

FCC&IC TEST REPORT for DTS Device (2.4G Band) No. 160200788SHA-001

Applicant : TELE RADIO AB
Datavägen 21, SE-436 32 Askim, Sweden

Manufacturer : TELE RADIO AB
Datavägen 21, SE-436 32 Askim, Sweden

Product Name : Transceiver radio modular

Type/Model : CL-TR600-1, D00005-15, D5-15

TEST RESULT : PASS

SUMMARY

The equipment complies with the requirements according to the following standard(s):

47CFR Part 15 (2015): Radio Frequency Devices

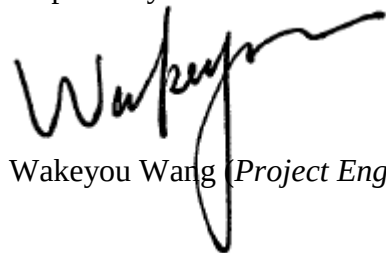
RSS-247 (Issue 1, 2015): Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

RSS-Gen Issue 4 (November 2014): General Requirements and Information for the Certification of Radiocommunication Equipment

ANSI C63.10 (2013): American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

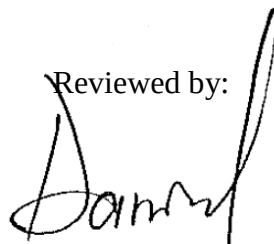
Date of issue: March 4, 2016

Prepared by:



Wakeyou Wang (Project Engineer)

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1. General Information

1.1 Applicant Information

Applicant: TELE RADIO AB
Datavägen 21, SE-436 32 Askim, Sweden

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Manufacturer: TELE RADIO AB
Datavägen 21, SE-436 32 Askim, Sweden

Sample received date : Feb 5, 2016

Sample Identification No : /

Date of test : Feb 5, 2016 ~ Feb 28, 2016

1.2 Identification of the EUT

Equipment: Transceiver radio modular

Type/model for FCC: CL-TR600-1, D00005-15, D5-15

FCC ID: ONFC1602A

IC: 4807A-C1602A

1.3 Technical specification

Frequency Range:	2405 - 2480 MHz
Modulation:	O-QPSK
Gain of Antenna:	Antenna 1 & 3: Chip antenna, 4.0dBi max; Antenna 2: External omni antenna, 3.0dBi max
Rating:	3-5.5VDC
Description of EUT:	There are three models. They are electrically identical except for different model names. Therefore, the model D00005-15 was chosen to perform test as representative.

Channel Description:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
11	2405	19	2445
12	2410	20	2450
13	2415	21	2455
14	2420	22	2460
15	2425	23	2465
16	2430	24	2470
17	2435	25	2475
18	2440	26	2480

1.4 Mode of operation during the test / Test peripherals used

While testing transmitting mode of EUT, the internal modulation and continuously transmission was applied. The EUT was tested together with the host device (Product name: transceiver; Model: R21-91).

The L, M and H channels were tested as representatives (2405MHz, 2440MHz and 2480MHz).

The EUT contains 3 antennas. Antenna 1 and 2 share the same Antenna port. Therefore, for RF conducted test, antenna 1 and 3 are tested as representative. For radiated emission test, Each antenna is assessed individually.

The EUT doesn't support simultaneously transmission. No combination emission is assessed.

Test peripheral: DC power supply manufactured by Chroma, model 62024P-100-50;
Laptop X201i manufactured by Lenovo

The EUT is powered by DC power supply. It was confirmed the RF output power of the EUT kept identical while the input voltage is adjusted from 3V to 5.5 V.

FCC ID: ONFC1602A
IC: 4807A-C1602A

2. Test Specification

2.1 Instrument list

Equipment	Type	Manu.	Internal no.	Cal. Date	Due date
Test Receiver	ESCS 30	R&S	EC 2107	2015-10-21	2016-10-20
Test Receiver	ESIB 26	R&S	EC 3045	2015-10-20	2016-10-19
A.M.N.	ESH2-Z5	R&S	EC 3119	2016-1-9	2017-1-8
Bilog Antenna	CBL 6112D	TESEQ	EC 4206	2015-4-28	2016-4-27
Horn antenna	HF 906	R&S	EC 3049	2015-4-28	2016-4-27
Pre-amplifier	Pre-amp 18	R&S	EC 3222	2015-4-12	2016-4-11
Semi-anechoic chamber	-	Albatross project	EC 3048	2015-5-12	2016-5-11
High Pass Filter	WHKX 1.0/15G-10SS	Wainwright	EC4297-1	2016-1-8	2017-1-7
Power sensor / Power meter	N1911A/N1921A	Agilent	EC4318	2015-04-12	2016-04-11
Temperature Camber	SETH-E	tayasaf	EC4315	2015-4-9	2016-4-8
Spectrum analyzer	E7402A	Agilent	EC2254	2015-08-16	2016-08-15

2.2 Test Standard

47CFR Part 15 (2015)
RSS-247 (Issue 1, 2015)
RSS-Gen Issue 4 (November 2014)
ANSI C63.10 (2013)
KDB 558074 (V03R03)

2.3 Test Summary

This report applies to tested sample only. This report shall not be reproduced in part without written approval of Intertek Testing Service Shanghai Limited.

TEST ITEM	FCC REFERENCE	IC REFERENCE	RESULT
Minimum 6dB Bandwidth	15.247(a)(2)	RSS-Gen Issue 3 Clause 4.6.1 RSS-210 Issue 8 Annex 8	Pass
Maximum peak output power	15.247(b)	RSS-210 Issue 8 Annex 8	Pass
Power spectrum density	15.247(e)	RSS-210 Issue 8 Annex 8	Pass
Radiated emission	15.205 & 15.209	RSS-210 Issue 8 Clause 2	Pass
Emission outside the frequency band	15.247(d)	RSS-210 Issue 8 Annex 8	Pass
Power line conducted emission	15.207	RSS-Gen Clause 8.8	Pass
Occupied bandwidth	-	RSS-Gen Clause 6.6	Tested

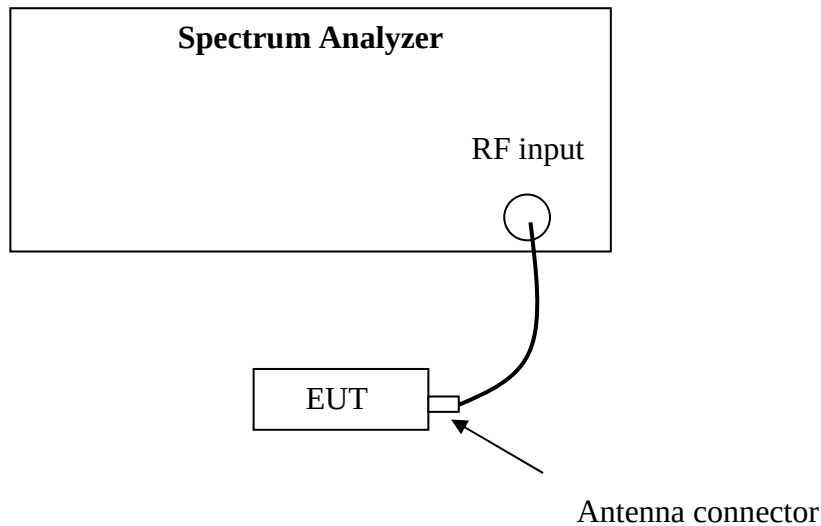
3. Minimum 6dB Bandwidth

Test result: PASS

3.1 Limit

For systems using digital modulation techniques that may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz bands, the minimum 6 dB bandwidth shall be at least 500 kHz.

3.2 Test Configuration



3.3 Test Procedure and test setup

This test is conducted according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r03":

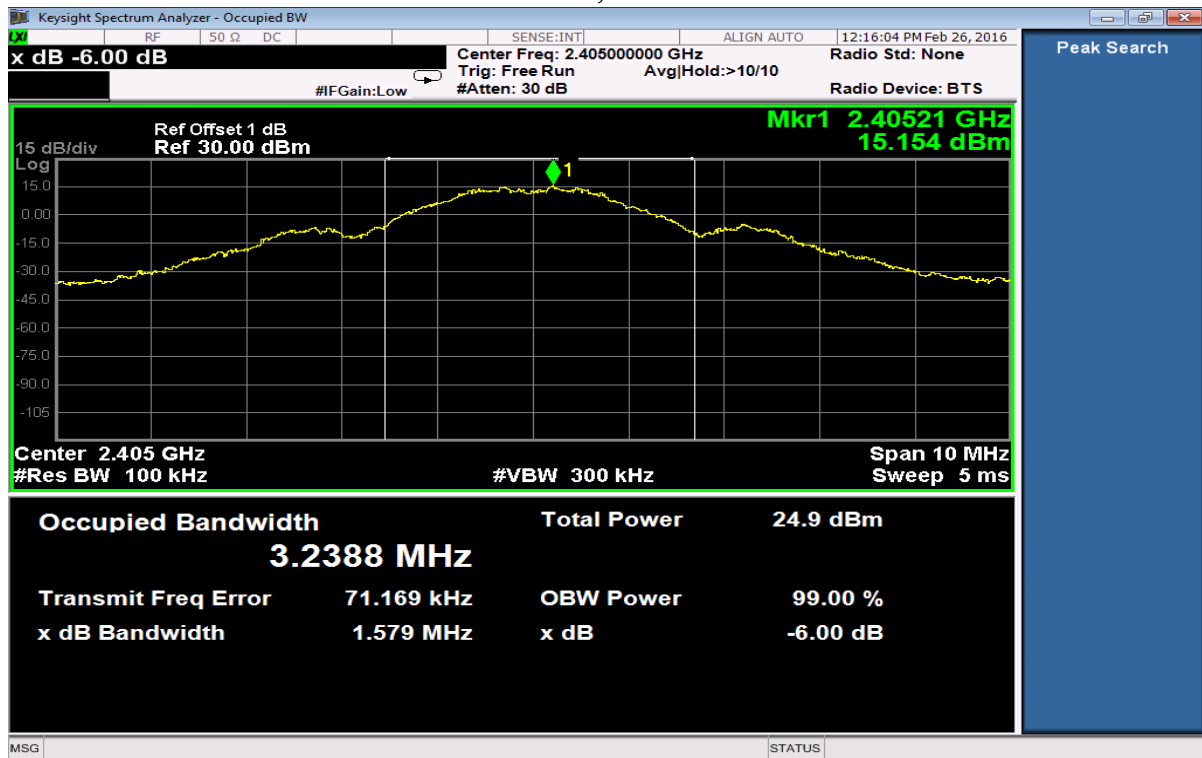
- a) Set RBW = 100 kHz.
- b) Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
- c) Detector = Peak.
- d) Trace mode = max hold.
- e) Sweep = auto couple.
- f) Allow the trace to stabilize.
- g) The automatic bandwidth measurement capability of an instrument is employed using the X dB bandwidth mode with X set to 6 dB.

