CLASS II CHANGE
MEASUREMENT AND TECHNICAL REPORT ON THE TIRIS TAG-IT READER 6000 (formerly called COMMANDER 320)

Southwest Research Institute
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Project 10-2333-040
Report Number EMCR 99/100

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1.0 GENERAL INFORMATION

1.1 Product Description

This is a request for a Class II permissive change in a previously authorized RF identification tag reader. The reader module (TI PN RI-R00-321A) is a battery or DC power supply operated device designed to use in system RI-K01-320A with computer interface and batteryless transponders such as inlays RI-I01-0110 (45x45mm) and RI-I02-0110 (45x76mm). This reader module could be integrated into commercial printers and fixed-point identification scanners. The transmitter portion of the reader operates at 13.56 MHz and is subject to FCC Part 15, Subpart C, "Intentional Radiator," Section 15.225 of the FCC Rules. Radiated emissions from the intentional radiator portion of the device meet the limits in Section 15.209 of the Rules outside of the 13.56 +/- 0.007 MHz band. The digital electronics portion of the reader is subject to FCC Part 15, Subpart B, "Unintentional Radiator," Section 15.109, under the Class A limits.

The Texas Instruments Tag-it interrogator, FCC ID A92COM320, was originally granted an equipment authorization by the FCC on November 6, 1998. The Class II Change testing was performed to show continuous compliance with FCC Part 15, Subpart C, due to changes of firmware and component layout of RFID analog module in eliminating anti-collision detection and FPGA software. The removal of the circuitry previously employed for managing the detection of signals from multiple tags in the presence of the reader has no effect on the basic frequency determining and stabilizing circuitry, frequency multiplication stages, basic modulator circuit or maximum power or field strength ratings of the RF ID transmitter that is authorized under. This change affects all production. The electrical schematic and, hardware of both digital control and RS-232 interface boards did not change. Attachment 1 contains a detailed technical and functional description of the reader system and its components.

1.2 Related Grants

No other host equipment was used in the test configuration. However, equipment was communicating to the host (laptop) during test.

1.3 Tested System Details

The reader is mounted into an enclosure such as a thermal transfer barcode printer or fixed-point conveyor identification scanner system. The reader system includes the analog RFM, CPU digital module, RS-232 interface board, 50Ω cable, and antenna module (matching board and antenna). The reader is attached to an electronics data host such as a computer or printer. These components were assembled as shown on page 4 in appendix D - "A92CIIEUT.pdf" file.

The reader operates from 12 V_{DC} supplied from either an external power supply or battery. During emission testing, the reader was powered using an external 12 V_{DC} battery. An outboard power supply was used for the supply voltage variation test. The components of the system are listed below in Table 1.1. The reader antenna measured 7.25" (L) x 3.5" (W). Photographs of the reader in Appendix D and its printed circuit boards are provided in Attachment 2c, (file 00121-C-01.pdf). Note that the revision labels on EUT were not updated with the revision actually tested (Firmware 2.0.0 and FPGA 1.2.0).

TABLE 1.1
RI-K01-320A READER SYSTEM COMPONENTS

Component Description	Model Number	Revision, Serial Number
Reader Module - Analog RFM (FPGA 1.2.0) - Digital CPU (FPGA 1.2.0) - Firmware	RI-R00-320A - RI-RFM-0320 - RI-CTL-0320 - RI-S00-0320	Rev. 1, S/N 485 Rev. 1, Rev. 0, Rev. 2.0.0
RS-232 Interface	RI-R00-232A	Rev. 0,
Antenna Module - Antenna Matching Network - 50Ω Cable	RI-A00-0315 - RI-A00-M50A - N/A	Rev. 1 Rev. 1 N/A

1.4 Test Methodology

Radiated testing was performed according to the procedures in ANSI C63.4-1992 and the limits prescribed in CFR 47, FCC Parts 15.109, 15.209 and 15.225. Radiated testing was performed at an antenna to EUT distance of 10 and 30 meters.

1.5 Test Facility

The Open Area Test Site and Conducted Measurement Facility used to collect data are located at Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas. Details concerning these test sites are found in the report entitled, "Description of Measurement Facility," dated 28 April 1997, which is on file with the FCC Laboratory Division in Columbia, Maryland. On June 12, 1997, the FCC approved the sites for the purpose of providing test results for submission with equipment authorization applications under the Commission's Equipment Authorization Program.

2.0 PRODUCT LABELING

2.1 FCC ID Label

FCC ID: A92COM320 This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

2.2 Location of Label on EUT

There is now no physical room to place label on directly on the EUT. Accordingly, the label is placed on the exterior of the housing.

3.0 SYSTEM TEST CONFIGURATION

3.1 Justification

Radiated tests were performed on the Reader intentional radiator from 13.56 MHz to 1 GHz for the highest fundamental and harmonics. Radiated tests were performed up to 1 GHz for harmonics of the fundamental emission and spurious emissions related to the digital electronics portion of the unit. Both vertical and horizontal polarizations were tested. Radiated signature scans were made at 3 meters in a shielded anechoic chamber.

3.2 EUT Exercise

The reader was powered by 12 V_{DC} and fully operational at power-up. A remotely located laptop computer connected to the reader's RS-232 serial port was capable of turning the transmitter portion of the unit on/off via keyboard command, while the digital electronics portion of the unit remained operational. This capability was used during radiated emissions testing to determine whether an emission was related to the digital portion of the unit or to the reader's transmitter.

3.3 Special Accessories

No special accessories were required.

3.4 Equipment Modification

The Reader hardware is factory configured to +20.78 dBm through resistive potentiometer and then sealed (which has been incorporated in the manufacturing procedure). No equipment modifications were required during testing.

