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Measured Radio Frequency Emissions
From

Siemens Transmitter
Model(s): 15294306, 15294307, 15294310, 15294311, 15803427, 15803428, 15780256, and 15780253

Report No. 415031-354
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Summary

Tests for compliance with FCC Regulations Part 15, Subpart C, and Industry Canada RSS-210/GEN, were performed on Siemens model(s) 15294306, 15294307, 15294310, 15294311, 15803427, 15803428, 15780256, 15780253. This device is subject to the Rules and Regulations as a Transmitter.

In testing completed on January 29, 2007, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 1.1 dB (see p. 6). Besides harmonics, there were no other significant spurious emissions found. The conducted emission tests do not apply, since the device is powered by a 3 VDC battery.

1. Introduction

Siemens models 15294306, 15294307, 15294310, 15294311, 15803427, 15803428, 15780256, 15780253 were 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 2057).

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, 1.5 x 0.25 x 1 inches in size. The DUT transmits ASK and FSK data and its carrier is PLL generated, sourced from a 9.844 MHz reference crystal. The antenna is a trace on the PCB. The DUT was designed and manufactured by Siemens VDO Automotive, 4685 Investment Drive, Troy, MI 48098. It is identified as:

Siemens Transmitter
Model(s): 15294306, 15294307, 15294310, 15294311,
15803427, 15803428, 15780256, 15780253
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 utilizes a greater duty cycle. The normal peak power (NP) setting 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. A CW modified device was tested in both the HP and LP modes. Modulation data is recorded and applied to the CW emissions, showing compliance for all modulations. The 5 button device demonstrated worst case emissions with the key inserted into the fob, and is the module tested.

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 9.6 kb/s ASK modulation and RKE LF actuated 9.6 kb/s ASK modulation. RKE is normal power 9.6 kb/s data rate ASK modulation

No. 295: A 5 button module with RKE 9.6 kb/s ASK modulation, RS 9.6 kb/s ASK, and RKE LF 9.6 kb/s ASK modulation

No. 322: A 5 button module with RKE 2.84 kb/s ASK modulation, RS 2.8 kb/s ASK, and RKE LF 9.6 kb/s FSK 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
15294306	215 Domestic 4 button TX # 1	15803427	295 Domestic 5 button TX # 1
15294307	215 Domestic 4 button TX # 2	15803428	295 Domestic 5 button TX # 2
15294310	245 Domestic 4 button TX # 1	15780256	322 Domestic 5 button TX #1
15294311	245 Domestic 4 button TX # 2	15780253	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 1.1 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 modes of operation discussed. The worst case duty cycle for the high and low power settings are applied in the data table. Supporting plots are shown in Figure 6.1.

NP ASK 2.84 kb/s: K_E = (46.0 ms / 100 ms) x (0.185 ms / 0.350 ms) = 0.243 or -12.3 dB.
NP ASK 9.6 kb/s: K_E = (47.4 ms / 100 ms) x (0.056 ms / 0.104 ms) = 0.255 or **-11.9 dB**.

HP ASK 2.84 kb/s: K_E = (35.5 ms / 100 ms) x (0.180 ms / 0.350 ms) = 0.183 or -14.8 dB.
HP ASK 9.6 kb/s: K_E = (36.5 ms / 100 ms) x (0.053 ms / 0.104 ms) = 0.186 or **-14.6 dB**.
FSK 9.6 kb/s: K_E = (2.34 ms + 6.25 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 148.0 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} = 3.23 V
	after testing	V_{oc} = 3.04 V
Ave. current from batteries		I = 15.2 mA (cw)

Table 5.1 Highest Emissions Measured

Radiated Emission - RF											Siemens, CorpFOB; 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	**High Power Setting**										
2	315.0	Dip	H	-13.9	Pk	18.6	23.3	73.8	75.6	**1.9**	flat
3	315.0	Dip	V	-18.6	Pk	18.6	23.3	69.1	75.6	6.6	side
4	630.0	Dip	H	-58.6	Pk	24.4	20.3	37.9	55.6	17.7	flat
5	630.0	Dip	V	-57.0	Pk	24.4	20.3	39.5	55.6	16.1	end
6	945.0	Dip	H	-80.6	QPk	28.8	18.4	22.2	55.6	33.4	max all, noise
7	945.0	Dip	V	-80.3	QPk	28.8	18.4	22.5	55.6	33.1	max all, noise
8	1260.0	Horn	H	-48.3	Pk	20.6	28.0	36.7	55.6	18.9	flat
9	1575.0	Horn	H	-50.2	Pk	21.5	28.0	35.7	55.6	19.9	side
10	1890.0	Horn	H	-45.8	Pk	22.2	28.0	40.8	55.6	14.8	side
11	2205.0	Horn	H	-47.7	Pk	23.0	27.0	40.7	55.6	14.9	side
12	2520.0	Horn	H	-49.5	Pk	23.9	26.3	40.5	55.6	15.1	flat
13	2835.0	Horn	H	-46.0	Pk	24.8	25.6	45.6	55.6	10.0	flat
14	3150.0	Horn	H	-56.8	Pk	25.8	24.9	36.5	55.6	19.1	end
15	* Includes worst case 14.6 dB duty factor										
16											
17	**Normal Power Setting**										
18	315.0	Dip	H	-15.8	Pk	18.6	23.3	74.6	75.6	**1.1**	flat
19	315.0	Dip	V	-20.2	Pk	18.6	23.3	70.2	75.6	5.5	side
20	630.0	Dip	H	-60.8	Pk	24.4	20.3	38.4	55.6	17.2	flat
21	630.0	Dip	V	-59.7	Pk	24.4	20.3	39.5	55.6	16.1	end
22	945.0	Dip	H	-80.5	QPk	28.8	18.4	25.0	55.6	30.6	max all, noise
23	945.0	Dip	V	-79.1	QPk	28.8	18.4	26.4	55.6	29.2	max all, noise
24	1260.0	Horn	H	-46.7	Pk	20.6	28.0	41.0	55.6	14.6	flat
25	1575.0	Horn	H	-53.8	Pk	21.5	28.0	34.8	55.6	20.8	side
26	1890.0	Horn	H	-47.9	Pk	22.2	28.0	41.4	55.6	14.2	flat
27	2205.0	Horn	H	-50.7	Pk	23.0	27.0	40.4	55.6	15.2	side
28	2520.0	Horn	H	-49.1	Pk	23.9	26.3	43.6	55.6	12.0	flat
29	2835.0	Horn	H	-48.3	Pk	24.8	25.6	46.0	55.6	9.6	end
30	3150.0	Horn	H	-56.0	Pk	25.8	24.9	40.0	55.6	15.6	side
31	** Includes worst case 11.9 dB duty factor										
32											
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
33											
34	Digital emissions more than 20 dB below FCC/IC Class B Limit.										
35											
36	* For devices used in transportation vehicles, digital emissions are exempt from FCC regulations per FCC 15.1										

Meas. 01/25/2007; U of Mich.

