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Measured Radio Frequency Emissions
From

TRW Inc. Transmitter
FCC ID: GQ4-52T
IC: 1470A-33T

Test Report No. 417124-618
February 20, 2012

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Summary

Tests for compliance with FCC Regulations, CFR 47, Part 15 and with Industry Canada RSS-210/Gen, were performed on a TRW, FCC ID: GQ4-52T, IC: 1470A-33T. This device under test (DUT) is subject to the rules and regulations as a Transmitter.

In testing completed on November 22, 2011, the DUT tested met the allowed specifications for radiated emissions by 2.8 dB. Conducted emissions are not subject to regulation as the DUT is powered by a 3 VDC battery.

Table of Contents

1. Introduction 3
2. Equipment Used 3
3. Device Under Test 4
   3.1 Description & Block Diagram 4
   3.2 Variants and Samples 4
   3.3 Modes of Operation 4
   3.4 Exemptions 4
   3.5 EMC Relevant Modifications 4
4. Emissions Limits 5
   4.1 Radiated Emissions Limits 5
5. Measurement Procedures 6
   5.1 Semi-Anechoic Chamber Radiated Emissions 6
   5.2 Outdoor Radiated Emissions 6
   5.3 Radiated Field Computations 6
   5.4 Indoor Power Line Conducted Emissions 6
   5.5 Supply Voltage Variation 7
6. Test Results 7
   6.1 Radiated Emissions 7
   6.1.1 Correction for Pulse Operation 7
   6.1.2 Emission Spectrum 7
   6.1.3 Emission Bandwidth 7
   6.1.4 Supply Voltage and Supply Voltage Variation 7
   6.2 Conducted Emissions 7

1. Introduction

This TRW Transmitter was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989 as subsequently amended, and with Industry Canada RSS-210/Gen, Issue 8. Tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-2003 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The Site description and attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland (FCC Reg. No: 91050) and with Industry Canada, Ottawa, ON (File Ref. No: IC 2057A-1).

2. Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1. Except where indicated as a pre-test, monitoring, or support device; all equipment listed below is a part of the University of Michigan Radiation Laboratory (UMRL) quality system. This quality system has been established to ensure all equipment has a clearly identifiable classification, calibration expiry date, and that all calibrations are traceable to national standards.

Table 2.1 Test Equipment.

Test Instrument	Used	Manufacturer/Model	Q Number
Spectrum Analyzer (9kHz-26GHz)	☒	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)	☒	Hewlett-Packard 8595E, SN: 3543A01546	JDB8595E
Power Meter	☐	Hewlett-Packard, 432A	HP432A1
Harmonic Mixer (26-40 GHz)	☐	Hewlett-Packard 11970A, SN: 3003A08327	HP11970A1
Harmonic Mixer (40-60 GHz)	☐	Hewlett-Packard 11970U, SN: 2332A00500	HP11970U1
Harmonic Mixer (75-110 GHz)	☐	Hewlett-Packard 11970W, SN: 2521A00179	HP11970W1
Harmonic Mixer (140-220 GHz)	☐	Pacific Millimeter Prod., GMA, SN: 26	PMPGMA1
S-Band Std. Gain Horn	☐	S/A, Model SGH-2.6	SBAND1
C-Band Std. Gain Horn	☐	University of Michigan, NRL design	CBAND1
XN-Band Std. Gain Horn	☐	University of Michigan, NRL design	XNBAND1
X-Band Std. Gain Horn	☐	S/A, Model 12-8.2	XBAND1
X-band horn (8.2- 12.4 GHz)	☐	Narda 640	XBAND2
X-band horn (8.2- 12.4 GHz)	☐	Scientific Atlanta , 12-8.2, SN: 730	XBAND3
K-band horn (18-26.5 GHz)	☐	FXR, Inc., K638KF	KBAND1
Ka-band horn (26.5-40 GHz)	☐	FXR, Inc., U638A	KABAND1
U-band horn (40-60 GHz)	☐	Custom Microwave, HO19	UBAND1
W-band horn(75-110 GHz)	☐	Custom Microwave, HO10	WBAND1
G-band horn (140-220 GHz)	☐	Custom Microwave, HO5R	GBAND1
Bicone Antenna (30-250 MHz)	☒	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	☒	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	☒	University of Michigan, RLDP-1,-2,-3	UMDIP1
Dipole Antenna Set (30-1000 MHz)	☐	EMCO 3121C, SN: 992 (Ref. Antennas)	EMDIP1
Active Rod Antenna (30 Hz-50 MHz)	☐	EMCO 3301B, SN: 3223	EMROD1
Active Loop Antenna (30 Hz-50 MHz)	☐	EMCO 6502, SN:2855	EMLOOP1
Ridge-horn Antenna (300-5000 MHz)	☒	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	☒	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	☒	Avantek	AVAMP2
Amplifier (4.5-13 GHz)	☐	Avantek, AFT-12665	AVAMP3
Amplifier (6-16 GHz)	☐	Trek	TRAMP1
Amplifier (16-26 GHz)	☐	Avantek	AVAMP4
LISN Box	☐	University of Michigan	UMLISN1
Signal Generator	☐	Hewlett-Packard 8657B	HPSG1