3.4 Test Protocol

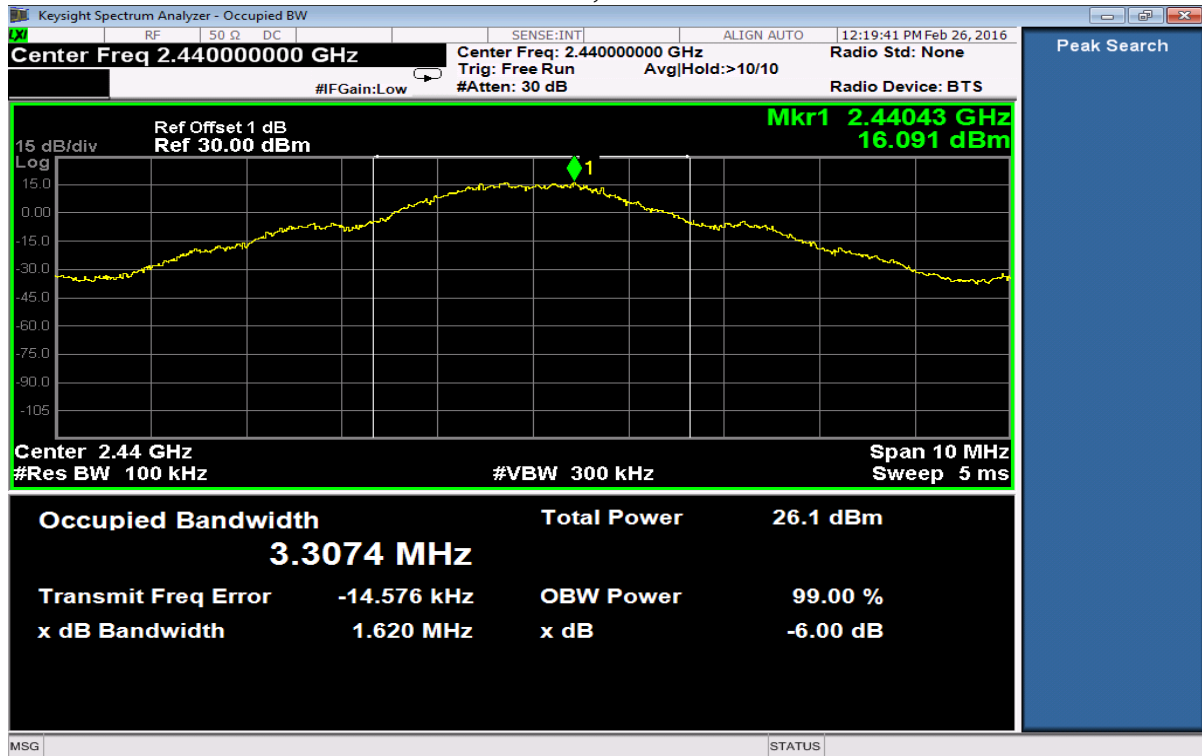
Temperature : 25°C
Relative Humidity : 55%

Antenna	CH	Bandwidth (MHz)	Limit (MHz)
1&2	L	1.58	≥ 0.5
	M	1.62	
	H	1.64	
3	L	1.58	≥ 0.5
	M	1.52	
	H	1.60	

