Measurement/Technical Report

Fukuda Denshi Co., LTD. , Model LX-5120

FCC ID: DV8LX5120A

August 16, 1999

This report concerns (check one): Original Grant__X_ _ Class II Change_____

Equipment Type Biomedical Telemetry Device

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

If yes, defer until: _____N/A_____
date

Fukuda Denshi Co., LTD. 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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Newberg, OR 97132
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Table of Contents

1.0 General Information

1.1 Product Description

Manufactured By ..... Fukuda Denshi Co., LTD.

Address ..... 17725 NE 65th St. Bldg. C Redmond, WA 98052

Test Requested By: ..... Drew Queen

Model LX-5120

FCC ID DV8LX5120A

Serial Number(s) 00000004

Date of Test..... August 10, 1999 through August 16, 1999

Job Number..... FUKU0005

The Equipment Under Test (EUT) is the Fukuda Denshi Co. Model LX-5120, Serial No. 00000004, FCC ID: DV8LX5120. The EUT is a radio telemetry transmitter designed for monitoring the ECG and Respiration.

Quanity Production is planned for this product.

Hardware Description:

- Clocks/Oscillators Frequencies: 2.4000 MHz (reference for carrier frequency), 84 kHz (clock for Gate Array)
- Ports: Patient Cable Connector, PC I/F Connector (for changing frequency when in service).
- Antenna Patient lead “COM”in patient cable is also used as the antenna

1.2 Related Submittals/Grants

None

1.3 Tested System Details

EUT and Peripherals

Item	FCC ID	Description and Serial No.
EUT	DV8LX5120A	Fukuda Denshi Co. Model LX-5120, Serial No. 00000004
Patient Simulator		DNI Nevada Inc. Model MedSim 300B Serial No. 2407.

Cables:

Patient Cable		~75 cm in length. Shielded cable x 4, Model No. CM-85C.

1.4 Test Methodology

See attached test plan submitted by Northwest EMC, Inc. , and the faxed approval from the Federal Communications Commissions located in Appendix II.

1.5 Test Facility

The Open Area Test Site and conducted measurement facility used to collect the radiated and conducted data is located at

Northwest EMC, Inc.
14128 3309th Ave SE
Sultan, WA 98294
(360) 793-8675
Fax: 793-2536

The Open Area Test Site, and conducted measurement facility used to collect this data is located at the address shown above. This site has been fully described in a report filed with the FCC, dated September 10,1998, and accepted by the FCC in a letter dated November 4, 1998 (31040/SIT)(1300F2).

Northwest EMC, Inc. is recognized under the United States Department of Commerce, National Institute of Standards and Technology, National Voluntary Laboratory Accreditation Program (NVLAP) for satisfactory compliance with criteria established in Title 15, Part 285 Code of Federal Regulations. These criteria encompass the requirements of ISO/IEC Guide 25 and the relevant requirements of ISO 9002 (ANSI/ASQC Q92-1987) as suppliers of calibration or test results. NVLAP Lab Code: 200059-0.

2.0 Technical Description

2.1 Type of Emission

The device has F1D emission.

The reference device uses a digital, frequency shift keying modulation scheme with no sub-carriers. The patient data (analog signals) are digitally encoded. The digital signal is used to frequency modulate the carrier with a maximum modulation frequency of 3.5 kHz and a maximum data rate of 7000 bits per second.

The emission designator “F1D” was selected based upon the guidelines in CFR 2.201. “F” designates an emission in which the main carrier is frequency modulated. “1” designates a single channel containing digital information without the use of a modulating sub-carrier (the applicant confirmed that no sub-carriers are used). “D” designates data transmission, telemetry. As detailed in the user manual, the device is used to transmit one way, non-voice, biomedical telemetry.

2.2 Frequency Range

The device has a frequency range of 460.0125 MHz to 469.9875 MHz

2.3 Operating Power Level

The Operating Power Level is 1.0 milliwatts (± 2dB). This level is not adjustable.

