

## 4. TEST REPORT

### 4.1 RF Power Measurements

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

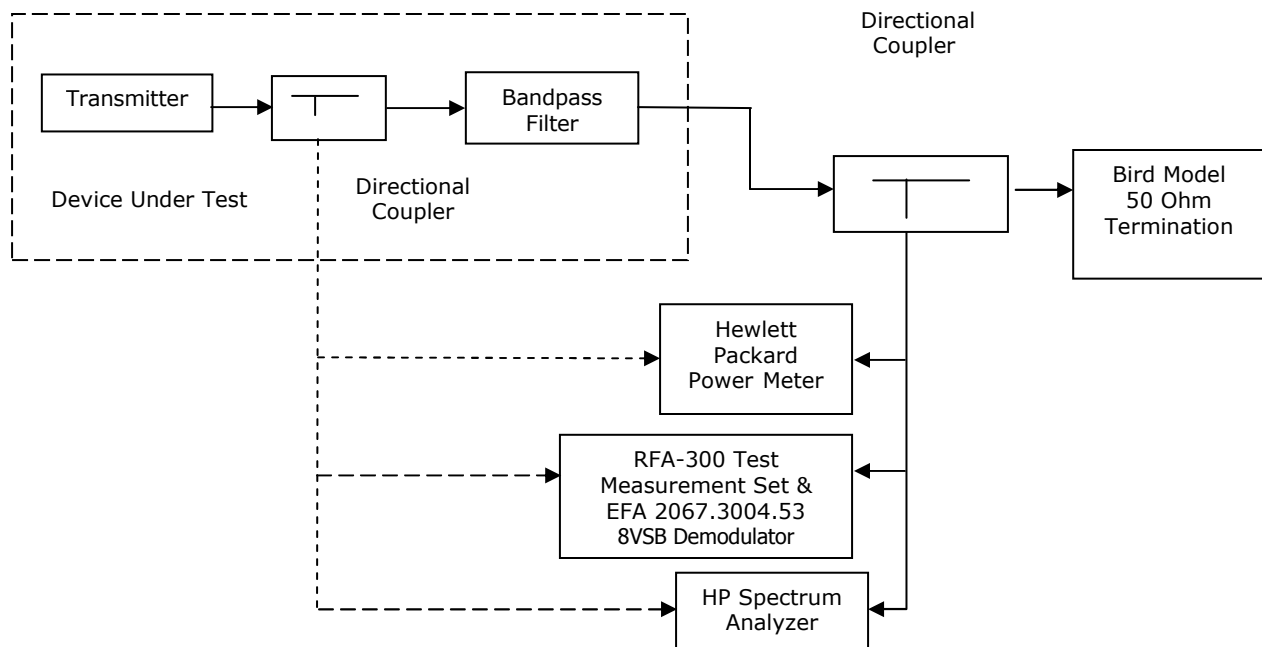


Figure 4-1. Test Equipment Setup for RF Power Measurements

The output power of the 6U1AD was adjusted to obtain 1325 watts average RF output as observed on the power meter.

Measured Power: +16.2 dBm  
 Coupling Loss: -45.0 dB  
 Power: +61.2 dBm  
 Power = 1325 Watts

Larger systems will be operating with multiple identical amplifier modules combined in parallel. The largest system covered under this type acceptance will consist of four amplifiers operating in parallel to achieve a system output power of 5 kW. The worst case combining loss for a four channel combiner is 0.25dB, which reduces the power from each amplifier that makes it to the output port to 1250W, for a total system power of 5 kW.

## 4. 2 Modulation Characteristics

The modulator tray incorporates a modulation technique known as 8-Level Vestigial Side-band (8-VSB), which uses a layered digital architecture and a single carrier frequency. A pilot tone is provided, to allow rapid acquisition of the signal by receivers. The 8-VSB system transmits a serial data bit stream at a rate of 19.4 Mbps in a 6 MHz television channel. This type of transmission is far less susceptible to propagation impairments such as multi-path, noise and interference as compared to analog transmissions.

