SolidLINK™
Industrial Radio Modem

USER MANUAL

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Notices

Modifications or changes to the SolidLink™ radio, not expressly authorized by Seimac Limited, could void the user's authority to operate the SolidLink™ radio.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1. Reorient or relocate the receiving antenna.
2. Increase the separation between the equipment and receiver.
3. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
4. Consult the dealer or an experienced radio/TV technician for help.

Operation of the SolidLink™ radio is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device has been designed to operate with an omni directional antenna having a maximum gain of 6dB, or a directional antenna having a gain of 26dB. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50ohms.

The installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population; consult Safety Code 6, obtainable from Health Canada's website at www.hc-sc.gc.ca/rpb.

This device complies with FCC RF radiation exposure limits; however it is important that the device be installed such that human exposure to harmful RF radiation is minimized. In order to comply with RF exposure limits, the following minimum separation distances between the transmitter antenna and all persons should be maintained:

Omnidirectional	20 cm
Directional (Yagi)	2 m
High Gain Directional (Parabolic)	2 m

The directional and high gain directional antennas are for fixed outdoor installations only.

1 SolidLink Introduction

Seimac's SolidLink™ industrial radio modem is a rugged, low power, frequency hopping, 2.4 GHz spread spectrum radio that reliably transports data for remote monitoring, telemetry and industrial SCADA applications. SolidLink combines state-of-the-art RF and digital design, compact, robust industrial design, and graphics based network software for rapid deployment, efficient network maintenance and long range license free operation.

The SolidLink radio and the SolidLink Network Manager software, together provide the complete data communication solution. For the latest information on SolidLink, please visit www.solidlinkradio.com.

1.1 Features

SolidLink has been developed to provide industrial data system developers and users with a full-featured industrial radio network providing:

1. a rugged, weatherproof, outdoor deployable package;
2. built in CRC error detection and automatic retransmission to guarantee error free data transmission through the network;
3. license free operation in the 2.4GHz ISM band;
4. RS-232 serial data interface, operating at 57.6Kbaud without Repeaters and 28.8Kbaud with Repeaters;

5. simple network development, configuration and deployment through the drag-and-drop SolidLink Network Manager PC application;
6. real-time online network diagnostic and performance information through the SolidLink Network Manager;
7. point-to-point and point-to-multipoint network topologies, both with and without Repeaters, to a maximum of 1000 radios per network; and
8. FCC and RSS-210 Industry Canada certification.

1.2 Warranty

Seimac Limited ("Seimac") shall repair or, at its option, replace, at no cost for labor, materials or return transportation, SolidLink™ if proven to be defective within two years from date of first purchase. No cash refunds. This warranty is available for first purchasers only.

Warranty does NOT cover replacement parts normally replaced during warranty term, or, damage from any of: (1) wear and tear or misuse; (2) failure to install, use or maintain in accordance with SolidLink manual; (3) repair or modification done by anyone other than Seimac or authorized dealer; (4) failure to adequately package for transit; or (5) damage by lightning.

To enforce the warranty, obtain a Return Merchandise Authorization (RMA) number from Seimac by calling (902) 468 3007 and ship the SolidLink, prepaid, to:

Seimac Limited
271 Brownlow Avenue,
Halifax, Nova Scotia,
B3B 1W6 Canada

We recommend you retain and use your original packaging to ensure safe shipping of your SolidLink™.

THIS IS THE ONLY WARRANTY PROVIDED BY SEIMAC FOR THE SolidLink™, AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING AS TO MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE EXCLUDED. SEIMAC SHALL HAVE NO LIABILITY FOR INJURIES, DEATH, PROPERTY DAMAGE OR OTHER LOSSES OR CLAIMS RELATED TO ANY USE OF THE SolidLink™, WHETHER CLAIMED AS INCIDENTAL, SPECIAL, DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES. ACTIVITIES ASSOCIATED WITH USE OF THE SolidLink™ ARE INHERENTLY DANGEROUS, AND THE PURCHASER ACCEPTS THE RISK OF THESE ACTIVITIES.

1.3 About This Manual

This manual is provided as a guide to developing, installing and operating SolidLink networks. It includes detailed technical details as well as introductory information for the first time user.

It is assumed that the user is familiar with the basic concepts of data communication and free space radio frequency transmission. While an introduction to frequency hopping spread spectrum technology is provided, it should not be considered a tutorial.

Topics covered in this manual include:

1. technical background information on spread spectrum technology, SolidLink operation, and network topologies;
2. Getting Started with SolidLink;
3. SolidLink hardware interface, operation and installation;
4. the SolidLink Network Manager - the PC application used to design networks, configure radios, debug network applications and monitor performance;
5. system troubleshooting guide;
6. system specifications; and
7. detailed serial command protocols.

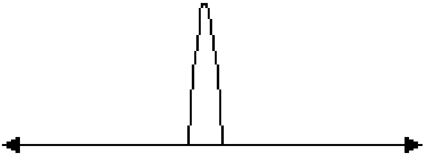
2 Overview

This section provides some background technical information and summarizes the capabilities and operation of the SolidLink technology. It is recommended that the reader become familiar with the material in the following sections before proceeding:

- Spread Spectrum Technology;
- SolidLink Theory of Operation;
- Network Configurations; and
- SolidLink Network Manager.

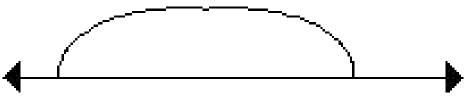
2.1 Spread Spectrum Technology

Traditional RF narrow-band communication techniques involve modulating a fixed radio frequency carrier signal with a low frequency signal that contains the information to be transmitted (refer to graphic below). Examples in everyday life are common: commercial AM and FM broadcast, television broadcast, licensed two-way voice radios, and cellular telephones. The advantage of this approach is that the receivers and transmitters can be fairly simple and need not be synchronized. Their disadvantage is that they are very susceptible to interference, and rely on sole access to a specific segment of the frequency spectrum. For example, it would be easy to disrupt a two-way voice radio link by simply transmitting an interfering signal at the frequency used by the voice link radios.

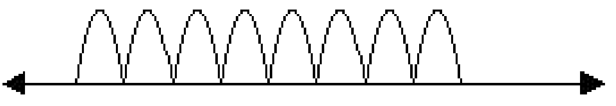


Spectrum spreading is simply an approach whereby the transmitted energy is spread across a relatively wide band, rather than being concentrated in a very narrow band. Its advantages and disadvantages are the converse of narrow band: it is less immune to interference, but is more complex because the receiver and transmitter must synchronize. Another advantage of spectrum spreading is that transmissions are much less detectable than narrowband approaches, because the average energy at any one narrow frequency will always be much less. Its immunity from interference is so high, that many spread spectrum radios can operate effectively in the same physical area, at the same time. Examples include IEEE 802.11 wireless LAN, Bluetooth, and cordless telephones.

There are two primary techniques for spreading the spectrum, direct sequence and frequency hopping. In a direct sequence system, a fixed carrier signal is first modulated with the information and then is further modulated by a fixed pattern pseudo-random code sequence. The effect of the latter action is to spread the energy across a wide band (following graphic). The receiver must demodulate the broadband signal with the same pseudo-random data sequence to recover the original modulated signal.



In a frequency hopping system, the information is used to directly modulate the carrier signal; however instead of using a fixed carrier (as in a narrow band radio), the carrier frequency is rapidly and predictably altered, following a specific pseudo-random pattern (called a hop sequence). The receiver must know the hop sequence, and once it has synchronized with the transmitted signal, can adjust its receiver to follow the changes in transmit carrier. FCC regulations require that the period between hops be no longer than 400 msec. SolidLink is a frequency hopping system, with a hop period of 25 msec.

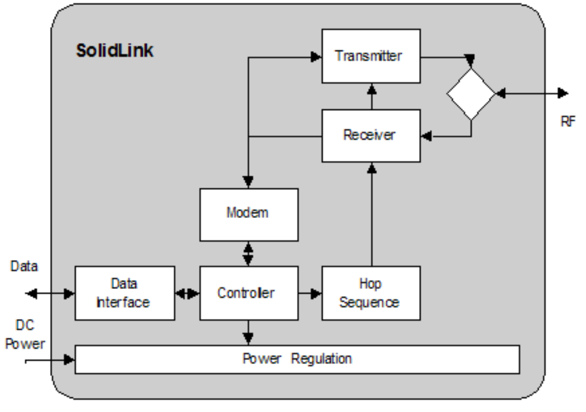


The frequency band 2400 MHz to 2483.5 MHz has been set aside in most countries, including the United States, Canada and Europe, for unlicensed spread spectrum radio operation.

2.2 SolidLink Theory of Operation

The following graphic illustrates the high level hardware functions of the SolidLink radio. An on-board micro-controller controls the overall radio operation. Firmware revisions can be downloaded into the radio by the user through the SolidLink Network Manager. SolidLink has two connectors. A

TNC Female connector provides a 50 interface to the antenna cable, used for both transmit and receive. In internal switch ensures that the transmitter and receivers remain isolated. An EN3 circular connector provides both 10-26 VDC power to the radio and provides RS-232 data and control signals.



For further information refer to the Serial Data Interface, Radio Interface, and Operating Mode sections.

2.2.1 Serial Data Interface

SolidLink accepts RS-232 data through the EN3 circular connector. Details of the communication protocol are provided in Command Protocol section. Hardware flow control signals are provided. For incoming data, the controller breaks the stream into packets which will fit within the 25 msec hop window.

The maximum number of user data bytes in a packet is 288. If data arrives in bursts, the controller will send a partially complete packet at the next hop. For outgoing data, the controller receives packets destined for that radio's serial port, strips off the packet header information, and sends the data payload out the RS-232 data port. It is important to note that, while serial data may enter one radio in a very continuous manner, it will leave another radio in bursts.

2.2.2 Radio Interface

As discussed in the Spread Spectrum Technology section, all frequency hopping spread spectrum radios must incorporate a known hop sequence, so that the transmitter and receiver can synchronize. SolidLink includes five hop tables; the user selects, which is used when the configuration is downloaded into the radio via the SolidLink Network Manager. Any radios that communicate directly with each other must be configured to use the same hop table.

Before any radios can communicate, they must establish hop synchronization. One and only one radio in the network must be configured as a Master. It periodically (nominally every four seconds) transmits a synchronization packet which is unique and which those radios that receive it can use to synchronize to the hop sequence. The sync packet is propagated through the network by all Repeaters so that all radios in the network can synchronize. If any one radio looses sync, it will wait no longer than four seconds before it can regain synchronization.

Header	Payload	CRC

The data payload is transmitted inside a packet, which includes source and destination address information in a header (refer to above graphic). Before transmission, a CRC is calculated and appended to the packet. Upon receipt the CRC is recalculated. If the two values do not match, then the receiver returns a negative acknowledgement to the transmitting radio at the next opportunity, and the packet is re-transmitted. The user can configure the radios with the maximum number of retries. If the two values match, then the receiver returns a positive acknowledgement to the transmitting radio during the next opportunity; and the transmitter discards the original packet. In this way, data is delivered without error through the network.

In some applications, the overall data volume may be small and low power operation may be important. A network of SolidLink radios can be configured to go to sleep periodically to save power. Because their individual clocks are not synchronized, the radios will awaken at slightly different times. The maximum time they can remain asleep and ensure that they can regain sync when they wake is TBD minutes. Once it awakens, the Master begins transmitting sync packets, which propagate through the network as the individual radios awaken.

2.2.3 Operating Modes

At any one time a SolidLink radio operates in one of two modes: data or command. In data mode it operates as a data pipe:

- Data received at the serial port is packetized and transmitted on the RF port;
- Data received for the radio at the RF port is extracted from the packet and transmitted out the data port; and
- In the case of Repeaters, packets received at the RF port and not destined for the radio are retransmitted to the next radio, as per its packet routing table.

In command mode, the SolidLink radio accepts a series of AT style commands at the serial port. Refer to the Commands section, which describes these in detail. In summary they support:

- Creating and terminating a connection between two radios;
- Obtaining ID and version information about the radio;
- Obtaining diagnostic information about the radio and network; and
- Leaving command mode and entering data mode.

By default a radio is in data mode. Entering command mode is accomplished by driving the CME serial interface control line low and then issuing an ATEC command; this is described in more detail in the Command Mode section.

The SolidLink radio also supports configuration and firmware reprogramming; however these interfaces are provided to the user through the SolidLink Network Manager.

2.3 Network Configurations

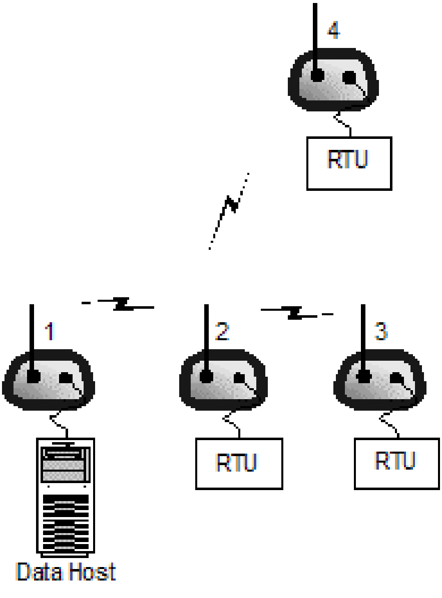
A SolidLink network consists of from 2 to 1000 SolidLink radios. A radio can be configured to operate as one of three different types: a Master, a Repeater or a Remote. It is important to note that there is no physical difference between these radios; it is simply a matter of how it is configured by the SolidLink Network Manager.

2.3.1 Radio Types

Each network must have one Master and can have no more than one Master. The Master must be either the source or destination for all information flow. A Master can connect to any number of Repeater and/or Remote radios and is at the upstream end of the network. Typically the serial interface of the Master is connected to a computer of some sort which executes the user's application software.

Remote radios can connect to only one other radio; they are at the extreme downstream end of the network. They typically interface with a Remote Terminal Unit (RTU), sensor device some other piece of remote equipment.

Repeaters can operate as Remotes, in that their serial interface connects to an RTU or other device. However, the Repeater can connect to more than one radio, and includes the capability to route packets not addressed to it. As part of their configuration, Repeaters include a routing table which instructs them where to send information being routed through.



The above graphic shows a simple SolidLink network comprising of four radios. Radio 1 is configured as the Master, radio 2 is a Repeater, and radios 3 and 4 are configured as Remote nodes. Through the Master, the user's application on the data host can communicate bi-directionally with any of the three RTUs. The RTUs cannot communicate with each other; all information must flow through the Master.

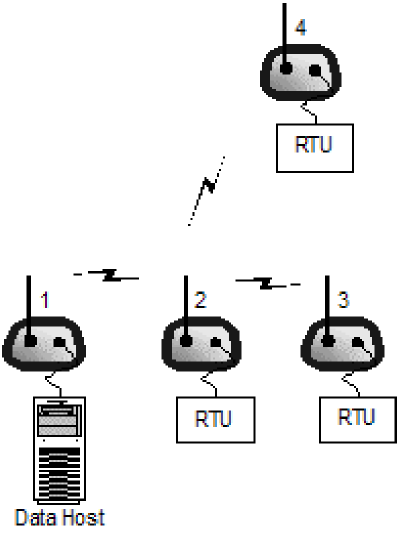
2.3.2 Network Types

Networks can be very complex. There can be many Repeaters and many network levels. Repeaters could be strung out along a line, such as along a pipeline or a river. The network could also be hierarchical, where one Master communicates with several Repeaters, each of which communicates with several Repeaters, and so on. In either case, all radios are addressable through the Master.

