

# NU-METRICS FCC INFORMATION

## **RF Measurement Report**

**Prepared by:**

### **National Certification Laboratory**

**8370 Court Avenue, Suite B-1  
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**In Support of:**

#### **FCC REPORT OF RADIO INTERFERENCE**

**For:**

**NU-METRICS  
University Drive Box 518  
Uniontown, Pennsylvania 15401**

**Model: RFM-2400 Transmitter**

**FCCID: MIK-NUMET24RFM**

#### **Demonstration of Compliance with FCC Rules Part 15.247**

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**April 9, 2001**

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***NCL PROJ.# Nu-Metrics-586***

## **1.0 General Information:**

This report has been prepared on behalf of **Nu-Metrics**, to support the attached Application for Certification of a Part 15 Spread Spectrum Transmitter. The Equipment Under Test (EUT) was the **Model: RFM-2400 Transceiver**. The EUT configuration consisted of an RFM-2400 transmitter, A.C. adapter, omni antenna, and 2.4 GHz in-line RF filter. The test results reported in this document relate only to the item that was tested.

Radio-Noise Emissions tests were performed according to *FCC Public Notice 54797, titled "Guidance on Measurement for Direct Sequence SST"*. The measuring equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

### **1.1 Summary:**

The Nu-Metrics, **RFM-2400 Transceiver**, complies with the FCC limits (15.247) for a Direct Sequence SST. Tests were performed on a single radio channel.

### **1.2 Test Methodology:**

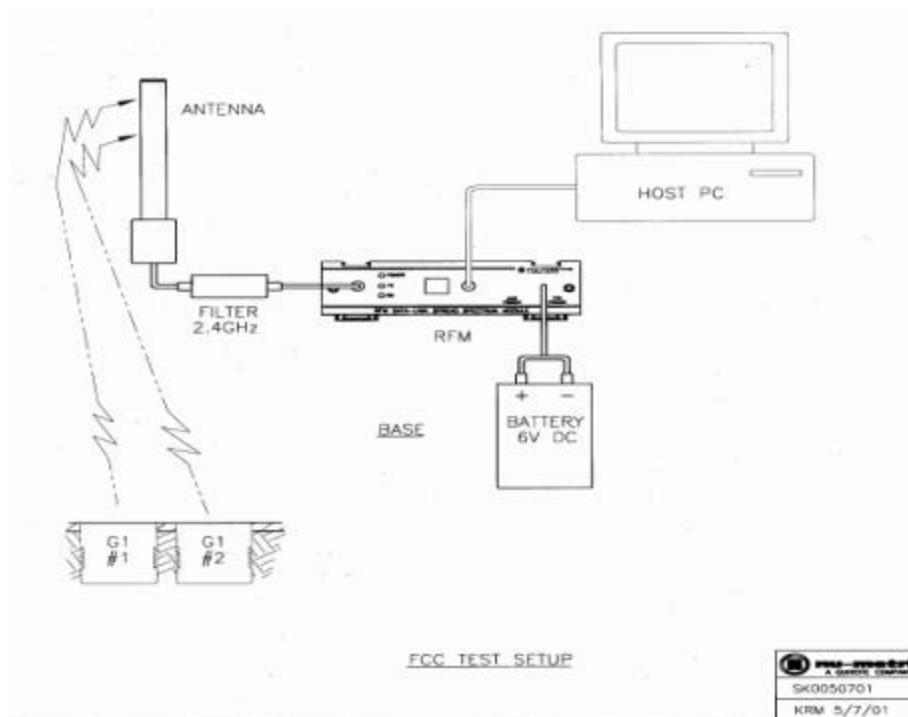
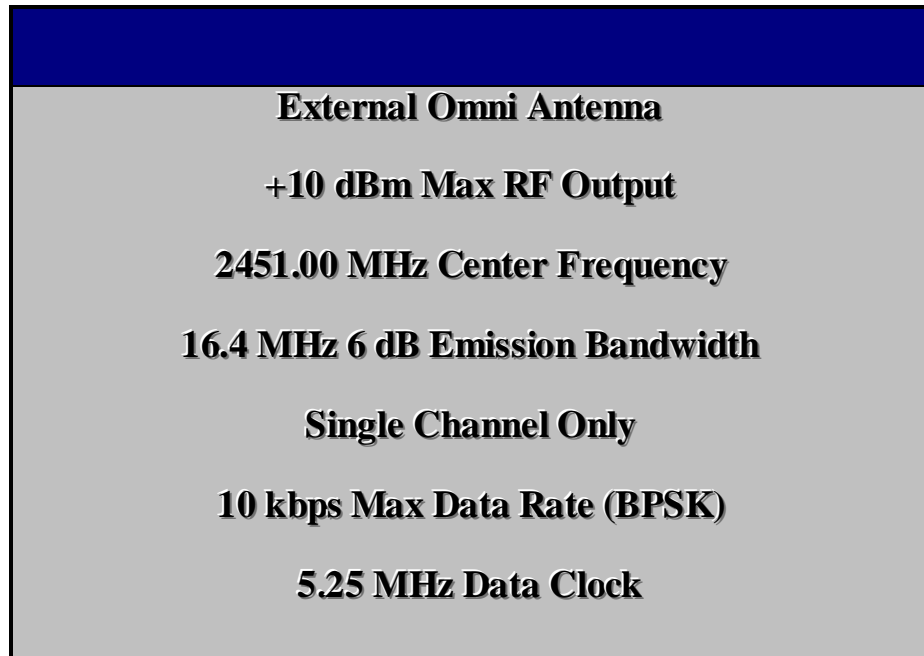
Both conducted and radiated testing were performed according to the procedures in ANSI C63.4 1992. Radiated testing was performed at an antenna to EUT distance of three (3) meters.

