
FCC TYPE ACCEPTANCE REPORT

LU2000AL

**2000 WATT UHF
TRANSLATOR**

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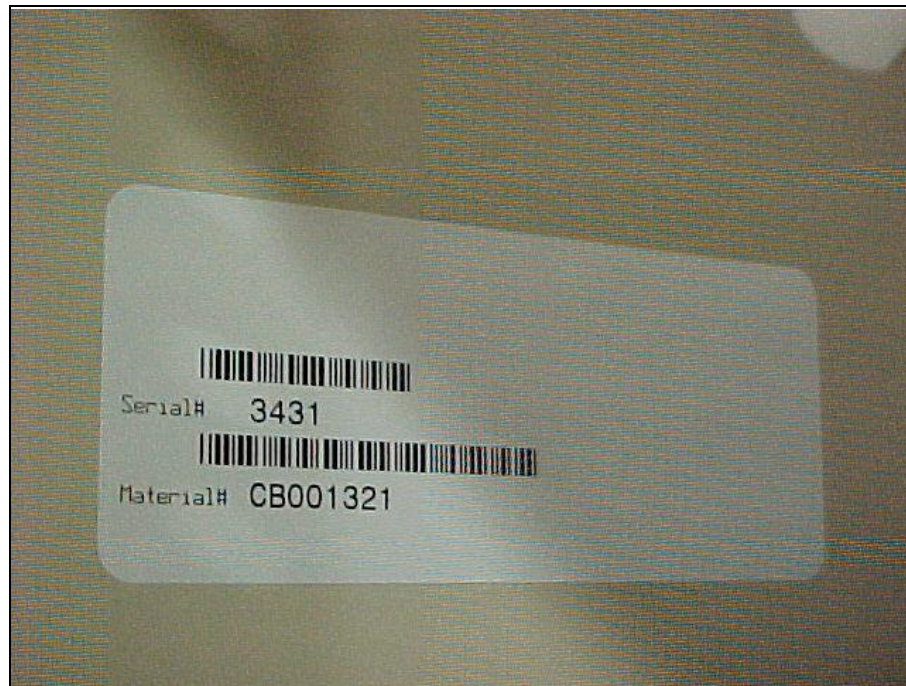
TRAK SYSTEMS MODEL 8821 DATASHEET	SHEET 1
TRAK SYSTEMS MODEL 8821 DATASHEET	SHEET 2

