4. TEST REPORT

4.1 RF Power Measurements

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

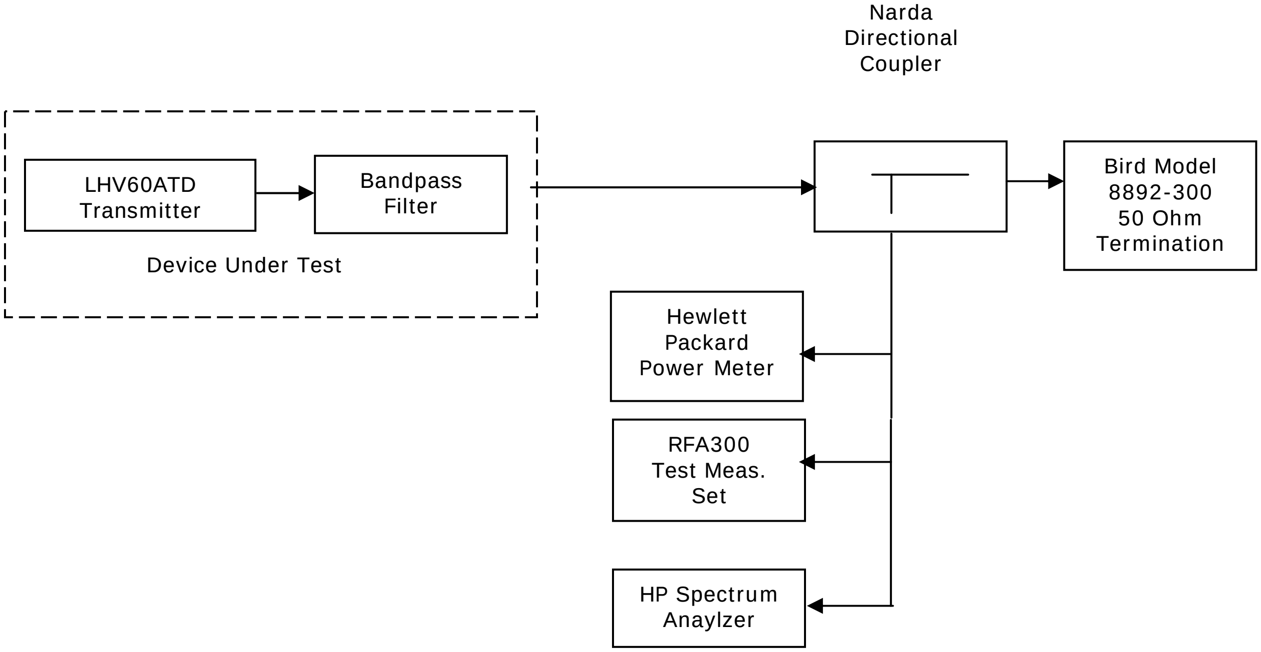

Figure 4-1. Test Equipment Setup for RF Power Measurements

The output power of the LHV60ATD was adjusted to obtain 60 watts average RF output as observed on the power meter.

Measured Power: +25.8 dBm
Coupling Loss: -22.0 dB
Power: +47.8 dBm
Power = 60 Watts

With the power level properly set to 60 watts average, all required tests were performed and recorded in the following sections.

4. 2 Modulation Characteristics

The internal modulator 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.

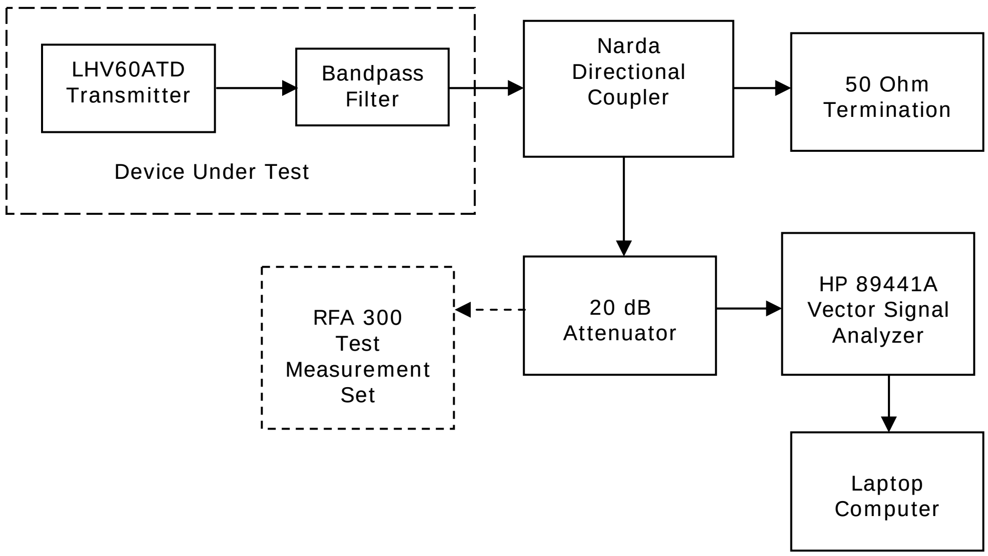

Figure 4-2. Typical Demodulation Test Setup

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

The Hewlett Packard Vector Signal Analyzer and Tektronix RFA 300 were used to measure that the un-equalized patterns are within the ATSC/FCC EVM limit of 4% and SNR limit of 27db.