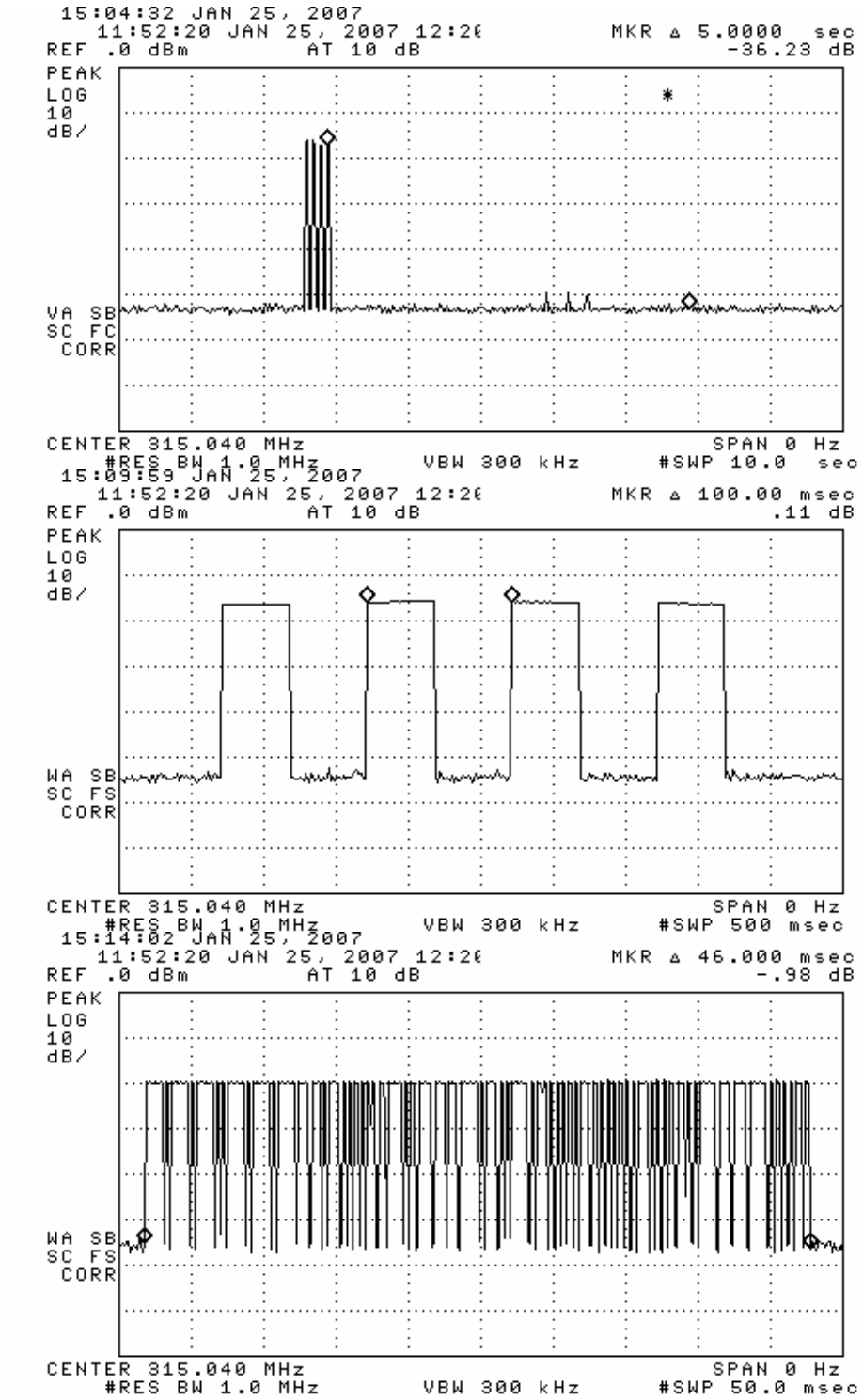


Figure 6.1(a). Transmissions modulation characteristics (2.8 kb/s ASK NP):
(top) complete transmission, (center) expanded bit, (bottom) expanded period.

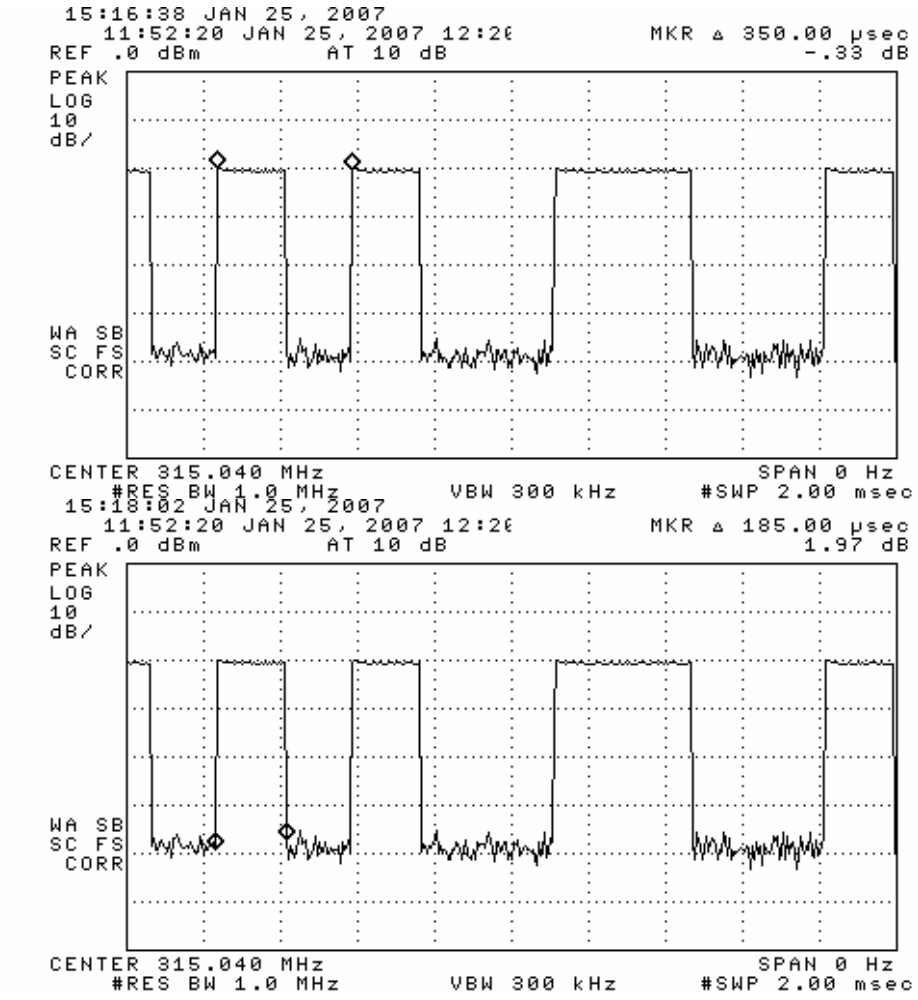


Figure 6.1(b). Transmissions modulation characteristics (2.8 kb/s ASK NP): (top) complete transmission, (center) expanded bit, (bottom) expanded period.

