ACCREDITED

Testing Certification # 1367-01

TEST REPORT

Model: 13614

2.4 GHz DSSS Transceiver

Applicant : FARO Technologies, Inc.
: 125 Technology Park
: Lake Mary, FL 32746

Date Tested : 08/06- 08/17 / 2010
Test Personnel: Jack Garner

: Test Specifications

FCC Part 15.247		
FCC Part 15.207		
FCC Part 15.205		
FCC Part 15.203		
FCC Part 1.1307(b)(1)		

Test Report By : Jack Garner
Approved By: Steven Hoke

Description of non-standard test method or test practice: ***None***
Special limitations of use: ***None***

Traceability: ***reference standards of measurement have been calibrated by a competent body using standards traceable to the NIST.***

According to testing performed at Product Safety Engineering, Inc., the above-mentioned unit is in compliance with the electromagnetic compatibility requirements defined in regulations listed above under specifications. The test results contained herein relate only to the model(s) identified above. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical characteristics.

As the responsible EMC Project Engineer, I hereby declare that the equipment tested as specified above conforms to the requirements indicated above.

Product Description

The product under test is a (2.4) GHz digital spread spectrum transceiver that the applicant purchases from Wiznet. The EUT will be used exclusively internally within a robotic arm manufactured by the applicant. The software used to exercise the EUT provided for the output power to be set at (15) dBm which is the maximum level that the applicant's operational software will allow.

Environmental conditions during testing

The ambient temperature during the testing was within the range of (50° - 104° F).
The humidity levels during the testing was within the range of (10% - 90%) relative humidity
Power supply system : 120 Volts 60 Hz SINGLE phase

Test Results Summary

Test	Requirement	Measured	Pass/Fail	Data Page(s)
RF Exposure	1.0 mW / cm^2	0.0113 mW/ cm^2	Pass	7
Antenna Requirements	FCC 15.203	Pass	Pass	7
Powerline conducted emissions	Table 1	See data	Pass	12-13
Transmitter Output Power	< 1Watt	0.035 Watts	Pass	13
Spurious Conducted Emissions	20dBc in any 100kHz BW	> 30dBc	Pass	14-16
Spurious Radiated Emissions	< FCC 15.209 limits	< FCC 15.209 limits	Pass	17-18
6 dB Bandwidth	> 500 kHz	>16 MHz	Pass	19-20
Power Spectral Density	< 8dBm / 3kHz	-2.6 dBm / 3 kHz	Pass	21-22

Revision History

Revision	Date	Description
---	08/30/2010	Initial Release

Test Requirements & Procedures

All measurements are made in accordance with ANSI C63.4:2003

- **Powerline conducted interference:** 15.207

Requirement - The radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 mH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Table 1

Freq. (MHz)	Conducted limit Peak	Conducted limit (QP)
0.15 - 0.5	66 to 56*	56 to 46*
0.5 - 5	56	46
5 - 30	60	50

* Decreases with the logarithm of the frequency.

Procedure - Tabletop devices shall be placed on a platform of nominal size, 1 m by 1.5 m, raised 80 cm above the reference groundplane. The vertical conducting plane or wall of a screened room shall be located 40 cm to the rear of the EUT. Floor-standing devices shall be placed either directly on the reference groundplane or on insulating material. All other surfaces of tabletop or floor-standing EUTs shall be at least 80 cm from any other grounded conducting surface, including the case or cases of one or more LISNs. AC powerline adapters that are used with EUTs such as laptop or notebook computers should be placed as typically used, i.e., on the tabletop if the adapter-to-EUT cord is too short to allow the power adapter to reach the floor.

Each current-carrying conductor of the EUT power cord(s), except the ground (safety) conductor(s), shall be individually connected through a LISN to the input power source. All 50 Ω ports of the LISN shall be resistively terminated in 50 Ω when not connected to the measuring instrument. When the test configuration is comprised of multiple units (EUT and associated/peripheral equipment, or EUT consisting of multiple equipment) that have their own power cords, ac powerline conducted emissions measurements shall be performed with the ac powerline cord of the particular unit under test connected to one LISN that is connected to the measuring instrument. Those power cords for the units in the remainder of the configuration not under measurement shall be connected to a LISN different from the LISN used for the power cord of the portion of the EUT being measured. This connection may be made using a multiple receptacle device.

Emissions from each current-carrying conductor of the EUT shall be individually measured. Where multipleportions of the EUT receive ac power from a common power strip, which is furnished by the manufacturer as part of the EUT, measurements need only be made on the current-carrying conductors of the common power strip. Adapters or extension cords connected between the EUT power cord plug and the LISN power receptacle shall be included in the LISN setup such that the calibration of the combined adapter or extension cord with an adapter and the LISN meets the requirements.

