SMITH ELECTRONICS, INC.
ELECTROMAGNETIC COMPATIBILITY LABORATORIES

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HEXAGRAM, INC.

"FOCUS"
METER TRANSMITTING UNIT (MTU)
with RECEIVER

Model 14280
FCC ID: LLB14280

May 6, 2008

Prepared by: James R. Pollock

Prepared for: Hexagram, Inc.
23905 Mercantile Road
Cleveland, OH 44122

Smith Electronics, Inc.
8200 Snowville Rd.
Brecksville, OH 44141
PH: (330) 289-9306

Mailing Address: 2730 Old Mill Rd.
Hudson, OH 44236

TEST REPORT

INTRODUCTION

The Hexagram Model 14280 transceiver is a designed to provide remote meter reading capability with the Landis & Gyr "Focus" family of electric meters. The transceiver is connected to, and receives power from, the meter circuitry and mounts within the meter enclosure. An on-board battery provides power for brief, "outage" transmissions when AC power is not available. The transmitter provides 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. The receiver can be used to request a meter reading or other options available in the system. The transmitter was tested with a 2S version of the Focus meter which operates on a nominal 240 VAC. One transmitter was tested and this report presents the data obtained in support of an application for certification.

MEASUREMENTS PERFORMED

The microprocessor and receiver portions of the transceiver were also examined for radiated emissions per Part 15, and have been verified to comply with the appropriate sections of that part. The data used for verification of the microprocessor and receiver is presented in a separate report.

POWER OUTPUT AND SPURIOUS EMISSIONS

Within the tuning range of 450 – 470 MHz, the transmitter portion was examined at three fundamental frequencies and their harmonics. All measurements below 1 GHz were made at a 3-meter distance on the Smith Electronics open area test site located at 8200 Snowville Road, Brecksville, OH. Data pertinent to this site is on file with the FCC (Reg.#90938) and Industry Canada(File #4541A-1). The harmonic measurements above 1 GHz were made at a distance of 1 meter over a suitable ground plane. The measurements were made using the substitution method described in TIA/EIA-603-A.

Tuned dipoles were used for measurements below 1000 MHz and a wave-guide antenna was used above 1000 MHz. A spectrum analyzer was used as a receiver.

The transmitter 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 a larger, external battery pack was connected directly to the transmitter and the transmitter was forced to continually transmit for these 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 signals recorded.

Peak detection 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 transmitter 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 receiving antenna was positioned for maximum reception. The signal generator output was then adjusted until the received signal was equal to the previously 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 Tables 1a – 1c.

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 in dBm, P_g is the generator output into the substitution antenna, also in dBm, and “antenna gain” is the gain of the substitution antenna with respect to a theoretical 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). The determined power outputs, the required harmonic attenuation as well as the attenuation for each harmonic are found in Tables 1a – 1c.

PICTORIAL 1
HEXAGRAM MODEL 14280 MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP

TABLE 1a
HEXAGRAM MODEL 14280 TRANSMITTER
SUBSTITUTION METHOD
450 MHz

Horizontal 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
450	10.5	0.9	-0.2	9.4	
900	-31.5	1.4	-0.5	-33.4	-42.8

Output = 9.4 dBm
= 0.009 W
Req. Att.= 29.5 Bm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1350	-56.7	0.7	5.5	-51.9	-61.3
1800	-45.9	0.8	5.9	-40.8	-50.2
2250	-45.9	1.0	6.8	-40.1	-49.5
2700	-37.7	1.1	7.6	-31.2	-40.6
3150	-56.6	1.2	7.7	-50.1	-59.5
3600	-56.0	1.3	7.7	-49.6	-59.0
4050	-45.2	1.4	7.6	-39.0	-48.4
4500	-37.5	1.5	8.3	-30.7	-40.1

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
450	18.8	0.9	-0.2	17.7	
900	-25.0	1.4	-0.5	-26.9	-44.6

