

***Electromagnetic Emissions Test Report
and
Application for Grant of Equipment Authorization
pursuant to
FCC Part 15, Subpart C (15.247) DTS Specifications and
Industry Canada RSS 210 Issue 6 for an
Intentional Radiator on the
Moteiv Corporation
Model: Tmote Sky***

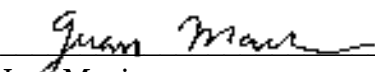
FCC ID: TOQTMOTESKY
UPN: 6142A-TMOTESKY

GRANTEE: Moteiv Corporation
7224 View Ave.
El Cerrito, CA 94530

TEST SITE: Elliott Laboratories, Inc.
684 W. Maude Avenue
Sunnyvale, CA 94086

REPORT DATE: September 30, 2005

FINAL TEST DATE: September 22, 2005

AUTHORIZED SIGNATORY: 
Juan Martinez
Senior EMC Engineer



2016-01

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DECLARATIONS OF COMPLIANCE

Equipment Name and Model:

Tmote Sky

Manufacturer:

Moteiv Corporation
7224 View Ave.
El Cerrito, CA 94530

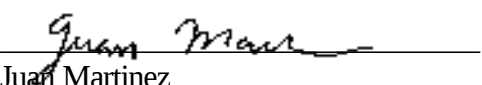
Tested to applicable standards:

RSS-210, Issue 6, September 2005 (Low Power License-Exempt Radiocommunication
Devices)
FCC Part 15.247 (DTS)

Measurement Facility Description Filed With Department of Industry:

Departmental Acknowledgement Number: IC2845 SV2 Dated August 16, 2007

I declare that the testing was performed or supervised by me; that the test measurements were made in accordance with the above mentioned departmental standards (through the use of ANSI C63.4:2003 as detailed in section 5.3 of RSS-210, Issue 6); and that the equipment performed in accordance with the data submitted in this report.

Signature	
Name	Juan Martinez
Title	Senior EMC Engineer
Company	Elliott Laboratories Inc.
Address	684 W. Maude Ave Sunnyvale, CA 94086 USA

Date: September 30, 2005

Maintenance of compliance with the above standards is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

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SCOPE

An electromagnetic emissions test has been performed on the Moteiv Corporation model Tmote Sky pursuant to Subpart C of Part 15 of FCC Rules for intentional radiators and RSS-210 Issue 6 for licence-exempt low power devices. Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in ANSI C63.4:2003 as outlined in Elliott Laboratories test procedures.

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of the Moteiv Corporation model Tmote Sky and therefore apply only to the tested sample. The sample was selected and prepared by Robert Szewczyk of Moteiv Corporation

OBJECTIVE

The primary objective of the manufacturer is compliance with Subpart C of Part 15 of FCC Rules and RSS-210 Issue 6 for license-exempt low power devices for the radiated and conducted emissions of intentional radiators. Certification of these devices is required as a prerequisite to marketing as defined in Part 2 the FCC Rules.

Certification is a procedure where the manufacturer or a contracted laboratory makes measurements and submits the test data and technical information to the FCC. The FCC issues a grant of equipment authorization upon successful completion of their review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units which are subsequently manufactured.

SUMMARY OF RESULTS

FCC Part 15 Section	RSS 210 Section	Description	Measured Value	Comments	Result
15.247(a)	6.2.2(o)(b)	Digital Modulation	Systems uses DSSS techniques	System must utilize a digital transmission technology	Complies
15.247 (a) (2)	6.2.2(o)(b)	6dB Bandwidth	1.6 MHz	Minimum allowed is 500kHz	Complies
	RSP 100	99% Bandwidth	16 MHz	For information only	Complies
15.247 (b) (3)	6.2.2(o)(b)	Output Power, 2400 - 2483.5 MHz	3.39 dBm EIRP = 0.0022 W	Multi-point applications: Maximum permitted is 1Watt, with EIRP limited to 4 Watts.	Complies
15.247(d)	6.2.2(o)(b)	Power Spectral Density	-40dBm / kHz	Maximum permitted is 8dBm/3kHz	Complies
15.247(c)	6.2.2(o)(e1)	Antenna Port Spurious Emissions – 30MHz – 26 GHz	All spurious emissions < -20dBc	Measurement was not made since antenna is permanently attached, so only radiated emissions was performed instead	Complies
15.247(c) / 15.209		Radiated Spurious Emissions – 30MHz – 26 GHz	53.9dBuV/m @ 2483.5 MHz (-0.1 dB)	Emissions in restricted bands must meet the radiated emissions limits detailed in 15.207. All others must be < -20dBc	Complies
15.207		AC Conducted Emissions	Battery Operated	N/A	N/A
	6.6	AC Conducted Emissions	Battery Operated	N/A	N/A
15.247 (b) (5)		RF Exposure Requirements	MPE calculation		
15.203		RF Connector	Antenna is permanently attached		Complies

EIRP calculated using antenna gain of dBi (-5) for the highest EIRP point-to-multipoint system.

MEASUREMENT UNCERTAINTIES

ISO Guide 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Frequency Range (MHz)	Calculated Uncertainty (dB)
Conducted Emissions	0.15 to 30	± 2.4
Radiated Emissions	30 to 1000	± 3.6

EQUIPMENT UNDER TEST (EUT) DETAILS**GENERAL**

The Moteiv Corporation model Tmote Sky is a wireless sensor node which is designed for low power, low bandwidth data collection and processing. The device is equipped with environmental sensors (temperature, humidity, photosynthetically active radiation). Additional sensors can be attached to the device through the expansion connector. The signals propagating through that connector may not exceed 2.5V in peak-to-peak amplitude and 100kHz in frequency and 1mA in current. The EUT is primarily powered from a battery (supply in the range 1.8 to 3.6V). The device can interface with personal computers over a USB port. Normally, the EUT would be placed on near a phenomenon to be sensed. The end user environment was approximated using a tabletop. The EUT cannot be powered from AC lines.

