User Manual

SafeTLink

4.9 GHz Public Safety Band

Point-to-Point Microwave Radio System

Ethernet + FT1 Version

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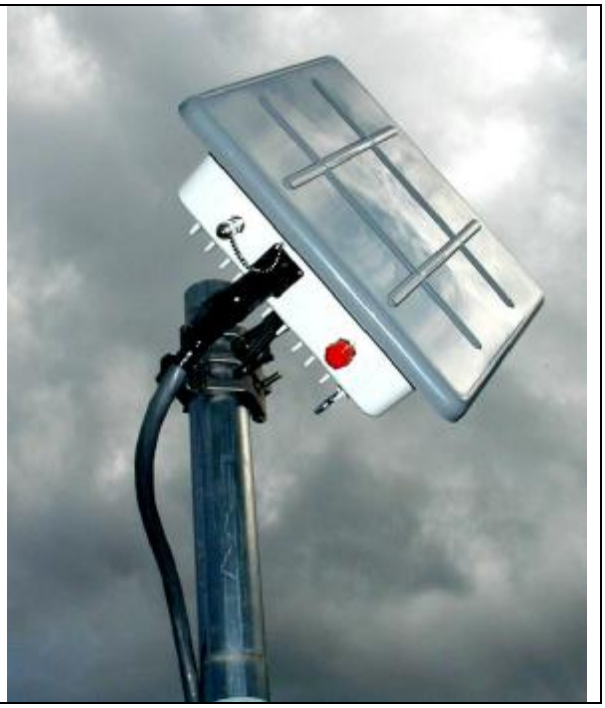
1 INTRODUCTION

The LPN Wireless SafeTLink 4.9 GHz Point-to-Point Microwave Radio is a carrier-class broadband wireless link for data, voice, and video telecommunication applications. The product line is specifically designed to operate in the licensed 4940 to 4990 MHz Public Safety frequency band. SafeTLink is available in two versions. The Ethernet +FT1 version multiplexes and transmits 1 standard full or fractional T1 input between terminals, while simultaneously providing Ethernet bridge operation between the two ends of the wireless link. This User Manual covers the Ethernet +FT1 version (a separate user manual covers the Ethernet version of the product).

The SafeTLink product family can be flexibly configured with terminals either each as a stand-alone outdoor unit (ODU) or as a split system with an indoor unit (IDU). The ODU houses all the Radio Frequency (RF) equipment in a compact weather-tight enclosure. The ODU comes either with an integrated 1 foot square antenna or with an “N” female connector for use with an external antenna. Either the stand-alone ODU or the split system is fully controlled by a digital command line interface or graphical user interface. The interconnections from the ODU to the user, or to the IDU, are all via standard twisted-pair network cables. The ODU can be located up to 330 feet (100 meters) from the indoor site, a limitation imposed by the Ethernet 802.3 standard.

SafeTLink radio links employ Frequency Division Multiplex (FDM, also known as Frequency Division Duplex, FDD) radio transmission with dedicated bandwidth in each direction. The SafeTLink supports connectivity to voice networks using an industry standard T1 interface and connectivity to data networks by a standard Ethernet interface.

The Ethernet +FT1 SafeTLink version can be configured to support 0 to 24 time slots of the T1 channel inputs. Additionally, the total bandwidth conveyed between a pair of ODUs is set by the user. Channel bandwidths of 1, 2 or 5 MHz provide 4, 8 or 24 MBPS (both directions inclusive) of user bandwidth.

Figure 1-1 **ODU with Integrated Antenna Mounted on a Mast**	

1.1 Applicable Model Numbers for this User Manual

LPN Model #	General Description
STL-A-ETH-EXT-48	A ODU, Ethernet + FT1, External Antenna, 24/48 VDC
STL-A- ETH -EXT-12	A ODU, Ethernet + FT1, External Antenna, 12 VDC
STL-A- ETH -INT-48	A ODU, Ethernet + FT1, Integrated Antenna, 24/48 VDC
STL-A- ETH -INT-12	A ODU, Ethernet + FT1, Integrated Antenna, 12 VDC
STL-B- ETH -EXT-48	B ODU, Ethernet + FT1, External Antenna, 24/48 VDC
STL-B- ETH -EXT-12	B ODU, Ethernet + FT1, External Antenna, 12 VDC
STL-B- ETH -INT-48	B ODU, Ethernet + FT1, Integrated Antenna, 24/48 VDC
STL-B- ETH -INT-12	B ODU, Ethernet + FT1, Integrated Antenna, 12 VDC
STL-IDU-R- ETH	IDU Ethernet + FT1, Rack mounted Indoor Unit
STL-IDU- ETH	Mini IDU Ethernet + FT1, Small format Indoor Unit

1.2 Applicable Serial Numbers

- All ODUs from the list above with Serial Numbers of 500 and greater are covered by this manual.
- All IDUs of either type with Serial Numbers of 500 and greater are covered by this manual.

1.3 General Overview of Point to Point Wireless Links

Point-to-point wireless links allow the transmission of digital data or digitized voice between two locations without the need for leased lines or a right-of-way. The SafeTLink system is specifically designed to transport data with a minimum of errors, providing a true carrier-class product. SafeTLink is ideal for backhaul of Wi-Fi data, video transport, and WAN and PBX connections between facilities. The basic SafeTLink point-to-point system design is shown in Figure 1-2.

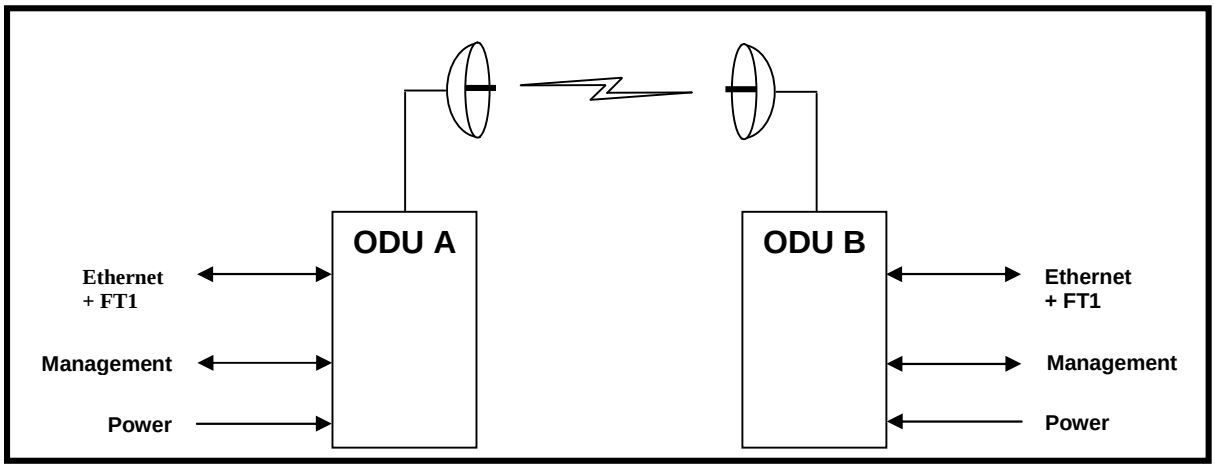


Figure 1-2
SafeTLink System Block Diagram

1.4 User Manual Conventions

Some material in this manual contains information of special importance. Such information will be found in blocked sections with the following forms:

CAUTION
These sections contain information about items or operating conditions that may cause difficulties in operation of the system.

WARNING!
These sections contain information about items or operating conditions that may pose danger to installers, operators or users of the system.

2 LICENSE REQUIREMENTS & REGULATORY COMPLIANCE

2.1 FCC Compliance Statement

This equipment has been tested and found to comply with FCC part 90 subpart Y requirements for intentional radiators. This equipment has also been tested and found to comply with the limits for a Class B digital device, pursuant to part 15, subpart B, of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a commercial or residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the user manual, may increase the potential for harmful interference to radio communications. No modifications or changes to this equipment are allowed, unless the changes or modifications are expressly approved by the manufacturer. It is recommended that only shielded cables be used to reduce interference whenever interference is suspected. 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:

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

2.2 Modifications Prohibited

The SafeTLink system is certified as an intentional radiator. As required by FCC regulations, part 15.21, the user is warned that: Changes or modifications to the SafeTLink equipment not expressly permitted could void the user's authority to operate this equipment.

2.3 International Operation

The SafeTLink system is designed to be used only within the United States. LPN Wireless does not warrant compliance with any international standards or regulations.

2.4 Safety Considerations

The SafeTLink system equipment is designed and manufactured in compliance with safety standard EN60950. Following these precautions will ensure personal safety and prevent damage to the SafeTLink equipment or to other connected equipment.

Note: Read and follow all warning notices and instructions marked on the product or included in this guide.

The SafeTLink system should be installed by experienced professionals. If this product was not purchased directly from LPN Wireless or an authorized dealer, contact LPN Wireless for referral to a professional installer. Non-authorized installation is in possible violation of FCC regulations.

DO NOT attempt to service the SafeTLink product as this will void the warranty. Refer all servicing to an LPN Wireless Authorized Dealer.

Special cables, which may be required by the regulatory inspection authority for the installation site, are the responsibility of the customer.

When installed in the final configuration, this product must comply with the applicable safety standards and regulatory requirements of the geographic location in which it is installed. If necessary, consult with the appropriate regulatory agencies and inspection authorities to ensure compliance.

2.4.1 RF Energy Precautions

WARNING!

There is no proven link between the low level of RF emitted by this device to any type of injury or disease, however, it is recommended that these precautions to minimize unnecessary RF exposure be followed:

• Do not connect power to the ODU and do not install the cable between the optional IDU and ODU until the antenna and ODU are installed. This will prevent radiation from the antenna when people are within close proximity.

• Do not install the antenna where it is possible for a person to stand within five feet of the radiating side.

2.4.2 Tower Safety Precautions

WARNING!

All industry standard safety procedures must be followed when working above ground, on a rooftop, or on a tower. Failure to follow these procedures may result in serious injury or death.

2.4.3 Grounding

WARNING!
Every part of this microwave radio system, including antennas, must be properly grounded. Grounding maximizes the system performance, minimizes the chances of lightning damage, and helps to ensure safety. Make sure ground connections are available for all of the equipment before beginning the installation.

3 SYSTEM DESCRIPTION

3.1 System Configurations

3.1.1 Bandwidth

The Ethernet + FT1 SafeTLink system is a point-to-point radio link which can transport 1 industry-standard 1.544 Mbps T1 signal or a fractional T1 operating at 1.544 MBPS with from 0 to 24 active DS0 slots, and simultaneously can transport Ethernet traffic. The SafeTLink system uses frequency division duplex and requires two RF channels, one for each direction of transmission. The SafeTLink can be configured by the user to transmit in one of three RF Channel bandwidths

RF Channel Width	User Bandwidth Available, MBPS in each direction, full duplex
1 MHz	2
2 MHz	4
5 MHz	12

3.1.2 1 E1 Note

The SafeTLink system can also transport 1 synchronous E1 (2048 kbps) framed user interfaces. This feature is not supported in standard US SafeTLink products and is not further described in this user manual.

3.2 System Components

The SafeTLink system consists of two ends. Each end requires an Outdoor Unit (ODU) which contains the radio and multiplexer equipment. Either or both ends may connect to an Indoor Unit (IDU) which contains indicator lights, alarm inputs and alarm relays as well as convenient places to terminate all cabling. The ODU

comes either with an integrated antenna or with capability to connect to an external antenna.

3.2.1 ODU Description

The ODU is a weather-resistant housing containing all Radio Frequency (RF) and digital electronics. The ODU is connected to a directional antenna that communicates to a second ODU/antenna using RF energy. The SafeTLink ODU is available either with an integrated directional antenna or with capability to connect to an external antenna.

In the transmit direction, the ODU receives the T1 input (either from the IDU, if provided, or from the communications network if an IDU is not used), and and Ethernet signal and multiplexes these together onto a single digital data stream. It then modulates the data onto a baseband carrier signal using 16 QAM digital modulation to achieve spectral efficiency and robust link performance. This baseband signal is upconverted, filtered and amplified for transmission to the antenna and the distant ODU.

Before transmission, the data stream is buffered, block-interleave coded, then Reed-Solomon forward error correction (FEC) coding bits are added. The entire data stream is modulated onto the RF carrier using 16 QAM mapping.

In the receive direction, the ODU receives the weak RF signals from the distant end equipment. First, the ODU amplifies and filters the faint signals. Then the ODU hardware demodulates the signal and demultiplexes the data stream into T1 and Ethernet signals. Interfering signals are rejected both in the RF and modem sections of the ODU. Transmission and reception are independent, and full duplex. The air interface is frequency division multiplex (FDM).

The T1 interfaces provide industry standard signal levels and formats. All interfaces are protected against line surges or short circuits.

3.2.2 Rack – Mounted IDU Description

The IDU is a rack mountable assembly which occupies 1U (1.75 inches) of vertical rack space. The IDU provides the following functions:

- Industry standard connectors for termination of all SafeTLink system cabling
- A series of colored LED lights which provide a visual indication of current system performance
- Alarm relay contacts (1 form C each) for major and minor alarms
- Alarm cut-off switch
- External alarm inputs

The IDU may be mounted in either 19 inch or 23 inch racks and can be mounted with the connectors located on either the front side or rear side of the rack. The LED indicator lights and alarm cut-off switch appear on both sides of the IDU, so these functions will appear on the front side of the rack regardless of orientation of the connectors. The IDU may be flush-mounted with the front panel flush with

the relay rack, or recessed mounted with the front panel located about 5 inches in front of the rack.

Figure 3-1 shows an IDU in its standard, as-shipped configuration with connectors to the rear, 19 inch rack mounting and flush mount.

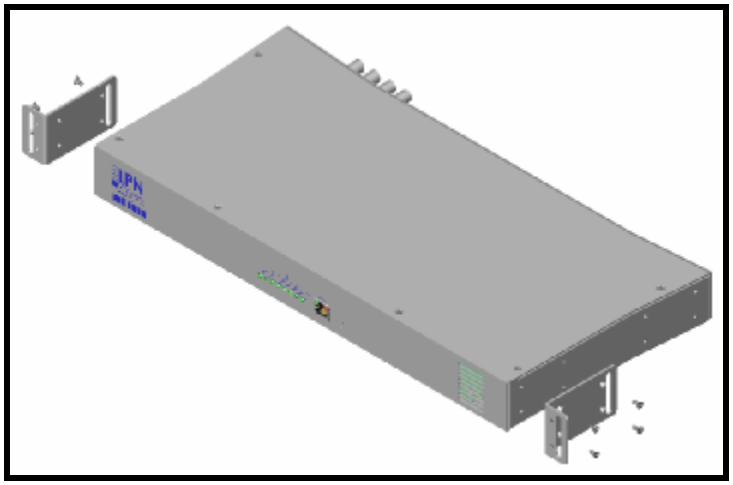
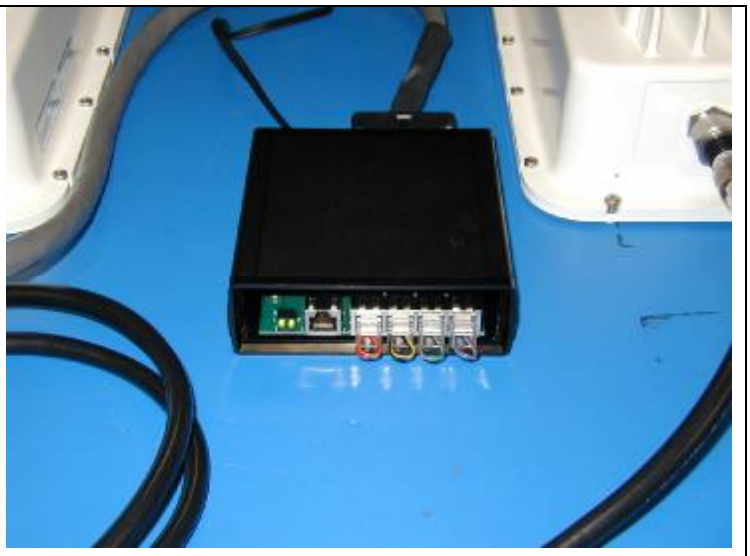


Figure 3-1
IDU, 19" Flush Mount with Rear Connectors

3.2.3 Mini- IDU Description

The small-format Mini-IDU provides the following functions:

- Industry standard connectors for termination of all SafeTLink system cabling
- LED lights which provide a visual indication of system powering
- Connectors for all user interfaces
    - o One standard T1 or FT1 on RJ45 connector
    - o Ethernet traffic and management on an RJ45 connector
    - o DC power input, two wire screw terminal

Figure 3-2 **IDU, small format** Picture of the Mini-IDU in use on bench testing. The DB37 connector (rear) connects to the ODU. The two RJ48 connectors (visible) connect to the Ethernet and T1 user equipment	

3.3 Detailed Specifications

The detailed specification list is in **APPENDIX I: ETHERNET SYSTEM SPECIFICATIONS.**

4 ENGINEERING AND PLANNING

4.1 System Configuration

4.1.1 General

SafeTLink is a point-to-point radio system available in two versions. The Ethernet plus T1 version transports an Ethernet channel and one T1 channel between the two endpoints. A link always consists of two ends, each with an Outdoor Unit (ODU). A link requires an “A” Outdoor Unit (A ODU) at one end and a “B” Outdoor Unit (B ODU) at the other end. Each ODU contains the radio and multiplexer equipment and may be equipped with an optional integrated antenna. Either or both ODUs may connect to an Indoor Unit (IDU) which contains indicator lights, alarm inputs and alarm relays as well as convenient places to terminate all cabling. Each ODU must either be equipped with an integrated antenna or be connected to an external antenna.

