4. TEST REPORT

4.1 RF Power Measurements

Figure 4-1 shows the test equipment setup for the RF power measurements.
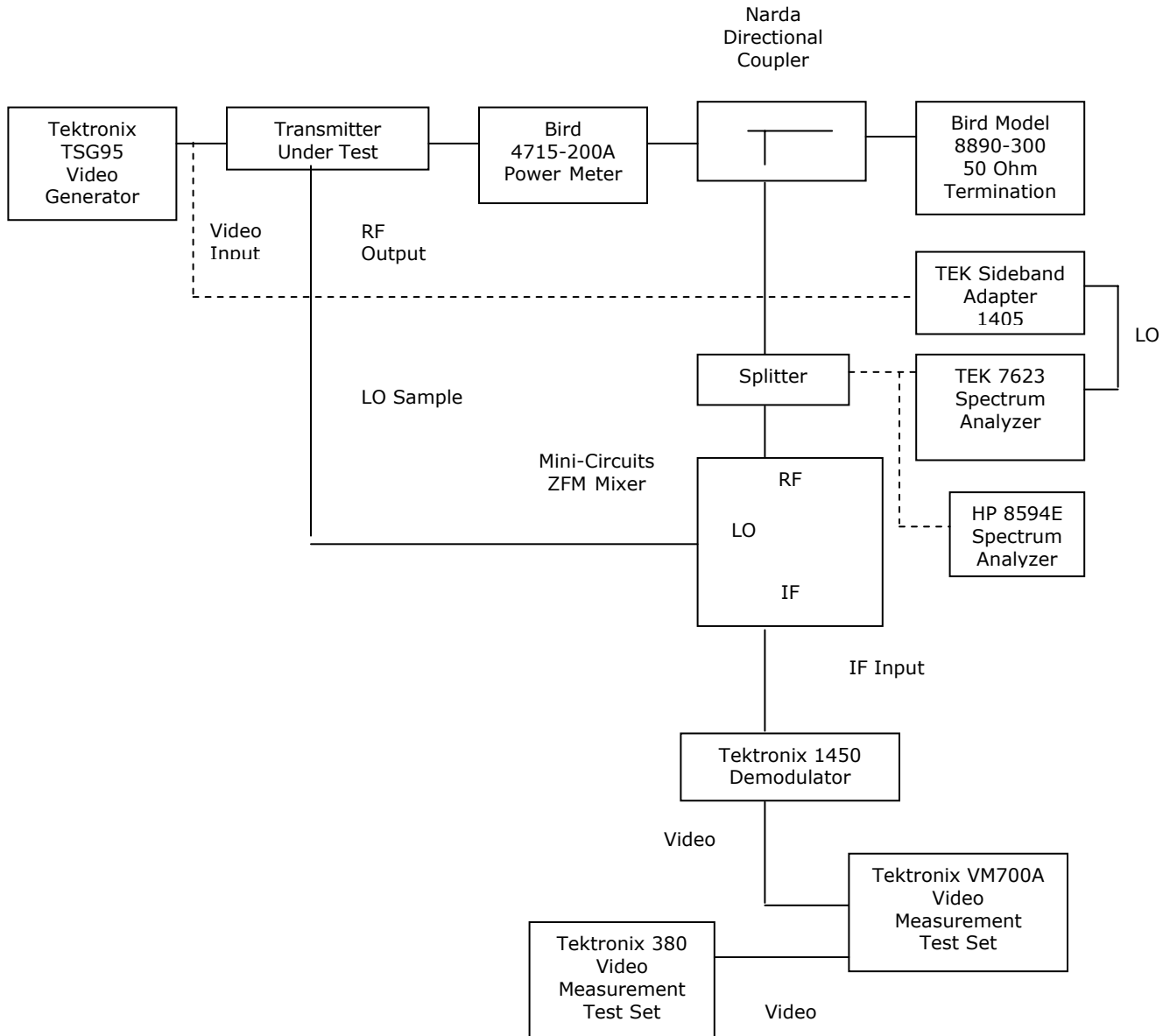

Figure 4-1. Test Equipment Setup for RF Power Measurements

The video modulation was adjusted for 25% modulation with sync and blanking video signals and the aural power was turned off. The power was then adjusted to obtain 2400 watts of average visual RF output (4000 watts peak sync at the output connector). This level was used to establish a reference on the spectrum analyzer.

Next, the aural power was turned on and adjusted to 10 dB below the visual power. The following operating parameters were recorded:

Peak Visual Power : 100%   Peak Aural Power :   100%
Reflected Power: <2%

4.2 Modulation Characteristics

4.2.1 Video Modulation

The test setup shown in Figure 4-1 was used to adjust the video signal to obtain a white picture level. The modulation was accurately measured to be 87.5% while maintaining a depth of modulation at blanking by using the Tektronix 1450 Demodulator chopper function.