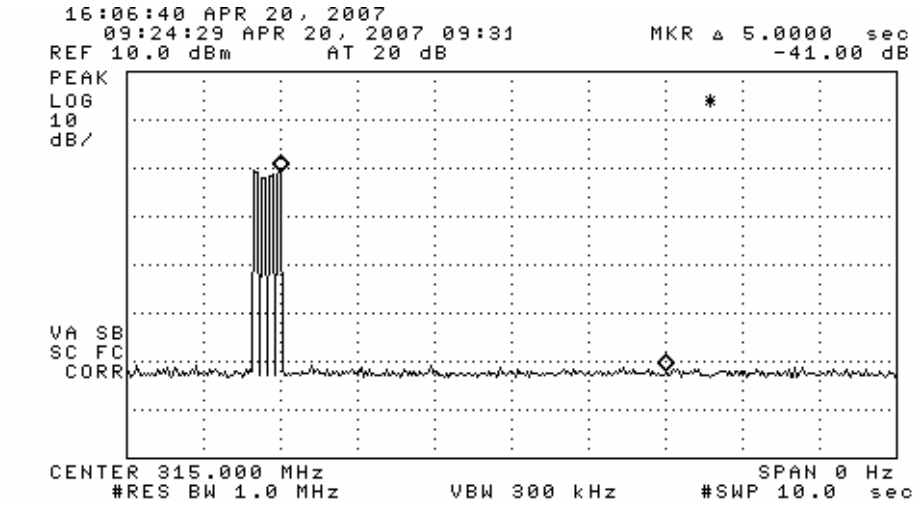


Figure 6.1(c). Transmissions modulation characteristics (9.6 kb/s ASK NP): complete transmission.

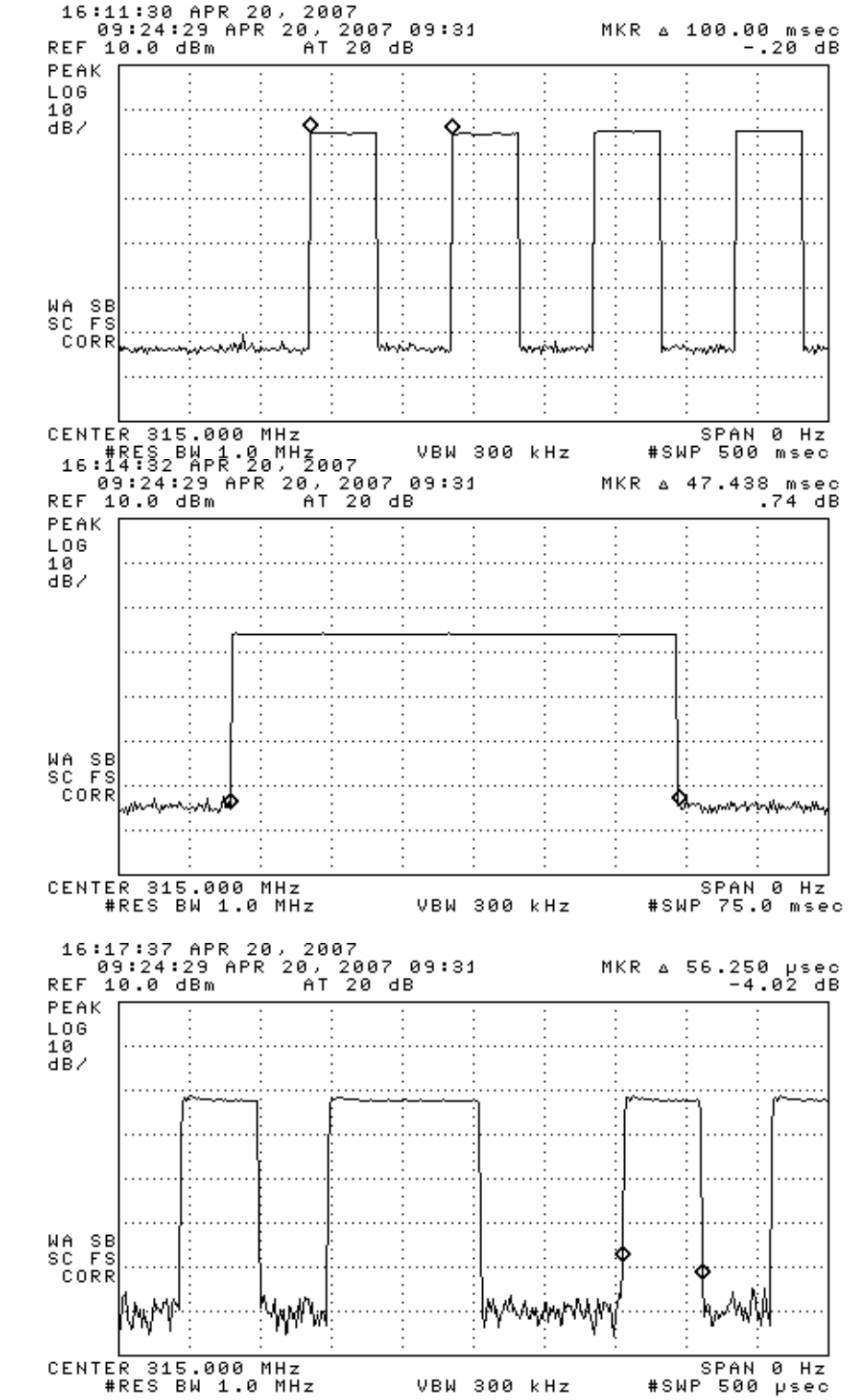


Figure 6.1(d). Transmissions modulation characteristics (9.6 kb/s ASK NP): (top) word period, (center) word length, (bottom) Manchester width

