

LAMBDA XL

EXTENDED-LIFE ILLUMINATOR WITH
INTEGRATED FILTER WHEEL &
SMARTSHUTTER[®] CONTROL SYSTEM

OPERATION MANUAL

REV. 2.01B (20190606)



SUTTER INSTRUMENT[®]

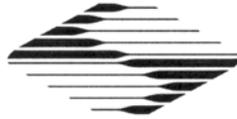
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CE EU Declaration of Conformity

Application of Council Directives:
2014/30/EU (EMC), 2014/35/EU (LVD), and 2011/65/EU (RoHS 2)

Manufacturer's Name: Sutter Instrument Company

Manufacturer's Address: One Digital Drive
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Equipment Tested: **Lambda XL** Extended Life Light Source System with Optical Filter Changer and SmartShutter Controller

Model(s): **LB-XL** system with **LB10-NWIK/XL** option

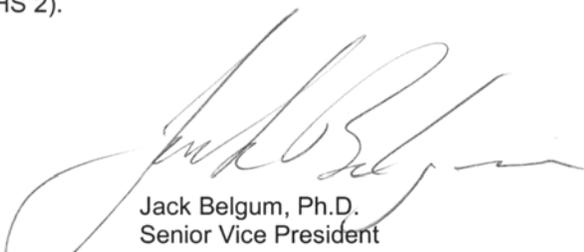
Conforms to Standards: EMC Emissions: EN 61326-1:2013, including:
EN 55011: 2009 Class B;
EN 61000-3-2:2015, & EN 61000-3-3:2014
EMC Immunity: EN 61000-4-2:2009, EN 61000-4-3:2011,
EN 61000-4-4:2012, EN 61000-4-5:2014,
EN 61000-4-6:2014, EN 61000-4-8:2010, &
EN 61000-4-11:2004
LVD (Safety): EN 61010-1:2010
Photobiological Safety of Lamps & Lamp Systems:
EN 62471: 2008 / IEC 62471, Ed 1.0 (2006-07)

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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 2011/65/EU (RoHS 2).

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DISCLAIMER

The **Lambda XL** is an extended life light source designed for the specific use as a microscope illuminator. The unit can optionally be equipped with internal optical filter switching designed for the specific use of changing filters into and out of an optical pathway. No other use is recommended.

This instrument is designed for use in a laboratory environment. It is not intended for use, 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

This light source should be operated only in accordance with the proper operating instructions provided in this manual or by the Sutter Instrument technical support. Please direct any questions you might have regarding this system to Sutter Instrument, by telephone at +1 415 883 0128, by fax at +1 415 883 0572 or by email at info@sutter.com.

Electrical

- Operate the Lambda 10-3 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:
5 Amp, 250V, 5 x 20mm, Time Delay fuse (EIC 60127-2, Sheet III)
(Examples: Bussmann S506-5-R (RoHS), or
Littelfuse 218.005.P (RoHS))

A spare fuse is located 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 in the event that 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.

NOTE: The Lambda XL does not produce ozone and no high voltages are employed in its operation

Operational Hazards

The operation of the Lambda XL light source involves one or more of the following hazards

Intense Light

The Lambda XL produces high levels of visible and near-UV radiation, which can cause eye damage, skin burns or, when concentrated, even fire.



WARNING

To avoid any physical injury while the unit is powered up and emitting light, NEVER LOOK DIRECTLY INTO THE LIGHT GUIDE OR INTO THE LAMP OUTPUT PORT, IF THE LIGHT GUIDE IS NOT INSTALLED! Keep skin, cloths, or anything that can be damaged by heat or intense radiation away from the end of the light guide or the lamp output port, if the light guide is not installed.

Explosion

During operation, the content of the bulb can reach high pressures. A risk of explosion exists, if the quartz envelope of the bulb fractures. To avoid any danger, do not operate the unit with the cabinet open. To avoid lamp overheating, operate only in a location where fresh air is allowed to flow freely all around the unit and keep the mesh screens covering the vents free of dust.

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 or component failure and is designed with the primary goal of ensuring that it will not allow any unintended exposure to the light.

The SmartShutter is intended for use in the controlling of the light in scientific and industrial applications. It was designed for high performance and durability, but it does not have certain features that would be desirable in a safety shutter application.

PRECAUTIONS

Operational Precautions

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

- **DO NOT DISCONNECT THE POWER CABLE WHEN THE LAMP IS ON. FAILURE TO SHUT THE LAMP DOWN FIRST MAY CAUSE DAMAGE TO THE LAMP MODULE.**
- **DO NOT REMOVE POWER OR ATTEMPT TO TURN OFF THE LAMP OR THE UNIT WITHIN 1 MINUTE OF TURNING ON THE LAMP.**
- Operate the Lambda XL using 100V - 240V AC, 50/60 Hz line voltage.
- The Lambda XL is designed for operation in a laboratory environment (pollution degree II).
- The Lambda XL is designed for connection to a standard laboratory power outlet (overvoltage category II).
- 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.**
- Since the Lambda XL is a microprocessor-controlled device, it should be wired according to the same system wiring precautions as any 'computer type' system. A surge protector is recommended.

Avoiding Damage to the Lamp Module

Once the lamp begins to power up, the contents of the capsule must be allowed to fully vaporize, or the lamp will not turn on properly in the future.



CAUTION

DO NOT REMOVE POWER OR ATTEMPT TO TURN OFF THE LAMP OR THE UNIT WITHIN ONE (1) MINUTE OF TURNING ON THE LAMP.



