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Measured Radio Frequency Emissions From

Davis Derby Tranceiver - Master
Model: MASTX

Report No. 415031-091
August 3, 2001

For:
Davis Derby Limited
Chequers Lane
Derby, UK DE216AW

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Tests supervised by:
Report approved by:
Valdis Liepa
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Summary

Tests for compliance with FCC Regulations subject to Part 15, Subparts B and C, and with Industry Canada Regulations, RSS-210, were performed on Davis Derby 914.5 MHz transceiver. This device is subject to the Rules and Regulations as a transmitter and as an unintentional radiator.

In testing performed on March 27, May 2, and August 3, 2001, the device tested in the worst case met the allowed FCC specifications for radiated emissions by 1.7 dB at the fundamental and by 7.4 dB at the harmonics (see p.6). Besides harmonics there were no other significant spurious emission found. There were no signals found from the reveiver portion; the digital circuitry met Class A limit by 7.5 dB (see p.7).

1. Introduction

Davis Derby transceiver, Model MASTX, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, and with Industry Canada RSS-210, Issue 5, Draft 1, dated December 2000. 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).

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)		Hewlett-Packard 8593A SN: 3107A01358
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E, SN: 3412A01131
Spectrum Analyzer (9kHz-26GHz)	X	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 Millimiter Prod., GMA, SN: 26
S-Band Std. Gain Horn		S/A, Model SGH-2.6
C-Band Std. Gain Horn	X	University of Michigan, NRL design
XN-Band Std. Gain Horn	X	University of Michigan, NRL design
X-Band Std. Gain Horn	X	S/A, Model 12-8.2
X-band horn (8.2- 12.4 GHz)		Narda 640
X-band horn (8.2- 12.4 GHz)	X	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)	X	Avantek, AFT-12665
Amplifier (6-16 GHz)		Trek
Amplifier (16-26 GHz)		Avantek
LISN (50 μH)		University of Michigan
Signal Generator (0.1-2060 MHz)		Hewlett-Packard, 8657B
Signal Generator (0.01-20 GHz)		Hewlett-Packard

3. Configuration and Identification of Device Under Test

The DUT is a 914.5 MHz digital transceiver (Master), that sends data and downloads data from an accompanying unit called Logger. Both devices operate at the same frequency, i,e,, in a simlex mode. It is powered by 12 VDC and communicates with a computer via an optical cable. Antenna is a monopole, permanently attached to the device.

The DUT was designed and manufactured by Davis Derby Limited, Chequers Lane, Derby, UK DE216AW. It is identified as:

Davis Derby Transceiver - Master
Model: MASTX
SN: FCCIC003
FCC ID: O7WMASTXUS
CANADA: to be provided by Canada

3.1 EMI Relevent Modifications

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

4. Emission Limits

4.1 Radiated Emission Limits

For radiated emissions the applicable testing frequencies with corresponding emission limits are given in Tables 4.1 and 4.2 below.

Table 4.1. Radiated Emission Limits (FCC: 15.249(a); IC: RSS-210, 6.2.2(m2))—Transmitter.

Frequency	Fundamental Ave. E_{lim} (3m)		Spurious* Ave. E_{lim} (3m)	
(MHz)	(μV/m)	dB (μV/m)	(μV/m)	dB (μV/m)
902-928	50000	94	500	54

* Measure up to tenth harmonic; 120 kHz BW up to 1 GHz (CISPR),
Above 1 MHz, average readings apply (1 MHz RBW).

Table 4.2. Radiated Emission Limits (FCC: 15.33, 15.35, 15.109; IC: RSS-210, 5.17) -- Digital.

Freq.	Class A, d_s=3m		Class B, d_s=3m	
MHz	μV/m	dB(μV/m)	μV/m	dB(μV/m)
30-88	300	49.5	100	40.0
88-216	500	54.0	150	43.5
219-960	700	56.9	200	46.0
960-	1000	60.0	500	54.0

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4.2 Conductive Emission Limits

Table 4.3. Conducted emission limits (Ref: FCC, Sec. 15.107).

