The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 764-0500

Measured Radio Frequency Emissions
From

Siemens/Continental Transmitter
FCC ID: M3N5WY7777A
IC: 267F-5WY7777A

Report No. 415031-413
May 1, 2008

For:
Siemens VDO Automotive
4685 Investment Drive
Troy, MI 48098

Contact:
Charles Muma
charles.muma@siemens.com
Tel: (248) 764-6771
Fax: (248) 764-7247
PO: verbal

Measurements made by: Valdis V. Liepa
Test Report Prepared by: Joseph D. Brunett

Tests supervised by:
Report approved by: Valdis V. Liepa
Research Scientist

Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on Siemens/Continental model/PN(s) 25926473, 25926474, 25926479, 25926480, 25946298, 25946299, 25943676, 25943677. This device is subject to the Rules and Regulations as a Transmitter.

In testing completed on February 14, 2008, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 2.2 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from digital circuitry were negligible. The conducted emission tests do not apply, since the device is powered from a 3 VDC battery.

1. Introduction

Siemens/Continental model/PN(s) 25926473, 25926474, 25926479, 25926480, 25946298, 25946299, 25943676, 25943677 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 6, September 2005. The 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 Area Tes Site 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. Test Procedure and 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.

Table 2.1 Test Equipment.

Test Instrument	Eqpt. Used	Manufacturer/Model
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard, 182T/8558B
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131
Spectrum Analyzer (9kHz-26GHz)		Hewlett-Packard 8563E, SN: 3310A01174
Spectrum Analyzer (9kHz-40GHz)		Hewlett-Packard 8564E, SN: 3745A01031
Power Meter		Hewlett-Packard, 432A
Power Meter		Anritsu, ML4803A/MP
Harmonic Mixer (26-40 GHz)		Hewlett-Packard 11970A, SN: 3003A08327
Harmonic Mixer (40-60 GHz)		Hewlett-Packard 11970U, SN: 2332A00500
Harmonic Mixer (75-110 GHz)		Hewlett-Packard 11970W, SN: 2521A00179
Harmonic Mixer (140-220 GHz)		Pacific Millimeter Prod., GMA, SN: 26
S-Band Std. Gain Horn		S/A, Model SGH-2.6
C-Band Std. Gain Horn		University of Michigan, NRL design
XN-Band Std. Gain Horn		University of Michigan, NRL design
X-Band Std. Gain Horn		S/A, Model 12-8.2
X-band horn (8.2- 12.4 GHz)		Narda 640
X-band horn (8.2- 12.4 GHz)		Scientific Atlanta , 12-8.2, SN: 730
K-band horn (18-26.5 GHz)		FXR, Inc., K638KF
Ka-band horn (26.5-40 GHz)		FXR, Inc., U638A
U-band horn (40-60 GHz)		Custom Microwave, HO19
W-band horn(75-110 GHz)		Custom Microwave, HO10
G-band horn (140-220 GHz)		Custom Microwave, HO5R
Bicone Antenna (30-250 MHz)	X	University of Michigan, RLBC-1
Bicone Antenna (200-1000 MHz)	X	University of Michigan, RLBC-2
Dipole Antenna Set (30-1000 MHz)	X	University of Michigan, RLDP-1,-2,-3
Dipole Antenna Set (30-1000 MHz)		EMCO 2131C, SN: 992
Active Rod Antenna (30 Hz-50 MHz)		EMCO 3301B, SN: 3223
Active Loop Antenna (30 Hz-50 MHz)		EMCO 6502, SN:2855
Ridge-horn Antenna (300-5000 MHz)	X	University of Michigan
Amplifier (5-1000 MHz)	X	Avantak, A11-1, A25-1S
Amplifier (5-4500 MHz)	X	Avantak
Amplifier (4.5-13 GHz)		Avantek, AFT-12665
Amplifier (6-16 GHz)		Trek
Amplifier (16-26 GHz)		Avantek
LISN Box		University of Michigan
Signal Generator		Hewlett-Packard 8657B

3. Device Under Test

3.1 Identification

The DUT is a 315 MHz transmitter, approximately 1 x 0.5 x 3.5 inches in size. The carrier is ASK and FSK modulated. The antenna is a PCB trace. The DUT was designed and manufactured by Siemens VDO Automotive / Continental Automotive Systems US Inc., 4685 Investment Drive, Troy, MI 48098. It is identified as:

Siemens/Continental Transmitter
Model/PN(s): 25926473, 25926474, 25926479, 25926480,
25946298, 25946299, 25943676, 25943677
FCC ID: M3N5WY7777A
IC: 267F-5WY7777A

3.2 Modes of Operation

The device is capable of transmitting 3 different modulations at two different peak power levels. The highest peak power (HP) setting (also called Remote Start) utilizes a greater duty cycle. The normal peak power (NP) setting (also called RKE) contains a transmission with greater on time.

Remote Start (RS) and Remote Keyless Entry (RKE) modes are software programmed to transmit either a 2.84 kb/s ASK or 9.6 kb/s ASK when actuated by button press (depending on DUT model). Some models of the device can be remotely actuated via encoded LF (125 kHz) interrogation, transmitting 9.6 kb/s ASK modulation or a 9.6 kb/s FSK modulation.

Note: The DUT is manually activated (both for button press and LF, as the user must lift the door handle) and ceases to transmit within 5 seconds of deactivation. See Figure 6.1. LF activation requires an encoded LF interrogation. A CW modified device was tested in both the HP and LP modes. Modulation duty is recorded and applied to the CW emissions, showing compliance for all modulations. The 5 button devices demonstrated worst case emissions with the key inserted into the fob, and are tested fully.

3.3 Variants

There are three main variants of the DUT associated with the eight model numbers above. All three contain the same PCB, with software modifications for the different modulations and different button configurations. These three variants are:

No. 215/245:	4 button modules with RKE normal power 9.6 kb/s ASK modulation and RKE normal power LF actuated 9.6 kb/s ASK modulation.
No. 295/322:	4 button modules with RKE normal power 2.84 kb/s ASK modulation and RKE high power LF 9.6 kb/s FSK modulation 5 button modules with RKE normal power 2.84kb/s ASK modulation, RS high power 2.84 kb/s ASK, and RKE high power LF 9.6 kb/s ASK modulation

All variants are electronically identical. The differences are in the packaging. There is a four button housing and a five button housing, as well as two types of emblems. These variants relate to the models listed via:

PART #	DESCRIPTION	PART #	DESCRIPTION
25926473	215 Domestic 4 button TX # 1	25946298	295/322 Domestic 4 button TX # 1
25926474	215 Domestic 4 button TX # 2	25946299	295/322 Domestic 4 button TX # 2
25926479	245 Domestic 4 button TX # 1	25943676	295/322 Domestic 5 button TX #1
25926480	245 Domestic 4 button TX # 2	25943677	295/322 Domestic 5 button TX #2

3.4 EMI/EMC Relevant Modifications

There were no modifications made to the DUT by this laboratory.

4. Emission Limits

The DUT tested falls under the category of an Intentional Radiators and the Digital Devices. For FCC, it is subject to Part 15, Subpart C, (Section 15.231(a-c), 15.209), and Subpart A, (Section 15.33). For Industry Canada it is subject to RSS-210 (Section 2.6 and 2.7). The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below.

4.1 Radiated Emission Limits

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.209; IC: RSS-210, 2.7 Table 2).
(Digital Class B)

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 BW)

Table 4.2. Radiated Emission Limits (FCC: 15.231(b), 15.205(a); IC: RSS-210; 2.7 Table 4).
(Transmitter)

Frequency (MHz)	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
	(µV/m)	dB (µV/m)	(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

4.3 Exemptions
None.

4.4 Power Line Conducted Emission Limits
The power line conducted emission limits and tests do not apply here, as the DUT is powered by a 3 VDC battery.

4.5 Supply Voltage Variation
Measurements of the variation in the fundamental radiated emission shall be performed with the supply voltage varied between 85% and 115% of the nominal rated value. For battery operated equipment, the equipment tests shall be performed using a new battery.

5. Test Procedures

5.1 Semi-Anechoic Chamber Radiated Emission Testing
To become familiar with the emission behavior of the DUT, the DUT was first studied and measured in a shielded semi-anechoic chamber. In the chamber is set-up similar to that of an outdoor 3-meter site, with a turntable, antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

In testing for radiated emissions, a transmitter was provided by the manufacturer that is capable of repeated emissions. It was placed on the test table flat, on its side, and on its end. In the chamber we studied and recorded all the emissions using a Bicone antenna up to 300 MHz and a ridged horn antenna above 200 MHz. The measurements made in the chamber below 1 GHz are used for pre-test evaluation only. The measurements made above 1 GHz are used in pre-test evaluation and in final compliance assessment. We note that for the horn antenna, the antenna pattern is directive and the measurement is essentially that of free space (no ground reflection). Consequently, it is not essential to measure the DUT for both antenna polarizations, as long as the DUT is measured on all three of its major axis. In the chamber we also recorded the spectrum and modulation characteristics of the carrier. These data are presented in subsequent sections.