Output = 17.7 dBm
= 0.060 W
Req. Att.= 37.8 dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1350	-56.0	0.7	5.5	-51.2	-68.9
1800	-46.1	0.8	5.9	-41.0	-58.7
2250	-45.8	1.0	6.8	-40.0	-57.7
2700	-36.0	1.1	7.6	-29.5	-47.2
3150	-54.0	1.2	7.7	-47.5	-65.2
3600	-59.1	1.3	7.7	-52.7	-70.4
4050	-48.5	1.4	7.6	-42.3	-60.0
4500	-42.8	1.5	8.3	-36.0	-53.7

TABLE 1b
HEXAGRAM MODEL 14280 TRANSMITTER
SUBSTITUTION METHOD
460 MHz

Horizontal 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
460	11.7	0.9	-0.2	10.6	
920	-34.1	1.4	-0.4	-35.9	-46.5

Output = 10.6dBm
= 0.011 W
Req. Att.= 30.6dBm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1380	-49.3	0.7	5.6	-44.4	-55.0
1840	-48.1	0.8	5.9	-43.0	-53.6
2300	-44.1	1.0	6.9	-38.2	-48.8
2760	-38.1	1.1	7.6	-31.6	-42.2
3220	-55.2	1.2	7.8	-48.6	-59.2
3680	-53.5	1.3	7.7	-47.1	-57.7
4140	-50.3	1.4	7.7	-44.0	-54.6
4600	-38.6	1.5	8.3	-31.8	-42.4

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
460	22.8	0.9	-0.2	21.7	
920	-30.9	1.4	-0.4	-32.7	-54.4

Output = 21.7 dBm
= 0.148W
Req. Att.= 41.7 dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1380	-58.5	0.7	5.6	-53.6	-75.3
1840	-50.0	0.8	5.9	-44.9	-66.6
2300	-41.9	1.0	6.9	-36.0	-57.7
2760	-35.0	1.1	7.6	-28.5	-50.2
3220	-53.9	1.2	7.8	-47.3	-69.0
3680	-57.6	1.3	7.7	-51.2	-72.9
4140	-51.5	1.4	7.7	-45.2	-66.9
4600	-44.2	1.5	8.3	-37.4	-59.1

TABLE 1c
HEXAGRAM MODEL 14280 TRANSMITTER
SUBSTITUTION METHOD
470 MHz

Horizontal 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
470	11.5	0.9	-0.2	10.4	
940	-37.4	1.4	-0.4	-39.2	-49.6

Output = 10.4 dBm
= 0.011 W
Req. Att.= 30.4 dBm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1410	-47.5	0.7	5.7	-42.5	-52.9
1880	-50.1	0.9	5.9	-45.1	-55.5
2350	-41.8	1.0	7.1	-35.7	-46.1
2820	-40.1	1.1	7.7	-33.5	-43.9
3290	-60.5	1.2	7.8	-53.9	-64.3
3760	-52.0	1.3	7.6	-45.7	-56.1
4230	-44.7	1.4	7.9	-38.2	-48.6
4700	-38.0	1.5	8.4	-31.1	-41.5

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
470	18.3	0.9	-0.2	17.2	
940	-33.2	1.4	-0.4	-35.0	-52.2

Output = 17.2 dBm
= 0.052 W
Req. Att.= 37.2dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1410	-54.3	0.7	5.7	-49.3	-66.5
1880	-47.8	0.9	5.9	-42.8	-60.0
2350	-38.6	1.0	7.1	-32.5	-49.7
2820	-38.4	1.1	7.7	-31.8	-49.0
3290	-60.0	1.2	7.8	-53.4	-70.6
3760	-53.8	1.3	7.6	-47.5	-64.7
4230	-48.7	1.4	7.9	-42.2	-59.4
4700	-43.5	1.5	8.4	-36.6	-53.8