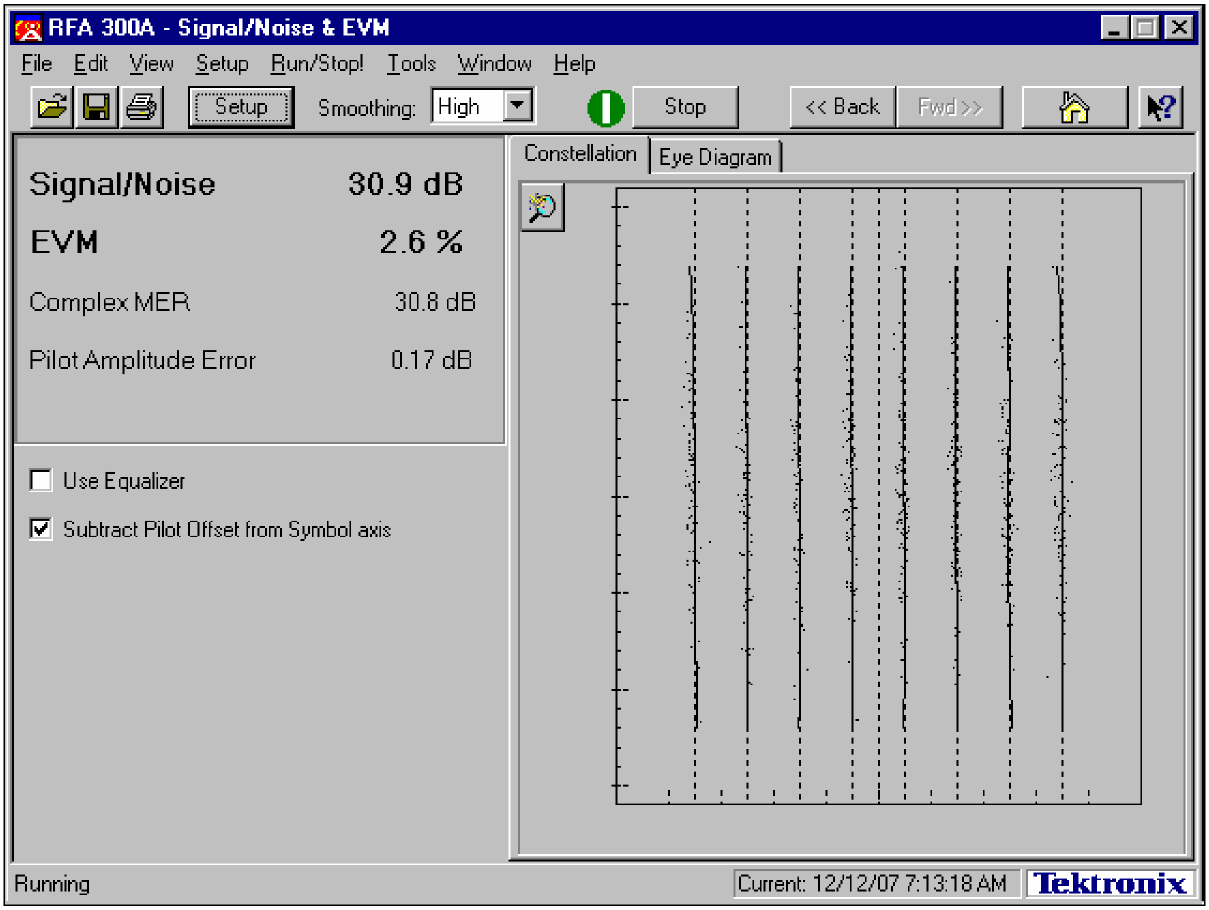

Figure 4-3. Constellation Diagram

4. 4 Frequency Response and Group Delay

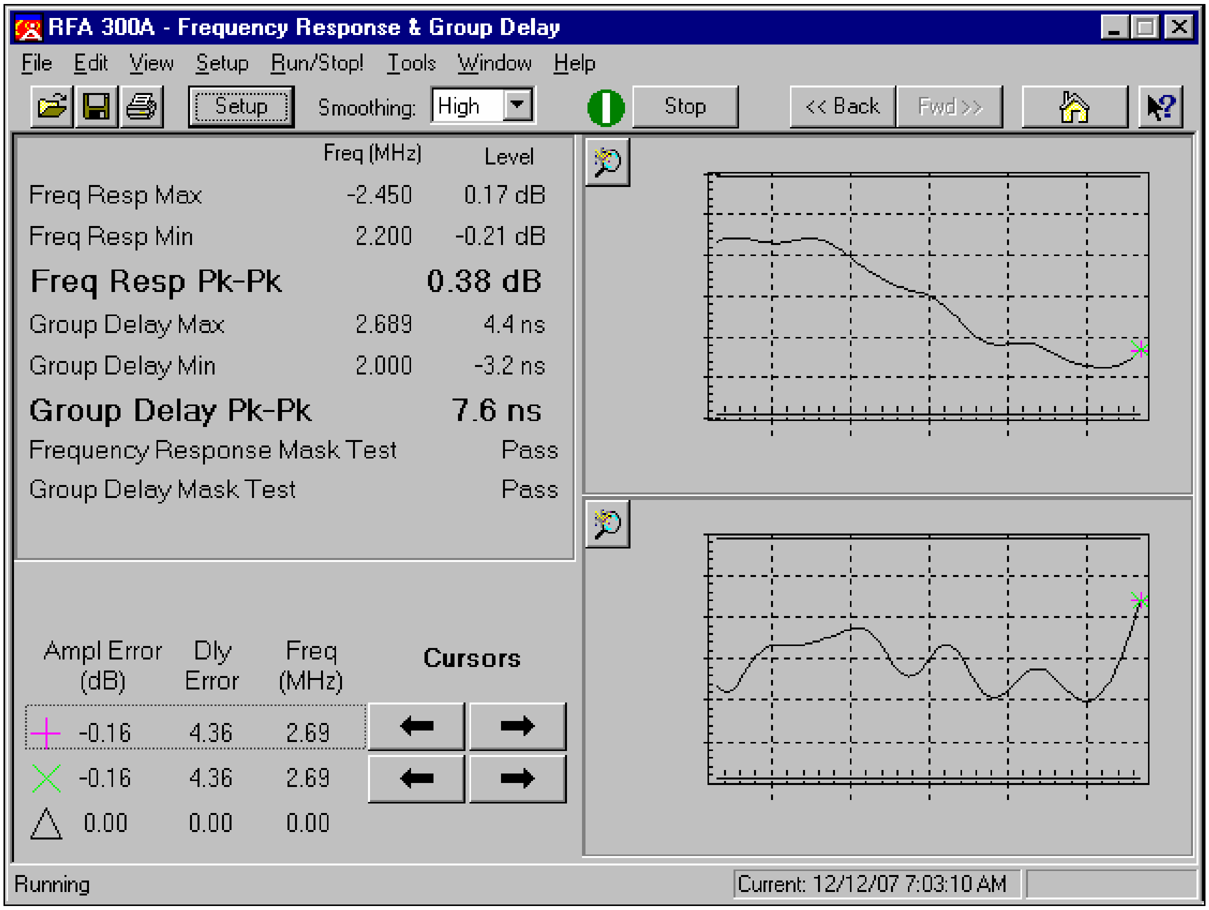

Figure 4-4. Frequency Response and Group Delay Plots

4. 5 Peak to Average

