User Manual

SafeTLink

4.9 GHz Public Safety Band

Point-to-Point Microwave Radio System

Ethernet plus T1
or
1, 2, 4 x T1

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Table of Contents

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 plus T1 version transmits both a 10/100 BaseT Ethernet input and a single T1 input between terminals. The 4xT1 version multiplexes and transmits 1, 2 or 4 synchronous T1 inputs between terminals.

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 660 feet (200 meters) from the indoor site.

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 plus T1 SafeTLink version can be configured to occupy a pair of 1, 2, or 5 MHz RF channels. The wider the RF channels, the higher the Ethernet data rate. The T1 is user configurable as a fractional T1 with any number of enabled time slots. Disabled time slot bandwidth is automatically reallocated to the Ethernet channel.

The 4xT1 SafeTLink version can be configured to support 1, 2 or 4 T1 inputs. Single T1 transmission requires a pair of 1 MHz RF channels. Two T1 transmission requires a pair of 2 MHz RF channels and four T1 transmission requires either a pair of 3 MHz or pair of 5 MHz RF channels.

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

1.1 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.

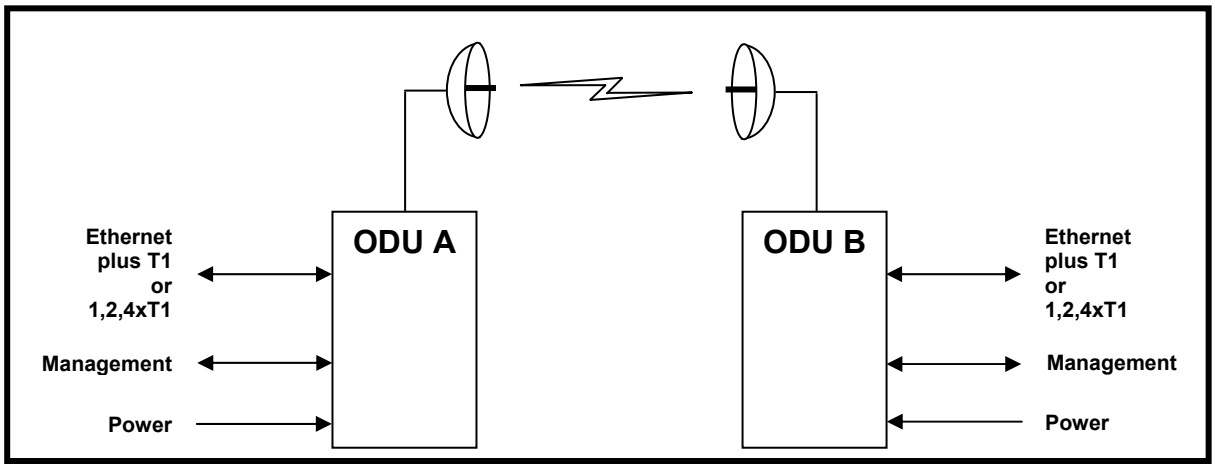


Figure 1-2
SafeTLink System Block Diagram

1.2 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 AND 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 Ethernet plus T1

The Ethernet plus T1 SafeTLink system is a point-to-point radio link which can transport both an industry standard 1.544 Mbps T1 signal and a 10/100BaseT Ethernet signal. The actual data rate carried on the Ethernet interface is dependent on several factors. 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 occupy a pair of 1 MHz RF channels, a pair of 2 MHz RF channels or a pair of 5 MHz RF channels. The wider the RF channels, the higher the Ethernet payload data rate. The T1 interface can be configured as a fractional T1, enabling any number of the 24 available 64 kbps time slots. SafeTLink reallocates the bandwidth from the disabled T1 time slots to the Ethernet channel. The resulting full duplex Ethernet data rates are as follows:

RF Channel Width	Ethernet Data Rate Range (dependent on fractional T1 usage)
1 MHz	0.4 to 2.0 Mbps (Full Duplex)
2 MHz	2.5 to 4.0 Mbps (Full Duplex)
5 MHz	10.7 to 12.2 Mbps (Full Duplex)

3.1.2 1, 2, 4 x T1

The 4xT1 SafeTLink system is a point-to-point radio link which can transport 1, 2 or 4 synchronous industry standard 1.544 Mbps T1 signals. 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 a single T1 in a pair of 1 MHz RF channels, two T1s in a pair of 2 MHz RF channels or four T1s in either a pair of 5 MHz RF channels.

RF Channel Width	Number of Available DS1 / T1 User Channels. Full Duplex:
1 MHz	1
2 MHz	2
5 MHz	4

3.1.3 1, 2, 4 x E1

The SafeTLink system can transport 1, 2 or 4 synchronous E1 (2048 kbps) framed user interfaces. This feature is not supported in standard US SafeTLink products.

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 and Ethernet inputs (either from the IDU, if provided, or from the communications network if an IDU is not used), and multiplexes these signals into 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 and Ethernet interfaces provide industry standard signal levels and formats. Both the T1 and Ethernet interfaces are protected against line surges or short circuits.

3.2.2 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.

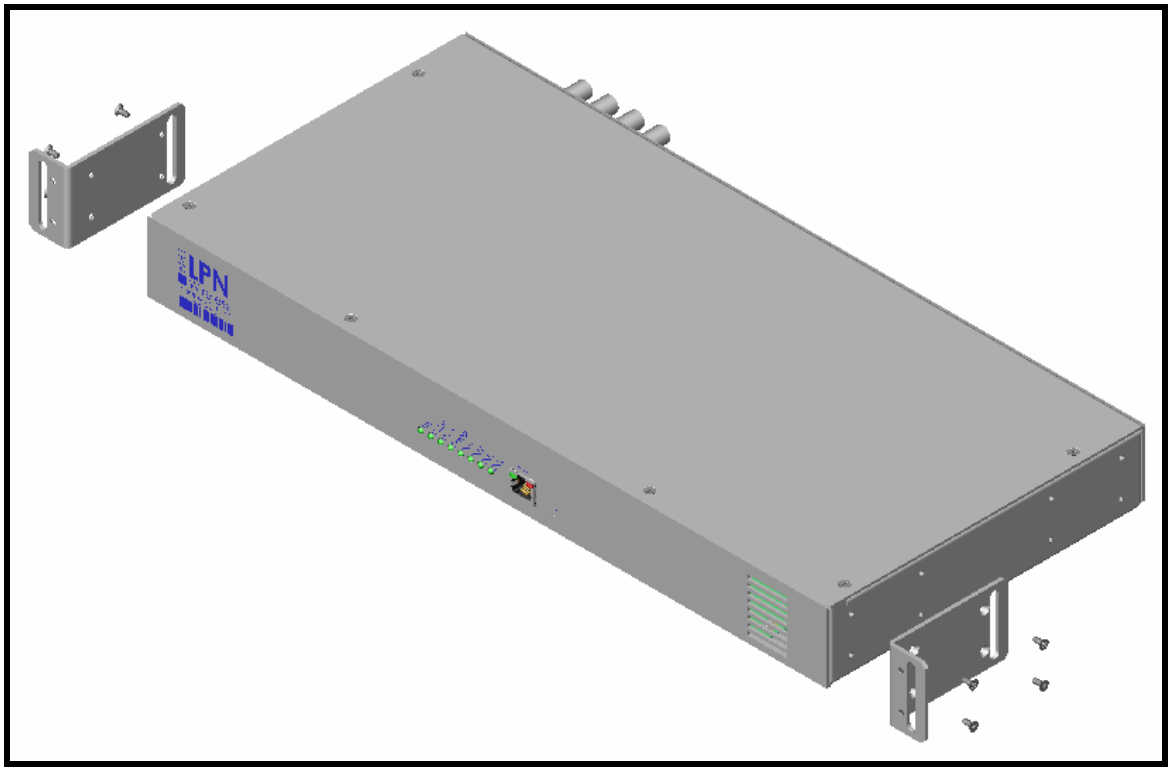


Figure 3-1
IDU, 19" Flush Mount with Rear Connectors

3.3 Specifications

3.3.1 Specifications for the Ethernet + T1 SafeTLink

Typical Link Operational Distance	With integrated antenna: 7.5 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	+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
T1 Line Interface	
Digital Interface	DSX-1 per Telcordia GR-499. Full or Fractional T1. Any DS0 slot user selectable.

T1 connector	28-pin weather-resistant (shared with Ethernet, management and power) on ODU RJ-48 on IDU
T1 Line Coding	AMI or B8ZS, selectable
T1 Line Buildout	short or long, selectable
Ethernet Interface	
Digital Interface	10/100BaseT per IEEE 802.3
Ethernet connector	28-pin weather-resistant (shared with T1, management and power) on ODU RJ-48 on IDU
Major and Minor Alarm Relay Contacts (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 (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, either polarity, 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
IDU Operating Environment	-40 to +70 C, 5-95% humidity, indoor mounted
IDU Physical Dimensions	19 or 23 inch rack mount, 1U high

3.3.2 Specifications for the 4 x T1 SafeTLink

Typical Link Operational Distance	With integrated antenna: 7.5 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	+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
T1 Line Interface	One, two or four T1 Interfaces, 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
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 (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 (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, either polarity, 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
IDU Operating Environment	-40 to +70 C, 5-95% humidity, indoor mounted
IDU Physical Dimensions	19 or 23 inch rack mount, 1U high

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. The 4xT1 version transports 1, 2 or 4 T1 channels 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 “A” ODU transmit channel is selectable within the frequency band 4980-4990 MHz, its receive channel is within 4940-4950 MHz. The “B” 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 plus T1 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	
300-00012-01	ODU/IDU Cable, 200 ft	1
300-00013-01	ODU/IDU Cable, 300 ft	
500-00022-01	CDROM, GUI Software and Manual	1
4xT1 Systems:		
STL-A-4T1-EXT-48	A ODU, External Antenna, 24/48 VDC	1
STL-A-4T1-EXT-12	A ODU, External Antenna, 12 VDC	
STL-A-4T1-INT-48	A ODU, Internal Antenna, 24/48 VDC	
STL-A-4T1-INT-12	A ODU, Internal Antenna, 12 VDC	
STL-B-4T1-EXT-48	B ODU, External Antenna, 24/48 VDC	1
STL-B-4T1-EXT-12	B ODU, External Antenna, 12 VDC	
STL-B-4T1-INT-48	B ODU, Internal Antenna, 24/48 VDC	
STL-B-4T1-INT-12	B ODU, Internal Antenna, 12 VDC	
300-00014-01	ODU/IDU Cable, 200 ft	1
300-00015-01	ODU/IDU Cable, 300 ft	
500-00022-01	CDROM, GUI Software and Manual	1

In addition to the required system components, a number of optional items are available for use in a SafeTLink system. These are listed below:

Part Number	Description
STL-IDU-ETH	IDU, Ethernet plus T1
STL-IDU-4T1	IDU, 4xT1
500-00015-01	Antenna, 1 ft panel, 21 dBi gain
500-00016-01	Antenna, 2 ft dish, 27 dBi gain
500-00017-01	Antenna, 3 ft dish, 31 dBi gain
500-00018-01	Antenna, 4 ft dish, 33 dBi gain
500-00019-01	Antenna, 40 deg. horn, 12 dBi gain
300-00009-01	Antenna Coaxial Cable, 3 feet
300-00010-01	Antenna Coaxial Cable, 6 feet
300-00011-01	Antenna Coaxial Cable, 10 feet
500-00020-01	Lightning Arrestor for Coaxial cable
500-00022-01	120 VAC/48 VDC Power Adapter
500-00023-01	User Manual, Paper Copy

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.