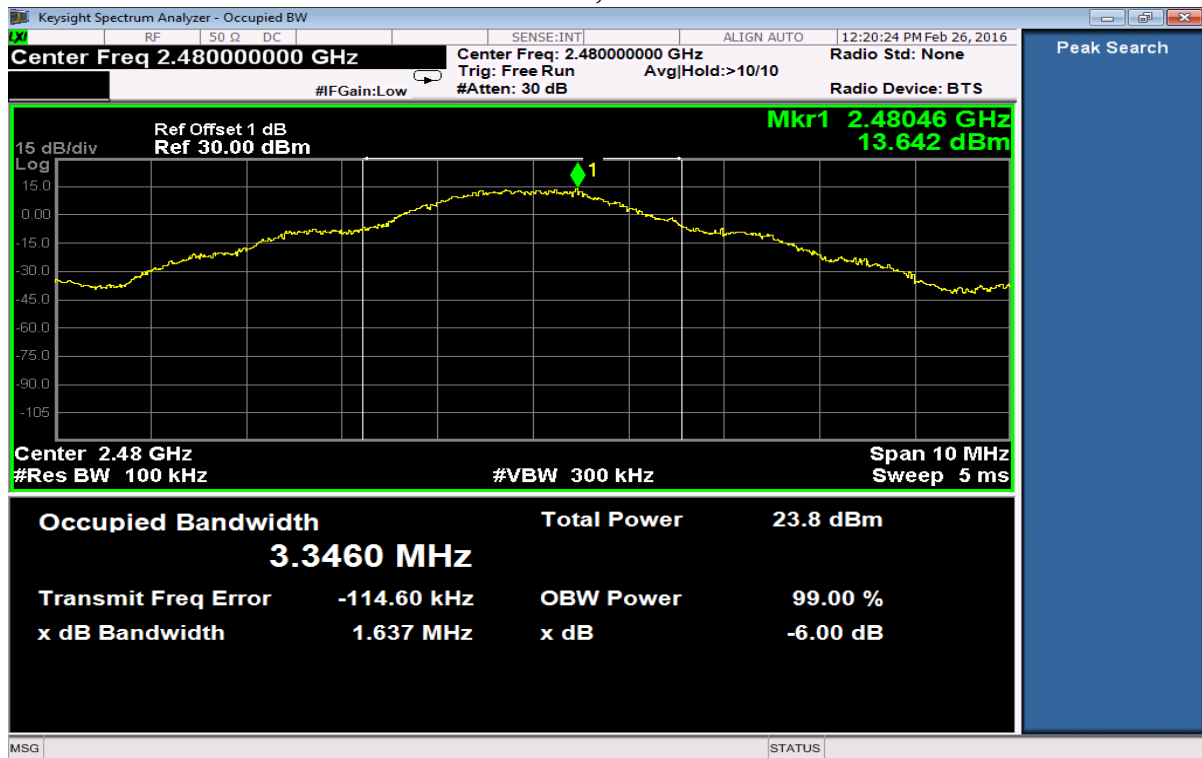
Antenna 1, Channel L



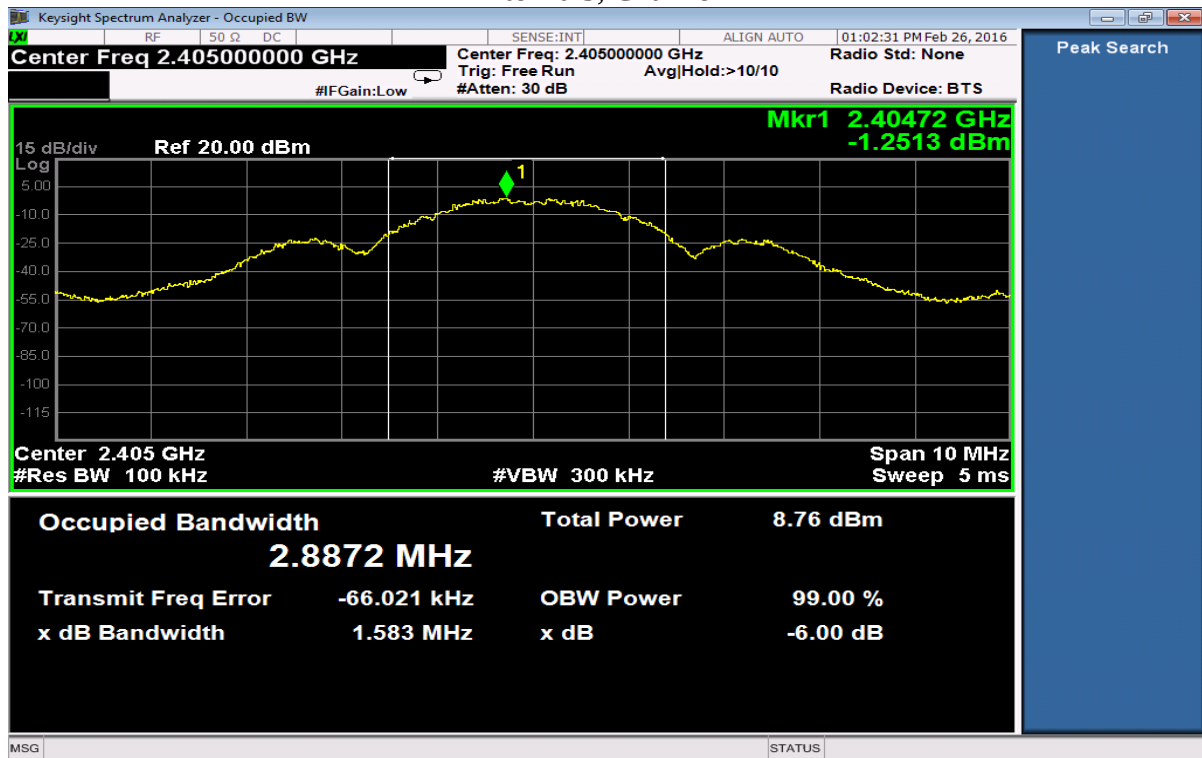
Antenna 1, Channel M



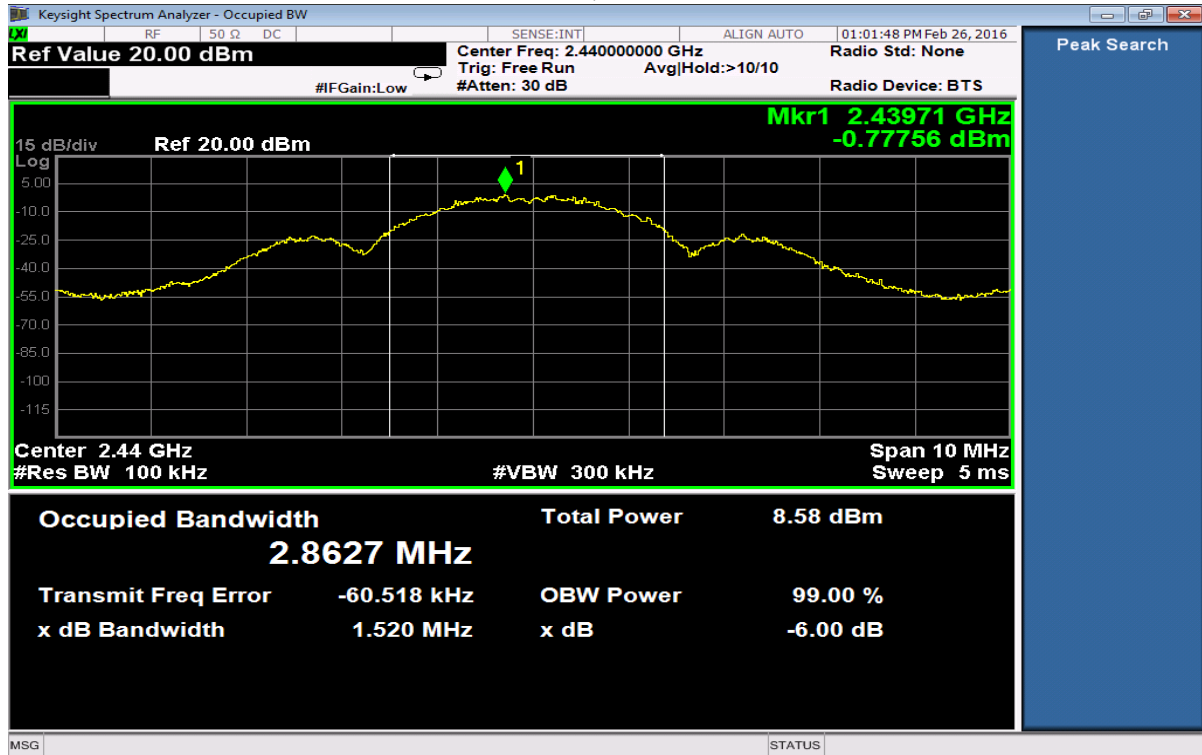
Antenna 1, Channel H



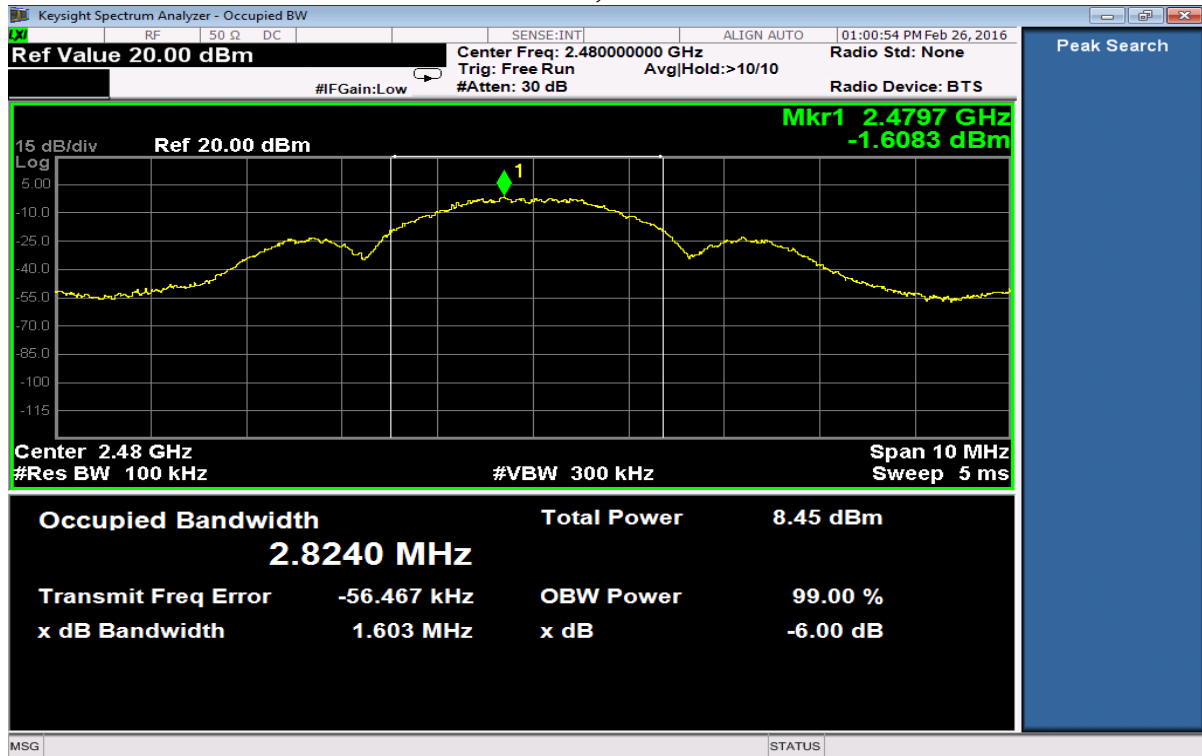
Antenna 3, Channel L



Antenna 3, Channel M



Antenna 3, Channel H



4. Maximum peak output power

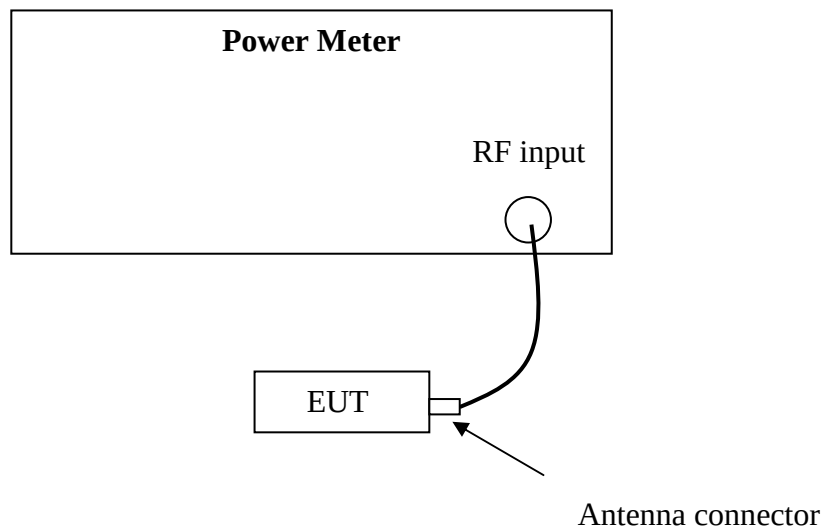
Test result: Pass

4.1 Test limit

- ☐ For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt
- ☐ For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts
- ☒ For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

If the transmitting antenna of directional gain greater than 6dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

4.2 Test Configuration



4.3 Test procedure and test setup

This test is conducted according to DTS test procedure of "KDB558074 D01 DTS Meas Guidance v03r03":

PKPM1 Peak power meter method: The maximum peak conducted output power is measured using a broadband peak RF power meter.

4.4 Test protocol

Temperature : 25 °C
Relative Humidity : 55 %

Antenna	CH	Conducted Power (dBm)	Limit (dBm)
1 & 2	L	25.10	≤30
	M	26.20	
	H	23.90	
3	L	8.90	
	M	8.70	
	H	8.50	

Maximum EIRP = 26.20dBm + 4.0dBi = 30.20dBm < IC EIRP limit of 36dBm

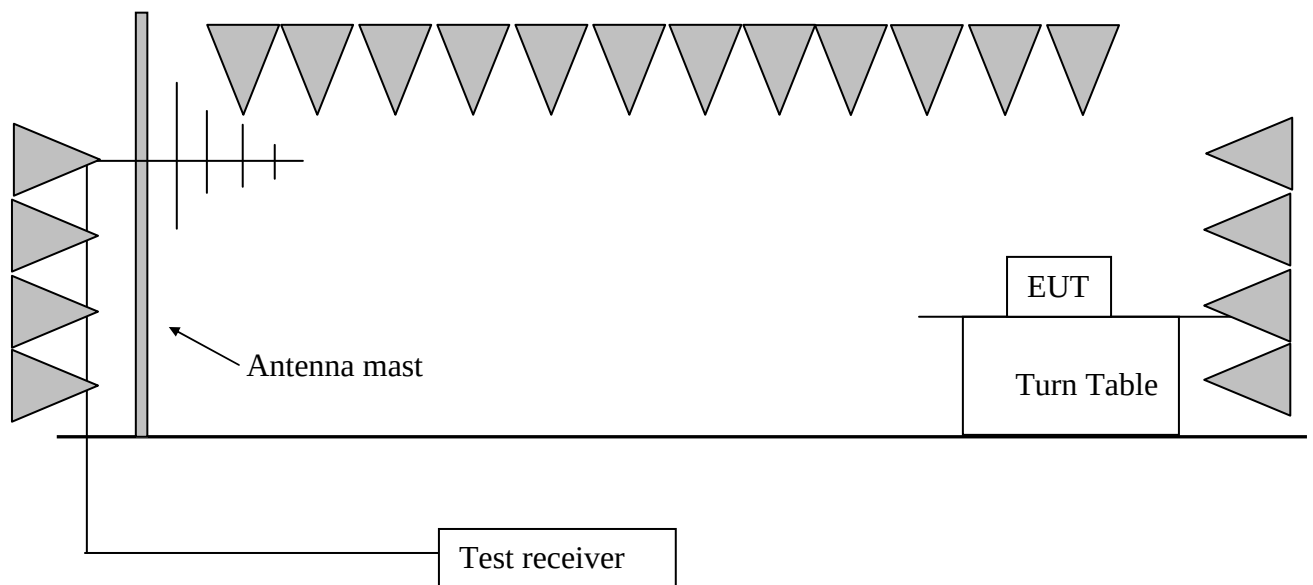
5. Power spectrum density

Test result: Pass

5.1 Test limit

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

5.2 Test Configuration



5.3 Test procedure and test setup

This test is conducted according to DTS test procedure of “KDB558074 D01 DTS Meas Guidance v03r03”:

- Set analyzer center frequency to DTS channel center frequency.
- Set the span to 1.5 times the DTS bandwidth.
- Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- Set the VBW $\geq 3 \times \text{RBW}$.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum amplitude level within the RBW.
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

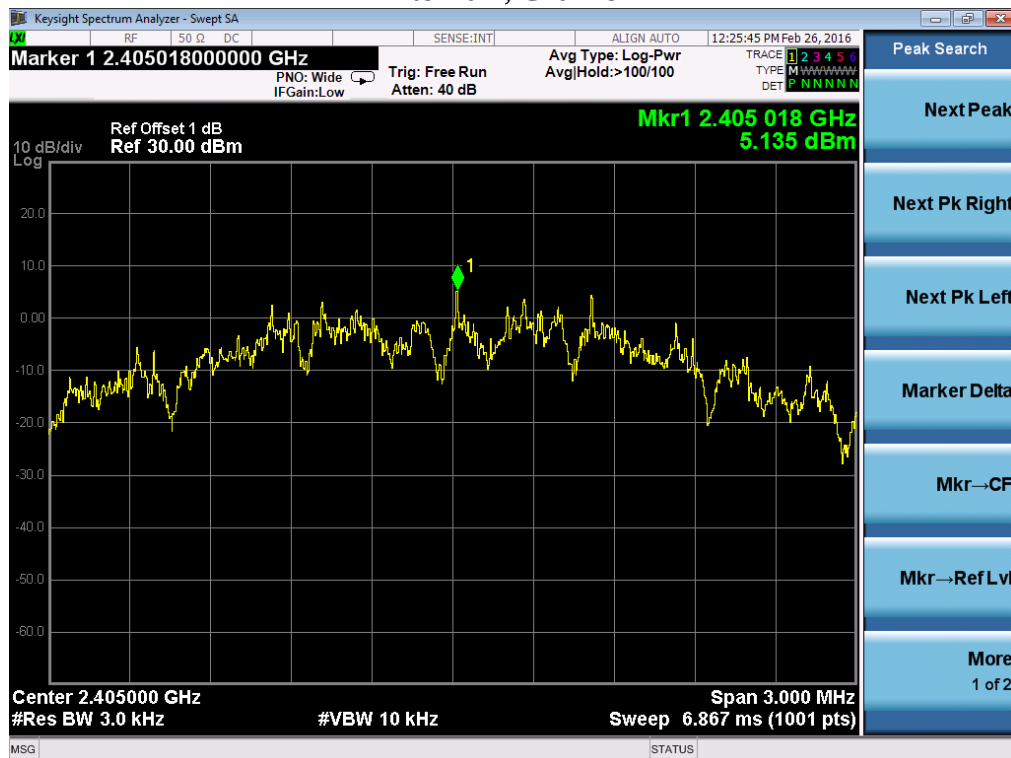
5.4 Test Protocol

Temperature : 25 °C

Relative Humidity: 55 %

Antenna	CH	Original Reading (dBm/3kHz)	Limit (dBm/3kHz)
1&2	L	5.14	≤8.00
	M	6.49	
	H	4.75	
3	L	-10.31	
	M	-10.35	
	H	-11.23	