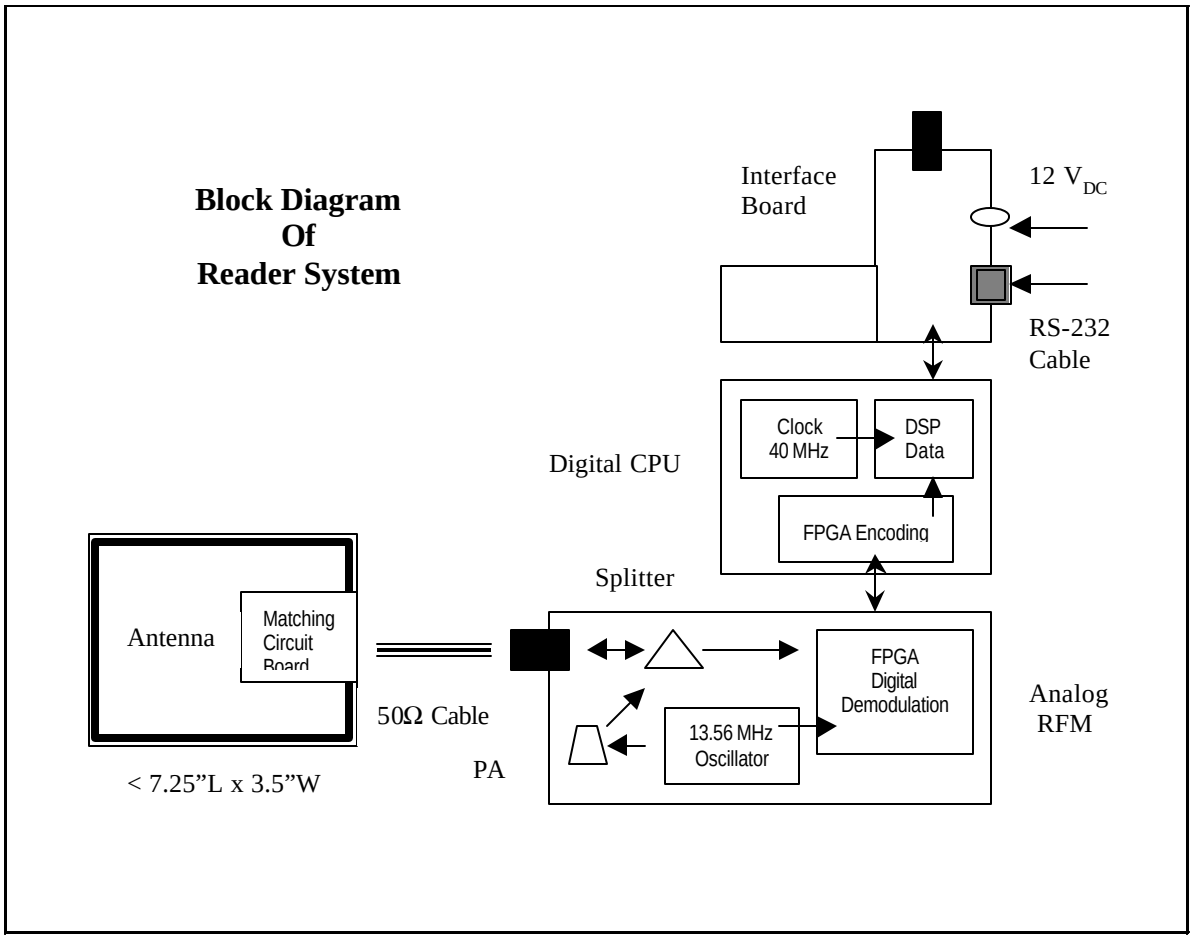
3.5 Configuration of Tested System

Refer to Section 4.0 for block diagram of tested configuration. Refer to Appendix C for photographs of the EUT test setup.

3.6 Antenna Connector

This device is intended for incorporation into other devices. It is not a consumer device. It requires installation by a technician or assembly line worker trained in its installation in order to properly install it in other devices such as a printer. The device, as originally approved and in the modified version uses an SMA antenna connector on the RF module board in order to facilitate the placement of the device within other devices so that the cable to the antenna may be more easily routed away from moving parts and hot surfaces. The SMA connector is located inside a closed fixed plastic housing as originally approved. Because this is a device that inherently requires professional installation, it complies with the requirements of Section 15.203 of the Commission's Rules. The written instructions packed with the device will explain the requirement for professional installation.

4.0 BLOCK DIAGRAM OF THE "Tag-it™" SYSTEM



5.0 RADIATED MEASUREMENT PHOTOS

Refer to Appendix C for photographs of the anechoic and OATS test setup.

6.0 RADIATED EMISSION DATA

The data below are the corrected highest-level EME measurements taken from the following radiated data sheets. The data sheets include the emission frequencies and the corrected level. An explanation of the field strength calculation is given in paragraph 6.3.

6.1 Radiated Measurement Data

The fundamental frequency of 13.56 MHz was measured at 30 meters. Additionally, the spectrum was investigated for harmonics and spurious emissions up to 30 MHz at 30 meters. No harmonics or other spurious emissions were detected. The measurement level of the fundamental at the center frequency, as well as the level of the fundamental at the band edges, is shown in Table 6.1.

TABLE 6.1
MEASUREMENTS OF FUNDAMENTAL FREQUENCY

Judgment: Fundamental Emission Passed by 38.1 dB Emission at Band Edges Passed by 19.0 dB		
Frequency (MHz)	**Corrected Level[1] dB(µV/m)**	**Limit 30 Meters dB(µV/m)**
13.56	41.9	80
13.5485	49.6 [2]	68.7[2] (3.15 Meters)
13.5715	49.7 [2]	68.7[2] (3.15 Meters)

1 All readings are quasi-peak manual measurements made with a receiver.

2 The level of the fundamental at the band edges was not detectable at 30 meters. The receive loop antenna was moved to a distance of 3.15 meters to measure the emission level of the fundamental at the band edges. The worst-case level at the band edges (at 13.5715 MHz) was 19 dB below the general limit in paragraph 15.209. The general limit in paragraph 15.209 was adjusted using a 40 dB/decade extrapolation factor as specified in paragraph 15.31, (f), (2). *Note that the data summarized above show a greater margin of compliance than the summary of data presented when the device was first approved.*

The spectrum from 30 MHz to 1 GHz was investigated for spurious emissions. The worst-case spurious emissions are given in Table 6.2. All spurious emissions were determined to be related to the digital electronics, which are required to meet the section 15.109, Class A limit. A remotely located laptop computer connected to the reader's RS-232 serial port was capable of turning the transmitter portion of the unit on/off via keyboard command, while the digital electronics portion of the unit remained operational. This capability was used to determine whether an emission was related to the digital portion of the unit or to the reader's transmitter. Peak signature scans are provided in Appendix A.

