RLH Fiber Optic Link Description and Installation

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1. General

1.1 Purpose

This practice describes the RLH Fiber Optic Link and includes the:

- Physical and functional descriptions.
- Characteristics.
- Engineering information.
- Ordering information.

1.2 Filing Instructions and Supersedures

Discard all previous issues and associated addenda of this practice and file this issue numerically in your GTE Telephone Operations practices set.

This practice supersedes and cancels:

- All policies, procedures, general instructions, letters, and memoranda which address this subject.
- Any document which provides information contrary to the information contained in this practice.

1.3 Reason for Reissuing

This practice has been reissued to incorporate multiple changes in the content. Read this entire practice to ensure your familiarity with the new information.

1.4 Responsibility

This practice was published by the GTE Telephone Operations Administrative Services Department. For more information about this practice, contact the GTE Telephone Operations Headquarters Protection Engineering Support Department._

1.5 Disclaimer

This practice was prepared solely for the use of GTE Telephone Operations. It must be used only by its employees, customers, and end users when installing, operating, maintaining, and repairing GTE Telephone Operations' equipment, facilities, and services. Any other use of this practice is forbidden. The information contained in this practice may not be applicable in all circumstances and is subject to change without notice. By using this practice the user agrees that GTE Telephone Operations will have no liability (to the extent permitted by applicable law) for any consequential, incidental, special, or punitive damages that may result.

2. Overview

2.1 Personal Safety

Safety precautions must be observed when working inside the zone of influence of high-voltage power facilities with remote-grounded facilities such as:

- Telephone conductors.
- Cable shields and armors.
- Messengers.
- Remote-grounded metallic structures.

Employees must:

- Avoid touching or stepping between the remote-grounded facilities and local ground or locally grounded facilities, such as:
  - Earth, walls, and fences.
  - Underground and ground-mounted terminals (e.g., cross connects and pedestal terminals).
  - Metallic conduits.
  - Foreign grounds or conductors.
- Use rubber mats, rubber shoes, and rubber gloves of at least 17 kV dielectric-strength rating to isolate parts of the body contacting with the earth, grounded conductors, or any extensions of earth (local ground).
- Contact the power company's representative before performing any work inside the power station or its surrounding facilities.

2.2 Definitions

The following chart provides definitions for the acronyms and terms used in this practice.

Acronym or Term	Definition
AC	Alternating Current
CO	Central Off ice
bPS	Bits per second -A measure of the speed of data communications.
dB	Decibel -A unit of measure of signal strength.
dBm	Decibels below 1 milliwatt
dBrnC	Decibels above reference noise with C-message weighing.
DC	Direct Current
DDS	Digital Data Service
FSK	Frequency Shift Keying-A modulation technique for data transmission.
Fx	Foreign Exchange

(continued)

2.2 Definitions, continued

Acronym	Definition
GPR	Ground Potential Rise
Hz	Hertz – Unit of frequency.
kbps	Kilobits per second- 1,000 bps.
kg	Kilogram – 1,000 grams.
km	Kilometer – 1,000 meters.
kV	Kilovolt – 1,000 volts.
LED	Light Emitting Diode
m	Meter
mA	Milliamperes
Mbps	Megabits per second- 1 ,OOO,OOO bps.
mm	Millimeter – 801 meter.
NID	Network Interface Device
OPX	Off-Premises Extension
PABX	Private Automatic Branch Exchange
PCB	Printed Circuit Board
PSB	Product Standardization Bulletin
POTS	Plain Old Telephone Service
PSU	Power Supply Unit
rms	Root-mean-square
RCV	Receive
SCADA	Supervisory Control and Data Acquisition
SUB	Subscriber

(continued)

2.2 Definitions, continued

Acronym	Definition
SVP	Surge Voltage Protector
µm	Micrometer – 1 ,000,000th of a meter.
V	Volts
VF	Voice Frequency
VOM	Volt-Ohm Meter
WATS	Wide Area Telephone Service
XMT	Transmit

2.3 References

The following chart provides sources of supplementary information relating to this practice. The documents could be required for performing certain tasks.

See...	**For Information About...**
075-190-100	Lineman's Rubber Gloves and Rubber Blankets – Description, Use, and Care
117-200-008	Protective Gloves- Description and Use
435-887-070	Provisioning High Voltage Protection at Power Stations
887-000-070	Electrical Protection of Telecommunications Facilities Serving Power Stations-Initial Considerations

2.4 Ordering Information

Refer to the following PSBs for ordering information on certain products mentioned in this practice.

PSB...	**For Information About...**
2394.2	Rubber Gloves/Blankets
5950	RLH Fiber Optic Link

3. System Description

3.1 Introduction

The RLH Fiber Optic Link:

- Provides electrical isolation for copper telephone cables going into or through an area of high voltage where a fault situation could create a dangerous GPR relative to the telephone company's CO and network.
- Is designed to replace dated isolation equipment (i.e., Isolation and Neutralizing Transformers, relays, and other devices) currently in use with:
  - Two small boxes or cards (CO Unit and SUB Unit).
  - Connecting fiber optic cables.
- Is capable of providing fiber optic separation of CO and SUB Cards and units to two miles (3.3 km) or beyond depending on application.

NOTE: The electrical isolation is specified as being 30 kV per foot (100 kV per meter) of cable. For additional information on determining the fault environment, refer to GTE Telephone Operations Practice 887-000-070.

3.2 Operation

The Fiber Optic CO interface unit:

- Takes compatible signals from 2-wire and 4-wire copper cable pairs and:
  - Converts the signals to modulated light.
  - Sends the signals through an all dielectric fiber optic cable to a SUB interface unit up to two miles (3.3 km) away.

NOTE: The CO end of the Fiber Optic Link is not necessarily installed at a CO.

The Fiber Optic Link SUB interface unit:

- Receives the light signal from the CO end and converts the light back to signals compatible with copper pairs without gain or loss.

NOTE: The Fiber Optic Link CO interface unit is installed beyond the voltage hazard (GPR) area of a substation, thus removing the telephone line remote ground and permanently isolating the telephone network from the high voltage source.

Powering of the CO interface end of the Fiber Optic Link via cable pair(s) by either:

- CO battery.
- Sealing current.

NOTE: The CO end cards are not polarity sensitive.

Powering of the SUB interface unit can be provided by:

- Local 24 V isolated DC power source.
- 120/24 V AC/DC converter.
- 48/24 V DC/DC converter.
- 130/24 V DC/DC converter.

NOTE: Refer to Exhibit 1 for a btock diagram of the system.

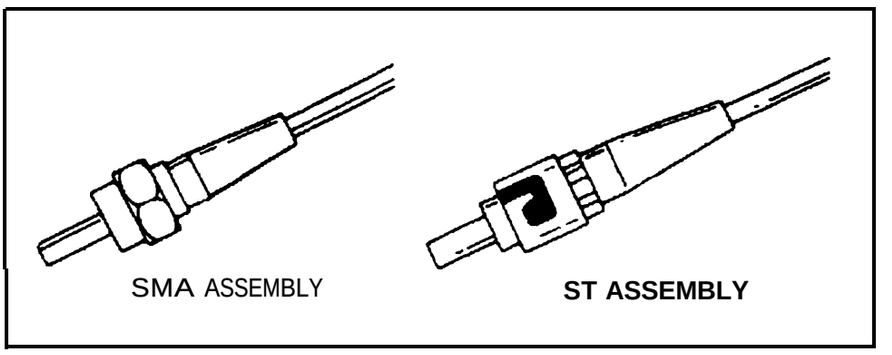
3.3 Equipment Configuration

There are two basic configurations of Fiber Optic Link equipment:

- Short Haul equipment:
  - Is designed to transmit optical signals only 66 feet (20 meters).
  - Uses low cost, 2-fiber cable.
- Extended Distance equipment:
  - Is designed to transmit optical signals to two miles (3.3 km).
  - Uses multimode fiber optic cable with ST or SMA 905/906 connectors.

NOTE: Refer to Section 3.6 for additional information on equipment selection considerations.

The following figure depicts ST and SMA Multimode Fiber Optic Connectors.



3.4 Service Compatibility

The Fiber Optic Link equipment is compatible with the following most offered telephone service:

- 2-wire telephone lines (POTS).
- 2-wire data lines (SCADA).
- 4-wire data lines.
- 4-wire data lines with E&M.
- 9600 bps digital data service.
- 56 kbps digital data service.
- T-l data service (1.544 Mbps).

NOTE: All systems will handle data to at least 9600 bps and are designed to be transparent to the network.

The Fiber Optic Link will accommodate the following service types and classes of service that are described in GTE Telephone Operations Practice 435-887-070.

- Type 1 Service-Classes A, B, and C.
- Type 2 Service-Classes A, B, and C.

  NOTE: In this service type, Fiber Optic Link equipment is used in conjunction with FSK conversion equipment.
- Type 3 Service-Classes A, B, and C.
- Type 4 Service-Classes A, B, and C.

3.5 Service Applications

RLH Fiber Optic Link is designed to broaden the base for electrical protection on telephone lines entering high voltage environments by:

- Increasing application flexibility.
- Decreasing the time for installation.
- Lowering the cost per protected line.

The Fiber Optic Link can be used to isolate network lines in the following applications:

- Isolation of 2-wire and 4-wire SCADA lines entering substations.
- Isolation of PABX trunks and lines.
- Removal of copper cable passing through a high voltage area.
- Removal of the copper connection between a microwave tower and a substation.
- Removal of copper connections between substations.
- Removal of copper telephone lines in lightning prone areas.
- Protection of telephone, computer, and PABX systems in lightning prone areas.

The system can be applied to networks with:

- Step-By-Step offices.
- Crossbar offices.
- Special services such as:
  - Key Systems (local telephone systems).
  - FX.
  - WATS.

me system:

- Operates on analog or digital carrier derived lines.
- Interfaces with exchange grade cable.
- Can be modified, by request, to reproduce ring frequencies to 66 2/3 Hz.
- Requires no adjustments for:
  - Net loss.
  - Ringing voltage.
- Is polarity insensitive beyond the CO.

3.6 Equipment Selection

Tables are used to list equipment required for various RLH Fiber Optic Link configurations.

In the following chart, RLH Fiber Optic Link applications are divided into groups.

Group	Applications
High density	Those that require protective treatment for five or more 2-wire or 4-wire lines in a single location.
Low density	Those that require protection for four or fewer lines.
Standard	Intended to: • Operate within 66 feet (20 m) of its opposite end. • Use the low cost plastic fiber cable.
Extended Distance	Designed to operate over 66 feet (20 m). An extended distance application can vary up to two miles (3.3 km) or beyond, depending on application and cable type.

3.7 System Specifications

RLH Fiber Optic Link System Specifications include the following:

- Fiber optic link systems.
- 2-wire systems (2-wire telephone, 2-wire data).
- 2-wire telephone line (POTS).
- 2-wire data system (SCADA).
- 4-wire data and 4-wire E&M systems.
- 4-wire data system.
- 4-wire E&M system.
- Digital data systems.
- 9600 bps digital data service.
- . 56 kbps.
- T-1 system.

3.7 System Specifications, continued

3.7.1 Fiber Optic Link System

The following chart describes the specifications common to all the Fiber Optic Link equipment.

Specification	Description
Transmission method	Frequency modulated light via two optical fibers.
Maximum Fiber Light	• Standard 66 feet (20 m). • Extended 2.0 miles (3.3 km).
Temperature Limits	-40 F to + 122°F (-40°C to + 50°C) + maximum solar load.
Humidity	95% noncondensing.
Housing Dimensions	Single card housing -9.59x7.4x3 inches (244x188x76 mm). Five card shelf-7.5x7.5x9 inches (190x190x230 mm). Twelve card shelf – 15x7.5x9 inches (380x190x230 mm).
PCB Dimensions	CO and SUB cards-7x4 inches (180x100 mm).

3.7.2 2-Wire Telephone and 2-Wire Data

The following chart describes 2-wire systems (2-w&e telephone and 2-wire data) specifications.

Specification	Description
Frequency Response	Terminated with 600 Ohms at 1000 Hz-300 - 3400 Hz +0.5 to -2.0 dB.
Insertion Loss	CO/SUB and SUB/CO 0.0 dB ± 0.5 dB.
Channel Noise	Less than 20 dBrnC (110 dBrnC typical).
Maximum Data Rate	9600 bps (Analog).
DC Resistance Limits	1600 Ohm loop (including CO DC feed).
Surge Protection	CO card-Varistor, Gas Tube, PTC Thermistors, Zeners, and Diodes. SUB card -Varistor, PTC Thermistors, Zeners, and Diodes.

3.7 **System Specifications, continued**

3.7.3 2-Wire Telephone Line (POTS)

The following chart describes 2-wire telephone line specifications.

Specification	Description
Dialing	Compatible with pulse and tone dialing.
Ringing Wave Form	Sine wave.
Ring Frequency Range	Standard – 16 - 30 Hz. Optional – 16 - **67** Hz.
Drop Voltage	48 VDC.
Drop Current	30 mA into 300 Ohms plus phone-23 mA minimum into 700 Ohms plus phone.
Power Requirements	CO card: • 18 - 54 VDC, 0.5 mA on-hook. • 18 mA minimum off-hook (card will sink up to 30 mA for line seizure). SUB card: • 24 - 30 VDC, 80 mA on-hook. • 190 mA off-hook. • 200 mA ringing.
Powering Methods	CO card-Normal CO battery through the loop. SUB Card-External **24 - 30** VDC power source wired to card terminals.

3.7 System Specifications, continued

3.7.4 2-Wire Data Systems (SCADA)

me following chart describes 2-wire data systems specifications.

Specification	Description
Power Requirements	CO card – 18 - 54 VDC, 18 mA minimum. SUB card-29 - 30 VDC, 45 mA.
Powering Methods	CO card – Normal CO sealing current or other DC voltage source inserted on cable pair. SUB card-External 20 - 30 VDC power source wired to card terminals.

3.7.5 4-Wire Data and 4-Wire E&M Systems

The following chart describes 4-wire data and 4-wire E&M systems specifications.

Specification	Description
Frequency Response	• 800 Ohm termination at 1000 Hz . 300 - 3400 Hz +0.5 dB to -1 .O dB.
Insertion Loss	0.0 dB ± 0.5 dB each direction.
Normal Impedance	800 Ohms input and output.
Overload Level	+ 8 dBm into 800 Ohms.
Maximum Data Rate	9800 bps (analog).1800 Ohm loop (including CO DC feed).
Channel Noise	Less than 20 dBmC (15 dBmC typical).
DC Resistance Limits	Typically 1600 Ohms for 50 V CO battery.
Surge Protection	CO/SUB cards-Varistors, PTC Thermistors, Zener Diodes, and Diodes.

3.7 System Specifications, continued

3.7.6 4-Wire Data System

me following chart describes 4-wire data system specifications.

Specification	Description
Power Requirements	CO/SUB cards-24 - 54 VDC, 12 mA minimum.
Powering Methods	CO card-Sealing current simplexed on 4-wire transmit and receive. SUB card- External DC power source wired to card terminals.

3.7.7 4-Wire E&M System

The following chart describes 4-wire E&M system specifications.

Specification	Description
Power Requirements	CO/SUB cards-24 - 54 VDC, 18 mA minimum.
Powering Methods	CO card – Battery simplexed on 4-wire transmit and receive. SUB card – External DC power source wired to card terminals.
E&M Inputs	Input current threshold -5 mA max. Input current maximum – 1 amp pulse, 200 mA continuous.
E&M Output	2500 Vrms isolation by solid state relay: • On resistance -25 Ohms. • Off resistance- > 1 M ohm. • Continuous current rating- 150 mA. • Maximum input voltage (output OFF) -330 VDC, 220 VAC rms.

3.7
System Specifications, continued

3.7.8 Digital Data Systems

The following chart describes Digital data systems specifications.

Specification	Description
Insertion Loss	0 dB + /- 1 dB in each direction.
Digital Data Type	Bipolar digital data bit stream with no DC reference.
Transmit Level	3.5 V peak to peak maximum (SUB input level limited at 3.W).
Surge Protection	CO/SUB cards-Varistors, PTC Thermistors, Zener Diodes, and Diodes.
Power Requirements	CO/SUB cards -24- 54 VDC, 18 mA minimum.
Powering Methods	CO card-Sealing current simplexed on 4-wire transmit and receive. SUB card – External DC power source wired to card terminals.

3.7.9 9600 bps DDS 4-W&e System

The following chart describes 9800 bps DDS 4-wire system specifications.

Specification	Description
Signal-to-noise	>45 dB for line attenuations up to 30 dB at 4.8 kHz.
Maximum data rate	9800 bps (digital).

3.7.10 56 kbps 4-Wire System

The following chart describes 56 kbps 4-wire system specifications.

Specification	Description
Signal-to-noise	>45 dB for line attenuations up to 30 dB at 28 KHz.
Maximum data rate	84 kbps (digital).

3.7
System Specifications, continued

3.7.11 T-1 System

The following chart describes T-l system specifications.

Specification	Description
Signal-to-noise	>45 dB for line attenuations up to **30** dB at 772 KHz.
Maximum data rate	2.048 Mbps (digital).
Transmission method	Amplitude modulated light via two optical fibers.
Maximum fiber length	Standard – 33 feet (10 m). Extended – 1 .0 miles (1.8 km).
Power requirements	CO/SUB cards – 24 - 54 VDC, 15- 70 mA (cards current limits at 75 mA).
Powering methods	CO card – Normal T-l span line power. SUB card- Dtemal DC power source wired to card terminals.

4. Equipment Description - CO End

4.1 Introduction

The following paragraphs describe operating parameters and physical characteristics of Fiber Optic Link CO interface equipment.

All Fiber Optic Link CO interface cards are designed to operate on a maximum of 20 mA. This amount of power is readily available at any CO or remote digital or analog switch. In those rare situations where switch power is not available, alternative power sources have been developed for the Fiber Optic Link.

4.2 Shelves

The CO end of a typical Fiber Optic Link installation can consist of any of the following:

- 12-card shelf.
- Ward shelf.
- Single Unit Housing.

NOTES: Spacer rings are available for Extended Distance applications.