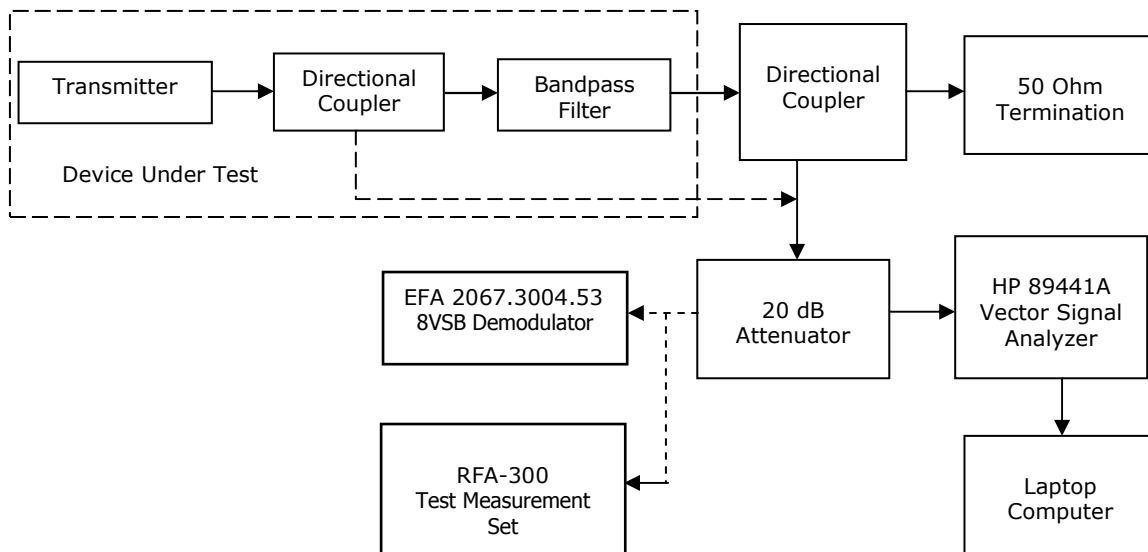


Figure 4-2. Typical Demodulation Test Setup

#### 4. 3 Error Vector Magnitude (EVM) and Signal to Noise Ratio (SNR)

The Rohde and Schwarz Demodulator was used to measure that the un-equalized patterns are within the ATSC/FCC EVM limit of 4% and SNR limit of 27db.

ATSC/VSB MEASURE			
CENTER FREQ <b>725.00 MHz</b>	CHANNEL <b>56</b>	ATTEN : 50 dB <b>9.2 dBm</b>	
SET CENTER FREQ	725.000000 MHz		CONSTELL DIAGRAM...
SET PILOT FREQ	722.3094406 MHz		
CALC PILOT FREQ	722.3095101 MHz		
PILOT FREQ OFFSET	69.5 Hz		FREQUENCY DOMAIN...
SYMBOL RATE OFFSET	-4.0 Hz		
MODULATION	8VSB		TIME DOMAIN...
MER (REAL,RMS)	30.6 dB		
MER (REAL,RMS)	2.94 %		
BER BEFORE RS	0.0E-9 (557/1K00)		VSB PARA- METERS...
BER AFTER RS	0.0E-8 (457/1K00)		
SEG ERR RATIO	0.0E-6 (457/1K00)		
SEG ERR / s	00000		RESET BER
TS BIT RATE 19.393 Mbit/s			ADD. NOISE OFF
SAW: OFF			

Figure 4-3. SNR

#### 4. 4 Frequency Response

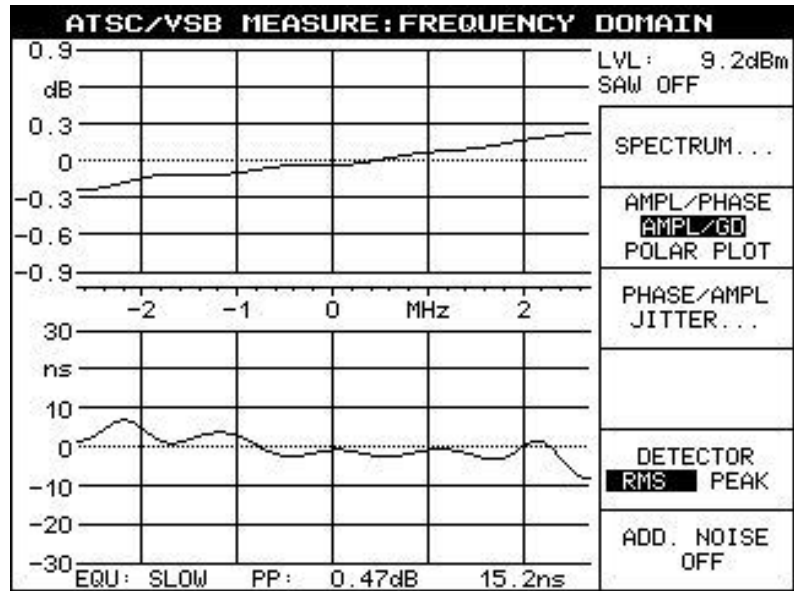


Figure 4-4. Frequency Response Plot

#### 4.5 Occupied Bandwidth

Using the test setup in Figure 4-2, with the transmitter operating at maximum power, a photograph of the transmitter occupied bandwidth spectrum was taken and is shown in Figure 4-7A and 4-7B.