The network topology is fixed when the network is designed (using the SolidLink Network Manager) and downloaded into the radios. If the user wishes to change the topology, for example by adding a node, then the Master and all routers affected must be reconfigured.

SolidLink supports two different types of networks point-to-point and point-to-multipoint. The network type is established when the network is designed, using the SolidLink Network Manager.

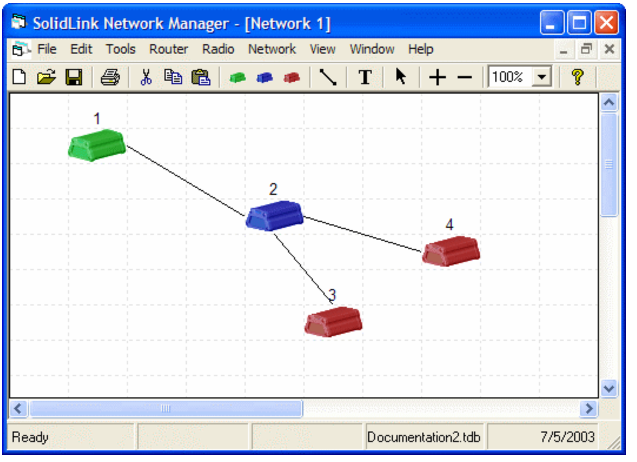
In a **point-to-point** network all communication is strictly controlled by the Master. The user's application on the data host will establish a channel between the Master and another radio by putting the Master into command mode and then using an ATDT command to make the link. For example, the graphic below, channels could be established between the Master and radio's 2,3 or 4. Until the connection is terminated (with an ATH0 command), all serial data that flows into the Master will flow out of the serial port of the connected radio. Similarly all serial data that flows into the connected radio will flow out of the Master. Radios that are not connected, will not transmit data. Each contains a 4096 Kbyte serial data buffer for holding data until a connection is made by the Master radio.



A **point-to-multipoint** network provides the same capability for connection based operation as does the point-to-point network. In addition, serial data from unconnected radios will be transmitted to the serial port of the Master radio. This latter method is significantly less efficient (from a throughput perspective) than the connection based method, because it relies on an internal (to the SolidLink network) arbitration scheme that is optimized for small, relatively infrequent, exception data. Point-to-multipoint also supports a broadcast connection, whereby any serial information entering the Master is replicated at the serial port of every other radio.

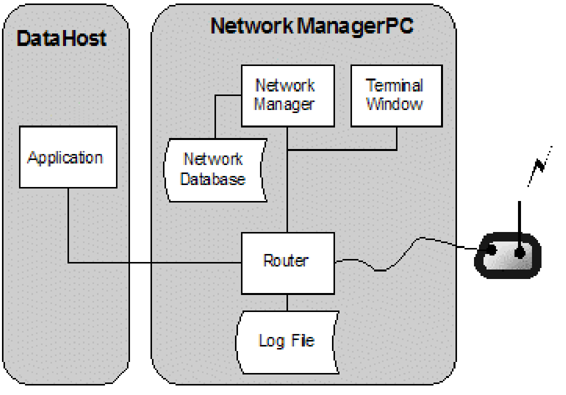
2.4 SolidLink Network Manager Software

The SolidLink Network Manager is a PC based application that is used to design networks, configure radios, debug applications, and support ongoing maintenance. It is more completely described in the SLNM software section. It makes no special demands of the PC other than requiring a serial port for configuring the radios. It is available on CD ROM and can also be downloaded from the SolidLink web site: www.solidlinkradio.com.



The network designer uses drag and drop techniques to graphically create a network, much like they would use a drawing tool such as Microsoft Visio to create a block diagram. Multiple networks can be create and are stored in a database file. Each radio in the network must be configured prior to use. This is easily accomplished by connecting the radio to the serial port of the PC and selecting configure from the command menu.

The real value of the SolidLink Network Manager can be seen when the user wishes to debug or maintain a new application. It actually comprises of three components, which execute independently: the network manager, a terminal window, and a router.



As illustrated in the above figure, the router can sit between the user's application (which would normally connect to the Master radio), and the Master radio. This does not affect the flow of information between the data host and the Master. It does allow the user to:

- Request online diagnostics of any radio on the network and display the results;
- Watch the flow of information (bidirectional) in a terminal window;
- Log the information flow (bidirectional) to a log file; and
- Temporarily pause the data host interface and communicate with the Master directly through the terminal window.

3 Getting Started

This section of the manual provides a step-by-step approach to getting started with SolidLink by building and bench testing a simple two radio network. If problems persist during this exercise, contact Seimac's technical support specialists at (902) 468-3007.

To proceed with this exercise refer to Bits and Pieces.

3.1 Bits and Pieces

The following SolidLink components should be ordered from Seimac Limited:

- Two SolidLink industrial radio modems;
- Two 2.2 dBi rubber duck antennas;
- Two power-data cables;
- One SLNM CD; and
- One SolidLink Manual (this document).

In addition, this test requires the following additional equipment:

- Two power supplies, capable of providing between 10 and 26 VDC at 500mA; and
- Two PCs with serial ports capable of hardware handshake.

To begin:

Unpack the SolidLink components and ensure everything is there and that nothing was damaged.

To proceed refer to Installing the SolidLink Software

3.2 Installing the SolidLink Software

Before the network can be created, the SolidLink Network Manager must be installed.

To install:

1. Determine which PC will be used as the network manager, the operating system must be Windows 98, NT, 2000, or XP.
2. Remove the SolidLink CD and insert into the CD reader of the network manager PC.
3. Follow the instructions to install the software; it uses the standard windows install shield.
4. If the computer is not restarted, it will be necessary to manually start the router, do this by selecting the Router item under the Seimac SolidLink Network Manager entry in the program menu. The router will automatically start each time the computer is started and the user logs on.
5. Start the SolidLink Network Manager. The first time that the program is run, the user will be prompted to create the network database file,

that will hold the designed networks. By default, the file will be called Network.tdb.

To proceed continue to the Creating the Network section.

3.3 Creating the Network

The next step is to create a simple network:

1. Select File | New Network to create a new network.
2. A Network Properties dialog box will appear. Enter a network ID, defaults are fine for other values. These values can be changed at any time through Network | Properties.
3. Select Tools | Master Radio and then click anywhere on the canvas, a Master radio icon will appear. Its ID number (1) will be displayed above.
4. Select Tools | Remote Radio and then click anywhere on the canvas, a Remote radio icon will appear. Its ID number (2) will be displayed above.
5. Select Tools | Straight Connector and draw a line between the two radios.
6. Select Tools | Selection Tool and then select the Master Radio.
7. Select Radio | Properties, a Radio Properties dialog box will appear.
8. Adjust the serial port protocols to match the PC to be used with it and adjust the RF output to 100 mW. Click OK.

9. Repeat Instructions 6,7, and 8 for the Remote Radio.
10. Select File | Save Network, a dialog box confirming a successful save will appear.

To proceed refer to the Configuring the Radios section.

3.4 Configuring the Radios

Before turning the network on, the radios must be configured.

1. Connect the serial / power cable to the circular connector on the Master Radio
2. Connect the serial cable to the appropriate COM port of the Network Manager PC, the default serial configuration of the radio is 57600-N-8-1. The radio requires that the COM port support hardware flow control.
3. Connect the +/- power leads to an 10-26 VDC supply and apply power to the SolidLink radio. The red LED will illuminate to indicate that the radio has power.
4. Select Router | Connect to Router. If this element is gray, then the router is not running. To activate the router select Programs | Seimac SolidLink Network Manager | Router and then try connecting to the router.
5. Select Router | Manually Select Router COM Settings and ensure that the settings are 57600-N-8-1 (the SolidLink radio default). The Radio COM port selection must match the port into

which the radio was connected in Instruction 2 (e.g. COM1).

6. Select the Master Radio by clicking on the network diagram.
7. Select Radio | Configure. The SolidLink Network Manager will verify the connection to the radio. Configuring the radio takes less than 30 seconds. During that time the status will be displayed on the status bar and a progress bar will be added to the bottom of the window to display progress.
8. Repeat steps 1,2,3,6, and 7 for the Remote Radio.

To proceed refer to the Testing the Network section.

3.5 Testing the Network

Once the radios have been configured, and are powered the Master will transmit sync packets every four seconds and the Remote will attempt to synchronize.

1. Separate the radios by approximately 5 feet and attach the 2.2 dBi omni antennas to the TNC connector. The green light on the Remote radio will turn on solid when the radios are in sync.
2. Connect a PC to the serial cable of the Remote Radio.
3. Configure the PC serial port to match the Remote Radio: 57600-N-8-1 with hardware flow control.

4. Use Microsoft Hyper-terminal or similar terminal window application to connect directly to the PC serial port, ensure that the port settings remain correct. This will provide a mechanism to send data into the Remote Radio and to view the data received by the Remote Radio.

5. Connect the Master Radio serial cable to the network manager PC serial port.

6. Select "**Tools**" | "**Open Terminal Window**" to create a SLNM terminal window to watch serial traffic on the Master Radio.

7. Select "**Tools**" | "**Put Radio in Command Mode**".

8. Enter "ATDT0002" in the data entry window of the terminal window and then press "Send". This will create a connection between the Master and the Remote.

9. Enter "ATQ" in the data entry window of the terminal window and then press "**Send**". This will terminate command mode and return the Master Radio to data mode.

10. Information typed into the Hyper-terminal window attached to the Remote Radio will appear in the SLNM terminal window (in red). Information typed into the data entry window of the SLNM terminal window will appear on the Hyper-terminal window.

Congratulations!

4 SolidLink Hardware

The SolidLink radio modem is packaged in a weatherproof enclosure suitable for mounting either inside or outside an enclosure. The main housing is an aluminum extrusion, which is coated with a marine epoxy paint. The end caps, which are rubber over molds over stainless steel inserts, provide a weather proof seal to each end of the extrusion. Stainless steel screws are sealed with o-rings, and should be torqued to TBD ft-lb to properly seal the end caps.

Internally, the electronics consist of a two board set. A radio board includes the 1W spread spectrum transmitter, receiver, modem and controller. A carrier board includes I/O protection, level control and DC power regulation.

There are four major elements visible on the outside of the enclosure:

1. Indicator lights;
2. RF connector;
3. Power-Data connector; and
4. Slidable mounting nuts (bottom view).

4.1 Light Indicators

This group of three light emitting diodes (LEDs), provides a graphical status indication of the SolidLink radio modem state.

The LED descriptions are as follows:

RED LED (Power)

Indicates that DC power applied. The SolidLink radio accepts DC power between 10 and 26 Volts.

GREEN LED (Lock)

Indicates the synchronization status. The Master Radio LED remains lit while the radio is powered on. The Green LED on Remote and Repeater radios remains unlit until it synchronizes with its upstream radio. If a radio at any time looses synchronization with the network, then the Green LED will go out until synchronization is reestablished.

YELLOW LED (Data Transmit Activity)

This light indicates that data is currently being transmitted by the radio. In general, the led flickers as data flows out of the unit, over the air.

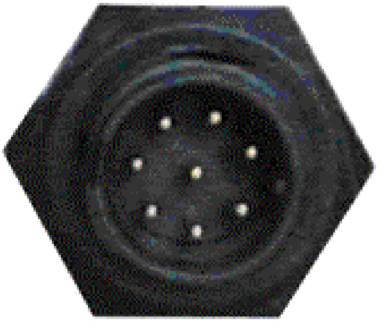
4.2 Connectors

RF Connector

This connector is a TNC Female connector used to connect the SolidLink radio modem with different external antennas. Proper rules and regulations must be followed when attaching external antennas; antenna installation is discussed in the Antenna and Cable Connection section.

Power-Data Connector

The power-data connector is an EN3 type weatherproof connector. It provides both DC power and the RS-232 serial data interface. A variety of cables with proper matching connectors are available from Seimac Limited. Pin 1 is in the first counter-clockwise position from the key. Pin 8 is in the center.



The following table describes the pin-out for the EN3 circular connector:

PIN Number	Signal Name	Description
1	Spare	Future Use
2	RXD	Received data (RS-232 input)
3	TXD	Transmit data (RS-232

		output)
4	GND	
5	Vin	DC Power Input
6	CME	Command Mode Enable
7	CTS	Clear to send (RS-232 output)
8	GND	Signal Ground

All data signals (RXD, TXD, CTS) and the CME in the SolidLink radio modem are RS-232 levels they must be in the -12 to +12 VDC range.

The SolidLink radio modem data port provides a DCE interface to be connected to a DTE in the user equipment side. If the SolidLink radio modem is connected to other DCE equipment the proper null modem cable must be used.

Refer to the Data Mode, Command Mode, and Command Protocol sections for more detail.

4.3 Data Interface

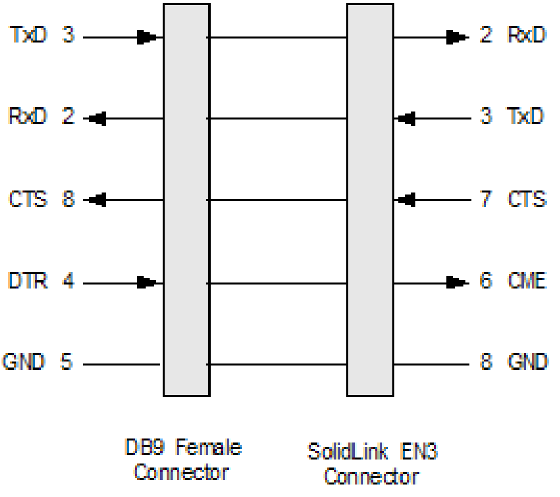
The Data interface is physically provided through the circular power – data connector. All signaling is as per RS-232. The data port configuration is set through the SolidLink Network Manager, refer to the Using the Router Software section.

1. The baud rate is selectable from 110 baud up to 57,600 baud,
2. Parity can be None, Odd or Even

3. Stop bits can be 1 or 2

4. Both 7 or 8 data bits are supported.

Each SolidLink radio modem is provided with a short power-data cable; however if needed, the following cable can be used to connect SolidLink with external devices through a DB-9 data connector.

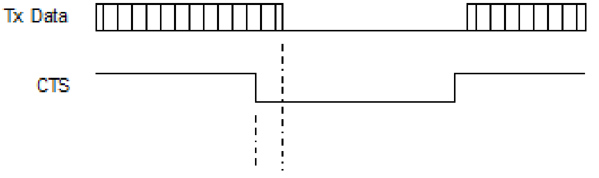


The radio, and data interface operate in two separate modes: data and command. These modes are discussed in SolidLink Theory of Operation.

4.3.1 Data Mode

When in Data Mode, the SolidLink radio modem transfers data between the RF interface and the serial port. The radio normally asserts Clear to Send (CTS) by driving it to +12V. This indicates to the

Remote Terminal Unit (RTU) that the radio will accept data. The radio includes a 4096 Kbyte serial data buffer, however at times, because of network congestion or RF interference, the buffer may fill. At that time, the radio will drop CTS, and the RTU must stop sending serial data. Once CTS is reasserted, the RTU can resume data flow.

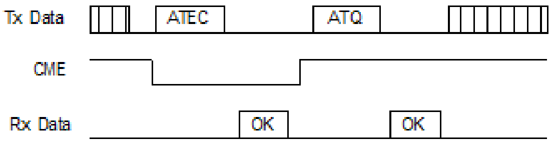


4.3.2 Command Mode

When in command mode, the SolidLink radio accepts commands allowing the user's application to:

1. Create and terminate a connection between two radios
2. Obtain ID and version information about the radio
3. Obtain diagnostic information about the radio and network
4. Leave command mode and enter data mode.

