ACLARA TECHNOLOGIES LLC

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ENGINEERING TEST REPORT

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HIGH READ-RATE
WATER METER TRANSMITTING UNIT

Model 2009-010B4
FCC ID: LLB09010B4
IC: 4546A-09010B4

May 16, 2012
Revised March 4, 2013

Report Prepared by

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Agency Certification Control Technician

TEST REPORT

INTRODUCTION

The Aclara Model 2009-010B4 transceiver is a "Meter Transmitting Unit" (MTU) designed to provide remote meter reading capability for utility meters that provide a pulsed or encoded output. The transceiver is self-powered and connects to the output of 1 or 2 water meters with an electrical cable. An on-board battery provides power. The transmitter provides a very short, intermittent radio frequency transmission to send 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 for upgrading firmware, requests for meter reads or other options available in the system. Special test firmware was used for testing in order to provide longer transmission than for normal operation. A prototype unit was used as a test subject for this report. The report presents the data obtained in support of an application for certification under Part 90 of the FCC rules and RSS-119-iss11 of Industry Canada.

MEASUREMENTS PERFORMED

UNITS TESTED

2009-010B4   SN's: – G 05309 & G 05299

LOW FREQUENCY EMISSIONS

Low frequency emissions were examined from 30 kHz to 330 MHz using an active loop antenna and a biconical antenna. Non-harmonic emissions above 330 MHz to 1000 MHz were determined with tuned dipoles.

All emissions observed between 30 kHz and 1 GHz, other than the harmonics of the transmitter were determined to be more than 20 dB below the limit levels for spurious emissions of Part 90.210 and RSS-119.

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280A SN: J300168 Cal Due: 4/27/2013
	Hewlett-Packard Model 8563A SN: 3020A00248 Cal Due 8/8/2012
Antennas	AH Systems Model SAS-563B Active Loop SN: 424 Frequency Range 1 kHz – 30 MHz Cal Date: 2/21/2012 Cal Due: 2/21/2013
	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:	April 30 – May 3, 2012

Unit Tested: 2009-010B4   SN: G 05309

POWER OUTPUT AND SPURIOUS EMISSIONS

Within the tuning range of 450 – 470 MHz, the transmitter portion of the Model 2009-010B4 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 a larger, external battery pack was connected directly to the transmitter and the transmitter was forced to transmit a 30 seconds on and 30 seconds off cycle for these measurements. A ferrite bead was placed on the external battery leads to minimize emissions that might come from the 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 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:

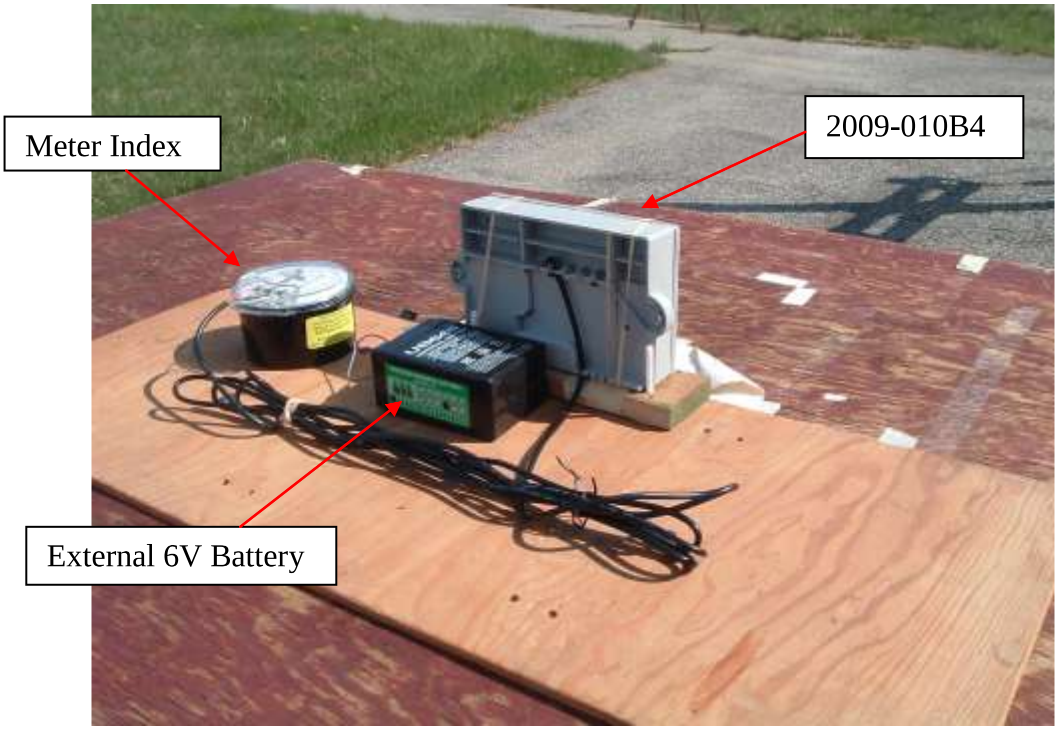
$$P_d = P_g - \text{cable loss(dB)} + \text{antenna gain}(dB_d)$$