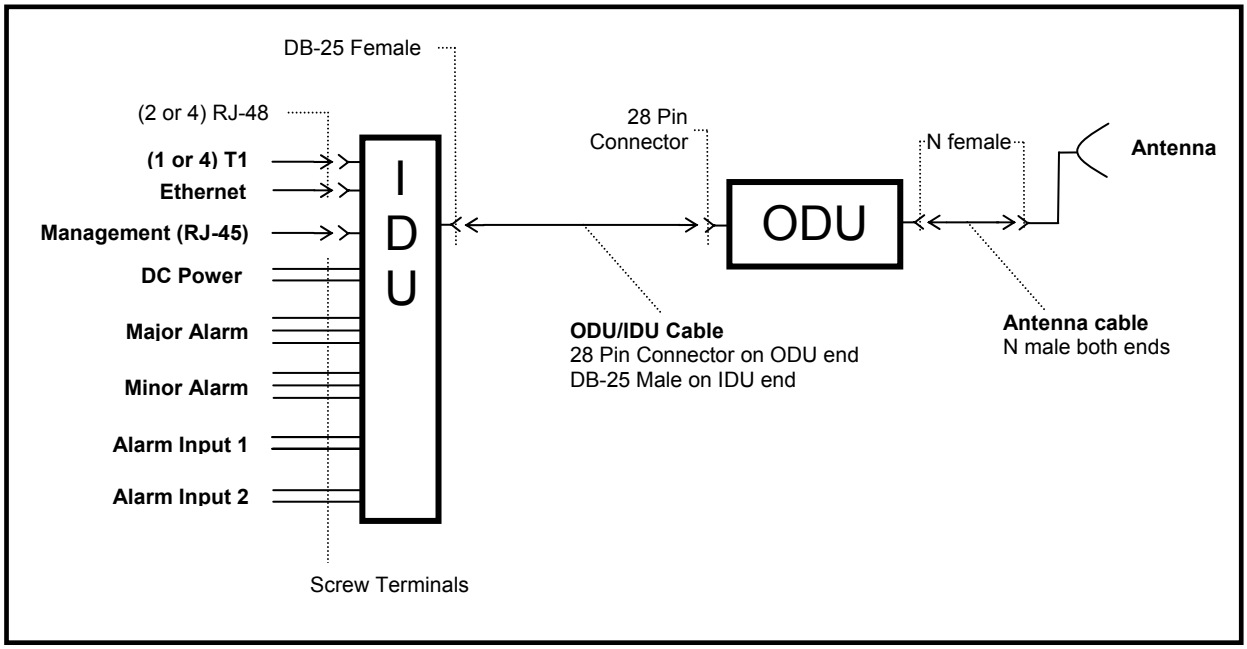


Figure 4-1
ODU with IDU

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.

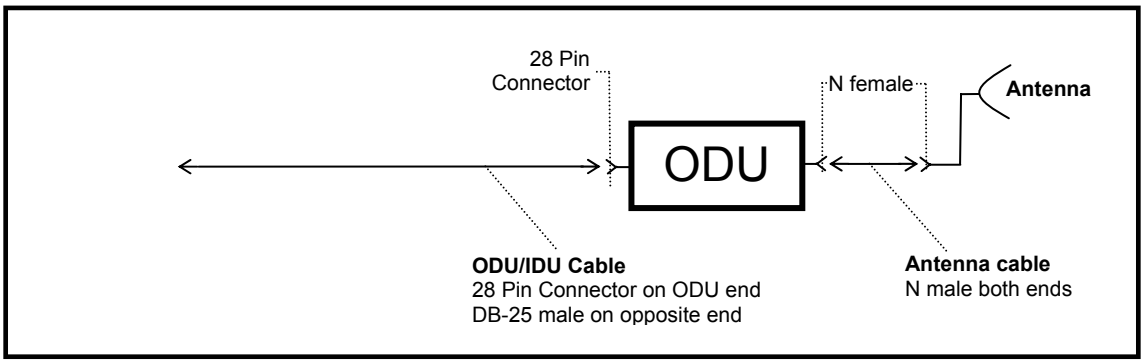


Figure 4-2
ODU without an IDU

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-25 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 I.

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.

4.2 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
- 25 watts maximum power

Optional 120 VAC/48 VDC plug-in Power Adapter modules are available for installations where only AC commercial power is available. Note that these Power Adapters can only be used with ODUs equipped with 24/48 VDC power option.

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, must be less than 10 ohms.

Figure 4-4
ODU Ground Lug

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. Wall mounting hardware is site specific and is not included.

Figure 4-5 shows a typical mast mount installation. The picture shows the rear of the ODU, mounted a few feet below a 24" diameter parabolic antenna. The two-axis gymbal 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.	

Figure 4-5
Typical ODU Mast Mount Mechanical Installation

Figure 4-6 shows a wall mount installation.

Figure 4-6
Typical ODU Wall Mount Mechanical Installation

4.4.2 IDU

Either the Ethernet plus T1 or 4xT1 IDU may be mounted in any of the following eight configurations:

Rack Size	Mount	Connector Location	
19 inch	Flush	Rear	As shipped
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	

The IDU is shipped configured for flush mounting in a 19 inch rack with connectors to the rear. Any of the other seven 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.

4.5 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 4-7 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.

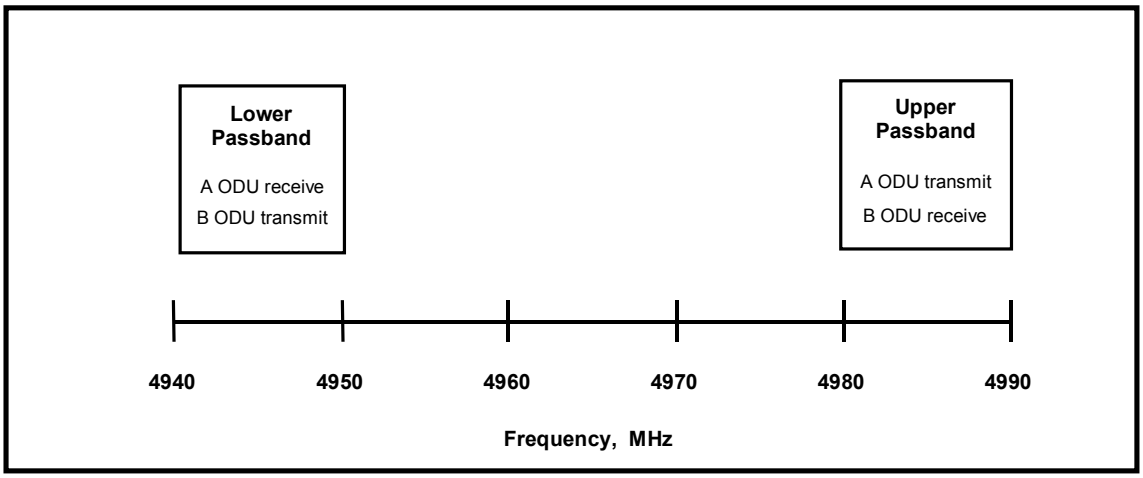


Figure 4-7
SafeTLink Frequency Plan

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 B ODU may be configured to transmit on any one of channels 1 through 5. The A 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 B 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 A 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 B ODU may be configured to transmit on combined channels 1-5 or channel 6. The A 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 2 MHz bandwidth operation are shown in the table below.

FCC Channel Number	Center Frequency (MHz)	Channel Bandwidth (MHz)
1+2+2+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 A ODU transmits on the higher frequencies within the band, and receives on the lower. The B 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:

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

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

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 "Received Signal Level and link budget", and compare it to the receive threshold of the SafeTLink version being used (see Specifications, section 3.3). 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 7 miles
Output power 100 milliwatts = +20 dBm
Antenna type: 1 foot square flat panel, with gain of +20 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 $\log_{10}$(7)
Lp_{miles} = 96.6 + 13.9 + 16.9
Lp_{miles} = 127.4 dB

And the received signal level will be:
RSL = Pout - FL1 + G1 + G2 - FL2 – Lp
RSL = +20 - 2 + 20 + 20 - 2 – 127.4
RSL = - 71.4 dBm

Likewise, 7 miles = 11.3 kilometers

$Lp_{kilometers}$ = 92.5 + 13.9 + 21.1 = 127.5 (using the metric version for km)

For a 1 MHz RF channel system, the minimum threshold signal is given in the specifications (Section 3.3) as -89 dBm.

The difference between the RSL of -71.4 and the minimum threshold of -89 dBm is equal to the fade margin:

Fade Margin (dB) = (-71.4) – (-89) = 17.6 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)	20 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 Approved Antennas

The SafeTLink product is certified under FCC Part 90 for use only with the antennas listed section 4.1.1 of this manual.

4.12 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.

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

TO BE PROVIDED See Figure 5-1 for mounting detail. Note that the ODU must be installed with its connectors pointing towards the ground.