TEST EQUIPMENT USED

Spectrum Analyzer	Rohde & Schwarz Model FSL6 Spectrum Analyzer SN: 100602 Cal Due: 3-11-09
Antennas	(2x) ETS-Lindgren Model DB-4 Tuned Dipole Frequency Range 400 – 1000 MHz
	(2x) ETS-Lindgren Model 3115 Double Ridged Guide Horn Frequency Range 0.75 – 18 GHz
Signal Generator	Hewlett-Packard Model 8340B, S/N 3010A01889 Calibration Verified: 5/4/08
Miscellaneous	12.2 m RG-214/U coaxial cable
	6.1 m RG-214/U coaxial cable
	(2x) 2.4 m RG-213/U coaxial cable
Tests Performed	April 24-25, 2008

OCCUPIED BANDWIDTH

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 14280 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 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 the maximum P was determined to be 0.148 W, 50 + 10 log(0.148) equals 41.7 dB (50 dB is shown in Fig. 1).

Both modulated and unmodulated transmissions were stored on the spectrum analyzer display. The plot of Fig. 1 shows both signals with Mask D superimposed on the plot. The plot indicates that the modulated emission does comply with the requirement for occupied bandwidth as found in 90.210.

For purposes of this test, the modulated signal 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.

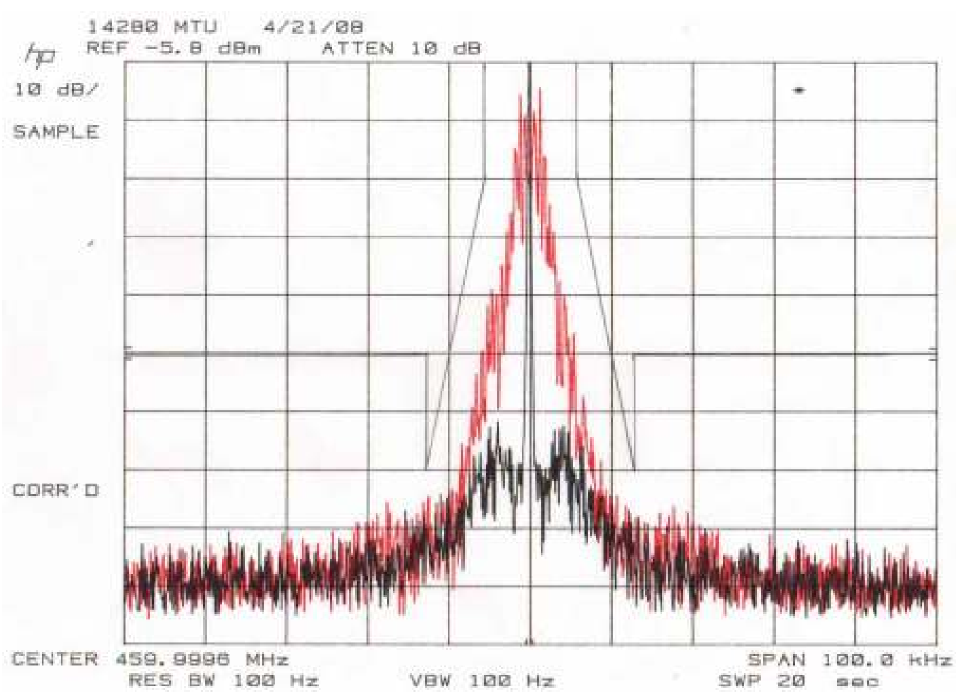

Fig. 1
Hexagram Model 14280
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer	Hewlett-Packard 8568B with 85680A RF Section S/N: 2216A02120 85662A Display Section SN: 2152A03683 Calibration due: 11/08
Antenna	EMCO Model 3146 Log Periodic Frequency Range 200 MHz – 1000 MHz
Test Performed	April 21, 2008

FREQUENCY STABILITY VS. TEMPERATURE

The temperature stability of the frequency generating components of the transmitter was observed. The transmitter was placed in a temperature chamber with a programming coil that allows a transmission to be requested from outside the chamber. 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 MHz, the chamber temperature was set to 20° C. After reaching the set temperature, the transmitter was allowed to stabilize for about 30 minutes. The transmission signal was captured by the real-time spectrum analyzer and the frequency was determined. The temperature in the chamber was then increased 85° C. At each temperature, al least 30 minutes were allowed for stabilization of the transmitter, a transmission was made and the frequency determined. The temperature was decreased to -30° C, and then increased in 10° steps to 80° C, again stabilizing at each 10° interval before a reading was made. The frequency at each temperature was recorded, compared to the 460 MHz tuned frequency, and is recorded in Table 2. It can be seen from the table that all readings are within the deviation limit of ±2.5 ppm or 1150 Hz at 460 MHz.