CAUTION

WHEN SHUTTING DOWN THE LAMBDA XL, FIRST STOP THE LAMP (MANUALLY, VIA THE KEYPAD, OR REMOTELY BY SOFTWARE RUNNING ON THE USB-CONNECTED COMPUTER) AND WAIT A FULL ONE (1) MINUTE BEFORE POWERING OFF THE SYSTEM. THIS ALLOWS FOR THE PROPER COOLING OF THE LAMP WHEN THE SYSTEM IS SHUTDOWN.

Preparation

It is recommended to establish a solid, leak-free, light path between the lamp cabinet and the microscope before turning on the lamp. The intensity and wavelengths of the light that can be produced by the Lambda XL are such that they could produce eye and skin damage, or it could burn heat sensitive objects. The device should not be turned on unless the light guide is attached and directed into a microscope or away from people's eyes, skin or clothes or any objects that might be damaged by heat. To reiterate:

**WARNING**

DO NOT LOOK DIRECTLY INTO THE LIGHT GUIDE! The output of the light or the light guide should be directed into the microscope using the appropriate adapters, directed away from anyone's eyes or skin and away from any heat sensitive objects, or reflective surfaces.

Optical Filter Type Selection and Usage**CAUTION**

To avoid damage to installed optical filters and to the Lambda XL system equipment, it is essential that only “hard-coated” (sputter-coated) optical filters be used, such as those available from Semrock and the ET Series from Chroma Technology Corp.

If purchasing optical filters from Chroma, make certain that only ET Series sets that do not contain soft-coated filters are specified.

If soft-coated (vacuum deposit) optical filters are used in the Lambda XL system, the intensity of the light source can melt the filters and cause the filters to be fused to the equipment.

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1. GENERAL INFORMATION

1.1 Introduction

The Lambda XL is an extended life light source with integrated filter wheel and SmartShutter® control system. Electrode-less lamp technology is used to produce high intensity, high stability output in the near-UV and visible range (330-700 nm). Within this range, the output of the Lambda XL is very similar to that of the Lambda LS, the Sutter xenon arc light source.

The Lambda XL is designed for use with a liquid light guide that transmits remarkably flat, intense, illumination to the optical train of a microscope or other instrumentation. Light guide adapters are available for most common microscope systems (Zeiss, Olympus, Nikon and Leica).

The Lambda XL cabinet can accommodate a standard Sutter Instrument filter wheel and SmartShutter or a standalone SmartShutter; either is easily installed in the light path.

This manual is continually being updated. If there are any areas that you feel should be covered in greater detail, we would like to hear from you. Please contact our Technical Support staff with your suggestions (+1 (415)-883-0128 or info@sutter.com).

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 Standard Time) at +1 (415) 883-0128. You may also E-mail your queries to info@sutter.com.

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2. INSTALLATION

2.1 Unpacking

The Lambda XL and associated accessories are shipped together in a single carton. The following is a list of components included. If you believe that any of the components are missing or show signs of damage from shipping, please contact Sutter Instrument Company by telephone at +1 (415) 883 0128, by fax at +1 (415) 883 0572 or by email at info@sutter.com.

1. Lamp cabinet with factory installed lamp module, optics, and power supply.
2. Power cord
3. USB cable
4. Manual
5. Light guide and light guide heat sink (if ordered)
6. Microscope adapter(s) (if ordered)
7. Filter wheel equipped with SmartShutter or stand-alone SmartShutter. Either of these items, if ordered at the same time, are installed inside the Lambda XL
8. Spanner wrench (with filter wheel; for installing/removing filters)
9. Spare spacer ring and retaining ring (with filter wheel)
10. Slide-in filter holder (with filter wheel)
12. Sutter Instrument catalogue

NOTE: Device drivers and software for controlling the Lambda XL over the USB interface by a host computer can be downloaded from Sutter Instrument's web site (<http://www.sutter.com/>).

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3. OPERATING INSTRUCTIONS

3.1 First Time Use

3.1.1 Some Basic Information

The LAMBDA XL is a microprocessor-controlled system, designed for microscopy imaging or other applications that require illumination in the near-UV and visible wavelength range. The device features a display and a keypad for local control and a USB input for remote control.

The Lambda XL is also equipped with an integrated filter wheel and SmartShutter controller. When present, the optional filter wheel with a SmartShutter[®], are installed inside the instrument to provide wavelength switching capability and/or light shuttering when such features are desired.

The remote control of the wheel and the shutter through the USB input uses the same simple protocol as the Sutter Lambda 10-B controller. If the USB control is not available in the software package used, it may be possible to use the virtual com port driver from Sutter Instrument to provide serial port functionality with the USB port. Please contact Sutter Instrument for more information. The following instructions are meant to help you set up the Lambda XL and familiarize you with the filter wheel and the SmartShutter. Details on the manual control and remote communications can be found in the following sections of this manual.

3.1.2 Line Power (Mains)

The power cord provided with the Lambda XL connects to the Power Entry Module located on the back of the unit (Figures 5.1 and 5.2). The following components are located on the rear panel of the Lambda XL:

USB PORT – A USB Type B receptacle, used to connect the Lambda XL controller as a USB device to a USB port of a host computer.

POWER SWITCH – This turns on the system power.

LINE POWER – This socket is used to connect the power cord to the Lambda XL. This module also includes the Line Fuse and Power Switch.

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.