2.4 Maximum Power Level

The maximum power level is the same as the operating power level of 1.0 milliwatts (± 2dB). The device will be operating under the exemption from technical standard (90.217) which permits output power levels to 120 mW. The device will also be operating under 90.267(a)(5) which permits output levels to 20 mW.

2.5 DC Voltage and Current Applied

The final RF amplifier is supplied with 1.5VDC and draws a current of 2.8 mA.

2.6 Active Circuit Device
(Refer to Block Diagram and Schematics)

Q2 and Q1 are NPN transistors that make up the cascade amplifier used as a Voltage Controlled

2.8 Operators Manual (Instruction Book)

Operators Manual is a separate attachment.

2.9 Tune-up Procedure
(Refer to Block Diagram and Schematics)

VC2 is adjusted for maximum amplitude of the RF OUTPUT.

VC3 brings the oscillator within 200 Hz of the correct frequency. VR1 is then adjusted for the specified level at the 460MHz to 470 MHz output.

2.10 Frequency Stabilizing Circuitry
(Refer to Block Diagram and Schematics)

The frequency is determined by the RF Reference Crystal Oscillator through the Phase Lock Loop mechanism. The active device is IC29. R177, C167, VC3, X1, C162, C60, D2, R173, and IC29 form the RF Reference Crystal Oscillator. The RF Reference oscillation frequency of 2.4000MHz feeds the Phase Lock Loop IC, IC28. The Phase Lock Loop IC, IC28 controls the voltage controlled oscillator through R170, R167, C155, R161, C147, R160, C141, R1, C4, R2, L1, and D1. The Voltage Controlled Oscillator of Q2 collector feeds to Q1 emitter and it's output connects to Q3 base through C11. The Q3 collector feeds to Q5 emitter and it's output connects to pre-scalar IC, IC21 through L3, C50. The IC21 output feeds to phase lock loop IC, IC28 through C59 to feed back. The frequency data is memorized in the IC31 and connectes to the phase lock loop IC, IC28 through IC22, R189. The frequency is determined primarily by crystal X1. X1 is specified to have an initial tolarance of $\pm$ 10ppm and a temperature stability of $\pm$ 2.5 ppm from 0 degrees C to 40 degrees C.

VC3 adjusts the RF reference oscillation frequency and which bring the transmission frequency within $\pm$ 200 Hz. D2 compensate the deviation of the frequency modulatioin of lower frequency components.

2.11 Spurious Suppression
(Refer to Block Diagram and Schematics)

Spurious frequencies are generated by VCO which is in the PLL and the RF power amplifier. Suppression of VCO spurious frequencies is performed by the CR low pass filter which acts as a smoother for VCO response in the PLL. The filter composed of R170, R167, C155, R161, C147, R160, and C141 has a cut off frequency of 2 Hz to reject the nearby carrier frequency of 12.5 kHz and its harmonics.

Suppression of RF power amplifier spurious frequencies are performed by the coupled resonator filters which act as tuned loads for Q1. The filter following Q2, composed of L9, C152, C148 is tuned to transmission frequency and rejects all other harmonics of 460 MHz. The filter following Q1 composed of

2.11 Spurious Suppression (con't)
(Refer to Block Diagram and Schematics)

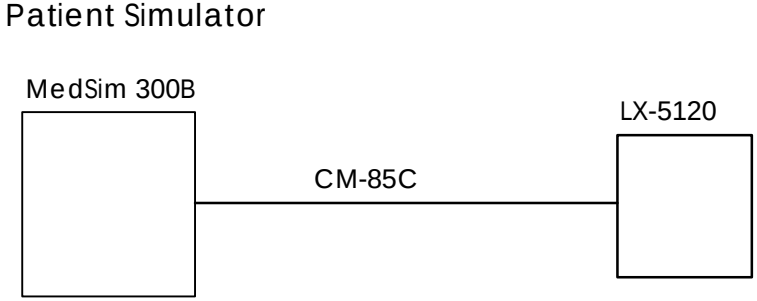
The output power is limited by the current drain of the final amplifier stage and the level of the signal going into the final stage. The current drain of the final stage is adjusted to be slightly less than the rated power. The cabinet which contains all of the circuitry is locked by a unique screw and cannot be opened by the customer, so the output power cannot be adjusted.

