

FCC- TEST REPORT

Report Number : **708882003211-00** Date of Issue: January 17, 2020

Model : ZS2S

Product Type : Zigbee Module

Applicant : Hangzhou Tuya Information Technology Co.,Ltd

Address : Room701,Building3,More Center,No.87 GuDun Road,Hangzhou,Zhejiang China

Production Facility : Hangzhou xicheng electronic technology co. LTD

Address : Building 5 and 6, 123 chutian road, xixing street, binjiang district, hangzhou city, zhejiang province, China

Test Result : **■ Positive** **Negative**

Total pages including Appendices : 35

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2 Details about the Test Laboratory

Details about the Test Laboratory

Test Site 1

Company name: TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
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Shanghai 201108,
P.R. China

Test Firm 820234

Registration
Number:

Telephone: +86 21 6141 0123
Fax: +86 21 6140 8600

3 Description of the Equipment under Test

Description of the Equipment Under Test

Product: Zigbee Module

Model no.: ZS2S

FCC ID: 2ANDL-ZS2S

Options and accessories: NA

Rating: 2.0V-3.8V

RF Transmission Frequency: 2405~2480MHz

No. of Operated Channel: 16

Modulation: 16-ary orthogonal modulation, O-QPSK PHY

Channel list:

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

Antenna Type: PCB antenna

Antenna Gain: 2.5dBi

Description of the EUT: The Equipment Under Test (EUT) is a Zigbee Module. We tested it and listed the worst data in this report.

The sample's mentioned in this report is supplied by client. The laboratory therefore assumes no responsibility for accuracy of information on the brand name, model number, origin of manufacture, consignment, antenna gain or any information supplied.

4 Summary of Test Standards

Test Standards	
FCC Part 15 Subpart C 10-1-2014 Edition	PART 15 - RADIO FREQUENCY DEVICES Subpart C - Intentional Radiators

All the test methods were according to KDB 558074 D01 15.247 Meas Guidance v05r02 and ANSI C63.10 (2013).

5 Summary of Test Results

Technical Requirements					Test Result		
FCC Part 15 Subpart C			Pages	Test Site	Pass	Fail	N/A
Test Condition							
§15.207		Conducted emission AC power port	12-14	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247 (b) (1)		Conducted peak output power	15-16	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247(a)(1)		20dB bandwidth	---	---	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
§15.247(a)(1)		Carrier frequency separation	---	---	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
§15.247(a)(1)(iii)		Number of hopping frequencies	---	---	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
§15.247(a)(1)(iii)		Dwell Time	---	---	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
§15.247(a)(2)		6dB bandwidth	17-18	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247(e)		Power spectral density	19-20	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247(d)		Spurious RF conducted emissions	21-24	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247(d)		Band edge	25-26	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.247(d) & §15.209		Spurious radiated emissions for transmitter	27-31	Site 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
§15.203		Antenna requirement	See note 1		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Remark 1: N/A – Not Applicable.

Note 1: The EUT uses a patch antenna, which gain is 2.5dBi. In accordance to §15.203, It is considered sufficiently to comply with the provisions of this section.

6 General Remarks

Remarks

This submittal(s) (test report) is intended for FCC ID: 2ANDL-ZS2S complies with Section 15.207, 15.209, 15.247 of the FCC Part 15, Subpart C Rules.

SUMMARY:

All tests according to the regulations cited on page 5 were

- Performed

- Not Performed

The Equipment under Test

- **Fulfills** the general approval requirements.

- **Does not** fulfill the general approval requirements.

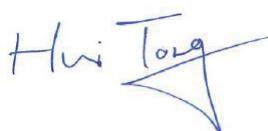
Sample Received Date: January 7, 2020

Testing Start Date: January 8, 2020

Testing End Date: January 9, 2020

- TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch

Reviewed by:



Hui TONG
Review Engineer

Prepared by:



Jiaxi XU
Project Engineer

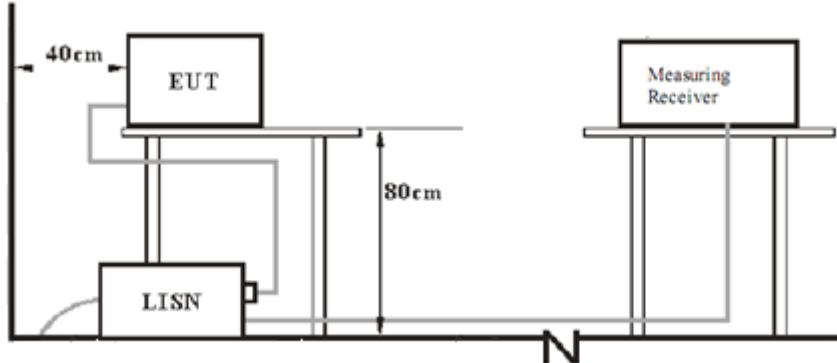
Tested by:



