TRANZEO
EMC LABS INC

EMC Test Report

TR-5plus Series

5 GHz Wireless Network Adapter
Tranzeo Wireless Technologies Inc.

Date: June 29, 2006

Report No.: TR5P070706.1

Labs: 19473 Fraser Way, Pitt Meadows, BC, Canada V3Y 2V4

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EMC Engineer	EMC Coordinator

Revision History

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1.0 General Information

1.1 EUT Description

Product Name	Wireless Access Point
Company Name	Tranzeo Wireless Technologies Inc.
FCC ID	QRF-58QGFKN2U
Model No.	TR-5plus-N and TR-5plus-24
Frequency Range	5250 to 5350 and 5725 MHz to 5850 MHz
Number of Channels	9
Transmit Rate	54 Mbps maximum bit rate specification
Type of Modulation	OFDM
Antenna Type	External and integrated
Antenna Gain	5250-5350: 20 dBi max 5725-5850: 26 dBi max
Product Software	Tranzeo 2.10
Test Software	Bandwidth test software
Operator Channel Selection	By software
Power Adapter	Tranzeo Wireless Supplied SP48-181000
	Input: AC 120V 60Hz, 25.9 W
	Output: DC 18 V, 1000 mA
	Serial: 0504

Product samples tested:

Manufacturer	Model No.	Serial No.
Tranzeo Wireless	TR-5plus-N	TR-5plus-ENGR-001
Tranzeo Wireless	TR-5plus-24	TR-5plus-ENGR-002

Frequency of each channel:

Channel	Frequency	Channel	Frequency	Channel	Frequency
Channel 52	5260	Channel 64	5320	Channel 157	5785
Channel 56	5280	Channel 149	5745	Channel 161	5805
Channel 60	5300	Channel 153	5765	Channel 165	5825

The EUT was tested with the following antennas:

Antenna	Antenna
TR-GD58-26	TR-58V-60-17
TR-HTQ-5.8-12	TR-58H-90-16

In addition to the above external antennas, the TR-5plus-24 was tested with the integrated 24 dBi antenna. As stated by the manufacturer, this antenna's gain is less than 20 dBi over the frequency range of 5250-5350.

For compliance with the EIRP limits specified in CFR 47, Part 15, Section E, 15.407, the output power of the device is limited by the Tranzeo supplied firmware based on the gain of the antenna used with the unit.

As an IEEE 802.11a compliant wireless bridge, this device includes a 5 GHz receiving function and a 5 GHz digital modulation transmit function. The unit is fitted with an N-female connector to facilitate the use of an external antenna. There are no user serviceable parts inside the device. It is factory sealed in a one-time use manner and inaccessible to the end user.

The tests were performed on production sample models to demonstrate compliance with FCC Part 15, Subparts B, C, and E, as well as Industry Canada RSS-210 Issue 5 for digitally modulated devices.

1.2 Operational Description

The TR-5plus Series is a wireless network bridge designed specifically for outdoor applications. The device provides a bridge between IEEE802.3 wired Ethernet LANs and IEEE802.11a compliant wireless networks. It uses an external antenna coupled with a 802.11a transceiver to connect to remote wireless clients. The transceiver is connected to N-female and operates in the frequency band 5250-5350 and 5725-5850 MHz. The device transmits digital network data. The unit is mounted externally in fixed point-to-point installations. It is mounted on the exterior of a building or typically for broadband internet access.

The type of RF modulation is OFDM. The device can transmit data at a bit rate of 54 Mbps or a real-world data rate of approximately 27 Mbps. A 64/128 bit Wired Equivalent Protection (WEP) algorithm is used for secure communications. The device's standard compliance ensures communication with any 802.11a network.

The firmware used with the device prevents the use of channels outside the 5.250-5.350 and 5725-5850 MHz bands. It also limits the output power of the device, based on the antenna gain, to maintain compliance with the 15.407 EIRP limits when using the 5.250-5.350 MHz band.

In line with the IEEE 802.11a standard, an OFDM physical layer (PHY) splits an information signal across 52 separate subcarriers to provide transmission of data at a rate of 6, 9, 12, 18, 24, 36, 48, or 54 Mbps. Four of the subcarriers are pilot subcarriers that the system uses as a reference to disregard frequency or phase shifts of the signal during transmission. A high speed Fast Fourier Transform (FFT)/Inverse Fast Fourier Transform (IFFT), combined with BPSK, QPSK, 16QAM and 64QAM modulation of the individual subcarriers, provides the data rates of 6, 9, 12, 18, 24, 36, 48, and 54Mbps, with rate compatible punctured convolutional coding with a coding rate of 1/2, 2/3, and 3/4.

In the 802.11a standard, a pseudo binary sequence is sent through the pilot subchannels to prevent the generation of spectral lines. In 802.11a, the remaining 48 subcarriers provide separate wireless pathways for sending the information in a parallel fashion. The resulting subcarrier frequency spacing is 0.3125 MHz (for a 20 MHz with 64 possible subcarrier frequency slots).

The OFDM PHY layer consists of two protocol functions. First, a PHY convergence function, which adapts the capabilities of the Physical Medium Dependent (PMD) system to the PHY service. This function is supported by the Physical Layer Convergence Procedure (PLCP), which defines a method of mapping the IEEE 802.11 PHY Sublayer Service Data Units (PSDU) into a framing format suitable for sending and receiving user data and management information between two or more stations using the associated PMD system. Second, a PMD system whose function defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more stations, each using the OFDM system.

The TR-5plus Series products are used exclusively in a professionally installed, fixed point-to-point environment.

1.3 EUT Testing Configuration

The unit was tested with the largest gain antenna of each type as listed in section 1.1:

Antenna	Antenna
TR-GD58-26	TR-58V-60-17
TR-HTQ-5.8-12	TR-58H-90-16

These antennas were used to determine compliance with radiated spurious and band edge emissions. Data is presented for worst case measurements only.

The EUT was mounted to a custom non-metallic stand to ease polarization changes and to best represent a typical user installation. The EUT was connected to the host PC so that it could be cycled through the various test modes and channels.

In order to ensure worst-case test results, the EUT was configured to transmit at maximum power during emission testing, regardless of antenna gain.

The EUT was tested in the following modes:

- **Standby/Receive mode:** In this mode the EUT beacons at the lowest possible rate while searching for a client with which to establish communication.
- **Data transfer mode:** In this mode the EUT is exercised with commercially available bandwidth test software. A link is established between two PCs through the unit and an access point and a transmit rate of 15 Mbps or 27 Mbps is specified reflecting the worst case data rate of the unit for specific tests.

1.4 EUT Modifications

Channel 52, centered on 5260 MHz, was disabled in the product firmware as the product did not meet the required emission limits in the 5150-5250 frequency band when configured for outdoor use. The firmware lockout prevents the device from receiving or transmitting data on this channel. See section 6.0 for details. The device is fully compliant with the referenced standards after this modification is performed.

1.5 Test Facilities

Tranzeo EMC Labs
19473 Fraser Way
Pitt Meadows, BC V3Y 2V4
Canada

Phone: (604) 460-6002
Fax: (604) 460-6005

FCC registration number: 960532
Industry Canada Number: 5238A

1.6 Test Equipment

Manufacturer	Model	Description	Serial No.	Cal Due Date
Sunol Sciences	SM46C	Turntable	051204-2	N/R
Sunol Sciences	Custom	Mast Motor	TREML0001	N/R
Sunol Sciences	JB3	Antenna	A042004	02-Jun-2007
Sunol Sciences	DRH-118	Antenna	A052804	02-Jun-2007
Com-Power	LI-115	LISN	241037	30-Jan-2007
Rohde & Schwarz	FSP40	Spectrum Analyzer	100184	24-Aug-2006
Rohde & Schwarz	NRP	Power Meter	100055	02-Aug-2006
Rohde & Schwarz	ESCI	EMI Receiver	100123	02-Jun-2007

1.7 Test System Details

The following auxiliary equipment and cables were used for performing the tests:

Manufacturer	Model	Description	Serial No.
Soyo	PW-930S	Laptop PC	6188
Pheenet	SW-05P	5 port switch	C0104260954
Tranzeo	POE-1	DC injection unit	n/a

Signal Cable Type	Signal Cable Description	Length
Cat 5 LAN	EUT to DC injection unit	50 m
Cat 5 LAN	DC Block to Ethernet switch	2 m

1.8 Test Results

The TR-5plus Series complies with FCC Part 15 Subparts B,C and E, as well as Industry Canada RSS-210 Issue 6.

2.0 Conducted Emissions

2.1 Test Standard

FCC Part 15, Subpart C, Section 15.207a

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

2.2 Test Limits

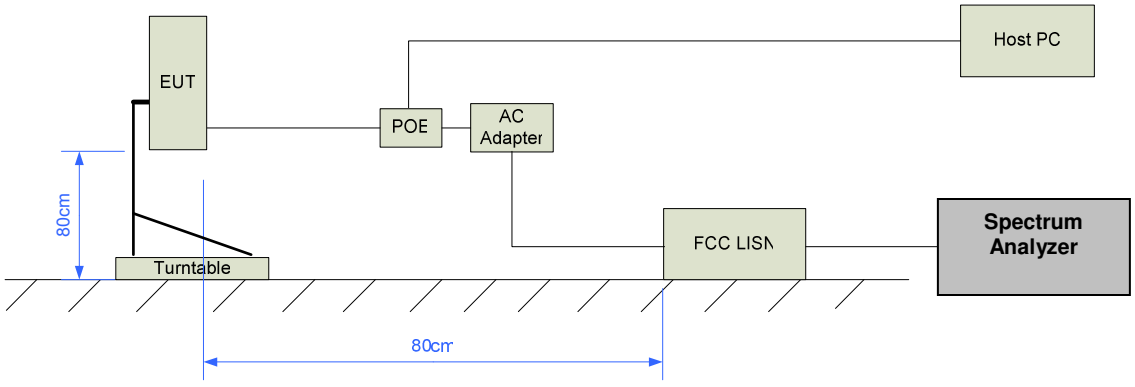
Frequency (MHz)	Maximum Level (dBuV) Quasi-Peak	Maximum Level (dBuV) Average
0.15-0.50	66-56 (Log Delta)	56-46 (Log Delta)
0.50-5.00	56	46
5.00-30.0	60	50

2.3 Test Setup

Both samples were scanned in all modes. Testing was performed over the frequency range of 0.15 MHz to 30 MHz. Only worst case data is shown below.

The unit was exercised using bandwidth test software at a rate of 15 Mbps representing the worst case data rate. Testing was performed on low, middle, and high channels in all frequency bands.

2.3.1 Test Setup Block Diagram



Note: The unused LISN terminal is terminated with a 50 Ohms terminator.

2.4 Test Results

2.4.1 Test Data

EUT – Line

EDIT PEAK LIST (Final Measurement Results)			
Trace1:	55022QPC		
Trace2:	55022AVC		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	150 kHz	44.47	-21.52
1 Quasi Peak	162 kHz	57.27	-8.08
2 Average	162 kHz	29.28	-26.07
1 Quasi Peak	174 kHz	56.56	-8.19
1 Quasi Peak	186 kHz	55.93	-8.27
2 Average	190 kHz	27.70	-26.33
1 Quasi Peak	202 kHz	54.98	-8.54
2 Average	202 kHz	26.87	-26.65
1 Quasi Peak	218 kHz	54.20	-8.69
1 Quasi Peak	230 kHz	53.65	-8.79
1 Quasi Peak	242 kHz	53.41	-8.60
2 Average	242 kHz	23.80	-28.22
1 Quasi Peak	250 kHz	53.26	-8.48
1 Quasi Peak	262 kHz	53.08	-8.28
1 Quasi Peak	274 kHz	52.85	-8.13
1 Quasi Peak	282 kHz	52.72	-8.02
2 Average	282 kHz	21.55	-29.19
1 Quasi Peak	294 kHz	52.47	-7.93
1 Quasi Peak	310 kHz	52.32	-7.65
2 Average	310 kHz	20.66	-29.31

Cond Emissions L N

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EDIT PEAK LIST (Final Measurement Results)			
Trace1:	55022QPC		
Trace2:	55022AVC		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	330 kHz	52.10	-7.35
1 Quasi Peak	350 kHz	51.81	-7.14
2 Average	350 kHz	20.13	-28.82
1 Quasi Peak	366 kHz	51.60	-6.98
1 Quasi Peak	382 kHz	51.48	-6.75
1 Quasi Peak	398 kHz	51.26	-6.63
1 Quasi Peak	422 kHz	51.02	-6.38
2 Average	434 kHz	18.15	-29.02
1 Quasi Peak	446 kHz	50.76	-6.18
2 Average	470 kHz	17.74	-28.76
1 Quasi Peak	490 kHz	50.42	-5.74
1 Quasi Peak	522 kHz	50.10	-5.89
2 Average	550 kHz	26.77	-19.22
1 Quasi Peak	558 kHz	49.63	-6.36
1 Quasi Peak	602 kHz	48.72	-7.27
2 Average	638 kHz	15.33	-30.66
1 Quasi Peak	682 kHz	45.57	-10.42
1 Quasi Peak	754 kHz	41.23	-14.76
1 Quasi Peak	814 kHz	36.87	-19.12
1 Quasi Peak	874 kHz	32.36	-23.63

Cond Emissions L N

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EDIT PEAK LIST (Final Measurement Results)

Trace1:	55022QPC
Trace2:	55022AVC
Trace3:	---

TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	1.314 MHz	32.75	-23.24
1 Quasi Peak	1.422 MHz	33.50	-22.49
2 Average	16.226 MHz	33.56	-16.44
1 Quasi Peak	16.226 MHz	39.04	-20.96
1 Quasi Peak	17.694 MHz	38.98	-21.01
1 Quasi Peak	18.918 MHz	37.65	-22.34
2 Average	24.35 MHz	20.62	-29.37

Cond Emissions L N

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Note: All data points are corrected for insertion loss.

