Part 15 Certification Application for FCC ID OZFT90001

EMI Test Report and Technical Documentation on the Tantalus TUNet-1200 Wireless LAN for use on the Tantalus Utility Network.

Prepared by:

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Burnaby, BC Canada

V5G 1B2

Document number 960-0003-FCC01

Version 1.0

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1 Objective

The purpose of this document is to present measured data and technical documentation that demonstrates compliance to the requirements listed in Part 15 of the FCC Rules and Regulations.

1.1 General Information

The Equipment Under Test (EUT) is the Tantalus Utility Network model 1200 (TUNet-1200) transceiver. Physically it is an electromechanical utility watt-hour meter retrofitted with a 902-928 MHz frequency hopping spread spectrum transceiver housed under the meter (glass) cover. The antennas are an integral part of the retrofitted meter and are neither accessible nor replaceable.

1.2 References

The following reference documents are supplied with this filing.

Document Identification	**Description**	**Revision**
280-0003-FAB	TUNet-1200 FCC Label	A
900-0001	TUNet-1200 Installation Manual	1.0
960-0003-TEO1	TUNet-1200 Theory of Operation	1.3
960-0003-AS01	TUNet-1200 Assembly Diagram	A
960-0003-BD	TUNet-1200 Network Transceiver Block Diagram	A
100-0013-SD	Transceiver Board Schematic Diagram	B
960-0003-BOM01	Transceiver Board Parts List	B
100-0013-AS	Transceiver Board Assembly Diagram	A
960-0003-AW01	Transceiver Board PCB Foil Pattern Artwork	A
100-0014-SD	Host Board Schematic Diagram	B
960-0003-BOM02	Host Board Parts List	B
100-0014-AS	Host Board Assembly Diagram	A
960-0003-AW02	Host Board PCB Foil Pattern Artwork	B
960-0003-TN01	TUNet-1200 Frequency List	1.0
Confidentiality Statement.pdf	Confidentiality Statement	
FRN_7474851	FCC Registration Number	
TCB_EXCLUSIONS_LIST.PDF	TCB Exclusions list document.	
FCC_email.pdf	FCC correspondence email regarding 20 cm grant note not being required for the EUT.	

2 Verification of Compliance

Equipment Under Test:	Tantalus Wireless LAN Device.
Model Number:	TUNet-1200.
Serial Number:	Pre-Production Model.
Applicant:	Tantalus Systems Corporation. 4224 Manor Street. Burnaby BC, Canada. V5G 1B2.
Tested as Per FCC Rules:	FCC Part 15.247.
Date of Tests:	February and April 2003.
Tested By:	Robert De Angelis, Tantalus Systems Corporation. Robert Stirling, Protocol Labs.

The above equipment was tested by Tantalus Systems Corporation and Protocol Labs and is in compliance with the requirements in Part 15 of the FCC Rules and Regulations.

Robert De Angelis

Product Development

Tantalus Systems Corporation

3 General Information

Applicant:	Tantalus Systems Corporation. 4224 Manor Street. Burnaby BC, Canada. V5G 1B2
Contact:	Robert De Angelis
Phone:	604-299-0458
Fax:	604-451-4111
Equipment Under Test:	Tantalus Wireless LAN Device.
Model Number:	TUNet-1200.
Serial Number:	Pre-Production Models.
Manufacturer:	Tantalus Systems Corporation.
Emissions Designator:	F1D
FCC ID:	OZFT9001

All power line conducted and radiated emission measurements are conducted at the approved test facility mentioned below:

Test Facility:	Protocol Labs 28945 McTavish Road. Abbotsford BC, Canada V4X 2E7 FCC Registration Number 96437 Industry Canada Registration Number IC3384
Contact:	Robert Stirling
Phone:	604-607-0012
Fax:	604-607-0019

4 Results Summary

The following is a summary of the tests and measurements performed to demonstrate compliance.

Paragraph	Test	Measured by	Limit	Measurement	Result
15.247(a)(1)	20 dB bandwidth.	Tantalus	500 kHz max.	61.250 kHz	Complies
15.247(a)(1)	Hop channel frequency separation.	Tantalus	Greater of 25 kHz or 20 dB bandwidth.	128.250 kHz	Complies
15.247(a)(1)	Pseudorandom ordered list of hopping frequencies.	Tantalus		See technical description.	Complies
15.247(a)(1)	Frequency hop synchronization of system receivers with system transmitted signals.	Tantalus		See technical description.	Complies
15.247(a)(1)	Receiver input bandwidth matches the transmitted signal bandwidth.	Tantalus	Transmitted signal bandwidth.	Transmitted signal bandwidth +/- 10 ppm. guard band at 928 MHz.	Complies
15.247(a)(1)(i)	Demonstration of a minimum of 50 hopping frequencies.	Tantalus	50 hopping frequencies minimum.	50 hopping frequencies.	Complies
15.247(a)(1)(i)	Average time occupancy per hopping frequency.	Tantalus	0.4 seconds max. in 20 seconds.	0.088 seconds in 20 seconds.	Complies
15.247(b)(2)	Maximum peak output power.	Protocol Labs	4 Watts ERP maximum when the intentional radiator has a capability of 1 Watt maximum.	0.414 W	Complies

15.247(b)(4)	Public RF exposure limits.	Tantalus	601 uW/cm^2	601 uW/cm^2 at d less than 3 cm. 0.71 uW/cm^2 at d equal to 1 m.	Complies
15.247(c)	Out of band emissions.	Tantalus	-20 dB with respect to peak in band power in a 100 kHz bandwidth.	All spurious measured are below the limit.	Complies
15.209(a)	Emissions in restricted bands.	Protocol Labs	Limits as per the defined restricted bands.	All spurious measured are below the limit.	Complies
15.109(a)	Class B unintentional radiated emissions.	Protocol Labs	Limits as per the defined frequency bands.	All spurious measured are below the limit.	Complies
15.107	Power line conducted emissions, Class B limits.	Protocol Labs	Limits as per the defined frequency bands.	All spurious measured are below the limit.	Complies
15.207	Power line conducted emissions.	Protocol Labs	Limits as per the defined frequency bands.	All spurious measured are below the limit.	Complies

5 Test Equipment List

The following is the list of test equipment used for the conducted RF measurements in this report.

Test Site	Test Equipment	Model Number	Serial Number	Last Calibration	Next Calibration.
Tantalus Engineering Lab.	Spectrum Analyzer	Anritsu M710C	MT33925	Feb. 11, 2003	Feb. 11, 2004
Tantalus Engineering Lab.	Vector Signal Analyzer	Hewlett Packard 89441A	3416A03552	Sept. 6, 2002	Sept. 6, 2003
Tantalus Engineering Lab.	30 dB Attenuator	BIRD 8306-300-N-30DB	MFC70998	June 2001	

The test equipment list for the radiated measurements are included in the Protocol EMC test report in appendix A.

5.1 Measurement Uncertainty for Conducted Measurements

The measurement uncertainty is predominantly a result of the frequency response of the 30 dB attenuator listed in the test equipment list. The measurement uncertainty is significantly less than the measured margin of all conducted spurious measurements to their respective allowable conducted limits. The measurement uncertainty for conducted measurements is as follows:

Frequency Range	**Measurement Uncertainty**
DC to 2 GHz	+/- 1.6 dB
2 GHz to 4 GHz	+/- 2.6 dB
4 GHZ to 10 GHz	Less than +/- 5 dB

6 Test Results

6.1 20 dB Bandwidth

Requirement:

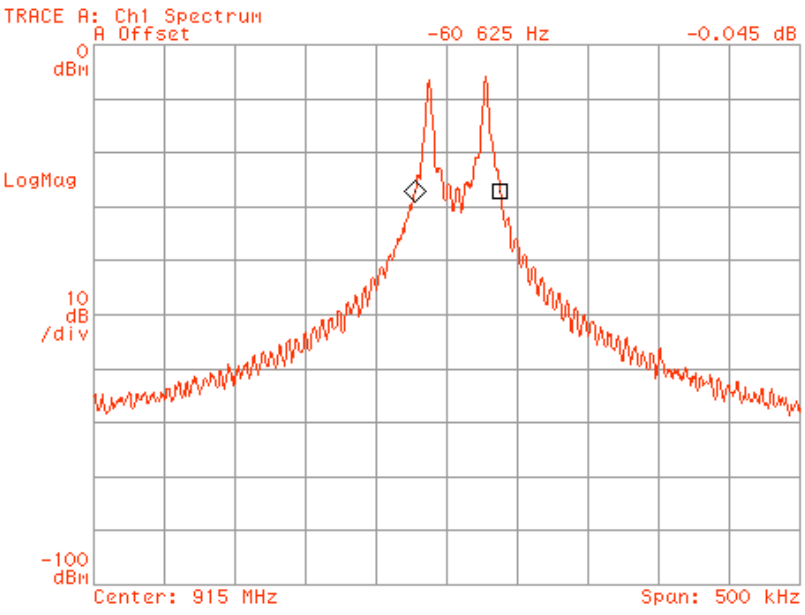
The 20 dB bandwidth of the emission is measured since it is required to set the minimum frequency spacing for the hopping channels. Part 15.247(a)(1)(i) states that the maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure:

The integral antenna of the EUT is removed from the transmitter output. The transmitter output is coupled directly into a Vector Signal Analyzer with appropriate in line attenuation to protect the input of the analyzer from damage. Markers are used to mark the 20 dB bandwidth and the measurement is performed at the lowest, the middle, and the highest frequency of operation and then recorded. The Vector Signal Analyzer settings are such that the span is at least two times the 20 dB bandwidth and that the resolution bandwidth is no less than 1% of the 20 dB bandwidth as per the FCC filing and measurement guidelines for frequency hopping spread spectrum systems.

Measurement Plots:

At the band centre



Vector Signal Analyzer Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free running

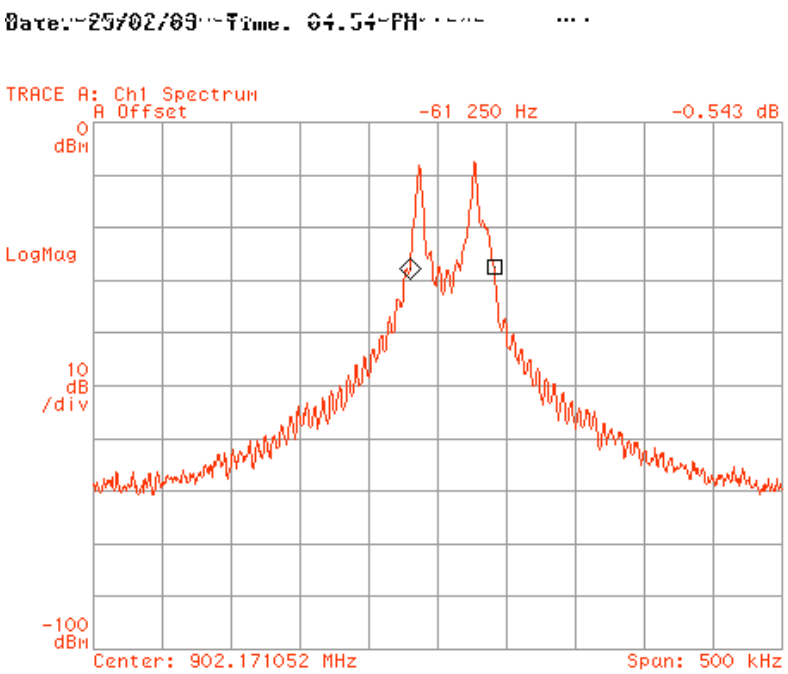
Center: 915 MHz

Span: 500kHz

Measurement Result:

The 20 dB bandwidth is 60.625 kHz.

At the lower edge of the band



Vector Signal Analyzer

Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free Running

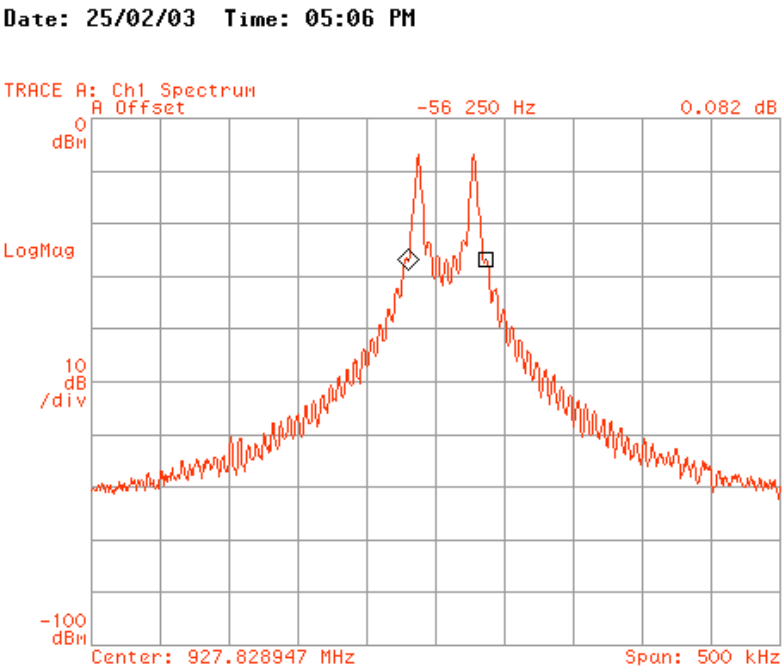
Center: 902.171052 MHz

Span: 500 kHz

Measurement Result:

The 20 dB bandwidth is 61.250 kHz.

At the upper edge of the band



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 928.828497 MHz

Span: 500 kHz

Measurement Result:

The 20 dB bandwidth is 56.250 kHz.

Result:

The maximum 20 dB bandwidth measured is 61.250 kHz.

Requirement	**Measured Result Complies**
The maximum allowed 20 dB bandwidth of the hopping channel is 500 KHz.	The maximum 20 dB bandwidth is 61.250 kHz.

6.2 Hopping Frequency Separation

Requirement:

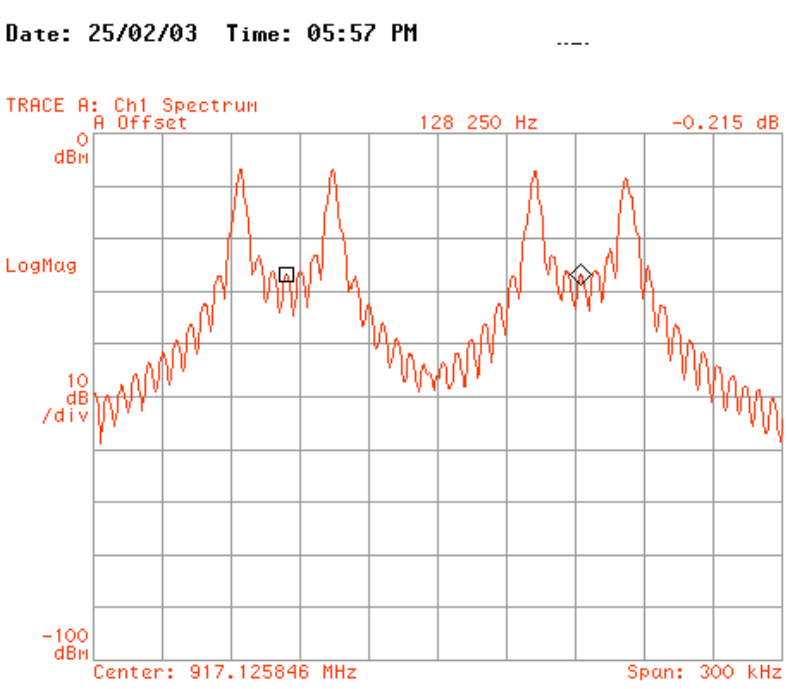
Part 15.247(a)(1) states that the frequency hopping carrier frequencies shall be separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Procedure:

The integral antenna of the EUT is removed from the transmitter output. The transmitter output is coupled directly into a Vector Signal Analyzer with appropriate in line attenuation to protect the input of the analyzer from damage. The separation of two operational frequencies is measured at the lower end, middle, and the higher end of the band and recorded. The separation must be equal to or greater than the 20 dB bandwidth measured in the previous section. The Vector Signal Analyzer resolution bandwidth is set to at least 1% of the span required to capture two adjacent frequencies to satisfy the FCC filing and measurement guidelines for frequency hopping spread spectrum signals.

Measurement Plots:

Adjacent frequencies near the centre of the band



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free running

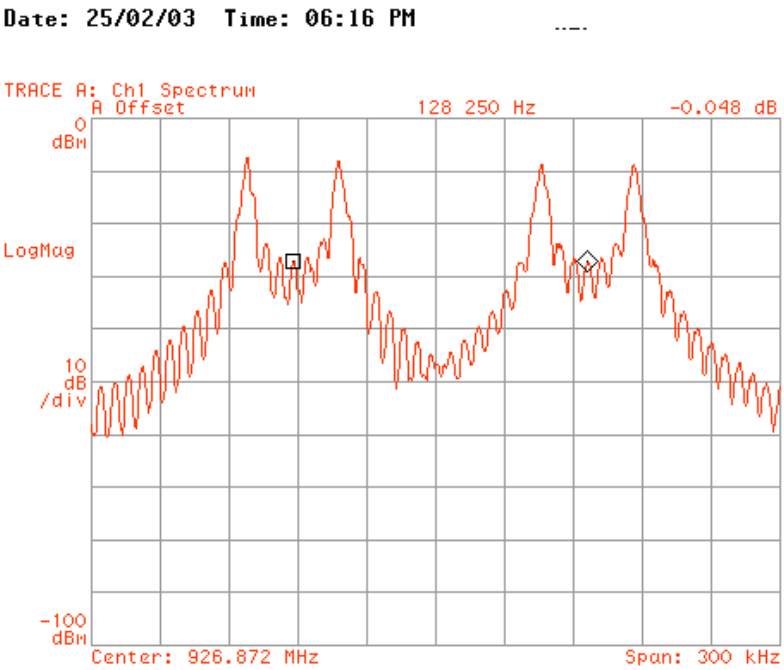
Center: 917.125846 MHz

Span: 300 kHz

Measurement Result:

The spacing of adjacent frequency carriers is 128.250 kHz.

Adjacent frequencies near the upper end of the band



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 926.872 MHz

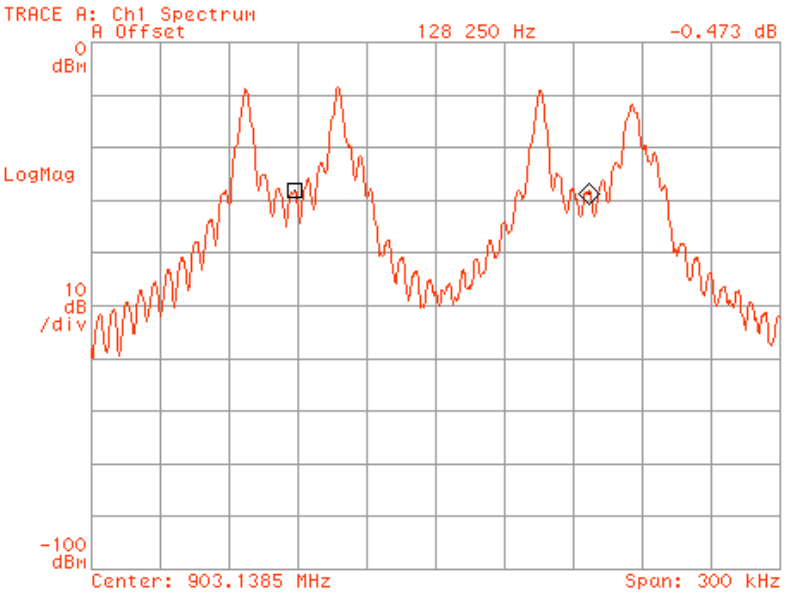
Span: 300 kHz

Measurement Result:

The spacing of adjacent frequency carriers is 128.250 kHz.

Adjacent frequencies near the lower end of the band

Date: 25/02/03 Time: 06:26 PM



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 3 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 903.1385 MHz

Span: 300 kHz

Measurement Result:

The spacing of adjacent frequency carriers is 128.250 kHz.

Result:

The measured spacing of adjacent frequency carriers is greater than the measured 20 dB bandwidth.

The spacing is 128.250 kHz. The 20 dB bandwidth is 61.250 kHz.

Requirement	**Measured Result Complies**
Adjacent hopping carrier frequencies shall be spaced by a minimum of the 20 dB bandwidth of the transmitted emission. The 20 dB bandwidth is 61.250 kHz	The adjacent hopping carrier frequencies are spaced by 128.250 kHz. The spacing exceeds the 20 dB bandwidth of the transmitted emission.

6.3 Pseudorandom Ordered List of Hopping Frequencies

Requirement:

Part 15.247(a)(1) states that the hop channel frequencies shall be selected at the system-hopping rate from a pseudorandomly ordered list of hopping frequencies.

Technical Documentation:

The PN hopping sequence is a maximal-length sequence generated with a linear feedback shift register sequence generator. A sequence of 50 out of 201 frequencies is generated where the seed for the generator is factory preset. The PN generator guarantees that any frequency in a sequence is not repeated. Refer to reference document 960-0003-TN01 frequency versus frequency number list.

