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TIMCO ENGINEERING, Inc.

An IIA Company

FCC PART 15.247
2.4 GHz DTS Test Report

APPLICANT	CATTRON NORTH AMERICA INC.
ADDRESS	655 N. RIVER ROAD NW SUITE A WARREN OH 44483-2254 USA
FCC ID	CN290275
MODEL NUMBER	**90275 TRX**
PRODUCT DESCRIPTION	IR LRMII 900 MHZ/2400MHZ MODULE
DATE SAMPLE RECEIVED	3/13/2020
FINAL TEST DATE	3/24/2020
TESTED BY	Tim Royer
APPROVED BY	Franklin Rose
TEST RESULTS	☒ PASS ☐ FAIL

Report Number	Report Version	Description	Issue Date
519BUT20_PT 15.247 DTS _ TestReport_		Initial Issue	3242020
	Rev1	Updated Calibration Dates	04/29/2020

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GENERAL REMARKS

Summary

The device under test does:

☒ Fulfill the general approval requirements as identified in this test report and was selected by the customer.

☐ Not fulfill the general approval requirements as identified in this test report

Attestations

This equipment has been tested in accordance with the standards identified in this test report. To the best of my knowledge and belief, these tests were performed using the measurement procedures described in this report.

All instrumentation and accessories used to test products for compliance to the indicated standards are calibrated regularly in accordance with ISO 17025 requirements.

I attest that the necessary measurements were made at:

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669
Designation #: US1070

Tested by:

Name and Title	Tim Royer, Project Manager / EMC Testing Engineer
Date	3/25/2020

GENERAL INFORMATION

EUT Information

EUT Description	IR LRMII 900 MHZ/2400MHZ MODULE		
FCC ID	CN290275		
Model Number	**90275 TRX**		
EUT Power Source	☐110–120Vac, 50–60Hz	☒ DC Power	☐ Battery Operated
Test Item	☐ Prototype	☒ Pre-Production	☐ Production
Type of Equipment	☒ Fixed	☐ Mobile	☐ Portable
Test Conditions	The temperature was 26ºC Relative humidity of 50%.		
Test Configuration	Normal use.		
Modification to the EUT	No Modification to EUT.		
Applicable Standards	FCC CFR 47 Part 2, Part 15, Referring to ANSI C63.10-2013 for Test Procedures		
Test Facility	Timco Engineering Inc. at 849 NW State Road 45 Newberry, FL 32669 USA. Designation #: US1070		

Peripherals Used in Testing

Description	Type	Connector	Length
n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a

EUT Modes of Operation

Description	Modulation Type
Coded 8	GFSK

Test Results Summary

FCC 47 CFR Part 15.247 Compliance Summary				
Aspect		**FCC Governing Rule(s)**	**Description**	**Compliance**
Device Profile	731 Rule Part	FCC 47 CFR Part 15	15.247	**PASS**
	731 Equipment Class	n/a	DTS	
	Frequency Band	15.247, 15.37(h)	902-928 MHz, 2.4-2.4835 GHz (Not for 5.725-5.85 GHz devices)	n/a
	Type of Device	n/a	Digital Transmission System Device	n/a
	Test Setup	n/a	Applicant must provide ≥ 2 samples with the following capabilities: Sample #1: 1 antenna connector per transmit antenna; Sample #2: normally radiating with antennas. Means to 1)Select Frequency, 2)Select Mode(s), 3)Continuously Transmit	n/a
Power Output	Antenna	15.247(b)(4)	Antenna Gain < 6 dBi. Greater gains are allowed provided Output Power is lowered 1 dB for every dB of gain above 6 dBi.	**Complies**
	Output Power	15.247(b)(3)	Output Power ≤ 1 W	**Complies**
	Duty Cycle	KDB 558074 D01 v05r02 s. 6	On/Off times of the device will be measured to determine the Duty Cycle. This is needed to determine other measurment methods.	n/a
	Power Spectral Density	15.247(e)	Power Spectral Density < +8 dBm measured with (3 kHz) < (Measurement BW) < (100 kHz)	**Complies**
	Unwanted Emissions at the Bandedge	KDB 558074 D01 v05r02 s. 8.1 c) 1)	Marker-Delta Method if Emission falls within 2 MHz of Bandedge. Otherwise, use Integrated Average Power measurement.	**Complies**
	Unwanted Emissions Out of Band	15.247(d)	In any 100 kHz BW unwanted emissions must be > 20 dB below Peak Power, or > 30 dB below RMS Power. RMS Emissions within restricted bands of operation (15.205(a) shall be below the limits of 15.209(a), and Peak Emissions above 1 GHz shall be below the limits of 15.209(a) + 20 dB per 15.35(b).	**Complies**
Frequencies & Bandwidth	Channel Scheme	n/a	Device transmits on discrete channels and does not make use of hopping	n/a
	Channel Selection	n/a	n/a	n/a
	Occupied Bandwidth	15.247(a)(2)	6 dB Occupied BW must be ≥ 500 kHz	**Complies**
	Number of Channels	n/a	n/a	n/a
	Channels Dwell Time	n/a	n/a	n/a
	Channel Separation	n/a	n/a	n/a

Definition of EUT

RULE PART NO.: FCC PART 15.3

(i) *Class B digital device.* A digital device that is marketed for use in a residential environment notwithstanding use in commercial, business and industrial environments. Examples of such devices include, but are not limited to, personal computers, calculators, and similar electronic devices that are marketed for use by the general public.

NOTE: The responsible party may also qualify a device intended to be marketed in a commercial, business or industrial environment as a Class B device, and in fact is encouraged to do so, provided the device complies with the technical specifications for a Class B digital device. In the event that a particular type of device has been found to repeatedly cause harmful interference to radio communications, the Commission may classify such a digital device as a Class B digital device, regardless of its intended use.

(k) *Digital device.* (Previously defined as a computing device). An unintentional radiator (device or system) that generates and uses timing signals or pulses at a rate in excess of 9,000 pulses (cycles) per second and uses digital techniques; inclusive of telephone equipment that uses digital techniques or any device or system that generates and uses radio frequency energy for the purpose of performing data processing functions, such as electronic computations, operations, transformations, recording, filing, sorting, storage, retrieval, or transfer. A radio frequency device that is specifically subject to an emanation requirement in any other FCC Rule part or an intentional radiator subject to subpart C of this part that contains a digital device is not subject to the standards for digital devices, provided the digital device is used only to enable operation of the radio frequency device and the digital device does not control additional functions or capabilities.

NOTE: Computer terminals and peripherals that are intended to be connected to a computer are digital devices.

(o) *Intentional radiator.* A device that intentionally generates and emits radio frequency energy by radiation or induction.

MEASUREMENT STANDARDS

Rule Part No.: FCC PART 15.31

(a) The following measurement procedures are used by the Commission to determine compliance with the technical requirements in this part. Except where noted, copies of these procedures are available from the Commission's current duplicating contractor whose name and address are available from the Commission's Consumer and Governmental Affairs Bureau at 1-888-CALL-FCC (1-888-225-5322).

(2) Unlicensed Personal Communications Service (UPCS) devices are to be measured for compliance using ANSI C63.17-2013: "American National Standard Methods of Measurement of the Electromagnetic and Operational Compatibility of Unlicensed Personal Communications Services (UPCS) Devices" (incorporated by reference, see §15.38).

(3) Other intentional radiators are to be measured for compliance using the following procedure: ANSI C63.10-2013 (incorporated by reference, see §15.38).

(e) For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

(l) Measurements of radio frequency emissions conducted to the public utility power lines shall be performed using a 50 ohm/50 uH line-impedance stabilization network (LISN).

(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

Frequency range over which device operates	**Number of frequencies**	**Location in the range of operation**
1 MHz or less	1	Middle.
1 to 10 MHz	2	1 near top and 1 near bottom.
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom.

(o) The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

FREQUENCY RANGE OF RADIATED MEASUREMENTS

Rule Part No.: FCC PART 15.33

§15.33 Frequency range of radiated measurements.

(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:

(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.

(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.

Frequency Range(s) of EUT

DTS	2400 – 2483.5 MHz

Testing Frequencies for EUT

DTS	2402, 2440, 2480 MHz

METHOD OF MEASUREMENT

Rule Part No.: FCC PART 15.35

§15.35 Measurement detector functions and bandwidths.

The conducted and radiated emission limits shown in this part are based on the following, unless otherwise specified in this part:

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long at the same bandwidth as indicated for CISPR quasi-peak measurements are employed.

(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, *e.g.,* see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, *e.g.,* the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

(c) Unless otherwise specified, *e.g.,* §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

DUTY CYCLE

FCC RULE PART NO.: KDB 558074 D01 v05r02 s. 6, ANSI C63.10 S. 4.1, S. 7.5

Requirements:

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (*i.e.*, with a duty cycle of greater than or equal to 98 %). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (*i.e.,* no transmitter off-time is to be considered).

When continuous transmission cannot be achieved and sweep triggering/signal gating cannot be implemented, alternate procedures are provided that can be used to measure the average power; however, they will require an additional measurement of the transmitter duty cycle. Within this guidance document, the duty cycle refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level. The duty cycle is considered to be constant if variations are less than ± 2 %, otherwise the duty cycle is considered to be non-constant.

The term "maximum power control level" is intended to distinguish between operating power levels of the EUT and differences in power levels of individual symbols that occur with some modulation types such as quadrature amplitude modulation (QAM). During testing, the EUT is not required to transmit continuously at its highest possible symbol power level. Rather, it should transmit all of the symbols and should do so at the highest power control level (*i.e.*, highest operating power level) of the EUT.

Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

a) A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on- and off-times of the transmitted signal.

b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on- and off-times of the transmitted signal.

  1) Set the center frequency of the instrument to the center frequency of the transmission.

  2) Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.

  3) Set detector = peak or average.

  4) The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100.

  (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≤ 16.7 microseconds.)

DUTY CYCLE

4.1.4.2.4 Average value of pulsed emissions

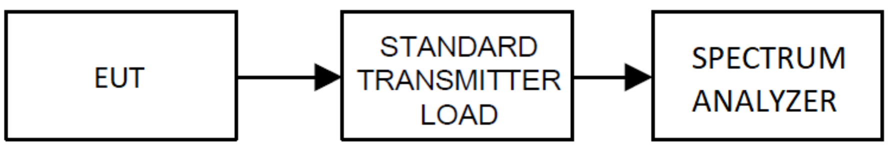
Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission and pulsed operation is employed, the average measurement shall be determined from the peak field strength after correcting for the worst-case duty cycle as described in 7.5. The exact method of calculating the average field strength shall be included in the test report.

7.5 Procedure for determining the average value of pulsed emissions

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval.[64] The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in Equation (10):

Test Procedure: ANSI C63.10 § 7.4

Test Setup:



DUTY CYCLE

Duty Cycle Formula: ANSI C63.10 Section 7.5, Equation 10:

$$\delta \text{ (dB)} = 20 \log [\Sigma (n_1 t_1 + n_2 t_2 \ldots) / T]$$

Where:

δ is the duty cycle correction factor (dB)
T is the pulse is the period that the pulses are averaged over
t_1 is the pulse width of subpulse 1
t_2 is the pulse width of subpulse 2 (and so on)
n_1 is the number of t_1 pulses
n_2 is the number of t_2 pulses (and so on)

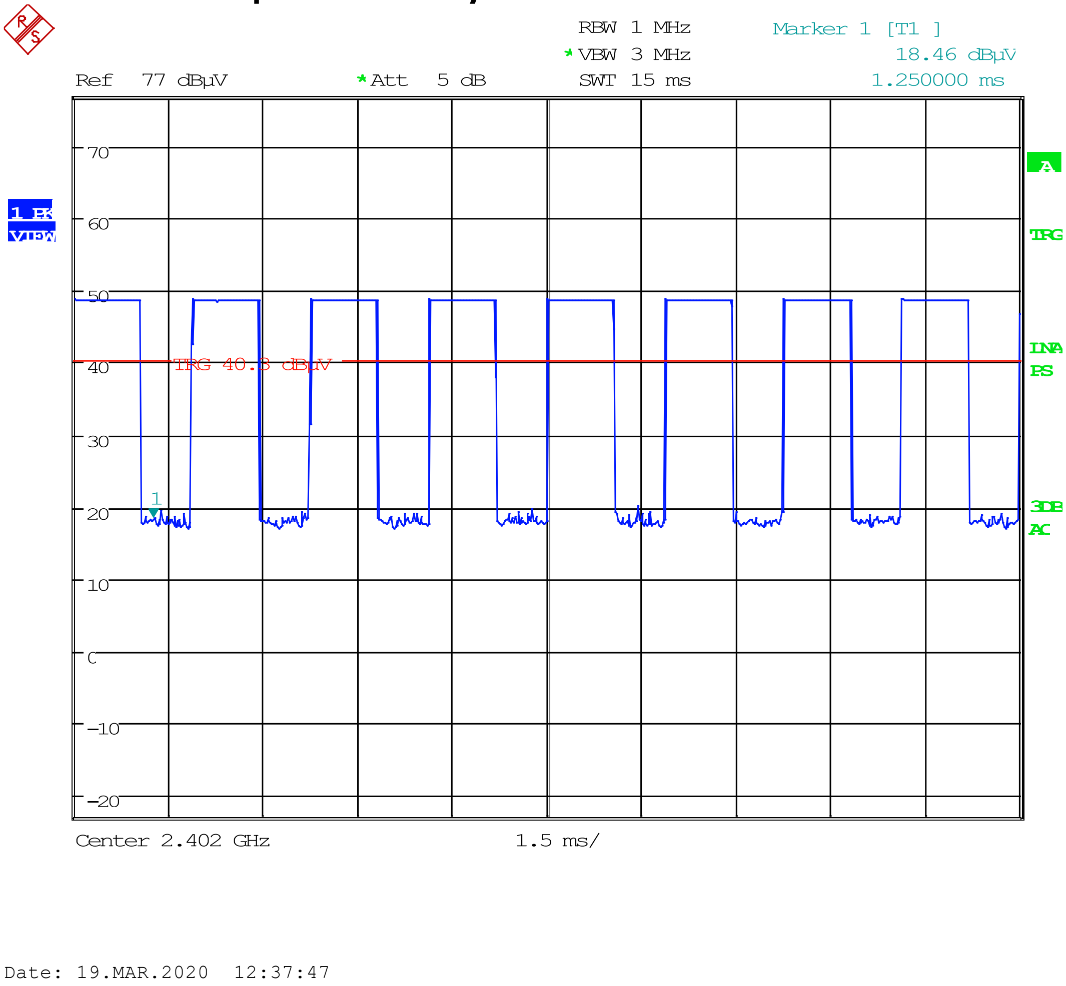
Test Data: Duty Cycle Calculation Table

Sub Pulse	Duration (ms)	Occurances	On-Time (ms)
1	1.0800	53	57.2400

Total On Time (ms)	57.2400
Period (ms)	100.00
Duty Cycle (%)	57.24%
Duty Cycle Correction Factor (dB)	-4.85