Freq.	Class A		Class B	
MHz	μV	dBμV	μV	dBμV
0.45-1.705	1000	60.0	250	48.0
1.705-30.0	3000	69.6	250	48.0

Note: Quasi-Peak readings apply here

5. Radiated Emission Tests and Results

NOTE: Even though the FCC and/or Industry Canada specify that both the radiated and conductive emissions be measured using the Quasi-Peak and/or average detection schemes, we normally use peak detection since especially the Quasi-Peak is cumbersome to use with our instrumentation. In case the measurement fails to meet the limits, or the measurement is near the limit, it is remeasured using appropriate detection. We note, that since the peak detected signal is always higher or equal to the Quasi-Peak or average detected signal, the margin of compliance may be better, but not worse, than indicated in this report. The type of detection used is indicated in the data table, Table 5.1.

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, an antenna mast, and a ground plane. Instrumentation includes spectrum analyzers and other equipment as needed.

In the chamber we studied and recorded all the emissions using a ridged horn antenna up to 3.66 GHz, and C-band, XN-band and X-band antennas for higher harmonic frequencies. 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 final compliance assessment. We note that for the horn antennas, the antenna pattern is more directive and hence the measurement is essentially that of free space (no ground reflection). In the chamber we also recorded the spectrum and modulation characterisics of the carrier, using the horn antenna. These data are presented in subsequent sections. We also note that in scanning from 900 MHz to 10 GHz using the ridge horn and pyramidal horn antennas, there were no other significant spurious emissions observed.

5.2 Outdoor Measurements

The DUT was then moved to the 3 meter Open Field Test Site where measurements were repeated up to 1000 MHz using a small bicone, or dipoles when the measurement is near the limit. The DUT was excersised as described in Sec. 5.1 above. The measurements were made with a spectrum analyzer using 120 kHz IF bandwidth and peak detection mode, and, when appropriate, using Quasi-Peak or average detection (see 5.0). The test set-up photographs are in Appendix (i.e., at end of this report, or in the Test Setup folder).

5.3 Computations and Results

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

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

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. There we see that the DUT meets the limit by 1.7 dB at the fundamental, and by 7.4 dB at the harmonics.

6. Other Measurements and Computations

6.1 Correction For Pulse Operation

When activated and talking to the Logger, the transmitted waveform is shown in Figure 6.1. The lower pulses are from the companion Logger and the higher pulses are from the DUT. The DUT pulses are 14.75 ms wide and repeat 48.75 ms. Within these pulses the data are encoded in an FSK format. Thus, the duty factor is

$$K_E = 14.75\text{ms} / 48.75\text{ ms} = 0.303 \text{ or } -10.4 \text{ dB}$$

6.2 Emission Spectrum

Using the ridge-horn antenna and DUT placed near its aperture, emission spectrum was recorded and is shown in Figure 6.2.

6.3 Emission Spectrum at Band-edges

The measured spectrum of the signal is shown in Figure 6.3. From the plot we see that the 50 dB down at the band-edges is easily met. The blip at 904 MHz is the receiver LO, which was too low to measure on the OATS.

6.4 Effect of Supply Voltage Variation

The DUT has been designed to operate from 12 VDC power. Using a spectrum analyzer, relative radiated emissions were recorded at the "fundamental" (914.5 MHz) as voltage was varied from 8.5 to 18.0 VDC. Figure 6.4 shows the emission variation.

6.5 Operating Voltage and Current

$$V = 12.0 \text{ VDC}$$
$$I = 65.0 \text{ mADC}$$

6.5 Unintentional Radiator Emissions

These measurements were made on the OATS using standard measurement procedures. For these tests both, the Master and the Logger were placed on the table. The data are presented in Table 6.1. There we see that the digital emissions from the DUT meet Class A limits by 8.6 dB. The receiver LO was not detectable.

