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Measured Radio Frequency Emissions From

DSA
RF Transceiver Module
(with ANT I and ANT II Antennas)
Model: GIGA3

Report No. 415031-083
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Summary

Tests for compliance with FCC Regulations, Part 15, Subpart C, and for compliance with Industry Canada RSS-210, were performed on a DSA GIGA3 modular transceiver. This device is subject to the Rules and Regulations as a transmitter, receiver, and as a digital device.

In testing performed on March 27, May 4 and 22, 2001, the device tested in the worst case met the allowed specifications for radiated emissions by 15.0 dB at fundamental and by 4.8 dB at harmonics (see p. 6). Besides harmonics, there were no other significant spurious emissions found; emissions from receiver portion were negligible. Digital emissions, Class A, were met by 5.9 dB. Since the device is powered by a 9-volt rechargable MNH battery pack, the conductive emission tests do not apply.

1. Introduction

DSA GIGA3 modular transceiver was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 2, dated February 14, 1998. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-1992 "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 2057).

2. Test Procedure and Equipment Used

The test equipment commonly used in our facility is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests. The HP 8593E spectrum analyzer is used for primary amplitude and frequency reference.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8593A SN: 3107A01358	October 1999/UM
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	September 1999/HP
Spectrum Analyzer (0.1-1500 MHz)		Hewlett-Packard 182T/8558B SN: 1529A01114/543592	October 1999/U of M Rad Lab
Preamplifier (5-1000MHz)	X	Watkins-Johnson A11 -1 plus A25-1S	October 1999/U of M Rad Lab
Preamplifier (5-4000 MHz)	X	Avantek	Oct. 1999/ U of M Rad Lab
Broadband Bicone (20-200 MHz)	X	University of Michigan	June 1996/U of M Rad Lab
Broadband Bicone (200-1000 MHz)		University of Michigan	June 1996/U of M Rad Lab
Dipole Antenna Set (25-1000 MHz)	X	University of Michigan	Dec. 1997/U of M Rad Lab
Dipole Antenna Set (30-1000 MHz)		EMCO 3121C SN: 992	June 1996/U of M Rad Lab
Active Loop Antenna (0.090-30MHz)		EMCO 6502 SN: 2855	December 1993/ EMCO
Active Rod (30Hz-50 MHz)		EMCO 3301B SN: 3223	December 1993/EMCO
Ridge-horn Antenna (0.5-5 GHz)	X	University of Michigan	March 1999/U of M Rad Lab
S-Band Std. Gain Horn	X	S/A, Model SGH-2.6	Manufacturer, NRL design
C-Band Std. Gain Horn	X	University of Michigan	Manufacturer, NRL design
XN-Band Std. Gain Horn	X	University of Michigan	Manufacturer, NRL design
X-Band Std. Gain Horn	X	S/A, Model 12-8.2	Manufacturer, NRL design
Ku-Band Std. Gain Horn	X	University of Michigan	Manufacturer, NRL design
K-Band Std. Gain Horn	X	FXR, Inc. K638KF	Manufacturer, NRL design
LISN Box		University of Michigan	Dec. 1997/U of M Rad Lab
Signal Cables	X	Assorted	January 1993/U of M Rad Lab
Signal Generator (0.1-990 MHz)		Hewlett-Packard 8656A	January 1990/U of M Rad Lab

3. Configuration and Identification of Device Under Test

The DUT is a 8 x 5.5 x 1 cm transceiver module designed to communicate with a similar product in the 2400 - 2483.5 MHz band. (It is like a PCMCIA card, with digital in/out, and RF out/in, but does not use spread spectrum). The module has been developed for use in numerous DSA products, such as Hand Held Terminal, Steering Wheel Ballancer, or ECOS Systems Radio Current Probe. The module will operate from 2403 to 2481 MHz on any of 79 available channels.

The GIGA3 was designed and manufactured by DSA - Daten- und Systemtechnik GmbH - Pascalstr. 28 - 52076 Aachen - Germany. It is identified as:

DSA RF Module
Model: GIGA3
FCC ID: PJY003
CANADA:

The GIGA3 Module was tested in conjunction with the DSA Hand Held Terminal. To meet the modular device testing requirements, i.e., to separate the DUT from the host device, a meter long ribbon cable was constructed and used. In addition, the tests were performed for two different patch antennas that will be used in future configurations.

