LBTEK

LBDA-FCA-50系列
数字可调光纤衰减器



用户使用手册

INTRODUCTION

The LBTEK Optics family of handheld test equipment includes the LBDA Digital Variable Attenuator, which provides controlled attenuation of optical power. The LBDA is a rugged instrument that provides versatility and accuracy in a wide range of applications. The LBDA is simple to use: The user interface takes the guesswork out of setting precise and repeatable optical attenuation in the lab or the field.

The degree of attenuation is controlled with an internal stepper-motor that is geared to give a balance of speed and precision. The versatile design allows each unit to be custom-built and calibrated to address the specific requirements of a user-defined fiber optic system.

Optical attenuation can be set directly with the LBDA attenuator keypad. The LBDA is configured with a large liquid crystal display (LCD) and a simple-to-use, menu-driven user interface. The unit allows for keypad entry of the wavelength and optical attenuation. It can also operate in a mode that allows for continuous increment and decrement.

The built-in USB interface on the LBDA enables attenuation control for computer-based applications. The host computer can send attenuation commands directly to the LBDA using the USB cable.

When a single-mode attenuator is required, a beam blocking technique is used; when a multimode attenuator is required, a variable neutral density filter is used.

Key Features

- High power handling
- High speed, high resolution
- Wide attenuation range
- Low insertion loss, low backreflection
- Polarization insensitive
- Wide wavelength range; flat wavelength response
- Communications interface
- Wide range of connectors available
- Blocking technique for single-mode applications; variable neutral density filter for multimode fiber applications
- Multi-wavelength calibration available
- Polarization maintaining (PM) versions available
- Rugged, compact design

Applications

- Testing for bit error rate (BER)
- Simulating optical link budgets
- Designing optical receiver front-ends
- Measuring power meter linearity
- Power setting

Parts and Accessories

The standard configuration of the LBDA includes:

- LBDA Digital Variable Attenuator, with protective rubber boot
- USB cable
- AC/DC power supply
- Molded carrying case
- Certificate of Compliance
- Operating Instructions (this document)

Contact LBTEK Optics for information on other models of the Digital Variable Attenuator, or custom specifications for the LBDA.

The LBDA Digital Variable Attenuator package includes the handheld unit, with impact-absorbent blue rubber boot (not shown), user-specified optical receptacles, USB cable, and AC/DC power adaptor. Figure 1 shows the standard configuration of the LBDA.

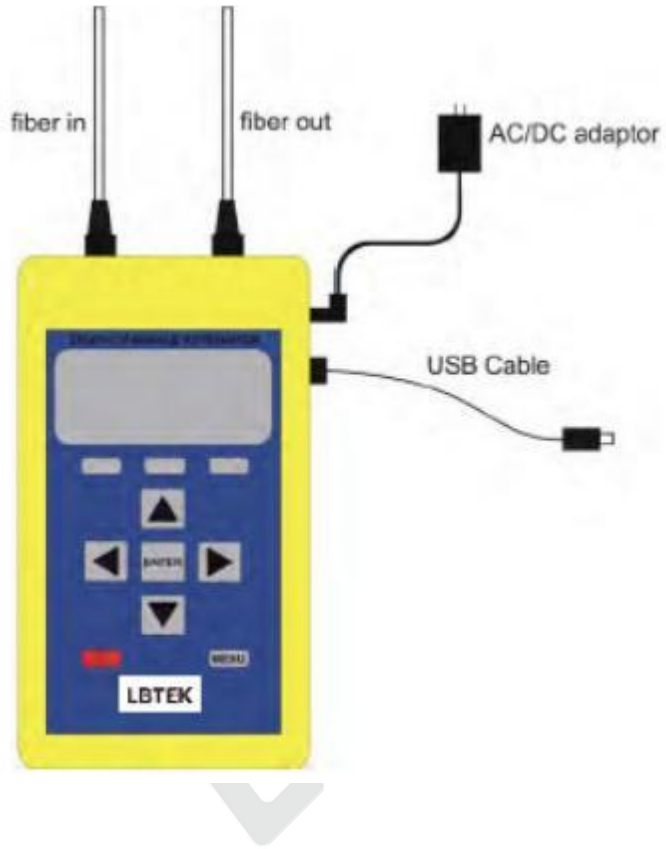


Figure 1: LBDA Digital Variable Attenuator and Connectors

Calibration

Each unit is individually calibrated as it comes from the production line. The range of attenuation is measured and the results are programmed into the look-up table memory of the unit. Each unit can be calibrated at the factory for use at multiple wavelengths.

	**Note** To ensure optimum performance, return the unit to LBTEK Optics after one year for recalibration.

LBDA Operating Modes

The unit can operate in a direct entry mode using the built-in keypad. This mode allows the user to program the wavelength, in nanometers, and attenuation level, in decibels, with just a few keystrokes.

Within direct entry mode, the LBDA can also operate in a convenient increment/decrement mode. In this mode, press the left (◄) or right (►) arrow keys on the keypad to change the optical attenuation level. On initial entry into this mode of operation, the user sets the amount by which the attenuation level increments or decrements.

A host computer can control the LBDA remotely through the USB interface. The USB cable is a standard accessory that connects the USB receptacle on the LBDA to any available USB port on a PC. In this mode, the LBDA can be controlled by a host computer. This allows it to be operated remotely in situations where the physical presence of an operator is not convenient.

LBDA Connections

The user specifies the type of input and output optical receptacles; they must be compatible with the intended application of the unit. Standard accessories include the USB cable. The standard AC/DC power adaptor connects to a 110/220 VAC wall outlet.

Attenuation Methods

The LBDA incorporates either the blocking-type or variable neutral density filter-type attenuator mechanism, with a micro-controller to provide the intelligence. The blocking technique allows for high-speed, high-resolution attenuation under digital stepper motor control. Each LBDA is calibrated for one or more specific wavelengths; the most accurate results are obtained when the device is used at one of these wavelengths.

Blocking Type Attenuator

In single-mode fiber applications, the blocking type attenuator is used. Light from the source fiber is collimated into a beam diameter of approximately 0.4 to 0.6 mm, within a wavelength range of 350 to 2050 nm. The width of the beam depends on the lens, wavelength, and numerical aperture (NA) of the fiber. A blocking device, shown in Figure 2, is inserted into the beam of collimated light to attain the attenuation required.

A precision stepper motor, through a reduction gear assembly, controls the blocking device. The motor drives a given number of steps from the home reference location to position the blocking device to intersect the beam.

The attenuator is calibrated so that there is a well-known relationship between the position of the blocking device and the level of attenuation.

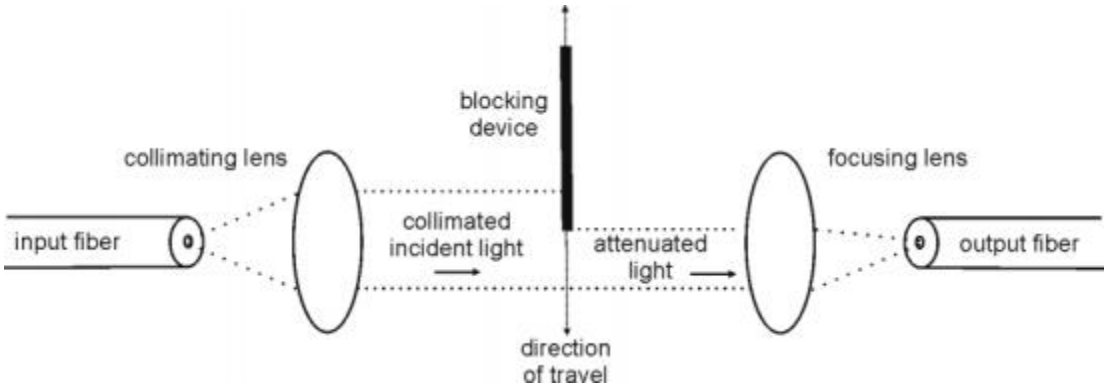


Figure 2: LBDA Blocking for Single-mode Operation

Neutral Density Filter Type Attenuator

In multimode fiber applications, a variable neutral density filter attenuator is used, as shown in Figure 3. The filter, with attenuation that varies from 0.0 dB to over 35 dB, is inserted into the beam of collimated light. The position of the filter within the beam determines the level of attenuation. The filter position is controlled using a spring-loaded cam system connected to a precision stepper motor through a gear reduction assembly.

