

Operator's Manual

L Band Fiberoptic Link

Model

Fiberoptic Transmitter

3110A/10346A 950-1450 MHz

3111A/10346B 950-1750 MHz

3112A/10347A 950-2050 MHz

Fiberoptic Receiver

4110A/10446A 950-1450 MHz

4111A/10446B 950-1750 MHz

4112A/10447A 950-2050 MHz



Making Light *Work* For You

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WARNINGS, CAUTIONS, AND GENERAL NOTES

Safety Considerations

When installing or using this product, observe all safety precautions during handling and operation. Failure to comply with the following general safety precautions and with specific precautions described elsewhere in this manual violates the safety standards of the design, manufacture, and intended use of this product. Ortel Corporation assumes no liability for the customer's failure to comply with these precautions.

CAUTION

Calls attention to a procedure or practice which, if ignored, may result in damage to the system or system component. Do not perform any procedure preceded by a CAUTION until described conditions are fully understood and met.

Electrostatic Sensitivity

ESD = Electrostatic Sensitive Device

Observe electrostatic precautionary procedures.

Semiconductor laser transmitters and receivers provide highly reliable performance when operated in conformity with their intended design. However, a semiconductor laser may be damaged by an electrostatic charge inadvertently imposed by careless handling.

Static electricity can be conducted to the laser chip from the center pin of the RF input connector, and through the DC connector pins. When unpacking and otherwise handling the transmitter, follow ESD precautionary procedures including use of grounded wrist straps, grounded workbench surfaces, and grounded floor mats.

Exposure to electrostatic charge is greatly reduced after the transmitter has been installed in an operational circuit.

If You Need Help

If you need additional help in installing or using the system, need additional copies of this manual, or have questions about system options, please call Ortel's Sales Department.

Service

Do not attempt to modify or service any part of the system other than in accordance with procedures outlined in this Operator's Manual. If the system does not meet its warranted specifications, or if a problem is encountered that requires service, return the apparently faulty plug-in or assembly to Ortel for evaluation in accordance with Ortel's warranty policy.

When returning a plug-in or assembly for service, include the following information: Owner, Model Number, Serial Number, Return Authorization Number (obtained in advance from Ortel Corporation's Customer Service Department), service required and/or a description of the problem encountered.

Warranty and Repair Policy

The Ortel Corporation Quality Plan includes product test and inspection operations to verify the quality and reliability of our products.

Ortel uses every reasonable precaution to ensure that every device meets published electrical, optical, and mechanical specifications prior to shipment. Customers are asked to advise their incoming inspection, assembly, and test personnel as to the precautions required in handling and testing ESD sensitive opto-electronic components.

These products are covered by the following warranties:

1. General Warranty

Ortel warrants to the original purchaser all standard products sold by Ortel to be free of defects in material and workmanship for one (1) year from date of shipment from Ortel. During the warranty period, Ortel's obligation, at our option, is limited to repair or replacement of any product that Ortel proves to be defective. This warranty does not apply to any product which has been subject to alteration, abuse, improper installation or application, accident, electrical or environmental over-stress, negligence in use, storage, transportation or handling.

2. Specific Product Warranty Instructions

All Ortel products are manufactured to high quality standards and are warranted against defects in workmanship, materials and construction, and to no further extent. Any claim for repair or replacement of a device found to be defective on incoming inspection by a customer must be made within 30 days of receipt of the shipment, or within 30 days of discovery of a defect within the warranty period.

This warranty is the only warranty made by Ortel and is in lieu of all other warranties, expressed or implied, except as to title, and can be amended only by a written instrument signed by an officer of Ortel. Ortel sales agents or representatives are not authorized to make commitments on warranty returns.

In the event that it is necessary to return any product against the above warranty, the following procedure shall be followed:

- a. Return authorization shall be received from the Ortel Sales Department prior to returning any device. Advise the Ortel Sales Department of the model, serial number, and the discrepancy. The device shall then be forwarded to Ortel, transportation prepaid.

Devices returned freight collect or without authorization may not be accepted.

- b. Prior to repair, Ortel Sales will advise the customer of Ortel test results and will advise the customer of any charges for repair (usually for customer caused problems or out-of-warranty conditions).

If returned devices meet full specifications and do not require repair, or if non-warranty repairs are not authorized by the customer, the device may be subject to a standard evaluation charge. Customer approval for the repair and any associated costs will be the authority to begin the repair at Ortel. Customer approval is also necessary for any removal of certain parts, such as connectors, which may be necessary for Ortel testing or repair.

- c. Repaired products are warranted for the balance of the original warranty period, or at least 90 days from date of shipment.

3. **Limitations of Liabilities**

Ortel's liability on any claim of any kind, including negligence, for any loss or damage arising from, connected with, or resulting from the purchase order, contract, or quotation, or from the performance or breach thereof, or from the design, manufacture, sale, delivery, installation, inspection, operation or use of any equipment covered by or furnished under this contract, shall in no case exceed the purchase price of the device which gives rise to the claim.

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Ortel will not be responsible for loss of output or reduced output of opto-electronic devices if the customer performs chip mounting, ribbon bonding, wire bonding, fiber coupling, fiber connectorization, or similar operations. These processes are critical and may damage the device or may affect the device's output or the fiber output.

Ortel test reports or data indicating mean-time-to-failure, mean-time-between-failure, or other reliability data are design guides and are not intended to imply that individual products or samples of products will achieve the same results. These numbers are to be used as management and engineering tools, and are not necessarily indicative of expected field operation. These numbers assume a mature design, good parts, and no degradation of reliability due to manufacturing procedures and processes.

Ortel is not liable for normal laser output degradation or fiber coupling efficiency degradation over the life of the device.

DANGER

This fiberoptic laser transmitter contains a class IIIb laser product as defined by the U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration. This laser product complies with 21 CFR, Chapter I, Subchapter J of the DHEW standards under the Radiation Control for Health and Safety Act of 1968. The laser module certification label is located on the top of the transmitter enclosure and it also shows the required **DANGER** warning logotype (as shown below).

The Ortel laser products are used in optical fiber communications systems for radio frequency and microwave frequency analog fiberoptic links. In normal operation, these systems are fully enclosed and fully shielded by the hermetically sealed laser metal package. Laser bias current is limited by the internal control circuitry. The transmitters are coupled to glass fiber and have 1300 nm optical output wavelength with typically .5 to 7 mW output depending on the model. The optical radiation is confined to the fiber core. Under these conditions, there is no accessible laser emission and hence no hazard to safety or health. Variations in the different models reflect the bandwidth, optical output, noise, and distortion of the laser.

Since there is no human access to the laser output during system operation, no special operator precautions are necessary when fiber is connected to the transmitter and receiver. During installation, service, or maintenance, the service technician is warned, however, to **take precautions which include not looking directly into the fiber connector or the fiber which is connected to the fiber connector before it is connected to the fiberoptic receiver. The light emitted from the fiberoptic connector or any fiber connected to the connector is invisible and may be harmful to the human eye. Use either an infrared viewer or fluorescent screen for optical output verification. All handling precautions as outlined by the FDA and ANSI Z136.2 and other authorities of class IIIb lasers must be observed.**

Do not attempt to modify or to service the laser transmitter. Return it to Ortel Corporation for service and repair. Contact the Ortel Corporation Customer Service Department for a return authorization if service is necessary.



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Chapter 1. Typical Applications & General Features

The fiberoptic transmitters and fiberoptic receivers described in this manual, connected with a singlemode fiberoptic cable, make up an L-Band interfacility link (IFL) designed for use in satellite earth terminals. Such a fiber IFL replaces the traditional coaxial cable between the antenna and the receiver or modem for applications including:

- TVRO – CATV, SMATV, Broadcast, Distance Learning, Business TV, Multiple Dwelling Units (MDU)
- Two Way – Intelsat, Eutelsat
- GPS
- Inmarsat

Some typical installation configurations are shown in Figure 1-1, while the primary models and frequency options are listed below:

TABLE 1-1. FREQUENCY & PACKAGE OPTIONS				
Freq. Range	Transmitters		Receivers	
	Flange-mount	10K Plug-in	Flange-mount	10K Plug-in
950 – 1450 MHz	3110A	10346A	4110A	10446A
950 – 1750 MHz	3111A	10346B	4111A	10446B
950 – 2050 MHz	3112A	10347A	4112A	10447A

The flange-mount versions are designed for mounting in outdoor NEMA box enclosures, in a 1U high 19 inch rack mount chassis, or in other small spaces. For powering, the standard flange-mount receivers take DC power via wire leads or via the center pin of the output RF connector. The standard flange-mount transmitters take power on two wire leads, but also pass this voltage through to the center pin of the input RF connector to power an LNB or similar device. There is also an option to order transmitters and receivers with the DC blocked so that the RF connection is purely AC-coupled.

The 10K plug-in versions are designed for mounting in Ortel's Model 10990A 3U high 19 inch rack mount chassis, which can be powered easily from standard AC inputs via the Model 10901A or B power supplies. The plug-in transmitters also have the option of sending DC power to an LNB through the RF connector.

At the heart of the fiberoptic link is a wideband, non-cooled, directly modulated laser/photodiode link. The laser is biased with a DC current, on top of which is modulated the RF of the satcom signal. This produces an intensity modulation of the optical output, as in Figure 1-2. This modulated light is then coupled into the fiber. At the other end of the fiber, a semiconductor PIN photodiode converts this optical signal into an electrical current, which is amplified and delivered to the output load, thus recovering the original RF signal.