Antenna 1, Channel L



Antenna 1, Channel M



Antenna 1, Channel H



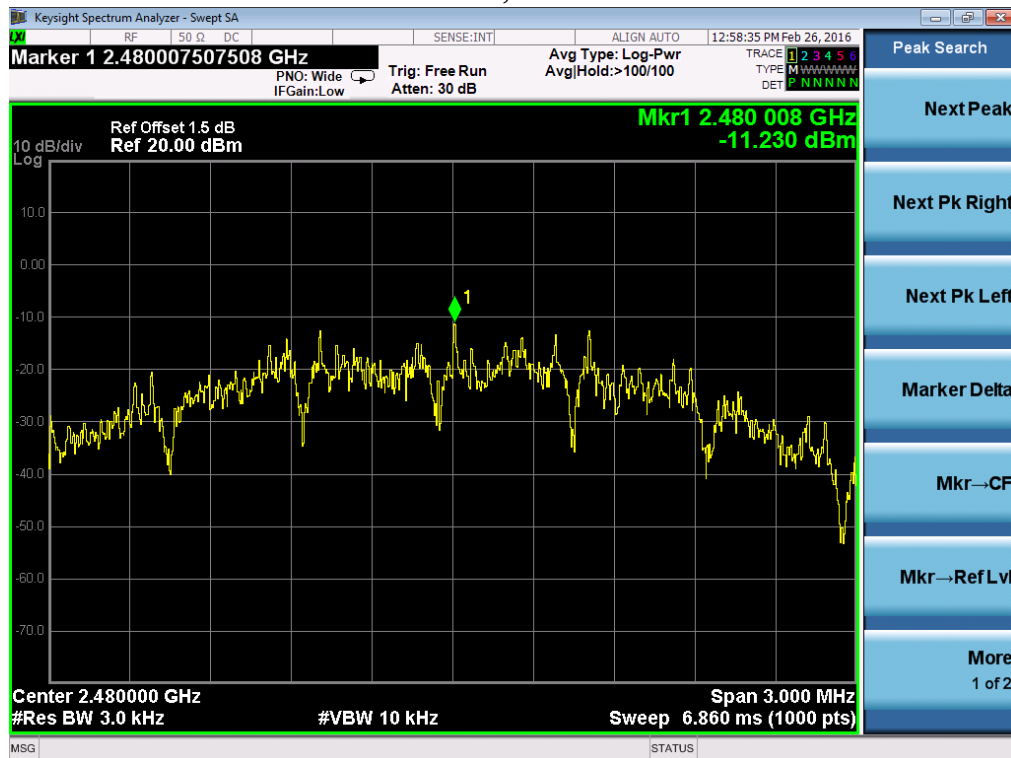
Antenna 3, Channel L



Antenna 3, Channel M



Antenna 3, Channel H



6. Radiated emission

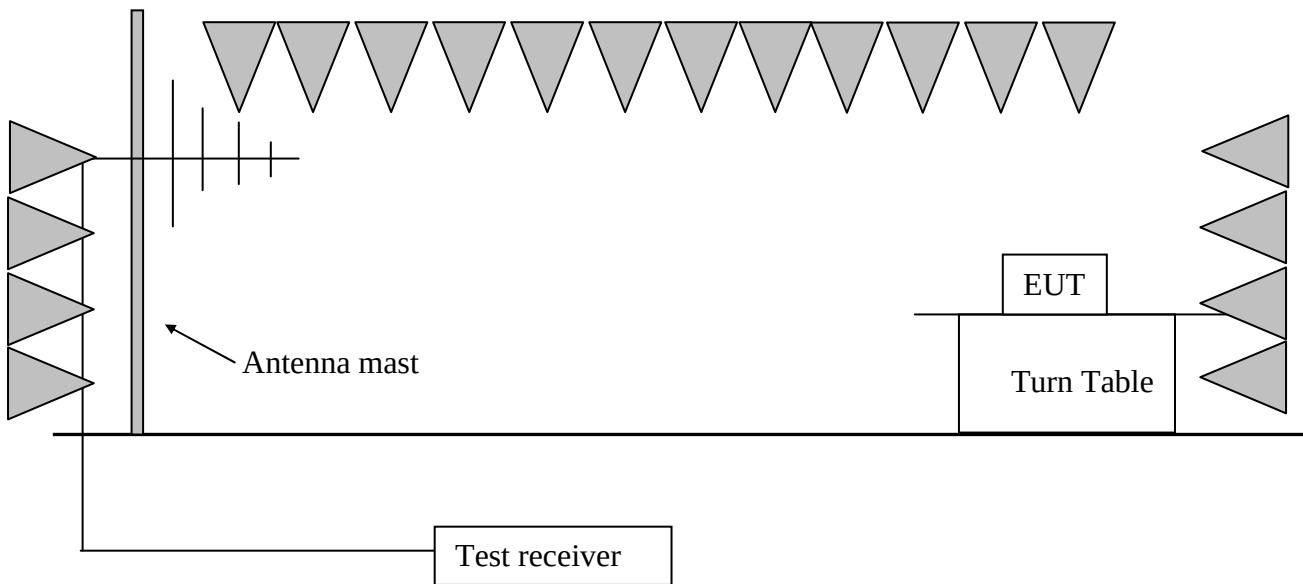
Test result: **PASS**

6.1 Test limit

The 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) showed as below:

Frequency (MHz)	Field Strength (dBuV/m)	Measurement Distance (m)
30 - 88	40.0	3
88 - 216	43.5	3
216 - 960	46.0	3
Above 960	54.0	3

6.2 Test Configuration



6.3 Test procedure and test setup

The measurement was applied in a semi-anechoic chamber. While testing for spurious emission higher than 1GHz, if applied, the pre-amplifier would be equipped just at the output terminal of the antenna.

The EUT and simulators were placed on a 0.8m high wooden turntable above the horizontal metal ground plane. The turn table rotated 360 degrees to determine the position of the maximum emission level. The EUT was set 3 meters away from the receiving antenna which was mounted on an antenna mast. The antenna moved up and down between from 1meter to 4 meters to find out the maximum emission level.

The EUT was tested according to DTS test procedure of KDB558074 D01 DTS “Meas Guidance v03r03” for compliance to FCC 47CFR 15.247 requirements.

6.4 Test protocol

Antenna 1

CH	Polarization	Frequency (MHz)	Correct Factor (dB/m)	Corrected Reading (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
L	V	2405.03	34.30	110.80	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK
	V	2390.00	34.30	62.10	74.00	11.90	PK
	V	2390.00	34.30	50.60	54.00	3.40	AV
	V	4809.61	-3.50	62.40	74.00	11.60	PK
	V	4809.61	-3.50	35.20	54.00	18.80	AV
	V	7208.42	2.00	62.10	74.00	11.90	PK
	V	7208.42	2.00	32.20	54.00	21.80	AV
	V	9621.24	4.90	52.00	54.00	2.00	PK
M	V	2440.16	34.50	111.60	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK
	H	4885.73	-3.30	63.40	74.00	10.60	PK
	H	4885.73	-3.30	36.00	54.00	18.00	AV
	H	7322.65	2.60	62.50	74.00	11.50	PK
	H	7322.65	2.60	32.80	54.00	21.20	AV
	V	9805.17	4.80	52.50	54.00	1.50	PK
H	V	2479.68	34.60	108.50	Fundamental	/	PK
	H	90.26	12.10	22.30	43.50	21.20	PK
	V	107.75	15.40	28.70	43.50	14.80	PK

	V	479.03	20.10	25.70	46.00	20.30	PK
	H	690.92	22.60	28.60	46.00	17.40	PK
	V	2483.50	34.60	73.20	74.00	0.80	PK
	V	2483.50	34.60	49.90	54.00	4.10	AV
	V	4949.90	-3.20	57.90	74.00	16.10	PK
	V	4949.90	-3.20	32.10	54.00	21.90	AV
	V	7446.89	2.70	65.10	74.00	8.90	PK
	V	7446.89	2.70	38.50	54.00	15.50	AV
	H	9929.85	5.00	48.60	54.00	5.40	PK

Antenna 2

CH	Polarization	Frequency (MHz)	Correct Factor (dB/m)	Corrected Reading (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
L	V	2405.03	34.30	112.40	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK
	V	2390.00	34.30	61.90	74.00	12.10	PK
	V	2390.00	34.30	50.50	54.00	3.50	AV
	V	4809.61	-3.50	62.70	74.00	11.30	PK
	V	4809.61	-3.50	35.50	54.00	18.50	AV
	V	7208.42	2.00	62.30	74.00	11.70	PK
	V	7208.42	2.00	32.40	54.00	21.60	AV
	V	9621.24	4.90	52.10	54.00	1.90	PK
M	V	2440.16	34.50	113.20	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK

	H	4885.73	-3.30	63.20	74.00	10.80	PK
	H	4885.73	-3.30	35.90	54.00	18.10	AV
	H	7322.65	2.60	62.60	74.00	11.40	PK
	H	7322.65	2.60	33.00	54.00	21.00	AV
	V	9805.17	4.80	52.70	54.00	1.30	PK
H	V	2479.68	34.60	110.60	Fundamental	/	PK
	H	90.26	12.10	22.30	43.50	21.20	PK
	V	107.75	15.40	28.70	43.50	14.80	PK
	V	479.03	20.10	25.70	46.00	20.30	PK
	H	690.92	22.60	28.60	46.00	17.40	PK
	V	2483.50	34.60	73.60	74.00	0.40	PK
	V	2483.50	34.60	50.30	54.00	3.70	AV
	V	4949.90	-3.20	57.90	74.00	16.10	PK
	V	4949.90	-3.20	32.10	54.00	21.90	AV
	V	7446.89	2.70	65.30	74.00	8.70	PK
	V	7446.89	2.70	38.70	54.00	15.30	AV
	H	9929.85	5.00	49.00	54.00	5.00	PK

Antenna 3

CH	Polarization	Frequency (MHz)	Correct Factor (dB/m)	Corrected Reading (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
L	V	2405.03	34.30	95.00	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK
	V	2390.00	34.30	61.70	74.00	12.30	PK
	V	2390.00	34.30	50.30	54.00	3.70	AV
	V	4809.61	-3.50	50.10	54.00	3.90	PK

	V	9621.24	4.90	46.30	54.00	7.70	PK
M	V	2440.16	34.50	95.20	Fundamental	/	PK
	V	66.93	7.90	35.20	40.00	4.80	PK
	H	96.09	12.10	34.60	43.50	8.90	PK
	V	107.76	13.60	38.30	43.50	5.20	PK
	H	146.63	13.20	35.80	43.50	7.70	PK
	H	4885.73	-3.30	50.50	54.00	3.50	PK
	V	9805.17	4.80	46.80	54.00	7.20	PK
	V	2480.46	34.60	95.60	Fundamental	/	PK
H	H	90.26	12.10	22.30	43.50	21.20	PK
	V	107.75	15.40	28.70	43.50	14.80	PK
	V	479.03	20.10	25.70	46.00	20.30	PK
	H	690.92	22.60	28.60	46.00	17.40	PK
	V	2483.50	34.60	66.40	74.00	7.60	PK
	V	2483.50	34.60	37.80	54.00	16.20	AV
	V	4949.90	-3.20	50.60	54.00	3.40	PK
	H	9929.85	5.00	46.60	54.00	7.40	PK

Remark: 1. Correct Factor = Antenna Factor + Cable Loss (-Amplifier, is employed)
2. Corrected Reading = Original Receiver Reading + Correct Factor
3. Margin = limit – Corrected Reading
4. If the PK reading is lower than AV limit, the AV test can be elided.
5. For all the frequencies assessed with QP detector, it is found they have pulse-repetition frequency higher than 20 Hz.

