

**SMITH ELECTRONICS, INC.
ELECTROMAGNETIC COMPATIBILITY LABORATORIES**

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

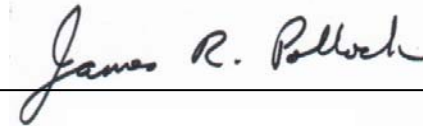
HEXAGRAM, INC.

METER TRANSMITTING UNIT (MTU)

Model 6327PW
FCC ID: LLB6327PW

December 9, 2003

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TEST REPORT

INTRODUCTION

The Hexagram Model 6327PW transmitter is a battery-powered transmitter designed to be connected to a typical utility meter. The transmitter is available in two configurations. One is for mounting directly on the meter and has no external wiring. The second is for mounting within about 3.6 m of the utility meter using pre-connected wiring. 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.

One transmitter of each configuration was tested. This report presents the worst case data obtained in support of an application for certification.

MEASUREMENTS PERFORMED

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The microprocessor portion of the transmitter was also examined for 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 sample of each configuration (with and without wires) was examined at three fundamental frequencies and their harmonics. All measurements below 1 MHz were made 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 and Industry Canada. The higher harmonics of one unit were measured on the open area site while, due to inclement weather, the harmonics above 1 MHz of the second unit were made in an unobstructed area of a garage. 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 tuned dipole was used for receiving 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 the measurements.

With the test receiver tuned to the unmodulated signal, the transmitter under test (MTU) 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.

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 MTU 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 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. Again, these are the worst case of the two units. Transmitting antenna gain and coax loss figures are also included in tables

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 $50 + 10\log(P)$. The determined power outputs, the required harmonic attenuation as well as the attenuation for each harmonic are found in Tables 1a – 1c.



PICTORIAL 1a
HEXAGRAM METER TRANSMITTING UNIT
MODEL 6327PW, with external wiring
OUTPUT POWER AND SPURIOUS EMISSIONS
TEST SETUP



PICTORIAL 1b
HEXAGRAM METER TRANSMITTING UNIT
MODEL 6327PW no external wiring
OUTPUT POWER AND SPURIOUS EMISSIONS
TEST SET UP

TABLE 1a
HEXAGRAM MODEL 6327PW 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)
450	22.5	1.1	0	21.4	
900	-21.0	1.7	0	-22.7	-44.1

1 meter measurement using horn transmit antenna

Frequency (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1350	-57.0	0.7	3.1	-54.6	-76.0
1800	-45.0	0.8	4.9	-40.9	-62.3
2250	-44.4	0.9	5.6	-39.7	-61.1
2700	-40.8	1.1	6.2	-35.7	-57.1
3150	-37.0	1.2	6.7	-31.5	-52.9
3600	-36.8	1.3	6.6	-31.5	-52.9
4050	-36.5	1.4	6.5	-31.4	-52.8
4500	-51.3	1.5	7.2	-45.6	-67.0

21.4 dBm = 138.0 mW or 0.138 W

Required attenuation for harmonics is $50 + \log (.138) = 41.4\text{dB}$

TABLE 1b
HEXAGRAM MODEL 6327PW 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	23.6	1.1	0	22.5	-
920	-20.0	1.7	0	-21.7	-44.2

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	-49.2	0.7	3.1	-46.8	-69.3
1840	-45.0	0.8	4.9	-40.9	-63.4
2300	-44.7	0.9	5.6	-40.0	-62.5
2760	-38.6	1.1	6.2	-33.5	-56.0
3220	-35.8	1.2	6.7	-30.3	-52.8
3680	-36.8	1.3	6.6	-31.5	-54.0
4140	-36.5	1.4	6.5	-31.4	-53.9
4600	-52.0	1.5	7.2	-46.3	-68.8

22.5dBm = 178 mW or 0.178 W

Required attenuation for harmonics is $50 + \log (.178) = 42.5\text{dB}$

TABLE 1c
HEXAGRAM MODEL 6327PW TRANSMITTER
SUBSTITUTION METHOD

3 meter measurement using tuned dipole antenna

Frequency (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Difference (dB)
470	21.9	1.1	0	20.8	-
940	-20.4	1.7	0	-22.1	-42.9

1 meter measurement using horn antenna

Frequency (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Difference (dB)
1410	-61.0	0.7	3.1	-58.6	-79.4
1880	-64.0	0.8	4.9	-59.9	-80.7
2350	-43.0	0.9	5.6	-38.3	-59.1
2820	-41.7	1.1	6.2	-36.6	-57.4
3290	-40.4	1.2	6.7	-34.9	-55.7
3760	-35.5	1.3	6.6	-30.2	-51.0
4230	-39.5	1.4	6.5	-34.4	-55.2
4700	-52.5	1.5	7.2	-46.8	67.6

20.8dBm = 120 mW or 0.120 W.