### **1.3 Test Facility:**

The open area test site and conducted measurement facility used to collect the radiated data is located on the parking lot of National Certification Laboratory 8370 Court Avenue, Suite B-1, Ellicott City, Maryland 21043. This site has been fully described in a report dated May 26, 1993, submitted to and approved by the Federal Communications Commission to perform AC line conducted and radiated emissions testing.

## **2.0 Description of Equipment Under Test (EUT):**

The EUT features:



### **2.1 EMI Countermeasure:**

The following modifications were made to the EUT, by the project engineer to assure compliance to specifications:

None.

### **3.0 Test Program:**

This report contains measurement charts and data as evidence for the following tests performed:

1. (15.247b) Peak RF output power.
2. (15.247a) 6 dB Emission Bandwidth.
3. (15.247d) Power Spectral Density (3kHz Bandwidth).
4. (15.247c) RF Antenna Conducted output of harmonics and spurious out-of-band emissions.
5. (15.247c) Field Strength of harmonics and spurious out-of-band emissions.
6. (15.207) AC Power Line Conducted Emissions.

#### **4.0 Test Configuration for Antenna Terminal Conducted:**

RF antenna conducted output tests such as Bandwidth, Spurious/Harmonics, Power Spectral Density, and Power output were taken with the antenna connector feeding directly into the spectrum analyzer via external **20 dB attenuator**, or into the **Peak RF meter** as appropriate. The analyzer's internal attenuator was adjusted to prevent overloading of the front end. The transmitter is modulated at 10 kbps that is the highest available data rate.

Field strength measurements were taken with the transmitter operating at maximum RF power output, and with the transmitter feeding a 3 dBi monopole omni antenna aligned with the measurement horn antenna. No other antennas are provided with the EUT.

#### **Professional Installation Requirement:**

The in-line RF filter unit incorporates a standard N connector to the antenna, therefore requiring professional installation. As shown in the user manual, this product is designed exclusively for monitoring road and traffic conditions, and has no use for the consumer market. The system will be purchased and installed by state highway and traffic engineers, who will be trained by NU-METRICS Company on the proper installation methods required to maintain FCC compliance. No additional antennas or accessories will be supplied, other than those listed in Table 1 of this report.



#### **4.1 Peak Power Test Results:**

Limit: 1 watt (30 dBm)

Condition: Transmitter is set to a single modulated channel at full RF power.

Readings from Peak RF Power meter.

**Channel: 2451 MHz - (+9.8 dBm)**

#### **4.2 6 dB Emission Bandwidth Test Results:**

Minimum 6 dB BW: 0.500 MHz  
RBW Setting on S.A.: 100 kHz

Condition: Transmitter is set to a single modulated channel at 10 kbps at full RF power.

