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**ENGINEERING TEST REPORT**

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HIGH READ-RATE  
GAS METER TRANSMITTING UNIT

Model 2011-006S, Rev. C  
FCC ID: LLB11006S

March 9, 2012

Report Prepared by

A handwritten signature in black ink that reads 'James R. Pollock'. The signature is written in a cursive style and is positioned above a horizontal line.

James R. Pollock  
Agency Certification Control Technician

# **TEST REPORT**

## **INTRODUCTION**

The Hexagram Model 2011-006S transceiver is a “Meter Transmitting Unit” (MTU) designed to provide remote meter reading capability for a gas meter. The transceiver is self-powered and mounts directly on a gas meter. On board batteries provide power. The transmitter provides a very short, intermittent radio frequency transmission to send a remote reading of the meter to a data collector unit. A microprocessor provides timing, control and data processing functions. The internal antenna is inaccessible to the user and no external antenna is provided. Two identical units were used as test subjects for this report. The unit used for each test is identified under the test procedure. This report presents the data obtained in support of an application for Certification under Part 90 of the FCC rules.

This product is identical to a previously certified transceiver (LLB11006S) except for a decrease in power implemented to provide customer satisfaction. Only the fundamental power and harmonic levels have changed.

## **MEASUREMENTS PERFORMED**

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## **LOW FREQUENCY EMISSIONS**

Low frequency emissions from the 2011-006S were examined from 9 kHz to 330 MHz using a vertical monopole antenna and a biconical antenna. Non-harmonic emissions above 330 MHz to 1000 MHz were determined with tuned dipoles.

All emissions observed between 9 kHz and 1 GHz, other than the harmonics of the transmitter were determined to be more than 30 dB below the limit levels of Part 90.210.

## **TEST EQUIPMENT USED**

### **Spectrum Analyzer**

Hewlett-Packard Model 8593EM Spectrum Analyzer  
SN: 3536A00147 Cal Due: 8/24/2012

### **Antennas**

AH Systems Model SAS-200/550-1 Vertical Monopole  
SN::402 Frequency Range 6 kHz – 50 MHz  
Cal Date: 6/9/2011 Cal Due: 6/9/2012

AH Systems Model FCC-4 Tuned Dipole  
SN: 592A  
Frequency Range 325 – 1000 MHz  
Cal Date: 8/19/2011 Cal Due: 8/19/2012

AH Systems Model SAS-540 Biconical  
SN: 705  
Frequency Range 20 MHz – 330 MHz  
Cal Date: 9/23/2011 Cal Due: 9/23/2012

### **Tests Performed:**

November 30, 2011

Unit Tested: 2011-006S Rev. C SN: 80003491

## **POWER OUTPUT AND SPURIOUS EMISSIONS**

Within the tuning range of 450 – 470 MHz, the transmitter portion of the Model 2011-006S (EUT) was examined at three fundamental frequencies and their harmonics. 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). 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 to transmit continuously with a 30 seconds on and 30 seconds off cycle for these measurements. Power to the meter necessary to sustain the transmission was provided by an external 6 V battery.

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:

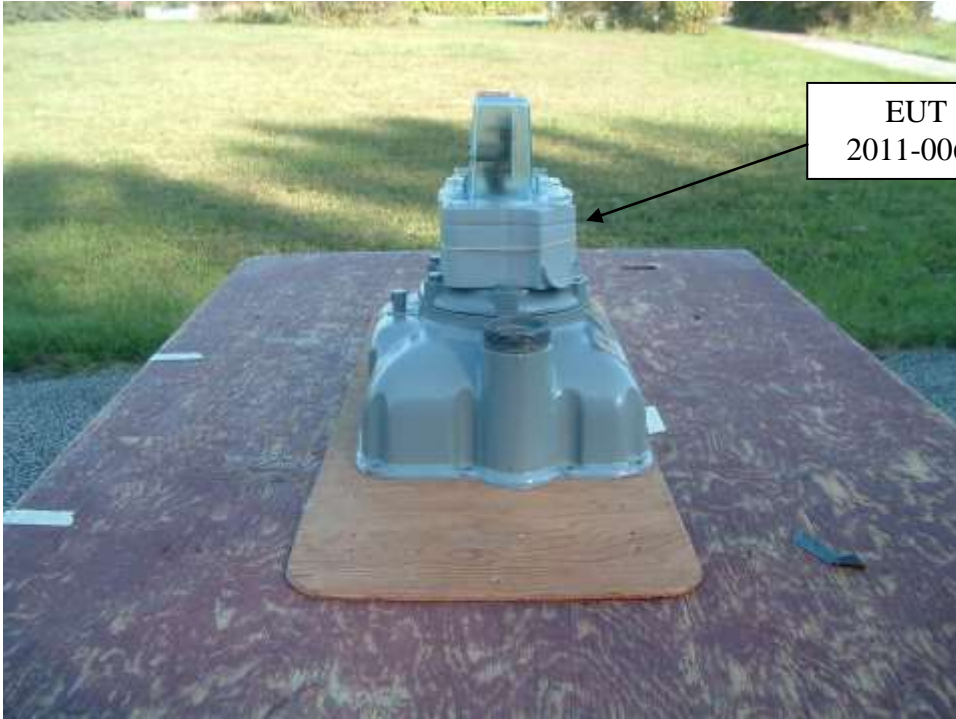
$P_d$  is the dipole equivalent power in dBm,  $P_g$  is the generator output into the substitution antenna, also in dBm, and “antenna gain” is the dB gain of the substitution antenna with respect to a theoretical dipole.

