1 1 Introduction

This document presents the results of the series of measurements performed on the AT7200 200 Watt UHF Digital TV Transmitter. For all tests the transmitter was operating at UHF channel 44 (653 MHz).

The equipment was designed to operate on the american ATSC 8VSB modulation scheme and complies with ATSC Doc. A/53B, adopted by FCC as a standard as described below:

§73.682 TV transmission standards.

(d) Digital broadcast television transmission standard. Effective February 1, 2005, transmission of digital broadcast television (DTV) signals shall comply with the standards for such transmissions set forth in ATSC A/52: "ATSC Standard Digital Audio Compression (AC–3)" (incorporated by reference, see §73.8000), ATSC Doc. A/53B, Revision B with Amendment 1 and Amendment 2: "ATSC Digital Television Standard," except for Section 5.1.2 ("Compression format constraints") of Annex A ("Video Systems Characteristics") and the phrase "see Table 3" in Section 5.1.1. Table 2 and Section 5.1.2 Table 4 (incorporated by reference, see §73.8000), and ATSC A/65B: "ATSC Program and System Information Protocol for Terrestrial Broadcast and Cable," (Revision B) 2003 (incorporated by reference, see §73.8000). Although not incorporated by reference, licensees may also consult ATSC Doc. A/54, Guide to Use of the ATSC Digital Television Standard, (October 4, 1995), and ATSC Doc. A/69, Recommended Practice PSIP Implementation Guidelines for Broadcasters (June 25, 2002)

2 2 Modulation Characteristics

Figure 2-1 shows the test equipment setup for the modulation characteristics RF measurements.

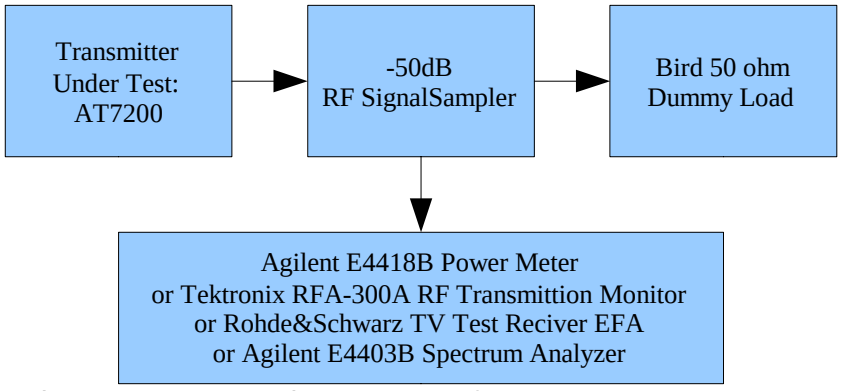

Figure 2-1. Test Equipment Setup for RF Power Measurements

The AT7200 was adjusted to obtain 200 W average power at the output connector using the Agilent E4418B power meter.

1. 2.1 Out of Channel Emissions

FCC rules codified in title 47 of the code of federal regulations ***Part §74.794 Digital emissions*** specifies that out of channel emissions shall be confined within one of the following emissions masks: simple or stringent.

(i) Simple mask. At the channel edges, emissions must be attenuated no less than 46 dB. More than 6MHz from the channel edges, emissions must be attenuated no less than 71 dB. At any frequency between 0 and 6 MHz from the channel edges, emissions must be attenuated no less than the value

determined by the following formula:

$$A\ (dB) = 46 + (\Delta f^2 / 1.44) \qquad (1)$$

(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:

$$A(dB) = 47 + 11.5\ (\Delta f - 0.5) \qquad (2)$$

AT7200 is made to comply with the simple mask. For this test the setup shown in figure 2-1 with the Tektronix RFA300A RF transmission monitor was used. The result is shown bellow in figure 2-2:

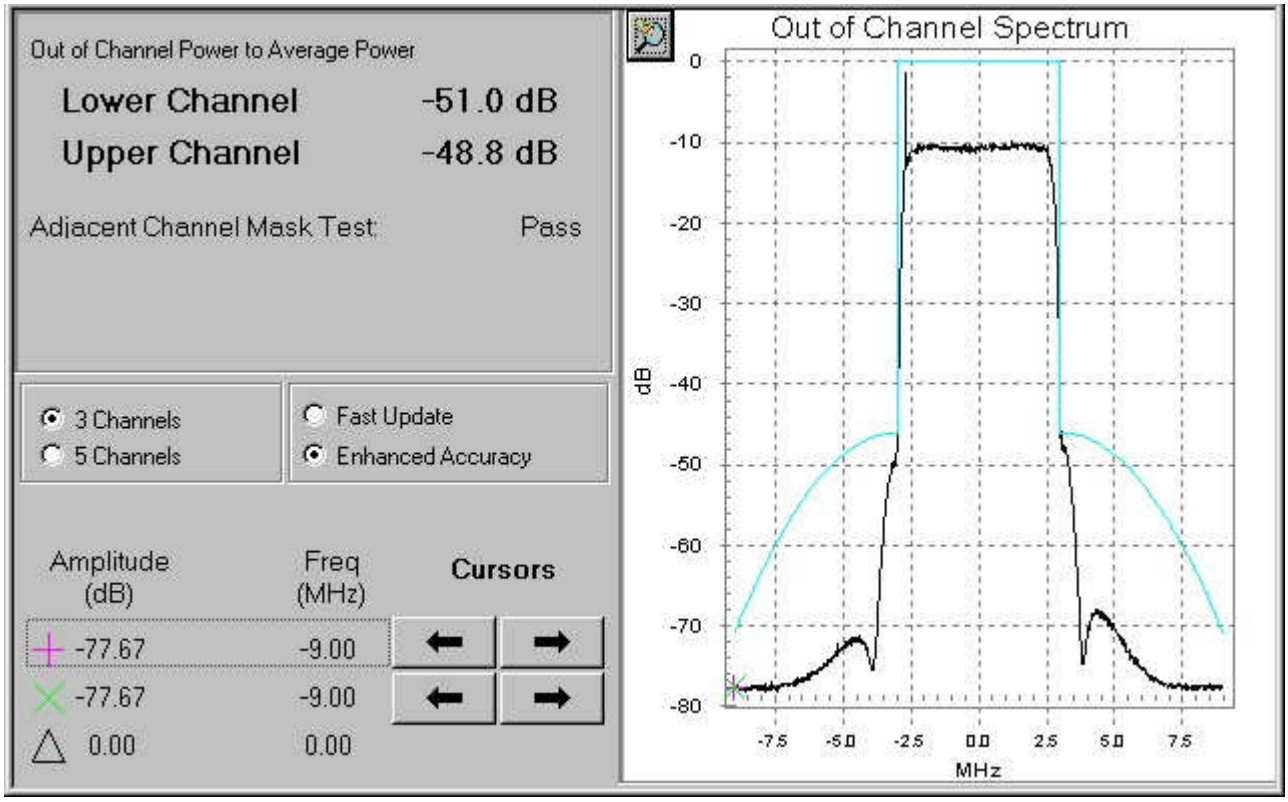

Figure 2-2. Out of channel emissions for simple mask

1 2.2 Frequency Response and Group Delay

AT7200 features a linear distortion equalizer for compensating distortions caused by output mask filter. This filter introduces severe group delay and some amplitude distortion on channel edges. Rohde&Schwarz TV test receiver EFA was used with the test setup shown in figure 2-1 to show the results when transmitter equalization is on. Figure 2-3(a) shows the linear distortions caused by output filter, and the figure 2-3(b) shows minimized frequency response and group delay peak to peak distiortion, when transmitter equalization is used.

