EESI
An Employee Owned Company

11696 Sorrento Valley Road, Suite "F"
San Diego, California 92121
(619) 259-4941 Fax: (619) 259-7170

FCC, PART 15, SUBPART C

CERTIFICATION REPORT

FOR THE

Go-Card Target (Transceiver)

MODEL: **MK5**

FCC ID: LVCMK5 (PENDING)

PREPARED FOR:

Cubic Transportation System – San Diego
(A Division of Cubic Automated Revenue Collection Group)
5650 Kearney Mesa Road
San Diego, CA 92186-5587

PREPARED ON:

MARCH 31, 1998

REPORT NUMBER 98-065

This report has been prepared in accordance with all applicable requirements of ANSI C63.4-1992

DOCUMENT HISTORY

Revision	Date	Comments
A	3/31/98	Initial Release T. B. Ketterling

NOTE: EESI hereby makes the following statements so as to conform to Chapter 10 (Test Reports) Requirements of ANSI C63.4 (1992) "Methods and Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz":

- The units described in this report were received at EESI's facilities on January 14, 1998. Testing was performed on the units described in this report January 14-15, 1998.
- The Test Results reported herein apply only to the Units actually tested, and to substantially identical Units.

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ATTACHMENTS:

Form 731 with Filing Fee
Attachment A: Label Design and Placement Diagram
Attachment B: Block Diagram
Attachment C: Draft User's Guide with FCC Statements

CERTIFICATION

The Radio Frequency Interference (RFI) testing, data evaluation and this report have been prepared by Electromagnetic Engineering Services, Inc., an independent electromagnetic compatibility consulting and test laboratory.

The testing and data collection were accomplished in accordance with the requirements of the ANSI, C63.4-1992 standard and the applicable sections of FCC, Part 15, Subpart C for intentional radiating equipment. Refer to the Administrative Summary for a description of the test sample.

I certify the data, data evaluation and equipment configuration herein to be a true and accurate representation of the sample's radio frequency interference emission characteristics, as of the test date(s), and for the design of the test sample utilized to compile this report.

T. Bruce Ketterling
V.P. for Technical Operations

1. ADMINISTRATIVE DATA AND TEST SUMMARY

1.1 Administrative Data

CLIENT: Cubic Transportation System – San Diego
(A Division of Cubic Automated Revenue Collection Group)
5650 Kearny Mesa Road
San Diego, CA 92186-5587
(619) 627-4589
(619) 292-9987 - fax

CONTACT: Guy Kelly / John Gehman

DATE(S) OF TEST: January 14-15, 1998

TEST SPECIFICATION: FCC, Part 15, Subpart C, for intentional radiators
(for periodic, low-power transmitters).

EQUIPMENT UNDER TEST (EUT): Go-Card Target (Transceiver)
Model Number: MK5 (13.5 MHz)
Serial Number: N/A
FCC ID Number (pending): LVCMK5

EUT transmitter fundamental frequency: 13.5 MHz

1.2 Tests Performed

Specification	*Frequency Range*	*Compliance Status*
FCC, Part 15C, §15.207 Conducted Emissions for Intentional Radiators	0.45 MHz - 30.00 MHz	**PASS**
FCC, Part 15C, §15.209 and §15.231 Radiated Emissions for Intentional Radiators	30.00 MHz - 1000 MHz	**PASS**

T. Bruce Ketterling, EES

Please refer to the Test Results section of this report for further details.

2. DESCRIPTION OF EUT

The MK5 Target is one of the components of a ***GO CARD***® System, which is designed to automatically process fares in environments such as a subway. The Target is a one-piece device with an integrated antenna. This configuration allows a single design to be tuned to operate in a variety of different metallic environments and different mountings. The Target can be surface or through-hole mounted without having to be neither redesigned nor re-certified for each new use. The Target is tuned with a tuning capacitor that is accessible from both the top and the bottom of the Target.

The system is designed to operate by waving a Tag within the Target's field. (The Tag is a credit card sized associated component that holds identifying data) The Target transmits a RF field that interrogates the Tag. This field powers the Tag, which transmits an identifying code to the Target. The Target can then interface with its associated computer system to verify the identifying code and verify the balance on the customer's account. If there is a sufficient balance then the system will allow the customer through and will automatically deduct the fare from the customer's account.

The Target measures 3.50 inches in diameter and 0.835 inches in thickness, with a mounting plate that is 5 inches in diameter and 0.040 inches in thickness (or optional 4 inch diameter mounting plate). The unit weighs 0.25 lbs. (about 1 lb. with optional surface-mounting case). The case is made of an optional scratch-resistant, self-colored antenna cover, is flame-retardant, and measures 5.5 inches in diameter and 1 inch in thickness. It can operate between -35°C to +70°C, and can be stored from -40°C to +85°C. Humidity tolerance is 10% - 90% for internal-mounted parts and 5% to 100% for external parts. Standard power supply is 7 through 28 volts at less than 2.5 watts (including backlighting), with optional power rating at 5 volts ± 10% at less than 400 mA (less than 340 mA without backlighting). Interfaces include RS232C, RS422/485 4-wire, or logic level. Two connectors include 1 signal (5 wire: TX, RX, Multi-drop address "0" & "1" and common) and 1 power (2 wire: +V and return). Range depends upon mounting (surface or through-hole and nearby metal). Bare target ranges from approximately 1 cm to 6 cm, metal ring ranted from contact to 5 cm. Minimum spacing between operation Targets is 12 inches.

