Aurora™ 2400

2.4 GHz Digital Radio

REFERENCE MANUAL

Issue 2 Preliminary, December 1998

RMN-001627-E01

HARRIS
Communications

Warning

Spread spectrum point-to-point radio relay links like Aurora's are allowed by various regulatory agencies to operate unlicensed on a "noninterference basis". Because of the unlicensed nature, the Aurora radios require neither frequency licensing nor prior coordination in most regions. Good engineering judgment needs to be exercised by the operator and professional installer to avoid selecting paths or locations near equipment or facilities that could generate interfering signals. Such equipment might include microwave ovens and other high-power ISM devices. Additionally, precaution should be taken when links are deployed in a region where a large number of other 2.4-GHz, point-to-point or point-to-multipoint links are installed.

The Aurora installation software with its adjustable power feature is for professional installer use *only*, as mandated by the Federal Communications Commission (FCC, Part 15) and the European Telecommunications Standard Institute (ETSI 300-328). The customer version is provided with the adjustable power feature disengaged.

Harris Corporation does not assume any liability or damage arising out of the application or *mis*use of this Aurora radio product and its software.

Warranty

Any warranties or conditions made herein by Harris are exclusive, made in lieu of all other warranties or conditions, express or implied (except to title) including, but not limited to, any implied warranty or condition of merchantability, any implied warranty or condition of fitness for a particular purpose, or any warranty or condition arising out of performance or custom or usage of trade. Customer acknowledges any circumstances causing any such exclusive or limited remedy to fail of its essential purpose shall not affect any Harris warranty.

Limitation of Damages

Harris' total and maximum liability under this agreement, or in connection with the subject matter of this agreement, or any transaction related to this agreement, shall be limited to one-half (1/2) of the aggregate amount paid to Harris, regardless of the basis for such liability. The customer acknowledges and agrees that this section shall be enforceable in the event of any claim made in connection with this agreement, including, but not limited to, any claim for failure of delivery. In no event shall Harris be liable for any punitive, special, incidental, or consequential damages, including, but not limited to, lost profits, opportunities, or savings, or for any loss of use of, or loss of data or information of any kind, however caused, or for any full or partial loss of performance of any product, even if Harris has been advised of the possibility of such damages.

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We're ISO certified.

HARRIS CORPORATION
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http://www.harris.com

Customer Support

Customer Service

Refer to CHAPTER 7 and CHAPTER 8 for detailed information on Customer Support.

Ordering Parts or Spares

Spare radio assemblies may be ordered from the **Spare Products Support Center** (SPSC).

Harris Microwave Communications Division
Spare Products Support Center
3, Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Tel: 1-800-465-4654 (Canada and U.S.A.)
(+1) 514-421-8333
Fax: (+1) 514-421-3555

Repair and Return

If you require module repair service, call the Customer Service Center and first request a Return Material Authorization (RMA) number. This request ensures that the repair will be done in a timely manner and prevents any delays caused by incomplete or missing information.

Please provide the following information when you call (or fax):

- Your name, company, and telephone number (fax number)
- Part Number and Serial Number (see label on the back of the shelf)
- Purchase Order Number
- Billing and shipping addresses
- Any special return packing or shipping instructions
- Any special customs clearance information required

The Customer Service Center telephone numbers and locations:

U.S.A.

Harris Microwave Communications Division Tel: 1-800-227-8332
Attn: Customer Service, RMA #_____ (+1) 210-561-7420
5727 Farinon Drive Fax: (+1) 210-561-7421
San Antonio, TX 78249

Canada

Harris Microwave Communications Division Tel: 1-800-465-4654
Attn: Customer Service, RMA #_____ (+1) 514-421-8333
3, Hotel de Ville Fax: (+1) 514-421-3555
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Technical Support

Customer Resource Center

If you are experiencing a traffic-affecting or traffic-threatening situation, technical assistance is available 24 hours a day, 7 days a week, including holidays. If you call the Customer Resource Center during nonbusiness hours, a Product Support Engineer will return your call within 30 minutes.

Please provide the following information when you call.

- Your name, company, and telephone number.
- Equipment type, part number, and serial number (see label on back of shelf).
- Detailed description of the problem.

Business Hours

Normal business hours for the Customer Resource Center:

6:30 A.M. to 5:00 P.M. (Pacific Time)
Monday through Friday

Telephone Numbers

Technical support telephone numbers:

U.S.A. only	1-800-227-8332
International	(+1) 650-594-3800

Fax Number

Technical support fax number:

(+1) 650-594-3621

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CHAPTER 1
Introduction

Aurora 2400 Overview

The Aurora 2400 is a digital microwave radio that operates in the 2.4 to 2.4835 GHz Industrial, Scientific, and Medical (ISM) frequency band. It provides reliable, full-duplex, digital communication between two sites with line-of-sight clearance. Standard T1 and E1 line interfaces allow the user to connect any T1 or E1 equipment, such as voice/data multiplexer, central office PBX, video conferencing equipment, and so forth.

The Aurora can also serve as the transport link between Base Station Controllers (BSCs) or between a BSC and the Mobile Switch Center (MSC) in Personal Communications Service (PCS) mobile communication networks.

The Aurora uses Direct Sequence Spread Spectrum (DSSS) processing that reduces the transmitted power density and the potential for interference into neighboring communication systems.

The Aurora can be used in point-to-point and repeater configurations. In the repeater configuration, the radios serve as links between sites that are beyond each other's range or whose paths are obstructed.

Physical Description

Aurora can be mounted in a standard 19-inch equipment rack or placed on a desktop. Figure 1-1 shows a front view of Aurora. The front panel contains a power ON/OFF switch, T1 and E1 line interface connectors, an LED power indicator, TX (transmit) and RX (receive) alarm LED indicators, Receive Signal Strength Indicator (RSSI) and GND test jacks, an 8-pin mini-DIN connector for alarms, and a 9-pin D-sub RS-232 interface connector.

Figure 1-1 Aurora 2400 front view

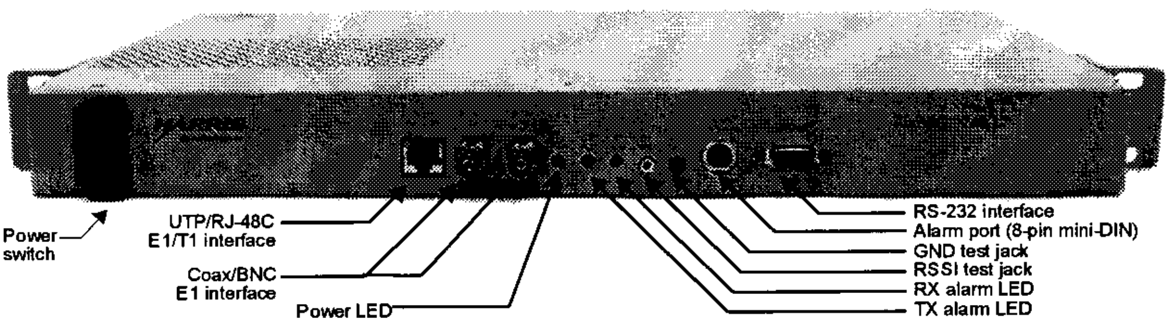


Figure 1-2 shows the Aurora radio's back panel with an N-type antenna connector. The standard input power connector is an AC connector as shown in Figure 1-2. Optionally, if DC power is required, an input battery power connector block can replace the AC power connector. See Figure 1-3.

Also, an example of a back label is shown in Figure 1-2. This label contains information such as technical data and serial number.

Figure 1-2 Aurora 2400 back view

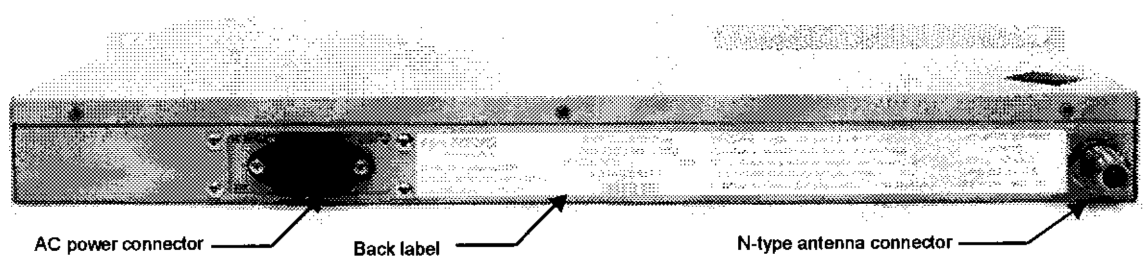
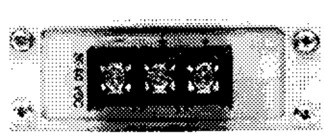


Figure 1-3 DC connector



Frequency Plans

The Aurora can co-exist with other similar radio links in the vicinity. Diversity with other links can be achieved through the use of different spreading codes, frequencies, and antenna pattern separation. Harris recommends the use of a directional antenna; the narrower beam width allows less interference into the receiving Aurora or other radios in the vicinity.

The Aurora has one standard frequency plan available. Figure 1-4 and Figure 1-5 illustrate this plan. The “A” frequency pair uses the first and third frequencies shown. One site transmits on A1 and receives on A2. The site at the opposite end of the link transmits on A2 and receives on A1. The “B” frequency pair uses the second and fourth frequencies shown in the illustration. One of the two pairs may work better than the other in a particular area based on the nature of the interference. In a remote area where only one channel is needed, using a pair made up of A1 and B2 is feasible. In this case, a better receiver sensitivity performance is achieved from more separation between transmit and receive frequencies.

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Figure 1-4 Aurora 2400 frequency plan (except in the U.S.A.)

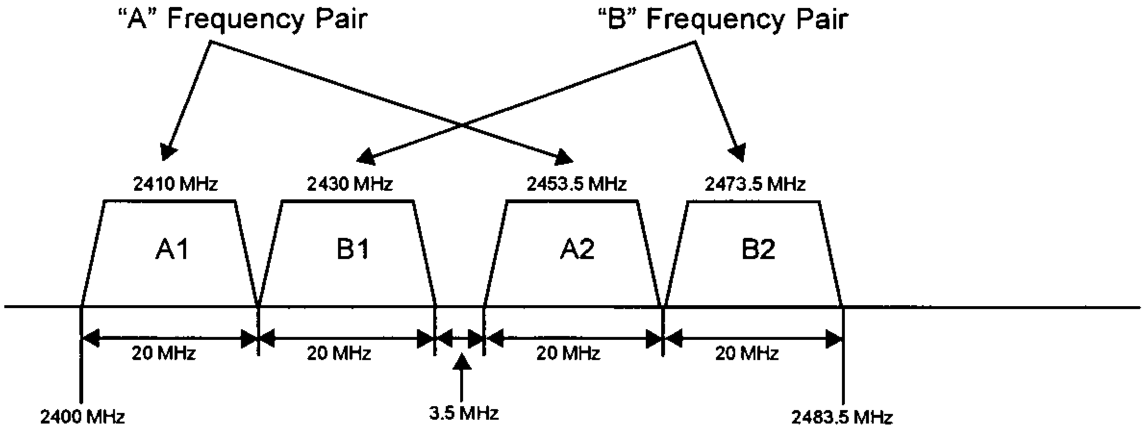
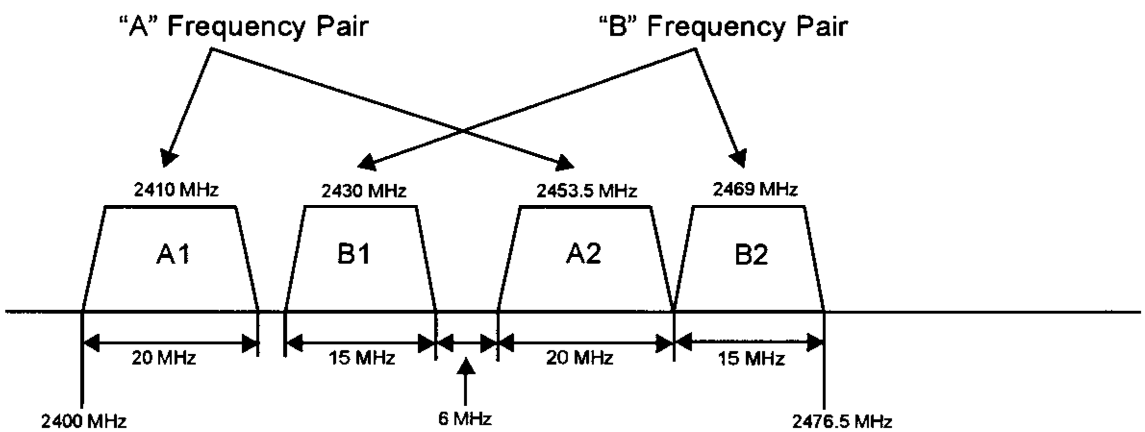


Figure 1-5 Aurora 2400 frequency plan



The Aurora radio can be configured with different spread sequence codes. All the units are shipped with a default code. Four different codes are stored in the Aurora utility software diskette. You can select and download a code from this diskette using a PC connected to the RS-232 interface. You can also configure the radio using a custom code.

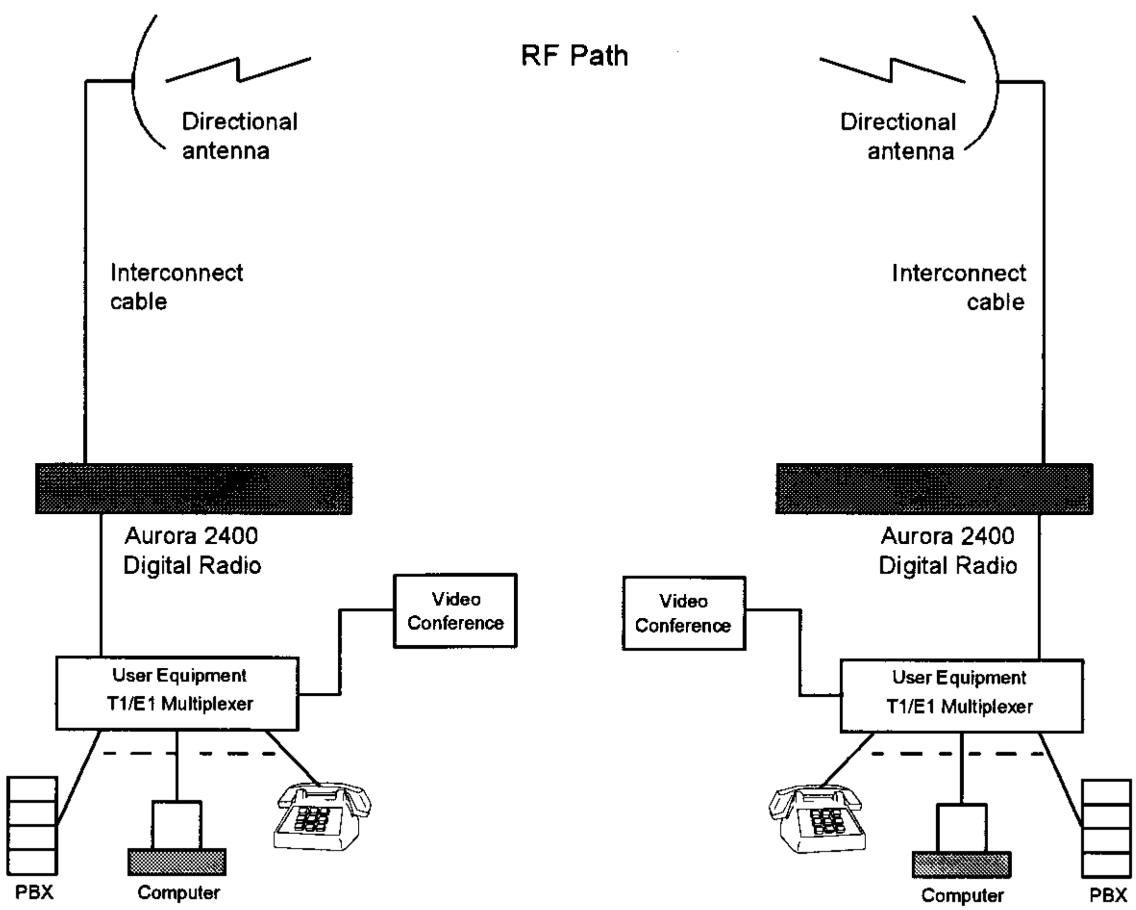
Aurora 2400 Radio Configurations

Point-to-Point Configuration

In a point-to-point configuration, two radios communicate only with each other. Either or both of the radios may be mobile, as long as they remain within each other's range. Figure 1-6 shows a typical point-to-point radio setup.

