## 4. TEST REPORT

### 4.1  RF Power Measurements

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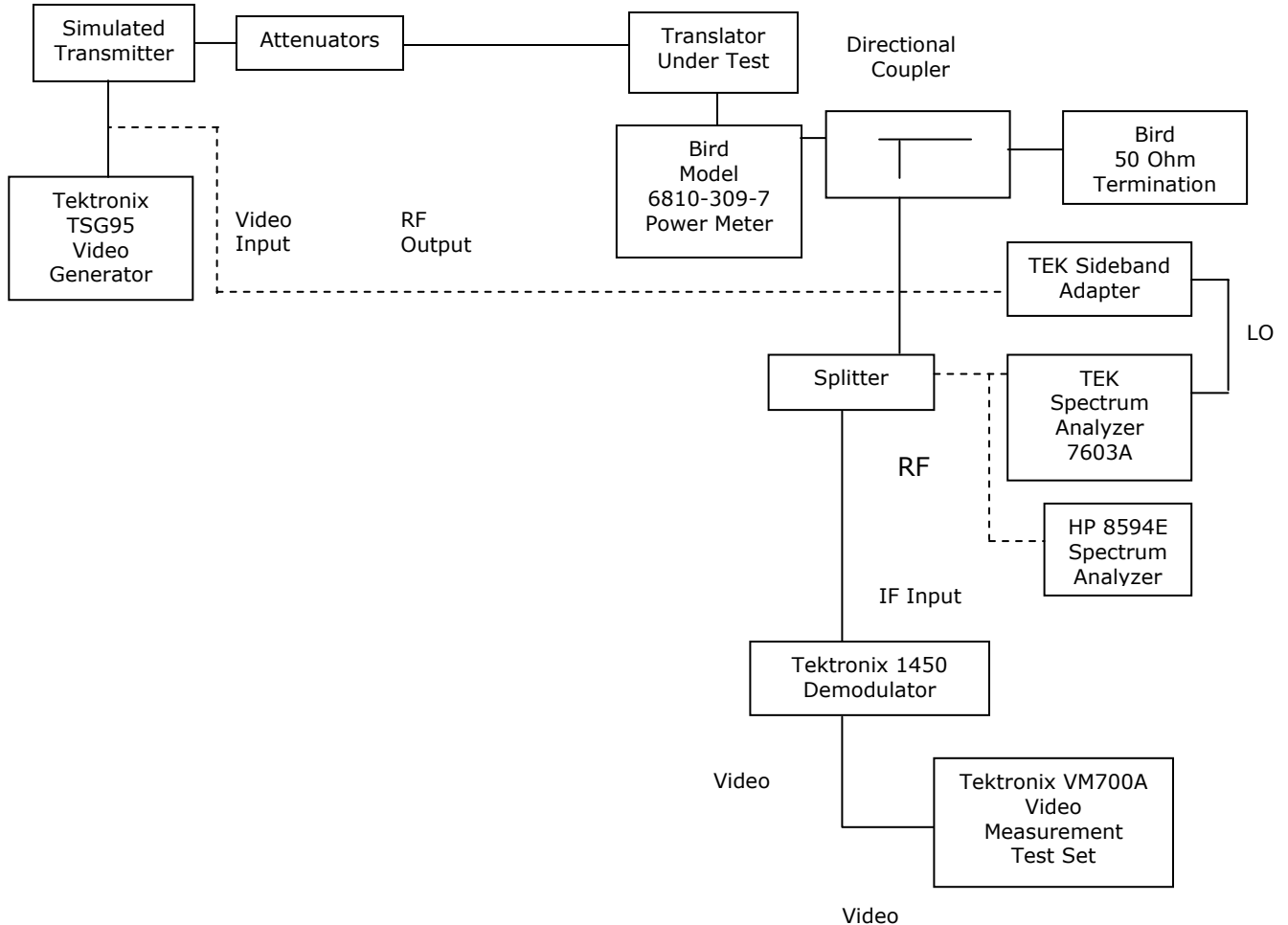


*Figure 4-1. Test Equipment Setup for RF Power Measurements*

The video modulation was adjusted for 25% with sync and blanking video signals and the aural power was turned off. The power was then adjusted to obtain 3600 watts of average visual RF output (6000 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% = 6000 Watts
Aural Power/100% = 600 Watts continuous wave (CW)
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 using the Tektronix 1450 Demodulator chopper function, the modulation was accurately measured to be 87.5% while maintaining a depth of modulation at blanking.