1. ID LABEL/LOCATION INFO

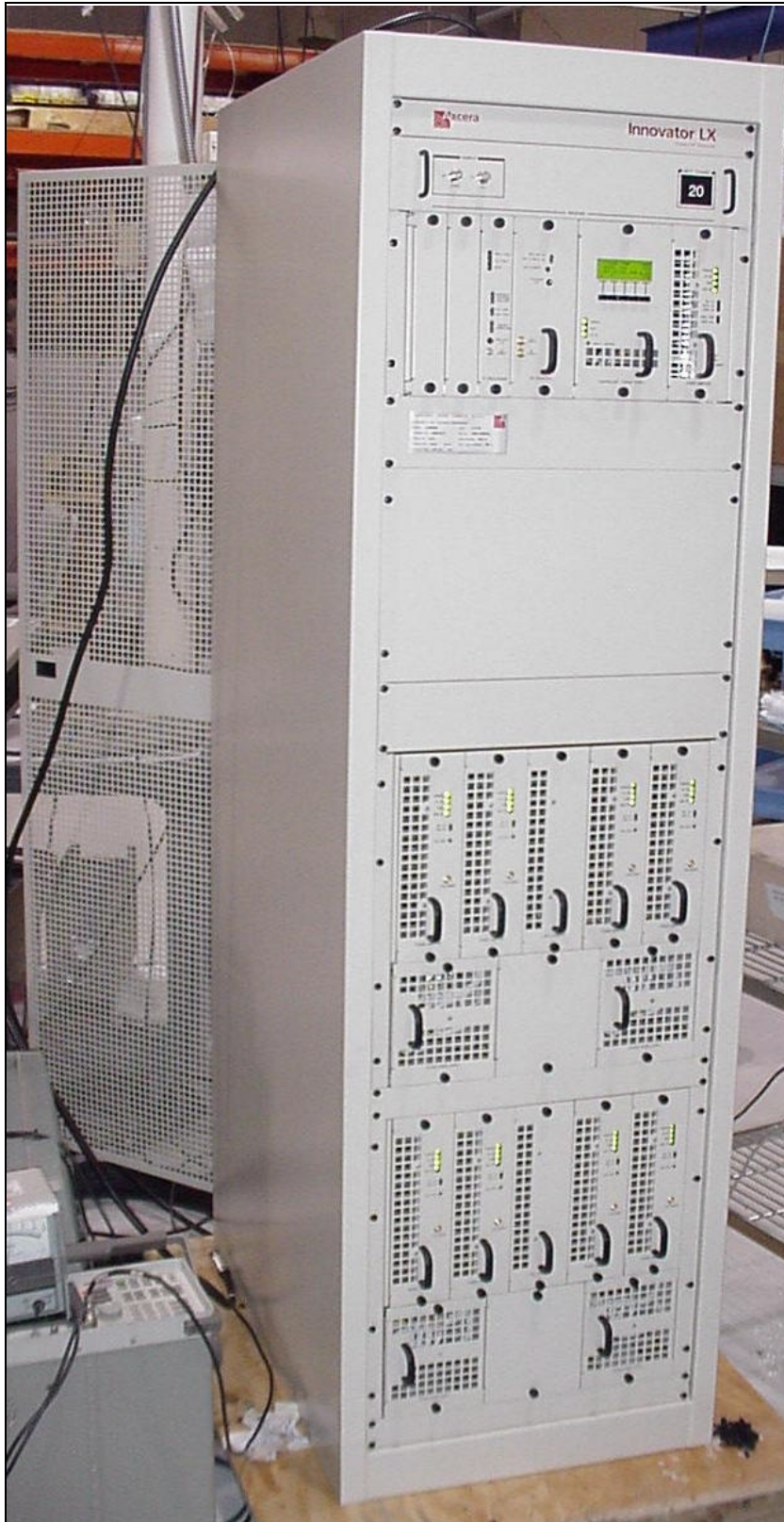
1.1 Front Panel FCC Label



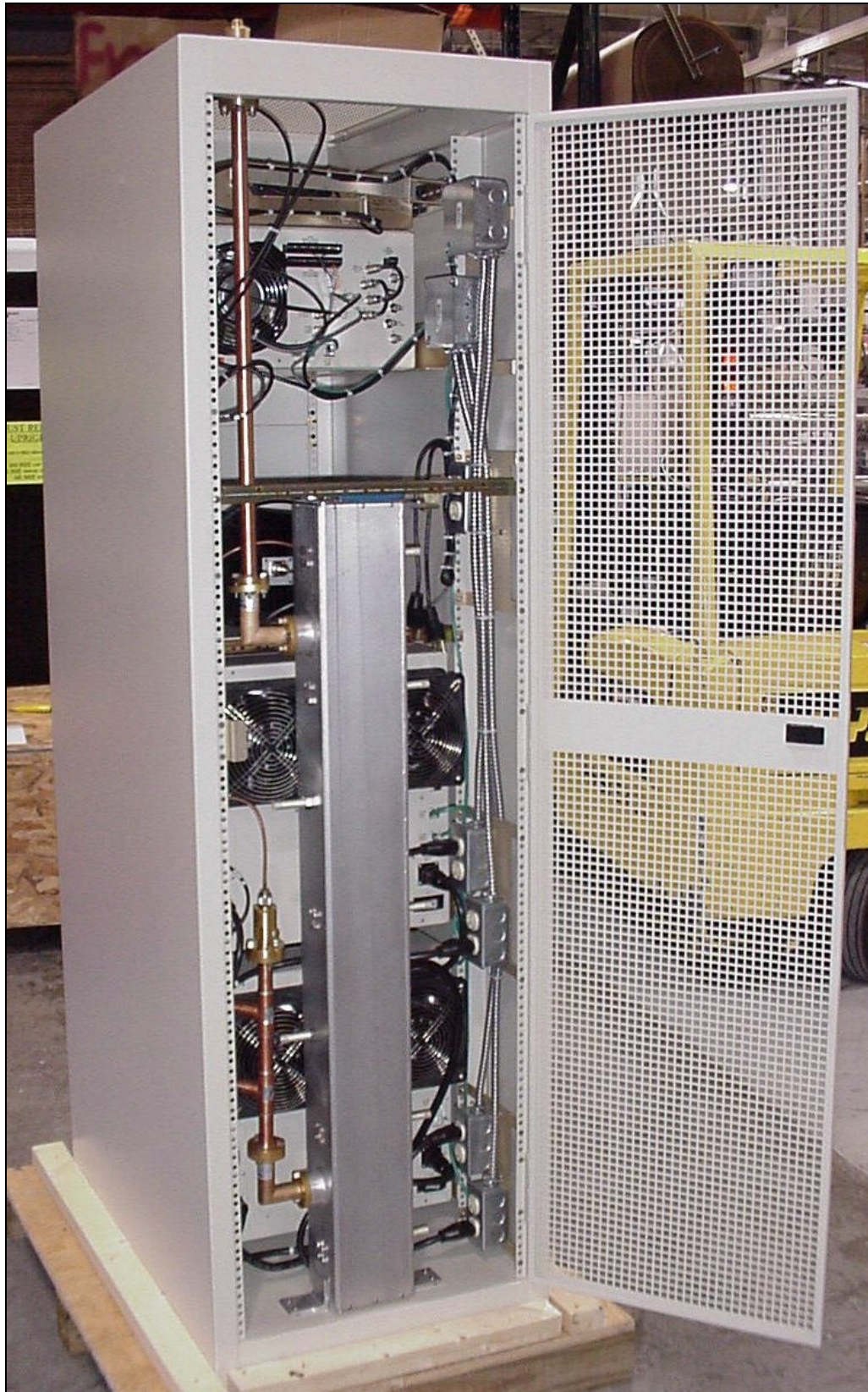