A special software was provided to help with testing. This provided 6 sec. continuous ON (FSK modulated) with 10 sec. breaks for cooling off.

3.1 EMI Relevant Modifications

There were no modifications made to the GIGA3 module by this laboratory.

4. Emission Limits

4.1 Radiated 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), Subpart B, (Section 15.109), and Subpart A, (Section 15.33). For Industry Canada it is subject to RSS-210, (Sections 6.1 and 6.3). The applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below. As a digital device, the DUT is considered as a Class B device.

Table 4.1. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 6.2.2(r)). (Digital Class A)

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; 6.1, 6.3)
Transmitter.

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious** Ave. E_{lim} (3m)	
(MHz)	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
2400 - 2483.5	50,000	94.0	500	54.0

** Measure up to tenth harmonic; 1 MHz RBW and VBW

4.2 Conductive Emission Limit
The conductive emission limits and tests do not apply here, since the DUT is powered by six NMH AAA battery pack. This battery pack can only be recharged in a special charging module and cannot be recharged in the device in which it is used.

5. Radiated Emission Tests and Results

5.1 Anechonic Chamber Measurements
To familiarize with the radiated emission behavior of the DUT, the DUT was first studied and measured in a shielded anechoic chamber. In the chamber there is a set-up similar to that of an outdoor 3-meter site, with a turntable, antenna pedestals, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

In testing for radiated emissions, horn antennas were used. Measurements were made from 2 to 25 GHz. Up to 8.5 GHz, measurements were made at 3 meter distance and, above that, at 1.0 and 0.5 meter distances. The field strengths were compensated in computations by 9.5 and 15.5 dB, respectively.

Through four harmonics emissions were detected, and above those, only the instrumentation noise. The receiver portion emissions (such as from the LO, that is 43 MHz below the carrier) were unmeasurable.

5.2 Outdoor Measurements
On the OATS, only digital emissions were measured.

5.3 Computations and Results
To convert the dBm measured on the spectrum analyzer to dB(μV/m), we use expression

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

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
K_E = pulse operation correction factor, dB (see 6.1)

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 (with antenna ANT I), Table 5.2 (with antenna ANT II), and Table 5.3 (digital emissions). There we see that the DUT meets the limits by 15.0 dB at fundamental and by 4.8 dB at harmonics. The Class A digital emissions were met by 5.9 dB.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

In normal operation, the device transmits 1.3 ms wide FSK modulated pulses 217.5 ms apart. See Figure 6.1. Thus, the duty factor is

$$K_E = 1.30 \text{ ms} / 100.0 \text{ ms} = 0.013 \text{ or } -37.7 \text{ dB}. \quad \text{(Use -20.0 dB)}$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed in its aperture, emission spectra were recorded for the three bands and is shown in Figure 6.2.

6.3 Bandwidth and Band-edge Emissions of the Radiated Emission Spectrum

Under 15.249 only the band-edge and outside the band regulations apply. The limits is 50 dB below the carrier, or General Limit of 54 dB(μV/m), whichever is higher.

See Figure 6.3. The spectra measurements were made with 1 MHz RBW and with 100 kHz RBW, the latter to show the more representative spectrum. At lower band-edge (top trace) and upper band-edge (bottom trace) the spectrum is down about 50 dB, which is marginal for meeting the 50 dB requirement. However, since the peak measures 79 dB(μV/m) (Table 5.2), the "50 dB down" takes it to 29 dB(μV/m), which more than satisfies the 54 dB(μV/m) requirement.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to be powered by a 9-volt battery pack. 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 6.0 to 10.0 volts. The emission variation is shown in Figure 6.4.