5.2 Open Area Test Site (OATS) Radiated Emission Testing
After the chamber measurements are complete, emissions are re-measured on the outdoor 3-meter open area test site at the fundamental and harmonics up to 1 GHz using tuned dipoles and/or a high frequency biconical antenna. The DUT is placed on the test table flat, on its side, and on its end, and worst case emissions are recorded. Photographs included in this filing show the DUT on the OATS.

5.3 Field Calculation for Radiated Emission Measurements
To convert the dBm's measured on the spectrum analyzer to dB(μV/m), we use expression

$$E_3(\text{dB}\mu\text{V/m}) = 107 + P_R + K_A - K_G$$

where P_R = power recorded on spectrum analyzer, dB, measured at 3m
K_A = antenna factor, dB/m
K_G = pre-amplifier gain, including cable loss, dB

When presenting the data, at each frequency the highest measured emission under all of the possible orientations is given. Computations and results are given in Table 5.1. There we see that the DUT meets the limit by 2.2 dB.

5.4 Power Line Conducted Emission Testing
These tests do not apply, since the DUT is powered from a 3 VDC battery.

6. Test Results

6.1 Correction For Pulse Operation

The following corrections for pulse operation are computed for the worst case modes of operation (greatest duty) as applied in the data table. Supporting plots are shown in Figure 6.1.

NP ASK 2.84 kb/s: K_E = (46.125 ms / 100 ms) x (0.185 ms / 0.350 ms) = 0.244 or -12.3 dB.
NP ASK 9.6 kb/s: K_E = (47.063 ms / 100 ms) x (0.056 ms / 0.104 ms) = 0.253 or **-11.9 dB.**
NP ASK 9.6 kb/s K_E = (2.1875 ms + 6.125 ms)/ 100 ms = 0.083 < -20.0 dB.

HP ASK 2.84 kb/s: K_E = (35.813 ms / 100 ms) x (0.184 ms / 0.352 ms) = 0.187 or -14.6 dB.
HP ASK 9.6 kb/s: K_E = (36.250 ms / 100 ms) x (0.056 ms / 0.104 ms) = 0.197 or **-14.1 dB.**
HP FSK 9.6 kb/s: K_E = (2.3375 ms + 6.250 ms)/ 100 ms = 0.086 < -20.0 dB.

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectrum was recorded and is shown in Figure 6.2. We note that in scanning from 30 MHz to 4.5 GHz using Bicone and the ridge horn antennas, there were no other significant spurious emissions observed.

6.3 Bandwidth of the Emission Spectrum

The measured spectrum of the signal is shown in Figure 6.3. The allowed (-20 dB, 99%) bandwidth is 0.25% of 315 MHz, or 787.25 kHz. From the plots we see that the worst case -20 dB bandwidth is 138.0 kHz.

6.4 Effect of Supply Voltage Variation and Test Battery Voltages

The DUT has been designed to be powered by a 3 VDC battery. For this test, the battery was replaced by a laboratory variable power supply. Relative power radiated was measured at the fundamental as the voltage was varied from 2 to 4 volts. The emission variation is shown in Figure 6.4.

Batteries:	before testing	V_{oc} =	3.29 V
	after testing	V_{oc} =	3.01 V
Ave. current from batteries		I =	13.0 mA (pulsed)

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Siemens 09-002; 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	**5 Button RKE NP (*11.9 dB Duty)**										
2	315.0	Dip	H	-17.8	Pk	18.6	22.6	73.2	75.6	**2.4**	flat
3	315.0	Dip	V	-21.3	Pk	18.6	22.6	69.7	75.6	5.9	side
4	630.0	Dip	H	-59.7	Pk	24.4	19.6	40.2	55.6	15.4	flat
5	630.0	Dip	V	-58.9	Pk	24.4	19.6	41.0	55.6	14.6	end
6	945.0	Dip	H	-74.5	Pk	28.8	17.5	31.9	55.6	23.7	flat
7	945.0	Dip	V	-74.5	Pk	28.8	17.5	31.9	55.6	23.7	end
8	1260.0	Horn	H	-45.9	Pk	20.6	28.1	41.7	54.0	12.3	flat
9	1575.0	Horn	H	-55.6	Pk	21.5	28.1	32.9	54.0	21.1	side
10	1890.0	Horn	H	-43.8	Pk	22.2	28.1	45.4	55.6	10.2	side
11	2205.0	Horn	H	-57.3	Pk	23.0	26.5	34.3	54.0	19.7	flat
12	2520.0	Horn	H	-47.9	Pk	23.9	26.0	45.1	55.6	10.6	flat
13	2835.0	Horn	H	-51.2	Pk	24.8	24.7	44.0	54.0	10.0	end
14	3150.0	Horn	H	-58.1	Pk	25.8	23.6	39.2	55.6	16.4	flat
15	**4 Button RKE NP (*11.9 dB Duty)**										
16	315.0	Dip	H	-17.6	Pk	18.6	22.6	73.4	75.6	**2.2**	flat
17											
18											
19	**5 Button Remote Start HP (*14.1 dB Duty)**										
20	315.0	Dip	H	-16.4	Pk	18.6	22.6	72.4	75.6	**3.2**	flat
21	315.0	Dip	V	-20.2	Pk	18.6	22.6	68.6	75.6	7.0	end
22	630.0	Dip	H	-57.6	Pk	24.4	19.6	40.1	55.6	15.5	flat
23	630.0	Dip	V	-57.1	Pk	24.4	19.6	40.6	55.6	15.0	end
24	945.0	Dip	H	-73.4	Pk	28.8	17.5	30.8	55.6	24.8	flat
25	945.0	Dip	V	-73.2	Pk	28.8	17.5	31.0	55.6	24.6	end
26	1260.0	Horn	H	-46.3	Pk	20.6	28.1	39.1	54.0	14.9	flat
27	1575.0	Horn	H	-57.6	Pk	21.5	28.1	28.7	54.0	25.3	side
28	1890.0	Horn	H	-44.7	Pk	22.2	28.1	42.3	55.6	13.3	flat
29	2205.0	Horn	H	-52.7	Pk	23.0	26.5	36.7	54.0	17.3	flat
30	2520.0	Horn	H	-49.4	Pk	23.9	26.0	41.4	55.6	14.3	flat
31	2835.0	Horn	H	-49.5	Pk	24.8	24.7	43.5	54.0	10.5	end
32	3150.0	Horn	H	-54.4	Pk	25.8	23.6	40.7	55.6	14.9	end
33	**4 Button Remote Start HP (*14.1 dB Duty)**										
34	315.0	Dip	H	-16.4	Pk	18.6	22.6	72.4	75.6	**3.2**	flat
35											
Digital Emissions**											
37	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
38											
39	** For devices used in transportation vehicles, digital emissions are exempt.										

Meas. 02/11,14/2008; U of Mich.

