TEST REPORT

Reference No.	:	WTF19F07049951W
FCC ID	:	2ASCM-PBR-07S
Applicant	:	PowerBox Systems GmbH
Address	:	Ludwig-Auer-Strasse 5D - 86609 Donauwoerth
Manufacturer	:	The same as above
Address	:	The same as above
Product Name	:	7 Channel 2.4GHz Receiver
Model No.	:	PBR-7S
Standards	:	FCC CFR47 Part 15 Subpart C (Section 15.247): 2017
Date of Receipt sample	:	2019-08-21
Date of Test	:	2019-08-21
Date of Issue	:	2019-08-22
Test Result	:	**Pass**

Remarks:
The results shown in this test report refer only to the sample(s) tested, this test report cannot be reproduced, except in full, without prior written permission of the company. The report would be invalid without specific stamp of test institute and the signatures of compiler and approver.

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1 Test Summary

Test Items	Test Requirement	Result
Conducted Emissions	15.207	N/A
Radiated Spurious Emissions	15.247(d) 15.205(a) 15.209	Pass
Band edge Emissions	15.247(d) 15.205(a)	Pass
20 dB Bandwidth	15.247(a)(1)	Pass
Occupied bandwidth (99%)	2.202(a)	Pass
Maximum Peak Output Power	15.247(b)(1)	Pass
Carrier Frequency Separation	15.247(a)(1)	Pass
Number of Hopping Frequency	15.247(a)(1)(iii)	Pass
Time of occupancy Dwell time	15.247(d)(1)(iii)	Pass
Antenna Requirement	15.203	Pass
RF Exposure	1.1307(b)(1)	Pass

Remark:

Pass Test item meets the requirement

Fail Test item does not meet the requirement

N/A Test case does not apply to the test object

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3 Revision History

Test report No.	Date of Receipt sample	Date of Test	Date of Issue	Purpose	Comment	Approved
WTF19F07049951W	2019-08-20	2019-08-20	2019-08-20	Original	-	Valid

4 General Information

4.1 General Description of E.U.T

Product Name ..... : 7 Channel 2.4GHz Receiver

Model No. ..... : PBR-7S

Model Description ..... : ---

Operation Frequency ..... : 2402-2467MHz, 66 Channels in total

Max. RF output power ..... : 16.930dBm

Tune-up Tolerance 2dB

Type of Modulation ..... : GFSK

Antenna installation ..... : PCB printed antenna

Antenna Gain ..... : 0dBi

Technical Data ..... : DC 4-9V

4.2 Channel List

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
0	2402	1	2403	2	2404	3	2405
4	2406	5	2407	6	2408	7	2409
8	2410	9	2411	10	2412	11	2413
12	2414	13	2415	14	2416	15	2417
16	2418	17	2419	18	2420	19	2421
20	2422	21	2423	22	2424	23	2425
24	2426	25	2427	26	2428	27	2429
28	2430	29	2431	30	2432	31	2433
32	2434	33	2435	34	2436	35	2437
36	2438	37	2439	38	2440	39	2441
40	2442	41	2443	42	2444	43	2445
44	2446	45	2447	46	2448	47	2449
48	2450	49	2451	50	2452	51	2453
52	2454	53	2455	54	2456	55	2457
56	2458	57	2459	58	2460	59	2461
60	2462	61	2463	62	2464	63	2465
64	2466	65	2467	---	---	---	---

4.3 Test Facility

The test facility has a test site registered with the following organizations:

● IC – Registration No.: 21895-1

Waltek Services (Foshan) Co., Ltd. has been registered and fully described in a report filed with the Industry Canada. The acceptance letter from the Industry Canada is maintained in our files. Registration IC number:21895-1, Nov. 14, 2016.

● FCC – Registration No.: 820106

Waltek Services (Foshan) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 820106, August 16, 2018

● FCC – Designation No.: CN5034

Waltek Services (Foshan) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Designation No. CN5034.

● NVLAP – Lab Code: 600191-0

Waltek Services (Foshan) Co., Ltd. EMC Laboratory is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP/NIST). NVLAP Code: 600191-0.
This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

4.4 Subcontracted

Whether parts of tests for the product have been subcontracted to other labs:

☐ Yes ☒ No

If Yes, list the related test items and lab information:

Test items: ---

Lab information: ---

4.5 Abnormalities from Standard Conditions

None.

5 Equipment Used during Test

5.1 Equipment List

Conducted Emissions						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal Date**	**Cal Due Date**
1.	EMI Test Receiver	RS	ESCI	101178	2019-01-18	2020-01-17
2.	LISN	RS	ENV216	101215	2019-01-10	2020-01-09
3.	Cable	HUBER+SUHNER	CBL2-NN-3M	223NN322	2019-01-10	2020-01-09
4.	Test Software	FARATRONIC	EZ-EMC	EMEC-3AA	-	-
3m Semi-anechoic Chamber for Radiation Emissions						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Calibration Date**	**Calibration Due Date**
1.	EMC Analyzer	Agilent	N9020A	MY48011796	2019-01-26	2020-01-25
2.	Active Loop Antenna	SCHWARZBECK	FMZB1519B	00004	2019-03-10	2020-03-09
3.	Trilog Broadband Antenna	SCHWARZBECK	VULB 9162	9162-117	2019-01-26	2020-01-25
4.	Broad-band Horn Antenna	SCHWARZBECK	BBHA 9120 D	01561	2019-04-28	2020-04-27
5.	Amplifier	Lunar E M	LNA1G18-40	20160501002	2019-04-03	2020-04-02
6.	Coaxial Cable (below 1GHz)	H+S	CBL3-NN-12+3 m	214NN320	2019-01-10	2020-01-09
7.	Coaxial Cable (above 1GHz)	Times-Micorwave	CBL5-NN	-	2019-01-10	2020-01-09
8.	Test Software	FARATRONIC	EZ-EMC	EMEC-3AA	-	-
RF Conducted Testing						
Item	**Equipment**	**Manufacturer**	**Model No.**	**Serial No.**	**Last Calibration Date**	**Calibration Due Date**
1.	Spectrum Analyzer	Agilent	N9020A	MY48011796	2019-01-26	2020-01-25
2.	Spectrum Analyzer	R&S	FSP40	100501	2018-11-13	2019-11-12
3.	Vector Signal Generator	Agilent	N5182A	MY50141533	2019-03-03	2020-03-02
4.	Analog Signal Generator	Agilent	N5181A	MY48180720	2019-01-26	2020-01-26
5.	Environmental Chamber	KSON	THS-D4C-100	5244K	2019-01-26	2020-01-26
6.	Test Software	FARATRONIC	EZ-EMC	EMEC-3AA	-	-

5.2 Measurement Uncertainty

Conducted Emission (150kHz-30MHz)

Input quantity	X_i	Uncertainty of x_i		$u(X_i)$	C_i	$C_iu(X_i)$ (dB)
		dB	Probability distribution function			
Receiver reading	V_r	±0.36	K=2	0.18	1	0.18
Attenuation: AMN-receiver	a_c	±0.20	K=2	0.10	1	0.10
AMN voltage division factor	F_{AMN}	±0.20	K=2	0.10	1	0.10
Receiver corrections:						
Sine wave voltage	δV_{sw}	±1.0	K=2	0.50	1	0.50
Pulse amplitude response	δV_{pa}	±0.0		0.00	1	0.00
Pulse repetition rate response	δV_{pr}	±0.0		0.00	1	0.00
Noise floor proximity	δV_{nf}	±0.05		0.00	1	0.00
Mismatch: AMN-receiver	δM	+0.7/-0.8	U-shaped	0.53	1	0.53
AMN impedance	δZ	+2.6/-2.7	Triangular	1.08	1	1.08
Note: $V = V_r + a_c + F_{AMN} + \delta F_{AMN} + \delta V_{sw} + \delta V_{pa} + \delta V_{pr} + \delta V_{nf} + \delta M + \delta Z$ $U(V)=2u_c(V)=$ ***2.66*** *dB*						

Radiated Emission (30MHz-1GHz)

Input quantity	X_i	Uncertainty of x_i		$u(X_i)$	C_i	$C_i u(X_i)$ (dB)
		dB	Probability distribution function			
Receiver reading	V_r	±0.36	K=2	0.18	1	0.18
Attenuation: antenna-receiver	a_c	±0.10	K=2	0.05	1	0.05
Antenna facotr	F_a	±1.6	K=2	0.8	1	0.8
Receiver corrections:						
Sine wave voltage	δV_{sw}	±1.0	K=2	0.5	1	0.5
Pulse amplitude response	δV_{pa}	±0.6	Rectangular	0.35	1	0.35
Pulse repetition rate response	δV_{pr}	±1.5	Rectangular	0.87	1	0.87
Noise floor proximity	δV_{nf}	±0.5	K=2	0.25	1	0.25
Mismatch: antenna-receiver	δM	+0.9/-1.0	U-shaped	0.67	1	0.67
Antenna corrections:						
AF frequency interpolation	δF_{af}	±0.3	Rectangular	0.17	1	0.17
AF variation due to FAR influence	δF_{ah}	±0.5	Rectangular	0.29	1	0.29
Directivity difference	δF_{adir}	±0.0		0.00	1	0.00
Phase centre location	δF_{aph}	±0.0		0.00	1	0.00
Cross-polarization	δF_{acp}	±0.0		0.00	1	0.00
Balance	δF_{abal}	±0.3	Rectangular	0.17	1	0.17
Site corrections:						
Site imperfections	δA_N	±4.0	Triangular	1.63	1	1.63
Separation distance	δd	±0.3	Rectangular	0.17	1	0.17
Table height	δh	±0.1	K=2	0.05	1	0.05
Note: $E= V_r + a_c + F_a + \delta V_{sw} + \delta V_{pa} + \delta V_{pr} + \delta V_{nf} + \delta M + \delta F_{af} + \delta F_{ah} + \delta F_{adir} + \delta F_{aph} + \delta F_{acp} + \delta F_{abal} + \delta A_N + \delta d + \delta h$ $U(E)=2u_c(E)=$ ***4.56***dB						

Radiated Spurious Emissions (25MHz-1GHz)

Input quantity	X_i	Uncertainty of x_i		$u(x_i)$ dB	c_i	$c_i u(x_i)$ dB
		dB	Probability distribution function			
Receiver reading	V_r	±0.4	k=2	0.20	1	0.20
Attenuation: antenna-receiver	a_c	±0.5	k=2	0.25	1	0.25
Cable loss and correction	L_{ac}	±1.6	k=2	0.80	1	0.80
Receiver corrections:						
Sine wave voltage	δV_{sw}	±0.9	k=2	0.45	1	0.45
Pulse amplitude response	δV_{pa}	±0.6	Rectangular	0.35	1	0.35
Pulse repetition rate response	δV_{pr}	±0.6	Rectangular	0.35	1	0.35
Noise floor proximity	δV_{nf}	+1.0/0.0	U-shaped	0.58	1	0.58
Mismatch: antenna-receiver	δM	+0.9/--1.0	U-shaped	0.67	1	0.67
Site imperfections	δMD	±3.0	Triangular	1.14	1	1.23
Reproducibility of measurement operation	δp	±0.60	k=2	0.30	1	0.30
Separation distance	δd	±0.3	Rectangular	0.17	1	0.17
Table height	δh	±0.1	k=2	0.05	1	0.05
Note: $E = V_r + a_c + L_{ac} + \delta V_{sw} + \delta V_{pa} + \delta V_{pr} + \delta V_{nf} + \delta M + \delta MD + \delta p + \delta d + \delta h$ $U(E) = 2u_c(E) =$ ***3.80*** dB						

Radiated Spurious Emissions (1GHz-18GHz)

Input quantity	X_i	Uncertainty of x_i		$u(x_i)$ dB	c_i	$c_i u(x_i)$ dB
		dB	Probability distribution function			
Receiver reading	V_r	±0.40	k=2	0.20	1	0.20
Attenuation: antenna-receiver	a_c	±0.80	k=2	0.40	1	0.40
Cable loss and correction	L_{ac}	±2.40	k=2	1.20	1	1.20
Mismatch: Preamplifiers - Signal Analyzers	δM_{ps}	+1.2/-1.4	U-shaped	0.92	1	0.92
Mismatch:antenna-receiver	δM_{ac}	+1.3/-1.5	U-shaped	1.00	1	1.00
Receiver corrections:						
Sine wave voltage	δV_{sw}	±0.9	k=2	0.45	1	0.45
Pulse amplitude response	δV_{pa}	±0.6	Rectangular	0.35	1	0.35
Pulse repetition rate response	δV_{pr}	±0.6	Rectangular	0.35	1	0.35
Noise floor proximity	δV_{nf}	+1.0/0.0	U-shaped	0.58	1	0.58
Site imperfections	$\delta Svswr$	±3.0	Triangular	1.22	1	1.22
Effect of setup table material	δANT	±1.0	Rectangular	0.58	1	0.58
Reproducibility of measurement operation	δp	±0.60	k=2	0.30	1	0.30
Note: $E = V_r + a_c + L_{ac} + \delta M_{ps} + \delta M_{ac} + \delta V_{sw} + \delta V_{pa} + \delta V_{pr} + \delta V_{nf} + \delta Svswr + \delta ANT + \delta p$ $U(E) = 2u_c(E) =$ ***4.97*** dB						

6 Mode of operation

6.1 Declaration of the manufacturer

6.1.1 Band usage

The system utilises the 2.4 GHz ISM band. The data are transmitted in time slices using the frequency-hopping process. The length of a time slice is 10 ms (transmitting 4 ms, quiet 6 ms). The transceiver IC employed (CC2500) supports 256 channels, of which 240 are used in the system (channel spacing 333251.9531 Hz).

6.1.2 Frequency-hopping process

The hopping sequence is 640 hops long and utilises 68 of the 204 channels which are available. In order to minimise the probability of collisions the hops are distributed within the band in accordance with a pseudo-random algorithm (Park-Miller-Carta-PRNG) which is additional controlled by a routine which ensures that one physical channel can be used only one time every 100ms. The seed for the PRNG is a random number which is generated in the transmitter, and a connection ID. The transmitter manages the connection ID for each model, and it changes every time a binding or importing process occurs. The synchronisation between transmitter and receiver is done by slowing down the hopping speed of the receiver.

As stated above one physical channel can be used repeating only after 10 hops which is 100ms. So in that way the maximum usage of a channel one time in 100ms.

The hopping sequence is stored in the FLASH as a complex data structure; it is renewed after every binding process and after each change of model in the transmitter. A dedicated FLASH page of at least 4 KB is used for this.

6.1.3 Listen before Talk

For adaptive systems the ETSI norm EN 300328 V1.8.1 dictates that an occupied channel must not be used again without consideration. The norm expects that transmission on a channel does not occur until a certain minimum period of reception has elapsed on that channel, and transmission only occurs if the channel is found to be ‘not in use’ (“Listen before Talk”). However, the norm allows fast switching between adaptive and non-adaptive behaviour.