6.5 Input Voltage and Current

V = 8.0 V

I = 120.0 mA (to Hand Held Terminal, pulsed)

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Table 5.4 Highest Emissions Measured

Radiated Emissions											GIGA Ant I
#	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	2403.0	HornS	H&V	-31.1	Pk	21.5	- 0.6	78.0	94.0	16.0	
1	2442.0	HornS	H&V	-32.0	Pk	21.5	- 0.6	77.1	94.0	16.9	
1	2481.0	HornS	H&V	-32.1	Pk	21.5	- 0.6	77.0	94.0	17.0	
2	4806.0	HornC	H&V	-66.6	Pk	25.5	- 0.8	46.7	54.0	7.3	
2	4884.0	HornC	H&V	-64.1	Pk	25.5	- 0.8	49.2	54.0	**4.8**	Worst case
2	4962.0	HornC	H&V	-68.9	Pk	25.5	- 0.8	44.4	54.0	9.6	
3	7209.0	HornXN	H&V	-71.5	Pk	25.0	- 1.0	41.5	54.0	12.5	
3	7326.0	HornXN	H&V	-72.5	Pk	25.0	- 1.0	40.5	54.0	13.5	
3	7443.0	HornXN	H&V	-70.6	Pk	25.0	- 1.0	42.4	54.0	11.6	
4	9612.0	HornX	H&V	-68.4	Pk	29.2	- 0.2	38.5	54.0	15.5	Noise; meas 1m, add -9.5dB
4	9768.0	HornX	H&V	-65.8	Pk	29.2	- 0.2	41.1	54.0	12.9	Meas 1m, add -9.5dB
4	9924.0	HornX	H&V	-65.1	Pk	29.2	- 0.2	41.8	54.0	12.2	Meas 1m, add -9.5dB
5	12015.0	HornX	H&V	-67.5	Pk	29.2	- 0.2	33.4	54.0	20.6	Noise; meas 0.5m, add -15.5dB
5	12210.0	HornX	H&V	-67.7	Pk	29.2	- 0.2	33.2	54.0	20.8	Noise; meas 0.5m, add -15.5dB
5	12405.0	HornX	H&V	-67.9	Pk	29.2	- 0.2	33.0	54.0	21.0	Noise; meas 0.5m, add -15.5dB
6	14418.0	HornKu	H&V	-67.5	Pk	30.9	- 0.2	35.1	54.0	18.9	Noise; meas 0.5m, add -15.5dB
6	14652.0	HornKu	H&V	-67.3	Pk	30.9	- 0.2	35.3	54.0	18.7	Noise; meas 0.5m, add -15.5dB
6	14886.0	HornKu	H&V	-67.3	Pk	30.9	- 0.2	35.3	54.0	18.7	Noise; meas 0.5m, add -15.5dB
7	16821.0	HornKu	H&V	-66.8	Pk	30.9	- 0.2	35.8	54.0	18.2	Noise; meas 0.5m, add -15.5dB
7	17094.0	HornKu	H&V	-65.3	Pk	30.9	- 0.2	37.3	54.0	16.7	Noise; meas 0.5m, add -15.5dB
7	17367.0	HornKu	H&V	-65.5	Pk	30.9	- 0.2	37.1	54.0	16.9	Noise; meas 0.5m, add -15.5dB
8	19224.0	HornK	H&V	-66.2	Pk	32.3	- 0.3	37.9	54.0	16.1	Noise; meas 0.5m, add -15.5dB
8	19536.0	HornK	H&V	-66.1	Pk	32.3	- 0.3	38.0	54.0	16.0	Noise; meas 0.5m, add -15.5dB
8	19848.0	HornK	H&V	-61.7	Pk	32.3	- 0.3	42.4	54.0	11.6	Noise; meas 0.5m, add -15.5dB
9	21627.0	HornK	H&V	-65.7	Pk	32.3	- 0.3	38.4	54.0	15.6	Noise; meas 0.5m, add -15.5dB
9	21978.0	HornK	H&V	-58.7	Pk	32.3	- 0.3	45.4	54.0	8.6	Noise; meas 0.5m, add -15.5dB
9	22329.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
10	24030.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
10	24420.0	HornK	H&V	-58.4	Pk	32.3	- 0.3	45.7	54.0	8.3	Noise; meas 0.5m, add -15.5dB
10	24810.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
			* Ave: measured with 1 MHz RBW and 100 Hz VBW								
			* Peak: measured with 1 MHz RBW and 3 MHz VBW								

