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Measured Radio Frequency Emissions From

HE Microwave/ Delphi Delco Presence Sensor Model: BUA

Report No. 415031-007
June 9, 1999

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

Summary
Tests for compliance with FCC Regulations, according to Part 15.209 (General Limits), were performed on HE Microwave presence sensor (16.95 GHz radar). In testing performed on March 22 and 23, 1999, the device tested had maximum emissions of 45.9 dB(μV/m) at 17.1 GHz (Available Band) and 33.5 dB(μV/m) at 17.9 GHz (Restricted Band).

RF Health Hazard measurements were also made; maximum level is <0.002 mW/cm2.

1. Introduction

HE Microwave/ Delphi Delco presence sensor, Model BUA, was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, plus the new guidelines to measure harmonics up to 200 GHz. 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" and new FCC Section 15.253, "Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz". The attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland. (FCC file 31040/SIT)

2. Test Equipment Used

The pertinent test equipment commonly used in our facility for microwave measurements is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)	X	Hewlett-Packard 8592L SN: 3710A00856	June 1997/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3107A01131	July 1998/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8563E SN: 3310A01174	July 1997/HP
Spectrum Analyzer (9kHz-40GHz)	X	Hewlett-Packard 8564E SN: 3745A01031	April 1998/HP
Power Meter w/ Thermistor		Hewlett-Packard 432A Hewlett-Packard 478A	August 1996/Uof M Rad Lab
Harmonic Mixer (40-60 GHz)	X	Hewlett-Packard 11970U SN: 2332A00500	Febr 1996/HP
Harmonic Mixer (75-110 GHz)	X	Hewlett-Packard 11970W SN: 2521A00179	Febr 1996/HP
X-band horn (8.2- 12.4 GHz)		Narda 640	1970/Manufacturer
K-band horn (18-26.5 GHz)	X	FXR, Inc., K638KF	1970/Manufacturer
Ka-band horn (26.5-40 GHz)	X	FXR, Inc., U638A	1970/Manufacturer
U-band horn (40-60 GHz)	X	Custom Microwave, WR-19	1996/Manufacturer
W-band horn (75-110 GHz)	X	Custom Microwave, WR-10	1996/Manufacturer

3. Configuration and Identification of Device Under Test

The Device Under Test (DUT) is was a CW ultra-wide-band radar operating at 16.95 GHz (Ku-band) with approx. 0.001 mW rated output. Its application is for presence detection behind a car. The unit is about 9 x 3 x 1 inches and mounts inside the rear plastic bumper. Its bandwidth is about 1 GHz. There are only four wires connecting the device, two for power and two for data out.

The DUT was manufactured by HE Microwave LLC, PO Box 23340, Tuscon, AZ 85734. It is identified as:

HE Microwave/ Delphi Delco Presence Sensor
Model: BUA
S/N: 9104
FCC ID: L2C0004TR
CAN: to be provided by IC

Nominal operating voltage is 8 VDC, and for tests was supplied by laboratory grade (HP) power supply.

3.1 Changes made to the DUT

None.

4. Microwave Emission Limits

4.1 Radiated Emission Limits

The DUT tested falls under the category of an Intentional Radiators subject to Subpart C, Sections 15.205 and 15.209, and Subpart A, Section 15.33. The applicable critical testing frequencies with corresponding emission limits are given in Tables 4.1. As a digital device, it is exempt.

Table 4.1. Radiated Emission Limits (Ref: 15.209, 15.205) --Transmitter.

Frequency (GHz)	Fundamental and Spurious* (dB(μV/m))
0.5 -up	54
15.35-16.2 17.7-21.4	Restricted Bands

* Measure up to 40 GHz

4.2 Conductive Emission Limits

The conductive emission limits for intentional radiator are 250 mV, 450 kHZ to 30 MHz. This is same level as for a digital device, Class B.

4.3 (Digital) Radiated Emission Limits

Table 4.2. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109) -- Digital.

Freq. (MHz)	Class A, E_{lim} dB(μV/m)	Class B, E_{lim} dB(μV/m)
30-88	49.5	40.0
88-216	54.0	43.5
216-960	56.9	46.0
960-2000	60.0	54.0

Note: Average readings apply above 1000 MHz (1 MHz BW)
Quasi-Peak readings apply to 1000 MHz (120 kHz BW)

5. Radiated Emission Tests and Results

5.1 Test Procedure

Prior to any measurements, all active components of the test setup were allowed a warm-up for a period of approximately one hour as recommended by their manufacturers.

To familiarize with emissions, the unit is held within a meter or less of the receiving antenna and the spectrum scanned from the fundamental through the harmonics.

For the tests, the unit is hand-held at a 3 or 1 (or even 0.25m) meter distance, depending on the available signal strength, and rotated through 360 degrees to determine the most intense radiation lobe. Care is taken such that there is no interference ffom the hand nor the body. Due to the rigid connection of the receive antenna to the spectrum analyzer, the DUT is also rotated around its antenna axes to match the polarizations of the emission for maximum reading.

5.2 Measurements

At the fundamental, 16.95+/-1 GHz, the emissions were measured at 3-m distance and the scan recorded on spectrum analyzer in Peak-hold mode as the DUT was slowly rotated though all its orientations. Figure 5.1 is the resultant plot. The measurement was made with RBW=1 MHz and VBW=10 kHz to simulated average measurement. Lower VBW would take "forever" to scan, and in the next figure, Figure 5.2, we show that the difference between 10 kHz and 300 kHz VBW measurement is 1.7 dB. Back in the Figure 5.1, there are two traces. The lower one is the measuring equipment noise and the upper one is the DUT emission (plus noise).

Values from Figure 5.1 are used to determine emissions near fundamental. The following adjustments are made before entering the values in the data crunching table, Table 5.1. At the fundamental, 17.12 GHz, the reading is reduced by 1.7 dB for 300 Hz VBW to give -64.1 dBm. In restricted bands, at 16.05 and 17.90 GHz, the readings are reduced by 1.7 dB for 300 Hz VBW measurement correction, plus additional 3 dB to remove the effect of noise. The latter is based on the premise that when two noise-like signals of equal amplitudes are added, the resultant value is 3 dB higher (i.e., add noise powers). In this case the signal-plus-noise value measures about 3 dB above noise.

