Testing Cert #1007.01

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Atlas Compliance & Engineering, Inc.

FCC
Test Report

FCC CFR 47 Part 15.207, 15.209 and 15.247 COMPLIANCE

WaterGuru Inc
115 Independence Drive
Menlo Park CA 94025

Product:
Swimming pool chemistry monitor
Model:
SENSE

FCC ID:	2ATXQWGSENSE
Test Report Number:	1925GURsense_fcc247
Date of Report:	August 23, 2019

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Change History

1925GURsense_fcc247

Rev.	Change Description	Reason/Application	Date	Appvd.
Draft	Report for review	Applies to SENSE	August 9, 2019	MEB
C1	Release of report	Applies to SENSE	August 12, 2019	MEB
C2	Update report	Applies to SENSE	August 14, 2019	MEB
C3	Update report	Applies to SENSE	August 21, 2019	MEB
C4	Update report	Applies to SENSE	August 23, 2019	MEB
C5	Update report	Applies to SENSE	August 23, 2019	MEB

General Information

Test Report Number:	1925GURsense_fcc247
Date Product Tested:	August 9 – 23, 2019
Date of Report:	August 23, 2019
Applicant:	WaterGuru Inc 115 Independence Drive Menlo Park CA 94025
Contact Person	Rafael Fried
Equipment Tested:	Swimming pool chemistry monitor
Transmitter Frequency:	2402 – 2480 MHz, 40 Channels, 2 MHz spacing
Modulation:	GFSK
Trade Name:	WaterGuru Inc
Model:	SENSE
Purpose of Test:	To demonstrate the compliance of the Swimming pool chemistry monitor, SENSE, with the requirements of FCC CFR 47 Part 15 Rules and Regulations to the limits of Subpart C 15.207, 15.209 and 15.247 using the procedure stated in ANSI C63.10.
Frequency Range Investigated:	9 KHz to 24.835 GHz
FRN:	0028617207
FCC ID:	2ATXQWGSENSE
Test Site Locations:	Field Strength Measurement Facility: Atlas Compliance & Engineering, Inc. 726 Hidden Valley Road Royal Oaks, California 95076 Conducted Measurement Facility: Atlas Compliance & Engineering, Inc. 1792 Little Orchard Street San Jose, California 95125
Test Personnel:	Bruce Smith EMC Engineer

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Test Equipment

The following list contains the test equipment that was utilized in making the measurements in this report.

Description _ Model	Serial	Manufacturer	Calibration Due
Biconilog 30-1000MHz _ 3143B	00217636	ETS Lindgren	10/3/19
Active Loop Antenna _ 6502	9108-2669	EMCO	5/18/20
Double Ridge Guide Horn Antenna 1-18GHz _ 3117	00218932	ETS Lindgren	12/8/19
Standard Gain Horn Antenna _ 3160-09	00057143	EMCO	11/22/19
Pre amp 9kHz-2GHz _ CPA9231A	3259	Schaffner	12/3/19
EMI Test Receiver 9 kHz - 2500 MHz _ ESPC	DE14459 843820/0015	Rohde & Schwarz	12/26/19
Pre amp 1Ghz-26.5GHz _ 8449B	3008A00910	HP	4/9/20
Spectrum Analyzer 100Hz-22GHz _ 8566B	2542A13058 (IF) 2637A03426 (RF)	HP	4/8/20
Quasi-Peak Adapter _ 85650A	2521A00716	HP	4/8/20
Spectrum Analyzer 9kHz-2.4GHz _ 8594E	3543A02886	HP	1/31/20
Temperature and humidity probe _ RH-20F	200-97-082591	Omega Engineering	4/10/20
RF Cable 45 ft. _ NPS-2301-5400-NPS	0110	IW Microwave	4/3/20
RF Cable 19m _ NPS-2801-1900M-NPS	1805	IW Microwave	11/30/19

Measurements from 22 GHz to 24.835 GHz were subcontracted by CKC Laboratories, Inc, 1120 Fulton Place, Fremont, CA 94539. A2LA Accreditation certificate number 0803.01.
Equipment used by CKC Laboratories listed below.

Asset #	Description	Manufacturer	Model	Calibration Date	Cal Due Date
P06900	Cable	Astrolab	32022-29094K-29094K-36TC	1/4/2018	1/4/2020
02660	Spectrum Analyzer	Agilent	E4446A	10/19/2018	10/19/2020
02046	Horn Antenna	ARA	MWH-1826/B	11/16/2018	11/16/2020
P01403	Cable	Semflex	58758-23	6/25/2018	6/25/2020
P00929	Cable	various	various	1/15/2018	1/15/2020
P06899	Cable	Astrolab	32022-29094K-29094K-72TC	1/4/2018	1/4/2020
02810	Preamp	HP	83051A	7/16/2019	7/16/2021
02115	Preamp	HP	83051A	4/3/2019	4/3/2021

Measurement uncertainty for testing at CKC Laboratories.

Uncertainty Parameter	Actual	Limit	Unit of Measure
RF output power, conducted	0.67	1.5	dB
Unwanted Emissions, conducted	0.67	3	dB
All emissions, radiated	3.73	6	dB

Uncertainties reported are worst case for all CKC Laboratories’ sites and represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2.
Compliance is deemed to occur provided measurements are below the specified limits.

Test Configuration

Customer:	WaterGuru Inc
Test Date:	August 9 – 23, 2019
Specification:	FCC CRF 47 Part 15.247 Limits, ANSI C63.10 Methods

General Description

Overview

This system measures some of the critical swimming pool chemistry variables. It communicates with the cloud via Wi-Fi to provide the cell phone app information on the pool water condition. Bluetooth Low Energy is used to initially set up the Wi-Fi credentials and to initiate a measurement-on-demand.

The system is battery powered (4x C cells) and is placed in the skimmer of the pool.

The Lab unit of the system is suspended into the water of the skimmer while the communication and power module is in the skimmer cover.

Controlled by a microprocessor, the chemistry is measured on a cyclic basis (usually once per day) by passing precision test pads for the various chemicals thru the pool water while it is being recirculated by the pool's main pump. These pads are then illuminated by an RGB LED with calibrated color output, and the color of the test pad is sensed by photodiodes.

The main board attached to the underside of the skimmer cover has the WiFi and Bluetooth communication modules along with the power supply and microprocessor controller for the system. This microprocessor has the functions to control the timing of the chemistry testing and the communication to "cloud" thru the WiFi connection. Phone App data is acquired from the cloud.

The main board microprocessor is connected to the Lab unit by a cable containing the power and differential communication channel to the Lab unit.

The Lab unit has an auxilliary microprocessor which gathers the data from the photodiodes, controls the RGB LED, controls the motor which advances the test pad cassette tape and the communication channel to the main processor. It also has a water flow sensor based on thermal dissipation measurements.

EUT Description / Note:

The EUT, SENSE, a Swimming pool chemistry monitor was powered up and the BLE transmitter was in a continuous transmitting mode at full power for fundamental emissions measurements. The EUT interface was through the host circuits to send commands to place it in the different operating modes. The power for the EUT was supplied by new batteries. The PCB antenna on the BLE transmitter is a meandered Inverted F Antenna (IFA). The IFA was designed to match an impedance of 50 ohm at 2.45 GHz. Thus no additional matching components are necessary. Details of the antenna are provided in Texas Instruments Application Note AN043. The design of the PCB antenna is an exact copy of the reference design. The max gain of the antenna is 5.3dB. The EUT also contains FCC ID: 2ADHKATWINC1500U for the WiFi module.

EUT Support Program

The EUT was tested at lowest channel, 2402 MHz, mid channel, 2440 MHz, and highest channel, 2480 MHz in a continuous transmit mode. The transmitter was at full power and 100% modulation. The EUT was then operated to find worst case levels of unwanted emissions. Preliminary radiated tests were performed to identify which operating mode produced the worst case (maximum) transmit level. Using this mode the EUT was tested to find maximum transmit level. Tests were performed while attached to a host computer to place the EUT in the different transmit channels.

EUT Modifications for Compliance

There were no modifications performed on the EUT. The test results state the emission levels of the EUT in the condition as it was received.

Measurement Uncertainty

Measurement uncertainty is caused by random effects and imperfect correction of systematic effects. The measurement uncertainties stated were calculated with a confidence level of approximately 95%, using a coverage factor of k = 2.

Expanded Measurement Uncertainty at 95% confidence probability;

Radiated emissions = ±3.92dB
Conducted emissions = ±1.16dB

EUT Support Devices

Table 1 – Support Equipment Used For Test

Model:	Description:	S/N	FCC ID#
Inspiron 5720	Dell Laptop computer	DZ53DT1	NA
A2133	Apple iPad	DMPYFF15LM93	BCGA2133

I/O Ports and Cables

Table 2 – EUT Port Termination's

I/O Port	Cable Type	Length	Connector	Termination
NA				

Table 3 – Host Port Termination's

I/O Port	Cable Type	Length	Connector	Termination
USB	Shielded	1 M	USB	USB-to-serial

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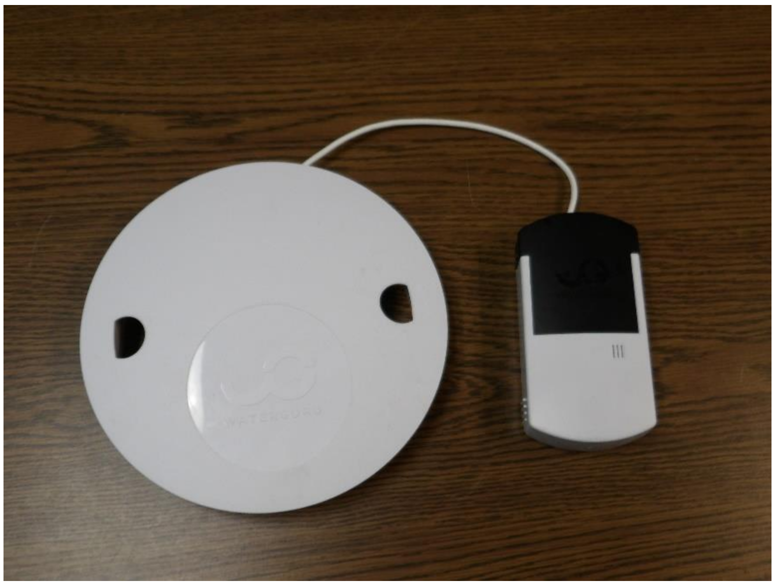
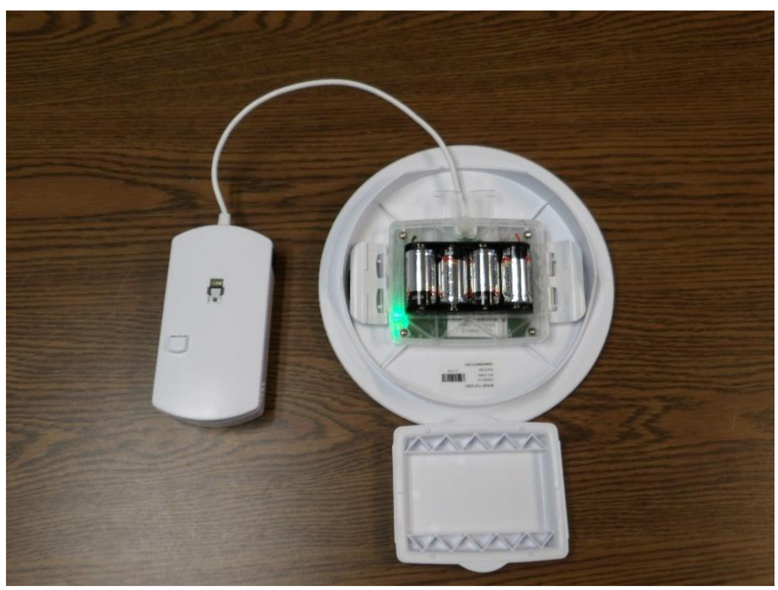
Equipment Under Test





