SMITH ELECTRONICS, INC.
ELECTROMAGNETIC COMPATIBILITY LABORATORIES

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HEXAGRAM, INC.

ELECTRIC METER TRANSMITTING UNIT (MTU)
Model 8877
FCC ID: LLB8877

September 10, 2003
Rev. 1

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TEST REPORT

INTRODUCTION

The Hexagram Electric MTU transmitter is a line-powered transmitter designed to be installed in a typical electric meter. The transmitter will be mounted inside the glass cover of the meter and provide a very short, intermittent radio frequency transmission to provide a remote reading of the meter. A microprocessor provides timing, control and data processing functions. The built in antenna is inaccessible to the user and no provision is made for an external antenna. This report describes the tests performed on the transmitter in support of an application for certification.

MEASUREMENTS PERFORMED

The microprocessor portion of the transmitter was also examined for conducted and radiated emissions per Part 15, and has been verified to comply with the appropriate sections of that part. The data used for verification of the microprocessor portion is presented in a separate report.

POWER OUTPUT AND SPURIOUS EMISSIONS

A series of measurements of the operating frequency and any harmonic emissions was made on the Smith Electronics, open field test site located at 8200 Snowville Road, Brecksville, OH. Data pertinent to this site is on file with the FCC. A scan of the transmitter emissions made in the shielded room showed no significant emissions other than the fundamental and its harmonics. The measurements were made using the substitution method described in TIA/EIA-603-A.

Measurements below 1000 MHz were made at a three-meter test distance with frequencies above 1000 MHz being measured at one meter. A receiver and a tuned dipole were used for receiving below 1000 MHz and a spectrum analyzer and a wave guide antenna were used above 1000 MHz.

The transmitter, installed in a typical meter, was placed on a remotely rotatable, non-conducting test stand. This general set up is shown in Pictorial 1. Because of the intermittent nature of the normally operating transmitter and its mode of operation while AC powered, an external battery pack was connected directly to the transmitter and the transmitter was forced to continually transmit for the measurements.

With the test receiver tuned to the unmodulated signal, the transmitter under test was rotated to the position of maximum signal. The receiving antenna was then varied between 1 and 4 meters in height to again maximize the signal. Measurements were made with the antennas positioned both vertically and horizontally and the maximum signal recorded.

No differences were observed with different signal detectors, so a quasi-peak detector was used for the signals below 1000 MHz and average detection above 1000 MHz.

After the maximum received meter readings were obtained for each frequency and polarity, the meter under test was removed from the area and replaced by a signal generator and transmitting antenna. With the transmit antenna placed as close as possible to the position of the test unit, the signal generator was activated at a test frequency. With the signal detected, the transmit antenna was rotated slightly to maximize the reading. The receive antenna was also positioned for maximum reception. The signal generator output was then adjusted until the received signal was equal to the received signal from the unit under test. These measurements were repeated for each frequency and antenna orientation and the maximum values obtained are noted in Table 1. Transmitting antenna gain and coax loss figures are also included in Table 1

In order to convert the signal generator output value to equivalent radiated power from a dipole, the following equation is used:

$$P_d = P_g - \text{cable loss(dB)} + \text{antenna gain}(dB_d)$$

where:

P_d is the dipole equivalent power, P_g is the generator output into the substitution antenna and “antenna gain” is the gain of the substitution antenna with respect to a dipole.

According to 90.210(d)(3) all emissions greater than 12.5 kHz from the center of the authorized band shall be attenuated below the unmodulated carrier by 50 + 10log(P). Using P = 0.0832 W, the required attenuation is 39.2 dB. An examination of Table 1 shows that all emissions are 49.8 dB or more below the carrier power level.