For U.S. operation the transmitter output power must be reduced by 1 dB below the 1-watt limit for each 3 dBi that the antenna gain exceeds 6 dBi (as referenced at the input of the antenna).

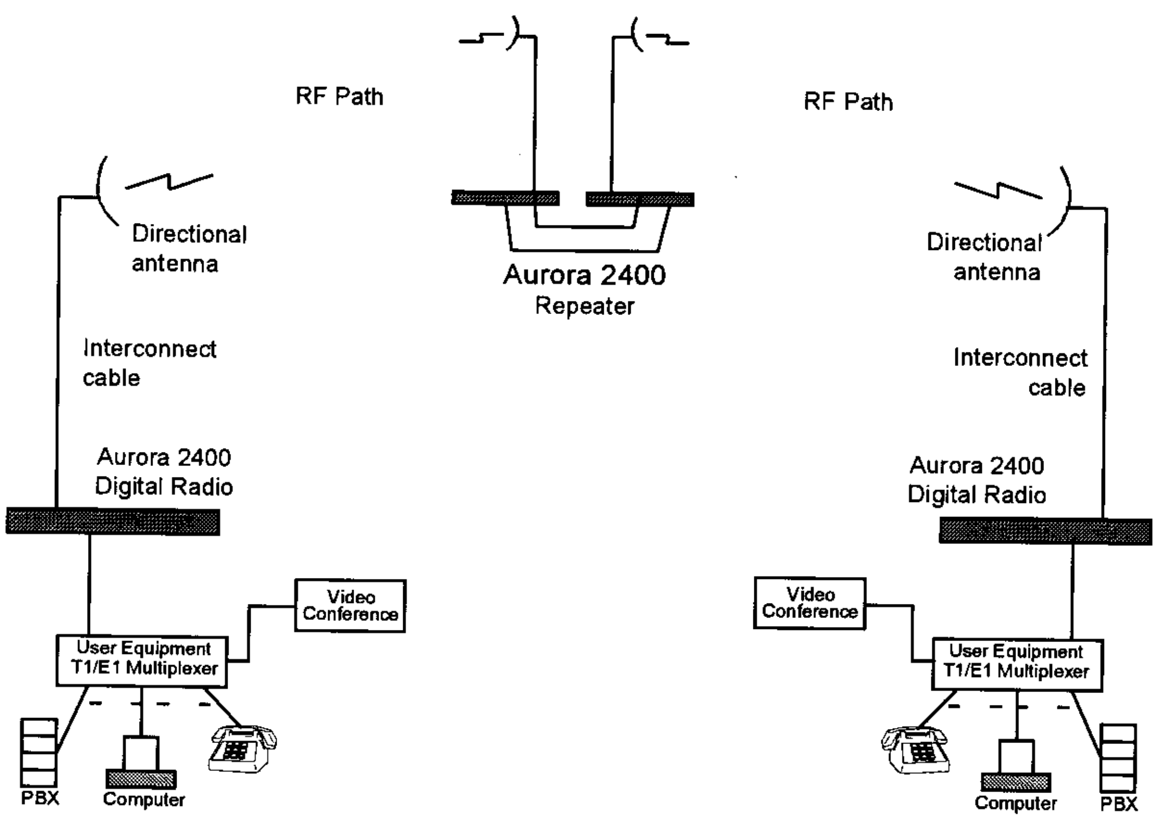
Figure 1-6 Point-to-point configuration



Repeater Configuration

A repeater extends the maximum communication range beyond that of a single hop. In this configuration, two additional radios are installed between the primary radios in the hop. Each of these intermediate radio faces one of the primary radios in the hop. A transmission from one end of the hop is intercepted by the repeater radio facing it, is passed on to the other radio in the repeater, and then relayed to the far-end radio. Figure 1-7 illustrates this configuration.

Figure 1-7 Radio repeater *



*. U.S. approval pending.

For repeater configurations, make sure there is enough frequency separation on the two transmitting channels. Use different antenna directions, polarization, or channel frequencies to achieve this separation.

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CHAPTER 2

Product Description

Hardware Modules

The Aurora 2400 radio contains five hardware modules.

- Modem
- Upconverter/Down Converter
- Tx Power Amplifier (for high-power version) or
  Tx Power Detector (for standard-power version)
- Antenna Diplexer
- Power Supply

A user interface software is included for field-specific programming and diagnostics.

Modem

Description

The Modem contains a Direct Sequence Spread Spectrum (DSSS) baseband processing section, an I and Q modulator, an IF AGC amplifier with an I/Q demodulator, and a microcontroller section. The circuits are loaded on a single PCB of approximately 5 inches by 7 inches. Figure 2-1 shows the Modem block diagram.

Transmit Direction

In the transmit direction (modulator), incoming T1 or E1 standard data is converted to NRZ data by a T1/E1 line interface circuit. The line interface circuit also recovers the bit rate clock (1.544 MHz or 2.048 MHz) from the input data and then inputs it to the DSSS processor.

A baseband processor performs scrambling, differential encoding, I and Q symbol generation, and spreading. The spreading PN code is user-programmable. Fifteen chips are used for T1 rate data ("A" frequency pair), and eleven chips for E1 rate data and T1 rate data ("B" frequency pair). The chip rate (f_{chip}) is 11.58 MHz for the T1 rate ("A" frequency pair), 8.492 MHz and 11.264 MHz for the E1 rate.

The I and Q outputs from the baseband processor then modulate an IF carrier to generate a 140-MHz IF DQPSK signal.

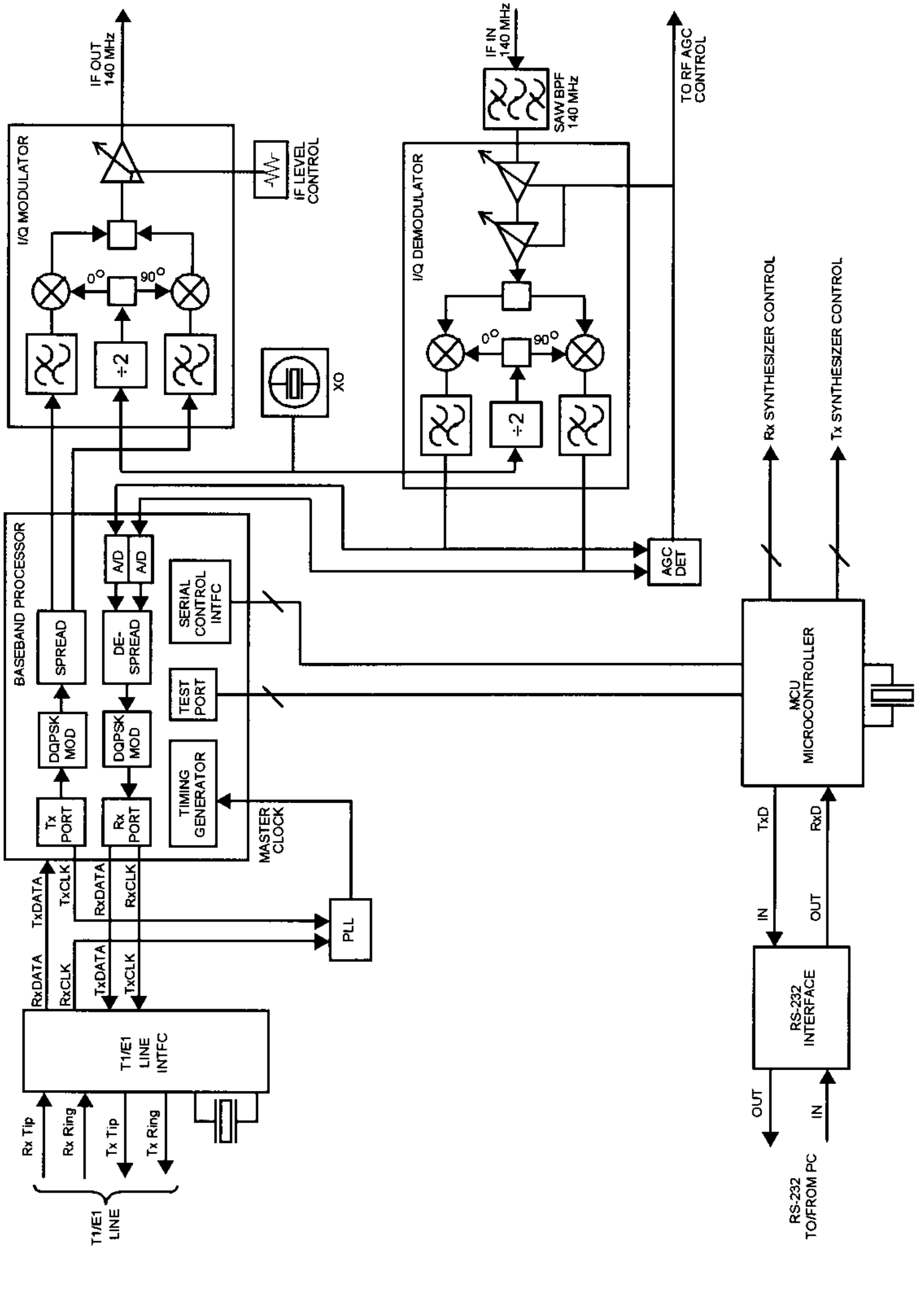
Receive Direction

In the receive direction (demodulator), a 140-MHz IF signal is demodulated into I and Q signals. The demodulator, together with a front-end AGC amplifier, provides a total of 80 dB of AGC. The demodulated I and Q signals are then passed to a baseband processor.

The baseband processor contains two 3-bit A/Ds, carrier and symbol synchronization and tracking, despreading, differential decoding, and descrambling. The quantized I and Q signals pass to a pair of 16-tap matched filters for calculating the signal correlation with the PN sequence. The output goes through a carrier phase rotation and acquisition process. The baseband processor also includes a frequency loop that tracks and removes the carrier frequency offset.

The PN correlator uses two samples per chip and despreads the chip rate back to the original data rate. This process provides 10.4 dB of processing gain for 11 chips per bit or 11.76 dB for 15 chips per bit. The correlator output pulse is further tracked by a symbol timing loop performing bit synchronization. The frequency and phase of the signal are corrected from an NCO that is driven by the phase-locked loop (PLL).

Figure 2-1 Modem block diagram



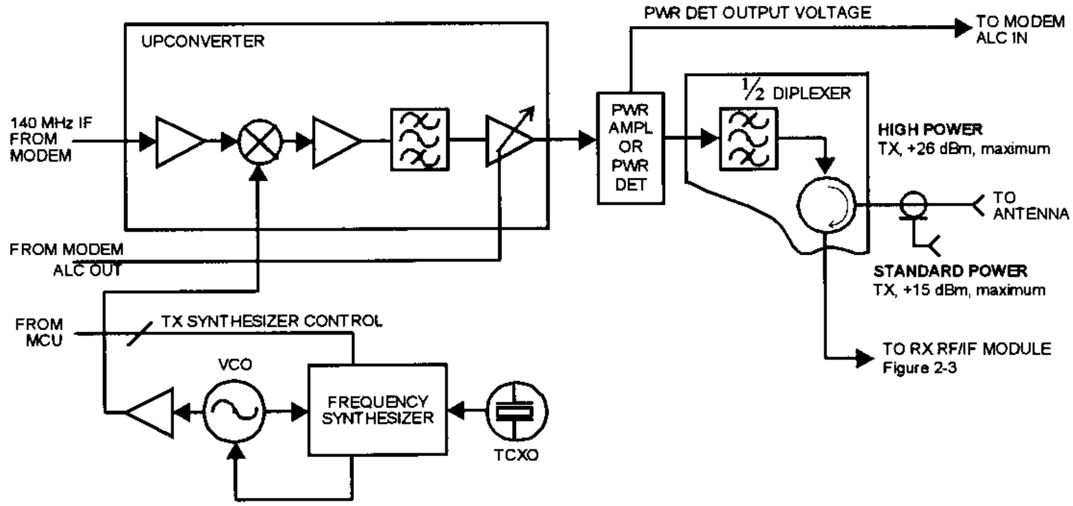
Demodulation of the signal in the early stages of acquisition is done by delay and subtraction of the phase samples. Once PLL tracking of the carrier is established, the PLL switches to a narrower loop, which achieves a better BER performance margin during the rest of demodulation. The demodulated signal is further differentially decoded and descrambled, then enters the T1 or E1 line interface circuit.

The radio uses a microcontroller to provide system configuration, including baseband processor, RF transmit and receive frequency synthesizer initialization, control, and monitoring. The system default configuration is initially built-in. The customer can use the Microsoft Windows-based Aurora 2400 software to reconfigure the baseband processor, and the transmit and receive synthesizers by using the radio's RS-232 interface. The new configuration can be downloaded into the radio and stored in the controller EEPROM.

Upconverter

The Upconverter receives a 140-MHz IF signal from the Modem. The Upconverter includes an RF bandpass filter at its output; this bandpass filter is centered at f_0 2.4425 GHz with a bandwidth (BW) of 90 MHz and a rejection ratio of 40 dBc at $f_0 \pm 130$ MHz. A local oscillator uses a synthesized source to generate the RF carrier in step sizes of 100 kHz. The 140-MHz IF is then mixed with the RF carrier; the resulting upconverted signal is filtered to pass its upper sideband to a Power Amplifier. Figure 2-2 shows the Upconverter block diagram.