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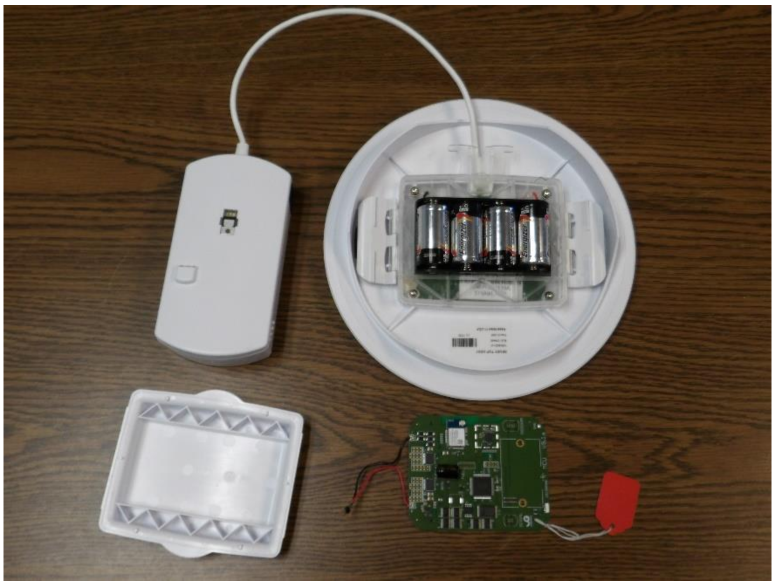

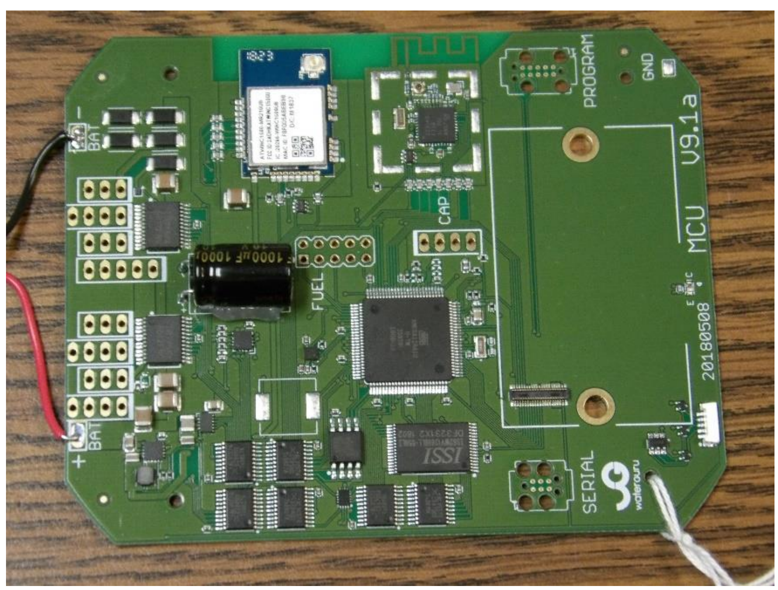

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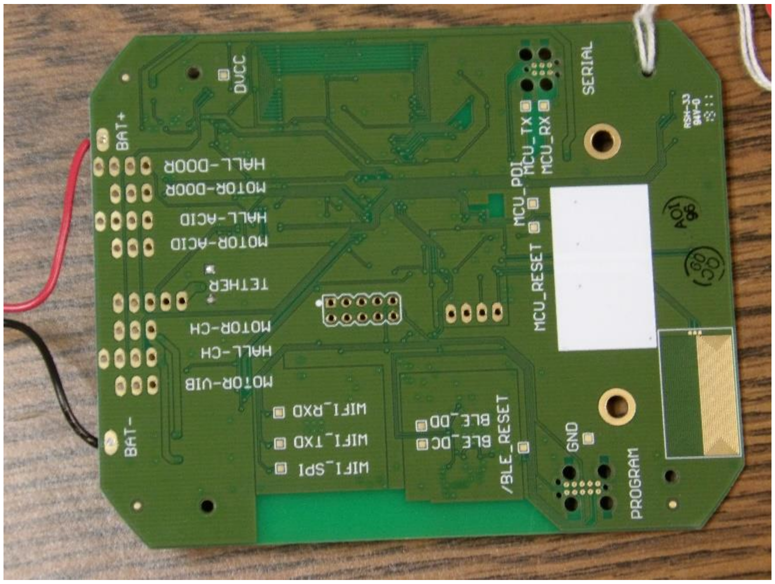

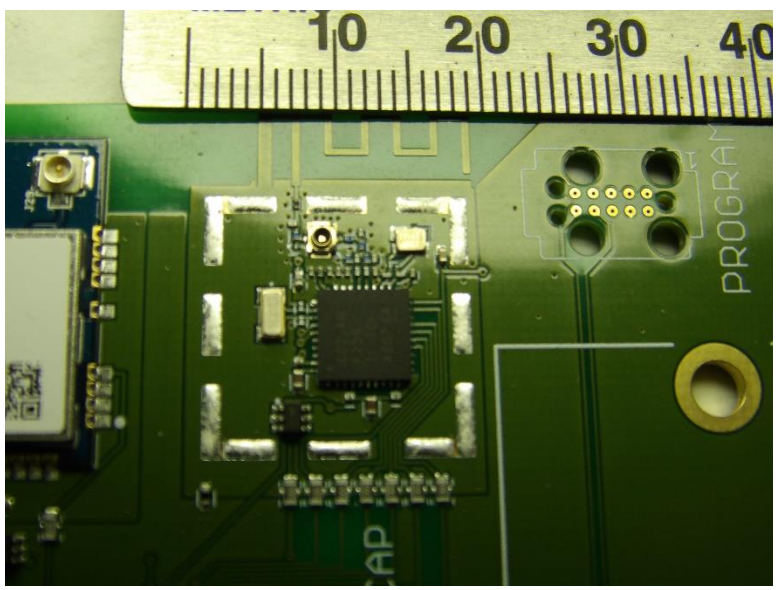

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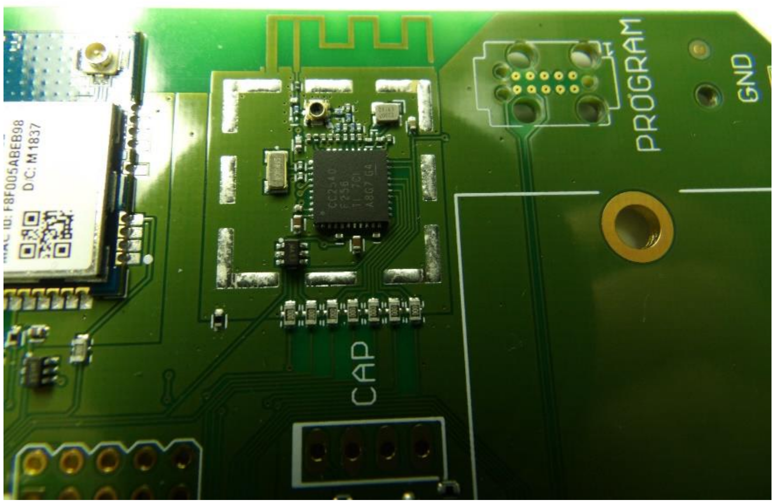
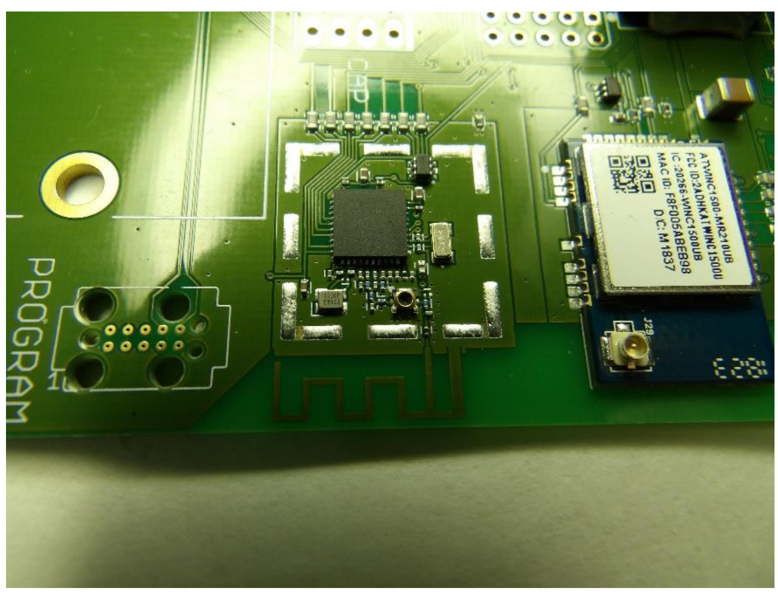
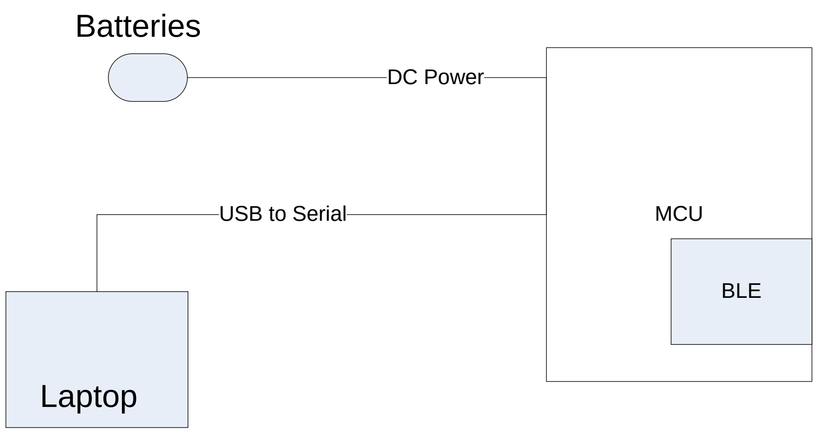




Equipment Block Diagram

Following is the block diagram of the test setup. Refer to TEST CONFIGURATION pages for port connections and information.