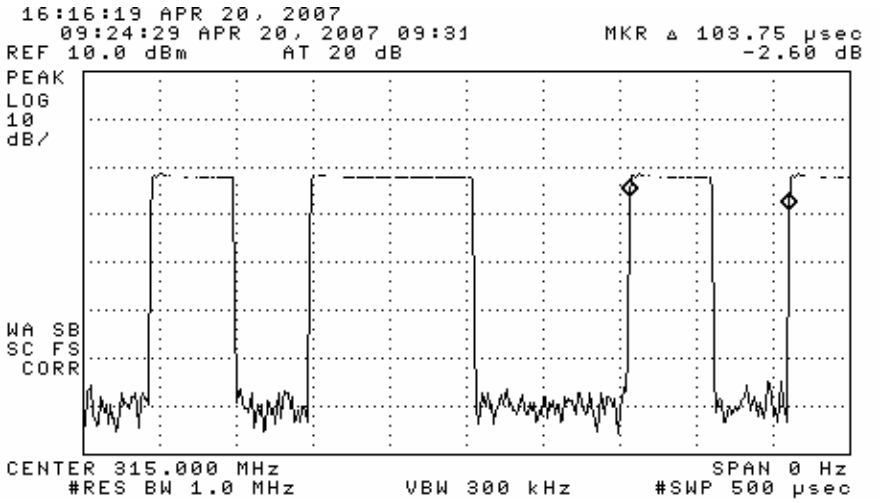


Figure 6.1(e). Transmissions modulation characteristics (9.6 kb/s ASK NP): Manchester period

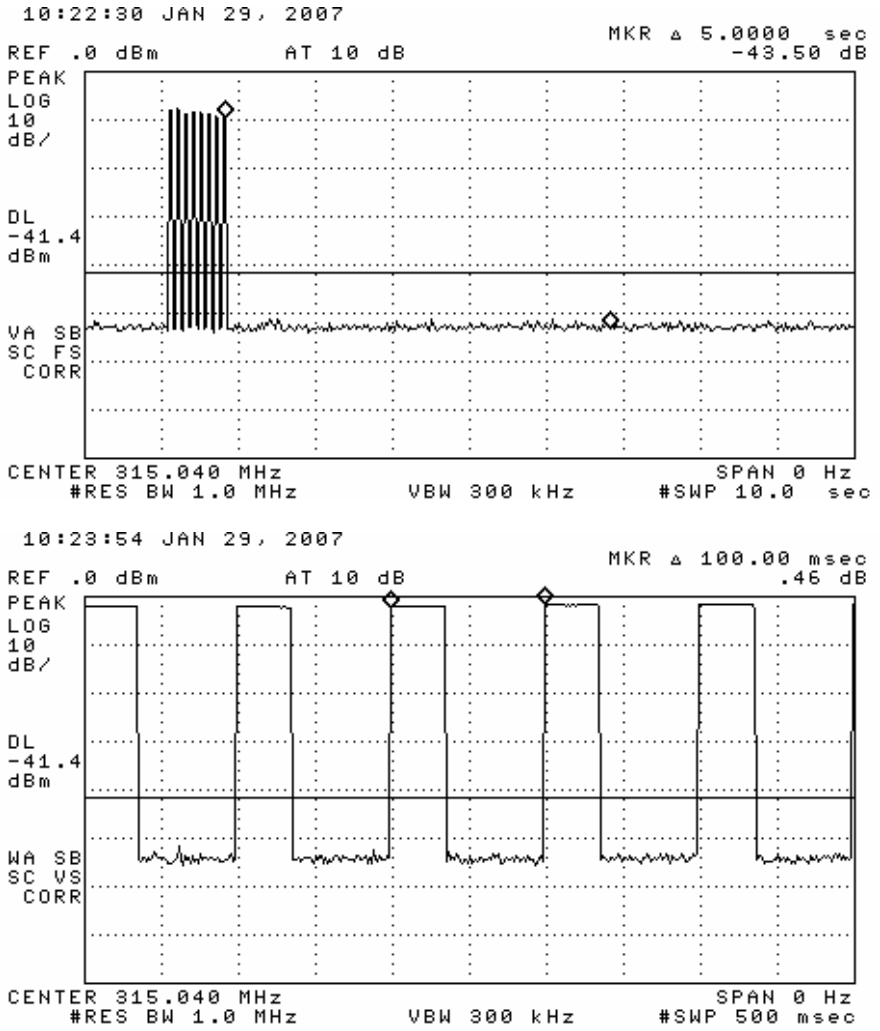


Figure 6.1(f). Transmissions modulation characteristics (2.8 kb/s ASK HP): (top) complete transmission, (bottom) word period

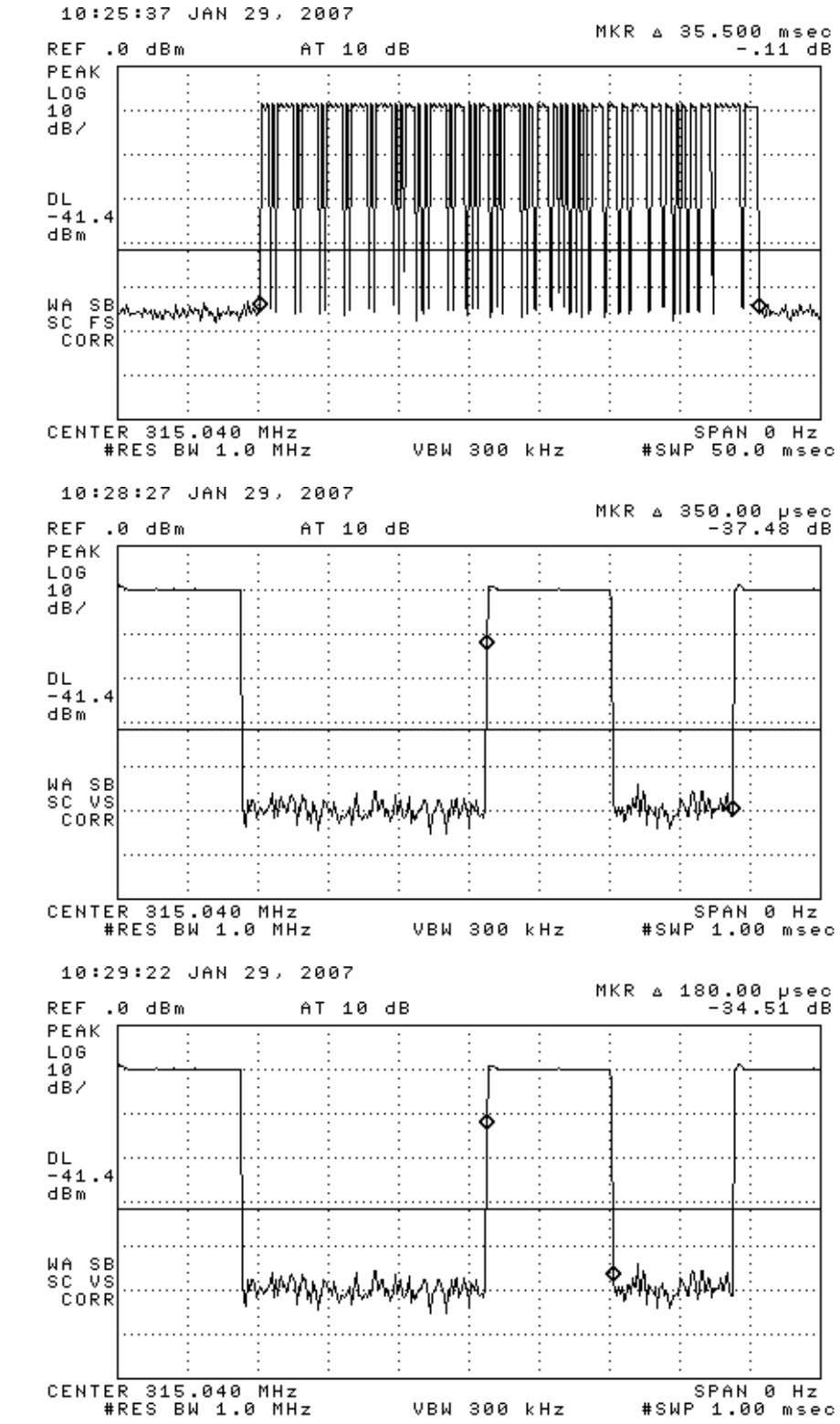


Figure 6.1(g). Transmissions modulation characteristics (2.8 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