Figure 2-2 ***Upconverter and Power Amplifier/Power Detector block diagram***



Transmitter Power

Tx Power Amplifier

For the high-power version the filtered upper sideband RF signal enters the MMIC RF power amplifier module. The power amplifier delivers a maximum of about +29 dBm of output power and has a gain of about 14 dB. The output power is maintained by an automatic level control (ALC) circuit located on the Modem card.

Tx Power Detector

For the standard-power version, only a power detector is installed. The detected voltage is fed back to the Modem card to generate an ALC function. Thus a constant Tx power level is maintained during temperature changes.

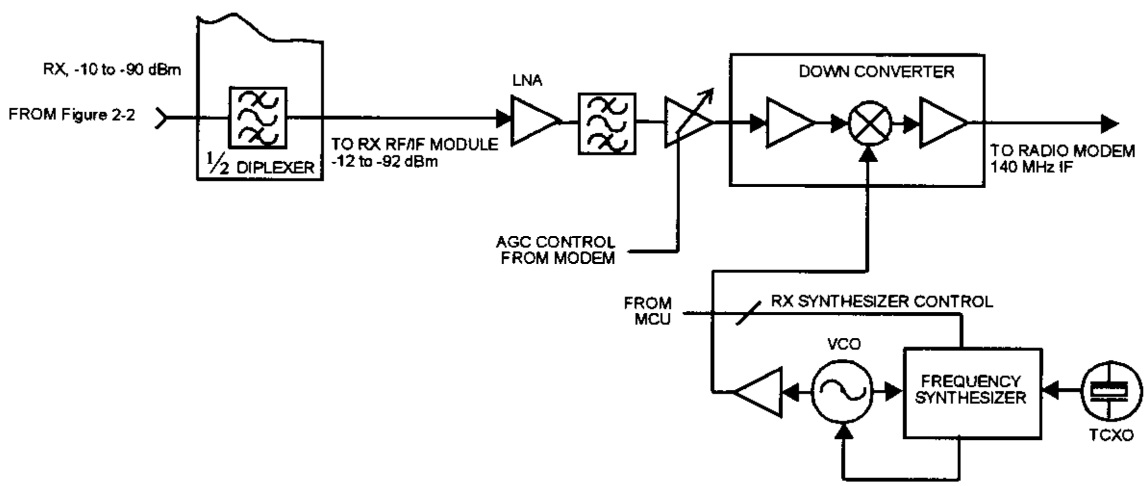
Down Converter

The Down Converter block diagram is shown in Figure 2-3. The received signal from an antenna diplexer is amplified by a low-noise amplifier (LNA) and then passed to an AGC amplifier. The incoming RF signal is then down-converted into a 140-MHz IF.

The Down Converter's local oscillator (LO) is generated by a synthesized source in 100-kHz step sizes.

The nominal frequencies of the Upconverter and Down Converter LO synthesizers are initially set at the factory. The LO frequencies can be reprogrammed in the field by using the Aurora 2400 utility software.

Figure 2-3 Down Converter block diagram



Antenna Diplexer

The antenna diplexer consists of two cavity-type filters. The transmit-section insertion loss and the receive-section insertion loss are both less than 2.5 dB. The return loss is expected to be typically better than 18 dB. The diplexer provides more than 80-dB isolation between the transmit and receive sections. This isolation prevents the receiver LNA from being overloaded due to transmitter power leakage.

The radio antenna is user-selectable. An antenna selection guideline is provided in CHAPTER 4.

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CHAPTER 3

Technical Specifications

Features

- 2.4 to 2.4835 GHz ISM bands
- Point-to-point, line of sight, up to 30 miles (48.3 km) range
- Full frequency duplex operation
- Standard T1 (DSX-1) or E1 (CEPT-1) interfaces
- Transmitter RF power up to +26 dBm
- Channel bandwidth, RF 3 dB at 16 MHz (12 MHz for U.S. "B" frequency pair)
- Direct sequence spread spectrum coding and DQPSK modulation
- Typical −90 dBm receiver threshold at BER=10^{-6}
- Synthesized transmitter and receiver frequencies
- Built-in self-diagnostics

Performance (One Hop)

System Gain (at BER=10^{-6})

115 dB, typical

Frequency Plan

S-Band

Frequency Pair	U.S.A.	non-U.S.A.
A	2.410/2.4535 GHz	2.410/2.4535 GHz
B	2.430/2.469 GHz	2.430/2.4735 GHz

Acquisition Time

≤ 50 milliseconds

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Transmission Delay

50 microseconds, maximum (radio only)

Residual Bit Error Ratio

Better than 10^{-12}, unfaded

Dispersive Fade Margin

Better than 60 dB at BER = 1×10^{-3}

MTBF

49 years

Transmitter Specifications

Output Power (Software-Adjustable)

High Power: +26 dBm maximum (+15 dBm minimum) at antenna port

Standard Power: +15 dBm maximum (−10 dBm minimum). Meets ETSI 300-328

Power Density

+8 dBm/3 kHz, maximum for FCC
+10 dBm/1 MHz, maximum for ETSI 300-328

Spurious/Harmonics

< −60 dBc

Frequency Range

2.4 to 2.4835 GHz

Frequency Stability

Within 0.0006%

Frequency Selection

Synthesizer default selection stored in MCU; software-selectable within ± 300 kHz from the center frequency.

Increments
100 kHz

IF Frequency
140 MHz

Modulation
Direct Sequence Spread Spectrum, DQPSK

PN Code and Chip Rate
Modified Barker Codes:

Chip Rate	Data Rate	Frequency Pair	Countries
15 chips/bit, 11.58 Mcp/s	T1 (1.544 Mb/s)	A	All
		B	non-U.S.A.
11 chips/bit, 11.264 Mcp/s	T1 (1.544 Mb/s)	B	U.S.A.
	E1 (2.048 Mb/s)	A and B	All

Receiver Specifications

Noise Figure
5 dB, maximum, at antenna port

Receiver Level
−40 dBm, nominal
−10 dBm, maximum, no performance degradation
−90 dBm, typical at 10^{-6} BER

Image Rejection
80 dB, minimum

AGC Range
80 dB

Frequency Selection
Synthesizer default selection stored in MCU; software-selectable within ± 300 kHz from the center frequency.

Increments

100 kHz

IF Frequency

140 MHz

Processing Gain

Frequency Pair	Countries	Data Rate	Processing Gain
A	All	T1 (1.544 Mb/s)	11.76 dB
B	non-U.S.A.		
B	U.S.A.	T1 (1.544 Mb/s)	10.4 dB
A and B	All	E1 (2.048 Mb/s)	

Demodulation

Noncoherent (matched filtering correlation)

Carrier Acquisition Range

Better than ±100 kHz

Carrier Tracking Range

Better than ± 150 kHz

Clock Acquisition Range

Better than ± 100 ppm

Threshold-to-Interference (T/I) Ratio

Co-channel: 7 dB (CW)
14 dB (like-signal)

Semi-channel: 0 dB (CW)
6 dB (like-signal)

Adjacent channel: –30 dB (CW)
–12 dB (like-signal)

Antenna/ Diplexer Specifications

Antenna (Optional)

Directional semiparabolic with 23.5-, 19-, or 15-dBi gain

Mechanics

External antenna, diplexer on shelf

Antenna Port

Connector:	N-type female
Impedance:	50 ohms
Return Loss:	>18 dB

Diplexer

Frequency Spacing:	43.5 MHz T-R (standard)
	39 MHz T-R (U.S. "B" pair frequency)
Diplexer Type:	cavity type
Branching Loss:	≤ 2.5 dB, Tx or Rx direction

Digital Interface Specifications

Data Capacity

1 × T1 or 1 × E1

Digital Interface

T1: DSX-1, meets CCITT G.823, AT&T Pub 62411, Bellcore GR-499-CORE

E1: CEPT-1, meets CCITT G.703

Connector

T1: RJ-48C balanced, 100 ohms

E1: RJ-48C balanced, 120 ohms, or BNC unbalanced, 75 ohms (jumper selectable; see Table 4-7)

Line Code

T1: B8ZS or AMI (DIP switch selectable)

E1: HDB3 or AMI (DIP switch selectable)

Controls, Indicators, Alarms, and Test Points

User Interface Port

RS-232 DTE interface

Alarm Port

Miniature DIN connector, 8-pin
Provides dry contact Tx and Rx alarms (see Table 4-9)

On-board Controller

AT89S252 8-bit CMOS microcontroller (8 kbytes flash program ROM, and 2 kbytes EEPROM on chip).

Programmability

System configuration initially programmed per customer requirements, and then can be field-programmable with a PC through the RS-232 interface.

Front-Panel LED Indicators

PWR: Green, power supply

TX ALM: Red, active high (activates when Tx power drops more than 4 dB)

RX ALM: Red, active high (activates when Rx signal disappears)

Front-Panel Test Point

RSSI: 1.4 to 4.5 VDC, corresponding to an approximate receiver input signal level of −90 to −10 dBm.

Built-in Diagnostics (through RS-232 Interface)

LOS, AIS (transmit all 1's), receive synthesizer lock alarm, transmit synthesizer lock alarm, Tx power, and Rx status.

Power Specifications

Input Voltage

Standard: AC power supply, 95 to 250 volts, 50 or 60 Hz

Optional: DC power supply, 21 to 60 volts, positive or negative reference

Power Consumption

20 watts, maximum

Fuse

Built in with the power supply

Environmental Specifications

Operational Temperature (full performance)	−10°C to +50°C	+14°F to +122°F
Storage Temperature	−40°C to +70°C	−40°F to +158°F
Humidity	95% noncondensing	
Altitude (above sea level)	4,572 meters	15,000 feet

Mechanical Specifications

The Aurora 2400 radio can be installed in a standard 19-inch equipment rack or placed on a desktop.

Height	1.75 inches	45 mm
Width	17 inches	432 mm
Depth (including the connectors)	11 inches	280 mm
Weight	7.7 lb	3.5 kg

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CHAPTER 4

Installation Planning

Warning

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Antenna Installation

Instructions for antenna installation usually are part of the antenna kit. Follow these instructions for good and effective antenna installation.

RF output power is set by Harris or authorized distributor. Do not change antennas, cable length, or type. To do so may violate regulatory rules.
If changes are necessary, contact Harris Customer Service or your authorized distributor.

Radio performance is affected by all aspects of antenna installation, including:

- Antenna type
- Line-of-sight path between antennas
- Antenna orientation
- Antenna placement
- Distance between antennas
- Distance between the radio and its antenna

Antenna Selection

The antenna option for all stations in a point-to-point Aurora 2400 radio network is directional semiparabolic with 15-, 19-, or 23.5-dBi gain.

This device emits non-ionizing radiation. To meet RF safety requirements, steps must be taken to prevent all personnel from being closer than one (1) meter from the antenna main beam when the transmitter is operational.

Antenna Selection Criteria

All antenna designs address two concerns: *directivity* and *gain*. A third criterion in selecting an antenna is *polarization*.

Directivity

A highly focused directional antenna should be used for maximum sensitivity and power. This type of antenna also rejects signals not coming from the desired direction and provides a desirable increase in signal-to-noise performance.

Gain

Antenna performance is measured in “dBi” where “i” stands for “isotropic,” which describes the standard spherical radiation pattern. The semiparabolic directional antenna has a gain of 23 dBi, representing power and sensitivity levels that are 200 times greater than those of a 0-dBi antenna. The FCC has a new rule on how much antenna gain affects the output power and effective output power of a radio operating in the 2400 MHz band. This rule requires that the output power of the radio must be reduced by 1 dB for every 3 dBi that the antenna gain exceeds the allowed 6 dBi.

For example, a radio has an output power of +30 dBm, and the antenna has a gain of 6 dBi, for an overall effective output power of +36 dBm. Should an antenna with a gain of 24 dBi be used, the radio’s output power must be reduced by 6 dB to +24 dBm (1 dB for each increase of 3 dBi in antenna gain beyond 6 dBi) for an overall effective output power of +48 dBm.

Polarization

Semiparabolic or parabolic antennas offer a choice of polarization. Aurora 2400 radios operate with antennas that are polarized either vertically or horizontally, *as long as the polarization is the same at both ends of the path.* Cross-polarization greatly reduces signal strength.

Site Selection

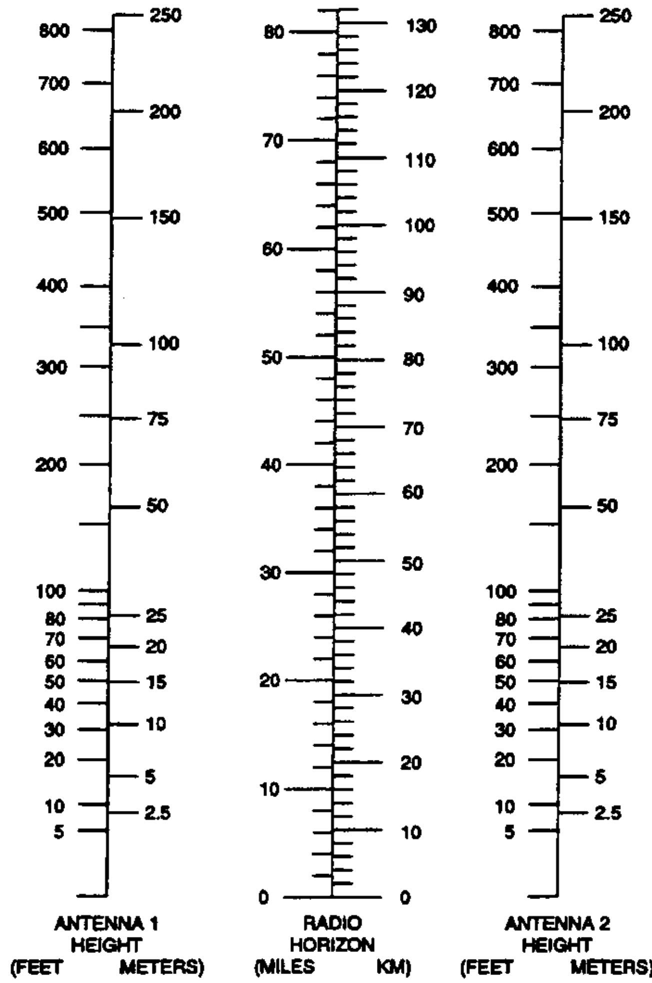
All antennas in the radio network must be able to "see each other". That is, there must be a direct line-of-sight path between the communicating antennas.

A good antenna site has the following qualifications:

- A clear line of sight for optimum power and maximum range
- Sufficient elevation for maximum line-of-sight range
- Correct orientation and correct directional aim at the target antenna
- Shortest possible distance between antenna and radio unit

A reasonable approximation of the radio horizon (line-of-sight) based on antenna height is shown in Figure 4-1. On the chart, set a straight-edge so that it crosses the height of one antenna in the column on the left and the height of the other antenna in the column on the right; the radio horizon in miles or kilometers is shown where the straight-edge crosses the center column.

Figure 4-1 Antenna height chart



Antenna Cable Selection

Harris recommends the use of low-loss and low-cost RF cables, such as Andrew's LDF series, to connect the radio to the antenna. Refer to Table 4-1 for cable characteristics.