The sample was received on September 22, 2005 and tested on September 22, 2005. The EUT consisted of the following component(s):

Manufacturer	Model	Description	Serial Number	FCC ID
Moteiv	Tmote Sky	Low power wireless sensing module	prototype	TOQTMOTESKY

OTHER EUT DETAILS

The supplied unit has been programmed to perform the following functions: receive, send on low channel (2405 MHz), mid channel (2440 MHz), and high channel (2480 MHz). The transmission could be enabled in two different modes: the packet mode, exercising maximum transmission rate of the radio stack, and continuous modulated carrier mode.

When powered up with supplied AA batteries, unit will function in receive mode, and all LEDs should remain off. Pressing the USER button will cycle between the modes Receive -> low channel -> mid channel -> high channel -> receive

When a transmit mode is selected, the device will send packets on the selected channel. The packets are sent one after another; there is a channel contention period between the packets. Each packet sent will blink the LED corresponding to the currently selected channel:

- . Red LED - low channel
- . Green LED - mid channel
- . Blue LED - high channel

The LED on selected channel blinks with a period of 1s; the continuous modulated carrier test mode cycles the LED between on and off; the packet mode cycles the LED between 75% and 25% duty cycle. The transmission power was set as follows:

Low channel: 0dBm

Mid channel: 0dBm

High channel: -3.5dBm

ENCLOSURE

The EUT RF shield is 0.008" tin-plated brass. The module measures 3.25"x1.25x3/16" without a default battery pack and 3.25"x1.25x.75" with the AA battery pack attached.

MODIFICATIONS

The EUT did not require modifications during testing in order to comply with the emission specifications.

SUPPORT EQUIPMENT

No equipment was used as support equipment for emissions testing.

EUT INTERFACE PORTS

The I/O cabling configuration during emissions testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
None				

EUT OPERATION DURING TESTING

The supplied unit has been programmed to perform the following functions: receive, send on low channel (2405 MHz), mid channel (2440 MHz), and high channel (2480 MHz). The transmission could be enabled in two different modes: the packet mode, exercising maximum transmission rate of the radio stack, and continuous modulated carrier mode.

ANTENNA REQUIREMENTS

Antenna is permanently attached. The internal antenna has the peak gain of -5dBi

TEST SITE**GENERAL INFORMATION**

Final test measurements were taken on September 22, 2005 at the Elliott Laboratories Open Area Test Site #2 located at 684 West Maude Avenue, Sunnyvale, California. The test site contains separate areas for radiated and conducted emissions testing. Pursuant to section 2.948 of the Rules, construction, calibration, and equipment data has been filed with the Federal Communications Commission. In accordance with Industry Canada rules detailed in RSS 210 Issue 6 and RSS-212, construction, calibration, and equipment data for the test sites have been filed with the Federal Communications Commission.

The FCC recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement with the exception of predictable local TV, radio, and mobile communications traffic. The test site contains separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent FCC requirements.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.4:2003. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4:2003 guidelines.

MEASUREMENT INSTRUMENTATION**RECEIVER SYSTEM**

An EMI receiver as specified in CISPR 16-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

INSTRUMENT CONTROL COMPUTER

The receivers utilize either a Rohde and Schwarz EZM Spectrum Monitor/Controller or contain an internal Spectrum Monitor/Controller to view and convert the receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers.

The Spectrum Monitor provides a visual display of the signal being measured. In addition, the controller or a personal computer run automated data collection programs which control the receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors are added automatically.

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

POWER METER

A power meter and peak power sensor are used for all direct output power measurements from transmitters as they provide a broadband indication of the power output.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A biconical antenna is used to cover the range from 30 MHz to 300 MHz and a log periodic antenna is utilized from 300 MHz to 1000 MHz. Narrowband tuned dipole antennas are used over the entire 30 to 1000 MHz range for precision measurements of field strength. Above 1000 MHz, a horn antenna is used. The antenna calibration factors are included in site factors programmed into the test receivers.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

ANSI C63.4:2003 specifies that the test height above ground for table mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES**EUT AND CABLE PLACEMENT**

The FCC requires that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.4:2003 , and the worst case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

RADIATED EMISSIONS

Radiated emissions measurements are performed in two phases as well. A preliminary scan of emissions is conducted in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed from 30 MHz up to the frequency required by the regulation specified on page 1. One or more of these is with the antenna polarized vertically while the one or more of these is with the antenna polarized horizontally. During the preliminary scans, the EUT is rotated through 360°, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit.

A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth which results in the highest emission is then maintained while varying the antenna height from one to four meters. The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain. Emissions which have values close to the specification limit may also be measured with a tuned dipole antenna to determine compliance.

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements are performed with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.

Measurement bandwidths (video and resolution) are set in accordance with FCC procedures for the type of radio being tested.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions from the AC power port are given in units of microvolts, the limits for radiated electric field emissions are given in units of microvolts per meter at a specified test distance and the output power limits are given in terms of Watts, milliwatts or dBm. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp) the following formula is used to determine the field strength limit in terms of microvolts per meter at a distance of 3m from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{3} \quad \text{microvolts per meter}$$

where P is the eirp (Watts)

For reference, converting the voltage and electric field strength specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. Conversion of power specification limits from linear units (in milliwatts) to decibel form (in dBm) is accomplished by taking the base ten logarithm, then multiplying by 10.

FCC 15.407 (a) and RSS 210 (o) OUTPUT POWER LIMITS

The table below shows the limits for output power and output power density. Where the signal bandwidth is less than 20 MHz the maximum output power is reduced to the power spectral density limit plus 10 times the log of the bandwidth (in MHz).

Operating Frequency (MHz)	Output Power	Power Spectral Density
902 – 928	1 Watts (30 dBm)	8 dBm/3kHz
2400 – 2483.5	1 Watts (30 dBm)	8 dBm/3kHz
5725 – 5850	1 Watts (30 dBm)	8 dBm/3kHz

The maximum permitted output power is reduced by 1dB for every dB the antenna gain exceeds 6dBi. Fixed point-to-point applications using the 5725 – 5850 MHz band are not subject to this restriction.