If the EUT is comprised of a number of devices that have their own separate ac power connections, e.g., a floor-standing frame with independent power cords for each shelf, that are able to connect directly to the ac power network, each current-carrying conductor of one device is measured while the other devices are connected to a second (or more) LISN(s). All devices shall be separately measured. If a power strip is provided by the manufacturer, to supply all of the devices making up the EUT, only the conductors in the common power cord to the power strip shall be measured.

If the EUT is normally operated with a ground (safety) connection, the EUT shall be connected to the ground at the LISN through a conductor provided in the lead from the ac power to the LISN. The excess length of the power cord between the EUT and the LISN receptacle (or ac power receptacle where a LISN cannot be used), or an adapter or extension cord connected to and measured with the LISN, shall be folded back and forth at the center of the lead to form a bundle not exceeding 40 cm in length. If the EUT does not have a flexible power lead, the EUT shall be placed at a distance of 80 cm from the LISN (or power receptacle where a LISN cannot be used) and connected thereto by a power lead or appropriate connection no more than 1 m long. The measurement shall be made at the LISN end of this power lead or connection.

• 6 dB bandwidth 15.247(a)(2)

Requirement - 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.

Procedure - The bandwidth at 6 dB below the highest inband spectral density was measured with a spectrum analyzer connected to the antenna terminal at the highest, middle and the lowest available channels.

The spectrum analyzer is set to:
Center frequency = the highest, middle and the lowest Frequencies
Span = 20 MHz (Greater than EBW)
RBW = 100 kHz Sweep = auto
VBW = RBW Detector function = peak
Trace = max hold.

- ## Transmitter Output Power: 15.247 (b)(3)

Requirement - 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.

Procedure - The peak output power was measured with a spectrum analyzer connected to the antenna terminal at the highest, middle and the lowest available channels. The transmitter output is connected to a spectrum analyzer and the analyzer`s internal channel power integration function is used to integrate the power over a bandwidth greater than or equal to the 26dB EBW. The test is performed in accordance with FCC document “Measurement of Digital Transmission Systems Operating under Section 15.247”, March 23, 2005. The transmitter operates continuously therefore Power Output Option 2, Method #1 is used.

- ## Spurious Conducted Emissions: 15.247(d)

Requirement - 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.

Procedure - The output of the test item was connected to the spectrum analyzer through 10dB of attenuation. The resolution bandwidth (RBW) was set to 100kHz. The peak detector and 'Max-Hold' function were engaged. The emissions in the frequency range from 30MHz to 25GHz were observed and plotted separately with the test item transmitting at low, middle and high hopping frequencies.

- ## Spurious Radiated Emissions:15.247(d), 15.205(a)

Requirement - 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).

Procedure - The final open field emission tests were then manually performed over the frequency range of 30MHz to 25GHz.

1) For all emissions in the restricted bands, the following procedure was used:

a) The field strengths of all emissions below 1 GHz were measured using biconical and log periodic antennas. The antennas was positioned at a 3 meter distance from the test item. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer.

b) The field strengths of all emissions above 1 GHz were measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the test item. A peak detector with a resolution bandwidth of 1 MHz was used on the spectrum analyzer.

c) To ensure that maximum or worst case emission levels were measured, the following steps were taken when taking all measurements:

i) The test item was rotated so that all of its sides were exposed to the receiving antenna.

ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.

iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.

iv) In instances were it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer, the measuring antenna was not raised or lowered to ensure maximized readings, instead the test item was rotated through all axis to ensure the maximum readings were recorded for the test item.

d) For all radiated emissions measurements below 1 GHz, if the peak reading is below the limits listed in 15.209(a), no further measurements are required. If however, the peak readings exceed the limits listed in 15.209(a), then the emissions are re-measured using a quasi-peak detector.

e) For all radiated emissions measurements above 1 GHz, the peak readings must comply with the 15.35(b) limits. 15.35(b) states that when average radiated emissions measurements are specified, there also is a limit on the peak level of the radiated emissions. The limit on the peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. Therefore, all peak readings above 1 GHz must be no greater than 20 dB above the limits specified in 15.209(a).

f) Next, for all radiated emissions measurements above 1GHz, the resolution bandwidth was set to 1MHz. The analyzer was set to linear mode with a 10Hz video bandwidth in order to simulate an average detector. An average reading was taken. If the dwell time per channel of the hopping signal is less than 100msec, then the reading obtained with the 10 Hz video bandwidth may be further adjusted by a “duty cycle correction factor”, derived from 20*log(dwell time/100msec). These readings must be no greater than the limits specified in 15.209(a).

- **Maximum Permissible Exposure:** 15.247(l), 1.1307(b)(1)

Requirement - Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Compliance is based upon section CFR 47 section 1.1310, Table (1) Limits for Maximum Permissible Exposure (MPE), (b) Limits for General Population/Uncontrolled Exposure. The stated limit is (1.0) mW/cm2 and compliance was calculated using the following formula:

$S=(P\ G) / (4\ \pi\ r^2)$

Where:
S = Power density in mW/cm2
P = Power in mW
G = Numerical antenna gain
r = Distance in cm

Procedure - The power is derived from the maximum conducted output measurements and the gain is derived from the manufacturer's specification for the highest gain antenna used with the EUT.