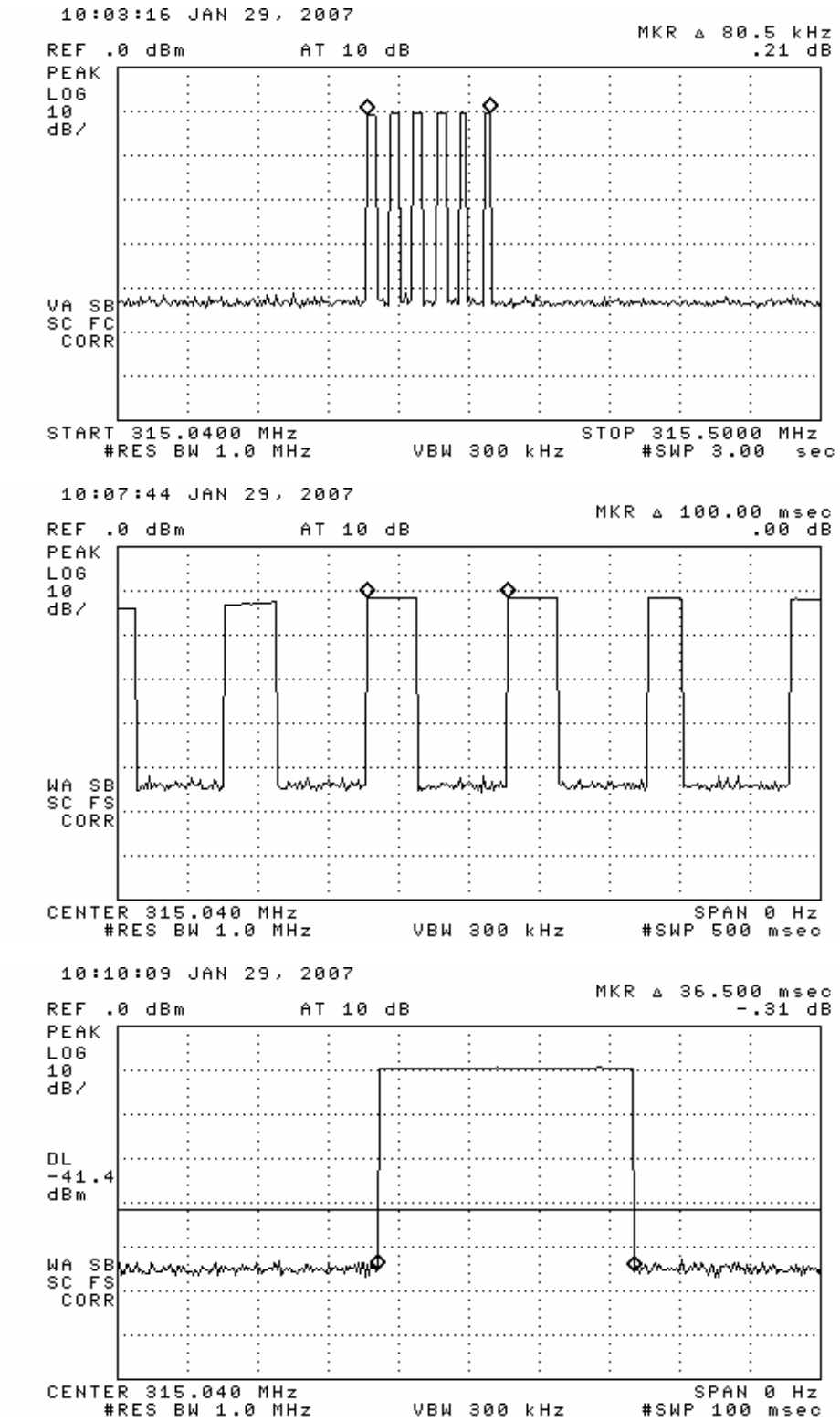


Figure 6.1(h). Transmissions modulation characteristics (9.6 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