For harmonics and other spurious emissions we scanned to 100 GHz (only up to 40 GHz is required) and there we could not detect anything, even right at the radome of the DUT. For digital emissions we scaned from 30 MHz to 2 GHz, and did not see any.

5.3 Computations and Results

When the measurement is made at a distance other than 3m, the reading is extrapolated to the 3m. This is done using the 20 dB/decade field behavior relation when translating in the far field, and 40 dB/decade relation when translating in the near field. The near-field/far-field criterion, N/F, is based on

$$N/F = 2*D*D/wavelength$$

where D is the max. of the transmitter or receiver antenna dimension, and the wavelength is that of the frequency measured. Suppose N/F = 2 m and the measurement is made at 1 m. Here the 40 dB/ decade relation is applied from 1 to 2 m, and 20 dB/decade relation is applied from 2 to 3 m. In dBs, this gives a 15.6 dB adjustment.

To convert the dBms measured or extrapolated to 3 m, the E_3(dBmV/m) is computed from

$$E_3(dBmV/m) = 107 + P_R + K_A + K_G + K_E$$

where
- P_R = power recorded on spectrum analyzer, dBm (or extrapolated to 3 m distance)
- K_A = antenna factor, dB/m
- K_G = pre-amp gain, dB
- K_E = pulse operation correction factor, dB (see 6.1)

For microwave measurements, either the receive antenna is connected directly to the spectrum analyzer (up to 40 GHz), or it is connected to the mixer followed by an insignificant length cables. Hence, no cable loss term is used. The mixer conversion losses are programmed in the spectrum analyzer and are included in the dB values.

The results are given in Table 5.1. There we see that the DUT had maximum emissions of 45.9 dB(μV/m) at 17.1 GHz (Available Band) and 33.5 dB(μV/m) at 17.9 GHz (Restricted Band).

6. Other Measurements and Computations

6.1 Peak-to-Average Ratio

The DUT is designed to operate in continuous mode. The Peak value was measured with RBW=VBW=1 MHz and is the upper curve in Figure 6.1. The lower curve in the same figure was measured with RBW=1 MHz and VBW=10 kHz. The "eyeballed" differnce between the two is 8 dB. Since Figure 5.2 that showed that there is additional 1.7 dB difference between VBW of 10 kHz and 300 Hz measurement, for the device tested the peak-to-average ratio is 9.7 dB.

6.2 Correction for Pulse Operation (Ref. 15.35)

None ($K_E = 0$ dB).

6.3 Effect of Supply Voltage Variation

The DUT has been designed to operate from 8 VDC that originates from vehicle 12-volt system. The relative radiated emissions and frequency were recorded at the "fundamental" (17.1 GHz) as the supply voltage was varied from 5.75 to 16 VDC. Figure 6.2 shows the emission power variation and Figure 6.3 shows the emission frequency variation. Current at 8 VDC was 300 mA.

6.4 Conducted Emission Measurements

Not applicable.

6.5 Potential Health Hazard EM Radiation Level
The maximum radiation level from the unit was determined by using an open-ended K-band waveguide probe feeding directly into a powert meter. In case the 1 mW/cm2 limit is exceeded, the maximum distance from the DUT is determined by measurement where the field density is 1 mW/cm2.

An open-end waveguide probe is as basic as a standard gain horn. Their characteristics have been extensively studied and experimentally verified. (Yaghjian, IEEE/APS pp. 378-384, April, 1984.) For the K-band (WR-42) waveguide, at 17.0 GHz, the open-end waveguide gain is 5.6 dBi that equals to Aeq = 0.876 cm2, giving

p(mW/cm2) = P(mW)/ 0.876 cm2 where P(mW) is power received.

For the subject DUT, we probed throughout the near-field region with the DUT transmitting continuous, but could not detect anything. See Figure 6.4. Hence, P(mW)<-30 dBm, or

p(mW/cm2)< 0.002 mW/cm2.