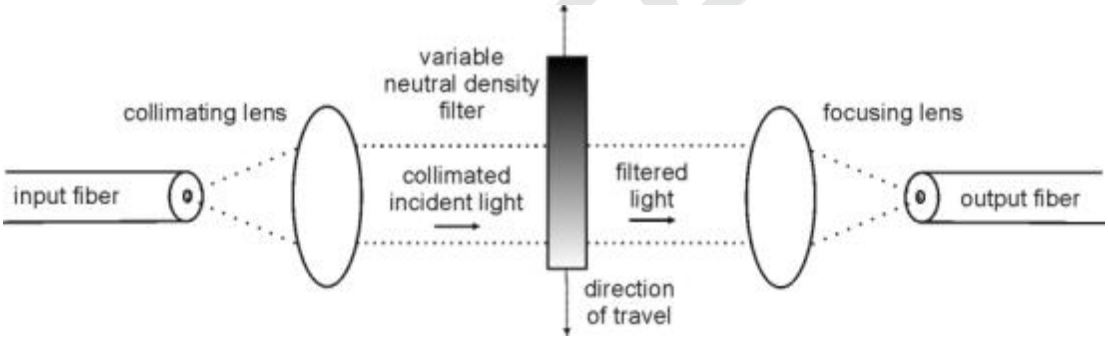


Figure 3: LBDA Neutral Density Filter for Multimode Operation

Theory of Operation

To control the intensity of light in the system, an attenuator is placed in the optic path. The simplest type of attenuator is fixed, whereby it reduces the intensity of light by a certain amount. Ideally, this attenuator is wavelength-insensitive and absorbs different wavelengths of light to the same degree. The LBDA Digital Variable Attenuator provides quantified and controlled variable attenuation with minimal wavelength dependency.

The intensity of light (P, in Watts) can vary over several orders of magnitude. When exposed to high optical power levels, the sensitive photo-detector of an optical power meter can become saturated or damaged, which leads to a loss of accuracy. A variable attenuator is used to avoid this problem, or to set an optical system to a known power level.

To describe wide variations in power, a relative logarithmic scale is useful, $P(dB) = 10\log(P/P_{ref})$. A negative value ($P<P_{ref}$) indicates a loss of power and can be correlated with a scale that shows per cent transmission (from 100 to 0%).

Some significant correlated values are listed in Table 1.

Table 1: Loss and Transmission Rates

dB	Transmission (%)
0	100
-0.01	99.8
-0.10	97.7
-1.00	79.4
-3.01	50
-5	31.6
-10	10
-20	1.0
-30	0.1
-40	0.01
-50	0.001
-60	0.0001

For a fiber optic system that uses single-mode or polarization-maintaining fiber, the LBDA is designed with a blocking device that moves step-wise into the optical path. Two conditions are defined well: 100% transmission (no blocking) and 0% transmission (full blocking). The built-in calibration data accurately defines intermediate degrees of attenuation. The attenuator can drive to full optical power, fix the attenuation at a known intermediate level, or gradually drive to the limit of detection of the power measurement system.

Known attenuation levels, provided by the LBDA, are significant for bit error rate testing, simulating optical link budgets, and designing optical receiver front-ends. The device can also be used to test the linear response of a questionable power meter, or to calibrate one power meter with another.

For controlled attenuation of optical power in a low-power system that uses multimode fiber, the LBDA is designed with a neutral-density, variable attenuator that does not change the spectral profile or the distribution of modes. This attenuator has an absorption gradient, which the stepper motor moves to various positions in the optical path.

All configurations of the LBDA give a direct and easy means to set optical attenuation, regardless of the system-specific options chosen. At the chosen wavelength, the attenuation can be set to any value required, directly or step-wise. Keypad operations allow step-wise increments or decrements to attenuation. When attenuation must be controlled from a remote location, the LBDA communications options are used.

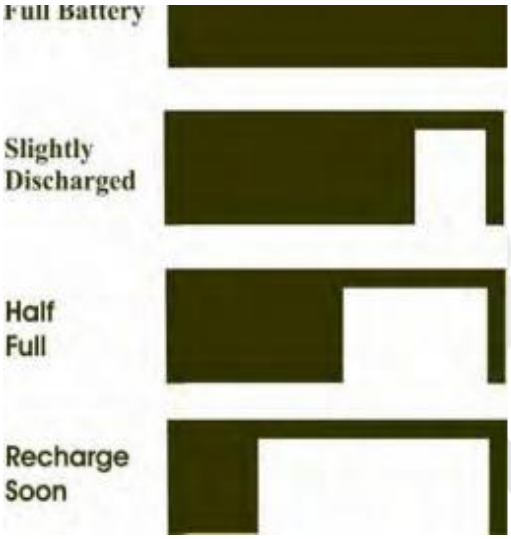
Battery Option

The LBDA-B is an alternate version of the LBDA, which incorporates a built-in rechargeable battery. The fully charged battery provides approximately six hours of continuous power, or more when used intermittently. The battery pack is automatically recharged when the unit is powered by the AC/DC adaptor.

If the battery option is installed, a battery charge indicator can be found on the display. As the battery discharges, the symbol will change to reflect the decreasing capacity.

The unit should be plugged in to charge the battery for several hours before it is first used.

Various states of charge are shown below:



Warning

- Do not open the LBDA. The battery cannot be serviced by the user.
- Do not incinerate the unit, as the battery may explode.
- Avoid exposing the unit to excessive heat, as this may damage the battery.
- Avoid contact with liquids, as this may damage the battery.

Safety

Although the LBDA is not a light source, caution is required with systems that use light and laser sources. Some sources have significant optical power of a specific wavelength, concentrated into a very narrow beam. Such a beam can travel great distances without dispersion and reflect into unanticipated spaces. The eye cannot detect an infrared source; therefore, the eyelid does not close to avoid exposure.

Read, and follow, the appropriate laser safety warnings. Warnings indicate that serious injury can result from improper use of the laser or other optical device.



Warning

• Never look into the end of an optical cable that is attached to an optical output device. Laser light can be invisible and can severely injure the human eye and skin.
• Read the laser safety labels that are affixed to the device. Implement a level of laser safety that is appropriate for the class of the device.
• Wear protective eyewear at all times. Ensure that the eyewear is compatible with the wavelength in use.
• Replace eyewear that is pitted, cracked, crazed, scratched, discolored, or otherwise not in perfect condition.
• Maintain a high ambient light level in the area of operation. High ambient light constricts the pupil of the eye, which can reduce eye damage.
• Avoid blocking the output beam or reflections with any part of your body.
• Enclose the path of the laser beam whenever possible.
• Do not make connections or splices when the laser is on.
• Set up experiments or operations so the laser beam is below eye level.
• Use shields to prevent the escape of unnecessary reflections or beams from the area of operation.
• Use a metal beam target as a beam dump to prevent accidental exposure.
• Ensure all devices that have an ON/OFF switch are set to the OFF position before assembling or disassembling the equipment.
• Only use the power cord supplied with the device.
• Establish controlled access to the laser operation area.
• Do not allow anyone to operate the laser who is not trained to do so.
• Do not allow anyone to service or maintain the laser who is not trained and authorized to do so.

SPECIFICATIONS

Table 2 lists the optical specifications, Table 3 lists the mechanical specifications, and Table 4 lists the environmental specifications of the LBDA attenuator.