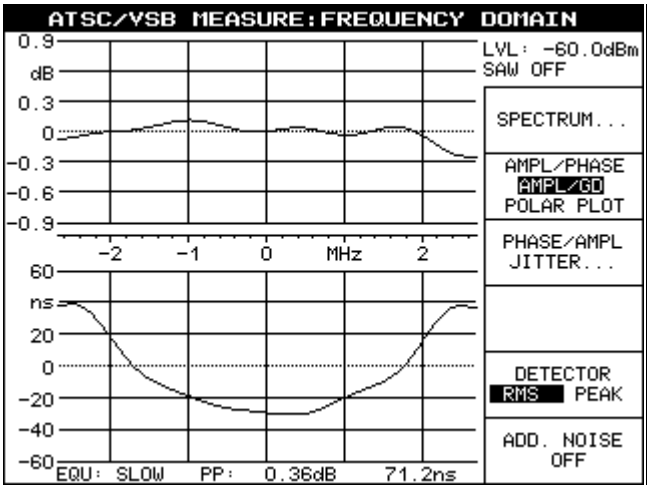

Figure 2-3(a). Frequency response & group delay without transmitter equalization

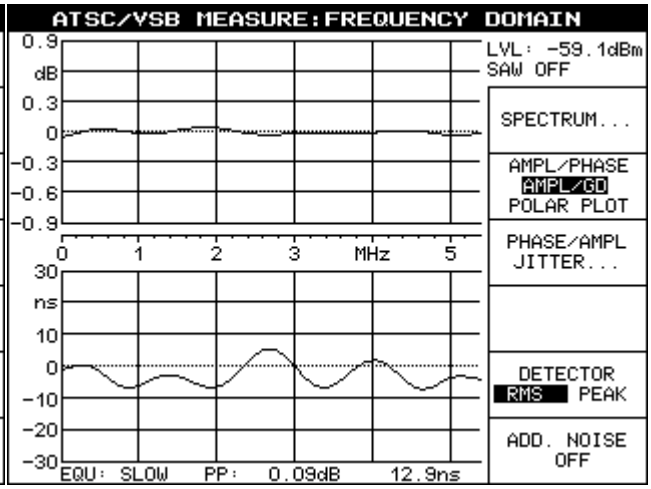

Figure 2-3(b). Frequency response & group delay with transmitter equalization

2 2.3 Modulation Error Rate

Modulation erros can be caused by amplitude noise, phase noise, linear or nonlinear distortion. The modulation error rate (MER) parameter reflect the quality of the 8VSB signal. The MER shows the relationship of the average error vector to the average signal power (without pilot carrier power). The rms value of MER is defined as:

$$MER(rms) = -10 * \log\left(\frac{\frac{1}{n} * \sum_{n} \left|error\ vector^2\right|}{Psig\ without\ pilot}\right) \tag{3}$$

To measure MER or Complex MER (Tektronix nomenclature), the receiver equalization is turned off. This measurement was done using both Rohde&Schwarz TV test receiver EFA (figure 2-4 and figure 2-5) and Tektronix RFA-300A RF transmission monitor (figure 2-6 and figure 2-7).