A SafeTLink system requires an A ODU and a B ODU. The “B” ODU transmit channel is selectable within the frequency band 4980-4990 MHz, its receive channel is within 4940-4950 MHz. The “A” ODU is opposite with its transmit channel selectable within the frequency band 4940-4950 MHz, its receive channel is within 4980-4990 MHz. The required system component part numbers are listed below:

Part number	Description	Number Required
Ethernet Systems:		
STL-A-ETH-EXT-48	A ODU, External Antenna, 24/48 VDC	1
STL-A-ETH-EXT-12	A ODU, External Antenna, 12 VDC	
STL-A-ETH-INT-48	A ODU, Internal Antenna, 24/48 VDC	
STL-A-ETH-INT-12	A ODU, Internal Antenna, 12 VDC	
STL-B-ETH-EXT-48	B ODU, External Antenna, 24/48 VDC	1
STL-B-ETH-EXT-12	B ODU, External Antenna, 12 VDC	
STL-B-ETH-INT-48	B ODU, Internal Antenna, 24/48 VDC	
STL-B-ETH-INT-12	B ODU, Internal Antenna, 12 VDC	

4.1.2 SafeTLink with both ODU and IDU

Either end or both ends of a SafeTLink system may be equipped with an Indoor Unit (IDU). The IDU is used to terminate all required cabling and provides status indicator lights, external alarm inputs and alarm relay contacts.

One end of a SafeTLink system configured with an IDU is shown in Figure 4-1.

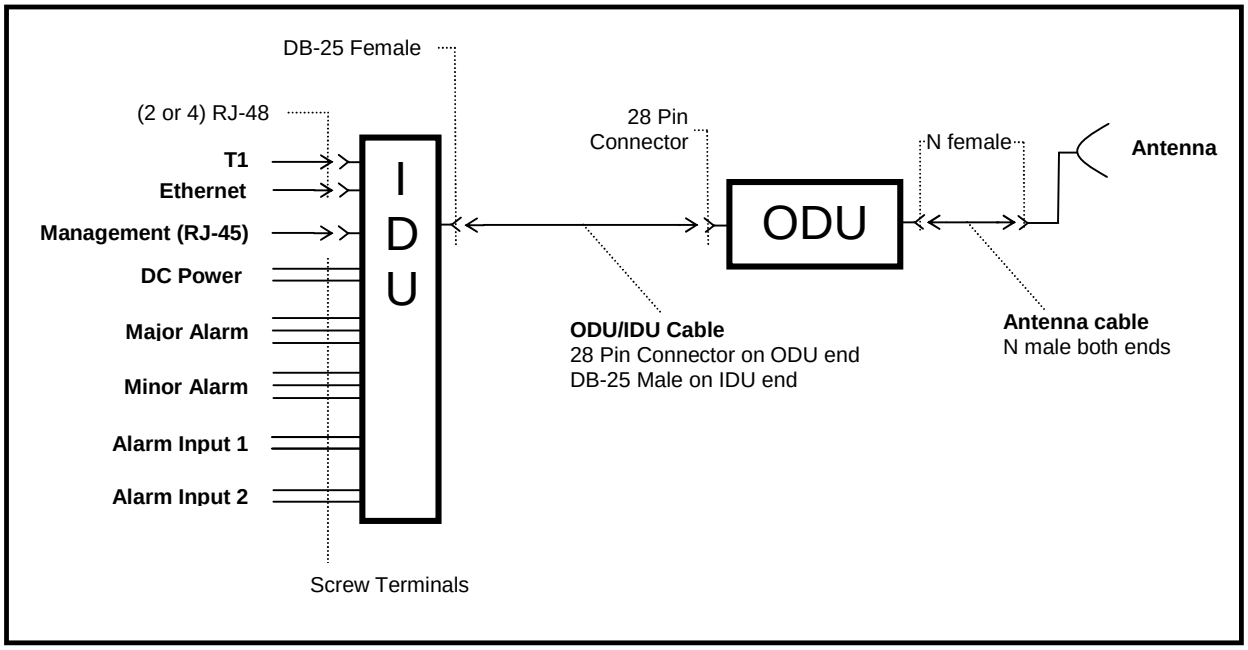


Figure 4-1
ODU with IDU

Figure 4-1 shows the ODU with an external antenna. ODUs equipped with an integrated antenna do not require a separate antenna or antenna cable.

For this configuration, the following items are required:

- ODU
- IDU
- ODU/IDU Cable
- Antenna Cable (if external antenna is used)
- 120 VAC Power Adapter (if powered from standard commercial power)

The ODU/IDU Cable is available in standard lengths as a SafeTLink optional accessory. Custom lengths are also available through LPN Wireless authorized cable manufacturers.

Antenna cables are available in standard lengths as a SafeTLink optional accessory. Custom length cables are available from a number of suppliers.

Caution

Ready-made cables, with connectors installed on both ends, may be difficult to pull through conduits and cable entry-ways.

4.1.3 SafeTLink with ODU only

One or both ends of a SafeTLink system may be configured without an IDU. The radio link will operate normally except that an end without an IDU will not have status indicator lights, external alarm inputs or alarm relay contacts. Some applications where an IDU might not be needed are back-to-back repeaters, remote ends of a system that have no alarm interfaces, or systems where alarms are generated from the management system rather than from relay contacts.

An end of a SafeTLink system without an IDU is shown in Figure 4-2.

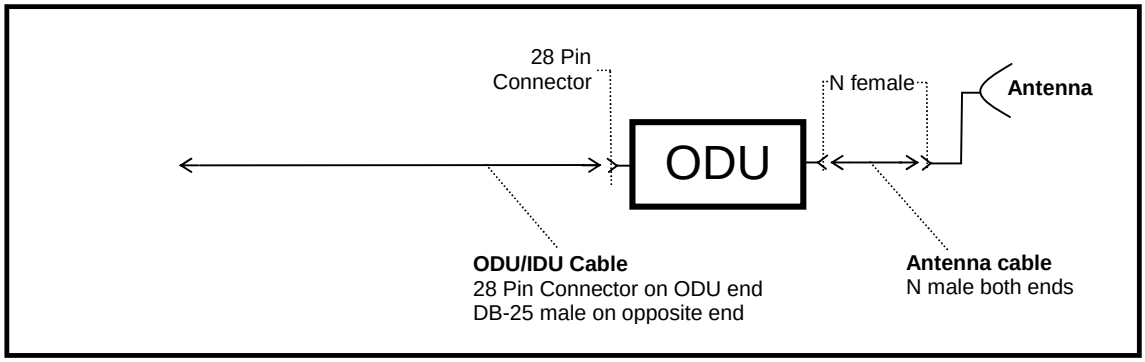


Figure 4-2
ODU without an IDU

Figure 4-2 shows the ODU with an external antenna. ODUs equipped with an integrated antenna do not require a separate antenna or antenna cable.

For this configuration, the following items are required:

- ODU
- ODU/IDU Cable
- Antenna Cable (if external antenna is used)
- 120 VAC Power Adapter (if powered from standard commercial power)

The ODU Cable connects directly to other customer provided equipment. The cable comes equipped with a DB-37 male connector. The connector can be cut off and replaced with another type of connector if required. The ODU/IDU Cable is available in standard lengths as a SafeTLink optional accessory. Custom lengths are also available through LPN Wireless authorized cable manufacturers.

Connector pin information is located in **APPENDIX** II: ODU / IDU Interface DefinitionS.

Antenna cables are available in standard lengths as a SafeTLink optional accessory. Custom length cables are available from a number of suppliers and distributors.

Caution

Ready-made cables, with connectors installed on both ends, may be difficult to pull through conduits and cable entry-ways.

4.2 Powering

4.2.1 System Requirements

Each end of the SafeTLink system requires the following power:

- 18 to 75 VDC or 9 to 18 VDC (depending on ODU power option) at the equipment connector
- 30 watts maximum power

Optional 120 VAC input plug-in Power Adapter modules are available for installations where only AC commercial power is available.

4.2.2 IDU Powering and Fusing

When configured with an IDU, power for the SafeTLink system is connected at the IDU. When the optional 120 VAC/48 VDC Power Adapter is used, no further engineering is required. If DC power is provided, the system powering requirements must be met. DC power should be fused with no less than a 2 amp slow-blow fuse for 24 volt powering and no less than a 1 amp slow-blow fuse for

48 volt powering. For installations using ODUs equipped for 12 VDC operation, DC power should be fused with no less than a 3 amp slow-blow fuse.

4.2.3 Power Failure Recovery

The SafeTLink system will recover from an interruption in power without any intervention and will retain all system configuration information entered prior to the interruption.

4.3 Grounding

The ODU safety ground is connected to the chassis ground lug as shown in Figure 4-3. LPN Wireless recommends a copper ground wire no smaller than a #6 AWG connecting the chassis ground point to earth ground. Grounding must be in compliance with local and national electrical codes. Resistance from the chassis ground point to earth ground should be as low as practical, and must be less than 10 ohms.

4.4 Mechanical

4.4.1 ODU

The ODU can be mounted either to a mast or pole with outside diameter between 0.75 inches and 2.5 inches or to a flat surface such as a wall. All mounting hardware required for ODU installation to a mast is included with the system.

Figure 4-4
Typical ODU Mast Mount Mechanical Installation

The two-axis gimbal mount is clearly visible.

The “N” connector for external antenna and the ODU cable with power and user interfaces each attach to the bottom of the ODU housing.

The “BNC” (capped) has a voltage proportional to received signal level – higher voltages indicate stronger receiver signals.

4.4.2 Rack-Mount IDU

The Ethernet Rack-Mount IDU may be mounted in any of the following eight configurations:

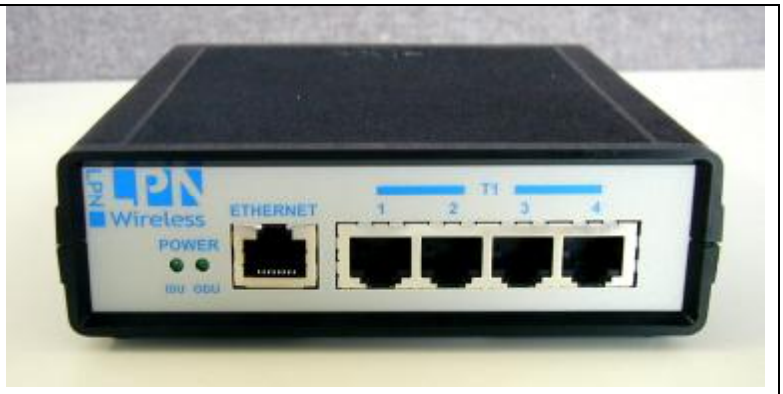
Rack Size	Mount	Connector Location
19 inch	Flush	Rear
19 inch	Flush	Front
19 inch	Recessed	Rear
19 inch	Recessed	Front
23 inch	Flush	Rear
23 inch	Flush	Front
23 inch	Recessed	Rear
23 inch	Recessed	Front

Any of the eight configurations can be achieved by removing and repositioning the mounting ears. The LED indicator lights and alarm cut-off switch appear on both sides of the IDU, so these functions will appear on the front side of the rack regardless of orientation of the connectors.

4.4.3 Mini IDU

The Ethernet mini IDU is available for use in systems where the alarms and indicators of the rack mounted IDU are not needed. This IDU is a passive device that interconnects the cables within the system.

4.4.4 Mini IDU Front Panel

Power LEDs Left – local power OK Right – ODU power OK Ethernet RJ45 connector for control and admin. T1 Port One RJ45 Ethernet One RJ45	

There are two LED indicators on the front panel of the mini IDU. The left LED shows power is connected to the IDU. The right-hand LED indicates the power supply in the ODU is active, and therefore that the cable to the ODU is connected.

4.4.5 Mini IDU Rear Panel

DB-37 connector to the ODU The 2-pin connector is for power input to the IDU and ODU.	

4.5 Frequency Selection

FCC regulations have divided the 4.9 GHz Public Safety Band into channels as shown below:

Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1	4940.5	1
2	4941.5	1
3	4942.5	1
4	4943.5	1
5	4944.5	1
6	4947.5	5
7	4952.5	5
8	4957.5	5
9	4962.5	5
10	4967.5	5
11	4972.5	5
12	4977.5	5
13	4982.5	5
14	4985.5	1
15	4986.5	1
16	4987.5	1
17	4988.5	1
18	4989.5	1

Figure 4-5 shows the overall band plan for the SafeTLink. There are two distinct passbands. Each end of a link transmits in one passband while simultaneously receiving in the other passband.

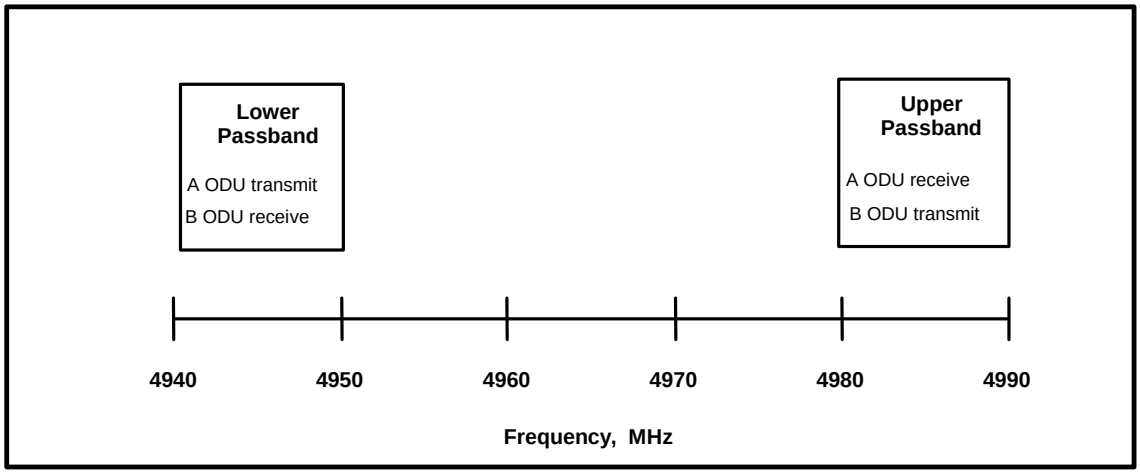


Figure 4-5
SafeTLink Frequency Plan

Channel assignment is an end-user configurable option and is dependent on the RF bandwidth desired for the link. Specific channel assignments are detailed in the following paragraphs.

4.5.1 1 MHz Operation Channel Plan

The A ODU may be configured to transmit on any one of channels 1 through 5. The B ODU may be configured to transmit on any one of channels 14 though 18. The allowable channels and center frequencies are shown in the table below.

Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1	4940.5	1
2	4941.5	1
3	4942.5	1
4	4943.5	1
5	4944.5	1
14	4985.5	1
15	4986.5	1
16	4987.5	1
17	4988.5	1
18	4989.5	1

4.5.2 2 MHz Operation Channel Plan

The A ODU may be configured to transmit on any adjacent pair of channels 1 through 5. The choices are (1,2), (2,3), (3,4) or (4,5). The B ODU may be configured to transmit on any adjacent pair of channels 14 though 18. The choices are (14,15), (15,16), (16,17) or (17,18).
The allowable channels and center frequencies for 2 MHz bandwidth operation are shown in the table below.

Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1+2	4941.0	2
2+3	4942.0	2
3+4	4943.0	2
4+5	4944.0	2
14+15	4986.0	2
15+16	4987.0	2
16+17	4988.0	2
17+18	4989.0	2

4.5.3 5 MHz Operation Channel Plan

The A ODU may be configured to transmit on combined channels 1-5 or channel 6. The B ODU may be configured to transmit on combined channels 14-18 or channel 13. The SafeTLink can transmit on a total of 4 different frequencies when in the 5 MHz bandwidth mode.

The allowable channels and center frequencies for 5 MHz bandwidth operation are shown in the table below.

FCC Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1+2+3+4+5	4942.5	5
6	4947.5	5
13	4982.5	5
14+15+16+17+18	4987.5	5

4.6 Pre-Installation Considerations

There are two types of ODU, labeled A and B. Each SafeTLink system must have one “A” ODU and one “B” ODU. The B ODU transmits on the higher frequencies within the band, and receives on the lower. The A ODU transmits on

the lower frequencies and receives on the higher. Either type can be used at one end of a link as long as the opposite type is used at the other end.

