Computational Systems, Inc.
FCC Part 15, Certification Application
8000RF

January 29, 2001

MEASUREMENT/TECHNICAL REPORT

COMPANY NAME: **Computational Systems, Inc.**

MODEL: **8000RF**

FCC ID: **NL58000RF**

DATE: **January 29, 2001**

This report concerns (check one): Original grant_X__
Class II change_____

Equipment type: **RF Data Transceiver Adapter**

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No_X_

If yes, defer until:_________________
date

N.A. agrees to notify the Commission by N.A.
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

SECTION 1

GENERAL INFORMATION

GENERAL INFORMATION

1.1 Product Description

The Equipment Under Test (EUT) is a Computational Systems, Inc. UltraSpec® RF Adapter, Model 8000RF. The Model 8000 RF is sold as part of a Computational Systems, Inc. UltraSpec® Laser Head Alignment System. This system consists of the following:

- Two Laser Head units (either model 8215 or 8225, but not used as a mixed system), approx. size 4" x 1.5" x 5" each

- One Model 8000RF RF Adapter, approx. size 2" x 1.5" x 1.5", which is the RF communications interface between the laser heads and auxiliary CSI data acquisition equipment not subject of this approval. An included 2 ft. head-head cable may be used optionally for a special data mode while in RF.

- One A821500 Wired Adapter cabled interface to optionally use between the laser heads and auxiliary CSI data acquisition equipment not subject of this approval (if RF communication is not desired).

Both above adapters connect directly to auxiliary CSI data acquisition equipment (not subject of this approval) via a DB-25 connector.

<u>System Description:</u>

The laser heads are used to align a shaft that spins (e.g., motor, pump, etc.) by mounting on the parked shaft separated by some distance determined by the length of the shaft and other factors. Each head has a laser output aperture and a photosensitive detector (PSD) aperture. The difference between each head of a pair is the configuration of these two apertures: one unit's apertures are inverted such that each laser beam will strike the opposite mounted unit's PSD surface. With both heads properly mounted on the shaft, the shaft is slowly rotated by hand while both heads are collecting position data on each PSD and rotation angle data via internal sensors. Data is transferred to auxiliary CSI data acquisition equipment for analysis and mathematical calculations, resulting in corrections reported to the user for moving the motor feet, mountings, etc. for straightening the spin axis. The difference between the 8215 and 8225 models is that the 8215 is specified for a maximum head-to-head separation distance of 30 feet, and the 8225 is specified for mounting up to 100 ft. apart. This difference is solely due to the optical parts used: a laser diode and the photosensitive detector. The laser diode has its optics modified for the appropriate range, and the PSDs are of differing surface area, the longer range 8225 having a 20 mm x 20 mm surface area vs. the 8215's 10 mm x 10 mm surface area. The electronics, laser and sensor drive levels, RF circuitry, metalwork cutouts, etc. are the same for both models.

1.1 Product Description (Cont.)

Power

The laser heads are each powered by a 4 cell, 650 mAH Ni-Cad battery. The batteries are not recharged while the system or its components are in use. Both communication adapters (RF and wired) obtain their power from 5 VDC regulated voltage supplies in the auxiliary data acquisition equipment to which they are connected.

RF

The RF circuitry in both heads and the 8000RF adapter is the same except for the transmit drive level circuit. Although component values are slightly different there, no unit is intended to transmit up to the vendor’s rated limit of about 0.85mW. The transmit frequency is 916.5 MHz and the modulation is OOK. The circuit used is per RF Monolithics, Inc. of Dallas, Texas and uses their model TR1000 transceiver integrated circuit chip. All three transceiver units use 2" helical whip antennas, Linx Technologies model ANT-900-CW-RH, which are mounted on reverse-SMA connectors.

1.2 Related Submittal(s)/Grant(s)

The EUT will be used with part of a system to send/receive data. The transceiver presented in this report will be used with another transceiver which has been submitted under FCC ID: NL58215

The EUT is subject to the following authorizations:

a) Certification as a transceiver
b) Verification as a receiver and digital device

The information contained in this report is presented for the certification & verification authorization(s) for the EUT.

SECTION 2

TESTS AND MEASUREMENTS

TEST AND MEASUREMENTS

2.1 Configuration of Tested System

The sample was tested per ANSI C63.4, Methods of Measurement from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (1992). Conducted and radiated emissions data were taken with the test receiver or spectrum analyzer's resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was off throughout the evaluation process. Interconnecting cables were manipulated as necessary to maximize emissions. Interconnecting cables were manipulated as necessary to maximize emissions. A block diagram of the tested system is shown in Figure 1a through Figure 1b. Test configuration photographs for spurious and fundamental emissions are shown in Figure 2a through Figure 2f.

The sample used for testing was received by U.S. Technologies on November 7, 2000 in good condition. Additional accessories necessary for some tests were received on December 5, 2000.

The tablet computer for use with the EUT was considered by Computational Systems, Inc. to be exempt from Part 15 since the unit is solely used as test equipment for industrial/commercial applications (as given by Part 15.103 (c)). In order to complete all tests for the EUT without possible interference from the tablet computer, two separate test configurations were used. The EUT was configured as a stand alone with an alternative power source for testing to Class B limits for the receiver/digital device emissions. However, it was necessary to attach the tablet computer in order to activate the EUT for RF transmitter tests.

2.2 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA. This site has been fully described and submitted to the FCC, and accepted in their letter marked 31040/SIT. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number IC2982.

2.3 Test Equipment

Table 2 describes test equipment used to evaluate this product.

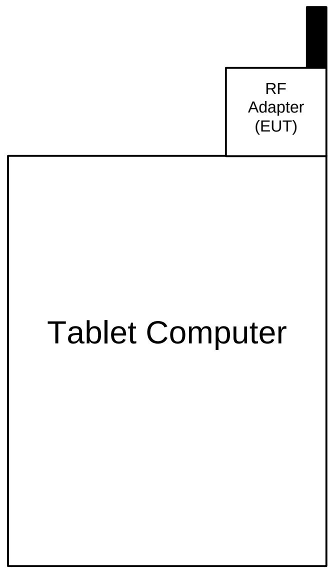
2.4 Modifications

No modifications were made by US Tech, to bring the EUT into compliance with FCC Part 15 limits for the transmitter portion of the EUT or the Class B Digital Device Requirements.

