SMITH ELECTRONICS, INC.
ELECTROMAGNETIC COMPATIBILITY LABORATORIES

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HEXAGRAM, INC.

RADIO-FREQUENCY EMISSIONS
FROM
METER TRANSMITTING UNIT (MTU)
With TWO-WAY CAPABILITY

Model 9845
FCC ID: LLB9845

CLASS II PERMISSIVE CHANGE

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TEST REPORT

INTRODUCTION

The Hexagram Model 9845 Meter Transmitting Unit (MTU) is a designed to provide advanced remote meter reading capability with the Landis & Gyr "RXRS4e" family of electric meters. The MTU is connected to and powered by the meter circuitry and mounts within the meter enclosure. An on-board battery provides power when AC power is not available. A 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. One MTU was tested and this report presents the data obtained in support of an application for certification.

EUT DESCRIPTION

The "Equipment Under Test" (EUT) is the Hexagram Model 9845 MTU designed for use with the Landis & Gyr "RXRS4e" family of electric meters. The Serial Number of the MTU tested was 001012. Testing was mostly performed with the MTU in an RXRS4e Meter, Form 9S/8S, Serial Number, 1046200.

MEASUREMENTS PERFORMED

Power Output and Spurious Emissions	Page 3
Occupied Bandwidth	Page 9
Frequency Stability vs. Temperature	Page 11
Frequency Stability vs. Supply Voltage	Page 12
Transient Stability	Page 14

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 with 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. This site is registered with the FCC(90938) and Industry Canada(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. This battery was placed inside the meter box with a ferrite bead placed on the battery leads.

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.

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:

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

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 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) where P is power in Watts.
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 9845 MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP

TABLE 1a
HEXAGRAM MODEL 9845 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	26.9	2.0	-0.4	24.5	
900	-48.0	2.9	-0.7	-51.6	-76.1

Output = 24.5 dBm
= 0.282 W
Req. Att.= 44.5Bm

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	-63.4	0.9	5.5	-58.8	-83.3
1800	-55.3	1.0	5.9	-50.4	-74.9
2250	-52.8	1.2	6.8	-47.2	-71.7
2700	-58.0	1.3	7.7	-51.6	-76.1
3150	-60.0	1.5	7.8	-53.7	-78.2
3600	-51.5	1.6	7.8	-45.3	-69.8
4050	-44.3	1.7	-7.7	-38.3	-62.8
4500	-44.8	1.8	8.3	-38.3	-62.8

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	16.5	2.0	-0.4	14.1	
900	-42.0	2.9	-0.7	-45.6	-59.7

Output = 14.1 dBm
= 0.026 W
Req. Att.= 34.1 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	-61.5	0.9	5.5	-56.9	-71.0
1800	-59.0	1.0	5.9	-54.1	-68.2
2250	-54.6	1.2	6.8	-49.0	-63.1
2700	-51.6	1.3	7.7	-45.2	-59.3
3150	-61.7	1.5	7.8	-55.4	-69.5
3600	-53.5	1.6	7.8	-47.3	-61.4
4050	-47.0	1.7	7.7	-41.0	-55.1
4500	-50.3	1.8	8.3	-43.8	-57.9

TABLE 1b
HEXAGRAM MODEL 9845 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	25.9	2.1	-0.4	23.4	
920	-46.7	3.0	-0.6	-50.3	-73.7

Output = 23.4 dBm
= 0.219 W
Req. Att.= 43.4 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)
1380	-65.5	0.9	5.6	-60.8	-84.2
1840	-54.8	1.0	5.9	-49.9	-73.3
2300	-56.6	1.2	7.0	-50.8	-74.2
2760	-55.8	1.3	7.7	-49.4	-72.8
3220	-60.4	1.5	7.8	-54.1	-77.5
3680	-43.5	1.6	7.7	-37.4	-60.8
4140	-46.3	1.7	7.8	-40.2	-63.6
4600	-49.3	1.9	8.4	-42.8	-66.2

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	17.0	2.1	-0.4	14.5	
920	-46.8	3.0	-0.6	-50.4	-64.9

