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RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

METER TRANSMITTING UNIT (MTU)
with RECEIVER
Rev. 1

Model 14973
FCC ID: LLB14973

November 12, 2010

Report Prepared by:

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Agency Certification Control Technician

TEST REPORT

INTRODUCTION

The Hexagram Model 14973 transceiver is designed to provide remote meter reading capability with the Landis & Gyr "S-4" family of electric meters. The transceiver is connected to the meter circuitry and mounts within the meter enclosure. An on-board battery provides power 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 permanently attached to the circuit board 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 transmitter was tested and this report presents the data obtained in support of an application for Part 90 certification.

MEASUREMENTS PERFORMED

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-C and noted in KDB 449343.

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 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:

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

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). 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 14973 MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP

TABLE 1a
HEXAGRAM MODEL 14973 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	31.3	2.0	-0.2	29.1	
900	-34.0	2.9	-0.5	-37.4	-66.5

Output = 29.1Bm
= 0.813 W
Req. Att.= 49.1Bm

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	-57.6	0.8	5.5	-52.9	-82.0
1800	-59.8	1.0	5.9	-54.9	-84.0
2250	-66.0	1.2	6.8	-60.4	-89.5
2700	-67.0	1.3	7.6	-60.7	-89.8
3150	-60.4	1.4	7.7	-54.1	-83.2
3600	-59.4	1.6	7.7	-53.3	-82.4
4050	-44.1	1.7	7.6	-38.2	-67.3
4500	-50.9	1.8	8.3	-44.4	-73.5

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)
450	21.9	2.0	-0.2	19.7	
900	-29.8	2.9	-0.5	-33.2	-52.9

Output = 19.7 dBm
= 0.093 W
Req. Att.= 39.7 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)
1350	-60.4	0.8	5.5	-55.7	-75.4
1800	-60.2	1.0	5.9	-55.3	-75.0
2250	-68.0	1.2	6.8	-62.4	-82.1
2700	-66.3	1.3	7.6	-60.0	-79.7
3150	-65.5	1.4	7.7	-59.2	-78.9
3600	-63.5	1.6	7.7	-57.4	-77.1
4050	-48.3	1.7	7.6	-42.4	-62.1
4500	-50.4	1.8	8.3	-43.9	-63.6

TABLE 1b
HEXAGRAM MODEL 14973 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	28.9	2.1	-0.2	26.6	
920	-38.0	3.0	-0.4	-41.4	-68.0

Output = 26.6dBm
= 0.457 W
Req. Att.= 46.6 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	-61.2	0.9	5.6	-56.5	-83.1
1840	-58.8	1.0	5.9	-53.9	-80.5
2300	-60.0	1.2	6.9	-54.3	-80.9
2760	-64.9	1.3	7.6	-58.6	-85.2
3220	-55.0	1.4	7.8	-48.6	-75.2
3680	-45.8	1.6	7.7	-39.7	-66.3
4140	-41.8	1.7	7.7	-35.8	-62.4
4600	-48.3	1.8	8.3	-41.8	-68.4

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	24.3	2.1	-0.2	22.0	
920	-29.8	3.0	-0.4	-33.2	-55.2

Output = 22.0 dBm
= 0.158W
Req. Att.= 42.0 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	-59.5	0.9	5.6	-54.8	-76.8
1840	-61.3	1.0	5.9	-56.4	-78.4
2300	-73.0	1.2	6.9	-67.3	-89.3
2760	-67.5	1.3	7.6	-61.2	-83.2
3220	-63.6	1.4	7.8	-57.2	-79.2
3680-	-47.3	1.6	7.7	-41.2	-63.2
4140	-51.0	1.7	7.7	-45.0	-67.0
4600	-50.0	1.8	8.3	-43.5	-65.5

TABLE 1c
HEXAGRAM MODEL 14973 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	28.5	2.1	-0.2	26.2	
940	-36.0	3.0	-0.4	-39.4	-65.6

Output = 26.2 dBm
= 0.417 W
Req. Att.= 46.2 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	-64.5	0.9	5.7	-59.7	-85.9
1880	-64.3	1.0	5.9	-59.4	-85.6
2350	-70.0	1.2	7.1	-64.1	-90.3
2820	-61.0	1.3	7.7	-54.6	-80.8
3290	-46.2	1.5	7.8	-39.9	-66.1
3760	-40.0	1.6	7.6	-34.0	-60.2
4230	-41.9	1.7	7.9	-35.7	-61.9
4700	-436.	1.8	8.4	-37.0	-63.2