EUT – Neutral

EDIT PEAK LIST (Final Measurement Results)			
Trace1:	55022QPC		
Trace2:	55022AVC		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	154 kHz	56.05	-9.73
1 Quasi Peak	162 kHz	55.74	-9.61
1 Quasi Peak	174 kHz	55.23	-9.53
2 Average	174 kHz	25.81	-28.95
1 Quasi Peak	186 kHz	54.89	-9.32
1 Quasi Peak	198 kHz	54.09	-9.59
2 Average	202 kHz	24.39	-29.13
1 Quasi Peak	214 kHz	53.47	-9.56
2 Average	214 kHz	23.65	-29.39
1 Quasi Peak	226 kHz	52.88	-9.71
1 Quasi Peak	238 kHz	52.37	-9.78
2 Average	242 kHz	21.85	-30.17
1 Quasi Peak	250 kHz	51.93	-9.81
2 Average	254 kHz	21.79	-29.83
1 Quasi Peak	262 kHz	51.59	-9.77
1 Quasi Peak	274 kHz	51.16	-9.83
2 Average	282 kHz	20.10	-30.64
1 Quasi Peak	294 kHz	50.55	-9.85
1 Quasi Peak	318 kHz	49.85	-9.90
2 Average	322 kHz	22.77	-26.87

Cond Emissions L N

Date: 17.JUL.2006 12:26:19

Note: All data points are corrected for insertion loss.

EDIT PEAK LIST (Final Measurement Results)			
Trace1:	55022QPC		
Trace2:	55022AVC		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2 Average	334 kHz	18.82	-30.52
1 Quasi Peak	354 kHz	48.88	-9.98
2 Average	362 kHz	18.12	-30.55
1 Quasi Peak	390 kHz	48.03	-10.03
1 Quasi Peak	442 kHz	46.98	-10.04
2 Average	442 kHz	18.83	-28.19
2 Average	482 kHz	15.76	-30.53
1 Quasi Peak	530 kHz	45.82	-10.17
2 Average	590 kHz	15.52	-30.47
1 Quasi Peak	610 kHz	44.46	-11.53
2 Average	730 kHz	30.85	-15.14
1 Quasi Peak	730 kHz	40.72	-15.27
1 Quasi Peak	810 kHz	37.61	-18.38
2 Average	1.318 MHz	35.24	-10.75
2 Average	1.322 MHz	35.23	-10.77
1 Quasi Peak	18.918 MHz	41.54	-18.45
2 Average	19.71 MHz	38.96	-11.03
1 Quasi Peak	19.71 MHz	44.00	-15.99
2 Average	20.258 MHz	37.74	-12.25
1 Quasi Peak	21.666 MHz	40.16	-19.83

Cond Emissions L N

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3.0 Peak Power Output

3.1 Test Standard

FCC CFR47, Part 15, Subpart B 15.247b

| (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 1 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.

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

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted output power.

(iii) Fixed, point-to-point operation, as used in Paragraphs (c)(4)(i) and (c)(4)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility. |

FCC CFR47, Part 15, Subpart E 15.407a

| *(a) Power limits*

(2) For the 5.25-5.35 and 5.47-5.735 GHz bands, the peak transmit power of the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the peak power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. |

3.2 Test Limits

When used exclusively for fixed, point-to-point operations in the 5.725-5.850 MHz band, the intentional radiator may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted output power. Therefore, the maximum peak power output of the intentional radiator shall be less than 1 watt = 30 dBm.

When used in the 5.25-5.35 MHz frequency band, the peak transmit power shall not exceed the lesser of 250 mW or 11 dBm + 10log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the peak transmit power must be reduced whenever antennas with greater than 6 dBi of gain are used.

3.3 Test Setup

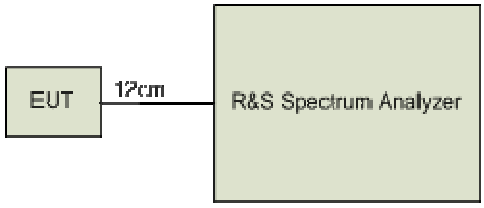
This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to measurement equipment. The output of the EUT was connected directly to the spectrum analyzer through an attenuator. Prescans using standby (beaconing) mode and data transfer mode were performed. The worst case measurements from standby mode are shown below.

Measurements were performed using the channel power measurement function of the spectrum analyzer. These conform to method 3 type of measurement specified in DA-02-2138.

The power reduction function was tested by specifying varying levels of antenna gain and measuring the conducted power output to confirm operation of the software.

This test was performed on channels 52, 60, 64, 149, 157, and 165.

3.3.1 Test Setup Block Diagram



3.4 Test Results

3.4.1 TR-5plus Maximum Conducted Output Power

Channel	Frequency (MHz)	Measurement (dBm)	Limit (dBm)	Result
52	5260	22.13	24.0	PASS
60	5300	21.64	24.0	PASS
64	5320	21.46	24.0	PASS
149	5745	22.94	30.0	PASS
157	5785	22.68	30.0	PASS
165	5825	21.78	30.0	PASS

3.4.2 TR-5plus Output Power Reduction

Channel	Frequency (MHz)	Measurement (dBm)	Limit (dBm)	Result
52	5260	7.94	10.0	PASS
60	5300	7.32	10.0	PASS
64	5320	7.19	10.0	PASS

The EUT demonstrated power reduction to accommodate up to 20 dBi antenna gain in the 5250-5350 frequency band.

4.0 Radiated Emissions, General Requirements

4.1 Test Standard

FCC Part 15, Subpart C, Section 15.209

| (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
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

*** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g.,Sections 15.231 and 15.241.*

(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 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector. |

4.2 Test Limits

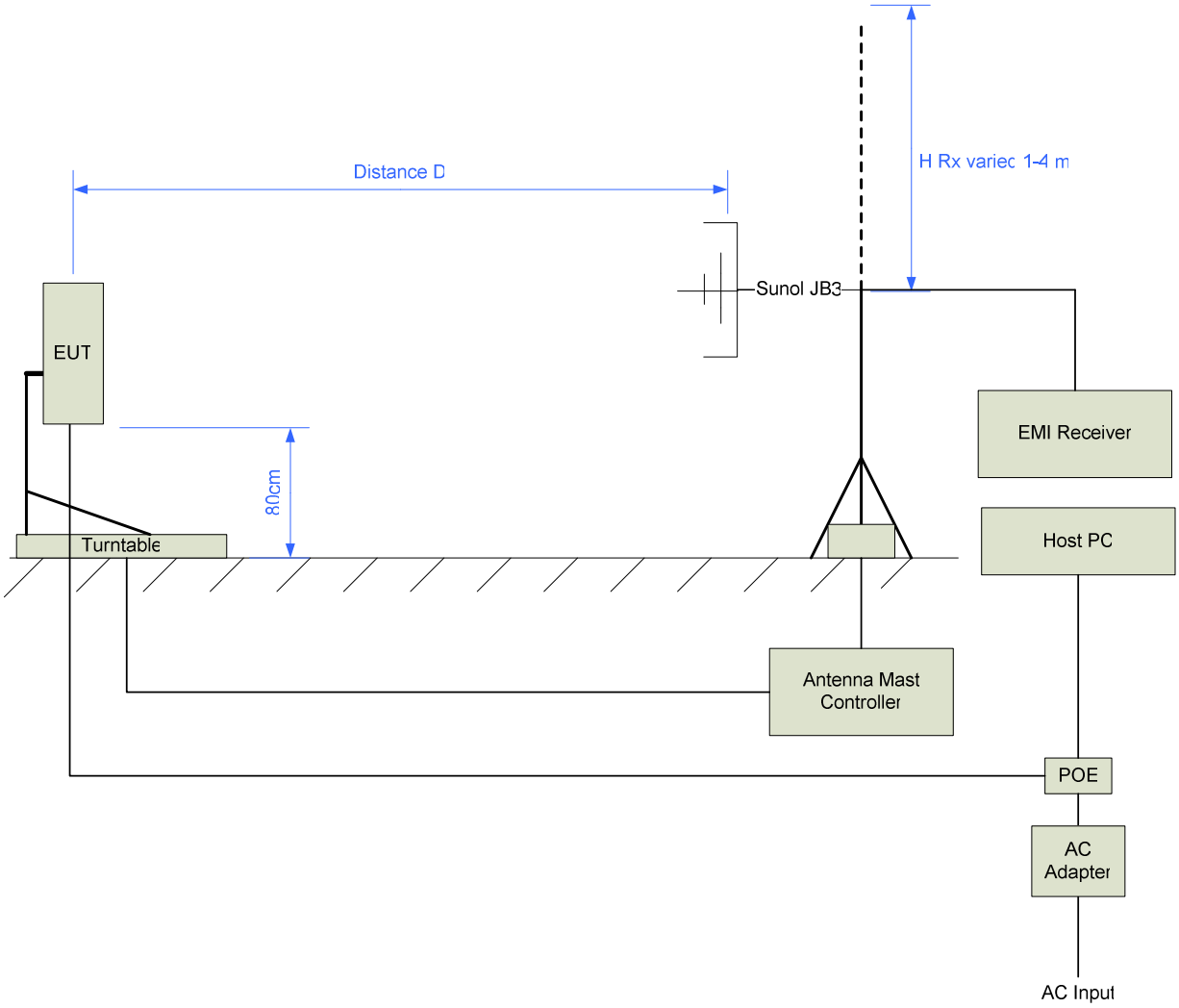
Frequency (MHz)	Maximum Field Strength (uV/m @ 3m)	Maximum Field Strength (dBuV/m @ 3m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-1000	500	54.0

4.3 Test Setup

The TR-5plus was prescanned in both orientations and at in all frequency bands. The EUT was exercised with bandwidth test software at a rate of 15 Mbps reflecting the worst case data-rate. It was rotated 360 degrees and the receive antenna swept from 1 m to 4 m to determine the maximum emissions level. The measurement distance was 3 m. Only the data taken from the worst case is shown below.

For test purposes, the EUT was configured to transmit at its maximum power level to ensure worst case test results.

4.3.1 Test Setup Block Diagram



Note: Measurements below 1 GHz were performed with the Sunol JB3 antenna with a measurement distance of 3 m.

Test Results

Freq (MHz)	Meter (dBuV)	Corr (dB)	Corr Readg (dBuV)	Limit (dBuV)	Margin (dB)	Polar	Rtype	Result
41.010	20.2	14.4	34.6	40	-5.4	V	Peak	PASS
43.807	19.4	12.4	31.8	40	-8.2	V	QP	PASS
51.900	24.0	8.9	32.9	40	-7.1	V	Peak	PASS
247.996	23.6	13.8	37.4	46	-8.6	H	Peak	PASS
374.992	21.4	17.7	39.1	46	-6.9	V	Peak	PASS
433.991	22.4	19.0	41.4	46	-4.6	V	Peak	PASS
495.999	22.9	20.3	43.2	46	-2.8	V	QP	PASS
496.001	22.7	20.3	43	46	-3	V	Peak	PASS
557.992	19.2	21.3	40.5	46	-5.5	V	Peak	PASS
744.000	18.6	24.1	42.7	46	-3.3	V	Peak	PASS
744.250	19.0	24.1	43.1	46	-2.9	H	Peak	PASS
806.010	17.4	24.9	42.3	46	-3.7	V	Peak	PASS
824.994	16.6	25.3	41.9	46	-4.1	V	Peak	PASS

5.0 Harmonic and Spurious Emissions

5.1 Test Standard

FCC CFR 47, Part 15, Subpart B 15.247d

| *(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 Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).* |

FCC CFR 47, Part 15, Subpart E 15.407b

| *(b) Undesireable Emission limits: Except as shown in Paragraph (b)(6) of this section, the peak emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:*

(2) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz. Devices operating in the 5.25-5.35 GHz band that generate emissions in the 5.15-5.25 GHz band must meet all applicable technical requirements for operation in the 5.15-5.25 GHz band (including indoor use) or alternatively meet an out-of-band emission EIRP limit of -27 dBm/MHz in the 5.15-5.25 band. |

5.2 Test Limits

5.725-5.850 GHz limits:

- Fundamental Limit = 137 dBuV
- Harmonics and Spurious Emissions = 20 dBc
- Restricted Band Emissions = AVG 54 dBuV, PK 74dBuV

5.250-5.350 GHz limits:

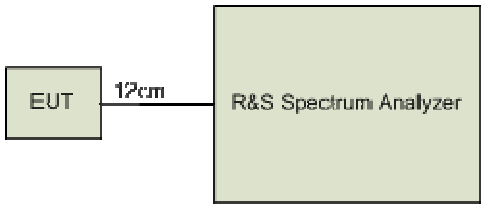
- All emissions outside of the 5.25-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz.
- Restricted Band Emissions = AVG 54 dBuV, PK 74dBuV

5.3 Test Setup – Conducted Measurements

This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to measurement equipment. The output of the EUT was connected directly to the spectrum analyzer. The unit was exercised with bandwidth test software at a rate of 15 MBps reflecting the maximum possible transmit rate. This test was performed on channels 52, 60, 64, 149, 157, and 165.