Wenqiang LU
Test Engineer

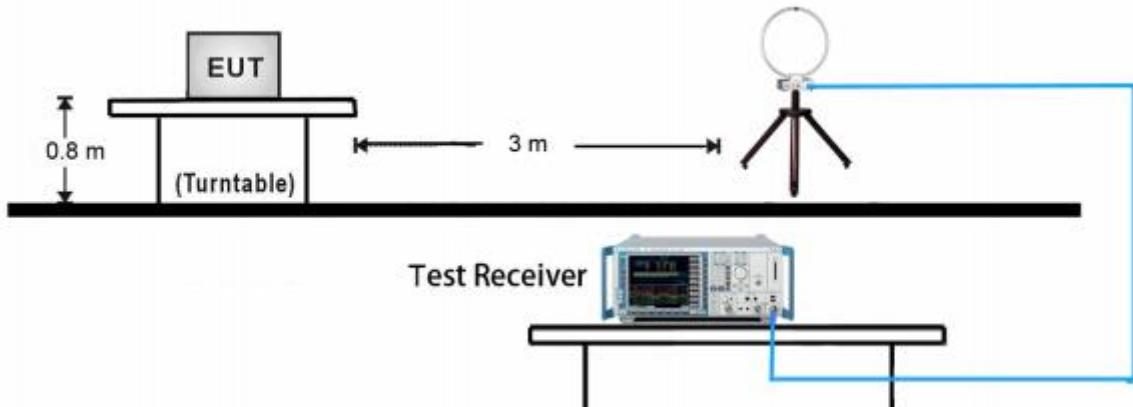
7 Test Setups

7.1 AC Power Line Conducted Emission test setups

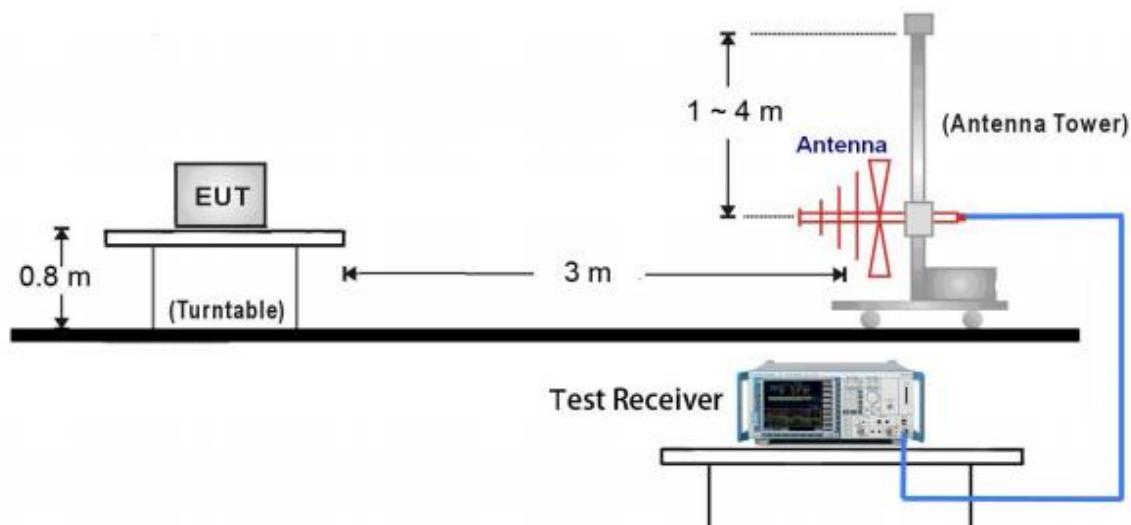


7.2 Radiated test setups

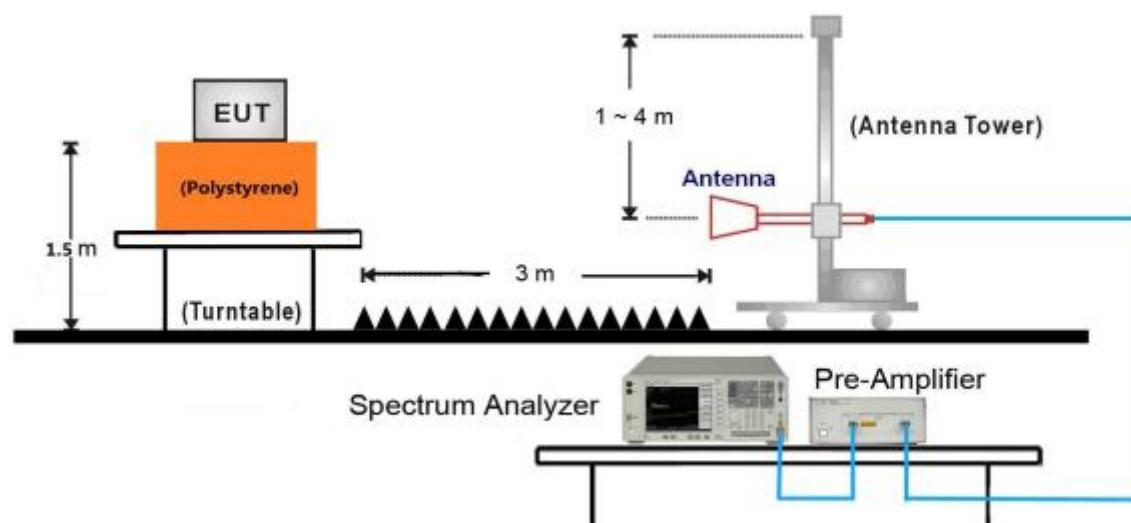
9kHz ~ 30MHz Test Setup:



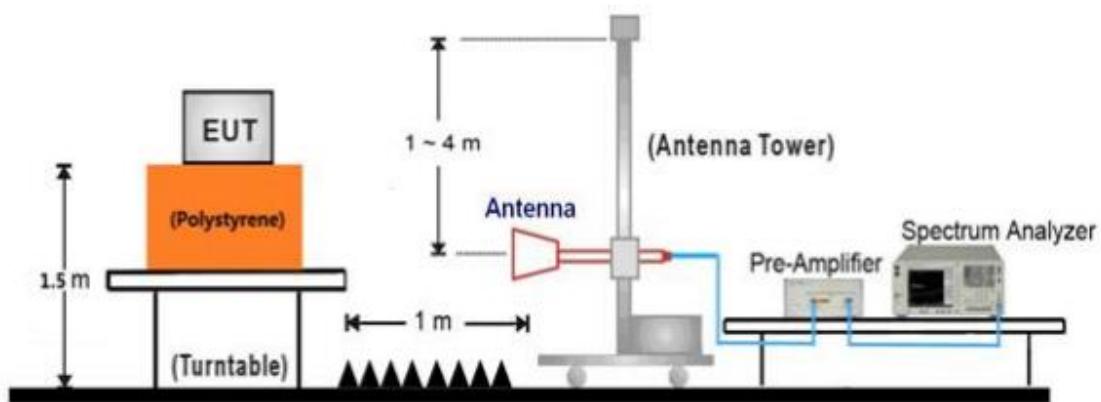
30MHz ~ 1GHz Test Setup:



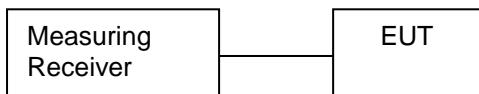
1GHz ~ 18GHz Test Setup:



18GHz ~ 25GHz Test Setup:



7.3 Conducted RF test setups



8 Systems test configuration

Auxiliary Equipment Used during Test:

DESCRIPTION	MANUFACTURER	MODEL NO.(SHIELD)	S/N(LENGTH)
Notebook	Lenovo	X240	Notebook

Test software: SecureCRT

The system was configured to channel 11, 20, and 26 for the test.

Non-hopping mode: The system was configured to operate at a signal channel transmitting. The test software allows the configuration and operation at the worst-case duty and the highest transmit power.

9 Technical Requirement

9.1 Conducted Emission

Test Method

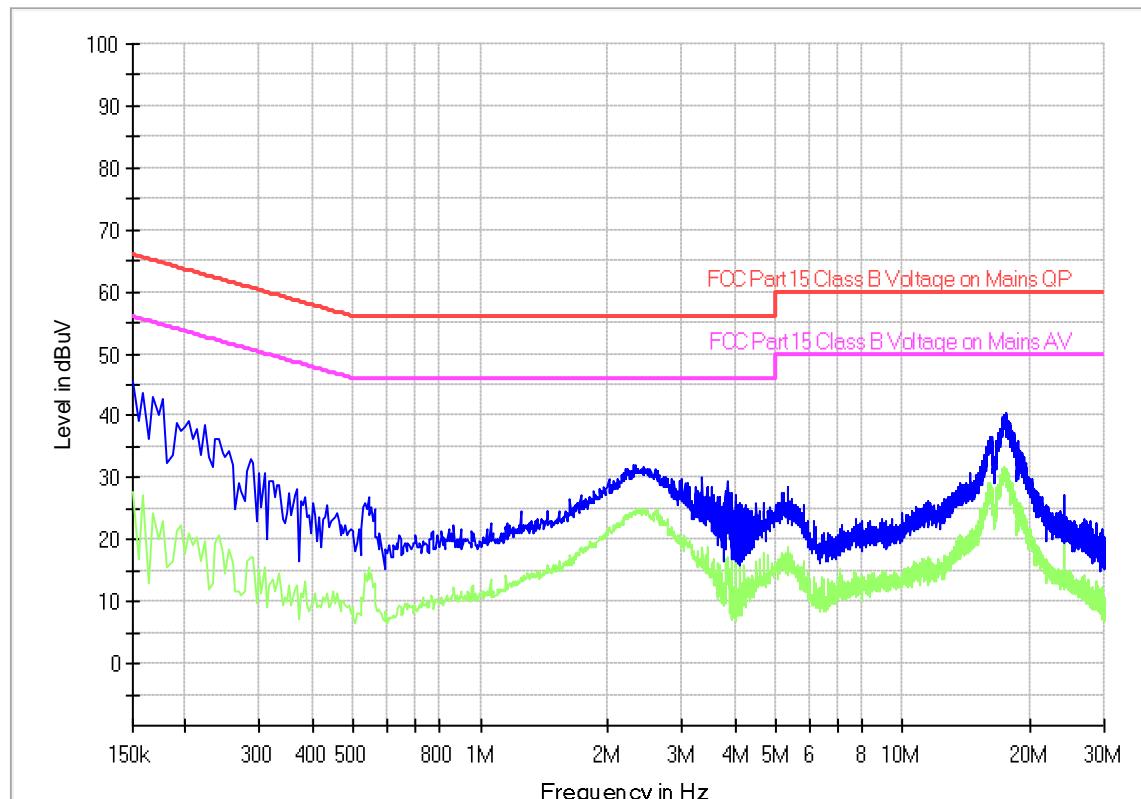
1. The EUT was placed on a table, which is 0.8m above ground plane
2. The power line of the EUT is connected to the AC mains through a Artificial Mains Network (A.M.N.).
3. Maximum procedure was performed to ensure EUT compliance
4. A EMI test receiver is used to test the emissions from both sides of AC line

Limit

Frequency MHz	QP Limit dB μ V	AV Limit dB μ V
0.150-0.500	66-56*	56-46*
0.500-5	56	46
5-30	60	50

