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2015 W. Chestnut Street Alhambra, CA 91803-1542 Tel: 626-293-3400 • Fax: 626-293-3428

Operator's Manual

Fiberoptic Transmitter

Models 3540A, 3541A/B/C, 3740A, 3741A, 10340A, 10341A/B/C, 10370A, 10371A

MAN-3540A Rev B

Disclaimer

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Ortel, a Division of Emcore
Alhambra, California, 91803, USA

July 27, 2004

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 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's Customer Service Department), service required and/or a description of the problem encountered.

Warranty and Repair Policy

The Ortel 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's sales agents or representatives are not authorized to make commitments on warranty returns.

In the even 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's 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's 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 the customer does not authorize non-warranty repairs, 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.

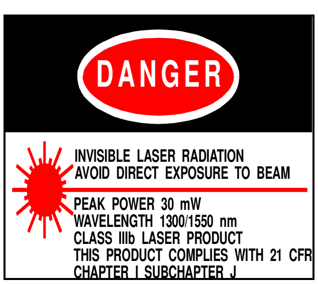
DANGER

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 for service and repair. Contact the Ortel's Customer Service Department for a return authorization if service is necessary.



AVOID EXPOSURE-
INVISIBLE LASER
RADIATION IS EMITTED
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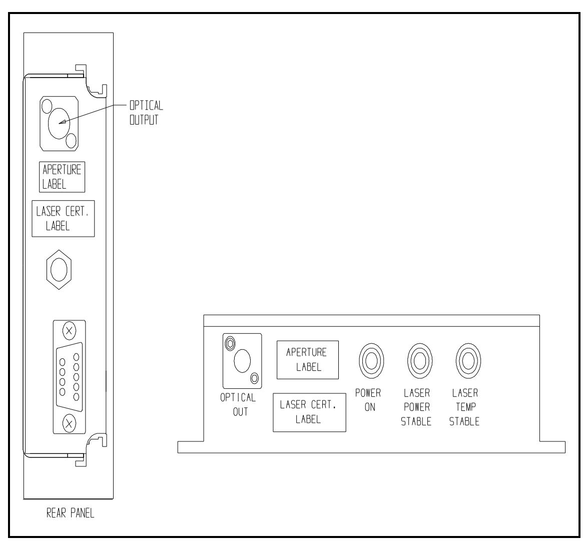

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Chapter 1

1.0 General Information

1.1 Description

This manual covers the operation of the following high-speed laser transmitter models:

MODEL #		Maximum Frequency	Wavelength
Flange-mount	Plug-in (for 19" rack)		
3540A	10340A	5 GHz	1310 nm
3541A	10341A	10 GHz	1310 nm
3541B	10341B	13 GHz	1310 nm
3541C	10341C	15 GHz	1310 nm
3740A	10370A	4 GHz	1550 nm
3741A	10371A	10 GHz	1550 nm

These transmitters feature singlemode fiber, an optical isolator, a high speed laser, circuits for the transmission of analog modulated optical signals with superior signal quality, and a package designed for compatibility with microwave and RF analog and telemetry signals.

CAUTION: Carefully read all of **Section 4** of this manual before attempting to operate the laser transmitter.

Each transmitter has an InGaAsP semiconductor, Distributed Feedback (DFB) laser with 1300 nm singlemode fiber coupled to its output, and a wideband microwave input circuit internally matched to 50 Ω. The laser chip is cathode grounded, and the input circuit is available either AC or DC coupled.

Each transmitter contains electronic circuits to stabilize the laser temperature and optical output power over a wide environmental range. Also, status monitoring and alarm circuits are included for use in systems that require self-diagnosis and failure analysis.

Each transmitter has a standard SMA jack connector for RF input.

1.2 Specifications

For detailed specifications of the product described in this manual, consult the individual Product Specification Table (**PST**) in **Appendix A** at the end of this manual.

Specifications apply over the entire specified operating range of the product and are guaranteed for 1 year after the date of shipment.

1.3 Identification and Model Numbers

Each laser is assigned a unique model number and serial number that appears on the label. Model numbers for this series have the form such as **3541A.**

1.3.1 Options

These lasers have the following standard performance options, which are designated by numeric suffixes to the model number, separated by a hyphen. Thus, **3541A-001** describes a laser with the input AC coupling capacitor deleted (Option 001). The performance of a product with any standard option is described on the Product Specification Table.

There is one standard electrical option available.

Option -001: DC coupled electrical input

This option removes the input series capacitor in the laser transmitter. Thus, the transmitter can be modulated at frequencies <100 kHz. This option is for the convenience of the user only. The RF parameters are not measured or guaranteed below 0.01 GHz. For this DC coupled option the center pin of the laser input will be at a positive voltage, therefore a DC blocking capacitor must be used in the input RF circuit, as outlined in section 4.3.3

The standard optical connector options follow:

Option #	Connector Style	Cable	Available in Flange-mount	Available in Plug-in
-020	FC/APC	bulkhead	x	x
-021	FC/SPC	bulkhead	x	x
-022	FC/APC	3 mm diam.	x	
-023	FC/SPC	3 mm diam.	x	
-026	FC/PC	bulkhead	x	x
-028	FC/PC	3 mm diam.	x	

Products with modified performance can be bought in accordance with individual customer requirements. They are designated by an alpha-numeric suffix,

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where A is alpha, and N is numeric. Such custom options should be discussed in advance with your Ortel sales representative for detailed performance and pricing.

1.4 Instructions for Service Returns

If the laser transmitter does not meet its warranted specifications, it must be returned to Ortel for test and evaluation, in accordance with Ortel's warranty policy. When returning the transmitter for service or repair, include the following information: owner, model number, serial number, return authorization number (obtained from Ortel's Customer Service), service required and/or a description of the problem encountered.

For safe shipment of the transmitter, use anti-static materials. The original packing material is reusable.