Each card slot may hold either 2-wire **or** 4-wire **cards depending on the application. The card shelf may be** instalted **vertically or horizontally.**

The CO/SUB Shelf is made of high dielectric plastic and consists of the following:

- Shelf base- Provides the slots for the 2-wire or 4-wire card PCBs.
- Cable section- Provides the channels for cable routing to the PCBs.
- Shelf cover- Provides environmental and physical protection.

All shelf card slots are equipped with card retaining clips to ensure that cards remain secure. In those applications requiring outdoor installation, the CO/SUB Shelf must be installed in a weatherproof enclosure.

3.2.1 12-Card Shelf

The CO/SUB 12-Card Shelf (P/N 8806-1230-01) is used to mount and connect the CO Card PCBs for up to 12 protected lines (2-wire or e-wire) in High-Density applications (see Exhibit 2).

NOTE: The shelf **measures approximately 15x7.5x9 inches (380x190x229 mm) and weighs 9 pounds (4.1 kg).**

The CO/SUB 12-Card Shelf Spacer Ring (P/N 8806-1299-01) provides three inches (76 mm) of additional depth to the CO/SUB 12-Card Shelf for cable clearance when the shelf is used in Extended Distance applications.

NOTE: The CO/SUB 12.Card Shelf Spacer Ring is used to prevent fiber damage due to crimping. The spacer ring measures 15~7.5~3 inches (380~190x76 mm) and weighs 2 pounds (0.9 kg).

4.2 Shelves, continued

4.2.3 5-Card Shelf

The CO/SUB 5-Card Shelf Spacer Ring (P/N 8806-1231-01) is used to mount and connect the CO Card PCBs for up to five protected lines (2-wire or 4-wire) in High-Density applications (see Exhibit 3).

NOTE: The shelf measures approximately 7.5x7.5x9 inches (190x190x229 mm) and weighs 5 pounds (2.3 kg).

The CO/SUB 5-Card Shelf Spacer Ring (P/N 8806-I 298-01) provides three inches (76 mm) of additional depth to the CO/SUB 5-Card Shelf for cable clearance when the shelf is used in Extended Distance applications.

NOTE: The CO/SUB 5-Card Shelf Spacer Ring prevents fiber damage due to crimping. The spacer ring measures 7.5x7.5x3 inches (190x190x76 mm) and weighs 1 pound (0.5 kg).

4.3 Low-Density

The Low-Density Housing (P/N 8806-I 200-03):

- Provides a mounting housing for a single PCB **in** Low Density applications (one of two lines).
- Consists of a weatherproof NID housing modified to mount Fiber Optic Link PCBs.
- Is made of high dielectric plastic (see Exhibit 4).
- Is designed to mount on a pole or backboard with the two screws provided.

The PCB is retained in the housing base by means of four nylon screws and standoffs. The housing cover is held in place by a single 3.8 inch captive retaining screw. A hasp on the cover can accommodate a standard padlock for increased security.

4.4 Weatherproof Cabinet

The weatherproof cabinet (P/N 8806-I 281-01) provides a weatherproof enclosure for Fiber Optic Link CO end shelves. The weatherproof cabinet (see Exhibit 5) consists of:

- Louvered metal box.
- Internal ¾ inch plywood backplane.
- Pole mounting bracket.

The metal box has two horizontal hinged doors equipped with dual internal locks. the plywood backplane measures 20x18 inches (508x457 mm) and provides enough space to mount two CO/SUB 12-Card shelves or four 5Card Shelves. Cable entrance and exists are provided by knockouts located in the bottom of the box. The pole mounting bracket is designed to attach the cabinet to the pole by means of two pole through bolts (the bolts are not provided with the housing).

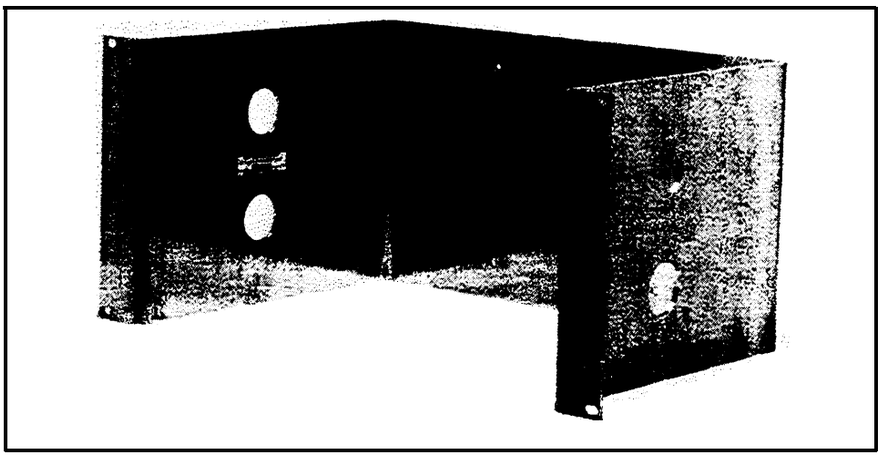
4.5 19-inch Rack Mounting Bracket

The 19 inch (483 mm) rack Mounting Brackets mount either 12-Card or 5Card CO/SUB Shelves into 19 inch (483 mm) inch equipment racks. Bracket:

- P/N 8806-l 291-02) is designed for shelves not using the spacer rings.
- P/N 8806-l 292-02) is used for shelf installations using the spacer ring to add depth to the shelf.

NOTE: Screws, washers, and bolts are provided to mount the Fiber Optic Link Card Shelves to the bracket. The rack mounting bracket card requires 8.75 inches (222 mm) of rack space and weighs 5.5 pounds (2.5 kg).

The following figure depicts a 19-inch (483 mm) mounting bracket.



4.6 CO Cards and CO Units

All Fiber Optic Link CO cards are designed to plug into 12-Card or 5-Card shelves or can be mounted in Low Density Housings. When a CO card is installed in a low density housing the assembly is called a Unit. All CO cards are designed to be powered via the copper cable pairs from the CO or switch. All cards have state-of-the-art surge protection, measure 7x4 inches (178x102 mm), and weigh about 1 pound (0.5 kg).

NOTE: A Unit (PCB installed in a low density housing) weighs 2 pounds (0.9 kg).

The following are CO Cards and CO Units:

- CO Cards-Short Haul.
- CO Cards-Extended Distance.
- CO Cards-2-wire.
- CO Cards-4wire data.
- CO Cards-4-wire E&M.
- E&M operation.
- CO Cards 9600 bps.
- CO Cards 56 kbps.
- CO Cards T-l data.

4.6 CO Cards and CO Units, continued

4.6.1 CO Cards-Short Haul

Short Haul cards are equipped with low cost transmitters and receivers. The transducers enable the transmission of light signals, through low cost plastic fiber, up to 66 feet (20 m) to SUB Cards or Units.

NOTE: Short Haul cards use plastic, push-pull fiber optic connectors.

4.6.2 CO Cards Extended Distance

Extended Distance Cards are equipped with more powerful transmitters and receivers that allow transmission of light signals through multimode fiber optic cable to SUB Cards or Units up to 2.0 miles (3.3 km) away.

NOTE: All extended distance cards can be equipped to handle fiber optic cable wtth ST connectors or SMA 905/906 connectors.

4.6.3 CO Cards 2-Wire

Fiber Optic Link 2-Wire CO Cards (Mended Distance P/N 8806-1234-03 or Short Haul P/N 8866-1232-03):

- Provide POTS, telemetering, and PBX (loop start) services that require ringing.
- Are compatible with any known CO Switch or PABX.
- Transmit analog data in the VF range to 9600 bps.

NOTE: The 2-wire CO PCB Is polarity insensitive and will operate satisfactorily at voltages as low as 18 VDC and currents as low as 18 mA.

4.6.4 CO Cards 2-Wire Data

Fiber Optic Link 2-Wire CO Cards (Extended Distance P/N 8806-1236-02 or Short Haul P/N 8866-I 232-02):

- Provide 2-wire analog data service up to 9600 bps for SCADA and other AC data transmission services that do not require ringing.
- Provide a constant transmission path in the VF range.
- Are designed to be powered by normal CO 20 mA sealing current and voltage.

Alternately, on leased lines, DC power can be inserted on the cable pair via the RLH Power Coupler.

NOTE: The PCB is polarity insensitive and will operate satisfactorily at voltages as low as 18 VDC and currents as low as 18 mA.

4.6
CO Cards and CO Units, continued

4.6.5 CO Cards 4-Wire Data

The 4-Wire CO Cards (Extended Distance P/N 8806-1235-03 or Short Haul P/N 8806-1233-03):

- Provide 4-wire analog data service up to 9600 bps.
- Provide full duplex service with constant transmission in both directions.
- Are the same electrically and can be interchanged end-to-end with Fiber Optic Link CO and SUB 4-wire cards.
- Are powered via normal sealing current.
- Is polarity insensitive and will operate satisfactorily at voltages as low as 24 VDC and currents as low as 12 mA.
- Can be powered from any 24 to 54 VDC source simplexed onto 4-wire transmit and receive pairs if sealing current is not available.

NOTE: **Alternately, all 4-wire cards can be powered by 24 to 54 VDC via auxiliary terminals located on the 4-wire PCB and be modified to enable power from the auxlllary terminals to be fed onto the transmit and receive cable pairs.**

4.6.6 CO Cards 4-Wire E&M

The 4-Wire E&M CO Cards (Extended Distance P/N 8806-1238-02 or Short Haul P/N 8896-l 237-02):

- Provide point-to-point isolation of CO or 4-wire PABX trunk-lines using E&M Leads.
- Are powered via normal sealing current.
- Are the same electrically as SUB Cards and can be interchanged end-to-end.
- Is polarity insensitive and will operate satisfactorily at voltages as low as 24 VDC and currents as low as 18 mA.
- Can be powered from any 24 - 54 VDC source simplexed onto 4-wire transmit and receive pairs if sealing current is not available.
- Are alternately powered by 24 - 54 VDC via auxiliary terminals located on the 4-wire PCB.
- Can be modified to enable power from the auxiliary terminals to be fed onto me transmit and receive cable pairs.

4.67 E&M Operation

Operation of a the 4-wire E&M Card can be visually monitored by three LEDs located on the card. LD1 indicates the state of the E&M relay (i.e., if LDl is On then relay RYl is Closed). LD2 and LD3 indicate the polarity of E&M input:

- If LD2 is On- input is Negative.
- If LD3 is On- input is Positive.

4.6
CO Cards and CO Units, continued

4.6.7 E&M Operation. continued

The 4-Wire E&M:

- Leads connect to the E&M IN and E&M OUT terminals on the PCB.
- IN terminals are isolated by optocoupler.
- Input current threshold is approximately 5 mA.
- Input voltage threshold is approximately 6 VDC.
- OUT terminals are isolated by a 100 Ohm solid state relay. Off resistance is greater than 1 M ohm.
- Current rating for the relay is 150 mA and maximum input voltage is 330 VDC (220 VAC rms).

4.6.8 CO Cards 9600 bps

The 4-Wire 9600 bps DDS CO Cards (Extended Distance P/N 8806-1313-01 or Short Haul P/N 8806-1313-01):

- Provide digital data service at 9600 bps.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within bandwidth of 500 Hz to 50 kHz at a maximum of 9600 bps.
- Is designed to be powered by normal voltage and sealing current of 20 mA on 4-wire transmit and receive.
- Is polarity insensitive and operates satisfactorily at voltages as low as 24 VDC and currents as low as 18 mA.
- Can power auxiliary terminals (labeled PS) on the card from any 24 - 54 VDC power source.
- Can be modified to enable power from the auxiliary terminals to be fed onto the transmit and receive cable pairs.

4.6.9 CO Cards 56 kbps

The 4-Wire 56 kbps CO Cards (Extended Distance P/N 8806-1314-01 or Short Haul P/N 8806-1312-01):

- Provide 4-wire 56 kbps service.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within bandwidth of 500 Hz to 350 kHz at a maximum of 64 kbps.
- Provide optimum gain, in the CO to SUB direction, via a jumper (PI) located on the PCB (see Exhibit 6).

  NOTE: PI has six jumper positions that match incoming signal strength by 6 dB increments. Gain is set by observing the green and red LEDs located on the PCB.

- Are designed to be powered by normal CO voltage and sealing current of 20 mA on 4-wire transmit and receive.
- Is polarity insensitive and operates satisfactorily at voltages as low as 24 VDC and currents as low as 18 mA.
- Can be powered from any 24 - 54 VDC power source using the auxiliary terminals (labeled PS) on the card.
- Can be modified to enable power from the auxiliary terminals to be fed onto the transmit and receive cable pairs.

4.6 CO Cards and CO Units, continued

4.6.10 CO Cards T-1 Data

The T-l CO Cards (Extended Distance P/N 8806-1315-01 or Short Haul P/N 8806-1316-01):

- Provide T-l data service.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within bandwidth of 10 kHz to 10 MHz at a maximum of 2.848 Mbps.
- Provide optimum gain, in the CO to SUB direction, via a jumper (PI) located on the PCB (see Exhibit 7).

  NOTE: Pl has six jumper positions that match incoming signal strength by 6 dB increments. Gain is set by observation of the green and red LEDs located on the PCB.
- Is designed to be powered by normal 24 - 54 VDC, 60 mA **T-l** span line power provided by the T-l repeaters.
- Operate at currents from 55 to 75 mA (card current limits at 75 mA).

5. Fiber Optic Cables and Hardware

5.1 Two Cable Types

Fiber Optic Link Cards convert all signals from standard copper pairs, convert them to light, transmit them over fiber optic cable, and convert them back to signals compatible with copper.

The Fiber Optic Link is designed to use two types of fiber optic cable. In applications:

- Requiring separation of Fiber Optic Link CO interface unit and SUB unit by no more than 66 feet (20 m), low cost Duplex Fiber Optic Cable with plastic fibers is used.
- Where the separation is greater than 66 feet (20 m), Standard Fiber Optic Cable with multimode glass fibers and ST or SMA connectors is used.

5.2 Plastic Fiber Cable

Fiber Optic Link Duplex Fiber Optic Cable Assemblies:

- Provide the transmission capability in applications where the CO and SUB interface units are no more than 66 feet (20 m) apart.
- Consist of two single step index plastic fibers sheathed in a PVC jacket and joined with a web.
- Identifiy each fiber by marking on only one of the fiber PVC jackets.
- Have each fiber terminated with gray and blue push-pull male fiber optic connectors located on opposite ends.
- Possess Connectors are color coded to easily identify transmit and receive channels and to match female connectors located on the following individual PCBs.
  - The gray connector mates with the gray or black transmit connector on the PCB.
  - The blue connector mates with the blue receive connector on the PCB.
- Possess cable that is a UL recognized and passes UL VW-l flame retardant specifications.

5.2 Plastic Fiber Cable, continued

NOTE: These safe cable properties in flammable environments, along with its nonconductive electrical characteristics, make use of conduit unnecessary in most applications.

Duplex Fiber Optic Cable Assemblies are customized for each application. The following chart describes the part numbers and length parameters.

Part Number	Length
8806-l 204-02	18 inches (457 mm).
8806-l 208-02	19 inches to 33 feet (483 mm - 10 m).
8806-l 213-02	33 feet to 66 feet (10 m - 20 m).

NOTE: Cable assemblies used with the 5- and 12-Card shelves must be at least three feet (1 m) long to allow for cable routing requirements.

5.3 Multimode Fiber Optic Cable

RLH Fiber Optic Link Extended Distance Cards are designated to use 62.5/125 µm multimode fiber optic cable equipped with ST or SMA multimode connectors. Other fiber sizes than can be utilized are:

- 50/125 µm.
- 85/125 µm.
- 100/140 µm.

NOTE: Ready to install fiber optic cable assemblies with ail necessary hardware is supplied by the Fiber Optic Link manufacturer – RLH industries. Alternately, fiber optic cable can be supplied by any standard vendor.

6. Equipment Description-SUB End

6.1 Typical Installation

The SUB end of a typical Fiber Optic Link installation consists of:

- A 5- or 12-Card CO/SUB Card shelf or a single-unit housing and SUB Card(s).
- A low-density or high-density power supply.

6.2 Housings

All Fiber Optic Link PCB housings are used at both ends of an installation (see Section 4).

6.3 SUB Cards and SUB Units

All Fiber Optic Link SUB Card(s):

- Are designed to plug into 5 or 12-card shelves or can be mounted in Low Density Housings.
- Result in an assembly called a Unit when a SUB card is installed in a Low Density (single card) Housing.
- Are designed to be powered via 24 VDC connected to terminals on the SUB PC9 and:
  - Have state-of-the-art surge protection.
  - Measure 7x4 inches (178x102 mm).
  - Weigh about one pound (0.5 kg).

NOTE: A Unit (PCB installed in a low density housing) weighs two pounds (0.9 kg).

6.3.1 SUB Cards-Short Haul

Short Haul Cards are equipped with low cost transmitters and receivers. These transducers enable the transmission of light signals through low cost plastic fiber (0 - 66 feet [0 - 20 m]) to CO Cards or Units.

NOTE: Short Haul Cards use, plastic, push-pull fiber optic connectors.

6.3.3 SUB Cards-Extended Distance

Extended Distance Cards are equipped with more powerful HP transmitters and receivers that allow transmission of light signals through multimode fiber optic cable to CO Cards or Units up to 2.0 miles **(3.3** km).

Extended Distance Cards can be equipped to handle fiber optic cable with ST connectors or SMA 905/906 connectors.

6.3.3 SUB Cards 2-Wire

Fiber Optic Link 2-Wire SUB Cards (Extended Distance P/N 8806-1244-03 or Short Haul P/N 8806-1242-03):

- Provide the following services that require ringing:
  - POTS.
  - Telemetering.
  - PBX (loop start).
- Provide sine wave ringing at 90 V rms and transmit analog data in the VF range to 9600 bps.
- Are designed to be powered by an isolated 24 VDC power supply and draws:
  - 70 mA on-hook.
  - 150 mA off-hook.
  - 200 mA ringing.

6.3 SUB Cards and SUB Units, continued

6.3.4 SUB Cards 2-Wire Data

Fiber Optic Link 2-Wire Data SUB Cards (Extended Distance P/N 8806-1246-02 or Short Haul P/N 8806-1249-02):

- Provide 2-wire analog data service up to 9600 bps for SCADA and other AC data transmission services that do not require ringing.
- Provide a constant transmission path in the VF range.
- Are designed to be powered by an isolated 24 VDC power supply and draw 45 mA.

