Intertek Testing Services
ETL SEMKO

# Test Report in Support of
# Class II Permissive Change

Robertshaw Controls Company
Tank Level Monitor
Model: 0625-0300
47 CFR, Part 15, Subpart C, §15.247
for
Spread Spectrum Transmitters

**FCC ID: NU9TX0625-0300**

Report Date: July 18, 2001

Test Dates: June 26 – June 29, 2001

J20053357
RPT# 0053357U.DOC

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# 1.0 General Description

## *1.1 Product Description*

The device is a tank level sensor that uses ultrasonic (≈50 kHz) frequencies to measure liquid levels. The information is stored in a microprocessor and transmitted by means of direct sequence spread spectrum transmitter operating at 923.58 MHz. The device transmits signals that indicate the status of measurement sensor inputs to a receiver. The device derives its power from an internally mounted 3 Vdc battery.

The reason for the permissive change is that the PWB was changed from a 2 layer board to a 4 layer board. The transmitter section of the PWB was not changed. However, testing was performed to ensure that the changes did not affect the transmitter's performance.

## *1.2 Related Submittal(s) Grants*

This is a single permissive change request for a previously submitted application.

## *1.3 Test Methodology*

Radiated emission measurements were performed according to the procedures in ANSI C63.4 (1992). All measurements were performed in a semi-anechoic 10 meter chamber. Preliminary scans were performed in the 10 meter chamber only to determine worst case modes. For each scan, the procedure for maximizing emissions in Section 4.3 was followed. All radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "**Justification Section**" of this application.

## *1.4 Test Facility*

The Duluth 10-meter chamber site is located at 1950 Evergreen Blvd., Suite 100, Duluth, Georgia. The test site is a 10-meter semi-anechoic chamber. The site meets the characteristics of CISPR 16-1: 1993 and ANSI C63.4: 1992. For measurements a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters.

# 2.0 System Test Configuration

## *2.1 Justification*

The system was configured for testing in a typical fashion (as a customer would normally use it). For simplicity of testing, the EUT was configured to transmit continuously.

## *2.2 EUT Exercising Software*

There was no special software to exercise the device. For simplicity of testing, the unit was configured to transmit continuously.

## *2.3 Special Accessories*

There are no special accessories for compliance of this product.

## *2.4 Equipment Modifications*

Any modifications installed previous to testing by Robertshaw Controls Company will be incorporated in each production model sold/leased in United States

No modifications were installed by Intertek Testing Services, Inc.

## *2.5 Support Equipment List and Description*

No support equipment was necessary to operate and exercise the Tank Level Monitor. The EUT was positioned in the center of the turntable and configured to transmit continuously.

## *2.6 Test Configuration Block Diagram*

The following diagram is very simplistic because the setup for this device was simple. There were no external cables attached to the EUT because it does not contain ports for external cables.

# 3.0 Test Results

Data is included of the worst case configuration (the configuration which resulted in the highest emission levels). A sample calculation, configuration photographs, data tables and plots of the emissions are included.

## *3.1 Emission Bandwidth*

§15.247(a)(2) specifies that direct sequence systems shall have a 6dB bandwidth of at least 500 kHz. From the plot shown below, the emission bandwidth was determined to be 1.375 MHz. For the measurement, the spectrum analyzer resolution bandwidth (RBW) was set to 100 kHz and the frequency span set to 5 MHz.