Required attenuation for harmonics is $50 + \log (.120) = 40.8$ dB

TEST EQUIPMENT USED

Spectrum Analyzer

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 (Rcv)

Eaton Model 96001 Double Ridged Guide Horn
Frequency Range 1 – 18 GHz (Xmt)

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

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 LLB6327PW 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 the maximum P was determined to be 0.178 W, $50 + 10 \log(0.178)$ equals 42.5 dB.

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 appear to comply with the requirement for occupied bandwidth as found in 90.210.

For the modulated signal, 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.

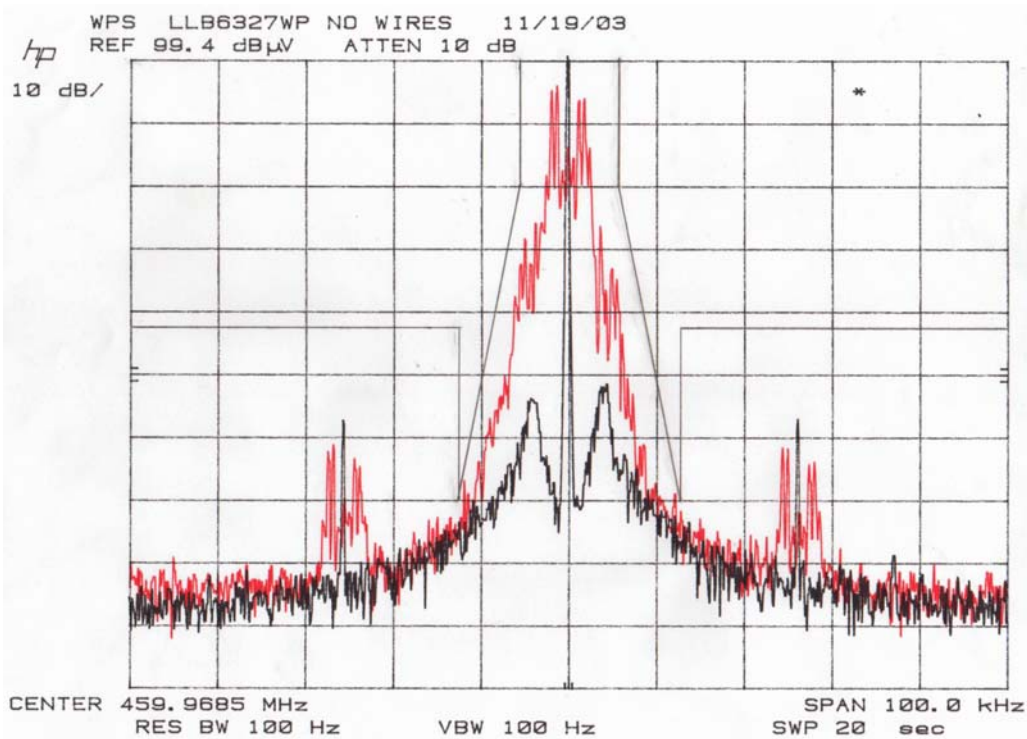


Fig. 1
Hexagram Model 6327PW MTU
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer

Hewlett-Packard 8568B
with 85680A RF Section S/N: 2216A02120
85662A Display Section SN: 2152A03683
Calibration 6/03

Antenna

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

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. The battery 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 461 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 considered the “reference” frequency. The temperature in the chamber was then increased in 10° C increments up to 70° C. At each new temperature, time was allowed for stabilization of the transmitter, a transmission was made and the frequency determined. The temperature was decreased to -30° C, again stabilizing before a reading was made. The temperature was increased again in 10°C increments up to 10°C, checking the frequency at each point. The frequency at each temperature was recorded, compared to the “reference” 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