2.12 Digital Modulation
(Refer to Block Diagram and Schematics)

The analog data channels are time multiplexed and then encoded to digital codes. These digital codes are mixed with specific pseudo random digital codes to keep the frequency deviation neutral. The system is constrained so the minimum pulse width is about 143 uS. The specific digital code combinations are used for synchronization.

The blunted edge digital waveform generator composed of R54 to R58 resistor ladder network simulates the gausshan filter. The splatter filter following the blunted edge digital waveform generator composed of IC23A, C187, C188, R213, VR2, R212, C181, R210, C180, R35, R1, C4, and R2 acts as a Bessel filter with cut-off frequency of 4.5 kHz before modulating the voltage controlled oscillator. The amplitude and phase response of this filter is attached.

Figure 2.1: Configuration of Tested System



3.0 RF Power Output Data

3.1 Test Setup

Power output was measured at the RF output terminals with the transmitter biased for normal operation. The output power level was factory set (to 1mW), and not adjustable by the user.

The output terminals were directly coupled to a spectrum analyzer input through a 20dB (2W) attenuator. The characteristic impedance of the attenuator and the front end of the analyzer are 50Ω. Power measurements were made with the carrier unmodulated using a peak detector on the spectrum analyzer. Resolution bandwidth was set to 120kHz.

Maximum permissible power was 20mW or the minimum required for satisfactory operation. This measurement verified 1mW of power output as specified by the manufacturer.

3.2 Test Results

Low Frequency	Mid Frequency	High Frequency
1.0495µW	952.80µW	770.90µW

Judgment: Passed, the power output is less than 20mW.

4.0 Modulation Characteristics Data

4.1 Test Setup

The reference device uses a digital, frequency shift keying modulation scheme with no sub-carriers. The patient data (analog signals) are digitally encoded. The digital signal is used to frequency modulate the carrier with a maximum modulation frequency of 3.5 kHz and a maximum data rate of 7000 bits per second.