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

- Differential phase: +/-1.5°
- Differential gain:  2.5%

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

Not Applicable - Unit under test is a translator.

### 4.2.3  Video Noise

Not Applicable - Unit under test is a translator.

### 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 | -0.5 dB |
| 500 kHz | 0 dB |
| 750 kHz | -0.2 dB |
| 1.0 MHz | -0.4 dB |
| 1.25 MHz | -0.5 dB |
| 1.5 MHz | +0.2 dB |
| 2.0 MHz | +0.4 dB |
| 2.5 MHz | +0.6 dB |
| 3.0 MHz | 0 dB |
| 3.5 MHz | -0.1 dB |
| 3.58 MHz | -0.4 dB |
| 4.0 MHz | -1.0 dB |
| 4.18 MHz | -1.5 dB |
| 4.5 MHz | -25 dB |
| 4.75 MHz | -35 dB |
| 5.0 MHz | -46 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 6000 watts peak of sync, the Tektronix TSG95 video generator was adjusted to provide a cable 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 |
|---|---|---|
| 495.25 | Carrier | -- |
| 495.45 | +200 KHz | 0 (reference) |
| 495.50 | +250 | -.9 |
| 495.75 | +500 | -4.0 |
| 496.00 | +750 | -4.1 |
| 496.25 | +1000 | -4.4 |
| 497.25 | +2000 | -4.0 |
| 498.25 | +3000 | -4.3 |
| 499.25 | +4000 | -4.5 |
| 499.75 | +4500 | -25.0 |
| 500.00 | +4750 | -35.0 |
| 500.25 | +5000 | -46.0 |
| 495.00 | -250 | -1.0 |
| 494.75 | -500 | -6.0 |
| 494.50 | -750 | -7.0 |
| 494.25 | -1000 | -8.0 |
| 494.00 | -1250 | -35.0 |
| 493.75 | -1500 | -43.0 |
| 493.50 | -1750 | -47.0 |
| 493.25 | -2000 | -51.0 |
| 492.25 | -3000 | -48.0 |
| 491.67 | -3580 | -52.0 |
| 491.25 | -4000 | -56.0 |
| 490.25 | -5000 | -58.0 |
| 501.00 | +5750 | -60.0 |
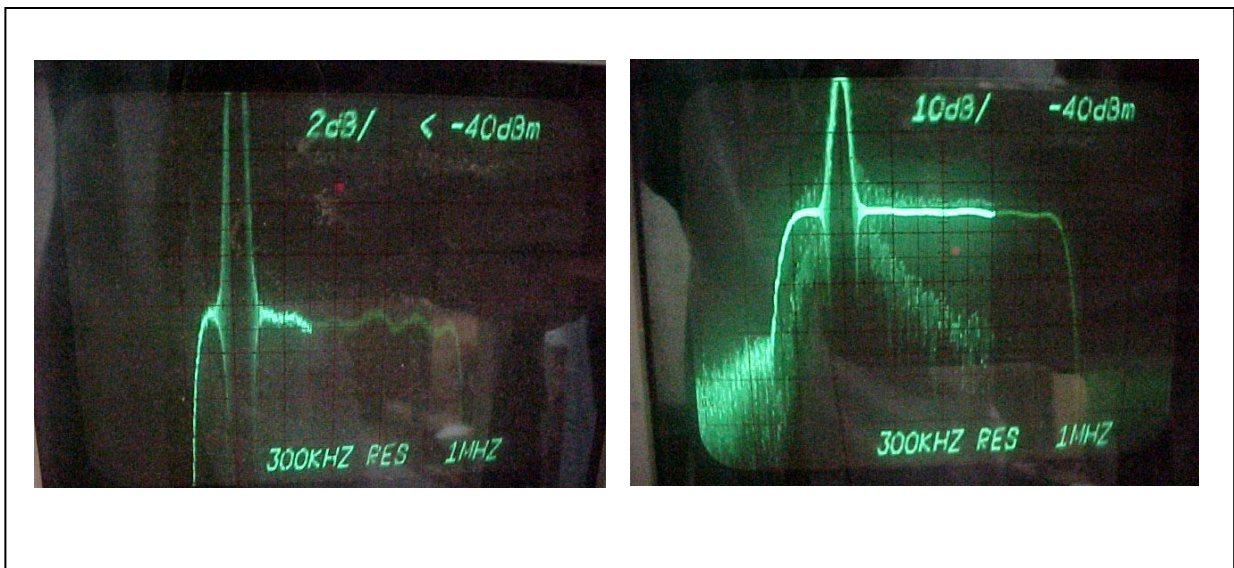