RSS 210 (o) AND FCC 15.247 SPURIOUS RADIATED EMISSIONS LIMITS

The limits for unwanted (spurious) emissions from the transmitter falling in the restricted bands detailed in Part 15.205 and for all spurious emissions from the receiver are:

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

All other unwanted (spurious) emissions shall be at least 20dB below the level of the highest in-band signal level.

FCC 15.205 AC POWER PORT CONDUCTED EMISSIONS LIMITS

The table below shows the limits for emissions on the AC power line as detailed in FCC Part 15.205.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

RSS-210 SECTION 6.6 AC POWER PORT CONDUCTED EMISSIONS LIMITS

The table below shows the limits for emissions on the AC power line as detailed in Industry Canada RSS-210 section 6.6.

Frequency Range (MHz)	Limit (uV)	Limit (dBuV)
0.450 to 30.000	250	48

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_T - B = C$$

and

$$C - S = M$$

where:

R_T = Receiver Reading in dBuV

B = Broadband Correction Factor*

C = Corrected Reading in dBuV

S = Specification Limit in dBuV

M = Margin to Specification in +/- dB

* Broadband Level - Per ANSI C63.4:2003 , 13 dB may be subtracted from the quasi-peak level if it is determined that the emission is broadband in nature. If the signal level in the average mode is six dB or more below the signal level in the peak mode, the emission is classified as broadband.

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements. A distance factor, when used for electric field measurements, is calculated by using the following formula:

$$F_d = 20 * \text{LOG}_{10} (D_m/D_s)$$

where:

$$F_d = \text{Distance Factor in dB}$$

$$D_m = \text{Measurement Distance in meters}$$

$$D_s = \text{Specification Distance in meters}$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

$$R_r = \text{Receiver Reading in dBuV/m}$$

$$F_d = \text{Distance Factor in dB}$$

$$R_c = \text{Corrected Reading in dBuV/m}$$

$$L_s = \text{Specification Limit in dBuV/m}$$

$$M = \text{Margin in dB Relative to Spec}$$

EXHIBIT 1: Test Equipment Calibration Data

1 Page

Radiated Emissions, 30 - 26,500 MHz, 22-Sep-05**Engineer: Mehran Birgani**

<u>Manufacturer</u>	<u>Description</u>	<u>Model #</u>	<u>Asset #</u>	<u>Cal Due</u>
EMCO	Horn antenna, D. Ridge 1-18GHz (SA40 system antenna)30Hz sunnyvale	3115	1142	11-Jun-06
Hewlett Packard	Microwave EMI test system (SA40, 30Hz - 40GHz), Sunnyvale	84125C	1149	09-Jun-06
EMCO	Log Periodic Antenna, 0.2-2 GHz	3148	1321	30-Mar-07
Rohde & Schwarz	Test Receiver, 0.009-2750 MHz	ESN	1332	23-May-06
EMCO	Biconical Antenna, 30-300 MHz	3110B	1497	15-Jun-06

Radiated Emissions, 30 - 12,500 MHz, 26-Sep-05**Engineer: Mehran Birgani**

<u>Manufacturer</u>	<u>Description</u>	<u>Model #</u>	<u>Asset #</u>	<u>Cal Due</u>
EMCO	Horn Antenna, D. Ridge 1-18GHz	3115	1242	19-Oct-06
Hewlett Packard	EMC Spectrum Analyzer 9kHz - 40 GHz, Fremont (SA40)	8564E (84125C)	1393	26-Oct-05

EXHIBIT 2: Test Data Log Sheets

ELECTROMAGNETIC EMISSIONS

TEST LOG SHEETS

AND

MEASUREMENT DATA

T 61218 14 Pages



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
		Account Manager:	Esther Zhu
Contact:	Robert Szewczyk		
Emissions Spec:	FCC 15.247, RSS-210 / FCC	Class:	Radio / B
Immunity Spec:		Environment:	

EMC Test Data

For The

Moteiv Corporation

Model

Tmote Sky

Date of Last Test: 9/22/2005



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
		Account Manager:	Esther Zhu
Contact:	Robert Szewczyk		
Emissions Spec:	FCC 15.247, RSS-210 / FCC	Class:	Radio / B
Immunity Spec:	Enter immunity spec on cover	Environment:	

EUT INFORMATION

General Description

The EUT is a wireless sensor node which is designed for low power, low bandwidth data collection and processing. The device is equipped with environmental sensors (temperature, humidity, photosynthetically active radiation). Additional sensors can be attached to the device through the expansion connector. The signals propagating through that connector may not exceed 2.5V in peak-to-peak amplitude and 100kHz in frequency and 1mA in current. The EUT is primarily powered from a battery (supply in the range 1.8 to 3.6V). The device can interface with personal computers over a USB port. Normally, the EUT would be placed on near a phenomenon to be sensed. The end user environment was approximated using a table-top. The EUT cannot be powered from AC lines.

Equipment Under Test

Manufacturer	Model	Description	Serial Number	FCC ID
Moteiv	Tmote Sky	Low power wireless	prototype	TOQTMOTESKY

Other EUT Details

Each package is 16 bits and 0.5 mS long. Time between packets is a minimum of 2.5ms. Measured about 12 packets in 50ms, total time of 0.8ms per packet = 9.6ms/50ms (19.25, ACF = 14.2dB)

EUT Antenna

The antenna is integral to the device. The internal antenna has the peak gain of -5dBi

EUT Enclosure

The EUT RF shield is 0.008" tin-plated brass. The module measures 3.25"x1.25x3/16" without a default battery pack and 3.25"x1.25x.75" with the AA battery pack attached.

Modification History

Mod. #	Test	Date	Modification
1	-	-	None

Modifications applied are assumed to be used on subsequent tests unless otherwise stated as a further modification.



