

*User Manual*  
**WaveMaster™**  
*Laser Wavelength Meter*





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*WaveMaster*  
*Laser Wavelength Meter*



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Wilsonville, OR 97070

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## **Preface**

This manual contains user information for the WaveMaster™ laser wavelength meter.

## **Export Control Laws Compliance**

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification must be obtained from Coherent or an appropriate U.S. Government agency.

Products manufactured in the European Union, Singapore, Malaysia, Thailand: These commodities, technology, or software are subject to local export regulations and local laws. Diversion contrary to local law is prohibited. The use, sale, re-export, or re-transfer directly or indirectly in any prohibited activities are strictly prohibited.

## **Publication Updates**

To view information that may have been added or changed since this publication went to print, connect to [www.Coherent.com](http://www.Coherent.com).

## Signal Words and Symbols in this Manual

This documentation may contain sections in which particular hazards are defined or special attention is drawn to particular conditions. These sections are indicated with signal words in accordance with ANSI Z-535.6 and safety symbols (pictorial hazard alerts) in accordance with ANSI Z-535.3 and ISO 7010.

### Signal Words

Four signal words are used in this documentation: **DANGER**, **WARNING**, **CAUTION** and **NOTICE**.

The signal words **DANGER**, **WARNING** and **CAUTION** designate the degree or level of hazard when there is the risk of injury:

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#### **DANGER!**

Indicates a hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

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#### **WARNING!**

Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

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#### **CAUTION!**

Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

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The signal word “**NOTICE**” is used when there is the risk of property damage:

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#### **NOTICE!**

Indicates information considered important, but not hazard-related.

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Messages relating to hazards that could result in both personal injury and property damage are considered safety messages and not property damage messages.

## Symbols

The signal words **DANGER**, **WARNING**, and **CAUTION** are always emphasized with a safety symbol that indicates a special hazard, regardless of the hazard level:



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**This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.**

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**This symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.**

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**This symbol is intended to alert the operator to the presence of dangerous voltages within the product enclosure that may be of sufficient magnitude to constitute a risk of electric shock.**

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**This symbol is intended to alert the operator to the danger of Electro-Static Discharge (ESD) susceptibility.**

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**This symbol is intended to alert the operator to the danger of crushing injury.**

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**This symbol is intended to alert the operator to the danger of a lifting hazard.**

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# SECTION ONE: SAFETY

Carefully review the following safety information to avoid personal injury and to prevent damage to this instrument or any sensor connected to it. WaveMaster contains no user-serviceable parts. For service information, refer to “Obtaining Service” (p. A-2).



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**DANGER!**

**The use and measuring of lasers is potentially dangerous. This instrument operates over wavelengths that include non-visible laser emissions.**

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Proper laser operating practice in accordance with manufacturer recommendations is vital.

Eyewear and other personal protective equipment must be used in accordance with applicable laws and regulations.

If in doubt of correct operating procedures, consult the laser manufacturer and your laser safety officer.

The equipment is not for use in critical medical environments.



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**WARNING!**

**Use only the power cord specified for the meter. The grounding conductor of the cord must be connected to earth ground.**

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**WARNING!**

**Do not operate the meter if its panels are removed or any of the interior circuitry is exposed.**

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**WARNING!**

**Do not operate the meter in wet or damp conditions, or in an explosive atmosphere.**

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***NOTICE!***

**Operate the meter only within the specified voltage range.**

---



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***NOTICE!***

**Do not apply a voltage outside the specified range of the input connections.**

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***NOTICE!***

**Do not operate the meter if there are suspected failures. Refer damaged units to qualified Coherent service personnel.**

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**Declaration of  
Conformity**

Declaration of Conformity certificates are available upon request.

## SECTION TWO: DESCRIPTION

In this section:

- Unpacking (p. 2-2)
- System description (p. 2-3)
- Maintenance (p. 2-9)
- Replacement parts (p. 2-10)

WaveMaster™ provides a simple and quick method of determining the wavelength of lasers in the 380 to 1095 nm range, to an accuracy of 0.01 nm or better. It can measure CW, pulsed, and single shot lasers. There are four available units of measurement:

- Wavelength in air (nm, at standard temperature and pressure)
- Wavelength in vacuum (nm)
- Wave number in vacuum ( $\text{cm}^{-1}$ )
- Frequency (GHz)

WaveMaster has an internal calibration system based on precisely known wavelengths of neon spectral lines. Periodic recalibration is performed automatically to ensure measurement accuracy.

Laser input to the instrument is by means of a standard ST type fiber optic connector, which means that WaveMaster can be situated in any convenient position and does not require alignment with the laser source.

An input sensor with a 2-meter fiber cable is supplied for capturing or sampling of the beam, but other inputs having a suitable connector may be provided by the user. The maximum input to this front panel connector should be limited to 100 mW so as to avoid internal damage.

A front panel intensity meter assists in aligning the sensor and in establishing a suitable signal strength level for measurement, which can be adjusted by means of the built in front panel attenuator.

The measured value is displayed in large, easily read characters on a LCD panel, which also carries information on the status of the instrument. The display contrast may be set by the user to suit the ambient conditions and back lighting is available as required.

Remote operation is accommodated by means of an RS-232 or USB serial port.

Specifications for WaveMaster are listed in “Appendix B: Specifications” (p. B-1).



## Unpacking



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**NOTICE!**

**WaveMaster contains accurately aligned optical components and should not be subjected to severe shocks, such as those generated when dropped. The supplied shipping carton is recommended for use whenever the instrument is transported.**

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The shipping carton should be inspected for any visible damage. Check that the carton contains:

1. CD containing the User manual and the USB driver.
2. The WaveMaster instrument
3. Another carton containing:
  - WaveMaster mains power supply plus three adapter plugs
  - Mounting base
  - Mounting post (½-inch dia. x 75 mm)
  - Post holder (3-inch, ¼ x 20)
  - WaveMaster sensor
  - USB cable

Inspect each of the following items for damage as they are removed from the cartons:

1. CD
2. The WaveMaster instrument
3. The WaveMaster sensor, post, holder, and stand
4. The power supply

The desiccant packed with the instrument should be discarded.