Prior to installing a SafeTLink microwave radio system, consider all factors of the proposed radio path, and also available power, antenna mounting structures, and availability of housing for the IDU (if used) and multiplexing equipment.

4.7 Antenna Path Guidelines

The wireless link using the SafeTLink system will not operate properly unless a line-of-sight radio path exists between the two antennas. High frequencies used in this system do not pass readily through trees or other obstacles. In general, consider the following when calculating line-of-sight clearances between the antennas:

- The curvature of the earth.
- Buildings and trees.
- Future tree growth and construction.

In addition to line-of-sight clearance, a well-engineered high-frequency path will also incorporate additional clearance for other reasons.

An extra clearance around the proposed radio path called the *Fresnel Zone* is required also. A typical Fresnel zone clearance required at mid-path over a 10 mile (14 km) link is 28 feet (9.5 M) at 5 GHz. An on-line resource for Fresnel zone calculations is available at:

http://home.infi.net/~allenk/freszone.html

Extra space may be needed to compensate for signal loss due to partial obstructions, atmospheric ducting, and multipath reflections.

4.8 Path Planning, Analysis and Measurement, Link Budget

The link budget is used to ensure there are no signal reception problems. A Received Signal Level (RSL) for the proposed link should be calculated and compared to the receive threshold of the SafeTLink radio before the system is installed.

4.8.1 Receive Signal Level Calculation

Use this formula to calculate the RSL:

RSL (dBm) = Pout - FL1 + G1 + G2 - FL2 – Lp

where:

Pout is the transmitter output power (in dBm).

FL1 is the feeder loss of the transmit side (in dB). This is the loss in the cable between the ODU and the antenna.

G1 is the gain of the transmit antenna (in dB).

G2 is the gain of the receive antenna (in dB).

FL2 is the feeder loss of the receive side (in dB). As with the transmit side, this is dependent on the cable used.

Use these formulas to determine the loss over a line of sight (LOS) path:

$\mathbf{Lp_{miles}}$ **in (dB) = 96.6 + 20** $\mathbf{\log_{10}F}$ **+ 20** $\mathbf{\log_{10}Dm}$ **(English)**

$\mathbf{Lp_{kilometers}}$ **in (dB) = 92.5 + 20** $\mathbf{\log_{10}F}$ **+ 20** $\mathbf{\log_{10}Dk}$ **(Metric)**

where:

F= 4.97 (frequency in GHz)
Dm=Distance of path in miles
Dk=Distance of path in kilometers

4.8.2 Fade margin calculations

The fade margin is the difference between the RSL and the receiver's threshold. Use the RSL as calculated in the section titled "Receive Signal Level Calculation", and compare it to the receive threshold of the SafeTLink version being used (see **APPENDIX** I: Ethernet System SPECIFICATIONS). Fade margin is the difference between the two signal levels. A fade margin of at least 20 dB is suggested for reliable performance, and larger margins may be required over areas with water or thermal inversions to meet ITU recommended standards for availability.

Fade Margin (dB) = RSL – Minimum Threshold Signal

4.8.3 Sample Link Budget Calculation

This is a sample of a typical link budget calculation:

Path length of 4 miles, single T1 configuration
Output power 20 milliwatts = +13 dBm
Antenna type: 1 foot square flat panel, with gain of +21 dBi at each end
Feeder line loss = 2 dB at each end

The path loss will be (use the English version for miles):

Lp_{miles} = 96.6 + 20 $\log_{10}$(4.97) + 20 $\log_{10}$(4)
Lp_{miles} = 96.6 + 13.9 + 12.1
Lp_{miles} = 122.6 dB

And the received signal level will be:
RSL = Pout - FL1 + G1 + G2 - FL2 – Lp
RSL = +13 - 2 + 21 + 21 - 2 – 122.6
RSL = - 71.6 dBm

Likewise, 4 miles = 6.5 kilometers

$Lp_{kilometers}$ = 92.5 + 13.9 + 16.3 = 122.7 (using the metric version for km)

For a 1 MHz RF channel system, the minimum threshold signal is given in the specifications (**APPENDIX** I: Ethernet System specifications) as -89 dBm.

The difference between the RSL of -76.4 and the minimum threshold of -89 dBm is equal to the fade margin:

Fade Margin (dB) = (-71.6) – (-89) = 17.4 dB

This is a fair fade margin (good would be 20 dB or more) and the path should provide adequate performance and good availability. For higher fade margin over this path, consider increasing the antenna gain at each end of the link.

4.9 Achievable Distances

4.9.1 1 MHz RF Channels

The following distances are achievable when operating with 1 MHz channels.

Antenna		Distance	
A End	B End	99.999% Availability	99.99% Availability
Integrated panel	Integrated panel	7.8 miles	12.5 miles
Integrated panel	2 ft. dish	9.9	15.8
2 ft. dish	2 ft. dish	13.0	20.0
2.5 ft. dish	2.5 ft. dish	14.3	22.9
3 ft. dish	3 ft. dish	15.7	25.1
4 ft. dish	4 ft. dish	17.2	27.5

4.9.2 2 MHz RF Channels

The following distances are achievable when operating with 2 MHz channels.

Antenna		Distance	
A End	B End	99.999% Availability	99.99% Availability
Integrated panel	Integrated panel	6.8 miles	10.9 miles
Integrated panel	2 ft. dish	8.6	13.7
2 ft. dish	2 ft. dish	11.3	18.1
2.5 ft. dish	2.5 ft. dish	12.4	19.9
3 ft. dish	3 ft. dish	13.7	21.8
4 ft. dish	4 ft. dish	15.0	23.9

4.9.3 5 MHz RF Channels

The following distances are achievable when operating with 5 MHz channels.

Antenna		Distance	
A End	B End	99.999% Availability	99.99% Availability
Integrated panel	Integrated panel	5.5 miles	8.7 miles
Integrated panel	2 ft. dish	6.9	11.0
2 ft. dish	2 ft. dish	9.1	14.5
2.5 ft. dish	2.5 ft. dish	10.0	16.0
3 ft. dish	3 ft. dish	11.0	17.5
4 ft. dish	4 ft. dish	12.0	19.2

4.10 Antenna Selection

SafeTLink ODUs are either equipped with an integrated 12 inch flat panel antenna or are equipped with an N female connector for connection to an external antenna. For ODUs requiring an external antenna, several sizes of panel and parabolic antennas are available. Parabolic antennas provide increased forward gain and protection from in-band interference on other azimuths. Typical antennas for this product are of these types:

Antenna Type	Antenna gain, typical	Comments
12 inch Flat panel (same characteristics as ODU integrated antenna)	21 dBi	Small, low gain antenna for moderate range operation, compact, low wind loading.
2 foot parabolic dish	27 dBi	Compact parabolic antenna suitable for smaller masts and towers, medium range operation.
3 foot parabolic dish	31 dBi	Parabolic antenna suitable for smaller masts and towers, medium range operation.
4 foot parabolic dish	33 dBi	Parabolic antenna for long range operation. Requires suitable mechanical mount or tower.

Note that FCC regulations for the 4.9 GHz Public Safety Band limit total radiated power to 46 dBi EIRP. The maximum transmitter power must be reduced to 19 dBm for use with the 2 foot parabolic, reduced to 15 dBm for use with the 3 foot parabolic and reduced to 13 dBm for use with the 4 foot parabolic antenna.

4.11 Integrated Antenna Polarization

SafeTLink may be used with either vertically or horizontally polarized antennas as long as both ends of a link are polarized in the same direction. The SafeTLink ODU with integrated antenna is shipped from LPN Wireless with the antenna mounted such that the radiated signal is vertically polarized. The antenna may be changed to horizontal polarization by removing the antenna assembly from the ODU housing, rotating the antenna 90 degrees and re-attaching the antenna to the housing. Specific instructions for this procedure are given in section 5.7 “Changing Integrated Antenna Polarization”.

Figure 4-5 Integral Antenna Polarization Indication The small double-headed arrow label shows the orientation of the electric field. In this case, the polarization is Vertical.	

5 INSTALLATION

5.1 Tools and Test Equipment

The following tools and test equipment are recommended to facilitate installation of a SafeTLink radio system.

- Common hand tools including screwdrivers, wire cutters, pliers, etc.
- Small English or adjustable wrenches
- Laptop computer, minimum capability:
    - Processor speed of 90 MHz
    - Operating system Windows 98 or newer
    - Processor type, Pentium II or higher equivalent
    - 1 MB minimum hard drive memory
    - 32 MB RAM
- Computer "Category 5" connector to mate the laptop computer's 10/100 BaseT network interface with the SafeTLink system OR serial cable to the laptop's RS-232 port plus a suitable RS-232 to RS-485 converter.
- Digital Voltmeter (DVM) or meter to read 0 to 3 VDC
- Cable to read RSSI – BNC – Male to Banana Plugs to mate with DVM

5.2 Site Preparation

No special site preparation is required for installation of the SafeTLink system. All local building codes, safety procedures, electrical codes and other regulations must be followed.

5.3 Outdoor Installation Procedures

5.3.1 Antenna Installation

WARNING!
It is the responsibility of the installer to ensure that the antenna is mounted so that it is not accessible to the public and is not directed where dangerous levels of human exposure could result. Due to the possibility of exposure to Radio Frequency (RF) radiation above the recommended levels, do not stand within five (5) feet of the front of the antenna during system operation.

The antennas must be mounted to a vertical pipe or tower leg that has sufficient rigidity to prevent the antenna being moved by wind. Follow the wind load guidelines in the antenna installation instructions, and design the antenna structure with the wind load guidelines in mind. The antenna assemblies include mounting hardware that provides adjustment in vertical and horizontal planes. Read and follow the installation instructions packaged with the antennas.

5.3.2 ODU Mechanical Installation

See **Error! Reference source not found.** for mounting detail. Note that the ODU must be installed with its connectors pointing towards the ground.

Error! Reference source not found. **Typical ODU Mechanical Installation** Details of the flexible mount are visible.	

5.3.3 Rack-Mounted IDU Mechanical Installation

The Rack-Mounted IDU may be flush or recessed mounted in either 19 inch or 23 inch racks with connectors to the rear or front. The LED indicator lights and alarm cut-off switch appear on both sides of the Rack-Mounted IDU, so these functions will appear on the “front side” of the rack regardless of orientation of the connectors. Any of the configurations can be achieved by removing and repositioning the mounting ears as shown in Figure 5-1 through Figure 5-8.

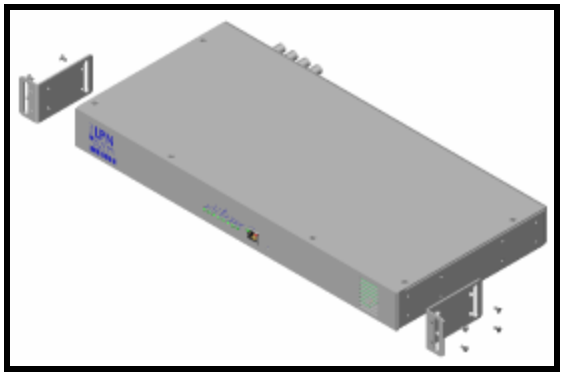


Figure 5-1
IDU, 19” Flush Mount with Rear Connectors

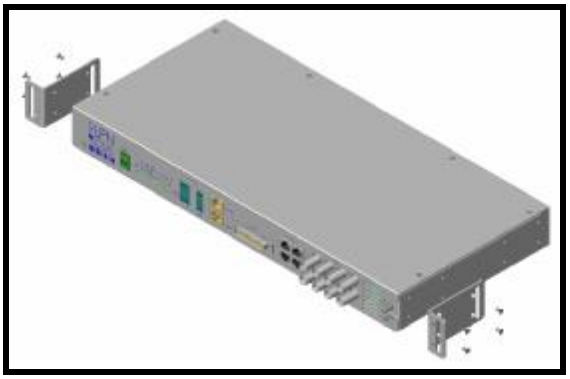


Figure 5-2
IDU, 19” Flush Mount with Front Connectors

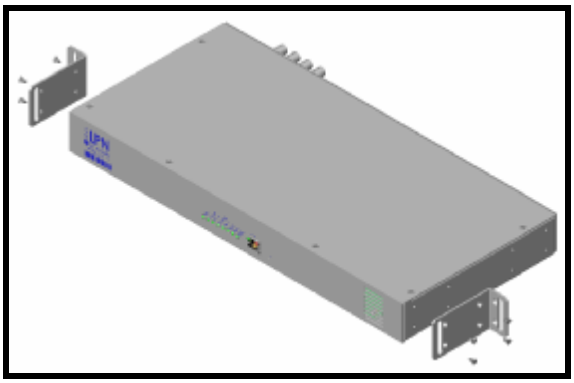


Figure 5-3
IDU, 19” Recessed Mount with Rear Connectors

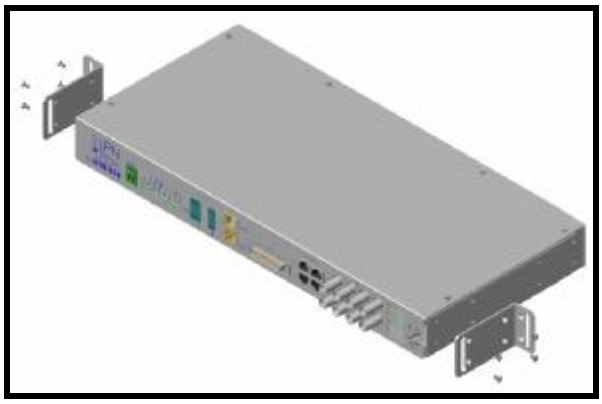


Figure 5-4
IDU, 19” Recessed Mount with Front Connectors

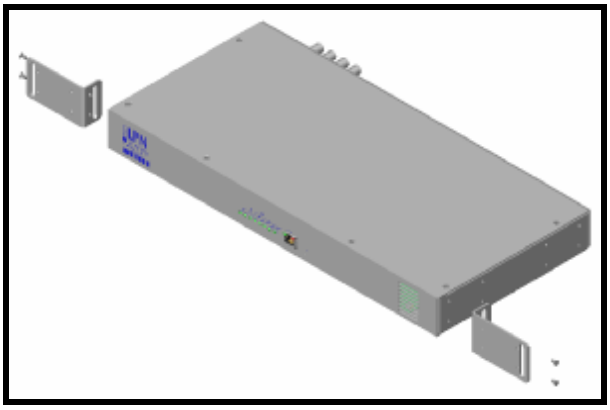


Figure 5-5
IDU, 23” Flush Mount with Rear Connectors

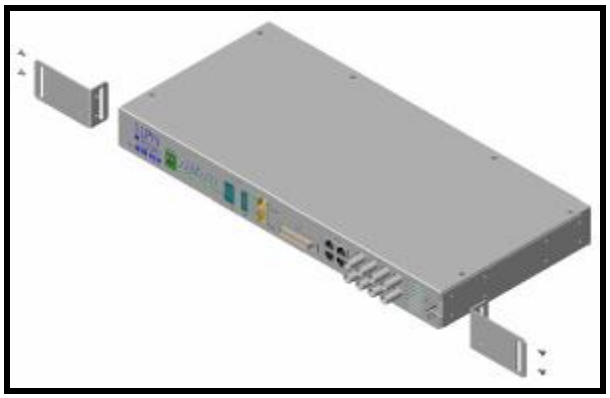


Figure 5-6
IDU, 23" Flush Mount with Front Connectors

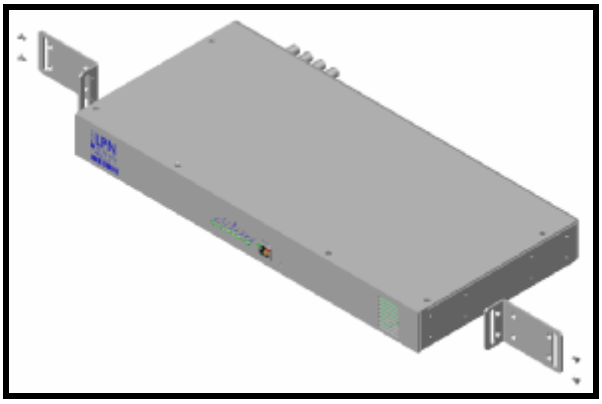


Figure 5-7
IDU, 23" Recessed Mount with Rear Connectors

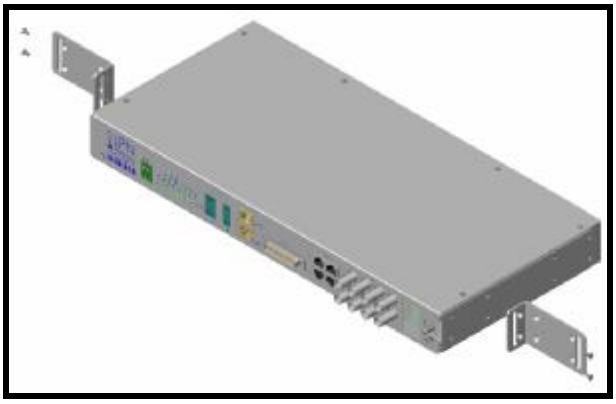


Figure 5-8
IDU, 23" Recessed Mount with Front Connectors

5.4 Electrical Connections

For reference, Appendix II details pin numbers for both the ODU and IDU connectors for SafeTLink systems.