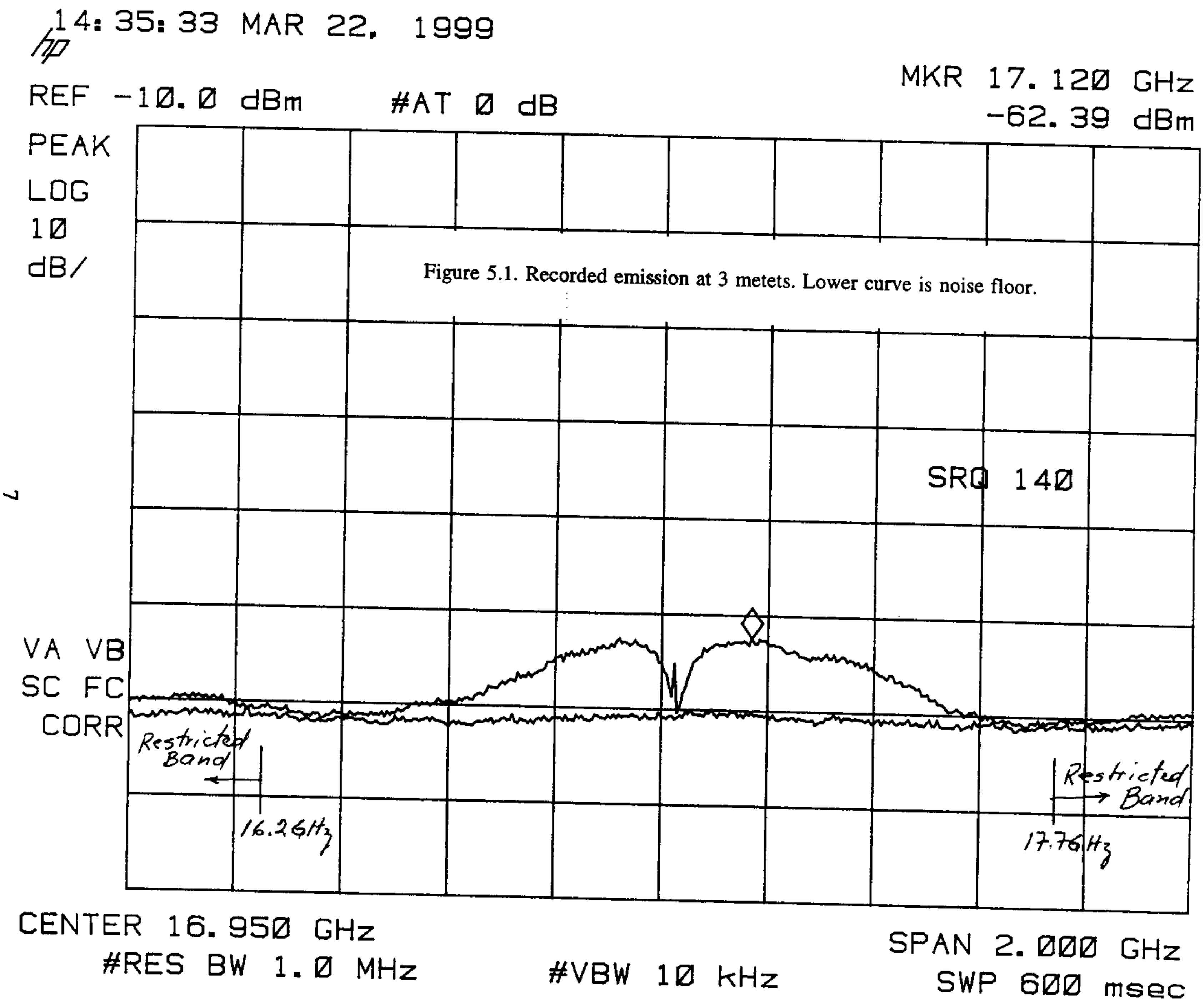

Figure 5.1. Recorded emission at 3 metets. Lower curve is noise floor.

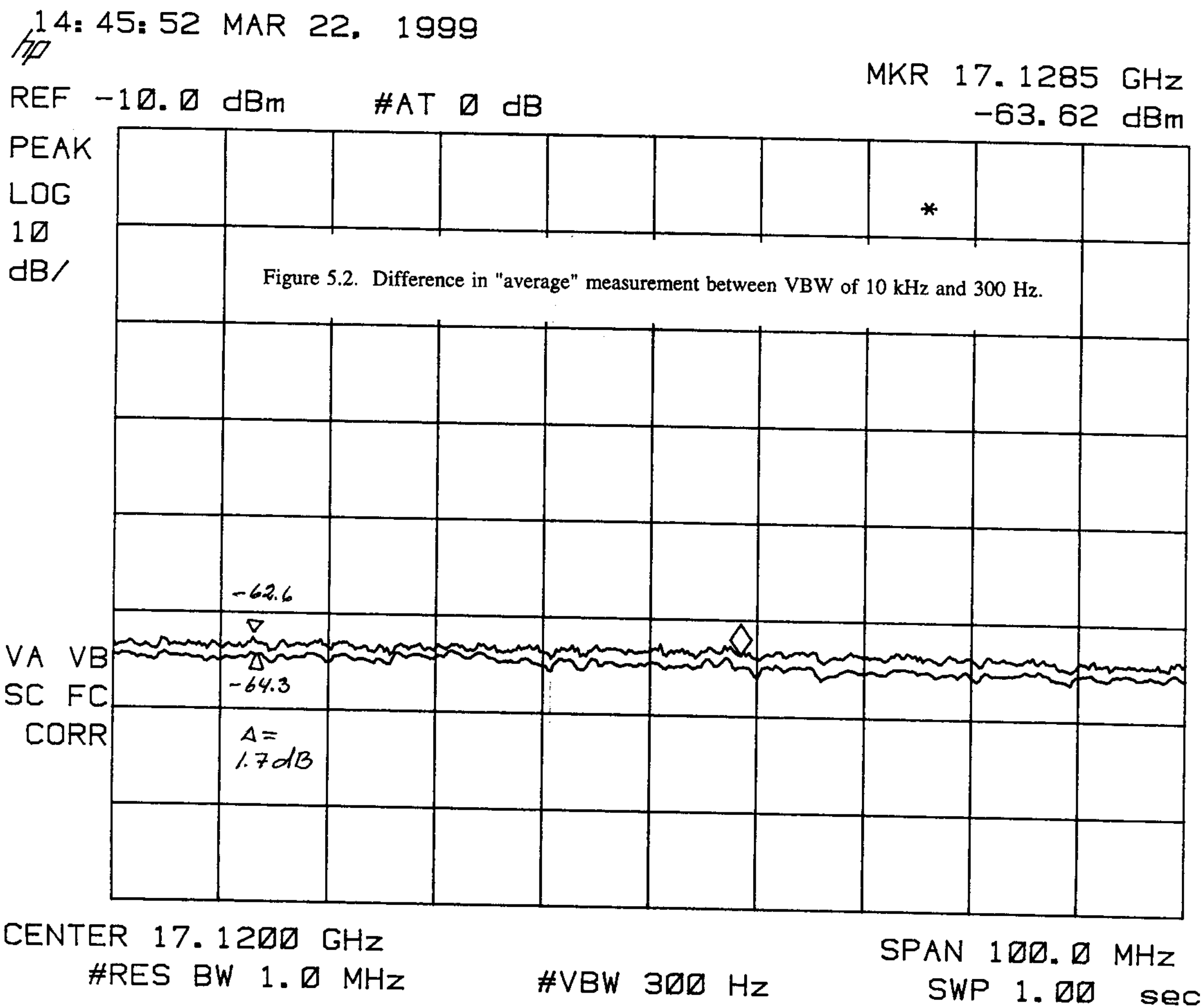

Figure 5.2. Difference in "average" measurement between VBW of 10 kHz and 300 Hz.