Next, the video was adjusted for modulated staircase and the differential phase and gain were measured and recorded as follows:

- Differential phase: +/- 2.5°
- Differential gain: 3.2%

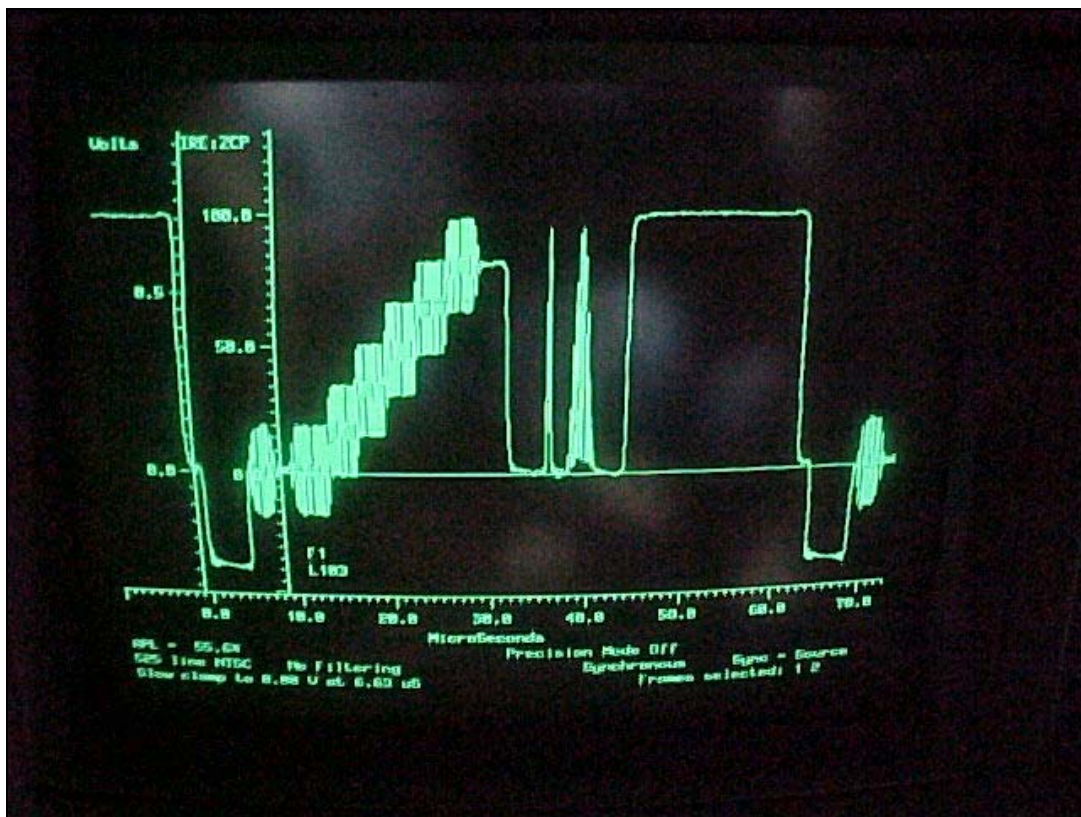Figure 4-2 shows the substantially linear transfer characteristics of the transmitter as a demodulated video waveform.

Figure 4-2. Substantially Linear Transfer Characteristics of the Transmitter as a Demodulated Video Waveform

4.2.2 Video Envelope Delay

Using the test setup in Figure 4-1, the envelope delay was measured and the data recorded as shown in Table 4-1. A sinx/x test pattern was used.

Table 4-1. Envelope Delay Measurements

VIDEO FREQUENCY (kHz)	DELAY (ns)
200	0
500	+12
1000	-12
1500	+33
2000	+4
2500	-31
3000	+17
3500	- 130
3580	- 148
4000	- 359
4180	- 430

4.2.3 Video Noise

Using the VM700A test set with a low pass 4.2 MHz filter and NTSC-7 weighting, a video noise spectrum of −55.5 dB was measured. The input video signal was 0 IRE with no burst.

4.2.4 Video Frequency Response

The test setup shown in Figure 4-1 was used to record the detected video frequency response; the results are shown in Table 4-2 and Figure 4-3.

Note: For this test, the video signal was adjusted to provide a 50% average picture level and the video sweep signal level was set to cover the range from black to white picture.

