CE Test Report

Equipment	:	**802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module** **(Please refer to section 1.1.1 for more details)**
Model No.	:	**ST60-2230C** **(Please refer to section 1.1.1 for more details)**
Brand Name	:	**Laird Connectivity**
Applicant	:	**Laird Connectivity, Inc.**
Address	:	**W66N220 Commerce Court, Cedarburg, Wisconsin 53012, USA**
Standard	:	**EN 300 328 V2.2.2 (2019-07)**
Received Date	:	**Jun. 05, 2020**
Tested Date	:	**Apr. 24 ~ Jun. 01, 2017 (for original test)** **Jun. 05, 2020 (for new test)**

We, International Certification Corp., would like to declare that the tested sample has been evaluated and in compliance with the requirement of the above standards. The test results contained in this report refer exclusively to the product. It may be duplicated completely for legal use with the approval of the applicant. It shall not be reproduced except in full without the written approval of our laboratory.

Reviewed by: **Approved by:**

James Fan / Assistant Manager **Gary Chang / Manager**

Testing Laboratory 2732

Table of Contents

1 GENERAL DESCRIPTION 5

1.1 Information 5
1.2 Local Support Equipment List 9
1.3 Test Setup Chart 9
1.4 Test Equipment List and Calibration Data 11
1.5 Testing Applied Standards 13
1.6 Deviation from Test Standard and Measurement Procedure 13
1.7 Measurement Uncertainty 13

2 TEST CONFIGURATION 14

2.1 Testing Condition 14
2.2 Testing Facility 14
2.3 The Worst Test Modes and Channel Details 14

3 TRANSMITTER TEST RESULTS 15

3.1 RF Output Power 15
3.2 Power Spectral Density 18
3.3 Occupied Channel Bandwidth 19
3.4 Transmitter Unwanted Emissions in the Out-Of-Band Domain 20
3.5 Transmitter Unwanted Emissions in the Spurious Domain 24

4 RECEIVER TEST RESULTS 38

4.1 Receiver Spurious Emissions 38

5 RECEIVER BLOCKING TEST RESULTS 52

5.1 Receiver Blocking 52

6 PHOTOGRAPHS OF THE TEST CONFIGURATION 57

7 TEST LABORATORY INFORMATION 60

Release Record

Report No.	Version	Description	Issued Date
ER740701-11AE	Rev. 01	Initial issue	Feb. 25, 2021

Summary of Test Results

Ref. Std. Clause	Test Items	Measured	Result
4.3.2.2	RF Output Power	9.85 dBm.	Pass
4.3.2.3	Power Spectral Density	Meet the requirement of limit.	Pass
4.3.2.4	Duty Cycle, Tx-sequence, Tx-gap	Only for non-adaptive equipment	N/A
4.3.2.5	Medium Utilisation (MU) factor	Only for non-adaptive equipment	N/A
4.3.2.6	Adaptivity	The RF Output power is less than 10 dBm e.i.r.p. This item is not applicable.	N/A
4.3.2.7	Occupied Channel Bandwidth	Meet the requirement of limit.	Pass
4.3.2.8	Transmitter unwanted emissions in the out of band domain	Meet the requirement of limit.	Pass
4.3.2.9	Transmitter unwanted emissions in the spurious domain	Meet the requirement of limit.	Pass
4.3.2.10	Receiver spurious emissions	Meet the requirement of limit.	Pass
4.3.2.11	Receiver Blocking	Meet the requirement of limit.	Pass
4.3.2.12	Geo-location Capability	The device has no this capability.	N/A

Declaration of Conformity:
The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.
Comments and Explanations:
The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.

1 General Description

1.1 Information

This report is issued as a supplementary report to original ICC report no. ER740701-08AE. The modification is

1. Additional model and product names
2. Resistance of CONFIG_HOST0/1/2 are different to switch interface
3. Update to the latest SW version

After verification, above changes does not impact to original test results. Thus test results remain the same.

1.1.1 Product Details

The following models are provided to this EUT.

Brand Name	Model Name	Product Name	Description
Laird Connectivity	ST60-2230C	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module	with carrier board
	ST60-2230C-P	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module PCIe/UART interface	PCIe/UART interface
	ST60-2230C-PU	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module PCIe/USB interface	PCIe/USB interface
	ST60-2230C-SS	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module SDIO/SDIO Interface	SDIO/SDIO Interface
	ST60-2230C-U	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module USB/UART Interface	USB/UART Interface
	ST60-2230C-UU	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module USB/USB interface	USB/USB interface
	ST60-2230C-Q	802.11 ac/a/b/g/n M.2 2230 + Bluetooth 4.2 module,ST60-2230C-Q	The difference between ST60-2230C and ST60-2230C-Q the OTP parameter is different for ID recognition. SW is exactly the same.
✦ The above models, model **ST60-2230C** was selected as a representative one for the final test and only its data was recorded in this report.			

1.1.2 Specification of the Equipment under Test (EUT)

RF General Information				
Frequency Range (MHz)	**Bluetooth Mode**	**Ch. Frequency (MHz)**	**Channel Number**	**Data Rate**
2400-2483.5	V4.2 LE	2402-2480	0-39 [40]	1 Mbps
Note 1: Bluetooth LE (Low energy) uses GFSK modulation.				

1.1.3 Antenna Details

Ant. No.	Model	Type	Connector	Operating Frequencies (MHz) / Antenna Gain (dBi)				
				2400~2483.5	5150~5250	5250~5350	5470~5725	5725~5850
1	LSR/001-0009	Dipole	IPEX U.FL	2	2	2	2	2
2	Laird NanoBlade-IP04	PCB Dipole	IPEX U.FL	2	3.9	3.9	4	4
3	Laird MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
4	LSR/FlexPIFA 001-0016	PIFA	IPEX U.FL	2.5	3	3	3	3
5	Ethertronics WLAN_1000146	Isolated Magnetic Dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5
6	Laird/MIMO FlexPIFA Antenna	PIFA	IPEX U.FL	2	3	3	3	3

1.1.4 EUT Operational Condition

Power Supply Type	DC 3.3V from host		
SW Version	laird-backport-7.0.0.136 (only for ST60-2230C-UU) laird-backport-7.0.0.70 (others)		
Operational Climatic	☒ Tnom (20°C)	☒ Tmax (85°C)	☒ Tmin (-30°C)

1.1.5 Accessories

N/A

1.1.6 Channel List

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

1.1.7 Test Tool and Duty Cycle

Test Tool	Command		
Duty Cycle and Duty Factor	**Modulation Mode**	**Duty Cycle (%)**	**Duty Factor (dB)**
	GFSK-1Mbps	62.90	2.01

1.1.8 Power Setting

Configuration 1 : Dipole Antenna

Modulation Mode	Test Frequency (MHz)		
	2402	2440	2480
GFSK-1Mbps	5	5	6

Configuration 2 : PCB Dipole Antenna

Modulation Mode	Test Frequency (MHz)		
	2402	2440	2480
GFSK-1Mbps	5	5	5

Configuration 3 : PIFA Antenna & Configuration 4: Isolated Magnetic Dipole Antenna

Modulation Mode	Test Frequency (MHz)		
	2402	2440	2480
GFSK-1Mbps	5	5	5

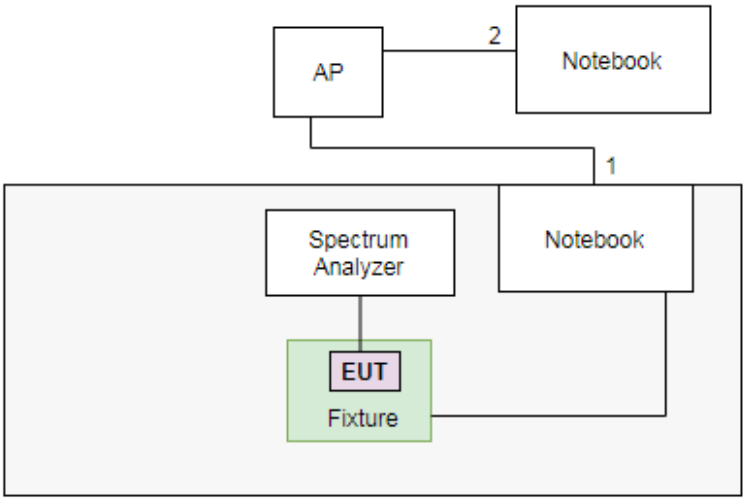
1.2 Local Support Equipment List

Support Equipment List					
No.	**Equipment**	**Brand**	**Model**	**FCC ID**	**Signal cable / Length (m)**
1	Notebook	DELL	Latitude E5420	DoC	RJ45, 1m non-shielded
2	Notebook	Lenovo	T430	DoC	RJ45, 1m non-shielded
3	50Ω terminator	---	---	---	---
4	Fixture	---	---	---	---

Note: No2 and 4 were provided by applicant.

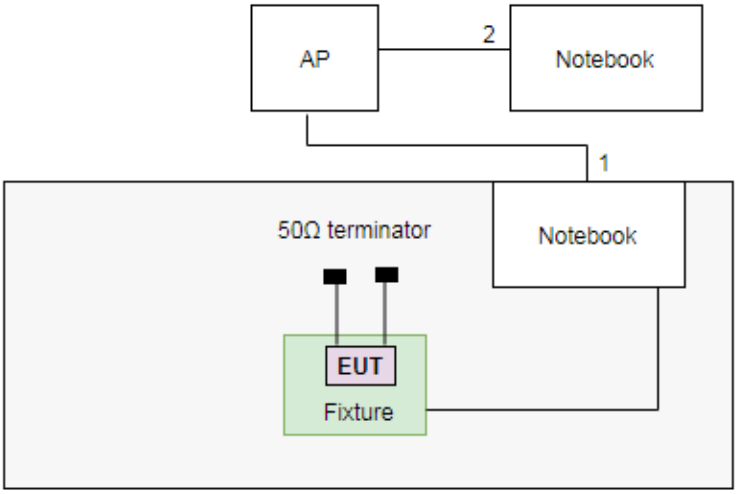
1.3 Test Setup Chart

Test Setup Diagram (Conducted)



1. RJ45, 1m non-shielded
2. RJ45, 1m non-shielded

Test Setup Diagram (Radiated)



1. RJ45, 1m non-shielded
2. RJ45, 1m non-shielded

1.4 Test Equipment List and Calibration Data

Test Item	Radiated Emissions				
Test Site	Fully-anechoic chamber 2 / (05CH02-WS)				
Tested Date	Apr. 24, 2017				
Instrument	**Brand**	**Model No.**	**Serial No.**	**Calibration Date**	**Calibration Until**
Spectrum Analyzer	Agilent	N9010A	MY52221474	Oct. 14, 2016	Oct. 13, 2017
Bilog Antenna 30-1000MHz	SCHWARZBECK	VULB9168	9168-563	Jan. 05, 2017	Jan. 04, 2018
Horn Antenna 1G-18G	SCHWARZBECK	BBHA 9120 D	9120D-1205	Jan. 05, 2017	Jan. 04, 2018
Horn Antenna 18G-40G	SCHWARZBECK	BBHA 9170	BBHA 9170508	Dec. 29, 2016	Dec. 28, 2017
Preamplifier	Agilent	83017A	MY53270013	Jan. 10, 2017	Jan. 09, 2018
Preamplifier 30-1000MHz	EMC	EMC02325	980188	Dec. 13, 2016	Dec. 12, 2017
Preamplifier	EMC	EMC184045B	980192	Aug. 24, 2016	Aug. 23, 2017
RF cable-1M	HUBER+SUHNER	SUCOFLEX104	MY22622/4	Dec. 13, 2016	Dec. 12, 2017
RF cable-1M	HUBER+SUHNER	SUCOFLEX104	MY22623/4	Dec. 14, 2016	Dec. 13, 2017
RF cable-3M	HUBER+SUHNER	SUCOFLEX104	MY22621/4	Dec. 14, 2016	Dec. 13, 2017
RF cable-4M	HUBER+SUHNER	SUCOFLEX104	MY22579/4	Dec. 14, 2016	Dec. 13, 2017
LF cable-0.8M	EMC	EMC8D-NM-NM-800	EMC8D-NM-NM-800-002	Dec. 14, 2016	Dec. 13, 2017
LF cable-3M	EMC	EMC8D-NM-NM-3000	131102	Dec. 14, 2016	Dec. 13, 2017
LF cable-10M	EMC	EMC8D-NM-NM-10000	131101	Dec. 14, 2016	Dec. 13, 2017
Measurement Software	AUDIX	e3	6.120210g	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

Test Item	RF Conducted				
Test Site	(TH01-WS)				
Tested Date	May 06, 2017				
Instrument	**Brand**	**Model No.**	**Serial No.**	**Calibration Date**	**Calibration Until**
Spectrum Analyzer	R&S	FSV40	101063	Mar. 15, 2017	Mar. 14, 2018
Spectrum Analyzer	Agilent	N9010A	MY53400091	Sep. 09, 2016	Sep. 08, 2017
TEMP&HUMIDITY CHAMBER	GIANT FORCE	GCT-225-40-SP-SD	MAF1212-002	Nov. 21, 2016	Nov. 20, 2017
Power Meter	Anritsu	ML2495A	1241002	Oct. 06, 2016	Oct. 05, 2017
Power Sensor	Anritsu	MA2411B	1207366	Oct. 06, 2016	Oct. 05, 2017
Signal Generator	R&S	SMB100A	175727	Oct. 19, 2016	Oct. 18, 2017
Radio Communication Analyzer	Anritsu	MT8820C	6201465544	Aug. 19, 2016	Aug. 18, 2017
MXG-B RF Vector Signal Generator	Agilent	N5182B	MY53050081	Apr. 15, 2017	Apr. 14, 2018
DC POWER SOURCE	GW INSTEK	GPC-6030D	EM892433	Oct. 20, 2016	Oct. 19, 2017
AC POWER SOURCE	APC	AFC-500W	F312060012	Oct. 28, 2016	Oct. 27, 2017
Measurement Software	Sporton	Sporton_1	1.3.30	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