Optical Specifications

Table 2: Optical Specifications

Parameter	Specification	
Available wavelengths	350 to 2050 nm	
Insertion loss (connector loss not included)	Single-mode	Multimode
	1.0 dB typical 2.0 dB maximum	2.0 dB typical 4.0 dB maximum
Repeatability	±0.03 dB for 0 to 10 dB attenuation ±0.10 dB for 0 to 30 dB attenuation	
Speed	1 dB to 30 dB within 3 s	
Resolution (<1 dB attenuation)	0.01 dB	
Power handling	≤2 W continuous wave (CW) single-mode ≤50 mW continuous wave (CW) multimode	
Polarization extinction ratio (PM fiber)	20, 25, or 30 dB	
Return loss	40 dB, single-mode, super NTT-FC/PC 50 dB, single-mode, ultra NTT-FC/PC 60 dB, single-mode, angled NTT-FC/PC 35 dB, multimode	
Accuracy, at 23 °C, from nominal values	0 to <40 dB: ± 0.3 dB ≥ 40 to <55 dB: ± 0.5 dB (single-mode) ≥ 55 to 60 dB: ± 1.0 dB (single-mode)	
Polarization dependent loss (PDL)	≤ 0.01 dB (minimum) ≤ 0.05 dB (typical)	
Wavelength dependence (typical)	0.3 dB change from 1300 to 1550 nm 0.1 dB change from 1520 to 1570 nm	

For additional information, please refer to the product's data sheet.

Mechanical Specifications

Table 3: Mechanical Specifications

Parameter	Specification
Dimensions (H x W x D)	150 x 81 x 46 mm (5.9 x 3.2 x 1.8 in.), without boot
Weight	450 g (~1 lb.)
Communications interface	Mini-B type USB port
Power supply	Universal 110/220 VAC to +12 VDC adaptor

Environmental Specifications

Table 4: Environmental Specifications

Parameter	Specification
Temperature range: Operating Storage	 -10 to 55 °C (14 to 131 °F) -30 to 70 °C (-22 to 158 °F)
Humidity (storage)	<90% RH, non-condensing, at -30 to 70 °C (-22 to 158 °F)

LBTEK



Warning

LBTEK Optics products are not authorized for use as critical components in life support devices or systems without the express written approval of LBTEK Optics.

- Life support devices or systems are defined as devices or systems that are intended for implant into the body, or that support or sustain life. Failure of the life support device or system can result in significant injury to the user.
- A critical component is defined as any component of a life support device or system whose failure to perform can reasonably be expected to cause the failure of the life support device or system, or to affect its safety.

INSTALLATION

Before connecting the Digital Variable Attenuator to the laser source and output fiber, read the complete installation instructions.



Caution

- Ensure that all personnel are familiar with all operation and safety instructions provided with the laser source and that are included with this document (*Safety*, **Introduction** section).
- Clean all optical connections, as described in the **Maintenance and Service** section of this document.
- LBTEK Optics Ltd. is not liable for any damage or harm caused by misuse of the source laser, LBTEK Optics devices, or both.

Checking the Shipment

When the LBDA is received from LBTEK Optics:

1. Carefully unpack the items in the shipping container.
2. Retain the original packing materials and documentation that are shipped with the device.
3. Verify that the shipment contains the items that are listed on the packing slip.
4. When an item is missing or damaged, immediately inform LBTEK Optics. Do not attempt to repair a damaged item. Do not return the shipment without a Return Merchandise Authorization Number (RMA #). See the **Warranty** section of this document for more information on the RMA # procedure.

   Always return the device in its original packing materials. These materials are selected to reduce or eliminate damage caused by ESD.

Connecting the Optical Components

The LBDA is shipped with customer-specified optical receptacles.

Before connecting optical cables to the LBDA:

- Always inspect and clean the connectors and receptacles. See the **Maintenance and Service** section of this document for information on cleaning connectors and receptacles.
- Ensure that the optical connectors on the cables are compatible with the optical receptacles on the LBDA.

Connecting the LBDA

Direct Entry Mode

To connect the LBDA in direct entry mode, the following components are required:

- LBDA Digital Variable Attenuator
- AC/DC power adaptor
- Light source
- Receiving device
- 110/220 VAC wall socket
- User-supplied fiber optic patchcords that are compatible in wavelength, fiber type, fiber connector, and fiber core and cladding diameter with the attenuator, light source, and receiving device.

In the typical setup shown in Figure 4, the LBDA optical input receptacle connects to a polarized fiber optic stable source (PFOSS) and the optical output receptacle connects to the receiving device, which in this case is a power meter.

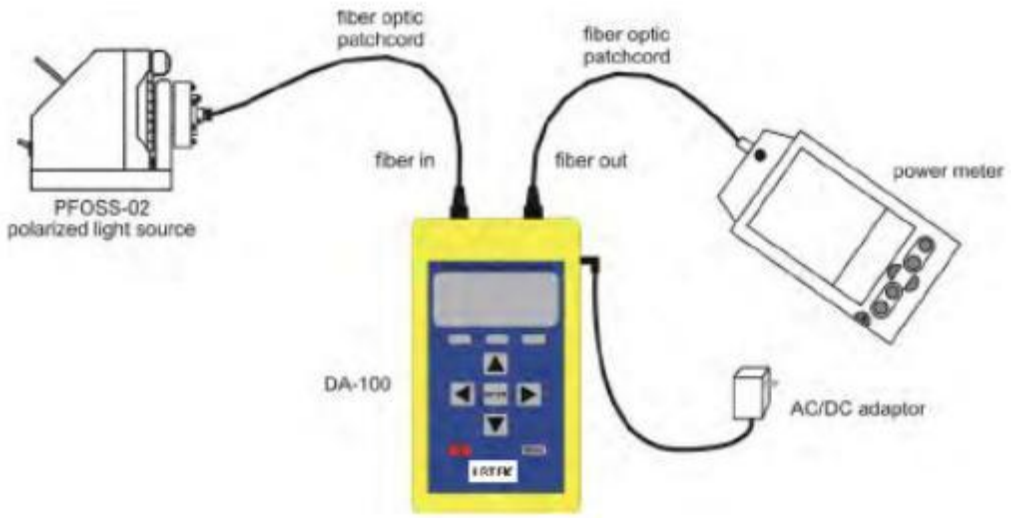


Figure 4: Typical LBDA Direct Entry Mode Connections

To connect the LBDA in direct entry mode:

1. Connect the AC/DC adaptor to the LBDA.
2. Plug the power cord into a 110/220 VAC wall socket.
3. Connect the light source to the input receptacle of the LBDA with a compatible patchcord, after cleaning the connector and receptacle.
4. Connect the output fiber to the output receptacle of the LBDA with a compatible patchcord, after cleaning the connector and receptacle.
5. Turn on the light source.
6. Press ⏻ (the ON/OFF button) on the LBDA.

Computer Control Mode

The personal computer used for computer control of the LBDA must have one available USB port.

To connect the LBDA in computer control mode, the following components are required:

- LBDA Digital Variable Attenuator
- AC/DC power adaptor
- USB cable, for remote LBDA-to-PC communications
- Personal computer
- Light source
- Receiving device
- 110/220 VAC wall socket
- User-supplied fiber optic patchcords that are compatible in wavelength, fiber type, fiber connector, and fiber core and cladding diameter with the attenuator, light source, and receiving device.

In Figure 5, the LBDA optical input receptacle connects to the light source (PFOSS-02, in this example), the optical output receptacle connects to the power meter, and the USB cable connects to the PC (not shown).