Table 4-2. Detected Video Frequency Response

VIDEO FREQUENCY	RELATIVE RESPONSE
200 kHz	+2.0 dB
500 kHz	0 dB
750 kHz	+0.2 dB
1.0 MHz	+0.3 dB
1.25 MHz	+0.3 dB
1.5 MHz	+0.2 dB
2.0 MHz	+0.4 dB
2.5 MHz	+0.5 dB
3.0 MHz	+0.2 dB
3.5 MHz	+0.3 dB
3.58 MHz	+0.2 dB
4.0 MHz	+0.5 dB
4.18 MHz	-0.6 dB
4.5 MHz	-20.0 dB
4.75 MHz	-40.0 dB
5.0 MHz	-44.0 dB

Figure 4-3. Graph of Detected Video Frequency Response

4.2.5 RF Sideband Response

The RF sideband response was recorded using the test setup shown in Figure 4-1. With the output power set to 4000 watts peak of sync, the TEK-1405 sideband adapter was adjusted to provide a sweep test signal and the RF sideband response was recorded. Data from this test is provided in Table 4-3.

Photographs of the spectrum analyzer results are shown in Figure 4-4.

Table 4-3. RF Sideband Response

| OUTPUT FREQUENCY (MHz)	VIDEO FREQUENCY	RESPONSES
591.24	Carrier	--
591.44	+200 KHz	0 (reference)
591.49	+250	-.5
591.74	+500	-4.0
591.99	+750	-4.2
592.24	+1000	-4.0
593.24	+2000	-4.2
594.24	+3000	-4.2
595.24	+4000	-4.8
595.74	+4500	-10
595.99	+4750	-29
596.24	+5000	-54
590.99	-250	-4.4
590.74	-500	-4.2
590.49	-750	-5.1
590.24	-1000	-10
589.99	-1250	-29
589.74	-1500	-34
589.49	-1750	-36
589.24	-2000	-37
588.24	-3000	-40
587.66	-3580	-48
587.24	-4000	-50
586.24	-5000	-58
596.99	+5750	-58
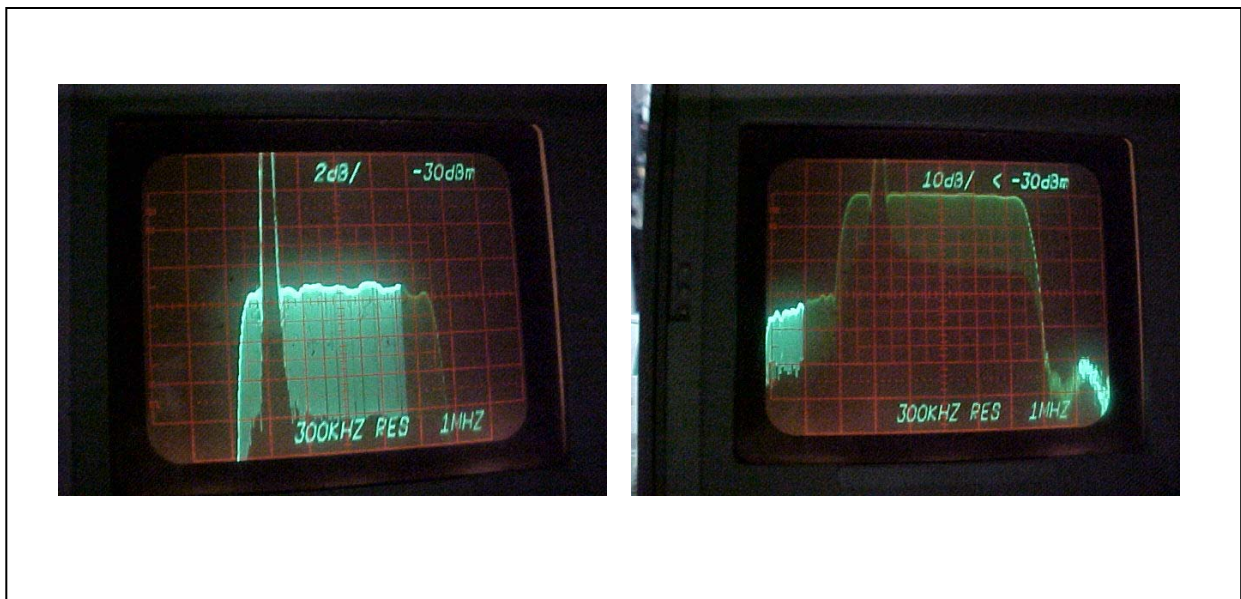
Figure 4-4. Spectrum Analyzer Results

