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Measured Radio Frequency Emissions
From

Schrader Electronics Limited Transmitter
FCC ID: MRXC4N3MF9
IC: 2546A-C4N3MF9

Test Report No. 417124-467
October 22, 2008

For:
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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 Schrader, FCC ID: MRXC4N3MF9, IC: 2546A-C4N3MF9. This device under test (DUT) is subject to the rules and regulations as a Transmitter.

In testing completed on October 22, 2008, the DUT tested met the allowed specifications for radiated emissions by 2.9 dB. Conducted emissions are not subject to regulation as the DUT is powered by a 3 VDC battery.

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1. Introduction

This Schrader 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 7, June 2007. 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 pertinent test equipment commonly used in our facility for measurements is listed in Table 2.1 below. The middle column identifies the specific equipment used in these tests. The quality system employed at the University of Michigan Radiation Laboratory Willow Run Test Range 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)	X	Hewlett-Packard 8593E, SN: 3412A01131	HP8593E1
Spectrum Analyzer (9kHz-6.5GHz)	X	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)	X	University of Michigan, RLBC-1	LBBIC1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2	HBBIC1
Dipole Antenna Set (30-1000 MHz)	X	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)	X	University of Michigan	UMRH1
Amplifier (5-1000 MHz)	X	Avantek, A11-1, A25-1S	AVAMP1
Amplifier (5-4500 MHz)	X	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 315 MHz Transmitter designed for automotive/vehicular applications. It is powered by a 3 VDC lithium battery and is housed in a plastic case approximately 8 x 6 x 1 cm in dimension. The DUT is potted and will be affixed in the rim of a tire. The DUT is designed and manufactured by Schrader Electronics Limited, 11 Technology Park, Belfast Road, Antrim BT41 1QS, Northern Ireland.

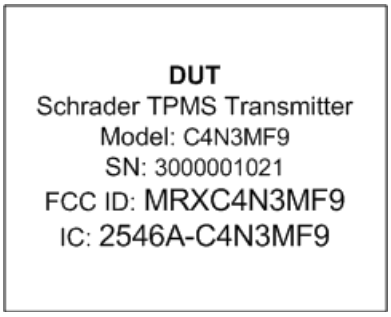

Figure 3.1 Block Diagram

3.2 Variants & Samples

There is only a single variant of this device. Three samples were provided for testing, one normal sample, one capable of CW transmission, and one un-potted for photographs and voltage variation.

3.3 Modes of Operation

The DUT periodically transmits tire pressure data. The device is also capable of being automatically actuated (via LF interrogation) either by in-vehicle LF initiators or by trained personnel during servicing. Per FCC correspondence, service modes fall under FCC part 15.231(a)(5). Figure 6.1 demonstrates compliance with both 15.231(a)(2) and (5). A detailed list of all operating modes is included in the Description of Operation exhibit.

3.4 Exemptions

☒ The DUT is permanently installed in a transportation vehicle. As such, digital emissions are exempt from regulation (per FCC 15.103(a) and IC correspondence on ICES-003).

☒ The DUT employs some modes of operation that alert the vehicle user of sudden changes in tire pressure. Such alert modes fall under FCC 15.231(a)(4), and may operate during the pendency of the alarm condition.

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(e), .205(a); IC: RSS-210 2.7 T5).

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	1500-5000*		150-500	
315.0	2417	67.7	241.7	47.7
433.9	4399	72.9	439.9	52.9
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 = -2833.2 + 16.67*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.

4.2 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)		Class B (dBμV)	
	Quasi-peak	Average	Quasi-peak	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. 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 the carrier are recorded. This 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. 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 devices with intentional emissions below 30 MHz, our shielded loop antenna is used and 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 DUT on the OATS.