Figure 5-1
Typical ODU Mechanical Installation

5.3.3 IDU Mechanical Installation

The 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 IDU, so these functions will appear on the front side of the rack regardless of orientation of the connectors. The IDU is shipped configured for flush mounting in a 19 inch rack with connectors to the rear. Any of the other seven configurations can be achieved by removing and repositioning the mounting ears as shown in Figure 5-2 through Figure 5-9.

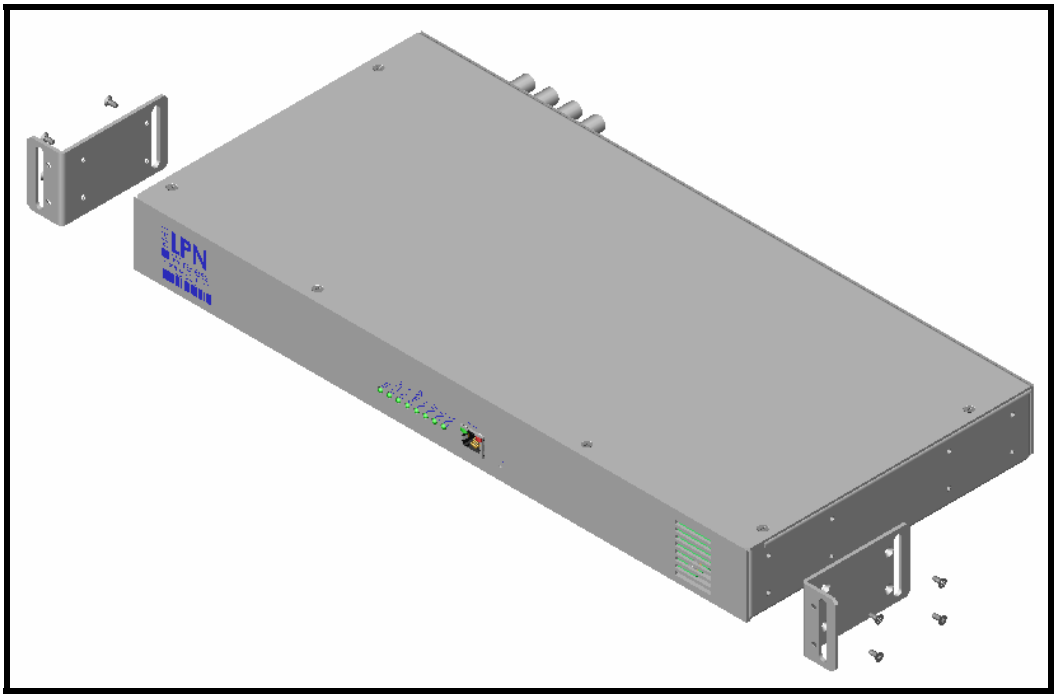


Figure 5-2
IDU, 19" Flush Mount with Rear Connectors
(As-Shipped Configuration)