To ensure compliance with the required EIRP limits, a worst case antenna gain factor was added to the measured emission level which is then converted to a radiated value.

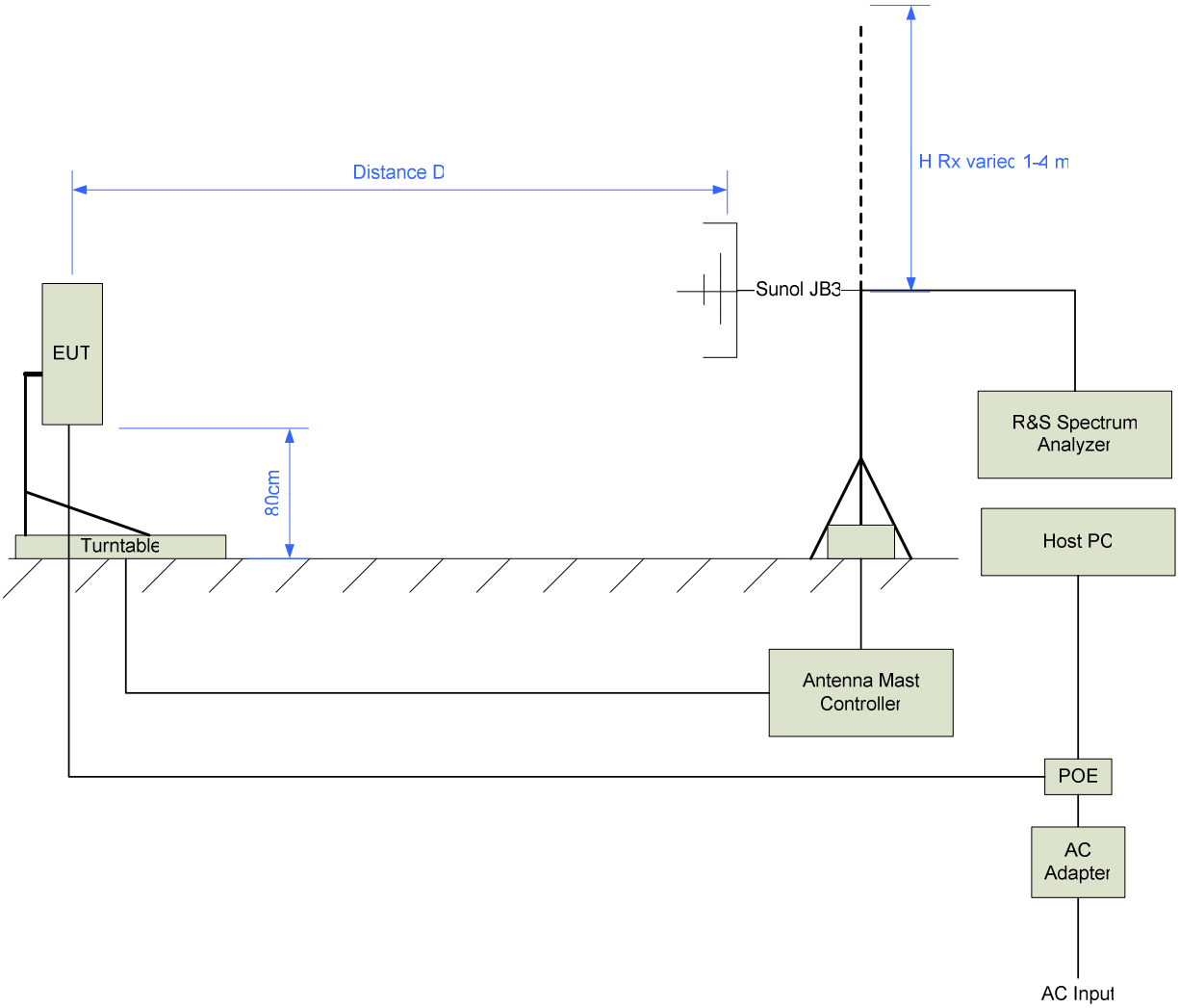
5.3.1 Test Setup Block Diagram



5.4 Test Setup – Radiated Measurements

The TR-5plus was prescanned in both orientations and at in all frequency bands. The EUT was exercised with bandwidth test software at a rate of 15 Mbps reflecting the worst case data-rate. It was rotated 360 degrees and the receive antenna swept from 1 m to 4 m to determine the maximum emissions level. The measurement distance was 3 m. Only the data taken from the worst case is shown below.

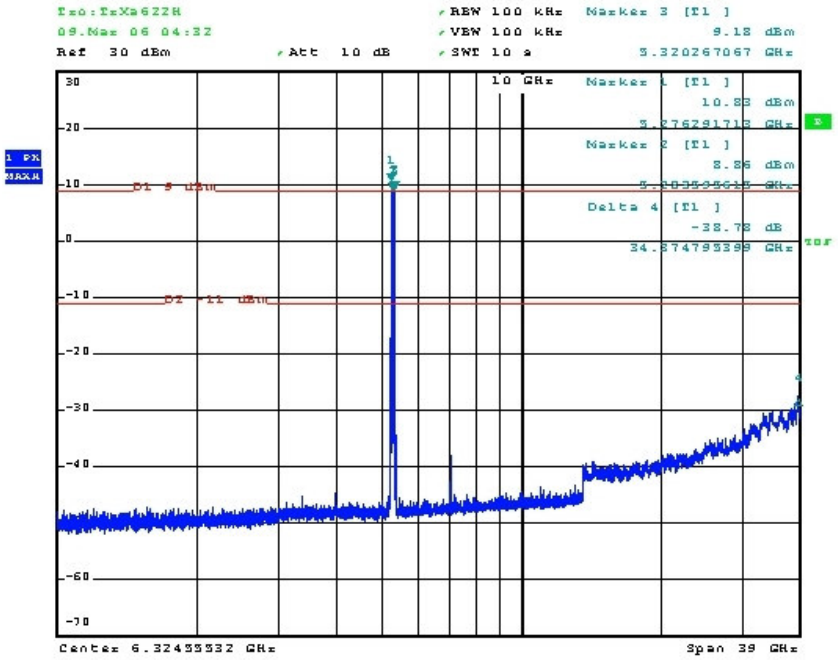
For test purposes, the EUT was configured to transmit at its maximum power level to ensure worst case test results.



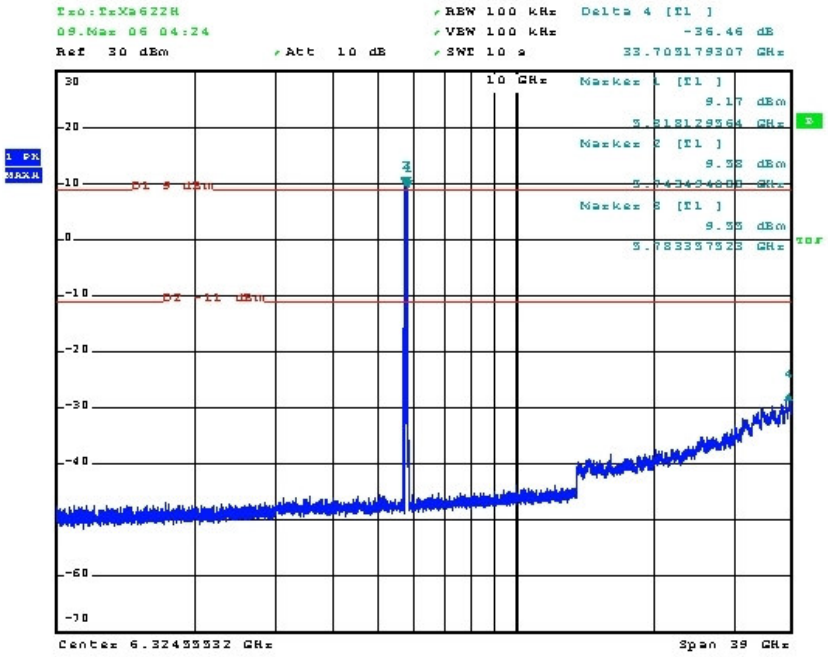
Measurements above 1 GHz were performed with the DRH-118 at a distance of 3 m.

5.5 Test Results

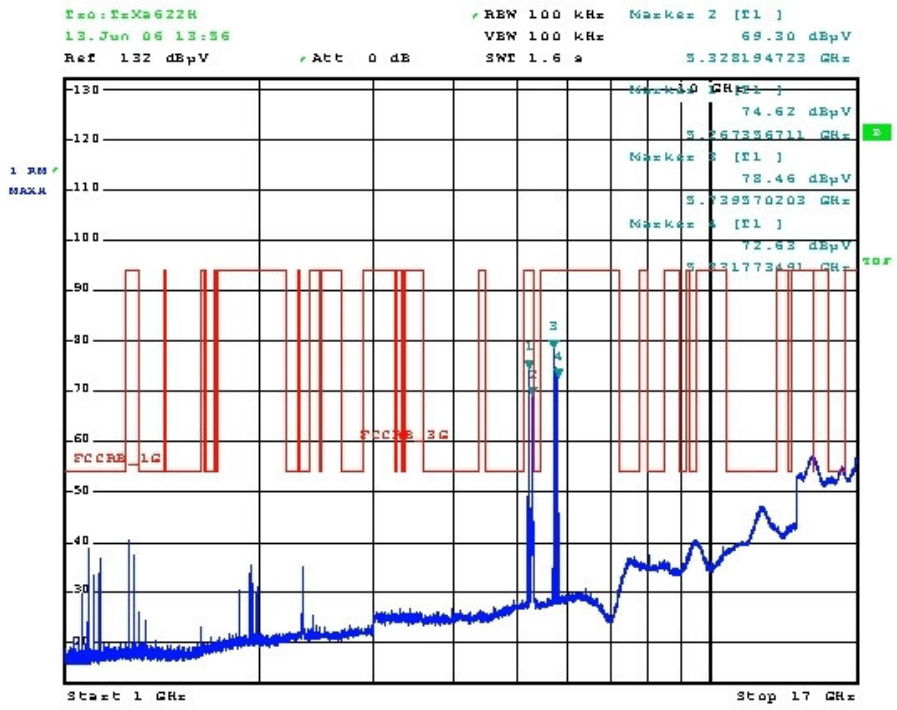
5.5.1 Test Results 15.407 Spurious Conducted



5.5.2 Test Results 15.247 Spurious Conducted



5.5.3 Test Results 15.247 and 15.407 Radiated



No spurious emissions were found within 20 dB of the limit.

6.0 Band Edge

6.1 Test Standard

FCC CFR 47, Part 15, Subpart B 15.247d

| (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 Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)). |

FCC CFR 47, Part 15, Subpart E 15.407b

| (b) Undesireable Emission limits: Except as shown in Paragraph (b)(6) of this section, the peak emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(2) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz. Devices operating in the 5.25-5.35 GHz band that generate emissions in the 5.15-5.25 GHz band must meet all applicable technical requirements for operation in the 5.15-5.25 GHz band (including indoor use) or alternatively meet an out-of-band emission EIRP limit of -27 dBm/MHz in the 5.15-5.25 band.

(7) The provisions of Section 15.205 of this part apply to intentional radiators operating under this section. |

6.2 Test Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

| *(2) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27 dBm/MHz. Devices operating in the 5.25-5.35 GHz band that generate emissions in the 5.15-5.25 GHz band must meet all applicable technical requirements for operation in the 5.15-5.25 GHz band (including indoor use) or alternatively meet an out-of-band emission EIRP limit of -27 dBm/MHz in the 5.15-5.25 band.*

(7) The provisions of Section 15.205 of this part apply to intentional radiators operating under this section. |

6.3 Test Setup

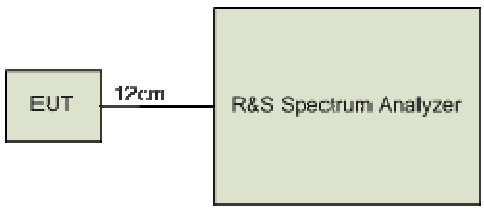
This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to the measurement equipment. The output of the EUT was connected directly to the spectrum analyzer through an attenuator. The unit was exercised with bandwidth test software at a rate of 27 MBps reflecting the worst case transmit rate.

For the 15.407 requirements, a worst case antenna gain factor was added to the conducted measurement.

Initially the device did not meet the emission limits when transmitting on the 5260 MHz center frequency. This channel was removed from the products firmware. Data is presented below detailing compliance with the emissions limits when the device is transmitting on the 5280 frequency.