3. Device Under Test

3.1 Description & Block Diagram

The DUT is a dual frequency 312.10 MHz and 314.35 MHz FSK transmitter designed for automotive/vehicular applications. It is powered by a 3 VDC lithium battery and is housed in a plastic case approximately 2 x 3 x 0.5 cm in dimension. The DUT is designed and manufactured by TRW Automotive, 24175 Research Drive, Farmington Hills, MI 48335-2642.

Device	[Make], Model	Description	EMC Consideration
DUT	[TRW], 226624-101	3 button	15.231(a), RSS-210
DUT	[TRW], 226624-102	4 button	15.231(a), RSS-210

3.2 Variants and Samples

There are two variants of the DUT, a 3 button version and a 4 button version. The 3 button variant is electrically identical to the 4 button device, with a single button/switch depopulated. For the 226624-102 variant, one normal operating sample and one each of software modified samples transmitting CW at 312.10 and 314.35 MHz were provided. For the 226624-101 (3 button) variant, only a single CW operating sample was provided for emissions comparison at the worst case emission frequency (fundamental).

3.3 Modes of Operation

The EUT is capable of only a single mode of operation. In the first single button press, the EUT will transmit an FSK frame at 312.10 MHz. The next single button press will result in a single FSK frame transmission at 314.35 MHz. Holding down a button on the EUT may result in alternating 312.10 MHz and 314.35 MHz transmissions at no less than 1 second intervals.

3.4 Exemptions

None.

3.5 EMC Relevant Modifications

No EMI Relevant Modifications were performed by this test laboratory.

4. Emissions Limits

4.1 Radiated Emissions Limits

The DUT tested falls under the category of an Intentional Radiator. The applicable testing frequencies and corresponding emission limits set by both the FCC and IC are given in Tables 4.1 and 4.2 below.

Table 4.1. TX Emission Limits (FCC: 15.231(b), .205(a); IC: RSS-210 2.7 T4).

Frequency (MHz)	Fundamental Ave. E_{lim} (3m) (μV/m)	dB (μV/m)	Spurious** Ave. E_{lim} (3m) (μV/m)	dB (μV/m)
260.0-470.0	3750-12500*		375-1250	
315	6042	75.6	604.2	55.6
433.9	10966	80.8	1096.6	60.8
322-335.4 399.9-410 608-614	Restricted Bands		200	46.0
960-1240/1427(IC) 1300-1427 1435-1626.5 1645.5-1646.5 (IC) 1660-1710 1718.9-1722.2 2200-2300	Restricted Bands		500	54.0

* Linear interpolation, formula: E = -7083 + 41.67*f (MHz)
** Measure up to tenth harmonic; 120 kHz BW up to 1 GHz, 1 MHz BW above 1 GHz

Table 4.2. Spurious Emission Limits (FCC: 15.33, .35, .109/209; IC: RSS-210 2.7, T2)

Freq. (MHz)	E_{lim} (3m) μV/m	E_{lim} dB(μV/m)
30-88	100	40.0
88-216	150	43.5
216-960	200	46.0
960-2000	500	54.0

Note: Average readings apply above 1000 MHz (1 MHz BW), Quasi-Peak readings apply to 1000 MHz (120 kHz RBW), PRF of intentional emissions > 20 Hz for QPK to apply.

