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PRELIMINARY

.

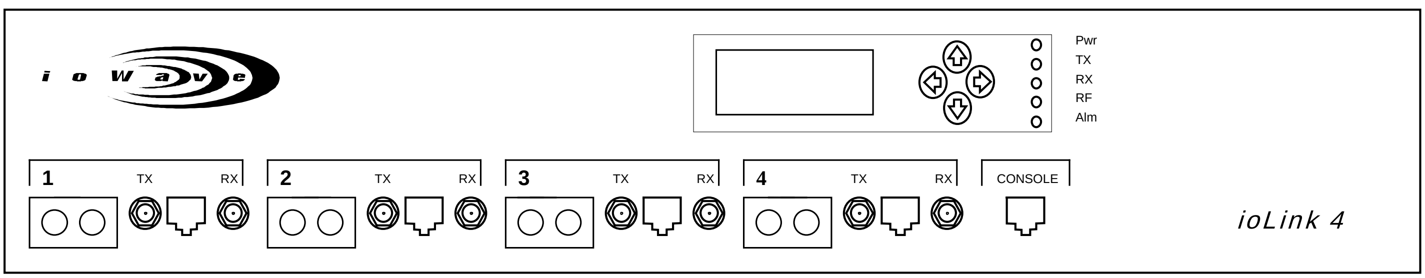
User Guide

Technical Reference

for

ioLink 4

Wireless System



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Welcome

We welcome you to the world of Wireless Communications. To familiarize you with the **ioLink 4** and help you get the most out of the system, please review the enclosed information and keep it for your reference. You will find:

1. Quick Start Installation Guide booklet to provide you with an overview of the system, installation instructions, and troubleshooting tips.

2. This User Technical Reference Guide that contains in depth information on how to use the system. It is designed for system managers, telecommunications engineers and electrical engineers — those involved in hands on operation, troubleshooting, and monitoring of communications systems.

Please be sure to read the section entitled "Important Information Regarding Your **ioLink 4** Wireless System" which appears in Appendix C.

We value your investment in our system and encourage you to call us with your comments and suggestions. We look forward to serving you.

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SECTION 1 *ioLink 4* PRODUCT DESCRIPTION

The **ioLink 4** provides four full-duplex Direct Sequence Spread Spectrum (DSSS) devices for T1/E1 rate wireless communications between two line of sight (LOS) locations. It can be connected to many types of interfaces to meet various communication needs. The technologies incorporated in the **ioLink 4** give you an efficient, minimal interference, error-resistant link compare to other services, and a superior carrier-to-interference (C/I) performance ratio.

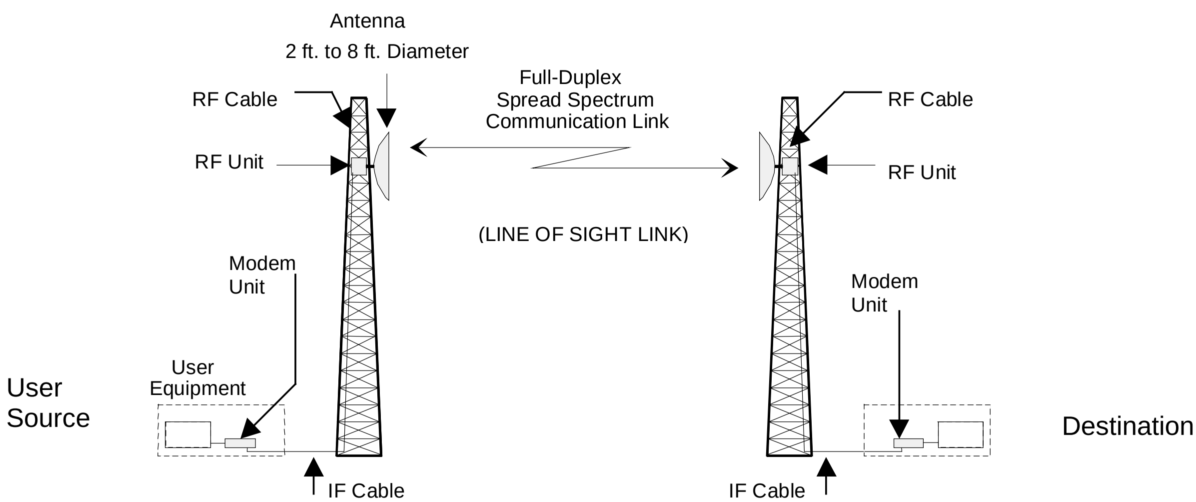
1.1 Key Features and Benefits

The **ioLink 4** system provides many important features and benefits:

- Offers quick turnaround on investment and savings versus recurring leased line charges
- Does not require user licensing (complies with FCC regulation Part 15)
- Provides clear and robust communications over a range of distances
- Is capable of voice, video, and data transmissions
- Operates in the precertified 2.4 – 2.4835 GHz and 5.725 – 5.850 GHz ranges which are virtually immune to atmospheric interference such as rain or snow
- Provides four full duplex T1 (1.544 Mbps) or E1 (2.048 Mbps) capacity with DSX-1 or G.703 interfaces, respectively
- Provides forward error correction (FEC) — rate-½ for E1 and rate- ¾ for T1 — for advance warning of potential errors in communication, and alerts the user of changes in the environment that may not have been present during installation which could impact the transmission path
- Is fully compliant with the simple network management protocol (SNMP)
- Provides configuration management via the front panel or a Personal Computer.

A schematic of an **ioLink 4** installation appears on the next page.

Figure 1-1. Typical Link Setup



One communications link consists of one **ioLink 4** terminal (RF Unit, Modem Unit, Antenna, and Cables) installed at each end of the line-of-sight link. The **ioLink4** link provides four E1 or T1 connections.

1.2 Advanced Features

The **ioLink 4** system includes several unique features:

- Performance monitoring
- Diagnostic testing
- Ability to place multiple links in the same area without interference.

These advanced features allow the user to keep the link up and running with little effort while giving the user a powerful set of diagnostics and statistics to detect or troubleshoot potential problems.

1.2.1 Performance Monitoring

Performance monitoring is an important quality control tool. The various statistics the user can obtain from the front panel menus or via a PC can inform how the system is performing. Even though the link is functioning properly, the ability to keep track of link performance allows the user to see changes in the link, which may degrade communications over time.

The **ioLink 4** wireless system is fully compliant with the simple network management protocol (SNMP) and provides the user with a performance monitoring system. The system allows the user or system manager to not only obtain the latest information on link performance, but also allows link performance to be observed over time. The **ioLink 4** management information base (MIB) enables the user to monitor link performance through the network management system (NMS) as well as from the front panel. Statistics for errored seconds, severely errored seconds, unavailable seconds, and degraded minutes are automatically tracked. The modem keeps track of these statistics internally for 24 hours at 15 minute intervals. This can help the system manager see if there is anything affecting the link as well as the ability to detect times of day which have more errors in the communication link.

1.2.2 Forward Error Correction Alert

As various alarms alert the user of errors in communication or of link failure, the system also provides an alert via forward error correction (FEC). The FEC corrects bit errors, which provides the user with error free performance even when bit errors are occurring during transmission. The system monitors the transmission errors and alerts the user when the rate reaches a preset limit. The user can set this alert to be triggered at a desired level to provide advance warning of potential errors and interference in the link. If the link transmission has a Bit Error Rate (BER) worse than the preset threshold, the system will give a warning. This warning can alert the user to changes in the environment that may not have been present during installation such as new interference, growth of trees, or obstructions that may impact the transmission path so the user can take corrective action.

1.2.3 How to Contact Us

If a problem persists after troubleshooting, or the specific problem does not appear in any of our charts, contact our technical support personnel at **ioWave**.

Any problems due to component failure are addressed in the warranty and service agreement. Any product that must be returned to **ioWave** must have the proper authorization number obtained prior to shipping. See warranty and service guidelines provided at the end of this guide and in the Installation and User Guide Technical Reference which comes with the equipment for more information.

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SECTION 2 *ioLink 4* SYSTEM COMPONENTS

The **ioLink 4** system consists of five parts:

1. Modem Unit (indoor)
2. Intermediate Frequency (IF) Cable
3. Radio Frequency Unit (outdoor)
4. Radio Frequency (RF) Cable
5. Antenna.

2.1 Modem (Indoor) Unit Description

The **ioLink 4** indoor modem unit measures 16.7" Wide x 3.5" High x 10.4" Deep. Its metal housing allows it to be rack-mounted in a standard 19" equipment rack or you may place it on a flat surface such as a table or desktop.

Figure 2-1. Modem Unit Front Panel

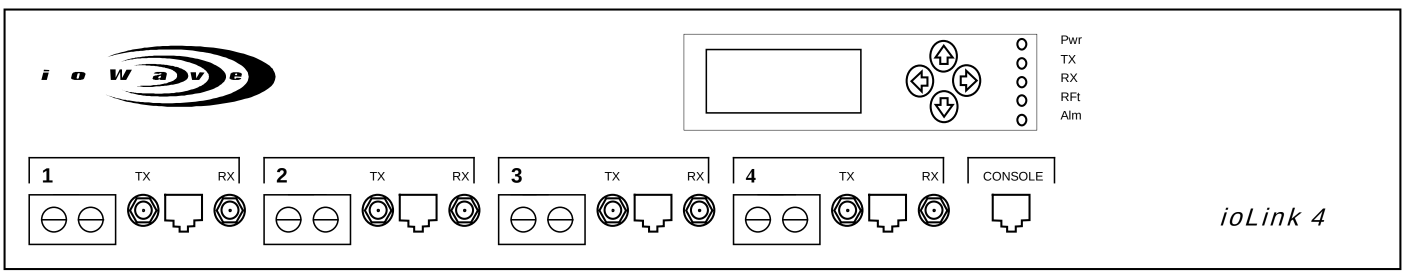
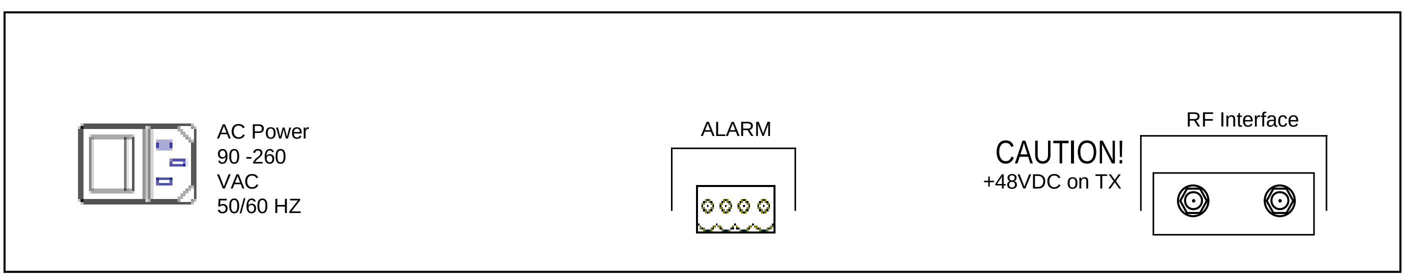


Figure 2-2. Modem Unit Rear Panel



The Modem unit consists of:

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- A spread spectrum, which spreads, modulates, demodulates, and despreads the user T1/E1 signal.

The modem board also contains an embedded microprocessor, which is used to control the link configuration. You may adjust settings via a front panel keypad or an RS232 interface. Default values are entered when the modem unit is manufactured. You may store configuration changes in non-volatile memory or you can restore the original default factory settings. The non-volatile RAM stores the current configuration settings and the firmware that controls the system; if there is a power loss to the unit, this information will not be lost.

- A power supply which powers both the modem unit and the RF unit.
- A four-key keypad and a liquid crystal display (LCD) that is used to configure and monitor the system. (All the settings in the configuration menu have default values that should be adequate for most system setups.)
- Five light-emitting diodes (LEDs) that indicate if the unit is transmitting and receiving normally or if there is an error preventing the system from working properly.
- Connections to the RF unit and Customer Premise Equipment (CPE).
- Circuitry for Forward Error Correction (FEC) on **ioWave**'s T1 version only.

The modem unit is designed for indoor use in normal office or electronics equipment room conditions. The suggested operational temperature range is from 0^{o} C to $+60^{o}$ C. Provide adequate ventilation to ensure that the unit stays well within the operating temperature range. The modem unit can operate in up to 95% humidity (non-condensing). The modem unit may be stored in a temperature range of $–40^{o}$ C to $+60^{o}$ C.

2.2 Intermediate Frequency Cable

The modem unit is connected to the RF unit via two coaxial cables called IF cables. These cables allow the information to pass between the modem and RF unit and carry power to the RF unit from the power supply in the modem unit enclosure. The maximum length of each IF cable is 500 feet. If longer cable lengths are required, contact **ioWave**'s sales or customer support personnel. The maximum resistance for this cable is 9 ohms.

2.3 RF (Outdoor) Unit Description

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The RF unit consists of two circuit boards, a power supply (PS) board and an RF board, placed in a 12" High x 12" Wide x 4 1/4" Deep NEMA-4 weatherproof enclosure. The RF unit is usually mounted directly behind the antenna, therefore it has mounting holes in its base-plate flange enabling easy attachment to a tower or pole. It has two TNC-type jacks for connecting to the modem unit via the IF cable and an N-type jack for connecting to the antenna via the RF cable.

