EMC Measurement / Technical Report

FCC Test Specification	:	FCC Part 90
Equipment Authorization	:	Certification
Manufacturer	:	IP Mobile Net
Equipment Under Test	:	INVADR^tm IP8HPV Data Transceiver
Test Report No.	:	FR1744-E
Purchase Order No.	:	TBD

Document History

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EMC Measurement / Technical Report
Document No. FR1744-E
From
Garwood Laboratories, Inc.
World Compliance Division

Test for
IP Mobile Net
INVADR[tm] IP8HV
Data Transceiver

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Test Personnel	*Test Dates*
Victor Ratinoff – Lead EMC Engineer Arnie Tapia - EMC Sr. Technician	16, 18, 20, 24, 26 August & 2 September 2001

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MEASUREMENT / TECHNICAL REPORT SUMMARY

Manufacturer Company ***Address*** ***City, State, Zip*** ***Country*** ***Contact Name*** ***Phone*** ***Fax***	IP Mobile Net 11909 East Telegraph Road Santa Fe Springs, CA 90670 USA Jim Jesse 562-946-9493 562-949-0223
Type of Authorization	Certification for 800MHz Mobile Radio
Applicable FCC Rules	Prepared in accordance with the requirements of the FCC Rules and Regulations as listed in 47 CFR Ch.1 (10-1-00 Edition). The following Parts and Subparts are applicable to the results in this test report: PART 90 – PRIVATE LAND MOBILE RADIO SERVICES Subpart I – General Technical Standards PART 2 – GENERAL RULES AND REGULATIONS Subpart J – Equipment Authorization Procedures The test data presented in this report has been acquired using the guidelines set forth in FCC Part 2 Subpart J §2.1046 (Power Output), §2.1047 (Modulation Characteristics), §2.1049 (Occupied Bandwidth), §2.1051 (Spurious emissions at antenna terminals), §2.1053 (Field strength of spurious radiation), and §2.1055 (Frequency Stability). The test results presented in this document are valid only for the equipment identified herein under the test conditions described. Repeatability of these test results will be achieved only with identical measurement conditions.
Equipment Under Test	INVADR^{tm} IP8HV Data Transceiver
FCC Identification of EUT	MI7-IPMNIP8
Production Quantity	Multiple Units

EMC Test Laboratory ***Facility*** ***Address*** ***City, State, Zip Code*** ***Country*** ***Contact Name*** ***Title*** ***Phone*** ***Fax***	Garwood Laboratories Inc. -OC World Compliance Division 565 Porter Way Placentia, CA 92870 USA Tony Masone General Manager (714) 572-2027 (714) 572-2025

1. General Information

1.1 Product Description

Equipment Under Test	INVADR[tm] IP8HPV Data Transceiver
Model Number	IP8HPV
Description	The Equipment Under Test is a Data Transceiver that operates in the 806-821 MHz frequency range. The maximum transmitting power of the EUT is 16W. The nominal operating voltage for the EUT is 13.8VDC.
Clock Frequencies	VCO1 815MHz, VCO2 865.5MHz, XTAL Quartz 4.9152MHz, TCXO 10MHz, XTAL 5.5926MHz, & 44.545000MHz Crystal

1.2 Tested System Details

The following table lists all of the components of the tested system. FCC ID numbers are included if available for a tested system component.

Tested System Details					
Item	*Manufacturer*	*Description*	*Model No.*	*Serial No.*	*FCC ID*
1.	IP Mobile Net	IP8HV Data Transceiver	IP8HPV	Not Available	MI7-IPMNIP8

The following table lists all of the cabling details for the tested system.

Cabling of the Tested System					
Item	*Description*	*Length (m)*	*Shielded or Unshielded*	*Connected From*	*Connected To*
A.	DB-25 to DB-25 Serial Cable	0.8	Shielded	Mobile Radio	Computer
B.	DC Power Lines	1.5	Unshielded	Mobile Radio	Power Supply
C.	50 Coax Cable	4.5	Shielded	RX Port Mobile Radio	50 Load
D.	50 Coax Cable	4.5	Shielded	TX Port Mobile Radio	50 Load or Spectrum Analyzer

1.3 Test Facility

The Open Area Test Site (OATS) and measurement facilities used to collect the test data are located at Garwood Laboratories Inc. World Compliance Division test facility in Placentia, CA. This facility has been fully described in a report submitted to the FCC and accepted in a letter dated 28 January 2000 (31040/SIT 1300F2) registration #90681.

The test facility is also recognized, certified, or accredited by the following organizations:

NVLAP

Garwood Laboratories, Inc. is recognized under the National Voluntary Laboratory Accreditation Program (*NVLAP/NIST*) for satisfactory compliance with criteria established in Title 15, Part 285 Code of Federal Regulations. These criteria encompass the requirements of ISO/IEC Guide 25 and the relevant requirements of ISO 9002:1994 (ANSI/ASQC Q9002-1994) for suppliers of calibration or test results. NVLAP Code: 200119-0, Effective through December 31, 2001.

FCC

This site has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Reference: 31040/SIT 1300F2, Registration #90681, January 28, 2000. With the above and NVLAP, Garwood Laboratories is an authorized test laboratory for the DoC process.

Technology International (I^2T)

Garwood Laboratories, Inc. has been assessed in accordance with ISO Guide *25* and with ITI's assessment criteria. Based upon this assessment, Technology International (Europe), Ltd. has granted approval for specifications implementing the EU Directive on EMC (89/336/EEC). The scope of the approval was provided on a Schedule of Assessment supplied with a certificate and is available upon request. Certificate #01-051, Dated: July 2001.

ACA

Garwood Laboratories, Inc. can also perform testing for the Australian C-Tick mark as a result of our NVLAP accreditation and the MRA (Mutual Recognition Agreement) between the US and Australia.

VCCI

Garwood Laboratories, Inc. has been accepted as a member to the VCCI. Our conducted and radiated measurement facilities have been registered in accordance with Regulations for Voluntary Control Measures. Registration C1226, C1184, R1127. Effective through January 27, 2003.

Industry Canada

Garwood Laboratories, Inc. is registered by Industry Canada for performance of measurements and complies with RSP 100. Reference IC 3298, Dated: March 11, 1999.

BSMI (Formerly known as BCIQ)

Garwood Laboratories, Inc. can perform testing for Taiwan to the CNS requirements. This is as a result of our NVLAP accreditation and the MRA (Mutual Recognition Agreement) between the US and Taiwan.

NMi (Nederlands Meetinstituut)

Garwood Laboratories, Inc. has entered into a cooperative agreement with Nmi Certin B.V. of the Netherlands. This is a Notified Body for the RATTE Directive and Maritime Directive as well as a Competent Body for the EMC Directive.

2. EUT Technical Information

Type of Emission	20K0F1D
Operating Frequency Range	806-821MHz
Range of Operating Power	0 - 16 Watts
Maximum Output Power	16 Watts

2.1 Circuit Schematics

Please refer to the Circuit Schematics in the Attachment section of this report.

2.2 Detailed Descriptions of Circuit Sections

This section provides detailed descriptions of each of the sections within the IP8 HPV Data Transceiver.

<u>*Microcontroller*</u>
The microcontroller is a major component of the radio as it manages the operation of the radio loading the selected transmit/receive frequencies into the injection synthesizer. It also controls the operation of the modem, and determines which receiver provides a better signal from a given transmission. It provides transmit time-out protection in the event a fault causes the radio to halt in the transmit mode.

It utilizes a reduced instruction set computer (RISC) architecture, which provides low power operation and a powerful instruction set. Other features include:

•Watchdog timer
•Serial UART
•Two 8-bit timers
•2 KB EEPROM storage

<u>*Support circuitry*</u>
The support circuitry consists of the following:

- A Supervisor Control Chip providing power-on reset.
- A clock controlling the microcontroller operation and is generated by crystal Y3 and a Pierce oscillator circuit inside the microcontroller.
- The latch decodes low order address bits from the address/data bits. It enables Address Latch Enable (ALE) output of the microcontroller and the bits are used by the modem and synthesizer circuitry.
- A 512Kx8 Static RAM Chip provides temporary storage of the radio’s configuration data facilitating the technician with access to make changes.
- Glue logic, also an important part in the microcontroller section. The RAM chip select and modem chip select command lines are created by gates that decode four (4) high order address bits, plus the read and write command lines. The RAM is addressed by five (5) memory addresses bits decoded by logic that decodes port address bits to produce memory address bits for the RAM chip.

Input/Output

Input/output components convert serial and handshake data from the modem section to RS232 levels, and vice-versa. A transceiver chip is an RS232 transmitter and receiver and converts data in 5-volt logic form to data in +/-12-volt form, as required by the RS232 standard. A charge pump power supply on the chip converts the +5-volt DC logic power on pin 26 to the +12-volt and –12-volt levels required. Capacitors C106-C109 generate these voltages by a charge pump. These values determine the operating voltages.