Power Line Conducted Emissions Limits

Table 4.3 Emission Limits (FCC:15.107 (CISPR); IC: RSS-Gen, 7.2.2 T2).

Frequency (MHz)	Class A (dBμV) Quasi-peak	Class A (dBμV) Average	Class B (dBμV) Quasi-peak	Class B (dBμV) Average
.150 - 0.50	79	66	66 - 56*	56 - 46*
0.50 - 5	73	60	56	46
5 - 30	73	60	60	50

Notes:
1. The lower limit shall apply at the transition frequency
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15-0.50 MHz:
   *Class B Quasi-peak: dBμV = 50.25 - 19.12*log(f)
   *Class B Average: dBμV = 40.25 - 19.12*log(f)
3. 9 kHz RBW

5. Measurement Procedures

5.1 Semi-Anechoic Chamber Radiated Emissions

To become familiar with the radiated emission behavior of the DUT, the device is first studied and measured in our shielded semi-anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with a turntable, an antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

The DUT is laid on the test table as shown in the included block diagram and/or photographs. A shielded loop antenna is employed when studying emissions from 9 kHz to 30 MHz. Above 30 MHz and below 250 MHz a biconical antenna is employed. Above 250 MHz a ridge or and standard gain horn antennas are used. The spectrum analyzer resolution and video bandwidths are set so as to measure the DUT emission without decreasing the emission bandwidth (EBW) of the device. Emissions are studied for all orientations (3-axes) of the DUT and all test antenna polarizations. In the chamber, spectrum and modulation characteristics of intentional carriers are recorded. Receiver spurious emissions are measured with an appropriate carrier signal applied. Associated test data is presented in subsequent sections.

5.2 Outdoor Radiated Emissions

After measurements are performed indoors, emissions on our outdoor 3-meter Open Area Test Site (OATS) are made, when applicable. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration. Any intentionally radiating elements are placed on the test table flat, on their side, and on their end (3-axes) and worst case emissions are recorded. For each configuration the DUT is rotated 360 degrees about its azimuth and the receive antenna is raised and lowered between 1 and 4 meters to maximize radiated emissions from the device. Receiver spurious emissions are measured with an appropriate carrier signal applied. For devices with intentional emissions below 30 MHz, our shielded loop antenna at a 1 meter receive height is used. Low frequency field extrapolation to the regulatory limit distance is employed as needed. Emissions between 30 MHz and 1 GHz are measured using tuned dipoles and/or biconical antennas. Care is taken to ensure that the RBW and VBW used meet the regulatory requirements, and that the EBW of the DUT is not reduced. The Photographs included in this report show the Test Setup.

5.3 Radiated Field Computations

To convert the dBm values measured on the spectrum analyzer to dB(μV/m), we use expression

$$E3(dB\mu V/m) = 107 + PR + KA - KG + KE - CF$$

where
- PR = power recorded on spectrum analyzer, dBm, measured at 3 m
- KA = antenna factor, dB/m
- KG = pre-amplifier gain, including cable loss, dB
- KE = duty correction factor, dB
- CF = distance conversion (employed only if limits are specified at alternate distance), dB

When presenting the data at each frequency, the highest measured emission under all of the possible DUT orientations (3-axes) is given.

5.4 Indoor Power Line Conducted Emissions

When applicable, power line conducted emissions are measured in our semi-anechoic chamber. If the DUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.4 are employed. Alternatively, an on-table layout more representative of actual use may be employed if the resulting emissions appear to be worst-case in such a configuration.

The conducted emissions measured with the spectrum analyzer and recorded (in dBμV) from 0-2 MHz and 2-30 MHz for both the ungrounded (Hi) and grounded (Lo) conductors. The spectrum analyzer is set to peak-hold mode in order to record the highest peak throughout the course of functional operation. Only when the emission exceeds or is near the limit are quasi-peak and average detection used.

5.5 Supply Voltage Variation

Measurements of the variation in the fundamental radiated emission were performed with the supply voltage varied by no less than 85% and 115% of the nominal rated value. For battery operated equipment, tests were performed using a new battery, and worst case emissions are re-checked employing a new battery.

