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ENGINEERING TEST REPORT

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HIGH READ-RATE
ELECTRIC METER TRANSMITTING UNIT

Model 2010-000A, Rev. D
FCC ID: LLB10000A

January 24, 2011

Report Prepared by

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Agency Certification Control Technician

TEST REPORT

INTRODUCTION

The Hexagram Model 2010-000A, Rev. D transceiver is a higher output version of the Model 2010-000 transceiver previously certified as LLB10000 on 11-4-10.. The transceiver is AC line powered with a battery back-up and is installed inside the electric meter housing. The transmitter provides short, intermittent radio frequency transmissions to provide meter reads, alarms and other required information. A microprocessor provides timing, control and data processing functions. The antenna is mounted outside the meter housing but within the transparent globe that protects the meter and would only be accessible to authorized personnel. The antenna is connected to the MTU circuit board with a short length of coaxial cable using a UFL connector. The receiver can be used for upgrading firmware, requests for meter reads or other options available in the system. This report presents the data obtained in support of an application for a new grant of certification under FCC ID: LLB10000A.

CHANGES MADE

The only change made to the previous version is the addition of a matching network consisting of a parallel capacitor of 6.8 pF and a series inductor of 22 nH between capacitor C119 and the antenna output port. A different antenna is also being used with revision. No other changes were made that affect the RF output characteristics.

New measurements were made of the power and harmonic output and the emissions mask. As no changes were made that would affect the other parameters, the previous data obtained from the Rev. C, lower power board was submitted for the frequency stability with temperature and voltage, and the start-up and shut down characteristics is submitted with this report.

MEASUREMENTS PERFORMED

POWER OUTPUT AND SPURIOUS EMISSIONS

Within the tuning range of 450 – 470 MHz, the transmitter portion of the Model 2010-000A Rev. D. 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.

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, the transmitter was forced transmit continuously for about 40 seconds at a 50% duty cycle for these measurements. Power to the meter was provided by a nominal 220 VAC source.

With the transmitter powered and 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.

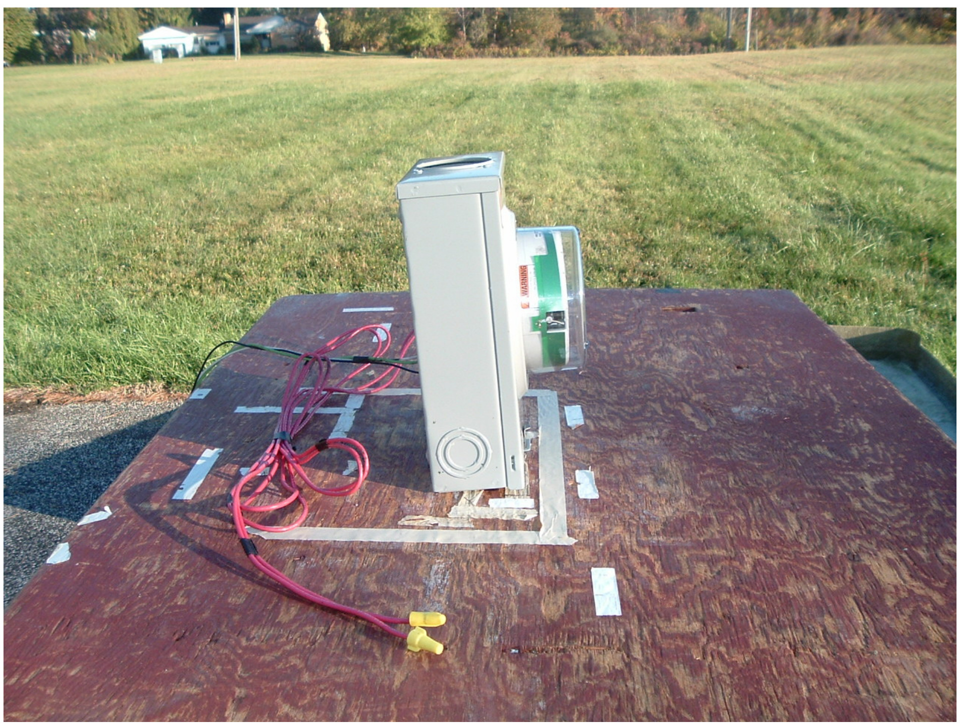
In order to convert the signal generator output value to equivalent radiated power from a dipole, the following equation is used:

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

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 dB 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 2010-000A, Rev D MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP

TABLE 1a
HEXAGRAM MODEL 2010-000A 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	14.7	2.0	-0.2	12.5	
900	-27.7	2.9	-0.5	-31.1	-43.6

Output = 12.5dBm
= 0.018 W
Req. Att.= 32.5 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)
1350	-43.1	0.8	5.5	-38.4	-50.9
1800	-48.3	1.0	5.9	-43.4	-55.9
2250	-44.4	1.2	6.8	-38.8	-51.3
2700	-61.0	1.3	7.6	-54.7	-67.2
3150	-61.2	1.4	7.7	-54.9	-67.4
3600	-55.4	1.6	7.7	-49.3	-61.8
4050	-60.5	1.7	7.6	-54.6	-67.1
4500	-64.5	1.8	8.3	-58.0	-70.5

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	27.7	2.0	-0.2	25.5	
900	-20.2	2.9	-0.5	-23.6	-49.1

Output = 25.5 dBm
= 0.355 W
Req. Att.= 45.5 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)
1350	-39.7	0.8	5.5	-35.0	-60.5
1800	-51.3	1.0	5.9	-46.4	-71.9
2250	-45.0	1.2	6.8	-39.4	-64.9
2700	-58.0	1.3	7.6	-51.7	-77.2
3150	-57.0	1.4	7.7	-50.7	-76.2
3600	-54.9	1.6	7.7	-48.8	-74.3
4050	-55.9	1.7	7.6	-50.0	-75.5
4500	-60.5	1.8	8.3	-54.0	-79.5

TABLE 1b
HEXAGRAM MODEL 2010-000A 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	14.3	2.1	-0.2	12.0	
920	-29.7	3.0	-0.4	-33.1	-45.1

Output = 12.0dBm
= 0.0158 W
Req. Att.= 32.0 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)
1380	-47.8	0.9	5.6	-43.1	-55.1
1840	-56.8	1.0	5.9	-51.9	-63.9
2300	-51.1	1.2	6.9	-45.4	-57.4
2760	-55.0	1.3	7.6	-48.7	-60.7
3220	-66.0	1.4	7.8	-59.6	-71.6
3680	-54.6	1.6	7.7	-48.5	-60.5
4140	-56.5	1.7	7.7	-50.5	-62.5
4600	-55.3	1.8	8.3	-48.8	-60.8

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)
460	27.2	2.1	-0.2	24.9	
920	-19.4	3.0	-0.4	-22.8	-47.7

Output = 24.9 dBm
= 0.309 W
Req. Att.= 44.9 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	-45.7	0.9	5.6	-41.0	-65.9
1840	-54.0	1.0	5.9	-49.1	-74.0
2300	-51.7	1.2	6.9	-46.0	-70.9
2760	-59.0	1.3	7.6	-52.7	-77.6
3220	-69.0	1.4	7.8	-62.6	-87.5
3680	-61.0	1.6	7.7	-54.9	-79.8
4140	-56.0	1.7	7.7	-50.0	-74.9
4600	-54.9	1.8	8.3	-48.4	-73.3

TABLE 1c
HEXAGRAM MODEL 2010-000A 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	15.0	2.1	-0.2	12.7	
940	-30.3	3.0	-0.4	-33.7	-46.4

Output = 12.7 dBm
= 0.0186 W
Req. Att.= 32.7 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	-46.3	0.9	5.7	-41.5	-54.2
1880	-50.8	1.0	5.9	-45.9	-58.6
2350	-43.4	1.2	7.1	-37.5	-50.2
2820	-58.3	1.3	7.7	-51.9	-64.6
3290	-59.3	1.5	7.8	-53.0	-65.7
3760	-62.4	1.6	7.6	-56.4	-69.1
4230	-61.9	1.7	7.9	-55.7	-68.4
4700	-68.0	1.8	8.4	-61.4	-74.1

Note: Actual test frequency was 469.9875 and its harmonics (2820=2819.925)

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	25.6	2.1	-0.2	23.3	
940	-21.4	3.0	-0.4	-24.8	-48.1