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)
470	23.7	2.1	-0.2	21.4	
940	-39.2	3.0	-0.4	-42.6	-64.0

Output = 21.4 dBm
= 0.138 W
Req. Att.= 41.4 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	-60.5	0.9	5.7	-55.7	-77.1
1880	-64.1	1.0	5.9	-59.2	-80.6
2350	-70.6	1.2	7.1	-64.7	-86.1
2820	-63.0	1.3	7.7	-56.6	-78.0
3290	-47.6	1.5	7.8	-41.3	-62.7
3760	-40.4	1.6	7.6	-34.4	-55.8
4230	-49.4	1.7	7.9	-43.2	-64.6
4700	-50.7	1.8	8.4	-44.1	-65.5

TEST EQUIPMENT USED

Spectrum Analyzer	Hewlett-Packard Model 8593EM Spectrum Analyzer SN: 3536A00147 Cal Due: 8/11
Antennas	(1x) ETS-Lindgren Model DB-4 Tuned Dipole (1x) Stoddart Model 91598-2 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 Cal Due: 6/11
Miscellaneous	12.2 m RG-214/U coaxial cable 6.1 m RG-214/U coaxial cable 2.4 m RG-8/U coaxial cable 1.8 m RG-/U coaxial cable
Test Performed	October 19-20, 2010

Unit Tested: 14973 Rev. D SN—80001132

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 $7.27(f_d - 2.88\text{ kHz})$ 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 0.812 W, 50 + 10 log(0.812) equals 49.1dB.

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.

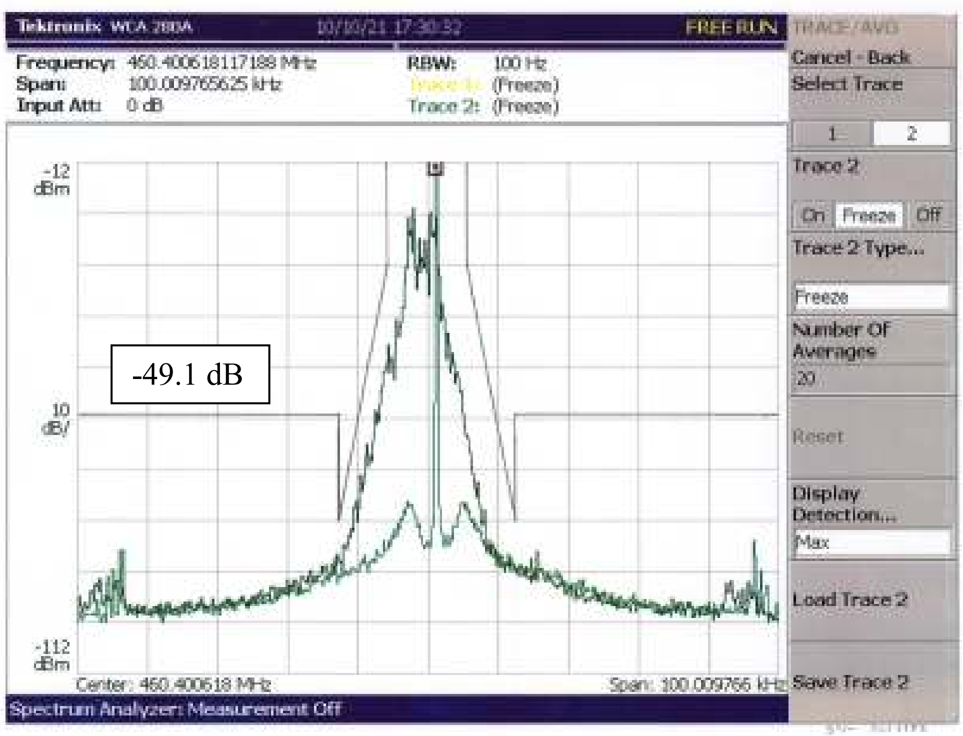


Fig. 1
Hexagram Model 14973 MTU
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280A SN: J300168 Cal Due: 4/2011
Antenna	Antenna Specialists Model AV-15 450 – 47- MHz
Test Performed	October 22, 2010 July 12, 2010

Unit Tested: 14973 Rev. D SN—80001132

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 the on-board battery-powered transmitter set to transmit upon command. A receiving antenna outside the chamber picked up the transmitted signal which was fed to the spectrum analyzer.