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 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 2009-010B4, MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP



PICTORIAL 2
HEXAGRAM MODEL 2009-010B4, MTU
OUTPUT POWER AND SPURIOUS EMISSIONS
TYPICAL TEST SETUP

TABLE 1a
ACLARA MODEL 2009-010B4 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)	Δ (dBc)	Δ (dB Limit)
450	25.8	2.1	-1.0	22.7		
900	-28.2	3.2	-0.7	-32.1	-54.8	-12.1

Output = 22.7 dBm
= 0.186 W
Req. Att.= 42.7 dBm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1350	-35.0	0.8	6.5	-29.3	-52.0	-9.3
1800	-44.2	1.0	7.4	-37.8	-60.5	-17.8
2250	-36.1	1.2	6.2	-31.1	-53.8	-11.1
2700	-51.3	1.3	6.4	-46.2	-68.9	-26.2
3150	-55.1	1.4	7.2	-49.3	-72.0	-29.3
3600	-45.3	1.6	8.3	-38.6	-61.3	-18.6
4050	-43.9	1.7	8.0	-37.6	-60.3	-17.6
4500	-40.2	1.8	8.6	-33.4	-56.1	-13.4

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Δ (dBc)	Δ (dB Limit)
450	28.4	2.1	-1.0	25.3		
900	-28.7	3.2	-0.7	-32.6	-57.9	-12.6

Output = 25.3 dBm
= 0.339 W
Req. Att.= 45.3 dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1350	-38.8	0.8	6.5	-33.1	-58.4	-13.1
1800	-43.3	1.0	7.4	-36.9	-62.2	-16.9
2250	-36.4	1.2	6.2	-31.4	-56.7	-11.4
2700	-52.6	1.3	6.4	-47.5	-72.8	-27.5
3150	-56.9	1.4	7.2	-51.1	-76.4	-31.1
3600	-46.5	1.6	8.3	-39.8	-65.1	-19.8
4050	-50.5	1.7	8.0	-44.2	-69.5	-24.2
4500	-40.6	1.8	8.6	-33.8	-59.1	-13.8

TABLE 1b
ACLARA MODEL 2009-010B4 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)	Δ (dBc))	Δ (dB Limit)
460	26	2.2	-1.1	22.7		
920	-20.8	3.3	-1.1	-25.2	-47.9	-5.2

Output = 22.7 dBm
= 0.186 W
Req. Att.= 42.7 dBm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1380	-48.7	0.9	6.8	-42.8	-65.5	-22.8
1840	-52.8	1.0	7.2	-46.6	-69.3	-26.6
2300	-39.6	1.2	6.2	-34.6	-57.3	-14.6
2760	-45.1	1.3	6.5	-39.9	-62.6	-19.9
3220	-45.7	1.4	7.5	-39.6	-62.3	-19.6
3680	-37.9	1.6	8.3	-31.2	-53.9	-11.2
4140	-42.2	1.7	8.1	-35.8	-58.5	-15.8
4600	-36	1.8	8.4	-29.4	-52.1	-9.4