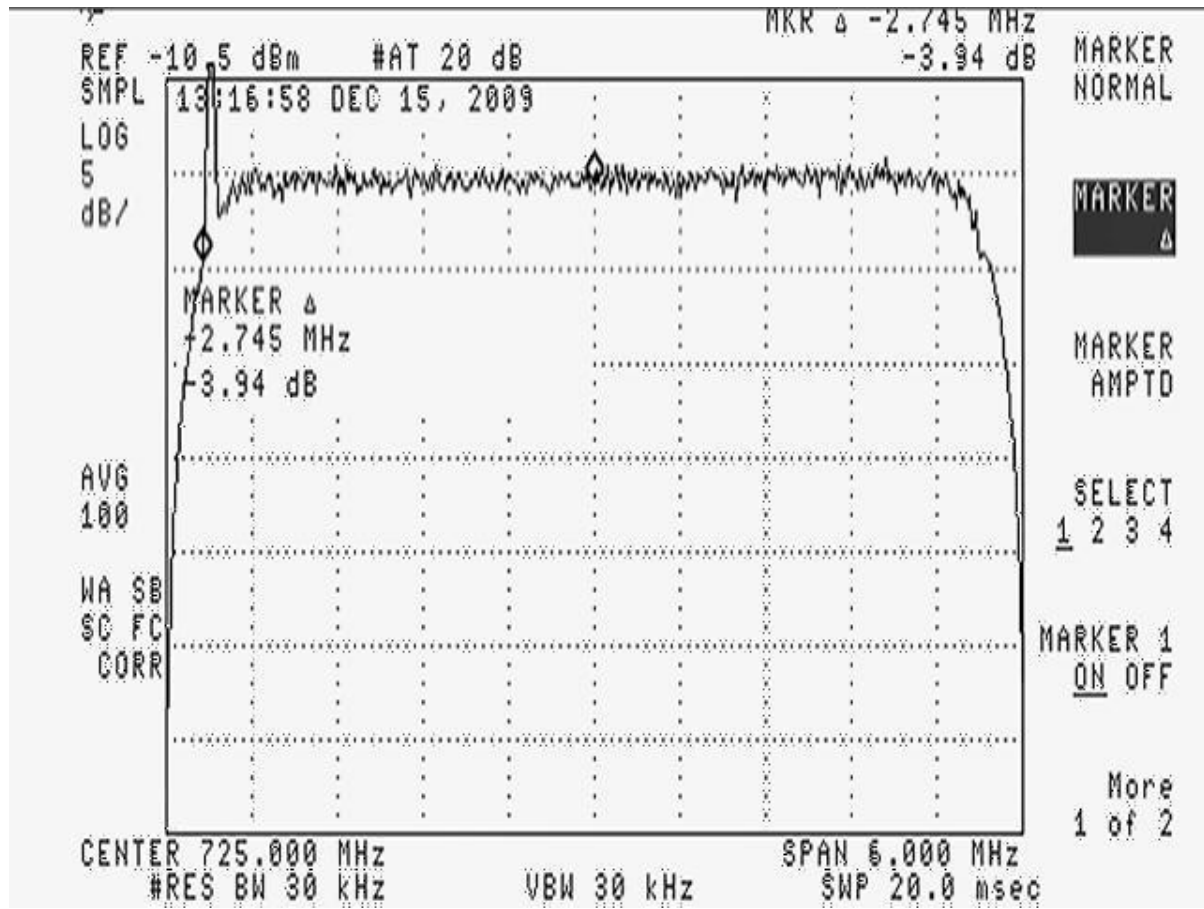


Figure 4-7A. Channel Occupied Bandwidth (lower channel edge)

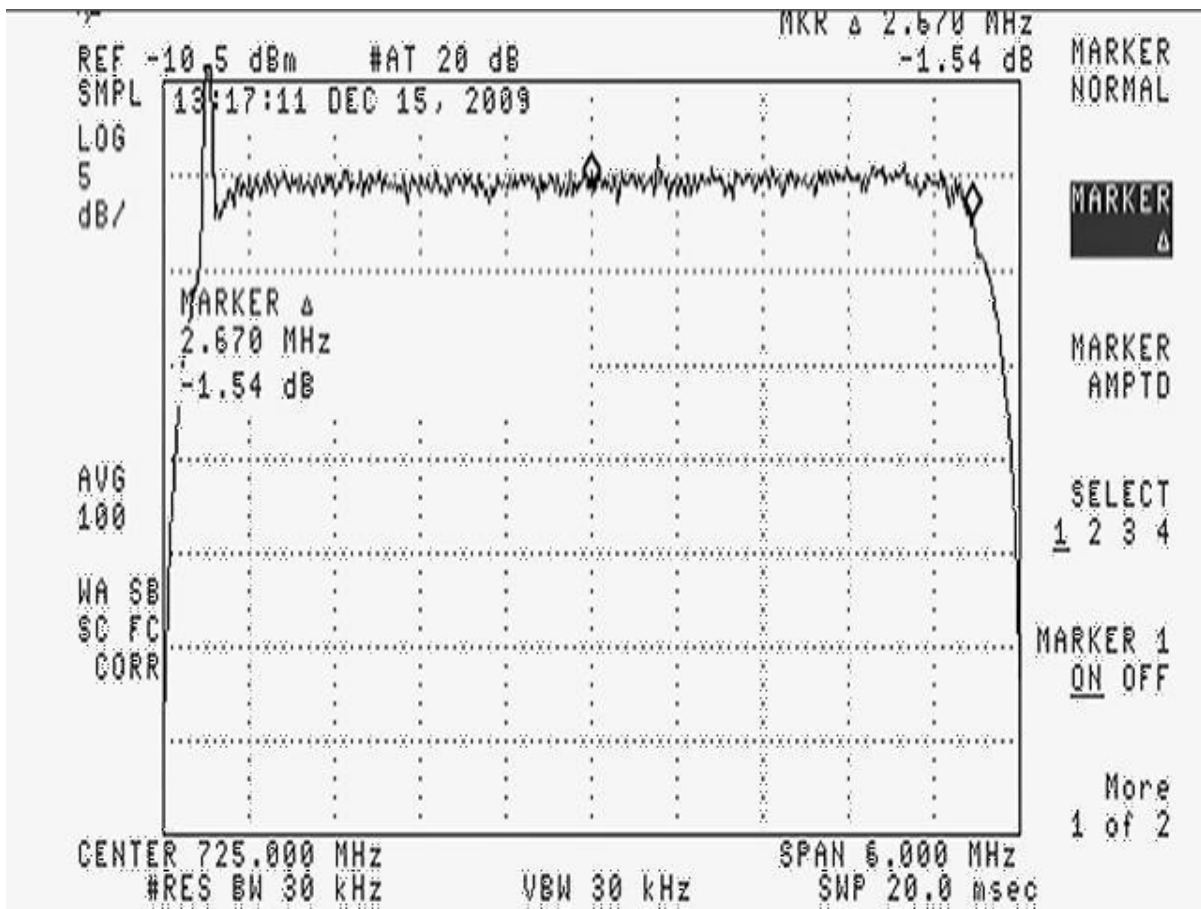


Figure 4-7B. Channel Occupied Bandwidth (Upper channel edge)