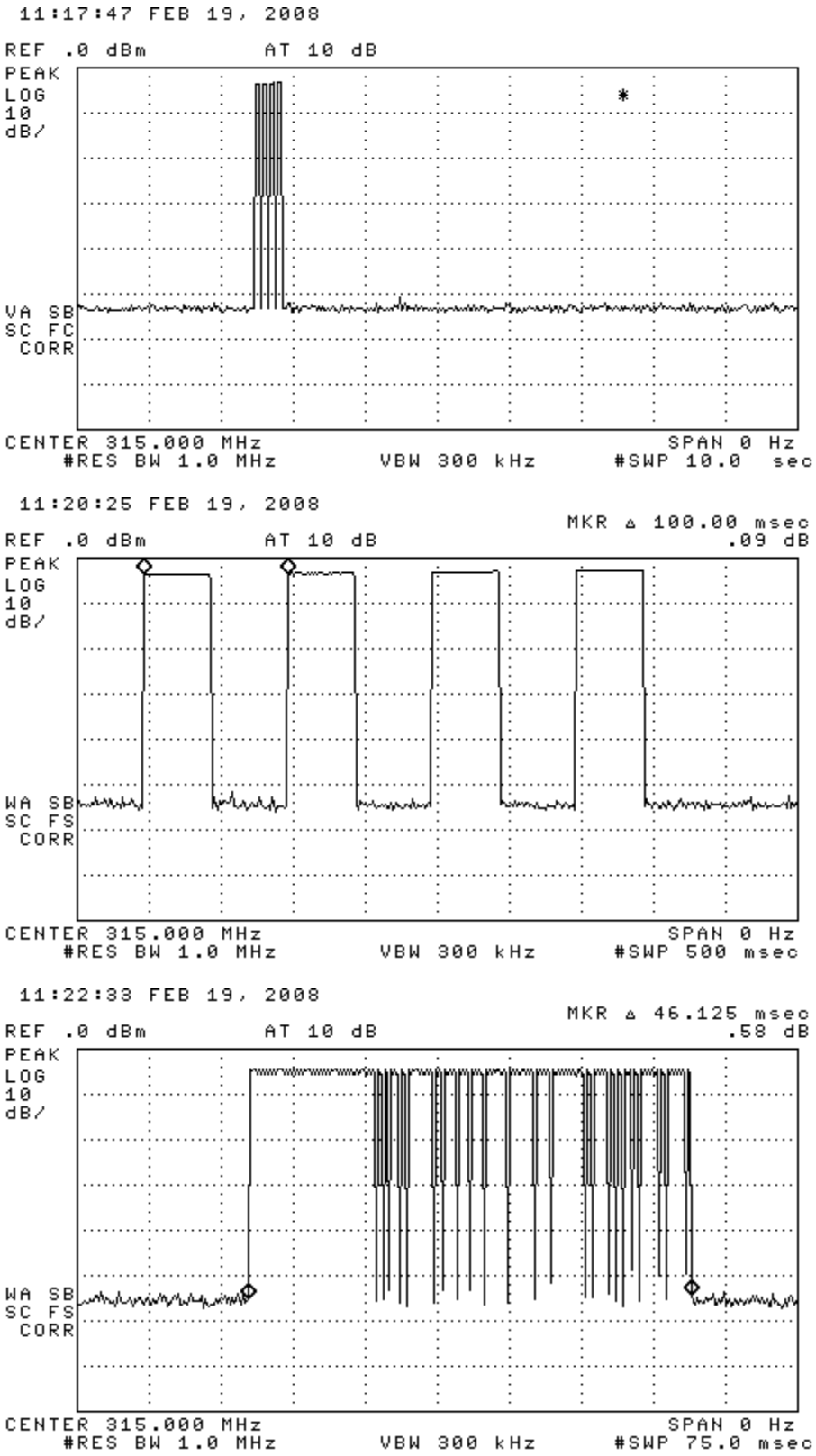


Figure 6.1(a). Transmissions modulation characteristics (2.8 kb/s ASK NP):
(top) complete transmission, (center) expanded bit, (bottom) expanded period.

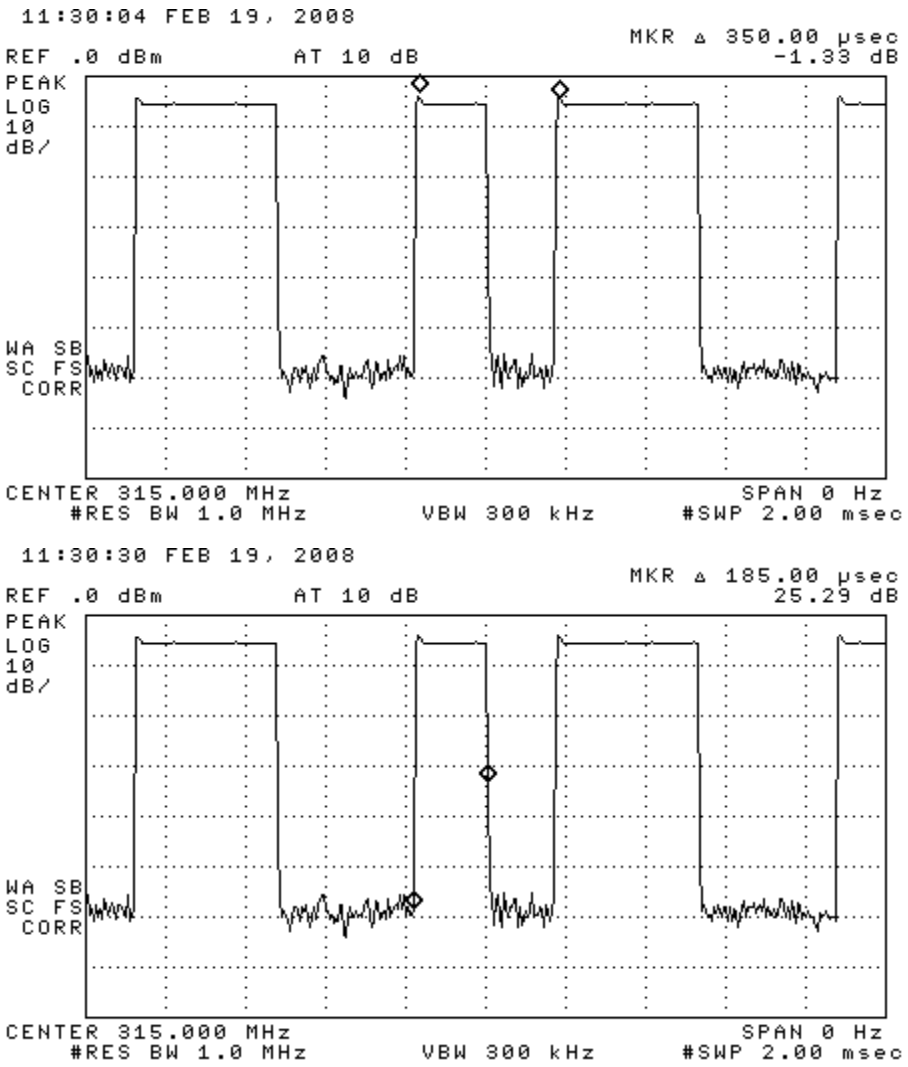


Figure 6.1(b). Transmissions modulation characteristics (2.8 kb/s ASK NP):
(top) complete transmission, (center) expanded bit, (bottom) expanded period.

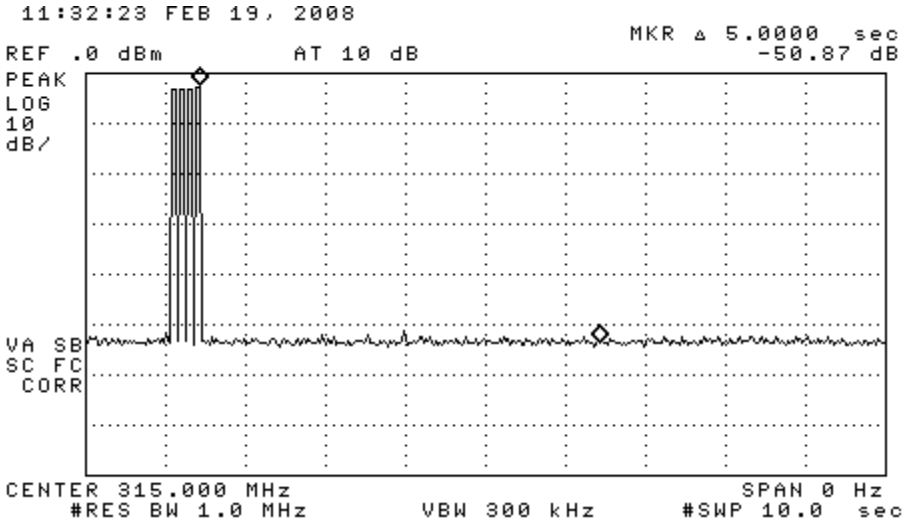


Figure 6.1(c). Transmissions modulation characteristics (9.6 kb/s ASK NP):
complete transmission.