1.5 Additional Manuals

Additional copies of this manual are available through the Ortel's Sales Department. Specify the Model Number from the title page or from your laser transmitter.

Chapter 2

2.0 Safety Precautions

Semiconductor lasers are high performance electronic devices that provide highly reliable performance when operated in conformance with their intended design.

For best results when using this product, general safety precautions must be observed during handling and operation.

Failure to comply with the general safety and with the specific precautions described in this manual would violate the safety standards of the design, manufacture, and intended use of the device. Ortel assumes no liability for the customer's failure to comply with these precautions.

2.1 Safety Symbols

*ESD Sensitive Device:*Observe electrostatic precautionary procedures.

DANGER: Indicates a hazard. It is to call attention to a procedure or practice which, if ignored, could lead to personal injury. Do not continue beyond the *DANGER* sign until the described conditions are fully understood and met.

CAUTION: Indicates a hazard. It is to call attention to a procedure or practice which, if ignored, could lead to damage to the laser transmitter or other equipment. Do not continue beyond the *CAUTION* sign until the described conditions are fully understood and met.

2.2 ESD Sensitive

Semiconductor lasers are static sensitive devices, and products containing them should be treated accordingly. Static electricity can be conducted to the laser chip from the center pin of the RF input SMA connector, and through the DC connector pins. When unpacking and handling the laser transmitter prior to installing it, use ESD precautionary procedures, such as grounded wrist straps and grounded work mats.

After the laser is installed in an operational circuit, these pins are protected from unintentional contact and ESD sensitivity is greatly reduced.

2.3 RF Connector

Do not apply excessive torque to the SMA connector. The use of standard wrenches can lead to a damaged connector. Use 7-9 inch pounds of torque. The use of a torque wrench is *strongly recommended.*

2.4 Power Supply

Operating the transmitter outside of its maximum ratings may cause device failure or a safety hazard. See section 4.3.1 for more details.

2.5 Grounding

All power supplies should be connected to an earth ground.

2.6 Input RF Power

The laser can be overdriven and damaged by the application of excessive RF input power. Refer to the Product Specification Table for information about the maximum input power.

2.7 Storage

Observe ESD precautions while storing the laser transmitter (i.e. anti-static containers) and store away from corrosive materials. Storage temperature: -40ºC to +85ºC.

2.8 Do Not Attempt to Modify or Service

Do not attempt to modify or service any part of the device. Doing so will void the warranty. Return it to Ortel for service and repair. Contact the Ortel's Customer Service Department for a return authorization number.

Chapter 3

3.0 Theory of Operation

3.1 Semiconductor LaserError! Bookmark not defined.

The semiconductor laser type contained in these transmitters is a Distributed Feedback (DFB) type, Indium Gallium Arsenide Phosphide (InGaAsP), buried heterostructure laser. DFB lasers incorporate a grating structure along the length of the active area, which provides positive feedback only at the optical frequency of interest. Thus a DFB laser only emits light at one wavelength. Since the optical spectrum of the laser shows only one peak, the laser may operate in highly dispersive applications (i.e. long fibers) where multimode lasers are inadequate. For further information about semiconductor lasers, see [1] or the Ortel publication, *A System Designer's Guide to RF and Microwave Fiber Optics.*

The microwave properties of a semiconductor laser are dependent on the bias current for the device. As the bias is increased above threshold, the optical power of the laser increases linearly. Most frequency dependent characteristics of the laser, (noise, frequency response, distortion) scale with the square root of optical power (or current above threshold). For example, if a laser exhibits a certain bandwidth at a bias of 10 mA above threshold, the bandwidth will double when the current is increased to 40 mA above threshold. There are some factors, such as internal heating, which will slightly degrade the expected performance at higher currents. Thus the actual scale factor will be slightly less than expected by the square-root law. The bias current for the transmitters described in this manual are factory set by Ortel to maximize the performance of the contained laser.

3.2 Optical Systems

The performance of most semiconductor lasers is affected by the optical system to which it is connected. The first problem is optical reflections. A reflection can destabilize laser performance, which is indicated by increased laser noise and, in severe cases, distortion. Additionally, long fibers have a certain amount of light reflected by impurities and imperfections in the fiber called backscatter. Both of these problems are largely alleviated by, the optical isolator included in this manual's transmitters. Another effect of long fiber is caused by dispersion. If the laser is multimode, dispersion from long fibers (>5 km) can degrade noise, distortion, and even bandwidth of the laser. The singlemode operation of DFB lasers eliminates this problem.

[1] Agrawal, G.P. and Dutta, N.K., **Long-wavelength Semiconductor Lasers**, Van Nostrand Reinhold Company, New York, New York, 1986.

3.3 Temperature Control

For consistent operation of semiconductor lasers, the temperature of operation must be maintained at some constant level. For this reason, all the lasers described in the manual incorporate both a thermoelectric (Peltier) cooler and a temperature-sensing resistor (thermistor). The transmitter includes a feedback loop, which senses the thermistor resistance and compensates for changes in laser temperature. The laser temperature is stabilized to 25°C ± 2°C.

As with the power control circuit, a current limiter prevents the TE cooler and laser from damage due to excessive heating or cooling functions should the thermistor fail.

3.4 Power Control

Over long periods of time, the laser chip will age slightly. In some applications, precise control of the optical power received is required. In the transmitter, the actual light output of the laser is sensed by the monitor photodiode, and a feedback circuit maintains this monitor current at a constant level. Typically, the laser power will remain stable to within ±2%. The power control circuit will not compensate for changes in the laser/fiber coupling efficiency. In addition to the DC current supply circuit; there are two additional circuits in the optical power control circuit. A *"slow start"* circuit operates when the transmitter is switched on. This circuit increases the laser current over 3 seconds from zero to its operating value. This eliminates transients, which could damage the laser. A current limiter, preset at the factor, establishes a maximum value for the laser current. Thus, a failure of the monitor photodiode will not result in uncontrolled laser current values, which could destroy the laser.