Test Item	Adaptivity				
Test Site	(TH01-WS)				
Tested Date	Jun. 01, 2017				
Instrument	**Brand**	**Model No.**	**Serial No.**	**Calibration Date**	**Calibration Until**
Spectrum	Keysight	N9010A	MY54200247	Aug. 30, 2016	Aug. 29, 2017
RF cable-4M	HUBER+SUHNER	SUCOFLEX_104	MY15686/4	Dec. 16, 2016	Dec. 15, 2017
RF cable-0.5M	HUBER+SUHNER	SUCOFLEX_104	296081/4	Dec. 16, 2016	Dec. 15, 2017
RF cable-0.2M	HUBER+SUHNER	SUCOFLEX_104	329023/4	Dec. 16, 2016	Dec. 15, 2017
RF cable-0.2M	HUBER+SUHNER	SUCOFLEX_104	329021/4	Dec. 16, 2016	Dec. 15, 2017
MXG-B RF Vector Signal Generator	Agilent	N5182B	MY53051912	Nov. 21, 2016	Nov. 20, 2017
Preamplifier	Burgeon	BPA-530	100219	Nov. 02, 2016	Nov. 01, 2017
Oscilloscope	National Instruments	USB-5133	F651FF	Jun. 22, 2016	Jun. 21, 2017
Measurement Software	Sporton	Sporton_3	2.2.0.0	NA	NA
Note: Calibration Interval of instruments listed above is one year.					

Test Item	Receiver Blocking				
Test Site	(05CH02-WS)				
Tested Date	Jun. 05, 2020				
Instrument	Brand	Model No.	Serial No.	Calibration Date	Calibration Until
Wireless connectivity tester	ROHDE&SCHWARZ	CMW270	100856	Oct. 24, 2019	Oct. 23, 2020
Signal Generator	ROHDE&SCHWARZ	SMB100A	175727	Dec. 27, 2019	Dec. 26, 2020
RF Cable	HUBER+SUHNER	SUCOFLEX_104	500202/4	Oct. 16, 2019	Oct. 15, 2020
RF Cable	HUBER+SUHNER	SUCOFLEX_104	296088/4	Oct. 16, 2019	Oct. 15, 2020
RF Cable	HUBER+SUHNER	SUCOFLEX_104	329023/4	Oct. 16, 2019	Oct. 15, 2020
Combiner(1X2)	WOKEN	2WAYDIV	12101200003	Oct. 16, 2019	Oct. 15, 2020
Note: Calibration Interval of instruments listed above is one year.					

1.5 Testing Applied Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

EN 300 328 V2.2.2 (2019-07)

1.6 Deviation from Test Standard and Measurement Procedure

None

1.7 Measurement Uncertainty

The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2)

Measurement Uncertainty		
Parameters	**Uncertainty**	**Limit**
Occupied Channel Bandwidth	±0.0034 %	±5 %
RF output power, conducted	±0.537 dB	±1.5 dB
Power Spectral Density, conducted	±0.463 dB	±3 dB
Unwanted Emissions, conducted	±2.505 dB	±3 dB
All emissions, radiated	±3.401 dB	±6 dB
Temperature	±0.6 ^{o}C	±3 °C
Supply voltages	±0.16 %	±3 %
Time	±0.1 %	±5 %

2 Test Configuration

2.1 Testing Condition

Test Item	Test Site	Ambient Condition	Tested By
RF Conducted	TH01-WS	23°C / 62%	Jack Li
Radiated Emission	05CH02-WS	24°C / 65%	Penguin Jiang
Receiver Blocking	05CH02-WS	25°C / 65%	Ryan Lee

2.2 Testing Facility

Test Laboratory	International Certification Corp.
Test Site	TH01-WS
Address of Test Site (Kwei Shan)	No. 3-1, Lane 6, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C.
Test Laboratory	International Certification Corp.
Test Site	05CH02-WS
Address of Test Site (Kwei Shan II)	No. 14-1, Lane 19, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C.

2.3 The Worst Test Modes and Channel Details

Test item	Modulation Mode	Test Frequency (MHz)	Data Rate	Test Configuration
RF Output Power	GFSK	2402 / 2440 / 2480	1 Mbps	1, 2, 3, 4
Power Spectral Density				
Transmitter unwanted emissions in the out of band domain	GFSK	2402 / 2480	1 Mbps	1, 2, 3, 4
Occupied Channel Bandwidth	GFSK	2402 / 2480	1 Mbps	1
Transmitter Spurious Emissions	GFSK	2402 / 2480	1 Mbps	1
Receiver Spurious Emissions				
Receiver Blocking	GFSK	2402 / 2480	1 Mbps	2

NOTE:

1. The EUT was pretested with 3 orientations placed on the table for the radiated emission measurement – X, Y, and Z-plane. The **Y-plane** results were found as the worst case and were shown in this report.
2. The device can be operated under adapter mode and charging mode. Each mode was selected for related test items as below configuration.

   Configuration 1 : Dipole Antenna

   Configuration 2 : PCB Dipole Antenna

   Configuration 3 : PIFA Antenna

   Configuration 4: Isolated Magnetic Dipole Antenna
3. Conducted emission is only measured for configuration 1 which has maximum conducted power.
4. Two 50Ω terminators are connected to antenna port of EUT for radiated emission measurement.

3 Transmitter Test Results

3.1 RF Output Power

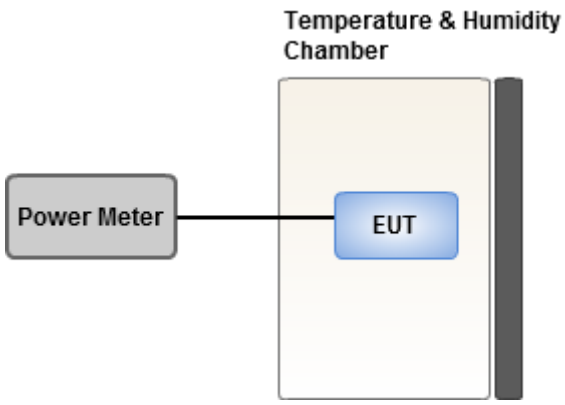
3.1.1 Limit of RF Output Power

The maximum RF output power shall be equal to or less than 20 dBm

3.1.2 Test Procedures

Reference to clause 5.4.2.2 of ETSI EN 300 328 V2.2.2 (2019-07).

3.1.3 Test Setup



3.1.4 Test Result of RF Output Power

Configuration 1 : Dipole Antenna

RF Output Power (dBm)				
Condition	**Freq. (MHz)**	**EIRP Power**	**Limit (dBm)**	**Results**
$T_{nom}V_{nom}$	2402	8.29	20	Pass
$T_{min}V_{nom}$	2402	9.06	20	Pass
$T_{max}V_{nom}$	2402	7.79	20	Pass
$T_{nom}V_{nom}$	2440	8.07	20	Pass
$T_{min}V_{nom}$	2440	8.78	20	Pass
$T_{max}V_{nom}$	2440	7.62	20	Pass
$T_{nom}V_{nom}$	2480	8.82	20	Pass
$T_{min}V_{nom}$	2480	**9.61**	20	Pass
$T_{max}V_{nom}$	2480	8.38	20	Pass

Note: EIRP = Measured conducted power + Antenna gain.

Configuration 2 : PCB Dipole Antenna

RF Output Power (dBm)				
Condition	**Freq. (MHz)**	**EIRP Power**	**Limit (dBm)**	**Results**
$T_{nom}V_{nom}$	2402	9.08	20	Pass
$T_{min}V_{nom}$	2402	**9.85**	20	Pass
$T_{max}V_{nom}$	2402	8.58	20	Pass
$T_{nom}V_{nom}$	2440	8.86	20	Pass
$T_{min}V_{nom}$	2440	9.57	20	Pass
$T_{max}V_{nom}$	2440	8.41	20	Pass
$T_{nom}V_{nom}$	2480	8.81	20	Pass
$T_{min}V_{nom}$	2480	9.60	20	Pass
$T_{max}V_{nom}$	2480	8.37	20	Pass

Note: EIRP = Measured conducted power + Antenna gain.

Configuration 3 : PIFA Antenna & Configuration 4: Isolated Magnetic Dipole Antenna

RF Output Power (dBm)				
Condition	**Freq. (MHz)**	**EIRP Power**	**Limit (dBm)**	**Results**
$T_{nom}V_{nom}$	2402	8.79	20	Pass
$T_{min}V_{nom}$	2402	**9.56**	20	Pass
$T_{max}V_{nom}$	2402	8.29	20	Pass
$T_{nom}V_{nom}$	2440	8.57	20	Pass
$T_{min}V_{nom}$	2440	9.28	20	Pass
$T_{max}V_{nom}$	2440	8.12	20	Pass
$T_{nom}V_{nom}$	2480	8.52	20	Pass
$T_{min}V_{nom}$	2480	9.31	20	Pass
$T_{max}V_{nom}$	2480	8.08	20	Pass

Note: EIRP = Measured conducted power + Antenna gain.

3.2 Power Spectral Density

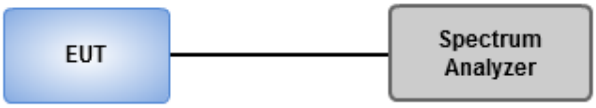
3.2.1 Limit of Power Spectral Density

For equipment using wide band modulations other than FHSS (e.g. DSSS, OFDM, etc.), the maximum Power Spectral Density is limited to 10 dBm per MHz.

3.2.2 Test Procedures

Reference to clause 5.4.3.2 of ETSI EN 300 328 V2.2.2 (2019-07).

3.2.3 Test Setup



3.2.4 Test Result of Power Spectral Density

Configuration 1 : Dipole Antenna

Modulation Mode	Freq. (MHz)	Power Density (dBm/1MHz)	Limit (dBm/1MHz)	Results
GFSK-1Mbps	2402	7.71	10	Pass
GFSK-1Mbps	2440	7.53	10	Pass
GFSK-1Mbps	2480	7.54	10	Pass

Configuration 2 : PCB Dipole Antenna

Modulation Mode	Freq. (MHz)	Power Density (dBm/1MHz)	Limit (dBm/1MHz)	Results
GFSK-1Mbps	2402	6.23	10	Pass
GFSK-1Mbps	2440	7.08	10	Pass
GFSK-1Mbps	2480	6.69	10	Pass

Configuration 3 : PIFA Antenna & Configuration 4: Isolated Magnetic Dipole Antenna

Modulation Mode	Freq. (MHz)	Power Density (dBm/1MHz)	Limit (dBm/1MHz)	Results
GFSK-1Mbps	2402	7.21	10	Pass
GFSK-1Mbps	2440	7.03	10	Pass
GFSK-1Mbps	2480	6.98	10	Pass

3.3 Occupied Channel Bandwidth

3.3.1 Limit of Occupied Channel Bandwidth

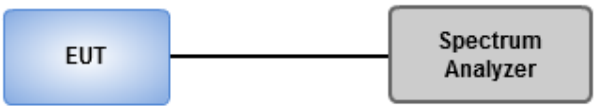
The Occupied Channel Bandwidth shall fall completely within 2.4~2.4835 GHz.

In addition, for non-adaptive equipment 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.

3.3.2 Test Procedures

Reference to clause 5.4.7.2 of ETSI EN 300 328 V2.2.2 (2019-07).