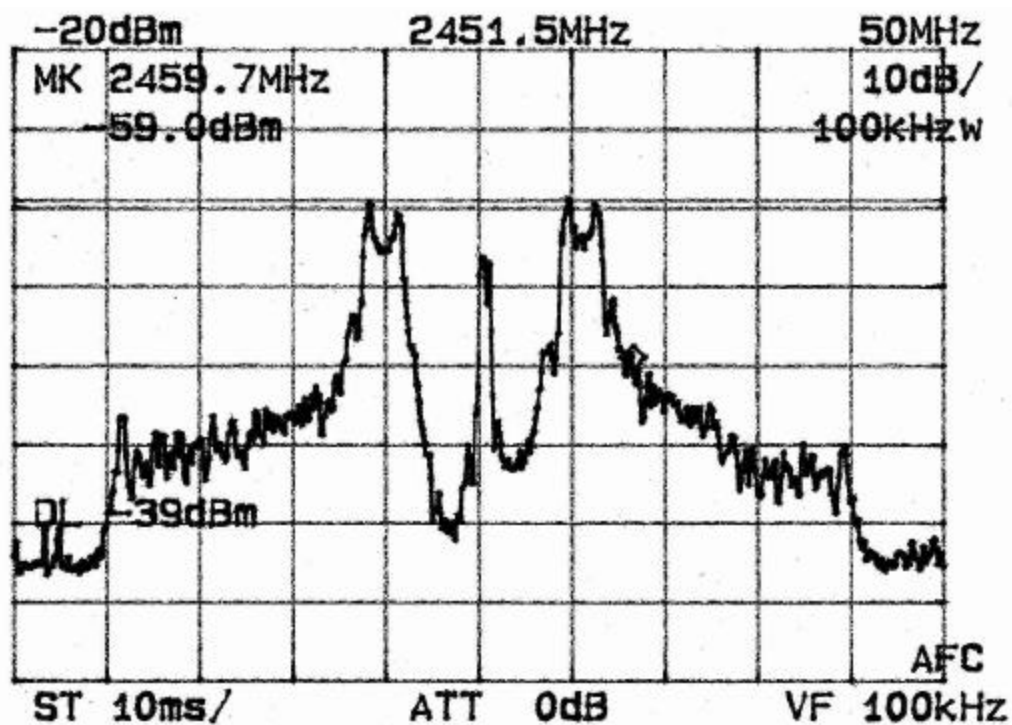
Readings from Spectrum Analyzer:

**Channel : 2451.00 MHz - (16.8 MHz)**

**SEE FOLLOWING PLOT OF MODULATED CARRIER**

#### 4.2.1 6 dB Bandwidth Emission (100 kHz Res. BW) Plot:

6 dB EMISSION BANDWIDTH – MODULATED CARRIER



### **4.3 Power Spectral Density:**

Limit: 8 dBm  
Resolution BW: 3 kHz  
Actual Time Interval used for testing:: 1.5 second/3kHz MHz

Condition: Transmitter is set to a single channel modulated at 10 kbps at full RF power.

