

LAMBDA 10[®]-B

OPTICAL FILTER CHANGER AND
SMARTSHUTTER[®] CONTROL SYSTEM

OPERATION MANUAL

REV. 1.20Q (20230227)



SUTTER INSTRUMENT[®]

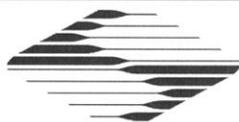
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CE EU Declaration of Conformity

Application of Council Directives:
2014/30/EU (EMC), 2014/35/EU (LVD), and 2015/863/EU (RoHS 3)

Manufacturer's Name: Sutter Instrument Company

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Equipment Tested: Lambda 10-B Optical Filter Switching & Shutter Control System

Model(s): Controller: **LB10-B/IQ**
10-Position Filter Wheels: **LB10-NW** (25mm (no shutter))
LB10-NWS (25mm, with standard shutter)
LB10-NWIIQ (25mm, with SmartShutter)
LB10-W32IQ (32mm, with SmartShutter)

Conforms to Standards: EMC Emissions: EN 61326-1:2013, including:
EN 55011: 2009 Class A;
EN 61000-3-2:2015, & EN 61000-3-3:2014
EMC Immunity: EN 61000-4-2:2009, EN 61000-4-3:2011,
EN 61000-4-4:2012, EN 61000-4-5:2014,
EN 61000-4-6:2014, EN 61000-4-8:2010, &
EN 61000-4-11:2004
LVD (Safety): EN 61010-1:2010

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20200520_REACH and RoHS Compliance Statement

Sutter Instrument Company hereby declares that the equipment specified above was tested and conforms to the EU Directives and Standards listed above, and further certifies conformation to the requirements of the European Union's Restriction on Hazardous Substances in Electronic Equipment Directive 2015/863 (2011/65/EU Annex II) for RoHS 3.

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DISCLAIMER

The **LAMBDA 10-B** is an optical filter switcher and shutter controller designed for the specific use of changing filters into and out of an optical pathway and no other use is recommended.

This instrument is designed for use in a laboratory environment. It is not intended, nor should it be used in human experimentation or applied to humans in any way. This is not a medical device.

Do not open or attempt to repair the instrument. Extreme heat and high voltages are present and could cause injury.

Do not allow unauthorized and/or untrained operative to use this device.

Any misuse will be the sole responsibility of the user/owner and Sutter Instrument Company assumes no implied or inferred liability for direct or consequential damages from this instrument if it is operated or used in any way other than for which it is designed.

SAFETY WARNINGS AND PRECAUTIONS

Electrical

- Operate the LAMBDA 10-B using 110-120 V AC, 60 Hz, or 220-240 V AC., 50 Hz line voltage. This instrument is designed for connection to a standard laboratory power outlet (Overvoltage Category II), and because it is a microprocessor-controlled device, it should be accorded the same system wiring precautions as any 'computer type' system. A surge protector and power regulator are recommended.

-  Fuse Replacement: Replace only with the same type and rating:

 If the serial number is equal to LB10IQ-1554 or greater, then the specified fuse is:
5 x 20 mm glass tube, Time Delay (IEC 60127-2, Sheet III)
T1.0A, 250V (219XA Series)

Use only Littelfuse 0219001.XAP (219XA Series)

 If the serial number is below LB10IQ-1554, then the specified fuse is:
5 x 20 mm glass tube, Time Delay (IEC 60127-2, Sheet III)
T1.0A, 250V

Use only Bussmann GDC-1A; or Littelfuse 218 001

A spare fuse is in the power input module. Please refer to the fuse-replacement appendix for more details on fuse ratings and for instructions on how to change the fuse.

Avoiding Electrical Shock and Fire-related Injury

-  Always use the grounded power supply cord set provided to connect the system to a grounded outlet (3-prong). This is required to protect you from injury if an electrical hazard occurs.

- Do not disassemble the system. Refer servicing to qualified personnel.
-  To prevent fire or shock hazard do not expose the unit to rain or moisture.

Optical Radiation

This system is designed for use in conjunction with high-intensity light sources. Failure to comply with any of the following precautions may result in injury to the users of this device as well as those working in the general area near the device.

-  Never look into the optical pathway of the high intensity light sources typically used with this instrument. Doing so can cause permanent eye damage.
-  The high-intensity light sources typically used with this instrument also produce a significant amount of heat. Direct contact with the housing of those instruments can cause serious burns.
-  **The SmartShutter is Not a Safety Shutter:** Sutter Instrument Co.'s SmartShutter is not intended to be a 'safety shutter.' A safety shutter usually closes automatically in the event of a power failure and is designed with the primary goal of ensuring that it will not allow any unintended exposure. For laser safety applications, a shutter is normally designed so that no single component failure allows an unintended exposure to the laser beam. The SmartShutter is intended for use in the controlling of light in scientific and industrial applications. The SmartShutter was designed for high performance and durability, but without certain features that would be desirable in a safety shutter application.

Electromagnetic Interference

To comply with FDA and CE electromagnetic immunity and interference standards; and to reduce the electromagnetic coupling between this and other equipment in your lab always use the type and length of interconnect cables provided with the unit for the interconnection of one or more filter wheels and/or shutters, host computer via serial RS-232 or USB interface, or other equipment via TTL connections (see the TECHNICAL SPECIFICATIONS appendix for more details).

Operational

Failure to comply with any of the following precautions may damage this device.

- This instrument is designed for operation in a laboratory environment (Pollution Degree I).
- This unit is not designed for operation at altitudes above 2000 meters nor was it tested for safety above 2000 meters.
-  **DO NOT CONNECT OR DISCONNECT THE CABLES BETWEEN THE CONTROLLER AND THE MECHANICAL UNITS WHILE POWER IS ON.**

Please allow at least 20 seconds after turning the unit off before disconnecting the mechanical units. Failure to do this may result in damage to the electronics.

-  Operate only in a location where there is a free flow of fresh air on all sides.
NEVER ALLOW THE FREE FLOW OF AIR TO BE RESTRICTED.

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1. GENERAL INFORMATION

1.1 Introduction

The LAMBDA 10-B is a filter wheel and shutter control system designed for the rapid change and aperture control of wavelength and is comprised of two subsystems: 1) a controller, and 2) a combination of filter wheels and shutters that are placed in the optical pathway(s) of your existing experimental setup. The controller is microprocessor-controlled with the capability of delivering power and control signals to a filter wheel, and optionally to one to two integrated shutters. Each integrated shutter may be a SmartShutter® or a conventional shutter. Each of the -filter wheel/shutter combinations may also consist of a standalone filter wheel and one or two standalone SmartShutters.

1.1.1 How to use this Manual

Installation of the filter wheel and filters is discussed in the FILTER WHEEL section, SmartShutter installation is discussed in the SMARTSHUTTER section, and installation and manual operation of the controller are discussed in the CONTROLLER section. This unit supports a **SmartShutter** or a traditional shutter. Up to one filter wheel is also supported with or without shutter, or up to two Smart Shutters (without a wheel). Finally, the remote operation of the LAMBDA 10-B through its serial and USB ports is discussed in the REMOTE-CONTROL sections.

1.1.2 Technical Support

Unlimited technical support is provided by Sutter Instrument Company at no charge to our customers. Our technical support staff is available between the hours of 8:00 AM and 5:00 PM (Pacific Time) at (415) 883-0128. You may also E-mail your queries to info@sutter.com.

1.2 General Description

The LAMBDA 10-B is a microprocessor controlled, high-speed filter wheel system designed for microscopy and other applications that require rapid and accurate wavelength switching. The LAMBDA 10-B controller can control either a single filter wheel with a high-speed shutter or up to two standalone SmartShutters (without a filter wheel). The controller features both USB and serial RS-232 input for remote control.

The controller is designed around an embedded microcontroller, which automatically determines the equipment installed. The electronics for controlling a shutter are already installed, even if you did not order that option. If you add a shutter later, there are no additional electronics to buy, although you may need to configure the circuit board for the size of shutter if you wish to install a UNIBLITZ shutter.

The controller can run up to one filter wheels (with or without a shutter) or up to two SmartShutters (no filter wheel), all under remote control through a USB or serial input using the same simple protocol as the previous Lambda 10- 2 controller with only minor differences. The USB and the serial RS-232 interfaces use the exact same remote-control command set. Some important considerations about using a combination of input sources (e.g., the keypad and the Serial port) are discussed in the Remote-Control section of this manual.

The following instructions are meant to help you set up the LAMBDA 10-B and become familiar with the manual mode of filter selection. Other sections of this manual contain detailed discussions on the functionality of the controller, how filters are installed, and setting up remote control communications.

The **Lambda SmartShutter** is a microprocessor controlled, high-speed shutter designed for microscopy and other applications that require a shutter function. The LAMBDA 10-B controller can control a single a single integrated or two standalone SmartShutters. Shutters are commonly used to turn off a light source to prevent photo bleaching or other photo damage. In addition, they may be used to select between multiple light sources or light paths, such as transmitted light versus fluorescence excitation. SmartShutters can be placed into one of several modes. These modes determine the way the actual shutter action works: Fast Mode, Soft Mode, and Neutral Density Mode. Fast Mode provides for the fastest open/close action of the shutter. Soft Mode is slightly slower than Fast Mode and provides for a somewhat gradual open/close action, as well as being quieter. Neutral Density Mode allows for the control of the aperture of the open state of the shutter – between 1 and 144 microsteps may be selected for the Neutral Density Mode. Neutral Density Mode also provides for the control of light intensity without affecting the wavelength.

The primary use of the shutter is as an accessory to the Lambda 10 series of filter wheels, but it is also used as a stand-alone piece for the transmitted light arm of inverted microscopes. The electromechanical shutters actuated by solenoids have been used by most optical manufacturers for decades and have some outstanding features. They act quickly, they can be driven by simple electronics, and the package is quite thin. However, these units are prone to frequent failures and usually cannot be repaired. There is effectively no warranty from the manufacturer for the end user. Although they can produce short bursts of operation at 30 Hertz, they will overheat and fail quickly if this rate of opening is maintained. These shutters also produce a good deal of vibration and audible noise.

1.3 Filter Wheel

1.3.1 Mechanical Description

The basic components of the filter wheel mechanical assembly are shown in following figures. The only components that are to be removed by the user are the drop-in or slide-in filter holders and the plug in the loading port. At no time should the user remove the cover plate from the wheel housing.

1. 10-position wheel (removed from motor hub)
2. Installed filter cup
3. Wheel housing
4. Cover plate (removed from wheel housing)
5. Stepper motor
6. Drop-in filter holder (Figure 1-1) or slide-in filter holder (Figure 1-2)
7. Mounting ears
8. Optical port
9. Loading port (plug installed)
10. Shutter housing

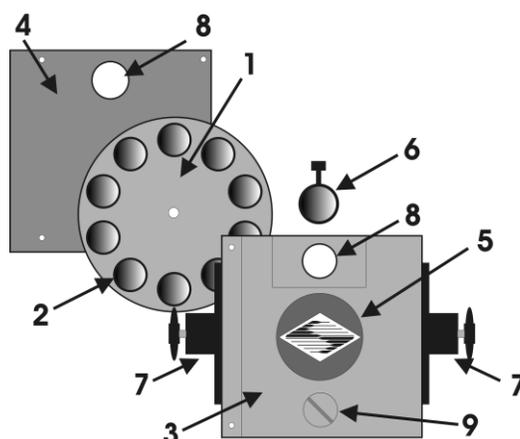


Figure 1-1. Lambda series 25mm filter wheel (without shutter).

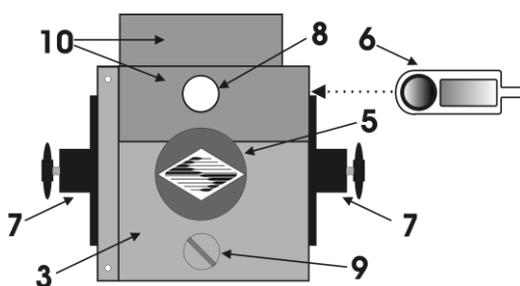


Figure 1-2. Lambda series 25mm filter wheel housing (with 25mm shutter).

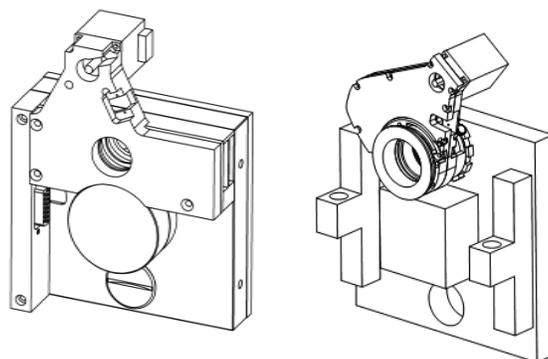


Figure 1-3. Lambda-series 25mm filter wheel housing with 25mm SmartShutter and 32mm filter wheel housing with 35mm SmartShutter.

1.3.1.1 Supported Filter Wheel and Shutter Configurations

The LAMBDA 10-B controller supports two basic filter wheel and/or shutter configurations:

1. Any combination of one filter wheel and one shutter:

One standalone filter wheel only (no shutter)

One standalone filter wheel and one standalone SmartShutter

One filter wheel with built-in shutter (SmartShutter or UNIBLITZ^{®1})

One standalone SmartShutter

2. Two standalone SmartShutters (no filter wheel)

Note that the operation of the LAMBDA 10-B, its manual-control menu structure, and remote-control command structure (serial and USB), all change between the two basic configurations listed previously.

1.3.1.2 Filter Wheel and Shutter Configurations NOT Supported

The following combinations of filter wheels and shutters are **not** supported by the LAMBDA 10-B.

- **More than one filter wheel.**
- **One standalone filter wheel and more than one shutter.**
- **More than one Uniblitz shutter.**
- **One Uniblitz shutter and one SmartShutter.**
- **More than two standalone SmartShutters (no filter wheel)**

1.3.2 Filter Wheels

When a LAMBDA 10-B Filter Wheel system is purchased, its configuration may include one filter wheel, with or without a shutter. If the LAMBDA 10-B system is purchased with a 10-position 25mm (1-inch) filter wheel, you may wish to exchange the filter wheel with a 10-position 32mm or a 5-position 50mm filter wheel. If the filter wheel being replaced is a 10-position 32mm filter wheel equipped with a 35mm shutter (UNIBLITZ[®] or SmartShutter), then LAMBDA 10-B controller must be modified by Sutter Instrument Co. before said filter wheel with shutter is connected. If the 32mm filter wheel is not equipped with a shutter, or if installing a 50mm filter wheel, then no modification to the LAMBDA 10-B controller is needed. **Note that you must only use filter wheels manufactured by Sutter Instrument Company.** All filter wheel options are listed in the Sutter Instrument catalogue and in the following list.

10-position, 25mm filter wheels:

- LB10-NW (without shutter)
- LB10-NWIQ (with 25mm SmartShutter)
- LB10-NWS (with UNIBLITZ[®] shutter)
- LB10-NWE (without shutter and set up for emission)

4-position, 25mm filter wheels:

- LB10-WHS4 (without shutter)
- LB10-WHS4IQ (with SmartShutter)
- LB10-WHS4E (without shutter and set up for emission)

10-position 32mm filter wheels:

- LB10-W32 (without shutter)
- LB10-NW32IQ (with 35mm SmartShutter)
- LB10-W32S (with 35mm UNIBLITZ[®] shutter)

5-position 50mm filter wheel:

- LB10-W50 (without shutter).

¹ UNIBLITZ is a registered trademark of Vincent Associates.

Belt-driven 4-position 25mm filter wheel (special):

LB4-W (without shutter). Requires a LAMBDA 10-B circuit board only (no keyboard or display), programmed with special firmware.

1.3.2.1 Mechanical Description

The basic components of the filter wheel mechanical assembly are shown in following figures. The only components that are to be removed by the user are the drop-in or slide-in filter holders and the plug in the loading port. At no time should the user remove the cover plate from the wheel housing.

1. 10-position wheel (removed from motor hub)
2. Installed filter cup
3. Wheel housing
4. Cover plate (removed from wheel housing)
5. Stepper motor
6. Drop-in filter holder (Figure 1-1) or slide-in filter holder (Figure 1-2)
7. Mounting ears
8. Optical port
9. Loading port (plug installed)
10. Shutter housing

1.3.3 Filters

The LAMBDA 10-B Controller can be used with a range of filter wheels. Most of these wheels accept both 25 mm and 1-inch diameter filters. When larger filters are required, a wheel is available that accepts 32 mm diameter filters.

Filter wheels designed for use with 1 inch or 25 mm filters will accept filters with a thickness that does not exceed the following dimensions:

- mm (0.18 in.) for Slide-in filter holders
- 5.38 mm (0.21 in.) for Drop-in filter holders
- 9 mm (0.35 in.) for Filter cups

Filter wheels designed for use with 32 mm filters will accept filters with a thickness that does not exceed the following dimensions:

- 9 mm (0.35 in.) for Filter cups

Instructions for installing filters into the filter wheel can be found in the FILTER WHEEL chapter of this manual. **Sutter Instrument Company does not supply filters but filters conforming to the above specifications can be purchased from any filter manufacturer.**

1.3.4 Slide-in or Drop-in Filter Holders

Many users prefer having extra Slide-in or Drop-in filter holders for more convenient replacement of these “fixed” filters. **Only use filter holders made by Sutter Instrument Company in the LAMBDA 10-B Filter Wheel.** Extra filter holders for one-inch wheels are readily available from Sutter Instrument Company or their distributors and are listed as

“SLIDE-IN” and “DROP-IN” in the Sutter catalogue. At this point there are no slide-in or drop-in filter holders for 32 mm systems, although there is a fixed filter position for a heat-blocking filter in most 32 mm microscope adapters offered by Sutter Instrument Company. Slide-in and drop-in filter holders are not available for the 50 mm filter wheels.

1.3.4.1 Filter Wheel Adapters

Most microscopes, cameras, light sources and other optical instruments to which the LAMBDA 10-B Filter Wheel may be interfaced will require some sort of adapter to link the devices. Adapters for interfacing the Filter Wheel to most instruments are available from Sutter Instrument Company or can be custom built by Sutter. **Suitable adapters are available from other sources, as well, but Sutter Instrument Company assumes no responsibility for the performance, suitability and safety of adapters built by the user or other manufacturers.**

1.3.5 Shutters

If you purchase a LAMBDA 10-B Filter Wheel system without a shutter and later decide to add one to the system, the Filter Wheel must be returned to the factory for the upgrade. The current version of the LAMBDA 10-B Filter Wheel controller can support a retrofit with a *SmartShutter* or traditional shutter, without modification. The installation of a traditional shutter may require the setting of a jumper to configure the driver circuit for the size of shutter installed. **You must only use shutters installed by Sutter Instrument Company -- contact Sutter Instrument Company or your distributor for details.** All shutter options are listed in the Sutter Instrument catalogue and in the following list.

- **25mm Shutters**

Uniblitz® shutter, as integrated in the housing of the LB10-NWS 10-position, 25mm filter wheel.

SmartShutter as integrated in the housing of the LB10-NWIQ (10-position, 25mm) filter wheel.

IQ25-W *SmartShutter* with housing to fit a Sutter Instrument 25mm filter wheel

IQ25-SA² *SmartShutter* with stand-alone housing

IQ25-LS *SmartShutter* with housing to fit inside a Lambda LS

IQ25-DG *SmartShutter* with housing to fit inside a Lambda DG-4 or Lambda DG-5

- **35mm Shutters**

IQ35-W *SmartShutter* with housing to fit filter wheel

IQ35-SA *SmartShutter* with stand-alone housing

1.3.6 **SmartShutter Mounts**

An 8-32 screw-mount hole exists on the edge of the *SmartShutter* opposite the motor, into which may be attached a mounting post of any desired length. When the *SmartShutter* is mounted on a post using this screw-mount hole, the exact center of the shutter aperture is precisely aligned with the vertical center of the post. Posts of various lengths are available

² Where vignetting is an issue, the 35mm *SmartShutter* (IQ35-SA) is recommended.

from Sutter Instrument Co. This post, along with posts of other dimensions, as well as post holders and bases, are available from most laboratory equipment suppliers.

A SmartShutter can also be mounted on a Sutter Instrument Co. Filter Wheel with a special enclosure, as well as with other Sutter Instrument Co. products, such as the Lambda LS, Lambda DG-4, Lambda DG-5, and various Lambda 10 series Filter Wheel controllers. Please consult with Sutter Instrument Co.'s Technical Support for the different configuration possibilities.

1.3.7 Cables

A special cable is required for connecting one or two standalone SmartShutters. The CIQ-2 cable is a split cable consisting of one DB-25 connector at the main end (for connecting to the "SmartShutter" connector on the rear of the LAMBDA 10-B cabinet) and a DB-9 connector at each of the split ends. One split end is shorter than the other. When connecting a single standalone SmartShutter to the LAMBDA 10-B, the SmartShutter connects to the DB-9 connector of the longer split, and a terminator is required to be attached to the DB-9 connector of the shorter split.

1.3.8 Devices for TTL-Control of Shutters

Two devices are available for the TTL control of shutters that are attached to the LAMBDA 10-B.

FSWITCH: A foot switch with BNC connector. It changes the ON/OFF state of the shutter with each foot press. The state is maintained if the switch remains depressed.

FSTOGGLE: Like the FSWITCH but alternates the ON/OFF state with each foot press.

1.4 Adapters

Most microscopes, cameras, light sources, and other optical instruments to which the LAMBDA 10-B Filter Wheel may be interfaced will require some sort of adapter to link the devices. Adapters for interfacing the Filter Wheel to most instruments are available from Sutter Instrument Company or can be custom built by Sutter Instrument. **Suitable adapters are available from other sources, as well, but Sutter Instrument Company assumes no responsibility for the performance, suitability, and safety of adapters built by the user or other manufacturers.**

1.5 SmartShutter

The SmartShutter is a lightweight motor-driven aluminum vane under microprocessor control. Because of the microprocessor control, the motion of the vane can be tailored for different roles. The vane starts and stops under motor control, eliminating the sharp jolt typical of other fast shutters.

1.5.1 Step Motor Based Shutter Advantages

The new step motor-based shutter is made from a handful of parts, any of which can be replaced if it fails. The speed of opening and closing of the shutter is practically the same as the traditional shutters, and the mechanism is more robust. The shutter blade is stopped by

action of the motor rather than by mechanical stops that might fail. Because the motion profile of the shutter is controlled by a microprocessor, the motion can be optimized for speed or for smoothness. The microprocessor-based controller also offers the potential for a very adaptable controller, which could include additional functions and modes of operation. If the electronics fail, the motor can be disconnected, and the blade set open or closed by hand. Operation does not require over-driving the windings, so it can maintain operation at up to 40 Hz continuously. The unit can operate at modest voltages, which are typically available in the Lambda 10 series controllers. The package size is comparable to the traditional shutters and can be customized when needed.

Another advantage of step motor-based shutter is the ability to control the aperture of shutter blade in its opened state. This mode is called Neutral Density and is used to control the intensity of the light coming through the opened shutter without affecting the light's wavelength. The neutral density aperture size of the shutter is determined by the number of microsteps (1 through 144) specified for the motor to open the shutter.

The following instructions describe how to set up the Lambda SmartShutter and selecting filters in manual mode. More detailed discussions on the controller functions, installation of filters, and remote communications are found in other sections of this manual.

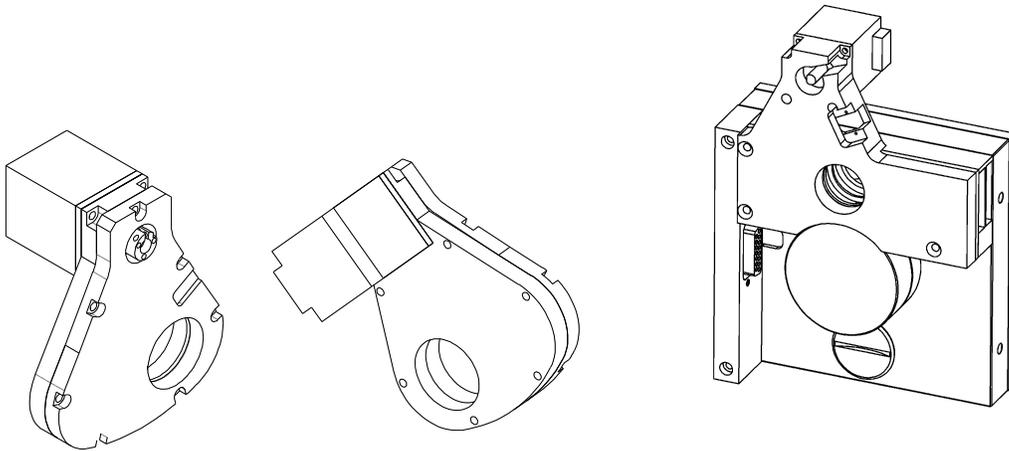


Figure 1-4. 25mm SmartShutter standalone and mounted on the housing of a 25mm filter wheel.

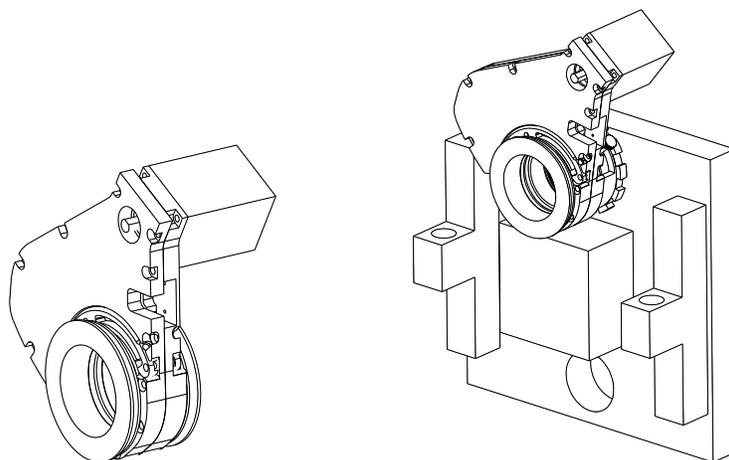


Figure 1-5. 35mm SmartShutter standalone and mounted on the housing of a 32mm filter wheel.

1.5.2 Modes

The LAMBDA 10-B supports three modes of operation for the SmartShutter.

- *Fast Mode:* In the fast mode the motion is optimized for the fastest open and close times, both of which will be about 8 msec.
- *Soft Mode:* The soft mode offers even less vibration at the expense of slower open and close times.
- *Neutral Density Mode:* In this mode the user selects the extent to which the shutter opens. When used with the Sutter Instrument light guide system (LLG), this allows the light output from the light guide to be attenuated without changing its wavelength or spatial distribution. The value for opening can be selected in steps from 1 (no opening) to 144 (complete opening).