Advise Coherent Inc. of any shortages or damage immediately—refer to “Obtaining Service” (p. A-2). A Returned Material Authorization (RMA) will be issued for any damaged instruments—refer to “Product Shipping Instructions” (p. A-3).

## System Description

The WaveMaster equipment consists of three units:

- The display unit
- The sensor
- The power supply

## Display Unit

### Front Panel Controls



*Figure 2-1. Front Panel*

Here is a description of the various controls and displays:

**ON/OFF:** Pressing this button toggles the power to the instrument. When switching ON, the yellow Pulse Received indicator will light and stay lit until characters appear on the display. This takes a few seconds. When switching OFF, the message “Powering Off” appears on the display for a few seconds while the instrument shuts down.

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**The current state of the instrument settings is saved during shut-down and reinstated at the next start-up.**

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**BACKLIGHT:** Pressing this button toggles the display back light and meter lamp on and off.

**CONTRAST:**   These two buttons allow the user to set a display contrast level appropriate to the ambient lighting conditions. Holding the buttons down causes the contrast to change continuously (between limits).

**AUTOCAL:** Pressing this button toggles the internal automatic calibration process on and off. The current state is shown in the “Autocal” box on the display above the button. In normal circumstances, AUTOCAL should be left ON to ensure measurement accuracy. Turning AUTOCAL off and then on forces an immediate internal calibration.

**UNITS:** Pressing this button cycles through the four available units: nm air, nm vacuum, wavenumber ( $\text{cm}^{-1}$ ), and frequency (GHz). The current unit selected is shown to the right of the measured value on the display.

**MODE:** Pressing this button cycles through the three modes: CW, CW Av, and Pulse. The mode in use is displayed in the “Mode” box on the display above the button.

**PULSE RECEIVED:** Apart from being lit during power up—refer to “ON/OFF” (p. 2-3)—this indicator is only active when the instrument is in pulse mode. In this mode, it flashes every time a valid pulse measurement is made.

**INPUT:** This is a combined fiber optic input connector and attenuator. The connector accepts the fiber optic cable that is part of the sensor assembly. Turning the attenuator clockwise (+) increases the signal delivered to the instrument, and turning the attenuator counterclockwise (-) decreases the signal.



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**NOTICE!**

**The connector is an ST type and only cables terminated with this type of coupling must be used. Attempts to use other connectors may cause damage. Additionally, to avoid internal damage, the maximum input power to the instrument front panel attenuator must not exceed 100 mW.**

---

**INTENSITY:** This indicates the signal strength as seen by the instrument on a meter scale with red and green zones. It is not a measurement of laser power.

The sensor and input attenuator should be adjusted so that the meter needle is in the green scale area and preferably towards the right-hand side. The red region to the right of the scale indicates danger of signal overload. The red region to the left of the scale indicates too low a signal, although a valid reading may still be displayed.

## Front Panel Display

The LCD presents all the information about the measurement and operation status of the instrument. Its contrast can be controlled between limits to suit the ambient lighting conditions. Additionally, it can be backlit, together with the intensity meter, to further improve visibility.

The upper part of the screen is used principally for the display of measurements in the selected units, with a blank display indicating that no valid reading is available or possible. The selected unit is indicated to the right of the numerical part of the display. The number format is shown in the following table.

**Table 2-1. Front Panel Display Numbers Format**

Units	Digits Before Decimal Place	Digits After Decimal Place	Display
nanometers air	up to 4	3	nm air
nanometers vacuum	up to 4	3	nm vac
wavenumber	5	2	cm <sup>-1</sup>
frequency	6	1	GHz

In *CW* mode the display is updated at 3 Hz with the last reading taken.

In *CW Av* mode, the display is updated at 3 Hz with an average of the last 10 readings taken by the instrument. When the signal is removed, the last reading is displayed for 3 seconds until the display blanks.

In *PULSE* mode, when a valid pulse is detected by WaveMaster, the display will show the reading for that pulse for 15 seconds or until another valid pulse or error condition is detected. Note that the Pulse Received light also flashes when a valid pulse is detected.

There are circumstances when a valid measurement cannot be displayed or such a display is not appropriate. In these cases a text message is presented in the measurement area. All such messages that can be generated by WaveMaster and the situations in which they are produced are discussed, below.

**INITIALIZING:** Appears immediately after power on while the internal hardware and software initialization takes place.

**AUTOCAL:** An internal wavelength calibration is taking place.

**AUTORANGING:** Internal adjustments are being made to accommodate the input signal level.

**SATURATED:** The input signal level is too high and must be reduced by using the front panel attenuator or other means.

**MULTI-LINE:** More than one wavelength is present in the input signal. Frequently this is the case with diode lasers.

**POWERING OFF:** The last message before the instrument switches off. It is usually a result of operating the OFF switch or automatic power-down (when enabled) in battery operation. Irrecoverable error situations can arise that result in automatic power off action being taken.

**AUTOCAL FAIL:** The internal wavelength calibration has failed. The instrument continues operating after this occurs and will shortly attempt a further calibration cycle. If it occurs as part of the power-on sequence, automatic power down follows.

**FATAL ERROR:** A serious irrecoverable internal error has been detected. Automatic power down follows. If it is a transient fault, then powering back on should be possible.

**MEM FAILURE:** A serious internal memory fault has been detected. This can only be rectified by return for servicing.

**FACTORY MODE:** A serious internal error has been detected. This can only be rectified by return for servicing.

The lower part of the display contains information about the state of the instrument.