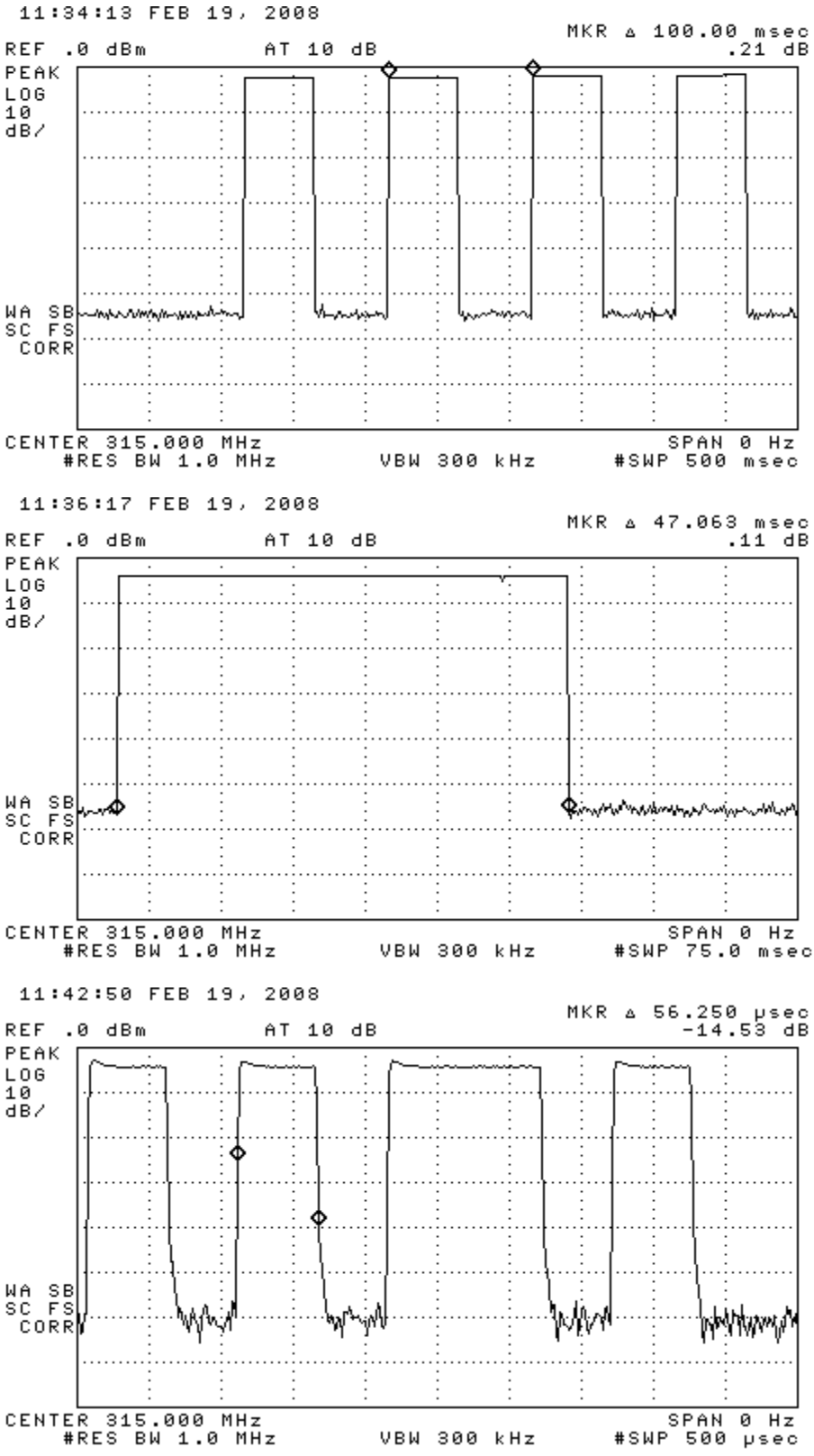


Figure 6.1(d). Transmissions modulation characteristics (9.6 kb/s ASK NP): (top) word period, (center) word length, (bottom) Manchester width

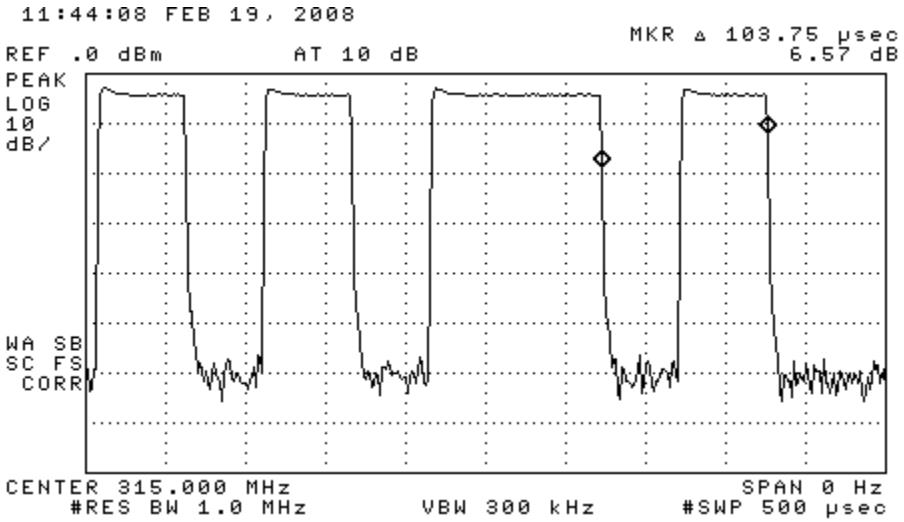


Figure 6.1(e). Transmissions modulation characteristics (9.6 kb/s ASK NP): Manchester period

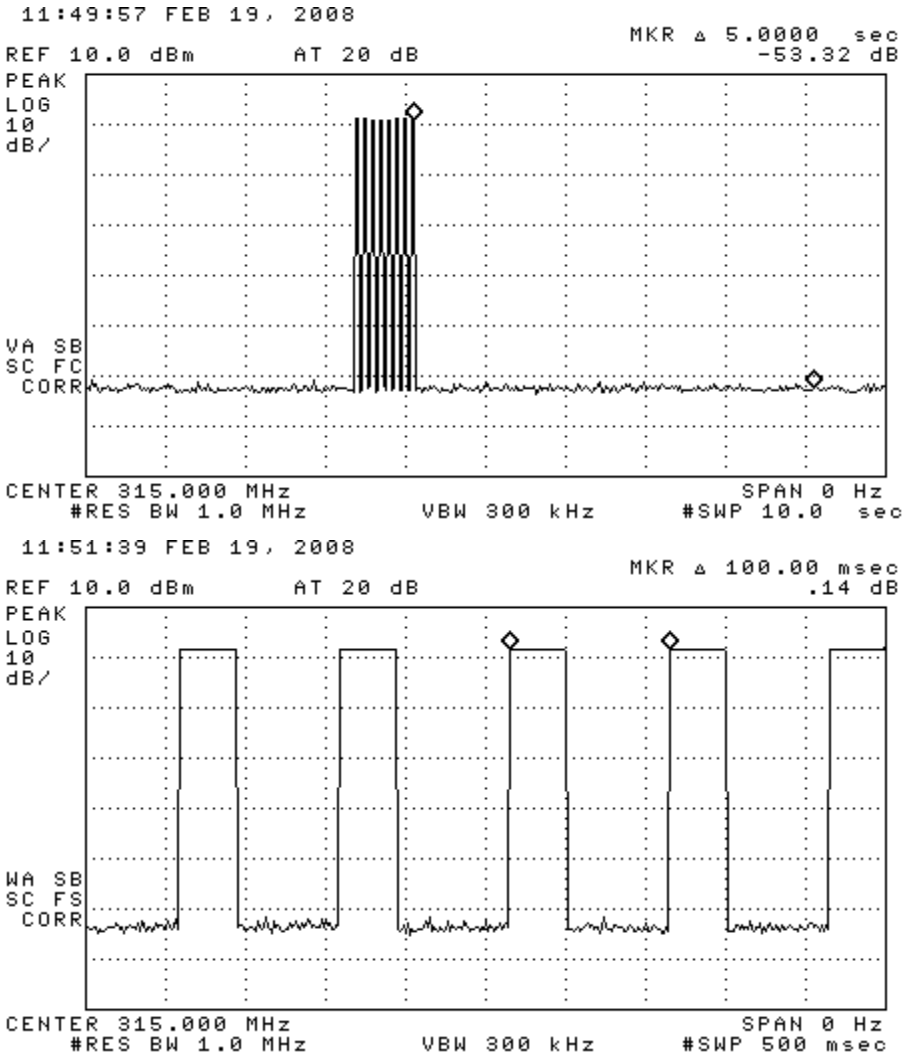


Figure 6.1(f). Transmissions modulation characteristics (2.8 kb/s ASK HP): (top) complete transmission, (bottom) word period