4.2.6 Audio Modulation

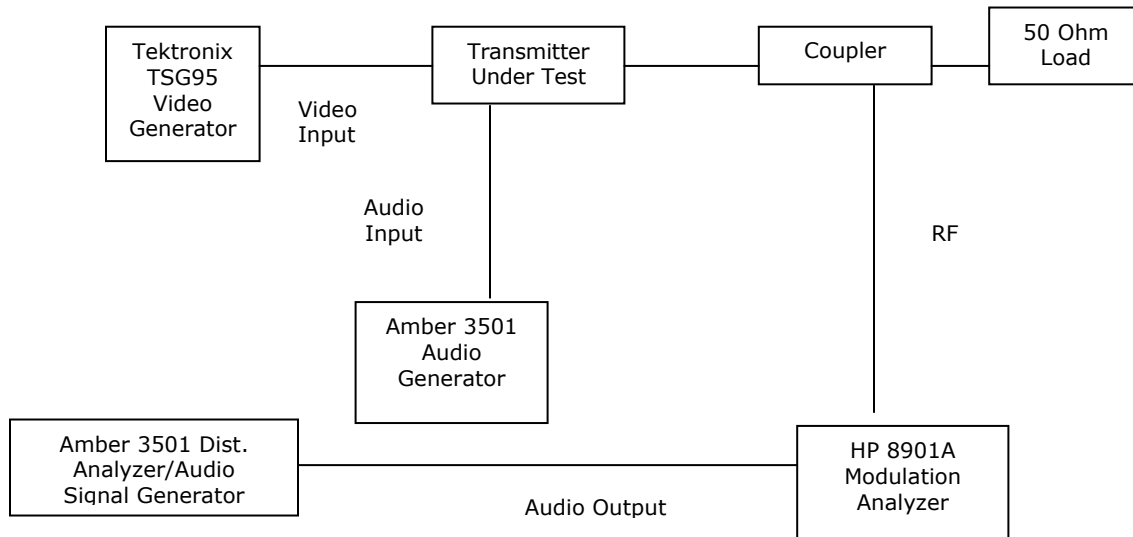The FM deviation and distortion was measured using the test setup shown in Figure 4-5.

Figure 4-5. Test Setup for Measuring FM Deviation and Distortion

The results of measuring the FM deviation and distortion are shown in Table 4-4.

Table 4-4. Results of FM Deviation and Distortion Measurements

AUDIO FREQUENCY	DEVIATION 6.25 KHz DISTORTION	DEVIATION 12.5 KHz DISTORTION	DEVIATION 25 KHz DISTORTION	DEVIATION 40 KHz DISTORTION
100 Hz	0.27%	0.24%	0.19%	0.05%
1000 Hz	0.26%	0.23%	0.14%	0.06%
5000 Hz	0.36%	0.22%	0.22%	0.26%
15000 Hz	0.45%	0.28%	0.24%	0.28%

While maintaining ±25 KHz deviation, the audio input frequency and level were varied and the response was recorded. The results are shown in Table 4-5.

Table 4-5. Results of Varying the Audio Input Frequency and Level

AUDIO FREQUENCY	RESPONSE (RELATIVE TO 100 Hz)
50 Hz	0.0
100 Hz	0.0
400 Hz	+0.1 dB
1000 Hz	+0.7 dB
2000 Hz	+2.3 dB
5000 Hz	+7.8 dB
10000 Hz	+13.0 dB
15000 Hz	+16.7 dB

Note: The HP modulation analyzer provides a calibrated audio output level that is suitable for determining the FM deviation. De-emphasis can be switched on or off for this measurement. It was off for the purposes of these tests. For the distortion measurements, the de-emphasis was switched on (pursuant to 73.687.b.3[I] of the FCC rules).

4.2.7 AM and FM Noise

The AM and FM noise was recorded using the test setup shown in Figure 4-2.

Dotted lines were used for AM tests and solid lines were used for FM tests with the following results:

- AM noise: -56 dB
- FM noise: -67 dB

4.3 Occupied Bandwidth

Using the test setup in Figure 4-6, with the transmitter operating at maximum power, photographs of the transmitter occupied bandwidth spectrum were taken and are shown in Figures 4-7 and 4-8.
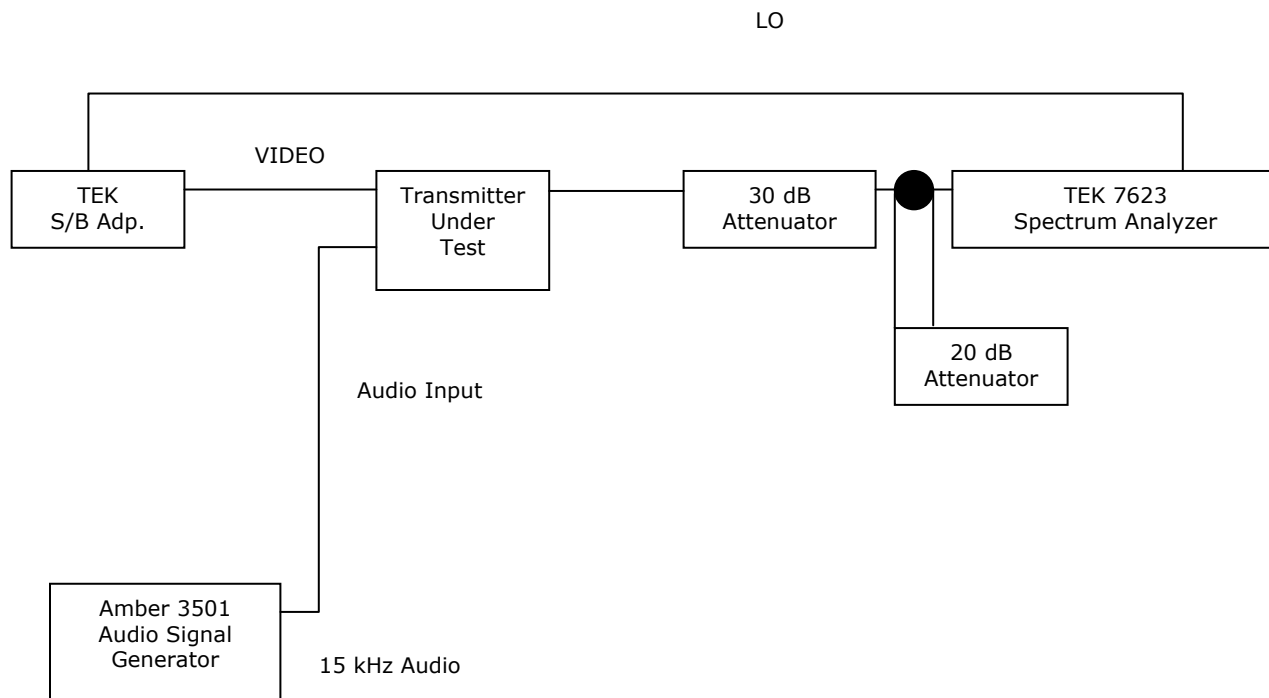

Figure 4-6. Test Setup for Occupied Bandwidth Spectrum Analysis

Note: Using the test procedure shown in Figure 4-1, the visual modulation was adjusted to 87.5% at white with the modulated staircase waveform and aural deviation adjusted to ±25 kHz (100%) with the 400 Hz audio tone.
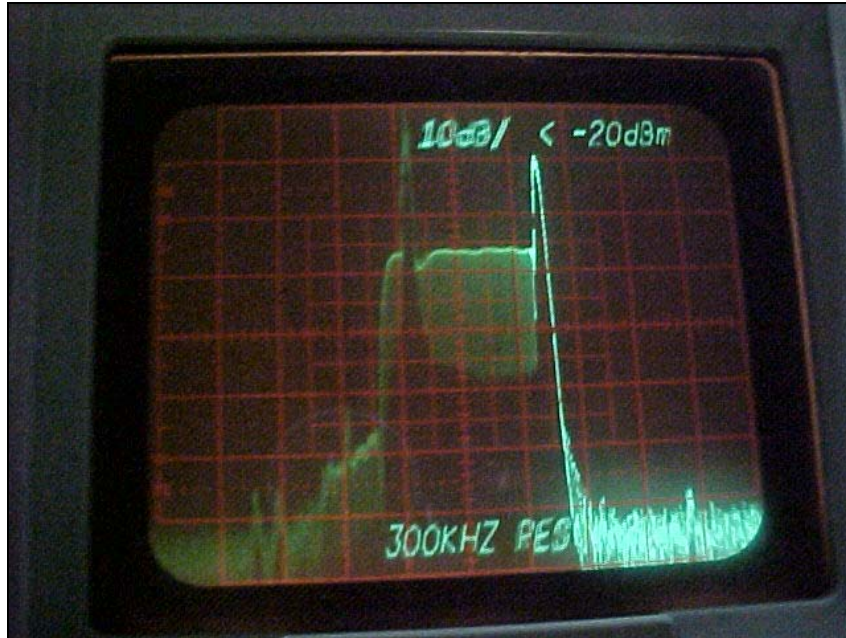
Figure 4-7. Channel Occupied Bandwidth

Figure 4-8. Aural Carrier Occupied Bandwidth

4.4 Conducted Spurious Emissions

Using the test setup shown in section 4.1, 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. This data is shown in Table 4-6 and is presented as graphs in Figures 4-9 and 4-10.