**REMOTE/LOCAL:** Indicates whether the instrument is being controlled from a separate computer (Remote) or from the front panel (Local). In remote mode, the AUTOCAL, UNITS, and MODE buttons are inoperative.

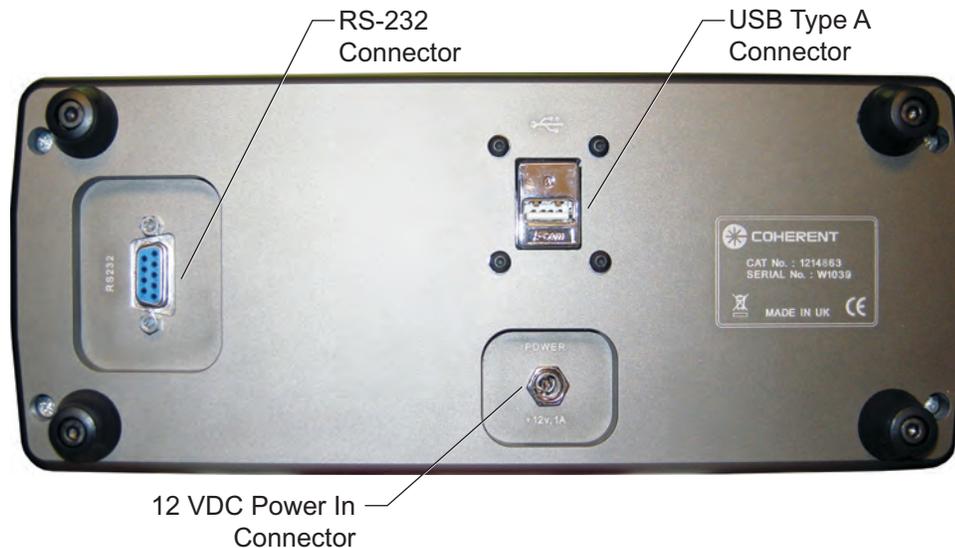
**AUTOCAL:** This box is positioned above the AUTOCAL button and indicates whether autocalibration is on or off. In the OFF state, the legend flashes to indicate that this non-preferred state (when quoted accuracy cannot be guaranteed) has been selected.

**MODE:** This box is positioned above the MODE button and indicates which of the three modes (CW, CW Av, or PULSE) is currently selected.

## Rear Panel

The rear panel of the WaveMaster (Figure 2-2, below) provides the electrical connections, as well as USB and RS-232 interfaces.

The WaveMaster serial number is engraved on the back panel and is of the form W, followed by four digits. This number should be noted whenever you contact Coherent in regards to your WaveMaster.



**Figure 2-2. Rear Panel**

The items on the rear panel and their respective functions are described, below.

**12 VDC Power In Connector:** Only the power supply shipped with the WaveMaster should be connected to the instrument. The power supply comes with mains plugs for most countries, and can be connected to voltages from 90 to 240 VAC.




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### **NOTICE!**

**Using a power supply other than the one shipped with the product may cause the instrument to fail.**

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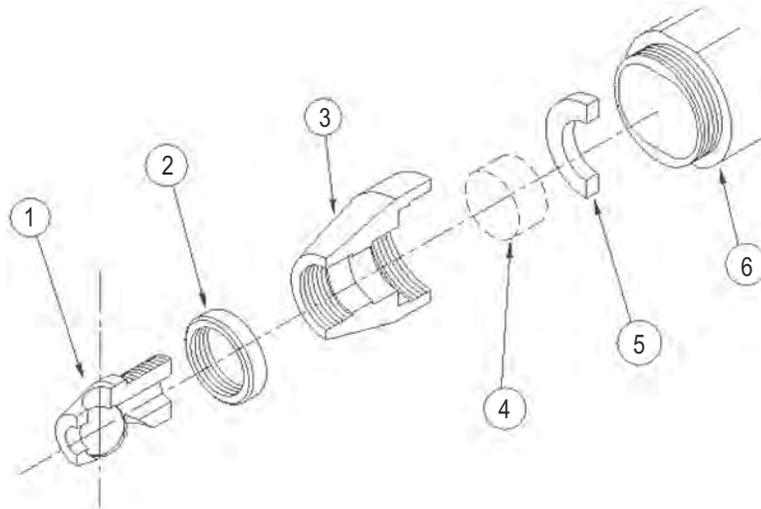
### **USB Type A Connector**

**RS-232 Connector:** This is a female 9-pin D connector. The pin out for this connector is given in Table 3-1 (p. 3-3).

## Sensor

An input sensor—supplied as part of the WaveMaster system—provides a versatile and convenient way of collecting laser energy for measurement. The sensor may be attached to a standard mounting post and a post, post-holder, and base are also supplied.

There is a switch on the top of the sensor which offers two input collection options: In one position the sensor has a wide field of view but reduced sensitivity. The other position provides maximum sensitivity but reduced collection angle. The sensor is provided with a captive fiber-optic cable—two meters in length—for connection to the WaveMaster.



**Figure 2-3. Exploded and Sectioned View of Laser Input Sensor Front End**

The front end of the sensor is designed to provide as much flexibility in the method of use as possible. The nosepiece (1) contains an uncoated thin glass plate at 45 degrees to the sensor axis. This allows the sensor to be inserted at 90 degrees to a beam to collect a few percent of the radiation, while allowing the remainder of the radiation to pass through. The nosepiece screws into the front part of the sensor assembly (3) and the orientation of the 45-degree plate can be set by means of the lock ring (2). There is a hole in the front of the nosepiece which may be used as an axial input for a laser beam. If this is used, care must be taken to ensure that the energy reflected from the glass plate is absorbed safely. The nosepiece can be completely removed for direct axial input.