An example of a frequency hopping sequence is as follows, (hop number, frequency number):

0000	163
0001	107
0002	105
0003	043
0004	091
0005	039
0006	035
0007	194
0008	068
0009	106
0010	168
0011	147
0012	198
0013	143
0014	025
0015	111
0016	160
0017	109
0018	128
0019	009
0020	192
0021	154
0022	157
0023	133
0024	103

0025	114
0026	164
0027	020
0028	056
0029	137
0030	167
0031	129
0032	053
0033	023
0034	052
0035	159
0036	028
0037	042
0038	099
0039	142
0040	041
0041	120
0042	108
0043	095
0044	015
0045	112
0046	199
0047	140
0048	161
0049	110

6.4 Synchronization of Receivers with Transmitted Signals

Requirement:

Part 15.247(a)(1) states that the system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Technical Description:

The input bandwidth of the receiver matches the bandwidth its corresponding transmitter. EUT receivers receive signals from corresponding EUT transmitters and as measured in section 6.1 of this report the 20 dB bandwidth of the transmitted signal is 61.250 kHz. The receiver input bandwidth is as wide as the transmitted signal and has guard band to allow for +/- 10 ppm of frequency error at the hopping channel frequencies.

The EUT receivers and transmitters use the same hop sequence. The receiver is idle at a factory set frequency until it receives information and synchronizes to its corresponding transmitter to begin hopping. The receivers are time base frequency shifted at the same rate as that of the transmitter. The EUT is designed with a common frequency synthesizer which has identical phase locked loop characteristics for both transmitter and receiver modes of operation.

6.5 Equal Hopping Frequency Use

Technical Description:

The packets generated in the system in which the EUT operates are transmitted in multiples requiring 50 frequency hops and since the EUT uses a hop sequence of 50 frequencies, equal frequency use is inherent and guaranteed.

6.6 Minimum Number of Hopping Frequencies

Requirement:

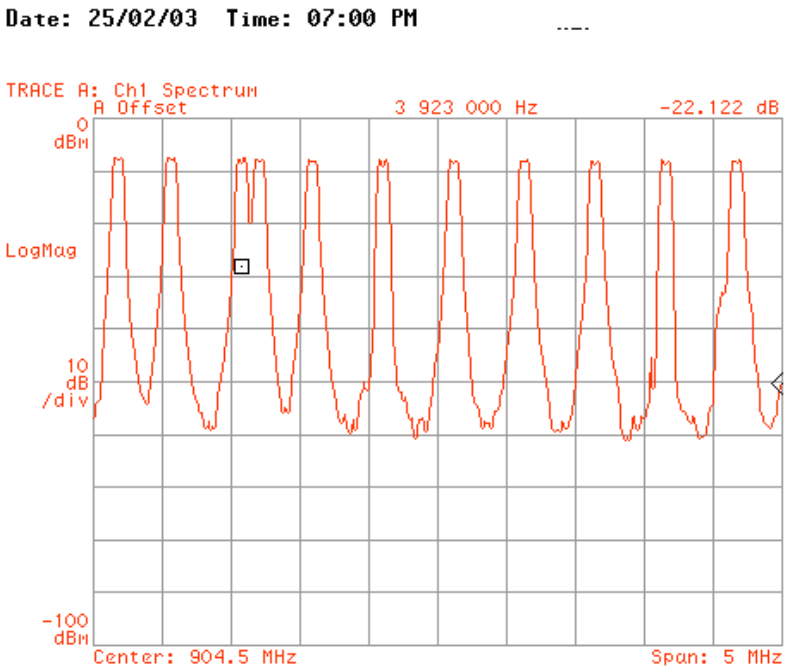
Part 15.247(a)(1)(i) states that if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use a minimum of 50 hopping frequencies.

Test Procedure:

The integral antenna of the EUT is removed from the transmitter output. The transmitter output is coupled directly into a Vector Signal Analyzer with appropriate in line attenuation to protect the input of the analyzer from damage. The Vector Signal Analyzer is set to maximum hold and the transmitter has its hopping function enabled. Each of the demonstrated frequencies will be memorized by the maximum hold function of the Vector Signal Analyzer and recorded. The Vector Signal Analyzer resolution bandwidth is set to at least 1% of the span required to capture the hop frequencies in order to satisfy the FCC filing and measurement guidelines for frequency hopping spread spectrum signals.

Measurement Plots:

902 to 907 MHz monitored for the hopping frequencies



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 50 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 904.5 MHz

Span: 5 MHz

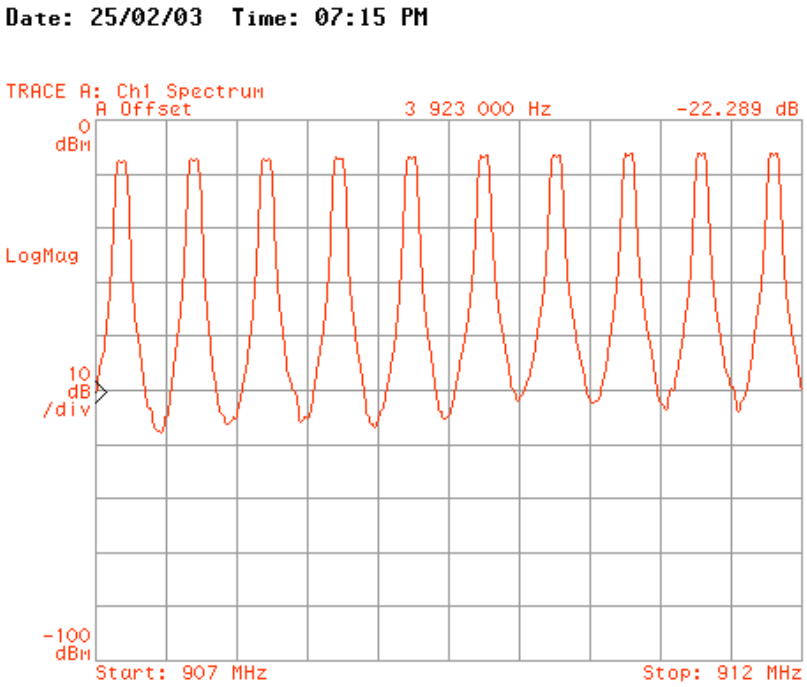
Start: 902 MHz

Stop: 907 MHz

Measurement Result:

Eleven (11) frequencies are demonstrated from 902 MHz to 907 MHz.

907 to 912 MHz monitored for the hopping frequencies



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 50 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 909.5 MHz

Span: 5 MHz

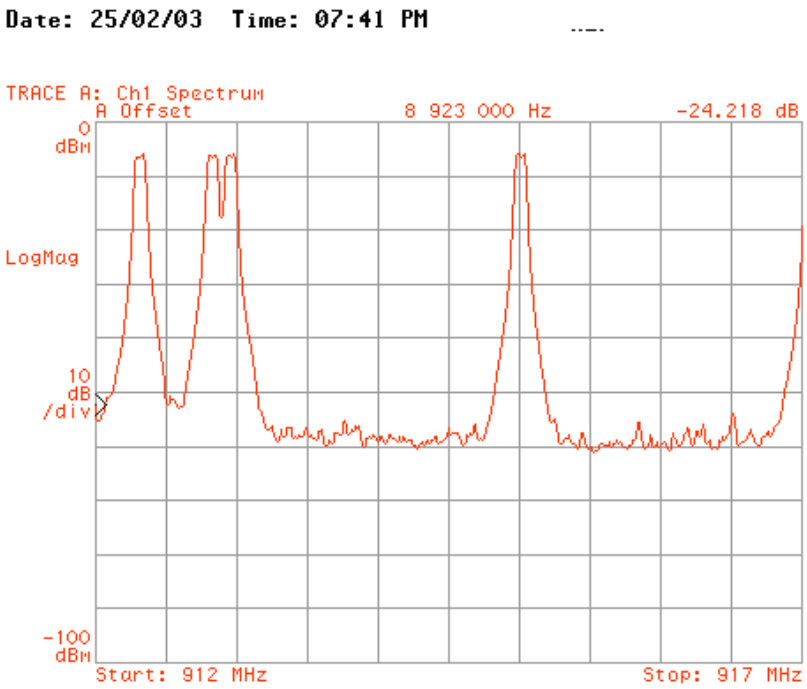
Start: 907 MHz

Stop: 912 MHz

Measurement Result:

Ten (10) frequencies are demonstrated from 907 MHz to 912 MHz.

912 to 917 MHz monitored for the hopping frequencies



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 50 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 914.5 MHz

Span: 5 MHz

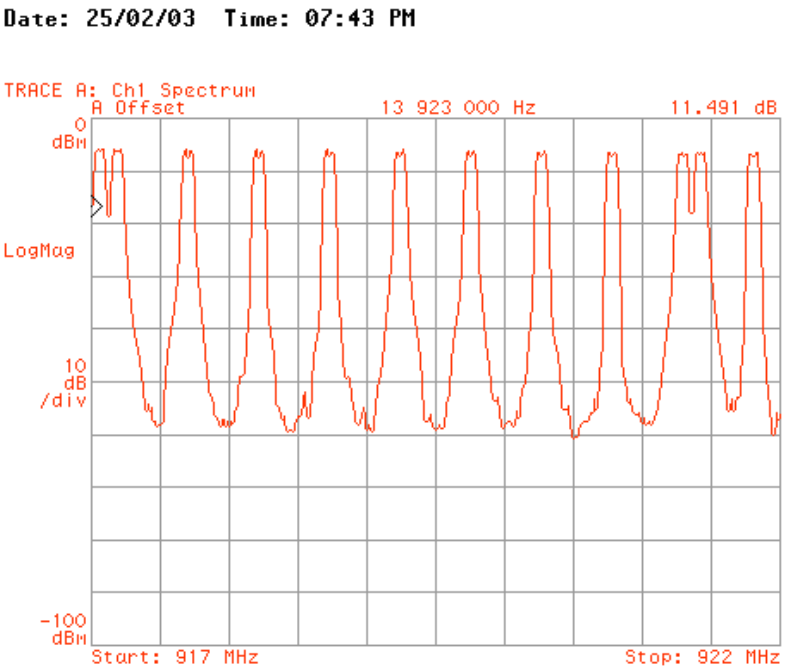
Start: 912 MHz

Stop: 917 MHz

Measurement Result:

Four (4) frequencies are demonstrated from 912 MHz to 917 MHz.

917 to 922 MHz monitored for the hopping frequencies



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 50 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 919.5 MHz

Span: 5 MHz

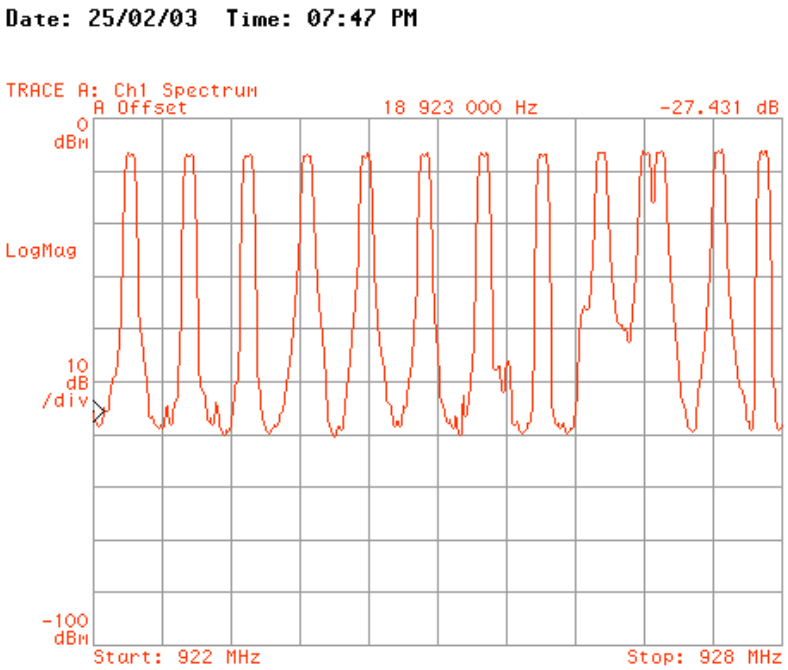
Start: 917 MHz

Stop: 922 MHz

Measurement Result:

Twelve (12) frequencies are demonstrated from 917 MHz to 922 MHz.

922 to 928 MHz monitored for the hopping frequencies



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 60 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 919.5 MHz

Span: 6 MHz

Start: 922 MHz

Stop: 928 MHz

Measurement Result:

Thirteen (13) frequencies are demonstrated from 912 MHz to 928 MHz.

Result:

In the band from 902 to 928 MHz a total of 11+10+4+12+13=50 hopping frequencies are demonstrated in the above plots for this section.

Requirement	**Measured Result Complies**
A minimum of 50 hopping frequencies.	50 hopping frequencies demonstrated.

6.7 Average Time Occupancy Per Frequency

Requirement:

Part 15.247(a)(1)(i) states that if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use a minimum of 50 hopping frequencies with the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Technical Documentation:

The hopping algorithm guarantees that transmission time on a given frequency is 5 mS maximum with a 500 uS transmitter ramp up and 500 uS ramp down interval per frequency hop. A transmission consists of a 50 frequency hop sequence burst. The actual time that the transmitter transmits power for each hop frequency is less than 5 mS. The minimum time between each hop sequence burst is 850 mS. The time occupancy per frequency within a 20 second period is calculated as follows:

Occupancy time per frequency for each of 50 frequencies transmitted:	<5 mS.
Ramp up and down guard time per frequency:	1 mS max.
Duration of a 50 frequency transmission burst:	250 mS.
The minimum time between transmission bursts:	850 mS.
Duration of a 50 frequency transmission burst plus minimum	
time between bursts, 250 mS + 850 mS = 1100 mS:	1100 mS.
Maximum Number of 50 frequency transmission bursts in a 20 second period:	18.18

Maximum time of occupancy per frequency in a 20 second period would therefore be 18.18 times 5mS = 90.9 mS.

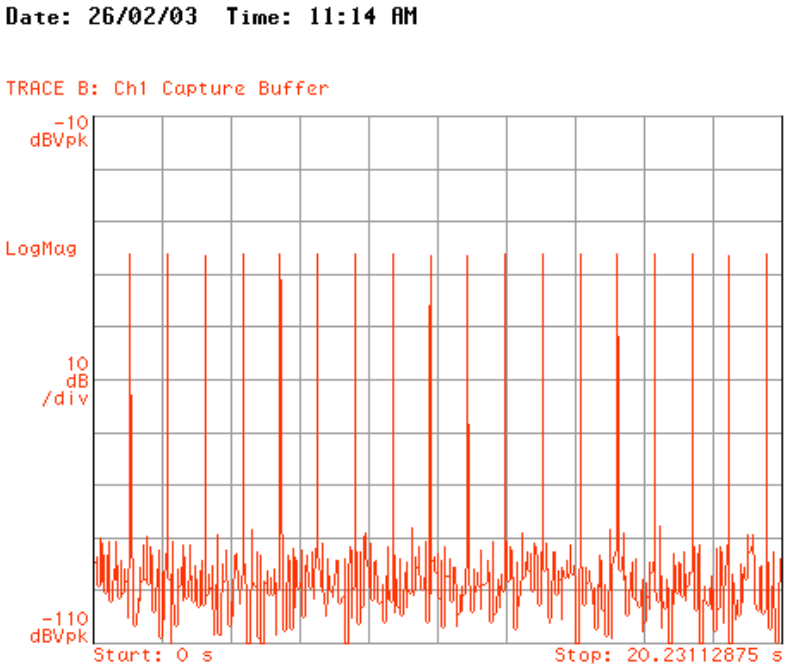
The above calculation represents the absolute maximum capability of the hardware and does not represent the normal usage of the EUT.

Average power in any 100 mS interval may be used for some radiated emissions in this report. Since the 100 mS interval is less than the period of 250 mS for a 50 frequency hop sequence transmission burst, the channel occupancy for any period less than 250 mS is 5 mS max.

Measurement Plots:

The measurement plots below are indicative of successive burst transmissions with 850 mS blank intervals. The plots represent occupancy on a single frequency of approximately 2.6 times greater than normal operation. The first plot will capture the number of pulses in a 20 second interval, the successive plots will zoom in on the 1st, 2nd, 10th, and 18th pulses in order to demonstrate that all the pulses are of equal time duration.

Twenty-second power envelope capture at 915 MHz



Settings:

Acquisition Mode: Power envelope versus time captured into a buffer.

RBW: 233 Hz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 1 kHz

Start: 914.9995 MHz

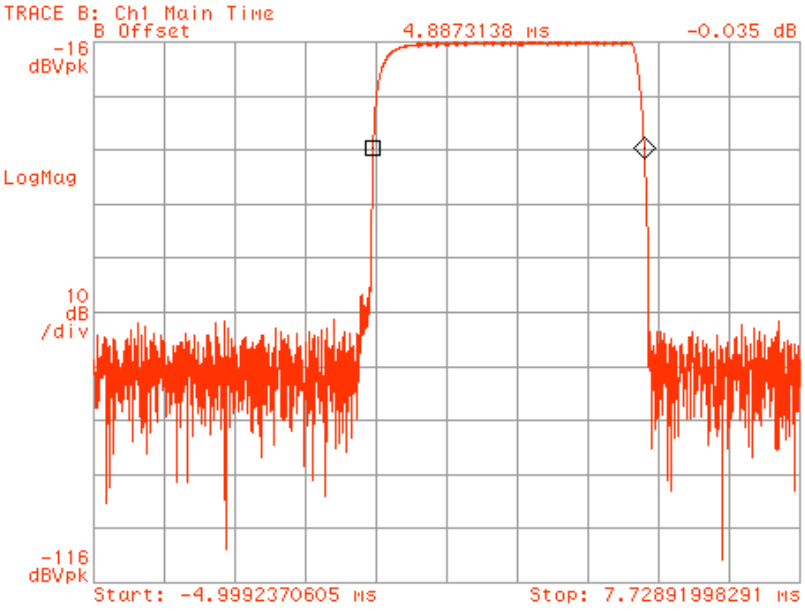
Stop: 915.0005 MHz

Measurement Result:

Eighteen (18) transmission pulses are demonstrated in a 20 second interval.

Zoom in on 1st pulse of a 20 second capture plot

Date: 26/02/03 Time: 12:02 PM



Settings:

Acquisition Mode: Power envelope versus (real) time.

RBW: 300 Hz

Detector type: Positive Peak

Trigger type: On input power

Trigger delay: -5 mS

Measurement time window: 12.7 mS

Center: 915 MHz

Span: 250 kHz

Start: 914.875 MHz

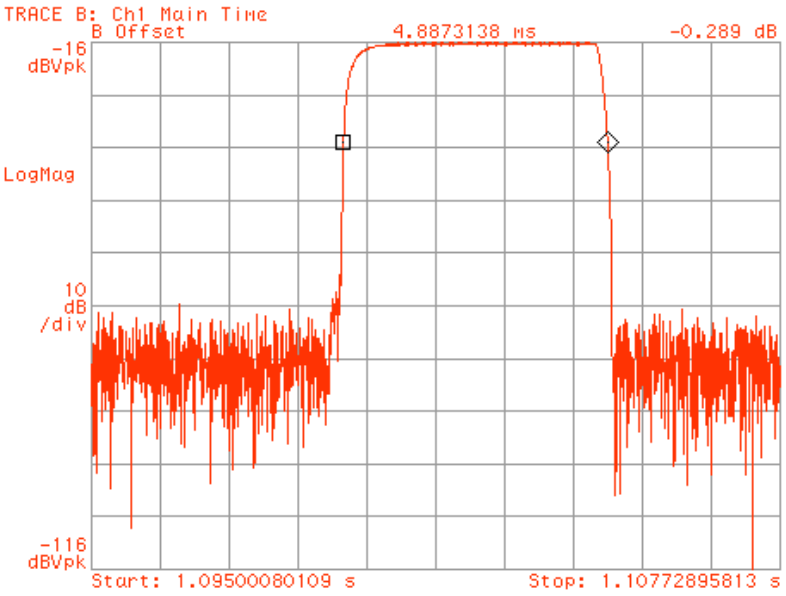
Stop: 915.125 MHz

Measurement Result:

The pulse width of the first transmission out of 20 is 4.89 mS measured from the 20 dB down points.

Zoom in on 2nd pulse of a 20 second capture plot

Date: 26/02/03 Time: 12:20 PM



Settings:

Acquisition Mode: Power envelope versus (real) time.

RBW: 300 Hz

Detector type: Positive Peak

Trigger type: On input power

Trigger delay: 1.095 mS

Measurement time window: 12.7 mS

Center: 915 MHz

Span: 250 kHz

Start: 914.875 MHz

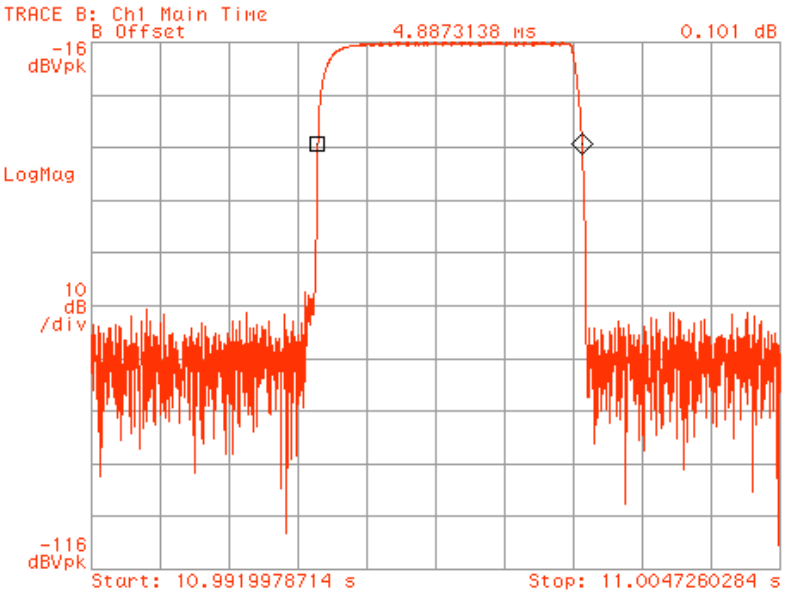
Stop: 915.125 MHz

Measurement Result:

The pulse width of the first transmission out of 20 is 4.89 mS measured from the 20 dB down points.