The following solution is implemented in the Core system:

- after a change of frequency the system ‘listens in’ to the channel for a minimum period of 1 ms.
- if the channel is found to be occupied (RSSI > -72 dbm), then the subsequent transmission takes place at the reduced power of 28 mW, and the system adheres to the norm for non-adaptive systems (Medium Utilisation factor < 10%). The reduced transmission power of 28 mW is produced from the max. burst duration of about 3.5 ms with a frame length of 63 bytes.
- if the channel is free, transmission occurs at full transmitter power (100 mW), and the system adheres to the norm for adaptive systems.
- transmitted power is never reduced on the organisation channels (also permissible for non- adaptive systems).

6.1.4 Listen before Talk

- Tthe transmitter plays the active role; it defines the hopping sequence and the timing.
- Where necessary, the receivers respond in the same time slice.
- In every frame the transmitter conveys the current index in the hopping sequence, and the receiver which is to answer in this time slice.

6.1.5 Behaviour in the case of loss of reception

If a device receives no valid frames in 30 sequential time slices, it is considered to be ‘unconnected’. The transmitter maintains its normal function, and the hopping sequence continues unchanged. The receiver leaves the hopping sequence and continues to receive on the organisation channels alone. This reception frequency is maintained constant for a fairly long time, and the next organisation channel is only selected after this period. Receivers with two RF branches receive on two organisation channels, but offset. If a correct frame is received, the device switches back to the ‘connected’ state.

6.2 Protocol limited duty cycle

As declared of the manufacturer in clause 4.2.1.1 on one channel the EUT only transmits 4 ms in 100 ms, so the duty cycle is 0.04. According to ANSI C63.10 clause 7.5 the duty cycle correction factor results from the following formula:

$$\delta\ (dB)=20\log(\Delta)$$

δ is the duty cycle correction factor (dB)

Δ is the duty cycle (dimensionless)

For this matter the duty cycle correction factor is:

$$\delta=20\log(0.04)= -27.96\ dB \rightarrow -28\ \text{dB correction}$$

7 Radiated Spurious Emissions

Test Requirement .....: FCC CFR47 Part 15 Subpart C 15.247

Test Method .....: ANSI C63.10:2013

Test Result .....: PASS

Measurement Distance .....: 3m

Limit .....:

Frequency (MHz)	Field Strength		Field Strength Limit at 3m Measurement Dist	
	uV/m	Distance (m)	uV/m	dBuV/m
0.009 ~ 0.490	2400/F(kHz)	300	10000 * 2400/F(kHz)	$20\log^{(2400/F(kHz))} + 80$
0.490 ~ 1.705	24000/F(kHz)	30	100 * 24000/F(kHz)	$20\log^{(24000/F(kHz))} + 40$
1.705 ~ 30	30	30	100 * 30	$20\log^{(30)} + 40$
30 ~ 88	100	3	100	$20\log^{(100)}$
88 ~ 216	150	3	150	$20\log^{(150)}$
216 ~ 960	200	3	200	$20\log^{(200)}$
Above 960	500	3	500	$20\log^{(500)}$

7.1 EUT Operation

Operating Environment:

Temperature..... : 23.5°C

Humidity ..... : 50.8% RH

Atmospheric Pressure ..... : 101.2kPa

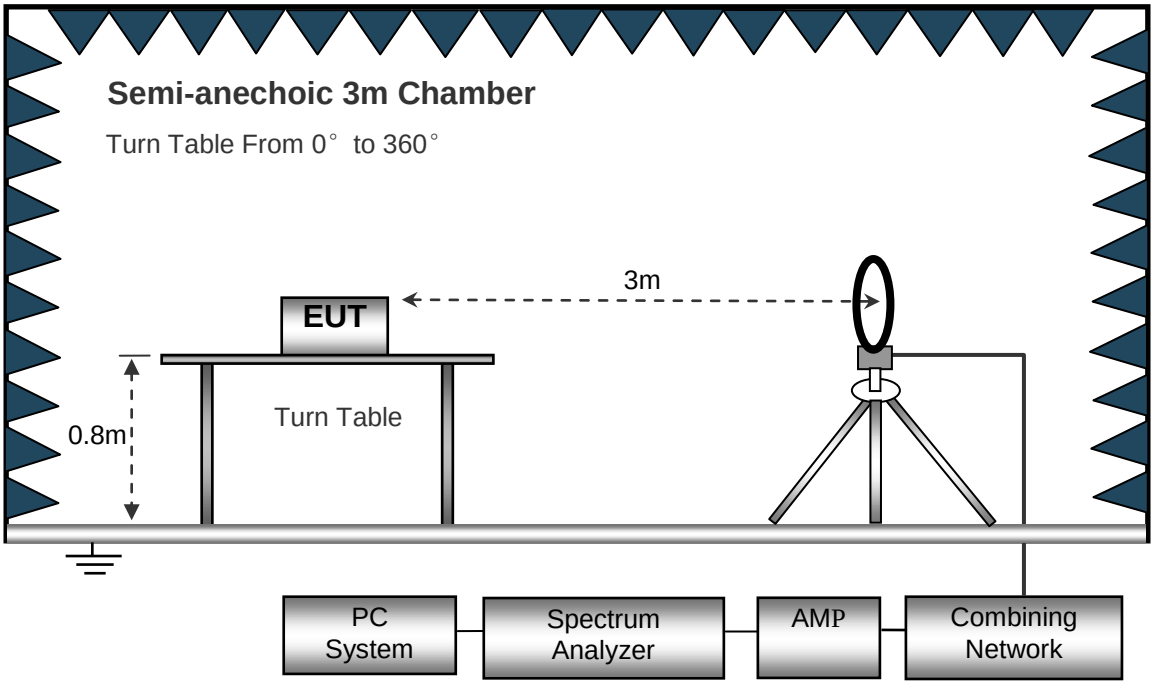
EUT Operation:

The test was performed in Transmitting mode, the worst test data (GFSK modulation) were shown in the report.

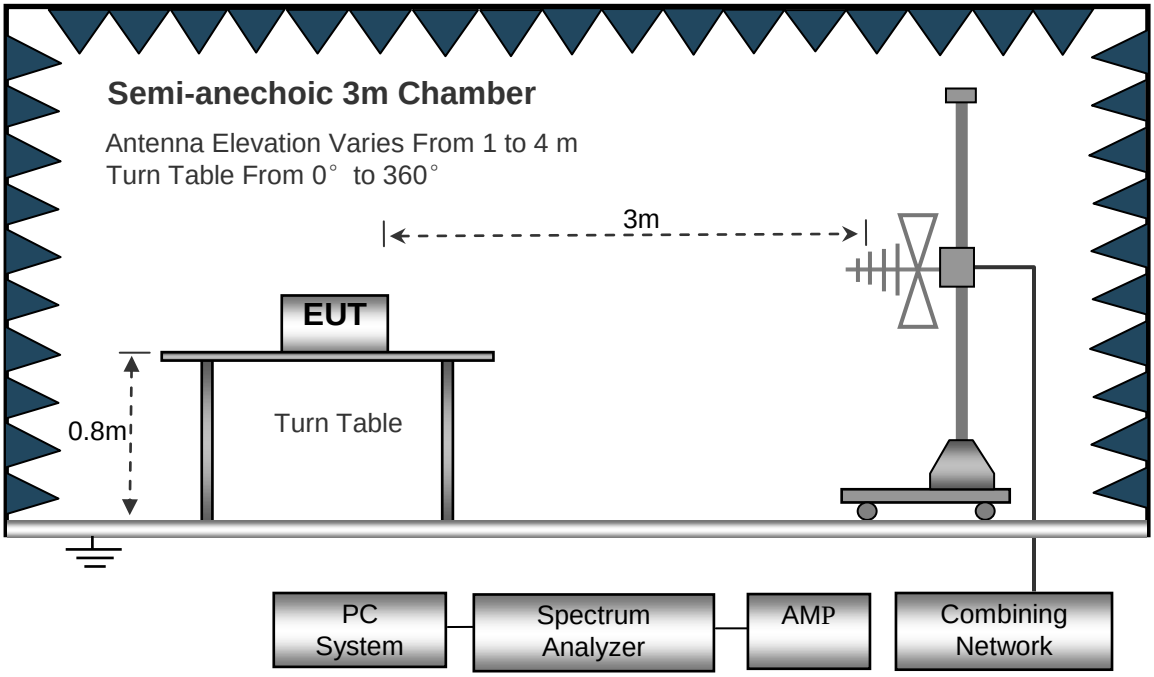
7.2 Test Setup

The radiated emission tests were performed in the 3m Semi- Anechoic Chamber test site, using the setup accordance with the ANSI C63.10: 2013.

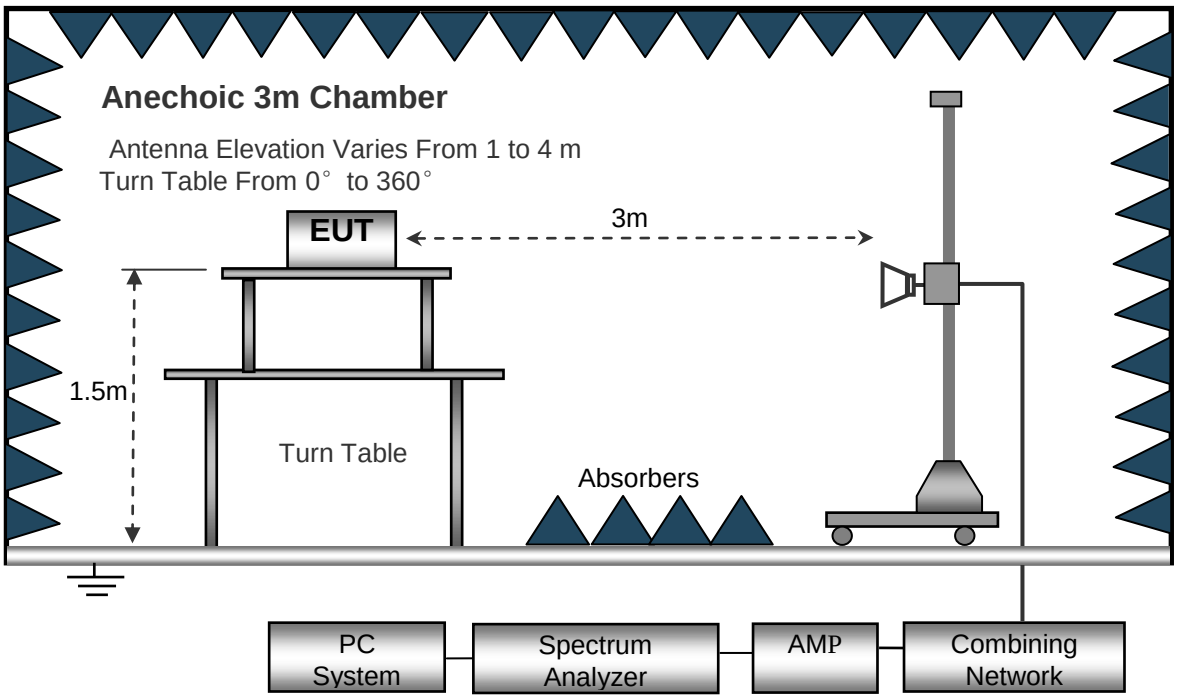
The test setup for emission measurement below 30MHz.



The test setup for emission measurement from 30 MHz to 1 GHz.



The test setup for emission measurement above 1 GHz.



7.3 Spectrum Analyzer Setup

Below 30MHz

Sweep Speed	:	Auto
IF Bandwidth	:	10kHz
Video Bandwidth	:	10kHz
Resolution Bandwidth	:	10kHz

30MHz ~ 1GHz

Sweep Speed	:	Auto
Detector	:	PK
Resolution Bandwidth	:	100kHz
Video Bandwidth	:	300kHz

Above 1GHz

Sweep Speed	:	Auto
Detector	:	PK
Resolution Bandwidth	:	1MHz
Video Bandwidth	:	3MHz
Detector	:	Ave.
Resolution Bandwidth	:	1MHz
Video Bandwidth	:	10Hz

7.4 Test Procedure

1) The EUT is placed on a turntable, which is 0.8m(Below 1G) 1.5m(above 1G)above ground plane.

2) The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

3) EUT is set 3m away from the receiving antenna, which is moved from 1m to 4m to find out the maximum emissions. The spectrum was investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

4) Maximum procedure was performed on the six highest emissions to ensure EUT compliance.

5) And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.

6) Repeat above procedures until the measurements for all frequencies are complete.

7) The radiation measurements are tested under 3-axes(X, Y, Z) position(X denotes lying on the table, Y denotes side stand and Z denotes vertical stand), After pre-test, It was found that the worse radiation emission was get at the Z position. So the data shown was the Z position only.

7.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

Corr. Ampl. = Indicated Reading + Antenna Factor + Cable Factor - Amplifier Gain

The “Margin” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7dB means the emission is 7dB below the maximum limit for Class B. The equation for margin calculation is as follows:

Margin = Corr. Ampl. – Limit

7.6 Summary of Test Results

Test Frequency: 9 kHz~30 MHz

The measurements were more than 20 dB below the limit and not reported.