DUTY CYCLE

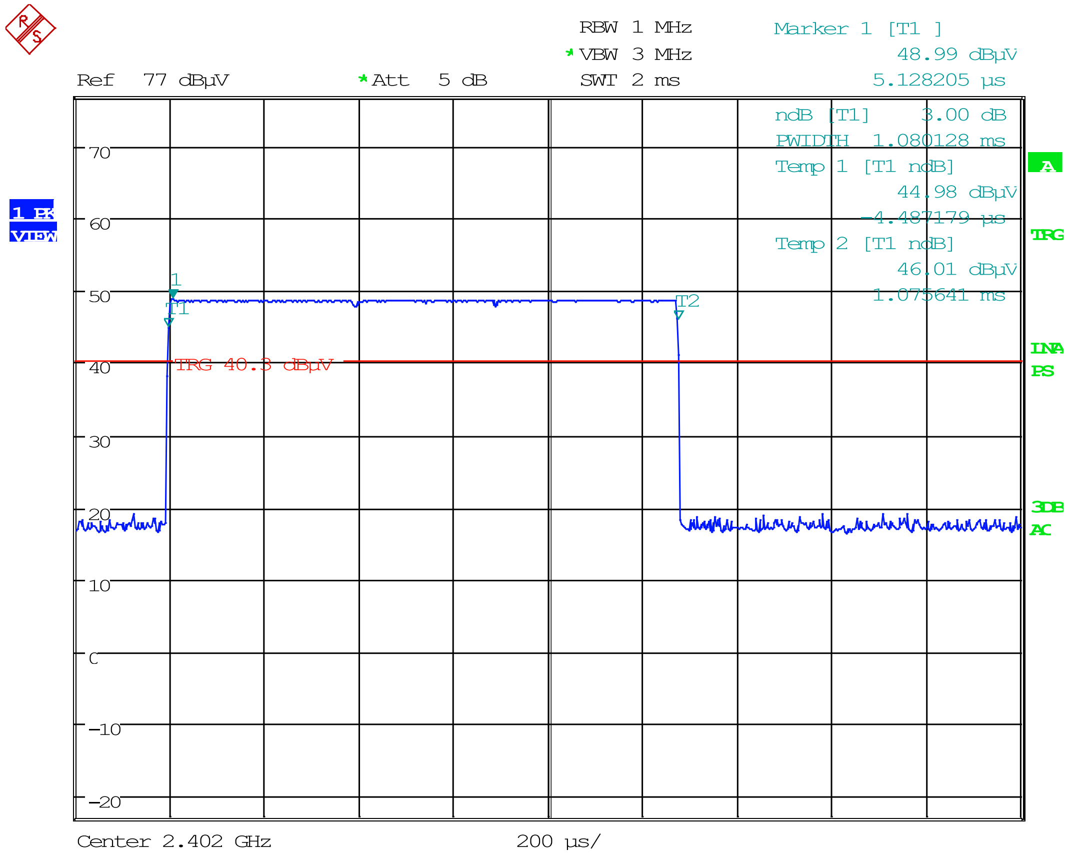
Test Data: Subpulse 1 Activity in 100 ms Plot



Subpulse 1 Occurances = 8

DUTY CYCLE

Test Data: Subpulse 1 Duration



Date: 19.MAR.2020 12:38:45

Subpulse 1 Duration = 1.08 ms

99% OCCUPIED BANDWIDTH

Rule Part No.: FCC 2.1049(h), 15.215(c)

Requirements: The 99% Bandwidth is for reporting only.

§15.215 Additional provisions to the general radiated emission limitations.

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, 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. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. 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.

OCCUPIED BANDWIDTH

Test Method: ANSI C63.10 § 6.9.3

6.9.3 Occupied bandwidth—power bandwidth (99%) measurement procedure

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Step a) through step c) might require iteration to adjust within the specified range.

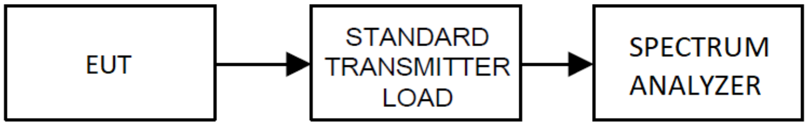
e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

    h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

OCCUPIED BANDWIDTH

Test Setup:

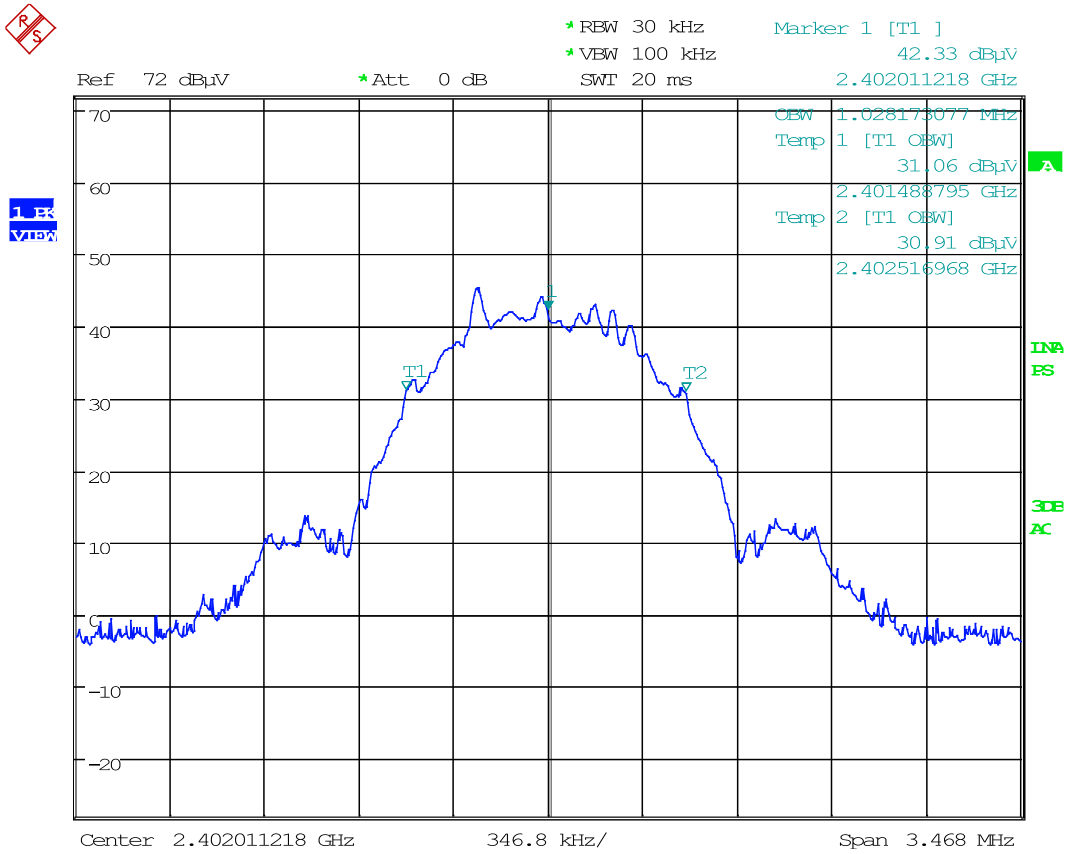


Test Data: Occupied Bandwidth Measurement Table

Tuned Frequency (MHz)	99% BW (MHz)
2402	1.03
2440	1.03
2480	1.02

OCCUPIED BANDWIDTH

Test Data: 99% Bandwidth, 2402 MHz

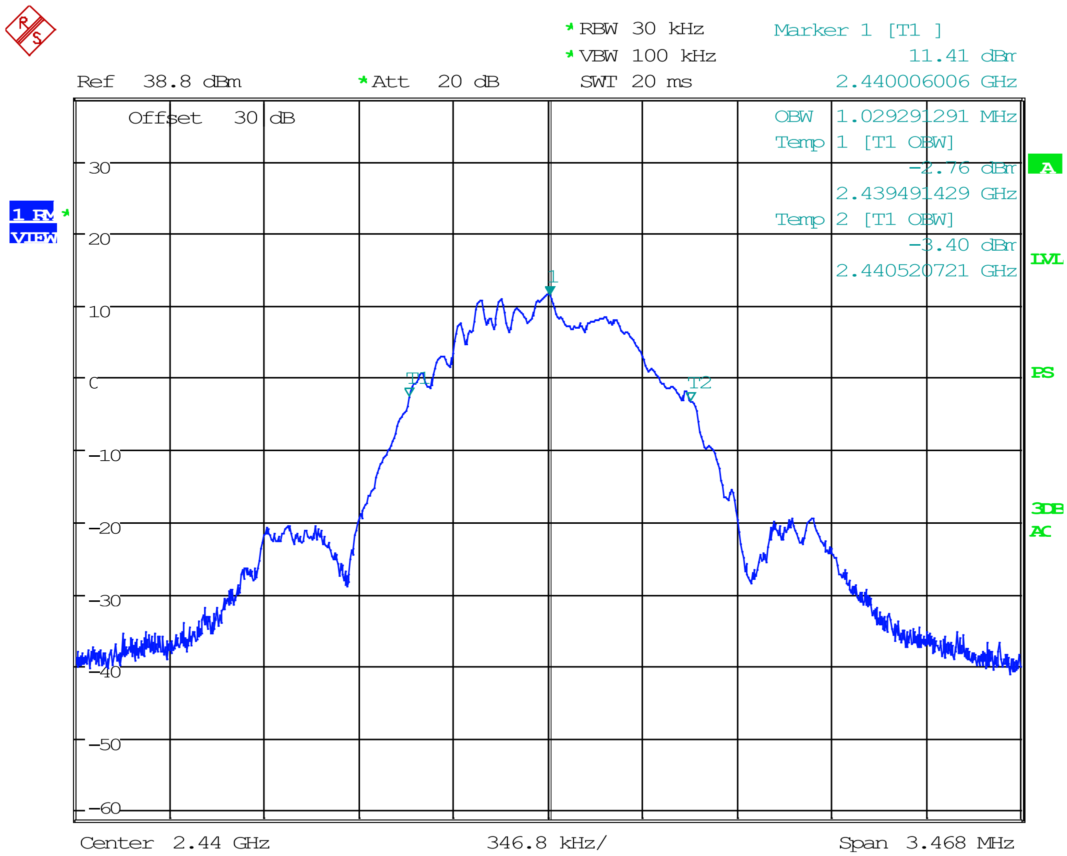


Date: 19.MAR.2020 16:50:38

RESULT: 99% OBW = 1.03 MHz

OCCUPIED BANDWIDTH

Test Data: **99% Bandwidth, 2440 MHz**

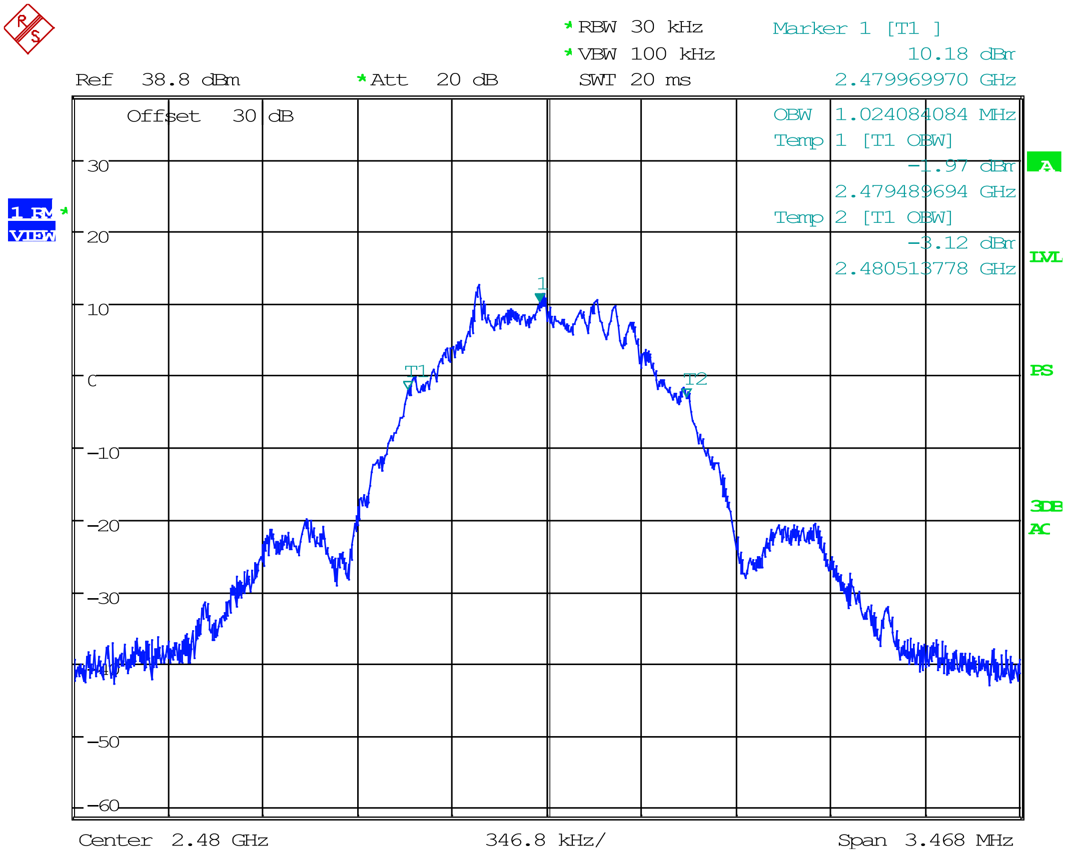


Date: 23.MAR.2020 12:35:17

RESULT: 99% OBW = 1.03 MHz

OCCUPIED BANDWIDTH

Test Data: 99% Bandwidth, 2480 MHz



Date: 24.MAR.2020 10:20:02

RESULT: 99% OBW = 1.02 MHz

DTS BANDWIDTH

Rule Part No.: FCC 15.247 (a)(2)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(2) Systems using digital modulation techniques 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.

Test Method: ANSI C63.10 § 11.8

11.8 DTS bandwidth

One of the following procedures may be used to determine the modulated DTS bandwidth.

11.8.1 Option 1

The steps for the first option are as follows:

a) Set RBW = 100 kHz.

b) Set the VBW ≥ [3 × RBW].

c) Detector = peak.

d) Trace mode = max hold.

e) Sweep = auto couple.

f) Allow the trace to stabilize.

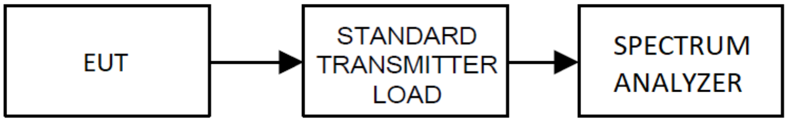
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

11.8.2 Option 2

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described in 11.8.1 (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, and peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥6 dB.