1.5.3 Special Considerations

The new step motor based SmartShutter is made from a handful of parts, any of which can be replaced for service. The SmartShutter can open or close in about 8 milliseconds, and the mechanism is robust. The shutter blade is stopped by action of the motor rather than by mechanical stops that might fail. Because the motion profile of the shutter is controlled by a microprocessor, the motion can be optimized for speed or for smoothness. The microprocessor-based controller also offers additional functions and modes of operation. If the electronics fail, the motor can be disconnected, and the blade set open or closed by hand.

1.5.3.1 Mounting

When a 25 mm SmartShutter is to be mounted to a Lambda 10 filter wheel, a special version of the SmartShutter is supplied which will attach directly to the slide-in filter housing. The C-mount threads in the SmartShutter housing will accept the standard Sutter microscope adapters.

When a 35 mm SmartShutter is mounted to a 32 mm Lambda 10 series filter wheel, a special adapter threads into the filter wheel T-mount, on which the SmartShutter is mounted. The 35 mm SmartShutter has a receptacle for the flange on the end of this T-mount tube and this allows the SmartShutter to mount to the flange on the end of the tube in many different orientations. On the other side of the SmartShutter a similar rotating mount accepts an

adapter that is used to couple to our standard microscope adapters. It is possible to install a T-mount instead, if desired.

1.5.3.2 Opening and Closing Times

The SmartShutter has a typical time to open of 8 milliseconds, from the point a complete command or TTL signal is received. The time to close is also eight milliseconds. This is true for both the 25 mm and the 35 mm versions operating in the fast mode. Note that the controller will not accept new commands or TTL pulses in the FAST mode for about 12 msec after a command has been received. The additional time is required for display changes and other overhead.

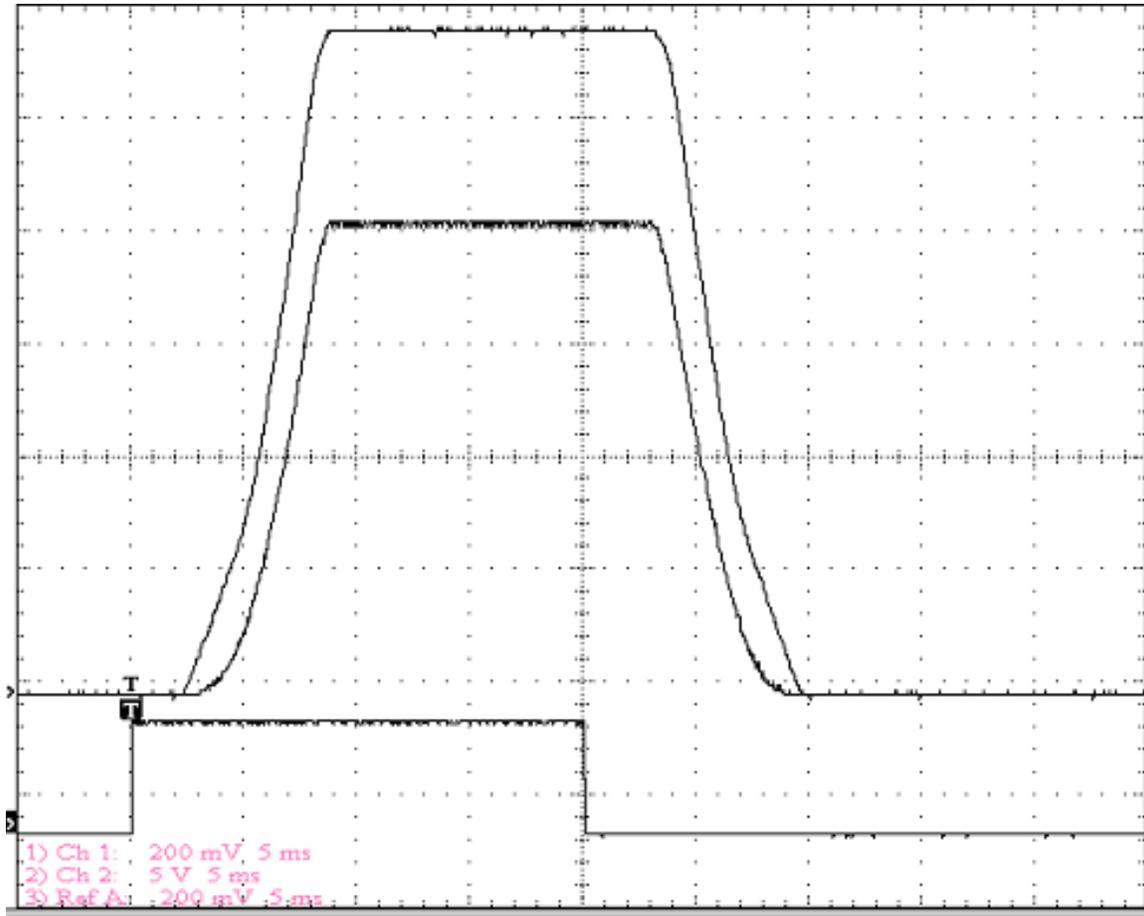


Figure 1-6. SmartShutter timing.

The timing of a SmartShutter is shown in the figure above. The bottom trace is a TTL signal, the middle trace is a 25 mm SmartShutter, and the upper trace is a 35 mm SmartShutter.

Operation is slower in the ND (Neutral Density) and SOFT modes. In the SOFT mode, the SmartShutter has a typical time to open of 60 msec. from the point a complete command or TTL signal is received. The time to close is also 60 msec. This is true for both the 25 mm and the 35 mm versions. In the ND mode, the time to open and the time to close will depend on the number of steps selected. For a complete opening of 144 steps, the time to open and the time to close will each be about 38 msec. The time required will be approximately proportional to the number of steps, or about 2.6 msec per 10 steps.

1.5.3.3 Repetition Rates and Duty Cycle

Operation does not require over-driving the motor windings, so the motor windings are not damaged by frequent opening and closing over long time periods. 25 mm (one inch) versions can usually operate well at up to 20 Hz. 35 mm versions can usually operate well at up to 15 Hz. These shutters may be operated at higher rates up to 40 Hz, but there will normally be specific frequencies in the higher ranges that will produce errors in motion of the shutter blade. This is the result of resonances in the mechanical and electrical systems.

If the duty cycle is substantially different from 50%, errors in movement may occur at lower frequencies. At 40 Hz, the cycle time is 25 msec., with 12.5 msec. between open and close commands. This is close to the absolute minimum time in either the open or closed state. If you attempt to reduce the time in either state below 12 msec, the controller will not start to change the shutter state until the 12-msec minimum period is over.

1.6 Controller

1.6.1 Principles of Operation

The LAMBDA 10-B controller can be operated locally (manually) from the controller keypad or remotely from a computer either through the serial or USB port. These operational modes (manual, USB, and serial) are functionally identical. Each allows the user to select:

- Filter Wheel
- Filter position
- Filter switching speed
- Shutter position
- Shutter mode

The remainder of this chapter provides a detailed description of the controller's rear panel connectors and front panel controls. Information needed to connect the power cord and filter wheel(s) is found in the FIRST TIME USE chapter. Instructions on operation of the controller and manual keypad control of the filter wheel(s) are presented in the MANUAL CONTROL chapter. The REMOTE-CONTROL chapter explains control of the unit from a remote device, as well as supplying some technical details relevant to local operation. Technical details, which are not required for operation, but which may help you understand the behavior of the unit, are found in APPENDIX A: Stepping Motor Operation.

1.6.2 Rear Panel Connectors

All electrical connections are all made on the rear panel of the LAMBDA 10-B. See the FIRST TIME USE chapter for details on connecting the power cord and filter wheel cable(s).

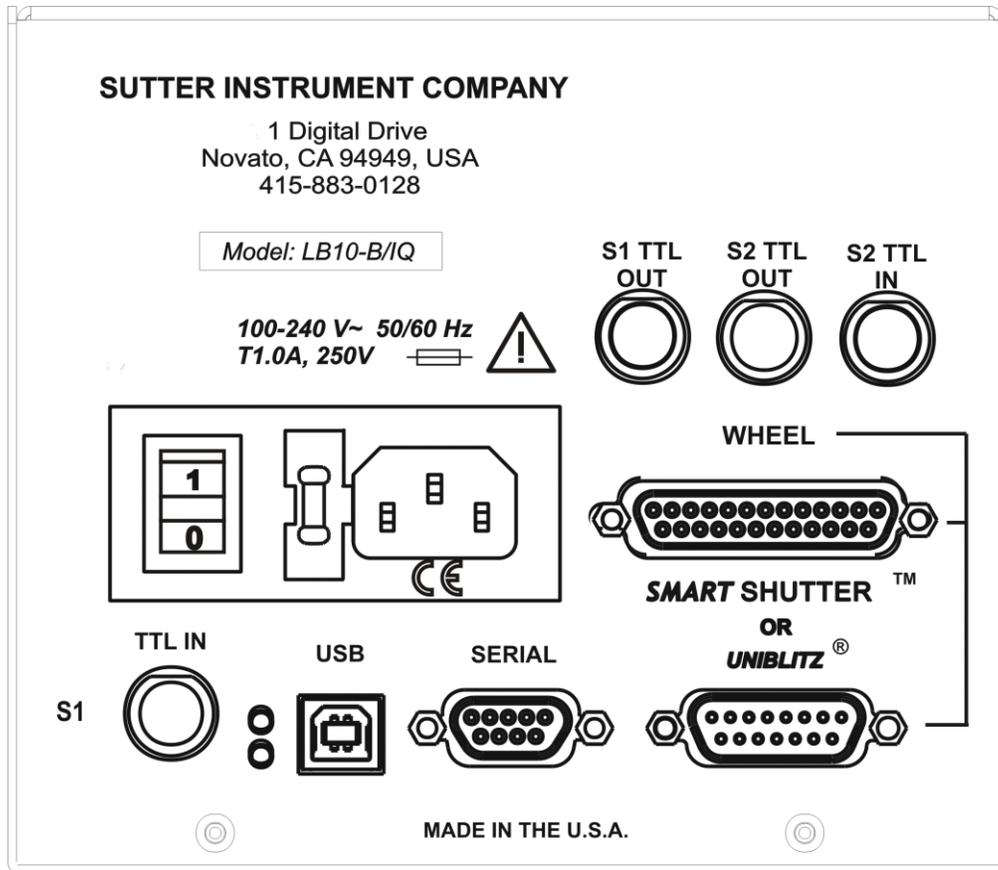


Figure 1-7 Rear panel electrical connections.

FILTER WHEEL WITH *SMARTSHUTTER* – A 25 pin, DSUB connector used to link the LAMBDA 10-B controller with the filter wheel (and *SmartShutter*, if installed), a standalone *SmartShutter*, or two *SmartShutters* via a DB25 to two DB9 split cable.

FILTER WHEEL WITH UNIBLITZ SHUTTER – A 15 pin, DSUB connector used to link the LAMBDA 10-B controller with the filter wheel (and UNIBLITZ shutter, if installed).

USB PORT – A USB Type B receptacle used to connect the LAMBDA 10-B controller as a USB device to a USB port of a host computer.

SERIAL PORT – A 9 pin, DSUB connector used for establishing a serial interface between the LAMBDA 10-B and a remote device (computer) using the cable provided. This cable should not be used simultaneously with the parallel port cable.

POWER SWITCH – This turns on the system power.

LINE POWER – This socket is used to connect the power cord to the LAMBDA 10-B.

FUSE LABEL – Information found here includes the model number of this instrument, appropriate supply voltage and the type of fuse required for the supply voltage.

FUSE – Fuse compartment containing the supply voltage fuse and an extra fuse. Replace blown fuses with a fuse of the appropriate value as given on the fuse label (back panel of the controller) or on the TECHNICAL SPECIFICATIONS page in this manual.

1.6.3 Front Panel Controls

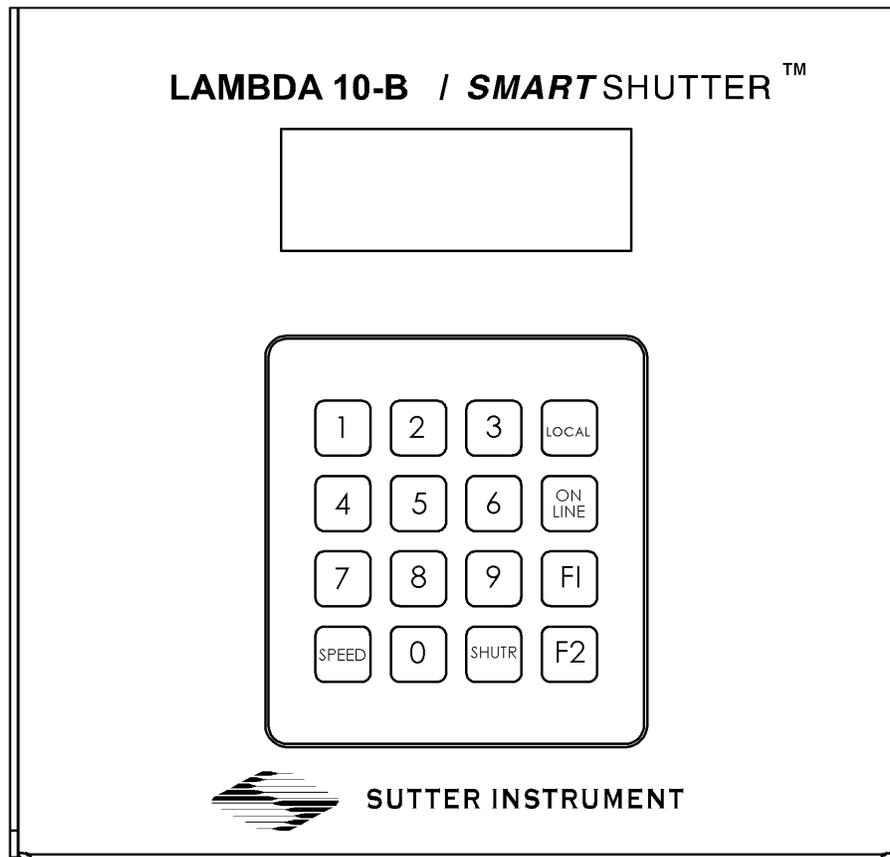


Figure 1-8. LAMBDA 10-B front panel controls.

1.6.3.1 Keypad

There are 16 keys on the LAMBDA 10-B keypad.

Numerical keys 0 to 9: These keys are used to manually select filter positions and, with the # key, to choose between the eight pre-set speeds

LOCAL: Takes the controller off-line

ON LINE: Puts the controller on-line

F1: Go to main menu.

F2: Used as “Enter” for neutral density shutter steps.

SPEED: This key is used to access the speed selection mode.

SHUTR: This key is used to manually open or close the shutter

Keys are read while depressed but the appropriate action will occur only when the key is released. If a key is pressed while a move is in progress but released after the move is over,

the key will read normally. Keys pressed and released while a move is in progress are ignored.

1.6.3.2 Display

When the controller is switched (powered) on, the controller homes all the attached filter wheels and activate all the attached shutters. During this initialization process, the following is displayed on the controller's display.

```
COPYRIGHT SUTTER
INSTRUMENT V2.13
```

After the copyright screen, the unit display should be similar to:

```
W: 25MM F0 SP1 U
S:                OFF
```

```
W: 25MM F0 SP1 L
S:                OFF
```

The first line of the status screen indicates what the filter wheel sizes are, and the position and speed setting of each. At the end of the first line is a character which indicates online/offline status of the controller (online is indicated by "U" if the USB interface is in control or "S" for the serial interface. "L" indicates local (offline) mode, allowing for keypad control).

The second line of the status screen shows the opened/closed state of the two possible shutters that can be attached to the controller. When an attached shutter is a SmartShutter, its mode is also shown.

See the next chapter for a detailed description of how to control the controller locally via the keypad and how to navigate through the various menus shown on the controller's front-panel display.

1.7 Functional Description

1.7.1 Stepping Motor Operation

Stepping motors are not as familiar to most people as the common DC motor, but there are some similarities. The DC motor consists of an armature, an electromagnet mounted on a rotating shaft, which is located inside a permanent magnet. Current is supplied to the electromagnet through brushes that rub on contacts on the armature. When the electromagnet is energized, the armature rotates to align the poles of the electromagnet with the opposite poles of the permanent magnet. Of course, before this can occur, the rotation of the armature changes the contact plates rubbing on the brushes so that the current is reversed. This causes the poles of the electromagnet to reverse, establishing a force for continued rotation. This switching action is called commutation.

In stepping motors, the rotating element, called a rotor, is generally a permanent magnet while the fixed element, the stator, is the electromagnet. The key difference between stepping motors and DC motors, however, is the method of commutation. The DC motor commutates automatically as it rotates. Thus, the timing of the commutation is determined by the speed of rotation, which may vary with the load or applied power. The commutation of the stepping motor is set by external electronics, forcing the motor to rotate at a predetermined rate. If the load is such that the motor does not have the force to produce the correct rate of rotation, the rotation will become erratic and may even reverse.

The force exerted between two magnet poles is proportional to the square of the distance between the poles. A motor with a single electromagnet and only two poles would exhibit considerable loss of power when the distance between the poles of the permanent magnet and the electromagnet was greatest. It is understandable that, in most practical DC motors, the armature has more than 2 poles. This allows the commutation to occur over a smaller angle of rotation, so that the active poles can always be relatively close to the poles of the permanent magnet.

Stepping motors are also made with multiple poles on both the rotor and stator; the exact arrangement determines the number of steps per revolution. The motor used in the LAMBDA 10-B has 200 steps per revolution (1.8 degrees per step). There are usually two windings in the stator and reversing the current on one of the windings produces a single step of rotation. Reversing the current on the second winding will then produce another step. If the first winding is then reversed again, returning to its original value, a third step will result. Finally, reversing the second winding, so that both windings are back to their original state, will produce a fourth step. This pattern may then be repeated to continue rotation in the same direction. Reversing the sequence produces steps of rotation in the opposite direction.

The rate and distance of rotation is determined by the rate and number of commutation steps. If the current is held constant in both windings, the rotor will not rotate. This makes the stepping motor ideal for producing fast start and stop movements. Some limitations should be considered. Given that there are only 4 states of the control electronics (2 polarities for each of the 2 windings) but 200 steps per revolution, it follows that, for each of these 4 states, there are 50 possible rotary positions. To establish the absolute position an external sensor must be added. Absolute position only needs to be determined once so long as the subsequent moves occur without errors.

Correct operation of stepping motors, which is outlined above, is not always obtained. If the motor lacks the torque to accelerate and decelerate the load at the rate indicated by the control electronics, the resulting move may differ from that commanded by the control electronics. For instance, if enough external force is applied, the motor shaft may be rotated even though the command signal has not changed. For small rotations (less than 3.6 degrees), the motor shaft will return to the correct position if the force is removed. For larger rotations, the shaft will stop at the nearest of the 50 correct positions for that command signal when the external force is removed.

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2. INSTALLATION

2.1 Unpacking

The LAMBDA 10-B and associated hardware comes packed in a single carton. The following is a list of the components found there. If you believe that any of these components are missing or show obvious signs of damage from shipping, please contact the factory.

- Optionally, one filter wheel: standalone, or mounted with a conventional shutter or SmartShutter.
- Optionally, one or two standalone SmartShutters or one standalone SmartShutter with a standalone filter wheel.
- LAMBDA 10-B controller
- One support base for filter wheel.
- Two support rods for filter wheel.
- Two base clamps for filter wheel.
- For each standalone 25mm SmartShutter, a mounting rod and base holder are included if ordered.
- Filter wheel to controller connecting cable (if filter wheel ordered).
 1. A 15-pin cable is used for filter wheels without a shutter mounted (standalone) or mounted with a UNIBLITZ[®] shutter.
 2. A 25-pin cable is used for filter wheels with a SmartShutter mounted.
 3. If a standalone filter wheel and a standalone Smart Shutter are to be connected, the filter wheel is connected with a 15-pin cable and the SmartShutter is connected using one end of the split cable (25-pin split to two 9-pin cables) as described next.
- Standalone SmartShutter(s) to controller connecting cable: If one or two standalone SmartShutters are to be configured, then a 25-pin cable split to two 9-pin cables is included. The 25-pin end of the cable connects to the LAMBDA 10-B controller, and the longer 9-pin split connects to the first SmartShutter (Shutter A). If only one SmartShutter is used, the second (shorter) 9-pin split is affixed with a terminator (supplied with the cable). In a two-SmartShutter configuration, the second (shorter) 9-pin split is connected to the second SmartShutter (Shutter B).
- USB interface cable (optionally for connecting to a host computer for remote control).
- 9-Pin serial interface cable (optionally for connecting to a host computer for remote control).
- Power cord.
- Two individual filter holders (if filter wheel ordered).
- Filter retaining ring and cup spanner wrench (different ones for 25, 32, or 50 mm filters).
- A disc (CD-ROM) containing the USB device drivers, and demo programs for use when either the USB port or the RS-232 serial port is used.
- Manual.
- Microscope adapters (if ordered).

Each filter wheel is shipped with nine positions of the wheel containing retaining rings, spacer rings and blanking discs. One of the individual filter holders contains the same three components. The second individual filter holder and one position of the wheel (position #1) contain only retainers and spacers.

The LAMBDA 10-B is shipped to you in a prefabricated foam mold. Please take note of this method of packaging. Should it ever be necessary to ship the LAMBDA 10-B to another location, the same method of packaging should be employed. Additional packing material may be purchased from Sutter Instruments Company.

IMPORTANT: Improper packaging is a form of abuse and, as such, can be responsible for voiding the warranty where shipping damage is sustained because of such packing.

2.2 Pre-Installation Considerations

2.2.1 Vibrations

The LAMBDA 10-B filter wheel system was designed to produce fast filter changes with a minimum of vibration. The microprocessor controls the trajectory of each move using microsteps with programmed acceleration and deceleration profiles. The result is a system so smooth that customers using the LAMBDA 10-B for the first time have called to report that their wheel isn't turning simply because they could not hear or feel anything.

Although the LAMBDA 10-B is smooth and quiet, even the slightest vibration can produce problems for the electrophysiologist. Vibration can come from several sources. The most pronounced effects normally come from the high-speed shutter if that option has been included. The shutter produces a very sharp impulse which is best avoided by finding another way of turning the light on and off, such as turning to a blanked filter position. When the motor accelerates and decelerates the filter wheel rapidly, the torque applied tends to turn the motor and the Lambda housing in the opposite direction. If the housing is not firmly attached, this may appear as vibration that increases with the selected speed and the weight of filters loaded. This is not usually a problem if the wheel is firmly mounted to a good solid surface.

Stepping motor-based systems can produce considerable vibration and noise if the rate at which steps are taken excites a system resonance. This problem is greatly reduced by decreasing the step size with microstepping. Even when microstepping is used, it is possible to produce vibration by selecting a speed that is not optimal or by starting a new move within a few milliseconds of the end of the previous move. For example, with only 2 typical filters loaded speed 1 should give a very smooth move that stops with little vibration. Speed 2, 3, and 7 may all produce more vibration at the end of a move with this load even though they are slower speeds.

At a minimum, we recommend that the LAMBDA 10-B should be firmly mounted to a solid surface by the support stand, which is included with each unit. Do not depend on the optical coupling between the microscope and the LAMBDA 10-B to support and stabilize the LAMBDA 10-B. This configuration will be adequate in many cases. If there is still too much vibration, the wheel may be mounted using the support stand, but with an air gap between the LAMBDA 10-B and the microscope.

The best cure for vibration is isolation. One simple approach is to mount the filter wheel to a wall or a separate table. If the microscope is on an air table, be aware that the microscope

might drift relative to a filter wheel mounted on a separate, stable surface. In such cases, it may be better to couple the LAMBDA 10-B to the microscope with a flexible light guide. Contact Sutter Instrument for detail of our light-guide adapter system.

2.3 Installing the Filter Wheel

If you have not yet mounted the filter wheel on the support hardware, please refer to the FIRST TIME USE chapter of this manual for instructions. Now move the mounted filter wheel to the approximate final location and adjust the filter wheel to the desired height. The filter wheel can be mounted on the posts in either orientation (optical port up or down), as required. The filter wheel can now be interfaced with other instruments (e.g., a microscope and a light source) using an appropriate adapter (Figure 2-1). If you need to purchase an adapter or require a custom adapter for your experimental setup, please contact the Technical Support staff at Sutter Instrument Company by phone (415 883-0128) or by E-mail (info@sutter.com).

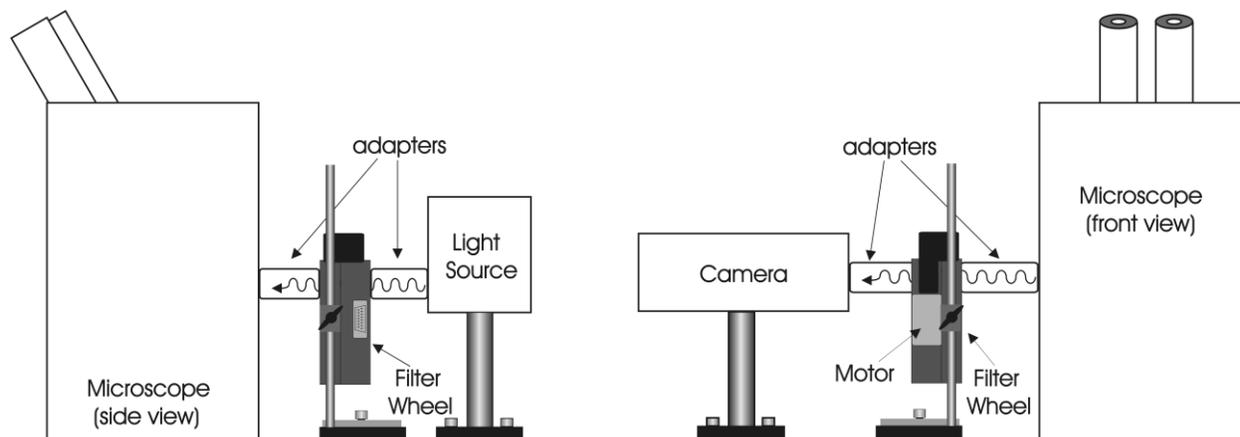


Figure 2-1. Schematic diagram of two possible experimental configurations.

The optical ports in the filter wheel housing and cover plate are threaded 1-32 (standard C-mount) allowing direct connection of like threaded devices (camera adapters, microscope adapters, etc.).