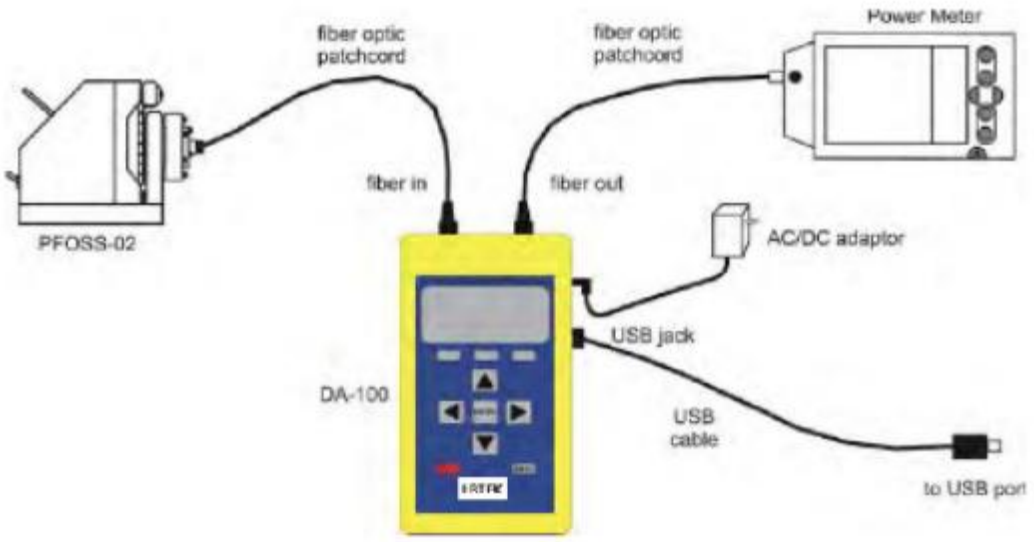


Figure 5: LBDA Computer Control Mode Connections

To connect the LBDA in computer control mode:

1. Connect the AC/DC adaptor to the LBDA.
2. Plug the power cord into a 110/220 VAC wall socket.
3. Connect the light source to the input receptacle of the LBDA with a compatible patchcord, after cleaning the connector and receptacle.
4. Connect the receiving device to the output receptacle of the LBDA with a compatible patchcord, after cleaning the connector and receptacle.
5. Connect the USB cable to the USB jack on the LBDA.
6. Connect the USB cable to a USB port on the computer.
7. On the PC, run the ASCII-based terminal software and set the COM*n* port parameters.
8. Turn on the light source.
9. Press ⏻ (the ON/OFF button) on the LBDA.

OPERATION

Using the Keypad

Figure 6 shows the front view of the LBDA Digital Variable Attenuator. The keypad is designed for self-instructive, intuitive use of features. The large (3 x 5.5 cm) LCD displays the LBTEK Optics logo momentarily before going to the initial display.



Figure 6: LBDA (front view)

Power On/Off

To turn on the power, press and hold the ON/OFF button (⏻) for about 2 seconds. An audible beep will be heard. The LBTEK Optics logo is displayed and the unit is initialized. When the wavelength, insertion loss, and attenuation are displayed, the unit can be used.

To turn off the power, press and hold the ON/OFF button, ⏻, for about 2 seconds.

Soft Keys

The blue keys below the LCD are “soft keys.” Press a key to select an “action” option that is displayed above the key.

Arrow Keys

Generally, to navigate sub-menus, active arrow keys are indicated on the right of the LCD. The left (◄) and right (►) arrow keys highlight specific digits, and the up (▲) and down (▼) arrow keys increase or decrease values. Hold the arrow key down to change values rapidly.

Figure 7 shows four possible LCD displays. Figure 7 A displays all of the arrow symbols; therefore, all of the arrow keys are active. The highlighted digit (“6”) is neither to the extreme left nor extreme right of the field, nor is it “0” or “9”.

In Figure 7 B, “9” is entered in the second position of the field. The up arrow key is not active. Similarly, in Figure 7 C, “0” is highlighted; therefore, the down arrow key is not active.

In Figure 7 D, the left arrow key is not active because the left-most digit in the field is highlighted. Similarly, when the right-most digit is highlighted, the right arrow key is inactive.

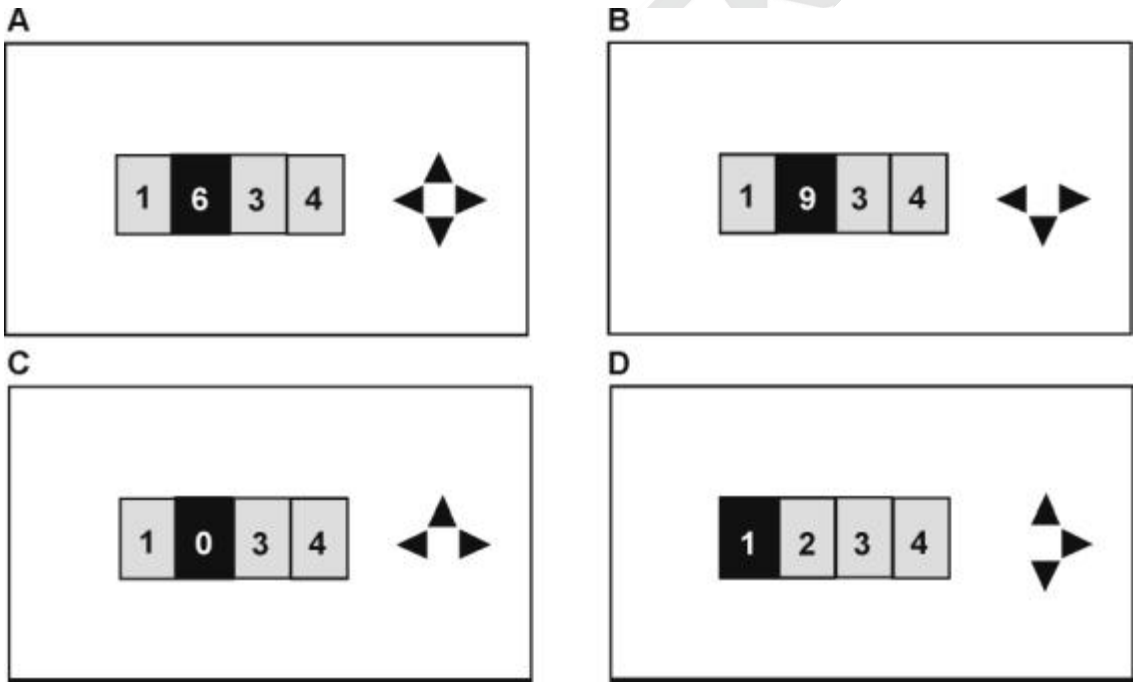


Figure 7: Using the LBDA Arrow Keys

When more than one condition applies to a field, both relevant arrows are inactive.

When the correct numerical value for all digits in the field are selected, press the ENTER key.

Note

The LCD representations in this section are not to scale.

Initial Display

The cursor (**>**) indicates which parameter can be changed. Press the up or down arrow keys to select calibrated wavelength, insertion loss, or attenuation (for example, λ: 1550 nm, IL: 00.00 dB (maximum 29.99 dB), and attenuation: 00.00 dB). Press the ENTER key to highlight the parameter field. Press the left, right, up, or down arrow keys to select the value for each parameter. Press the ENTER key to save the values that are displayed.

Entering Default Parameters

Wavelength Parameter

When the cursor is pointed toward the wavelength symbol (λ) and the wavelength symbol is highlighted, the wavelength can be changed. To change the wavelength:

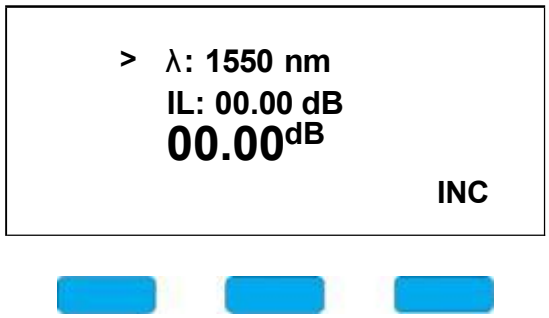
1. Press the ENTER button to highlight the wavelength field.
2. Press the up or down arrows to highlight the selected calibrated wavelength. If the attenuator has been calibrated at only one wavelength, then this selection cannot be changed.
3. Press the ENTER button to select the calibrated wavelength. This wavelength will be stored in flash memory and be recalled the next time the unit is turned on.

Increment Parameter

In some applications it may be desirable to make several optical measurements at a variety of attenuation levels. With the LBDA it is possible to change the attenuation by a user-defined amount by pressing a single key. For example, if one wants to check the linearity of an optical power meter by making measurements that are spaced one dB apart, the user can set the INC parameter to 1 dB, and then change the attenuation by this amount with a single keystroke.

When the LBDA is turned on, the second line of the display will show IL (Insertion Loss), discussed later. INC will be displayed above one of the blue “soft” keys. To set the increment amount, press the blue soft key below “INC”. The second line of the display will change to “INC”, while the mnemonic “IL” will now appear above the soft key that was pressed. Using the up and down arrow keys, highlight the mnemonic “INC” on the second line of the display. Press the ENTER key to change the default increment value. The first digit of the increment value will now be highlighted. Use the up or down arrow keys to change the value of the highlighted digit. When the first digit is set to the desired number, move to the next digit using the right arrow key. In a similar manner, use the arrow keys to change any of the displayed digits until the desired increment value is shown. Press the ENTER key to save this increment value as the default.