Meas. 5/04/01; U of Mich

Table 5.4 Highest Emissions Measured

Radiated Emissions											GIGA3 Ant II
#	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	2403.0	HornS	H&V	-30.1	Pk	21.5	- 0.6	79.0	94.0	15.0	
1	2442.0	HornS	H&V	-31.8	Pk	21.5	- 0.6	77.3	94.0	16.7	
1	2481.0	HornS	H&V	-32.4	Pk	21.5	- 0.6	76.7	94.0	17.3	
2	4806.0	HornC	H&V	-64.9	Pk	25.5	- 0.8	48.4	54.0	**5.6**	Worst case
2	4884.0	HornC	H&V	-66.5	Pk	25.5	- 0.8	46.8	54.0	7.2	
2	4962.0	HornC	H&V	-69.9	Pk	25.5	- 0.8	43.4	54.0	10.6	
3	7209.0	HornXN	H&V	-68.9	Pk	25.0	- 1.0	44.1	54.0	9.9	
3	7326.0	HornXN	H&V	-67.3	Pk	25.0	- 1.0	45.7	54.0	8.3	
3	7443.0	HornXN	H&V	-69.6	Pk	25.0	- 1.0	43.4	54.0	10.6	
4	9612.0	HornX	H&V	-65.0	Pk	29.2	- 0.2	41.9	54.0	12.1	Meas 1m, add -9.5dB
4	9768.0	HornX	H&V	-63.5	Pk	29.2	- 0.2	43.4	54.0	10.6	Meas 1m, add -9.5dB
4	9924.0	HornX	H&V	-63.3	Pk	29.2	- 0.2	43.6	54.0	10.4	Meas 1m, add -9.5dB
5	12015.0	HornX	H&V	-67.7	Pk	29.2	- 0.2	33.2	54.0	20.8	Noise; meas 0.5m, add -15.5dB
5	12210.0	HornX	H&V	-67.7	Pk	29.2	- 0.2	33.2	54.0	20.8	Noise; meas 0.5m, add -15.5dB
5	12405.0	HornX	H&V	-68.7	Pk	29.2	- 0.2	32.2	54.0	21.8	Noise; meas 0.5m, add -15.5dB
6	14418.0	HornKu	H&V	-67.7	Pk	30.9	- 0.2	34.9	54.0	19.1	Noise; meas 0.5m, add -15.5dB
6	14652.0	HornKu	H&V	-67.3	Pk	30.9	- 0.2	35.3	54.0	18.7	Noise; meas 0.5m, add -15.5dB
6	14886.0	HornKu	H&V	-67.3	Pk	30.9	- 0.2	35.3	54.0	18.7	Noise; meas 0.5m, add -15.5dB
7	16821.0	HornKu	H&V	-66.3	Pk	30.9	- 0.2	36.3	54.0	17.7	Noise; meas 0.5m, add -15.5dB
7	17094.0	HornKu	H&V	-65.4	Pk	30.9	- 0.2	37.2	54.0	16.8	Noise; meas 0.5m, add -15.5dB
7	17367.0	HornKu	H&V	-65.3	Pk	30.9	- 0.2	37.3	54.0	16.7	Noise; meas 0.5m, add -15.5dB
8	19224.0	HornK	H&V	-65.3	Pk	32.3	- 0.3	38.8	54.0	15.2	Noise; meas 0.5m, add -15.5dB
8	19536.0	HornK	H&V	-65.1	Pk	32.3	- 0.3	39.0	54.0	15.0	Noise; meas 0.5m, add -15.5dB
8	19848.0	HornK	H&V	-61.7	Pk	32.3	- 0.3	42.4	54.0	11.6	Noise; meas 0.5m, add -15.5dB
9	21627.0	HornK	H&V	-59.7	Pk	32.3	- 0.3	44.4	54.0	9.6	Noise; meas 0.5m, add -15.5dB
9	21978.0	HornK	H&V	-58.6	Pk	32.3	- 0.3	45.5	54.0	8.5	Noise; meas 0.5m, add -15.5dB
9	22329.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
10	24030.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
10	24420.0	HornK	H&V	-58.4	Pk	32.3	- 0.3	45.7	54.0	8.3	Noise; meas 0.5m, add -15.5dB
10	24810.0	HornK	H&V	-58.5	Pk	32.3	- 0.3	45.6	54.0	8.4	Noise; meas 0.5m, add -15.5dB
			* Ave: measured with 1 MHz RBW and 100 Hz VBW								
			* Peak: measured with 1 MHz RBW and 3 MHz VBW								