Result -

Maximum output power = (35.5) mW
Antenna gain (numeric) = (1.6)
Distance = 20 cm
S = (35.5 * 1.6) / (12.57 * 400)
S= (56.8) / (5,026.5)
S= (0.0113) mW / cm2
Limit = (1.0) mW / cm2

- **Antenna Requirement:** 15.203

Antenna requirement. - An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

This device employs a SMA plug reverse type (left-hand thread) for the unique connector.

Test Equipment

Manufacturer	Model	Description	Serial Number	Cal Due
Hewlett Packard	8566B	Spectrum Analyzer	2421A00526	08/03/11
Hewlett Packard	85662A	Display	2403A07352	08/03/11
Hewlett Packard	85650A	Quasi-Peak Adapter	2043A00209	08/03/11
Hewlett Packard	8447D	Preamp 0.1 - 1,000 MHz	2944A06832	12/22/10
Hewlett Packard	8449B	Preamp 1 - 26.5 GHz	3008A00320	04/08/11
EMCO	3104C	Biconical Antenna	00075927	01/17/11
EMCO	3148	Log Periodic Antenna	00075741	01/29/11
EMCO	3115	Double Ridge Guide Ant.	3810	04/08/11
Solar	8028	LISN	829012/809022	03/10/11
Electro-Metrics	EMC-30	EMI Receiver	44191	07/20/11
Agilent	7402A	Spectrum Analyzer	US40240204	09/04/10

* Cal Due Date Format = MM/DD/YY

Last calibration date is one year prior to the calibration due dates listed unless otherwise noted.

System Configuration

3.1 General Description

The test item is a 2.4 GHz transceiver, Part No. 13614 purchased from Wiznet.

3.1.1 Power Input

The test item obtained 5VDC from the host

3.1.2 Peripheral Equipment

None

3.1.3 Interconnect Cables

All cables are internal to the host device.

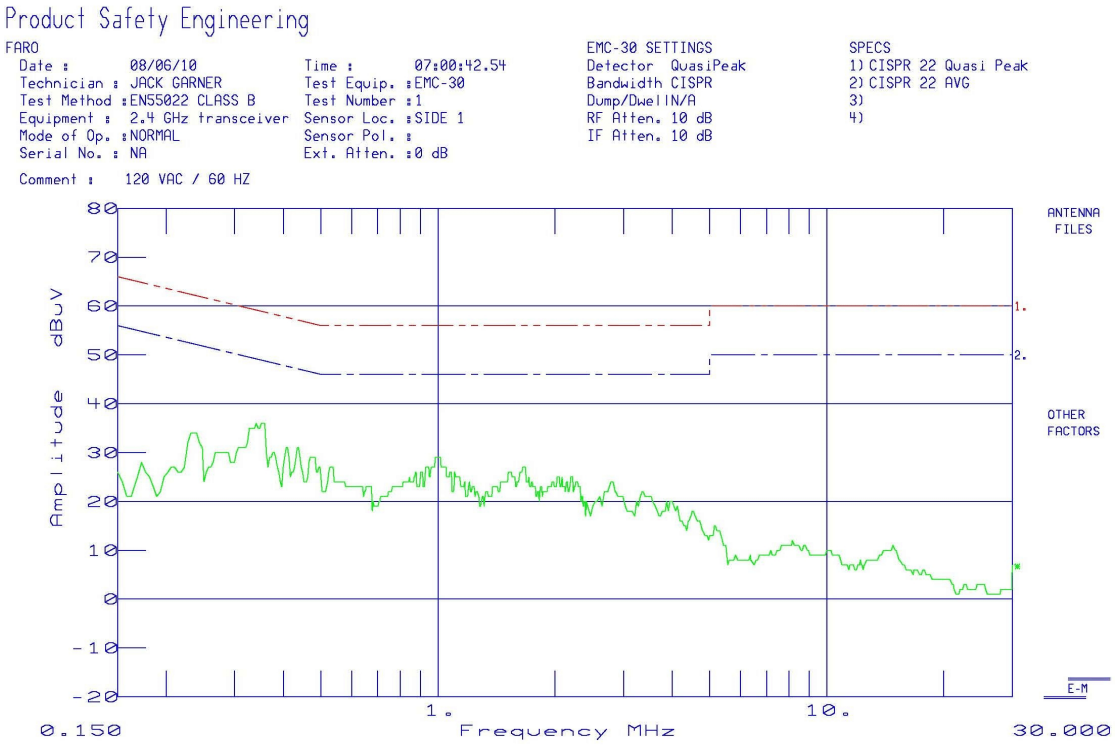
3.2 Operational Mode

For all radiated tests the test item was placed on an 80cm high non-conductive stand. The other testing was completed on bench environment.