Once the increment value has been entered and saved, the attenuation can be increased (or decreased) by that amount simply by pressing the right (or left) arrow key.





To change the increment to a higher or lower number, press the blue key below INC to toggle to the INC parameter. Enter the new default increment in the increment field (INC) with the arrow keys. Press ENTER to save the new value.

Insertion Loss Parameter

The insertion loss is a measure of the minimum possible loss of light between the input and output of the unit. The insertion loss is factory-measured, with no attenuator in the optical path (100% transmission). The beam diameter varies with wavelength, and the insertion loss is similarly wavelength-dependent.

The factory-measured insertion loss is the minimum achievable loss, and includes losses from the input connector, the output connector, and the internal optical components. This IL value is recorded on the Certificate of Compliance that is included with the LBDA.

From the initial display, press the blue key below INC to toggle to the IL parameter. Enter the new default IL in the IL field with the arrow keys. Press ENTER to save the new value. If the input and output fibers are connected to the LBDA, the unit is now ready for use.

The IL can be changed to include the wavelength-specific calibrated loss of cables connected to the LBDA. The insertion loss values are saved when the unit is turned off, and these will become the default values the next time the unit is turned on.

The displayed value of attenuation will be equal to the sum of the programmed insertion loss plus the internally generated attenuation. For example, if the insertion loss is set to zero using the IL command, and the user enters a desired attenuation level of 5 dB, then the LBDA will internally generate a loss of 5 dB. However, if the insertion loss is set to 2 dB and the user requests an attenuation of 5 dB, then the LBDA will generate an attenuation of 3 dB, thereby giving a total signal reduction of 5 dB, as requested.

There is a limit to the maximum attenuation that can be generated within the attenuator. Typically, this is around 60 dB for single-mode devices. If the insertion loss is set to 2 dB and the maximum internally generated attenuation is 60 dB, then the user can request an attenuation of up to 62 dB. Requests for higher attenuation will be limited to the sum of the maximum possible attenuation plus the insertion loss. If the insertion loss in this example is then reduced from 2 to 1 dB, then the displayed value will automatically be reduced from 62 to 61 dB.

The displayed value of attenuation cannot be less than the insertion loss. For example, if the insertion loss is set to 1 dB, then requests for an attenuation of less than that value will automatically be increased to match the minimum insertion loss of 1 dB. If the insertion loss is then increased to 3 dB, then the displayed value of attenuation will automatically be increased to 3 dB.

It is important to realize that changing the value of the insertion loss will change the attenuation. The displayed value of attenuation is the sum of the entered insertion loss plus the optical loss provided by the attenuator. For example, if the insertion loss is set to 1 dB and the attenuation is set to 10 dB, the internal optics of the attenuator will produce a loss of 9 dB, for a total loss of 10 dB. If the insertion loss is increased to 2 dB, the loss introduced by the optical attenuator will change to 8 dB, to maintain a total loss of 10 dB. If the insertion loss were then changed to 0.7 dB, the optical loss would be increased to 9.3 dB. If the insertion loss is set to a value that is higher than the actual insertion loss, then the actual loss through the attenuator will not match the displayed value.

Under most circumstances, the insertion loss will only be changed to null out a known or measurable loss within a system. Improper setting of the insertion loss can result in optical power losses that do not match the expected values. If this happens, set the insertion loss back to the factory default value.



Note

Insertion loss is affected by the cleanliness of the connectors; refer to the *Maintenance and Service* section of this document for proper connector and receptacle cleaning procedures.

Using the Menus

Main Menu

Press the MENU key to display the list of options for the LBDA. When the MENU key is pressed, the LCD displays:

MAIN MENU:
1. **Device**
2. **Setup**
3. **Return**

Press the arrow keys (▲ up, ▼ down) to highlight options 1 to 4; valid arrow keys are also indicated on the LCD display. When the correct option is highlighted, press ENTER to select the option.

Device Menu

From the Main Menu, press the up or down arrow keys to highlight Device and press ENTER. The Device Menu displays the model, the serial number (S/N), the calibration date (C/D) and the version of hardware and software of the device (for example, software version 0.3 and hardware version 6.B). The LCD displays:

DEVICE MENU:
LBDA
S/N: 21037-4
C/D: Sep17 2001
Ver: SV0.3_HV6.B
Return

Press the ENTER key to return to the Main Menu.

Setup Menu

From the Main Menu, press the up or down arrow keys to highlight Setup. Press the ENTER key to select Setup. The Display option is highlighted.

When Setup is selected, the LCD displays:

SETUP MENU:

1. **Display**
2. **Serial**
3. **Return**

Display Setup

The Display option on the Setup Menu is used to set the contrast on the LCD and the backlight options. The values for contrast are: 0 for low contrast, 32 for high contrast, 16 is the factory-set default. ON turns on the backlight when the device is on; OFF turns off the backlight at all times. AUTO turns on the backlight for a pre-set time following the last keypad entry. Every time a key is pressed, the internal timer is reset. If the backlight is off, then pressing any key will turn it back on, and start the timer.

From the Setup Menu, press the up or down arrow keys to highlight Display. Press the ENTER key to select Display. The contrast value is highlighted. When no changes are required to the displayed values, press the ENTER key twice to return to the Setup Menu.

The LCD displays:

DISPLAY SETUP:

Contrast: 16
Backlight: OFF

To change the contrast or backlight value:

1. Press the up or down arrow keys to change the value of the contrast. It will increase or decrease by 2 counts. Hold the arrow key down to change the value continuously.
2. Press the ENTER key to save the contrast value and highlight the backlight value.
3. Press the up and down arrow keys to select OFF, ON, or AUTO.
4. Press the ENTER key to save the backlight value. The Setup Menu is displayed.
5. On the Setup Menu, select RETURN and press the ENTER key to return to the Main Menu.

Serial Setup

The LBDA uses a USB bridge in order to communicate with a computer. Prior to communicating with a computer, a software driver must be installed on the computer. See the section on Remote Operation for instructions on installing the driver.

Even though the hardware is USB, the software treats it as if it is communicating via a COM port. This means that the LBDA needs to be configured as if it is connected via a COM port. The settings in the LBDA must match the corresponding settings in the software that is communicating with the unit. Consequently, the baud rate and other communication parameters must be properly set to allow the device to communicate with the computer. These parameters are set at the factory, and the user usually does not need to change them. If they do need to be changed for some reason, this section describes how to do it. There is generally no benefit to changing these settings.

The Serial option on the Setup Menu is used to display or change the parameters used for serial communication.

The factory set defaults (and other options) are:

- **Baud:** 9600 (19200, 38400, 57600, 115200, 128000, 256000), rate of transmission in bits per second.
- **Bit:** 8 (7), indicates the number of data bits per character.
- **Parity:** NONE (EVEN, ODD), indicates when there is a parity bit in the character.
- **Stop bit:** 1 (2), indicates the number of stop bits in the character.
- **Flow control:** None. There is no provision for handshaking.

From the Setup Menu, press the up or down arrow keys to highlight Serial. Press the ENTER key to select the Serial Setup menu. When the Serial Setup menu is displayed, the baud rate field is highlighted. When no changes are required to the values displayed in the Serial Setup menu, press the ENTER key four times to return to the Setup Menu.

The LCD displays:

SERIAL SETUP:
Baud: 9600
Bit: 8
Parity: NONE
Stop bit: 1

When changes are required to a value displayed in the Serial Setup menu:

1. Press the ENTER key to highlight the Baud, Bit, Parity, or Stop bit field.
2. Press the up or down arrow keys to display and select a new value for a field.
3. Press the ENTER key to save the displayed value. When the ENTER key is pressed to save the displayed value, the next field is highlighted.
4. When all changes are entered, press the ENTER key to return to the Setup Menu.
5. On the Setup Menu, select RETURN and press the ENTER key to return to the Main Menu.
6. On the PC, ensure that the communications parameters match the settings on the LBDA.