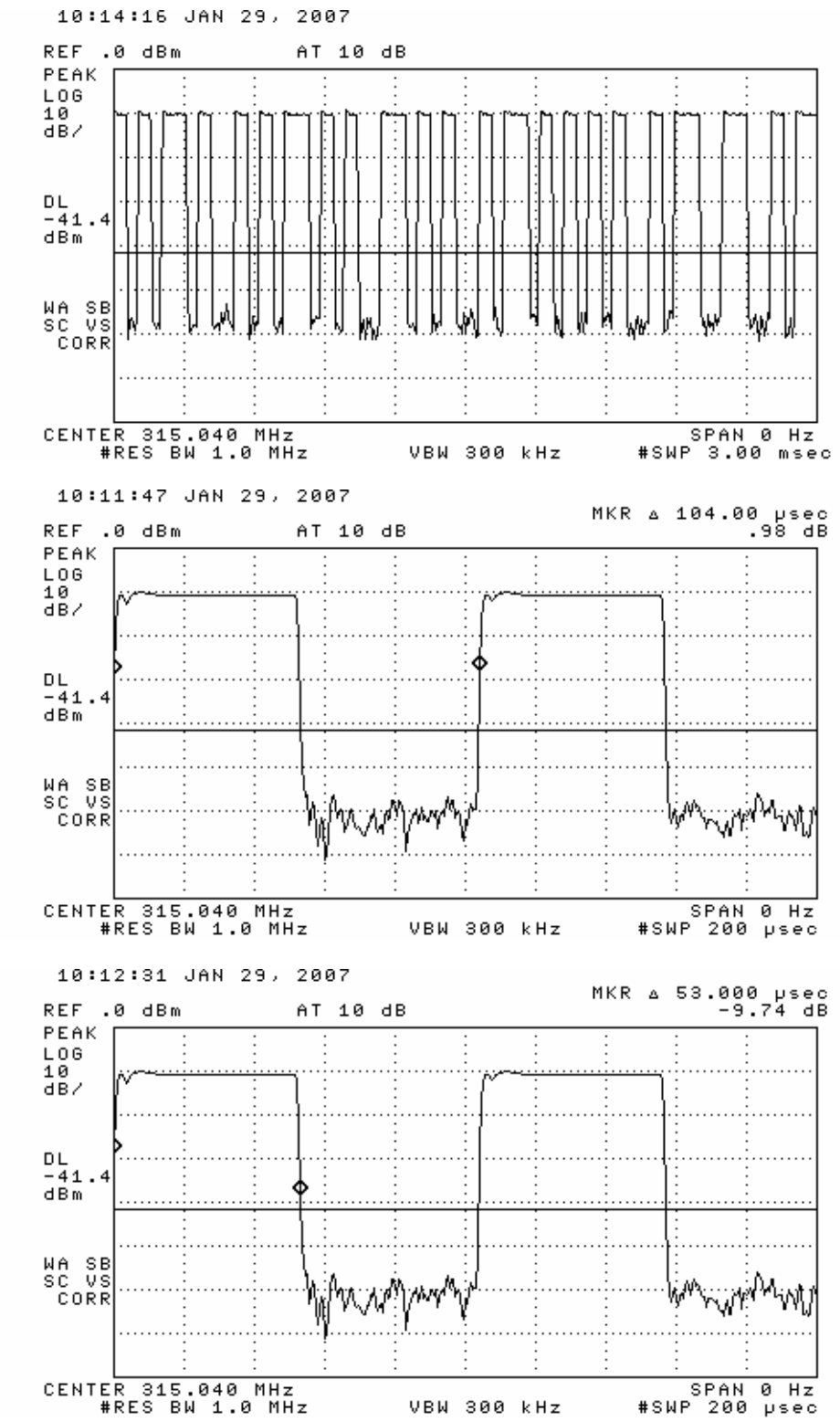


Figure 6.1(h). Transmissions modulation characteristics (9.6 kb/s ASK HP): (top) complete word, (center) Manchester period, (bottom) width

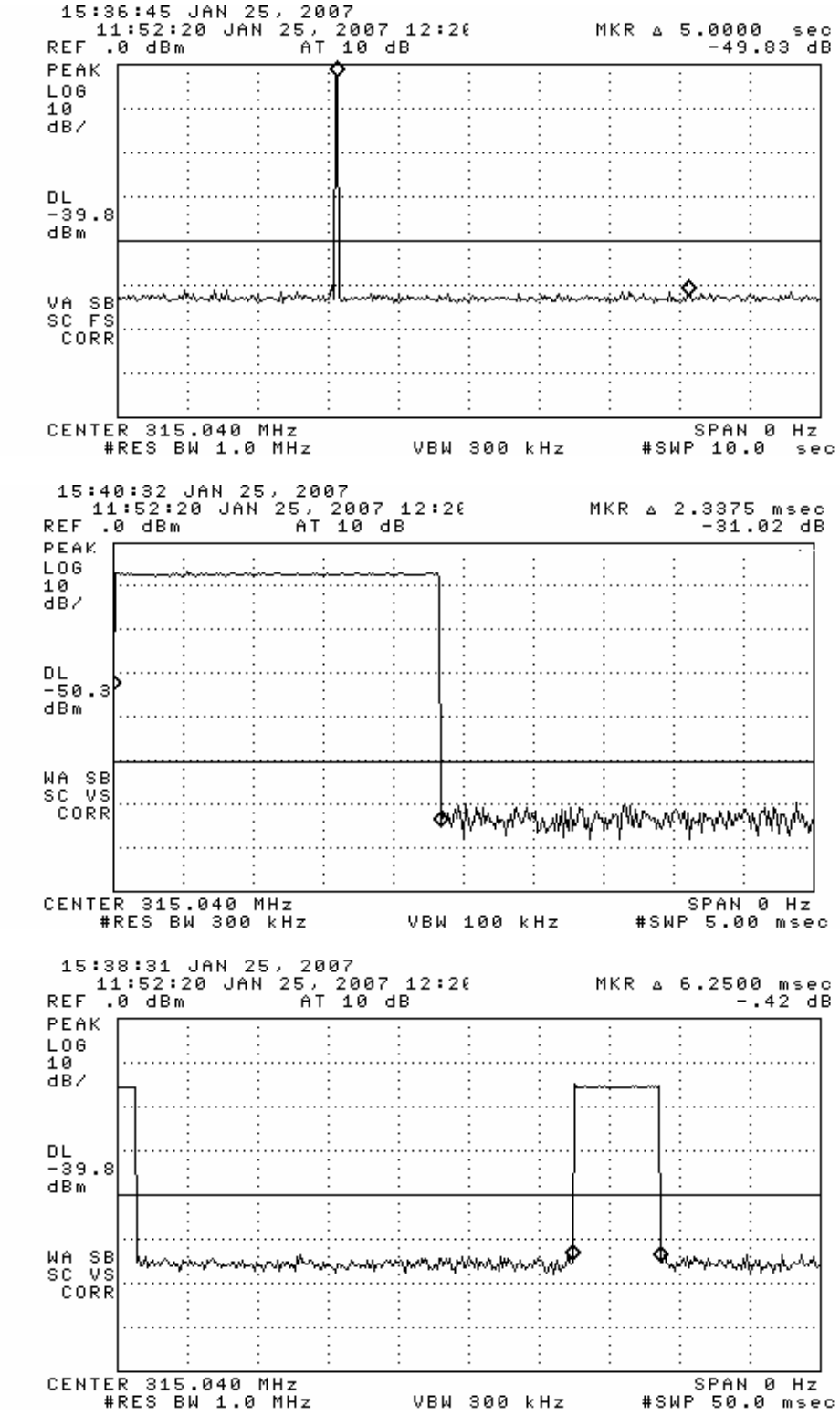


Figure 6.1(i). Transmissions modulation characteristics (9.6 kb/s FSK HP): (top) complete transmission, (center) first pulse, (bottom) second pulse