CAUTION: Take care that any devices threaded into the ports *NOT* project more than 0.180 inches (4.572 mm) into the port. Allowing threaded devices to penetrate further could result in damage to the filter wheel or filter cups.

Once the filter wheel is attached to the other instrument(s), tighten the wing screws to lock the filter wheel at its final height. The filter wheel housing is designed to be supported on the two posts included with your system. These posts can be screwed into the base provided or into any surface with 1/4"-20 holes drilled on 6" centers at an appropriate position on the tabletop or optical bench. When using the support rod base always secure it to the tabletop using the toe clamps provided with the system.

If a heavy light source is to be used (such as a vapor lamp with integral igniter) it should have its own separate support system.

If your filter wheel has a shutter, the side of the filter wheel on which the shutter is installed (the “motor side” as shown in Figure 1-2 and Figure 1-3) would typically be mounted toward the light source. Placing the shutter between the lamp and filters limits the amount of heat and light to which the filters are exposed and increases the filters’ useful lifetime.

2.4 Filter Wheel Assembly

1. Assemble the two Support Rods to the Support Base. Flats have been machined near the threaded end of these rods to facilitate tightening with a wrench. The two support-base clamps should be used to anchor the base to some convenient location for testing. These clamps are designed to allow anchoring to any of the popular hole patterns found in optical benches.
2. Slide the filter wheel down onto the support rods and lock it at a convenient height using the wing screws on the mounting ears of the filter wheel.

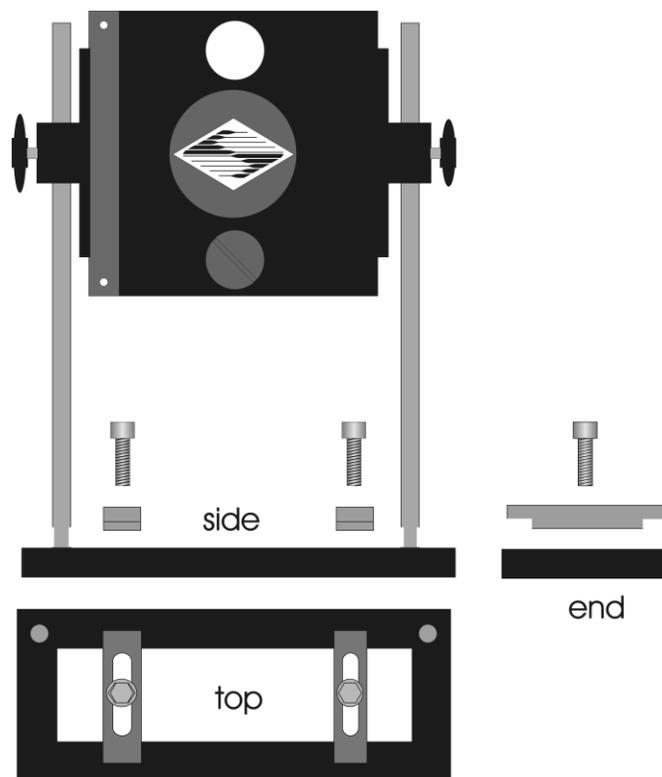


Figure 2-2. Filter wheel-mounting stand.

3. **IMPORTANT: Make sure that the LAMBDA 10-B controller has its power turned OFF before connecting any of the filter wheels or any of standalone SmartShutters to the controller!** Once the controller has been turned off, connect the controller and filter wheel with the appropriate cable provided. It is important that the screws anchoring the cable ends be tight to ensure a good connection for the motor power leads and positioning signals.

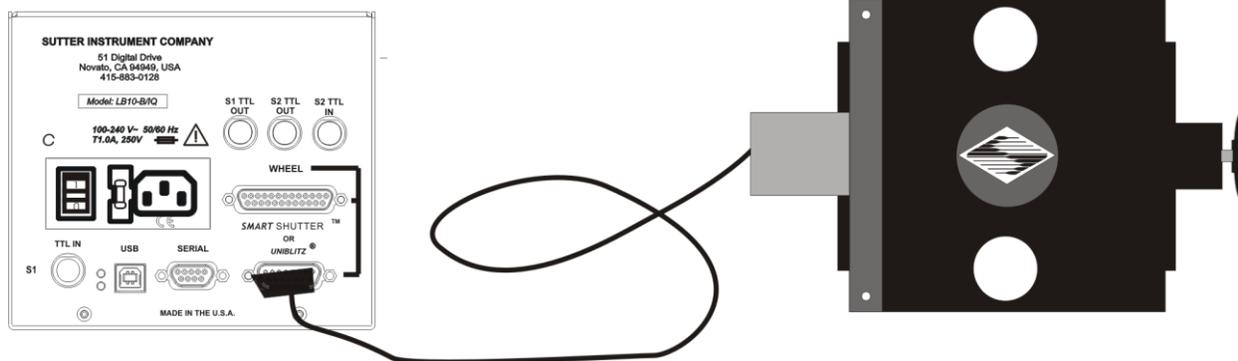


Figure 2-3. Filter wheel connection



CAUTION: DO NOT CONNECT OR DISCONNECT THE CABLES BETWEEN THE CONTROLLER AND THE MECHANICAL UNITS (FILTER WHEELS AND/OR SHUTTERS) WHILE POWER IS ON.

Please allow at least 20 seconds after turning the unit off before disconnecting the mechanical units. Failure to do this may result in damage to the electronics.

2.5 Loading Filters

2.5.1 Filter Orientation

The two sides of a filter are usually not identical due to differences in their surface coatings. Some form of labeling will be present to differentiate the two sides if this is the case. It is important to refer to the filter manufacturer's documentation to interpret the labeling and determine the proper orientation relative to the light source.

2.5.2 Filter Cups and Filter Holders

At each filter position on the filter wheel is a filter cup assembly to hold one filter. The LAMBDA 10-B 25-mm filter wheel also comes with two removable filter holders that can be placed into the optical pathway to accommodate "fixed" filters, such as neutral density filters. The style of the filter holder will either be "drop in" if no shutter is installed (Item 6 in Figure 1-1), or "slide in" if a shutter is installed (Item 6 in Figure 1-2).

There are at least two components installed into each filter cup or holder before the LAMBDA 10-B is shipped: A threaded retaining ring to secure the filter into the cup (or holder), and a spacer ring. In all but one of the filter cups, and in one of the filter holders, there will also be a blanking disc. Figure 2-4 depicts these items using the drop-in filter holder as an example.

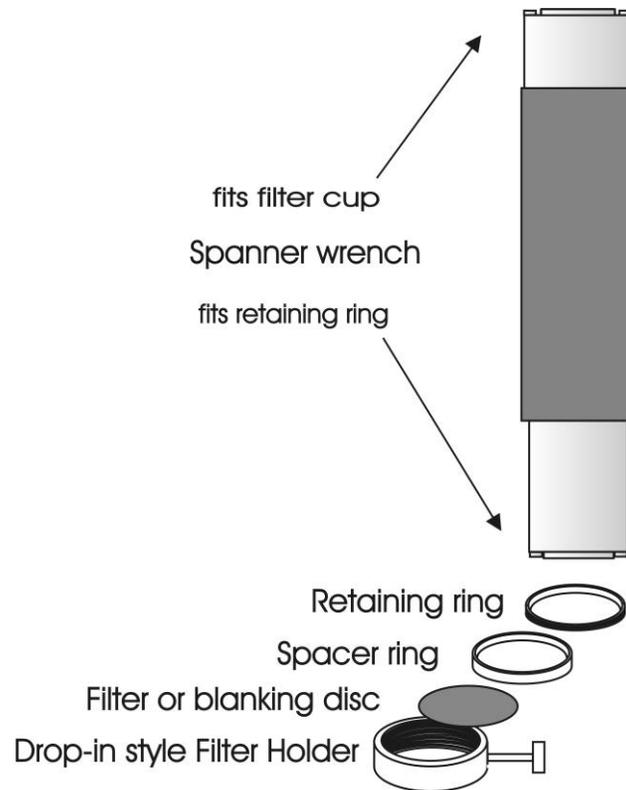


Figure 2-4. Filter holder components.

- **Retaining Ring.** This ring is threaded on its outside surface and has two slots on its top edge. The purpose of the two slots is for the removal and installation of the retaining ring when using the retaining ring driver or spanner wrench that is provided with the LAMBDA 10-B (shown in Figure 2-4). Note how the design of the spanner wrench differs between 25-, 32-, and 50-mm filter sizes.
1. **Spacer Ring.** This ring is unthreaded and serves to evenly carry the force of the retaining ring to the bottom of the filter cup or holder. It is recommended that the spacer be used anytime a blanking disc, or the filter cup or holder is installed. The spacer ring should also be used whenever the thickness of an installed filter allows its use. Maximum filter thicknesses for the filter cup and holders are specified in Table 2-1.
- **Blanking Disc.** In all but one of the filter cups (and one of the filter holders) there will also be a blanking disc. These are meant to prevent transmission of the high intensity light to the microscope through unused filter positions. This is primarily a safety feature that reduces the probability that the operator will look into the optical pathway when dangerous, high intensity, unfiltered light is present and magnified. A blanking disc in a filter cup can also function as a shutter in an experimental protocol.

Table 2-1. Maximum allowable filter thickness.

| | With Spacer | | Without Spacer | |
|------------------------|---------------|----------|----------------|----------|
| | (Millimeters) | (Inches) | (Millimeters) | (Inches) |
| Slide-In Holder | 1.38 | 0.054 | 4.56 | 0.18 |
| Drop-In Holder | 2.2 | 0.086 | 5.38 | 0.212 |
| Filter Cup | 5.89 | 0.2315 | 9.07 | 0.3575 |

2.5.3 Installation of Filters into Filter Holders

Installation of filters into the filter holders requires care and patience to avoid damaging the threads as well as the filters. The following procedures describe this process and should be practiced with a drop-in (or slide-in) filter holder before attempting to load filters into the filter cups.

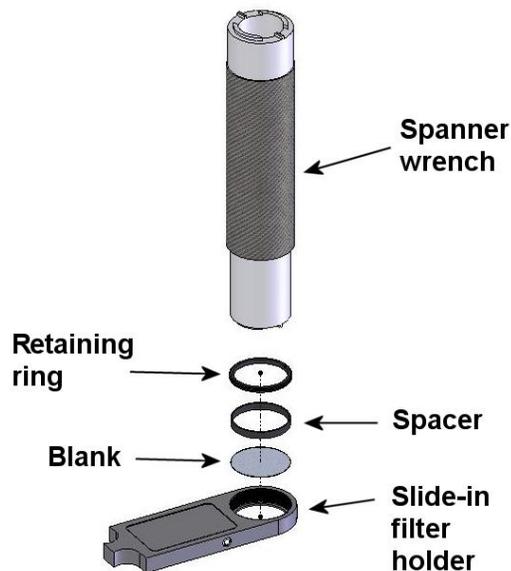


Figure 2-5. Changing filters in the Slide-In Filter Holder.

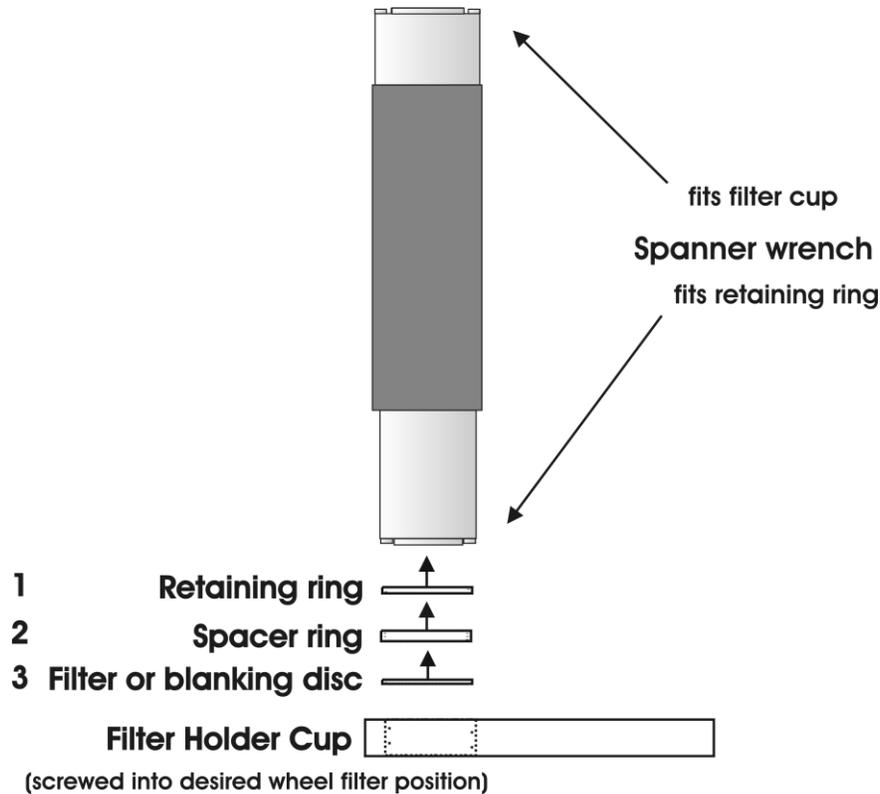


Figure 2-6. Removing the retaining ring.

The threaded retaining ring has two notches cut into it, 180 degrees apart. Place the notched end of the brass spanner wrench (Figure 2-6, right) into the notches on the retaining ring and carefully turn it counterclockwise to unscrew it.

Once the retaining ring is removed, the spacer (and blank, if present) should be easily removed. You should become familiar with the assembly of this retaining system. In particular, you should develop a feel for turning the retaining ring without pushing down on the driver or wrench. This is important because if you forcefully push on the filter holder while you are trying to load a filter, you run the risk of scratching the filter if the tool slips out of place!

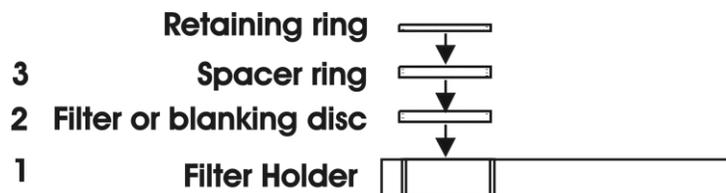


Figure 2-7. Assembly order of filter holder parts.

Place the desired filter into the filter holder, first. With some 1" filters extra care must be taken to avoid getting the filters jammed at an angle.

Next, install the spacer ring into the filter holder. Unless the filter thickness precludes the use of the spacer ring (see Figure 2-6 and Figure 2-7), always install the spacer. This helps to

provide maximum separation between the filter surface and end of the tool that is used to turn the retaining ring.

Finally, install the threaded retaining ring. **DO NOT OVER TIGHTEN THE RETAINING RING!** It need only be tightened until it is firmly seated.

2.5.4 Installation of Filters into Filter Cups

Loading filters into the filter cups on the filter wheel follows the same procedure as described above for loading filters into filter holders. There is, however, the additional complication of working through the filter wheel housing. To gain access to the filter cups on the wheel unscrew the access plug from the loading port on the motor housing (i.e., the motor side of the filter wheel). A large coin or other suitable implement can be used to remove the plug. Once removed, the retaining ring in the underlying filter cup is accessible through that port.

To align the filter position, you wish to load with the loading port, it is easiest to use the controller to identify and position the filter cups. To begin, connect the Filter Wheel to the controller (see the **FIRST TIME USE** chapter for a brief description of the principles of operation). When you first turn on the controller, the Filter Wheel will “HOME” itself, aligning the “0” filter position with the Optical Port and filter position #5 with the Loading Port. The filter currently in the Loading Port is five positions removed from the one indicated by the controller display (i.e., the one at the **OPTICAL PORT**). This relationship between the filter position indicated by the controller and the filter position at the **LOADING PORT** is illustrated in Figure 2-8.

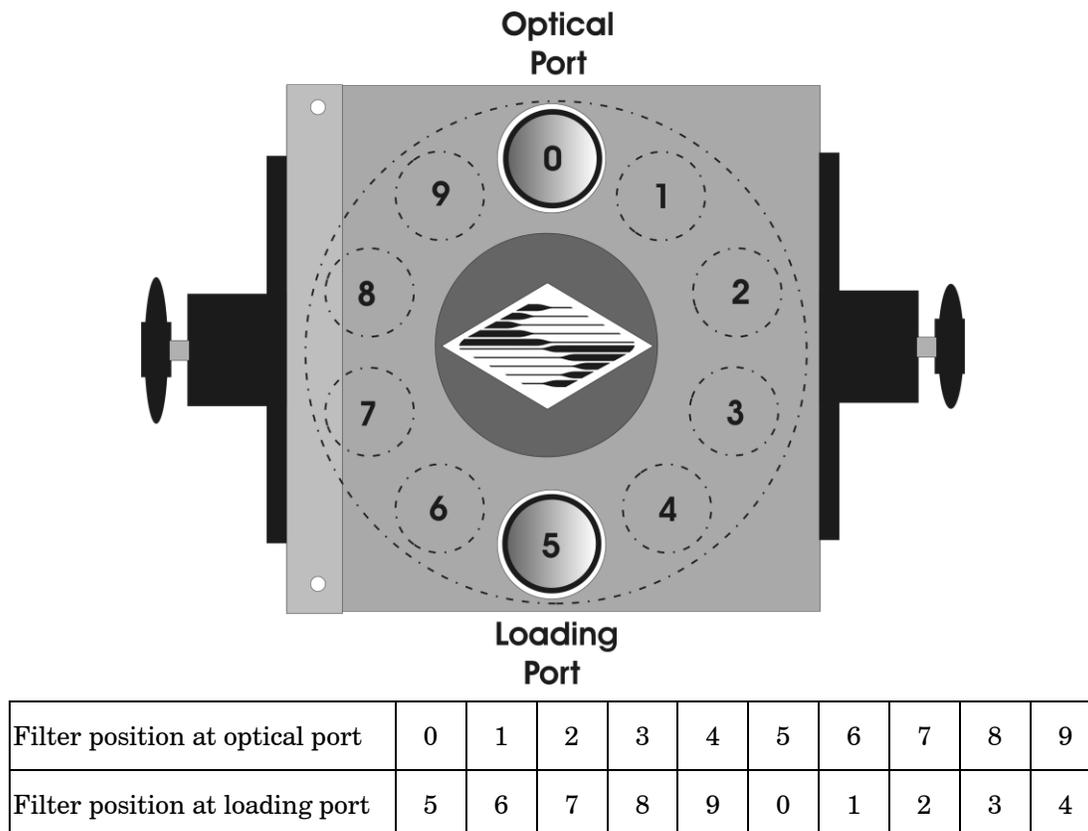


Figure 2-8. Filter ports (plug is removed from the loading port).

After identifying and positioning the filter cup to be loaded, it is advisable to turn off the controller before removing the retaining ring from the filter cup. Follow the procedures described above for installation of filters into filter holders.

CAUTION: An extra word of caution about excessive force is warranted at this point. DO NOT APPLY EXCESSIVE FORCE! Not only do you run the risk of damaging the filter but also the filter wheel itself can be permanently distorted by pushing too hard against the retaining ring with the driver or wrench. If you experience problems securing the retaining ring, back the ring off the filter cup and try again.

After loading the filter(s), check each newly loaded filter position to make sure that the retaining ring is not projecting above the top edge of the filter cup then replace the loading port plug.

Another potential complication of loading filters into the filter cups can occur if the retaining ring has been previously over-tightened. In this case, it is possible that the filter cup itself will begin to unscrew from the wheel as the retaining ring is turned. If this occurs, STOP! Turn the spanner wrench so that the widest end is toward the filter cup and slip the wrench into the two notches in the edge of the cup. Then turn the wrench clockwise to screw the cup back into the slider. DO NOT push on the cup. Just screw it in until it seats firmly. It should then be possible to remove the retaining ring as described above without the cup turning.

It may appear that removal of the cover plate from the housing would facilitate loading filters. This is not the case! Removal of the cover plate will not give you access to the filter cup side of the wheel and may lead to misalignment of and damage to the Filter Wheel. **Under no conditions should you ever remove the cover plate or the filter wheel from the motor shaft.** Removal of the cover plate or the wheel from the shaft will void your warranty.

2.6 Filter Loading Tips

2.6.1 Selection of a Filter Position

In most cases any given filter could be installed at any of the ten FILTER POSITIONS. However, some minor considerations may improve the performance of the system. Adjacent FILTER POSITIONS will require less switching time. Therefore, if an experiment requires rapid switching between two filters, they should be located next to one another. If separation by one or more occupied filter positions is necessary, keep in mind that there will be brief transitions through, possibly, undesirable wavelengths as light transmits through those intervening filter(s) unless a shutter is installed and programmed for use.

2.6.2 Use of Blanking Discs

The blanking discs should only be removed from those positions that will contain a filter. The discs are intended as a safety device to reduce the risk of the user sustaining serious and permanent eye damage from looking in the microscope when dangerous high intensity light is present. We strongly urge that the discs be used. Please be careful and avoid the possibility of direct visualization of high intensity light.

2.6.3 Neutral Density Filters

The individual filter holders are typically used for neutral density filters and are installed as described above.

2.7 Shutter Options

The LAMBDA 10-B can drive a wheel-mounted shutters or one or two standalone SmartShutters. If wheel-mounted shutter, the shutter can be either a Sutter Instrument SmartShutter or a Uniblitz shutter; whereas if two SmartShutters, then no filter wheels is allowed. In the case of the wheel, it can be either a one inch or a 32 mm wheel. A wheel with a SmartShutter installed will attach to the DB-25 connector on the back of the controller. A wheel with a Uniblitz shutter attached will connect via the DB-15 connector on the rear of the controller.

CAUTION: Do not attempt to connect more than one shutter or one wheel. Do not try to use both the DB-25 and the DB-15 connector at the same time, except when connecting a standalone filter wheel (no integrated shutter) and a standalone SmartShutter (one which is not integrated with a filter wheel). If you do not have a shutter, use the connector that matches the type on the wheel.

The controller will detect the SmartShutter, if installed. The controller will assume that there is a Uniblitz shutter if no SmartShutter is detected.

2.8 Mounting a SmartShutter in a Lambda LS

The one-inch stand-alone version of the SmartShutter can be mounted inside current versions of the Lambda LS. A male-to-male c-mount adapter is used to couple the SmartShutter to the C-mount block inside the Lambda LS. Stacking c-mount extension tubes are threaded into the other side of the SmartShutter to provide an enclosed light path from the SmartShutter to light port on the Lambda LS.

The stacking c-mount extensions that have been used in the past add 1 inch of length beyond the male threads. These pieces are stepped down in outside diameter so that they can slip inside a dovetail tube just as the lens tube does. The overall length of these tubes will be reduced by 0.070 inches so that two tubes stacked will fit between the SmartShutter and the external wall of the Lambda LS. These pieces will still be usable in conjunction with the dovetail tube to enclose the light path when no shutter or a Vincent shutter is installed. Until new parts are available, a single tube cut down by 0.14 inches can be stacked with a 1-inch tube.

Since the Lambda LS does not have any inherent capability of controlling the SmartShutter, an externally positioned LAMBDA 10-B (or another Lambda model capable of controlling a SmartShutter) can be used to control the SmartShutter. Additionally, the LAMBDA 10-B can be used to control one or two filter wheels, one of which may be installed inside the Lambda LS, and another, which may be installed on the external part of the Lambda LS cabinet.

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3. OPERATIONS

3.1 First Time Use

3.1.1 Line Power (Mains)

The power cord provided with the LAMBDA 10-B connects to the Power Entry Module located on the back of the unit (see diagram below). This module also includes the line fuse .

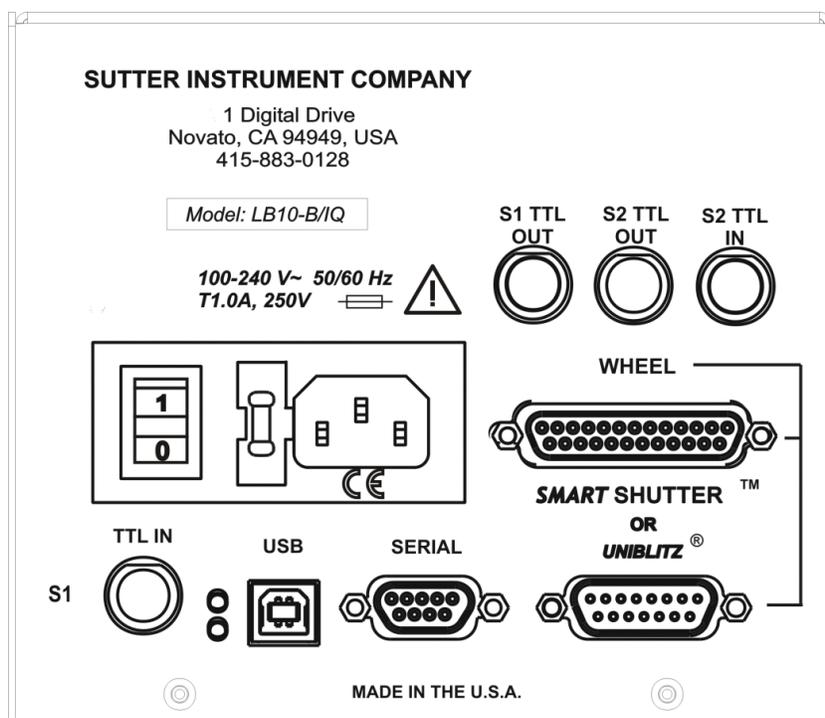


Figure 3-1. LAMBDA 10-B Cabinet (rear view).

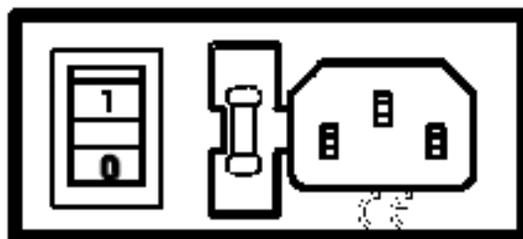


Figure 3-2. Switch, fuse, and power connection.

The power switch is located on the rear panel as shown in the figure.

The LAMBDA 10-B has a “universal” power supply that runs on 110 volts or 220 volts AC, 50 or 60 Hz. You do not need to change settings or fuses to suit local conditions. Make certain that the ON/OFF Switch located on the rear panel of the LAMBDA 10-B cabinet is turned OFF. Plug the power cord provided with the LAMBDA 10-B into the Line Input socket on the Power Entry Module and then to a power source of the appropriate voltage and frequency.