TABLE 2
FREQUENCY STABILITY
VS. TEMPERATURE

Temperature ° C	Measured Frequency MHz	Dev. Hz	Dev. ppm
+20	461.000156*	0	0
+30	461.000000	-156	-0.338
+40	461.000156	0	0
+50	461.000000	-156	-0.338
+60	460.999688	-468	-1.015
+70	460.999844	-312	-0.677
-30	461.000000	-156	-0.338
-20	460.999844	-312	-0.677
-10	460.999844	-312	-0.677
-0-	460.999844	-312	-0.677
+10	461.000313	+157	+0.341

* = reference frequency

FREQUENCY STABILITY VS. SUPPLY VOLTAGE

The frequency stability was also determined as a function of the DC battery voltage. A variable DC power supply was used to set the voltage between about 85% and 115% of the nominal 3.60 VDC input. Measurements were made at 3.60 V, 3.06 V and 4.14 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 “reference” frequency obtained at the nominal operating voltage. 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.

**TABLE 3
FREQUENCY STABILITY
VS. SUPPLY VOLTAGE**

INPUT DC Volts	Measured Frequency MHz	Dev. Hz	Dev. ppm
	458.000000		
3.06	457.999688	-312	-0.681
3.60	457.999844	-156	-0.341
4.14	457.999844	-156	-0.341

TEST EQUIPMENT USED

Real-Time Spectrum Analyzer

Tektronix/Sony Model 3086
S/N J300195 Calibration 12/02

Antenna

SEI Loop Probe 2” diameter

DC Power Supply

Harrison Laboratories, Inc. Model 8028
Twin Low Voltage Power Supply

Thermometer

Radio Shack 63-1011 Digital Thermometer

Digital Volt Meter

Fluke Model 23

Temperature Chamber

Standard Environmental Systems, Inc.
Model TK/5

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 6 show the Model 6327PW's transient frequency characteristics. The limit masks are indicated on each of the figures.

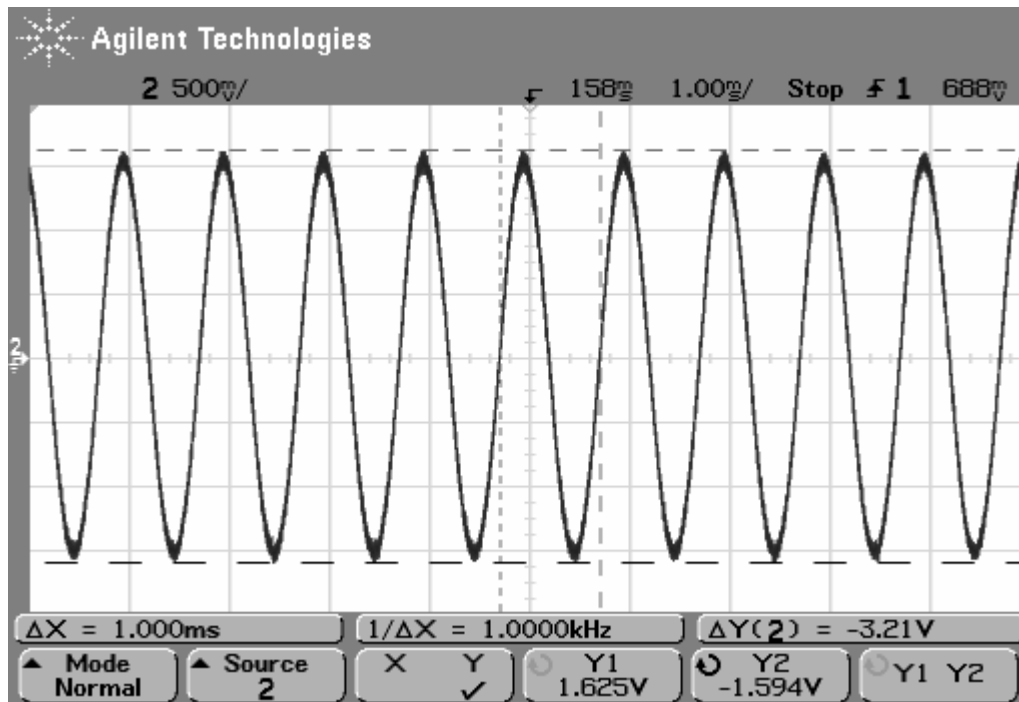


Fig. 3 ± 12.5 kHz modulated test signal 25 kHz = 3.21 V.