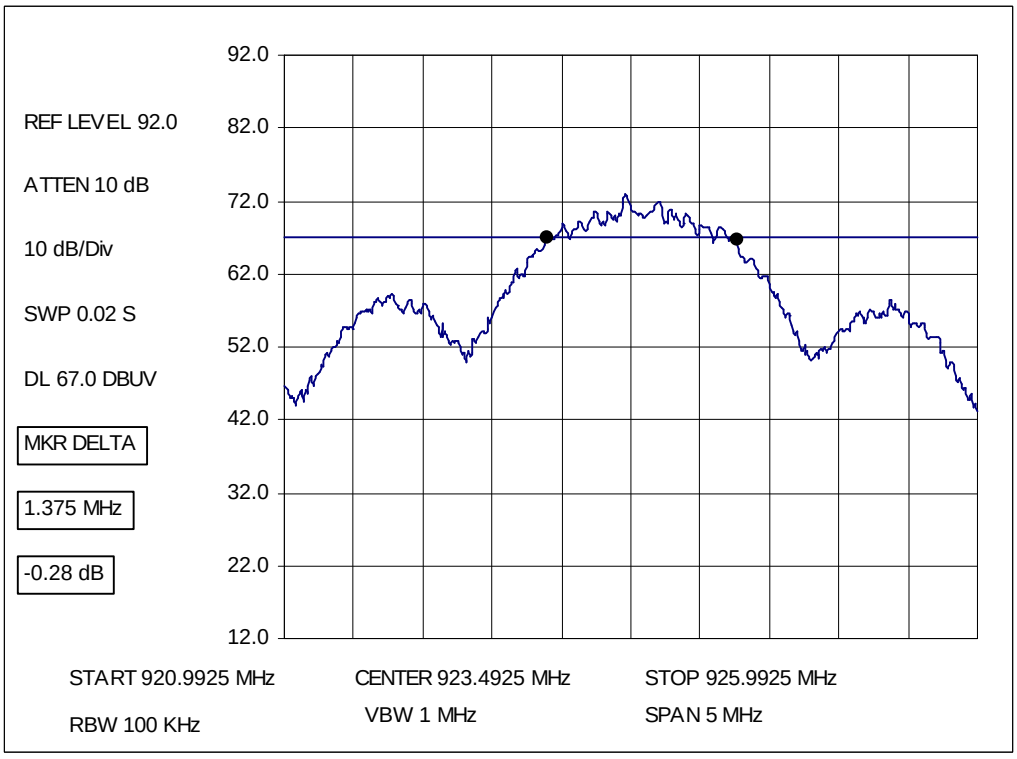



**Figure 3.3-1 – Emission Bandwidth Plot**

## *3.2 Power Output*

§15.247(b)(1) specifies that the maximum peak output power of a direct sequence spread spectrum transmitter shall not exceed one watt. If transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by one dB for every three dB that the directional gain of the antenna exceeds 6 dBi.

The peak output power was measured to be 13.4 dBm (22mW). The rated output power of this device is 16 dBm (40 mW). The measured value was within manufacturing tolerances of the product. The power level submitted for the original application was 14.3 dBm.

The power was determined by measuring the maximum field strength of the EUT at a distance of 3 meters. This measurement in dB(uV/m) was then converted to dBm using the following equation.

$$P=(E\times d)^2/(30\times G)$$

Where E is the field strength in V/m,

P is the power in Watts

G is the numeric gain of the transmit antenna

d is the distance in meters

The spectrum analyzer resolution bandwidth (RBW) was set to 3 MHz and the video bandwidth (VBW) was set to 3 MHz (this is the maximum VBW setting for the test equipment).

## *3.3 Field Strength Calculation*

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
where FS = Field Strength in dB(uV/m)
RA = Receiver Amplitude (including preamplifier) in dB(uV)
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB(1/m)
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows:

Assume a receiver reading of 52.0 dB(uV) is obtained. The antenna factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dB(uV/m). This value in dB(uV/m) was converted to its corresponding level in V/m.

RA = 52.0 dB(uV)
AF = 7.4 dB
CF = 1.6 dB(1/m)
AG = 29.0 dB

FS = 52.0 + 7.4 + 1.6 - 29.0 = 32 dB(uV/m)

Level in uV/m = Common Antilogarithm [(32 dB(uV/m))/20] = 39.8 uV/m

## *3.4 Transmitter Spurious Emissions*

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

RF Antenna conducted test
To perform this test the EUT is directly connected to the spectrum analyzer with appropriate attenuation. The resolution bandwidth (RBW) was set to 100kHz, and the video bandwidth (VBW) was set > RBW. A scan was performed up to the tenth harmonic to ensure that all harmonics/spurs were at least 20 dB down from the highest emission level within the authorized frequency band. The results of this test are shown in Table 3 – 1.