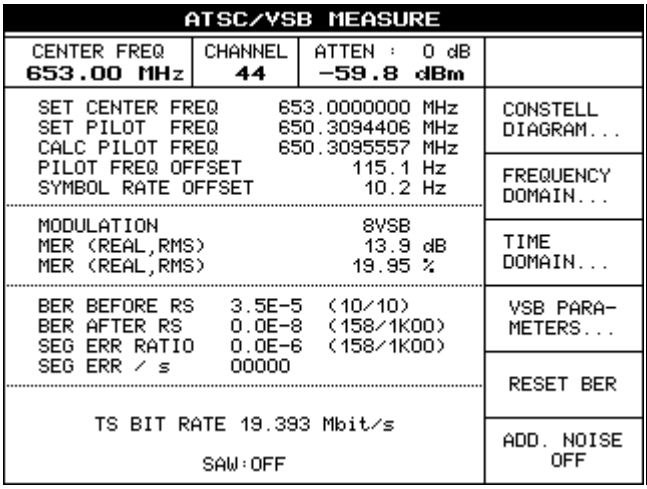

Figure 2-4(a). Modulation Error Rate without transmitter equalization

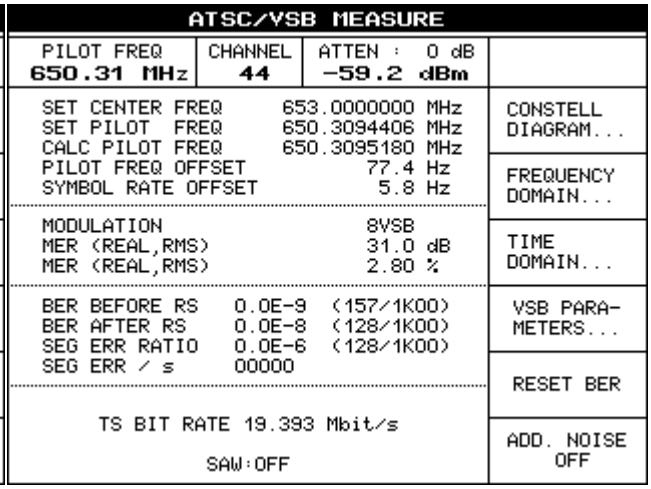

Figure 2-4(b). Modulation Error Rate with transmitter equalization

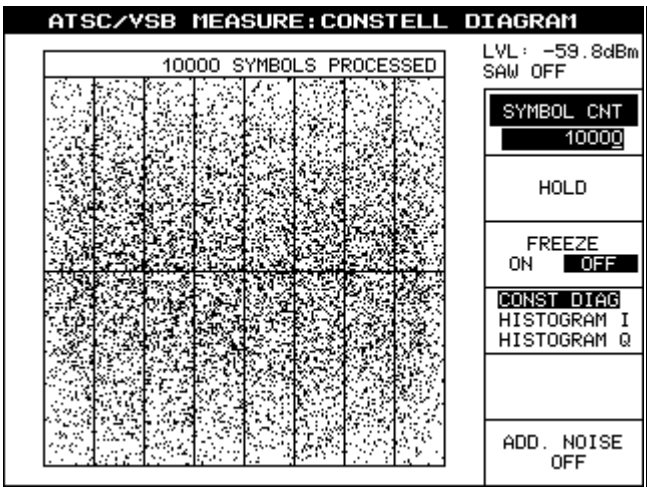

Figure 2-5(a). Constellation diagram without transmitter equalization

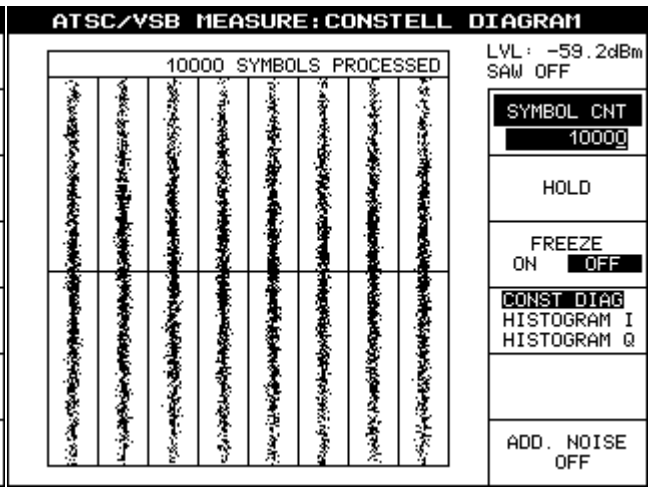

Figure 2-5(b). Constellation diagram with transmitter equalization

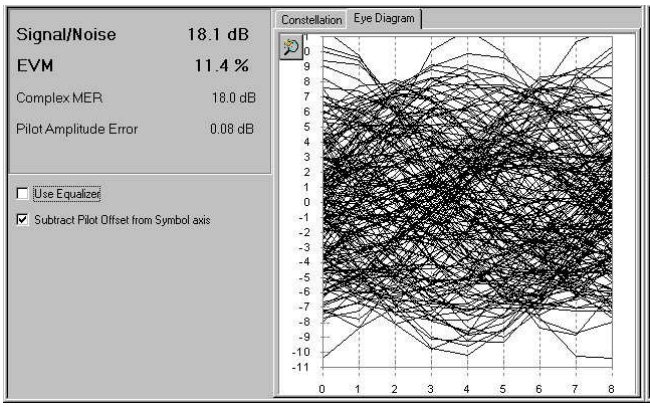

Figure 2-6(a). Eye diagram without transmitter equalization

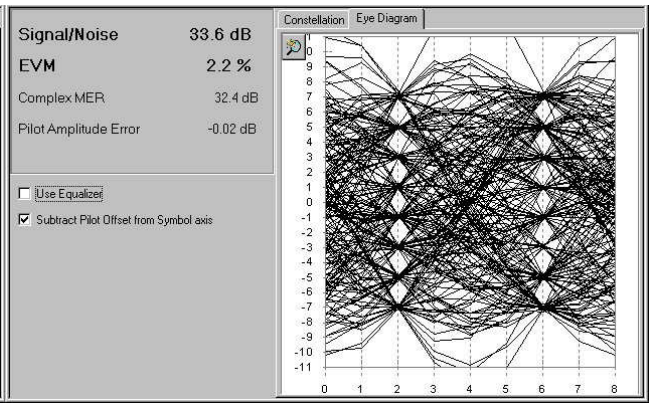

