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588RL
RETURN LOSS POWER METER

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RIFOCS CORPORATION
833 Flynn Road
Camarillo, CA
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declare under sole responsibility that the below listed Fiber Optic Instruments, manufactured in the United States of America, meet the intent of the Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

EN 50081-1 Emissions:	EN55022	Radiated, Class B
	EN 55022	Conducted, Class B
	EN 60555-2	Power Harmonics
EN 50082-1 Immunity:	IEC 801-2	Electrostatic Discharge
	IEC 801-3	RF Radiated
	IEC 801-4	Fast Transients
	IEC 801-5	Surge

Instruments:

Handheld	250 Series Handheld LED Sources
	260 Series Handheld Laser Sources
	330 Series Handheld Optical Attenuator
	550 Series Handheld Optical Power Meter
Benchtop	752 Series Benchtop Dual LED Source
	570 Series Benchtop Optical Power Meter
	580 Series Benchtop Return Loss Meter
Modular	670 Series Optical Power Meter Modules
	610 Series Nearfield/Farfield Scanner
	650 Series LED Source Modules
	660 Series Laser Source Modules
	671 Series Universal Controller Module
	680 Series Coupler/Splitter Module
	CP-1147 Optical Bypass Switch Module

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FOR A QUICK DESCRIPTION OF HOW TO MAKE RETURN LOSS MEASUREMENTS SEE SECTION 1.6

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1 QUICK START

This section will give the practiced technician an overview of the functionality of the 588RL as well as a description of the operating procedures. A more detailed description of the functions can be found in **Section 4.0 Front Panel Operation**.

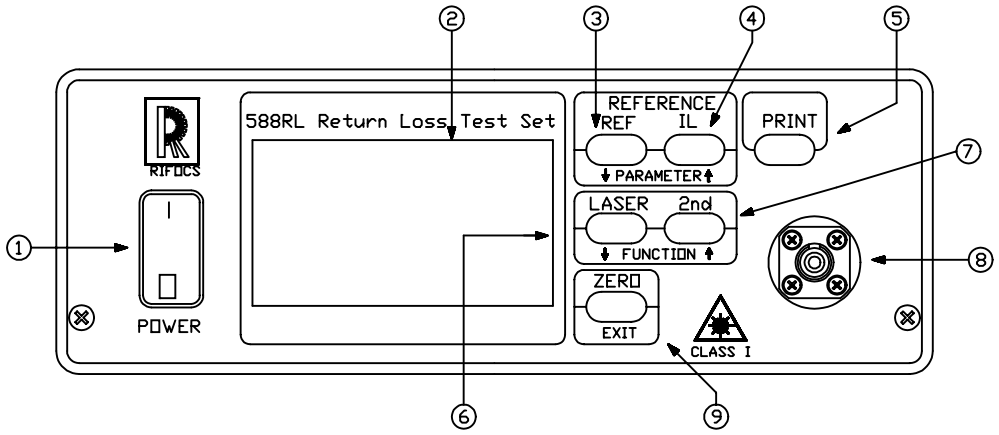


Figure 1-1 Front Panel Assignments

1.1 Front Panel Description (Refer to Figure 1-1)

1.) **Power Switch** - Turns power on/off.
2.) **LCD Display** - Readings are displayed here. (See Figure 1-2 for a detailed description)
3.) **REF** - Selects the Return Loss mode of operation.
4.) **IL** - Takes an insertion loss reading.
5.) **PRINT** - When properly interfaced to a printer, this switch will activate a hard copy label. See **Section 4.12** for detailed operating procedures.
6.) **LASER** - Select laser. With this button the lasers can be turned on or off.
7.) **2nd** - This button is used to access the secondary functions. See Section 1.4 for accessing the secondary functions.
8.) **Laser Output/RCVR Input** - Connect your reference fiber to this port.
9.) **ZERO** - Zeroes the input power detector. The input power detector must be darkened when using this function or the error code -E2- will result.

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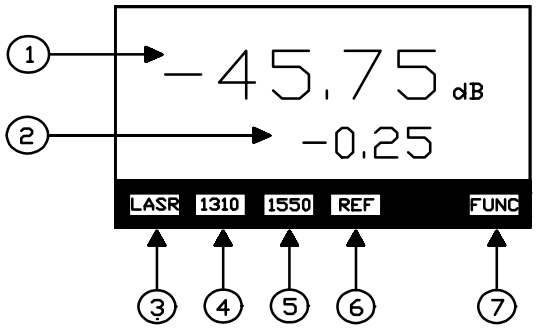


Figure 1-2 Detailed description of the 588RL display.

1.2 LCD Display (Refer to Figure 1-2)

1.) **Big Digits** - This area of the LCD displays the return loss power reading.
2.) **Small Digits** - This area of the LCD displays the insertion loss power reading.
3.) **LASR Annunciator** - This annunciator is turned on when a laser is turned on.
4.) **1310 Annunciator** - This annunciator is turned on when the 1310nm laser is turned on.
5.) **1550 Annunciator** - This annunciator is turned on when the 1550nm laser is turned on.
6.) **REF Annunciator** - This annunciator is turned on when the REF button is pressed.
7.) **FUNC Annunciator** - This annunciator is turned on while the unit is in the secondary functions mode.

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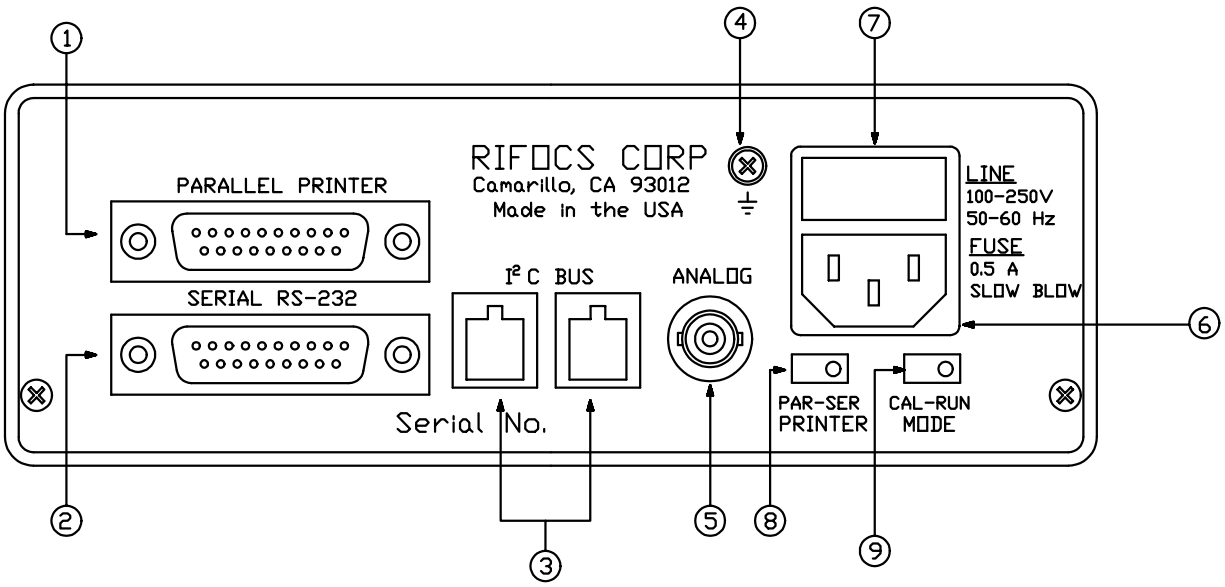


Figure 1-3 Rear Panel Assignments

1.3 Rear Panel Description

1. **Parallel Printer Interface** - This interface allows for connection to a printer for generation of labels and reports. Activated by the PRINT function.

2. **Serial RS-232 Interface** - This interface allows for remote control of the unit.

3. **I²C Bus** - The Inter-Integrated Circuit BUS interface of the 588RL allows for other equipment to be joined and addressed in series for multi channel test applications. See also **Section 5.1.3** I²C Bus connector pinout.

4. **Grounding Point** - This provide a connection to the instrument chassis ground.

5. **Analog Output** - This BNC output provides a voltage of 0..3V, relative to the optical power level being displayed.

6. **Line Input** - The unit accepts any line input from 100..250VAC at 50..60Hz.

7. **0.75A Fuse** - Slow blow. Fuse cover is easily opened with a flat-head screwdriver.

8. **Par-Ser Printer Switch** - Directs the device to output to either a parallel or serial printer for the label printing function.

9. **Cal-Run Mode Switch** - Not applicable to the 588RL.

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1.4 Secondary Functions

The secondary function sequence is initiated by pressing the "2nd" button and keeping it pressed for two seconds. Once the selected secondary function's annunciator is displayed on the LCD (in small digits - ITEM 1 of Figure 1-4) and the desired parameters set (displayed on the LCD in large digits - ITEM 2 of Figure 1-4), the function is automatically initiated and the unit will now default back to those selected functions when powered OFF and ON. (For the following items numbers refer to Figure 1-1)

7.) **2nd (FUNCTION ↑)** - Pressing this button for longer than 2 seconds initiates the secondary functions mode. *Figure 1-4 shows what the LCD display looks like when in the secondary functions mode.* Once the secondary functions mode has been initiated, pressing this button will increment the secondary function number.

6.) **↓ FUNCTION** - Pressing this button while in the secondary functions mode will decrement the secondary function number.

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4.) **PARAMETER** ↑ - Pressing this button while in the secondary functions mode will increment the secondary function parameter.

3.) ↓ **PARAMETER** - Pressing this button while in the secondary functions mode will decrement the secondary function parameter.

9.) **EXIT** - Pressing this button while in the secondary functions mode will terminate the secondary functions mode.

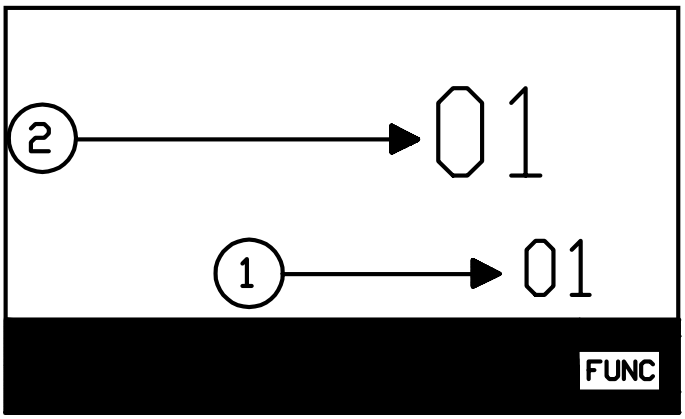


Figure 1-4 LCD display while in Secondary Functions Mode.

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Table 1-1 Secondary Functions Quick Reference.

Secondary Function	Description	Parameter
1	Select Label Format	1..7
2	Select Label Serial Number	0..65000
3	Select I2C Address	1..16
4	Select BAUD Rate	1200, 2400, 4800, 9600
5	Select Year	1993..2100
6	Select Date (Day & Month)	DD-MM
7	Select Time	00:00..23:59
8	Select Glass to air return loss value for 1310nm.	00..30.00dB
9	Select glass to air return loss value for 1550nm.	00..30.00dB
10	Select dual laser mode or single laser mode.	0,1
11	Select the zero mode configuration	0,1
12	Display Software Revision Level	

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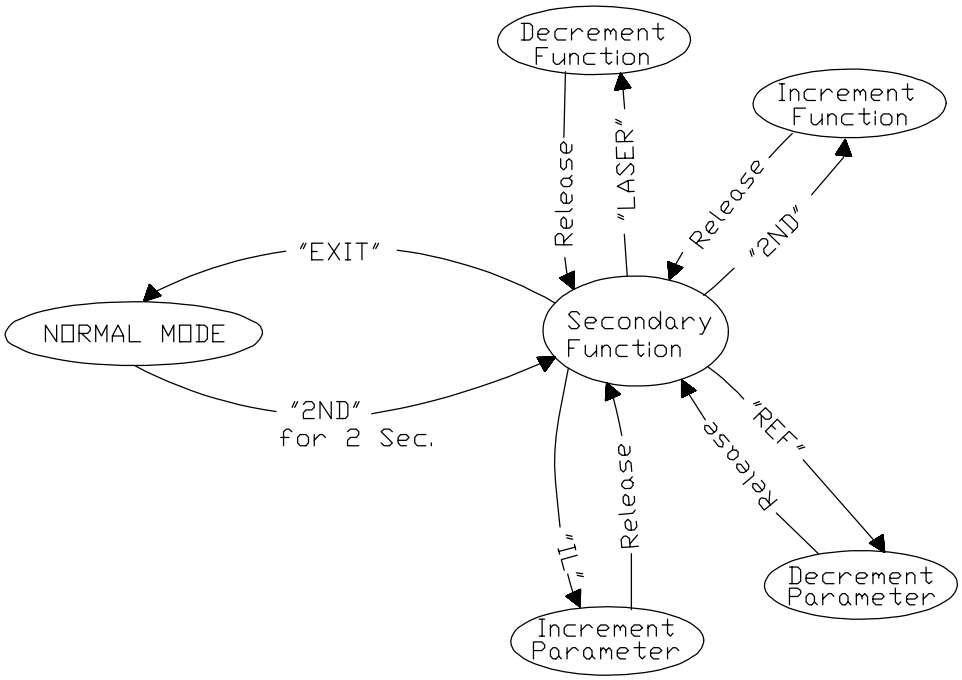


Figure 1-5 Secondary Function State Diagram

1.5 Remote Terminal Commands

The 588RL can be remotely controlled with any computer having a compatible RS-232 interface.