Output = 14.5 dBm
= 0.028W
Req. Att.= 34.5 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	-62.7	0.9	5.6	-58.0	-72.5
1840	-59.6	1.0	5.9	-54.7	-69.2
2300	-55.4	1.2	7.0	-49.6	-64.1
2760	-52.4	1.3	7.7	-46.0	-60.5
3220	-62.6	1.5	7.8	-56.3	-70.8
3680-	-45.0	1.6	7.7	-38.9	-53.4
4140	-45.0	1.7	7.8	-38.9	-53.4
4600	-51.7	1.9	8.4	-45.2	-59.7

TABLE 1c
HEXAGRAM MODEL 9845 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	26.5	2.1	-0.4	24.0	
940	-43.1	3.0	-0.6	-46.7	-70.7

Output = 24.0 dBm
= 0.251 W
Req. Att.= 44.0 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	-66.3	0.9	5.7	-61.5	-85.5
1880	-58.3	1.1	5.9	-53.5	-77.5
2350	-55.0	1.2	7.2	-49.0	-73.0
2820	-54.2	1.4	7.7	-47.9	-71.9
3920	-61.8	1.5	7.8	-55.5	-79.5
3760	-39.5	1.6	7.7	-33.4	-57.4
4230	-47.1	1.8	7.9	-41.0	-65.0
4700	-49.0	1.9	8.4	-42.5	-66.5

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	19.2	2.1	-0.4	16.7	
940	-51.5	3.0	-0.6	-55.1	-71.8

Output = 16.7 dBm
= 0..0468
Req. Att.= 36.7 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)
1410	-68.3	0.9	4.4	-64.8	-81.5
1880	-62.3	1.1	4.7	-58.7	-75.4
2350	-55.9	1.2	6.7	-50.4	-67.1
2820	-58.0	1.4	7.9	-51.5	-68.2
3920	-63.5	1.5	8.1	-56.9	-73.6
3760	-39.4	1.6	7.9	-33.1	-49.8
4230	-46.3	1.8	8.5	-39.6	-56.3
4700	-56.0	1.9	9.6	-48.3	-65.0

TEST EQUIPMENT USED

Spectrum Analyzer	Hewlett-Packard Spectrum Analyzer Model 8563A S/N 3020A00248 Cal. Due: 9/09
Antennas	(2x) ETS-Lindgren Model 3121 DB-4 Tuned Dipole Frequency Range 400 – 1000 MHz (2x) ETS-Lindgren Model 3115 Double Ridged Guide Horn Frequency Range 1 – 18 GHz
Signal Generator	Hewlett-Packard Model 8340B, S/N 3010A01889 Cal. Due: 5/09
Miscellaneous	12.2 m RG-214/U coaxial cable 22.5 m LMR-400 coaxial cable 3 m RG-214/U coaxial cable 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 9845 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 0.281 W, 50 + 10 log(0.281) equals 44.5 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 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.