DTS BANDWIDTH

Test Setup:



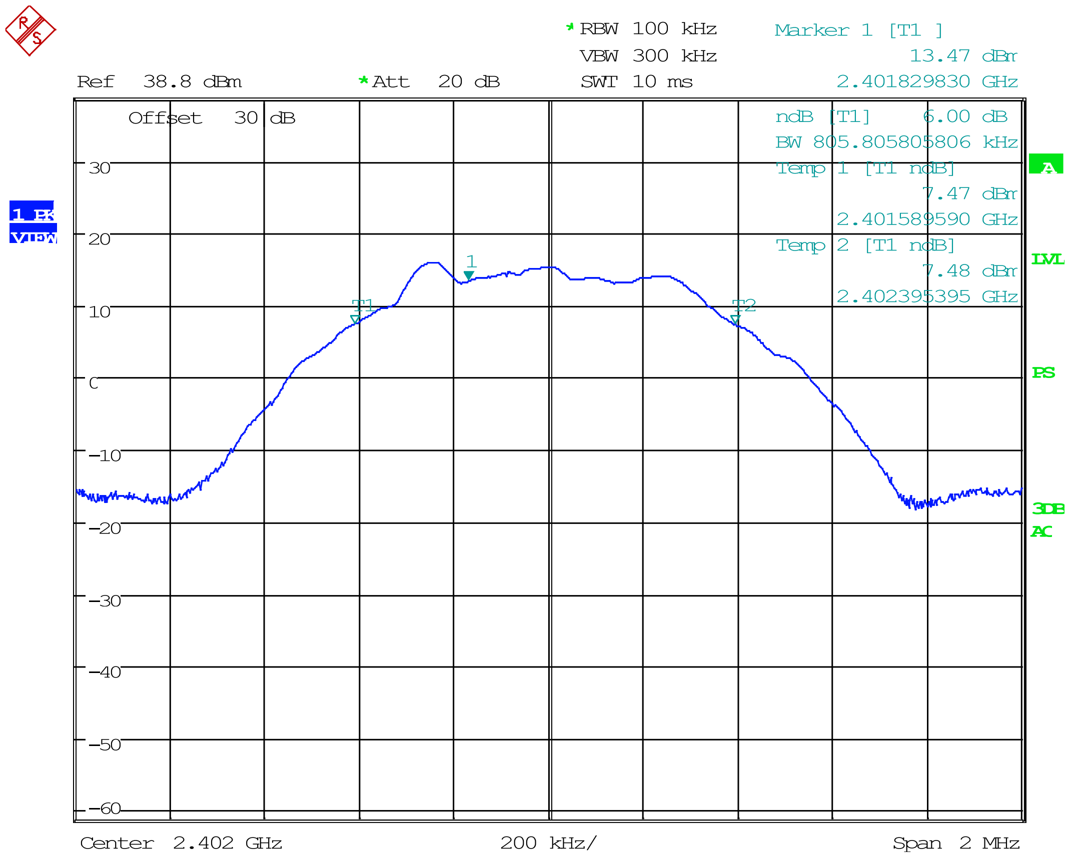
Test Data: DTS Bandwidth Measurement Table

Tuned Frequency (MHz)	DTS BW (kHz)
2402	805.8
2440	681.68
2480	677.67

Result: Complies.

DTS BANDWIDTH

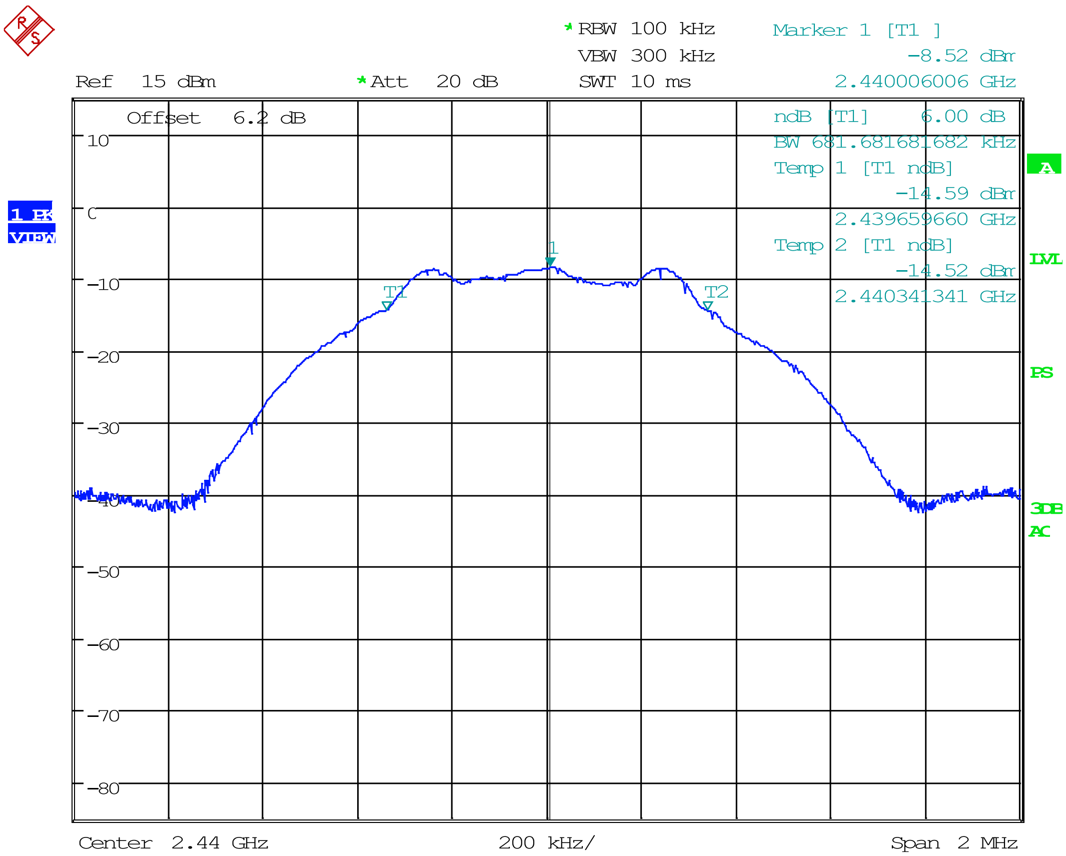
Test Data: **DTS Bandwidth, 2402 MHz**



Date: 26.MAR.2020 14:16:15

RESULT: DTS Bandwidth = 805.8 kHz

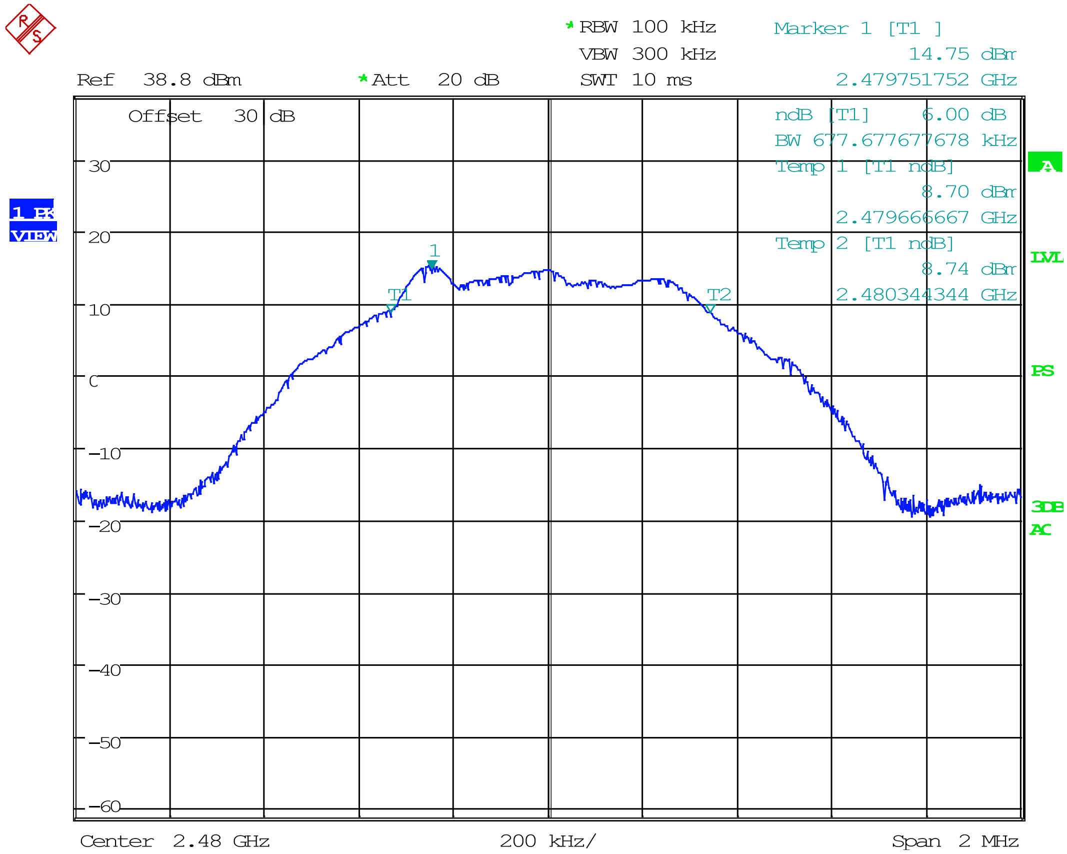
Test Data: DTS Bandwidth, 2440 MHz



Date: 23.MAR.2020 12:33:54

RESULT: DTS Bandwidth = 681.68 kHz

Test Data: DTS Bandwidth, 2480 MHz



Date: 24.MAR.2020 10:21:20

RESULT: DTS Bandwidth = 677.67 kHz

PEAK POWER SPECTRAL DENSITY

Rule Part No.: FCC 15.247(e)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test Method: ANSI C63.10 § 11.10

11.10.2 Method PKPSD (peak PSD)

The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

a) Set analyzer center frequency to DTS channel center frequency.

b) Set the span to 1.5 times the DTS bandwidth.

c) Set the RBW to 3 kHz $\leq$ RBW $\leq$ 100 kHz.

d) Set the VBW $\geq$ [3 $\times$ RBW].

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum amplitude level within the RBW.

j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

AVERAGE POWER SPECTRAL DENSITY

Rule Part No.: FCC 15.247(e)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

Test Method: ANSI C63.10 § 11.10

11.10.1 Selection of applicable test method

Some regulatory requirements specify a conducted PSD limit within the *DTS bandwidth* during any time interval of continuous transmission.[88] Such specifications require that the same method as used to determine the conducted output power shall be used to determine the power spectral density. If maximum peak conducted output power was measured, then the peak PSD procedure 11.10.2 (method PKPSD) shall be used. If maximum conducted output power was measured, then one of the average PSD procedures shall be used, as applicable based on the following criteria (the peak PSD procedure is also an acceptable option):

a) **Method AVGPSD-1** or **method AVGPSD-1A (alternative)** shall be applied if either of the following conditions can be satisfied:

   1) The EUT transmits continuously (or with a $D \geq 98\%$).

   2) Sweep triggering can be implemented in such a way that the device transmits at the maximum power control level throughout the duration of each of the instrument sweeps to be averaged. This condition can generally be achieved by triggering the instrument's sweep if the duration of the sweep is equal to or shorter than the duration T of each transmission from the EUT, and if those transmissions exhibit full power throughout these durations.

b) **Method AVGPSD-2** or **method AVGPSD-2A (alternative)** shall be applied if the conditions of the preceding item a) cannot be achieved, and the transmissions exhibit a constant duty cycle during the measurement duration. Duty cycle will be considered to be constant if variations are less than ±2%.

c) **Method AVGPSD-3** or **method AVGPSD-3A (alternative)** shall be applied if the conditions of the preceding paragraphs a) and b) cannot be achieved.

If the average PSD is measured with a power averaging (rms) detector or a sample detector, then the instrument shall be capable of using several measurement points in each sweep that is greater than or equal to twice the span / RBW, to set a bin-to-bin spacing of ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.

Where the measured power (peak conducted output power or maximum conducted output power) complies with the regulatory requirement for the PSD, then measurement of PSD is not required, provided that the PSD level is reported as being equal to the measured output power.

11.10.3 Method AVGPSD-1

Method AVGPSD-1 uses trace averaging with EUT transmitting at full power throughout each sweep.

The following procedure may be used when the maximum (average) conducted output power was used to determine compliance to the fundamental output power limit. This is the baseline method for determining the maximum (average) conducted PSD level. If the instrument has a power averaging (rms) detector, then it must be used; otherwise, use the sample detector. The EUT must be configured to transmit continuously ($D \geq 98\%$), or else sweep triggering/signal gating must be implemented to ensure that measurements are made only when the EUT is transmitting at its maximum power control level (no transmitter OFF time to be considered):

a) Set instrument center frequency to DTS channel center frequency.

b) Set span to at least 1.5 times the OBW.

c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

d) Set VBW ≥ [3 × RBW].

e) Detector = power averaging (rms) or sample detector (when rms not available).

f) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].

g) Sweep time = auto couple.

h) Employ trace averaging (rms) mode over a minimum of 100 traces.

i) Use the peak marker function to determine the maximum amplitude level.

j) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

11.10.4 Method AVGPSD-1A (alternative)

Method AVGPSD-1A uses rms detection with slow sweep speed and EUT transmitting continuously at full power.

The following procedure may be used as an alternative to 11.10.3 when the maximum (average) conducted output power was used to determine compliance to the fundamental output power limit and the EUT can be configured to transmit continuously ($D \geq 98\%$), or when sweep triggering and/or signal gating can be implemented to ensure that measurements are made only when the EUT is transmitting at its maximum power control level (no transmitter OFF time to be considered):

a) Set instrument center frequency to DTS channel center frequency.

b) Set the instrument span to 1.5 times the OBW.

c) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

d) Set the VBW ≥ [3 × RBW].

e) Detector = power average (rms).

f) Ensure that the number of measurement points in the sweep ≥ 2 × span / RBW.

g) Manually set the sweep time to: ≥ [10 × (number of measurement points in sweep) × (transmission symbol period)], but no less than the auto sweep time.

NOTE—The transmission symbol period (in seconds) is the reciprocal of the symbol rate (in baud or symbols per second). Note that each symbol can represent one or several data bits, and thus, the symbol rate should not be confused with the gross bit rate (expressed in bits/second). In no case should the sweep time be set less than the auto sweep time.

h) Perform the measurement over a single sweep.

i) Use the peak marker function to determine the maximum amplitude level.

j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

Average Power Spectral Density

11.10.5 Method AVGPSD-2

Method AVGPSD-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction.

The following procedure is applicable when the EUT cannot be configured to transmit continuously (i.e., $D < 98\%$), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is constant (i.e., duty cycle variations are less than ±2%):

a) Measure the duty cycle (D) of the transmitter output signal as described in 11.6.

b) Set instrument center frequency to DTS channel center frequency.

c) Set span to at least 1.5 times the OBW.

d) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

e) Set VBW ≥ [3 × RBW].

f) Detector = power averaging (rms) or sample detector (when rms not available).

g) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].

h) Sweep time = auto couple.

i) Do not use sweep triggering; allow sweep to "free run."

j) Employ trace averaging (rms) mode over a minimum of 100 traces.

k) Use the peak marker function to determine the maximum amplitude level.

l) Add [10 log (1 / D)], where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time.

m) If measured value exceeds requirement specified by regulatory agency, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

11.10.6 Method AVGPSD-2A (alternative)

Method AVGPSD-2A uses rms detection with slow sweep speed with spectrum bin averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction.

The following procedure is applicable as an alternative to 11.10.5 when the EUT cannot be configured to transmit continuously (i.e., $D < 98\%$), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is constant (i.e., duty cycle variations are less than ±2%):

a) Measure the duty cycle (D) of the transmitter output signal as described in 11.6.

b) Set instrument center frequency to DTS channel center frequency.

c) Set the instrument span to 1.5 times the OBW.

d) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

e) Set the VBW ≥ 3 × RBW.

f) Detector = power average (rms).

g) Ensure that the number of measurement points in the sweep ≥ 2 × span / RBW.

h) Manually set the sweep time to: ≥ 10 × (number of measurement points in sweep) × (total ON/OFF period of the transmitted signal).

i) Do not use sweep triggering. Allow sweep to “free run.”

j) Perform the measurement over a single sweep.

k) Use the peak marker function to determine the maximum amplitude level.

l) Add [10 log (1 / D)], where D is the duty cycle measured in step a), to the measured PSD to compute the average PSD during the actual transmission time.

m) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

11.10.7 Method AVGPSD-3

Method AVGPSD-3 uses rms detection across ON and OFF times of the EUT with max hold.