PICTORIAL 1
HEXAGRAM ELECTRIC METER TRANSMITTING UNIT
OUTPUT POWER AND SPURIOUS EMISSIONS
TEST SETUP

TABLE 1
HEXAGRAM EMU 8877 TRANSMITTER
SUBSTITUTION METHOD

3 meter measurement using tuned dipole transmit antenna

Frequency (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
460	19.5	0.3	0	19.2	--
920	-33.7	0.5	0	-34.2	-53.4

1 meter measurement using horn transmit antenna

Frequency (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
1380	-35.5	0.7	3.1	-33.1	-52.3
1840	-47.4	0.8	4.9	-43.3	-62.5
2300	-38.0	0.9	5.6	-33.4	-52.5
2760	-35.7	1.1	6.2	-30.6	-49.8
3220	-46.3	1.2	6.7	-40.8	-60.0
3680	-50.9	1.3	6.6	-45.6	-64.8
4140	-50.5	1.4	6.5	-45.4	-64.6
4600	-54.7	1.5	7.2	-49.0	-68.2

19.2 dBm = 83.2 mW or 0.0832 W
Required attenuation for harmonics is 50 + 10log (.0832) = 39.2 dB

Measurements made with 10 kHz IFBW and 10 kHz video BW

TEST EQUIPMENT USED

Meters & Analyzers	Singer-Stoddart EMI Field Intensity Meter Model NM 37/57 S/N 0366-06168 Calibrated 6/03
	Hewlett-Packard Spectrum Analyzer Model 8593EM S/N 3536A00147 Calibrated 6/00
Antennas	(2x) Stoddart 91598-2 Tuned Dipole Frequency Range 400 – 1000 MHz
	EMCO 3115 Double Ridged Guide Horn Frequency Range 1 – 18 GHz
	Eaton Model 96001 Double Ridged Guide Horn Frequency Range 1 – 18 GHz
Signal Generator	Hewlett-Packard Model 8340B, S/N 3010A01889 Calibrated 1/03
Miscellaneous	12.2 m RG-214/U coaxial cable
	6.1 m RG-214/U coaxial cable
	(2x) 1.8 m RG-214/U coaxial cable

<u>OCCUPIED BANDWIDTH</u>

The emissions close to the center of the specified channel are limited by the emissions masks described in 90.210. For the frequency range of the "Electric MTU" transmitter, Mask D is specified. From the center frequency of the band ±5.625 kHz, 0 dB of attenuation is required. From 5.625 kHz to 12.5 kHz from the center frequency, attenuation must be at least $7.27(f_d - 2.88 \text{ kHz})$ dB, where f_d is the displacement frequency from the center of the band in kHz.

At more than 12.5 kHz from the band center, the attenuation must be 70 dB or 50 + 10 log(P), whichever is less. Since P was determined to be 0.0832 W, 50 + 10 log(0.0832) equals 39.2 dB.

The short transmission was caught by the Real-Time-Spectrum-Analyzer and stored to disk for evaluation.

The plot of Fig. 1a shows the unmodulated carrier, while Fig. 1b shows the modulated signal. Both Figs. have Mask D superimposed on the plot. The plots indicate that the modulated emission does appear to comply with the requirement for occupied bandwidth as found in 90.210.

For purposes of this test, the transmitter was FSK modulated with a continuous sequence of Manchester encoded 1's at the specified 1200 bits per second data rate. The Manchester encoding scheme forces a mid-bit transition for an encoded "1". Therefore, the sequence of continuous 1's sends the highest frequency waveform to the modulator circuit.