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
		Account Manager:	Esther Zhu
Contact:	Robert Szewczyk		
Emissions Spec:	FCC 15.247, RSS-210 / FCC	Class:	Radio / B
Immunity Spec:	Enter immunity spec on cover	Environment:	

Test Configuration #1

Local Support Equipment

Manufacturer	Model	Description	Serial Number	FCC ID
None				

Remote Support Equipment

Manufacturer	Model	Description	Serial Number	FCC ID
None				

Interface Cabling and Ports

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
None				

EUT Operation During Emissions Tests

The supplied unit has been programmed to perform the following functions:

receive, send on low channel (2405 MHz), mid channel (2440 MHz), and high channel (2480 MHz). The transmission could be enabled in two different modes: the packet mode, exercising maximum transmission rate of the radio stack, and continuous modulated carrier mode.

When powered up with supplied AA batteries, unit will function in receive mode, and all LEDs should remain off. Pressing the USER button will cycle between the modes Receive -> low channel -> mid channel -> high channel -> receive

When a transmit mode is selected, the device will send packets on the selected channel. The packets are sent one after another; there is a channel contention period between the packets. Each packet sent will blink the LED corresponding to the currently selected channel:

- . Red LED - low channel
- . Green LED - mid channel
- . Blue LED - high channel

The LED on selected channel blinks with a period of 1s; the continuous modulated carrier test mode cycles the LED between on and off; the packet mode cycles the LED between 75% and 25% duty cycle. The transmission power was set as follows:

Low channel: 0dBm

Mid channel: 0dBm

High channel: -3.5dBm



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

FCC 15.247 DTS - Power, Bandwidth and Spurious Emissions

Test Specifics

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 9/22/2005
Test Engineer: Mehran Birgani
Test Location: SVOATS #2

Config. Used: 1
Config Change: None
EUT Voltage: Battery Mode

General Test Configuration

The EUT was located on the turntable for radiated spurious emissions testing.

For radiated emissions testing the measurement antenna was located 3 meters from the EUT.

Ambient Conditions: Temperature: 20 °C
Rel. Humidity: 60 %

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	RE, 30 - 26500 MHz - Tx Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	53.9dB μ V/m (495.5 μ V/m) @ 2483.6MHz (-0.1dB)
1d	RE,30 - 12500 MHz - Rx Spurious Emissions	FCC Part 15.209 / 15.247(c)	Pass	Refer to run
2	6dB Bandwidth	15.247(a)	Pass	1.6 MHz
3	Output Power	15.247(b)	Pass	3.39 dBm
4	Power Spectral Density (PSD)	15.247(d)	Pass	-40 dBm

Modifications Made During Testing:

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.



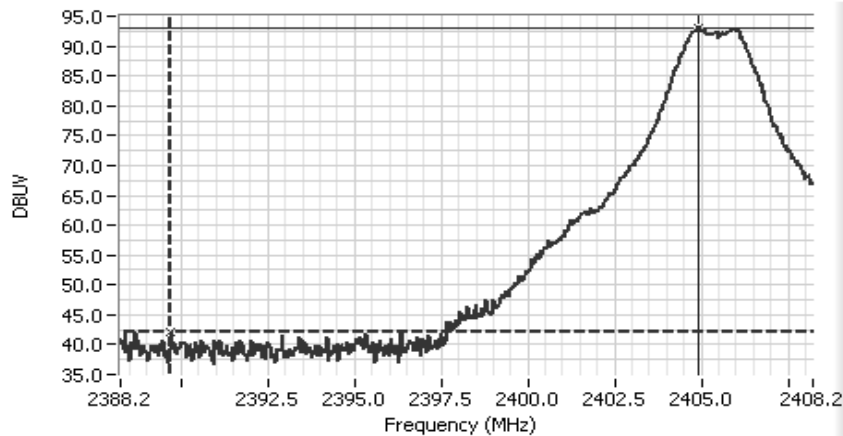
EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Run #1a: Radiated Spurious Emissions, 30 - 26500 MHz. Low Channel @ 2405 MHz

Fundamental Signal Field Strength: Peak and average values measured in 1 MHz, and peak value measured in 100kHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2405.058	89.2	H	-	-	AVG	74	2.4	RB = 1MHz, VB = 10Hz
2405.058	92.9	H	-	-	PK	74	2.4	RB = VB = 1MHz
2405.083	96.9	V	-	-	AVG	160	1.0	RB = 1MHz, VB = 10Hz
2405.083	100.7	V	-	-	PK	160	1.0	RB = VB = 1MHz

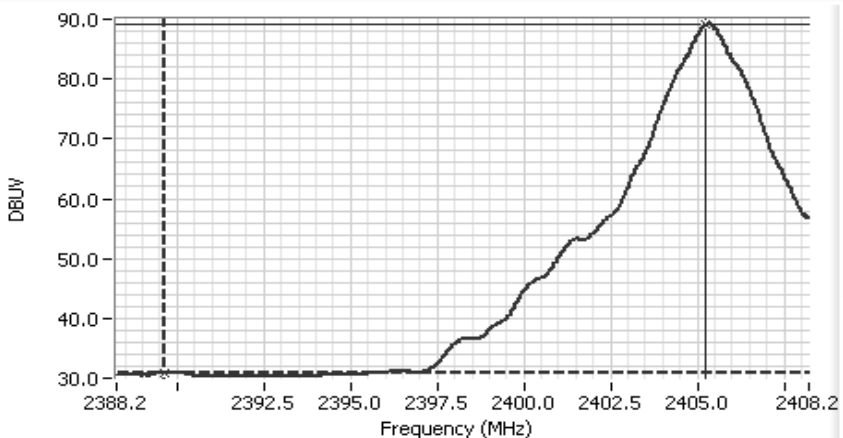


Analyzer Settings
HP8564E,006,EMI,UK6
CF: 2398.2 MHz
SPAN:20.0 MHz
RB 1.0 MHz
VB 1.0 MHz
Detector POS
Att 10
RL Offset 0.00
Sweep Time 50.0ms
Ref Lvl:104.40DBU