DATA

Powerline conducted emissions

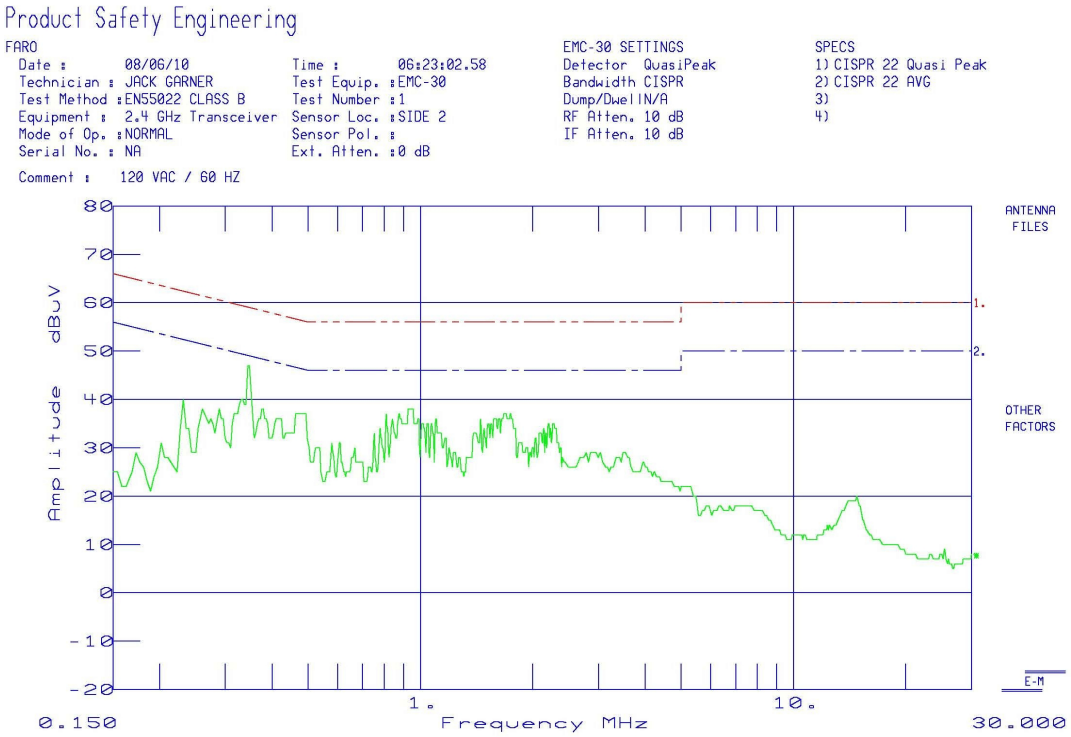
Line Side



Freq (MHz)	Amplitude (dBuV)	QP.Limit (dBuV)	Delta (dB)
0.223	34.2	63.0	-28.8
0.320	36.6	60.5	-23.9
0.411	30.3	57.4	-27.1

Powerline conducted emissions

Neutral Side

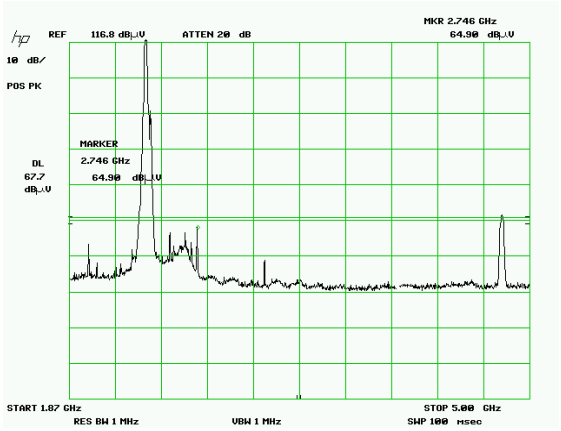


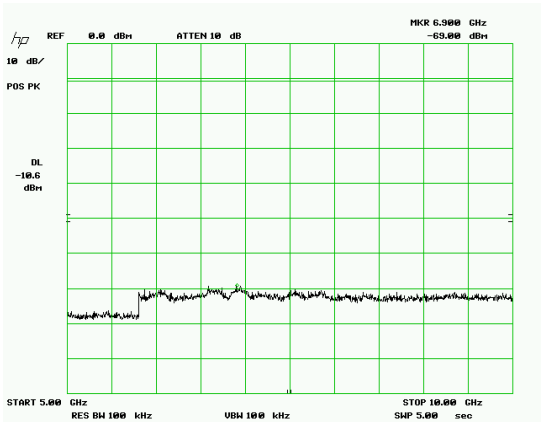
Freq (MHz)	Amplitude (dBuV)	QP.Limit (dBuV)	Delta (dB)
0.223	39.9	63.0	-23.1
0.320	49.3	60.5	-11.2
0.92	38.9	56.0	-17.1