TABLE 2
FREQUENCY STABILITY
VS. TEMPERATURE
460 MHz

Temperature ° C	Measured Frequency MHz	Dev. Hz	Dev. ppm
+20	460.000266	266	+0.58
+85	460.000391	391	+0.85
-30	460.000406	406	+0.88
-20	460.000547	547	+1.19
-10	460.000500	500	+1.09
0	460.000453	453	+0.98
+10	460.000109	109	+0.24
+20	460.000250	250	+0.54
+30	460.000141	141	+0.31
+40	460.000219	219	+0.48
+50	460.000328	328	+0.71
+60	460.000438	438	0.95
+70	460.000516	516	+1.12
+80	460.000609	609	+1.32

Reference frequency = 460.000000 MHz

FREQUENCY STABILITY VS. SUPPLY VOLTAGE

As the primary power source for the transmitter is the AC line that powers the electric meter, the frequency stability of the transmitted signal was measured at the nominal 240 Volt level as well as at 115% and 85% of that level. In the event of a power outage, the on-board battery provides power to the transmitter. Because of this, the transmitter was also checked with no AC applied and the DC voltage at a nominal 3.6 V as well as at 85% of that value.

For the AC frequency stability test, a variable voltage AC supply was connected to the AC input of the electric meter. The transmitted frequency was checked at the nominal 240 V level. The frequency was also measured at 115% (276 V) and at 85% (240 V) of the nominal value.

For the DC test, the AC power was removed and a variable DC source connected to the transmitter, bypassing the battery. The frequency was measured at both the nominal 3.60 V of the battery and at the 85% level or 3.06 V.

With the voltage set to a measurement point, the transmitted signal was captured by the real-time spectrum analyzer and the frequency value determined. The frequencies are compared to the tuned frequency. All data for these measurements are found in Table 3. Again, it can be seen that all values obtained are within the deviation limit of ±2.5 ppm or 1150 Hz at the 460 MHz test frequency.

TABLE 3
FREQUENCY STABILITY
VS. SUPPLY VOLTAGE
460 MHz

INPUT Volts	Measured Frequency MHz	Dev. Hz	Dev. ppm
276 VAC	460.000250	250	+0.54
240 VAC	460.000391	391	+0.85
204 VAC	460.000281	281	+0.61
3.60 VDC	460.000594	594	+1.29
3.06 VDC	460.000562	562	+1.22

Reference frequency = 460.000000 MHz

TEST EQUIPMENT USED

Real-Time Spectrum Analyzer	Tektronix/Sony Model 3086 S/N J300247 Cal. Due: 10/08
Antenna	Maxrad 450-470 band whip antenna
DC Power Supply	Tenma Model 72-420 SN: M9000693
AC Power Supply	Variable AC Supply (Generic)
Digital Volt Meter	Fluke Model 87 III
Temperature Chamber	Test Equity Model 1007H Calibration due: 2/12/2010
Tests Performed	Temperature April 28-29, 2008 Voltage May 2 & 4, 2008

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 at the end of the transmission.

The Model 14280 transmitter was tested for transient frequency behavior using the test method of 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 test signal was at least 50 dB below the received signal level from the 14280.