Comments

Cursor 1	2389.71	42.23	↔	✱	🔍
Cursor 2	2404.92	92.90	↔	✱	🔍

Delta Freq. 15.2 MHz
Delta Amplitude 50.67



Analyzer Settings
HP8564E,006,EMI,UK6
CF: 2398.2 MHz
SPAN:20.0 MHz
RB 1.0 MHz
VB 10 Hz
Detector Sample
Att 10
RL Offset 0.00
Sweep Time 7.4s
Ref Lvl:104.40DBU

Comments

Cursor 1	2389.61	30.90	↔	✱	🔍
Cursor 2	2405.25	89.07	↔	✱	🔍

Delta Freq. 15.6 MHz
Delta Amplitude 58.17





EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Delta Marker - Peak	50.7 dB	Delta between highest in-band and highest
Delta Marker - Average	58.2 dB	

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2389.615	38.7	V	54.0	-15.3	AVG	160	1.0	
2389.710	50.0	V	74.0	-24.0	PK	160	1.0	

Note 1: Calculated by subtracting the marker delta values from the fundamental field strength measurements.

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
4809.189	46.8	V	54.0	-7.2	Avg	166	1.0	Note 2
4809.244	60.8	V	74.0	-13.2	PK	166	1.0	
4809.283	52.8	H	54.0	-1.2	AVG	183	2.0	Note 2
4809.283	66.8	H	74.0	-7.2	PK	183	2.0	
7213.610	53.3	V	74.0	-20.8	PK	113	1.4	
7213.650	39.3	V	54.0	-14.7	Avg	113	1.4	Note 2
7213.655	41.3	H	54.0	-12.7	Avg	117	1.4	Note 2
7213.955	55.3	H	74.0	-18.8	PK	117	1.4	

Note 1: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.

Note 2: Average value calculated from peak value with duty cycle of <20% in any 100ms period (14dB correction).



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Run #1b: Radiated Spurious Emissions, 30 - 26500 MHz. Center Channel @ 2440 MHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
4879.135	60.2	H	74.0	-13.9	PK	242	2.0	
4880.094	46.2	H	54.0	-7.8	AVG	242	2.0	Note 2
7318.664	52.2	H	74.0	-21.8	PK	308	2.1	
7318.398	38.2	H	54.0	-15.8	AVG	308	2.1	Note 2
4879.105	60.6	V	74.0	-13.4	PK	147	1.6	
4880.100	46.6	V	54.0	-7.4	AVG	147	1.6	Note 2

Note 1: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.

Note 2: Average value calculated from peak value with duty cycle of <20% in any 100ms period (14dB correction).

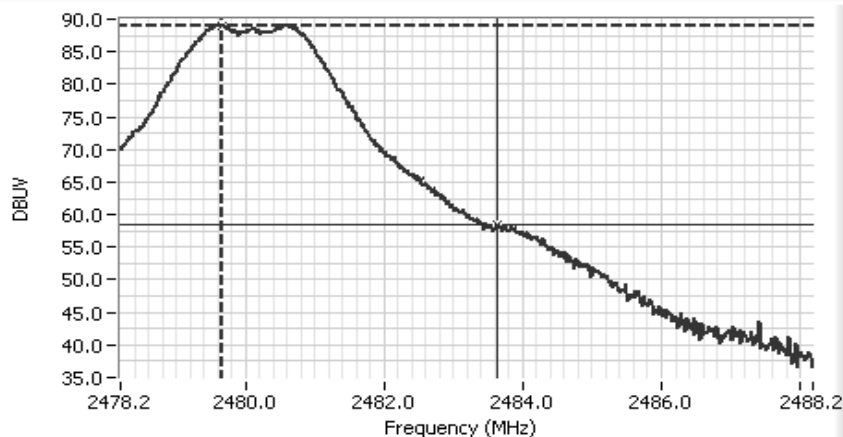


EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Run #1c: Radiated Spurious Emissions, 30 - 26500 MHz. High Channel @ 2480 MHz

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dB μ V/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2480.067	89.3	V	-	-	AVG	149	1.0	RB = 1MHz, VB = 10Hz
2480.067	93.2	V	-	-	PK	149	1.0	RB = VB = 1MHz
2480.050	89.4	H	-	-	AVG	137	1.8	RB = 1MHz, VB = 10Hz
2480.050	93.2	H	-	-	PK	137	1.8	RB = VB = 1MHz

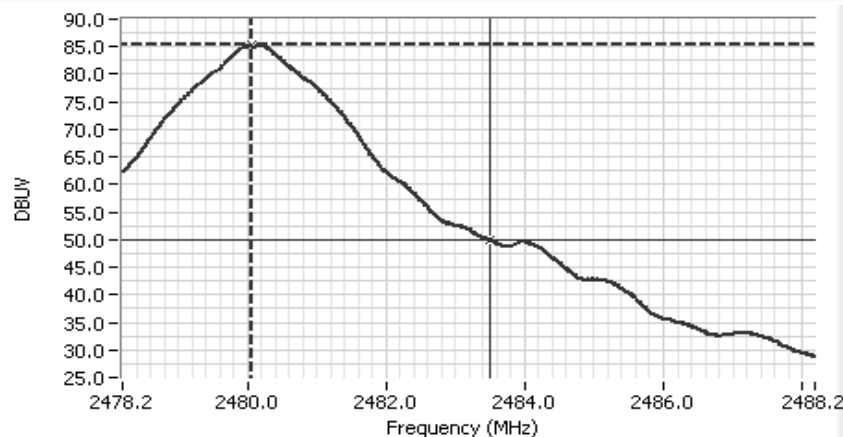


Analyzer Settings
HP8564E,006,EMI,UK6
CF: 2483.2 MHz
SPAN:10.0 MHz
RB 1.0 MHz
VB 1.0 MHz
Detector POS
Att 10
RL Offset 0.00
Sweep Time 50.0ms
Ref Lvl:92.00DBUW