Zoom in on 10th pulse of 20 second capture plot

Date: 26/02/03 Time: 12:25 PM



Settings:

Acquisition Mode: Power envelope versus (real) time.

RBW: 300 Hz

Detector type: Positive Peak

Trigger type: On input power

Trigger delay: 10.99 mS

Measurement time window: 12.7 mS

Center: 915 MHz

Span: 250 kHz

Start: 914.875 MHz

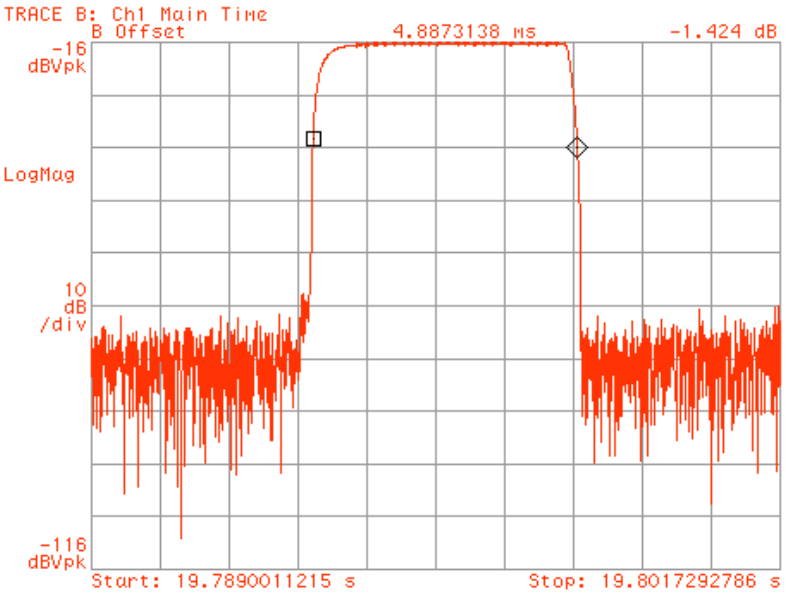
Stop: 915.125 MHz

Measurement Result:

The pulse width of the first transmission out of 20 is 4.89 mS measured from the 20 dB down points.

Zoom in on 18th pulse of 20 second capture plot

Date: 26/02/03 Time: 12:53 PM



Settings:

Acquisition Mode: Power envelope versus (real) time.

RBW: 300 Hz

Detector type: Positive Peak

Trigger type: On input power

Trigger delay: 19.79 mS

Measurement time window: 12.7 mS

Center: 915 MHz

Span: 250 kHz

Start: 914.875 MHz

Stop: 915.125 MHz

Measurement Result:

The pulse width of the first transmission out of 20 is 4.89 mS measured from the 20 dB down points.

Result:

The measured time occupancy in a 20 second interval is the duration of a measured transmission pulse multiplied by the number of pulses measured in the 20-second interval. 18 pulses X 4.89 mS/pulse = 88 mS.

Requirement	**Measured Result Complies**
400 mS maximum average occupancy per frequency every 20 seconds.	88 mS occupancy per frequency every 20 seconds.

6.8 Transmitter Power Output

Requirement:

Part 15.247(b)(2) states that the maximum peak output power of the intentional radiator shall not exceed 1 watt for systems employing at least 50 hopping channels.

Technical Documentation:

The maximum output power capability of the transmitter power amplifier is 0.5 W. The losses in the path from the transmitter power amplifier output to the antenna terminals are a minimum of 1.5 dB. The maximum power available at the antenna terminals is 0.354 W. The maximum predicted gain of the integral antenna is –1.5 dB and therefore the peak effective radiated power is 0.25 W.

Measurement Performed by Qualified Test Site

Refer to test report by Protocol EMC in Appendix A.

Result:

The peak radiated field strength measured at 3m is computed to power radiated by the EUT.

121.4 dBuV/m = 1.175 V/m

$P = (1.175 \text{ V/m} * 3 \text{ m})^2 / 30 = 0.414 \text{ W}$

Requirement	Measured Result Complies
1W maximum transmitter output power.	0.414 W

6.9 Public RF Exposure Limit

Requirement:

Part 15.247(b)(4) states that systems operating under the provisions of part 15.247 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 and refers to part 1.1307(b)(1).

Investigation:

A publication from the FCC Office of Engineering and Technology, OET Bulletin 65 is used as a guideline to determine compliance with the FCC RF exposure limit. In this bulletin and in the Rules and Regulations it is stated that unlicensed transmitting devices are normally categorically excluded from routine environmental evaluation for RF exposure. Nevertheless the following analysis is performed using the FCC OET Bulletin 65 to ensure that the EUT does not exceed the RF exposure limit using "worse case" transmitted power levels and equations that over-predict power density in the near field.

In addition the FCC has allowed to omit the 20 cm grant note and user manual statement specifically for utility meters if the source-based time-averaged output powers are below the July 17, 2002 TCB Exclusion List footnote 3 General Population, distance greater than or equal to 2.5 cm threshold levels.

Analysis:

As per OET Bulletin 65 guidelines:

The EUT is classed to meet the RF exposure that it subjects to the "General Population/Uncontrolled Environment". Under this class the limit is calculated by:

$$S = f/1500$$

Where S is the Power Density in mW/cm^2.

F is the frequency of operation in MHz.

The EUT operates in the 902 to 928 MHz band, the lower exposure limit would be obtained by using a frequency at the lower edge of the band, therefore:

$$S = 902 /1500 = 0.601\ mW/cm^2$$

As stated in the technical documentation in section 6.8 the peak effective radiated power of the EUT is 0.25 watts when the transmitter is on.

$ERP_{(continuous)} = 0.25$ W

Under normal operation the transmitter is not on continuously and therefore its power must be time averaged.

Every transmitted packet of 50 hop frequencies contains 50 transmissions with duration of 4 mS with a guard time of 1 mS between frequency hops. The time that the EUT transmitting (TX) during this duration of a packet is:

50 hops per packet * 4 mS TX per hop = 200 mS transmit time per packet

When deployed in the network the EUT transmits a maximum of 128 packets every 300 seconds. The maximum duty cycle of the EUT is therefore:

(200 mS TX time per packet *128 packets)/300 seconds = 8.53% duty cycle.

The average ERP is therefore:

$ERP_{(average)} = ERP_{(continuous)}$ * duty cycle

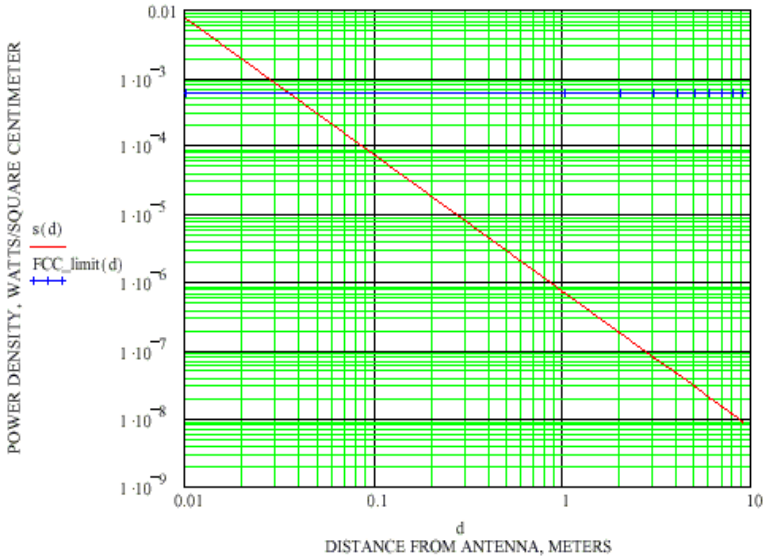
$ERP_{(average)} = 0.25$ W * 0.0853 = 0.0213 W

The predicted power density at a distance d, in the same horizontal plane as the elevation of the antenna is calculated and graphed on the following page:

$aa := 1$ azimuth pattern power factor $gd := 1.64$ gain of dipole antenna $ar := 2.56$ ground reflection constant

$d := .01 .. 10$ distance from antenna in meters $erp\_average := .0213$

$s(d) := \frac{(ar \cdot aa \cdot gd \cdot erp\_average)}{10000 \cdot 4 \cdot 3.14 \cdot d^2}$ power density in watts per square centimeter $FCC\_limit(d) := 601 \cdot 10^{-6} \cdot d^0$



The EUT is normally operated and housed within an electromechanical utility meter. From the predicted exposure levels graphed above the distance away from the EUT antenna where the RF exposure limit is exceeded is required to be less than 3 cm. Typically occupants of the building in which the EUT is installed are many times farther than 3 cm from the EUT and therefore typical exposures occur at distances greater than one meter. At one meter the predicted power density is 0.711 uW/cm^2 or 0.12% of the allowable FCC exposure limit.

As per TCB Exclusion List, Footnote 3, General Population $\geq$ 2.5 cm:

Specifically for telemetry utility meters, the maximum time averaged source based output power must be below the following in order to allow omission of the 20 cm note and statement on a TCB Grant Of Equipment Authorization and EUT user manual respectively.

$$120/f_{(GHz)} \text{ mW}$$

or

$$120/0.928 = 129 \text{ mW}$$

As in the previous analysis the maximum time averaged sourced based output power is 21.3 mW and represents 16% of the limit.

Result:

The EUT does not expose the public to radio frequency energy levels in excess of the FCC guidelines. The following statement is not required on a TCB Grant of Equipment Authorization or in the EUT user manual:

The antenna used for this transmitter must be fixed-mounted in a permanent structure providing a separation distance of at least 20 cm from all persons during normal operation.

6.10 Out Of Band Emissions

Requirement:

Part 15.277(c) states: 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 must 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 in part 15.209(a) is not required.

Test Procedure:

The integral antenna of the EUT is removed from the transmitter output. The transmitter output is coupled directly into a Vector Signal Analyzer with appropriate in line attenuation to protect the input of the analyzer from damage. The EUT has two antennas for antenna diversity. The out of band measurements are all repeated for the second antenna.

In Band Peak Power Measurement:

The Vector Signal Analyzer span is set to capture the entire 902 to 928 MHz band. The resolution bandwidth is set much wider than the 20 dB bandwidth measured in section 6.1 of this report in order to record the peak power within the band.

Band Edge Measurements:

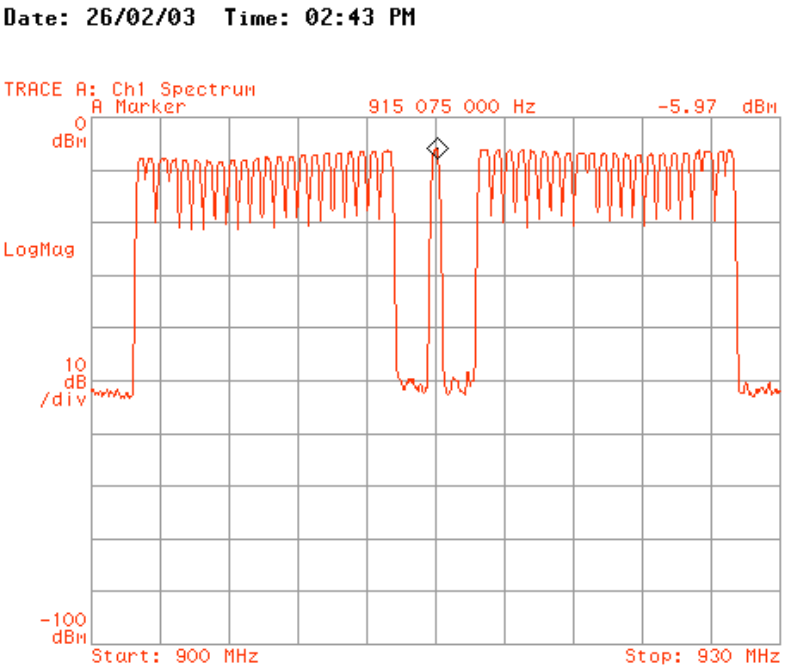
At the band edges the band power marker function of the Vector Signal Analyzer is used. The power in a 100 kHz bandwidth is measured out of band at the band edges with the transmitter set to the corresponding band edge frequencies, hopping function turned off. With the same analyzer settings, the measurement is repeated with the hopping function turned on. The measured band edge power is compared to the peak power measured within 902-928 MHz.

Out Of Band Measurements:

For the out of band measurements a spectrum analyzer with the capability to measure up to 10 GHz is also used. The resolution bandwidth of the analyzer is set to 100 kHz in order to directly read the out of band emission levels from the display, relative to the peak power within the band.

6.10.1 Measurement Plots At First Antenna Connector:

In band peak power identified



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 300 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 30 MHz

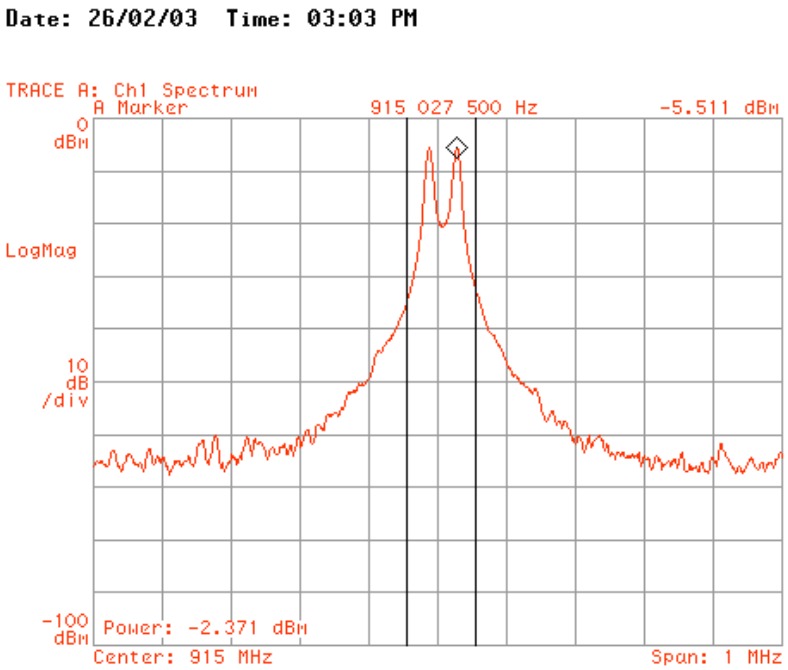
Start: 900 MHz

Stop: 930 MHz

Measurement Result:

The peak power occurs at the centre of the 902 to 928 MHz Band.

Identified in band peak power measured within a 100 kHz bandwidth



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 1 MHz

Start: 914.5 MHz

Stop: 915.5 MHz

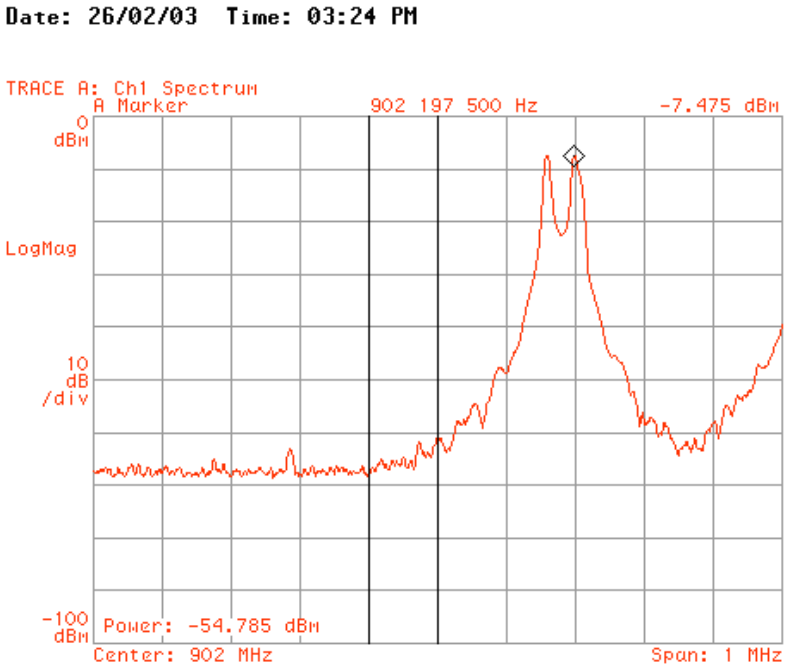
Band Power Marker Bandwidth: 100 kHz

Measurement Result:

The peak in band power integrated over a 100 kHz bandwidth is –2.371 dBm. This level shall be used as a reference for the band edge out of band emission measurements that follow.

Lower band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping enabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 902 MHz

Span: 1 MHz

Start: 901.5 MHz

Stop: 902.5 MHz

Band Power Marker Bandwidth: 100 kHz

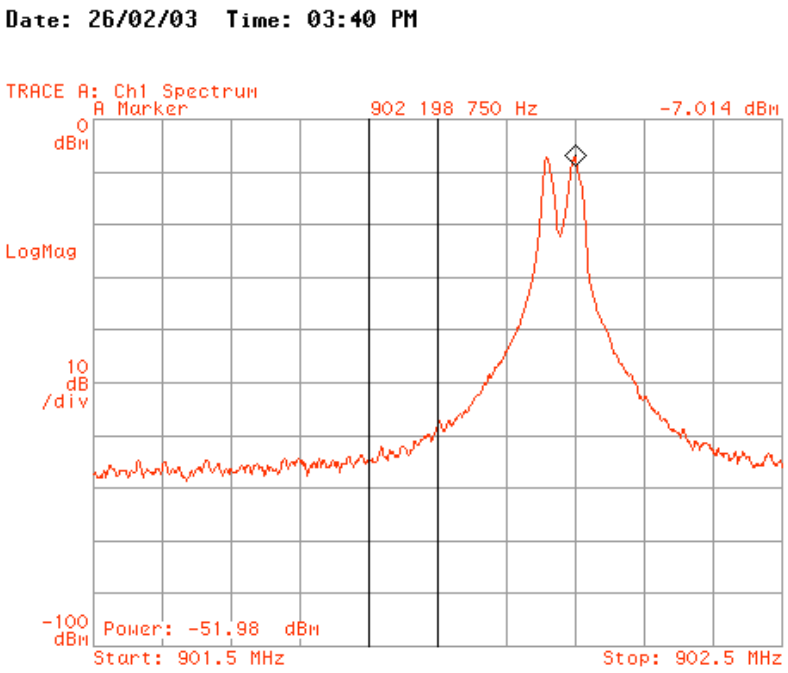
Band Power Marker Center: 901.950 MHz

Measurement Result:

The peak lower band edge power integrated over a 100 kHz bandwidth is –54.8 dBm. The lower band edge power is 52.43 dB below the peak in band power when frequency hopping is enabled.

Lower band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 902 MHz

Span: 1 MHz

Start: 901.5 MHz

Stop: 902.5 MHz

Band Power Marker Bandwidth: 100 kHz

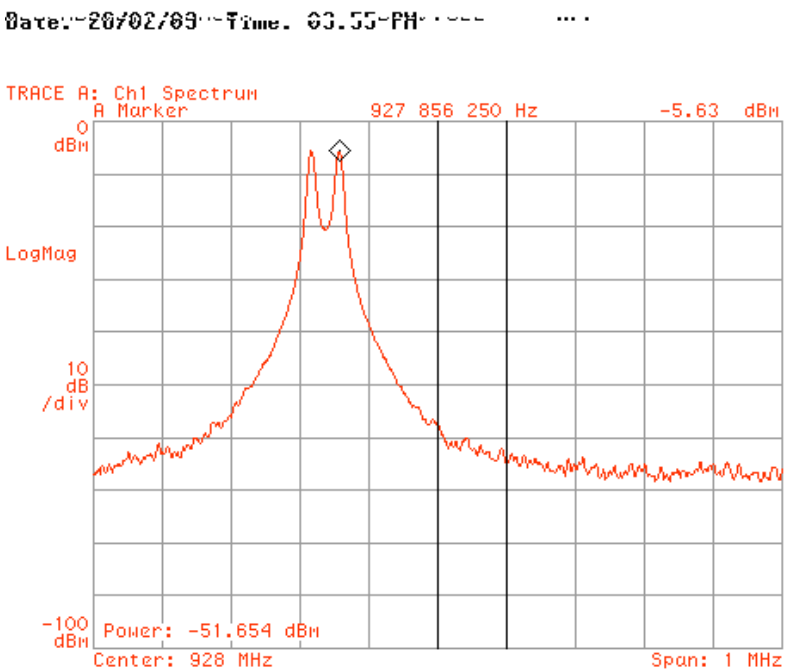
Band Power Marker Center: 901.950 MHz

Measurement Result:

The peak lower band edge power integrated over a 100 kHz bandwidth is –52 dBm. The lower band edge power is 49.63 dB below the peak in band power when frequency hopping is disabled.