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, dB, 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 a single LF interrogation, it can, in the worst case, transmit four datasets the first of which is the worst case. In this dataset, twelve packets of Manchester encoded ASK data (with a 55.2 us/ 104.4 us duty) are transmitted. Alternatively, when activated by vehicle movement (roll) the DUT transmits, in the worst case, three 9.375 ms FSK pulses with period greater than 100 ms. See Figure 6.1. Computing the duty factor results in:

$K_{E_{LF}}$ = (12 x 1.638 ms) / 100 ms x (55.2 us)/(104.4 us) = 0.103 < **-19.7 dB**.

$K_{E_{Roll}}$ = 9.375 ms / 100 ms = 0.094 < -20.0 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. The allowed 99% bandwidth is 0.25% of 315 MHz, or 787.25 kHz. From the plot we see that the EBW is 178 kHz, and the center frequency is 315 MHz.

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 3.75 volts. The emission variation is shown in Figure 6.4.

Batteries:	before testing	V_{oc} = 3.3 V
	after testing	V_{oc} = 3.1 V
Ave. current from batteries		I = 7.3 mA (cw)

6.2 Conducted Emissions

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

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Table 6.1 Highest Emissions Measured

Radiated Emission - RF											Schrader, 315 Snap; 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	315.0	Dip	H	-19.6	Pk	18.6	21.5	64.8	67.7	**2.9**	flat
2	315.0	Dip	V	-24.0	Pk	18.6	21.5	60.4	67.7	7.3	end
3	630.0	Dip	H	-57.5	Pk	24.4	18.4	35.8	47.7	11.9	flat
4	630.0	Dip	V	-59.9	Pk	24.4	18.4	33.4	47.7	14.3	end
5	945.0	Dip	H	-59.5	Pk	28.8	16.4	40.2	47.7	7.5	flat
6	945.0	Dip	V	-59.4	Pk	28.8	16.4	40.3	47.7	7.4	side
7	1260.0	Horn	H	-37.7	Pk	20.6	28.1	42.1	54.0	11.9	flat
8	1575.0	Horn	H	-33.8	Pk	21.5	28.1	46.9	54.0	7.1	flat
9	1890.0	Horn	H	-46.0	Pk	22.2	28.1	35.4	54.0	18.6	flat
10	2205.0	Horn	H	-51.4	Pk	23.0	26.5	32.4	54.0	21.5	flat
11	2520.0	Horn	H	-60.0	Pk	23.9	26.0	25.2	54.0	28.8	flat
12	2835.0	Horn	H	-53.2	Pk	24.8	24.7	34.2	54.0	19.8	flat
13	3150.0	Horn	H	-62.7	Pk	25.8	23.6	26.8	54.0	27.1	flat
14											
15											
16											
17											
18	* Includes 19.7 dB duty factor										
19											
20											
21											
22											
23											
24											
25											
26											
27											
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
1											
2											
3											
4	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
5											
6											
7											
8											
9	* For devices used in transportation vehicles, digital emissions are exempt from FCC regulations per FCC 15.103(a)										

Meas. 10/10/2008 U of Mich.