Test Frequency: 30MHz ~ 18GHz

GFSK_Low Channel

Frequency (MHz)	Receiver Reading (dBμV/m)	Detector (PK/QP/AVG)	Turn table Angle (°)	RX Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247	
				Height (m)	Polar (H/V)			Limit (dBμV/m)	Margin (dB)
43.51	2.89	QP	166	1.5	H	15.16	18.05	40	-21.95
43.51	5.34	QP	101	1.7	V	14.66	20.00	40	-20.00
4818.75	77.56	PK	258	1.2	H	-6.68	70.88	74	-3.12
4818.75	73.50	PK	288	1.8	V	-2.91	70.59	74	-3.41
7198.13	72.48	PK	124	1.2	H	-1.49	70.99	74	-3.01
7198.13	66.58	PK	193	1.4	V	3.51	70.09	74	-3.91
9606.87	59.25	PK	244	1.7	H	3.94	63.19	74	-10.81
9606.87	51.42	PK	102	1.6	V	5.88	57.30	74	-16.70
12015.63	53.43	PK	259	1.6	H	9.30	62.73	74	-11.27
12015.63	49.17	PK	255	1.7	V	9.41	58.58	74	-15.42

AV = Peak +20Log$_{10}$(duty cycle) =PK+(-28) [refer to section 6.2 for more detail]

Frequency (MHz)	PK (dBμV/m)	RX Antenna Polar (H/V)	Duty cycle Factor (dB)	Calculated AV (dBμV/m)	FCC Part 15.247	
					Limit (dBμV/m)	Margin (dB)
4818.75	70.88	H	-28	42.88	54	-11.12
4818.75	70.59	V	-28	42.59	54	-11.41
7198.13	70.99	H	-28	42.99	54	-11.01
7198.13	70.09	V	-28	42.09	54	-11.91
9606.87	63.19	H	-28	35.19	54	-18.81
9606.87	57.30	V	-28	29.30	54	-24.70
12015.63	62.73	H	-28	34.73	54	-19.27
12015.63	58.58	V	-28	30.58	54	-23.42

GFSK_Middle Channel

Frequency (MHz)	Receiver Reading (dBμV/m)	Detector (PK/QP/AVG)	Turn table Angle (°)	RX Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247	
				Height (m)	Polar (H/V)			Limit (dBμV/m)	Margin (dB)
77.05	12.69	QP	127	1.8	H	9.49	22.18	40	-17.82
77.05	11.99	QP	246	1.7	V	9.71	21.70	40	-18.30
4877.50	70.66	PK	248	1.4	H	-2.63	68.03	74	-5.97
4877.50	77.28	PK	155	1.7	V	-6.51	70.77	74	-3.23
7315.63	59.86	PK	241	1.5	H	3.84	63.70	74	-10.30
7315.63	71.87	PK	211	1.4	V	-1.16	70.71	74	-3.29
9724.38	47.58	PK	249	1.7	H	5.92	53.50	74	-20.50
9724.38	64.61	PK	163	1.5	V	4.26	68.87	74	-5.13
11839.38	47.01	PK	106	1.2	H	9.39	56.40	74	-17.60
11839.38	60.44	PK	138	1.2	V	9.09	69.53	74	-4.47

AV = Peak +20Log$_{10}$(duty cycle) =PK+(-28) [refer to section 6.2 for more detail]

Frequency (MHz)	PK (dBμV/m)	RX Antenna Polar (H/V)	Duty cycle Factor (dB)	Calculated AV (dBμV/m)	FCC Part 15.247	
					Limit (dBμV/m)	Margin (dB)
4877.50	68.03	H	-28	40.03	54	-13.97
4877.50	70.77	V	-28	42.77	54	-11.23
7315.63	63.70	H	-28	35.70	54	-18.30
7315.63	70.71	V	-28	42.71	54	-11.29
9724.38	53.50	H	-28	25.50	54	-28.50
9724.38	68.87	V	-28	40.87	54	-13.13
11839.38	56.40	H	-28	28.40	54	-25.60
11839.38	69.53	V	-28	41.53	54	-12.47

GFSK_High Channel

Frequency (MHz)	Receiver Reading (dBμV/m)	Detector (PK/QP/AVG)	Turn table Angle (°)	RX Antenna		Corrected Factor (dB)	Corrected Amplitude (dBμV/m)	FCC Part 15.247	
				Height (m)	Polar (H/V)			Limit (dBμV/m)	Margin (dB)
131.30	10.78	QP	183	1.4	H	10.24	21.02	43.50	-22.48
131.30	12.21	QP	269	1.2	V	11.46	23.67	43.50	-19.83
4936.25	75.95	PK	127	1.9	H	-6.35	69.60	74	-4.40
4936.25	70.74	PK	241	1.4	V	-2.36	68.38	74	-5.62
7403.75	71.73	PK	274	1.4	H	-0.90	70.83	74	-3.17
7403.75	65.49	PK	238	1.1	V	4.10	69.59	74	-4.41
9871.25	66.24	PK	218	1.5	H	4.68	70.92	74	-3.08
9871.25	53.60	PK	269	1.7	V	5.98	59.58	74	-14.42
12338.75	60.99	PK	119	1.7	H	8.84	69.83	74	-4.17
12338.75	48.57	PK	172	1.4	V	9.01	57.58	74	-16.42

AV = Peak +20Log$_{10}$(duty cycle) =PK+(-28) [refer to section 6.2 for more detail]

Frequency (MHz)	PK (dBμV/m)	RX Antenna Polar (H/V)	Duty cycle Factor (dB)	Calculated AV (dBμV/m)	FCC Part 15.247	
					Limit (dBμV/m)	Margin (dB)
4936.25	69.60	H	-28	41.60	54	-12.40
4936.25	68.38	V	-28	40.38	54	-13.62
7403.75	70.83	H	-28	42.83	54	-11.17
7403.75	69.59	V	-28	41.59	54	-12.41
9871.25	70.92	H	-28	42.92	54	-11.08
9871.25	59.58	V	-28	31.58	54	-22.42
12338.75	69.83	H	-28	41.83	54	-12.17
12338.75	57.58	V	-28	29.58	54	-24.42

Test Frequency: 18GHz~25GHz

The measurements were more than 20 dB below the limit and not reported.

8 Band Edge Measurement

Test Requirement .....: FCC CFR47 Part 15 Subpart C 15.247(d)

Test Method .....: KDB 558074 D01, Section 13

Test Mode.....: Transmitting

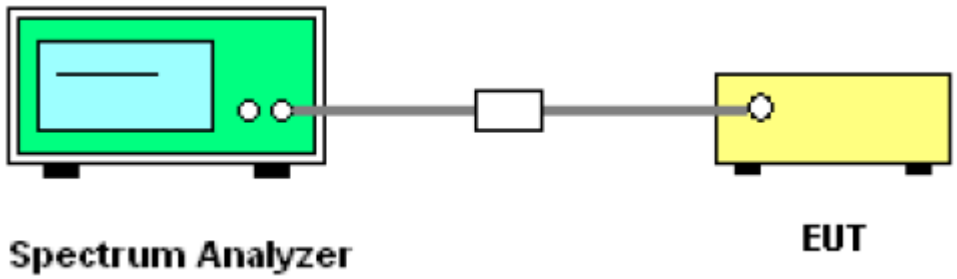
8.1 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

2) Set the spectrum analyzer: RBW = 100kHz, VBW = 300kHz, Sweep = auto

Detector function = peak, Trace = max hold

8.2 Test Setup

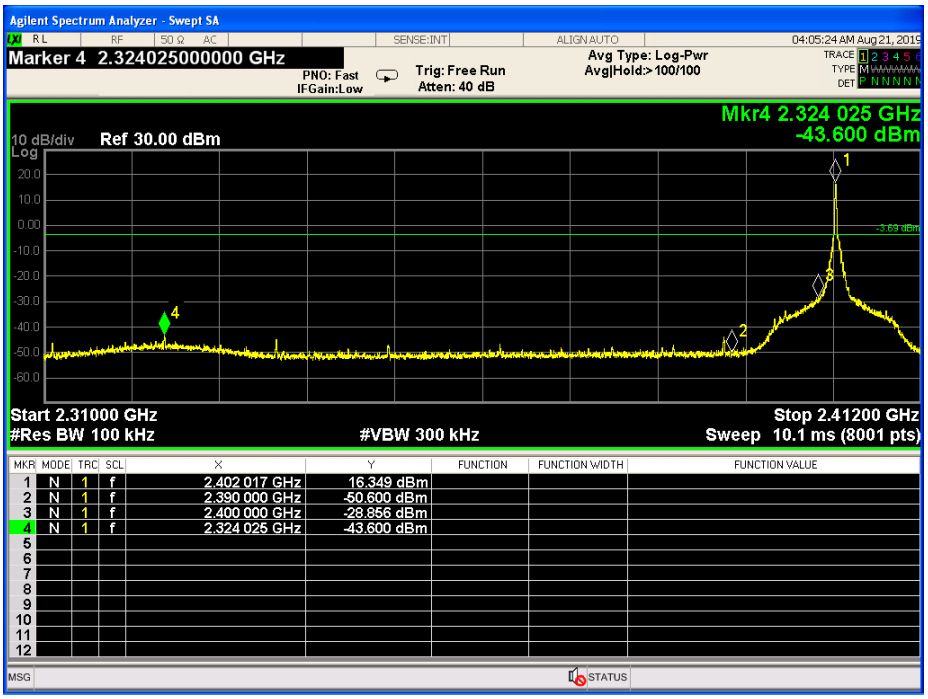


8.3 Limits

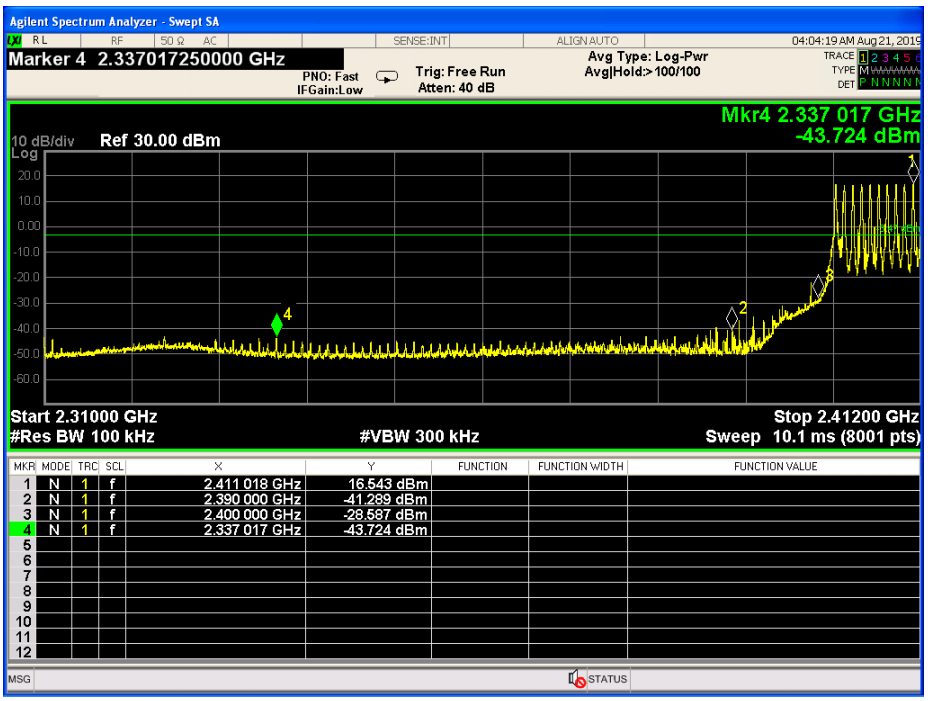
According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

8.4 Test Result

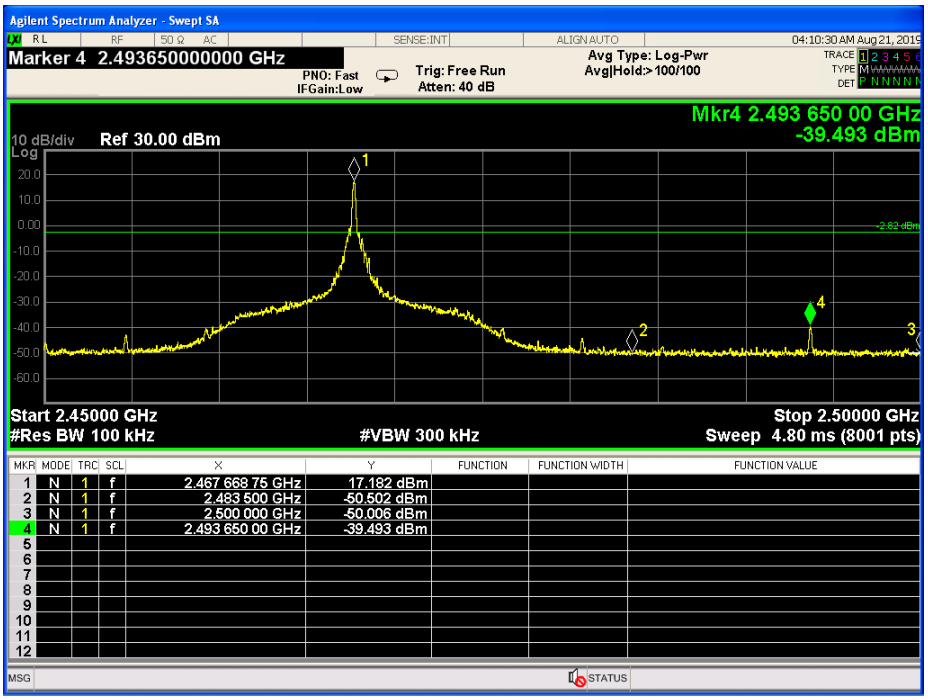
GFSK Transmitting Band edge-left side



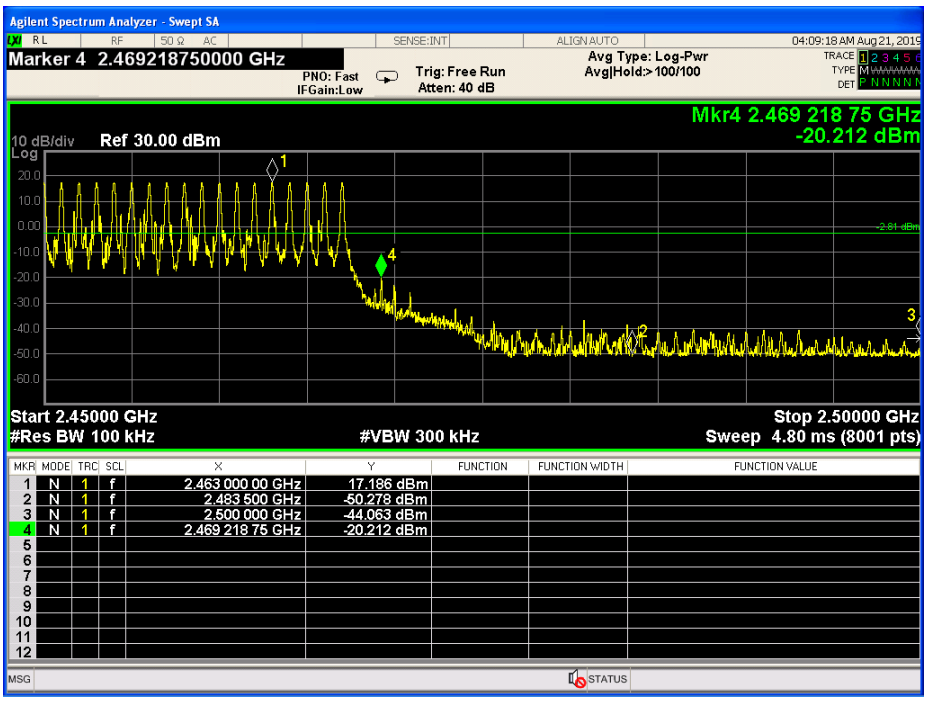
GFSK Hopping Band edge-left side



GFSK Transmitting Band edge-right side



GFSK Hopping Band edge-right side



9 20 dB Bandwidth Measurement

Test Requirement .....: FCC CFR47 Part 15 Subpart C 15.215(c)

Test Method .....: ANSI C63.10:2013 Clause 6.9.2

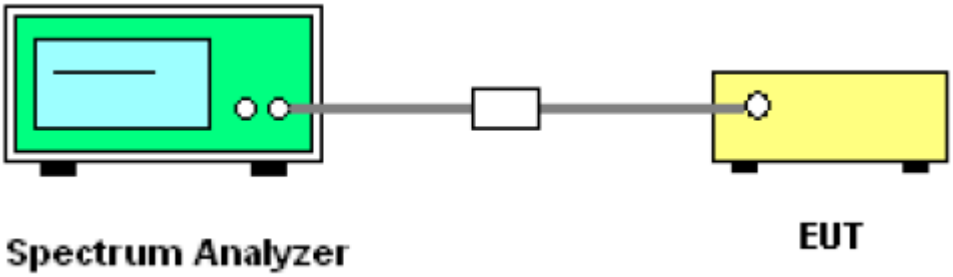
Test Mode.....: Test in fixing operating frequency at low, Middle, high channel.