The front part of the sensor (3) screws onto the main sensor body (6) and may be used to hold a 12.7 mm filter or diffuser (4 - not supplied) in place. Item (5) is a plastic retaining washer.

The uncoated glass plate used for beam splitting in the sensor nose unit may not preserve the wave front quality in certain applications, although the signal passed to the WaveMaster is of acceptable quality for its measurement. If continuous sampling of a signal in an optical set up is required, then the signal to the WaveMaster sensor should be extracted using appropriate laser quality beam splitting optics.

As an alternative to using the sensor, the user may supply their own input, provided it is a fiber terminated in a standard ST connector for connection to the front panel of the instrument.



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**NOTICE!**

**The maximum safe input (to prevent damage) must be limited to 100 mW, although this level is far too high for measurement.**

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## Power Supply



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**NOTICE!**

**The switch-mode mains power supply provided as part of the WaveMaster system is the only power supply that is to be used to provide external power.**

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The power supply requires assembly by sliding the mains plug adapter appropriate to the country of use onto the power supply body. It is not recommended that the adapter is changed frequently, but this interchangeability can be convenient if WaveMaster is to be operated in different countries.

The output lead from the power supply is connected to the socket on the rear panel of the instrument.

## Maintenance



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**NOTICE!**

**The display and window should be cleaned using only a cloth moistened with water. Do not use chemicals or cleaners. The WaveMaster should not be sprayed with anything.**

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WaveMaster contains no user-serviceable parts. Under no circumstances should the instrument case be opened. WaveMaster contains delicate optical components that have been carefully aligned.

WaveMaster includes an internal calibration system, which the system uses to self-calibrate against the output spectrum of a neon source. During this calibration, WaveMaster measures the wave-

length of 13 separate neon emission lines distributed across its measurement range, and compares measured values with known, published values. WaveMaster automatically recalibrates itself if these measurements fall outside tolerance.

WaveMaster performs this internal calibration when first powered up and at intervals of approximately 1 minute thereafter.

Due to its automatic internal calibration against atomic spectral lines, WaveMaster does not require additional calibration during manufacture or during service life. WaveMaster should be considered permanently calibrated.

## Replacement Parts

Table 2-2 (below) lists available replacement items.

*Table 2-2. Replacement Parts*

Item	Part Number
WaveMaster sensor	1058563
WaveMaster manual	(available on our website: <a href="http://www.Coherent.com">www.Coherent.com</a> )

The nose unit accepts ½-inch diameter filters of various thicknesses—item 4 in Figure 2-3 (p. 2-8). The thread on the front of the nose unit is 0.535 inch x 40 UNC—item 3 in Figure 2-3 (p. 2-8).

The fiber optic cable on the sensor can be extended using readily available standard cables that are terminated with an ST connector on each end. They should be attached to the sensor ST connector using a female-female adapter. These items are available from many general distributors as standard fiber patch cords intended for networking/communications applications. A multi-mode 62.5/125 micron fiber is recommended. The very high input sensitivity of WaveMaster ensures there are no problems with attenuation by the cable, even if very long lengths are used.

## SECTION THREE: OPERATION

In this section:

- Making a measurement (this page)
- Remote operation (p. 3-2)
- Getting the best from WaveMaster (p. 3-10)

### **Making a Measurement**

Once the instrument has been set up, press the POWER button. The instrument will now cycle through its self-test sequence. If this does not occur, refer to “Section Four: Frequently Asked Questions” (p. 4-1) for advice on possible easily-rectified error conditions. After approximately five seconds, the instrument will enter its auto-calibration mode. Once the AUTOCAL message has cleared from the display area, WaveMaster is ready to take measurements. The best results, as with any high-accuracy measurement instrument, are achieved after a suitable warm up period. System settings at the last power off will have been remembered by the instrument and will now be in effect. (Even though autocalibration may have been disabled, WaveMaster will always perform an initial calibration as part of its power up sequence. Also, it will always power up ready for local control.)

It is now necessary to adjust the level of input signal to the instrument. This is achieved using the messages and reading on the display in conjunction with the indication on the intensity meter. The aim is to have the intensity indication well into the right-hand side of the green sector of the scale.

If the display screen is currently blank and the intensity meter indicating in the red region at the left-hand of the scale, more input signal is required. It is worth first adjusting the front panel attenuator in a clockwise direction (+) to see if this achieves the necessary increase in signal. If not, then adjust the alignment of the sensor with the laser beam. The acceptance angle of the sensor is quite small and care must be taken in the alignment to ensure that the laser radiation is focused onto the sensor fiber-optic cable.

Note that while adjustments to the input signal level are being carried out, the message AUTORANGING may appear on the display screen. This occurs as the instrument responds to significant input level changes by automatically making internal adjustments.

The intensity meter indicates the absolute input signal level and takes account of any internal ranging carried out. Internal ranging occurs in the CW and CW Av mode, but not in Pulse mode.

If the display screen currently shows the message SATURATED and the intensity meter is in the red region at the right-hand of the scale, less input signal is required. Adjust the front panel attenuator in a counter-clockwise direction (-) to decrease input signal. If this does not reduce the signal level far enough then the alignment of the sensor with the laser beam may be altered to sample less of the signal or additional attenuation placed between the signal being measured and the sensor.

When adjusted for the correct intensity level, the wavelength reading should be displayed on the screen. It will be in the currently-selected unit chosen from nm in “air” (at standard laboratory temperature and pressure (STP)), nm vacuum calculated by conversion from STP, wave number ( $\text{cm}^{-1}$ ), or frequency (GHz). A valid measurement can be achieved over a wide range of front panel attenuator settings and is not influenced by the input signal level. The preferred signal level, however, is with the intensity reading in the right-hand part of the green region of the scale.