Radiated spurious emissions test
The antenna of the EUT is embedded in the printed circuit board and therefore does not allow for direct attachment from the antenna to the measuring receiver. All spurious measurements were made through radiated emissions testing.

To perform this test the EUT is set to operate continuously on the emissions test site. Field strength measurements are made and compared to the limit, which is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)). The resolution bandwidth (RBW) was set to 1 MHz, and the video bandwidth (VBW) was set to 10 Hz. The readings were adjusted to average readings by subtracting the peak-average correction factor derived from the duty cycle calculation. See Section 4.2 for details. The results of this test are shown in Table 3-2 and Table 3-3.

### *3.4.1 Antenna Conducted Test per §15.247(c)*

The data shown below lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

**Table 3 – 1: Antenna Conducted Emissions**

**Note: The antenna for the EUT is embedded in the printed circuit board. This test was not performed. All emissions were measured as a field strength and reported in Table 2.**

### *3.4.2 Radiated Spurious Emission Test per §15.247(c)*

The data shown below lists the significant emission frequencies, the limit and the margin of compliance. Numbers with a minus sign are below the limit.

**Table 3 - 2: Radiated Spurious Emissions, 30 – 1000 MHz**

Company: **Robertshaw**
Model: **Centeron Tank Monitor**
Job No.: **J20053357**
Date: 06/26/01
Standard: FCC Part 15.247

Tested by: Matthew Van Steen
Location: Duluth
Detector: HP8546
Antenna: EMCO3141
PreAmp: HP-1G
Cable(s): CABLETW2 CABLEN2
Distance: **10**

| Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB |
|---|---|---|---|---|---|---|---|---|---|
| H | 205.330 | 33.7 | 10.5 | 2.2 | 25.7 | -10.5 | 31.1 | 88.5 | -57.4 |
| H | 307.900 | 39.9 | 14.2 | 2.7 | 25.5 | -10.5 | 41.7 | 88.5 | -46.8 |
| H | 410.720 | 29.0 | 16.9 | 3.2 | 26.4 | -10.5 | 33.2 | 88.5 | -55.3 |
| V | 513.060 | 29.3 | 19.3 | 3.6 | 26.9 | -10.5 | 35.7 | 88.5 | -52.8 |
| V | 616.120 | 32.9 | 20.5 | 3.9 | 27.1 | -10.5 | 40.7 | 88.5 | -47.8 |
| H | 718.700 | 32.3 | 22.1 | 4.5 | 27.0 | -10.5 | 42.3 | 88.5 | -46.2 |

## Table 3 - 3: Radiated Spurious Emissions, 1 – 10 GHz

Company: **Robertshaw**
Model: **Centeron Tank Monitor**
Job No.: **J20053357**
Date: 07/05/01
Standard: FCC 15.247
Group: None
Notes: nf denotes a noise floor reading

Tested by: Matthew Van Steen
Location: Duluth
Detector: HP8566
Antenna: AHSYS571
PreAmp: Hp1-26g
Cable(s): CABLEH3
Distance: **3**

| Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Average Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB |
|---|---|---|---|---|---|---|---|---|---|
| V | 923.660 | 84.6 | 24.2 | 2.0 | 0.0 | 0.0 | 110.8 | - | - |
| V | 1847.320 | 33.2 | 28.5 | 2.8 | 0.0 | 9.9 | 54.6 | 90.8 | -36.2 |
| V (nf) | 2770.980 | 20.8 | 32.1 | 3.4 | 0.0 | 9.9 | 46.4 | 54.0 | -7.6 |
| V | 3694.640 | 43.4 | 32.2 | 6.5 | 36.4 | 9.9 | 35.9 | 54.0 | -18.1 |
| V | 4618.300 | 47.4 | 34.0 | 6.6 | 36.3 | 9.9 | 41.8 | 54.0 | -12.2 |
| V | 5541.960 | 49.7 | 34.9 | 5.1 | 36.0 | 9.9 | 43.8 | 90.8 | -47.0 |
| V | 6465.620 | 41.2 | 37.4 | 5.0 | 36.5 | 9.9 | 37.2 | 90.8 | -53.6 |
| V | 7389.280 | 31.3 | 37.9 | 6.7 | 36.4 | 9.9 | 29.6 | 54.0 | -24.4 |
| V | 8312.940 | 31.4 | 38.1 | 6.3 | 36.8 | 9.9 | 29.0 | 54.0 | -25.0 |
| V | 9236.600 | 37.0 | 39.5 | 6.2 | 37.6 | 9.9 | 35.2 | 90.8 | -55.6 |
| H | 923.660 | 69.7 | 24.2 | 2.0 | 0.0 | 0.0 | 95.9 | - | - |
| H | 1847.320 | 31.0 | 28.5 | 2.8 | 0.0 | 9.9 | 52.4 | 90.8 | -38.4 |
| H (nf) | 2770.980 | 22.1 | 32.1 | 3.4 | 0.0 | 9.9 | 47.7 | 54.0 | -6.3 |
| H | 3694.640 | 51.4 | 32.2 | 6.5 | 36.4 | 9.9 | 43.9 | 54.0 | -10.1 |
| H | 4618.300 | 56.5 | 34.0 | 6.6 | 36.3 | 9.9 | 50.9 | 54.0 | -3.1 |
| H | 5541.960 | 50.6 | 34.9 | 5.1 | 36.0 | 9.9 | 44.7 | 90.8 | -46.1 |
| H | 6465.620 | 49.6 | 37.4 | 5.0 | 36.5 | 9.9 | 45.6 | 90.8 | -45.2 |
| H | 7389.280 | 30.2 | 37.9 | 6.7 | 36.4 | 9.9 | 28.5 | 54.0 | -25.5 |
| H | 8312.940 | 32.3 | 38.1 | 6.3 | 36.8 | 9.9 | 29.9 | 54.0 | -24.1 |
| H | 9236.600 | 38.7 | 39.5 | 6.2 | 37.6 | 9.9 | 36.9 | 90.8 | -53.9 |

## *3.5 AC Power Line-Conducted Emissions*

For AC powered devices, line-conducted emissions testing is performed based on the requirements in §15.207.