In addition to the primary options of packaging and frequency range, several other options are available, as listed in Table 1-2 and shown in Figures 1-3 and 1-4. The main options here include gain, impedance, and DC powering. For example, the amount of amplification in the standard transmitter and receiver was designed to provide an overall RF link gain of greater than -4 dB when used with an optical loss of 1 dB; and to provide a S/N and C/I roughly equivalent when the total input power is near -10 dBm. However, for those applications with lower power input signals, or where a different link gain is required, option -002 may be used (as detailed in chapter 2.)

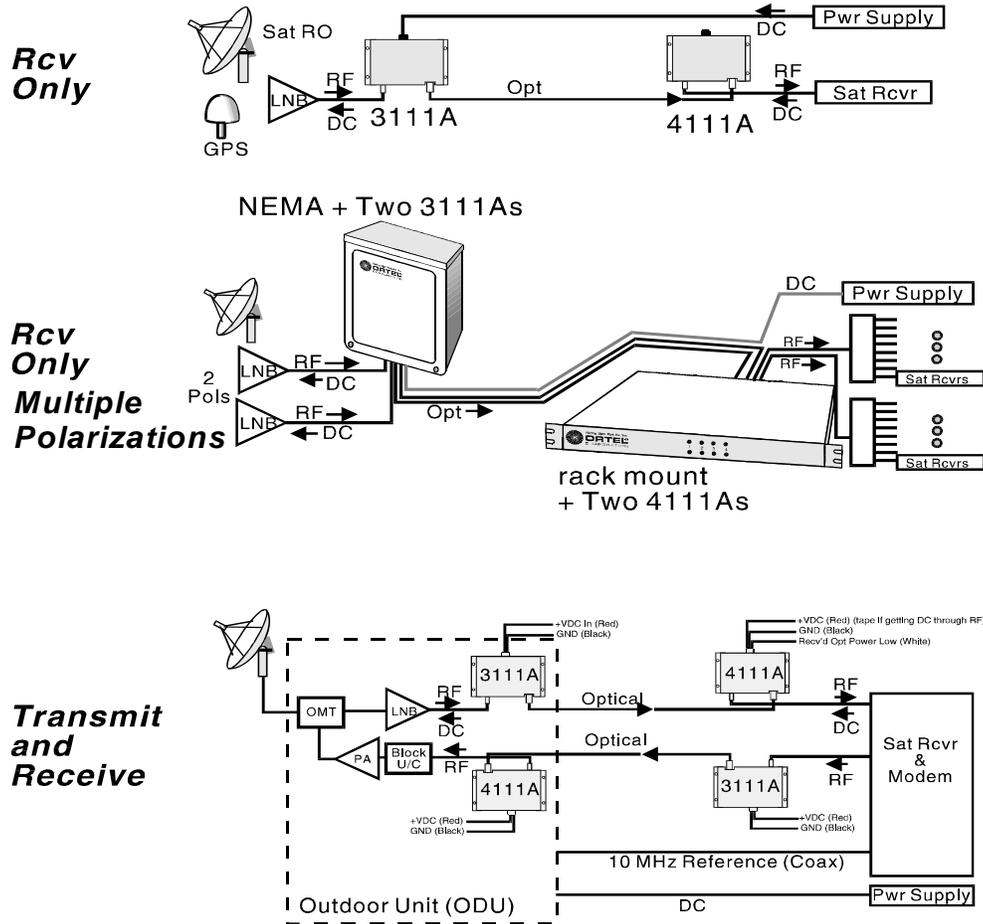


Figure 1-1. Typical applications of the L-band IFL.

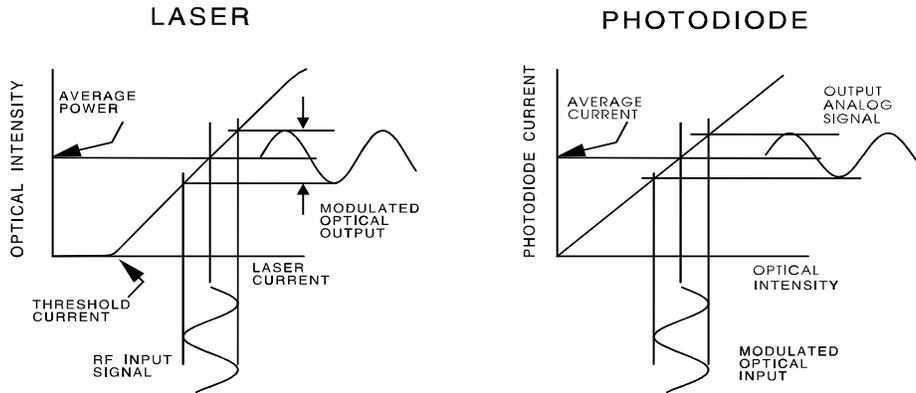


Figure 1-2. Heart of a fiberoptic link—conversion of electrical and optical RF signals.

TABLE 1-2. L-BAND OPTIONS				
Option	Option Availability		Option Description	Standard Configuration
	Flange Mount	Plug-in		
-001	X	X	50Ω SMA, female.	75Ω F-type connector, female.
-002	X	X	For lower signal input. Tx: Two stages of amplification. Rx: Single stage of amplification.	Tx: Single stage of amplification. Rx: Two stages of amplification.
-003	X		Unit to run from +5.0V±0.2V. No internal DC regulator.	DC regulator operates from +8V to +24V input.
-004	X		RF connector is AC coupled, with no DC on center pin.	Flange-mount Tx & Rx: RF connects to DC INPUT, so DC is on RF center pin. (Caution is needed to avoid shorting.) Tx Plug-in: DC voltage can be coupled on RF connector with field-configurable jumper. Rx Plug-in: RF connector is AC coupled.
-006		X	75Ω CANARE BNC connector.	75Ω input impedance with F-type connector.

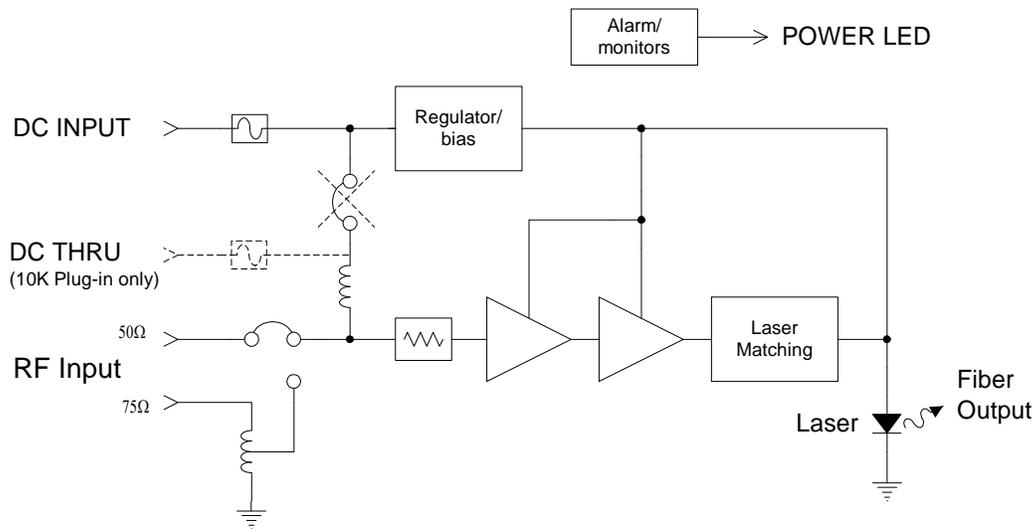


Figure 1-3. L-band Transmitter block diagram. High gain (option -002) configuration is shown. Standard model has a single stage pre-amplifier. DC jumper is removed for flange-mount -004 option and for all plug-in versions.

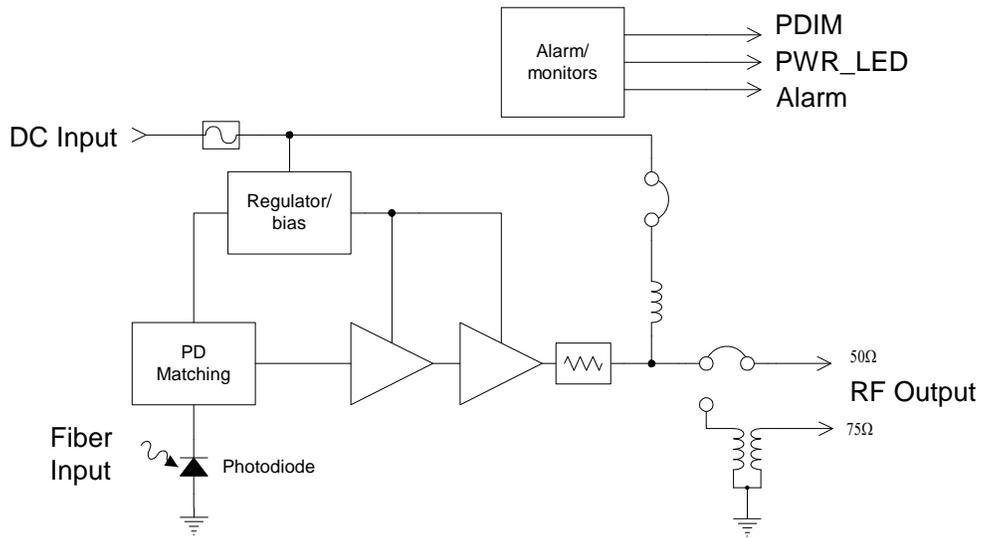


Figure 1-4. L-band Receiver block diagram. Standard configuration is shown. Low gain model has a single stage pre-amplifier. DC jumper is removed for flange-mount -004 option and for all plug-in versions.