Table 5.1 Highest Emissions Measured

Microwave Radiated Emissions

HE Microwave; BUA

#	Freq. GHz	Ant. Used	Ant. D,cm	Meas. dist., m	Pr dBm	N/F m	Pr(3m) dBm	Ka dB/m	Kg dB	E3 dBμV/m	E3lim dBμV/m	Pass dB	Comments
1	16.05	K-horn	10.2	3.00	-74.2	1.18	-74.2	29.8	30.0	32.6	54.0	21.4	**Restr. Band**
2	17.12	K-horn	10.2	3.00	-64.1	1.18	-64.1	30.0	27.0	45.9	54.0	**8.1**	Max.
3	17.90	K-horn	10.2	3.00	-73.7	1.18	-73.7	30.2	30.0	33.5	54.0	20.5	**Restr. Band**
4	33.94	Ka-horn	6.9	0.25	-94.0	1.08	-129.9	36.3	0.0	13.4	54.0	40.6	Noise floor
5	50.91	U-horn	4.6	0.25	-79.3	0.94	-112.7	41.1	0.0	35.4	54.0	18.6	Noise floor
6	67.90	W-horn	2.5	0.25	-73.3	1.25	-109.2	44.7	0.0	42.5	54.0	11.5	Noise floor
7	84.85	W-horn	2.5	0.25	-73.2	1.56	-111.0	45.9	0.0	41.9	54.0	12.1	Noise floor

NOTES:

(1) When measured at 0.25 cm from the DUT, no signal was detected anywhere, even at the radome

(2) Mixer conversion loss is programmed in the spectrum analyzer and automatically adjusts the readings

(3) When extrapolating to 3 m, use Near (40 dB/dec) and Far Fld (20 dB/dec) behavior

(4) For Ave. measurement a 300 Hz VBW was used, sometimes higher; RBW was always 1 MHz

(5) DUT max. antenna size, D= 5.26 cm

Digital Radiated 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		All digital emissions more than 20 dB below Class B limit									
4											
5											
6											
7											
8											
9											
10											
11											
12											

Conducted Emissions, Class B

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

Meas. 3/22,23/99; U of Mich.

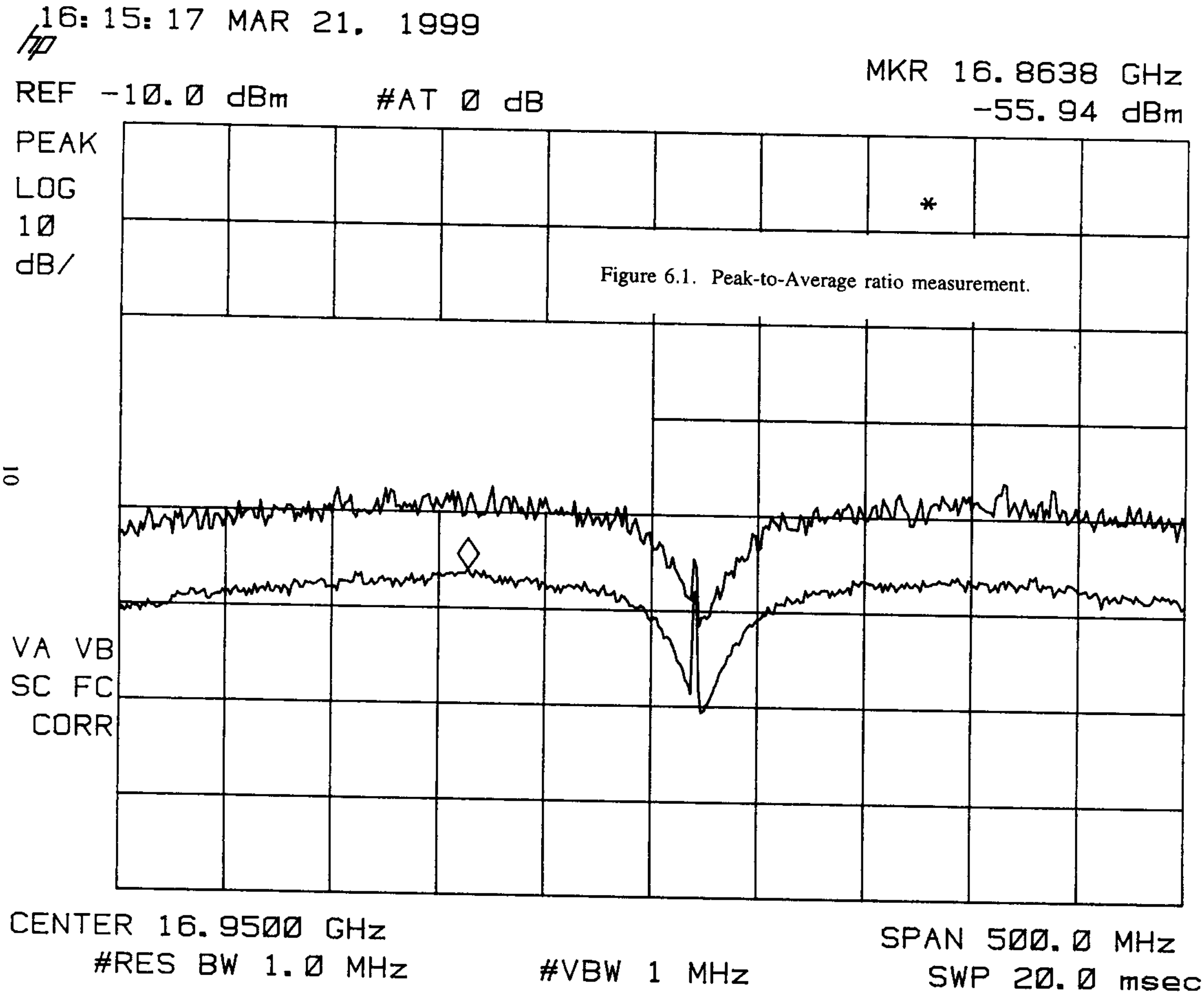

Figure 6.1. Peak-to-Average ratio measurement.