TABLE 6.2
MEASUREMENTS OF SPURIOUS EMISSIONS

Judgment EUT passed by 3.6 dB			
Frequency (MHz)	**Corrected Level [1] dB(µV/m)**	**Limit dB(µV/m)**	**"dB" Under limit**
54.24	34	39	5.0
67.80	34.2	39	4.8
81.36	35.4	39	3.6
108.48	37.3	43.5	6.2

1 All readings are quasi-peak manual measurements made with a receiver. *Note that the data summarized above show a greater margin of compliance than the summary of data presented when the device was first approved.*

Radiated Emissions Test Data

FREQUENCY (MHz)	13.56	13.56	27.12	27.12	13.56	27.12	13.56	13.5485	13.5715
TRANSDUCER	ALR-25	ALR-25	ALR-25	ALR-25	ALR-25	ALR-25	ALR-25	ALR-25	ALR-25
Antenna to DUT distance (meters)	30	30	30	30	30	30	3.15	3.15	3.15
Antenna height (meters)	1	1	1	1	1	1	1	1	1
POLARIZATION to DUT: (|| Parallel, ⊥ Perpendicular, = Parallel to Ground)	||	⊥	||	⊥	=	=	||	||	||
SIGNAL DIRECTION	0E	0E	0E ambient	0E ambient	0E ambient	0E ambient	0E	0E	0E
RECEIVER ATTENUATION (dB)	0	0	0	0	0	0	0	0	0
METER (dBΦV)	5.0	2.0	-5.2	-1.5	-6.8	-6.9	32.3	12.7	12.8
TRANSDUCER FACTOR (dB)	34.9	34.9	28	28	34.9	28	34.9	34.9	34.9
EXTERNAL GAIN/CABLE LOSS (dB)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
CORRECTED LEVEL (dBΦV/m)	41.9	38.9	24.8	28.5	30.1	23.1	69.2	49.6	49.7
LIMIT (dBΦV/m)	80	80	29.5	29.5	80	29.5	119.2[1]	68.7[1]	68.7[1]

Date: 27 SEP 1999 Detection Method: _X_ CISPR ___ PEAK ___ AVERAGE ___ Other
Project No.: 10-2333-040 EUT: TAG-IT
Test Category: FCC Part 15 OPR/Asst.: C.Hale Scanned three polarizations of loop antenna.
Temp, & %r.H: 102, 32%

.

NOTE 1: Used 40 dB per decade roll-off to adjust limit for measurements at a distance of 3.15 meters.

Radiated Emissions Test Data

FREQUENCY (MHz)	81.36	81.36	54.24	67.80	94.92	108.48	122.04	40.68
TRANSDUCER	BDA-25	BDA-25	BDA-25	BDA-25	BDA-25	BDA-25	BDA-25	BDA-25
Antenna to DUT distance (meters)	10	10	10	10	10	10	10	10
Antenna height (meters)	4.0	1.74	2.22	1.77	1.66	2.89	1.67	1.78
POLARIZATION (V =Vertical H= Horizontal)	H	V	V	V	V	V	V	V
SIGNAL DIRECTION	176E	347E	360E	5E	360E	360E	91E	360E
RECEIVER ATTENUATION (dB)	0	0	0	0	0	0	0	0
METER (dBΦV)	18.1	25.4	23.7	25.1	21.4	22.4	20.4	7.3
TRANSDUCER FACTOR (dB)	6.9	6.9	7.7	6.3	10.2	11.2	11.7	12.6
EXTERNAL GAIN/CABLE LOSS (dB)	3.1	3.1	2.6	2.8	3.4	3.7	4.0	2.3
CORRECTED LEVEL (dBΦV/m)	28.1	35.4	34	34.2	34.8	37.3	36.1	22.2
LIMIT (dBΦV/m)	39	39	39	39	43.5	43.5	43.5	39

Date: 27 SEP 1999
Project No.: 10-2333-040
Test Category: FCC Part 15
Temp, & %r.H.: 100°F, 32%

Detection Method: _ X_ CISPR ___ PEAK ___ AVERAGE ___ Other
EUT: TAG-IT
OPR/Asst.: C.Hale

Radiated Emissions Test Data

FREQUENCY (MHz)	135.60	320	610.22					
TRANSDUCER	BDA-25	T-2	T-3					
Antenna to DUT distance (meters)	10	10	10					
Antenna height (meters)	4.0	3.11	1.86					
POLARIZATION (V =Vertical H= Horizontal)	H	V	V					
SIGNAL DIRECTION	281E	241E	97E					
RECEIVER ATTENUATION (dB)	0	0	0					
METER (dBΦV)	15.1	29.7	19.4					
TRANSDUCER FACTOR (dB)	13.1	18.2	24.3					
EXTERNAL GAIN/CABLE LOSS (dB)	4.2	-20.9	-16.8					
CORRECTED LEVEL (dBΦV/m)	32.4	27.0	26.9					
LIMIT (dBΦV/m)	43.5	46.5	46.5					

Date: 27 SEP 1999
Project No.: 10-2333-040
Test Category: FCC Part 15
Temp, & %r.H.: 100°F, 32%

Detection Method: _ X_ CISPR ___ PEAK ___ AVERAGE ___ Other
EUT: TAG-IT
OPR/Asst.: C.Hale

The frequency tolerance of the Reader System 13.56 MHz fundamental emission was verified to be within the +/-0.01% (+/-1.356 kHz) requirement from Part 15, paragraph 15.225, when exposed to temperature variations of –20 degrees to +50 degrees C. The fundamental emission was monitored on a spectrum analyzer as the Reader System was exposed to +50 degrees C for 10 minutes, and then –20 degrees C for 10 minutes, in accordance with the procedure in ANSI C63.4-1992, paragraph 13.1.6.1. In addition, the 12 Vdc supply voltage was varied from 85% (10.2 Vdc) to 115% (13.8 Vdc) at room temperature in accordance with paragraph 15.225. The frequency of the fundamental emission did not vary more than approximately 100 Hz during the entire procedure.