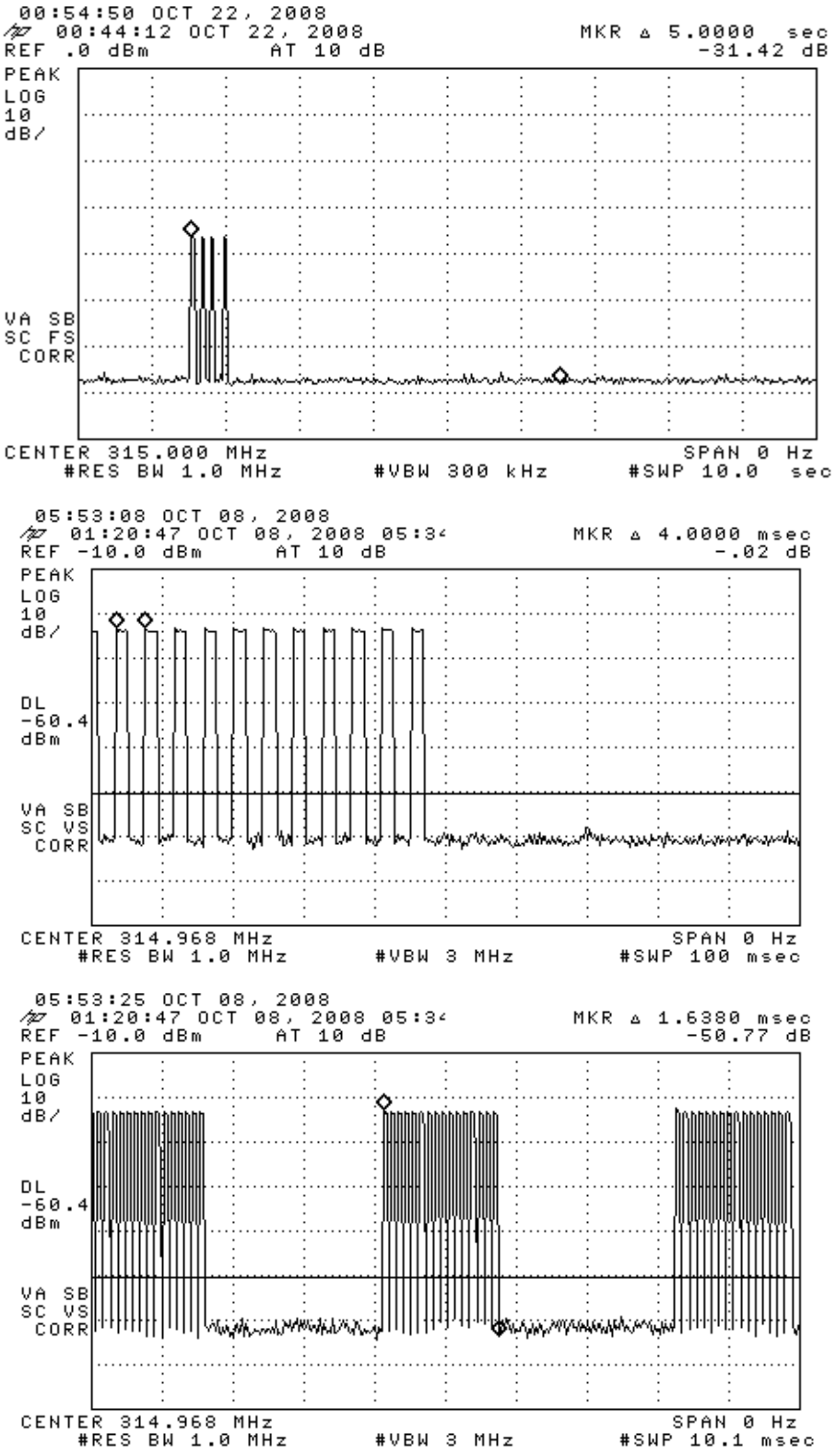

Figure 6.1(a). Transmission modulation characteristics. (top) LF response transmission, (center) expanded worst case LF words, (bottom) expanded word showing Manchester encoding (~50% duty).