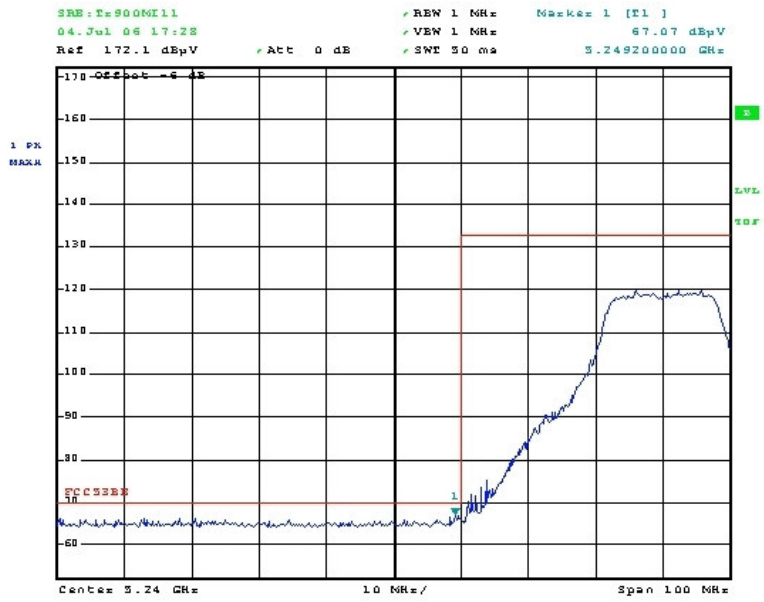
This test was performed on low, middle, and high channels.

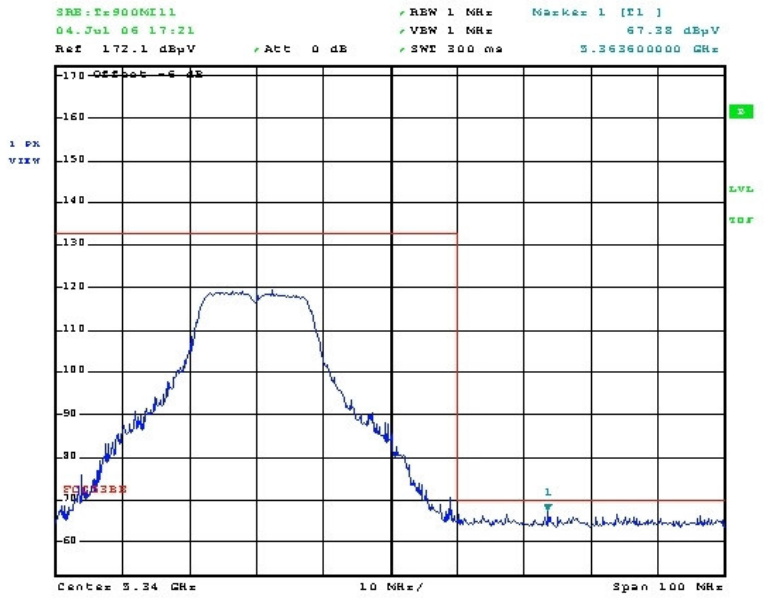
6.3.1 Test Setup Block Diagram



6.4 Test Results

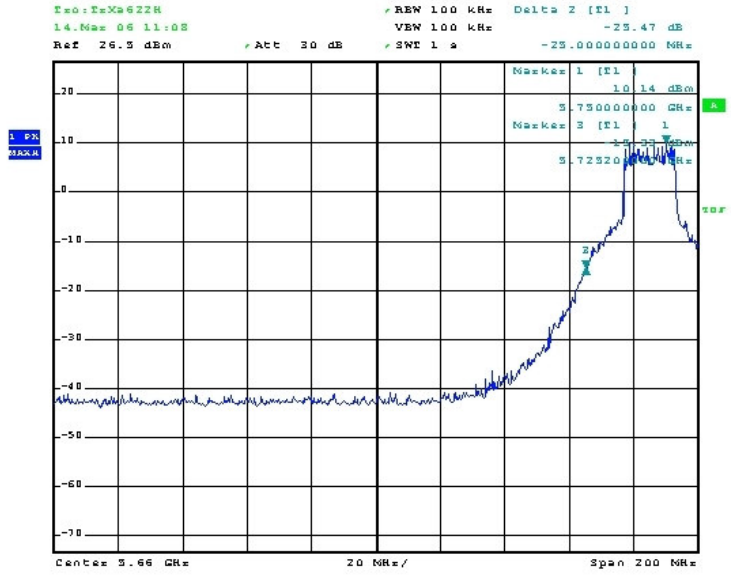
6.4.1 Test Results 15.407

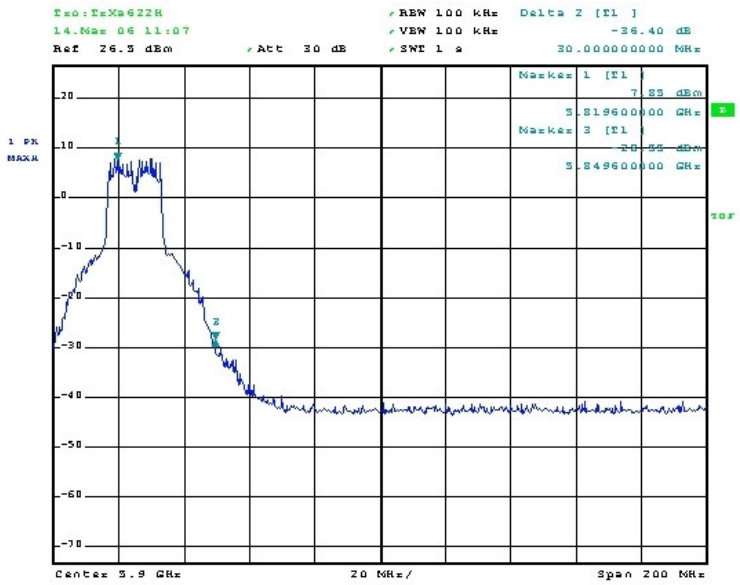




Frequency	Reading (dBuV)	Limit (dBuV)	Margin (dB)	Result
5249.20	67.07	70.5	-3.43	PASS
5363.60	67.38	70.5	-3.12	PASS

6.4.2 Test Results 15.247





Chan	Hi Reading (dBm)	Low Reading (dBm)	Delta	Limit (dBc)	Margin (dB)	Result
149	10.14	-15.33	-25.47	-20	-5.47	PASS
165	7.85	-28.55	-36.40	-20	-16.40	PASS

7.0 Occupied Bandwidth

7.1 Test Standard

FCC CFR47, Part 15, Subpart B 15.247a

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

(3) 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. |

FCC CRF47, Part 15, Subpart E 15.403i

|(i) Emission bandwidth. For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement. |

7.2 Test Limits

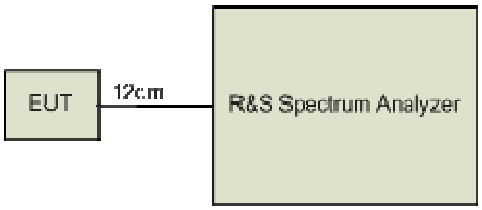
The minimum 6dB bandwidth shall be at least 500 kHz.

7.3 Test Setup

This test was performed with a modified unit. The antenna was removed and the intentional transmitter was fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to the measurement equipment. The output of the EUT was connected directly to the spectrum analyzer through an attenuator. The unit was exercised with bandwidth test software at a rate of 27 MBps reflecting the worst case transmit rate.

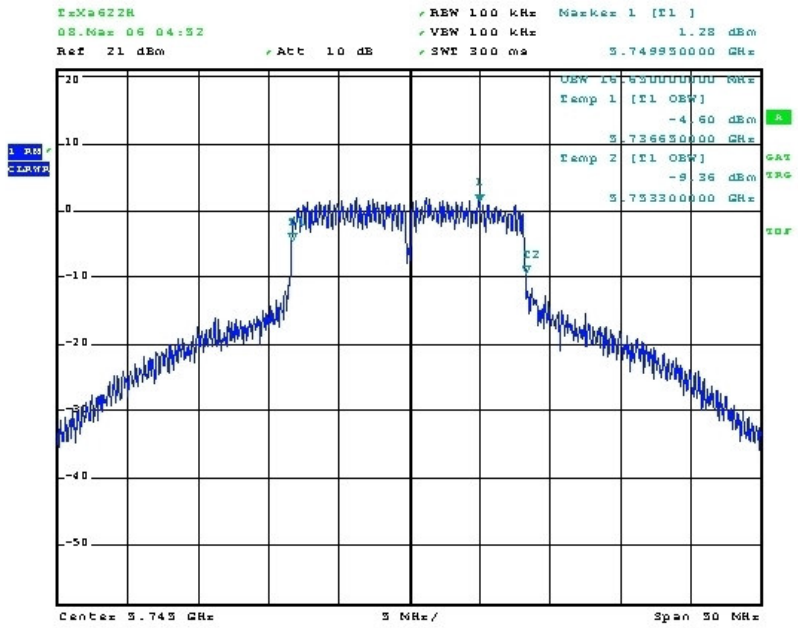
This test was performed on channels 52, 60, 64, 149, 157 and 165.