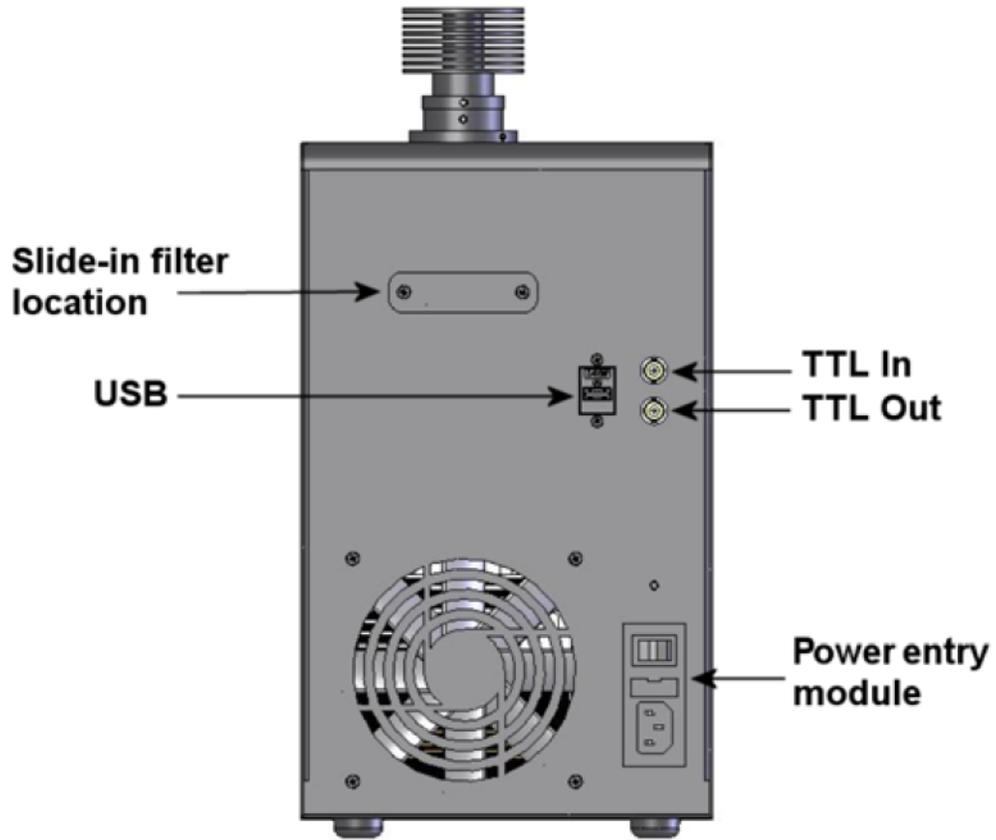


Figure 3-1. Lambda XL Cabinet (rear view).

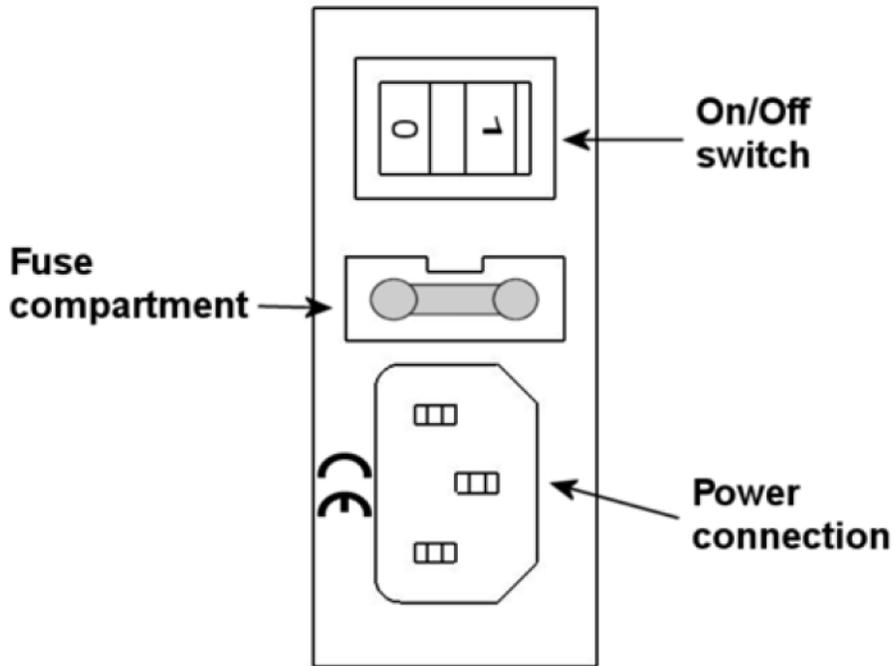


Figure 3-2. Power Entry Module

The Lambda XL 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 back panel of the Lambda XL cabinet is in the OFF position. Plug the power cord provided with the Lambda XL into the line input socket on the power entry module and then to a power source of the appropriate voltage and frequency.

3.2 Light Guide Installation

The light output of the Lambda XL is focused into the input end of a liquid light guide, which allows it to be coupled into the microscope.

The liquid light guide provided has one bare end and one end covered by a black “end sleeve”. Insert the bare end of the light guide all the way into protective heat sink provided and fasten it in place using the setscrew located in the heat sink. A 0.05 hex wrench is included with the heat sink for this purpose. The end of the light guide covered by the sleeve is to be installed in the microscope adapter. The adapters are microscope specific. For installation instructions, please refer to the documentation included with each adapter. For best performance, keep the end portions straight and avoid sharp bends in the light guide.

CAUTION: PLEASE NOTE THAT THE LIGHT GUIDE HAS A MINIMUM-BENDING RADIUS OF 40 MM (ABOUT 1.6 INCHES), but performance is better if you use more gradual bends. The light guide should be supported so that there is minimal bending in the first 10 cm in order to get the best throughput.

NOTE: The distance between the heat sink at the top of the cabinet and the light source is maintained by a retaining ring. This retaining ring is factory-installed so that the heat sink is the correct distance from the light source. It is strongly advised that this retaining ring not be adjusted. The heat sink contains a stopper for the liquid light guide that ensures a minimum safe distance from the light source.

