature (°C)	segment 2 400 MHz - 2BW to 2 400 MHz - BW	segment 2 400 MHz - BW to 2 400 MHz	Segment 2 483,5 MHz to 2 483,5 MHz + BW	segment 2 483,5 MHz + BW to 2 483,5 MHz + 2BW
T_{norm} = 25	-69.9	-70.2	-61.9	-63.8

Remark:

1) BW= Max. Occupied Channel Bandwidth=1.131109 MHz
2) Test the EIRP in EUT continuously transmitting mode in the lowest frequency and highest frequency in normal conditions.
3) Antenna gain(G): -0.5 dBi
   Cable loss: -0.3 dB
   P(e.i.r.p)=A(RMS level)+G+Cable loss

Measurement Uncertainty: ±1.49dB

4.10 Transmitter unwanted emissions in the spurious domain

Test requirement: EN 300 328 clause 4.3.2.9

The transmitter unwanted emissions in the spurious domain shall not exceed the values given in below table:

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

(exclude frequency band: 2400-2BW~2483.5+2BW)

Test Method: EN 300 328 clause 5.4.9

EUT Operation:

Status: Entered test mode for the product. Tested in lowest channel 2402 MHz and highest channel 2480 MHz kept in continuously transmitting status with normal modulation.
Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture). Following channel(s) and data rates were selected for the final test as listed below.
These tests were performed at normal environmental conditions

Test Procedure:

Substitution method was performed to determine the actual spurious emission levels of the EUT.
The following test procedure as below:
1) Below 1GHz test procedure:

1. On the test site as test setup graph below, the EUT was placed at the 1.5m support on the turntable and in the position closest to normal use as declared by the provider.
2. The test antenna was oriented initially for vertical polarization and was chosen to correspond to the test frequency of the transmitter. The output of the test antenna was connected to the measuring receiver.
3. The transmitter was switched on, if possible, without modulation and the measuring receiver was tuned to the test frequency of the transmitter under test.
4. The test antenna was raised and lowered from 1m to 4m until a maximum signal level was detected by the measuring receiver. Then the turntable was rotated through 360° in the horizontal plane, until the maximum signal level was detected by the measuring receiver.
5. Repeated step 4 for test frequency with the test antenna polarized horizontally.
6. Removed the transmitter and replaced it with a substitution antenna (the antenna was half-wavelength for each frequency involved). The center of the substitution antenna was approximately at the same location as the center of the transmitter. The lower end of the antenna was 0.3 m above the ground when the antenna was polarized vertically.
7. Fed the substitution antenna at the transmitter end with a signal generator connected to the antenna by means of a nonradiating cable. With the antennas at both ends vertically polarized, and with the signal generator tuned to a particular test frequency, raised and lowered the test antenna to obtain a maximum reading at the spectrum analyzer. Adjusted the level of the signal generator output until the previously

recorded maximum reading for this set of conditions was obtained. This was done carefully repeating the adjustment of the test antenna and generator output.

8. Repeated step 7 with both antennas horizontally polarized for each test frequency.
9. Calculated power in dBm into a reference ideal half-wave dipole antenna by reducing the readings obtained in steps 7 and 8 by the power loss in the cable between the generator and the antenna, and further corrected for the gain of the substitution antenna used relative to an ideal half-wave dipole antenna by the following formula:

ERP(dBm) = Pg(dBm) – cable loss (dB) + antenna gain (dBd)

where:

Pg is the generator output power into the substitution antenna.

2) Above 1GHz test procedure:

Different between above was the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber, and the test antenna did not need to raise from 1 to 4m, just test at 1.5m height.

Test Setup:

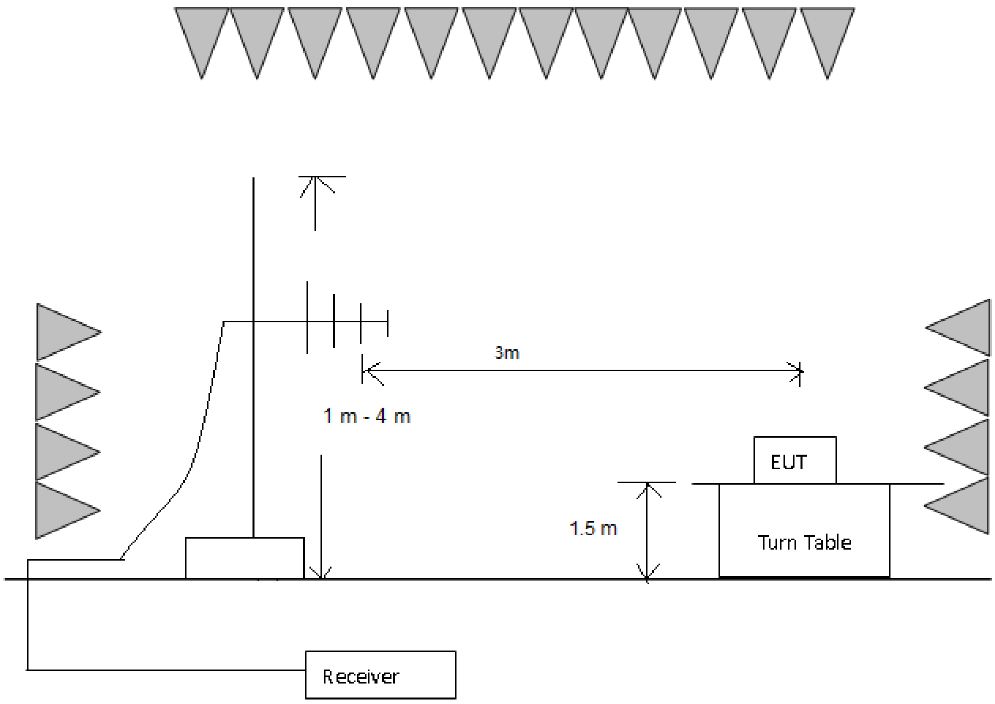

Figure 1. 30 MHz to 1 GHz

TEST REPORT

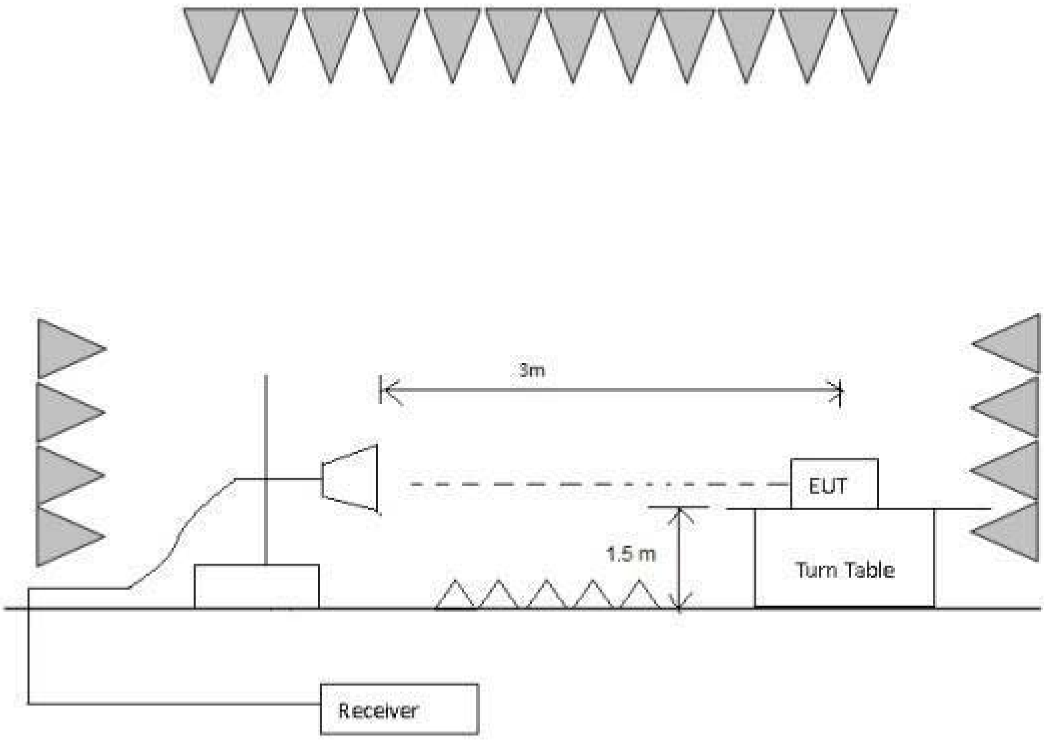

Figure 2. Above 1GHz

4.10.1 Used Test Equipment List

3m Semi-Anechoic Chamber, Super Broadband test Antenna, Bouble-Ridged Waveguide Horn Antenna, EMI Test Receiver, Spectrum Analyzer, Coaxial cable.
Refer to Clause 5 Test Equipment List for details.

4.10.2 Test Result and Data

Test in lowest Channel (2402 MHz)

	Frequency	Measured Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
H	45.52	-71.749	-36	-35.749
H	243.788	-77.308	-36	-41.308
H	720.737	-65.437	-36	-29.437
H	1466.893	-59.363	-30	-29.363
H	4803.143	-43.374	-30	-13.374
H	7713.786	-48.079	-30	-18.079

TEST REPORT

V	34.171	-62.265	-36	-26.265
V	52.504	-61.699	-54	-7.699
V	246.31	-68.805	-36	-32.805
V	1159.679	-55.944	-30	-25.944
V	3186.321	-53.832	-30	-23.832
V	4804.357	-46.488	-30	-16.488

Test in highest Channel (2480 MHz)

	Frequency	Measured Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
H	34.171	-70.347	-36	-34.347
H	244.855	-76.003	-36	-40.003
H	723.162	-68.37	-36	-32.37
H	1901.607	-52.342	-30	-22.342
H	4959.786	-49.349	-30	-19.349
H	7982.750	-48.186	-30	-18.186
V	52.504	-61.336	-54	-7.336
V	86.066	-69.893	-36	-33.893
V	245.922	-68.258	-36	-32.258
V	1595.000	-57.03	-30	-27.03
V	4959.786	-49.772	-30	-19.772
V	9781.714	-46.333	-30	-16.333

Notes:
1. Negative sign (-) in the margin column signify levels below the limit.
2. The test frequency range is 30MHz to 12.75GHz.
3. Other emissions found were at least 10 dB below the limit.
4. Harmonic Emissions was tested with filter (Product name: MICRO-TRONICS, model name:BRM50702), other radiated emissions were found below the reference noise level

4.11 Spurious Emissions (Receiver)

Test requirement: EN 300 328 clause 4.3.2.10

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

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

Test Method: EN 300 328 clause 5.4.10

EUT Operation Status: Entered test mode for the product. Tested in lowest channel 2402 MHz and highest channel 2480 MHz kept in continuously transmitting status with

normal modulation.
Pre-Scan had been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture). Following channel(s) and data rates were selected for the final test as listed below.
These tests were performed at normal environmental conditions

Test Setup:

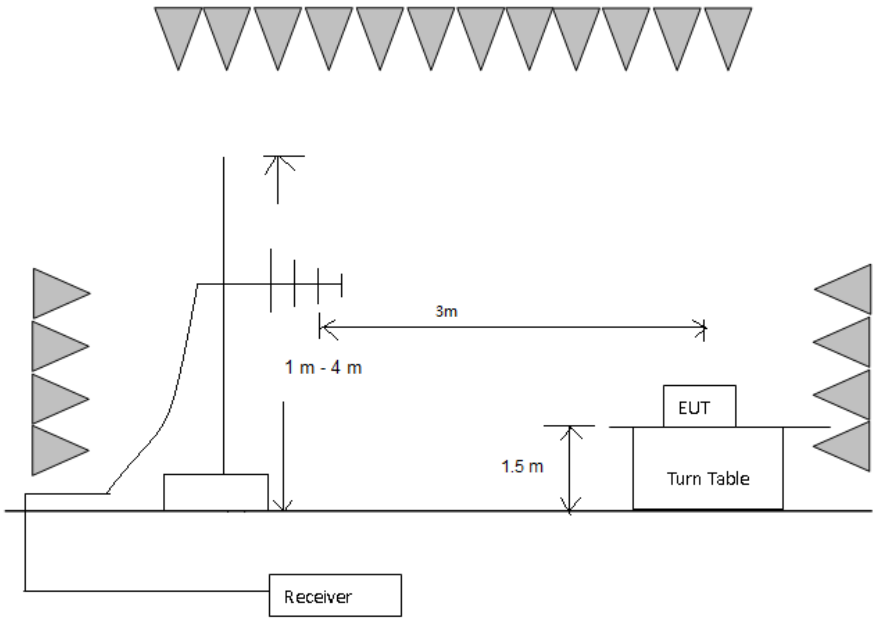

Figure 1. 30 MHz to 1 GHz

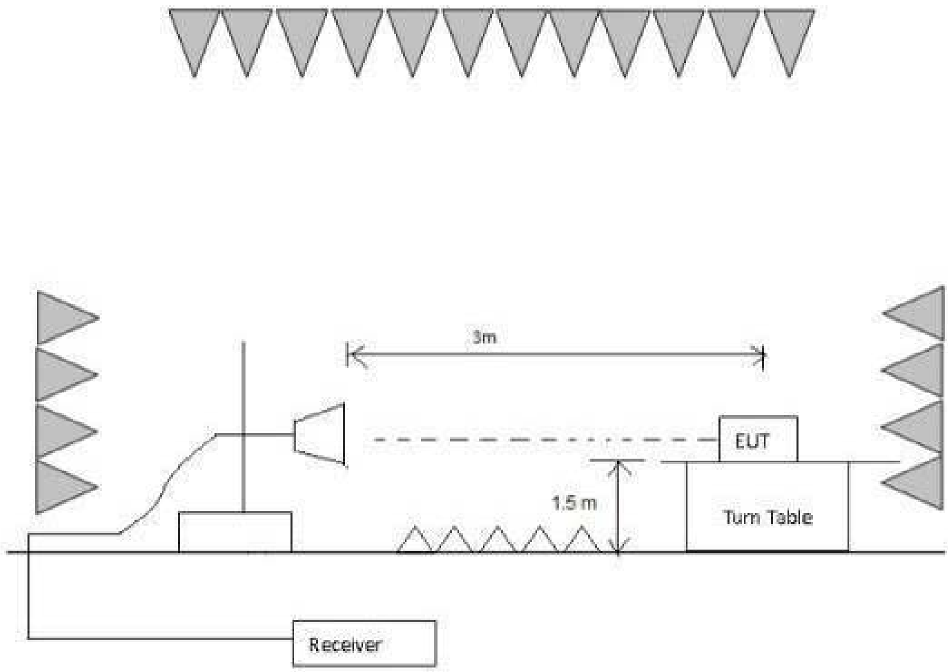

Figure 2. Above 1GHz

Test Procedure:
Substitution method was performed to determine the actual spurious emission levels of the EUT.
The following test procedure as below:
1) Below 1GHz test procedure:

1. On the test site as test setup graph below, the EUT was placed at the 1.5m support on the turntable and in the position closest to normal use as declared by the provider.
2. The test antenna was oriented initially for vertical polarization and was chosen to correspond to the test frequency of the transmitter. The output of the test antenna was connected to the measuring receiver.
3. The Receiver was switched on, if possible, without modulation and the measuring receiver was tuned to the test frequency of the transmitter under test.
4. The test antenna was raised and lowered from 1m to 4m until a maximum signal level was detected by the measuring receiver. Then the turntable was rotated through 360° in the horizontal plane, until the maximum signal level was detected by the measuring receiver.
5. Repeated step 4 for test frequency with the test antenna polarized horizontally.
6. Removed the Receiver and replaced it with a substitution antenna (the antenna was half-wavelength for each frequency involved). The center of the substitution antenna was approximately at the same location as the center of the transmitter. The lower end of the antenna was 0.3 m above the ground when the antenna was polarized vertically.
7. Fed the substitution antenna at the transmitter end with a signal generator connected to the antenna by means of a nonradiating cable. With the antennas at both ends vertically polarized, and with the signal generator tuned to a particular test frequency, raised and lowered the test antenna to obtain a maximum reading at the spectrum analyzer. Adjusted the level of the signal generator output until the previously recorded maximum reading for this set of conditions was obtained. This was done carefully repeating the

adjustment of the test antenna and generator output.

8. Repeated step 7 with both antennas horizontally polarized for each test frequency.
9. Calculated power in dBm into a reference ideal half-wave dipole antenna by reducing the readings obtained in steps 7 and 8 by the power loss in the cable between the generator and the antenna, and further corrected for the gain of the substitution antenna used relative to an ideal half-wave dipole antenna by the following formula:
   ERP(dBm) = Pg(dBm) – cable loss (dB) + antenna gain (dBd)

where:

Pg is the generator output power into the substitution antenna.

