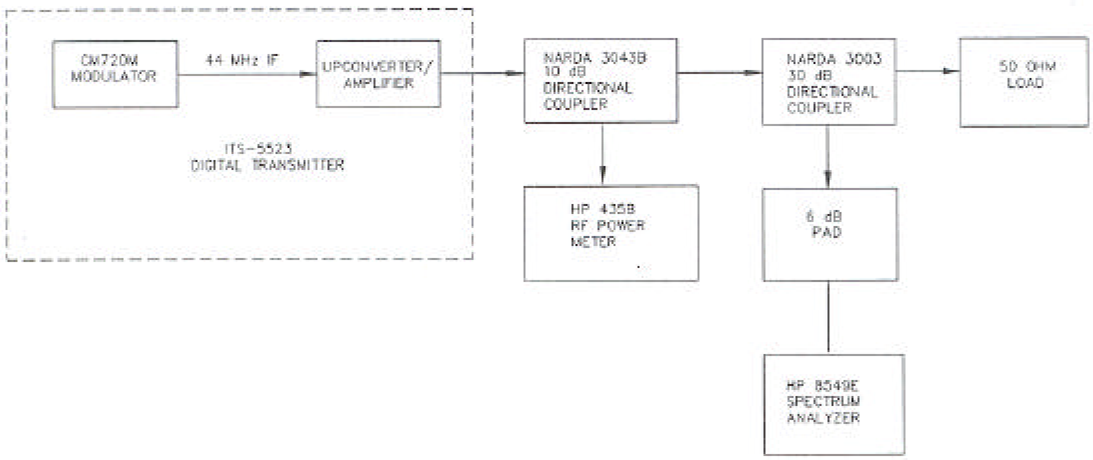
3.0 ENGINEERING DATA

3.1 RF Power Measurements

The following block diagram describes the test equipment set-up for the following measurements:



The output power of the ITS-5523 was adjusted to obtain 5 watts average RF output as observed on the power meter.

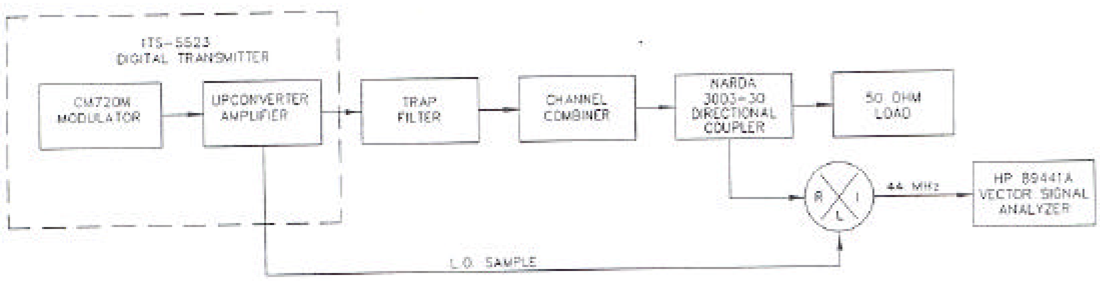
With the power level properly set to 5 watts (average), all required test were performed and recorded in the following sections.