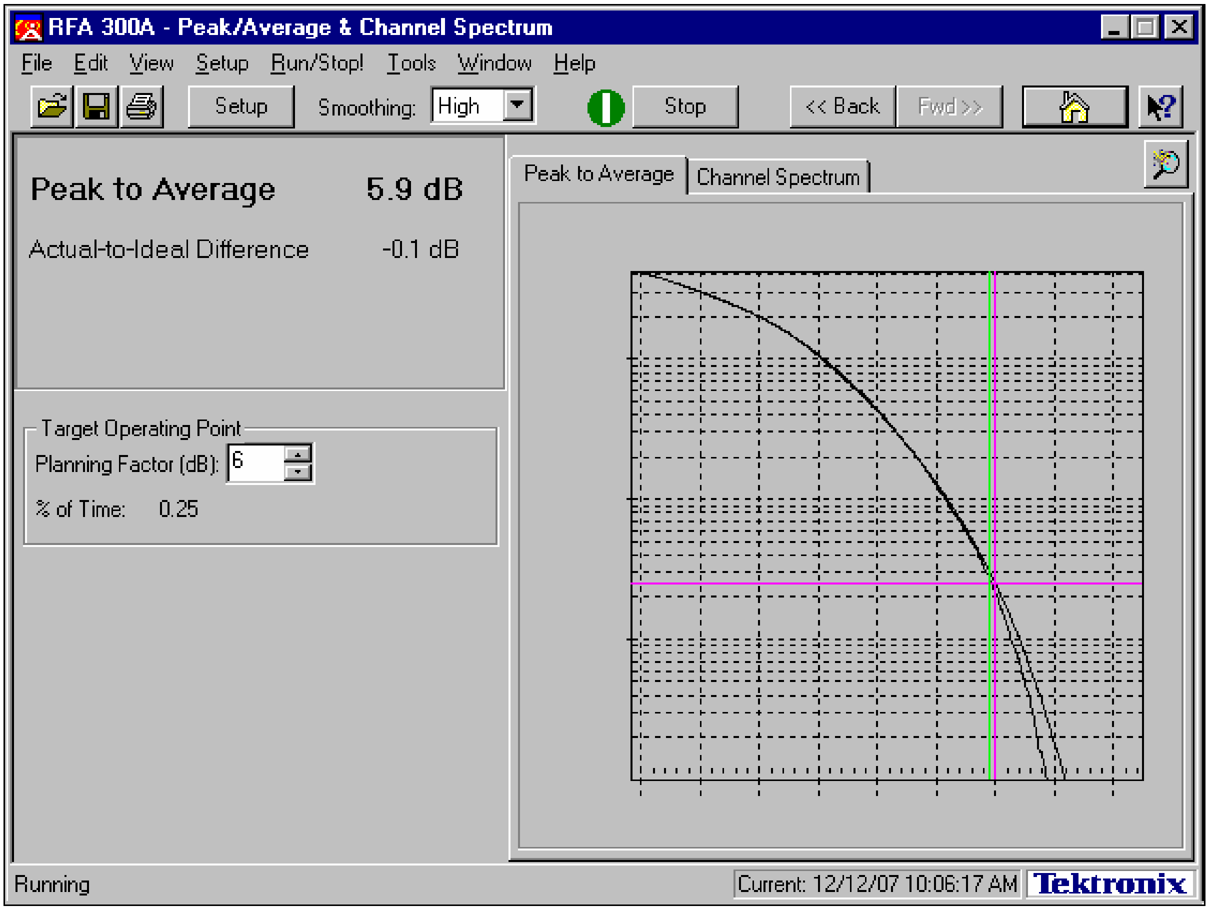

Figure 4-5. Peak to Average Plot

4. 6 Phase Noise

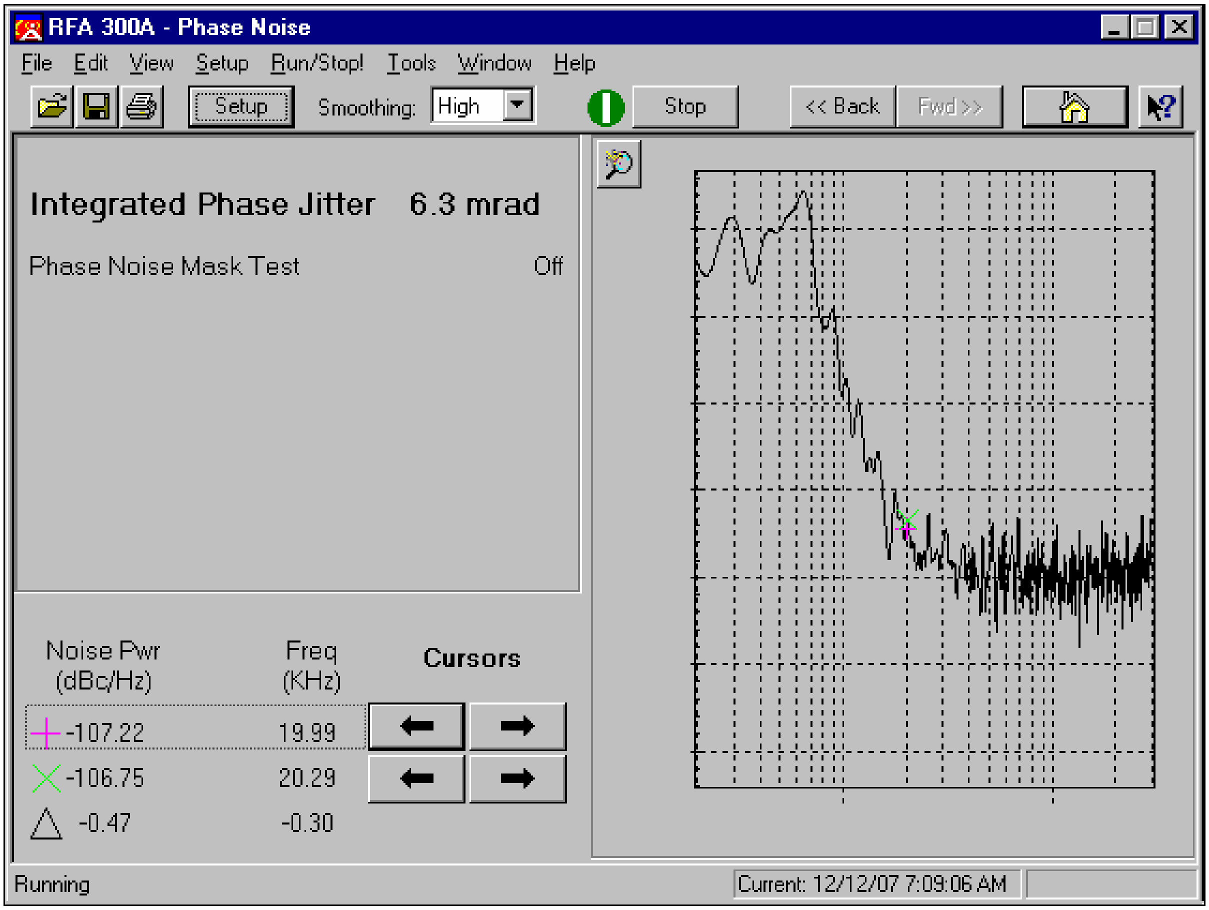

Figure 4-6. Phase Noise Plot

4.7 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 4-7.