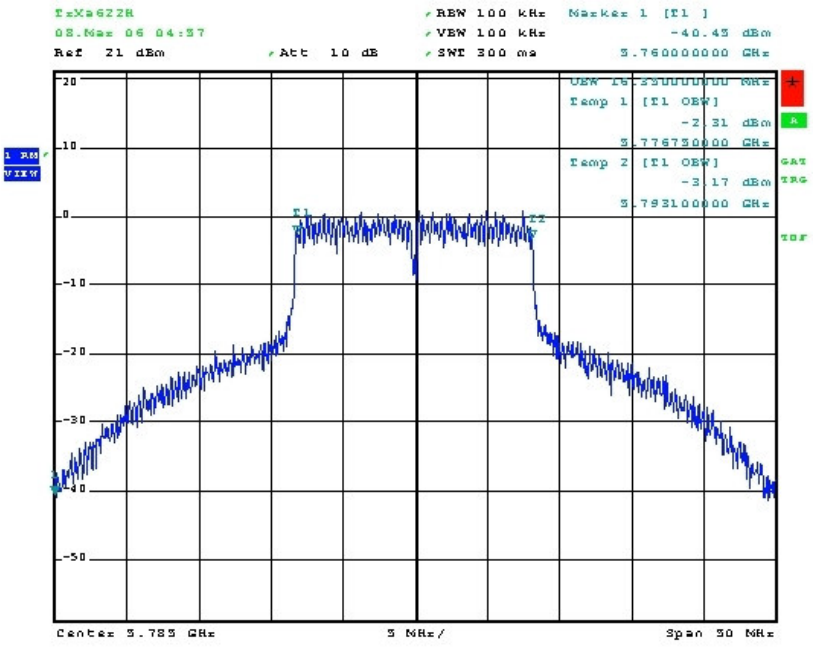
7.3.1 Test Setup Block Diagram

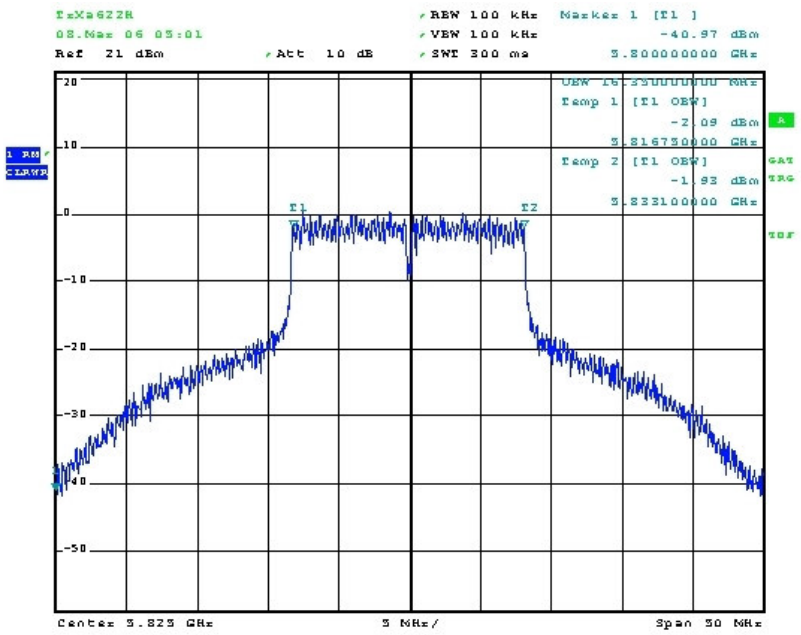


7.4 Test Results

7.4.1 5.725-5.850 6 dB Occupied Bandwidth

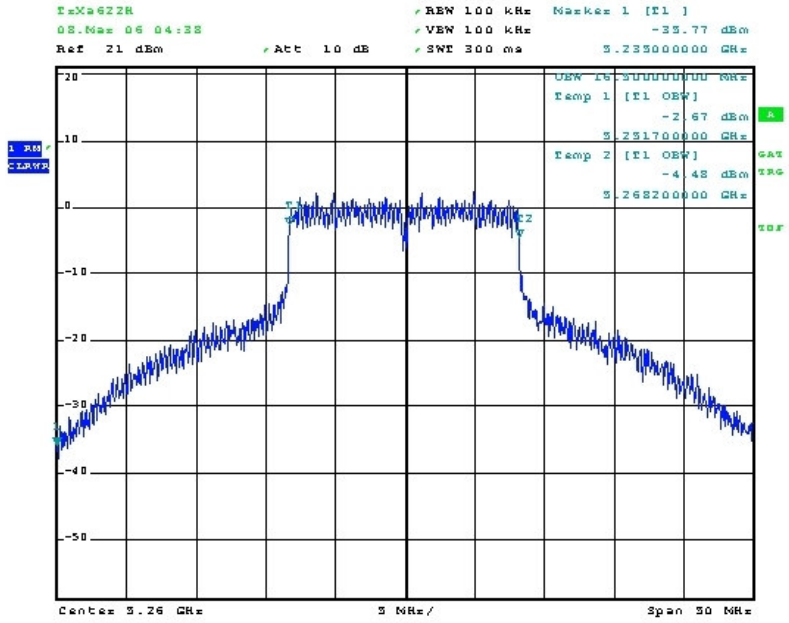


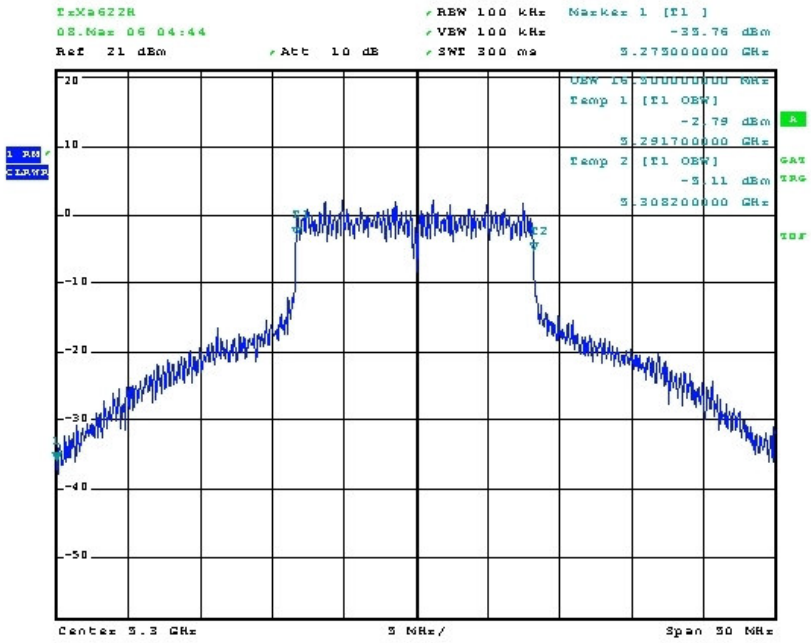


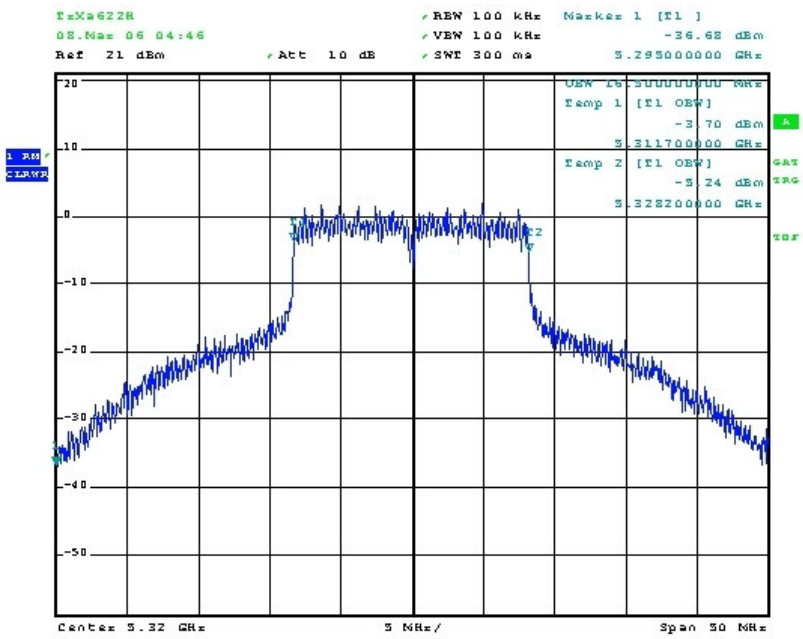


	Start Frequency (Mhz)	Stop Frequency (MHz)	Occupied Bandwidth (MHz)	Result
Ch 149	5736.65	5753.30	16.65	PASS
Ch 157	5776.75	5793.10	16.35	PASS
Ch 165	5816.75	5833.10	16.35	PASS

7.4.2 5.250-5.350 6 dB Occupied Bandwidth

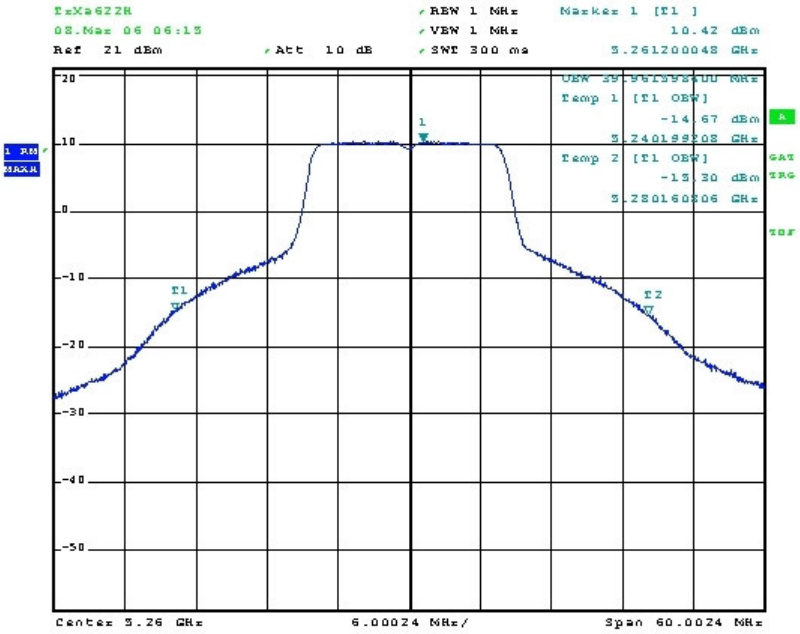


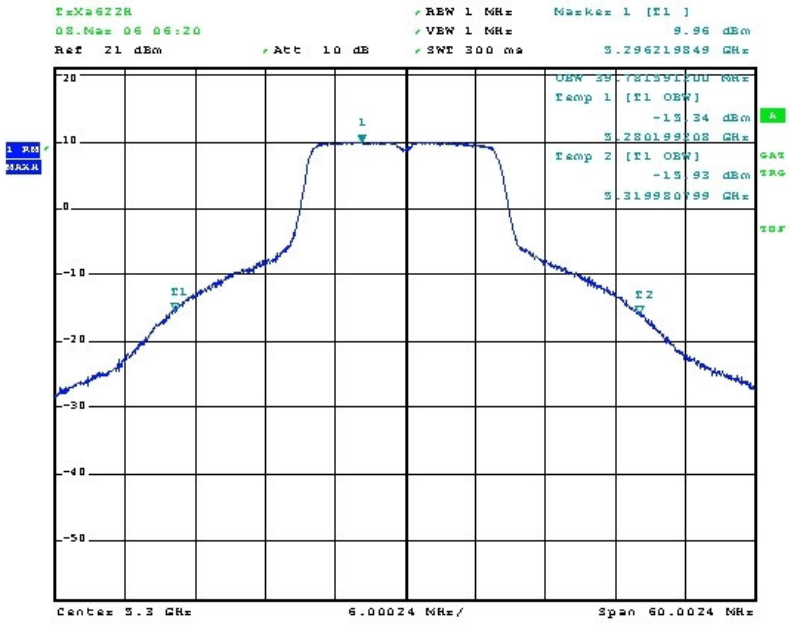


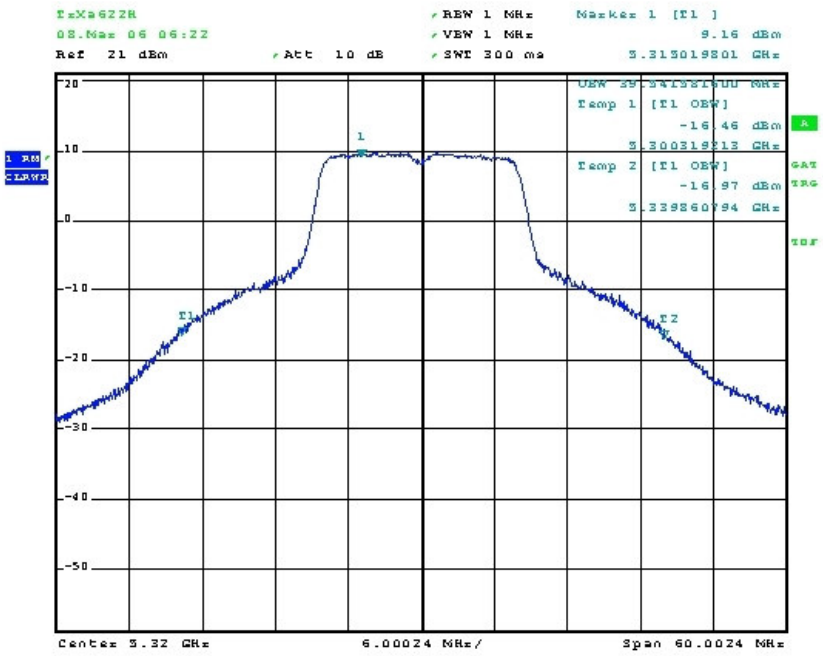


	Start Frequency (Mhz)	Stop Frequency (MHz)	Occupied Bandwidth (MHz)	Result
Ch 52	5251.70	5268.20	16.50	PASS
Ch 60	5291.70	5308.20	16.50	PASS
Ch 64	5311.70	5328.20	16.50	PASS

7.4.3 5.250-5.350 26 dB Emission Bandwidth







Channel	Start Frequency (Mhz)	Stop Frequency (MHz)	Occupied Bandwidth (MHz)
Ch 52	5240.20	5280.16	39.96
Ch 56	5280.20	5319.98	39.78
Ch 64	5300.32	5339.86	39.54

8.0 Power Spectral Density

8.1 Test Standard

FCC CFR 47, Part 15, Subpart B 15.247e

| (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. |

FCC CFR47, Part 15, Subpart E 15.407a

| (2) For the 5.25-5.35 and 5.47-5.735 GHz bands, the peak transmit power of the frequency bands of operation shall not exceed the lesser of 250 mW or 11 dBm + 10 log B, where B is the 26 dB emission bandwidth in megahertz. In addition, the peak power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. |

8.2 Test Limits

The transmitted power density shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

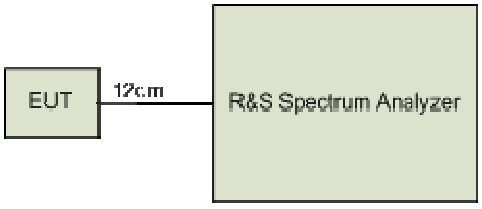
In addition, the peak power spectral density shall not exceed 11 dBm in any 1 MHz band.

8.3 Test Setup

This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to measurement equipment. The unit was exercised with bandwidth test software at a rate of 27 MBps reflecting the worst case transmit rate.

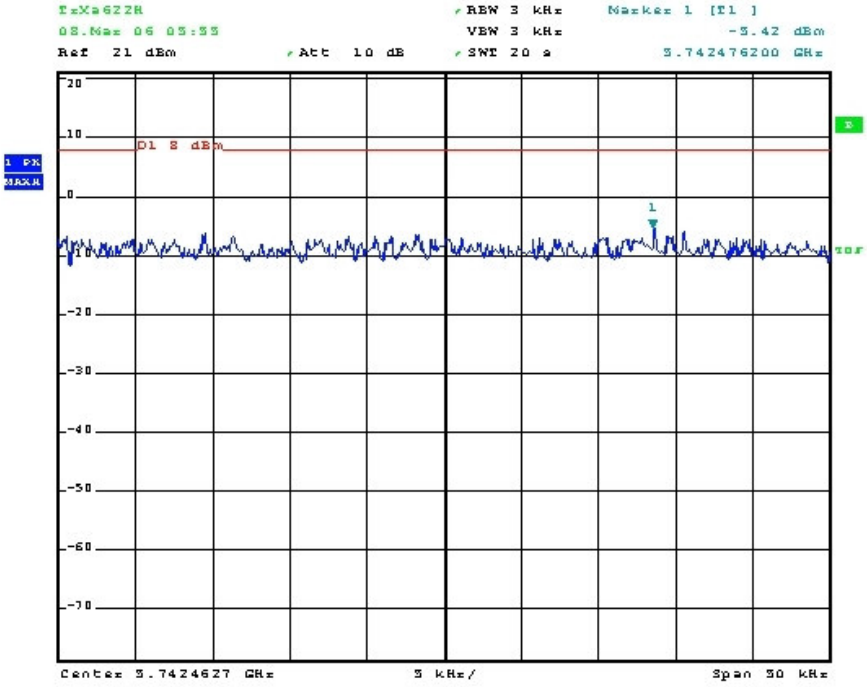
This test was performed on channels 52, 60, 64, 149, 157 and 165.