3.5 External Displays and Controls

The fiberoptic transmitter needs no external controls or adjustments. The laser current is preset at the factory to provide optimum performance according to the specifications published in the data sheet and the Product Specification Table.

3.5.1 LED Displays

There are three external visual LED displays that provide information about the operating state of the transmitter. These LED's are normally on. If any of the LED's is off after applying DC power to the transmitter and waiting for a few seconds, recheck all power connections. If the condition persists, consult with Ortel's Customer Service department.

Power On: This LED is normally ON, and indicates that +15 V is present at Pin #1 of the DC 9-pin connector.

Laser Power Stable: This LED is normally ON, and indicates that the laser optical power, as measured by the internal monitor photodiode, is above 90% of the factory preset value.

Laser Temp Stable: This LED is normally ON, and indicates that the laser substrate temperature (as determined by the thermistor resistance) is within ±2° C of the factory setpoint. The transmitter may require several seconds of operation before the LED goes on. If the temperature does not stabilize, refer to section 4.3.1.

3.5.2 Status Monitors

Two monitor voltages are available on the DC connector. They are designed to provide information about the operating condition of internal optical power circuits for routine operational maintenance.

PIN 6: Photodiode Current. 1 V/mA, ±2% (1.0 MΩ load). Provides a buffered voltage proportional to the monitor photodiode current. Measuring and recording this voltage provides a record of the laser output power over time, as measured by the photodiode.

PIN 8: Laser DC Current. 1 V/100 mA, ±2% (1.0 MΩ load). Provides a buffered voltage proportional to the laser DC current. Measuring and recording this voltage provides a record of the laser current over time.

3.5.3 Alarm Functions

In addition to the LED visual displays of transmitter operational status, there are two alarm circuits in the transmitter, which can be used to drive remote indicators. They are designed to provide a positive interrupt capability if the laser transmitter drifts out of factory set operating conditions, but before the laser fails completely. This provides the capability of replacing or servicing the unit before the link operation is interrupted.

The alarms are designed to interface with user-supplied circuits. Alarms are open collector outputs capable of sinking 20 mA when ON and withstanding 15 VDC when OFF. Normal operation of the alarm circuit is the off state. A suggested use of the alarm circuit would be a series connection of an external LED, or a relay, from the system 15 V supply through a 1 kΩ resistor. Assuming negligible voltage drop through the LED or relay, this would provide a 15 mA activation current when the alarm is active.

The alarm functions and pin assignments are as follows:

PIN 7: Low Optical Power. This alarm is *ON* (sinks current) if the laser monitor photodiode current drops from its factory set value by more than 10%. The alarm is not activated if the photocurrent is *HIGHER* than the setpoint.

PIN 9: Laser Temperature. This alarm is *ON* (sinks current) if the laser substrate temperature is more than 2°C higher than the factory setpoint. The alarm is not activated if the temperature is *LOWER* than the setpoint.

Chapter 4

4.0 Installation

The information in this section can be used to make initial performance tests on the laser transmitter. It is not intended as a complete performance verification procedure.

4.1 Unpacking and Visual Inspection

ESD Sensitive Device

The laser transmitter was inspected before shipment and found to be free of mechanical and electrical defects. Observe ESD precautions while handling the transmitter and unpack and examine the device for any damage due to transit. Keep all packing materials until your inspection is complete. Verify that the pins and connectors are free from obvious shipping or handling damage.

If damage is discovered, file a claim with the carrier immediately. Notify the Ortel's Sales Department as soon as possible.

4.2 Operating Conditions

This product is designed and tested to withstand harsh environmental operating and storage conditions. The basic design and manufacturing processes have been subjected to rigorous product qualification tests of temperature cycling, mechanical shock, and vibration. However, the device can be permanently damaged by severe mechanical shock. Please handle carefully while unpacking and installing.

	Flange-mount	Plug-in
Operating Temperature of Baseplate	-40 °C to +65°C	0 °C to 50 °C
Storage Temperature	-40 °C to +85 °C	-20 °C to +65 °C

To operate either style of transmitter at room temperature in a laboratory setting, it can be placed on a convenient flat surface without any particular concern for a good heatsink. In a field-operating environment, to obtain reliable operation over the full temperature range, flange-mount transmitters should be fastened to a solid metallic surface with a good heat sink using screws through the mounting holes provided. Plug-ins should be installed in the Ortel Model 10990A Chassis and provided a clear opening at the top and bottom to allow convection cooling.

4.3 Electrical Connection

Observe the following procedures while making electrical connection to the transmitter.

4.3.1 DC Connection

DANGER: Connecting the transmitter to its appropriate DC voltages will energize the laser and emit light from the fiber. This light is invisible and may be harmful to the human eye. Avoid looking directly into the fiber pigtail or into the collimated beam along its axis when the device is in operation. Operating the laser diode outside of its maximum ratings may cause device failure or a safety hazard.

4.3.1.1 User-supplied Power Supply

Connect the transmitter to the required DC voltages using a standard 9-pin DSUB connector. The transmitter contains internal regulator and transient suppression circuits. Most high quality power supplies will provide excellent results, although at a minimum the power supply must provide the following:

Pin #	Min.	Nom.	Max.	Max. Ripple	Current
1	+14 V	+15 V	+16 V	100 mV p-p	0.3 A max.
2	+4.75 V	+5 V	+5.5 V	200 mV p-p	1.5 A max.

For best results, make the DC connection to the transmitter and verify that the power supply is correctly adjusted before switching on the supply. When turning the transmitter on, there is a "*slow start*" circuit that introduces a 2 to 3 second delay in the turn on. When the LED's are all lit, the transmitter is ready to use. If the laser temperature fails to stabilize, verify that the current capability of the 5 Volt supply exceeds 1.5 Amps.