6. Test Results

6.1 Radiated Emissions

6.1.1 Correction for Pulse Operation

When the transmitter is activated by manual button press, it will, in the worst case, transmit no less than one FSK frame that is 700 ms in length. See Figure 6.1. As the transmission length is greater than 100 ms, no duty cycle is employed.

$$K_E = 0 \text{ dB}$$

6.1.2 Emission Spectrum

The relative DUT emission spectrum is recorded and is shown in Figure 6.2.

6.1.3 Emission Bandwidth

The emission bandwidth of the signal is shown in Figure 6.3 at each of the two operating frequencies. Per FCC KDB 926416, if the highest frequency used is less than 900 MHz, the cumulative bandwidth for any mode employing multiple frequencies is restricted to 0.0025 (.25%) of the center frequency. For this product, the frequency half way between the lowest and highest frequency employed is 313.225 MHz. Thus, the maximum permissible cumulative bandwidth is 313.225 MHz x 0.25% = 783.1 kHz for the two frequencies employed. . From the plot we see that their cumulative bandwidth is 135 kHz + 125 kHz = 260 kHz

6.1.4 Supply Voltage and Supply Voltage Variation

The DUT has been designed to be powered by a 3 VDC battery. For this test, relative radiated power was measured at the fundamental as the voltage was varied from 2.0 to 4.0 volts. The emission variation is shown in Figure 6.4.

Batteries:	before testing	V_{oc}	=	3.2 V
	after testing	V_{oc}	=	3.0 V
Ave. current from batteries		I	=	7 mA (cw)

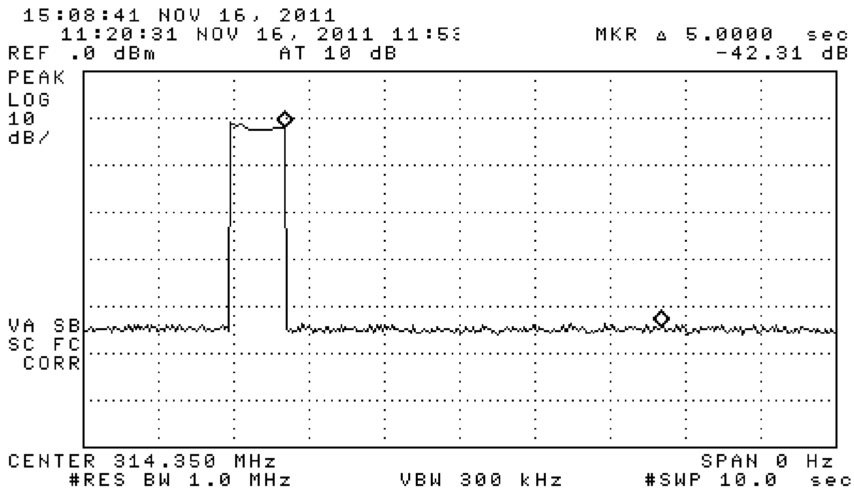
6.2 Conducted Emissions

These tests do not apply, since the DUT is powered from a 3 VDC battery.