3.3.3 Test Setup

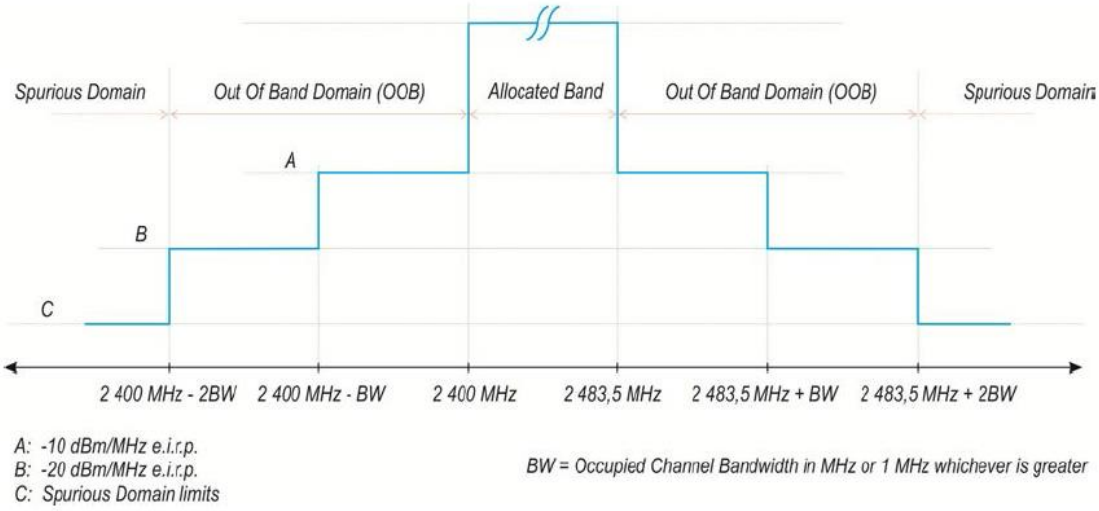


3.3.4 Test Result of Occupied Channel Bandwidth

Modulation Mode	Frequency (MHz)	99% Bandwidth (MHz)	F_L at 99% BW (MHz)	F_H at 99% BW (MHz)	Limit F_L / F_H (MHz)
GFSK-1Mbps	2402	1.02	2401.49	2402.52	2400.0
GFSK-1Mbps	2480	1.03	2479.49	2480.52	2483.5

3.4 Transmitter Unwanted Emissions in the Out-Of-Band Domain

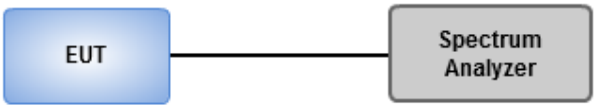
3.4.1 Limit of Transmitter Unwanted Emissions in the Out-Of-Band Domain



3.4.2 Test Procedures

Reference to clause 5.4.8.2 of ETSI EN 300 328 V2.2.2 (2019-07).

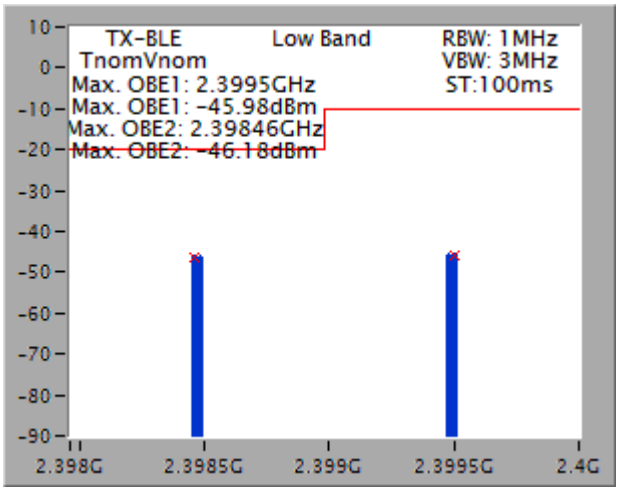
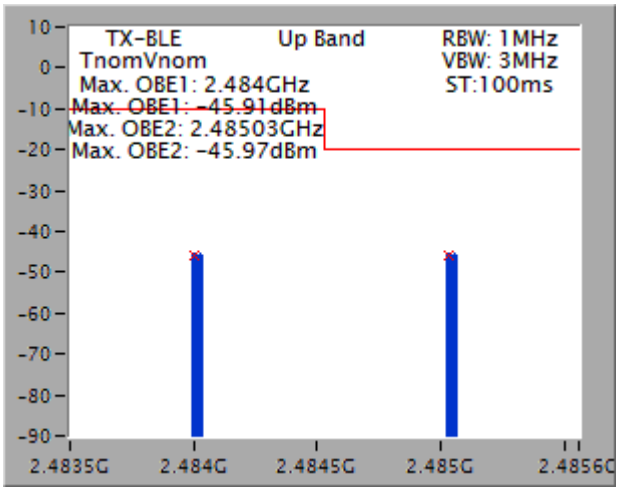
3.4.3 Test Setup



3.4.4 Test Result of Transmitter Unwanted Emissions in the Out-Of-Band Domain

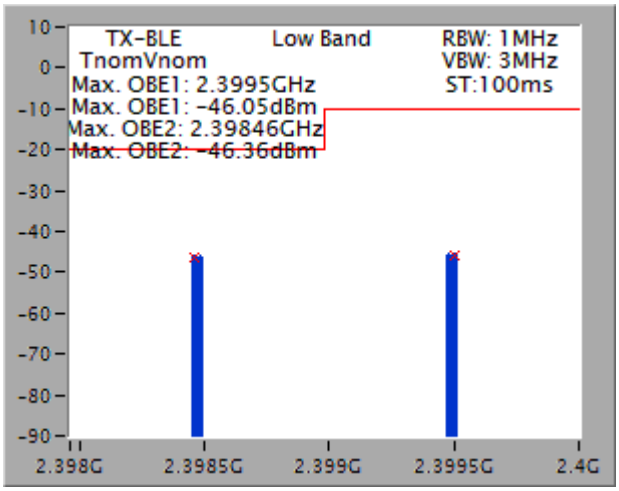
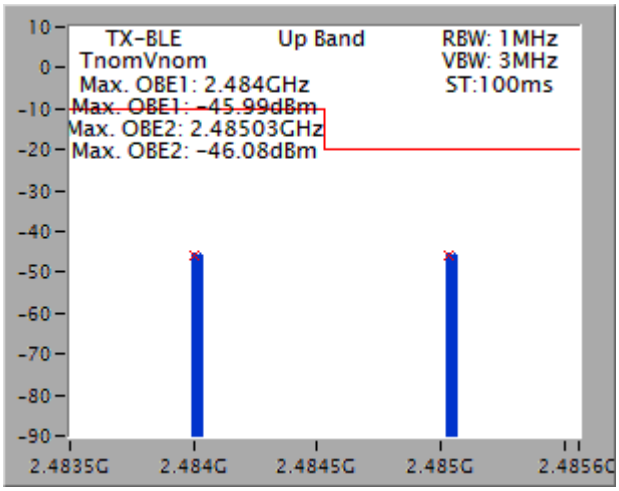
Configuration 1 : Dipole Antenna

Condition	Modulation Mode	Freq. (MHz)	OOB Freq. (MHz)	OOB Emissions (dBm)	Limit (dBm)
TnomVnom	GFSK-1Mbps	2402	2399.50	-45.98	-10
TnomVnom	GFSK-1Mbps	2402	2398.46	-46.18	-20
TnomVnom	GFSK-1Mbps	2480	2484.00	-45.91	-10
TnomVnom	GFSK-1Mbps	2480	2485.03	-45.97	-20

Low Band	Up Band
	

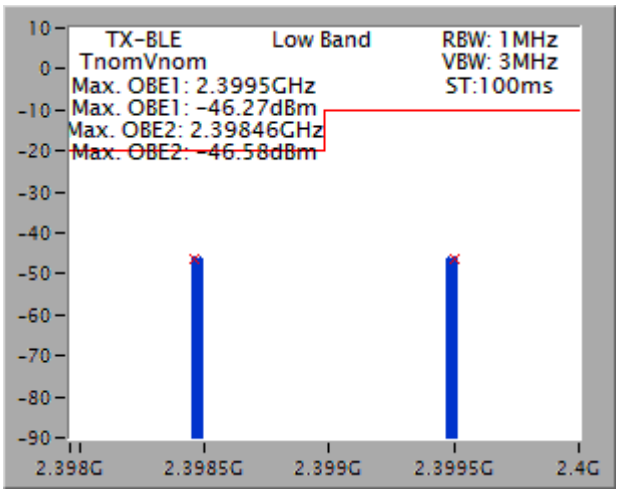
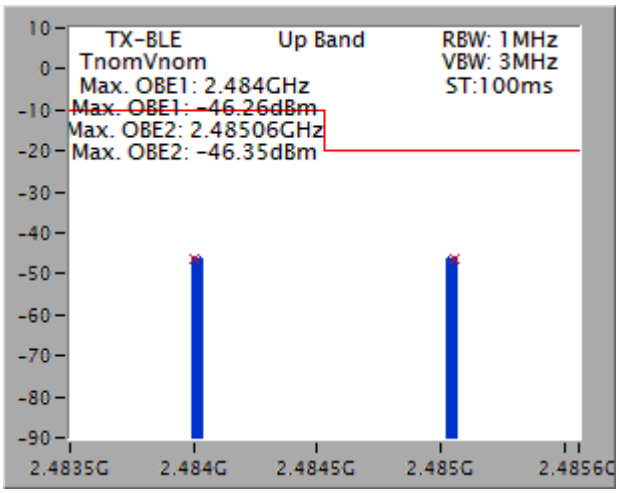
Configuration 2 : PCB Dipole Antenna

Condition	Modulation Mode	Freq. (MHz)	OOB Freq. (MHz)	OOB Emissions (dBm)	Limit (dBm)
TnomVnom	GFSK-1Mbps	2402	2399.50	-46.05	-10
TnomVnom	GFSK-1Mbps	2402	2398.46	-46.36	-20
TnomVnom	GFSK-1Mbps	2480	2484.00	-45.99	-10
TnomVnom	GFSK-1Mbps	2480	2485.03	-46.08	-20

Low Band	Up Band
	

Configuration 3 : PIFA Antenna & Configuration 4: Isolated Magnetic Dipole Antenna

Condition	Modulation Mode	Freq. (MHz)	OOB Freq. (MHz)	OOB Emissions (dBm)	Limit (dBm)
TnomVnom	GFSK-1Mbps	2402	2399.50	-46.27	-10
TnomVnom	GFSK-1Mbps	2402	2398.46	-46.58	-20
TnomVnom	GFSK-1Mbps	2480	2484.00	-46.26	-10
TnomVnom	GFSK-1Mbps	2480	2485.06	-46.35	-20

Low Band	Up Band
	

3.5 Transmitter Unwanted Emissions in the Spurious Domain

3.5.1 Limit of Transmitter Unwanted Emissions in the Spurious Domain

Conducted Emission		
Frequency Range (MHz)	**Maximum power (dBm)**	**Bandwidth (kHz)**
30 to 47	-39.01	100
47 to 74	-57.01	100
74 to 87,5	-39.01	100
87,5 to 118	-57.01	100
118 to 174	-39.01	100
174 to 230	-57.01	100
230 to 470	-39.01	100
470 to 694	-57.01	100
694 to 1000	-39.01	100
1000 to 12750	-33.01	1000

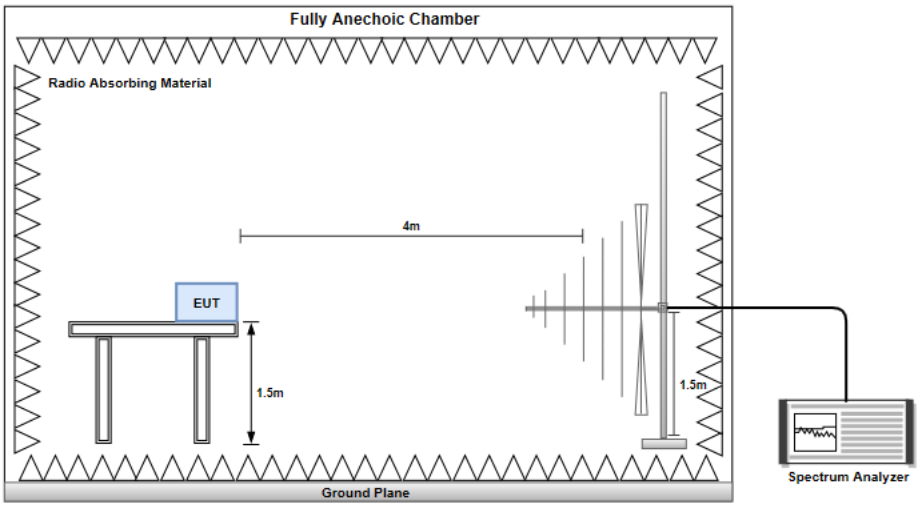
Radiated Emission		
Frequency Range (MHz)	**Maximum power (dBm)**	**Bandwidth (kHz)**
30 to 47	-36	100
47 to 74	-54	100
74 to 87,5	-36	100
87,5 to 118	-54	100
118 to 174	-36	100
174 to 230	-54	100
230 to 470	-36	100
470 to 694	-54	100
694 to 1000	-36	100
1000 to 12750	-30	1000

3.5.2 Test Procedures

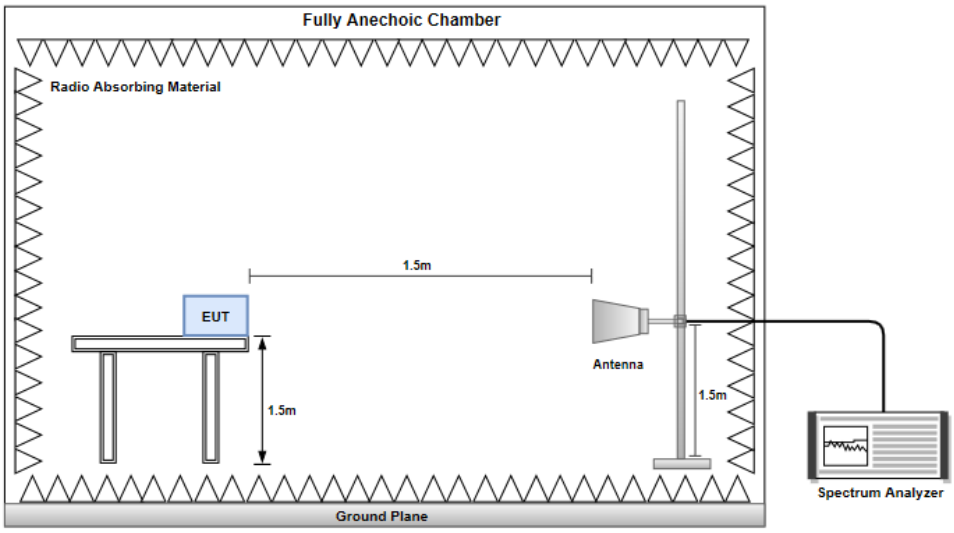
Reference to clause 5.4.9.2 of ETSI EN 300 328 V2.2.2 (2019-07).