Format BAUD Rate - 1200,2400,4800,9600
(The 588RL default BAUD Rate is 9600)
Parity - None
Bits - 8
Stop Bit - 1

(Command strings are not case sensitive)

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EXAMPLE 1 - Sets unit to dBm mode (Using an IBM PC compatible computer)

C:**mode com1:9600,n,8,1,p**[ENTER] (Format BAUD Rate)
C:**copy con com1:**[ENTER] (Enable Remote Command)
DBM [ENTER] (Watt Mode Active Command)
[CTRL][**Z**][ENTER] (End of file command)

Table 1-2 Remote Command Quick Reference.

COMMAND	DESCRIPTION
CH	Active remote channel select
DBM	Absolute log units
GET_DATE	Returns the date (DY-MN-YR)
GET_LBLNUM	Returns the currently selected label number
GET_SN	Returns the label serial number
GET_TIME	Returns the time (International format)
INIT_CLOCK	Used after the clock battery has been replaced
INSLOSS	Take an insertion loss reading
LASER	Turns on/off the laser(s)
LOCAL	Enables the front panel buttons
LOCKOUT	Disables the front panel buttons
LSR_MODE	Selects the single/dual laser mode of operation
PRINT	Prints a label
READ	Returns the optical power
READ_LABEL	Returns the indicated label format file
RESET	Resets the 588RL
RESTORE	Loads the EEPROM with its default factory set parameters

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Table 1-2 Remote Command Quick Reference. (continued)

COMMAND	DESCRIPTION
RTNLOSS	Put the 588RL into the return loss mode
SAVE	Make the present operating mode the default
SET_DATE	Set date (DD,MM,YYYY)
SET_LABEL	Label format select
SET_SN	Set the label serial number
SET_TIME	Set time (HH,MM)
VER	Returns the software revision level
ZERO	Zeros the optical input
ZERO_MODE	Sets the zero configuration

1.6 Quick Instructions Return Loss/Insertion Loss Testing (588RL/575L Combination).

MODEL	BUTTON	STEP	INSTRUCTIONS
		SETUP TEST	Interconnect OPM and RLTS with 933 IIC Interface Cable, see Figure 1-6. RLTS set to address #1; OPM set to #2. Be sure RLTS Laser is ON. Inspect both ends of HRL Ref Cable to be free of dirt and scratches.
		⮟	
575L	[HOLD]	INITIATE SPECIAL MODE	Access secondary function #13, select parameter 4. This puts the 575L into a mode which is compatible with the 588RL
		⮟	
575L	[ZERO]	OPM ZERO	Push Dust Cap over OPM Optical Port. Press [ZERO] button on OPM. Note OPM reading between -90.00dBm and -LO-.

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588RL	[ZERO]	RLTS ZERO	Connect Green End of HRL Cable to RLTS. Do Mandrel Wrap near reference end of HRL Cable so that RLTS reads <-40dBm. Press [ZERO] button on RLTS and -00- will appear but waiting until -00- disappears or dBm display appears before releasing Mandrel Wrap. See Figure 7-1.
588RL	[REF]	14dB R.L. REFERENCE LEVEL	Press and hold [REF] button on RLTS until the dashes on the display disappear and the display reads 14.00 dB. The return loss of an unmated PC connector is 14dB. See Figure 1-7.
575L	[dB]	0dB I.L. REFERENCE LEVEL	Connect Ref End of HRL Cable to OPM. In dBm mode, initial dBm level reading should be 0 to -5 dBm. Press [dB] button on OPM to establish 0dB reference level for 1310nm and 1550nm insertion loss measurements. See Figure 7-3.
		CONNECT D.U.T.	Couple D.U.T. to Ref End of HRL Cable. If cable assembly, connect far end of D.U.T. cable to OPM. Note 1310nm I.L. reading on OPM. See Figure 7-4. Press the [LASER] button of the 588RL to toggle between 1310nm and 1550nm I.L. and R.L. readings.
588RL	[I.L.]	MEASURE INSERTION LOSS	Press [I.L.] button on RLTS and note transfer of I.L. reading from OPM to bottom field of RLTS display. See Figure 7-4.
		MEASURE RETURN LOSS	Do Mandrel Wrap near D.U.T. Note return loss reading on RLTS, see Figure 7-2.
588RL	[PRINT]	PRINT TEST RESULTS	If RLTS is hooked up to printer, press [PRINT] button on RLTS to print serialized QC label. Release Mandrel Wrap. Pressing the [PRINT] button freezes the return loss readings. They can be viewed at each wavelength by pressing the [LASER] button. To unfreeze the readings press the [2nd] button.

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1.7 Quick Instructions Return Loss Testing (588RL Only).

MODEL	BUTTON	STEP	INSTRUCTIONS
		SETUP TEST	Be sure RLTS Laser is ON. Inspect both ends of HRL Ref Cable to be free of dirt and scratches.
588RL	[ZERO]	RLTS ZERO	Connect Green End of HRL Cable to RLTS. Do Mandrel Wrap near reference end of HRL Cable so that RLTS reads <-40dBm. Press [ZERO] button on RLTS and -00- will appear but waiting until -00- disappears or dBm display appears before releasing Mandrel Wrap. See Figure 7-1.
588RL	[REF]	14dB R.L. REFERENCE LEVEL	Press and hold [REF] button on RLTS until the dashes on the display disappear and the display reads 14.00 dB. The return loss of an unmated PC connector is 14dB. See Figure 1-7.
		CONNECT D.U.T.	Couple D.U.T. to Ref End of HRL Cable.
		MEASURE RETURN LOSS	Do Mandrel Wrap near D.U.T. Note return loss reading on RLTS. See Figure 7-2. Press the [LASER] button of the 588RL to toggle between 1310nm and 1550nm R.L. readings.
588RL	[PRINT]	PRINT TEST RESULTS	If RLTS is hooked up to printer, press [PRINT] button on RLTS to print serialized QC label. Release Mandrel Wrap. Pressing the [PRINT] button freezes the return loss readings. They can be viewed at each wavelength by pressing the [LASER] button. To unfreeze the readings press the [2nd] button.

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1.8 Return Loss Testing of an APC connector (588RL Only).

MODEL	BUTTON	STEP	INSTRUCTIONS
		Initial Setup	Connect APC/PC Reference Cable.
588RL	[REF]	14dB R.L. REFERENCE LEVEL	Press and hold the [REF] button on RLTS until the dashes appear on the display. When the display reads 14.0 dB the referencing is complete. The return loss of an unmated PC connector is 14dB. See Figure 1-7.
		Switch Reference Cables	Disconnect the APC/PC Reference cable and connect APC/APC Reference Cable.
588RL	[ZERO]	RLTS ZERO	Wrap fiber tightly around Mandrel near reference end of HRL Cable so that RLTS reads < -44dBm. Press [ZERO] button on RLTS and wait for the zero function to complete before releasing Mandrel Wrap. See Figure 7-1.
		CONNECT D.U.T.	Couple D.U.T. to Ref End of HRL Cable.
		MEASURE RETURN LOSS	Do Mandrel Wrap near D.U.T. Note return loss reading on RLTS. See Figure 7-2. Press the [LASER] button of the 588RL to toggle between 1310nm and 1550nm R.L. readings.
588RL	[PRINT]	PRINT TEST RESULTS	If RLTS is hooked up to printer, press [PRINT] button on RLTS to print serialized QC label. Release Mandrel Wrap. Pressing the [PRINT] button freezes the return loss readings. They can be viewed at each wavelength by pressing the [LASER] button. To unfreeze the readings press the [2nd] button.

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Glossary

OPM = Optical Power Meter (575L)

I.L. = Insertion Loss

D.U.T. = Device Under Test

RLTS = Return Loss Test Set (588RL)

R.L. = Return Loss

Mandrel Wrap = 3-4 turns around a hex-shaped rod or pencil

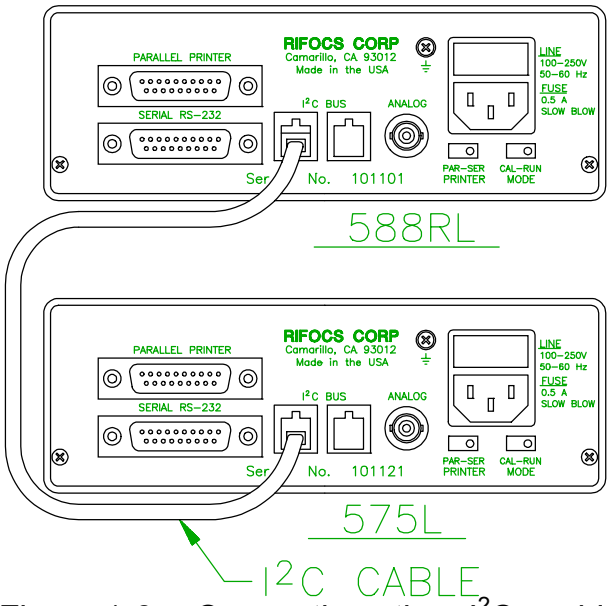


Figure 1-6 Connecting the I²C cable between the 588RL and the 575L.

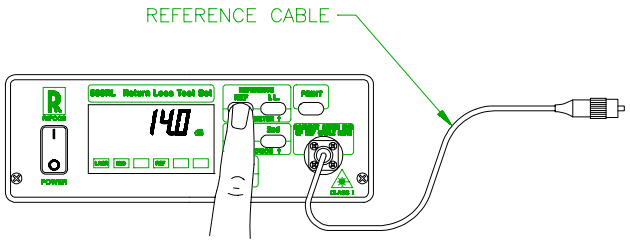


Figure 1-7 Initiating the Return Loss Mode.

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2 GENERAL INFORMATION

The 588RL is a high performance, programmable return loss meter. It is used in both manual and computer controlled test set-ups.

Powerful interface features include an RS232 interface which enables the 588RL to be controlled from a computer, and an Inter-Integrated Circuit (I^2C) Bus which allows the 588RL to be connected to a 575L for taking insertion loss readings. The combination of RS232 and I^2C interface makes it possible to control the 588RL and the 575L with just one computer and only one RS232 port. The 588RL can be connected to a printer via either the parallel printer port or the RS232 interface on the unit's back panel. This feature allows the user to get hard copies of power measurements, for example to label the losses of connectors.

Main Features

* Maximum Performance
  (0 to 70dB)
* Dual Wavelength Operation (1310nm & 1550nm)
* Automatic Zeroing
* RS232 Interface for Remote Control
* Inter-Integrated (I^2C) Circuit Bus Interface
* Parallel Printer Port Interface
* Universal Power Supply (100-250VAC, 50-60 Hz)
* Daisy Chain Capability

Applications

* Singlemode fiber connector testing
* Singlemode component testing
* System testing
* Measuring insertion loss

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2.1 Specifications

Table 2-1 Specifications at 18 to 25◦C.

1	Wavelength	1310±40nm 1550±30nm
2	Measurement Range	0 to 65dB
3	Accuracy	< ±0.5dB 0dB to 55dB < ±1.0dB 56dB to 60dB < ±2.0dB 61dB to 65dB < ±3.0dB 66dB and higher
4	1310nm Laser Output Power 1550nm Laser Output Power	-1dBm ±1dB -1dBm ±1dB
5	Laser Power Stability	0.05dB (2 hours at 22◦C) 0.10dB (24 hours at 22◦C)
6	Resolution	Log: 0.1dB
7	Calibration Traceability	U.S.N.I.S.T
8	Recommended Recalibration Period	12 Months
9	Settling Time	2 Seconds
10	Display	Custom tri-plexed liquid crystal display with 4 digit data field.

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Table 2-1 Specifications at 18 to 25°C (continued).

11	Measurement Modes	dB relative dBm absolute
12	Optical Connector Interface	Seiko Gicken (FC-APC). FC-APC to FC-PC reference cable supplied. Singlemode fiber SMF-28
13	RS232 Interface	Conforms to RS232C standard. 25 pin D connector female
14	I^2C Interface	Conforms to the Inter-Integrated (I^2C) Circuit Bus specification
15	Parallel Printer Interface	Logic level: 0-5V Drives 1 TTL load 25 pin D connector, female
16	Analog Output Interface	0 TO 3V (Amplifier output) Maximum analog output load > 5k ohm
17	Line Power	100VAC TO 25 0VAC, 50-60 Hz
18	Warm Up Time	5 minutes

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Table 2-1 Specifications at 18 to 25°C (continued).

19	Operating Environment	-5°C to 55°C, 0-95% RH (Non-condensing)
	Storage Environment	-15°C to 70°C, 0-95% RH (Non-condensing)
	Weight/ Dimensions	Weight, kg (lbs) Height x Width x Depth cm (in.)
	Basic Instrument	2.5kg (5.51 lbs.) 8 X 19 X 29cm (3.125 x 7.375 x 11.375 in.)
	Shipping Weight	3.95kg (8.71 lbs.) 15 X 28 X 38cm (5.750 x 10.75 x 14.875 in.)

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2.2 Specification Definitions

1. Wavelength: The 588RL is configured with both a 1310nm Laser and a 1550nm Laser.

2. Measurement Range: The measurement region where the instrument does not deviate from the instrument's accuracy specification.