FIGURE 1a

TEST CONFIGURATION

(RF TRANSMITTER TESTS)

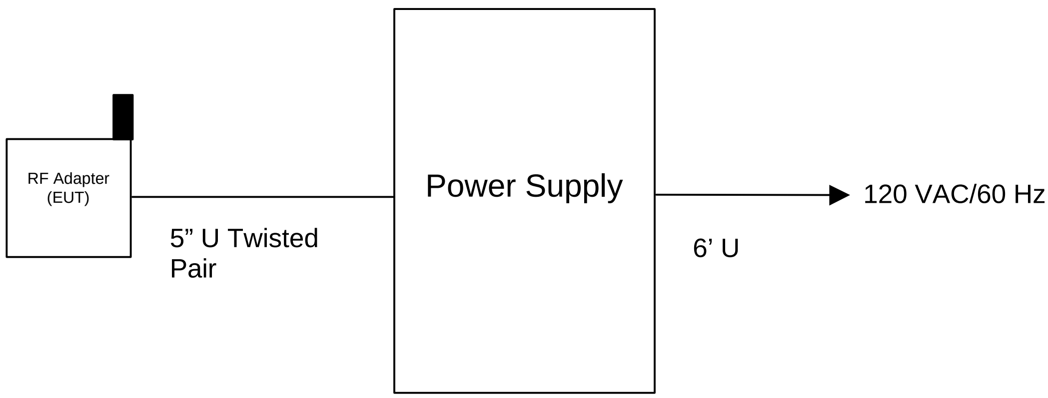


S = Shielded
U = Unshielded

FIGURE 1b

TEST CONFIGURATION

(RECIEVER & DIGITAL DEVICE TESTS)

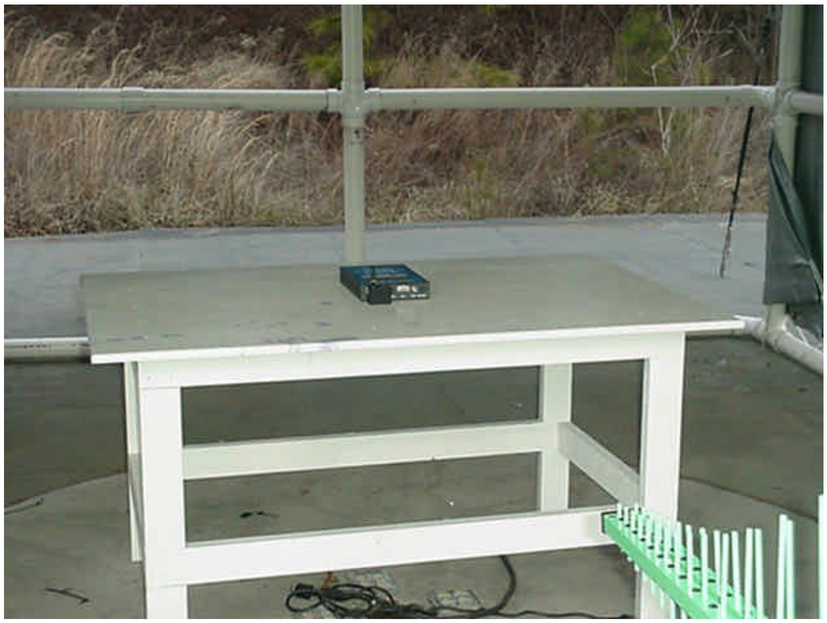


S = Shielded
U = Unshielded

Test Date: January 23 & 25, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2a

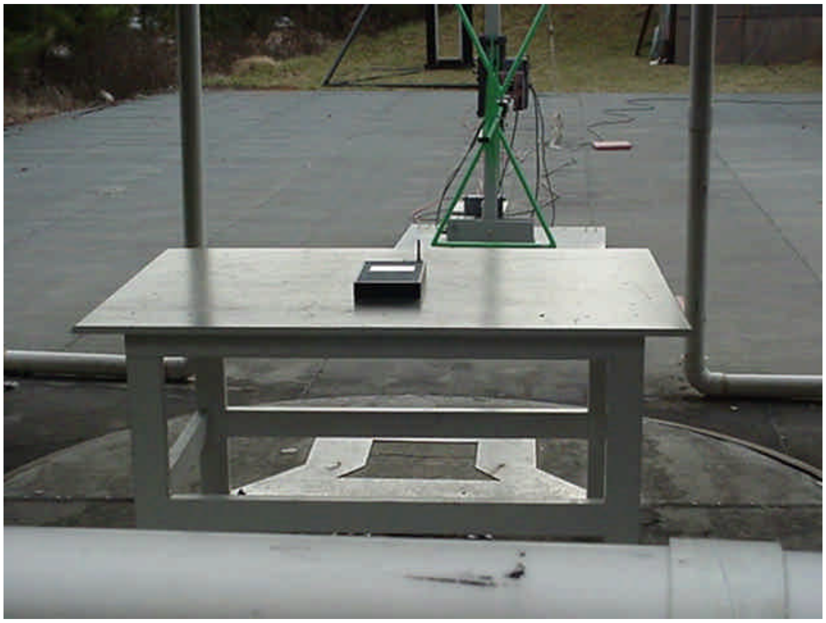
Photograph(s) for Spurious and Fundamental Emissions (Front)



Test Date: January 23 & 25, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2b