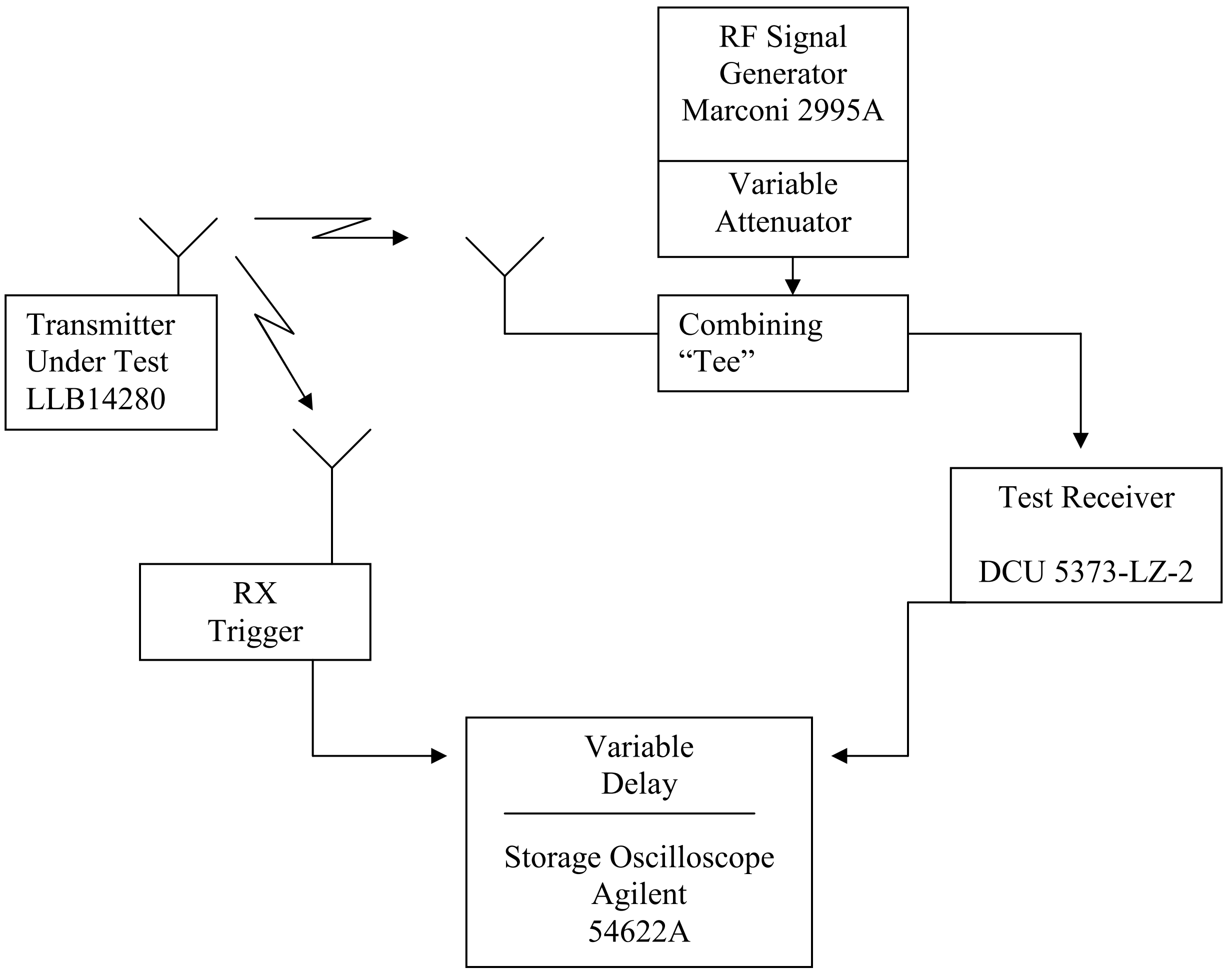

Fig. 2
Transient Frequency Behavior
Test Setup

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 than ±2.5 ppm. or ±1150 Hz at 460 MHz.

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 14280's transient frequency characteristics. The limit masks are indicated on each of the figures.