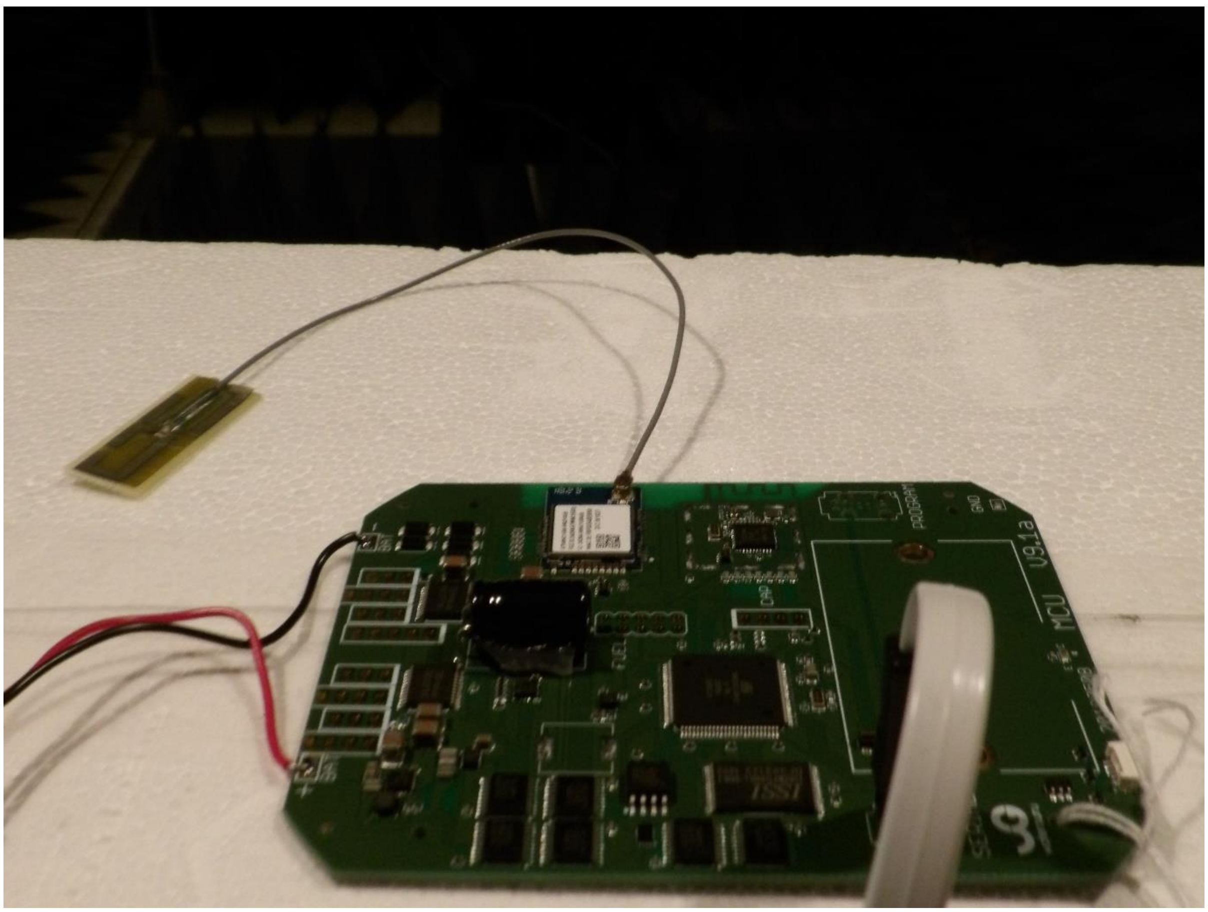
Figure 1 – Test Setup Diagram



EUT:
SENSE

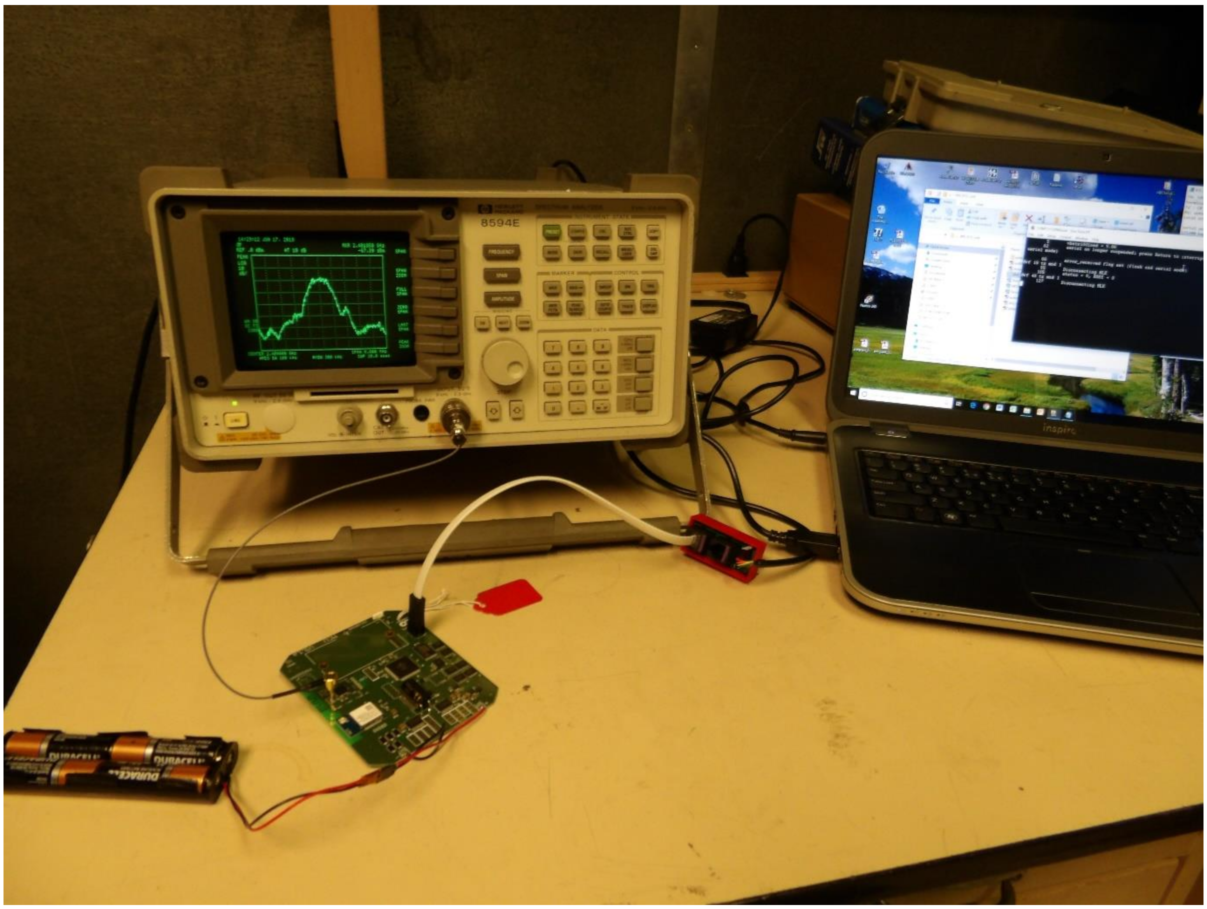
Test Setup (Radiated Emissions)

The photographs below show the test setup for radiated emission testing.



Test Setup (Conducted RF)

The photographs below show the test setup for conducted RF testing.



Test Methods for Emissions

The test procedure stated in ANSI C63.10-2013 was used to collect the test data. The emission data of the EUT was taken with the Rohde & Schwarz EMI Test Receiver, HP 8594E and HP 8566B. Incorporating the application of correction factors programmed into the Test Receiver and verified for distance, antenna, cable loss, and amplifier gain, the data was reduced as shown in the Sample Calculations. These correction factors are available upon request. The corrected data was then compared to the emission limits to determine compliance.

During radiated emission testing between 9 kHz to 1000 MHz, the EUT was placed on a nonconductive rotating table 0.8 meter above the conductive grid. The nonconductive table dimensions were 1 meter deep by 1.5 meters wide at 0.8 meter high. The EUT is centered on the tabletop and the measurement antenna was placed 10 or 3 meters from the EUT as noted in the test data.

For emissions testing, scans in the frequency range of 9 kHz to 24.835 GHz were made. Measurement bandwidths and detectors stated in ANSI C63.10 4.1.4 were used.

Measurements from 22 GHz to 24.835 GHz were subcontracted by CKC Laboratories, Inc, 1120 Fulton Place, Fremont, CA 94539. A2LA Accreditation certificate number 0803.01. These measurements are included in this report and are noted as subcontracted tests.

Measurements were made at a distance of 3 or 10 meters. Tests were performed with the measurement antenna in both horizontal and vertical orientations and the EUT in all three orthogonal orientations.

Conducted Emission Testing

The EUT is a battery powered device therefore no conducted emissions testing was performed.

Temperature and Humidity

The ambient temperature of the actual EUT was within the range of 10° to 40° C (50° to 104° F) unless the particular equipment requirements specify testing over a different temperature range. The humidity levels were within the range of 10% to 90% relative humidity unless the EUT operating requirements call for a different level.

Sample Calculations

An example of how the EMI Test Receiver reading is converted using correction factors is given for the emissions recorded. These correction factors are programmed into the EMI Test Receiver and verified. For radiated emissions in dBμV/m, the EMI Test Receiver reading in dBμV is corrected by using the following formula:

33.90	Meter Reading (dBμV/m)
34.01	- Pre amp Gain (dB)
12.48	+ Cable Loss (dB)
33.12	+ Antenna Factor (dB)
45.49	= Corrected Reading (dBμV/m)

This reading is then compared to the applicable specification limits and the difference will determine compliance.