2) Above 1GHz test procedure:

Different between above was the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber, and the test antenna did not need to raise from 1 to 4m, just test at 1.5m height.

4.11.1 Used Test Equipment List

3m Semi-Anechoic Chamber, Super Broadband test Antenna, Bouble-Ridged Waveguide Horn Antenna, EMI Test Receiver, Spectrum Analyzer, Coaxial cable
Refer to Clause 5 Test Equipment List for details

4.11.2 Test Result and Data

After conducting pre-scan on the frequencies of 2402 MHz and 2480 MHz, the worst case was found at 2402 MHz.
Test in lowest Channel (2402 MHz)

	Frequency	Measured Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
H	45.811	-71.462	-57	-14.462
H	246.019	-75.341	-57	-18.341
H	719.67	-66.849	-57	-9.849
H	4805.733	-48.672	-47	-1.672
H	7215.767	-49.161	-47	-2.161
H	10381.733	-48.236	-47	-1.236
V	34.462	-62.148	-57	-5.148
V	52.892	-62.167	-57	-5.167
V	245.243	-67.194	-57	-10.194
V	7150.600	-55.2	-47	-8.2
V	9729.500	-55.7	-47	-8.7
V	11515.067	-56.7	-47	-9.7

TEST REPORT

Notes:
1. The test frequency range is 30MHz to 12.75GHz.
2. Other emissions found were at least 10 dB below the limit.

4.12 Receiver Blocking

Test requirement: EN 300 328 clause 4.3.2.11

The minimum performance criterion shall be a PER less than or equal to 10 %. While maintaining the minimum performance criteria, 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 in the standard.

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 + $10 \times \log_{10}$(OCBW)) or -68 dBm whichever is less (see note 2)	2 380 2 504	-34	CW
(-139 dBm + $10 \times \log_{10}$(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.

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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
$(-139\text{ dBm} + 10 \times \log_{10}(\text{OCBW}) + 10\text{ dB})$ or $(-74\text{ dBm} + 10\text{ dB})$ 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
$(-139\text{ dBm} + 10 \times \log_{10}(\text{OCBW}) + 20\text{ dB})$ or $(-74\text{ dBm} + 20\text{ dB})$ whichever is less (see note 2)	2 380 2 504 2 300 2 584	-34	CW

NOTE 1: OCBW is in Hz.
NOTE 2: In case of radiated measurements using a companion device and the level of the wanted signal from the companion device cannot be determined, a relative test may be performed using a wanted signal up to P_{min} + 30 dB where P_{min} is the minimum level of wanted signal required to meet the minimum performance criteria as defined in clause 4.3.1.12.3 in the absence of any blocking signal.
NOTE 3: The level specified is the level at the UUT receiver input assuming a 0 dBi antenna assembly gain. In case of conducted measurements, this level has to be corrected for the (in-band) antenna assembly gain (G). In case of radiated measurements, this level is equivalent to a power flux density (PFD) in front of the UUT antenna with the UUT being configured/positioned as recorded in clause 5.4.3.2.2.

As the maximum RF output power of the EUT is not greater than 10dBm e.i.r.p., it was considered as receiver category 2 equipment

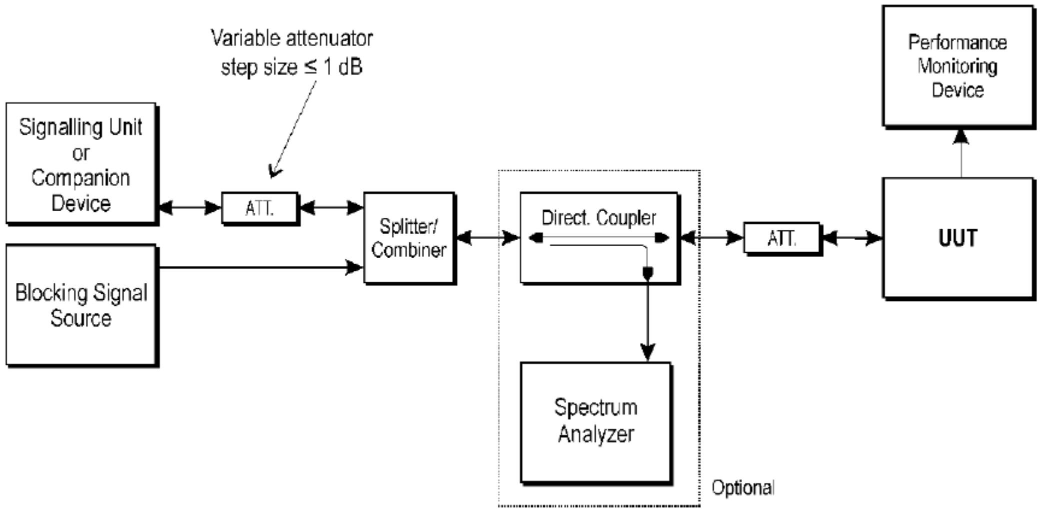
Test Method: EN 300 328 clause 5.4.11

EUT Operation

Status: Tested the EUT with the normal data rate at the lowest and highest operation frequency.
These tests were performed at normal environmental

Test Setup:

TEST REPORT



Test Procedure:

Step 1:

•For non-frequency hopping equipment, the UUT shall be set to the lowest operating channel.

Step 2:

•The blocking signal generator is set to the first frequency as defined in the appropriate table corresponding to the receiver category and type of equipment.

Step 3:

•With the blocking signal generator switched off, a communication link is established between the UUT and the associated companion device using the test setup shown in figure 6. The attenuation of the variable attenuator shall be increased in 1 dB steps to a value at which the minimum performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is still met. The resulting level for the wanted signal at the input of the UUT is Pmin.