3.5.3 Test Setup

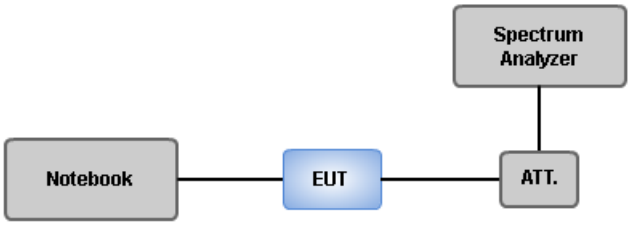
Below 1GHz



Above 1 GHz

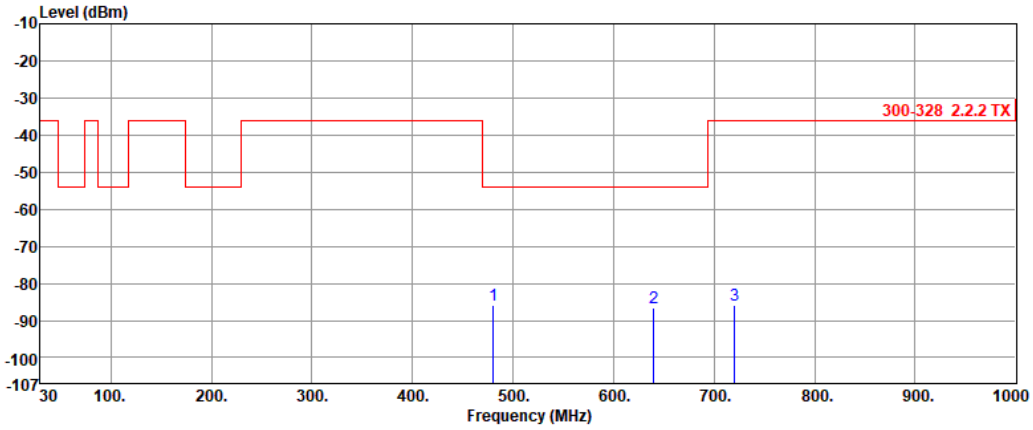


Conducted Emission



3.5.4 Transmitter Conducted Unwanted Emissions (Below 1GHz)

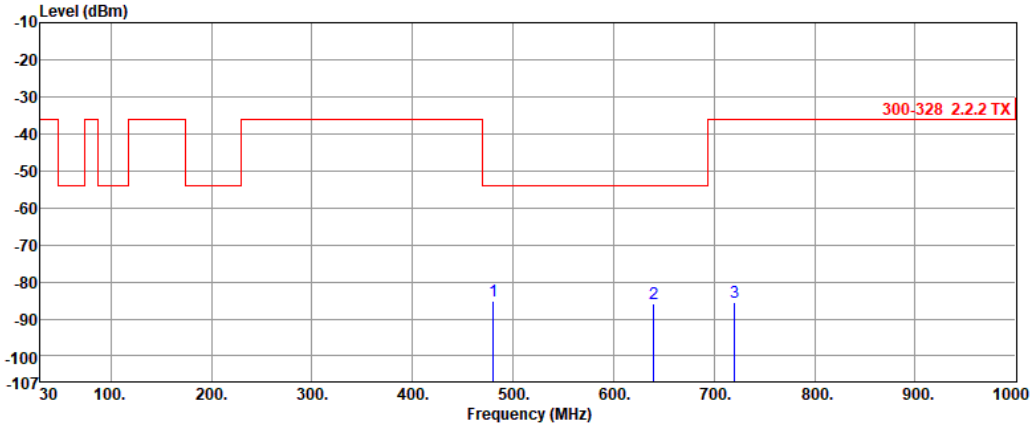
Modulation	GFSK	Test Freq. (MHz)	2402



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	480.08	-86.00	-54.00	-32.00	0.00	-86.00
2	640.13	-86.54	-54.00	-32.54	0.00	-86.54
3	720.64	-85.73	-36.00	-49.73	0.00	-85.73

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480

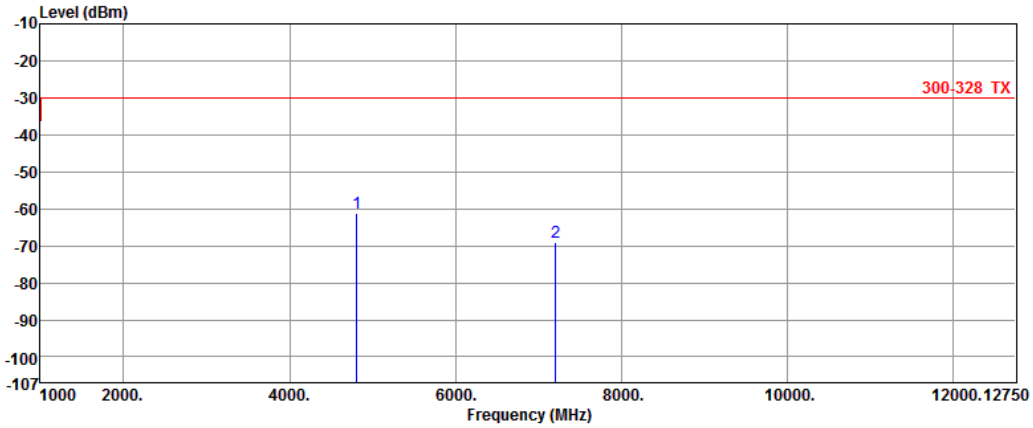


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	480.08	-85.30	-54.00	-31.30	0.00	-85.30
2	640.13	-85.90	-54.00	-31.90	0.00	-85.90
3	720.64	-85.41	-36.00	-49.41	0.00	-85.41

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

3.5.5 Transmitter Conducted Unwanted Emissions (Above 1GHz)

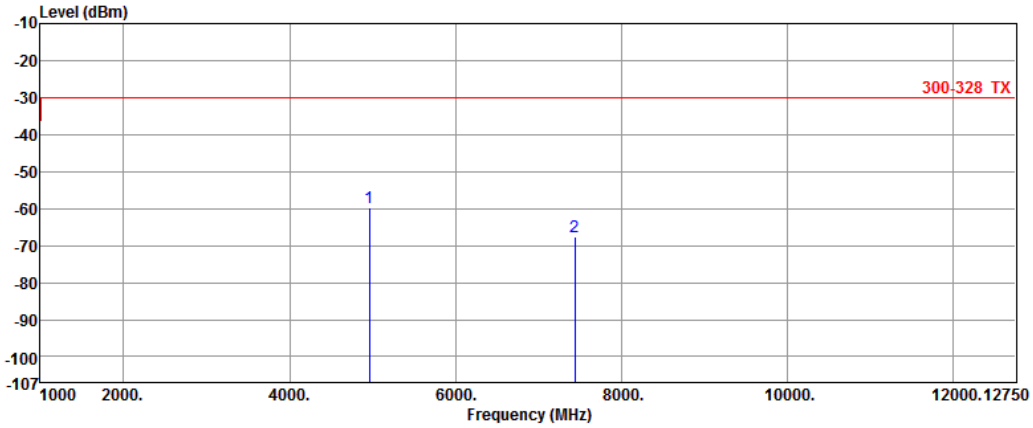
Modulation	GFSK	Test Freq. (MHz)	2402



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4807.00	-61.08	-33.01	-28.07	0.00	-61.08
2	7204.00	-68.96	-33.01	-35.95	0.00	-68.96

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480

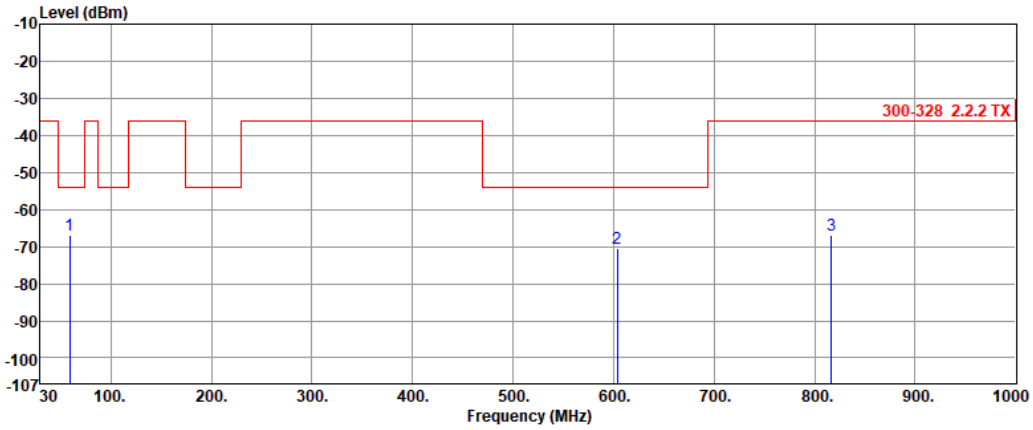


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4959.75	-59.66	-33.01	-26.65	0.00	-59.66
2	7439.00	-67.51	-33.01	-34.50	0.00	-67.51

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

3.5.6 Transmitter Radiated Unwanted Emissions (Below 1GHz)

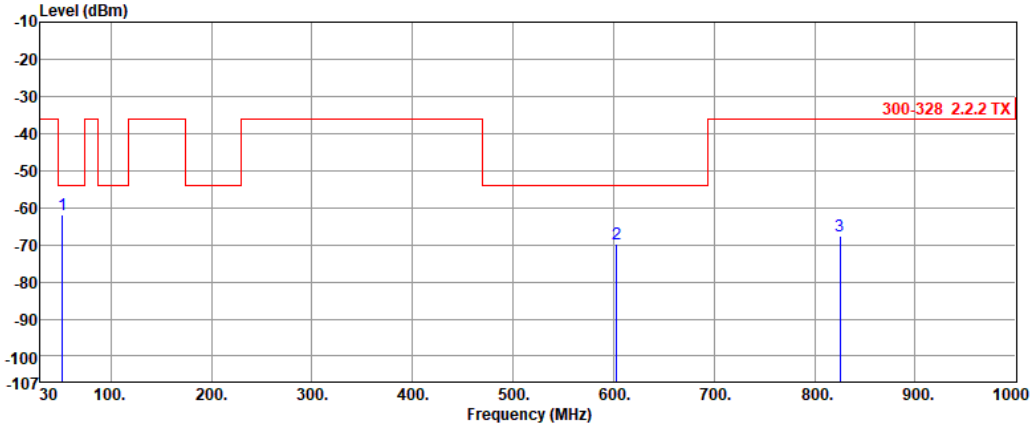
Modulation	GFSK	**Test Freq. (MHz)**	2402
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	59.29	-66.81	-54.00	-12.81	-1.55	-65.26
2	603.51	-70.61	-54.00	-16.61	6.92	-77.53
3	816.67	-66.77	-36.00	-30.77	9.87	-76.64

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

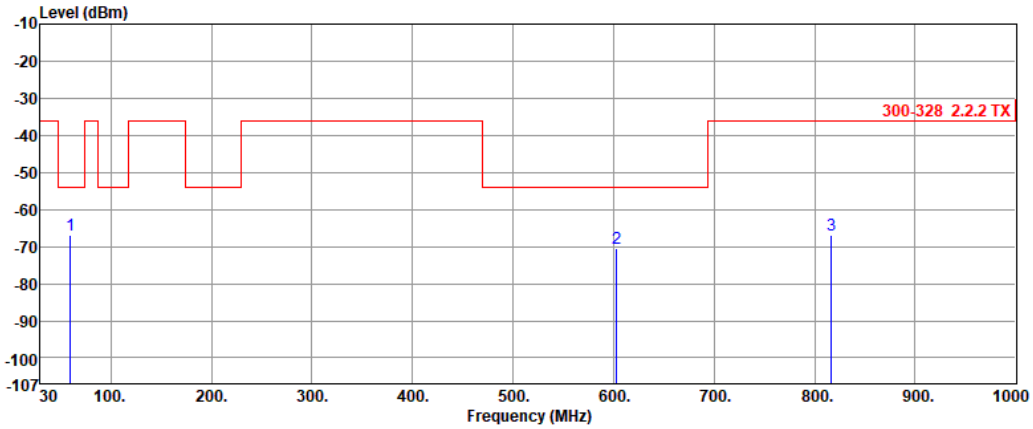
Modulation	GFSK	Test Freq. (MHz)	2402
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	51.84	-62.00	-54.00	-8.00	-0.44	-61.56
2	603.35	-69.81	-54.00	-15.81	7.40	-77.21
3	825.38	-67.57	-36.00	-31.57	10.00	-77.57