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Table 5.1 Highest Emissions Measured

Radiated Emission - RF											DD Logger master; 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	914.5	Dip	H	-25.9	Pk	28.6	17.4	92.3	94.0	1.7	flat
2	914.5	Dip	H	-27.4	Pk	28.6	17.4	90.8	94.0	3.2	side
3	914.5	Dip	H	-36.0	Pk	28.6	17.4	82.2	94.0	11.8	end
4	914.5	Dip	V	-34.8	Pk	28.6	17.4	83.4	94.0	10.6	flat
5	914.5	Dip	V	-34.0	Pk	28.6	17.4	84.2	94.0	9.8	side
7	914.5	Dip	V	-34.4	Pk	28.6	17.4	83.8	94.0	10.2	end
8	1829.0	Horn	H	-44.1	Pk	22.2	28.1	46.6	54.0	7.4	max all
9	2745.0	Horn	H	-54.5	Pk	24.7	25.7	41.1	54.0	12.9	max all
10	3660.0	Horn	H	-65.7	Pk	27.3	24.2	34.0	54.0	20.0	max all, noise
11	4572.5	C-horn	H	-79.5	Pk	25.5	33.0	9.6	54.0	44.4	max all, noise
12	5487.0	C-horn	H	-79.3	Pk	25.8	38.6	4.5	54.0	49.5	max all, noise
13	6401.5	XN-horn	H	-74.8	Pk	24.2	37.8	8.2	54.0	45.8	max all, noise
14	7316.0	XN-horn	H	-75.5	Pk	25.0	36.0	10.1	54.0	43.9	max all, noise
15	8230.5	X-horn	H	-74.9	Pk	27.1	36.0	12.8	54.0	41.2	max all, noise
16	9145.0	X-horn	H	-74.8	Pk	27.5	37.0	12.3	54.0	41.7	max all, noise
17											
18			*includes -0.0 dB duty factor below 1000 MHz, and								
19			-10.4 dB duty factor above 1000 MHz								
20											
21											

Digital Emissions											
#	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											
2											
3			Digital emissions are more than 20 dB below FCC Class B limit								
4											

Conducted Emissions							
#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1							
2		Not applicable					
3							
4							

Meas. 05/02/01; U of Mich.

Table 6.1. Highest Radiated Emissions Measured

											DD Logger and Master; 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	26.7	40.9	49.5	8.6	
2	47.0	Bic	H	-56.0	Pk	11.8	26.6	36.2	49.5	13.3	
3	64.0	Bic	V	-63.0	Pk	11.0	26.3	28.7	49.5	20.8	
4	85.4	Bic	V	-59.0	Pk	11.3	25.9	33.4	49.5	16.1	
5	110.0	Bic	H	-65.0	Pk	9.4	25.6	25.8	54.0	28.2	
6	116.1	Bic	H	-65.0	Pk	12.9	25.5	29.5	54.0	24.5	
7	116.1	Bic	V	-64.0	Pk	12.9	25.5	30.5	54.0	23.5	
8	132.0	Bic	H	-62.0	Pk	13.9	25.2	33.6	54.0	20.4	
9	185.0	Bic	H	-63.0	Pk	15.6	24.5	35.1	54.0	18.9	
10	210.0	Bic	H	-67.0	Pk	16.0	24.2	31.8	54.0	22.2	
11	224.0	Bic	H	-68.0	Pk	16.3	24.0	31.3	56.9	25.6	
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Meas. 03/27/01; U of Mich.