Chapter 2. RF Performance

Since the fiberoptic link has an analog RF input and output, its performance can be specified and analyzed like any RF component, with parameters such as noise figure, third order intercept (IP3), VSWR, etc. as shown below. The main caveat is that the optical loss and the specific choice of transmitter and receiver must be known. In the tables below, the worst case RF performance has been specified for the case of 1 dB of optical loss. Some units may have gain much higher than that listed below.

If the optical loss differs from 1 dB, the RF gain will drop 2 dB for each additional 1 dB of optical loss and the noise figure will begin to degrade. (For example, a standard gain link with 2 dB of optical loss would have an RF gain of ≥ -6 dB, while the same link with 1 dB optical loss would have ≥ -4 dB.) The exact amount of noise degradation will depend on the optical back reflections and length of the fiber, but as a rough rule of thumb, the noise will stay fairly close to the value for 1 dB optical loss up to about 3-4 dB of optical loss, and then begins degrading about 2 dB for each additional 1 dB of optical loss. For high optical losses, optical back-reflections also must be minimized to avoid degrading the C/I. This generally means that these L-band transmitters can be used well with quality optical splitters and connectors, but may suffer some RF degradation when used with fibers with lengths upwards of several kilometers. Chapter 4 describes in greater detail the use of fiberoptic components with these links.

When optimizing the RF performance, the main concern involves setting the input RF signal level. A detailed analysis may be carried out using Table 2-2 below, or as another rough rule of thumb, the optimal total RF power into the transmitter should be near -10 dBm for a standard gain transmitter and -27 dBm for a high gain unit. Due to the dynamic range of these links, the RF power can deviate some from this optimal level and still provide good results. For specific examples of optimizing links, see chapter 6.

TABLE 2-1. FREQUENCY & PACKAGE OPTIONS				
Freq. Range	Transmitters		Receivers	
	Flange-mount	10K Plug-in	Flange-mount	10K Plug-in
950 – 1450 MHz	3110A	10346A	4110A	10446A
950 – 1750 MHz	3111A	10346B	4111A	10446B
950 – 2050 MHz	3112A	10347A	4112A	10447A

TABLE 2-2 RF PERFORMANCE					
for complete link of Tx, Rx, 1 dB optical loss, & >60 dB optical return loss					
Tx gain option		Std.	-002 (high)	Std.	-002 (high)
Rx gain option		Std.	-002 (low)	-002 (low)	Std.
Gain (at 25°C), min.		-4.0 dB	-4.0 dB	-21.0 dB	+13.0 dB
Amplitude Flatness	any 500 MHz	± 1.5 dB	± 1.5 dB	± 1.5 dB	± 1.5 dB
	any 40 MHz	± 0.35 dB	± 0.35 dB	± 0.35 dB	± 0.35 dB
Noise Figure, max.		45 dB	28 dB	45 dB	28 dB
Input IP3, min.	Tx to -20°C	+7.5 dBm	-9.5 dBm	+7.5 dBm	-9.5 dBm
	Tx to -40°C	+4.5 dBm	-12.5 dBm	+4.5 dBm	-12.5 dBm
Input 1dB compr. (typ.)	Tx to -20°C	≥ 0 dBm	≥ -17 dBm	≥ 0 dBm	≥ -17 dBm
	Tx to -40°C	≥ -3 dBm	≥ -20 dBm	≥ -3 dBm	≥ -20 dBm
Gain vs. Temp. (typ.)	Tx	0.09 dB/°C	0.12 dB/°C	0.09 dB/°C	0.12 dB/°C
	Rx	0.06 dB/°C	0.03 dB/°C	0.03 dB/°C	0.09 dB/°C
VSWR	Tx (input)	2.0 : 1	2.0 : 1	2.0 : 1	2.0 : 1
	Rx (output)	1.8 : 1	1.8 : 1	1.8 : 1	1.8 : 1
Max. RF Input (Tx)		+3 dBm	-14 dBm	+3 dBm	-14 dBm
In/Out Impedance	75 Ohm F-type, female (50 Ohm SMA, option -001)				

TABLE 2-3.	Flange-mount	10K style Plug-in
TEMPERATURE		
Operating Temp.	-40 to +60°C	0 to +50°C
Storage Temp.	-45 to +85°C	-40 to +85°C

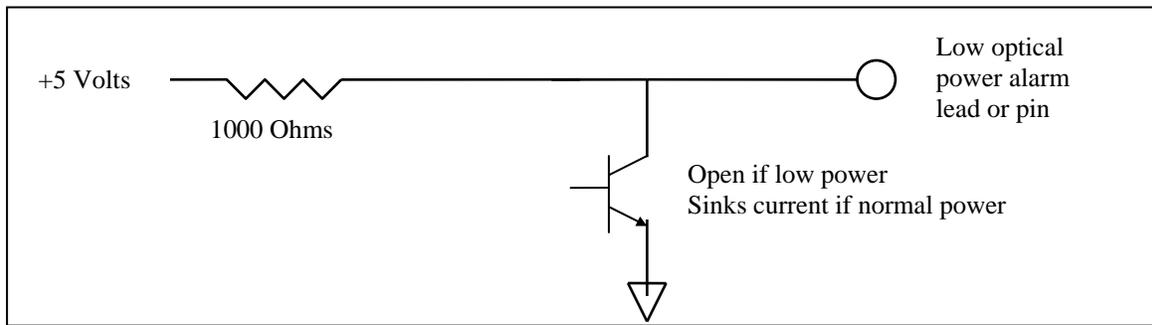
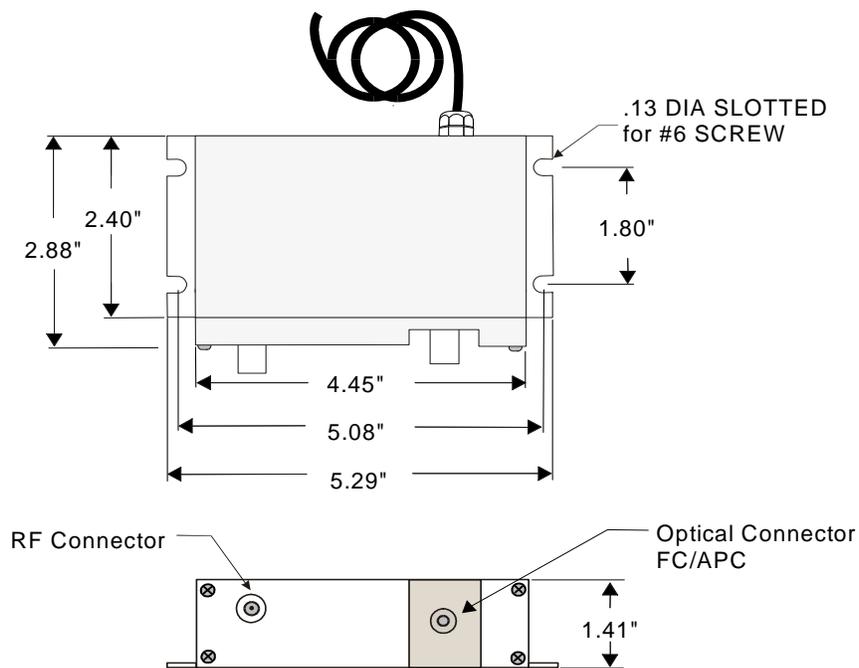


Figure 3-1. ALARM Circuit for both flange mount and plug-in style L-band receivers switches at approximately 0.03 mW.

CAUTION!—*Powering an LNB:* As shown in Figures 1-3 and 1-4, the voltage applied at the unit's DC INPUT connects directly to the RF center pin. In the case of the fiberoptic transmitter, this connection allows an LNB or similar device to be powered with up to 400 mA of DC current. However, caution should be used. If ground is shorted to the RF center pin of the Tx or any RF cable connected to it, the internal fuse or other components may be damaged. Similarly, other components connected to the Tx may be damaged if they can not withstand the DC voltage present at the connector. If possible, it is safer to connect the RF cables first and then turn on the DC power, thus avoiding the chance of shorting a live wire.

In the case of the fiberoptic receiver (Rx), the DC INPUT to RF center pin connection is provided to allow powering of the Rx when a DC voltage is provided on the RF cable, as is the case with many RF radio receivers. Similar to the fiberoptic Tx, care should be taken so that this DC voltage does not damage the Rx or any other devices due to shorting to ground or other DC voltages. (If the DC coupling of the RF connector poses a systematic problem, option -004 may be ordered, or if only standard units are available then a DC block may be inserted on the RF line.)



Dimensions are in inches

Figure 3-2. Flange-mount package dimensions.