1.2 Rear Panel Manufacturer's Label



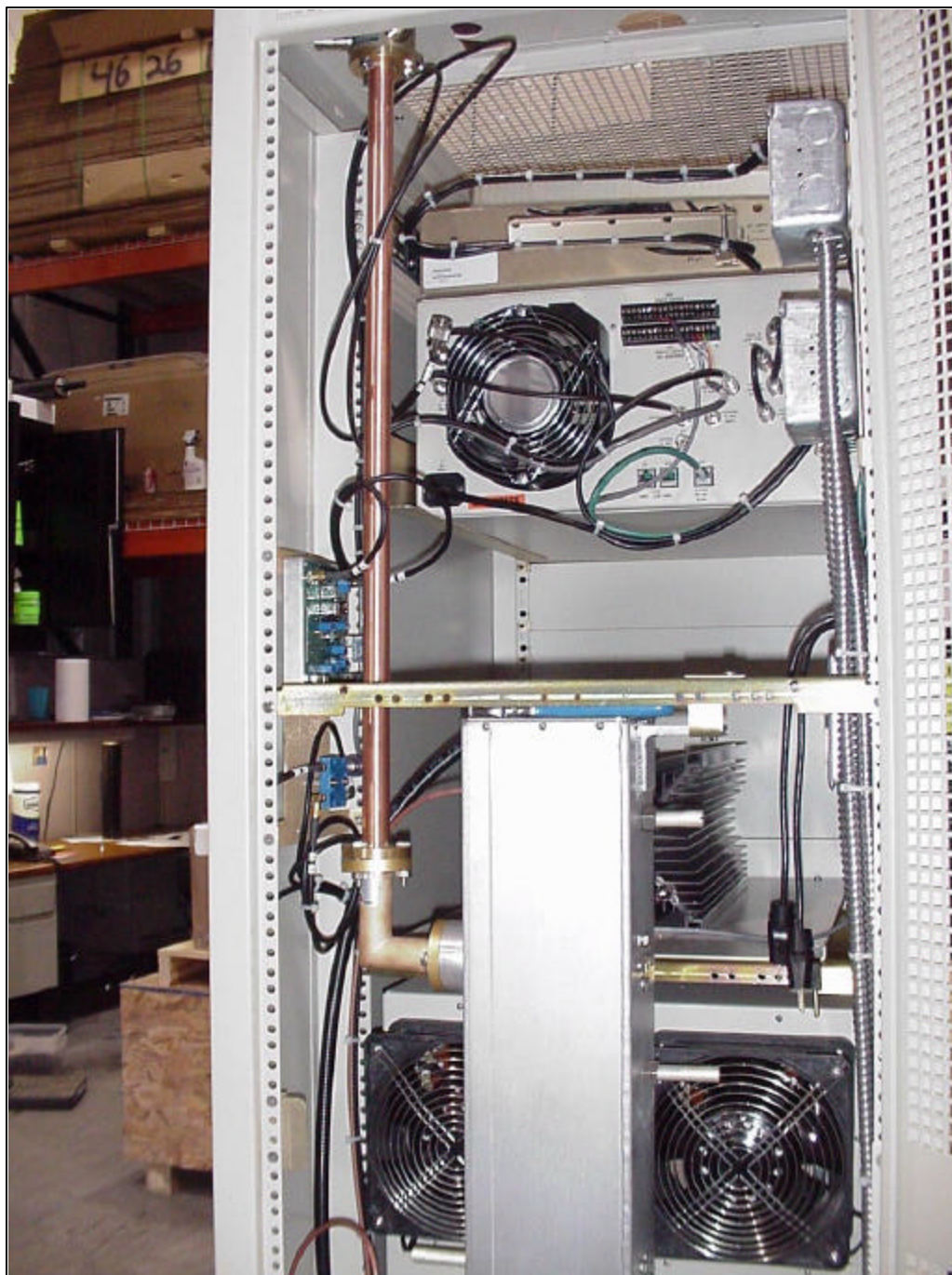
1.3 Front view, complete Axcera-LU2000AL Translator with FCC Label