When the SolidLink radio is in data mode, and CME is driven low, it expects the next serial port data to be an "ATEC" command, putting the radio into command mode. It will respond with "OK". The controlling device must then de-assert CME. The radio will remain in command mode until it receives an "ATQ" command. The CME line is normally connected to the DTR signal in the controlling device, and must be driven.



4.3.3 Command Protocol

All commands are issued by the controlling device as ASCII strings starting with the ASCII characters "AT". This is immediately followed by the command type and then any qualifying arguments. The command arguments may be variable in length. The entire command string must be terminated with a carriage return (0xd), denoted here by <CR>

The radio will respond with an ACK if the command is accepted and with a NAK if the command is rejected. ACK consists of the ASCII string "OK<CR>". If the command returns a value, it will arrive after the ACK and will also be terminated by a carriage return. NAK consists of the ASCII string "-nn<CR>" where nn is a one or two digit error code.

The commands, their arguments and returns are described in detail in the Commands section.

4.4 Mounting Options

The SolidLink radio modem is designed to be installed in a variety of ways according to the customer and project needs. Since the SolidLink radio is weather proof the unit can be installed either in the typical configuration next to the user DTE equipment or as close as possible to the RF antenna.

Each SolidLink radio includes two slideable stainless steel mounting nuts, which are captive in the channel on the bottom of the radio chassis. They can slide along the channel to adjust the spacing to suit the customer. These nuts accept 1/4-20 threaded bolts and are used to attach the SolidLink radio to a variety of optional mounting hardware.

Seimac Limited provides several mounting options, sold separately:

1. DIN Rail;
2. Pole; and
3. 19" rack shelf.

4.4.1 DIN Rail Mounting Option

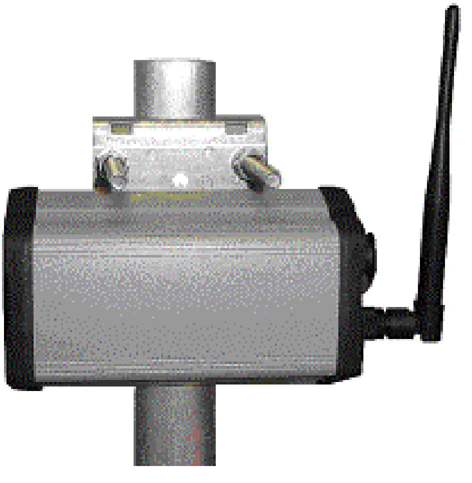
The SolidLink radio can be installed on a DIN rail inside a NEMA box or other type of enclosure. The DIN rail mounting kit includes a universal mounting plate with a pair of DIN rail mounting clips. The SolidLink radio is bolted to the universal mounting bracket with a pair of 8-32 bolts (provided) that attach to the captive mounting nuts. The whole assembly is then clipped onto the DIN rail, either vertically or horizontally (as shown below).

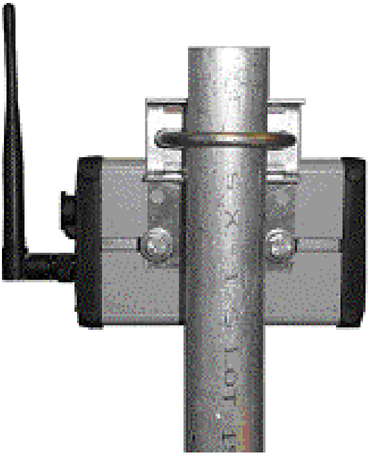
The following graphic shows a SolidLink mounted inside a NEMA box with a flex antenna, that antenna can be removed and the SolidLink unit can be installed with the proper external antenna.

4.4.2 Tower and Pole Mounting Option

Similar to DIM rail installations, the SolidLink radio modem can be installed in towers or poles next to the RF antenna to reduce the RF cable losses. The tower brackets are sold separately. Assembly instructions are provided.

The tower brackets use the same universal adapter that is provided with the DIN rail mounting option. Instead of DIN clips, the pole adapter uses a U shaped pole clamp, as illustrated below. The radio can be mounted horizontally or vertically (refer below).



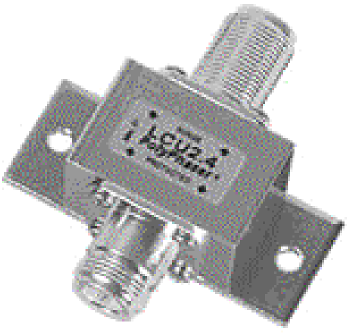


4.4.3 19" Rack Mounting Options

To support situations where it is convenient to mount the SolidLink radio in a 19” rack mount enclosure, Seimac provides a 19” rack mount option (sold separately). This consists of a sturdy 10” deep shelf pre-drilled to allow the SolidLink radio to be attached with 8-32 bolts, in several orientations.

4.5 Lightning Protection

Always install the SolidLink radio modem with the proper lighting arrester for 2.4GHz, even for short RF cable lengths. Seimac Limited provides the Polyphaser LCU 2.4 surge protector as an option.



The LCU2.4 is provided with an N-Male connector on the antenna side and an N-Female connector on the radio side. It has an insertion loss of less than 0.2dB, which is negligible. Full details are provided on the SolidLink web site www.solidlinkradio.com.

Note: The SolidLink product warranty does not cover damage caused by lightning.

4.6 Antenna Selection

When operated under FCC or Industry Canada regulations, antennas and RF cables used as part of the installation must be purchased from Seimac Limited. All of the antennas provided by Seimac Limited are FCC and Industry Canada approved for use with SolidLink.

Type	Gain (dBi)	Seimac Model	Manufacturer Model	Connector
Omni	2.2	SLA-2400-2O	Maxrad MHWS2400	TNC-M

			C	
Omni	5.5	SLA-2400-5O	Maxrad MMO24005 PTCRP	N-F
Directional	12	SLA-2400-12D	Hyperlink HG2412	N-F
Directional	16	SLA-2400-16D	Pacific Wireless PAWVA24-16	N-F
High Gain	18	SLA-2400-18D	Conifer 18T-2400	N-F
High Gain	24	SLA-2400-24D	Conifer 26T-2400	N-F

Seimac provides a wide variety of antennas to suit different applications. They range from a 2.2 dBi omni that mounts directly onto the SolidLink radio to a 24 dBi parabolic. Details and data sheets on the various antennas can be found on the SolidLink web site www.solildlinkradio.com and within the following sections:

1. Omni Directional Antennas
2. Directional Antennas
3. High Gain Directional Antennas

4.6.1 Omni Directional Antennas

Seimac provides two omni directional antennas:

1. The **Maxrad 2.2dBi MHWS2400C** TNC female antenna is offered to perform in lab tests. This is a basic “rubber duck” antenna that mounts directly to the TNC Female connector on the SolidLink radio. This antenna is also suitable for in-plant applications where short distances between antennas allow low radiated power and low antenna height.
2. The **Maxrad 5.5 dBi MMO24005PTCRP** N female connector antenna is intended to be used with SolidLink radio modems when the radio is the Master unit in point-to-multipoint applications. The antenna is intended to be mounted to a mast. The technician must take in consideration that since this is an antenna that radiates power in all directions it is also susceptible to receive undesired RF signals from all directions.

4.6.2 Directional Antennas

The reason for using directional antennas is to create links between two units with the reduced signal degradation and interference with other RF sources. It can also reduce transmitter power levels which can be important when operating on batteries. Another benefit is reduced interference with other receivers, not in the “line of sight”.

SolidLink networks can use directional antennas for Remote site locations linked to the Master unit or to Remote units linked to the Repeater. Also, directional antennas can be used to link a Master radio with a Repeater radio. Directional antennas can be used to make directional link configurations more efficient and to reduce the impact of undesired RF signals, both received and transmitted.

The use of directional antennas may require that output power be reduced to maintain the EIRP within regulations. Please refer to the Installation section.

Seimac Limited provides two directional antennas, the **Hyperlink 12 dBi Yagi HG2412Y** with an N female connector and the **Pacific Wireless 16 dBi Yagi PAWVA24-16** with an N female connector. Both of these antennas are intended to be pole mounted, and are provided with mounting hardware.

4.6.3 High Gain Directional Antennas

High gain antennas provide a very reliable RF link between two point-to-point SolidLink radio modems. Seimac recommends that high gain directional antennas be used when SolidLink radio modems are used to link two sites in a point-to-point configuration. The use of high directional antennas reduces the impact of undesired interference with a SolidLink network, while also helps to keep a cleaner RF environment.

Seimac Limited provides two high gain directional antennas: the **Conifer 18 dBi 18T-2400** with an N female connector and the **Conifer 24 dBi 26T-2400** with an N Female

4.7 Installation

SolidLink complies fully with FCC part 15 rules, and with Industry Canada RSS-210. If SolidLink is being used under FCC or Industry Canada jurisdiction, it must be installed by a professional installer. Only antennas certified for use may be used, these are provided by Seimac Limited.

Seimac Limited offers technical training courses to properly install and configure SolidLink radio modems according to the FCC and Industry Canada regulations.

In Canada, the installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population; consult Safety Code 6, obtainable from Health Canada's web site www.hc-sc.gc.ca/rpb.

This device complies with FCC RF radiation exposure limits; however it is important that the device be installed such that human exposure to harmful RF radiation is minimized. In order to comply with RF exposure limits, the following minimum separation distances between the transmitter antenna and all persons should be maintained:

Omnidirectional	20 cm

Directional (Yagi)	2 m
High Gain Directional (Parabolic)	2 m

The directional and high gain directional antennas are for fixed outdoor installations only.

4.7.1 Mounting Considerations

The SolidLink radio includes a weather tight package that can be installed in an outdoor environment. Radio mounting options are discussed in the Mounting Options section. The unit will operate over the temperature range -40°C to +75°C, so care must be taken to ensure that ambient temperatures do not exceed these maximums.

If RF performance is an issue, it often is, that the antennas should be mounted as high as possible to reduce path loss. Refer to the Estimating RF Performance section for more information. If RF performance is not an issue, for example if a network is setup within a small area so that link distances are short, then antenna height is less important.

At 2.4 GHz, cable loss can be significant. Seimac provides WBC-400 and WBC-600 coaxial cable with losses of 7 dB and 4.4 dB per 100 ft. In order to minimize cable loss, the SolidLink radio can be located close to the antenna. All antennas and the SolidLink radio are available with pole mounting hardware.

If the SolidLink radio is mounted on the pole, then the data and power cable must be run up the pole to the radio. Seimac provides optional power-data cables of up to 15m in length. This is the longest practical cable run for the RS-232C signaling protocol at 57,600 baud.

4.7.2 Estimating RF Performance

The performance of a radio link between two devices is a function of the system gain and path loss. The difference between the two is the link margin. Seimac recommends that the system be designed for a link margin of at least 10dB.

System gain includes the transmitter power, the gain and loss through the transmitter antenna and cables, the gain and loss through the receiver antenna and cables, and the receiver sensitivity. In general

$$G_S = P_O + G_{TA} + G_{RA} + S_R$$

For example, a typical SolidLink installation might include:

1. Output power 30 dBm (1W maximum)
2. Transmitter cable loss 2dB
3. Transmitter antenna gain 5.5 dB
4. Receiver antenna gain 5.5 dB
5. Receiver cable loss 2dB
6. Receiver sensitivity -104dB

$G_S = 30 – 2 + 5.5 + 5.5 -2 + 104 = 141dB.$

Calculating the path loss is more complicated and much less precise. It is very much a function of the distance between the transmitter and receiver, the height of each, the atmospheric conditions and the terrain. In general, path loss decreases as distance decreases and as antenna height increases. The plane earth model can be used as first approximation of the propagation loss:

$$L_{PE} = 10*Log_{10} [D^4 / (HT^2*HR^2)]$$

where:

D = distance between the transmitter and receiver in meters

HT = height of the transmit antenna above ground in meters

RT = height of the receive antenna above ground in meters

Based on this formula, the following table illustrates expected propagation losses for a variety of distance and height combinations. It also includes a link margin calculation based on the system gain calculation above. Link margins below 10 are not recommended.

Ht (m)	Hr (m)	D (km)	Lpe (dB)	Gs (dB)	Lm (dB)
2	2	1	107.96	141	33.04
5	5	1	92.04	1416	48.9
15	15	1	72.96	141	68.04

2	2	5	135.92	141	5.08
5	5	5	120.00	141	21.00
15	15	5	100.92	141	40.08
2	2	15	155.00	141	-14.00
5	5	15	139.08	141	1.92
15	15	15	120.00	141	21.00
2	2	25	163.88	141	-22.88
5	5	25	147.96	141	-6.96
15	15	25	128.87	141	12.13

4.7.3 Power and Grounding

The SolidLink radio requires a DC supply voltage of between 10 and 26 Volts. The installer must consider the cable loss when determining the supply voltage. Assuming an active radio, the resistive voltage drop on the power and ground leads across a 15m cable will be approximately 1V at the low end of the power range. This means that the power supply must supply at least 12V across the cable in order to provide the minimum 10V to the SolidLink radio DC power input.

The RF shield ground and DC power ground are coupled in the SolidLink radio. Seimac recommends that the RF cable shield be grounded externally through a lightning protector located in close proximity to the radio.

Because of the durable marine epoxy paint that is covers the SolidLink case; a reliable ground cannot be made by physically connecting the SolidLink radio to a grounded object, such as a tower or mast. The ground should be made through the RF cable shield.

4.7.4 Surge Protection

Seimac Limited strongly recommends that the SolidLink radios and antennas be installed with lightning protection. Seimac provides the optional Polyphaser LCU2.4 for this purpose.

Where the SolidLink radio is located very close to the antenna, with a short co-axial cable, then one LCU2.4 should be installed between the transmitter and the antenna. The installer must be careful to ground the surge protector. If the SolidLink radio is located at the base of a tower or in an equipment enclosure, then Seimac recommends that surge protectors be installed at the antenna and at the transmitter, again they must both be carefully grounded.

4.7.5 Antenna and Cable Connection

Under FCC and Industry Canada regulations, the maximum allowed transmitted power, out of the SolidLink radio (PR) is 30dBm, or 1 Watt. The maximum antenna gain (GA) is 6dB. Assuming no cable loss, the maximum effective radiated power (ERP) is:

$$ERP = P_R + G_A = 36dBm$$

Seimac Limited provides a variety of antennas and cables:

Type	Gain (dBi)	Seimac Model	Manufacturer Model	Connector
Omni	2.2	SLA-2400-2O	Maxrad MHWS2400C	TNC-M
Omni	5.5	SLA-2400-5O	Maxrad MMO24005PTCRP	N-F
Yagi	12	SLA-2400-12D	Hyperlink HG2412	N-F
Yagi	16	SLA-2400-16D	Pacific Wireless PAWVA24-16	N-F
Parabolic	18	SLA-2400-18D	Conifer 18T-2400	N-F
Parabolic	24	SLA-2400-24D	Conifer 26T-2400	N-F

Cable Loss (dB)		
Cable Type	WBC 400	WBC 600
Loss (dB/100m)	22.97	14.44
Cable Length (m)		
1	0.23	0.14

5	1.15	0.72
10	2.30	1.44
15	3.44	2.17

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power is not more than that required for successful communication.

From an FCC and Industry Canada regulatory perspective, there are two types of links, with slightly different rules regarding maximum allowable ERP.

A **point-to-multipoint** link is a situation where a radio communicates with more than one other radio, and therefore cannot radiate in a single direction. Examples include a Master radio that communicates with several Remote radios that were geographically dispersed, and any Repeater. Omni directional antennas must be used.