#### 4.6 Conducted Spurious Emissions

The Hewlett Packard Spectrum Analyzer was used to measure harmonics before the mask filter. The levels were then added to the filter attenuation at the 2<sup>nd</sup> and 3<sup>rd</sup> harmonics in order to obtain the final harmonic levels after the mask filter.

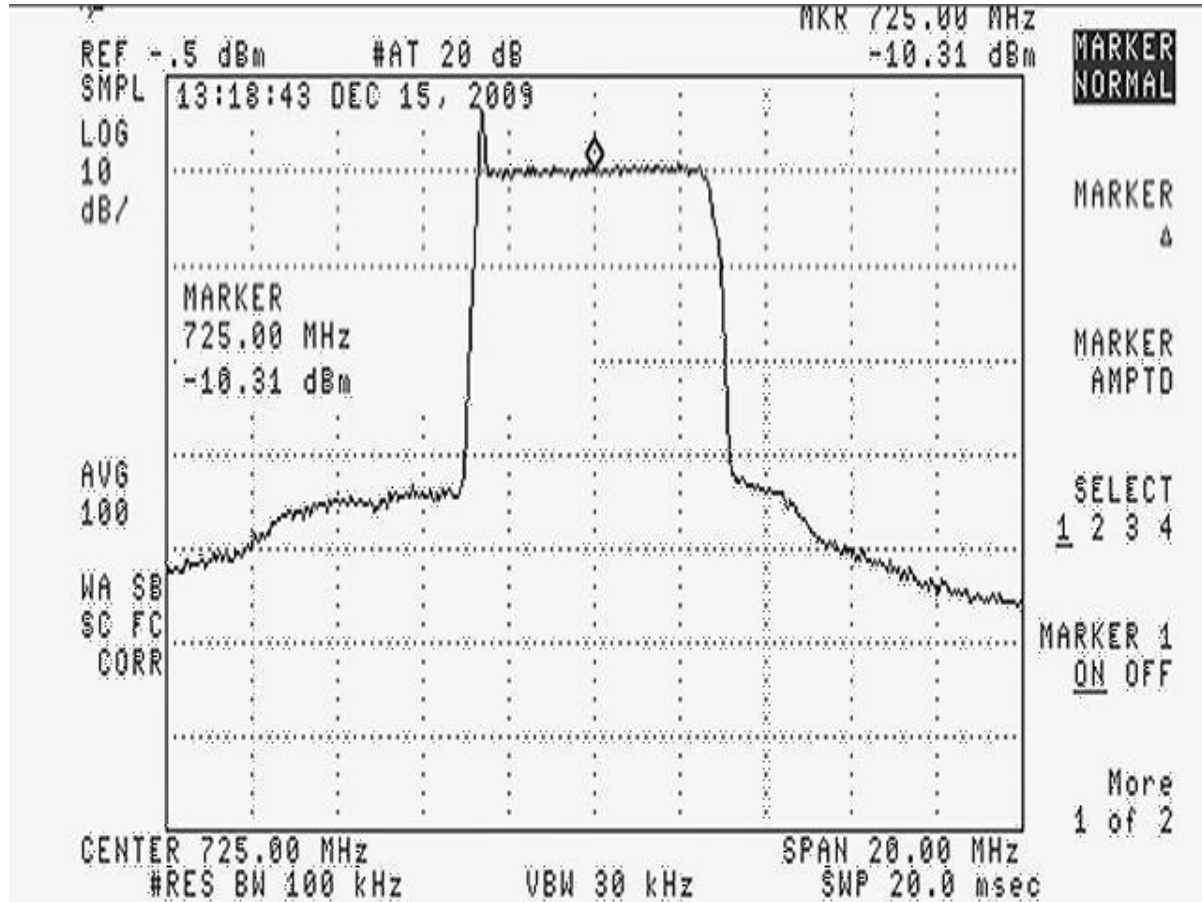


Figure 4-8A. Reference (725.00 MHz) (Pre-Channel Filter)