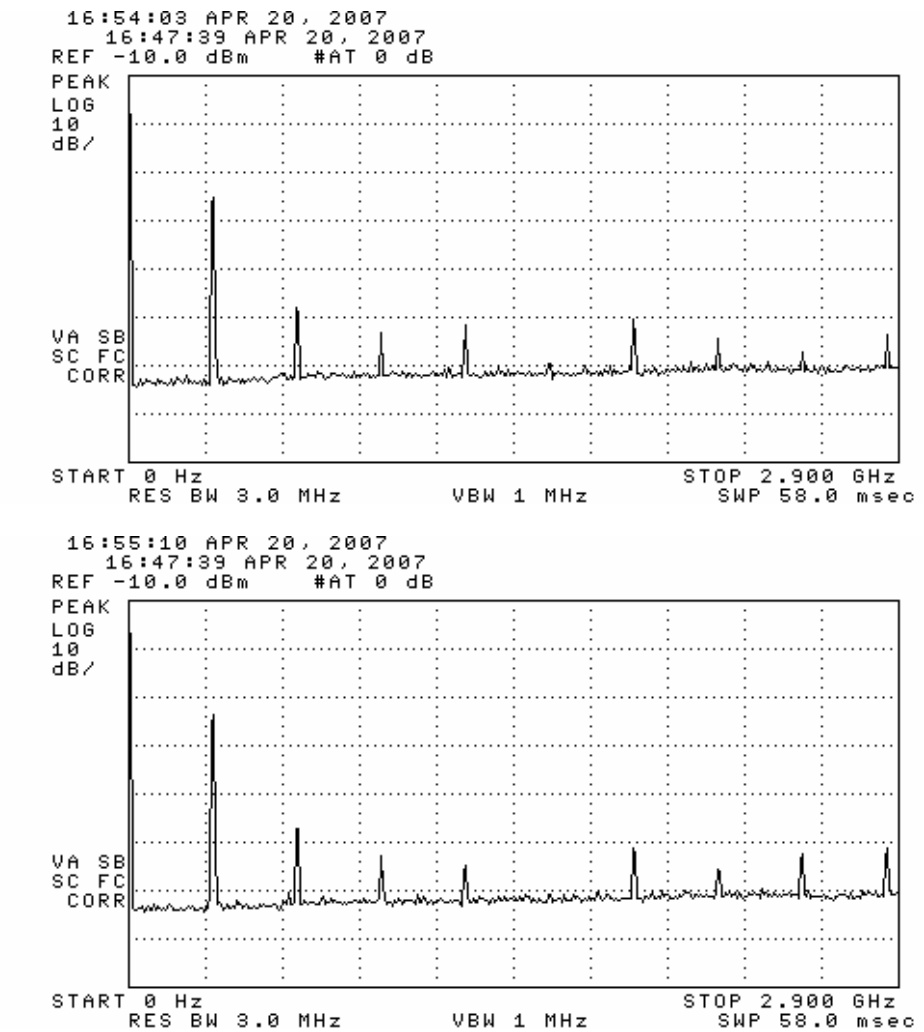


Figure 6.2. Emission spectrum of the DUT (pulsed emission). The amplitudes are only indicative (not calibrated). (top) High Power Transmission, (bottom) Low Power Transmission.