Meas. 5/04/01; U of Mich

Table 5.1. Highest Radiated Emissions Measured

GIGA3; FCC A

#	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	39.0	Bic	V	-52.0	Pk	12.6	24.0	43.6	49.5	**5.9**	
2	47.0	Bic	H	-56.0	QP	11.8	23.9	38.9	49.5	10.6	
3	64.0	Bic	V	-63.0	Pk	11.0	23.6	31.4	49.5	18.1	
4	85.4	Bic	H	-59.0	Pk	11.3	23.2	36.1	49.5	13.4	
5	110.0	Bic	H	-65.0	Pk	12.6	22.9	31.7	54.0	22.3	
6	116.1	Bic	H	-66.0	Pk	9.9	22.8	28.1	54.0	25.9	
7	116.1	Bic	V	-64.0	Pk	12.9	22.8	33.2	54.0	20.8	
8	132.0	Bic	H	-62.0	Pk	13.9	22.5	36.3	54.0	17.7	
9	185.0	Bic	H	-63.0	Pk	15.6	21.8	37.8	54.0	16.2	
10	210.0	Bic	H	-62.0	QP	16.0	21.5	39.5	54.0	14.5	
11	224.0	Bic	H	-68.0	Pk	16.3	21.3	34.0	56.9	22.9	
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Meas. 3/27/01; U of Mich.