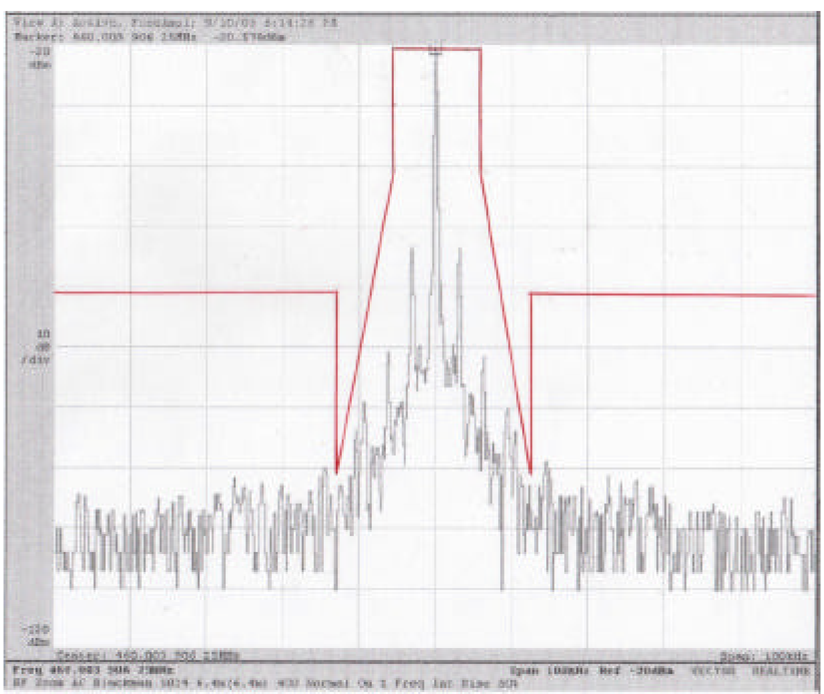

Fig. 1a
Hexagram Model 8877 Electric Meter Unit
Unmodulated Emissions Mask

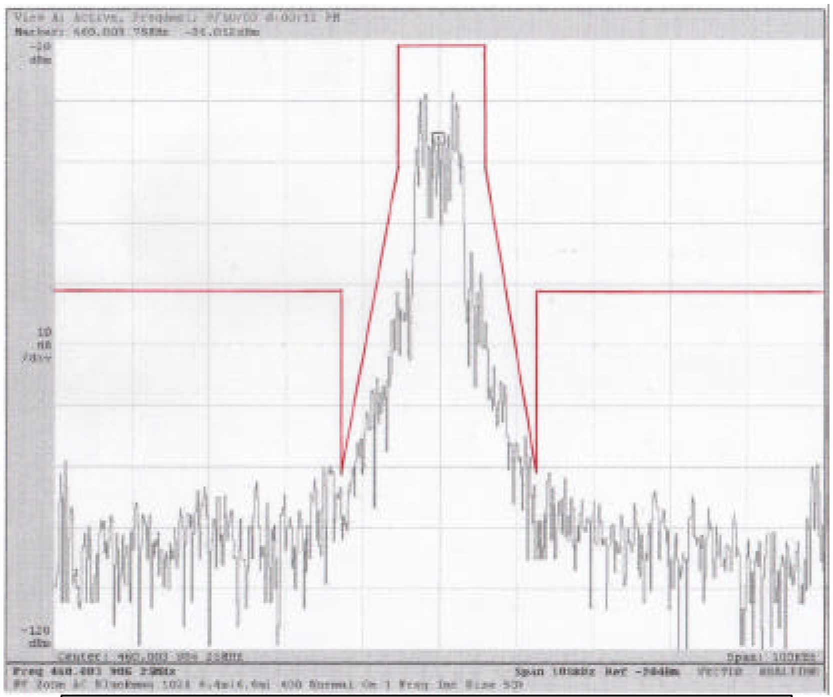

Fig. 1b
Hexagram Model 8877 Electric Meter Unit
Modulated Emissions Mask

EMU 8877   September 10, 2003

TEST EQUIPMENT USED

Real-Time Spectrum Analyzer — Tektronix/Sony Model 3086
S/N J300195   Calibration 12/02

Antenna — EMCO Model 3146 Log Periodic
Frequency Range 200 MHz – 1000 MHz

FREQUENCY STABILITY VS. TEMPERATURE

With the transmitter installed on a typical electric meter assembly, the temperature stability of the frequency generating components was observed. The meter assembly was placed in a temperature chamber. The AC powered meter was set to transmit at intervals of about 40 seconds. A receiving antenna outside the chamber picked up the transmitted signal which was fed to the real-time spectrum analyzer.