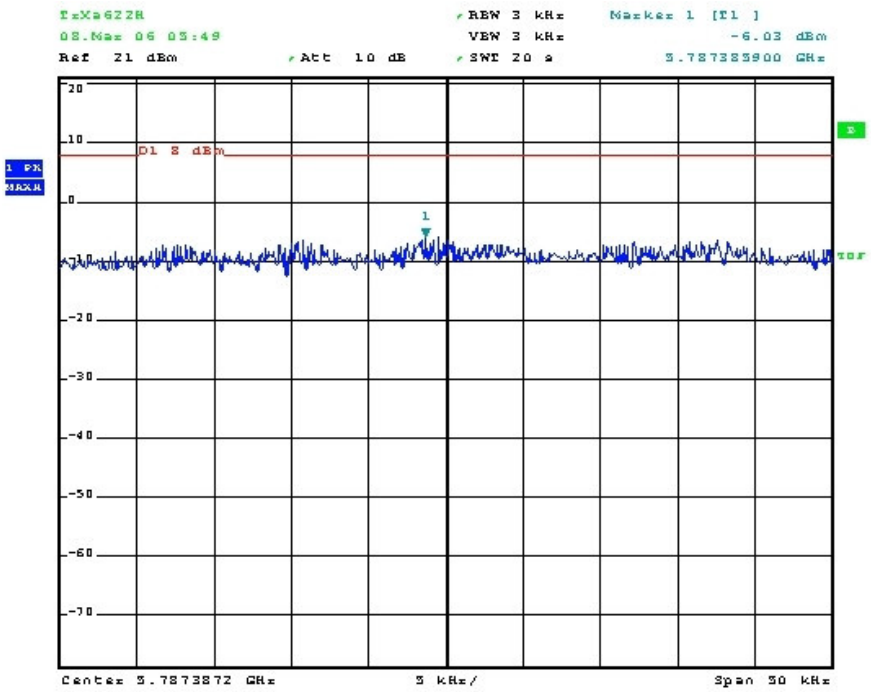
8.3.1 Test Setup Block Diagram

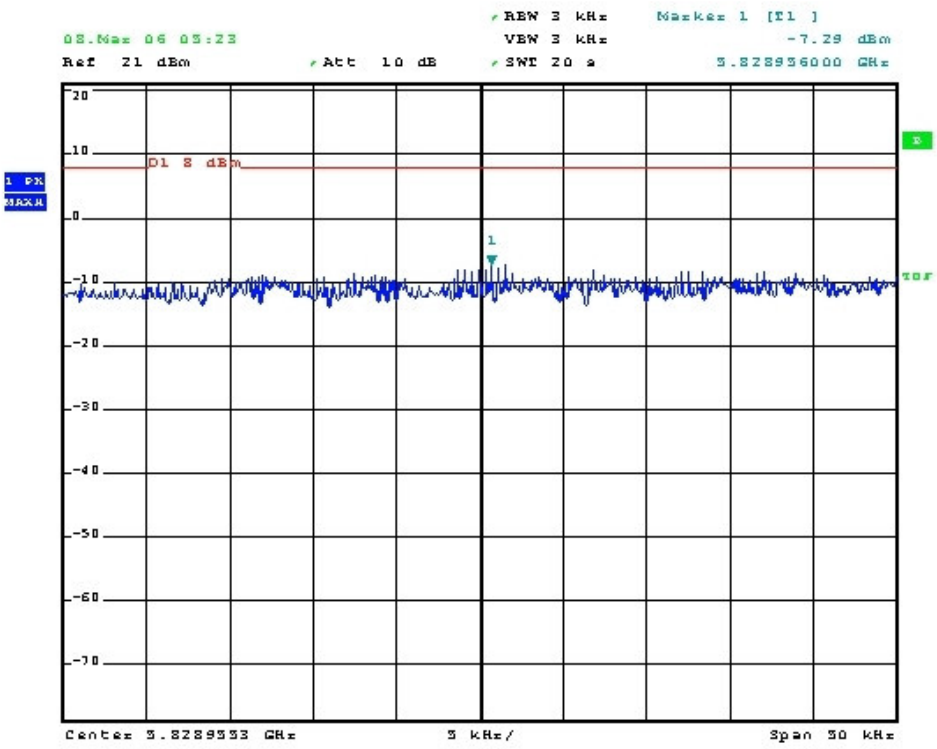


8.4 Test Results

8.4.1 15.24 7- 5.725-5.850 GHz

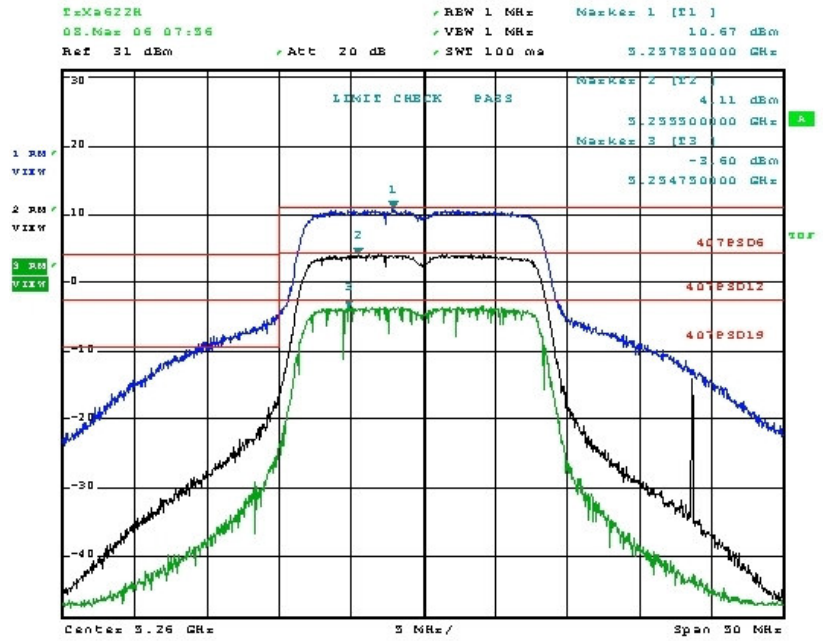


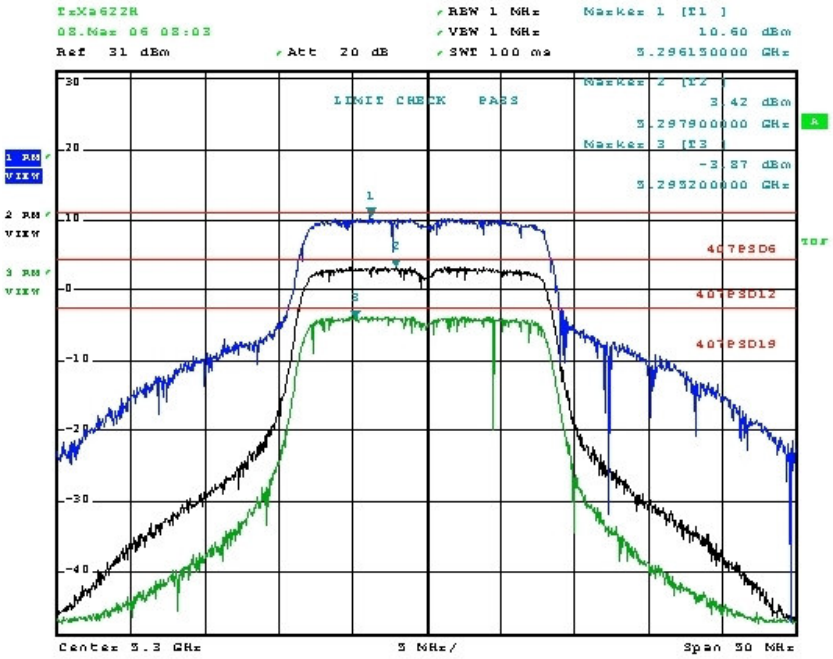


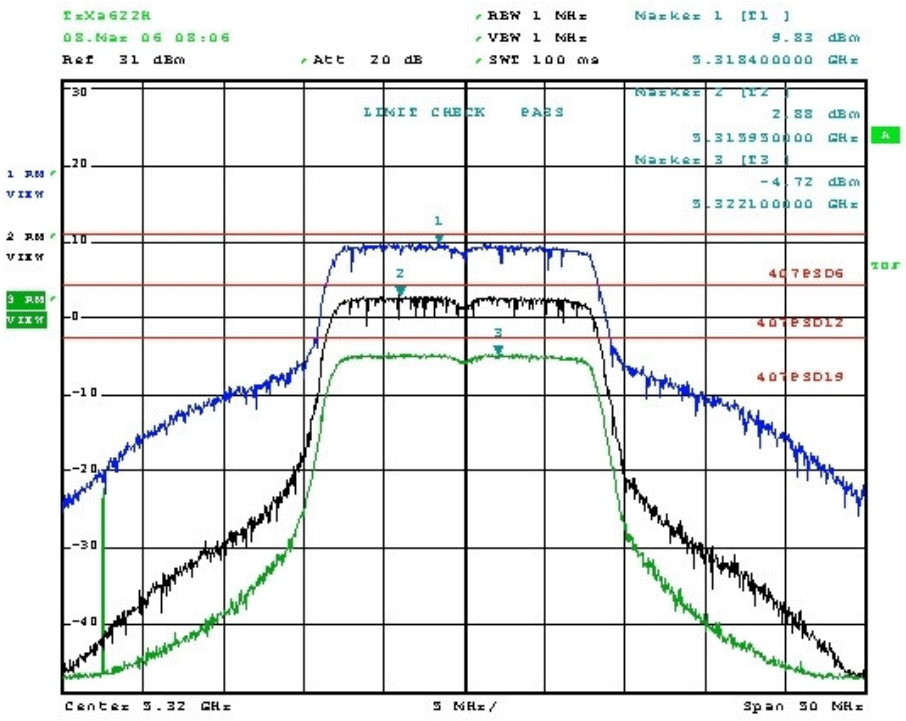


Frequency (MHz)	Measurement (dBm)	Limit (dBm)	Result
5743	-5.42	8	PASS
5787	-6.03	8	PASS
5829	-7.29	8	PASS

8.4.2 Test Results 15.407 - 5.250-5.350 Ghz







Peak PSD

Channel	Measurement (dBm)	Limit (dBm)	Result
52	10.67	11	PASS
60	10.60	11	PASS
64	9.83	11	PASS

Worst Case Antenna Reduction PSD

Channel	Measurement (dBm)	Limit (dBm)	Result
52	-3.60	-2	PASS
60	-3.87	-2	PASS
64	-4.72	-2	PASS

9.0 Peak Excursion

9.1 Test Standard

FCC CFR47, Part 15, Subpart E 15.407a

| (6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak ptransmit power (measured as a specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

9.2 Test Limits

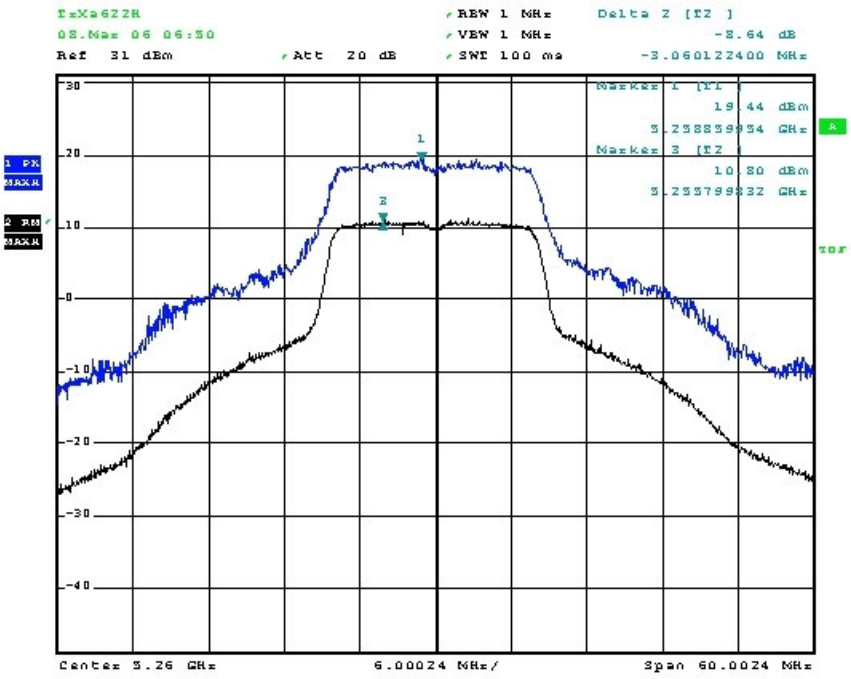
The peak excursion ratio shall not exceed 13 dB across any 1 MHz bandwidth.