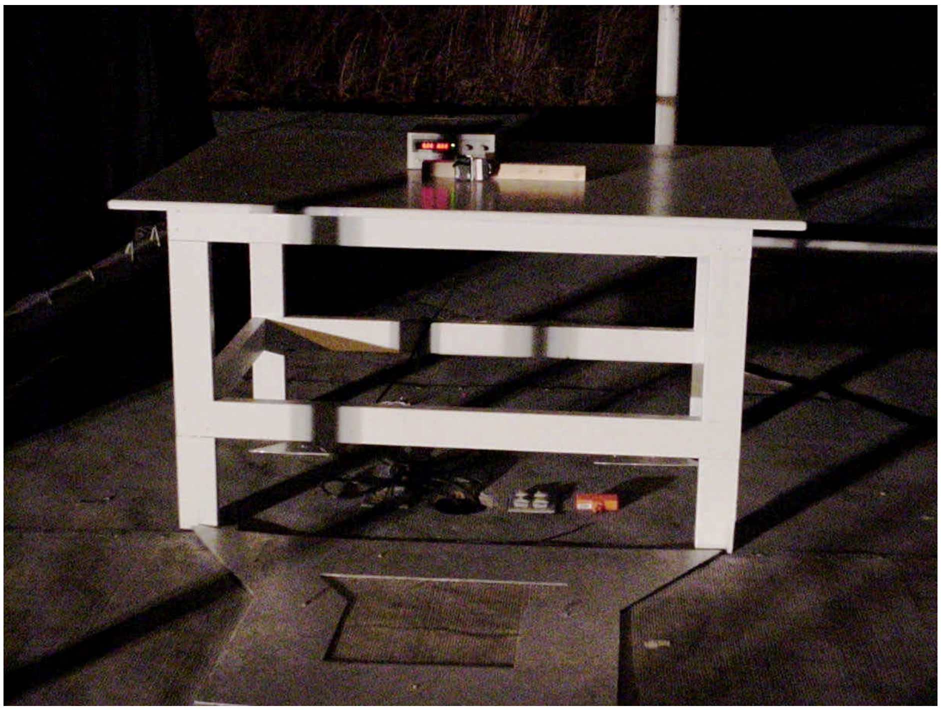
Photograph(s) for Spurious and Fundamental Emissions (Back)



Test Date: December 18, 2000 & January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2c

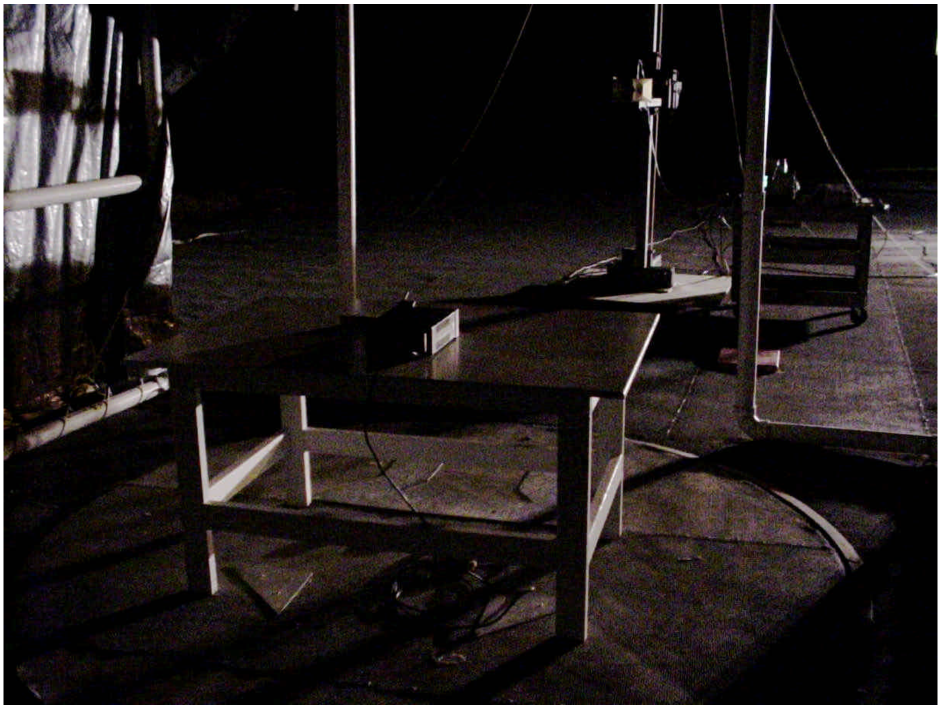
Photograph(s) for Digital Device Emissions (Front)



Test Date: December 18, 2000 & January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2d

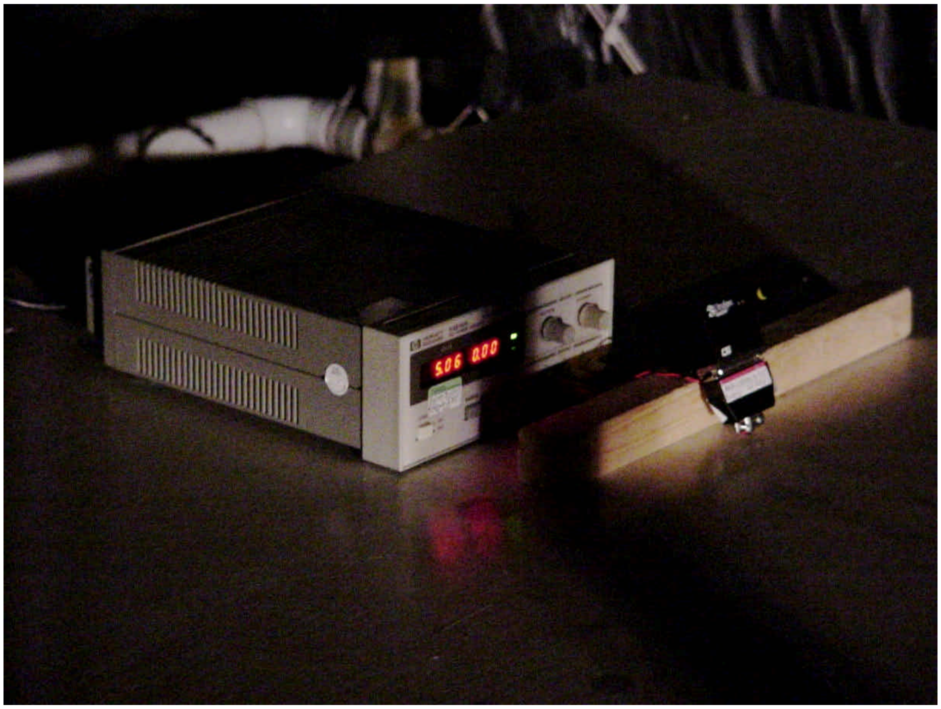
Photograph(s) for Digital Device Emissions (Back)



Test Date: December 18, 2000 & January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2e

Photograph(s) for Digital Device Emissions (Table Top View)



Test Date: December 18, 2000 & January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

FIGURE 2f

Photograph(s) for Digital Device Conducted Emissions

Since the EUT operates from battery operated devices, this test was deemed not necessary.