•This signal level (Pmin) is increased by the value provided in the table corresponding to the receiver category and type of equipment.

Step 4:

•The blocking signal at the UUT is set to the level provided in the table corresponding to the receiver category and type of equipment. It shall be verified and recorded in the test report that the performance criteria as specified in clause 4.3.1.12.3 or clause 4.3.2.11.3 is met.

Step 5:

•Repeat step 4 for each remaining combination of frequency and level for the blocking signal as provided in the table corresponding to the receiver category and type of equipment.

Step 6:

•For non-frequency hopping equipment, repeat step 2 to step 5 with the UUT operating at the highest operating channel.

4.12.1 Used Test Equipment List

Refer to Clause 5 Test Equipment List for details.

4.12.2 Test Result and Data

☐ **Receiver Category 1:**

2402MHz:

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-133 dBm+10 x $\log_{10}$(OCBW)) or -68dBm whichever is less	2380	-34	-	10
(-139 dBm+10 x $\log_{10}$(OCBW)) or -74 dBm whichever is less	2300		-	
	2330		-	
	2360		-	

2480MHz:

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-133 dBm+10 x $\log_{10}$(OCBW)) or -68dBm whichever is less	2504	-34	-	10
(-139 dBm+10 x $\log_{10}$(OCBW)) or -74 dBm whichever is less	2524		-	
	2584		-	
	2674		-	

☑ **Receiver Category 2:**

2402MHz:

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-139 dBm+10 x $\log_{10}$(OCBW)+10dB) or (-74 dBm+10dB) whichever is less	2380	-34	**0**	10
	2300		**0.01**	

2480MHz:

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-139 dBm+10 x $\log_{10}$(OCBW)+10dB) or (-74 dBm+10dB) whichever is less	2504	-34	**0.11**	10
	2584		**0.12**	

☐ **Receiver Category 3:**

2402MHz:

TEST REPORT

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-139 dBm+10 x $\log_{10}$(OCBW)+20dB) or (-74 dBm+20dB) whichever is less	2380	-34	-	10
	2300		-	

2480MHz:

Wanted signal mean power from companion device (dBm)	Blocking signal frequency (MHz)	Blocking signal power(dBm)	PER(%)	Limit(%)
(-139 dBm+10 x $\log_{10}$(OCBW)+20dB) or (-74 dBm+20dB) whichever is less	2504	-34	-	10
	2584		-	

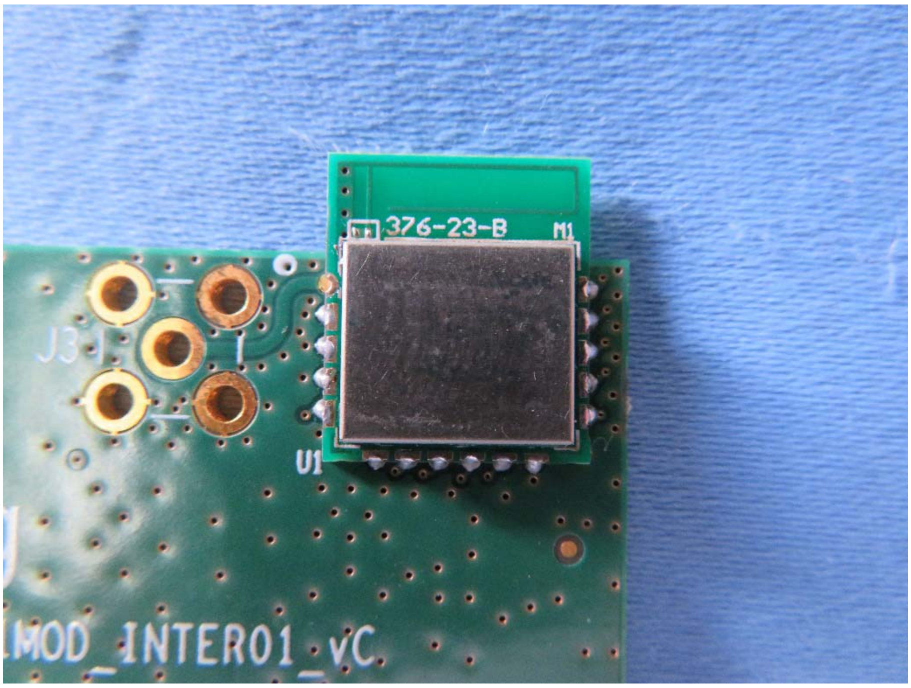
The result is complied with the standard requirement.