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  $50 + 10\log(P)$ .

The determined power outputs, the required harmonic attenuation as well as the attenuation for each harmonic are found in Tables 1a – 1c.



PICTORIAL 1  
HEXAGRAM MODEL 2011-006S MTU  
OUTPUT POWER AND SPURIOUS EMISSIONS  
TYPICAL TEST SETUP



EUT  
2011-006S



EUT  
2011-006S

PICTORIAL 2  
HEXAGRAM MODEL 2011-006S MTU  
OUTPUT POWER AND SPURIOUS EMISSIONS  
TYPICAL TEST SETUP

**TABLE 1a**  
**HEXAGRAM MODEL 2011-006S 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	13.6	2.1	-1.0	10.5	
900	-46	3.2	-0.7	-49.9	-60.4

**Output = 10.5dBm**  
**= 0.011 W**  
**Req. Att.= 30.5 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	-74.0	0.8	6.5	-68.3	-78.8
1800	-85.0	1.0	7.4	-78.6	-89.1
2250	-85.0	1.2	6.2	-80.0	-90.5
2700	-73.0	1.3	6.4	-67.9	-78.4
3150	-77.0	1.4	7.2	-71.2	-81.7
3600	-73.0	1.6	8.3	-66.3	-76.8
4050	-70.0	1.7	8.0	-63.7	-74.2
4500	-69.0	1.8	8.6	-62.2	-72.7

**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	25.2	2.1	-1.0	22.1	
900	-37.4	3.2	-0.7	-41.3	-63.4

**Output =22.1 dBm**  
**= 0.162 W**  
**Req. Att.= 42.1 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	-77.0	0.8	6.5	-71.3	-93.4
1800	-84.0	1.0	7.4	-77.6	-99.7
2250	-80.0	1.2	6.2	-75.0	-97.1
2700	-73.0	1.3	6.4	-67.9	-90.0
3150	-73.0	1.4	7.2	-67.2	-89.3
3600	-72.0	1.6	8.3	-65.3	-87.4
4050	-68.0	1.7	8.0	-61.7	-83.8
4500	-70.0	1.8	8.6	-63.2	-85.3

**TABLE 1b**  
**HEXAGRAM MODEL 2011-006S 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	15.2	2.2	-1.1	11.9	
920	-46.5	3.3	-1.1	-50.9	-62.8

**Output = 11.9 dBm**  
**= 0.015 W**  
**Req. Att.= 31.9 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	-76	0.9	6.8	-70.1	-82.0
1840	-81	1.0	7.2	-74.8	-86.7
2300	-81	1.2	6.2	-76.0	-87.9
2760	-67	1.3	6.5	-61.8	-73.7
3220	-68	1.4	7.5	-61.9	-73.8
3680	-65	1.6	8.3	-58.3	-70.2
4140	-68	1.7	8.1	-61.6	-73.5
4600	-68	1.8	8.4	-61.4	-73.3