The following connections need to be made at the Rack-Mounted IDU:

Function	Connector type	Number of Connections
Power input	Plug-in screw terminals	2
ODU/IDU cable	DB-37 male	14
T1 line	RJ-48 jack	1
Ethernet	RJ-45 jack	1
External alarm input 1	Plug-in screw terminals	2
External alarm input 2	Plug-in screw terminals	2

5.4.1 With Ethernet + FT1 IDU

On ends of a SafeTLink system with an IDU, the ODU/IDU cable needs to be installed. The DB-37 connector end of the cable mates with the IDU and the 28 pin connector mates with the ODU.

For reference, **APPENDIX** II: ODU / IDU Interface DefinitionS details pin numbers for both the ODU and IDU connectors for Ethernet systems.

The following connections need to be made at the IDU:

Function	Connector type	Number of Connections
Power input	Plug-in screw terminals	2
ODU/IDU cable	DB-37 male	25
T1 line	RJ-48 jack	4
Ethernet Data and Management	RJ-45 jack	4
Major alarm contacts (1 form C)	Plug-in screw terminals	3
Minor alarm contacts (1 form C)	Plug-in screw terminals	3
External alarm input 1	Plug-in screw terminals	2
External alarm input 2	Plug-in screw terminals	2

All connections are labeled on the IDU for ease of connecting cables. For reference, the IDU connector side is shown in Figure 5-9.

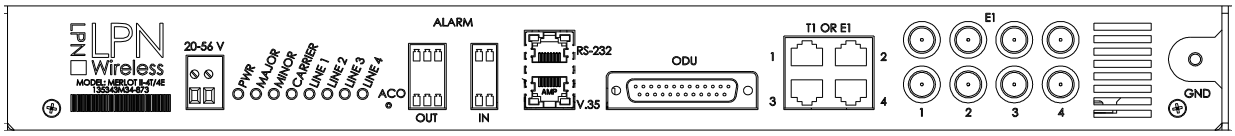


Figure 5-9
Ethernet + FT1 IDU Connector Side

5.4.2 Without IDU

On ends of a SafeTLink system without an IDU, the ODU/IDU cable is used to physically wire the ODU to its respective connecting equipment. One of the standard ODU/IDU cables should be used. If the DB-37 connector is not appropriate for the required connections, it can be removed and replaced with the needed connector or the wires may be physically connected individually.

Appendix II details pin numbers for both the ODU and DB-37 connectors. The appropriate appendix should be used when wiring the ODU to its connecting equipment.

5.5 Grounding

5.5.1 ODU

The ODU must be properly grounded to ensure safe operation. A ground lug is provided which can be attached to either of two threaded inserts in the mounting plate to connect a low-resistance path to earth ground as shown in Figure 5-10. The threaded inserts are tapped ¼" – 20 UNF.

LPN Wireless recommends a copper ground wire no smaller than a #6 AWG connecting the common ground point to earth ground. Grounding must be in compliance with local and national electrical codes. Resistance from the common ground point to earth ground must be less than 10 ohms.

Figure 5-10
ODU Ground Lug

5.5.2 IDU

The IDU must be properly grounded to ensure safe operation. A ground terminal is provided on the connector side of the IDU which can be used to connect a low-resistance path to earth ground. LPN Wireless recommends a copper ground wire no smaller than a #6 AWG connecting the IDU to earth ground. Grounding must be in compliance with local and national electrical codes and practices. Resistance from the common ground point to earth ground must be less than 10 ohms.

5.6 RF Connections

This section only applies for ODUs operated with an external antenna.

The ODU ideally should be installed within 2 meters of the antenna, although longer distances can be supported depending on the RF cable chosen. RF cable between the ODU and antenna should be 50 ohm, low loss type such as Belden 9913, Times LMR-400 or similar. If longer cable length is required, consider the cable losses when selecting the cable.

If the cable is built in the field, be sure to follow carefully the cable and connector instructions to the letter. Improper cable selection or improper assembly of connectors onto the cable can easily degrade performance. Take special care to weatherproof the connections. Degraded coaxial RF cables are the most common cause of failure of installed RF equipment. LPN Wireless strongly advises against the use of RF cables assembled on site, in the field.

LPN Wireless strongly recommends that pre-built cable assemblies be used for the installation of the equipment. Cables assembled, sealed, and tested in a production line have a much higher field reliability than cables assembled at the site. Antenna cables are available in standard lengths as a SafeTLink optional accessory.

Note the following concerning the antenna connection:

- Antenna connector torque. The type “N” connectors should be tightened firmly with fingers only. Do not use a wrench to tighten the “N” connectors.
- Antenna connector sealing. It is common practice to wrap plastic tape or weathersealing tape around the exposed metal of the “N” connectors on both the ODU and antenna ends of the cable. This helps to seal out moisture from the connector, and from entering the coaxial cable.

5.7 Changing Integrated Antenna Polarization

The SafeTLink ODU with integrated antenna is shipped from LPN Wireless with vertical polarization. The antenna may be changed to horizontal polarization by removing the antenna assembly from the ODU housing, rotating the antenna 90 degrees and re-attaching the antenna to the housing.

To perform this change, first remove antenna.

- Use a Phillips type screwdriver to remove all 16 screws that attach the antenna to the metal ODU housing.
- separate antenna from housing
    - CAUTION do not let the antenna hang from the coax cable or damage to the antenna or its cable may occur.
- Rotate the antenna 90 degrees, use care with antenna cable. There is a label on the back (normally hidden) side of the antenna showing polarization. Align the arrows for the desired polarization.
- verify drain hole is at bottom, if not – rotate antenna 180 degrees.

- Polarization arrows should be at (TO BE PROVIDED) for horizontal polarization, at (TO BE PROVIDED) for vertical polarization.
- Ensure the elastic "O" ring is properly seated into its machined groove in the ODU flange. "O" ring seating is essential for weatherproofing the ODU.
- Reattach antenna to ODU housing with 16 screws removed in first step.

5.8 Antenna Alignment

Each antenna is aimed directly at, and must have a radio line-of-sight path to the antenna on the other end of the link. In the case of an ODU with integrated antenna, the entire ODU is adjusted to aim the antenna properly. The presence of buildings, foliage or other obstructions within the radio path or the first Fresnel zone will impede performance and could prevent communications. Depending upon the antenna gain used, the beam width of most of the transmitted signal will be 5 degrees or less, requiring that the antenna be accurately aimed. The higher the antenna gain, the narrower the antenna "beam."

5.8.1 Optical Alignment

A magnetic compass and spirit level be should be used to aim the antenna. The azimuth of the other site must be known and magnetic deflection considered. Topographical maps can be consulted to determine the amount of local magnetic deflection.

The antenna mounting hardware can be adjusted after the antenna is installed. To use the adjusting points, the clamping bolts must be slightly loose. After the antenna is aligned for maximum signal strength, tighten the mounting bolts. The antenna should be connected to earth ground using #6 AWG copper ground wire, in compliance with local and national electrical codes.

5.8.2 Maximizing the Received Signal Level

After the antennas at each end of the link are approximately aligned visually, it is important to adjust for maximum signal power received at each end. Visual alignment alone will not be adequate except for very short range links.

Note that the installer needs to be sure the proper signal is being used for alignment. There is a clear test to ensure the proper signal is in use, no matter which alignment method is used:

- if one antenna is moved, the RSSI at *each* end of the link should vary about the same amount.
- if one antenna is moved, and the RSSI changes on only ONE end of the link, then at least one end of the link is tracking an undesired signal. In that case, change channels until both ends vary equally with antenna changes.

Three ways to adjust the antennas are described here.

5.8.2.1 Using CLI or NMS RSSI indication

Required equipment: PC or terminal to communicate with the ODU or IDU and to command the SafeTLink link via CLI (Command Language Interface) or NMS (Network Management System).

Adjust the antenna in azimuth and elevation in SMALL increments while watching RSSI. It is best to adjust one axis at a time – move the antenna in elevation for best RSSI, hold that elevation adjustment, move in azimuth to again peak RSSI.

5.8.2.2 Using RSSI indication from ODU's BNC connector

Required equipment:

- Voltmeter, analog or digital, to read a DC voltage at the ODU. Voltmeter should read 0 to 3 VDC.
- Cable from Voltmeter to BNC connector on the ODU.

This method permits the installer to adjust the antenna for best alignment while he/she is right at the antenna.

Remove dust cover from BNC connector on the ODU. Attach voltmeter to the BNC connector on the ODU. Polarity is insensitive, but center lead is + and the shell is -. Range is 0 to >3VDC. The voltage readings are relative. A higher voltage indicates higher (stronger) RSSI.

Adjust the antenna in azimuth and elevation in SMALL increments while watching RSSI indication. It is best to adjust one axis at a time. Move the antenna in elevation for best RSSI, hold that elevation adjustment, move in azimuth to again peak RSSI.

Replace the dust cover on the BNC connector after use.

Repeat at each end of the link.

Figure 5-12
ODU RSSI Test Port

DVM showing RSSI signal at the ODU BNC connector.

The RSSI signal is DC, with a range of 0 to 3 volts.

The larger the voltage, the stronger the received RF signal.

5.8.2.3 Receiver Signal Strength versus Voltage at RSSI Port

The RSSI is a relative indication of signal strength. It is not a calibrated RF power meter. However, the approximate relationship between RSSI port voltage and actual receiver input power is given in the table below

RSSI, Volts DC	Receiver Input Power, dBm
2.25	-30
2.00	-40
1.85	-50
1.51	-60
1.15	-70
1.00	-80

5.8.2.4 Using the Transmit CW Tone mode with a spectrum analyzer

Required equipment: Spectrum analyzer covering the 4.9 to 5.0 GHz frequency range.

Set the transmitter at one end into the Transmit CW Tone mode. This causes the ODU modem to stop modulation of the carrier, and a narrowband signal at center of the desired channel will be sent instead of the normal wider-band modulated signal. No data link is possible from the ODU in CW Tone mode.

For antenna alignment, turn off the transmitter at the other end of the link.

At the end of the link where the transmitter is OFF: Connect a spectrum analyzer to the antenna cable normally attached to the ODU's "N" connector. The cable between the antenna and spectrum analyzer should be short, or low loss type.

Set spectrum analyzer to the frequency of the far end's transmitter. Use a narrow scan bandwidth to improve the spectrum analyzer's sensitivity.

Locate the CW tone transmitted from the far end. Once a probable signal is located on the spectrum analyzer, it is useful to move the far end transmitter frequency by a fixed step, 1 MHz for example, to positively identify the signal, or to turn it on and off for positive identification. These two commands may be issued by the GUI, if connected to the far end ODU.

Adjust the antennas for maximum signal observed on the spectrum analyzer. Note that the antennas at EACH end of the link can be adjusted with the spectrum analyzer readings from just one end of the link. It is usually not necessary to transmit from each site in turn.

Adjust each antenna in azimuth and elevation in SMALL increments while watching the spectrum analyzer display. It is best to adjust one axis at a time – move the antenna in elevation for peak amplitude, hold that elevation adjustment, move in azimuth to again peak amplitude on the spectrum analyzer's display.

After adjustment is complete, reattach the coaxial cable to the ODU "N" connector. Reset the Transmit Mode command to "ON-Normal" for normal system operation.

5.9 Initial System Tests

TO BE PROVIDED

6 CONFIGURATION AND MONITORING

6.1 Introduction to What Can be Configured and Monitored

6.1.1 Local

All of the settings required to configure a SafeTLink system can be controlled via a computer link. There are no manual adjustments of the ODU or IDU.

The user or system operator of the SafeTLink system controls the settings via one of several interfaces. The use of each of these interface types is described in this chapter of the User Manual.

The user can control and/or monitor the following configuration information:

- Transmitter and receiver frequencies
- Transmitter RF power level, and Transmitter on/off control
- ODU type (TX frequency high, or TX frequency low)
- Received signal strength
- Bit Error Rate information
- User interface (T1 and Ethernet) settings and operation

- Overall status of the system (with a single byte)
- ODU temperature
- ODU and IDU internal voltages
- Resets of the equipment
- Equipment serial numbers
- Software version numbers

6.1.2 Remote

Each of the controls or monitors listed in "local" above can also be operated from the far end of the SafeTLink system when it is operating. The system operator or user can read or configure the far end of an operating link from either end. The commands and formats are the same when reading or configuring either end. The remote end is considered to be the end of a link away from the direct connection to the ODU or IDU hardware.

It is important to be aware that some changes made to the remote end of the link will result in a breaking of the link. If a series of commands are to be sent to both near and far end radios, it is important to put some thought into the sequence that these commands are sent.

For instance, if you wish to change an ODU pairs transmit and receive frequencies, you would want to send the commands in the following order:

- Change remote receive frequency
- Change local transmit frequency
- Change remote transmit frequency
- Change local receive frequency.

If you changed (for instance) the local transmitter first, the remote receiver would go out of lock, and no commands would be received by it.

6.2 Using the Command Language Interface

6.2.1 Command Line Interface Introduction

The ODU communicates with a host processor via a simple command line interface (CLI). The CLI is primarily intended for machine to machine communications. Although human operators can enter the exact command strings, the intention in most networks is to operate this equipment via a network management system (NMS) or a Windows based Graphical User Interface (GUI).

CLI commands are all a single alphabetic command character, followed by a pair of command type ("register") characters. The command may be followed by data, if data are to be sent to the ODU. If the command requests data from the ODU, there is no data in the command to the ODU. All commands are followed by the `<enter>`, which signals the ODU to respond. Also note that all CLI commands are case sensitive.

The ODU / host emulator only replies to commands sent. It does not send data automatically. That is, the ODU must always be polled by the user. Replies from the ODU echo the command, and append data.

6.2.2 Configuration via direct connection to the ODU

6.2.2.1 RS-485

- RS-485 is available only on Ethernet SafeTLink systems.

For connection problems, see section 8.3.2.2 RS 485 Configuration Problems.

6.2.2.2 10/100 BaseT IP Connection

- Physical Connection -The other option for direct CLI control is through the 10/100BaseT port located in the ODU. This interface uses four wires of the ODU multiconductor cable, Pair #'s 13 and 14. Refer to **APPENDIX** II: ODU / IDU Interface DefinitionS for multiconductor cable pinout.
- IP Address - Once connected to the 10/100BaseT port, you must configure the SafeTLink product to work on your network. On the CD that ships with every SafeTLink system, you will find a program called "SafeTLink Discovery.exe". Copy this program onto the PC you wish to use to configure the ODU. Launch the program by double clicking it. You will see the following:

{insert Digi-Discover Screen Shot}

{insert default IP Address information}

6.2.3 Configuration via the Rack-Mount IDU

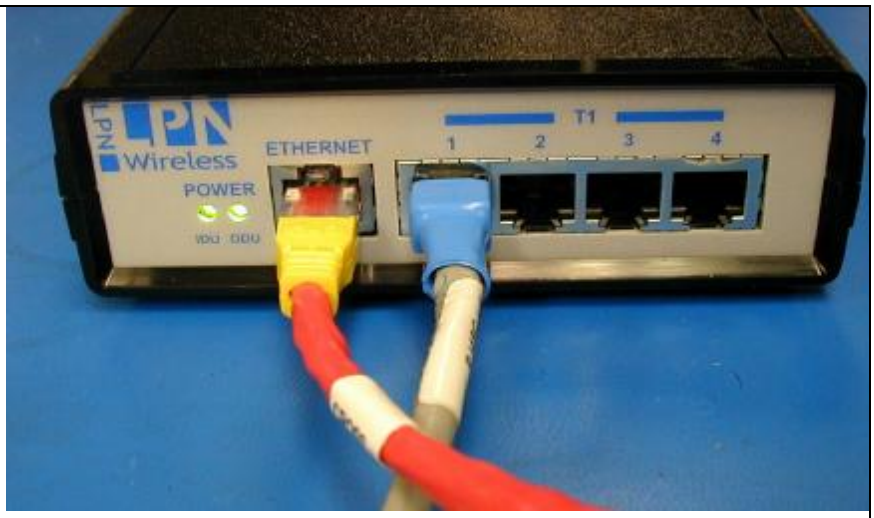
6.2.3.1 Using Ethernet 10/100BaseT with the Rack-Mount IDU

The user may connect either a PC/Laptop directly to the IDU 10/100BaseT interface, or a router/hub/switch. If using a PC, use a **cross-over** cable. If connecting via a router, use a standard straight cable.

Once connected, refer to section 6.3"Using the LPN Wireless GUI" to configure the IP Interface.

6.2.4 Configuration via the small-format IDU

When using the optional small format ("mini-") IDU, the Ethernet cables *????*

Figure 6-5 Ethernet configuration port on the small format IDU. The RED CAT5 cable (cross-over type) connects directly to the PC's 10/100 Base T "NIC" port.	