Table 4-1 LDF series cable parameters

Cable Part Number	LDF1-50	LDF2-50	LDF4-50A
Nominal Size	1/4 inch	3/8 inch	1/2 inch
Impedance (ohms)	50	50	50
Max. Operating Freq. (MHz)	15,800	13,500	8,800
Approx. Atten, dB/100 ft (dB/100 m) at 2.5 GHz	5.96 (19.60)	5.84 (19.16)	3.88 (12.76)
Approx. Ave. Pwr. Rating (kW)	0.383	0.546	0.814
Weight, lb/ft (kg/m)	0.06 (0.09)	0.08 (0.12)	0.15 (0.22)
Diameter over Jacket, in. (mm)	0.345 (8.8)	0.44 (11.2)	0.63 (15.9)
Min. Bending Radius, in. (mm)	3 (76)	3.75 (95)	5 (125)

Antenna Alignment

The antenna can be aligned by monitoring the RSSI test jack. Use a digital multimeter to measure the RSSI voltage when adjusting the direction of the antenna. The RSSI level of 1.4 to 4.5 VDC corresponds to the receiver input level approximately −90 to −10 dBm. See Table 4-2.

Typical RSSI Voltage versus Receiver Input Level

Table 4-2 ***Typical RSSI voltage versus receiver input level***

RX Input Level (dBm)	RSSI Voltage (V)
–90	1.38
–85	1.66
–80	1.96
–75	2.30
–70	2.61
–65	2.88
–60	3.14
–55	3.36
–50	3.57
–45	3.75
–40	3.91
–35	4.06
–30	4.20
–25	4.31
–20	4.42
–10	4.51

Point-to-Point Path Analysis

Programs that allow you to perform path analysis are available from several vendors. In any case, the following steps should be followed.

Step 1 Plot the location of each antenna on a topographical site map.

Step 2 Draw lines showing the radio path between sites.

Step 3 On a graph paper, plot the ground elevation (vertical axis, in feet or meters) versus distance (horizontal axis, in miles or kilometers).

Step 4 Identify all obstructions on the radio path line on the map, including hills, vegetation, and buildings or structures that will interfere with radio transmission.

Step 5 Plot each obstruction on the graph, marking the elevation and distance from the sites.

Step 6 Add an increment to the height of each obstruction to allow for the earth's curvature.

$$d = \frac{d1 \times d2 \times C}{K}$$

where

d = additional height increment in feet or meters,

$d1$ = distance of obstruction from site in miles or kilometers,

$d2$ = distance of the obstruction from the second site in miles or kilometers,

C = 0.667 for English units or 0.79 for metric units,

and K = a refractive index of 1.33 for both English and metric units.

Add the additional d increments to the elevations plotted on your graph.

Step 7 Add another increment to the height of each obstruction because of the Fresnel zone, using the following formula to calculate the increment.

$$d = C\sqrt{\frac{d1 \times d2}{F \times D}}$$

where

d = 60% of the first Fresnel zone in feet or meter,

C = 1368 for English or 259 for metric units,

$d1$ = the distance of the obstruction from the first site in miles or kilometers,

$d2$ = the distance of the obstruction from the second site in miles or kilometers,

F = 2400 MHz in English or metric units, and

D = total path length ($d1 + d2$) in miles or kilometers.

Add the d increments to the elevations on the graph.

Step 8 Determine the ideal antenna height by drawing a line on the graph between the sites and across the top of the obstruction heights. Note the elevation of each antenna site.

Step 9 Determine the free-space path loss with the following formula.

$$L = C + 20\log(D) + 20\log(F)$$

where

L = the path loss in dB,

C = 96.6 for English units (distance in miles) and 32.5 for metric units (distance in kilometers),

D = distance in miles or kilometers, and

F = the signal frequency (2400 MHz for both English and metric units in the case of the Aurora radio).

For example, for a 15-mile path, path loss

= 96.6 + 20 log 15 + 20 log 2400 MHz = 188 dB.

For a 15-km path, path loss

= 32.5 + 20 log 15 + 20 log 2400 MHz = 124 dB.

Step 10 Calculate the overall receiver gain for each radio. For each site, determine the transmission line loss and add this figure to the antenna gain. For example:

Line loss = 2 dB
Antenna gain = +23 dB
Overall receiver gain = –2 dB + 23 dB = +21 dB

Step 11 Determine the Effective Isotropic Radiated Power (EIRP) at the transmit antenna required by the receiver as follows:

EIRP = receiver sensitivity + path loss – overall receiver gain.

For example, if the receiver sensitivity is –90 dBm, the path loss is 130 dB, and the overall receiver gain is +21 dB, the

EIRP = –90 dB + (130 dB) – (+21 dB) = +19 dBm.

Step 12 Determine the overall transmitter gain for each radio. Overall transmitter gain = the line loss + the transmit antenna gain.

For example, if the line loss is 2 dB and the transmit antenna gain is +23 dB, then the
overall transmitter gain = –2 dB + (+23 dB) = +21 dB.

Step 13 Calculate the required transmitter output power by subtracting the overall transmitter gain from the transmit EIRP required by the receiver.

Assuming +19 dBm required EIRP and +21 dB overall transmitter gain,
required transmitter output power

= +19 dBm – (+21 dB) = –2 dBm.

Step 14 Calculate the link margin by subtracting the required transmitter output power from the actual transmitted output power.

Assuming the transmitted power for the Aurora 2400 is +26 dBm,

the link margin = +26 dBm – (–2 dB) = +28 dB.

The link margin is the amount of fading the system will tolerate.

Examples of Transmission Distances

Table 4-3 lists some examples of the Aurora 2400 possible transmission distances for different antennas and different transmit output powers.

Table 4-3 Examples of maximum free-space transmission distance

Assumption: 32.8 ft (10 m) LDF2-50A cable feed for both antennas and 25 dB fade margin for BER $10^{-6}/10^{-3}$.

Antenna Gain (dBi)	Standard Transmit Output Power (+15 dBm)		Maximum Transmit Output Power (+26 dBm)	
	EIRP (dBm)	Transmission Distance (miles) BER $10^{-6}/10^{-3}$	EIRP (dBm)	Maximum Transmission Distance (miles) BER $10^{-6}/10^{-3}$
15	28	0.6/0.8	39	4.0/5.0
19	32	2.8/3.5	43	10.0/13.0
23	36	7.0/9.0	47	25.0/30.0

Notes:

1. 32.8 ft (10 m) LDF2-50A cable loss approximately 2 dB.
2. Aurora receiver threshold –90 dBm at BER 10^{-6} and –92 dBm at BER 10^{-3}.
3. Free-space, path-loss calculation:

   $L = C + 20 \log (D) + 20 \log (F)$.

   L = the path loss in dB.

   C = 96.6 for distance in miles and 32.5 for distance in kilometers.

   D = distance in miles or kilometers.

   F = the signal frequency in MHz.

   For example, for maximum output power = 26 dBm, antenna gain = 23 dBi, TX antenna cable loss = 2 dB,

   the TX EIRP = 26 + 23 – 2 = 47 dBm.

   The receiver antenna net gain = 23 – 2 (cable loss) = 21 dB;

   hence the total path loss with this radio system = 47 + 21 + 90 – 25 (required fade margin) = 133 dB,

   and corresponds to a free-space distance of about 25 miles for BER 10^{-6} and 30 miles for BER 10^{-3}.

If the actual transmission distance is 15 miles, the path loss is about 188 dB; then the system has about 29-dB fade margin for BER 10^{-6} and 31-dB fade margin for BER 10^{-3}.

T1/E1 Line Interface

Interface Cable

A RJ-45 connector is provided on the front panel of the radio for this line interface. The connection follows FCC Section 68.104(c) specified RJ-48C standard. The pinout is shown in Table 4-4.

Table 4-4 RJ-48C pinout specification

Pin Number	Pin Function
1	RX ring
2	RX tip
3, 6	Not used
4	TX ring
5	TX tip
7, 8	GND

Unbalanced E1 Interface

Two BNC connectors are provided on the front panel of the radio for this line interface, one for transmit data and the other for receive data. Use 75-ohm coaxial cables for these connections.

Line Interface Settings

The radio line interface supports T1 (DSX-1), Option 1, or E1 (CEPT-1), Option 2. The interface impedance and line codes are preset at the factory with default values. For each option, these values can be changed in the field in accordance with the user's needs.

T1 Interface, Option 1

Table 4-5 lists both the factory default settings and alternative settings for the T1 interface. The affected components, SW1 and jumpers JP1-4, are on the Radio Modem Card. Table 4-6 lists the SW1 settings required for different cable lengths used with the T1 terminal equipment.

Table 4-5 T1 line interface settings

Component	Default Setting	Alternative Setting
SW1-Position 1	ON (B8ZS Encoder)	OFF (AMI Encoder)
SW1-Position 2	ON (Factory use only)	ON (Factory use only)
SW1-Position 3	ON (B8ZS Encoder)	OFF (AMI Encoder)
SW1-Position 4	ON (Factory use only)	ON (Factory use only)
SW1-Position 5	ON (Factory use only)	ON (Factory use only)
SW1-Position 6	ON (0 to 133 ft cable)	See Table 4-6
SW1-Position 7	OFF (0 to 133 ft cable)	See Table 4-6
SW1-Position 8	OFF (0 to 133 ft cable)	See Table 4-6
JP1	OFF (Balanced)	N/A
JP2	OFF (Balanced)	N/A
JP3	OFF (100 ohms)	N/A
JP4	OFF (100 ohms)	N/A
JP6	ON (Factory use only)	N/A
JP7	ON (Factory use only)	N/A
JP8	ON (Factory use only)	N/A
JP9	ON (Factory use only)	N/A

Table 4-6 SW1 position options and line cable lengths

SW1 Positions 6, 7, 8	Line Cable Length (ft)
ON, OFF, OFF	0 to 133
OFF, ON, ON	133 to 266
OFF, ON, OFF	266 to 399
OFF, OFF, ON	399 to 533
OFF, OFF, OFF	533 to 655

E1 Interface, Option 2

Table 4-7 lists both the factory default settings and the alternative settings for the E1 interface. The affected components, SW1 and jumpers JP1-4, are on the Radio Modem Card.

Table 4-7 E1 line interface settings

Component	Default Setting	Alternative Setting
SW1-Position 1	ON (HDB3 Encoder)	OFF (AMI Encoder)
SW1-Position 2	ON (Factory use only)	ON (Factory use only)
SW1-Position 3	ON (HDB3 Encoder)	OFF (AMI Encoder)
SW1-Position 4	ON (Factory use only)	ON (Factory use only)
SW1-Position 5	ON (Factory use only)	ON (Factory use only)
SW1-Position 6	ON	N/A
SW1-Position 7	ON	N/A
SW1-Position 8	ON	N/A
JP1	OFF (Balanced)	ON (Unbalanced)
JP2	OFF (Balanced)	ON (Unbalanced)
JP3	OFF (120 ohms)	ON (75 ohms)
JP4	OFF (120 ohms)	ON (75 ohms)
JP6	ON (Factory use only)	ON (Factory use only)
JP7	ON (Factory use only)	ON (Factory use only)
JP8	ON (Factory use only)	ON (Factory use only)
JP9	ON (Factory use only)	ON (Factory use only)

Radio Modem Card

Figure 4-2 shows the locations of the DIP switch unit and the strapping units on the Radio Modem Card. Figure 4-3 shows details of SW1.

Figure 4-2 Radio Modem Card

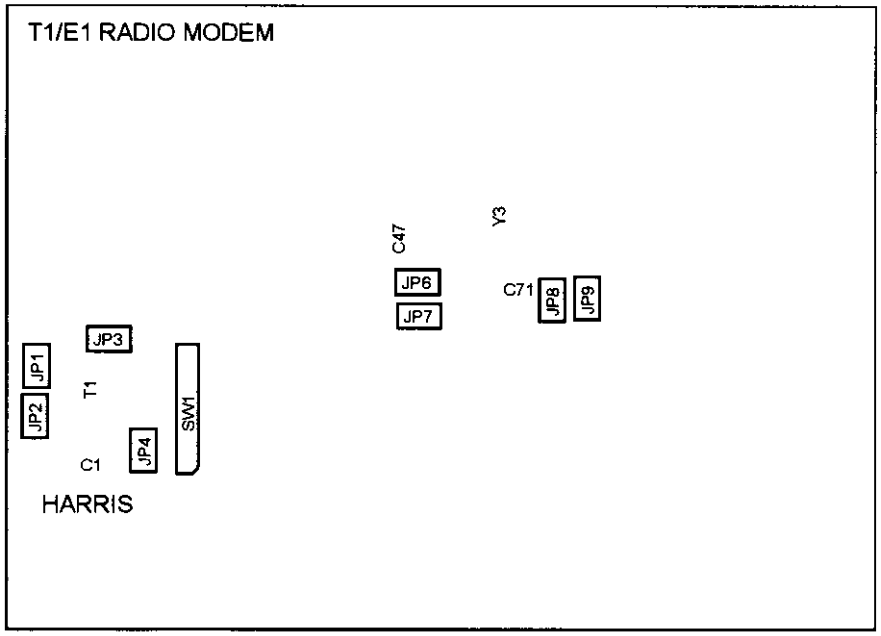
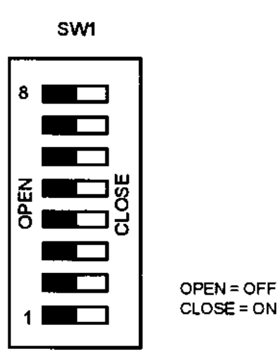


Figure 4-3 SW1, DIP switches



Alarm Port

Aurora 2400 has an 8-pin, mini-DIN alarm port on the front panel. Dry relay contacts are provided for the TX power alarm and RX signal alarm. Interface to third-party element manager system is through these contacts. The specifications for the relays are listed in Table 4-8.

Table 4-8 Specifications for the relays

Characteristic	Value
Current	125 mA DC, resistive load
Voltage	250 VDC
Isolation	3,750 V_{RMS}

The pinout of the 8-pin, mini-DIN connector is shown in Table 4-9.

Table 4-9 Alarm port pinout specification

Pin No.	Label on SD	Function
1	K1_NC	TX alarm relay NC (alarm open)
2	K1_P	TX alarm relay COM
3	K2_NC	RX alarm relay NC (alarm open)
4	K2_NO	RX alarm relay NO (alarm close)
5	K1_NO	TX alarm relay NO (alarm close)
6	K2_P	RX alarm relay COM
7		No connection
8		No connection

Transmitter Power Adjustment

The Aurora radio TX power default setting is +25 dBm nominal for the high-power version, and is −8.5 dBm for the standard-power version. The TX power may need to be readjusted in the field during initial installation, because of different configurations of different antenna size, cable length, and different regulation requirement.

The adjustment must be performed only by an approved professional installer!