TABLE 1

EUT and Peripherals

(RF TRANSMITTER TESTS)

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
RF Data Transceiver Adapter (EUT) Computational Systems, Inc.	8000RF	00110457	NL58000RF (Pending)	
Antenna (EUT) Linx Technologies	ANT-900-CW-RH	N/A	N/A	
Tablet Computer Computational Systems, Inc.	B811701	822063	N/A	

(RECIEVER/DIGITAL DEVICE TESTS)

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
RF Data Transceiver Adapter (EUT) Computational Systems, Inc.	8000RF	00110457	NL58000RF (Pending)	5” U Twisted Pair
Antenna (EUT) Linx Technologies	ANT-900-CW-RH	N/A	N/A	
DC Power Supply Hewlett Packard	E3610A	KR41808243	N/A	6’ U Power Cord

TABLE 2
TEST INSTRUMENTS

TYPE	MANUFACTURER	MODEL	SN.
SPECTRUM ANALYZER	HEWLETT-PACKARD	8593E	3205A00124
SPECTRUM ANALYZER	HEWLETT-PACKARD	8558B	2332A09900
S A DISPLAY	HEWLETT-PACKARD	853A	2404A02387
COMB GENERATOR	HEWLETT-PACKARD	8406A	1632A01519
RF PREAMP	HEWLETT-PACKARD	8447D	1937A03355
RF PREAMP	HEWLETT-PACKARD	8449B	3008A00480
HORN ANTENNA	EMCO	3115	3723
HORN ANTENNA	EMCO	3116	9505-2255
BICONICAL ANTENNA	EMCO	3110	9307-1431
LOG PERIODIC ANTENNA	EMCO	3146	9110-3600
BILOG	CHASE	CBL6112B	2584
PLOTTER	HEWLETT-PACKARD	7475A	2325A65394

2.6 Antenna Description (Paragraph 15.203)

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

The Model Computational Systems, Inc. 8000RF incorporates an external antenna only.

Manufacturer:	Linx Technologies
Type:	2“ Whip
Model Number:	ANT-900-CW-RH
Gain:	< 0 dBi
Connector:	Reverse Polarity SMA

2.7 Field Strength of Fundamental within the Band 902-928 MHz per FCC Section 15.249(a)

Peak power within the band 902-928 MHz has been measured with a spectrum analyzer. Peak measurements were made using a peak or quasi-peak detector. Average emissions are not considered applicable since the measurement was below 1000 MHz.

The results of the measurements for peak fundamental emissions are given in Table 3 and Figure 3.

Table 3
FIELD STRENGTH OF FUNDAMENTAL EMISSION

Test Date: January 26, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

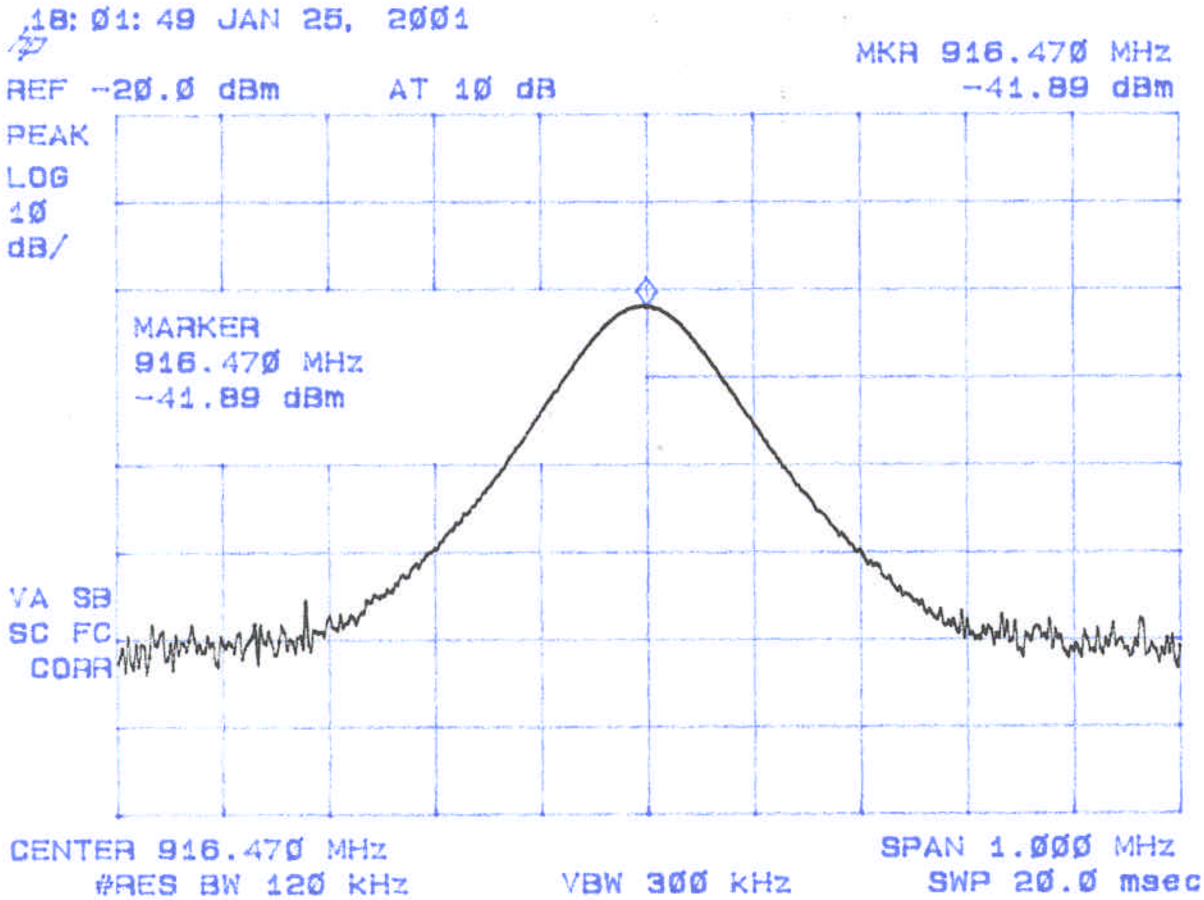
FREQ. (MHz)	TEST DATA (dBm) @ 3m	ANTENNA FACTOR + CABLE ATTENUATION	RESULTS (uV/m) @ 3m	PEAK FCC LIMITS (uV/m) @ 3m
916.5	-41.9	28.6	48,685.5	50,000

SAMPLE CALCULATIONS:

RESULTS uV/m @ 3m = Antilog ((-41.9 + 28.6 + 107)/20) = 48,685.5
CONVERSION FROM dBm TO dBuV = 107 dB

Tested By: ____________________ **Name:** Cyril Binnom

Figure 3
Field Strength of Fundamental Emissions 15.249(a)



2.8 Peak Radiated Spurious Emissions in the Frequency Range 30 - 10000 MHz (FCC Section 15.247(c))

A preliminary scan was performed on the EUT to determine frequencies that were caused by the transmitter portion of the product. Radiated measurements below 1 GHz were tested with a RBW = 120 kHz. Radiated measurements above 1 GHz were measured using a RBW = VBW = 1 MHz. The results of peak radiated spurious emissions are given in Table and Figure 4a through Figure 4c.