3. Accuracy: This is the maximum uncertainty of a return loss reading for a given measurement range.

4. Laser Output Power: This is the laser output power measured at the optical interface of the instrument.

5. Laser Power Stability: This is the maximum power deviation of the laser.

7. Resolution: This specification defines the smallest power change the power meter can display during the power measurement.

8. Calibration Traceability: The laser's output power is traceable to N.I.S.T.

9. Recommended Recalibration Period: This is the recommended time period for re-calibration.

10. Settling Time: This is the amount of time it takes for the 588RL to read within 0.10dB of the actual power reading when the input power makes an instant transition from -70dBm to 0dBm.

12. Display: The LCD display is used for displaying return loss power readings, insertion loss readings, laser on/off status, measurement units and secondary function configurations.

13. Measurement Modes: The 588RL measures return loss in relative units (dB). When the 588RL is in the dBm mode, power is in absolute units (dBm).

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14. Optical Connector Interface: This field provides information of the type of connector interface that is available with the 588RL.

15. RS232 Interface: The RS232 Interface of the 588RL provides a means of transmitting and receiving data between a host computer or a printer. Serial communication is popular because most computers have at least one serial port. For examples of how the RS232 interface is used see section 5

16. I^2C Interface: The Inter-Integrated I^2C Circuit Bus Interface of the 588RL provides a means of connecting it to a 575L for insertion loss measurements. For examples of how the I^2C Bus is used see section 5.

17. Parallel Printer Interface: The parallel printer interface is for printing labels. For a pinout diagram of the parallel printer interface see Table 5-3.

18. Analog Output Interface: The analog output provides an electrical signal which can be used to monitor the optical input signal. The connection to the Analog Output is made via a BNC connector.

19. Line Power This specification defines the AC line voltage requirements necessary to operate the 588RL .

20. Warm Up Time: The 588RL must be powered on for this time in order to conform with all the specifications.

21. Environmental:
Operating Temperature: This is the temperature range in which the 588RL will conform to the specifications after the specified warm up time.

Storage Temperature: This is the temperature range at which the instrument can be stored with the power off, without any damage or any loss of specification to the instrument. It is required that the instrument be brought back to within the operating temperature range before it is turned on.

Humidity: The relative non-condensing humidity levels allowed in the operating temperature range.

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2.3 Warranty Information

RIFOCS Corp. warrants this product to be free from defects in material and workmanship for a period of 1 (one) year from date of shipment. During the warranty period we will, at our option, either repair or replace any product that proves to be defective. To exercise this warranty, write or call your local RIFOCS Corp. Representative, or contact RIFOCS Corp. Headquarters. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

Limitation of Warranty

This warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to fuses or AC line cords.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability of fitness for a particular use. RIFOCS Corp. shall not be liable for any indirect, special or consequent damages.

2.4 Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by RIFOCS Corp. The accuracy and calibration of this instrument is traceable to the N.I.S.T. through equipment which is calibrated at planned intervals by comparison to certified standards.

The instrument should be calibrated annually in order to maintain specifications. This provides the basis for an effective quality assurances/standards program. These services are available for RIFOCS products for a nominal fee.

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3 INITIAL PREPARATION

This section provides information needed for incoming inspection and preparation for use.

3.1 Unpacking And Inspection

The unit was carefully inspected, mechanically, electrically and optically before shipment. When received, the shipping carton should contain the items listed in Section 3.3. Account for and inspect each item. In the event of a damaged instrument, write or call RIFOCS Corp. in Camarillo, California. Please retain the shipping container in case re-shipment is required for any reason.

3.2 Damaged In Shipment

All instruments are shipped F.O.B. Camarillo when ordered from RIFOCS. If you receive a damaged instrument you should:

1) Report the damage to your shipper immediately.
2) Inform RIFOCS Corporation.
3) Save all shipping cartons.

Failure to follow this procedure may affect your claim for compensation.

3.3 Standard Contents

1 588RL Return Loss Meter
1 Singlemode SMF-28 reference cable
1 Certificate of Calibration and Metrology Report
1 Instruction Manual for the 588RL
1 AC line cord (compatible with available AC line)
1 Package of two 0.75 amp fuses
1 Warranty Registration Card (mail immediately after checking out the unit)

3.4 Preparation For Use

The 588RL is shipped ready for use. The instrument is powered from the AC line (100-250VAC, 50-60Hz). See Section 4.1 for additional information.

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4 FRONT PANEL OPERATION

This section includes operating instructions such as front and rear panel controls, and connections. Refer to Table 4-1 concerning the available front panel commands:

Table 4-1 Summary of Front Panel Functions

COMMAND KEY	DESCRIPTION	SECTION
[REF]	Puts meter into return loss mode	4.5
[I.L.]	Get an insertion loss reading	4.6
[LASER]	Turn on/off a laser(s)	4.8
[ZERO]	Zero Detector input	4.4
[PRINT]	Print Label	4.7
[2nd]	Initiates secondary functions mode	1.4
[FUNCTION ↑]	Increment secondary function	1.4
[↓ FUNCTION]	Decrement secondary function	1.4
[PARAMETER ↑]	Increment secondary function parameter	1.4
[↓ PARAMETER]	Decrement secondary function parameter	1.4
[EXIT]	Exit secondary functions mode	1.4

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Table 4-2 Summary of Front Panel Secondary Functions

Secondary Function Number	Secondary Function Description	Parameter	Section
1	Select Label Format	1-7	4.9.2
2	Select Serial Number	0-65,535	4.9.3
3	Set I^2C Address	1-16	4.9.4
4	Set BAUD Rate	1200, 2400, 4800, 9600	4.9.5
5	Set Year	1993-2100	4.9.6
6	Set Date (dd-mm)	1-1 to 31-12	4.9.7
7	Set Time (international)	0:00 - 23:59	4.9.8
8	Set the glass to air return loss value for 1310nm	00.00dB to 30.00dB	4.9.9
9	Set the glass to air return loss value for 1550nm	00.00dB to 30.00dB	4.9.10
10	Select single laser mode or dual laser mode	0,1	4.9.11
11	Select the zero mode configuration	0,1	4.9.12
12	Display the software revision level	none	4.9.13

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For Model 588RL front and rear panel illustrations refer to Figure1-1 and Figure 1-3. For references to the Model 588RL custom LCD, refer to Figure 1-2.

4.1 Power-Up

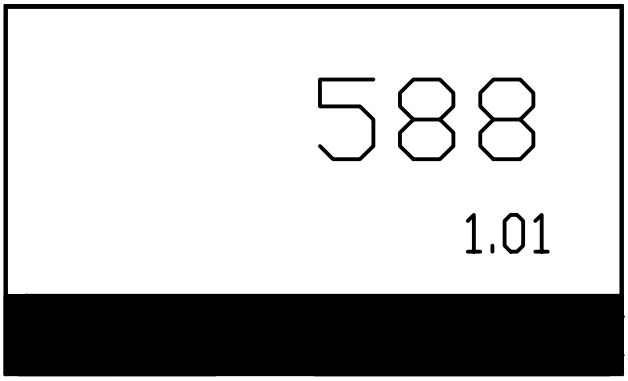


Figure 4-1 LCD during power up.

The internal power supply of the Model 588RL operates from an AC line voltage in the range of 100-250VAC 50-60Hz.

WARNING

Ground the instrument through a properly earth grounded receptacle before AC operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

The POWER ON/OFF switch operates on the rocker principle. Pressing the upper portion turns the instrument on. Pushing the lower portion turns the instrument off. Immediately after turning on the power, the display will indicate as shown in Figure 4-1. The upper field of the display will show "588" and the lower field of the display will show the software revision level. The 588RL will then display the power reading in dBm units.

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Table 4-3 Factory Parameters Stored in EEPROM

INSTRUMENT FUNCTION	DESCRIPTION	RESTORE DEFAULT VALUES
I^2C Address	I^2C Bus Address	1
Serial Number	Auto Incrementing Serial Numbers for Label Printing	10101
Label Format	User-Defined Label Formats (7 Label Formats Possible)	1
RS232 BAUD Rate	Data Rate of the RS232 Interface	9600 BAUD
Zero	Software Zero	Value
Laser Configuration	Determines whether the 588RL operates in single or dual laser mode	Single Laser Mode

4.2 EEPROM

The EEPROM allows for the storage of the parameters described in Table 4-3 when the unit is turned off. The EEPROM can retain these values for several years. The 588RL checks the EEPROM during its power-up self test. If for some reason the EEPROM loses any of its memory, the 588RL will display error code -E1-. Pressing the **[PRINT]** button will clear the error and write factory default data to the EEPROM.

4.3 Warm-Up Period

The Model 588RL requires a minimum of 5 minutes to stabilize after the power has been turned on, or if there is a change in ambient temperature. Then proceed to Section 4.4 and follow the procedures for zeroing the instrument.

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4.4 How to ZERO

Connect the Reference Cable to the 588RL input. Wrap 5 tight loops of the reference cable around a pencil *(or some other device that eliminates back reflections from the end of the reference cable)* and press the **[ZERO]** button. The 588RL will show -00- in the upper field of the display while it zeros the receiver. When zeroing is complete the **-00-** will disappear. If too much light is being received at the optical input, ie. power > -40 dBm, the 588RL will display error code **-E2-**. Press the **[REF]** button to clear this error. The 588RL has a special zero mode where the lasers are not turned on during the zeroing process. This mode is enabled by entering secondary function #11 and selecting a parameter of 1.

4.5 How to Make a Return Loss Measurement

This section describes how to make a return loss measurement. Once the meter has been successfully zeroed as described in section 0, remove the fiber coils from the pencil and allow the fiber to relax. Press and hold down the **[REF]** button for 4 seconds, when the dashes appear on the display release the **[REF]** button. When the dashes disappear and 14.00dB is displayed, the referencing is complete. Connect your D.U.T. (Device Under Test) to the reference cable. The 588RL will now display the return loss of your D.U.T. If the 588RL is in the dual laser mode, referencing will have occurred at both 1310 and 1550. To view the return loss of the D.U.T. at each wavelength, press the [LASER] button. If the 588RL is in the single laser mode, only the return loss of the currently selected wavelength will be displayed. The single/dual laser mode of operation is selected by entering secondary function #10.

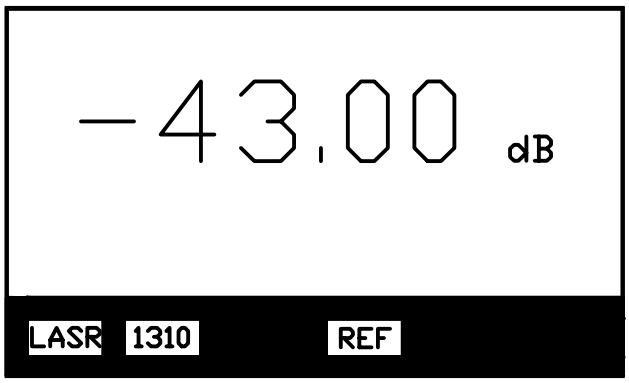


Figure 4-2 LCD showing a return loss of 43.00 dB at 1310nm.

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4.6 How to Make an Insertion Loss Measurement

In order to make an insertion loss measurement it will be necessary to connect a 575L to the I2C bus of the 588RL. The 575L must have an I2C address of 2. Set the I2C address of the 588RL to 1. Access secondary function #13 of the 575L and select a parameter value of 4. This enables the 575L to operate correctly with the 588RL. Once the 588RL has been successfully zeroed as described in section 0, remove the fiber coils from the pencil and allow the fiber to relax. Connect the reference cable to the 575L and press its **[dB]** button. Wait for the 575L to complete the dB referencing, when the dashes disappear from the display the referencing is complete. Disconnect the reference cable from the 575L and connect the D.U.T. between the reference cable and the 575L. The insertion loss will now be displayed on the LCD of the 575L. To toggle between 1310nm and 1550nm insertion loss readings, press the [LASER] button of the 588RL. If you need to store this insertion loss reading so that it can be printed later, press the **[IL]** button. The insertion loss reading will now be displayed on the lower portion of the 588RL display.

4.7 How to Print a Label

The 588RL has the capability of taking a reading from the display and printing that reading on a label. To do this the 588RL must be connected to a printer. The serial/parallel switch on the back panel of the 588RL must be in the parallel position if printing to a parallel printer or in the serial position if printing to a serial printer. When the [PRINT] button is pressed the return loss is measured at each wavelength. These values are stored internally and can be viewed by pressing the [LASER] button. At this point only the stored return loss values are being displayed. To resume the normal operation press the [2nd] button.

Note

It is assumed that the user has already selected a default label format. The default label format can be set to 1 of 7 possible formats. The process for setting the default label format is covered in Section 1.4 (Secondary Functions). To create a label format it is necessary to connect the 588RL to a computer over the RS232 interface. The label format is created on the computer and then down loaded to the 588RL. The process for creating label formats is covered in Section 6.2.1 (Creating a Label Format File)

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4.8 Turning On/Off the Laser(s)

Pressing the **[LASER]** button of the 588RL momentarily will toggle the unit between one of two states:

1.) 1310nm laser on and 1550nm laser off
2.) 1310nm laser off and 1550nm laser on

Pressing and holding down the [LASER] button of the 588RL for 4 seconds will turn both lasers off.