6.2.5 CLI Command Structure

The CLI, or Command Language Interface, consists of a short command optionally followed with values or data. Note that the CLI for the Ethernet + FT1 SafeTLink has been changed from that of the Ethernet SafeTLink.

Note that CLI commands are case sensitive.

6.2.6 Error Messages

6.2.7 Status Byte

6.2.8 Register Command Details

This section of the document contains an overview discussion of the registers, the commands, and how they operate within the overall ODU and the radio link system.

In the table below, commands in **BOLD** are saved in non-volatile memory within the ODU. If the ODU is reset, or after power is restored after an interruption, these registers are reloaded automatically with the last saved value. For example, the ODU type, power level, operating frequency, and interface settings are retained and automatically re-established after any reset.

6.2.8.1 General Information CLI - ODU

These CLI commands read general information about the ODU, returning the data requested.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
Software Version		R	Returns the Software Version of the ODU.	X.XX	Current version, e.g. 2.64	NONE
Firmware Version		R	Returns the Firmware (or Hardware) Version of the ODU.	X.XX	Current version, e.g. 1.00	NONE
Serial Number		R	This command returns the internal serial number of the ODU. This is not the same as the bar coded serial number posted on the outside of the ODU (which is the external serial number).	XXXXX	00000 to 00000FFFFFF	NONE

6.2.8.2 Reset and Restore CLI – ODU

These two CLI commands are used to return the ODU to earlier or default states.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
Reset ODU		W	If this command is sent (pbbb) the ODU will reset itself. This will cause a service disruption	X	b = reboot	NONE
Restore ODU		W	Reset the ODU to the default values. (not recommended for customer use)	X	r = restore	NONE

6.2.8.3 General Status CLI Commands - ODU

This section lists general CLI commands concerning the ODU.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
ODU Status		R	The ODU provides a status byte, polled by the CLI. This status byte signals overall status. The user can scan the status byte and determine if there is any abnormal condition. If there is an abnormal condition in the ODU, the status byte provides information where to seek more details.	XXXXX XXX	See 6.2.7 “Status Byte” for details	NONE
ODU Temperature		R	There is a temperature sensor in the ODU, on the RF board. This sensor provides a measure of the PWB substrate temperature.	{sign} XX.X	-99.9 to +99.9	Degrees Celsius
12 VDC		R	Monitors an ODU internal voltage.	XX.XX	11.00-13.00	(VDC)
7 VDC		R	Monitors an ODU internal voltage.	X.XX	6.90-7.25	VDC
5 VDC		R	Monitors an ODU internal voltage.	X.XX	4.90-5.10	VDC
3.3 VDC		R	Monitors an ODU internal voltage.	X.XX	3.25-3.35	VDC

6.2.8.4 Radio Configuration CLI

These CLI are general commands relevant to the radio.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
ODU Type		R/W	The two ends of a radio link require different types of ODU. ODU Type A transmits on a lower set of frequencies, and receives on a higher set of frequencies. ODU Type B is the opposite. It is possible for the user to reconfigure an ODU to the opposite radio type, but the ODU must be disassembled first. See section 8.4.4 "Duplexer Reconfiguration" for details.	X	a,b	NONE
TX Frequency		R/W	This is the transmit frequency of the ODU in kHz. See section 4.5.1 through 4.5.3 for valid frequency options. If the commanded frequency is out of the listed range, an error message is returned.	XXXXX XX	Type A ODU 4940500 to 4947500 Type B ODU 4982500 to 4989500	kHz
RX Frequency		R/W	This is the receive frequency of the ODU in kHz. See section 4.5.1 through 4.5.3 for valid frequency options. If the commanded frequency is out of the listed range, an error message is returned.	XXXXX XX	Type A ODU 4982500 to 4989500 Type B ODU 4940500 to 4947500	kHz
TX Level		R/W	The Tx Level command sets the desired power level of the transmitter. The ODU will automatically adjust the output power to the commanded level. The FCC mandated limits vary depending on Antenna gain and channel bandwidth (1,2,5 MHz mode). See section 4.5 for details.	XX	0 to 19 99 = manual mode (disable auto power control)	dBm
TX Carrier		R/W	The command TX Carrier permits the user to turn off the RF Transmitter. Before this command will be accepted, the user must set TX Level (see above) to 99. This allows the TX carrier to be toggled on and off. To reactivate the automatic gain control once testing is complete, enter a valid TX Level command between 0-19.	X	a = active, transmitter operating i = inactive, TX off	NONE

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
TX CW Tone		R/W	The command TX CW Tone permits the user to turn off the modulated signal and transmit the carrier tone only. This is useful for antenna alignment. The transmitted tone can easily be observed at the far end using a spectrum analyzer.	X	a = active, tone-only on i = inactive, tone-only off	NONE
RF Bandwidth		R/W	This command controls the operating mode of the ODU, whether it is in 1X mode, 2X mode, or 4X mode. 1X Mode is 1MHz BW, 2 Mbps 2X Mode is 2MHz BW, 4 Mbps 4X Mode is 5Mhz BW, 12 Mbps If a write is issued (where the CLI command is pln4) the ODU immediately resets itself, and reboots with the new configuration. Both radios in a link must be set to the same mode for them to communicate.	X	1,2,4	NONE

6.2.8.5 Radio Monitoring CLI

These CLI commands provide general radio monitoring information.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
RSSI		R	Receive Signal Strength Indicator (RSSI) measures the power level of the RF signal reaching the ODU from the far end transmitter.	{sign} XX.X	-110.0 to 00.0	dBm
TSSI		R	Transmitter Signal Strength Indicator (TSSI) measures the power level of the RF signal from the ODU final amplifier stages for transmission towards the far end receiver.	{sign} XX.X	+/- 1 from TX Level setting.	dBm

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
RX FEC Correction		R/W	There is Reed-Solomon Forward Error Correction (FEC) within the modem demodulator. This counter indicates the total number of errored blocks received by the modem, both corrected and uncorrected. This counter must manually be zeroed out by the user (the CLI command is pfc0). Thereafter it will register any errors. The counter rolls over at 65535. Errors recorded here are not necessarily errors in the T1 data stream, as they were likely corrected by the modem.	XXXXX	0 to 65535	NONE
RX FEC Bad Blocks		R	There is Reed-Solomon Forward Error Correction (FEC) within the modem demodulator. This counter indicates the total number of uncorrectable errored blocks received by the modem. This counter must manually be zeroed out by the user (the CLI command is pfb0). Thereafter it will register any errors. The counter rolls over at 65535. Any errors that are recorded here will be real errors in the T1 data.	XXXXX	0 to 65535	NONE
MODEM Lock		R	This variable indicates that the radio is receiving and demodulating the far side transmitter. Normal operation provides a "locked" reply at all times.	X	u = unlocked l = locked	NONE
Signal to Noise Ratio		R	This variable returns a "raw" Signal to Noise Ratio (SNR) reading. To obtain a dB value, calculate the transformation as (78-20log(nr)). See "**APPENDIX** V: Receiver snr table**"** for a table showing the nr return versus SNR in dB.	XXX		NONE

6.2.8.6 T1 Line Interface Unit (LIU) Configuration CLI

This section of the table lists general commands for configuration of the 1 to 4 T1 LIUs. EACH of the CLI commands in this section are subordinate to the LIU Select command. Note that CLI commands in **BOLD** are stored in non-volatile memory, and are saved across a reboot or system failure.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
LIU Select		R/W	Sets the LIU number for subsequent read and write commands for each LIU. If you wish to configure the first T1 channel, you would enter “pls0”. Any LIU commands that follow, such as Tx Build Out “ptb0”, would affect T1 channel 1 only. If you wish to set T1 channel 2, you would enter “pls1”, and then the subordinate command.	X	0, 1, 2, 3	None
TX Build Out		R/W	Sets the LIU T1 analog output drive level to the appropriate level. Both CSU and DSX values are supported: 0=DSX-1 (0-133ft.)/0 dB CSU 1=DSX-1 (133-266ft.) 2=DSX-1 (266-399ft.) 3=DSX-1 (399-533ft.) 4=DSX-1 (533-655ft.) 5=-7.5dB CSU 6= -15bB CSU 7=-22.5dB CSU	X	0 – 7	None
RX Build Out		R/W	Sets the LIU T1 analog input threshold sensitivity to the appropriate level. 0=-36dB (long haul) 1=-30dB (limited long haul)	X	0 , 1	None
LIU Facility Loopback (FLB)		R/W	In Facility Loopback (FLB), data coming into the ODU’s T1 interface from the network will be looped back and sent out the same T1 interface to the network. This is a useful test for checking the wiring to the ODU. This setting is saved through a reboot, the user must deactivate the command when finished.	X	a = active i = inactive	NONE
LIU Equipment Loopback (ELB)		R/W	In Equipment Lopback (ELB), data received from the radio will be looped back to the radio transmitter at the T1 analog interface. This loopback should only be employed on the ODU set as the Timing Slave. This is a useful test as it tests nearly the entire radio link. This setting is saved through a reboot, the user must deactivate the command when finished.	X	a = active i = inactive	NONE

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
LIU_MASK		R/W	This command masks out the LOS reporting in the Status byte of whichever LIU it is set for. So if for instance you were using a radio with all 4 T1's enabled, but were only passing data on 3 of those T1's, you would want to mask out the error reporting on the unused T1 channel. In this way the Status byte LIU reporting will only indicate errors on channels in use.	X	a = active i = inactive	NONE
LIU Alarm Indication Signal (AIS)		R/W	Each of the LIUs contains a pattern generator to produce the Alarm Indication Signal (AIS). If the AIS generator is active the LIU transmits AIS towards the network. This variable indicates AIS is active. AIS may be turned on by the user via this CLI, or the far end LIU may turn on this signal automatically when near end system reports LOS.	X	a = active i = inactive	NONE
LIU Built In Self Test (BIST)		R/W	Each LIU contains a 2^{15}-1 built in self test (BIST) pattern generator. This command sets the LIU to transmit this data pattern out towards the network.	X	a = active i = inactive	NONE
LIU Line Code Type		R/W	Sets selected LIU to AMI or B8ZS Line Coding.	X	a = B8ZS i = AMI	NONE

6.2.8.7 T1 Line Interface Unit (LIU) Monitoring CLI

These CLI commands are relevant to LIU monitor functions. These CLI commands return information on the status of the T1 signals at the LIUs. Recall there is an LIU for each T1 channel, and a corresponding monitor result for each LIU numbers 0 through 3. EACH of the CLI in this section are subordinate to the LIU Select command.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
LIU AIS Detection (AD)		R	The LIUs contain AIS Detection (AD). If the LIU detects an incoming T1 data stream containing the AIS pattern, the AD variable is set to true.	X	t = TRUE f = FALSE	NONE
LIU Loss of Signal (LOS)		R	Each LIU monitors the incoming data stream, and if 192 or more consecutive zeroes are detected, this variable is set to true.	X	t = TRUE f = FALSE	NONE

6.2.8.8 Timing and Synchronization CLI

Timing for the system T1 user interfaces can be sourced at either end of a wireless link. Timing comes into the Master end, and is delivered to the Slave end. Either Type "A" or "B" ODUs can be set to slave or master. Each link must have one master and one slave ODU.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Description / Range	Units
Master Slave		R/W	Sets the SOURCE of the timing signal for the T1 LIUs. All T1s are synchronous and all 4 LIUs are set together by this command.	X	m = master s = slave	NONE

6.2.8.9 Remote Alarm CLI

These CLI are used only when the rack-mounted IDU is present in the system. The remote alarm inputs at one rack-mounted IDU are sent via the wireless link to the rack-mounted IDU at the far end to control relay contact closure. The CLI may also be used to read the status of an alarm input.

COMMAND NAME	CLI CMD	Read/ Write	Discussion of the command function and operation	Data Format	Range	Units
Alarm Input 1		R/W	Read the status of the ODU alarm input #1. The Alarm inputs are for local low speed signaling (< 10 Hertz) from end to end.	XXX	0-255	NONE
Alarm Input 2		R/W	Read the status of the ODU alarm input #2. The Alarm inputs are for local low speed signaling (< 10 Hertz) from end to end.	XXX	0-255	NONE

6.3 Using the LPN Wireless GUI

The LPN Wireless graphical user interface (GUI) runs on a Windows based personal computer (PC). The GUI communicates with the ODU via the serial data link. The GUI uses the same CLI described above, but presents the user a higher-level view of the ODU operation.

6.3.1 GUI Host PC Requirements

The GUI must be installed on the user's PC before it can be used. Installation requirements for the user's PC are listed in the table below:

Item	Requirement
Minimum Processor Speed	90 MHz
Operating Systems Supported	Windows 98, Windows 2000, Windows XP
Processor Type	Pentium II or higher

	equivalent
Available Disk memory	1 MB minimum
Available RAM	32 MB

The GUI can be downloaded from the support web site at
http://www.LPNWireless.com/support.htm
The GUI is also supplied on a Compact Disk (CD) with the ODU.

6.3.2 GUI Overview

The GUI appears on the screen of the PC with five available pages. Each of the pages is accessed via the tab near the bottom of the screen. The GUI permits the user to control the most commonly used settings for normal operation of the ODU. The GUI also provides performance monitoring of the ODU.

6.3.3 GUI Configuration Page

This page of the GUI is the control panel for the SafeTLink. Select the page by clicking on the “Configuration” tab in the lower left. The left side column labeled “Links” shows all the SafeTLink systems controlled by this GUI. Select the system to view in detail by clicking on the button with the name of the system. The button will highlight to show its selection.

There are two main windows, one for each end of the selected system or link. The user enters a local name for each end of the link. In the example shown below, one end is named “Mt. Hood” and the other “Mt. Shasta.” The names appear at the top of each panel.

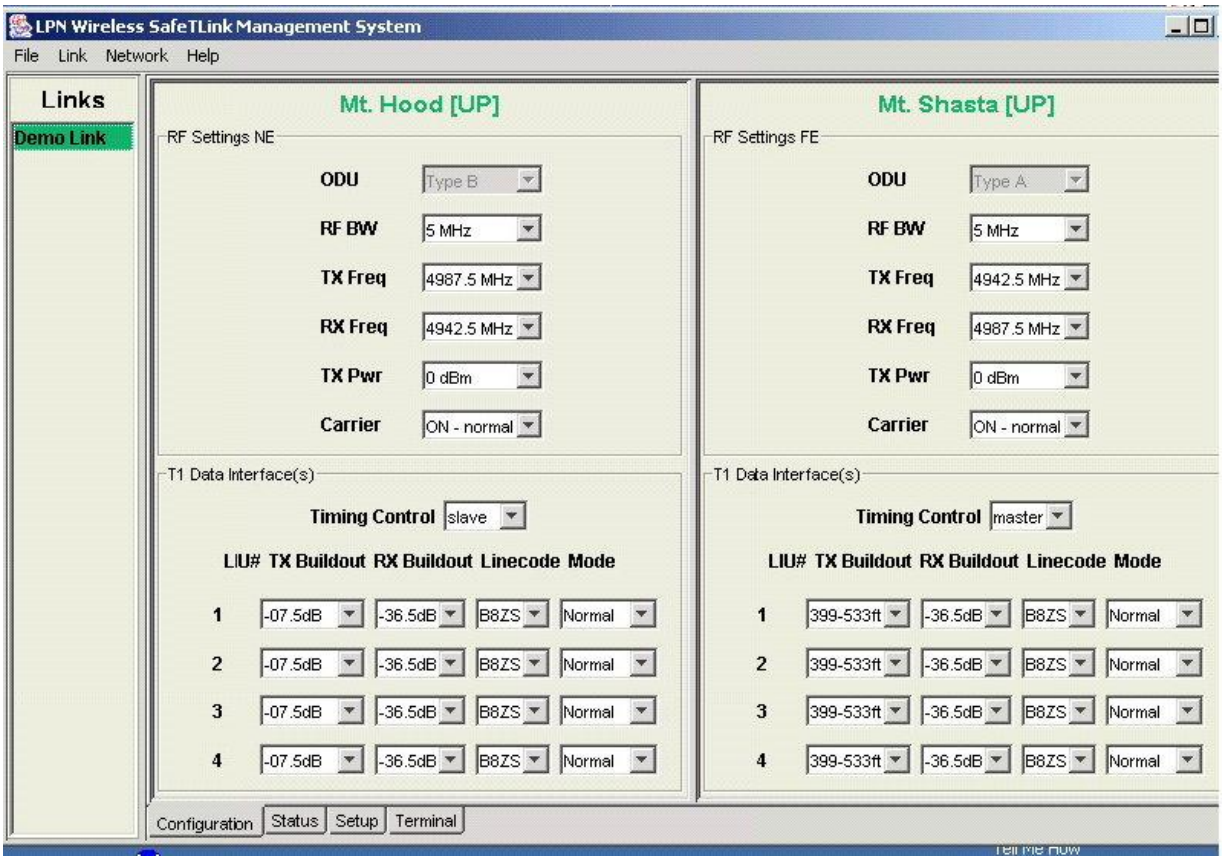


Figure 6-1
GUI Configuration Page

Figure 6-1 is a view of the GUI Configuration page. This example shows:

- "Demo Link" is selected and shown on the detailed view panels
- 5 MHz channels = 4 x T1 Mode
- The Near End (left side window) is named "Mt. Hood":
  - The [UP] indicates the link is up and operating. Green lettering indicates normal operation with no status alarms
  - ODU Type is B (read only via the GUI, can only be changed at the CLI level)
  - Transmitter is on 4987.5 MHz (channel center frequency)
  - Receiver is set to 4942.5 MHz
  - The transmitter output is set to 0 dBm
  - The carrier is set for normal operation
  - This is a T1 system, with 4 T1 LIUs operational
  - T1 LIU #1 is set to:
    - TX Line buildout is set to -7.5 dB
    - RX Line buildout is set to -36.5 dB

  - § The T1 line code is set to B8ZS
  - § The LIU is set for normal operation
- The far end (right side of the screen) is named “Mt. Shasta”

The GUI has a limited set of commands in each of its pull-down choices. See **APPENDIX** III: GUI Configuration Details for details of the GUI Selections and options.