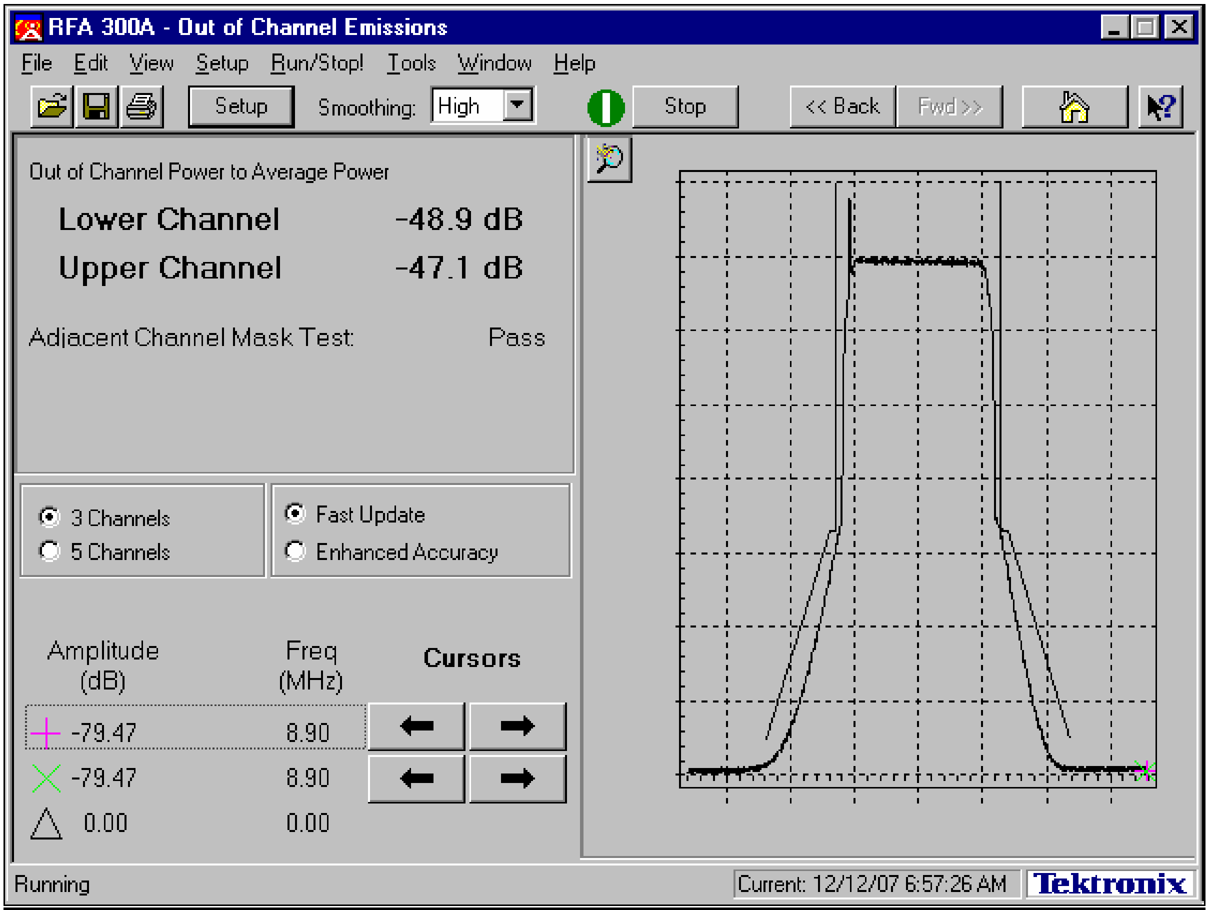

Figure 4-7. Channel Occupied Bandwidth (Post-Filter)

4.8 Conducted Spurious Emissions

The Hewlett Packard Spectrum Analyzer was used to measure harmonics before the low pass and mask filter. The levels were then added to the filter attenuation at the 2nd and 3rd harmonics for a reading of less than –110dB at output of the mask filter.

Figure 4-8A. Reference (183.00 MHz) = -13.0 dBm (Pre-Filter)

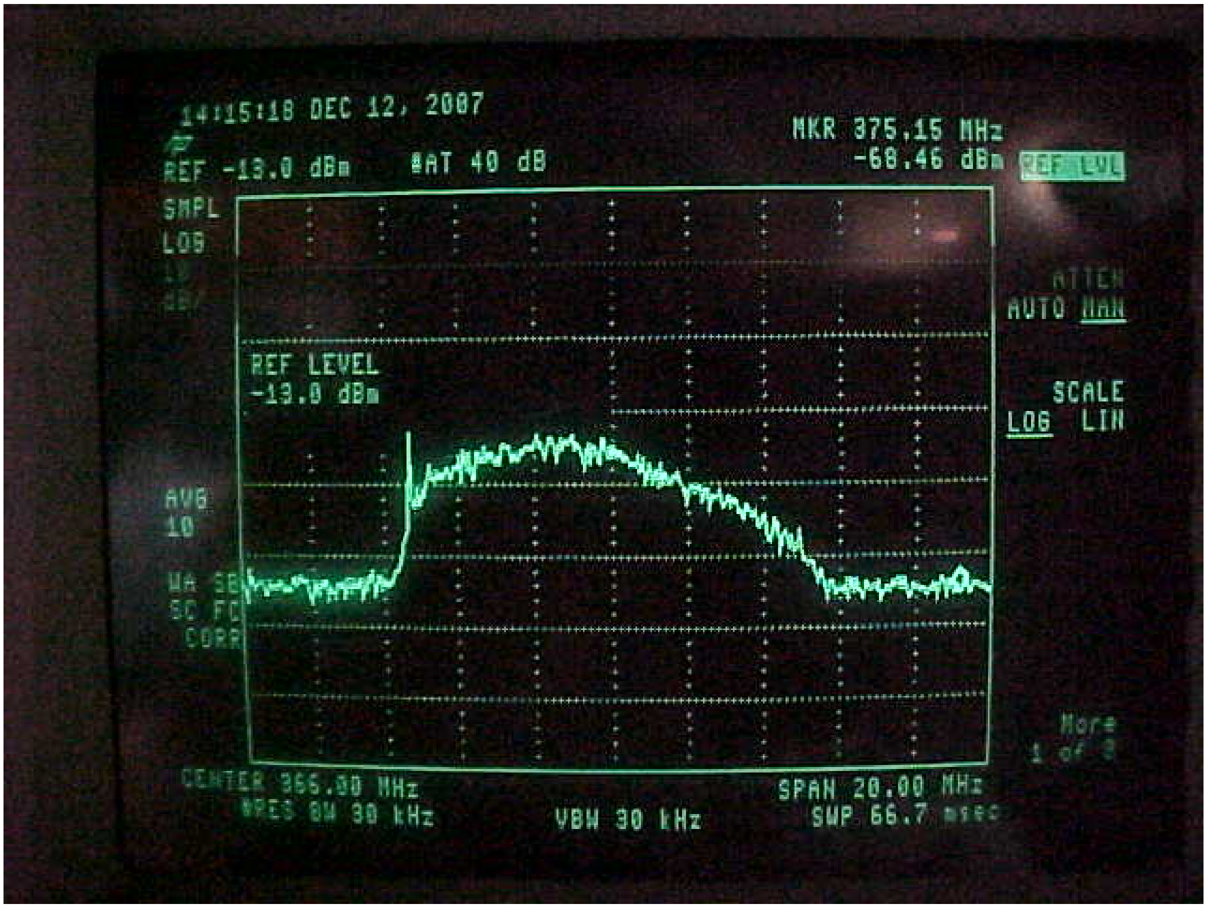

Figure 4-8B. Second Harmonic (366.00 MHz) = -46.0 dBm (Pre-Filter)