9.1 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

2) Set the spectrum analyzer: RBW = 30kHz, VBW = 100kHz

9.2 Test Setup



9.3 Limits

According to §15.215(c), intentional radiators operating under the alternative provisions to the general emission limits must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

The specific rule section under which the equipment operates is §15.247. According to §15.247(a)(2), for systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is specified as the bandwidth of the emission. In this case, measuring the 20 dB bandwidth is not required.

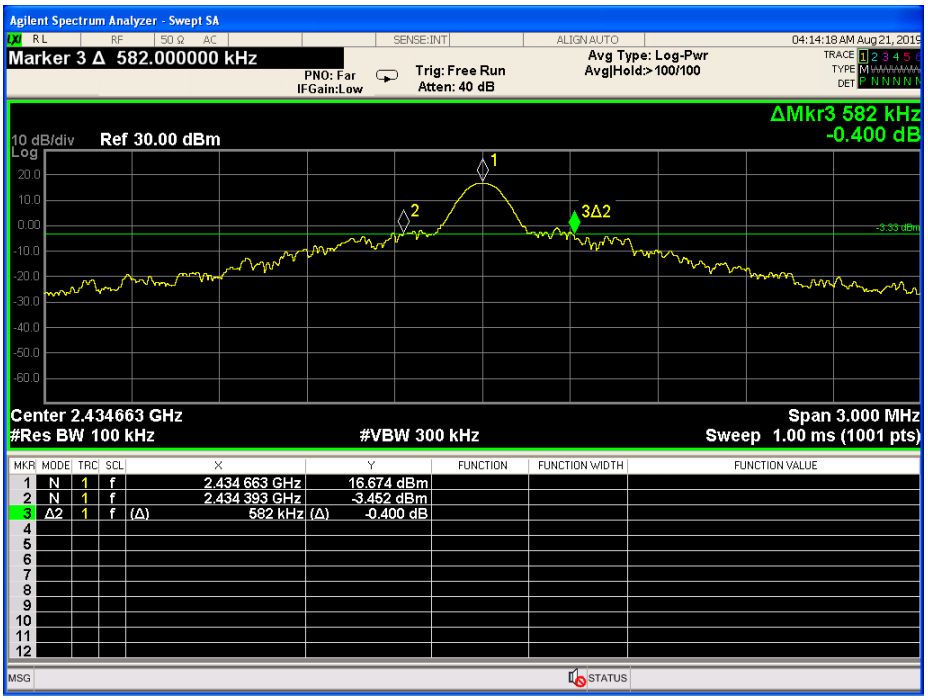
9.4 Test Result

Modulation	Test Channel	20dB Bandwidth (kHz)	Band edge left		Band edge right		Result
			Frequency (MHz)	Limit (MHz)	Frequency (MHz)	Limit (MHz)	
GFSK	Low	648	2401.700	2400	2402.35	2483.5	Pass
GFSK	Middle	582	2434.393	2400	2434.98	2483.5	Pass
GFSK	High	654	2467.333	2400	2467.99	2483.5	Pass

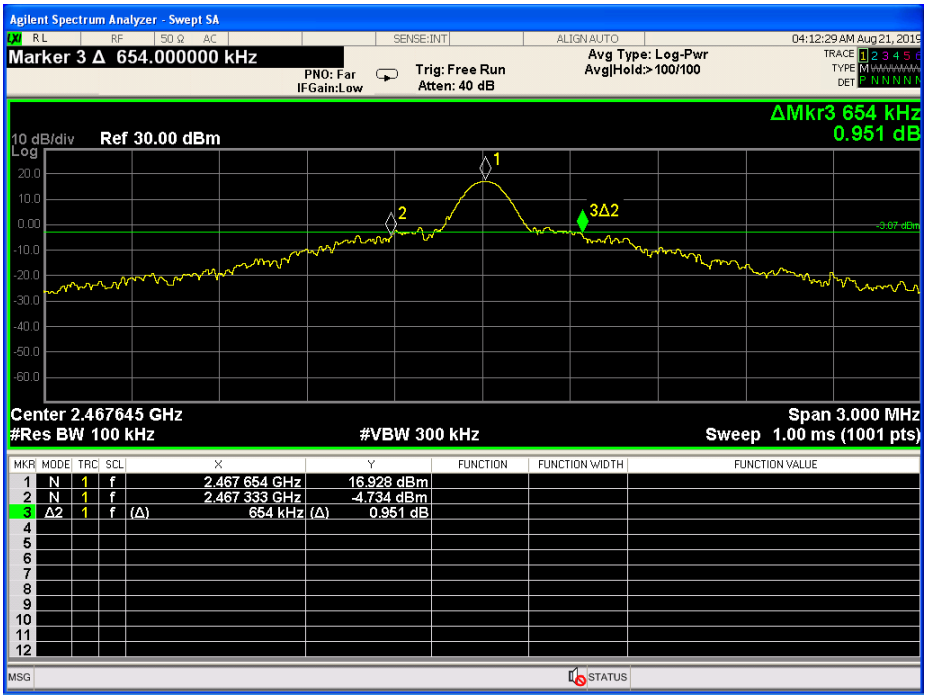
Test result plot as follow:

GFSK Low Channel

GFSK Middle Channel



GFSK High Channel



10 Occupied Bandwidth Measurement

Test Requirement .....: FCC CFR47 Part 15 Subpart C 2.202(a), KDB 558074 D01, section 5.2

Test Method .....: ANSI C63.10, clause 6.9

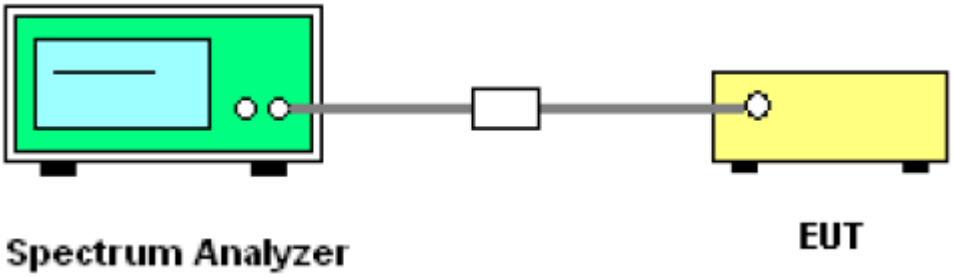
Test Mode.....: Test in fixing operating frequency at low, Middle, high channel.

10.1 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

2) Set the spectrum analyzer: RBW = 30kHz, VBW = 100kHz

10.2 Test Setup



10.3 Limits

According to section 5.2 of KDB Publication 558074, document D01, the 99 % occupied bandwidth is necessary for setting the proper reference level and input attenuation.

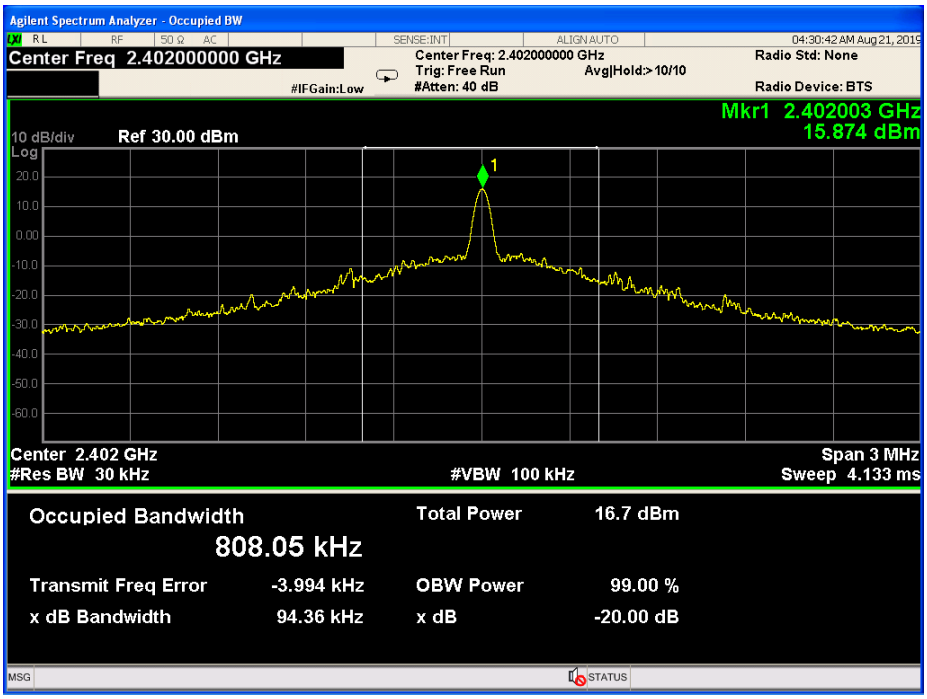
Although there is no limit specified, the occupied bandwidth has to be recorded and reported.

10.4 Test Result

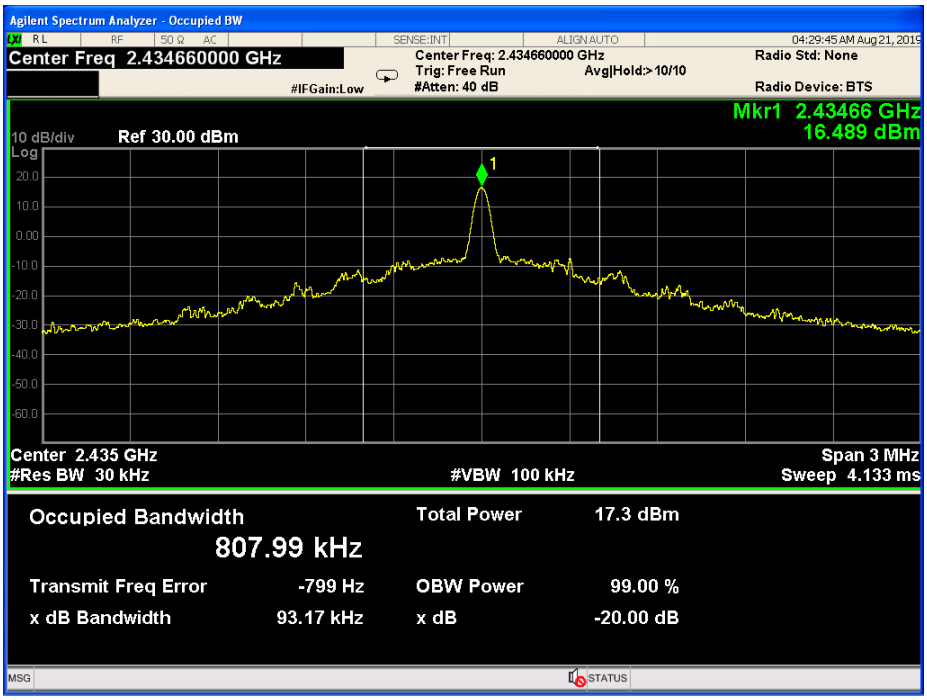
Modulation	Test Channel	99% Occupied Bandwidth (kHz)	Result
GFSK	Low	808.05	Pass
GFSK	Middle	807.99	Pass
GFSK	High	811.91	Pass

Test result plot as follow:

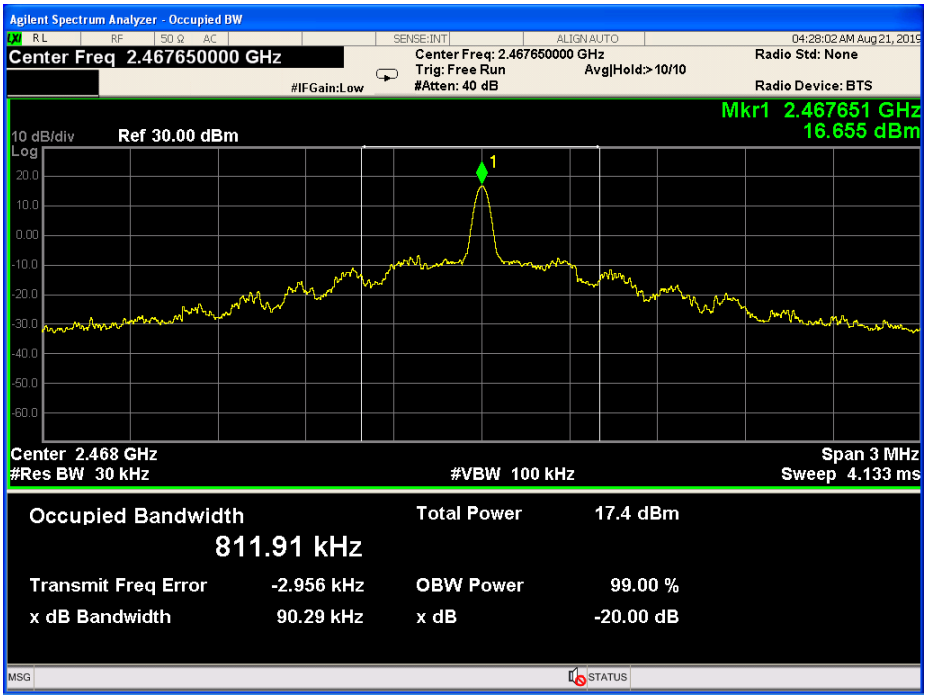
GFSK Low Channel



GFSK Middle Channel



GFSK High Channel



11 Maximum Peak Output Power

Test Requirement ..... : FCC CFR47 Part 15 Subpart C 15.247(b)

Test Method ..... : KDB 558074 D01, Clause 7.8

Test Mode..... : Test in fixing frequency transmitting mode.

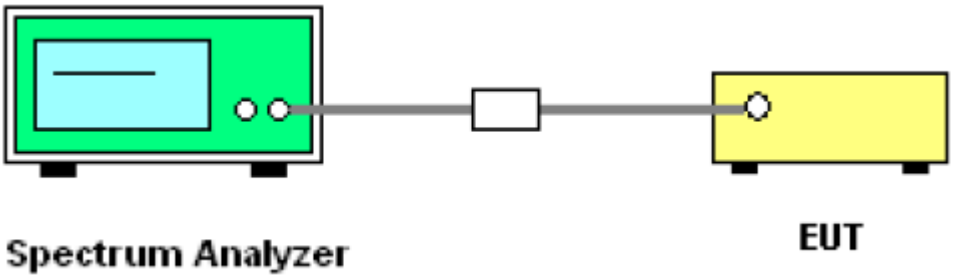
11.1 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set the spectrum analyzer: RBW = 3MHz. VBW = 3MHz. Sweep = auto; Detector Function = Peak.

3) Keep the EUT in transmitting at lowest, medium and highest channel individually. Record the max value.

11.2 Test Setup



11.3 Limits

As specified in section 15.247(b)(3) of 47 CFR Part 15, for systems using digital modulation (DTS), the maximum peak conducted output power of the intentional radiator shall not exceed 1 Watt (30 dBm).