*Figure 4-4. Spectrum Analyzer Results*

### 4.2.6 Audio Modulation

*Not Applicable - Unit under test is a translator.*

### *4.2.7 AM and FM Noise*

- Not Applicable - Unit under test is a translator.

### 4.3 Occupied Bandwidth

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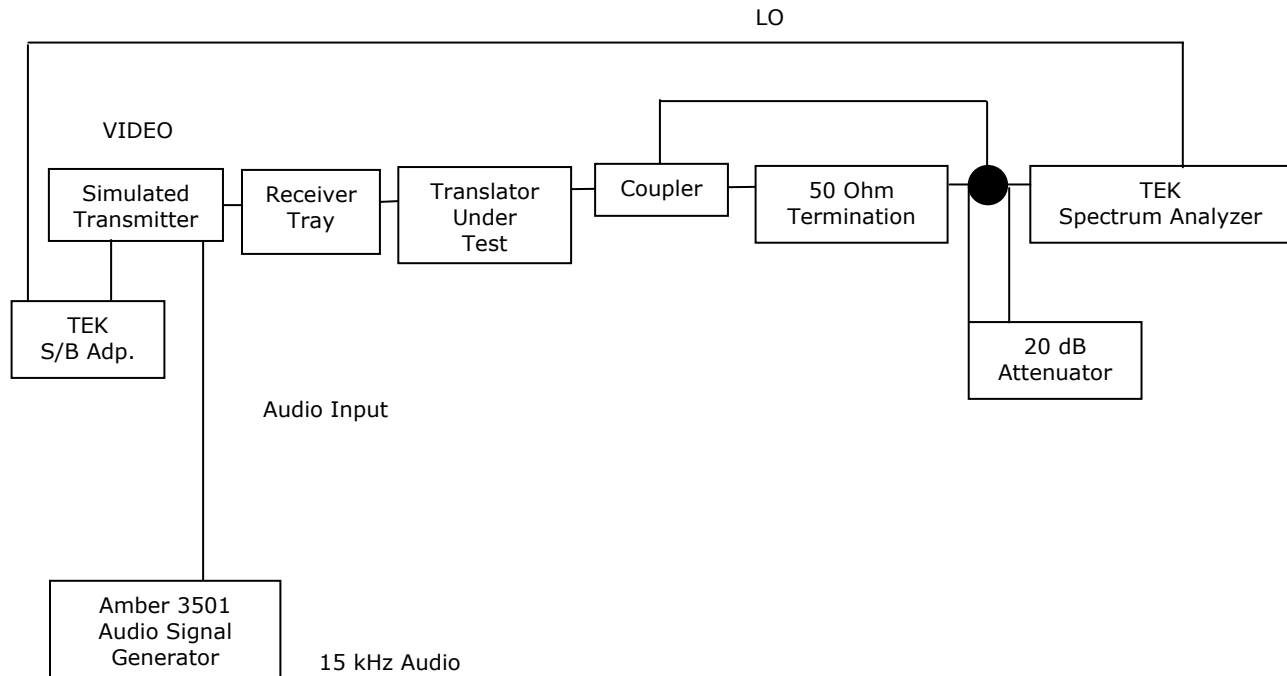