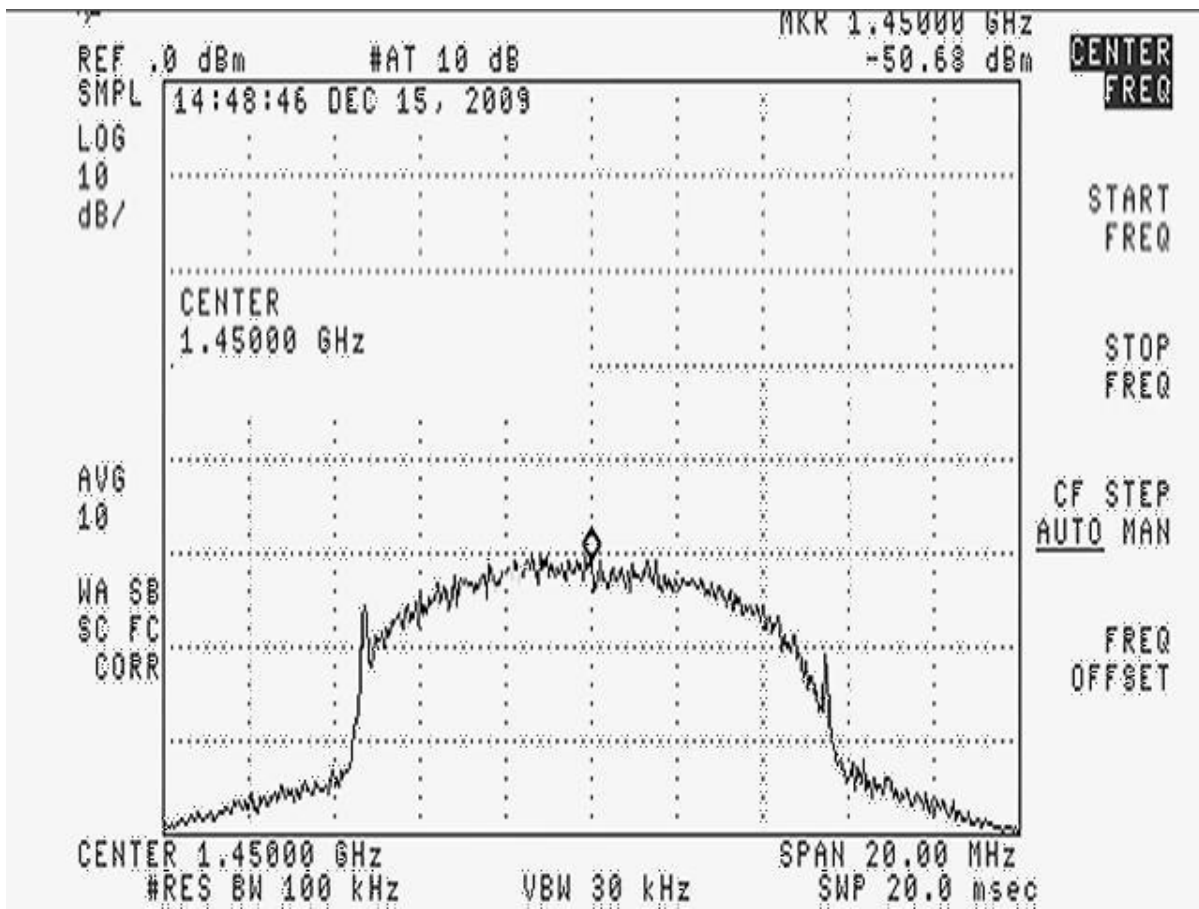


Figure 4-8B Second Harmonic (Pre-Filter)