1.4 Rear view, complete Axcera-LU2000AL Translator

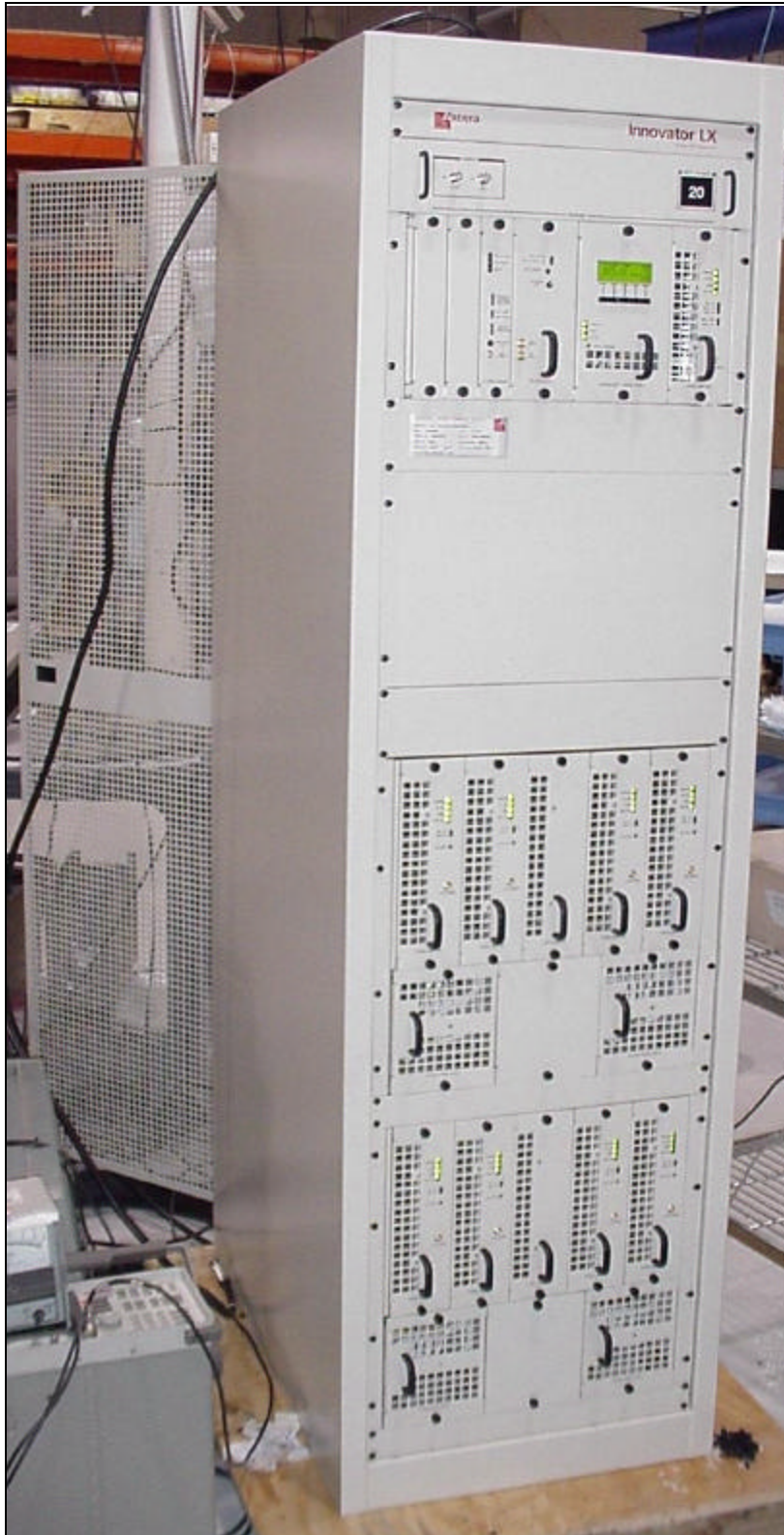


Rear view, Axcera-LU2000AL Translator with Manufacturer's Label.

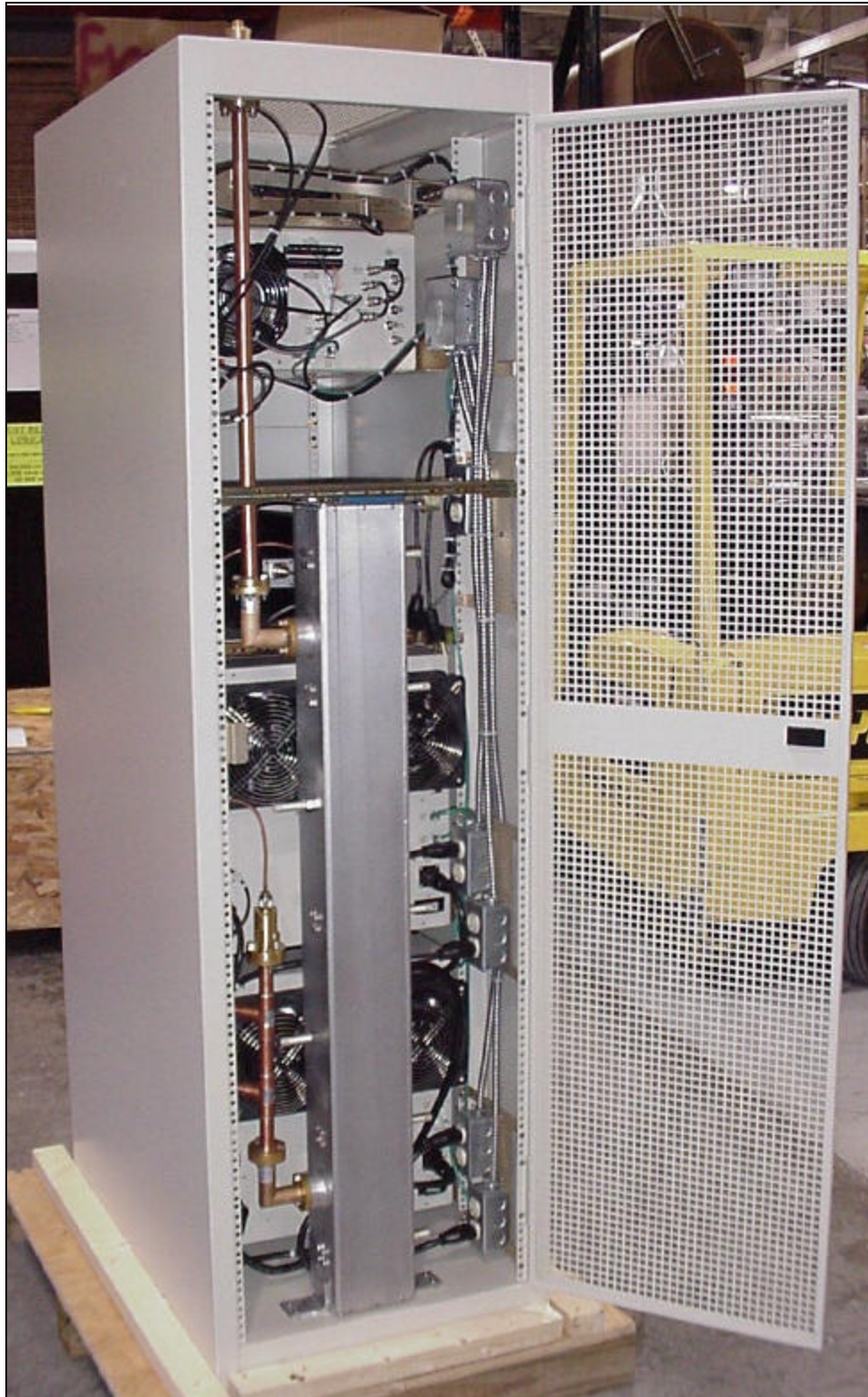


2. EXTERNAL PHOTOS

2.1 Front view, complete LU2000AL Translator



2.2 Rear view, complete Axcera-LU2000AL Translator



3. SCHEMATICS

The schematics for the Axcera-LU2000AL system are provided as separate PDF files.