With the transmitter programmed to transmit at 460.4 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 spectrum analyzer and the frequency was determined and considered the "reference" frequency. The temperature in the chamber was then adjusted in the order shown in Table 2. At each temperature, time was allowed for stabilization of the transmitter, a transmission was made and the frequency determined. 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 or 1151 Hz at 460.4 MHz.

TABLE 2
FREQUENCY STABILITY
VS. TEMPERATURE

Temperature ° C	Measured Frequency MHz	Dev. Hz	Dev. ppm
+20	460.401875*	Ref.	0
+30	460.401768	-107	-0.232
+40	460.401768	-107	-0.232
+50	460.401689	-186	-0.404
+60	460.401826	-49	-0.106
+70	460.401924	+49	+0.106
+80	460.402002	+127	+0.276
+85	460.401914	+39	+0.085
+20	460.401904	+29	+0.063
+10	460.402002	+127	+0.276
0	460.402109	+234	+0.508
-10	460.402129	+254	+0.552
-20	460.402051	+176	+0.382
-30	460.402031	+156	+0.339
-40	No Transmission	--	--
+20	460.401885	+10	+0.022

* = "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 operating voltages of the meter as well as at 115% and 85% of those levels. The electric meter is designed to operate at nominal voltages between 120 VAC and 480 VAC. Tests were performed at these levels as well as an intermediate level of 240 VAC. The test levels are shown in Table 3. (Note: The power supply available could not provide the 115% level of 480 V, or 552 V. The maximum level tested was 540 V or 112.5% of the nominal 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 and considered the "reference" frequency value

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 default 3.8 V as well as at lower values.

For the DC test, the AC power was removed and the battery replaced by a variable DC supply. The frequency was measured at the cell test voltage of 3.8 V and at lower levels to below the 85% value of 3.2 V.

With the voltage set to a measurement point, the transmitted signal was captured by the 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 1151 Hz at the 460.4 MHz test frequency.

TABLE 3
FREQUENCY STABILITY VS. SUPPLY VOLTAGE

INPUT Volts	Measured Frequency MHz	Dev. Hz	Dev. ppm
102 VAC	460.401797	+49	+0.1060
120 VAC	460.401748*	Ref.	
138 VAC	460.401885	+137	+0.298
204 VAC	460.401865	+117	+0.254
240 VAC	460.401797	+49	+0.106
276 VAC	460.401914	+166	+0.361
408 VAC	460.401855	+107	+0.232
480 VAC	460.401816*+68	+68	+0.148
540 VAC	460.401816	+195	+0.424
3.8 VDC	460.401855*	Ref.	0
3.4 VDC	460.401516	-39	-0.085
3.0 VDC	460.401748	-107	-0.232
2.8 VDC	460.401729	-126	-0.274

Note: Transmitter tuned to 460.4 MHz.