Output = 23.3 dBm
= 0.214 W
Req. Att.= 43.3 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	-43.7	0.9	5.7	-38.9	-62.2
1880	-49.8	1.0	5.9	-44.9	-68.2
2350	-50.2	1.2	7.1	-44.3	-67.6
2820	-61.5	1.3	7.7	-55.1	-78.4
3290	-62.0	1.5	7.8	-55.7	-79.0
3760	-64.5	1.6	7.6	--58.5	-81.8
4230	-62.0	1.7	7.9	-55.8	-79.1
4700	-68.0	1.8	8.4	-61.4	-84.7

Note: Actual test frequency was 469.9875 and its harmonics (4230 = 4229.8875)

TEST EQUIPMENT USED

Spectrum Analyzer	Hewlett-Packard Model 8593EM Spectrum Analyzer SN: 3536A00147 Cal Due: 8/25/2011
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: 6/2011
Miscellaneous	12.2 m RG-213/U coaxial cable 22.5 m LMR-400 coaxial cable 3.0 m RG-213/U coaxial cable 3.0 m RG-213/U coaxial cable
Tests Performed	October 1, 5, 2010

Unit Tested: 2010-000A Rev. D SN—2010000204

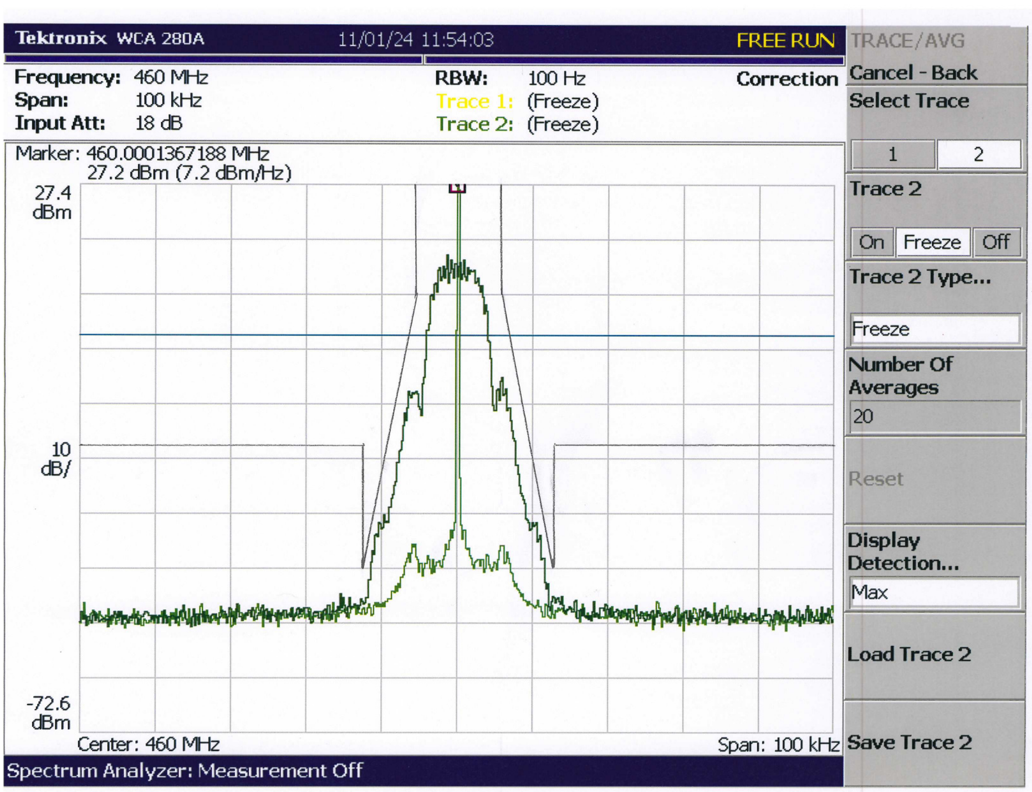
OCCUPIED BANDWIDTH

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 2010-000A 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. The maximum dipole equivalent power was determined to be 22.5 dBm or 0.355 W and 50 + 10 log(0.355) equals 45.5 dB. The mask measurement was made directly from the antenna port, and as seen in Fig. 1, the direct output power was 27.2 dBm so the maximum allowed is shown on the plot as 47.2 dB below the output level.

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 PN9 modulated at the specified 7200 bits per second data rate.