The Target provides baud-rate conversion, collision-resolution, and RS232 multi-drop capability. The Target provides control of its red/yellow/green LED indicators and of the four yellow LEDs used for backlighting. The Target operates over a wide range of supply voltages and does not require a well-regulated and filtered power supply because of the included DC to DC converter.

The Target is a RF device operating at a carrier frequency of 13.560 MHz, amplitude modulated at 10% (Target to Tag) and Impedance modulated (Tag to Target). The Target operates at a baud rate of 115.2 kBaud using MK5 protocol and 38.4 kBaud using the MK3 Dual-Mode Tag, selectable via four select switches. Multi-drop capability is via two-wire selection, and control is via serial two-byte command from application to Target. (Bits in the command message control the operating mode, turn on and off the RF power, invert the receiver's modulation direction, and control the indicator and backlight LEDs) Communications protocol is asynchronous, using 8 data bits (LSB first), no parity, with 1 or more stop bits. Inter-character time is greater than 2.2 msec, followed by a sync character.

On power-up or watchdog timer time-out, a status message is sent to the application unless the multi-drop address is non-zero. The state of the baud-rate switches and the multi-drop connector pins are read at power-up and at least as often as a command message is received.

3. DESIGN MODIFICATIONS FOR COMPLIANCE

Device: Cubic Transportation System – San Diego Go-Card Target (Transceiver)

Model: MK5

No design modifications were made to this unit during testing.

4. SYSTEM CONFIGURATION

4.1 System Configuration and Power Cables

DEVICE	MANUFACTURER MODEL # SERIAL # FCC ID#	POWER AND I/O CABLE
EUT: Go-Card Target (Transceiver)	Cubic Transportation System – San Diego MK5 N/A LVCMK5 (pending)	*(To Power Supply):* 1.75m, shielded/ferrite-loaded, 20 AWG to 2.1mm inline cable-mount jack, to hardwired 18 AWG, 2.1mm plug adapter
Power Supply	Phihong PSA-30U-120 M71607443D3 N/A	2m, shielded/ferrite-loaded and filtered, 18 AWG, 3-wire, IEC connector
Laptop Computer	Notebook N/A Y428NTM0057-A FMA7500AC	*(To Power Supply):* 2m, unshielded, 18 AWG, 3-wire, 2.1mm power jack
Power Supply (for Laptop)	Lien Electronics LE-9215B20-6 005524 N/A	2m, unshielded, 18 AWG, IEC connectors

4.2 Device Interconnection and I/O Cables

CONNECTION	I/O CABLE
EUT to Laptop Computer	1.75m, shielded, 20 AWG, hardwired to DB9 connector

5. DESCRIPTION OF TESTING METHODS

5.1 Introduction

As required in 47 CFR, Parts 2 and 15, the methods employed to test the radiated and conducted emissions (as applicable) of the EUT are those contained within the American National Standards Institute (ANSI) document C63.4-1992, titled "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz." All applicable FCC Rule Sections which provide further guidance for performance of such testing are also observed.

For General Test Configuration please refer to Figure #1 on page 8.

5.2 Configuration and Methods of Measurements for Conducted Emissions

Section 7 of ANSI C63.4 determines the general configuration of the EUT and associated equipment, as well as the test platform for conducted emissions testing. Tabletop devices are placed on a non-conducting surface 80 centimeters above the ground plane floor and 40 centimeters from the ground plane wall. The EUT and associated system are configured to operate continuously, representing a "normally operating" mode. The emissions are recorded using the required bandwidth of 9 kHz in the quasi-peak mode. The average amplitude is also observed employing a 10 kHz bandwidth to determine the presence of broadband RFI. When such interference is caused by broadband sources (as defined by the FCC and ANSI Rules), the deviation guidelines contained in Section 11.3.1 of ANSI C63.4 are employed, which allows a correction factor of 13 dB to be subtracted from the quasi-peak reading. The emission levels are then compared to the applicable FCC limits to determine compliance.

For Conducted Emissions Test Configuration please refer to Figure #2 on page 9.

5.3 Configuration for Determining Location of Maximum Radiated Emissions

Section 8 of ANSI C63.4 determines the general configuration and procedures for measuring the radiated emissions of equipment under test. Initially, the primary emission frequencies are identified inside the test lab by positioning a broadband receive antenna one meter from the EUT to locate frequencies of significant radiation. Normally this is done inside a shielded or shielded, anechoic chamber to eliminate ambients. Next, the EUT and associated system are placed on a turntable on an meter open area test site (registered with the FCC in accord with its Rules and ANSI C63.4) and the receive antenna is located at a distance of ten or three meters from the EUT.

The EUT and associated system are configured to operate with a series of periodic transmissions, representing a "normally operating" mode. To ensure that the maximum emission at each discrete frequency of interest is observed, the receive antenna is varied in height from one to four meters and rotated to produce horizontal and vertical polarities, and the turntable is also rotated to determine the worst emitting configuration.