Test setup for conducted measurements

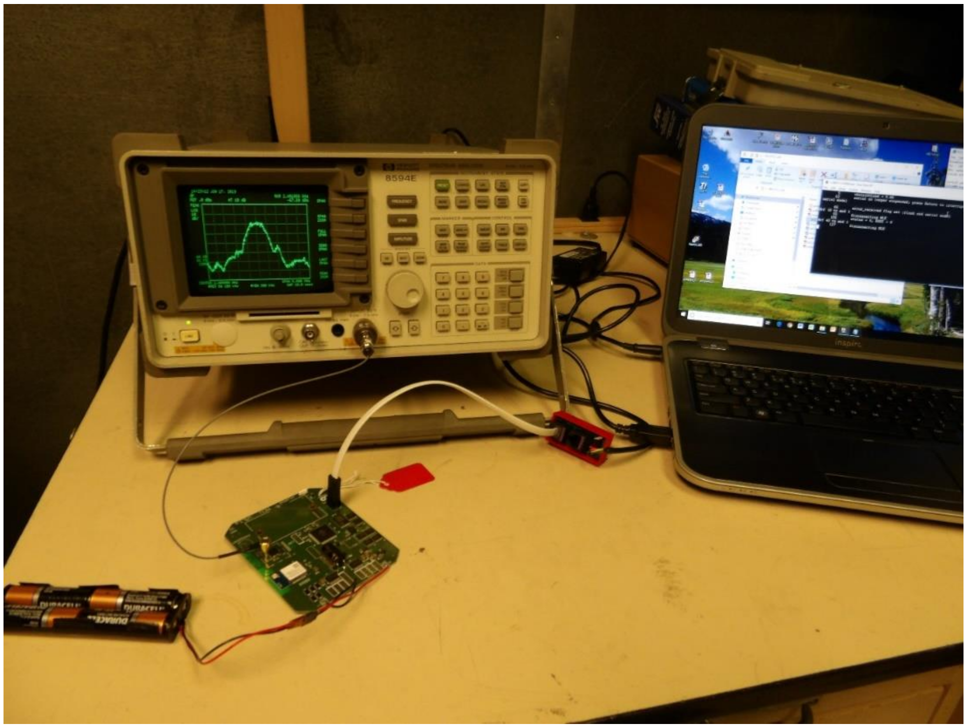
Characterization of cable and attenuator

The RF cable and external attenuator used during the conducted measurements was characterized as follows:

Cable Loss = 0.66dB
Attenuator = 10.18db

Correction factor = 10.84dB

Setup configuration



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Minimum -6dB Bandwidth

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

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

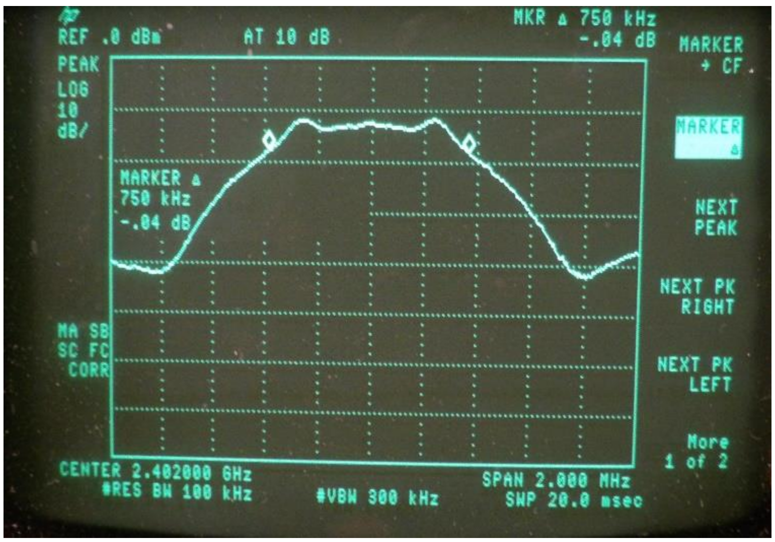
(2) Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

ANSI C63.10 11.8.1 Option 1

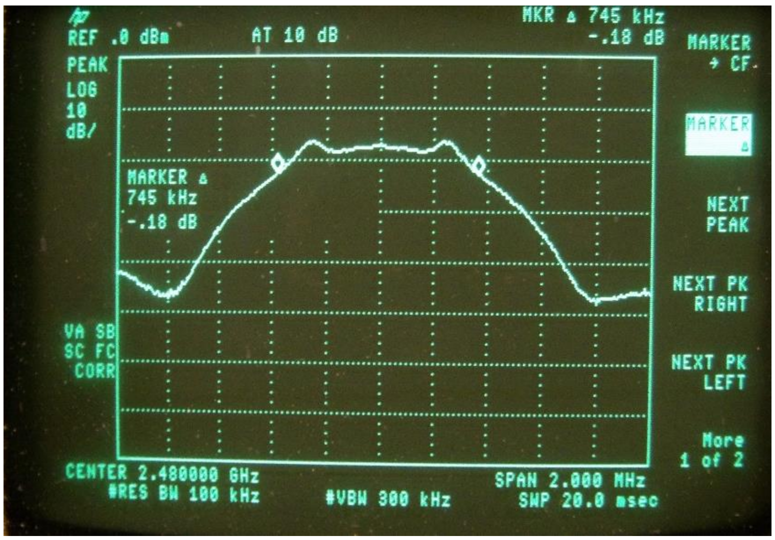
The steps for the first option are as follows:
a) Set RBW = 100 kHz.
b) Set the VBW ≥ [3 × RBW].
c) Detector = peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Table 4 – Minimum -6 dB Bandwidth

Channel	Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)	Result
Low	**2402**	**750**	**>500**	**Pass**
Mid	**2440**	**750**		**Pass**
High	**2480**	**745**		**Pass**




REF .0 dBm
AT 10 dB
-.05 dB
PEAK
LOG
10
dB/
MARKER
→ CF
MARKER Δ
750 kHz
-.05 dB
NEXT PEAK
NEXT PK RIGHT
NEXT PK LEFT
More 1 of 2
VA SB
SC FC
CORR
CENTER 2.440000 GHz
#RES BW 100 kHz
#VBW 300 kHz
SPAN 2.000 MHz
SWP 20.0 msec


REF .0 dBm
AT 10 dB
MKR Δ 745 kHz
-.18 dB
PEAK
LOG
10
dB/
MARKER
→ CF
MARKER Δ
745 kHz
-.18 dB
NEXT PEAK
NEXT PK RIGHT
NEXT PK LEFT
More 1 of 2
VA SB
SC FC
CORR
CENTER 2.480000 GHz
#RES BW 100 kHz
#VBW 300 kHz
SPAN 2.000 MHz
SWP 20.0 msec

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Peak Power Spectral Density

§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.

ANSI C63.10 11.10.2 Method PKPSD (peak PSD)

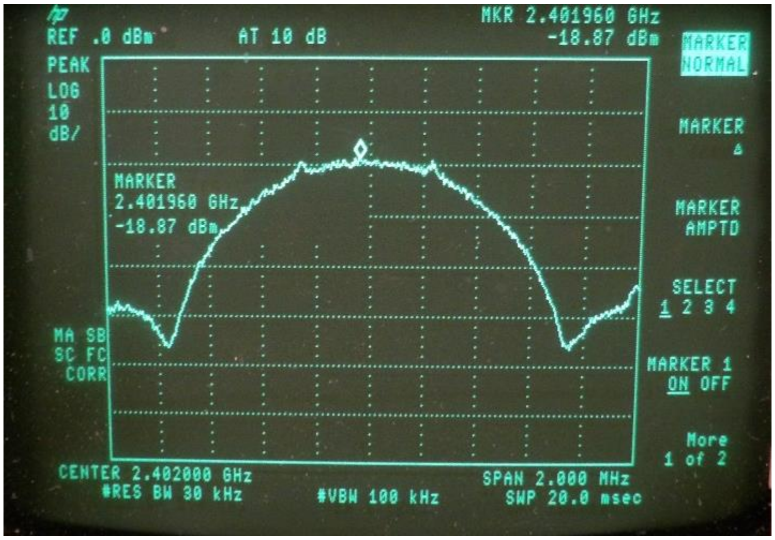
The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

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 ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ [3 × 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.

Table 5 – Peak Power Spectral Density

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Result
Low	2402	-8.03		Pass
Mid	2440	-8.24	8	Pass
High	2480	-7.54		Pass

Measurement bandwidth used was 30 kHz, attenuator and cable correction factor 10.84dB



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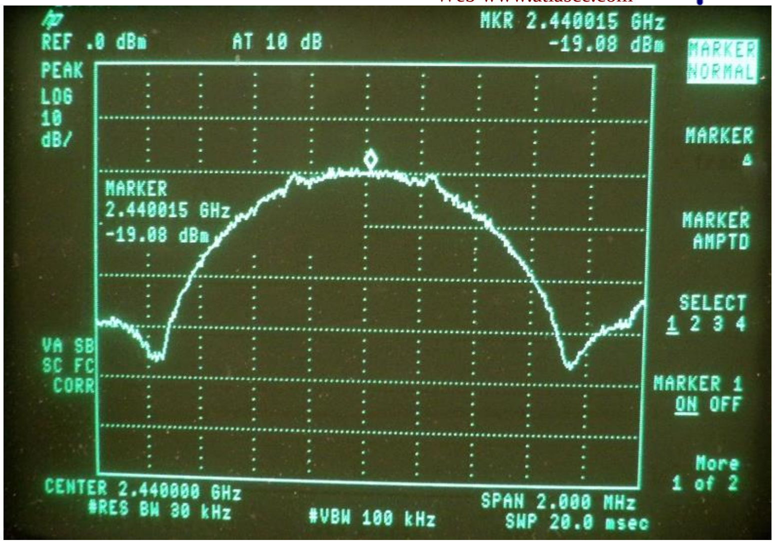

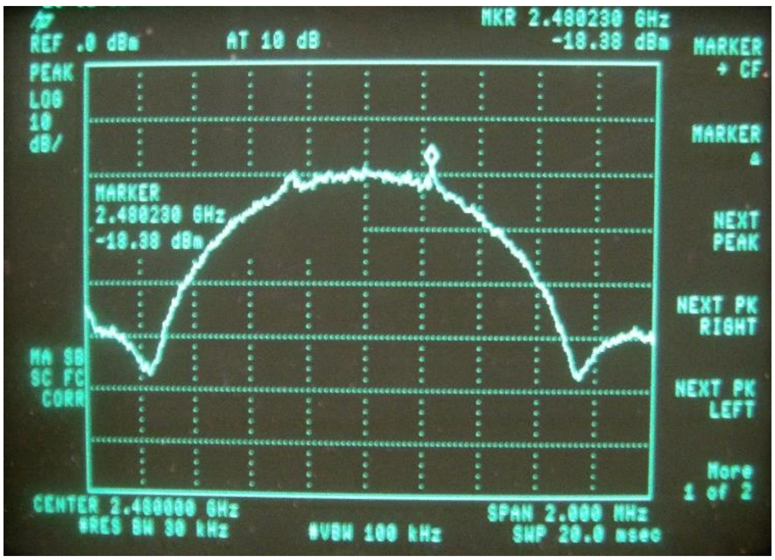

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Maximum Peak Output Power

§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.