This section also includes a DIP switch and an octal tri-state buffer. S1 provides hardware programming for external modulation. This buffer is used only in MDT-870 applications. When enabled by S1 (870MODE line), it provides a serial interface for the MDT-870. Notice that only the RX data (RXD) and all handshake lines are buffered. Transmit data (TXD) is derived from a modem interface circuit.

Injection Synthesizer

The synthesizer chip is the major contributor of the injection synthesizer. This device contains the key components of a phase locked loop (PLL), including a prescaler, programmable divider, and phase detector. The selected frequencies are loaded into the synthesizer chip as a clocked serial bit stream via the PLL DATA and PLL CLOCK inputs. The microcontroller provides the serial data.

A 10 MHz reference frequency is provided by voltage controlled, temperature controlled crystal oscillator module. This device has an input that accepts transmit modulation and voltage from a RX FREQ ADJUST pot. The pot allows the receiver to be fine-tuned to the exact operating frequency.

The injection signals are generated by a voltage controlled oscillator (VCO) module VCO1 (approximately 850-870 MHz). A voltage on the C input determines the VCO frequency. The voltage is generated by the phase detector output (PDOUT) of U14 driving a loop filter consisting of R42, C50, C51, and R39. It integrates the pulses that normally appear on PDOUT into a smooth DC control signal for the VCO. Upon transmit, the analog signal from the modem and transmit modulation circuitry is applied to VCO1 via the M input.

The output of VCO1 passes through a high-linear switch (SW3), which is then attenuated by resistors R114-R116 for improved loop stability, and then amplified by an RF amplifier (U11). From U11 the signal passes through a two-way divider (U10). One port of U10 passes through another two-way divider (U12). The first port of U12 provides the receive injection (RXINJ1) signal for Receiver 1, while the second port output provides the receive injection (RXINJ2) signal for Receiver 2. The other port of U10 passes through another two-way divider (U13). One port returns to the synthesizer FIN+ input via the VCO feedback completing the loop signal path. The other port of U13 provides the transmit injection (TXINJ) signal for the transmitter circuit.

A second VCO module (VCO2) is included for future applications.

Transmitter/TR Switch
The transmitter section consists of an exciter, power amplifier, and power control circuitry. The exciter is built around an RF power amplifier chip. To transmit, TXKEYOUT* is pulled low. This causes this amplifier to power up and amplify the TXINJ signal input through a voltage variable absorptive attenuator. PA12V is also powered up. This causes the power amplifier to boost the RF power to the desired level. Up to 16 watts are available from the transmitter.

Receiver 1 Front-End
This section consists of the components that form Receiver 1 Front-End. These components include surface acoustic wave (SAW) filters, a low-noise amplifier, and a mixer.

Incoming signals pass through a low-loss SAW filter that provides a high degree of out-of-band signal rejection. A low-noise amplifier amplifies the selected signals and another low-loss SAW filter provides additional selectivity. The output from this low-loss SAW filter connects to a mixer. This mixer is a MMIC mixer which heterodynes the receive injection signal from the synthesizer. The result is a 45 MHz IF signal and the IF signal goes through crystal filters (FLT3 and FLT4) to the Receiver 1 IF section for further processing.

Receiver 1 IF
This section consists of 1 IF subsystem. The major contributor of the IF subsystem a complete 45 MHz superheterodyne receiver chip incorporating a mixer/oscillator, two limiting intermediate frequency amplifiers, quadrature detector, logarithmic received signal strength indicator (RSSI), voltage regulator and audio and RSSI op amps.

Incoming 45 MHz signals appearing at RX1_45MHz pass through a low-voltage high performance monolithic FM IF system. Within this system, the signals pass through a simple LC filter and are boosted by the RF amplifier. The output of the RF amplifier drives a mixer. A crystal oscillator is controlled by crystal Y4 and provides the injection frequency for the mixer. The mixer output passes through a 455 kHz ceramic filter. It is then amplified and passed through another ceramic filter to a second gain stage. The IF output drives a quadrature detector. The RSSI1 detector converts the AGC voltage generated inside the chip into a DC level corresponding logarithmically to the signal strength. The Diversity Reception Controller uses signal BRSSI1 to select the receiver with the best quality signal.

The audio is amplified by an op amp and delivered to the baseband routing circuitry via the RXMOD1 output. High frequency de-emphasis is provided by a filter consisting of a resistor and a capacitor. In order to match the audio signal levels with the other circuitry, a gain control is included. A pot is necessary to adjust gain.

Transmit Modulation
The analog circuitry in this section modulates the Transmitter. The data-bearing audio signal from the modem appears at TXMOD. The audio is amplified by op amp (U9D). The output of the op amp drives two (2) amplifiers (U9B and U9C).

The upper amplifier (U9C) has adjustable gain. The output drives op amp (U9A), which inverts the phase of the signal. Upon the start of a transmission, the modulating signal passes through to the 10 MHz reference oscillator in the synthesizer. Some makes of 10 MHz oscillators do not require the modulation signal to be inverted and a jumper block is provided to accommodate the oscillators. The lower op amp (U9B) amplifies the signal and applies it to the VCO via the VCOMOD output.

Baseband Routing
This circuitry routes the audio signal from a Receiver to the modem circuit. Provisions are also made to route an analog modulation source attached to the radio to the transmitter.

During the receive operation, data-bearing audio signals from the two (2) receivers pass through an IC analog switch (SW2). The microcontroller makes the TXKEYOUT* line high and the RX1/RX2* line high or low to pass data from Receiver 1 or Receiver 2. The Receiver audio signal appearing on pin 5 of the analog switch is routed directly to the modem circuit via DIVAUDIO. Simultaneously, the data-bearing audio signal is routed through an eighth order Bessel filter (U6). The filter removes high frequency signals from the data.

In the transmit mode, when external modulation is selected with the DIP Switch, voice audio arriving on pin 5 of the RS232 data connector appears at the input of analog switch. The controller makes TXKEYOUT* low, and RX1/RX2* high in order to pass the audio signal through the analog switch.

Power and Analog Ground
These sections consist of the power supplies and transmit control circuitry. Power from the vehicle's battery appears at VBATT. A diode protects the voltage regulators by clamping any transient spikes on the supply line. Such spikes typically occur while the engine is started. The supply line powers a series of voltage regulators and the transmitter control circuitry, as follows:

- Voltage regulator VR1 provides switched 9-volt power for most other sections in the radio.
- Voltage regulator U21 powers the analog circuitry in the radio and is also switched on by the microcontroller.
- Voltage regulator VR2 provides a low noise 3.3-volt source for the synthesizer chip.

In the transmit control circuitry, to transmit, the microcontroller makes TXKEYOUT* high forcing the P-channel device to conduct, applying 12-volts via PA12V to the transmitter power amplifier.

Receiver 2 Front-End
The circuitry for Receiver 2 is identical to Receiver 1.

Receiver 2 IF
This section is identical to the Receiver 1 IF.

Modem

The IP uses a single-chip modem circuit that converts serial data to an analog audio waveform for transmission and analog audio from a receiver to serial data. In addition to the modem functions, the chip provides forward error detection and correction, bit interleaving for more robust data communications, and third generation collision detection and correction capabilities.

The microcontroller section controls the modem operation. Address bus, address/data bus, and control lines operate the modem chip. The modem circuitry is also run by a crystal-controlled clock, which consists of crystal Y1 and an internal Pierce oscillator.

Incoming audio from the baseband routing circuit appears on the DIVAUDIO input. The audio signal is demodulated into digital data appearing on the AD0-AD7 lines when the MODEMCS* and RD* lines are low. The data goes to the microcontroller section for further processing, and then to the input/output section for conversion to RS232 signal levels. At this point, the received data is available to the user’s MDC and VIU.

During a transmission, outgoing data appearing on the AD0-AD7 lines is converted into a 4-level FSK audio signal by the modem chip. This operation takes place when the MODEMCS* and WR* lines are low. Data from the user’s MDC or VIU passes through the input/output section and microcontroller section to the AD0-AD7 bus. After processing, data passes through a root raised cosine filter and is output to TXMOD.

This modem supports 115.2 KBPS (serial port) and 19.2 KBPS (over-the-air) data transmission rates.

VLogic and Digital Ground

The VLogic and Digital Ground section consists of a pulse-width modulation (PWM) step-down DC-DC converter (U20) that provides an adjustable output. It also reduces noise in sensitive communications applications and minimizes drop out voltage.

An external Schottky diode (D2) is required as an output rectifier to pass inductor current during the second half of each cycle to prevent the slow internal diode of the N-channel MOSFET from turning on. This diode operates in pulse-frequency modulation (PFM) mode and during transition periods while the synchronous rectifier is off.