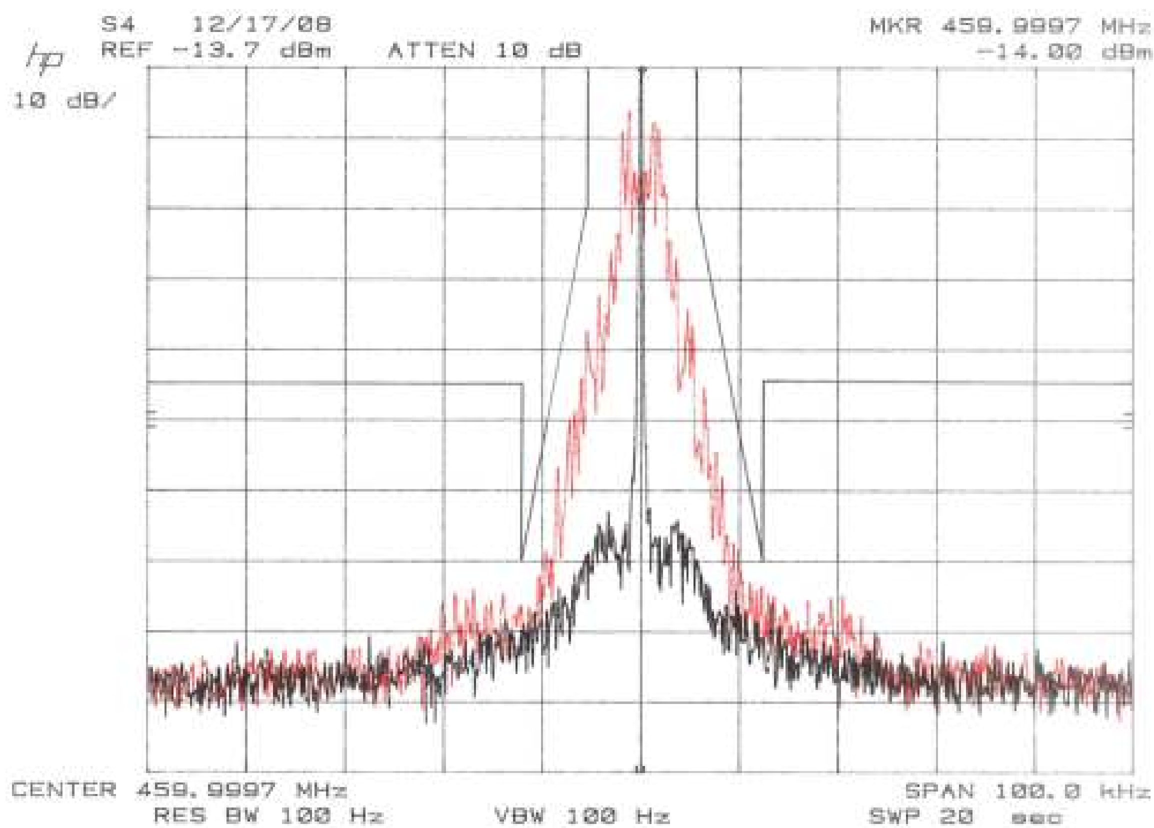

Fig. 1
Hexagram Model 9845 MTU
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer	Hewlett-Packard 8568B with 85680A RF Section S/N: 2216A02120 85662A Display Section SN: 2152A03683 Cal. Due 11/09
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. For this test the MTU was tested independently of the electric meter. The MTU was placed in a temperature chamber connected to a power supply located outside the chamber. A computer controlled programming coil was provided to trigger a transmission when desired. 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 20 minutes or more. The transmission signal was captured by the real-time spectrum analyzer, the frequency was determined and considered the "reference" frequency. The temperature in the chamber was then increased to 85° C in 10° intervals. At each temperature, time was allowed for stabilization of the transmitter, a transmission was made and the frequency determined. From 85° C, the temperature was decreased to 20° C, where it sat overnight. The frequency was read and the temperature was then decreased in 10° steps to -30° C, again stabilizing at each 10° interval before a reading was made. The frequency at each temperature was recorded, compared to the "reference" frequency, and is recorded in Table 2. As can be seen from the table, all readings are within the deviation limit of ±2.5 ppm or 1150 Hz at 460 MHz.

TABLE 2
FREQUENCY STABILITY
VS. TEMPERATURE

Temperature ° C	Measured Frequency MHz	Dev. Hz	Dev. ppm
+20	460.002188*	0	0.000
+30	460.002109	-79	-0.172
+40	460.002031	-157	-0.341
+50	460.001875	-313	-0.680
+60	460.002031	-157	-0.341
+70	460.002031	-157	-0.341
+80	460.002109	-79	-0.172
+85	460.002031	-157	-0.341
+20	460.002109	-79	-0.172
+10	460.002344	156	0.339
0	460.002188	0	0.000
-10	460.002188	0	0.000
-20	460.002266	78	0.170
-30	460.002422	234	0.509

* = "reference frequency"

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 120 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 with a 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 meter. The transmitted frequency was checked at the nominal 120 V level, as well as at 115% (138 V) and at 85% (102 V) of the nominal value.

For the DC test, the AC power was removed and the battery replaced by a variable DC supply. 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 "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 or 1150 Hz at the 460 MHz test frequency.