TEST EQUIPMENT USED

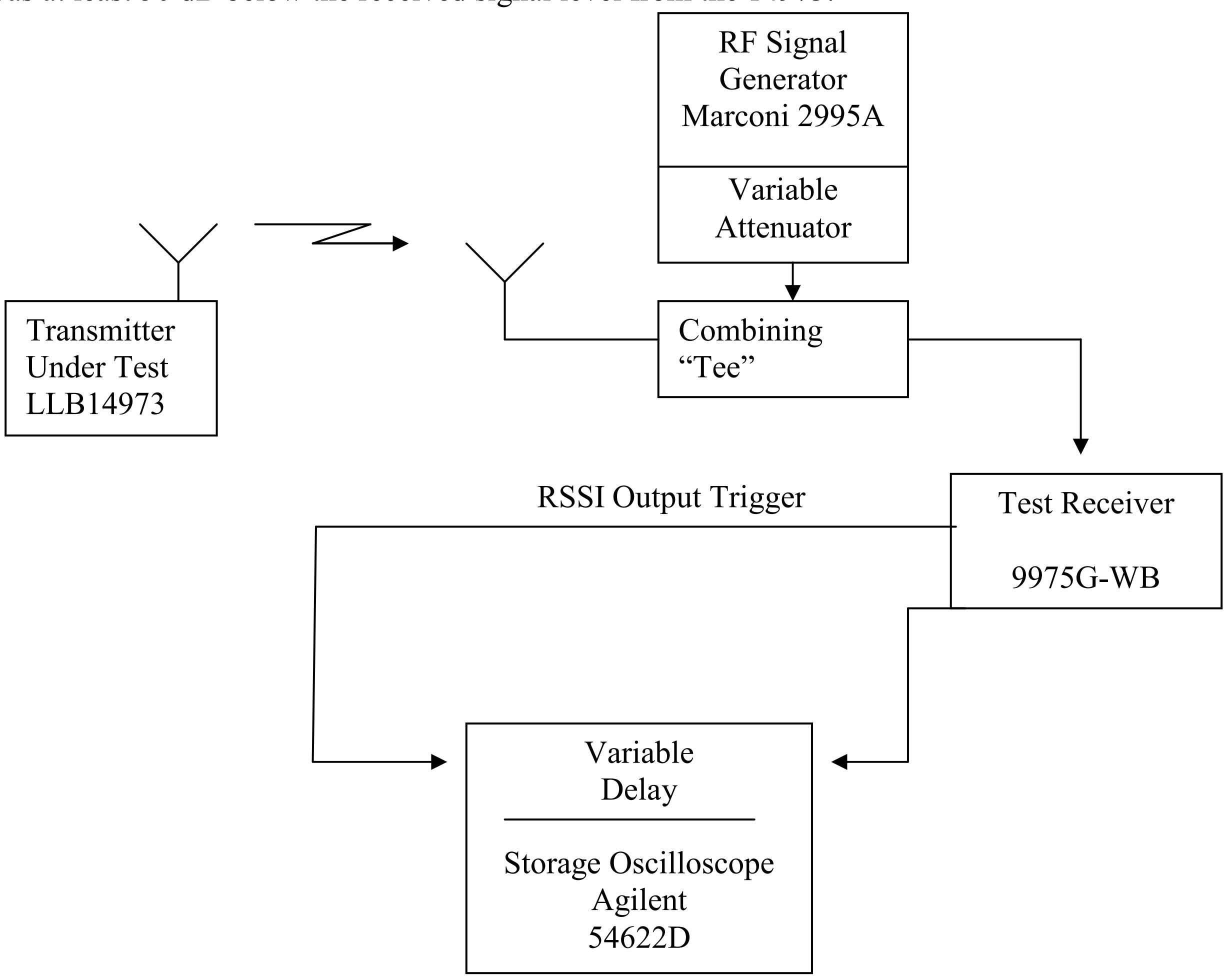
Spectrum Analyzer	Tektronix Model WCA 280A SN: J300168 Cal Due: 4/11
Antenna	Antenna Specialists Model AV-15 450 – 47- MHz
DC Power Supply	Mastech Model HY1503D SN: 0036790
Thermometer	Cooper Instrument Corp. Model SRH 77A Calibration 6/11
AC Power Supply	Variable Transformer Model TDGC-2KM Switched step-up transformer
Digital Volt Meter	Fluke Model 87V SN: 97480078 Cal Due 7/11
Temperature Chamber	Test Equity Model 115, SN: 150202 Cal Due: 2/12
Test Performed	October 26-27, 2010

Unit Tested: 14973 Rev. D SN—80001132

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 14973 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 modified DCU wideband receiver was used. The storage oscilloscope was triggered by the RSSI output of the receiver. Appropriate delay was provided by the digital delay circuitry of the oscilloscope. The 1 kHz modulated test signal at 460 MHz was provided by the 8920D test set. 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 14973.



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 14973's transient frequency characteristics. The limit masks are indicated on each of the figures.