6.3.5 SUB Cards 4-Wire Data

Fiber Optic Link 4-Wire SUB Cards (Extended Distance P/N 8806-1245-03 or Short Haul P/N 8806-l 243-03):

- Provide 4-wire analog data service up to 9600 bps.
- Provide service that is full duplex with constant transmission in both directions.
- Are the same electrically as CO Cards and can be interchanged end-to-end.
- Are designed to be powered by an isolated 24 VDC power supply connected to auxiliary terminals on the PCB.
- Can alternately can be powered from any 24 - 64 VDC sourced simplexed onto 4-wire transmit and receive pairs.
- Can be modified to enable power from the auxiliary terminals to be fed onto transmit and receive cable pairs.

6.3.6 SUR Cards 4-Wire E&M

Fiber Optic Link 4-Wire E&M SUB Cards (Extended Distance P/N 8806-1248-02 or Short Haul P/N 8806-1247-02):

- Provide point-to-point isolation of 4-wire trunk-lines using E&M Leads.
- Are designed to be powered by an isolated 24 VDC power supply connected to auxiliary terminals on the PCB.
- Can alternately be powered from any 24 - 54 VDC power sourced simplexed onto 4-wire transmit and receive pairs.
- Are the same electrically as E&M CO Cards and can be interchanged end-to-end.
- Can be modified to enable power from the auxiliary terminals to be fed onto transmit and receive cable pairs.

6.3 SUB Cards and SUB Units, continued

6.3.7 E&M Operation

Operation of a the 4-wire E&M Card can be visually monitored by three LEDs located on the card. LD1 indicates the state of the E&M relay (i.e., if LD1 is ON then relay RY1 is Closed). LD2 and LD3 indicate the polarity of E&M input:

- If LD2 is On – input is Negative.
- If LD3 is On- input is Positive.

The E&M:

- Leads connect to the E&M IN and E&M OUT terminals on the PCB.
- IN terminals are isolated by optocoupler.
- Input current threshold is approximately 5 mA.
- Input voltage threshold is approximately 6 VDC.
- OUT terminals are isolated by a 100 ohm solid state relay. Off resistance is greater than 1 M ohm.
- Current rating for the relay is 150 mA and maximum input voltage is 330 VDC (220 VAC rms).

6.3.8 SUB Cards 9600 bps

The 4-Wire 9600 bps DDS SUB Cards (Extended Distance P/N 8806-1323-01 or Short Haul P/N 8806-1323-01):

- Provide digital data service at 9600 bps.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within bandwidth of 500 Hz to 50 kHz at a maximum of 9600 bps.
- Are designed to be powered by an isolated 24 VDC power supply connected to auxiliary terminals on the PCB.
- Can alternately be powered from any 24 - 54 VDC source simplexed onto 4-wire transmit and receive pairs.
- Can be modified to enable power from the auxiliary terminals to be fed onto the transmit and receive cable pairs.

6.3.9 SUB Cards 56 kbpS

The 4-Wire 56 kbps SUB Cards (Extended Distance P/N8806-1324-01 or Short Haul P/N 8806-I 322-01):

- Provide 4-wire 56 kbps service.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within bandwidth of 500 Hz to 350 kHz at a maximum of 64 kbps (see Exhibit 8).

NOTE: The Pl jumper on the card PCB enables the gain selected on the 56 kbps CO Card to be duplicated (as loss) on the 56 kbps SUB Card. P1 has six jumper positions that correspond to six jumper positions on the CO Card.

- Are designed to be powered by an isolated 24 VDC power supply connected to auxiliary terminals on the PCB.
- Can alternately be powered from any 24 - 54 VDC source simplexed onto (Q-wire transmit and receive pairs.
- Can be modified to enable power from the auxiliary terminals to be fed onto the transmit and receive cable pairs.

6.3 SUB Cards and SUB Units, continued

6.3.10 SUB Cards T-l Data

The T-1 SUB Cards (Extended Distance P/N 8806-1325-01 or Short Haul P/N 8806-1326-01):

- Provide T-1 data service.
- Possess incoming bipolar signals (4V P-P Max) with no DC reference within a bandwidth of 10 kHz to 10 MHz at a maximum of 2.048 Mbps (see Exhibit 9).

NOTE: The P2 jumper on the SUB Card enables the gain on the T-l CO Card to be duplicated (as loss) on the T-l SUB Card. P2 has six jumper positions that correspond to six jumper positions on the CO Card.

- Are powered by an isolated 24 VDC power supply connected to auxiliary terminals on the PCB.
- Can alternately be powered from any 24 - 54 VDC source simplexed onto 4wire transmit and receive pairs.
- Draws 60 mA and current limits at 75 mA.

NOTE: The T-l SUB Card PCB can be modified to enable power from the auxiliary terminals to be fed onto the transmit and receive cable pairs.

6.4 Low-Density AC/DC Power Supply

The Low-Density AC/DC Power Supply (P/N 8806-1203-04):

NOTE: A green LED on the housing indicates an AC input and a yellow LED indicates a DC output.

- Provides a 24 VDC power source for powering up to four Fiber Optic Link SUB Units or Cards (2 or 4-wire).
- Consists of an AC/DC rectifier and a 24V, 1.2 A battery backup contained in a modified NID housing (see Exhibit 10).
- Power supply requires 115VAC mains supply for operation.
- Is protected by a 1.6 A fuse on the mains input and a 3.0 A fuse on the DC output.
- Has a battery backup that provides:
  - Approximately 11 hours of emergency service on a 2-wire SUB or 48 hours of service for a 4-wire circuit.
  - Three hours of emergency service for application using four 2-wire SUB Cards, depending on usage.
- Possesses a weatherproof housing and measures 9.59x7.4x inches (244x188x76m m) and weighs 5.23 pounds (2.4 kg including battery).

6.5 Low-Density Replacement Battery

The Low-Density replacement battery (P/N 8806-1205-03):

- Is used to replace a battery backup that has been in service for five years or longer.
- Consists of two, 12V, 1.2 A/hour, rechargeable, lead-acid batteries with approximately five years of service life.
- Charge is maintained by the Low Density Power Supply rectifier.

6.6 High-Density Power Supply

The Fiber Optic Link High-Density Power Supply (P/N 8806-1206-03):

- Provides a 24 VDC, 2.5 A power source for powering up to 12 SUB cards, either 2-wire or 4-wire, in a CO/SUB card shelf.
- Consists of an AC/DC converter (PSU), 24 VDC, 2.6 A/hour battery pack and connecting battery cable.
- Has screw-down terminals that provide independent connections for each card to be powered.
- Requires a 115 VAC main supply for operation and is protected with an internal 3 A fuse on the output and a 1.6 A fuse on the 115 VAC input.
- Provides a green LED on the power supply which indicates AC operation.
- Provides approximately two hours of emergency service for 12, 2-wire SUB cards or for hours of back-up for six 2-wire cards depending on configuration and usage. (See Section 7, System Engineering, for more information.)
- Operates from **-40°C** to **+50°C**. In outdoor applications, however, the unit must be installed in a weatherproof enclosure.
- Has an associated battery pack that weighs 9.5 pounds (4.3 kg).

6.7 High-Density Replacement Battery

The high-density power supply replacement battery (P/N 8806-1207-02):

- Replaces a battery back-up that has been in service for five years or longer.
- Consists of two, 12V, 2.6 A/hour, rechargeable, lead-acid batteries.
- Has a service life of approximately five years.

6.8 130V/24V DC/DC Converter

The 130V high-density DC/DC converter (P/N 8806-I 275-01):

- Provides a means to convert 130 VDC to 24 VDC for powering Fiber Optic Link SUB-end equipment.
- Has maximum output of 1.5 A.
- Powers up to twelve, 2-wire and 4-wire SUB units or cards.
- Operates from **0°C** to **+50°C**. If used outdoors, however, the unit must be mounted in a weatherproof enclosure.
- Measures 9.8x4.9x2.5 (249x124x64 mm) and weighs 1.3 pounds (0.6 kg).

6.9 48V/24V DC/DC Converter

The 48V high-density DC/DC converter (P/N 8806-1278-01):

- Provides a means to convert 48 VDC to 24 VDC for powering Fiber Optic Link SUB-end equipment.
- Has maximum output of 1.5 A, which is sufficient to power up to twelve, 2-wire and 4-wire SUB units or cards.
- Operates from **0°C** to + **50°C**. If used outdoors, however, the unit must be mounted in a weatherproof enclosure.
- Measures 9.8x4.9x2.5 (249x124~64 mm) and weighs 1.3 pounds (0.6 kg).

7. System Engineering

7.1 Initial Considerations

The Fiber Optic Link provides high-voltage protection by isolating the CO exchange cable pairs (ground) from any source of high voltage by a section of non-conductive fiber optic cable.

NOTE: To m**aintain the integrity of this protective system, give careful consideration before installation to the areas of:**

- **Safety.**
- **Service requirements.**
- **Isolation requirements.**
- **Equipment placement.**
- **CO-end powering requirements.**
- **SUB-end powering requirements.**
- **Fiber optic power budgets.**
- **Equipment selection.**
- **System applications.**

7.2 Service Requirements

Fiber Optic Link equipment provides high-voltage isolation for most common telecommunications services including:

- Standard 2-wire telephone (POTS).
- 4-wire data.
- 2-wire data.
- DC signaling.
- 4-wire E&M.
- 9600 bps.
- 56 kbps.
- T-1 data.

7.3 2-Wire Telephone Service

Fiber Optic Link 2-wire equipment:

- Provides high-voltage isolation for standard 2-wire telephone lines.
- Is compatible with both tone and pulse dialing.
- Is used for:
  - Dial-up modems with speed to 9600 bps.
  - Loop start and manual PBX operation and OPX service.

Note: A modiied version of the Fiber Optic Link is available that will reproduce ring frequencies up to $66^{2}/_{3}$ Hz.

7.4 4-Wire Data Service

Fiber Optic Link 4-wire equipment:

- Is used when 4-wire data transmission is required. Such service may include service to 4-wire:
  - On-line modems.
  - SCADA systems.
  - Audio-tone protective relaying systems.
- Transmits analog data in the VF range (300 - 3400 Hz) at 9600 bps or less.

7.5 2-Wire Data Service

The 2-wire data equipment:

- Provides high-voltage isolation when 2-wire data transmission is required. Such service may include 2-wire:
  - On-line modems.
  - SCADA systems.
  - Audio-tone protective relaying systems.
- Transmits data to 9600 bps or less in the VF range (300 - 3400 Hz).

7.6 DC Signaling

The Fiber Optic Link must be used in conjunction with equipment that converts DC signaling schemes into analog frequencies in the VF range (300 - 3400 Hz). The schemes are:

- DC trip systems.
- AC/DC pilot-wire systems.
- Other DC transmission systems using leased lines that require high-voltage isolation.

By using FSK conversion techniques, up to 64 DC telemetry ports can be multiplexed for transmission over one Fiber Optic Link 4-wire or 2-wire system.

NOTE: The FSK conversion equipment is provided by a different vendor.

7.7 4-Wire E&M Service

Fiber Optic Link 4-Wire E&M equipment is used to provide isolation for 4-wire E&M lines. The service is used for:

- PABX trunks.
- Remote relay closures.
- Extending E&M resistance limits.

7.8 9600 bps Digital Data Service

Fiber Optic Link 9600 bps equipment provides service for Digital Data Service entering a high voltage area. The equipment is used to:

- Isolate 9600 bps lines between sub-stations.
- Isolate 9600 bps connecting metering or PABX.
- Transmit 9600 bps data up to 2.0 miles (3.3 km) without loss.

7.9 56 kbps Service

56 kbps equipment issued to provide isolation on medium capacity digital metering lines. These lines can feed:

- On-line modems.
- SCADA systems.

NOTE: **Can isolate copper lines from the effects of radiation and high frequency interference.**

7.10 T-1 Data Services

Fiber Optic Link T-l equipment can be used on high capacity 4-wire T-1 lines entering high voltage areas.

T-l cards will transmit digital data up to 2.08 Mbps over fiber optic cable with a length to 1.0 mile (1.6 km) without gain or loss.

7.11 Isolation Requirements

The Fiber Optic Link isolates cable pairs via fiber optic cable. However, when both CO and SUB ends of a system are to be installed within the zone of GPR, consideration must be given to the electrical isolation of the CO-end housings. Because of these GPR considerations, all equipment is designed to be wall mounted on a minimum one-inch thick plywood backplane. Following the recommended installation procedures, this installation provides:

- A minimum 35 kV rms isolation for applications using the low-density housing.
- More than 50 kV rms for applications using the 12-Card or 5-Card CO/SUB card shelves. The isolation voltages are adequate for most applications.

7.12 Site Preparation

Care must be taken during backplane installation and location to minimize the possibility of moisture contamination of the backplane. Moisture contamination can substantially reduce the isolation provided by a particular installation. Isolation can be compromised:

- If screws and hardware used to mount the backplane are not staggered to prevent contact with hardware used to install the Fiber Optic Link housings.
- By using a backplane of less than one-inch thickness to reduce the isolation provided.

NOTE: See **Exhibit 11- Fiber Optic Link Breakdown Voltages, for isolation voltages provided by various conditions.**

7.13 Equipment Placement

The Fiber Optic Link can be used in two configurations:

- Short haul.
- Extended distance.

7.14 Short Haul Systems

Short haul systems are those in which the physical separation is 66 feet (20 m) or less. In these systems:

- Both CO and SUB-ends are usually located in the zone of GPR.
- A high-dielectric, copper, telephone-company cable from outside the zone of GPR is routed to the CO-end equipment.
- The closer the Optical Link CO end is installed to the entrance of the exchange cable pairs into the hazard area, the less risk there is for cable pairs to become a conduit for potentially high voltage during a fault condition. CO-end equipment, therefore, must be:
  - Located at the entrance of the exchange pairs into the hazard area or as near as possible to the entrance.
  - Installed before any distribution block, punch-down block, etc.

WARNING: To **prevent the possibility of personnel bridging the protective length of fiber optic cable with their person or tools, the CO and SUB-end equipment must be physically separated by at least five feet (1.5 m).**

Another consideration must be the proximity of CO- and SUB-end equipment. CO- and SUB-end equipment located within five feet (1.5 m) of one another present the possibility of maintenance personnel bridging the protective fiber optic cable with their hands or tools, thus compromising the high-voltage protection as well as their own safety.

One way to achieve CO- and SUB-end separation is to locate the Fiber Optic Link CO and SUB equipment in different rooms and run the connecting fiber optic cable through the wall.

To achieve the goal of physical separation, preparation of two locations might be required, one each for:

- CO equipment.
- SUB equipment.

Only the site for the CO-end equipment has to be prepared, however, with high-voltage GPR considerations in mind. No special precautions, other than normal plant practices, need to be taken with site preparation of SUB-end equipment.

7.15 Extended Distance Systems

Extended distance systems are those in which the CO- and SUB-end equipment is separated by more than 66 feet (20 m). The design of the Fiber Optic Link allows for separations of two miles or more. In such installations:

- me CO equipment is usually located outside the zone of any GPR of 300V peak or more.
- Fiber optic cable is run into the zone of influence to the SUB-end equipment.
- For outdoor location:
  - All Fiber Optic Link assemblies are temperature rated to –40°C and +50°C plus maximum solar load.
  - The Fiber Optic Link single PCB housing is weatherproof.
  - 12-Card and 5-Card shelves require weatherproof enclosures.

SUB-end equipment in extended distance systems may be located in the zone of influence as normal plant practices dictate. All equipment, however, is designed for wall mounting. If one of the power supplies is to be used, an AC outlet must be accessible.

7.16 CO-End Powering Requirements

The Fiber Optic Link:

- Is an "active" system designed to provide high-voltage isolation via a variable length of fiber optic cable (see Exhibit 12).
- Requires power to operate both CO- and SUB-end equipment.
- Is designed to enable the powering of all CO cards via the copper 2-wire or 4-wire cable pairs. Powering of:
  - 2-Wire CO Cards are via normal CO battery.
  - 4-Wire CO Cards are via normal sealing current.
  - T-l CO Cards are via normal T-l span line power.

NOTE: Refer to Exhibit 13 for Fiber Optic Link CO Card power requirements.

7.17 2-Wire Powering in OPX Applications

The extended distance version of the Fiber Optic Link can be used to provide high-voltage isolation for a telephone located outside the zone of GPR but operating on a line derived from a PBX located within the GPR zone (OPX). In this application the extended distance CO 2-wire cards or unit must be located within the zone of GPR and the extended distance 2-wire SUB cards or units located outside the area of GPR.

7.18 4-Wire CO- End Powering via CO Battery

Fiber Optic Link standard systems, using short fiber optic cable lengths, usually have both ends of the system located within the zone of GPR. In this application:

- If both ends were powered by the same power source, e.g., AC/DC converter, customer battery, etc., the power source will become a conduit for a high-voltage potential during a fault condition and compromise the isolation.
- The CO 4-wire card, like the Z-wire data card and Z-wire POTS card, is designed to be powered via the Transmit and Receive cable pairs, while the SUB end is powered via an entirely separate source.

The power source of choice is normal sealing current. Fiber Optic Link 4-wire cards require only 12 mA to operate and 4-wire cards require 18 mA.

If sealing current is not available, CO battery or other DC power source can be simplexed onto 4-wire transmit and receive via the 4-wire powering coil (P/N 8806-I 251-01). See Exhibit 14.

NOTE: However, use of the powering coil adds 1.5 dB loss in each direction of transmission.

7.19 4-Wire CO- End Powering via Current Generators

Current generators can be used to add power to 4-wire Transmit and Receive pairs. However, there should be at least:

- 12 mA available for proper 4-wire card operation.
- 18 mA available for 4-wire E&M Card operation.

7.20 4-Wire CO- End Powering via Auxiliary Power Feed Terminals

For extended distance applications-those outside the zone of GPR -auxiliary terminals are provided on the 4-wire CO card for local powering from a 24 - 54 VDC power source. This power source can be the low-density power supply (P/N 8806-1203-04). A voltage of 115 VAC must be available for the low-density power supply.