Table 4 Peak Radiated Spurious Emissions

Freq. (GHz)	Test Data (dBm) @3m	Amp. Gain (dB)	Antenna Factor (dB)	Cable Loss (dB)	Results (uV/m) @3m	FCC Limits (uV/m) @3m
1.8332	-53.5	35.2	28.6	3.4	326.0	5000
2.6339	-58.6	34.8	30.8	4.1	265.6	5000
2.7494	-61.4	34.8	30.9	4.2	198.9	5000

SAMPLE CALCULATION:
RESULTS (uV/m @ 3m) = Antilog ((-53.5 - 35.2 + 28.6 + 3.4 + 107)/20) = 326.0
CONVERSION FROM dBm TO dBuV = 107 dB

Tester
Signature: J McDonald **Name:** Jim McDonald

Figure 4a
Peak Radiated Spurious Emission 15.247(c)

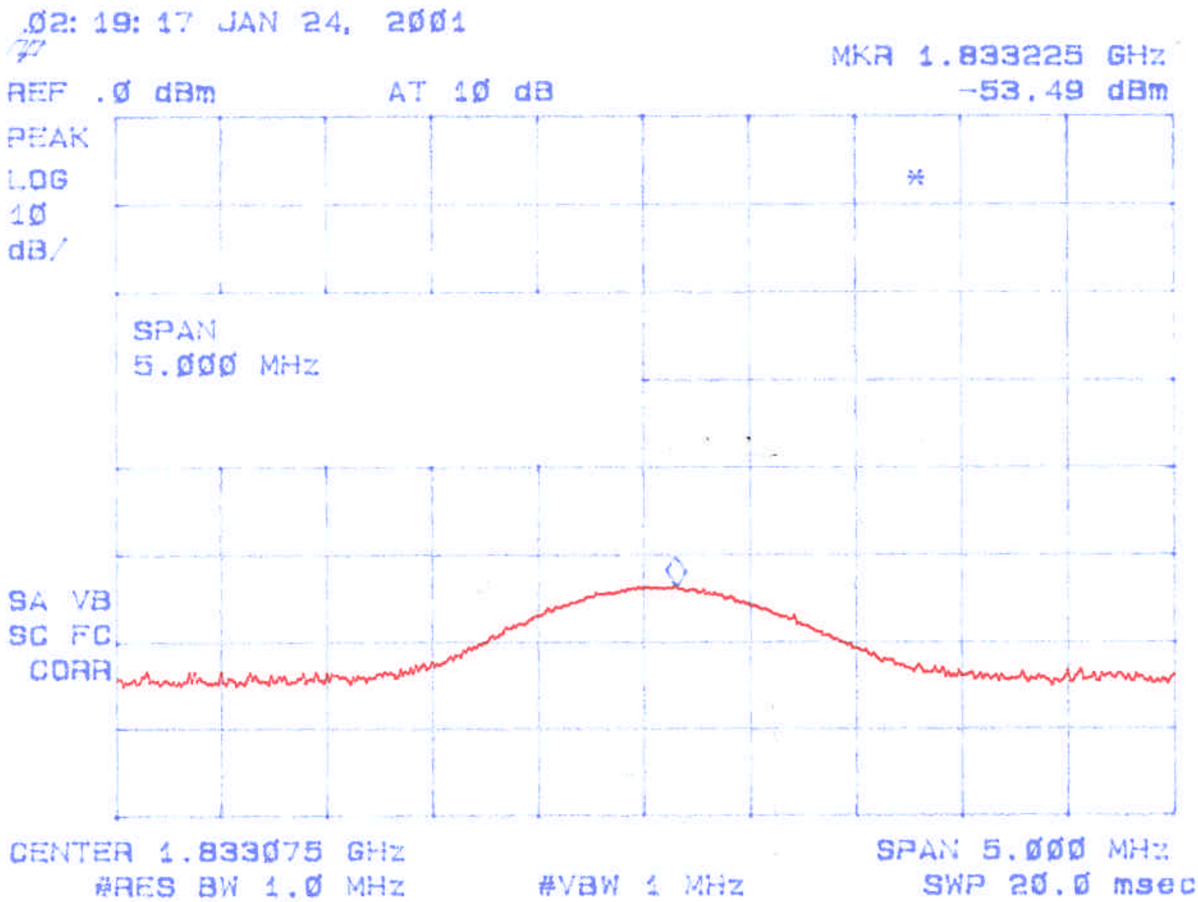


Figure 4b
Peak Radiated Spurious Emission 15.247(c)