4.9 Secondary Functions

4.9.1 Secondary Functions Menu

For an explanation of how to access and select the secondary functions see Section 1.4.

4.9.2 FUNCTION 1 - Selecting the Label Format

The 588RL has the capability of printing hard copies (labels) to a parallel or serial printer. The user can store up to 7 different labels in the 588RL's non-volatile memory. Each label can have its own unique format. To select a label format go into the secondary functions menu, select secondary function number 1. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired label format number is displayed on the parameter field of the LCD.

4.9.3 FUNCTION 2 - Setting the Label Serial Number

To set a 5 digit user definable label serial number enter into the secondary functions menu. Select secondary function number 2. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired serial number is displayed on the parameter field of the LCD. (NOTE: each time a serial number is printed it is incremented.)

4.9.4 FUNCTION 3 - Setting the I^2C ADDRESS

To set the I^2C address (remote address) enter into the secondary functions menu. Select secondary function number 3. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired I^2C address is displayed on the parameter field of the LCD. (NOTE: each 588RL that is connected to the I^2C bus must have its own unique address.) Valid addresses are 1-16. The default

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I^2C address as shipped from the factory is 1.

4.9.5 FUNCTION 4 - Setting the BAUD Rate

To set the BAUD Rate of the 588RL's RS232 interface port, enter into the secondary functions menu. Select secondary function number 4. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired BAUD Rate is displayed on the parameter field of the LCD. The 588RL's RS232 interface uses the following communications parameters: 8 data bits, 1 stop bit, no parity. The default BAUD Rate as shipped from the factory is 9600.

4.9.6 FUNCTION 5 - Setting the Year

To set the year that is stored in the 588RL's internal clock/calendar enter into the secondary functions menu. Select secondary function number 5. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired year is displayed on the parameter field of the LCD.

4.9.7 FUNCTION 6 - Setting the Date (day-month)

To set the date (day and month) that is stored in the 588RL's internal clock/calendar enter into the secondary functions menu. Select secondary function number 6. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired date is displayed on the parameter field of the LCD.

4.9.8 FUNCTION 7 - Setting the Time

To set the time of the 588RL's internal clock/calendar enter into the secondary functions menu. Select secondary function number 7. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired time is displayed on the parameter field of the LCD. Note that the time is displayed in the international time format. (00.00-23.59)

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4.9.9 FUNCTION 8 - Setting the Glass to Air Return Loss Value for 1310nm

Depending on the D.U.T. and the type of reference cable used, the operator may need to set the glass to air return loss value at 1310nm to some value other than 14.00dB. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired value is displayed on the parameter field of the LCD.

4.9.10 FUNCTION 9 - Setting the Glass to Air Return Loss Value for 1550nm

Depending on the D.U.T. and the type of reference cable used, the operator may need to set the glass to air return loss value at 1550nm to some value other than 14.00dB. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired value is displayed on the parameter field of the LCD.

4.9.11 FUNCTION 10 - Setting the Default Laser Configuration

To set the default laser configuration of the 588RL, enter into the secondary functions menu. Select secondary function number 10. Press the **[↓ PARAMETER]** or **[PARAMETER ↑]** button until the desired value is displayed on the parameter field of the LCD. To enable the dual laser mode select a parameter value of 0, to enable the single laser mode, select a parameter value of 1. See Table 4-4 for an explanation of what the differences are between single and dual laser modes.

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Table 4-4 Description of Dual and Single Laser Modes.

LASER CONFIGURATION	FRONT PANEL BUTTON	FUNCTION
DUAL LASER MODE	[REF]	Establishes the 14.0 dB reference point for both 1310nm and 1550nm.
	[I.L.]	Calculates the insertion loss of the device under test at both 1310nm and 1550nm
	[ZERO]	Zeros the 588RL at both 1310nm and 1550nm.
	[PRINT]	In addition to printing a label, the return loss at both 1310nm and 1550nm will be measured and the reading will be frozen on the LCD. To view the return loss at each wavelength press the [LASER] button. To un-freeze the display, press the [2nd] button.
SINGLE LASER MODE	[REF]	Establishes the 14.0 dB reference point at 1310nm or 1550nm, depending on which laser is on when the [REF] button is pressed.
	[I.L.]	Calculates the insertion loss of the device under test at 1310nm or 1550nm, depending on which laser is on when the [I.L.] button is pressed.
	[ZERO]	Zeros the 588RL at 1310nm or 1550nm, depending on which laser is on when the [ZERO] button is pressed.
	[PRINT]	In addition to printing a label, the return loss at 1310nm or 1550nm will be measured and the reading will be frozen on the LCD. To un-freeze the display, press the [2nd] button.

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4.9.12 FUNCTION 11 - Select the Zero Mode Configuration

The 588RL can be zeroed with the lasers on or off. The default is for the zero to be performed with the lasers on. However, this can be changed via secondary function #11. Selecting a parameter value of 1 means that the lasers will not be turned on when zeroing. Selecting a parameter value of 0 means that the lasers will be turned on during zeroing.

4.9.13 FUNCTION 12 - Display Software Revision Level

To display the software revision level enter into the secondary functions menu. Select secondary function number 12. The software revision level will be displayed on the parameter field of the LCD. The **[↓ PARAMETER]** and **[PARAMETER ↑]** buttons are not used for this secondary function.

4.10 Error Codes

When the 588RL detects an error condition during its operation, the error will be indicated by the appropriate error message being displayed on the 588RL's LCD display. Table 4-5 lists the error codes and what they mean. For information on how to recover from an error condition see Section 11.2 Troubleshooting.

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Table 4-5 Error Codes

ERROR CODE	CONDITION
E1	This error indicates that the EEPROM lost some of its data. The factory default values will be loaded into EEPROM. If this problem persists, the EEPROM chip is bad, contact the factory for repair.
E2	Zeroing error. Excessive background reflections are being received at the optical input port.
E3	ROM error. This indicates that the ROM chip has lost some of its data. Contact factory for repair.
E4	The 588RL is not able to get an insertion loss reading from the 575L. Make sure that the I2C cable is connected, that each unit's I2C address is set correctly and that the units are in the correct mode.
E5	The 588RL is not able to establish a reference. Make sure that the correct reference cable is connected to the unit.

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5 SYSTEM CONFIGURATION

The 588RL is equipped with an RS232 interface, an I^2C Bus interface, and a parallel printer interface. The RS232 interface makes it possible to control the 588RL from a remote computer. The I^2C interface makes it possible to connect the 588RL to a 575L power meter. The printer interface enables the user to print hard copies of return loss readings, insertion loss readings and other information to a parallel printer. This section deals with the RS232, I^2C interface, and parallel printer connections.

5.1 Typical Systems

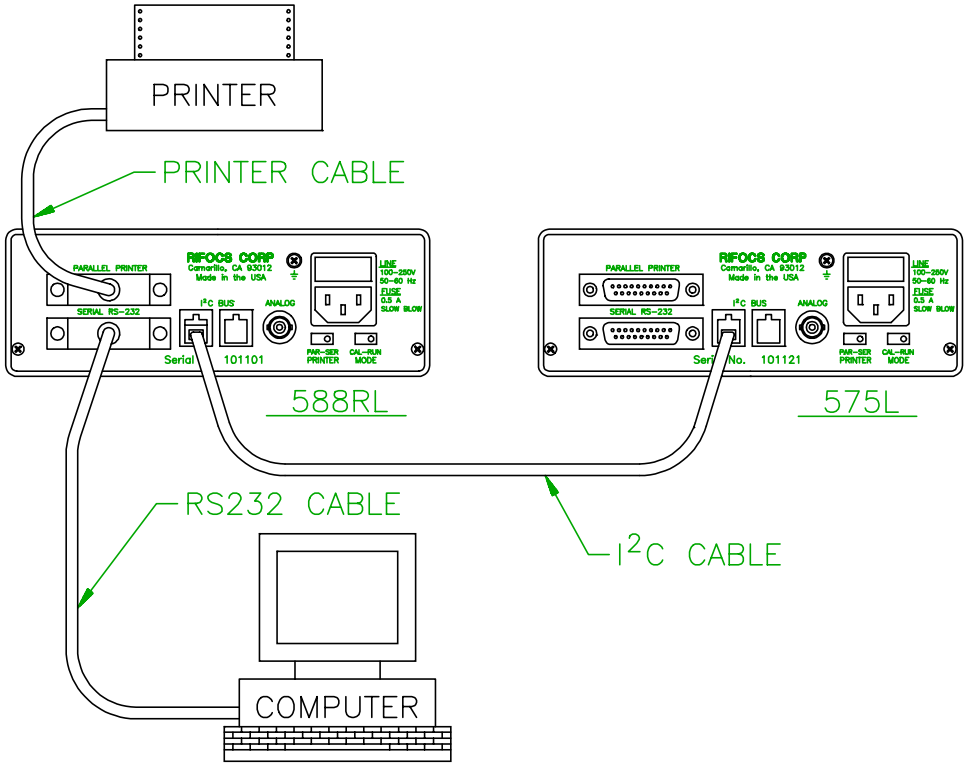


Figure 5-1 Typical System Configuration.

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5.2 RS232 Interface

Table 5-1 RS232 Interface Pinout

PIN NUMBER	DESCRIPTION	DIRECTION
Pins 1, 8-19, 21-25	No Connection	
Pin 2	RxD	Input (to 588RL)
Pin 3	TxD	Output (from 588RL)
Pin 4	RTS	Input
Pin 5	CTS	Output
Pin 6	DSR	Output (This line is always +9V)
Pin 7	Ground	
Pin 20	DTR	Input

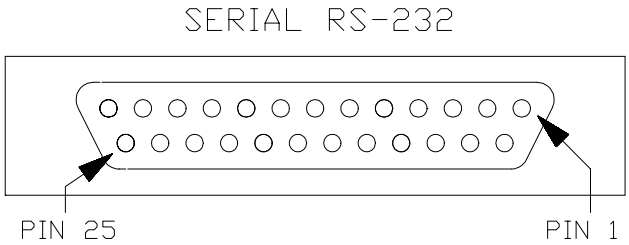


Figure 5-2 RS232 Interface Pin Numbering Scheme.

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The 588RL RS232 interface is designed to communicate using 8 data bits, 1 stop bit, no parity. Table 5-1 shows how the RS232 interface is wired.

Table 5-2 shows how the cable, for connecting between a PC compatible computer and the 588RL, is wired.

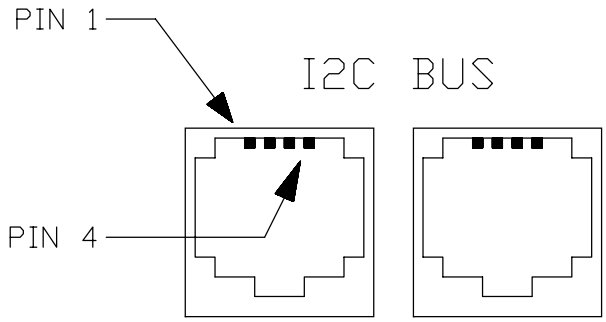
Table 5-2 RS232 Interface Cable.

Host PC			Cable	588RL Cable Connector (Male DB-25)	
	Cable Connector Pin				
SIGNAL	PC / XT (FEMALE DB-25)	PC / AT (FEMALE DB-9)		Pin	Signal
TxD	2	3	>> Data to 588RL	2	RxD
RxD	3	2	<< Data to Host	3	TxD
RTS	4	7	Handshake	4	RTS
CTS	5	8	Handshake	5	CTS
DSR	6	6	<< DSR to Host	6	DSR
GND	7	5		7	GND
DTR	20	4	>> DTR to 588RL	20	DTR

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5.3 I²C Bus Connections

The I²C interface is wired as shown in Figure 5-3. The I²C Bus cable is shown in Figure 5-4.



PIN #	DESCRIPTION
1	CLOCK
2, 3	GROUND
4	DATA

Figure 5-3 I²C Bus Interface Pinout.

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P1 (Modular Plug 6P4C) P2 (Modular Plug 6P4C)



P1 pin#	P2 pin#
1	1
2	2
3	3
4	4

Figure 5-4 I^2C Bus Cable.

NOTE

The I^2C Bus cable is not compatible with the wiring of the standard modular telephone jack cables.

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Table 5-3 588RL Parallel Printer Connector Pinout.

PIN NUMBER	PIN DESCRIPTION	DIRECTION
1	!Strobe	Output
2	Data 1	Output
3	Data 2	Output
4	Data 3	Output
5	Data 4	Output
6	Data 5	Output
7	Data 6	Output
8	Data 7	Output
9	Data 8	Output
10	!Ack	Input
11	Busy	Input
12	Ground	
13	No Connection	
14	No Connection	
15	No Connection	
16	No Connection	
17	No Connection	
18-25	Ground	

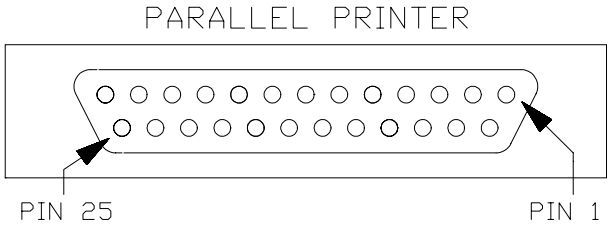


Figure 5-5 Printer Connector Pin Numbering Scheme.