If the display shows MULTI-LINE, the input signal is composed of multiple wavelengths or is too wide in bandwidth. Many diode lasers will exhibit this until they thermally stabilize. By decreasing the input signal level using the front panel attenuator, it may be possible to get wavelength readings by decreasing the very adjacent spectral lines below the detection level of the instrument. Such a technique will not work with genuinely polychromatic sources.

Further advice on making measurements can be found in “Getting the Best from WaveMaster” (p. 3-10) and “Section Four: Frequently Asked Questions” (p. 4-1).

By connecting the WaveMaster to an external computer (through either of the interfaces), measurements and other instrument settings can be read, stored, and controlled. The WaveMaster also features a mode for automatic periodic output of wavelength data and allows the computer to be used as a logging device.

## **Remote Operation**

The WaveMaster offers a choice of RS-232 and USB computer interfaces for remote operation. Once data has been sent on an interface, only that interface can be used to control the instrument. It is necessary to power off to effect a change of controlling interface.

## Introduction

Computer interface features:

1. WaveMaster can be treated as a wavelength transducer.
2. The command set is the same for both RS-232 and USB hardware interfaces.
3. Commands are insensitive to case (in this document, UPPER CASE is used throughout).
4. Commands that take parameters ignore unnecessary white space characters.
5. Multiple commands can be sent on a single line, separated by the semicolon (;) character.
6. Only one of the RS-232 or USB interfaces can be active at any time and is automatically selected after the data is received from the host controller. If the type of interface is changed, the instrument must be powered off and back on.

Unless stated otherwise, values given are in decimal unless the number is of the form 0xdd, which is used for bit patterns more naturally expressed in hexadecimal. The input and output of such values do not use the 0x characters. Single-bit values in byte type values (that is, status bytes) are active high (=1) unless otherwise indicated.

## RS-232 Hardware Connection

Table 3-1 shows how the 9-pin socket on the rear panel is wired.

*Table 3-1. 9-Pin Socket Pinout*

<b>Pin</b>	<b>Function</b>
1	No connection
2	RXD
3	TXD
4	No connection
5	GND
6	No connection
7	RTS
8	CTS
9	No connection

Table 3-2 (p. 3-4) lists the serial line communication parameters.

**Table 3-2. Serial Line Communication Parameters**

<b>Parameter</b>	<b>Setting</b>
Baud rate	9600
Parity	None
Data bits	8
Stop bits	1

WaveMaster uses the CTS & RTS hardware flow control facilities. The above assignment is designed to be compatible with other Coherent instruments.

A straight-through (not null modem) connection is needed when connected to a serial port.

If a three-wire interface is more convenient, it is essential that pins 7 and 8 (CTS/RTS signals) are wired together at the WaveMaster end of the connecting cable (this is most readily achieved inside the connector).

## USB Hardware Parameters

USB (Universal Serial Bus) is an industry standard that defines the cables, connectors, and protocols used for connection, communication, and power supplies between computers and electronic devices.

Communication with the Wavemaster USB can be made via a terminal emulator program.

**Table 3-3. USB Hardware Parameters**

Signal	5 VDC
Max. voltage	5V ( $\pm 5\%$ )
Max current	500 mA @ 5V
Data signal	Packet data
Width	1 bit
Bit rate	4,000 Mbit/sec.
Protocol	Serial
Standard USB A plug	
Pin 1	Vcc (+ 5V)
Pin 2	Data -
Pin 3	Data +
Pin 4	Ground

## Commands Overview

The commands offered are the same whether control is through RS-232 or USB.

In WaveMaster, all commands are sequential. The IEEE488.2 commands provided for synchronization are recognized in the implementation but have no effect on the operation. When using RS-232 it is not possible to generate a Service Request signal. The six commands used to configure or interrogate for a Service Request-related function have no effect when used on RS-232; the value returned will reflect any values sent or its default state.

Each command sent with any parameters is checked for correctness. If in error, the command is not executed. The error is reported as a numeric code in the error return message. The format and codes are defined in “Error Formats” (p. 3-9) and Table 3-14 (p. 3-9). The user is responsible for checking any error return made.

In the case of multiple commands on a line, all commands up to the one in error are executed; the one in error and any remaining commands are not executed. The error return additionally indicates the numeric order of the command causing the error.

## IEEE 488.2 Commands when using RS-232

*Table 3-4. IEEE 488.2 Commands When Using RS-232*

<b>Mnemonic</b>	<b>Meaning</b>	<b>Comments</b>
*CLS	Clear status registers	Clears event status and status byte registers
*ESE	Set Event Status Enable register	See Table 3-5 (p. 3-6) - typical value is 0x34
*ESE?	Read Event Status Enable register	See Table 3-5 (p. 3-6) - typical return is 0x34
*ESR?	Event Status register query	See Table 3-5 (p. 3-6)
*IDN?	Instrument Identity query	See Table 3-8 (p. 3-6)
*OPC	Operation complete	Sets bit 0 of ESE register on operation complete. Not applicable since all operations sequential.
*OPC?	Operation complete query	All operations sequential so always returns 1
*RST	Reset	The WaveMaster can only be reset through power down. Command has no effect on operation.
*SRE	Set Service Request Enable register	Not applicable - any parameter set has no effect. See Table 3-1 (p. 3-3)
*SRE?	Service Request Enable register query	Not applicable - always returns 0
*STB?	Status Byte query	See Table 3-6 (p. 3-6)
*TST?	Self Test query	See Table 3-9 (p. 3-7) - output in hexadecimal
*WAI	Wait to continue command	No effect

**Event Status Enable and Event Status Register**

Each bit set in the enable register will result in setting of same status register bit when the event occurs. All input and output is in hexadecimal.

*Table 3-5. Event Status Enable and Event Status Register*

Bit	Meaning
0	Output complete
2	Execution error
4	Query error
5	Command error
1, 3, 6 and 7	Currently undefined

Reading event status register resets it to 0.