With the transmitter programmed to transmit at 460.00000 MHz, the chamber temperature was set to 20° C. After reaching the set temperature, the transmitter was allowed to stabilize for about 10 minutes or more. The transmission signal was captured by the real-time spectrum analyzer and the frequency was determined and compared to the expected 460.000000. The temperature in the chamber was then increased in 10° C increments. At each new temperature, time was allowed for stabilization of the transmitter, a transmission was made and the frequency determined. The temperature was increased at the 10° C increments to 80° C, and then to 85° C. The temperature was then reduced to 10° C for a frequency measurement and then continuing to decrease in 10° C increments, checking the frequency at each point, until a temperature of -30° C was reached. The frequency at each temperature was recorded and is found in Table 2. It can be seen from the table that all readings are exactly on frequency with no deviation.

TABLE 2
FREQUENCY STABILITY
VS. TEMPERATURE

Temperature ° C	Measured Frequency MHz	Dev. Hz	Dev. ppm
	Expected = 460.00000		
+85	460.000000	0	0
+80	460.000000	0	0
+70	460.000000	0	0
+60	460.000000	0	0
+50	460.000000	0	0
+40	460.000000	0	0
+30	460.000000	0	0
+20	460.000000	0	0
+10	460.000000	0	0
0	460.000000	0	0
-10	460.000000	0	0
-20	460.000000	0	0
-30	460.000000	0	0

FREQUENCY STABILITY VS. SUPPLY VOLTAGE

The frequency stability was also determined as a function of the power line input voltage. A variable transformer was used to set the voltage between about 85% and 115% of the nominal 220 VAC input. To cover the voltage range of 187 V to 253 V, measurements were made every 10 V between 180 V and 260 V. When the voltage was set to a measurement point, the transmitter was instructed to transmit and the signal captured by the real-time analyzer and the frequency value determined. The data for these measurements are found in Table 3. Again, it can be seen that all values obtained are exactly on frequency..

TABLE 3
FREQUENCY STABILITY
VS. SUPPLY VOLTAGE

INPUT AC Volts	Measured Frequency MHz	Dev. Hz	Dev. ppm
	Expected = 460.00000		
180	460.000000	0	0
190	460.000000	0	0
200	460.000000	0	0
210	460.000000	0	0
220	460.000000	0	0
230	460.000000	0	0
240	460.000000	0	0
250	460.000000	0	0
260	460.000000	0	0

TEST EQUIPMENT USED

Real-Time Spectrum Analyzer	Tektronix/Sony Model 3086 S/N J300195 Calibration 12/02
Antenna	EMCO Model 3146 Log Periodic Frequency Range 200 MHz – 1000 MHz
Thermometer	Radio Shack 63-1011 Digital Thermometer
Digital Volt Meter	Fluke Model 23
Temperature Chamber	Standard Environmental Systems, Inc. Model TK/5

TRANSIENT STABILITY

The transient stability measurements indicate the variation in tuned frequency during the brief interval of time during the start of the transmission and the end of the transmission.

The Model 8877 transmitter, mounted in an electric meter, was tested for transient frequency behavior using the test method TIA/EIA-603. A block diagram of the test setup is seen in Fig. 2. A model DCU-1 receiver with an audio bandwidth of 16 kHz (low Pass) was used. The storage oscilloscope was triggered by the radiated signal from the transmitter. Appropriate delay was provided by the digital delay circuitry of the oscilloscope. The 1 kHz test signal was provided by the Marconi signal generator. The generator's output control was used to insure that the signal was at least 50 dB below the received signal level from the 8877.