For Frequency ID and Radiated Emissions test configuration please refer to Figures #3 and #4 on pages 10-11.

5.4 Procedure for Exercising EUT

The EUT was placed in close proximity to the Tag so that it was within the RF field of the Tag. This activated the EUT and enabled the Tag and the EUT to continually transmit data back and forth. Emissions were measured and compared to FCC limits to determine compliance, with results included in this report.

6. TEST RESULTS & SAMPLE CALCULATIONS

6.1 Conducted Emissions

Not applicable.

6.2 Radiated Emission Field Strength

47 CFR sections §15.201, §15.203, §15.205, §15.209 and §15.225 specify the general emission specification limits and several specific parameter measures for low power periodic transmitters operating in the frequency range 13.553 to 13.567 MHz. Compliance to the specific sections is listed below.

§15.203: The device under test has no external antenna. Instead the antenna is etched onto the printed circuit board. The user has no practical means to attach external antennas to the transmitter. This complies with the requirements of this section.

§15.225 (a): The device under test operates at 13.56 MHz frequency and emits a carrier signal for a tag identification system. No emission in this band exceeds 10,000 μV per meter at 30 meters. Thus the provisions of this section are met.

§15.225 (b): All emissions outside the band from 13.553 MHz to 13.567 MHz are below the limits of paragraph 15.209.

§15.231 (c): The frequency tolerance of this transmitter is within ±0.01% of the operating frequency over a temperature variation of –20 to +50°C. Also, the output is stable with an input voltage variation from 85% to 115% of rated voltage.

§15.205, §15.209 and §15.225: These sections specify the radiated emissions limits and restricted bands of operation. Please refer to the data sheets attached to this report for a tabulated list of the emission frequencies and their compliance status.

In order to obtain the true field strength reading, the spectrum analyzer reading is corrected for amplifier gain, antenna factor and cable loss. From the test plots of the fundamental harmonic (seen at zero span on a spectrum analyzer), the averaging factor is calculated as follows:

As per §15.231 (b), the emission specification limit for transmitters operating in the 13.553 – 13.567 MHz frequency range is 10 mV/m at 30 meters for the fundamental frequency. The general limits given in §15.209 apply to all other emissions.

The Corrected Analyzer Reading is then given by the following formula:

Corrected Analyzer Reading = (Spectrum Analyzer Reading) - AG + AF + CL + AV

where AG = Amplifier Gain
AF = Antenna Factor
CL = Cable Loss
AV = Duty Cycle Averaging Factor

The corrected analyzer reading is then compared with the above determined emission specification limits. The following is a sample calculation using this procedure:

Frequency:	13.56	MHz
Spectrum Analyzer Reading (at 3 m):	63.20	dBμV
Combined Amp. Gain, Cable & Antenna Factor:	+22.00	dB/m
Corrected Analyzer Reading (at 3 m):	85.20	dBμV/m
Corrected Analyzer Reading (at 3 m):	**18,197**	**μV/m**
Emission Spec. Limit (at 3 m):	**100,000**	**μV/m (≈ 100 dBμV/m)**

The bandwidth of the fundamental frequency (defined at the points 20 dB below the peak) was measured to be less than 5 kHz. This meets the requirement of this section that the bandwidth shall be completely inside the band from 13.553 to 13.567 MHz.

7. INFORMATION RELEVANT TO TRANSITION PROVISIONS IN 47 CFR, §15.37

Equipment authorization of the device under test is NOT being requested under the transition rules in 47 CFR, §15.37.

8. DESCRIPTION OF TEST SITE

The test site is located at:

11696 Sorrento Valley Road, Suite F
San Diego, CA 92121

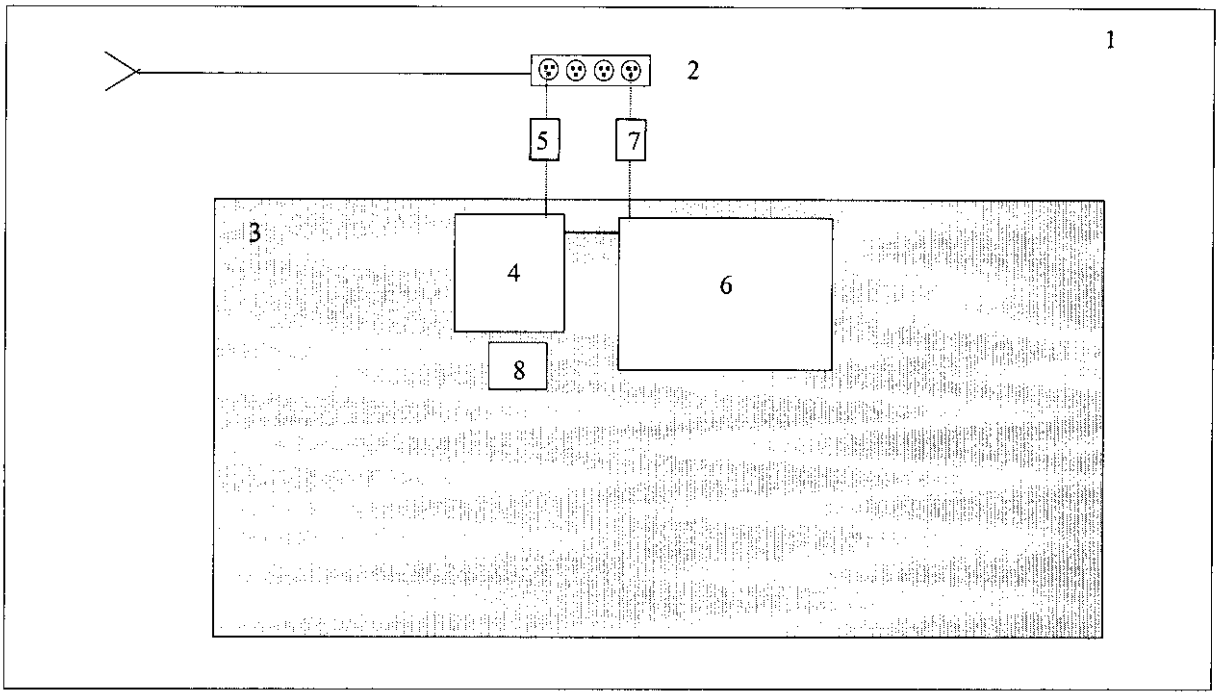
This 11 x 17 meter open area test site is located behind the office/lab building. It conforms to the normalized site attenuation limits and construction specifications as set in the EN55022 (1987), CISPR 16 and 22 (1985) and ANSI C63.4-1992 documents. The site attenuation characteristics are verified for compliance every three years and was last registered with the Federal Communications Commission on October 21, 1996, FCC Document Number 31040/SIT (1300B3). The test site is physically located 18 miles Northwest of downtown San Diego. The general area is a valley 1.5 miles east of the Pacific Ocean. This particular part of the valley tends to minimize ambient levels, i.e. radio and TV broadcast stations and land mobile communications.

9. TEST EQUIPMENT

The following test equipment were used to collect data for this report. All devices used were of current calibration and of the type required in the applicable documents section of this report.

DEVICE	MANUFACTURER	MODEL # SERIAL #
Spectrum Analyzer	Hewlett Packard	8568A 2216A02160
Quasi-peak adapter (CISPR)	Hewlett Packard	85650A 2043A00211
Powerline filter	Lindgren	C-150-30-2
Power mains network, Line Impedance Stabilization Network (LISN)	EMCO	3825/2
High pass filter	Solar	7801-5.0 838132
Amplifier	Mini-Circuits	ZHL-2 (SMA) 091887-21
Antenna, Conical Log Spiral	Electro Mechanics	3101
Antenna, Biconical	Electro-Metrics	3104 3020