Table 6.1 Highest Emissions Measured

Radiated Emission - RF											TRW 226624-101/102; FCC/IC
#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3* dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	**TRW Model: 226624-102 (4 button)**										
2	312.1	Dip	H	-30.8	Pk	18.5	22.6	72.1	75.4	**3.4**	flat
3	312.1	Dip	V	-33.3	Pk	18.5	22.6	69.6	75.4	5.9	end
4	624.2	Dip	H	-62.0	Pk	24.3	19.6	49.7	55.4	5.7	flat
5	624.2	Dip	V	-64.7	Pk	24.3	19.6	47.0	55.4	8.4	end
6	936.3	Dip	H	-76.1	Pk	28.7	17.5	42.1	55.4	13.4	flat
7	945.0	Dip	V	-81.3	Pk	28.8	17.5	37.0	55.4	18.4	side
8	1248.4	Horn	H	-50.0	Pk	20.6	28.1	49.5	54.0	4.5	flat
9	1560.5	Horn	H	-70.0	Pk	21.4	28.1	30.4	54.0	23.6	end
10	1872.6	Horn	H	-66.4	Pk	22.2	28.1	34.7	55.4	20.8	side
11	2184.7	Horn	H	-55.8	Pk	22.9	26.5	47.7	55.4	7.8	end
12	2496.8	Horn	H	-71.9	Pk	23.8	26.1	32.8	54.0	21.2	flat
13	2808.9	Horn	H	-69.3	Pk	24.7	24.9	37.6	54.0	16.4	side
14	3121.0	Horn	H	-70.4	Pk	25.7	23.7	38.7	55.4	16.8	flat
15											
16	314.4	Dip	H	-30.2	Pk	18.6	22.6	72.8	75.6	**2.8**	flat
17	314.4	Dip	V	-33.1	Pk	18.6	22.6	69.9	75.6	5.7	side
18	628.7	Dip	H	-62.0	Pk	24.4	19.5	49.8	55.4	5.6	flat
19	628.7	Dip	V	-66.1	Pk	24.4	19.5	45.7	55.4	9.7	end
20	943.1	Dip	H	-82.5	Pk	28.8	17.5	35.8	55.4	19.7	flat
21	945.0	Dip	V	-82.1	Pk	28.8	17.5	36.2	55.4	19.2	end
22	1257.4	Horn	H	-51.2	Pk	20.6	28.1	48.3	54.0	5.7	flat
23	1571.8	Horn	H	-69.9	Pk	21.5	28.1	30.5	54.0	23.5	flat
24	1886.1	Horn	H	-67.9	Pk	22.2	28.1	33.2	55.4	22.3	side
25	2200.5	Horn	H	-54.7	Pk	23.0	26.5	48.8	54.0	5.2	side
26	2514.8	Horn	H	-71.2	Pk	23.9	26.0	33.6	55.4	21.8	flat
27	2829.2	Horn	H	-69.3	Pk	24.8	24.8	37.7	54.0	16.3	side
28	3143.5	Horn	H	-70.2	Pk	25.8	23.6	39.0	55.4	16.4	side
29											
30	**TRW Model: 226624-101 (3 button)**										
31	314.4	Dip	H	-30.2	Pk	18.6	22.6	72.8	75.6	**2.8**	flat
32											
33	* Includes 0 dB duty factor										
34											
Digital Radiated Emissions*											
#	Freq. kHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
8											
9	* For devices used in transportation vehicles, digital emissions are exempt from FCC regulations per FCC 15.103(a)										

Meas. 11/15/2011; U of Mich.



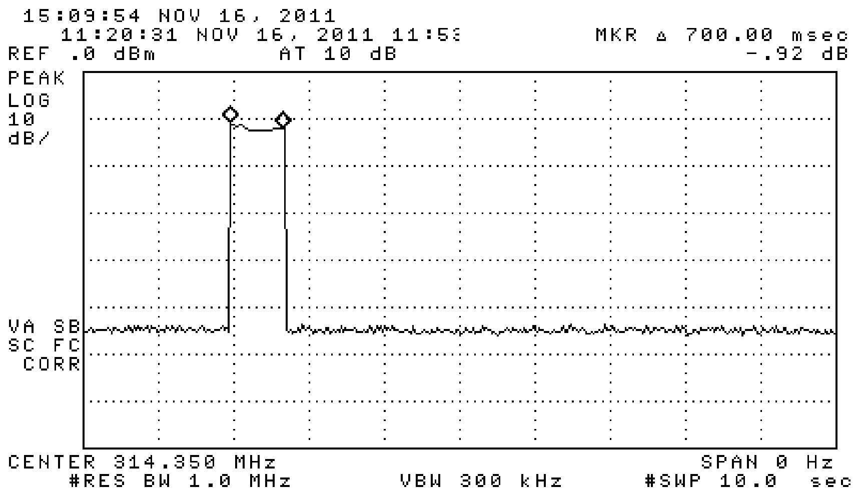
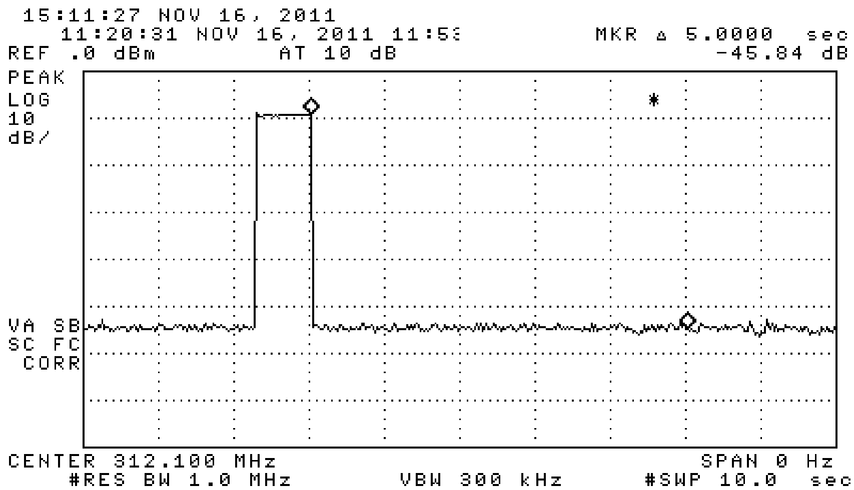