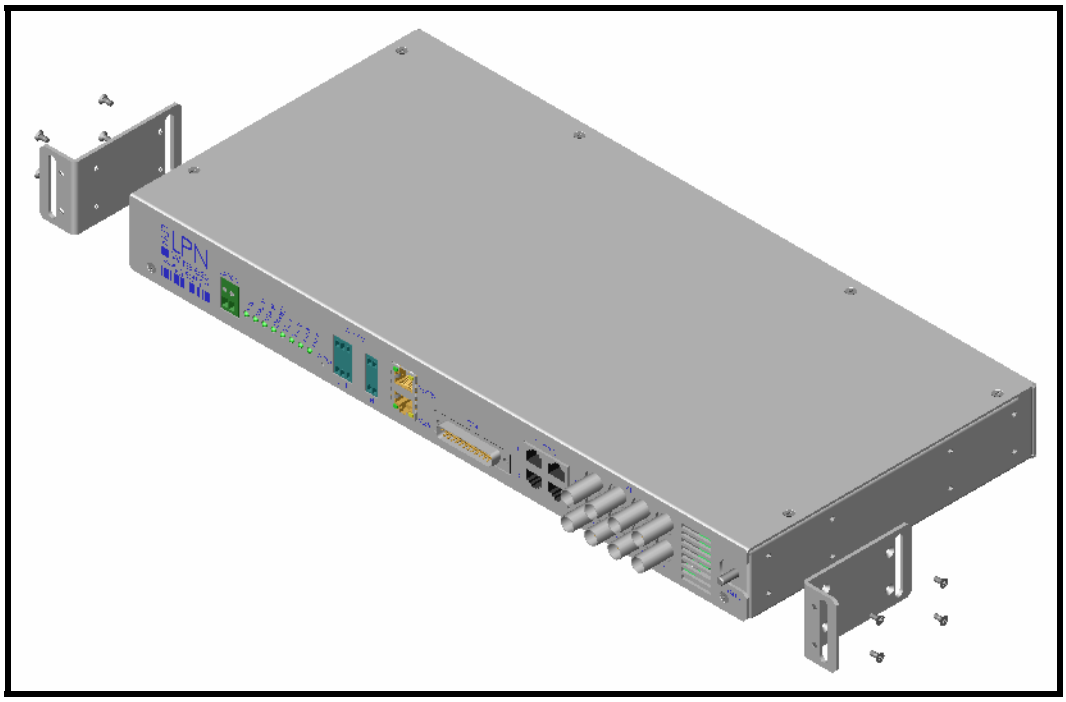


Figure 5-3
IDU, 19” Flush Mount with Front Connectors

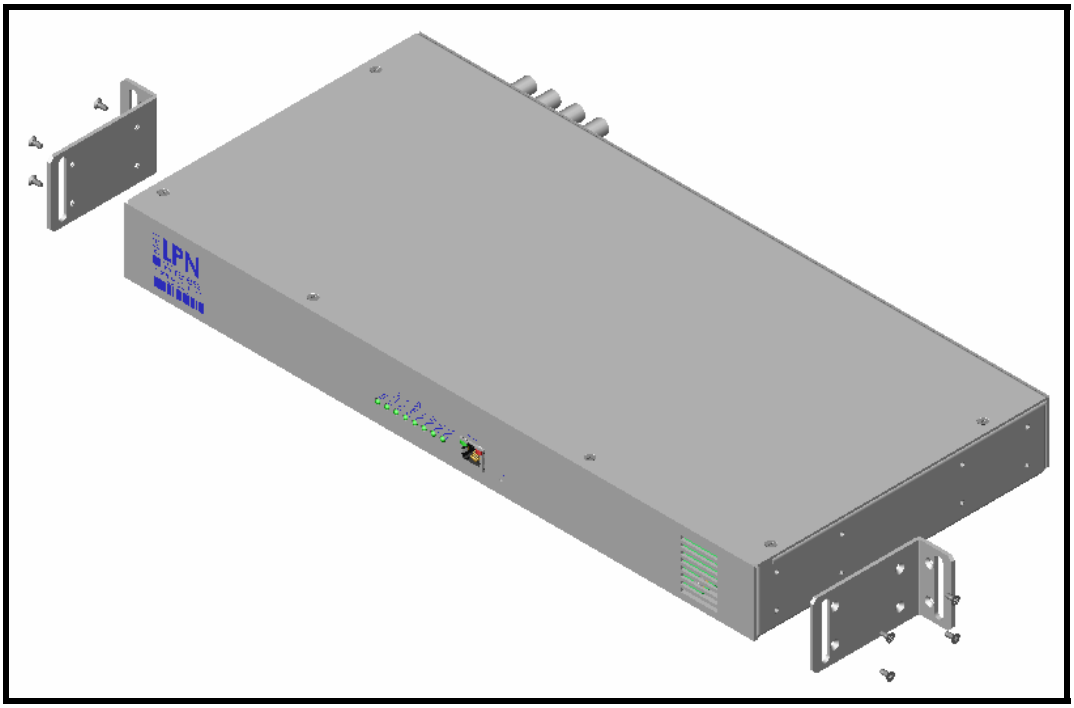


Figure 5-4
IDU, 19” Recessed Mount with Rear Connectors

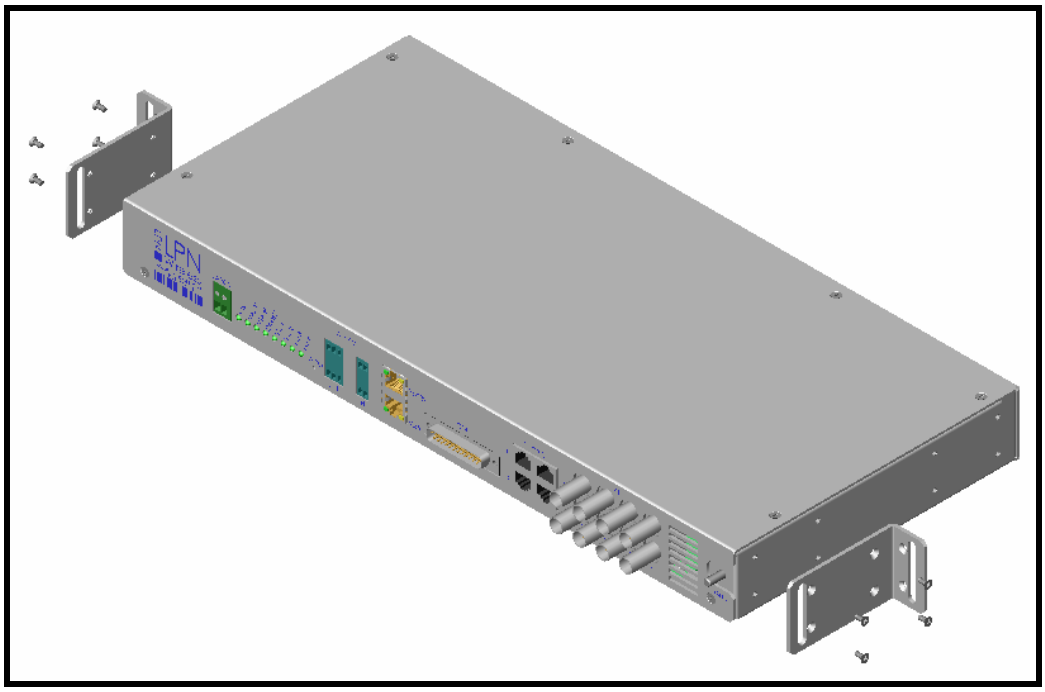


Figure 5-5
IDU, 19" Recessed Mount with Front Connectors

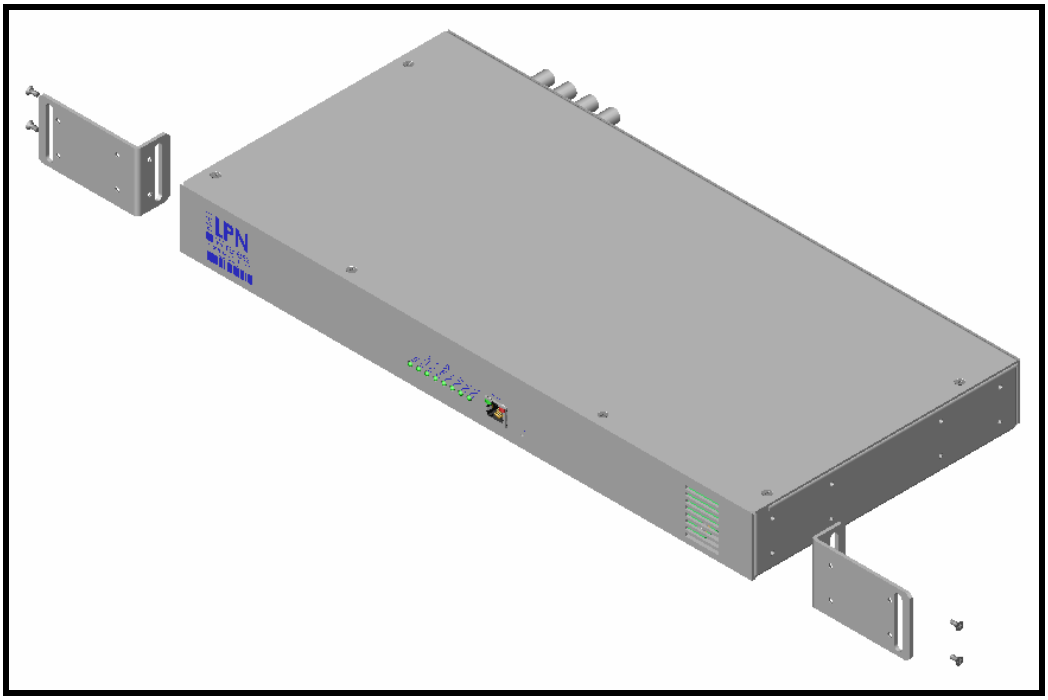


Figure 5-6
IDU, 23" Flush Mount with Rear Connectors

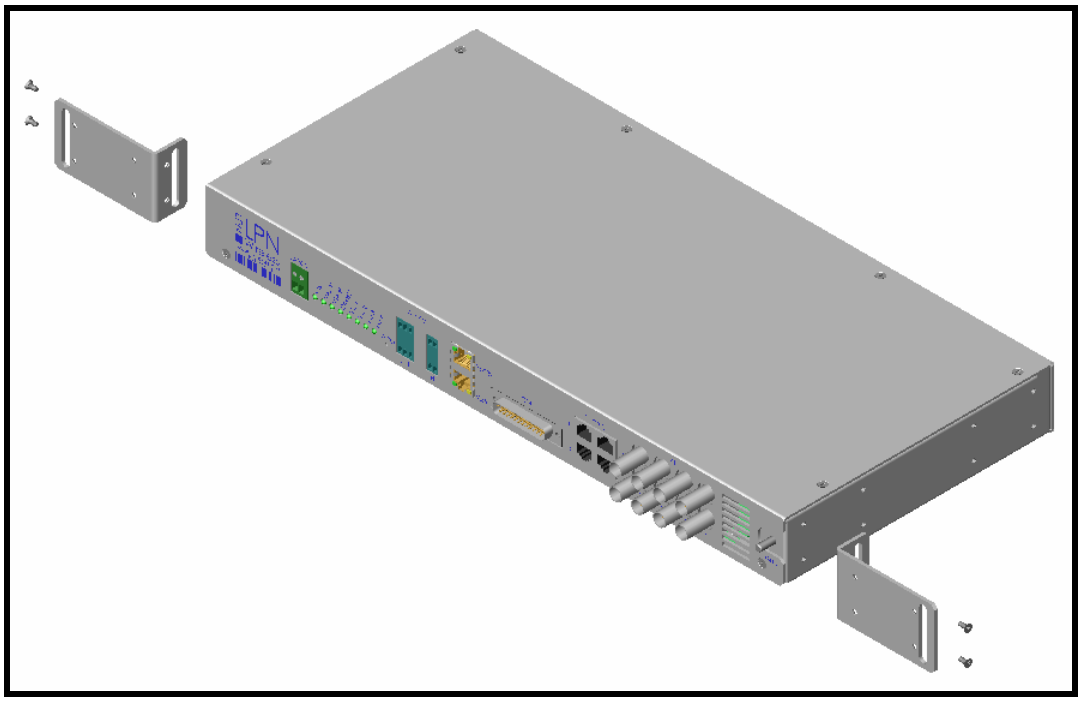


Figure 5-7
IDU, 23" Flush Mount with Front Connectors

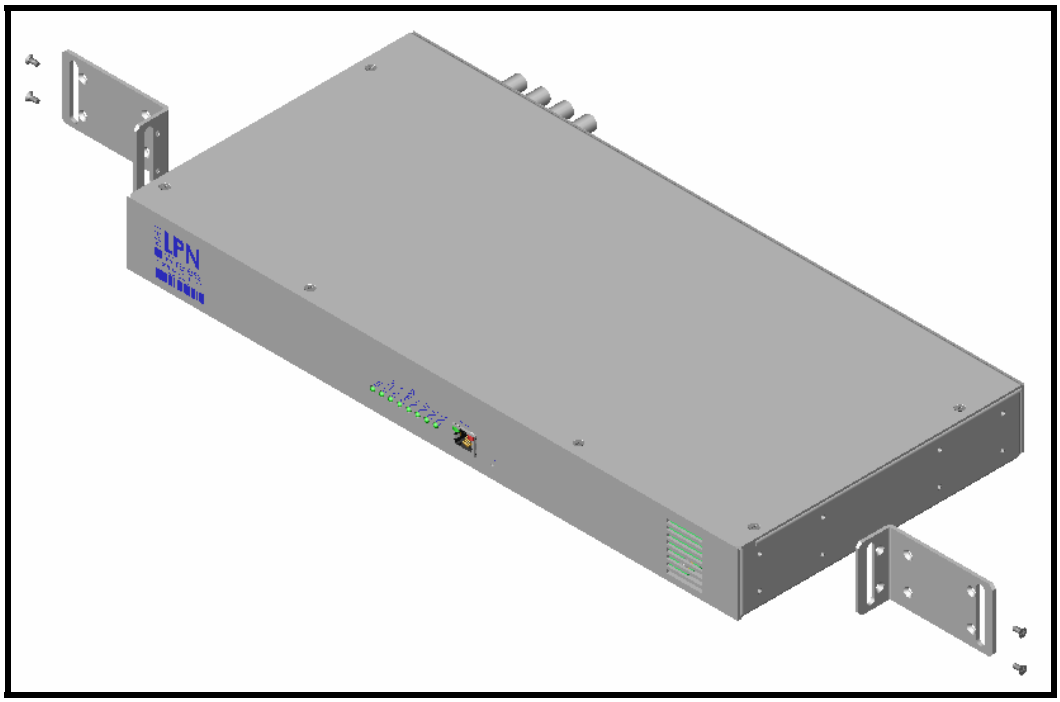


Figure 5-8
IDU, 23" Recessed Mount with Rear Connectors

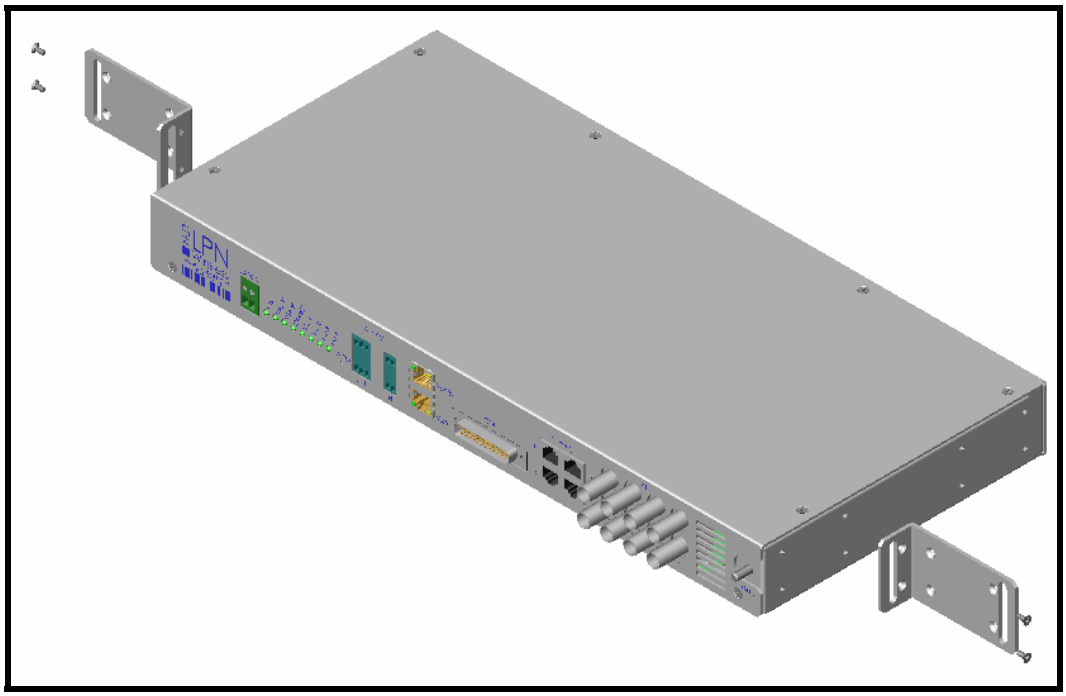


Figure 5-9
IDU, 23" Recessed Mount with Front Connectors

5.4 Electrical Connections

5.4.1 With Ethernet plus T1 IDU

On ends of an Ethernet plus T1 SafeTLink system with an IDU, the ODU/IDU cable needs to be installed. The DB-25 connector end of the cable mates with the IDU and the 28 pin connector mates with the ODU.