4. TEST REPORT

4.1 RF Power Measurements

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

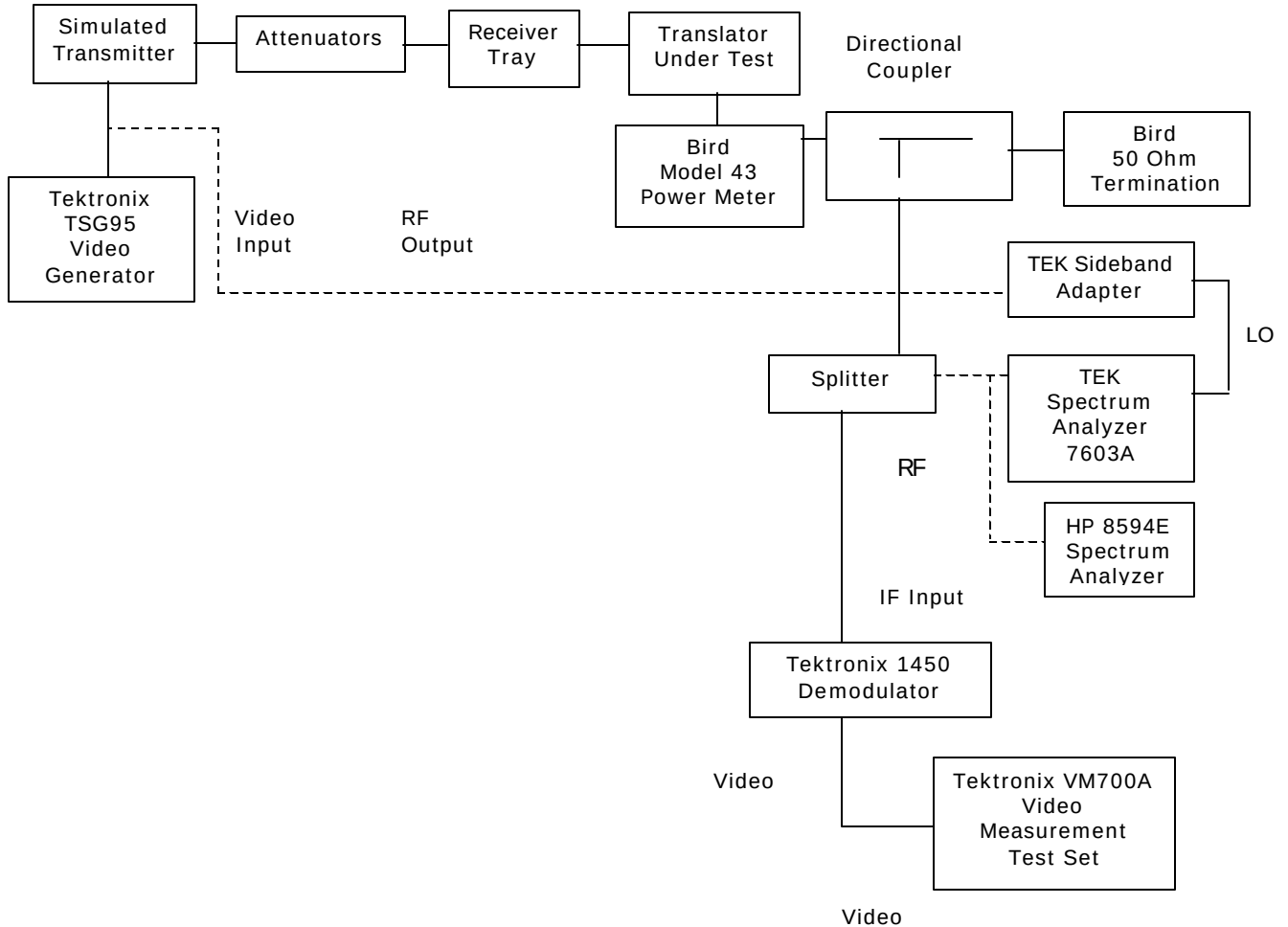


Figure 4-1. Test Equipment Setup for RF Power Measurements

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 1200 watts of average visual RF output (2000 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%=2000 Watts

Aural Power/100%=200 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: $\pm 1.5^\circ$
- Differential gain : 2.3%

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 dB
2.5 MHz	+0.1 dB
3.0 MHz	-0.3 dB
3.5 MHz	-0.3 dB
3.58 MHz	-0.2 dB
4.0 MHz	-1.0 dB
4.18 MHz	-1.2 dB
4.5 MHz	-30 dB
4.75 MHz	-35 dB
5.0 MHz	-48 dB