**Status Byte**

*Table 3-6. Status Byte*

Bit	Meaning
4	Message available
0-3 and 5-7	Currently undefined

Reading status byte resets it to 0. All output is in hexadecimal.

**Service Request Enable Register**

*Table 3-7. Service Request Enable Register*

Bit	Meaning
4	Message available
5	Event occurred in Event Status register
0-3 and 6-7	Currently undefined

**IDN Fields**

*Table 3-8. IDN Fields*

Field	Contents
1	Coherent Inc.
2	WaveMaster
3	Unique serial number {W####}
4	Firmware revision {A#.V#.#}

The four fields are separated by the ‘,’ character. The “#” character represents a single decimal digit. The format of field 4 reflects that there are two distinct programmable units within WaveMaster.

## Self-Test Codes

**Table 3-9. Self-Test Codes**

Bit	Meaning
0	Power on self check status (1 = passed)
1	Battery status (1 = battery low)
2	Power source (0 = Mains PSU, 1 = internal battery (no longer available))
4-7	Number of autocalibration failures since last interrogated. 0xF is maximum count. Reset to 0 after reading.

## IEEE 488.2 Commands when using USB

The tables above apply, with the exception of \*SRE & \*SRE?, which are defined below. The USB serial polling facility is used to set bit 0 in the SRQ register for every message sent from WaveMaster. This is necessary to allow the USB controlling program remote to the instrument to handle the generation of unsolicited data that is produced when running in a logging mode of operation using the PRD command.

**Table 3-10. IEEE 488.2 Commands When Using USB**

Mnemonic	Meaning	Comments
*SRE	Set Service Request Enable register	Any parameter set has no effect since this mode is mandated.
*SRE?	Service Request Enable register query	Bit 4 is set to 1 if there is an unserviced message waiting. See Table 3-7 (p. 3-6)

## User Commands

Almost all commands exist in both the set data form and return data (query) form. The latter always needs to have ? as the last character. Where appropriate, values returned will use the same format as setting of parameters.

## Parameter Setting Commands

**Table 3-11. Parameter Setting Command**

Mnemonic	Meaning	Parameters
CAL	Change autocalibration state	ON or OFF
LOC	Set to LOCAL mode	None
MDE	Set data capture mode	C for CW A for CW Average P for Pulse
PRD	Set period between regular output of data and initiate process	Integer for seconds 0 turns process off 5 seconds is minimum
REM	Set to REMOTE mode	None
UNI	Set measurement units	A for wavelength in air in nm V for vacuum wavelength in nm F for frequency in GHz W for wave number in $\text{cm}^{-1}$

## Query Commands

Queries return the three-character mnemonic followed by \$ and then the value returned, unless otherwise indicated.

**Table 3-12. Query Commands**

Mnemonic	Meaning	Value Returned
CAL?	Return autocalibration state	ON or OFF
LOC?	Return front panel status	LOC\$ if local REM\$ if remote
MDE?	Return data capture mode	C for CW A for CW Average P for Pulse
PRD?	Return period between regular outputs of data	Integer in seconds 0 indicates turned off
REM?	Return front panel status	REM\$ if remote LOC\$ if local
UNI?	Return measurement units	A for wavelength in air in nm V for vacuum wavelength in nm F for frequency in GHz W for wave number in $\text{cm}^{-1}$
VAL?	Return last valid measurement and its time tag	Uses VAL\$ - see Table 3-13 (p. 3-9)

**VAL\$ Format**

Output of measured data is provided by the VAL\$ returned from the WaveMaster. There are two fields separated by a ',' character.

**Table 3-13. VAL\$ Format**

<b>Field</b>	<b>Contents</b>
1	Integer time tag in internal timing units of 10 ms
2	Measurement in currently selected units (max. of 8 characters, including a decimal point or other text mirroring the display)

The same format is used regardless of whether it is a single enquiry or data being output periodically at the user's request. It is the obligation of the user to remove any periodic data at a reasonable rate.

Field 2 text can be the message SATURATED, MULTI-LINE, or NO SIGNAL. The latter only applies to single use of the VAL? command and indicates that the last valid measurement has already been output. In the case of periodic output, no new data is produced if there has been no signal input in the current period.

**Error Formats**

A single message type (ERR\$, followed by a two-digit code) is provided for reporting detected command errors. In the case of multiple commands on a line, this is then followed by a slash (/) and the command number in the sequence that generated the reported error. Only the first command in error is reported.

**Table 3-14. Error Codes**

<b>Code</b>	<b>Error</b>	<b>Possible Cause</b>
1	Invalid command or query	Incorrect spelling of command, missing ;
2	Invalid parameter	Error in non-numeric text parameter or additional information detected.
3	Invalid value	Numeric parameter out of range
4	Privilege violation	Privileged command sent but not in privileged mode or password in error
5	Too many multiple commands on a single line	Limit is 32.
6	Parameter missing	Command that takes parameter has not had one supplied.
7	Data unavailable	Internal error. The exact circumstances generating the error should be reported to Coherent.

## **Getting the Best from WaveMaster**

WaveMaster is inherently capable of giving highly accurate and repeatable results. This can be enhanced by a few elementary precautions.

The fiber input should be fastened down to avoid any undue movement. Due to mode structure changes as the fiber is moved, amplitude variations may be seen if it is left so that its position can change. Similarly, a very small change in wavelength (still well within the accuracy specification) may be reported as the fiber is moved.

The best results, as with any high-accuracy measurement instrument, are achieved after a suitable warm up period. WaveMaster requires approximately four hours to reach the best thermal stability; however, measurements taken during this stabilization period are still well within the accuracy specification.

The embedded optics are protected from vibration by the internal mounting method used, but shocks adjacent to the WaveMaster during measurements should be avoided.