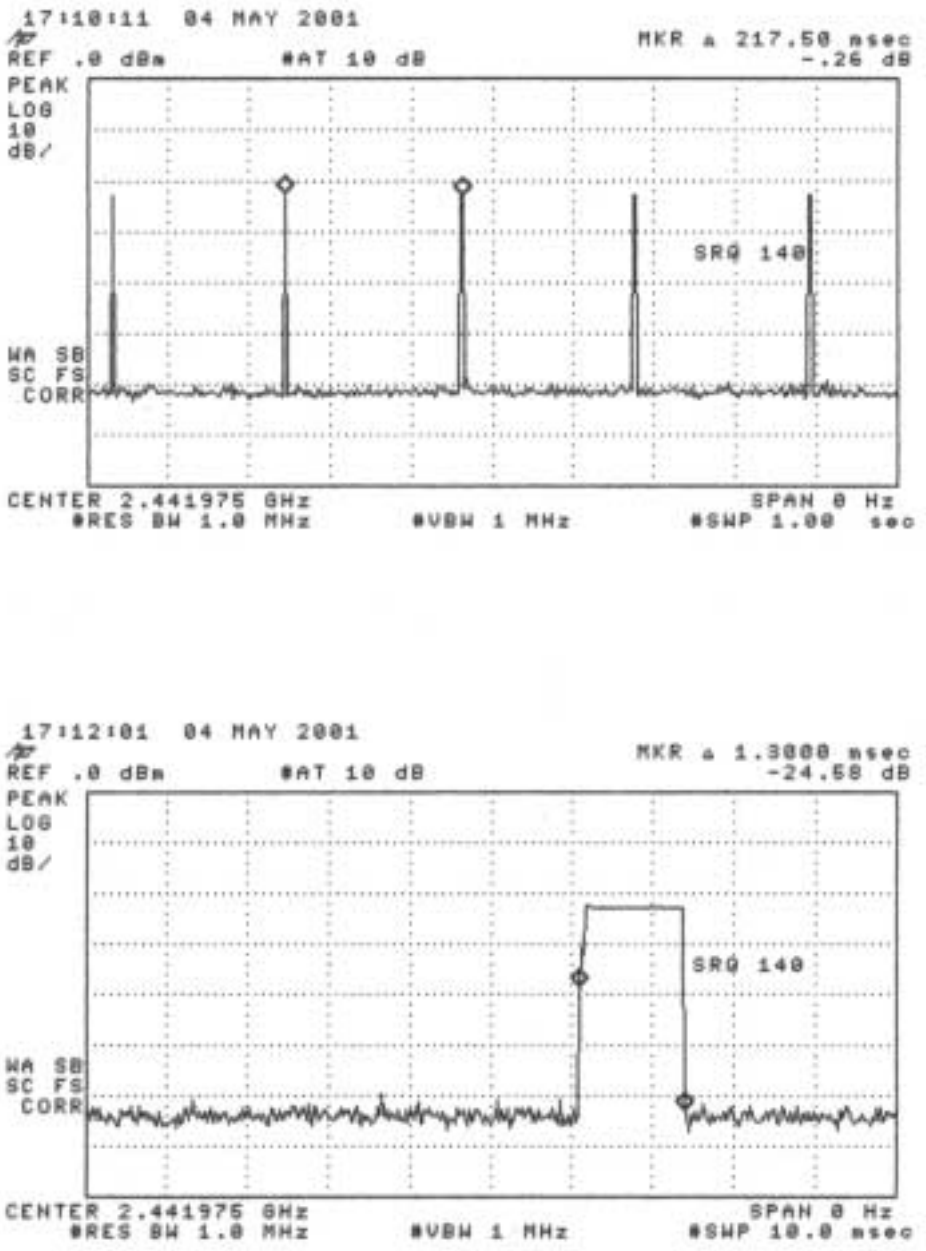
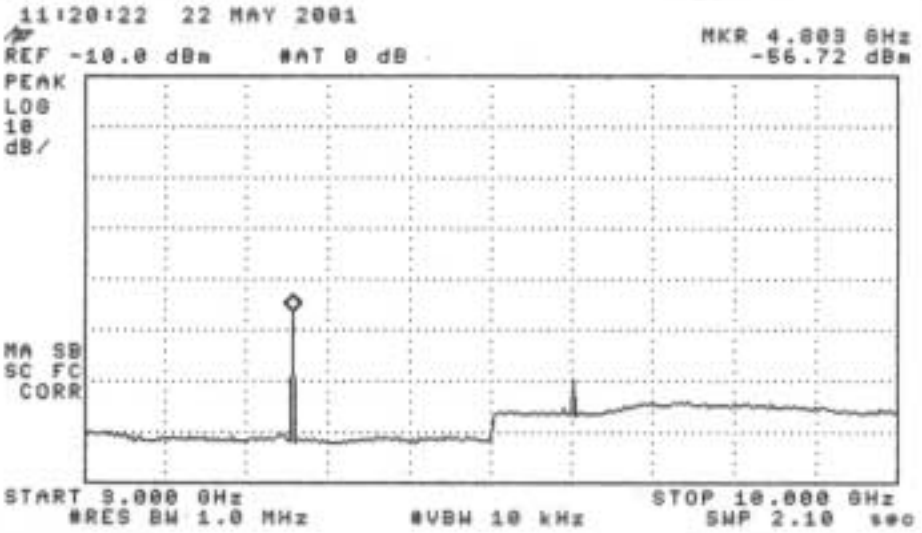
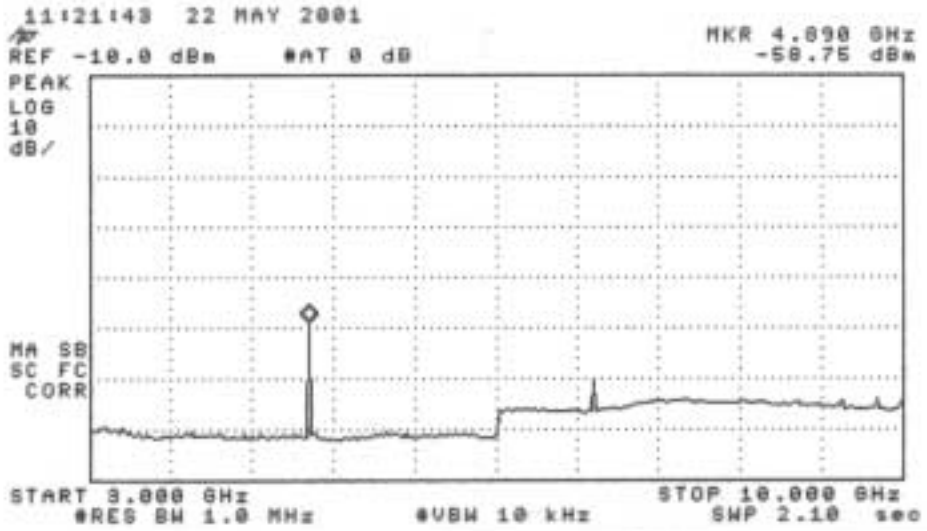


Figure 6.1. Transmissions modulation characteristics: (top) transmission repetition, (bottom) pulse widths.