3.0 ENGINEERING DATA

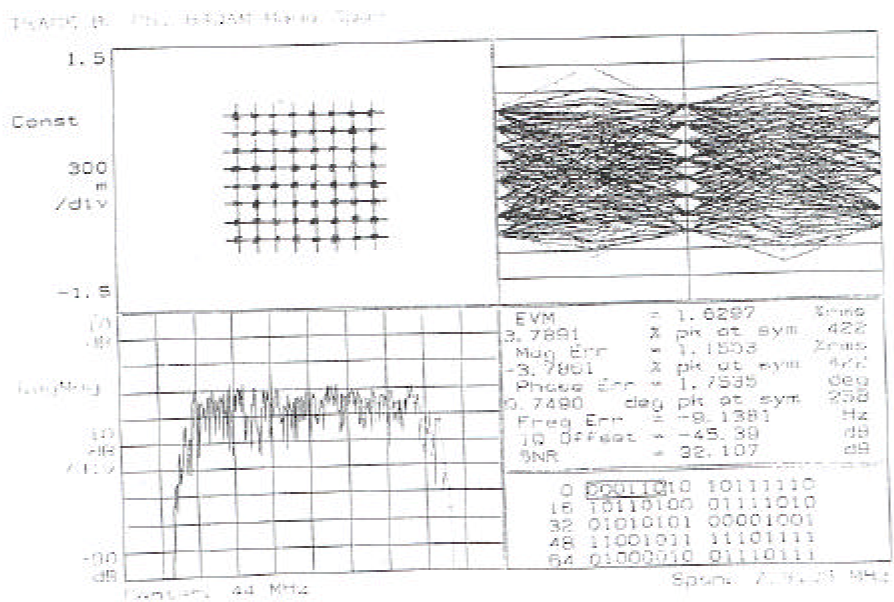
3.2 Modulation Characteristics

The modulator tray incorporates a modulation technique known as QAM, Quadrature Amplitude Modulation, which uses two carriers, each of the same frequency, but 90° apart in phase. This means that one carrier trails the other by one fourth of a cycle. Each is then phase and amplitude modulated by a portion of the digital input signal. The two modulated signals are then combined and transmitted as a single waveform. The spectrum of a QAM signal is noise-like in appearance and has a relatively stable average power and a widely varying peak-envelope-power (PEP). The power is normally referred to in average power. QAM, used in conjunction with digital compression, provides a high bandwidth efficiency allowing a data rate of 30 MBPS in a 6 MHz channel bandwidth.

The following information and diagram is for descriptive purposes only, since there are currently no FCC MMDS/ITFS regulations for digital modulation characteristics.



Typical QAM Demodulation Test Set-up



Typical Demodulated Vector Signal Analyzer Display

3.2 Modulation Characteristics - continued

Constellation Diagram	(Upper left box) This diagram displays the in-phase signal (I) on the x-axis versus the quadrature phase signal (Q) on the y-axis. The points shown on the constellation vector diagram correspond only to the symbol clock time. These points are commonly referred to as detection decision points and are called symbols. Constellation diagrams help identify such things as amplitude imbalance, quadrature error or phase noise.
Eye Diagram	(Upper right box) Eye diagrams are commonly used in digital communication systems and help identify problems such as ISI (inter- symbol interference) and jitter. The eye diagram is the display of I (real) or Q (imaginary) signal versus the time that is triggered by the symbol clock.
Spectrum Display	(Lower left box) This display shows the spectrum of the QAM modulated signal and is useful for determining and adjusting the frequency response of the signal.
Error Vector Magnitude	(Lower right box) This parameter indicates the magnitude of the vector which connects the I Q reference signal phasor to the I Q measured signal phasor. The error vector magnitude (EVM) is computed by the square root of the sum of the squares for each complex pair of points, in the time record, normalized to a reference point.
Magnitude Error	(Lower right box) This parameter indicates the difference in amplitude between the I Q reference signal and the I Q measured signal. Magnitude error is an indication of the quality of the amplitude component of the modulated signal. Magnitude error might indicate a high incidental AM modulation on the signal.
Phase Error	(Lower right box) This parameter indicates the difference in phase between the I Q reference signal and the I Q measured signal. The magnitude of the parameter is an indication of the quality of the phase component of the modulated signal. Phase error might be attributed by high incidental FM modulation on the signal.
Frequency Error	(Lower right box) This parameter indicates the carrier frequency error in relation to the analyzer's center frequency and is measured in Hz. Typical examples of frequency error are errors in RF frequency, LO frequency or digitizer clock rate.

3.0 ENGINEERING DATA

3.2 Modulation Characteristics - continued

I Q Offset (Origin Offset) (Lower right box) This parameter indicates the magnitude of the carrier feed-through (if the carrier is 100% suppressed, the I Q offset is zero). Carrier feed-through is an indication of the balance of the I Q modulator used to generate the modulated signal. If the modulator is balanced, the carrier is nulled by the RF spectrum. Imbalance in the I Q modulator results in carrier feed-through and appears as an origin offset in the constellation diagram.