3.3 Filter Wheel

3.3.1 Mechanical Description

A ten-position 25 mm diameter filter wheel with or without SmartShutter can be accommodated inside the cabinet of the Lambda XL. Although all the units have the integrated filter wheel and SmartShutter driver, both the filter wheel and the SmartShutter are optional. If ordered at the same time as the Lambda XL, the filter wheel is installed in the unit at the factory, but it has to be removed by the user for filter installation.

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

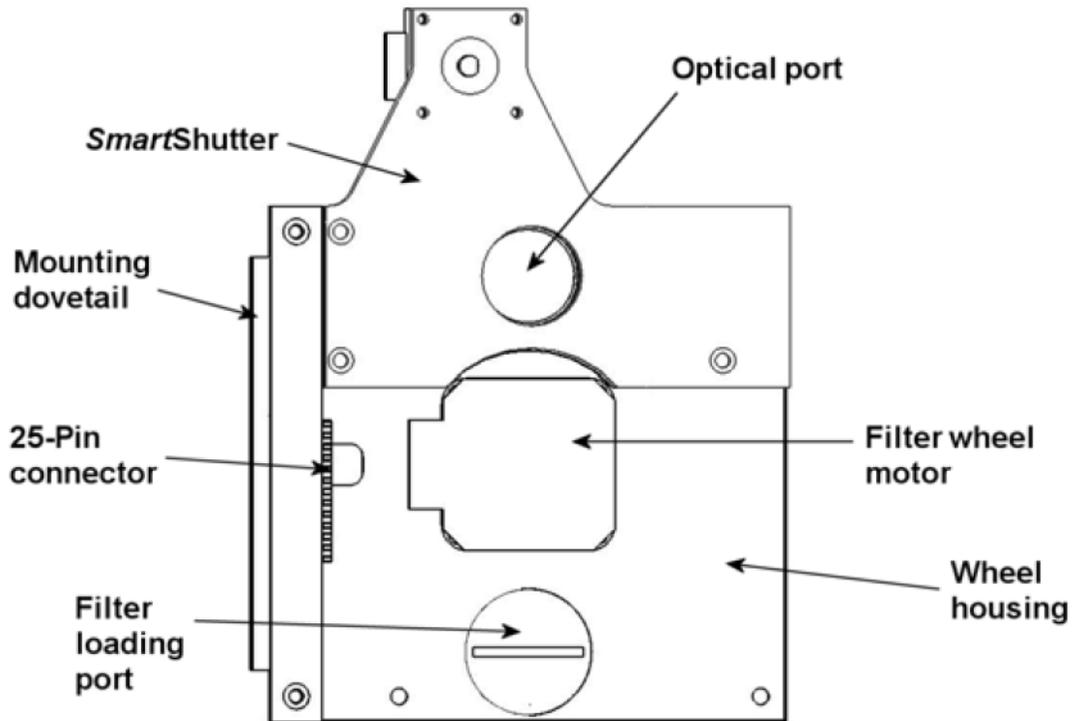


Figure 3-3. Lambda XL filter wheel with SmartShutter - back side

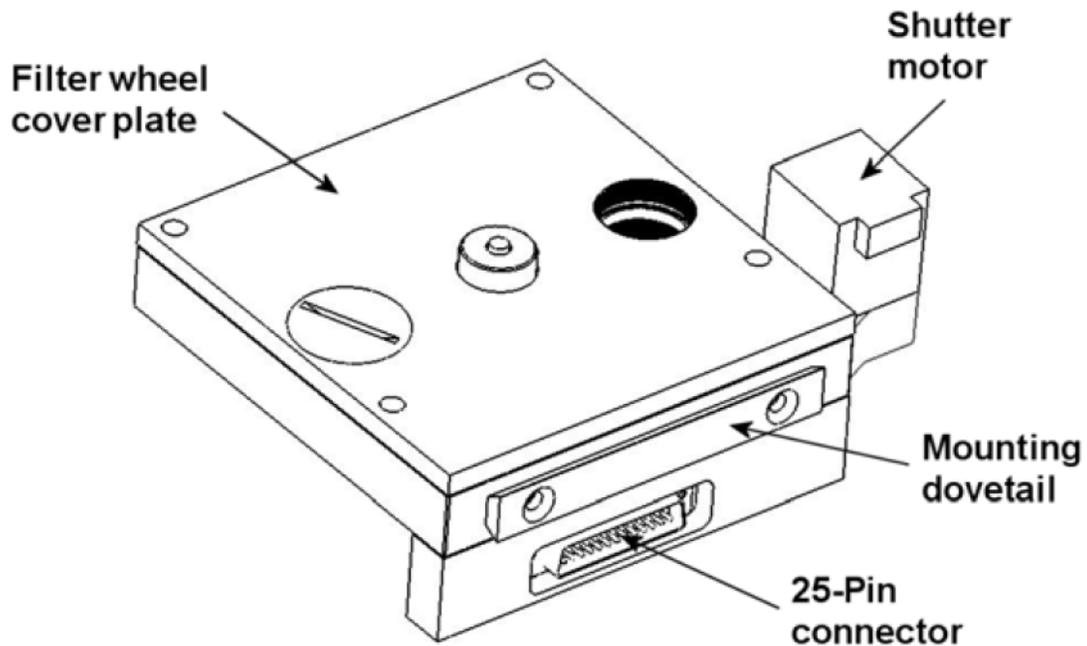


Figure 3-4. Lambda XL filter wheel with SmartShutter - front side

If a filter wheel, with or without shutter, was ordered at the same time as the Lambda XL, it would be shipped installed inside the unit. To gain access to the wheel, remove the upper portion of the left side panel (the filter access panel) as shown in Figure 3-5 A. Locate and

remove the two wheel lock screws (Figure 3-5 B) and retaining bracket. Pull the filter wheel out, (Figure 3-5 C), but do not disconnect the 25- or 15-pin ribbon cable.