TABLE 3
FREQUENCY STABILITY
VS. SUPPLY VOLTAGE

INPUT Volts	Measured Frequency MHz	Dev. Hz	Dev. ppm
138 VAC	460.001875	0	0.000
120 VAC	460.001875*	0	0.000
102 VAC	460.001875	0	0.000
3.6 VDC	460.001875*	0	0.000
3.06 VDC	460.001719	-156	-0.339

* = "reference frequency"

TEST EQUIPMENT USED

Real-Time Spectrum Analyzer	Tektronix/Sony Model 3086 S/N J300247 Cal. Due: 5/09
Antenna	Small Wire
DC Power Supply	RSR Model PW-3032R
AC Power Supply	Hexagram Power Supply
Thermometer	Cooper Instrument Corp. Model SRH 77A Cal. Due: 5/09
Digital Volt Meter	Fluke Model 87III Cal. Due: 9/09
Temperature Chamber	Test Equity Model 115 Cal. Due 2/10

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 9845 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 9845.

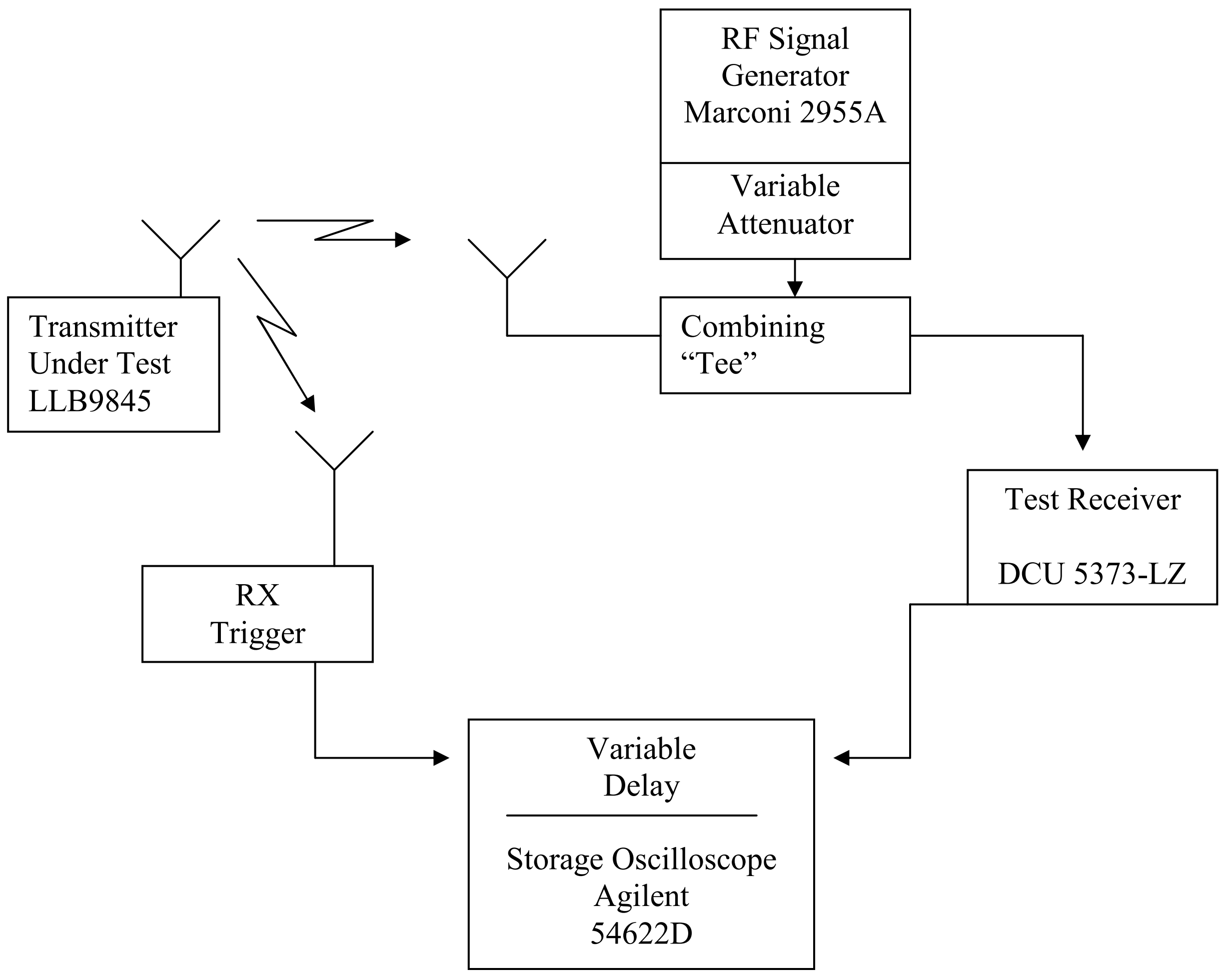

Fig. 2
Transient Frequency Behavior
Test Setup

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 9845's transient frequency characteristics. The limit masks are indicated on each of the figures.