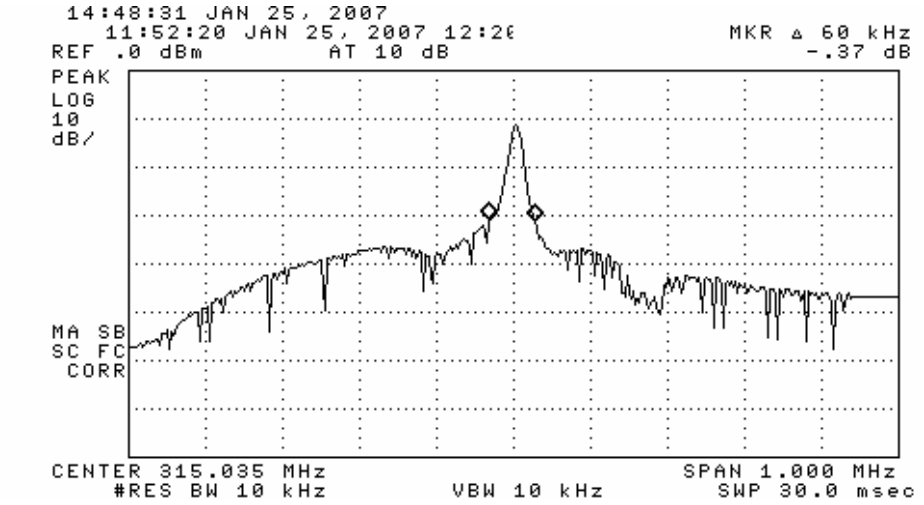


Figure 6.3(a). Measured bandwidth of the DUT (pulsed emission). 2.8 kb/s ASK HP

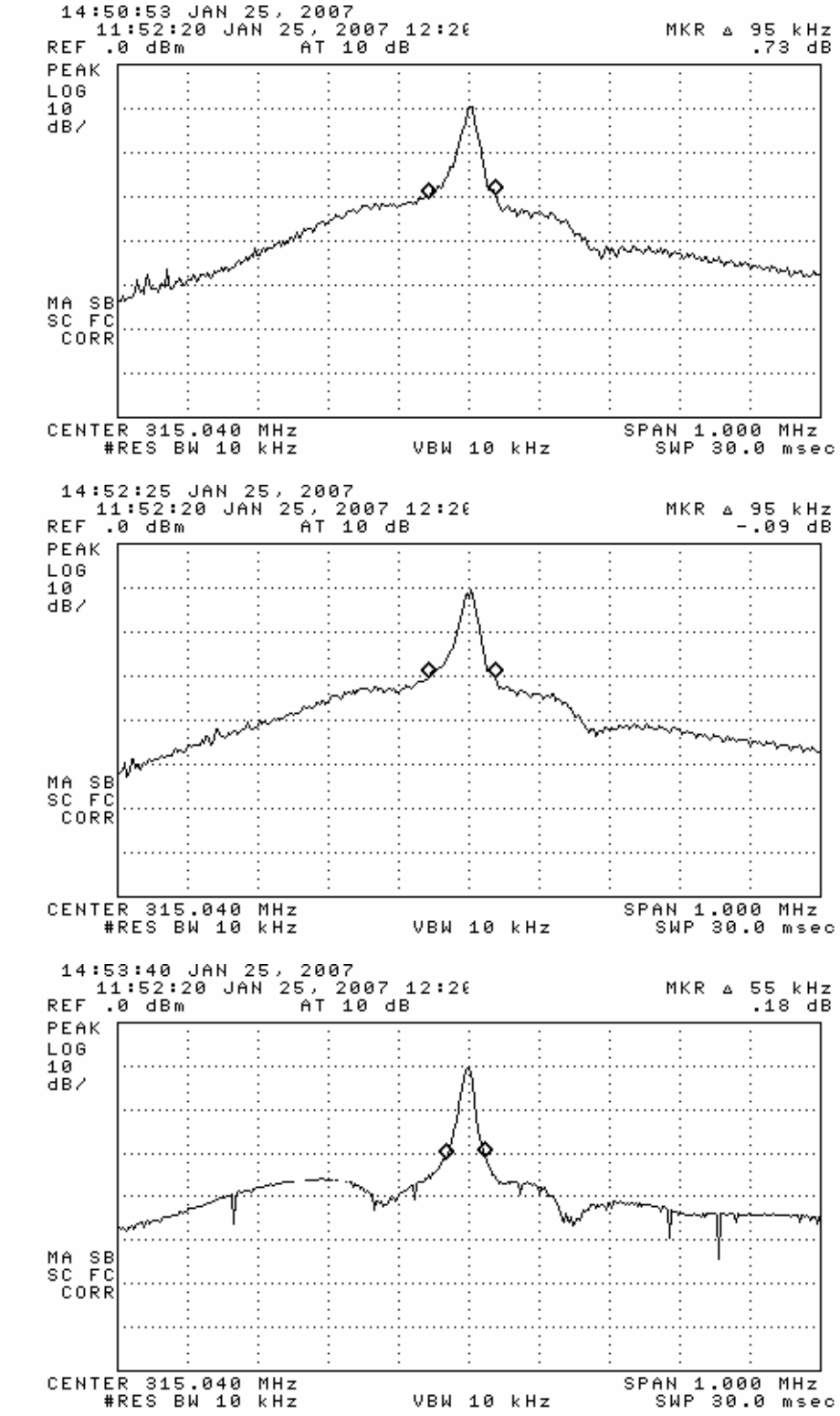


Figure 6.3(b). Measured bandwidth of the DUT (pulsed emission).
(top) 9.6 kb/s ASK HP, (middle) 9.6 kb/s ASK (NP), (bottom) 2.8 kb/s ASK NP

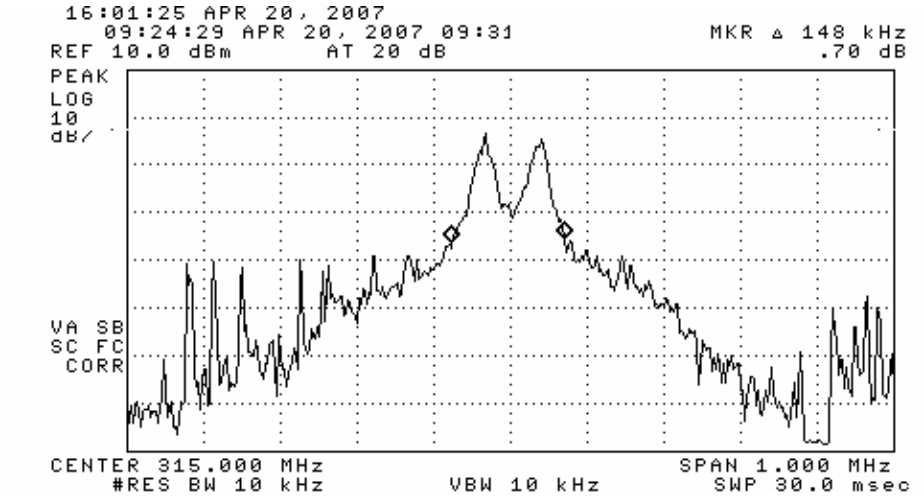


Figure 6.3(c). Measured bandwidth of the DUT (pulsed emission). 9.6 kb/s FSK (HP)

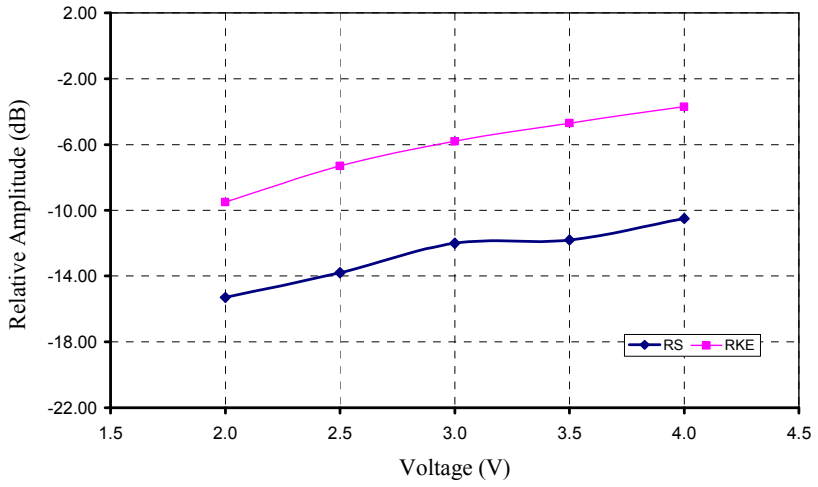
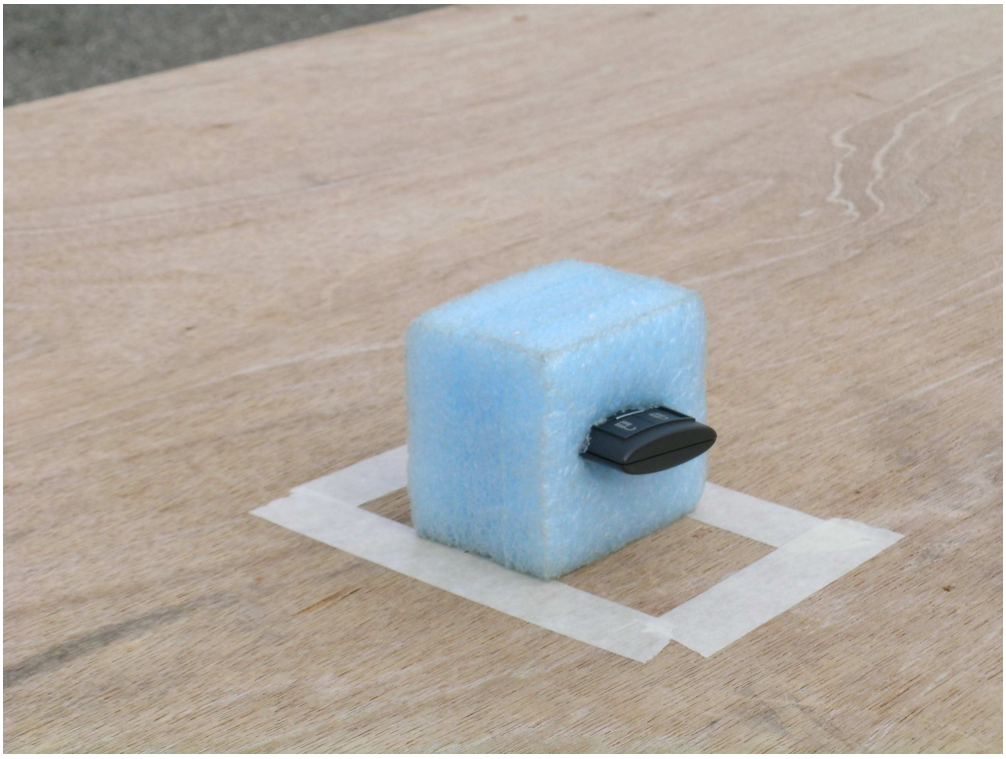


Figure 6.4. Relative emission at 315.0 MHz vs. supply voltage (pulsed emission).

DUT on OATS



DUT on OATS (close-up)