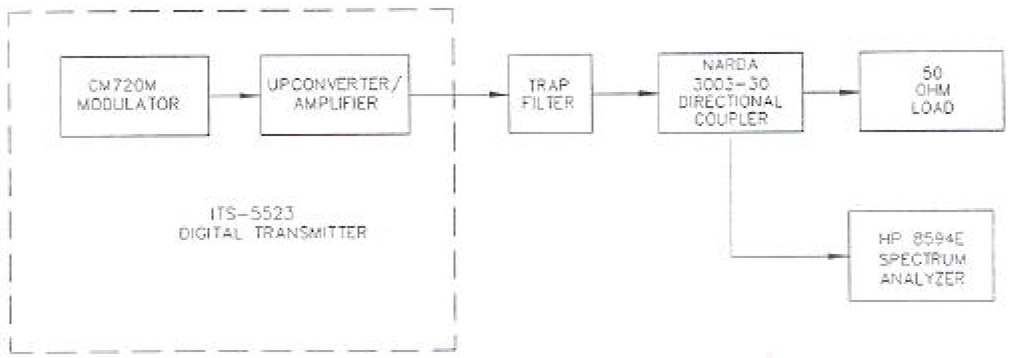
Signal to Noise Ratio (Lower right box) The signal to noise ratio (SNR) is the average symbol power of the transmitted waveform relative to the noise power. The noise power includes any term that causes the symbol to deviate from the ideal state position, such as additive noise, distortion and ISI (inter-symbol interference).

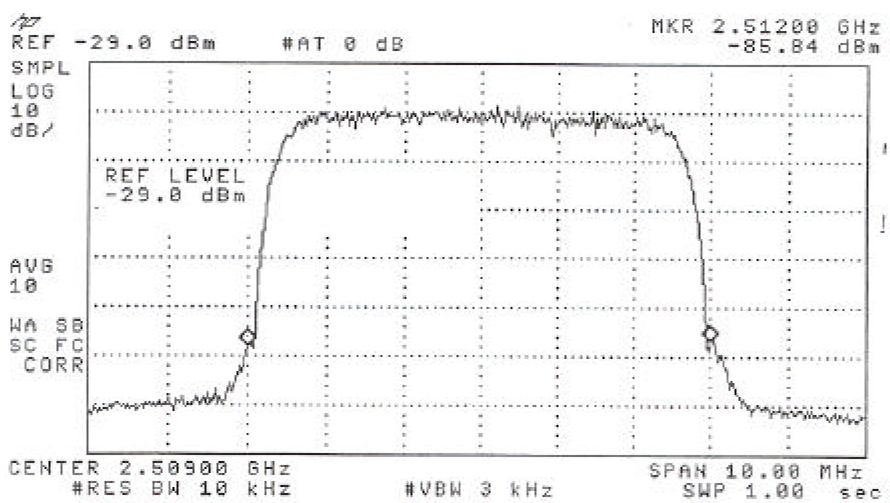
Detected Data (Lower right box) The binary data in the box represents the detected or recovered data from the digitally modulated signal.

3.0 ENGINEERING DATA

3.3 Occupied Bandwidth

Using the following test set-up, the transmitter was operated at maximum power and a plot of the transmitter occupied bandwidth spectrum was taken and is shown below.





As observed above, the occupied bandwidth of a quadrature amplitude modulated signal is approximately 6 MHz.

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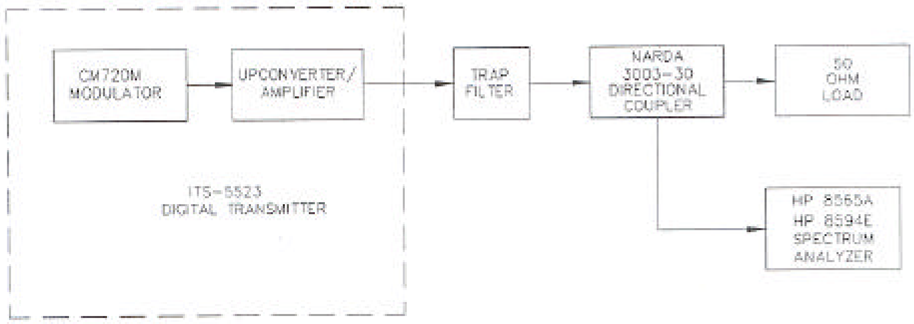
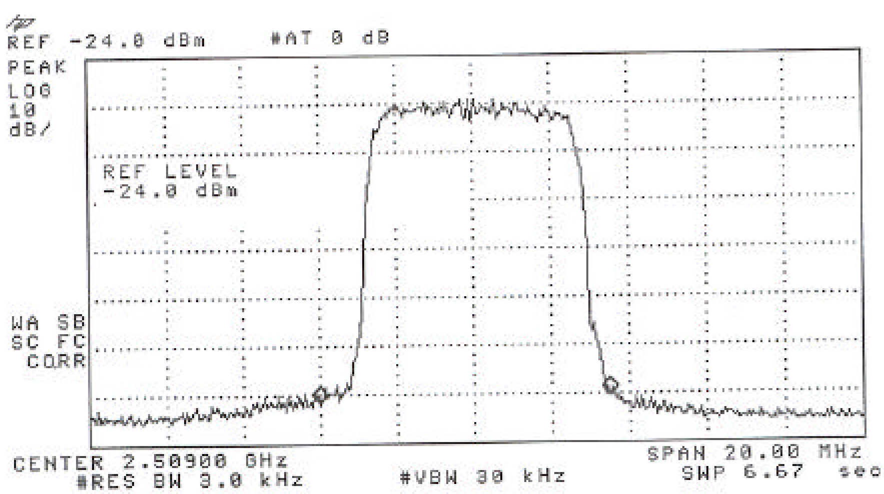
3.4 Out-of-Band Power