The Configuration Screen defaults to the following settings upon “reset factory default values” only.

Field	Value
ODU	Type as entered at factory, either A or B
RF BW	1 MHz
TX Freq	4941.4 for Type A 4988.5 for Type B
RX Freq	4988.5 for Type A 4941.4 for Type B
TX Pwr	+13 dBm
Carrier	ON - Normal
Interfaces	1 X T1
LIU #1	Active
LIU #2,3,4	Inactive
LIU#1:	
TX Build Out	
RX Build Out	-30 dBm
Line Code	B8ZS
Mode	Normal

Once set, all set values will be retained by the ODU after power interruption or system reset.

6.3.4 GUI Status Page

System status information is displayed on the status page, accessed by selecting the “Status” tab on the lower edge of the GUI screen.

The name of the site is shown normally in green. If an alarm occurs on a site, then that site’s name shows as orange on all pages, not just on the status page.

Also, the link name under “Links” shows in orange if either or both of the ODUs in that link has an alarm.

If an ODU is not reachable, the ODU name is shown in red and so does the corresponding link name.

6.3.4.1 Sample Status Page

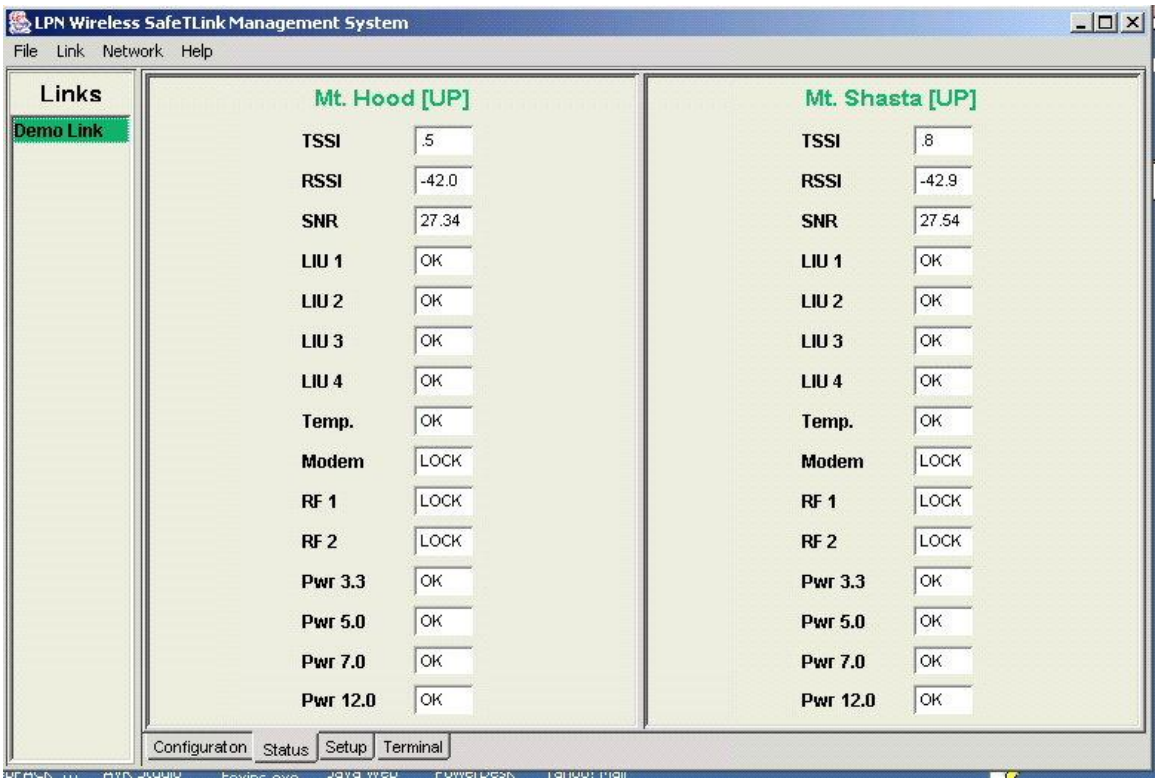


Figure 6-2
GUI Status Page

Figure 6-2 is a view of the GUI Status Page. This example shows a link in normal operation, with no alarms set:

- The link named “Demo Camera Link” is selected and its data are shown on the detailed view panels
- Near End is “Mt. Hood: “
    - The [UP] indicates the link is up and operating. Green lettering indicates normal operation with no status alarms
- The far end (right side of the screen) is named “Mt. Shasta”

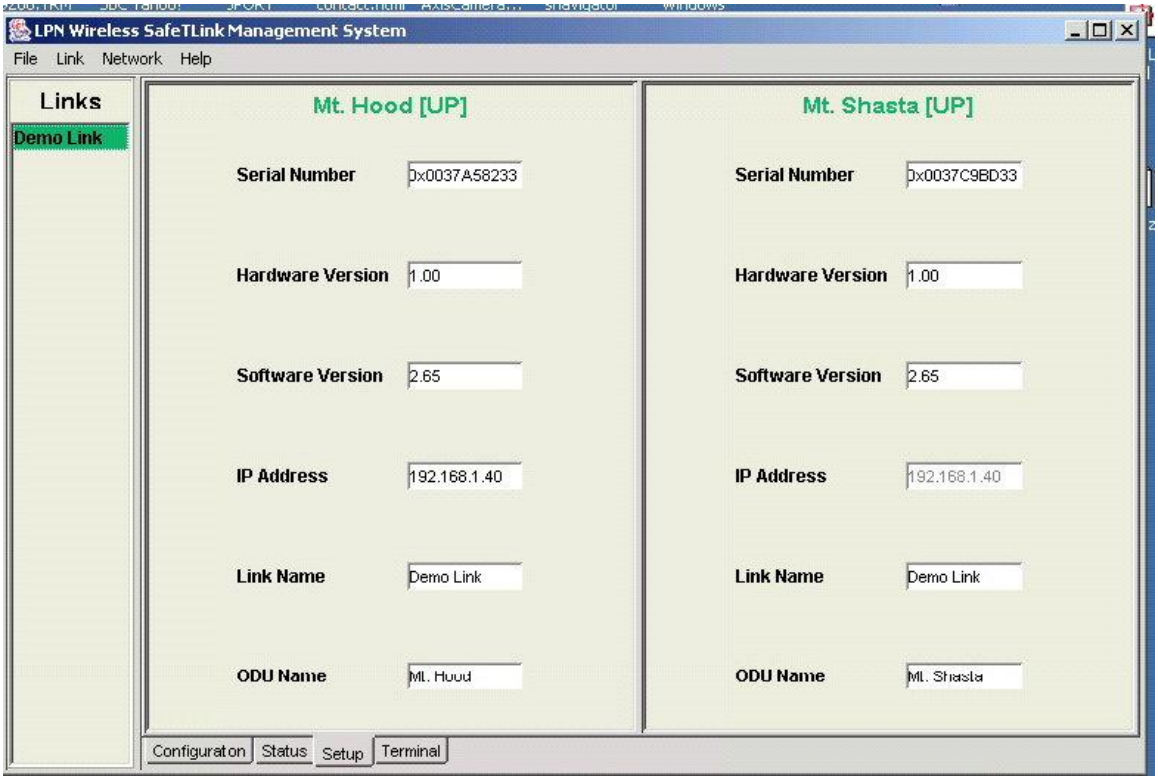
During normal operation, where all alarms have been cleared, all of the titles should show in green color. An alarmed item shows red if it is out of normal ranges.

The table in APPENDIX IV: GUI Status Page Details describes each detail window from the status page. The two sides of the screen are identical, the panel on the Left side being the "local" ODU – the one through which the management system is connected. The panel on the right is the "far end" ODU, accessed via the management system to the near end and then via overhead channel to the far end ODU.

6.3.5 GUI Setup Page

System configuration and version information is displayed on the setup page, accessed by clicking the "Setup" tab on the lower left of the GUI screen.

6.3.5.1 Sample Setup Page

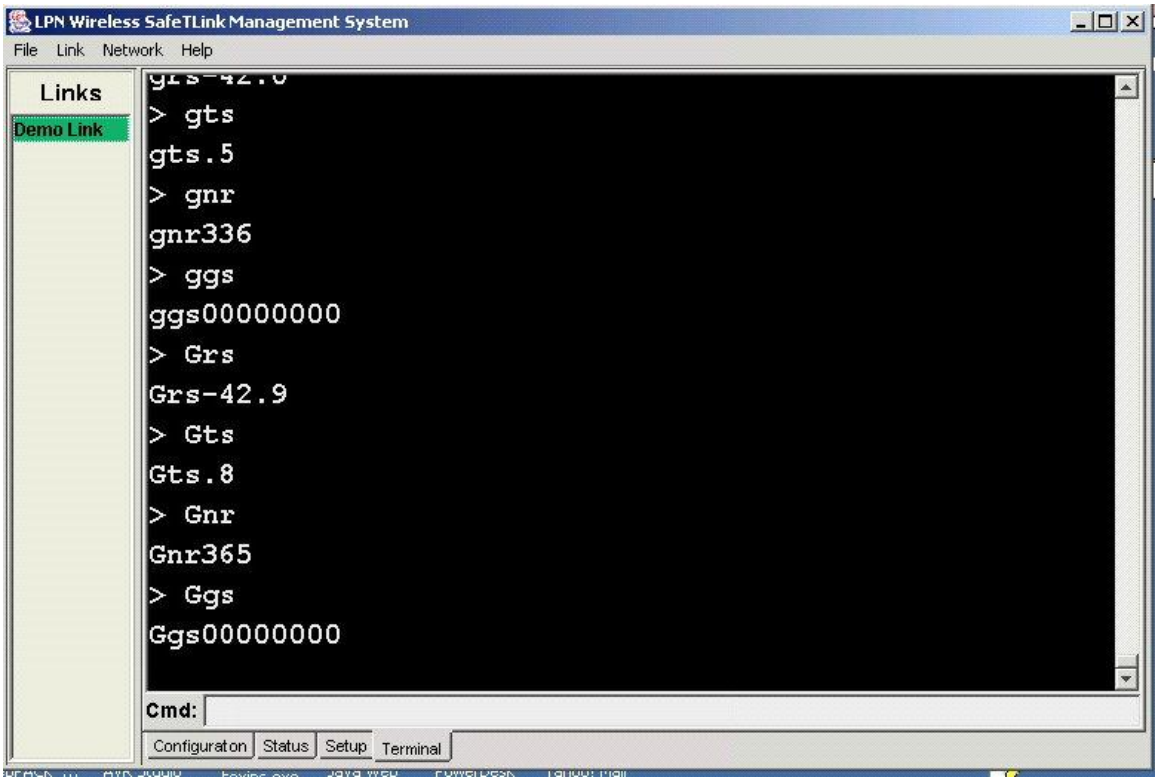


6.3.6 GUI Terminal Page

The terminal page is used for advanced setup and configuration. It is mainly intended for factory and depot use. The CLI commands listed in this User Manual may be used to control and poll the ODU in place of the GUI. Some ODU values, for example, ODU type, may ONLY be set via the CLI command interface.

Note that the polling feature should be disabled before using the Terminal page. See section 6.3.7.3 for details.

6.3.6.1 Sample Terminal Page



6.3.7 GUI Menu Bar

A menu bar provides for common GUI operations.

6.3.7.1 File Menu

Use File-exit to exit close the GUI down.

6.3.7.2 Link Menu

Use Link-send changes to send configuration changes to the link.
Use Link-retrieve all to reconcile information on the GUI with the radio.
Use Link-new link to create a new link for the GUI to monitor.
Use Link-delete link to delete a link from the list.
Use Link-connect to link to force a new attempt to connect to the radio link.
Use Link-reset NE radio to reset the radio on the near end.
Use Link-reset FE radio to reset the radio on the far end.

6.3.7.3 Network Menu

Use Network-polling off/on to toggle polling. By default the GUI audits link information once in a while. Turning this off will improve performance but the GUI will have a stale view of the network unless you force a retrieve with Link-retrieve all. You should disable polling before working from the terminal window.

6.3.7.4 Help Menu

Use Help-about LPN Wireless SafeTLink Management System to find out about the GUI software in use.

6.4 IDU Monitoring

6.4.1 Ethernet IDU Visual Indicator Lights

If a Ethernet SafeTLink system is installed with the optional Indoor Unit (IDU), a series of indicator lights can be used to monitor system performance. The following table summarizes the functions, indications and meaning of these lights.

Front Panel Label	Function	Red Indication	Green Indication	Yellow Indication	Dark Indication
PWR	Power	N/A	Power ON	N/A	Power OFF
Major Alarm	Major alarm	Major alarm (blink on ACO) see section 6.4.2	N/A	N/A	No major alarm
Minor Alarm	Minor alarm	N/A	N/A	Minor alarm (blink on ACO) see section 6.4.2	No minor alarm
Carrier	Carrier and bit error detection	Loss of signal	Carrier present, no bit errors	Bit errors (1 sec. per error)	N/A
T1 Line 1	T1 signal present	Loss of signal	Signal present	N/A	Disabled
T1 Line 2	T1 signal present	Loss of signal	Signal present	N/A	Disabled
T1 Line 3	T1 signal present	Loss of signal	Signal present	N/A	Disabled
T1 Line 4	T1 signal present	Loss of signal	Signal present	N/A	Disabled

6.4.2 Rack-Mounted IDU Alarm Cut-Off Switch

The front panel of both types of IDU contains an Alarm Cut-Off (ACO) pushbutton switch. Under an alarm condition, the ACO switch, when pushed, returns the alarm relays to the non-alarm state even though the system is still in an alarm condition. The ACO switch allows repair technicians to silence an external audio alarm while working on the system. The ACO does not change any IDU visual alarm indication except that the Major and/or Minor Alarm Indicators blink when the alarms exist but the system has been put into the ACO condition. The ACO does not mask new alarms from the system. Any new alarms received set the

alarm relays to the alarm state regardless of the state of ACO. The ACO is automatically cleared when alarm conditions no longer exists.

6.5 SNMP

Simple Network Management Protocol (SNMP) is hosted on a processor outside the ODU.

7 ROUTINE PREVENTATIVE MAINTENANCE

No routine or preventative maintenance is required.

8 TROUBLESHOOTING AND SERVICING

8.1 Identification of problems

8.2 Field Service Items

This section lists what can be done in the field, without the need to return the ODU to the distributor or manufacturer:

- Change ODU type from A to B, or from B to A
- software upgrades
- replace Digital Board
- replace RF Board and chassis housing
- replace RF, signal and power cables within the ODU
- replace duplexer filter
- replace ODU mechanical housing
- replace RF cable between the ODU and antenna
- replace antenna

8.3 Troubleshooting

8.3.1 Introduction

The LPN Wireless SafeTLink product is designed to be easy to both configure and maintain. For those users very familiar with digital microwave radio technology, many of the settings and controls of the SafeTLink will be very familiar. You will be able to use that general knowledge, and the monitoring and configuration capabilities of the product, to pinpoint and quickly sort out any problems. Use the following sections as an aid to help either in initial bring up of the product, or to help diagnose any problems that arise with an existing installation.

8.3.2 Configuration and Monitoring Problems

There are two ways to communicate with a SafeTLink ODU directly, either through a standard 10/100BaseT interface, or an RS-485 serial interface. The specifications for the IP Interface, and instruction for communicating with it, are found in section 6.2.2. If you have gone through those steps and are still not able to communicate with it, see section 8.3.2.1 below. The details for accessing the RS-485 interface are found in section 6.2.2.1. If you have gone through those steps and are still not able to communicate with the ODU, see section 8.3.2.2 below.