Upper band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 928 MHz

Span: 1 MHz

Start: 927.5 MHz

Stop: 928.5 MHz

Band Power Marker Bandwidth: 100 kHz

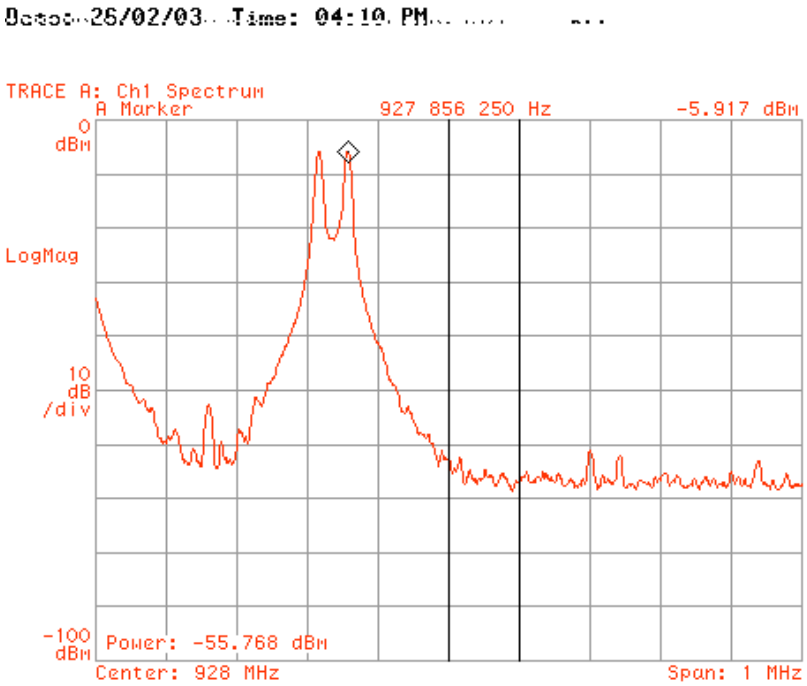
Band Power Marker Center: 928.050 MHz

Measurement Result:

The peak upper band edge power integrated over a 100 kHz bandwidth is –51.65 dBm. The lower band edge power is 49.27 dB below the peak in band power when frequency hopping is disabled.

Upper band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping enabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 928 MHz

Span: 1 MHz

Start: 927.5 MHz

Stop: 928.5 MHz

Band Power Marker Bandwidth: 100 kHz

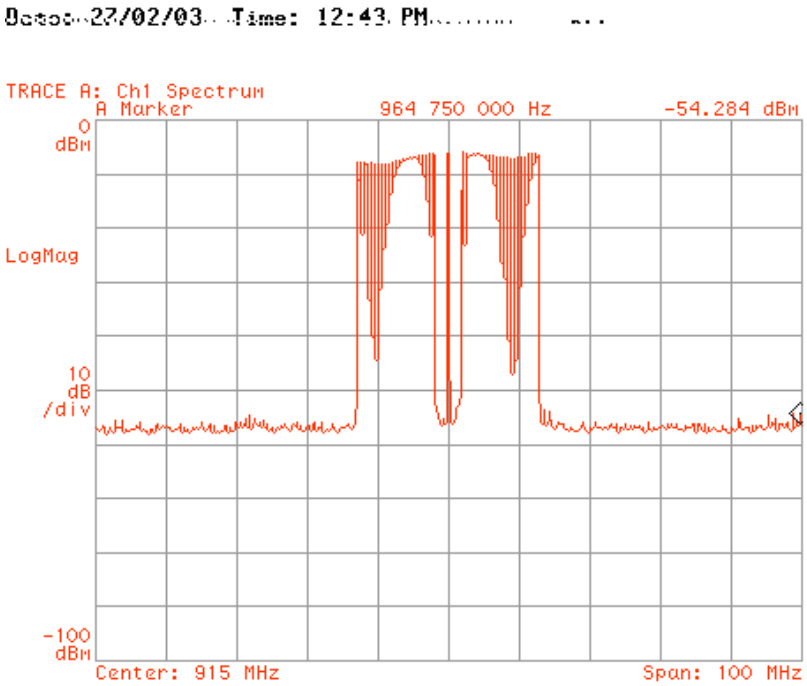
Band Power Marker Center: 928.050 MHz

Measurement Result:

The peak upper band edge power integrated over a 100 kHz bandwidth is –55.77 dBm. The lower band edge power is 53.4 dB below the peak in band power when frequency hopping is enabled.

Out of band emissions measured from 865 to 902 MHz and from 928 to 965 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 100 MHz

Start: 865 MHz

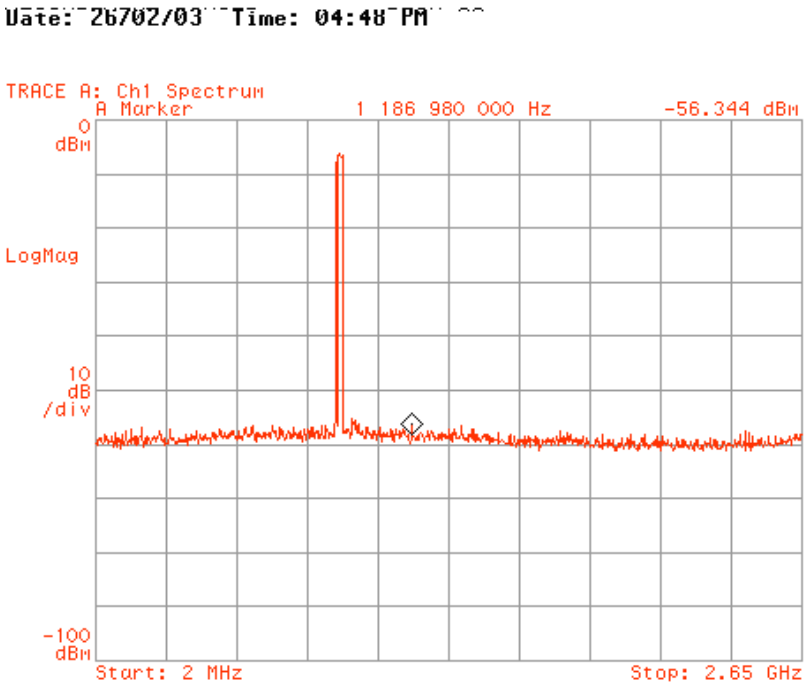
Stop: 965 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 964.750 MHz at a level of –54.28 dBm or 51.91 dB below the peak in band power.

Out of band emissions measured from 2 to 865 MHz and from 965 to 2650 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 1326 MHz

Span: 2648 MHz

Start: 2 MHz

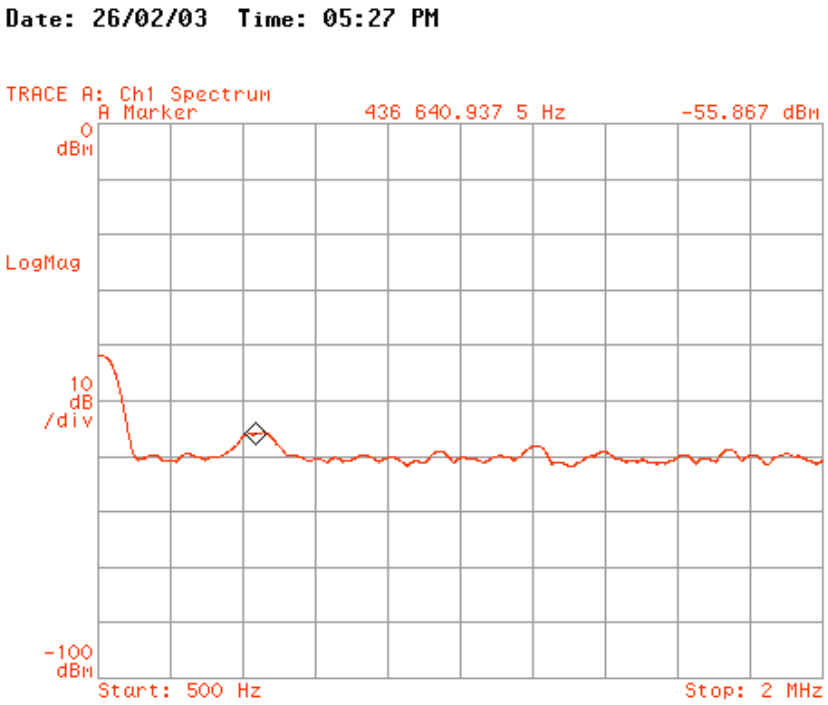
Stop: 2650 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 1186.98 MHz at a level of –56.3 dBm or 53.97 dB below the peak in band power.

Out of band emissions measured from 500 Hz to 2 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 1.00025 MHz

Span: 1.995 MHz

Start: 500 Hz

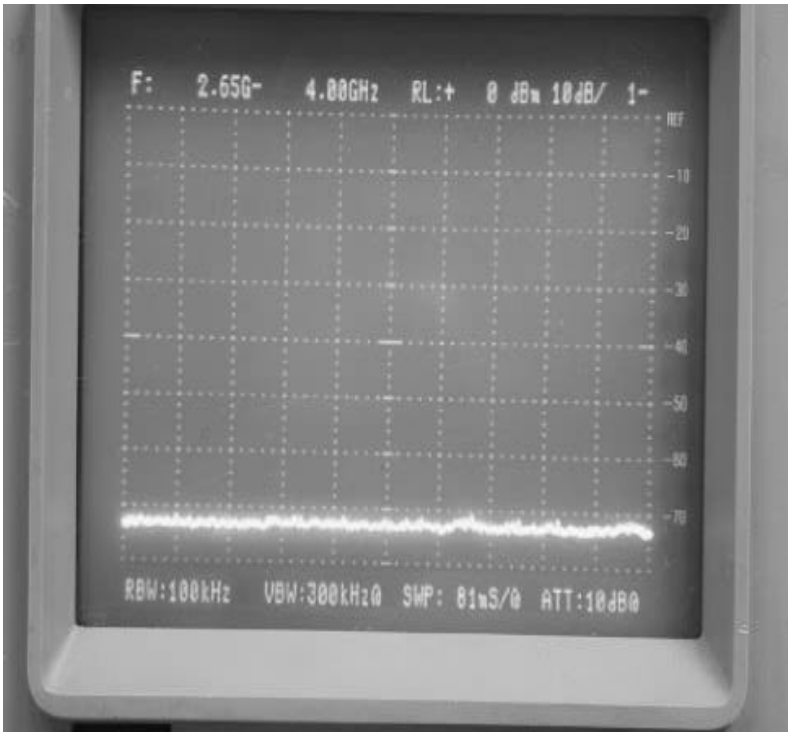
Stop: 2 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 436.641 kHz at a level of –55.87 dBm or 53.5 dB below the peak in band power.

Out of band emissions measured from 2650 MHz to 4000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 1350 MHz

Start: 2650 MHz

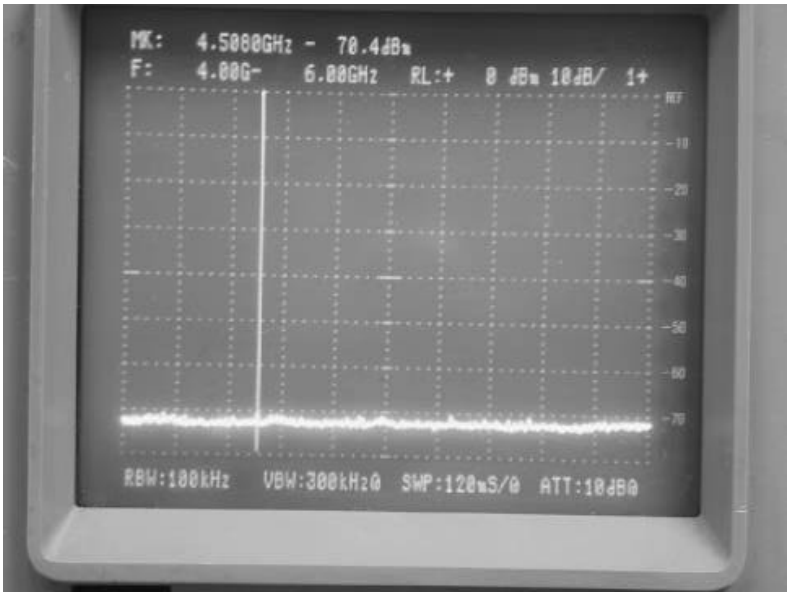
Stop: 4000 MHz

Measurement Result:

All emissions in this measurement are below –70 dBm in a 100 kHz bandwidth, therefore all emissions in a 100 kHz bandwidth are 67.63 dB below the peak in band power.

Out of band emissions measured from 4000 MHz to 6000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 4000 MHz

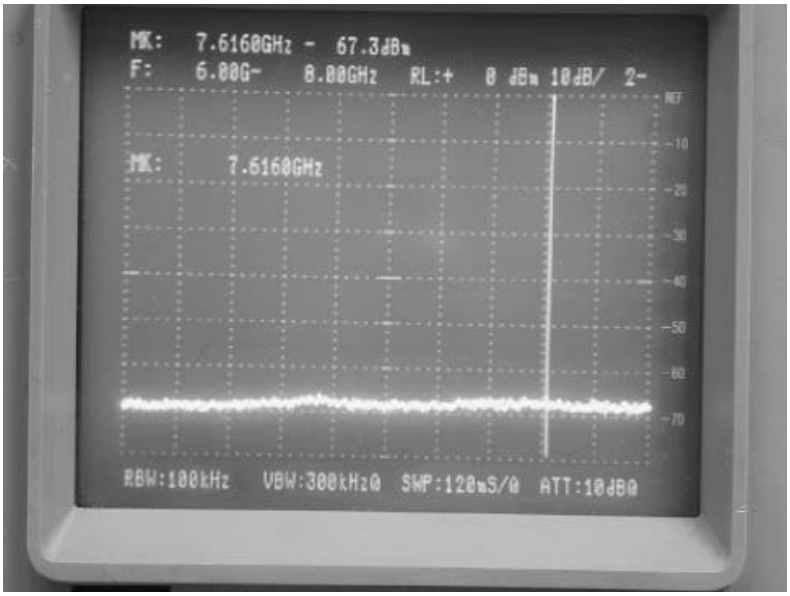
Stop: 6000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 4508 MHz at a level of –70.4 dBm or 68.03 dB below the peak in band power.

Out of band emissions measured from 6000 MHz to 8000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 6000 MHz

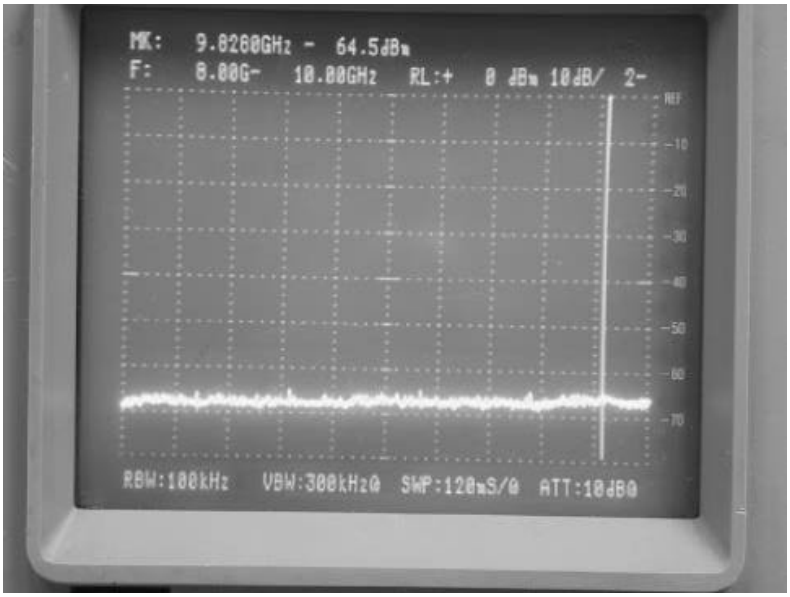
Stop: 8000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 7616 MHz at a level of –67.3 dBm or 64.93 dB below the peak in band power.

Out of band emissions measured from 8000 MHz to 10 000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 8000 MHz

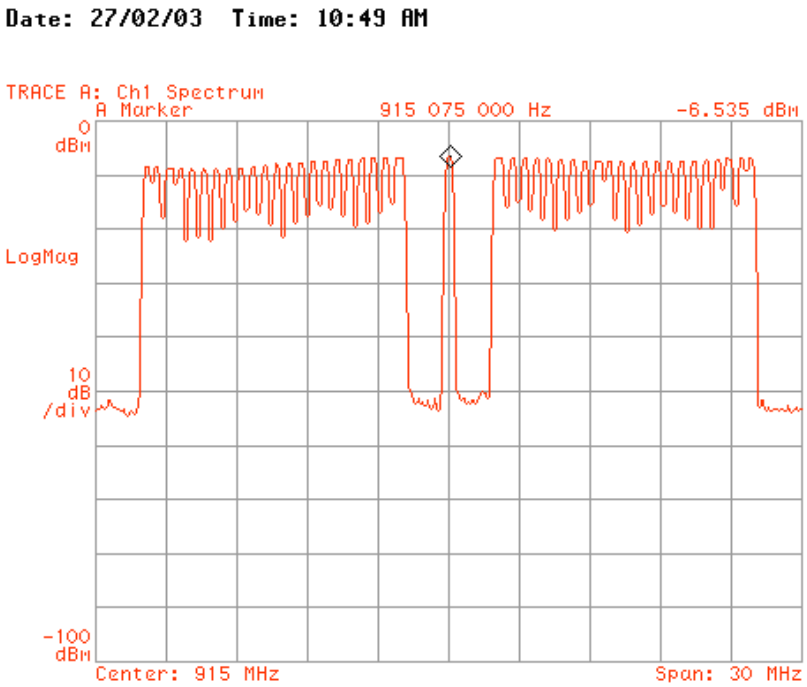
Stop: 10 000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 9828 MHz at a level of –64.5 dBm or 62.13 dB below the peak in band power.

6.10.2 Measurement Plots At Second Antenna Connector

In band peak power identified



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 300 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 30 MHz

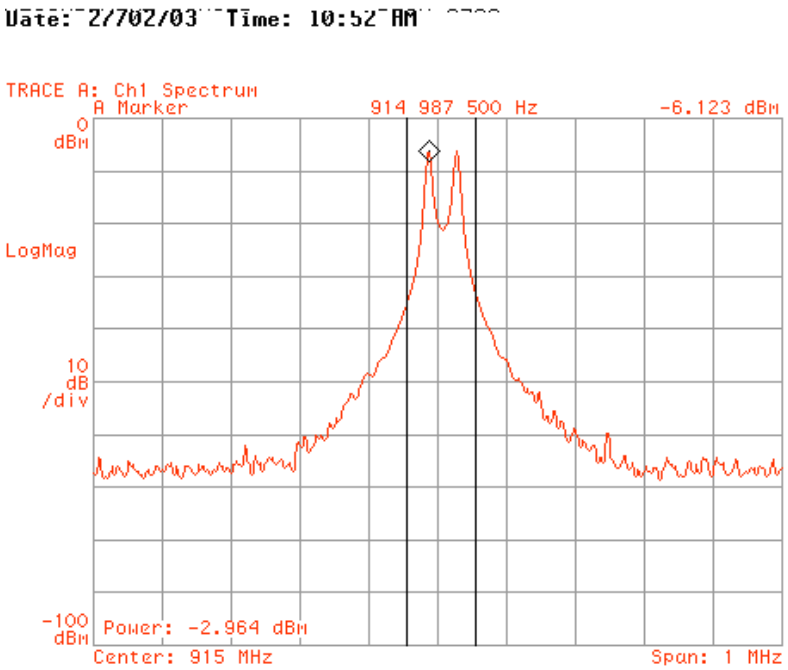
Start: 900 MHz

Stop: 930 MHz

Measurement Result:

The peak power occurs at the centre of the 902 to 928 MHz Band.

Identified in band peak power measured within a 100 kHz bandwidth



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 1 MHz

Start: 914.5 MHz

Stop: 915.5 MHz

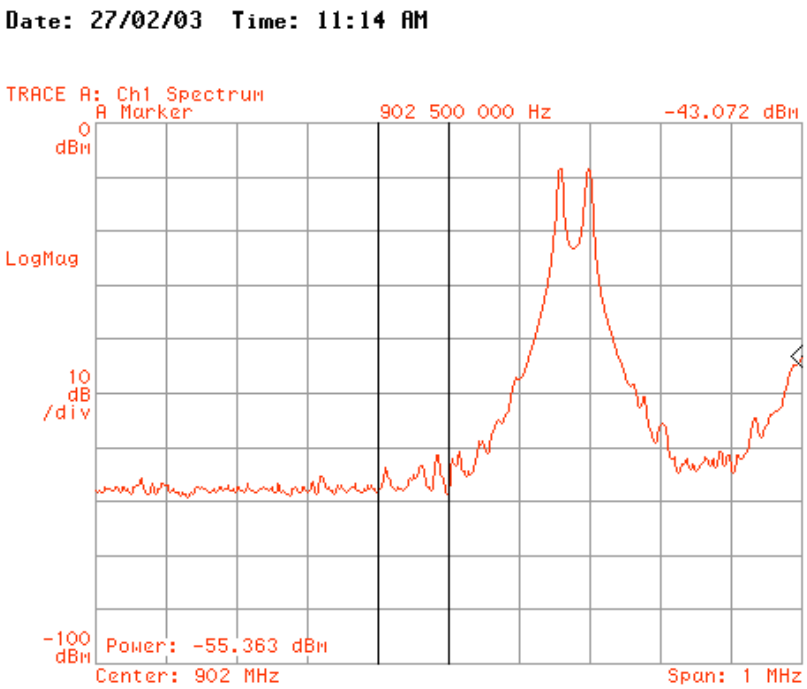
Band Power Marker Bandwidth: 100 kHz

Measurement Result:

The peak in band power integrated over a 100 kHz bandwidth is –2.964 dBm. This level shall be used as a reference for the band edge out of band emission measurements that follow.