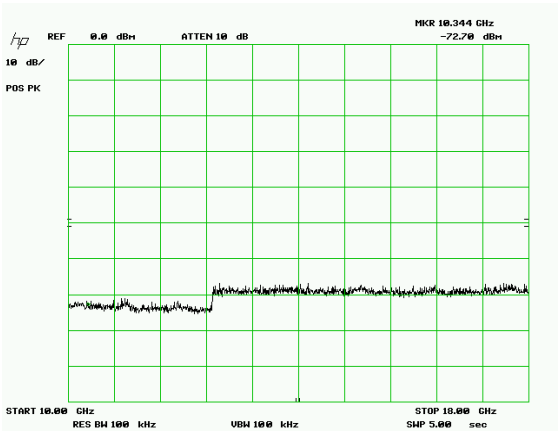
Peak Output Power

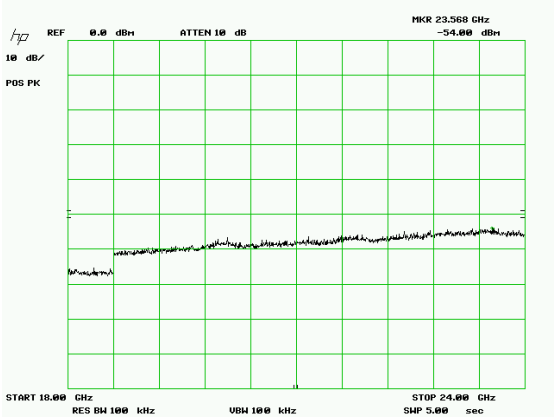
Channel Freq (GHz)	802.11 b or g	Measured (dBuV)	Cable loss (dB)	Actual (dBuV)	Actual Power (dBm)	Actual Power (mW)
Low (2.412)	b	118.6	0.7	119.3	12.3	17.0
Low (2.412)	g	121.8	0.7	122.5	15.5	35.5
Mid (2.437)	b	119.7	0.7	120.4	13.4	21.9
Mid (2.437)	g	120.0	0.7	120.7	13.7	23.4
High (2.462)	b	121.8	0.7	122.5	15.5	35.5
High (2.462)	g	120.6	0.7	121.3	14.3	26.9