*Figure 4-6. Test Setup for Occupied Bandwidth Spectrum Analysis*

**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.**
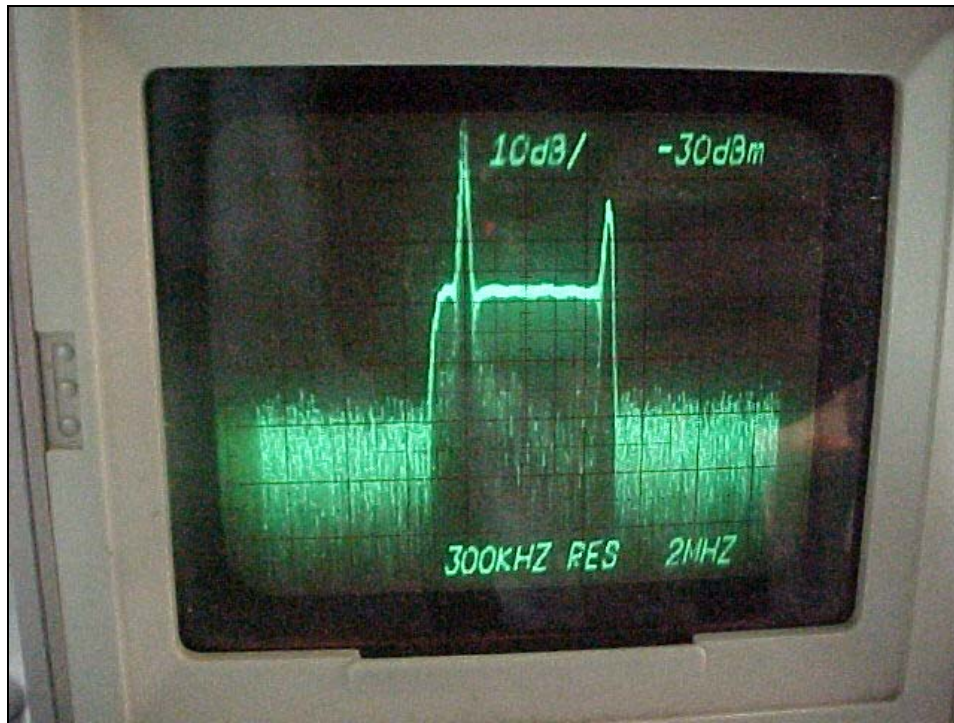
*Figure 4-7. Channel-Occupied Bandwidth*



*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 recorded 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) |
|---|---|---|
| 586.75 | Image Visual Carrier | None observed |
| 582.25 | Image Aural Carrier | None observed |
| 541.00 | Local Oscillator | None observed |
| 486.25 | -9 MHz Product | -68 |
| 490.75 | -4.5 MHz Product | -65 |
| 499.75 | Aural Carrier | -10 |
| 495.25 | Visual Carrier | 0 |
| 502.45 | +7.2 MHz Product | None Observed |
| 506.05 | +10.8 MHz Product | None observed |
| 504.25 | +9 MHz Product | None Observed |
| 503.33 | +8.08 MHz Product | None Observed |
| 500.67 | +5.42 MHz Product | -60 |
| 491.67 | -3.58 MHz Product | -66 |
| 999.50 | Second Harmonic-Aural Carrier | None observed |
| 990.50 | Second Harmonic-Visual Carrier | None observed |
| 1499.25 | Third Harmonic-Aural Carrier | None observed |
| 1485.75 | Third Harmonic-Visual Carrier | None observed |
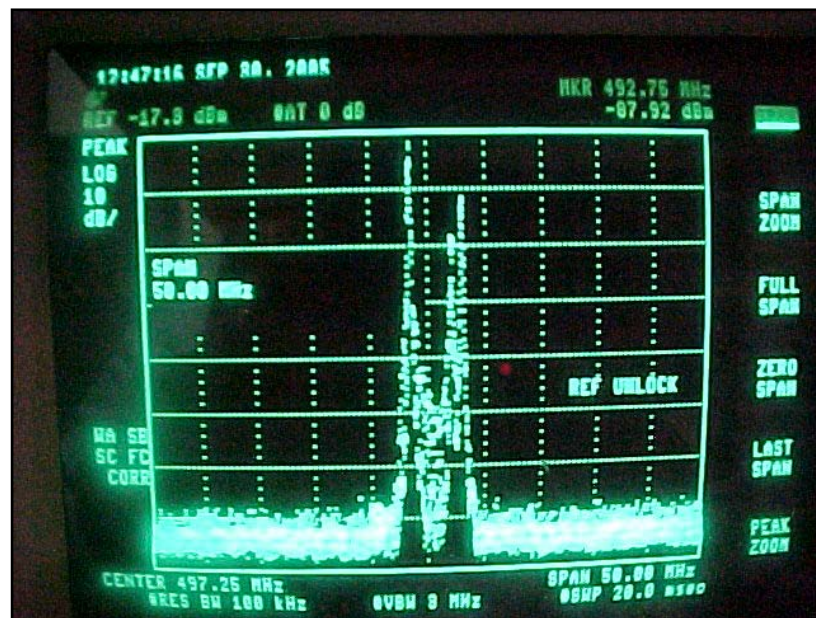