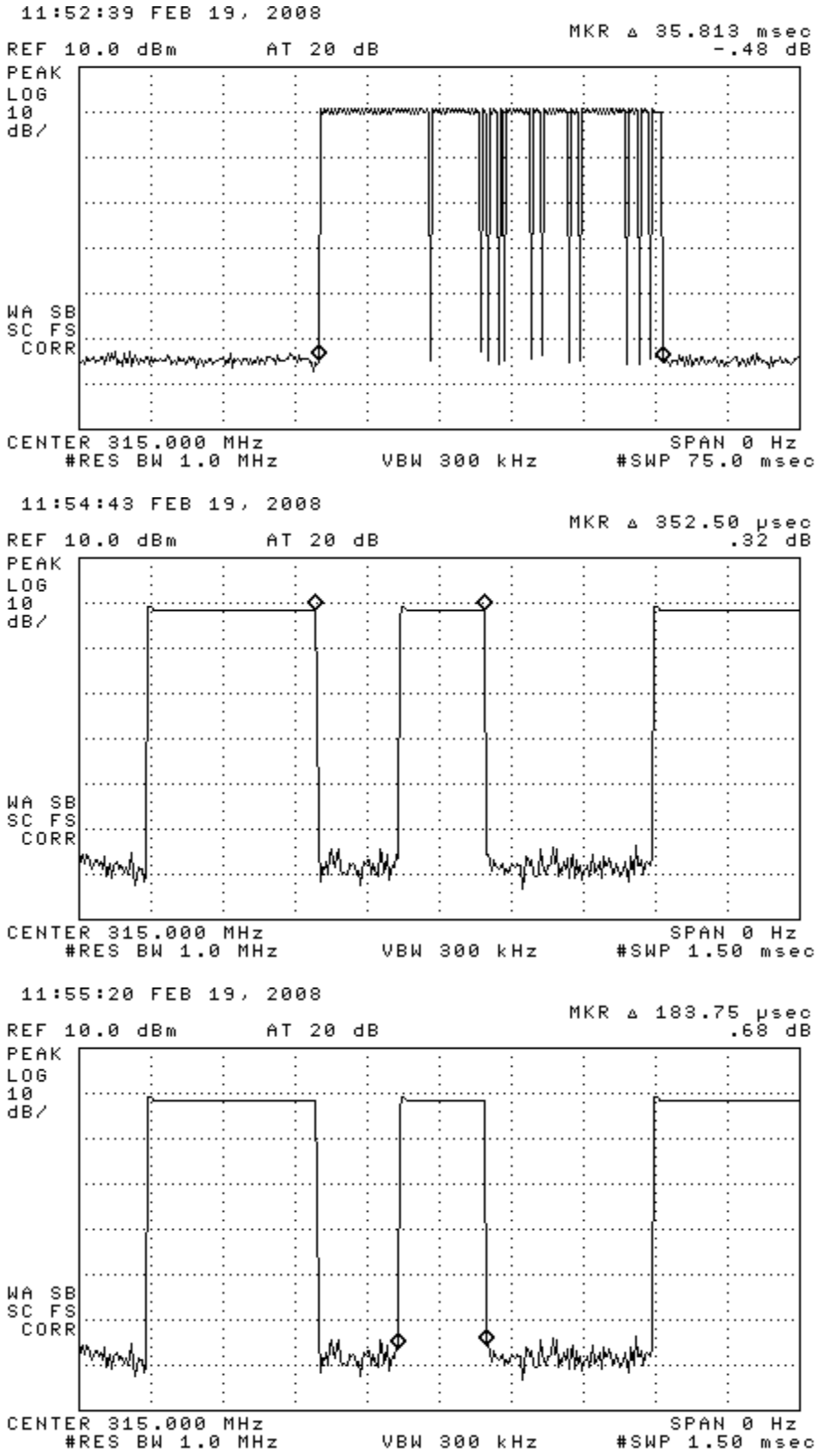


Figure 6.1(g). Transmissions modulation characteristics (2.8 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

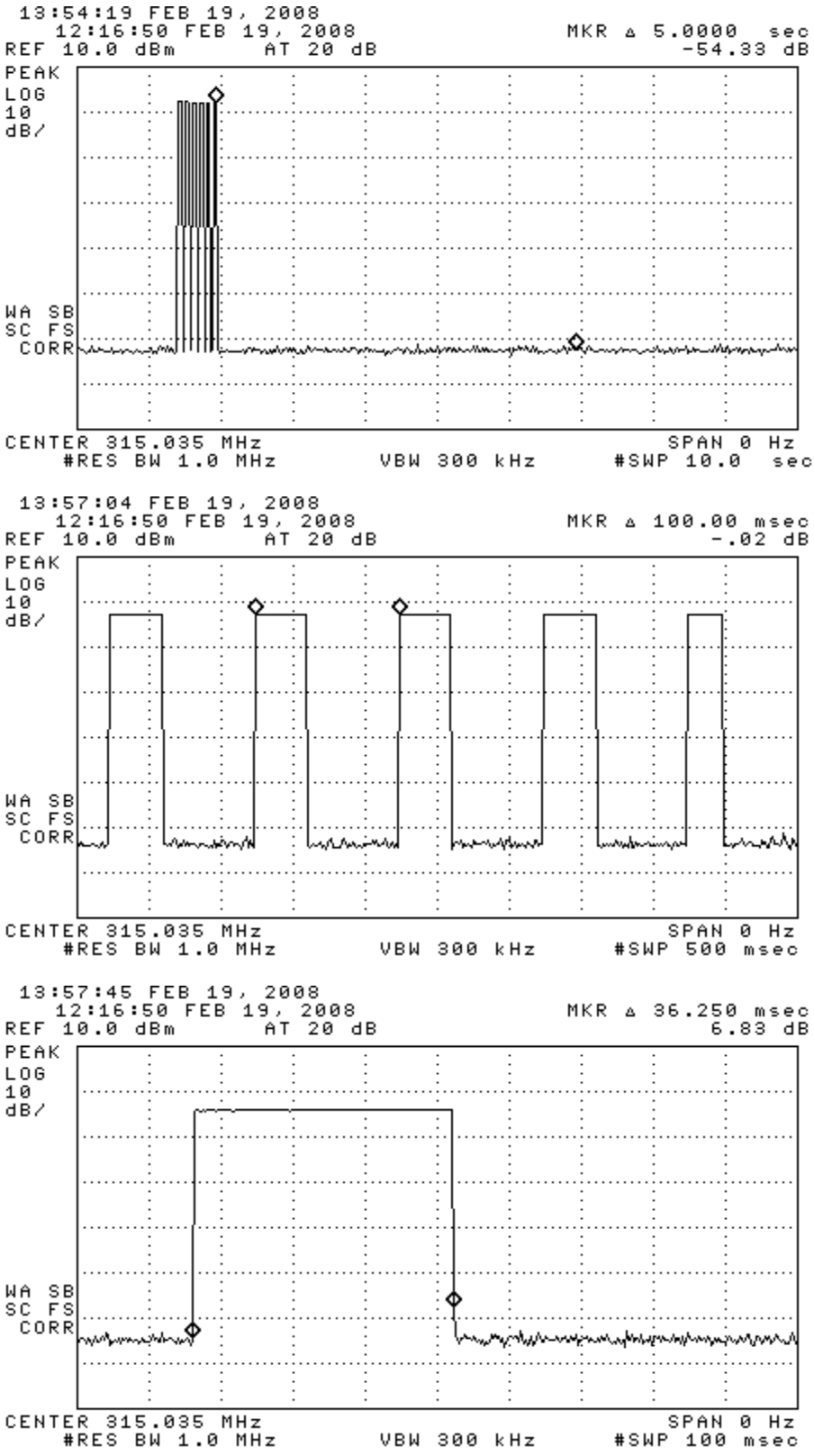


Figure 6.1(h). Transmissions modulation characteristics (9.6 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

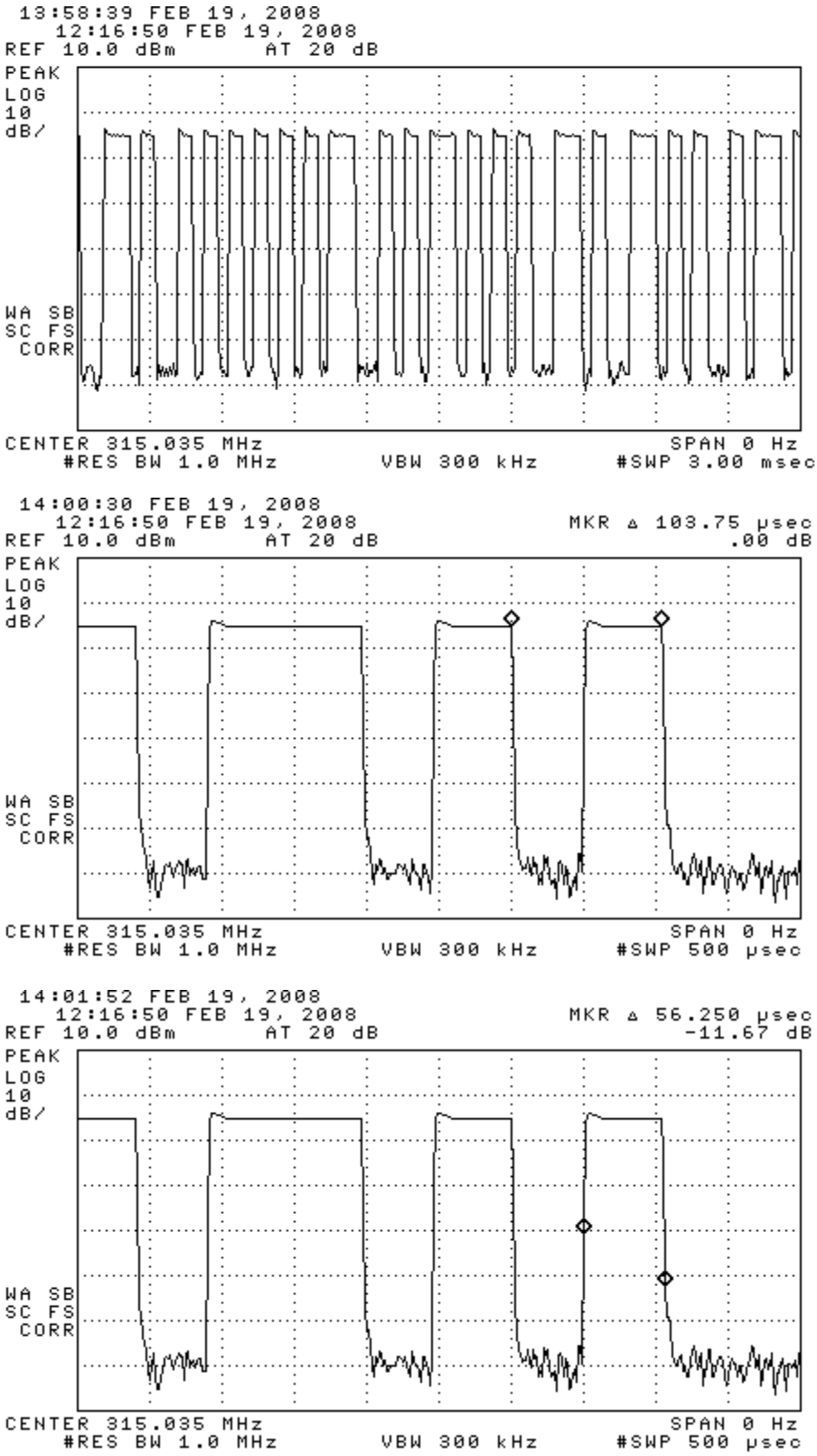


Figure 6.1(i). Transmissions modulation characteristics (9.6 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