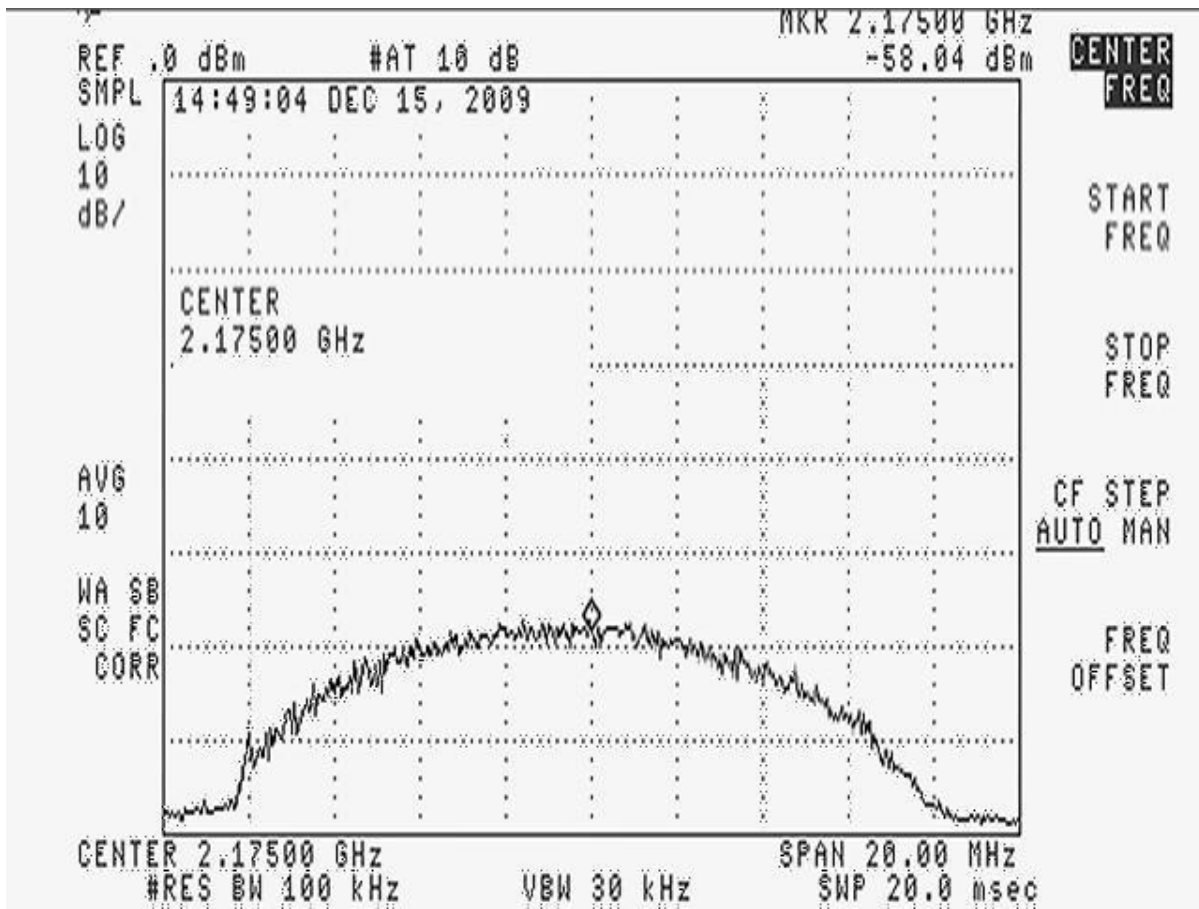


Figure 4-8C Third Harmonic (Pre-Filter)