Table 4-6. Products Above the 70 dB Noise Floor of the Spectrum Analyzer

| FREQUENCY (MHz)	SOURCE	PEAK LEVEL OBSERVED (dB)
682.74	Image Visual Carrier	None observed
678.24	Image Aural Carrier	None observed
636.99	Local Oscillator	None observed
582.24	-9 MHz Product	None observed
586.74	-4.5 MHz Product	-60
595.74	Aural Carrier	-10
591.24	Visual Carrier	0
598.44	+7.2 MHz Product	-66
602.04	+10.8 MHz Product	None observed
600.24	+9 MHz Product	-61
599.32	+8.08 MHz Product	-61
596.66	+5.42 MHz Product	-52
587.66	-3.58 MHz Product	-62
1191.48	Second Harmonic-Aural Carrier	None observed
1182.48	Second Harmonic-Visual Carrier	-69
1787.22	Third Harmonic-Aural Carrier	None observed
1773.72	Third Harmonic-Visual Carrier	None observed
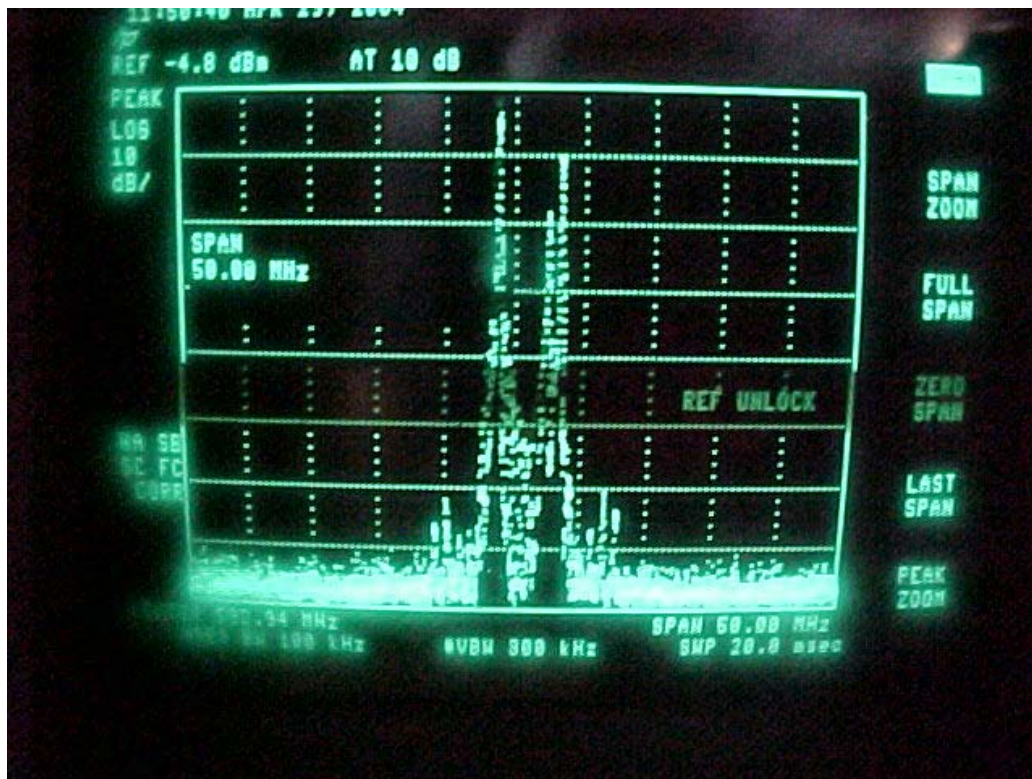
Figure 4-9. Products Above the 70 dB Noise Floor of the Spectrum Analyzer (One of Two)
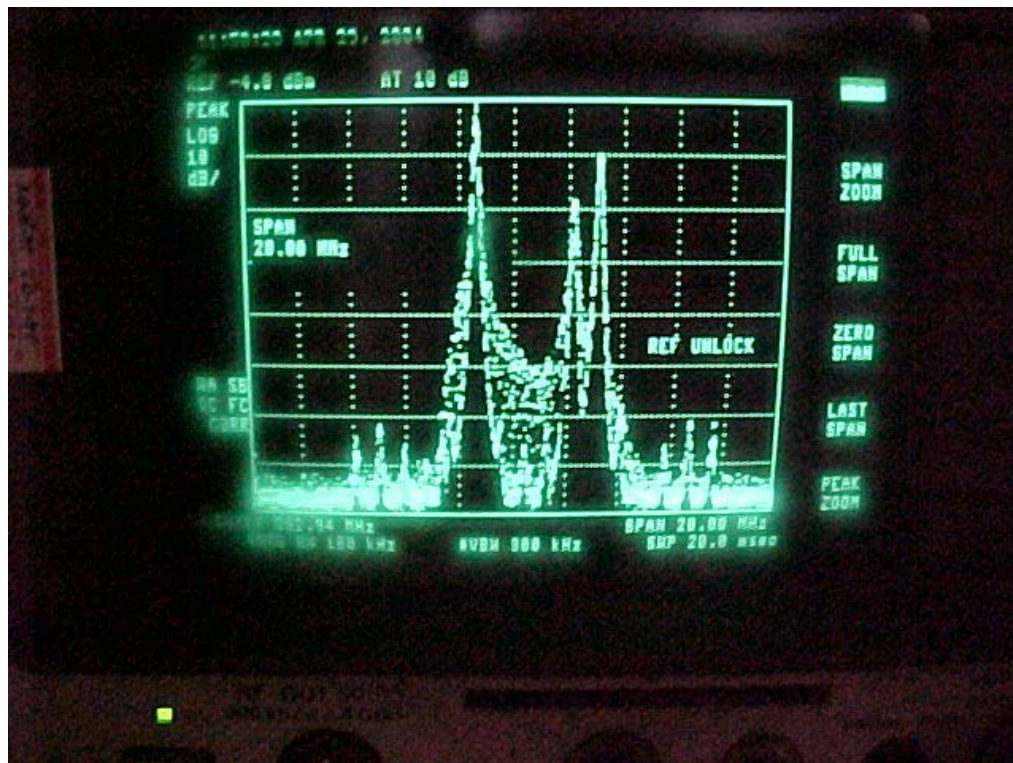
Figure 4-10. Products Above the 70 dB Noise Floor of the Spectrum Analyzer (Two of Two)