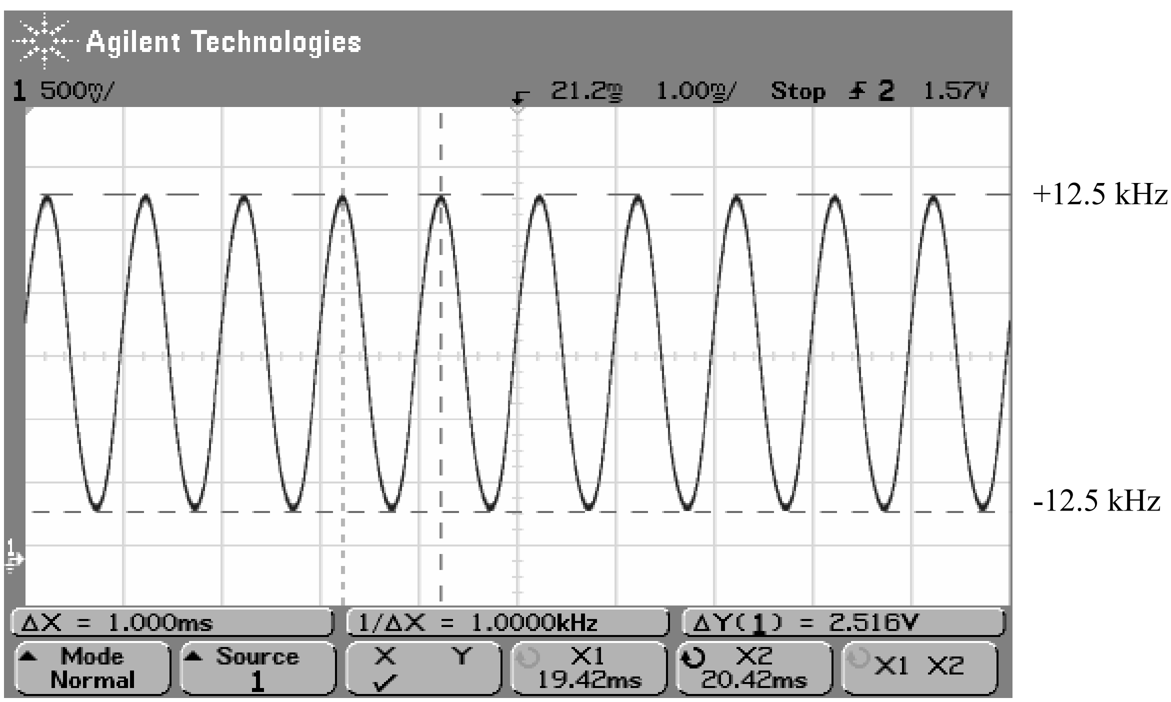

Fig. 3   ±12.5 kHz modulated test signal   .