8.3.2.1 IP Configuration Problems

Symptom:

Can't see ODU when running Discovery program

Resolution Steps:

- Verify ODU is powered.
- If ODU has just been powered up, keep in mind that it takes up to 2 minutes for the ODU to boot and be visible to the network.
- See Section XXXX for the correct wiring to the ODU 10/100BT port. Verify that these connections are made correctly. An RX LED located on whatever netwrok equipment you are connecting should light when it is connected to the ODU. If the LED does not light, verify that you are using the correct cable connection.
- If you are connecting a computer directly to the ODU IP port, you will want to make sure you are connecting your wires with a cross-over configuration.
- If you are connecting a switch or router to the ODU IP port, you will want to use a straight configuration.

Symptom:

Can see ODU, but can't open a telnet session to it

Resolution Steps:

8.3.2.2 RS 485 Configuration Problems

Symptom:

Get garbled response, or no response from ODU

Resolution Steps:

- The most common cause of problems with the RS-485 link is polarity reversal of the RS-485 lines. These lines are commonly referred to as the "A" and "B" lines. They are sometimes also referred to as "+" and "-".
- Use a voltmeter across the lines of the RS-485 device you are using to connect to the ODU, open circuit. You should see a voltage across those two lines, the "A" terminal should be negative in respect to the "B" terminal. The "A" terminal, or negative,

connects to wire #1 RED of the ODU multiconductor cable. The "B" terminal, or positive, connects to #1 BLACK.

- If you are having problems with garbled messages, try swapping your polarity to see if this solves your problem.

8.3.2.3 CLI Problems

Symptom:

Get a ~1 response following all typed commands.

Resolution Steps:

- This is most likely caused by Caps Lock being on. Note that the CLI is case sensitive, and the command gsn for example will fail if typed is as GSN.

Symptom:

Get a ~5 response following all typed commands.

Resolution Steps:

- Under rare circumstances an incorrectly typed message can corrupt the CLI buffer on the ODU. In this instance everything you type thereafter will return a ~5. To clear this case, either reboot the ODU by cycling power, or continue to type valid commands. After roughly 20 valid commands, the buffer will clear and return to normal.

Symptom:

Get no response from ODU following typed commands.

Resolution Steps:

- If you are unable to talk with the ODU at all, but are certain that the IP or RS-485 connections are correct, double check the settings of your terminal program. See sections 6.2.8.4 and 6.2.8.5 for details.
- There are some commands that will not return anything when entered under normal operation. These are:
  - pbbb – Reset ODU. The ODU immediately enters into its reset routine and will not return anything.
  - pln1, pln2, and pln4 – This sets the RF BW and number of T1s active. Upon receiving this command the ODU resets itself and boots with the new configuration.
  - pota, and potb – This changes the ODU Type of the radio (requires radio dissasembly to complete). As with the pln command, the radio resets and boots with the new configuration.
  - Far End Commands – Any far end command that momentarily disrupts the radio path may not return a value. If for instance you change the TX Frequency on the far end ODU, it may not return a value as the frequency change causes the near end modem to lose lock with the far end radio. Once lock is regained after any such command,

simply issue a read command to that register to verify the change has been made.

8.3.2.4 Far End Communications Problems

Symptom:

Can't communicate with far end.

Resolution Steps:

- If you are unable to pass messages back and forth with the far end radio, you likely do not have a modem lock condition, or your SNR is low enough to be causing errors. The communications path between the two ODUs will experience the same BER as the data path, if those errors are caused in the radio section of the ODU. To troubleshoot, see section 8.3.4.2.

8.3.3 Data Interface Problems

8.3.3.1 High Bit Error Rate (BER)

A high error rate can be a symptom of many different things. In order to diagnose what is causing a bit error rate problem, we must methodically step through and eliminate sources. All sections of the ODU must be working for the Data Interfaces to be running error free. Therefore, when the Data Interfaces are not running error free, all parts of the system must be examined to determine the cause.

We first must verify that the ODU T1 Interfaces are configured properly for the equipment it is connected to. Refer to section 8.3.3.2 for resolution steps.

8.3.3.2 T1 Configuration Problems

Potential Problem Area:

Line Build-Out

Resolution Steps:

- The SafeTLink has standard T1 DSX-1 and CSU Line Build Out options available.
- If using DSX-1 type equipment, calculate the line length between the ODU and the network port, and select the appropriate ODU LBO option (between 0-655ft.)
- If using CSU/DSU type equipment, the ODU LBO options are 0, -7.5, -15, and -22.5dB. These are the TX levels out of the SafeTLink ODU.

Potential Problem Area:

Line Coding

Resolution Steps:

- The SafeTLink has two coding options supported, AMI or B8ZS. These are independantly selectable per T1 channel. Set the LPN ODU to whatever line coding option your equipment is using. B8ZS

guarantees a baseline “1’s” density on the T1 lines, which is preferable for recovering timing. If available, it is suggested you use B8ZS coding.

Potential Problem Area:
Framing
Resolution Steps:

- The SafeTLink ODU is transparent to T1 framing, and no adjustments to the ODU need be made. This includes unframed T1.

8.3.3.3 Master / Slave Timing Problems

This section explains what the Master and Slave timing designations mean, and how they affect your system. The LPN Wireless SafeTLink product is designed to work only with synchronous T1 inputs. That means the T1s (if more than one) connected to an ODU (or IDU) must all share the same exact clock frequency. They do not need to be aligned with each other, meaning that it does not matter what the relative bit positions or framing positions are between them, but the clocks on each T1 must be synchronous..

On the ODU designated as the timing Master, all T1s connected to it, whether coming from different network sources or not, must be clock synchronous with each other. Most channel banks have an option for external reference input. If you are using several different pieces of equipment to each source T1 that will be connected to the ODU, a Master in this case, they should all use a stable ***external timing*** source to lock them together.

The Master ODU derives the timing from one of the incoming T1 lines, and sends this timing information over to the Slave ODU. ALL of the T1 data coming out of the Slave will be clocked at the same rate as the Master, and all of the T1 data accepted into the Slave will be clocked in at the same rate as the Master.

Therefore any network equipment that is connected to the Slave should be set to recover the timing from the T1 lines, and use this ***recovered timing*** to clock its T1 transmitter back to the ODU. Most network equipment will refer to this as “recovered” or “line” timing.

A common approach to setting up your network to communicate properly with our ODUs is shown below:

Insert Figure 8-1 here showing PBX and Channel Banks with GPS ref. connected to Master, other stuff connected to Slave with recovered timing.

This Master Slave relationship must be taken into account as well when the user is performing Bit Error Rate Testing. See section 6.2.8.5 for details.

8.3.3.4 Low Receiver Signal Level (RSSI)

The commands for radio monitoring are detailed in section 6.2.8.5. Read the RSSI voltage (grs) and verify that the signal level is adequate for operation (should be -75dBm or above under most circumstances). If the level is lower than this, or if it is lower than you think it should be, it is possible that a variety of things have happened:

8.3.4 Radio Problems

It is sometime difficult to determine what exactly is causing a fault condition, in this case the Radio is suspected of generating bit errors. The general troubleshooting flow is from RSSI to SNR to BER. In each step we attempt to isolate and rule out certain causes. The following sections walk through the steps.

8.3.4.1 Receiver Low Signal to Noise Ratio

Low signal to noise ratio is a possible cause of Bit error rate problems. The commands for reading Signal to Noise Ratio are detailed in Section 6.2.8.5. If the SNR of your system is outside of the ranges listed in that section, there are several possible causes:

- **Low (or excessively high) Receiver Signal Level (Operating near threshold)**
  If you see low receive SNR, first check your RSSI readings. See section 8.3.3.4 for details. If your RSSI is above -30dBm, this may also cause problems.
- **Interference from a jamming signal**
  If your RSSI readings are healthy, yet you have a low SNR, it is possible that your receiver is being interfered with. Suggest powering down the far side transmitter. The RSSI reading should fall to -100dBm or less. If the near end RSSI stays in the -60 to -80 range when the far end TX is off, you likely have an interferer that could be causing this degradation.
- **Far side Transmitter is not operating correctly**
  Check the TX level and TSSI of the far side transmitter. Verify that they are set to a valid setting, detailed in section 6.2.8.5. If they are not valid, correct them. If they are valid, try reducing the TX Level of the unit. If a reduction in far end TX Level causes a significant increase in near end SNR, it is possible that your far end transmitter is compromised.

8.3.4.2 Receiver Excessive Bit Error Rate (BER)

At this point you should have already gone through sections 8.3.3.4 and 8.3.4.1. This test assumes that both the RSSI and SNR are high enough for proper operation.

The SafeTLink product has a BER floor of approx. 1X10-11. Under normal operation this is the maximum BER you should see. If your BER is significantly higher, you likely have either a configuration problem or there has been a failure somewhere in the unit.

Since the RSSI and SNR are valid, we want to check to see whether it is in fact the radio portion of the ODU causing the problem, or if it lies elsewhere. **For this test to be optimal it is best to disconnect all T1s from the ODU, and to disengage any internal or external loopbacks**. This gives us a "clean slate" to look at, and rules out any problems that may be caused by an improper T1 setting. **It is also important at this point to verify that one unit is set to Master timing, and the other is set to Slave**. It does not matter which ODU is which, just that both are not set the same.

In section 6.2.8.5 the "fc" and "fb" commands are described. These are error counters that exist in the radio modem. Enter "pfc0" and "pfb0", on both near end and far end units. This sets both error counters to zero. Let the units run undisturbed for a period of time, commensurate with the bit error rate. If you are investigating a very high BER (1X10-6) for instance, five minutes or less will suffice. If you are investigating a lower level BER, it may take several hours for an error to appear.

Under normal operation the "fc" register (the CLI command is "gfc" to read) will accumulate error counts. These are normal, and are 100% corrected under normal operation. As your SNR decreases, the rate of these corrected errors will increase, from 1 or 2 every few hours at high SNR, to 100's per minute at low SNR.

The "fb" register will indicate any errors that were uncorrectable, and occurred over the radio portion of the link (as opposed to something introduced in the T1 interface, or in the ODU but prior to the modem). Under normal operation, the "fb" register will accumulate errors at a rate commensurate with a 1X10-11 BER or less, i.e. one per day or less. Even under low SNR conditions, the Forward Error Correction will correct very close to 100% of all errors.

So, for this test, we want to monitor this "fb" register to see if it registers errors. If you are experiencing a 1X10-6 BER with your test set, during this test the "fb" counter should be counting many many errors. If it is not, then the problem lies elsewhere in the unit, NOT in the radio settings. If this is the case, proceed to section 8.3.3.

If you are seeing many “fb” counts after the above testing, please call your authorized reseller to request support.

The following bullets list symptoms and suggested resolutions.

- **Far end ODU no longer powered**

Verify that the far end ODU is powered up.

- **Receive frequency does not match far end transmit frequency.**

Verify that far end transmit frequency is the same as near end receive frequency.

- **Far End Transmitter power level has changed.**

It is possible that the far side transmitter is no longer putting out the correct power level. Use the gtl and gts commands (detailed in section 6.2.8.4) to verify that the settings are what you expect them to be. If in a lab environment, verify using a power meter that the total average power measured at the antenna port of the ODU is within a dB or two of the value returned by the gts command. Examine and replace the Antenna cable on the far side of the link if it is suspected.

- **Antenna Alignment has changed.**

If your RSSI has changed dramatically, and is now stable at a much lower level than it was previously it is possible that your antenna alignment has changed. If this is suspected, try a realignment.

- **Antenna Feed Cable is damaged.**

If the Line Loss of the antenna cable (External Antenna models only) has increased due to aging or inadequate sealing, this can cause a significant reduction in Receive Singal Level. If this is suspected, examine cable and replace.

- **Link was not designed with adequate margin. (New Installations only)**

If it is found that the far side TX is putting out the correct amount of power, and the antennas are aligned properly, yet you still do not have an adequate receive signal level, you likely have underestimated the loss of the path the system is spanning. You may need higher gain antennas.

8.3.4.3 Low or High Transmitter Output Power

8.4 Accessing the ODU

8.4.1 Antenna Removal --- ODU with integral antenna

The antenna is mounted to the housing with 16 screws…

8.4.2 Cover Removal --- ODU without antenna

The weatherproof cover is mounted to the housing with 16 screws…

Figure 8-2
ODU with cover removed.

Duplexer (type “A” label visible) at lower center.

This figure shows a view of the Electronics Package assembly within the ODU housing.

Figure 8-3 Electronics Package Removed From the ODU

The Electronics Package may be removed from the ODU mechanical chassis.

Duplexer (type "B" label visible) at lower center.

8.4.3 Duplexer Removal

The duplexer is mounted to a metal plate. This top plate is a structural mount for the duplexer, and it also protects the electronics package from damage during handling and servicing personnel against contacting the voltages on the electronics package, which can reach 75 VDC.

Caution

While 75 VDC is not normally harmful to the operator or user of this system, arcing caused by a misplaced tool could damage the electronics within the ODU.

The duplexer is attached to the top plate with 4 screws accessible from the top side. The duplexer can be removed to access the electronics below by disconnecting the 3 RF coaxial cables, then removing the 4 screws at the 4 corners of the duplexer. After this removal, the plate can be removed by taking out the several screws at its exterior limits.

Caution

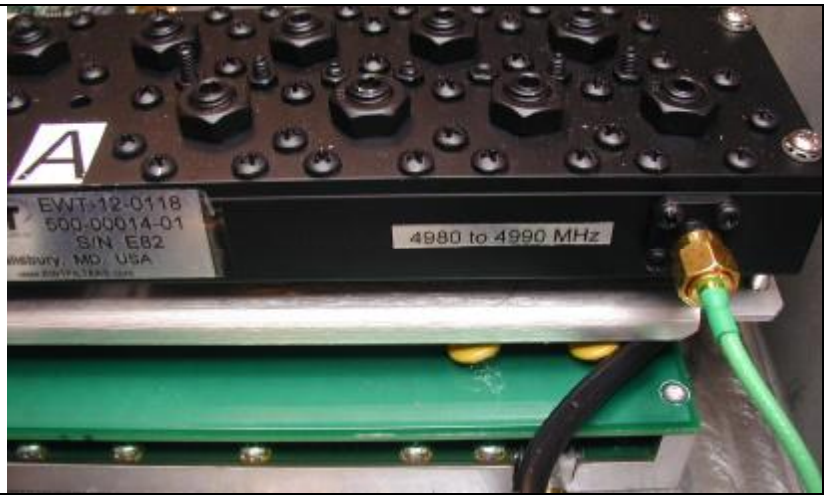
It is important to make sure that no other screws on the duplexer are turned when the duplexer is removed. All of the painted screws are used to tune the duplexer and may cause the equipment to fail if adjusted in any way. There are no field adjustments required on the duplexer.

8.4.4 Duplexer Reconfiguration

The SafeTLink uses a frequency selective duplexer to separate the transmitted and received signals. Transmission and reception takes place simultaneously. The duplexer is connected in one of two ways. For Type A ODUs, the transmitter is connected to the low frequency side of the duplexer. For Type B ODUs, the transmitter is connected to the high frequency side of the duplexer. To change the ODU Type, disconnect the 3 coaxial cables connected to the large (approximately 9 x 2 x 1 inch) RF duplexer near the connector side of the ODU. Use a 5/16 inch wrench on the type SMA connectors. Remove the 4 (or in some cases 5) long mounting screws with a Phillips type screwdriver.
Lift the duplexer out of the housing, turn it over 180 degrees, and reinstall it. Refer to the two figures below to help identify “A” and “B” configurations.

Figure 8-4 Duplexer Connections – ODU Type A

View of the EP with duplexer installed in configuration “TYPE A”



In Figure 8-4 the receiver end – to the right side of the case when the connectors are towards you – has the higher frequency end of the duplexer. Here, the duplexer port marked 4980 to 4990 MHz is connected to the receiver side of the RF board.

Figure 8-5 **Duplexer Connections –** **ODU Type B** View of the EP with duplexer installed in configuration "TYPE B"	

Reattach the coaxial cables and torque the connections to 8 inch pounds. If no torque wrench is available, take care to make the connections lightly. Only a single finger's force at the end of a 4" long wrench is sufficient torque.

Reinstall the duplexer by inserting the 4 mounting screws and tightening to a torque limit of 10 – 12 in lbs. Reconnect the 3 RF coaxial cables in the same configuration as previously installed. Note that reversing the connections will prevent proper operation of the ODU.

8.4.5 Digital Electronics Package Access

Figure 8-6 shows the Electronics Package with the duplexer and cover plate removed. This exposes the Digital Board which houses the T1 and Ethernet interfaces and processor, plus filter and multiplexing circuitry. This circuit board is sensitive to damage from electrostatic discharge and should not be handled without ESD precautions being taken. If this board must be shipped to a repair site for service, it must be packaged in a bag designed for protection from ESD.

Figure 8-6 **Electronics Package with Duplexer and Cover Removed** For reference use only: SafeTLink Digital PWBA circuit side, after removal of the duplexer and duplexer mounting bracket.	

8.4.6 RF Board Access

The RF components of the SafeTLink radio are housed within the metal enclosure below the digital board. This assembly has shielding and special connections and should not be disassembled without special knowledge. If service is required, return the assembly as an intact unit.