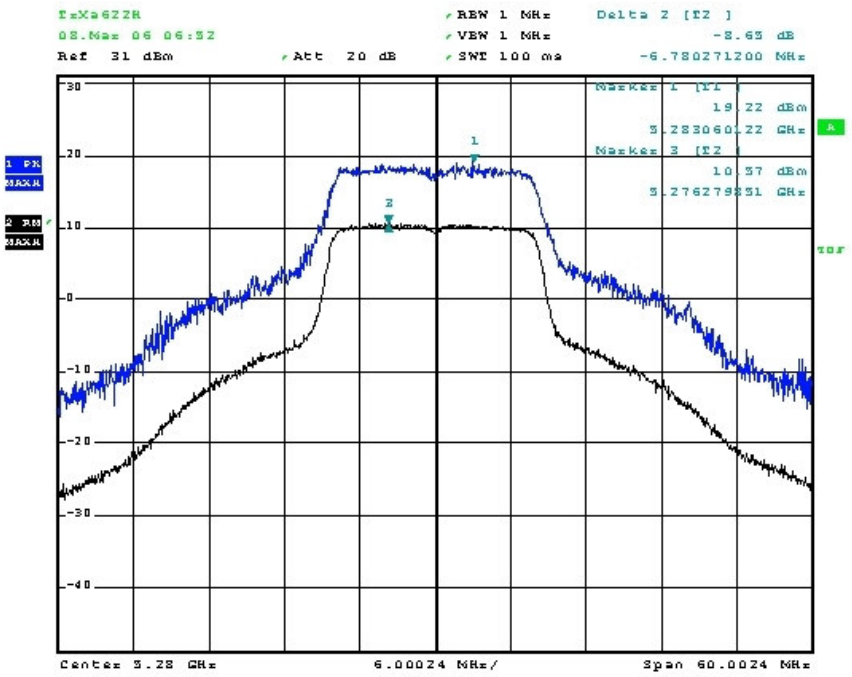
9.3 Test Setup

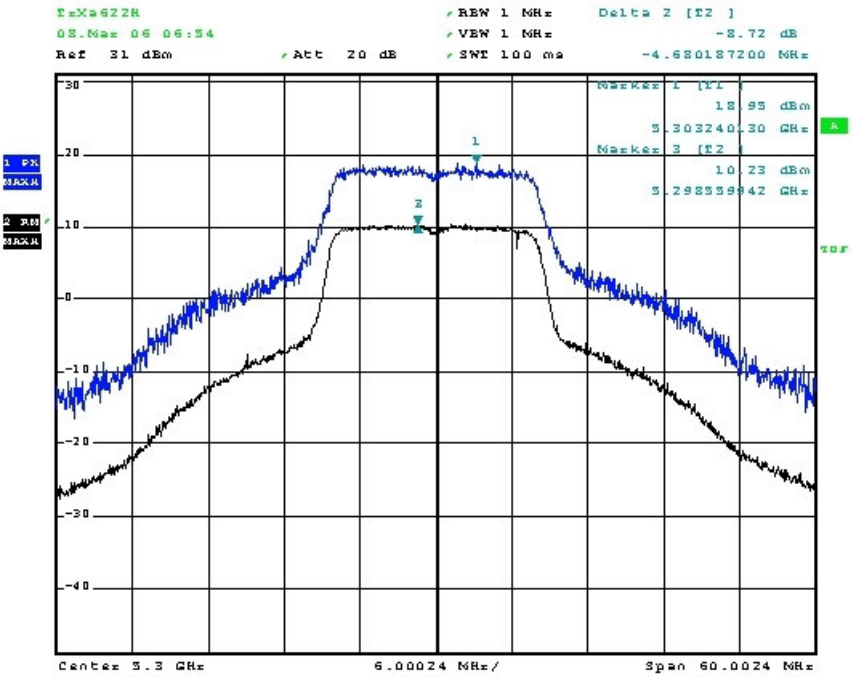
This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to measurement equipment. The unit was exercised with bandwidth test software at a rate of 27 MBps reflecting the maximum possible transmit rate.

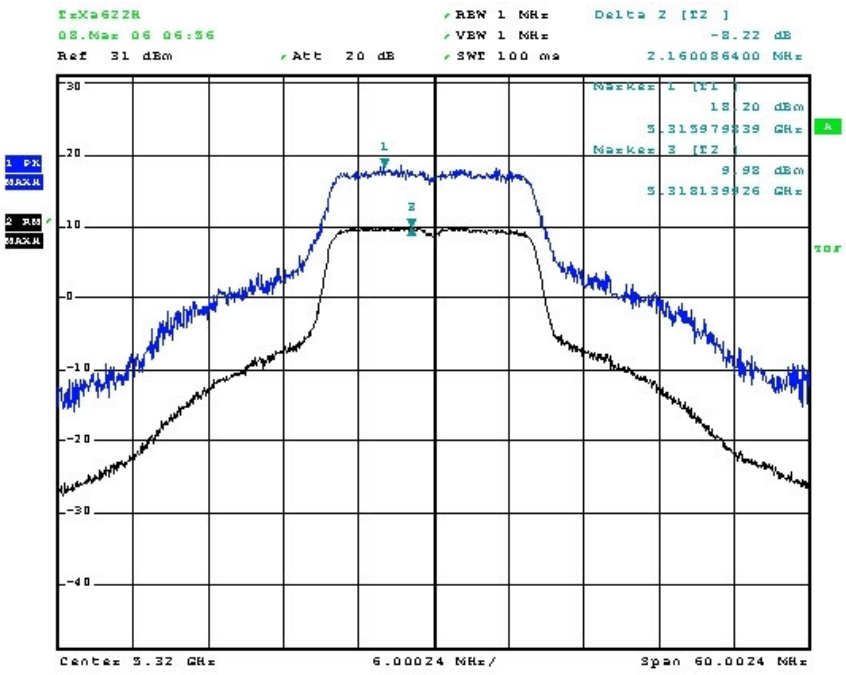
This test was performed on channels 52, 56, 60, and 64.

9.4 Test Results




RBW 1 MHz
VBW 1 MHz
SWT 100 ms
Delta 2 [T2]
-8.65 dB
-6.780271200 MHz
Ref 31 dBm
Att 20 dB
Marker 1 [T1]
19.22 dBm
5.283060122 GHz
Marker 3 [T2]
10.57 dBm
5.276279351 GHz
Center 5.28 GHz
6.00024 MHz/
Span 60.0024 MHz


RBW 1 MHz
VBW 1 MHz
SWT 100 ms
Delta 2 [T2]
-8.72 dB
-4.680187200 MHz
Ref 31 dBm
Att 20 dB
Marker 1 [T1]
18.95 dBm
5.303240130 GHz
Marker 3 [T2]
10.23 dBm
5.298559842 GHz
Center 5.3 GHz
6.00024 MHz/
Span 60.0024 MHz



Channel	Reading (dB)	Limit (dB)	Margin (dB)	Result
52	8.64	13	-4.36	PASS
56	8.65	13	-4.35	PASS
60	8.72	13	-4.28	PASS
64	8.22	13	-4.78	PASS

10.0 Frequency Stability

10.1 Test Standard

FCC CFR 47, Part 15, Subpart E 15.407g

(g) Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the users manual.

10.2 Test Limits

Fundamental emissions from the transmitter must remain in the specified frequency band of 5250-5350 MHz over the specified frequency and voltage ranges.

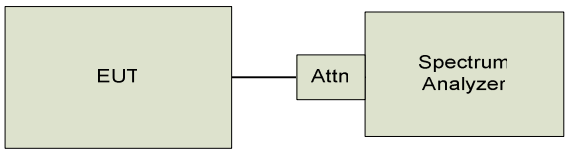
10.3 Test Setup – Conducted Measurements

This test was performed with a modified unit. The antenna was removed and the intentional transmitter fitted with a modified production cable. The only modification to the cable was the addition of an appropriate connector that allowed a direct connection to measurement equipment. The output of the EUT was connected directly to the spectrum analyzer through an attenuator. The unit was exercised using beaconing. The test was performed on channels 56 and 64.

All measurements were performed conducted. To ensure compliance with the required EIRP limits, a worst case antenna gain factor was added to the measured emission level which is then converted to a radiated value.

Compliance is established by measuring the lowest and highest frequencies of the emission envelope at the lowest and highest fundamental frequencies respectively..

10.3.1 Test Setup Block Diagram



10.4 Test Results

V	Temp C	Freq (MHz)	F1 (MHz)	F2 (MHz)	Center Freq (MHz)	Drift (MHZ)
nom	25	5280-5320	5271.080000	5328.800000	5307.720000	ref
max	55	5280-5320	5271.200000	5328.800000	5307.600000	-0.12
min	55	5280-5320	5271.140000	5328.900000	5307.760000	0.04
max	30	5280-5320	5271.080000	5328.800000	5307.720000	0.00
min	30	5280-5320	5271.180000	5328.900000	5307.720000	0.00
max	5	5280-5320	5271.200000	5328.800000	5307.600000	-0.12
min	5	5280-5320	5271.160000	5328.840000	5307.680000	-0.04
max	-20	5280-5320	5271.200000	5328.800000	5307.600000	-0.12
min	-20	5280-5320	5271.180000	5328.830000	5307.650000	-0.07
max	-50	5280-5320	5271.200000	5328.800000	5307.600000	-0.12
min	-50	5280-5320	5271.170000	5328.820000	5307.650000	-0.07

Voltage was varied from 12V to 24V per manufacturer's specifications.

11.0 Transmission Failure

11.1 Test Standard

FCC CFR47, Part 15, Subpart E 15.407c

(c) The device shall automatically discontinue transmission in case of either absence of information to transmit or operational failure. These provisions are not intended to preclude the transmission of control or signalling information or the use of repetitive codes used by certain digital technologies to complete frame or burst intervals. Applicants shall include in their application for equipment authorization a description of how this requirement is met..

11.2 Justification

The EUT meets this requirement through the implementation of it's IEEE 802.11 compliant MAC layer. The following is excerpted from the 802.11 1999 standard. Please see Section 9.2 of the standard for more details:

> Error recovery is always the responsibility of the STA that initiates a frame exchange sequence, as defined in 9.7. Many circumstances may cause an error to occur that requires recovery. For example, the CTS frame may not be returned after an RTS frame is transmitted. This may happen due to a collision with another transmission, due to interference in the channel during the RTS or CTS frame, or because the STA receiving the RTS frame has an active virtual carrier-sense condition (indicating a busy medium time period).
>
> Error recovery shall be attempted by retrying transmissions for frame exchange sequences that the initiating STA infers have failed. Retries shall continue, for each failing frame exchange sequence, until the transmission is successful, or until the relevant retry limit is reached, whichever occurs first. STAs shall maintain a short retry count and a long retry count for each MSDU or MMPDU awaiting transmission. These counts are incremented and reset independently of each other.
>
> After an RTS frame is transmitted, the STA shall perform the CTS procedure, as defined in 9.2.5.7. If the RTS transmission fails, the short retry count for the MSDU or MMPDU and the STA short retry count are incremented. This process shall continue until the number of attempts to transmit that MSDU or MMPDU reaches dot11ShortRetryLimit.

12.0 RF Exposure Evaluation

FCC 1.1310 states the criteria listed in the table below shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Section 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Section 2.1093 of this chapter. Further information on evaluating compliance with these limits can be found in the FCC's OST/OET Bulletin Number 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radiofrequency Radiation."

Frequency Range (MHZ)	Electric Field Strength (V/m)	Magnetic Field Strength (A/M)	Power Density (mW/cm^2)	Average Time
(A) Limits for Occupational/Control Exposures				
300-1500	--	--	F/300	6
1500-100,000	--	--	5	6
(B) Limits for General Population/Uncontrolled Exposures				
300-1500	--	--	F/1500	30
1500-100,000	--	--	1	30

12.1 EUT Operating Condition

Maximum EIRP is obtained with the 24 dBi grid and 26 dBi dish antenna. When using this antenna, the output of the radio is reduced to a maximum of 24 dBm as part of the hardware installation.

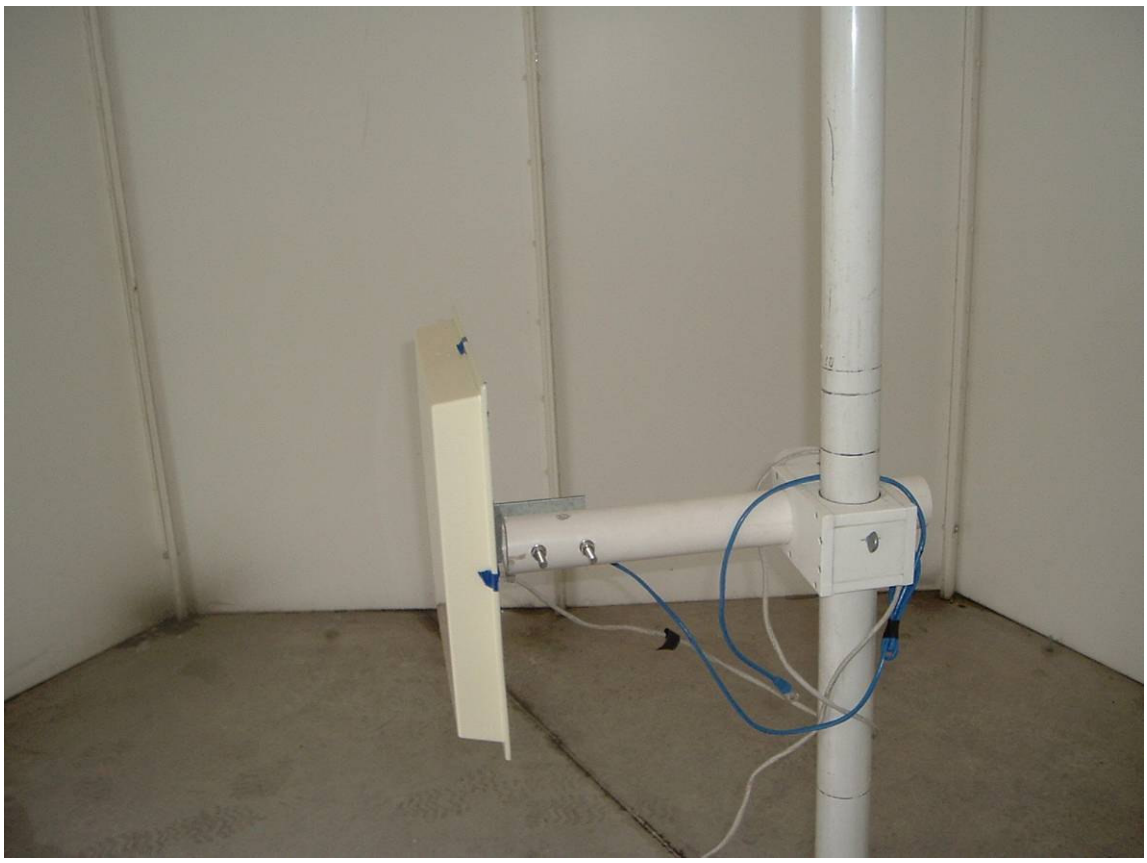
12.2 RF Exposure Evaluation Distance Calculation