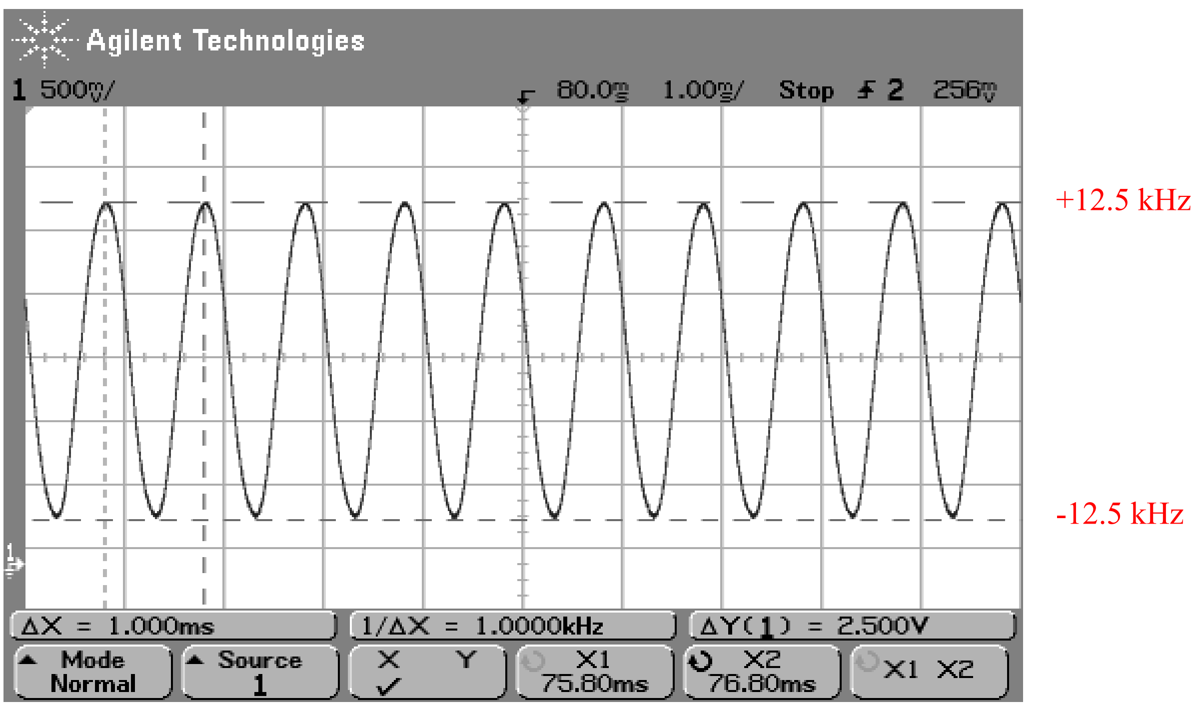

Fig. 3 ±12.5 kHz modulated test signal 25 kHz = 2.50 V.