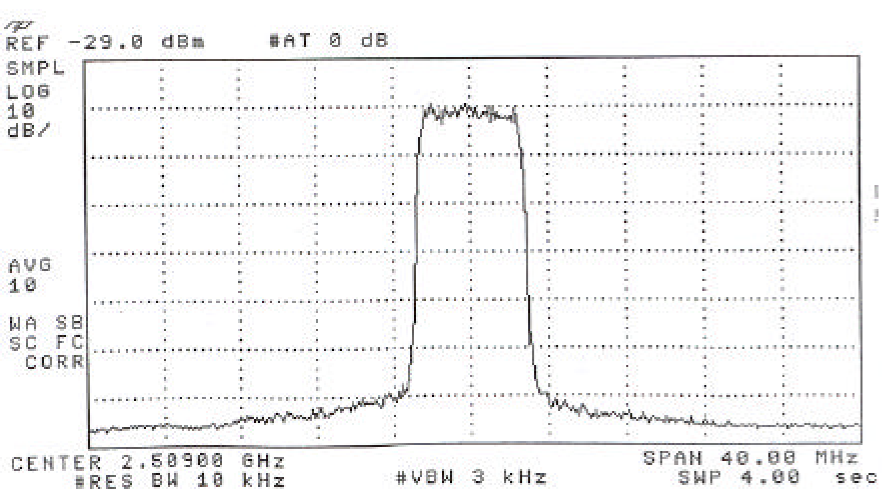
Using the test set-up shown below, the spectrum outside of the specified channel was observed and the data was taken on all products above the -70 dB noise floor of the spectrum analyzer. The measured data is shown in the table on the following pages for 5 watts average output power.

Note: The HP 8565A spectrum analyzer was used to monitor frequencies above 2900 MHz.

Spurious Emissions were observed on the analyzer at both 20 MHz and 40 MHz span (see spectrum plots below). With the average in band signal set as the reference, the spurious emissions were observed (see table on the following page).







3.0 ENGINEERING DATA

3.4 Out-of-Band Power - continued

Frequency	Source	Level Observed
2509.00 MHz	Center of Channel	0 dB (reference)
44 MHz	IF	None Observed
2553.00 MHz	Local Oscillator	None Observed
5018.00 MHz	2nd Harmonic	None Observed
7527.00 MHz	3rd Harmonic	None Observed
2506.00 MHz	Channel Edge	-48 dB
2512.00 MHz	Channel Edge	-44 dB
2503.00 MHz	3 MHz Below Channel	-61 dB
2515.00 MHz	3 MHz Above Channel	-63 dB
2505.00 MHz	1 MHz Below Channel Edge	-60 dB
2512.00 MHz	.5 MHz Above Channel Edge	-60 dB