4.5 Radiated Emissions

Using the test setup shown in Figure 4-11, with the transmitter operating at full power, the spectrum analyzer was moved 20 meters from the transmitter and connected to a dipole antenna cut to 591 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 of the 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 700 MHz, the frequency spectrum from 40 MHz to 12,000 MHz was observed. The only measurable levels observed were at 591.24 and 595.74 MHz. These levels are shown below in Table 4-8 and an analysis of the relative field and strength are provided in the following paragraphs.

Table 4-8. Measurable Levels Observed in Frequency Spectrum

FREQUENCY	MEASURED LEVEL (INTO 50 Ω)
591.24	-44 dBm
595.74	-50 dBm

The spectrum analyzer had a maximum sensitivity of -110 dBm during these tests.
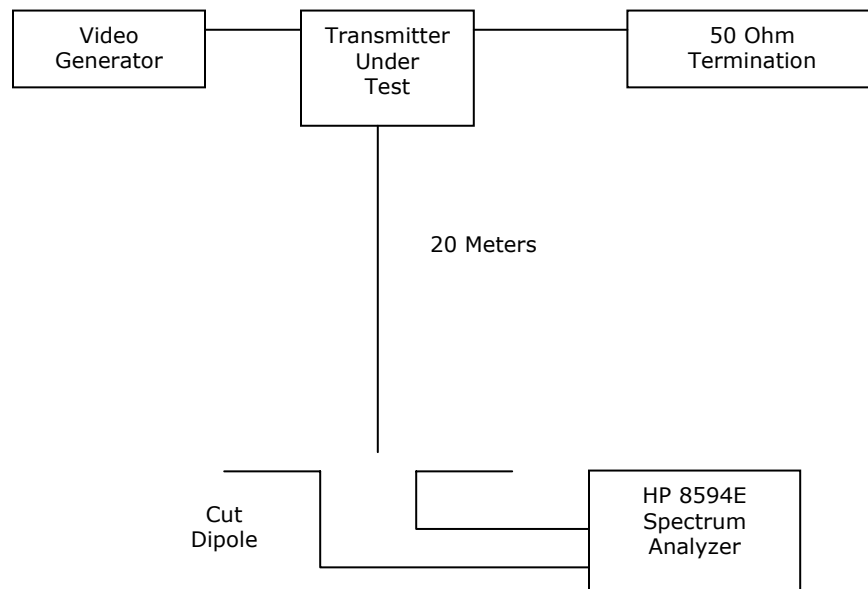
Figure 4-11. Test Setup for Measuring Radiated Emissions

Three levels were compared to the following reference level.

If all of the power of the transmitter was radiated by an isotropic radiator, the power density at 20 meters would be:

$$P = Pt/4\pi R^2 \ = \ 4000/4\pi \bullet (20)^2 \ = \ .8 \ w/m^2$$

Using a dipole-transmitting antenna increases this by 1.64 to:

$$1.64 \ x \ .8 = \ 1.3 \ w/m^2$$

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

$$1300 \ mw = \ +31.1 \ dBm$$

The receive levels at −44 dBm and −50 dBm were therefore at −75.1 dB and −81.1 dB relative to this level.

The receive levels were therefore at the relative levels shown in Table 4-9.