ANSI C63.10 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

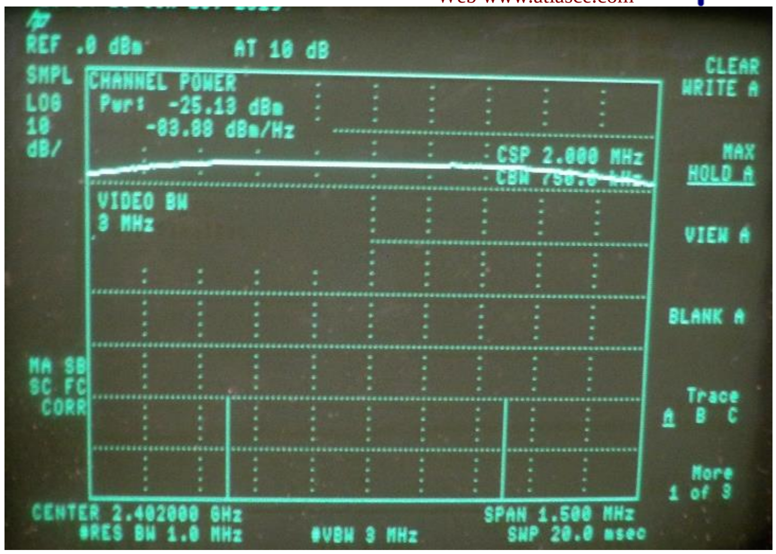
DTS bandwidth:

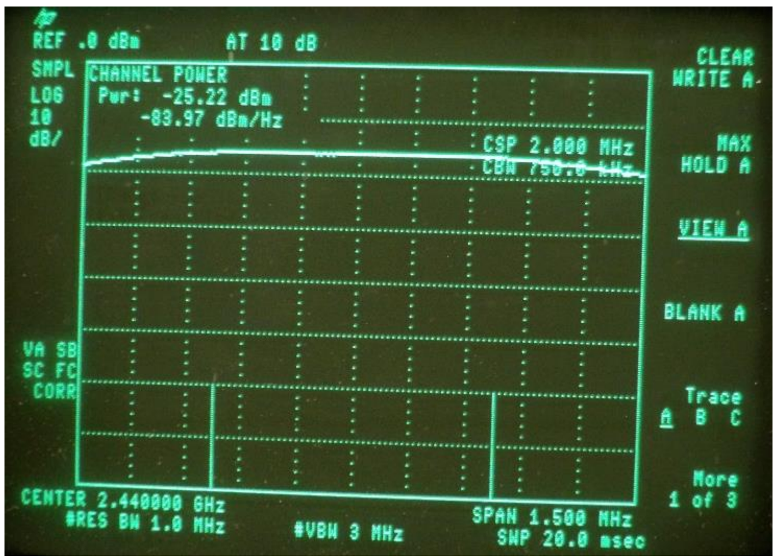
a) Set the RBW = 1 MHz.
b) Set the VBW ≥ [3 × RBW].
c) Set the span ≥ [1.5 × DTS bandwidth].
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the instrument's band/channel power measurement function with the band limits set equal to 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.

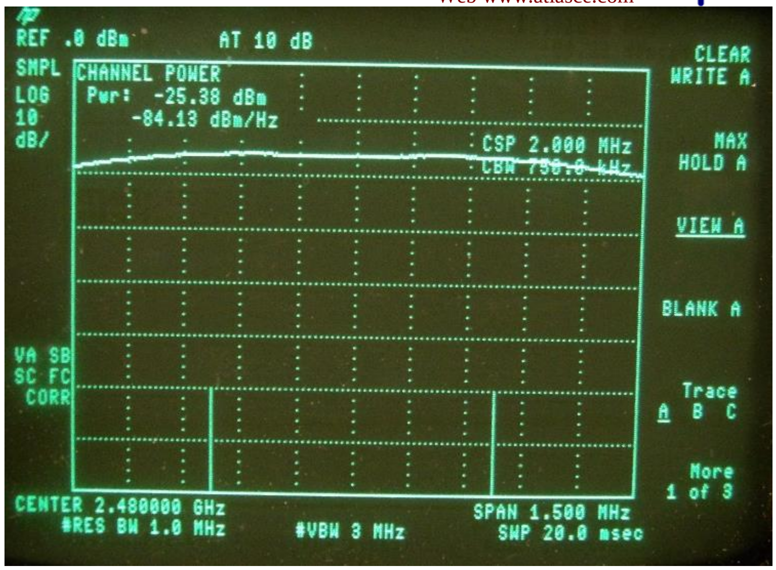
Table 6 – Maximum Peak Output Power

Channel	Frequency (MHz)	Maximum Transit Power (dBm)	Limit		Result
			dBm	Watts	
Low	2402	-14.29	30	1	Pass
Mid	2440	-14.38			Pass
High	2480	-14.54			Pass

Attenuator and cable correction factor 10.84dB


REF .0 dBm
AT 10 dB
SMPL
LOG
10
dB/
CHANNEL POWER
Pwr: -25.13 dBm
-83.88 dBm/Hz
CSP 2.000 MHz
VIDEO BW
3 MHz
MA SB
SC FC
CORR
CLEAR
WRITE A
MAX
HOLD A
VIEW A
BLANK A
Trace
A B C
More
1 of 3
CENTER 2.402000 GHz
#RES BW 1.0 MHz
#VBW 3 MHz
SPAN 1.500 MHz
SWP 20.0 msec


REF .0 dBm
AT 10 dB
SMPL
LOG
10
dB/
CHANNEL POWER
Pwr: -25.22 dBm
-83.97 dBm/Hz
CSP 2.000 MHz
VA SB
SC FC
CORR
CLEAR
WRITE A
MAX
HOLD A
VIEW A
BLANK A
Trace
A B C
More
1 of 3
CENTER 2.440000 GHz
#RES BW 1.0 MHz
#VBW 3 MHz
SPAN 1.500 MHz
SWP 20.0 msec


REF .0 dBm
AT 10 dB
SMPL
LOG
10
dB/
CHANNEL POWER
Pwr: -25.38 dBm
-84.13 dBm/Hz
CSP 2.000 MHz
VA SB
SC FC
CORR
CENTER 2.480000 GHz
#RES BW 1.0 MHz
#VBW 3 MHz
SPAN 1.500 MHz
SWP 20.0 msec
CLEAR
WRITE A
MAX
HOLD A
VIEW A
BLANK A
Trace
A B C
More
1 of 3

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Equivalent Isotropically Radiated Power

ANSI C63.10 G.3 Power approach (logarithmic terms)

ERP/EIRP = $P_T + G_T - L_C$ (G.3)

where

ERP/EIRP is the equivalent (or effective) radiated power [in same units as P_T, typically dBW, dBm, or power spectral density (psd)], relative to either a dipole antenna (ERP) or an isotropic antenna (EIRP)

P_T is the transmitter output power, in dBW, dBm, or psd (power over a specified reference bandwidth)

G_T is the gain of the transmitting antenna, in dBd (ERP) or dBi (EIRP)

L_C is the signal attenuation in the connecting cable between the transmitter and the antenna, in dB

G.4 Relationship between ERP and EIRP

The numeric gain of an ideal half-wave dipole antenna is 1.64, and the numeric gain of an ideal isotropic antenna is 1.0. The gain of an ideal half-wave dipole antenna relative to an ideal isotropic antenna is [10 log (1.64)] or 2.15 dBi. Therefore, if the antenna gain in dBd is unknown, it may be determined from the gain in dBi via the following relationship in Equation (G.4):

G_T(dBd) = G_T(dBi) – 2.15 dB (G.4)

Alternatively, the EIRP may be determined from Equation (G.3) and then converted to ERP based on the maximum antenna gain relationship by applying Equation (G.5):

ERP = EIRP – 2.15dB (G.5)

Similarly, the EIRP may be determined from the ERP as follows in Equation (G.6):

EIRP =ERP +2.15dB (G.6)

The antenna used is an Inverted F Antenna with 5.3 dBi gain. The antenna is identical to the design stated in Texas Instruments Application Note AN043.

EIRP = -14.29dBm + 5.3dBi - 0 = -8.99 dBm = 0.00012618275346Watts

Unwanted Emissions

§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)).

ANSI C63.10 11.11.2 Reference level measurement

Establish a reference level by using the following procedure:

a) Set instrument center frequency to DTS channel center frequency.
b) Set the span to ≥ 1.5 times the DTS bandwidth.
c) Set the RBW = 100 kHz.
d) Set the VBW ≥ [3 × 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 PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

ANSI C63.10 11.11.3 Emission level measurement

Establish an emission level by using the following procedure:

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

Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in 11.11. Report the three highest emissions relative to the limit.

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ANSI C63.10 11.12 Emissions in restricted frequency bands

Typical regulatory requirements for DTS specify that emissions that fall into restricted frequency bands shall comply with the general radiated emission limits. §15.205 Restricted bands of operation.

ANSI C63.10 11.12.1 Radiated emission measurements

Because the typical emission requirements are specified in terms of radiated field strength levels, measurements performed to determine compliance have traditionally relied on a radiated test configuration. Radiated measurements remain the principal method for determining compliance to the specified requirements; however antenna-port conducted measurements are also now acceptable to determine compliance (see 11.12.2 for details). When radiated measurements are utilized, test site requirements and procedures for maximizing and measuring radiated emissions that are described in 6.3, 6.5, and 6.6 shall be followed.

Antenna-Port Conducted Measurements

Table 7 – Unwanted Emissions

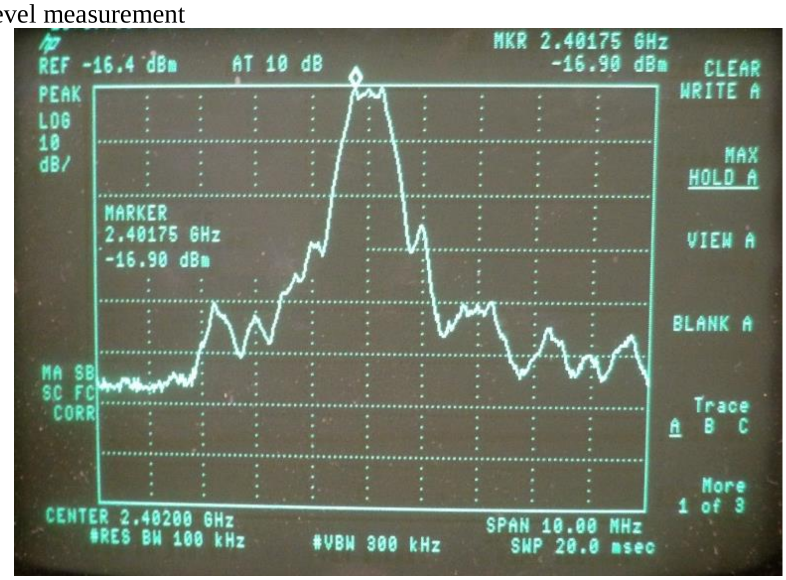
Channel	Frequency (MHz)	Within the frequency band (dB)	Outside the frequency band (dB)	dB Below >20	Result
Low	**2400**	**-5.56**	**-48.72**	**43.16**	**Pass**
Low	**2399.23**	**-5.56**	**-46.03**	**40.47**	**Pass**
Low	**2396.8**	**-5.56**	**-58.06**	**52.50**	**Pass**
High	**2483.25**	**-6.26**	**-60.84**	**54.58**	**Pass**
High	**2485.18**	**-6.26**	**-59.59**	**53.33**	**Pass**

Attenuator and cable correction factor 10.84dB

Note: Measurements from 22 GHz to 24.835 GHz were subcontracted by CKC Laboratories, Inc, 1120 Fulton Place, Fremont, CA 94539.