Example: Assuming Antenna Factor = 30.20dB/m, Cable Loss = 2.00dB,
Gain of Preamplifier = 32.00dB, Original Receiver Reading = 10dBuV.
Then Correct Factor = 30.20 + 2.00 – 32.00 = 0.20dB/m; Corrected Reading =
10dBuV + 0.20dB/m = 10.20dBuV/m
Assuming limit = 54dBuV/m, Corrected Reading = 10.20dBuV/m, then Margin =
54 -10.20 = 43.80dBuV/m

7. Emission outside the frequency Band

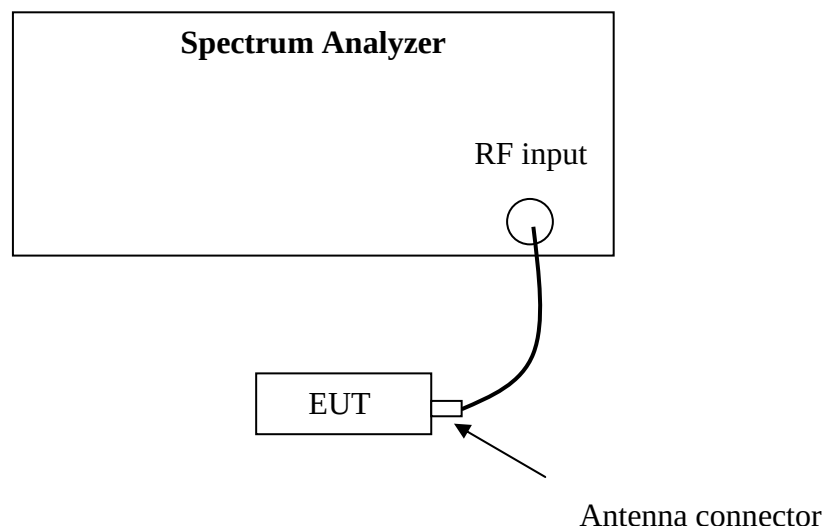
Test result: PASS

7.1 Limit

☒ If the maximum peak conducted output power procedure was used to demonstrate compliance, then the peak output power measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc).

☐ If maximum conducted (average) output power was used to demonstrate compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 30 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 30 dBc).

7.2 Test Configuration



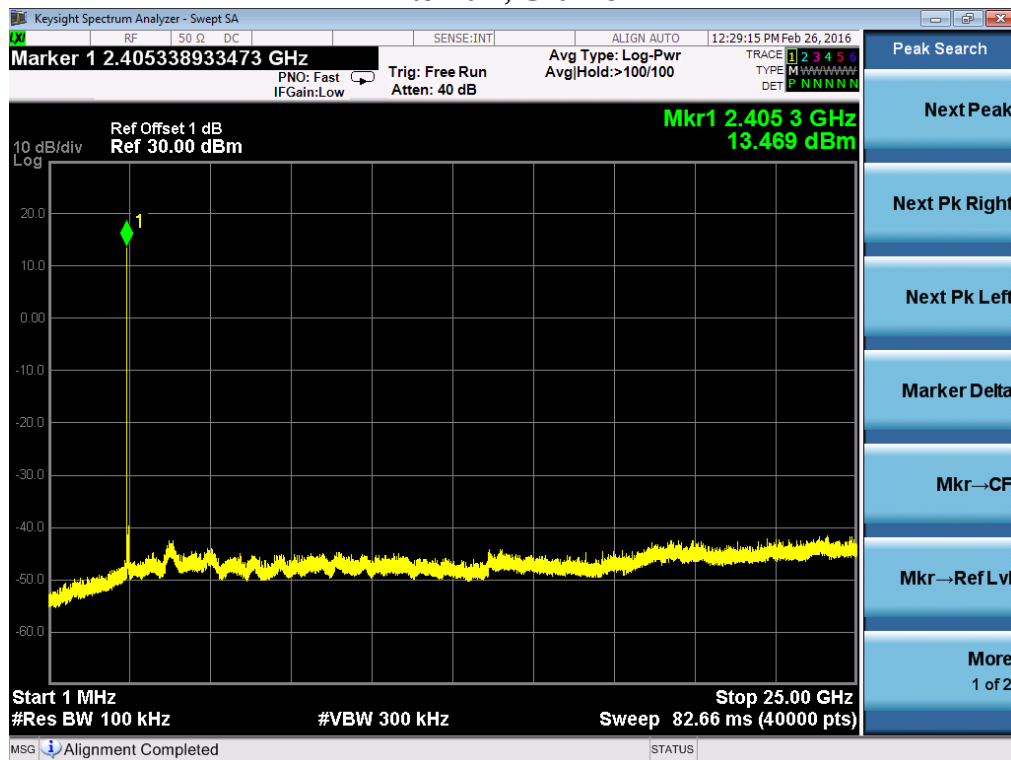
7.3 Test procedure and test setup

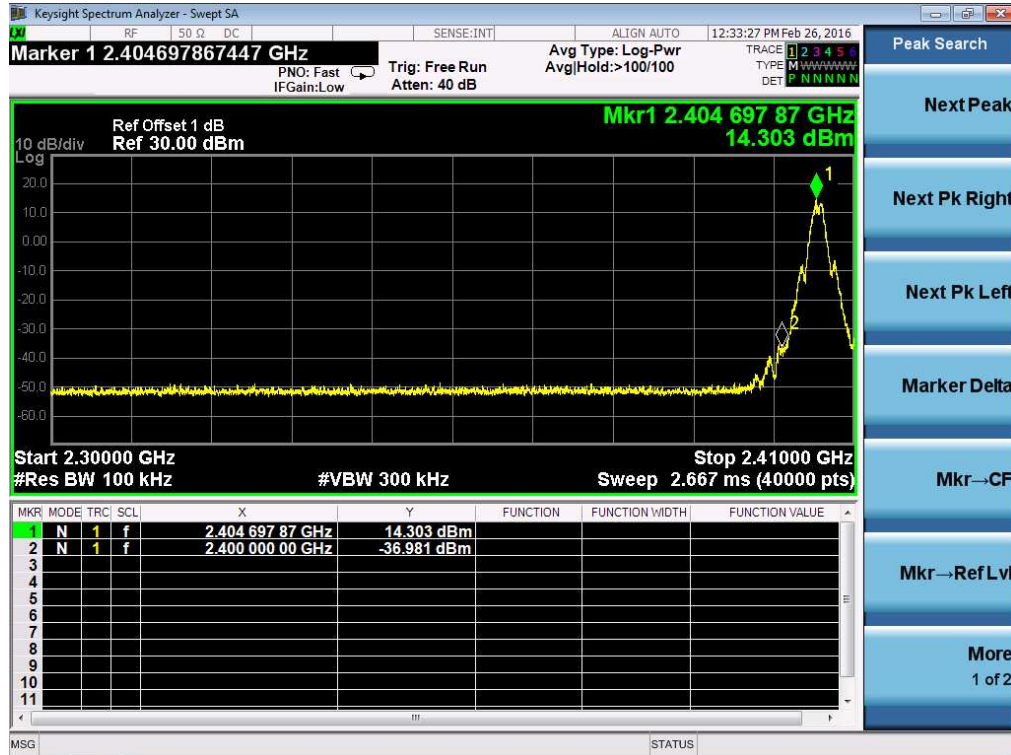
- a) Set the center frequency and span to encompass frequency range to be measured.
- b) Set the RBW = 100 kHz.
- c) Set the VBW $\geq 3 \times$ RBW.
- d) Detector = peak.
- e) Sweep time = auto couple.
- f) Trace mode = max hold.
- g) Allow trace to fully stabilize.
- h) Use the peak marker function to determine the maximum amplitude level.

7.4 Test protocol

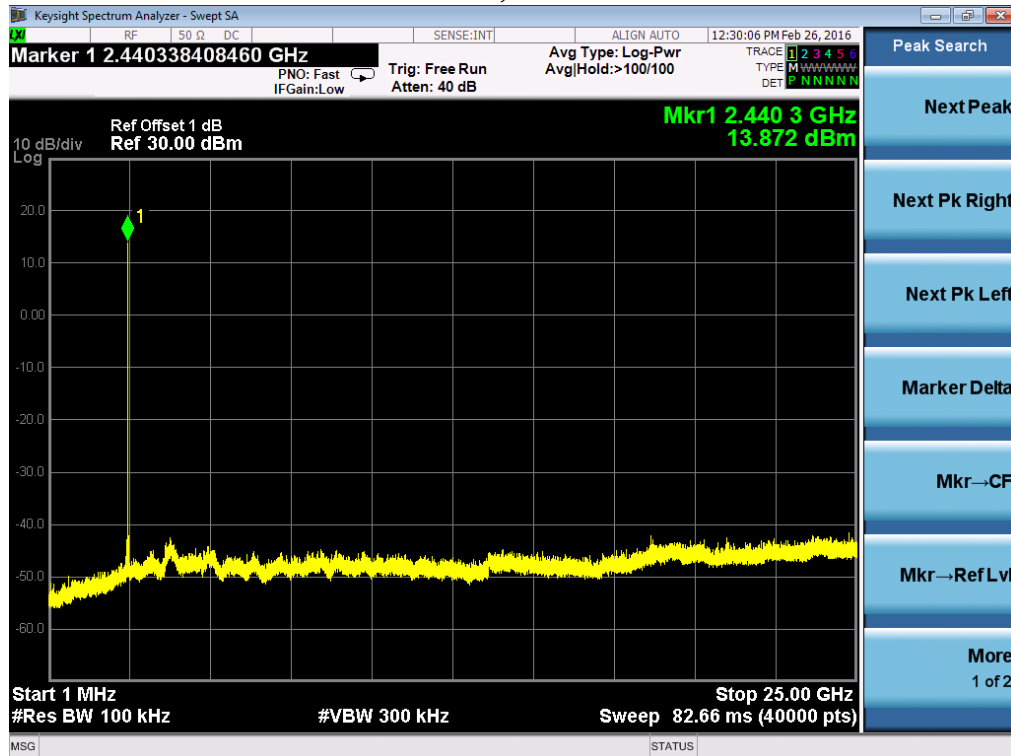
Antenna	CH	Out of band Emission (dB)	Limit (dB)
1&2	L	>20	≥20
	M	>20	
	H	>20	
3	L	>20	
	M	>20	
	H	>20	