**Table 3 - 4: Power Port Conducted Emissions**

**Note: This test was not required because the EUT was battery powered.**

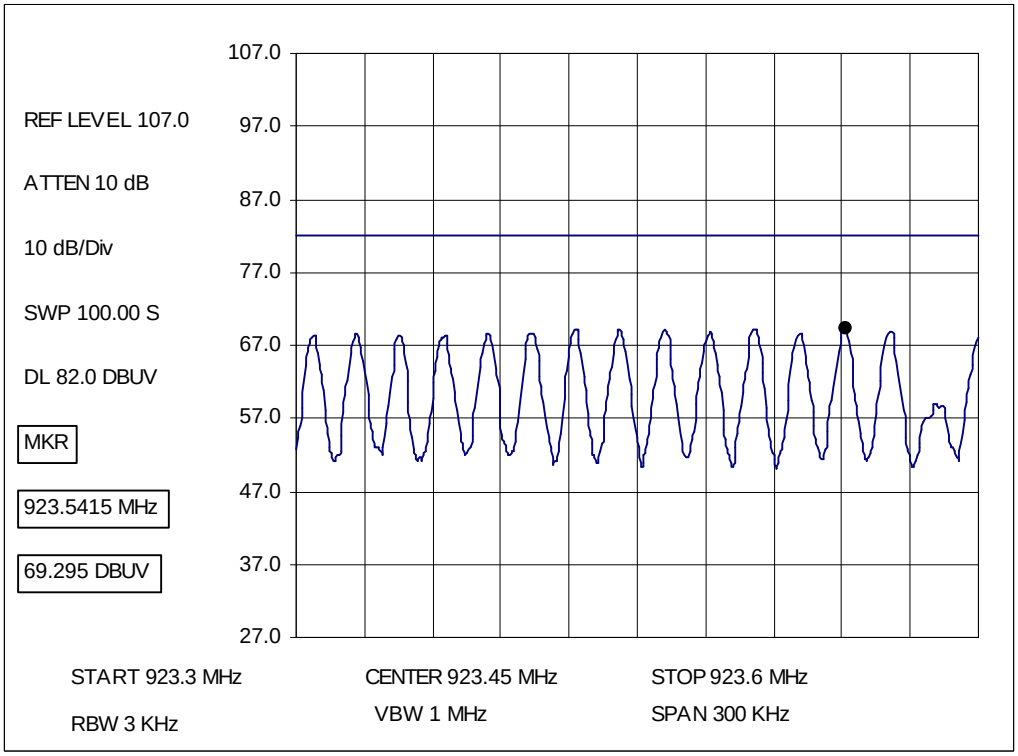
## *Power Spectral Density*

For direct sequence systems, the peak power spectral density conducted from the intentional radiator shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Below is a plot that shows the power spectral density. This EUT does not have an antenna port as the antenna is embedded in the printed circuit board. This measurement was made with the azimuth of the turntable and the height of the measuring antenna positioned such that the highest emission is detected.

The resolution bandwidth is set to 3 kHz, the span is set to 300 kHz, and the sweep time is 100 seconds. The highest peak field strength was measured to be 69.29 dB(uV/m) which converts to –28 dBm. See Figure 3.7 – 1 for the plot.

**Figure 3.7 - 1: Power Spectral Density Plot**



# 4.0 Miscellaneous Information

This miscellaneous information includes details of the measured bandwidth, the test procedure and calculation of factors such as pulse desensitization and averaging factor.

## *4.1 Discussion of Pulse Desensitization*

The determination of pulse desensitivity was made in accordance with Hewlett Packard Application Note 150-2, *Spectrum Analysis ... Pulsed RF*.

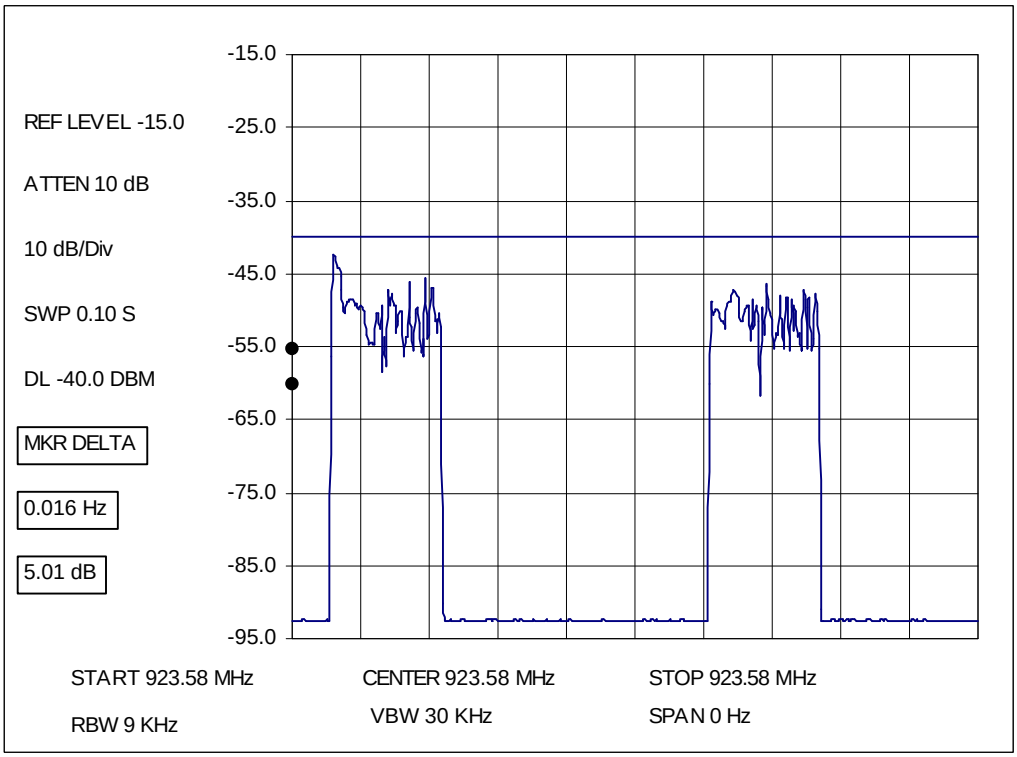
## *4.2 Calculation of Average Factor*

The detector functions for radiated emission measurements are peak and quasi-peak mode. Average readings, when required, were taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings according to the following formula:

Average Factor in dB = 20 LOG (duty cycle)

The time over which the duty cycle was measured: 100 msec. The worst-case (highest percentage on) duty cycle was used and described specifically in the calculation contained in this section. A plot of the worst case duty cycle, if applicable, is also provided in this report.

**Figure 4.2 – 1: Duty Cycle Plot**



## *4.3 Emissions Test Procedures*

The following is a description of the test procedure used by Intertek Testing Services in the measurements of transmitters operating under Part 15, Subpart C rules. The test setup and procedures described below are designed to meet the requirements of ANSI C63.4: 1992.

The transmitting equipment under test (EUT) is placed on a wooden table, which is 1.0m x 1.5m and 0.8m in height above the ground plane. The table is positioned in the center of a remotely controlled turntable. During the radiated emissions test, the turntable was rotated and any cables leaving the EUT were manipulated to find the configuration resulting in maximum emissions. The antenna height and polarization were also varied during the testing to search for maximum signal levels. The height of the antenna was varied from one to four meters.

The detector function for radiated emissions measured below 1 GHz was quasi-peak mode. Above 1 GHz a peak detector was used and adjusted to an average reading using the duty cycle correction. Average readings, when required, are taken by measuring the duty cycle of the equipment under test and subtracting the corresponding amount in dB from the measured peak readings. A detailed description for the calculation of the average factor can be found in Section 4.2.

The EUT is warmed up for 15 minutes prior to the test. Since it is battery powered, a new, fully charged battery is used.

The frequency range scanned was from the lowest radio frequency signal generated in the device, which was greater than 9 kHz, to the tenth harmonic of the highest fundamental frequency or 40 GHz, whichever was lower. For line conducted emissions, the range scanned was 450 kHz to 30 MHz.

Conducted measurements were made as described in ANSI C63.4: 1992. An IF bandwidth of 9 kHz was used, and quasi-peak detection was employed. The Tank Level Monitor was DC powered, and therefore, no AC conducted emissions testing was performed.

The IF bandwidth used for measurement of radiated signal strength was 120 kHz or below 1000 MHz. Above 1000 MHz, a resolution bandwidth of 1 MHz was used.

Radiated measurements were taken at an EUT to antenna distance of three or ten meters. The actual distance is indicated on the emissions data tables.

## 5.0 Test Equipment

Located below is a table outlining the test equipment used in this evaluation.

| Description | Make | Model | Serial # | Calibration Date |
|---|---|---|---|---|
| EMI Receiver | HP | 85462A | 3650A00362 | 7/3/2000 |
| RF Filter Selector | HP | 85460A | 3704A00331 | 7/3/2000 |
| Spectrum Analyzer | HP | 8566B | 2134A01032 | 10/24/2000 |
| RF Preselector | HP | 85685A | 2602A00241 | 10/24/2000 |
| Q.P. Adapter | HP | 85650A | 2412A00382 | 10/24/2000 |
| PreAmp | HP | 8449B | 3008A0089 | 9/25/2000 |
| PreAmp | CDI | P950 | PA2 | 2/15/2001 |
| BiLog Antenna | Chase | 2622 | CBL6112B | 7/6/2001 |
| Horn Antenna | EMCO | 3115 | 9208-3919 | 2/7/2001 |
| Horn Antenna | AH Systems | SAS200/571 | 246 | 1/6/2001 |
| Antenna | EMCO | 3141 | 9508-4166 | 4/18/2001 |
| Cable | Andrews | Cable TW3 | TW3 | 4/6/2001 |
| Cable | N/A | Cable N2 | N2 | 4/6/2001 |