6.25 kHz = 625 mV
1.15 kHz = 115 mV

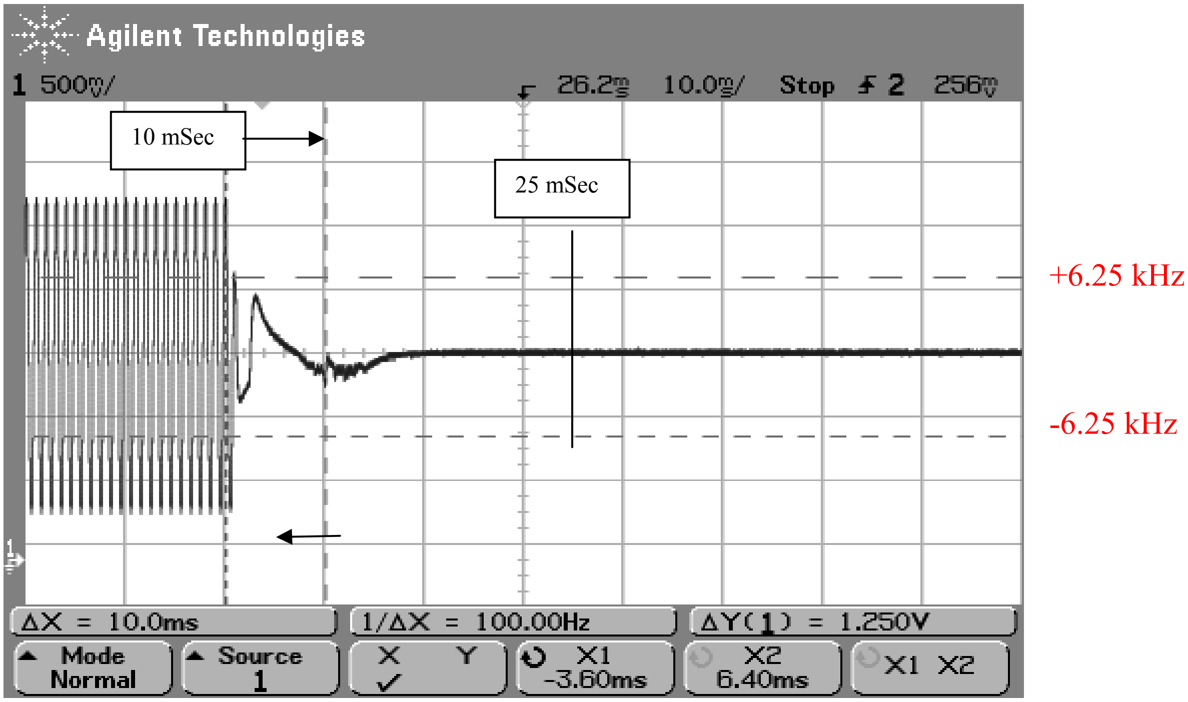

Fig. 4 Start of Transmission

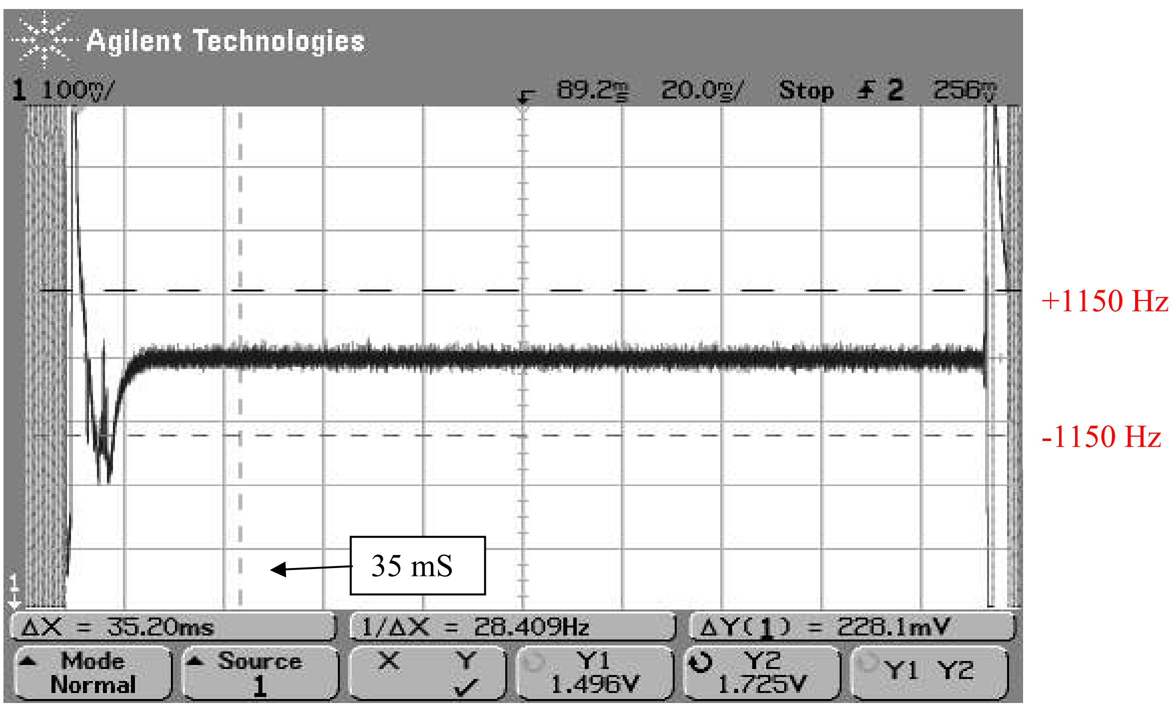

Fig. 5 Full Transmission

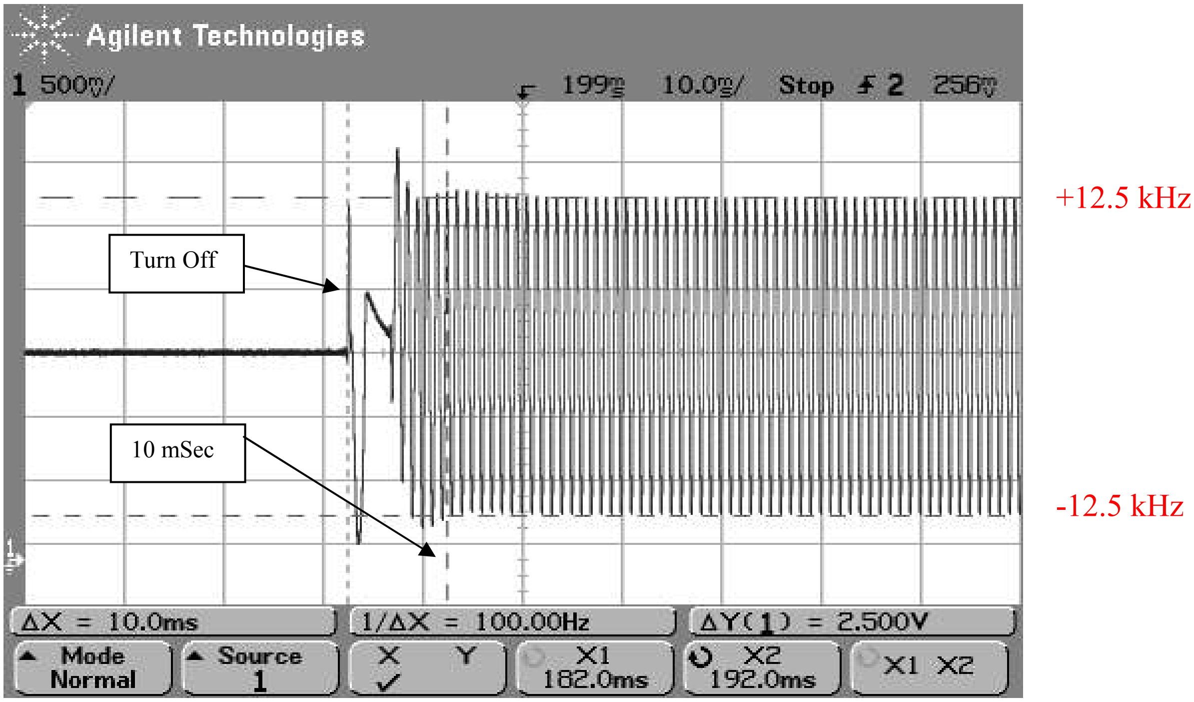

Fig. 6 Turn Off Transient

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 S/N:132004/153 Cal. Due: 9/09
Test Receiver	Hexagram DCU-1 (Modified)
Oscilloscope	Agilent Model 54622D S/N MY40003551 Cal. Due: 11/09
RF Trigger	Hexagram Detector Circuit

TEST INFORMATION

SUMMARY

The Hexagram Model 9845 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 9845 S/N: 001012
MANUFACTURER	Hexagram, Inc. 23905 Mercantile Cleveland, OH 44122
TEST DATES	12/16/2008 – 1/7/2009