EXHIBIT B.3

INSTALLATION & OPERATING INSTRUCTIONS

From Document

RMN-001627-E01, issue 2 Preliminary, December 1998
CHAPTER 4

CHAPTER 4

Installation Planning

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 misuse of this Aurora radio product and its software.

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

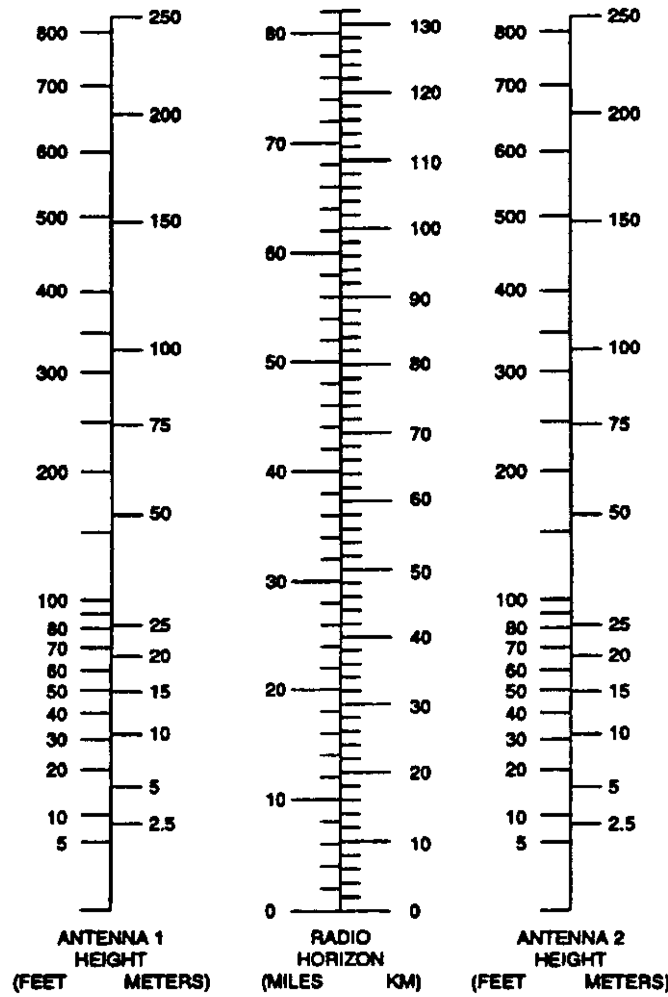
All antennas in the radio network must be able to "see each other". That is, there must be a direct line-of-sight path between the communicating antennas.

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

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

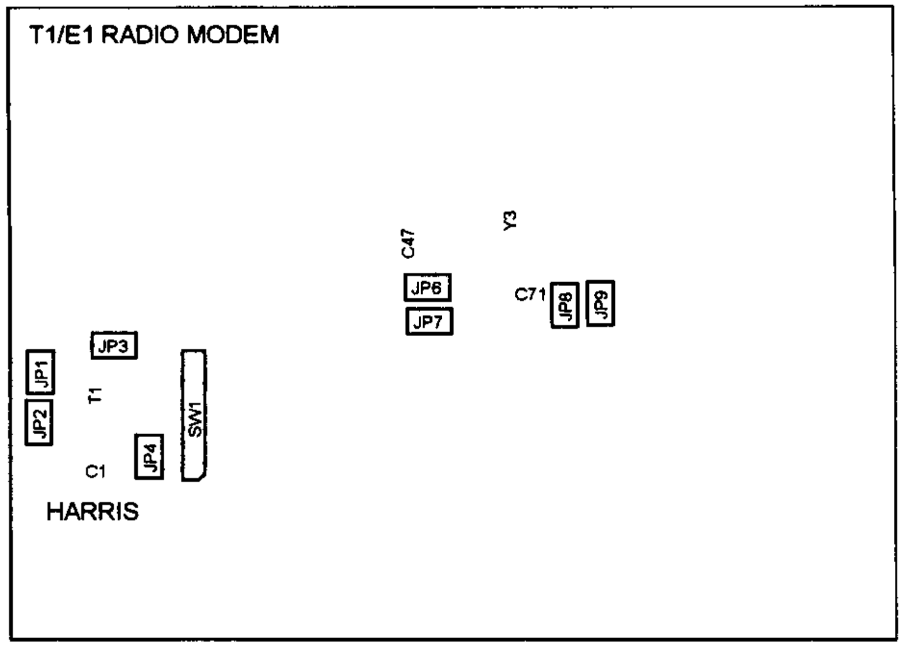
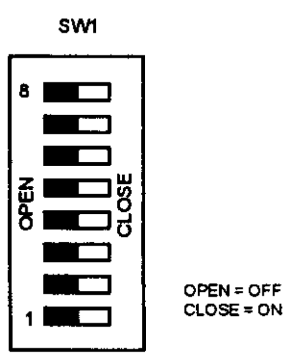


Figure 4-3 SW1, DIP switches



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

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

and the radio's unadjusted EIRP is

$P_{EIRP} = 25 + G_A - L_C$ (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.

EXHIBIT B.4

Brief Description of Circuit functions.
Description of how the System Operates.
Description of Ground System.
Description of Antenna System.