Spurious Conducted Emissions



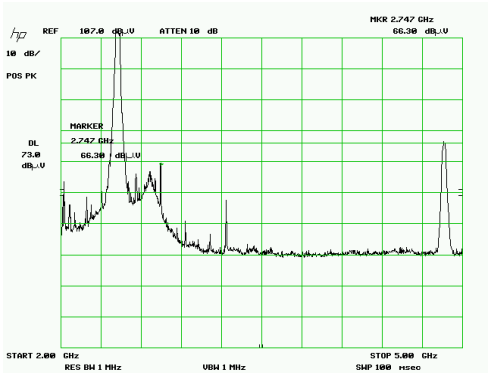


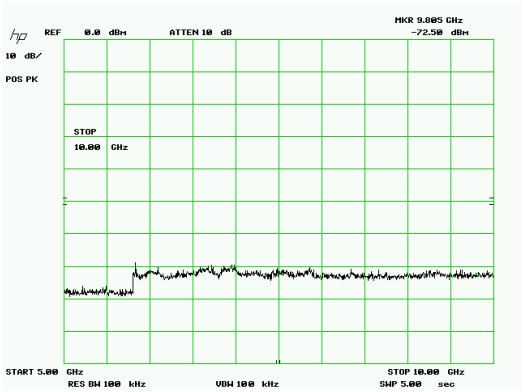


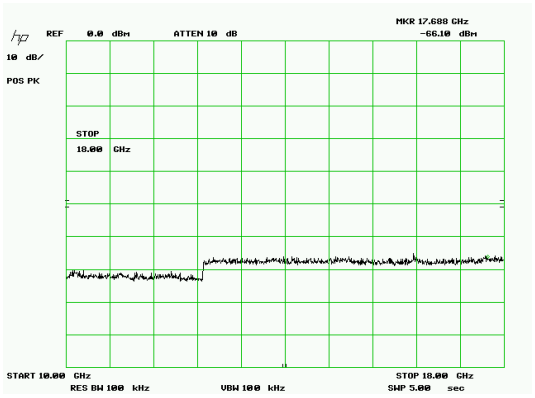


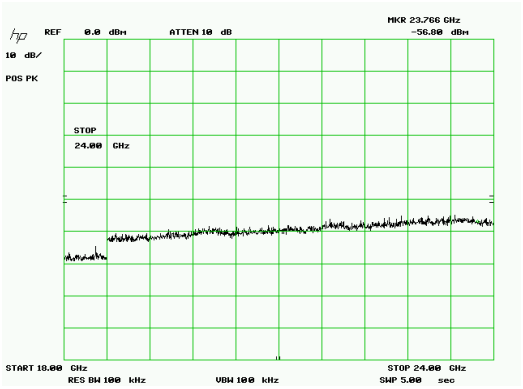
Low Channel

Spurious Conducted Emissions



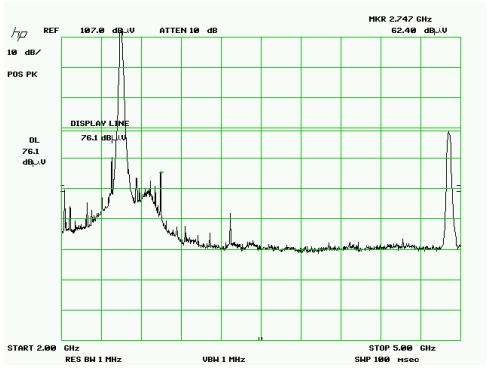


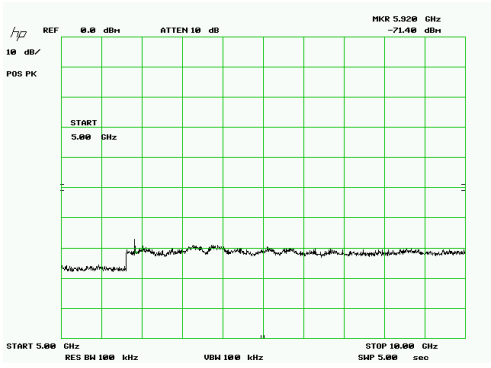


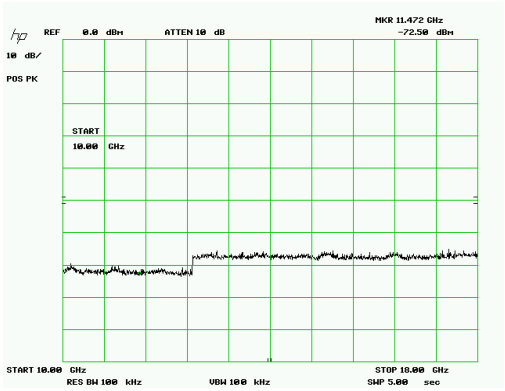


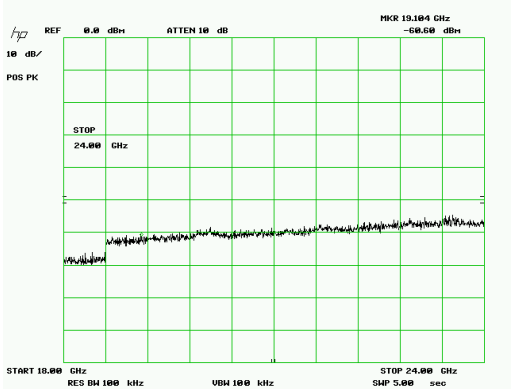
Middle Channel

Spurious Conducted Emissions





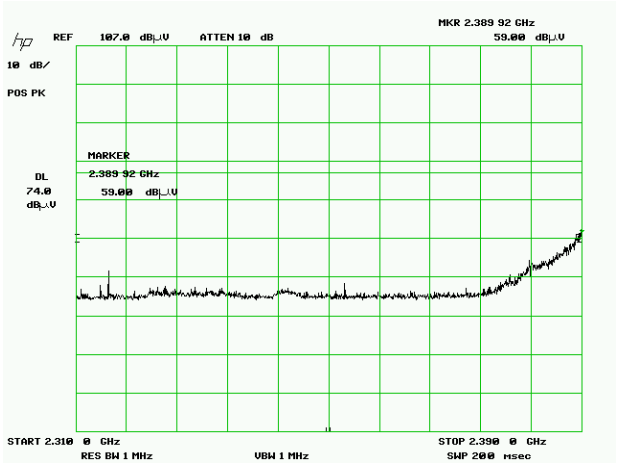




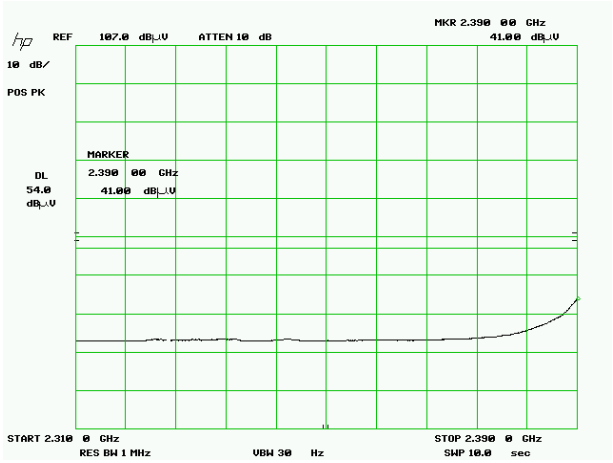
High Channel

Spurious radiated emissions

Note: In peak, the amplitudes were greater than (10) dB under the 74 dBuV/m limit for restricted band spurs. Measurements were also made using an average detector