FIGURE 1: EUT and Associated System - General Configuration

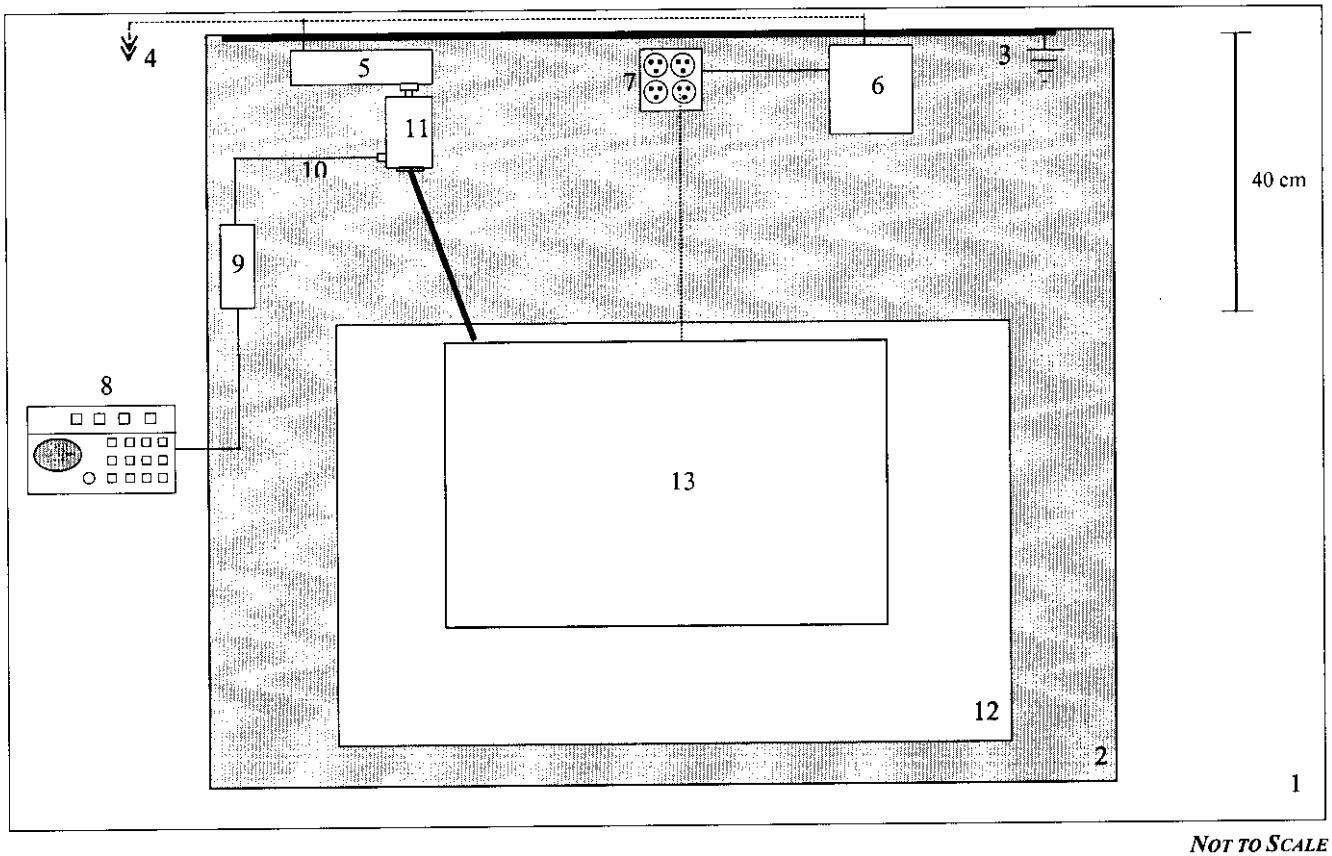


NOT TO SCALE

CONFIGURATION LEGEND

1. Test Laboratory
2. AC Power for Devices (120V, 60 cycles, single phase)
3. Non-Conducting table 80 cm above ground plane
4. EUT: Go-Card Target (Transceiver)
5. Power Supply for EUT
6. Laptop Computer
7. Power Supply for Laptop Computer
8. Tag (Associated Component)

Figure 2: Test Configuration, Conducted Emissions

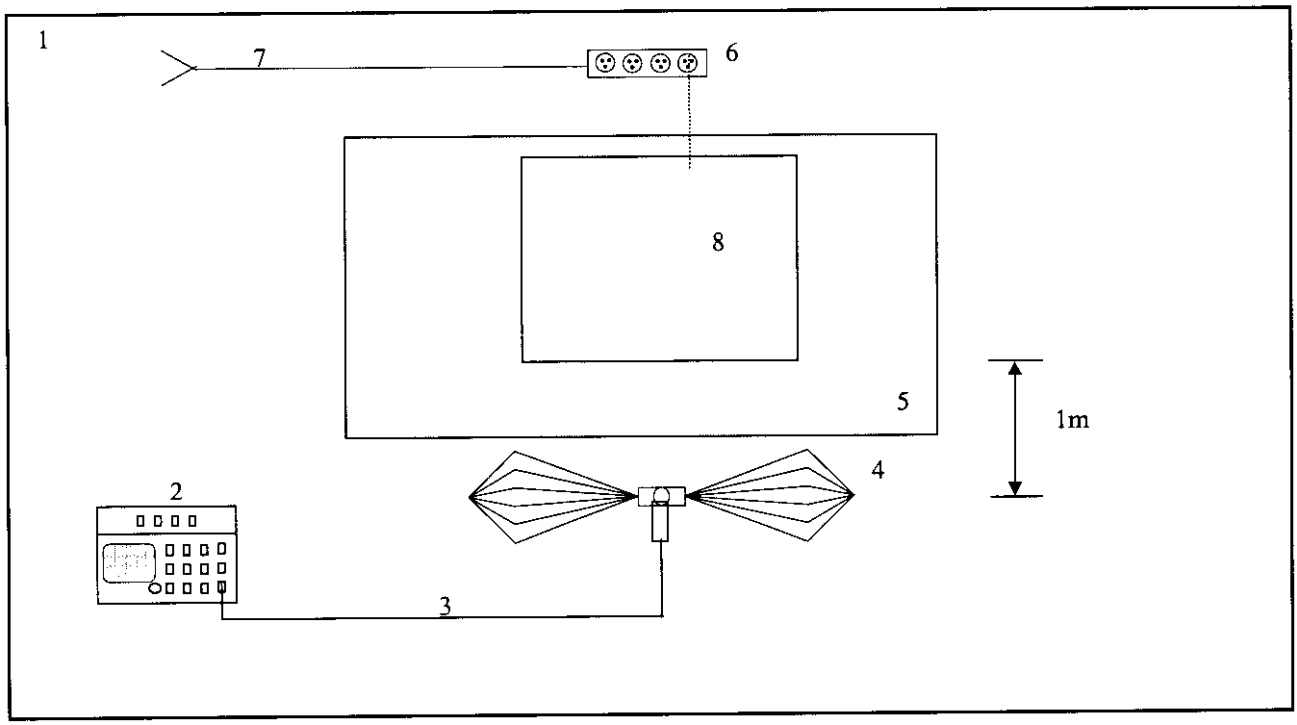


NOT TO SCALE

CONFIGURATION LEGEND

1. Test Laboratory (6 X 6 meters)
2. Ground Plane (15 square meters)
3. Vertical Conducting Wall (Grounded through Ground Plane via 10' ground rod)
4. AC Power for Devices (120V, 60 cycles, single phase)
5. Power Line Filter, Lindgren, 120 dB, 30 amp
6. Line Impedance Stabilization Network (LISN) for peripheral devices
7. Power Distribution Box for peripheral devices
8. Spectrum Analyzer with Quasi-Peak Adapter
9. High Pass Filter
10. Coax input from EUT LISN to Spectrum Analyzer
11. LISN for EUT
12. Non-Conducting table 80 cm above ground plane
13. EUT and associated system