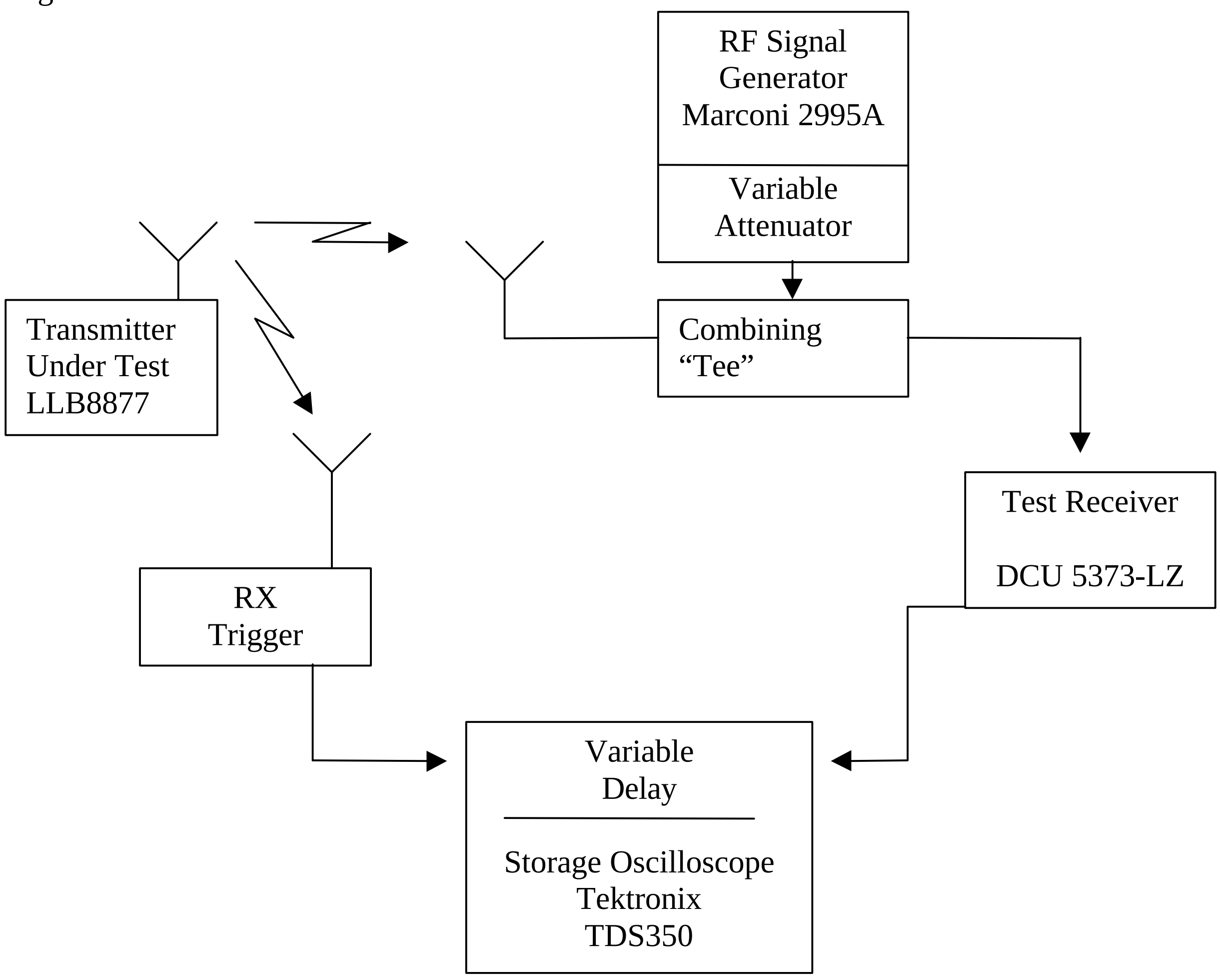

Fig. 2
Transient Frequency Behavior
Test Setup

Test Requirements

The test requirements per 90.214 are:

1. Frequency deviation during t_1 (10 ms duration after t_{on}) may be greater than ±12,5 kHz because the output power is less than 6 Watts.

2. Frequency deviation during t_2 (25 ms duration after t_1) must be less than ±6.25 kHz.

3. Frequency deviation after t_2 must be less the ±2.5 ppm. or ±1150 Hz.

4. Frequency deviation during t_3 (10 ms duration after transmitter is turned off) may exceed ±12.5 kHz because output power is less than 6 Watts.

Test Data

Figures 3 through 7 show the Model 8877's transient frequency characteristics. The limit masks are overlaid or indicated on each of the figures.