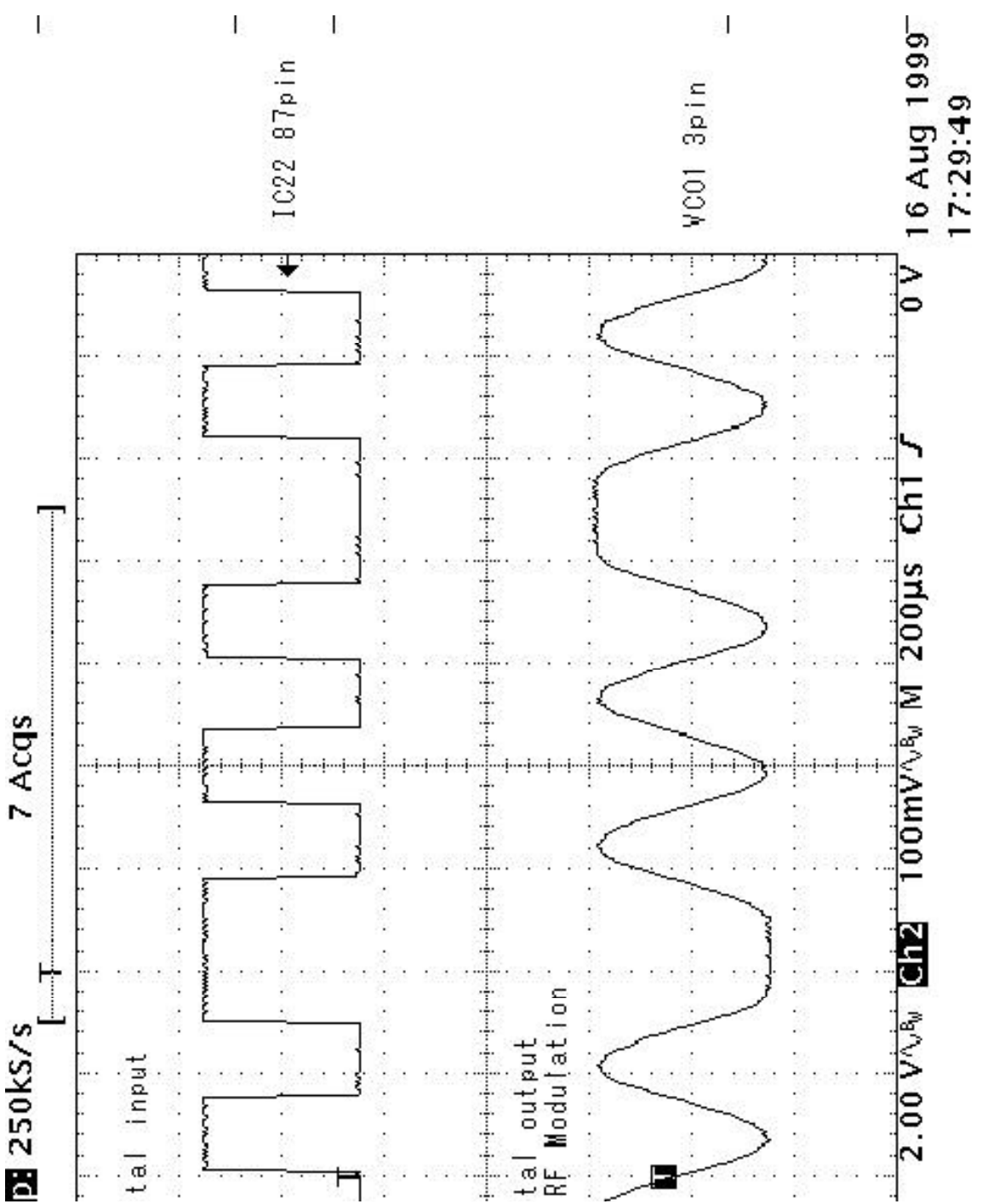
The emission designator “F1D” was selected based upon the guidelines in CFR 2.201: “F” designates an emission in which the main carrier is frequency modulated. “1” designates a single channel containing digital information without the use of a modulating sub-carrier (the applicant confirmed that no sub-carriers are used). “D” designates data transmission, telemetry. As detailed in the user manual, the device is used to transmit one way, non-voice, biomedical telemetry.

A waveform of the modulating signal as stored on the oscilloscope screen was recorded on a printer.

For telemetry operations, only A1D, A2D, F1D, and F2D emissions are authorized. The EUT utilizes F1D emissions.

4.2 Test Results

See data sheet on next page.


250kS/s
7 Acqs
tal input
IC22 87pin
tal output
RF Modulation
VCO1 3pin
2.00 V/
Ch2
100mV/
M 200µs Ch1
0 V
16 Aug 1999
17:29:49

5.0 Necessary Bandwidth

The applicant specifies a maximum modulation frequency of 3.5 kHz. The necessary bandwidth, calculated using Carson's Rule: 2M + 2D = 2(3500) + 2(1750) = 10.5 kHz.

The applicant specifies a maximum data rate of 7kBpS (7000 bits per second).

6.0 Occupied Bandwidth Data

6.1 Test Setup

The occupied bandwidth was measured at the RF output terminals with the EUT set for normal operation. The output terminals were directly coupled to a spectrum analyzer input through a 20dB (2W) attenuator.

The spectrum analyzer was set with a peak detector, a resolution bandwidth of 100Hz (VBW≥ 100 Hz), and a frequency span of 125kHz. No video filtering was used. The carrier was modulated (typical of normal operation). The peak envelope of the out-of-band emissions, as stored on the spectrum analyzer screen, was recorded on a plotter.

"...the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability was adjusted so that any emission appearing on a frequency 25 kHz or more removed from the assigned frequency was attenuated at least 30 dB below the unmodulated carrier."