Comments

Cursor 1 2479.66 89.00
Cursor 2 2483.62 58.50

Delta Freq. 4.0 MHz
Delta Amplitude 30.50



Analyzer Settings
HP8564E,006,EMI,UK6
CF: 2483.2 MHz
SPAN:10.0 MHz
RB 1.0 MHz
VB 10 Hz
Detector Sample
Att 10
RL Offset 0.00
Sweep Time 5.0s
Ref Lvl:92.00DBUW

Comments

Cursor 1 2480.06 85.33
Cursor 2 2483.50 49.83

Delta Freq. 3.4 MHz
Delta Amplitude 35.50





EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Delta Marker - Peak	30.5 dB	Delta between highest in-band and highest
Delta Marker - Average	35.5 dB	

Band Edge Signal Field Strength

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
2483.550	53.9	V	54.0	-0.1	AVG	164	1.0	
2483.620	62.7	V	74.0	-11.3	PK	164	1.0	

Note 1: Calculated by subtracting the marker delta values from the fundamental field strength measurements.

Other Spurious Emissions

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
4960.120	55.7	V	74.0	-18.3	PK	70	1.1	
4960.110	41.7	V	54.0	-12.3	AVG	70	1.1	Note 2
7439.355	49.7	V	74.0	-24.3	PK	232	1.1	Noise Floor
7439.355	38.5	V	54.0	-15.5	AVG	232	1.1	Noise Floor
4960.105	60.5	H	74.0	-13.5	PK	245	2.0	
4960.135	46.5	H	54.0	-7.5	AVG	244	2.0	Note 2
7438.645	50.4	H	74.0	-23.6	PK	245	2.0	Noise Floor
7438.645	38.8	H	54.0	-15.2	AVG	245	2.0	Noise Floor

Note 1: For emissions in restricted bands, the limit of 15.209 was used. For all other emissions, the limit was set 20dB below the level of the fundamental.

Note 2: Average value calculated from peak value with duty cycle of <20% in any 100ms period (14dB correction).

Run #1d: Radiated Spurious Emissions, 30 - 12500 MHz. Receive Mode

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBμV/m	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
Note 1								

Note 1: No signal was found within 15 dB of limit line.

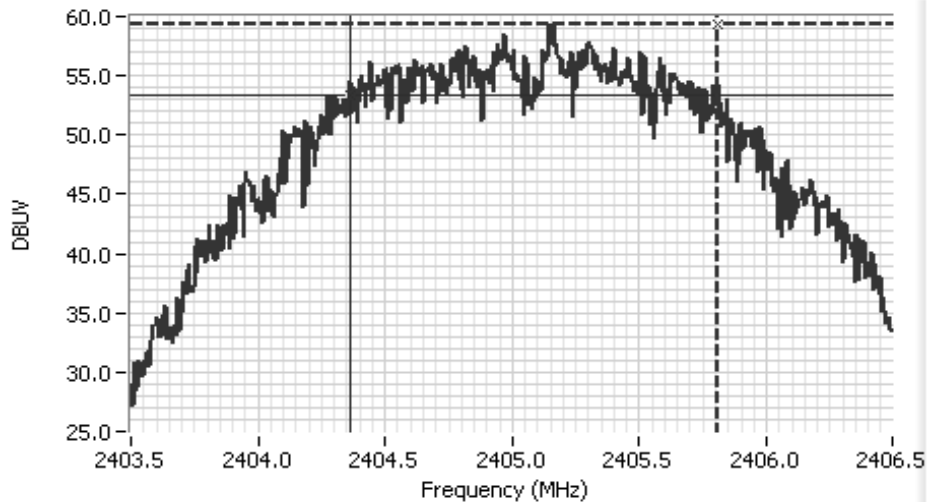


EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Run #2: Signal Bandwidth

Power Setting	Frequency (MHz)	Resolution Bandwidth	6dB Signal Bandwidth (MHz)	99% Signal Bandwidth (MHz)
	2405	100kHz	1.4	4.5
	2440	100kHz	1.6	4.5
	2480	100kHz	1.6	4.5



Analyzer Settings

HP8564E,EMI
CF: 2405.0 MHz
SPAN: 3.0 MHz
RB 100 kHz
VB 100 kHz
Detector POS
Att 10
RL Offset 0.00
Sweep Time 50.0ms
Ref Lvl: 63.20DBU

Comments

Cursor 1 2405.81: 59.37
Cursor 2 2404.36: 53.37

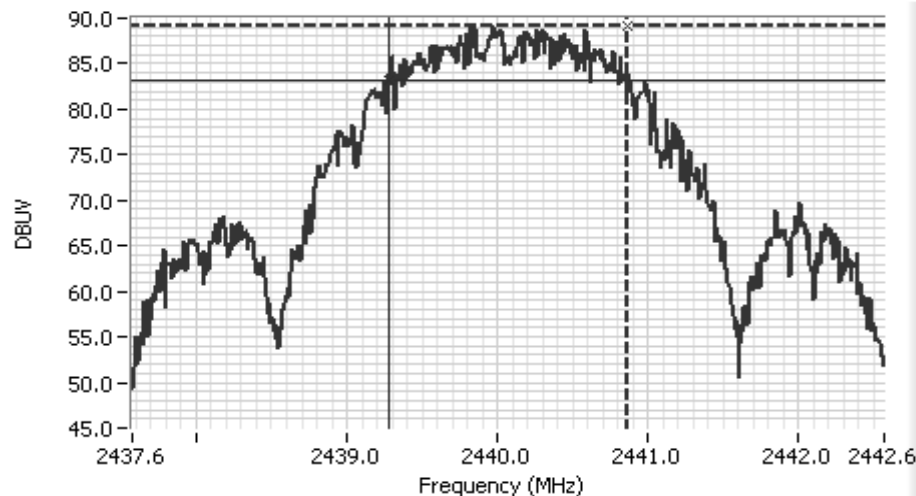
Delta Freq. 1.4 MHz
Delta Amplitude 6.00