For reference, Appendix I details pin numbers for both the ODU and IDU connectors for Ethernet plus T1 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-25 male	14
T1 line	RJ-48 jack	4
Ethernet	RJ-48 jack	4
Major alarm contacts (1 form C)	Plug-in screw terminals	3
Minor alarm contacts (1 form C)	Plug-in screw terminals	3
Management	RJ-45 jack	4
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 5-10.

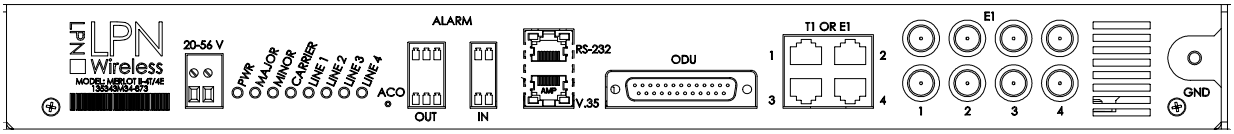


Figure 5-10
Ethernet plus T1 IDU Connector Side

5.4.2 With 4xT1 IDU

On ends of a 4xT1 SafeTLink system with an IDU, the ODU/IDU cable needs to be installed. The DB-25 connector end of the cable mates with the IDU and the 28 pin connector mates with the ODU.

For reference, Appendix II details pin numbers for both the ODU and IDU connectors for 4xT1 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-25 male	25
T1 line #1	RJ-48 jack	4
T1 line #2	RJ-48 jack	4
T1 line #3	RJ-48 jack	4
T1 line #4	RJ-48 jack	4
Major alarm contacts (1 form C)	Plug-in screw terminals	3
Minor alarm contacts (1 form C)	Plug-in screw terminals	3
Management	RJ-45 jack	4
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 5-11.

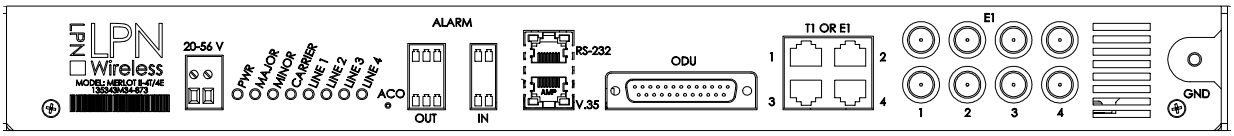


Figure 5-11
4xT1 IDU Connector Side

5.4.3 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-25 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.

For Ethernet plus T1 systems, Appendix I details pin numbers for both the ODU and DB-25 connectors. For 4xT1 systems, Appendix II details pin numbers for both the ODU and DB-25 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 5-12. 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 5-12
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.
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 or NMS.

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.

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.	*<insert picture of ODU with RSSI cable and DVM reading > 1.5 VDC>*

5.8.2.3 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 in this mode 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.

6.2 Configuration Options

6.2.1 Configuration of "A" or "B" type ODU

The hardware of the A and B ODUs is identical. The A and B ends differ only in the connections to the RF duplexer within the ODU. The ODU type can be configured in the field, if necessary, to convert an A to a B, or a B to an A type ODU.

6.2.1.1 Required Tools

Screwdriver to open ODU, Phillips head.
Screwdriver, Phillips head, to remove the Duplexer
5/16" open end wrench, preferably a torque wrench set to 8 inch-pounds for SMA connectors
computer to configure the ODU via software CLI or GUI.

6.2.1.2 Opening Procedure – Integral Antenna Versions

Open the ODU by removing the antenna's 16 mounting screws. The antenna is connected to the ODU by a short RF cable inside the ODU. DO NOT let the antenna dangle or pull on the coaxial cable. Carefully disconnect the antenna using the 5/16" wrench to loosen the SMA connector at the end of the cable from the antenna to the duplexer. See Figure 6-1.

Figure 6-1
Integrated Antenna Removal

6.2.1.3 Opening Procedure – External Antenna Versions

Open the ODU by removing the ODU top plate's 16 mounting screws. See Figure 6-2.

Figure 6-2
ODU Top Plate Removel

6.2.1.4 Duplexer Reconfiguration

6.2.1.4.1 Hardware 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. See Figure 6-3a and -3b.
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.

View of the EP with duplexer installed in configuration "TYPE A" Note: • There are **NO** tuning screws on the exposed face of the duplexer • The higher frequency port (in this picture 4960 to 4990 MHz on the label) is to the RIGHT hand side of this image.	

Figure 6-3a
Duplexer Connections – ODU Type A

View of the EP with duplexer installed in configuration "TYPE B" Note: • There **ARE** visible tuning screws on the exposed face of the duplexer • The higher frequency port (in this picture 4960 to 4990 MHz on the label) is to the LEFT hand side of this image	<insert photo>

Figure 6-3b
Duplexer Connections – ODU 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 cover or the integral antenna after reconfiguring the duplexer.

6.2.1.4.2 Software Reconfiguration

Use the CLI to change the ODU type to match the installation of the duplexer. Note that the GUI configuration screen can NOT be used to make this change. The GUI terminal screen can be used to issue the correct CLI command. For type A type pota and see the response pota. Likewise, for type B ODU type potb and see response potb.

6.3 Using the Command Language Interface

6.3.1 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).

Commands are all a single alphabetic byte, followed by a pair of alphabetic register list bytes. 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 carriage return and line feed, which signals the ODU to respond.

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.

6.3.2 Direct CLI Use at the ODU

The CLI may be used directly from a terminal or PC. The terminal or PC should be set to emulate a type VT-100 terminal. This permits the ODU to be set up, in a depot before installation, or at the installed site. All control features of the ODU are available via the CLI.

Local control of the ODU via the CLI takes place at 19200 baud via an RS-485 serial interface to the host emulator. Basic format of the ASCII is N 8 1 (no parity, 8 bit, 1 stop). The host emulator does not echo local commands; the user will want to set up local echo mode on the terminal.

Figure 6-4 shows the connection point in the ODU for connecting a laptop PC.

	<insert photo>

Figure 6-4
Laptop Connection to ODU

The PC is emulating a VT-100 using a commercial terminal emulator software program such as ProComm, Hyperterminal, or similar communications software. To connect a PC with an RS-232 interface directly to the ODU, a level translator such as the (model) may be used.

The CLI may be used directly from a terminal or PC. The terminal or PC should be set to emulate a type VT-100 terminal. This permits the ODU to be set up, in a depot before installation, or at the installed site. All control features of the ODU are available via the CLI.

6.3.3 CLI Use via the IDU

When using the optional IDU, the PC interface is connected to the IDU with a standard RS-232 interface. Local control via the IDU takes place at 19200 baud via an RS-232 serial interface to the host emulator. Basic format of the ASCII is N 8 1 (no parity, 8 bit, 1 stop). The host emulator does not echo local commands; the user will want to set up local echo mode on the terminal. All control features of the ODU are available via the CLI, whether direct to the ODU or via the IDU.

6.3.4 CLI Commands

The command is the first byte of the string sent. This list contains a mnemonic name, the command itself contained within ‘ ‘ marks, and a comment on the command function.

```
PUT_LOCAL     'p'    // put command to local ODU
GET_LOCAL     'g'    // get response from local ODU
PUT_REMOTE  'P'     // put command to remote ODU
GET_REMOTE  'G'     // get response from remote ODU
```

6.3.5 CLI Register Commands and Replies

The register is defined by the second and third bytes of the alphabetic string sent to the ODU. The command defines the operation type. Any data sent to or from the ODU follow these bytes.

The CLI command names, formats, ranges and units are listed in Appendix IV. A detailed description of each command is in this section.

6.3.6 Error Messages

If the ODU micro controller receives an invalid string, an errored string, or other incorrect format, it replies with an error message. An error message is a reply from the ODU towards the user, and is always prefixed by the tilde '~' symbol. The basic list of error messages is listed below:

ERROR_PREFIX	'~'
COMMAND_OK	(0x00)
INVALID_COMMAND	'1'
INVALID_REGISTER	'2'
INVALID_DELIM	'3'
INVALID_DATA	'4'
NON_NUMERIC_DATA	'5'
READ_ONLY_REG	'6'
COMMAND_TIMEOUT	'7'

6.3.7 Status Byte

The ODU provides a status byte. When polled, the ODU replies with a single byte. If all the bits in that byte are zero (00H) the ODU is reporting normal operation with no faults. If one or more of the bits is 1, the bit position gives indication to the user where the abnormal condition is found.

The ODU status byte is masked by the LIU mask command. If, for example, the T1 channel is not in use, the T1 alarms can be masked so the LOS alarms do not appear in the status byte.

The status byte provides current information only. It is not latched with historical data.

Status Byte Chart

7 (MSB)	6	5	4	3	2	1	0 (LSB)
Spare Bit	TSSI or RSSI below threshold =1	Errors on any unmasked LIU =1	ODU Temp. not in allowed range =1	Receiver BER is worse than 10^{-8} =1	Transmitter is off =1	PLLs are out of lock =1	Power Supplies out of limits =1

6.3.8 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.