A **point-to-point** link is a situation where a radio communicates with one other and therefore can radiate in a single direction. Examples are a Master that communicates with a single Remote or any Remote radio. Directional antennas can be used to improve performance and reduce unintentional interference with other ISM band equipment.

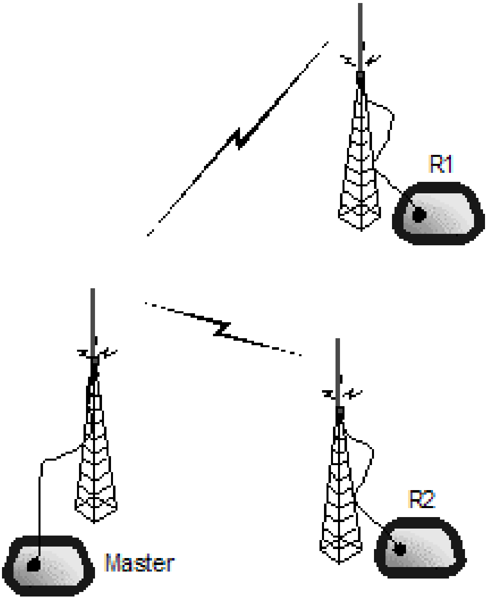
For information on configuring these links refer to the Point-to-Multipoint and Point-to-Point sections.

4.7.6 Point-to-Multipoint

When configuring a point-to-point link, the maximum ERP is calculated as follows:

$$ERP = P_R + G_A - L_C = 36dBm$$

Consider the following network:



The links from the Master radio to the Remote radios are point-to-multipoint links because the Master communicates with several spatially diverse locations. The Master must use an omni directional antenna. The Remote obey point-to-point rules. All Repeaters obey point-to-multipoint rules.

Seimac provides two omni directional antennas, one with a 2.2 dB gain and the other with 5.5 dB gain. With full transmit power, and the highest gain antenna, and assuming the best case cable loss (0dB), the ERP is:

$$ERP = P_R + G_A - L_C = 30dB + 5.5dB - 0dB = 35.5dB$$

This is less than the maximum allowable ERP; therefore the installer is free to set the SolidLink output power to any value between 100mW and 1W. Refer to the Setting the RF Output Power section for details on this and on cable length.

4.7.7 Point-to-Point

When configuring a point-to-point link, the maximum allowable ERP can be increased above 36dBm as follows:

For every 3dB increase in antenna gain above 6dB, the transmitter output power must be decreased by 1dB. The antenna gain calculation includes cable losses, so is a function of complete installation.

For example, with an antenna gain of 12dBi, the transmitter power output could be set to:

$$P_R = 30dBm - (12dBi-6dBi)/3 = 28dBm$$

$$ERP = 27.8dBm + 12dBi = 39.8dBm$$

The following tables show the output power setting that must be used for each cable length, when used with each antenna. There are four directional antennas, two cable types, and four cable lengths.

Maximum Output Power Settings (mW)		
Antenna Type	HG2412Y	
Antenna Gain (dB)	12	
Cable Type	WBC 400	WBC 600
Cable Length (m)		
1	600	600
5	600	600
10	700	700
15	800	700

Maximum Output Power Settings (mW)		
Antenna Type	PAWVA24-16	
Antenna Gain (dB)	16	
Cable Type	WBC 400	WBC 600
Cable Length (m)		
1	400	400
5	500	400
10	500	500
15	600	500

Maximum Output Power Settings (mW)		
Antenna Type	18T-2400	
Antenna Gain (dB)	18	
Cable Type	WBC 400	WBC 600
Cable Length (m)		
1	400	400
5	400	400
10	400	400
15	500	400

Maximum Output Power Settings (mW)		
Antenna Type	26T-2400	
Antenna Gain (dB)	24	
Cable Type	WBC 400	WBC 600
Cable Length (m)		
1	200	200
5	200	200
10	200	200
15	300	200

4.7.8 Setting the RF Output Power

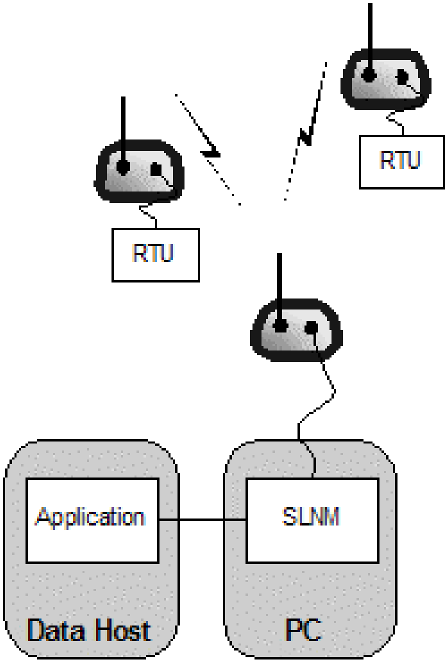
The RF output power is set through the SolidLink Network Manager (refer to the section on Network Properties), when designing the network and configuring the radio. Available options (in mW) and the equivalent output power in dB are:

Power (mW)	**Power (dBm)**
100	20.0
200	23.0
300	24.8
400	26.0
500	27.0
600	27.8
700	28.5
800	29.0
900	29.5
1000	30.0

5 SolidLink Network Manager

The SolidLink radio and the SolidLink Network Manager (SLNM) software, together, provide the complete data communication system. SLNM is a Windows application program that runs on a PC under Windows 98, NT, 2000 or XP where it supports the design and maintenance of SolidLink networks. It allows its user to:

1. design SolidLink radio networks using a graphical network design tool;
2. configure individual radios to deploy networks;
3. watch traffic flowing between a user's application and the network; and
4. obtain network and radio diagnostics online.



While an application computer can connect directly to the Master radio, the SLNM can transparently sit between the two and allow the user to effectively monitor the network and diagnose problems.

5.1 Installation

Installation of SLNM is made easy through an automatic install process upon inserting the SLNM CD. This one time procedure includes the SLNM user interface, Router software, and Terminal

Window. If for any reason automatic installation does not begin instructions have been provided below.

Note: In order to install SLNM on a system having a Windows NT operating system, or later version of Windows, you must have 'Administrator' privileges for that installation computer. If you do not have Administrator privileges, contact your System Administrator and have them perform the installation.

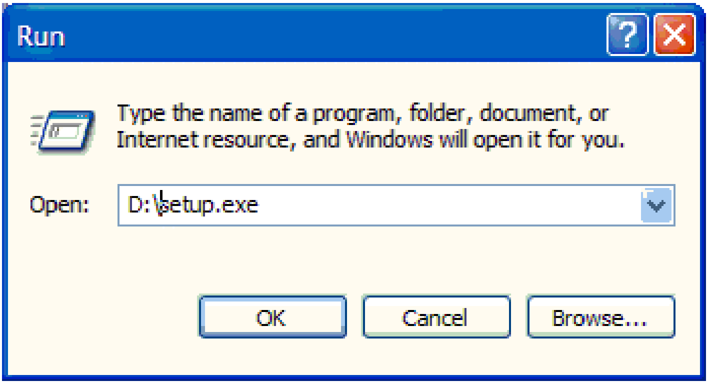
Once installed the SLNM, Router, and Terminal Window are available.

Note: the Terminal Window will run on a continuous basis unless terminated by you.

- Double-click the "**setup.exe**" file or click the Windows' "**Start**" button, then select "**Run**".

- Click the "**Browse...**" button and browse to the "**setup.exe**" file on the CD-ROM and select it.

  You will be returned to the "**Run**" window.



From this “Run” dialog window:

- Click "**OK**" to begin the installation program.

When the installation program starts, you will be presented with several dialogs that require your input or response.

- Follow the instructions presented, making the selections you desire, clicking the "**Next**" button after you have completed each dialog.

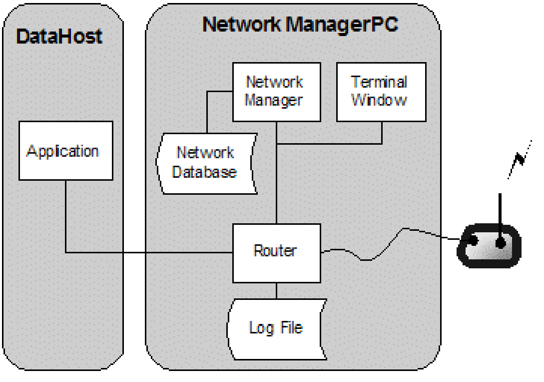
- Once you have provided all the required information, click the "**Install**" button to complete the installation of SLNM.

The installation will create a program group in the Windows Start menu and a shortcut on the Windows desktop to allow easy access to SLNM.

The first time that SLNM is run, the user is prompted to create the default network database. This database file contains up to 64 different network designs.

5.2 Components

The SolidLink Network Manager includes several components that work together to provide the complete application:

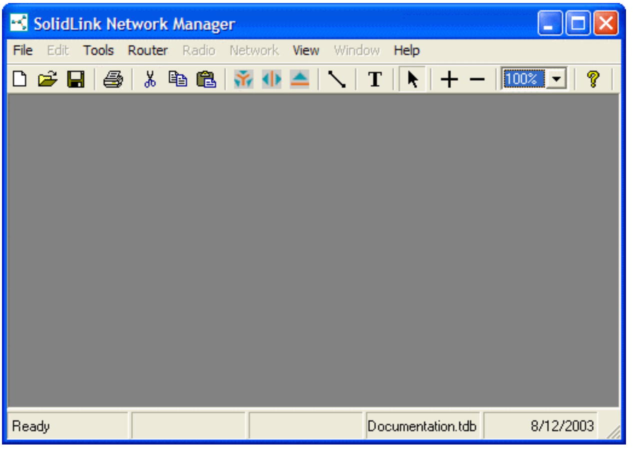


The primary elements are:

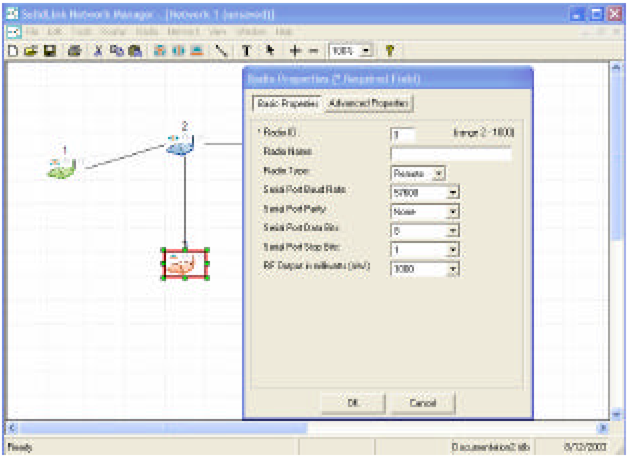
1. Network Manager;
2. Terminal Window; and
3. Router.

5.2.1 Network Manager

The Network Manager is the user's primary interface with the SLNM. It is written as a conventional windows application, with familiar menus, toolbars and window size controls. When the user selects "**SolidLink Network Manager**" from the "**Program**" menu; it is the Network Manager that launches.



From here the user can open existing networks, create new networks, and configure networks and radios. Standard and frequently used functions are available as toolbar elements. The Network Manager includes familiar "right-click" menus on the graphical components to provide quick access to commonly used menu functions.



The user controls the router and the terminal window from the Network Manager, both are available through menu controls. This user manual is available as online help, accessible through the Help menu or the "?" tool.

The user works with networks through a graphical interface. Icons representing Master, Remote or Repeater radios are dropped onto the canvas, and interconnected with an interconnection tool. The radio icons can be moved anywhere; their physical location on the canvas has no bearing on the network topology. What matters is how they are interconnected. Once a network is operational, the SLNM can remain connected to the Master radio. In this situation, the user can obtain diagnostics from a radio by simply selecting the radio on the canvas and then selecting diagnostics from the radio menu.

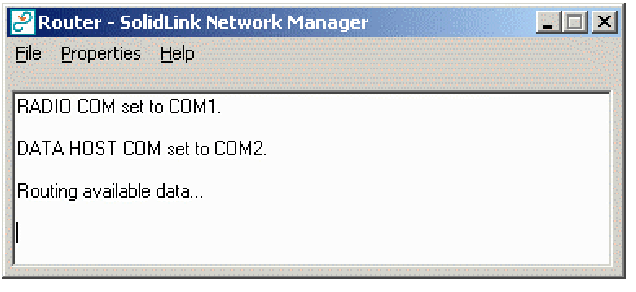
Note: When the user stops the network manager by selecting "**File**" | "**Exit**", the Terminal Window and Router remain active.

5.2.2 Router

The Router is installed as part of the SolidLink Network Manager and starts when the user logs in. It can also be started and/or restarted manually from the Windows Start menu.

Note: The Router has been designed as a stand-alone application in the case that a user requires only this application to be running at any given time.

As its name suggests, the Router passes information between the SolidLink network, the Data Host, and the Network Manager and Terminal Window.



Normally, the Router is placed in the "**Startup**" section of the "**Program**" menu, so that it starts automatically when the user logs in. When active, the Router icon is located in the system tray (by the system clock usually at the bottom right of the screen). Double-clicking on the icon opens the Router interface shown above.

The Master radio and the user's application (if connected) must be connected to different COM ports, which are user selectable through the "**Properties**" menu. Both ports share the same configuration, so that the Network Manager PC can be easily removed and the Data Host connected directly to the Master SolidLink radio.

The Router can auto-baud in situations where the user does not know the radio baud rate. This feature is available through the Network Manager's "**Router**" menu. When auto-baud is selected, the Router will determine which baud rate is correct, by sequentially stepping through all available choices and will set the port characteristics accordingly.

The Router also includes a data logging feature which allows the user to capture to file the serial traffic that flows in and out of the Master radio. The user can set the default logging directory and can limit the amount of disk space consumed the log files.

The default communications settings, which are used when the Router is run the first time, are:

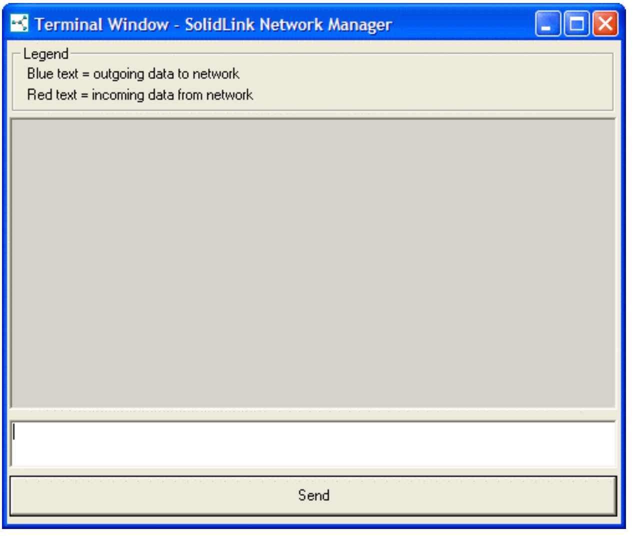
1. Data Host COM Port = NONE;
2. Radio COM Port = NONE;
3. Port settings 57600, 8, N, 1, hardware flow control;

4. Logging is disabled;
5. No selected log file directory; and
6. Default log directory size = 10Mbytes.

Note: The Network Manager must be explicitly connected to the Router in order to communicate with the SolidLink network or to control and configure the Router itself.

5.2.3 Terminal Window

The Terminal Window is, like the Router, installed as part of the Network Manager application. Unlike the Router, the Terminal Window is started explicitly from the Network Manager. Its purpose is to displays all serial traffic that flows in to and out of the connected Master radio. The Terminal Window is designed for use during application system testing for monitoring traffic between the network and application. It also provides a command window whereby the user can enter data or AT commands directly.