You must replace the fuse with the appropriate value (see the Technical Specifications), otherwise your protection from fire and electric shock will be compromised.

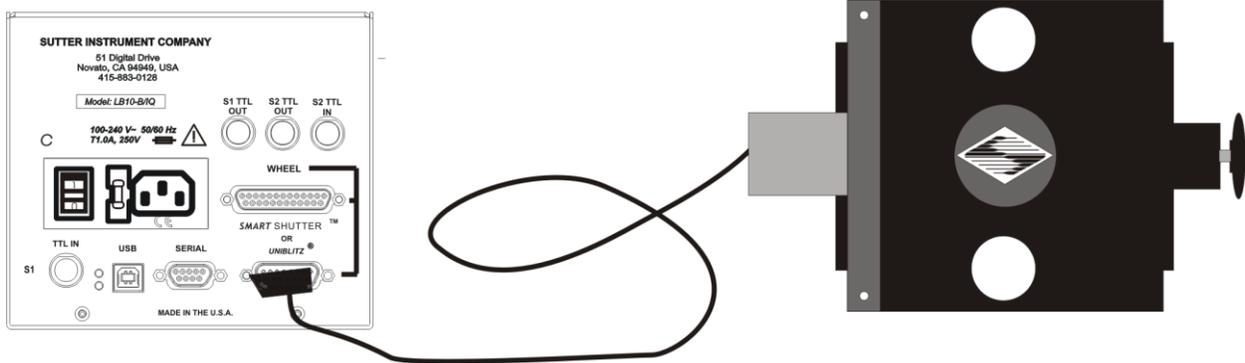


Figure 3-3. Power connection.

3.2 Basic Operation

3.2.1 Initialization

At power on the LAMBDA 10-B will rotate the filter wheel to filter position 0. If the wheel does not rotate to this position as detected by a Hall effect sensor, the display will indicate that there is an error. Once the wheel is properly initialized to filter 0, it will move to filter 9 and then back to filter 0 to complete the power on sequence. While in filter position 9 the microprocessor checks the optical sensor to determine if a full 10-position wheel is installed. If the optical switch indicates that it is not a 10-position wheel, the controller will only execute moves to filters 0 through 3.

At power on the first display will be the copyright message:

```
COPYRIGHT SUTTER
INSTRUMENT V2.13
```

After the copyright screen, the unit display should be similar to:

```
W: 25MM F0 SP1 U
S: OFF
```

Where “**W:**” is the type of wheel detected, “**F**” is the filter selected, “**SP**” is the selected speed, “**U**” is the local/on-line state, and “**S:**” is the state of the shutter.

Once the unit has been initialized, it is ready for USB or serial input. To use the keypad, press the LOCAL key. You can then select filters using the numeric keys. The action associated with a key generally occurs when the key is released. Menu choices will be covered in later sections.

3.3 Make It Go

1. Turn on the power using the ON/OFF switch on the back panel of the LAMBDA 10-B controller cabinet. The filter wheel will automatically go to the “Home” (0) filter position. The current filter position will appear on the controller front panel display.
2. The LAMBDA 10-B will default to on-line at power-on or after a reset. If the unit is connected to a USB port with properly installed software, the USB port will be selected as the default remote control interface.
3. The LAMBDA 10-B will be in the on-line mode at power on, ready for serial port or USB port commands. However, it will need a valid remote-control command to pass control to the correct input.
4. To operate in local mode, press the LOCAL key. You can then press any numeric key on the keypad to manually select the corresponding filter position.
5. Press the shutter key to toggle the shutter open and closed (if installed).

Now that you have completed this FIRST TIME USE section of this manual, you should be familiar with the basic components and the MANUAL operation of the LAMBDA 10-B. To get set up for an experimental application you will need to:

- **Install the desired filters into the FILTER WHEEL.**
- **Install the filter wheel into the optical pathway using the appropriate adapter.**
- **Establish the desired INTERFACE between the LAMBDA 10-B and your computer.**

Each of these steps is discussed in the following sections of the manual

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4. OPERATIONS: MANUAL CONTROL

4.1 Power up Sequence

The control electronics for the filter changer are activated by the POWER switch (MAINS) on the back panel of the unit. Remember, when using an arc lamp with this system it is best to turn the lamp power supply on BEFORE turning on the LAMBDA 10-B. Arc lamp power supplies produce a high voltage lamp starting pulse that may interrupt normal operation of microprocessor-controlled devices or damage electronics.

When power is applied, the **LAMBDA 10-B** performs several initial tests in order to determine the mechanical equipment attached to the controller. As part of this process, the filter wheel will rotate at a slow rate until sensors in the mechanical units signal that the “0” filter position is lined up with the optical port. The wheel will then make an additional move away from filter 0 and then back to filter 0. The controller currently automatically recognizes three different classes of filter wheels: standard 10-position, high-speed 4-position and high-current 10 position (32 mm). At power on, the LAMBDA 10-B rotates the filter wheel to filter position 0. If the wheel does not rotate to this position as detected by a Hall effect sensor, the display will indicate that there is an error. If the microprocessor detects that it is not a 10-position wheel, the controller will only execute moves to filter positions 0 through 3.

While the unit is going through these steps, the following screen is displayed:

```
COPYRIGHT SUTTER
INSTRUMENT V2.13
```

4.2 Main Status Screen

After the copyright screen, the unit display should be similar to one of the following, depending on your configuration:

4.2.1 Filter Wheel/Shutter Configuration

If the LAMBDA 10-B is configured with one filter wheel and/or one shutter, the status screen indicates the state of the filter wheel on the first line (filter size, current filter position, and current speed), and the state of the shutter (on/off), including the mode if SmartShutter.

```
W: 25MM F0 SP1 U
S:                OFF
```

4.3 Dual-SmartShutter Configuration

The LAMBDA 10-B is configured for dual-SmartShutter operation when two SmartShutters are connected to the controller with the DB25-to-two-DB9 split cable (CIQ-2). In such a configuration, no filter wheel or other shutter may be connected, and the status screen appears as follows.

```
S1: FAST    OFF U
S2: FAST    OFF
```

4.4 Placing LAMBDA 10-B into Local Mode

Once the unit has been initialized, it is ready for USB input, as indicated by the U at the right side of the first display line. Serial input can be activated as noted in the section on the serial port. To use the keypad, press the local key. When you press the local key, the last character on the first line will change from a U to an L.

```
W: 25MM F0 SP1 L
S:                               OFF
```

4.5 Immediate Key Control of Attached Devices

4.5.1 Filter Wheel and/or Shutter Configuration

Wheel Filter Position: Wheel filter positions are selected using the numeric keys. Movement to the specified filter position occurs when the key is released.

Wheel Speed: Speed can be selected by pressing the speed key followed by a numeric key. A slight pause between releasing the speed key and pressing the numeric key will ensure that the new speed is recorded. When you press the speed key, the display will switch to

```
ENTER NEW SPEED
VALUE IN 0-7
```

When you press and release a valid numeric key, the normal display will return with the new speed value. If the ENTER NEW SPEED message remains, try the numeric key again.

NOTE: Speed values above seven (7) entered through the keypad are reserved for special options and may not function properly on your unit.

Shutter Control: If a shutter is attached (integrated with the filter wheel or standalone), it's On/OFF state can be toggled using the SHUTTR key. The status screen is immediately updated with the state of the shutter.

```
W: 25MM F0 SP1 L
S:                               OFF
```

```
W: 25MM F0 SP1 L
S:                               ON
```

4.6 Main Menu (F1)

In order to access the main menu in the local mode, press F1. There will be a brief display of the message:

```
PRESS KEY 0 TO
EXIT ANYTIME!
```

The main menu, shown below, then quickly replaces the momentary screen shown previously:

| | |
|----------|------------|
| 1 - TTL | 2 - TEST |
| 3 - MODE | 4 - CONFIG |

4.6.1 TTL Shutter Control Menu (F1 1)

Pressing **1** (“1-TTL”) at the main menu (or **F1 1**), displays the menu enabling or disabling TTL input for control of the shutter

| |
|-----------------|
| 1 - ENABLE TTL |
| 2 - DISABLE TTL |

While in the *TTL Shutter Control Menu*, pressing **1** enables TTL shutter control, and pressing **2** disables it. If **1** is pressed to enable TTL shutter control, the *TTL Shutter Control Configuration Menu* is displayed as shown in the following.

| |
|--------------------|
| OPEN ON: 1 - HIGH |
| 2 - LOW 3 - TOGGLE |

4.6.1.1 Configuring TTL Shutter Control for Open on High (F1 1 1 1)

While the *TTL Shutter Control Configuration Menu* is displayed, pressing **1** (1-HIGH) configures the LAMBDA 10-B to open the shutter when the signal on TTL IN goes high.

4.6.1.2 Configuring TTL Shutter Control for Open on Low (F1 1 1 2)

While the *TTL Shutter Control Configuration Menu* is displayed, pressing **2** (2-LOW) configures the LAMBDA 10-B to open the shutter when the signal on TTL IN goes high.

4.6.1.3 Configuring TTL Shutter Control for Toggling Open and Close on High (F1 1 1 3)

While the *TTL Shutter Control Configuration Menu* is displayed, pressing **3** (3-TOGGLE) configures the LAMBDA 10-B causes the shutter to alternate between open and close on each time TTL IN goes high.

4.6.2 Test Mode Menu (F1 2)

Pressing **2** (“2-TEST”) at the main menu (or **F1 2**), displays the menu that lists the types of tests available for the LAMBDA 10-B.

| | |
|-------------|-----------|
| 1 - LOOP | 2 - SPEED |
| 3 - SHUTTER | 4 - DEMO |

4.6.2.1 Loop Test (F1 2 1)

The Loop Test is designed to perform a continuous test of all devices attached. To stop the test, press any key on the keypad.

4.6.2.2 Speed Test (F1 2 2)

The Speed Test tests all devices cycling at all the available speeds.

4.6.2.3 Shutter Test (F1 2 3)

The Shutter Test tests shutter(s). If one or two SmartShutters are attached, the Shutter Test cycles through the various SmartShutter modes during the test.

4.6.2.4 Demo (F1 2 4)

The Demo selection places the LAMBDA 10-B in demo mode, whereby the all the features of the filter wheel and/or shutter(s) are cycled through, in continuous mode.

4.6.3 SmartShutter Mode Menu (F1 3)

Pressing **3** (“3-MODE”) at the main menu (or **F1 3**), displays the menu that lists the modes available for the shutter (SmartShutter only), if installed.

| | |
|-----------------|-----------------|
| 1 - FAST | 2 - SOFT |
| 3 - ND | |

The mode selection in this menu controls the way in which the *SmartShutter* opens and closes.

4.6.3.1 Fast Mode (F1 3 1)

In the Fast mode, the SmartShutter opens and closes as quickly as possible, which is about 8 msec.

4.6.3.2 Soft Mode (F1 3 2)

In the Soft mode, the SmartShutter’s motion is slowed considerably in order to reduce the chance of producing vibration.

4.6.3.3 Neutral Density Mode (F1 3 3)

In the ND (Neutral Density) mode, the extent of opening is determined by additional numeric key presses with a value of **1** to **144**. When you have keyed in the desired value, press the F2 key to store the result. **1** produces so little movement that the shutter blade should still block the aperture, whereas **144** produces full opening. Owing to the geometry of the blade and the aperture, the amount of attenuation will not be a linear function of the value entered. In addition, partial opening may cause shading if the SmartShutter is not used in an appropriate optical system.

4.6.4 Configuration Menu (F1 4)

Select the Configuration Menu if you wish to save or restore a configuration. The following menu is displayed.

| |
|---------------------------|
| 1 - SAVE CONFIG |
| 2 - RESTORE CONFIG |

4.6.4.1 Save Configuration (F1 4 1)

If saving the configuration, the following menu is displayed providing you with the choice of three possible configurations into which to store the current configuration.

```
SAVE AS: 1-CFG1
         2-CFG2  3-CFG3
```

4.6.4.2 Restore Configuration (F1 4 2)

If restoring one of the saved configurations, the following menu is displayed providing you with the choice of three possible configurations from which to restore.

```
RESTORE: 1-CFG1
         2-CFG2  3-CFG3
```

4.7 Selecting the Filter Position

Pressing the corresponding numeric key when the controller is in the local mode chooses a filter position on the wheel. Keys are read while depressed but the appropriate action will occur only when the key is released. If a key is pressed while a move is in progress but released after the move is over, the key will read normally. Keys pressed and released while a move is in progress are ignored. The filter position currently located in the optical port will be indicated on the display (see example above).

4.8 Selecting the Filter Switching Speed

To enter the speed selection mode, press the speed key on the keypad. Speed 0 is the fastest speed and speed 7 is the slowest. Entering the selected speed under computer control is covered in a separate section.

The switching times (in milliseconds) for each of the eight speeds is given in the Table 4-1. Note that a 5-filter position move is the longest move on the 10-position filter wheel since the controller will always rotate the correct direction to make the fastest change of position. For a given speed, the time for a move to a non-adjacent filter will take about 1.8, 2.5, 3.3 or 4 times as long as a move to an adjacent filter, depending on the number of filters to be skipped. The highest speed that can be used will depend on the weight of the filters mounted in the wheel. With 2 typical filters and 8 blocking disks, adjacent filters can be changed in less than 90 milliseconds.

Table 4-1. Filter Switching Times (in milliseconds).

| Speed Setting | Number of Filter Positions Moved | | | | |
|---------------|----------------------------------|-----|------|------|------|
| | 1 | 2 | 3 | 4 | 5 |
| 0* | 31 | 51 | 74 | 95 | 115 |
| 1 | 40 | 65 | 95 | 120 | 148 |
| 2 | 44 | 75 | 105 | 136 | 168 |
| 3 | 50 | 88 | 127 | 165 | 205 |
| 4 | 60 | 108 | 156 | 205 | 250 |
| 5 | 68 | 123 | 178 | 235 | 290 |
| 6 | 124 | 235 | 350 | 460 | 580 |
| 7 | 230 | 440 | 1100 | 1100 | 1100 |

* **NOTE:** Speed 0 should be used only with 4-position filter wheels (LB10-WHS4, LB10-WHS4IQ, or LB10-WHS4E).

4.9 Selecting the Shutter Position (Open/Close)

Press the **SHUTR** key on the 10-B controller keypad to manually toggle the shutter to its open or closed position.

4.10 Shutter Movement Errors: Causes and Solutions

The **LAMBDA SMARTSHUTTER** is optimized for the fast shutter action. One element of the *SmartShutter*'s overall design that contributes to its superior performance is the acceleration and deceleration profiles that are pre-programmed into the microprocessor commanding the motor. There is a separate profile for each mode of operation. The motor commands produced from these profiles result in smooth and efficient *SmartShutter* movements.

Movement Errors After Successive Moves. The *SmartShutter* operates with great reliability for each selectable type of action. It is possible, however, to produce movement failures by combining multiple actions with short intervals between the actions. As each action ends there may be a small, brief oscillation about the new blade location. This may carry-over from the end of one move to the beginning of the next when the delay between moves is slight. This can occur even when the delay between moves is less than 50 msec. It is possible, then, to experience movement errors after changing only the delay interval between moves. If you are making moves with a short delay interval and errors are produced, it might be desirable to adjust the interval to obtain the most secure result. Experiment with small changes in the delay to find the best value and then keep the delay at that value. If you do see errors in movement, try using a long time interval (1 second) between moves to test whether the length of the interval is contributing to the error rate.

4.11 Error Detection and Recovery

The **LAMBDA 10-B** contains two sensor systems that are used to monitor the actual position of the filter wheel. After the controller sends the step sequence for a move to a new filter position, it compares the output of these sensors with the expected position. If there is no

match, the error recovery sequence is started. First, the wheel is rotated until filter 0 is in position. Then the unit continues to rotate at a slow rate until the correct filter is in position. An ERROR signal is reported to the active interface.

4.12 Movement Errors: Causes and Solutions

Filter Weight vs. Speed: The LAMBDA 10-B is optimized for the fastest exchange of 2 filters in research applications. One element of the LAMBDA 10-B's overall design that contributes to its superior performance is the acceleration and deceleration profiles that are pre-programmed into the microprocessor commanding the motor. There is a separate profile for each combination of *selected speed* and *number of positions to be moved*. The motor commands produced from these profiles result in exceedingly smooth and efficient filter wheel movements. The motor, however, is driven at its rated power which limits its ability to overcome the inertial load of the filter wheel if the weight of the wheel is increased by installing more (or heavier) filters. Increases in filter wheel weight, then, can lead to movement errors unless a slower *speed setting* is selected¹. Detection of a movement error will initiate the RECOVERY routine described above, sending the wheel to the HOME (0) position.

Oscillation when Stopping: If the desired configuration of filters in your filter wheel results in a weight that is slightly excessive for the chosen speed, the filter wheel may oscillate instead of stopping quickly when the selected filter has rotated into position. Even though this may not be detected as an error by the controller, it is advisable to use a slower speed. This will cause a slower acceleration and deceleration profile to be used and, by eliminating the oscillations, may actually allow the move to be completed more quickly.

Oscillations when Moving: Selecting a slower speed will generally eliminate errors caused by excessive total filter wheel weight, but there are other considerations. For a given weight some of the slow speeds may induce oscillations during movement. This is a result of stepping the motor near the resonance frequency (see Appendix A). Selecting a higher or lower speed will generally solve this problem.

Movement Errors after Successive Moves: With an optimal combination of speed and load-weight, it may be possible to give a new command as soon as the last move is complete. On the other hand, if the selected speed is improper for the load, as outlined above, oscillations (too small to be detected as movement errors) may be sufficient to carry-over from the end of one move to the beginning of the next. This can occur even when the delay between moves is more than 50 msec. It is possible, then, to experience movement errors after changing only the delay interval between moves. If you are making moves with a very short delay interval and errors are detected with some frequency, it is wise to consider this possibility before addressing the *selected speed*. Try using a long time interval (1 second) between moves to test whether the length of the interval is contributing to the error rate.

¹ WHY NOT JUST USE A LARGER MOTOR? As the inertia increases, the force required to achieve a given acceleration and deceleration also increases. Since the step motor in the **LAMBDA 10-C** is operated at rated power, an increase in force could only be obtained by using a larger motor. This, in fact, is not a very satisfactory solution for the following reasons. First, larger motors have a higher *intrinsic inertia*. Second, if the larger motor has a larger diameter, it would require that the filter wheel diameter also be expanded to move the filters radially so that the optical pathway clears the motor housing. Third, if the larger motor were longer, it would increase the optical path length, which is not desirable. At best, the net result of a larger motor might be a slight increase in speed when fully loaded, but at a cost of slowing the response when relatively few filters are loaded.

4.13 Helpful Tips about Movement Errors

Always determine the appropriate speed by using the same filter wheel load weight and timing intervals that will be required in your experimental protocol. There is a tendency for users to test the LAMBDA 10-B in their system using little, if any, delay between commands even though a pause occurs during an actual experiment.

If your application requires the delay between moves to be minimal, experiment with small changes in the delay to find the best value and then keep the delay at that value. If your protocol precludes you from increasing the delay, use a slower speed to eliminate the oscillation. If you cannot use a slower speed, you must reduce the filter wheel weight to eliminate the movement errors.

If the weight is clearly excessive for the chosen speed, select a slower speed. Make sure you also address the question of the delay interval before you become very serious about the speed of operation.

Remember, unless having a short delay interval is important the solution to frequent movement errors will usually require some compromise between having fast filter switching speed and having the convenience of keeping many filters loaded.

4.14 *SmartShutter* Movement Errors: Causes and Solutions

The LAMBDA *SMARTSHUTTER* is optimized for the fast shutter action. One element of the *SmartShutter*'s overall design that contributes to its superior performance is the acceleration and deceleration profiles that are pre-programmed into the microprocessor commanding the motor. There is a separate profile for each mode of operation. The motor commands produced from these profiles result in smooth and efficient *SmartShutter* movements.

4.14.1 Movement Errors after Successive Moves

The *SmartShutter* operates with great reliability for each selectable type of action. It is possible, however, to produce movement failures by combining multiple actions with short intervals between the actions. As each action ends, there may be a small, brief oscillation about the new blade location. This may carry-over from the end of one move to the beginning of the next when the delay between moves is slight. This can occur even when the delay between moves is less than 50 msec.

The 1-inch version of the *SmartShutter* can operate at opening rates up to about 20 Hz without problems. Above 20 Hz at certain frequencies, there may be frequent errors in movement. Avoid operation at these frequencies. The maximum rate of opening is about 40Hz, which normally provides solid operation.

The 35 mm version of the *SmartShutter* can operate at opening rates up to about 15 Hz without problems. Above 15 Hz at certain frequencies, there may be frequent errors in movement. Avoid operation at these frequencies. The maximum rate of opening is about 40Hz, which normally provides solid operation.

It is possible, then, to experience movement errors after changing only the delay interval between moves. If you are making moves with a short delay interval and errors are produced, it might be desirable to adjust the interval to obtain the most secure result. Experiment with small changes in the delay to find the best value and then keep the delay at

that value. If you do see errors in movement, try using a long time interval (1 second) between moves to test whether the length of the interval is contributing to the error rate.

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5. EXTERNAL COMMAND CONTROL OPERATIONS OVERVIEW

The remote control of the LAMBDA 10-B can be achieved by issuing commands on a remote computer and transmitting them to the LAMBDA 10-B over a **serial** (RS-232) or **USB** (Universal Serial Bus) connection. This chapter provides a description of these commands and how they are used. Limited remote control can also be achieved with a TTL connection, a description for which is provided later in this manual.

The following table shows how remote commands are categorized.

Table 5-1. Remote Control Command Categories.

| Category | Description |
|------------------|--|
| Filter commands | These are commands used exclusively for controlling filter wheels. |
| Shutter commands | These are commands used exclusively for controlling shutters (<i>SmartShutters</i> and/or Vincent shutters). |
| Special commands | These are commands for the general control of the LAMBDA 10-B controller and are not specifically related to either filter wheels or shutters. |

Most of the commands described in this chapter are ones that are sent from the computer to the LAMBDA 10-B. Some of these commands will cause the LAMBDA 10-B to return certain special codes or one or more bytes of data. Some commands must be followed by one or more bytes containing parameters. For each byte sent to the LAMBDA 10-B, that same byte is echoed (transmitted) back to the remote computer as confirmation that the byte was received. This echoing back of command bytes in no way indicates validation of a command or parameter, but rather is an acknowledgement on the part of the controller that it has received the byte. When the LAMBDA 10-B controller has finished performing the task associated with a command (or command followed by one or more parameter bytes), the controller will transmit to the host computer an ASCII carriage return (CR, 13 decimal, or 0D hexadecimal) as an indication that function associated with the command has completed and that the controller is now ready for another command. This echoing back of bytes sent by the remote computer to the controller, and the return of an ASCII carriage return after a command's task is complete, is the same for both serial and USB interfaces.

5.1 Input Command Structure

5.1.1 Commands Description

The following table provides a complete list of all the remote commands for the LAMBDA 10-B.

The following table provides a list of all the remote control commands.

Table 5-2. External Commands.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|---|---------------------|------|----------------|--------------------------|--|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Set filter wheel, speed, and position | Tx | All | 1 | 0 | (See the following tables for possible value ranges and filter command structure.) | | | | | | Sets the filter wheel speed (0 – 7) and the filter position (0 – 9). Note that for the LAMBDA 10-B, the most significant bit (Bit 7) of the command byte is always 0. The filter wheel speed is encoded in octal (base 8) using Bits 6, 5, & 4. The filter position is encoded in BCD (Binary Coded Decimal) using the least significant nibble (Bits 3, 2, 1, & 0). |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter A | Tx | All | 1 | 0 | 170 | AA | 1010 1010 | 0170 | | | Sets the state of Shutter A to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter A Conditionally | Tx | All | 1 | 0 | 171 | AB | 1010 1011 | 0171 | | | Configures Shutter A to open while filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter A | Tx | All | 1 | 0 | 172 | AC | 1010 1100 | 0172 | | | Sets the state of Shutter A closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter B | Tx | All | 1 | 0 | 186 | BA | 1011 1010 | 0186 | | | Sets the state of Shutter B to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter B | Tx | All | 1 | 0 | 188 | BC | 1011 1100 | 0188 | | | Sets the state of Shutter B closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Status | Tx | All | 1 | 0 | 204 | CC | 1100 1100 | 0204 | | | Returns status of unit (see status table) |
| | Rx | All | | 13 | 13 | 0D | 0000 1101 | | ^M | <CR> | Completion indicator |
| All Motors Power On | Tx | All | 1 | 0 | 206 | CE | 1100 1110 | 0206 | | | Instruct the controller to power on all motors. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| All Motors Power Off | Tx | All | 1 | 0 | 207 | CF | 1100 1111 | 0207 | | | Instruct the controller to power off all motors. |

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|--|---------------------|------|----------------|--------------------------|-------|-----------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Fast-mode Shutter | Tx | All | 2 | 0 | 220 | DC | 1101 1100 | 0220 | | | Sets fast mode (SmartShutter only) |
| | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Soft-mode Shutter | Tx | All | 2 | 0 | 221 | DD | 1110 1101 | 0221 | | | Sets soft mode (SmartShutter only) |
| | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Neutral Density-mode Shutter | Tx | All | 3 | 0 | 222 | DE | 1110 1110 | 0222 | | | Sets neutral-density mode (SmartShutter only) |
| | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |
| | | | | 2 | 1 | 01 | 0000 0001 | 0001 | | | 3 rd byte contains 1 - 144 indicating microsteps |
| | 144 | 90 | 1001 0000 | | 0144 | | | | | | |
| Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator | |
| Transfer to On Line | Tx | All | 1 | 0 | 238 | EE | 1110 1110 | 0238 | | | Puts controller on-line |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Transfer to Local | Tx | All | 1 | 0 | 239 | EF | 1110 1111 | 0239 | | | Puts controller in local mode |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Reset | Tx | All | 1 | 0 | 251 | FB | 11111011 | 0251 | | | Resets the controller |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Get Controller Type and Configuration | Tx | All | 1 | 0 | 253 | FD | 11111011 | 0253 | | | Queries the controller as to its type and configuration (see controller type & config, table) |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

* Note: Commands marked with * are not available in early versions of the LAMBDA 10-B (those prior to Revision D).

Commands sent to the controller via the serial or USB interface are structured in a one-byte (8-bit) signal. Some commands are followed by one or more bytes containing additional parameter information for the command. The 8 bits can be used to convey three types of commands.