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

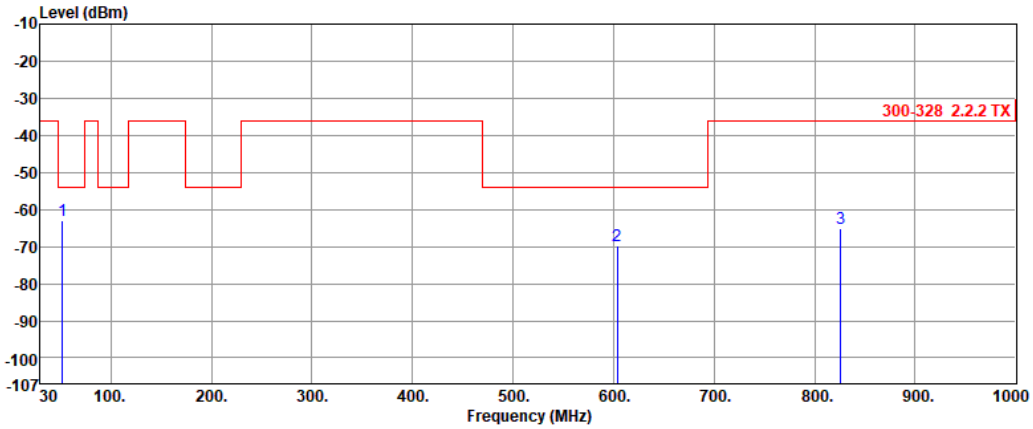
Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	59.72	-66.81	-54.00	-12.81	-1.67	-65.14
2	603.30	-70.61	-54.00	-16.61	6.91	-77.52
3	816.54	-66.91	-36.00	-30.91	9.87	-76.78

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Vertical		

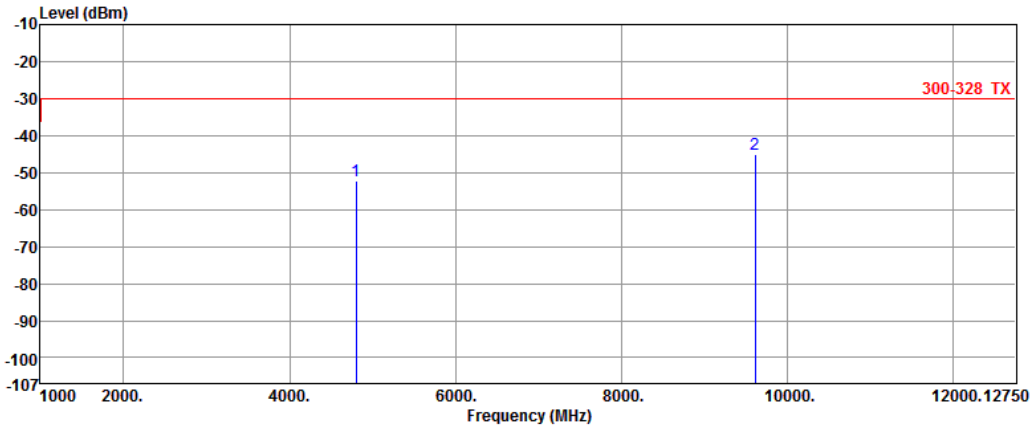


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	51.52	-62.95	-54.00	-8.95	-0.19	-62.76
2	603.44	-69.74	-54.00	-15.74	7.41	-77.15
3	825.97	-65.26	-36.00	-29.26	9.99	-75.25

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

3.5.7 Transmitter Radiated Unwanted Emissions (Above 1GHz)

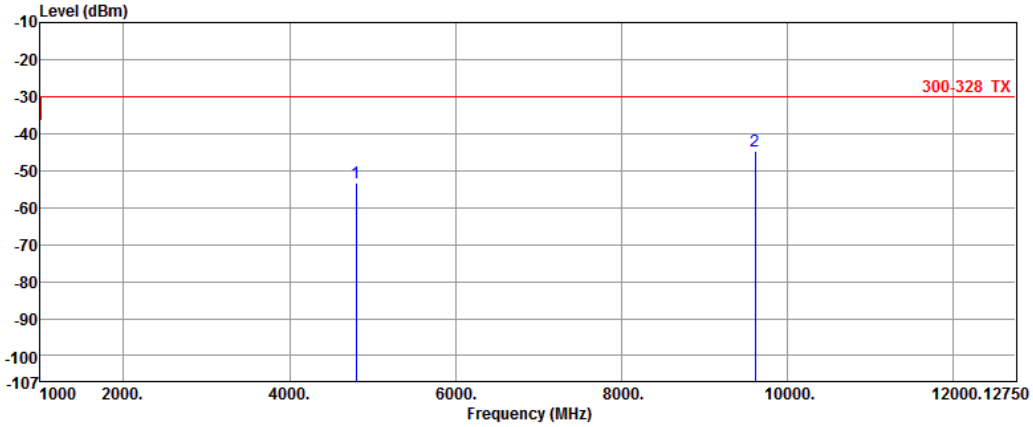
Modulation	GFSK	**Test Freq. (MHz)**	2402
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4805.25	-52.18	-30.00	-22.18	11.64	-63.82
2	9608.13	-45.15	-30.00	-15.15	20.87	-66.02

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

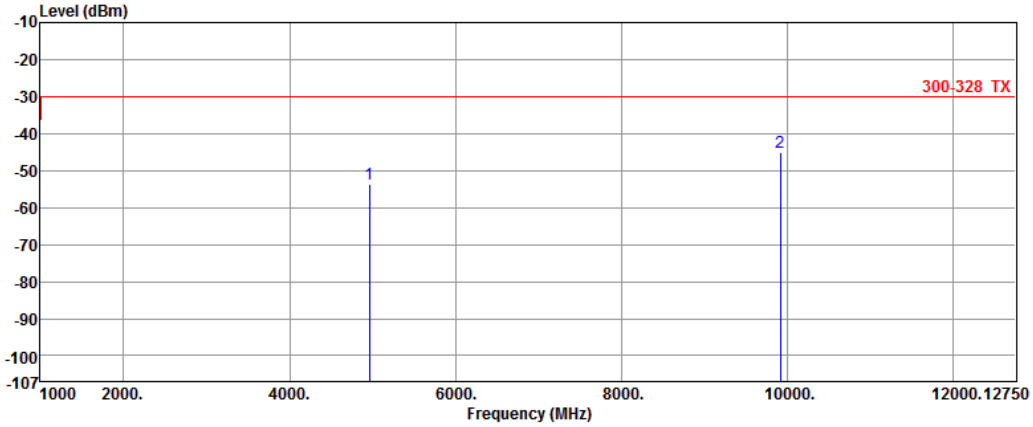
Modulation	GFSK	Test Freq. (MHz)	2402
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4801.81	-53.42	-30.00	-23.42	11.91	-65.33
2	9608.13	-44.75	-30.00	-14.75	21.27	-66.02

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

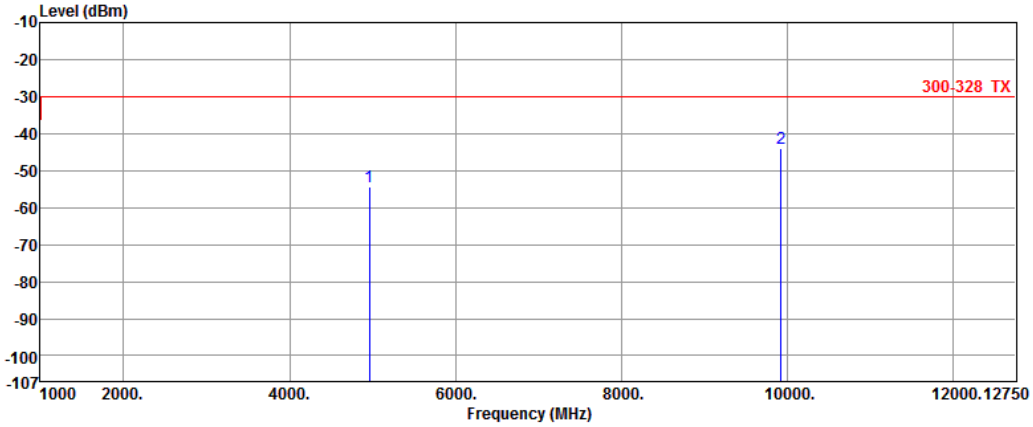
Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4961.49	-53.73	-30.00	-23.73	12.25	-65.98
2	9917.79	-44.96	-30.00	-14.96	21.92	-66.88

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	4961.35	-54.37	-30.00	-24.37	11.67	-66.04
2	9919.14	-43.88	-30.00	-13.88	22.18	-66.06

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

4 Receiver Test Results

4.1 Receiver Spurious Emissions

4.1.1 Limit of Receiver Spurious Emissions

Conducted Emission		
Frequency Range	**Maximum power (dBm)**	**Measurement bandwidth (kHz)**
30 MHz to 1 GHz	-60.01	100
Above 1 GHz to 12.75 GHz	-50.01	1000

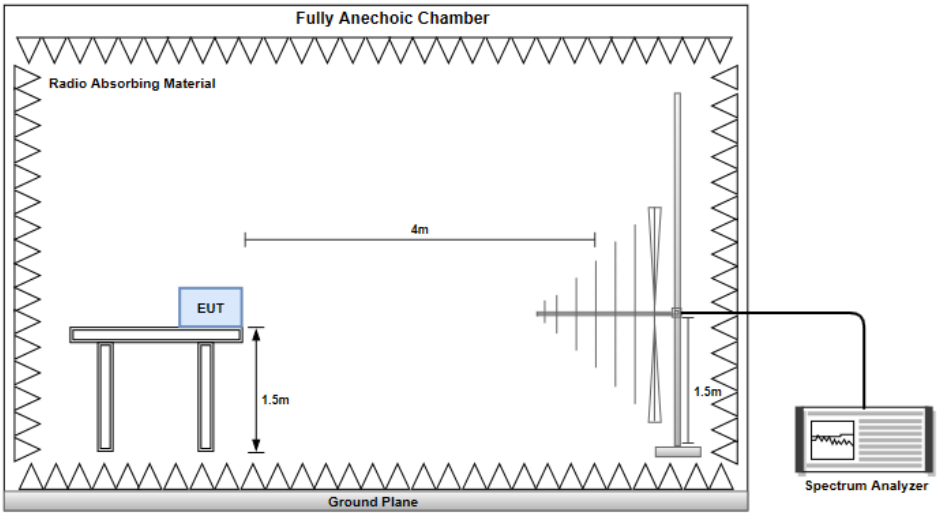
Radiated Emission		
Frequency Range	**Maximum power (dBm)**	**Measurement bandwidth (kHz)**
30 MHz to 1 GHz	-57	100
Above 1 GHz to 12.75 GHz	-47	1000

4.1.2 Test Procedures

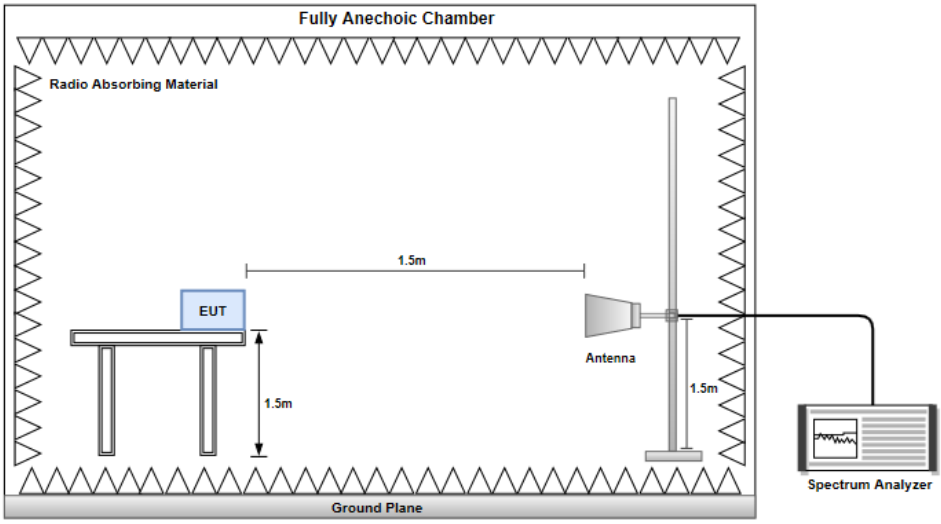
Reference to clause 5.4.10.2 of ETSI EN 300 328 V2.2.2 (2019-07).