Lower band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping enabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 902 MHz

Span: 1 MHz

Start: 901.5 MHz

Stop: 902.5 MHz

Band Power Marker Bandwidth: 100 kHz

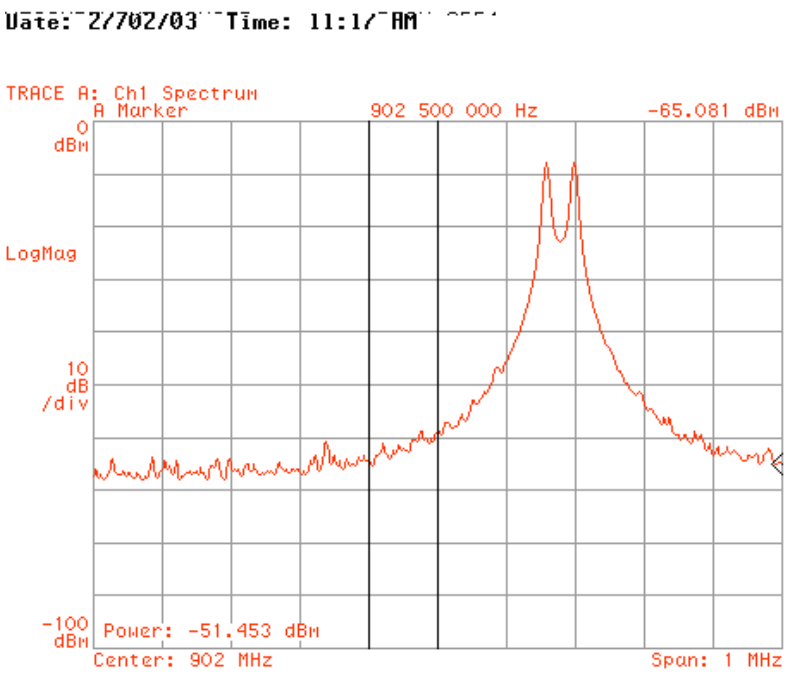
Band Power Marker Center: 901.950 MHz

Measurement Result:

The peak lower band edge power integrated over a 100 kHz bandwidth is –55.36 dBm. The lower band edge power is 52.40 dB below the peak in band power when frequency hopping is enabled.

Lower band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 902 MHz

Span: 1 MHz

Start: 901.5 MHz

Stop: 902.5 MHz

Band Power Marker Bandwidth: 100 kHz

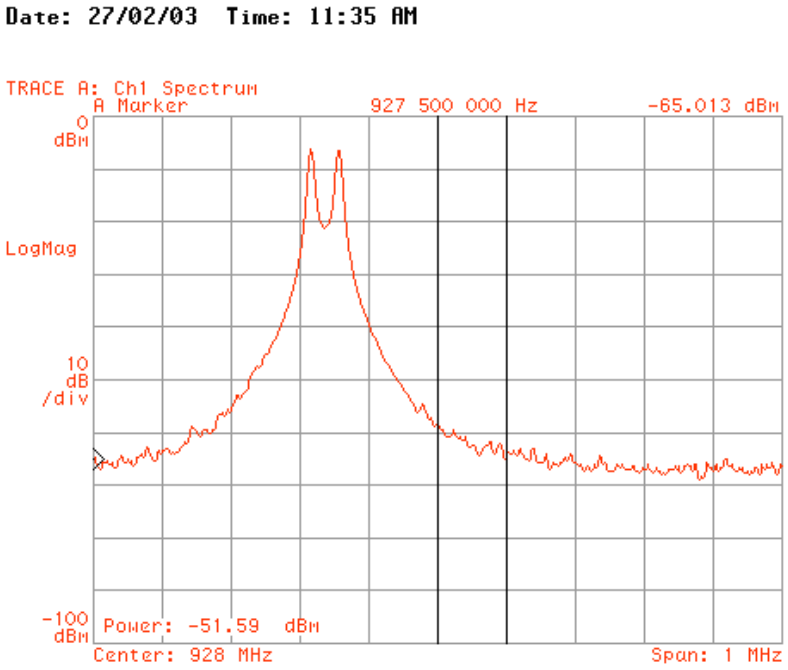
Band Power Marker Center: 901.950 MHz

Measurement Result:

The peak lower band edge power integrated over a 100 kHz bandwidth is –51.45 dBm. The lower band edge power is 48.49 dB below the peak in band power when frequency hopping is disabled.

Upper band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 928 MHz

Span: 1 MHz

Start: 927.5 MHz

Stop: 928.5 MHz

Band Power Marker Bandwidth: 100 kHz

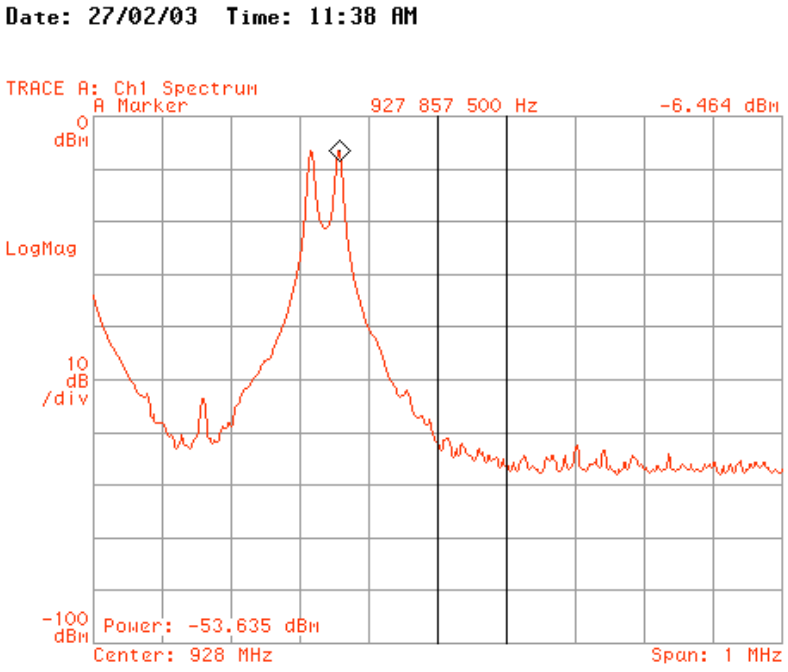
Band Power Marker Center: 928.050 MHz

Measurement Result:

The peak upper band edge power integrated over a 100 kHz bandwidth is –51.59 dBm. The lower band edge power is 48.63 dB below the peak in band power when frequency hopping is disabled.

Upper band edge out of band emission power level measured within a 100 kHz bandwidth

Frequency hopping enabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 10 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 928 MHz

Span: 1 MHz

Start: 927.5 MHz

Stop: 928.5 MHz

Band Power Marker Bandwidth: 100 kHz

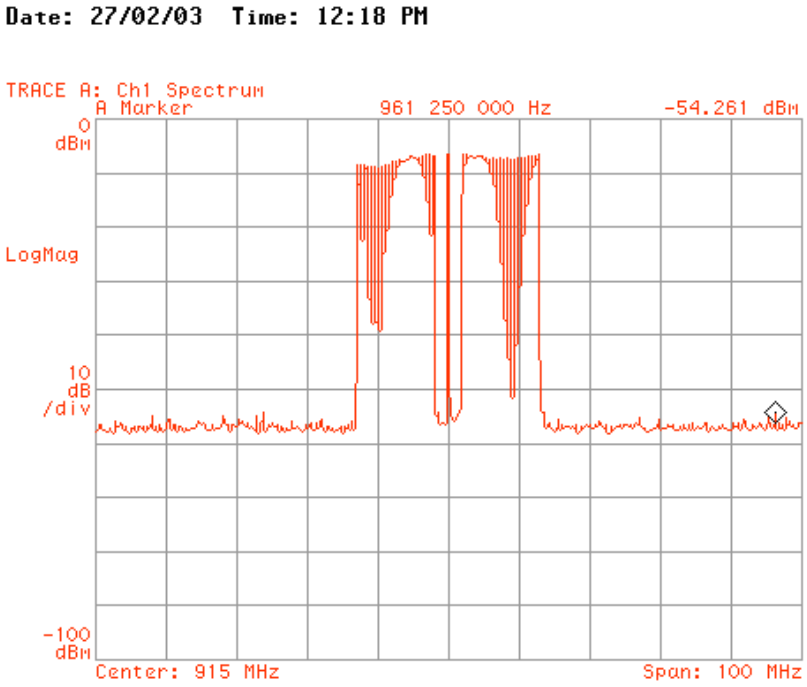
Band Power Marker Center: 928.050 MHz

Measurement Result:

The peak upper band edge power integrated over a 100 kHz bandwidth is –53.64 dBm. The lower band edge power is 50.68 dB below the peak in band power when frequency hopping is enabled.

Out of band emissions measured from 865 to 902 MHz and from 928 to 965 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 915 MHz

Span: 100 MHz

Start: 865 MHz

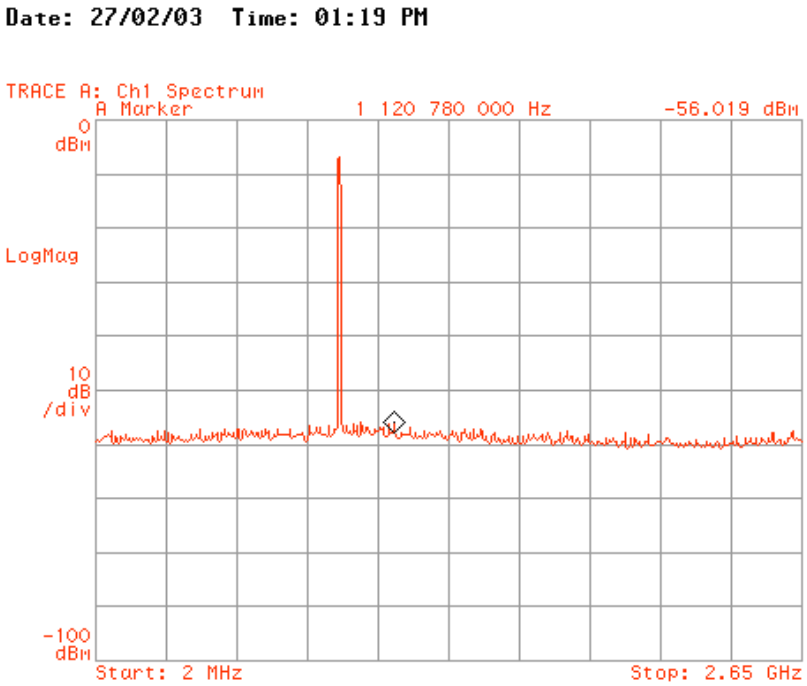
Stop: 965 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 961.250 MHz at a level of –54.26 dBm or 51.30 dB below the peak in band power.

Out of band emissions measured from 2 to 865 MHz and from 965 to 2650 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 1326 MHz

Span: 2648 MHz

Start: 2 MHz

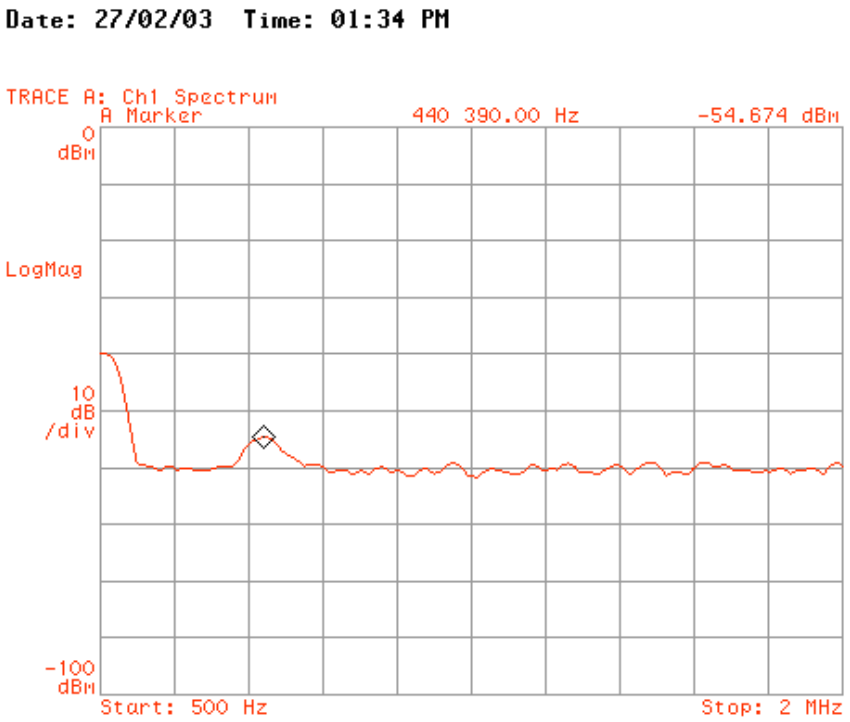
Stop: 2650 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 1120.78 MHz at a level of –56.02 dBm or 53.06 dB below the peak in band power.

Out of band emissions measured from 500 Hz to 2 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Continuous Peak Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Center: 1.00025 MHz

Span: 1.995 MHz

Start: 500 Hz

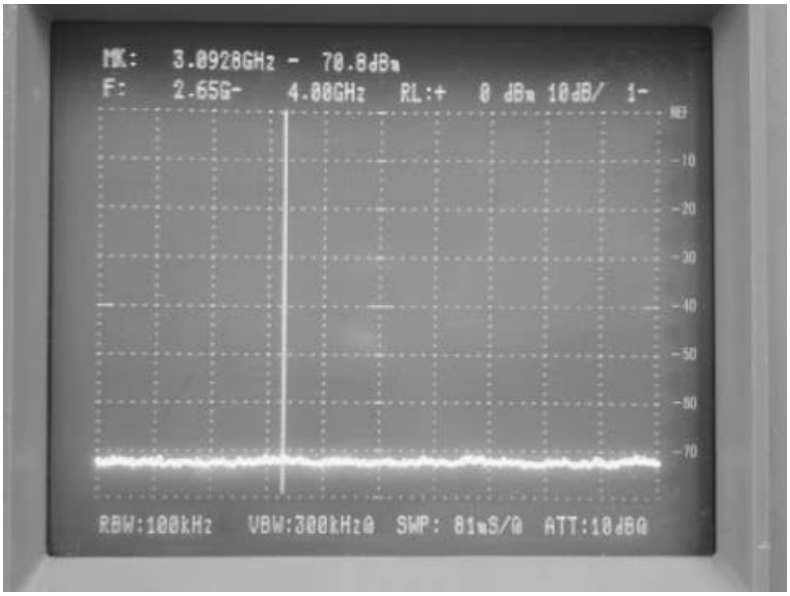
Stop: 2 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 440.390 kHz at a level of –54.67 dBm or 51.71 dB below the peak in band power.

Out of band emissions measured from 2650 MHz to 4000 MHz

Frequency hopping enabled and disabled.



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 1350 MHz

Start: 2650 MHz

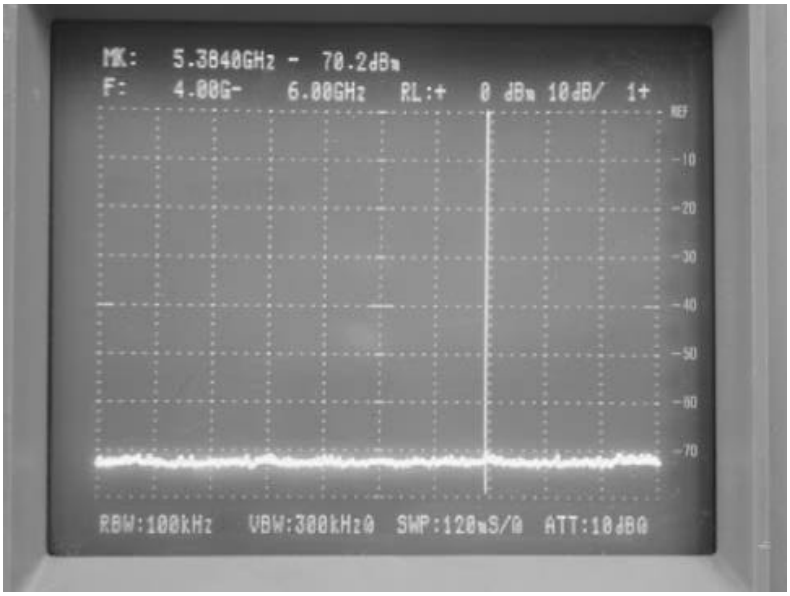
Stop: 4000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 3092.8 MHz at a level of –70.8 dBm or 67.84 dB below the peak in band power.

Out of band emissions measured from 4000 MHz to 6000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 4000 MHz

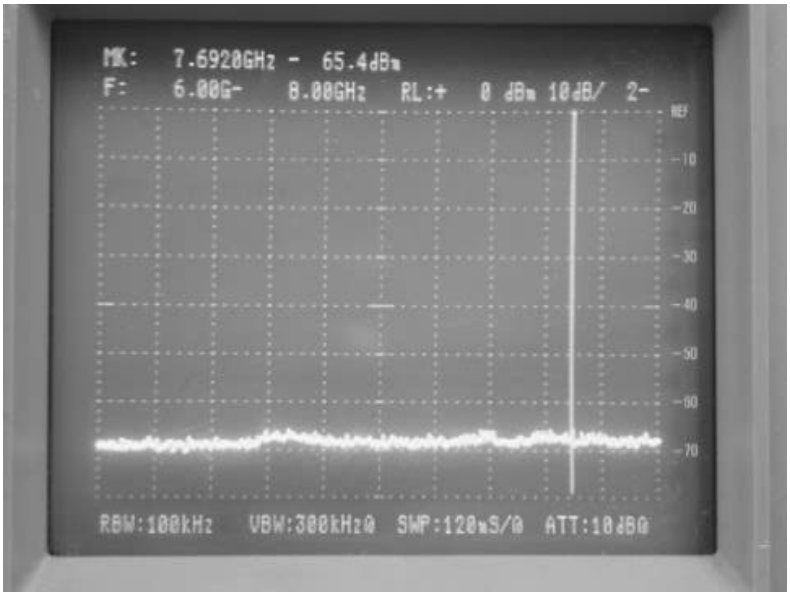
Stop: 6000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 5384 MHz at a level of –70.2 dBm or 67.24 dB below the peak in band power.

Out of band emissions measured from 6000 MHz to 8000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 6000 MHz

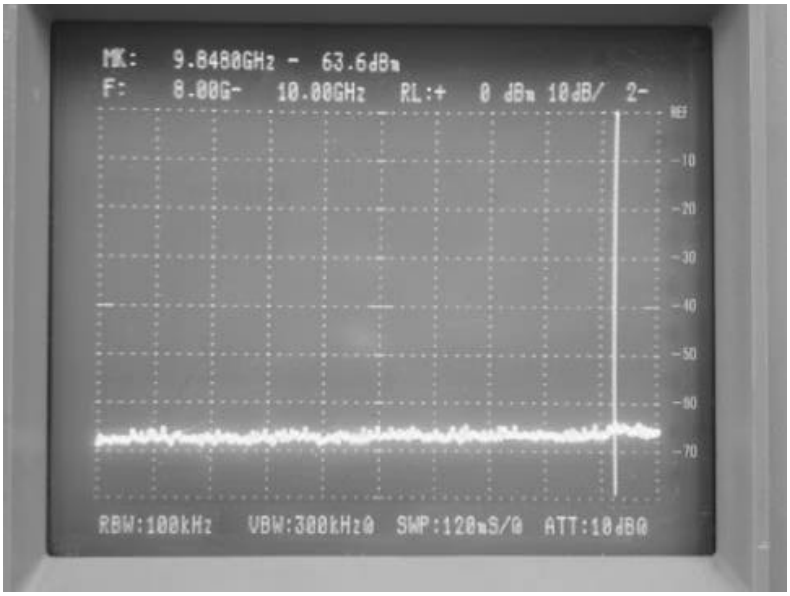
Stop: 8000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 7692 MHz at a level of –65.4 dBm or 62.44 dB below the peak in band power.

Out of band emissions measured from 8000 MHz to 10 000 MHz

Frequency hopping enabled and disabled



Settings:

Acquisition Mode: Maximum Hold

RBW: 100 kHz

Detector type: Positive Peak

Trigger type: Free running

Span: 2000 MHz

Start: 8000 MHz

Stop: 10 000 MHz

Measurement Result:

The peak out of band emission in a 100 kHz bandwidth occurs at 9848 MHz at a level of –63.6 dBm or 60.64 dB below the peak in band power.

Result:

All of the RF conducted out of band emissions, including those near the 902 and 928 MHz band edges exceed the requirement to be below 20 dB of the peak in band power in a 100 kHz bandwidth.

Out of Band Measurement	**Requirement** (dB below peak in band power in a 100 kHz bandwidth)	**Measured Result Complies** (dB below peak in band power in a 100 kHz bandwidth)
First Antenna Output		
Lower band edge. Frequency hopping enabled	20	52.43 at 901.950 MHz
Lower band edge. Frequency hopping disabled		49.63 at 901.950 MHz
Upper band edge. Frequency hopping disabled		49.27 at 928.050 MHz
Upper band edge. Frequency hopping enabled		53.40 at 928.050 MHz
865 to 902 MHz and 928 to 965MHz. Frequency hopping enabled and disabled		51.91 at 964.750 MHz
2 to 865 MHz and 965 to 2650 MHz. Frequency hopping enabled and disabled		53.97 at 1186.98 MHz
500 Hz to 2 MHz. Frequency hopping enabled and disabled		53.50 at 436.641 kHz
2650 MHz to 4000 MHz. Frequency hopping enabled and disabled		67.63 min. over measurement
4000 MHz to 6000 MHz. Frequency hopping enabled and disabled		68.03 at 4508 MHz
6000 MHz to 8000 MHz. Frequency hopping enabled and disabled		64.93 at 7616 MHz
8000 MHz to 10 000 MHz. Frequency hopping enabled and disabled		62.13 at 9828 MHz
Second Antenna Output		
Lower band edge. Frequency hopping enabled	20	52.40 at 901.950 MHz
Lower band edge. Frequency hopping disabled		48.49 at 901.950 MHz
Upper band edge. Frequency hopping disabled		48.63 at 928.050 MHz
Upper band edge. Frequency hopping enabled		50.68 at 928.050 MHz
865 to 902 MHz and 928 to 965MHz. Frequency hopping enabled and disabled		51.30 at 961.250 MHz
2 to 865 MHz and 965 to 2650 MHz. Frequency hopping enabled and disabled		53.06 at 1120.78 MHz

500 Hz to 2 MHz. Frequency hopping enabled and disabled	20	51.71 at 440.390 kHz
2650 MHz to 4000 MHz. Frequency hopping enabled and disabled		67.84 at 3092.8 MHz
4000 MHz to 6000 MHz. Frequency hopping enabled and disabled		67.24 at 5384 MHz
6000 MHz to 8000 MHz. Frequency hopping enabled and disabled		62.44 at 7692 MHz
8000 MHz to 10 000 MHz. Frequency hopping enabled and disabled		63.3 at 9848 MHz

6.11 Emissions In Restricted Bands

Requirement:

Part 15.247(c) states: Radiated emissions which fall in the restricted bands, as defined in part 15.205(a), must also comply with the radiated emission limits specified in part 15.209(a).