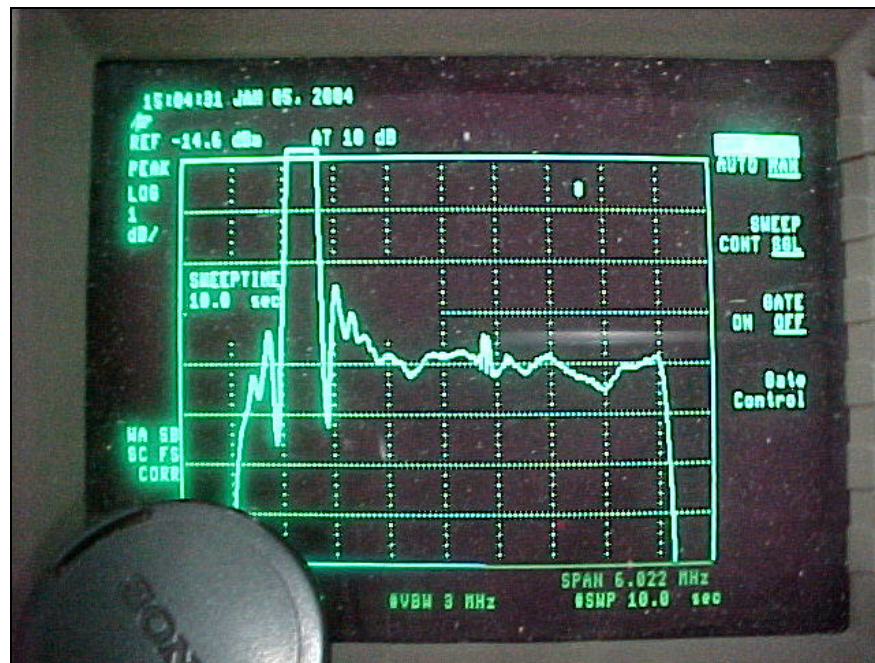


Figure 4-3. Graph of Detected Video Frequency Response

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 2000 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
675.24	Carrier	--
675.44	+200 KHz	0 (reference)
675.49	+250	-.9
675.74	+500	-4.0
675.99	+750	-4.1
676.24	+1000	-4.4
677.24	+2000	-4.0
678.24	+3000	-4.3
679.24	+4000	-5.0
679.74	+4500	-30.0
679.99	+4750	-35.0
680.24	+5000	-48.0
674.99	-250	-1.0
674.74	-500	-5.2
674.49	-750	-6.0
674.24	-1000	-7.0
673.99	-1250	-34.0
673.74	-1500	-42.0
673.49	-1750	-44.0
673.24	-2000	-50.0
672.24	-3000	-46.0
671.66	-3580	-49.0
671.24	-4000	-55.0
670.24	-5000	-55.0
669.49	+5750	-60.0

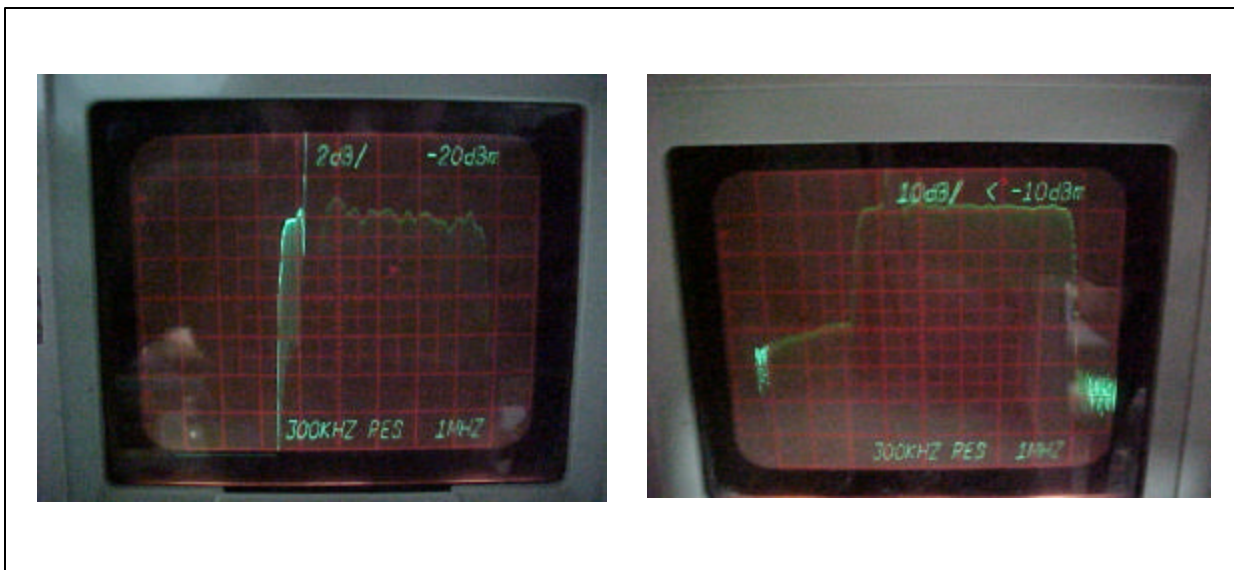


Figure 4-4. Spectrum Analyzer Results

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.

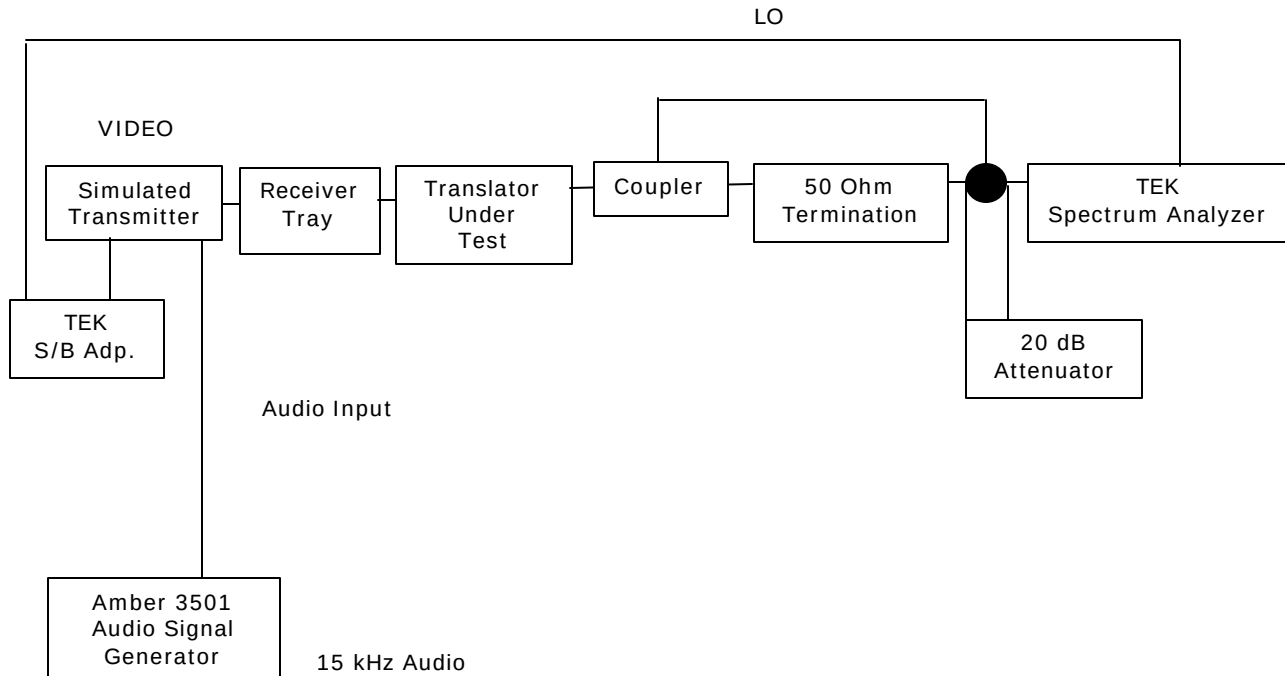


Figure 4-6. Test Setup for Occupied Bandwidth Spectrum Analysis

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.