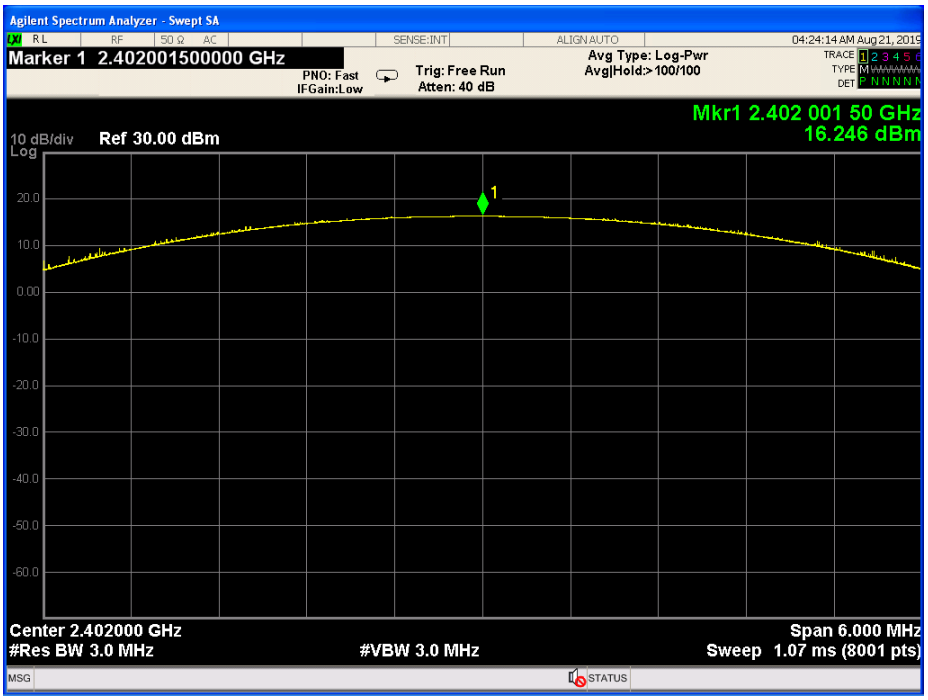
This limit is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

11.4 Test Result

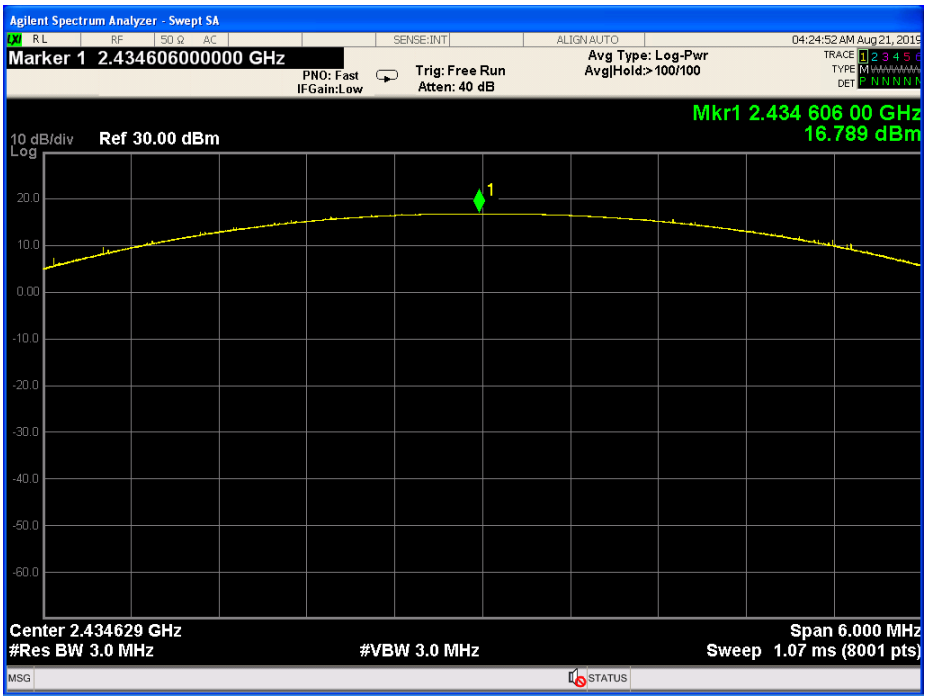
Modulation	Test Channel	Conducted Output Power (dBm)	Limit (dBm)	Margin
GFSK	Low	16.246	30	-14.522
GFSK	Middle	16.789	30	-14.854
GFSK	High	16.930	30	-14.538

Test result plot as follow:

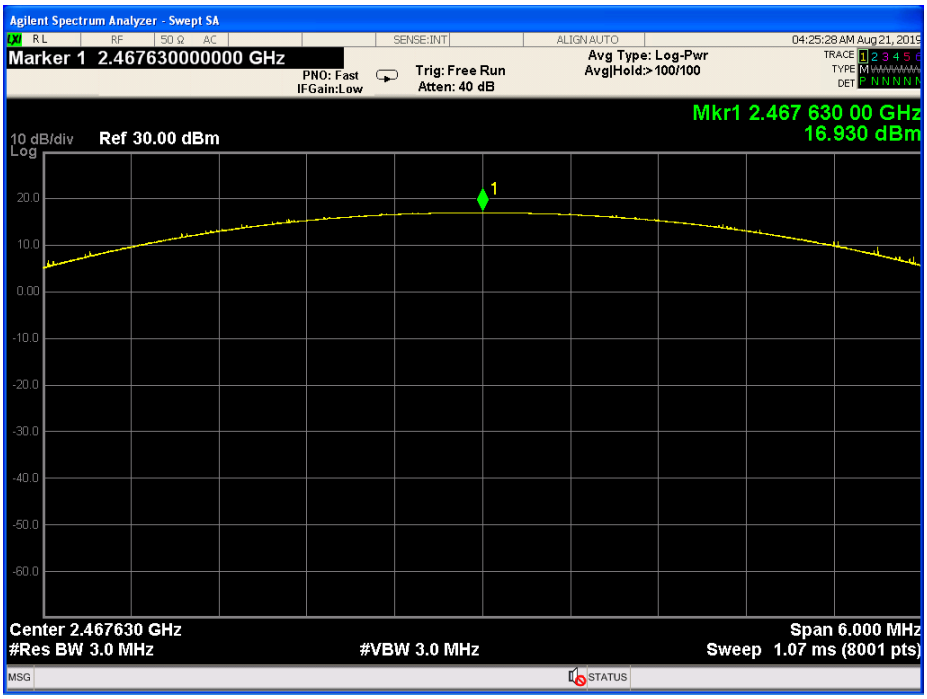
GFSK Low Channel



GFSK Middle Channel



GFSK High Channel



12 Carrier Frequency Separation

Test Requirement ..... : FCC CFR47 Part 15 Subpart C 15.247(a)

Test Method ..... : ANSI C63.10:2013, Clause 7.8

Test Mode..... : Test in hopping transmitting operating mode.

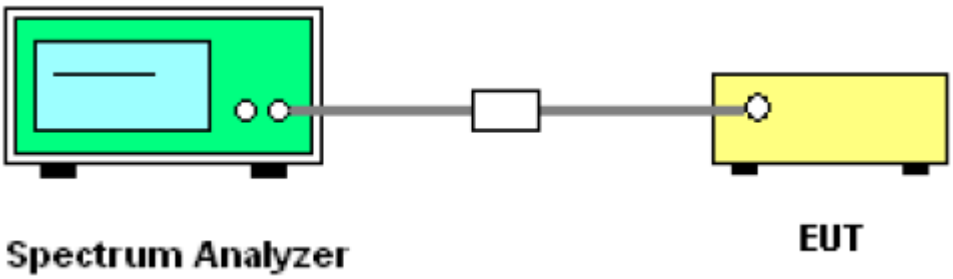
12.1 Test Procedure

1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set the spectrum analyzer: RBW = 30kHz. VBW = 100kHz , Span = 3.0MHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.

3) Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section Submit this plot.

12.2 Test Setup



12.3 Limits

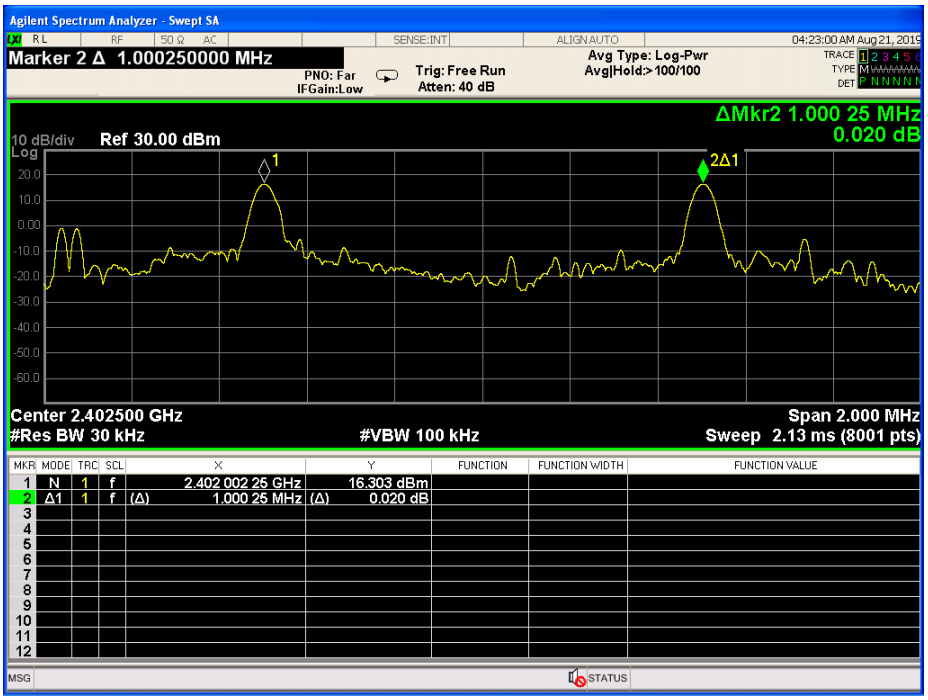
As specified in section 15.247(a) of 47 CFR Part 15, for frequency hopping systems the carrier frequency separation shall not be less than 25 KHz or 20 dB bandwidth of the hopping channel, whichever is greater. For frequency hopping systems operating in the 2400-2483.5 MHz band the carrier frequency separation shall be 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

12.4 Test Result

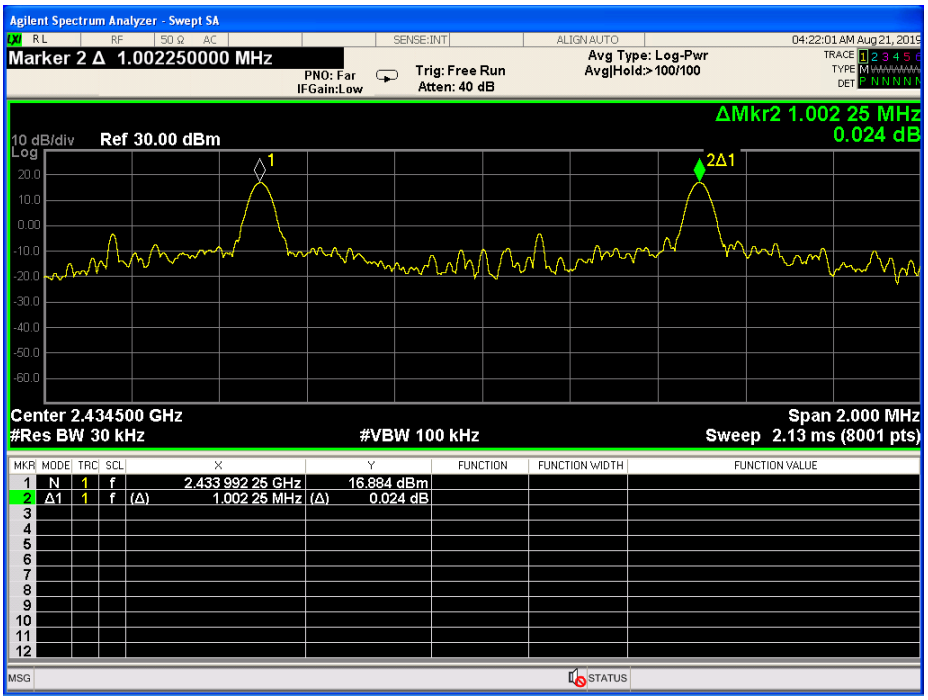
Modulation	Test Channel	Separation (MHz)	Result
GFSK	Low	1.000	Pass
GFSK	Middle	1.002	Pass
GFSK	High	1.000	Pass

Test result plot as follow:

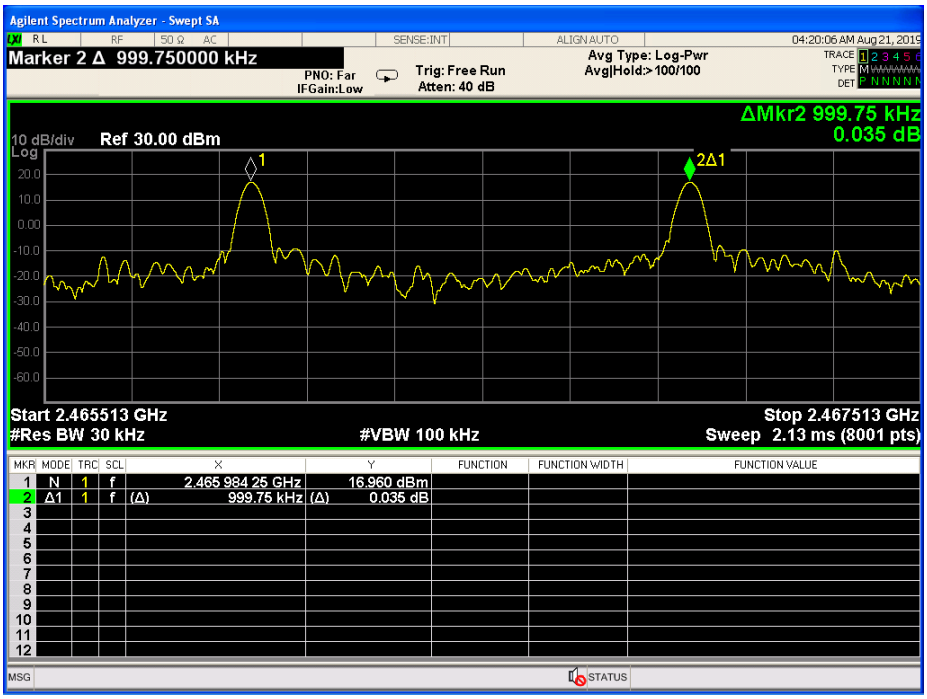
GFSK Low Channel



GFSK Middle Channel



GFSK High Channel



13 Number of Hopping Frequency

Test Requirement ..... : FCC CFR47 Part 15 Subpart C 15.247(a)

Test Method ..... : ANSI C63.10:2013, Clause 7.8

Test Mode..... : Test in hopping transmitting operating mode.