Test Procedure:

The EUT is placed in the standard 3-meter field strength measurement set up. This test is performed at the lowest, the middle, and the highest frequency of operation. While the UUT is transmitting, the field strength of the radiated emissions that fall into the restricted bands are measured and recorded. The test is repeated with the EUT's alternate integral diversity antenna.

Measurement Plots:

See radiated emissions test report by Protocol EMC in appendix A.

6.12 Class B Unintentional Radiated Emissions

Requirement:

Part 15.109 states: Except for Class A digital devices, the field strength of radiated emissions form unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of Emission (MHz)	**Field Strength, (microvolts/meter)**
30-88	100
88-216	150
216-960	200
Above 960	500

Test Procedure:

The EUT is turned on and in receive mode for the purpose of measuring unintentional radiators. The EUT is placed in the standard 3-meter field strength measurement set up and the radiated emissions are recorded.

See radiated emissions test report by Protocol EMC in appendix A.

6.13 Power Line Conducted Emissions

The EUT is designed to be connected to the public utility (AC) power line. When the EUT is not transmitting it is subject to the conducted limits as per part 15.107 and is classed as a Class B digital device. When the EUT transmits it is classed as an intentional radiator and is subject to the conducted limits as per part 15.207. The part 15.107 Class B limits and the Part 15.207 limits happen to be the same.

6.13.1 FCC Part 15.107 Class B Limits

Requirement:

With the EUT powered up but not transmitting, the power line conducted spurious emissions shall not exceed the limits defined in part 15.107 for a Class B digital device.

Test Procedure:

The EUT is powered up through a LISN and is set up as per the standard power line conducted spurious measurement set up. The spurious emissions conducted back onto each of the two AC power lines are measured and recorded.

Measurement Plots:

See radiated emissions test report by Protocol EMC in appendix A.

6.13.2 FCC Part 15.207 Limits

Requirement:

With the transmitting, the power line conducted spurious emissions shall not exceed the limits defined in part 15.207 for an intentional radiator.

Test Procedure:

The EUT is powered up in transmit mode through a LISN and is set up as per the standard power line conducted spurious measurement set up. The spurious emissions conducted back onto each of the two AC power lines are measured and recorded.

Measurement Plots:

See radiated measurement test report by Protocol EMC in appendix A.

6.14 Antenna

Requirement:

Part 15.203 states that 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.

Technical Description:

The EUT is designed with two integral diversity antennas. The antennas are an integral part of the design and they do not utilize any connectors to interface them to the EUT. The transceiver portion of the EUT assembly is coupled to the antennas with coaxial cable. The coaxial cable is soldered to the coupling point of the antennas and to their respective transceiver interface points. When the EUT is deployed in its system it is an un-manned device and it is enclosed and sealed under the glass of a public utility Watt-hour meter where there is no access to the EUT antennas.

6.15 How EUT Meets The Definition Of A Frequency Hopping Spread Spectrum System

Requirement:

The definition of a frequency hopping spread spectrum system from part 2.1 is as follows:

A frequency hopping system is a spread spectrum system in which the carrier is modulated with the coded information in a conventional manner causing a conventional spreading of the RF energy about the carrier frequency. However, the frequency of the carrier is not fixed but changes at fixed intervals under the direction of a pseudorandom coded sequence. The wide RF bandwidth needed by such a system is not required by a spreading of the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop.

Technical Description:

The hop frequencies utilized by the EUT are modulated with conventional 2FSK resulting in a 20 dB bandwidth of approximately 61.250 kHz as measured in section 6.1 of this test report. The hop sequence of the hop frequencies utilized is generated with a pseudorandom generator. The hop frequencies change according to the pseudorandom generator at fixed intervals by the design of the internal timing of the EUT. The EUT utilizes hop frequencies in the entire 902 MHz to 928 MHz band where the band edge frequencies are as follows:

Lower band edge carrier: 902.171052 MHz.

Upper band edge carrier 927.828947 MHz.

An example of a hop sequence is listed in section 6.3 of this report.

6.16 Operation As A True Frequency Hopping System

Requirement:

Part 15.247(g) states the following:

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

Technical Description:

The EUT operates in a frequency hopping system that is based on data packets. Continuous data or information is divided into packets. The packets are generated by design to require whole frequency hopping sequence multiples and therefore by design a hopping sequence is never discontinued and restarted. Valid data is transmitted and received on all hop sequence frequencies during all transmissions. Since the hopping sequence is generated by a PN generator as stated in section 6.3 of this report the transmissions are always distributed over the minimum of 50 frequencies where on average each frequency is used equally. In addition the packet generator and hopping sequence timing has been designed to limit the average frequency occupancy to less than that allowable and is described in section 6.7 of this report. Physical hardware limitations limit the maximum transmission duty cycle and therefore specific timing related to transmissions has been incorporated and with such timing the conclusions at the end of section 6.9 of this report, (Public RF Exposure Limit) do not change. A system of EUT transmitters and receivers complies with all the regulations in part 15.247 as demonstrated in this report and operates as a true frequency hopping system.

6.17 No Coordination Of Hopping Frequencies.

Requirement:

Part 15.247(h) states the following:

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies my multiple transmitters is not permitted.

Technical Description:

The EUT or the system in which it operates does not incorporate intelligence to adapt its hopsets to avoid hopping on occupied frequencies from other users within the spectrum band. Multiple access in a system network of EUT devices is not achieved by coordination of hopping frequencies. Hopsets are factory set and are generated by a pseudorandom sequence generator as stated in section 6.3 of this report.

Revision History

The following table shows the revision history of this document.

Date dd/mm/yy	Author	Changes	Revision
06/02/03	Robert De Angelis	Draft started	Draft
27/02/03	Robert De Angelis	Added in house measurements	Draft 1.1
16/04/03	Robert De Angelis	Added radiated measurements test report by Protocol EMC as appendix A.	1.0

Appendix A Protocol EMC Test Report

FCC Part 15 Subpart B and C Compliance Test Report

Applicant Name: Tantalus Systems Corp.

Product Name: TUNet 1200
Model No.: TUNet 1200

Date of Test Report: April 16, 2003
Date of Test completion: April 3, 2003
Report Version: 1.3

Approvals		
Approved By	_____ **Robert Stirling, P.Eng.**	_____ **Date**

Report Revision		
Rev. #	Report Change	Date

Table of Contents

1.0 General Information

1.1. EUT Description

All EUT descriptions are located in the Tantalus Systems Corp. test report for this product.

Note:

1.0 The tests were conducted on a production model sample to demonstrate compliance with FCC Part 15 Subpart C section 15.247 for frequency hopping devices.

1.2 Operational Description

The EUT operational description is located in the Tantalus Systems Corp. test report for this product.

1.3 Test Facilities

Protocol EMC
28945 McTavish Rd.
Abbotsford B.C., Canada, V4X 2E7

Phone: 604-607-0012
Fax: 604-607-0019

FCC Registration Number 96437
Industry Canada Registration Number IC3384

1.4 Test System Details

The EUT is setup in the normal operating mode for the duration of the test. Any additional information that is required is located in the Tantalus Systems Corp. test report for this product.

1.5 EUT Modifications

There were no modifications required for this unit to comply with FCC Part 15 Subpart B and C section 15.247.

1.6 EUT Testing Configuration

The EUT was setup with all required cables and was set in its normal operating mode for the duration of the test.

1.7 Test Results

The TUNet 1200 complies with FCC Part 15 Subpart C.

2.0 Conducted Emissions

2.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
LISN	Solar 8012-50-R-24-BNC	863092	09/18/02	09/18/03
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Turntable	Protocol	Custom	N/A	N/A

2.2 Test Standard

FCC Part 15 Subpart C Section 15.207 Conducted emission limits.

2.3 Test Setup

The EUT was setup in its normal operating mode for the duration of the test. All lines were tested to find the maximum conducted emissions that the EUT emitted. All Conducted Emissions measurements were performed according to ANSI C63.4: 1992 on conducted measurement. Conducted Emissions were tested over the frequency range from 0.15 MHz to 30 MHz using a receiver bandwidth of 9kHz.

2.4 Test Limits

Class B Limits:

Frequency (MHz)	Maximum Level (dBµV) Quasi-Peak	Maximum Level (dBµV) 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

2.5 Test Results Receiving Mode

Product : TUNet 1200
Test Item : Conducted Emissions
Test Site : Protocol EMC
Test Mode : Receiving mode

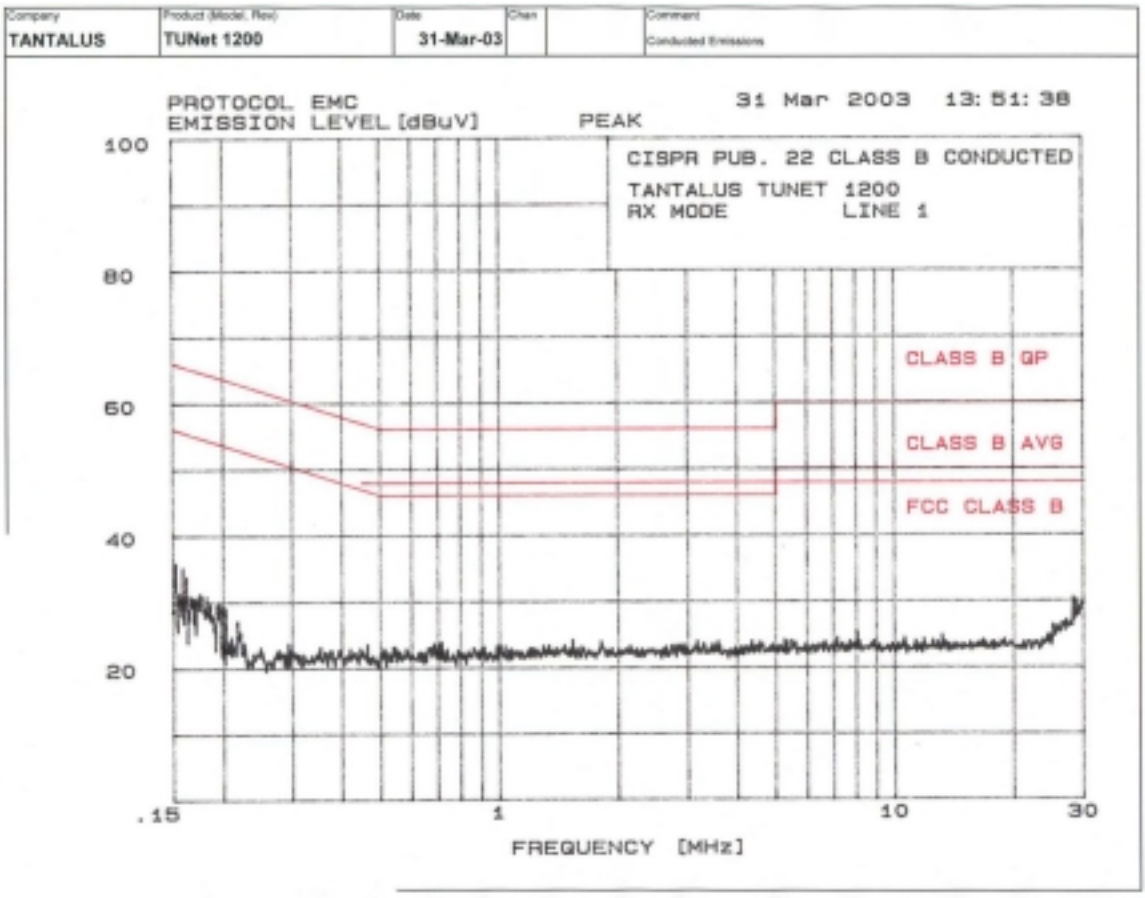
Line 1

Frequency MHz	Test Reading	Delta Limit
0.1524	35.9	-19.9
0.1590	35.2	-20.3
0.1624	33.9	-21.4
0.1758	31.3	-23.3
0.1965	30.1	-23.6

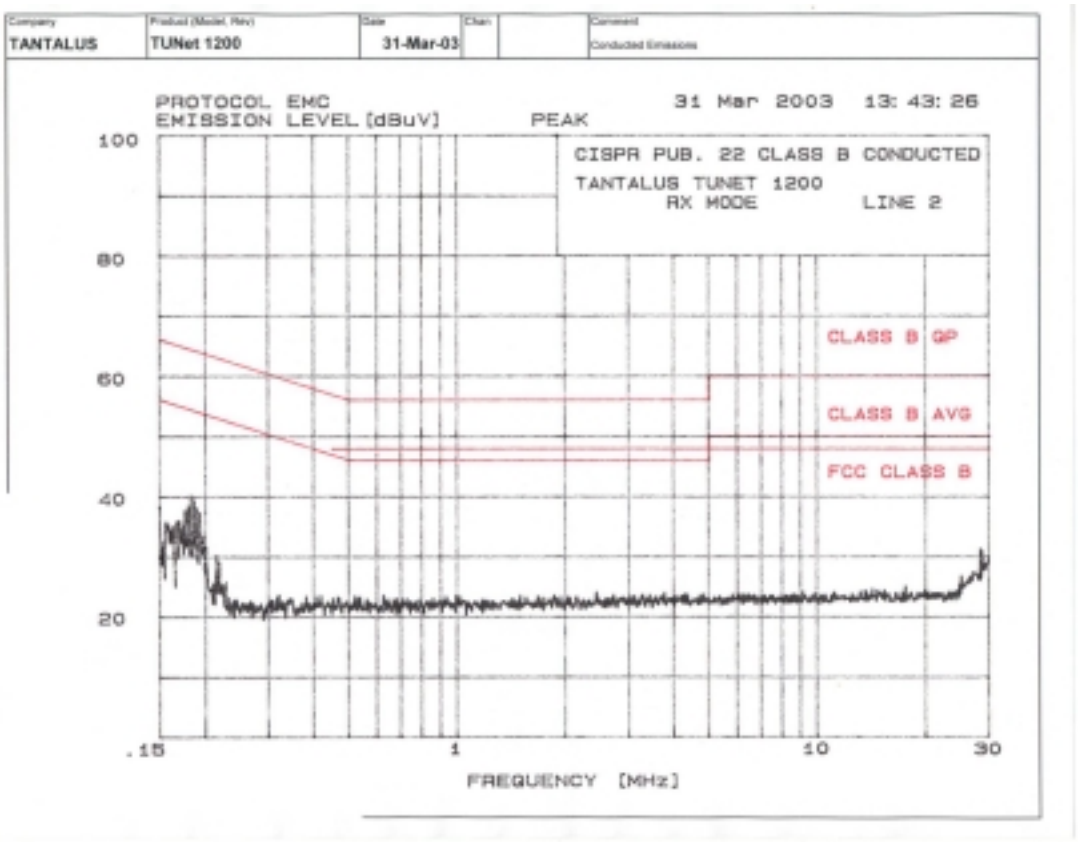
Line 2

Frequency MHz	Test Reading	Delta Limit
0.1834	40.2	-14.1
0.1873	39.4	-14.7
0.1805	39.4	-14.7
0.1903	38.5	-15.9
0.1944	37.4	-16.4

2.5.1 Conducted Emissions plots for Receiving Mode



Line 1 Receiving Mode



Line 2 Receiving Mode

2.6 Test Results Transmitting Mode

Product : TUNet 1200
Test Item : Conducted Emissions
Test Site : Protocol EMC
Test Mode : Transmitting mode

Line 1

Frequency MHz	Test Reading	Delta Limit
0.4681	48.9	2.4
0.2196	48.2	-4.6
0.2255	47.7	-4.9
0.2327	45.7	-6.6
0.2390	44.4	-7.7

Average Data

Frequency MHz	Test Reading	Delta Limit
0.2861	20	-30.6
0.2560	20.4	-31.1
0.3181	18.6	-31.1
0.2243	21.2	-31.4
0.2161	18.2	-34.7

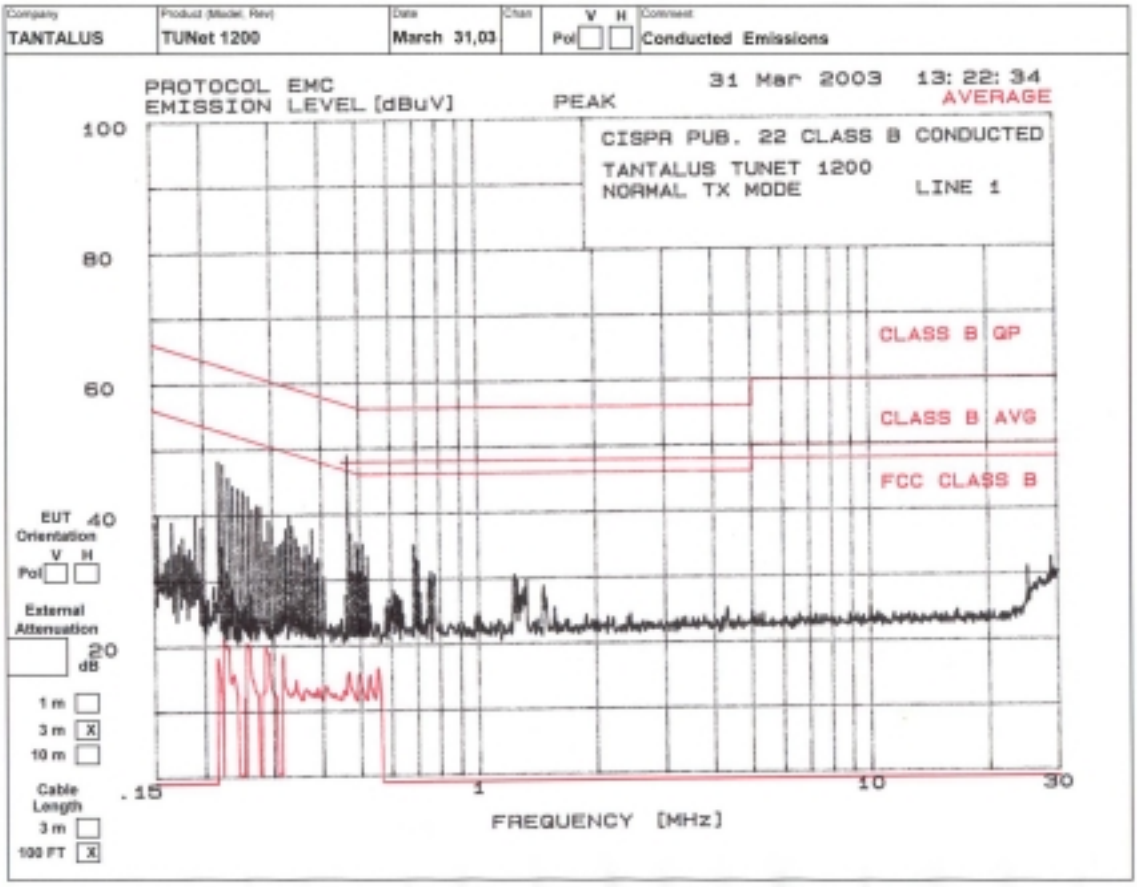
Line 2

Frequency MHz	Test Reading	Delta Limit
0.4806	47.7	1.4
0.5068	47.4	1.4
0.4988	44.8	-1.2
0.2243	50.3	-2.3
0.3517	45.1	-3.8

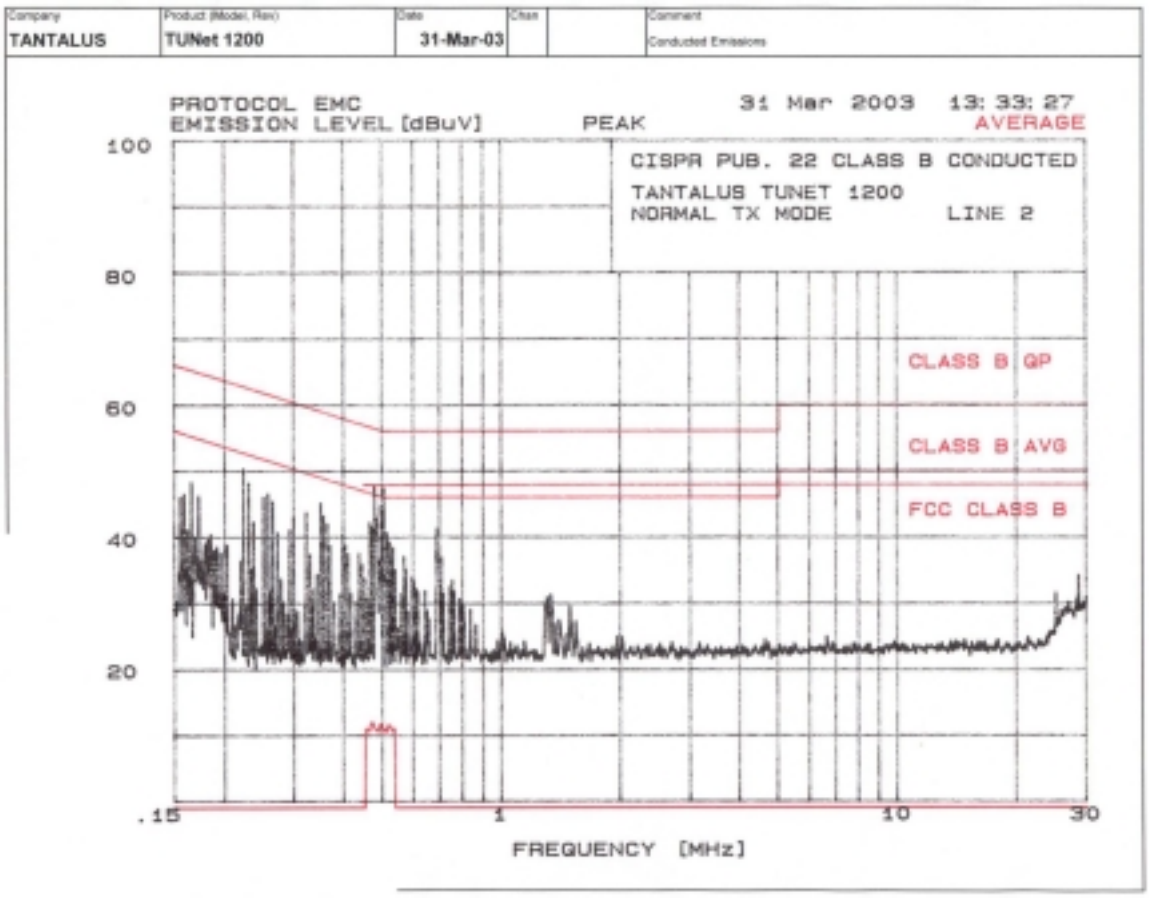
Average Data

Frequency MHz	Test Reading	Delta Limit
0.4731	12	-34.4

2.6.1 Conducted Emissions plots for Transmitting Mode



Line 1 Transmitting Mode



Line 2 Transmitting Mode

3.0 Radiated Emissions

3.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
Antenna	EMCO 3105 Horn	2024	10/30/02	10/30/03
Antenna	Microlab FXR K638A Horn		03/04/03	03/04/04
Antenna	EMCO 3141 Bilog	1127	09/26/02	09/26/03
Harmonic Mixer	HP11971K Mixer	2332A01250	03/04/03	03/04/04
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Microwave Amplifier	HP8349A	2512A00824	09/13/02	09/13/03
Tower	Rhientech Labs	Custom	N/A	N/A
Turntable	Protocol	Custom	N/A	N/A

3.2 Test Setup

The EUT was placed in receive mode for the duration of the test. The EUT was rotated 360 degrees to determine the worst case angle for the maximum emissions level. The antenna was raised and lowered from 1 m to 4 m to find the maximum emissions level. Both horizontal and vertical antenna polarization were tested to find the worst case polarization. This test was performed at a distance of 3 m from the EUT to the measurement antenna.