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Δ (dBc)	Δ (dB Limit)
460	28.4	2.2	-1.1	25.1		
920	-21.7	3.3	-1.1	-26.1	-51.2	-6.1

Output = 25.1 dBm
= 0.324 W
Req. Att.= 45.1 dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1380	-48.3	0.9	6.8	-42.4	-67.5	-22.4
1840	-47.3	1.0	7.2	-41.1	-66.2	-21.1
2300	-36	1.2	6.2	-31	-56.1	-11
2760	-47.5	1.3	6.5	-42.3	-67.4	-22.3
3220	-46.4	1.4	7.5	-40.3	-65.4	-20.3
3680	-38.2	1.6	8.3	-31.5	-56.6	-11.5
4140	-47.3	1.7	8.1	-40.9	-66	-20.9
4600	-38.8	1.8	8.4	-32.2	-57.3	-12.2

TABLE 1c
ACLARA MODEL 2009-010B4 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)	Δ (dBc)	Δ (dB Limit)
470	25.6	2.2	-1.2	22.2		
940	-17.2	3.3	-1.1	-21.6	-43.8	-1.6

Output = 22.2 dBm
= 0.166 W
Req. Att.= 42.2 dBm

Horizontal 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1410	-53.3	0.9	7.0	-47.2	-69.4	-27.2
1880	-50.4	1.0	7.0	-44.4	-66.6	-24.4
2350	-41.7	1.2	6.3	-36.6	-58.8	-16.6
2820	-43.9	1.3	6.5	-38.7	-60.9	-18.7
3290	-41.0	1.5	7.8	-34.7	-56.9	-14.7
3760	-30.9	1.6	8.2	-24.3	-46.5	-4.3
4230	-43.0	1.7	8.2	-36.5	-58.7	-16.5
4700	-35.8	1.8	8.2	-29.4	-51.6	-9.4

Vertical 3 meter measurement using tuned dipole antenna

Freq. (MHz)	Gen. Output (dB)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (dBm)	Δ (dBc)	Δ (dB Limit)
470	28.6	2.2	-1.2	25.2		
940	-25.7	3.3	-1.1	-30.1	-55.3	-10.1

Output = 25.2 dBm
= 0.331W
Req. Att.= 45.2 dBm

Vertical 1 meter measurement using horn antenna

Freq. (MHz)	Gen. Output (dBm)	Coax Loss (dB)	Ant. Gain (dBd)	Dipole Eq. Power (Dbm)	Δ (dBc)	Δ (dB Limit)
1410	-52.9	0.9	7.0	-46.8	-72.0	-26.8
1880	-48.8	1.0	7.0	-42.8	-68.0	-22.8
2350	-38.0	1.2	6.3	-32.9	-58.1	-12.9
2820	-46.3	1.3	6.5	-41.1	-66.3	-21.1
3290	-42.2	1.5	7.8	-35.9	-61.1	-15.9
3760	-34.6	1.6	8.2	-28.0	-53.2	-8.0
4230	-41.6	1.7	8.2	-35.1	-60.3	-15.1
4700	-37.9	1.8	8.2	-31.5	-56.7	-11.5

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 F 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	April 18 - 20, 2012

Unit Tested: 2009-010B4 SN: G 05309

OCCUPIED BANDWIDTH

The emissions close to the center of the specified channel are limited by the emissions masks described in Part 90.210. For the frequency range of the 2009-010B4 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 0.339 W, 50 + 10 log(0.339) equals 45.3 dB. The mask measurement was a conducted measurement, and as seen in Fig. 1, the measured output power was 27.1dBm so the maximum allowed is shown on the plot as -20 dBm or 47.1 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.