Data that is destined for the network is shown in blue, incoming data is shown in red. Printable ASCII characters are displayed directly. Non printable characters are shown in their hexadecimal representation and enclosed in a pair of curly braces { }. For example, the carriage return character is displayed as {0xd}.

To send commands or data manually, the user types data into the white data entry pane and then clicks the "**Send**" button. Data is not removed from the data entry pane when sent, so the same data can be sent repeatedly by repeated clicks of the "**Send**" button.

5.2.4 Network Database

The Network Manager stores networks in the Network Database. Through the File menu, the user can create a new network database file, select a database or set the default. Up to 64 networks can be stored in one Network Database.

5.2.5 Log File

The SLNM Router allows the user to log serial traffic to a log file as demonstrated by the following example:

```
[07-07-2003_16.34.16]

>>ATEC{0x0d}

[07-07-2003_16.34.16]

<<OK{0x0d}

[07-07-2003_16.34.16]

>>ATDM02000001{0x0d}

[07-07-2003_16.34.16]

<<OK{0x0d}=0000000000{0x0d}

[07-07-2003_16.34.16]

>>ATQ{0x0d}

[07-07-2003_16.34.16]
```

```
<<OK{0x0d}

[07-07-2003_16.34.22]

>>ATEC{0x0d}

[07-07-2003_16.34.22]

<<OK{0x0d}

[07-07-2003_16.34.22]

>>ATDM16000001{0x0d}

[07-07-2003_16.34.22]

<<OK{0x0d}=0000000000,0000000000,0000000000,0000000000,0000
000000,0000000000,0000000000,0000000000,0000000000,00000000
00,0000000000,0000000000,0000000000,0000000000{0x0d}

[07-07-2003_16.34.22]

>>ATQ{0x0d}

[07-07-2003_16.34.22]

<<OK{0x0d}
```

Each entry in the log file is composed of the following three components:

- time stamp;
- data direction symbol; and
- data.

The time stamp is formatted as follows:

```
[mm-dd-yyyy_hh.mm.ss]
```

where mm-dd-yyyy is the date in month-day-year format, and hh.mm.ss is the 24 hour system time when the data was added to the log file in hours.minutes.seconds. This is the system time of the PC running the Router application. A time stamp is added to the file whenever there is a change in data direction. The example above shows commands being issued to the network, and then command responses being received from the network. The data direction is indicated by the data direction symbol.

The data direction symbol indicates the source of the data relative to the Router. Specifically, the characters indicate:

>>	outgoing data sent through the Router to the radio network; and
<<	incoming data sent through the Router from the radio network.

The last component of each log file entry is the data. If the data sent or received is, or contains, printable ASCII characters, the data is recorded in the log file as those characters. If the data sent or received is, or contains, non-printable ASCII characters, then a curly brace { } bound hexadecimal representation of the character value is recorded in the log file. From above, the line:

```
>>ATDM16000001{0x0d}
```

should be interpreted as follows:

`>>`	data direction symbol
`ATDM16000001`	printable ASCII characters
`{0x0d}`	non-printable ASCII character (in this case a carriage return character)

5.3 Menu Reference

This section of the manual describes each of the menu items available in the Network Manager and Router applications. Whenever a menu item is not available, it will be de-selected and displayed in light gray (instead of black). For example, if there is no open network, then the Save Network menu item will be unavailable and displayed in light gray. Also, if the Network Manager is not connected to the router, all of the menu items that involve the router or communicating with the network will be unavailable.

5.3.1 Network Manager

The Network Manager provides the primary user access to the SLNM, through the following menus:

1. File
2. Edit
3. Tools
4. Router
5. Radio

6. Network
7. View
8. Window
9. Help

5.3.1.1 Menu Items

File

The File menu contains commands associated with managing networks and network databases.

Menu	Description
New Network	Create a new SolidLink network.
Open Network	Open an existing SolidLink network.
Close Network	Close the currently selected network and save to the selected Network Database.
Save Network	Save the currently selected network to the selected Network Database.
Select Network Database	Select a Network Database to use as the repository for SolidLink networks.
Create New Network Database	Create a new and empty Network Database.
Set Default Network Database	Establish which Network Database to use as the default when the SolidLink Network Manager starts.
Delete Network	Delete a network from a Network Database.

Print	Print the currently active window.
Exit	Close SLNM, leaving the Terminal Window and Router as they were.

Edit

The Edit menu contains a standard set of Windows edit functionality.

Menu	Description
Undo	Undo the last edit command, insert or delete.
Redo	Redo the last edit command, insert, delete, or undo.
Cut	Cut the selected item to the windows clipboard.
Copy	Copy the selected item to the windows clipboard.
Paste	Paste the windows clipboard onto the screen at the current cursor.
Delete	Delete the currently selected item, or text past the cursor.

Tools

The Tools menu contains the network design and radio interaction tools. It gives access to network design functionality through Master, Repeater, and Remote radios, as well as the connector and text tools.

Menu	Description
Master Radio	Select a Master radio to be placed on the network design pane. The radio is placed by left-clicking on the design pane.
Repeater Radio	Select a Repeater radio to be placed on the network design pane. The radio is placed by left-clicking on the design pane.
Remote Radio	Select a Remote radio to be placed on the network design pane. The radio is placed by left-clicking on the design pane.
Straight Connector	Select a straight connector to be placed on the network design pane. Two radios are interconnected by left-clicking on the first radio and then dragging to the second.
Text Tool	Select a text tool for placing a free-form text blocks on the design pane. Left-click on the design pane to place a text block.
Selection Tool	Select the selection tool, used to select and move radio icons on the design pane.
Put Radio in Command Mode	Causes the CME line to be pulsed and the ATEC command string to be sent to the radio, putting it into command mode. The Network Manager must be connected to the Router.
Terminal Window	Opens the Terminal Window.

Router

The Router menu provides the user with a means to control the SLNM Router.

Menu	Description
Connect to Router	Establishes a connection between the Network Manager and the Router
Enable Logging to File	Sends a message to the Router, requesting that it start logging serial data. The log file directory is set-up through the Properties menu of the Router
View Router COM Settings	Displays the current Router COM port configuration.
Manually Configure Router COM Settings	Provides a dialog box that allows the user to setup the COM port settings used by the Router to communicate with the Master and the Data Host
Auto Configure Router COM Settings	Requests that the Router automatically determine the connected SolidLink radio communication settings and set the COM port to match.

Radio

The Radio menu contains menu items enabling access to radio properties, configuration, diagnostics, and the ability to view a radio’s route table. They all require that a network be open and that the user select a single radio.

Menu	Description
View Route Table	Displays the routing table for the selected radio.
View Last Diagnostics	Display the most recent set of diagnostics collected for the selected radio.
Diagnostics->	Provides a sub-menu that allows the user to pick a specific diagnostic for the selected radio. The router submits a diagnostic request to the SolidLink network, through the Master radio, and the results are displayed.
Configure	Downloads the configuration for the currently selected radio. A radio must be connected to a COM port and the router properly configured.
Radio Firmware->	Provides the user with a sub-menu that allows a firmware update to be download into the radio.
Properties	Provides a dialog box that lets the user set the radio properties of the selected radio.

Network

The Network menu provides access to the currently selected network's properties, verify a network to determine if its information and topology are valid, and view the network's route table.

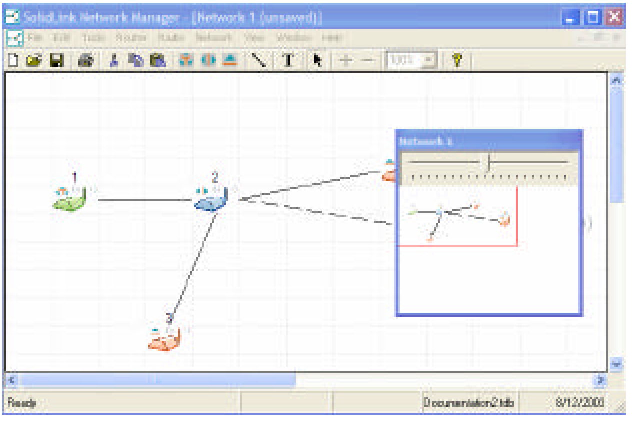
Menu	Description
View Route Table	Displays the routing table for the entire network.
Verify Network Design	Tests the network against a set of design rules to ensure that the configuration and topology are consistent.
Properties	Provides a dialog box that lets the user set the network properties.

View

The View menu provides the user with functions that help to organize and view the network diagrams displayed in the network pane.

Menu	Description
Toolbar	When checked displays the toolbar below the menu bar.
Gridlines	When checked displays gridlines on the network pane.
Snap to Grid	When checked forces the radio objects to snap to the gridlines.
Zoom In	Increases the network pane zoom by

	10%.
Zoom Out	Decreases the network pane zoom by 10%.
Zoom Window	Opens a zoom window (refer to the graphic below).



The Zoom window displays the entire network and allows for panning, jumping to a specific location in the network, and zooming - all from a single interface. This is particularly useful for very large network designs. Note however, that the toolbar zoom buttons are disabled when the Zoom window itself is open. Zooming is accomplished by manipulating a slider at the top of the Zoom window:

Window

The Window menu is common to most Windows-based applications. It provides options for organizing the view and toggling between currently open networks.

Menu	Description
Cascade	Open all network windows and arrange in a cascade.
Tile Horizontal	Open all network windows and arrange horizontally.
Tile Vertical	Open all network windows and arrange vertically.
Arrange Icons	Arrange the closed network icons so that they are adjacent, starting in the lower left corner.

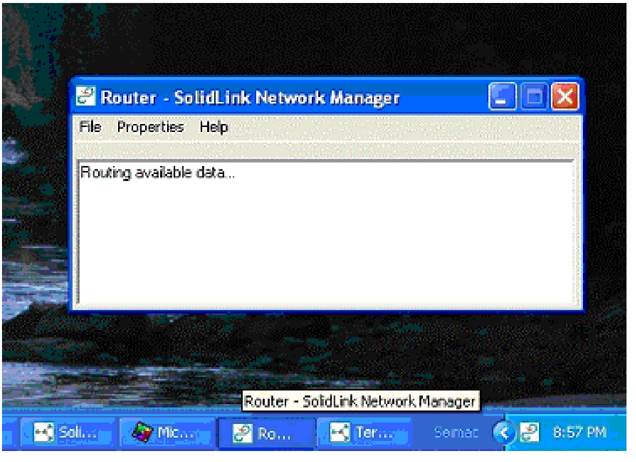
Help

The Help menu provides each access to information about SolidLink and the SolidLink Network Manager.

Menu	Description
Contents	Opens the SolidLink users manual (this document).
SolidLink Radio Home Page	Opens www.solildlinkradio.com in the default browse.
About	Provides copyright, version, and Seimac contact information.

5.3.2 Router

Some router controls are provided in the Network Manager Router menu. Others are accessed from the router window directly. The router is normally started when the user logs in. It is accessible as an icon in the system tray, located near the system clock. Double-click on the router icon to open its window.



File

Menu	Description
Enable Logging to File	Start logging serial data
Close Existing Socket Connections	Close all internal connections to the Network Manager and the Terminal Window. They should be re-initiated by the Network Manager and by restarting

	the Terminal Window
Reinitialize Serial Ports	Close and re-open the configured COM ports
Exit	Exit the Router application

Properties

Menu	Description
COM Port Settings	Opens a dialog box that lets the user configure the COM ports.
Set Log Directory Size	Opens a dialog box that lets the user establish the maximum size of the log file directory, so that the SLNM cannot inadvertently use up all available disk space.
Set Path to LogFile Directory	Opens a dialog box that lets the user set the directory into which log files will be created.

Help

Menu	Description
Contents	Opens the SolidLink users manual (this document).
SolidLink Radio Home Page	Opens www.solildlinkradio.com in the default browse.
About	Provides copyright, version, and Seimac contact information.

5.4 How To

This section of the manual describes how to use the SolidLink Network Manager to design networks, configure and deploy radios, and test networks and maintain them in the field.

5.4.1 Building a Network

Developing a network is done through the Network Manager.

5.4.1.1 Working with the Network Database

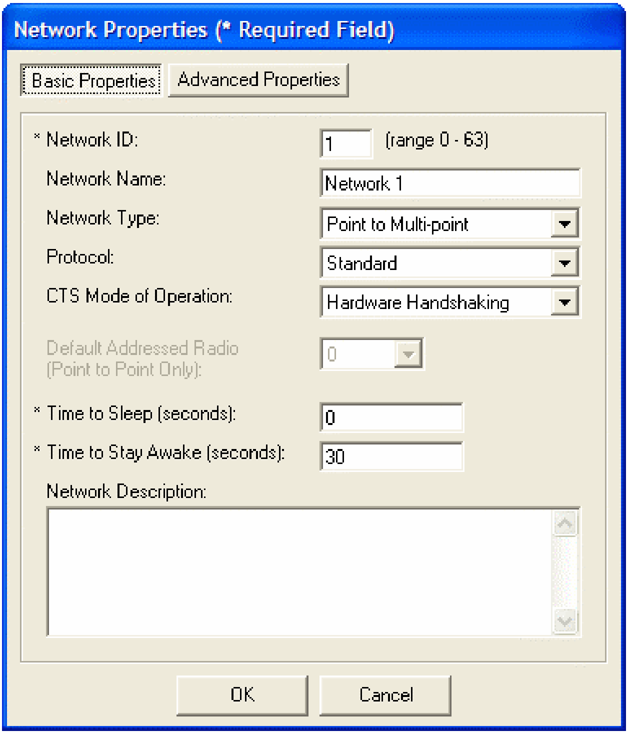
The SolidLink Network Manager can hold up to 64 separate networks in a network database. The current network database is set through a dialog box accessed through the "**Select Network Database**" from the "**File**" menu. A user can have several databases, although only one is open at a time. Switching between databases during a single session is accomplished by simply selecting another; the user will be prompted to close all open networks. The currently active database is displayed in the status bar on the bottom of the Network Manager window.

Existing networks are opened by selecting "**Open**" from the "**File**" menu. The user selects from a list of networks that exist in the currently open network database. The "**File**" menu also includes elements that allow the user to save, close, and create new networks.

Networks or segments of networks can be copied from one database to another by first opening a network, selecting the desired elements and then copying them to the clipboard by selecting "**Copy**" from the "**Edit**" menu. The user then opens the destination network (either in the same or a different database) and then pastes in the elements by selecting "**Paste**" from the "**Edit**" menu.

5.4.1.2 Setting Network Properties

Each network has a set of associated network properties. These are set or modified by selecting "**Properties**" from the "**Network**" menu, which causes the network properties dialog box to be displayed. This dialog box is also automatically displayed when a new network is created. There are two pages in this box: basic and advanced. These parameters are loaded into all radios when they are configured.



Network ID	This required field is unique for the network (within the database), it identifies the network the both within the database and also in the field in case multiple SolidLink networks are operating in the same area.
Network Name	An arbitrary name for the network.
Network Type	This identifies whether the network is configured to operate as point-to-point or point-to-multipoint, as described in Network Configurations.