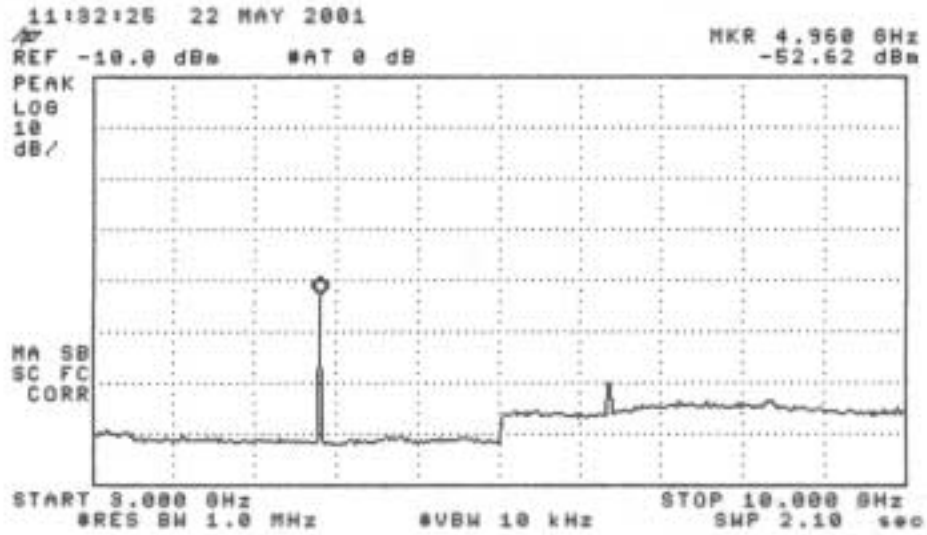


Figure 6.2. Emission spectrum of the DUT in free space (pulsed emission). The amplitudes are only indicative (not calibrated). Low, Mid, and High channels.