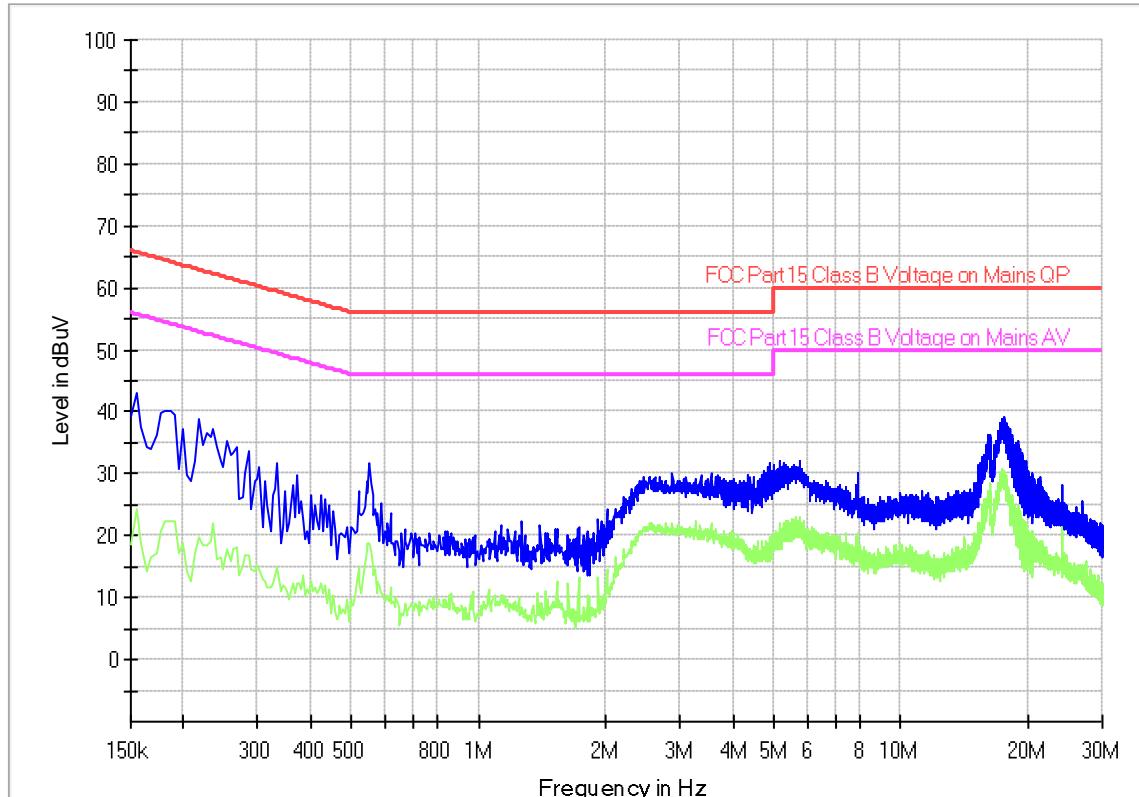
Decreasing linearly with logarithm of the frequency

Product Type : Zigbee Module
M/N : ZS2S
Operating Condition : Mode 1: Tx_2405MHz
Test Specification : L-line
Comment : AC 120V/60Hz (powered by notebook)



Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)
Factor (dB) = Cable Loss (dB) + LISN Factor (dB) + 10dB Attenuator

Product Type : Zigbee Module
M/N : ZS2S
Operating Condition : Mode 1: Tx_2405MHz
Test Specification : N-line
Comment : AC 120V/60Hz (powered by notebook)



Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)
Factor (dB) = Cable Loss (dB) + LISN Factor (dB) + 10dB Attenuator

9.2 Conducted peak output power

Test Method

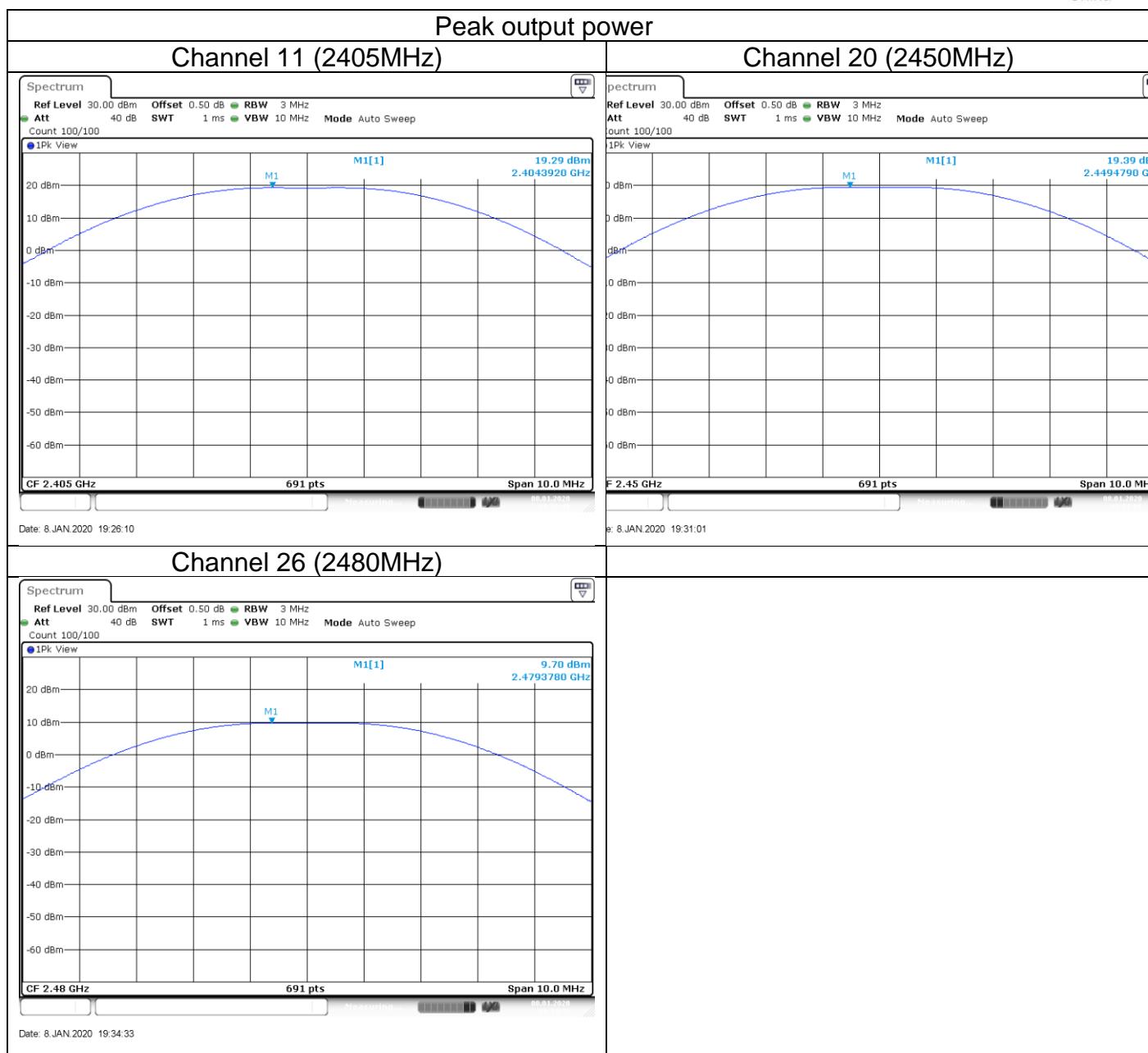
1. Use the following spectrum analyzer settings:
RBW > the 6 dB bandwidth of the emission being measured, VBW \geq 3RBW, Span \geq 3RBW
Sweep = auto, Detector function = peak, Trace = max hold.
2. Add a correction factor to the display.
3. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power.

Limits

Frequency Range MHz	Limit W	Limit dBm
2400-2483.5	≤ 1	≤ 30

Test result as below table

Frequency MHz	Conducted Peak Output Power dBm	Result
Low channel 2405MHz	19.29	Pass
Middle channel 2450MHz	17.39	Pass
High channel 2480MHz	9.70	Pass



9.3 6dB bandwidth

Test Method

1. Use the following spectrum analyzer settings:
RBW=100K, VBW \geq 3RBW, Sweep = auto, Detector function = peak, Trace = max hold
2. Use the automatic bandwidth measurement capability of an instrument, may be employed using the X dB bandwidth mode with X set to 6 dB, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be \geq 6 dB.
3. Allow the trace to stabilize, record the X dB Bandwidth value.