13.1 Test Procedure

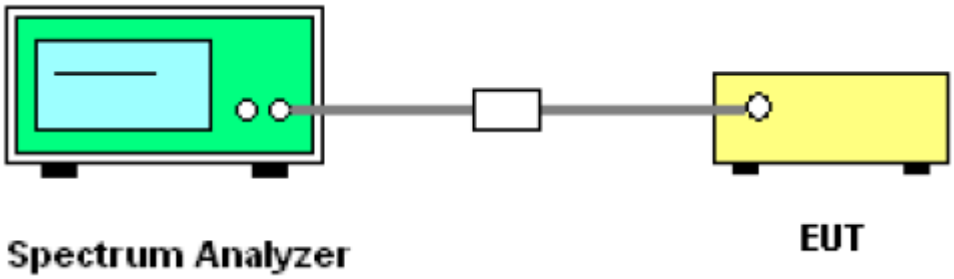
1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set the spectrum analyzer: RBW = 100 KHz. VBW = 300 KHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.

3) Allow the trace to stabilize. It may prove necessary to break the span up to sections. in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section.

4) Set the spectrum analyzer: Start Frequency = 2.4GHz, Stop Frequency = 2.483GHz. Sweep=auto.

13.2 Test Setup

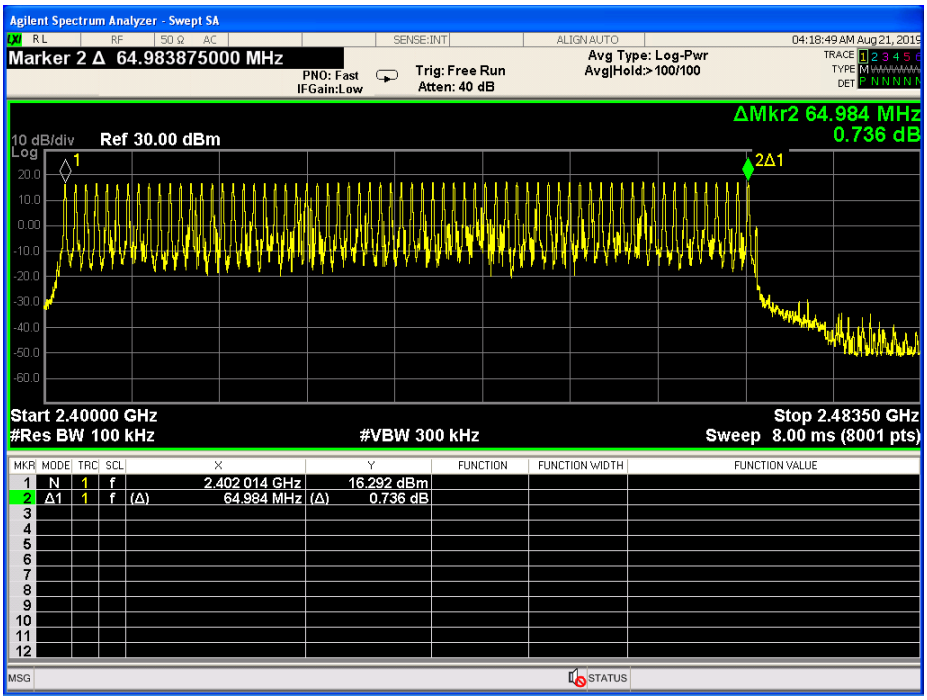


13.3 Limits

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

13.4 Test Result

66 Channels in total GFSK



14 Time of occupancy (Dwell Time)

Test Requirement ..... : FCC CFR47 Part 15 Subpart C 15.247(a)

Test Method ..... : ANSI C63.10:2013, Clause 7.8

Test Mode..... : Test in hopping transmitting operating mode.

14.1 Test Procedure

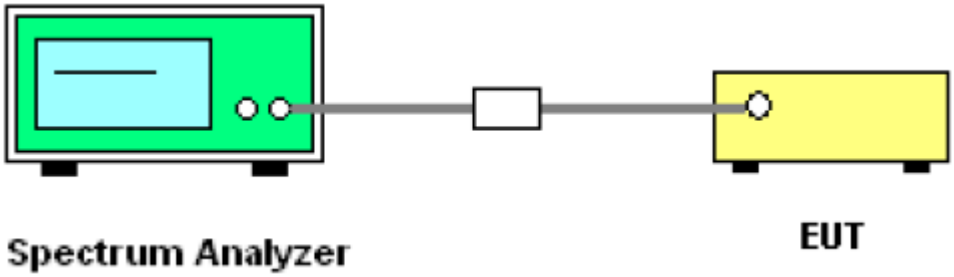
1) Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.

2) Set spectrum analyzer span = 0. Centred on a hopping channel;

3) Set RBW = 1MHz and VBW = 3MHz.Sweep = as necessary to capture the entire dwell time per hopping channel.

4) Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g.. data rate. modulation format. etc.). repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

14.2 Test Setup



14.3 Limits

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

14.4 Test Result

As declared in §15.247(a)(iii) the observation period should 0.4 s multiplied by the number of hopping channels. So in this case the observation period is

t=0.4s*65=26s

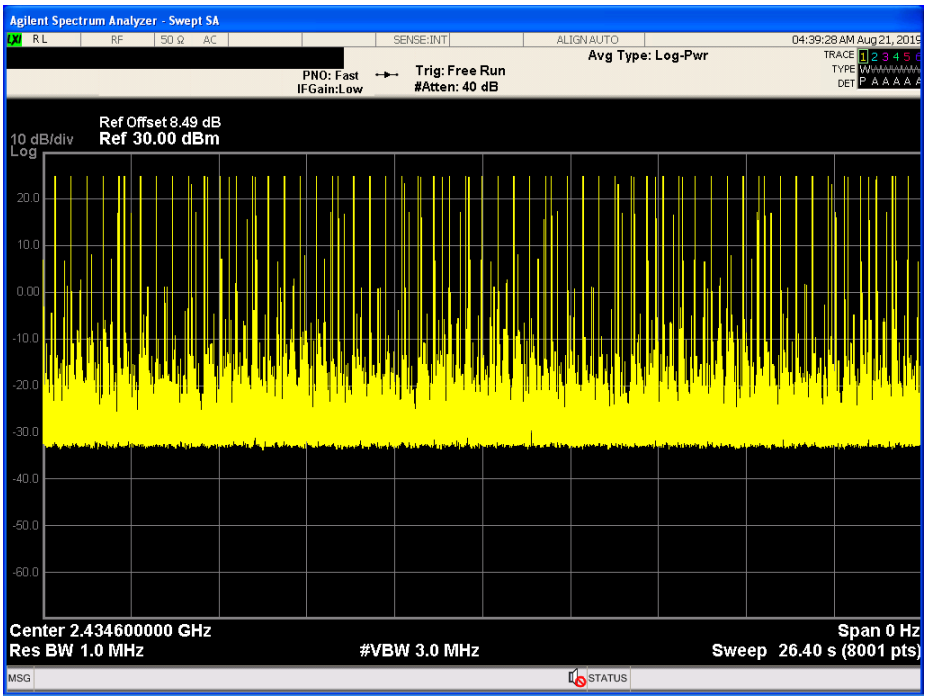


Chart of number of bursts in 26s

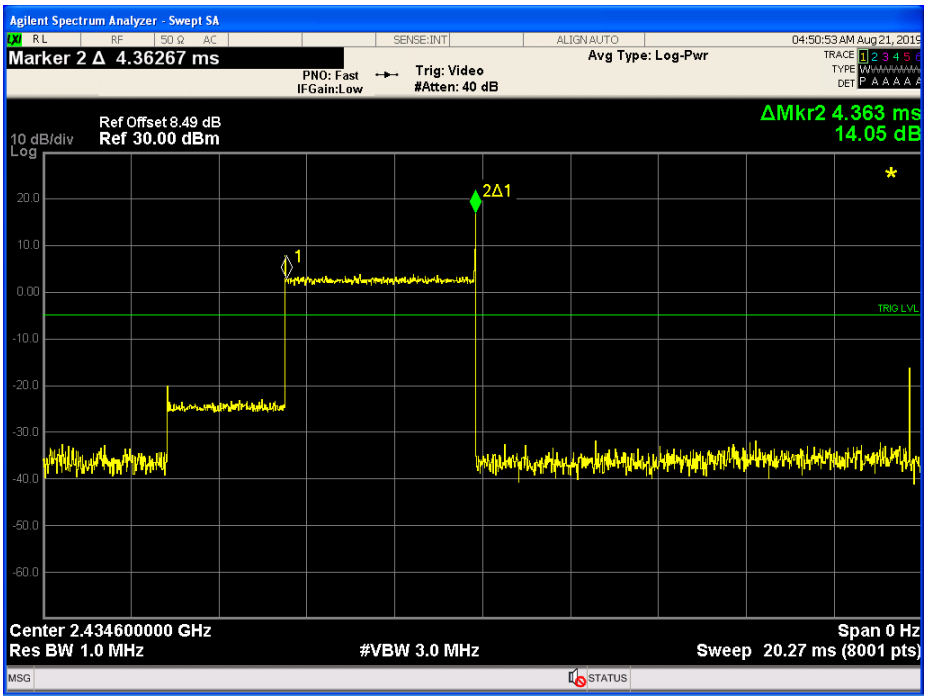


Chart of burst length in 20ms (trigger offset-0.5ms)

Number of hops in 26s	Burst length in 20 ms	Time of occupancy	Limit
66	4.363ms	287.958ms	400ms

*Remark: Time of occupancy = (Number of hops) x (Burst length)

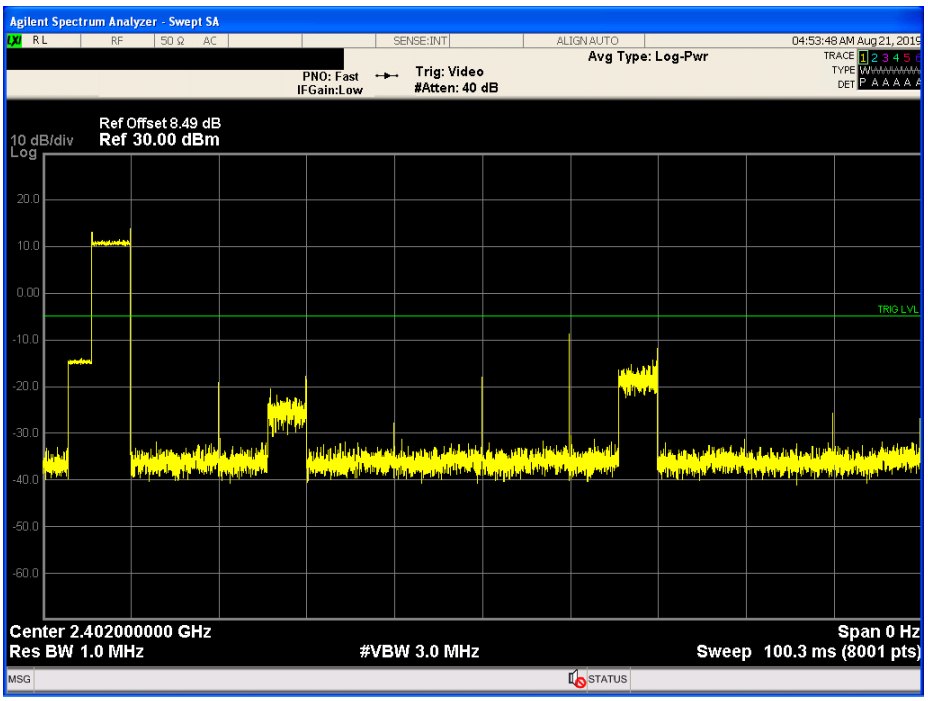


Chart of burst length in 100ms (trigger offset-0.5ms)

*In 100 ms the EUT does not transmit again as shown above

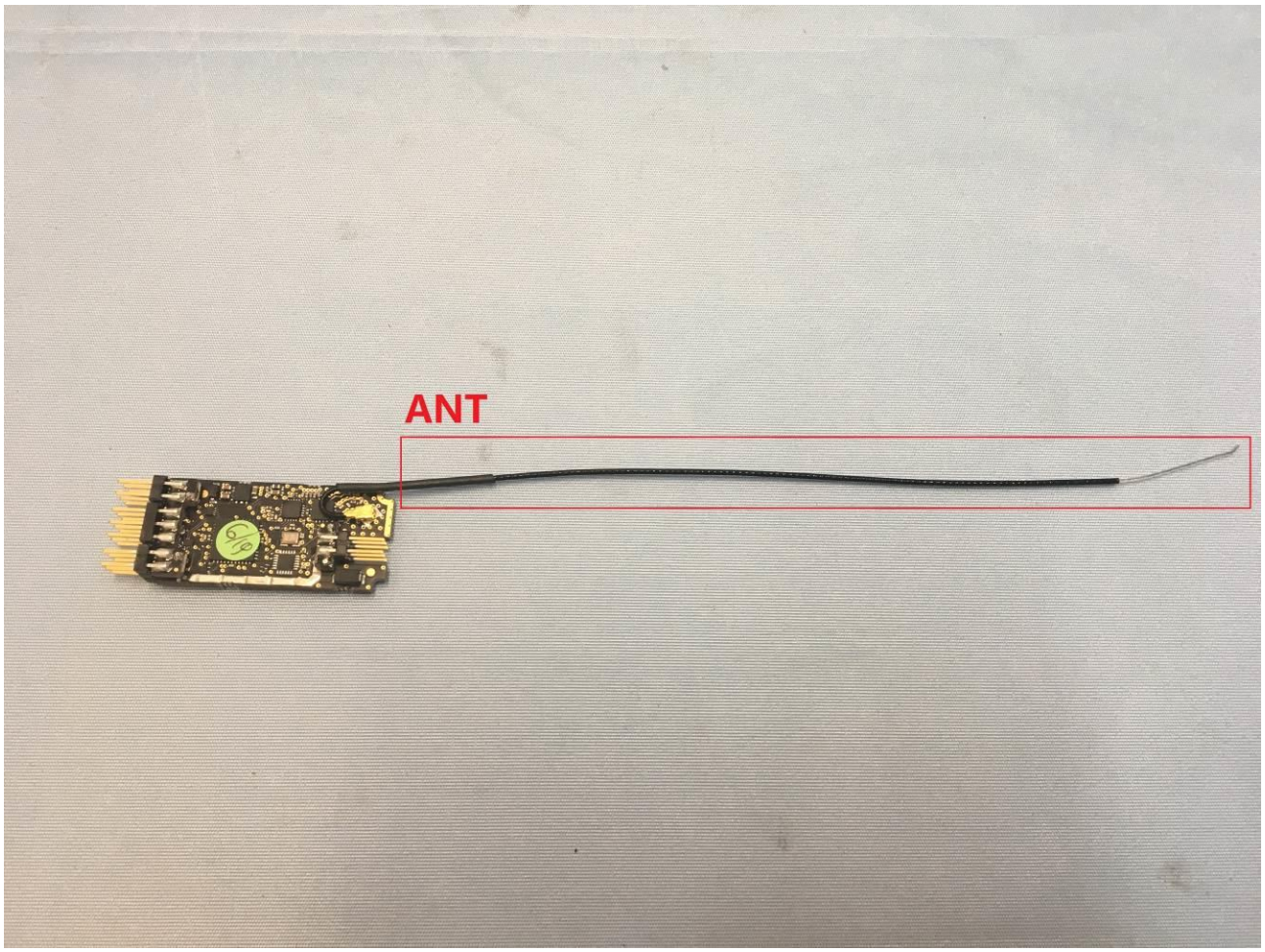
15 Antenna Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacture may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221.Further ,this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

For intentional device, according to FCC 47 CFR Subpart C Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

Result:

The EUT has one Integrated Antenna, the gain is 0dBi meets the requirements of FCC Subpart C 15.203.