The following procedure is applicable when the EUT cannot be configured to transmit continuously (i.e., $D < 98\%$), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is not constant (i.e., duty cycle variations exceed ±2%):

a) Set the instrument span to a minimum of 1.5 times the OBW.

b) Set sweep trigger to "free run."

c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

d) Set VBW ≥ [3 × RBW].

e) Number of points in sweep ≥ [2 × span / RBW]. (This ensures that bin-to-bin spacing is ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Sweep time ≤ (number of points in sweep) × *T*, where *T* is defined in 11.6.

NOTE—If this results in a sweep time less than the auto sweep time of the instrument, then this method shall not be used (use AVGPSD-2A instead). The purpose of this step is to ensure that averaging time in each bin is less than or equal to the minimum time of a transmission.

g) Detector = RMS (power averaging).

h) Trace mode = max hold.

i) Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize.

j) Use the peak marker function to determine the maximum PSD level.

k) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

Average Power Spectral Density

11.10.8 Method AVGPSD-3A (alternative)

Method AVGPSD-3A uses reduced VBW averaging across ON and OFF times of the EUT with max hold.

The following procedure is applicable as an alternative to 11.10.7 when the EUT cannot be configured to transmit continuously (i.e., $D < 98\%$), when sweep triggering/signal gating cannot be used to measure only when the EUT is transmitting at its maximum power control level, and when the transmission duty cycle is not constant (i.e., duty cycle variations exceed ±2%):

a) Set the instrument span to a minimum of 1.5 times the OBW.

b) Set sweep trigger to "free run."

c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

d) Set VBW ≥ 1/ T, where T is defined in 11.6.

e) Number of points in sweep ≥ [2 × span / RBW]. (This ensures that bin-to-bin spacing is ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Sweep time = auto.

g) Detector = peak.

h) Video filtering shall be applied to a voltage-squared or power signal (i.e., rms mode), if possible. Otherwise, it shall be set to operate on a linear voltage signal (which can require use of linear display mode). Log mode shall not be used:

    1) The preferred voltage-squared (i.e., power or rms) mode is selected on some instruments by setting the "average-VBW type" to power or rms.

    2) If rms mode is not available, then linear voltage mode is selected on some analyzers by setting the display mode to linear. Other instruments have a setting for "average-VBW type" that can be set to "voltage" regardless of the display mode.

i) Trace mode = max hold.

j) Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize.

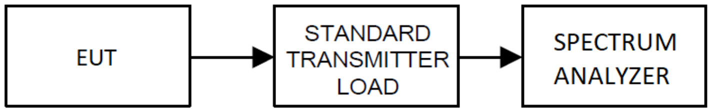
k) Use the peak marker function to determine the maximum PSD level.

l) If linear mode was used in step h), then add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.

m) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

Power Spectral Density

Test Setup:



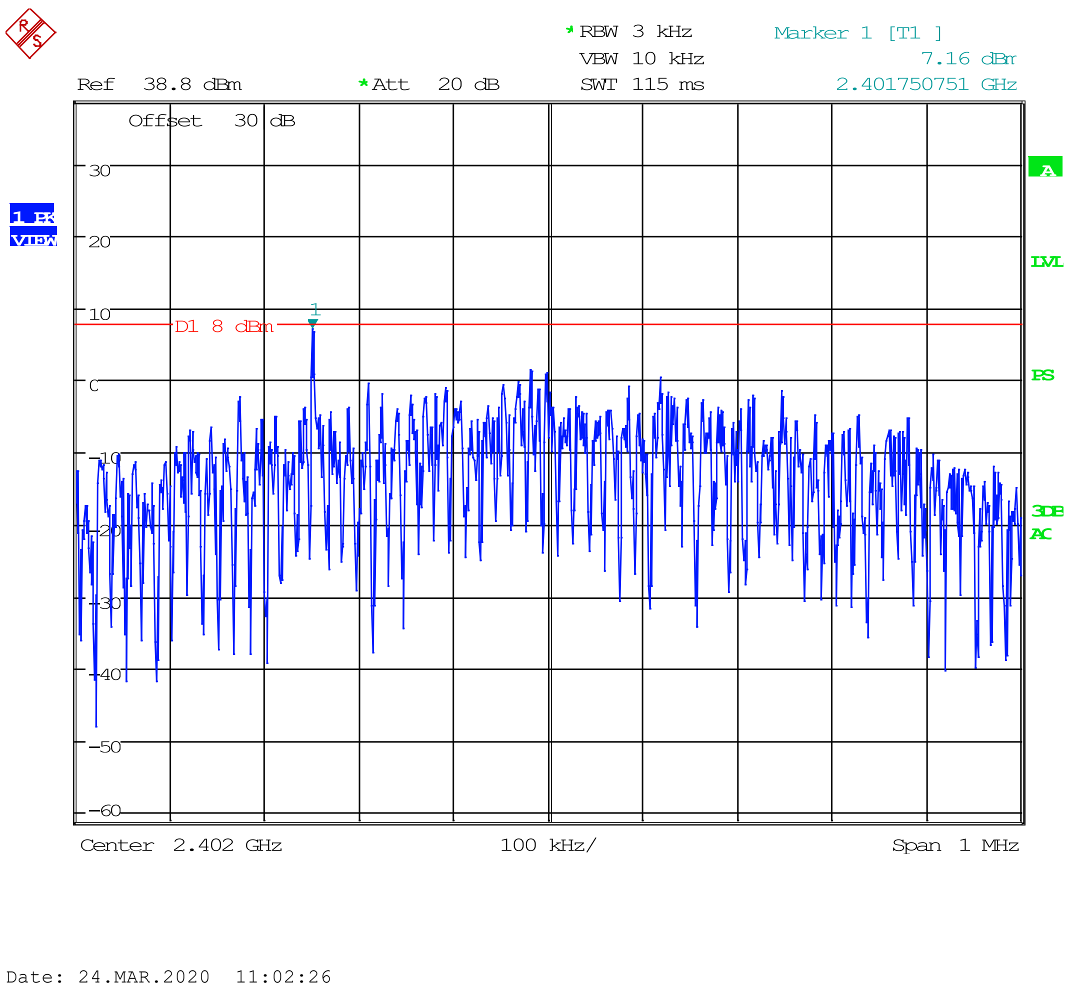
Test Data: PSD Measurement Table

Tuned Frequency (MHz)	PSD Level (dBm)
2402	7.16
2440	7.7
2480	5.98

Result: Complies.

Power Spectral Density

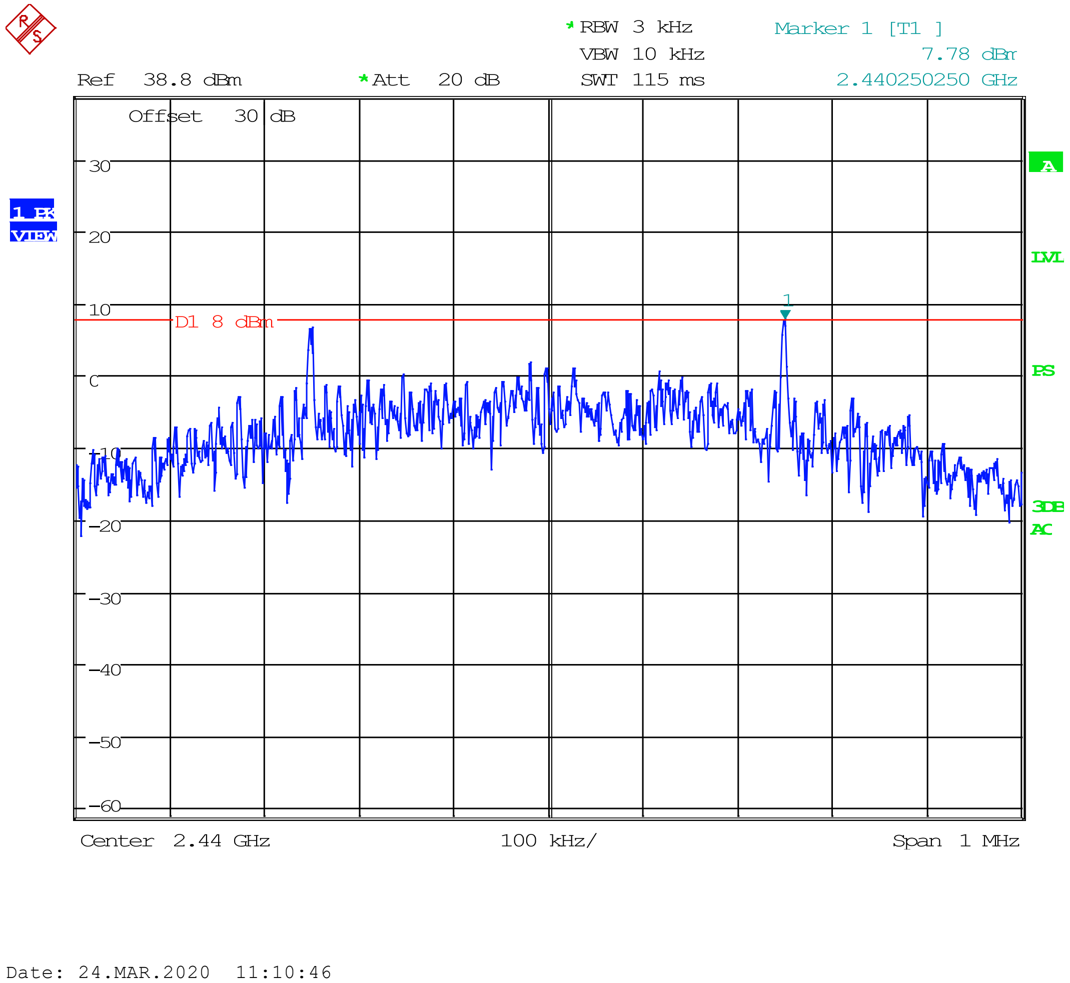
Test Data: PSD 2402 MHz



RESULT: PSD = 7.16 dBm

Power Spectral Density

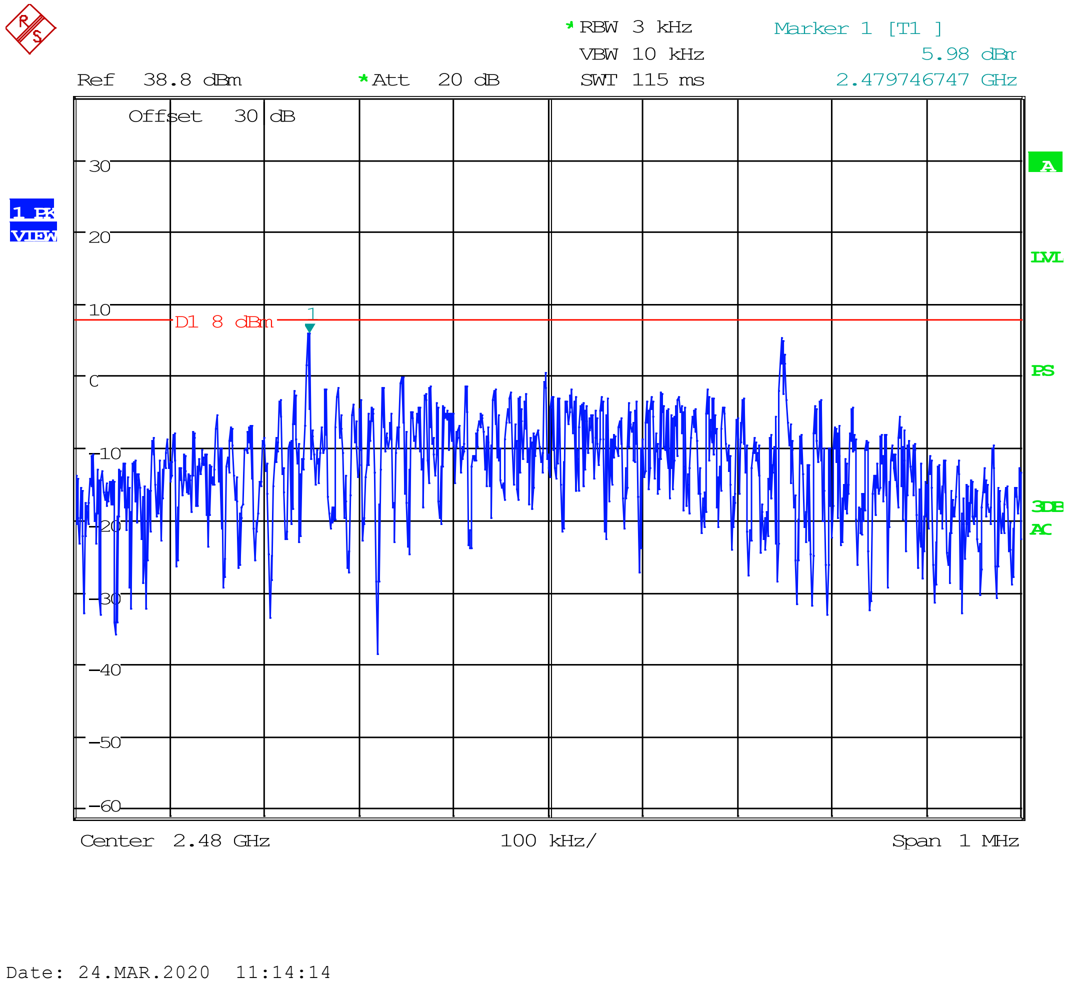
Test Data: **PSD 2440 MHz**



RESULT: PSD = 7.7 dBm

Power Spectral Density

Test Data: **PSD 2480 MHz**



RESULT: PSD = 5.98 dBm

PEAK POWER OUTPUT

Rules Part No.: FCC 15.247(b)(3)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

Test Method: ANSI C63.10 § 11.9

11.9.1 Maximum peak conducted output power

One of the following procedures may be used to determine the maximum peak conducted output power of a DTS EUT.

POWER OUTPUT

11.9.1.1 RBW ≥ DTS bandwidth

The following procedure shall be used when an instrument with a resolution bandwidth that is greater than the DTS bandwidth is available to perform the measurement:

a) Set the RBW ≥ DTS bandwidth.

b) Set VBW ≥ [3 × RBW].

c) Set span ≥ [3 × RBW].

d) Sweep time = auto couple.

e) Detector = peak.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use peak marker function to determine the peak amplitude level.

11.9.1.2 Integrated band power method

The following procedure can be used when the maximum available RBW of the instrument is less than the DTS bandwidth:

a) Set the RBW = 1 MHz.

b) Set the VBW ≥ [3 × RBW].

c) Set the span ≥ [1.5 × DTS bandwidth].

d) Detector = peak.

e) Sweep time = auto couple.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use the instrument's band/channel power measurement function with the band limits set equal to the DTS bandwidth edges (for some instruments, this may require a manual override to select the peak detector). If the instrument does not have a band power function, then sum the spectrum levels (in linear power units) at intervals equal to the RBW extending across the DTS channel bandwidth.

11.9.1.3 PKPM1 Peak power meter method

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall use a fast-responding diode detector.

AVERAGE POWER OUTPUT

Rules Part No.: FCC 15.247(b)(3)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

Test Method: ANSI C63.10 § 11.9

11.9.1 Maximum peak conducted output power

One of the following procedures may be used to determine the maximum peak conducted output power of a DTS EUT.