CAUTION: ***Do not*** solder wires directly to the pins of the DC connector.

The reference ground provides a separate ground path for more accurate use of the monitor and alarm circuit, although it may be connected to pin 4 and then the two used together as a common ground.

9 Pin D-sub Connector	Corresponding 5 Pin Connector (P11-P18) on 10990A Chassis	Function
1	--	+15 V DC, 0.3 A
2	--	+5 V DC, 1.5 A
3	--	NC
4	--	power ground
5	1	reference ground
6	2	photodiode current monitor
7	3	low optical power alarm (open collector output)
8	4	laser current monitor
9	5	over temperature alarm (open collector output)

4.3.1.2 Ortel Model 10990A Chassis and 10901A/B Power Supplies

Plug-in style units may be used with an Ortel provided rack mount chassis (Model 10990A), main power supply (Model 10901A), and optional auxilary power supply (Model 10901B). With these products, simply slide the transmitter 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, although it is recommended that the power supplies be plugged into a wall circuit to guarantee a good ground. Due to power limitations, at most 4 transmitters or 8 receivers should be used in a single chassis.

The status of the plug-ins can be monitored on the back panel of the chassis. The 8-transmitter/receiver slots each have a 5 pin connector directly connected to the 9 pin D-sub. The power supplies status can be monitored from the 9 pin Molex connector (P19) which is wired into a series of relays.

Model 10990A Chassis Power Supply Status Connector (P19)					
Pin	Description	Main OFF	Main ON	Aux. OFF	Aux. ON
1	No connection				
2	No connection				
3	Aux. Status			closed	open
4	Aux. Status (center)				
5	Aux. Status			open	closed
6	Main Status (center)				
7	Main Status	closed	open		
8	Main Status	open	closed		
9	Ground				
Mating Connector			Molex P/N 22-01-2097		
Crimp Pins			Molex P/N 08-50-0114		

The voltages from the main power supply may be monitored and used directly with connector P20.

Model 10990A Chassis, Main Power Supply Status Connector (P20)	
Pin	Description
1	+5 V DC
2	+15 V DC
3	-15 V DC
4	GND
Mating Connector	Molex P/N 09-50-3031
Crimp Pins	Molex P/N 08-50-0108

4.3.2 Optical Connection

DANGER: The light emitted from Ortel transmitters is invisible and may be harmful to the human eye. Avoid looking directly into the fiber pigtail or into the collimated beam along its axis when the device is in operation.

When inserting light into a receiver, if optical connector is used, repeatable performance requires that the connector end surface be kept free of dirt and dust. Before mating, clean with a cotton swab and alcohol, and blow dry with a lint free aerosol air spray. Many high quality connectors use keying polarity, and it is important to observe such mating requirements.

Should the internal connector of a bulkhead connector become dirty, the mating sleeve assembly must be removed. This is accomplished by removing the small setscrews and gently sliding the assembly out of the receiver a few inches. The connector will still be connected to the mating sleeve and can then be loosened and cleaned.

Some connectors can be improved by the use of index matching fluid, although in most cases this is not used. Consult with the connector manufacturer or Ortel for recommendations regarding specific connectors. In general, tighten the connectors finger tight. Do not use a wrench, as it will cause excessive optical loss and can damage the connector end faces.

If a non-connectorized fiber option is provided, the fiber tip must be cleaved well and the tip must be clean. If not properly cleaved or cleaned, optical power may be scattered and the insertion loss may be high. For temporary splices, the use of index matching fluid is recommended to reduce reflections.

For best performance, optical reflections should be minimized below -35 dB. Optical reflections can destabilize the laser diode, creating unwanted noise and distortion.

4.3.3 RF Connection

CAUTION: RF power applied to an unbiased laser may damage the device, therefore apply RF power *only* after DC power has been supplied to the transmitter and always disconnect the RF power *before* disconnecting the DC power.

Connect the RF signal source to the SMA input connector. Absolute maximum signal level shall not exceed 100 mW (+20 dBm) at the risk of damaging the laser diode.

CAUTION: ***Do not*** apply excessive torque to the SMA connector. The use of standard wrenches can lead to a damaged connector. Use 7 to 9 inch pounds of torque. The use of a torque wrench is **strongly recommended.**

The input impedance of the transmitter is 50Ω. Use signal sources with the same characteristic impedance.

CAUTION: The standard laser transmitters are AC coupled with an internal DC blocking capacitor on the RF input. If the product has been ordered without a DC blocking capacitor (Option 001), there can be effects on the test equipment due to the DC voltage present at the RF connector, or, conversely, a change in the bias point of the laser due to the DC characteristics of the test equipment. If possible, for Option 001 it is recommended to use a DC blocking network, such as the 5500 series provided by Picosecond Pulse Labs (303-443-1249, Boulder, CO, USA).

4.3.4 Optical Power

CAUTION: These laser transmitters can deliver optical powers into the fiber which are high enough to saturate or damage some optical receivers. Generally, some optical attenuation is needed to prevent performance degradation. This attenuation can be provided by a long fiber length or by inclusion of an intentional optical loss. See the Product Specification Table, the test data, and the specifications of the photodiode to determine the amount of attenuation needed.

4.3.5 General Considerations

The maximum input power level is dependent on the laser bias point: if the laser is biased at 50 mA above threshold, the maximum power input to the laser before clipping is approximately +18 dBm. Beyond this point laser damage may occur due to reverse biasing of the laser junction.

4.4 Initial Turn On Procedure

For initial operation of the transmitter, the use of a simple test circuit as shown in **Figure 4.1** is recommended. A fiberoptic receiver of sufficient bandwidth is required to convert the optical signal to electrical form. Because of their superior operating characteristics for analog signals, the use of Ortel receivers is recommended. Choose a bandwidth that matches the frequency range of the transmitter.