U.S. Operations

For U.S. operation, the FCC requires that the transmitter power be reduced by 1 dB from +30 dBm (1 watt in the 50-ohm system) for every 3 dBi that the directional antenna gain exceeds 6 dBi.

The maximum FCC permitted EIRP is given as

$$P_{FCC} = 30 - (G_A - 6) / 3 \text{ (dBm)},$$

and the radio's unadjusted EIRP is

$$P_{EIRP} = 25 + G_A - L_C \text{ (dBm)},$$

where

G_A = the antenna gain in dBi, and

L_C = the cable loss in dB.

If P_{EIRP} is greater than P_{FCC}, then the TX power needs to be reduced so that the adjusted P_{EIRP} does not exceed P_{FCC}.

Table 4-10 shows some typical examples with different antenna gains and different cable length.

Table 4-10 TX power examples for U.S. operations

Antenna Gain (dBi)	Nominal TX Power Out (dBm)	Actual TX Power Out (dBm)	Cable Length ft (m)	Cable Loss (LDF2-50) (dB/ft)(dB/m)	Max. FCC Permitted EIRP (dBm)	Unadjusted EIRP (dBm)
23.5	25.0	**24.2**	0 (0)	0	47.7	48.5
23.5	25.0	**25.0**	49 (15)	3	47.7	45.5
23.5	25.0	**25.0**	98 (30)	6	47.7	42.5
23.5	25.0	**25.0**	197 (60)	12	47.7	36.5
19	25.0	**25.0**	0 (0)	0	44.7	44.0
19	25.0	**25.0**	49 (15)	3	44.7	41.0
19	25.0	**25.0**	98 (30)	6	44.7	39.0
19	25.0	**25.0**	197 (60)	12	44.7	33.0
15	25.0	**25.0**	0 (0)	0	42.0	40.0
15	25.0	**25.0**	49 (15)	3	42.0	37.0
15	25.0	**25.0**	98 (30)	6	42.0	34.0
15	25.0	**25.0**	197 (60)	12	42.0	28.0

ETSI Operations

The Aurora radio has to maintain an equivalent EIRP of +15 dBm in order to comply with ETSI 300-328 requirement. Table 4-11 shows some typical examples with different antenna gains and different cable lengths.

The factory default setting is −8.5 dBm, with a 15-dB SMA attenuation pad installed between upconverter output and diplexer TX input. Note that the pad value may need to change according to the different configurations.

Table 4-11 TX power examples for ETSI 300-328 operations

Antenna Gain (dBi)	TX Power Out (dBm)	Cable Length (m)	Cable Loss (LDF2-50 type) (dB)	TX Power Out w/o pad (dBm)	Fixed Pad Value (dB)	ETSI 300-328 EIRP (dBm)
23.5	-8.5	0	0	6.5	15	15
23.5	-5.5	15	3	9.5	15	15
23.5	-2.5	30	6	12.5	15	15
23.5	3.5	60	12	13.5	10	15
19	-4.0	0	0	11.0	15	15
19	-1.0	15	3	9.0	10	15
19	2.0	30	6	12.0	10	15
19	8.0	60	12	8.0	0	15
15	0.0	0	0	10.0	10	15
15	3.0	15	3	13.0	10	15
15	6.0	30	6	6.0	0	15
15	12.0	60	12	12.0	0	15

Aurora Software

Use *ConfigSS* software referenced in CHAPTER 5 to adjust the RF power.

From the main menu bar, click on **RF Setting** and then select **Adjust RF Power** to open the adjustment dialog box. Select **High Power** or **Standard Power** accordingly.

Refer to the preceding section "U.S. Operations" or "ETSI Operations" for the regulatory requirement and examples. Click the button "up" or "down" to get the required power level. It is strongly recommended that an RF Power Meter be used to monitor the TX level at the antenna port because the actual Output Power is ±1 dB of the displayed value in the dialog box.

Spacing Requirement

If the Aurora radio is being installed in an equipment rack, leave one rack space above the radio and one rack space below the radio.

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CHAPTER 5
Utility Software

Aurora Software

The Aurora 2400 is shipped with a diskette containing a utility software, *SSRADIO*, that is used to configure the radio for proper operation. The utility can also be used to monitor the built-in alarms and status indicators.

Installing the Software

The *SSRADIO* utility software can be installed and executed on any PC running the Microsoft® Windows® 95 or Windows NT® operating system. To install the software, do the following:

Step 1 Insert *SSRADIO** **Setup Disk 1** in the computer's disk drive (usually drive A:).

Step 2 From the Windows 95 or NT **Start** menu, select **Run**.

Step 3 In the **Run** dialog box, type `A:\setup.exe` and click **OK**.

The setup program guides you through the install process; follow the instructions that appear on the screen.

Running the Software

Once it is installed, you can run the *SSRADIO* utility software by choosing **Programs** from the Windows 95 or NT **Start** menu and then choosing **SSRADIO**.

A few moments after starting *SSRADIO*, the main window (Figure 5-2) appears.

*. *ConfigSS* for professional installer's version.

Serial Port Connection

The RS-232 user interface connector is on the front panel of the Aurora radio.

Connecting the Serial Port

From the main menu bar (Figure 5-2) choose

Serial Port and then
Connect.

The *SSRadio* automatically makes a connection.

If the PC to radio serial interface is working properly, the Serial indicator light in the main dialog box (Figure 5-2) will be green.

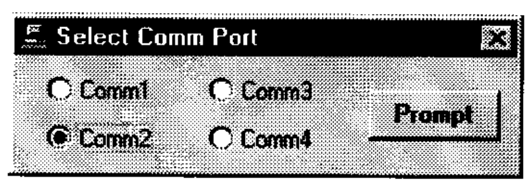
Changing the Serial COMM Port Setting

Step 1 From the main menu bar (Figure 5-2) choose

Serial Port and then
COMM Port.

The **Select Comm Port** dialog box appears (Figure 5-1).

Figure 5-1 Select Comm Port dialog box



Step 2 There are four Comm Port settings to choose from.

Choose the appropriate COMMx to match the PC hardware configuration.

The software checks to see if the serial port chosen is correct.

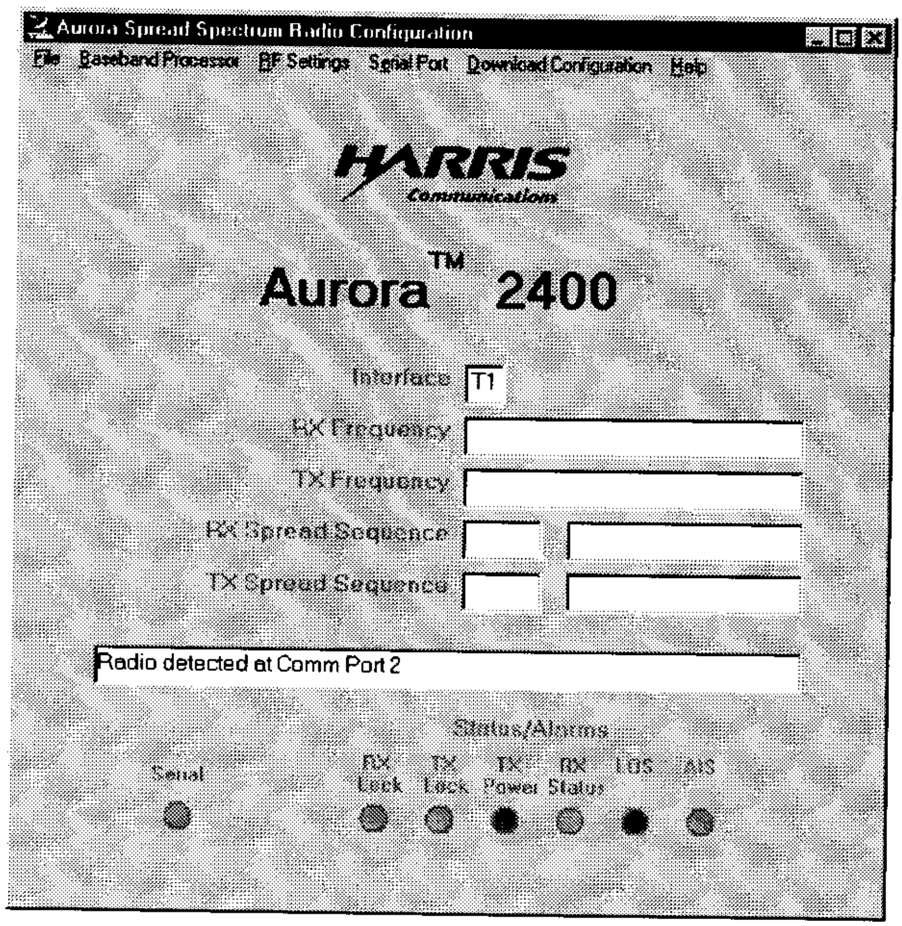
Step 3 If error message is displayed, check the PC Comm Port setting in Windows.

Step 4 Whenever necessary, click on the **Prompt** button for a comm link check.

If the PC to radio serial interface is working properly, the Serial indicator light in the main dialog box (Figure 5-2) will be green.

SSRadio Main Window

Figure 5-2 SSRADIO main window



Features

From the main window you can

- Connect serial comm port or change the serial comm port setting.
- Choose and define the spread sequence Pseudorandom Number (PN).
- Save configuration settings in text file format and later recall file to reconfigure a radio.
- Make small adjustments to receive and/or transmitter synthesizer frequencies.
- Monitor radio output power setting (not adjustable by the customer).

Main Window

Main Menu Bar

Table 5-1 lists the commands of the main menu.

Table 5-1 Main menu

Menu Name	Command
File	Open Baseband Processor File Save Baseband Processor File Save As Baseband Processor File Exit
Baseband Processor	MODEM configuration...T1/E1
RF Settings	Rx Synthesizer Tx Synthesizer View Power
Serial Port	COMM Port Connect (not available on *ConfigSS*)
Download Configuration	To Baseband Processor To Rx Synthesizer To Tx Synthesizer

Display Area

Table 5-2 explains what information is displayed in the main window.

Table 5-2 Display area of the main window

Name	Information
Interface	The default interface (T1/E1) is displayed here.
RX Frequency **TX Frequency**	RX and TX frequencies are displayed only after RX and/or synthesizer frequencies are downloaded via the Receive/Transmit Synthesizer Adjustment dialog boxes.
RX Spread Sequence **TX Spread Sequence**	RX and TX Spread Sequences are displayed only after information is downloaded via the Modem Configuration dialog box.

Status/Alarms

Seven status and alarm conditions are monitored and displayed on the *SSRADIO* main window.

Serial	The serial port connection, PC to radio
RX Lock	Receive synthesizer lock
TX Lock	Transmitter synthesizer lock
TX Power	Transmit power
RX Status	Receive status
LOS	Loss of signal
AIS	Transmit all 1's

Green indicates that everything is running okay. Red indicates an alarm condition.

Changing the Spread Sequence

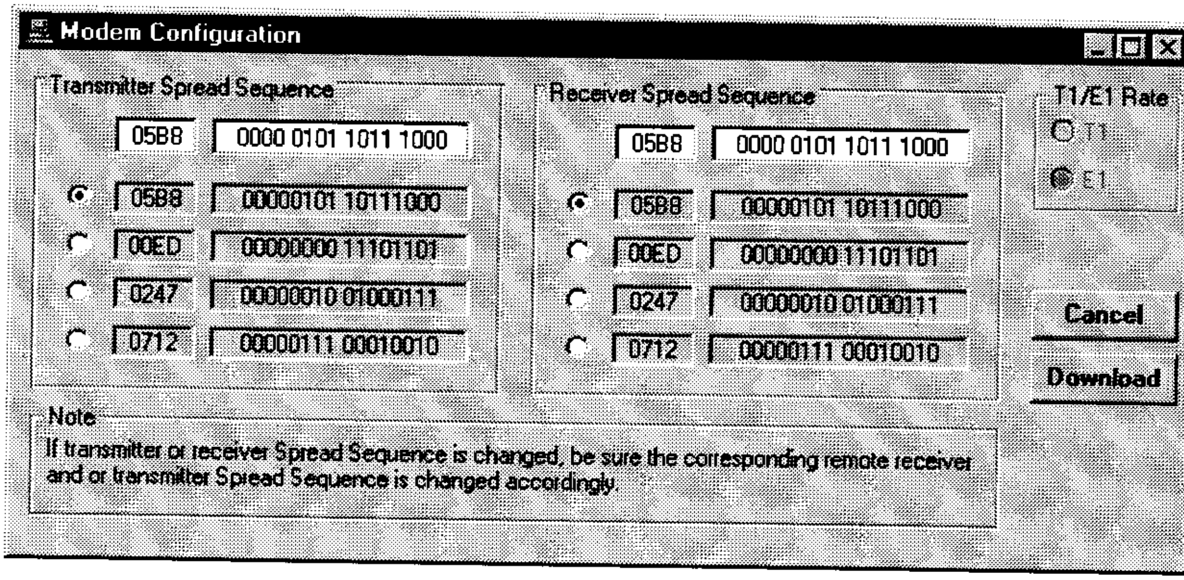
The radio's transmit and receive spread sequence PN may be changed as follows.

Step 1 From the main menu bar (Figure 5-2) choose

Baseband Processor and then
MODEM Configuration T1/E1.

The **Modem Configuration** dialog box (Figure 5-3) appears.

Figure 5-3 Modem Configuration dialog box



Step 2 There are four each preset **Spread Sequence** configurations to choose from.

a. Choose a **Spread Sequence** for the **Transmitter**.

b. Choose a **Spread Sequence** for the **Receiver**.

c. Ensure that the **Transmitter Spread Sequence** at the far end is the same as the **Receiver Spread Sequence** at the near end. See the **Note** in the dialog box.

Step 3 To download the new modem configuration,

click the **Download** button.

The new spread sequence PN is now installed in the radio.

The T1/E1 Rate setting is set at the factory and is not customer-selectable.

Managing Files

The baseband processor configuration file can be saved as a text file on the PC as follows.

Step 1 From the main menu bar (Figure 5-2) choose

File and then
Save Baseband Processor File.

Step 2 Follow the prompts to save the configuration file.

In addition, a previously saved file can be downloaded to configure the radio as follows.

Step 1 From the main menu bar (Figure 5-2) choose

File and then
Open Baseband Processor File.

Step 2 Select the file to open from a list, and click **Open**.

Step 3 In the **Modem Configuration** dialog box,

click **Download** to update radio.