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6 REMOTE OPERATION

Table 6-1 Summary of Remote Commands

COMMAND	DESCRIPTION	PARAMETER	SECTION
CH	Send remote commands to the specified I^2C address	1-16	6.1.1
DBM	Select absolute log units	None	6.1.2
GET_DATE	Returns the date (dd-mm-yyyy)	None	6.1.3
GET_LBLNUM	Returns the currently selected label number	None	6.1.4
GET_SN	Returns the label serial number	None	6.1.5
GET_TIME	Returns the time (International format)	None	6.1.6
INIT_CLOCK	Used after the clock battery has been replaced	None	6.1.7
INSLOSS	Take an insertion loss reading	1,2	6.1.8
LASER	Turns on/off the laser(s)	0,1,2	6.1.9
LOCAL	Enables the front panel buttons	None	6.1.10
LOCKOUT	Disables the front panel buttons	None	6.1.11
LSR_MODE	Selects the dual/single laser mode of operation.	0,1	6.1.12
PRINT	Prints a label	None	6.1.13
READ	Returns power reading	None	6.1.14
READ_LABEL	Returns the indicated label format file	1-7	6.1.15
RESET	Resets the 588RL	None	6.1.16
RESTORE	Loads EEPROM with factory default values	None	6.1.17
RTNLOSS	Establish the glass to air reference.	1,2	6.1.18

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Table 6-1 Summary of Remote Commands (continued)

COMMAND	DESCRIPTION	PARAMETER	SECTION
SAVE	Make the present operating parameters the power on defaults	None	6.1.19
SET_DATE	Set the internal calendar date (DD,MM,YYYY)	1-1-1993 to 31-12-2100	6.1.20
SET_LABEL	Label format select	1-7	6.1.21
SET_SN	Set label serial number	0-65535	6.1.22
SET_TIME	Set time (HH,MM)	00:00-23:59	6.1.23
VER	Returns the software revision level	None	6.1.24
ZERO	Zeros the optical input	None	6.1.25
ZERO_MODE	Sets the zero mode configuration	0,1	6.1.26

The 588RL is supplied with an RS232 interface and an I^2C Bus interface. This makes it possible to control the 588RL from a single computer. This section describes how to operate and control the 588RL from a remote computer.

6.1 Remote Commands

The 588RL can be controlled by remote over the RS232 interface. To communicate with the 588RL over the RS232 interface first select one of four BAUD Rates (1200,2400,4800,9600). The BAUD Rate selection is covered in Section 4.9.5. Then connect the 588RL to a computer with an RS232 cable. Make sure the computer is set to the same BAUD Rate as the 588RL. Command strings can be sent as either upper or lower case.

6.1.1 The "CH" Remote Command

This command is used when the 588RL is connected to other devices on the I^2C Bus. Refer to Figure 6-1.

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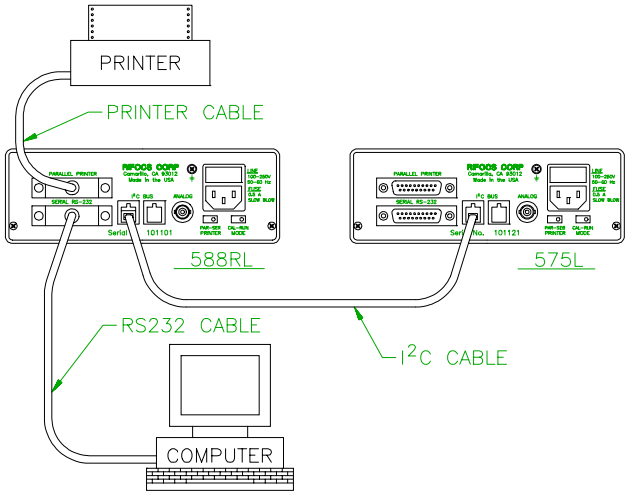


Figure 6-1 Sending commands to a 588RL and to a 575L.

If the user wants to have control of the 575L with the computer, send the string "ch,2", now all remote commands will be sent to the 575L.

6.1.2 The "DBM" Remote Command

The 588RL can be put into the dBm mode by remote over the RS232 interface. This is done by sending the string "dBm". When the unit is put into the dBm mode, return loss will no longer be measured with relative units. The dBm reading on the display is the reflected power.

6.1.3 The "GET_DATE" Remote Command

To get the date from the 588RL send the string "get_date". The 588RL will return the date that is stored in its internal calendar. The date will be returned in the 3rd field of the 588RL data return string.
For example this is what the data return string would look like if the date was October 12, 1993: "1,3,**12-10-1993**,7,0,1310,0". See Table 6-4 for examples of the data return string.

6.1.4 The "GET_LBLNUM" Remote Command

To get the currently selected label number send the "get_lblnum" string. The label number will be returned in the 3rd field of the 588RL data return string. For example if the currently selected label number is 6 the data return string would look like this: "1,3,**6**,7,0,1310,0". See Table 6-4 for examples of the data return string.

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6.1.5 The "GET_SN" Remote Command

To get the label serial number, send the "get_sn" string. The label serial number will be returned in the 3rd field of the 588RL data return string. For example if the label serial number = 10101, the data return string would look like this: "1,3,**10101**,7,0,1310,0". See Table 6-4 for examples of the data return string.

6.1.6 The "GET_TIME" Remote Command

To get the time from the 588RL, send the "get_time" string. The time that is stored in the 588RL's internal clock will be returned in the 3rd field of the 588RL data return string. For example if the time = 14:55, the data return string would look like this: "1,3,**14:55**,7,0,1310,0". See Table 6-4 for examples of the data return string.

6.1.7 The "INIT_CLOCK" Remote Command

The 588RL's internal clock/calendar circuit is powered by a rechargeable AA size 1.25V Nicad battery. Normally the user should never need to replace the battery, however if it is replaced, it will be necessary to initialize the clock/calendar. This is done by sending the string "init_clock".

6.1.8 The "INSLOSS" Remote Command

Send the string "INSLOSS,X" to get an insertion loss reading. If X = 1 an insertion loss reading at 1310nm is returned. If X = 2 an insertion loss reading at 1550nm is returned. See section 4.6 for details of how to set up the 588RL to get an insertion loss reading.

6.1.9 The "LASER" Remote Command

Send the string "LASER,X" to turn on/off the lasers. If X = 0 the lasers are turned off, if X = 1 the 1310nm laser is turned on and the 1550nm laser is turned off, if X = 2 the 1550nm laser is turned on and the 1310nm laser is turned off.

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6.1.10 The "LOCAL" Remote Command

To enable the 588RL front panel buttons send the string "local".

6.1.11 The "LOCKOUT" Remote Command

To disable the 588RL front panel buttons send the string "lockout".

6.1.12 The "LSR_MODE" Remote Command

As described in section 4.9.11 the 588RL can operate in single or dual laser mode. To enable the dual laser mode of operation send the string "LSR_MODE,0", to enable the single laser mode of operation send the string "LSR_MODE,1".

6.1.13 The "PRINT" Remote Command

To print a label send the string "print".

6.1.14 The "READ" Remote Command

To get a power reading from a remote 588RL send the string "read". The power reading will be returned in the 3rd field of the 588RL data return string. For example this is what the data return string would look like if power = 10.00dB: "1,3,**+10.00**,7,0,1310,0". See Table 6-4 for examples of the data return string.

6.1.15 The "READ_LABEL" Remote Command

To read the contents of a label format file, send the string "read_label,n" where n corresponds to the label number (1 <= n <= 7).

6.1.16 The "RESET" Remote Command

To reset the 588RL, send the string "reset". The 588RL will be initialized to its default operating mode.

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6.1.17 The "RESTORE" Remote Command

Sending the string "restore" will load the 588RL EEPROM with factory set default values.

6.1.18 The "RTNLOSS" Remote Command

Send the string "RTNLOSS,X" to initiate the return loss mode. If X = 1 the 14dB reference level for 1310nm is established. If X = 2 the 14dB reference level for 1550nm is established. Sending this command has the same effect as pressing the **[REF]** front panel button. See section 4.5 for details of how to put the 588RL into the return loss mode.

6.1.19 The "SAVE" Remote Command

To make the current operating parameters the default send the string "save".

6.1.20 The "SET_DATE" Remote Command

To set the date of the 588RL's internal clock/calendar send the string "set_date,dy,mn,year" where 1 <= dy <= 31 , 1 <= mn <= 12 and 1993 <= year <= 2100.

6.1.21 The "SET_LABEL" Remote Command

To select a label by remote send the string "set_label,n" where n corresponds to the label number (1 <= n <= 7).

6.1.22 The "SET_SN" Remote Command

To set the label serial number by remote send the string "set_sn,nnnnn" where 0 <= nnnnn <= 65535.

6.1.23 The "SET_TIME" Remote Command

To set the time of the 588RL's internal clock/calendar send the string "set_time,hr,min" where 0 <= hr <= 23 and 0 <= min <= 59.

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6.1.24 The "VER" Remote Command

To get the software revision level from a remote 588RL send the string "ver". The revision will be returned in the 3rd field of the 588RL data return string. For example if this command was sent to a 588RL, this is what the data return string would look like if the revision level is 1.01: "1,3,**588-V1.01**,7,0,1310,0". See Table 6-4 for examples of the data return string.

6.1.25 The "ZERO" Remote Command

To zero the 588RL's detector send the string "zero". If background reflections are not sufficiently limited an error will result.

6.1.26 The "ZERO_MODE" Remote Command

As described in section 4.9.12 the 588RL can be zeroed with the lasers on or off. If it is desired to zero with the lasers off, send the string "ZERO_MODE,1". If it is desired to zero with the lasers on, send the string "ZERO_MODE,0".

6.2 Creating and Loading Label Format Files

The 588RL has the capability of printing hard copies (labels) to a parallel or serial printer. The user can store up to 7 different labels in the 588RL's non-volatile memory (EEPROM). This section describes how to create a label format, and how to down load it to the 588RL.

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6.2.1 Creating a Label Format File

The label format file is created by using a text editor and by following certain rules. The 1st character in the label format file **must** always be the '@' character followed immediately by a number from 1-7. The number specifies which label the file will be stored as, ie Label 1, Label 2, Label 3, Label 4, Label 5, Label 6, Label 7. The last character in the file must always be the '~' (tilde) character, this is the label end of file character. The file size must not exceed 256 characters.

The following example shows how to create a label format file.

@1

.

. (label format data goes here)

.

~

It is possible to print on a label the following parameters:

1) Return Loss
2) Insertion Loss
3) Time
4) Date
5) Serial number
6) Special ASCII characters

To print these parameters on a label refer to Table6-22.

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Table 6-2 Format Specifiers For Label Printing

Control Sequence	Description
%R	This will print the return loss reading for 1310nm. If no return loss reading has been taken at 1310nm, a question mark will be printed.
%U	This will print the return loss reading for 1550nm. If no return loss reading has been taken at 1550nm, a question mark will be printed.
%I	This will print the insertion loss reading at 1310nm. If no insertion loss reading has been taken at 1310nm, a question mark will be printed.
%J	This will print the insertion loss reading at 1550nm. If no insertion loss reading has been taken at 1550nm, a question mark will be printed.
%L	This will print the wavelength of the laser being used.
%S	This will print the serial number. The serial number will be incremented each time it is printed. To set the serial number from the front panel see Section 4.9.3. To set the serial number by remote see Section 6.1.22.
%D	This will print the date, (mmm-dd-yyyy).
%d	This will print the date, (dd-mmm-yyyy). To set the date from the front panel see Section 4.9.7 and 4.9.6. To set the date by remote see Section 6.1.20.
%T	This will print the time using the international format. To set the time from the front panel see Section 4.9.8. To set the time by remote see Section 6.1.23.
%t	This will print the time using the standard format.

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Table 6-2 Format Specifiers For Label Printing (continued)

Control Sequence	Description
/nnn	This will print the code corresponding to the 3 digit decimal number nnn. (Note: 3 digits must follow the '/' character). If you want to print a '/' character, you must type it in as "//". EXAMPLE: /218 will print ┌ /179 will print │ /192 will print └ // will print /
@	The '@' character must always be the 1st character in a label format file. This lets the 588RL know that the text following the '@' is label format data.
~	The '~' character is used as the label format file End-Of-File flag. The '~' character must always be the last character in the label format file.

The following example shows a label format file.

```
-------------------------------------------------------
@1
RIFOCS Corporation
Return Loss:        %R
Insertion Loss:     %I
Time:               %T
Date:                     %D
sn:                 %S
~
-------------------------------------------------------
```

NOTE

All characters are taken literally except for the Control Sequence Characters in Table 6-2.

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6.2.2 Down Loading a Label Format File

Once the file has been created it can be down loaded via the RS232 data link. Make sure that the computer and the 588RL are set up to communicate at the same BAUD Rate. To set the BAUD Rate of the 588RL see Section 4.9.5.

The 588RL RS232 interface is designed to communicate using 8 data bits, 1 stop bit, no parity. Table 5-1 shows how the RS232 interface is wired.
The following example shows how a label format file would be down loaded to a 588RL from an IBM compatible computer:

"c:\copy label.dat com1:"

where label.dat is the label format file that was created in Section 6.2.1.