Antenna 1, Channel L

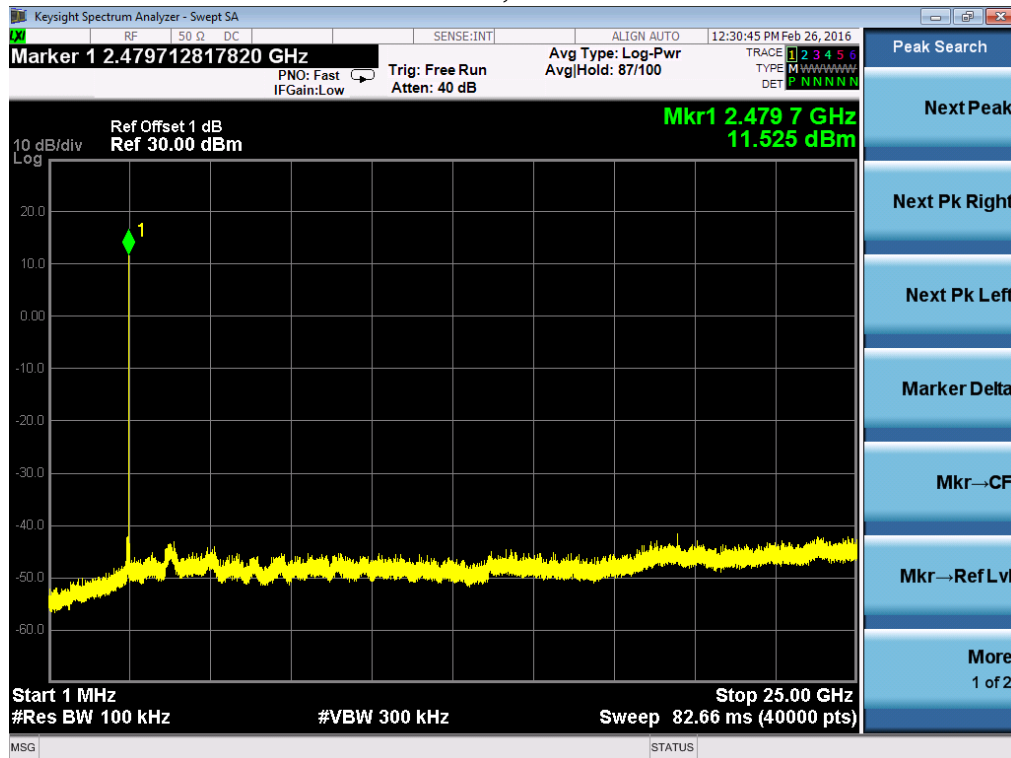




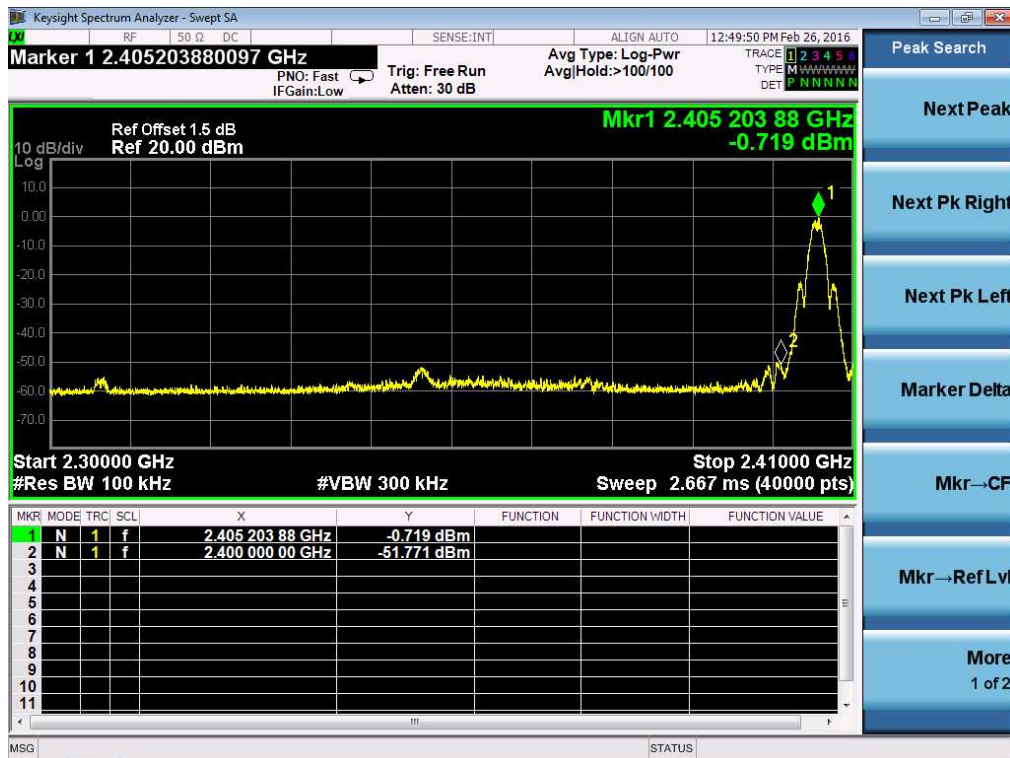
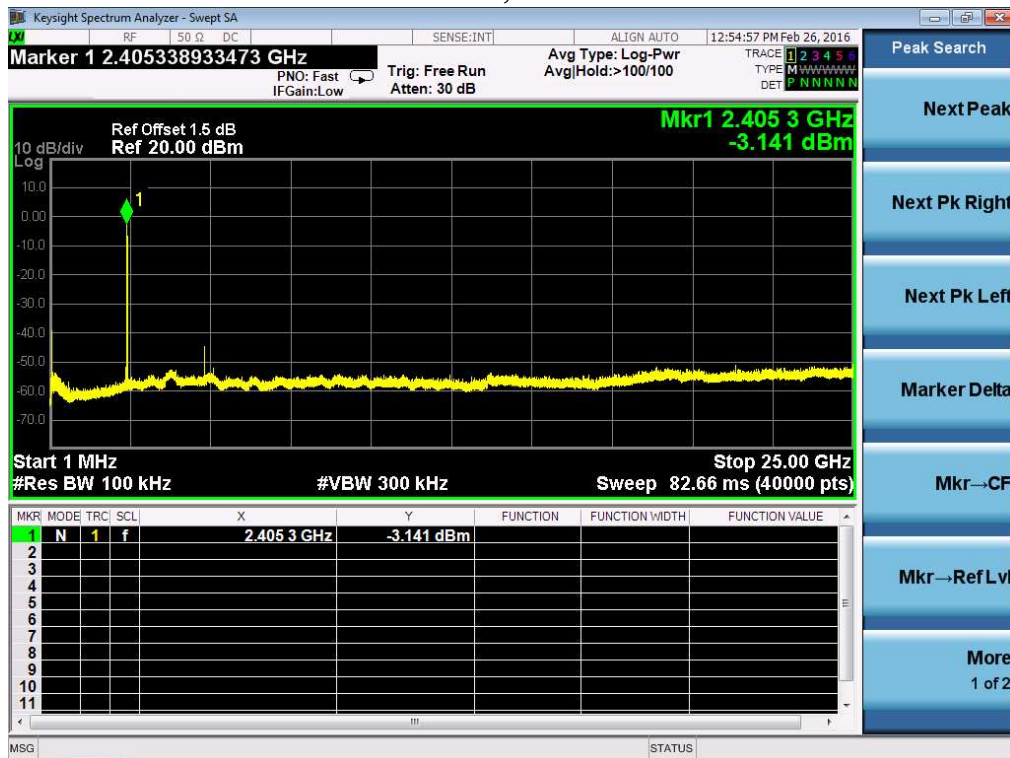
Antenna 1, Channel M



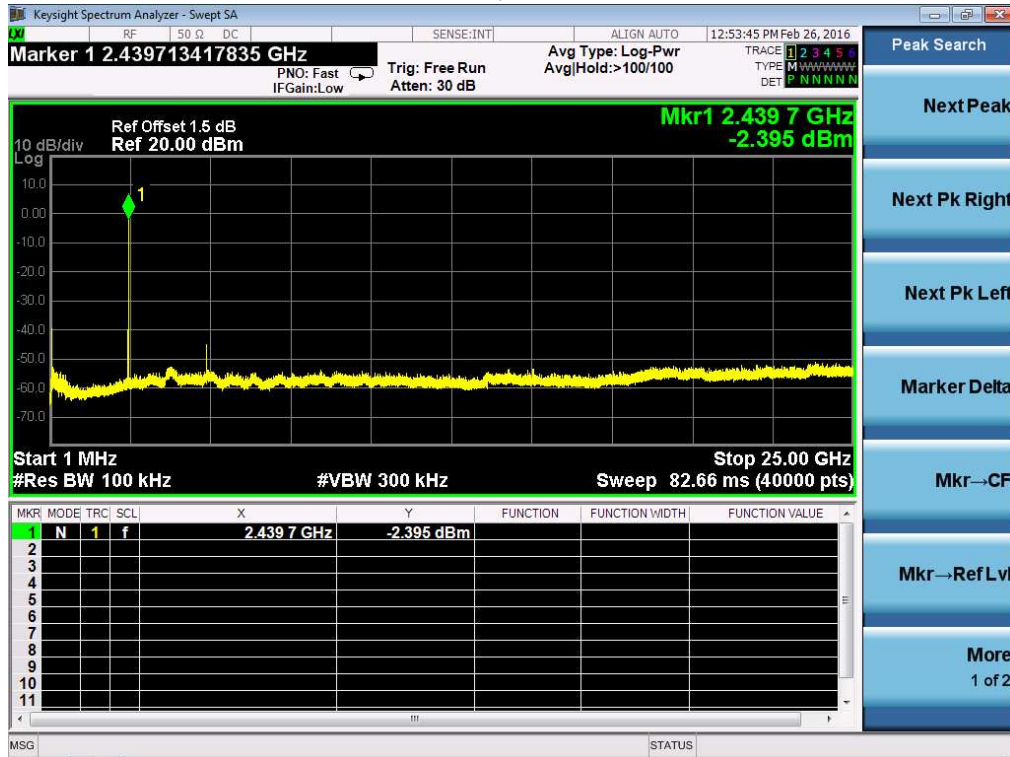
Antenna 1, Channel H



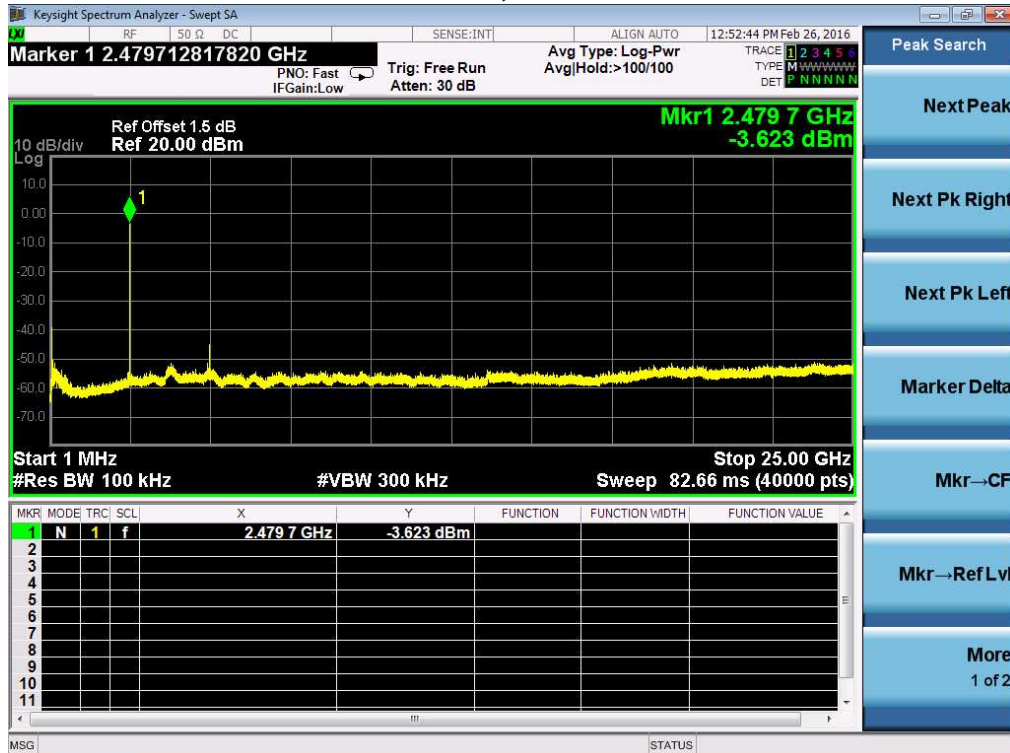
Antenna 3, Channel L



Antenna 3, Channel M



Antenna 3, Channel H





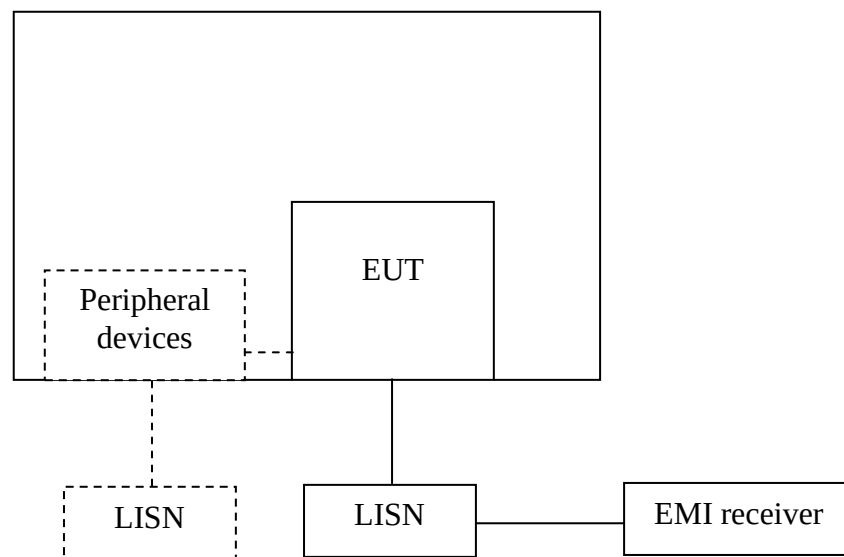
8. Power line conducted emission

Test result: Pass

8.1 Limit

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	QP	AV
0.15-0.5	66 to 56*	56 to 46 *
0.5-5	56	46
5-30	60	50
* Decreases with the logarithm of the frequency.		