6.2 Test Results

Low Frequency	Mid Frequency	High Frequency
-64.73dBc	-61.82dBc	-67.29dBc

Judgment: Passed, the highest emission within 25 kHz of the assigned frequency is attenuated greater than 60dBc

7.0 Spurious Emissions at Antenna Terminals Data

7.1 Test Setup

No testing is required for spurious emissions at the antenna terminals **if** the antenna is integral to the construction of the EUT. If the antenna is detachable, then measurement data is required:

Spurious emissions were measured at the RF output terminals with the EUT set for normal operation. The output terminals were directly coupled to a spectrum analyzer input through a 20dB (2W) attenuator. The carrier was modulated (typical of normal operation).

The spectrum was scanned from 30MHz to 1GHz with a 10kHz resolution bandwidth and a peak detector. The spectrum was also scanned from 1GHz to 5GHz (10^{th} harmonic of carrier is 4.6 to 4.7 GHz) with a resolution bandwidth of 1MHz and a peak detector. No video filtering was used. The peak envelope of the spurious emissions, as stored on the spectrum analyzer screen, was recorded on a plotter. The magnitude and frequency of any spurious emission attenuated less than 50 dB (within 20 dB of the limit) below the power of the unmodulated carrier was recorded.

For up to 5GHz, any spurious emission appearing on a frequency 25 kHz or more removed from the assigned frequency was attenuated at least 30 dB below the unmodulated carrier.

7.2 Test Results

Low Frequency		Mid Frequency		High Frequency	
460 MHz (carrier)	105 dBµV	465 MHz (carrier)	104 dBµV	470 MHz (carrier)	103 dBµV
915.1 MHz	53.04 dBµV	924.8 MHz	50.75 dBµV	936.9 MHz	49.11 dBµV
1.846 GHz	60.92 dBµV	1.863 GHz	57.1 dBµV	1.884 GHz	53.97 dBµV
3.223 GHz	52.93 dBµV	2.792 GHz	53.06 dBµV	2.792 GHz	53.11 dBµV

Judgment: Passed, all spurious emissions 25 kHz or more removed form the assigned frequency are attenuated greater than 50dB

8.0 Field Strength of Spurious Radiation Data

8.1 Test Setup

The field strength of spurious emissions that may be radiated from the EUT were measured in the far field. The EUT was taken to an Open Area Test Site on file with the FCC and set for normal operation. The carrier was modulated by patient data from the host device (typical of normal operation). The EUT's antenna was attached to the transmitter.

The measurement antenna to EUT test distance was 3 meters. With the spectrum analyzer connected to the appropriate measurement antenna, the spectrum was scanned from 30MHz to 1GHz with a 10kHz resolution bandwidth and a peak detector. The spectrum was also scanned from 1GHz to 5GHz with a resolution bandwidth of 1MHz and a peak detector. No video filtering was used.

The measurement antenna was scanned in height from 1 to 4 meters and the orientation of the EUT varied to maximize the level of any spurious emissions. Each spurious emission was maximized with the magnitude and frequency recorded for any signal attenuated less than 40 dB (within 20 dB of the limit) below the power of the unmodulated carrier. Measurement procedure ANSI C63.4 (1992) were referenced.

For up to 5 GHz, the field strength of any radiated spurious emission appearing on a frequency 25 kHz or more removed from the assigned frequency was attenuated at least 30 dB below the unmodulated carrier.

8.2 Test Results

Low Frequency		Mid Frequency		High Frequency	
460.012 (carrier)	93.9dBuV/m	465.012 (carrier)	93.3dBuV/m	469.987	87.0dBuV/m
920.029	51.8dBuV/m	930.028	49.9dBuV/m	939.978	52.0dBuV/m
No other spurious emissions less than 50dBc were detected.		No other spurious emissions less than 50dBc were detected.		No other spurious emissions less than 50dBc were detected.	

Judgment: Passed

9.0 Frequency Stability (Supply Voltage) Data

9.1 Test Setup

The frequency stability of the EUT's unmodulated carrier was measured. The transmitter was biased for normal operation. The output power level was factory set (≈1mW) , and not adjustable by the user.