3. Product Labeling

3.1 FCC ID Label

All devices authorized under the certification procedures are required to display an identification label showing the FCC Identifier (FCC ID) under which they are authorized.
Example:

FCC ID: XXX123

XXX = Indicates manufacturer's Grantee Code
123 = Indicates manufacturer's Equipment Product Code

In addition, the manufacturer (or importer) is responsible for having the compliance label produced, and for having it affixed to each unit that is marketed or imported.

FCC Compliance Label:

> 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 including interference that may cause undesired operation.

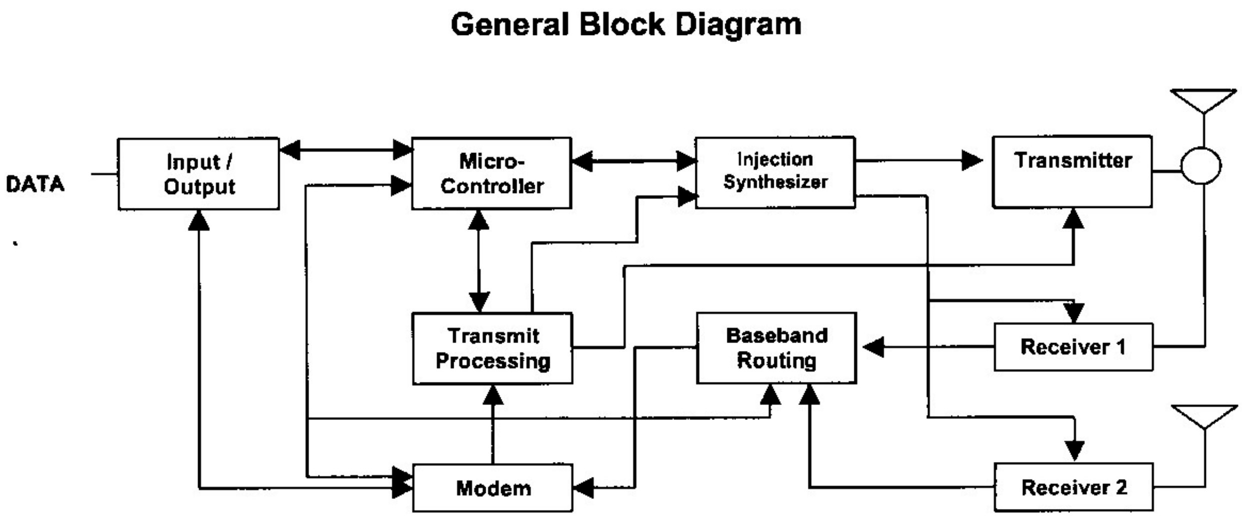
3.2 Location of Label on the EUT

As stated in §15.19, the label shall be located in a conspicuous location on the device. When the device is so small or for such use that it is not practicable to place the compliance label on it, the information required should be placed in a prominent location in the instruction manual or pamphlet supplied to the user. Alternatively, the compliance label can be placed on the container in which the device is marketed. However, the FCC identifier must be displayed on the device.

3.3 Information to the user

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

4. Block Diagram of the EUT



General Block Diagram Definitions
The standard IP circuit board contains ten (10) sections defined below.

Input/Output Circuitry associated with the radio's DB9 data connector providing all the RS232 data and handshake functions, including the necessary level changes.

Microcontroller Manages the operation of the radio loading the selected transmit/receive frequencies into the injection synthesizer, controls the operation of the modem, and determines which receiver provides a better signal from a given transmission. Also provides transmit time-out protection in the event a fault causes the radio to halt in the transmit mode.

Transmit Modulation Circuitry that amplifies the analog audio signal from the modem and uses it to modulate the voltage controlled oscillator (VCO) and 10 MHz reference oscillator in the injection synthesizer section. Modulating the VCO and reference oscillator simultaneously results in a higher quality FM signal.

Modem Converts serial data into an analog audio waveform for transmission and analog audio from the receiver to serial data. Serial data appears on the radio's RS232 port, which connects a Mobile Data Computer (MDC) or a Voice Interface Unit (VIU). The modem supports a 115.2 Kbps data transmission rate on the serial port, SLIP protocol, and up to 19.2 Kbps over-the-air rate. Within a single chip it provides forward error detection and correction, bit interleaving for more robust data communications, and third generation collision detection and correction capabilities.

Injection Synthesizer Provides programmable, ultra stable signals for the radio. One synthesizer incorporates phase lock loop technology used for both receiving and transmitting.

Low Side Injection In the receive mode, the synthesizer provides a local oscillator signal of 45MHz below the selected receive channel frequency.

Baseband Routing Allows the microcontroller to select one of the two diversity receiver audio outputs for demodulation by the modem. Switching is done by the microcontroller comparing the Received Signal Strength Indication (RSSI) outputs from each receiver. Provision is also made for switching an external modulation source from the DB9 data connector to the transmitter input.

Transmitter/TR Switch Consists of an exciter and power amplifier module. The transmitter circuitry includes a T/R switch switching the antenna between transmitter and receiver 1 (TX/RX1).

Receiver 1/Receiver 2 Required to support the mobile DRS; two (2) discrete receivers are tuned to the same channel and use two (2) antennas.

The receivers are double-conversion superheterodyne with a first Intermediate Frequency (IF) of 45 MHz and a second IF frequency of 455 KHz. Each receiver consists of bandpass filters, an RF amplifier, a crystal filter, a double-balanced mixer, and a one-chip IF system. The injection synthesizer provides the first local oscillator signal. Outputs from each receiver include RSSI and analog audio for the baseband routing circuitry and modem.

Power Supply Consists of circuitry that derives the various operating voltages for the radio. A group of fixed and adjustable voltage regulators are used for this purpose. The transmitter power control circuitry is also found in this section.

5. System Test Configuration

5.1 Operating Mode During Testing of the EUT

The EUT interfaced with the computer by means of serial port 1. A command to transmit was then sent to the EUT from the computer by software provided by the manufacturer. This exercised the transmit function of the EUT during testing.

5.2 Special Accessories

The EUT requires no special accessories to comply with the FCC regulations.

5.3 Equipment Modifications

No modifications and or adjustments were made to the EUT during compliance testing to achieve the required specification limits.

5.4 Configuration of the Tested System

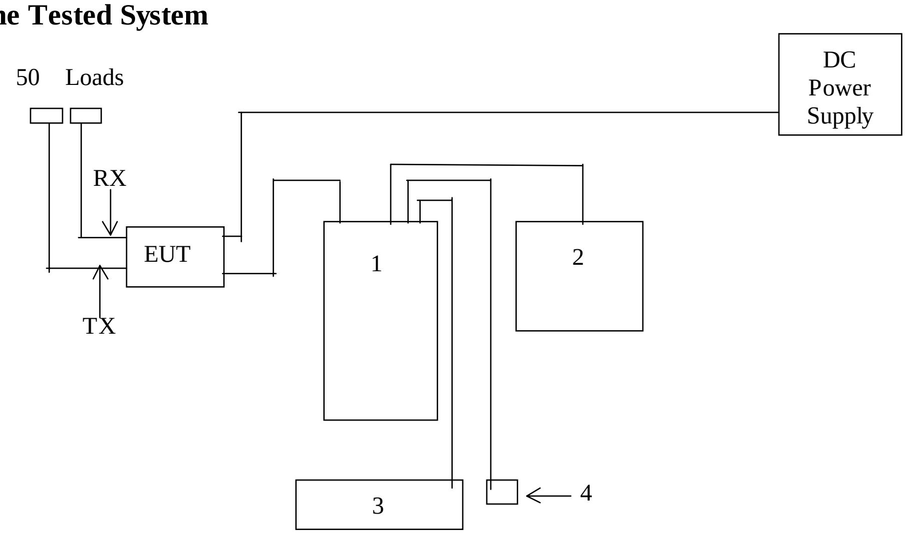


Figure 1: Test Configuration 1

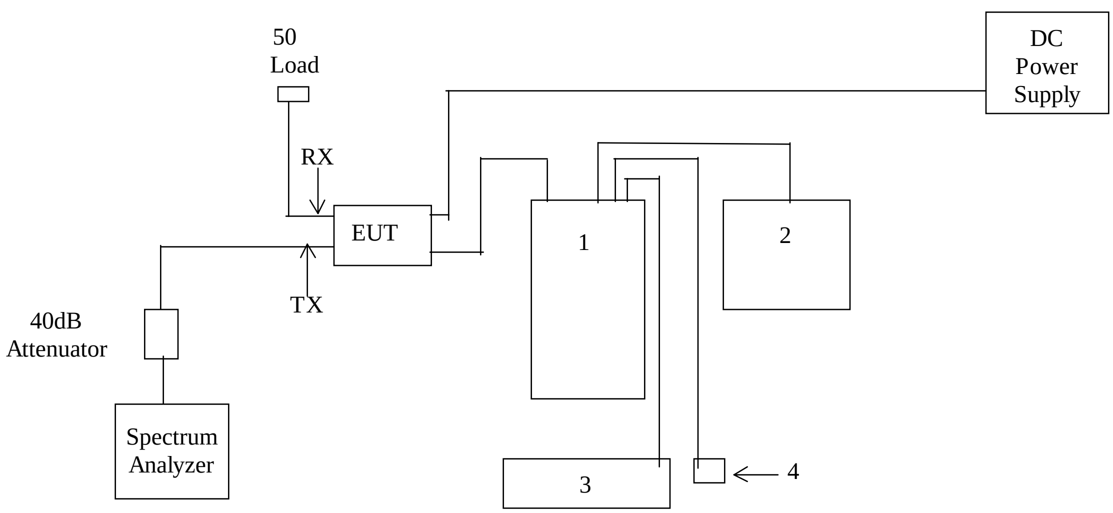


Figure 2: Test Configuration 2

Legend:

Item	Manufacturer	Description	Model No.	Serial No.	FCC ID
1.	Compaq	Personal Computer	163874-003	1X01DCT6F06R	Not Applicable
2.	Dell	Video Monitor	D825HT	8439185	Not Applicable
3.	Hewlett Packard	Keyboard	RT2858TW	C0182003	Not Applicable
4.	Hewlett Packard	Mouse	MU07J	47J07184	Not Applicable

6. Test Results

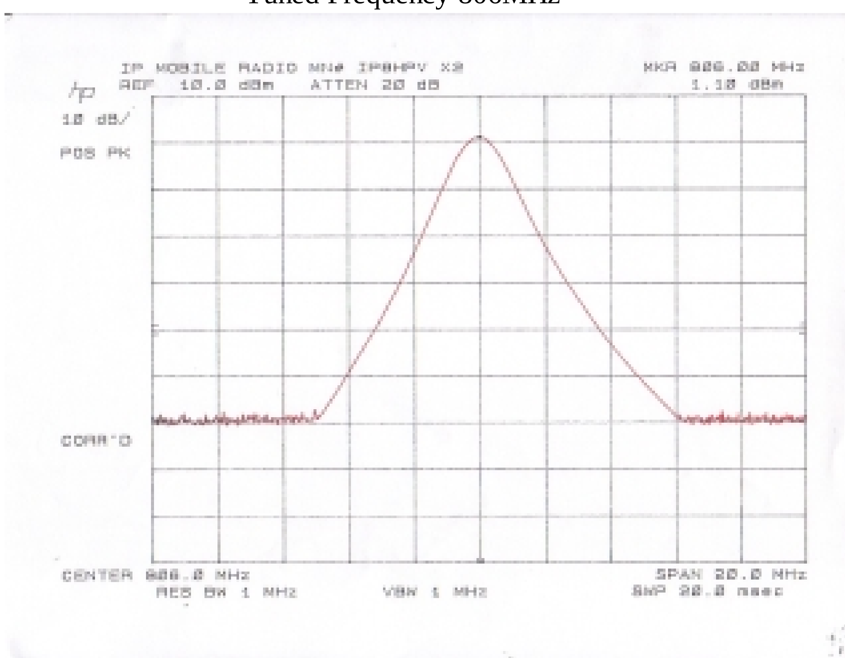
6.1 RF Power Output

The power output was measured at the EUT's transmit RF output terminal. A measurement was made at the bottom frequency (806MHz), the middle frequency (814MHz), and the top frequency (821MHz) of the operating frequency range of the transmitter. A spectrum analyzer was used to measure the RF power output. The test setup used during testing is shown in Figure 2 of Section 5.4. The following table and plots show the test results.

Test Results:

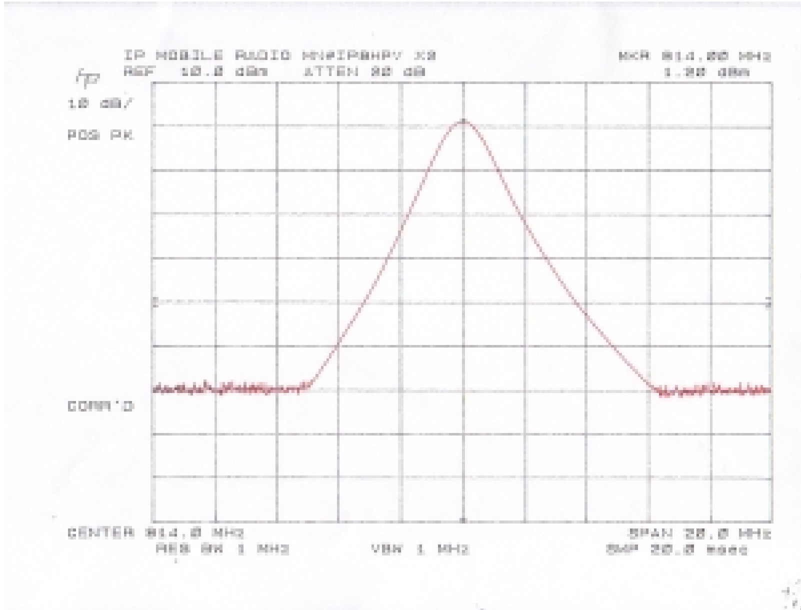
Frequency Tuned (MHz)	**RF Power Output (Watts)**		
	85% Nominal Voltage (11.73 VDC)	**Nominal Voltage (13.8 VDC)**	**115% Nominal Voltage (15.87 VDC)**
806	12.3	15.85	18.6
814	10.7	15.85	22.4
821	11.75	15.85	19.5

Tuned Frequency 806MHz



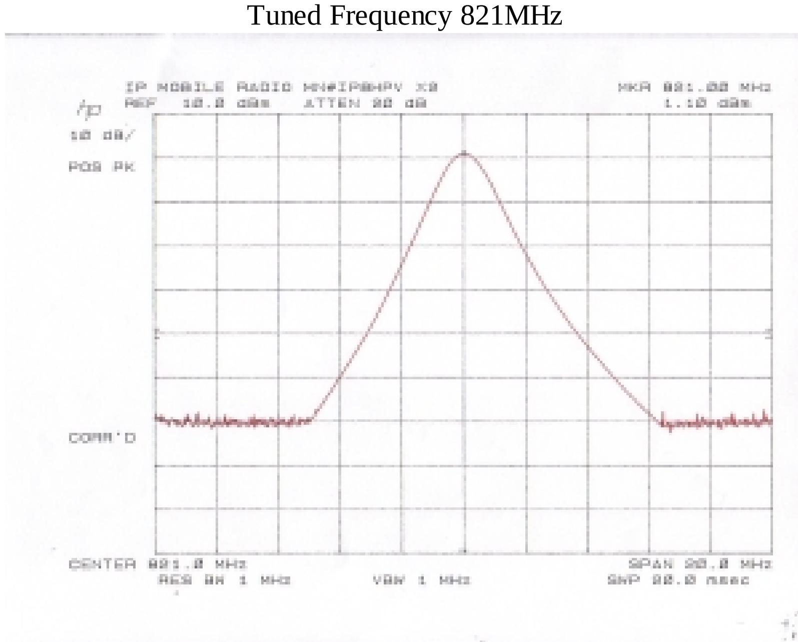
Power Output (dBm) = S.A. Reading + Correction Factor
Power Output = 1.10dBm + 40.9dB = 42dBm
Power Output (Watts) = {10^[Power(dBm)/10]}*1mW
Power Output = [10^(42dBm/10)]*1mW = 15.85W

Tuned Frequency 814MHz



Power Output (dBm) = S.A. Reading + Correction Factor
Power Output = 1.20dBm + 40.8dB = 42dBm
Power Output (Watts) = {10^[Power(dBm)/10]}*1mW
Power Output = [10^(42.2dBm/10)]*1mW = 15.85W

Tuned Frequency 821MHz



Power Output (dBm) = S.A. Reading + Correction Factor
Power Output = 1.10dBm + 40.9dB = 42dBm
Power Output (Watts) = {10^[Power(dBm)/10]}*1mW
Power Output = [10^(42.2dBm/10)]*1mW = 15.85W

6.2 Bandwidth Limitations

As stated in §90.209, for a transmitter operating in the frequency band of 806-821/851-866 the channel spacing and bandwidth that will be authorized for that frequency band is 25kHz (channel spacing) and 20kHz (authorized bandwidth).