The recommended test equipment for an initial evaluation is as follows:

Description	Range	Preset To
Signal Generator	0.01 to 15 GHz -10 to 10 dBm	1 GHz 0 dBm
Power Supply - 2 way		+15 V, +5 V
Spectrum Analyzer	0.01 to 15 GHz	1 GHz
Optical Power Meter		1300 nm/1550 nm 0 to 5 mW
Amplifier (optional) 30 dB gain	1 GHz	
Fiberoptic Receiver	Same as transmitter	
Digital Voltmeter	0 to 10 V	

Since the link insertion loss (including an optical attenuator to limit the optical received power to 2mW) is approximately 40 dB, an amplifier improves the measurement by raising the signal level to the spectrum analyzer. An amplifier is usually required to measure the output noise floor of the link. The amplifier is usually not required to make basic operating measurements of the link, since most spectrum analyzers will easily display signal levels of -40 dBm, which is the expected output power from a link with 0 dBm input level.

4.4.1 DC Operation

Using grounded, shielded cable for power supply connections, verify that the cables are correctly wired and that power supplies are properly adjusted before applying power. Switch on the power supplies simultaneously to the transmitter and receiver. Verify that the LED's are lit. If one or more of the LED's are not lit, double check the power supply connections. If the trouble persists, contact Ortel Customer Service for advice.

When the transmitter is operated at room temperature, it will draw only limited current (approximately 50 mA) from the +5 V supply, since the thermoelectric cooler will be drawing minimal current.

If an Ortel receiver is in use, Pin 6 of the receiver DC connector provides a simple indication of the optical power reaching the receiver. (If a plug-in receiver is used, pin 6 connects directly to pin 2 of the 5-pin connector on the back panel.) The proportionality factor is 1 V/mA of receiver photocurrent. Typically, 1 mW of optical power will result in 0.7 to 0.8 mA of photocurrent, resulting in a measured voltage of 700 to 800 mV.

If an Ortel receiver is not in use, use an optical power meter to verify that the optical output power of the transmitter meets specifications.

4.4.2 RF Operation

Preset the signal generator to 1 GHz at 0 dBm, or to some convenient frequency within the operating range of the transmitter. It is advisable to calibrate the signal generator and spectrum analyzer by making a direct connection to set a zero dB reference measurement level.

Apply the signal to the transmitter and measure the output of the receiver on the spectrum analyzer. Verify that the output signal is clean with no amplitude jitter or spurious signals.

Measure the power level of the receiver output. The gain of the fiberoptic link will depend on the receiver characteristics, as well as the optical loss of the test cable. For short cables (<100 meters) and good quality connectors, and with an Ortel receiver, the link insertion loss should be approximately 40 dB. Variations of ±5 dB in this value can occur and should not be considered unusual.

Adjust the input power up and down by 3 to 4 dB and verify that the receiver output tracks the input power linearly. If the spectrum analyzer has sufficient bandwidth, measure the amplitude of the second harmonic as a function of input signal power. The second harmonic power should vary as 2:1 relative to the input power, indicating normal linear operation of the transmitter.

There are three types of measurement equipment used for lasers:

Spectrum analyzer: noise and distortion
Network analyzer: frequency response
Oscilloscope: time domain and transient response

The measured frequency response of the laser necessarily includes the response of the photodetector. In the factory, Ortel uses calibrated receivers to reduce measurement errors due to the detector.

4.5 Performance Verification Procedure

The following procedures are based on the factory test procedure.

4.5.1 Frequency Response

In this manual the frequency response of the laser transmitters is measured by, measuring the response of the transmitter, a calibrated photodiode, RF cables, and correcting for the photodiode and cable response. The first step is to measure the frequency response of the measurement system **(see Figure 4.1)** including cables. The sweep oscillator should be set to a nominal output power of +5 dBm. This response is then stored. The transmitter and calibrated PD are then inserted into the link. The link response is now measured using the input-memory mode. The resulting curve represents the frequency response of the transmitter.

4.5.2 VSWR

The **V**oltage **S**tanding **W**ave **R**atio characterizes the RF reflections from a microwave component. It can be determined by measuring the microwave return loss or S_{11}. A system for making this measurement is shown in **Figure 4.1**. The network analyzer is pre-calibrated using the open/short/load routine. This calibration is usually stored continuously in memory.

4.5.3 Noise Measurements

There are two related but separate measures of the noise performance of a laser: Equivalent Input Noise (**EIN**) and Relative Intensity Noise (**RIN**). The equivalent input noise of a laser is equal to the noise that would be observed if the laser itself generated no noise and a noise source generating an equivalent amount of electrical noise was connected to the input of the laser. In a hypothetical link, one in which the laser is the only source of noise, if a signal that is *x* dB larger than the EIN level is injected into the transmitter, the output signal of the link will be *x* dB above the noise floor that is observed in the absence of an input signal. The RIN of a laser is a similar measure of laser performance but relates the DC optical power of the laser to the optical power fluctuations (noise).

$$RIN = \frac{<\Delta P^2>}{\overline{P}^2}$$

In practice, these measurements are made at several fixed frequencies.

A. EIN Measurement:

In a real link, the laser is not the only noise source; therefore corrections must be made for other noise sources. The system for making EIN measurements is shown in **Figure 4.2**. For the standard transmitter, the photodiode used must have an optical return loss of at least 45 dB. To determine EIN, three measurements must be made.

A signal at a power level of *Y* dBm (*Y* ≤10 dBm) is injected into the laser transmitter. The output signal level (*Z* dBm) is measured and recorded.

With no RF input signal, the link output noise floor in a 3 MHz resolution bandwidth is measured with a 10 kHz video filter bandwidth. This measures the noise from the laser and from the receiver.