Return

From the Main Menu, press the up or down arrow keys to highlight Return. Press the ENTER key to select Return and display the main screen, as described in **Initial Display**.

LBTEK

Remote Operation

The LBDA is a self-contained device, and does not need an external computer to operate it. However, for anyone who may want an automated system, it is possible to control it using a personal computer. Before writing your own program, it is suggested that you try to use a terminal program such as HyperTerminal to communicate with the unit. That will help you to fully understand the operation of the commands.

Before the LBDA can be controlled by a personal computer, USB driver routines must be installed on the computer. Instructions for installing the USB driver are included in the following section. **Depending on the operating system, the pop-up windows might look a little different than the ones shown.**

The USB driver may be periodically updated by the manufacturer of the USB interface chip. The latest version of the USB interface driver may be freely downloaded from the Silicon Laboratories web site at:
https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

Virtual Com Port (VCP) Drivers for a number of different operating systems are supported. Click on "Download VCP" corresponding to the operating system on the computer on which the driver is to be installed. Drivers for a number of different operating systems can be found at this web site.

Driver Installation

A driver needs to be installed on the host computer to allow the PC to communicate with the LBDA. This USB driver allows the computer to treat the communications with the LBDA as if it is occurring over a COM port. This allows the LBDA to be controlled by programs such as HyperTerminal. The user may also write his own program to control the LBDA, using simple ASCII character strings, and treating the LBDA as if it were connected to a COM port. The actual sequence of steps required for installing the driver may be different than what is shown here, depending on the operating system being used. In any case, the goal is to install the USB driver for the UART to USB interface..

1) Connect power to the LBDA, and turn it on. Connect the LBDA to the computer using the USB cable.

2) After a couple of seconds, the "Installing device driver software" message will appear, as shown below:



3) After a few seconds, this will be replaced by:



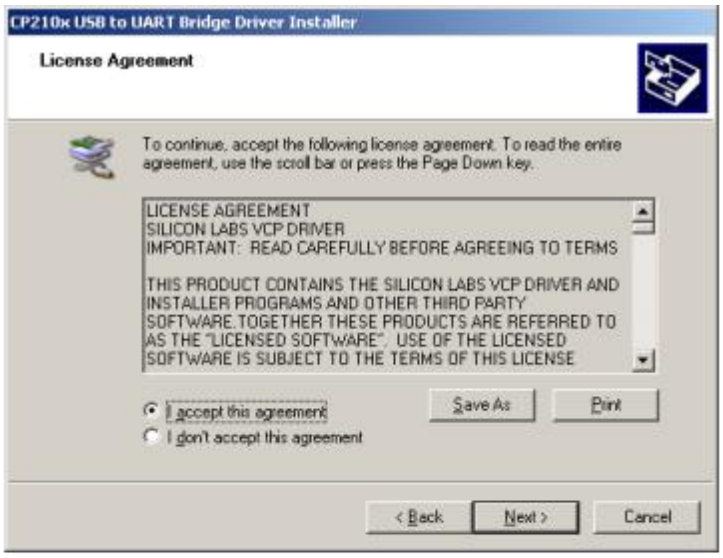
At this point, the driver installation is complete. In the event that the above messages do not appear, it may be necessary to install the files from the Silicon Labs web site. In that case, follow the sequence of steps outlined below:

4) Unplug the USB cable connecting the device to the computer.
5) Go to the Silicon Labs website, at the following address: https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers
6) Download the appropriate VCP file, based on the operating system of the computer on which the driver will be loaded. This will download a zipped file. Decompress the file. This will produce several files.
7) Double click on the installation program, “CP210xVCPInstaller_x86.exe“ if you are using a 32-bit operating system, or " CP210xVCPInstaller_x64.exe" if you are using a 64-bit

   operating system. After a few seconds, a window similar to the one below should appear.



8) Click “Next” to continue.
9) Click on the circle to accept the license agreement, as shown in the following image:



10) Click the “Next” button to proceed. A message should appear to indicate that the driver has been installed, as shown below:



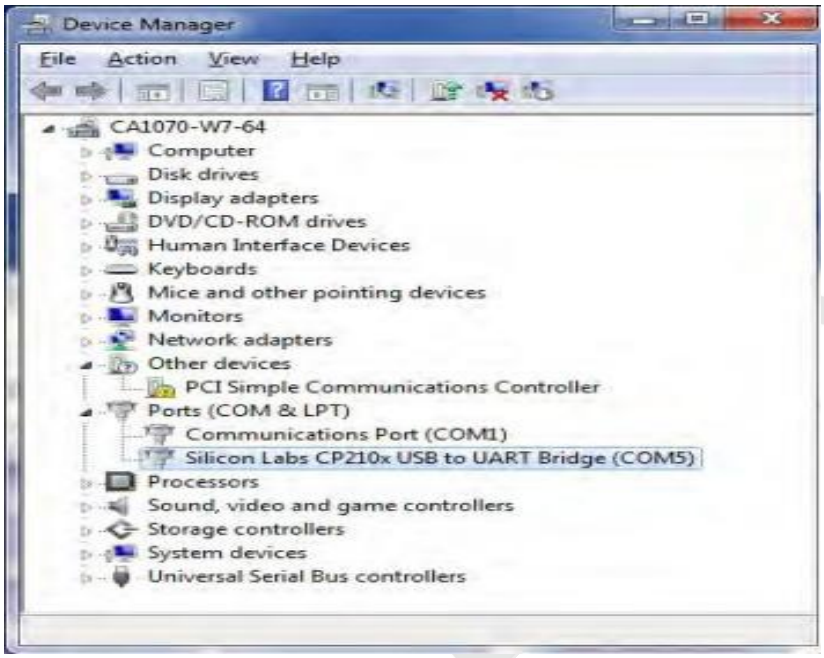
11) Click on the “Finish” button to exit from the installation procedure.

Plug the USB cable from the LBDA back into the computer. The unit should now be ready to be controlled by the computer.

Configuring the COM Port

To configure the software for hardware communications, determine which COM port to use:

1. Using the Device Manager, find the Silicon Labs CP210x USB to UART Bridge. The required COM port is displayed.
2. In the following screen shot, the required port is shown as COM 5. Set the communications software to match this COM port



COMMUNICATIONS

The hand-held Digital Variable Attenuator is easily used with keypad control. However, the LBDA also has options for a computer communications setup to control attenuation from a host computer. The USB jack is used to interface with the host personal computer (PC). Many applications benefit from direct control of attenuation using a PC.

Applications can be written in high-level programming languages such as Visual Basic[1] or C, and lab automation software such as LabWindows or LabVIEW[2]. The programs can be used to develop shortcut commands to collect, analyze, and plot data.

To enable communications through a USB port, the default settings, listed in Table 5, are used. When the default settings are changed, the settings on the computer must also be changed.

Table 5: Default LBDA Communications Parameters

Parameter	Settings
Bits per second	9600 baud
Data bits	8 bits
Parity	none
Stop bits	1 bit
Flow control	none



Note

- The unit cannot be turned on or off with a remote computer terminal.
- When the LBDA is used in an inaccessible place, ensure that it is properly connected, configured, and powered on.

[1] Visual Basic is a registered trademark of Microsoft Corporation.
[2] LabWindows and LabVIEW are registered trademarks of National Instruments Corporation.

Initial Computer Display

When the LBDA is powered-on, and USB connections are correct, the PC displays an initial message, similar to the sample shown below:

LBTEK Optics Ltd.
LBDA
V5.00B_2.32
Finding home …
Step: 0
Wavelength: 1550 (nm)
Atten: 01.00 (dB)
Ready

The messages identify the unit (LBDA), hardware version (V5.00B), software version (for example, 2.32), and the status of the unit after initialization (step, wavelength, and attenuation). When *Ready* is displayed, the message indicates that computer communications are enabled and the unit can begin remote operation.

Using Remote Commands

ASCII commands are not case sensitive. Do not use spaces before, after, or between a command and a query (?) or numerical data entry (<n>). To enter a command, type the command and press carriage return (<CR>). The command can be entered in upper or lower case (for example, b? or B?), but the syntax must be correct.