*Figure 4-9. Products Above the 70 dB Noise Floor of the Spectrum Analyzer (1 of 2)*
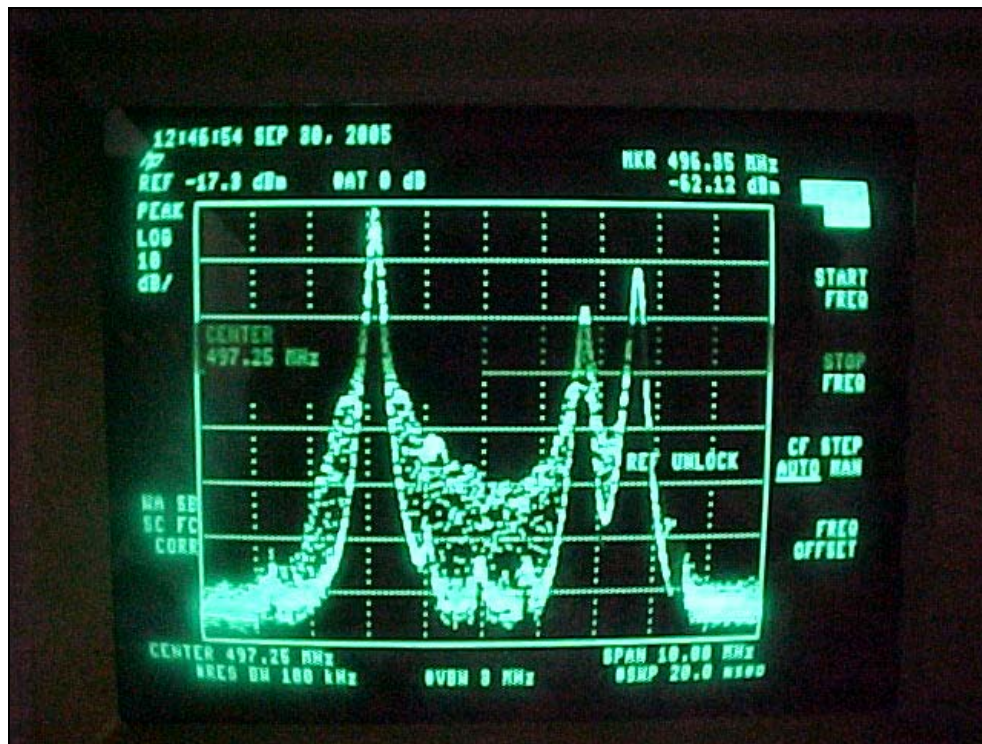
*Figure 4-10. Products Above the 70 dB Noise Floor of the Spectrum Analyzer (2 of 2)*

### 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 495 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 2,100 MHz, the frequency spectrum from 40 MHz to 2,100 MHz was observed. The only measurable levels observed were at 495.25 and 499.75 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 $\Omega$) |
|---|---|
| 495.25 | -40 dBm |
| 499.75 | -48 dBm |