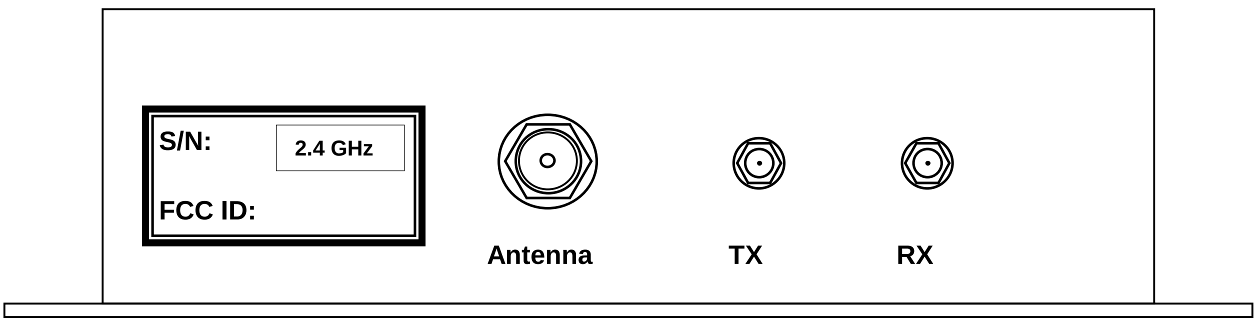

Figure 2-3. RF Unit Connections

The PS board contains cavity filters, an isolator, circulator, and a DC-DC converter, which supplies the various voltages needed in the RF unit.

Note: ioWave`s standard RF unit transmits a 15 dbm power output. A "high power" option is now available which transmits 25 dbm. This option can be utilized in any instance where an antenna upgrade in gain is not a viable alternative, while at the same time keeping in mind FCC threshold regulations.

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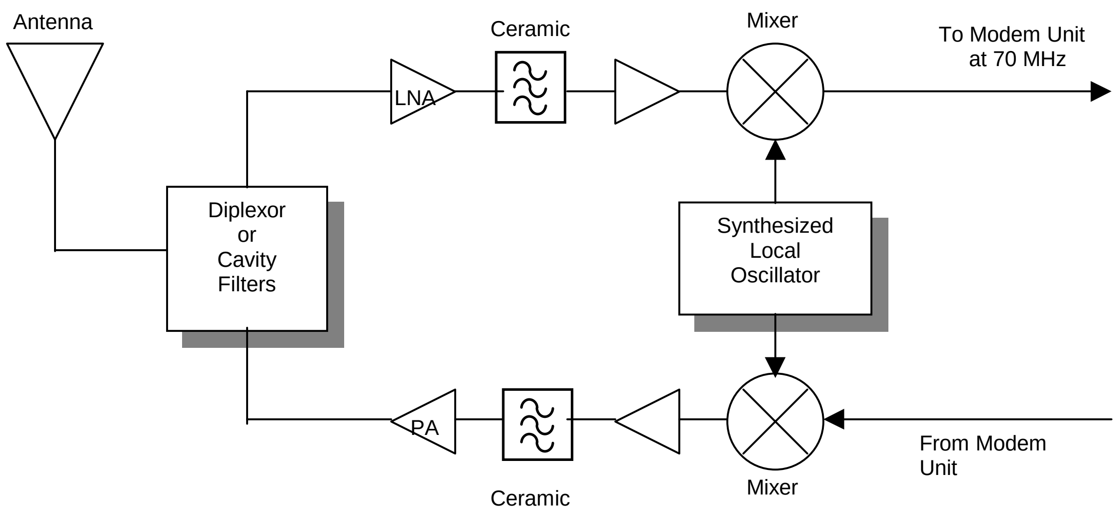
The RF board contains oscillators and amplifiers, including the Power Amplifier (PA), Voltage Controlled Oscillator (VCO), the Low Noise Amplifier (LNA), ceramic filters, a mixer, and synthesizer chip. The RF board also contains the connections to the modem unit as well as to the antenna (see the following RF unit block diagram).

Figure 2-4. RF Unit Block Diagram



The RF unit has a NEMA-4 enclosure to protect the unit from harsh environmental conditions. The enclosure is sealed to be weatherproof and can operate at temperatures between –40^{o} C and +60^{o} C without damage to the internal circuitry. A vent device on the enclosure allows pressure equalization without compromising the environmental seal. The RF unit must be mounted so that vent immersion is not possible. To help protect against lightning strikes, the unit should be grounded to a support structure via the unit's grounding stud. The RF unit may be stored in a temperature range of –40^{o} C to +60^{o} C.

2.4 Radio Frequency Cable

The RF unit is connected to the antenna by a single, low-loss 50 ohm coaxial cable called an RF cable. The antenna and the RF unit should be placed as close as possible. The RF cable should also be tied down to the support structure to minimize movement and stress from high wind. In lightning susceptible installations, a lightning arrestor such as a Poly Phaser™ Mode IS-MF 50LN is recommended.

2.5 Antenna Description

The antenna is usually a grid or parabolic-dish type and normally is no larger than two feet in diameter. For short distances (2 miles or less) Yagi antennas may be used. The antenna chosen can have linear, elliptical, or circular polarization. Each antenna can be mounted on a roof, a tower, or positioned inside a non-metalized glass window and must have a radio line-of-sight (LOS) link with the receiving antenna. The type of antenna required is based on the distance of the link, number of co-located links and region. Please consult **ioWave**, or **ioWave** qualified vendors, when selecting the antennas.

2.6 Antenna Selection and Consideration

2.6.1 Size

The distance the signal must travel from one end of the link to the other is the primary factor in determining the size of the antenna. In addition, the environment in which you place the antennas needs to be considered in selecting the antenna size.

The gain of the antenna is usually proportional to the size of the antenna. Antenna gain is a measure of the amount of focusing of a signal the antenna achieves upon transmission or reception. **ioWave**'s Systems Integration team can calculate the required antenna gain after completing a site survey and path analysis for a particular link.

The larger the antenna, the narrower its beam width and the higher the resulting gain. Narrower beam widths increase the possibility of making a successful link, especially when there are possible obstructions and interference. If you are placing an antenna in an urban environment, you may need a larger antenna to transmit and receive signals than you would in a rural environment even if the distance between antennas is the same. This is due to urban environments usually having more obstructions and interference.

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2.6.2 Polarization

Another important antenna characteristic is polarization. Polarization refers to the direction in which the electrical field (i.e., wave) of a signal is oriented. For example, antennas may have linear, elliptical, or circular polarization. The antenna at each end of the link must have the same type of polarization, and they must be oriented in the same direction (e.g., horizontal to horizontal or right-hand circular to right hand circular). Linearly polarized antennas are the most common type used with this kind of system. Most often, linearly polarized antennas are oriented either horizontally or vertically. Antennas with circular or elliptical polarization have their signal constantly rotating either clockwise or counter-clockwise (commonly called right-handed or left-handed). The advantage of this is that it helps to eliminate multi-path fading due to the nature of circular polarization rejection. The degree to which "the other" polarization is ignored is called "cross polarization rejection." This can be used to an advantage, allowing parallel installation of **ioLink 4** links (e.g., a horizontal link and a vertical link).

Multipath fading is a situation in which the signal reflects off some object (typically the ground or a building) and causes interference at the receiving antenna. The rejected, multipath signal travels farther so it is slightly delayed from the main signal. If the "true" signal and the reflected signal reach the antenna out of phase, the reflected signal will destructively interfere with the "true" signal. When linearly polarized signals reflect off an object they retain their orientation, but when signals with circular polarization reflect off an object their polarization is reversed (i.e., left-handed becomes right-handed and vice versa). It is for this reason that circular polarization is more effective at eliminating multi-path fading and recommended under certain conditions. The destructive cancellation of multipath is highly frequency specific; so, broadband spread spectrum systems such as **ioLink 4** are inherently multipath tolerant. Installation in severe multipath areas may however benefit from the use of circular polarization.

> **Note:** Antenna sizes and their corresponding distances from each other should be calculated for each individual path. **ioWave**'s System Integration team can make accurate recommendations for the antenna once the sites for the link have been determined.

2.7 Typical Link Setup

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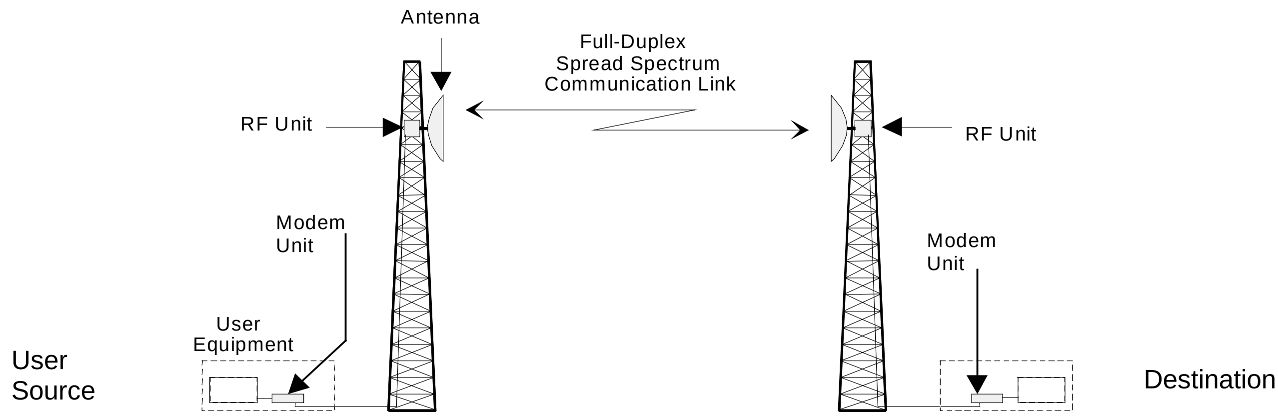
The **ioLink 4** provides full-duplex communications – both ends of the link can transmit and receive signals simultaneously, which enables real time voice, video, and data communications. The diagram below shows a typical setup.

Figure 2-5. Typical Link Diagram



One communications link consists of one **ioLink 4** terminal (RF Unit, Modem Unit, Antenna, and Cables) installed at each end of the line-of-sight link. Once the link is established between the two terminals:

1. The sending user's data is fed through the modem where it is multiplied by a pseudo-random noise (PN) code to spread the signal. It is then connected to a 110 MHz Intermediate Frequency (IF) and sent to the RF unit.

2. The IF signal is further upconverted to a 2.4 GHz RF, or a 5.7 GHz RF, and is passed through a series of filters and amplifiers and transmitted via the antenna to the other end of the link. There, the information goes to the receiving user's device by reversing the process used on the transmit side.

2.7.1 Normal Operation

Once the installation is complete, power on the **ioLink** system to verify correct installation. Once you power the modem unit, it should cycle through the light emitting diodes (LEDs) and show the following on the LCD screen.

2.7.2 LCD Screen Cycling

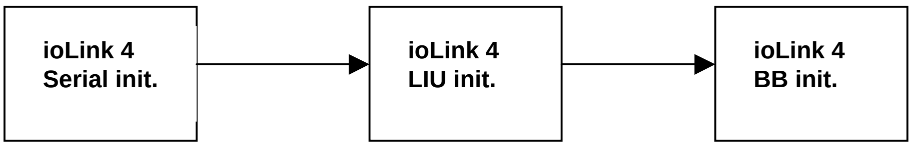


Figure 2-6. Liquid Crystal Display (LCD) Screen Cycling

After about 10-20 seconds, the “Pwr,” “RX,” and “TX” green LEDs should be on and the LCD should present the Signal Level display. The Signal Level should be above 40%. If these conditions exist, then communication over the link should be possible.

If the red “RF” LED and/or the red “Alm” LED are on, or the Customer Premise Equipment (CPE) cannot communicate with the other end of the link, there is a problem somewhere in the system. If the Modem unit does not show the characteristics of normal operation, see Troubleshooting, Section 5, for help in diagnosing and correcting the problem.

2.8 Advanced Features

The **ioLink 4** system also contains several unique features that result in superior operation:

- Performance monitoring
- Diagnostic testing
- The ability to place multiple units in the same area without interference.

These features allow the user to keep the link up and running with little effort while giving the user a powerful set of diagnostics and monitors to detect or troubleshoot any potential problems.

2.8.1 Performance Monitoring

Performance monitoring is an important quality control tool. The various statistics the user may obtain from the LCD menus or via a PC tell you how well the system is performing. Even though the link is functioning properly, the ability to keep track of link performance allows you to see changes in the link, which may cause problems in communication over time. This saves money and prevents downtime by allowing the user to correct problems in their early stages and keep the link functioning at maximum performance. For example, the **ioLink 4** features alarm status, signal power indicators and monitors performance to provide the number of errored seconds and unavailable seconds.

ioWave's wireless systems are fully compliant with the Simple Network Management Protocol (SNMP) and readily interface with existing user software. The system allows the user or system manager to not only obtain the latest information on link performance, but it also allows them to observe link performance over a period of time. Even though the link may be up and running, there could be factors degrading it that probably wouldn't be noticed without this monitoring capability. The system allows for early detection of possible problems, preventing downtime.