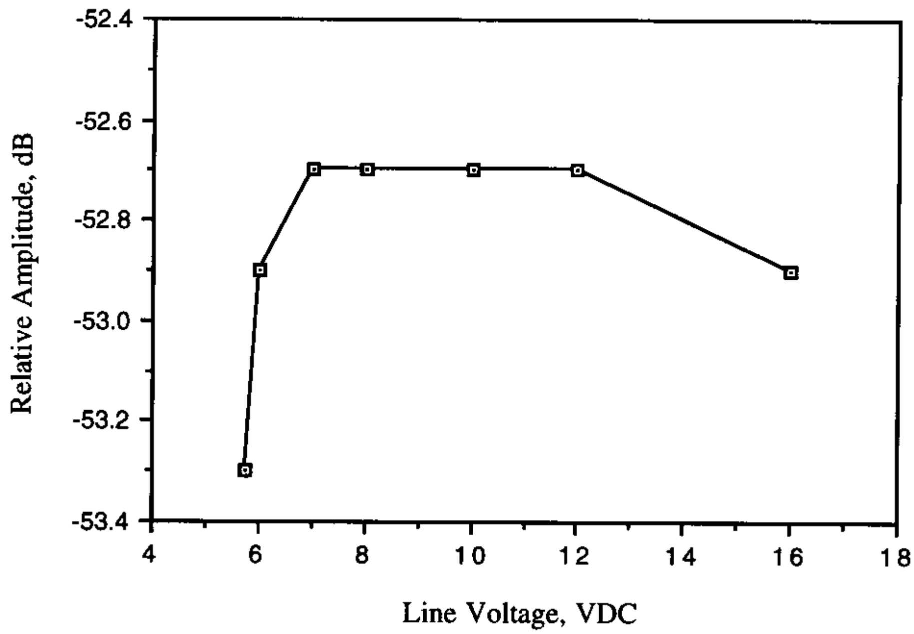

Figure 6.2. Relative emission at fundamental vs. supply voltage.

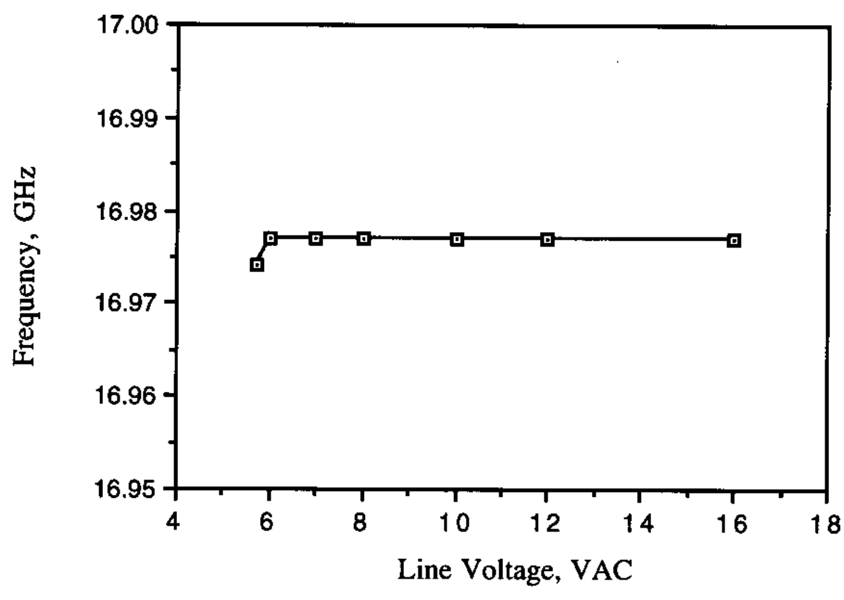

Figure 6.3. Fundamental frequency vs. supply voltage.

DATE	SYM	SH.REV'D	REVISION RECORD	DR.	CK.
30OCT97	A		PRELIMINARY RELEASE	DMR	JR
04NOV97	B		RELEASE PER ECO 1002662AB	DMR	JR

EXHIBIT F
Page 7 of 19
U of Mich file 415031-007

SPECIFICATION FOR MICROWAVE TRANSCEIVER

BACK UP AID RADAR SENSOR

APR 19 1999

H E MICROWAVE PROPRIETARY

HE MICROWAVE

SUBSIDIARY OF GM HUGHES ELECTRONICS TUCSON, ARIZONA

DR: J. REED	DWG DATE: 30OCT97
CK:	
APPVD:	
APPVD:	

PROGRAM: BUA	NAME: MCRWV TRANS SPEC, BUA
NEXT ASSY:	
SCALE: NONE	SIZE: A
PART NO. 1002662	SHT. 1 OF 13
REV. LETT. B	

Table of Contents

EXHIBIT F
Page 8 of 19
U of Mich file 415031- 007

EXHIBIT F
Page 9 of 19
U of Mich file 415031- 007

1. INTRODUCTION

The Back Up Aid system is a collection of sensors along the rear of a car, connected to a controller and display unit(s), which assists the driver of the car in backing up maneuvers. The intent of the system is to notify the driver when objects which the driver cannot normally see are in the rearward path of the car, thus preventing or reducing the severity of a collision with the object.

1.1 Item Definition

The Backup Aid Systems have one or more radar sensors in which parts are specified herein. The radar sensor for Back Up Aid is a short range (~ 5 meters) precision ranging radar. Azimuth coverage is approximately the width of the car (~ 2 meters) at the 5 meter range. Range resolution is approximately 30 cm.

The microwave Transceiver for the radar sensor is functional subsystem, constructed as a collection of circuits, termed as an electronics "section", within the sensor which functions to :

1) generate a microwave carrier signal, which is bi-phase modulated by an input signal and provide said modulated signal to a port (transmit port) at a specified total CW power,
2) amplify an input signal as applied to the receive port, and bi-phase modulate the receive signal after amplification,
3) amplify the input receive signal in such a way as to establish the system receiver noise figure,
4) down-convert the input receive signal to a 0 hz IF frequency (homodyne), providing two "IF" output channels where the down-conversion process in one of the IF channels is in phase quadrature with the other IF channel.