6.2 Test Instrumentation for Radiated Measurements

Scans were made at an open area test site (OATS) and in an RF semi-anechoic chamber 28' long x 16' wide x 16' high with its interior lined on the ceiling and four walls with pyramidal absorber material up to four feet in length. Measurements were made with a spectrum analyzer and a quasi-peak adapter in the anechoic chamber and with a receiver at the OATS. The list of test instrumentation used to perform the testing is shown in Appendix B.

6.3 Field Strength Calculation

The field strength was calculated by adding the antenna factor and cable factor, and subtracting the amplifier gain (when used) from the measured reading. The basic equation with a sample calculation is provided below:

FS = RA + AF + CF - AG

Where FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Attenuation
AG = Amplifier Gain

For example, reducing the 81.36 MHz measurement on the data sheet on page 12 (1st column) yields:

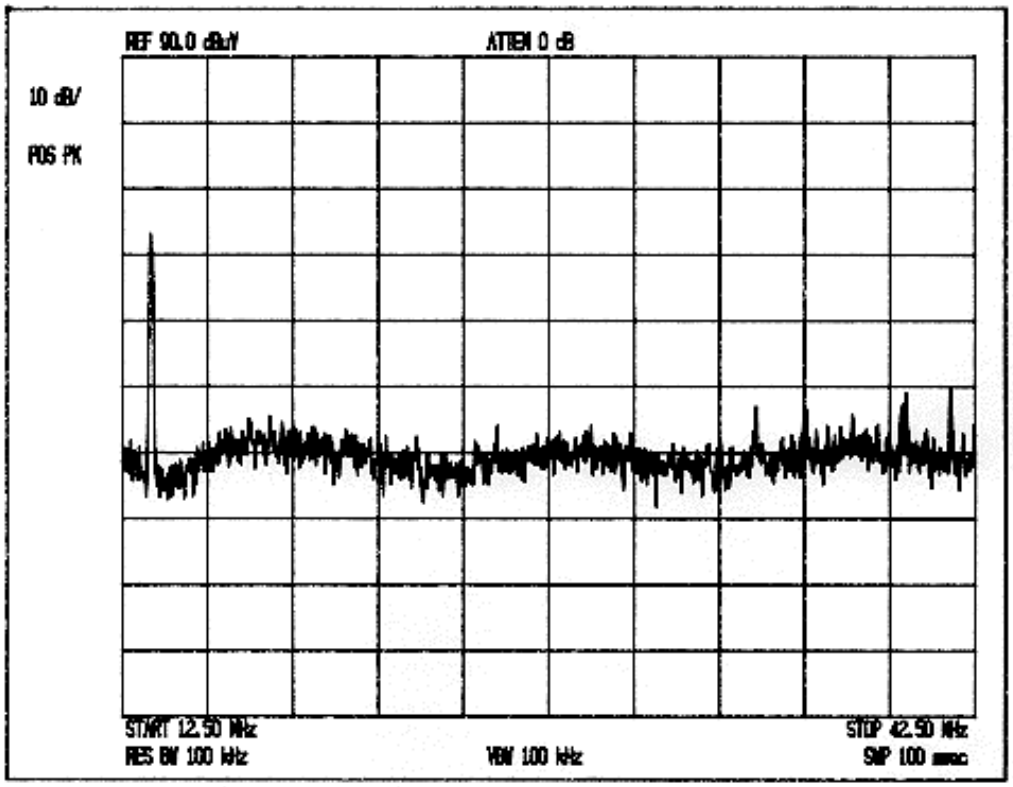
18.1 dB (µV)
6.9 dB (1/m)
3.1 dB (CF/AG FACTOR)
FS = 28.1 dB (µV/m)

To equation convert the dB (µV/m) value to its corresponding level in µV/m is as follows:

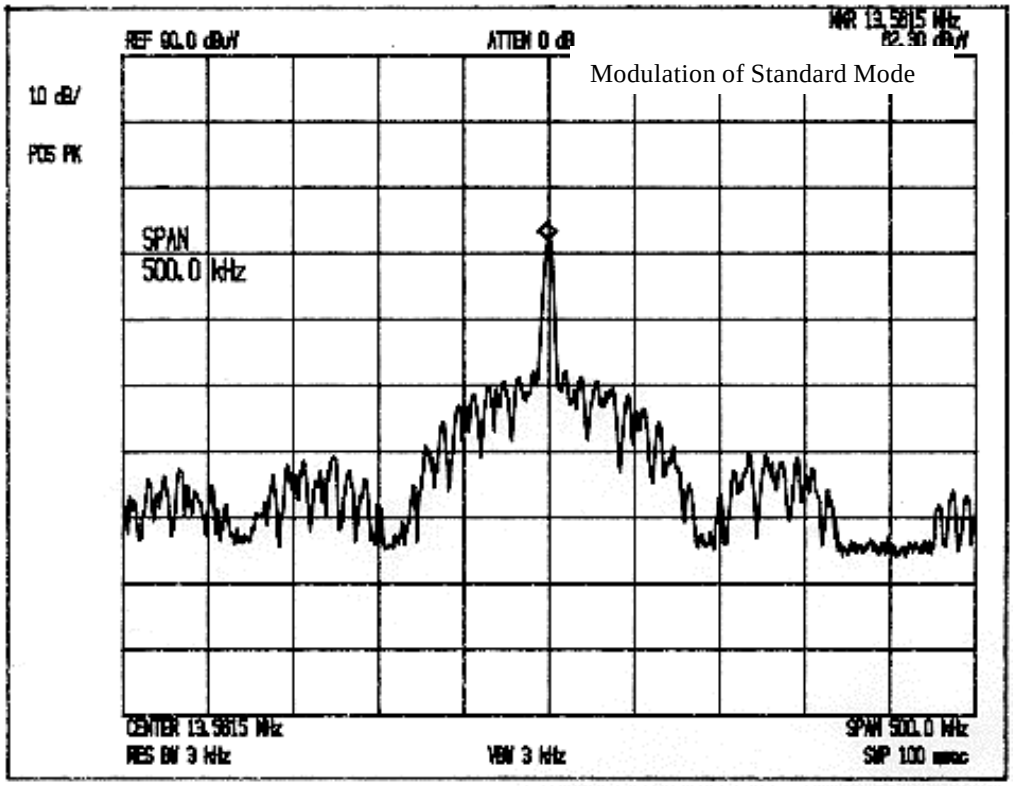
Level in µV/m Common Antilogarithm [(28.1 dB µV/m)/20] = 25.4 µV/m