Correct alignment of the sensor can assist in getting the optimum level of signal for WaveMaster operation. The sensor allows for entry of the input signal either along, or perpendicular to, the sensor axis. The collar on the front can be rotated to align the pick off beam splitter. It should be firmly tightened after setting to prevent any further rotation. The nosepiece can be completely removed to allow the maximum signal into the sensor along its axis. The lever on the top of the sensor provides two options: narrow field of view/high sensitivity, and wider field/lower sensitivity.

WaveMaster only requires a very small amount of laser energy to make measurements. If plenty of energy is available, it may be possible to place a diffuser in the sensor, which then makes alignment much less critical. Alternatively, a rotating diffuser placed just before the sensor can ease the alignment requirements and overcome most of the fiber movement problems at the same time. However, this is not suitable for pulsed laser measurements.

When running in a logging mode, the input on the intensity meter is best adjusted to about mid-scale of what is expected to be the maximum input signal level. Any amplitude variations to lower signal levels are then automatically handled by the autoranging feature and there is less chance of saturation occurring if the signal increases. Note that many lasers exhibit quite wide amplitude variations when run over an extended period.

When taking measurements of single shot pulse lasers, no triggering of the WaveMaster is required. To ensure the event is captured, it is recommended that the autocalibration be turned off immediately prior to the event. The autocalibration should be reinstated after the measurement to ensure continuing measurement accuracy. This

procedure avoids the instrument performing a periodic autocalibration during a critical time for the user. Such a sequence can be readily automated using the external communication facilities provided.



## SECTION FOUR: FREQUENTLY ASKED QUESTIONS

FAQs listed in the following table provide information about the internal operation of WaveMaster, and answer to the most commonly-encountered problems.

*Table 4-1. Frequently Asked Questions (Sheet 1 of 2)*

Question	Response
How does it work?	The WaveMaster is a high diffraction order spectrometer. Wavelength is determined by careful measurement of the separation between the diffracted orders. Much of the accuracy and simplicity in use is achieved through software-implemented algorithms running in the digital signal processor and conventional microprocessor in the instrument.
Why won't it power up?	If WaveMaster is connected to the mains power unit and the yellow Pulse Received light does not light, then the rear panel connector may not be making a good connection and should be re-inserted. It is also possible that the mains psu has failed. This should give 12 VDC with the center of the connector positive.
Why does it power up but powers off very shortly afterwards?	This does happen very occasionally. Restarting the instrument a second time should clear the problem.  A persistent failure to start indicates a serious internal problem. The message that appears briefly on the display provides some information about the cause of the failure. The most likely cause is that the internal optics have become misaligned (probably through undue shock) or the spectral calibration source has failed. The WaveMaster should be returned to Coherent for servicing—refer to “Obtaining Service” (p. A-2).
Why won't it power down?	Under a rare temporary fault condition, it is possible that the Power button on the front panel will not operate. To power down the instrument, insert a non-metallic sensor or adjustment tool into the small hole on the right-hand side of the case and press the internal cut-out switch. If the problem recurs, contact Coherent for assistance—refer to Table A-1 (p. A-2) for contact information.
Why does it appear to be working but there is nothing on the display?	The LCD has contrast that is sensitive to temperature. If the instrument has been taken from a cold environment, the LCD contrast will need adjusting. This is done by using the front panel controls to restore the displayed information.
What is autoranging?	Autoranging is displayed when the instrument is making internal adjustments to its integration period for the detector array. This ensures that a very wide dynamic range can be offered to the user with the minimal need for intervention.
Why does it display multi-line?	Due to the method of operation, WaveMaster has to work on the assumption that the input is monochromatic. Laser diodes are particularly prone during periods of unstable operation to generate distinct spectral content of very small amplitude very close to the principal wavelength. Other laser sources may contain much more diversely-separated wavelengths. In neither case can the WaveMaster algorithms resolve the spectral content.
Why does the displayed measurement flip between values?	This is due to the behavior exhibited by the input source. Laser diodes are particularly prone to this and WaveMaster has the accuracy to report such events. It has even been observed on sophisticated frequency stabilized lasers when they have shown an odd period of instability.

**Table 4-1. Frequently Asked Questions (Sheet 2 of 2)**

<b>Question</b>	<b>Response</b>
Why does the signal level change rapidly?	This may be caused by movement of the fiber input to WaveMaster. The fiber is multi-mode, and the various modes propagating down the fiber interfere, thereby causing intensity variations at the detector array. To overcome this, try to ensure that the fiber cannot move, possibly by securing it with tape at one or more points. Even very small movements can cause significant intensity changes.
Why does movement of the fiber cause changes to the wavelength measurement?	This is due to multi-mode interference causing slight changes in the distribution of energy at the detector array. The variations in wavelength are, however, very small and well within the accuracy of the instrument.
Why is the displayed measurement drifting?	The autocalibration may have been turned off. This is indicated by the flashing legend in the Autocal box on the display. It could also be caused by the behavior exhibited by the input source and WaveMaster has the accuracy and stability to track the wavelength drift. Many apparently stable sources show drift characteristics when measured to the accuracy that WaveMaster offers. Pulsed YAG laser drift as the crystal heats up is easily observed, as are the rapid wavelength changes a diode laser makes.
Why does the autocalibration interval vary?	The internal calibration is principally needed to overcome internal optical drift as a result of thermal changes. Once the temperature of the instrument has stabilized, longer periods are used to ensure that the WaveMaster spends as much time as possible making input signal measurements and not calibrating itself. The user is unaware of the effect of external ambient temperature changes through the adaptive autocalibration scheme employed.
Why turn autocal off?	It is normally recommended that the WaveMaster be left in autocalibration mode. When using CW or pulsed lasers with a high repetition rate, a continuous reading can be displayed. In pulse mode with single shot operation, it is possible that the signal will arrive while an internal calibration is taking place and thus an input measurement cannot be made. By turning the autocalibration off before the event, such situations can be avoided. The autocalibration should be reinstated after the measurement to ensure continuing measurement accuracy. Note that turning autocalibration back on will cause WaveMaster to recalibrate immediately, so that if the user wishes to force a recalibration, it is only necessary to turn Autocal off and then on again.
Why can't I get RS-232 communications?	Check that the receiving serial port has been set to the correct parameters as given in "RS-232 Hardware Connection" (p. 3-3). A null modem is not required, all connections being wired directly. The RTS/CTS lines are used, but can be unconnected at the host end provided they are wired together at the WaveMaster connector.