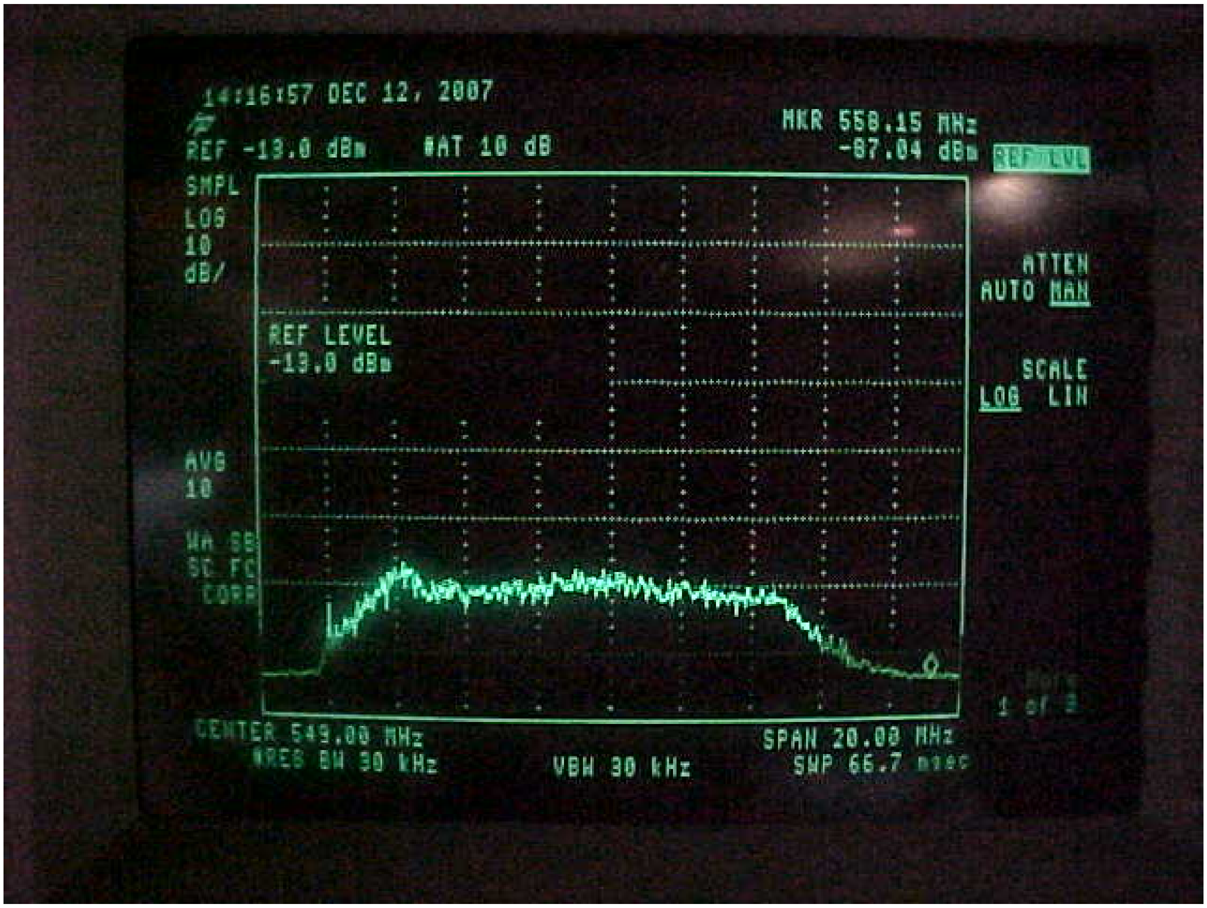

Figure 4-8C. Third Harmonic (549.00 MHz) = -73.0 dBm (Pre-Filter)