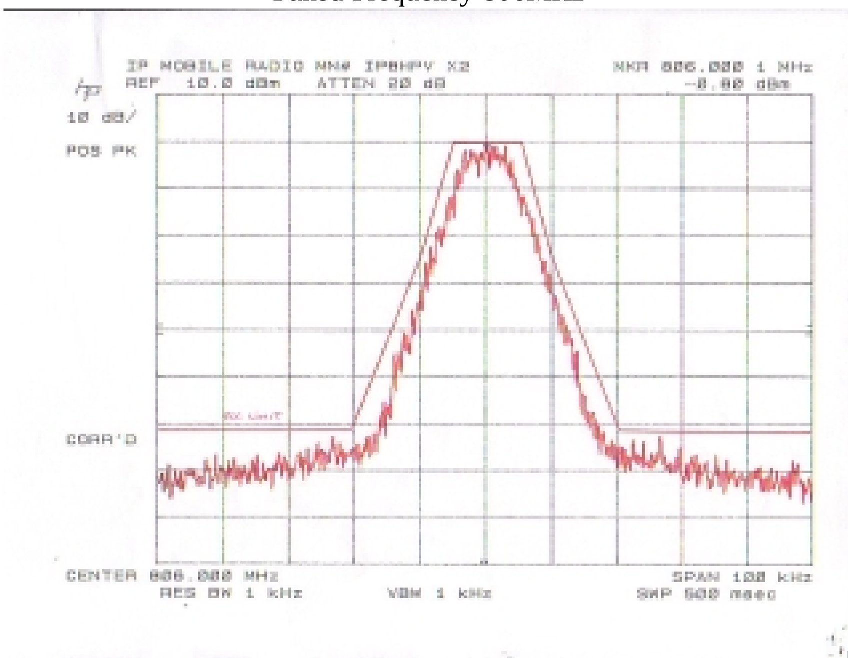
In addition, the transmitter must comply with the emission mask outlined in §90.210. For a transmitter operating in the frequency band of 806-821/851-866 and that is not equipped with an audio low pas filter, the applicable Emission Mask is G.

Emission Mask G:
The power of any emission must be attenuated below the un-modulated carrier power (P) as follows:

(1.) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5kHz, but not more than 10kHz: at least 83log (fd/5) dB;
(2.) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10kHz, but no more than 250 percent of the authorized bandwidth: at least 116log (fd/6.1) dB, or 50 + 10log (P) dB, or 70dB, whichever is the lesser attenuation;
(3.) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: at least 43 + 10log (P) dB.

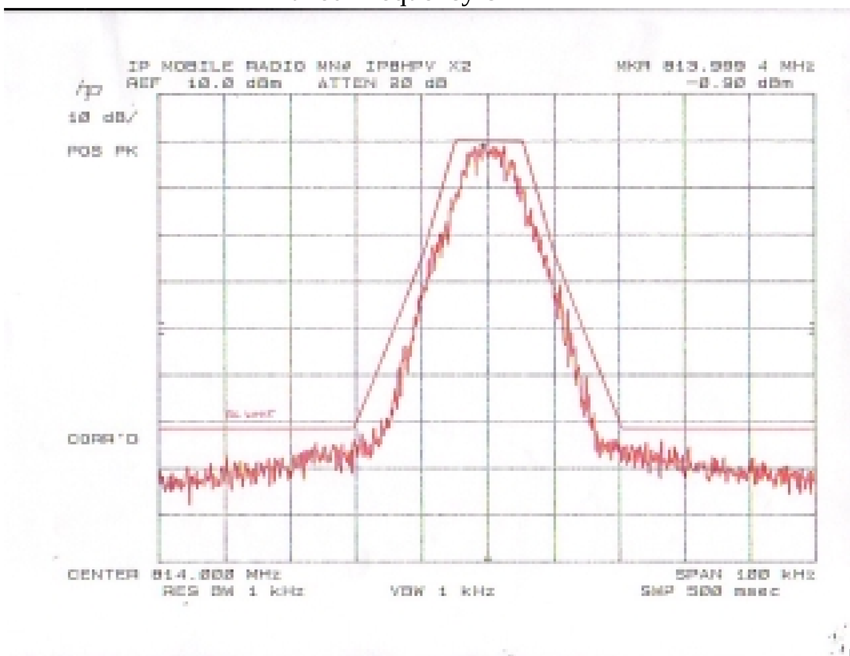
Test Results:
The EUT complied with the bandwidth and Emission Mask requirements. The plots below contain the test results.

Tuned Frequency 806MHz

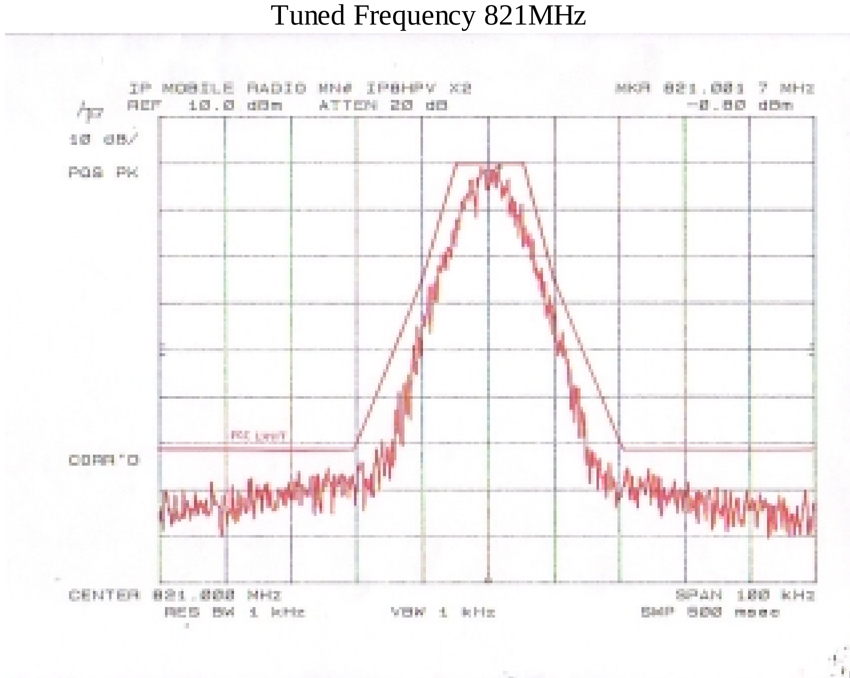


Bandwidth Test Results – continued -

Tuned Frequency 814MHz



Tuned Frequency 821MHz



6.3 Field Strength of Spurious Radiation

Measurements were made to detect spurious radiation from the EUT when connected to a non-radiating load. The test setup used during testing is shown in Figure 1 of Section 5.4. The EUT was placed 80 centimeters above the ground plane on a non-conductive tabletop 1.0-meter width by 1.5-meter length. The configuration of the EUT and its cables were varied to maximize the amplitude level of the emissions. Rotating the turntable 360 degrees and varying the antenna height from 1 to 4 meters maximized the emissions. Measurements were made with a Bi-Log antenna up to the 10th harmonic of the fundamental in both vertical and horizontal polarization. The distance between the EUT and the measuring antenna was 3 meters. The power of any emission must be attenuated below the unmodulated carrier power (P) by at least 43 + 10 log (P) dB for any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth.

Sample Calculation FCC Limit:
Calculated Field Strength = (1/D) * (P*RL), where D=3m, P=15.85W (for 806MHz), RL=50
= (1/3) * (15.85*50)
= 9.38 V/m = 139.4 dBµV/m

FCC Limit = Calculated Field Strength – 43 + 10 log (P) dB, where P=15.85W (for 806MHz)
= 139.4 dBµV/m – 55dB = 84.4dBµV/m

Test Results:
Tuned Frequency: 806MHz Measurement Distance: 3m

Emission Frequency (GHz)	Antenna Polarization (V or H)	S.A. Reading (dBµV)	Correction Factor (dB)	Corrected Reading (dBµV/m)	FCC Limit (dBµV/m)	Delta to FCC Limit (dB)
1.612	V	68.0	-6.3	61.7	84.4	-22.7
1.612	H	69.4	-6.3	63.1	84.4	-21.3
2.418	V	60.2	0.4	60.6	84.4	-23.8
2.418	H	62.7	0.4	63.1	84.4	-21.3
3.224	V	38.3	4.5	42.8	84.4	-41.6
3.224	H	39.1	4.5	43.6	84.4	-40.8
4.03	V	62.2	8.7	70.9	84.4	-13.5
4.03	H	67.5	8.7	76.2	84.4	-8.2
4.836	V	45.4	11.5	56.9	84.4	-27.5
4.836	H	43.5	11.5	55.0	84.4	-29.4
5.642	V	51.2	21.0	72.2	84.4	-12.2
5.642	H	49.7	21.0	70.7	84.4	-13.7
6.448	V	36.6	26.3	62.9	84.4	-21.5
6.448	H	33.6	26.3	59.9	84.4	-24.5
7.254	V	35.7	19.95	55.65	84.4	-28.75
7.254	H	31.8	19.95	51.75	84.4	-32.65
8.06	V	33.6	23.4	57	84.4	-27.4
8.06	H	30.8	23.4	54.2	84.4	-30.2

* The Correction Factor consist of Antenna Factor + Cable Loss – Preamp Gain.
* All readings are peak with the specified CISPR bandwidth unless stated otherwise.