A2LA Accreditation certificate number 0803.01.

Reference level measurement



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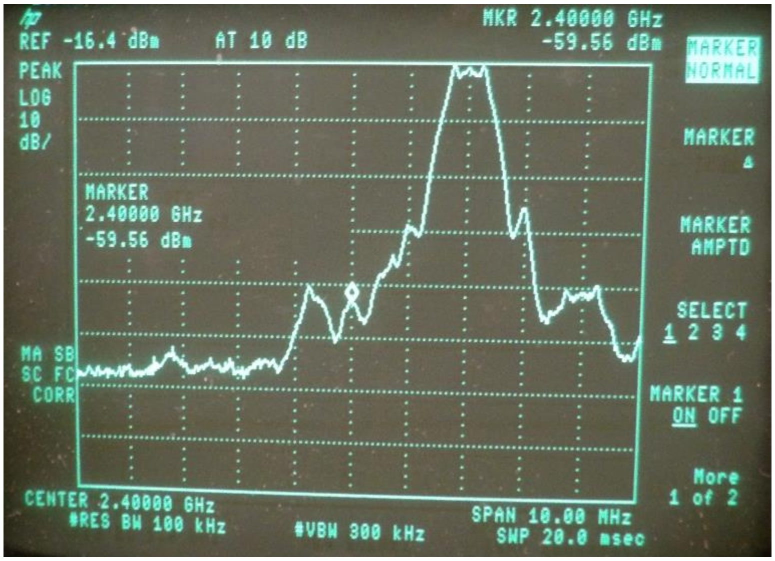
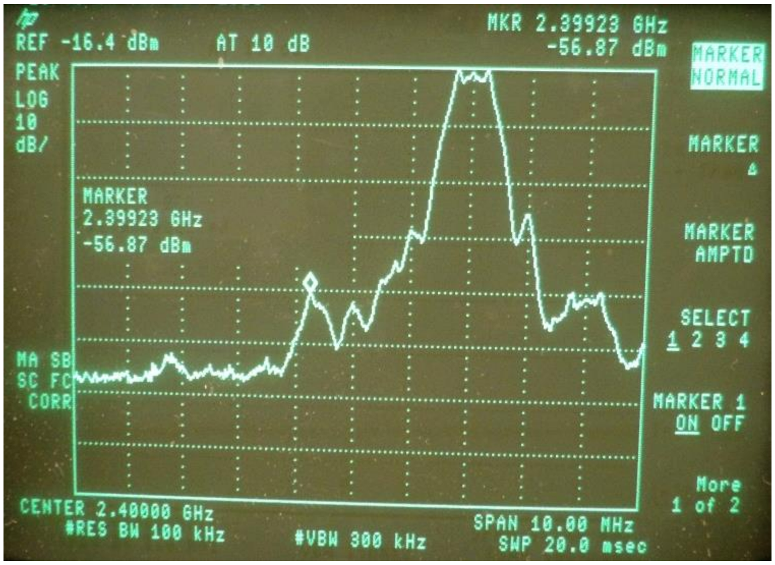
Emission level measurement



Emission level measurement



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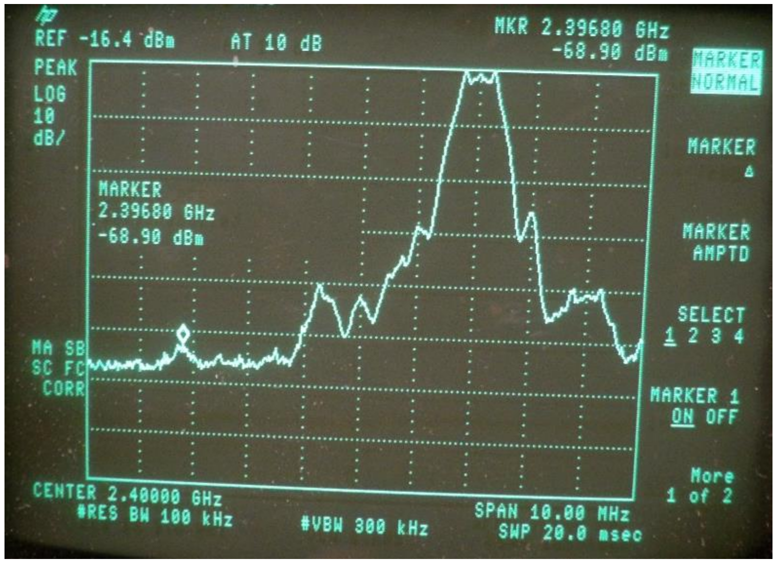
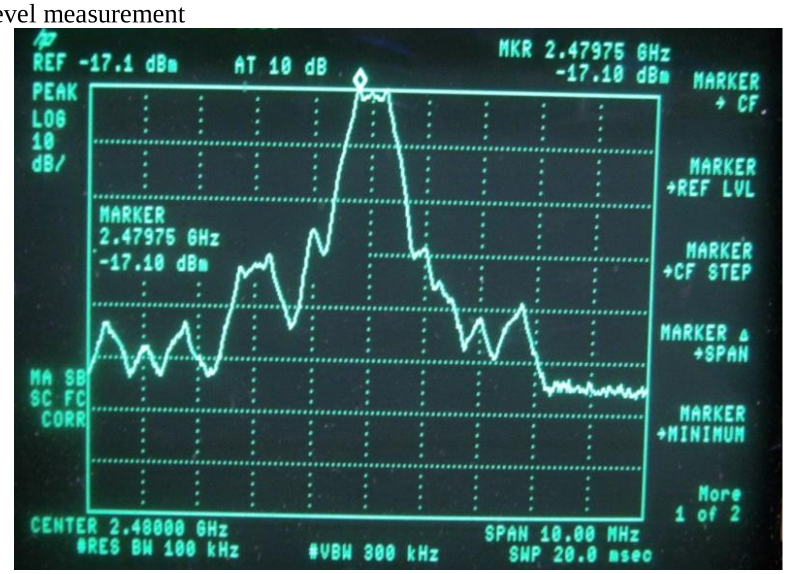
Emission level measurement



Reference level measurement



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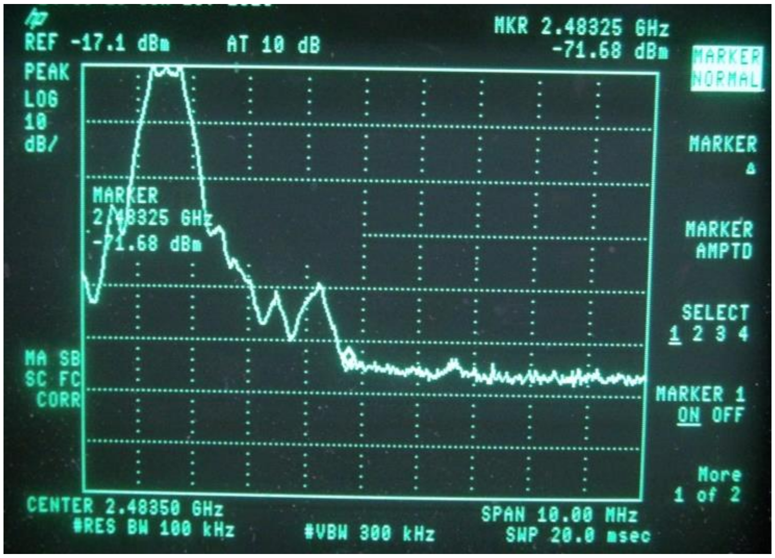
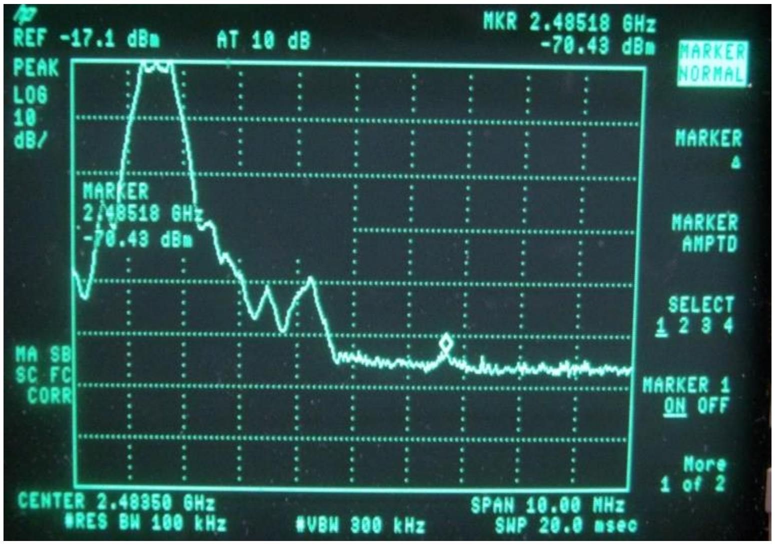
Emission level measurement