APPENDIX A

RADIATED SIGNATURE MEASUREMENT PLOTS



LOOP ANTENNA - PRESCAN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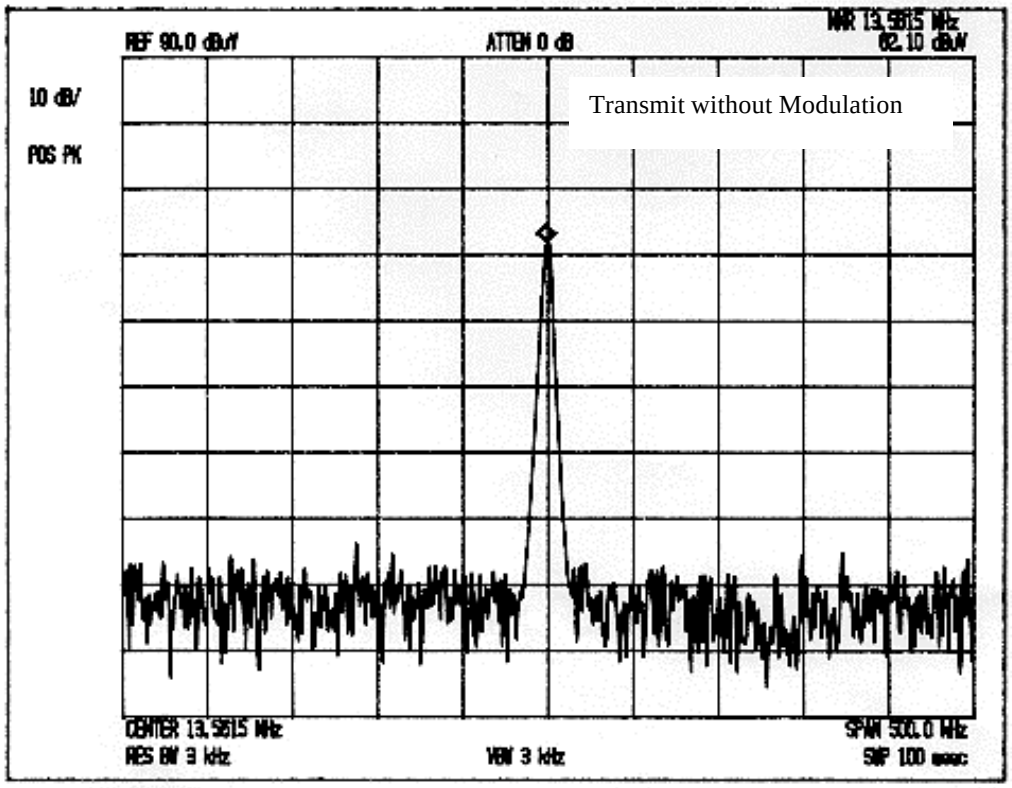
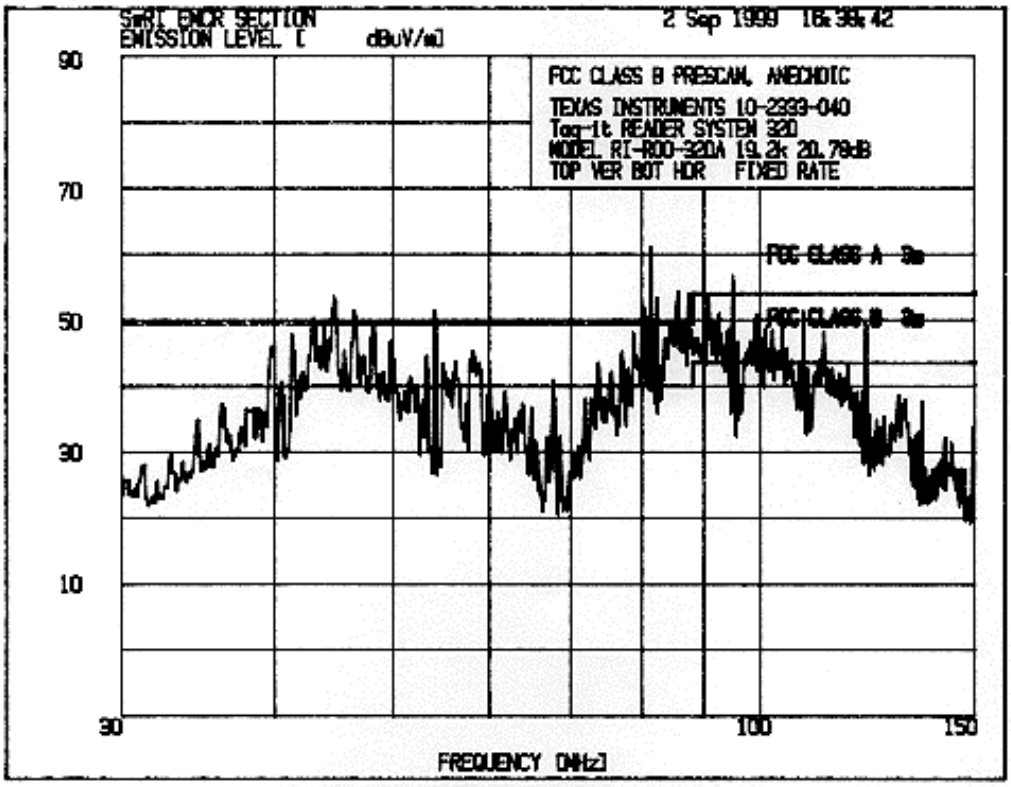
ATTEN 0 dB
MKR 13.5615 MHz
82.50 dBuV
Modulation of Standard Mode
10 dB/
POS PK
SPAN
500.0 kHz
CENTER 13.5615 MHz
RES BW 3 kHz
VBW 3 kHz
SPAN 500.0 kHz
SWP 100 msec