EMC Test Data

Client: Moteiv Corporation	Job Number: J61193
Model: Tmote Sky	T-Log Number: T61218
Contact: Robert Szewczyk	Account Manager: Esther Zhu
Spec: FCC 15.247, RSS-210 / FCC	Class: N/A



Analyzer Settings

HP8564E,EMI
CF: 2440.1 MHz
SPAN:5.0 MHz
RB 100 kHz
VB 100 kHz
Detector POS
Att 10
RL Offset 0.00
Sweep Time 50.0ms
Ref Lvl:90.40DBUW

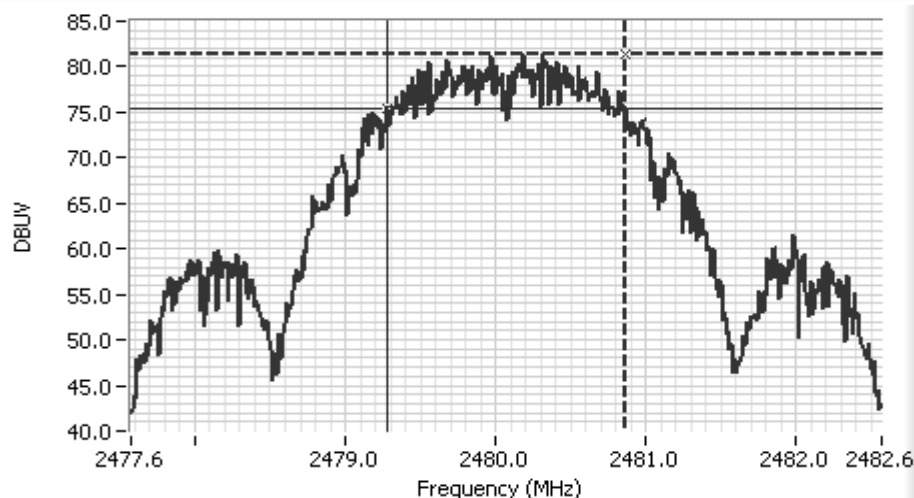
Comments

Cursor 1 2440.86 89.23

Cursor 2 2439.27 83.23

Delta Freq. 1.6 MHz

Delta Amplitude 6.00



Analyzer Settings

HP8564E,EMI
CF: 2480.1 MHz
SPAN:5.0 MHz
RB 100 kHz
VB 100 kHz
Detector POS
Att 10
RL Offset 0.00
Sweep Time 50.0ms
Ref Lvl:85.00DBUW

Comments

Cursor 1 2480.86 81.42

Cursor 2 2479.27 75.42

Delta Freq. 1.6 MHz

Delta Amplitude 6.00





EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

Run #3: Output Power

Maximum antenna gain: dBi

Power Setting	Frequency (MHz)	Field Strength at 3m (dBuV/m)	Antenna Pol. (H/V)	Res BW (MHz)	Signal BW (MHz)	Bandwidth Correction	Power (dBm)	Power (Watts)
	2405	95.70	H	2	1	0	0.4	0.00109648
	2440	95.03	H	2	1	0	-0.27	0.00093972
	2480	92.62	H	2	1	0	-2.68	0.00053951
	2405	98.11	V	2	1	0	2.81	0.00190985
	2440	98.69	V	2	1	0	3.39	0.00218273
	2480	94.95	V	2	1	0	-0.35	0.00092257

Note 1: Output power calculated from field strength at 3m based on free space path loss formula $E = \sqrt{(30PG) / d}$, where E is the field strength (V/m), PG is the effective isotropic radiated power (W) and d is the distance (3m). Additional correction to the calculated power is made to account for the difference between the measurement bandwidth and signal bandwidth.



EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

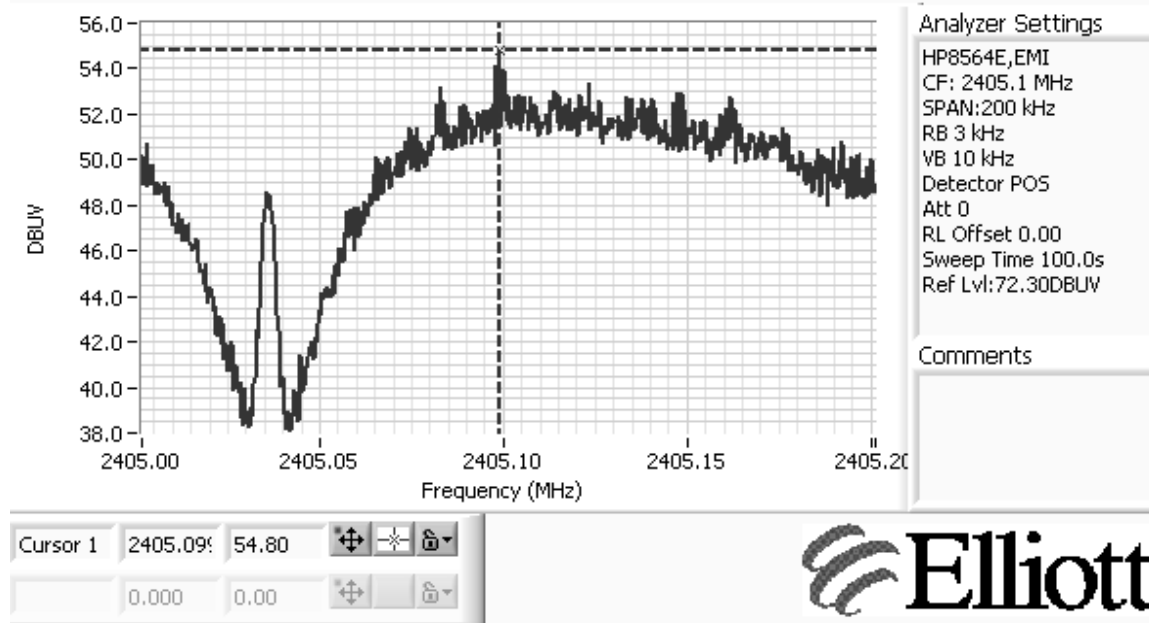
Run #4: Power Spectral Density

Power Setting	Operating Frequency (MHz)	Freq. @ PPSD	Res BW	Field Strength (dBuV/m/3kHz)	Power Spectral Density (dBm / 3kHz) ^{Note 3}
	2405	2405.09	3kHz	54.80	-40.5
	2440	2440.10	3kHz	55.30	-40.0
	2480	2479.93	3kHz	49.33	-46.0

Note 1: Freq. @ PPSD: Frequency of the Peak Power Spectral Density (PPSD)

Note 2: Power spectral density measured using RB=3 kHz, VB=10kHz with a sweep time set to ensure a dwell time of at least 1 second per 3kHz. The measurement is made at the frequency of PPSD determined from preliminary scans using RB=3kHz using multiple sweeps at a faster rate over the 6dB bandwidth of the signal.