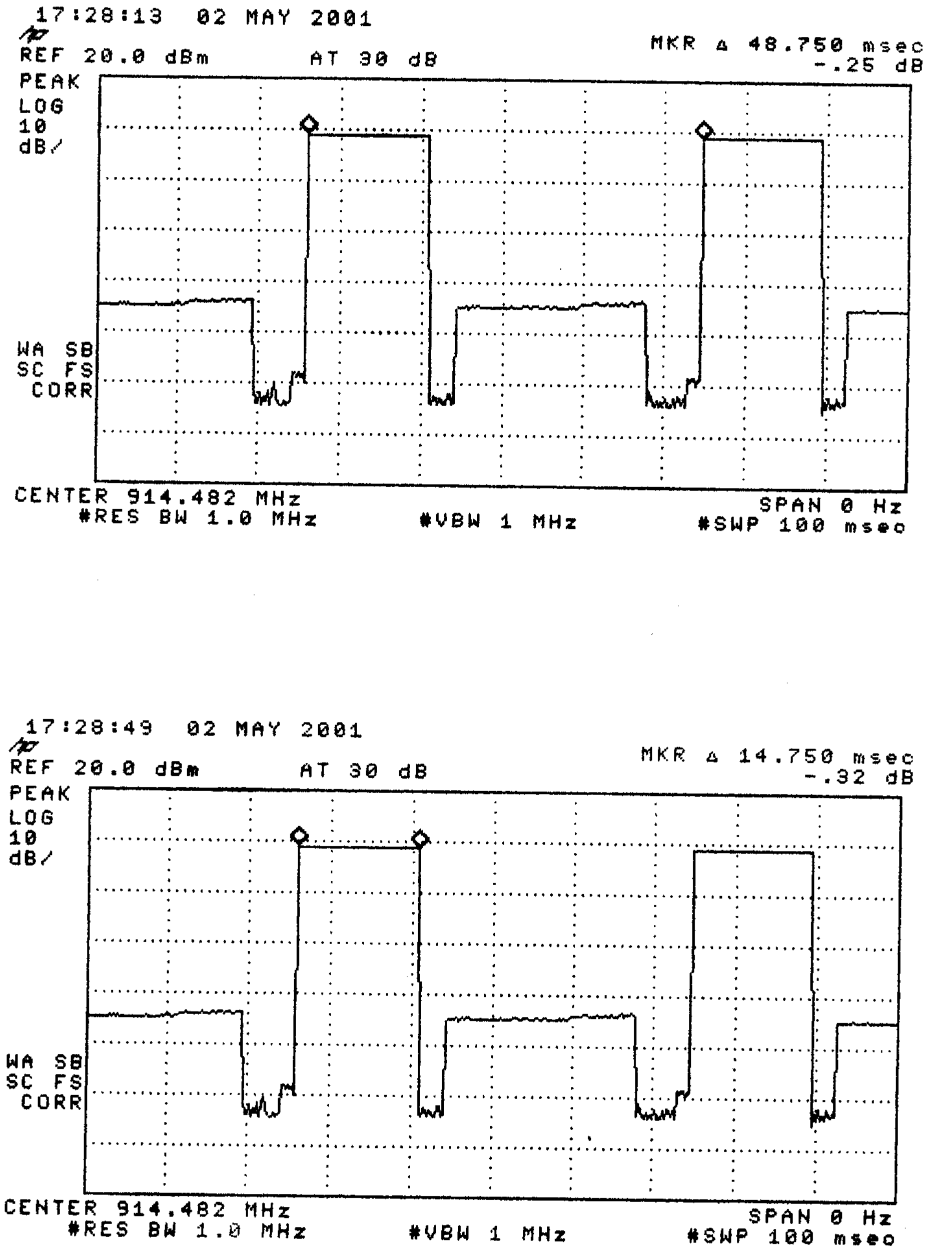

Figure 6.1. Transmissions modulation characteristics: (top) pulse period, (bottom) pulse width.