5.0 Test Equipment List

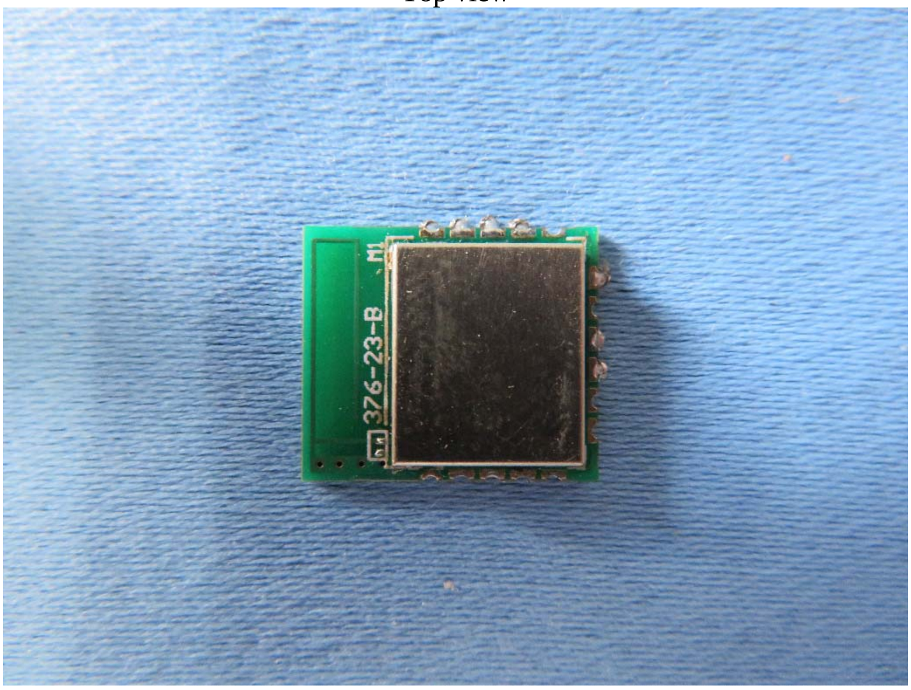
Equipment No.	Equipment	Model	Manufacturer	Cal. Due date (YYYY-MM-DD)	Calibration Interval
EM030-04	3m Semi-Anechoic Chamber	$9 \times 6 \times 6$ m^3	ETS• LINDGREN	4/10/2021	1Y
EM080-05	EMI Test Receiver (9 kHz~3 GHz)	ESCI	R&S	7/17/2020	1Y
EM031-02	EMI Test Receiver (9 kHz~7 GHz)	R&S ESR7	R&S	10/22/2020	1Y
EM031-03	Signal and Spectrum Analyzer (10 Hz~40 GHz)	R&S FSV40	R&S	9/8/2020	1Y
EM011-04	Loop antenna (9 kHz-30 MHz)	HFH2-Z2	R&S	6/24/2020	1Y
EM061-03	TRILOG Super Broadband test Antenna (TX)	VULB 9161	SCHWARZBECK	6/22/2020	1Y
EM033-01	TRILOG Super Broadband test Antenna(RX)	VULB 9163	SCHWARZBECK	9/19/2020	1Y
EM033-06	Bouble-Ridged Waveguide Horn Antenna (800 MHz-18 GHz)(TX)	3115	ETS	9/6/2022	3Y
EM033-02	Bouble-Ridged Waveguide Horn Antenna (800 MHz-18 GHz)(RX)	R&S HF907	R&S	6/22/2020	1Y
EM033-05	Pyramidal Horn Antenna (18 GHz-26.5 GHz)(TX)	3160-09	ETS	8/12/2020	1Y
EM033-03	High Frequency Antenna & preamplifier(18 GHz~26.5 GHz) (RX)	R&S SCU-26	R&S	4/24/2021	1Y
EM033-04	High Frequency Antenna & preamplifier (26 GHz-40 GHz)	R&S SCU-40	R&S	4/24/2021	1Y
EM031-02-01	Coaxial cable(9 kHz-1 GHz)	N/A	R&S	4/12/2021	1Y
EM033-02-02	Coaxial cable(1 GHz-18 GHz)	N/A	R&S	4/12/2021	1Y
EM033-04-02	Coaxial cable(18 GHz~40 GHz)	N/A	R&S	4/24/2021	1Y
EM045-01	Broadband power meter	OSP120/OSP-B157	R&S	11/24/2020	1Y
EM082-02	Vector signal generator	SMBV100A	R&S	4/15/2021	1Y
EM031-01	Signal Generator (9 kHz~6 GHz)	SMB100A	R&S	7/18/2020	1Y
EM040-01	Band Reject/Notch Filter	WRHFV	Wainwright	N/A	1Y
EM040-02	Band Reject/Notch Filter	WRCGV	Wainwright	N/A	1Y
EM040-03	Band Reject/Notch Filter	WRCGV	Wainwright	N/A	1Y
EM022-03	2.45 GHz Filter	BRM50702	Micro-Tronics	5/10/2021	1Y
SA016-16	Programmable Temperature & Humidity Test Chamber	MHU-800LJ	TERCHY	10/13/2020	1Y
SA016-22	Climatic Test Chamber	C7-1500	Vötsch	11/10/2020	1Y
SA012-74	Digital Multimeter	FLUKE175	FLUKE	10/13/2020	1Y
EM010-01	Regulated DC Power supply	PAB-3003A	GUANHUA	N/A	1Y
SA040-22	Regulated DC Power supply	IT6721	ITECH	9/8/2020	1Y
EM084-06	Audio Analyzer	8903B	HP	4/15/2021	1Y
EM045-01-01	EMC32 software (RE/RS)	V10.01.00	R&S	N/A	N/A
EM045-01-09	EMC32 software (328/893)	V10.01.00	R&S	N/A	N/A
100607	Base station	CMW270	R&S	2021/07/12	1Y
260592	Vector Signal Generator	SMBV100A	R&S	2021/07/12	1Y