REF 90.0 dBuV
ATTEN 0 dB
MKR 13.5615 MHz
82.10 dBuV
Transmit without Modulation
10 dB/
POS PK
CENTER 13.5615 MHz
RES BW 3 kHz
VBW 3 kHz
SPAN 500.0 kHz
SWP 100 msec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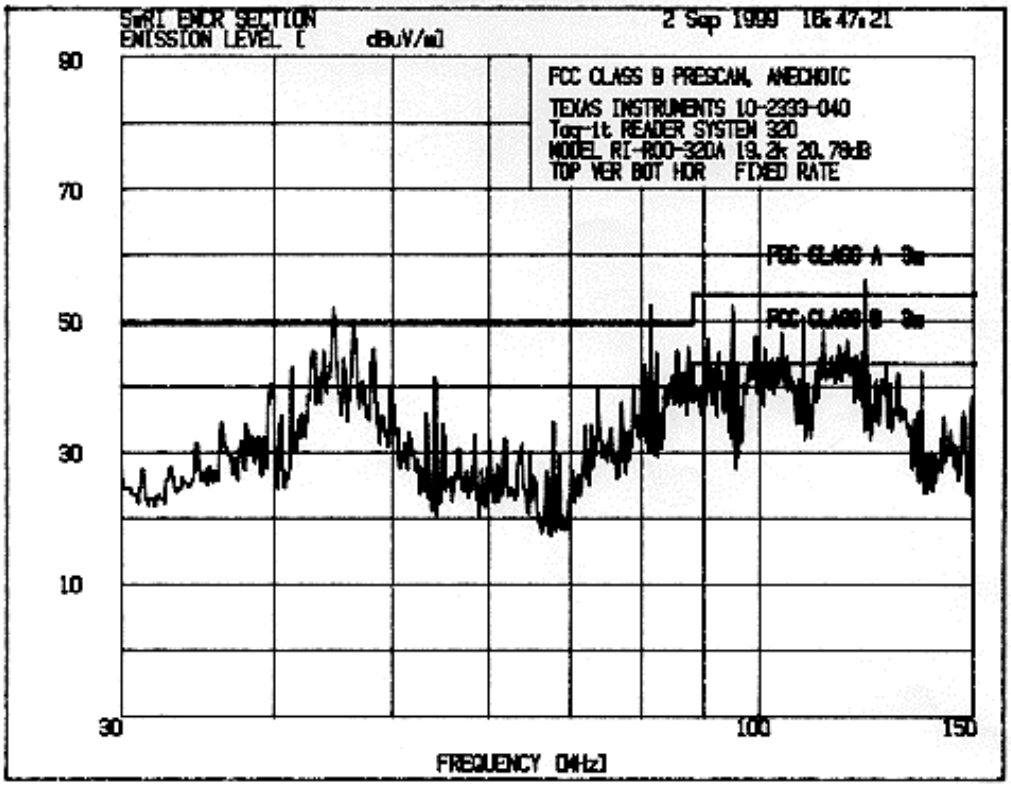
EMISSION LEVEL [dBuV/m]
2 Sep 1999 16:36:42
FCC CLASS B PRESCAN, ANECHOIC
TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.79dB
TOP VER BOT HOR FIXED RATE
FCC CLASS A 3m
FCC CLASS B 3m
90
70
50
30
10
30
100
150
FREQUENCY [MHz]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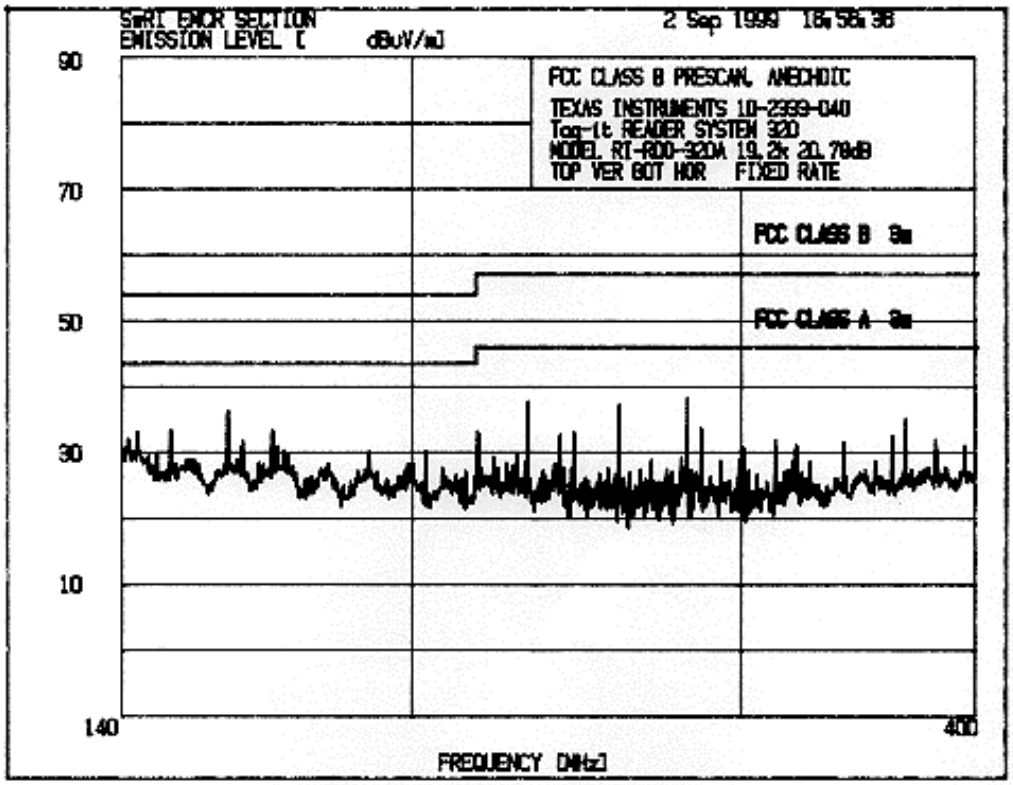
TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.79dB
TOP VER BOT HOR FIXED RATE
FCC CLASS A 3m
FCC CLASS B 3m
90
70
50
30
10
30
100
150
FREQUENCY [MHz]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2 Sep 1999 18:58:38
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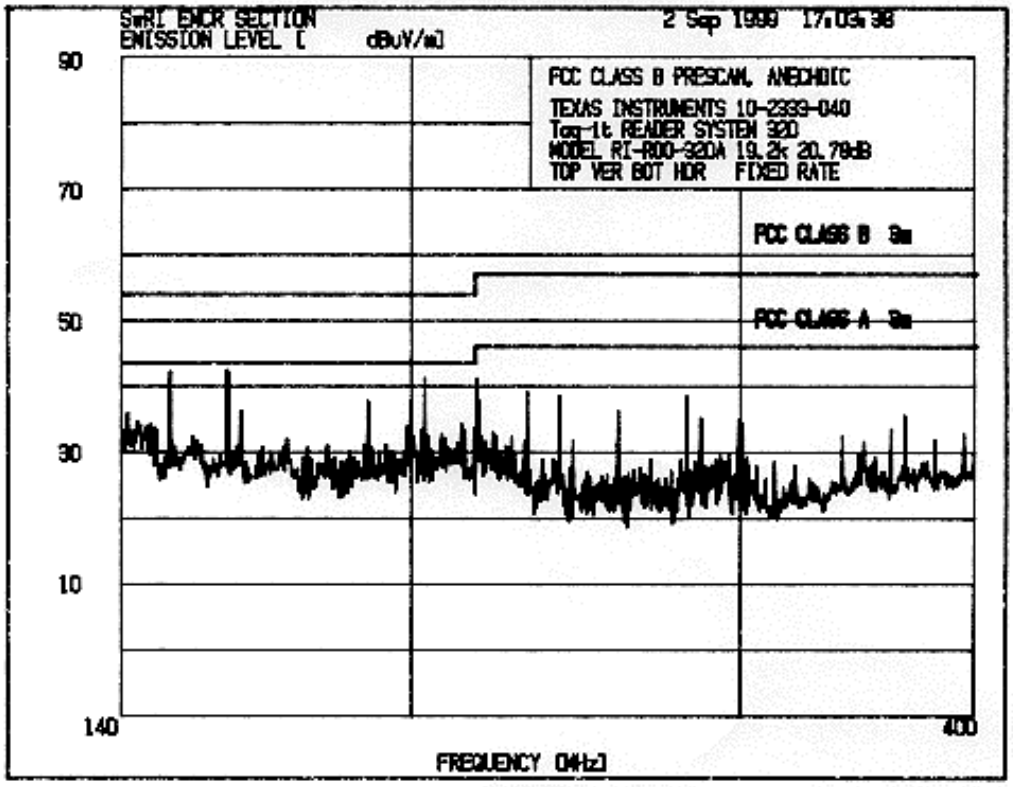
TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.70dB
TOP VER BOT HOR FIXED RATE
FCC CLASS B 3m
FCC CLASS A 3m
90
70
50
30
10
140
400
FREQUENCY [MHz]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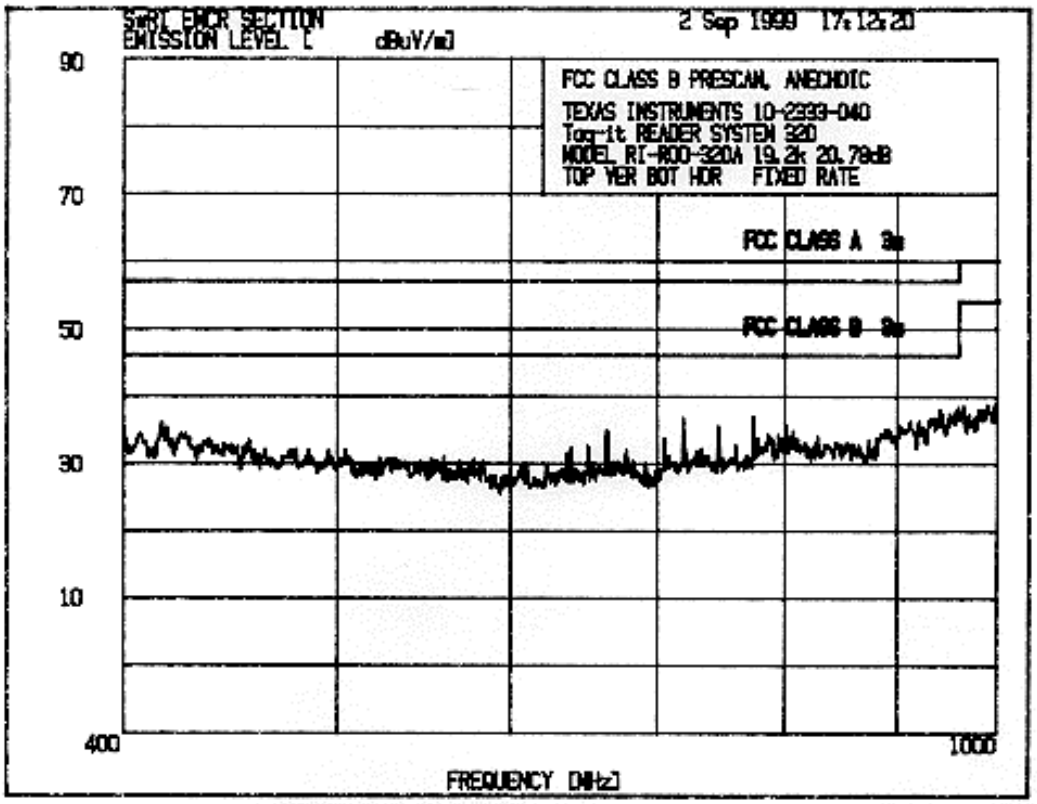
TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.70dB
TOP VER BOT HOR FIXED RATE
FCC CLASS B 3m
FCC CLASS A 3m
90
70
50
30
10
140
400
FREQUENCY [MHz]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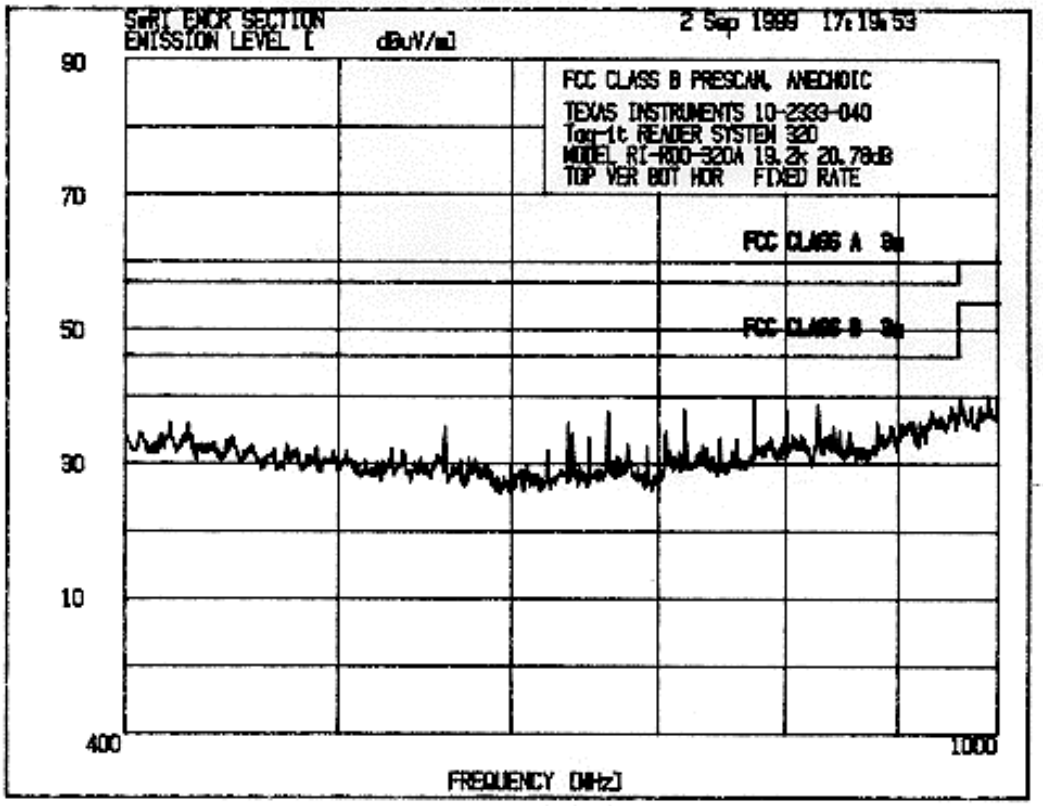
TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.78dB
TOP VER BOT HOR FIXED RATE
FCC CLASS A 3m
FCC CLASS B 3m
90
70
50
30
10
400
1000
FREQUENCY [MHz]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TEXAS INSTRUMENTS 10-2333-040
Tag-it READER SYSTEM 320
MODEL RI-R00-320A 19.2k 20.78dB
TOP VER BOT HOR FIXED RATE
FCC CLASS A 3m
FCC CLASS B 3m
90
70
50
30
10
400
1000
FREQUENCY [MHz]