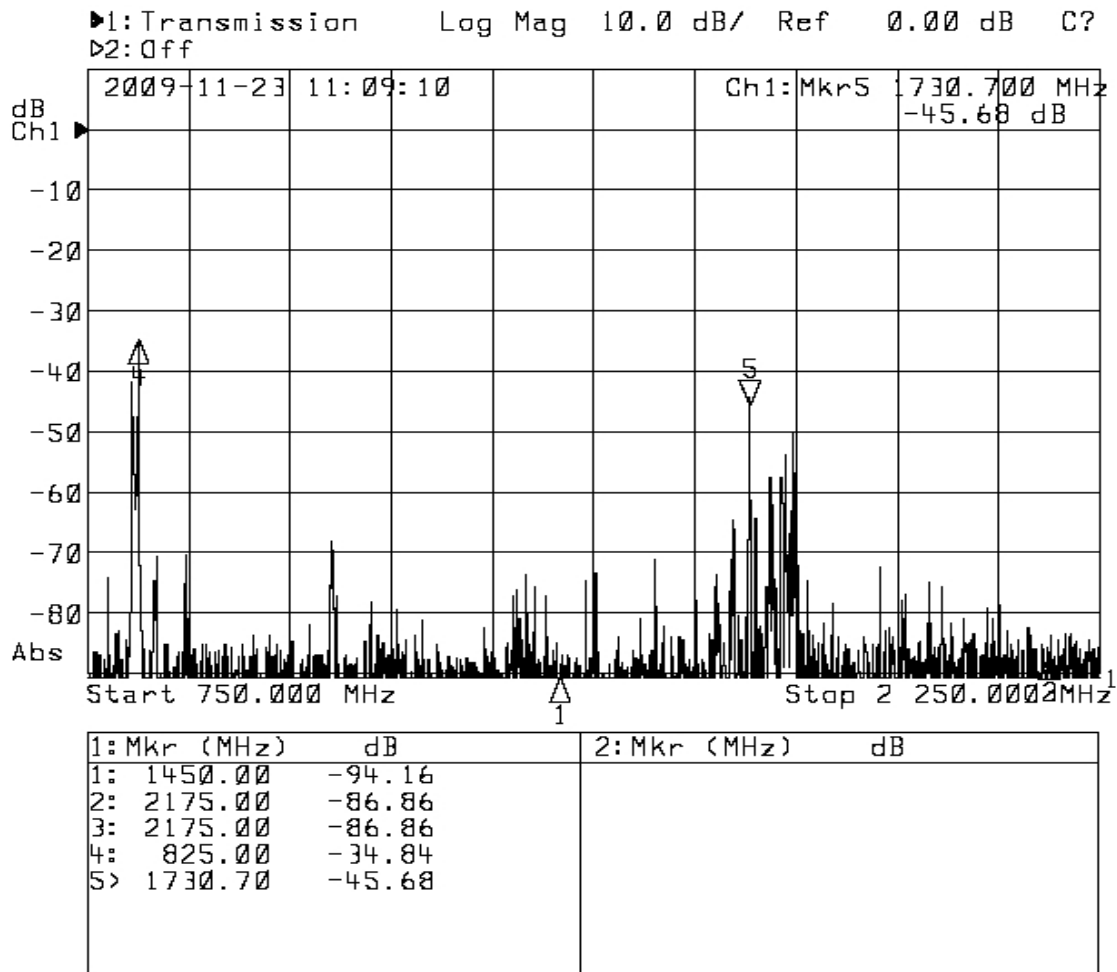


Figure 4-8D. Harmonics Filter Response

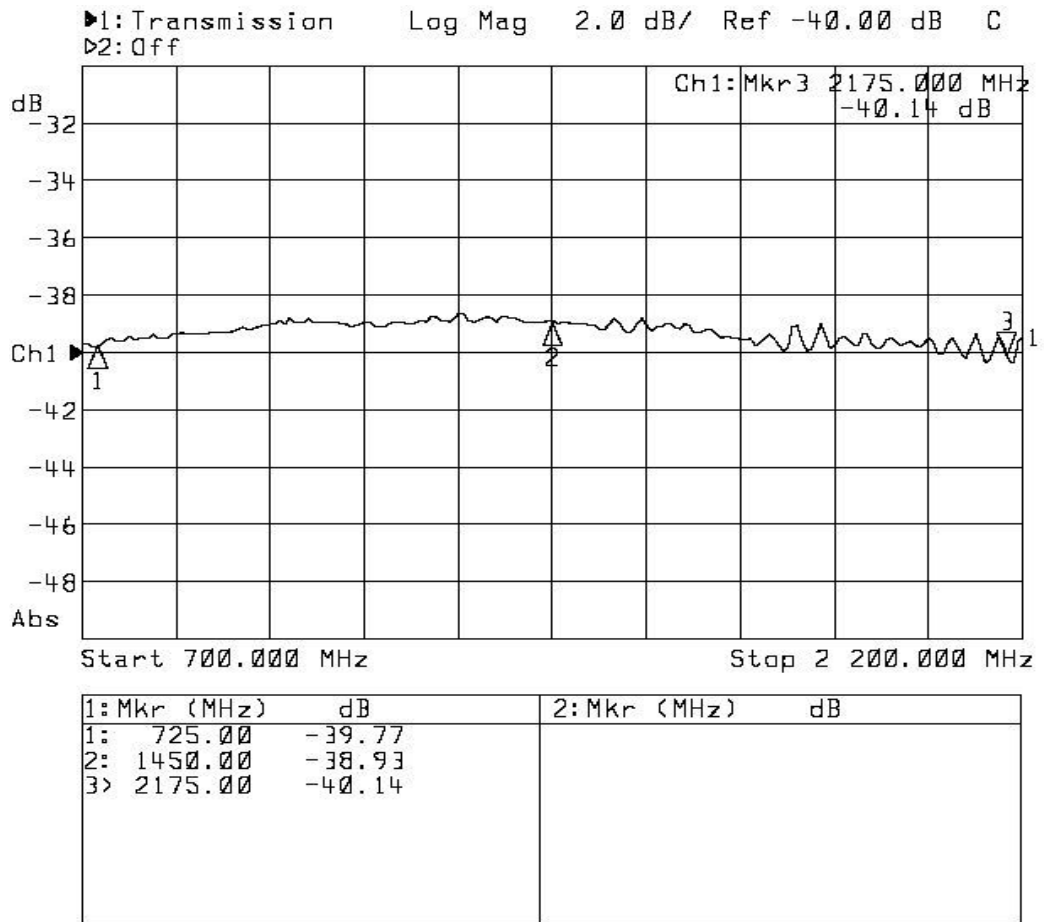


Figure 4-E. Directional Coupler Response

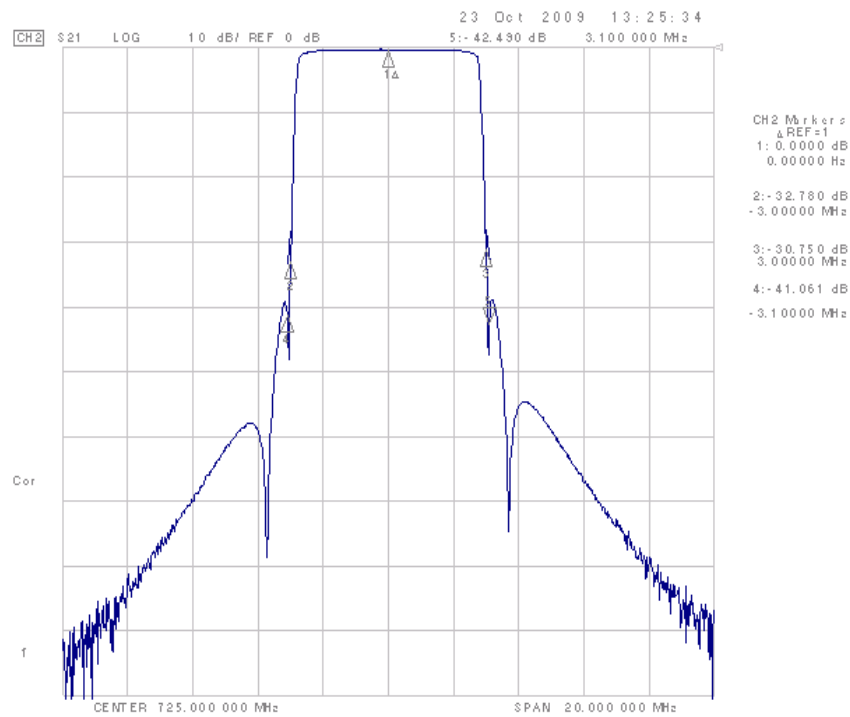


Figure 4-8F. Filter response

Part 27.53 of the Rules states:

*(g) For operations in the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least  $43 + 10 \log (P)$  dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.*

$$43 + 10 \log(5000) = \mathbf{80 \text{ dB.}}$$

The output power is spread over an occupied bandwidth of 5.4 MHz, while the out of band energy is measured in a bandwidth of either 30 kHz or 100 kHz, depending on the offset from carrier.

The worst case transmitter pre-mask filter IMD = 33 dB, so the ratio between in band and out of band energy, when measured in the same bandwidth = 33 dB. To convert between the in band energy in 100 kHz to the total channel power, the energy must be integrated over the entire channel, adding a correction factor =  $10 \log(5.4 \text{ MHz}/100 \text{ kHz}) = 17 \text{ dB}$ . For 30 kHz, the correction factor =  $10 \log(5.4 \text{ MHz}/30 \text{ kHz}) = 22 \text{ dB}$ .