AVERAGE POWER OUTPUT

11.9.2.1 General

Some regulatory agencies permit the maximum conducted (average) output power to be measured as an alternative to the maximum peak conducted output power for determining compliance to the limit. When this option is exercised, the measured power is to be referenced to the OBW rather than to the DTS bandwidth (see 11.2 for definitions and 6.9.2 for measurement guidance).

When using a spectrum analyzer or EMI receiver to perform these measurements, it shall be capable of utilizing a number of measurement points in each sweep that is greater than or equal to twice the span / RBW, to set a bin-to-bin spacing of ≤ RBW / 2 so that narrowband signals are not lost between frequency bins. If possible, configure or modify the operation of the EUT so that it transmits continuously at its maximum power control level (see 11.6).

The intent is to test at 100% duty cycle; however, a small reduction in duty cycle (to no lower than 98%) is permitted, if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test laboratory to permit such continuous operation.

If continuous transmission (or at least 98% duty cycle) cannot be achieved because of hardware limitations (e.g., overheating), the EUT shall be operated at its maximum power control level, with the transmit duration as long as possible, and the duty cycle as high as possible during which sweep triggering/signal gating techniques may be used to perform the measurement over the transmission duration.

11.9.2.2 Measurement using a spectrum analyzer (SA)

11.9.2.2.1 Selection of test method

The proper test method is selected based on the following criteria:

a) **Method AVGSA-1** or **method AVGSA-1A (alternative)** shall be applied if either of the following conditions can be satisfied:

   1) The EUT transmits continuously (or with a $D \geq 98\%$).

   2) Sweep triggering can be implemented in such a way that the device transmits at the maximum power control level throughout the duration of each of the instrument sweeps to be averaged. This condition can generally be achieved by triggering the instrument's sweep if the duration of the sweep (with the instrument configured as in method AVGSA-1) is equal to or shorter than the duration T of each transmission from the EUT, and if those transmissions exhibit full power throughout their durations.

b) **Method AVGSA-2** or **method AVGSA-2A (alternative)** shall be applied if the conditions of the preceding item a) cannot be achieved and the transmissions exhibit a constant duty cycle during the measurement duration. Duty cycle will be considered to be constant if variations are less than ±2%.

c) **Method AVGSA-3** or **method AVGSA-3A (alternative)** shall be applied if the conditions of the preceding item a) and item b) cannot be achieved.

11.9.2.2.2 Method AVGSA-1

Method AVGSA-1 uses trace averaging with the EUT transmitting at full power throughout each sweep. The procedure for this method is as follows:

a) Set span to at least 1.5 times the OBW.

b) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

c) Set VBW ≥ [3 × RBW].

d) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

e) Sweep time = auto.

f) Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.

g) If transmit duty cycle < 98%, use a sweep trigger with the level set to enable triggering only on full power pulses. The transmitter shall operate at the maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no OFF intervals) or at duty cycle ≥ 98%, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run."

h) Trace average at least 100 traces in power averaging (rms) mode.

i) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function, with band limits set equal to the OBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

11.9.2.2.3 Method AVGSA-1A (alternative)

Method AVGSA-1A uses rms detection with slow sweep and EUT transmitting continuously at full power. The procedure for this method is as follows:

a) Set span to at least 1.5 times the OBW.

b) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

c) Set VBW ≥ [3 × RBW].

d) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

e) Manually set sweep time ≥ [10 × (number of points in sweep) × (transmission symbol period)], but not less than the automatic default sweep time.

NOTE—The transmission symbol period (in seconds) is the reciprocal of the symbol rate (in baud or symbols per second). Note that each symbol can represent one or several data bits, and thus, the symbol rate should not be confused with the gross bit rate (expressed in bits/second). In no case should the sweep time be set less than the auto sweep time.

f) Set detector = RMS (power averaging).

g) The EUT shall be operated at ≥98% duty cycle or sweep triggering/signal gating shall be employed such that the sweep time is less than or equal to the transmission duration *T*.

h) Perform a single sweep.

i) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function, with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

11.9.2.2.4 Method AVGSA-2

Method AVGSA-2 uses trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

a) Measure the duty cycle D of the transmitter output signal as described in 11.6.

b) Set span to at least 1.5 times the OBW.

c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

d) Set VBW $\geq$ [3 $\times$ RBW].

e) Number of points in sweep $\geq$ [2 $\times$ span / RBW]. (This gives bin-to-bin spacing $\leq$ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Sweep time = auto.

g) Detector = RMS (i.e., power averaging), if available. Otherwise, use the sample detector mode.

h) Do not use sweep triggering. Allow the sweep to "free run."

i) Trace average at least 100 traces in power averaging (rms) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the ON and OFF periods of the transmitter.

j) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

k) Add [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times (because the measurement represents an average over both the ON and OFF times of the transmission). For example, add [10 log (1/0.25)] = 6 dB if the duty cycle is 25%.

POWER OUTPUT

11.9.2.2.5 Method AVGSA-2A (alternative)

Method AVGSA-2A uses rms detection with slow sweep with spectrum bin averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction. The procedure for this method is as follows:

a) Measure the duty cycle D of the transmitter output signal as described in 11.6.

b) Set span to at least 1.5 times the OBW.

c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

d) Set VBW ≥ [3 × RBW].

e) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Manually set sweep time ≥ [10 × (number of points in sweep) × (total ON/OFF period of the transmitted signal)].

g) Set detector = RMS (power averaging).

h) Perform a single sweep.

i) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW.

j) Add [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times.

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11.9.2.2.6 Method AVGSA-3

Method AVGSA-3 uses rms detection across ON and OFF times of the EUT with max hold. The procedure for this method is as follows:

a) Set span to at least 1.5 times the OBW.

b) Set sweep trigger to "free run."

c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

d) Set VBW ≥ [3 × RBW].

e) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Sweep time ≤ (number of points in sweep) × *T*, where *T* is defined in 11.6. If this gives a sweep time less than the auto sweep time of the instrument, then method AVGSA-3 shall not be used (use AVGSA-3A). The purpose of this step is so that the averaging time in each bin is less than or equal to the minimum time of a transmission.

g) Detector = RMS (power averaging).

h) Trace mode = max hold.

i) Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize.

j) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, then sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW.

11.9.2.2.7 Method AVGSA-3A (alternative)

Method AVGSA-3A uses reduced VBW averaging across ON and OFF times of the EUT with max hold. The procedure for this method is as follows:

a) Set span to at least 1.5 times the OBW.

b) Set sweep trigger to "free run."

c) Set RBW = 1% to 5% of the OBW, not to exceed 1 MHz.

d) Set VBW ≥ 1 / *T*, where *T* is defined in 11.6).

e) Number of points in sweep ≥ [2 × span / RBW]. (This gives bin-to-bin spacing ≤ RBW / 2, so that narrowband signals are not lost between frequency bins.)

f) Sweep time = auto.

g) Detector = peak.

h) Video filtering shall be applied to a voltage-squared or power signal (i.e., rms mode), if possible. Otherwise, it shall be set to operate on a linear voltage signal (which can require use of linear display mode). Log mode shall not be used.

  1) The preferred voltage-squared (i.e., power or rms) mode is selected on some instruments by setting the "average-VBW type" to power or rms.

  2) If rms mode is not available, then linear voltage mode is selected on some instruments by setting the display mode to linear. Other instruments have a setting for "Average-VBW Type" that can be set to "voltage" regardless of the display mode.

i) Trace mode = max hold.

j) Allow max hold to run for at least 60 s or longer as needed to allow the trace to stabilize.

k) Compute power by integrating the spectrum across the 26 dB OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW.

l) If linear mode was used in step h), then add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.

11.9.2.3 Measurement using a power meter (PM)

11.9.2.3.1 Method AVGPM

Method AVGPM is a measurement using an RF average power meter, as follows:

a) As an alternative to spectrum analyzer or EMI receiver measurements, measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied:

   1) The EUT is configured to transmit continuously, or to transmit with a constant duty cycle.

   2) At all times when the EUT is transmitting, it shall be transmitting at its maximum power control level.

   3) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

b) If the transmitter does not transmit continuously, measure the duty cycle, *D*, of the transmitter output signal as described in 11.6.

c) Measure the average power of the transmitter. This measurement is an average over both the ON and OFF periods of the transmitter.

d) Adjust the measurement in dBm by adding [10 log (1 / *D*)], where *D* is the duty cycle.

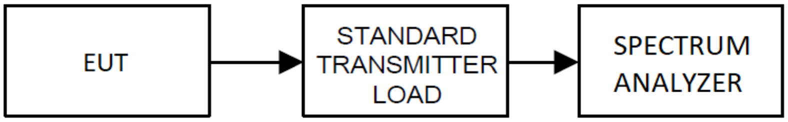
11.9.2.3.2 Method AVGPM-G

Method AVGPM-G is a measurement using a gated RF average power meter.

Alternatively, measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Because the measurement is made only during the ON time of the transmitter, no duty cycle correction factor is required.

POWER OUTPUT

Test Setup:



Test Data: Power Output Measurement Table

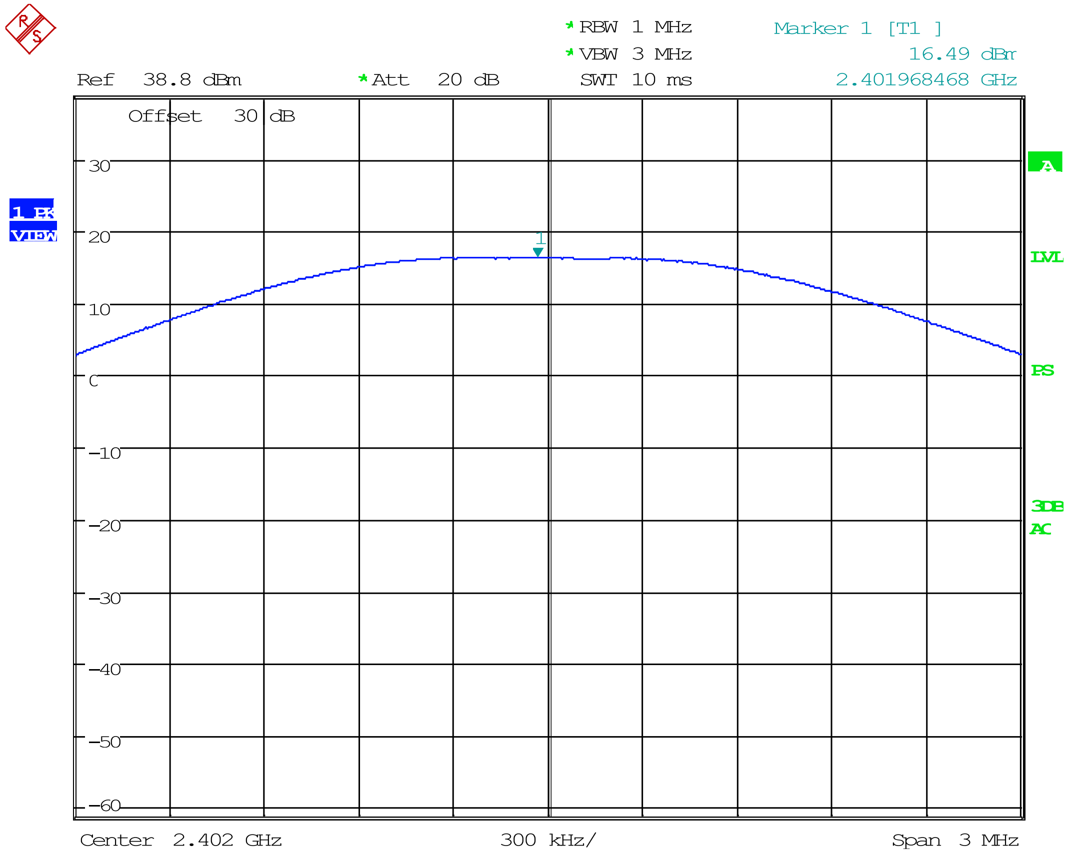
Tuned Frequency (MHz)	Power Output (dBm)
2402	16.49
2440	16.35
2480	15.81

Result: Complies.