Frequency stability of the unmodulated carrier was measured for variations in battery voltage. The primary supply voltage was reduced to the battery operating end point specified by the manufacturer: 1.0Vdc Frequency measurements were made at the nominal battery voltage (1.5Vdc) and at the end point (1.0Vdc).

The carrier frequency had to be within the assigned frequency by a margin no greater than the sum of: the bandwidth occupied by the emitted signal, plus the bandwidth required for frequency stability (2.5ppm ≈1.15kHz), plus 25 kHz. This is equal to 12.5 kHz + 1.15 kHz + 25 kHz, which is equal to 38.65 kHz.

9.2 Test Results

Supply Voltage	Low Frequency	Mid Frequency	High Frequency
1.5 V	460.01306 MHz	465.00058 MHz	469.98789 MHz
1.0 V	460.01325 MHz	465.00058 MHz	469.98808 MHz

Judgment: Passed, the carrier frequency stayed within the assigned frequency by a margin no greater than 38.65 kHz.

10.0 Frequency Stability (Temperature) Data

10.1 Test Setup

The frequency stability of the EUT's unmodulated carrier was measured. The transmitter was biased for normal operation. The output power level was factory set (≈1mW) , and not adjustable by the user. 2.995(a1) specifies that the ambient temperature will be varied from -30° to +50° centigrade. The EUT is specified to be used from +10° to +40° centigrade (hospital or clinic environment). Frequency measurements were made at the extremes of the test range
(-30° to +50° centigrade), and at intervals of 10° centigrade through the range. A sufficient period of time was allowed at each temperature interval to allow the components of the oscillator / clock circuitry to stabilize (see attached Time vs. Temperature graph).

The carrier frequency had to be within the assigned frequency by a margin no greater than the sum of: the bandwidth occupied by the emitted signal, plus the bandwidth required for frequency stability (2.5ppm ≈1.15kHz), plus 25 kHz. This is equal to 12.5 kHz + 1.15 kHz + 25 kHz, which is equal to 38.65 kHz.

10.2 Test Results

Temperature	Low Frequency	Mid Frequency	High Frequency
+50°	460.01295 MHz	465.00039 MHz	469.98783 MHz
+40°	460.01295 MHz	465.00039 MHz	469.98744 MHz
+30°	460.01256 MHz	465.00039 MHz	469.98783 MHz
+20°	460.01256 MHz	465.00019 MHz	469.98783 MHz
+10°	460.01275 MHz	465.00019 MHz	469.98725 MHz
0°	460.01218 MHz	465.00019 MHz	469.98744 MHz
-10°	460.01237 MHz	465.00000 MHz	469.98763 MHz
-20°	460.01218 MHz	465.00000 MHz	469.98763 MHz
-30°	460.01256 MHz	464.99981 MHz	469.98725 MHz

Judgment: Passed,.

11.0 Measurement Equipment

Instrument	Model	Serial No.	Freq Range	Last Cal	Cal Due
Spectrum Analyzer	HP 8593E	3710A02766	10 kHz - 22 GHz	02/05/99	02/05/00
Spectrum Analyzer	HP 8591E	3346A02097	10 kHz – 1.8 GHz	10/05/98	10/05/99
Spectrum Analyzer	HP 8568B	2601A02125	100 Hz – 1.5 GHz	09/01/98	09/01/99
Quasi-Peak Adapter	HP 85650A	2043A00214	10 kHz - 1000 MHz	09/01/98	09/01/99
Log Periodic Antenna	EMCO 3146	5060	200 MHz - 1000 MHz	12/31/98	12/31/99
Pre-Amplifier	HP 83017A	3123A00288	0.5 GHz – 26.5 GHz	07/17/99	07/17/00
Horn Antenna	EMCO 3115	9906-5818	1 GHz - 18 GHz	06/08/99	12/08/00
High Pass Filter	Microlab FH-1001	TE-447910	1 GHz	01/28/99	01/28/01
DC Power Supply	HP 6266B	2549A05642	N/A	NCR	NCR
AC Power Supply	Instek APS-9050	E991295	N/A	NCR	NCR
Multi-Meter	Fluke 79	56470635	N/A	07/22/99	07/22/00