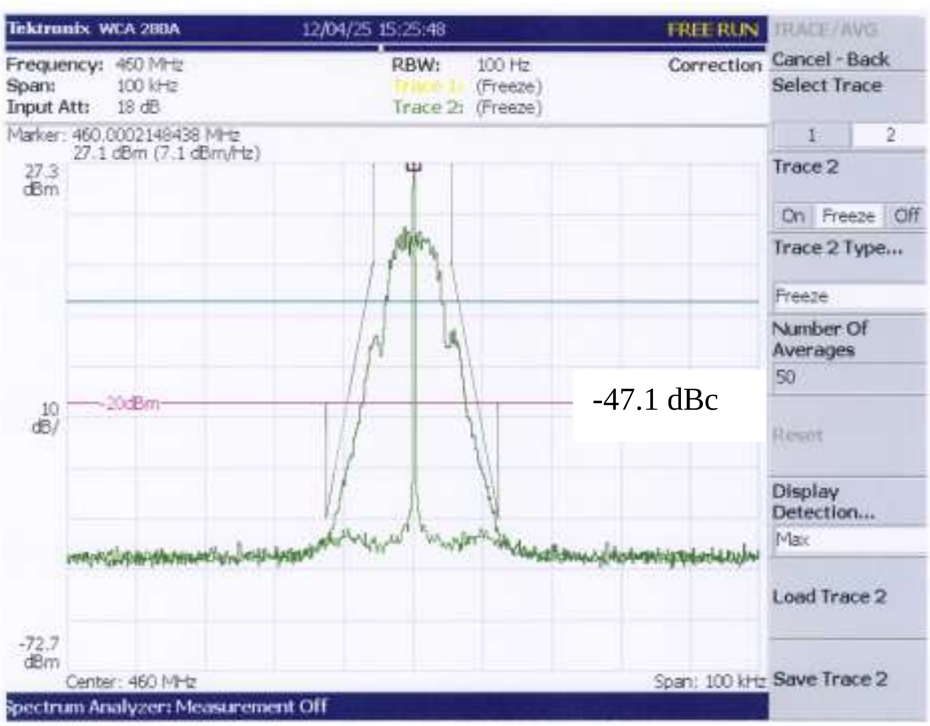


Fig. 1
Hexagram Model 2009-010B4
Emissions Mask

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280A SN: J300168 Cal Due: 4/26/2012
Antenna	Conducted measurement
Test Performed	April 25, 2012

Unit Tested: SN: G 05309

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 frequency tolerance 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	460.000176	176	0.383
+40	460.000156	156	0.339
+50	460.000176	176	0.383
+60	460.000215	215	0.467
+70	460.000254	254	0.552
+80	460.000352	352	0.765
+85	460.000352	352	0.765
+20	160.000234	234	0.509
+10	460.000215	215	0.467
0	460.000234	234	0.509
-10	46.000273	273	0.593
-20	460.000215	215	0.467
-30	460.000313	313	0.680
-40	460.000313	313	0.680
+20	460.000215	215	0.467

Reference frequency = 460.000000 MHz

FREQUENCY STABILITY VS. SUPPLY VOLTAGE

To vary the DC test voltage, a variable DC source was connected to the transmitter, in place of BT1. The frequency was measured at the TIA default standard of 7.50 V (2x3.75 V)of the Lithium Ion battery pack, and at, or below, the 85% level of 6.37 V.

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 frequency tolerance of ±2.5 ppm or 1150 Hz at the 460 MHz test frequency.

TABLE 3
FREQUENCY STABILITY
VS. SUPPLY VOLTAGE
460 MHz

INPUT Volts DC	Measured Frequency MHz	Dev. Hz	Dev. ppm
7.5	460.000293	293	0.636
7.2	460.000293	293	0.636
7.0	460.000293	293	0.636
6.5	460.000293	293	0.636
6.0	460.000293	293	0.636
5.5	460.000293	293	0.636
5.0	460.000273	273	0.593
4.5	460.000273	273	0.593
4.0	460.000273	273	0.593

Reference frequency = 460.000000 MHz

TEST EQUIPMENT USED

Spectrum Analyzer	Tektronix Model WCA 280 S/N J300168 Cal Due: 4/27/2013
Antenna	Antenna Specialists AV-15 (450 – 470 MHz)
DC Power Supply	MPJA DC Regulated Supply SN: 012021
Digital Multi-Meter	Fluke Model 117 SN: 98940615 Cal. Due: 2/15/2013
Temperature Chamber	Test Equity Model 1007H Cal. due: 2/17/2014
Tests Performed	Temperature: 5/8 – 10/2012 Voltage: 5/10/2012

Unit Tested: Temperature & Voltage: SN: G 05299

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 2009-010B4 transmitter was tested for transient frequency behavior using the test method of TIA/EIA-603 Rev C. 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 8657B 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 2009-010B4.