**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	26.6	2.2	-1.1	23.3	
920	-40.5	3.3	-1.1	-44.9	-68.2

**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)
1380	-83	0.9	6.8	-77.1	-100.4
1840	-78	1.0	7.2	-71.8	-95.1
2300	-73	1.2	6.2	-68	-91.3
2760	-67	1.3	6.5	-61.8	-85.1
3220	-69	1.4	7.5	-62.9	-86.2
3680	-66	1.6	8.3	-59.3	-82.6
4140	-64	1.7	8.1	-57.6	-80.9
4600	-70	1.8	8.4	-63.4	-86.7



**TABLE 1c**  
**HEXAGRAM MODEL 2011-006S 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	16.2	2.2	-1.2	12.8	
940	-41.5	3.3	-1.1	-45.9	-58.7

**Output = 12.8 dBm**  
**= 0.019 W**  
**Req. Att.= 32.8 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	-71.0	0.9	7.0	-64.9	-77.7
1880	-75.0	1.0	7.0	-69.0	-81.8
2350	-74.0	1.2	6.3	-68.9	-81.7
2820	-65.0	1.3	6.5	-59.8	-72.6
3290	-65.0	1.5	7.8	-58.7	-71.5
3760	-56.0	1.6	8.2	-49.4	-62.2
4230	-67.0	1.7	8.2	-60.5	-73.3
4700	-70.0	1.8	8.2	-63.6	-76.4

**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)
470	25.8	2.2	-1.2	22.4	
940	-39.0	3.3	-1.1	-43.4	-65.8

**Output = 22.4 dBm**  
**= 0.174 W**  
**Req. Att.= 42.4 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	-71.0	0.9	7.0	-64.9	-87.3
1880	-77.0	1.0	7.0	-71.0	-93.4
2350	-77.0	1.2	6.3	-71.9	-94.3
2820	-64.0	1.3	6.5	-58.8	-81.2
3290	-64.0	1.5	7.8	-57.7	-80.1
3760	-57.0	1.6	8.2	-50.4	-72.8
4230	-62.0	1.7	8.2	-55.5	-77.9
4700	-70.0	1.8	8.2	-63.6	-86.0

## **TEST EQUIPMENT USED**

### **Spectrum Analyzer**

Hewlett-Packard Model 8593EM Spectrum Analyzer  
SN: 3536A00147 Cal Due: 8/24/2012

### **Antennas**

ETS-Lindgren Model DB-4 Tuned Dipole  
SN: 69064 Receive Only  
Frequency Range 400 – 1000 MHz Cal N/A

A.H. Systems Model FCC-4 Tuned Dipole  
SN: 592A Transmit Only  
Frequency Range 325 – 1000 MHz  
Cal Date: 8/19/2011 Cal Due: 8/19/2012

ETS-Lindgren Model 3115 Double Ridged Guide  
Horn SN: 69713 Receive Only  
Frequency Range 0.75 – 18 GHz Cal N/A

A.H. Systems Model SAS-571 Double Ridged Guide  
Horn SN: 1488 Transmit Only  
Frequency Range 0.7 – 18 GHz  
Cal Date: 8/19/2011 Cal Due: 8/19/2012

### **Signal Generator**

Hewlett-Packard Model 8340B,  
S/N 3010A01889 Cal Due: 6/10/2012

### **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**

March 6-7, 2012

Unit Tested: 2011-006S Rev. C SN: 80003492

## 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 2011-006S transmitter, Mask D is specified. From the center frequency of the band  $\pm 5.625$  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. The maximum dipole equivalent power was determined to be 23.3 dBm or 0.214 W and  $50 + 10 \log(0.214)$  equals 43.3 dB. The mask measurement was a conducted measurement, and as seen in Fig. 1, the measured output power was 24.8 dBm so the maximum allowed is shown on the plot as -20 dBm or 44.8 dB below the measured 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.