Protocol	Only the standard protocol is currently supported.
CTS Mode of Operation	Only hardware handshaking is currently supported.
Default Addressed Radio	This parameter identifies radio that the Master will communicate with by default, when it first powers up. It is useful in two node point-to-point connections, because it the virtual link is established without having to issue an ATDT command.
Time to Sleep	SolidLink provides a low power capability whereby communications will cycle off and on as defined by the Time to Sleep and Time to Stay Awake parameters. When the network turns on after being asleep, it re-establishes synchronization and then information can flow. The maximum time to sleep is TBD seconds. If this parameter is set to zero, then the network will not sleep.
Time to Stay Awake	As described above, defines the awake time if the network power is cycling, it must be greater than zero.
Network Description	An arbitrary description of the network.
Number of Non-broadcast Message Retries	This parameter defines the number of times that a transmitting radio will resend a packet, if the receiver detects an error in the data. Broadcast messages are treated differently.
Number of Times to Repeat Broadcast Messages	Broadcast messages (addressed to radio ID 0) are not acknowledged or retried. They are always re-broadcast the number of times defined by this

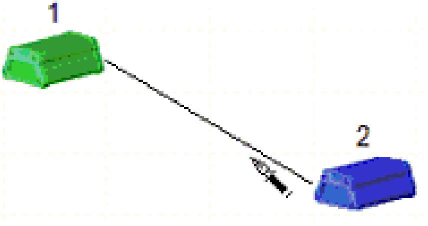
	parameter. Higher numbers increase the probability of the message getting through (in the presence of channel noise), but decreases the available bandwidth.
Timeout on Packet Retry	If a non-broadcast packet is retransmitted, the transmitting radio waits a fixed timeout plus a random timeout (to ensure two radios do not continuously collide). This parameter is the fixed timeout portion.
Time to Lose Lock on Network	A radio is in network sync when it continuously receives synchronization packets, which are propagated through the network from the Master nominally every 4 seconds. This parameter defines the length of time that a radio will allow to pass, without receiving a valid sync packet, before it declares that it has lost sync (extinguishing the sync light) and tries to re-acquire network sync.

5.4.1.3 Adding and Connecting Radios

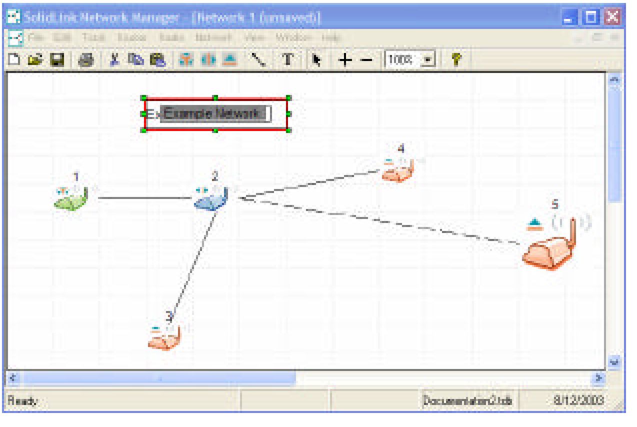
Networks are built up by creating a graphical picture of the network on the network canvas. The tools for doing this are available in the "**Tools**" menu.

Select the Master Radio tool icon (), from the application toolbar or "**Master Radio**" from the menu and then click in the Network Diagram to place a Master radio. Similarly, Repeater and Remote radios can be placed. The physical position on the canvas does not affect the network operation or configuration.

Select the Straight Connector tool () or select "**Straight Connector**" from the menu to create network connections between radios. With the connector tool selected, drag between two radios to create a connection between.

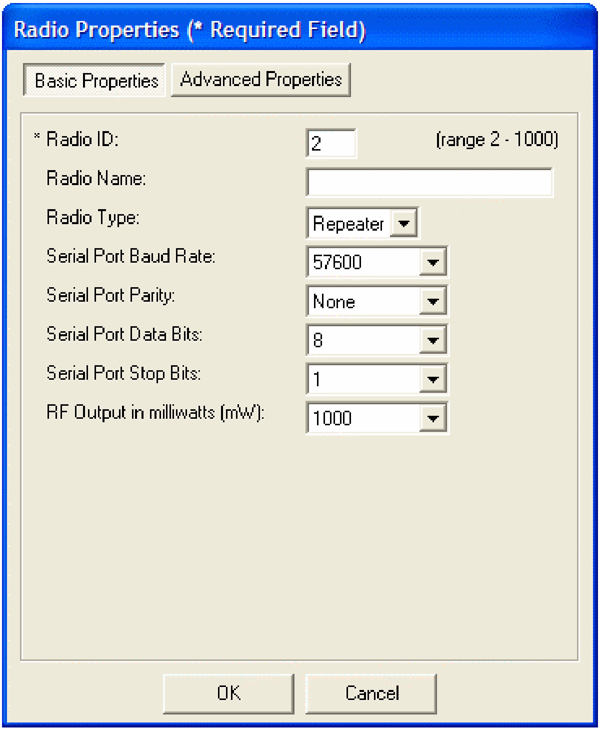


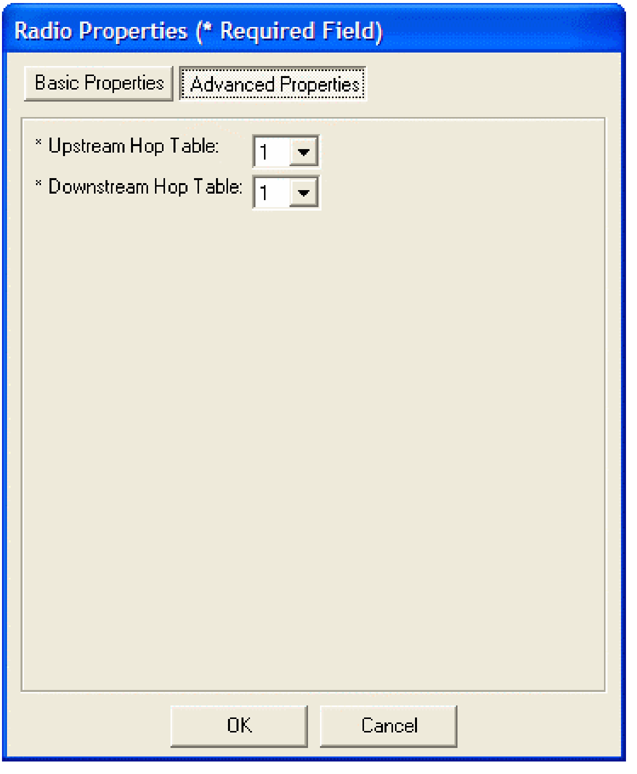
A text tool is available to add arbitrary text blocks any where on the canvas, for example to title the network.



5.4.1.4 Setting Radio Properties

In addition to the network properties described in Setting Network Properties, each radio is configured with a set of individual properties. Radio properties are accessed in either of two ways. Either right click on a radio and select "**Radio Properties**" from the pop-up menu or select a radio and then select "**Properties**" from the "**Radio**" menu.





Radio ID	The address of the radio, this must be unique within the network. It is the address used to dial a radio with the ATD command.
Radio Name	An arbitrary name for the radio.
Radio Type	This parameter determines whether the radio will operate as a Master, Repeater or a Remote.

Serial Port Baud Rate	The serial port communication rate, established from a drop down menu to be between 110 and 57.6K. The baud rate, and the other communication parameters must be selected to be compatible with the device that is connected to the radio.
Serial Port Parity	The serial port parity, either None, Odd or Even.
Serial Port Data Bits	The number of data bits used in serial port communications, either 7 or 8.
Serial Port Stop Bits	The number of stop bits used in serial port communications, either 1 or 2.
RF Output Power in milliwatts	This parameter determines the transmit output power. Under FCC and IC regulations, the radio output power must be set according to the limits described in point-to-point and point-to-multipoint.
Upstream Hop Table	SolidLink provides five independent hop tables for use in situations where multiple radios will have overlapping coverage. The upstream table is table used to communicate with the next upstream radio (towards the Master).
Downstream Hop Table	As above, this table is used to communicate with all directly connected downstream nodes (away from the Master).

5.4.1.5 Verifying Network Integrity

There are a few rules that must be kept in mind when designing a network. SLNM provides a design rule check, accessible by selecting “Verify Network Design” from the “Network” menu. A design rule check is also performed when a network is saved.

1. A valid network must consist of at least two radios, and if only two radios are present, one must be a Master and the other must be a Remote.
2. A network can consist of up to1000 radios
3. A valid network must have one Master radio.
4. The Master radio must be the most upstream radio; it can have only downstream links to Repeaters and/or Remotes and can have up to 999 links.
5. Remote radios can have only one link and that is an upstream link to a Master or to a Repeater.
6. Repeaters must have one upstream link, to the Master or another Repeater, and can have up to 997 downstream links to other Repeaters and/or Remotes.
7. Connected radios must use the same hop table.

5.4.2 Deploy a Network

To deploy a network, the user must configure the router to communicate with the radios over the PC COM port, and then connect each radio in sequence to the PC and download its configuration.

5.4.2.1 Set up the Router

Normally, the router starts when the user logs in, it is placed in the Program Startup menu. When running, the Router Icon () will appear in the Windows system tray, near the clock. Refer to the Router section for details.

With the router running, select "**Connect to Router**" from the "**Router**" menu, the Network Manager is now connected to the Router. Also under the "**Router**" menu, the user can view the COM port settings, set them and have them automatically set to match the radio. It is vital that the port settings match the radio.

Auto-configuration steps through the various baud rate settings, starting at the highest and works down to 110 baud, until it finds the correct match. It also searches for the correct start bits, stop bits, and parity settings.

If the router has only one COM port, or will not be connected to a data host, then the Data Host COM port should be set to "None".

If the radios in the network are set to different baud rates, then the user will have to adjust the Router baud rate as appropriate prior to configuring each radio.

5.4.2.2 Configuring a Radio

Configuring a radio is a simple operation.

- Open the appropriate network
- Connect the Network Manager to the router and properly configure the Router serial port as discussed in the Setting up the Router section.
- Connect the radio's serial cable to the COM port refer to the Data Interface section.
- Connect DC power to the radio and apply power. At this point the radio power light should be on.
- Select the specific network node to be configured and configure the radio by either right-clicking on the radio and selecting "**Configure**" from the pop-up menu or selecting "**Configure**" from the "**Radio**" menu.
- The Network Manager will now download the configuration into the radio; this operation takes between 10 seconds and 3 minutes, depending on how much of the current configuration is at 57K baud. The user will be notified when the operation is complete.
- If the configuration is successful, the radio will reset and start-up with its new configuration.

5.4.2.3 Loading Firmware Updates

Loading firmware is similar to loading a configuration, except that it is not necessary that a network be open. Seimac will distribute firmware updates from time to time. They are provided in "A90" format files which a specific hex representation of the code to be loaded into the SolidLink radio's microprocessor.

There are two types of loads, each identified with a specific menu selection. Normally, the user will select the "**Update Existing Firmware**" option, as this is used to over-write existing valid firmware. If for some reason the radio firmware has become corrupt, the user will select "**Install Initial Firmware**". The latter should only be done under the advice of Seimac's technical support representative.

The process is straight-forward:

1. Connect the Network Manager to the router and properly configure the Router serial port as discussed in the Setting up the Router section.
2. Connect the radio's serial cable to the COM port as discussed in the Data Interface section.
3. Connect DC power to the radio and apply power. At this point the radio power light should be on.
4. Open any network and select any radio.
5. Select the "**Update Existing Firmware**" from the "**Radio**" menu. The user will be presented with a standard Windows file selection dialog

box, from which the A90 firmware load file should be selected.

6. The Network Manager will now download the firmware into the radio; this operation takes approximately 3 minutes at 57K baud. The user will be notified when the operation is complete.
7. If the download is successful, the radio will reset and start-up with its new firmware.

Normally, the user would then configure the radio as detailed in the Configuring a Radio section.

5.4.3 Testing a Network

Once the network has been configured, it should be then tested to see that the radios work and that the connections are intact. This can be readily accomplished in a lab setting, by connecting each a 2.2dBi rubber duck omni antenna to each radio and setting the transmit power to 100mW. The following sections assume that this is the situation, and that each radio has DC power applied and serial cable that can be connected to a PC COM port. The user can:

1. Connect the SLNM to a SolidLink radio in order to control or query the network or to monitor data flow.
2. Obtain diagnostic information about any node in the network.
3. Use the terminal window to monitor data and to act as a data source.

4. Send commands to a radio in order to create virtual links.

In general, each radio can be connected to a real data source, such as would be used in the field, or can be connected to a PC running SLNM or a terminal window program such as Hyperterminal or Procomm.

5.4.3.1 Connecting SLNM to a SolidLink Radio

This operation is similar to configuring a radio:

- Open the appropriate network as described in the Working with the Network Database section.
- Connect the Network Manager to the router and properly configure the Router serial port as discussed in the Setting up the Router section.
- Connect the radio's serial cable to the COM port; refer to the Data Interface section.
- Connect DC power to the radio and apply power. At this point the radio power light should be on.

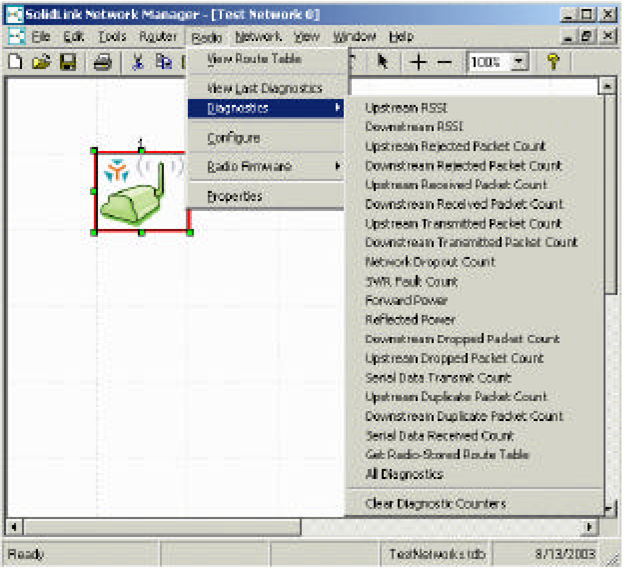
The user can now use the SLNM to communicate with the network. If connected to the Master radio, the user can obtain diagnostic information, and issue commands to make a virtual connection.

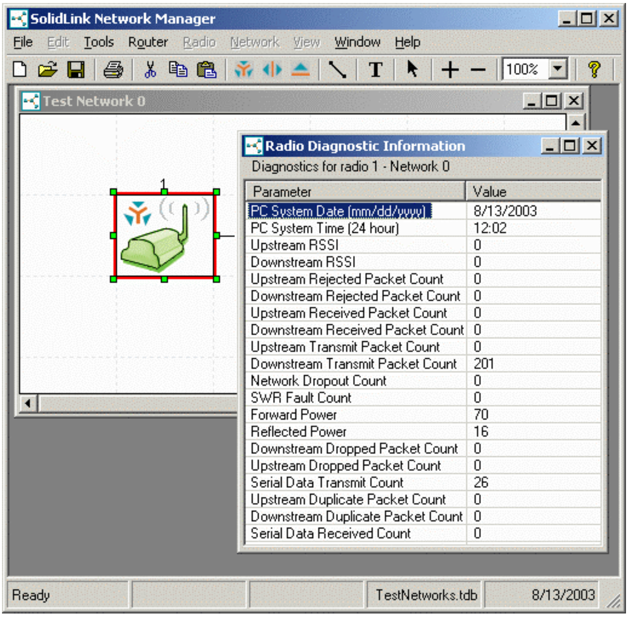
5.4.3.2 Obtaining Diagnostic Information

Once the SLNM is connected to the network Master Radio, as described in the Connecting SLNM to a SolidLink Radio section, the user can obtain diagnostics from each network node. This is a good way to establish that all nodes and links are active.