NOTE: **4-wire cards are the sameelectrically and can be interchanged card-to-end.**

7.21 SUB-End Powering Requirements

All SUB-end equipment requires an external 24 VDC power source in order to operate.

The 24 VDC can be supplied by the customer or by one of the Fiber Optic Link power supplies.

Power supplies are available to operate off standard 115 VAC or to convert either 130 VDC or 48 VDC for SUB-end operation.

NOTE: Refer to Exhibit 15 for Fiber Optic Link SUB card power requirements.

7.22 SUB-End Powering Using AC/DC Converters

AC/DC converters available to power Fiber Optic Link SUB units or cards are the:

- High-density power supply (P/N 8806-1206-03), which will convert 115 VAC to 24 VDC to power up to twelve SUB cards or units.
- Low-density power supply (P/N 8806-1203~04), which will power up to four SUB-end cards or units.

NOTE: Each AC power supply is provided with an external battery back-up.

7.23 Power-Supply Battery Back-Up Calculations

Battery back-ups are designed to enable the functioning of telecommunications circuits in the event of a local AC power outage. The battery back-up for the:

- High-density power supply is a 2.6 A/hour lead-acid, rechargeable battery.
- Low-density power supply is a 1.2 A/hour battery.

The amount of time a protected line operates on its battery back-up depends on the:

- Equipment type and amount of current required for operation.
- Number of systems operating on the backup.
- Telephone usage standard used.

See Exhibit 15 for a listing of the current required for the various Fiber Optic Link SUB-end cards.

Normal telephone usage is estimated to be seven minutes per hour. For the purpose of estimating back-up times for Fiber Optic Link serviced systems, usage is routinely more than doubled to 15 minutes of every hour. A 2-wire SUB card or unit, therefore, is estimated to require an average 90 mA per hour to operate.

EXAMPLE: For an installation using two standard 2-wire lines and one 4-wire circuit, the average current draw per hour is approximately 200 mA.

If the low-density power supply is used to power all lines, the 1.2 A/hour battery back-up will provide approximately six hours of emergency service.

7.24 SUB-End Powering with DC/DC Converters

The two DC/DC converter options available for powering SUB-end equipment are:

- 130V high-density converter (P/N 8806-I 275-02), which converts an in-house 120-I 50 VDC power source to a regulated 24 VDC, 1.5 A (peak) output for powering up to twelve SUB-end cards or units.
- 48V high-density convener (P/N 8806-1278-02), which converts a 45-55 VDC source to a regulated 24 VDC, one A (peak) output for powering up to twelve SUB-end cards or units.

NOTE: The in-house source voltage must have a battery back-up in case of AC failure, or communications will be lost during power outages.

7.25 Fiber Optic Cable Notes

The short haul version of the Fiber Optic Link is designed to operate over a maximum length of 66 feet (20 m) of 100/140 µm all plastic, duplex, fiber optic cable. The plastic cable is fitted with color coded (blue = RCV, gray/black = XMT) push/pull connectors.

NOTE: **Fiber optic link requires a separate fiber for each direction of transmission (full duplex). This cable assembly can be ordered in any length up to 66 feet (20 m).**

The extended distance version of the fiber optic link is designed to operate over standard multimode glass fiber cable fitted with ST or SMA 905/906 connectors. (The 906 connector has a step at the end fitted with a plastic ferrel for closer alignment.) One fiber is required in each direction of transmission, or two fibers per system. Although the most common multimode fiber is 62.5/125 µm, other glass fiber sizes can be used with the system. Exhibit 12 lists:

- me maximum and minimum LED power budget available with four alternative cable types.
- Typical attenuations for the cable types.

7.25 **Fiber Optic Cable Notes, continued**

The attenuation for a particular cable, however, is verified with the manufacturer.

Cable for high-voltage isolation must be all dielectric and specified for aerial or conduit application. In conduit routes, a five percent excess must be ordered to ensure adequate cable length and flexibility of installation. When engineering aerial applications using all-dielectric cable, cable sag characteristics must be satisfied as well as the recommended five percent coverage (see Exhibit 16).

7.26 **CO-End Equipment Selection**

Fiber Optic Link CO-end equipment interfaces the CO exchange-cable pairs with the SUB-end equipment. The 12-Card CO/SUB card shelf holds up to twelve 2-wire or 4-wire cards, which are interchangeable in the shelf slots (see Exhibit 17). Care must be taken, however, that 2-wire and 4-wire cards are matched end-to-end (between CO and SUB).

Short haul and extended distance applications require different cable types fitted with different connectors. All CO cards in a particular application, whether 2-wire or 4-wire, must be either short haul or extended distance.

7.27 **SUB-End Equipment Selection Notes**

SUB-end equipment interfaces the customer premises equipment with the CO-end equipment. The 12-Card CO/SUB card shelf holds up to twelve 2-wire or 4-wire cards, which are interchangeable in the shelf slots. Care must be taken, however, that 2-wire and &wire cards are matched end-to-end (between CO and SUB).

Short haul and extended distance applications require different cable types fitted with different connectors. All SUB cards in a particular application, whether 2-wire or 4-wire, must be either short haul or extended distance. SUB-end equipment requires an external 24 VDC power source to operate.

7.26 **Optional Equipment Selection**

The Fiber Optic Link optional equipment consists of:

- Cable.
- Power supplies.
- Battery back-up.

NOTE: Review the powering options available before selecting optional equipment.

Fiber Optic Link SUB-end equipment requires a 24 VDC power source. If the customer premises has a source of 24 VDC with a back-up battery supply, the Fiber Optic Link power supplies need not be selected.

Short haul system fiber optic cable length can be varied to any distance up to 66 feet (20 m) by selecting fiber optic duplex cable (P/N 8806-1208-02 or P/N 8806-l 213-02). Specify the cable length on the ordering document.

NOTE: Due to cable routing requirements, when using Fiber Optic Link CO/SUB-card shelves, a minimum of three feet of cable must be ordered.

7.29 **Recommended Spares**

Appropriate spare parts quantities are determined by the amount and configuration of Fiber Optic Link equipment installed in the plant to be supported by the spares. See Exhibit 18 for a listing of recommended spares based on the number of units in service . The estimated product failure rate and system performance impact of each assembly is taken into consideration.

8. System Installation

8.1 Personnel Requirements

The Fiber Optic Link can be installed by exchange plant personnel without special in-depth training in fiber optic transmission. Some training in high-voltage protection procedures is desirable.

8.2 Tool and Test Equipment Requirements

Standard hand tools required for a typical installation are:

- Wire cutters.
- Wire strippers.
- 1/4-inch drill or its equivalent.
- Screwdrivers (common).
- Standard VOM for measuring:
  - DC line voltage/current.
  - Line or subscriber VF pair resistance.
  - SUB drop voltage/current.
  - Induced AC.

8.3 Equipment Storage

Fiber Optic Link equipment is stored in its shipping carton. All loose items (such as cards, plug-ins, etc.), are stored to prevent damage from handling or environment. Cards may be stored in a spare terminal or shelf if not kept in their original shipping carton.

8.4 Equipment Labels

The equipment labels sent with or attached to the various Fiber Optic Link assemblies contain necessary identification data and, in some cases, valuable installation information.

8.5 Low-Density System Installation

The typical Fiber Optic Link low-density, short haul system consists of a:

- CO unit, either 2-wire or ldwire.
- A fiber optic duplex cable assembly (5 feet/l.5 m).
- SUB unit, either 2-wire or 4-wire.
- Low-density power supply (see Exhibit 19).

The length of the fiber optic cable can vary to 66 feet (20 m) using P/N 8806-1208-02 or P/N 8806-1213-02, or to three miles (4.9 km) in extended distance systems. The installation procedures will remain the same.

8.6 Mounting the Housing to the Backplane

Care must be taken to locate CO and SUB units within reach of the fiber optic cable assembly supplied with the system.

All low-density housings have the same dimensions (see Exhibit 20).

Use the instructions in the following chart for mounting the low-density housings to the backplane.

Step	Mounting a Low-Density Housing to Backplane
1	Position the housing on the backplane so that the cable access holes are at the bottom.
2	Use the housing base as a template to mark the screw hole locations on the plywood backplane (see Exhibit 20).
3	Drill pilot holes using a 1/8-inch drill.
4	Line up the housing with the pilot holes and attach to the backplane using the two wood screws provided with the housing.

NOTE: **Housings must be arranged so that the hinged access can open fully.**

8.7 Connect Fiber Optic Cable

The fiber optic duplex cable assembly (P/N 8806-1204-02, P/N 8806-1208-02, or P/N 8806-1213-02) has two color-coded connectors on each end which plug in as follows:

Connectors	Plug Into the Fiber Optic
Blue	Receiver on the CO unit and SUB unit
Gray or Black	Transmitter on the CO and SUB units

NOTE: The fiber optic duplex cable assembly connectors must be plugged into terminations of the same color for the system to operate.

8.8 Connecting CO-Unit Wiring

Route CO exchange pairs to the CO unit.

CAUTION: Ensure that the cable or cable pairs from the CO exchange are insulated from any possible contact with high voltage or GPR up to the connection to the CO unit.

8.9 Connecting CO Unit, 2-Wire

Inside the CO-unit housing cover is a label illustrating wiring connections (see Exhibit 21). Note that the 2-wire CO unit is not sensitive to polarity.

8.10 Connecting CO Unit, 4-Wire

Inside the 4-wire unit housing cover is a label illustrating wiring connections (see Exhibit 22). The 4-wire unit is not sensitive to polarity. me 4-wire service is designed to be transparent to the telephone company network and customer premises data equipment.

The 4-wire unit cards will pass through any signals with levels up to + 7 dBm without gain or loss. No adjustment is needed.

8.11 Connecting SUB Unit, 2-Wire

Inside the SUB-unit housing cover is a label illustrating wiring connections. (See Exhibit 23 - SUB 2-Wire Card/Unit Wiring Label.)

NOTE: Two-wire SUB units will not operate If the powering connection is reversed. Verify connection before powering up the system.

8.12 Connecting SUB Unit, 4-Wire

Inside the 4-wire SUB-unit housing cover is a label illustrating wiring connections (see Exhibit 24).

The 4-wire service is designed to be transparent to the telephone company network and customer premises data equipment. The 4-wire unit cards, therefore, will pass through any signals with levels up to +7 dBm without gain or loss. No adjustment is needed.

8.13 Installing the Low-Density Power Supply

The low-density power supply consists of an AC/DC converter and 24 VDC battery back-up in a Low Density Housing. Installation requires:

- Installing the power supply.
- Troubleshooting the power supply

One low-density power supply will power up to four Fiber Optic Link SUB units, 2-wire and e-wire.

8.13.1 Installing the Power Supply

The following chart describes the Low-Density Power Supply installation steps.

Step	Installing a Low-Density Power Supply
1	Locate power supply within six feet (1.8 m) of a source of mains AC.
2	Attach the housing to the backplane.
3	Use a screwdriver to open the box at the Customer Access.
4	Remove the three A fuse (F2) taped to the inside of the power supply housing. **CAUTION: Installing F2 will immediately put battery output of 24 VDC across connectors PI and P2.**

(continued)

8.13 Installing the Low-Density Power Supply, continued

8.13.1 Installing the Power Supply, continued

Step	Installing a Low-Density Power Supply
5	Insert the fuse into the fuseholder (F2) on the power supply PCB. **CAUTION: To prevent discharge of power supply batteries, plug the Power Supply AC power cord in to a mains outlet.**
6	Connect the fiber optic cards or units to Pl (+) and P2 (-) on the PCB. **NOTE: The rubber grommet can be removed for this process.**
7	Make a hole in the rubber grommet with a screwdriver and pass the connecting wire through.
8	Connect the wires to Pl and P2 and replace the grommet.
9	Close the access door and secure using the screwdriver.
10	The power supply is now operational.

8.13.2 Troubleshooting the Power Supply

Troubleshooting the AC/DC Power Supply always begins with the observation of the two LEDS on the housing. LED indications:

- Green indicates AC input.
- Yellow indicates DC input.

The following chart describes the AC/DC Power Supply troubleshooting LED indications.

Green Indication	Yellow Indication	What Happens...
LED On	LED On	Normal operation- Note that these LEDs will be On even if the backup battery is discharged or disconnected from the system.
LED Off	LED On	Loss of AC – Power supply is operating on the backup battery. 1. Check AC supply. 2. Check the AC input fuse (Fl) on the power supply PCB. 3. Replace the fuse if blown.

(continued)

8.13 Installing the Low-Density Power Supply, continued

8.13.2 Troubleshooting the Power Supply, continued

Green indication	Yellow indication	What Happens...
LED On	LED Off	Output voltage less than 24 VDC. 1. Check the load on the power supply. 2. Disconnect all cards/units. **NOTE: A defective card/unit is indicated if a yellow LED illuminates.** **3.** Reconnect cards one at a time to pinpoint trouble. NOTE: **Yellow LED shorted or disconnected.**
LED Off	LED Off	Power supply is inoperative. **1.** Check if the batteries are discharged or disconnected. 2. Check the mains supply. 3. If the mains supply is OK, check the fuse (Fl) on the power supply PCB. 4. Replace the fuse with a 1.6 A (5x20 mm). NOTE: **if still no output, power supply must be repaired.** **5.** Replace with spare and return inoperative power supply to supply/vendor.

8.14 System Test-Low-Density

After connecting the 24 VDC wiring from the SUB unit to the power supply terminals, perform the test outlined in the following chart.

Step	Testing the System – Low-Density
1	Replace all low-density unit housing covers and plug the power supply AC plug into a 115 VAC outlet.
2	Test the system installation by using a handset or data set.

If the System	Then...
Does not operate properly	1. Review installation procedures. 2. Check all connections, 3. Retest.
Still does not operate	Request assistance from: • The Engineer - Transmission and Protection. • Protection Engineering Support.

3	After system operation is verified, lead security seals or locks can be used to seal each low-density housing to prevent tampering (see Exhibit 25).

8.15 High-Density System

The typical Fiber Optic Link high-density system consists of:

- Two CO/SUB-card shelves (P/N 8806-1230-01 or P/N 8806-1231-01).
- Five to twelve CO cards – either 2-wire (P/N 8806-1232-03), 4-wire (P/N 8806-1233-03), or other service.
- Five to twelve fiber optic duplex cable assemblies (P/N 8806-1208-02 or P/N 8806-I 213-02).
- Five to twelve SUB-unit cards – either 2-wire (P/N 8806-1242-03) 4-wire (P/N 8806-1243-03), or other service.
- A high-density power supply (P/N 8806-1206-03) with battery back-up.

The length of the fiber optic cable can vary to 66 feet (20 m). At least 3 feet (1 m) of cable is required because of CO/SUB shelf cable routing requirements.

8.16 Mounting CO/SUB Card Shelves to the Backplane

NOTE: Care must be taken to locate the two CO/SUB-card shelves within reach of the fiber optic cable assemblies supplied with the system.

Use the procedures in the following chart for mounting the CO/SUB-card shelves to the backplane.

Step	Mountlng CO/SUB-Card Shelves to the Backplane
1	Remove the shelf cover by unscrewing the four comer screws.
2	Remove the cable section by unscrewing the four tamper-proof comer screws that secure it to the shelf base. (A tamper-proof screw adapter is supplied with the shelf.)
3	Use the CO/SUB-card shelf base as a template to mark screw-hole locations on the plywood backplane.
4	Drill pilot holes using a 1/8-inch drill bit.
5	Line up the card shelf base with the drilled holes and attach the shelf to the backplane with the four #12 wood screws provided (see Exhibit 26).

NOTE: **CO/SUB-unit card shelves can be installed vertically or horizontally.**

8.17 Install CO/SUB Shelf Spacer Ring (if used)

The CO/SUB shelf spacer rings provide an added three inches of depth to the sheives when used in extended distance applications.

The added depth prevents crimping of glass fibers used in the applications.

Install the spacer ring using the four tamper proof screws and adaptor provided.

NOTE: The **spacer ring must be installed next to the shelf base.**

8.18 Reattaching the Cable Routing Section

The cable routing section has pm-drilled, plugged and grommeted holes located in two sides. Reattach the cable routing section using the four tamper-proof screws and the adaptor provided

NOTE: **Tamper-proof screws are provided to prevent unauthorized relocation of high-voltage equipment. To ensure this, the installer must store the tamper-proof screw adaptor in a tool kit or base shop. If this feature is not desired, the screw adaptor can be stored or taped inside the shelf.**

8.19 Installing the CO Card

Install CO cards – 2-wire (P/N 8806-1232-03) or 4-wire (P/N 8806-1233-03) – in the card slots in the CO/SUB-card shelf base. To install cards, depress the card retaining clip, insert the card, and release.

NOTE: Two-wire and **4-wire cards are interchangeable in the card shelf slots; however, care must be taken that 2-wire and 4-wire cards are matched end-to-end (between the CO and the SUB).**

8.20 Routing and Connecting Fiber Optic Cable

The cable-routing section of the CO/SUB shelf provides various routing channels for both the fiber optic cable and the CO exchange cable pairs. Select those routes that fit a particular application.

NOTE: It **is recommended that cable access holes be provided at the sides or bottom of the cable section and not at the top. This decreases the possibility of any debris or moisture accumulating in the card shelf.**

Connect the fiber optic duplex cable assembly (P/N 8806-1208-02 or P/N 8806-1213-02) to the respective CO cards. Each cable assembly has two color-coded connectors on each end. The blue connectors plug into the fiber optic Receiver on the CO and SUB cards. The gray or black connectors plug into the fiber optic Transmitter on the CO and SUB cards.

NOTE: The **flber optic duplex cable-assembly connectors MUST be plugged into terminations of the same color for the system to operate.**

8.21 Connecting CO-End Wiring

Route the CO exchange cable pairs through the CO/SUB shelf cable section to their card positions.

CAUTION: Extreme care must be taken to ensure that the cable or cable pairs from the CO exchange are insulated from any possible contact with high voltage and GPR up to their connection to the CO/SUB shelf.

8.22 Connecting CO Card, 2-Wire

Inside the CO/SUB shelf cover is a label illustrating wiring connections. The 2-wire CO card is polarity insensitive. Connect the CO 2-wire exchange pair to the two terminals on the front of the PCB (see Exhibit 21).