3.0 ENGINEERING DATA

3.5 Radiated Emissions

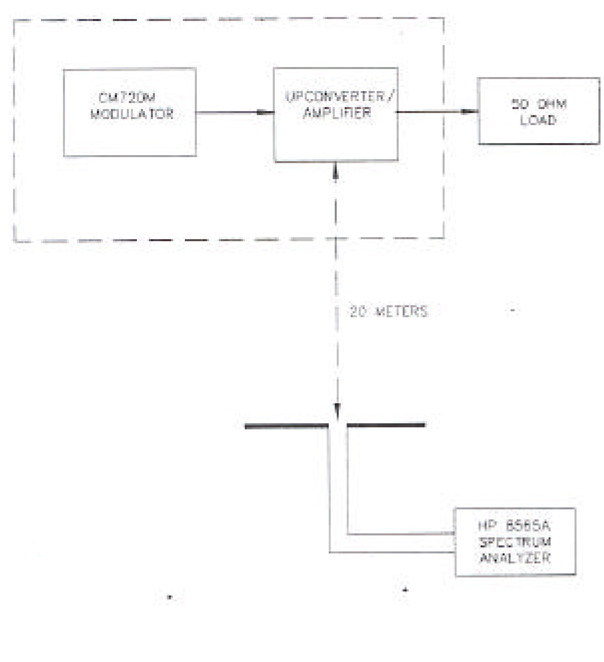
Using the test set-up below, with the transmitter operating at 5 watts output power and at a carrier frequency of 2509.00 MHz, the spectrum analyzer was moved 20 meters from the booster and connected to a dipole antenna cut to 2509.00 MHz. This antenna was oriented to maximize the received level, and the data was recorded. The antenna was then cut to the local oscillator frequency, and the second and third harmonic frequencies of the transmitter and all signals received were maximized by antenna orientation, and their absolute levels were recorded.

With these various antennas and with an adjustable length dipole for 40 to 2600 MHz, the frequency spectrum from 40 MHz to 12,000 MHz was observed. The following data was recorded:

	MEASURED LEVEL
Frequency(MHz)	**(into 50 ohms)**
2509.00	None Observed
2553.00	None Observed
5018.00	None Observed
7527.00	None Observed
44.00	None Observed

The spectrum analyzer had a maximum sensitivity of -100 dBm during these tests.

Test Set-up:



3.0 ENGINEERING DATA

3.5 Radiated Emissions - Continued

Three levels were then compared to the following reference level:

If all of the transmitter's power (5 Watts) was radiated by an isotropic radiator, the power density at 20 meters would be:

$$Pd = Pt/4\pi R^2 = 5/4\pi (20)^2 \cong 0.995x10^{-3} \ w/m^2$$

Using a dipole transmitting antenna increases this by 1.64 to:

$$1.64 * 0.995x10^{-3} = 1.632 \ x10^{-3} \ w/m^2$$

If a dipole receive antenna of area 1.64 * $?^2/4\pi$ is used to receive the signal, the received level would be:

$$1.632 \ x10^{-3} * 1.64 * ?^2/4\pi = 3.0 \ x10^{-6} w = -55 \ dBw = -25 \ dBm$$

Therfore, with a carrier reference level of -25 dBm, and a analyzer measurement threshold of -100 dBm, no measured values exceeded a level of -75 dBc (100 dBm -25 dBm = 75 dB).

The cabinet radiation was also checked with the receive dipole antenna cut to 2509.00 MHz, within very close proximity to the transmitter's trays, and the received level recorded at no time exceeded a level in excess of -10 dBm. The power density at this level would then be:

$$Pr/A = 5.7x10^{-3} \ mW/cm^2$$

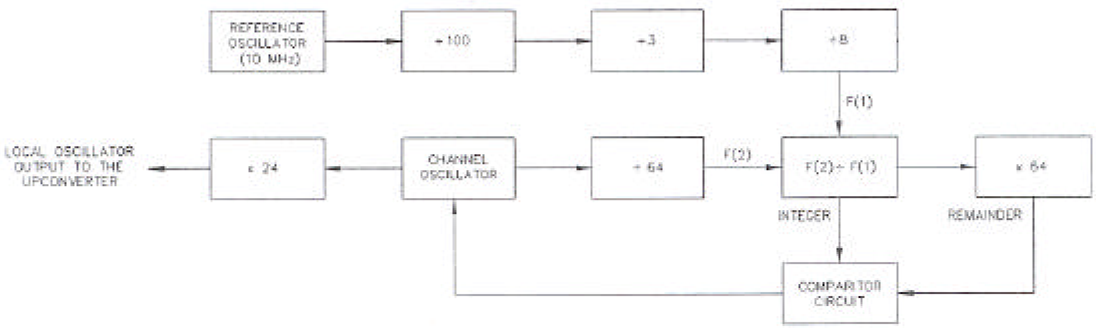
This level is far less than the current or proposed standard for safe radiation levels.