With the laser turned off, the link output noise floor in a 3 MHz resolution bandwidth is measured and recorded. This measures the noise from the receiver. (Measurement *C*)

The EIN (per 1 Hz) is given by:

$$EIN(mW / Hz) = \frac{Y(mW)}{Res\ BW(Hz) * \left(\frac{Z(mW)}{Output\ noise\ due\ to\ laser(mW)}\right)}$$

The link output noise due to the laser is obtained by subtracting the receiver noise (measurement *C*) from the laser plus receiver noise (measurement *B*). In the presence of noise fluctuations due to reflections and dispersion, the noise level is generally defined to be the highest noise level that is observed on the spectrum analyzer in the frequency band. A convenient method to calculate this is to use correction factors as described below:

$$EIN(dBm / Hz) = Y\,(dBm) - \frac{Z}{(Output\ noise)}(dB) - 65 - \Delta$$

where Δ 3 is given in the table below:

Difference between curves from *B* and *C*	Δ 4
1.0 dB	7.0
2.0 dB	4.0
3.0 dB	3.0
4.0 dB	2.0
5.0 dB	1.5
7.0 dB	1.0
10.0 dB	0.5
>10.0 dB	0

If the difference between curves *B* and *C* is less than 1 dB, the measurement is not a valid measurement of laser noise. More low noise amplification is needed after the test photodiode.

B. Relative Intensity Noise:

For this measurement, you need the data measured above and you need to have a calibrated photodiode without RF impedance matching. The following characteristics need to be known at the frequency of measurement:

The gain of the amplifier G_a 5 (**Figure 4.2**)

The loss of the photodiode L_{pd} 6 (relative to DC)

The photodiode current in mA I_{pd} 7

The noise power in dBm at the amplifier output from as in *A*.

To actually derive the RIN, calculate:

$$- 10 \log (I^2_{pd} * 50) - 30 \qquad \text{(in dB/Hz)}$$

Figure 4.1: Frequency Response, VSWR

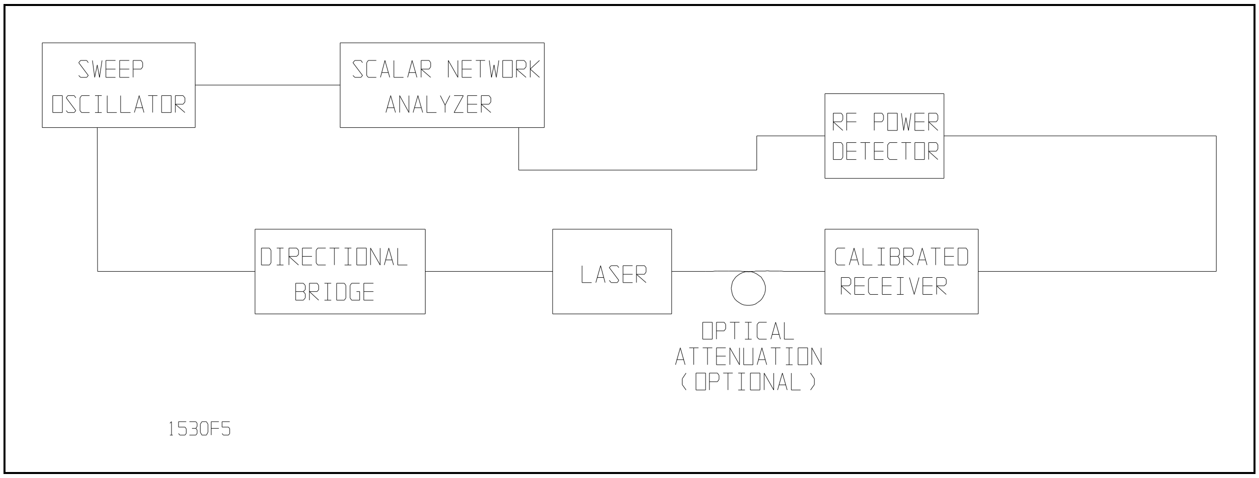
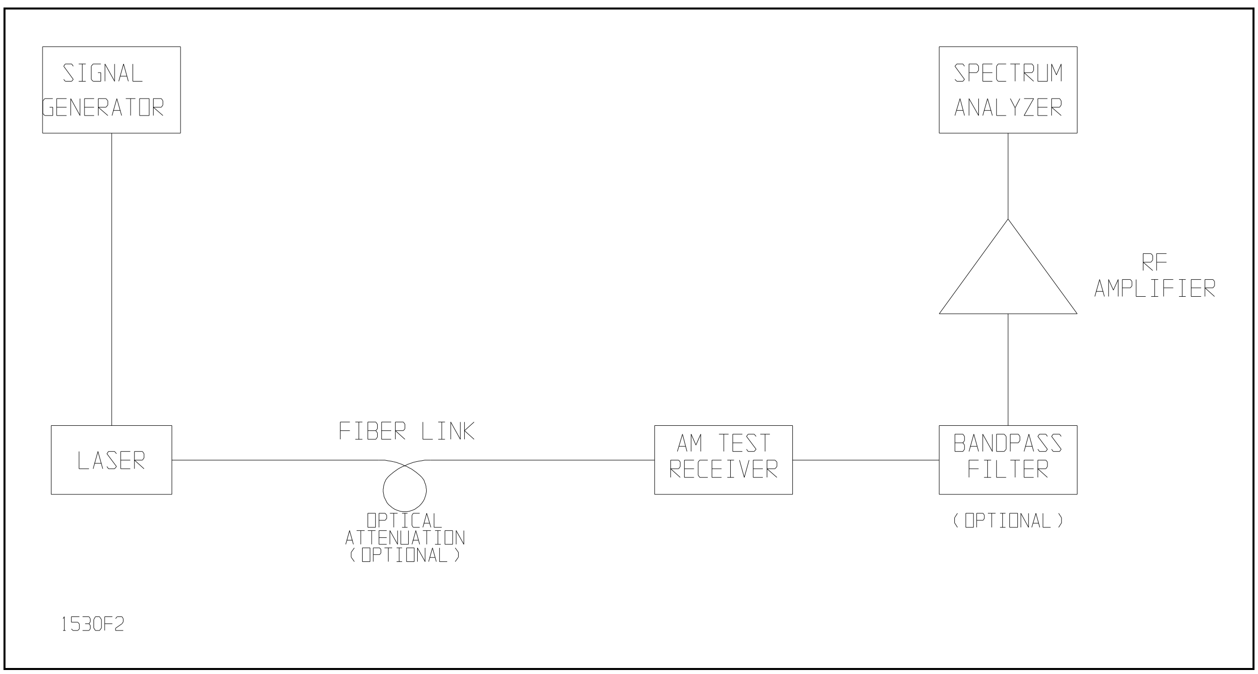