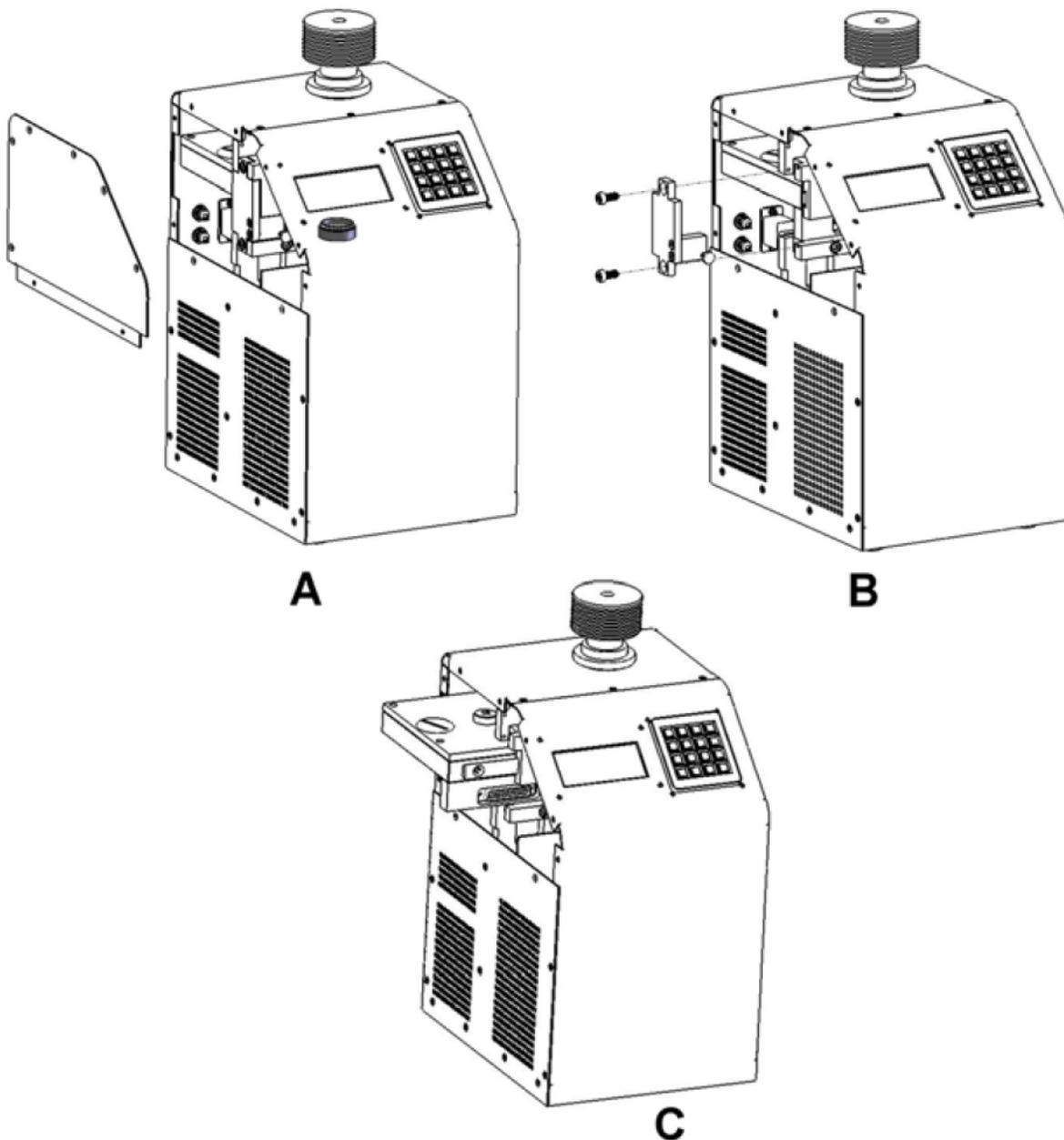


Figure 3-5 A-C. Filter wheel access and installation

3.3.2 Loading Filters

3.3.2.1 Filters and Filter Orientation

The Lambda XL filter wheel can be used with a range of 1 inch or 25mm diameter filters whose thickness should not exceed the values in Table 3-1.

Table 3-1. Maximum Allowable Filter Thickness.

	With Spacer		Without Spacer	
	(Millimeters)	(Inches)	(Millimeters)	(Inches)
Slide-in Holder	1.38	0.054	4.56	0.18
Filter Cup	5.89	0.2315	9.07	0.3575

Filters used with the Lambda XL should be rated for high power and have a substrate that has low absorbance in the near-UV and/or visible regions. Filters protected by reflective coatings are recommended for the near UV region of the spectrum. For more information, please call or email Sutter Instrument.

Sutter Instrument Company does not supply filters, but filters conforming to the above specifications can be purchased from filter manufacturers.

The two sides of a filter are usually not identical due to differences in their surface coatings. Some form of labeling will be present, usually on the filter frame, 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.

3.3.2.2 Filter Cups and Filter Holders

At each filter position on the filter wheel there is a filter cup assembly to hold one 1" filter. The Lambda XL also comes with one removable 1" slide-in filter holder that can be placed into the optical pathway to accommodate "fixed" filters, such as neutral density filters. The slide-in filter holders can be inserted in the light path through the slot in the upper side of the back panel.

Many users prefer having extra Slide-in filter holders for more convenient replacement of these "fixed" filters. **Only use filter holders made by Sutter Instrument Company in the Lambda XL 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" in the Sutter catalogue.