16 FCC ID: 2ASCM-PBR-07S RF Exposure

Test Requirement	:	FCC Part 1.1307
Test Method	:	FCC Part2.1093 & KDB 447498 D01 General RF Exposure Guidance v06

16.1 Requirements

This estimation follows the general guidelines for RF Exposure according to KDB 447498.

As noted in §2.1091(b) a mobile device is defined as “a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.” According to §2.1091(c) the limits to be used for evaluation are defined in §1.1310.

As specified in §1.1310(d)(2) at operating frequencies less than or equal to 6 GHz, the limits for maximum permissible exposure (MPE), derived from whole-body SAR limits and listed in Table 1 of §1.1310(e) may be used.

Table 1 below shows the limits for Maximum Permissible Exposure (MPE) to radiofrequency electromagnetic fields.

16.2 The procedures / limit

(A) Limits for Occupational / Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm^2)	Averaging Time $\|E\|^2$,$\|H\|^2$or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842 / f	4.89 / f	(900 / f)*	6
30-300	61.4	0.163	1.0	6
300-1500			F/300	6
1500-100,000			5	6

(B) Limits for General Population / Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/ cm^2)	Averaging Time $\|E\|^2$,$\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			1.0	30

Note: f = frequency in MHz ; *Plane-wave equivalent power density

16.3 MPE Calculation Method

$$S = \frac{P \times G}{4 \times \pi \times R^2}$$

S = power density (in appropriate units, e.g. mW/cm^2)
P = output power to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

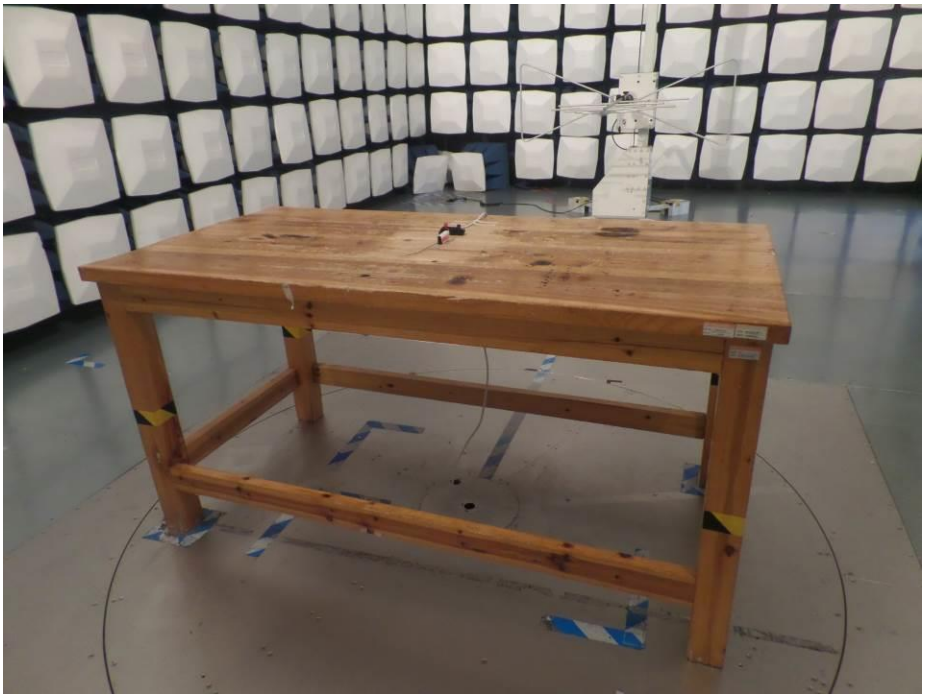
From the peak EUT RF output power, the minimum mobile separation distance, R=20cm, as well as the gain of the used antenna, the RF power density can be obtained

Separation distance (mm)	Channel Frequency (MHz)	Rated Power + tolerance (dBm)	Rated Power + tolerance (mW)	Pd (mW/cm2)	Limit Pd (mW/cm2)
>200	2467	18.930	78.16	0.016	1.0