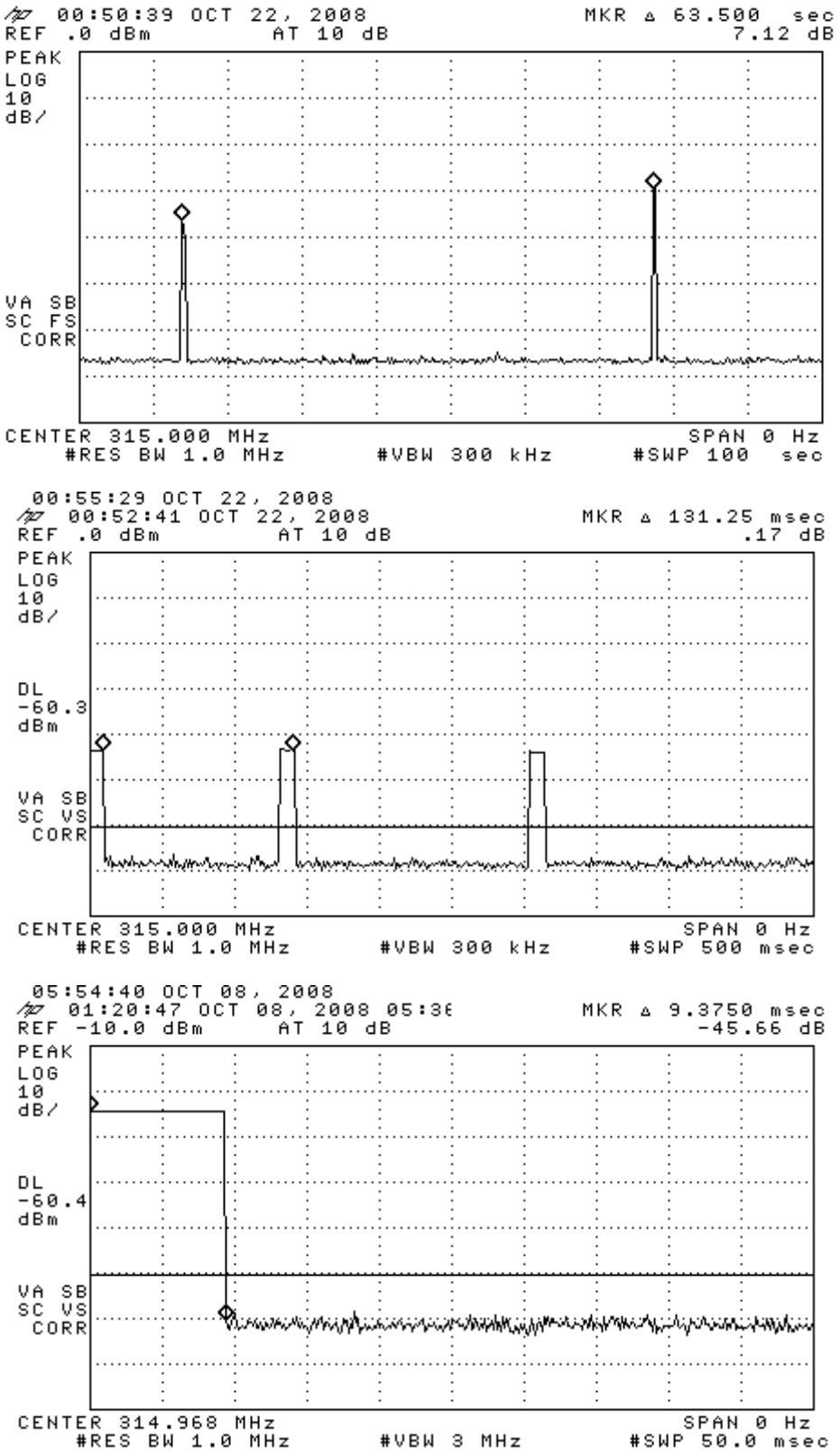

Figure 6.1(b). Transmission modulation characteristics. (top) FSK Periodic roll-mode transmissions, (center) expanded single transmission, (bottom) expanded FSK bit.