To gain access to the filter cups, remove the plug covering the loading port shown in Figure 3-4. There are at least two components installed into each filter cup or holder before the Lambda XL 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 the slide-in filter holder(s), there will also be a blanking disc. As an example, Figure 3-6 depicts these items using the slide-in filter holder.

3.3.2.3 Retaining Ring

This ring is threaded on its outside surface and has two slots on its top edge. The two slots are designed for the removal and installation of the retaining ring when using the retaining ring driver or spanner wrench that is provided with the Lambda XL (Figure 3-6).

3.3.2.4 Spacer Ring

This spacer 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 the

thickness of the filter permits or a blanking disc is installed in either a filter cup or a slide-in filter holder. Maximum filter thickness for the filter cup and holders are specified in Table 3-1.

3.3.2.5 Blanking Disc

In all but one of the filter cups in the wheel 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.

3.3.3 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 slide-in filter holder before attempting to load filters into the filter cups.

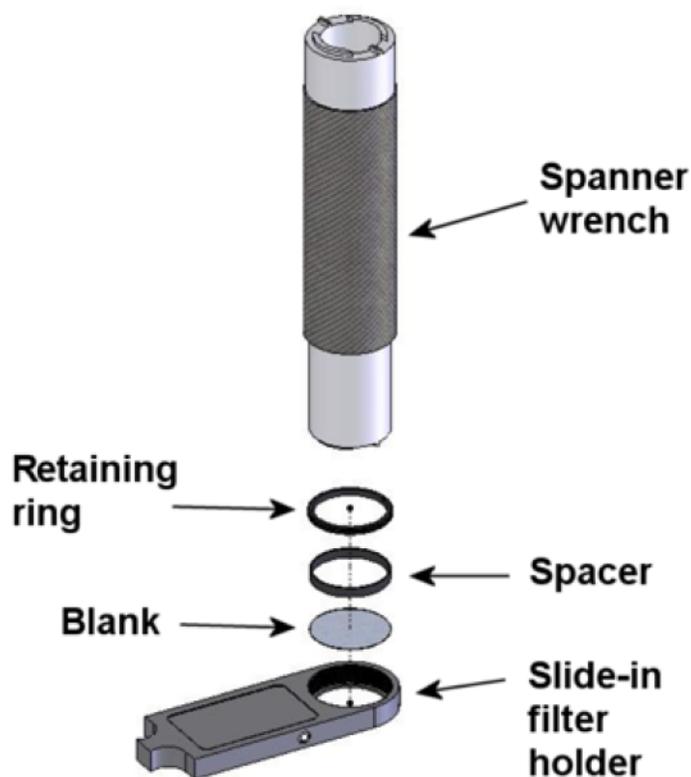


Figure 3-6. Installation of filters into slide-in filter holders

The threaded retaining ring has two notches cut into it, 180 degrees apart. Place the smaller notched end of the brass spanner wrench (Figure 3-6) into the notches on the retaining ring and carefully turn it counter-clockwise 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!

Place the desired filter into the filter holder, first. Extra care must be taken to avoid getting the filters jammed at an angle. Refer to the filter manufacturer instructions to find out which side of the filter should be installed towards the light.

Next, install the spacer ring into the filter holder (Figure 3-6), if the filter thickness does not preclude the use of the spacer ring. 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.

3.3.4 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 side of the filter wheel (Figure 3-4). 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. If the filter wheel was installed inside the unit, remove it without disconnecting it from the board as explained in the beginning of this section. If the filter wheel was not installed, use the 25 pin ribbon cable provided to connect the filter wheel to the Lambda XL electronic board, then turn on the unit. See the following chapter for instructions on the keypad control of the unit. There is no need to turn on the lamp at this time.

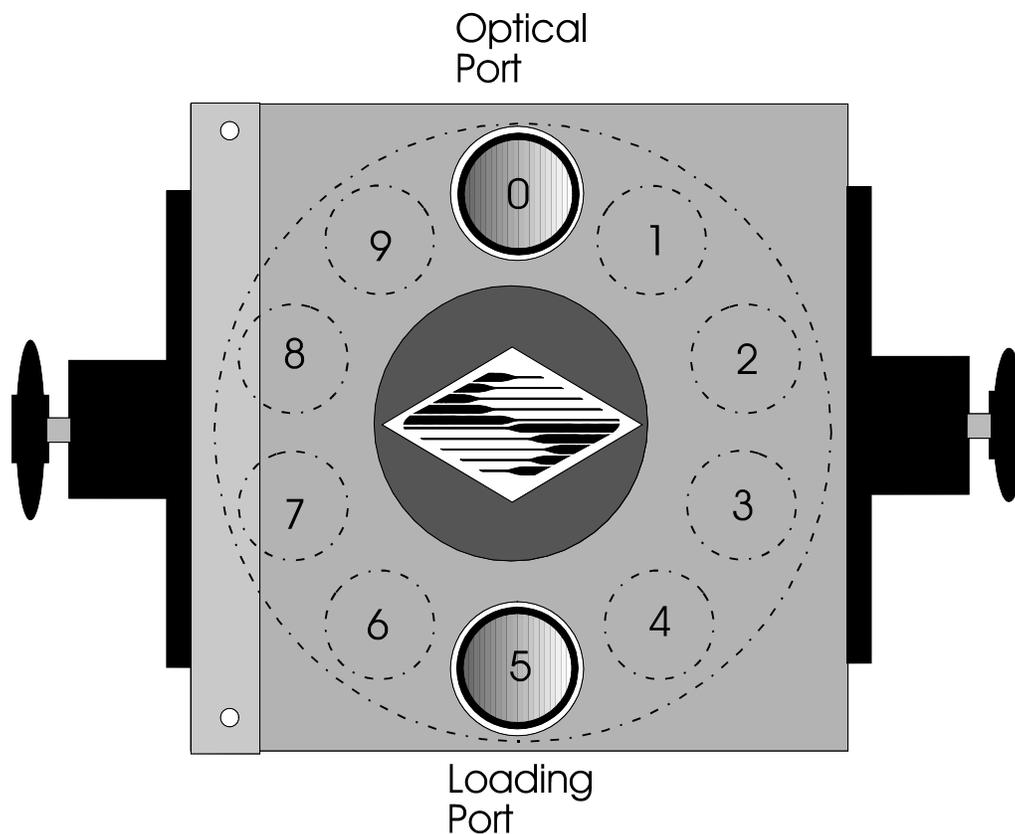
When the unit is turned on, the filter wheel will “HOME” itself, aligning the “0” filter position with the optical port and filter position #5 with the loading port. The filter currently in the loading port is five positions removed from the one indicated by the display (i.e., the one at the OPTICAL PORT). This relationship between the filter position indicated by the controller and the filter position at the LOADING PORT is illustrated in Figure 3-7.