Table 4-9. Receive Levels

FREQUENCY	(REF = +25 dBm) RELATIVE MEASURED LEVEL
591.24	-75.1 dB
595.75	-81.1 dB

The cabinet radiation was also checked with the receive dipole antenna cut to 591.24 MHz, within very close proximity to the trays of the transmitters, and the received level that was recorded at no time exceeded a power density in excess of +1.0 dBm:

$$Pr/A = 1.2 \text{ mw/cm}^2$$

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

4.6 Frequency Stability

The LU4000AT is designed to operate using an external 10 MHz precise reference oscillator. The frequency stability of this external reference determines the frequency stability of the transmitter.

The frequency determining variables of the transmitter may be defined as follows:

F_{LO} = Desired local oscillator frequency
F_{IF} = Desired IF oscillator frequency
F_R = Desired external reference oscillator frequency
F_{RF} = Desired RF output frequency
E_{LO} = Local oscillator frequency offset error
E_{IF} = IF oscillator frequency offset error
E_R = External reference oscillator frequency offset error
E_{RF} = RF output frequency error

The PLL circuitry maintains a constant ratio between the external reference frequency and the output frequency of the oscillator. This ratio is defined below for both the LO and IF oscillators.

$G_{LO} = F_{LO} / F_R$
$G_{IF} = F_{IF} / F_R$

Any change in the external 10 MHz reference will effect a corresponding change in the output frequency such that the above ratios are maintained.

$G_{LO} = (F_{LO} + E_{LO}) / (F_R + E_R) = F_{LO} / F_R$
$G_{IF} = (F_{IF} + E_{IF}) / (F_R + E_R) = F_{IF} / F_R$

Solving for the change in output frequency yields:

$E_{LO} = E_R * (F_{LO} / F_R) = E_R * G_{LO}$

$E_{IF} = E_R * (F_{IF} / F_R) = E_R * G_{IF}$

The desired RF carrier frequency is equal to the LO frequency minus the IF frequency:

$F_{RF} = F_{LO} - F_{IF}$

The actual RF frequency, including any error introduced by the external reference, may be defined as follows:

$F_{RF} + E_{RF} = (F_{LO} + E_{LO}) - (F_{IF} + E_{IF})$
$F_{RF} + E_{RF} = (F_{LO} + F_{IF}) - (E_{LO} - E_{IF})$
$F_{RF} + E_{RF} = F_{RF} + (E_{LO} - E_{IF})$

Calculating for the error of the carrier yields:

$E_{RF} = (E_{LO} – E_{IF})$
$E_{RF} = E_R * G_{LO} - E_R * G_{IF}$
$E_{RF} = E_R (G_{LO} – G_{IF})$
$E_{RF} = E_R / F_R * (F_{LO} – F_{IF})$
$E_{RF} = E_R / F_R * F_{RF}$

Therefore, the error of the RF carrier is a function of the external 10 MHz reference error.

The maximum RF frequency error for this service is +/- 1.0 KHz. The highest channel frequency for this service (CH. 69 = 801.25 MHz) represents the worst case condition. With these values, the maximum allowable reference error ($E_{R(max)}$) can be calculated.

$E_{R(max)} = 12.48$ Hz

The required reference oscillator stability may be calculated as follows:

Stability $= E_{R(max)} / F_R$
Stability $= 12.48$ Hz$/10$ x 10^6 Hz $= 1.248$ x 10^{-6}

Therefore, the RF frequency error of the LU4000AT will not exceed +/- 1.0 KHz when operated with a precise reference oscillator with a stability equal to or better than 1.248 x 10^6.

Commercially available GPS precise reference oscillators, such as the TRACK Systems 8821, which has a frequency stability of 1 x 10^{-9} over a temperature range of 0 to 50 degrees C and a line voltage/frequency range from 85 to 265 VRMS/48 to 440Hz (See included TRACK Systems 8821 Specifications), insures a frequency stability within tolerance specified in the Rules and Regulations for this service.

4.7 Test Equipment

The test equipment that was used to analyze the Axcera LU4000AT system is listed in Table 4-14.

Table 4-14. Test Equipment

MODEL	MANUFACTURER	DESCRIPTION	SERIAL #
TSG95	Tektronix	Video Generator	10346
1450-1	Tektronix	Demodulator	10028
4715-200A	Bird	Power Meter	11776
5000E1	Bird	5000W Power Meter UHF Element	11776A
8890-300	Bird	50 Ω Termination	2308
5253B	Hewlett-Packard	Frequency Counter	716-18295
VM-700A	Tektronix	Delay and Test Set	10911
ZFM-15	Mini-Circuits	Mixer	N/A
3501	Amber	Distortion Analyzer	20014
1405	Tektronix	Sideband Adapter	20018
7603A	Tektronix	Spectrum Analyzer	20019
8594E	Hewlett-Packard	Spectrum Analyzer	10118
4715-200A	Bird	Thru-line Section	11776