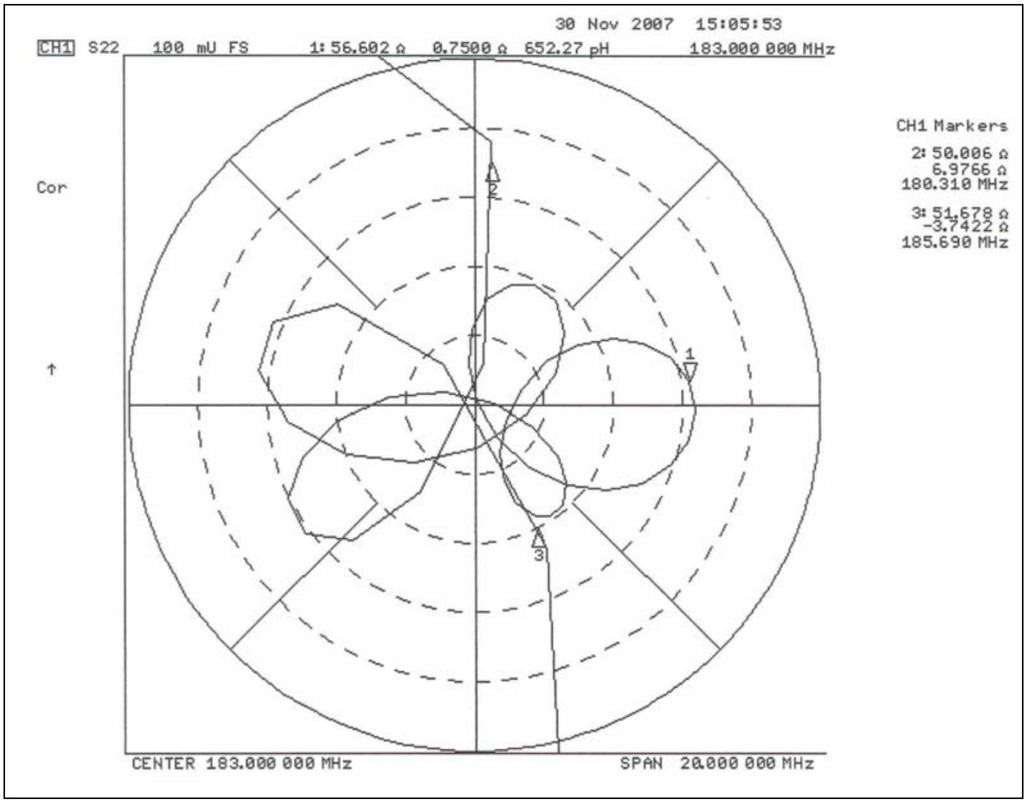

Figure 4-8D. Bandpass Filter VSWR

Figure 4-8E. Bandpass Filter Return Loss

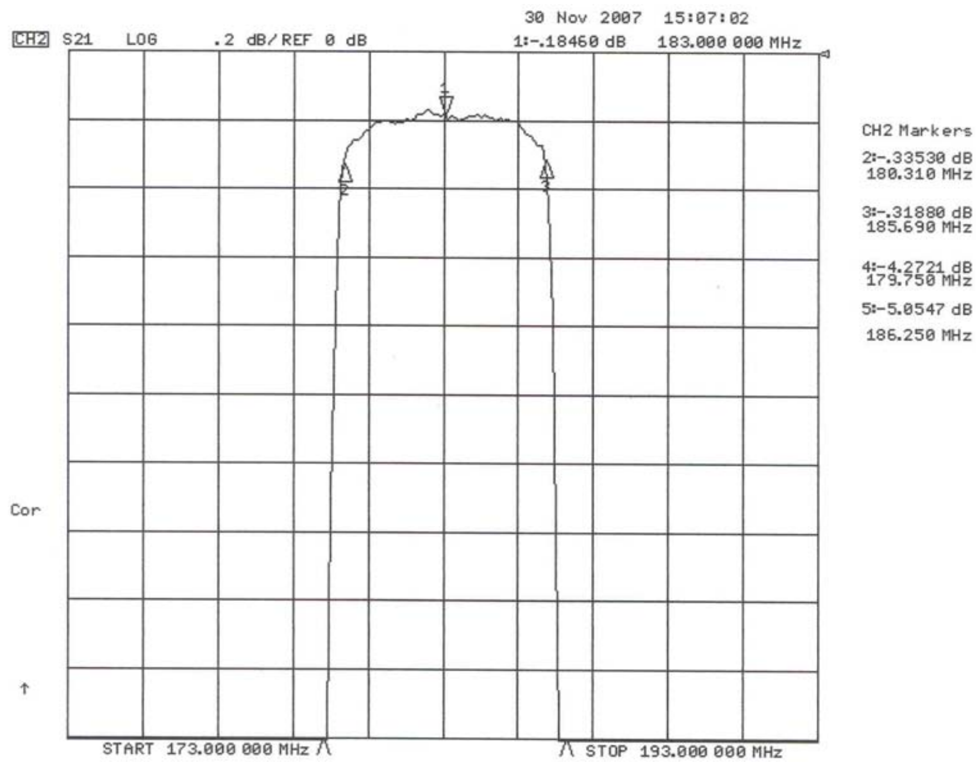

Figure 4-8F. Insertion Loss

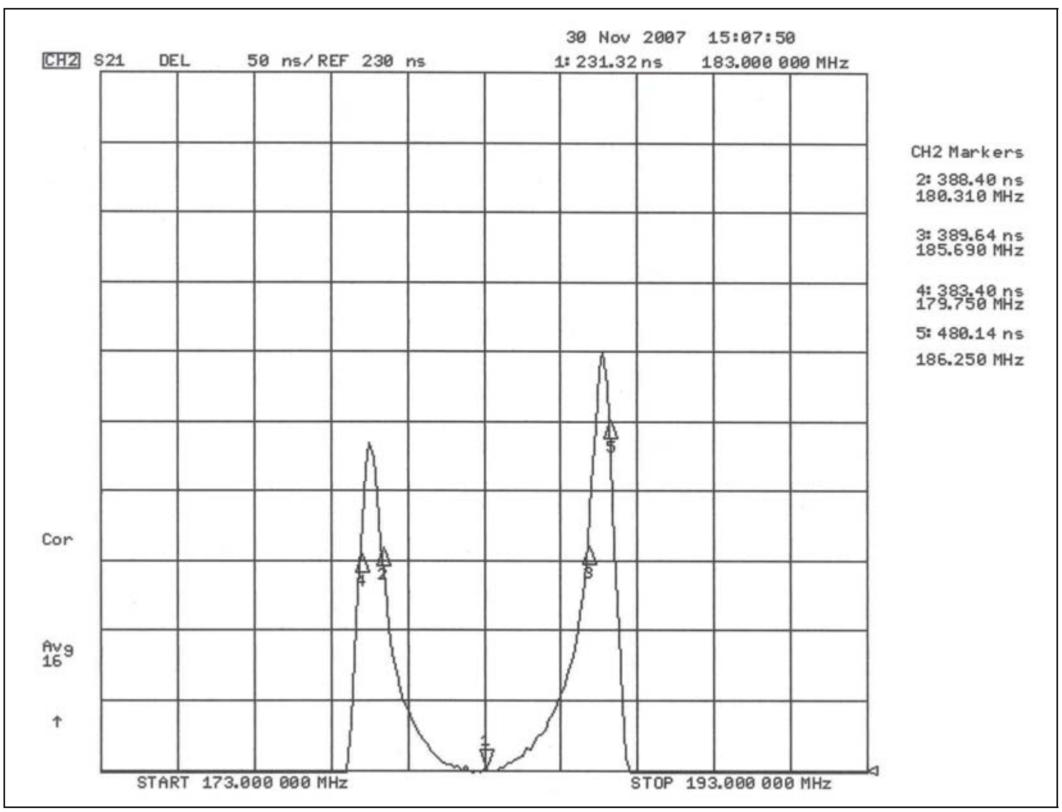

Figure 4-8G. Group Delay

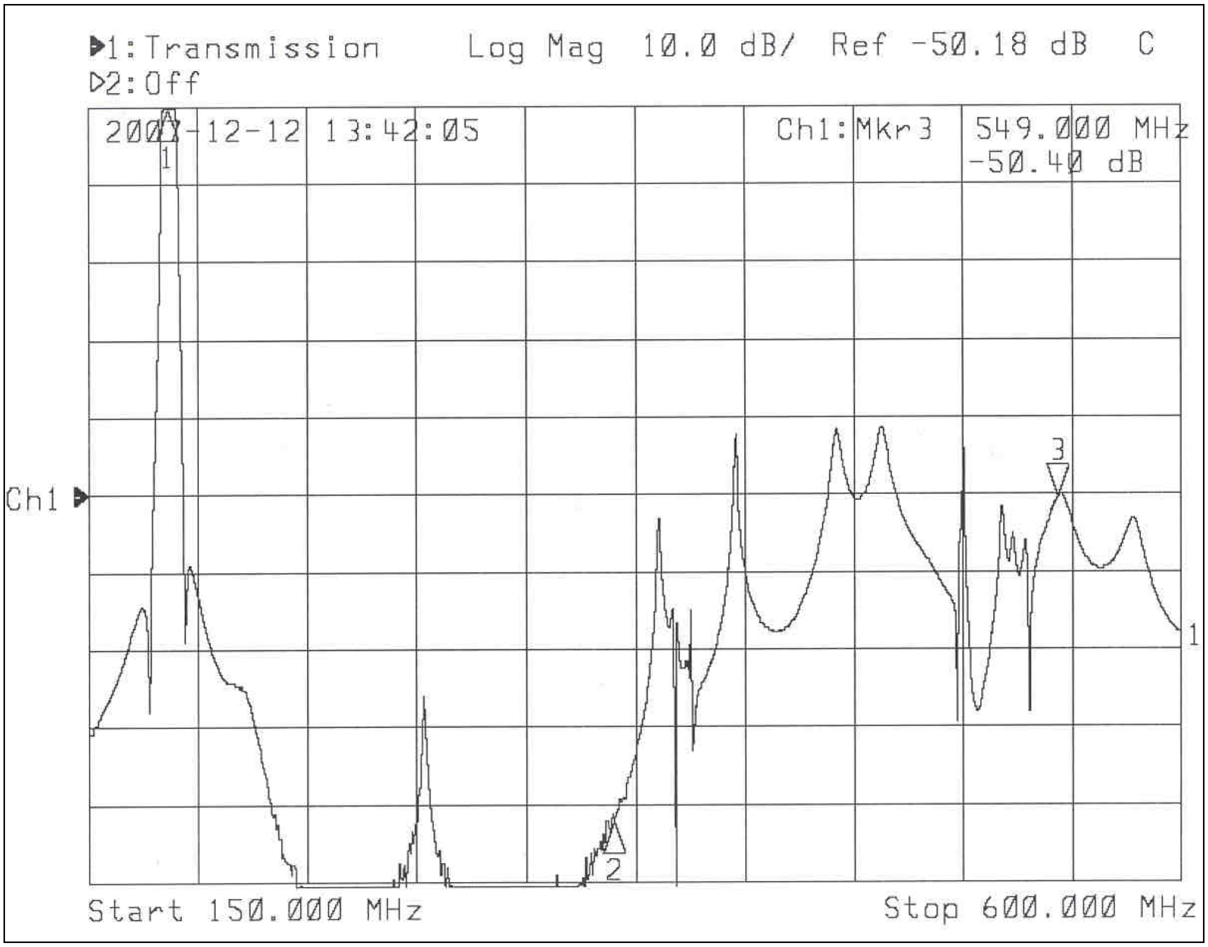

Figure 4-8H. Lowpass Filter Response

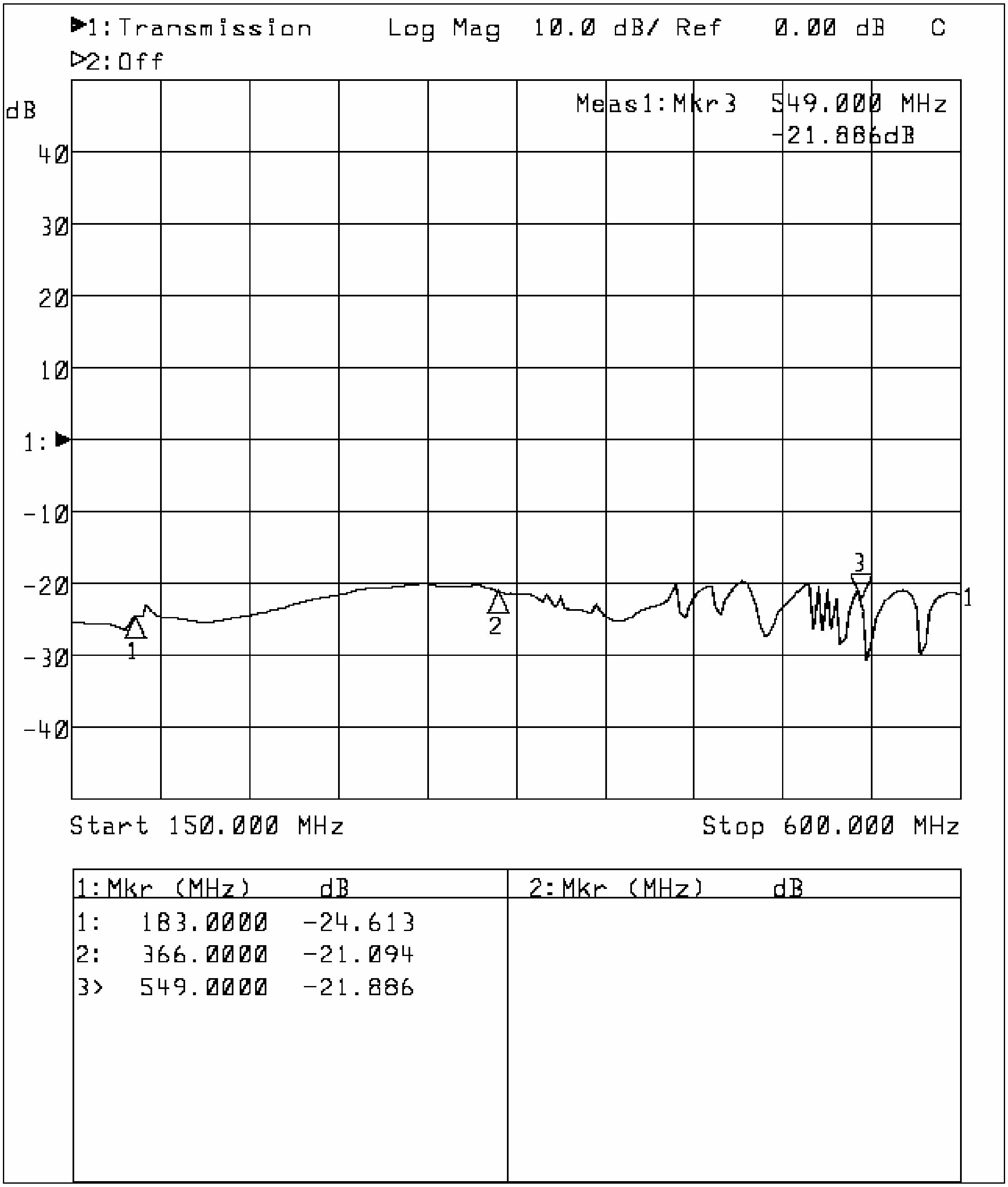

Figure 4-8I. Coupler Response

Harmonic (MHz)	Pre Filter Level (dBm)	Filter Rejection (dB)	Post Filter Level (dBm)
Second 366.00	-36.0	-93	-129
Third 549.00	-63.0	-50	-113