- **Filter Commands.** These commands select the desired filter position and switching speed. The filter position and switching speed are each specified by the encoding of specific bits within the command byte.
 - The filter position is specified in the least significant 4 bits (nibble) of the byte (Bits 3, 2, 1, and 0), providing value range of 0 through 9. Because only 10 possible filter positions are encoded in these bits, they are effectively encoded in Binary Coded Decimal (BCD) format, leaving the values of 10 through 15 (decimal) available for use by Shutter and Special commands.
 - The filter switching speed is specified in the least significant 3 bits within the most significant nibble of the byte (Bits 6, 5, & 4), providing a value range of 0 through 7. These bits are interpreted as the filter switching speed only if the bits in the lower nibble of the byte contain a value of 0 through 9, specifying the filter position as described previously
 - The filter wheel selection is specified in the most significant bit of the byte (Bit 7). Because the LAMBDA 10-B supports only one filter wheel, Bit 7 of the command byte is always set to 0.
- **Shutter Commands.** These commands control the open and closed states of shutters as well as various modes in which *SmartShutters* can operate.
- **Special Commands.** These commands are used to control various aspects of the controller that are not specifically related to either filters or shutters. Some of these commands are also used to obtain status and configuration information of the controller.

The microprocessor in the controller is programmed to distinguish between these two types of Input Commands based on the bit pattern of the Command and will respond accordingly. These two types of Commands are discussed in more detail in the following sections.

5.2 Filter Wheel Commands

A byte command sent to the controller that contains a value from 0 through 121 decimal (00 through 79 hexadecimal) is interpreted as a Filter Wheel Command. Within a Filter Wheel Command byte, three parameters are encoded: Filter Wheel, Speed, and Position. The accommodation of these three parameters within a single byte is accomplished by breaking up the byte into three parts: two bit groups, and one single bit, as follows.

- **WHEEL BIT:** In Sutter's Lambda 10-2 Filter Wheel this bit selects the filter wheel to which the Filter and Speed commands will be directed. The model 10-B filter wheel, however, does not support a second wheel and this bit should always be low. Some models of the Lambda series of controllers support the connecting of two filter wheels at a time, and thus the filter wheel bit (Bit 7) is used to select the filter wheel. The LAMBDA 10-B controller, however, supports only one filter wheel, so the filter wheel bit (Bit 7) is always 0.
- **SPEED GROUP:** These 3 bits select the speed of movement used in advancing to the next filter. The speed group is treated as a three-place binary number whose equivalent decimal value, 0 through 7, correspond to the selected speed.
- **FILTER POSITION GROUP:** This group consists of all 4 bits within the lower nibble of the byte (the least significant 4 bits of the byte). These 4 bits select the desired filter (i.e., the filter wheel position). This group is treated as a four-place binary number, with the equivalent decimal values 0 through 9 corresponding to the selected filter position. These four bits can also be thought of as containing a BCD (Binary Coded Decimal) value, since

BCD always use four bits to encode only decimal values 0 through 9. Values 10 through 15 decimal (A through F hexadecimal) in these four bits are currently undefined and should never occur. Binary codes with decimal values greater than 9 are ignored, unless the binary value (in conjunction with the SPEED GROUP bits) corresponds with the decimal equivalent of one of the Special Command Codes listed later in this chapter (see).

To send a Filter Command via the USB port the binary value must first be determined for the desired Filter Position and Switching Speed (4 bits and 3 bits, respectively). As mentioned above, the Filter Wheel (1 bit) will always be 0. Then these 8 bits must be set, in the proper order, on the controller's USB port, as shown below.

Table 5-3. Filter Command Structure.

| Byte Bit # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|--------------------------|-------|-----------|---|---|-----------------|---|---|---|
| Group | Wheel | Speed | | | Filter Position | | | |
| Group Bit # | 0 | 2 | 1 | 0 | 3 | 2 | 1 | 0 |
| Decimal Group Values | 0 | 0 - 7 | | | 0 - 9 | | | |
| Hexadecimal Group Values | 0 | 0 - 7 | | | 0 - 9 | | | |
| Binary Group Values | 0 | 000 - 111 | | | 0000 - 1001 | | | |

In the above table, "Decimal Group Values" are equivalent to the values of the desired Filter Wheel (always 0), Switching Speed (0 through 7) and Filter Position (0 through 9). Their hexadecimal and binary equivalents are shown as the "Hexadecimal Group Values" and "Binary Group Values", respectively. These 8 bits are the raw data, then, that serve as a Filter Command to select the Filter Position and Switching Speed via the LAMBDA 10-B controller's serial and USB ports. The Wheel bit (Bit 7) is used to select the filter wheel in models of the Lambda 10 series that support more than one filter wheel; since the LAMBDA 10-B supports only a single filter wheel, Bit 7 should always be set to zero. In summary, the controller will treat any byte it receives from the remote computer as a "filter command" if the byte's least significant nibble contains a value of 0 through 9. If the received byte's least significant nibble contains a decimal value of 10 through 15, then the controller treats the entire byte as a "special command" or "shutter command".

5.2.1 Filter Wheel Command Byte Encoding

The following formula may be used to encode all three filter wheel commands into a single byte. All values are in decimal):

$$wheel + (speed * 16) + position = \text{command byte}$$

Where:

wheel = 0 (always 0 in the LAMBDA 10-B since only one filter wheel is supported)

speed = 0 through 7

position = 0 through 9

Table 5-4. Codes for filter wheel configuration.

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description Shutter or Special Command |
|------------|------|----------|------------------|------------|-------------------|-----------------------|-----------------------|----------------------------|--|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W h e e l | S p e e d | F i l t e r | |
| 0 | 00 | 00000000 | Alt-0000 | ^@ | (NUL) | A | 0 | 0 | |
| 1 | 01 | 00000001 | Alt-0001 | ^A | (SOH) | | | 1 | |
| 2 | 02 | 00000010 | Alt-0002 | ^B | (STX) | | | 2 | |
| 3 | 03 | 00000011 | Alt-0003 | ^C | (ETX) | | | 3 | |
| 4 | 04 | 00000100 | Alt-0004 | ^D | (EOT) | | | 4 | |
| 5 | 05 | 00000101 | Alt-0005 | ^E | (ENQ) | | | 5 | |
| 6 | 06 | 00000110 | Alt-0006 | ^F | (ACK) | | | 6 | |
| 7 | 07 | 00000111 | Alt-0007 | ^G | (BEL) | | | 7 | |
| 8 | 08 | 00001000 | Alt-0008 | ^H | (BS) | | | 8 | |
| 9 | 09 | 00001001 | Alt-0009 | ^I | (HT) | | | 9 | |
| 10 | 0A | 00001010 | Alt-0010 | ^J | (LF) | A | 1 | 0 | |
| - | - | - | - | - | - | | | 1 | |
| 15 | 0F | 00001111 | Alt-0015 | ^O | (SI) | | | 2 | |
| 16 | 10 | 00010000 | Alt-0016 | ^P | (DLE) | | | 3 | |
| 17 | 11 | 00010001 | Alt-0017 | ^Q | (DC1) | | | 4 | |
| 18 | 12 | 00010010 | Alt-0018 | ^R | (DC2) | | | 5 | |
| 19 | 13 | 00010011 | Alt-0019 | ^S | (DC3) | 6 | | | |
| 20 | 14 | 00010100 | Alt-0020 | ^T | (DC4) | 7 | | | |
| 21 | 15 | 00010101 | Alt-0021 | ^U | (NAK) | 8 | | | |
| 22 | 16 | 00010110 | Alt-0022 | ^V | (SYN) | 9 | | | |
| 23 | 17 | 00010111 | Alt-0023 | ^W | (ETB) | A | 2 | 0 | |
| 24 | 18 | 00011000 | Alt-0024 | ^X | (CAN) | | | 1 | |
| 25 | 19 | 00011001 | Alt-0025 | ^Y | (EM) | | | 2 | |
| 26 | 1A | 00011010 | Alt-0026 | ^Z | (SUB) | | | 3 | |
| - | - | - | - | - | - | | | 4 | |
| 31 | 1F | 00011111 | Alt-0031 | ^_ | (US) | | | 5 | |
| 32 | 20 | 00100000 | Alt-0032 | | (space) | A | 3 | 0 | |
| 33 | 21 | 00100001 | Alt-0033 | | ! | | | 1 | |
| 34 | 22 | 00100010 | Alt-0034 | | " | | | 2 | |
| 35 | 23 | 00100011 | Alt-0035 | | # | | | 3 | |
| 36 | 24 | 00100100 | Alt-0036 | | \$ | | | 4 | |
| 37 | 25 | 00100101 | Alt-0037 | | % | | | 5 | |
| 38 | 26 | 00100110 | Alt-0038 | | & | | | 6 | |
| 39 | 27 | 00100111 | Alt-0039 | | ' | | | 7 | |
| 40 | 28 | 00101000 | Alt-0040 | | (| | | 8 | |
| 41 | 29 | 00101001 | Alt-0041 | |) | | | 9 | |
| 42 | 2A | 00101010 | Alt-0042 | | * | A | 3 | 0 | |
| - | - | - | - | | - | | | 1 | |
| 47 | 2F | 00101111 | Alt-0047 | | / | | | 2 | |
| 46 | 30 | 00110000 | Alt-0048 | | 0 | | | 3 | |
| 49 | 31 | 00110001 | Alt-0049 | | 1 | | | 4 | |
| 50 | 32 | 00110010 | Alt-0050 | | 2 | | | 5 | |
| 51 | 33 | 00110011 | Alt-0051 | | 3 | | | | |
| 52 | 34 | 00110100 | Alt-0052 | | 4 | | | | |
| 53 | 35 | 00110101 | Alt-0053 | | 5 | | | | |

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description |
|------------|------|----------|------------------|------------|-------------------|-----------------------|-----------------------|----------------------------|-------------------------------|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W h e e l | S p e e d | F i l t e r | |
| 54 | 36 | 00110110 | Alt-0054 | | 6 | | | 6 | Shutter or Special Command |
| 55 | 37 | 00110111 | Alt-0055 | | 7 | | | 7 | |
| 56 | 38 | 00111000 | Alt-0056 | | 8 | | | 8 | |
| 57 | 39 | 00111001 | Alt-0057 | | 9 | | | 9 | |
| 58 | 3A | 00111010 | Alt-0058 | | : | | | | Shutter or Special Command |
| - | - | - | - | | - | | | | |
| 63 | 3F | 00111111 | Alt-0063 | | ? | | | | |
| 64 | 40 | 01000000 | Alt-0064 | | @ | | | 0 | Shutter or Special Command |
| 65 | 41 | 01000001 | Alt-0065 | | A | | | 1 | |
| 66 | 42 | 01000010 | Alt-0066 | | B | | | 2 | |
| 67 | 43 | 01000011 | Alt-0067 | | C | | | 3 | |
| 68 | 44 | 01000100 | Alt-0068 | | D | A | 4 | 4 | |
| 69 | 45 | 01000101 | Alt-0069 | | E | | | 5 | |
| 70 | 46 | 01000110 | Alt-0070 | | F | | | 6 | |
| 71 | 47 | 01000111 | Alt-0071 | | G | | | 7 | |
| 72 | 48 | 01001000 | Alt-0072 | | H | | | 8 | |
| 73 | 49 | 01001001 | Alt-0073 | | I | | | 9 | |
| 74 | 4A | 01001010 | Alt-0074 | | J | | | | Shutter or Special Command |
| - | - | - | - | | - | | | | |
| 79 | 4F | 01001111 | Alt-0079 | | O | | | | |
| 80 | 50 | 01000000 | Alt-0080 | | P | | | 0 | |
| 81 | 51 | 01000001 | Alt-0081 | | Q | | | 1 | |
| 82 | 52 | 01000010 | Alt-0082 | | R | | | 2 | |
| 83 | 53 | 01000011 | Alt-0083 | | S | | | 3 | |
| 84 | 54 | 01000100 | Alt-0084 | | T | A | 5 | 4 | |
| 85 | 55 | 01000101 | Alt-0085 | | U | | | 5 | |
| 86 | 56 | 01000110 | Alt-0086 | | V | | | 6 | |
| 87 | 57 | 01000111 | Alt-0087 | | W | | | 7 | |
| 88 | 58 | 01001000 | Alt-0088 | | X | | | 8 | |
| 89 | 59 | 01001001 | Alt-0089 | | Y | | | 9 | |
| 90 | 5A | 01001010 | Alt-0090 | | Z | | | | Shutter or Special Command |
| - | - | - | - | | - | | | | |
| 95 | 5F | 01011111 | Alt-0095 | | | | | | |
| 96 | 60 | 01010000 | Alt-0096 | | ` | | | 0 | Shutter or Special Command |
| 97 | 61 | 01010001 | Alt-0097 | | a | | | 1 | |
| 98 | 62 | 01010010 | Alt-0098 | | b | | | 2 | |
| 99 | 63 | 01010011 | Alt-0099 | | c | | | 3 | |
| 100 | 64 | 01010100 | Alt-0100 | | d | | | 4 | |
| 101 | 65 | 01010101 | Alt-0101 | | e | A | 6 | 5 | |
| 102 | 66 | 01010110 | Alt-0102 | | f | | | 6 | |
| 103 | 67 | 01010111 | Alt-0103 | | g | | | 7 | |
| 104 | 68 | 01011000 | Alt-0104 | | h | | | 8 | |
| 105 | 69 | 01011001 | Alt-0105 | | i | | | 9 | |
| 106 | 6A | 01011010 | Alt-0106 | | j | | | | Shutter or Special Command |
| - | - | - | - | | - | | | | |
| 111 | 6F | 01011111 | Alt-0111 | | o | | | | |
| 112 | 70 | 01110000 | Alt-0112 | | p | A | 7 | 0 | |

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description |
|------------|------|----------|------------------|------------|-------------------|-----------------------|-----------------------|----------------------------|-------------------------------|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W h e e l | S p e e d | F i l t e r | |
| 113 | 71 | 01110001 | Alt-0113 | | q | | | 1 | Shutter or Special Command |
| 114 | 72 | 01110010 | Alt-0114 | | r | | | 2 | |
| 115 | 73 | 01110011 | Alt-0115 | | s | | | 3 | |
| 116 | 74 | 01110100 | Alt-0116 | | t | | | 4 | |
| 117 | 75 | 01110101 | Alt-0117 | | u | | | 5 | |
| 118 | 76 | 01110110 | Alt-0118 | | v | | | 6 | |
| 119 | 77 | 01110111 | Alt-0119 | | w | | | 7 | |
| 120 | 78 | 01111000 | Alt-0120 | | x | | | 8 | |
| 121 | 79 | 01111001 | Alt-0121 | | y | | | 9 | |

NOTES:

- Task-Complete Indicator:** All commands will send back to the computer the “Task-Complete Indicator” to signal the command and its associated function in controller is complete. The indicator consists of one (1) byte containing a value of 13 decimal (0D hexadecimal), and which represents an ASCII CR (Carriage Return).
- Intercommand Delay:** A short delay (usually around 2 ms) is recommended between commands (after sending a command sequence and before sending the next command).
- Clearing Send/Receive Buffers:** Clearing (purging) the transmit and receive buffers of the I/O port immediately before sending any command is recommended.
- Encoding a Command:** Encoding filter wheel commands into a single byte:

$$\text{Command byte} = (\textit{wheel} * 128) + (\textit{speed} * 16) + \textit{position}$$
Where
 $\textit{wheel} = 0$ (Wheel A),
 $\textit{speed} = 0$ through 7, and
 $\textit{position} = 0$ through 9.
- Use of Bit 7:** The LAMBDA 10-B supports only one filter wheel (Wheel A). Therefore, Bit 7 should always be set to 0.
- ASCII Definition Character Codes 128 through 255:** The “ASCII def./char.” column for codes 128 through 255 (80 through FF hex) is left blank, since there are no ASCII character definitions for the codes in this range. However, many computers and operating systems do support characters within this range, although there is no single standard across all platforms. Furthermore, many operating systems, such as Microsoft Windows and Apple Mac OS X, have several “code pages” (character sets), many of which are country/language specific, from which the user can select. Therefore, this part of the table is left blank – if you wish, you may write in the characters defined in the character set you use on a regular basis.
- Commands prior to Rev. D:** All commands indicated with “*” are not available in early versions of the LAMBDA 10-B (those prior to Revision D).

5.3 Shutter Commands

When the 8-bit command is identified by the controller as one which is not a filter wheel command, the entire byte is then treated as either a “special” or “shutter” command. Shutter Commands are described in the following table, along with the decimal, hexadecimal and binary values that encode them. The paragraphs that follow the table describe these commands in more detail.

Table 5-5. Shutter open/close commands.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|------------------------------------|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Open Shutter A | Tx | All | 1 | 0 | 170 | AA | 1010 1010 | 0170 | | | Sets the state of Shutter A to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter A Conditionally | Tx | All | 1 | 0 | 171 | AB | 1010 1011 | 0171 | | | Configures Shutter A to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter A | Tx | All | 1 | 0 | 172 | AC | 1010 1100 | 0172 | | | Sets the state of Shutter A closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter B | Tx | All | 1 | 0 | 186 | BA | 1011 1010 | 0186 | | | Sets the state of Shutter B to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter B Conditionally | Tx | All | 1 | 0 | 187 | BB | 1011 1011 | 0187 | | | Configures Shutter B to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter B | Tx | All | 1 | 0 | 188 | BC | 1011 1100 | 0188 | | | Sets the state of Shutter B closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter C | Tx | All | 1 | 0 | 235 | EB | 1110 1011 | 0235 | | | Sets the state of Shutter C to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter C Conditionally | Tx | All | 1 | 0 | 236 | EC | 1110 1100 | 0236 | | | Configures Shutter C to open while the filter wheel is stopped. The shutter will |

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|-----------------|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|---|
| | | | | | Dec. | Hex. | Binary | | | | |
| | | | | | | | | | | | close each time the filter wheel moves and then will open again at the end of the move. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter C | Tx | All | 1 | 0 | 237 | ED | 1110 1101 | 0237 | | | Sets the state of Shutter C closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

NOTE: All commands indicated with "*" are not available in early versions of the LAMBDA 10-B (those prior to Revision D).

The following two tables described the formats for the SmartShutter mode commands in the "Wheel/Shutter" configuration versus the "Dual-Shutter Configuration".

Table 5-6. SmartShutter Mode commands in the "Wheel/Shutter" configuration.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|------------------------------|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Fast-mode Shutter | Tx | All | 1 | 0 | 220 | DC | 1101 1100 | 0220 | | | Sets fast mode (SmartShutter only) |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Soft-mode Shutter | Tx | All | 1 | 0 | 221 | DD | 1110 1101 | 0221 | | | Sets soft mode (SmartShutter only). |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Neutral Density-mode Shutter | Tx | All | 2 | 0 | 222 | DE | 1110 1110 | 0222 | | | Sets neutral-density mode (SmartShutter only). |
| | | | | 2 | 1 | 01 | 0000 0001 | 0001 | | | 2 nd byte contains 1 - 144 indicating microsteps. |
| | | | | | 144 | 90 | 1001 0000 | 0144 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

Table 5-7. SmartShutter Mode commands in the "Dual-SmartShutter" configuration.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|-------------------|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Fast-mode Shutter | Tx | All | 2 | 0 | 220 | DC | 1101 1100 | 0220 | | | Sets fast mode (SmartShutter only) |
| | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2). |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

| Command | Tx/- Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|------------------------------------|----------------------|------|----------------|--------------------------|-------|-----------|-----------|---|---------------|--------------------------|---|
| | | | | | Dec. | Hex. | Binary | | | | |
| Soft-mode Shutter | Tx | All | 2 | 0 | 221 | DD | 1110 1101 | 0221 | | | Sets soft mode (SmartShutter only). |
| | | | | 1 | - | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2). |
| | | | | 3 | - | 02 | 0000 0011 | 0003 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Neutral Density-mode Shutter | Tx | All | 3 | 0 | 222 | DE | 1110 1110 | 0222 | | | Sets neutral-density mode (SmartShutter only). |
| | | | | 1 | - | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2). |
| | | | | | 3 | 03 | 0000 0011 | 0003 | | | |
| | 2 | - | 01 | 0000 0001 | 0001 | | | 3 rd byte contains 1 - 144 indicating microsteps. | | | |
| | | | | 144 | 90 | 1001 0000 | 0144 | | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

The following paragraphs describe the shutter commands in more detail.

5.3.1 Open Shutter A

Sets Shutter A to the open state.

5.3.2 Open Shutter A Conditionally

Configures Shutter A to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move.

5.3.3 Close Shutter A

Sets Shutter B to the closed state.

5.3.4 Open Shutter B

Sets Shutter B to the open state.

5.3.5 Open Shutter B Conditionally

Same as the “Open Shutter A Conditionally” command, but applicable to Shutter B. **NOTE: This command is valid only with models of the Lambda 10 series that support both a pair of filter wheels and a pair of shutters installed at the same time. This command is not valid in the LAMBDA 10-B.**

5.3.6 Close Shutter B

Sets Shutter B to the closed state.

5.3.7 Fast-Mode Shutter

Sets the mode of the specified shutter to FAST (*SmartShutter* only). In the “Dual-SmartShutter” configuration, a second byte following the command byte indicates Shutter A (1) or B (2).

5.3.8 Soft-Mode Shutter

Sets the mode of the specified shutter to SOFT (*SmartShutter* only). In the “Dual-SmartShutter” configuration, a second byte following the command byte indicates Shutter A (1) or B (2).

5.3.9 Neutral Density Mode Shutter

Sets the mode of the specified shutter to NEUTRAL DENSITY (*SmartShutter* only). In the “Dual-SmartShutter” configuration, a second byte following the command byte indicates Shutter A (1) or B (2). The command ends with a byte, which contains a value of 1 through 144 indicating the number of microsteps. This last byte containing the neutral density setting is the second byte if configured for “Wheel/Shutter”, or the third byte if configured for “Dual-SmartShutter”.

5.4 Special Commands

Special commands are those that are not specifically related to the control of filter wheels or shutters. They are used primarily for the control, and the obtaining of status, of the LAMBDA 10-B controller. These commands make use of all eight bits of the command byte and begin with the value of 204 (decimal) or CC (hexadecimal). The following table lists all the LAMBDA 10-B’s special commands.

Table 5-8. Special command codes.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|--|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Status | Tx | All | 1 | 0 | 204 | CC | 1100 1100 | 0204 | | | Returns status of unit |
| | Rx | All | | 13 | 13 | 0D | 0000 1101 | | ^M | <CR> | Completion indicator |
| All Motors Power On | Tx | All | 1 | 0 | 206 | CE | 1100 1110 | 0206 | | | Instruct the controller to power on all motors. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| All Motors Power Off | Tx | All | 1 | 0 | 207 | CF | 1100 1111 | 0207 | | | Instruct the controller to power off all motors. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Transfer to On Line | Tx | All | 1 | 0 | 238 | EE | 1110 1110 | 0238 | | | Puts controller on-line |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Transfer to Local | Tx | All | 1 | 0 | 239 | EF | 1110 1111 | 0239 | | | Puts controller in local mode |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Reset | Tx | All | 1 | 0 | 251 | FB | 11111011 | 0251 | | | Resets the controller |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Get Controller Type and Configuration | Tx | All | 1 | 0 | 253 | FD | 11111011 | 0253 | | | Queries the controller as to its type and configuration. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

NOTE: All commands indicated with “*” are not available in early versions of the LAMBDA 10-B (those prior to Revision D).

The following paragraphs describe the special commands in more detail.

5.4.1 Status

The Status command is used to return information about the filter wheel state (if installed) and the state of one or two shutters (if, and as, installed). The following tables describe the type of data and information returned by the Status command. The first table shows the data returned when the LAMBDA 10-B is in the “Filter Wheel/Shutter” configuration, whereas the second table shows the status data returned when in the “2 Shutter” configuration.

Table 5-9. “Get Status” command return data in a “Wheel & Shutter” configuration.

| Byte Offset | Label | Byte Value | | | Description | Bit Values | |
|-------------|----------------------------------|------------|------|---------------------------|--|-------------|-------------------|
| | | Dec. | Hex. | Binary | | Dec./Hex | Binary |
| 0 | Command echo | 204 | CC | 11001100 | The Status command byte code echoed back. | | |
| 1 | Wheel A status | | | 0xxxxxxx | WHEEL A SELECT: 1 bit.(Bit 7) Pattern: 0xxxxxx (always zero) | 0 | 0 |
| | | | | x000xxxx - x111xxxx | SPEED: 3 bits. (Bits 6, 5, & 4) Bit Pattern: x000xxx – x111xxxx | 0 - 7 | 000 - 111 |
| | | | | xxxx0000 - xxxx1001 | POSITION: 4 bits (Bits 3, 2, 1, & 0) Bit Pattern: xxxx0000 – xxxx1001 | 0 - 9 | 0000 - 1001 |
| | | 10 | 0A | 00001010 | Either no filter wheel is installed or there is an error on the 15-pin wheel port. | | |
| 2 | Shutter open/closed state | 170 | AA | 10101010 | Open | | |
| | | 171 | AB | 10101011 | Open is conditional | | |
| | | 172 | AC | 10101100 | Closed | | |
| 3 | SmartShutter mode (1 or 2 bytes) | 219 | DB | 11011011 | Indicates no SmartShutter or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| (4)* | | 1 | 01 | 00000001 | Number of microsteps (1 – 144) for neutral density mode. NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)). | | |
| | | - | - | - | | | |
| | | 144 | 90 | 10010000 | | | |
| 4 or (5)* | Return data terminator | 13 | 0D | 00001101 | ASCII CR (carriage return). | | |

* **NOTE:** The length of the status data structure when the LAMBDA 10-B is in the “Wheel & Shutter” configuration is 5 or 6 bytes depending on whether a SmartShutter is connected and, if connected, what mode it is in. If no SmartShutter is installed or if the SmartShutter Mode is not Neutral Density, then the length of the data is 5 and ends with the return data terminator at Offset 4. If a SmartShutter is connected and its mode is set to Neutral Density, then the level of neutral density (1-144 microsteps) is present at Offset 4 and the return data terminator is moved to Offset 5.