## APPENDIX A: WARRANTY

In this section:

- Limited warranty (this page)
- Warranty limitations (this page)
- Obtaining service (p. A-2)
- Product shipping instructions (p. A-3)

### **Limited Warranty**

Coherent, Inc. (the “Company”) warrants WaveMaster (“Product”) to the original purchaser (the “Customer”) that the product is free from defects in materials and workmanship and complies with all specifications, active at the time of purchase, for a period of twelve (12) months.

Coherent, Inc. will, at its option, repair or replace any product or component found to be defective during the warranty period. This warranty applies only to the original purchaser and is not transferable.

### **Warranty Limitations**

The foregoing warranties shall not apply, and Coherent reserves the right to refuse warranty service, should malfunction or failure result from:

- Damage caused by improper installation, handling, or use.
- Laser damage (including sensor elements damaged beyond repair).
- Failure to follow recommended maintenance procedures.
- Unauthorized product modification or repair.
- Operation outside the environmental specifications of the product.

Coherent assumes no liability for Customer-supplied material returned with Products for warranty service or recalibration.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, ORAL, OR IMPLIED. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL THE COMPANY BE LIABLE FOR ANY INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS PRODUCTS.

## Obtaining Service

In order to obtain service under this warranty, Customer must notify the Company of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. The Company shall, in its sole discretion, determine whether to perform warranty service at the Customer's facility, at the Company's facility or at an authorized repair station.

If Customer is directed by the Company to ship the product to the Company or a repair station, Customer shall package the product (to protect from damage during shipping) and ship it to the address specified by the Company, shipping prepaid. The customer shall pay the cost of shipping the Product back to the Customer in conjunction with repair; the Company shall pay the cost of shipping the Product back to the Customer in conjunction with product failures within the first twelve months of time of sale.

A Returned Material Authorization number (RMA) assigned by the Company must be included on the outside of all shipping packages and containers. Items returned without an RMA number are subject to return to the sender.

For the latest Customer Service information, refer to our website: [www.Coherent.com](http://www.Coherent.com).

Detailed instructions on how to prepare a product for shipping are shown under "Product Shipping Instructions" (p. A-3).

**Table A-1. Coherent Service Centers**

<b>Location</b>	<b>Phone</b>	<b>Fax</b>	<b>E-mail</b>
USA	1.800.343.4912	503.454.5777	info_service@Coherent.com
Europe	+49-6071-968-0	+49-6071-968-499	info_service@Coherent.com
International	503.454.5700	503.454.5777	info_service@Coherent.com

## **Product Shipping Instructions**

To prepare the product for shipping to Coherent:

1. Contact Coherent Customer Service—refer to Table A-1 (p. A-2) for a Return Material Authorization number.
2. Attach a tag to the product that includes the name and address of the owner, the person to contact, the serial number, and the RMA number you received from Coherent Customer Service.
3. Wrap the product with polyethylene sheeting or equivalent material.
4. If the original packing material and carton are not available, contact Coherent for an appropriate shipping container. The WaveMaster instrument is susceptible to damage if not returned in original packaging materials, so take care to carefully package this instrument for shipping according to Coherent instructions.
5. Seal the shipping carton with shipping tape or an industrial stapler.
6. Ship the product to:

Coherent, Inc.

27650 SW 95th Ave.

Wilsonville, OR 97070

Attn: RMA # *(add the RMA number you received from Coherent Customer Service)*



## APPENDIX B: SPECIFICATIONS

Table B-1 lists specifications for the WaveMaster.

*Table B-1. Specifications*

<b>Parameter</b>	<b>Description</b>
Wavelength Coverage	380 to 1095 nm
Accuracy	0.005 nm
Resolution	0.001 nm
Display Update	3 Hz
Max. Safe Input Signal	100 mW cw @ 632 nm 100 mJ pulsed @ 1064 nm
Min. Pulse Repetition Rate	Single shot
Max. Pulse Repetition Rate	CW
Max. Signal Bandwidth	2 nm @ 400 nm 3 nm @ 600 nm 5 nm @ 1000 nm
Size (excluding handles) (h x w x d)	115.0 x 280.0 x 370.0 mm (4.5 x 11.0 x 14.6 in.)
Weight	6.25 kg (13.8 lb.)
External Communications	RS-232 and USB
Storage Conditions	-10° to 50°C
Relative Humidity	Non-condensing and < 80%
Shock	< 4 g
Operational Conditions	+ 5° to 40°C
Relative Humidity	Non-condensing and < 80%
Shock	< 4 g
Power Supply Unit	
Input	100 to 240 VAC, 47 to 63 Hz
Output	12V, 2.5 A DC
Size (excluding mains adapter plugs)	120.0 x 65.0 x 40.0 mm (4.8 x 2.6 x 1.6 in.)
Weight	285.0 g (10.0 oz.)
Laser Input Sensor	
Size (excluding mounting pin) (h x w x d)	30.0 x 25.0 x 110.0 mm (1.1 x 1.0 x 4.3 in.)
Weight	100.0 g (3.5 oz.)
Fiber-Optic Cable	Captive, 2 meters long, ST connector
Nose Thread	0.535 inch x 40 UNC