Frequency Adjustment

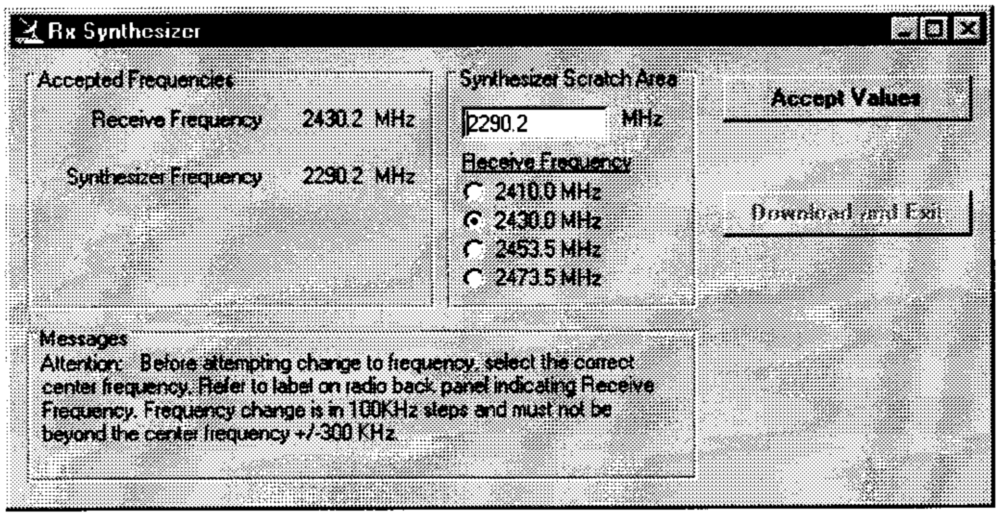
Receive Synthesizer Adjustment

Step 1 From the main menu bar (Figure 5-2) choose

RF Settings and then
Rx Synthesizer.

The **Rx Synthesizer** dialog box (Figure 5-4) appears.

Figure 5-4 Receive Synthesizer adjustment dialog box



Step 2 There are four **Receive Frequencies** to choose from.

Choose the correct center **Receive Frequency**. (RCV FREQ is on the label in back panel of the radio.)

If the selected frequency is not the same as the frequency displayed on the label, the radio does not function correctly.

Small adjustments are possible. Frequency can be adjusted up to 300 kHz away from the selected center frequency.

Step 3 Adjust the synthesizer within ± 300 kHz? (**Synthesizer Frequency** is 140 MHz lower than the **Receive Frequency**.)

If **yes**, continue with **Step 4**.
If **no**, go to **Step 5**.

Step 4 In the **Synthesizer Scratch Area**, change the frequency.

For example, the 2313.5 MHz can be changed to 2313.7.

Step 5 Click **Accept Values**.

The system checks for frequency errors.

Step 6 If there is no error message, go to **Step 7**.

If the wrong frequency is selected, the following message appears in the **Messages** box.

"VCO frequency cannot exceed 300 KHz from nominal selected frequency."

Change the frequency.

Step 7 If there is no error message, click

Download and Exit.

The synthesizer frequency is updated.

Step 8 If the frequency is changed, ensure that the corresponding frequency at the far end is changed also.

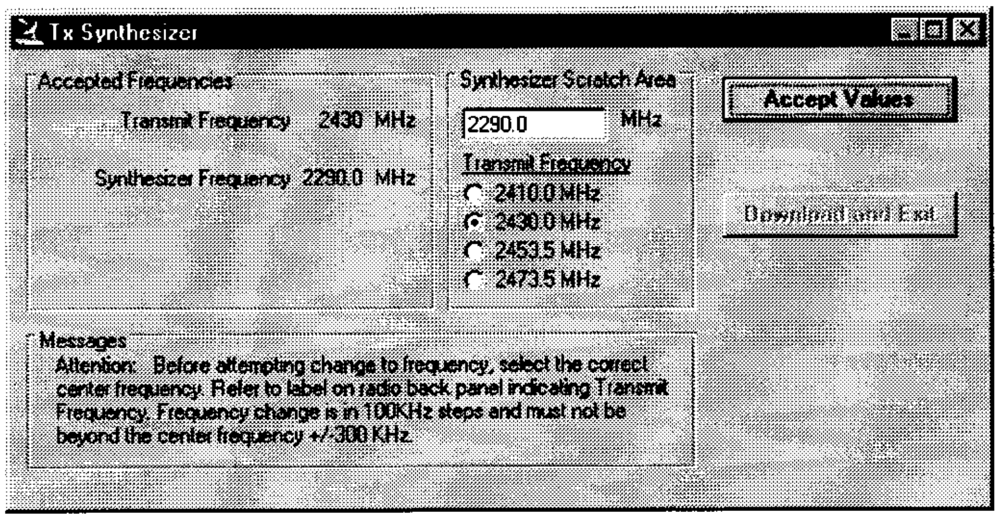
Transmit Synthesizer Adjustment

Step 1 From the main menu bar (Figure 5-2) choose

RF Settings and then
Tx Synthesizer.

The **Tx Synthesizer** dialog box (Figure 5-5) appears.

Figure 5-5 Transmit Synthesizer adjustment dialog box



Step 2 There are four **Transmit Frequencies** to choose from.

Choose the correct center **Transmit Frequency**. (XMT FREQ is on the label in the back panel of the radio.)

If the selected frequency is not the same as the frequency displayed on the label, the radio does not function correctly.

Small adjustments are possible. Frequency can be adjusted up to 300 kHz away from the selected center frequency.

Step 3 Adjust the synthesizer within ± 300 kHz? (**Synthesizer Frequency** is 140 MHz lower than the **Transmit Frequency**.)

If **yes**, continue with **Step 4**.
If **no**, go to **Step 5**.

Step 4 In the **Synthesizer Scratch Area** change the frequency.

For example, the 2290.0 MHz can be changed to 2290.2.

Step 5 Click **Accept Values**.

The system checks for frequency errors.

Step 6 If there is no error message, go to **Step 7**.

If the wrong frequency is selected, the following message appears in the **Messages** box.

"VCO frequency cannot exceed 300 KHz from nominal selected frequency."

Change the frequency.

Step 7 If there is no error message, click

Download and Exit.

The synthesizer frequency is updated.

Step 8 If the frequency is changed, ensure that the corresponding frequency at the far end is changed also.

Download Configuration

You can access the Baseband Processor, Rx Synthesizer, or Tx Synthesizer dialog box by choosing Download Configuration from the main menu. You can then download the new configuration to the radio.

RF Power Dialog Box

Professional Radio Installer's Version

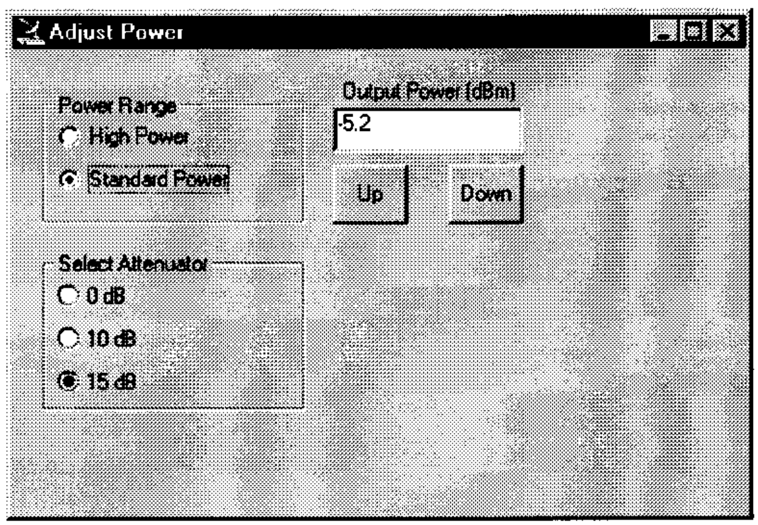
The RF power must be adjusted only by an approved professional installer or by a Harris professional.

Step 1 From the main menu bar of the Professional Radio Installer's Version choose

RF Setting and then
Adjust RF Power.

Figure 5-6 is the Adjust RF Power dialog box that appears on the screen when the *ConfigSS* is first installed.

Figure 5-6 Adjust Power dialog box (first installation)



Step 2 There are two **Power Ranges** to choose from.

a. If **High Power** is chosen, do not **Select Attenuator**.

b. If **Standard Power** is chosen, **Select** the correct **Attenuator** (provided by the manufacturer).

   Note: For ETSI operations the manufacturer's default setting for attenuation is 15 dB, and power output is –8.5 dBm.

   See Table 4-11 for Tx power examples with different antenna gains and different cable lengths.

Step 3 Click the **Up** or **Down** button to get the correct **Output Power (dBm)**.

It is strongly recommended that an RF Power Meter be used to monitor the TX level at the antenna port because the actual Output Power is ±1 dB of the displayed value.

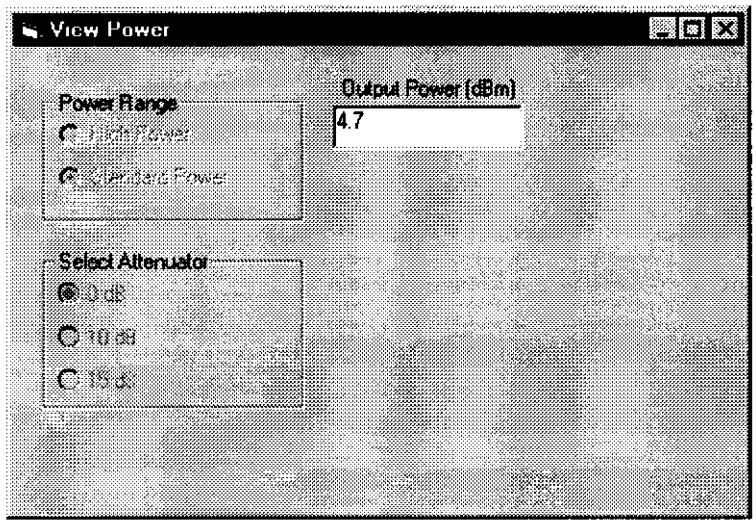
Customer's Version

To view the RF power setting, from the main menu bar (Figure 5-2) choose

RF Settings and then
View Power.

The **View Power** dialog box (Figure 5-7) appears.

Figure 5-7 View RF Power dialog box (view only)



Output Power cannot be adjusted in the field by using this dialog box. **Output Power** can only be adjusted by an approved professional installer.

In the Figure 5-7 example the **Output Power** is 4.7 dBm, and power is set to **Standard Power**. Note that the actual Output Power is ± 1 dB of the displayed value.

Exiting the SSRADIO

From the main menu bar (Figure 5-2)

choose **File** and **Exit**.

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CHAPTER 6

Troubleshooting Procedures

General

The following guideline is offered in troubleshooting the Aurora radio in the unlikely event a trouble occurs. This guideline is intended for new installations only.

Always check the radio pairs on a bench before field installation. Use 0-dBi omni antennas, or use cables with a serial 60-dB attenuator to perform the bench test.

Once the radio is installed, normal operation is indicated by the following conditions:

- The green PWR LED is on.
- The red TX ALM and RX ALM LEDs are off.
- The RSSI level is between 1.4 and 4.5 VDC.

Call the Harris Customer Resource Center if the trouble is not resolved.

Power LED Off

If no communication link is achieved, and if the PWR LED (green) is off:

- Check the connections to the power source.
- Check the power source itself for availability of power.
- Check the fuse of the power supply (the power supply may require replacing).

TX Power Alarm

If the TX ALM LED (red) is on:

- The transmit output power level may be too low (4 dB lower than nominal).
- There may be a problem with the LED driver.

Use the *SSRADIO* software to check the power level.

RX Data Alarm

If the RX ALM LED (red) is on,

- there may be a problem in the receive path resulting in a low received signal level, or
- the far-end transmitter output power is too low, or
- there may be a problem with the antenna connection or alignment.

Check the receiver's RSSI voltage level with a DMM (level should be between 1.4 and 4.5 VDC); if it is too low (closer to 1.4 VDC), the antenna is probably not properly aligned. Adjust the antenna direction to increase RSSI reading. Check the coaxial cable connections.

If the RSSI level cannot be improved with antenna adjustment, the remote site transmit power level might be too low. Go to the remote site and check and correct the transmitter's output power level.

Software Diagnosis

If the LEDs and RSSI are normal but still no communication link can be established, use the Aurora 2400 user interface utility software to troubleshoot the problem. The software's diagnostics provides additional information about the receive and transmit synthesizers, and the status of the LOS and AIS for the digital interface.

If the synthesizer has failed or if there is an LOS or AIS alarm, then the radio does not operate normally. In addition, make sure the radio pairs are configured correctly by re-downloading the receive and transmit synthesizer frequencies and the spread sequence into the radio processor, and then reset the radio transmit power.

Interference Resolution

If, after the link is installed, too many path errors are indicated on the T1 or E1 test set, a potential interference problem may exist. Try the following corrective steps.

Step 1 Rotate the antenna direction slightly and see if there is an improvement in the BER.

Step 2 If no improvement is achieved, rotate the polarization of the antenna at both ends of the link by 90°.

Step 3 If still no improvement is achieved after Step 2, use the *SSRADIO* utility software to change the Transmitter and Receiver Spread Sequence.

The software provides four different PNs. Use a PN other than the currently installed one, and check for improvement. Make sure the Transmitter Spread Sequence at one end is the same as the Receiver Spread Sequence at the opposite end. Harris recommends that you use different transmit and receive codes within the same radio to minimize the transmit power leakage into the receiver.

Step 4 If no obvious improvement is achieved from the preceding steps, use the *SSRADIO* software and make a slight adjustment to either the transmit or receive synthesizer frequency, or both.

- Do not make an adjustment of more than ± 300 kHz from the center frequencies (to avoid operating outside of the diplexer filters' passband).
- Make sure the transmit synthesizer frequency at one end matches the receive synthesizer frequency at the opposite end.

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CHAPTER 7

Customer Service and Warranty Information

Warranty and Product Support

Warranty and product support information is provided at the time of purchase with the sales invoice and other sales documents. Read the warranty information on page 7-5 for the equipment or assembly before contacting the Microwave Communications Division (MCD) Customer Service.

Ordering Parts or Spares

Harris MCD equipment is designed to be repaired by replacement at the unit level with readily available spares. For this reason, parts lists are not furnished with an order, nor are they recommended as a requirement.

Any order above the component level must be for a complete unit (a unit marked with a six-digit SD number), or for an assembly that includes one or more units. Make all inquiries for spare units to the Spare Products Support Center at the following address.

Harris Microwave Communications Division	Tel: 1-800-465-4654
Spare Products Support Center	(Canada and U.S.A.)
3, Hotel de Ville	(+1) 514-421-8333
Dollard-des-Ormeaux, Quebec	Fax: (+1) 514-421-3555
CANADA H9B 3G4	

The Customer Resource Center is now available on the worldwide web at http://www.microwave.harris.com/cservice/.

Repair and Return

Harris MCD repairs all its manufactured products as well as coordinates repairs on vendor items that are part of its systems. The standard repair turnaround time for current models of some products is 5 working days upon receipt of the defective parts. Repair turnaround time for other products is 15 working days. Discontinued items repair turnaround is subject to the availability of spares.

Emergency repair is available with a 24-hour turnaround time for current production models of some products and 48 hours for other products. Turnaround time for Manufacturing Discontinued items is subject to the nature of the problems. Emergency repairs are billed at actual repair price (zero for warranty units) plus some surcharge per unit. Our normal shipping time is 4:00 P.M. (Central Time) unless special shipping instruction is requested.