Figure 4.2: EIN; RIN



Product Specification Table

Model 3541A/B/C

The following specifications describe the guaranteed performance that will be obtained under the specified operating conditions, listed below, with the exception of typical (typ.) values, which describe expected but not guaranteed performance.

1.0 Product Options

Option #	**Description**
-001	DC-coupled RF output
-005	1.5 x optical isolator

Optical cable options

Option #	Connector Style	Cable	Available in Flange-mount	Available in Plug-in
-020	FC/APC	bulkhead	x	x
-021	FC/SPC	bulkhead	x	x
-022	FC/APC	3 mm diam.	x	
-023	FC/SPC	3 mm diam.	x	
-026	FC/PC	bulkhead	x	x
-028	FC/PC	3 mm diam.	x	

2.0 Operating Conditions

Optical Return Loss of User's Fiber > 35 dB
RF Source Impedance 50 Ω

	Flange-mount	Plug-in
Operating Temperature of Baseplate	-40°C to +65°C	0 °C to 50°C
Storage Temperature	-40°C to +85°C	-20°C to +65°C

3.0 RF Parameters

PACKAGE STYLES						
Flange-mount	3540A	3541A	3541B	3541C	3740A	3741A
Plug-in for 19" rack	10340A	10341A	10341B	10341C	10370A	10371A
RF PARAMETERS						
Max. Freq. (GHz)	5	10	13	15	4	10
Min. Freq. (GHz)	0.1	0.1	0.1	0.1	0.1	0.1
option -001 (GHz)	0.01	0.01	0.01	0.01	0.01	0.01
Amplitude Flatness (dB)	±2	±2.5	±3	±3	±2.5	±2.5
option -001 (dB)	±3	±3	±3.5	±3.5	±3	±3
Input VSWR (0.1 GHz to Max)	1.8 : 1	1.8 : 1	2.5 : 1	2.5 : 1	1.8 : 1	1.8 : 1
Input 1dB comprsn.,typ. dBm)	13	13	20	20	13	13
Input Third Order Inter., (dBm) (2 tone test)						
0.1/0.01 to 2.5 GHz	30	35	35	35	28	23
2.5 to 4 GHz	22	30	30	30	28	23
4 to 5 GHz	22	25	25	25		23
5 to 10 GHz		25	25	25		23
10 to 13 GHz			25	25		
13 to 15 GHz				25		
Equiv. Input Noise (dBm/Hz)						
0.1/0.01 to 1 GHz	-130	-130	-130	-130	-118	-118
1 to 2.5 GHz	-126	-130	-130	-130	-118	-118
2.5 to 3 GHz	-115	-130	-130	-130	-118	-118
3 to 4 GHz	-115	-125	-125	-125	-118	-118
4 to 5 GHz	-115	-125	-125	-125		-118
5 to 6 GHz		-125	-125	-125		-113
6 to 10 GHz		-120	-120	-120		-113
10 to 13 GHz			-115	-115		
13 to 15 GHz				-115		
Input Impedance 50 Ohms	**RF connector SMA, female**					

4.0 Optical Parameters

PACKAGE STYLES						
Flange-mount	3540A	3541A	3541B	3541C	3740A	3741A
Plug-in for 19" rack	10340A	10341A	10341B	10341C	10370A	10371A
OPTICAL PARAMETERS						
Wavelength (nm)	1310±30	1310±30	1310±30	1310±30	1550±30	1550±30
Spectral Width, typ. (MHz) no RF input	10	10	10	10	10	10
Optical Power, min. (mW)	4	3	3	3	3	3
DC Modulation Gain, min (mW/mA)	0.10	0.06	0.06	0.06	0.05	0.05
Relative Intensity Noise, max (dB/Hz), no RF input						
0.1/0.01 to 1 GHz	-149	-149	-149	-149	-137	-137
1 to 2.5 GHz	-145	-149	-149	-149	-137	-137
2.5 to 3 GHz	-134	-149	-149	-149	-137	-137
3 to 4 GHz	-134	-144	-144	-144	-137	-137
4 to 5 GHz	-134	-144	-144	-144		-137
5 to 6 GHz		-144	-144	-144		-132
6 to 10 GHz		-139	-139	-139		-132
10 to 13 GHz			-134	-139		
13 to 15 GHz				-139		

Optical Power Stability
(at constant Monitor PD Current, laser temperature) ±15%
Fiber core/cladding 9/125 µm (Standard singlemode, SMF-28 compatible)