Early detection of system problems is a key feature of the system. **ioLink**'s Management Information Base (MIB) enables the user to monitor link performance through the NMS as well as from the front panel. Statistics for errored seconds, severely errored seconds, unavailable seconds, and degraded minutes are automatically tracked. The system keeps track of these internally for 24 hours at 15 minute intervals. This helps the system manager to see if there is anything degrading the link and allows him/her to track times of day when there are more errors (if any) in the communication.

This information can be tracked by the system manager over an extended period of time so that the user can observe link performance on a larger scale. This helps immensely in detecting potential problems very early so that they can be corrected before they become serious.

2.8.2 Forward Error Correction Alert

As our various alarms alert the user of errors in communication or of link failure, the system also provides an alert via Forward Error Correction (FEC). The FEC corrects bit errors, which provides

the user with error-free performance even when bit errors occur during transmission. The **ioLink** monitors the transmission errors and alerts the user when the rate reaches a pre-set limit. The user can set this alert to be triggered at a desired level to provide advance warning of potential errors in communications. If the link transmission has a Bit Error Rate (BER) worse than the preset threshold, the system will give a warning. This warning can alert the user to changes in the environment that

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were not present at installation that may impact the transmission path, so the user can take corrective action.

- **Circuitry for Forward Error Correction (FEC)**
  Once the link is established, the FEC works in the following manner:

  "All user data bits are encoded by the transmitting side's modem unit and sent to the receiver. The receiving modem unit uses an algorithm along with the previously received set of bits to determine the possible valid configurations for the current set of bits. If the current set of bits are not of a valid form, an alarm is registered (see "FEC decoder not locked" in section IV, Network Management). Since the receiving modem unit knows all the possibilities of what the current set of bits should be, it can then use this information along with the FEC algorithm to correct most bit errors that may have been introduced during transmission."

- **Influence of FEC on Bit Error Rate (BER)**
  Forward Error Correction is used in the **ioLink 4** to reduce the number of bit errors encountered in normal wireless transmission. To do this, the transmitting unit uses the previous block of data to predict what form the current data signal should have so that the receiver may use the redundant signal to find any errors in the original signal and correct them. Depending on the nature and periodicity of the errors, FEC may not always detect and correct every error that is introduced into the signal. If the errors are singular in the signal, it is easier for the error detection circuitry to find and correct the errors. If the errors are introduced in large bursts, it is more likely that the circuitry will be unable to correct all of the errors.

The following example shows the difference between the two cases. Both link A and link B may be experiencing a total of 3,600 uncorrected errors every hour, but the post-FEC BER for the two links may be quite different. If link A receives 1 error every second, the FEC circuitry should be able to correct all of the errors as there are few errors at any point in time. If link B receives a burst of 1,200 errors every half-hour on the half-hour, the FEC circuitry will have more difficulty correcting the errors because of the high volume of errors introduced. Notice that both links get an average of 3,600 errors per hour, but the distribution in which they get them affects the ability of the FEC to find and correct those errors. Link A will have a post-FEC BER of nearly zero while Link B's post-FEC BER will be around 10(-7).

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As mentioned in the Advanced Menu section, the **ioLink 4** has a menu item that displays the Pre-FEC BER. This gives the user an indication of how many errors the unit receives prior to the signal going to the FEC circuitry in the modem unit.

This menu item does not display the BER once the signal is corrected for errors, since the post-FEC BER cannot be determined very accurately by the very nature of how FEC works. The BER that the user equipment sees is much better than that displayed on the Pre-FEC BER menu item.

Although the post-FEC BER cannot be exactly determined, it can be estimated. The following chart shows approximately how the BER is improved by the particular FEC scheme that is used in the modem unit. This chart assumes that the errors are introduced into the signal periodically rather than in bursts. For example, this chart may represent BER improvement given a uniform average of 300 errors per minute (i.e., 5 errors every second). The chart would look different for bursts of 300 errors every minute (i.e., all 300 errors occur at the end of each minute).

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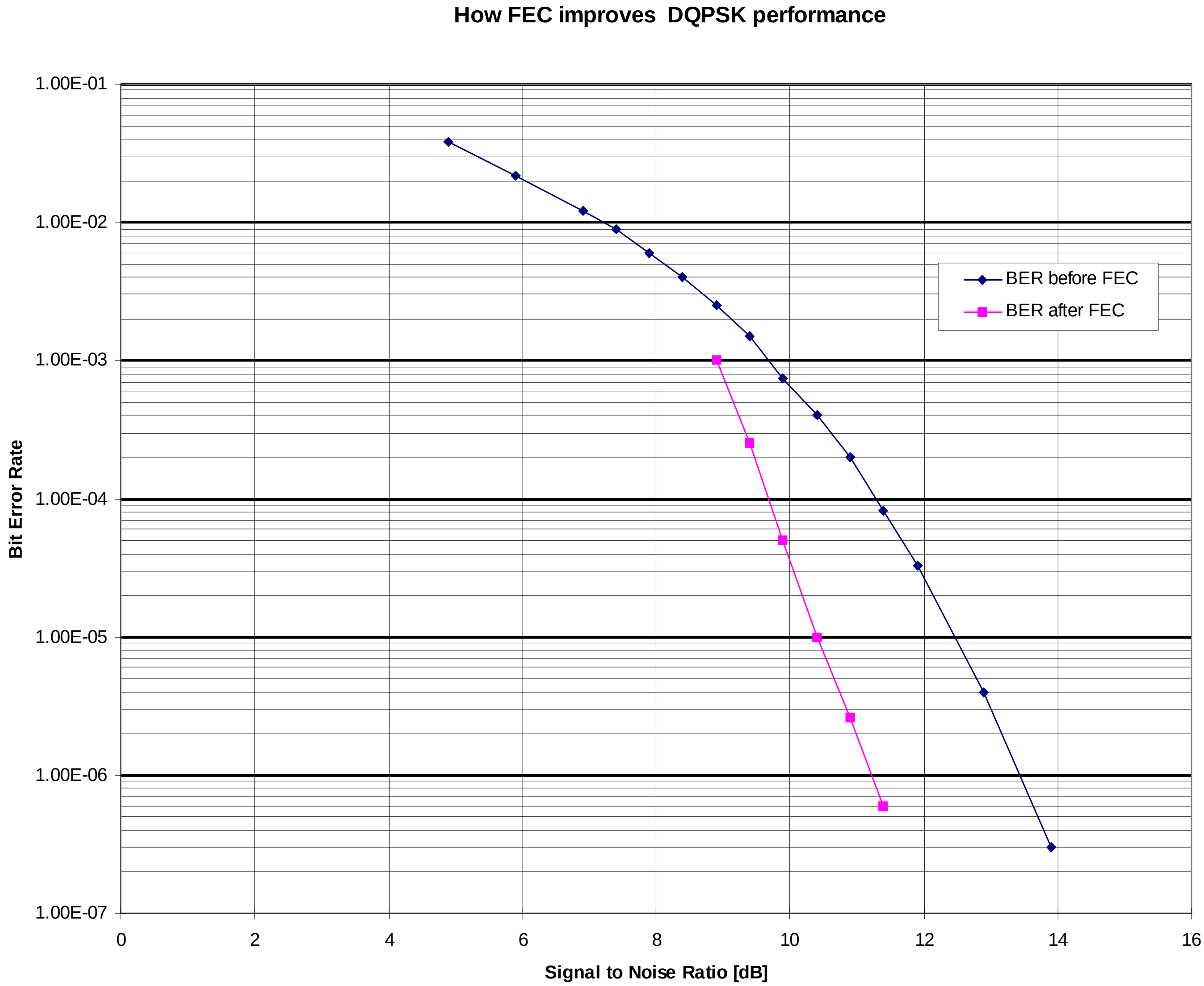

Figure 2-7. Forward Error Correction (FEC) Improvement of Bit Error Rate (BER) for Differential Quadrature Phase Shift Keying (DQPSK)

Note: This chart does not represent the actual performance of FEC in every situation. It is meant to show that the addition of FEC circuitry in the **ioLink 4** improves BER as seen by the user equipment.

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2.8.3 Diagnostic Testing

The **ioLink** system has several diagnostic tests and alarm indicators to pinpoint performance problems. By performing a few simple tests and noting the alarms, the user can isolate the source of the problem for diagnosis and correction or repair. Determining whether the communication error is in the **ioWave** equipment or Customer Premise Equipment (CPE) simplifies troubleshooting and reduces unnecessary equipment returns.

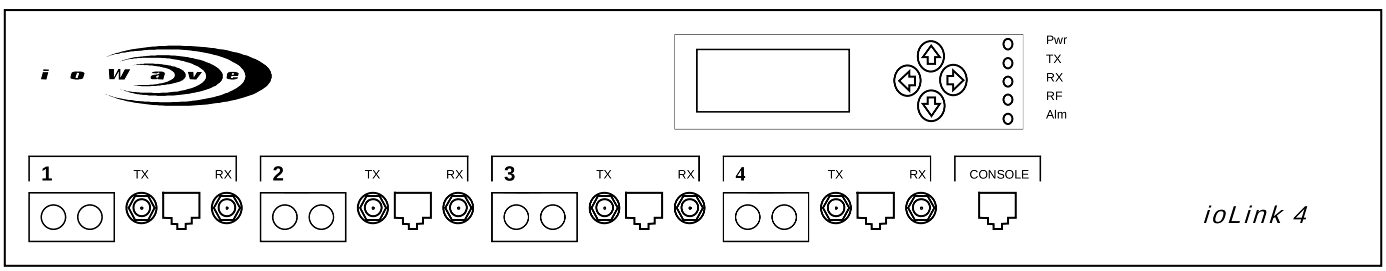
SECTION 3 OPERATING THE *ioLink 4*

The modem unit of the **ioLink 4** contains all the software and interfaces you will need. The unit has several connectors on the rear panel as well as LEDs, an LCD display, and a keypad on the front panel. This section describes the function of the connections, indicators, and features in the modem unit.

3.1 Front Panel Interactions

The LEDs, LCD, and keypad are on the modem unit's front panel. All system events and errors that occur are indicated on the LCD or the LEDs. Because the **ioLink 4** is SNMP-compliant, you can remotely monitor and control the device via a serial DE-9 connection to troubleshoot and diagnose problems and to measure network reliability for quality control.

Figure 3-1. Modem Unit Front Panel



3.1.1 LED Indicators

The front panel's five LEDs indicate the status of the link. The following table describes each light.

Table 3-1. Light Emitting Diode (LED) Indicators

LED	Color	Meaning
Pwr	Green	The unit is connected to line power and the internal power supply is supplying 5 V.
TX	Green	Indicates the unit is receiving valid input at the DSX or G.703 interface.
RX	Green	Indicates the unit is receiving valid information from the RF unit.
RF	Red	Indicates the signals received from the RF unit are either too weak or non-existent.
Alm	Red	Indicates an alarm condition exists. The specific alarm will then be displayed in the ALARM Menu on the LCD.

In normal operation, only the green "Pwr," "TX," and "RX" LEDs are lit. If the system encounters any problem, the red "RF" and/or the "Alm" LEDs will light up. If either the "RF" or the "Alm" LED is on, the LCD will show an error message. (See Section 5, Troubleshooting.)

3.1.2 Keypad and LCD

To interact directly with the **ioLink 4**, use the LCD and the four-key keypad on the front of the modem unit. The information that may be displayed on the LCD is arranged into five cyclical menus: STATUS, CONFIG, TEST, ALARM, and ADVANCED. Using the arrow keys on the keypad, you can:

- Cycle between the five menu headings (<- -> at the top pages of each)
- Scroll through each of the menus (/\) and (\/)
- Change options in the CONFIG, TEST and ADVANCED menus.

These menus are cyclic. Thus, paging down past the last menu item listed in each column would return the display to the top. Also, the headers for the menus are linked this way as well. By pressing both the up and down keys simultaneously, the display is automatically returned to the current menu heading.

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3.1.3 ioLink 4 LCD Menus

The currently selected item is indicated by parenthesis (the defaults are indicated below). When an item changes, the entire display flashes to indicate that the change has been completed.