Repair charges and turnaround time for OEM (vendor) items are set by Harris MCD suppliers. Our close working relationships with our suppliers assure us of the best repair prices and turnaround time. Repair charges are billed at supplier's cost plus the necessary handling fee.

Module Exchange

You may prefer to receive a replacement unit before you send your defective unit to us. Harris MCD maintains an inventory of many different modules that can be shipped to you within 24 hours. Parts requiring retuning can be shipped within 48 hours.

All exchanged units must be returned to us within 15 days to avoid getting invoiced for the difference between the exchange price and the list price.

Evaluation Fee

There is an evaluation charge per unit if no trouble is found and no repair is required.

Unrepairable Units

Equipment which has been damaged due to customer negligence or which has parts removed will be repaired at the prevailing flat repair fee, or on a time-and-material basis, whichever is higher and regardless of the warranty status. Any equipment that is determined unrepairable will be returned to the customer. An evaluation fee will be assessed. This fee will be refunded if the customer purchases a replacement unit within 30 days.

Return Freight

Harris MCD prepays standard return freight back to our customers on warranty repairs. Return freight back to customers on billable repairs is invoiced to the customers. The customer pays for shipping units to Harris MCD for both warranty and out-of-warranty repairs. Special shipping requests may be subject to additional charge.

All shipments outside the continental USA and Canada are subject to additional handling charge per shipment.

Please pack the unit carefully using static-free, sturdy packaging to prevent damage during transit.

Return Material Authorization

Before sending in your equipment for repair, first contact the Harris MCD and request a return material authorization (RMA) number. Obtaining an RMA number insures you that the repairs will be done in a timely manner and prevents any delays due to incomplete information.

Please provide the following information:

1. Your name, company, and telephone number.
2. Equipment type, part number, and sales order number (labeled on back of shelf).
3. Detailed description of the problem.
4. Purchase order number.
5. Billing and shipping addresses.
6. Any special return packing or shipping instructions.
7. If required, customs clearance information.

Repair Telephone and Fax Numbers

U.S.A.

Tel: 1-800-227-8332 (U.S.A. only)
(+1) 210-561-7420

Fax: (+1) 210-561-7421

Canada

Tel: 1-800-465-4654 (Canada only)
(+1) 514-421-8333

Fax: (+1) 514-421-3555

Repair Service Locations

When you receive the RMA number, the Harris MCD customer service representative will instruct you to ship your defective unit(s) to one of the following addresses.

U.S.A.

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
5727 Farinon Drive
San Antonio, TX 78249

Canada

Harris Microwave Communications Division
Attn: Customer Service, RMA #_ _ _ _ _
3, Hotel de Ville
Dollard-des-Ormeaux, Quebec
CANADA H9B 3G4

Technical Support

Refer to CHAPTER 8 for information on obtaining Technical Support from the Customer Resource Center.

Customer Training

Harris MCD offers courses in microwave, lightwave, and multiplex system operation designed to maximize product performance and minimize maintenance costs. Regular classes are held in our Redwood Shores, California, and Montreal, Canada facilities. Special classes can be held at customer sites. Training is available for standard products. All other training requirements must be quoted by the Customer Training Department.

Standard Product Warranty Terms

Harris MCD warrants that each product of its own manufacture shall, at the time of delivery and for a period of 24 months thereafter, be free from defects in materials and workmanship. For such products that are installed by Harris MCD, this warranty shall extend for 18 months from date of installation, provided that the time from the date of delivery to the date of installation does not exceed 6 months. Such warranty shall not include any consumable components to which a specific manufacturer's guarantee applies. If any Harris MCD product shall prove to be defective in materials or workmanship under normal intended usage, operation, and maintenance during the applicable warranty period as determined by Harris MCD after examination of the product claimed to be defective, then Harris MCD shall repair or replace, at Harris MCD's sole option, such defective product, in accordance with procedures specified below, at its own expense, exclusive, however, of the cost of labor by the customer's own employees, agents or contractors in identifying, removing or replacing the defective part(s) of the product.

In composite equipment assemblies and systems, which include equipment of such other than Harris MCD manufacture, Harris MCD's responsibility under this warranty provision for the non-Harris MCD manufactured portion of the equipment shall be limited to the other equipment manufacturer's standard warranty. Provided, however, that if the other manufacturer's standard warranty period is of a shorter duration than the warranty period applicable to Harris MCD's manufactured equipment, then Harris MCD shall extend additional coverage to such other equipment manufacturer's warranty equal to the differential in time between the expiration of the other manufacturer's warranty and the duration of Harris MCD's manufactured equipment warranty applicable to such order. Harris MCD shall repair or replace, at Harris MCD's sole option, such other manufacturer's defective part(s) within 60 days after receipt of such parts by Harris MCD in accordance with the below specified procedures, at Harris MCD's own expense, exclusive, however, of cost of labor by the customer's own employees, agents or contractors in identifying, removing or replacing the defective part(s) of the product.

An authorization to return products to Harris MCD under this warranty must be obtained from a Harris MCD representative prior to making shipment to Harris MCD's plant, and all returns shall be shipped freight prepaid. Collect shipments will not be accepted, but Harris MCD will prepay return freight charges on repaired and replaced products found to be actually defective.

Liability of Harris MCD for breach of any and all warranties hereunder is expressly limited to the repair or replacement of defective products as set forth in this section, and in no event shall Harris MCD be liable for special, incidental or consequential damages by reason of any breach of warranty or defect in materials or workmanship. Harris MCD shall not be responsible for repair or replacement of products that have been subjected to neglect, accident or improper use, or that have been altered by other than authorized Harris MCD personnel.

Any warranties or conditions made herein by Harris are exclusive, made in lieu of all other warranties or conditions, express or implied (except to title) including, but not limited to, any implied warranty or condition of merchantability, any implied warranty or condition of fitness for a particular purpose, or any warranty or condition arising out of performance or custom or usage of trade. Customer acknowledges any circumstances causing any such exclusive or limited remedy to fail of its essential purpose shall not affect any Harris warranty.

Limitation of Damages

Harris' total and maximum liability under this agreement or in connection with the subject matter of this agreement or any transaction related to this agreement, shall be limited to one-half (1/2) of the aggregate amount paid to Harris, regardless of the basis for such liability. Customer acknowledges and agrees this section shall be enforceable in the event of any claim made in connection with this agreement, including, but not limited to, any claim for failure of delivery. In no event shall Harris be liable for any punitive, special, incidental, or consequential damages, including, but not limited to lost profits, opportunities or savings or for any loss of use of, or loss of data or information of any kind, however caused or for any full or partial loss of performance of any product, even if Harris has been advised of the possibility of such damages.

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CHAPTER 8
Technical Support

Customer Resource Center

If you are experiencing a traffic-affecting or traffic-threatening situation, technical assistance is available 24 hours a day, 7 days a week, including holidays. If you call the Customer Resource Center during nonbusiness hours, a Product Support Engineer will return your call within 30 minutes.

Please provide the following information when you call.

- Your name, company, and telephone number.
- Equipment type, part number, and serial number (see label on back of shelf).
- Detailed description of the problem.

Business Hours

Normal business hours for the Customer Resource Center:

6:30 A.M. to 5:00 P.M. (Pacific Time)
Monday through Friday

Telephone Numbers

Technical support telephone numbers:

U.S.A. only	1-800-227-8332
International	(+1) 650-594-3800

Fax Number

Technical support fax number:

(+1) 650-594-3621

Address

Mailing address for the Customer Resource Center:

Harris Corporation
Microwave Communications Division
Attn: CRC
330 Twin Dolphin Drive
Redwood Shores, CA 94065-1421

The Customer Resource Center is now available on the worldwide web at http://www.microwave.harris.com/cservice/.

Ordering Parts or Spares

Refer to CHAPTER 7 for information on ordering parts or returning parts for repair.

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Glossary

A/D
Analog to Digital.

AGC
Automatic Gain Control; automatic gain adjustment of a varying input signal level to produce a constant output signal level.

AIS
Alarm Indication Signal.

ALC
Automatic Level Control.

AMI
Alternate Mark Inversion.

B8ZS
Bipolar with Eight Zero Substitution.

baseband
A frequency band occupied by a modulating information signal.

Bellcore
Bell Communications Research, Inc. (source of telephony standards in the U.S.).

BER
Bit Error Ratio.

BERT
Bit Error Ratio Tester.

BPF
BandPass Filter.

BSC
Base Station Controller.

BW
BandWidth.

CCITT
Comité Consultatif International Télégraphique et Téléphonique.

CEPT
Conference Européen des Administrations des Postes et des Télécommunications.

CW
Continuous Wave.

DFM
Dispersive Fade Margin.

DIP
Dual In-line Package (switch).

directivity
The distribution in space of the energy radiated by an antenna.

DMM
Digital MultiMeter.

DQPSK
Differential Quadrature Phase-Shift Keying.

DSSS
Direct Sequence Spread Spectrum.

DTE
Data Terminal Equipment.

EEPROM
Electronically Erasable Programmable Read-Only Memory.

EIRP
Effective Isotropic Radiated Power.

ETSI
European Telecommunications Standards Institute.

FCC
Federal Communications Commission (U.S.).

hop
The span between a transmitter and a receiver.

IF
Intermediate Frequency; frequency below the radio frequency.

ISM
Industrial, Scientific, and Medical.

LED
Light-Emitting Diode.

LNA
Low-Noise Amplifier.

LO
Local Oscillator.

LOS
Loss Of Signal.

MCD
Microwave Communications Division, formerly Farinon Division.

MCU
MicroController Unit.

MMIC
Microwave Monolithic Integrated Circuit.

MSC
Mobile Switch Center.

MTBF
Mean Time Between Failures.

NC
Normally Closed.

NCO
Numerically Controlled Oscillator.

NMS
Network Management System.

NO
Normally Open.

NRZ
NonReturn to Zero (coding).

OEM
Original Equipment Manufacturer.

PCB
Printed Circuit Board.

PCS
Personal Communications Service.

PLL
Phase-Locked Loop.

PN
Pseudorandom Number.

RF
Radio Frequency.

RMA
Return Material Authorization.

ROM
Read-Only Memory.

RSSI
Receive Signal Strength Indicator.

RX
Receiver.

SD
Schematic Drawing.

SPSC
Spare Products Support Center.

TCXO
Temperature-Controlled Crystal Oscillator.

T/I
Threshold-to Interference ratio.

TIA
Telecommunication Industries Association.

TX
Transmitter.

VCO
Voltage-Controlled Oscillator.

XO
Crystal Oscillator.

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EXHIBIT C.3

SPURIOUS RF OUTPUT POWER
Transmitter Radiated Emissions Above 1 GHz

(Paragraph 15.247(c))

Tx Frequency
2410 MHz
&
2469.1 MHz

Refer to Appendix C of EMI Test Report

EXHIBIT C.4

Transmitter Power Density

(Paragraph 15.247(d))

This test data was gathered for the AURORA 2400-1 on 17 Dec 1997. The AURORA 2400-3 & -4 are identical Radios, except that the operating frequency of the -3 & -4 is at the high end of the band, therefore this data is the same within the limits of manufacturing tolerances.

Transmitter Power Density = -26.6 dBm over 3KHz
Limit = +8 dBm

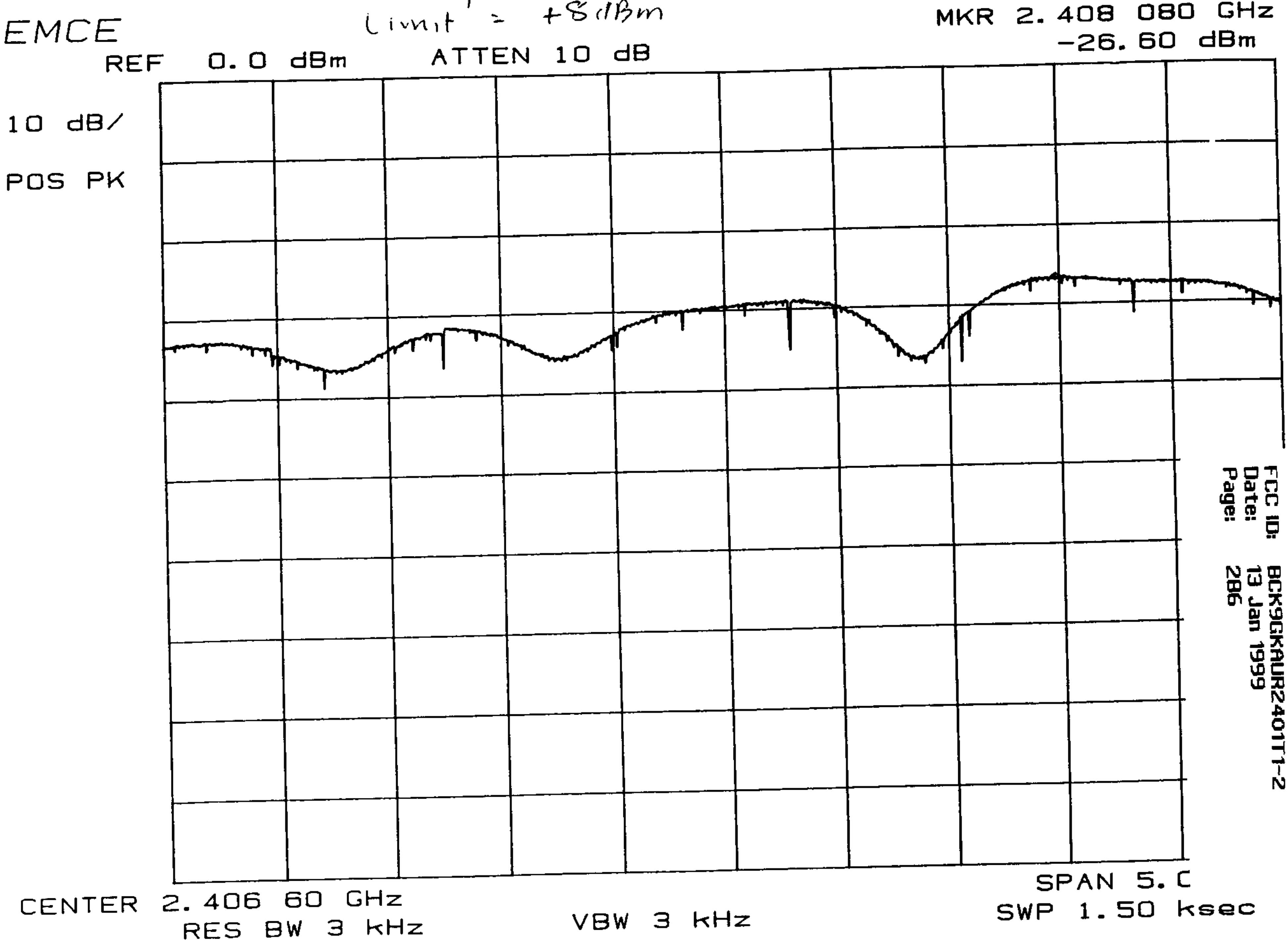

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EXHIBIT C.5

Processing Gain, Direct Sequence System.

Processing Gain.