Limit

Limit [kHz]

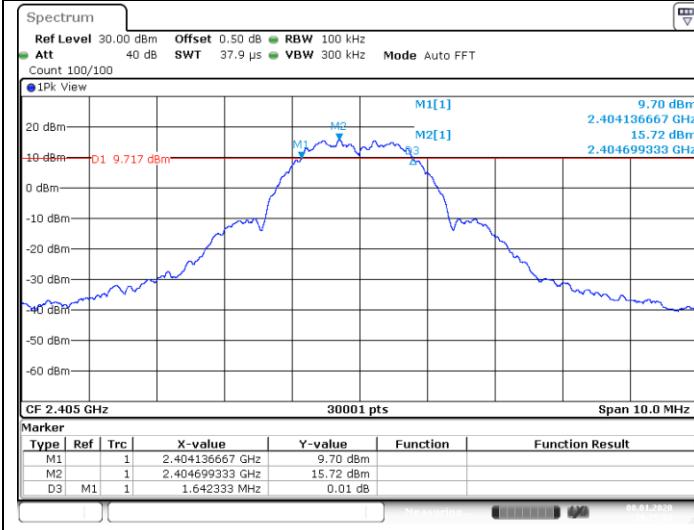
≥ 500

Test result

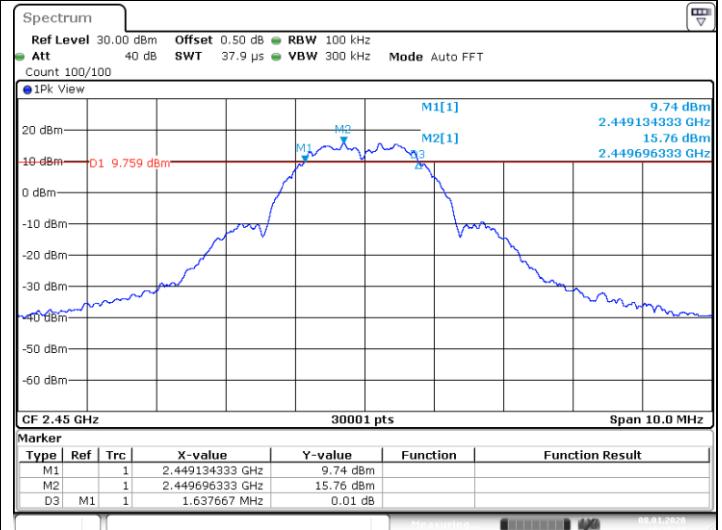
Frequency MHz	6dB bandwidth kHz	Result
Top channel 2405MHz	1642	Pass
Middle channel 2450MHz	1638	Pass
Bottom channel 2480MHz	1647	Pass

6dB Bandwidth

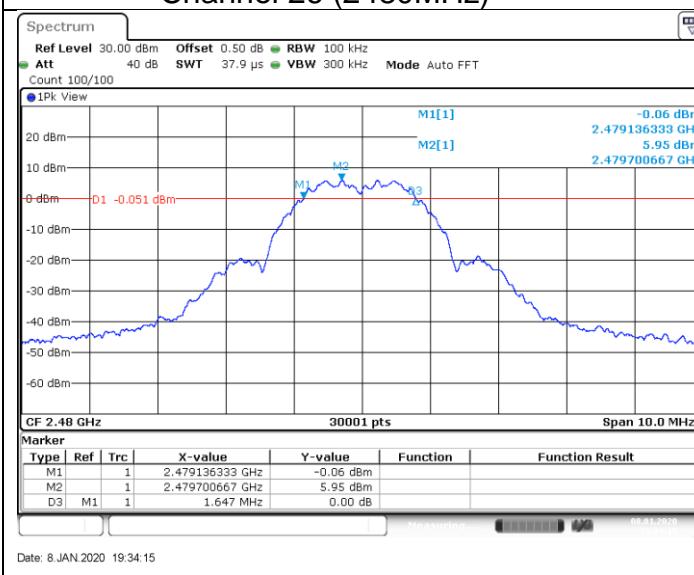
Channel 11 (2405MHz)



Channel 20 (2450MHz)



Channel 26 (2480MHz)



9.4 Power spectral density

Test Method

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance:

1. Set analyzer center frequency to DTS channel center frequency.
RBW=3kHz, VBW \geq 3RBW, Span=1.5 times DTS bandwidth, Detector=Peak, Sweep=auto, Trace=max hold.
2. Allow trace to fully stabilize, use the peak marker function to determine the maximum amplitude level within the RBW.
3. Repeat above procedures until other frequencies measured were completed.

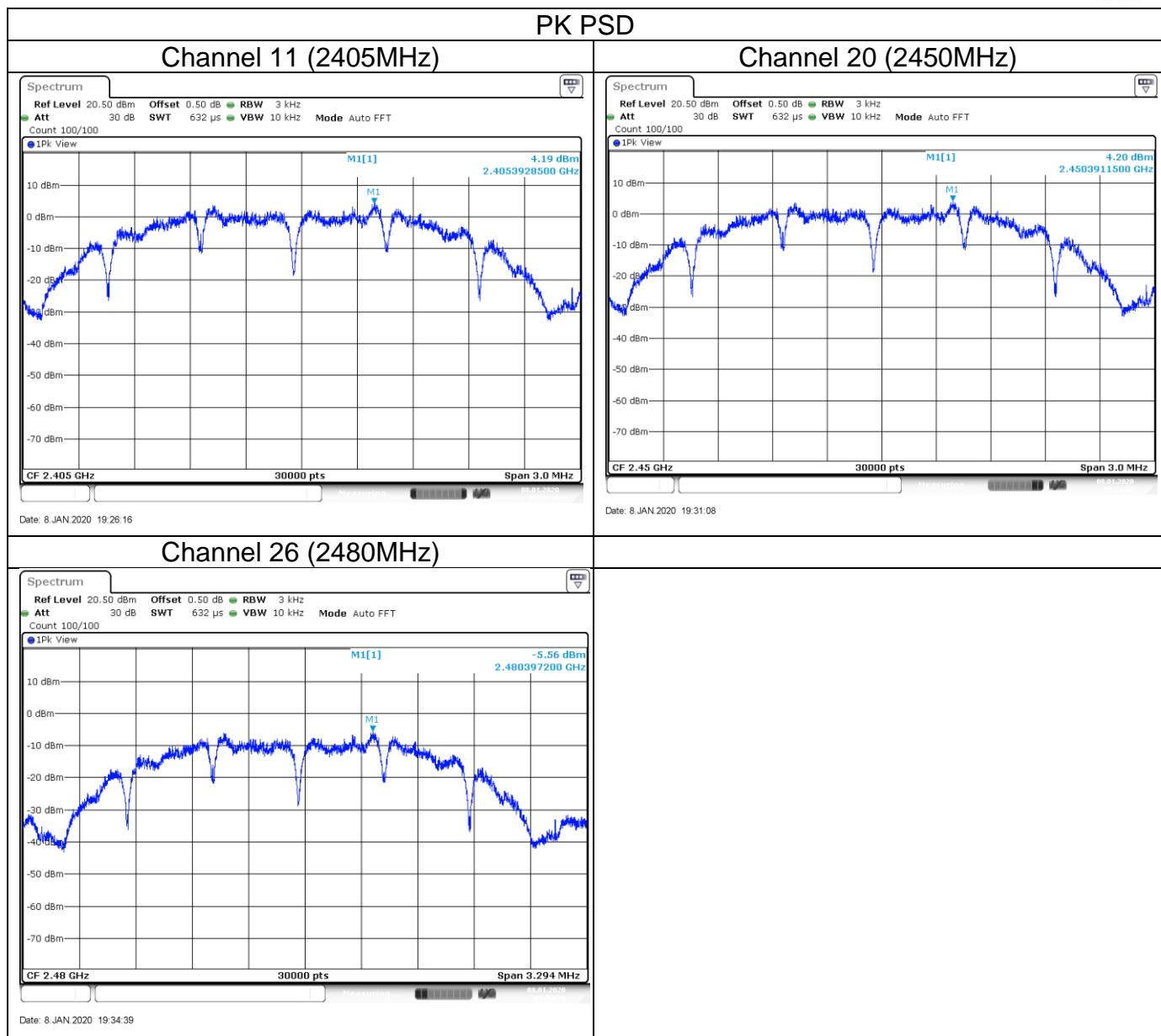
Limit

Limit [dBm]

≤ 8

Test result

Frequency MHz	Power spectral density dBm	Result
Top channel 2405MHz	4.19	Pass
Middle channel 2450MHz	4.20	Pass
Bottom channel 2480MHz	-5.56	Pass