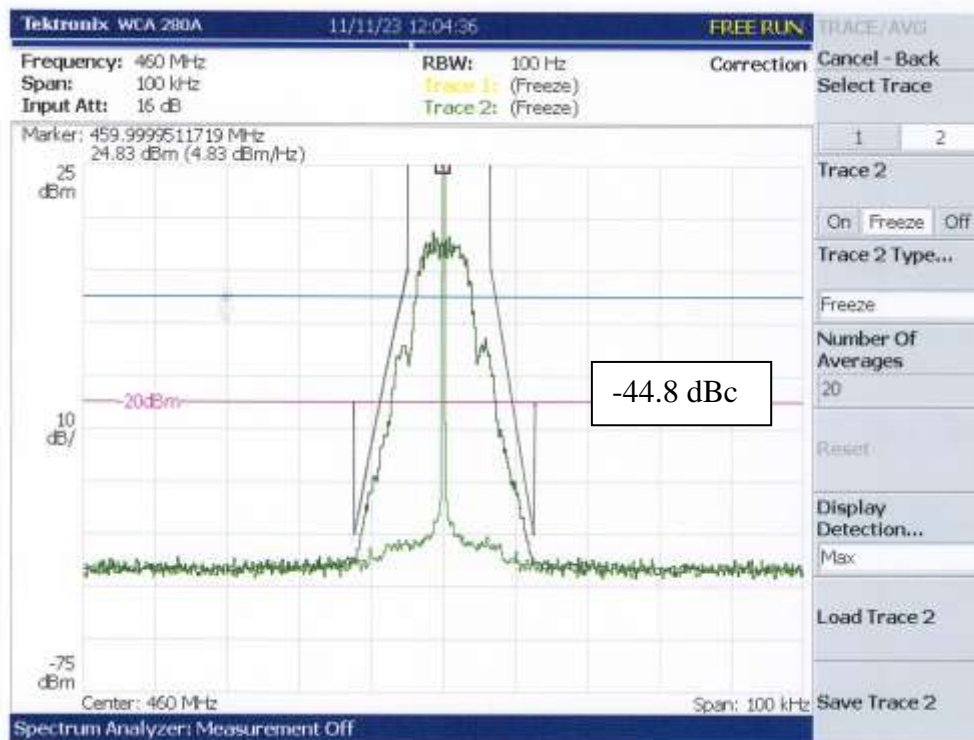


Fig. 1  
Hexagram Model 2011-009S  
Emissions Mask

## **TEST EQUIPMENT USED**

### **Spectrum Analyzer**

Tektronix Model WCA 280A  
SN: J300168 Cal Due: 4/26/2012

### **Antenna**

Direct Measurement

### **Test Performed**

November 18, 2011

Unit Tested: 2011-005. Rev. C SN: 80003491

## **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 temperature stabilize. The transmitted signal was captured by the spectrum analyzer and the frequency was determined. The temperature in the chamber was then increased in 10° C intervals to +70° C, returned to +20° C and then decreased in 10° intervals down to -40° C, before returning to 20° C for the final measurement. At each temperature, at least 40 minutes were allowed for stabilization of the transmitter, a transmission was made and the frequency determined. The frequency at each temperature was recorded, compared to the 460 MHz reference frequency, and is recorded in Table 2. It can be seen from the table that all readings are within the deviation limit of  $\pm 2.5$  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	459.999941	-59	-0.128
+30	459.999941	-59	-0.128
+40	459.999941	-59	-0.128
+50	459.999941	-59	-0.128
+60	459.999883	-117	-0.254
+70	459.999922	-78	-0.170
+20	459.999961	-39	-0.085
+10	460.000020	20	0.043
0	460.000000	0	0.000
-10	459.999883	-117	-0.254
-20	459.999746	-254	-0.552
-30	459.999863	-137	-0.298
-40	460.000059	59	0.128
+20	459.999961	-39	-0.085

Reference Frequency= 460.000000 MHz

## **FREQUENCY STABILITY VS. SUPPLY VOLTAGE**

To vary the DC test voltage, a variable DC power supply was inserted in place of one of the series lithium cells. The frequency was measured at the TIA-603-C default standard test voltage of lithium ion cells ( $3.75 \times 2 = 7.5\text{V}$ ). Measurements were also made at voltages down to and below the 85% level of 6.375 Volts.

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  $\pm 2.5$  ppm or 1150 Hz at the 460 MHz reference frequency.

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

**460 MHz**

<b>INPUT Volts</b>	<b>Measured Frequency MHz</b>	<b>Dev. Hz</b>	<b>Dev. ppm</b>
7.5 VDC	460.000000	0	0
7.2 VDC	460.000000	0	0
7.0 VDC	460.000000	0	0
6.5 VDC	460.000000	0	0
6.0 VDC	460.000000	0	0
5.5 VDC	460.000000	0	0