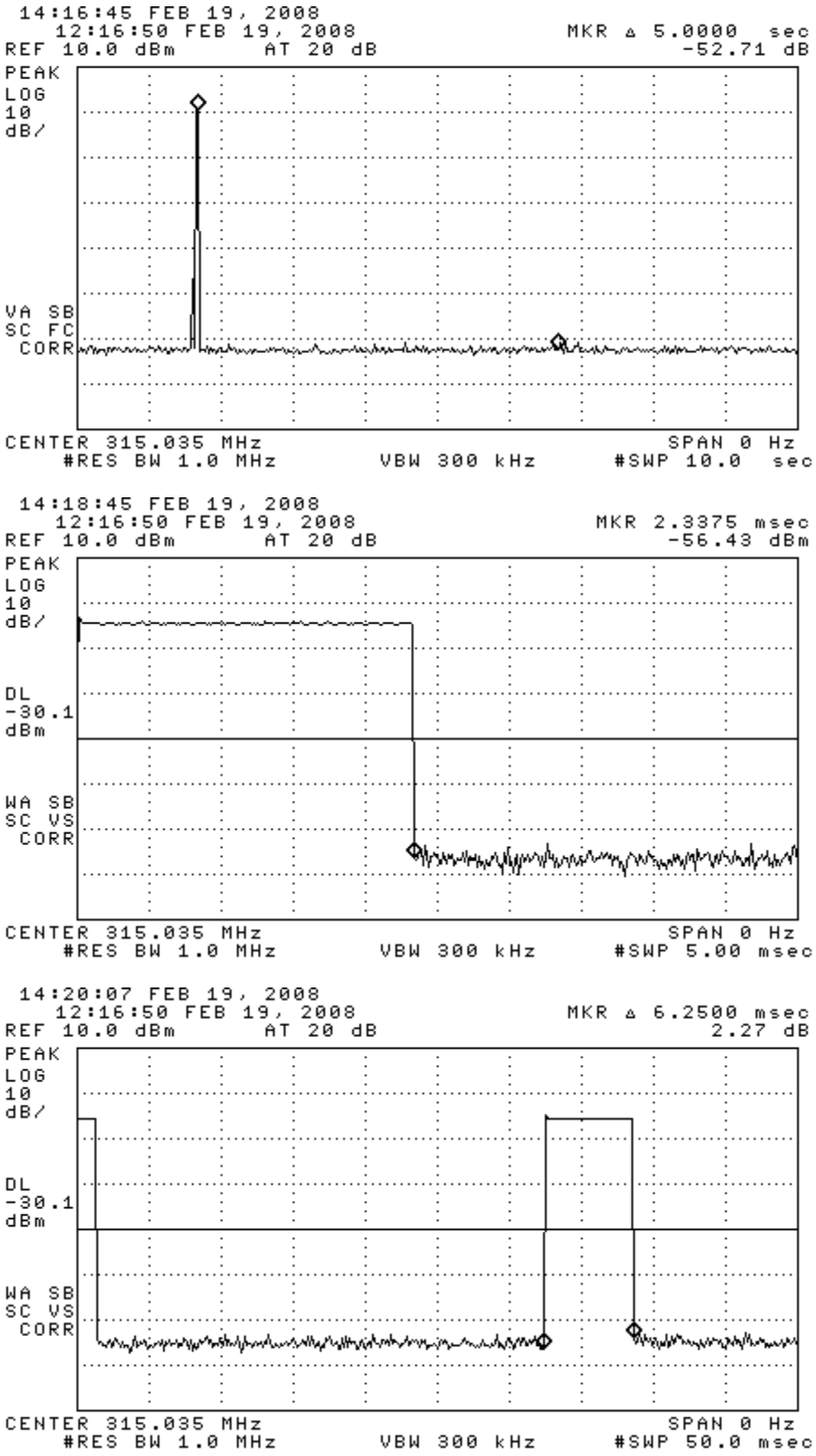


Figure 6.1(j). Transmissions modulation characteristics (9.6 kb/s FSK HP):
(top) complete transmission, (center) first pulse, (bottom) second pulse

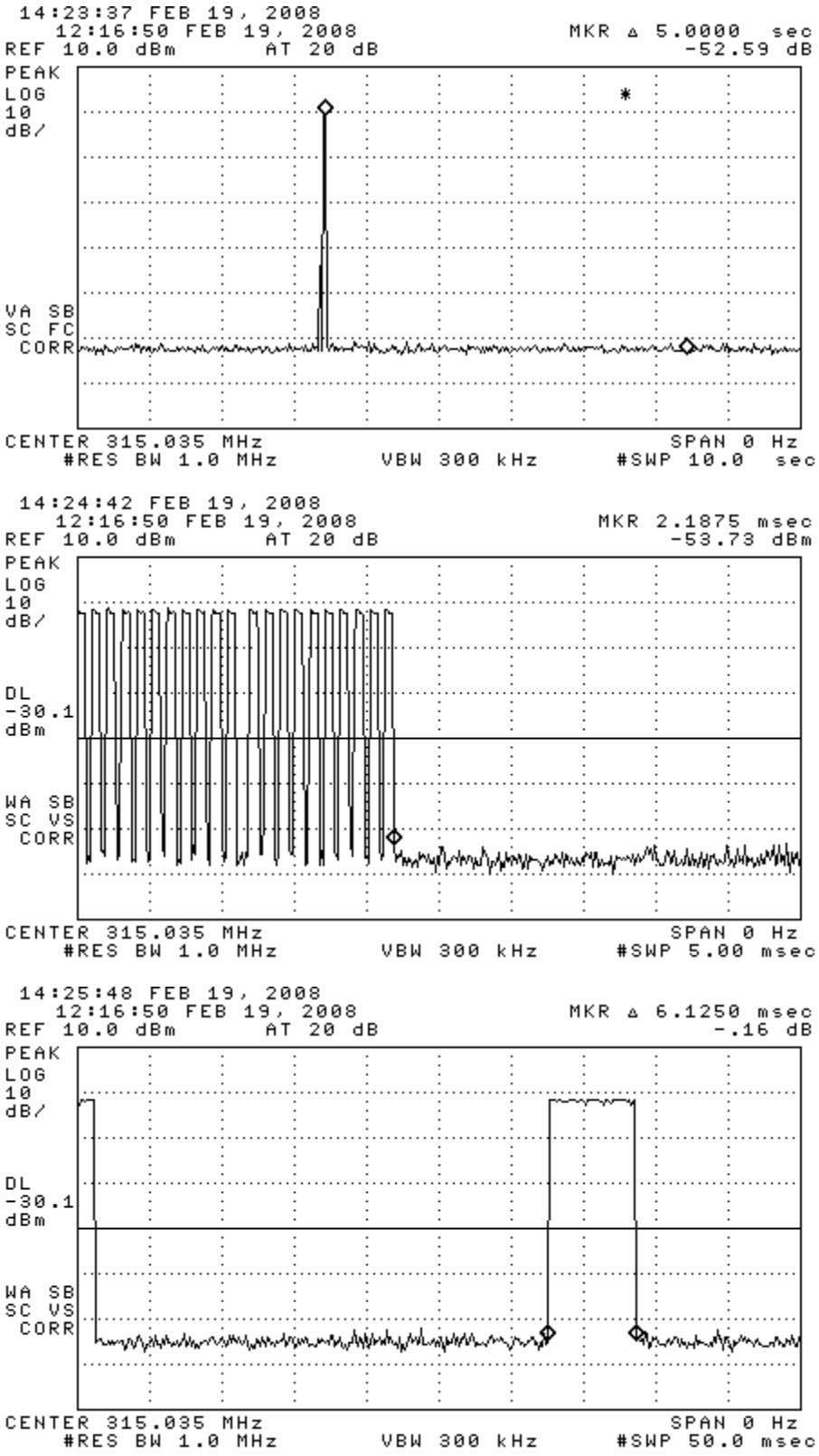


Figure 6.1(k). Transmissions modulation characteristics (9.6 kb/s ASK HP):
(top) complete transmission, (center) first pulse, (bottom) second pulse