Table 4-1. Post Filter Harmonic Levels

Part 74.794 of the Rules states:

(ii) *Stringent mask. In the first 500 kHz from the channel edges, emissions must be attenuated no less than 47 dB. More than 3 MHz from the channel edges, emissions must be attenuated no less than 76 dB. At any frequency between 0.5 and 3 MHz from the channel edges, emissions must be attenuated no less than the value determined by the following formula: A(dB) = 47 + 11.5 (Df–0.5).*

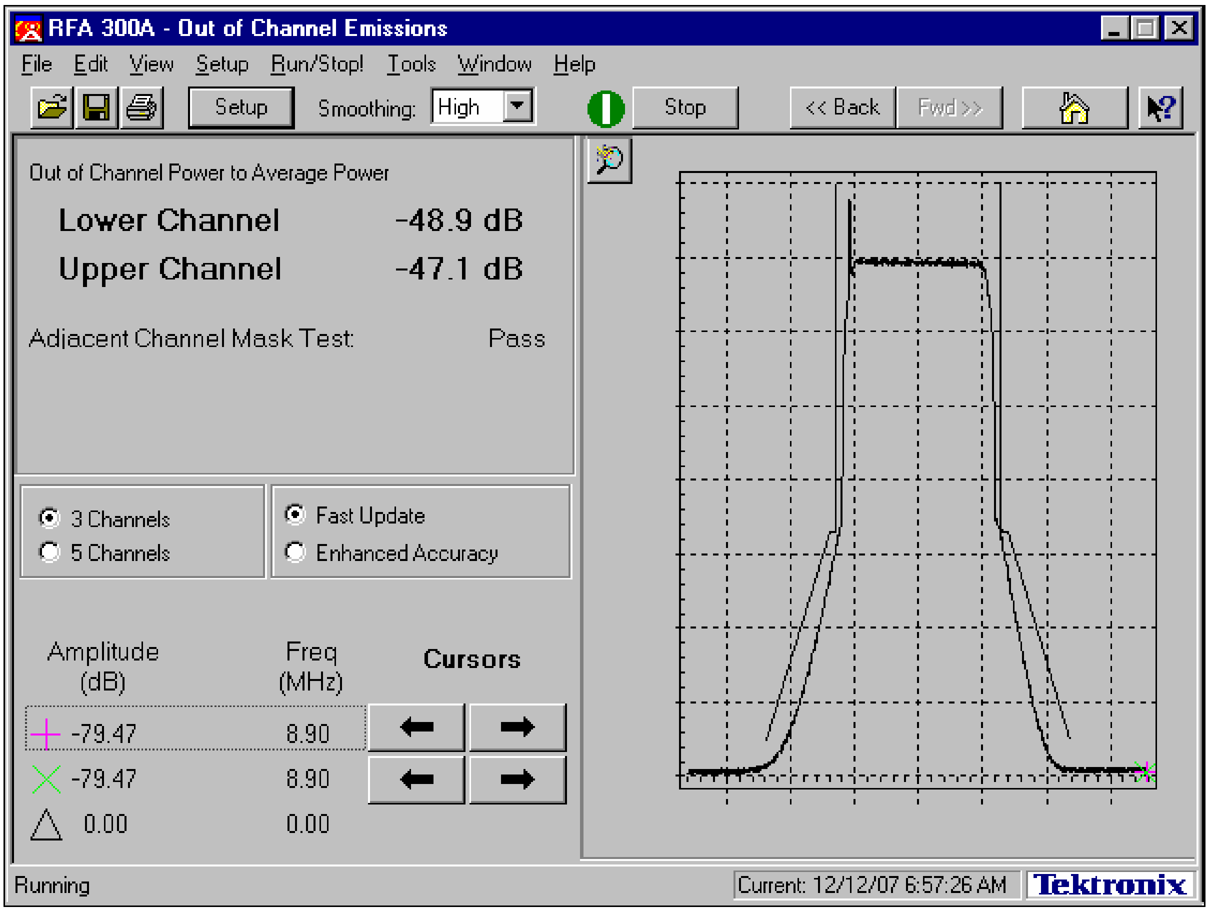

Figure 4-8J. Out of Band Emissions Plot (Post-Filter)