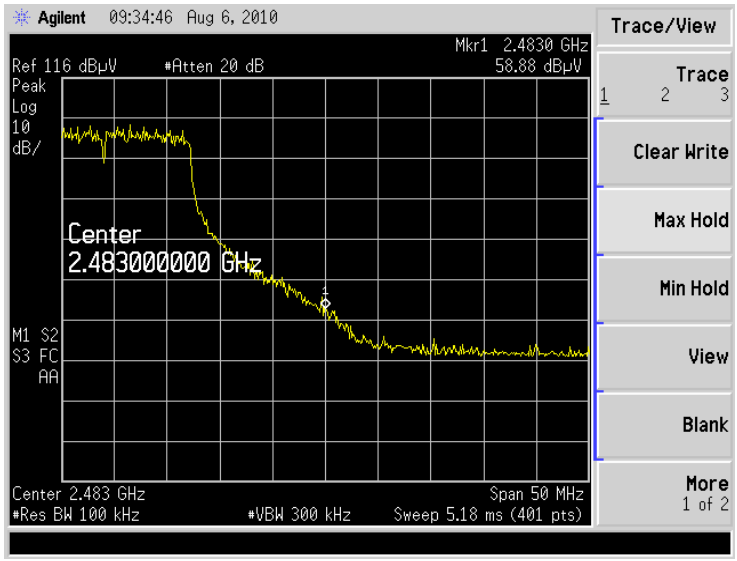


Peak - 2310-2390 MHz



Average - 2310-2390 MHz

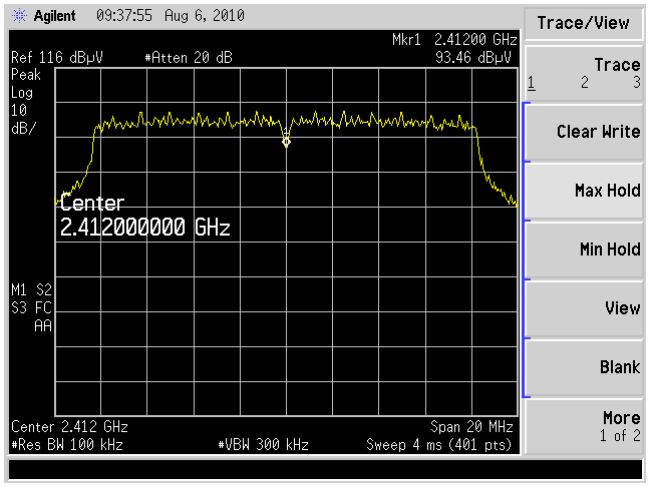
Spurious radiated emissions



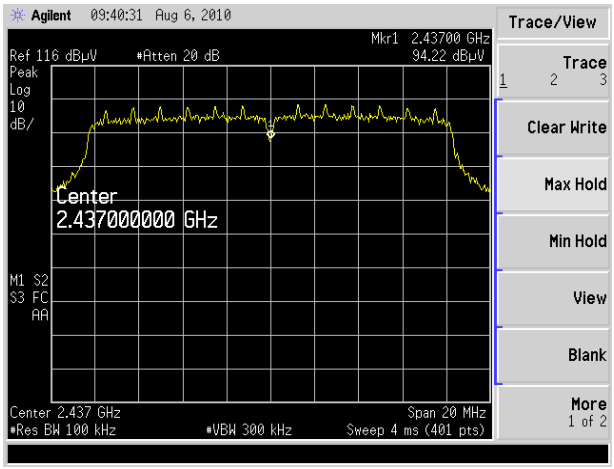
Peak -2483.5-2500 MHZ

There were no emissions found in any of the other restricted bands.

6 dB bandwidth

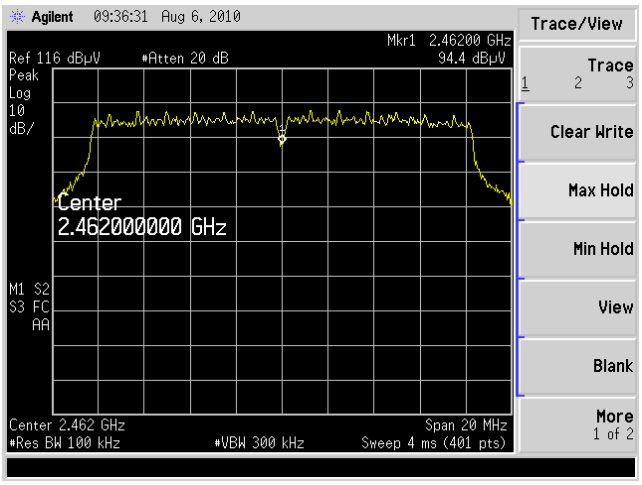


(Low ch)