Figure 2-6(b). Eye diagram with transmitter equalization

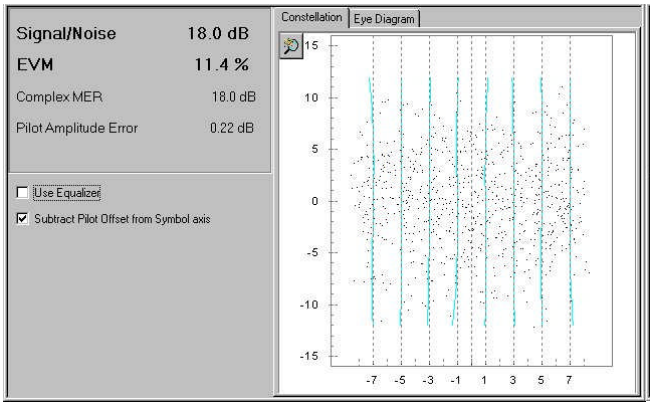

Figure 2-7(a). Constellation diagram without transmitter equalization

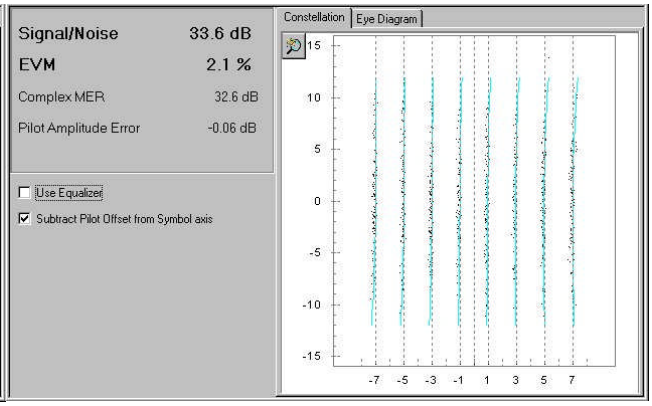

Figure 2-7(b). Constellation diagram with transmitter equalization

3 2.4 Carrier Phase Noise

Document A/64, from ATSC recommends that the level of (pilot) carrier phase noise should be no greater than -104 dBc/Hz @ 20 kHz offset from the carrier frequency. The test setup shown in figure 2-1 was used with the Tektronix RFA-300A RF transmission monitor. Figure 2-8 shows the measurement:

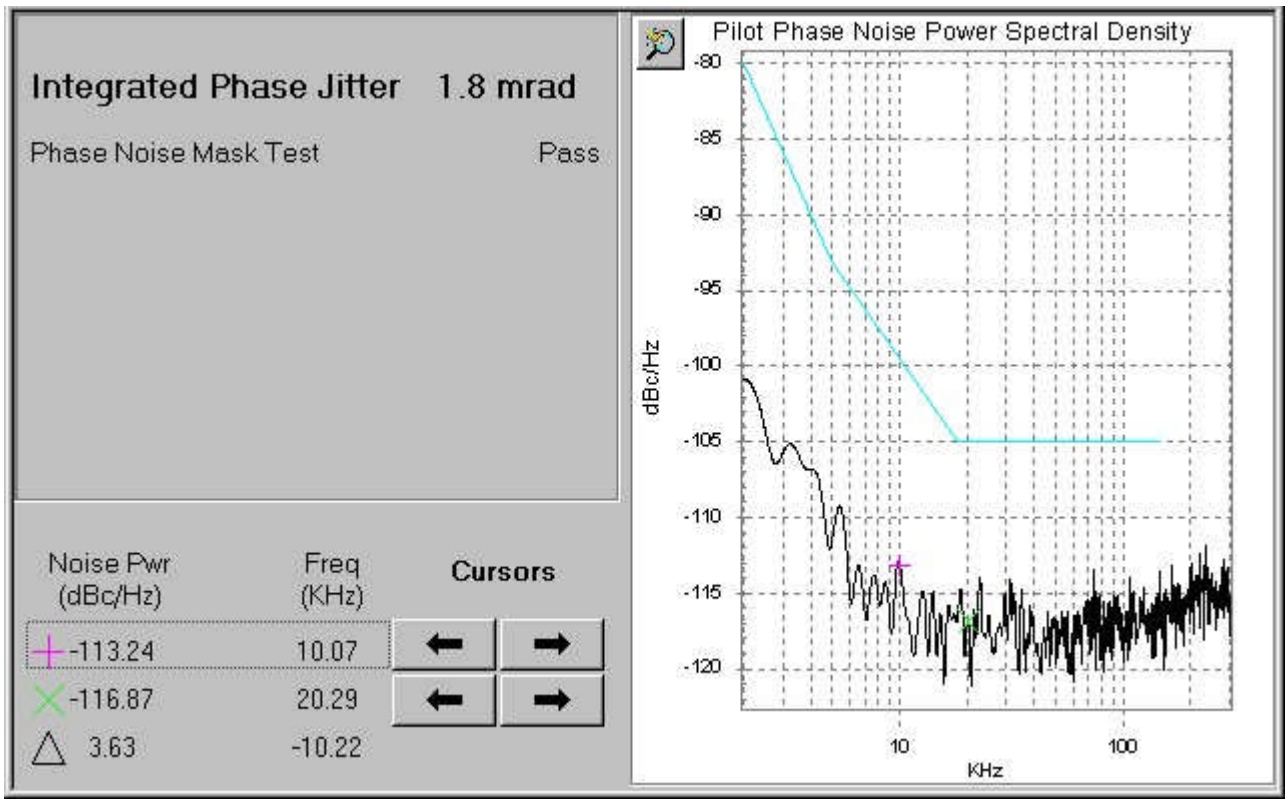

Figure 2-8. Pilot carrier phase noise

1. 3 Spurious Emissions

1. 3.1 Conducted Spurious Emissions

FCC specifies a rule for conducted spurious emissions:

§ 74.750 Transmission system facilities.
(2) Radio frequency harmonics of the visual and aural carriers, measured at the output terminals of the transmitter, shall be attenuated no less than 60 dB below the peak visual output power within the assigned channel. All other emissions appearing on frequencies more than 3 megacycles above or below the upper and lower edges, respectively, of the assigned channel shall be attenuated no less than:
(i) 30 dB for transmitters rated at no more than 1 watt power output.
(ii) 50 dB for transmitters rated at more than 1 watt power output.
(iii) 60 dB for transmitters rated at more than 100 watts power output.

Using the test setup shown in figure 2-1, the spectrum outside the specified channel was observed and the data was recorded on all products above the 70 dB noise floor of the Agilent E4403B Spectrum Analyzer. Figure 3-1(a) and figure 3-1(b) show the second and third harmonic respectively. Those hamonics for channel 44 always appeared to be attenuated no less then 60 dB, with 0 dB being the fundamental.