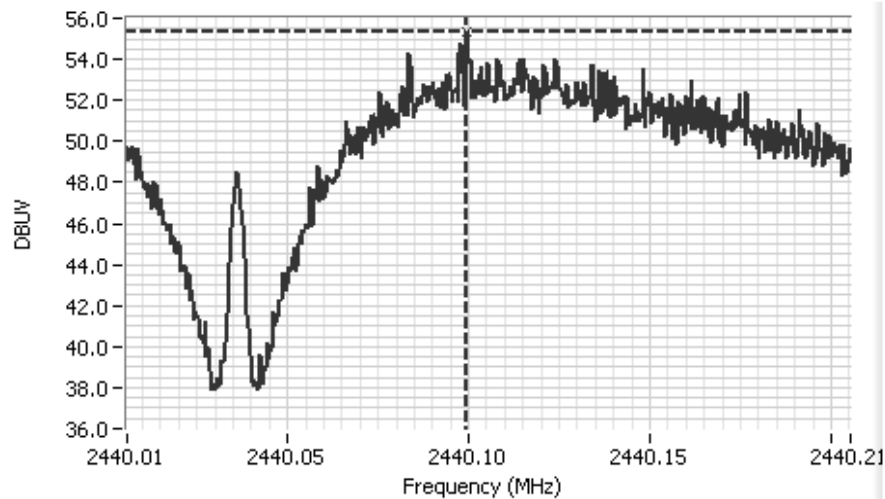
Note 3: Power spectral density calculated from field strength at 3m based on free space path loss formula $E = \sqrt{(30PG) / d}$, where E is the field strength (V/m), PG is the effective isotropic radiated power (W) and d is the distance (3m).





EMC Test Data

Client:	Moteiv Corporation	Job Number:	J61193
Model:	Tmote Sky	T-Log Number:	T61218
Contact:	Robert Szewczyk	Account Manager:	Esther Zhu
Spec:	FCC 15.247, RSS-210 / FCC	Class:	N/A

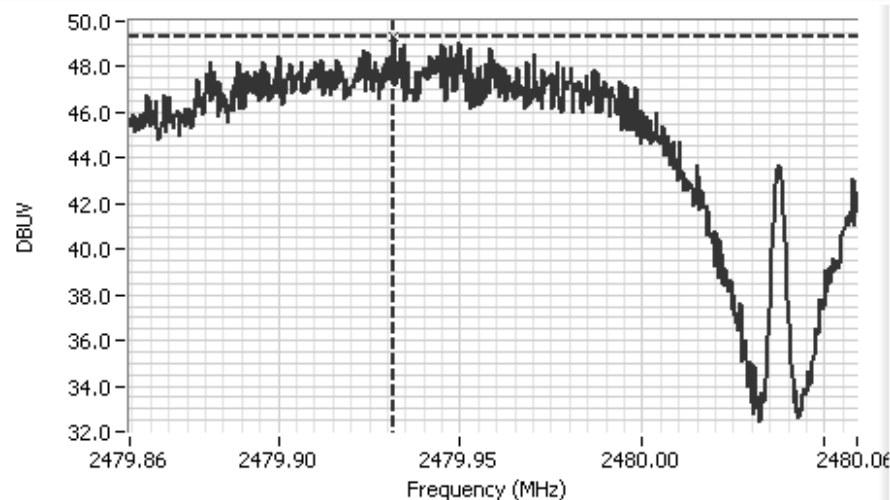


Analyzer Settings

HP8564E,EMI
CF: 2440.1 MHz
SPAN:200 kHz
RB 3 kHz
VB 10 kHz
Detector POS
Att 0
RL Offset 0.00
Sweep Time 100.0s
Ref Lvl:64.80DBUV

Comments

Cursor 1 2440.10 55.30
0.000 0.00



Analyzer Settings

HP8564E,EMI
CF: 2480.0 MHz
SPAN:200 kHz
RB 3 kHz
VB 10 kHz
Detector POS
Att 0
RL Offset 0.00
Sweep Time 100.0s
Ref Lvl:67.75DBUV

Comments

Cursor 1 2479.93 49.33
0.000 0.00



EXHIBIT 3: Test Configuration Photographs

Uploaded as A Separate Attachment

EXHIBIT 4: Proposed FCC ID Label & Label Location

Uploaded as A Separate Attachment

**EXHIBIT 5: Detailed Photographs
of Moteiv Corporation Model Tmote SkyConstruction**

Uploaded as A Separate Attachment

**EXHIBIT 6: Operator's Manual
for Moteiv Corporation Model Tmote Sky**

Uploaded as A Separate Attachment

**EXHIBIT 7: Block Diagram
of Moteiv Corporation Model Tmote Sky**

Uploaded as A Separate Attachment

**EXHIBIT 8: Schematic Diagrams
for Moteiv Corporation Model Tmote Sky**

Uploaded as A Separate Attachment

**EXHIBIT 9: Theory of Operation
for Moteiv Corporation Model Tmote Sky**

Uploaded as A Separate Attachment

EXHIBIT 10: Advertising Literature

Uploaded as A Separate Attachment

EXHIBIT 11: RF Exposure Information

Uploaded as A Separate Attachment