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

For the first time filter installation, one can also use the fact that the only position without a blank is position 0 (the home position). Looking at the wheel from the motor side, the first position from the right is filter 1, as shown in Figure 3-7. Once position 0 is identified, follow the loading instructions above.

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.



Filter position at optical port	0	1	2	3	4	5	6	7	8	9
Filter position at loading port	5	6	7	8	9	0	1	2	3	4

Figure 3-7. Filter ports (plug is removed from the loading port).

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 the warranty.

3.3.5 Filter Loading Tips

3.3.5.1 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 performance of the system. Adjacent FILTER POSITIONS will require less switching time. Therefore, if an experiment will require 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.

3.3.5.2 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.

3.3.5.3 Neutral Density Filters

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

3.4 Shutter Option

The Lambda XL can accommodate one 25mm wheel-equipped with a 25mm SmartShutter or a single SmartShutter®. The controller will automatically detect the SmartShutter. Alternatively, just like the Lambda 10-B controller, the PCB in the Lambda XL is able to drive two SmartShutters instead of one filter wheel and one shutter. However, at the time being, the connector for the second shutter has not been yet installed. If you would like to take advantage of this option, please call Sutter Instrument.

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.

3.4.1 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 shutter operates at modest voltages and 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 (ND) 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.

3.4.2 Opening and Closing Times

The SmartShutter has a typical time to open of 8 msec. from the point a complete command or TTL signal is received. The time to close is also 8 msec. This is true for the 25 mm 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.

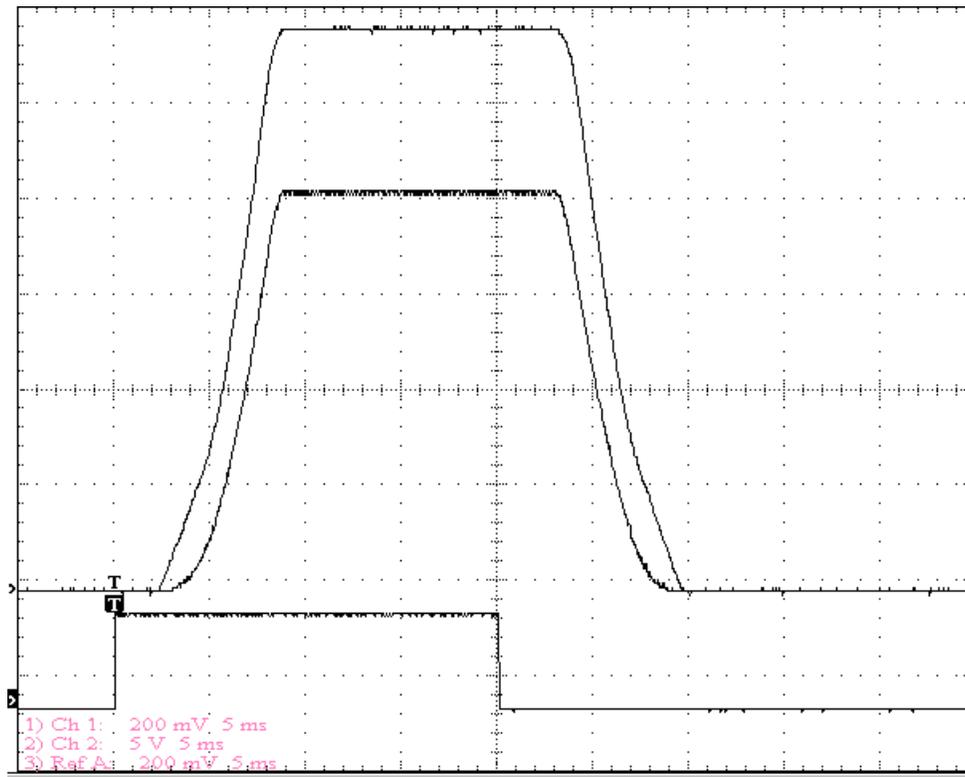


Figure 3-8. SmartShutter timing.

The timing of a SmartShutter is shown in Figure 3-8. 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.

3.4.3 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. These shutters may be operated at higher rates up to 40 Hz, but there will normally be specific frequencies in these 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 milliseconds, 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.

3.4.4 SmartShutter™ Modes

The Lambda XL supports three modes of operation for the SmartShutter.

3.4.4.1 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. from the command/trigger.

3.4.4.2 Soft Mode

The soft mode offers less vibration at the expense of slower open and close times.

3.4.4.3 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).

4. OPERATIONS – LOCAL (MANUAL) CONTROL

4.1 Power-up

Once the light guide and filter wheel/shutter are installed and the connection to the microscope established, the unit may be turned on from the ON/OFF switch located in the power entry module. When power is applied, the Lambda XL performs several initial tests. As part of this process, if a filter wheel and/or shutter were installed, the 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 and the shutter will home.