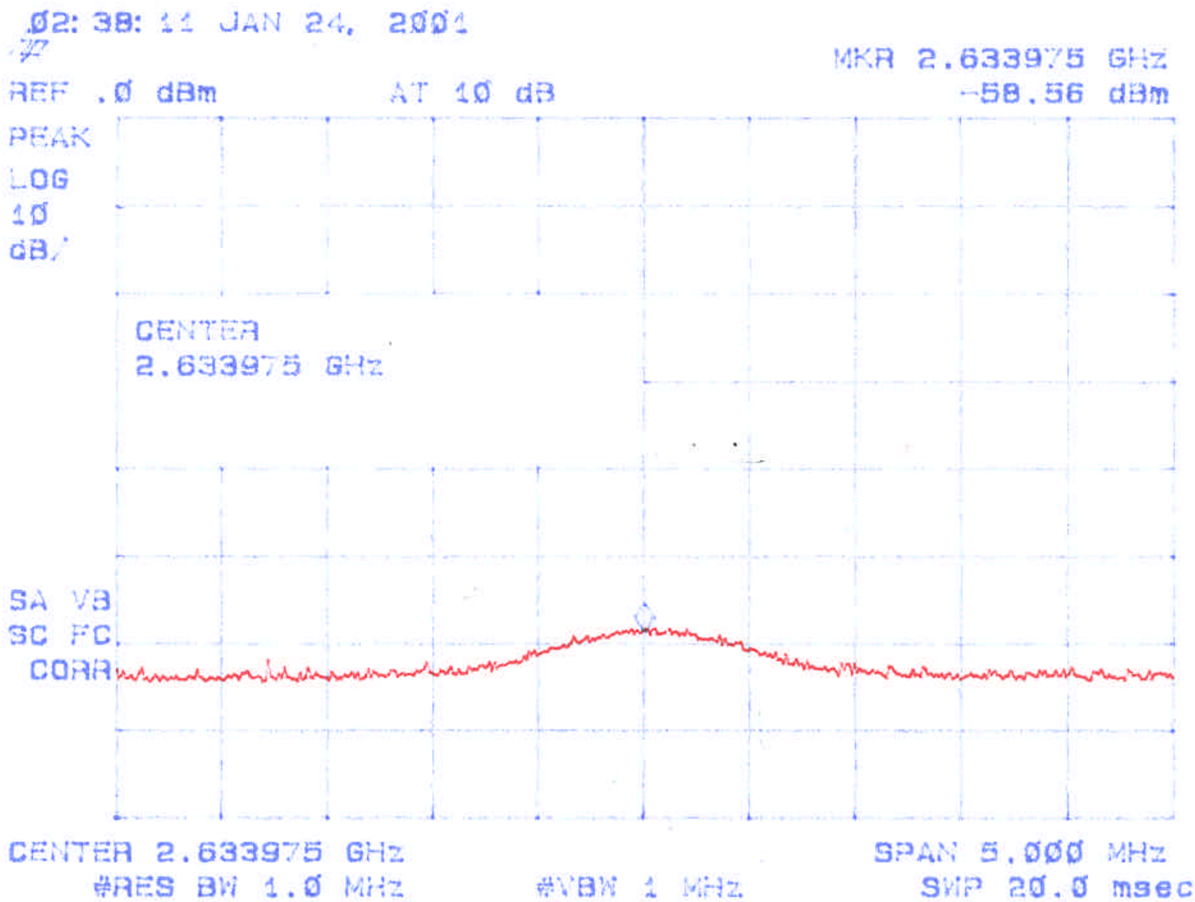
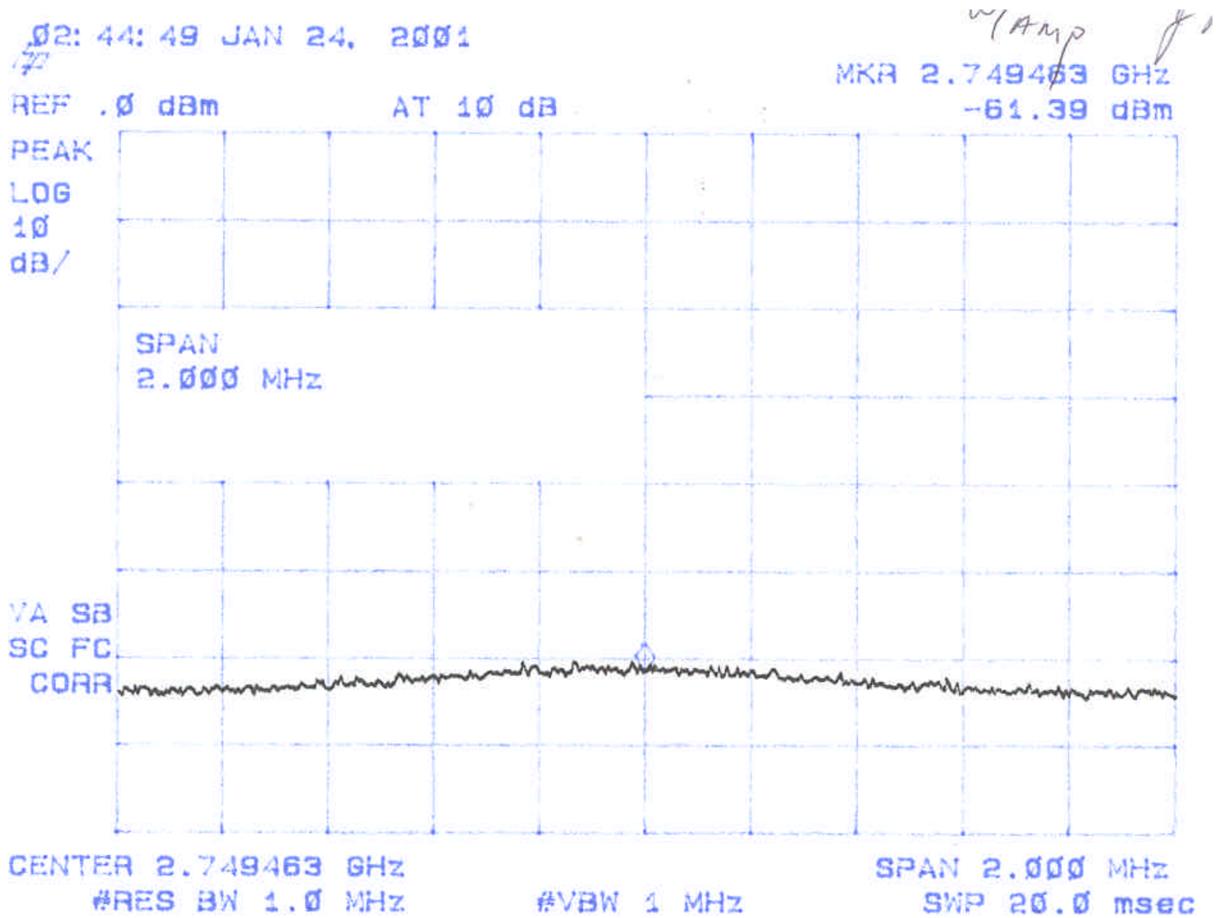


Figure 4c
Peak Radiated Spurious Emission 15.247(c)



2.9 Average Spurious Emission in the Frequency Range 30 - 10000 MHz (FCC Section 15.247(c))

The Average measurement was derived from applying any possible duty cycle correction to the peak reading. The results of average radiated spurious emissions are given in Table 5.