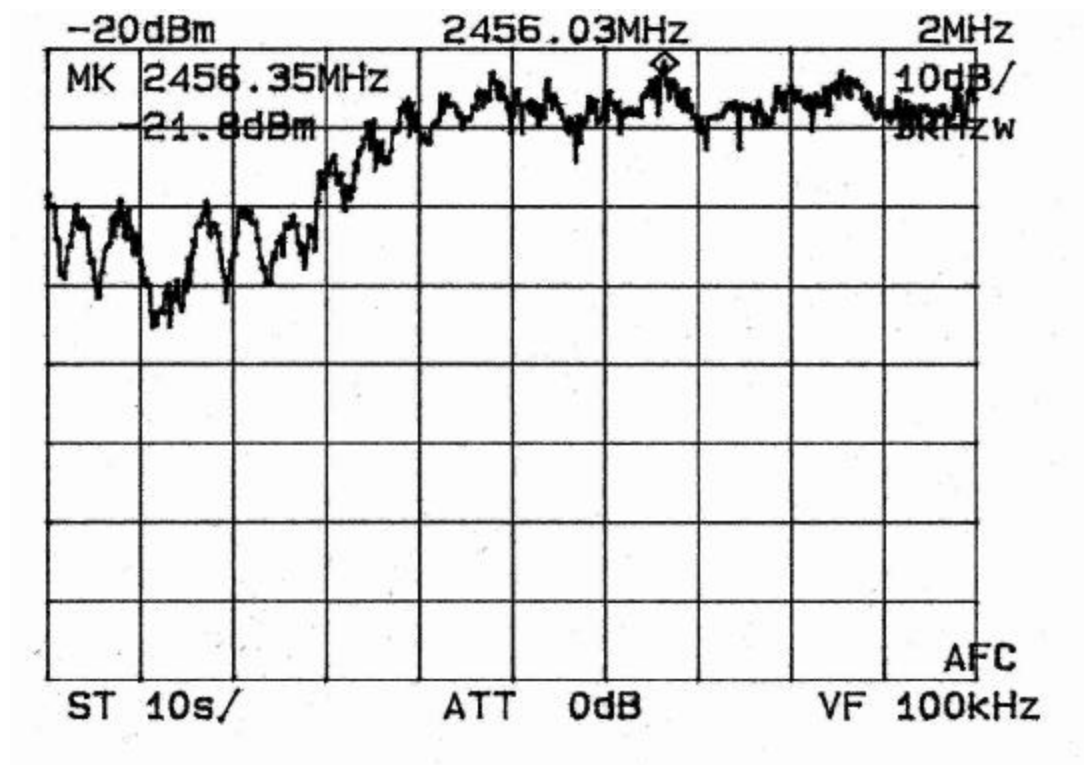
**Note:** 20 dB front-end attenuator on analyzer

Reading from spectrum analyzer:

**Channel: 2451.00 MHz - -1.8 dBm**

**SEE FOLLOWING PLOT & DATA TABLES**

#### 4.3.1 FCC Part 15.247(c) Power Spectral Density Plot:



#### **4.4 FCC Part 15.247(c) Conducted Spurious, 2451 MHz Frequency Of Carrier:**

Frequency of Carrier = 2451 MHz  
Limit Below Fc Level = 20 dB below Carrier Level Measured with 100 kHz RBW

Condition: Transmitter is set to a single modulated channel at full RF power.

**SEE FOLLOWING DATA TABLE**

**4.4.1 FCC Part 15.247(c) Conducted Spurious, 2451 MHz Frequency of Carrier Data Table:**

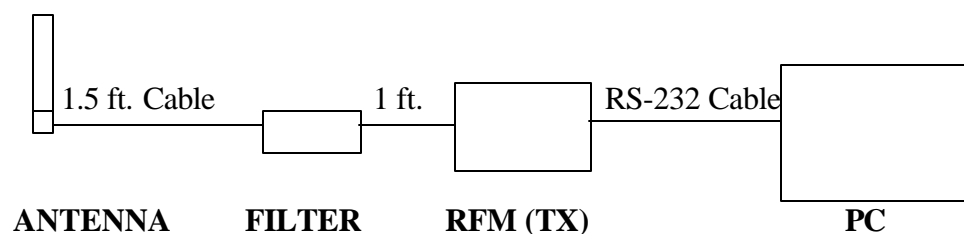
**TEST RESULTS**

**LIMIT:        -20 dBc**

<b><u>Component</u></b>	<b><u>Frequency (MHz)</u></b>	<b><u>Result (dB Below Peak)</u></b>
Harmonic	4902.00	-59.0
Harmonic	7353.00	-61.0
Harmonic	9804.00	-62.0
Harmonic	12255.00	-65.0
Harmonic	14706.00	-70.0
Harmonic	17157.00	-71.0
Harmonic	19608.00	-73.0
Harmonic	22059.00	-75.0
Harmonic	24510.00	-75.0

## **5.0 Test Configuration for Conducted and Radiated Emissions:**

The EUT was set up on the center of the test table, in a manner which follows the general guidelines of ANSI C63.4, Section 6 **“General Operating Conditions and Configurations”**. The in-line filter is connected to the RF output of the RFM TX unit. The filter output then feeds the omni antenna. Minimum cable lengths of 1.5 ft. and 1 ft. lengths were used for testing to allow for worse-case emissions. The transmitter is turned on and automatically begins transmission at full RF power output, once initialized by the PC.