Figure 6.1(a). 314.35 MHz Transmission characteristics.

(top) single button press, (bottom) frame length



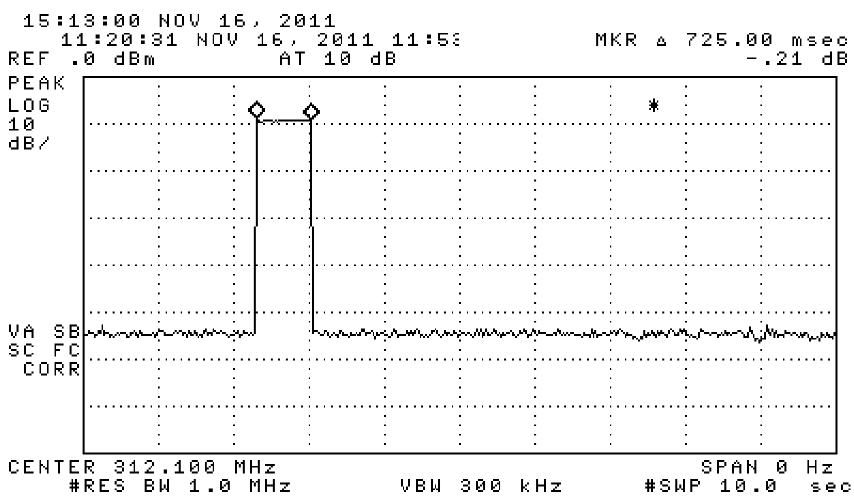
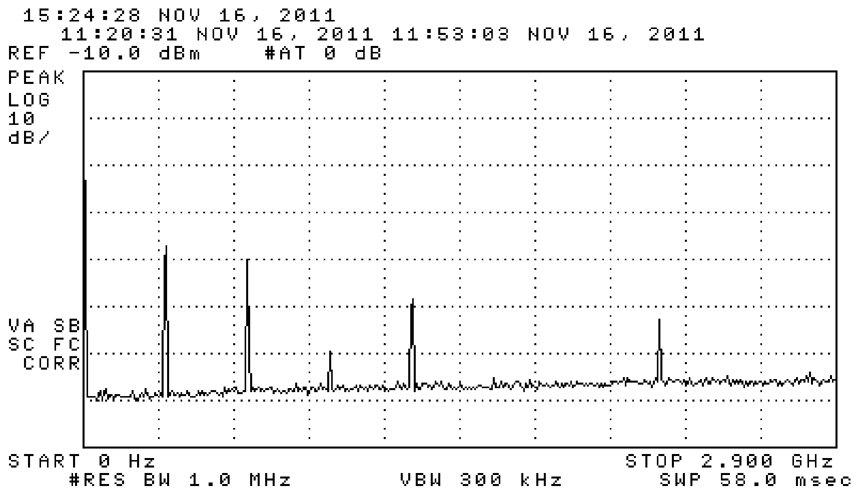


Figure 6.1(b). 312.10 MHz Transmission characteristics.