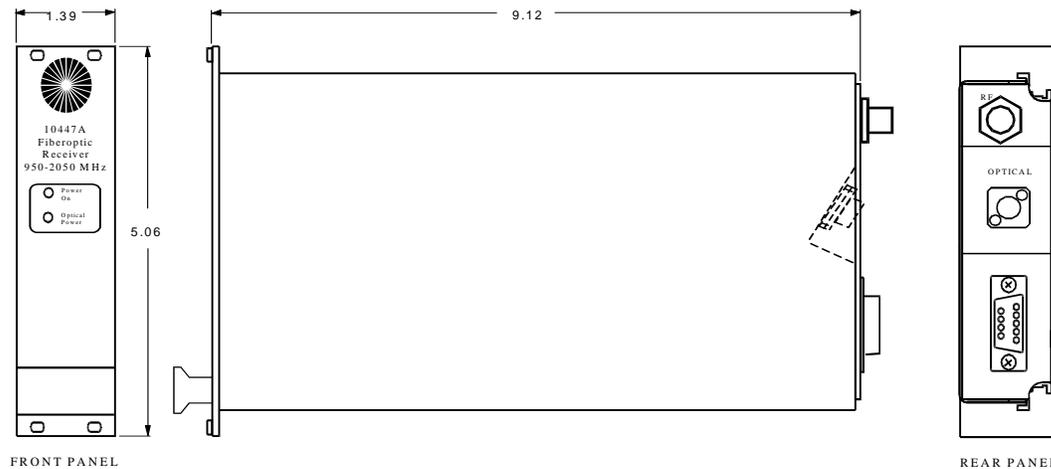


Figure 3-3. Plug-in package dimensions.

3.2.2. 10K Plug-in package DC inputs/outputs

Plug-in style units may be used with an Ortel provided rack mount chassis (Model 10990A), main power supply (Model 10901A), and optional back-up power supply (Model 10901B). With these products, simply slide the fiberoptic transmitter or receiver into any slot in the chassis. Blind-mate connectors on the back plane are wired to the power supplies. Transmitters and receivers may be inserted with the power supply turned on or off. Refer to Table 3-4 for a listing of the input and output signals for this unit.

The status of the Tx and Rx plug-ins and power supplies can be monitored either from the front panel LEDs or the back panel DC connectors. Both the Tx and Rx have a “Power On” LED, while the Rx also has an “Optical Power” LED which turns on if the optical power into the receiver is more than approximately 0.03 mW. The 8 transmitter/receiver slots of the 10990A chassis each have a 5 pin connector (P11-P18) which directly connects to the 9 pin D-connector of the plug-in.

3.2.2.1. Powering of an LNB with plug-in style transmitter

Three options exist for DC powering via the plug-in style transmitters, all three of which can be configured in the field as follows. For options 1 and 2 **CAUTION** should be used because a DC voltage will be present on the RF center pin (see section 3.1.2). The current via pin 5 should be kept below 400 mA. If a high current does burn the fuse it can be replaced as described in Chapter 7, Troubleshooting and Maintenance.

Option 1. Power from chassis power supply

Insert jumper 8315-001 onto the associated 5-pin connector (P11–P18) on the back plane of the chassis. This will route the high voltage (V_A) from the chassis power supply down the center pin of the RF connector. For Models 10901A or 10901B power supplies $V_A = 15$ volts. If jumper 8315-001 has been lost, an alternate can be made simply by shorting pins 4 & 5 (see table 3-4 and 3-6), or contact Ortel for a replacement.

Option 2. Power from external power supply

If a different voltage is required on the RF center pin, an external power supply can be routed through pin 5 of P11-P18.

Option 3. AC coupled RF center pin. (i.e., no DC)

Leave a blank jumper connector on P11-P18.

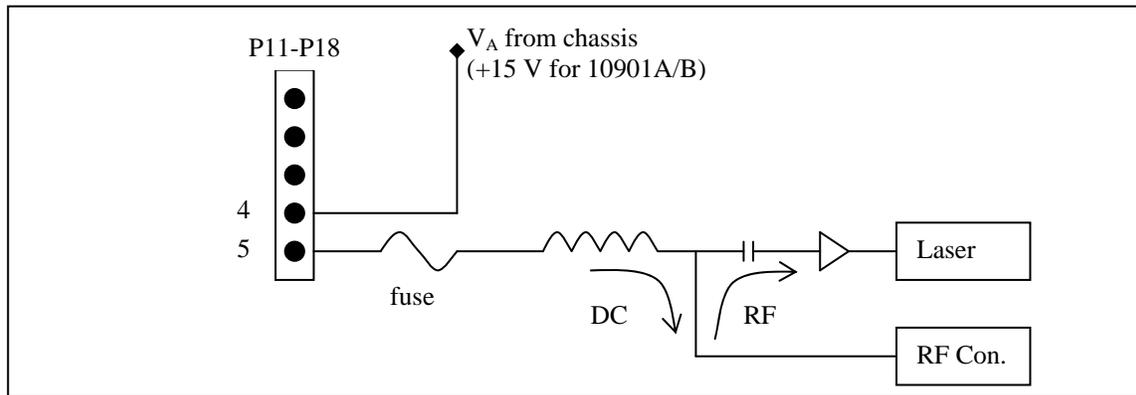


Figure 3-4. Plug-in Tx circuit for DC powering of an LNB or similar device through the RF center pin.

TABLE 3-4 BACK PANEL FUNCTIONS OF MODEL 10990A CHASSIS AND L-BAND PLUG-INS					
Tx/Rx D-sub Pin #	Chassis Back Panel P20	Chassis Back Panel P11-P18	Mating 5-pin	Tx, L-band, Plug-in	Rx, L-band, Plug-in
1	2			DC INPUT Typically +15 V.	DC INPUT Typically +15 V.
2	1 (+5V)			nc	nc
3	3 (-15V)			nc	nc
4	4			GND	GND
5		1	5	GND	GND
6		2	4	nc	PDIM Photodiode current monitor. 1 V/mA
7		3	3	nc	ALARM Low optical power alarm. Gnd if >0.03 mW. Open or High if <0.03 mW.
8		4	2	DC OUTPUT Connected to pin 1. Provides DC voltage to power pin 9.	nc
9		5	1	DC THRU Connected to RF center pin.	nc

nc = No Connection

3.2.2.2. Model 10990A chassis & power supply monitoring and connections

The power supplies' status also can be monitored, in this case from a pair of relays wired to a 9 pin in-line connector (P19) on the chassis, as described in table 3-5. Another connector (P20) connects directly to the power supply in the "main" slot, which is the farthest left slot when viewed from the back. This P20 allows monitoring directly of the DC power voltages of the main power supply, or powering of the chassis via an external source without a 10901A or B. The main power supply slot and P20 connect to the plug-ins through a set of diodes which allows for the power supply redundancy, hence the back-up power supply and the actual voltage at the plug-in can not be monitored directly via P20.

TABLE 3-5 10990A POWER SUPPLY STATUS CONNECTOR (P19)					
Pin	Description	Main OFF*	Main ON*	Aux. OFF*	Aux. ON*
1	No connection	--	--	--	--
2	No connection	--	--	--	--
3	Aux. Status	--	--	connected to center	open
4	Aux. Status (center)	--	--	center	center
5	Aux. Status	--	--	open	connected to center
6	Main Status (center)	center	center	--	--
7	Main Status	connected to center	open	--	--
8	Main Status	open	connected to center	--	--
9	Ground	--	--	--	--

* Power supply status is determined by monitoring the +5 volt output, which is the primary power source of the supplies. The "Main" slot is the farthest left slot when viewed from the back.

TABLE 3-6 10990A CHASSIS MATING CONNECTORS AND PINS		
Back Plane Connector	Mating Connector	Crimp Pins
P11-P18	Molex P/N 22-01-2057	Molex P/N 08-50-0114
P19	Molex P/N 22-01-2097	Molex P/N 08-50-0114
P20	Molex P/N 09-50-3031	Molex P/N 08-50-0108

Chapter 4. Fiberoptic Components

TABLE 4-1 OPTICAL SPECIFICATIONS	
Transmitter	
Wavelength	1310 ± 30 nm
Power	1.10 ± 0.3 mW
Laser DC modulation gain	≥ 0.02 W/A
Receiver	
Photodiode DC responsivity	≥ 0.75 A/W
Fiber	Singlemode, 9/125 (Corning SMF-28 or equivalent)
Connector	FC/APC "tight fit" (Type 'R' per IEC 1754-10-1) ≥ 60 dB optical return loss

4.1. Optical fiber

Ortel transmitters and receivers are designed for use with singlemode optical fiber at 1310 nm. While many styles exist for the outer jackets and cables, the fundamental glass portion of the fiber is consistently 125 microns in total diameter, with the inner 8-10 microns being the core which actually contains the light. As can be imagined, with such a small core, cleanliness and care of bare fiber is critical. This is why most singlemode fibers are covered with several layers of protection, the first of which is a 250 micron coating. After that, indoor cables have a 900 micron plastic "tight buffer", while many outdoor cables use a "loose tube" instead in which the fiber floats in a petroleum-based jelly. Other cable designs include strength members, armor plating, and often multiple fibers. As an example, 5/8 inch diameter cable assemblies are available containing as many as 96 fibers. The exact cable style will depend on the application.

Regardless of the type of cable chosen, several considerations are universal, with perhaps the most critical being bend radius. Like many types of RF cables, when an optical fiber is bent tighter than roughly a 1 inch (25 mm) radius, the light will escape thus decreasing the RF gain of the link. Much tighter than 1 inch also may permanently damage some fibers. Thus when storing or installing fiberoptic cable it should be wound and bent in loose coils or turns. On the convenient side, optical fiber is immune to all electrical cross-talk, therefore optical cables can be installed next to power and communication lines with no concern of signal degradation.