(Mid ch)

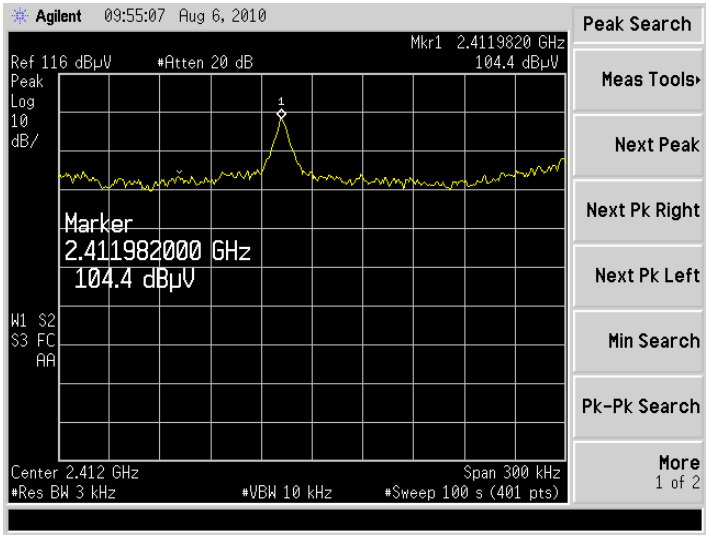
6 dB bandwidth



(High ch)

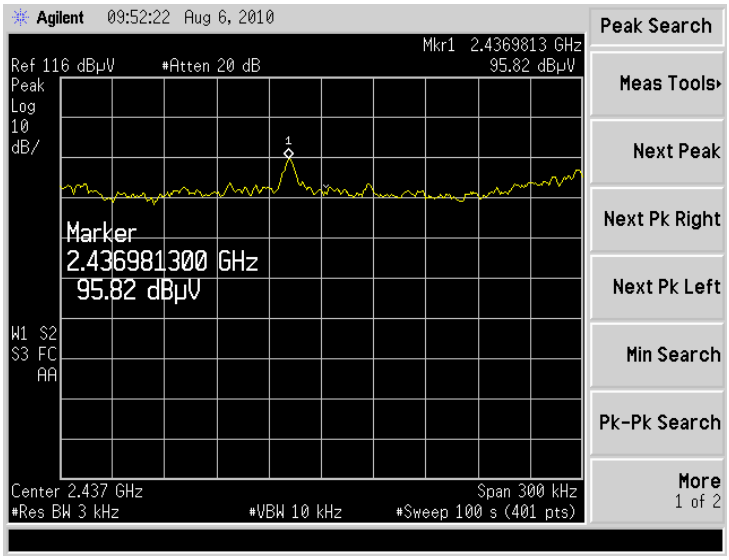
Power Spectral Density

Peak equals 104.4 dBuV
PSD = 104.4 - 107
PSD = -2.6 dBm



Low Channel

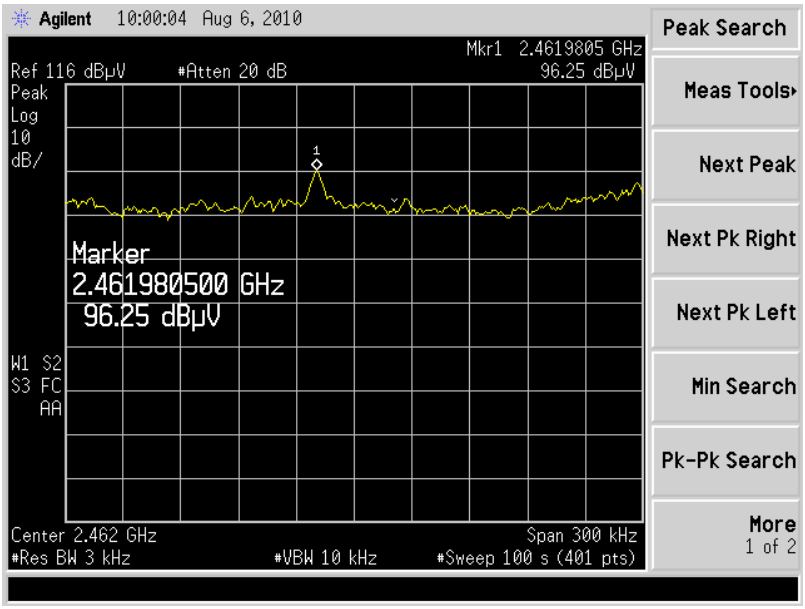
Peak equals 95.8 dBuV
PSD = 95.8 - 107
PSD = -11.2 dBm



Middle Channel

Power Spectral Density

Peak equals 96.3 dBuV
PSD = 96.3 - 107
PSD = -10.7 dBm



High Channel