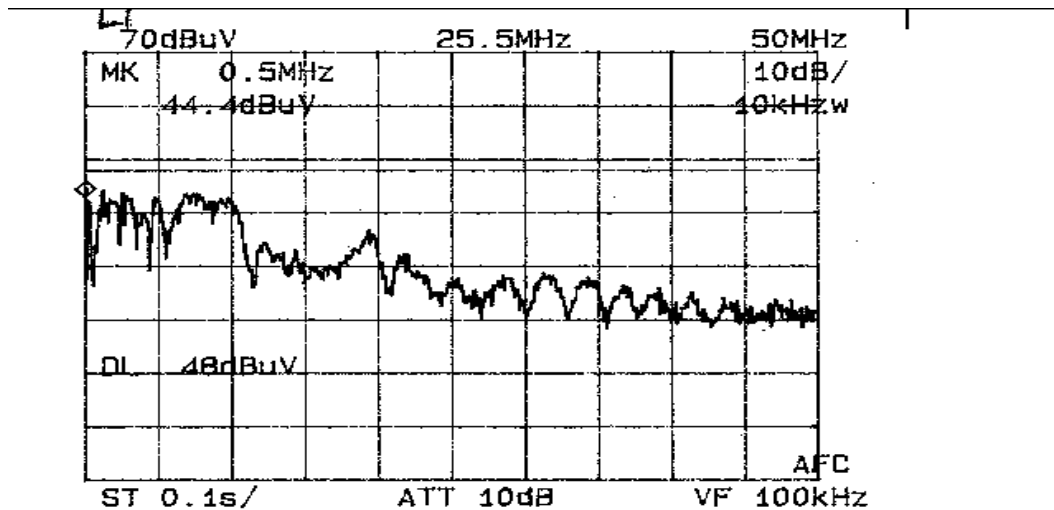
## **6.0 A.C. Conducted Emissions Scheme:**

The EUT is placed on an 80 cm high 1 X 1.5 m non-conductive table. Power to the RF amplifier is provided through a Solar Corporation 50  $\Omega$  / 50 uH Line Impedance Stabilization Network bonded to a 2.2 X 2 meter horizontal ground plane, and a 2.2 X 2 meter vertical ground plane. The LISN has its AC input supplied from a filtered AC power source. A separate LISN provides AC power to the peripheral equipment. I/O cables are moved about to obtain maximum emissions.

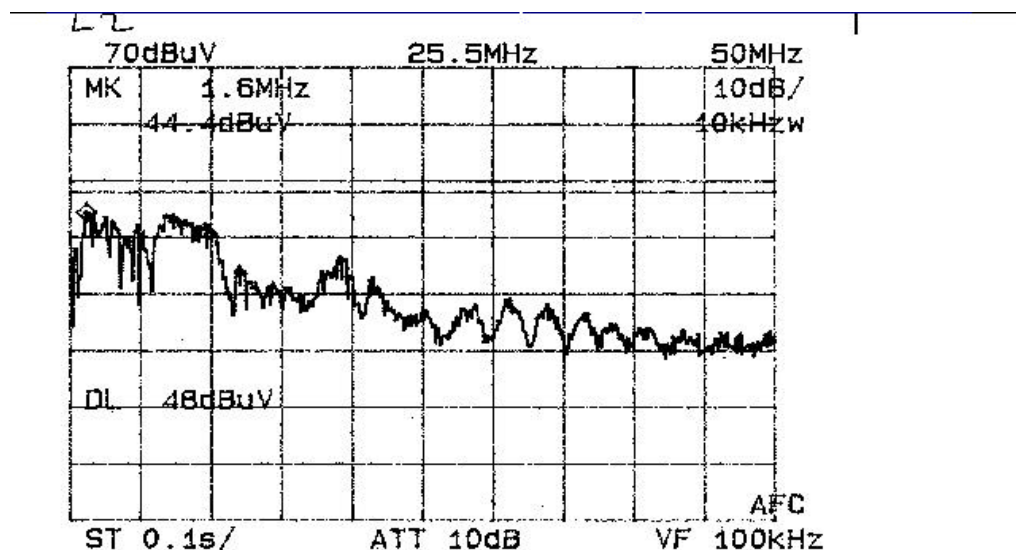
The 50  $\Omega$  output of the LISN is connected to the input of the spectrum analyzer and emissions in the frequency range of 450 kHz to 30 MHz are searched. The detector function is set to Quasi-Peak and the resolution bandwidth is set at 9 kHz, with all post detector filtering no less than 10 times the resolution bandwidth for final measurements. All emissions within 20 dB of the limit are recorded in the data tables.