COMMAND NAME	CLI CMD	R/W	Discussion of the command function and operation	CMD Format	Range	Units
ODU_TYPE	ot	R	The two ends of a radio link require different types of ODU. One end has TX Frequency = x and RX Frequency = y. The other end of the link has TX Frequency = y and RX Frequency = x. The ODU_TYPE command returns information on which type of ODU is at each end of the link.	X	a,b	NONE
ODU_STATUS	st	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.	XXXXXXXX	See ODU status byte section of this document for details	NONE
TX_FREQUENCY	tf	R/W	This is the transmit frequency of the ODU. The command loads a frequency synthesizer in the ODU to control the carrier center frequency. The reply is the commanded frequency. This variable is pre-set by the ODU_TYPE command. If the commanded frequency is out of the listed range, an error message is returned.	XXXXXXX	4940000 to 4990000	kHz
RX_FREQUENCY	rf	R/W	This is the receive frequency of the ODU. If the ODU_TYPE and TX_FREQUENCY produce a RX_FREQUENCY out of the allowed range, the RX_FREQUENCY will return an error message.	XXXXXXX	4940000 to 4990000	kHz
RSSI	rs	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	-99.9 to 00.0	dBm
TSSI	ts	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. This is a detected signal and indicates a measure of the total transmitter spectrum power. The full range is not necessarily available for operation. 0 to +20 dBm actual TX Output power guaranteed.	{sign} XX.X	-19.9 to 29.9	dBm

COMMAND NAME	CLI CMD	R/W	Discussion of the command function and operation	CMD Format	Range	Units
TX_LEVEL	tl	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. Note that if a value of 99 is entered, the automatic power level loop is disabled, and the CABLE_ATTEN and TX_ATTEN commands control the RF power output. Automatic RF Power level operation is restored when a command is sent within the Range.	{sign}XX	0 to +21 99 = manual mode (disable auto power control)	dBm
TX_CARRIER	tc	R/W	The command TX_CARRIER permits the user to control the RF transmission of the ODU. If TX_CARRIER is set to i = inactive = OFF, the radio does not transmit an RF signal towards the far end. Reception of RF signals is not affected.	X	a = active, transmitter operating I = inactive, TX off	NONE
TX_CW_TONE	tt	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
SOFT_VERSION	sv	R	The microcontroller in the ODU returns the software version number of the currently loaded code. This version number is upgraded with each software change for revision control.	X.XX	Current version, e.g. 2.04	NONE
FPGA_VERSION	hv	R	The fpga in the ODU returns the hardware version number of the currently loaded code. This version number is upgraded with each fpga change for revision control.	X.XX	Current version, e.g. 2.04	NONE
FPGA_MASTER_ SLAVE	ms	R/W		X	m = master s = slave	NONE
SERIAL_NO	sn	R	The ODU returns the serial number of the ODU. This serial number is unique to each ODU. The serial number resides in the digital board crypto-hardware and can not be changed by the user.	XXXXX	00000 to 00000FFFFFF	NONE
TEMPERATURE	tp	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
RECEIVE_FEC_ CORR	fc	R	There is Reed-Solomon Forward Error Correction (FEC) within the modem for the QAM system. When this command is issued, the modem returns the number of receive corrected symbol errors and clears the counter. The normal value is zero, indicating there are no uncorrected bytes.	XXXXX	0 to 65535	NONE

COMMAND NAME	CLI CMD	R/W	Discussion of the command function and operation	CMD Format	Range	Units
RECEIVE_FEC_ BBLK	fb	R	There is Reed-Solomon Forward Error Correction (FEC) within the modem for the QAM system. When this command is issued, the modem returns the number of uncorrectable blocks and clears the counter. The normal value is zero, indicating there are no uncorrected bytes.	XXXXX	0 to 65535	NONE
MODEM_LOCK	ml	R	The modem locks to the carrier and the symbol rates of the incoming demodulated data stream. This variable provides information on the current lock of the digital loops within the modem. Normal operation provides a "locked" reply at all times.	X	u = unlocked l = locked	NONE
12_VDC	ph	R	An Analog to Digital (AD) converter within the ODU provides a reading of the main power supply voltages on the PWBs in the ODU. This variable returns the most recent averaged value of the 11 Volt main power buss. This is the 'backplane' voltage for the ODU from which all other power is converted.	XX.XX	Usual range is 11 to 13 volts	Volts Direct Current (VDC)
7_VDC	p7	R	This variable returns the most recent averaged value of the 7 Volt power buss. This is the main supply for the RF sections of the ODU.	X.XX	Usual range is 6.90 to 7.25 volts	VDC
5_VDC	P5	R	This variable returns the most recent averaged value of the 5 Volt power buss. This is the main supply for the E1 line interface units (LIU) within the ODU.	X.XX	Usual range is 4.90 to 5.10 volts	VDC
3.3_VDC	p3	R	This variable returns the most recent averaged value of the 3.3 Volt power buss. This is the main supply for the digital and microcontroller sections of the ODU.	X.XX	Usual range is 3.25 to 3.35 volts	VDC
RESET_ODU	bb	W	If the RESET_ODU command is sent, the ODU will cause its watchdog timer to command a 'hard reset' of the entire ODU.	X	b = reset	NONE
LIU_BUILD	bo	R/W	The sensitivity and drive level of the LIU can be set to accommodate the loop length (build out) of various E1 or T1 hardware. This variable sets the LIU to lower sensitivity (Short loops) or higher sensitivity (Long loops)	X	s = short l = long	NONE
LIU_T1_E1	te	R/W	Each LIU can be set to T1 (1.544 MBPS) or E1 (2.048 MBPS) modes. This command sets the selected LIU to one of these two modes.	X	t = T1 e = E1	NONE
LIU_FLB	lf	R/W	In Facility Loopback (FLB), data from the far end of the link will be looped back towards the far end. FLB tests virtually the entire radio link.	X	a = active i = inactive	NONE

COMMAND NAME	CLI CMD	R/W	Discussion of the command function and operation	CMD Format	Range	Units
LIU_ELB	le	R/W	This command sets the LIU into a local loopback mode. In Local, also known as equipment loopback (ELB), incoming E1/T1 transmit data will be looped back to the receiver path passing through the jitter attenuator if it is enabled. Data in the transmit path will pass to the far end of the radio link as normal.	X	a = active i = inactive	NONE
LIU_MASK	mk	R/W	(use to set the Fractional T1 active channels (?))	X	a = active i = inactive	NONE
LIU_AIS	as	R/W	Each of the LIUs contains a pattern generator to produce the Alarm Indication Signal (AIS). If the AIS generator is on the LIU transmits AIS forward towards the far end of the radio link. This variable indicates AIS is active. AIS may be turned on by the user via this CLI, or the LIU may turn on AIS automatically when the input signal is faulted.	X	a = active i = inactive	NONE
LIU_AD	ad	R	The LIUs contain AIS Detection (AD). If the LIU detects an incoming E1 or T1 data stream containing the AIS pattern, the AD variable is set true.	X	t = TRUE f = FALSE	NONE
LIU_BIST	bt	R/W	Each LIU contains a 2^{15}-1 built in self test (BIST) pattern generator. This command sets the LIU to disconnect the input data stream and to send towards the far end a BIST pattern. The far-end LIU can detect this BIST pattern.	X	a = active i = inactive	NONE
LIU_LOS	sl	R	Each LIU contains a threshold detector monitoring the incoming E1 or T1 data signal level. If the signal level falls below the level for useful operation, the LIU signals a loss of signal (LOS).	X	t = TRUE f = FALSE	NONE
LIU_LCODE	lc	R/W	Sets selected LIU to AMI or B8ZS	X	a = B8ZS i = AMI	NONE
ALARM_IN_1	a1	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_IN_2	a2	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
MODULATION_ TYPE	mt	R	Determines the modulation type. SafeTLink uses only 16QAM.	X	m = 16QAM	NONE

6.4 Using the LPN Wireless GUI

The LPN Wireless GUI is a graphical user interface that 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.

6.4.1 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, or is supplied on a Compact Disk (CD) with the ODU.

6.4.2 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 top 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 graphical performance monitoring of the ODU.

6.4.3 GUI Configuration Page

This page of the GUI is the control panel for the SafeTLink. Select the page by clicking on the "Config." Tab in the lower left. The right side column shows all the SafeTLink systems controlled by this GUI. Select the system to view in detail by clicking on the button with name of 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 above, one end is named "LPN 1" and the other "LPN 2." The names appear at the top of each panel.

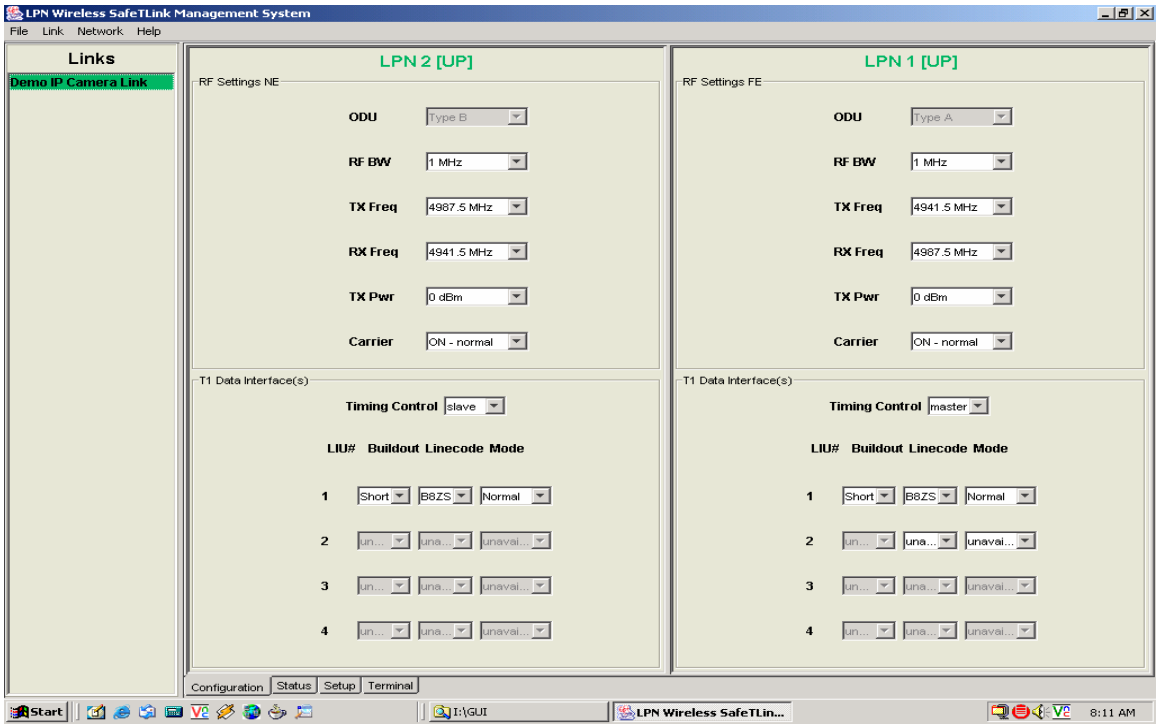


Figure 6-5
GUI Configuration Page

Figure 6-5 is a view of the GUI Configuration page. This example shows:

- Demo IP Camera Link is on the detailed view panels
- 1 MHz channels = 2 MBPS data rate
- Near End is LPN 2:
    - 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)
    - Transmitter is on 4987.5 MHz (channel center frequency)
    - Receiver is set to 4941.5 MHz
    - The transmitter output is set to 0 dBm
    - Normal operation is enabled
    - This is a T1 system, with 1 T1 LIU operational
        - T1 Line buildout is set to short
        - 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 LPN 1
- One T1 channel is operating, 3 are not available with 1 MHz channels

The GUI has a limited set of commands in each of its pull-down choices. The table below describe each choice in sufficient detail to operate the 4.9 GHz SafeTLink system.