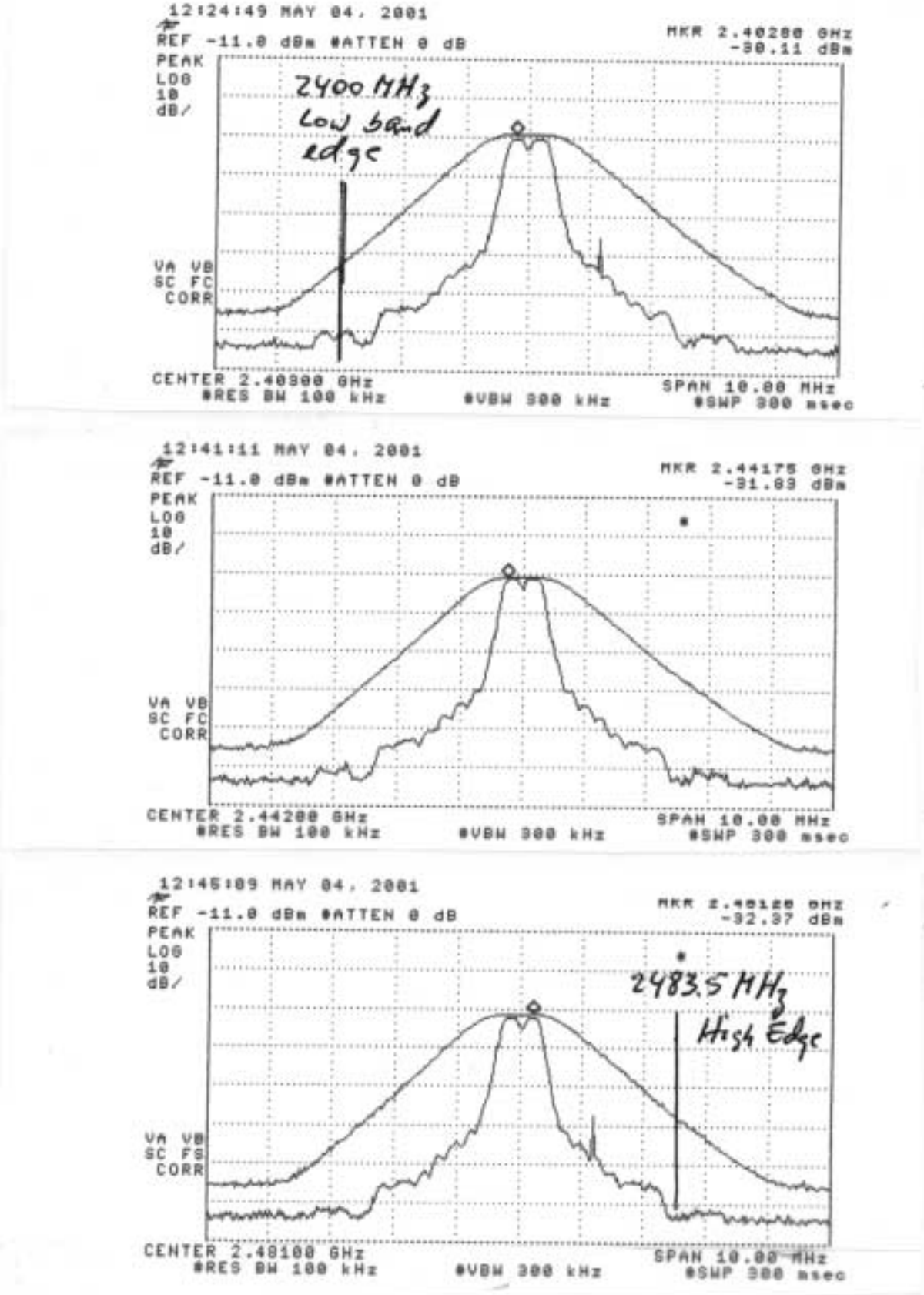


Figure 6.3. Measured bandwidth of the DUT (repated pulsed emission). Low, Mid, and High channels. Band-edge compliance is demonstrated by Top and Bottom plots.

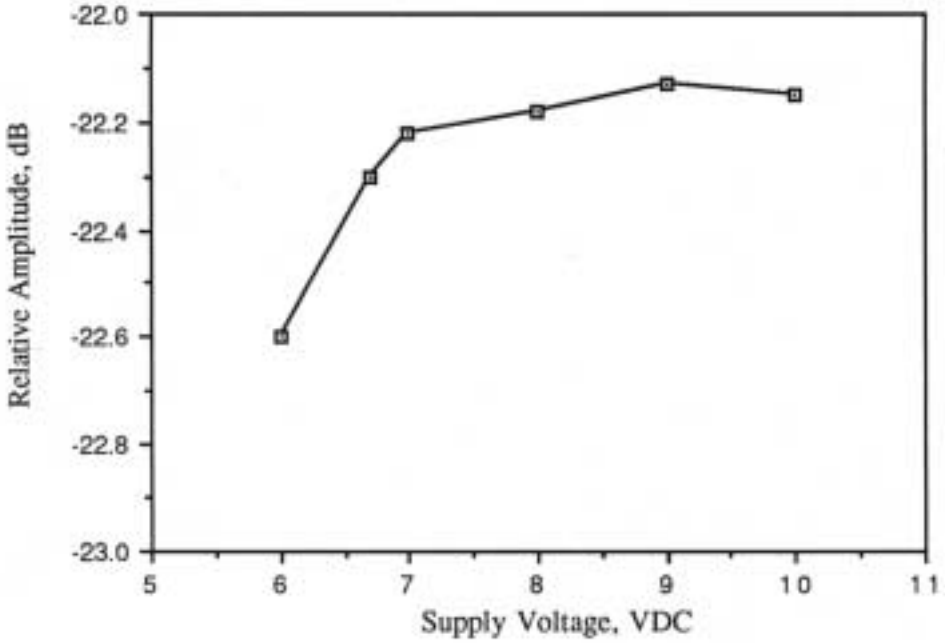


Figure 6.4. Relative emission at 2442.0 MHz vs. supply voltage. (pulsed emission)