8.23 Connecting CO Card, 4-Wire

Inside the CO/SUB shelf cover is a label illustrating 4-wire CO-card wiring connections (see Exhibit 22). The 4-wire card is not sensitive to polarity. The 4-wire service is designed to be transparent to the telephone network and the customer premises data equipment. Thus, the 4-wire cards will pass through any signals with levels up to + 7 dBm without gain or loss. No adjustment is needed.

8.24 Installing SUB Cards

Install SUB cards -2-wire card(P/N 8806-1242-03) or 4-wire card (P/N 8806-1243-03) – in the card slots in the SUB-card shelf base. To install cards, depress the card retaining clip, insert the card, and release.

NOTE: The **2-wire and 4-wlre cards are interchangeable in the card-shelf slots; however, care must be taken that 2-wire and 4-wire cards are matched end-to-end (between the CO and the SUB).**

8.25 Connecting SUB-End Wiring

Route the customer cable pairs through the CO/SUB shelf cable section to their respective SUB cards. Route the cable that provides the 24 VDC to the SUB cards (refer to Section 7).

CAUTION: The **powering cable must be disconnected from the DC power source while routing cable and connecting to cards, or serious arcing might occur.**

NOTE: Because high-vottage isolation provided by the Fiber Optic Link is a function of the length of fiber optic cable separating the CO shelf from the SUB shelf, no special precautions other than normal plant practices need to be taken with SUB-end equipment or customer cable pairs.

8.26 Connecting SUB Card, 2-Wire

Inside the CO/SUB-shelf cover is a label illustrating wiring connections (see Exhibit 23).

NOTE: The 2-wire SUB cards will not operate if the powering connection is reversed. Verify connection before powering up the system.

8.27 Connecting SUB Card, 4-Wire

Inside the CO/SUB-shelf cover is a label illustrating 4-wire wiring connections (see Exhibit 24).

The 4-wire service is designed to be transparent to the telephone company network and the customer premises data equipment. Thus the 4-wire cards will pass through any signals with levels up to + 7 dBm without gain or loss. No adjustment is needed.

8.28 Installing a High-Density Power Supply

The high-density power supply (P/N 8806-1206-03) consists of:

- One AC/DC converter (PSU).
- 24V battery back-up.

Installation requires:

- Attaching the battery cable.
- Mounting the hardware.

8.28 Installing the High-Density Power Supply, continued

One high-density power supply powers one fully equipped Fiber Optic Link high-density SUB-end (12 cards), 2-wire or 4-wire. Use the following procedure for installation.

Step	Installing the High-Density Power Supply
1	Mount the high-density power supply PSU mounting bracket with three #6 screws provided.
2	After the bracket is secured to the wall of backplane, clip the power supply PSU into the bracket. **NOTE: The 115 VAC power outlet must be within reach of the PSU power cord.**
3	Mount the battery back-up (see Exhibit 27).
4	Drill pilot holes using a ⅛-inch drill bit.
5	Install the battery back-up using the four #8 wood screws provided. It must be located within reach of the battery cable provided with the power supply.
6	Attach the battery cable to the battery terminals on the PSU.

CAUTION: Do not connect the battery cable to the battery back-up until all wiring to SUB unlts or cards is complete.

8.29 Connecting the High-Density Power Supply

Use the following procedure for the high-density power supply connection.

Step	Connecting the High-Density Power Supply
1	Route the wiring from the high-density power supply PSU terminals through the SUB-end card shelf cable section to the SUB cards.
2	Connect the power supply wiring to the SUB cards.
3	Make all power connections before plugging the power supply into an AC outlet.
4	Attach the other end of the battery cable to the battery back-up.

NOTE: me a-wire SUB cards will not operate if the powering connection is reversed. Verify the connection before powering up the system.

8.30 System Test – High-Density

Perform a system test, using the procedure in the following chart.

Step	Testing the System – High-Density
1	After connecting the wiring from the power supply to the SUB cards, replace the CO/SUB-card shelf covers.
2	Plug the power supply AC plug into a 115 VAC, 60 Hz main outlet.
3	Test the lines of the system by using a handset or data set.
4	If all lines do not operate properly: • Review installation procedures. • Check all wiring connections. • Retest.
5	If the system still does not operate, request assistance from: • The Engineer - Transmission and Protection. • Protection Engineering Support.

8.31 Installing 130V/48V DC/DC Converters

DC/DC converters are used to convert a customer's 130 VDC or 48 VDC power source to 24 VDC for Fiber Optic Link SUB cards or units.

Step	Installing 130V/48V DC/DC Converters
1	Remove the converter cover and drill out three holes for mounting to the backplane or wall.
2	Mount the converter to the wall using the three #6 wood screws provided.
3	Route the wiring from the converter to the SUB cards or unit.
4	The converter powers up to twelve SUB cards or units.
5	After all wiring is complete to the converter, connect the 130 or 48 VDC source voltage.

8.32 9600 bps Installation

Installation of 9600 bps DDS units.

- Mount 9600 bps DDS units.
- Connect the fiber optic cable.
- Connect 9600 bps DDS transmit and receive.
- Connect and verify power to (short haul) 9600 bps DDS Cards.

8.32.1 Mount 9600 bps DDS Units.

The 9600 bps DDS CO Unit consists of a 9600 bps DDS CO Card mounted inside a Low Density Housing and shipped as a unit with two wood screws.

The procedures in the following chart are used to mount the unit to a plywood backboard.

Step	Mount the 9600 bps DDS Unit
1	Use the housing as a template to mark the hole location.
2	Mark the wood screw location.
3	Pilot the drill holes (approximately ⅜ inch) with a ⅛ inch drill bit.
4	Attach housing to the backboard using the wood screws provided.
	NOTE: Similarly, unpack and install the 9600 bps DDS SUB Unit to the plywood blackboard.
	CO and SUB Units must be located within reach of the connecting fiber optic cable assembly provided with the system.

8.32 9600 bps Installation, continued

8.32.2 Connect the Fiber Optic Cable

The procedures in the following chart are used to connect the fiber optic cable.

Step	Connect the Fiber Optic Cable
1	Open the CO and SUB Unit housing covers. **NOTE: There is a transmit and receive terminal on each PCB. Each terminal has the following color coding:** • Transmit terminal is gray. • Receive terminal is blue. **The connectors on the Short Haul fiber optic cable assemblies are color coded (blue and gray).**
2	Connect the blue (male) connectors on the fiber optic cable to the blue (female) connectors on the CO and SUB Card PCBs.
3	Connect the gray (male) connector on the fiber optic cable to the gray (female) connectors on the PCBs. **NOTE: The connectors on the Extended Distance muitimode fiber optic cable assemblies are identified end-to-end with a alpha/numeric identifier.**
4	Connect two fibers to the SMA transmit and receive connectors.
5	At the other end connect the same fibers to the opposite terminals.

8.32 9600 bps Installation, continued

8.32.3 Connect the 9600 bps DDS Transmit and Receive

The procedures in the following chart are used to connect the 9600 bps DDS transmit and receive.

Step	Connect the 9600 bps DDS Transmit and Receive
1	Connect the 9600 bps DDS 4-wire cable pairs from the SUB equipment to four screw-down terminals on the 9600 bps DDS SUB Cards.
2	Connect the SUB Receive to the PCB Rx terminals (signal comes out of PCB).
3	Connect the SUB Transmit to the PCB Tx terminals (signal goes into PCB).
4	Connect the 4-wire cable pairs from the CO to four screw-down terminals on the 9600 bps DDS CO Card.
5	Connect the CO Receive to the PCB Rx terminals (signal comes out of PCB).
6	Connect the CO transmit to the PCB Tx terminals (signal goes into PCB).

8.32.4 Connect and Verify Power to (Short Haul) 9600 bps DDS Cards

The procedures in the following chart are used to connect and verify power to (Short Haul) 9600 bps DDS Cards.

Step	Connect and Verify Power to (Short Haul) 9600 bps Cards
1	Connect a 24 - 54 VDC, 20 mA power source to the auxiliary PS terminals on the 9600 bps DDS SUB Card. **NOTE: The terminals are polarity insensitive.**
2	Verify the 9600 bps DDS SUB Card operation by removing the fiber optic cable push-pull connector from then 9600 bps DDS CO Card Rx (receive) and that a red light is visible at the fiber optic cable connector.
3	Verify that there is power connected to the CO Card by removing the fiber optic push-pull connector from the 9600 bps DDS SUB Card Rx (receive) connection and checking for the Red light at the cable connector. **NOTE: The operation of Extended Distance Systems cannot be verified by sight (pin hole is too small).**

8.33 56 kbps Units Installation

Installation of 56 kbps DDS units.

- Mount 56 kbps units.
- Connect the fiber optic cable.
- Connect 56 kbps transmit and receive.
- Connect and verify power to (short haul) 56 kbps cards.
- Set the 56 kbps System Gain.

8.33.1 Mount 56 kbps DDS Units

The 56 kbps CO Unit consists of a 56 kbps CO Card mounted inside a Low Density Housing and shipped as a unit with two wood screws.

The procedures in the following chart are used to mount the unit to a plywood backboard.

Step	Mount the 56 kbps DDS Unit
1	Use the housing as a template to mark the hole location.
2	Mark the wood screw location.
3	Pilot the drill holes (approximately 3/8 inch) with a 1/8 inch drill bit.
4	Attach housing to the backboard using the provided screws. **NOTE: Similarly, unpack and install the 56 kbps SUB Unit to the plywood blackboard.** **CO and SUB Units must be located within reach of the connecting fiber optic cable assembly provided with the system.**

8.33 56 kbps Units Installation, continued

8.33.2 Connect the Fiber Optic Cable

The procedures in the following chart are used to connect the fiber optic cable.

Step	Connect the Fiber Optic Cable
1	Remove the CO and SUB Unit housing covers. **NOTES: There is a transmit and receive terminal on each PCB. Each terminal has the following color coding:** • **Transmit terminal is gray.** • **Receive terminal is blue.** **The connectors on the Short Haul fiber optic cable assemblies are also color coded (blue and gray).**
2	Connect the blue (male) connectors on the fiber optic cable to the blue (female) connectors on the CO and SUB Card PCBs.
3	Connect the gray (male) connector on the fiber optic cable to the gray (female) connectors on the PCBs. NOTE: The **connectors on the Extended Distance multimode fiber optic cable assemblies are identified end-to-end with a alpha/numeric identifier.**
4	Connect two fibers to the SMA transmit and receive connectors.
5	At the other end connect the same fibers to the opposite terminals.

8.33 56 kbps Units Installation, continued

8.33.3 Connect the 56 kbps Transmit and Receive

The procedures in the following chart are used to connect the 56 kbps transmit and receive.

Step	Connect the 56 kbps Transmit and Receive
1	Connect the 56 kbps 4-wire cable pairs from the SUB equipment to four screw-down terminals on the 56 kbps SUB Cards.
2	Connect the SUB Receive to the PCB Rx terminals (signal comes out of the PCB).
3	Connect the SUB Transmit to the PCB Tx terminals (signal goes into the PCB).
4	Connect the 4-wire cable pairs from the CO to four screw-down terminals on the 56 kbps CO Card.
5	Connect the CO Receive to the PCB Rx terminals (signal comes out of the PCB).
6	Connect the CO transmit to the PCB Tx terminals (signal goes into the PCB).

8.33.4 Connect and Verify Power to (Short Haul) 56 kbps Cards

The procedures in the following chart are used to connect and verify power to (Short Haul) 56 kbps Cards.

Step	Connect and Verify Power to (Short Haul) 56 kbps Cards
1	Connect a 24 - 54 VDC, 20 mA power source to the auxiliary PS terminals on the 56 kbps SUB Card. **NOTE: The terminals are polarity insensitive.**
2	Verify the 56 kbps SUB Card operation by removing the fiber optic cable push-pull connector from then 56 kbps CO Card Rx (receive) and that a red light is visible at the fiber optic cable connector.
3	Verify that there is power connected to the CO Card by removing the fiber optic push-pull connector from the 56 kbps SUB Card Rx (receive) connection and checking for the red light at the cable connector. **NOTE: The operation of Extended Distance Systems cannot be verified by sight (pin hole is too small).**

8.33 56 kbps Units Installation, continued

8.33.5 Set the 56 kbps Svstem Gain

The procedures in the following chart are used to connect the 56 kbps System gain.

Step	Set the 56 kbps System Gain
1	Set the gain with P1 on the 56 kbps CO Card by observing the green and red LEDs on the PCB to indicate the optimum setting (see Exhibit 28).
2	Set the gain on the CO Card in 6 dB increments by selecting the highest numbered P1 position that will not illuminate the red LED but does illuminate the green LED. **NOTES: If the red LED is illuminated the green LED will also be illuminated. A red LED indicates signal overload.** **If the green LED is not illuminated, select a higher number position on the P1 until the red LED is illuminated.**
3	Set P1 to the next lower numbered position.
4	Position P1 jumper on 56 kbps SUB Card to the same position as P1 jumper on the CO Card after the gain is set on the CO Card. EXAMPLE: If the P1 jumper on the CO Card is set to position 3, then the P1 jumper on the SUB Card must be set to position 3.

8.34 T-1 Units Installation

Installation of T-1 units.

- Mount T-1 units.
- Connect the fiber optic cable.
- Connect T-1 transmit and receive.
- Connect and verify power to (short haul) T-1 Cards.
- Set the T-1 System Gain.

8.34.1 Mount the T-1Unit

The T-1 CO Unit consists of a T-1 CO Card mounted inside a Low Density Housing and shipped as a unit with two wood screws.

The procedures in the following chart are used to mount the unit to a plywood backboard.

Step	Mount the T-1 Unit
1	Use the housing as a template to mark the hole location.
2	Mark the wood screw location.

(continued)

8.34 T-1 Units Installation, continued

8.34.1 Mount the T-1 Unit. continued

The procedures in the following chart are used to mount the unit to a plywood backboard.

Step	Mount the T-l Unit
3	Pilot the drill holes (approximately 3/8 inch) with a 1/8 inch drill bit.
4	Attach the housing to the backboard using the provided wood screws. **NOTES: Similarly, unpack and install the T-1 SUB Unit to the plywood blackboard.** **CO and SUB Units must be located within reach of the connecting fiber optic cable assembly provided with the system.**

8.34.2 Connect the Fiber Optic Cable

The procedures in the following chart are used to connect the fiber optic cable.

Step	Connect the Fiber Optic Cable
1	Remove the CO and SUB Unit housing covers. **NOTES: There is a transmit and receive terminal on each PCB. Each terminal has the following color coding:** • **Transmit terminal is gray.** • **Receive terminal is blue.** **The connectors on the Short Haul fiber optic cable assembles are color coded (blue and gray).**
2	Connect the blue (male) connectors on the fiber optic cable to the blue (female) connectors on the CO and SUB Card PCBs.
3	Connect the gray (male) connector on the fiber optic cable to the gray (female) connectors on the PCBs. **NOTE: The fibers on the Extended Distance multimode fiber optic cable assemblies are identified end-to-end with a alpha/numeric identifier.**
4	Connect two fibers to the ST or SMA transmit and receive connectors.
5	At the other end connect the same fibers to the opposite terminals.

8.34 T-1 Units Installation, continued

8.34.3 Connect the T-1 Transmit and Receive

The procedures in the following chart are used to connect the T-1 transmit and receive.

Step	Connect the T-1 Transmit and Receive
1	Connect the T-1 4 wire cable pairs from the SUB equipment to four screw-down terminals on the T-1 SUB Cards.
2	Connect the SUB Receive to the PCB Receive/Output terminals (signal comes out of PCB).
3	Connect the SUB Send to the PCB Send/Input terminals (signal goes into PCB).
4	Connect the 4-wire cable pairs from the CO to four screw-down terminals on the T-1 CO Card.
5	Connect the CO Receive to the PCB Receive/Output terminals (signal comes out of PCB).
6	Connect the CO Send to the PCB Send/Input terminals (signal goes into PCB).

8.34.4 Connect and Verify Power to (Short Haul) T-1 Cards

The procedures in the following chart are used to connect and verify power to (short haul) T-1 Cards.

Step	Connect and Verify Power to (Short Haul) T-1 Cards
1	Connect a 24 - 54 VDC, 20 mA power source to the auxiliary PS terminals on the T-1 SUB Card. **NOTE: The terminals are polarity insensitive.**
2	Verify the T-1 SUB Card operation by removing the fiber optic cable push-pull connector from then T-1 CO Card Rx (Receive) and that a red light is visible at the fiber optic cable connector.
3	Verify that there is power connected to the CO Card by removing the fiber optic push-pull connector from the T-1 SUB Card Rx (receive) connection and checking for the Red light at the cable connector. **NOTE: The operation of Extended Distance Systems cannot be verified by sight. The optical fiber is small and the LED is toward infrared.**

8.34 T-1 Units Installation, continued

8.34.5 Set the T-1 System Gain

The procedures in the following chart are used to connect the T-l system gain.

Step	Set the T-l System Gain
1	Set the gain with **P1** on the T-l CO Card by observing the green and red LEDs on the PCB to indicate the optimum setting (see Exhibit 35).
2	Set the gain on the CO Card in 6 dB increments by selecting the highest numbered **P1** position that will not illuminate the red LED but does illuminate the green LED. **NOTES: If the red LED is illuminated the green LED will also be illuminated. A red LED indicates signal overload.** **If the green LED Is not illuminated, select a higher number posltion on the P1 until the red LED is illuminated.**
3	Set **P1** to the next lower numbered position.
4	Position the P2 jumper on the T-l SUB Card to the same position as the **P1** jumper on the CO Card after the gain is set on the CO Card. EXAMPLE: If the **P1** jumper on the CO Card is set to position 3, then the P2 jumper on the SUB Card must be set to position 3.