6.0 Appendix I - Photos of EUT

Overall view

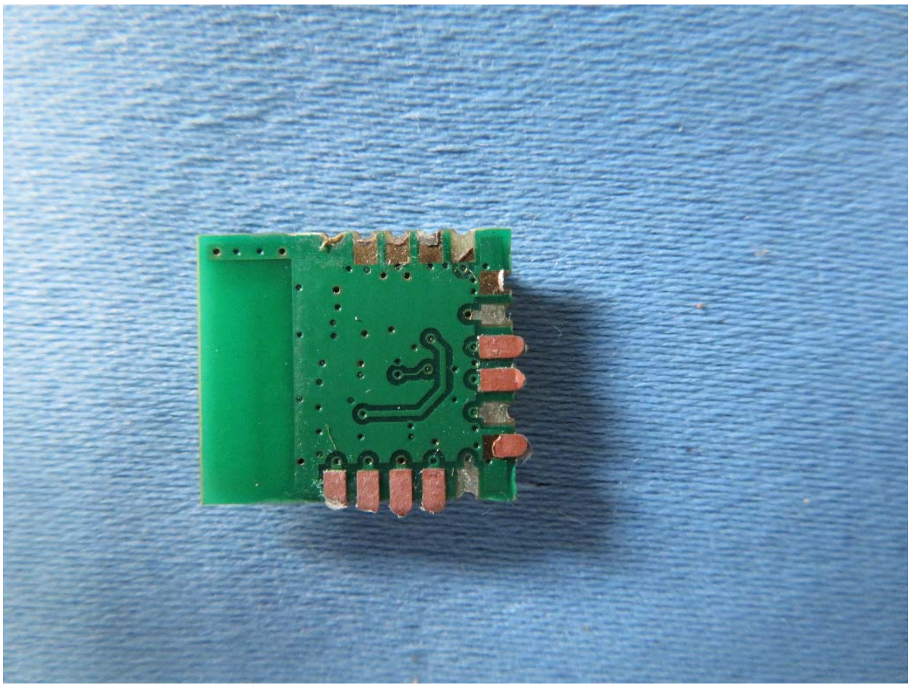


Top view

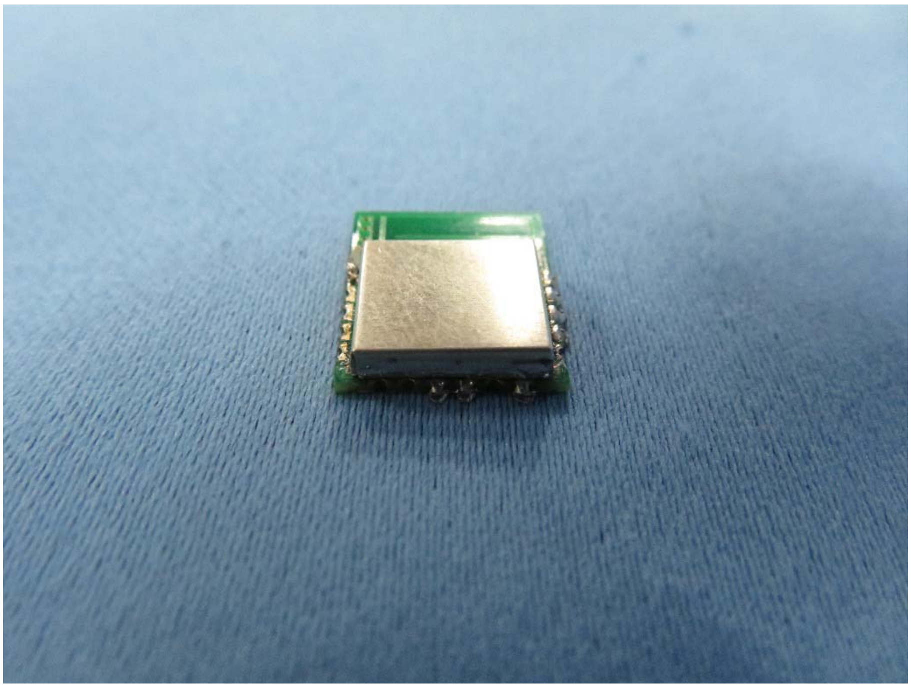


TEST REPORT

Back view

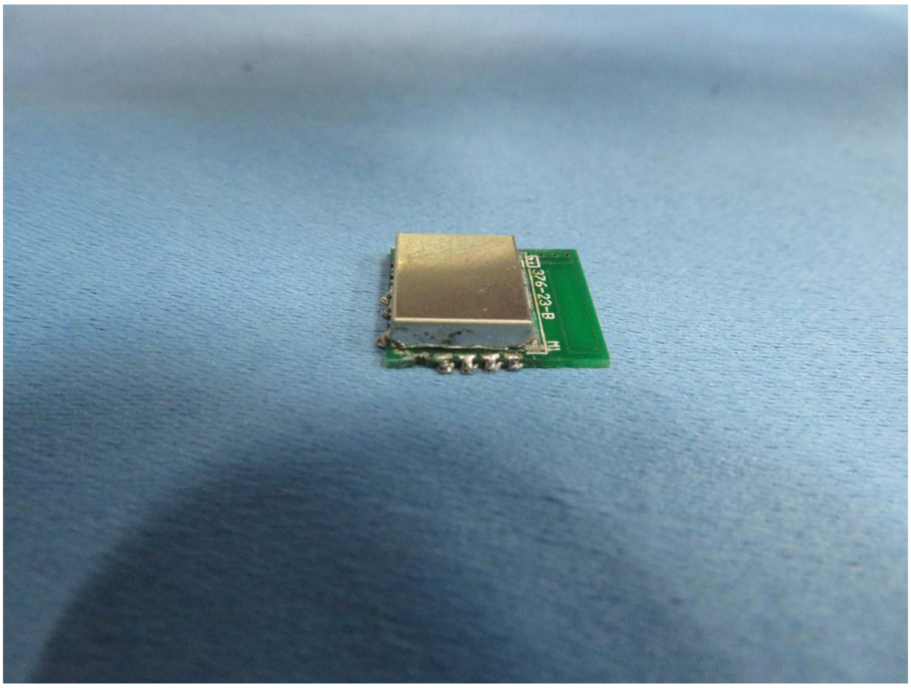


Side view



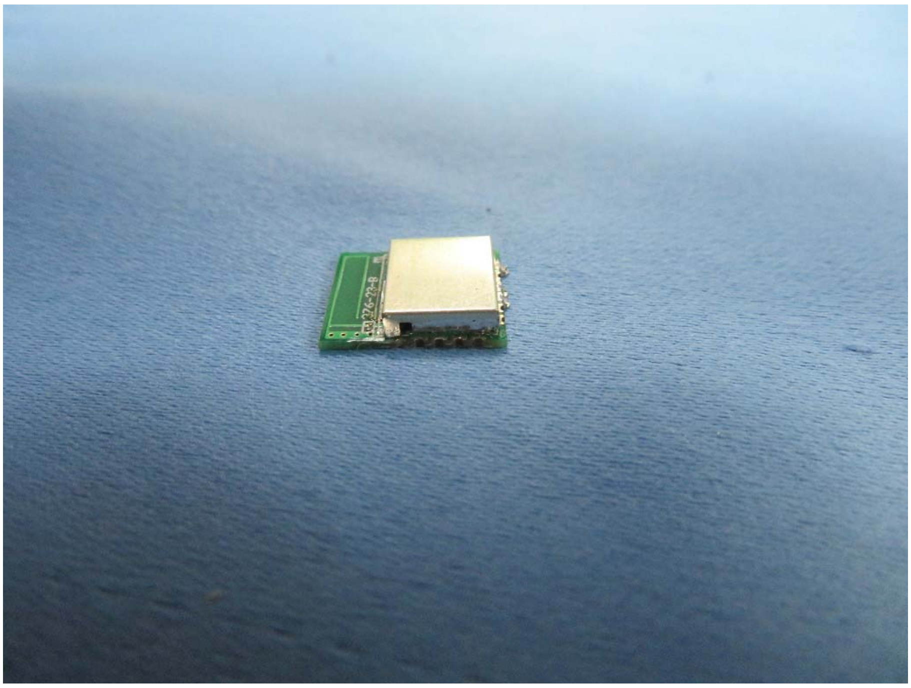
TEST REPORT