Finally, the fiber also must be singlemode, not multimode. Multimode fiber does not have sufficient bandwidth nor gain stability for the applications serviced by Ortel links.

4.2. Optical connectors

There are many optical connectors on the market. For high performance, high frequency RF applications, the connector must be for singlemode fiber and be repeatable, low loss and, most importantly, have a low optical return loss. Connectors with no return loss specification are for low speed digital and analog. Return loss is important because optical reflections can degrade noise and linearity performance.

Connector styles. The Ortel connector of choice is the FC/APC indicated in Figure 4-2. In particular, the connector used is the FC/APC "tight fit" compatible with the Seikoh Giken connector. It has proved to be reliable and repeatable, and most important, has very low backreflections of < -60 dB. There are a number of manufacturers who make connectors compatible with this connector; e.g., Seikoh Giken, Alcoa Fujikura and the Molex "Tight Fit". Note that the Diamond FC/APC has a larger "key" and will not fit in the slot on the bulkhead optical connector. If in doubt on the connector style, the width of the mating key can be measured. The tight fit style has a key width of 2.00 mm (+.02, -.03 mm) while the wider styles typically are 2.14 mm.

Two other common styles of connectors include the ST, which is a bayonet style connector analogous to an RF BNC, and the SC, which is a "snap together" connector. The FC style has a threaded sleeve. In all these cases the

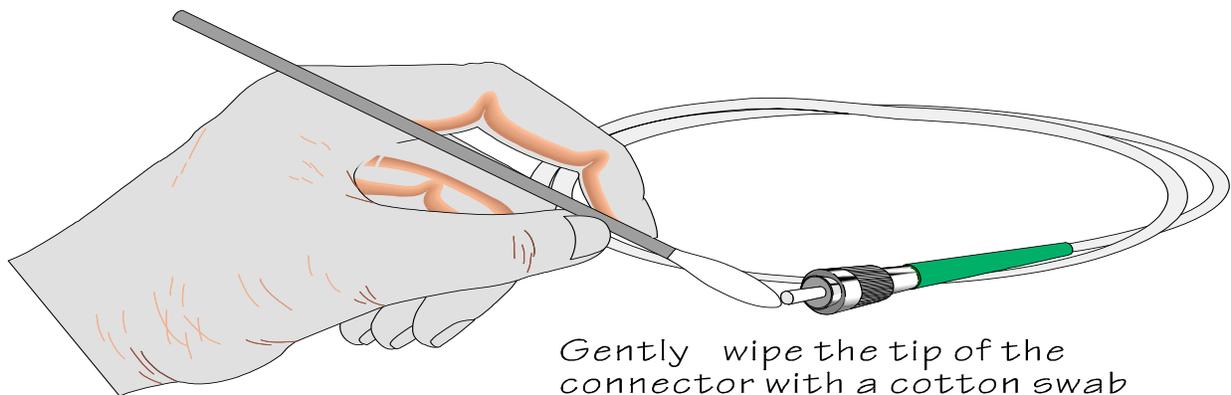
connectors themselves are sexless, with connections being made using adapters that simply guide the tips of two common connectors together to make a continuous optical path. While only FC/APC connectors can be mated directly with the Ortel transmitters and receivers, other connector styles or optical splices may be used at patch panels provided the optical backreflections are kept low. The best way to insure this is to use connectors with an 8 degree APC style polish or splices with optical reflections comparable to that of APC connectors. Although no permanent damage to the transmitters or receivers occur, high optical reflections can degrade the gain, noise, and linearity during operation.

Cleaning. Fiberoptic connectors on cable that come pre-terminated should be clean and capped, so one can usually simply remove the cap and make the connection without cleaning the connector. But if there is any doubt, it is good practice to clean the optical connectors before making the connection. Once the connection is made, there is no need to periodically clean the connector as long as it remains connected. Additionally, the laser and photodiode of the transmitter and receiver never require cleaning, although it is recommended to keep them covered when not in use.

When handling or cleaning, remember that the light is emitted from an aperture only 9 μm in diameter, so grease from your finger or a small scratch can easily interfere. The concern is not just optical loss, but also optical reflections, which can affect laser noise and distortion. To clean, moisten a cotton swab in alcohol and gently wipe the tip of the connector ferrule several times. Allow to air dry.

CAUTION: Take precautions when working with fiber that may be carrying laser light. Looking directly into the connector or bare fiber may cause serious eye damage.

Connecting. Once the connector is clean, bring it up to the bulkhead optical connector on the laser or photodiode module. Note the connector has a "key" on the side of it's housing that must fit into the slot in the bulkhead connector, as shown in figure 4-2. Once these are aligned, carefully push the fiber connector into the bulkhead connector so the key fits into the slot. (Not having the key properly aligned in the slot is the most common problem when using such optical connectors.) Next, push the threaded outer shell of the connector onto the bulkhead and screw it on. *The connector should be screwed on finger tight only. Overtightening can damage the laser or photodiode.*



Gently wipe the tip of the connector with a cotton swab soaked in alcohol.

Air dry

Figure 4-1. Cleaning optical connectors.

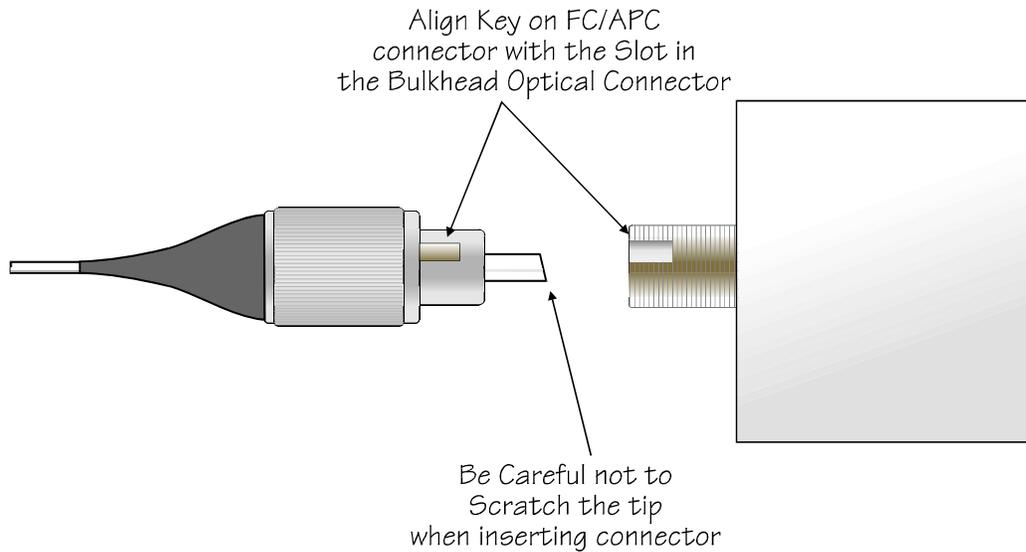


Figure 4-2. Inserting FC-APC connectors.

4.3. Detecting optical power

The light from the transmitter is infrared and invisible to the human eye, hence some indirect method is needed to detect it. The cheapest and easiest way to determine if a laser or fiber has light is to direct the laser or a fiber connector onto an infrared detection card (available, for example, from Fiber Instrument Sales, Inc., Part #F1-4103 for approximately \$10. Orsinsky, New York, USA, phone: 315-736-2206). Such cards glow an orangish-red with an intensity and shape corresponding to the infrared light. These cards are ideal for telling if a laser is on or if a fiber has light in it.

For a more quantitative measurement, an optical power meter with a calibrated detector can be used. (In North America, Fiber Instrument Sales, EXFO [at 418-683-0211, or www.exfo.com], Newport Corporation [at 714-253-1680, or www.newport.com] and many other companies make commercially available power meters.) Additionally, the plug-in style receiver's pin 6 gives a voltage that is proportional to the DC current on the photodiode. When the photodiode is illuminated with light the DC current goes from near zero to a value which is proportional to the intensity of the light.

The following describes the relationship between a link's optical parameters and its corresponding RF performance.

$$\Delta G_{RF} = -20 \log (P_{Tx} / P_{Rx}) = -20 \log [(P_{Tx} * r_{Rx}) / I_{Rx}] = 2 * L_{optical}$$

Where ΔG_{RF} is the difference in the RF gain between a link with 0 dB optical loss and one with the above measured optical loss; P_{Tx} is the optical power from the transmitter; P_{Rx} is the power into the receiver; r_{Rx} is the DC responsivity of the receiver; I_{Rx} is the DC photocurrent of the receiver; and $L_{optical}$ is the optical loss between the transmitter and the receiver.

Chapter 5. Installation

This guide and checklist starts by listing the contents of the shipping cartons. It is followed by instructions to install the flange mount modules in the outdoor enclosure and the 1U high rack mount chassis and the plug-in units into the 3U high rack mount chassis.