Reference frequency = 460 MHz

## **TEST EQUIPMENT USED**

### **Spectrum Analyzer** Voltage

Tektronix Model WCA 280A  
SN: J300168 Cal Due: 4/26/2012

### **Antenna**

A/S Model AV-15 450 – 470 MHz  
Cal: N/A

### **DC Power Supply**

MPJA DC Regulated Power Supplies  
SN: 012021

### **Digital Multi-Meter**

Fluke Model 87 III  
SN: 85290183  
Cal. Due: 4/20/2012

### **Temperature Chamber**

Test Equity Model 1000H  
SN: 61135  
Cal. due: 2/17/2012

### **Tests Performed**

Temperature December 1-2, 2011  
Voltage November 23, 2011

### **Temperature & Voltage**

Unit Tested : 2011-006S Rev. C  
Temperature & Voltage: SN: 80003491

## 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 2011-006S transmitter was tested for transient frequency behavior using the test method of TIA/EIA-603-C. A block diagram of the test setup is seen in Fig. 2. A Hexagram model 9975G-WB receiver was used. The storage oscilloscope was triggered by the output of the RSSI output of the receiver. 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 2011-006S.

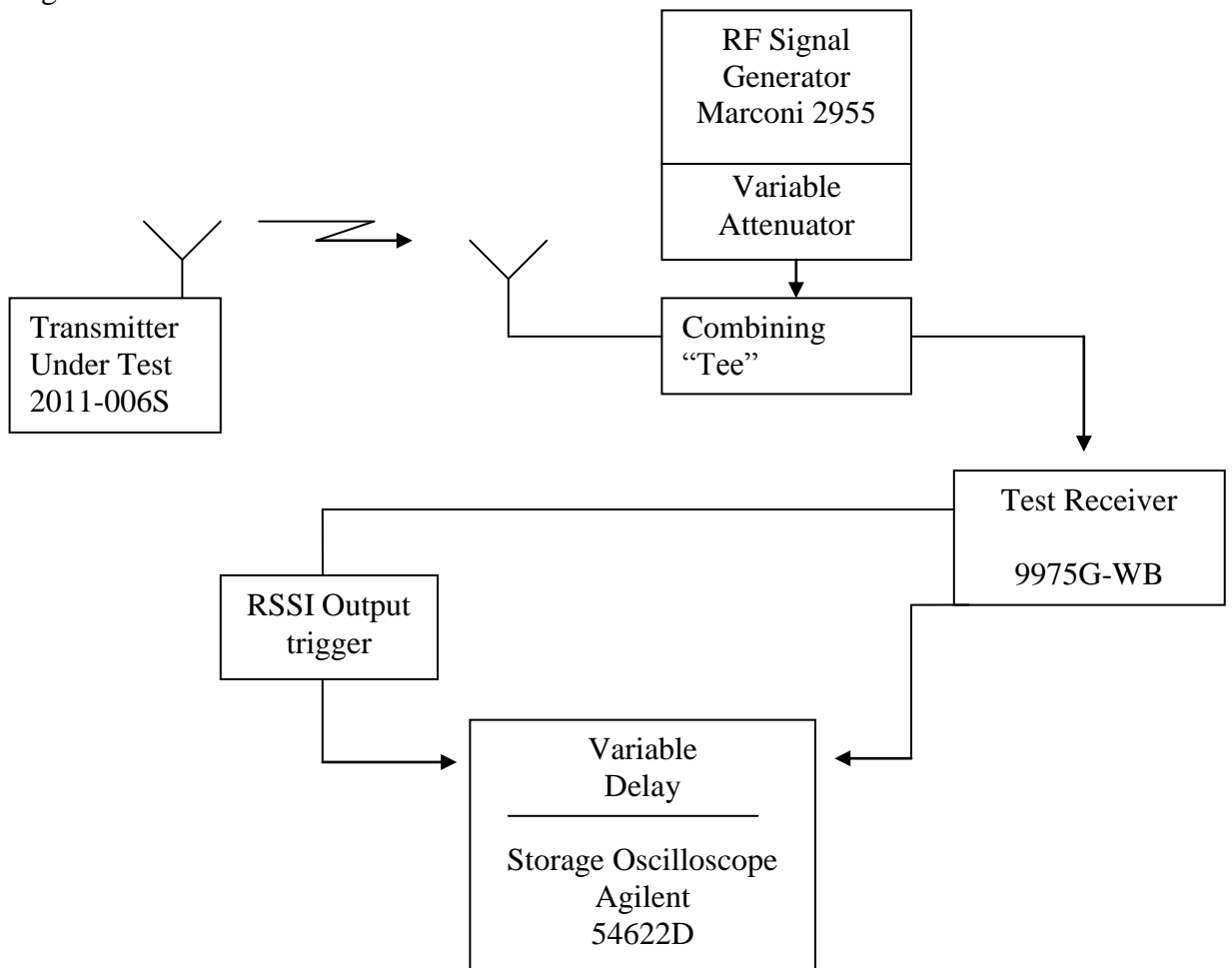


Fig. 2  
Transient Frequency Behavior  
Test Setup



## 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  $\pm 12.5$  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  $\pm 6.25$  kHz.
3. Frequency deviation after  $t_2$  must be less than  $\pm 2.5$  ppm, or  $\pm 1150$  Hz at 460 MHz.
4. Frequency deviation during  $t_3$  (10 ms duration after transmitter is turned off) may exceed  $\pm 12.5$  kHz because output power is less than 6 Watts.

## Test Data

Figures 3 through 7 show the Model 2011-006S transient frequency characteristics. The limit masks are indicated on each of the figures.

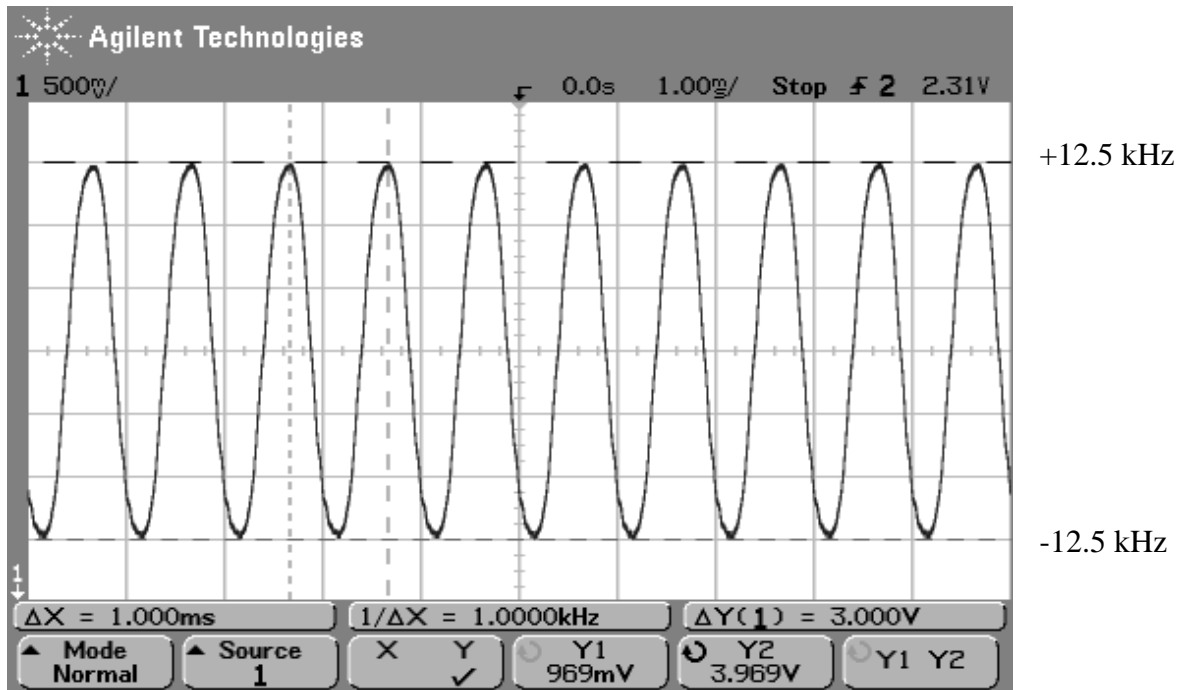


Fig. 3  $\pm 12.5$  kHz modulated test signal .