Figure 3. Test Configuration, Frequency Identification of Radiated Emissions

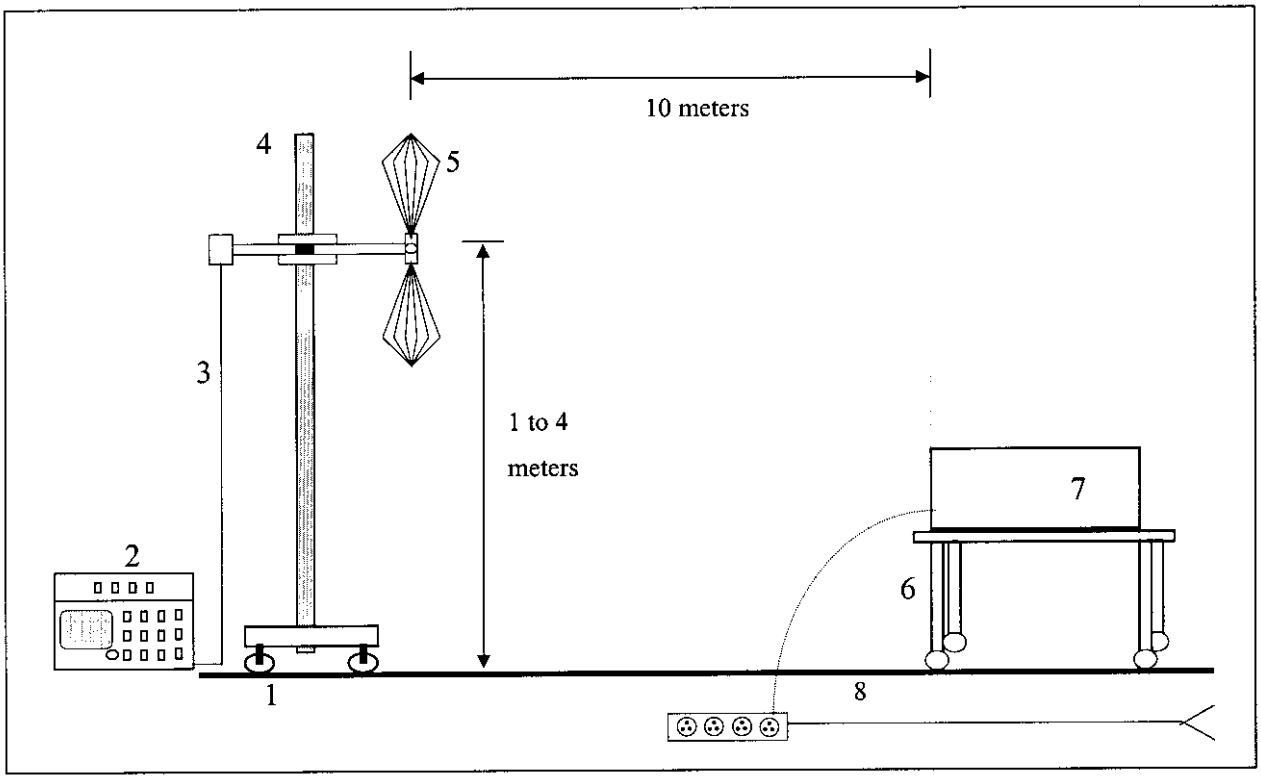


NOT TO SCALE

CONFIGURATION LEGEND

1. Test Laboratory
2. Spectrum Analyzer with Quasi-Peak Adapter
3. Coax interconnect from Antenna to Spectrum Analyzer
4. Receive Antenna (basic relative position)
5. Non-Conducting table 80 cm above ground plane
6. Power strip for EUT and peripherals
7. AC power for devices (120 VAC, 60 cycles, single phase)
8. EUT and Associated System