5.1. Checklist for Unpacking Flange-mount Enclosure Cartons

- A) Outdoor Enclosure Carton
- One (1) Type 3R NEMA Enclosure P/N 1260-001-001.
 - One (1) Mounting Kit. This hardware is for mounting up to two modules inside the NEMA box, not for mounting the NEMA box itself. It includes:
 - 8 #6 x 3/16 inch long Philips style pan head screws. The back panel of the NEMA is pre-drilled and tapped for this hardware.
 - 8 #6 split lock washers.
 - 2 wire saddles with adhesive base to be mounted inside the NEMA box on the back panel. Used for strain relief for RF and optical cables.
- B) Rack Mount Chassis Carton
- One (1) 1U high, 19 inch Rack Mount Chassis with optional Internal Universal Power Supply or without Internal Power Supply.
 - One (1) AC power cord (North America version).
 - One (1) Mounting Kit. This hardware is for mounting up to four modules inside the chassis, not for mounting the chassis itself. It includes:
 - 16 #6 flat head screws¹
 - 8 #6 split lock washers²
 - 8 #6 flat washers²
 - 8 #6 hex nuts²
 - 2 wire saddles with adhesive base to be mounted inside the chassis. Used for strain relief for RF and optical cables.
 - 4 resistors, 2.2k Ω (for use with older transmitter and receiver modules)
 - Two (2) Chassis Mounting Brackets. Front panel rack mounting flanges.

¹ Applies to early versions of the 1U high chassis. Later versions come with pre-installed threaded studs, eliminating the need for the user installed mounting screws.

² Early versions of the 1U chassis utilized quantity 16 for each of the washer types and nuts.

5.2. Installing Flange-mount Modules in the Outdoor NEMA Enclosure

The outdoor enclosure available from Ortel is pre-drilled to mount one or two modules. You will need a screwdriver and an open end or socket wrench for the #6 screws and nuts.

1. For a watertight seal, pot the optical connectors with RTV. This will be easier to do before the module is secured to the back panel in the outdoor enclosure. Do not use silicone. Silicone outgases and, over time, will darken the fiber. If the NEMA box provides enough protection for the modules, skip this step.
2. Fasten the module to the back panel of the NEMA box using the #6 screws and split lock washers. The holes in the back panel are tapped. You will need a Philips head screwdriver. Make sure that the RF and optical connectors are pointed down.
3. The connections are shown in Figure 5-1. Connect the red and black wire leads from the module to the terminal block. Make sure the red lead goes to the terminal where the +VDC wire from the remote power supply is connected. The other lead is Ground.
4. An attenuator at the RF input to the Tx may or may not be necessary to optimize the RF performance (see Chapters 2 and 6).
5. Use the adhesive-backed wire saddles and tie wraps supplied to secure the RF and optical cables to the back panel. This provides strain relief for the RF and optical connectors.
6. Replace the NEMA box front panel and secure it with the proper fasteners.

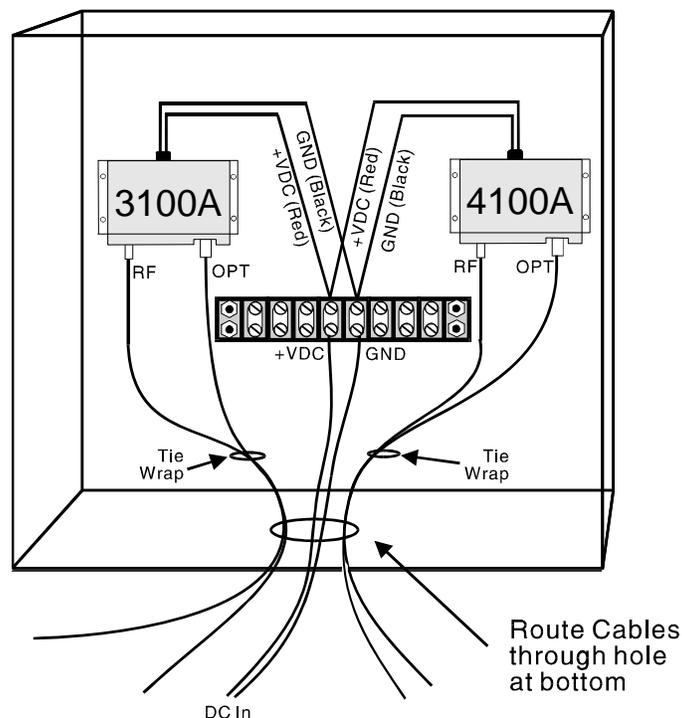


Figure 5-1. Installing flange-mount units in the outdoor NEMA enclosure.

5.3. Installing Flange-mount Modules in the 1U Rack Mount Chassis

The 1U rack mount chassis available from Ortel is designed to mount up to four flange-mount modules. There are two versions: one includes a +15VDC power supply with a universal AC input and a power cord (North America version). The other does not include an internal power supply. You will need a screwdriver and a nut driver or socket wrench for the terminal screws and mounting nuts. If the chassis is to be mounted in a rack, make sure to install the front panel rack mount flanges (supplied).

1. Fasten the modules to the bottom panel using the screws³, flat washers, lock washers and nuts.
2. The DC connections are made to the terminal blocks as shown in Figure 5-2. Refer to Table 5-1 for a list of all the connections to be made. For older Model 31xx and 41xx fiberoptic transmitter and receiver modules (with the three wire DC harness), refer to Figure 5-3 for proper assembly information.

CAUTION

Any unused wire lead should be shielded or otherwise protected to safeguard against potentially damaging short circuits.

3. Position the chassis in front of the rack space where it is to be mounted. Pull the fiberoptic and RF cables through from behind the rack. Route them through the opening in the chassis rear panel. Connect each input and output to the appropriate module.

CAUTION

Make sure the optical connectors are finger tight only - do not over tighten or the connector may be damaged.

4. Use the adhesive-backed wire saddles and tie wraps supplied to secure the RF and optical cables to the bottom panel providing service loops where possible. This provides strain relief for the RF and optical connectors on the modules.
5. Replace the top panel and attach it with the provided hardware.

³ Applies to early versions of the 1U high chassis. Later versions come with pre-installed threaded studs, eliminating the need for the user installed mounting screws.

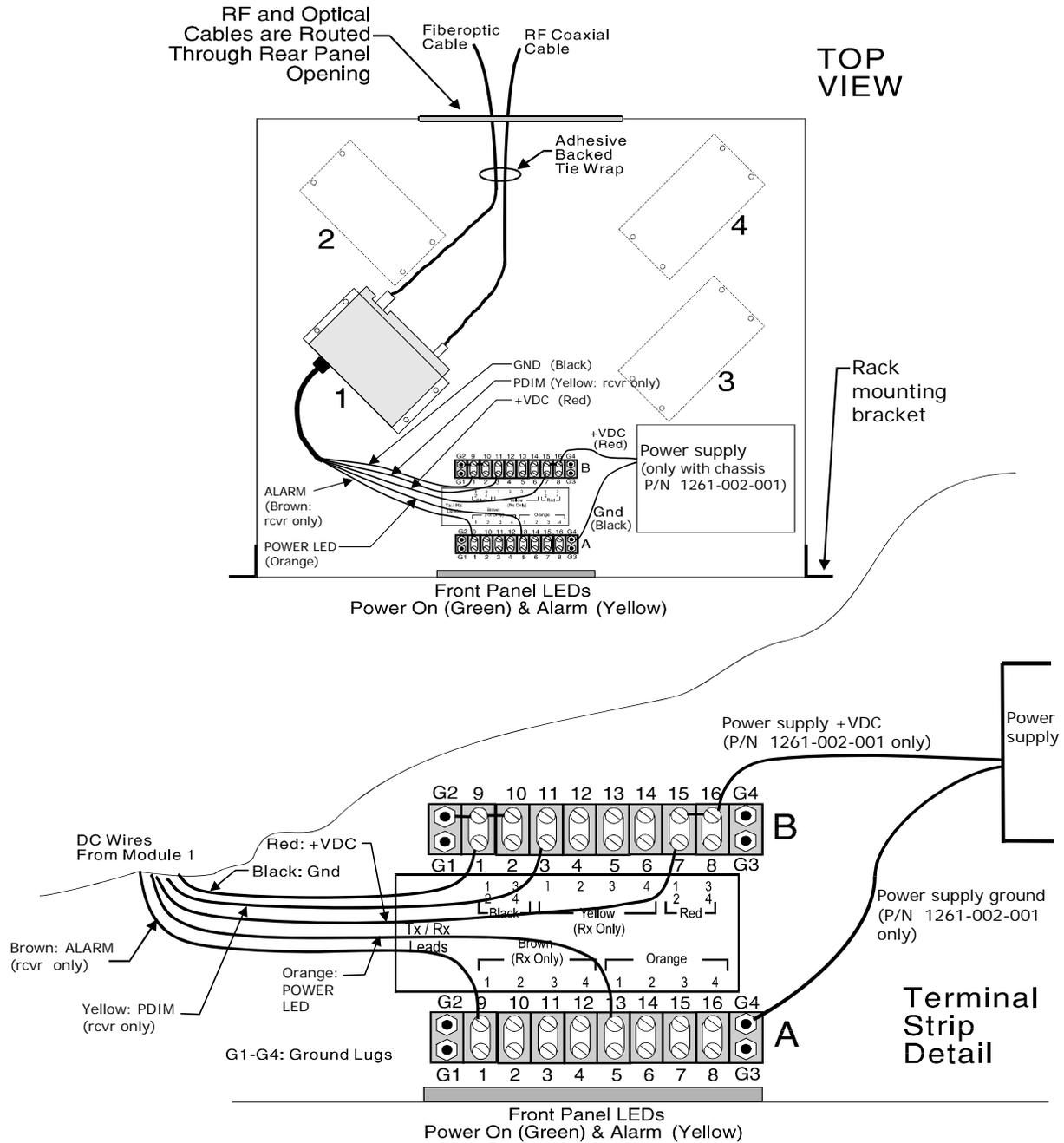


Figure 5-2. Installing flange-mount units in the 1U chassis.