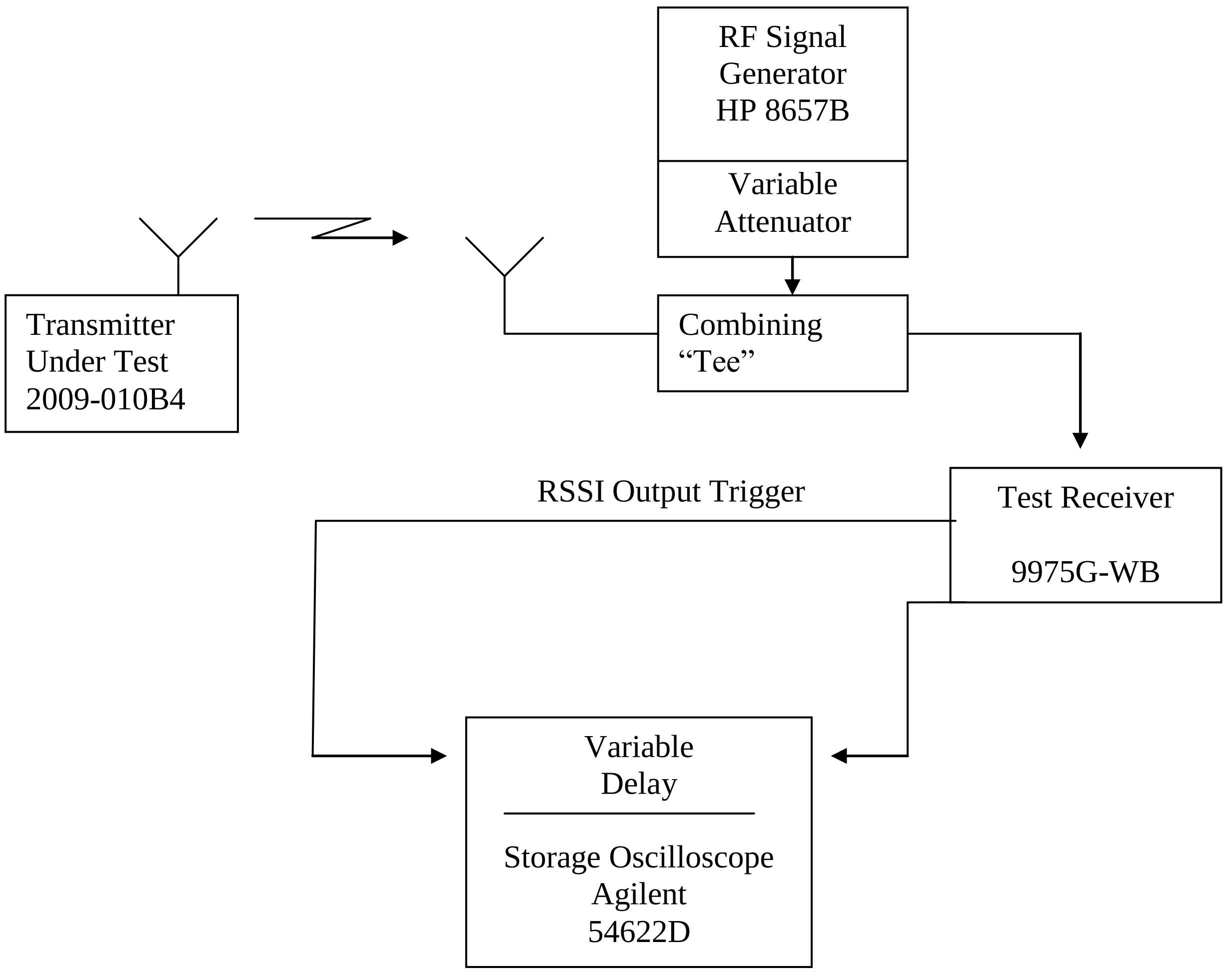


Fig. 2
Transient Frequency Behavior
Test Setup

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 2009-010B4's transient frequency characteristics. The limit masks are indicated on each of the figures.