Table 5-10. “Get Status” command return data in a “Dual-SmartShutter” configuration.

| Byte Offset | Label | Byte Value | | | Description | Bit Values | |
|-------------|------------------------------------|------------|------|----------|--|------------|--------|
| | | Dec. | Hex. | Binary | | Dec./Hex | Binary |
| 0 | Command echo | 204 | CC | 11001100 | The Status command byte code echoed back. | | |
| 1 | Shutter A open/closed state | 170 | AA | 10101010 | Open | | |
| | | 171 | AB | 10101011 | Open is conditional | | |
| | | 172 | AC | 10101100 | Closed | | |
| 2 | Shutter B open/closed state | 186 | BA | 10111010 | Open | | |
| | | 188 | BC | 10111100 | Closed | | |
| 3 | Shutter A mode (SmartShutter only) | 219 | DB | 11011011 | SmartShutter A not connected: Indicates either that no SmartShutter is connected, or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| 4 | | 1 | 01 | 00000001 | Device designator: Shutter A | | |
| (5) | | 1 | 01 | 00000001 | A third byte contains the number of microsteps (1 – 144). NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)). | | |
| | | – | – | - | | | |
| | | 144 | 90 | 10010000 | | | |
| 5 or 6 | Shutter B mode (SmartShutter only) | 219 | DB | 11011011 | SmartShutter B not connected: Indicates either that no SmartShutter is connected, or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| 6 or 7 | | 2 | 02 | 00000002 | Device designator: Shutter B | | |
| (7 or 8) | | 1 | 01 | 00000001 | A third byte contains the number of microsteps (1 – 144). NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter B Mode is set to Neutral Density (Offset 5 or 6 = 222 (0xDE)). | | |
| | | – | – | - | | | |
| | | 144 | 90 | 10010000 | | | |
| 7, 8, or 9 | Return data terminator | 13 | 0D | 00001101 | ASCII CR (carriage return). | | |

* **NOTE:** The block of data returned by the Get Status command will vary in length depending on whether neither, either, or both SmartShutters (A and/or B) is/are in Neutral Density mode. All modes are followed by an additional byte indicating which device to which the mode pertains (1 = Shutter A and 2 = Shutter B. When Neutral Density mode is selected, a third byte exists that contains the number of microsteps (1 – 144) used to indicate the Neutral Density level. The following table outlines the characteristics of the status block of data according to the mode of each of the two SmartShutters.

5.4.2 All Motors Power On

This command is used to instruct the controller to switch ON electrical power to the motors of all connected filter wheels and shutters.

5.4.3 All Motors Power Off

This command is used to instruct the controller to switch OFF electrical power to the motors of all connected filter wheels and shutters.

5.4.4 Transfer to On Line

This command is the equivalent to pressing the ON LINE key on the LAMBDA 10-B's keypad. If the controller is in local mode (i.e., it is off line), this command will cause the controller to go on line (the opposite of local mode), enabling it to respond to other commands from the remote computer.

5.4.5 Transfer to Local

This command is the opposite of the Transfer to On Line command. It causes the controller to go into local mode and is the equivalent to pressing the LOCAL key on the controller's keypad. Once in local mode, the controller will not respond to any commands sent to it from the remote computer except the Transfer to On Line command.

5.4.6 Reset

Causes the LAMBDA 10-B controller to reset, changing all settings back to their defaults. After the reset has completed, status information similar to that returned by the Status command is returned to the remote computer.

5.4.7 Get Controller Type and Configuration

This command is used to obtain information about the controller as to its model and configuration. The following table shows the type of information returned when issuing this command.

Table 5-11. “Get Controller Type and Configuration” command return data in a wheel & shutter configuration.

| Total num. bytes | Category | Byte Offset | Length | Value (Decimal, hexadecimal, & binary) | ASCII Char. Seq. | Description |
|--------------------------------|-------------------|-------------|---|--|---|--|
| 14 | Command echo back | 0 | 1 | 253 ₁₀ , FD ₁₆ , 11111101 ₂ | ý | “Get Controller Type & Config.” command echoed back. * |
| | Controller Type | 1 | 4 | | 10-B | LAMBDA 10-B ** |
| | Filter Wheel Type | 5 | 4 | | W-25 | 25 mm |
| | | | | | W-32 | 32 mm |
| | | | | | W-HS | High Speed |
| | | | | | W-BD | Belt Driven |
| | | | | | W-NC | Not Connected |
| | | | | | W-ER | Error |
| | Shutter Type | 9 | 4 | | S-IQ | SmartShutter |
| | | | | S-VS | Vincent Shutter (or no shutter connected) | |
| Command return data terminator | 13 | 1 | 13 ₁₀ , 0D ₁₆ , 00001101 ₂ | <CR> | ASCII CR (carriage return). | |

Table 5-12. “Get Controller Type and Configuration” command return data in a dual-SmartShutter configuration.

| Total num. bytes | Category | Byte Offset | Length | Value (Decimal, hexadecimal, & binary) | ASCII Char. Seq. | Possible Values |
|------------------|--------------------------------|-------------|--------|--|------------------|--|
| 16 | Command echo back | 0 | 1 | 253 ₁₀ , FD ₁₆ , 11111101 ₂ | ý | “Get Controller Type & Config.” command echoed back. * |
| | Controller Type | 1 | 4 | | 10-B | LAMBDA 10-B ** |
| | Shutter A Type | 5 | 5 | | SA-IQ | 1 st SmartShutter (A) |
| | Shutter B Type | 10 | 5 | | SB-IQ | 2 nd SmartShutter (B) |
| | Command return data terminator | 15 | 1 | 13 ₁₀ , 0D ₁₆ , 00001101 ₂ | <CR> | ASCII CR (carriage return). |

*NOTE: The character shown in the “ASCII Character Sequence” column for the command echo in the previous two tables is a typical visual representation of the byte value 253 decimal (FD hexadecimal) on both Windows and Linux platforms. However, other platforms may display a different character or nothing at all. For the command return data terminator (ASCII carriage return (13 decimal, 0D hexadecimal), generally no character will be displayed, although the carriage return is acted upon in most cases in text-based console programs.

**NOTE: Other Sutter Instrument Lambda-series instruments can be configured by the user to identify themselves as “10-B” so they can be treated as compatible by existing software. These instruments are the Lambda XL and Lambda VF series. With the Lambda XL, the data returned by the “Get Controller Type & Configuration” and “Get Status” commands are identical to an actual LAMBDA 10-B, with the exception that “Controller Type” in the previous two tables can be either “10-B” or “LBXL”. In the case of the Lambda VF series, the data returned by both commands differs considerably from what is returned by an actual LAMBDA 10-B, and differences further exist between Lambda VF series models (Lambda VF-5, Lambda VF-1 (Single-Channel configuration), and Lambda VF-1 (Dual-Channel configuration)). It is strongly recommended to anyone writing code to identify a connected LAMBDA 10-B that the exceptions just discussed are considered so as to avoid confusing an actual LAMBDA 10-B from a Lambda VF-5 or VF-1 that is configured to appear as a LAMBDA 10-B. Please consult the manual for the Lambda VF-5 or VF-1 for specifics of the data structures returned by both commands.

NOTE: The “Batch Transfer of Commands” and batch-related commands are not supported in the LAMBDA 10-B controller.

5.5 Shutter Control without Remote Control Commands via the Dedicated TTL Line

The Special Commands shown above can be sent to the controller via the serial RS-232 port or the USB (Universal Serial Bus) port. The protocol used to transmit these commands is as described above in this chapter. The features of the *SmartShutter* can be used even without proper software support of the various modes of operation. The fast, soft and neutral density modes can be selected from the keypad. When so selected, open and close commands and the TTL input will act in the selected fashion.

For a description of this alternative method of remote shutter control, please refer to the REMOTE CONTROL: LOGIC LEVEL INPUT chapter later in this manual.

5.6 Remote Control Command Programming

This section describes some suggested tips and techniques when writing programs on the remote control computer for communicating with the LAMBDA 10-B via either the serial RS-232 port or the USB (Universal Serial Bus) port. The following paragraphs and the code examples deal with remote control command programming in a general manner, abstracted from telecommunications medium. The discussions and examples are applicable to either the serial RS-232 port or the USB port. The programming specifics for either the serial or USB ports are covered in the respective chapters, following this chapter. The discussions and examples are also relatively platform independent. The code samples written in the C programming language, for example, are written in a relatively primitive form, and thus should be easily portable to any platform for which C support exists (Windows, UNIX, Linux, Macintosh OS, etc.). Should another programming language be desired to implement the examples, the gist of examples should be fairly easy to glean if they are viewed as pseudo code – the examples should be easy to port to C++, Java, Pascal, BASIC, and other high level languages, or even various forms of scripting languages.

5.6.1 Preparing the Command Byte

All remote control command codes for the LAMBDA 10-B require no more than one byte (8 bits) of storage for each command. If using a programming language that make a distinction between unsigned and signed bytes, always select unsigned only. “Unsigned” means that only positive numbers can be stored, whereas “signed” means that either positive or negative values can be stored. An unsigned byte can hold 256 different positive values (0 through 255). A signed byte can store only 128 different positive values (0 through 127, and 127 different negative values (-1 through -127). In the C programming language, an unsigned byte type is expressed as “unsigned char” followed by the name of the variable, such as:

```
unsigned char command_byte;
```

...where “command_byte” is the name, the programmer chooses to give the variable.

5.6.1.1 Encoding Filter Commands Into a Single Byte

Filter commands are encoded into specific bit groups of the command byte. As discussed earlier in this chapter, and as shown in the table titled “Filter Command Structure”, there are actually three commands stored at the same time in the command byte. The filter wheel selector is stored in Bit 7 (the most significant bit (MSB)) of the command byte, allowing 2

values (0 and 1)¹. The filter wheel speed is stored in the next lower three bits (Bits 6, 5, and 4), allowing 8 different values (0 through 7). In addition, the filter selector is stored in the next lower four bits (least significant nibble, Bits 3, 2, 1, and 0). Of the 16 possible values that can be stored in the least significant nibble, only the first 10 (0 through 9) are used for the filter selector. Any value above 9 will invalidate the entire command byte as a “filter command”, making the value stored in the byte as whole as either a shutter, special, or undefined command.

5.6.1.2 Shutter or Special Commands

Shutter and Special Commands make use of the remaining command byte bit patterns not being used by Filter Commands.

5.6.2 Command Transmission Protocol

The LAMBDA 10-B does not use any of the standard protocols commonly used for serial line or USB communications between computers or between a computer and a peripheral device. The LAMBDA 10-B controller, however, does generate a primitive form of protocol of which control software running on the remote computer can, and should, make use. This protocol consists of two main components: “confirmation command echo” and “command completion indicator”. This command transmission protocol is used in the same manner for RS-232 serial and USB port connections.

5.6.2.1 Confirmation Command Echo

When the host computer sends a command to the LAMBDA 10-B, each byte received is immediately echoed back to the host computer. This echoing back of each sent byte is a confirmation that the byte has been received and will be acted upon shortly. A short period after the last byte of a command has been echoed back, the LAMBDA 10-B sends a confirmation byte (described next) that indicates the operation associated with the command completed.

5.6.2.2 Command Completion Indicator

When the LAMBDA 10-B completes the operation associated with the command it has just received, it transmits back to the host computer a byte value of 13 decimal (0D hexadecimal, 00001101 binary). This byte value corresponds to an ASCII carriage return (often abbreviated as “CR”).

¹ Note that the LAMBDA 10-B supports the connection of only one filter wheel. Therefore, the filter wheel selector stored in Bit 7 of the command byte must always be 0.

6. EXTERNAL SERIAL RS-232 INTERFACE CONTROL

The LAMBDA 10-B microprocessor sets the serial RS-232C port, by default, as the input source upon startup and anytime the ON LINE key is pressed. An appropriate command from the remote computer through the serial port will automatically set that port as the active input source and the display on the controller will reflect that change on its bottom line. The serial port will remain active until an appropriate command is sent from a remote computer through the USB port or until the LOCAL key is pressed on the controller keypad.

There are, obviously, some basic differences in the physical connections and the modes by which serial and USB data are transmitted to the controller. The command code and return code structures are, however, for the most part, the same. The connection and command structure required to control the LAMBDA 10-B via the Serial port are discussed in this chapter.

6.1 Connecting to the Serial Port

The serial interface connector on the back of the LAMBDA 10-B controller cabinet is a DB-9 female connector. The connections are arranged so that a standard DB-9 serial cable can be used to connect the controller to a PC serial port. The port operates on a minimal RS-232 protocol where only the signal ground and the two data lines (transmit and receive) are connected; the hardware control lines are not connected. This port is designed for connection to a standard computer serial port. It should not be connected to any other type of interface or device. The pin assignments for this connector are, as viewed from the back of the controller:

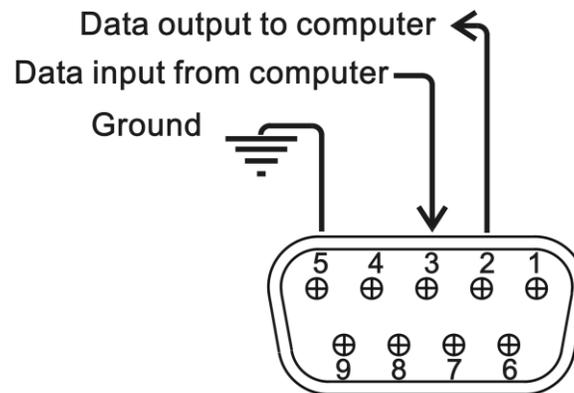


Figure 6-1. Serial port pin assignments.

Communication for the serial port requires the following settings:

Table 6-1. Serial interface serial port settings.

| Property | Setting |
|--|---------|
| Data (“Baud”) Rate (bits per second (bps)) | 9600 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |
| Flow Control * | None |

* Some terminal programs may require this setting.

No hardware control lines are connected. You must either set the communication mode so that these lines are ignored or provide connections that will satisfy the mode of communication that you use. In Microsoft QuickBasic the communication channel may be opened with a statement such as:

```
OPEN "COM1:9600,N,8,1, CD0,CS0,DS0 " FOR RANDOM AS #1 LEN = 256
```

This sets COM1 to the correct mode for bi-directional communication through channel #1. The option list “CD0,CS0,DS0” causes QuickBasic to ignore the DCD, CTS and DSR control lines. Other variants of the BASIC programming language (implemented for the PC) will have a similar syntax for the above statement.

6.2 Input Command Set and Protocol

Input Commands to the controller via the serial port are structured and adhere to the same protocol as described in the REMOTE CONTROL chapter. The Filter, Shutter, and Special commands, as described in the REMOTE CONTROL chapter, all apply to the serial port interface. Each command consists of one byte (8-bits), and some commands are followed by one or more bytes as parameters. The command protocol is also the same as described in the EXTERNAL COMMAND CONTROL chapter: As a command is sent to the controller, it is immediately echoed back to the computer, and when the controller has completed the task associated with the command it has just received, it sends an ASCII CR (carriage return) byte (13 decimal, 0D hexadecimal) to the computer.

Since the serial data stream format is a single byte, each command can be sent as an ASCII character. If you have used a *BASIC* language open statement to establish serial communications, the subsequent 8 bit command values may be sent using a *BASIC* PRINT # command such as:

```
PRINT #1, CHR$(DATANUM) ;
```

...where #1 is the file number used in the open statement, and DATANUM is the value of the command to be sent. Note that the CHR\$ function allows the actual number to be sent rather than the ASCII numbers of the characters that represent the number. Sending “;” disables the automatic addition of characters such as a linefeed or a space.

7. EXTERNAL USB INTERFACE CONTROL

Controlling the LAMBDA 10-B externally via computer is accomplished by sending commands between the computer and the equivalent connector on the rear of the controller.

Controlling the externally via computer is accomplished by sending commands over the USB interface between the computer and the USB connector on the rear panel of the LAMBDA 10-B. The USB device driver for Windows is downloadable from Sutter Instrument's web site (www.sutter.com). The device requires USB CDM (Combined Driver Model) Version 2.10.00 or higher. The CDM device driver consists of two device drivers: 1) USB device driver, and 2) VCP (Virtual COM Port) device driver. Install the USB device driver first, followed by the VCP device driver. The VCP device driver provides a serial RS-232 I/O interface between a Windows application and the device. Although the VCP device driver is optional, its installation is recommended even if it is not going to be used. Once installed, the VCP can be enabled or disabled.

The CDM device driver package provides two I/O methodologies over which communications with the controller over USB can be conducted: 1) USB Direct (D2XX mode), or 2) Serial RS-232 asynchronous via the VCP device driver (VCP mode). The first method requires that the VCP device driver not be installed, or if installed, that it be disabled. The second method requires that the VCP be installed and enabled.

Virtual COM Port (VCP) Serial Port Settings: The following table lists the required RS-232 serial settings for the COM port (COM3, COM5, etc.) generated by the installation and enabling of the VCP device driver.

The settings shown in the above table can be set in the device driver's properties (via the Device Manager if in Windows) and/or programmatically in your application.

Table 7-1. USB interface serial port settings.

| Property | Setting |
|--|---------|
| Data ("Baud") Rate (bits per second (bps)) | 9600 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |
| Flow Control | None |

Table 7-2. USB interface serial port settings (later firmware).

| Property | Setting |
|--|---------------------------------------|
| Data ("Baud") Rate (bits per second (bps)) | 9600*, 19200, 115200, 128000 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |
| Flow Control * | None |

The settings shown in the above table can be set in the device driver's properties (via the Device Manager if in Windows) and/or programmatically in your application.

Four versions of the USB device driver for Windows are available offering different compatibility and functionality:

1. Ver. 1.06.02 is for use with Windows 98, 98 SE, ME, and 2000 and 32-bit edition only of Windows releases after that. This version supports only the direct D2XX mode of operation VCP (Virtual COM Port) mode is not supported).
2. Ver. 2.06.00 is for use with Windows 2000 and 32-bit and 64-bit editions of Windows released after that. This version is a Combined Driver Model (CDM) that can be installed for either direct D2XX or VCP (Virtual COM Port) modes of operation. Following the section on installing the standard device driver (next), is the section that describes downloading and installing the CDM device driver.
3. Ver. 2.10.00 supports Windows XP on up.
4. Ver. 2.12.24 supports Windows 7 on up.

7.1 Installation Steps

To install the LAMBDA 10-B as a USB device on a remote computer, follow these steps.

1. Make sure that the device is plugged into a power source and that its power switch is set to OFF.
2. Connect the “device” connector of the USB cable to the USB receptacle in the back of the device. Of the two connectors on the supplied USB cable, the one that is square in shape is the one that connects the USB device.

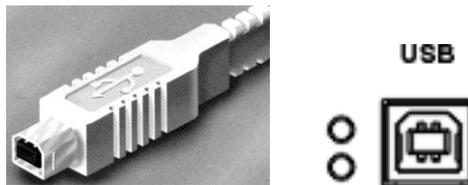


Figure 7-1. The USB cable device connector and device USB receptacle.

3. Turn the power switch in the back of the device to ON.
4. Make sure the computer is powered up and the Windows operating system has fully finished starting up. Plug in the other end of the USB cable (the “host” connector) to any of the unused USB ports on your computer. You can also use an unused port of a USB hub connected to your computer, provided that the driver/software for the hub has already been installed and the hub is functioning properly. The “host” USB receptacle and connector are rectangular, as shown in the following figures.

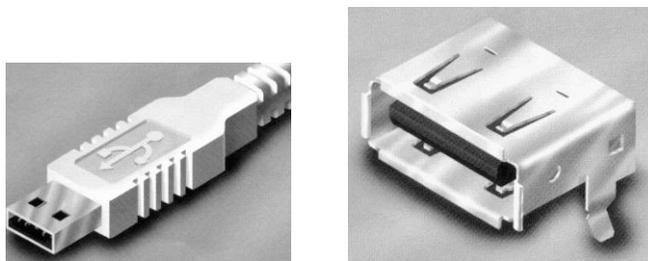


Figure 7-2. Host connector end of USB cable and USB host receptacle on remote computer.

The following paragraphs describe what Windows displays after the host connector of the USB cable has been connected to the computer, and how you can interact with the computer to reach the goal of getting the appropriate USB device drivers properly installed.

7.2 Installing the LAMBDA 10-B as a USB Device on a Windows System using the Standard Device Driver

The LAMBDA 10-B can be used as a USB device running one of the following versions of Microsoft Windows: Windows Interactive USB Device Driver Installation

Once the USB “host” connector is inserted into the appropriate receptacle on the remote computer, the Windows operating system should immediately start the “new USB device” detection process. The following message box should appear on your screen:

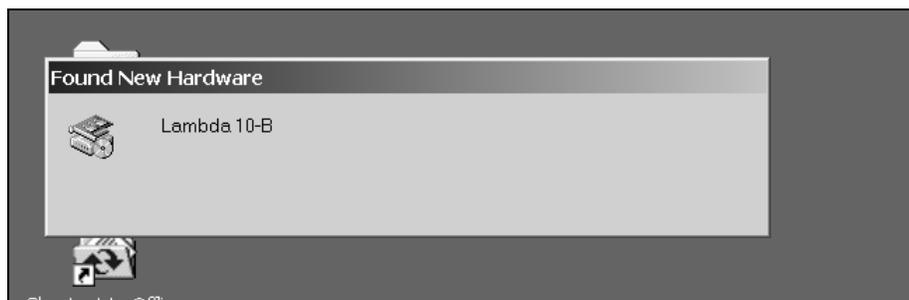


Figure 7-3. New USB device detected message box.

The above message box will display for a period, possibly up to a couple of minutes, while Windows goes through the process of determining if it already has device driver information for this new device.

If the LAMBDA 10-B USB device drivers have already been installed on this computer, then Windows will usually find them and automatically reactivate them. If the drivers had been previously installed and then removed (uninstalled), it is possible that Windows is still able to locate the drivers and automatically reinstall them. Windows may also automatically install the appropriate drivers if another Sutter Instrument Company instrument with a USB interface (such as a LAMBDA 10-B, a Lambda SC, an MPC-200, or even another LAMBDA 10-B) is already connected and configured with your computer. If this is the first time the LAMBDA 10-B USB device drivers are being installed, it is then quite likely that Windows will display the dialog box shown in Figure 7-4.



Figure 7-4. Digital Signature dialog box.

Do not be concerned that Windows is unable to find a Microsoft digital signature for the LAMBDA 10-B as shown in Figure 7-4. Simply press the “Yes” button to continue to the next step. Figure 7-5 shows the dialog box that Windows displays when it is ready ask you for the location of the LAMBDA 10-B USB device drivers.

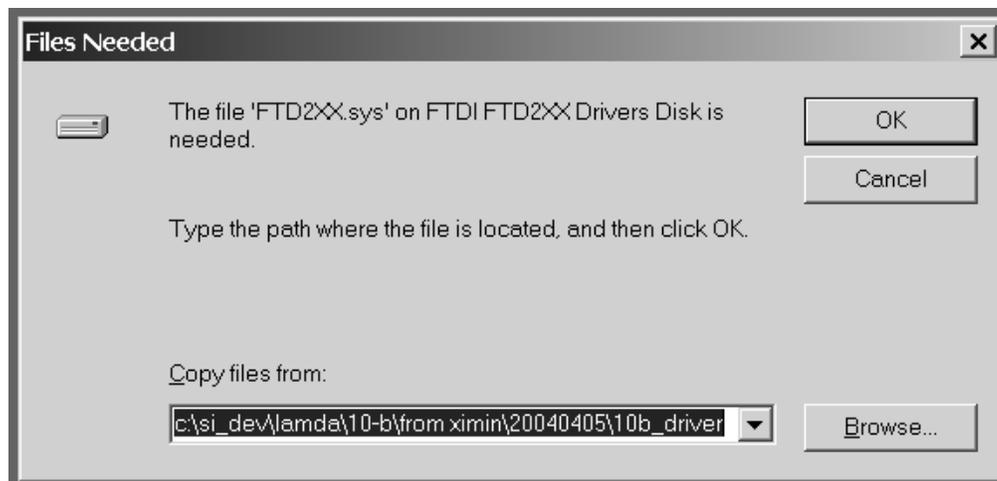


Figure 7-5. Specifying location of driver files.

In Figure 7-5, the dialog box displayed contains a combo box that contains a path to a location from which Windows remembered it had last copied a USB device driver. This may or may not be the path that currently contains the necessary files for the LAMBDA 10-B USB interface installation. You have the following three choices for this dialog box:

2. Enter a path in the “Copy files from” combo box and then press OK.

3. Select from the memory list in the “Copy files from” combo box, by pressing the inverted triangle to the right of the combo box, and then selecting and clicking on one of the items (if any) displayed in the pulldown list, and finally pressing OK.
4. Alternatively, clicking the Browse button displays another dialog that allows you to navigate through your system’s drives and folders for the location containing the needed LAMBDA 10-B USB device driver files. Once found, and you’ve returned to the previous dialog box, the path chosen will now be shown in the “Copy files from” combo box, whereupon clicking OK will continue the process by using the path chosen. The following figure shows the dialog that is displayed after the Browse button is clicked.

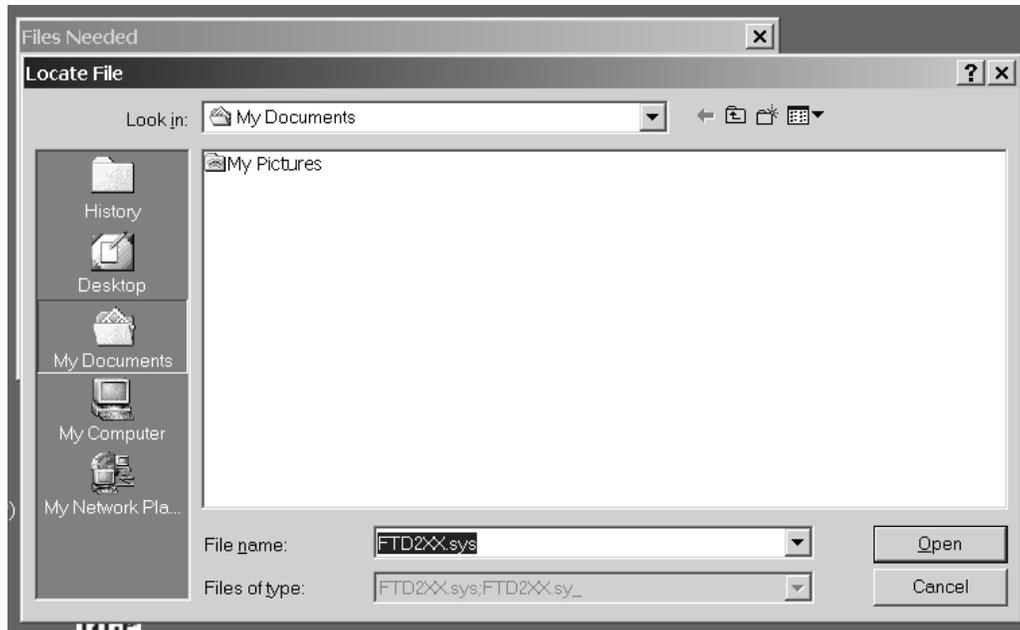


Figure 7-6. Browsing for the driver file needed.