6.3 Data Format

Whenever a command is sent to the 588RL a data return string will be sent back, with the exception of the "read_label" command which sends back the contents of the indicated label format file.
When the 588RL sends the data return string to the host computer the data is in a format as shown below.

"I^2C addr., mode, return value, range, laser on/off, wavelength, error/status"

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Table 6-3 588RL Return String Data Format

PARAMETER	VALUE
I^2C Address	1-16 (This is the address of the unit that was read from)
Mode	Not used on 588RL
Return Value	±nn.nn (This format is returned for dBm readings) nn.nn (This format is used for dB readings)
Range	(1-7) 1 = Amplifier range 1 (least sensitive) 2 = Amplifier range 2 3 = Amplifier range 3 4 = Amplifier range 4 5 = Amplifier range 5 6 = Amplifier range 6 7 = Amplifier range 7 (most sensitive)
Laser Status	(0-1) 0 = Laser off 1 = Laser on
Laser wavelength	1310nm/1550nm

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Table 6-3 588RL Return String Data Format (continued)

PARAMETER	VALUE
Error	(0-23) 0 = No errors 1 = EEPROM error. This indicates that the EEPROM lost some of its data. The factory default EEPROM values will be loaded into EEPROM. If this problem persists, the EEPROM chip is bad, contact the factory for repair. 2 = Zeroing error. Optical input port not completely darkened. 3 = ROM error. This indicates that the ROM chip has lost some of its data. Contact factory for repair. 4 = The 588RL is unable to retrieve an insertion loss reading from the 575L. Check the configuration of both units. 5 = The 588RL is unable to take a reference. Check the reference cable. 11 = Power level too high to measure. 12 = Power level too low to measure. 15 = An unrecognized command was received. 16 = Illegal number format received. 17 = A command parameter is outside of its accepted range. 18 = Too few parameters were sent with a command. 19 = Too many parameter were sent with a command. 20 = The command string was not terminated correctly. 21 = Parameter string was too long. 22 = Improper character at string location. 23 = Invalid I^2C address.

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Table 6-4 588RL Return String Examples

Return String	Description
1,1,+45.06,5,1,1310,0	This is the string returned after the "READ" command was sent to the 588RL. I^2C address = 1 Mode = 1 (Return Loss Mode) Return Loss = +40.06dB Amplifier range = 5 Laser Status = 1 (On) Laser Wavelength = 1310nm Error/status = 0 (No errors)
1,0,-72.04,6,0,1310,0	This is the string returned after the "READ" command was sent to the 588RL. I^2C address = 1 Mode = 0 (dBm mode) Power reading = -72.04dBm Amplifier range = 6 Laser Status = 0 (Off) Laser Wavelength = 1310nm Error/status = 0 (No errors)
1,1,10101,5,1,1310,0	This is the string returned after the "GET_SN" command was sent to the 588RL. I^2C address = 1 Mode = 1 (Return Loss Mode) Label s/n = 10101 Amplifier range = 5 Laser Status = 1 (On) Laser Wavelength = 1310nm Error/status = 0 (No errors

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6.4 Using a Terminal Emulation Program with the 588RL

The 588RL can be controlled from a host computer with a terminal emulation software package such as Procomm or Telix. The following example shows how to control the 588RL by remote with the Procomm software package.

1) Start the Procomm program on the host computer.
2) Verify that the communications parameters are set correctly. (ie COM port, BAUD rate, parity, data bits, and stop bit. Press ALT+P to view the currently selected communications parameters.
3) Put the host computer into the chat mode by pressing ALT+O. The host computer screen will now be split into a local section and a remote section. Remote commands can be sent to the 588RL (from the local section of the host computer screen) and if the command returns a string, it will appear in the remote section of the host computer screen.

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6.5 Programming Examples in BASIC

```
'*************************************************************************
'
' Program Filename:
'
' Purpose: This program is listed in the 588RL operators manual, it gives
'        user of the Test Set a working example of how to control it
'        from a computer using the BASIC programming language.
'
' Programmer: Ed Feten
'
' Date:
'
' Compiler: Microsoft QuickBasic
'
' Description of program operation:
'  This program gets a reading from the 588RL.
'
'*************************************************************************
'********************** MAIN PROGRAM ***********************************
  CLS
  OPEN "com1:9600,n,8,1" FOR RANDOM AS #1       ' Com1 is connected to the 588RL
  PRINT #1, "read"                              ' Send the read command to 588RL
  LINE INPUT #1, temp$                                  ' Get data string back from the
                                        ' 588RL
  LOCATE 20, 13, 1                                      ' Position cursor of host computer's
                                        ' screen
  PRINT temp$                                           ' Display return data on host
                                ' computer
  CLOSE #1
END                                             ' End of program
```


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7 APPLICATIONS

This section illustrates how the 588RL is used for measurement of return loss and insertion loss of fiber optic components. If the 588RL is in the dual laser mode, the return loss and insertion loss measurements will automatically be made at both 1310nm and 1550nm. If the 588RL is in the single laser mode, the return loss and insertion loss measurements will be made at either 1310nm or 1550nm.

7.1 Return Loss Measurement

Before beginning a series of return loss measurements, the 588RL must be zeroed. Figure 7-1 shows the equipment setup for zeroing the 588RL. The procedure for zeroing the 588RL is as follows:

1.) Turn the 588RL on.
2.) If it is not already connected, connect the reference cable to the 588RL. The end of the cable which is terminated with an FC-APC connector is the end that is connected to the 588RL.
3.) Wrap 5 turns of the reference cable tightly around a pencil to block any back reflections from the unconnected end of the reference cable.
4.) While keeping the reference wrapped around the pencil, press the ZERO button.

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5.) When the 588RL has completed zeroing release the fiber from around the pencil.

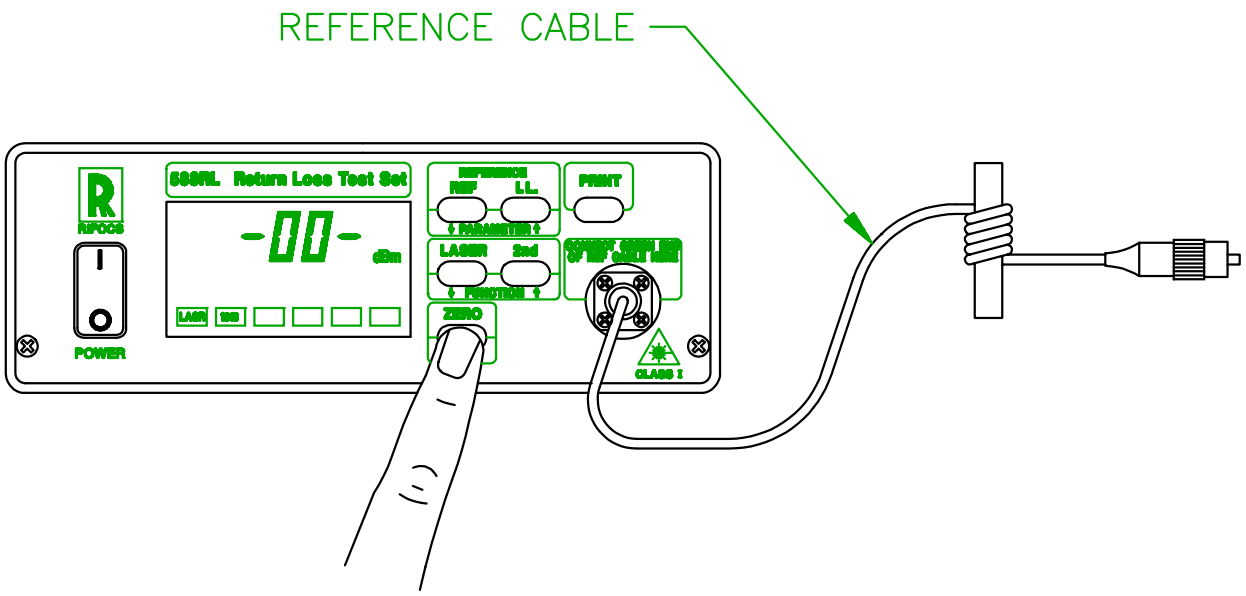


Figure 7-1 Zeroing the 588RL.

Now the 588RL is ready to perform a return loss measurement. Figure 7-2 shows the equipment setup for performing the return loss reading. The procedure for performing a return loss measurement is as follows:

1.) Press the REF button, the button must be pressed and held down for about 5 seconds. This will establish the 14.00dB reference point. If a reference point other than 14.00dB is required, see section 4.9.9 for instructions on how to change the reference point.
2.) Now connect the reference cable to the device under test (D.U.T.). Wrap the unconnected end of the D.U.T. tightly around a pencil to block any background reflections.
3.) The return loss reading is now displayed on the LCD of the 588RL.

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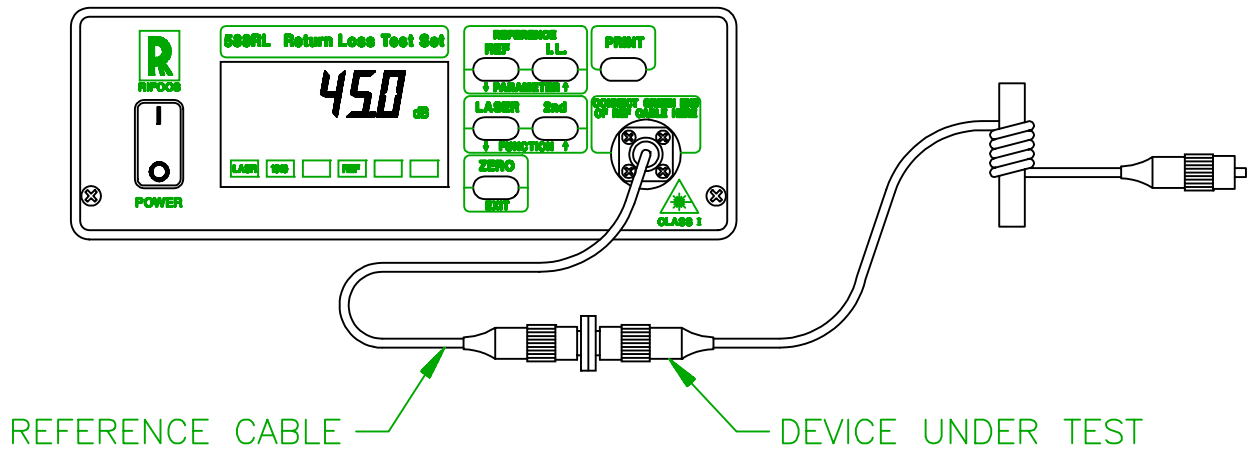


Figure 7-2 Measuring return loss of the Device Under Test (D.U.T.)

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7.2 Insertion Loss Measurement

The procedure for making an insertion loss measurement first requires that the user establish the dB reference point, Figure 7-3 shows the equipment setup for doing this. The procedure for establishing the dB reference point is as follows:

1.) Turn the 588RL on.
2.) If it is not already connected, connect the reference cable to the 588RL. The end of the cable which is terminated with an FC-APC connector is the end that is connected to the 588RL.
3.) If the of the laser of the 588RL is not on, turn it on now.
4.) Connect the other end of the reference cable to the 575L. Put the 575L into the dBm measurement mode.
5.) Press the dB button of the 575L. When the 575L has finished taking the dB reference, the LCD of the 575L will display 0.00dB.
6.) Disconnect the reference cable from the 575L.

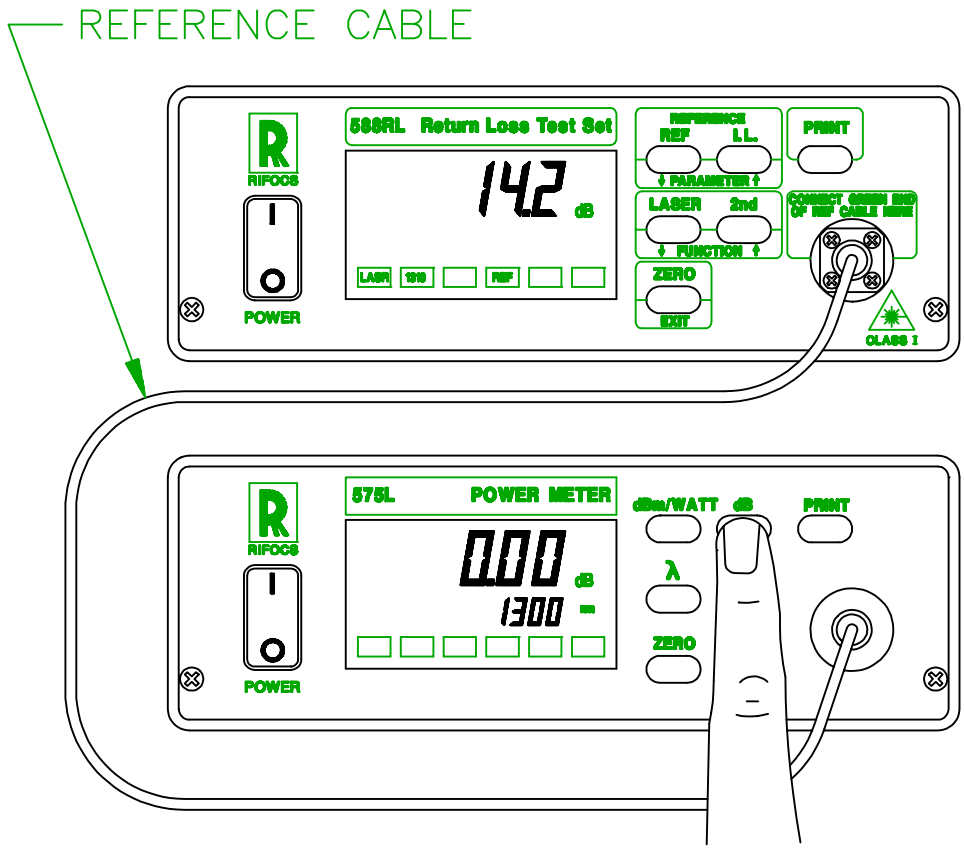


Figure 7-3 Establishing dB Reference Point for Insertion Loss Measurement.