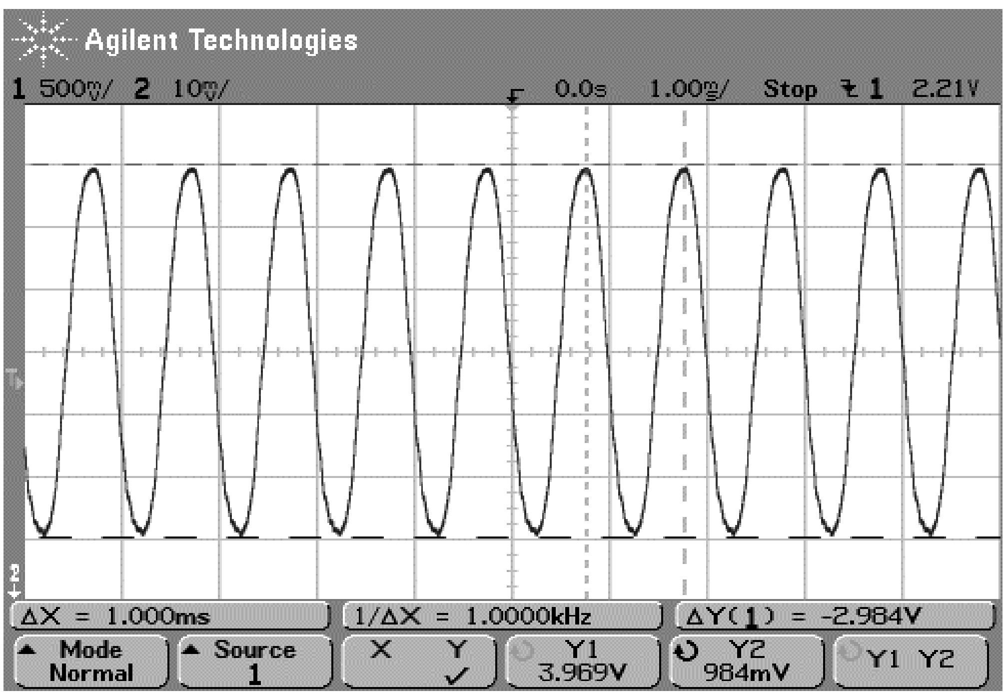


Fig. 3   ±12.5 kHz modulated test signal   .