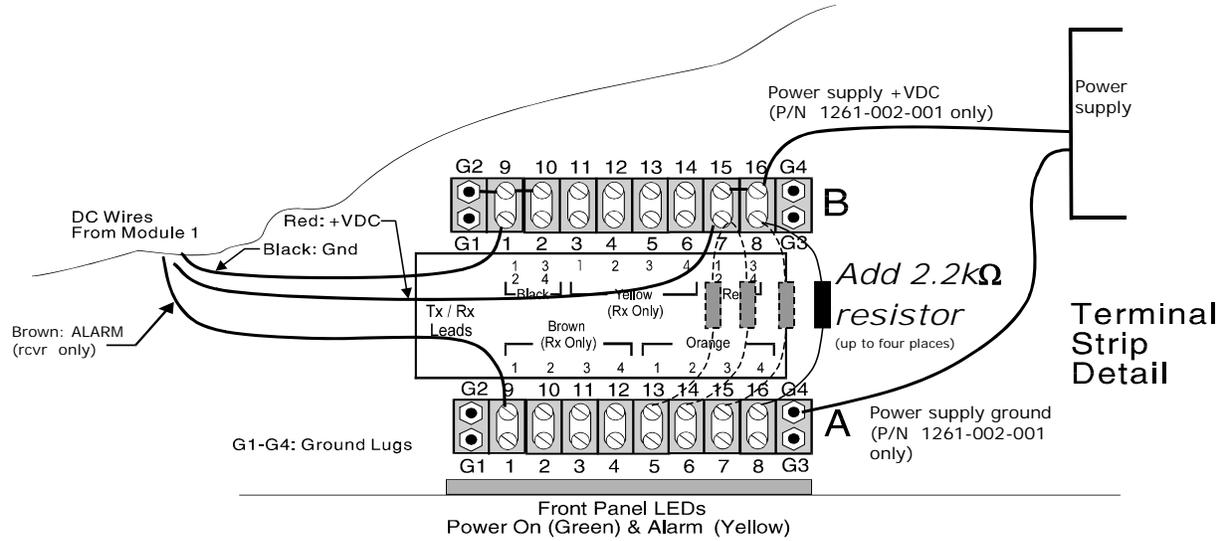


Figure 5-3. Installing older flange-mount units with the three wire DC harness in the 1U chassis.

Table 5-1 Terminal Block Connections			
Block A	Module # / wire color	Block B	Module # / wire color
1		1	1 / Black & 2 / Black
2		2	3 / Black & 4 / Black
3		3	1 / Yellow
4		4	2 / Yellow
5		5	3 / Yellow
6		6	4 / Yellow
7		7	1 / Red & 2 / Red 1 / 2.2kΩ & 2 / 2.2kΩ**
8		8	3 / Red & 4 / Red 3 / 2.2kΩ & 4 / 2.2kΩ**
9	1 / Brown	9	G2
10	2 / Brown	10	G2
11	3 / Brown	11	
12	4 / Brown	12	
13	1 / Orange	13	
14	2 / Orange	14	
15	3 / Orange	15	+15VDC*
16	4 / Orange	16	PS / +15VDC*
G1		G1	
G2		G2	
G3		G3	
G4	PS / Ground*	G4	

* PS = Power Supply.

**Resistor to be used with older products containing 3-wire DC harness.

5.4. Installing 10k Plug-in Style Modules in the 3U Rack Mount Chassis

The 3U chassis supplied by Ortel can hold up to eight plug-in modules. Install the model 10357 transmitter and 10457 receiver plug-ins into the 10990A chassis starting with the left-most slot.

1. Carefully align the plug-in unit with the track in the desired slot of the chassis.
2. Gently slide the plug-in unit into the chassis until the rear panel sets against the backplane. The 9-pin D-connector will self align with the mating backplane connector. Do not force the unit against the backplane. If excessive resistance is felt, remove the unit and re-align it in the chassis.
3. Secure the plug-in by tightening the four corner screws on each module's front panel.

Refer to Tables 3-5 and 3-6 for connection information for the power supply status and monitoring signals available on the model 10990A 3U rack mount chassis. Table 3-4 details the back panel connections for the status monitoring features for the fiberoptic plug-in modules.

Chapter 6. Optimizing RF Performance, Examples

The 3100/4100 Fiberoptic Link has been designed to provide a transparent interfacility link for a wide range of small satellite earth terminals. The link itself has fixed gain, noise figure and linearity characteristics so its effect on earth station performance can be analyzed like any other active element in the signal path. The following sections give some guidance to optimizing the RF performance for a number of different applications. Optimizing the RF performance means setting the input RF drive level to the optimum value. If the available RF signal level is too high, an RF attenuator should be used (if DC is on the center pin, an attenuator must be used that passes this DC through). If the available RF level is lower than the optimum level, some graphs are given that indicate the expected link performance and its effect on the system.

6.1. TVRO - CATV, SMATV Headends, etc.

The example used here is for a typical 3.6m or 4.5m antenna with a 30°K, 65 dB gain LNB looking at Galaxy V. The earth station is assumed to be located in Los Angeles, California. The fiberoptic link feeds an 8-way RF splitter and the satellite receivers have a 15 dB noise figure.

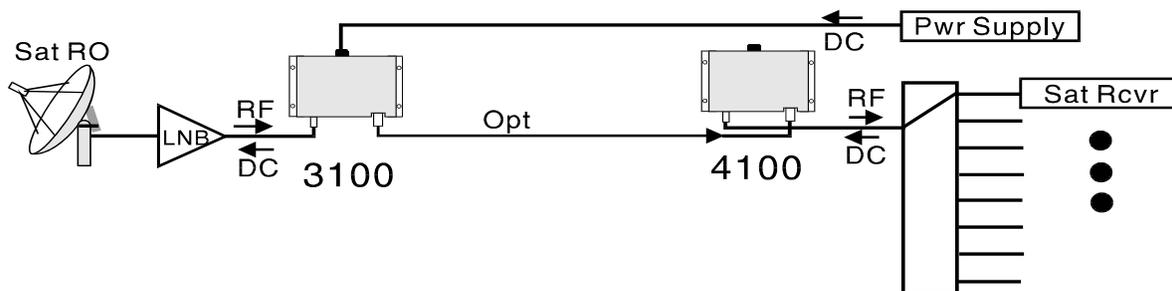


Figure 6-1. Example of TVRO application.

Link Performance Figure 6-2 indicates the performance of the 3100/4100 fiberoptic link in this earth station. The equivalent baseband video signal to noise given is a combination of the carrier to noise through the link plus the process gain or FM improvement factor. The process gain is assumed to be 38 dB for 36 MHz FM satellite video. The noise is the noise of the fiberoptic link itself plus intermodulation product noise. As can be seen, there is an optimal point at which the S/N is greatest. At low RF drive levels, the S/N is limited by thermal type noise whereas at high input levels the S/N is limited by distortion product noise. Indicating the desired demodulated video performance allows comparison to the RS-250B specification. Note that over an input range of about -13 to -7 dBm total power, the link exceeds the Short Haul performance (67dB) criterion. If 12 channels are present, the channel power is $10 \log(12) = 11$ dB lower than the total, hence the input signal range is -24 to -18 dBm/channel.

System Performance vs. Placement of Fiberoptic Transmitter. The link is designed to have the 3100 Series Fiberoptic Transmitter placed outside, close to the LNB output. In the present example of a 4.5m antenna looking at Galaxy V with a 30°K, 65dB gain LNB, the $P_{TOTAL} = -10$ dBm optimum RF drive level (see figure above) is achieved with 1dB RF loss between the LNB output and the 3100 input. A 1dB loss corresponds to about 12 feet of RG-6 which is about what one needs if the 3100 is mounted at the antenna pedestal. Fiberoptic link and earth station performance is indicated in Figure 6-3 for a 4.5m and a 3.6m antenna as a function of cable loss between the LNB output and the 3100 input.

As indicated in Figure 6-3, the maximum advantage of the fiberoptic link is achieved by minimizing the coaxial cable as much as possible. Note that the fiberoptic link cannot be treated like a passive cable loss. The noise figure seems high but the loss is near zero. In systems analysis, the link must be treated as an active device like an amplifier.

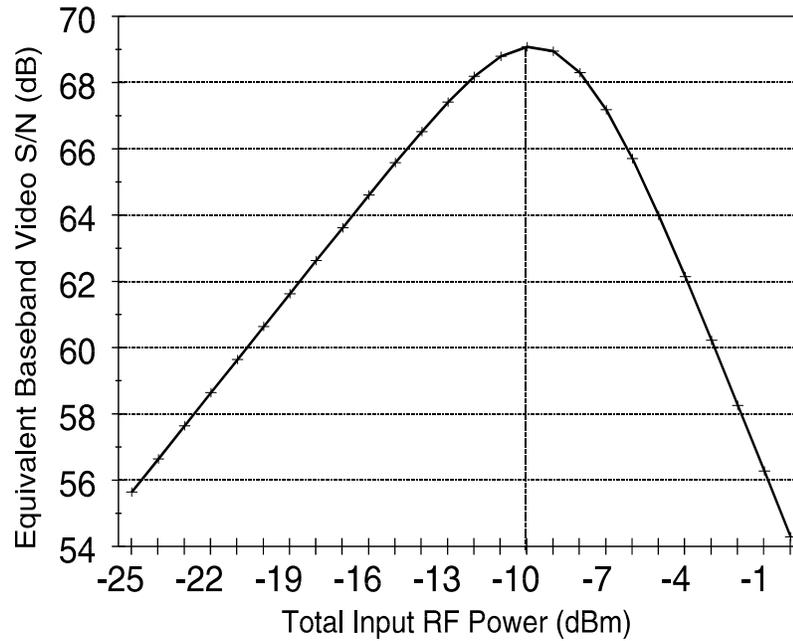


Figure 6-2. Performance vs. input RF power for TVRO example. Note that the optimal point occurs at -10 dBm independent of the total number of channels.