4.1.3 Test Setup

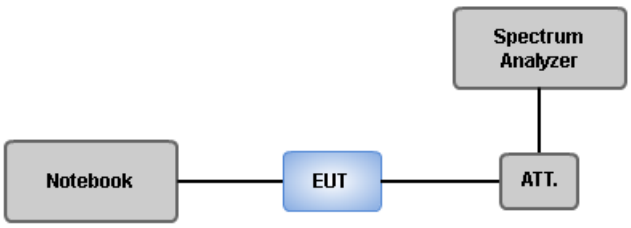
Below 1GHz



Above 1 GHz

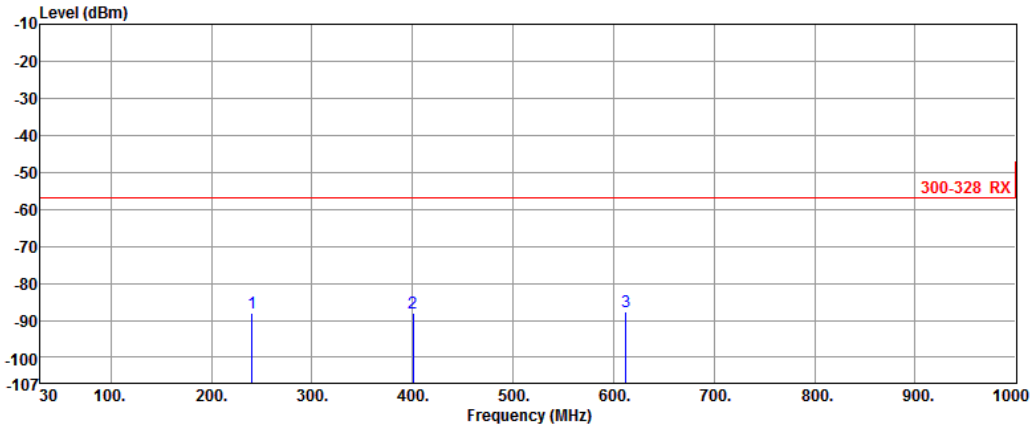


Conducted Emission



4.1.4 Receiver Conducted Unwanted Emissions (Below 1GHz)

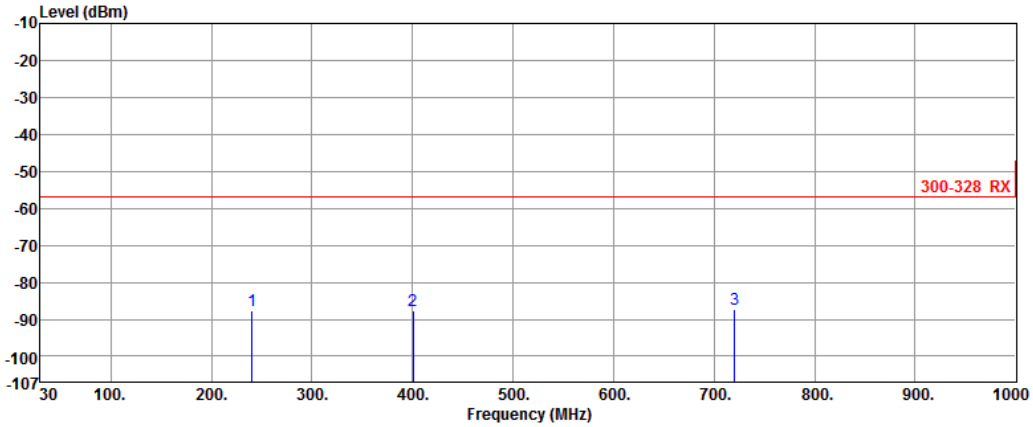
Modulation	GFSK	Test Freq. (MHz)	2402



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	240.49	-88.13	-60.01	-28.12	0.00	-88.13
2	400.54	-87.90	-60.01	-27.89	0.00	-87.90
3	612.00	-87.72	-60.01	-27.71	0.00	-87.72

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480

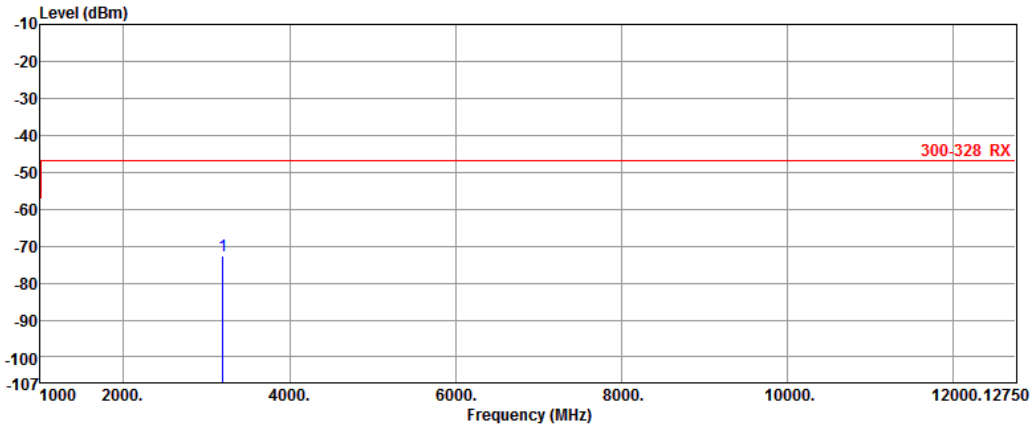


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	240.49	-87.80	-60.01	-27.79	0.00	-87.80
2	400.54	-87.60	-60.01	-27.59	0.00	-87.60
3	720.64	-87.35	-60.01	-27.34	0.00	-87.35

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

4.1.5 Receiver Conducted Unwanted Emissions (Above 1GHz)

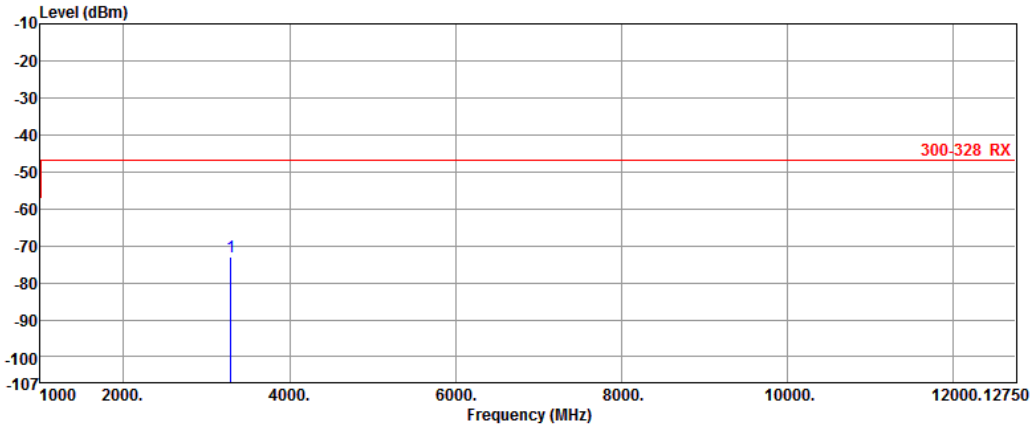
Modulation	GFSK	**Test Freq. (MHz)**	2402



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3194.35	-72.78	-50.01	-22.77	0.00	-72.78

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480

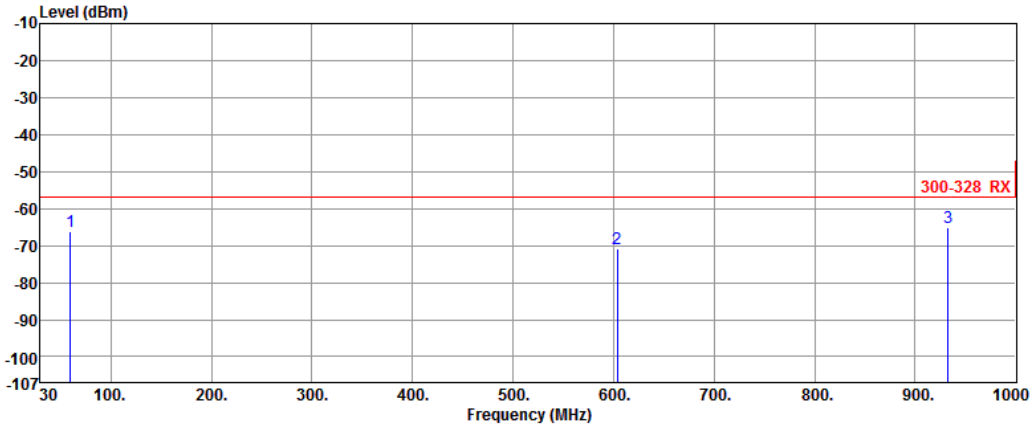


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3294.25	-73.10	-50.01	-23.09	0.00	-73.10

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

4.1.6 Receiver Radiated Unwanted Emissions (Below 1GHz)

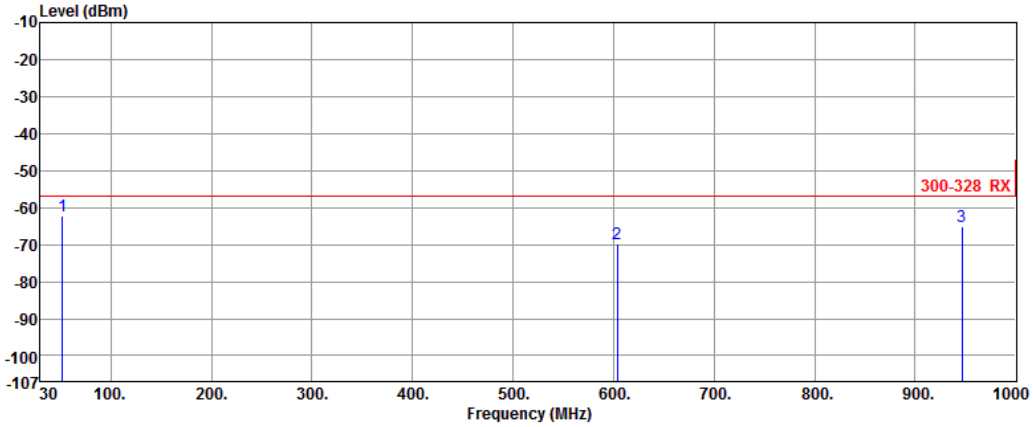
Modulation	GFSK	**Test Freq. (MHz)**	2402
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	59.74	-66.35	-57.00	-9.35	-1.68	-64.67
2	603.47	-70.94	-57.00	-13.94	6.92	-77.86
3	932.63	-65.28	-57.00	-8.28	11.79	-77.07

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

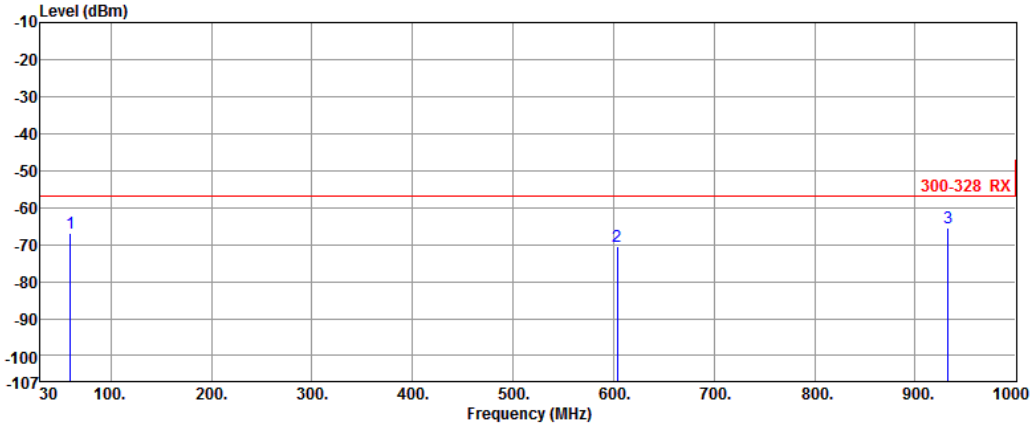
Modulation	GFSK	Test Freq. (MHz)	2402
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	51.71	-62.33	-57.00	-5.33	-0.34	-61.99
2	603.72	-69.67	-57.00	-12.67	7.43	-77.10
3	946.47	-65.25	-57.00	-8.25	12.30	-77.55

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

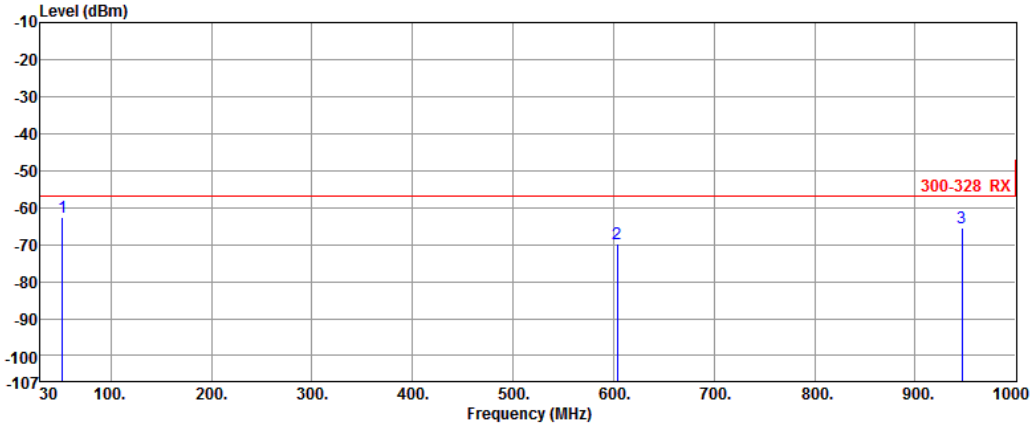
Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	59.41	-66.91	-57.00	-9.91	-1.59	-65.32
2	603.41	-70.51	-57.00	-13.51	6.92	-77.43
3	932.72	-65.63	-57.00	-8.63	11.79	-77.42