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

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
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.
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
RF		4988.5		Channel center frequency is 4988.5 MHz. 1 MHz channel. Valid with RF Bandwidth 1 MHz Only

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
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

GUI Section	Control Name	Choices Available on pull-down list	Function of the command	Operational Notes
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 and4) are active	Valid with both 4 X T1/E1 and FT1/FE1 + Ethernet Interface selections.
RF	TX Pwr	0 to +20 dBm in 1 dB steps. (21 choices total)	Use the minimum 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.

At initial powering of the ODU, the Configuration Screen will default to the following settings:

ODU	Type as entered at factory 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:	
Build Out	Short
Line Code	B8ZS
Mode	Normal

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

6.4.4 GUI Status Page

System status information is displayed on the status page. The only controls on this page are the audible alarm toggle and a reset button for the BER reading.

The name of the site is shown normally in green. If an alarm occurs on a site, then that site's name shows as red on all pages, not just on the status page. Also, the link name under "systems" shows in red if either or both of the ODUs in that link has an alarm.

6.4.4.1 Sample Status Page

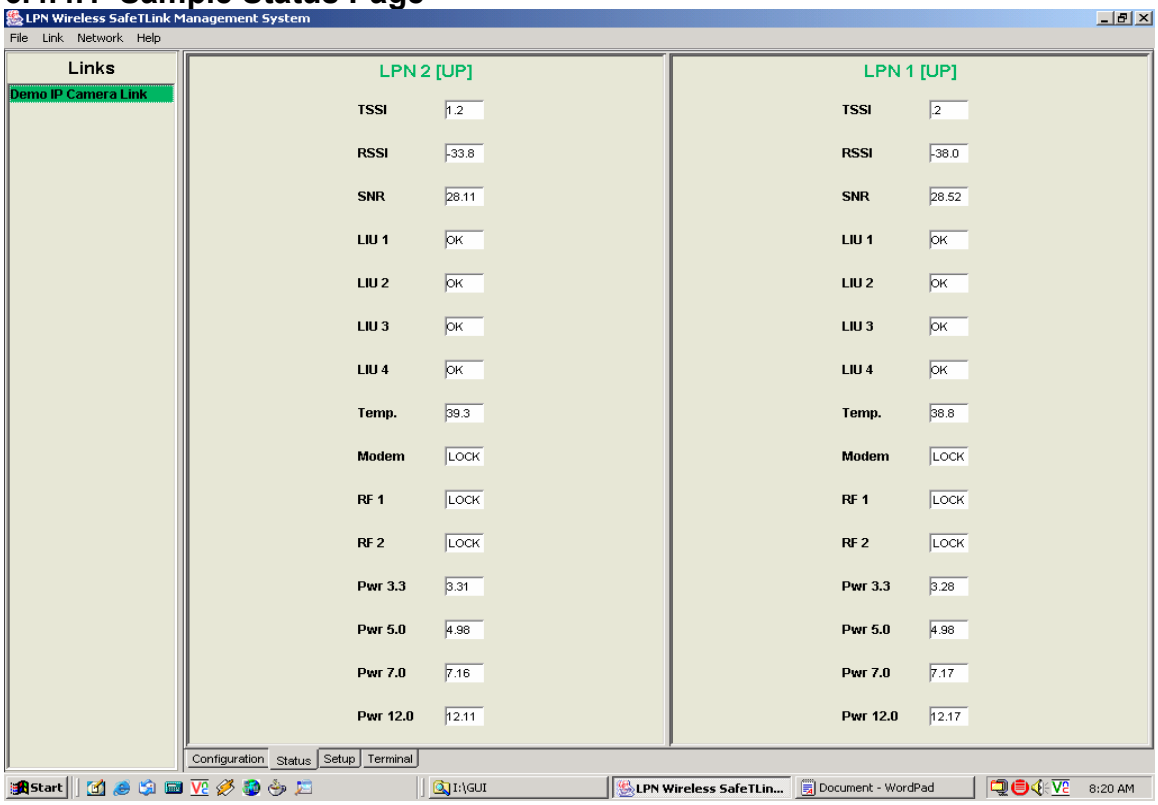


Figure 6-6
GUI Status Page

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

- The link named “Demo IP Camera Link” is selected and its data are shownj on the detailed view panels
- Near End is LPN 2:
    - 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 LPN 1

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 below 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.

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		
Status 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	
Status LIU #2	Same choices as LIU # 1		
Status LIU #3	Same choices as LIU # 1		

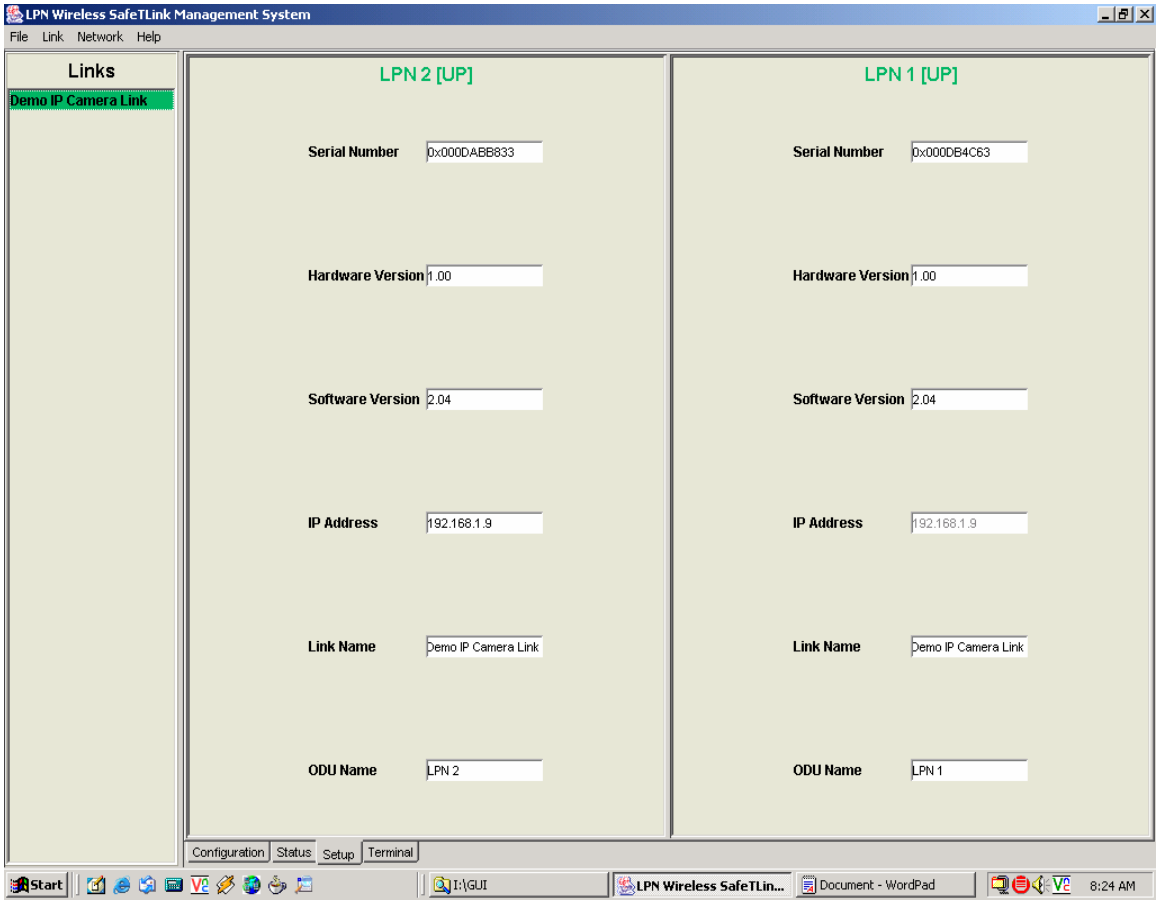
Status Item Name	Available Outputs	Meaning of the Item	Operational Notes
Status LIU #4	Same choices as LIU # 1		
Temp. temperature	-40 to +60 C Normal		Reads the temperature on the PWBA within the ODU
	< -40 C Cold		Reads down to at least -50C.
	> + 60 C Hot		Reads up to at least +99C.
Modem	Locked	Normal 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
	Abnormal voltage of < 3.12 VDC or > 3.48 VDC		
PWR 5.0	Normal voltage of 4.75 to 5.25 VDC		

Status Item Name	Available Outputs	Meaning of the Item	Operational Notes
	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		

6.4.5 GUI Setup Page

System configuration and version information is displayed on the setup page.