±12.5 kHz = 2.98 V
±6.25 kHz = 1.49 V
±1.15 kHz = 275 mV

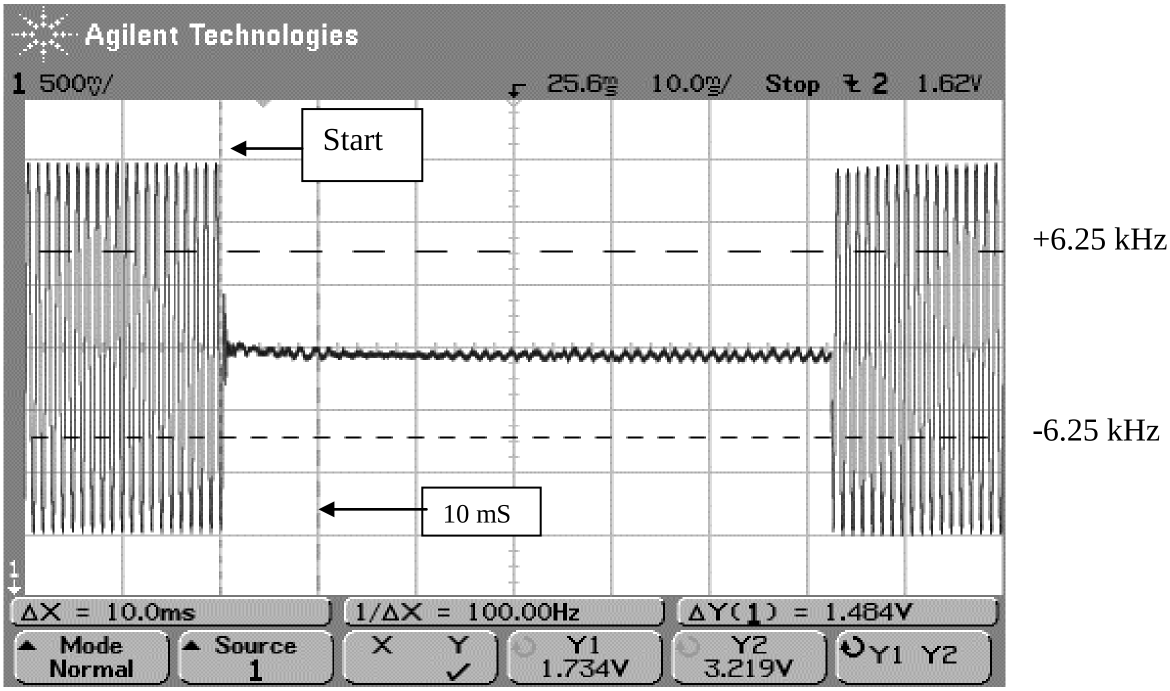


Fig. 4   Start of Transmission

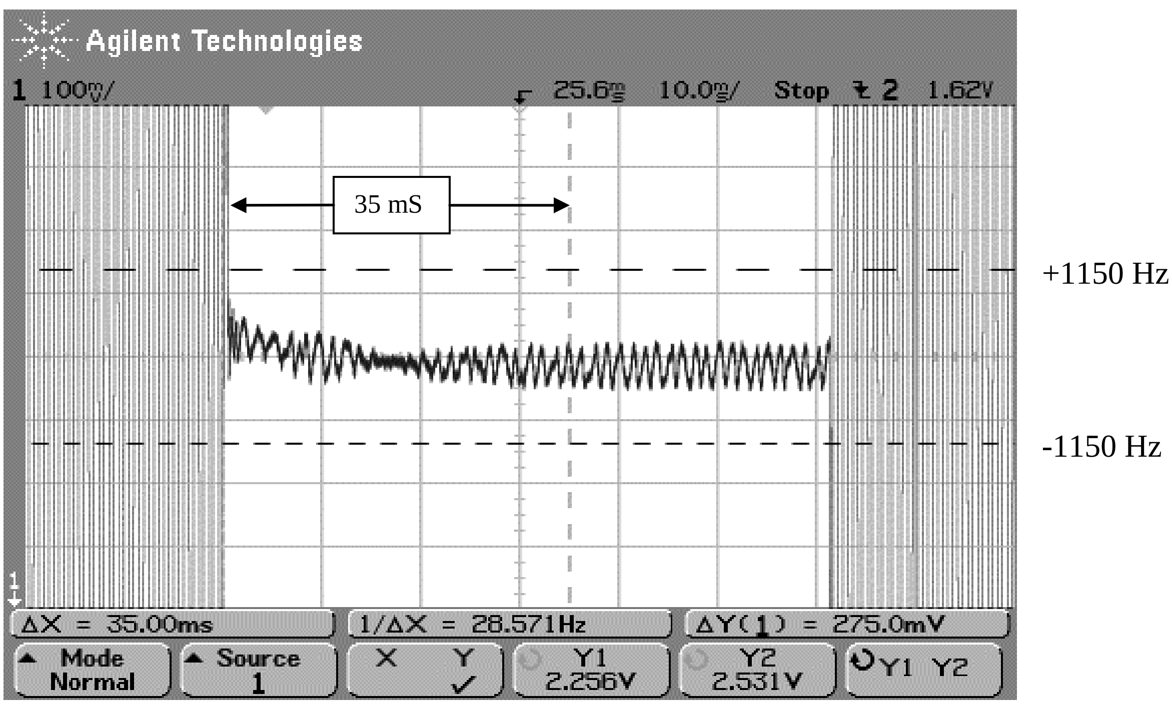


Fig. 5   Full Transmission

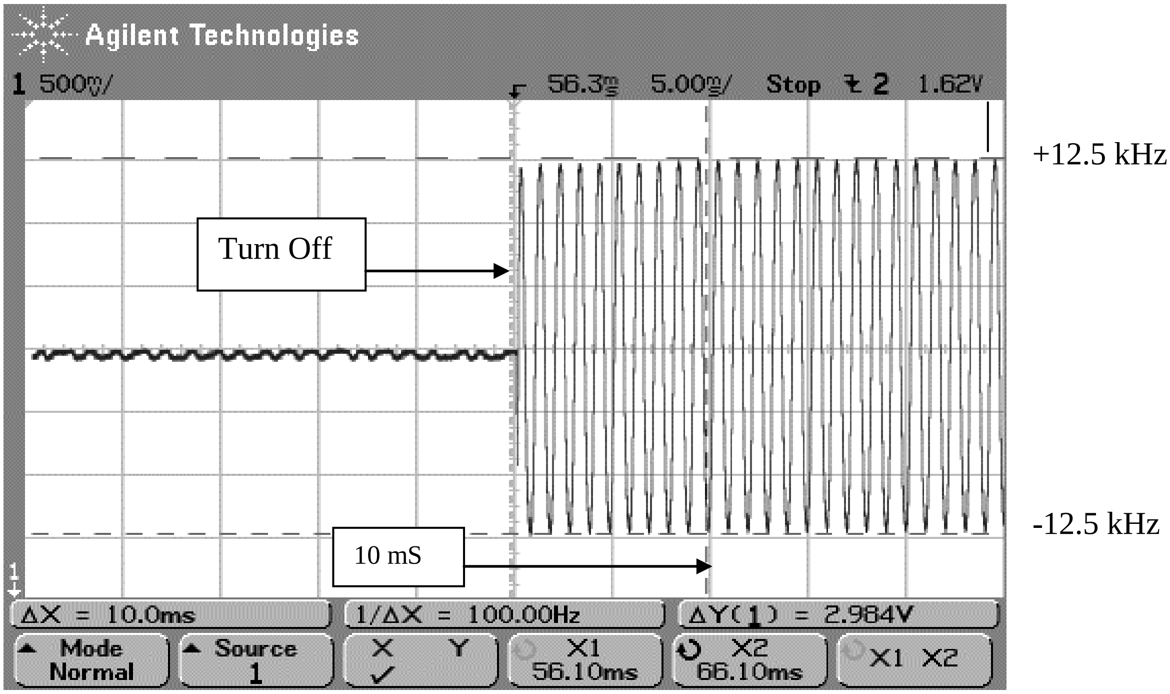


Fig. 6 Turn Off Transient

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	Hewlett-Packard Model 8657B Signal Generator SN: 3631U08840 Cal Due: 7/22/2012
Test Receiver	Hexagram Broadband Receiver Model 9975G-WB
Oscilloscope	Agilent Model 54622D SN: MY40003551 Cal Due: 2/15/2013
Test Performed	May 10, 2012

Unit Tested: SN: G 05309

TEST INFORMATION

SUMMARY

The Aclara Model 2009-010B4 transmitter has been shown to be capable of complying with the following transmitter requirements.

Federal Communications Commission	Part 90
Industry Canada	RSS-119-iss11

EQUIPMENT UNDER TEST	MTU Transmitter, Model 2009-010B4
MANUFACTURER	Aclara Technologies LLC 30400 Solon Rd. Solon, OH 44139
TEST PROCEDUREs	TIA/EIA-603-C ANSI C63.4-2003
TEST DATES	April 18 – May 10, 2012
OPEN AREA TEST SITE	Smith Electronics, Inc. 8200 Snowville Road Cleveland, OH 44141 (330) 289-9306 FCC (Reg. #90938) Industry Canada (Reg. #4541A-1)