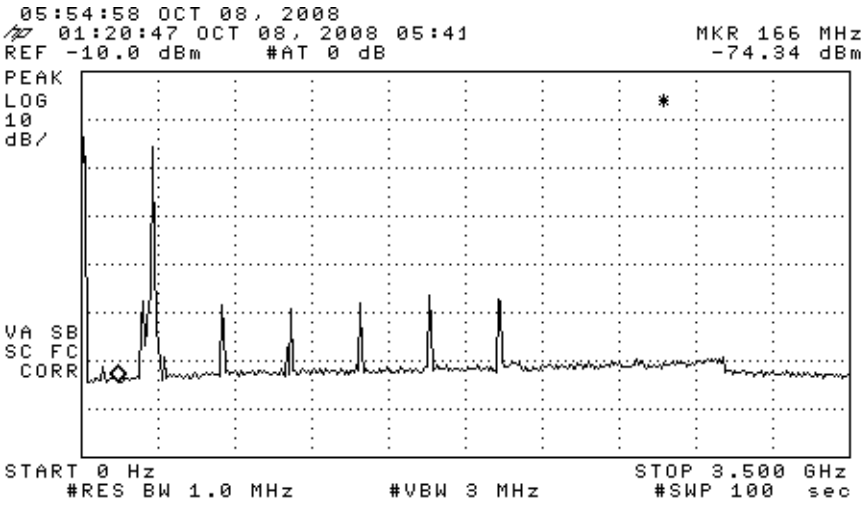

Figure 6.2. Emission spectrum of the DUT (pulsed emission). Amplitudes are only indicative (not calibrated).

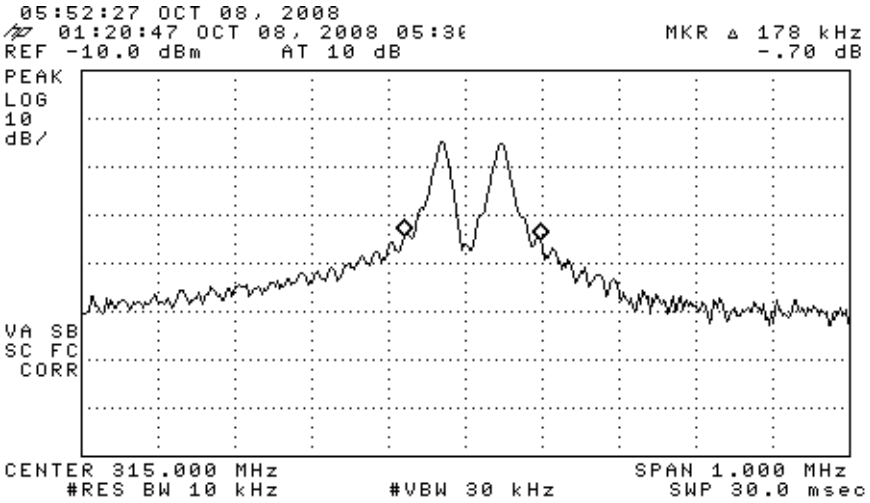

Figure 6.3. Measured emission bandwidth of the DUT (pulsed).

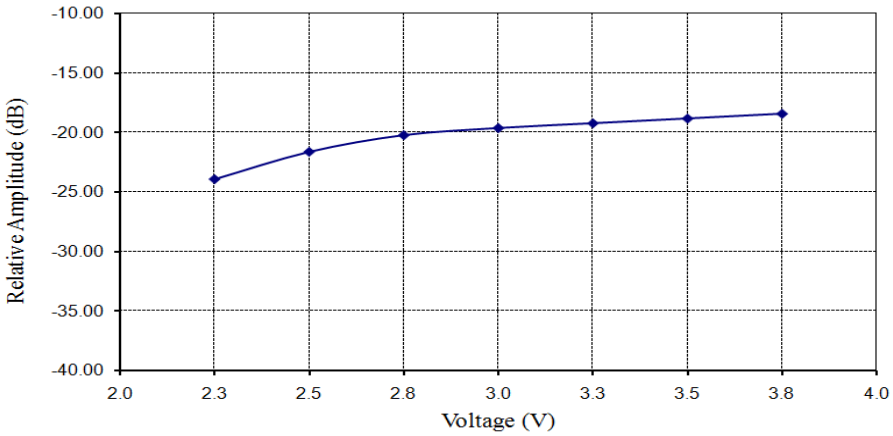

Figure 6.4. Relative emission at fundamental vs. supply voltage (pulsed).

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)