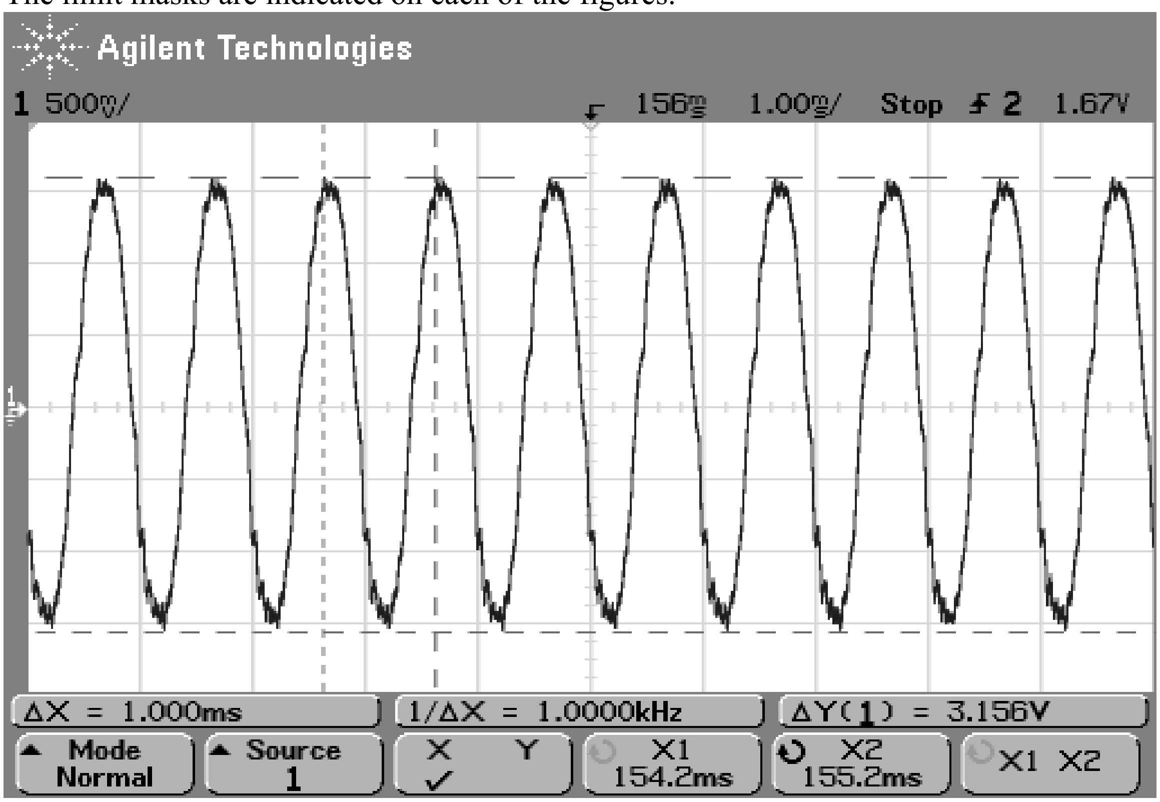


Fig. 3 ±12.5 kHz modulated test signal 25 kHz = 3.156 V.