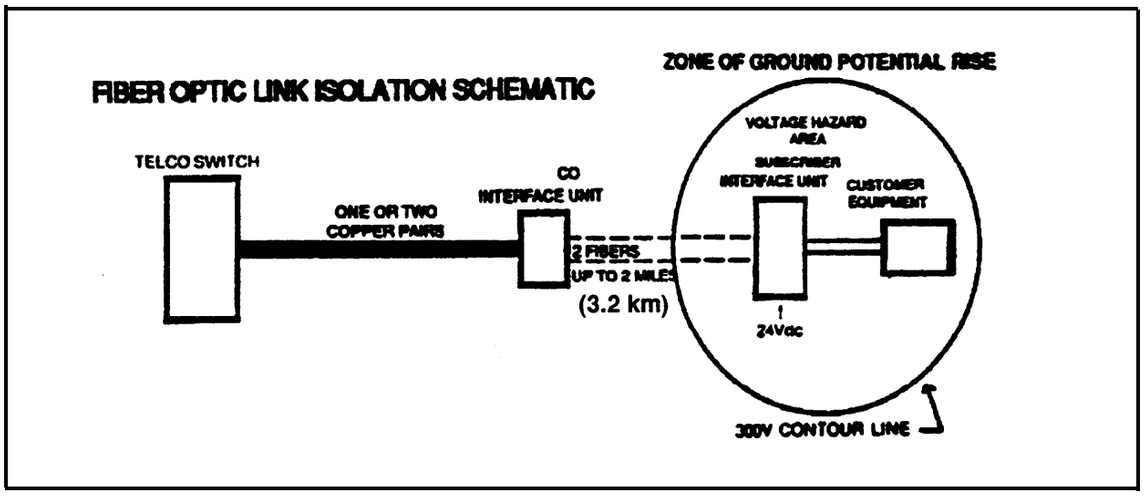


Exhibit 1 – Basic Isolation Schematic

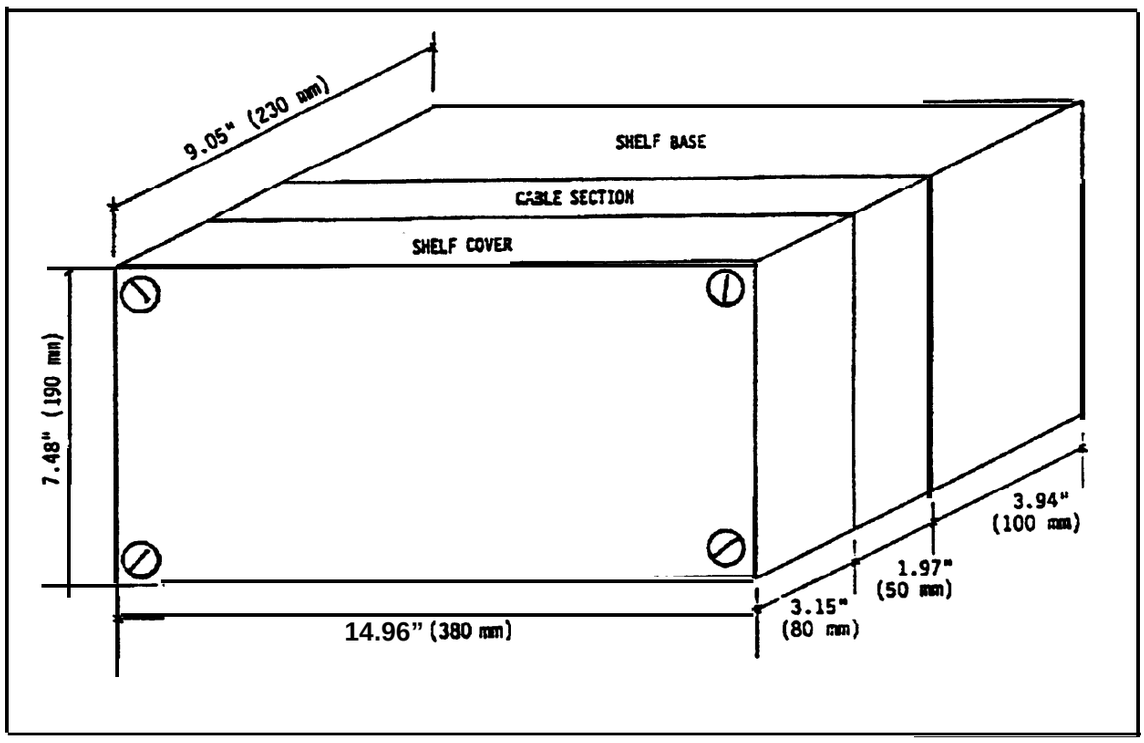


Exhibit 2 - 12.Card Shelf

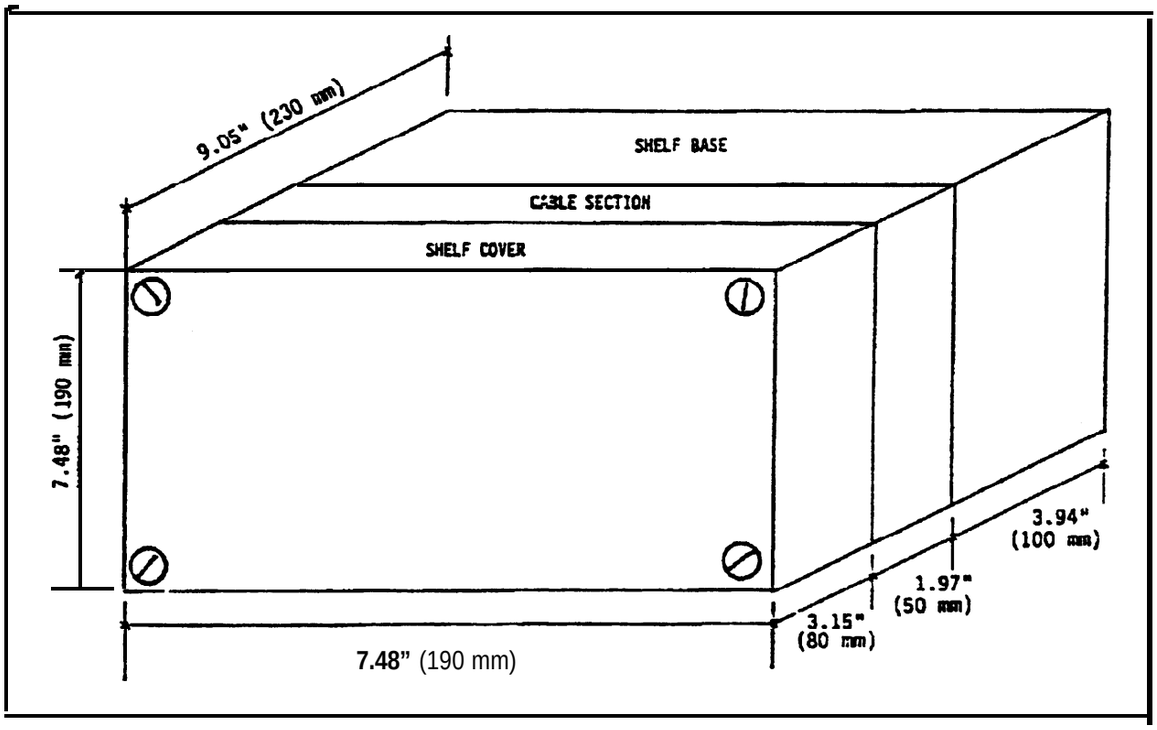


Exhibit 3 - 5-Card Shelf

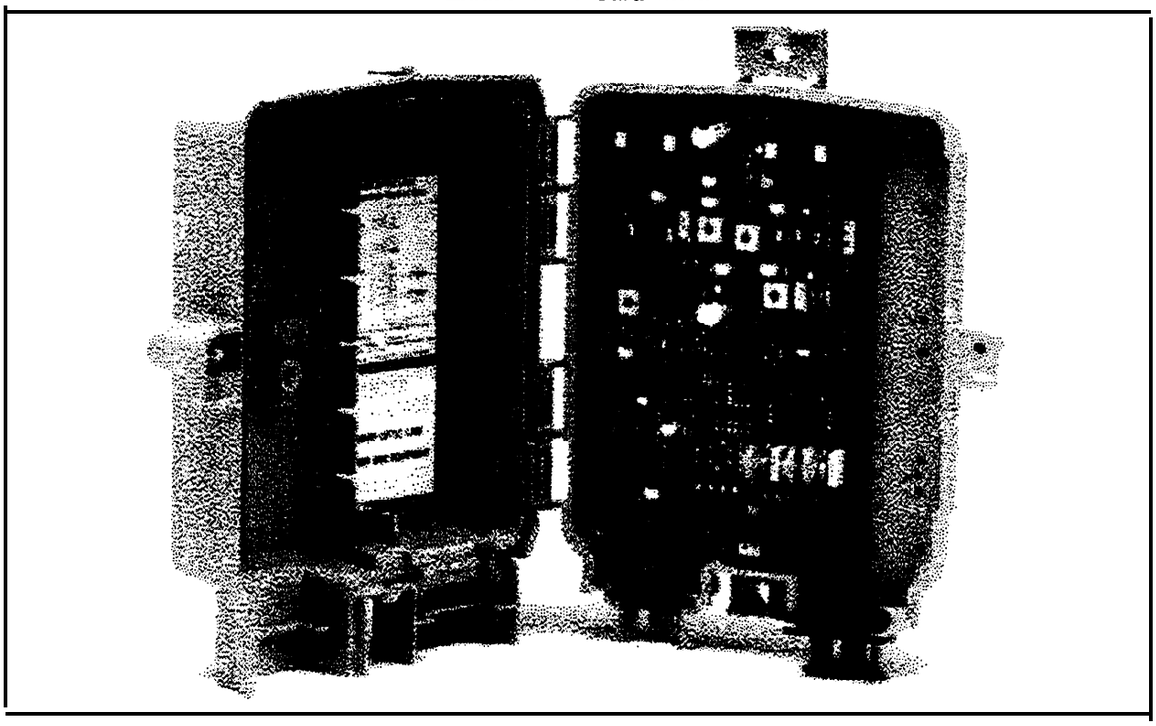
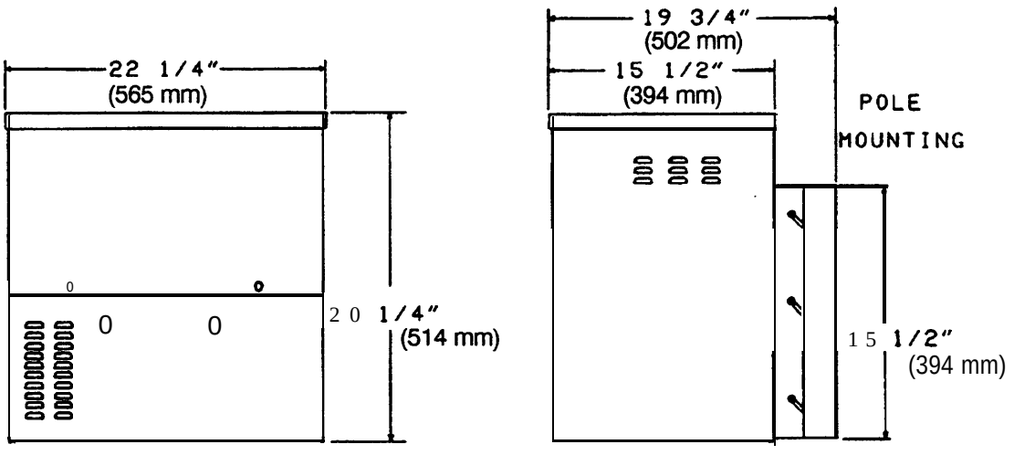


Exhibit 4 - Fiber Optic Link Single Card Housing



FEATURES:

DUAL LOCKS
LOUVERED VENTILATION OPENINGS
WEATHER RESISTANT HOUSING
1" **PLYWOOD BACKPLANE** (25 **mm)**
POLEMOUNT

Exhibit 5 - Fiber Optic Link Weatherproof Cabinet

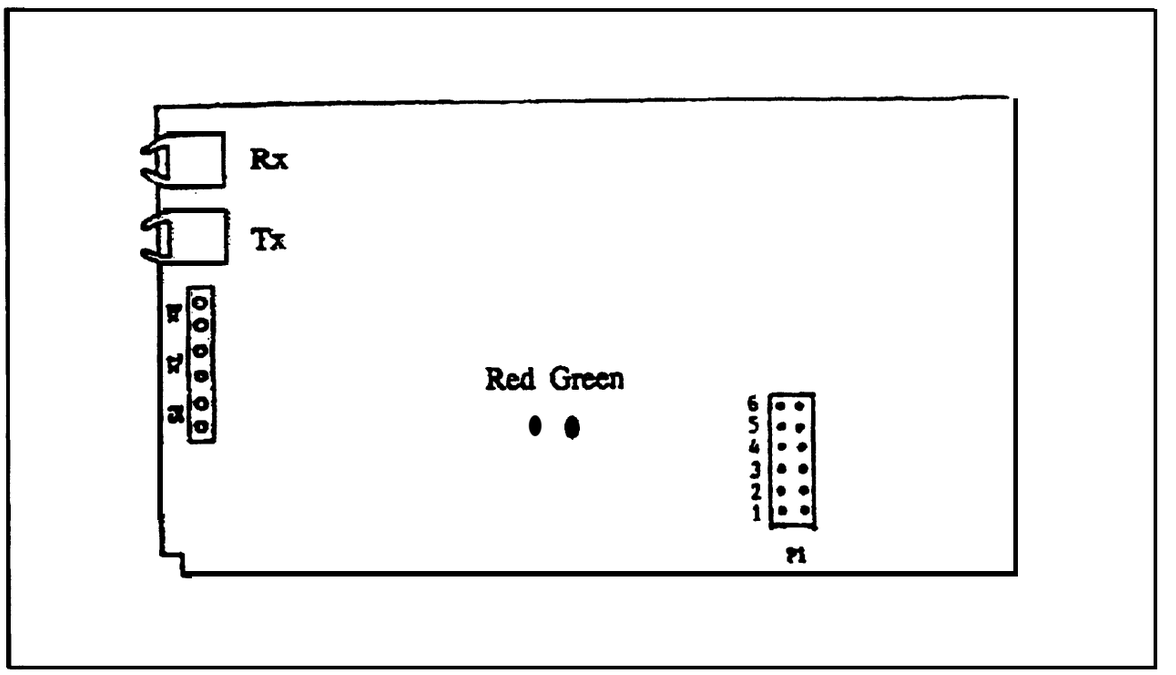


Exhibit 6 – 56 kbps CO Card PCB

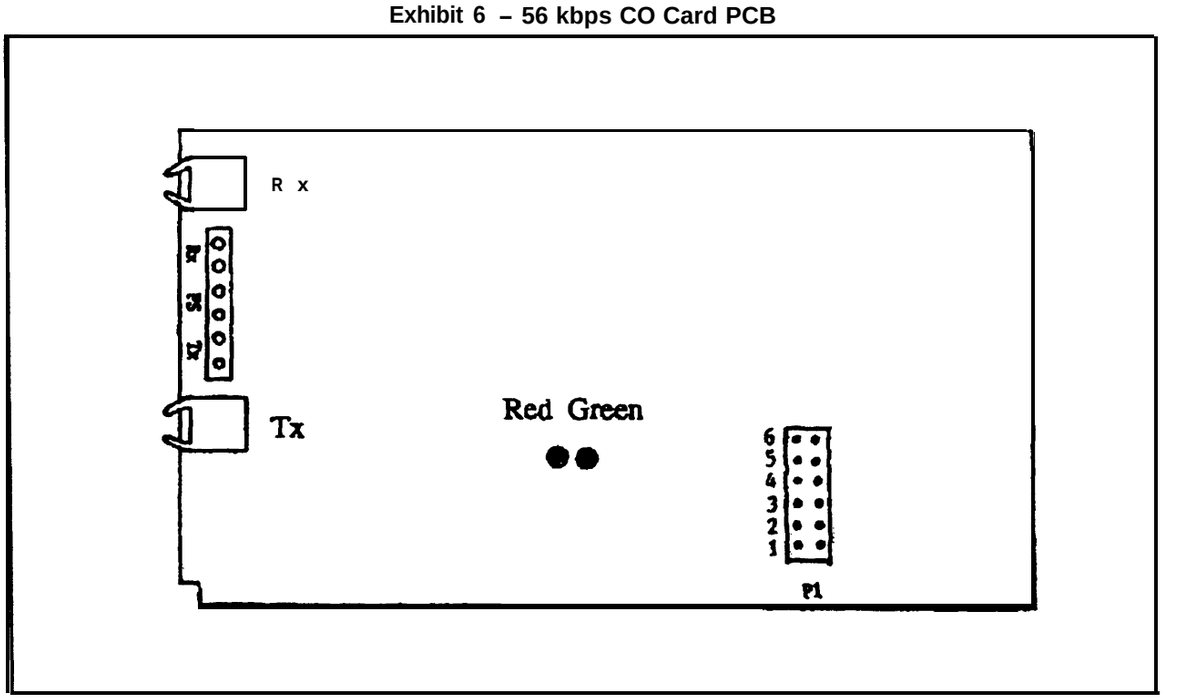


Exhibit 7 – T-1 CO Card PCB

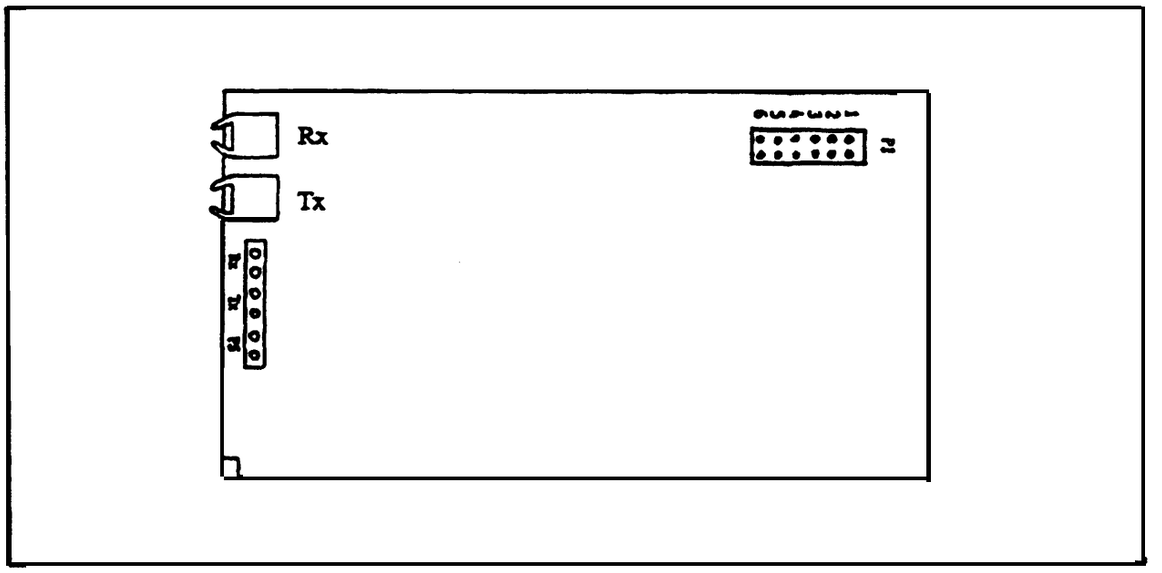


Exhibit 8 – 56 kbps SUB Card

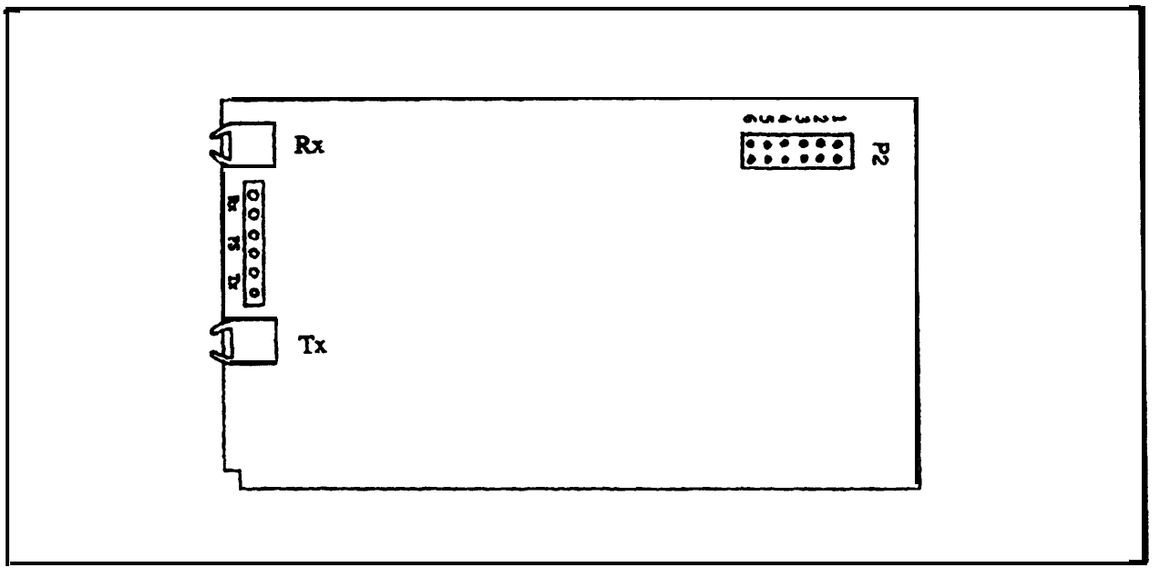


Exhibit 9 – **T-1 SUB Card PCB**

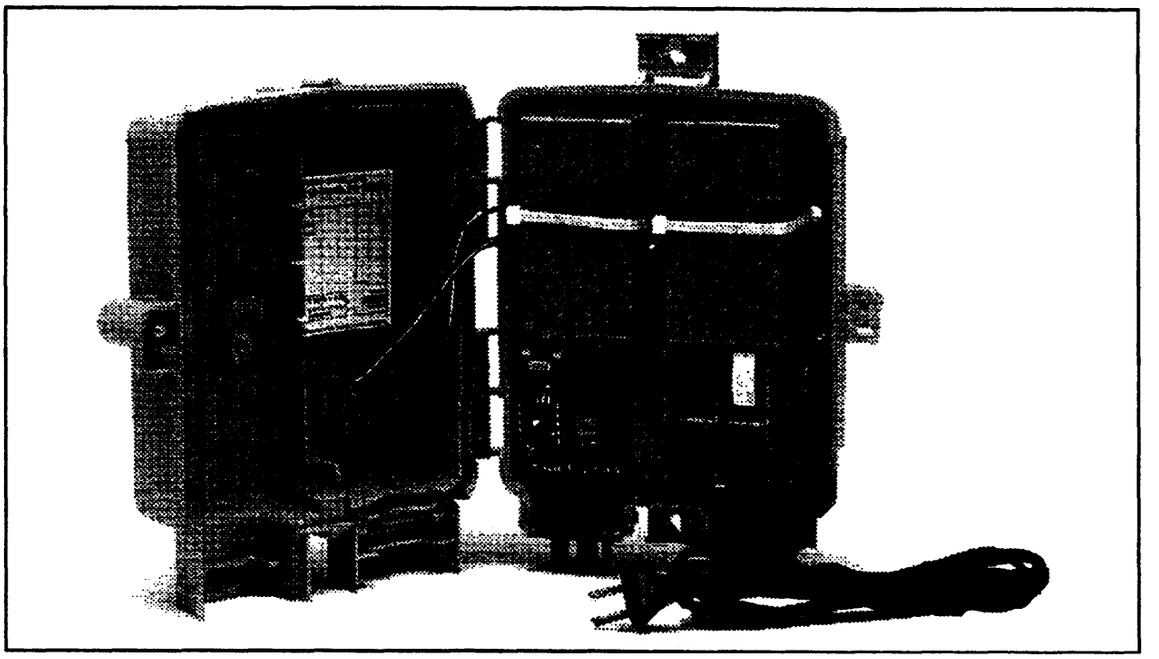


Exhibit 10 - Low-Density AC/DC Power Supply

EQUIPMENT	BREAKDOWN VOLTS		
	RMS*	PEAK	PEAK-TO-PEAK
CO Unit (Single Housing)			
No Backboard	**9kV**	**12.7kV**	**25.4kV**
1" Dry Backboard	35kV	**49.5kV**	**99.0kV**
1" Wet Backboard**	20kV	**28.3kV**	**56.6kV**
3/4" Dry **Backboard**	25kV	**35.4kV**	**70.8kV**
3/4" Wet Backboard**	18kV	**25.5kV**	51 .OkV
12-6 CO/SUB Shelf (88064 230-01) or 5-Card CO/SUB Shelf (8806-l 231-01) No Backboard	42kV	**59.4kV**	**118.8kV**
1" Dry Backboard	50kV	**70.7kV**	**141.4kV**
1" wet **Backboard****	50kV	**70.7kV**	**141.4kV**
3/4" Dry Backboard	**45kV**	**63.5kV**	**126.9kV**
3/4" wet **Backboard***	**45kV**	**63.5kV**	**126.9kV**

* All results in MS column indicate that sample held voltage for at least 1 minute without breaking down.
** For this test, backboard was immersed overnight In tank of water.

Exhibit 11 - Fiber Optic Link Breakdown Voltages

CABLE TYPE	TYPICAL CABLE ATTENUATION/KM	FIBER OPTIC LINK POWER BUDGET*		MAXIMUM DISTANCE MILES		KM	
		-40°**	25°	-40°	25°	-40°	25
200 PCS"	10 dB/Km	18.5 dB	21 .O dBm	1.1	1.3	1.9	2.1
100/140um	5-6 dB/Km	13.5 dBm	17.5 dBm	1.7	2.2	2.7	3.5
62.5/125um	3-5 dB/Km	8.0 dBm	12.0 dBm	1.7	2.5	2.7	4.0
50/125um	3-5 dB/Km	3.5 dBm	7.5 dBm	.8	1.5	1.2	2.5

• Power Budget is measured through 1 meter of connectarized cable.
** All Temperatures in °C.
• ** 200 PCS cable is recommended only to -20°C.

NOTE: 25°C = 77°F
-40°C = -40°F

Exhibit 12 – Fiber Optic Link Power Budgets

APPROXIMATE CURRENT REQUIRED FOR OPERATION
(Fiber Optic Link CO Cards)

Part No.	Description	mA Required
8806-1232-03	2W CO Card	18 mA
8806-1234-03	2W CO Card (EXT)	18 mA
8806-1233-03	4W CO Card	12 mA
8806-1235-03	4W CO (EXT)	12 mA
8806-1237-02	4W E&M CO Card	18 mA
8806-1238-02	4W E&M CO (EXT)	18 mA
8806-1239-02	2W Data CO Card	18 mA
8806-1236-02	2W Data CO (EXT)	18 mA
8806-1311-01	9.6K DDS CO	20 mA
8806-1313-01	9.6K DDS CO(EXT)	20 mA
8806-1312-01	56 KBPS CO Card	20 mA
8806-1314-01	56 KBPS CO (EXT)	20 mA
8806-1316-01	T-I CO Card	60 mA
8806-1340-01	T-I CO Card(EXT)	60 mA

Exhibit 13 - Current Required for CO Card Operation

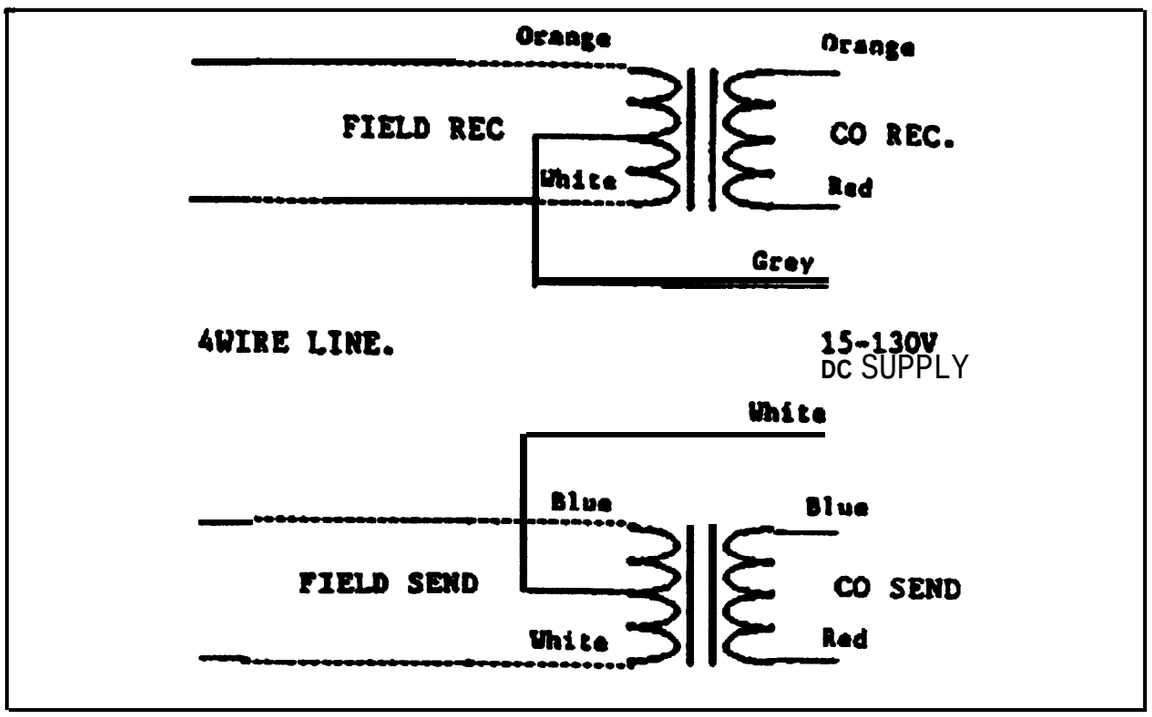


Exhibit 14 - 4Wire Powering Coil Wiring Diagram

APPROXIMATE CURRENT REQUIRED FOR OPERATION
(Fiber Optic Link Sub Cards)

Part No.	Description	mA Required
8806-1242-03	2W Sub Card	On-Hook: 70 mA Off-Hook: 150 mA Ringing: 200 mA
8806-1244-03	2W Sub Card (EXT)	On-Hook: 70 mA Off-Hook: 150 mA Ringing: 200 mA
8806-1243-03	4W Sub Card	12 mA
8806-1245-03	4W Sub (EXT)	12 mA
8806-1247-02	4W E&M Sub Card	18 mA
8806-1248-02	4W E&M Sub (EXT)	18mA
8806-1249-02	2W Data Sub Card	18 mA
8806-1246-02	2W Data Sub (EXT)	18 mA
8806-1321-01	9.6K DDS Sub	20 mA
8806-1323-01	9.6K DDS Sub(EXT)	20 mA
8806-1322-01	56 KBPS Sub Card	20 mA
8806-1324-01	56 KBPS Sub (EXT)	20 mA
8806-1326-01	T-1 Sub Card	60 mA
8806-1325-01	T-1 Sub Card(EXT)	60 mA

Exhibit 15 - Current Required for SUB Card Operation

CABLE TYPE* 0.525 O.D., WT.0.036 LBSm.	SAG FEET	SPAN LENGTH	
		AT MAX TENSILE RATING	AT 1/2 MAX TENSILE RATING
Light Loading			
(No Redial Ice)	5	442	300
Temp -1 °C	10	625	442
Wind 9 lbs/ft^2	20	003	625
Medium Loading			
(1/4" Radial Ice)	5	346	250
Temp. –10°C	10	408	346
wind 4 lbs/ft^2	20	691	488
Heavy Loading			
(1/2" Radial Ice)	5	284	200
Temp –20°C	10	400	284
Wind 4 lbs/ft^2	20	569	400

• Cable is all dielectric and self supporting

Exhibit 16 – Typical Fiber Optic Cable SAG Characteristics

COEND EQUIPMENT PART NUMBER	DESCRIPTION	APPLICATION							
		HIGH DENSITY				LOW DENSITY			
		STNDRD		XTNDED		STNDRD		XTNDED	
		2W	4W	2W	4W	2W	4W	2W	4W
8806-1202-02	CO Unit, 2-Wire					X			
880601210-02	CO Unit, 4-Wire						X		
8806-1212-02	CO Unit, 2-Wire (Ext.)							X	
8806-1220-02	CO Unit, 4-Wire (Ext.)								X
8806-1230-01	CO/SUB Card shelf	x	x	x	x				
8806-1232-02	CO Card, 2~Wire	X							
8806-1233-02	CO Card,4-Wire		X						
8806-1234-02	CO Card, 2wire (Ext.			X					
8806-1235-02	CO Card, 4-wire (Ext.)				X				

Exhibit 17 – CO End Equipment Selection

PART NUMBER	EQUIPMENT DESCRIPTION	UNITS IN SERVICE	
		1–10	10–100
2-WIRE EQUIPMENT			
8806-1232-03	co Card, 2-Wire	1	2
8806-1242-03	SUB Card, 2-Wire	1	2
8806-1234-03	CO Card, 2-Wrre, Extended	1	2
8806-1244-03	SUB Card, 2-Wtre, Extended	1	2
4-WIRE EQUIPMENT			
8806-1233-03	CO Card, 4-Wire	1	2
8806-1243-03	SUB Card, 4-Wire	1	2
8806-1235-03	CO Card, 4-Wire, Extended	1	2
8806-1245-03	SUB Card, 4-Wire, Extended	1	2
COMMON EQUIPMENT			
8806-1203-04	**Low-Density** Power Supply w/Batt.	1	2
8806-I 204-02	Fiber Optic Cable (18")	0	1
8806-1208-02	High-Density Power Supply w/Batt.	1	2
8806-I 208-02	**F.O. Cable** (specify length)	0	1
8806-I 251-01	4-Wire Simplex Power Coil	0	1
8806- 12750 02	~130V DC/DC Converter	1	2
8806-1278-02	48V DC/DC Converter	1	2