12.5 kHz = 1.26 V
6.25 kHz = 630 mV
1.15 kHz = 116 mV

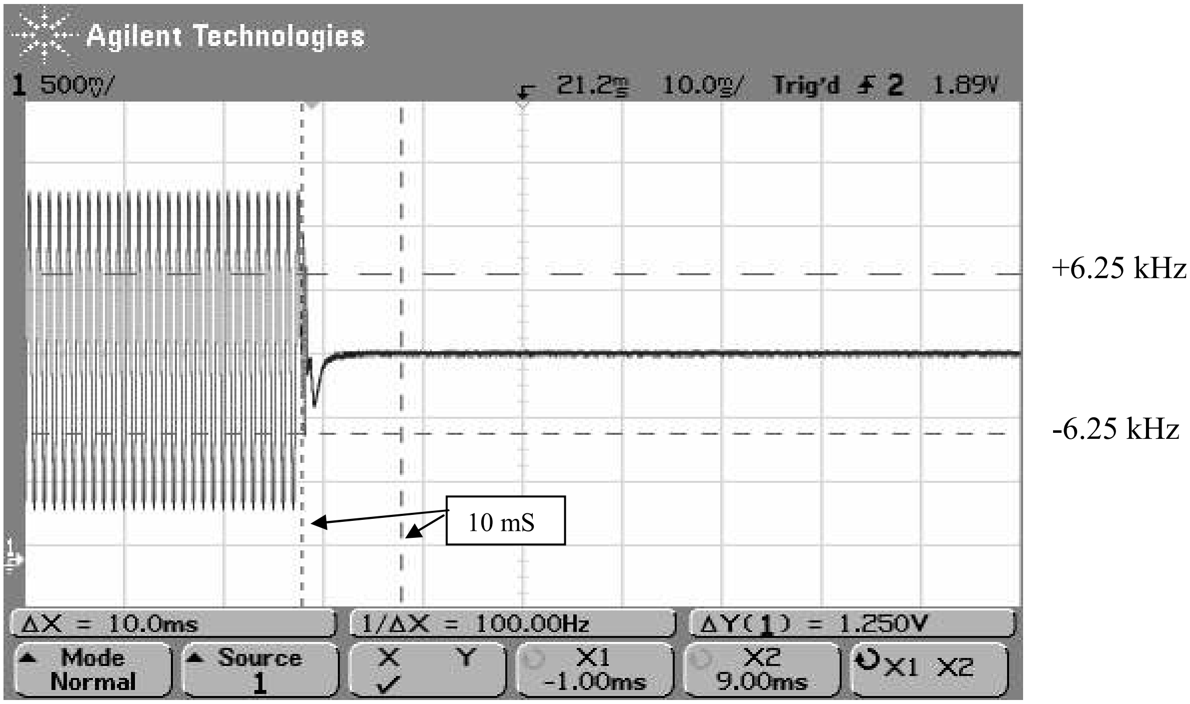

Fig. 4 Start of Transmission

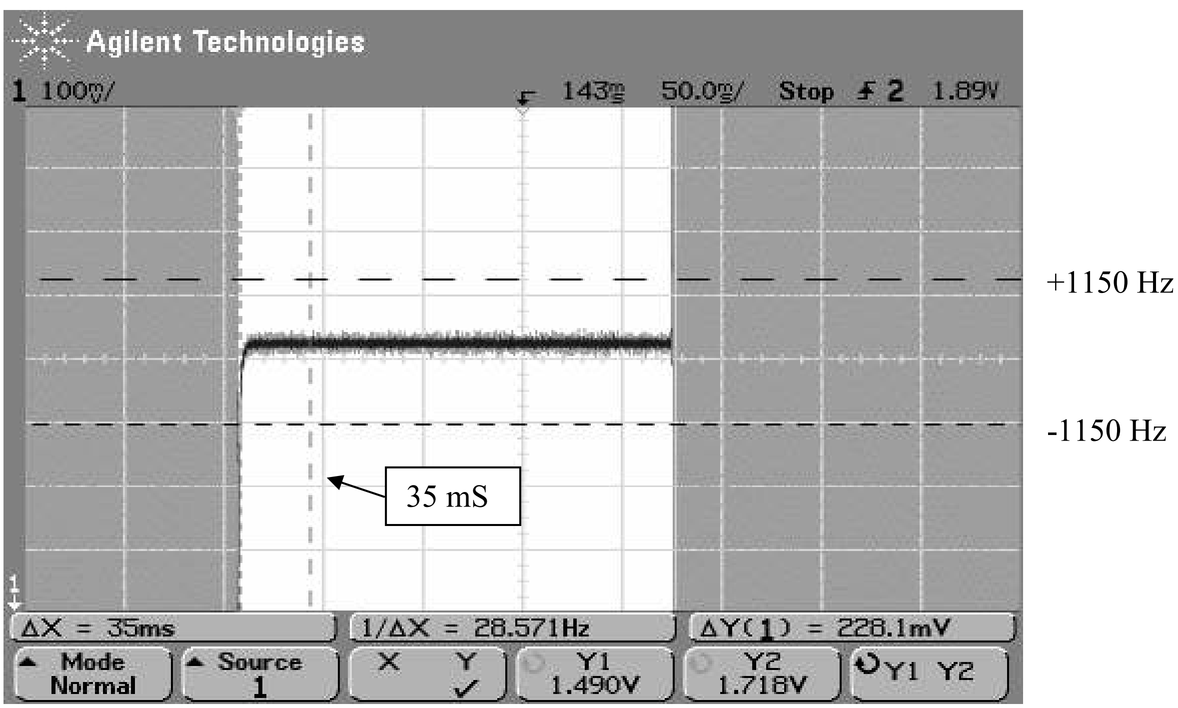

Fig. 5 Full Transmission

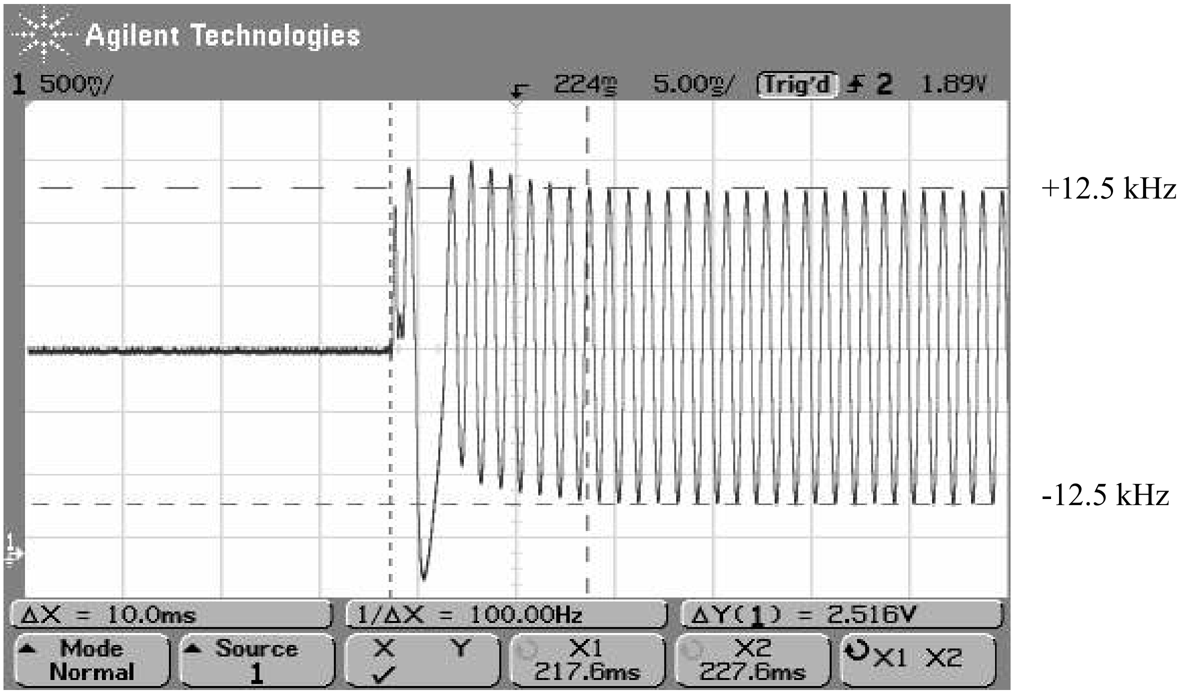

Fig. 6 Turn Off Transient

The modulated signal appears well within the allowed 10 ms and does not exceed ±12.5 kHz beyond 10 ms.

TEST EQUIPMENT USED

Signal Generator	Marconi Model 2955A
Test Receiver	Hexagram Broadband Receiver
Oscilloscope	Agilent Model 54622A SN: MY40006115 Cal: 11-12-2007
RF Trigger	Hexagram Detector Circuit
Test Performed	April 30, 2008

TEST INFORMATION

SUMMARY

The Hexagram Model 14280 transmitter 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	"MTU" Transmitter, Model 14280
MANUFACTURER	Hexagram, Inc. 23905 Mercantile Cleveland, OH 44122
TEST DATES	April 21 – May 4, 2008
TEST LABORATORY	Smith Electronics, Inc. 8200 Snowville Road Cleveland, OH 44141 (330) 289-9306 Mail: 2730 Old Mill Rd. Hudson, OH 44236