Maximum Power Output: 16.49 dBm

POWER OUTPUT

Test Data: **Power Output 2402 MHz**

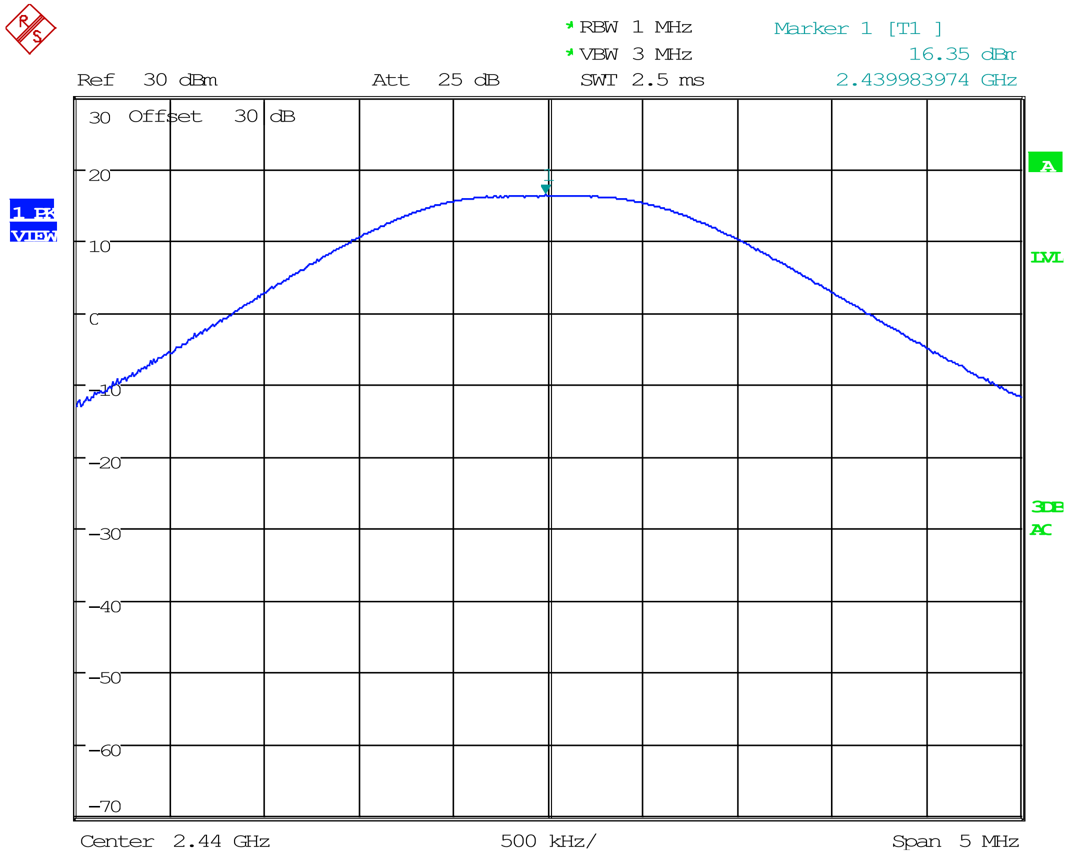


Date: 24.MAR.2020 10:54:06

RESULT: Power Output = 16.49 dBm

POWER OUTPUT

Test Data: **Power Output 2440 MHz**

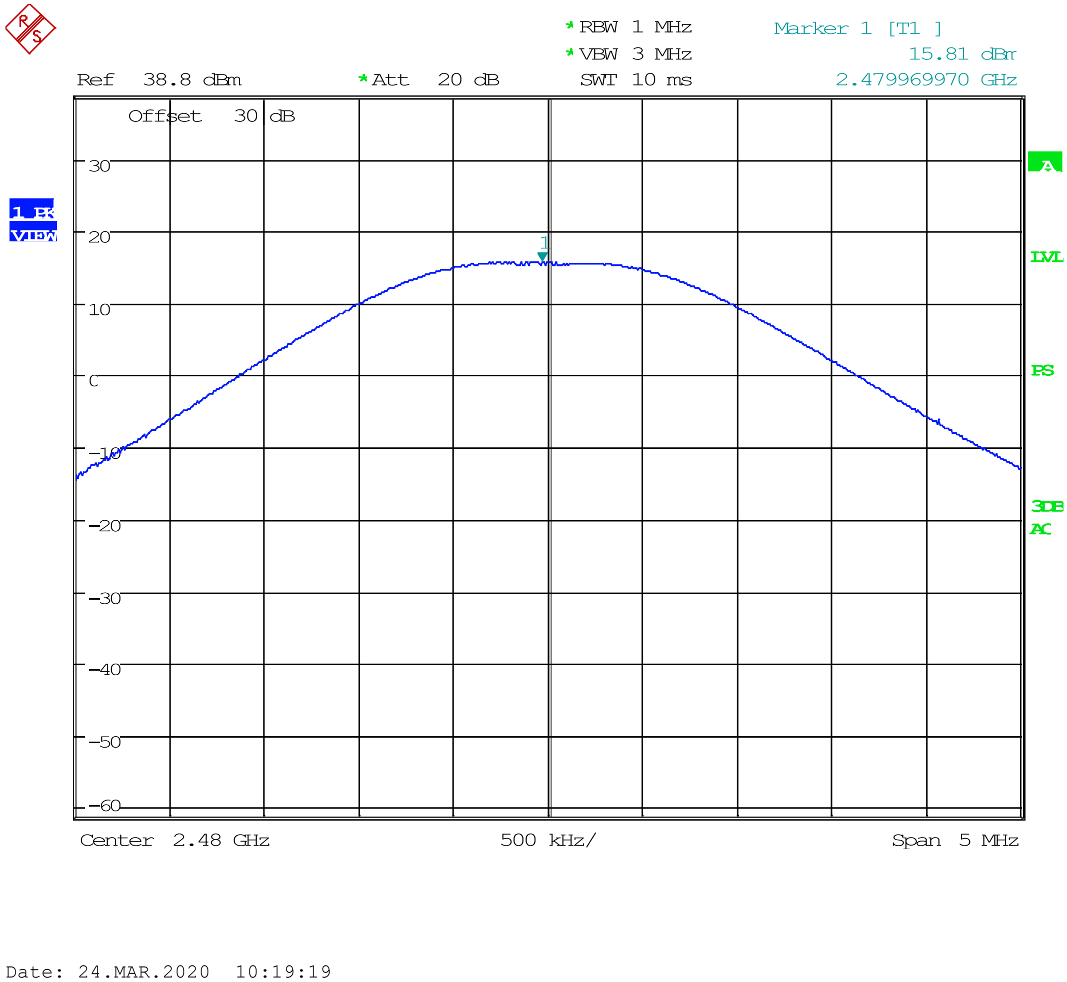


Date: 23.MAR.2020 12:31:34

RESULT: Power Output = 16.35 dBm

POWER OUTPUT

Test Data: **Power Output 2480 MHz**



RESULT: Power Output = 15.81 dBm

AUTHORIZED BANDEDGE EMISSIONS

Rule Part No.: FCC 15.247(d)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(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)).

Test Method: ANSI C63.10 § 6.10.4

6.10.4 Authorized-band band-edge measurements (relative method)

These procedures are applicable for determining compliance at authorized-band band-edges where the requirements are expressed as a value relative to the in-band signal level. Procedures for determining compliance with field strength limits at or close to the band-edges are given in 6.10.6 (see also Table A.2).

Band-edge tests are typically performed as a conducted test but may be performed as radiated measurements on a test site meeting the specifications in 5.2, at the measurement distances specified in 5.3. The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2.

When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3.

For other than frequency-hopping devices, this test sequence shall be performed once.

AUTHORIZED BANDEDGE EMISSIONS

a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).

b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).

c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent "normal mode of operation" as specified in 6.10.3.

d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.

e) Perform the test as follows:

  1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.

  2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

  3) Attenuation: Auto (at least 10 dB preferred).

  4) Sweep time: Coupled.

  5) Resolution bandwidth: 100 kHz.[56]

  6) Video bandwidth: 300 kHz.[56]

  7) Detector: Peak.[56]

  8) Trace: Max hold.[56]

f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.

g) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

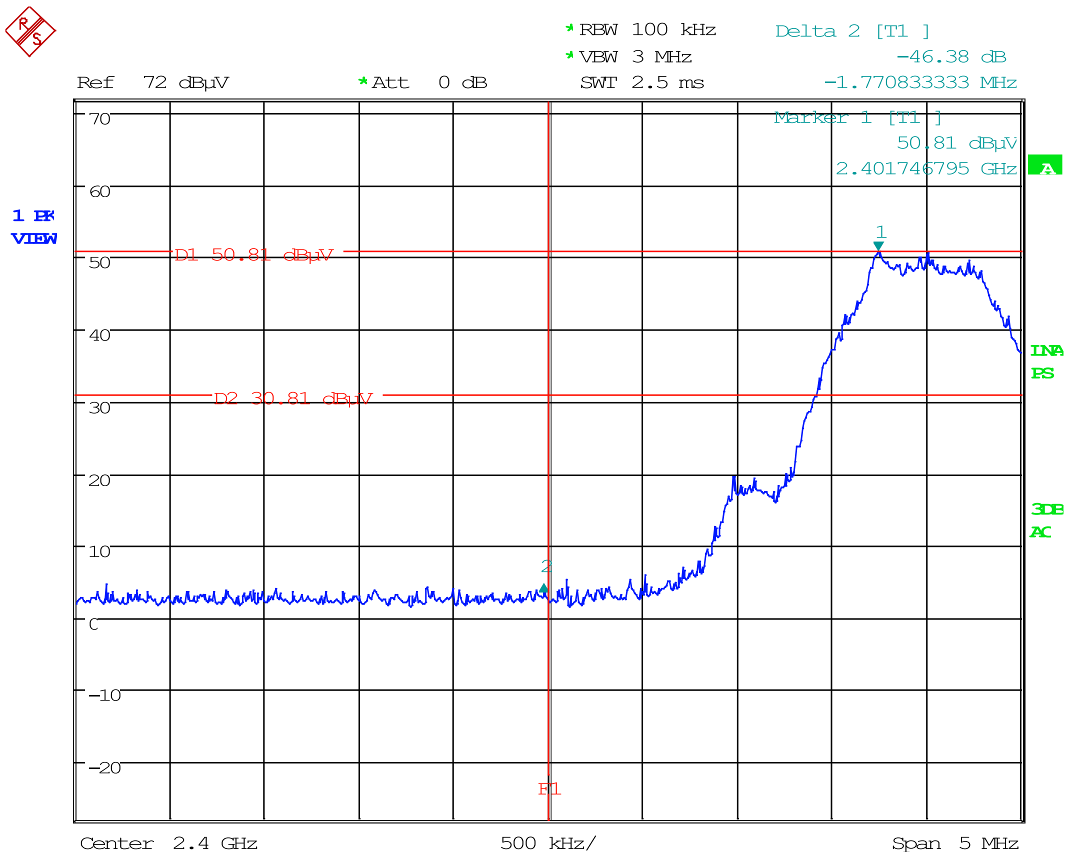
h) Repeat step c) through step e) for every applicable modulation.

i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).

j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

BANDEDGE EMISSIONS

Test Data: **Lower Band Edge Plot**



Date: 19.MAR.2020 16:49:04

RESULT: Meets Requirements

BANDEDGE EMISSIONS

RESTRICTED BANDEDGE EMISSIONS

Rule Part No.: FCC 15.247(d), KDB 558074 D01 v05r02 c) 1)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(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)).

Test Method: ANSI C63.10 § 6.10.5

6.10.5.1 Test setup

Restricted-band band-edge tests shall be performed as radiated measurements, on a test site meeting the specifications in 5.2 at the measurement distances specified in 5.3.[57]

The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2. Considering the requirements of 5.8, the antenna(s) shall be connected to the antenna ports. When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3, and the relevant procedure in 6.4, 6.5, or 6.6.

6.10.5.2 Test methodology

The following test methodology shall be used for the restricted-band band-edge measurements:

a) For frequency-hopping systems, the hopping shall be turned OFF during this test.

b) Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).

c) Set the unlicensed wireless device to the lowest frequency channel.

d) Set the unlicensed wireless device to operate at maximum output power and 100% duty cycle, or equivalent "normal mode of operation" as specified in 6.10.3.

e) Perform the test as follows:

   1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.

   2) Reference level offset: Corrected for gains and losses of test antenna factor, preamp gain and cable loss, so as to indicate field strength, in units of dBμV/m at 3 m, directly on the instrument display. Alternatively, the reference level offset may be set to zero and calculations shall be provided showing the conversion of raw measured data to the field strength in dBμV/m at 3 m.

   3) Reference level: As required to keep the signal from exceeding the maximum spectrum analyzer input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

   4) Attenuation: Auto (at least 10 dB preferred).

   5) Sweep time: Coupled.

6.10.5.2 Con't.

6) Resolution bandwidth:

   i) Below 150 kHz: 300 Hz or CISPR 200 Hz (CISPR 200 Hz required if using QP detector)

   ii) 150 kHz to 30 MHz: 10 kHz or CISPR 9 kHz, (CISPR 9 kHz required if using QP detector)

   iii) 30 MHz to 1000 MHz: 100 kHz or CISPR 120 kHz, (CISPR 120 kHz required if using QP detector)

   iv) Above 1 GHz: 1 MHz

7) Video bandwidth:

   i) VBW for Peak, Quasi-peak, or Average Detector Function: 3 × RBW

   ii) VBW for alternative average measurements using peak detector function; refer to 4.1.4.2.3

8) Detector (unless specified otherwise):

   i) QP below 1 GHz (however, peak detector measurements may be used to determine compliance with QP requirements).

   ii) Peak and average above 1 GHz

9) Trace: Max hold for final measurement; a combination of two traces, clear-write and max hold, is recommended for maximizing the emission.

f) Using the applicable procedure(s) of 6.4, 6.5, or 6.6, orient the EUT and measurement antenna positions to produce the highest emission level.

g) Set the marker on the emission at the restricted band edge, or on the highest modulation product within the restricted band, if this level is greater than that at the band edge.

h) Repeat step d) through step g) for every applicable modulation.

i) Repeat step d) through step h) for the highest gain of each type of antenna to be used with the EUT.

j) Set the EUT to the highest frequency channel and repeat step d) through step i).

k) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

RESTRICTED BANDEDGE EMISSIONS

KDB 558074 D01 v05r02 c) 1)

c) Test procedures for DTS device EMC and radio parameters, such as power, OBW, radiated and band-edge measurements, are described in the following subclauses, including cross-references to Clause 11 of ANSI C63.10.

In addition the following clarifications relative to ANSI C63.10 are also applicable.

1) Concerning 11.13 (Band-edge measurements) of ANSI C63.10:

The requirement in 11.13.1 that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge applies only for use of the marker-delta method; use of the integration method is not subject to the same limitation.

ANSI C63.10 s.11.13

11.13.1 General

Emissions within a restricted band and within 2 MHz of an authorized band edge may be measured using either the marker-delta method or the integration method, which is described in 11.13.3, provided that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge. Otherwise, all unwanted emissions measurements shall be performed using the standard methods.

11.13.2 Marker-delta method

The marker-delta method, as described in 6.10.6, can be used to perform measurements of the unwanted emissions level at the band edges.

6.10.6 Marker-delta method

6.10.6.1 General requirements

In making radiated band-edge measurements, there can be a problem obtaining meaningful data because a measurement instrument that is tuned to a band-edge frequency might also capture some in-band signals when using the specified RBW. In an effort to compensate for this problem, the following technique has been developed for determining band-edge compliance.

This method may be used only when the edge of the occupied bandwidth of the emission falls within two "standard bandwidths" of the restricted-band band-edge frequency, where "standard bandwidth" is the RBW required by the measurement procedure (generally, the "standard bandwidth," i.e., reference bandwidth, is 10 kHz for measurements below 30 MHz, 100 kHz for measurements between 30 MHz and 1000 MHz, and 1 MHz for measurements above 1 GHz). For this purpose, the occupied bandwidth is based on the 99% power bandwidth. Detailed explanations and examples of these constraints are given subsequently.

For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, a measurement bandwidth of 1 MHz is required. Therefore the "delta" technique may be used if the upper frequency edge of the occupied bandwidth of the fundamental emission is greater than or equal to 2481.5 MHz (2 MHz removed from the band edge). If the upper frequency edge of the occupied bandwidth is less than 2481.5 MHz, then radiated emissions within the restricted band shall be measured in the conventional manner. The report shall include photographs or plots of the measuring instrument display, with the lower and/or upper frequency limit(s), as applicable, clearly labeled.

Additionally this method may be used only when the emission being measured falls within two "standard bandwidths" of the restricted band band-edge frequency. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, a measurement bandwidth of 1 MHz is required. Therefore the "delta" technique may be used if the restricted-band emission is between 2483.5 MHz and 2485.5 MHz. If the restricted-band emission is at a frequency greater than 2485.5 MHz, then radiated emissions within the restricted band shall be measured in the conventional manner.

6.10.6.2 Marker-delta procedure

The following procedure shall be used for the marker-delta method:

a) Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function required for the frequency being measured. For example, for a device operating in the 902 MHz to 928 MHz band,[56] use a 120 kHz RBW with a CISPR QP detector (a peak detector with 100 kHz RBW alternatively may be used). For transmitters operating above 1 GHz, use a 1 MHz RBW, a 3 MHz VBW, and a peak detector, as required.[58] Repeat the measurement with an average detector (or alternatively, a peak detector and reduced VBW). For pulsed emissions, other factors shall be included; see 4.1.4.2.6.

b) Choose an EMI receiver or spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the instrument RBW to 1% of the total span (but never less than 30 kHz), with a VBW equal to or greater than three times the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.

c) Subtract the delta measured in step b) from the field strengths measured in step a). The resulting field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge emissions compliance, where required.[59]

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[57] Conducted testing may be an acceptable alternative to radiated testing for devices operating under certain regulatory requirements: examples include 47 CFR 15.247 and 47 CFR 15.407, as well as Annex 8 and Annex 9 of IC RSS-210. See FCC/KDB-789033 [B28] and FCC/KDB-558074 [B26].

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[58] See 47 CFR 15.35.
[59] See 47 CFR 15.205 or RSS-Gen.