Duty Cycle Correction During 100 msec:

Worst case duty cycle for the EUT is when it is in continuous status mode (case “A” or “B” shown in the section to follow). This mode must be commanded via external CSI data acquisition test equipment. See below for transmit waveforms including duty cycle information. The Worse Case Duty Cycle Calculation for these modes is:

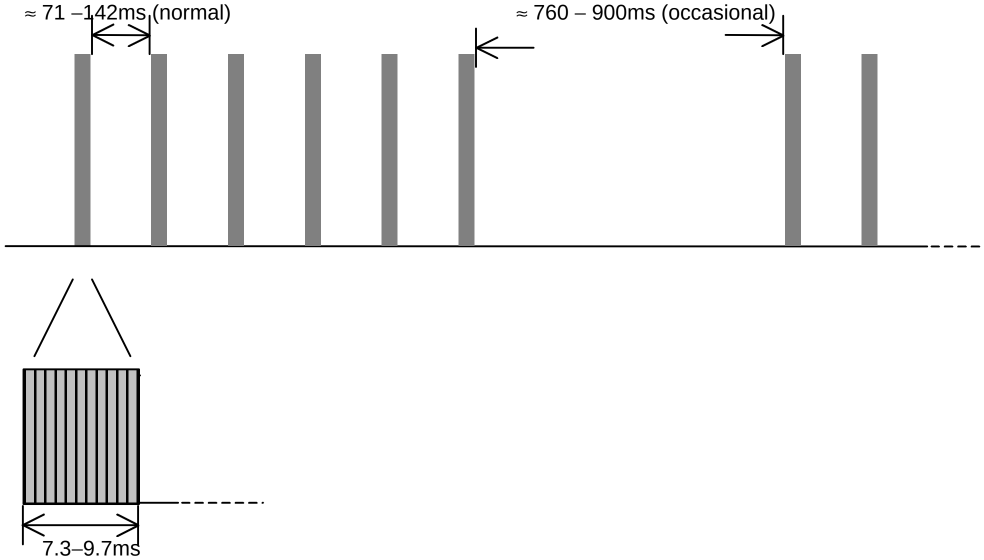
$$\text{Duty Cycle Correction} = 20 \log (0.0145) = -36.8 \text{ dB}$$

<u>The CSI 8000RF Adapter RF Output (Transmit) Data Streams</u>

The Computational Systems, Inc. (CSI) UltraSpec® model 8000RF Adapter transmits RF data via a 916.5 MHz carrier frequency which is On-Off Key (OOK) modulated by an 11.52 kbps data stream of approximately 50% average density (i.e., number of zeroes ≈ number of ones). This unit sends RF data requests to CSI UltraSpec® models 8215 or 8225 Laser Heads in a system comprised of two of either 8215 or 8225 model laser heads and one 8000RF adapter. Since the adapter initiates all RF transmission in the system, it can send requests whether or not the heads are responding back with data, depending on whether the receiving heads are powered and are addressed appropriately. Thus the RF data output timing waveforms for the adapter are slightly different for the mode of continuous status reception with data being received (case “A” as per below), and not being received (case “B” as per below). “Status” refers to instantaneous sensor information. A third RF output waveform is produced when shaft alignment data is transferred from the heads to the adapter (case “C” as per below).

Duty Cycle Correction During 100 msec (Continued):

A. CONTINUOUS STATUS MODE **WITH** RECEPTION FROM 8215 OR 8225 LASER HEADS:

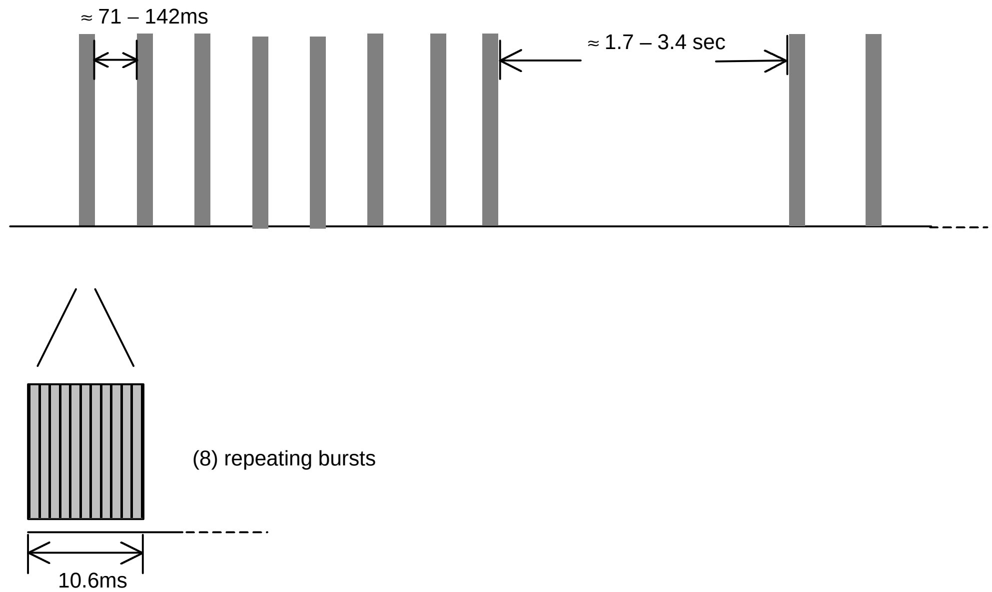


Each data burst: 11.5kbps with ≈50% duty cycle

The maximum data rate for the above case would be 9.7 ms of 50% duty cycle data out of every (71ms + 9.7 ms) (ignoring the longer gaps). This is equivalent of about 12 ms of such data every 100 ms, or ≈ 6 ms of on time per 100 ms (12 ms x 50% = 6 ms). Worst case over any 100 ms, there could be a minimum of 71ms spacing with the remainder of the 100 ms, or 29 ms, filled with data. This would be 14.5 ms of on time (29 ms x 50%) over a 100 ms span.