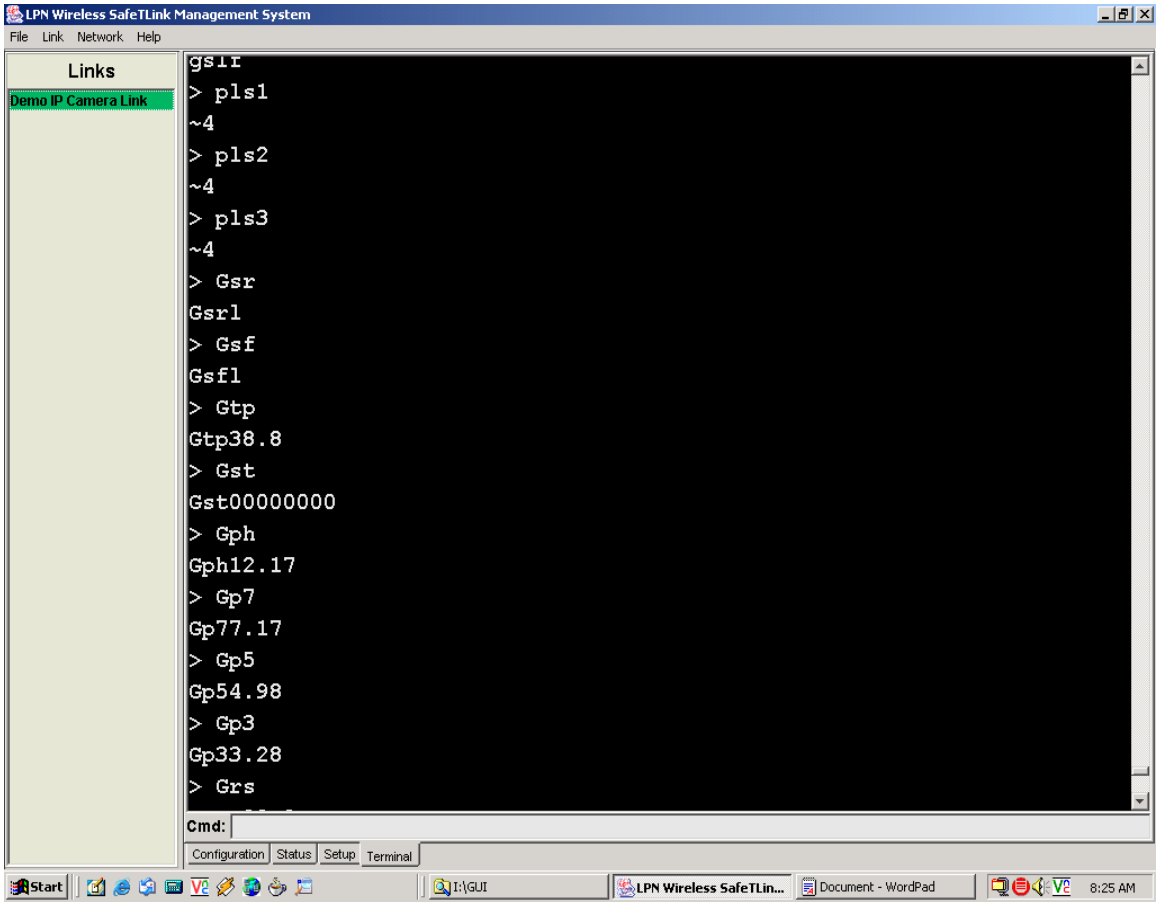
6.4.5.1 Sample Setup Page



6.4.6 GUI Terminal Page

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

6.4.6.1 Sample Terminal Page



6.5 IDU Monitoring

6.5.1 Ethernet plus T1 IDU Visual Indicator Lights

If an Ethernet plus T1 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)	N/A	N/A	No major alarm
Minor Alarm	Minor alarm	N/A	N/A	Minor alarm (blink on ACO)	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	T1 signal present	Loss of signal	Signal present	N/A	Disabled
Ethernet	Ethernet signal present	Loss of signal	Signal present	N/A	Disabled

6.5.2 4xT1 IDU Visual Indicator Lights

If a 4xT1 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)	N/A	N/A	No major alarm
Minor Alarm	Minor alarm	N/A	N/A	Minor alarm (blink on ACO)	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

6.5.3 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.

6.6 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

TO BE PROVIDED

8.2 Field Service items

8.2.1 List of What Can be Done in the Field

- 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 Matrix of Problems and Troubleshooting

TO BE PROVIDED

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 8-1a shows a view of the Electronics Package assembly within the ODU housing.

	<insert photo>

Figure 8-1a
Electronics Package Within the ODU

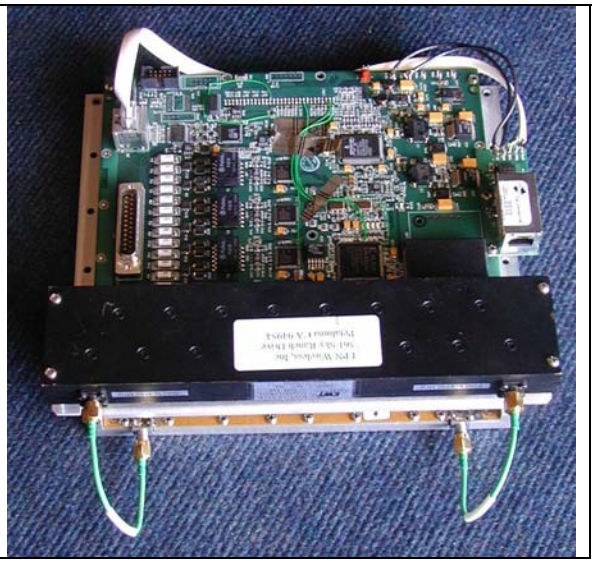
The EP may be removed from the ODU mechanical chassis.	

Figure 8-2b
Electronics Package Removed From the ODU

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 Mounting Plate Removal

The top plate attaches to the electronics package with six screws into steel standoffs. To remove the top plate, first remove the duplexer, then remove the six screws in the top plate.

8.4.5 Digital Electronics Package Access

Figure 8-3 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.

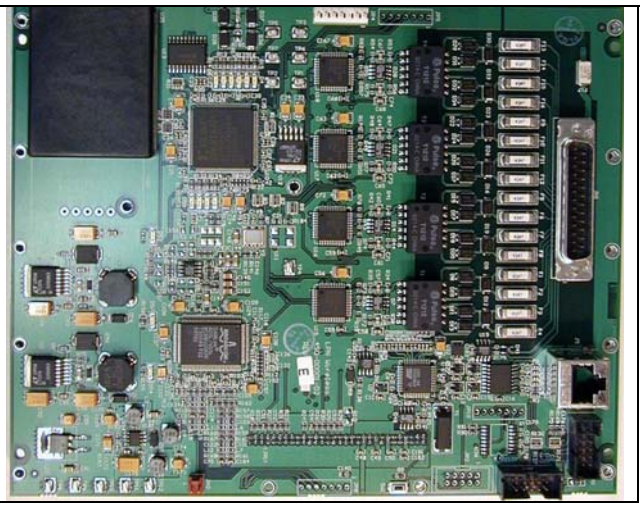
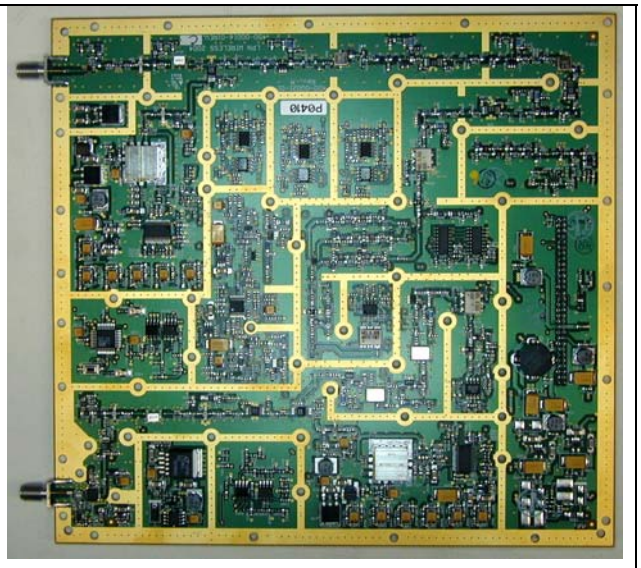
For reference use only: SafeTLink Digital PWBA circuit side, after removal of the duplexer and duplexer mounting bracket.	

Figure 8-3
Electronics Package with Duplexer and Cover Removed

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.

For reference use only: SafeTLink RF PWBA circuit side, after removal from the EP 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 Reassembly

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.

8.4.8 RF Cable Details

The semi-rigid RF cables used within the ODU are low loss conduits for the microwave signals. They are copper outer shields, with 100% coverage, with an inner dielectric of expanded Teflon, and a solid center conductor of beryllium copper. 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. Additional information on these topics can be found in the references listed in the bibliography.

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 mW. milliwatts
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:
ETSI:
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 PLUS T1 ODU AND IDU INTERFACE CONNECTOR PIN DESCRIPTION

ODU Connector Pin Number	IDU Connector Pin Number	Function
1	1	Management RS485 (-)
2	2	TX Tip T1
3	3	RX Tip T1
4	4	
5	5	
6	6	
7	7	
8	8	
9	9	
10	10	12 VDC for IDU powering
11	11	ETH + TX for GUI
12	12	Power (+)
13	13	Power (+)
14	14	Management RS485 (+)
15	15	TX Ring T1
16	16	RX Ring T1
17	17	
18	18	
19	19	
20	20	
21	21	
22	22	
23	23	Chassis Ground
24	24	Power (-)
25	25	Power (-)
26		ETH - TX for GUI
27		ETH + RX for GUI
28		ETH - RX for GUI

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.

APPENDIX II: 4XT1 ODU AND IDU INTERFACE CONNECTOR PIN DESCRIPTION

ODU Connector Pin Number	IDU DB-37 Connector Pin Number	Function
1	1	Management RS485 (-)
2	2	TX Tip T1 Line 1
3	3	RX Tip T1 Line 1
4	4	TX Tip T1 Line 2
5	5	RX Tip T1 Line 2
6	6	TX Tip T1 Line 3
7	7	RX Tip T1 Line 3
8	8	TX Tip T1 Line 4
9	9	RX Tip T1 Line 4
10	10	12 VDC for IDU powering
11	11	ETH + TX for GUI
12	12	Power (+)
13	13	Power (+)
14	14	Management RS485 (+)
15	15	TX Ring T1 Line 1
16	16	RX Ring T1 Line 1
17	17	TX Ring T1 Line 2
18	18	RX Ring T1 Line 2
19	19	TX Ring T1 Line 3
20	20	RX Ring T1 Line 3
21	21	TX Ring T1 Line 4
22	22	RX Ring T1 Line 4
23	23	Chassis Ground
24	24	Power (-)
25	25	Power (-)
26		ETH - TX for GUI
27		ETH + RX for GUI
28		ETH - RX for GUI

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.