(top) single button press, (bottom) frame length



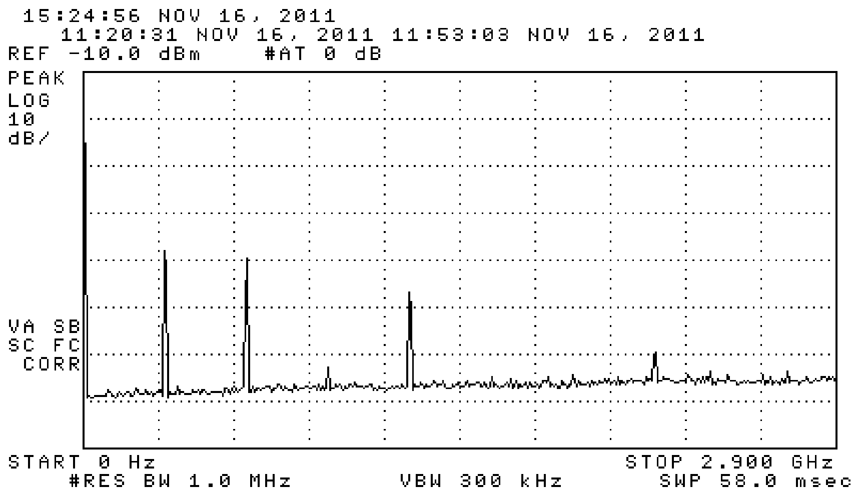


Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated). (top) 312.10 MHz emissions, (bottom) 314.35 MHz emissions.

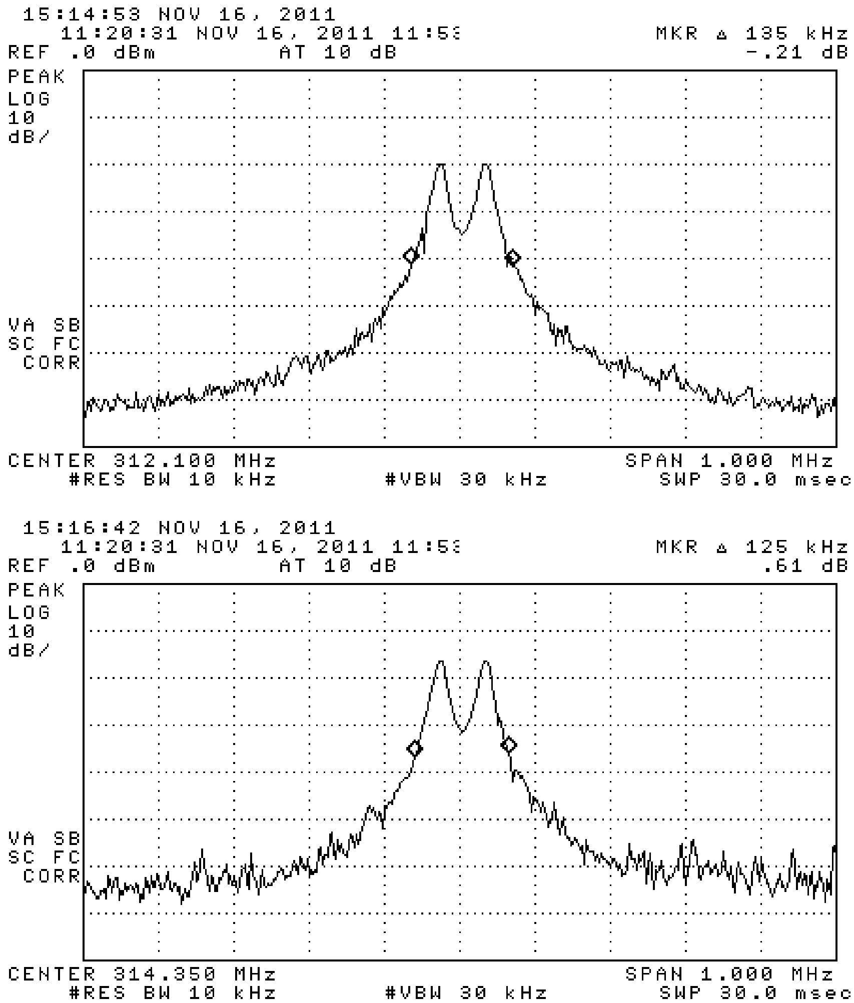


Figure 6.3. Measured emission bandwidth of the DUT (pulsed). (top) 312.10 MHz FSK, (bottom) 314.35 MHz FSK.