8.2 Test configuration



☒ For table top equipment, wooden support is 0.8m height table

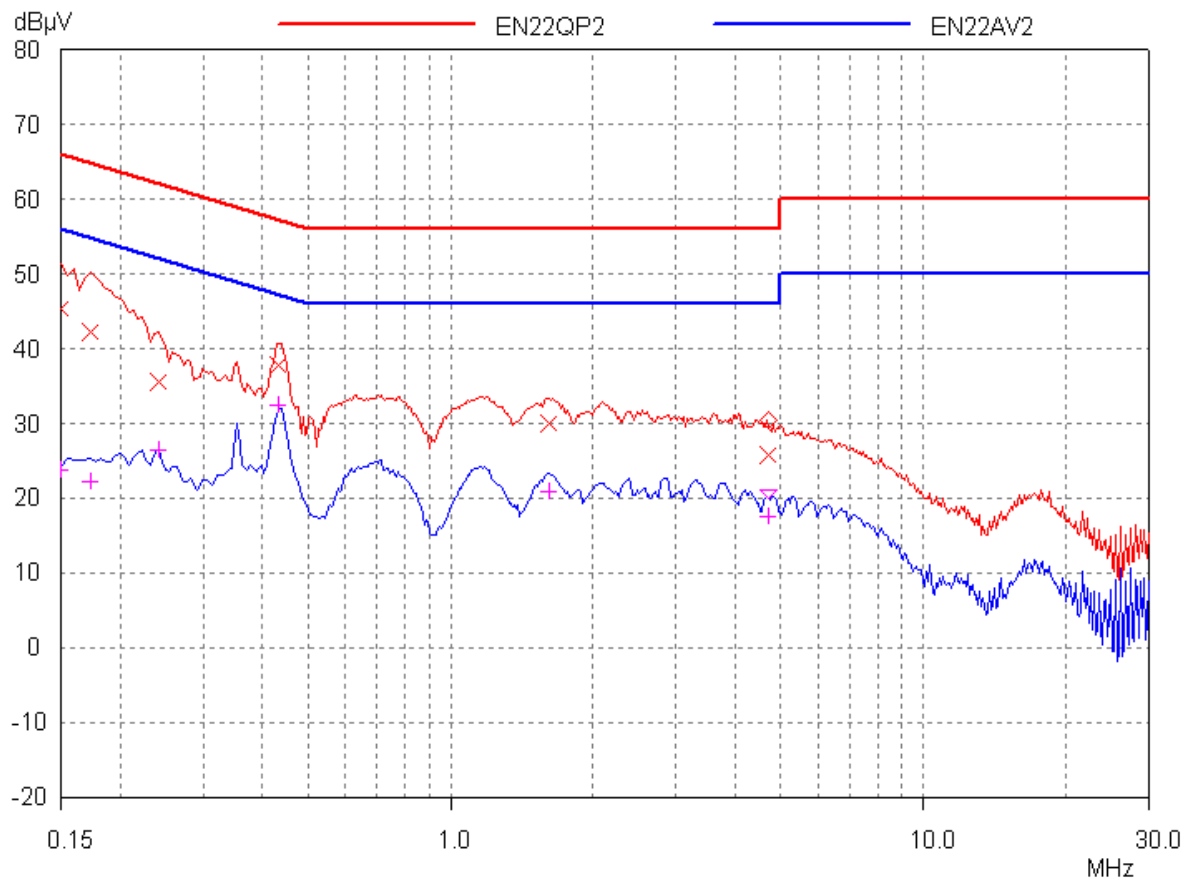
☐ For floor standing equipment, wooden support is 0.1m height rack.

8.3 Test procedure and test set up

The EUT are connected to the main power through a line impedance stabilization network (LISN). This provides a $50\Omega/50\mu\text{H}$ coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a $50\Omega/50\mu\text{H}$ coupling impedance with 50Ω termination.

Both sides (Line and Neutral) of AC line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4 on conducted measurement. The bandwidth of the test receiver is set at 9 kHz.

8.4 Test protocol



Frequency	Correct Factor (dB)	Corrected Reading (dBuV)		Limit (dBuV)		Margin (dB)	
		QP	AV	QP	AV	QP	AV
0.15 (N)	3.00	45.36	23.75	66.00	56.00	20.64	32.25
0.17 (L)	3.00	42.13	22.21	64.84	54.84	22.71	32.63
0.24 (N)	3.00	35.47	26.34	62.10	52.10	26.63	25.76
0.43 (N)	3.00	37.89	32.52	57.19	47.19	19.30	14.67
1.61 (N)	3.00	30.01	20.92	56.00	46.00	25.99	25.08
4.67 (L)	3.00	25.73	17.50	56.00	46.00	30.27	28.50
Remark: 1. Correction Factor (dB) = LISN Factor (dB) + Cable Loss (dB). 2. Margin (dB) = Limit - Corrected Reading.							

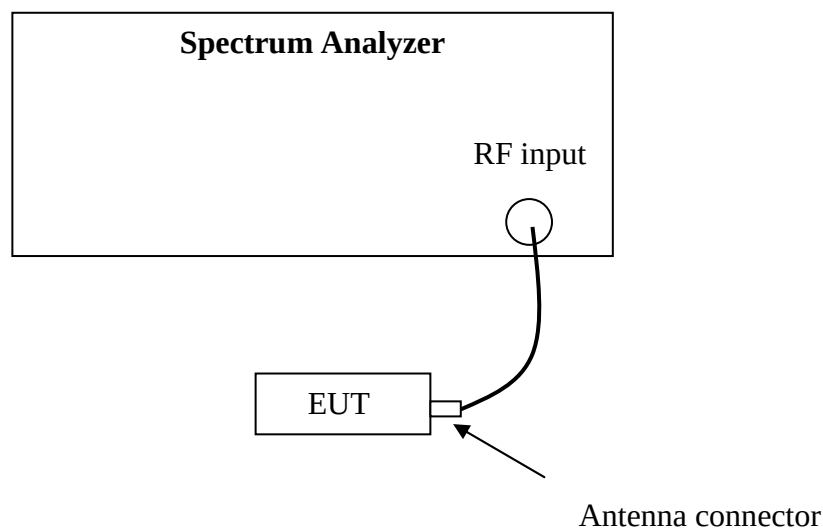
9. Occupied Bandwidth

Test Status: Tested

9.1 Test limit

None

9.2 Test Configuration



9.3 Test procedure and test setup

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

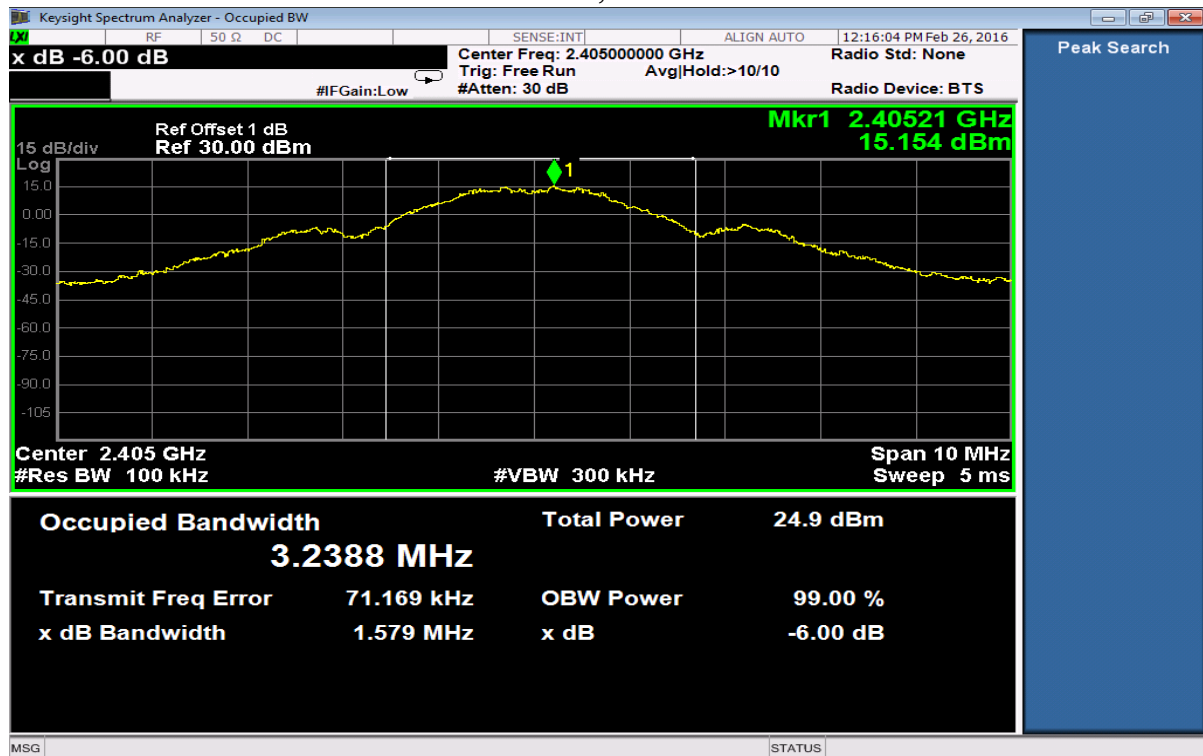
The difference between the two recorded frequencies is the 99% occupied bandwidth.