-47.2 dBc

Fig. 1
Hexagram Model 2010-000A Rev. D
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280A SN: J300168 Cal Due: 4/2011
Antenna	Direct Measurement
Test Performed	January 24, 2011

Unit Tested: 2010-000A Rev D SN—2010000204

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 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. The transmitted signal was captured by the spectrum analyzer and the frequency was determined. The temperature in the chamber was then increased to 30° C. At each temperature, at least 20 minutes were allowed for stabilization of the transmitter, a transmission was made and the frequency determined. The temperature was increased in 10° C intervals to 80° C and then to 85° C. The temperature was then returned to 20° C. stabilized and the decreased to -30° C in 10° intervals. The temperature was stabilized 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	460.000195	+195	+0.424
+30	460.000198	+195	+0.424
+40	460.000049	+49	+0.107
+50	460.000029	+29	+0.063
+60	460.000029	+29	+0.063
+70	460.000039	+39	+0.085
+80	460.000117	+117	+0.317
+85	460.000146	+146	+0.467
+20	460.000215	+215	+0.467
+10	460.000117	+117	+0.317
0	460.000215	+215	+0.467
-10	460.000225	+225	+0.489
-20	460.000059	+59	+0.128
-30	460.000029	+29	+0.063
+20	460.000156	+156	+0.339

Reference frequency = 460.000000 MHz

FREQUENCY STABILITY VS. SUPPLY VOLTAGE

To vary the AC test voltage, a variable AC source was connected to the electric meter containing the MTU. The frequency was measured at nominal operating voltages of 120 VAC, 220 VAC and 240 VAC. Measurements were also made at voltage settings of ±15% for each of these nominal values

With the voltage set to a measurement point, the transmitted signal was captured by a spectrum analyzer and the frequency value determined. The frequencies are compared to the tuned frequency. The 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
102 VAC	459.699951	-49	-0.107
120 VAC	459.699951	-49	-0.107
138 VAC	459.699951	-49	-0.107
187 VAC	459.699951	-49	-0.107
220 VAC	459.699951	-49	-0.107
253 VAC	459.699951	-49	-0.107
204 VAC	459.699951	-49	-0.107
240 VAC	459.699951	-49	-0.107
276 VAC	459.699902	-98	-0.213

Reference frequency = 459.700000 MHz

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280 S/N J300168 Cal Due: 4/2011
Antenna	Maxrad MUF4505 whip antenna
AC Power Supply	Variable Transformer Model TDGC2 SN:GS200704SF001445
Digital Multi-Meter	Agilent Model U1242A SN: MY49160026 Cal. Due: 7/22/2011
Temperature Chamber	Test Equity Model 115 Cal. due: 2/17/2012
Tests Performed	Temperature July 13, 2010 Voltage August 17,2010

Temperature

Unit Tested: 2010-000 Rev C SN—2010000126

Voltage

Unit Tested: 2010-000 Rev C SN—2010000121

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 2010-000 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 2010-000