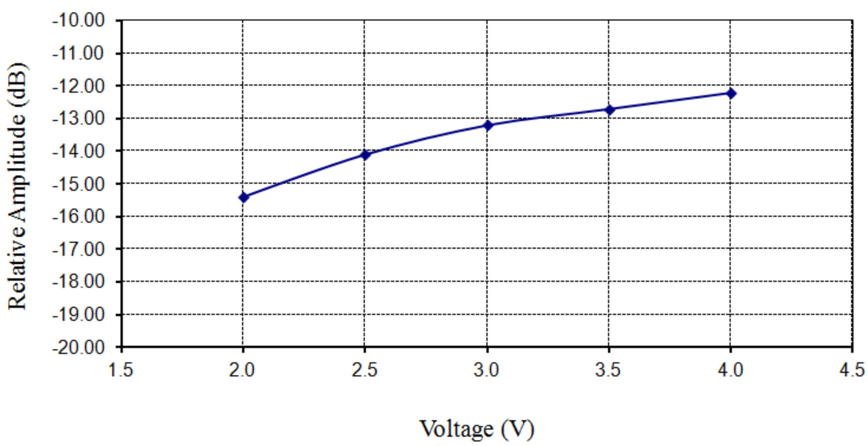
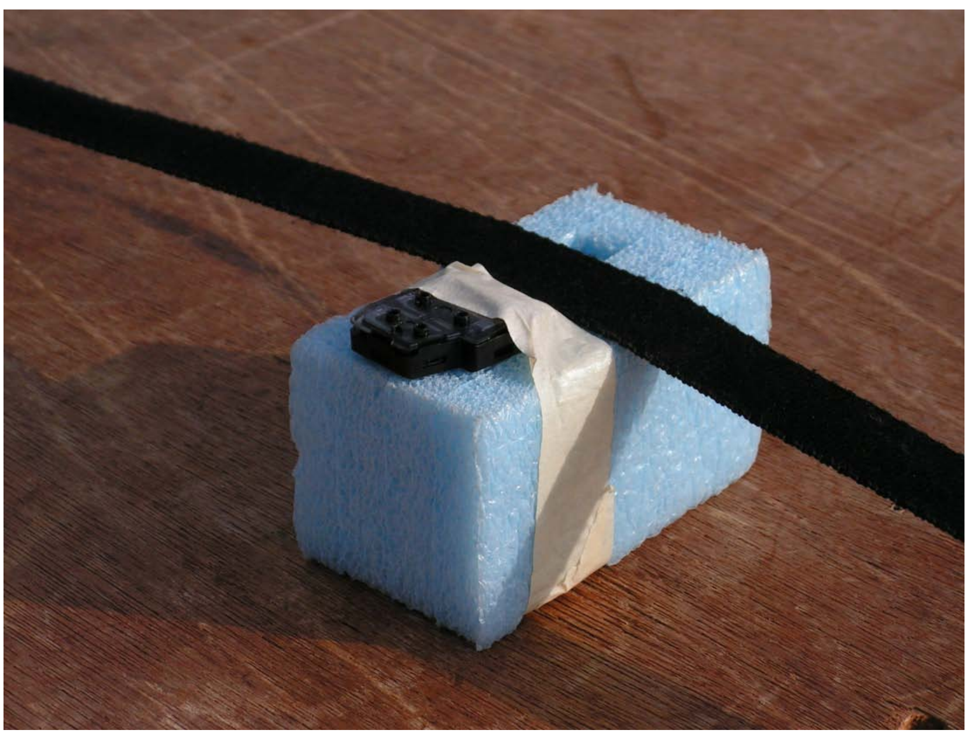


Figure 6.4. Relative emission at fundamental vs. supply voltage (pulsed).

Photograph 6.5. DUT on OATS (one of three axes tested)



Photograph 6.6. Close-up of DUT on OATS (one of three axes tested)