The spectrum analyzer had a maximum sensitivity of -110 dBm during these tests.

```
                          ┌──────────┐              ┌──────────┐
                          │Translator│              │  50 Ohm  │
┌─────────────────────────│  Under   │──────────────│Termination│
│                         │   Test   │              │          │
│                         └──────────┘              └──────────┘
│                              │
┌──────────┐                   │
│Simulated │                   │
│Transmitter│                  │
└──────────┘              20 Meters
│
│
┌──────────┐
│  Video   │
│Generator │
└──────────┘

              ┌──────┐        ┌──────┐   ┌──────────┐
     Cut      │      │        │      │   │ HP 8594E │
     Dipole   │      │        │      │   │ Spectrum │
              └──────┘        └──────┘   │ Analyzer │
                                         └──────────┘
```
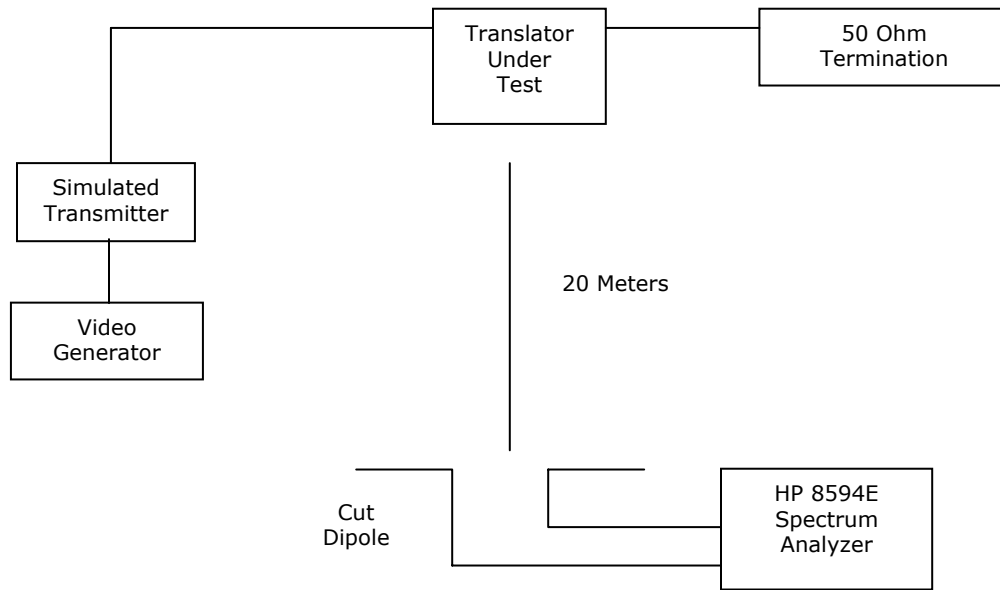
*Figure 4-11. Test Setup for Measuring Radiated Emissions*

Three levels were compared to the following reference level.

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

$$P = Pt/4\pi R^2 = 6000/4\pi \cdot (20)^2 = 1.2 \text{ w/m}^2$$

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

$$1.64 \times .40 = 1.96 \text{ w/m}^2$$

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

$$1.96 \text{ W} = +33 \text{ dBm}$$

The receive levels at −40 dBm and −48 dBm were therefore at −73 dB and −81 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 = +33 dBm) RELATIVE MEASURED LEVEL |
|-----------|------------------------------------------|
| 495.25 | -73 dB |
| 499.75 | -81 dB |

With the receive dipole cut to 495.25 MHz, the cabinet radiation was also checked, within very close proximity to the trays of the translator, and the received level that was recorded, and shown below, did not exceed a power density above of 0 dBm:

$$Pr/A = 1 \ mw/cm^2$$

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

### 4.6 Frequency Stability

The LU6000AL is designed to operate using an either an internal or external 10 MHz precise reference oscillator.  The frequency stability of this reference determines the frequency stability of the transmitter.  Both the upconverter and receiver modules utilize the same circuitry.

The frequency determining variables of the transmitter may be defined as follows:
$F_{LO1}$ = Desired local oscillator 1 frequency
$F_{LO2}$ = Desired local oscillator 2 frequency
$F_{IF}$ = Desired IF oscillator frequency
$F_R$ = Desired external reference oscillator frequency
$F_{RF}$ = Desired RF output frequency
$E_{LO1}$ = Local oscillator 1 frequency offset error
$E_{LO2}$ = Local oscillator 2 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.