Frequency	Transmitter IMD (dB)	Filter Response (dB)	Correction Factor (dB)	Total Relative to Channel Power (dB)
Fc < 3.1 MHz	- 34	- 38	-17	<b>- 89</b>
Fc - 3.0 MHz	- 34	- 32	-22	<b>- 88</b>
Fc + 3.0 MHz	- 33	- 30	-22	<b>- 85</b>
Fc > 3.1 MHz	- 33	- 39	-17	<b>- 89</b>

Table 4-1.

Harmonic (MHz)	Measured Level Relative to Fundamental (dB)	Filter Response (dB)	Coupler Response Relative to Fundamental (dB)	Bandwidth Correction Factor (dB)	Total (dB)
Second (1450)	- 40	< - 70	+1	-17	<b>&lt; - 128</b>
Third (2175)	- 48	< - 70	0	-17	<b>&lt; - 135</b>

Table 4-2. Post Filter Harmonic Levels

#### 4.7 Radiated Emissions

Using the test setup shown in Figure 4-1, with the transmitter operating at full power, the spectrum analyzer was moved 3 meters from the transmitter and connected to a dipole antenna cut to the 725 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 through 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, the only measurable level observed was at 725 MHz. This level is shown below in Table 4-2 and an analysis of the relative field and strength is provided in the following paragraphs.

FREQUENCY	MEASURED LEVEL (INTO 50 $\Omega$ )
725.00	-32 dBm

*Table 4-3. Measurable Levels Observed in Frequency Spectrum*

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

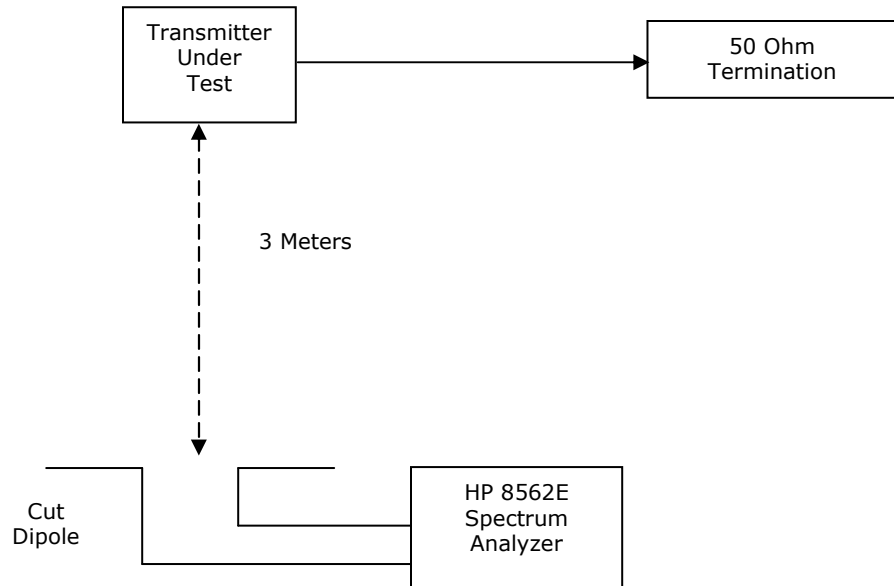


Figure 4-9. Test Setup for Measuring Radiated Emissions

One level was compared to the following reference level.

If all of the power of the transmitter was radiated by an isotropic radiator, the power density at 3 meters would be:

$$P = P_t / 4\pi R^2 = 1250 / 4\pi \cdot (3)^2 = 11 \text{ w/m}^2$$

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

$$1.64 \times 11 = 18 \text{ w/m}^2$$

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: +27 dBm

The receive level at -32 dBm was therefore at -59 dB relative to this level.

The cabinet radiation was also checked with the receive dipole antenna cut to 725.00 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 0 dBm.

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

#### 4.8 Frequency Stability

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

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:

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

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

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

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 frequency stability requirements are described in 27.54:

*The frequency shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.*

The 10 MHz oscillator was tested over temperature and voltage below:

TEMP. (°C)	10 MHz Error
-30	3.0 Hz
-20	2.1 Hz
-10	1.2 Hz
0	0.7 Hz
+10	0.5 Hz
+20	0.1 Hz
+30	0.2 Hz
+40	0.3 Hz
+50	0.8 Hz

Table 4-4.

Line Voltage	Reference Oscillator Error
95V	0.0 Hz
115V	0.0 Hz
135V	0.0 Hz

Table 4-5.

The frequency error at final frequency is  $3.0 \times \text{channel frequency} / 10 \text{ MHz}$ . The highest frequency for this application is 728 MHz, giving a frequency error of  $3 \times 728 / 10 = 218 \text{ Hz}$ .

#### 4.9 Test Equipment

The test equipment that was used to analyze the Axcera 6U4AD system is listed in Table 4-6.

MODEL	MANUFACTURER	DESCRIPTION	SERIAL #
435B	Hewlett Packard	Power Meter	2732UO9080
8482B	Hewlett Packard	Power Sensor	N/A
8892-300	Bird	50 $\Omega$ Termination	2867
EFA 2067.3004.53	Rohde & Schwarz	8VSB Demodulator	100137
450029	Connecticut Microwave	Directional Coupler	891P
8562E	Hewlett-Packard	Spectrum Analyzer	03760
8714B	Hewlett-Packard	Network Analyzer	U535490409
RFA300	Tektronix	Test Measurement Set	B010226

Table 4-6. Test Equipment