Field Strength of Spurious Radiation – continued –

Test Results:
Tuned Frequency: 814MHz Measurement Distance: 3m

Emission Frequency (GHz)	Antenna Polarization (V or H)	S.A. Reading (dBμV)	Correction Factor (dB)	Corrected Reading (dBμV/m)	FCC Limit (dBμV/m)	Delta to FCC Limit (dB)
1.628	V	68.2	-6.3	61.9	84.4	-22.5
1.628	H	65.9	-6.3	59.6	84.4	-24.8
2.442	V	54.0	0.4	54.4	84.4	-30.0
2.442	H	60.0	0.4	60.4	84.4	-24.0
3.256	V	41.7	4.5	46.2	84.4	-38.2
3.256	H	39.5	4.5	44.0	84.4	-40.4
4.07	V	56.4	8.7	65.1	84.4	-19.3
4.07	H	58.2	8.7	66.9	84.4	-17.5
4.884	V	47.5	11.5	59.0	84.4	-25.4
4.884	H	43.7	11.5	55.2	84.4	-29.2
5.698	V	48.5	21.0	69.5	84.4	-14.9
5.698	H	43.1	21.0	64.1	84.4	-20.3
6.512	V	33.9	26.3	60.2	84.4	-24.2
6.512	H	31.5	26.3	57.8	84.4	-26.6
7.326	V	30.5	19.95	50.45	84.4	-33.95
7.326	H	31.1	19.95	51.05	84.4	-33.35
8.14	V	32.2	23.4	55.6	84.4	-28.8
8.14	H	31.5	23.4	54.9	84.4	-29.5

* The Correction Factor consist of Antenna Factor + Cable Loss – Preamp Gain.
* All readings are peak with the specified CISPR bandwidth unless stated otherwise.

Field Strength of Spurious Radiation – continued –

Test Results:
Tuned Frequency: 821MHz Measurement Distance: 3m

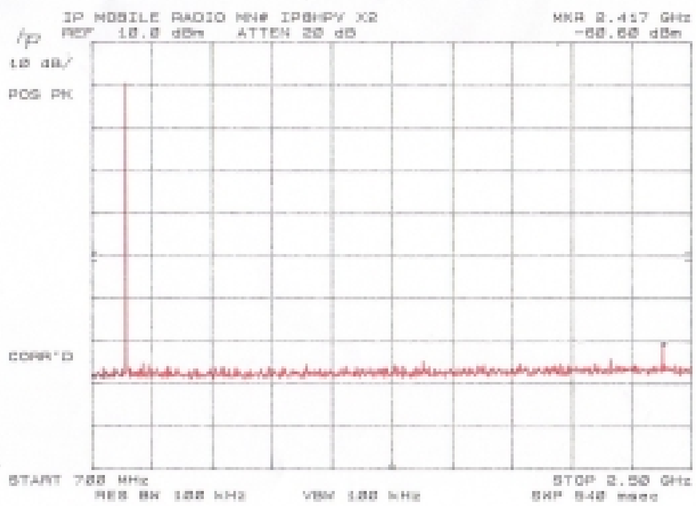
Emission Frequency (GHz)	Antenna Polarization (V or H)	S.A. Reading (dBμV)	Correction Factor (dB)	Corrected Reading (dBμV/m)	FCC Limit (dBμV/m)	Delta to FCC Limit (dB)
1.642	V	58.5	-6.3	52.2	84.4	-32.2
1.642	H	60.0	-6.3	53.7	84.4	-30.7
2.463	V	60.4	0.4	60.8	84.4	-23.6
2.463	H	58.6	0.4	59.0	84.4	-25.4
3.284	V	41.9	4.5	46.4	84.4	-38.0
3.284	H	41.0	4.5	45.5	84.4	-38.9
4.105	V	55.2	8.7	63.9	84.4	-20.5
4.105	H	54.1	8.7	62.8	84.4	-21.6
4.926	V	39.4	11.5	50.9	84.4	-33.5
4.926	H	40.4	11.5	51.9	84.4	-32.5
5.747	V	43.2	21.0	64.2	84.4	-20.2
5.747	H	39.4	21.0	60.4	84.4	-24.0
6.568	V	36.2	26.3	62.5	84.4	-21.9
6.568	H	33.1	26.3	59.4	84.4	-25.0
7.389	V	30.8	19.95	50.75	84.4	-33.65
7.389	H	29.9	19.95	49.85	84.4	-34.55
8.21	V	29.8	23.4	53.2	84.4	-31.2
8.21	H	29.3	23.4	52.7	84.4	-31.7

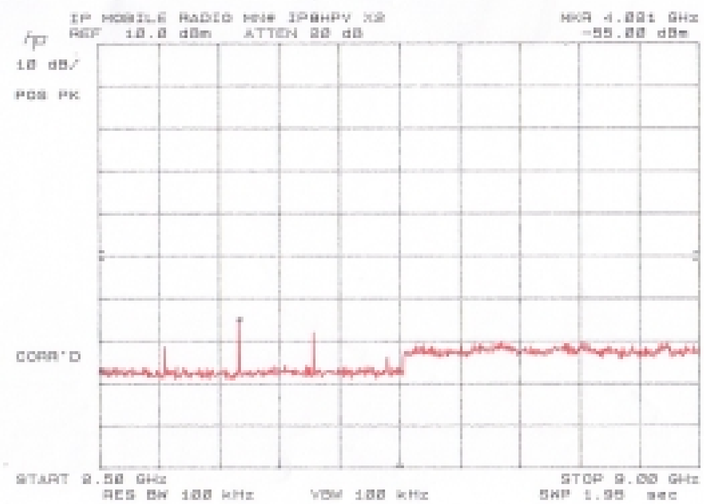
* The Correction Factor consist of Antenna Factor + Cable Loss – Preamp Gain.
* All readings are peak with the specified CISPR bandwidth unless stated otherwise.

6.4 Spurious Emissions at Antenna Terminals

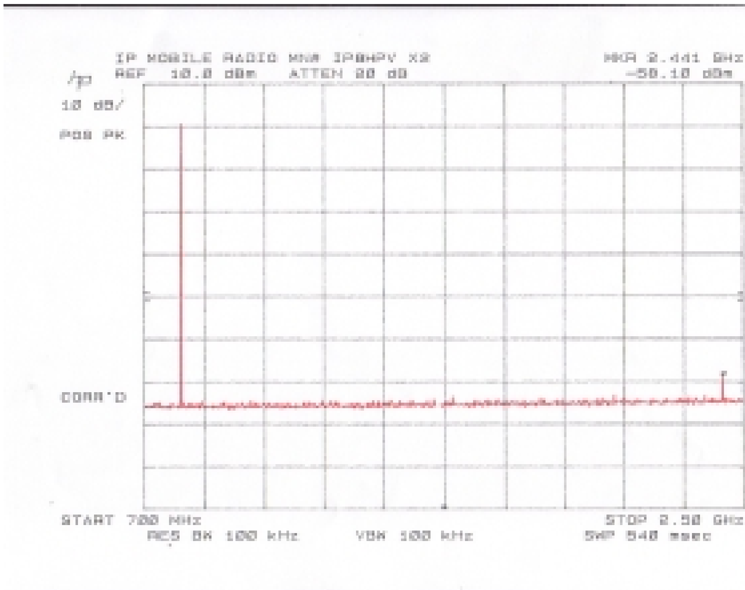
Measurements were made to detect spurious emissions at the EUT's antenna terminal. The test setup used during testing is shown in Figure 2 of Section 5.4. A spectrum analyzer was used to scan the frequency spectrum from the lowest radio frequency generated in the EUT up to the 10^{th} harmonic of the carrier frequency. The power of any spurious emission at the EUT's antenna terminal must be attenuated below the unmodulated carrier power (P) by at least 43 + 10 log (P) dB, for any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth. The following plots contain the test results:

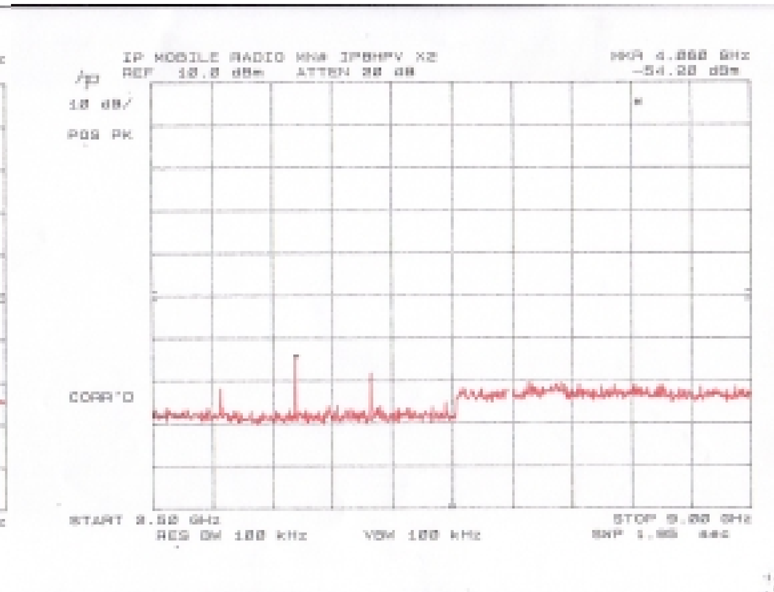
Test Results:
Tuned Frequency: 806MHz



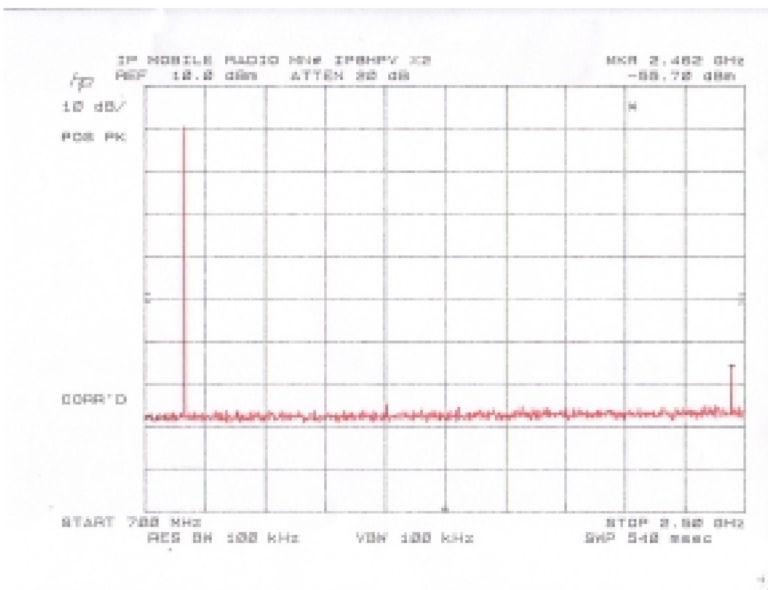


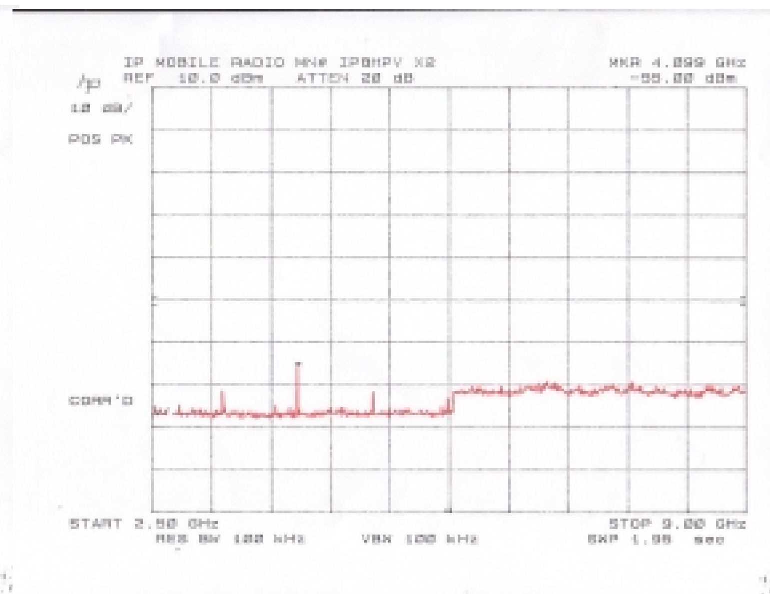
Test Results:
Tuned Frequency: 814MHz





Test Results:
Tuned Frequency: 821MHz





6.5 Frequency Stability

Frequency stability is a measure of the frequency drift due to temperature and supply voltage variations.

Test Requirement:
For mobile transmitters operating in the frequency range of 806-821 MHz and with output power greater than 2 Watts, the carrier frequency stability should be maintained at 2.5 parts per million (ppm) for temperature and voltage variations. Frequency measurements were made as follows:

(a) at 10 degree intervals of temperatures between -30ºC and +50ºC at the manufacturer's rated supply voltage, and
(b) at +20ºC temperature and ±15% supply voltage variations.

Test Results:
The following tables contain the frequency stability test results. The EUT complied with the frequency stability requirements.

Frequency Stability vs. Temperature

Frequency tuned: 806MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Voltage: 13.8VDC

Operating Temperature (°C)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
-30	805.999162	-838	-0.000104
-20	805.999164	-836	-0.000104
-10	805.999290	-710	-0.000088
0	805.999554	-446	-0.000055
+10	805.999270	-730	-0.000091
+20	805.999112	-888	-0.000110
+30	805.999350	-650	-0.000081
+40	805.999076	-924	-0.000115
+50	805.999412	-588	-0.000073

Frequency Stability vs. Temperature

Frequency tuned: 814 MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Voltage: 13.8VDC

Operating Temperature (°C)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
-30	813.999174	-826	-0.000101
-20	813.999506	-494	-0.000061
-10	813.999528	-472	-0.000058
0	813.999296	-704	-0.000086
+10	813.999228	-772	-0.000095
+20	813.999284	-716	-0.000088
+30	813.999670	-330	-0.000041
+40	813.999614	-386	-0.000047
+50	813.999248	-752	-0.000092

Frequency Stability vs. Temperature

Frequency tuned: 821 MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Voltage: 13.8VDC

Operating Temperature (°C)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
-30	820.999498	-502	-0.000061
-20	820.999430	-570	-0.000069
-10	820.999744	-256	-0.000031
0	820.999246	-754	-0.000092
+10	820.999258	-742	-0.000090
+20	820.999084	-916	-0.000112
+30	820.999352	-648	-0.000079
+40	820.999534	-466	-0.000057
+50	820.999882	-118	-0.000014

Frequency Stability vs. Supply Voltage

Frequency Tuned: 806MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Input Voltage: 13.8 VDC
Temperature: 20°C

Input Voltage (VDC)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
+15% - 11.73	805.999198	-802	-0.000100
-15% - 15.87	805.999246	-754	-0.000094

Frequency Stability vs. Supply Voltage

Frequency Tuned: 814MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Input Voltage: 13.8 VDC
Temperature: 20°C

Input Voltage (VDC)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
+15% - 11.73	813.999330	-670	-0.000082
-15% - 15.87	813.999328	-672	-0.000083

Frequency Stability vs. Supply Voltage

Frequency Tuned: 821MHz
Frequency Stability Requirement: 2.5 ppm or 0.00025%
Nominal Input Voltage: 13.8 VDC
Temperature: 20°C

Input Voltage (VDC)	Frequency Measured (MHz)	Frequency Deviation (Hz)	Frequency Deviation (%)
+15% - 11.73	820.999070	-930	-0.000113
-15% - 15.87	820.999034	-966	-0.000118

6.6 Modulation Characteristics

Please refer to Appendix B for detailed plots of the modulation characteristics.

7. Photographs of Test Set-Ups and EUT

Refer to picture Exhibits
Test Setup Pictures (Front View)

Refer to picture Exhibits
Test Setup Pictures (Rear View)

Refer to picture Exhibits
Top of EUT

Refer to picture Exhibits
Bottom of EUT

Refer to picture Exhibits
TX & RX N-Type Ports of EUT

Refer to picture Exhibits
Power Port & Serial Port of the EUT

Refer to picture Exhibits
EUT Inside Chassis w/ Top Removed

Refer to picture Exhibits
EUT PCB Top Side

Refer to picture Exhibits
EUT PCB Bottom Side

APPENDIX A - TEST EQUIPMENT USED

The absolute performance calibration of equipment requiring calibration is performed on an as needed basis in accordance with ANSI/NCSL Z540-1-1994. However, calibration periods do not exceed one (1) year. The test equipment is capable of making measurements within tolerances of at least +/- 2dB amplitude and +/- 2% frequency deviation. Equipment certifications showing trace ability to NIST (National Institute of Standards and Technology) are maintained on file at Garwood Laboratories, Inc. Placentia, CA. All equipment is checked and verified for proper operation before and after each series of tests.