## 6.1 AC Conducted Emissions Data Table

### A.C. LINE-CONDUCTED EMISSIONS – L1



### A.C. LINE-CONDUCTED EMISSIONS – L2



## **7.0 Radiated Emissions Scheme:**

The EUT is placed on an 80 cm high 1 X 1.5 meter non-conductive motorized turntable for radiated testing on the 3 meter open area test site. The emissions from the EUT are measured continuously at every azimuth by rotating the turntable. Guided horn and log periodic broadband antennas are mounted on an antenna mast to determine the height of the maximum emissions. The heights of the antennas are varied between 1 and 4 meters. Both the horizontal and vertical field components are measured.

The RF spectrum is searched from 30 MHz to 24 GHz.

The output from the antenna is connected to the input of the preamplifier. The pre-amp out is connected to the spectrum analyzer. The detector function is set to PEAK. The resolution bandwidth of the spectrum analyzer is set at 120 kHz for the frequency range of 30-1000 MHz, and 1 MHz for the frequency range of 1-24 GHz. A 10Hz video BW setting is used to average readings above 1 GHz when applicable. All emissions within 20 dB of the limit are recorded in the data tables.

To convert the spectrum analyzer reading into a quantified E-field level to allow comparison with the FCC limits, it is necessary to account for various calibration factors. These factors include cable loss (CL) and antenna factors (AF). The AF/CL in dB/m is algebraically added to the Spectrum Analyzer Voltage in dBμV/m. This level is then compared to the FCC limit.

### **EXAMPLE**

<b>Spectrum Analyzer Voltage:</b>	<b>VdBmV</b>
<b>Composite Factor:</b>	<b>AF/CL dB/m</b>
<b>Electric Field:</b>	<b>E dBmV/m = V dBmV + AF/CL dB/m</b>
<b>Linear Conversion:</b>	<b>E mV/m = Antilog (E dBmV/m /20)</b>

## 7.1 Radiated Emissions Data Table:

### FCC RADIATED EMISSIONS DATA

CLIENT: Nu-Metrics  
EUT: RFM-2400

FREQ.: 2451.00 MHZ  
POWER: 10 dBm

3 METER TEST DETECTOR - PEAK DATE: 06/17/2001

FREQUENCY MHz	POLARITY		SPEC A dBuV	AF/C dB/m	AMP Gain dB	Average Factor dB	PEAK E-Field dbuV/m	Average Limit dBuV/m	MARGIN dB	CONDITION
	H	V								
4,902.00	H	V	37.00	35.00	25.00	0.00	47.00	54.00	7.00	PASS
12,255.00			30.00	40.00	25.00	0.00	45.00	54.00	9.00	PASS
14,706.00	H	V	25.00	43.00	25.00	0.00	43.00	54.00	11.00	PASS
19,608.00			30.00	36.00	25.00	0.00	41.00	54.00	13.00	PASS

TEST ENGINEER:

Brian Haghtalab

**TABLE 1 – EUT ACCESSORIES**

CushCraft S2403B: 3 dBi omni antenna
2.4 GHz external in-line RF filter
120 VAC to 12 VDC adapter (linear)
1 ft. coax cable from TX to filter
1.5 ft. coax cable from filter to antenna

**TABLE 2**  
**SUPPORT EQUIPMENT**

MANUFACTURER	FCC ID #	SERIAL #
Host PC: Panasonic Model CF35 Pent. Laptop		

**TABLE 3**  
**MEASUREMENT EQUIPMENT USED**

The following equipment is used to perform measurements:

<b>EQUIPMENT</b>	<b>SERIAL #</b>
HP 434A RF Peak Power Meter	1362016
EMCO Model 3110 Biconical Antenna	1619
Antenna Research MWH-1825B Horn Antenna	1005
EMCO Model 3115 Ridged Horn Antenna	3007
HP 8348A Pre-Amplifier	197-2564A
Solar 8012-50-R-24-BNC LISN	924867
Bird 8306-300-N-30dB Attenuator	29198391515
HP 14IT w/8555A Spectrum Analyzer	6-95-1124
4 Meter Antenna Mast	
Motorized Turntable	
Heliac FSJ1-50A ¼" Superflex Coax Cable	