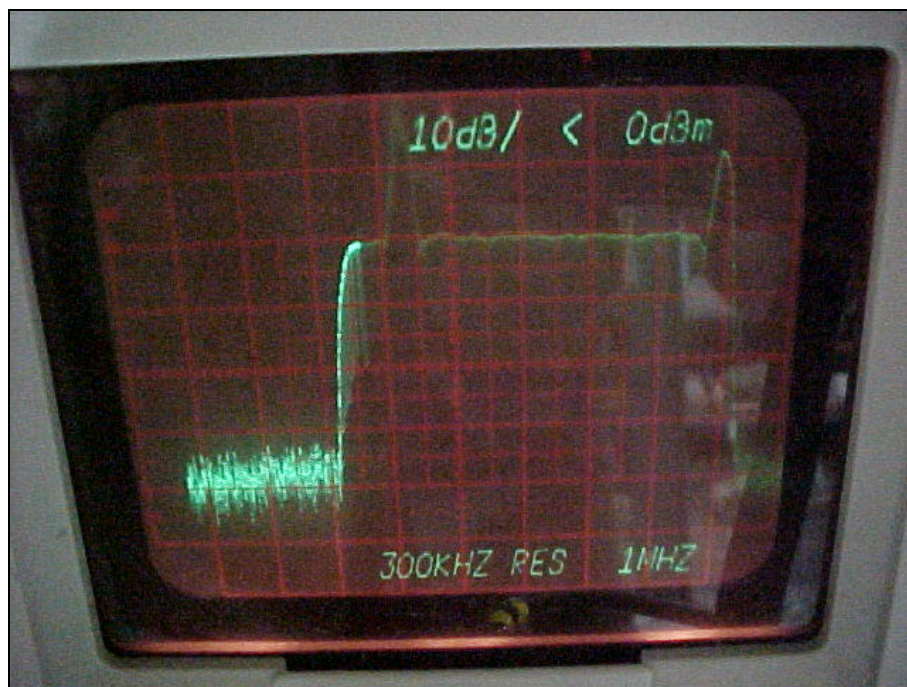


Figure 4-7. Channel-Occupied Bandwidth



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)
766.74	Image Visual Carrier	None observed
762.24	Image Aural Carrier	None observed
720.99	Local Oscillator	None observed
666.24	- 9 MHz Product	- 68
670.74	- 4.5 MHz Product	- 62
679.74	Aural Carrier	- 10
675.24	Visual Carrier	0
682.44	+ 7.2 MHz Product	- 58
686.04	+ 10.8 MHz Product	None observed
684.24	+ 9 MHz Product	- 68
683.32	+ 8.08 MHz Product	- 62
680.66	+ 5.42 MHz Product	- 55
671.66	- 3.58 MHz Product	- 67
1359.48	Second Harmonic - Aural Carrier	None observed
1350.48	Second Harmonic - Visual Carrier	None observed
2039.22	Third Harmonic - Aural Carrier	None observed
2025.72	Third Harmonic - Visual Carrier	None observed



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

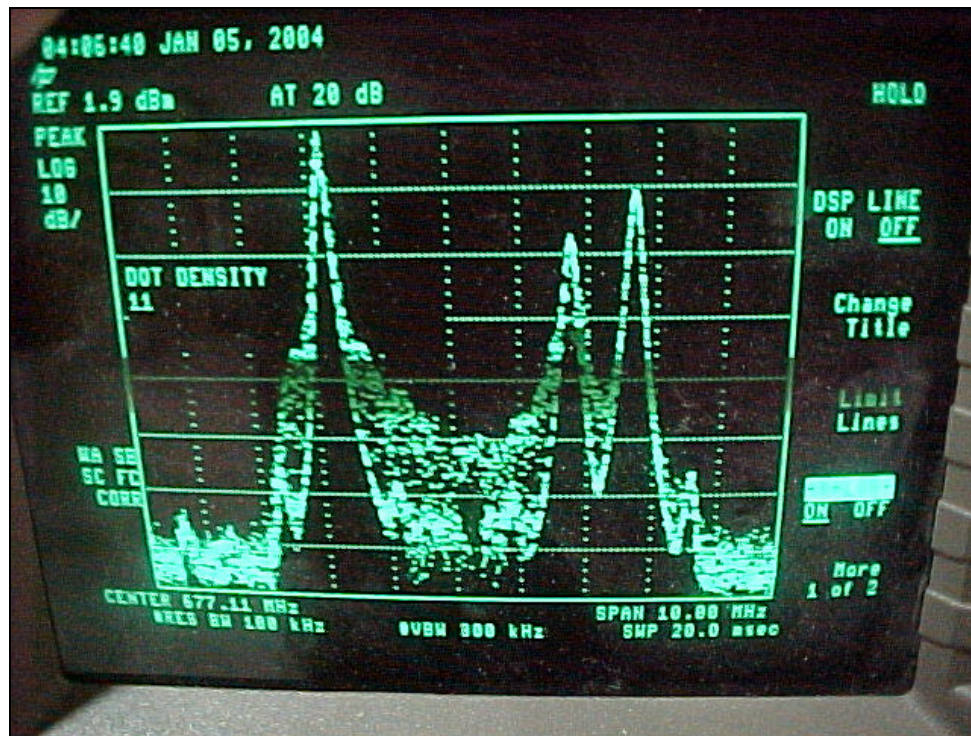


Figure 4-10. Products Above the 70 dB Noise Floor of the Spectrum Analyzer (2 of 2)