Once the requested files are located, the Windows USB device installer will complete. Note that you may need to cycle through the two dialogs shown in the last two figures before the requested file is located and installed.

This completes the description for installing the LAMBDA 10-B as a USB device connected to a Windows system.

7.3 Installing the LAMBDA 10-B as a USB Device on a Windows System using CDM (Combined Driver Model) Device Driver

The CDM device driver is compatible with all versions and editions of Windows from Windows 2000 and up.

NOTE: The CDM device driver is not compatible with any version of Windows prior to Windows 2000 (i.e., it must not be used with Windows 98, 98 SE (Second Edition), nor ME (Millennium Edition)).

To install the CDM device driver for the LAMBDA 10-B, first download the device driver and installation instructions from the following links:

http://www.sutter.com/SOFTWARE/SI_CDM_vx_xx_xx.zip

and the installation instructions at

http://www.sutter.com/SOFTWARE/CDM_driver_Install_Guide.pdf

Extract the contents of the device driver into a folder and disk drive of your choosing. To install the device driver, please refer to the “CDM_driver_Install_Guide.pdf” downloaded separately.

7.4 Installing the USB interface for non-Windows systems

The LAMBDA 10-B can be connected via USB interface to computers that are not running Windows. However, limited support and information is provided for them. For the Linux and Macintosh operating systems, please visit the following web sites for more information.

1. Linux drivers and tools:

<http://ftdi-usb-sio.sourceforge.net/>

2. Apple Macintosh drivers, tools, and information:

<http://www.ftdichip.com/FTMacDriver.htm>

7.5 Verifying USB Communication between Remote Computer and LAMBDA 10-B

Once the LAMBDA 10-B has been connected to the remote computer with the USB cable and the remote computer has had the necessary device drivers installed, you will probably want to test and verify that the remote computer is, in fact, communicating correctly with the LAMBDA 10-B over its USB connection. Probably the most expedient method for doing this testing is to install and run on the remote computer the USB Test and Demo program for the Lambda 10-series (a Windows program). This program is called “USBTest”, and once installed, can be used to determine if the remote computer is able to communicate with the LAMBDA 10-B as a USB device. The USBTest program is provided on a 3.5-inch HD floppy diskette or CD-ROM, shipped with the LAMBDA 10-B or it can be downloaded from Sutter Instrument Co.’s web site (www.sutter.com). The files that make up the distribution of the USBTest program include the Setup program. Simply run this setup program to install USBTest on your system (Windows-based systems only).

The USB Test & Demo program can be downloaded from Sutter Instrument’s web site using the following link:

https://www.sutter.com/SOFTWARE/Lambda_Test.zip

NOTE: The USB version of the program is for use only when the LAMBDA 10-B is connected to your computer over the USB interface and either the standard device driver is installed or the CDM device driver is installed with VCP disabled.

If VCP is enabled, then the COM Port version of the program should be used instead.

7.6 Uninstalling the USB Driver for the LAMBDA 10-B

Normally, the device drivers installed on your system that enable communications with the LAMBDA 10-B over the USB, once installed, do not need removing from your system. If you do need to remove the USB drivers installed specifically for the LAMBDA 10-B (e.g., the LAMBDA 10-B will no longer be used with the system in question), the following steps can be followed for Windows.

1. Open the *Control Panel* (click on *Start* to bring up the main Windows menu, then click on *Settings*, and then *Control Panel* in the submenu).
2. Within the Control Panel window, double click *Add/Remove Programs*. A new window is opened in which a list of software that is installed on your system is displayed.
3. Select the line that has "FTD2XX Uninstaller" as the description and click the "Remove" button towards the right of the description. The FTD2XX Uninstaller program starts and displays a dialog asking you to disconnect the USB cable if it is still connected.
4. Unplug the USB cable connected to the LAMBDA 10-B, and then click the Continue button. The uninstall process completes (one more dialog shows up indicating that registry entries and files are getting deleted). The uninstall process is now complete -- click the Finish button to finish. Alternatively, click Cancel to cancel the whole uninstall process.
5. If the uninstall process is completed, the FTD2XX entry in the Add/Remove list should now be gone.

Note that although the above procedure will remove the LAMBDA 10-B USB device driver from active use, not all related files on your system are deleted. Should you decide to reinstall the USB driver for the LAMBDA 10-B after having gone through the uninstall process, Windows will most likely be able to locate the necessary USB driver file on your system during the installation process, without requiring you to supply the disk containing the driver.

If you wish to completely remove the USB driver and related files from the system, use either of the following two methods.

1. Manually delete the file FTD2XX.sys from the "system32" directory in your Windows directory.
2. Navigate via My Computer or Windows Explorer to the "system32" directory in your Windows directory, locate the file FTD2XXUN.EXE, and double click on it to launch the general-purpose FTDI uninstaller program. Running this uninstall program will remove all pertinent FTDI entries in the Windows registry, a far safer approach to removing the entries manually.

7.7 Remote Commands and the USB Interface

The same set of commands described in the External Control: Serial Port chapters are available for use when the LAMBDA 10-B is connected to a computer as a USB device.

7.8 Command Sequence Formatting and Protocol:

Each command sequence consists of at least one byte, the first of which is the “command byte”. Those commands that have parameters or arguments require a sequence of bytes that follow the command byte. No delimiters are used between command sequence arguments, and command sequence terminators are not used. Although most command bytes can be expressed as ASCII displayable/printable characters, the rest of a command sequence must generally be expressed as a sequence of unsigned byte values (0-255 decimal; 00 – FF hexadecimal, or 00000000 – 11111111 binary). Each byte in a command sequence transmitted to the controller must contain an unsigned binary value. Attempting to code command sequences as “strings” is not advisable. Any command data returned by the controller should be initially treated as a sequence of unsigned byte values upon reception.

7.8.1 Confirmation Command Echo

When the host computer sends a command, each byte received is immediately echoed back to the host computer. This echoing back of each sent byte is a confirmation that the byte has been received and will be acted upon shortly. A short period after the last byte of a command has been echoed back, the device sends a confirmation byte (described next) that indicates the operation associated with the command completed.

7.8.2 Command Completion Indicator

When this device completes the operation associated with the command it has just received, it transmits back to the host computer a byte value of 13 decimal (0D hexadecimal, 00001101 binary). This byte value corresponds to an ASCII carriage return (often abbreviated as “CR”).

8. OPERATING INSTRUCTIONS: EXTERNAL LOGIC LEVEL (TTL) SHUTTER CONTROL

In addition to the control of the shutter via the keypad, USB port and the serial port, the direct TTL logic input can also control the shutter. However, input must be selected and configured for the mode desired. TTL level inputs could come from a wide variety of devices, such as cameras, imaging boards, or a parallel port.

8.1 Using the PC's Parallel Port for Control

The parallel port has been used extensively for control of shutters through logic level signals. The outputs available at pins 14 and 16 of the 25-pin parallel port are usually employed. By connecting Pin 14 to "S1 TTL IN" and Pin 16 to "S2 TTL IN" BNC receptacles on the rear of the LAMBDA 10-B, a computer's parallel port can be used to set the correct TTL levels for controlling one or two shutters.

The PC parallel port's Pin 14 corresponds to the bit that encodes the value 2 and Pin 16 corresponds to the bit that encodes the value 4. Sending a value of 2 to this port will set Pin 14 low, which closes the shutter. Pin 14 can be set high to open the shutter by sending a value such as zero. The logic for Pin 16 is the reverse of Pin 14. To open Shutter B, send a value of 4 to the port. To close Shutter B, send 0 to the port. Since both shutters are controlled by the same port, you must combine the values for the two shutters by addition if you have two shutters installed.

Table 8-1. Commands for PC parallel port control of dedicated TTL line.

| | | SHUTTER A | |
|-----------|--------|-----------|--------|
| | | OPEN | CLOSED |
| SHUTTER B | OPEN | 4 | 6 |
| | CLOSED | 0 | 2 |

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9. MAINTENANCE

Routine cleaning of the LAMBDA 10-B system is required to prevent excessive dust accumulations. This is done by wiping all exterior surfaces with a dry, soft, cotton cloth.

All retaining rings should be inspected occasionally to be certain that they are seated into the filter holders and cups.

The filter wheel is a precision-machined part, mounted on a stepper motor shaft. As such, it DOES NOT REQUIRE LUBRICATION. Attempting to lubricate any part of the filter wheel or shutter assembly will void the warranty and may harm the motor or shutter.

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APPENDIX A. LIMITED WARRANTY

- Sutter Instrument Company, a division of Sutter Instrument Corporation, limits the warranty on this instrument to repair and replacement of defective components for two years from date of shipment, provided the instrument has been operated in accordance with the instructions outlined in this manual.
- Abuse, misuse, or unauthorized repairs will void this warranty.
- Warranty work will be performed only at the factory.
- The cost of shipment both ways is paid for by Sutter Instrument during the first three months this warranty is in effect, after which the cost is the responsibility of the customer.
- The limited warranty is as stated above and no implied or inferred liability for direct or consequential damages is intended.
- Consumables, PMTs, galvanometers, and Uniblitz^{®1} shutters are exempt from this warranty.
- An extended warranty for up to three additional years can be purchased at the time of ordering, or until the original warranty expires. For pricing and other information, please contact Sutter Instrument.

¹ [Uniblitz[®] is a registered trademark of Vincent Associates.](#)

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APPENDIX B. ACCESSORIES

B.1. Filter Wheels

| | |
|--------------------|---|
| LB10-NW | 10-position 25mm filter wheel without shutter. |
| LB10-NWIQ | 10-position 25mm filter wheel with SmartShutter. |
| LB10-NWS | 10-position 25mm filter wheel with Uniblitz® shutter. |
| LB10-NWE | 10-position 25mm filter wheel set up for emission. |
| LB10-WHS4 | 4-position 25mm filter wheel without shutter. |
| LB10-WHS4IQ | 4-position 25mm filter wheel with SmartShutter. |
| LB10-WHS4E | 4-position 25mm filter wheel set up for emission. |
| LB10-TW | 10-position 25mm THIN filter wheel without shutter. |
| LB10-TWIQ | 10-position 25mm THIN filter wheel with SmartShutter. |
| LB10-TWE | 10-position 25mm THIN filter wheel set up for emission. |
| LB10-WD | Back-to-back mounting of two 25mm filter wheels (no drop-in filter holders). |
| LB10-WDIQ | Back-to-back mounting of two 25mm filter wheels with one SmartShutter and one slide-in filter holder. |
| LB10-WDS | Back-to-back mounting of two 25mm filter wheels with one Uniblitz and one slide-in filter holder. |
| LB10-W32 | 10-position 32mm filter wheel without shutter. |
| LB10-W32IQ | 10-position 32mm filter wheel with SmartShutter. |
| LB10-W32S | 10-position 32mm filter wheel with Uniblitz® shutter. |
| LB10-TW32 | 10-position 32mm filter wheel without shutter. |
| LB10-W50 | 5-position 50mm filter wheel without shutter. |
| LB10-W12 | 10-position 12.5mm filter wheel without shutter. |

LB4-W Belt drive 4-position 25mm filter wheel without shutter.

B.2. SmartShutter

IQ12-SA 12.5mm SmartShutter with standalone housing.

IQ12-AN 12.5mm hard anodized SmartShutter.

IQ25-SA¹ 25mm SmartShutter with standalone housing.

IQ25-W² 25mm SmartShutter with housing to fit a 25mm filter wheel.

IQ25-WU² 25mm SmartShutter to retrofit non-shuttered filter wheel.

IQ25-LS 25mm SmartShutter with housing designed for installation into a Lambda LS system.

IQ25-DG 25mm SmartShutter with housing designed for installation into a Lambda DG-4 or DG-5 system.

IQ35-W 35mm SmartShutter with housing to fit 32mm filter wheel.

IQ35-SA 35mm SmartShutter with standalone housing.

IQ50-SA 50mm SmartShutter with standalone housing.

¹ If vignetting is an issue, a 35mm shutter is recommended instead.

² For upgrading a 25mm filter wheel with existing Uniblitz® shutter to SmartShutter™.

² For upgrading a 25mm filter wheel with existing Uniblitz® shutter to SmartShutter™.

APPENDIX C. FUSE REPLACEMENT

If the controller fails to power up when the power switch is turned on, check the line power fuse to see if it has blown. The fuse is in the fuse holder on the power entry module on the back of the controller. To remove the fuse holder first unplug the power cord from the power entry module. This will reveal a slot just under the edge of the fuse holder. Use a screwdriver to pry the holder straight out of the power entry module.

The fuse that is readily visible in the fuse holder when you take it out is the one that is “active” when the holder is installed. A spare fuse is also stored within the fuse holder. It is concealed in a compartment as shown in Figure C-1. To remove the spare fuse, press down on the end of the compartment to push it out of the other end. The old fuse can serve as a convenient tool for pushing the spare fuse compartment out. Replace the active fuse with the spare and re-install the fuse holder and power cord. If the controller fails to power up with the new fuse installed, call Sutter Instrument technical support personnel for assistance.

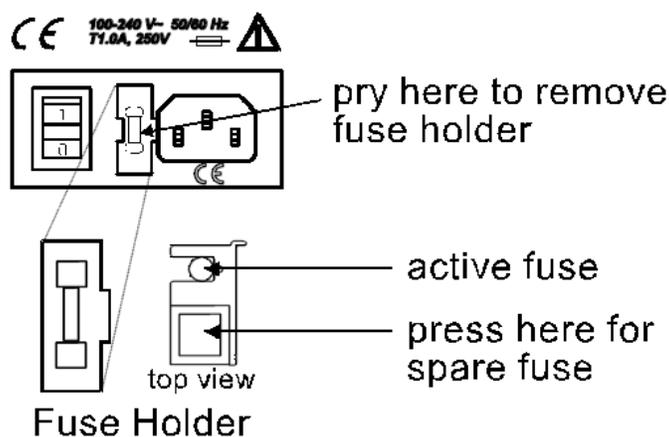


Figure C-1. Power entry module and fuse holder.

! The fuse holder holds two fuses. Both fuses are of the same type and rating. If either fuse is blown, it is recommended that both fuses be replaced. The type and rating of both fuses are as follows:

! If the serial number is equal to **LB10IQ-1554** or greater, then the specified fuse is:
5 x 20 mm glass tube, Time Delay (IEC 60127-2, Sheet III)
T1.0A, 250V (219XA Series)
Use only Littelfuse 0219001.XAP (219XA Series)

! If the serial number is below **LB10IQ-1554**, then the specified fuse is:
5 x 20 mm glass tube, Time Delay (IEC 60127-2, Sheet III)
T1.0A, 250V
Use only Bussmann GDC-1A; or Littelfuse 218 001)

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APPENDIX D. TECHNICAL SPECIFICATIONS



Dimensions (H x W x D):

| | |
|--|---|
| Controller | 5.38" x 5.86" x 8.25" 13.67 cm x 14.88 cm x 20.96 cm |
| 25 mm (1") SmartShutter: | |
| Height (from motor top to shutter bottom): | 3.88" 9.86 cm |
| Width and depth (W x D): | |
| Motor end (top): | 1.06" x 1.88" 2.69 cm x 4.78 cm |
| Shutter end (bottom): | 2.88" x 0.66" 7.32 cm x 1.68 cm |
| 35 mm (1.38") SmartShutter: | |
| Height (from motor top to shutter bottom): | 4.25" 10.80 cm |
| Width and depth (W x D): | |
| Motor end (top): | 1.38" x 2.31" 3.51 cm x 5.87 cm |
| Shutter end (bottom): | 3.13" x 0.88" 7.95 cm x 2.24 cm |
| 25 mm (1") Filter Wheel (H x W x D): | |
| Wheel only (no housing): | 6.25" x 7" x 2" 15.88 cm x 17.75 cm x 5.8 cm |
| 32 mm (1.27") Filter Wheel (H x W x D): | |
| Wheel only (no shutter housing): | 6.5" x 6.5" x 1" 16.51 cm x 16.51 cm x 2.54 cm |
| For motor, | add 1.19" (3.02 cm) D |
| For connector bracket: | add 0.75" (1.91 cm) D |
| For mounting bracket: | add 1" (2.54 cm) D |
| For thumbscrews: | add 0.38" (0.97 cm) to 0.63" (1.60 cm) D |

Weight:

| | |
|---------------------------------------|---------------------------------------|
| Controller | 2.55 lb. (2 lb., 9 oz.) 1.16 kg. |
| 25 mm <i>SmartShutter</i> : | 0.6 lb. (9.6 oz) 0.27 kg |
| 35 mm <i>SmartShutter</i> : | 0.75 lb. (12 oz) 0.34 kg |
| 25 mm (1") Filter wheel: | |
| Wheel only (no shutter housing): | 1.2 lb. (1 lb., 3.2 oz.) 0.54 kg |
| With shutter housing (without stand): | |
| 25 mm Vincent: | 3.10 lb. (3 lb., 1.6 oz.) 1.41 kg. |
| 25 mm <i>SmartShutter</i> : | 2.8 lb. (2 lb., 12.8 oz.) 1.27 kg |
| 32 mm Filter Wheel | |
| Wheel only (no shutter housing): | 4.40 lb. 2.00 kg |

Electrical:

| | |
|-----------------------|------------------------------------|
| Input voltage (Mains) | 115 V, 60 Hz 230 V, 50 Hz |
| Power cord | 10A, 250V, with safety ground plug |

Table D-1. Controller Cables.

| Port (connector/ receptacle) | Cable Connector Types | Connects to ... | Cable Max. Length | Cable Type |
|---|---|--|-----------------------------|--|
| WHEEL UNIBLITZ 15-Pin DSUB Receptacle | ←DB-15 male DB-15 female→ | Filter Wheel (standalone or in housing with UNIBLITZ shutter) | 3 meters (approx. 10 feet) | Minimum of 26 awg stranded wire with 500 Volt. |
| WHEEL SMART-SHUTTER 25-Pin DSUB Receptacle | ←DB-25 male DB-25 female→ | Filter Wheel in housing with SmartShutter | 3 meters (approx. 10 feet) | Minimum of 26 awg stranded wire with 500 Volt. |
| | ←DB-25 male split DB-9 male (Terminator on) DB-9 male→ | 1 standalone SmartShutter | | |
| | ←DB-25 male split DB-9 male→ (Terminator removed) DB-9 male→ | 2nd standalone SmartShutter (Shutter B) 1st standalone SmartShutter (Shutter A) | | |
| SERIAL 9-Pin DSUB Receptacle | ←DB-9 male DB-9 female→ | Remote control computer's serial (RS-232) 9-pin connector | 3 meters (approx. 10 feet) | Connected to metal faceplates of connectors on both ends. |
| USB USB A (Device) Receptacle | ←A connector B connector→ | Remote control computer's USB B (Host Computer) receptacle | 3 meters (approx. 10 feet) | Dielectric separation of circuits. Foil shielding. |
| (S1) TTL OUT BNC receptacle | ←BNC connector BNC connector→ | A TTL-signal receiving device (from Shutter A) | User specified/ supplied | 2-wire solid or twisted, or coax with braid or foil shielding. |
| (S1) TTL IN BNC receptacle | ←BNC connector BNC connector→ | A TTL-signal triggering device (for Shutter A) | | |

NOTE: A second pair of BNC receptacles can be optionally installed on the LAMBDA 10-B for use with a second SmartShutter (Shutter B). If installed, these are labeled **S2 TTL OUT** and **S2 TTL IN**, and labels for Shutter A shown in the table are each prefixed with "S1".

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APPENDIX E. LAMBDA 10-B REV C AND EARLIER VERSIONS

When introduced, the LAMBDA 10-B was capable of controlling both a *SmartShutter* and a filter wheel at the same time. The original LAMBDA 10-B, however, supported only a filter wheel and traditional shutter. A modified version of this controller was produced in limited numbers as a *SmartShutter* controller able to drive one *SmartShutter*. These units can be identified by the lack of a DB25 connector for the *SmartShutter*/filter wheel combination.

These units also have a different display at power-on.

```
COPYRIGHT SUTTER  
INSTRUMENT V1.12
```

After the copyright screen, the unit display should be similar to:

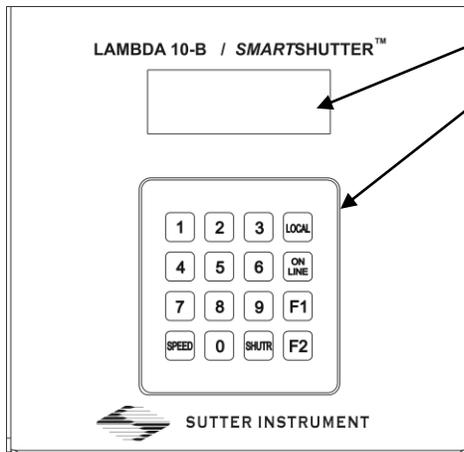
```
F NO.=0  SPEED=0  
SHUTR=OFF W=25MM
```

LAMBDA 10-B units without support for a *SmartShutter* do not have the extensive set of menus found in the current units. Special *SmartShutter* only units have menus for accessing the Smart Shutter options, but do not have filter wheel options.

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APPENDIX F. EXTERNAL CONTROL COMMAND REFERENCE

Manual Operation



Display

Keypad

Filter Wheel and Shutter configuration

1 - 9 and **0**: Filter Wheel Position 0 – 9 commands

SPEED: 0 - 7

F1:

1. TTL: Enable/Disable
2. TEST: Loop, speed, shutter, demo
3. MODE: Fast, Soft, Neutral Density: 1-144 steps (F2 cancels)
4. CONFIG: Default; Shutter Mode: Save/Restore Mode

F1 (2nd Time): VERSION, HOME (repeat by F2 key),
ERROR COMMAND: On/Off

F2: Data Rate: 9600, 19200, 115.2K, 128K*

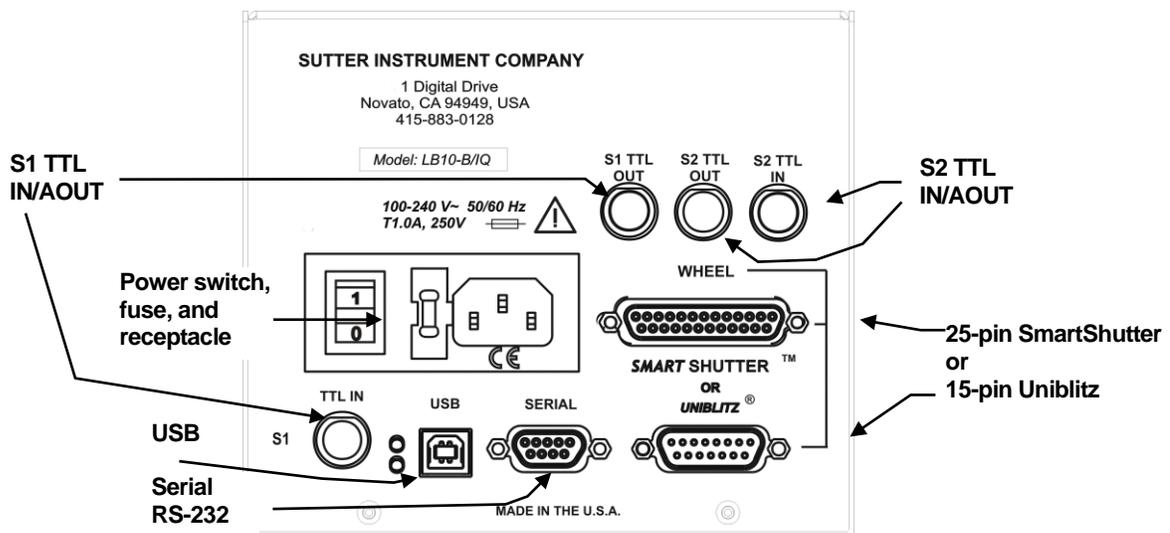
Dual SmartShutter configuration

1 - 9 and **SPEED** nonfunctional; all other commands are functional

LOCAL: Manual operation

ON LINE: External operation (USB/Serial)

Configuration



Filter wheel with optional SmartShutter or Uniblitz shutter (25- or 15-pin cable) configuration



OR



Dual SmartShutter (25-pin to two 9-pin split cable) configuration

Table F-1. Commands for PC parallel port control of dedicated TTL line.

| | | SHUTTER A | |
|-----------|--------|-----------|--------|
| | | OPEN | CLOSED |
| SHUTTER B | OPEN | 4 | 6 |
| | CLOSED | 0 | 2 |

External Control

Controlling the LAMBDA 10-B externally via computer is accomplished by sending commands between the computer and the equivalent connector on the rear of the controller: **RS-232** (Serial, 9-pin DSUB), or **USB**.

The RS-232 (Serial) Interface: RS-232-C, minimal 3-wire (Ground, Transmit, & Receive), 9-pin D-Shell connector (labeled “RS-232” on the rear panel of the controller).

The USB Interface: Controlling the externally via computer is accomplished by sending commands over the USB interface between the computer and the USB connector on the rear panel of the LAMBDA 10-B. The USB device driver for Windows is downloadable from Sutter Instrument’s web site (www.sutter.com). The device requires USB CDM (Combined Driver Model) Version 2.10.00 or higher. The CDM device driver consists of two device drivers: 1) USB device driver, and 2) VCP (Virtual COM Port) device driver. Install the USB device driver first, followed by the VCP device driver. The VCP device driver provides a serial RS-232 I/O interface between a Windows application and the device. Although the VCP device driver is optional, its installation is recommended even if it is not going to be used. Once installed, the VCP can be enabled or disabled.

The CDM device driver package provides two I/O methodologies over which communications with the controller over USB can be conducted: 1)

USB Direct (D2XX mode), or 2) Serial RS-232 asynchronous via the VCP device driver (VCP mode). The first method requires that the VCP device driver not be installed, or if installed, that it be disabled. The second method requires that the VCP be installed and enabled.

Virtual COM Port (VCP) Serial Port Settings:

The following table lists the required RS-232 serial settings for the COM port (COM3, COM5, etc.) generated by the installation and enabling of the VCP device driver.

The settings shown in the above table can be set in the device driver’s properties (via the Device Manager if in Windows) and/or programmatically in your application.

Table F-2. Serial and USB- interface serial port settings.

| Property | Setting |
|--|---------|
| Data (“Baud”) Rate (bits per second (bps)) | 9600 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |
| Flow Control | None |

Table F-3. USB interface serial port settings (later firmware).

| Property | Setting |
|--|--------------------------------------|
| Data (“Baud”) Rate (bits per second (bps)) | 9600* , 19200, 115200, 128000 |
| Data Bits | 8 |
| Stop Bits | 1 |
| Parity | None |
| Flow Control | None |

The settings shown in the above table can be set in the device driver's properties (via the Device Manager if in Windows) and/or programmatically in your application.