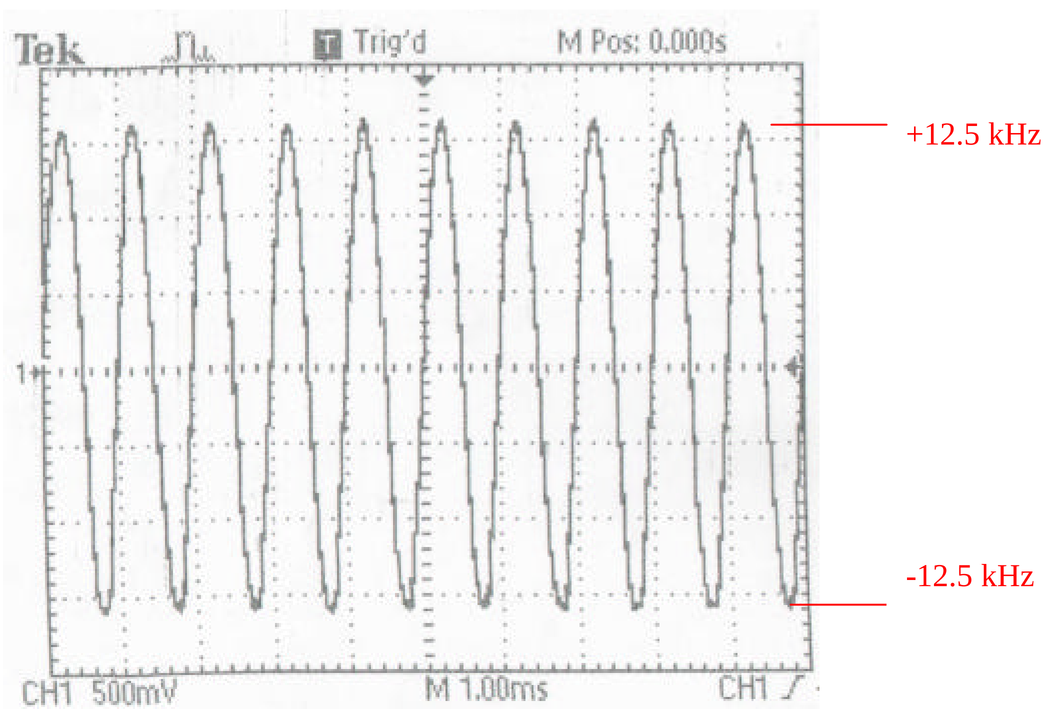

Fig. 3   ±12.5 kHz modulated test signal   25 kHz/6.2 div. = 4 kHz/div.

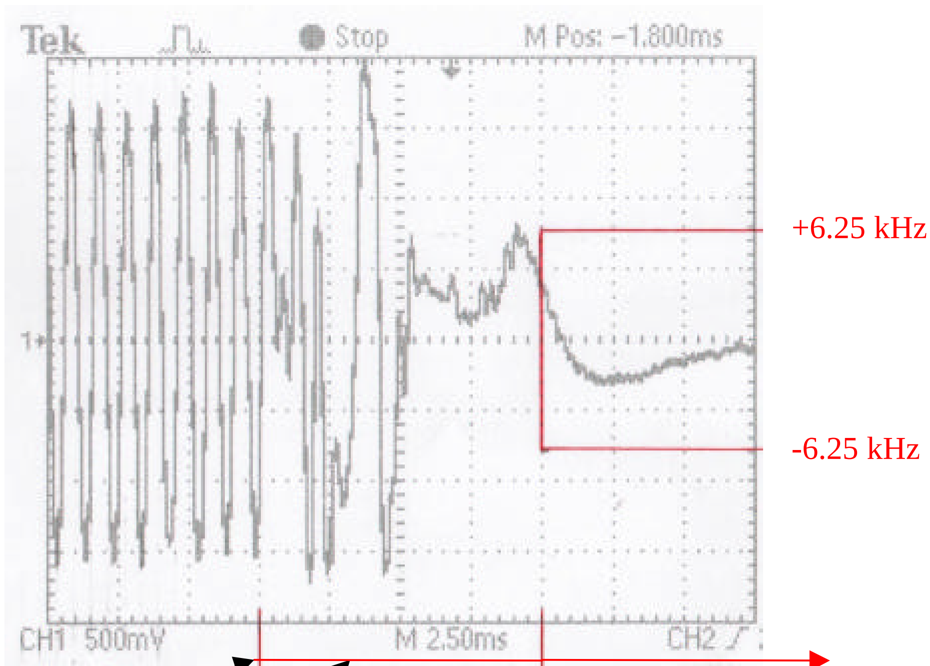

Fig. 4 Start of Transmission

t_1 = 10 ms (Unlimited deviation)