Table 3-2. Liquid Crystal Display (LCD) Menu Defaults

STATUS	CONFIG	TEST	ALARM*	ADVANCED
Status Menu <- Next Menu ->	Config Menu <- Next Menu ->	Test Menu <- Next Menu ->	Alarm Menu <- Next Menu ->	Advanced Menu <- Next Menu ->
RF Signal Level xx%	Encoding (B8ZS) AMI	Full Loopback (Off) On	Alarm 1 …	BER Threshold 2.0 E-7
Signal Level xx%	T1 Data Cable (133) 266 399 533 655	Far-end Loopback (Off) On	Alarm 2 …	BER Interval 100 s
Pre-FEC BER x.x E-x	TX Code (1) 2 3 4	Source Loopback (Off) On		Jitter Atten (RX) TX None
Data Rate T1	RX Code (1) 2 3 4 Channel Plan (A1) A2	Set Factory Def (No) Yes		Acquire Thresh 050H
Data Rate E1	RX Code (2) 2 3 4 Channel Plan (A1) A2	Set Factory Def (No) Yes		Acquire Thresh 050H
Software Version 1.1.0	Store Config (No) Yes			Symbol Thresh 010H
Firmware Version 2.1.0	Set Factory Def (No) Yes			FEC BER (Off) (On)
Serial Number MUXXXXX				FEC Loopback (Off) On
Channel Plan A1 .. A2				LIU Loopback (Off)Loc RM Net BER Threshold 2.0 E-7 BER Interval 100 s

* When there are active Alarms, they will be displayed via this menu.

3.1.3.1 STATUS Menu Item Definitions

The STATUS Menu displays information about the hardware configuration of the link and the performance of the modem unit and the link. The items in this menu do not accept user input.

Table 3-3. Status Menu Items

RF Signal Level	The relative strength (arbitrary normalization) of the power received by the RF unit from the antenna. Typical values are from 83% to 100%.
Signal Level	The relative strength (arbitrary normalization) of the power received at the baseband processor. This is a measure of whether the signal received by the antenna is from the other end of the link or from a noise source. Typical values are 40% to 70%.
Pre-FEC BER	This is the rate of bit errors that are received from the link, before correction by the Forward Error Correction (FEC) circuitry. In usual operation, the FEC circuitry corrects most of the bit errors so that the error rate of the data sent to the user's equipment is smaller than this rate. See Advanced Menu section for details.
Data Rate	This will read either E1 or T1, depending on how the modem was configured at the factory.
Software Version **Firmware Version**	Displays the version numbers of the software and firmware that are installed in the modem unit.
Serial Number	Displays the serial number of the modem unit.
Channel Plan ***Note:*** *A "B" channel plan is also available which operates at a slightly different frequency.*	The RF channel plan for the link. The possible options are A1..A2 and A2..A1, where the first value is that of the local RF unit and the second that of the far-end RF unit. This setting has no operational effect on your link.

3.1.3.2 CONFIGURATION Menu Item Descriptions

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The configuration menu displays the current configuration parameters for the modem and allows the user to change the configuration. The items in this menu can be changed to suit the conditions of a given link. Using the Set Factory Default command (see below) can restore all default settings, but the unit must be restarted for the modem to reset all of the integrated circuits.

Table 3-4. Configuration Menu Parameters

Encoding	For modems configured as T1, the user may choose between AMI or the default B8ZS. For modems configured as E1, the user may choose between AMI or the default HDB3. B8ZS and HDB3 are zero-suppression encoding algorithms.
T1 Data Cable	This is the approximate length of cable between the modem unit and the user's data source. Changing this parameter will change the pulse shape of the DSX-1 signal transmitted from the DSX port. The cable lengths correspond to the standard Line Build Out (LBO) settings from +0.6 dB to +3.0 dB. This menu item is only present for T1 modems.
TX Code **RX Code**	There are four choices for the PN (pseudo-random noise) sequence used to spread and de-spread the signal. For the link, the RX code for each modem must match the TX code for the other modem, but different codes may be used for transmission in the two directions. See section IV, Network Management, for more details on selecting PN codes.
Store Config	This menu item allows the user to store the present configuration parameters in EEPROM so that the modem will return to the same configuration at the next power-up. When the units are shipped from the factory, the default parameters are stored in EEPROM. If the user changes the configuration stored in EEPROM, the factory defaults may be restored by the Set Factory Default menu item (see below).
Set Factory Default	Selecting YES at this menu item sets the modem to the default configuration (indicated by the parentheses in the above table).
Channel Plan ***Note:*** *A "B" channel plan is also available which operates at a slightly different frequency.*	This menu item allows the user to select the value of the local RF unit. Changes made here are reflected in the Channel Plan page of the Status Menu. This setting has no operational effect on your link and is only used for component location monitoring.

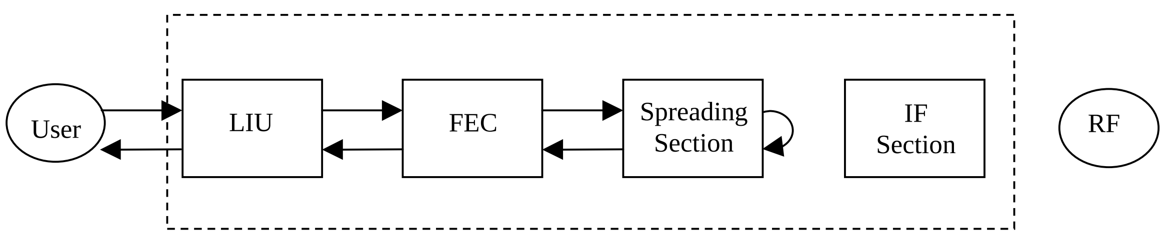
3.1.3.3 TEST Menu Item Descriptions

The TEST menu permits the user to place the modem into configurations that enable the testing of the modem to confirm the operating status. These modes are useful when the data input device is capable of providing a bit stream that may be detected and checked for bit errors (e.g., a Bit Error Rate Tester).

The tests that are available in the TEST and ADVANCED menus are powerful tools for diagnosing many problems in the system. These tests are especially helpful in determining where a problem may lie in the system (i.e., in the modem unit, user equipment, local or remote end, etc.). These tests must be performed with the use of a Bit Error Rate Tester (BERT). The BERT can be connected to either the DSX or G.703 interfaces on the back of the modem unit to read out the conditions of the test. The BERT can be used to provide bit streams for performing a test, or it can be used simply to test the signal already present in the system.

The following block diagrams are useful tools for visualizing what each test is doing and how they may be used in getting essential information to check the system. Items inside the dashed box denote modem unit sections. The arrows denote the signal path. An "X" in the path shows where the signal is terminated.

Figure 3-2. Full Loopback



a. Full Loopback

Selecting ON for this test mode places the modem into a loopback mode at the spreading chip in the baseband processing section. In this mode, the input data is processed by the LIU, FEC, and spreading circuitry, then looped back through the de-spreading FEC and LIU circuitry and returned to the input device. This allows the user to determine whether the line interface, forward error correction, and spreading sections of the modem are operating correctly.

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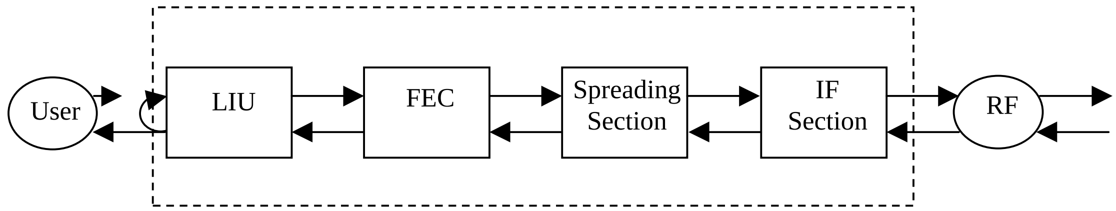
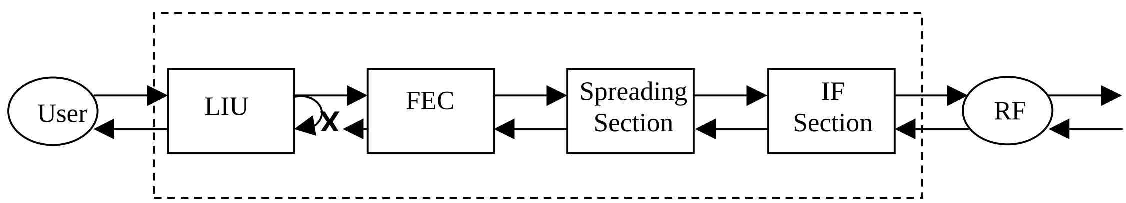
Figure 3-3. Far-end Loopback



b. Far-end Loopback

Selecting ON for this test mode places the modem into an internal loopback mode at the line interface chip. In this mode, the data from the far end of the link is looped back to it (as well as passed through to the DSX or G.703 interface). Input from the DSX or G.703 interface is ignored. This mode permits one to test the whole link from the far side.

Figure 3-4. Source Loopback



c. Source Loopback

Selecting YES for this test mode places the modem into a loopback mode at the line interface chip. In this mode, the data from the user device connected to the DSX or G.703 interface is looped back to it as well as passed through the modem to the far end of the link. Data from the far end of the link is ignored. This mode ensures that the input data source is operating correctly.

d. Set Factory Default

Selecting OK at this menu item sets the modem to the default configuration (indicated by the parentheses in the above table) cycle power.

3.1.3.4 ALARM Menu Item Descriptions

Initially, the ALARM Menu is empty. When an alarm condition occurs, the Alarm LED will light and a menu item will be added that indicates the cause of the current alarm. If multiple alarms are present, there will be multiple menu items available here. For all of these alarms, there are component failures that might cause the alarm condition to exist; however, for several of these alarms, there are non-fatal conditions. See Troubleshooting, Section 5, for additional information about the alarm conditions and for corrective action to be taken.

Table 3-5. Alarm Menu Conditions

Near-end Related Alarms	
• Transmit LOS	• This alarm is caused by a loss of signal from the user's device into the DSX or G.703 interface. In addition to causing the Alarm LED to light, it will cause the TX Data LED to be extinguished. The likely causes of this alarm condition are that the user's input device has been turned off or disconnected from the modem.
• LIU not Responding	• This alarm indicates an error with the communication between the control processor and the line-interface chip. This is generally a fatal alarm condition in that it indicates a component failure.
• Firmware not Responding	• This alarm indicates an error with the communication between the control processor and the firmware controlling the FEC and spreading chips. This is generally a fatal alarm condition in that it indicates a component failure.

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RF or Far-End Related Alarms	
• FEC BER > x.x E-x	• This alarm indicates that the pre-FEC BER has exceeded the BER Threshold for BER Interval consecutive seconds. Both the BER Threshold and the BER Interval may be set by the user in the Advanced Menu.
• FEC decoder not locked	• This alarm indicates that the forward error correction circuitry has discovered an error in the bit stream. If this is the only alarm condition, it is usually an indication that there is a problem with the far-end modem.
• RX Low Signal Power	• This alarm is caused by a low value of signal power being received by the RF unit. In addition to causing the Alarm LED to light, it will cause the RF Fault LED to light.
• RX Low Symbol Power	• This alarm is caused by a low value of power being received at the baseband processor. In addition to causing the Alarm LED to light, it will cause the RX Data LED to be extinguished.
• No Acquisition	• This alarm is caused by an acquisition failure by the de-spreading circuitry. The likely source of failure is the loss of signal from the far end of the link.
• AIS (Alarm Indicator Signal)	• This is caused by the modem receiving "all ones" from the DSX or G.703 interface. This indicates that a failure of the "upstream", or user, device has occurred.

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3.1.3.5 ADVANCED Menu Item Descriptions

The Advanced Menu has advanced options that are intended to allow knowledgeable users and technicians to debug problems. In general, most users will not need to use these features.

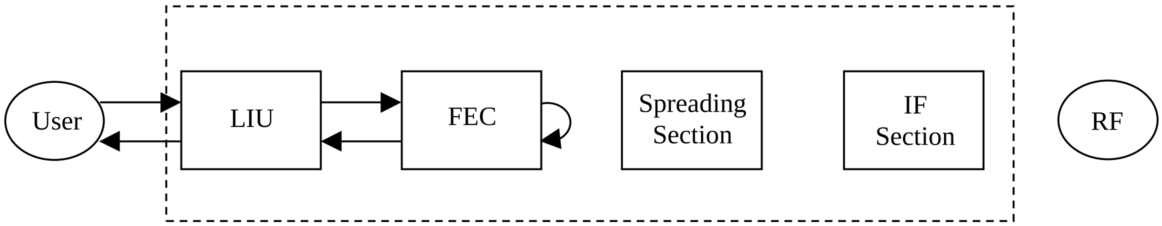
Table 3-6. Advanced Menu Options

BER Threshold	This threshold is used to monitor the Pre-FEC BER of the link. If this threshold is exceeded for the specified BER Interval (see below), the FEC BER alarm is given in the ALARM menu. The BER Threshold defaults to 2.0 E-7.
BER Interval	This is the interval of time, in seconds, that the BER Threshold must be exceeded to cause the FEC BER alarm to appear in the ALARM menu. Once the Pre-FEC BER exceeds the BER Threshold, the **ioLink** begins timing. If the Pre-FEC BER falls back below the BER Threshold, the timer is reset to zero. Otherwise the timer continues until the specified interval is surpassed, which then causes the FEC BER alarm to register in the ALARM menu. The BER Interval defaults to 100 seconds.
Jitter Atten	Jitter attenuation is provided by an elastic store in the LIU. When enabled, data bits are clocked into the elastic store using the line clock and then clocked out using the de-jittered clock from the jitter attenuation loop. Insertion of jitter attenuation produces a delay of 16 bits.
Acquire Thresh	This is a threshold parameter that affects the initial synchronization process of the link. Typical values are from 30_H to 60_H ($_H$ = hexidecimal).
Tracking Thresh	This is a threshold parameter that affects the continuing synchronization process of the link. Typical values are from $0A_H$ to 12_H ($_H$ = hex).
FEC BER	This menu item allows the user to turn the error rate testing on or off.

a. FEC Loopback

Selecting ON for this test mode places the modem into a loopback mode at the FEC chip. In this mode, data from the input device is passed through the LIU and FEC, looped back through the FEC and LIU and returned to the input device. This mode allows the user to determine whether the line interface and forward error correction sections of the modem are operating correctly.