1. Select node for which diagnostics is to be requested.
2. Select "**All Diagnostics**" from the "**Diagnostic**" sub-menu of the "**Radio**" menu, this is also available on the pop-up menu accessed by right clicking the network node icon.
3. The SLNM will send a diagnostic command to the Master radio, which will in turn be forwarded to the requested radio. This radio will return its diagnostic information to the Master radio where it will be sent out its serial port, captured by the SLNM and presented to the user.

There is a wide variety of diagnostic information available; it is best described in the Diagnostic Commands section. At this stage, without data traffic, the important event is just getting the diagnostic data back, as it indicates that the node is reachable. The following graphics show such data.


SolidLink Network Manager - [Test Network 0]
File Edit Tools Router Radio Network View Window Help
View Route Table
View Last Diagnostics
Diagnostics
Configure
Radio Firmware
Properties
Upstream RSSI
Downstream RSSI
Upstream Rejected Packet Count
Downstream Rejected Packet Count
Upstream Received Packet Count
Downstream Received Packet Count
Upstream Transmitted Packet Count
Downstream Transmitted Packet Count
Network Dropout Count
SWR Fault Count
Forward Power
Reflected Power
Downstream Dropped Packet Count
Upstream Dropped Packet Count
Serial Data Transmit Count
Upstream Duplicate Packet Count
Downstream Duplicate Packet Count
Serial Data Received Count
Get Radio-Stored Route Table
All Diagnostics
Clear Diagnostic Counters
Ready
TestNetworks.tdb
8/13/2003



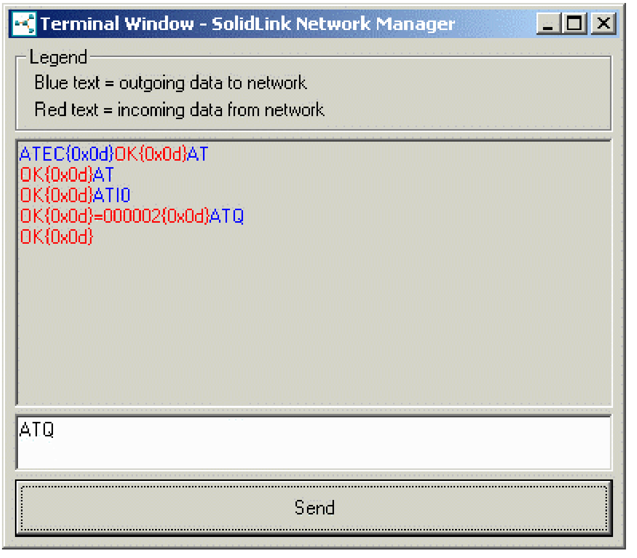
Once the network is operational and some data moved, then the same technique can be used to obtain packet counts, and signal strength information.

It is important to note that diagnostic information must be requested through the Master node.

5.4.3.3 Sending Commands to a Radio

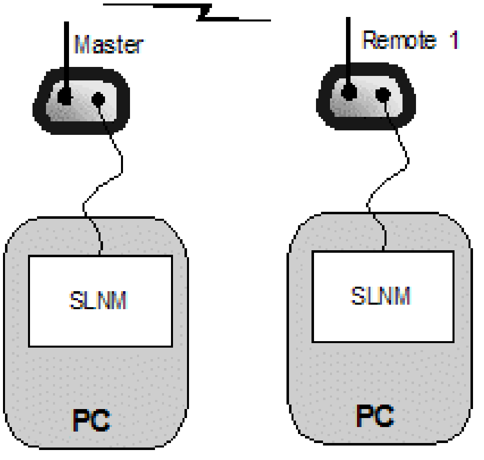
With the terminal window, the user can monitor the flow of data in and out of the attached radio, can send data to the radio and can issue commands. The radio will be either in data or command mode as described in the Operating Modes section.

1. With the router active, the terminal window is activated by selecting "**Open Terminal Window**" from the "**Tools**" menu. Terminal window operation is described in the Terminal Window section.
2. Put the radio into command mode by selecting "**Put Radio in Command Mode**" in from the "**Tools**" menu. The dialog associated with this will be visible in the terminal window.
3. Enter the string "AT" followed by the "**Enter**" key into the dialog area of the command window and then press the "**Send**" button.
4. Watch the dialog evolve - the radio will respond with the string "**OK**".
5. Pressing "**Send**" again will re-enter the command, the contents of the dialog area are not destroyed when they are sent.
6. Additional commands can be sent, refer to the Commands and Diagnostic Commands sections for a detailed description of the available commands.
7. Enter the command "**ATQ**" to leave command mode and return to data mode.



5.4.3.4 Sending Data across the Network

This section shows how to easily send small amounts of data across a network; it illustrates the process of making a connection. The exercise requires two PCs each running SLNM.



Alternatively, the PC connected to the Remote could run HyperTerminal or some other terminal emulator that was properly connected to the radio COM port.

1. At the Master node, use SLNM to put the radio into command mode as described in the Sending Commands to a Radio section.
2. At the Remote node, start the router and open the Terminal Window as described in the Terminal Window section.
3. At the Master node, enter the command ATDTnnnn<enter> into the dialog area of the terminal window where nnnn is the four digit decimal node number of the Remote. Each node on the network graph is labeled with its ID. For example, if the Remote node was ID 1, then the command to establish a virtual connection is ATDT0001<enter>.

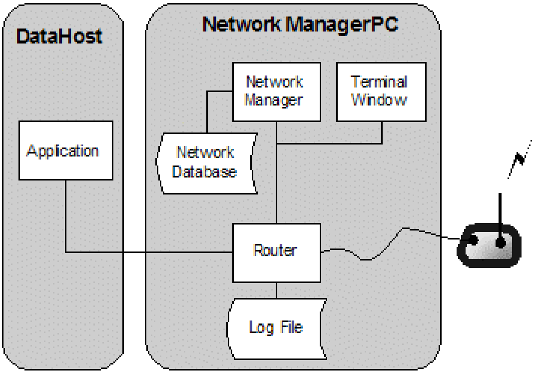
4. Press "**Send**" and observe the dialog, the Master should respond with "**OK**". At this point, a virtual connection has been created between the serial port on the Master and the serial port on Remote 1.
5. Return the Master to Data Mode by issuing the command “ATQ<enter>”. At this point, any data that enters the Master serial port, is transmitted out the serial port of Remote 1 and vice versa.
6. Type something into the dialog window of the Master terminal window and press Send. The information will appear at the Remote terminal window. Similarly, anything entered into the Remote terminal window dialog area will appear at the Master’s terminal window.
7. Put the Master back into command mode, and enter the command ATH0, followed by the command ATQ. This causes the connection to be terminated and the Master to be placed back into data mode. Now, anything typed at the Master and Remote will not appear at the other node.

5.4.4 Monitoring an Operating Network

Over the long term, one of the advantages of the SLNM is that it can be used on-line with an operational system. It can be used to obtain diagnostics, log traffic, or watch traffic with the terminal window.

5.4.4.1 Using SLNM with a Data Host

The connection between an application running on a data host and the SLNM is illustrated below:



One of the router's functions is to transparently pass data through between the application and the network. The router forces the two COM ports (one connected to the Data Host and the other to the Master) to use the same communication parameters. Thus, it is always possible to simply disconnect the Data Host from the Master and insert the SLNM between. The only change that must be made is to insert a null modem between the Network Manager PC and the Data Host. Of course, there will be some small differences in data timing as it flows through the SLNM and it will introduce some data latencies.

Once the SLNM is operating in this manner, and the user has opened the appropriate network database and network, information about the running network can be obtained through the SLNM.

1. To obtain diagnostic information about a node, right click on the node and select the appropriate diagnostic from the "Diagnostic" entry on the pop-up menu. Refer also to the Obtaining Diagnostic Information section.
2. Similarly, the most recently obtained diagnostics can be viewed. A description of the diagnostic data can be found in the Diagnostic Commands section.
3. The user can open a terminal window and observe the flow of data between the Master and the application.
4. Also, the user can setup the router to create a log file which will log traffic, similar to the terminal window except that it is stored in a file.

The section that discusses problem solving, provides lots of useful information about using SLNM to collect ongoing data about the network.

6 Solving Problems

SolidLink was designed and built to operate reliably in harsh environments. However, radio networks are complex and subject to many external variables. Things will go wrong. This section of the manual will help the maintenance technologist to:

1. Prepare to make the SolidLink network more maintainable
2. Solve some common problems, this is by no means comprehensive, but should provide some inspiration for solving other problems encountered
3. Interpreting diagnostic information
4. Contact Seimac for technical support

6.1 Preparing to Maintain a SolidLink Network

Before problems occur, there are some things that should be done to make maintenance and support easier:

1. Once the network is deployed, establish a network performance baseline. To do this, obtain diagnostic status for each radio, at times when the network appears to be functioning properly. Statistics should be taken at several times so that some idea of the variability can be determined. For example, the propagation characteristics of a link will vary, and therefore so will the reported RSSI average.

2. Periodically obtain diagnostic parameters from the network. Compare them against the network performance baseline and look for trends. For example, if the reported reflected power was increasing over time, it might indicate a failing RF cable.

3. Have spare SolidLink radio that can be used to create an ad-hoc network with a suspect radio. Design a simple two radio test network that does not interfere with the operational network (has a different ID, uses a different hop table). Configure the spare radio as the Master node of the test network. If a radio is suspect, it can be loaded in the field with the configuration of the Remote node of the test network and then exercised through the test network Master node.

6.2 Addressing Some Common Problems

6.2.1 Power Light Does Not Illuminate

The Red LED will illuminate when the SolidLink radio is provided with adequate DC power.

1. Verify the proper voltage is applied. The voltage must be between 10 and 26 Volts at the radio. The 15m data/power cable provided by Seimac will drop approximately 1V across the cable, so the user must supply 12V at the cable end.

2. Check the cable continuity with an ohm meter, the power connector pin outs are described in the Connectors section.
3. If the problem remains, it is possible that the firmware has been corrupted. Refer to the Loading Firmware Updates section for details .

6.2.2 Network Lock Light Does Not Illuminate

The red power LED is on, but the green network lock LED, which indicates that the radio has synchronized with the network, is not illuminated. If a radio is configured such that it has a network ID, unit ID and route table, then it automatically try to achieve network lock when powered up. It will not do so if it does not have a valid configuration. It is also important to note that synchronization between two nodes requires that the downstream node receive a correct sync packet and that the upstream node receive a positive ACK. Only then will the two radios be in sync.

The Unit is a Master

If the unit is a Master, the green LED will flash once every four seconds, as it transmits a sync packet. If this does not occur, then most probably the unit is not configured as a Master. The easiest way to ensure proper configuration, is to reconfigure the radio by:

1. Connecting it to the PC running SLNM,
2. Opening the network design

3. Selecting the Master node and configuring a radio.

The radio type can also be verified without reconfiguring by:

1. connect the SolidLink radio to the PC running SLNM;
2. connect the network manager to the router (refer to the Router section for details);
3. open a terminal window ;(refer to the Terminal Window section);
4. put the radio into command mode;
5. in the terminal window type the command ATI1<cr> and click "**Send**"; and
6. the radio will respond with its configured type, which can be seen in the terminal window. 1 = Master, 2 = Remote, 3 = Repeater.

If the unit is not configured properly, then it should be reconfigured as the network Master as described in the Network Configurations section. If the unit is configured as a Master, but the green LED does not flash periodically, then contact Seimac Technical Support.

If the unit is a Master and the green LED is flashing, it indicates that the Master is trying to synchronize, but that no downstream radios are responding. Consider the following:

1. Ensure that the antenna is properly mounted and connected and if a directional antenna that it is pointed at the Remote radio.

2. Ensure that at least one downstream radio is configured, powered up and within range.
3. Ensure that the output power settings of the Master and downstream radios are correct Antenna and Cable Connection.
4. Check the antenna mounts and connections of the downstream radios.
5. Ensure that the downstream radios are configured and are powered on (red LED illuminated).
6. Configure a spare radio as one of the downstream radios in the network, and locate it in close proximity (within 50m) to the Master radio to ensure that path loss is not a problem.

If none of these resolve the problem, then contact Seimac Technical Support.

The Unit is a Remote or a Repeater

If the radio is a Remote or a Repeater, it will not flash its green network lock LED. It will not achieve network lock unless it receives sync packets (on a 4 second cycle) from the upstream radio. The most likely cause for this is that the unit is not properly configured. The easiest and most reliable way to ensure configuration is to reconfigure the radio:

1. Connecting it to the PC running SLNM;
2. Opening the network design; and
3. Selecting the proper node from the network diagram and configuring the radio.

If configuring the radio does not resolve the problem, the next most likely problem is that the upstream radio is not locked. If it is not locked then all radios downstream of it will not be locked. Check to see that it is locked using the procedures described in this section.

If the upstream radio is locked, then the most likely cause is insufficient received signal at the either the radio in question or the upstream radio. Consider the following:

1. ensure that the antenna is properly mounted and connected and if a directional antenna that it is pointed at the upstream radio;
2. check the antenna mounts and connections of the upstream radio;
3. ensure that the upstream radio is configured and is powered on (red LED illuminated);
4. ensure that the output power settings of the radio in question and the upstream radio are correct (refer to the Antenna and Cable Connection section) and as high as possible; and
5. reduce the distance between the radio in question and the upstream radio, or increase the antenna height (refer to the Estimating RF Performance section) to improve the link margin.

If none of these resolve the problem, then contact Seimac Technical Support.

6.2.3 Radio Does Not Transmit Data

If the SolidLink radio has power and network lock (green and red LEDs on solid), but the yellow transmit light does not illuminate; this indicates that the radio is locked to the network but is not transmitting data. This situation can also be determined at the application level, if expected data from an RTU or other device connected to a radio is not received. Either way, this indicates that the radio is not receiving data to transmit, or is not allowed to transmit because it does not have a connection.

The easiest way to check this is with an SLNM connected to the Master radio:

1. Connect the PC running SLNM to the serial port of the Master radio.
2. Connect to the Router.
3. Open the network design.
4. Select the radio in question on the network diagram.
5. Obtain a full set of diagnostics for the radio.

This will provide a great deal of information, described more fully in Interpreting Diagnostic Information. Among this are serial data receive count which indicates if serial data is flowing into the radio and downstream packet receive count which indicates if data is being received from downstream nodes (if current radio is a Repeater). Using the diagnostic menu, the user can clear the counters for the radio and then determine if data is flowing. Note that serial commands and responses are included in the serial data counts.

If downstream network traffic is expected but not received, obtain diagnostics for downstream nodes to determine where the problem lies.

If serial data is expected, the problem will have to be diagnosed on site. The best way to do this is to connect a SLNM PC between the RTU (or device) and the SolidLink radio (refer to the Using SLNM with a Data Host section).

1. Run SLNM and connect to the Router.
2. Open a Terminal Window.
3. The serial traffic between the radio and RTU will be displayed on the terminal window. Data going out to the network is displayed in blue, incoming data in red.
4. If data is not flowing, probe the CTS line with a meter or scope (refer to the Data Interface section).

If CTS is asserted (refer to the Data Mode section) at +12V, then the RTU is enabled. The problem with lack of data most probably resides in the RTU or in the user's application.

If it is low, then the SolidLink internal serial buffer is filled and the RTU is blocked.

The most likely reason for this is that the Master has not created a connection to the radio for some time in order to flush data. The creation and termination of connections is under the control of the user's application, it does so by issuing commands to the Master radio (refer to the Command Mode section).

6.2.4 Radio is Not Accessible Over the Network

To test for a radio's accessibility, probe the radio through SLNM:

1. Connect the PC running SLNM to the serial port of the Master radio.
2. Connect to the Router.
3. Opening the network design.
4. Select the radio in question on the network diagram.
5. Request a full set of diagnostics for the radio.