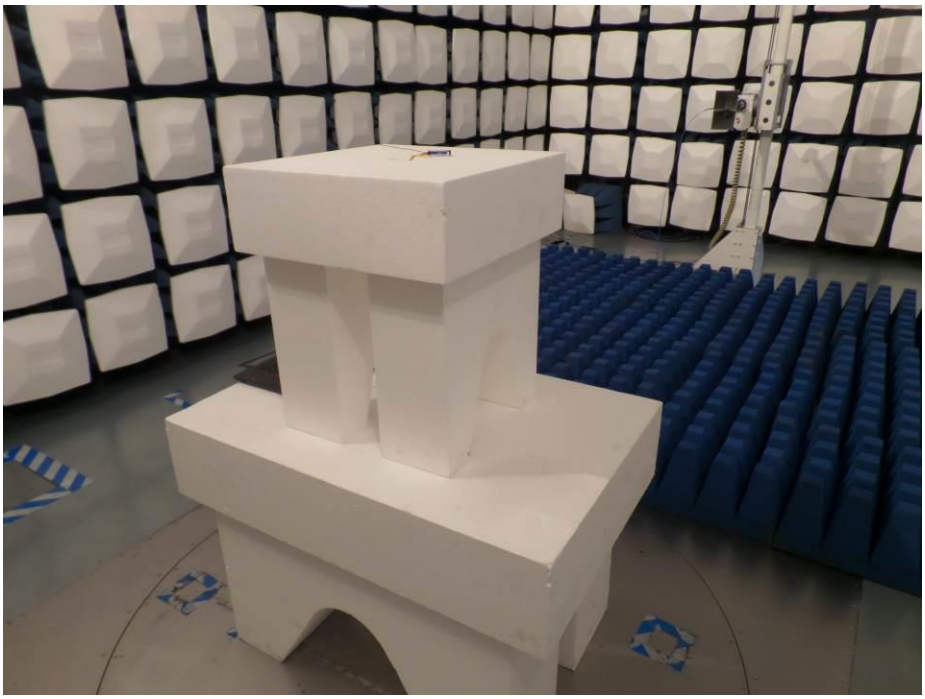
17 Photographs Test Setup

17.1 Photographs - Radiated Emission Test Setup

30MHz-1GHz

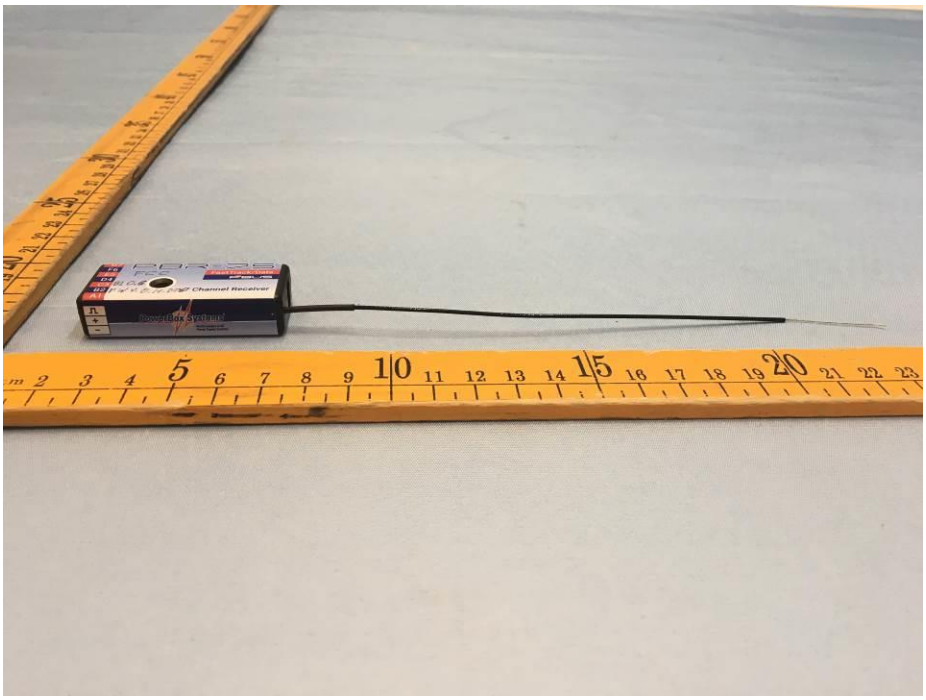


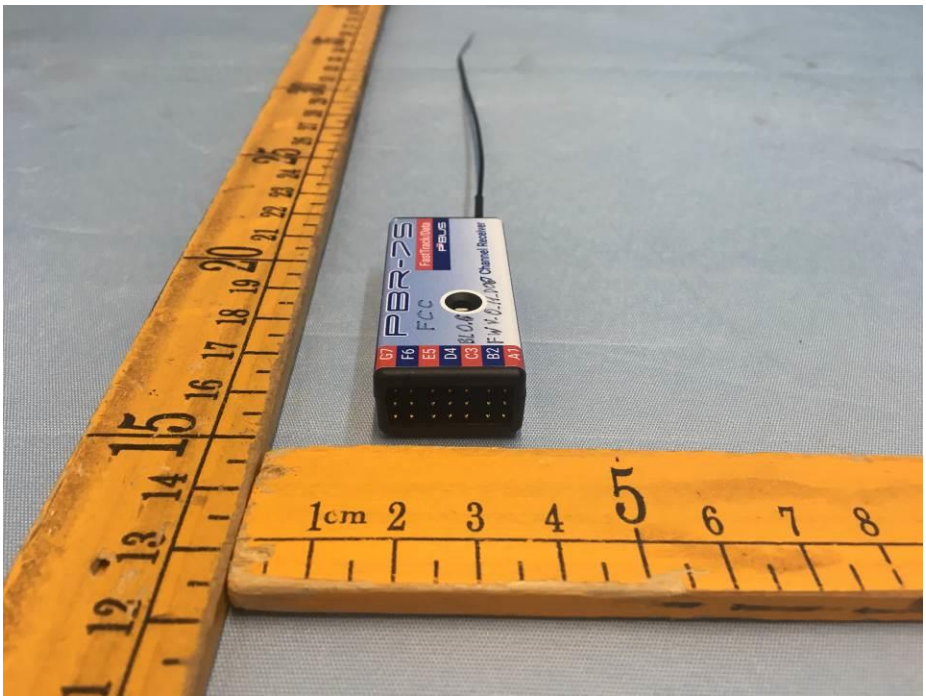
Above 1GHz

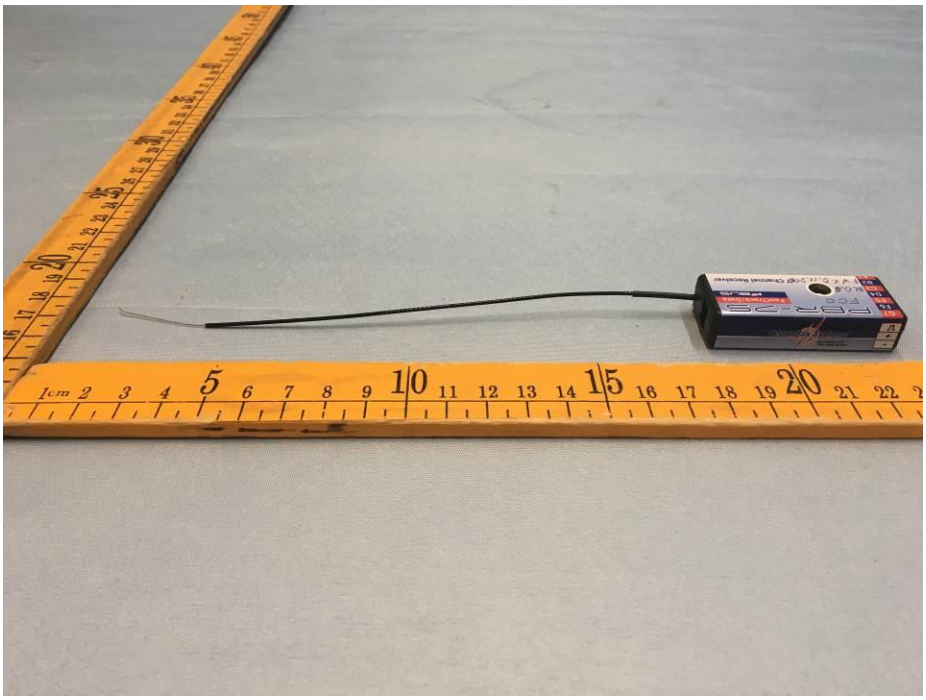


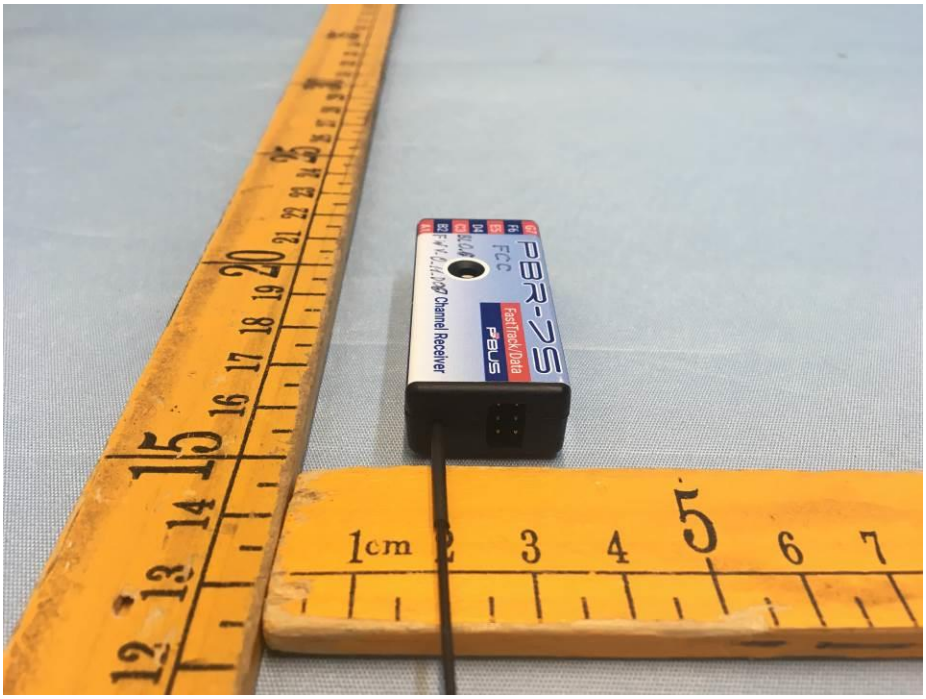
18 Photographs - Constructional Details

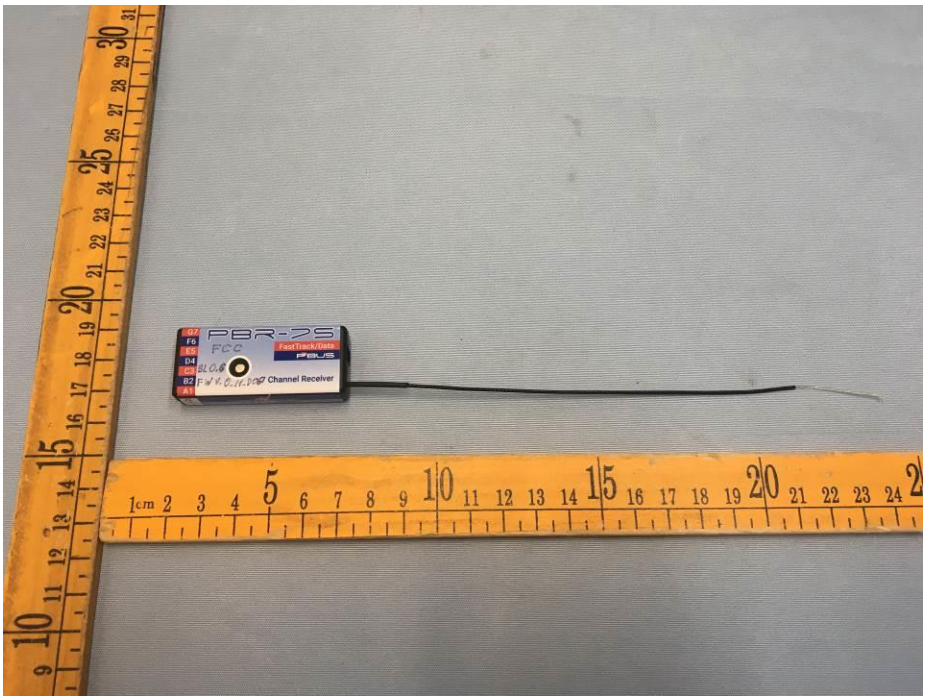
18.1 EUT - External View

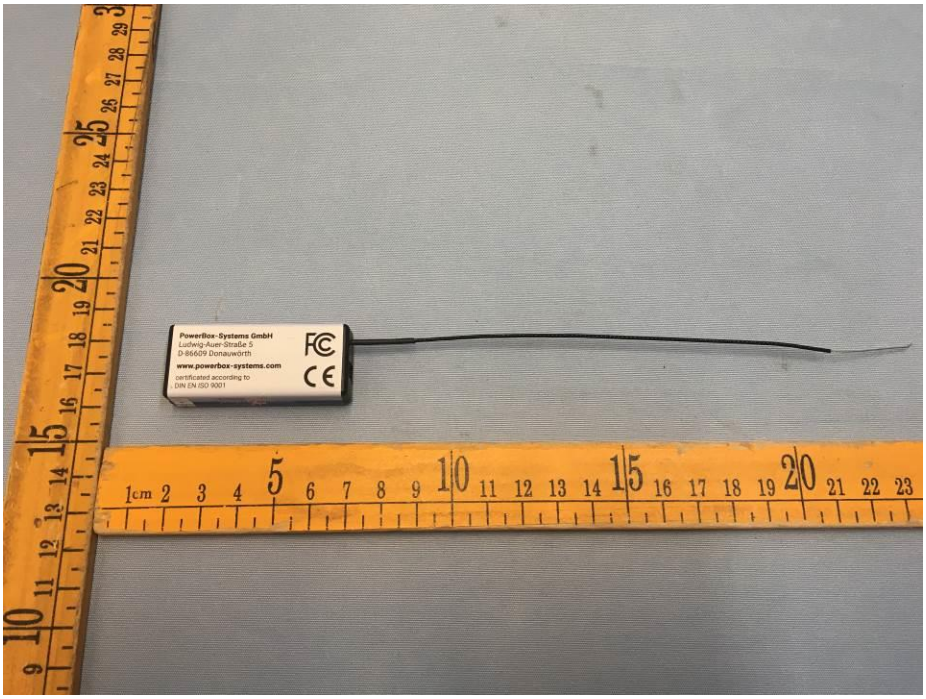




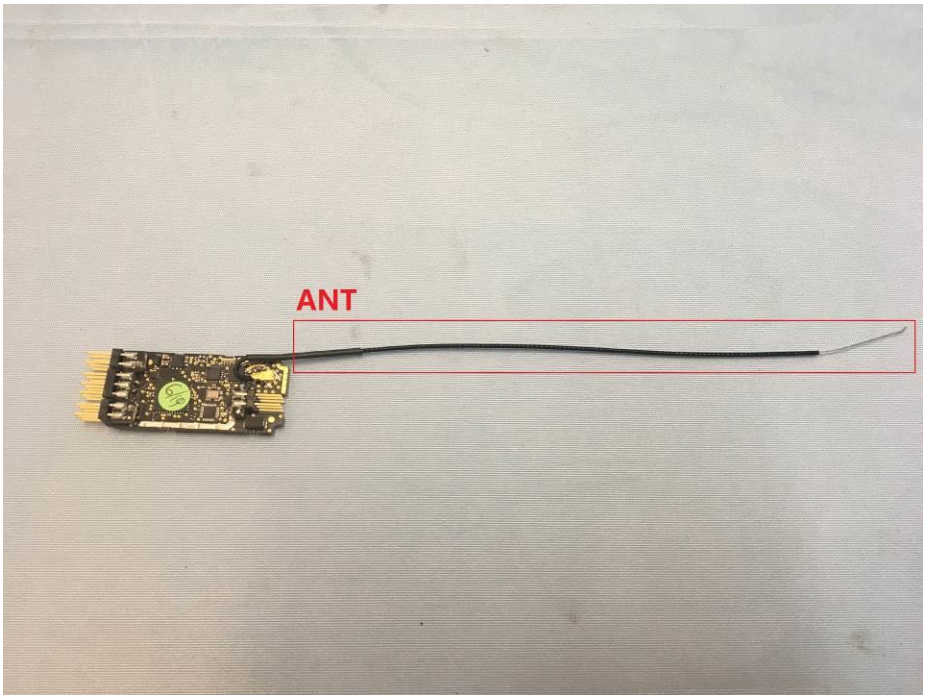


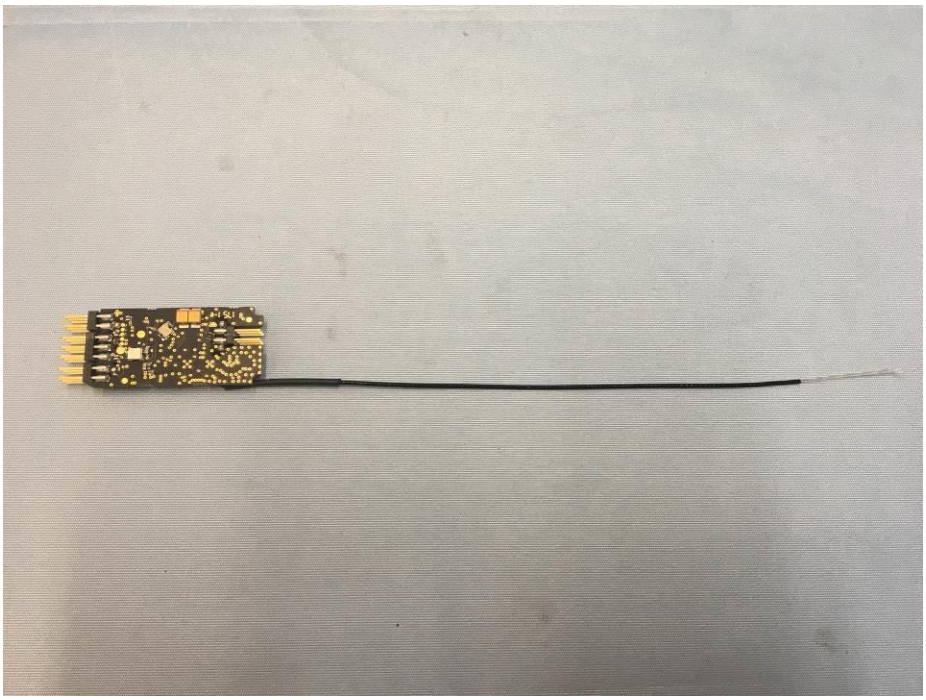

PBR-75
FCC
Fast Ack/Data
PBUS
Channel Receiver

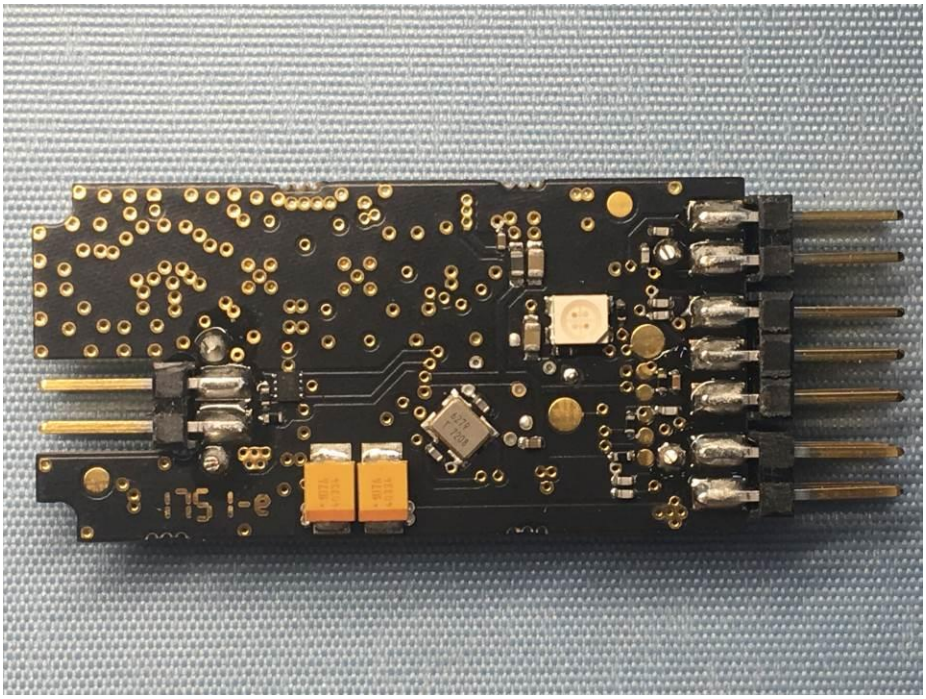

PBR-75
FCC
FastTrack/Data
PBUS
Channel Receiver

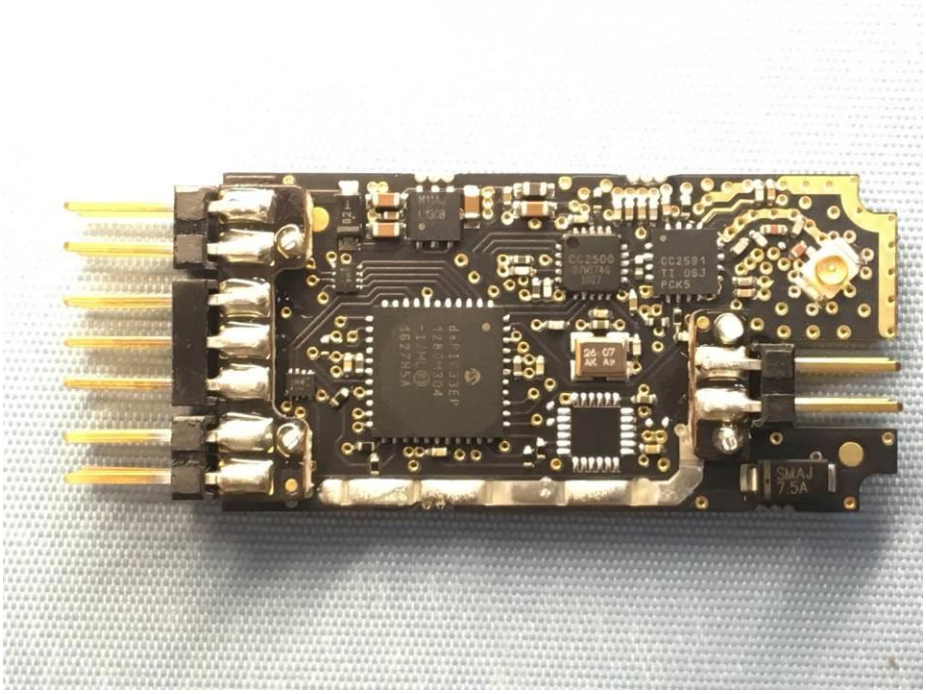

PowerBox-Systems GmbH
Ludwig-Auer-Straße 5
D-86609 Donauwörth
www.powerbox-systems.com
certificated according to
DIN EN ISO 9001
FC
CE

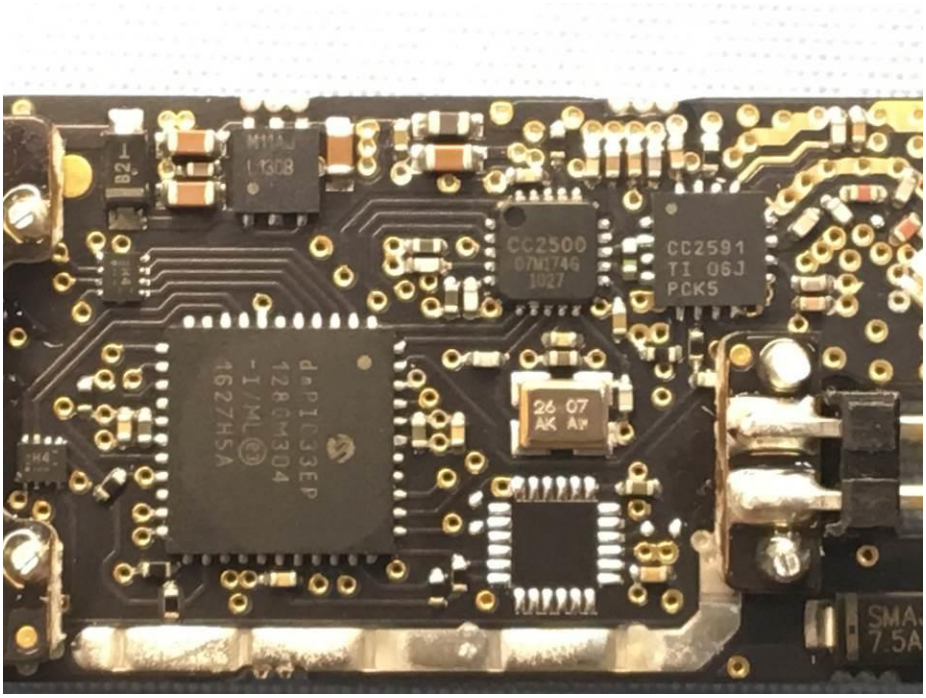
18.2 EUT - Internal View











======End of Report======