A correctly entered command is acknowledged at completion with “Done”. An incorrect command or data entry generates the message: Error(100): Invalid command or number. The Remote commands used by the LBDA are listed in Table 6.

Table 6: LBDA Remote Commands

Command	Description
?	List Remote commands
A?	Get current attenuation
A<n>	Set attenuation to <n> dB
A#	Get current increment size
A#<n>	Set default increment/decrement size
A+	Increment attenuation by set increment size
A+<n>	Increment attenuation by <n>
A-	Decrement attenuation by set decrement size
A-<n>	Decrement attenuation by <n>
B?	Get current baud rate and communication setting
BL	Get baud rate list
B<n>	Set baud rate to <n>
D?	Get date of calibration
E?	Echo query

Command	Description
E0	Set echo off
E1	Set echo on
L?	Get current insertion loss
L<n>	Set insertion loss to <n>
S?	Get current step
S<n>	Set step to <n>
S+	Increment by one step
S+<n>	Increment by <n> steps
S-	Decrement by one step
S-<n>	Decrement by <n> steps
V?	Get device name and version
V2	Get the device serial number
W?	Get current wavelength
WL	Get wavelength list
W<n>	Set wavelength

Note

- A carriage return (<CR>) is ASCII code 13.
- A line feed (<LF>) is ASCII code 10.
- During transmission, the LBDA ignores each incoming line feed. The unit sends a line feed after all carriage returns.

Rounding and Truncation

The LBDA normally operates with a minimum resolution of 0.01 dB. When setting the attenuation, any characters beyond the second digit after the decimal point will be ignored. When setting the increment value or insertion loss, additional digits may be received as part of a serial string. Values will be rounded upwards to the next hundredth of a dB if the value is greater than x.xx5 dB, or truncated (rounded down to the nearest hundredth of a dB) if the value is less than or equal to x.xx5 dB. Values such as .01, 0.01, 3, 66.01 can be entered, but x.xxn values are rounded. For example, 1.006 is rounded to 1.01, 1.005 is truncated to 1.00.

Note that although the displayed attenuation has a resolution of 0.01 dB, this does not imply that any arbitrary attenuation can be set with a resolution of 0.01 dB. Due to the non-linear nature of the device, low levels of attenuation can be selected with resolution of 0.01 dB or better. However, the resolution at high levels of attenuation will generally not achieve this level of control. For example, setting the attenuation to 56.03 dB may give the same level of attenuation as setting it to 56.04 dB. The displayed value will be the same for both settings, and will have a displayed resolution of 0.01 dB.

Understanding the Values

For each calibrated wavelength, there is a maximum calibrated range and insertion loss. Insertion loss can be set while the device is active to show the initial internal insertion loss of the device, which is the total loss from the input receptacle, output receptacle, and internal optic components. Also while the device is active, insertion loss can be set to include losses generated by other inline devices that are part of the optical path.

Values are restricted to those between the initial insertion loss and the maximum calibrated range plus the initial insertion loss. For example, if the initial insertion loss is set to 1.60 dB and the LBDA is calibrated for a maximum range to 60 dB at 1300 nm, the value displayed is between 1.60 dB and 61.60 dB.

Using the same example of an initial insertion loss set to 1.60 dB, any attempt to set a value of attenuation greater than 61.60 dB will be limited to 61.60 dB. An insertion loss entered as less than 1.60 dB will be displayed as 1.60 dB.

Commands

Attenuation

The LBDA is calibrated at dB = 0 for 100% transmission. As the beam is attenuated, the dB values go to increasingly larger numbers, where 60 dB corresponds to 0.0001% transmission, which is near the limit of detection of most optical power meters. The dB values are positive with respect to attenuation. Values are restricted between the set insertion loss (for example, IL = 1.6 dB) and the maximum attenuation plus the set insertion loss. For example, if this total equals 61.60 dB and *A90* is entered, the unit displays *Atten:61.60(dB)*.

To display or change the attenuation, use the attenuation commands, as listed in Table 6. Values must be within the range of calibration. In the example below, the starting attenuation is 1.9 dB and the current default increment is 2.0 dB. To see the result of each attenuation command on these values, follow the example in sequence from left to right.

Input	**A?**	**A#**	**A+**	**A-**
Response	**Atten:01.90(dB)** **Done**	**INC:02.00(dB)** **Done**	**Atten:03.90(dB)** **Done**	**Atten:01.90(dB)** **Done**

Input	**A33.03**	**A#3**	**A+3**	**A-3**
Response	**Atten:33.03(dB)** **Done**	**INC:03.00(dB)** **Done**	**Atten:36.03(dB)** **Done**	**Atten:33.03(dB)** **Done**

Note that the maximum increment value (A#n) is A#99.99. Greater values will produce an error.

Baud Rate

The baud commands display or change the baud rate. Enter B? to display current baud rate, BL to list the available baud rates, and B<n> to set the baud rate. If the baud rate is changed, the host computer must immediately change its own baud rate to continue communicating.

Input	**B?**	**BL**	**B19200**
Response	**9600 (bps)** **8NONE1** **Done**	**Baud rate (bps):** **9600** **19200** **38400** **57600** **115200** **128000** **256000** **Done**	**19200** **Done**

Date

The date query command (D?) displays the date of calibration.

Input	**D?**
Response	**Sep17 2001** **Done**

Echo

When echo is on, the command (input) is transmitted back to the sending device. When echo is off, the response to the command is transmitted, but the input is not. To use the echo command, enter E? to display the echo status, E0 to set echo off, and E1 to set echo on.

Input	**E?**	**E0**	**E1**
Response	**Echo on (or off)** **Done**	**Echo off** **Done**	**Echo on** **Done**

Insertion Loss

The insertion loss commands display or change the insertion loss. Enter L? to display current insertion loss or L<n> to set the insertion loss (up to 29.99 dB).

Input	**L?**	**L1.45**
Response	**Loss: 01.23 (dB)** **Done**	**Loss: 01.45 (dB)** **Done**

Step

A step is the minimum increment that the attenuator (blanking device or filter) can be moved into, or out of, the optical path. The total number of steps required to move the attenuator from the home position (0% attenuation), to maximum attenuation (100%), and back to home (0%) depends on the gear ratio of the stepper motor. Steps must always be entered as integers.

The step commands, as listed in Table 6, display or change the step. In this example, the starting step is 233, which is 233 steps from the home position. To see the result of each step command on this value, follow the example below in sequence from left to right. When instructing the attenuator to move <n> steps, the value of n must be an integer. Any characters following a valid integer are ignored. For instance, “S2000P” will be read as “S2000”. Similarly, “S1234.5” will be read as “S1234”.

Input	**S?**	**S+**	**S-**
Response	**Step:233 Done**	**Step:234 Done**	**Step:233 Done**

Input	**S10**	**S+10**	**S-5**
Response	**Step:10 Done**	**Step:20 Done**	**Step:15 Done**

When the LBDA receives a step command, the attenuation value is updated to reflect the new setting.

Version

The version query command (V?) displays the model of the unit and the version of hardware (V5.00B) and software (2.32).

Input	**V?**
Response	**LBDA V5.00B_2.32 Done**

The serial number request command (V2) displays the serial number of the unit in a string, up to a maximum of 13 characters in length.

Input	**V2**
Response	**67123-1R**

Communications

Wavelength

The wavelength commands display or set the wavelength. Enter W? to display the current wavelength, WL to list the calibrated wavelengths, and W<n> to set the wavelength. When setting the wavelength, the value entered must be an integer. Any characters following a valid wavelength are ignored. For instance, “W1550h” will be read as “W1550”.

Input	**W?**	**WL**	**W1550**
Response	**Current Wavelength: 0980 (nm)** **Done**	**0980 (nm)** **1550 (nm)** **Done**	**1550 (nm)** **Done**

When a new wavelength value is set, the LBDA uses the last insertion loss for that wavelength and adjusts the attenuation for that insertion loss. The IL value for each calibrated wavelength is recorded on the Certificate of Compliance that is included with the LBDA documentation.

Error Message

When an incorrect command is entered, an error message is displayed.