t_2 = 25 ms (±6.25 kHz deviation or ±1.56 div.

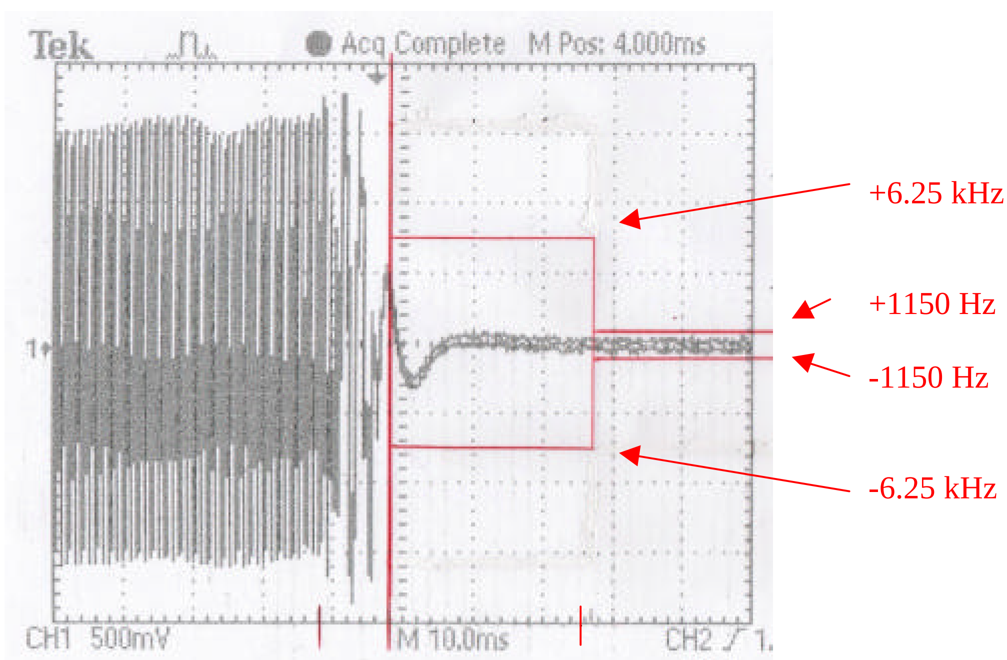

Fig. 5 Turn On Transient **t_1** **t_2** **t_3**

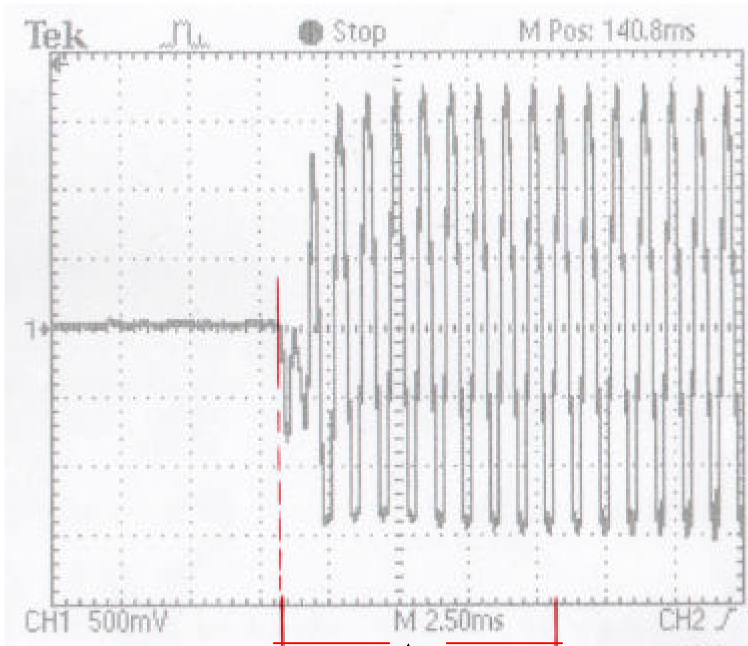

Fig. 6 Turn Off Transient

Turn Off 10 ms

Modulated signal appears well within the allowed 10 ms.