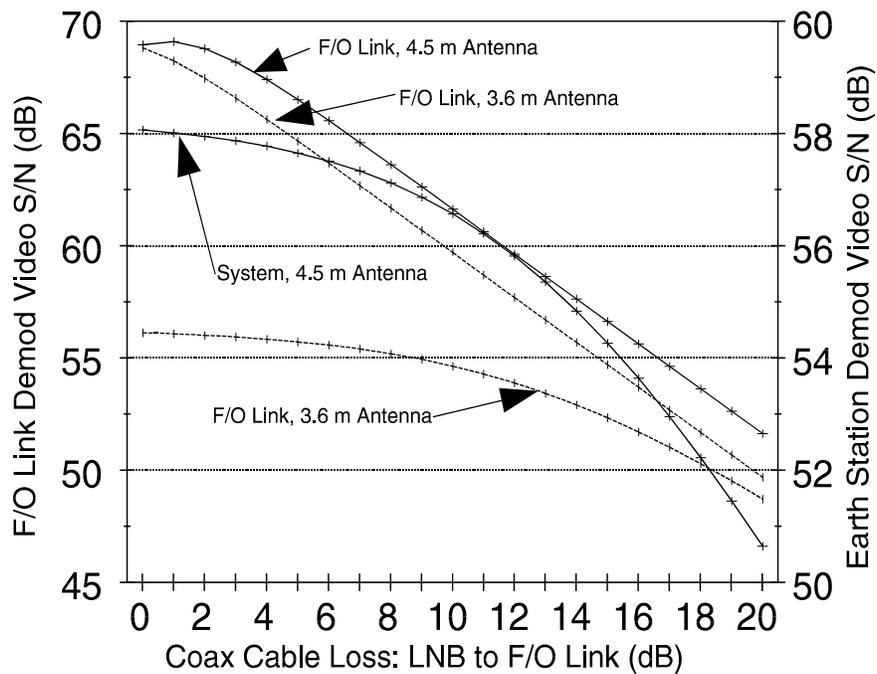


Figure 6-3. The solid lines represent the fiberoptic link and the earth station (system) S/N for a 4.5 m antenna site. The dashed lines are for a 3.6 m antenna. Note that there is little system S/N degradation for cable loss up to about 4 dB or 50 feet of RG-6.

General Rule-of-Thumb Analysis. A general rule-of-thumb for satellite earth terminal design is that the satellite receiver noise referred to the input of the interfacility link should be at least 10 dB below the noise at the output of the LNB. In this case, assume a 30°K, 65dB gain LNB with a 35°K antenna temperature. The noise output from the LNB is then:

$$N_{LNB} = 10\log k(T_0 + T_{LNB} + T_{ANT}) + 10\log BW = 10\log [1.38 \times 10^{-20}(290 + 30 + 35)] + 87\text{dB}$$

$$= -21.1\text{dBm}/500\text{ MHz} \quad \text{where } BW = 500\text{MHz} \rightarrow 10\log(500\text{ MHz}) = 87\text{dB}.$$

The higher noise figure of the fiberoptic interfacility link swamps most of the noise of the splitter and satellite receiver so their contribution may be ignored. The total noise at the input of the IFL is;

$$N_{IFL} = 41\text{dB} - 174\text{dBm}/\text{Hz} + 87\text{dB}$$

$$= -38\text{dBm}/500\text{ MHz}$$

where 41dB is the IFL noise figure and $-174\text{ dBm}/\text{Hz} = 10\log(kT_0)$ and $T_0 = 290\text{K}$.

So the IFL + receiver noise is 17dB below that of the LNB & antenna - plenty of margin according to the rule-of-thumb.

6.2 Remoting GPS Antennas

A typical rule-of-thumb for GPS systems is that the IFL + satellite receiver should not degrade the LNA noise figure by more than 1dB. The figure shows a typical GPS system, although the receiver noise figure shown is closer to worst case.

Performing a cascaded noise analysis on the system shown in Figure 6-4, one gets a total noise figure of 3.1dB. This is only 0.6dB worse than the 2.5dB LNA noise figure and well within the rule-of-thumb limit. In this example, one could have up to 2.5dB of RF coax cable loss from the LNA output to the fiberoptic IFL input and still meet the < 1dB noise figure degradation criterion. This corresponds to about 24 feet of 1800MHz RG59 or 30 feet of RG6.

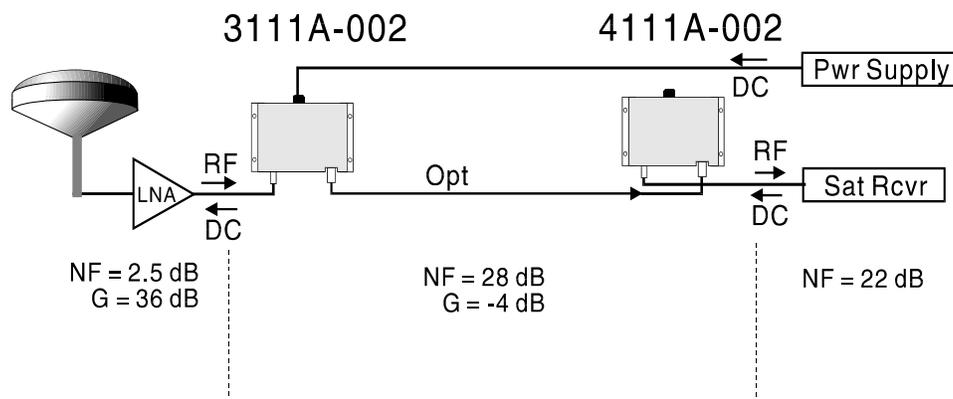


Figure 6-4. Option -002 is designed for GPS and Inmarsat applications where the input RF signal is very low. With the -002 option for both the 3111A and the 4111A, the link gain remains the same but the sensitivity increases by 17dB over the standard link.

Chapter 7. Troubleshooting and Maintenance

Once the fiberoptic link has been installed, there is no need for any regular maintenance. However, if problems do arise the most common cures are listed here.

7.1. Low or no RF gain

For low RF gain, first check the option numbers and optical loss and then verify from Table 2-2 that the correct gain is being measured. If the gain is lower than it should be, first verify that the DC power to the optical transmitters and receivers has the correct voltage and current (Chapter 3). Next, check the optical elements as highlighted in 7.3. Another possibility is that the receiver is being saturated by a transmitter which has too much optical power (approximately 2mW or greater) or the link has an excessive RF input level. The transmitters in this manual emit <2mW of optical power - low enough to never saturate the receivers in this manual - so this is only a concern if another transmitter is used. Lastly, the DC circuitry of the unit itself may be verified as described in 7.4.

7.2. High noise or intermodulation distortion

For a system with good gain but poor noise or intermods, the most likely cause is RF inputs that are either too high or too low. Review Chapter 2 to determine the optimal RF power and adjust as necessary. High optical back reflections into the laser also can degrade noise and linearity, so verify that the FC-APC style connector is used to connect to the transmitters and receivers. Also check that all other connectors and splices between the transmitter and receiver also have good optical return loss.

7.3. Low optical power at the receiver

If it appears that low gain or poor noise is due to low received optical power, review Chapter 4 to be sure that the optical connectors and fibers are used properly. The most common problem, and easiest to fix, is that the connector key is not aligned with the mating slot. Other common causes include dirty connectors, bent fibers, broken fibers, disconnected connectors and overly tightened optical connectors. To determine exactly where light is being lost, start at the transmitter and work forward to the receiver, measuring or detecting power along the way. (As noted in section 4.3., an IR detection card at less than \$10 is an indispensable piece of test equipment.)

Another good clue is the power alarm and/or photodiode current monitor outputs from the receiver. Bear in mind though that the power alarm triggers at approximately 0.1mW, therefore this only gives an indication of extreme cases. Also, some applications expect and can tolerate high optical losses, so in such cases if the RF performance is OK, the optical alarm may be ignored.

7.4. DC circuit verification

Chapter 3 details the DC monitoring and powering functions. Beyond the more obvious external problems such as no electrical power, disconnected cables or shorting of the RF center pin on DC-coupled units, the internal DC circuits also can be quickly verified. For the transmitter, when DC power is applied, light should be emitted from the laser connector and be seen with an IR card. For the receiver, when DC power is applied and the optical connector is disconnected, +5 volts should be present on the alarm pin. If these conditions are not observed, then the unit may have a DC failure or burned fuse.

7.5. Fuse replacement

The fuse of the plug-in versions of the L-band transmitters can be replaced by pulling the unit from the chassis, removing the four small screws holding the U-shaped side panel, and removing this panel. (Removing the cautionary stickers to replace the fuse does not void the warranty.) The fuse should be replaced with a quick-blow style for ≤ 0.8 Amps.

The flange mount style product does not have a user replaceable fuse and must be returned to the factory for fuse replacement.