Emission level measurement



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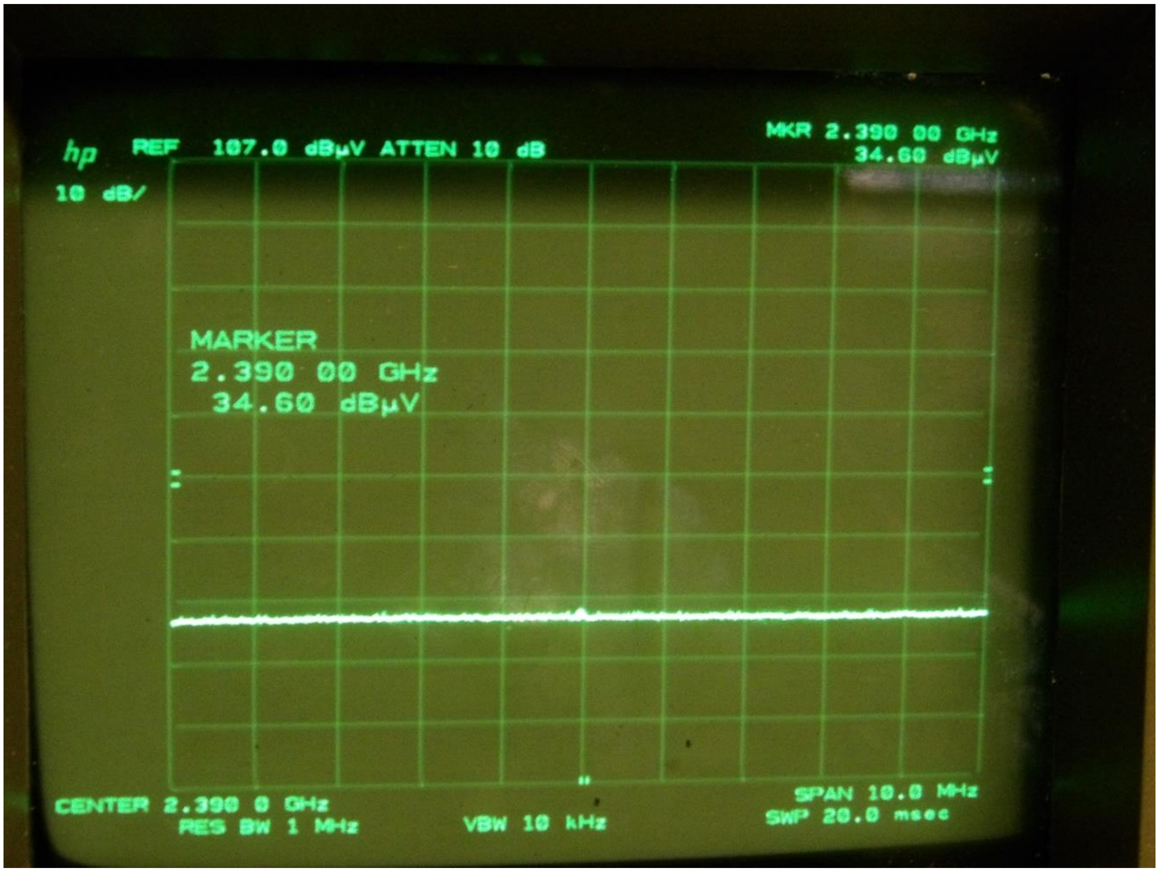
Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)). The peak measurements of all radiated emissions levels meet the requirement of 74dBuV/m at 3 meter distance, FCC 15.35(b).

Restricted Bands – Radiated Measurements

Horizontal measurements

Frequency MHz	**dBuV/m**	**CF**	**Corrected dBuV/m @ 3 meter**
2390	34.6	2.25	36.85



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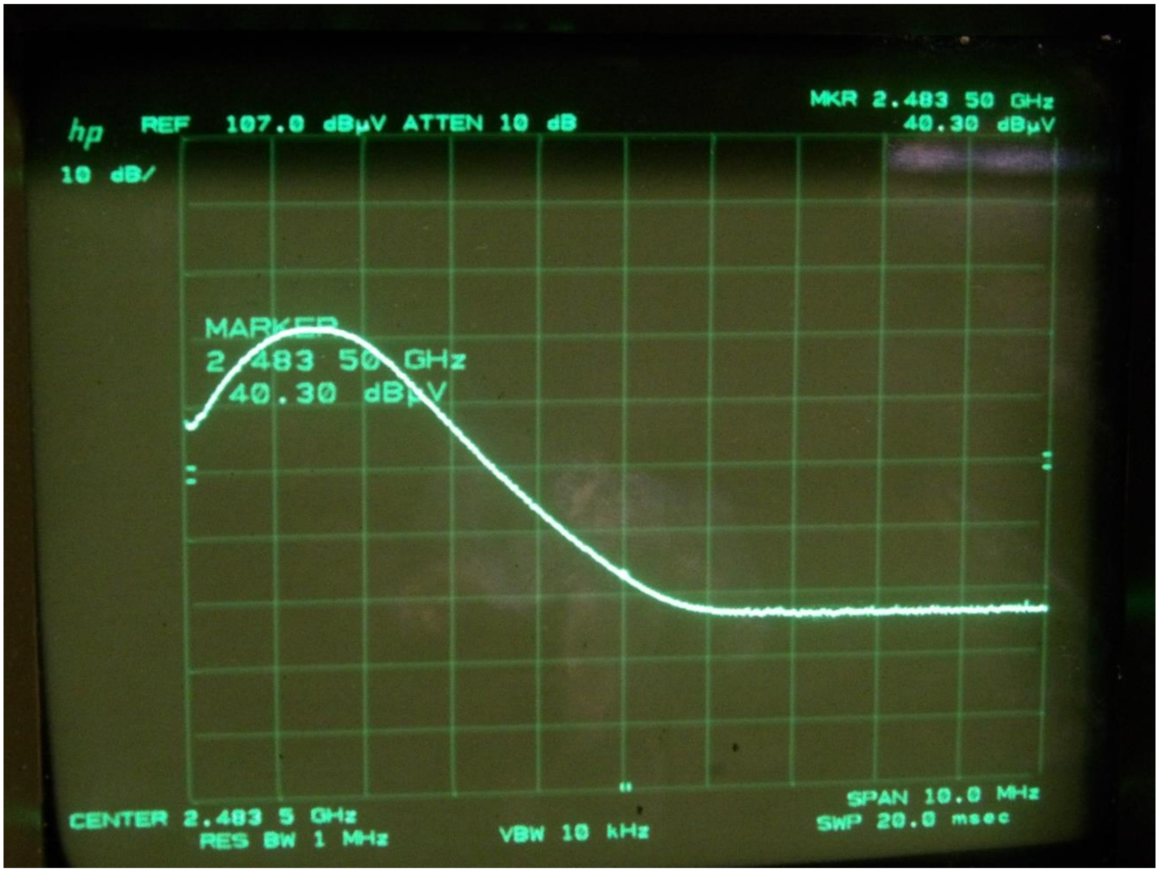
Restricted Bands – Radiated Measurements

Horizontal measurements

Frequency MHz	dBuV/m	CF	Corrected dBuV/m @ 3 meter
2483.5	40.3	2.51	42.81



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Restricted Bands – Radiated Measurements

Vertical measurements

Frequency MHz	dBuV/m	CF	Corrected dBuV/m @ 3 meter
2390	34.2	2.25	36.45

Restricted Bands – Radiated Measurements

Vertical measurements

Frequency MHz	**dBuV/m**	**CF**	**Corrected dBuV/m @ 3 meter**
2483.5	35.4	2.51	37.91

Occupied Bandwidth (99% emissions bandwidth)

ANSI C63.10 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.

g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

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).

Table 8 – 99% Occupied Bandwidth

Channel	Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)	Result
Low	2402	1070	>500	Pass
Mid	2440	1070		Pass
High	2480	1055		Pass

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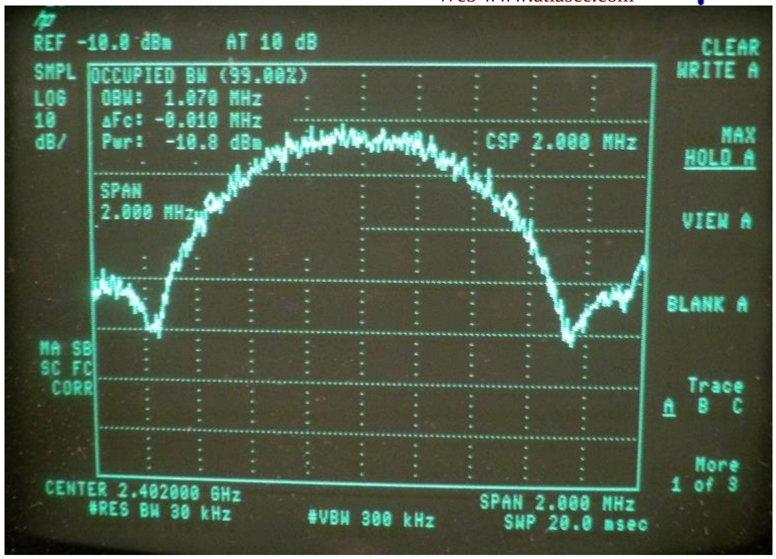

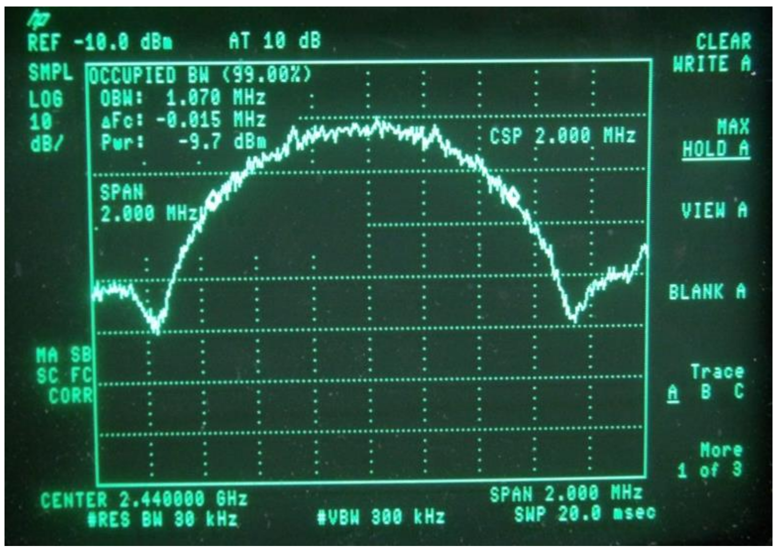

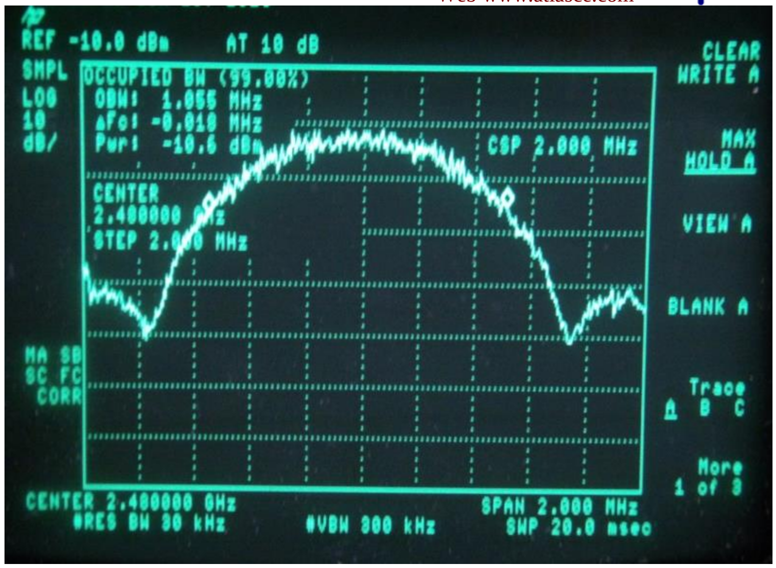
REF -10.0 dBm AT 10 dB
SMPL
LOG
10
dB/
OCCUPIED BW (99.00%)
OBW: 1.055 MHz
Pwr: -10.6 dBm
CSP 2.000 MHz
CENTER
STEP
MA SB
SC FC
CORR
CENTER 2.400000 GHz
#RES BW 30 kHz
#VBW 300 kHz
SPAN 2.000 MHz
SWP 20.0 msec
CLEAR
WRITE A
MAX
HOLD A
VIEW A
BLANK A
Trace
A B C
More
1 of 3

AC Power Line Conducted Emissions

§15.207 Conducted limits.