9.4 Test protocol

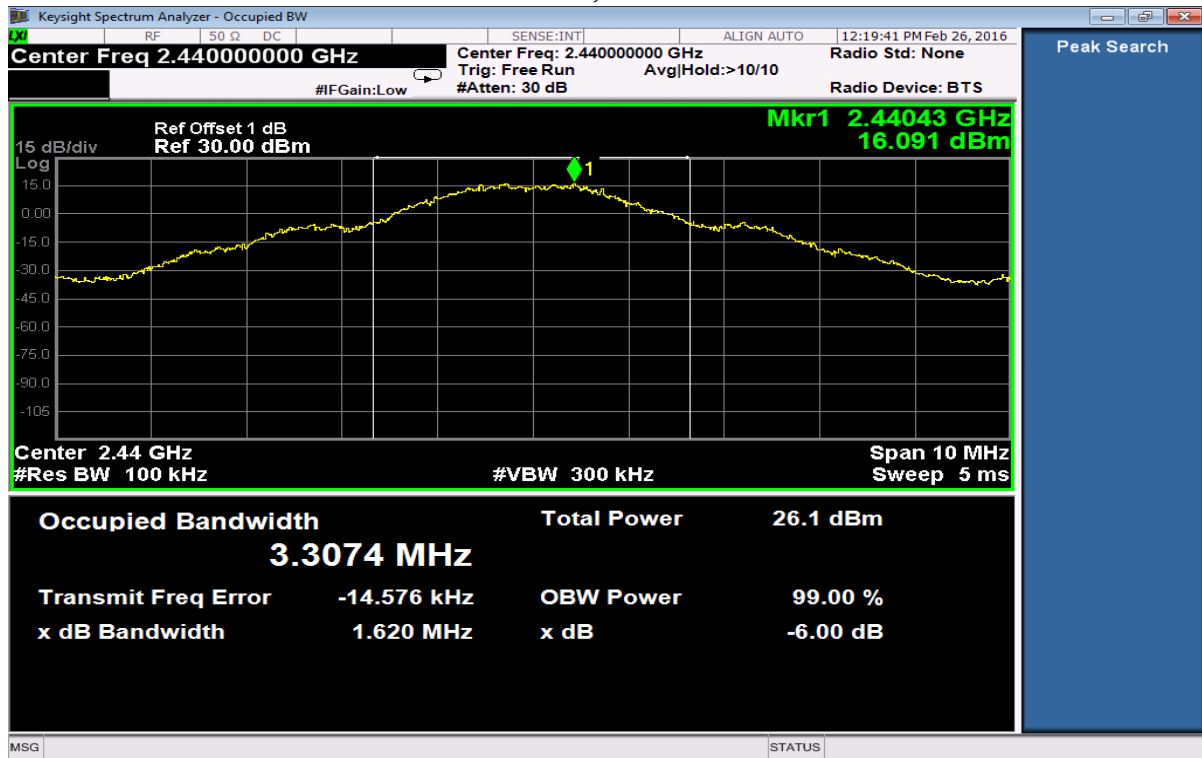
Temperature : 25 °C
Relative Humidity : 55 %

Antenna	CH	99% Bandwidth (MHz)
1&2	L	3.24
	M	3.31
	H	3.35
3	L	2.89
	M	2.86
	H	2.82

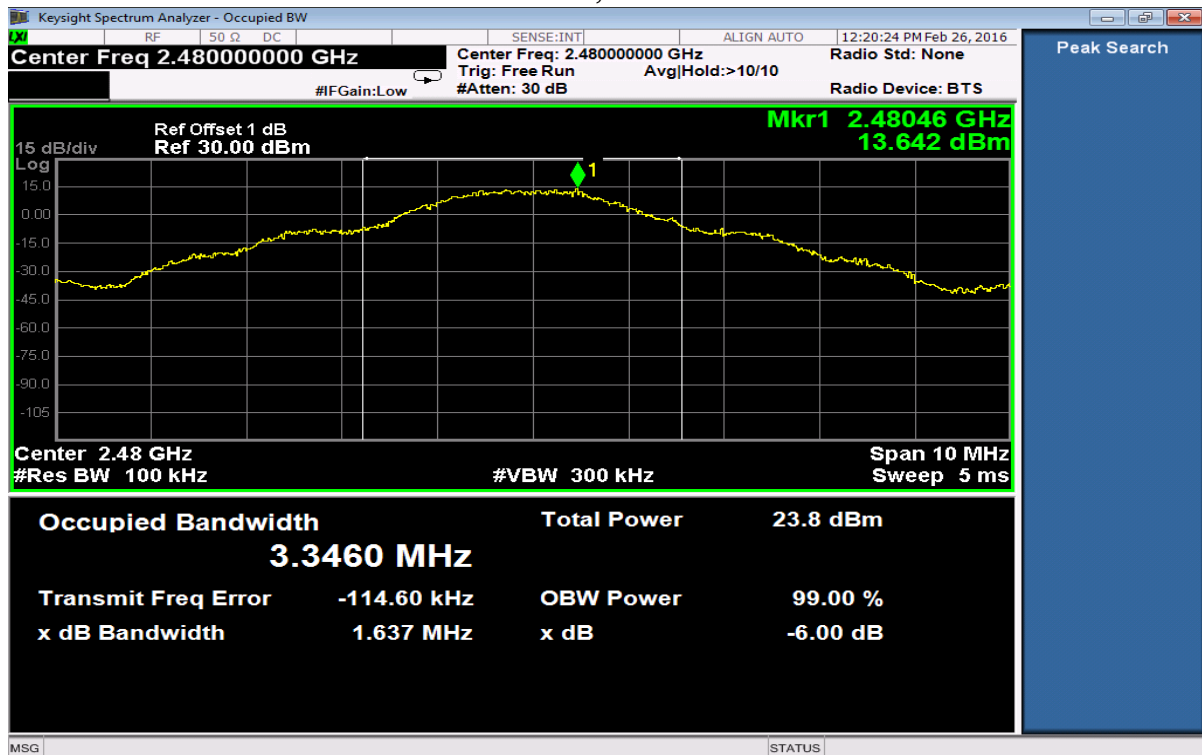
Antenna 1, Channel L



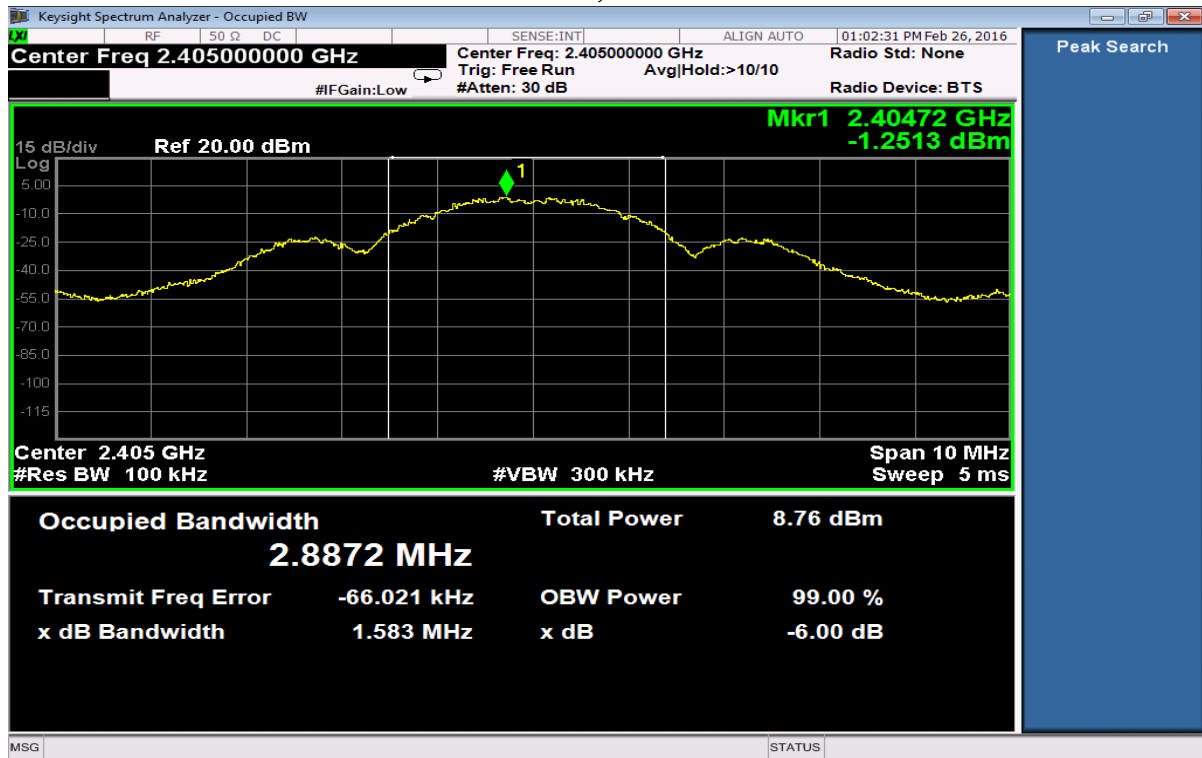
Antenna 1, Channel M



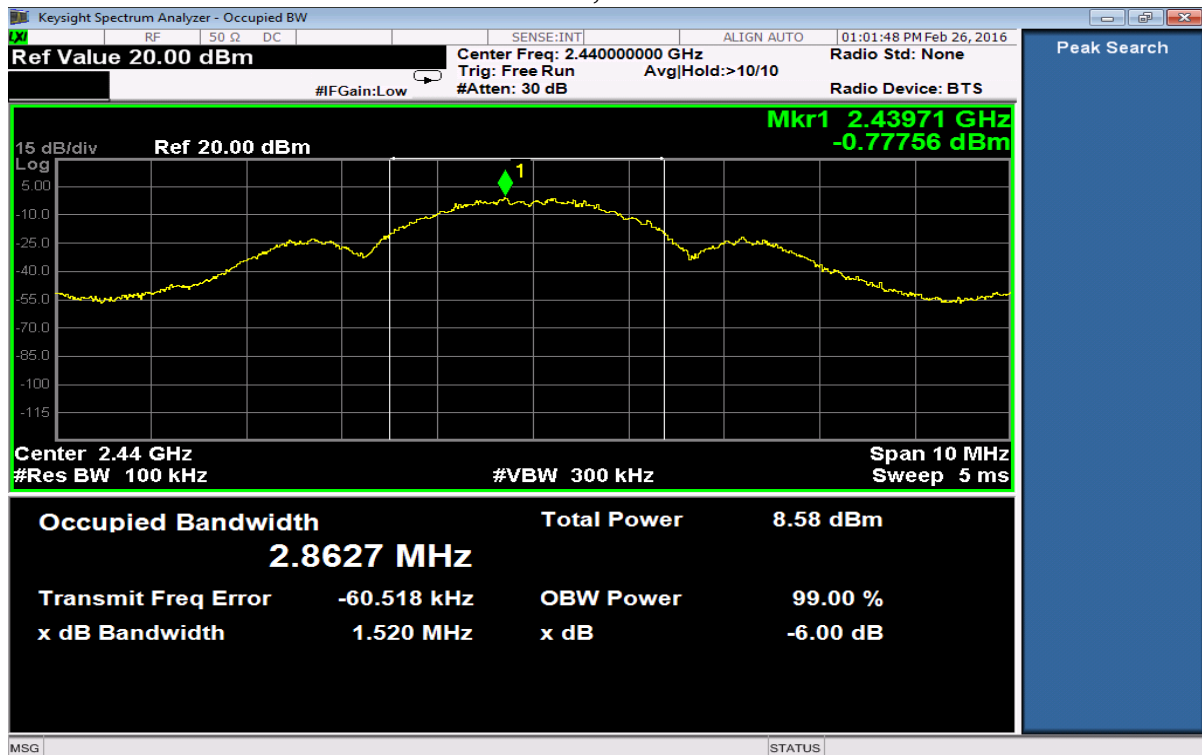
Antenna 1, Channel H



Antenna 3, Channel L



Antenna 3, Channel M



Antenna 3, Channel H