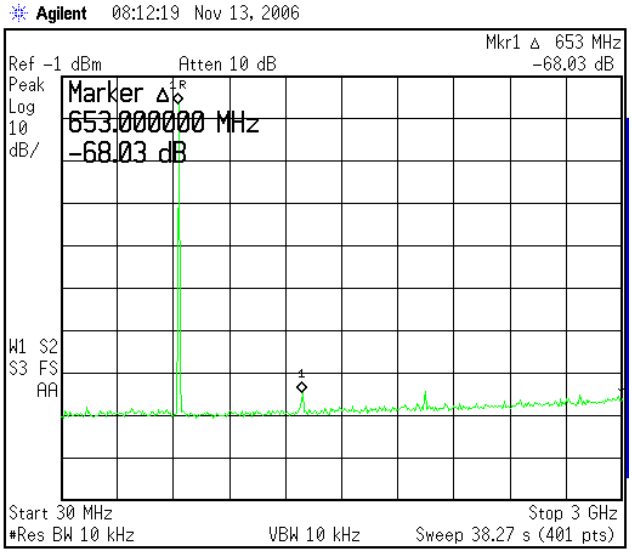

Figure 3-1(a). Second harmonic

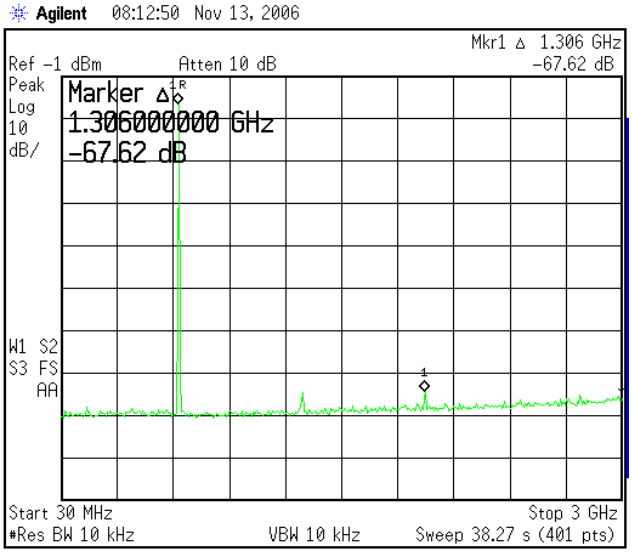

Figure 2-4(a). Third hamonic

2 4 Frequency Stability

The pilot carrier frequency is dertermined by a local oscillator wich is synthesized by a Phase Locked Loop wich is referenced by a 10 MHz signal from an internal OCXO or an external reference. The tests for pilot carrier frequency stability were done using the internal 10 MHz reference OCXO. The nominal oscillator frequency for channel 44 is 671,833,916 Hz. For the next tests the Hewlett Packard 5350B Frequency Counter was used. The FCC reference rule for this measurement is:

§ 74.795 Digital low power TV and TV translator transmission system facilities.
(4) When subjected to variations in ambient temperature between 0 and 40 degrees Centigrade and variations in power main voltage between 85% and 115% of the rated power supply voltage, the frequency stability of the local oscillator in the RF channel upconverter shall be maintained within 10 kHz of the nominal value.

3 4.1 Frequency Versus Temperature

The oscillator cicuitry was placed in a temperature controlled chamber and the temperature was varied from -5°C to +60°C. The oscillator was allowed to stabilize at each temperature before measurements were recorded. Table 4-1 shows the results.

Table 4-1. Frequency Stability Versus Temperature

Temperature [°C]	Frequency [Hz]	Offset [Hz]
-5	671,834,041.	125
0	671,834,045	129
+20	671,833,930	14
+30	671,833,919	3
+40	671,833,916	0
+50	671,833,912	-4
+60	671,833,910	-6

4 4.2 Frequency Versus Line Voltage

The oscillator frequency was measured as the input line voltage of the exciter drawer was varied from 171 to 245 Vac. Table 4-2 shows the results.

Table 4-2. Frequency Stability Versus Line Voltage

Line Voltage [Vac]	Frequency [Hz]	Offset [Hz]
171	671,833,215	-1
208	671,833,215	-1
245	671,833,215	-1

3 5 Test Equipment

The test equipment used to analyze the AT7200 is listed in table 4-1.

Table 5-1. Test Equipment

Model	Manufacturer	Description	Serial #
E4418B	Agilent	Power Meter	GB43317717
RFA-300A	Tektronix	RF Transmission monitor	B020427
EFA Model 53	Rohde & Schwarz	TV Test Receiver	100144
E4403B	Agilent	Spectrum Analyzer	MY45102038
5350B	Hewlett Packard	Frequency Counter	3049A05771

4 6 Conclusion

It was determined that AT7200 – 200 Watt ATSC digital TV transmitter did meet all requirements of the FCC Code of Federal Regulations Title 47, Part 74, Subpart G. It is also fully compliant with ATSC Document A/53B.