For example (with echo on), the incorrect format for a command (display calibration date) is entered:

Input	**D01**
Response	**Error(100): Invalid command or number**

To correct the error, input the correct command.

MAINTENANCE AND SERVICE

Maintenance

The LBDA requires minimal maintenance.

- Inspect all optical connectors and receptacles before use. Worn or damaged connectors or receptacles require replacement.
- Keep the device free of dust, dirt, or other contaminants.
- When not attached to an optical system, the connector must be covered with the supplied cap, which protects the connector from dirt and contamination.
- Never disassemble the unit. This action invalidates the warranty on the device.

Cleaning the Fiber Optic Connectors

The connectors on the fibers must be kept as clean as possible at all times. Dirt on the connectors can scratch the optical surfaces and damage the connector and can affect the optical properties of the fiber. Cleaning also ensures that the ferrule or connector and the fiber mate properly.



Warning

- Turn off all light-emitting devices. Concentrated or laser light can severely damage the eye. Reflected light from a concentrated source can severely damage the eye.
- Never look directly at a beam of light, regardless of its source.
- Disconnect fiber optic cables from the light source before cleaning the ferrules, connectors, or receptacles.

Cleaning Ferrules and Connectors

Cleaning ensures that the ferrule or connector and the fiber mate properly. Dirt can also affect the optical properties of the fiber. To clean fiber optic ferrules and connectors:

1. Assemble all cleaning supplies or equipment. It is recommended that connectors be cleaned each time they are connected or reconnected.
2. Ensure all devices that have ON/OFF power switches are set to the OFF position.
3. Carefully remove the protective cap, if it is in place, from the ferrule or connector or disconnect the fiber optic cable from the device to which it is attached.
4. Inspect each ferrule or connector for visible physical defects and damage. Defects and damage to the core or cladding, indicated by a high insertion loss, can be confirmed by examination with a microscope.

5. Fold several layers of lint-free paper tissues to form a small pad. Place the pad on a firm surface.
6. Apply one or two drops of isopropanol on the pad.
7. Gently wipe the tip of the ferrule or connector across the pad of tissues. Hold the ferrule or connector perpendicular to the pad.
8. With the same motion, finish the wiping motion on a dry section of the pad of tissues.
9. Frequently refresh the pad of tissues and the isopropanol when cleaning several ferrules or connectors.
10. Carefully inspect the tip of the fiber under reflected light. The tip must be clean and shiny.
11. Ensure that the protective cap is clean and free from defects. Replace caps that are stained, worn, misshapen, or defective in any way.
12. Carefully place the protective cap on the ferrule or connector, or immediately connect the ferrule or connector to a port or receptacle.

Cleaning Receptacles

Female receptacles require periodic cleaning. Cleaning ensures that the connector and fiber mate properly and can prevent damage to the receptacle and the fiber. To clean female receptacles:

1. Assemble all cleaning supplies or equipment. It is recommended that connectors be cleaned each time they are connected or reconnected.
2. Ensure all devices that have ON/OFF power switches are set to the OFF position.
3. Carefully remove the protective cap, if it is in place, from the receptacle.
4. Use compressed air to blow dust or dirt off the connector. Do not blow air directly into the receptacle.
5. With a pair of scissors, cut off one end of a round toothpick, to make the end flat. Remove splinters, if present, from the flat end of the toothpick.
6. Wrap a single leaf of lint-free tissue, about 25 mm (about 1.0 in) square, around the flat end of the toothpick, as shown in Figure 8. The tissue must be wrapped smoothly and tightly and extend approximately 2 mm past the end of the toothpick. Taper the end of the paper slightly.

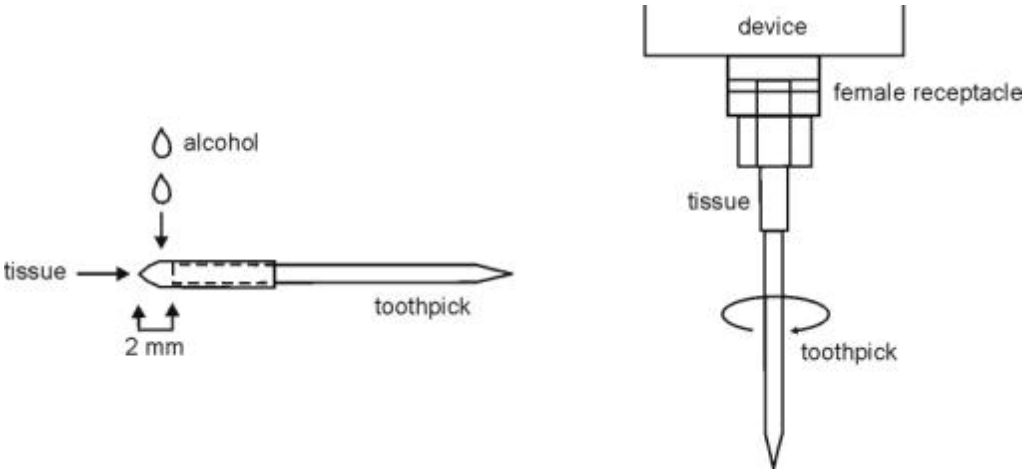


Figure 8: Cleaning Female Receptacles

7. Apply one or two drops of isopropanol or methanol to the tip of the tissue paper.
8. Hold the device so that the receptacle of the device is pointing down. Insert the toothpick and tissue into the receptacle until the end of the toothpick is flat against the ferrule inside the receptacle.
9. Rotate the toothpick and tissue two or three turns. Remove the toothpick and tissue.
10. Inspect the tissue. If dirt is visible on the tissue, repeat Step 6 to Step 9 until the tissue remains clean. Re-wrap the toothpick with new tissue each time.
11. Use new tissue for each receptacle when cleaning more than one receptacle.

Troubleshooting

When results are other than expected:

- Ensure that the connectors are clean and free of contamination.
- Check that the fiber is securely seated in the receptacle on the connector.
- Ensure that there are no stresses applied to the digital variable attenuator or the fiber connected to it; stresses can affect the alignment.

Problem: When the ON button is pressed, nothing happens.

Action: Verify that the connections between the device and the AC/DC power adaptor and the power adaptor and the wall receptacle are correctly in place. Press ⏻ (the ON/OFF button). Hold the button down for at least 2 seconds. If the LCD does not display the LBTEK Optics logo and the LBDA is receiving adequate power, contact LBTEK Optics technical support.

Maintenance and Service

Problem: There is difficulty setting up computer communications.

Action: Ensure that the unit is powered on and is in the initial display. If the unit is in a sub-menu, press ENTER to return to the initial menu. Verify that the cables have good connections. Verify that the PC settings match those on the LBDA (defaults are 9600 baud, 8 data bits, no flow control, parity none, and one stop bit).

Problem: There are no readings at the start of a new session, with no response to new commands.

Action: The LBDA must take a few readings before the first result is displayed. When the LBDA is first turned on, it automatically drives to the step-zero home position and then displays last value of attenuation recorded (for IL = 0, the time from step zero to maximum attenuation is ~12 s). The stepper motor is geared (typically 485:1) for an optimal balance of speed and precision. With computer control, a task must end before a new command can be entered. To see the entered commands, ensure that echo is on.

Problem: When using the LBDA for fiber optic budget calculations, the numbers don't seem to add up. Is there a problem with the calibration?

Action: Ensure that the settings for the wavelength and insertion loss are correct. Ensure that all connectors are clean. It is recommended that reliable patchcords be reserved specifically for connection to the LBDA. Refer to the Certificate of Compliance supplied with the unit that indicates the measured insertion loss.

Problem: How many steps must be driven before the beam begins to be blocked? How is this number calculated?

Action: Set the insertion loss to zero and enter a level of attenuation. Drive to *A0* for 100% transmission or *A0.01* for 99.8% transmission. Next, enter a step query (*S?*) to display the number of steps from home position to initial blocking. For 0.0001% transmission, enter *A60* followed by *S?* to display the number of steps from home position to full blocking.

Service

The internal components of the LBDA do not require service by the user. Contact Technical Support at LBTEK Optics Limited to determine if service is required. See the **Contact Us** section of this document for more information.



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