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The insertion loss of the D.U.T. can now be measured. The equipment setup for performing the insertion loss measurement is shown in Figure 7-4. The procedure for performing the insertion loss measurement is as follows:

1.) Connect the reference cable to the D.U.T.
2.) Connect the other end of the D.U.T. to the 575L.
3.) The insertion loss of the D.U.T. is now being displayed on the LCD of the 575L.
4.) If the I.L. button of the 588RL is now pressed, the insertion loss reading of the 575L will be displayed on the lower portion of the 588RL LCD. The insertion loss value can now be sent to a printer by pressing the PRINT button of the 588RL.

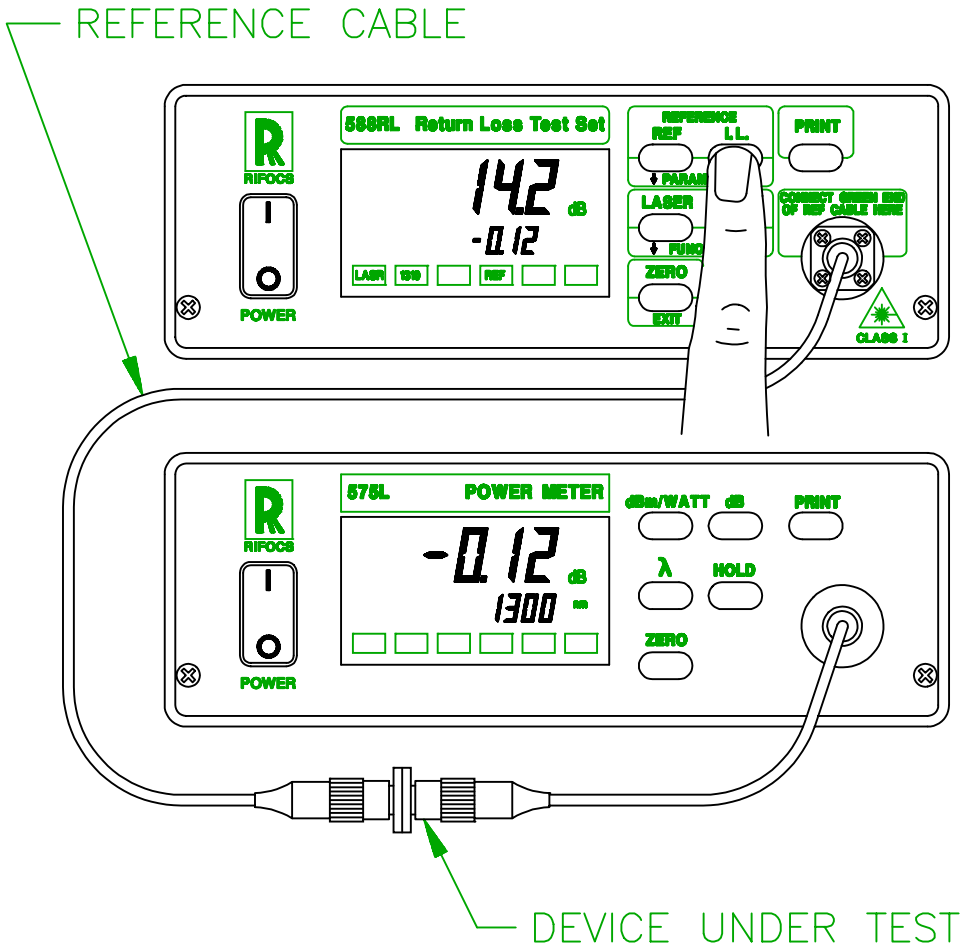


Figure 7-4 Making the insertion loss measurement.

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8 THEORY OF OPERATION

This section contains an overall functional description of the 588RL.

8.1 Functional Description

The basic components of the 588RL are shown in Figure 8-1.

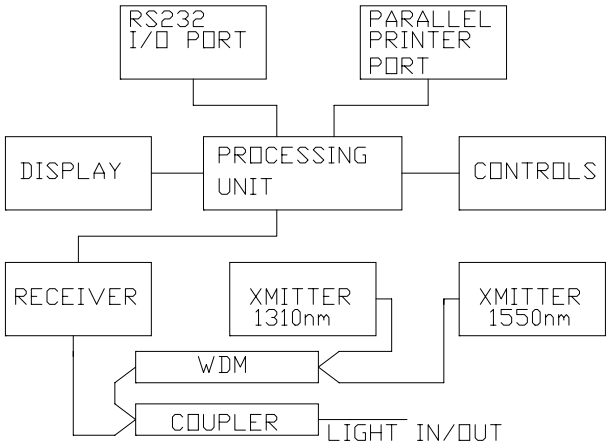


Figure 8-1 Basic Components of the 588RL.

The 588RL electronics are divided among three circuit boards - the main board, the laser board and the display board. This section briefly describes the basic operation of each electronic block.

8.1.1 The Processing Unit

The Processing Unit centers around a derivative of the 8051 microcontroller.

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8.1.2 Memory

Memory is composed of ROM (program memory), RAM (program data memory) and EEPROM (for system parameter storage).

8.1.3 Receiver

The receiver circuit consists of a transimpedence amplifier used to convert detector current to voltage. The amplifier has seven decades of gain. The output of this amplifier is passed to the A/D circuit. The A/D circuit converts the signal to a digital value which can be read by the microcontroller.

8.1.4 Analog Output

The output of the amplifier is also sent to the analog output BNC connector located on the rear panel of the 588RL. The voltage level at the analog output BNC connector is determined by the optical input power, and by the present range of amplification.

8.1.5 RS232 Interface

The RS232 interface makes it possible to control the 588RL from a computer. The interface meets all RS232C and V.28 specifications. Refer to Table 5-1 for the wiring of the RS232 interface.

8.1.6 Inter-Integrated (I^2C) Circuit Bus

The I^2C Bus interface consists of a serial data (SDA) line and a serial clock (SCL) line which carry information between devices connected to the bus, and a ground line which connects the grounds between devices connected to the bus. Basically this interface makes it possible to connect a 575L to the 588RL. Refer to Figure 5-3 for the wiring of the I^2C interface.

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8.1.7 Parallel Printer Interface

With the parallel printer interface it is possible to print data to a parallel printer. Refer to Table 5-3 for the wiring of the parallel printer interface.

8.1.8 Power Supply Circuit

All power supply requirements are furnished via the linear power supply circuit. This circuit provides regulated ±5VDC. The power supply circuit has an input voltage range of 100-250 VAC, 50-60 Hz.

8.1.9 Transmitter

The transmitter consists of a laser driver circuit which turns on and off the lasers. In addition to driving the laser, this circuit will automatically shut off the laser if the ambient temperature inside of the 588RL becomes excessive.

8.1.10 Display/Keyboard

The custom LCD (liquid crystal display), associated display driver, and the push buttons make up the major components of the Display Board. In operation the microcontroller outputs data to the board which is processed by the display driver and drives the tri-plexed LCD. When a user presses a button on the front panel that information is sent from the Display Board to the microcontroller.

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9 ACCESSORIES

The 588RL is shipped from the factory with an instruction manual, a reference cable, an optical metrology report, the AC line cord and spare fuses. The AC line cord supplied with the 588RL is the 3-prong US=type (specify if a different configuration is required for over seas).

9.1 Rack Mount Adapter

The rack mount adapter can hold two instruments side by side in a 19 inch wide rack system. For example a 588RL and a 575L could be mounted side by side in the Rack Mount Adapter.

9.4 Interface Cables

There are two different RS232 cables which are available for the 588RL from RIFOCS as well as an I^2C Bus interface cable. Refer to 1 for the RIFOCS part number and description of the cables.

Table 9-1 Rifocs Interface Cables.

RIFOCS P/N	**Description**	**Cable Wiring**
933	Multimeter bus (I^2C interface cable), length = 3m	Refer to Figure 5-4
935	D25 male to D25 female, length = 3m	Refer to Table 5-2
936	D25 male to D9 female, length = 3m	Refer to Table 5-2

NOTE:

The I^2C Bus interface cable is not compatible with the wiring of the standard modular telephone jack cables.

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10 PERFORMANCE VERIFICATION

This section contains the information necessary to verify that the 588RL is performing within the published specifications. Ideally performance verification should be performed when the instrument is first received to ensure that no damage has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect.

NOTE

If the instrument does not meet the specifications and is still under warranty (less than 12 months since the data of shipment), contact RIFOCS Corporation to determine the action to be taken.

10.1 Environmental Conditions

All measurements should be made at an ambient temperature between 18◦C and 25◦C (65◦ to 77◦F) with a relative humidity of less than approximately 70%.

10.2 Recommended Test Equipment

The procedures described in this section are for verifying the performance of the 588RL. The recommended equipment list is given in Table 10-1. The test set-up requires a stable source at either 1310nm or 1550nm, a precision optical attenuator, and reference standard such as a calibrated radiometer or photodiode. A precision optical attenuator is required to verify linearity of the 588RL. The reference standard should be one provided by your country's National Standards Laboratory (such as U.S. National Institute of Standards and Technology) or a commercial calibration lab providing similar services.

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Table 10-1 Recommended Test Equipment

EQUIPMENT	SPECIFICATIONS
N.I.S.T. Secondary Transfer Standard for Optical Fiber Power (STSOFPM) Measurements	Accuracy: ±2% at 1310nm or 1550nm
RIFOCS Model 666R Laser Source or equivalent	Single-mode laser source, laser pigtailed using SMF-28 fiber Peak wavelength: 1550nm
RIFOCS Model 665R Laser Source or equivalent	Single-mode laser source, laser pigtailed using SMF-28 fiber Peak wavelength: 1310nm
Photodyne Model 1975XQ-010J SM Optical Attenuator or equivalent	Single-mode optical attenuator with FC-PC connectors on the optical ports Accuracy: Greater of ±0.20dB or ±2% Max. Insertion loss: Less than 5dB
RIFOCS single-mode fiber optic cable assembly P/N 2020-101-05 (Qty. 2)	Single-mode cable assembly terminated with FC-PC connectors on both ends Core/Cladding dia: 9/125µm

10.3 Initial Conditions

If the instrument has been subject to temperatures below 18◦C (65◦F) or above 25◦C (77◦F), allow sufficient time for the instrument to reach temperatures within this range. Generally, it takes one hour to stabilize an instrument that is 10◦C (18◦F) outside of this range.

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10.4 Equipment Set-Up

Figure 10-1 shows how the appropriate equipment should be hooked together. Connect the output of the Model 665 Laser Source to the input of the attenuator using one of the single mode patch cables. Connect one end of the second patch cable to the output of the attenuator. The uncoupled end should be initially connected to the 588RL.

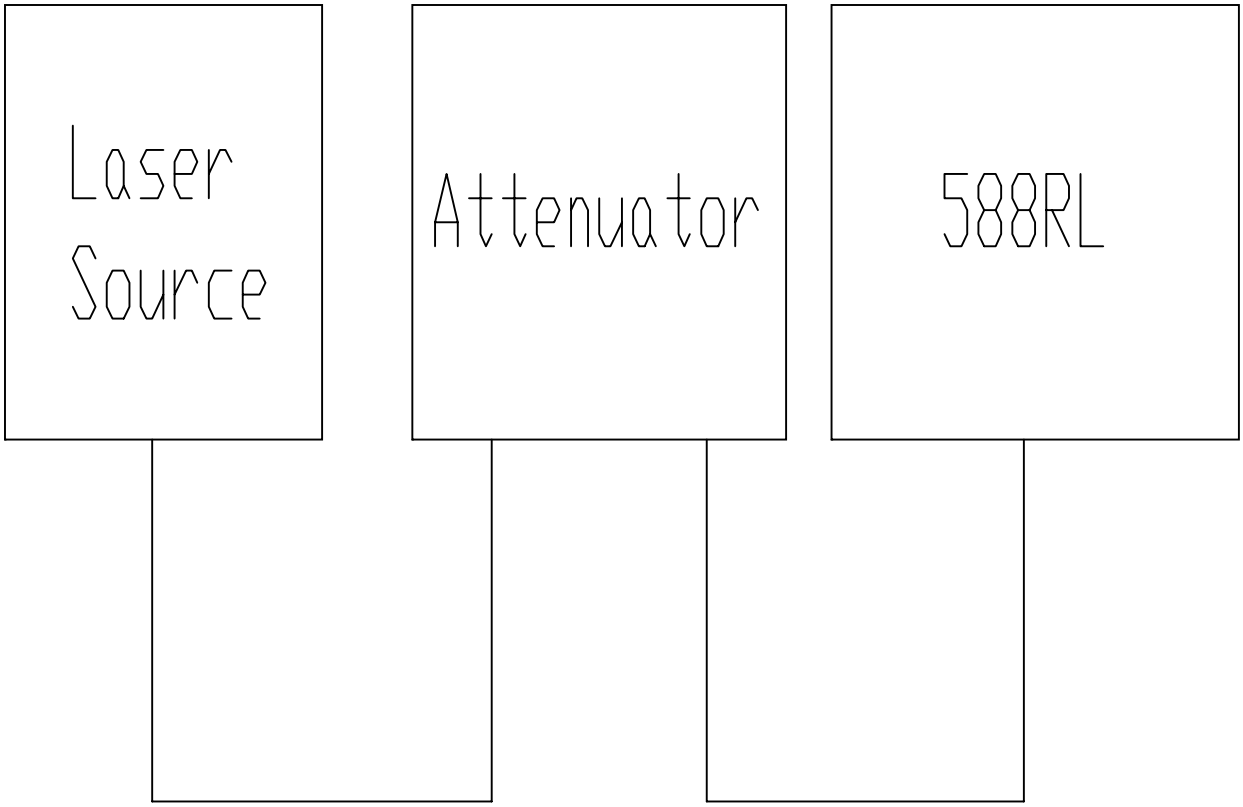


Figure 10-1 Equipment Setup for Linearity Verification

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10.5 Verifying Linearity

Proceed as follows to check the linearity of the 588RL:

1) Press the **[RESET]** on the 1975XQ to reset the attenuation to -0.00dB. The calibration wavelength of the attenuator should read 1310nm or 1550nm, depending on the wavelength of the source.