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 675 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 675.24 and 679.74 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 W)
675.24	-38 dBm
679.74	-46 dBm

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

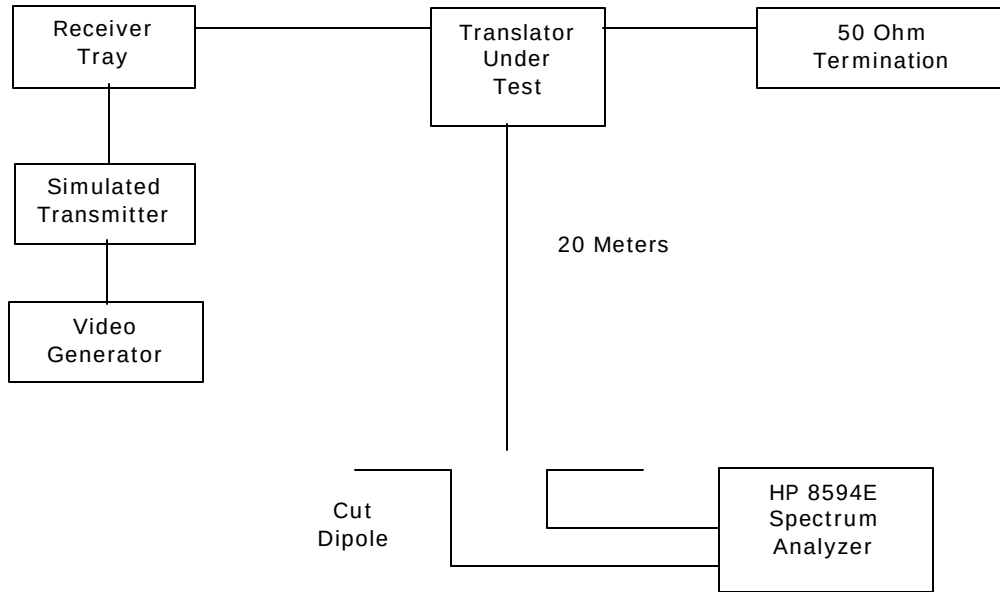


Figure 4-11. Test Setup for Measuring Radiated Emissions

Three levels were compared to the following reference level.

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

$$P = P_t / 4\pi R^2 = 2000 / 4\pi \cdot (20)^2 = .4 \text{ w/m}^2$$

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

$$1.64 \times .40 = .66 \text{ w/m}^2$$

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:

$$660 \text{ mw} = +28.2 \text{ dBm}$$

The receive levels at -38dBm and -46 dBm were therefore at -66.2 dB and -74.2 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 = +28 dBm) RELATIVE MEASURED LEVEL
675.24	- 66.2 dB
679.74	- 74.2 dB

With the receive dipole cut to 675.24 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:

$$Pr/A = 1 \text{ mw/cm}^2$$

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

4.6 Frequency Stability

The output carrier frequencies are determined by the crystal oscillator/multipliers in the exciter and receiver tray.

The Receiver's oscillator was placed in a temperature-controlled chamber and the temperature was varied from -30°C to $+50^{\circ}\text{C}$. The chamber was slowly heated and the frequency was measured at 10°C increments up to $+50^{\circ}\text{C}$. The oscillator was allowed to stabilize at each temperature before measurements were recorded.

Tables 4-10, 4-11, and 4-12 provide data on the individual oscillator frequencies; a calculation of the output frequency error indicates that the output frequency of the transmitter is well within the FCC tolerance for this service.

Table 4-10. Oscillator Data

TEMP (°C)	OVEN CONTROLLED EXCITER CRYSTAL OSCILLATOR (MHz)
- 30	81.124932
- 20	81.124968
- 10	81.124969
0	81.124975
10	81.124986
20	81.125000
30	81.125031
40	81.125057
50	81.125070

Table 4-11. Calculated Frequency Errors

TEMP (°C)	DUAL OVEN OSCILLATOR ERROR D ¹ KHz	TOTAL OUTPUT ERROR (kHz)
-30	-0.068	-0.544
-20	-0.032	-0.256
-10	-0.031	-0.248
0	-0.025	-0.200
10	-0.014	-0.112
20	0.0	0.0
30	0.031	+0.248
40	0.057	+0.456
50	0.070	+0.560

Table 4-12. Frequency Stability Versus Line Voltage

LINE VOLTAGE	OSCILLATOR (MHz)	TOTAL OUTPUT ERROR kHz
95V	81.125000	0.00
115V	81.125000	0.00
135V	81.125000	0.00

The LU2000AL 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 translator.

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.

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

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 LU2000AL will not exceed +/- 1.0 KHz when operated with a precise reference oscillator with a stability equal to or better than 1.248×10^{-6} .

Commercially available GPS precise reference oscillators, such as the TRACK Systems 8821, which has a frequency stability of 1×10^{-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 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	+62.3
-58	+62.5
-56	+62.8
-46	+63.0 (2000 Watts)
-36	+63.1
-26	+63.2

4.8 Test Equipment

The test equipment that was used to analyze the Axcera LU2000AL 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
43	Bird	Power Meter	20060
2500E1	Bird	2500W Power Meter UHF Element	11776B
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	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
1265-1100	Axcera	Receiver	N/A
4715-200A	Bird	Thru-line	11776