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Vertical		

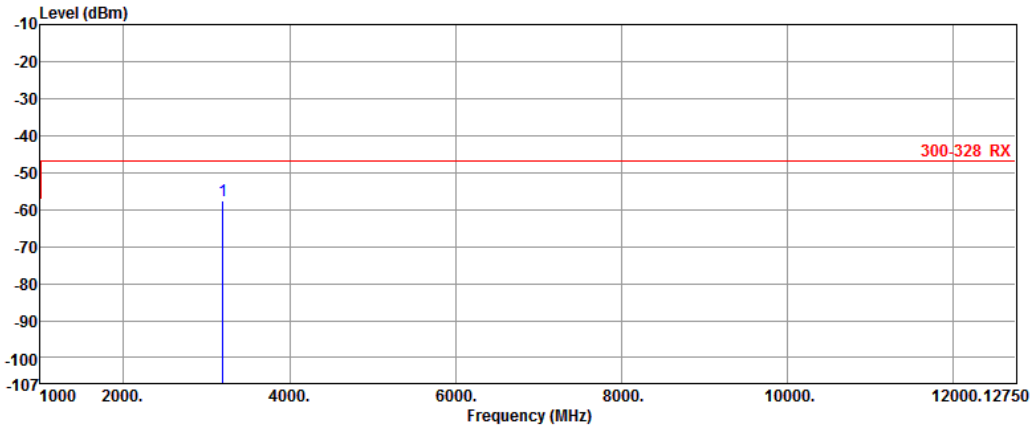


	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	51.49	-62.51	-57.00	-5.51	-0.17	-62.34
2	603.67	-69.81	-57.00	-12.81	7.42	-77.23
3	946.75	-65.59	-57.00	-8.59	12.29	-77.88

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

4.1.7 Receiver Radiated Unwanted Emissions (Above 1GHz)

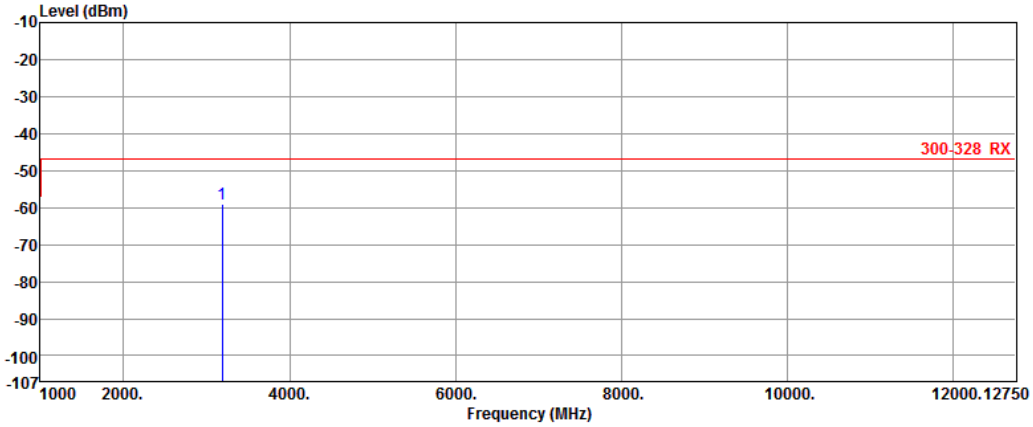
Modulation	GFSK	**Test Freq. (MHz)**	2402
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3195.17	-57.49	-47.00	-10.49	6.81	-64.30

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

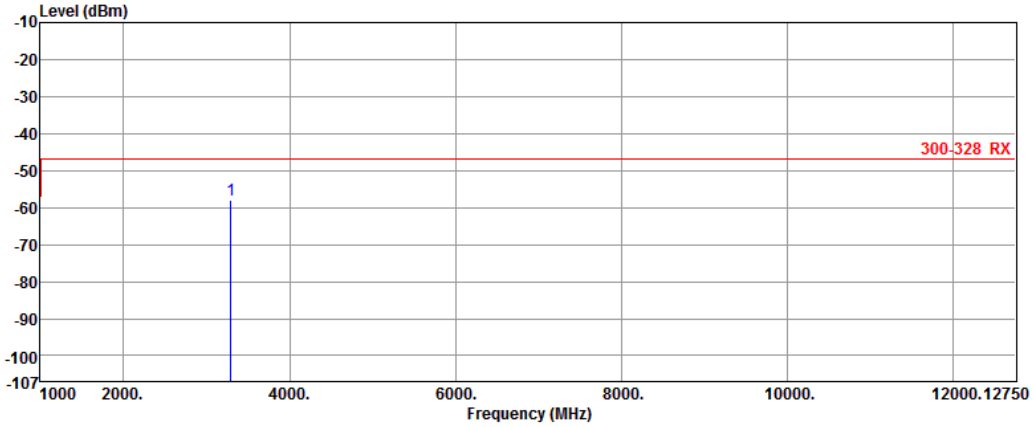
Modulation	GFSK	Test Freq. (MHz)	2402
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3192.41	-59.03	-47.00	-12.03	6.85	-65.88

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

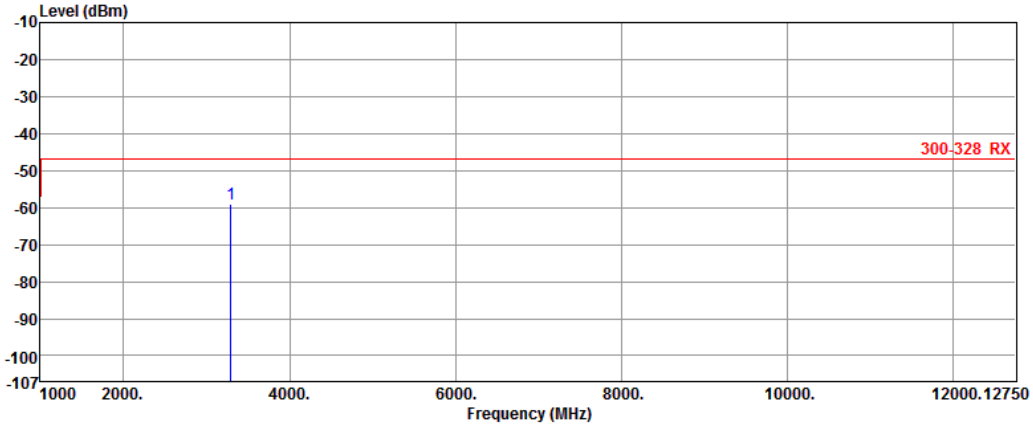
Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Horizontal		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3294.53	-57.93	-47.00	-10.93	7.48	-65.41

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

Modulation	GFSK	Test Freq. (MHz)	2480
Polarization	Vertical		



	Freq.	Measured value	Limit	Margin	Factor	Reading
	MHz	dBm	dBm	dB	dB	dBm
1	3294.94	-59.13	-47.00	-12.13	5.70	-64.83

Note 1: Measured Value (dBm) = Reading (dBm) + Factor (dB)
Note 2: Margin (dB) = Measured Value (dBm) – Limit (dBm)

5 Receiver Blocking Test Results

5.1 Receiver Blocking

5.1.1 Limit of Receiver Blocking

Receiver Blocking Parameters for Receiver Category 1 Equipment Limit			
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 × log10(OCBW)) or -68 dBm whichever is less (see note 2)	2 380 2 504	-34	CW
(-139 dBm + 10 × log10(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.

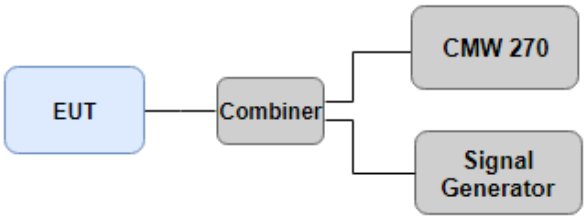
Receiver Blocking Parameters for Receiver Category 2 Equipment Limit			
Wanted Signal Mean Power from Companion Device (dBm) (see notes 1 and 3)	**Blocking Signal Frequency (MHz)**	**Blocking Signal Power (dBm) (see note 3)**	**Type of Blocking Signal**
(-139 dBm + 10 × log10(OCBW) + 10 dB) or (-74 dBm + 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.			

Receiver Blocking Parameters for Receiver Category 3 Equipment Limit			
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 × log10(OCBW) + 20 dB) or (-74 dBm + 20 dB) whichever is less	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 the 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.			

5.1.2 Test Procedures

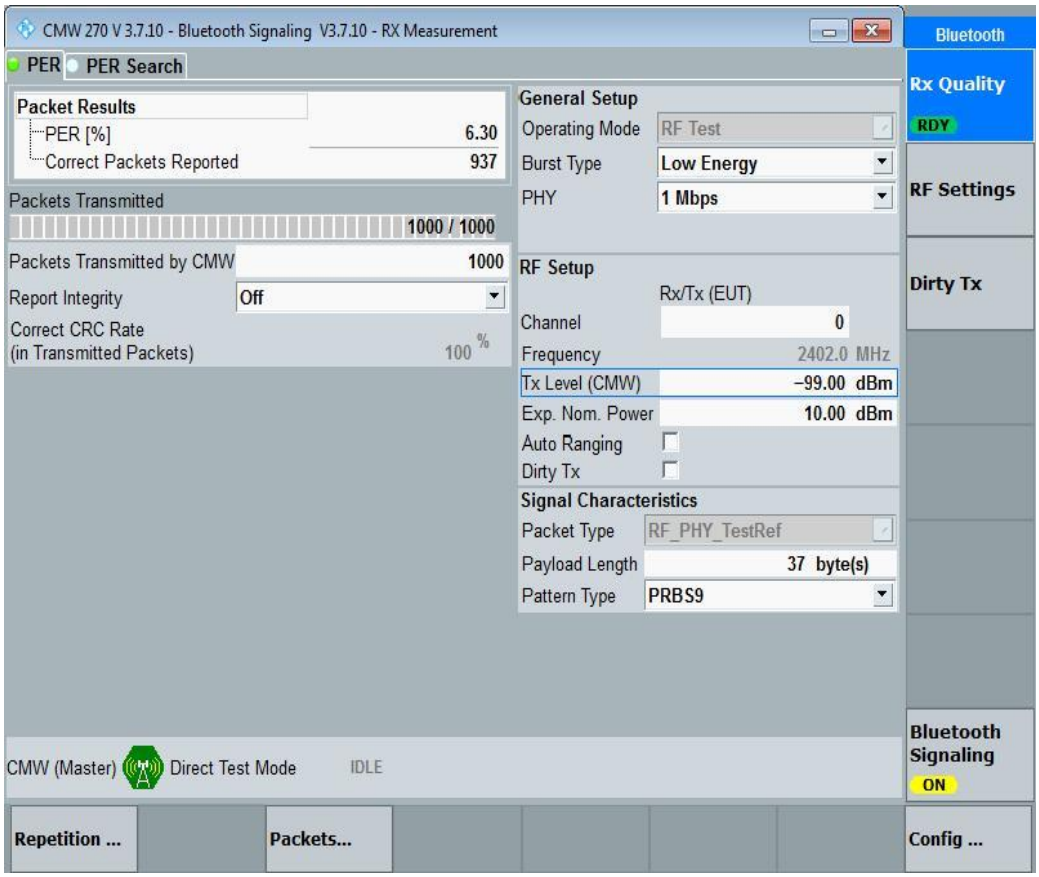
Reference to clause 5.4.11.2 of ETSI EN 300 328 V2.2.2 (2019-07).

5.1.3 Test Setup



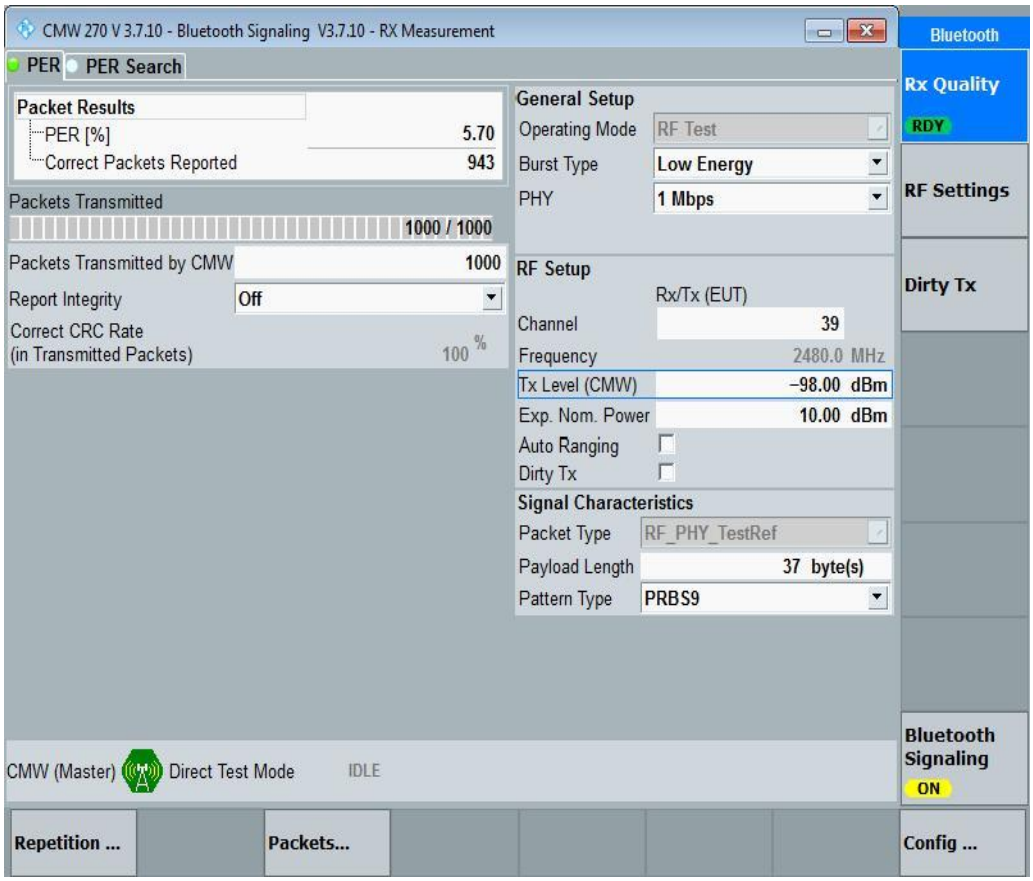
5.1.4 Test Result of Receiver Blocking

2402 MHz



Receiver Category	2		
Performance Criteria Limit	PER ≤ 10 %		
Wanted Signal Mean Power from Companion Device (dBm)	Blocking Signal Frequency (MHz)	Blocking Signal Power (dBm)	Test Result
-66.09	2380	-31.21	Pass
-66.09	2504	-31.21	Pass
-66.09	2300	-31.21	Pass
-66.09	2584	-31.21	Pass