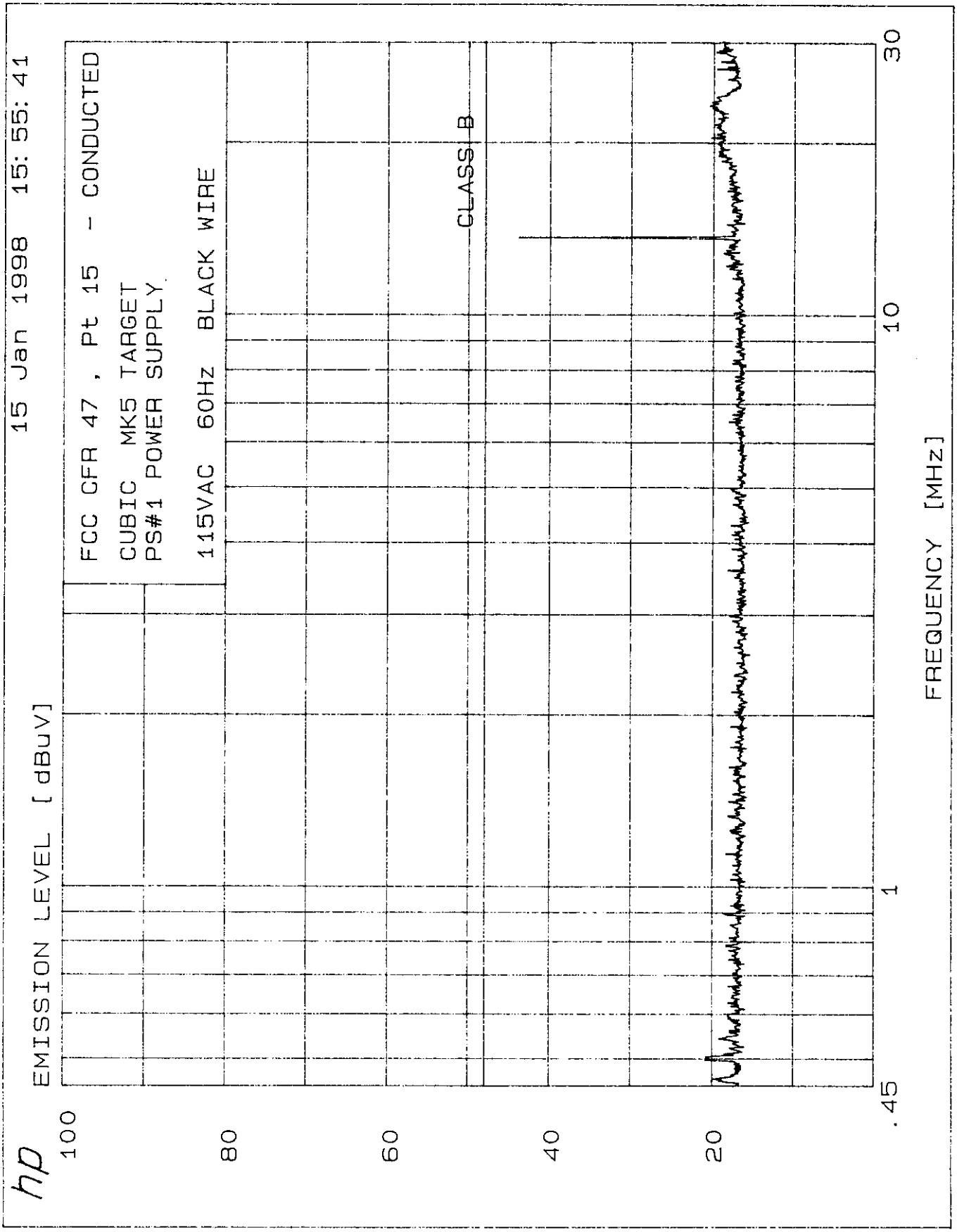
Figure 4: Test Configuration, Radiated Emissions, 10-Meter Open Field Site