The purpose of this test is to show that the processing gain of the RF unit is at least 10 dB. Tho test method used here is applicable to any direct sequence spread spectrum radio with an arbitrary jammer, where the total power of tho jammer is known. The test is performed in a self-loop mode via a test translator. The **BER** vs **S/N** (or Eb/No) characteristics of the 16QAM modulation format is utilized. Initially the system is set for error-free operation. Then a jamming signal is injected until a nominal **BER** of about 1E-5 is achieved. Then the processing gain, **Gp**, is computed from the equation:
(per Dixon, Ref. 1)

$$G_p = (S/N)_0 + M_j + L_{sys} \qquad [\text{dB}\}$$

where: S/N = signal-to-noise ratio of the 16QAM system
M_j = J/S ~ jamming-to-signal power ratio
L_{sys} = system implementation loss (taken as 2 dB maximum here).

G_p is computed for 640 points within the l6 MHz band while maintaining the same **BER**. The points are spaced 50 KHz apart. Twenty (20) percent of the data points may be discarded and the remainder should meet the l0 dB minimum processing gain.

The test setup and 16QAM performance curve (Ref. 2) is attached.

REFERENCES. 1. Dixon, R. Spread Spectrum systems, Chapter 1 (New York, Wiley, 1984)

2. Townsend, A.A. R. , Digital Line-of-Sight Radio Links, a handbook, Chapter 6 (Prentice-Hall, 1988, UK Ltd)

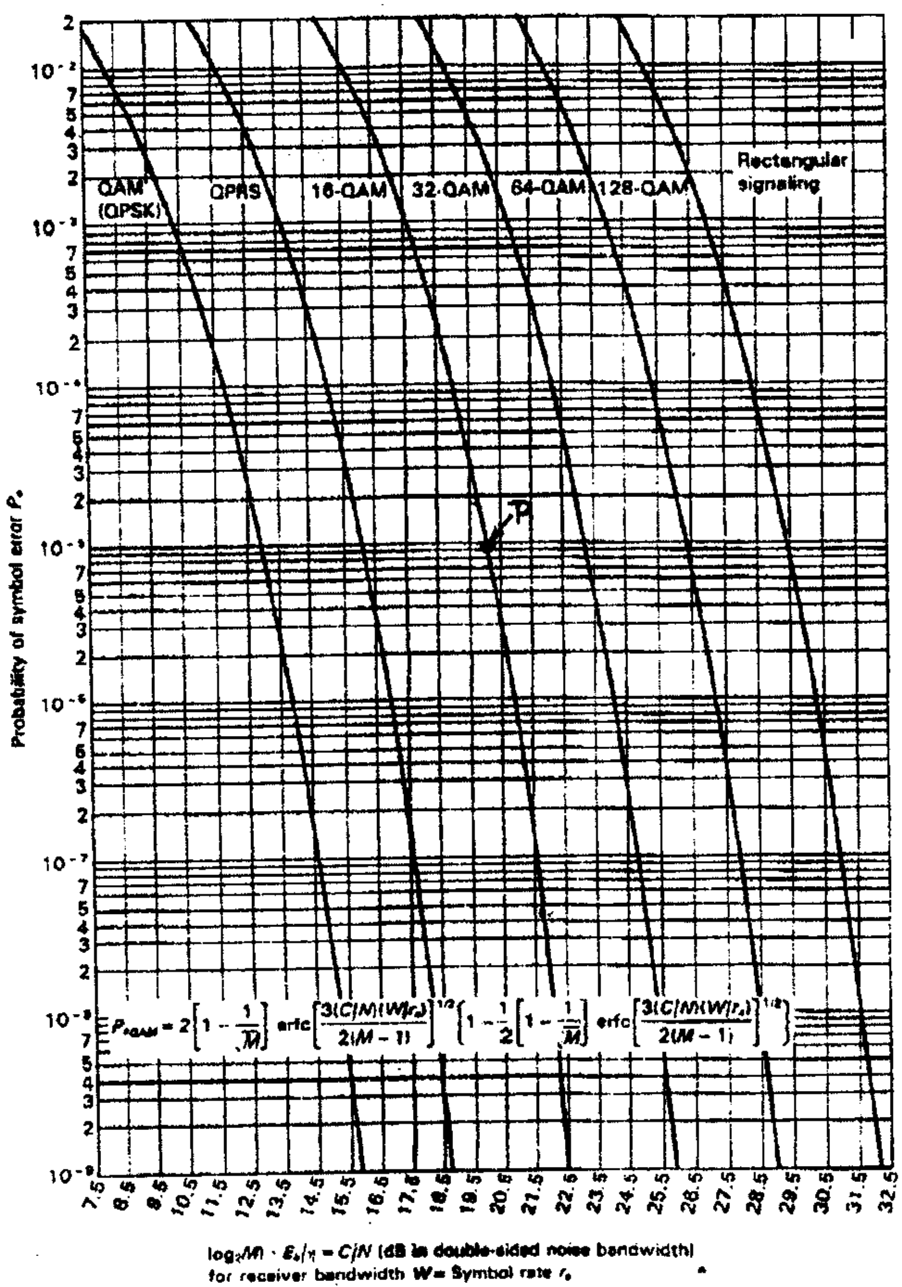

Figure 6.28 Probability of error versus double-sided noise C/N for QAM and QPRS systems

Figure B10-2.

Probability of error vs. signal-to-noise ratio curves. The curve corresponding to 16 QAM was utilized; the point of measurements is indicated with 'P' (from Ref. 2).

AURORA 2
Direct Sequence Spread Spectrum Radio
Processing Gain Test Results

(12/22/1997)

Test Method: Recommended by FCC 97-114: CW jamming margin method

Data Rate: T1 (1.544 Mbps)
Chip Rate: 15 chips/bit
Designed Processing Gain: 11.76 dB

1. Test Setup is shown in Figure 1:

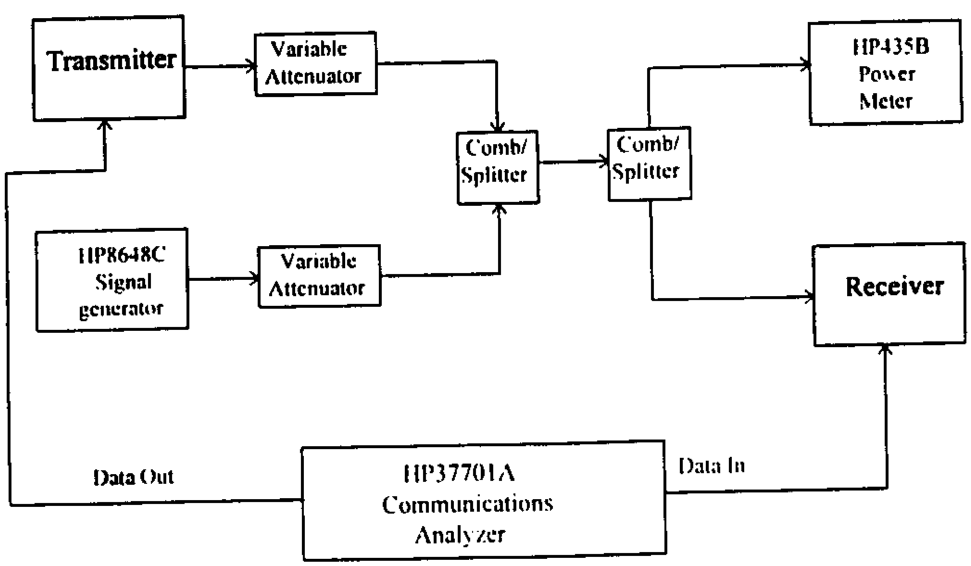

Figure 1. Processing Gain Test Setup

3. The S/N ratio for ideal non-coherent receiver is calculated from $Pe = \frac{1}{2} e^{(-\frac{1}{2}(S/N)o)}$, where $Pe = 10^{-5}$. Hence $(S/N)_o$ = 13.3 dB.

4. The processign gain can be calculated as:

   $G_p = (S/N)_O + M_j + L_{sys}$

   Where L_{sys} = System Loss, and it's allowed to be no more than 2 dB (we assumed to be 0 dB).

   Hence G_p = 13.3 - 0.5 + 0.2 = 12.8 dB, better than the designed coding gain of 11.76 dB. It's better than FCC required minimum requirement of 10 dB.

1. Jamming Margin (J/S ratio) (for BER 10^{-5}):
   50 KHz increments are used in this test, the worst 20% were discarded.

Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)
2402.00	5.2	2404.00	0.8	2406.00	2.5
.05	5.3	.05	-0.1	.05	2.0
.10	5.6	.10	(x) -1.0	.10	1.5
.15	6.1	.15	(x) -1.7	.15	1.4
.20	6.0	.20	(x) -1.8	.20	1.6
.25	6.2	.25	(x) -2.0	.25	1.3
.30	6.5	.30	(x) -2.0	.30	1.3
.35	6.5	.35	(x) -1.7	.35	1.8
.40	6.8	.40	(x) -0.8	.40	1.6
.45	7.2	.45	-0.2	.45	1.2
.50	7.2	.50	1.2	.50	0.8
.55	6.7	.55	1.9	.55	0.3
.60	6.2	.60	2.8	.60	0.0
.65	6.0	.65	3.3	.65	-0.4
.70	5.4	.70	3.4	.70	-0.5
.75	5.4	.75	3.6	.75	(x) -0.8
.80	4.6	.80	3.9	.80	-0.2
.85	4.2	.85	3.8	.85	(**) -0.5
.90	3.8	.90	3.6	.90	-0.5
.95	3.9	.95	2.9	.95	0.4
2403.00	3.8	2405.00	2.3	2407.00	0.5
.05	3.7	.05	1.9	.05	1.0
.10	3.8	.10	1.2	.10	1.3
.15	3.7	.15	1.0	.15	1.2
.20	3.7	.20	0.5	.20	2.0
.25	3.8	.25	0.8	.25	2.6
.30	3.3	.30	0.8	.30	3.0
.35	3.7	.35	0.8	.35	3.9
.40	3.7	.40	1.5	.40	4.5
.45	4.2	.45	1.5	.45	4.4
.50	4.3	.50	1.6	.50	4.2
.55	3.7	.55	2.1	.55	4.0
.60	3.1	.60	2.1	.60	3.5
.65	3.0	.65	2.8	.65	3.2
.70	2.9	.70	2.8	.70	2.9
.75	2.8	.75	2.9	.75	2.1
.80	3.1	.80	3.4	.80	1.9
.85	3.5	.85	3.9	.85	0.8
.90	3.0	.90	3.9	.90	0.8
.95	3.4	.95	3.3	.95	0.3

Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)
2408.00	(x) -0.5	2410.00	(x) -4.3	2412.00	(x) -2.1
.05	(x) -0.8	.05	(x) -4.3	.05	(x) -2.1
.10	(x) -1.1	.10	(x) -4.9	.10	(x) -1.8
.15	(x) -1.3	.15	(x) -4.7	.15	(x) -1.1
.20	(x) -1.4	.20	(x) -3.8	.20	0.0
.25	(x) -1.5	.25	(x) -3.5	.25	0.5
.30	(x) -1.9	.30	(x) -2.2	.30	1.1
.35	(x) -1.3	.35	(x) -1.4	.35	2.0
.40	(x) -1.3	.40	(x) -0.5	.40	2.6
.45	(x) -1.3	.45	0.1	.45	3.3
.50	(x) -0.6	.50	0.3	.50	3.5
.55	-0.3	.55	0.3	.55	3.3
.60	0.1	.60	0.7	.60	2.8
.65	0.1	.65	0.8	.65	2.4
.70	-0.2	.70	0.8	.70	1.9
.75	-0.1	.75	0.8	.75	1.3
.80	-0.3	.80	1.2	.80	0.6
.85	-0.2	.85	1.2	.85	-0.3
.90	0.1	.90	1.3	.90	(x) -0.8
.95	0.0	.95	0.8	.95	(x) -1.1
2409.00	0.6	2411.00	0.4	2413.00	(x) -1.4
.05	0.9	.05	-0.2	.05	(x) -0.5
.10	1.8	.10	(x) -0.5	.10	-0.1
.15	2.1	.15	(x) -1.5	.15	-0.1
.20	2.1	.20	(x) -1.7	.20	0.0
.25	2.1	.25	(x) -1.8	.25	0.0
.30	2.4	.30	(x) -2.6	.30	0.8
.35	2.5	.35	(x) -2.2	.35	1.0
.40	2.3	.40	(x) -2.5	.40	1.1
.45	2.2	.45	(x) -2.1	.45	1.2
.50	1.5	.50	(x) -2.4	.50	0.8
.55	1.0	.55	(x) -2.3	.55	0.7
.60	-0.1	.60	(x) -2.4	.60	0.8
.65	(x) -1.7	.65	(x) -3.0	.65	0.9
.70	(x) -3.0	.70	(x) -2.5	.70	0.7
.75	(x) -4.0	.75	(x) -1.7	.75	1.4
.80	(x) -4.6	.80	(x) -1.9	.80	1.2
.85	(x) -4.8	.85	(x) -1.9	.85	1.3
.90	(x) -5.2	.90	(x) -1.8	.90	2.2
.95	(x) -5.8	.95	(x) -2.1	.95	2.8

Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)	Freq. (MHz)	J/S (dB)
2414.00	3.9	2416.00	-0.2	2418.00	6.7
.05	4.4	.05	2.0		
.10	4.1	.10	2.2		
.15	4.0	.15	2.8		
.20	3.5	.20	3.6		
.25	3.5	.25	4.5		
.30	2.8	.30	5.1		
.35	2.3	.35	6.0		
.40	1.7	.40	6.1		
.45	1.2	.45	6.4		
.50	1.0	.50	6.0		
.55	0.7	.55	5.1		
.60	0.7	.60	4.4		
.65	1.1	.65	4.0		
.70	1.1	.70	3.4		
.75	1.6	.75	3.1		
.80	1.6	.80	3.1		
.85	2.2	.85	3.4		
.90	2.4	.90	3.4		
.95	2.8	.95	4.0		
2415.00	3.5	2417.00	4.1		
.05	3.4	.05	4.2		
.10	3.4	.10	5.2		
.15	2.9	.15	5.9		
.20	2.3	.20	6.4		
.25	1.9	.25	7.2		
.30	2.2	.30	7.6		
.35	2.2	.35	7.9		
.40	2.1	.40	7.9		
.45	2.3	.45	7.9		
.50	1.7	.50	7.7		
.55	1.3	.55	7.0		
.60	0.8	.60	6.2		
.65	0.8	.65	5.5		
.70	-0.2	.70	5.4		
.75	(x) -0.5	.75	5.7		
.80	(x) -0.5	.80	5.9		
.85	-0.3	.85	6.4		
.90	-0.3	.90	6.3		
.95	(x) -0.7	.95	6.5		

After discarding the worst 20% (64 points marked with (x)), the lowest J/S ratio is -0.5 dB (marked with (**)).

Hence $M_j = -0.5\ dB$.

EXHIBIT C.6

Label Content & Location.