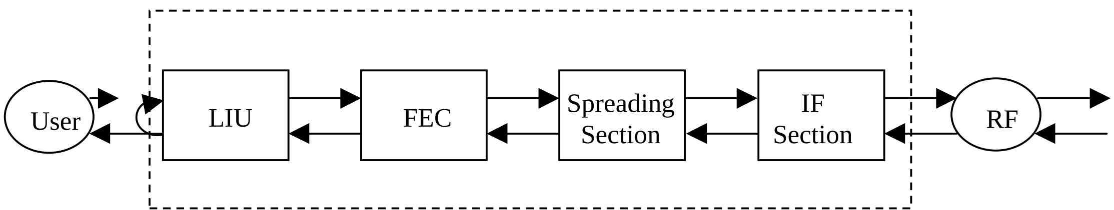
Figure 3-5. FEC Loopback



b. LIU Loopback

There are three loopback modes available from this menu item, all of which are enabled within the line interface (LIU) section of the modem.

Figure 3-6. LIU Loopback (Local)



(1) Local — The data from the far end of the link is looped back to it as well as passed through to the DSX or G.703 interface. Input from the DSX or G.703 interface is ignored.

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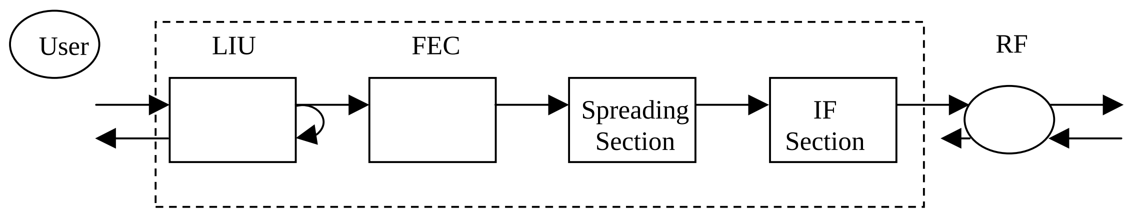
Figure 3-7. LIU Loopback (Remote)



(2) Remote — The data from the user device connected to the DSX or G.703 interface is looped back to it as well as passed through the modem to the far end of the link. Data from the far end of the link is ignored.

(3) Network — The line interface chip looks at the data stream received from the DSX or G.703 interface for the NLOOP enable and disable data patterns. When the enable pattern is repeated for five seconds, the modem is placed into remote loopback (as above).

3.1.4 Remote Control (CONSOLE) Connector

The DE-9 connector is used to interact with the SNMP-compliant agent embedded into the modem unit. This feature allows user SNMP software to interface with the **ioWave** SNMP-compliant agent. The Revision 1.1.1 version of the embedded software includes a serial interface that communicates via User Datagram Packets (UDP). Future versions will have a Point-to-Point Protocol (PPP) interface.

3.1.5 E1/G.703 Interface

The two female BNC connectors, labeled TX and RX, are used to connect an E1 device to the modem unit. You may also connect the E1 device to the modem unit using the RJ-48C connector. There is a two-pin jumper inside the modem unit to provide an (optional) ground to the outer conductors of the TX and RX connector.

Note: The termination impedance is selected via an internal jumper, JP319. Units shipped as E1 are terminated at 75 ohms (jumper installed).

3.1.6 T1 Interface

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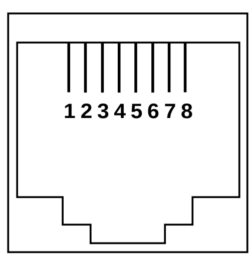
This female RJ-48C connector, labeled DSX-1, is a standard DS1 input. The connector is wired as a “network” device, expecting to receive the signal to be transmitted on pins 1 and 2, and supplying the received signal on pins 4 and 5. Alternatively, you may connect the DS1 input device to the modem unit via the female BNC connectors labeled TX and RX. These BNC connectors are tied directly to the pins of the RJ-48C connector, with TX connected to pins 1 and 2, and the RX connected to pins 4 and 5.
There are fuses, diodes, and transformers between these connectors and the circuitry of the modem unit to protect the DS1 input device against voltage and current surges.

Note: The termination impedance is selected via an internal jumper, JP319. Units shipped as T1 are terminated at 100 ohms (jumper removed).

3.1.7 Pin Outs for Front Panel Connectors

The Modem Unit of the **ioLink 4** has five connectors on its front panel for the user to connect to various networks. The following diagram shows the pin assignments of the jacks from the perspective of looking at the front panel of the Modem Unit:

Figure 3-8. DSX-1 (RJ-48C – female) Pin Assignments _RJ-45 NOW_



1. TX ring
2. TX tip
3. Not used
4. RX ring
5. RX tip
6. Not used
7. Not used
8. Not used

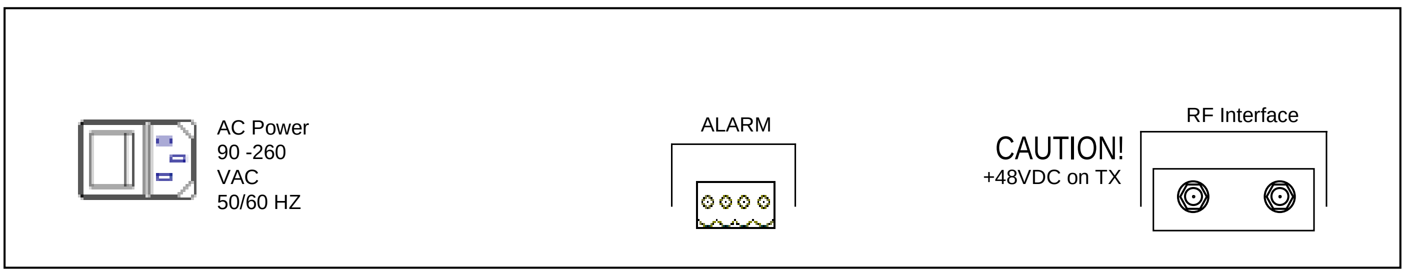
Is the CONSOLE connector wired differently from the other four?

3.2 Rear Panel Connections

The connectors on the rear panel are used for coupling the modem unit to:

- The RF unit, through two female TNC coaxial connectors.
- A "hot-standby" switch, through a terminal block.
- A remote control device (e.g., terminal, PC, or modem), through a male DE-9 connector.
- An E1 input device, through two female BNC connectors (TX and RX).
- A T1 input device, through an RJ-48C connector (DSX). ***RJ-45?***
- A three-prong EIA connector for supplying AC power to the modem unit.

Figure 3-9. Modem Unit Rear Panel



The following sections explain, in detail, the function of each connector on the back of the Modem Unit.

3.2.1 Power Connector

The power-input module is a combination male three-prong EIA interface, AC inlet, and a rocker on/off switch. A standard grounded power cable is sufficient for connecting to an AC power source (e.g., any common wall-mounted receptacle). As indicated in the Technical Specifications in Appendix A of this document, the modem unit uses less than 250 mA AC. The ground for the internal power supply is attached to the enclosure of the Modem Unit

The DC Input module is a combination rocker switch and terminal block as shown in the DC variant of the Modem Unit Rear Panel figure. The unit will accept DC input from 36 – 72 volts. The chassis of the Modem Unit and the grounding of the internal power converters are connected to the ground pins on the terminal block. As indicated in the Technical Specifications, the current draw is 450 mA at 48 V input; this is used to power both the Modem Unit and the 2.4 GHz, or 5.7 GHz, RF Unit.

3.2.2 ALARM Fault Connector

The "ALARM" connector is a removable terminal block that allows you to connect the Modem Unit to a switch for hot-standby redundancy. The terminal block is connected to Normally-Open and Normally-Closed FORM-C contacts. Pin 4 (the rightmost pin when facing the rear panel) of the terminal block is normally open, pin 3 is normally closed, pin 2 is the common and pin 1 is the ground. If the Modem Unit fails, the contacts reverse sense.

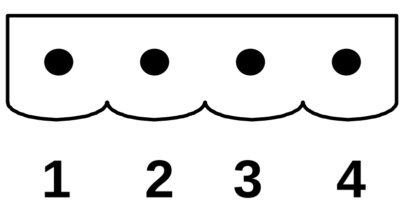
3.2.3 RF Interface Connectors

The connection to the RF Unit is made by attaching a dual coaxial cable to the TNC-type connectors labeled TX (transmit) and RX (receive). A 24 V DC offset on the TX cable supplies power to the RF Unit. When the Modem Unit is on, the center pin of the TX connector is at +48 V relative to the (grounded) outer conductor. Because of this, when configuring the cables be sure the power to the Modem Unit is off. Also, avoid plugging the RX Cable into the TX connector even though the RF Unit has circuitry to protect against this mistake. In addition to the received signal from the RF Unit, the RX Cable is used to transmit a DC signal to the Modem Unit that is used to determine the received signal level of the RF Unit.

3.2.4 Pin Outs for Rear Panel Alarm Terminal Block

The Modem Unit of the **ioLink 4** has one connector on its back panel. The following diagram shows the pin assignments of the jacks from the perspective of looking at the back panel of the Modem Unit:

Figure 3-10. Terminal block (Form-C contacts) Pin Assignments



1. Ground
2. Common
3. Normally closed
4. Normally open

SECTION 4 NETWORK MANAGEMENT FOR *ioLink 4*

The **ioLink 4** modem has an embedded agent for remote monitoring and control using a Network Management Station (NMS). Communication between the agent and the NMS is performed through an asynchronous serial connection at the male DE-9 connector labeled “Remote Control” on the back of the modem. Version 1.1.1 of the control software allows communication with a PC (or equivalent); later versions will allow dial-up connections via an external modem. To be SNMP-compliant, User Datagram Protocol (UDP) packets are used as the communication protocol on the serial connection. Any NMS that can direct UDP packets through a serial port may communicate with the agent. As an alternate means of communicating with the embedded agent, a DOS-based console program that accepts keyboard entry of SNMP-type Set, Get and Next commands, and then communicates with the agent via UDP packets, is available from **ioWave**.

4.1 Functionality

The agent is built to conform to the DS1 Management Information Base (MIB) outlined in RFC 1406. At the present time we do not have the ability to track all of the statistics, but this feature is under current development. Also, a proprietary MIB has been developed to allow the user to monitor and control other sections of the modem. This proprietary MIB is available from **ioWave**. The proprietary MIB includes variables to implement, through SNMP, all of the non-test functionality that is available at the front panel (via the LCD and keypad).

There are four important areas of monitor, or control, that are available through either the DS1 MIB or the proprietary MIB which are:

- Configuration
- Test modes
- Performance monitoring
- Error/alarm monitoring.

The features associated with each of these are discussed on the following pages.

4.2 Configuration

RFC 1406 specifies several configuration parameters for DSX-1 devices. In addition to these, the **ioWave** Management Information Base (MIB) includes several configuration parameters that correspond to features available at the control panel of the modem.

The specific items that may be configured via the front panel, and thus via the agent are:

- **Line Encoding**: The **ioLink 4** modem may be configured as either T1 or E1. For modems configured as T1, the user may choose between Alternate Mark Inversion (AMI) and the default B8ZS. For modems configured as E1, the user may choose between AMI and the default HDB3. (B8ZS and HDB3 are zero-suppression encoding algorithms)**.**
- **Cable Length:** This is the maximum length of cable from the modem unit to the user's data source. Changing this parameter will change the pulse shape of the DSX-1 signal transmitted from the DSX port to the user's device. The cable lengths correspond to the standard Line Build Out (LBO) settings from +0.6 dB to +3.0 dB.
- **Jitter Attenuation:** For input devices with a significant amount of noise, the line interface unit may provide jitter attenuation. Jitter attenuation is provided by an elastic store (ES) which clocks in the received bits and then clocks them out of the ES using the clock from the internal jitter attenuation loop. Inclusion of jitter attenuation produces a delay of 16 bits. The options are to attenuate in the receive path (default), the transmit path or not at all.
- **Symbol Threshold:** This is a threshold parameter that affects the initial synchronization process of the link. If the link is performing poorly, especially if it exhibits difficulty establishing synchronization, lowering this threshold may improve performance. However, too low a value might cause one end of the link to achieve synchronization to a noise signal. The default value is 50_H; values less than 28_H are not recommended.
- **Tracking Threshold:** This is a threshold parameter that affects the continuing synchronization process of the link. If the link is performing poorly, especially if it loses synchronization, lowering this threshold may improve performance; however, too low a value might cause one end of the link to achieve synchronization to a noise signal. The default value is 10_H; values less than $0A_H$ are not recommended.