$G_{LO1} = F_{LO1} / F_R$
$G_{LO2} = F_{LO2} / F_R$
$G_{IF} = F_{IF} / F_R$

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

$G_{LO1} = (F_{LO1} + E_{LO1}) / (F_R + E_R) = F_{LO1} / F_R$
$G_{LO2} = (F_{LO2} + E_{LO2}) / (F_R + E_R) = F_{LO2} / F_R$
$G_{IF} = (F_{IF} + E_{IF}) / (F_R + E_R) = F_{IF} / F_R$

Solving for the change in output frequency yields:

$E_{LO1} = E_R * (F_{LO1} / F_R) = E_R * G_{LO1}$
$E_{LO2} = E_R * (F_{LO2} / F_R) = E_R * G_{LO2}$
$E_{IF} = E_R * (F_{IF} / F_R) = E_R * G_{IF}$

The desired RF carrier frequency is equal to the LO2 frequency minus the LO1 Frequency and the IF frequency:

$F_{RF} = F_{LO2} - F_{IF} - F_{LO1}$

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

$$F_{RF} + E_{RF} = (F_{LO2} + E_{LO2}) - (F_{IF} + E_{IF}) - (F_{LO1} + E_{LO1})$$
$$F_{RF} + E_{RF} = (F_{LO2} - F_{LO1} - F_{IF}) - (E_{LO2} - E_{LO2} - E_{IF})$$
$$F_{RF} + E_{RF} = F_{RF} + (E_{LO2} - E_{LO1} - E_{IF})$$

Calculating for the error of the carrier yields:

$$E_{RF} = (E_{LO2} - E_{LO1} - E_{IF})$$
$$E_{RF} = E_R (G_{LO2} - G_{LO1} - G_{IF})$$
$$E_{RF} = E_R / F_R * (F_{LO2} - F_{LO1} - F_{IF})$$
$$E_{RF} = E_R / F_R * F_{RF}$$

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.

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

The required reference oscillator stability may be calculated as follows:

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

Therefore, the RF frequency error of the LU6000AT will not exceed +/- 1.0 KHz when operated with a precise reference oscillator with a stability equal to or better than $1.248 \times 10^6$.

The internal 10 MHz reference oscillator used in the LU6000AT has a stability of $1.000 \times 10^{-6}$ (See included Crystek Crystals Corporation Datasheet, Part Number CXOH-APY-10.00) which insures a frequency stability within tolerance specified in the Rules and Regulations for this service.

Commercially available GPS precise reference oscillators, such as the TRACK Systems 8821, which has a frequency stability of $1 \times 10^{-9}$ 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.

**Automatic Level Control Test**

Using the test setup of Figure 4-1, the RF input level to the receiver tray was varied with Telsonic 5070-04 and 5010-02 step attenuators.  The output level was monitored on the spectrum analyzer and recorded.

*Table 4-13. Automatic Level Control Results*

| RF Input (dBm) | RF Output (dBm) |
|---|---|
| -62 | Shut down (below receiver threshold) |
| -60 | +67.1 |
| -58 | +67.3 |
| -56 | +67.7 |
| -46 | +67.8 (6000 Watts) |
| -36 | +67.9 |
| -26 | +68.0 |

**4.8 Test Equipment**

The test equipment that was used to analyze the Axcera LU6000AL system is listed in Table 4-14.  All Test equipment is calibrated annually.

*Table 4-14. Test Equipment*

| MODEL | MANUFACTURER | DESCRIPTION | SERIAL # |
|-------|--------------|-------------|----------|
| TSG95 | Tektronix | Video Generator | 10346 |
| 1450-1 | Tektronix | Demodulator | 10028 |
| 6810-309-7 | Bird | Power Meter | 10779 |
| 10KE3 | Bird | 10,000W Power Meter UHF Element | 11776B |
| 8645-115 | Bird | 50 $\Omega$ Termination | 1382 |
| 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 | 20159 |
| 7603A | Tektronix | Spectrum Analyzer | 20019 |
| 8594E | Hewlett-Packard | Spectrum Analyzer | 10118 |
| 5010-02 | Telsonic | Step Attenuator | N/A |
| 5070-04 | Telsonic | Step Attenuator | N/A |
| 1265-1300 | Axcera | Exciter | N/A |
| 4805 | Bird | Thru-line | 1934 |
| 20220 | Marconi | Signal Generator | 20069 |