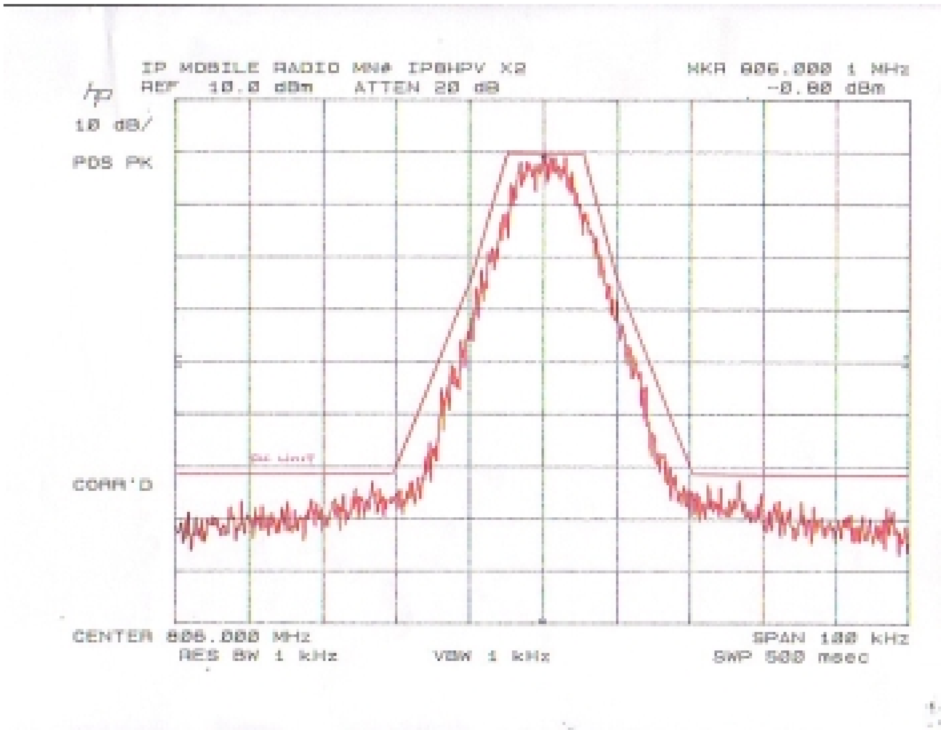
A.1 Specific Equipment Used

Test	*Instrument*	*MFG / Model No.*	*Asset No.*	*Cal. Due Date*
Radiated Emission Test				
	Quasi-Peak	Hewlett Packard	20021	10/17/01
	Spectrum Analyzer / Display	Hewlett Packard / 8568B	20018 / 20020	01/13/02
	RF Preselector	Hewlett Packard / 82685A	20022	01/13/02
	RF Coax Cable	Times Microwave / LMR 600	20180	07/30/02
	BiLog Antenna	Chase / CBL6111A	20062	04/26/02
	Pre-Amplifier	ISCI / RFPA/Z FL-2000	20007	07/30/02
	Preamp 1-26.5GHz	Hewlett Packard / 8449B	20003	11/03/01
	Double Ridge Guide Horn Antenna	Eaton / 96001	20388	11/07/01
	Spectrum Analyzer / Display	Hewlett Packard / 8566B	20257 / 20258	01/11/02

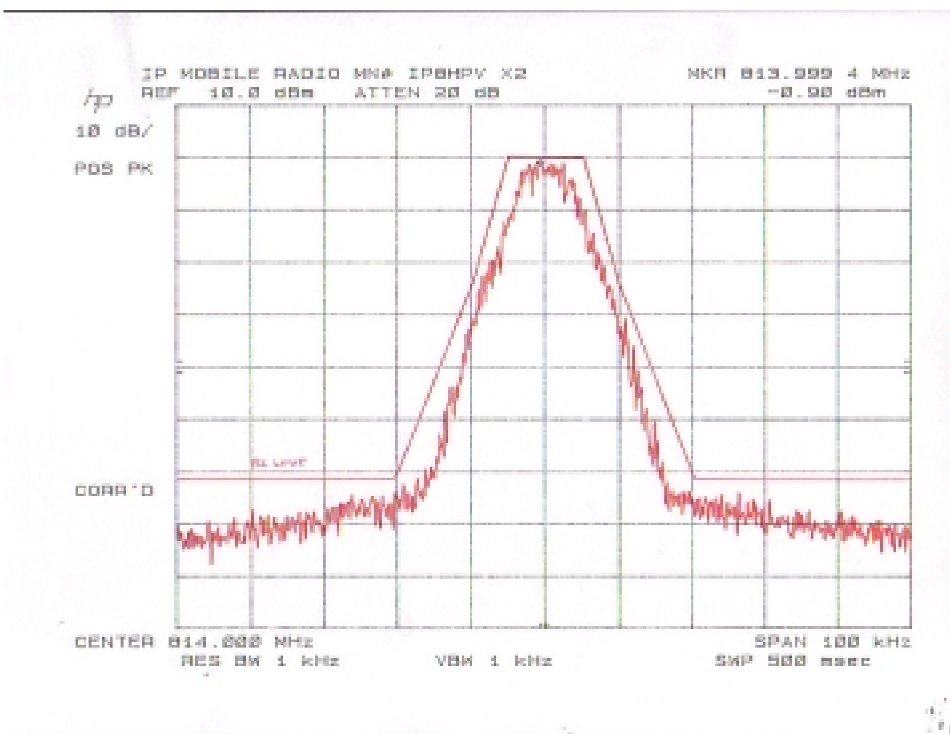
APPENDIX B – SUPPLEMENTAL TEST DATA

Basic Standard	***Test Type***	***Data Format***	***Page No.***
FCC Pt.90	Modulation Characteristics 806MHz	Plotted	B1
	Modulation Characteristics 814MHz	Plotted	B2
	Modulation Characteristics 821MHz	Plotted	B3

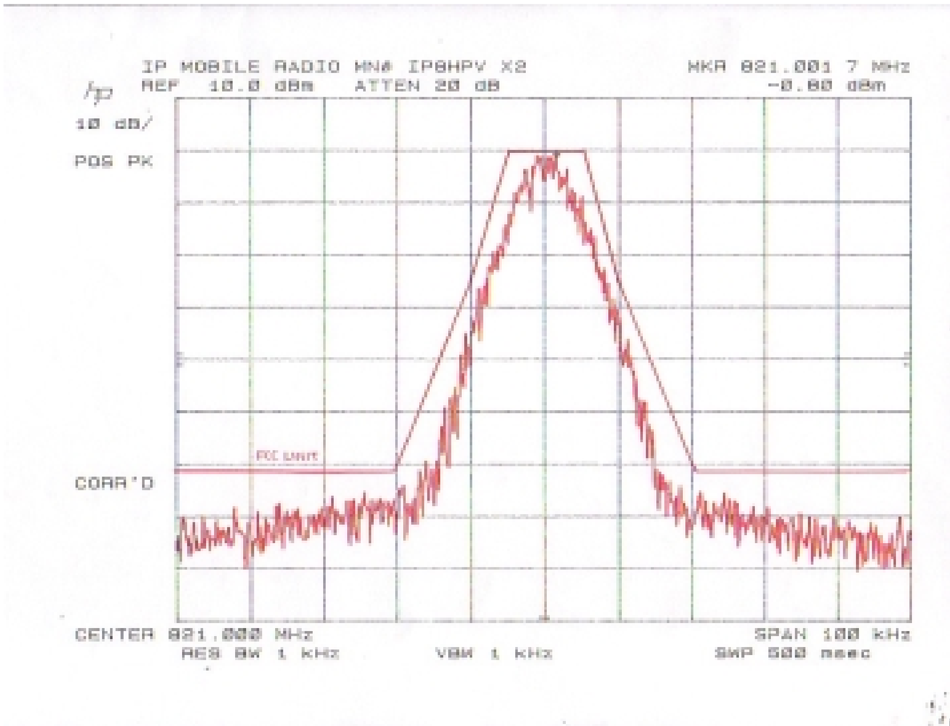
B1


IP MOBILE RADIO MN# IP8HPV X2
MKR 806.000 1 MHz
REF 10.0 dBm ATTEN 20 dB
-0.80 dBm
10 dB/
POS PK
CORR'D
CENTER 806.000 MHz
RES BW 1 kHz
VBW 1 kHz
SPAN 100 kHz
SWP 500 msec

B2


IP MOBILE RADIO MN# IP8HPV X2
MKR 813.999 4 MHz
REF 10.0 dBm ATTEN 20 dB
-0.90 dBm
10 dB/
POS PK
CORR'D
CENTER 814.000 MHz
RES BW 1 kHz
VBW 1 kHz
SPAN 100 kHz
SWP 500 msec

B3


IP MOBILE RADIO MN# IP8HPV X2
REF 10.0 dBm ATTEN 20 dB
MKR 821.001 7 MHz
-0.80 dBm
10 dB/
POS PK
CORR'D
CENTER 821.000 MHz
SPAN 100 kHz
RES BW 1 kHz
VBW 1 kHz
SWP 500 msec

ATTACHMENTS

INDEX OF ATTACHMENTS