$$6.25 \text{ kHz} = 802 \text{ mV}$$

1.15 kHz = 147 mV

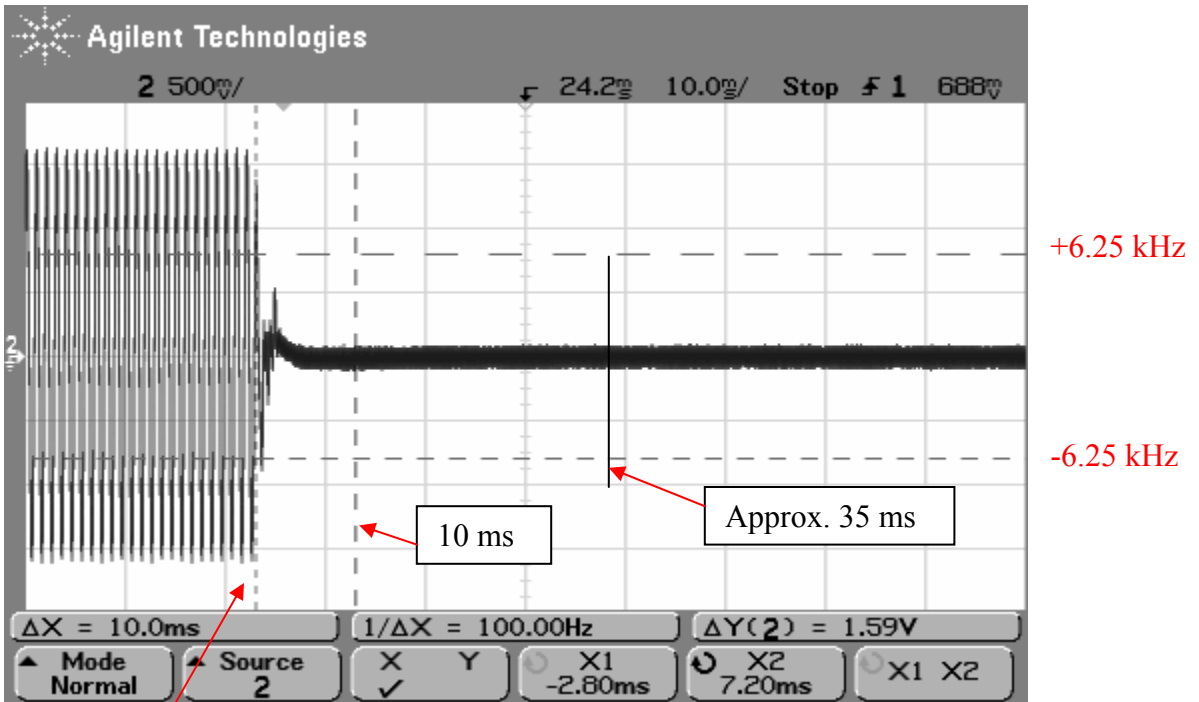


Fig. 4 Start of Transmission

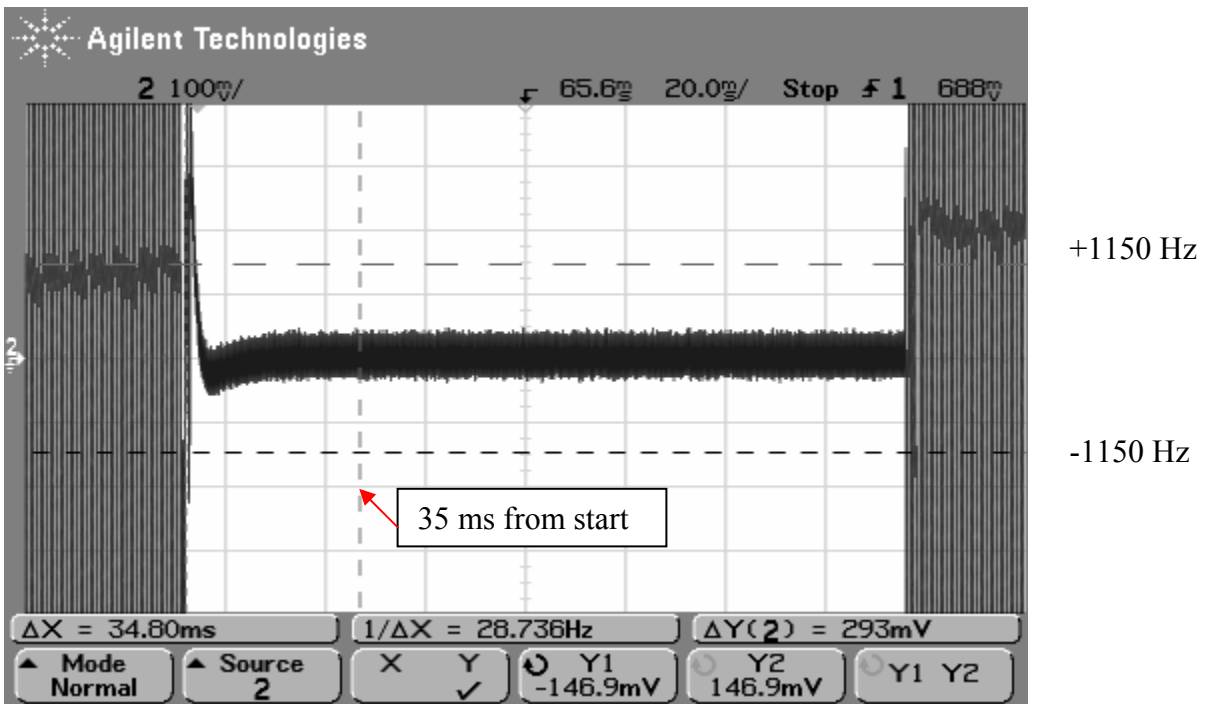
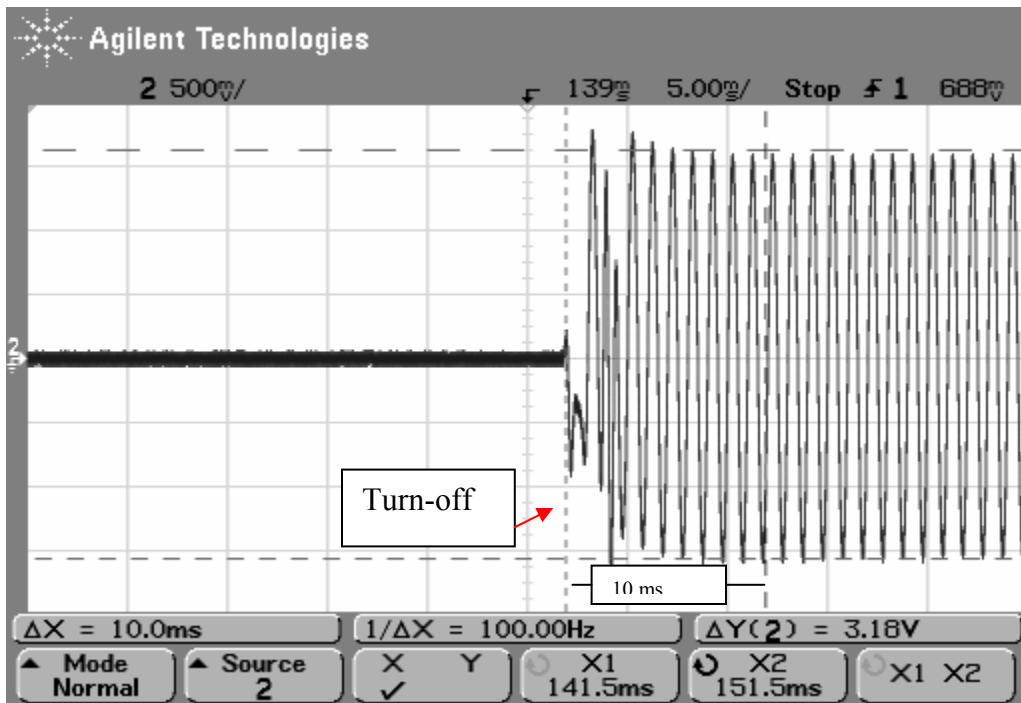


Fig. 5 Full Transmission**Fig. 6 Turn Off Transient**

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
Calibration 10/02

Test Receiver

Hexagram DCU-1 (Modified)

Oscilloscope

Agilent Model 54622D
S/N MY40006228 Calibration 7/03

RF Trigger

Hexagram Detector Circuit

TEST INFORMATION**SUMMARY**

The Hexagram Meter Transmitting Unit, Model 6327PW 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 6327PW

MANUFACTURER

Hexagram, Inc.
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TEST DATES

November 19 – December 3, 2003

TEST LABORATORY

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