Four versions of the USB device driver for Windows are available offering different compatibility and functionality:

1. Ver. 1.06.02 is for use with Windows 98, 98 SE, ME, and 2000 and 32-bit edition only of Windows releases after that. This version supports only the direct D2XX mode of operation. VCP (Virtual COM Port) mode is not supported.
2. Ver. 2.06.00 is for use with Windows 2000 and 32-bit and 64-bit editions of Windows released after that. This version is a Combined Driver Model (CDM) that can be installed for either direct D2XX or VCP (Virtual COM Port) modes of operation. Following the section on installing the standard device driver (next), is the section that describes downloading and installing the CDM device driver.
3. Ver. 2.10.00 supports Windows XP on up.
4. Ver. 2.12.24 supports Windows 7 on up.

Command Sequence Formatting and Protocol:

Each command sequence consists of at least one byte, the first of which is the "command byte". Those commands that have parameters or arguments require a sequence of bytes that follow the command byte. No delimiters are used

between command sequence arguments, and command sequence terminators are not used. Although most command bytes can be expressed as ASCII displayable/printable characters, the rest of a command sequence must generally be expressed as a sequence of unsigned byte values (0-255 decimal; 00 – FF hexadecimal, or 00000000 – 11111111 binary). Each byte in a command sequence transmitted to the controller must contain an unsigned binary value. Attempting to code command sequences as "strings" is not advisable. Any command data returned by the controller should be initially treated as a sequence of unsigned byte values upon reception.

Confirmation Command Echo: When the host computer sends a command, each byte received is immediately echoed back to the host computer. This echoing back of each sent byte is a confirmation that the byte has been received and will be acted upon shortly. A short period after the last byte of a command has been echoed back, the device sends a confirmation byte (described next) that indicates the operation associated with the command completed.

Command Completion Indicator: When this device completes the operation associated with the command it has just received, it transmits back to the host computer a byte value of 13 decimal (0D hexadecimal, 00001101 binary). This byte value corresponds to an ASCII carriage return (often abbreviated as "CR").

Command Reference: The following table lists all the external-control commands for the LAMBDA 10-B.

Table F-4. Complete Command Reference.

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|---------------------------------------|---------------------|------|----------------|--------------------------|--|------|--------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| Set filter wheel, speed, and position | Tx | All | 1 | 0 | (See the following tables for possible value ranges and filter command structure.) | | | | | | Sets the filter wheel speed (0 – 7) and the filter position (0 – 9). Note that for the LAMBDA 10-B, the most significant bit (Bit 7) of the command byte is always 0. The filter wheel speed is encoded in octal (base 8) using Bits 6, 5, & 4. The filter position is encoded in BCD (Binary Coded Decimal) using the least significant nibble (Bits 3, 2, 1, & 0). |

| Command | Tx/ Delay/ Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|------------------------------------|---------------------|------|----------------|--------------------------|-------|------|-----------|-----------------------|---------------|--------------------------|--|
| | | | | | Dec. | Hex. | Binary | | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter A | Tx | All | 1 | 0 | 170 | AA | 1010 1010 | 0170 | | | Sets the state of Shutter A to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter A Conditionally | Tx | All | 1 | 0 | 171 | AB | 1010 1011 | 0171 | | | Configures Shutter A to open while filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter A | Tx | All | 1 | 0 | 172 | AC | 1010 1100 | 0172 | | | Sets the state of Shutter A closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Open Shutter B | Tx | All | 1 | 0 | 186 | BA | 1011 1010 | 0186 | | | Sets the state of Shutter B to open |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Close Shutter B | Tx | All | 1 | 0 | 188 | BC | 1011 1100 | 0188 | | | Sets the state of Shutter B closed. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Status | Tx | All | 1 | 0 | 204 | CC | 1100 1100 | 0204 | | | Returns status of unit (see status table) |
| | Rx | All | | 13 | 13 | 0D | 0000 1101 | | ^M | <CR> | Completion indicator |
| All Motors Power On | Tx | All | 1 | 0 | 206 | CE | 1100 1110 | 0206 | | | Instruct the controller to power on all motors. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| All Motors Power Off | Tx | All | 1 | 0 | 207 | CF | 1100 1111 | 0207 | | | Instruct the controller to power off all motors. |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Fast-mode Shutter | Tx | All | 2 | 0 | 220 | DC | 1101 1100 | 0220 | | | Sets fast mode (SmartShutter only) |
| | | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Soft-mode Shutter | Tx | All | 2 | 0 | 221 | DD | 1110 1101 | 0221 | | | Sets soft mode (SmartShutter only) |
| | | | | | 1 | 1 | 01 | 0000 0001 | 0001 | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | | 3 | 02 | 0000 0011 | 0003 | | | |

| Command | Tx/ Delay- Rx | Ver. | Total Bytes | Byte Offset (Len.) | Value | | | Alt- key- pad # | Ctrl- char | ASCII def./- char. | Description |
|--|---------------------|------|----------------|--------------------------|-------|------|-----------|---|---------------|--------------------------|---|
| | | | | | Dec. | Hex. | Binary | | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Neutral Density-mode Shutter | Tx | All | 3 | 0 | 222 | DE | 1110 1110 | 0222 | | | Sets neutral-density mode (SmartShutter only) |
| | | | | 1 | - | 01 | 0000 0001 | 0001 | | | 2 nd byte indicates Shutter A (1) or B (2) |
| | | | | 3 | - | 02 | 0000 0011 | 0003 | | | |
| | 2 | 1 | 01 | 0000 0001 | 0001 | | | 3 rd byte contains 1 - 144 indicating microsteps | | | |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Transfer to On Line | Tx | All | 1 | 0 | 238 | EE | 1110 1110 | 0238 | | | Puts controller on-line |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Transfer to Local | Tx | All | 1 | 0 | 239 | EF | 1110 1111 | 0239 | | | Puts controller in local mode |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Reset | Tx | All | 1 | 0 | 251 | FB | 11111011 | 0251 | | | Resets the controller |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |
| Get Controller Type and Configuration | Tx | All | 1 | 0 | 253 | FD | 11111011 | 0253 | | | Queries the controller as to its type and configuration (see controller type & config, table) |
| | Rx | All | 1 | 0 | 13 | 0D | 0000 1101 | | | <CR> | Completion indicator |

Table F-5. Filter Command Structure.

| Byte Bit # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|--------------------------|-------|-----------|---|---|-----------------|---|---|---|
| Group | Wheel | Speed | | | Filter Position | | | |
| Group Bit # | 0 | 2 | 1 | 0 | 3 | 2 | 1 | 0 |
| Decimal Group Values | 0 | 0 - 7 | | | 0 - 9 | | | |
| Hexadecimal Group Values | 0 | 0 - 7 | | | 0 - 9 | | | |
| Binary Group Values | 0 | 000 - 111 | | | 0000 - 1001 | | | |

Table F-6. Codes for filter wheel configuration.

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description Shutter or Special Command | | | |
|------------|------|----------|------------------|------------|-------------------|-----------------------|-----------------------|----------------------------|--|---|---|--|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W h e e l | S p e e d | F i l t e r | | | | |
| 0 | 00 | 00000000 | Alt-0000 | ^@ | (NUL) | A | 0 | 0 | | | | |
| 1 | 01 | 00000001 | Alt-0001 | ^A | (SOH) | | | 1 | | | | |
| 2 | 02 | 00000010 | Alt-0002 | ^B | (STX) | | | 2 | | | | |
| 3 | 03 | 00000011 | Alt-0003 | ^C | (ETX) | | | 3 | | | | |
| 4 | 04 | 00000100 | Alt-0004 | ^D | (EOT) | | | 4 | | | | |
| 5 | 05 | 00000101 | Alt-0005 | ^E | (ENQ) | | | 5 | | | | |
| 6 | 06 | 00000110 | Alt-0006 | ^F | (ACK) | | | 6 | | | | |
| 7 | 07 | 00000111 | Alt-0007 | ^G | (BEL) | | | 7 | | | | |
| 8 | 08 | 00001000 | Alt-0008 | ^H | (BS) | | | 8 | | | | |
| 9 | 09 | 00001001 | Alt-0009 | ^I | (HT) | | | 9 | | | | |
| 10 | 0A | 00001010 | Alt-0010 | ^J | (LF) | | | | | | | |
| - | - | - | - | - | - | | | | | | | |
| 15 | 0F | 00001111 | Alt-0015 | ^O | (SI) | | | | | | | |
| 16 | 10 | 00010000 | Alt-0016 | ^P | (DLE) | | | | A | 1 | 0 | |
| 17 | 11 | 00010001 | Alt-0017 | ^Q | (DC1) | | | | | | 1 | |
| 18 | 12 | 00010010 | Alt-0018 | ^R | (DC2) | | | | | | 2 | |
| 19 | 13 | 00010011 | Alt-0019 | ^S | (DC3) | 3 | | | | | | |
| 20 | 14 | 00010100 | Alt-0020 | ^T | (DC4) | 4 | | | | | | |
| 21 | 15 | 00010101 | Alt-0021 | ^U | (NAK) | 5 | | | | | | |
| 22 | 16 | 00010110 | Alt-0022 | ^V | (SYN) | 6 | | | | | | |
| 23 | 17 | 00010111 | Alt-0023 | ^W | (ETB) | 7 | | | | | | |
| 24 | 18 | 00011000 | Alt-0024 | ^X | (CAN) | 8 | | | | | | |
| 25 | 19 | 00011001 | Alt-0025 | ^Y | (EM) | 9 | | | | | | |
| 26 | 1A | 00011010 | Alt-0026 | ^Z | (SUB) | | | | | | | |
| - | - | - | - | - | - | | | | | | | |
| 31 | 1F | 00011111 | Alt-0031 | ^_ | (US) | | | | | | | |
| 32 | 20 | 00100000 | Alt-0032 | | (space) | A | 2 | 0 | | | | |
| 33 | 21 | 00100001 | Alt-0033 | | ! | | | 1 | | | | |
| 34 | 22 | 00100010 | Alt-0034 | | " | | | 2 | | | | |
| 35 | 23 | 00100011 | Alt-0035 | | # | | | 3 | | | | |
| 36 | 24 | 00100100 | Alt-0036 | | \$ | | | 4 | | | | |
| 37 | 25 | 00100101 | Alt-0037 | | % | | | 5 | | | | |
| 38 | 26 | 00100110 | Alt-0038 | | & | | | 6 | | | | |
| 39 | 27 | 00100111 | Alt-0039 | | ' | | | 7 | | | | |
| 40 | 28 | 00101000 | Alt-0040 | | (| | | 8 | | | | |
| 41 | 29 | 00101001 | Alt-0041 | |) | | | 9 | | | | |
| 42 | 2A | 00101010 | Alt-0042 | | * | | | | | | | |
| - | - | - | - | | - | | | | | | | |
| 47 | 2F | 00101111 | Alt-0047 | | / | | | | | | | |
| 46 | 30 | 00110000 | Alt-0048 | | 0 | A | 3 | 0 | | | | |
| 49 | 31 | 00110001 | Alt-0049 | | 1 | | | 1 | | | | |
| 50 | 32 | 00110010 | Alt-0050 | | 2 | | | 2 | | | | |
| 51 | 33 | 00110011 | Alt-0051 | | 3 | | | 3 | | | | |
| 52 | 34 | 00110100 | Alt-0052 | | 4 | | | 4 | | | | |
| 53 | 35 | 00110101 | Alt-0053 | | 5 | | | 5 | | | | |

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description |
|------------|------|----------|------------------|------------|-------------------|----------------------|---|---|-------------------------------|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W | S | F | |
| | | | | | | h | p | i | |
| | | | | | | e | e | t | |
| | | | | | | e | e | r | |
| 54 | 36 | 00110110 | Alt-0054 | | 6 | | | 6 | Shutter or Special Command |
| 55 | 37 | 00110111 | Alt-0055 | | 7 | | | 7 | |
| 56 | 38 | 00111000 | Alt-0056 | | 8 | | | 8 | |
| 57 | 39 | 00111001 | Alt-0057 | | 9 | | | 9 | |
| 58 | 3A | 00111010 | Alt-0058 | | : | | | | |
| - | - | - | - | - | - | | | | |
| 63 | 3F | 00111111 | Alt-0063 | | ? | | | | |
| 64 | 40 | 01000000 | Alt-0064 | | @ | A | 4 | 0 | |
| 65 | 41 | 01000001 | Alt-0065 | | A | | | 1 | |
| 66 | 42 | 01000010 | Alt-0066 | | B | | | 2 | |
| 67 | 43 | 01000011 | Alt-0067 | | C | | | 3 | |
| 68 | 44 | 01000100 | Alt-0068 | | D | | | 4 | |
| 69 | 45 | 01000101 | Alt-0069 | | E | | | 5 | |
| 70 | 46 | 01000110 | Alt-0070 | | F | | | 6 | |
| 71 | 47 | 01000111 | Alt-0071 | | G | | | 7 | |
| 72 | 48 | 01001000 | Alt-0072 | | H | | | 8 | |
| 73 | 49 | 01001001 | Alt-0073 | | I | | | 9 | |
| 74 | 4A | 01001010 | Alt-0074 | | J | | | | |
| - | - | - | - | - | - | | | | |
| 79 | 4F | 01001111 | Alt-0079 | | O | | | | |
| 80 | 50 | 01000000 | Alt-0080 | | P | A | 5 | 0 | |
| 81 | 51 | 01000001 | Alt-0081 | | Q | | | 1 | |
| 82 | 52 | 01000010 | Alt-0082 | | R | | | 2 | |
| 83 | 53 | 01000011 | Alt-0083 | | S | | | 3 | |
| 84 | 54 | 01000100 | Alt-0084 | | T | | | 4 | |
| 85 | 55 | 01000101 | Alt-0085 | | U | | | 5 | |
| 86 | 56 | 01000110 | Alt-0086 | | V | | | 6 | |
| 87 | 57 | 01000111 | Alt-0087 | | W | | | 7 | |
| 88 | 58 | 01001000 | Alt-0088 | | X | | | 8 | |
| 89 | 59 | 01001001 | Alt-0089 | | Y | | | 9 | |
| 90 | 5A | 01001010 | Alt-0090 | | Z | | | | |
| - | - | - | - | - | - | | | | |
| 95 | 5F | 01011111 | Alt-0095 | | - | | | | |
| 96 | 60 | 01010000 | Alt-0096 | | ` | A | 6 | 0 | |
| 97 | 61 | 01010001 | Alt-0097 | | a | | | 1 | |
| 98 | 62 | 01010010 | Alt-0098 | | b | | | 2 | |
| 99 | 63 | 01010011 | Alt-0099 | | c | | | 3 | |
| 100 | 64 | 01010100 | Alt-0100 | | d | | | 4 | |
| 101 | 65 | 01010101 | Alt-0101 | | e | | | 5 | |
| 102 | 66 | 01010110 | Alt-0102 | | f | | | 6 | |
| 103 | 67 | 01010111 | Alt-0103 | | g | | | 7 | |
| 104 | 68 | 01011000 | Alt-0104 | | h | | | 8 | |
| 105 | 69 | 01011001 | Alt-0105 | | i | | | 9 | |
| 106 | 6A | 01011010 | Alt-0106 | | j | | | | |
| - | - | - | - | - | - | | | | |
| 111 | 6F | 01011111 | Alt-0111 | | o | | | | |
| 112 | 70 | 01110000 | Alt-0112 | | p | A | 7 | 0 | |

| Byte Value | | | Keyboard Entry | | | Filter Wheel Command | | | Description |
|------------|------|----------|------------------|------------|-------------------|-----------------------|-----------------------|----------------------------|-------------------------------|
| Dec. | Hex. | Binary | Alt-keypad entry | Ctrl-char. | ASCII def./-char. | W h e e l | S p e e d | F i l t e r | |
| 113 | 71 | 01110001 | Alt-0113 | | q | | | 1 | Shutter or Special Command |
| 114 | 72 | 01110010 | Alt-0114 | | r | | | 2 | |
| 115 | 73 | 01110011 | Alt-0115 | | s | | | 3 | |
| 116 | 74 | 01110100 | Alt-0116 | | t | | | 4 | |
| 117 | 75 | 01110101 | Alt-0117 | | u | | | 5 | |
| 118 | 76 | 01110110 | Alt-0118 | | v | | | 6 | |
| 119 | 77 | 01110111 | Alt-0119 | | w | | | 7 | |
| 120 | 78 | 01111000 | Alt-0120 | | x | | | 8 | |
| 121 | 79 | 01111001 | Alt-0121 | | y | | | 9 | |

NOTES:

- Task-Complete Indicator:** All commands will send back to the computer the “Task-Complete Indicator” to signal the command and its associated function in controller is complete. The indicator consists of one (1) byte containing a value of 13 decimal (0D hexadecimal), and which represents an ASCII CR (Carriage Return).
- Intercommand Delay:** A short delay (usually around 2 ms) is recommended between commands (after sending a command sequence and before sending the next command).
- Clearing Send/Receive Buffers:** Clearing (purging) the transmit and receive buffers of the I/O port immediately before sending any command is recommended.
- Encoding a Command:** Encoding filter wheel commands into a single byte:

$$\text{Command byte} = (\text{wheel} * 128) + (\text{speed} * 16) + \text{position}$$
Where
wheel = 0 (Wheel A),
speed = 0 through 7, and
position = 0 through 9.
- Use of Bit 7:** The LAMBDA 10-B supports only one filter wheel (Wheel A). Therefore, Bit 7 should always be set to 0.
- ASCII Definition Character Codes 128 through 255:** The “ASCII def./char.” column for codes 128 through 255 (80 through FF hex) is left blank, since there are no ASCII character definitions for the codes in this range. However, many computers and operating systems do support characters within this range, although there is no single standard across all platforms. Furthermore, many operating systems, such as Microsoft Windows and Apple Mac OS X, have several “code pages” (character sets), many of which are country/language specific, from which the user can select. Therefore, this part of the table is left blank – if you wish, you may write in the characters defined in the character set you use on a regular basis.
- Commands prior to Rev. D:** All commands indicated with “*” are not available in early versions of the LAMBDA 10-B (those prior to Revision D).

Table F-7. “Get Status” command return data in a “Wheel & Shutter” configuration.

| Byte Offset | Label | Byte Value | | | Description | Bit Values | |
|-------------|----------------------------------|---------------|---------------|---------------------------|--|-------------|-------------------|
| | | Dec. | Hex. | Binary | | Dec./Hex | Binary |
| 0 | Command echo | 204 | CC | 11001100 | The Status command byte code echoed back. | | |
| 1 | Wheel A status | | | 0xxxxxxx | WHEEL A SELECT: 1 bit.(Bit 7) Pattern: 0xxxxxx (always zero) | 0 | 0 |
| | | | | x000xxxx - x111xxxx | SPEED: 3 bits. (Bits 6, 5, & 4) Bit Pattern: x000xxx – x111xxxx | 0 - 7 | 000 - 111 |
| | | | | xxxx0000 - xxxx1001 | POSITION: 4 bits (Bits 3, 2, 1, & 0) Bit Pattern: xxxx0000 – xxxx1001 | 0 - 9 | 0000 - 1001 |
| | | 10 | 0A | 00001010 | Either no filter wheel is installed or there is an error on the 15-pin wheel port. | | |
| 2 | Shutter open/closed state | 170 | AA | 10101010 | Open | | |
| | | 171 | AB | 10101011 | Open is conditional | | |
| | | 172 | AC | 10101100 | Closed | | |
| 3 | SmartShutter mode (1 or 2 bytes) | 219 | DB | 11011011 | Indicates no SmartShutter or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| (4)* | | 1 - 144 | 01 - 90 | 00000001 - 10010000 | Number of microsteps (1 – 144) for neutral density mode. NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)). | | |
| 4 or (5)* | Return data terminator | 13 | 0D | 00001101 | ASCII CR (carriage return). | | |

*** NOTE:** The length of the status data structure when the LAMBDA 10-B is in the “Wheel & Shutter” configuration is 5 or 6 bytes depending on whether a SmartShutter is connected and, if connected, what mode is it in. If no SmartShutter is installed or if the SmartShutter Mode is not Neutral Density, then the length of the data is 5 and ends with the return data terminator at Offset 4. If a SmartShutter is connected and its mode is set to Neutral Density, then the level of neutral density (1-144 microsteps) is present at Offset 4 and the return data terminator is moved to Offset 5.

Table F-8. “Get Status” command return data in a “Dual-SmartShutter” configuration.

| Byte Offset | Label | Byte Value | | | Description | Bit Values | |
|-------------|------------------------------------|------------|------|----------|--|------------|--------|
| | | Dec. | Hex. | Binary | | Dec./Hex | Binary |
| 0 | Command echo | 204 | CC | 11001100 | The Status command byte code echoed back. | | |
| 1 | Shutter A open/closed state | 170 | AA | 10101010 | Open | | |
| | | 171 | AB | 10101011 | Open is conditional | | |
| | | 172 | AC | 10101100 | Closed | | |
| 2 | Shutter B open/closed state | 186 | BA | 10111010 | Open | | |
| | | 188 | BC | 10111100 | Closed | | |
| 3 | Shutter A mode (SmartShutter only) | 219 | DB | 11011011 | SmartShutter A not connected: Indicates either that no SmartShutter is connected, or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| 4 | | 1 | 01 | 00000001 | Device designator: Shutter A | | |
| (5) | | 1 | 01 | 00000001 | A third byte contains the number of microsteps (1 – 144). NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)). | | |
| | | – | – | – | | | |
| | | 144 | 90 | 10010000 | | | |
| 5 or 6 | Shutter B mode (SmartShutter only) | 219 | DB | 11011011 | SmartShutter B not connected: Indicates either that no SmartShutter is connected, or a Vincent shutter is connected. | | |
| | | 220 | DC | 11011100 | Fast Mode | | |
| | | 221 | DD | 10111011 | Soft Mode | | |
| | | 222 | DE | 10111100 | Neutral Density Mode | | |
| 6 or 7 | | 2 | 02 | 00000002 | Device designator: Shutter B | | |
| (7 or 8) | | 1 | 01 | 00000001 | A third byte contains the number of microsteps (1 – 144). NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter B Mode is set to Neutral Density (Offset 5 or 6 = 222 (0xDE)). | | |
| | | – | – | – | | | |
| | | 144 | 90 | 10010000 | | | |
| 7, 8, or 9 | Return data terminator | 13 | 0D | 00001101 | ASCII CR (carriage return). | | |

*** NOTE:** The block of data returned by the Get Status command will vary in length depending on whether neither, either, or both SmartShutters (A and/or B) is/are in Neutral Density mode. All modes are followed by an additional byte indicating which device to which the mode pertains (1 = Shutter A and 2 = Shutter B. When Neutral Density mode is selected, a third byte exists that contains the number of microsteps (1 – 144) used to indicate the Neutral Density level. The following table outlines the characteristics of the status block of data according to the mode of each of the two SmartShutters.

Table F-9. “Get Controller Type and Configuration” command return data in a wheel & shutter configuration.

| Total num. bytes | Category | Byte Offset | Length | Value (Decimal, hexadecimal, & binary) | ASCII Char. Seq. | Description |
|--------------------------------|-------------------|-------------|---|--|---|--|
| 14 | Command echo back | 0 | 1 | 253 ₁₀ , FD ₁₆ , 11111101 ₂ | ý | “Get Controller Type & Config.” command echoed back. * |
| | Controller Type | 1 | 4 | | 10-B | LAMBDA 10-B ** |
| | Filter Wheel Type | 5 | 4 | | W-25 | 25 mm |
| | | | | | W-32 | 32 mm |
| | | | | | W-HS | High Speed |
| | | | | | W-BD | Belt Driven |
| | | | | | W-NC | Not Connected |
| | | | | | W-ER | Error |
| | Shutter Type | 9 | 4 | | S-IQ | SmartShutter |
| | | | | S-VS | Vincent Shutter (or no shutter connected) | |
| Command return data terminator | 13 | 1 | 13 ₁₀ , 0D ₁₆ , 00001101 ₂ | <CR> | ASCII CR (carriage return). | |

Table F-10. “Get Controller Type and Configuration” command return data in a dual-SmartShutter configuration.

| Total num. bytes | Category | Byte Offset | Length | Value (Decimal, hexadecimal, & binary) | ASCII Char. Seq. | Possible Values |
|------------------|--------------------------------|-------------|--------|--|------------------|--|
| 16 | Command echo back | 0 | 1 | 253 ₁₀ , FD ₁₆ , 11111101 ₂ | ý | “Get Controller Type & Config.” command echoed back. * |
| | Controller Type | 1 | 4 | | 10-B | LAMBDA 10-B ** |
| | Shutter A Type | 5 | 5 | | SA-IQ | 1 st SmartShutter (A) |
| | Shutter B Type | 10 | 5 | | SB-IQ | 2 nd SmartShutter (B) |
| | Command return data terminator | 15 | 1 | 13 ₁₀ , 0D ₁₆ , 00001101 ₂ | <CR> | ASCII CR (carriage return). |

***NOTE:** The character shown in the “ASCII Character Sequence” column for the command echo in the previous two tables is a typical visual representation of the byte value 253 decimal (FD hexadecimal) on both Windows and Linux platforms. However, other platforms may display a different character or nothing at all. For the command return data terminator (ASCII carriage return (13 decimal, 0D hexadecimal), generally no character will be displayed, although the carriage return is acted upon in most cases in text-based console programs.

****NOTE:** Other Sutter Instrument Lambda-series instruments can be configured by the user to identify themselves as “10-B” so they can be treated as compatible by existing software. These instruments are the Lambda XL and Lambda VF series. With the Lambda XL, the data returned by the “Get Controller Type & Configuration” and “Get Status” commands are identical to an actual LAMBDA 10-B, with the exception that “Controller Type” in the previous two tables can be either “10-B” or “LBXL”. In the case of the Lambda VF series, the data returned by both commands differs considerably from what is returned by an actual LAMBDA 10-B, and differences further exist between Lambda VF series models (Lambda VF-5, Lambda VF-1 (Single-Channel configuration), and Lambda VF-1 (Dual-Channel configuration)). It is strongly recommended to anyone writing code to identify a connected LAMBDA 10-B that the exceptions just discussed are considered so as to avoid confusing an actual LAMBDA 10-B from a Lambda VF-5 or VF-1 that is configured to appear as a LAMBDA 10-B. Please consult the manual for the Lambda VF-5 or VF-1 for specifics of the data structures returned by both commands.

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