Duty Cycle Correction During 100 msec (Continued):

B. CONTINUOUS STATUS MODE **WITHOUT** RECEPTION FROM 8215 OR 8225 LASER HEADS:

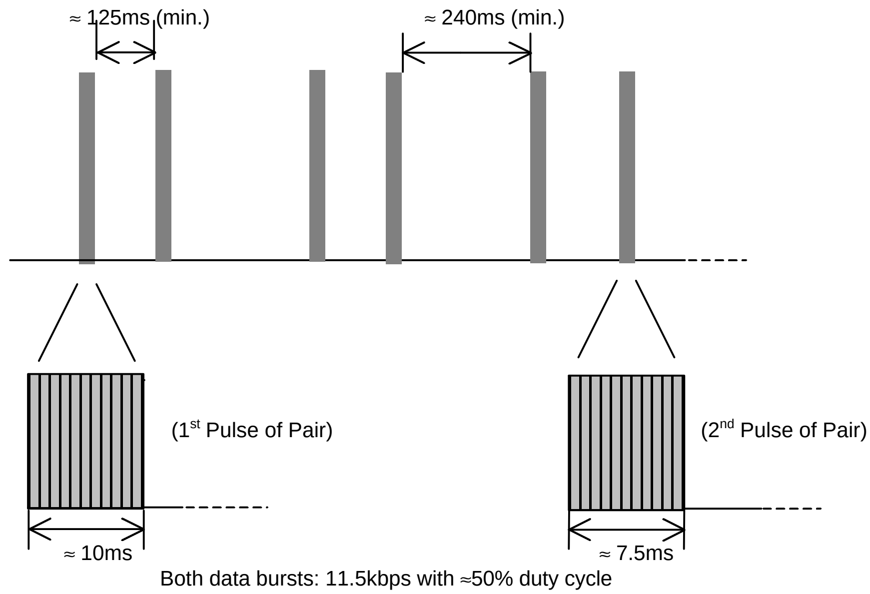


Each data burst: 11.5kbps with ≈50% duty cycle

The maximum data rate for the above case would be: [(10.6 ms of 50% duty cycle data) x 8] = 84.8 ms of 50% duty cycle data out of every [84.8 ms + (71 ms x 7) + 1.7 sec] = 2.28 sec. Worst case over any 100 ms, there could be a minimum of 71 ms spacing with the remainder of the 100 ms, or 29 ms, filled with data. This would be 14.5 ms of on time over a 100 ms span.

Duty Cycle Correction During 100 msec (Continued):

C. DOWNLOAD DATA MODE:



The maximum data rate for the above case would be 10 ms of 50% duty cycle every (10 ms + 125 ms) (worst case). Over any 100 ms, the worst case density would be just the 10 ms of 50% duty cycle data or 5 ms of on time per 100 ms.

Table 5 Average Radiated Spurious Emissions

Freq. (GHz)	Test Data* (dBm) @3m	Amp. Gain (dB)	Antenna Factor (dB)	Cable Loss (dB)	Results (uV/m) @3m	FCC Limits (uV/m) @3m
1.8332	-90.3	35.2	28.6	3.4	4.7	500
2.6339	-95.4	34.8	30.8	4.1	3.8	500
2.7494	-98.2	34.8	30.9	4.2	2.9	500

*** = Data adjusted by 20 log (0.0145) = –36.8 dB for duty cycle.**

SAMPLE CALCULATION:

RESULTS (uV/m @ 3m) =
Antilog ((-90.3 - 35.2 + 28.6 + 3.4 + 107)/20) = 4.7
CONVERSION FROM dBm TO dBuV = 107 dB

Tester
Signature: ______________ **Name:** __Jim McDonald__

2.10 Power Line Conducted Emissions for Transmitter FCC Section 15.207

The conducted voltage measurements have been carried out in accordance with FCC Section 15.207, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmit. The results are given in Table 6.

Table 6. Conducted Emissions Data
Class B

Test Date: January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Product: 8000RF

Frequency (MHz)	Test Data (dBm) Phase Neutral	RESULTS (uV) Phase Neutral	FCC Limits (uV)
Conducted Emissions were considered not applicable since the EUT is portable and only battery powered.			

Tester Signature: ____________________ **Name:** Cyril Binnom

2.11 Radiated Emissions (47 CFR 15.109a)

Radiated emissions were evaluated from 30 to 5000 MHz. Measurements were made with the analyzer's bandwidth set to 120 kHz measurements made less than 1 GHz and 1 MHz are shown in Table 7a. Measurements made over 1 GHz results are shown in Table 7b.

Table 7a. Radiated Emissions Data

Class B

Test Date: December 18, 2000
UST Project: 00-0562
Customer: Computational Systems, Inc.
Product: 8000RF

Frequency (MHz)	Receiver Reading (dBm) @3m	Correction Factor (dB)	Corrected Reading (uV/m)	FCC Limit (uV/m) @3m
132.8	-88.0	14.5	47.5	150.0
143.8	-89.0	15.0	44.7	150.0
149.3	-89.0	15.2	45.6	150.0
154.8	-90.0	15.2	41.0	150.0
165.8	-87.0	15.4	59.0	150.0
177.0	-89.0	16.1	50.5	150.0

SAMPLE CALCULATIONS:

RESULTS uV/m @ 3m = Antilog ((-88.0 + 14.5 + 107)/20) = 47.5
CONVERSION FROM dBm TO dBuV = 107 dB

Test Results Reviewed By Signature: ____________________ **Name:** Timothy R. Johnson

Table 7b Radiated Emissions Data

Class B

Test Date: January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Model: 8000RF

Measurements >1 GHz

FREQ. (GHz)	TEST DATA (dBm) @ 3m	AMP GAIN (dB)	ANT. FACTOR (dB)	CABLE LOSS (dB)	RESULTS (uV/m) @ 10m	FCC LIMITS (uV/m) @ 3m
No emissions detected from 1 GHz to 5 GHz at 3 meters						

Tester Signature: ____________________ Name: Cyril Binnom

2.12 Power Line Conducted Emissions for Digital Device FCC Section 15.107

The conducted voltage measurements have been carried out in accordance with FCC Section 15.107, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmit. The results are given in Table 8.

Table 8. Conducted Emissions Data – Digital Device Class B

Test Date: January 10, 2001
UST Project: 00-0562
Customer: Computational Systems, Inc.
Product: 8000RF

Frequency (MHz)	Test Data (dBm) Phase Neutral	RESULTS (uV) Phase Neutral	FCC Limits (uV)
Conducted Emissions were considered not applicable since the EUT is portable and only battery powered.			

Tester Signature: ____________________ **Name:** Cyril Binnom