- $\pm 12.5$  kHz = 3.00 V
- $\pm 6.25$  kHz = 1.50 V
- $\pm 1.15$  kHz = 276 mV

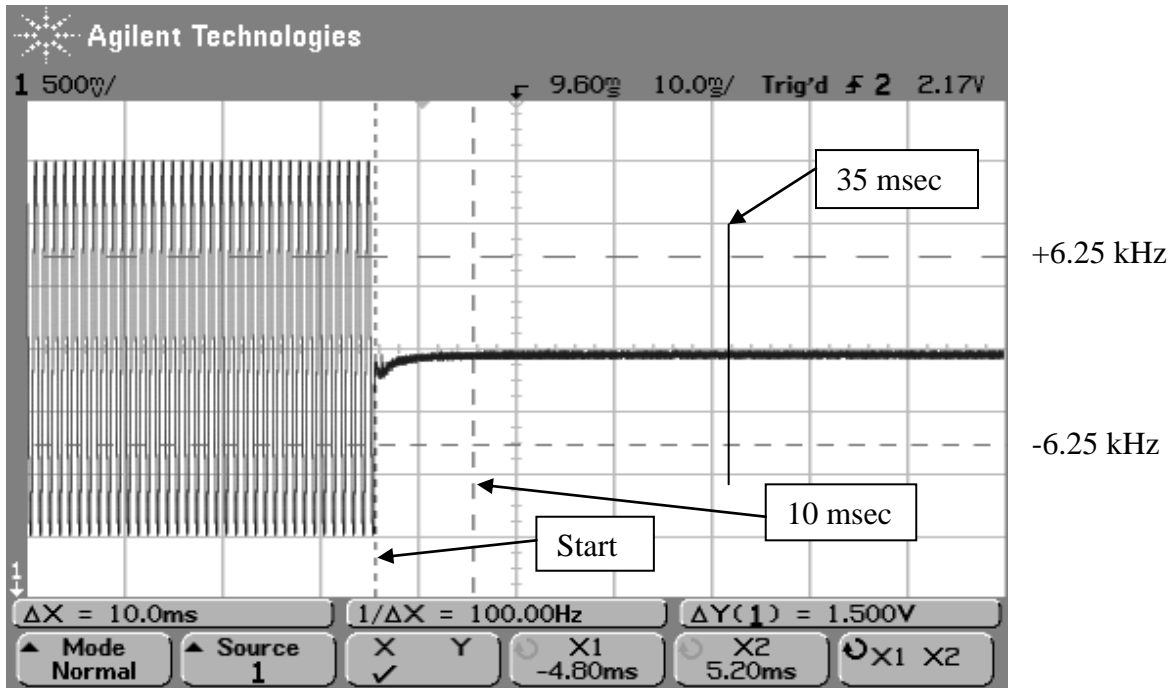


Fig. 4 Start of Transmission

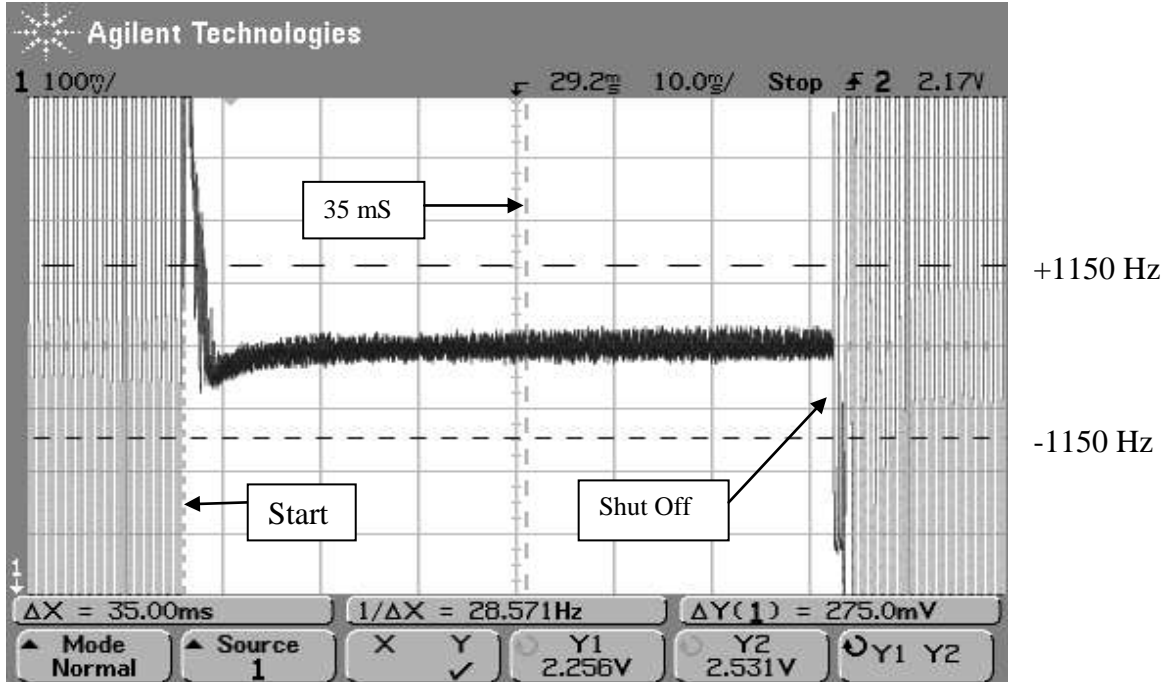
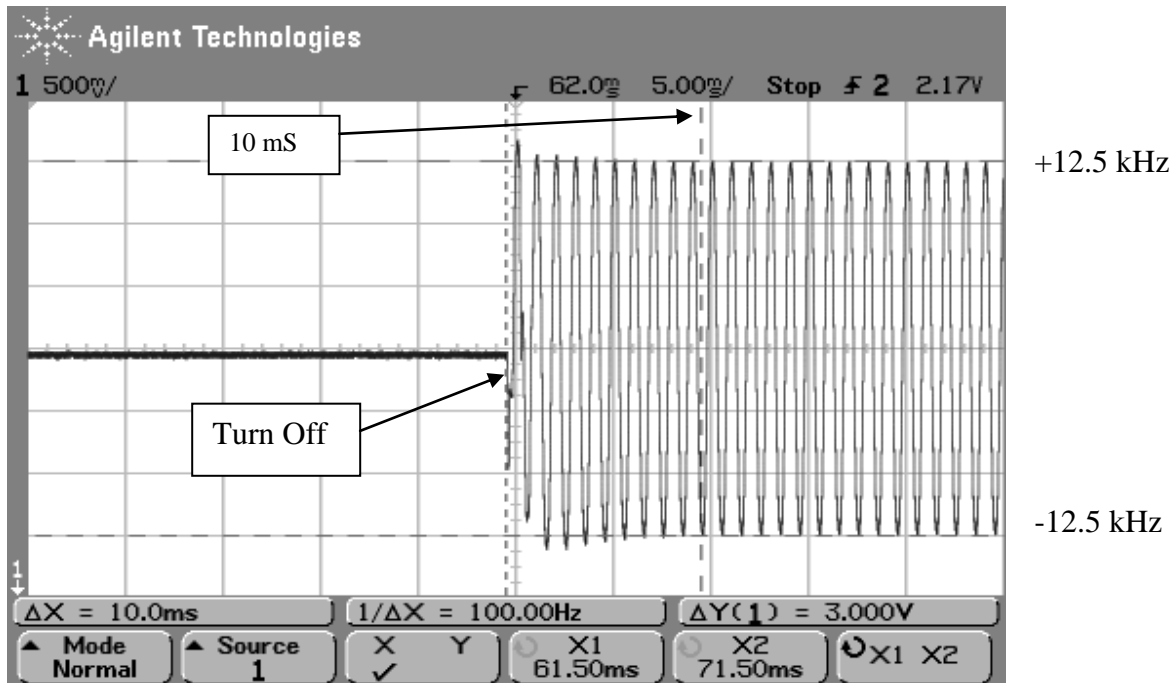


Fig. 5 Full Transmission



**Fig. 6 Turn Off Transient**

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

### TEST EQUIPMENT USED

<b>Signal Generator</b>	Marconi Model 2955 RF Test Set S/N 132061 Cal Due: 2/25/2012
<b>Test Receiver</b>	Hexagram 9975G-WB w/ RSSI trigger output
<b>Oscilloscope</b>	Agilent Model 54622D SN: MY40003551 Cal Due: 2/28/12
<b>Rx Antenna</b>	Antenna Specialists Model AV-15 450 – 470 MHz
<b>Test Performed</b>	November 21, 2011

Unit Tested: 2011S-006 Rev. C SN: 80003491

## **TEST INFORMATION**

### **SUMMARY**

The Hexagram Model 2011-006S 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 2011-006S Rev. C

### **MANUFACTURER**

Hexagram, Inc.  
30400 Solon Rd.  
Solon, OH 44139

### **TEST DATES**

November 8, 2011 – March 7, 2012

### **OPEN AREA TEST SITE**

Smith Electronics, Inc.  
8200 Snowville Road  
Cleveland, OH 44141  
(330) 289-9306

FCC (Reg. #90938)