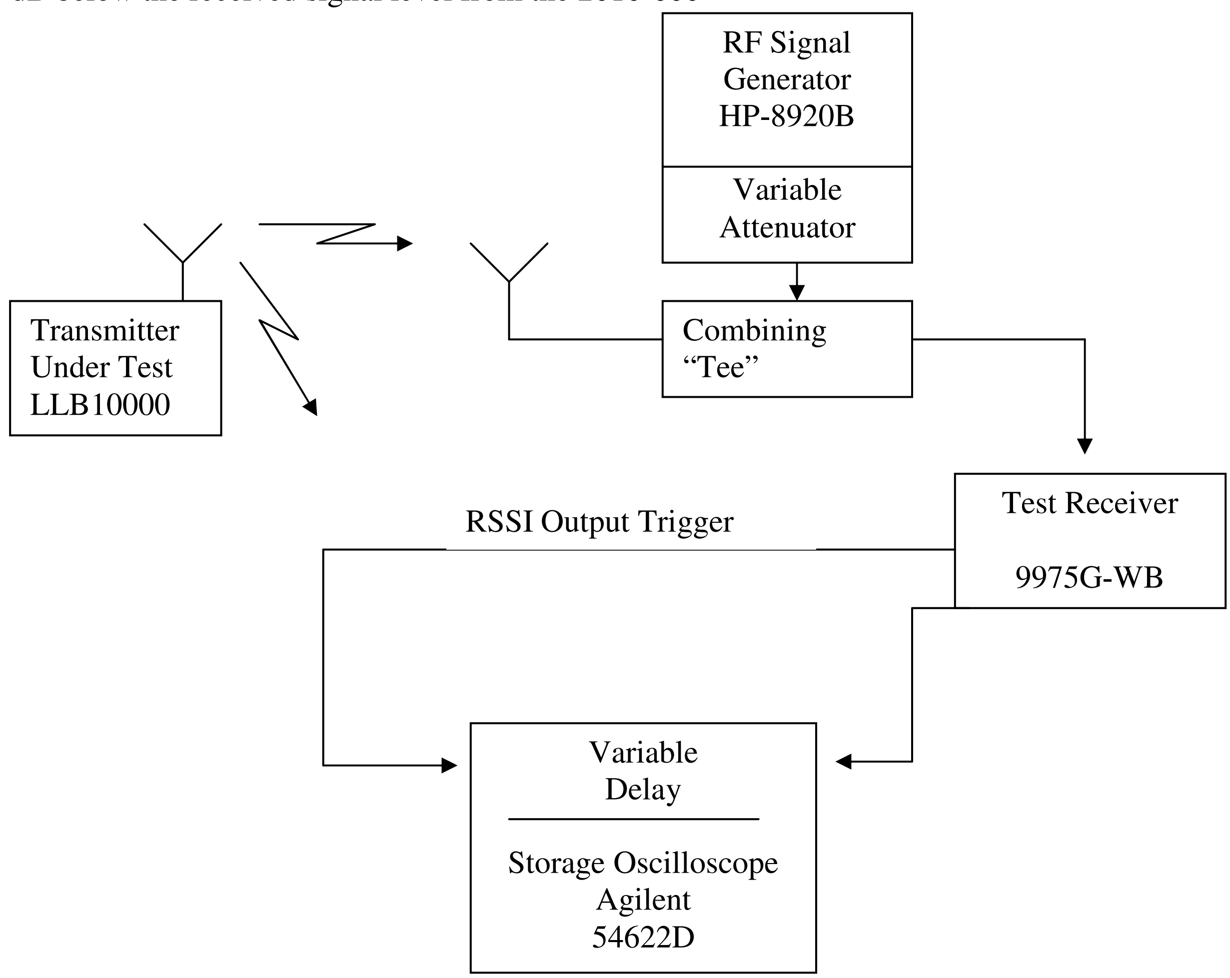


Fig. 2
Transient Frequency Behavior
Test Setup

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.

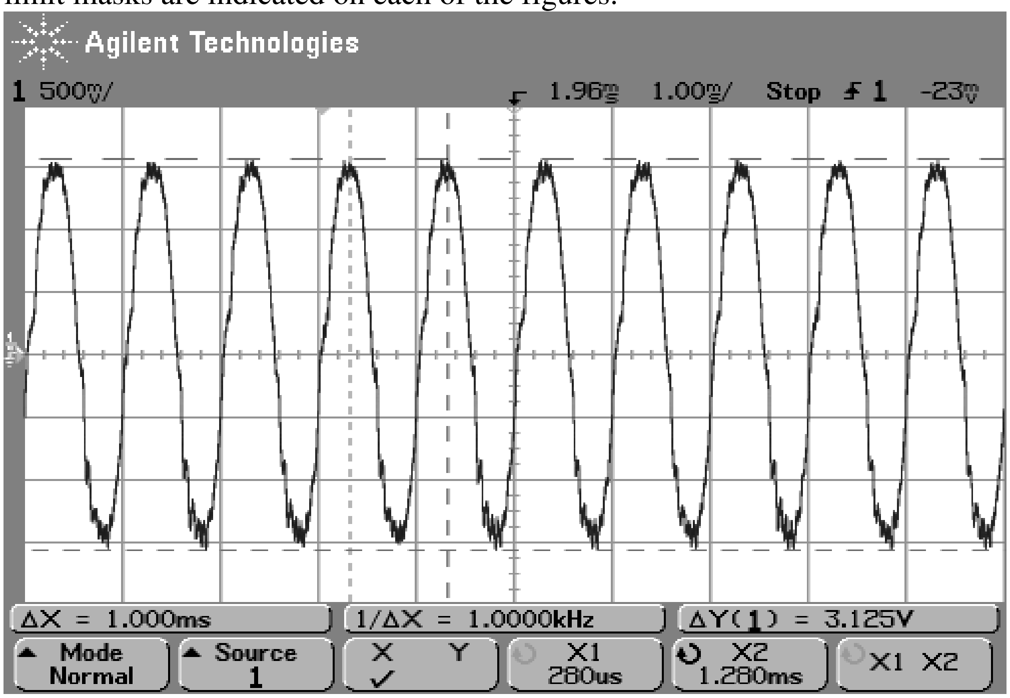
2. Frequency deviation during t_2 (25 ms duration after t_1) must be less than ±6.25 kHz.