9.5 Spurious RF conducted emissions

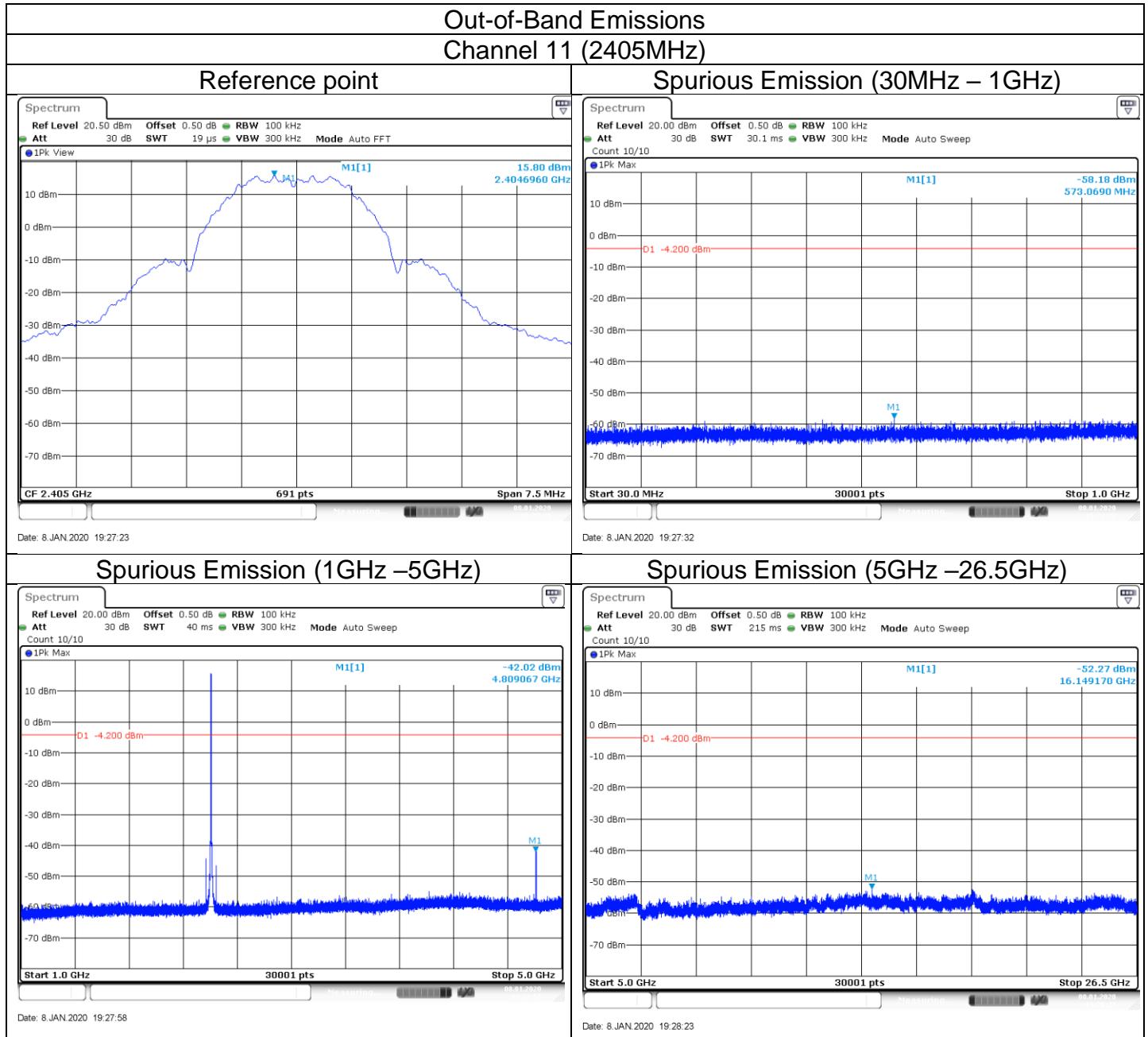
Test Method

1. Establish a reference level by using the following procedure:
 - a. Set RBW=100 kHz. VBW \geq 3RBW. Detector =peak, Sweep time = auto couple, Trace mode = max hold.
 - b. Allow trace to fully stabilize, use the peak marker function to determine the maximum PSD level.
2. Use the maximum PSD level to establish the reference level.
 - a. Set the center frequency and span to encompass frequency range to be measured.
 - b. Use the peak marker function to determine the maximum amplitude level. Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) are attenuated by at least the minimum requirements, report the three highest emissions relative to the limit.
3. Repeat above procedures until other frequencies measured were completed.

Limit

Frequency Range MHz	Limit (dBc)
30-25000	-20

Spurious RF conducted emissions

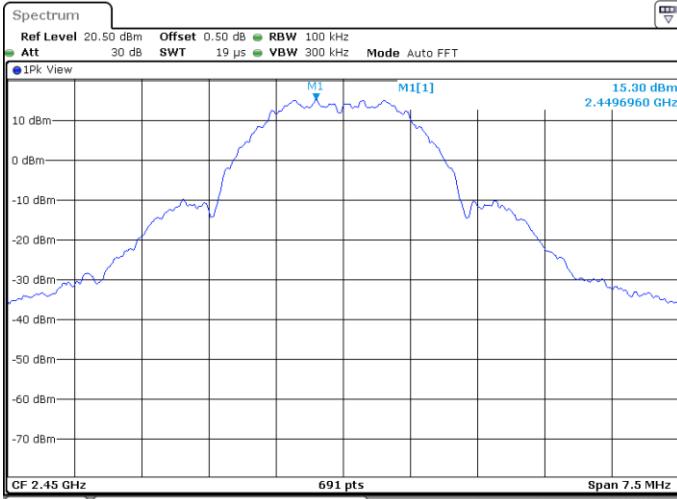


Out-of-Band Emissions

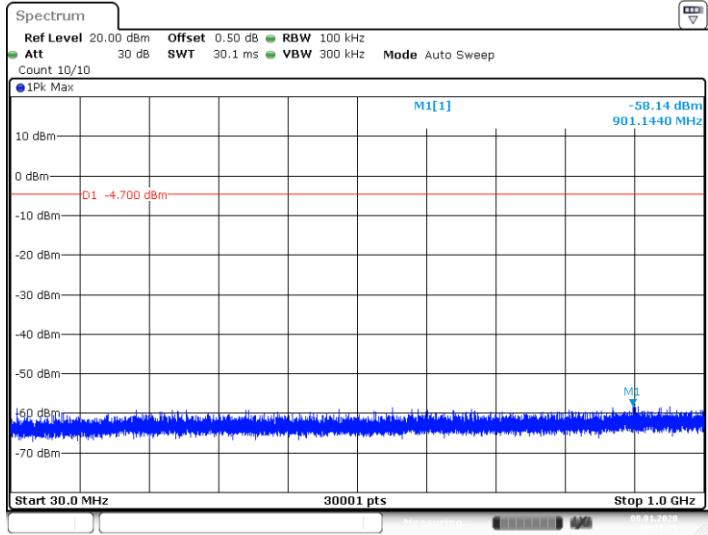
Channel 20 (2450MHz)

Reference point

Spurious Emission (30MHz – 1GHz)

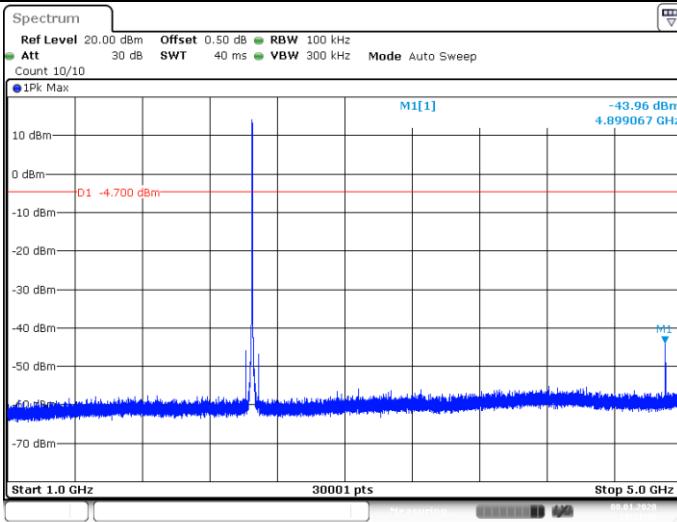


Date: 8.JAN.2020 19:31:13



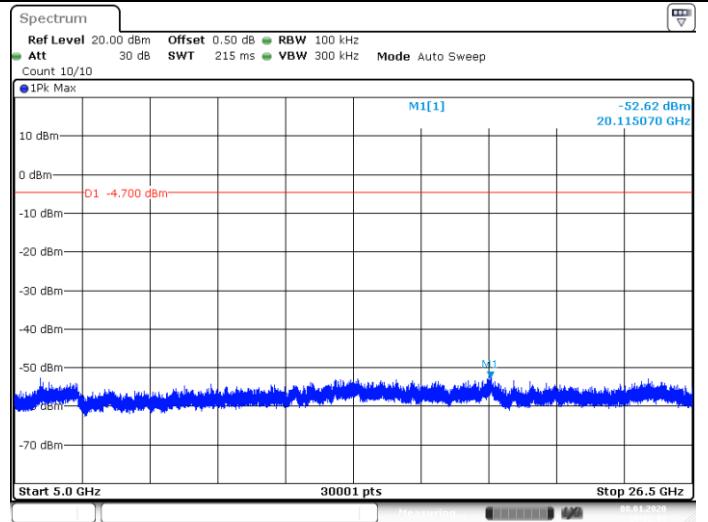
Date: 8.JAN.2020 19:31:22

Spurious Emission (1GHz – 5GHz)