2) Set the 1975XQ **UP/DOWN STEP** parameter to 5.00dB. This will make it easy to step through the linearity test using the STEP function.

3) To verify proper linear operation of the 588RL over its measurement range. Adjust the power controls of the laser source for maximum power output.

4) Turn the laser of the 588RL off. Zero the 588RL by darkening the optical input port and pressing the **[ZERO]** button.

5) Set the 588RL up to measure power in dbm units.

6) Connect the output of the attenuator to the optical input of the 588RL.

7) With the attenuator set to 0dB attenuation, write the power reading of the 588RL in column 2 of Table 10-2.

8) Use the 1975XQ UP function to sequence through each 5dB step again. Record the power readings of the 588RL in column 1 of Table 10-2.

9) Calculate the deviation by computing the results for column 4. For each attenuator setting, compute the following result:

   588RL reading - Offset - attenuator setting

To verify proper operation within specifications, the results of column 4 should fall within the ranges of column 5 of Table 10-2

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Table 10-2 Linearity Test Chart

588RL power reading (dBm)	Offset Value (dBm)	Attenuator Setting (dB)	Deviation (dB)	Tolerance
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5
				±0.5

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10.6 Verifying Laser Output

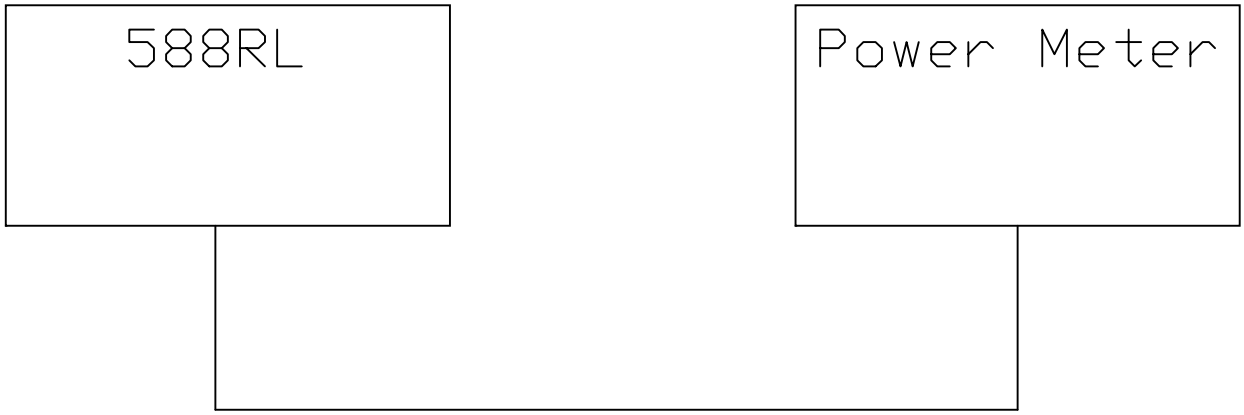


Figure 10-2 Equipment Setup for Laser Output Verification

Refer to Figure 10-2 equipment setup for laser output verification. Turn the 588RL on, and if it is not already on, turn on the 1310nm laser. Connect a fiber between the 588RL and the power meter. The power meter should read -3.00dBm ±1dB. Now turn off the 1310nm laser and turn on the 1550nm laser. The power meter should read -3.00dBm ±1dB.

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10.7 Laser Safety Information

Operator safety is a prime concern when using diode laser sources. Safety standards established by the US. Government (CDRH, Center for Radiological Health) and other governments have been carefully considered and adhered to.

The 588RL is a CLASS I laser device conforming to the applicable CDRH requirements of 21 CFR Subchapter J at date of manufacture. While there is limited potential for eye damage due to unaided direct exposure, users must always avoid looking directly into the Output Port.

CAUTION
LASER LIGHT DO NOT STARE INTO BEAM

THE USE OF OPTICAL VIEWING INSTRUMENTS WITH THIS PRODUCT WILL INCREASE EYE HAZARD.

The use of optical viewing aids (i.e. microscopes, magnifiers, etc.) should always be avoided. The use of these devices around active fibers can focus a highly intense beam onto the retina which can result in permanent eye damage. Make sure that the unit is switched OFF before using a microscope or other optical viewing devices.

10.8 Power Adjustment and Internal Controls

The user of the 588RL has no way of adjusting the laser diode output power. The lasers can only be turned on or off. At the time of manufacture RIFOCS Corp. tests each unit to the established safety requirements of CDRH and keeps the appropriate documents on file.

10.9 Laser Safety Acceptance Test Procedure for Class I, 588RL Return Loss Power Meter

10.9.1 Required Equipment

575L-3MM OPTICAL POWER METER (3mm InGaAs detector)
Mechanical fixture defining a 3mm diameter measuring aperture at a distance of 8.5cm. Fixture must locate the output axial to the detector.

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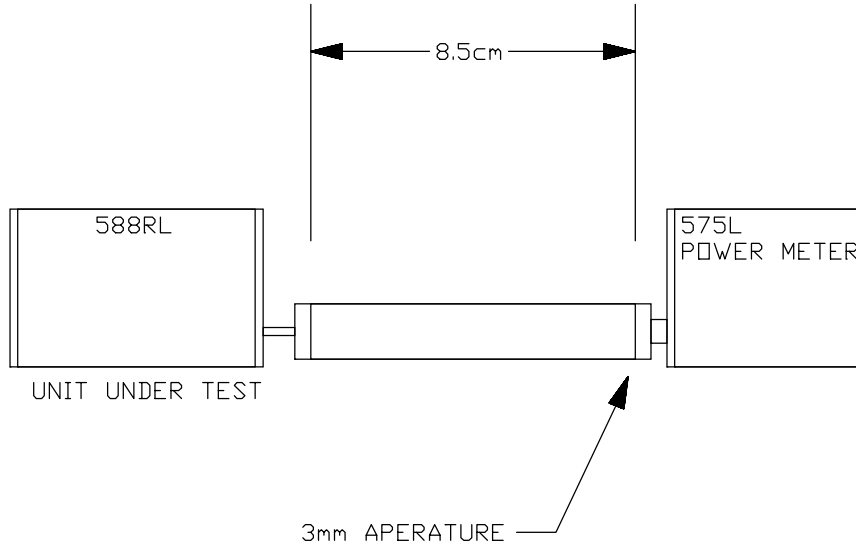


Figure 10-3 Laser Safety Test Fixture.

10.9.2 Procedure - Power Verification

Set up the equipment and verify the 575L-3MM has a valid calibration.
Select the WATT mode.
Make sure calibration is set to the correct wavelength.

Return Loss Test Set Model No.	Power Meter Wavelength
588RL	1310nm 1550nm

Turn ON the 588RL 1310nm laser and insert the output ferrule into the Laser Safety Test Fixture. While reading the power on the 575L-3MM move the output ferrule of the unit under test to find the maximum emanated power at 1310nm. Record the value on laser safety data sheet together with serial number of the 1310nm laser. Turn on the 1550nm laser and insert the ferrule into the Laser Safety Test Fixture. While reading the power on the 575L-3MM move the output ferrule of the unit under test to find the maximum emanated power at 1550nm. Record the value on laser safety data sheet together with serial number of the 1550nm laser and the serial number of the instrument. File safety data sheet with the metrology reports. Reject unit if maximum power of **100µW** is exceeded.

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10.10 Procedure - Beam-Attenuator and Label Verification

10.10.1 Dust Cap/Safety Cap Verification

Verify that the dust/safety cap is attached and that the dust cap screws onto the output connector of the instrument. If this is possible, check-mark the YES on the safety record sheet. Otherwise reject unit.

10.10.2 Laser On Indicator Verification

Turn on the 1310nm laser and verify that the LASER annunciator for the 1310nm laser is on. Turn on the 1550nm laser and verify that the LASER annunciator for the 1550nm laser is on. If the indicators for both lasers are operating correctly, check-mark the YES on the safety record sheet. Otherwise reject unit.

10.10.3 ID/Certification Label Verification

Verify the ID/Certification label on the back of the instrument, it must contain the following information.

Manufacturer and Address:	RIFOCS Corp. Camarillo, CA 93012
Model No:	588RL
Serial No:	xxxxxx
Date of Manufacture:	Month and Year Month must be fully spelled out.
Certification:	Conforms to 21 CFR subchapter J at date of manufacture.

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Laser Safety Record

DATE:		
OPERATOR:		
MODEL NO:	588RL RETURN LOSS POWER METER	
INSTRUMENT SERIAL NO:		
LASER MODEL (1310):		
LASER SERIAL NO (1310):		
MAXIMUM POWER (1310)	µW	100µW MAX
MEAN WAVELENGTH (1310)	nm	1310nm
LASER MODEL (1550):		
LASER SERIAL NO (1550):		
MAXIMUM POWER (1550):	µW	100µW MAX
MEAN WAVELENGTH (1550):	nm	1550nm
LASER ON INDICATORS	YES	NO
SAFETY CAP	YES	NO
ID CERTIFICATION LABEL	YES	NO
APERTURE LABEL	NA	NA
WARNING LABEL	NA	NA
ACCEPTANCE	ACCEPT	REJECT

NOTES: _____

_____

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11 MAINTENANCE

11.1 Fuse Installation/Replacement

The 588RL is powered from the AC line (100-250VAC, 50-60Hz). The fuse holder is integrated with the AC line receptacle. To replace the fuse, remove the AC power cable from the AC line receptacle and use a small screw driver to open the fuse holder door. Replace the fuse with a 5mm X 20mm 0.5 amp slow blow fuse.

11.2 Troubleshooting

Table 11-1 describes the causes and possible solutions for many common problems. All other problems should be referred directly to the factory.

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Table 11-1 Troubleshooting Chart

ERROR CODE	CAUSE OF ERROR CONDITION	CHECK(s)
E1	EEPROM error. This indicates that the EEPROM chip has lost some or all of its data. The factory default EEPROM values will be loaded into EEPROM.	If this problem persists, the EEPROM chip is bad, contact the factory for repair.
E2	Zeroing error. This indicates that the 588RL's zero offset is excessive.	Refer to section 4.4 and verify that the correct zeroing procedures are being followed.
E3	ROM error. This indicates that the ROM chip has lost some of its data.	This error is non-recoverable, contact the factory for repair.
E4	The 588RL is not able to get an insertion loss reading from the 575L.	Make sure that the I2C cable is connected, that each unit's I2C address is set correctly and that the units are in the correct mode.
E5	The 588RL is not able to establish a reference.	Make sure that the correct reference cable is connected to the unit.
E11	Power level too high to measure.	The optical power input to the 588RL exceeds the dynamic range specification.
E12	Power level is too low to measure.	The optical power input to the 588RL is outside of the dynamic range specification.
E15	An unrecognized command was received.	Refer to section 6.1 for valid remote commands.

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Table 11-1 Troubleshooting Chart (continued)

ERROR CODE	CAUSE OF ERROR CONDITION	CHECK(s)
E16	Illegal number format received.	Check that the number format of each command parameter is correct.
E17	A command parameter is outside of its accepted range.	One or more of the parameters sent with a command is outside of its accepted range.
E18	Too few parameters sent with a command.	One or more of the parameters associated with a command is not be sent.
E19	Too many parameters were sent with a command.	One or more too many parameters are being sent with a command.
E20	The command string is not terminated correctly.	Command strings are terminated with a CR,LF
E21	Parameter string is too long.	Check that the parameters being sent with a command are valid.
E22	Improper character was encountered in a string parameter.	Check that the parameters being sent with a command are valid.
E23	Invalid I^2C address.	The device specified with the "ch" command is not responding. Check if there is a device connected to the I^2C bus with the specified I^2C address.

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