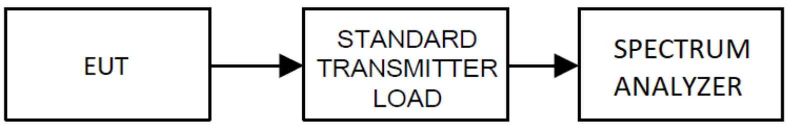
RESTRICTED BANDEDGE EMISSIONS

11.13.3 Integration method

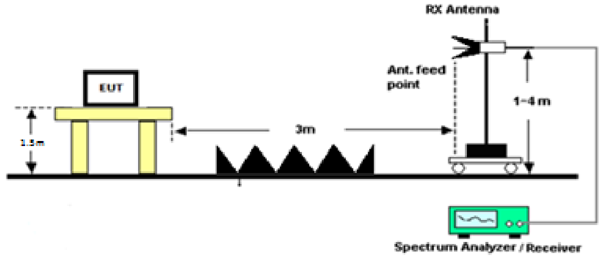
11.13.3.1 General

The following procedures may be used to determine the peak or average field strength or power of an unwanted emission that is within 2 MHz of the authorized band edge. If a peak detector is used, then use the procedure described in 11.13.3.2. Use the procedure described in 11.13.3.3 when using an average detector and the EUT can be configured to transmit continuously (i.e., $D \geq 98\%$). Use the procedure described in 11.13.3.4 when using an average detector and the EUT cannot be configured to transmit continuously but the duty cycle is constant (i.e., duty cycle variations are less than ±2%). Use the procedure described in 11.13.3.5 when using an average detector for those cases where the EUT cannot be configured to transmit continuously and the duty cycle is not constant (duty cycle variations equal or exceed 2%).

Test Setup: (conducted)



Test Setup: (radiated)

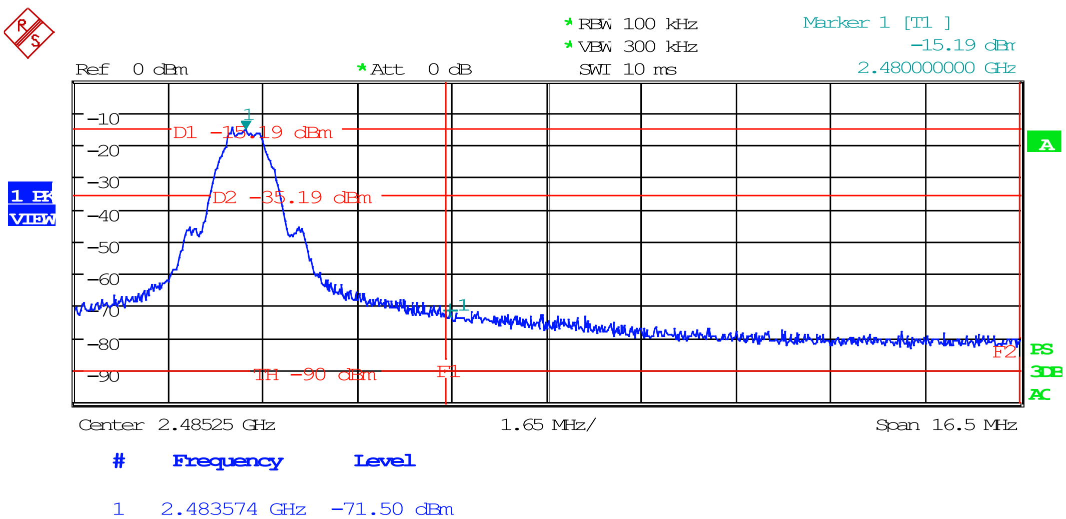


RESTRICTED BANDEDGE EMISSIONS

Test Data: Upper Band Edge Table

Tuned Frequency (MHz)	Fundamental Field strength (dBuV/m)	Detector	dBc	Calculated Field strength (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2480	87.32	Peak	56.13	31.19	74	42.81
2480	29.28	Average	56.13	-26.85	54	80.85

Upper Band Edge Plot



Date: 24.MAR.2020 10:23:52

RESULT: Meets Requirements

CONDUCTED SPURIOUS EMISSIONS

RULE PART NO.: FCC part 15.247(d)

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(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)).

Test Procedure: ANSI C63.10 7.8.8

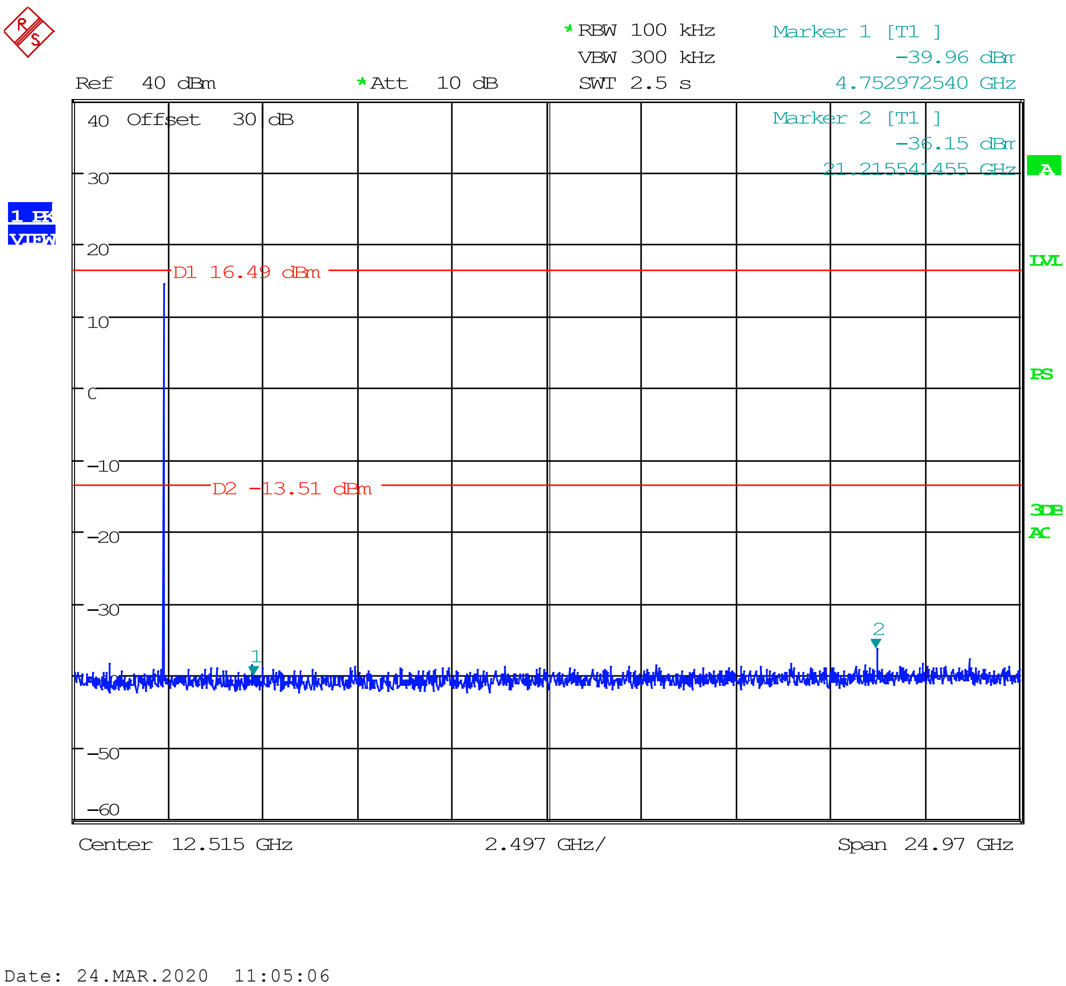
7.8.8 Conducted spurious emissions test methodology

Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at the maximum transmit powers.

Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

CONDUCTED SPURIOUS EMISSIONS

Test Data: 2402 MHz

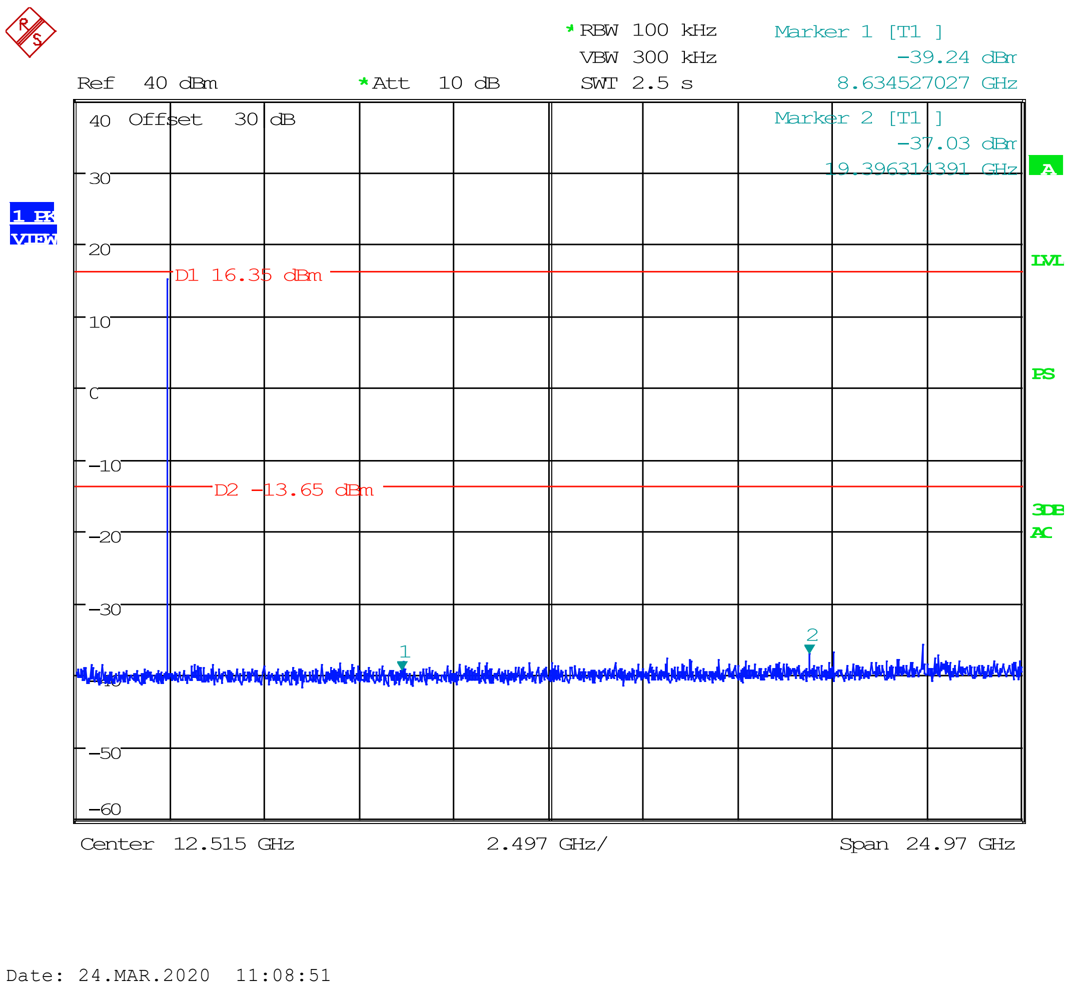


MHz

RESULT: Complies.

CONDUCTED SPURIOUS EMISSIONS

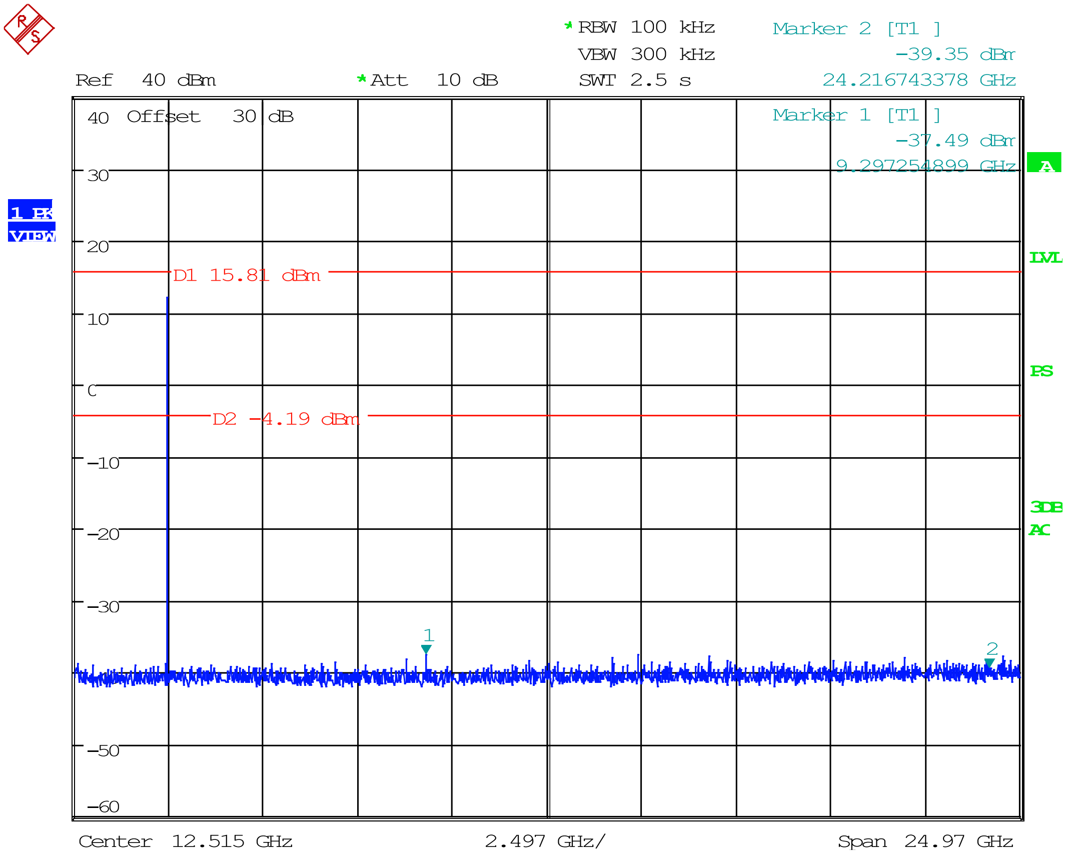
Test Data: 2440 MHz



RESULT: Complies.

CONDUCTED SPURIOUS EMISSIONS

Test Data: 2480 MHz



Date: 24.MAR.2020 11:16:28

RESULT: Complies.

RADIATED SPURIOUS EMISSIONS

RULE PART NO.: FCC part 15.247(b)(4), (d), 15.205, 15.209

Requirements:

§15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(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)).

§15.205 Restricted bands of operation.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

RADIATED SPURIOUS EMISSIONS

§15.31 Measurement standards.

(f) To the extent practicable, the device under test shall be measured at the distance specified in the appropriate rule section. The distance specified corresponds to the horizontal distance between the measurement antenna and the closest point of the equipment under test, support equipment or interconnecting cables as determined by the boundary defined by an imaginary straight line periphery describing a simple geometric configuration enclosing the system containing the equipment under test. The equipment under test, support equipment and any interconnecting cables shall be included within this boundary.

(2) At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). This paragraph (f) shall not apply to Access BPL devices operating below 30 MHz.

§15.209 Radiated emission limits; general requirements.

(a) Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency	Limit (µV/m)	15.31 Extrapolation factor (dB)	3m Limit (dBµV/m)
9 kHz – 30 kHz	2400/F(in kHz) @ 300m	80 dB	-31.48 to -41.94
30 kHz – 300 kHz	2400/F(in kHz) @ 300m	80 dB	-41.94 to -61.94
300 kHz – 490 kHz	2400/F(in kHz) @ 300m	80 dB	-61.94 to -66.2
490 kHz – 1.705 MHz	24000/F(in kHz) @ 30m	40 dB	-6.2 to -17.03
1.705 MHz – 3 MHz	30.0 @ 30 m	40 dB	-10.46
3 MHz – 30 MHz	30.0 @ 30 m	40 dB	-10.46

RADIATED SPURIOUS EMISSIONS

(1) At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. Measurements shall not be performed at a distance greater than 30 meters unless it can be further demonstrated that measurements at a distance of 30 meters or less are impractical. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

§15.209 Radiated emission limits; general requirements.