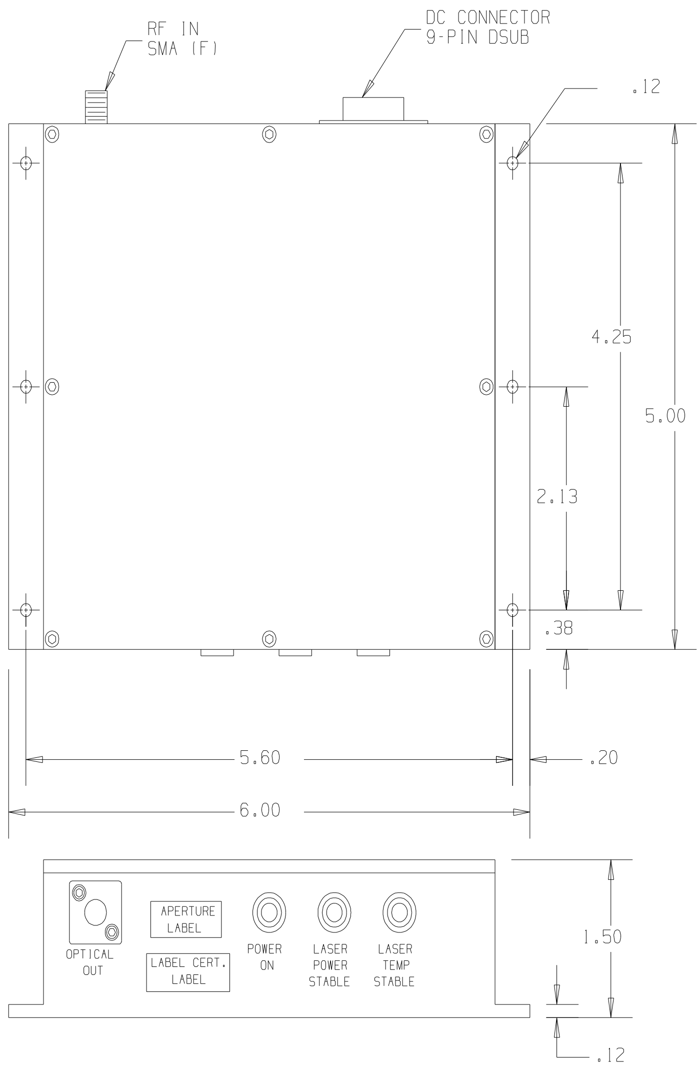
5.0 DC Parameters

Pin	Min	Nom	Max	Max Ripple	Max Current
1	+14 V	+15 V	+16 V	100 mV p-p	0.3 A
2	+4.75 V	+5 V	+5.5 V	200 mV p-p	1.5 A

6.0 Maximum Ratings

RF Input Power	+20 dBm/60 sec
ESD Sensitivity (Using Human Body Model, 150 V RF pin; i.e. 200 pF capacitor discharged through 1.5 kΩ resistor).	500 V DC pin
Peak Reverse Laser Voltage	1 V

Flange Mount Transmitter: Outline Drawing, Dimensions, and Pinouts



9 PIN CONNECTOR

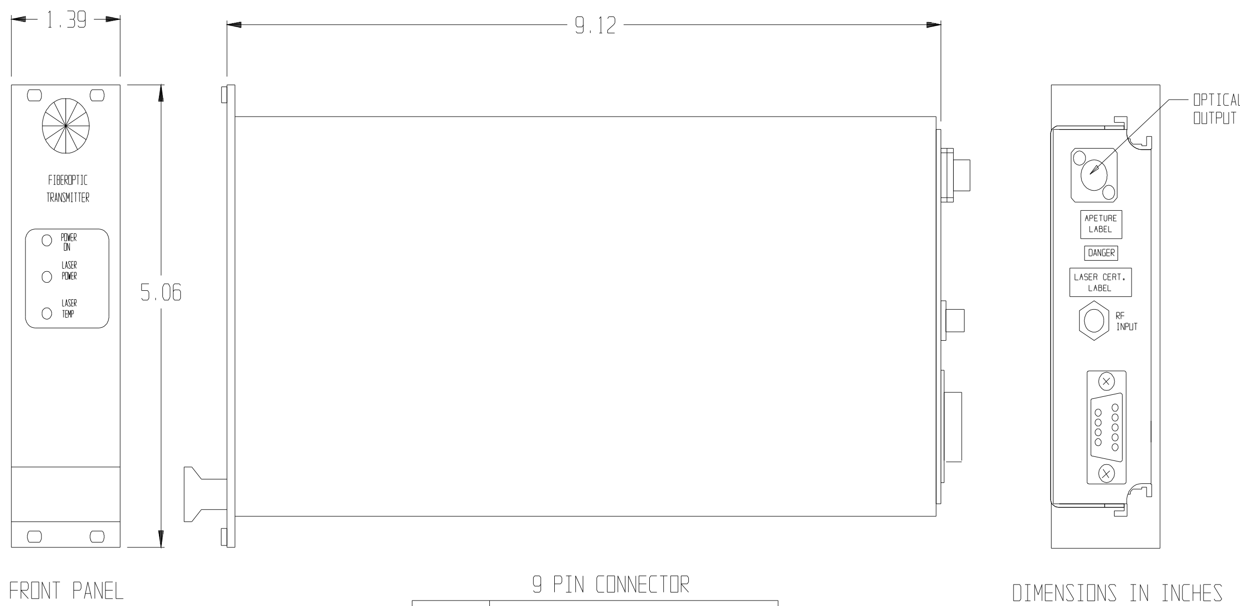
PIN NO.	FUNCTIONS
1	+15 Vdc
2	+5 Vdc
3	NC
4	POWER GROUND
5	REF. GROUND
6	PHOTODIODE CURRENT MONITOR
7	LOW OPTICAL POWER ALARM*
8	LASER CURRENT MONITOR
9	OVERTEMPERATURE ALARM*

* OPEN COLLECTOR OUTPUTS

ALL DIMENSIONS ARE IN INCHES

3540ENV

Plug-In Transmitter: Outline Drawing, Dimensions, and Pinouts



9 PIN CONNECTOR

PIN NO	FUNCTION
1	+15 Vdc
2	+5 Vdc
3	NC
4	POWER GROUND
5	REF. GROUND
6	PHOTODIODE CURRENT MONITOR
7	LOW OPTICAL POWER ALARM [1]
8	LASER CURRENT MONITOR
9	OVERTEMPERATURE ALARM [1]

[1] OPEN COLLECTOR OUTPUTS

10340ENV