Figure 8-7 **Electronics Package, Circuit Side** For reference use only: SafeTLink RF PWBA circuit side, after removal from the Electronics Package chassis. The receiver SMA connector is at the upper left. The receiver chain is along the top of the image. The transmitter SMA connector is at the lower left. There are no field serviced parts in this assembly. All adjustments can be made via software without removal of this PWBA from its housing.	

8.4.7 RF Cable Details

The RF cables used within the ODU are low loss conduits for the microwave signals. They have flexible outer shields, with 100% coverage, with an inner dielectric of expanded Teflon. At each end is an SMA male connector.

When installing the SMA connectors, insert the center conductor, then turn the outer shell to tighten the connection. Take care to not rotate the cable, only rotate the outer shell. The connectors should be tightened only to "snug" and not treated as mechanical bolts. The SMA torque limits are 8 inch–pounds.

Caution

The torque limits for the type SMA connector is 8 inch-pounds maximum. Take care to not apply excessive force to these connectors.

8.5 Repair Depot Items

8.5.1 Items that can ONLY be repaired at depot

- board level component replacement
- duplexer alignment
- RF board alignment

8.5.2 RMA procedure

An RMA number must be obtained from LPN Wireless prior to return of any equipment for repair or upgrade, whether in or out of warranty. Contact LPN Wireless at 707-781-9210 to have an RMA number issued. Specifics concerning the return will be determined at the time the RMA number is assigned.

9 GLOSSARY OF TERMS

This section contains an annotated explanation of abbreviations and terms used in this manual.

AC:	Alternating Current
AIS:	Alarm Identification Signal – a T1 line signal indicating an alarm
AMI:	Alternate Mark Inversion
ASCII	
ASIC:	Application Specific Integrated Circuits
AWG	American wire gauge – a wire size standard
Azimuth:	
Baseband	
BIST:	Built In Self Test
B8ZS:	Bit 8 Zero Substitution

CLI: Command Line Interface
Connector DB25
Connector DB37
Connector 28 Pin
Connector N
Connector RJ-45
Connector RS-232
Connector: 50-pin
Connector: DB-25
CW: Continuous Wave. Unmodulated RF carrier.

dBi: gain in decibels relative to an isotropic (omni-directional) radiator
dBm: power expressed as decibels relative to one milliwatt 0 dBm = 1
DC: Direct Current
Downconverter
Duplexer filter to separate two different frequencies

EIRP: Effective Isotropic Radiated Power (transmitter power times antenna gain)
Electronics package – EP
The contents of the ODU, minus the protective housing. Includes the chassis, Digital Board, RF Board, mounting plate, duplexer filter and RF cables.
Elevation: Height above ground or height above sea level
ETSI: Standards group

FCC Federal Communications Commission
FDD: Frequency Division Duplex
FDM Frequency Division Multiplex
FEC: Forward Error Correction
FPGA: Field Programmable Gate Array
Fresnel Zone

GUI: Graphical User Interface

IDU: InDoor Unit
IF: Intermediate Frequency
in-lbs: Inch pounds

LIU: Line Interface Unit
Link budget
LNA: Low Noise Amplifier
Loopback

MBPS: Mega Bits Per Second

MHz:	Megahertz, frequency unit equal to one million cycles per second
Milliwatt:	one thousandth of a watt
Multiplexer	
NMS:	Network Management System
ODU:	OutDoor Unit
P2P:	Point to point
PCB:	Printed Circuit Board
PHY:	Physical Layer
PLL:	Phased Locked Loop
QAM:	Quadrature Amplitude Modulation
R:	Read, Read only
R/W:	Read and Write
RF:	Radio Frequency
RS-232	
RS-485	
RSL:	Receive Signal Level
RX:	Receive, Receiver
SMA:	3.5 mm threaded RF connector type
SNR:	Signal to Noise Ratio
TX:	Transmit, Transmitter
U/C:	Upconverter
VDC	Volts Direct Current
Watts	
W	Write, write only

APPENDIX I: ETHERNET SYSTEM SPECIFICATIONS

Feature	Specification
Typical Link Operational Distance, I MHz channels	With integrated antenna: 7.8 miles with 99.999% availability 12.5 miles with 99.99% availability With external 2' dish antenna: 13 miles with 99.999% availability 20 miles with 99.99% availability
Antenna Connector (on ODUs without integrated antenna)	Type "N" Female
Antenna (on ODUs with integrated antenna)	
Physical Size	12 inches square by 1 inch deep (radome size)
Gain	20 dBi minimum
Polarization	Shipped vertically polarized, may be reconfigured to horizontal polarization
Transmitter Power	Up to +20 dBm at the antenna connector
Transmitter Attenuation	Greater than 15 dB power adjustment available
Minimum Receive Level	1 MHz RF Channels: -89 dBm 2 MHz RF Channels: -86 dBm 5 MHz RF Channels: -81 dBm
Maximum Receive Level	-30 dBm, up to +0 dBm input with no damage
Duplex Method	Frequency Division Duplex
Modulation	16 QAM
Forward Error Correction	Concatenated Reed-Solomon coding with interleaving
Regulatory Compliance	FCC Part 90. Unintentional emissions per FCC part 15 for class B device
Network Management	CLI, GUI, SNMP options
Local Control	ASCII Command Line Interface 10/100BaseT and RS-485
T1 Line Interface Diagnostics	Near and Far-end T1 loopback, AIS generation, 2^{15}-1 BIST pattern test, independently selectable for each active T1 channel
Fractional T1 and Ethernet Line Interface	Fractional T1 and Ethernet Interface, selected by user control of RF Channel bandwidth
Digital Interface	DSX-1 per Telcordia GR-499.
T1 connector	28-pin weather-resistant (shared with management and power) on ODU RJ-48 on optional IDU
T1 Line Coding	AMI or B8ZS, selectable for each T1 channel

Feature	Specification
T1 Line Buildout	short or long, selectable for each T1 channel
T1 Clocking	All T1 clock sources are synchronous. User selection of clock source at either end of the SafeTLink system.
Major and Minor Alarm Relay Contacts (rack-mounted IDU required)	1 form C each, nominal switching load 1A at 30 VDC, 0.3A at 125 VAC, maximum switching voltage 110 VDC, 125 VAC
External Alarm Inputs (rack-mounted IDU required)	Contact closure
DC Power Input 24/48 VDC option	18 to 75 VDC operating range, either polarity, floating relative to ground
DC Power Input 12 VDC option	9 to 18 VDC operating range, polarized, floating relative to ground
Power Dissipation	25 watts maximum
Operating Altitude	15,000 feet maximum
ODU Operating Environment	-40 to +70 C, 0-100% humidity, weather resistant, outdoor mounted
ODU Physical Dimensions	12 x 12 x 5 inches not including antenna
Rack-mounted IDU Operating Environment	-40 to +70 C, 5-95% humidity, indoor mounted
Rack-mounted IDU Physical Dimensions	19 or 23 inch rack mount, 1U high

APPENDIX II: ODU / IDU INTERFACE DEFINITIONS

Belden 9524 Pair #	Wire Insulator Color	Circular Conn. Pin #	Signal Name	DB 37 IDU Pin #	Description
1	black	1	RS485+	19	alternate serial port (opt.)
	red	14	RS485-	37	alternate serial port (opt.)
2	black	2	TX TIP 1	18	From Unit to DLC
	red	15	TX RING 1	36	From unit to DLC
3	black	3	RX TIP 1	17	From DLC to Unit
	red	16	RX RING 1	35	From DLC to Unit
4	black	4	TX TIP 2	16	From Unit to DLC
	red	17	TX RING 2	34	From Unit to DLC
5	black	5	RX TIP 2	15	From DLC to Unit
	red	18	RX RING 2	33	From DLC to Unit
6	black	6	TX RING 3	14	From Unit to DLC
	red	19	TX TIP 3	32	From Unit to DLC
7	black	7	RX TIP 3	13	From DLC to Unit
	red	20	RX RING 3	31	From DLC to Unit
8	black	8	TX TIP 4	12	From Unit to DLC
	red	21	TX RING 4	30	From Unit to DLC
9	black	9	RX TIP 4	11	From DLC to Unit
	red	22	RX RING 4	29	From DLC to Unit
10	black	10	12V FOR IDU	10	for powering IDU if used (opt.)
	red				not used
11	black	12	SUPPLY POS	8	18-75VDC Positive
	red	13	SUPPLY POS	7	18-75VDC Positive
12	black	24	SUPPLY NEG	27	18-75VDC Negative
	red	25	SUPPLY NEG	26	18-75VDC Negative
13	black	11	ETH TX+	6	TX to LAN/PC (1) for control and monitoring
	red	26	ETH TX-	25	TX to LAN/PC (2) for control and monitoring
14	black	27	ETH RX+	5	RX from LAN/PC (3) for control and monitoring
	red	28	ETH RX-	24	RX from LAN/PC (6) for control and monitoring
15	black				not used
	red				not used
Drain Wire		23	Chassis Ground	28	grounded to box

Note: On T1 connections, transmit and receive designations are referenced to the ODU. The TX pair is carrying signals from the ODU, the RX pair is carrying signals to the ODU.

Note that the pair number is written out as a word on each strand. For example, cable pair 12 has the label “twelve” written on both the red and black insulation on each wire within the cable.

APPENDIX III: GUI CONFIGURATION DETAILS

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
RF	**ODU**	Type A	TX is on the low frequency end of the band	Each system must have one type A and one type B ODU to operate as a link.
RF		Type B	TX is on the high frequency end of the band for Type B ODU.	ODU Type is read-only on the Configuration screen.
RF	**TX Freq.**	4940.5	Selects the transmitter (TX) frequency. Must match RX frequency of other end of the link for normal operation.	Channel center frequency is 4940.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4941.5	For a Type A ODU, only channels 1 – 6 are valid entries in the TX Freq. menu.	Channel center frequency is 4941.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4942.5	For a Type B ODU, only channels 13 – 18 are valid entries in the TX Freq. menu.	Channel center frequency is 4942.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz and 5 MHz channel.
RF		4943.5		Channel center frequency is 4943.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4944.5		Channel center frequency is 4944.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4947.5		Channel center frequency is 4947.5 MHz. 5 MHz channel. Valid with RF Bandwidth 5 MHz Only
RF		4982.5		Channel center frequency is 4982.5 MHz. 5 MHz channel. Valid with RF Bandwidth 5 MHz Only
RF		4985.5		Channel center frequency is 4985.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4986.5		Channel center frequency is 4986.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4987.5		Channel center frequency is 4987.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz & 5 MHz Only

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
RF		4988.5		Channel center frequency is 4988.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only
RF		4989.5		Channel center frequency is 4989.5 MHz. Valid with RF Bandwidth 1 MHz Only
RF		4941.0		Channel center frequency is 4941.0 MHz. 2 MHz channel. Valid with RF Bandwidth 2 MHz Only
RF		4942.0		Channel center frequency is 4942.0 MHz. 2 MHz channel. Valid with RF Bandwidth 2 MHz Only
RF		4943.0		Channel center frequency is 4943.0 MHz. 2 MHz channel. Valid with RF Bandwidth 2 MHz Only
RF		4944.0		Channel center frequency is 4944.0 MHz. 2 MHz channel. Valid with RF Bandwidth 2 MHz Only
RF		4986.0		Valid with RF Bandwidth 2 MHz Only
RF		4987.0		Valid with RF Bandwidth 2 MHz Only
RF		4988.0		Valid with RF Bandwidth 2 MHz Only
RF		4989.0		Valid with RF Bandwidth 2 MHz Only
RF	**RX Freq.**	Same choices as for TX Freq.	Selects the receiver operating frequency. Must match TX frequency of other end of the link.	Same restrictions as for TX Freq.
RF	**RF BW**	1 MHz	User Data bandwidth is up to 2 mpbs. A single T1 (channel 1) is active	Sets the RF transmission bandwidth and the resulting user data bandwidth. Both ends of the link must be set to the same RF BW value. Valid with both 4 X T1/E1 and FT1/FE1 + Ethernet Interface selections.
RF		2 MHz	User Data bandwidth is up to 4 mpbs. Two T1 (channels 1&2) are active	Valid with both 4 X T1/E1 and FT1/FE1 + Ethernet Interface selections.
RF		5 MHz	User Data bandwidth is up to 12 mpbs. Four T1 (channels 1,2,3 and 4) are active	Valid with both 4 X T1/E1 and FT1/FE1 + Ethernet Interface selections.
RF	**TX Pwr**	0 to +13 dBm in 1 dB steps. (14 choices total)	Use the minimum average power needed for a link.	Sets the transmitter RF output power level. Measured in average power dBm.
RF	**Carrier**	ON – Normal	Normal link operation	Normal operation. Default

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
RF		ON – CW Tone	For antenna alignment or other testing ONLY, transmits narrow-band carrier without modulation	Test use only. No data link is established in this mode from the ODU in CW tone. This ODU can receive if far end is in ON – NORMAL carrier mode.
RF		OFF	Turns the transmitter signal Off	Stand-by. System can receive signal from other end of link but does not transmit. Attenuation > 50 dB.
User	Build Out	Short		
User		Long		
User	Line Code	HDB3		
User		B8ZS		
User		AMI		
User	Mode	Normal	T1/E1 interface is normal operation mode.	
User		Disable	T1/E1 interface is off, and is disregarded in status alarms	No user data passed to far end of the link.
User		Fac LB	T1/E1 interface is set to local loopback	Loop back to the local end. Alarm flag set.
User		Equip LB	T1/E1 interface is set to remote loopback	Loop back T1 to the far end. Alarm flag set.
User		AIS	T1/E1 interface forced to transmit the AIS signal.	No user data passed to far end of the link. Alarm flag set.
User		BIST	T1/E1 interface transmits the built-in self test (BIST) sequence	No user data passed to far end of the link.

APPENDIX IV: GUI STATUS PAGE DETAILS

Status Item Name	Available Outputs	Meaning of the Item	Operational Notes
TSSI	Normal values +20 to 0 dBm		Reads the ODU transmitter output power in dBm, average.
	Abnormal >20 dBm		
	Abnormal < 0 dBm		
RSSI	Normal values -30 to -70 dBm		System will operate to approx. -25 dBm
	Abnormal > -30 dBm		
	Abnormal < -70 dBm		System will operate below -80 dBm, depending on bandwidth selected.
SNR	Normal values +20 dB to +40 dB		Typical SNR will be 26 to 29 dB.
	Low < +20 dB		
LIU #1	OK		
	LOS	Loss of signal received by the LIU from the user side	Abnormal
	AIS	LIU is receiving an AIS input signal from user side.	Abnormal
	OFF	LIU has been turned off by user	
LIU #2	Same choices as LIU # 1		
LIU #3	Same choices as LIU # 1		
LIU #4	Same choices as LIU # 1		
Temp. (temperature)	-40 to +60 C Normal		Reads the temperature on the PWBA within the ODU
	< -40 C Cold		Reads down to at least -50C.
	> + 60 C Hot		Reads up to at least +99C.
Modem	Locked	Normal data link operation	Digital PLLs within the demodulator indicate lock to the incoming received signal
	OOL	Receiver unlocked, no data decoded	
RF 1	Locked	Normal operation	Frequency synthesizer in the microwave TX section.
	OOL	Abnormal condition	
RF 2	Locked	Normal operation	Frequency synthesizer in the microwave RX section.
	OOL	Abnormal condition	
PWR 3.3	Normal voltage of 3.13 to 3.47 VDC		PWR monitors the status of various DC power supplies within the ODU

Status Item Name	Available Outputs	Meaning of the Item	Operational Notes
	Abnormal voltage of < 3.12 VDC or > 3.48 VDC		
PWR 5.0	Normal voltage of 4.75 to 5.25 VDC		
	Abnormal voltage of < 4.74 VDC or > 5.26 VDC		
PWR 7.0	Normal voltage of 6.60 to 7.4 VDC		
	Abnormal voltage of < 6.59 VDC or > 7.41 VDC		
PWR 12.0	Normal voltage of 11 to 13 VDC		Normally 12 VDC ± 3% This is the main voltage source driving all other supplies.
	Abnormal voltage of < 10.9 VDC or > 13.1 VDC		

APPENDIX V: RECEIVER SNR TABLE

The demodulator in the receiver measures its post-detection SNR and returns the value in an unconverted number, "nr." The relationship between nr and the receiver SNR is expressed by the formula:

$$\textbf{SNR (dB) = \{ 78 – 20 log}_{10}\textbf{ (nr) \}}$$

This table shows the correlation between the values returned by the CLI command "gnr" and the receiver signal to noise ratio in dB. The qualitative readings are valid for the SafeTLink's 16QAM modulation.

CLI "nr" numeric value	Receiver post-detection SNR, dB	Qualitative Meaning
300	28.5	Excellent SNR
350	27.1	
400	26.0	Very Good
450	24.9	
500	24.0	Good
550	23.2	
600	22.5	Adequate
650	21.7	
700	21.1	Marginal
750	20.5	
800	19.9	Near 10^{-6} BER threshold