APPENDIX B

TEST INSTRUMENTATION

EQUIPMENT USE REPORT

MANUFACTURER	MODEL NO.	DESCRIPTION	SERIAL NO.	CAL DATE
ANECHOIC CHAMBER				
SWRI	UTC 10 221-1	PREAMP 10-1000 MHz 35dB GAIN	9112SN15	NCR
HP	8566B	SPECTRUM ANALYZER	2209A01333	12FEB00
HP	9816	CONTROLLER	2320A06479	NCR
EMCO	3121-DB3	ANTENNA, DIPOLE	148	verified
EMCO	3121-DB4	ANTENNA, DIPOLE	1097	verified
EMCO	3121-DB2	ANTENNA, DIPOLE	147	verified
OATS				
RHODE & SWARTZ	9kHz-1GHz	TEST RECEIVER	DE31157	23SEP99
SWRI	2 MHz-1GHz	OATS PRE-AMP	1	NCR
ELECTROMETRICS	BDA25S	ANTENNA, DIPOLE	535	29APR00
EMPIRE	DM-105-T2	ANTENNA, DIPOLE	L-000178	29APR00
EMPIRE	DM-105-T3	ANTENNA, DIPOLE	L-000108	30APR00
ELECTROMETRICS	ALR-25	LOOP ANTENNA	086	3FEB00
TEMPERATURE AND VOLTAGE VARIATION				
TEKTRONIX	PS280	POWER SUPPLY	TW51893	NCR
HP	8568B	SPECTRUM ANALYZER	2140A01685	9SEP99
FLUKE	K/J	THERMOMETER	3910515	1OCT99
TENNY	TEMP GUARD III	TEMPERATURE CHAMBER	NSN	NCR
HP	8566B	SPECTRUM ANALYZER	2209A01333	12FEB00

Appendix C

Photos of Radiated Measurement Test Setup (A92CIISWRI.pdf)

Appendix D

Photos of Equipment Under Test (A92CIIEUT.pdf)