3.0 ENGINEERING DATA

3.6 Frequency Stability

Channel Oscillator Analysis

The following is the functional block diagram for phase-locking the channel oscillator:



F_r = Reference oscillator frequency
F_{co} = Channel oscillator frequency
E_r = Reference oscillator error
E_{co} = Channel oscillator error

$F(1) = F_r/2400$
$F(2) = F_{co}/64$

$F(2)/F(1) = 37.5 \times (F_{co}/F_r)$ (Equation 1)

The comparitor circuit sends an error voltage to the channel VCXO, which maintains the value derived by equation 1. If error is introduced to the reference oscillator (E_r), the comparitor offsets the channel VCXO in a manner that preserves the relationship in equation 1. This offset is defined as the channel oscillator error (E_{co}). The following is an algebraic definition for the channel oscillator error:

$[37.5 \times (F_{co} + E_{co})]/(F_r + E_r) = 37.5 \times F_{co}/F_r$
$(F_{co} + E_{co})/(F_r + E_r) = F_{co}/F_r$
$[F_r \times (F_{co} + E_{co})] = F_{co} \times (F_r + E_r)$
$F_r \times E_{co} = F_{co} \times E_r$

$E_{co} = E_r \times (F_{co}/F_r)$ (Equation 2)

The local oscillator (L.O.) frequency is 24 times the channel oscillator, or $24 \times F_{co}$. The RF output frequency is the lower product of mixing the L.O. with the modulated IF signal. The following is the algebraic expression for the output frequency:

$RF = [24 \times F_{co}] - F_{if}$ or,
$RF = [24 \times (F_{co} + E_{co})] - (F_{if} + E_{if})$ (error introduced into the equation)

3.0 ENGINEERING DATA

3.6 Frequency Stability - continued

Based on the above equation, the following equation gives the expression for the error in the output RF:

$RF_{error} = [24 \times E_{co}] - E_{if}$

Substituting equation 2 into the above error equation yields the following:

$RF_{error} = [24 \times (E_r \times F_{co}/F_r)] - (E_{if})$ (Equation 3)

The following values are substituted into equation 3. The highest channel oscillator frequency (113.625 MHz for NTSC channel G4), and the maximum IF frequency error (440 Hz) of the CM720M modulator were chosen to represent the worst possible case.

$F_r = 10$ MHz, $F_{co} = 113.625$ MHz, $E_{if} = 440$ Hz

$RF_{error} = 272.7 \times E_r - (- E_{if})$ or,
$RF_{error} = 272.7 \times E_r + 440$ (Hz) (Equation 4)

The maximum allowable RF frequency error for this service is ±1.0 kHz. This translates to a maximum reference oscillator error of $E_{r(max)} = 2.054$ Hz. The required reference oscillator stability can be calculated as follows:

Stability = $E_{r(max)} / F_r$

Stability = 2.054 Hz/10 x 10^6 Hz = 0.254 x 10^{-6}

Therefore, the RF frequency error of the ITS-5523 will not exceed ± 1.0 KHz when operated with a precise reference oscillator with a stability equal to or better than 0.254 x 10^{-6}.

The recommended GPS precise reference oscillator used with the ITS-5523 (Trak Systems Model 8821 with B4 oscillator) has a frequency stability of 1 x 10^{-9} over a temperature range of 0 to 50 °C, and a line voltage/frequency range from 85 to 265 VRMS/48 to 440 Hz (see Trak Systems 8821 specifications on the following pages) insuring a frequency stability within the tolerance specified in the Rules and Regulations (pursuant to FCC rules part 21.101 (a) and 74.961 (a)) for this service.

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3.7 Test Equipment

MODEL	MANUFACTURER	DESCRIPTION	SERIAL #
89441A	Hewlett Packard	Vector Sig. Analyzer (IF sect.)	3416A01020
89441A	Hewlett Packard	Vector Sig. Analyzer (RF sect.)	3415A00333
8594E	Hewlett Packard	Spect. Analyzer 9 kHz - 2.9 GHz	3340A0D665
8565A	Hewlett Packard	Spect. Analyzer .01 GHz - 40 GHz	1911A01004
3003-30	Narda	Directional Coupler	41991
435B	Hewlett Packard	RF Power Meter	2445A12428
2349A	Hewlett Packard	30 Watt Power Head	01948
2120	BK Precision	Oscilloscope	167-13074
1992	Racal-Dana	Frequency Counter	950304
8135	Bird	50 Ohm Termination	8520
79	Fluke	Digital Multimeter	56660032
F-11-CHM-2-2	Thermotron	Temperature Test Chamber	5737