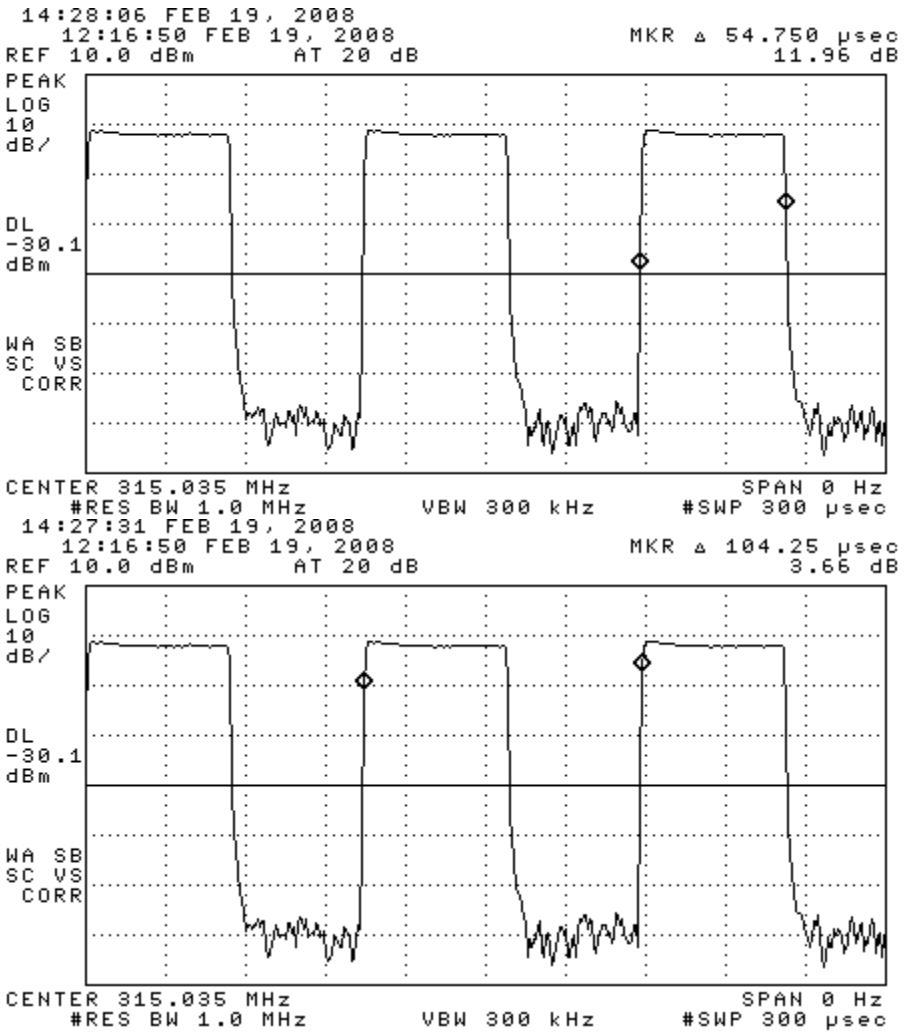


Figure 6.1(l). Transmissions modulation characteristics (9.6 kb/s ASK HP):
(top) complete transmission, (center) first pulse, (bottom) second pulse

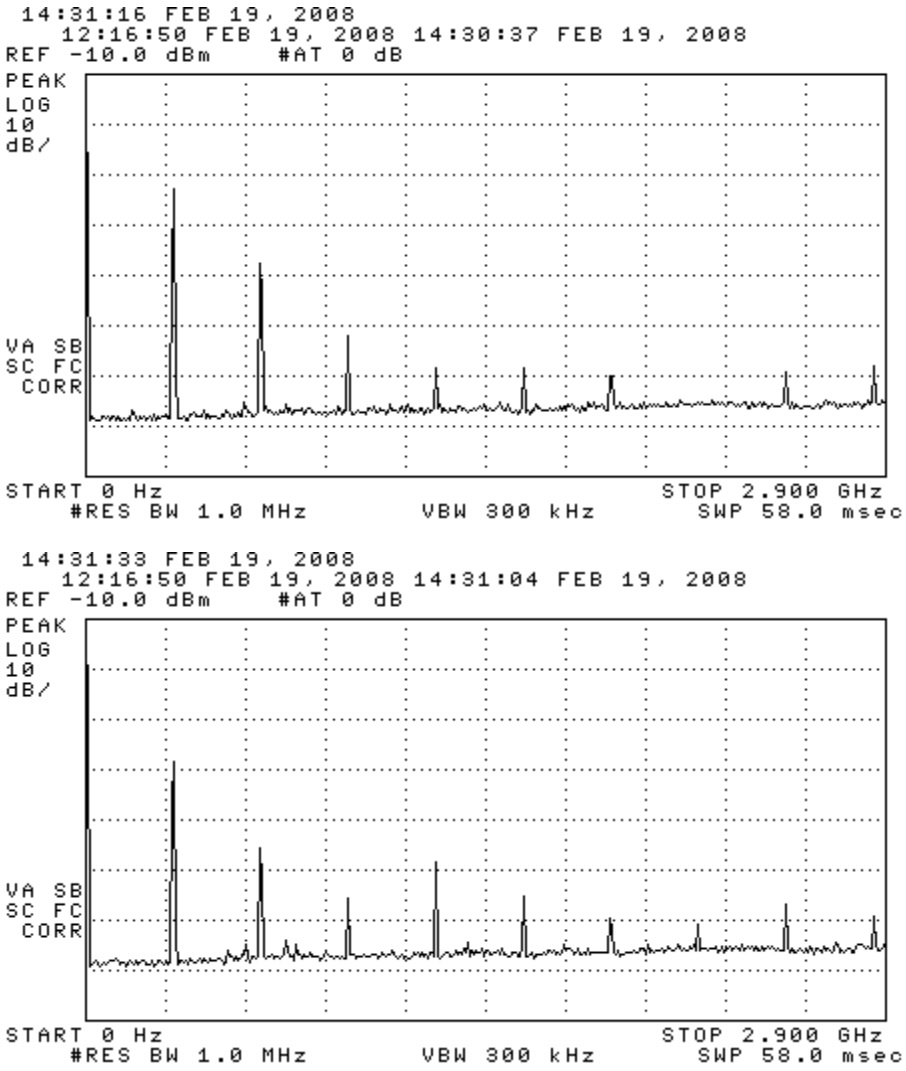


Figure 6.2. Emission spectrum of the DUT (pulsed emission). The amplitudes are only indicative (not calibrated). (top) High Power Transmission, (bottom) Low Power Transmission.