Exhibit 18 – Recommended Spares

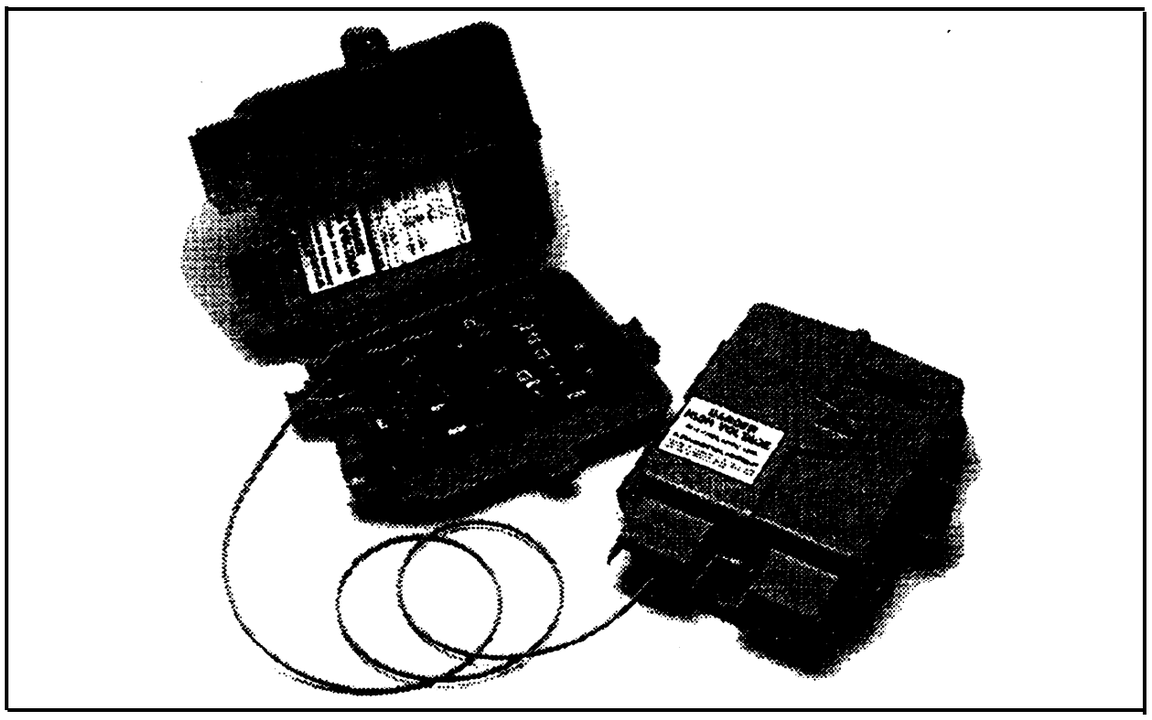


Exhibit 19 - Fiber Optic Link Low Density, Short Haul System

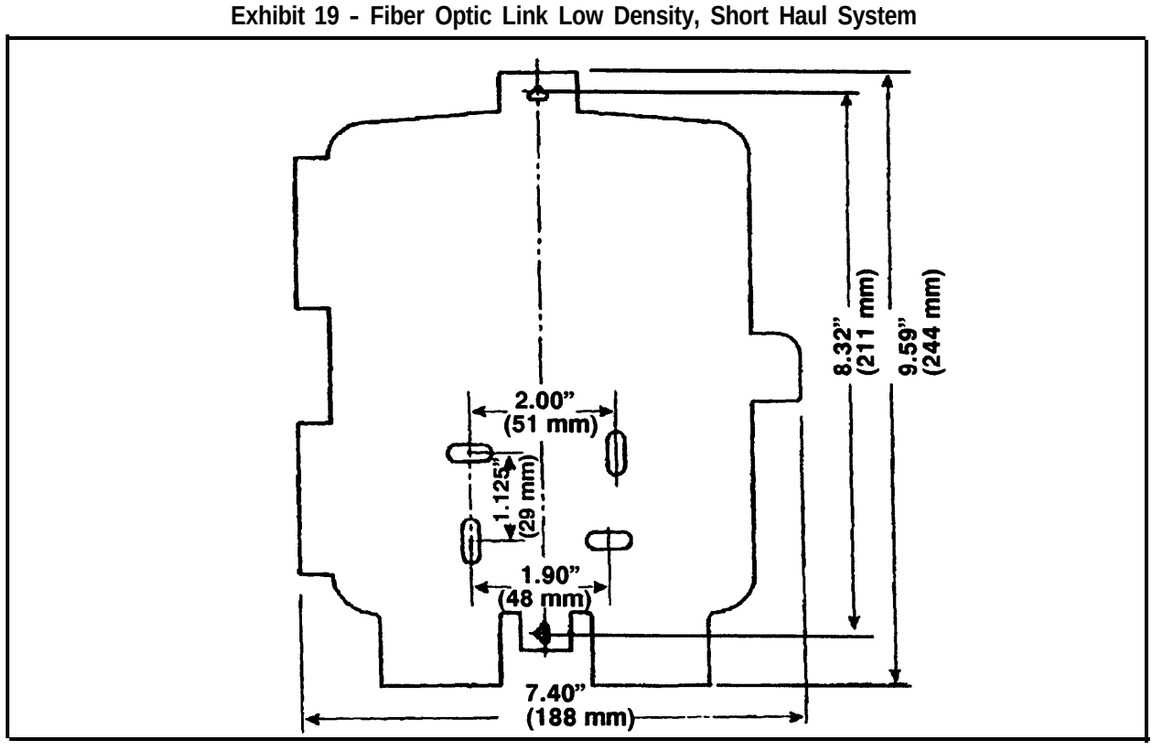


Exhibit 20 - Low Density Housing Footprint

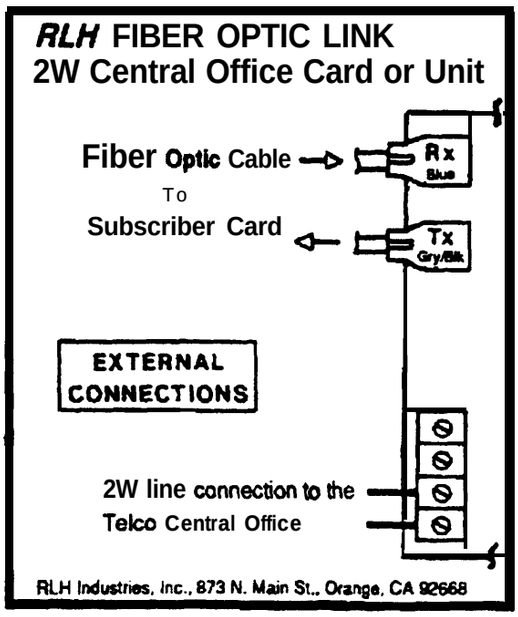


Exhibit 21 - CO 2-Wire Card/Unit Label

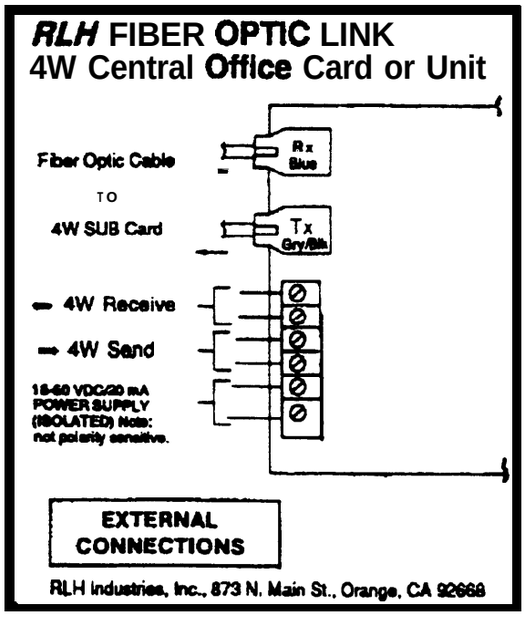


Exhibit 22 - CO 4-Wire Card/Unit Wiring Label

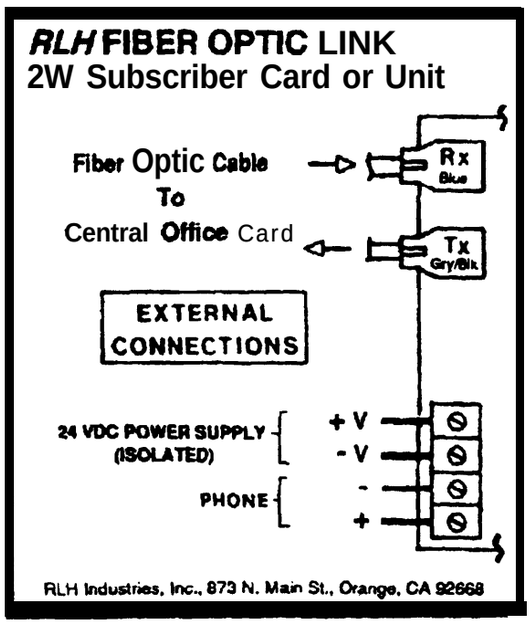


Exhibit 23 - 2-Wire SUB Card/Unit Wiring Label

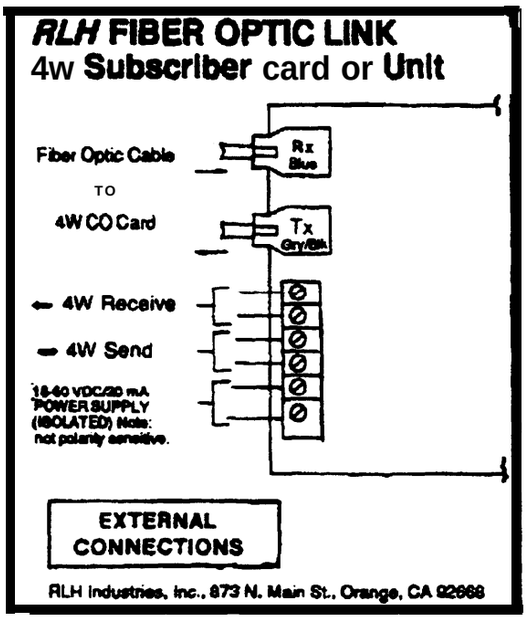


Exhibit 24 - 4-Wire SUB Card/Unit Wiring Label

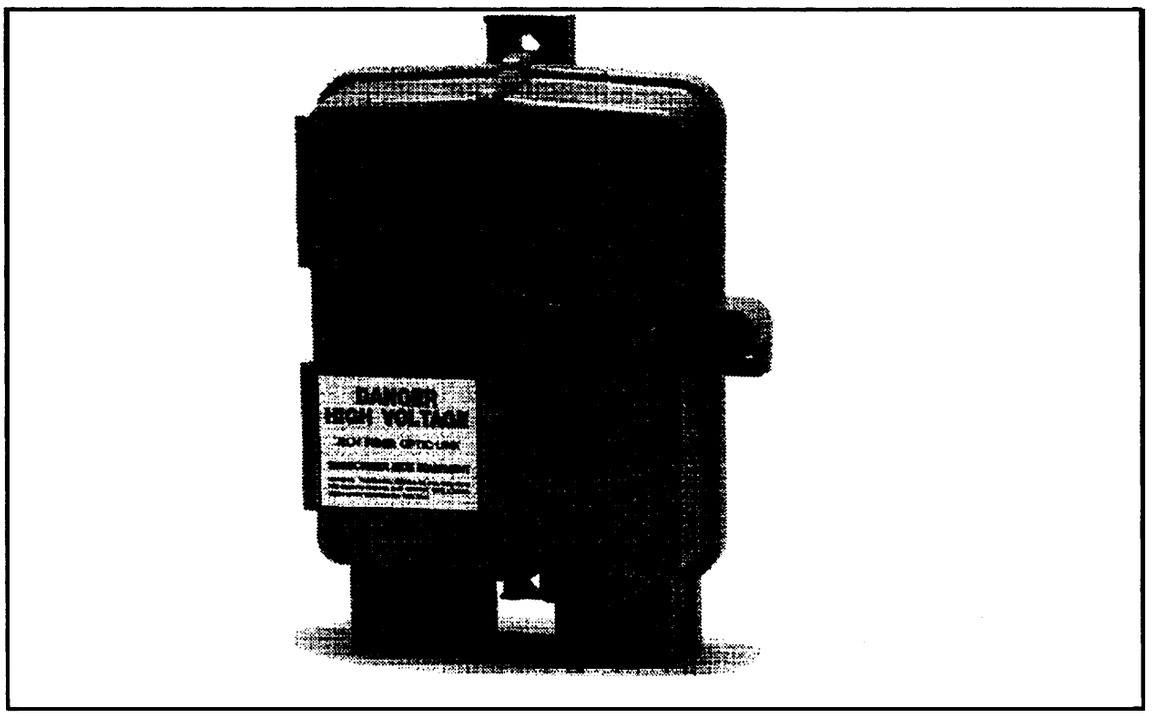


Exhibit 25 - Fiber Optic Link Low Density Housing

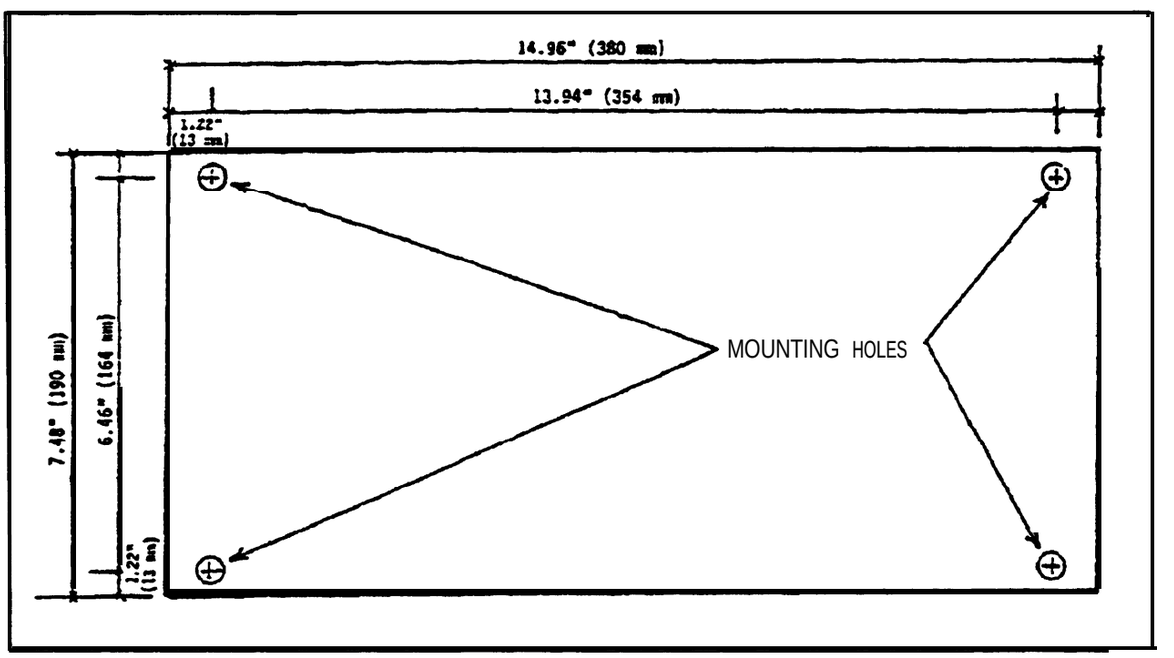


Exhibit 26 – High-Density CO/SUB Shelf Footprint

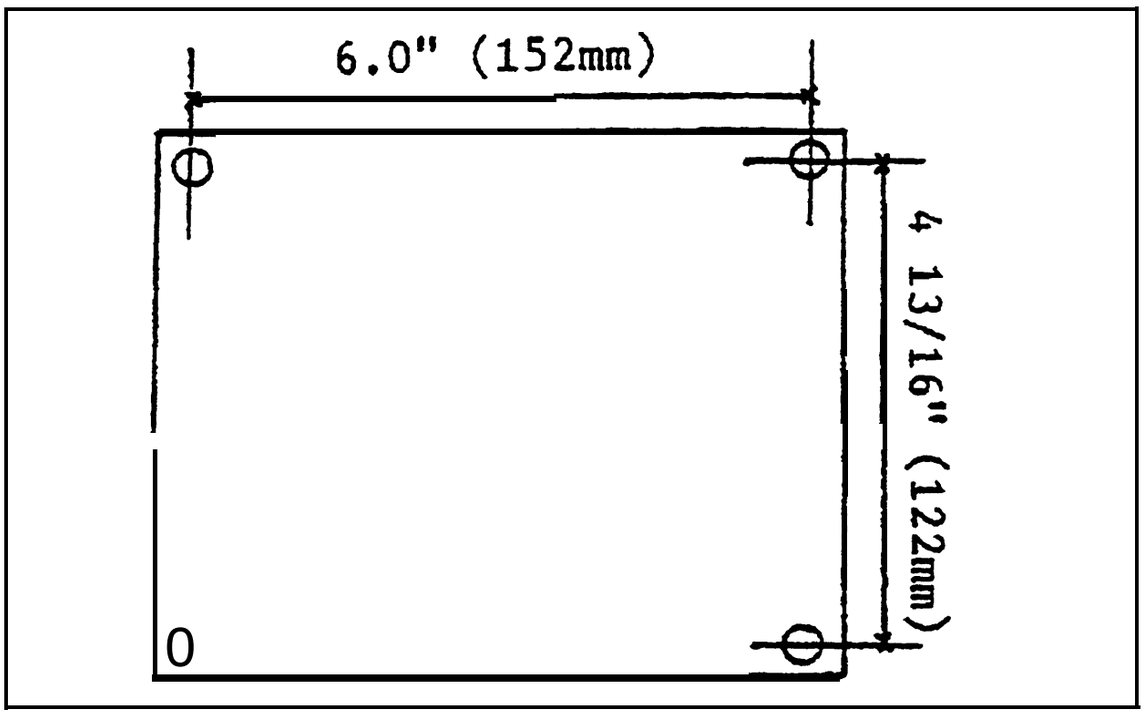


Exhibit 27 – High-Density Power Supply Battery Back-up Footprint

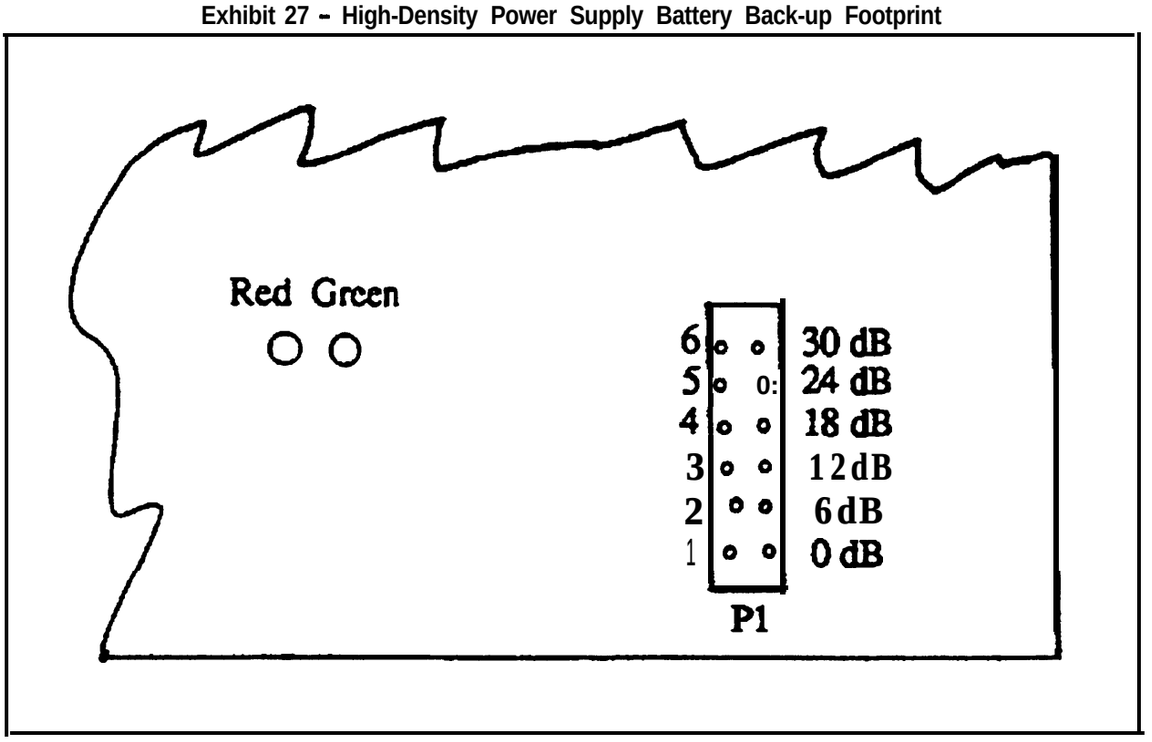


Exhibit 28 - 56 kbps and T-1 CO Card Gain Adjust