If the radio is accessible, the diagnostics will be returned. If not then the user will see a dialog box indicating that the SLNM timed out waiting for a response.

If the upstream radio supports multiple downstream radios, then its diagnostic information will not be particularly useful because it is not possible to isolate the performance of a single link. However, if the upstream radio supports only one downstream radio (the inaccessible unit), then it is useful to obtain diagnostics for the upstream radio, following the directions above.

Look at the downstream RSSI, this will provide an indication of the strength of the received signal (refer to the Interpreting Diagnostic Information section) . If they are abnormally low, then this is an indication of an impending link failure. Also look at the downstream received packet count. Reset the counters and see if it increases.

The most likely cause for failure is a cable or antenna problem. If the upstream radio is accessible, the problem is likely at the inaccessible radio. Visit the site and troubleshoot as per (refer to the Power Light Does Not Illuminate and Network Lock Light Does Not Illuminate sections) . Once the radio is locked to the network, then it will be accessible.

6.2.5 Link Performance Decreasing

By monitoring RSSI values for the network radios, the user can see if link performance is decreasing. This will be indicated by reducing values of RSSI (refer to the Interpreting Diagnostic Information).

This will be most likely caused by deterioration in the antenna or cable system. From the Master node, obtain diagnostics for the two radios at either end of the link (refer to the Obtaining Diagnostic Information section). Observe the SWR fault count, and forward and reflected power readings in the SolidLink radio.

- SWR fault counts an high reflected power readings indicate a problem in the antenna or cabling system. Possibly a cable or connector has been damaged.

- Low forward power indicates that the transmitter is loosing power, likely an internal failure. Contact Seimac Technical support as described in Getting Help From Seimac.

Another possible cause is that the antenna has become misaligned because its physical mount has failed.

6.2.6 Some Data is Missing

SolidLink radios ensure the integrity of data by adding a checksum to each packet and then comparing the checksum with the recalculated value upon receipt. There is a very high probability that this system will detect errors. Packets with errors are automatically retransmitted up to a user selectable retry limit at which time the packet is discarded.

Data can be “missed” for two reasons:

1. A link margin is low or there is interference on a link which causes a temporary loss of reliable connection. Packets are retried to the maximum limit and then discarded. The information that would have been transmitted is lost. The user can determine this by obtaining diagnostics on all relevant radios in the network and observing the upstream and downstream dropped packet count.
2. The RTU was blocked from sending serial data and has been forced to drop some information. In a point-to-point network, Remote or Repeaters transmit serial data only when there

is a connection to the Master radio. This is set-up by the user's application connected to the Master (refer to the Operating Modes section). If a SolidLink serial buffer fills, it will drop its CTS line (refer to the Data Mode section) and therefore block the RTU. If the RTU remains blocked beyond its ability to buffer data, then information will be lost.

6.3 Interpreting Diagnostic Information

As described in the Diagnostic Commands section, SolidLink provides a set if diagnostic information that can aid component and network troubleshooting. Often parameters are available for both receive and transmit (such as packet count) and for upstream and downstream connections. Upstream is towards the Master, downstream away from the Master.

A radio can have only one upstream connection, so it is clear to which link upstream information refers. Master and Repeaters can have multiple downstream connections, and the statistics that refer to downstream connections (again such as packet count) refer the all downstream links. For example, the downstream transmitted packet count refers to the count of all packets transmitted to all downstream radios.

Counters can be cleared by diagnostic command, and the effect is immediate.

Diagnostics can be grouped into several categories:

1. RF performance;
2. Network performance;
3. Packet counters; and
4. Serial data counters.

6.3.1 RF Performance

The SolidLink radio RF circuitry includes devices that measure both the forward transmitted power and the power reflected back from the antenna. Ideally, the antenna is perfectly matched and reflected power is zero, however a match is never perfect. Measurements are made during the initial portion of each transmission.

Received Signal Strength Indicator (RSSI)

The received signal strength is measured during each received packet. Assuming the transmitter stays constant, RSSI will vary as the transmission channel changes, due to interference, atmospheric conditions etc. RSSI varies from 1 to 10, where 1 is a very weak signal and 10 is very strong.

Forward Power

This is a measure of the power transmitted in milliwatts.

Reflected Power

This is a measure of power reflected from the antenna in milliwatts.

SWR Fault Count

The forward and reflected power measurements made during each transmission are used to calculate a mismatch, as a standing wave ratio. If the mismatch exceeds 3-1 then SolidLink declares a fault and counts the event. Generally, this indicates an antenna or cable problem.

6.3.2 Network Performance

Network Dropout Count

A network dropouts occurs when the radio looses synchronization with the upstream node in the network. After a radio synchronizes with the upstream radio, it hops in sync with that radio. While there may be no data, there will always be a synchronization packet nominally each 4 seconds. If radio does not see a synchronization packet when expected, it dropped out of sync (quite possibly the problem exists upstream) and counts the event. The green network lock LED will illuminate. It will then try to recover network lock.

6.3.3 Packet Counters

SolidLink counts five different packets:

Transmit Packet Count

The upstream and downstream transmit packet counters contain the number of packets that were transmitted since the counters were cleared.

Received Packet Count

The upstream and downstream receive packet counters contain the number of packets that were received since the counters were cleared.

Rejected Packet Count

The upstream and downstream rejected packet counters contain the number of packets that were rejected since the counters were cleared. Packets are rejected when their calculated checksum does not match the checksum transmitted at the end of the packet.

Dropped Packet Count

The dropped packet count is the number of transmitted packets that were dropped because the maximum number of retries expired.

Duplicate Packet Count

The duplicate packet count is the number of duplicate packets received.

6.3.4 Serial Data Counters

The SolidLink radio provides two serial data counters:

Serial Data Transmit Count

The serial data transmit counter contains the number of bytes transmitted out the serial port since the counter was cleared. It includes all characters sent in command mode.

Serial Data Receive Count

The serial data receive counter contains the number of bytes received in the serial port since the counter was cleared. It includes all characters received in command mode.

6.4 Getting Help From Seimac

Seimac Limited is proud to stand behind their products.

The latest information about Solid Link can be obtained on the product web site: www.solidlinkradio.com.

The Seimac technical support team is available to answer any questions and provide assistance to resolve problems. They can be contacted as follows:

Phone - (902) 468-3007
Fax - (902) 468-3009
Email - techsupport@seimac.com

Before returning any product to Seimac, a Return Materials Authorization (RMA) number must be obtained. This should be done by contacting Seimac Technical Support as listed above. Once an RMA number is obtained, the material should be shipped to:

Seimac Limited
271 Brownlow Avenue
Dartmouth, NS
Canada
B3B 1W6

Attention: Technical Support

RMA#: nnnnnnnn

7 System Specifications

Transmitter	Transmit Frequencies Transmit Power Modulation Type	2.4 - 2.4835 GHz 100mW - 1 Watt Adjustable GMSK
Receiver	Receive Frequencies Sensitivity Selectivity	2.4 - 2.4835 GHz -104 dB@10^{-6} BER
Power Supply	Power Supply Voltage Power Supply Current Transmit Receive Sleep	10 - 26 VDC 500 mA (at 12 volts nominal) 50 mA (at 12 volts nominal) <1mA
Data Communications	Serial Baud Rate Parity Flow Control Error Correction (over the air) Hardware Data Interface	1200 - 57,600 bps none, even, odd CTS (output) 32 Bit CRC; resend on error RS-232
Network	Max. Sustained Serial Data Rate without Repeaters	57,600 bps

	Max. Sustained Serial Data Rate Spectrum Spreading Configuration	28,800 bps Frequency Hopping Point-to-point; point-to-multipoint w ith or without Repeaters
Environmental	Operating Temperature Range Vibration Shock Humidity Waterproof	-40°C to +75°C -40°F to +165°F In accordance with MIL STD 810 In accordance with MIL STD 810 100% Submersible to 12"
Mechanical	Dimensions Weight Mounting	6.5"x3.5"x2" (16.5cmx9.9cmx5.1cm) 1.1lb (499.4 grams) 1/4" - 20 UNC, two on sliding track for various RTU, 19" rack and mast/pole mounting
Certifications	US Canada	FCC (Pending) Industry Canada (Pending)
		Patents Pending

8 Glossary

Master – The controlling industrial radio modem. All communication is between this industrial radio modem and the Remotes. This industrial radio modem controls hop-timing for the network.

Point-to-point – A network where the Master industrial radio modem unit communicates to one Remote at a time.

Point-to-multipoint – A network where the Master industrial radio modem communicates to all Remotes at the same time. Only one Remote industrial radio modem at a time may communicate to the Master.

Remote - A Remote industrial radio modem is one that links with the Master and sends data to it.

Repeater - This industrial radio modem may repeat data from the Master to a Remote or to another Repeater. It is used

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TBD

10 Warranty Registration Card

TBD

ANNEX A: COMMANDS

Commands

As discussed in the Data Interface section, the SolidLink radio supports a command mode whereby it accepts commands at its serial interface port. The procedure for entering command modes is described in the Command Mode section.

All commands are issued by the controlling device as ASCII strings starting with the ASCII characters "AT". This is immediately followed by the command type and then any qualifying arguments. The command arguments may be variable in length. The entire command string must be terminated with a carriage return (0xd), denoted here by <cr>.

The radio will respond with an ACK if the command is accepted and with a NAK if the command is rejected. ACK consists of the ASCII string "OK<cr>". If the command returns a value, it will arrive after the ACK and will also be terminated by a carriage return. NAK consists of the ASCII string "-nn<cr>" where nn is a one or two digit error code.

1. All alphabetic characters must be in upper case.
2. All numeric characters are decimal.
3. All fields are fixed width and must include leading zeroes if necessary.

The following illustrates a typical dialog:

ATI2<cr> ß controlling device requests unit type

OK<cr> ßradio responds with ACK

1<cr> ßradio responds with type indicating it is a Master

In the following tables, the term attached unit or radio refers to the SolidLink radio who's serial port is connected to the controlling unit and which is directly receiving commands. The term addressed unit or radio refers to a radio with which a connection has been made. It is important to remember that only the Master radio can create a connection with another radio (ATDT command).

Command	**Attention**
Description	Determine that the radio is in command mode
Format	AT
Arguments	none
Return	none

Command	**Create a Connection**
Description	Create a virtual connection between the Master and another radio in the network.
Format	ATDT
Arguments	dddd dddd = radio id number if dddd is zero, then the connection is made to all radios in the network
Return	none

Command	**Terminate a Connection**
Description	Terminate a previously opened connection

Format	ATH0
Arguments	none
Return	none

Command	**Get Lock Status**
Description	Determine if the attached radio is locked to the network
Format	AT\S
Arguments	none
Return	1 = radio is locked 0 = radio is not locked

Command	**Get Currently Addressed Unit**
Description	Return the id of the radio to which a current connection is made.
Format	ATI0
Arguments	none
Return	nndddd nn = network number dddd = radio id number

Command	**Get Unit Type**
Description	Return the type of the attached radio
Format	ATI1
Arguments	none

Return	t t = 1 if unit is a Master t = 2 if unit is a Remote t = 3 if unit is a Repeater

Command	**Get Firmware Version**
Description	Return a string containing the firmware revision identifier
Format	ATI2
Arguments	none
Return	DSDD-DDD-DD VD.D

Command	**Get Unit ID**
Description	Return the ID of the attached radio
Format	ATI3
Arguments	none
Return	nndddd nn = network number dddd = radio id number

Command	**Exit Command Mode**
Description	Exit command mode, returning to data mode
Format	ATQ
Arguments	none
Return	none

Diagnostic Commands

SolidLink radios also support a suite of diagnostic commands. These are used to determine the status of any radio in the network and to monitor network performance. Each SolidLink radio maintains a set of event counters and measured values that provide a indication of its own performance and the performance of the RF links to neighboring SolidLink radios. The commands follow the same protocols as do the standard commands.

Diagnostic commands all have the form:

ATDMxxnndddd

Where:

xx is a two digit diagnostic command identifier

nn is the network ID

dddd is the unit ID for which information is requested

Command	**Upstream RSSI**
Description	Get the upstream link RSSI value, averaged over the last 10 received packets.
Command	01
Return	dddddddddd dddddddddd = average RSSI in millivolts.

Command	Downstream RSSI
Description	Get the downstream link RSSI value, averaged over the last 10 received packets.
Command	02
Return	dddddddddd dddddddddd = average RSSI in millivolts.

Command	Upstream Rejected Packet Count
Description	Get the number of rejected packets (checksum mismatch) on the upstream link.
Command	03
Return	dddddddddd dddddddddd = number of packets

Command	Downstream Rejected Packet Count
Description	Get the number of rejected packets (checksum mismatch) on the downstream link.
Command	04
Return	dddddddddd dddddddddd = number of packets

Command	Upstream Received Packet Count
Description	Get the number of packets received on the upstream link.
Command	05

Return	dddddddddd dddddddddd = number of packets

Command	**Downstream Received Packet Count**
Description	Get the number of packets received on the downstream link.
Command	06
Return	dddddddddd dddddddddd = number of packets

Command	**Upstream Transmit Packet Count**
Description	Get the number of packets transmitted on the upstream link.
Command	07
Return	dddddddddd dddddddddd = number of packets

Command	**Downstream Transmit Packet Count**
Description	Get the number of packets transmitted on the downstream link.
Command	08
Return	dddddddddd dddddddddd = number of packets

Command	Network Dropout Count
Description	Get the number of times that the radio has lost network lock.
Command	09
Return	dddddddddd dddddddddd = number of dropouts

Command	SWR Fault Count
Description	Return the number of SWR faults.
Command	10
Return	dddddddddd dddddddddd = number of dropouts

Command	Forward Power
Description	Get the reading from the forward power sensor, taken at last transmission.
Command	12
Return	dddddddddd dddddddddd = millivolts from 0 - 1023

Command	Reflected Power
Description	Get the reading from the reflected power sensor, taken at last transmission.
Command	13
Return	dddddddddd

	dddddddddd = millivolts from 0 - 1023

Command	Route Table
Description	Get the entire route table, this command always returns the route table of the attached radio.
Command	15
Return	ddd1,ddd2…ddde <1000 values> ddd1 = position 1 entry ddd2 = position 2 entry ddde = position 1000 entry

Command	Dump Diagnostics
Description	Get results from all diagnostic commands, except 15-Route Table.
Command	16
Return	Results from all diagnostics are provided sequentially, each separated by a comma. They are ordered by command ID.

Command	Downstream Dropped Packet Count
Description	Get the number packets dropped from the downstream link.
Command	17
Return	dddddddddd dddddddddd = number of packets dropped

Command	Upstream Dropped Packet Count
Description	Get the number packets dropped from the upstream link.
Command	18
Return	dddddddddd dddddddddd = number of packets dropped

Command	Clear Diagnostic Counters
Description	Set the diagnostic counters to zero.
Command	19
Return	none

Command	Serial Data Transmit Count
Description	Get the number of bytes sent out the serial port.
Command	20
Return	dddddddddd dddddddddd = number of bytes

Command	Upstream Duplicate Packet Count
Description	Get the number of duplicate packets received on the upstream link.
Command	21
Return	dddddddddd dddddddddd = packet count

Command	Downstream Duplicate Packet Count
Description	Get the number of duplicate packets received on the downstream link.
Command	22
Return	dddddddddd dddddddddd = packet count

Command	Serial Data Received Count
Description	Get the number of bytes received in the serial port.
Command	23
Return	dddddddddd dddddddddd = number of bytes