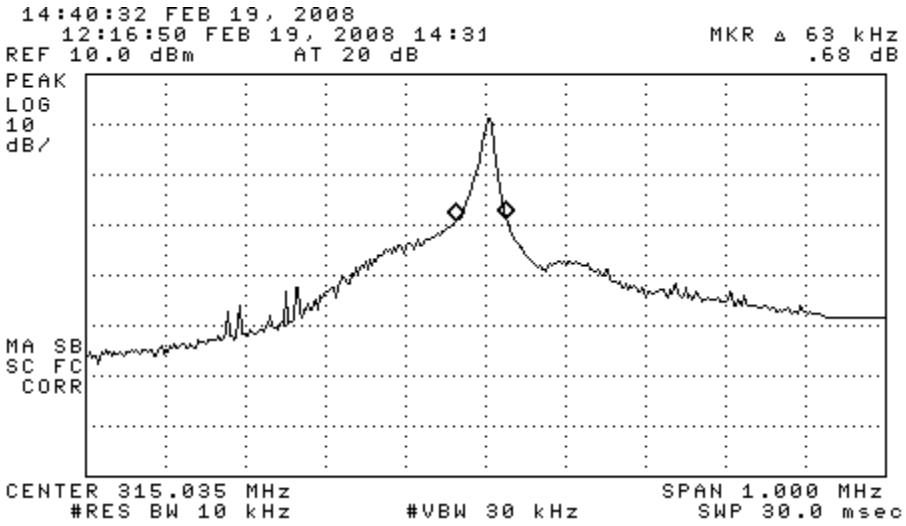


Figure 6.3(a). Measured bandwidth of the DUT (pulsed emission). 2.8 kb/s ASK HP

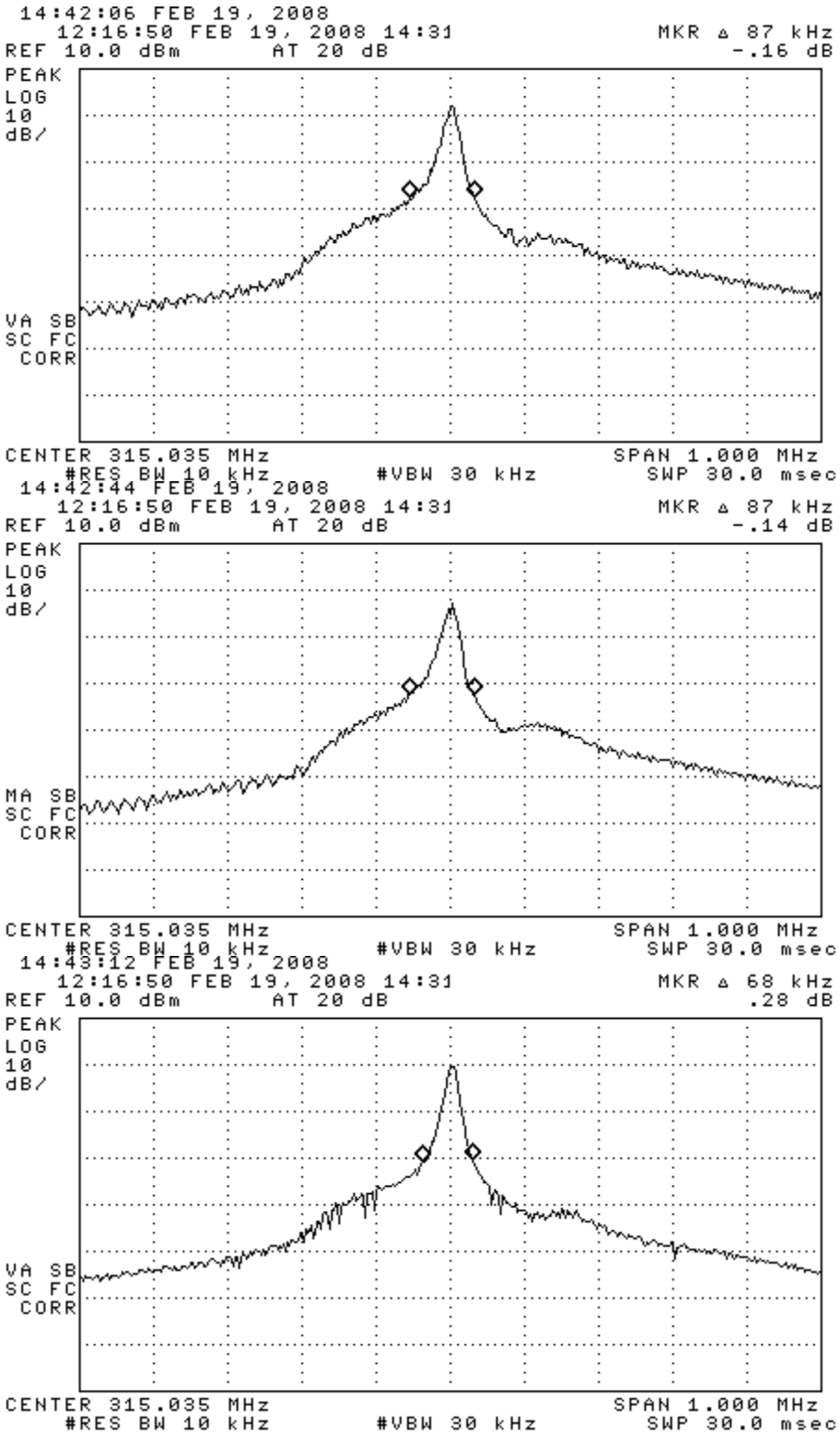


Figure 6.3(b). Measured bandwidth of the DUT (pulsed emission).
(top) 9.6 kb/s ASK HP, (middle) 9.6 kb/s ASK (NP), (bottom) 2.8 kb/s ASK NP

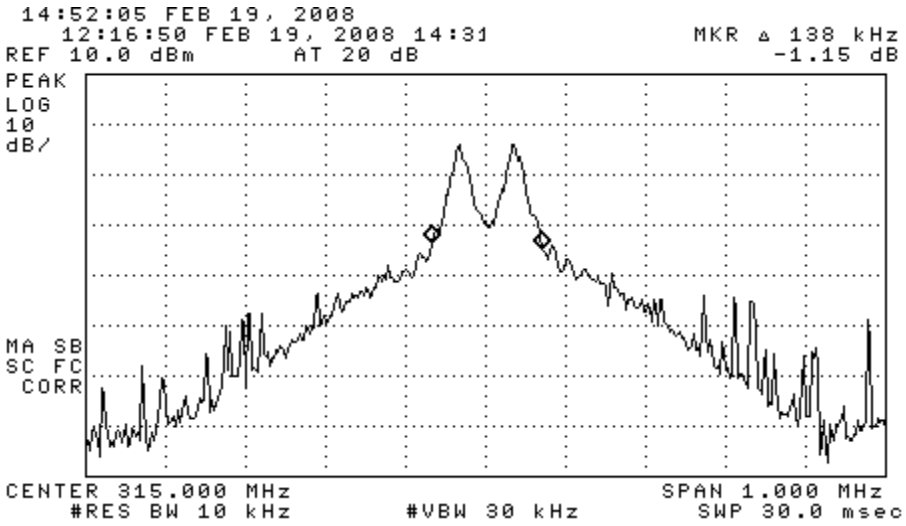


Figure 6.3(c). Measured bandwidth of the DUT (pulsed emission). 9.6 kb/s FSK (HP)

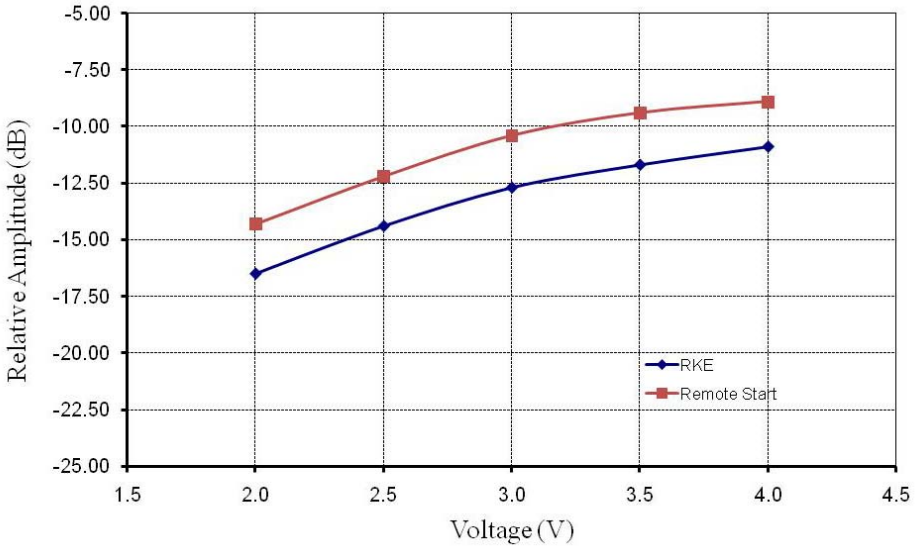
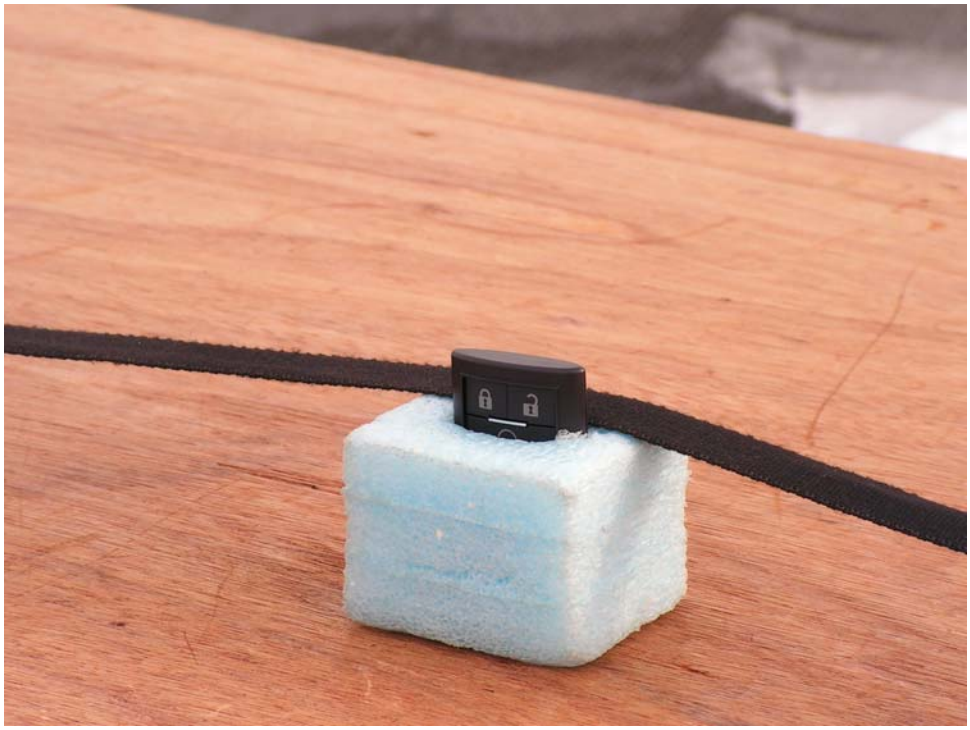


Figure 6.4. Relative emission at 315.0 MHz vs. supply voltage (pulsed emission).

DUT on OATS – one of three axes tested



DUT on OATS (close-up) – one of three axes tested