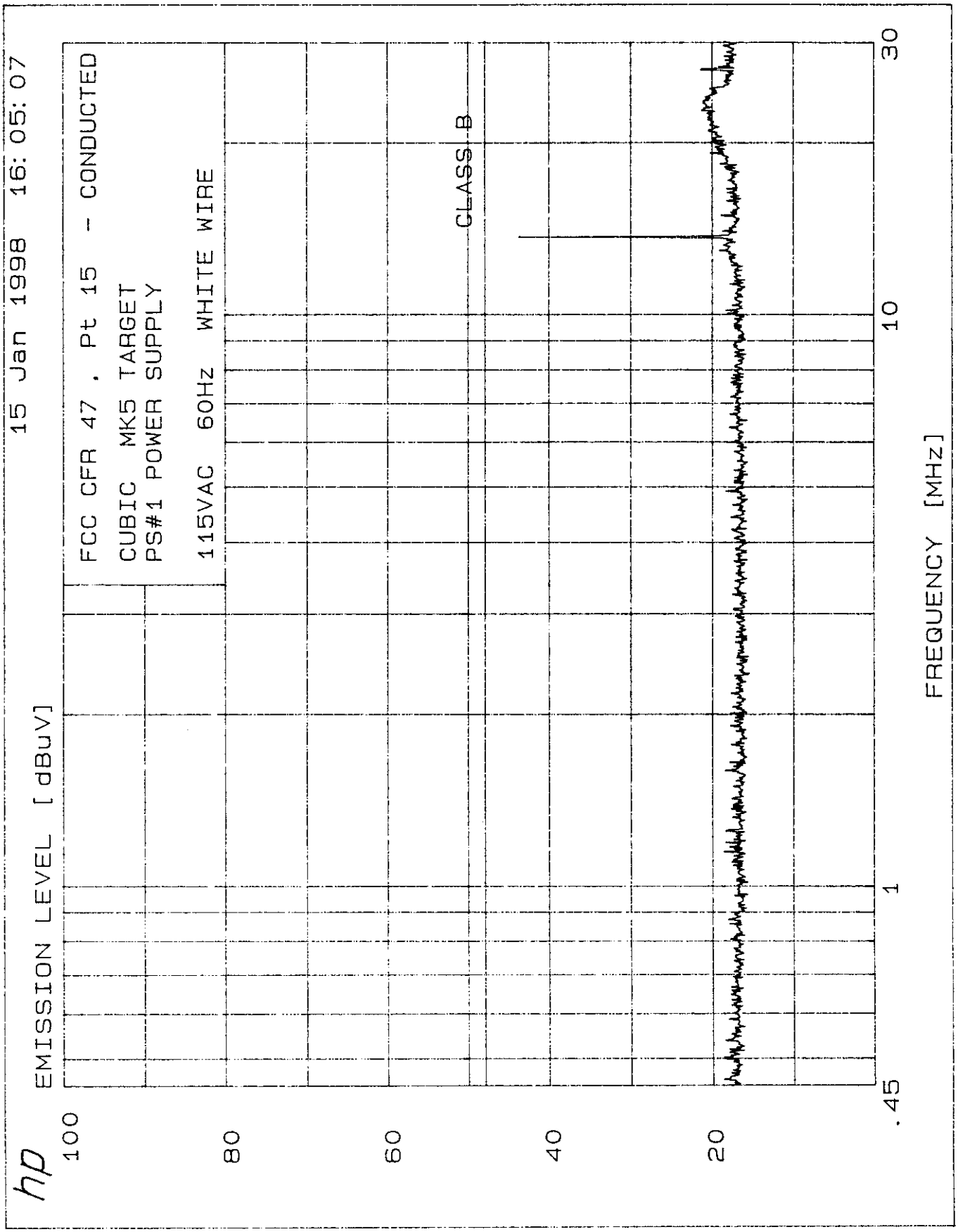


NOT TO SCALE

CONFIGURATION LEGEND

1. Ground plane (11 X 17 meters)
2. Spectrum Analyzer with Quasi-Peak Adapter
3. Coax interconnect from Receive Antenna to Spectrum Analyzer
4. Antenna Mast with motorized mounting assembly
5. Receive Antenna (basic relative position)
6. Non-Conducting table 80 cm above ground plane
7. EUT and associated system
8. AC power for devices (120/230 VAC, 50/60 cycles, single phase)


15 Jan 1998 15:55:41
FCC CFR 47 , Pt 15 - CONDUCTED
CUBIC MK5 TARGET
PS#1 POWER SUPPLY
115VAC 60Hz BLACK WIRE
CLASS B
EMISSION LEVEL [dBuV]
100
80
60
40
20
.45
1
10
30
FREQUENCY [MHz]
hp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FCC CFR 47 , Pt 15 - CONDUCTED
CUBIC MK5 TARGET
PS#1 POWER SUPPLY
115VAC 60Hz WHITE WIRE
CLASS B
EMISSION LEVEL [dBuV]
FREQUENCY [MHz]
100
80
60
40
20
30
10
1
.45
hp

Electromagnetic Engineering Services, Incorporated
FCC, Part 15.209 Radiated Emissions Data Sheet
(3m Open Area Test Site)

Client: **Cubic ARCG**
EUT: **Tag/Target System**
Model #: **13.5MHz**

Conducted by: C. Richard
Date of Test: **01-14-98**
Test Distance, Amp. gain: **3 m, 0 dB**

Frequency (MHz)	Spectrum Analyzer Reading at 3m (dBμV)	Antenna Polori-zation (vertical or horizontal)	Amp. Gain & Cable Loss, Distance & Antenna Factor Correction for 3 m (dBuV/m)	Total Interference Level at 3 m (dBμV/m)	Emission Spec. Limit at 3 m (dBμV/m)	Difference Margin at 3m
67.819	17.7	h	12.8	30.5	40.0	-9.5
149.179	13.4	h	17.5	30.9	43.5	-12.6
176.310	8.1	v	20.6	28.7	43.5	-14.8
474.635	8.6	v	25.9	34.5	46.0	-11.5
501.755	12.4	v	27.0	39.4	46.0	-6.6
515.315	9.9	v	27.1	37.0	46.0	-9.0
528.908	9.1	v	27.3	36.4	46.0	-9.7
542.468	10.6	v	27.4	38.0	46.0	-8.0
556.028	7.6	v	27.7	35.3	46.0	-10.7
569.588	8.3	v	28.1	36.4	46.0	-9.6
596.708	12.7	v	28.5	41.2	46.0	-4.8
623.828	10.9	v	29.0	39.9	46.0	-6.2
650.948	13.1	v	29.8	42.9	46.0	-3.1
678.068	9.3	v	32.1	41.4	46.0	-4.6
718.748	9.1	v	32.0	41.1	46.0	-4.9
745.868	8.4	v	31.9	40.3	46.0	-5.7

Test Conditions: Standard radiated emissions test set up on FCC registered open field site. The highest emissions for all antenna heights, polarities, and table orientations are the only emissions recorded.

Cubic ARCG - Tag/Target System: 13.5MHz
Radiated Emissions Profile (01-14-98) - EESI