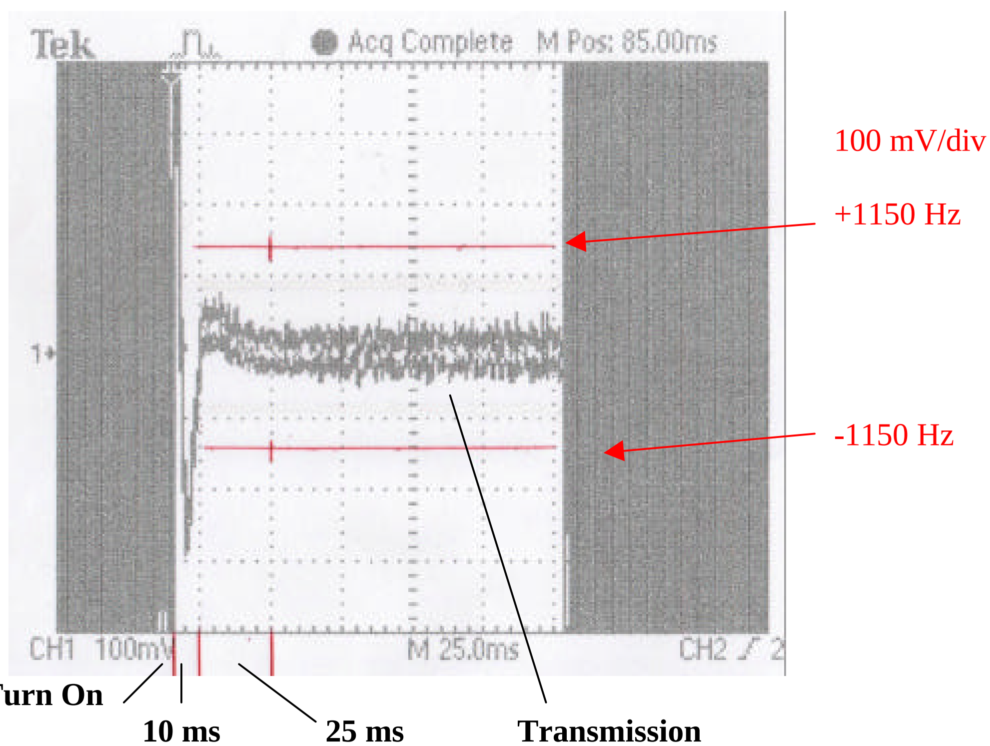

Fig. 7 Complete Transmission

TEST EQUIPMENT USED

Signal Generator	Marconi Model 2955A Calibration 10/02
Test Receiver	Hexagram DCU-1 (Modified)
Oscilloscope	Tektronix Model TDS 1002 S/N CO15640 Calibration 10/02
Printer	Hewlett-Packard Thinkjet
RF Trigger	Hexagram Detector Circuit

TEST INFORMATION

SUMMARY

The Hexagram Electric Meter Transmitting Unit transmitter, Model 8877, has been shown to be capable of complying with those requirements of the Federal Communications Commission for a Part 90 transmitter that are covered by this report.

EQUIPMENT UNDER TEST	"Electric MTU" Transmitter, Model 8877
MANUFACTURER	Hexagram, Inc. 23905 Mercantile Cleveland, OH 44122
TEST DATES	July 2 – September 10, 2003
TEST LABORATORY	Smith Electronics, Inc. 8200 Snowville Road Cleveland, OH 44141 (440)526-4386