1.2 Scope

The scope of this document is to define and specify the electrical and mechanical performance of the Back Up Aid microwave electronics subsection.

2. DEFINITIONS, AND APPLICABLE DOCUMENTS

2.1 Applicable Documents

The following specifications are for reference and are not a part of this specification :

1) PN Code Delay ASIC for RDS HEM 1002301, rev 1, February 21, 1997
2) Design Requirements Document for Rear Detection Sensor HEM 1002143, rev B, October 1, 1996

2.2 Definition of terms

no special terms at this time

EXHIBIT F

Page 10 of 19

U of Mich file 415031-007

3. ELECTRICAL REQUIREMENTS

The following performance requirements shall be met by the Microwave Transceiver under all specified environmental operating conditions, and all combinations of operating conditions.

3.1 Subsystem Block Diagram

A functional block diagram of the Transceiver subsystem is shown in figure 1. The $\Delta\varphi$ symbol shown in the Transceiver represents a bi-phase modulation function. The input ports Receive Code and Transmit Code are "logic" in nature where digital data streams appear to effect either a "1" or "0" phase state in the phase modulators. The absolute phase imparted to the relevant carrier input by either logic state is immaterial, but the phase difference between the two states is tightly controlled herein and ideally will approach 180^0. By modulating a single frequency carrier as generated by the LO with the Transmit Code, which in the BUA application will be a true noise code or psuedo-noise code, the output spectrum at TX OUT will be a spread spectrum signal. If the TX OUT signal is applied to the RX IN port, with a delay that is the same as that between the input Transmit and Receive Codes, and if the Transmit and Receive Codes inputs are identical except for said time delay, the output of the receive modulator will be a replica of the LO signal, i.e. the carrier.

There is a difference between the Transmit and Receive codes, other than delay, in the BUA Radar sensor application; it is that the Transmit code shifts phase relative to the receive code at a predetermined rate. The phase excursion is 180^0, and is transferred as phase modulation onto the carrier by the correlation process, which is the function of the receive modulator. After down-conversion, the mixer output is the signal which phase modulated the Transmit code.

EXHIBIT F

Page 11 of 19

U of Mich file 415031-007

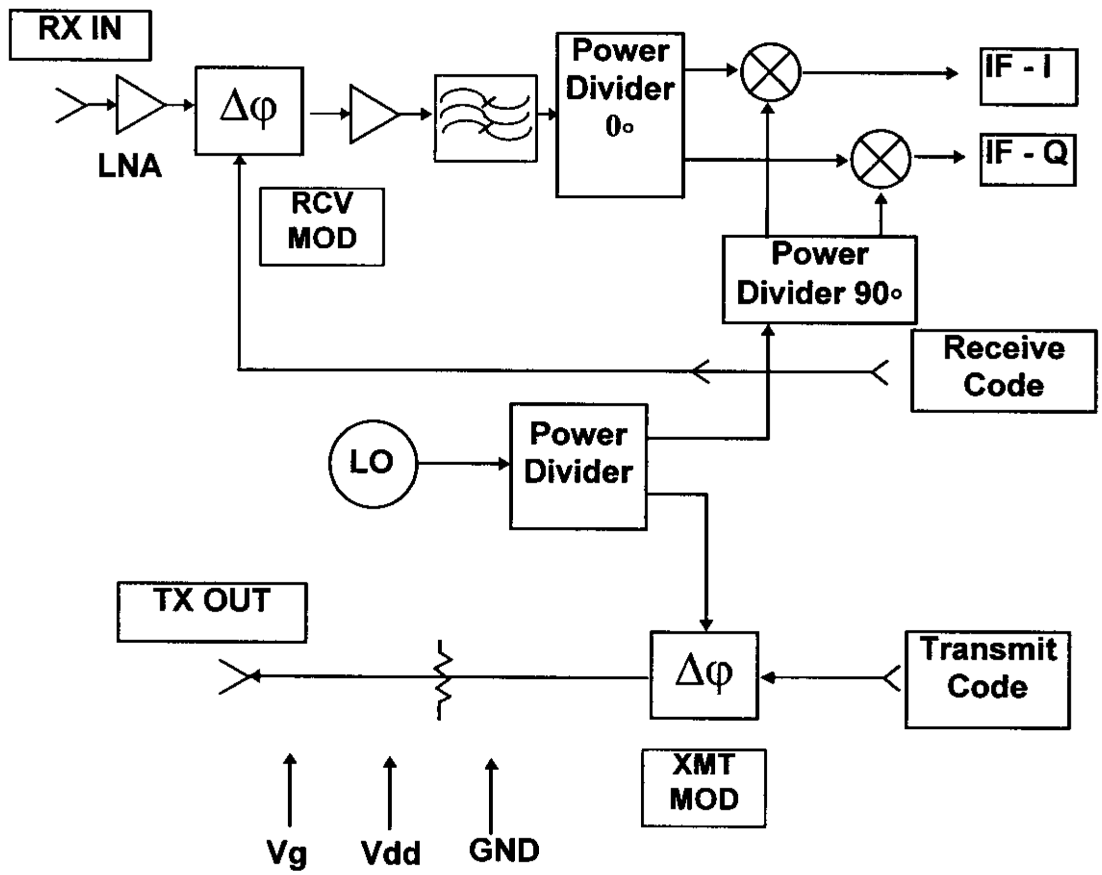

Figure 1. Radar sensor Transceiver Subsystem block diagram. The transceiver generates an RF carrier, phase modulates the carrier, and phase modulates the RX IN signal. The RX IN signal is then down-converted to a DC IF with a quadrature down-converter.

EXHIBIT F

Page 12 of 19

U of Mich file 415031-007

3.2 Performance Requirements

The electrical performance requirements of the transceiver are defined in this section.

3.2.1 Transceiver Transfer Function Specifications

The following sections define the required functional performance of the transceiver transfer functions, and certain properties of various signal paths.