(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, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

AC Power Line Conducted Emissions Limits

	Conducted limit (dBµV)	
Frequency of emission (MHz)	**Quasi-peak**	**Average**
0.15 – 0.5	66 to 56*	56 to 46*
0.5 - 5	56	46
5 - 30	60	50

* The level decreases linearly with the logarithm of the frequency.

The EUT is a battery powered device and therefore no conducted emissions are required.

Transmitter Emission

§15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

(b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 990 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part. i.e. 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).

(f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device.

(g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

Report of Measurements Radiated Data

Radiated emissions measurements were performed from 9 kHz to 30 MHz at 3-meter distance. The loop antenna was placed at 1-meter height and was rotated about its vertical axis. The EUT was also rotated 360 degrees in front of the measurement antenna. Tests were performed with the EUT in all three orthogonal orientations. **No emissions were observed from the EUT in this frequency range.**

Measurements were performed in the frequency range of 30 MHz to 1 GHz at 10-meter distance. The Bilog antenna was searched from 1 to 4 meters in height in both horizontal and vertical orientation. The EUT was also rotated 360 degrees in front of the measurement antenna. Tests were performed with the measurement antenna in both horizontal and vertical orientations.

Measurements were performed in the frequency range of 1 GHz to 24.835 GHz at 3-meter distance. The Horn antenna was in both horizontal and vertical orientation. The EUT was also rotated 360 degrees in front of the measurement antenna. Only the second harmonic of the transmitter was observed, all others were baseline of the noise floor measurements. Measurements above 18 GHz were performed with the standard gain horn. Measurements from 22 GHz to 24.835 GHz were subcontracted by CKC Laboratories, Inc, 1120 Fulton Place, Fremont, CA 94539. A2LA Accreditation certificate number 0803.01. No emissions were observed above the third harmonic of the fundamental frequency.

Exploratory radiated emissions measurements of the transmitter frequencies were made to determine the maximum transmit level of the EUT. All frequencies were searched for any emissions from the EUT. No other emissions were observed.

Radiated Data

Table 9 – Radiated Data

The data below is at 10 meter distance.					
Frequency MHz	**QP Level dBμV/m**	**QP Limit dBμV/m**	**Margin dB**	**Azimuth, Height**	**Antenna, Polarization**
84.29	24.60	30.00	-5.40	0, 3.8m	BiLog, H
229.44	24.52	30.00	-5.48	185, 3.5m	BiLog, H
230.12	29.27	37.00	-7.73	0, 3.3m	BiLog, H
233.72	26.82	37.00	-10.18	0, 3.3m	BiLog, H
284.24	25.79	37.00	-11.21	5, 3.1m	BiLog, H
487.16	26.70	37.00	-10.30	330, 2.6m	BiLog, H
708.44	22.94	37.00	-14.06	10, 1.9m	BiLog, H
876.6	23.67	37.00	-13.33	185, 1.5m	BiLog, H
902.28	20.35	37.00	-16.65	195, 1.4m	BiLog, H
34.64	15.14	30.00	-14.86	65, 1.2m	BiLog, V
86.74	16.07	30.00	-13.93	15, 1.2m	BiLog, V
191.88	23.77	30.00	-6.23	350, 1.3m	BiLog, V
194.24	25.35	30.00	-4.65	350, 1.3m	BiLog, V
230.12	33.79	37.00	-3.21	225, 1.2m	BiLog, V
280.8	17.04	37.00	-19.96	185, 1.3m	BiLog, V
485.96	21.55	37.00	-15.45	190, 1.3m	BiLog, V
710.34	19.98	37.00	-17.02	5, 1.2m	BiLog, V
887.28	23.38	37.00	-13.62	10, 1.1m	BiLog, V

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	The data below is at 3-meter distance						
Polarization	**Emission Frequency MHz**	**PK Level dBμV/m**	**PK Limit dBμV/m**	**AV Level dBμV/m**	**AV Limit dBμV/m**	**PK Margin dB**	**AV Margin dB**
	Lowest Channel						
H	4804	34.8	74	30.6	54	-39.2	-23.4
V	4804	35.8	74	31.1	54	-38.2	-22.9
H	7206bl	37.5	74	35.5	54	-36.5	-18.5
V	7206bl	37.4	74	34.9	54	-36.6	-19.1
H	9608bl	38.2	74	36.4	54	-35.8	-17.6
V	9608bl	37.3	74	36.8	54	-36.7	-17.2
	No other emissions were observed						

	Middle Channel						
H	4880	31.1	74	30.2	54	-42.9	-23.8
V	4880	36.5	74	34.6	54	-37.5	-19.4
H	7320bl	38.1	74	35.1	54	-35.9	-18.9
V	7320bl	37.6	74	34.9	54	-36.4	-19.1
H	9760bl	38.2	74	35.5	54	-35.8	-18.5
V	9760bl	39	74	35.9	54	-35	-18.1
	No other emissions were observed						

	Highest Channel						
H	4960	34.4	74	30.9	54	-39.6	-23.1
V	4960	33.1	74	30.5	54	-40.9	-23.5
H	7440bl	35.9	74	34.6	54	-38.1	-19.4
V	7440bl	36.3	74	34.9	54	-37.7	-19.1
H	9920bl	38.2	74	36.8	54	-35.8	-17.2
V	9920bl	39.9	74	37.9	54	-34.1	-16.1
	No other emissions were observed						

Operating mode of the transmitter was GFSK modulation. Only baseline noise floor was observed after the second harmonic. (bl) Note: PK – peak readings, AV – average readings, H – horizontal polarization, V – vertical polarization. Measurements from 22 GHz to 24.835 GHz were subcontracted by CKC Laboratories, Inc, 1120 Fulton Place, Fremont, CA 94539. A2LA Accreditation certificate number 0803.01.

Frequency Stability

§15.215 Additional provisions to the general radiated emission limitations. (c)

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.

ANSI C63.10 6.8 Frequency stability tests

Some unlicensed wireless device requirements specify frequency stability tests with variation of supply voltage and temperature; the requirements can be found in the regulatory specifications for each type of unlicensed wireless device. The procedures listed in 6.8.1 and 6.8.2 shall be used for frequency stability tests.

ANSI C63.10 6.8.1 Frequency stability with respect to ambient temperature

a) Supply the EUT with a nominal ac voltage or install a new or fully charged battery in the EUT. If possible, a dummy load shall be connected to the EUT because an antenna near the metallic walls of an environmental test chamber could affect the output frequency of the EUT. If the EUT is equipped with a permanently attached, adjustable-length antenna, then the EUT shall be placed in the center of the chamber with the antenna adjusted to the shortest length possible. Turn ON the EUT and tune it to one of the number of frequencies shown in 5.6.

b) Couple the unlicensed wireless device output to the measuring instrument by connecting an antenna to the measuring instrument with a suitable length of coaxial cable and placing the measuring antenna near the EUT (e.g., 15 cm away), or by connecting a dummy load to the measuring instrument, through an attenuator if necessary.

c) Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

d) Turn the EUT OFF and place it inside the environmental temperature chamber. For devices that have oscillator heaters, energize only the heater circuit.

e) Set the temperature control on the chamber to the highest specified in the regulatory requirements for the type of device and allow the oscillator heater and the chamber temperature to stabilize.

f) While maintaining a constant temperature inside the environmental chamber, turn the EUT ON and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

g) Measure the frequency at each of frequencies specified in 5.6.

h) Switch OFF the EUT but do not switch OFF the oscillator heater.

i) Lower the chamber temperature by not more than 10 °C, and allow the temperature inside the chamber to stabilize.

j) Repeat step f) through step i) down to the lowest specified temperature.

ANSI C63.10 6.8.2 Frequency stability when varying supply voltage

Unless otherwise specified, these tests shall be made at ambient room temperature (+15 °C to +25 °C). An antenna shall be connected to the antenna output terminals of the EUT if possible. If the EUT is equipped with or uses an adjustable-length antenna, then it shall be fully extended.

a) Supply the EUT with nominal voltage or install a new or fully charged battery in the EUT. Turn ON the EUT and couple its output to a frequency counter or other frequency-measuring instrument.

NOTE—An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

b) Tune the EUT to one of the number of frequencies required in 5.6. Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

c) Measure the frequency at each of the frequencies specified in 5.6.

d) Repeat the above procedure at 85% and 115% of the nominal supply voltage as described in 5.13.

Table 10 – Frequency stability with temperature

Channel Frequency kHz	Time	-20 C kHz	20 C kHz	50 C kHz	Change Min kHz	Change Max kHz	
2402000	**0 min**	**2401986.1**	**2401993.2**	**2401982.9**	**-17.8**	**-6.7**	**Pass**
	2 min	**2401984.9**	**2401993.2**	**2401982.3**			
	5 min	**2401984.4**	**2401993.2**	**2401982.3**			
	10 min	**2401985.1**	**2401993.3**	**2401982.2**			
2480000	**0 min**	**2479984.2**	**2479993.3**	**2479981.6**	**-18.5**	**-6.7**	**Pass**
	2 min	**2479983.9**	**2479993.1**	**2479981.5**			
	5 min	**2479983.5**	**2479993.1**	**2479981.5**			
	10 min	**2479983.4**	**2479993.1**	**2479981.5**			

Table 11 – Frequency stability with varying voltage supply

No change in frequency was observed.	**Pass**

Note: new batteries were used for test.

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COMPLIANCE VERIFICATION REPORT

TEST CERTIFICATE

APPLICANT:	WaterGuru Inc 115 Independence Drive Menlo Park CA 94025
Trade Name:	WaterGuru Inc
Model:	SENSE

I HEREBY CERTIFY THAT:

The measurements shown in this report were made in accordance with the procedures indicated and that the energy emitted by this equipment, as received, was found to be within the FCC CFR 47 Part 15 Rules and Regulations Subpart C requirements. Additionally, it should be noted that the results in this report apply only to the items tested, as identified herein.

I FURTHER CERTIFY THAT:

On the basis of the measurements taken at the test site, the equipment tested is capable of operation in compliance with the requirements set forth in FCC CFR 47 Part 15.207, 15.209 and 15.247 Rules and Regulations.

On this Date: August 23, 2019

Bruce Smith
Atlas Compliance & Engineering, Inc.