3.3 Test Standard

FCC Part 15 Subpart C Section 15.209 Radiated emission limits.

3.4 Limits

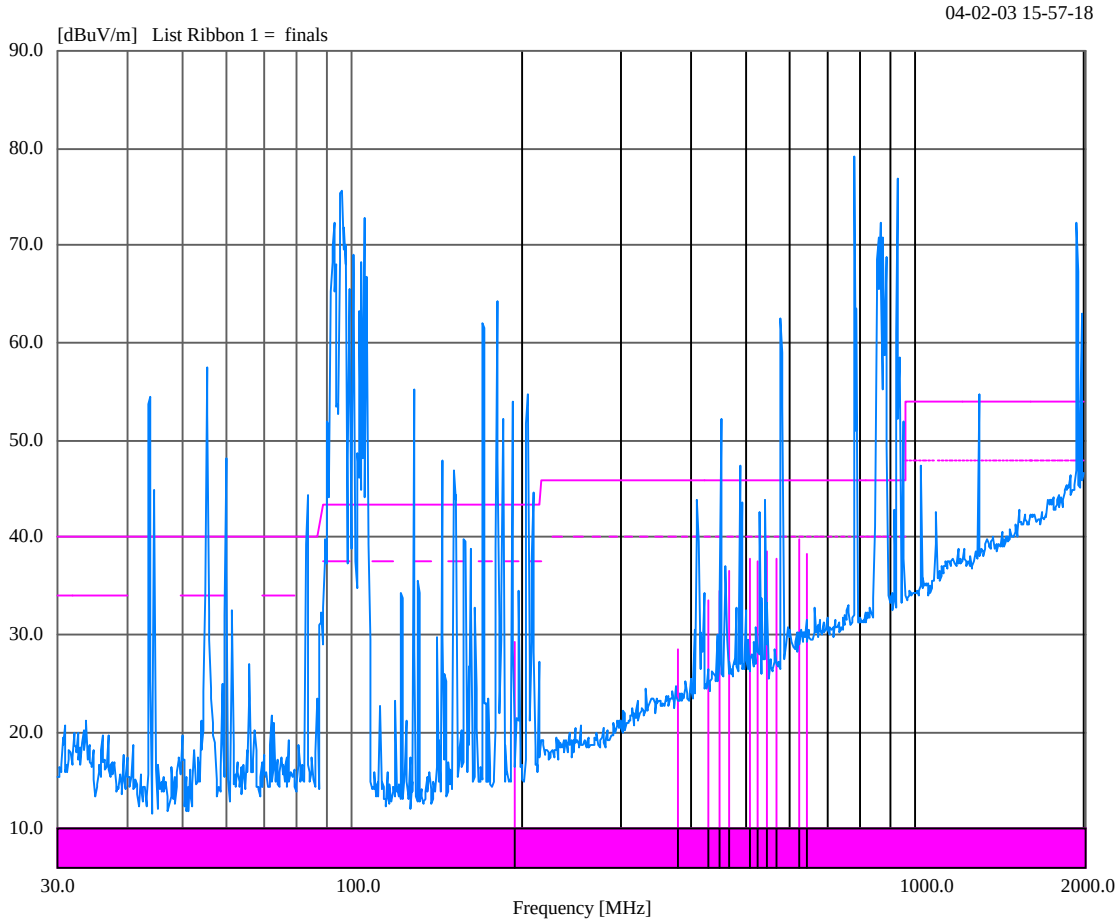
Frequency (MHz)	Maximum Field Strength µV/m at 3m	Maximum Field Strength dBµV/m at 3m
30 - 88	100	40.0
88 - 216	150	43.5
216 - 960	200	46.0
960 - 1000	500	54.0

3.5 Test Result

Product : TUNet 1200
Test Item : Radiated Emissions
Test Site : Protocol EMC
Test Mode : Receive mode

Frequency (MHz)	Pol	Height (m)	Angle (deg)	Un Corr Pk (dB)	Tot Corr (dB)	Peak (dBµV/m)	DelLim-Pk FCC (dB)
194.994093	Vert	1.0	45	17.40	11.83	29.23	-14.27
380.269043	Vert	1.2	35	10.00	18.44	28.44	-17.56
429.013603	Vert	1.0	40	14.30	19.37	33.67	-12.33
448.523027	Vert	1.0	45	14.70	19.82	34.52	-11.48
468.031257	Vert	1.1	45	16.00	20.48	36.48	-9.52
507.020556	Vert	1.0	15	16.90	21.03	37.93	-8.07
526.527635	Vert	1.2	35	15.80	21.90	37.70	-8.30
546.019530	Vert	1.0	45	16.30	22.19	38.49	-7.51
565.497322	Vert	1.0	30	15.30	22.42	37.72	-8.28
624.001421	Vert	1.0	45	15.60	24.14	39.74	-6.26
643.510950	Vert	1.1	35	14.10	24.23	38.33	-7.67

3.6 Emissions Plots



Radiated Emissions

FCC Limit

10 dB below FCC Limit

CISPR Limit

10 dB below CISPR Limit

(Dark Blue Traces) All Emissions including ambient noise.

(Vertical Pink Line) – Markings of each Suspect Frequency
("X") – indicates Quasi-Peak

4.0 Radiated Harmonic

4.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
Antenna	EMCO 3105 Horn	2024	10/30/02	10/30/03
Antenna	Microlab FXR K638A Horn		03/04/03	03/04/04
Antenna	EMCO 3141 Bilog	1127	09/26/02	09/26/03
Harmonic Mixer	HP11971K Mixer	2332A01250	03/04/03	03/04/04
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Microwave Amplifier	HP8349A	2512A00824	09/13/02	09/13/03
Tower	Rhientech Labs	Custom	N/A	N/A
Turntable	Protocol	Custom	N/A	N/A

4.2 Test Setup

The EUT was placed in normal operating mode for the duration of the test. The EUT was rotated 360 degrees to determine the worst case angle for the maximum emissions level. The antenna was raised and lowered from 1 m to 4 m to find the maximum emissions level. Both horizontal and vertical antenna polarizations were tested to find the worst case polarization. 3 channels were tested. This test was performed at a distance of 3 m from the EUT to the measurement antenna. Both antennas were tested to show complete compliance.

4.3 Test Standard

FCC CFR47, Part 15, Subpart B 15.247c

4.4 Limits

Fundamental Limit = 137 dBµV/m at antenna or 125.23 @ 3m

Harmonics and Spurious Emissions = 20 dBc

Restricted Band Emissions = AVG 54 dBµV/m

4.5 Test Result Channel 1 902.17 MHz Antenna 1

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	902.17	Horz	83.2	28.1	111.3	125.23	-13.93	-
2nd	1804.34	Horz	67.5	7	74.5	91.3	-16.8	-36.8
3rd	2706.51	Vert	31.8	11.8	43.6	74.0	-30.4	-67.7
4th	3608.68	Horz	30.5	19.2	49.7	74.0	-24.3	-61.6
5th	4510.85	Vert	30.4	28.8	59.2	74.0	-14.8	-52.1
6th	5413.02	Vert	29.2	38.1	67.3	74.0	-6.7	-44.0
7th	6315.19	Horz	31.9	36.5	68.4	91.3	-22.9	-42.9
8th	7217.36	Horz	33.1	37.5	70.6	91.3	-20.7	-40.7
9th	8119.53	Horz	34.5	34.3	68.8	74.0	-5.2	-42.5
10th	9021.71	Horz	33.3	38.8	72.1	74.0	-1.9	-39.2

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2706.51	Vert	20.3	-14.2	6.1	54.0	-47.9
4th	3608.68	Horz	17.9	-6.9	11.0	54.0	-43.0
5th	4510.85	Vert	19.4	2.8	22.2	54.0	-31.8
8th	5413.02	Vert	19.9	12	31.9	54.0	-22.1
9th	8119.53	Horz	21.2	8.3	29.5	54.0	-24.5
10th	9021.71	Horz	20.3	12.8	33.1	54.0	-20.9

Note:
1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

4.6 Test Result Channel 2 915 MHz Antenna 1

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	915	Horz	93.3	27.8	121.1	125.23	-4.13	-
2nd	1830	Horz	66.3	6.7	73.0	101.1	-28.1	-48.1
3rd	2745	Vert	35.7	11.3	47.0	74.0	-27	-74.1
4th	3660	Vert	30.1	18.8	48.9	74.0	-25.1	-72.2
5th	4575	Vert	30.1	28.6	58.7	74.0	-15.3	-62.4
6th	5490	Vert	27.4	38.1	65.5	101.1	-35.6	-55.6
7th	6405	Horz	32.8	36.7	69.5	101.1	-31.6	-51.6
8th	7320	Vert	33.0	38.2	71.2	74.0	-2.8	-49.9
9th	8235	Horz	35.3	34.9	70.2	74.0	-3.8	-50.9
10th	9150	Vert	32.1	39.9	72.0	74.0	-2	-49.1

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2745	Vert	23.5	-13.9	9.6	54.0	-44.4
4th	3660	Vert	18.4	-7.2	11.2	54.0	-42.8
5th	4575	Vert	16.5	2.6	19.1	54.0	-34.9
8th	7320	Vert	20.2	12.2	32.4	54.0	-21.6
9th	8235	Horz	23.9	8.9	32.8	54.0	-21.2
10th	9150	Vert	19.8	13.9	33.7	54.0	-20.3

Note:
1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

4.7 Test Result Channel 3 927.8 MHz Antenna 1

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	927.82	Horz	90.9	27.5	118.4	125.23	-6.83	-
2nd	1855.65	Horz	62.5	6.4	68.9	98.4	-29.5	-49.5
3rd	2783.48	Vert	37.1	12.4	49.5	74.0	-24.5	-68.9
4th	3711.31	Vert	28.5	18.6	47.1	74.0	-26.9	-71.3
5th	4639.14	Horz	27.6	28.9	56.5	74.0	-17.5	-61.9
6th	5566.97	Horz	25.9	39.5	65.4	98.4	-33.0	-53.0
7th	6494.80	Horz	32.6	36.7	69.3	98.4	-29.1	-49.1
8th	7422.63	Horz	32.8	38.8	71.6	74.0	-2.4	-46.8
9th	8350.46	Vert	33.3	35.5	68.8	74.0	-5.2	-49.6
10th	9278.2	Horz	32.8	40.8	73.6	98.4	-24.8	-44.8

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2783.48	Vert	27.7	-13.6	14.1	54.0	-39.9
4th	3711.31	Vert	17.4	-7.4	10.0	54.0	-44.0
5th	4639.14	Horz	15.0	2.9	17.9	54.0	-36.1
8th	7422.63	Horz	19.6	12.8	32.4	54.0	-21.6
9th	8350.46	Vert	21.3	9.5	30.8	54.0	-23.2

Note:

1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

4.8 Test Result Channel 1 902.17 MHz Antenna 2

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	902.17	Horz	85.0	28.1	113.1	125.23	-12.13	-
2nd	1804.34	Vert	67.0	7	74.0	93.1	-19.1	-39.1
3rd	2706.51	Horz	35.6	11.8	47.4	74.0	-26.6	-65.7
4th	3608.68	Vert	30.9	19.2	50.1	74.0	-23.9	-63.0
5th	4510.85	Horz	29.1	28.8	57.9	74.0	-16.1	-55.2
6th	5413.02	Vert	25.9	38.1	64.0	74.0	-10.0	-49.1
7th	6315.19	Horz	32.7	36.5	69.2	93.1	-23.9	-43.9
8th	7217.36	Vert	33.3	37.5	70.8	93.1	-22.3	-42.3
9th	8119.53	Vert	33.5	34.3	67.8	74.0	-6.2	-45.3
10th	9021.71	Vert	33.1	38.8	71.9	74.0	-2.1	-41.2

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2706.51	Horz	23.4	-14.2	9.2	54.0	-44.8
4th	3608.68	Vert	19.5	-6.9	12.6	54.0	-41.4
5th	4510.85	Horz	16.2	2.8	19.0	54.0	-35.0
6th	5413.02	Vert	13.3	12.0	25.3	54.0	-28.7
9th	8119.53	Vert	20.4	8.3	28.7	54.0	-25.3
10th	9021.71	Vert	19.3	12.8	32.1	54.0	-21.9

Note:
1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

4.9 Test Result Channel 2 915 MHz Antenna 2

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	915	Horz	93.3	27.8	121.1	125.23	-4.13	-
2nd	1830	Vert	69.6	6.7	76.3	101.1	-24.8	-44.8
3rd	2745	Horz	36.4	12.1	48.5	74.0	-25.5	-72.6
4th	3660	Vert	33.6	18.8	52.4	74.0	-21.6	-68.7
5th	4575	Vert	29.7	28.6	58.3	74.0	-15.7	-62.8
6th	5490	Horz	27.2	38.1	65.3	101.1	-35.8	-55.8
7th	6405	Horz	32.5	36.7	69.2	101.1	-31.9	-51.9
8th	7320	Vert	33.1	38.2	71.3	74.0	-2.7	-49.8
9th	8235	Horz	33.8	34.9	68.7	74.0	-5.3	-52.4
10th	9150	Horz	33.0	39.9	72.9	74.0	-1.1	-48.2

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2745	Horz	22.8	-13.9	8.9	54.0	-45.1
4th	3660	Vert	24.0	-7.2	16.8	54.0	-37.2
5th	4575	Vert	16.5	2.6	19.1	54.0	-34.9
8th	7320	Vert	20.3	12.2	32.5	54.0	-21.5
9th	8235	Horz	22.5	8.9	31.4	54.0	-22.6
10th	9150	Horz	19.8	13.9	33.7	54.0	-20.3

Note:
1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

4.10 Test Result Channel 3 927.8 MHz Antenna 2

Product : TUNet 1200
Test Item : Harmonic Emissions
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Harmonic	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)	dBc
1st	927.82	Horz	93.9	27.5	121.4	125.23	-3.83	-
2nd	1855.65	Horz	66.2	6.4	72.6	101.4	-28.8	-48.8
3rd	2783.48	Horz	38.7	12.4	51.1	74.0	-22.9	-70.3
4th	3711.31	Horz	30.0	18.6	48.6	74.0	-25.4	-72.8
5th	4639.14	Horz	28.0	28.9	56.9	74.0	-17.1	-64.5
6th	5566.97	Vert	33.4	39.5	72.9	74.0	-1.1	-48.5
7th	6494.80	Horz	32.0	36.7	68.7	101.4	-32.7	-52.7
8th	7422.63	Vert	33.6	38.8	72.4	74.0	-1.6	-29.0
9th	8350.46	Horz	33.2	35.5	68.7	74.0	-5.3	-32.7
10th	9278.2	Horz	32.9	40.8	73.7	101.4	-27.7	-47.7

*These Harmonics are in restricted band and are subject to Average limit of 54 (dBµV/m)

Harmonic	Frequency (MHz)	Polarity	Uncor Average (dBµV)	Tot Corr (dB)	Average (dBµV/m)	Average Limit (dBµV/m)	Delta Limit (dB)
3rd	2783.48	Horz	28.3	-13.6	14.7	54.0	-39.3
4th	3711.31	Horz	15.8	-7.4	8.4	54.0	-45.6
5th	4639.14	Horz	15.8	2.9	18.7	54.0	-35.3
8th	7422.63	Horz	19.5	12.8	32.3	54.0	-21.7
9th	8350.46	Horz	20.7	9.5	30.2	54.0	-23.8

Note:

1 Receiver Settings (Peak Detector) RBW: 1 MHz VBW: 1 MHz
2 Receiver Settings (Average Detector) RBW: 1 MHz VBW: 30 Hz

5.0 Radiated Spurious Emissions

5.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
Antenna	EMCO 3105 Horn	2024	10/30/02	10/30/03
Antenna	Microlab FXR K638A Horn		03/04/03	03/04/04
Antenna	EMCO 3141 Bilog	1127	09/26/02	09/26/03
Harmonic Mixer	HP11971K Mixer	2332A01250	03/04/03	03/04/04
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Microwave Amplifier	HP8349A	2512A00824	09/13/02	09/13/03
Tower	Rhientech Labs	Custom	N/A	N/A
Turntable	Protocol	Custom	N/A	N/A

5.2 Test Setup

The EUT was placed in normal operating mode for the duration of the test. The EUT was rotated 360 degrees to determine the worst case angle for the maximum emissions level. The antenna was raised and lowered from 1 m to 4 m to find the maximum emissions level. Both horizontal and vertical antenna polarizations were tested to find the worst case polarization. 3 channels were tested. This test was performed at a distance of 3 m from the EUT to the measurement antenna. Both antennas were tested to show complete compliance. Only one set of plots is shown in the test report, if required additional plots can be included. There were no non-harmonic spurious emissions.