TR-5plus with 26 dBi antenna

Chan	Freq (MHz)	Output Power to Antenna (dBm)	Output Power to Antenna (mW)	Antenna Gain (dBi)	r (cm)
52	5260	7.94	6.22	20	6.9
60	5300	7.32	5.40	20	6.3
64	5320	7.19	5.24	20	6.3
149	5745	22.94	197	26	79.0
157	5785	22.68	185	26	76.6
165	5825	21.78	151	26	69.2

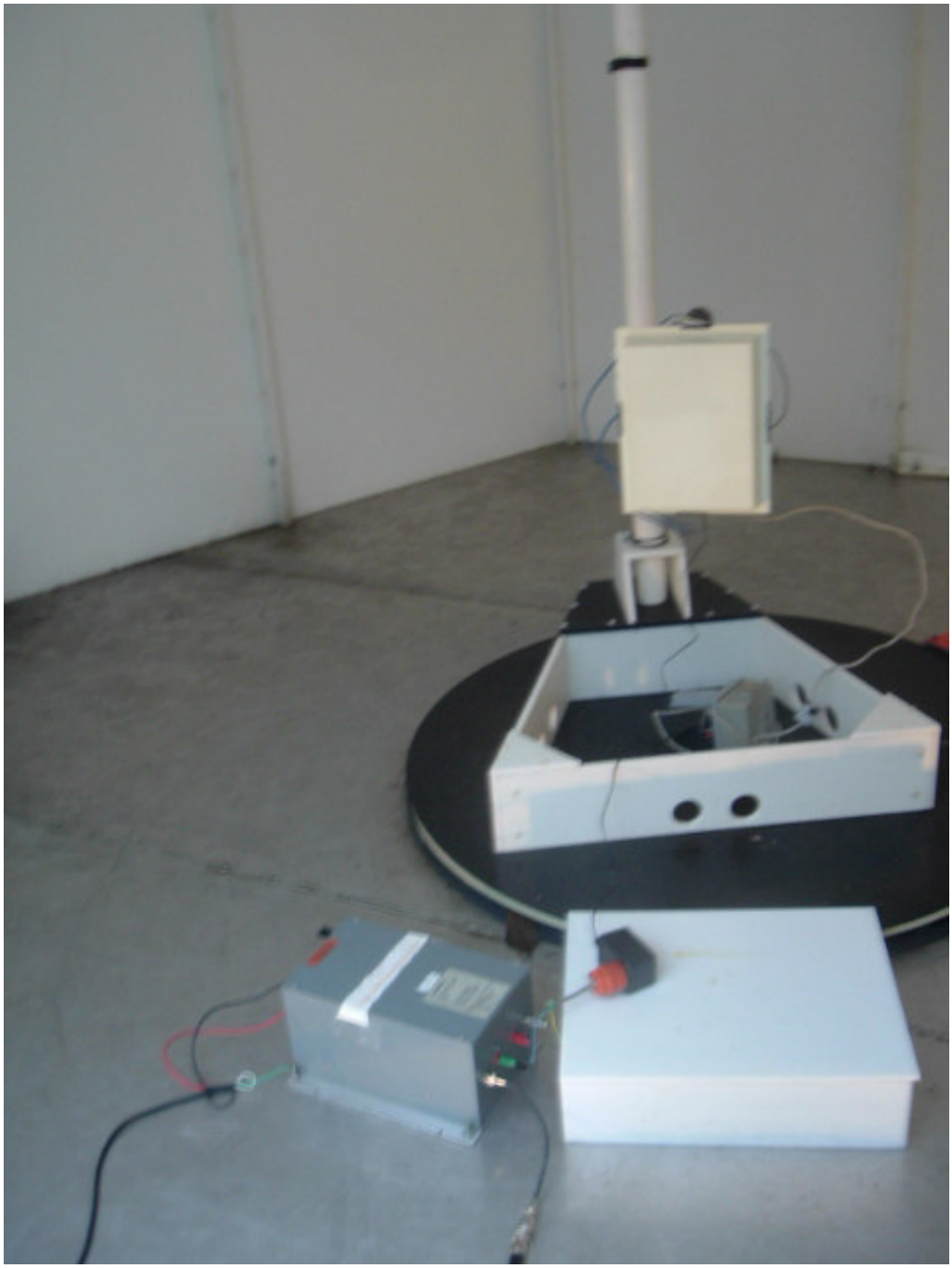
As shown above, the minimum distance where the MPE limit is reached is **79.0** cm for the TR-5plus product family.

13.0 Test Photos



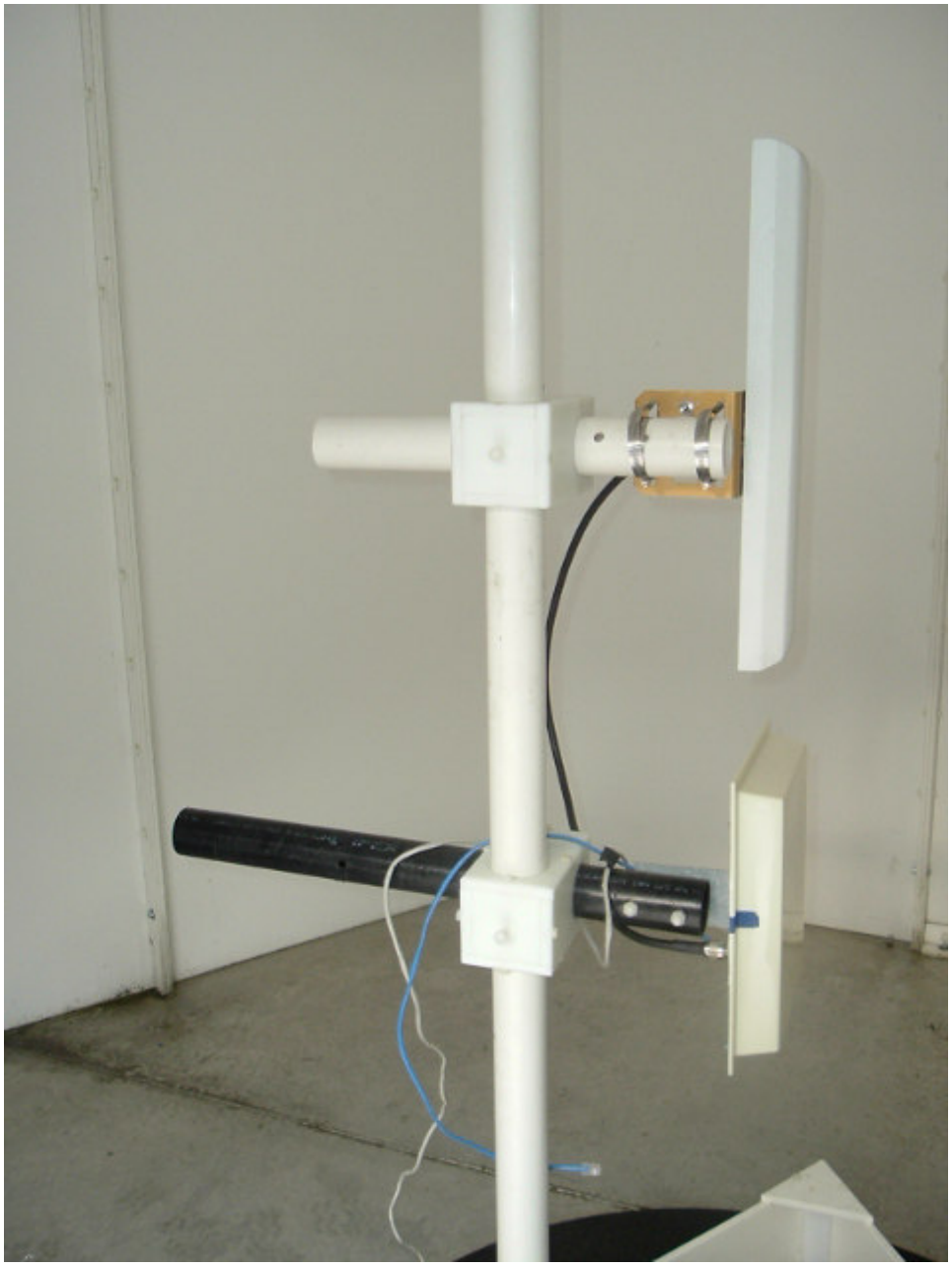
24 dBi Integrated

26 dBi Grid

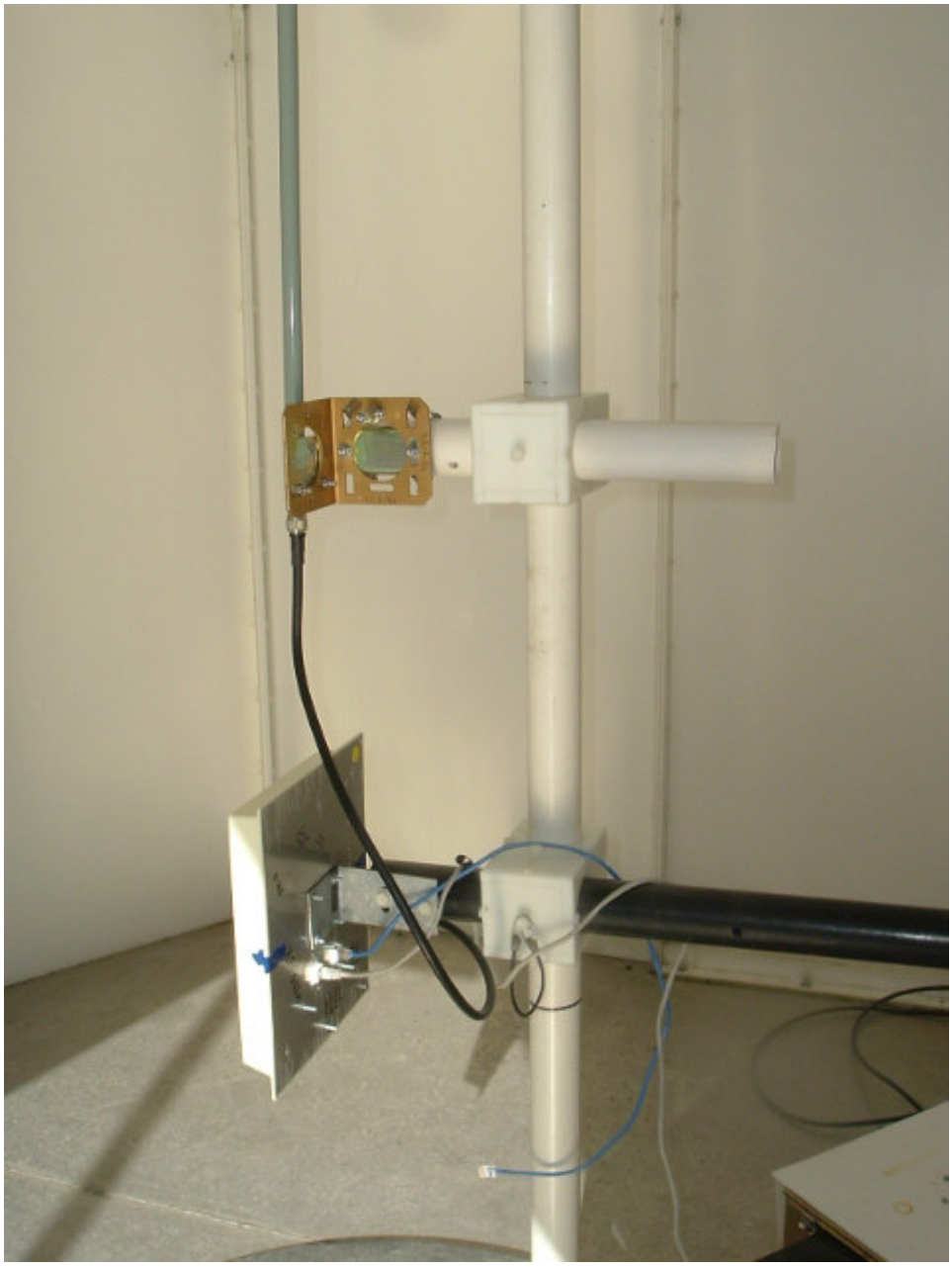


Conducted Emissions

Horizontal Sector



Vertical Sector



Omni