Side view

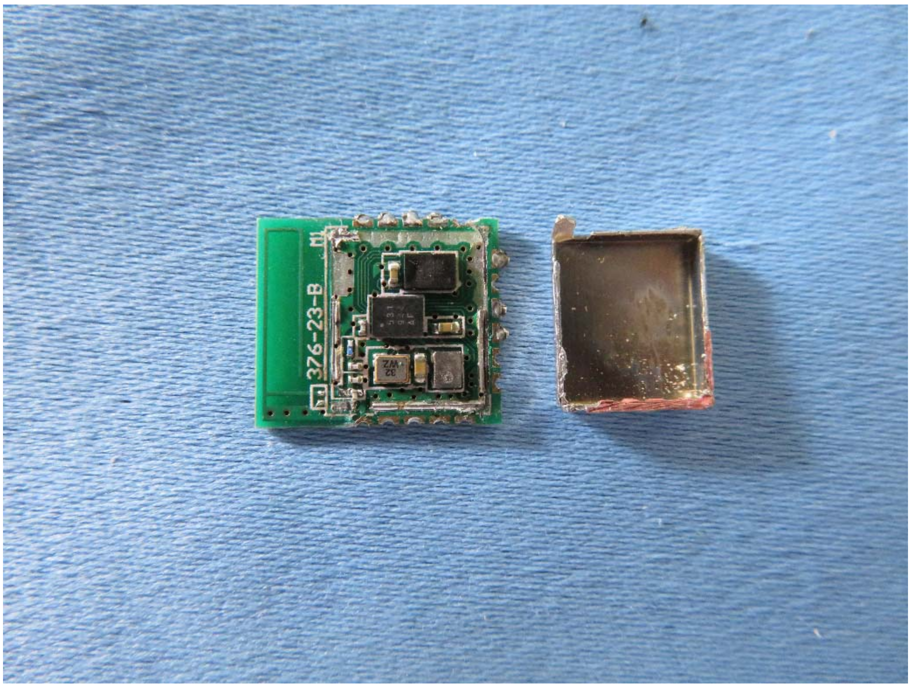


Side view

Side view

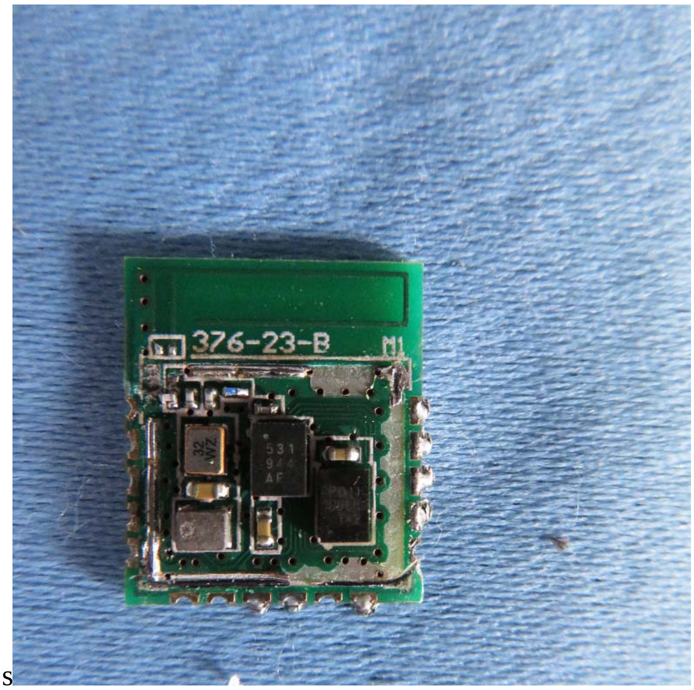


Internal view



TEST REPORT

Internal view



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End of the test report**********************************