5.3 Test Standard

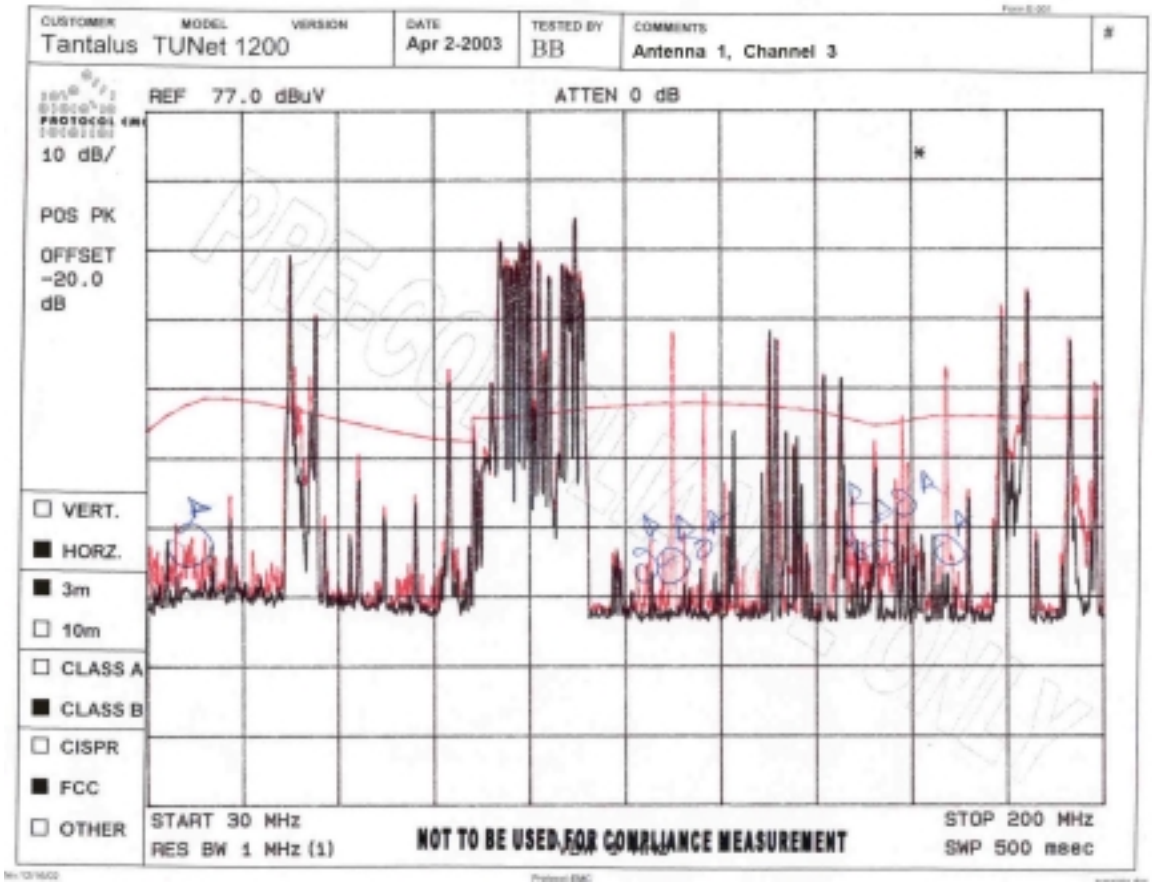
FCC CFR47, Part 15, Subpart B 15.247c

5.4 Limits

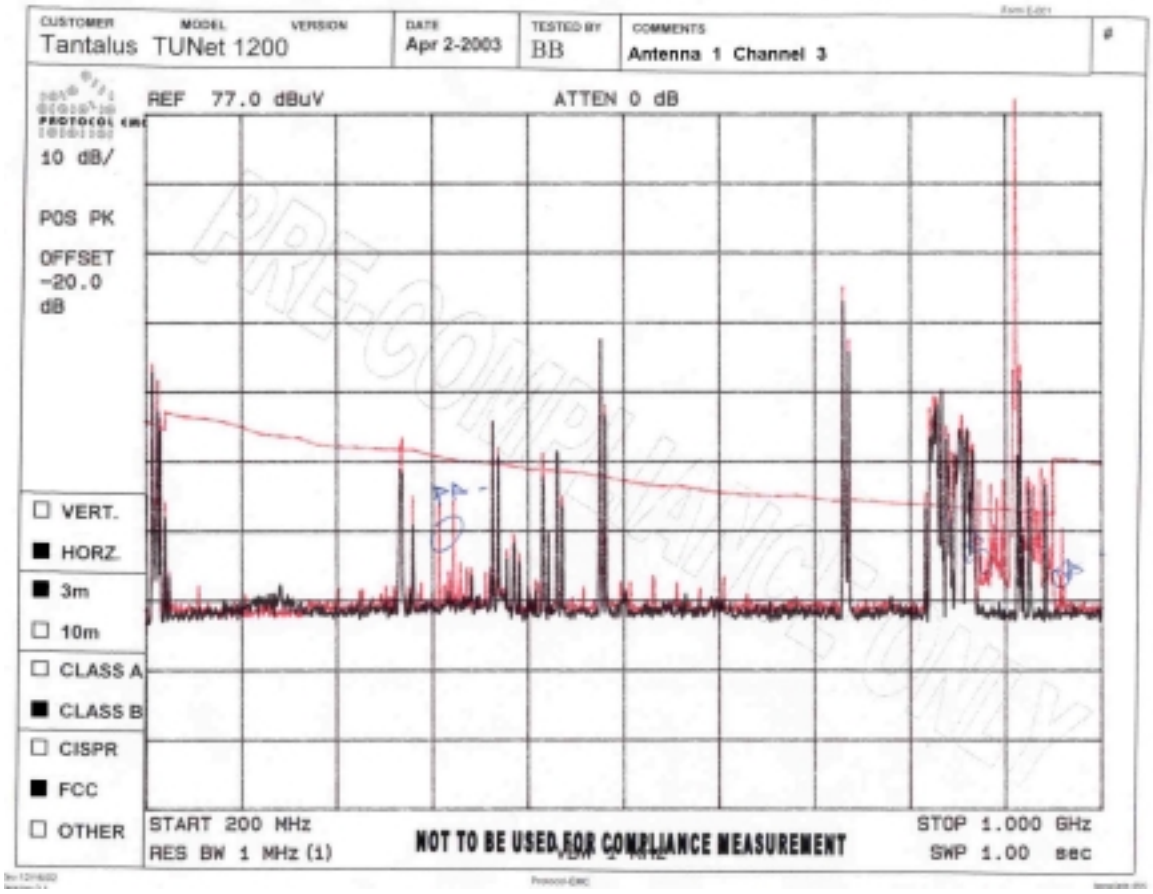
Harmonics and Spurious Emissions = 20 dBc

Restricted Band Emissions = AVG 54 dBµV/m

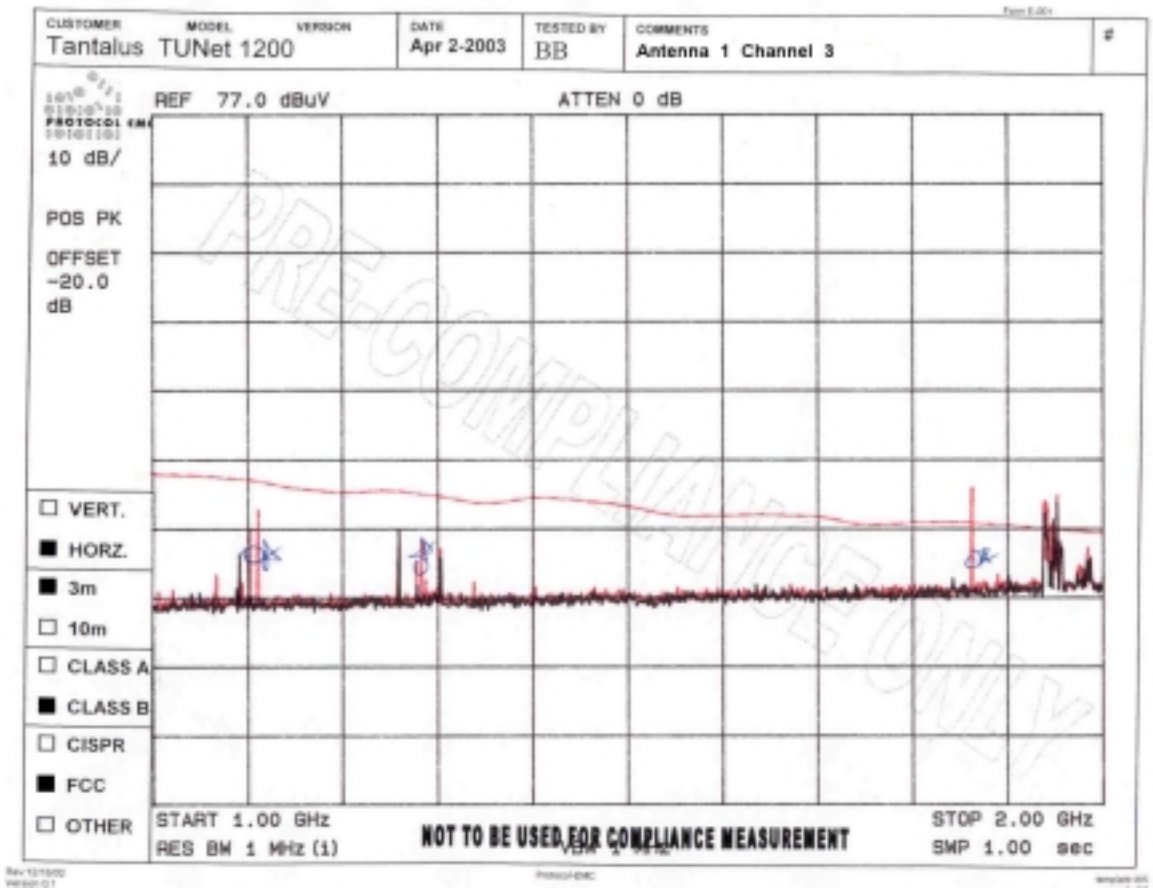
5.5 Spurious Emissions Plots



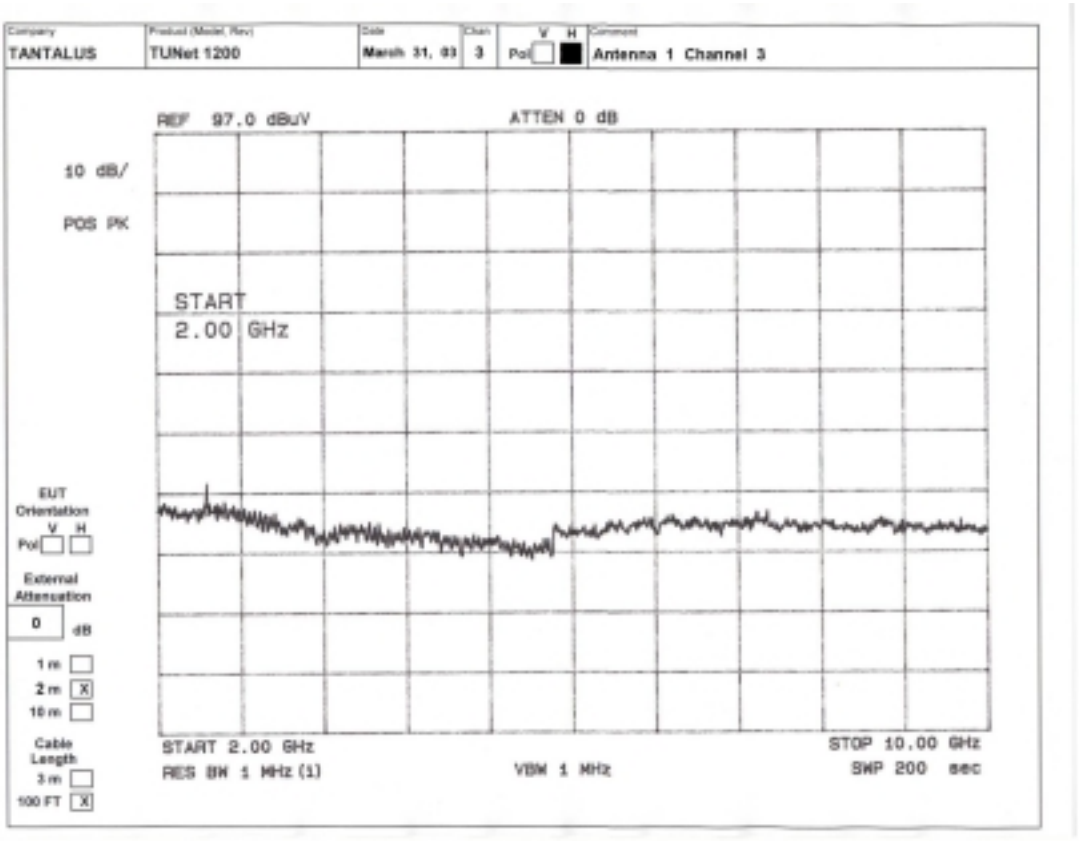
30 MHz to 200 MHz



200 MHz to 1 GHz


CUSTOMER
Tantalus
MODEL
TUNet 1200
VERSION
DATE
Apr 2-2003
TESTED BY
BB
COMMENTS
Antenna 1 Channel 3
#
REF 77.0 dBuV
ATTEN 0 dB
10 dB/
POS PK
OFFSET
-20.0
dB
VERT.
HORZ.
3m
10m
CLASS A
CLASS B
CISPR
FCC
OTHER
START 1.00 GHz
RES BW 1 MHz (1)
NOT TO BE USED FOR COMPLIANCE MEASUREMENT
STOP 2.00 GHz
SWP 1.00 sec

1 GHz to 2 GHz



2 GHz to 10 GHz

6.0 Band Edge

6.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
Antenna	EMCO 3105 Horn	2024	10/30/02	10/30/03
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Microwave Amplifier	HP8349A	2512A00824	09/13/02	09/13/03
Tower	Rhientech Labs	Custom	N/A	N/A
Turntable	Protocol	Custom	N/A	N/A

6.2 Test Setup

The EUT was placed in normal operating mode for the duration of the test. The EUT was rotated 360 degrees to determine the worst case angle for the maximum emissions level. The antenna was raised and lowered from 1 m to 4 m to find the maximum emissions level. Both horizontal and vertical antenna polarizations were tested to find the worst case polarization. 3 channels were tested. This test was performed at a distance of 3 m from the EUT to the measurement antenna. Both antennas were tested to show complete compliance.

6.3 Test Standard

FCC CFR47, Part 15, Subpart B 15.247c

6.4 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 an RF 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)).

6.5 Observations

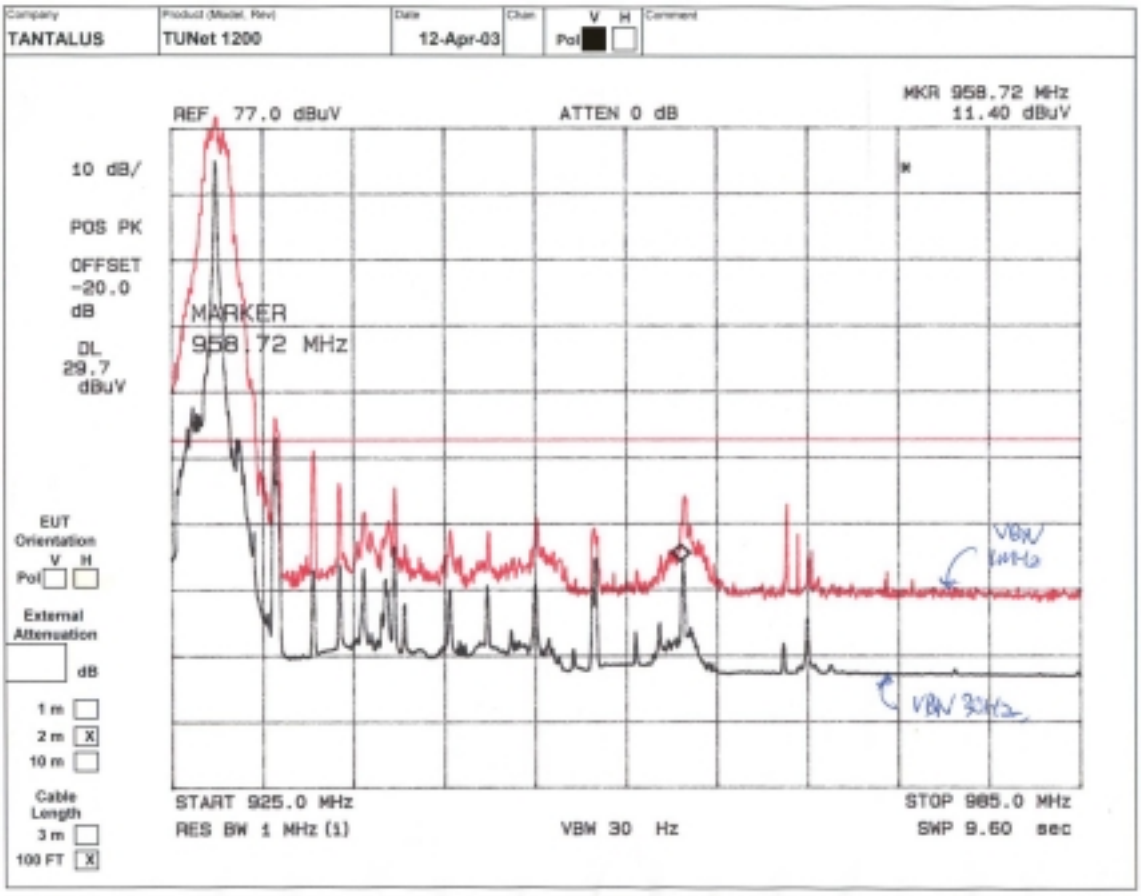
The band edges of the EUT are within the limits for emissions in the restricted bands.

6.6 Test Result Channel 3

Product : TUNet 1200
Test Item : Band Edge Measurement
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Orientation	Frequency MHz	Limit dBc	Result
Horizontal	<2400	>20	Pass
Vertical	<2400	>20	Pass

6.6.1 Channel 3 Band Edge Plot Horizontal



7.0 Radiated Output Power

7.1 Test Equipment

Device	Model Number	Serial No.	Last Cal.	Next Cal
Antenna	EMCO 3105 Horn	2024	10/30/02	10/30/03
Spectrum Analyzer	Hewlett Packard 8566B	2241A02102	01/13/03	01/13/04
RF-Preselector	Hewlett Packard 85685A	3107A01222	01/10/03	01/10/04
Quasi-Peak Adapter	Hewlett Packard 85650A	2043A00240	01/13/03	01/13/04
Microwave Amplifier	HP8349A	2512A00824	09/13/02	09/13/03
Tower	Rhientech Labs	Custom	N/A	N/A
Turntable	Protocol	Custom	N/A	N/A

7.2 Test Setup

The EUT was placed in normal operating mode for the duration of the test. The EUT was rotated 360 degrees to determine the worst case angle for the maximum emissions level. The antenna was raised and lowered from 1 m to 4 m to find the maximum emissions level. Both horizontal and vertical antenna polarizations were tested to find the worst case polarization. 3 channels were tested. This test was performed at a distance of 3 m from the EUT to the measurement antenna. Both antennas were tested to show complete compliance.

7.3 Test Standard

FCC CFR47, Part 15, Subpart B 15.247c

7.4 Limits

The limit for maximum radiated power is 30 dBm at antenna or 125.23 dBµV/m @ 3m.

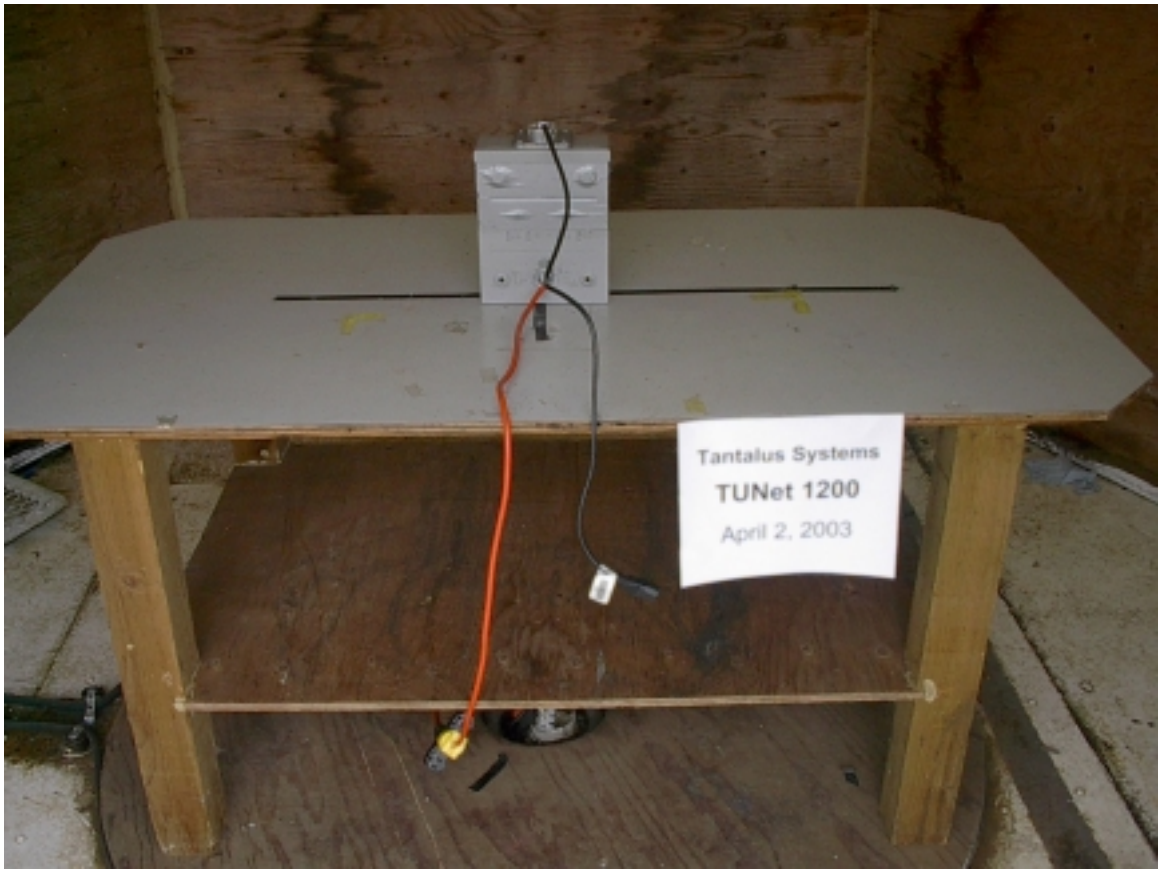
7.5 Test Result for all Antennas

Product : TUNet 1200
Test Item : Radiated power measurements
Test Site : Protocol EMC
Test Mode : Full Transmit Mode

Antenna	Frequency (MHz)	Polarity	Uncor Pk (dBµV)	Tot Corr (dB)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Delta Limit (dB)
1	902.17	Horz	83.2	28.1	111.3	125.23	-13.93
1	915.00	Horz	93.3	27.8	121.1	125.23	-4.13
1	927.82	Horz	90.9	27.5	118.4	125.23	-6.83
2	902.17	Horz	85.0	28.1	113.1	125.23	-12.13
2	915.00	Horz	93.3	27.8	121.1	125.23	-4.13
2	927.82	Horz	93.9	27.5	121.4	125.23	-3.83

8.0 Test Photos

Front Test Photo



Rear Test Photo