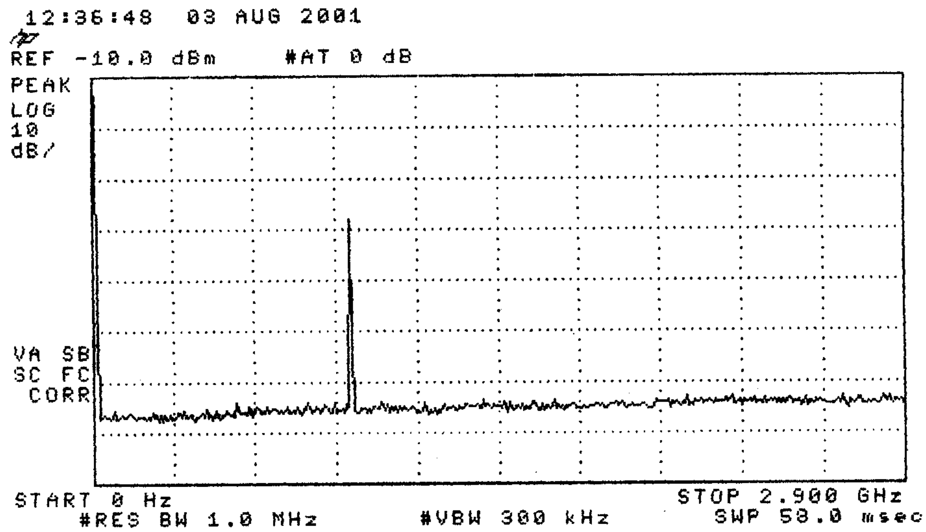

Figure 6.2. Emission spectrum of the DUT (repeated pulsed emission). The amplitudes are only indicative (not calibrated).

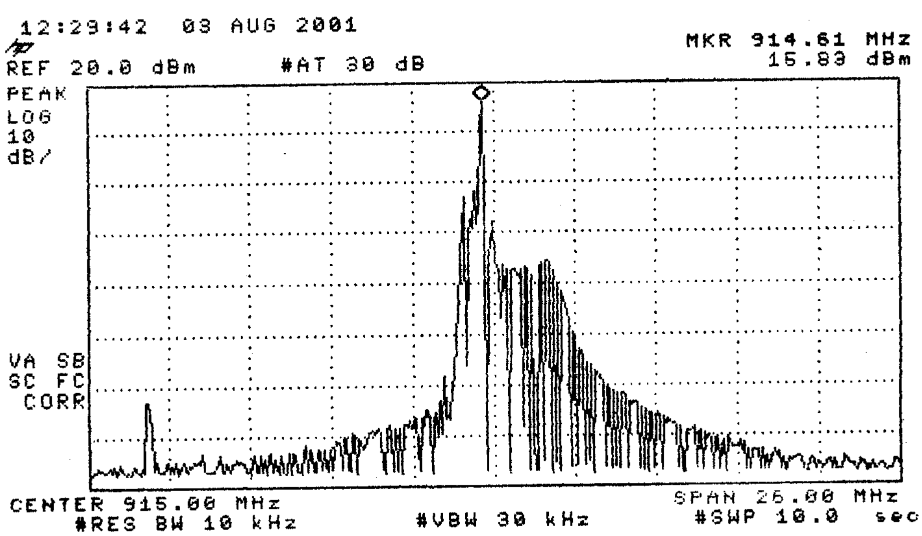

Figure 6.3. Band-edge emissions of the DUT (repeated pulsed emission).

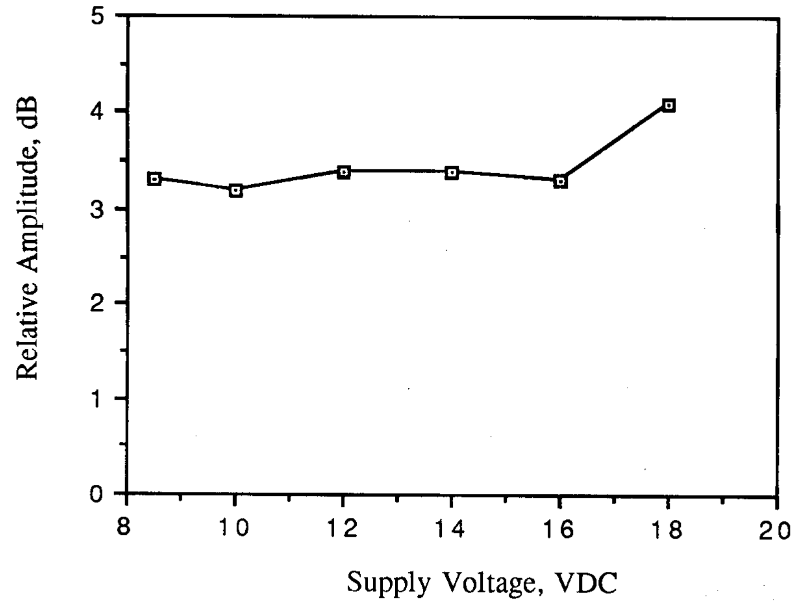

Figure 6.3. Relative emission at fundamental vs. supply voltage.