4.9 Radiated Emissions

Using the test setup shown in Figure 4-1, 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 the 183 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 183 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.

Table 4-2. Measurable Levels Observed in Frequency Spectrum

FREQUENCY	**MEASURED LEVEL (INTO 50 Ω)**
183.00	-45 dBm

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

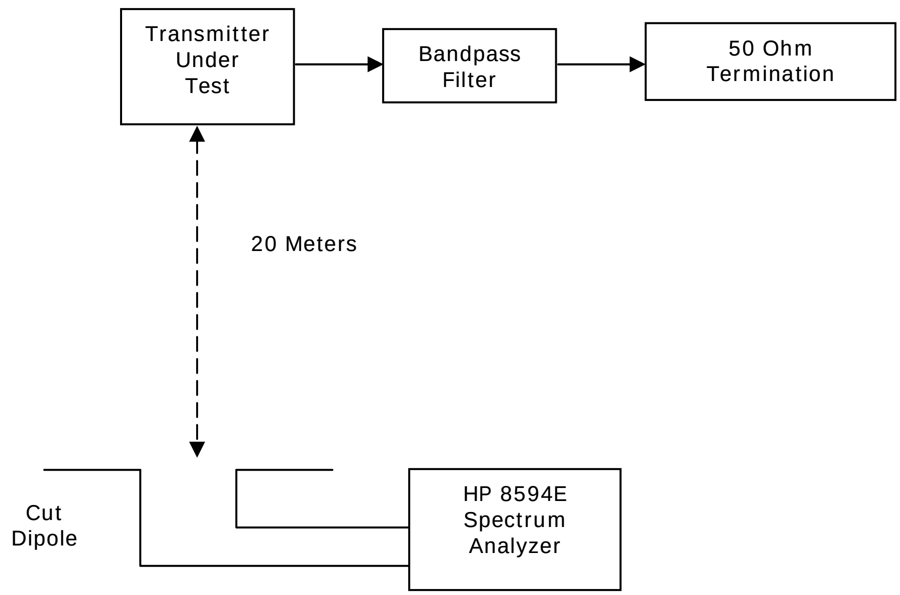

Figure 4-9. Test Setup for Measuring Radiated Emissions

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 20 meters would be:

$$P = Pt/4\pi R^2 = 60/4\pi \bullet (20)^2 = .011 \text{ w/m}^2$$

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

$$1.64 \times .01 = .02 \text{ w/m}^2$$

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:

$$20 \text{ mw} = +13 \text{ dBm}$$

The receive level at –45 dBm was therefore at -59 dB relative to this level.

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

Table 4-3. Receive Levels

FREQUENCY	(REF = +13 dBm) RELATIVE MEASURED LEVEL
183.00	-59 dB

The cabinet radiation was also checked with the receive dipole antenna cut to 183.00 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 -10 dBm:

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

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

4.10 Frequency Stability

The LHV60ATD 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.

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 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 LHV60ATD 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.

The internal 10 MHz reference oscillator used in the LHV60ATD has a stability of 1.000 x 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 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.

4.10.1 Pilot Frequency Measurement

The Hewlett Packard Spectrum Analyzer was used to verify the pilot frequency met the frequency stability of +/- 1000 Hz. The ideal frequency should be 180.309441 MHz.

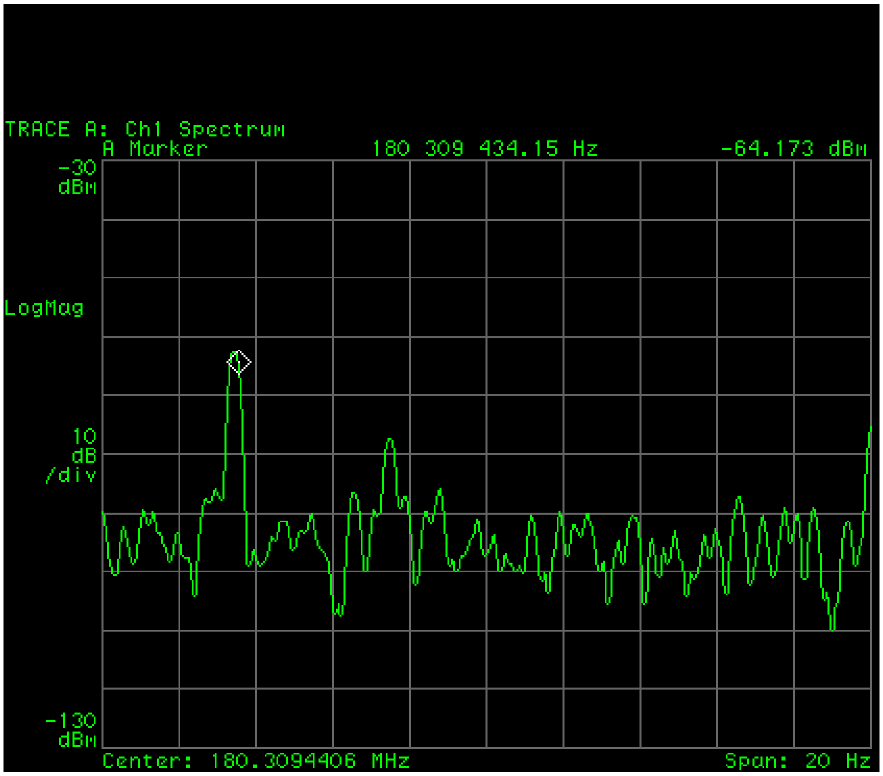

Figure 4-12. Pilot Frequency Plot

4.11 Test Equipment

The test equipment that was used to analyze the Axcera LHV60ATD system is listed in Table 4-14.

Table 4-4. Test Equipment

MODEL	MANUFACTURER	DESCRIPTION	SERIAL #
435B	Hewlett Packard	Power Meter	2445A10994
8482B	Hewlett Packard	Power Sensor	N/A
8892-300	Bird	50 Ω Termination	2867
8594E	Hewlett-Packard	Spectrum Analyzer	10118
3020A	Narda	Bi-Directional Coupler	40660
RFA300	Tektronix	Test Measurement Set	B010226
89441A	Hewlett-Packard	Vector Signal Analyzer	3416A01547
8714ET	Agilent	Network Analyzer	VS40512357