12.5 kHz = 1,58 V **6.25 kHz = 790 mV**
1.15 kHz = 145 mV

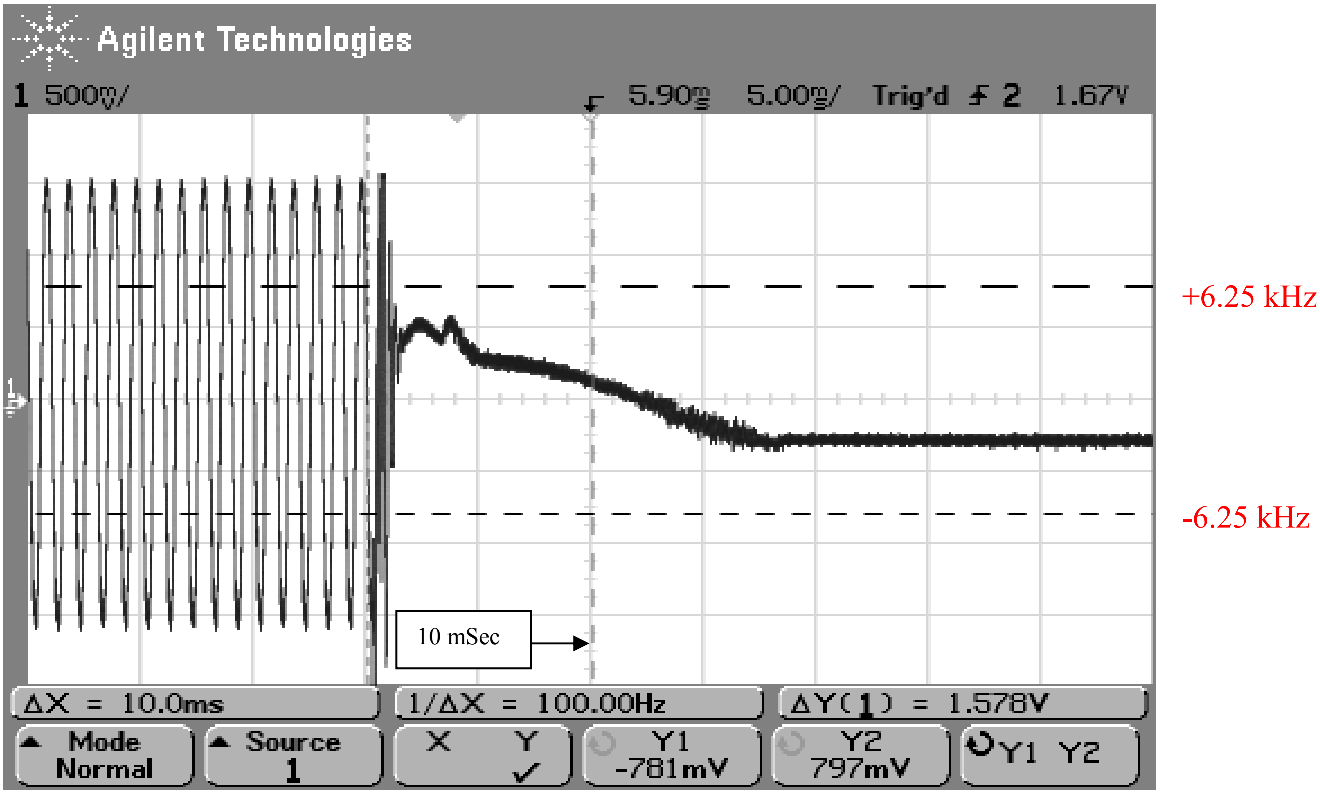


Fig. 4 Start of Transmission

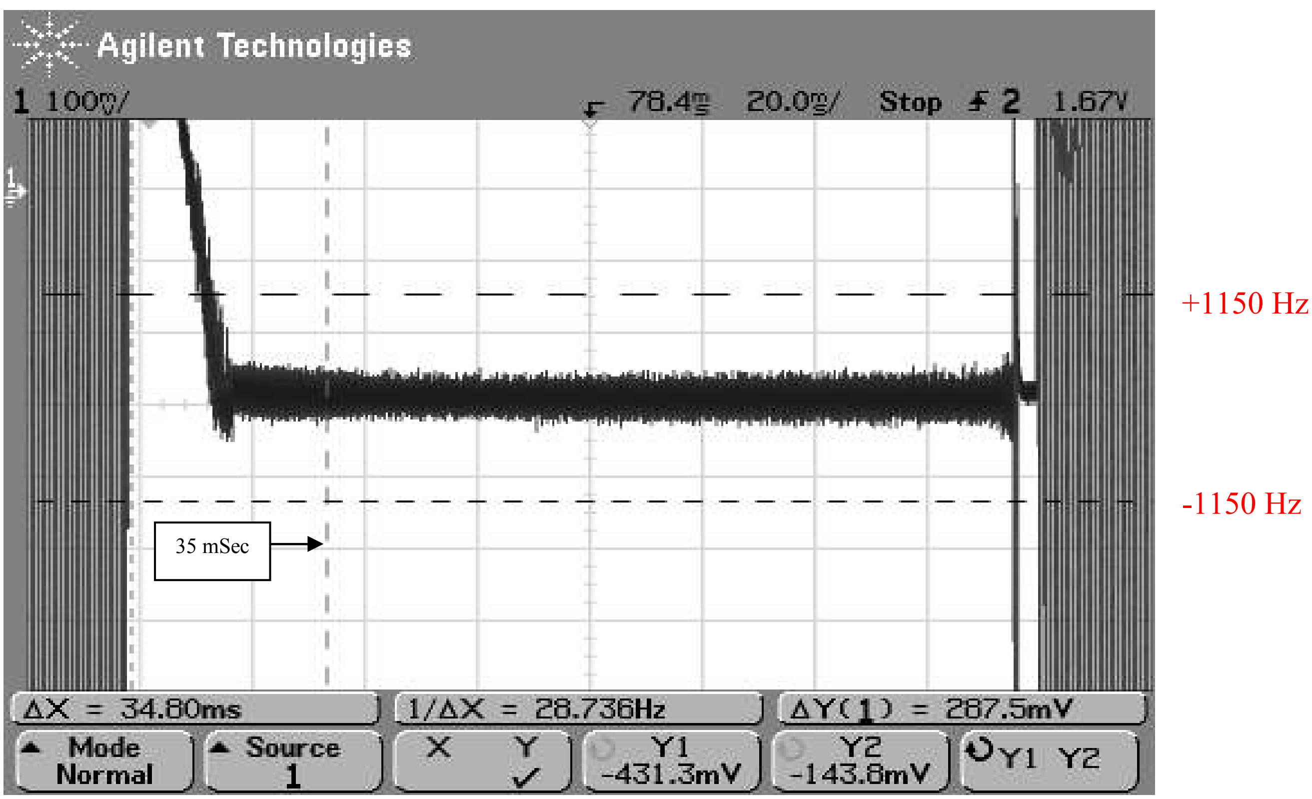


Fig. 5 Full Transmission

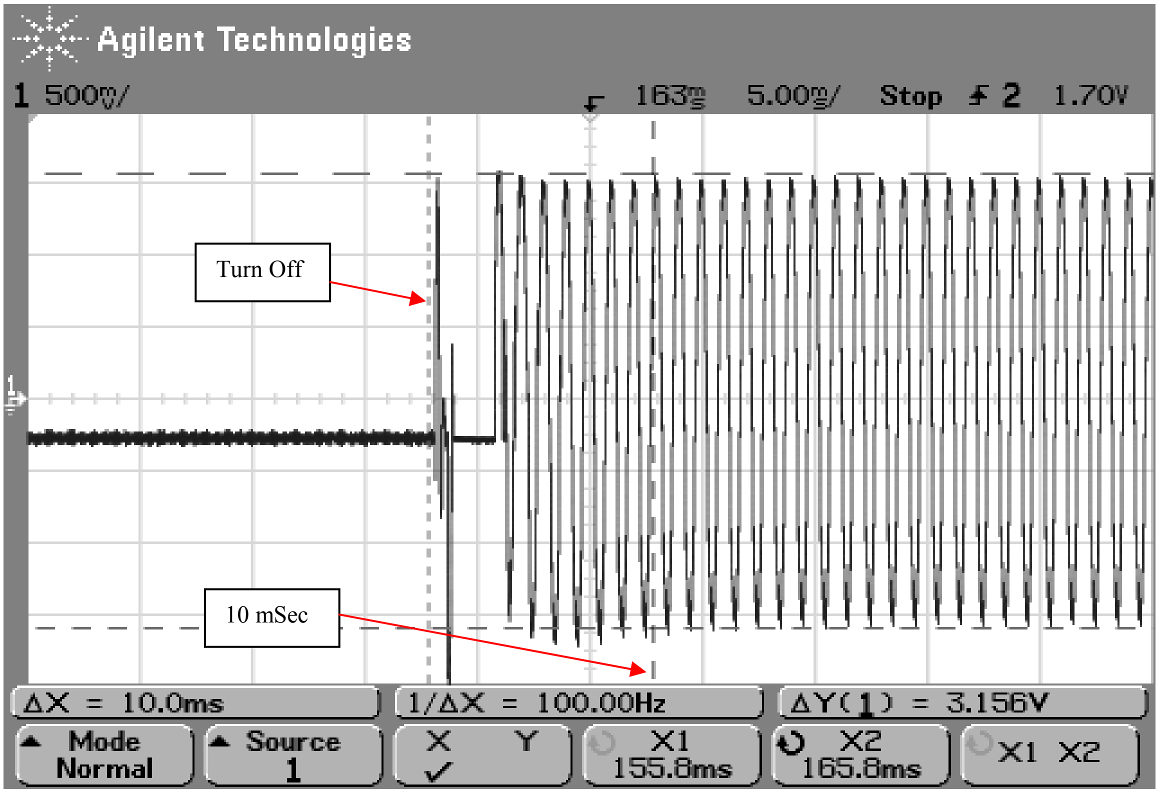


Fig. 6 Turn Off Transient

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 2955 SN: 132061 Cal Due: 12/10
Test Receiver	Hexagram 9975G-WB
Oscilloscope	Agilent Model 54622D S/N MY40006228 Cal Due: 11/10
RF Trigger	RSSI output of Receiver
Test Performed	Oct. 22, 2010

Unit Tested: 14973 Rev. D SN—80001132

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 14973
MANUFACTURER	Hexagram, Inc. 30400 Solon Rd. Solon, OH 44139
TEST DATES	October 19-29, 2010
TEST SITE USED	Smith Electronics, Inc. 8200 Snowville Road Cleveland, OH 44141 330-289-9306