4.3 Test Modes

The **ioWave** Management Information Base (MIB) includes several options for placing the modem into a loopback mode. These modes are useful for testing sub-sections of the modem when attempting to isolate a failure. The subsections that are present are the Line Interface Unit (LIU), the Forward Error Correction (FEC) unit, the Baseband processing section and the Intermediate Frequency (IF) section. A useful means for performing tests of the modem is to use a Bit Error Rate Tester (BERT) as the input device. The specific test modes that may be configured via the front panel or the agent are:

- **LIU Loopback:** There are three loopback modes available from within the line interface section of the modem.
  1. **Local** — The data from the far end of the link is looped back to it as well as passed through to the DSX or G.703 interface of the near-end modem. Input from the near-end DSX or G.703 interface is ignored. By setting the far-end modem into this mode, a test of the complete link may be made.
  2. **Remote** — The data from the user device connected to the DSX or G.703 interface is looped back to it as well as passed through the modem to the far end of the link. Data from the far end of the link is ignored. This is useful for testing the line interface unit of the near-end modem.
  3. **Network** — The line interface chip looks at the data stream received from the DSX or E1 interface for the NLOOP enable and disable data patterns. When the enable pattern is repeated for five seconds, the modem is placed into remote loopback (as above). The modem is removed from this loopback mode by receiving the NLOOP disable pattern for five seconds or by turning the network loopback mode off.
- **FEC Loopback:** When the modem is in FEC loopback mode, the input data passes through the line interface unit, the FEC encoder, the FEC decoder and then the line interface unit. This allows the user to determine whether the line interface and forward error correction sections of the modem are operating correctly.

- **Full Loopback:** This test mode places the modem into a loopback mode at the spreading chip (in the baseband processing section). The signal path is then from the user's device through the line interface circuitry, the forward error correction circuitry and then the spreading circuitry, back through each of these and out to the user's device. This allows the user to determine whether the line interface, forward error correction and baseband processing sections of the modem are operating correctly.

4.4 Performance Monitoring

There are several performance statistics for DSX-1 devices that are described in RFC 1406. In addition to these, the **ioWave** Management Information Base (MIB) provides performance-monitoring variables for features not included in RFC 1406. The additional features that may be monitored are:

- **Pre-FEC:** This is a measure of the rate of bit errors that are received from the link. In usual operation, the FEC circuitry corrects most of the bit errors so that the error rate of the data sent to the user's equipment is smaller than this rate. As this is a feature of the FEC circuitry, it is not available for E1 modems.
- **RF Signal Level:** The strength of the power received from the RF unit, as a percentage of that received for an ideal 1 mile link. If this value is 0%, there is a problem with the signal received from the RF unit; it is likely non-existent. In normal operation, this value should be greater than 83%.
- **Signal level:** The strength of the power associated with the demodulated signal, as a percentage of that received for an ideal 1 mile link. This is a measure of whether the signal received from the RF unit is from the other end of the link or from a noise source. If this value is less than 25%, the signal being received by the RF unit is not correctly encoded, indicating that the RF unit is receiving a noise signal. The likely causes are either a problem with the other end of the link or the presence of a strong interference signal. In normal operation, this value should be between 40% and 70%.

4.5 Error/Alarm Monitoring

There are several error and alarm conditions for DSX-1 devices that are described in RFC 1406. In addition to these, the **ioWave** Management Information Base (MIB) provides alarm conditions for features not included in RFC 1406. The additional alarms that may be monitored are as described below. All of the following indications may be used for troubleshooting as described in Section 5.

4.5.1 Near-end Related Alarms

a. **Transmit LOS:** This alarm is caused by a loss of signal from the user's device into the DSX or E1 interface. In addition to causing the Alarm LED to light, it will cause the TX Data LED to be extinguished. The likely causes of this alarm condition are that the user's input device has been turned off or disconnected from the modem.

b. **LIU not responding:** This alarm indicates an error with the communication between the control processor and the line-interface chip. This is generally a fatal alarm condition in that it indicates a component failure.

c. **Firmware not responding:** This alarm indicates an error with the communication between the control processor and the firmware controlling the FEC and spreading chips. This is generally a fatal alarm condition in that it indicates a component failure.

4.5.2 RF or Far-end Related Alarms

a. **FEC BRE > x.x E-x:** TBD.

b. **FEC decoder not locked:** This alarm indicates that the forward error correction circuitry has discovered an error in the bit stream. If this is the only alarm condition, it is usually an indication that there is a problem with the far-end modem. A possible corrective action for this alarm is to power the far-end modem off and on.

c. **RX Low Signal Power:** This alarm is caused by a low value of signal power being received from the RF unit. In addition to causing the Alarm LED to light, it will cause the RF Fault LED to light. The likely causes of this alarm condition are that the RF unit has been disconnected from the modem, the antenna has been disconnected from the RF unit, the RF unit has failed, or that the far-end of the link is turned off or has failed.

d. **RX Low Symbol Power:** This alarm is caused by a low value of demodulated symbol power being received from the RF unit. If this alarm condition exists and "RX Low Signal" does not exist, the likely causes of this alarm condition are that the far-end of the link is turned off or has failed.

e. **No Acquisition:** This alarm is caused by an acquisition failure by the de-spreading circuitry. The likely source of failure is the loss of signal from the far end of the link. In addition to causing the Alarm LED to light, it will cause the RX Data LED to be extinguished. If this alarm condition exists and “RX Low Signal Power” does not exist, the likely causes of this alarm condition are either that the far-end of the link is turned off (or has failed) or that the attenuation of the signal between the antenna has increased. A possible corrective action for this alarm condition is to decrease the Symbol Threshold on the “CONFIG Menu.”

f. **AIS:** Alarm Indicator Signal. This is caused by the modem receiving “all ones” from the DSX or G.703 interface. This indicates that a failure of the “upstream,” or user, device has occurred.

SECTION 5 TROUBLESHOOTING ALARM CONDITIONS FOR *ioLink 4*

These troubleshooting tips are intended to help the user fix any problems that may cause an alarm alert. When a certain alarm condition exists, read through all the troubleshooting steps to make sure you understand all of the possible causes of the alarm conditions.

The steps provided do not necessarily need to be performed in the order they are given, rather they should be performed in order of convenience. For example, if the first step is to check the far end Modem unit and the second step is to check the antenna alignment but it is much easier to check the antenna first, then you should do that before going to the far end of the link. When prompted to run any tests, make sure to use a good input data stream. Using a BERT to generate the data can do this. The BERT will then read and compare the output to the original input. If the alarm continues after going through the troubleshooting steps, please contact **ioWave** Technical Support.

Singular Alarm Conditions

5.1 Transmit LOS — *No data into DSX or G.703*

1. Check connection to CPE.
   a. Verify that the CPE is connected to either the DSX or G.703 interface.
   b. If connecting to the G.703 interface, make sure that TX on the Modem unit is connected to RX on the CPE and that RX on the Modem unit is connected to TX on the CPE.
   c. Check the cable for continuity or visible damage.
2. Check that CPE is configured correctly and working properly. Consult the documentation for the CPE for this.

5.2 LIU Not Responding — *Error in the communication between the control processor and the LIU chip*

This is usually a fatal alarm condition that indicates a problem the user cannot fix. Call **ioWave** Technical Support.

5.3 Firmware Not Responding — *Error in the communication between the control processor and the firmware controlling the FEC and spreading chip*

This is usually a fatal alarm condition that indicates a problem the user cannot fix. Call **ioWave** Technical Support.

5.4 FEC BER > x.x E-x — *Pre-FEC BER has exceeded the BER Threshold for the BER Interval*

1. Check that the RF Signal Level is acceptable (>83%). If it is below 83%, go to the section on troubleshooting the Low RF Power alarm.
2. Check that the BB Signal Level is acceptable (>40%). If it is below 40%, go to the section on troubleshooting the RX Low Symbol Power Alarm.
3. Check the Pre-FEC BER in the STATUS menu:
   a. If it has dropped back below the BER Threshold, note the time of day that the alarm occurred. This may allow you to track down the source of the fade if this alarm periodically appears. Some possible sources of fading could be noise, interfering signals, temporary obstructions (such as someone standing directly in front of the antenna) or the operation of a microwave oven in the vicinity.
   b. If the Pre-FEC BER continues to remain above the BER Threshold, check the link for possible obstructions or interference. Obstructions could be anything from new buildings or walls to growing trees or changes in the landscape. For example, if a stand of trees between the two antennas grows enough to sufficiently block the Fresnel zone, the Pre-FEC BER will increase. Also, if that same stand of trees is removed, there could be multi-path fading effects causing a problem. To check for sources of interference, look for other similar systems in the area or use a spectrum analyzer to detect the noise floor and any other signals in the vicinity of the antennas that are in or near the ISM band. Note the frequency, power and direction of the interfering signal. This will help in adjusting the antenna direction or polarization to reduce the interference.

5.5 FEC Decoder Not Locked — *FEC circuitry has discovered an error in the bit stream*

1. Restart the near end Modem unit. Since the cause of this alarm is that the FEC detects a data bit set that is not one of the valid possibilities it is looking for, it is most likely that the circuitry is out of sync. This means it is looking at the end of one set and the beginning of the next set instead of looking at each individual set completely. Usually the spreading section will fix this problem automatically, but if it doesn't, this alarm condition will appear. Restarting the near end Modem unit attempts to bring the FEC back into sync with the other side.

2. Restart the far end Modem unit. Since the far end Modem unit is the source of the problem and this alarm is not cleared by restarting the near end, restarting the far end Modem unit will fix the problem.

5.6 RX Low Signal Power — *Low signal power received by the RF unit*

1. Check that the Modem units are configured properly:
   a. Check that the encoding in the CONFIG menu for each unit is the same.
   b. Check the TX code and RX code in the CONFIG menu. The near end TX code **must** be the same as the RX code of the far end and vice versa. If they are not, the link most likely will not be able to establish a connection.
2. Make sure that none of the tests in the TEST or ADVANCED menu are on.
3. Check the antenna alignment. Make sure the antenna is aligned properly and that the RF cable is connected correctly and not damaged. Do this for both the near and far ends of the link.
4. Check that the IF cable is connected properly and not damaged.
5. Verify that the far end Modem unit is on and operating normally. If any alarm conditions exist, troubleshoot them first to see if that clears the "Low RF Power" alarm.

5.7 RX Low Symbol Power — *Low value for power received at the baseband processor*

1. Check the RF and Baseband (BB) Signal Level. If both are low (RF<83%, BB<40%) then see the steps in "RX Low Signal Power."

   Note: Refer to the RF Input Level vs. RSSI Voltage graph on the next page.
2. Check for possible interference from noise or another system. If the BB Signal level is low (< 40%), but the RF Signal Level is good (> 83%), the system has either locked onto noise or another signal, or the ambient noise has become too great for the system to receive signals from the other end. If there is still a signal level upon powering down the far end Modem unit, then the near end is picking up noise or another signal.
3. Restart the system. This may cause the system to lock back onto the far end's signal.
4. Check for possible sources of the interference. See if any other systems have been placed in the area and find out their operational frequencies and power.