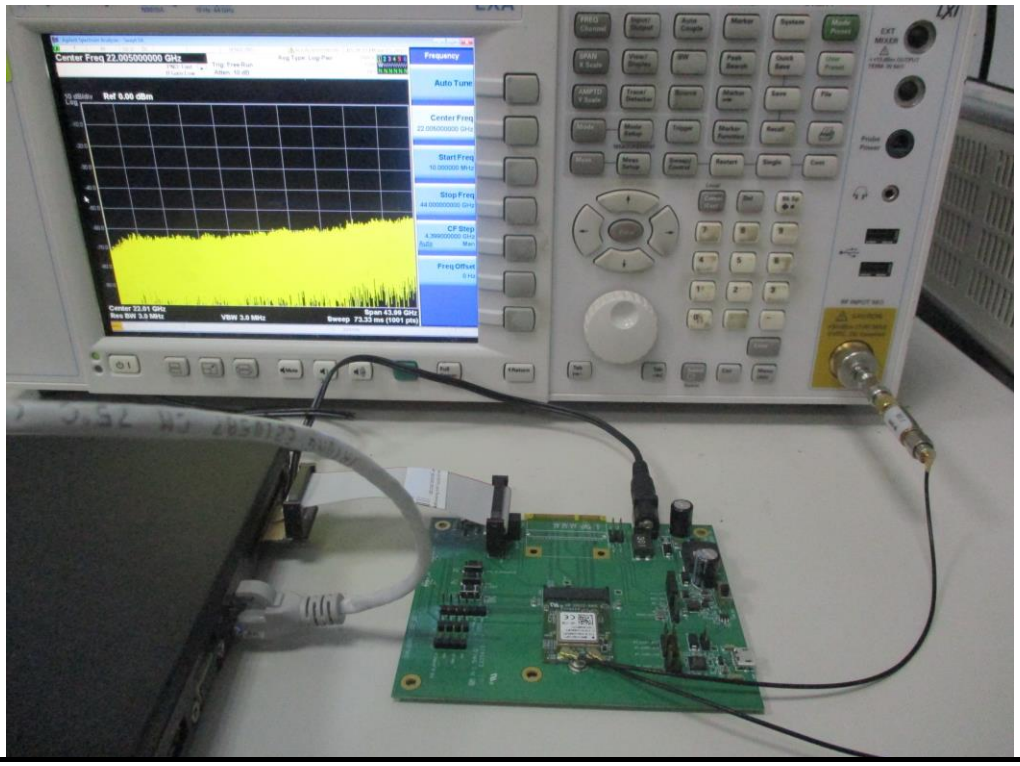
2480 MHz



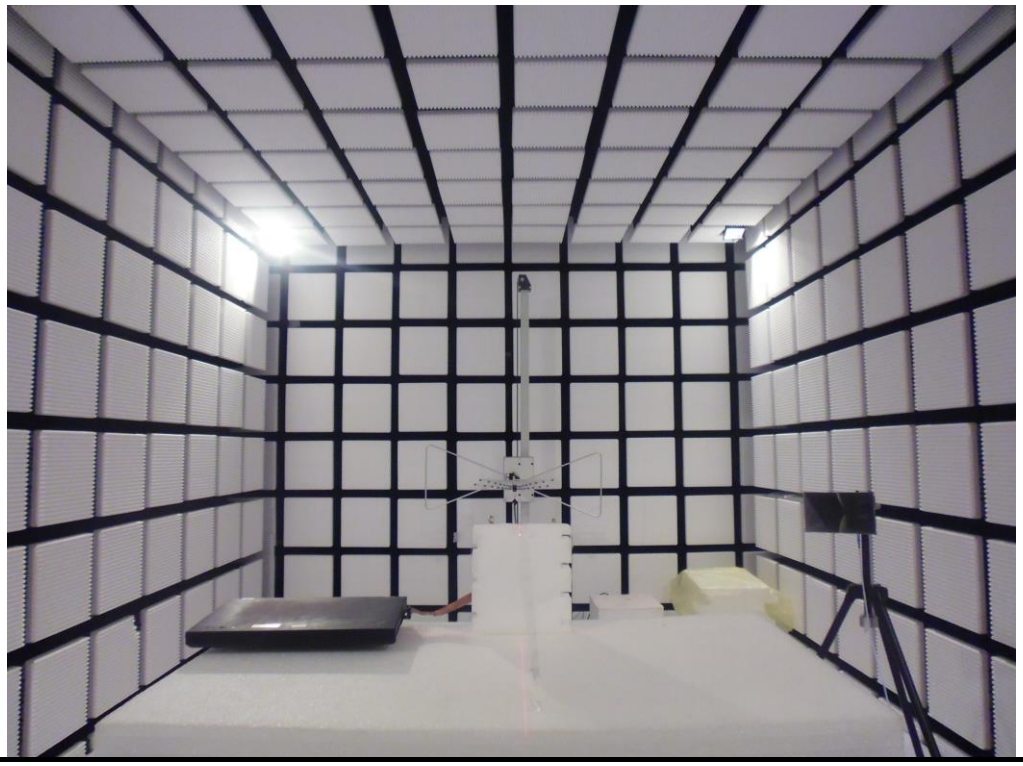
Receiver Category	2		
Performance Criteria Limit	PER ≤ 10 %		
Wanted Signal Mean Power from Companion Device (dBm)	**Blocking Signal Frequency (MHz)**	**Blocking Signal Power (dBm)**	**Test Result**
-66.07	2380	-31.21	Pass
-66.07	2504	-31.21	Pass
-66.07	2300	-31.21	Pass
-66.07	2584	-31.21	Pass

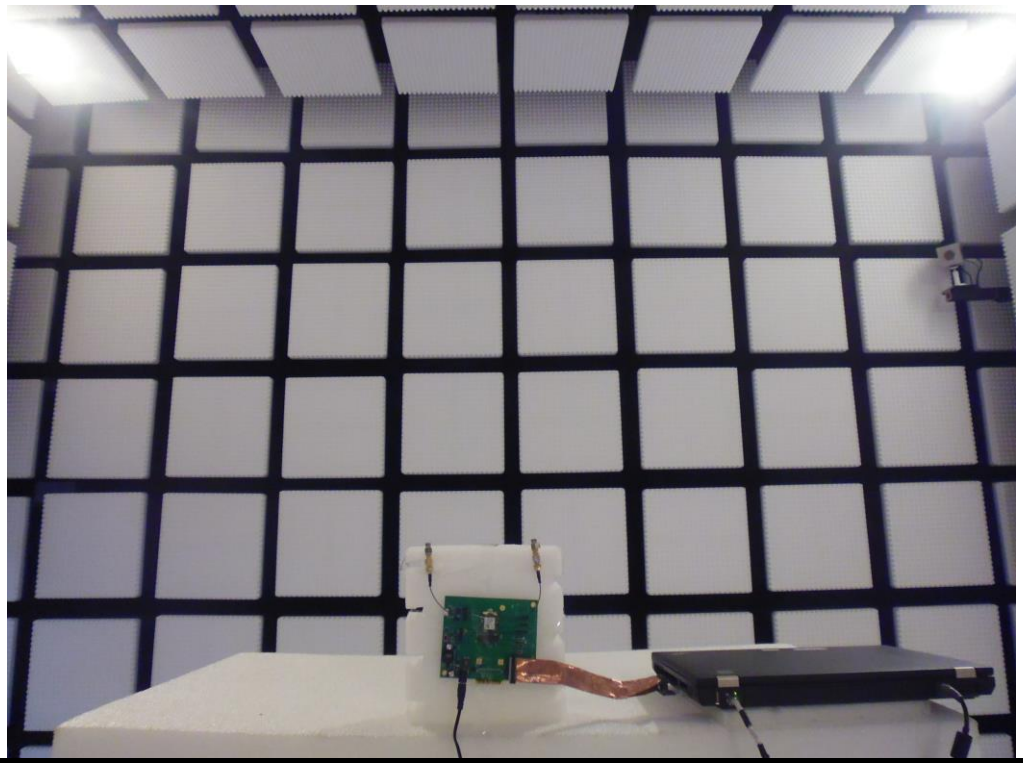
6 Photographs of the Test Configuration

Conducted Spurious Emission Test

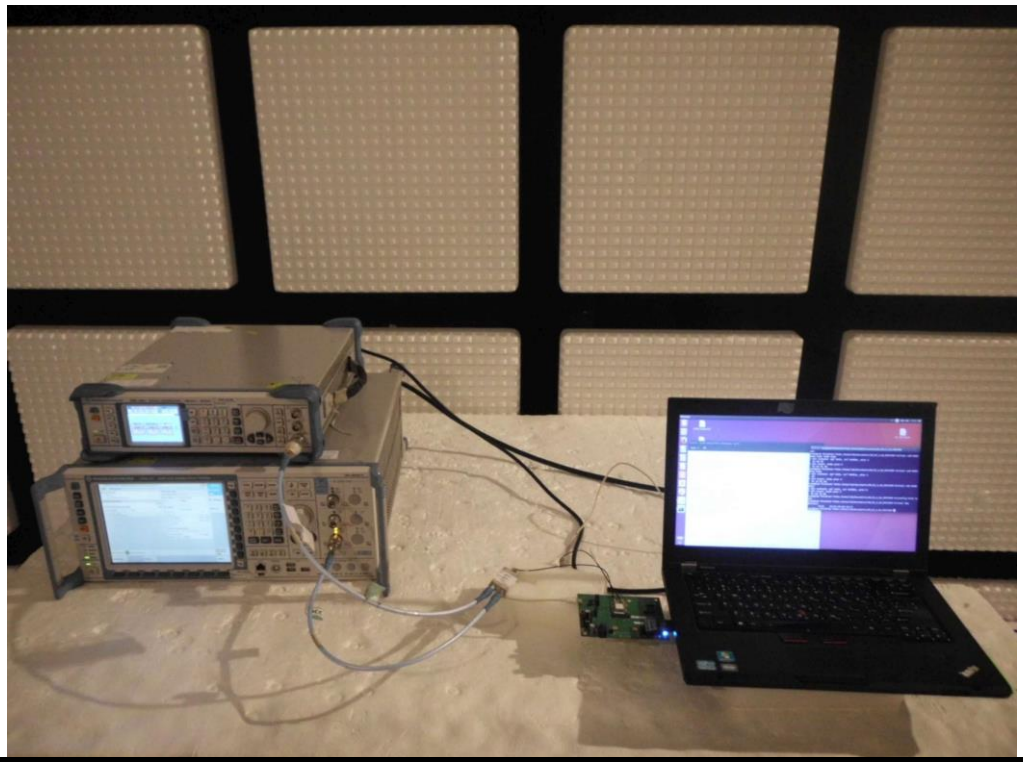


Radiated Spurious Emission Test





Receiver Blocking Test



7 Test laboratory information

Established in 2012, ICC provides foremost EMC & RF Testing and advisory consultation services by our skilled engineers and technicians. Our services employ a wide variety of advanced edge test equipment and one of the widest certification extents in the business.

International Certification Corp (EMC and Wireless Communication Laboratory), it is our definitive objective is to institute long term, trust-based associations with our clients. The expectation we set up with our clients is based on outstanding service, practical expertise and devotion to a certified value structure. Our passion is to grant our clients with best EMC / RF services by oriented knowledgeable and accommodating staff.

Our Test sites are located at Linkou District and Kwei Shan District. Location map can be found on our website http://www.icertifi.com.tw.

Linkou	**Kwei Shan**	**Kwei Shan Site II**
Tel: 886-2-2601-1640	Tel: 886-3-271-8666	Tel: 886-3-271-8640
No. 30-2, Ding Fwu Tsuen, Lin Kou District, New Taipei City, Taiwan, R.O.C.	No. 3-1, Lane 6, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C.	No. 14-1, Lane 19, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C..

If you have any suggestion, please feel free to contact us as below information

Tel: 886-3-271-8666
Fax: 886-3-318-0155
Email: ICC_Service@icertifi.com.tw

══END══