Date: 8.JAN.2020 19:31:47

Spurious Emission (5GHz – 26.5GHz)



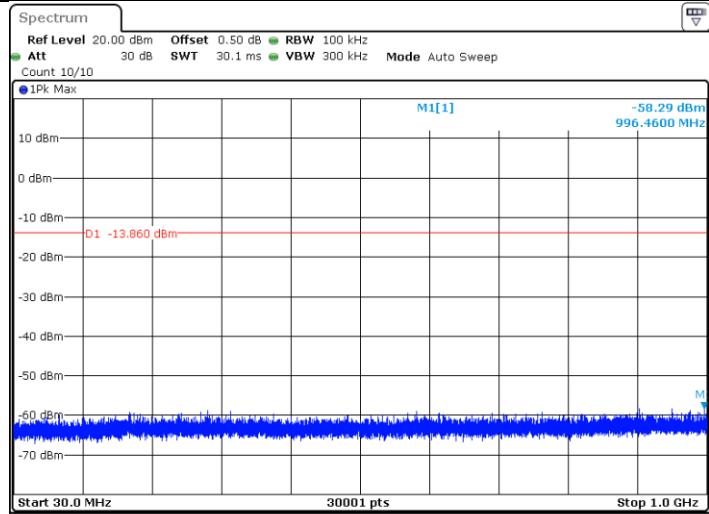
Date: 8.JAN.2020 19:32:13

Out-of-Band Emissions Channel 26 (2480MHz)

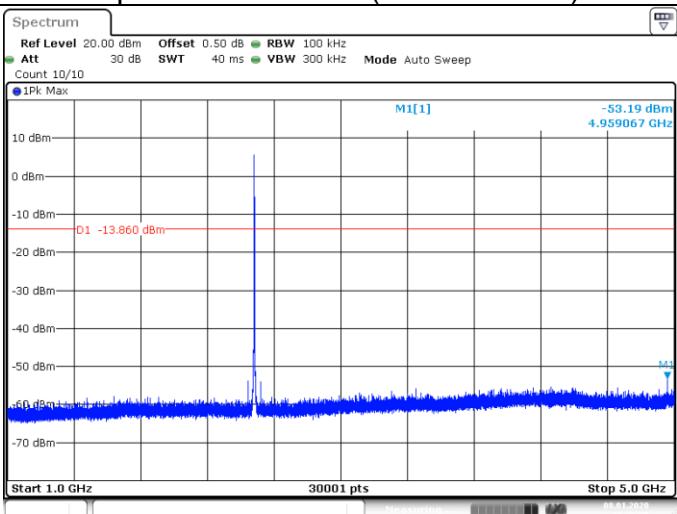
Reference point



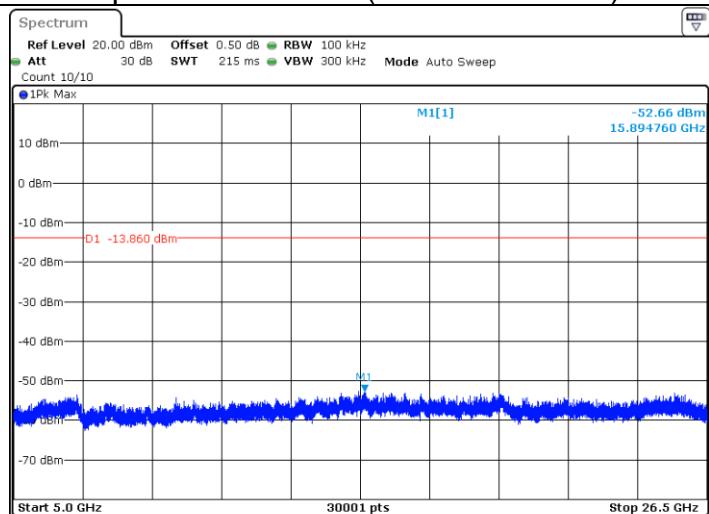
Spurious Emission (30MHz – 1GHz)



Spurious Emission (1GHz – 5GHz)



Spurious Emission (5GHz – 26.5GHz)



9.6 Band edge

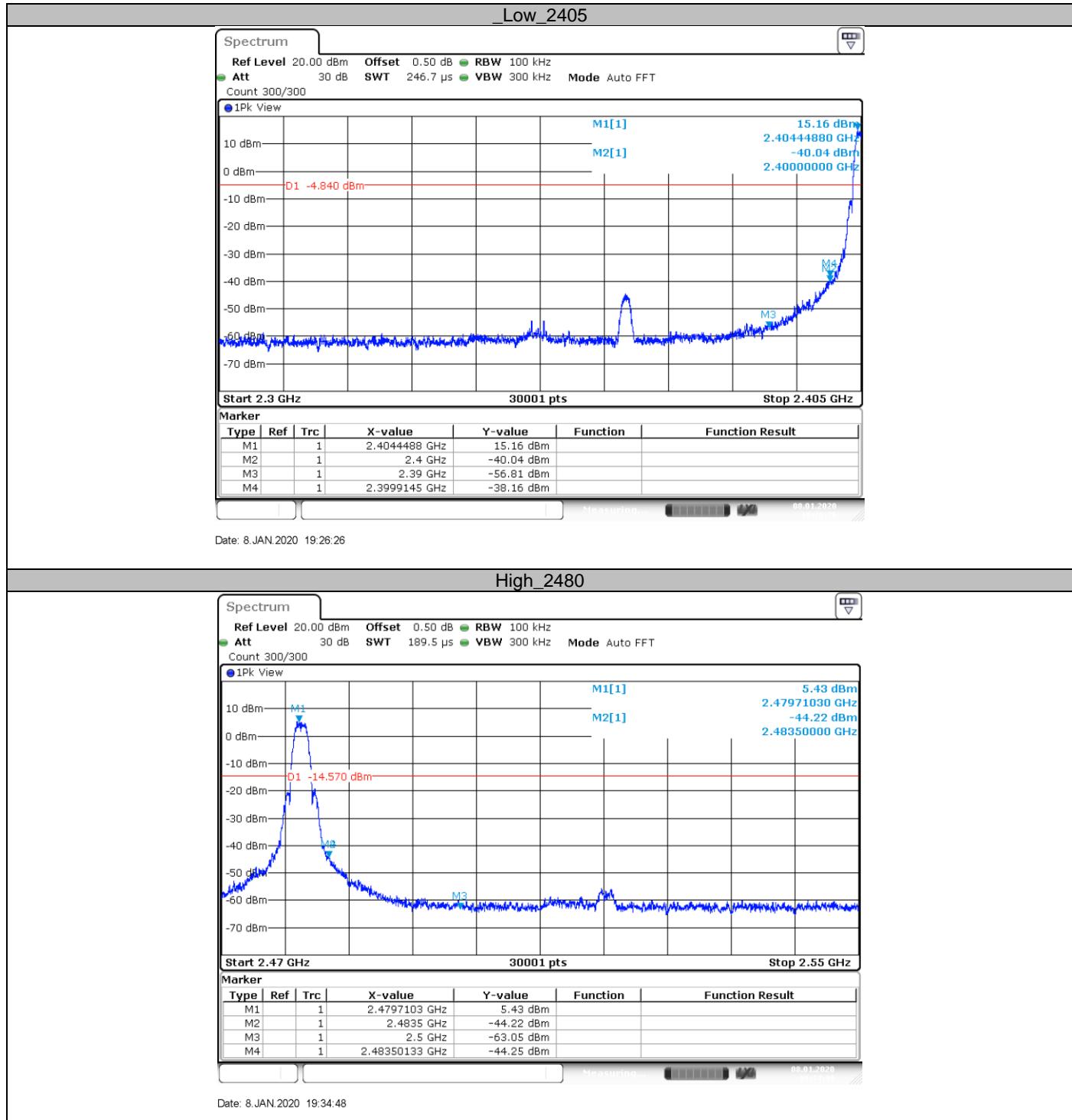
Test Method

- 1 Use the following spectrum analyzer settings:
Span = wide enough to capture the peak level of the in-band emission and all spurious
RBW = 100 kHz, VBW \geq RBW, Sweep = auto, Detector function = peak, Trace = max
hold.
- 2 Allow the trace to stabilize, use the peak and delta measurement to record the result.
- 3 The level displayed must comply with the limit specified in this Section.