3.2.1.1 TRANSMIT PHASE MODULATION - TRANSMIT CODE TO TX OUT

The TX OUT signal is a bi-phase modulated microwave carrier where the phase shift between the two phase states is 180°. The transceiver shall bi-phase modulate an internally generated carrier according to the Transmit Code input to make the TX OUT signal. The Transmit Code input is a serial digital bit stream, where each (of 2) logic states in the bit stream shall produce the corresponding phase state of the carrier at the output, TX OUT.

3.2.1.2 RECEIVE PHASE MODULATION - RX IN TO IF-I AND IF-Q OUT

The RX IN signal is a bi-phase modulated microwave carrier where the phase shift between the two phase states is 180°. The transceiver shall bi-phase modulate the RX IN signal according to the Receive Code input to demodulate the RX IN signal. The Receive Code input is a serial digital bit stream, where each (of 2) logic states in the bit stream shall produce the corresponding phase (de)modulation of the RX IN signal at the demodulator output.

3.2.1.3 PHASE MODULATION PERFORMANCE

The Receive Phase Modulation function and Transmit Phase Modulation function shall be performed in accordance with the following specifications.

3.2.1.3.1 MODULATOR INPUT BANDWIDTH

The phase modulator shall impart two state (bi-phase) modulation in accordance with the following specifications when the modulator input signal frequency is 16.95 Ghz ± 200 Mhz

3.2.1.3.2 AMPLITUDE BALANCE

The amplitude difference between the two phase states of the modulator output shall be no more than 1 db.

3.2.1.3.3 PHASE BALANCE

The phase difference imparted to the modulator input signal between the two states of the modulation input shall be $180^{\circ} \pm 6^{\circ}$.

3.2.1.3.4 MODULATION BANDWIDTH

The modulation voltage to phase transfer function shall have a minimum half power bandwidth of 10 Khz to 3600 Mhz.

EXHIBIT F
Page 13 of 19
U of Mich file 415031- 007

3.2.1.4 SPREAD SPECTRUM SIGNAL TRANSFER FUNCTION PROPERTIES

The following transfer function requirements apply to the two spread spectrum phase modulated signal paths in the transceiver. These signal paths are :

1) between the XMT phase modulator and TX OUT port
2) between the RX IN port and the RCV phase modulator.

3.2.1.4.1 SPREAD SPECTRUM SIGNAL PATH BANDWIDTH

The minimum half power bandwidth of the signal path shall be 2 Ghz. The signal path passband shall be centered at 16.95 Ghz, ± 100 Mhz.

3.2.1.4.2 SPREAD SPECTRUM SIGNAL PATH GROUP DELAY FLATNESS

The group delay of the signal path shall not vary more than 200 psec from the average signal path group delay at any frequency between 16.2 Ghz and 17.7 Ghz.

3.2.1.4.3 SPREAD SPECTRUM SIGNAL PATH PASS BAND AMPLITUDE RIPPLE

The signal path power transmission amplitude ripple at any frequency between 16.2 Ghz and 17.7 Ghz shall be no more than 1.0 db peak to peak.

3.2.1.4.4 SPREAD SPECTRUM SIGNAL PATH BAND REJECT PROPERTY

For signals at frequencies between DC and 3600 Mhz, the signal path shall provide for a minimum of 20 db of power loss relative to the power transmission of the path at frequencies between 16.2 Ghz and 17.7 Ghz

3.2.2 Receiver / Down Converter Performance

The following Receiver Down-Converter specifications apply under the conditions where the IF output ports are loaded by 50 Ω, and the RX IN port is driven by a signal generator with source impedance of 50 Ω.

3.2.2.1 RECEIVE SIGNAL DOWN CONVERTER POWER GAIN : RX IN TO IF-I AND RX IN TO IF-Q

The RX IN signal shall be substantially amplified as a first step in analog signal processing, with adequate amplification so as to make the entire receiver down-converter noise figure nearly equal to the noise figure of the amplifier at the RX In port.

3.2.2.1.1 POWER GAIN

The power gain from RX IN to the IF-I port and the IF-Q port shall be 19 ± 3 db at 25°C. The power gain shall vary by no more than 2 db from its value at 25°C when the transceiver is operated over the entire extent of the operating temperature range.

3.2.2.1.2 POWER GAIN CHANNEL MATCHING

The power gain between the RX IN port and the IF-I output port shall be the same as the power gain from the RX IN port to the IF-Q output port. The power gains shall be matched to within 1.5 db.

EXHIBIT F

Page 14 of 19

U of Mich file 415031-007

3.2.2.2 DOWN-CONVERTER NOISE FIGURE

The noise figure of the down-converter, from the RX IN port to either the IF-I port or the IF-Q port shall be no more than 3 db.

3.2.2.3 NARROW BAND SIGNAL PATH PROPERTIES

The signal path between the receive phase modulator and the receive down-converter shall comply with the specifications defined in the sub-sections of this paragraph.

3.2.2.3.1 PASSBAND CENTER FREQUENCY

The signal path passband shall be centered at 16.95 Ghz, ± 100 Mhz.

3.2.2.3.2 PASSBAND AMPLITUDE RIPPLE

The signal path shall exhibit no more than 1.3 db amplitude ripple in its transmission characteristic in any 500 Khz band which is within the path passband.

3.2.2.3.3 PASSBAND BANDWIDTH

The half power bandwidth of the signal shall be no more than 1000 Mhz, and no less than 300 Mhz.

3.2.2.3.4 PASSBAND SELECTIVITY (STO PBAND ATTENUATION)

The transmission loss of the path relative to the path transmission at the passband center frequency shall be no less than 50 db over the frequency ranges of dC - 14.6 Ghz and 19.7 Ghz - 30.0 Ghz.

3.2.2.4 QUADRATURE DOWN CONVERSION

The Receiver Down-Converter shall power split the de-modulated RX IN signal, the split channels being designated "I" and "Q" and mix each of those split signals with an LO signal which is a replica of the un-modulated transmit carrier.