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 2010-000 transient frequency characteristics. The limit masks are indicated on each of the figures.



+12.5 kHz

-12.5 kHz

Fig. 3 ±12.5 kHz modulated test signal .

±12.5 kHz = 3.125 V
±6.25 kHz = 1.56 V
±1.15 kHz = 287 mV

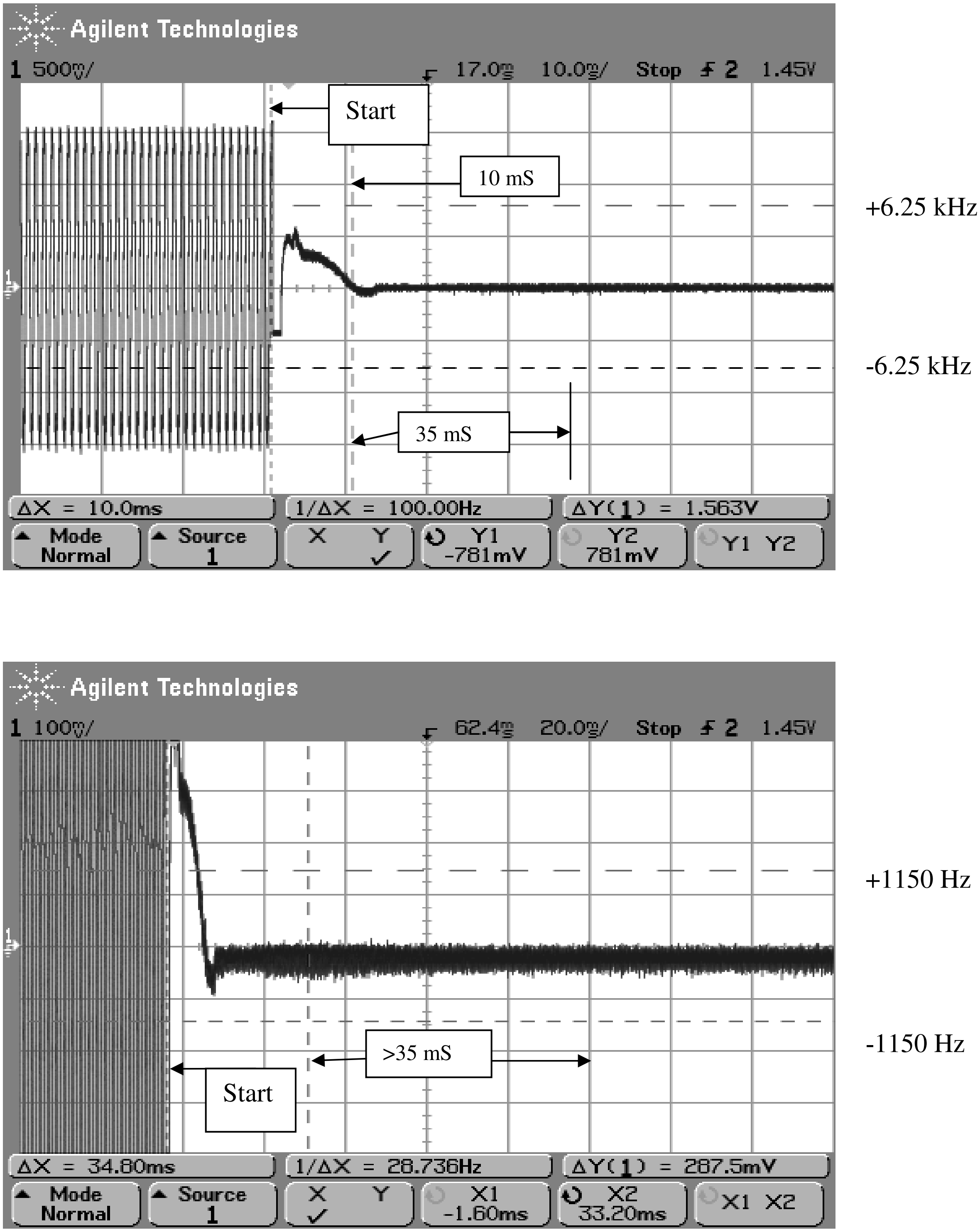


Fig. 5 Full Transmission

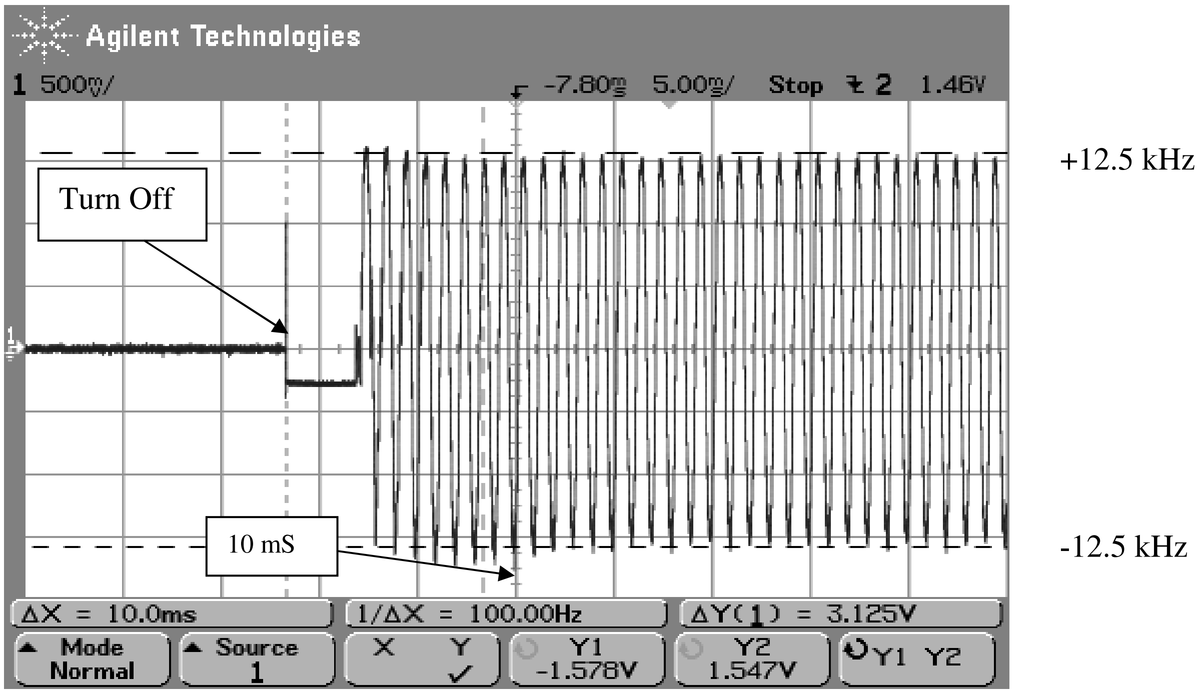


Fig. 6 Turn Off Transient

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	HP Model 8920B/SN: US37253192 Cal. Due: 8/2010
Test Receiver	Hexagram Broadband Receiver w/ RSSI trigger output
Oscilloscope	Agilent Model 54622D SN: MY40003551 Cal Due: 11/2010
Test Performed	July 12, 2010

Unit Tested: 2010-000 Rev C SN—2010000126

TEST INFORMATION

SUMMARY

The Hexagram Model 2010-000A 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 2010-000A
MANUFACTURER	Hexagram, Inc. 30400 Solon Rd. Solon, OH 44139
TEST DATES	July 12, 2010-January 24, 2011
OPEN AREA TEST SITE	Smith Electronics, Inc. 8200 Snowville Road Cleveland, OH 44141 (330) 289-9306 FCC (Reg. #90938) Industry Canada (File #4541A-1).