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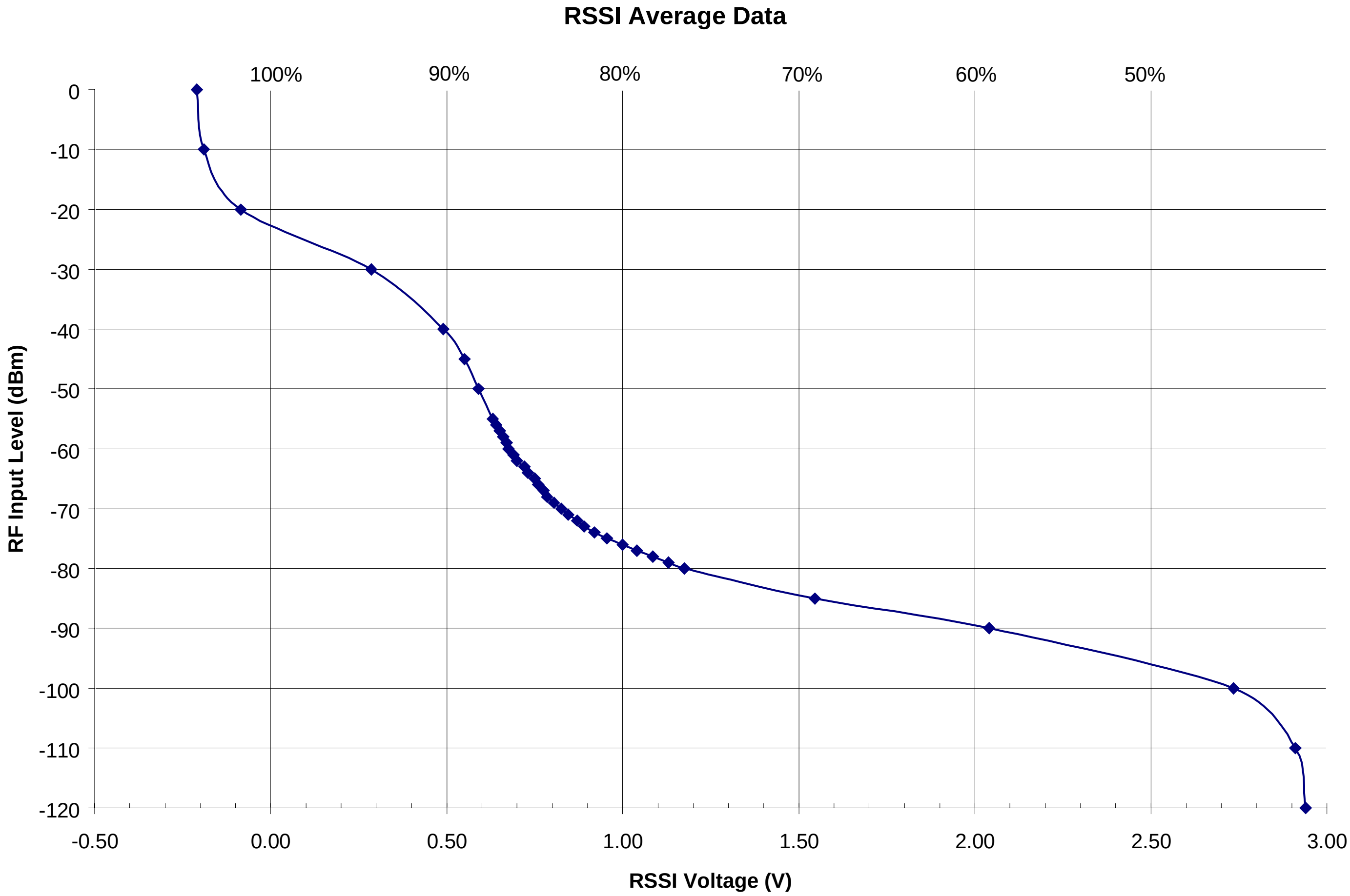

Figure 5-1. Received Signal Strength Indicator (RSSI) Voltage Conversion

5.8 No Acquisition — *Acquisition failure by the de-spreading circuitry*

1. Spot check the antenna alignment. Just do a visual check to see that the antenna is aligned correctly and doesn't appear damaged in any way. If getting to the antenna is not difficult, check the alignment as per the installation instructions and verify that the RF cable is connected properly and undamaged. If the antenna is out of alignment as well, there will most likely be an "RX Low Signal Power" or "RX Low Symbol Power" alarm as well (see above).
2. Check the status of the Modem unit at the far end. Make sure it is powered on and in normal operating mode. If any other alarm conditions exist, troubleshoot that end of the link.

5.9 AIS (Alarm Indicator Signal) — *Modem unit receives all 1's at the DSX or G.703 interface*

1. Check that the T1 Data Cable length is set properly. This shouldn't be the entire cause of the alarm, but it may be part of the problem.
2. Check that the Customer Premise Equipment (CPE) is configured and working properly. This alarm differs from the "Transmit LOS" alarm in that there **is** a signal present at the DSX or G.703 interface. Consult the CPE documentation for this.

APPENDIX A TECHNICAL SPECIFICATIONS FOR *ioLink 4*

Table A-1. Technical Specifications for ioLink 4

Features	
• Supports 4 user T1 or E1 connections	
• Compatible with ioWave's **ioLink**® 1 2.4 and 5.7 GHz RF Units	
Electrical	
Transmitter	
Output Power	+TBD dBm to + TBD dBm (adjustable at the factory)
Frequency Range	TBD to TBD MHz
Channel Bandwidth	22 MHz
IF Frequency	110 MHz
Frequency Selection	TBD MHz and TBD MHz (Plan TBD)
Modulation	Differential Quadrature Phase Shit Keying (DQPSK)
Spreading Method	Direct Sequence
Spreading Codes	4x 12 bit orthogonal Walsh Hadamard
Code Length	TBD
Number of Stored Codes	TBD
Forward Error Correction	Viterbi mode _ rate encoding 3 bit soft decision receive decoding
Receiver	
Receive Level	TBD dBm (no error) to –TBD dBm (1E-6 BER)
Max Receive Level (no damage)	TBD dBm
Receive Sensitivity (at 1E-6 BER)	-88 dBm, T1 and E1
IF Frequency	70 MHz
Processing Gain	>10 dB

RF Unit: Connector Types	
To Antenna	Type N Female
To Modem	Type BNC Female (4x)

Modem Unit: Data Interface	
Interfaces	DSX-1 (T1), G.703 (E1) — software selectable
Data Rates	1.544 each (DSX - 4x T1), 2.048 each (G.703 - 4x E1) Mbps
Line Codes	AMI, B8ZS (T1), AMI, HDB3 (E1)
Line Build-Out	0-655 ft.
Diagnostics	

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Front Panel	Power and Alarm LEDs, Keypad, LCD Display
Monitor/Control	Local via keypad, Remote via RS232, SNMP-compliant agent, Hot-standby relay (four contact sets), Far-end monitor / control using RF orderwire, Accessible via front panel or SNMP agent, Designed to operate reliably even under marginal link conditions

Modem Unit: Connectors	
User Data	
TX and RX IF cable connections	TNC Female
DSX-1, 4x T1	RJ-48C, Female (100 ohms, twisted pair cable), x4
G.703, 4x E1	BNC (x2), Female (75 ohms, coaxial cable) (x4)
Monitor and Control	Designed to operate reliably even under marginal link conditions
Remote	RS232, SNMP-compliant agent
Local	TBD

Modem Unit: Power	
Connector, AC Version	EIA, 3 contact, Male
Connector, DC Version	TBD
Voltage, DC Version	TBD
Voltage, AC Version	Worldwide 90-260 VAC, 50/60 Hz 70 Watts maximum (not including RF unit power)

Environmental	**Modem**	**RF**
Operational Temperature	0° C to +60° C	-40° C to +60° C
Storage	TBD	-40° C to +60° C
Humidity	TBD	0-95% Rain (4 in/hr) Non-immersion

Mechanical	**Modem**	**RF**
Width	17”	12”
Height	3.5”	12” (14” baseplate)
Depth	13”	4.125”
Weight	TBD lb. (TBD kg)	9 lb. (4.1 kg)

* All specifications may be subject to change

APPENDIX B GLOSSARY OF TERMS

Term	Meaning
	A
Active Repeater	A re-radiation device associated with a transmitting/receiving antenna system that re-directs and boosts the power of intercepted radio frequency energy. They may also apply some processing to the signal as well.
Alarm Indication Signal (AIS)	A signal that is transmitted in lieu of the normal signal in order to maintain transmission continuity. It indicates to the receiving terminal that there is a transmission fault located either upstream or at the transmitting terminal.
Alternate Mark Inversion (AMI)	Digital transmission in which successive “1” signals are of opposite polarity.
American Wire Gauge (AWG)	A system that specifies wire size. The gauge varies inversely with the wire diameter.
Ampere	Unit of electrical current based on charge per second.
Amplitude	The magnitude of a waveform when measured from the mid-point to the peak of the wave.
Analog	A signal in the form of a continuously varying quantity such as voltage, frequency or phase.
Analog to Digital Converter (ADC)	A device that takes an analog signal (e.g., voice) and digitizes it into data format.
Antenna	Device used to concentrate and direct the energy of a signal into a tight beam. Parabolic or dish, grid, and Yagi are different varieties of antennas.
Antenna Gain	The ratio of the power radiated by an antenna in a specific direction versus the power required to produce this same strength if an isotropic antenna were used.
Attenuation	The measure of the loss of power in a microwave signal as it travels between two points. It is measured in dB.
Automatic Gain Control (AGC)	Circuitry by which the gain of an amplifier is automatically controlled so that the signal level is virtually constant for varying input signal levels.

PRELIMINARY

Azimuth	The horizontal angle in degrees between true North and the direction the antenna is pointed.

B

Band	A portion of the Electromagnetic frequency spectrum.
Bandwidth	The range of frequencies over which a device will transmit information.
Baseband (BB) Transmission	An analog term that applies to the small section of the transmit side of the information stream between the STEL-2000 DSSS chip and the IF up conversion mixer. There are only digital signals in the receive side. Both the DSSS transmit and receive sides are "digital baseband" processed, although some analog baseband functions are also performed.
Beamwidth	The beamwidth of a dish antenna is the angle of sky that can be illuminated (picked up or sent out) by the dish. Large antennas have narrow beamwidths, which reduces the noise from its sides. Smaller antennas have wider beamwidths and, therefore, are noise.
Binary	A Base-2 numbering system. A binary code consists of elements represented by two distinct conditions such as 0-1, on-off, or mark-space. This numbering system is the basis for digital code.
Bipolar eight Zero Substitution (B8ZS)	A line coding scheme to eliminate data streams with 8 or more consecutive zeros by substituting 000+-0-+ for 00000000 if the preceding pulse was +, and 000-+0+- for 00000000 if the preceding pulse was done to maintain density.
Bit	A single element in a binary code. An abbreviation for binary digit.
Bit Error Rate (BER)	A measure of the number of errors in a digital transmission. Typically given as an exponential number that represents the ratio of errors to total bits.
Bit Error Rate Tester (BERT)	A tester used for measuring the BER.
Bit Rate	The speed at which bits are transmitted by a system, typically expressed in bps.
BNC	A bayonet-locking connector for coaxial cable. Short for Bayonet-Neill-Concelman.
Byte	A data unit consisting of eight bits.

C

Carrier to Interference ratio (C/I)	The ratio of the power of the carrier signal and an interfering signal.
Channel	A specific band of frequencies designated for a specific purpose; the data path between two nodes.

PRELIMINARY

Channel Service Unit/Data Service Unit (CSU/DSU) Manages digital transmission and monitors signals for problems. Performs many functions similar to a modem with the exception of converting digital signals to/from analog since the end device and transmission facility are both digital.

Common Management Information Protocol (CMIP) A network management protocol that is consistent with an Open Systems Interconnection (OSI) network communication model.

Coaxial cable A type of transmission line consisting of a center conductor wire surrounded by insulation which is in turn surrounded by a conductive shield made of metal foil or wire braid. Often used to connect the RF unit and modem unit of a wireless system.

Code Division Multiple Access (CDMA) A system in which all users occupy the same bandwidth. Uncorrelated codes are used to allow for higher bandwidth occupancy. Also known as spread spectrum systems.

Customer Premise Equipment (CPE) Any equipment which is located at the customer site. Usually in reference to those that are connected to a network.

D

dBm dB relative to 1 milliwatt.

dBw dB relative to 1 watt.

Decibel (dB) The standard unit of measurement for expressing relative signal power. It is dimensionless and is instead referenced to a certain level.

Diffraction The distortion of a wave as it is partially obstructed by an object in its path.

Digital Transmission The transmission of data over a communications medium using a dual-state (binary) mechanism to represent information.

Direct Sequence (DS) A type of spreading technique that multiplies a higher rate PN code to the signal in order to spread the energy of the narrow band signal over a much wider bandwidth for transmission.

Direct Sequence Speed Spectrum (DSSS) DSSS may be seen as the result of two processes:

- Data is multiplied with a higher rate digital sequence (spreading code). The sequence has many “chips” for every data bit.
- The resultant signal modulates the RF carrier.

DQPSK Differential Quadrature Phase Shift Keying.

DS-0 The base unit of digital capacity equivalent to a single 64 Kbps voice-grade communication channel.

DS-1 The equivalent of 24 multiplexed DS-0 channels. T1 or 1.544 Mbps.

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DSX-1	Refers to the signal levels for terminal equipment connected at a digital cross connect. DSX-1 refers to DS-1, or T1, signals.
Dual Tone Multi Frequency (DTMF)	TBD
Duplex	A circuit configuration in which information can be sent in both directions simultaneously.

E

E1	European Standard also used in South America nations, among others. Speed is 2.048 Mbps. Uses a G.703 data interface.
Effective Radiated Power (ERP)	The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.
Electrically Erasable Programmable Read-Only Memory (EEPROM)	A special type of Programmable Read-Only Memory that can be erased by exposing it to an electrical charge, thus allowing it to be reprogrammed. It retains its contents even when the device is turned off.
Elevation	1) Height above sea level; 2) The vertical angle in degrees between the ground and the direction the antenna is pointed.
Equivalent Isotropically Radiated Power (EIRP)	The product of the power supplied to the antenna and its gain in a given direction relative to an isotropic antenna.
ESD	Electro-Static Discharge.

F

Fade Margin	The difference between the receiver signal input level and the receiver sensitivity. Fade margin is usually considered the safety factor allowing the system to remain operating under additional forms of attenuation.
Fading	The loss of signal strength due to changes in the atmosphere.
Federal Communications Commission (FCC)	Government organization appointed by the U.S. President that regulates interstate communications (licenses, standards, rates, etc.).
Firmware	Alterable programs in semitransparent storage, e.g., some type of read-only or flash reprogrammable memory.
Forward Error Correction (FEC)	The ability of a receiving station to correct a transmission error. The transmitter sends redundant information along with the original bits and the receiver uses this information to find and correct errors. Can increase the throughput of a data link operation.
Framing	Dividing data for transmission into groups of bits, and adding a header and a check sequence to form a frame.