3.2.2.4.1 DOWN CONVERSION PHASE SHIFT

The phase difference between the baseband I and Q channels of the down-conversion process (IF-I and IF-Q outputs) shall be $90^{\circ} \pm 15^{\circ}$ over the baseband bandwidth.

3.2.2.4.2 BASEBAND BANDWIDTH

The baseband 1/2 power bandwidth of the down-converter process shall be a minimum of 300 hz to 500 Khz.

EXHIBIT F
Page 15 of 19
U of Mich file 415031-007

3.2.3 Transmitter Performance

The transmitter shall generate a single frequency LO signal, split said signal into two parts, and phase modulate one of those parts in accordance with the phase modulation specification (above), and apply the modulated signal to the TX OUT port.

3.2.3.1 LO SIGNAL CHARACTERISTICS

3.2.3.1.1 LO SIGNAL FREQUENCY

The generated LO signal shall have a frequency of 16.950 Ghz ± 50 Mhz

3.2.3.1.2 LO SIGNAL PHASE NOISE

The Single SideBand Phase Noise of the LO signal shall not exceed the following limits :

offset frequency from carrier	phase noise limit (dbc / hz)
400 hz	-48
1000 hz	-50
2000 hz	-58
5000 hz	-68
10 Khz	-80
> 10 khz	≤ -80

3.2.3.1.3 LO SIGNAL SPURIOUS FREQUENCY OUTPUT

Spurious frequency power in the LO signal shall not exceed the following limits:

offset frequency from carrier	spur power limit (dbc)
0 - 25 Khz	- 117
25 - 50 Khz	- 97
50 - 100 Khz	-92
100 - 200 Khz	- 82
200 Khz - 1 Mhz	- 65
> 1.0 Mhz	≤ - 65

EXHIBIT F

Page 16 of 19

U of Mich file 415031-007

3.2.4 Isolation Requirements

3.2.4.1 PORT TO PORT COUPLING

The transceiver shall exhibit isolation (limited coupling) between ports over the specified frequency ranges :

Port Definition	Isolation Requirement	Applicable Frequency Range
TX OUT -> RX IN	≥ 60 db	15.5 - 18.5 Ghz
	≥ 80 db	DC - 3600 Mhz
Transmit Code -> TX OUT	≥ 40 db	DC - 3600 Mhz
Transmit Code -> IF ports	≥ 70 db	DC - 3600 Mhz
Receive Code -> IF ports	≥ 40 db	DC - 3600 Mhz

3.2.4.2 LO SIGNAL POWER AT RCV MODULATOR

The LO signal injected into the RCV modulator shall have a power no greater than -30 dbm.

3.2.5 Input / Output Port Characteristics

The following specifications describe the power, impedance, and input drive electrical signal levels appropriate to each input and output port.

3.2.5.1 DC POWER

The transceiver shall have two terminals (Vdd1 and Vg) for the application of DC power, and one or more GROUND terminals, where this terminal defines the transceiver voltage datum.

3.2.5.1.1 OPERATING DC VOLTAGE

The transceiver shall comply with all performance specifications when operated with DC voltages applied to the DC terminals as specified below.

3.2.5.1.1.1 Vdd1 Power Terminal

The applied DC voltage shall be 5 Vdc ± 5%. The maximum current required by the Vdd terminal shall be no more than 120 mA.

3.2.5.1.1.2 Vg Power Terminal

The applied DC voltage shall be - 5 Vdc ± 10%. The maximum current required by the Vg terminal shall be no more than 2.50 mA.

3.2.5.1.1.2.1 Vg Spike and Ripple

The transceiver shall operate properly when the following switching power supply noise characteristics are present at the Vg power teminal :

spike :	no less than 60 mVpp
ripple :	no less than 20 mVpp

EXHIBIT F
Page 17 of 19
U of Mich file 415031-007

3.2.5.1.2 Maximum DC Voltage Rating

The transceiver shall not be damaged when DC voltages between 0 Vdc and 7 Vdc are applied to the Vdd DC input terminal.
The transceiver shall not be damaged when DC voltages between 0 Vdc and -7 Vdc are applied to the Vg DC input terminal.

3.2.5.2 TX OUT PORT

3.2.5.2.1 Input Impedance

The VSWR of the port shall be no more than 1.5:1 with respect to 50 Ω over the frequency range of 15.95 to 17.95 Ghz.

3.2.5.2.2 Output Power

The total modulated output power of the transmit signal at the port shall be -29.0 dbm ± 2 db at 25°C. The transmit power shall vary be no more than 1 db from its value at 25°C when the transceiver is operated over the entire extent of the operating temperature range.

3.2.5.3 RX IN PORT

3.2.5.3.1 Input Impedance

The VSWR of the port shall be no more than 1.5:1 with respect to 50 Ω over the frequency range of 15.95 to 17.95 Ghz.

3.2.5.3.2 Dynamic Range

The receiver shall operate as specified above with an applied input signal powers at the port of no greater than -50 dbm.

3.2.5.4 IF-I PORT AND IF-Q PORT SOURCE IMPEDANCE

The IF ports shall have a source impedance of no more than 200 Ω Resistance, and series Reactance of no more than 20 Ω , over the frequency range 300 hz to 500 Khz.

3.2.5.5 RECEIVE CODE PORT AND TRANSMIT CODE PORT

3.2.5.5.1 Port Impedance

The VSWR of the port shall be no more than 1.5:1 with respect to 50 Ω over the frequency range of DC to 3600 Mhz.

EXHIBIT F
Page 18 of 19
U of Mich file 415031- 007

3.2.5.5.2 PORT SIGNAL LEVEL

The transceiver shall phase modulate the receive and transmit signals with the port signals in accordance with specifications given above when the peak-to-peak voltage level at the port is no less than 500mV and no more than 1000 mV

4. CONFIGURATION REQUIREMENTS

configuration definition

5. ENVIRONMENTAL

5.1 Operating Temperature Range

The required operating temperture is -40°C to +60°C.

EXHIBIT F
Page 19 of 19
U of Mich file 415031-007