Limit

In any 100 kHz bandwidth outside the frequency bands in which the spread spectrum 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. 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 Section 15.205(c)).

Test result



9.7 Spurious radiated emissions for transmitter

Test Method

1. The EUT was place on a turn table which is 1.5m above ground plane for above 1GHz and 0.8m above ground for below 1GHz at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
2. The EUT was set 3 meters away from the interference – receiving antenna, which was mounted on the top of a variable – height antenna tower.
3. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. Use the following spectrum analyzer settings According to C63.10:

For Below 1GHz

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious
RBW = 100 kHz to 120 kHz, VBW≥RBW for peak measurement, Sweep = auto, Detector
function = peak, Trace = max hold.

For Peak unwanted emissions Above 1GHz:

Span = wide enough to capture the peak level of the in-band emission and all spurious
RBW = 1MHz, VBW≥RBW for peak measurement, Sweep = auto, Detector function =
peak, Trace = max hold.

Procedures for average unwanted emissions measurements above 1000 MHz

- a) RBW = 1MHz.
- b) VBW \geq [3 \times RBW].
- c) Detector = RMS (power averaging), if [span / (# of points in sweep)] \leq RBW / 2.
Satisfying this condition can require increasing the number of points in the sweep or
reducing the span. If the condition is not satisfied, then the detector mode shall be set to
peak.
- d) Averaging type = power (i.e., rms) (As an alternative, the detector and averaging type
may be set for linear voltage averaging. Some instruments require linear display mode to
use linear voltage averaging. Log or dB averaging shall not be used.)
- e) Sweep time = auto.
- f) Perform a trace average of at least 100 traces if the transmission is continuous. If the
transmission is not continuous, then the number of traces shall be increased by a factor
of 1 / D, where D is the duty cycle. For example, with 50% duty cycle, at least 200 traces
shall be averaged. (If a specific emission is demonstrated to be continuous—i.e., 100%
duty cycle—then rather than turning ON and OFF with the transmit cycle, at least 100
traces shall be averaged.)
- g) If tests are performed with the EUT transmitting at a duty cycle less than 98%, then a
correction factor shall be added to the measurement results prior to comparing with the
emission limit, to compute the emission level that would have been measured had the
test been performed at 100% duty cycle. The correction factor is computed as follows:
1) If power averaging (rms) mode was used in the preceding step e), then the correction

factor is $[10 \log (1 / D)]$, where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 3 dB shall be added to the measured emission levels.

2) If linear voltage averaging mode was used in the preceding step e), then the correction factor is $[20 \log (1 / D)]$, where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 6 dB shall be added to the measured emission levels.

3) If a specific emission is demonstrated to be continuous (100% duty cycle) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Limit

The radio emission outside the operating frequency band 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. Radiated emissions which fall in the restricted bands, as defined in section 15.205, must comply with the radiated emission limits specified in section 15.209.

Frequency MHz	Field Strength uV/m	Measured Distance Meters
0.009~0.490	2400/F (kHz)	300
0.490~1.705	24000/F (kHz)	30
1.705~30	30	30

Frequency MHz	Field Strength uV/m	Field Strength dB μ V/m	Detector
30-88	100	40	QP
88-216	150	43.5	QP
216-960	200	46	QP
960-1000	500	54	QP
Above 1000	500	54	AV
Above 1000	5000	74	PK

Spurious radiated emissions for transmitter

According to C63.10, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement, so AV emission value did not show in below table if the peak value complies with average limit.

Transmitting spurious emission test result as below:

Test mode: O-QPSK					
Channel 11 (2405MHz)					
Frequency (MHz)	Measure Level (dBuV/m)	Limit (dBuV/M)	Margin (dB)	Detector	Polarization
2366.0	54.28	74.0	19.72	Peak	Horizontal
2366.0	48.11	54.0	5.89	Average	Horizontal
2390.0	51.36	74.0	22.64	Peak	Horizontal
4810.0	55.48	74.0	18.52	Peak	Horizontal
4810.0	51.50	54.0	2.50	Average	Horizontal
7216.4	44.60	74.0	29.4	Peak	Horizontal
2365.7	53.11	74.0	20.89	Peak	Vertical
2365.7	43.89	54.0	10.11	Average	Vertical
2390.0	40.17	74.0	33.83	Peak	Vertical
4809.0	49.91	74.0	24.09	Peak	Vertical
Test mode: O-QPSK					
Channel 20 (2450MHz)					
Frequency (MHz)	Measure Level (dBuV/m)	Limit (dBuV/M)	Margin (dB)	Detector	Polarization
4898.6	52.85	74.0	21.15	Peak	Horizontal
4898.6	46.34	54.0	7.66	Average	Horizontal
7348.4	50.34	74.0	23.66	Peak	Horizontal
4898.6	48.23	74.0	25.77	Peak	Vertical
7351.2	54.71	74.0	19.29	Peak	Vertical
Test mode: O-QPSK					
Channel 26 (2480MHz)					
Frequency (MHz)	Measure Level (dBuV/m)	Limit (dBuV/M)	Margin (dB)	Detector	Polarization
2484.0	60.38	74.0	13.62	Peak	Horizontal
2484.0	48.90	54.0	5.10	Average	Horizontal
4960.6	42.87	74.0	31.13	Peak	Horizontal
2484.0	55.77	74.0	18.23	Peak	Vertical
2484.0	44.10	54.0	9.90	Average	Vertical
4960.6	41.22	74.0	32.78	Peak	Vertical

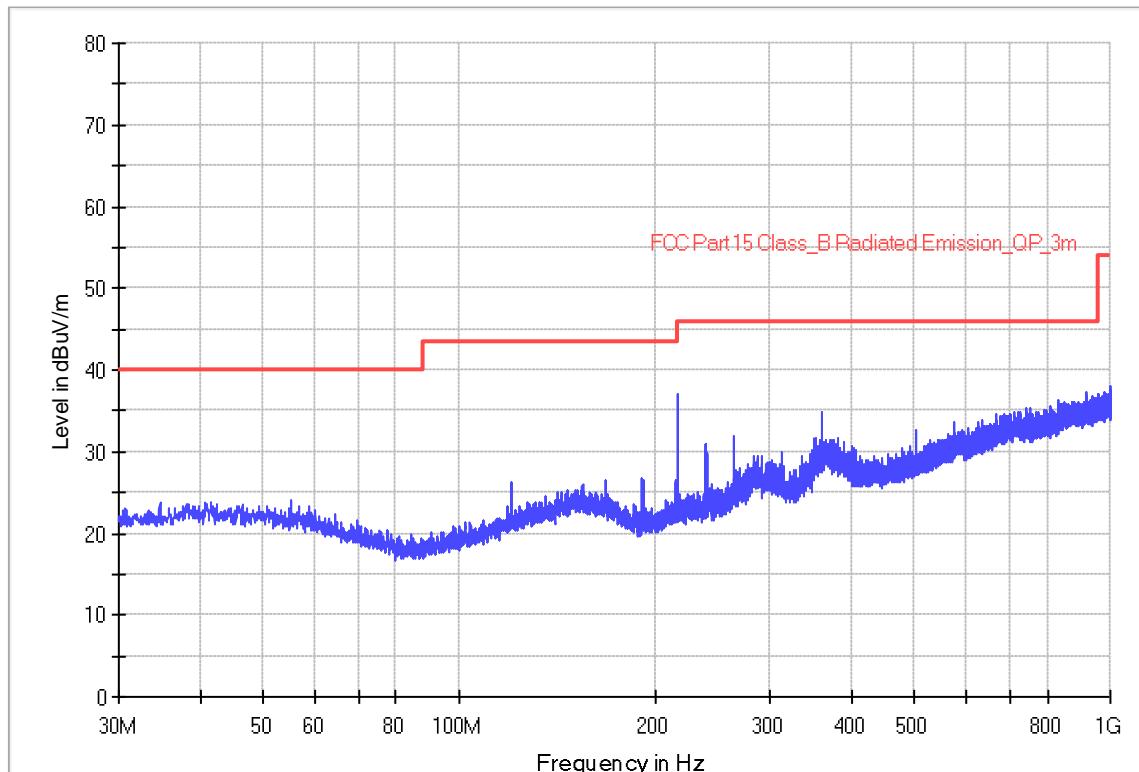
Remark:

- (1) Emission level= Original Receiver Reading + Correct Factor
- (2) Correct Factor = Antenna Factor + Cable Loss -Amplifier gain
- (3) Margin = limit – Corrected Reading

The worst case of Radiated Emission below 1GHz:

Site: 3 meter chamber	Time: 2020/01/08 - 14:44
Limit: FCC_Part15.209_RE(3m)_ClassB	Engineer: Jiaxi XU
Probe: VULB9168	Polarity: Horizontal
EUT: BT Module, Model no: ZS2S	Power: 120VAC, 60Hz
Note: Transmit by at channel 2405MHz.	
Note: There is the worst case within frequency range 30MHz~1GHz.	

RE_VULB9168_pre_Cond_30-1000



Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)

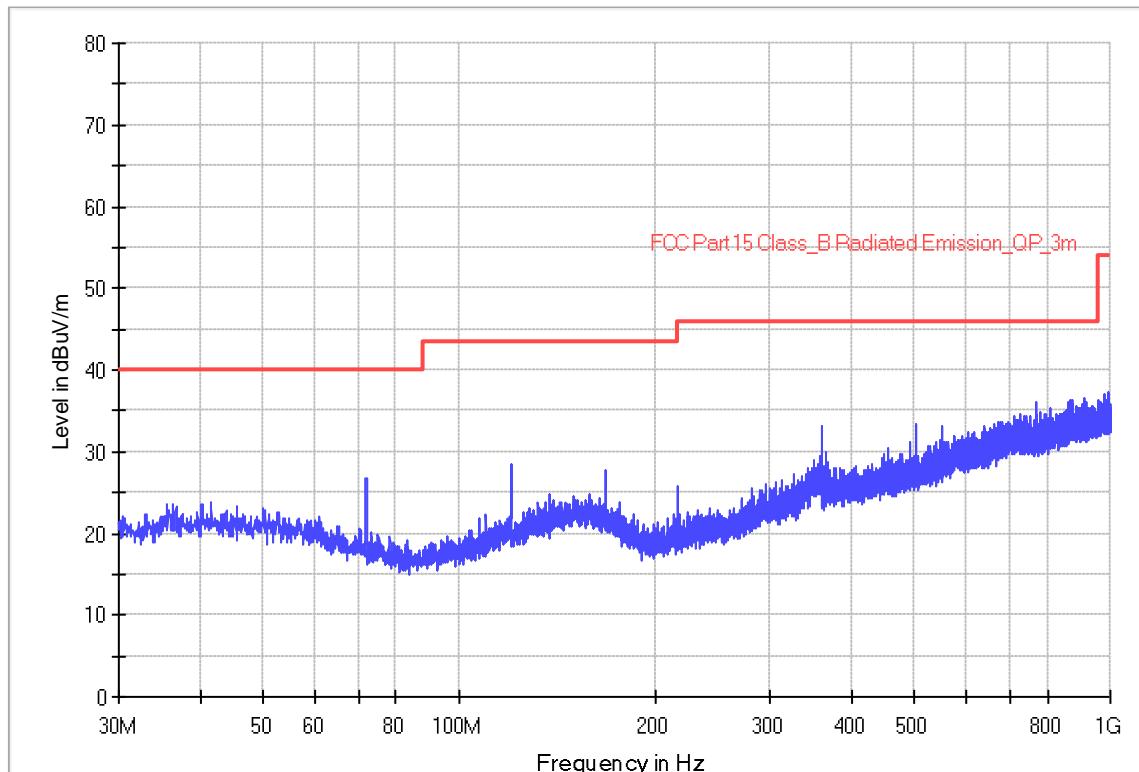
Factor (dB) = Cable Loss (dB) + Antenna Factor (dB/m)

Note 2: The test trace is same as the ambient noise and the amplitude of the emissions are attenuated more than 20dB below the permissible (the test frequency range: 9kHz ~ 30MHz, 18GHz ~ 25GHz), therefore no data appear in the report.

The worst case of Radiated Emission below 1GHz:

Site: 3 meter chamber	Time: 2020/01/08 - 14:51
Limit: FCC_Part15.209_RE(3m)_ClassB	Engineer: Jiaxi XU
Probe: VULB9168	Polarity: Vertical
EUT: BT Module, Model no: ZS2S	Power: 120VAC, 60Hz
Note: Transmit by at channel 2405MHz.	
Note: There is the worst case within frequency range 30MHz~1GHz.	

RE_VULB9168_pre_Cond_30-1000



Note 1: Measure Level (dBuV/m) = Reading Level (dBuV) + Factor (dB)

Factor (dB) = Cable Loss (dB) + Antenna Factor (dB/m)

Note 2: The test trace is same as the ambient noise and the amplitude of the emissions are attenuated more than 20dB below the permissible (the test frequency range: 9kHz ~ 30MHz, 18GHz ~ 25GHz), therefore no data appear in the report.

10 Test Equipment List

List of Test Instruments

Test Site1

	DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	CAL. DATE	CAL. DUE DATE
C	Signal Analyzer	Rohde & Schwarz	FSV40	101091	2019-8-5	2020-8-4
RE	EMI Test Receiver	Rohde & Schwarz	ESR3	101906	2019-8-5	2020-8-4
	Signal Analyzer	Rohde & Schwarz	FSV40	101091	2019-8-5	2020-8-4
	Trilog Super Broadband Test Antenna	Schwarzbeck	VULB 9168	961	2019-3-16	2022-3-15
	Horn Antenna	Rohde & Schwarz	HF907	102393	2018-6-11	2021-4-1
	Pre-amplifier	Rohde & Schwarz	SCU-18D	19006451	2019-8-5	2020-8-4
	Loop antenna	Rohde & Schwarz	HFH2-Z2	100443	2019-6-28	2020-6-27
	DOUBLE-RIDGED WAVEGUIDE HORN WITH PRE-AMPLIFIER (18 GHZ - 40 GHZ)	ETS-Lindgren	3116C-PA	002222727	2018-1-29	2021-1-28
	3m Semi-anechoic chamber	TDK	9X6X6	----	2018-5-11	2021-5-10
CE	EMI Test Receiver	Rohde & Schwarz	ESR3	101907	2019-8-5	2020-8-4
	LISN	Rohde & Schwarz	ENV216	101924	2019-8-5	2020-8-4

Measurement Software Information

Test Item	Software	Manufacturer	Version
RE	EMC 32	Rohde & Schwarz	V9.15.00
CE	EMC 32	Rohde & Schwarz	V9.15.03

C - Conducted RF tests

- Conducted peak output power
- 6dB bandwidth and 99% Occupied Bandwidth
- Power spectral density*
- Spurious RF conducted emissions
- Band edge

11 System Measurement Uncertainty

For a 95% confidence level, the measurement expanded uncertainties for defined systems, in accordance with the recommendations of ISO 17025 were:

Items	Extended Uncertainty
Conducted Disturbance at Mains Terminals	150kHz to 30MHz, LISN, $\pm 3.16\text{dB}$
Radiated Disturbance	30MHz to 1GHz, $\pm 5.03\text{dB}$ (Horizontal) $\pm 5.12\text{dB}$ (Vertical) 1GHz to 18GHz, $\pm 5.49\text{dB}$ 18GHz to 40GHz, $\pm 5.63\text{dB}$
Carrier power conducted measurement	50MHz~18GHz, $\pm 1.238\text{dB}$
Spurious Emission Conducted Measurement	9kHz ~40GHz, $\pm 1.224\text{dB}$

12 Photographs of Test Set-ups

Refer to the < Test Setup photos >.

13 Photographs of EUT

Refer to the < External Photos > & < Internal Photos >.

THE END