Frequency The number of complete cycles per second existing in a waveform. Measured in Hertz.

Frequency Hopping (FH) A type of spreading technique that uses a PN code to change the signal's frequency between several pre-assigned values (hopping). Although the signal itself looks like a narrow band signal at any given point in time, it acts like a spread signal because of the frequency hopping.

Fresnel Zone An imaginary ellipse surrounding the direct transmission path formed by all the points from which a reflected wave would have an increased path length of multiple of the transmitted signal's wavelength.

Full Duplex Independent, simultaneous two-way transmission in both directions.

G

Gain The increase in signal power caused by a device such as a transmitter or antenna.

H

Hertz (Hz) A unit of measurement equal to one cycle per second.

Hexadecimal (Hex, or H) A Base-16 numbering system.

High Density Bipolar Three (HDB3) A line interface standard, similar to B8ZS, for E1 that eliminates data streams with 4 or more consecutive zeros. Allows for 64 Kbps clear channel capacity and still assures a minimum ones density required by E1 lines.

Hop A term used to describe a single radio path between two points.

Hot-standby A condition whereby when the primary method of communication goes down, the secondary method instantly takes over.

I

IF cable In an **ioLink** system, the coaxial cables which connect the Modem unit to the RF unit. These cables are terminated with male TNC-type connectors at both ends.

Interface The signal standard for connecting a microwave system to the connecting equipment.

Interference Unwanted signals that cause performance degradation or loss of information.

Intermediate Frequency (IF) The frequency to which a microwave signal is converted to permit signal processing. Typically around 70-200 MHz.

PRELIMINARY

Internet — A series of interconnected local, regional, national and international networks linked using TCP/IP.

Internet Service Provider (ISP) — A company that provides access service to the Internet for its customers.

Intranet — An IP-based network that resides behind a firewall. A network within a community with which dedicated users access specific company or community-dedicated information.

ISM — Industrial, Scientific, Medical Bands (900-928 MHz; 2.4-2.4835 GHz; 5.725-5.85 GHz). These bands were allocated by the FCC for unlicensed use with a restriction on the output power.

Isotropic — Uniform in all directions.

L

Light Emitting Diode (LED) — An electronic device that emits light with little generation of heat.

Line Build-Out (LBO) — This refers to the signal level required at the CPE. It can be adjusted according to the length of cable connecting the **ioLink** to the CPE.

Line Interface Unit (LIU) — The first unit inside the modem units encountered by signals from the user.

Line Of Sight (radio) (LOS) — Condition whereby the antennas of a given link have a sufficient path for communication. It requires that at least 60% of the Fresnel zone between them be unobstructed.

Liquid Crystal Display (LCD) — The display on the Modem Unit used to configure and monitor the system.

Local Area Network (LAN) — A short distance data communications network used to link together computers and peripheral devices (such as printers) under some form of standard control.

Local Bypass — Bypass of the Local Exchange Carriers by providing a direct link to the Public Switched Telephone Network.

Local Exchange Carrier (LEC) — Telephone company that provides local telephone service.

Low Noise Amplifier (LNA) — An amplifier, usually in the first stage of a receiver, that amplifies the incoming signal while contributing very little extra noise.

M

Management Information Base (MIB) — A database of network parameters used by SNMP and CMIP to monitor and change network device settings. It provides a logical naming of all information resources on the network that are pertinent to the network's management.

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Mean Time Between Failure (MTBF) A measure of the theoretical time a component or device will operate without failing.

Modulation The process of varying characteristics of a carrier signal to represent changes in the transmitted information.

MOdulator-DEModulator (MODEM) A device that converts a digital signal to analog, or vice versa, and is used to transfer data between computers over communications lines.

Monitored Hot Stand-By (MHSB) The system configuration in which two transmitter/receivers are arranged such that one acts as a backup if the primary fails. A microprocessor monitors the on-line circuitry and switches to the backup if a failure is detected.

Multi-path fading The condition in which the "true" signal from an antenna reflects off an object (usually the ground) and, as a result, the reflected signal causes destructive interference at the receiving antenna. Multi-path fading affects linearly polarized signals more than circularly polarized signals.

MUltipleXer (MUX) A device that allows the simultaneous transmission of two or more signals over one transmission path.

N

Network Two or more locations tied together with equipment and communications channels.

Network Equipment Building System (NEBS) An industry standard of compliance regarding various aspects (environmental suitability, electrical safety, etc.) of telecommunications equipment.

Network Management Software (NMS) The software used to monitor and control a system of connected devices. It refers to a host system which is running the network management protocol (such as SNMP) and one or more network management applications.

Noise Any unwanted signal or disturbance which degrades the quality of a transmitted signal.

O

Obstruction Any man-made or natural object which blocks, diffracts, or reflects a transmitted signal.

P

Part 15 The section of the FCC Code of Federal Regulations which defines the restrictions regarding the use of Spread Spectrum systems.

Passive Repeater A re-radiation device associated with a transmitting/receiving antenna system that re-directs intercepted radio frequency energy without boosting or processing the

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signal.

Path Length The distance between two ends of a wireless system.

Path Loss The decrease in signal power experienced when a signal is transmitted between two points.

Path Profile A drawing of the terrain including buildings, trees, hills, lakes, etc. along a transmission path to determine if a given path is viable for the communication link. Usually done with a computer.

Personal Communication Services (PCS) A lower powered, higher frequency competitive technology to cellular.

Point-to-Point Protocol (PPP) A method of connecting to a network that provides error checking features.

Polarization The direction of the amplitude of a radio wave. Polarization is usually horizontal or vertical.

Power Output The power produced by a transmitter. Measured in dBm.

Propagation The transmission of a wave along a given path through a medium.

Pseudo-random Noise code (PN code) A high rate digital code that mimics random noise-like properties. It is multiplied with a lower rate data signal in order to achieve spread spectrum transmission signals. The receiver then multiplies the same code back into the transmission to recover the data signal.

Public Switched Telephone Network (PSTN) Refers to a worldwide voice telephone network accessible to all those with telephones and access privileges.

Q

QPSK Quadrature Phase Shift Keying

R

Radiation The flow of electromagnetic energy from a transmitter.

Radiation Pattern An illustration of the energy level radiated by an antenna in every direction.

Radio Frequency (RF) The frequency at which microwave systems transmit.

Received Signal Strength Indicator (RSSI) The RSSI voltage is used to determine the RF Input Level.

Reflection The sharp change in direction of a wave after hitting an obstruction in its path.

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Refraction	The bending of a wave as it moves from one medium to another.
Reliability	A measure of the percentage of time the system is operating. Reliability is usually a measure of both the availability of the signal and the MTBF of the equipment.
RF cable	In an **ioLink** system, the coaxial cable that connects the RF unit to the antenna. It is terminated at both ends by male N-type connectors.
RS-232	The interface between Data Terminal Equipment and Data Communications Equipment (such as a modem) employing serial binary data interchange. Used for the transmission of serial data.

S

Sensitivity	The minimum signal level a receiver can accept and still perform at a specified BER. This is also referred to as Receiver Threshold.
Simple Network Management Protocol (SNMP)	The standard protocol for TCP/IP network management that has the most common worldwide use.
Spread Spectrum Technology (SST)	A method of encoding (with a PN code) a digital signal in a transmitter so as to spread it over a wide range of frequencies so that the average signal power is close to the noise floor. The same code is known to the receiver and is used to decode the signal.
System Gain	The sum of the transmitter power output and the receiver sensitivity. System gain is an important measure of a system's ability to overcome attenuation and perform to a satisfactory level. Measured in dBm.
System Integration (SI)	A method by which a company uses its expertise regarding all of the products in a certain market in order to integrate them into one cohesive network, thus suiting the unique needs of each customer.

T

T1	United States standard used in the Pacific Rim nations, among others. Its speed is 1.544 Mbps. It uses the DSX data interface.
Throughput	The quantity of data processed during a given period over a given bandwidth. It is usually measured as the rate of bits transmitted per second.
To Be Determined (TBD)	Information is not available at this time.
Transmission Control Protocol/ Internet Protocol (TCP/IP)	A suite of protocols that includes TCP, IP, the User Datagram Protocol (UDP), and several other service protocols.

U

PRELIMINARY

Unfaded BER — The BER of the system in the absence of signal attenuation due to all forms of signal fading. Unfaded bit errors are caused by thermal noise in radio electronics during transmission.

User Datagram Packets (UDP) — A connectionless protocol that runs on top of IP networks. It offers a direct way to send and receive datagrams over the network but provides very little error recovery service.

V

VDC — Direct Current Voltage.

Voltage Controlled Oscillator (VCO) — An oscillator whose frequency can be adjusted by varying the input voltage.

W

Watt — A unit of power.

Wave (electromagnetic) — An electromagnetic signal that periodically changes in intensity as it travels through a medium.

APPENDIX C IMPORTANT INFORMATION ABOUT YOUR SYSTEM

C.1 FCC Regulatory Notice

This equipment complies with FCC Regulation 15.247, which specifies the license-free operation of direct sequence, spread-spectrum wireless communications devices. This device operates in the 2.4 to 2.4835 GHz frequency band reserved for industrial, scientific and medical applications. Since this device generates radio frequency waves, it may interfere with other radio signals in the same area unless the proper installation and operations procedures are followed. It has been proven in testing that this device complies within the limits of FCC Regulations that are designed to provide reasonable protection against such interference in a commercial environment.

NOTE: Installation and maintenance must be performed by authorized **ioWave** personnel or those persons properly trained and authorized to do such procedures. **ioWave** is not responsible for any damages, incidental or otherwise, in connection with use of this manual by anyone not described above.

C.2 Warranty

ioWave, Inc. manufactured products are warranted to be free from material defect in material and workmanship under normal use for a period of one (1) year from the date of shipment. This warranty extends only to products manufactured by **ioWave, Inc.** and is expressly conditioned upon the equipment having been installed in accordance with the standard installation and configuration practices recommended by **ioWave**, by authorized **ioWave** personnel or those persons certified and authorized to do such procedures, and the equipment having been maintained in accordance with **ioWave** recommended standard maintenance practices.

If any **ioWave** product is found to be defective while still under warranty, **ioWave** will, at **ioWave**'s option, repair or replace the defective product with another **ioWave** product at its own expense, or provide a refund of the purchase price. **ioWave** is not responsible for costs of labor or any other costs incurred by the customer's own employees or contractors in identifying the problem or replacing the defective product.

This warranty shall automatically terminate and **ioWave** will not be responsible, if the product is used in other than its normal and customary manner, and/or has been subject to neglect, misuse, accident, damage, abuse, improper or unauthorized assembly, disassembly or alteration. **ioWave** will not be responsible under this warranty and agreement if the defect results from the use or existence of non-**ioWave** equipment, software or hardware. Repair at **ioWave**'s option may include the replacement of parts or equipment and all replaced parts or equipment shall become the property of **ioWave**. The above constitutes the customer's sole and exclusive remedy in the event of breach of warranty.

In the event of a defect during the warranty period, Buyer must return item, freight pre-paid, to the **ioWave** repair facility for repair or replacement. Proper authorization from **ioWave** to return products under this warranty must be obtained prior to shipping. **ioWave** *will only accept returned goods with the proper returned material authorization number (RMA).* All products will be returned to the customer after repair or replacement by method of delivery of **ioWave**'s choice within the continental United States of America. **ioWave** shall be responsible for return freight charges only on repaired and replaced products found to be defective under this warranty. If the customer desires a different method of delivery than that chosen by **ioWave**, or if the return location is beyond continental USA borders, then **ioWave** is not responsible for cost of return shipment.

This warranty shall extend only to the original purchaser of the products and is non-transferable to a third party. This warranty shall not cover any consequences or damages caused by Act of God and events of *Force Majeure,* including, but not limited to, third-party equipment, fire, flood, explosion, and war. Except as stated herein, **ioWave** makes no other warranties for the products, and the foregoing warranties are in lieu of all other warranties, express, implied or statutory, including but not limited to any implied warranties or merchantability or fitness for a particular purpose, or of any other warranty obligation.

C.3 Disclaimer

Only **ioWave** certified personnel shall install and perform maintenance on any **ioWave** product. **ioWave, Inc.** assumes no responsibility for any problems during or as a result of installations performed by non-**ioWave** certified personnel.

ioWave, Inc. also assumes no responsibilities for any incorrect information given by the customer about the site or network that the **ioWave** components will be placed in. Any alterations in structures on the site where the **ioWave** equipment is installed may void any warranties that exist for the structure (e.g., drilling holes in walls, floors, or ceilings may void leakage warranties).

C.4 Use of ioWave Products Outside of the United States

ioWave, Inc. has received selected approval for the use of its products in countries outside of the United States and Canada. For specific information regarding the approval status of **ioWave** products in your country, please contact your **ioWave** sales representative. **ioWave** does not recommend the use of its products in non-approved areas, and accepts no responsibility for any consequences, legal or otherwise, resulting from the use of our products in such areas.