(a) Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency (MHz)	Limit (μV/m)	3m Limit (dBμV/m)
30 – 88	100.0	40.00
88 – 216	150.0	43.52
216 – 960	200.0	46.02
Above 960	500.0	53.98

§15.35 Measurement detector functions and bandwidths.

(b) Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, *e.g.*, see §§15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, *e.g.*, the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

RADIATED SPURIOUS EMISSIONS

Test Procedure: ANSI C63.4 § Annex D Validation of radiated emissions standard test sites
ANSI C63.10 § 6.3 Common requirements radiated emissions
ANSI C63.10 § 6.4 Emissions below 30 MHz
ANSI C63.10 § 6.5 Emissions between 30 & 1000 MHz
ANSI C63.10 § 6.6 Emissions above 1 GHz

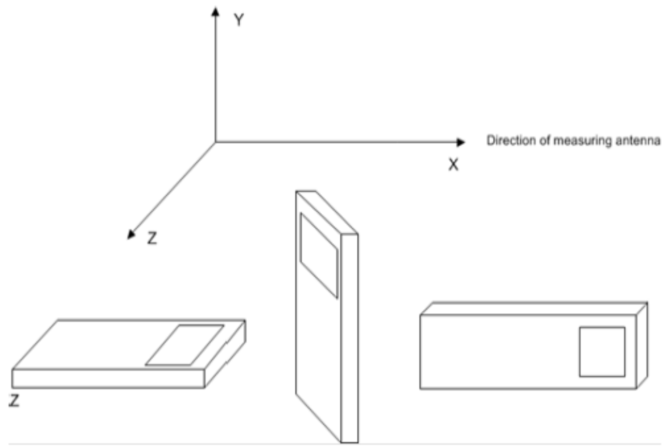
Radiated Emissions Test Setup:

EUT setup and arrangement was completed as described in ANSI C63.4. Exploratory measurements were taken following different peripheral placement and cable manipulations as described in ANSI C63.4. A photo is provided of the Test setup to record the exact peripheral equipment and cable manipulation arrangement found to produce the highest possible level of radiated emissions.

The test procedure used for radiated emissions is described ANSI C63.10 using a spectrum analyzer. The resolution bandwidth used was 100 kHz with an appropriate sweep speed. The analyzer was calibrated in dB above a microvolt at the output of the antenna. All cable loss and antenna factors were calibrated to provide plots with correction factors applied to results using the formula and example described below. The video bandwidth of the analyzer was always greater than or equal to the resolution bandwidth, and a peak detector with max hold was used.

The unit under test was placed on a table 80 cm high and with dimensions of 1m by 1.5m. The table used for radiated measurements is capable of continuous rotation. When an emission was found, the table was rotated to produce the maximum signal strength. At this point, the antenna was raised and lowered from 1m to 4m. The antenna was placed in both the horizontal and verticals planes. The frequency was scanned from 30 MHz to 1.0 GHz. The EUT was measured in three parts of the tunable band of EUT and (3) orthogonal planes when necessary.

EUT Orientation(s):



RADIATED SPURIOUS EMISSIONS

Formula of Conversion Factors:

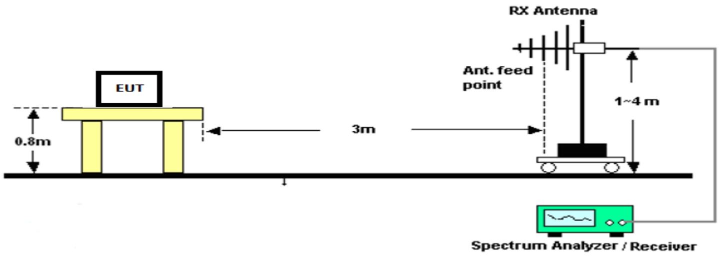
The field strength at 3m was established by adding the meter reading of the spectrum analyzer (which is set to read in units of dBµV) to the antenna correction factor supplied by the antenna manufacturer plus the coax loss. The antenna correction factors are stated in terms of dB. The gain of the preselector was accounted for in the spectrum analyzer meter reading.

Field Strength Correction Factor Conversion Example:

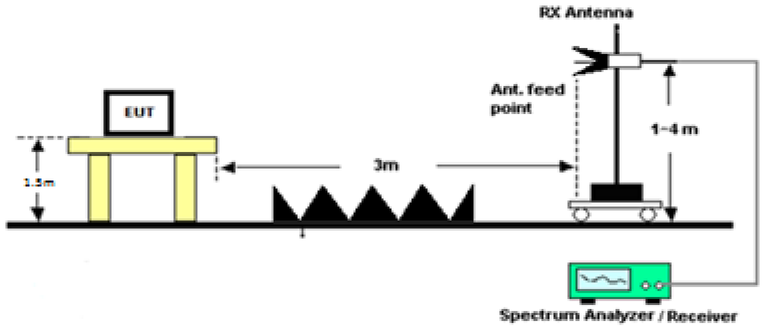
Freq (MHz)	Meter Reading	+ ACF	+CL	= FS
33	20 dBµV	+ 10.36 dB/m	+0.40 dB	=30.76 dBµV/m @ 3m

Test Setup:

Emissions 30 – 1000 MHz



Emissions above 1 GHz



RADIATED SPURIOUS EMISSIONS

Test Data: Field Strength of the Fundamental

Tuned Frequency (MHz)	Detector	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)
2402.00	PK	61.59	H	5.62	31.88	3.00	99.08
2402.00	AV	53.20	H	5.62	31.88	3.00	90.69
2402.00	PK	52.16	V	5.62	31.88	3.00	89.65
2402.00	AV	41.00	V	5.62	31.88	3.00	78.49
2440.00	PK	59.03	H	5.61	31.85	3.00	96.49
2440.00	PK	51.39	V	5.61	31.85	3.00	88.85
2480.00	PK	49.60	H	5.62	32.10	3.00	87.32
2480.00	AV	-2.10	H	5.62	32.10	3.00	35.62
2480.00	PK	44.23	V	5.62	32.10	3.00	81.95
2480.00	AV	-7.90	V	5.62	32.10	3.00	29.82

Test Data: Low End of Band Field Strength table

Tuned Frequency (MHz)	Emission Frequency (MHz)	15.205 Restricted Band	15.205, 15.35, 15.247(d) Detector	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Duty Cycle Correction (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	Limit	Margin (dBm)
2402.00	4804.00	X	PK	13.21	H	7.10	-4.85	33.93	3.00	49.39	73.98	24.59
2402.00	4804.00	X	PK	10.33	V	7.10	-4.85	33.93	3.00	46.51	73.98	27.47
2402.00	4804.00	X	AVG	6.74	H	7.10	-4.85	33.93	3.00	42.92	53.98	11.06
2402.00	4804.00	X	AVG	6.74	V	7.10	-4.85	33.93	3.00	42.92	53.98	11.06
2402.00	7206.00		PK	12.29	H	9.54	-4.85	36.39	3.00	53.38	79.08	25.71
2402.00	7206.00		PK	2.29	V	9.54	-4.85	36.39	3.00	43.38	79.08	35.71
2402.00	9608.00		PK	-0.80	H	10.70	-4.85	36.62	3.00	41.67	79.08	37.41
2402.00	9608.00		PK	1.50	V	10.70	-4.85	36.62	3.00	43.97	79.08	35.11
2402.00	12010.00	X	PK	-1.80	H	12.40	-4.85	39.08	3.00	44.83	73.98	29.15
2402.00	12010.00	X	PK	-0.90	V	12.40	-4.85	39.08	3.00	45.73	73.98	28.25
2402.00	12010.00	X	AVG	-1.80	H	12.40	-4.85	39.08	3.00	44.83	53.98	9.15
2402.00	12010.00	X	AVG	-0.90	V	12.40	-4.85	39.08	3.00	45.73	53.98	8.25

Test Data: Middle of Band Field Strength table

Tuned Frequency (MHz)	Emission Frequency (MHz)	15.205 Restricted Band	15.205, 15.35, 15.247(d) Detector	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Duty Cycle Correction (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	Limit	Margin (dBm)
2440.00	4880.00	X	PK	6.74	H	7.33	-4.85	33.93	3.00	43.15	73.98	30.83
2440.00	4880.00	X	PK	6.74	V	7.33	-4.85	33.93	3.00	43.15	73.98	30.83
2440.00	4880.00	X	AVG	6.74	H	7.33	-4.85	33.93	3.00	43.15	53.98	10.83
2440.00	4880.00	X	AVG	6.74	V	7.33	-4.85	33.93	3.00	43.15	53.98	10.83
2440.00	7320.00	X	PK	1.05	H	9.61	-4.85	36.24	3.00	42.05	73.98	31.93
2440.00	7320.00	X	PK	2.29	V	9.61	-4.85	36.24	3.00	43.29	73.98	30.69
2440.00	7320.00	X	AVG	1.05	H	9.61	-4.85	36.24	3.00	42.05	53.98	11.93
2440.00	7320.00	X	AVG	2.29	V	9.61	-4.85	36.24	3.00	43.29	53.98	10.69
2440.00	12200.00	X	PK	-3.24	H	12.52	-4.85	39.23	3.00	43.67	73.98	30.31
2440.00	12200.00	X	PK	-3.31	V	12.52	-4.85	39.23	3.00	43.60	73.98	30.38
2440.00	12200.00	X	AVG	-3.24	H	12.52	-4.85	39.23	3.00	43.67	53.98	10.31
2440.00	12200.00	X	AVG	-3.31	V	12.52	-4.85	39.23	3.00	43.60	53.98	10.38

RADIATED SPURIOUS EMISSIONS

Test Data: High End of Band Field Strength table

Tuned Frequency (MHz)	Emission Frequency (MHz)	15.205 Restricted Band	15.205, 15.35, 15.247(d) Detector	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Duty Cycle Correction (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	Limit	Margin (dBm)
2480.00	4960.00	X	PK	14.11	H	7.72	-4.85	33.96	3.00	50.94	73.98	23.04
2480.00	4960.00	X	PK	14.16	V	7.72	-4.85	33.96	3.00	50.99	73.98	22.99
2480.00	4960.00	X	AVG	-7.10	H	7.72	-4.85	33.96	3.00	29.73	53.98	24.25
2480.00	4960.00	X	AVG	-9.90	V	7.72	-4.85	33.96	3.00	26.93	53.98	27.05
2480.00	7440.00	X	PK	6.28	H	9.56	-4.85	36.01	3.00	47.01	73.98	26.97
2480.00	7440.00	X	PK	3.00	V	9.56	-4.85	36.01	3.00	43.73	73.98	30.25
2480.00	7440.00	X	AVG	6.28	H	9.56	-4.85	36.01	3.00	47.01	53.98	6.97
2480.00	7440.00	X	AVG	3.00	V	9.56	-4.85	36.01	3.00	43.73	53.98	10.25
2480.00	9920.00		PK	4.83	H	11.15	-4.85	37.08	3.00	48.21	79.08	30.87
2480.00	9920.00		PK	3.73	V	11.15	-4.85	37.08	3.00	47.11	79.08	31.97
2480.00	12400.00	X	PK	-2.90	H	12.54	-4.85	39.23	3.00	44.03	73.98	29.95
2480.00	12400.00	X	PK	0.25	V	12.54	-4.85	39.23	3.00	47.18	73.98	26.80
2480.00	12400.00	X	AVG	0.95	H	12.54	-4.85	39.23	3.00	47.88	53.98	6.10
2480.00	12400.00	X	AVG	-3.60	V	12.54	-4.85	39.23	3.00	43.33	53.98	10.65
2480.00	14880.00		PK	-4.75	H	13.44	-4.85	40.29	3.00	44.14	79.08	34.94
2480.00	14880.00		PK	-6.04	V	13.44	-4.85	40.29	3.00	42.85	79.08	36.23

Result: Complies.

POWER LINE CONDUCTED INTERFERENCE

FCC Rule Part No.: FCC Part 15.207(a)

Requirements:

§15.207 Conducted limits.

(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
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.

(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtainig their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

Method of Measurement:

The procedure used was ANSI C63.4 using a 50uH LISN. Both lines were observed. The bandwidth of the spectrum analyzer was 10 kHz with an appropriate sweep speed. The spectrum was scanned from 0.15 to 30 MHz.

The following plots represent the emissions for power line conducted. Both lines were observed.

Test Data: N/A

The EUT does not connect to an external powerline.

TEST EQUIPMENT LIST

Device	Manufacturer	Model	Serial Number	Cal/Char Date	Due Date
Antenna: Active Loop	ETS-Lindgren	6502	62529	12/11/2017	12/11/2020
Antenna: Biconical 1057	Eaton	94455-1	1057	12/13/2017	12/13/2020
Antenna: Log-Periodic 1122	Electro-Metrics	LPA-25	1122	7/26/2017	7/26/2020
CHAMBER	Panashield	3M	N/A	3/15/2019	3/15/2021
EMI Test Receiver R & S ESU 40 Chamber	Rohde & Schwarz	ESU 40	100320	08/28/18	08/28/2021
Software: Field Strength Program	Timco	N/A	Version 4.10.7.0	N/A	N/A
Antenna: Double-Ridged Horn/ETS Horn 2	ETS-Lindgren	3117	41534	3/1/2017	4/1/2020
Bore-sight Antenna Positioning Tower	Sunol Sciences	TLT2	N/A	N/A	N/A
Coaxial Cable #103 - KMKM-0180-01 Aqua	Micro-Coax	UFB142A-0-0720-200200	225363-002 (#103)	4/12/2019	4/12/2021
Coaxial Cable - Chamber 3 cable set (Primary)	Micro-Coax	Chamber 3 cable set (Primary)	KMKM-0244-01 KMKM-0670-00 KFKF-0198-01	4/12/2019	4/12/2021
Band Reject Filter 2.4 GHz	Micro-Tronics	BRM50702-02	0	4/12/2019	4/12/2021
Pre-amp	RF-LAMBDA	RLNA00M45GA	N/A	2/27/2019	2/27/2021
Antenna: Double-Ridged Horn 18-40 GHz	EMCO	3116	9011-2145	2/27/2019	2/27/2021
Attenuator SMA 30dB 5W DC-18G	Pasternack	PE7013-30	#23	11/19/2017	11/19/2020

***EMI RECEIVER SOFTWARE VERSION**
The receiver firmware used was version 4.43 Service Pack 3

STATEMENT OF MEASUREMENT UNCERTAINTY

The data and results referenced in this document are true and accurate. The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16–4 or ENTR 100-028 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: “Uncertainty in EMC Measurements” and is documented in the Timco Engineering, Inc. quality system according to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.
Hereafter the best measurement capability for Timco Engineering, Inc. is reported:

Test Items	Measurement Uncertainty	Notes
RF Frequency Accuracy	± 49.5 Hz	(1)
RF Conducted Power	±0.93dB	(1)
Conducted spurious emission of transmitter valid up to 40GHz	±1.86dB	
Occupied Bandwidth	±2.65%	
Radiated RF Power	±1.4dB	
Maximum frequency deviation: Within 300 Hz and 6kHz of audio freq. Within 6kHz and 25kHz of audio Freq.	 ±1.88% ±2.04%	
Radiated Emissions up to 26.5GHz	±2.14dB	
Temperature	±1.0°C	(1)
Humidity	±5.0%	

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=1.96.

END OF REPORT