If the Lamp does not respond, the display will show the following message: LAMP NC. If the wheel does not rotate to position 0 as detected by a Hall-Effect sensor, the display will indicate that there is an error.

The controller recognizes automatically the type of filter wheel installed (4- or 10-position) and the presence or the absence of the SmartShutter. 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 corresponding to the number of filter positions detected.

When powered-up, the Lambda XL will default to USB (ON LINE) mode, indicated by the letter U in the upper corner of the display. To gain keypad control, press the LOCAL key.

4.1.1 Display

The Lambda XL is equipped with a four-line display (Figure 4-1). The upper two lines are allocated to the lamp functions and status and the lower two lines to the filter wheel and shutter. To toggle between the two menus, use the LOCAL key.

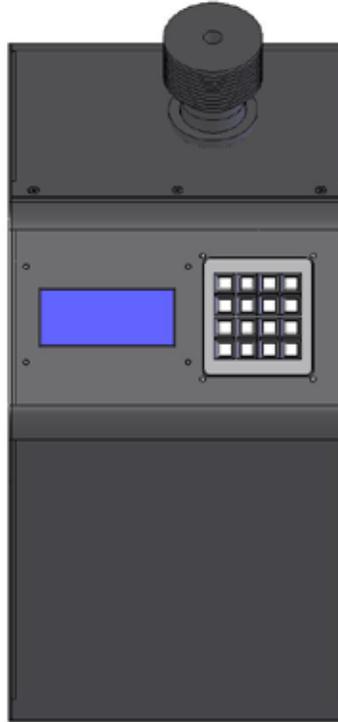


Figure 4-1. Top panel of the Lambda XL – display and keypad.

The notations on the display indicate: U/L- the local/on-line state, W - the type of wheel detected, F- the filter selected, SP - the selected speed, and S - the shutter mode. The display also gives information about the lamp status: current (A), temperature (°C) and on/off or starting (LIT/OFF/LST)

4.1.2 Keypad

There are 16 keys on the Lambda XL keypad (Figure 4-1).

Numerical keys 0 to 9: These keys are used to manually select lamp functions, filter positions and the speed of the filter wheel.

LOCAL: Sets the controller in manual/local mode and toggles between the lamp and the filter wheel/shutter menus.

ON LINE: Sets the controller on-line (computer control).

F1: Go to main menu.

F2: Used as “Enter” for the wheel and shutter menu.

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

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

NOTE: 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.

4.2 Lamp Menu

Upon turn on, the Lambda XL defaults to the USB mode, indicated by the letter U in the upper right corner of the display and the following lamp, wheel and shutter information will be displayed. The lamp will not turn on until instructed to do so from the USB port or via keypad input.

```

LOCAL=> FOR LAMP  U@
:0.0A 26.7C OFF 0%
W- 25MM F0 SP1
S- FAST    OFF

```

Pressing the LOCAL key will switch the unit in manual mode and the letter U will be replaced by L. To return to remote control, press ONLINE. The display and the keypad offer full control of the light source as well as the optional filter wheel and SmartShutter. The upper two lines on the display are allocated to the light source control menu, while the lower two lines to the filter wheel/shutter menu. To toggle between them, press the LOCAL key. The @ symbol in the upper right corner of each menu indicates which menu is active at any time.

When the unit is set in LOCAL mode, the lamp menu is activated automatically and the following set of functions is scrolled on the display: 1 - START LAMP, 2 - STOP LAMP, 3 - SET BRIGHTNESS, 4 - EDIT BRIGHTNESS, 5 - GET VERSION, 6 - GET LAMP TIMER

4.2.1 Start/Stop Lamp

To turn on the lamp, press 1. The display will indicate that the lamp is starting, the change in lamp current and temperature, and the set intensity (i.e. 100%). When the lamp stabilizes, the six functions above will be scrolled again on the first line. The second line will show the current, temperature and intensity information and the letters LIT to indicate that the turn-on sequence is completed. The lamp takes about 12 s to turn on to full intensity. The lamp current increases and stabilizes around 8.1 A.

To turn off the lamp, press 2. The display will show:

```

ARE YOU SURE TO STOP
THE LAMP?  1-Y, 0-N
W- 25MM F0 SP1
S- FAST    OFF

```

Choose 1 to turn it off, or 0 to leave it on.

NOTE: To avoid possible damage to the lamp, DO NOT TURN OFF THE LAMP within 1 minute of turning it on.

4.2.2 Intensity Adjustment

The Lambda XL light source allows the user to adjust the light intensity between 25% and 100% in single unit increments. The actual percentage decrease will be smaller than indicated. This is because the decrease in output power is partly in the form of a reduction in size of the source, which is too large to be completely captured by the light guides. For the lowest intensities the percent decrease can also be a function of wavelength.

When a filter wheel is installed in the unit, a common intensity level can be set for all filters, or different filters can be programmed to have different intensities. The set choice is saved in the memory and will be automatically recalled every time the unit is turned on.

To adjust the intensity level in the absence of the wheel or to set a common intensity level to all the filters in the wheel, press 3 (SET BRIGHTNESS) from the lamp menu. The following will appear on the display:

```

ENTER BRIGHTNESS  L@
(25%-100%):      ?
W- 25MM F0 SP1
S- FAST    OFF

```

Input the desired intensity value and press F2. Once the change is completed, the new lamp current and intensity values will be shown on the second line.

To enter different levels of intensity for different filters, press 4 (EDIT BRIGHTNESS) from the lamp menu. The display will show:

```

F1 BROWSE          L@
F2 ENTER    0    EXIT
W- 25MM F0 SP1
S- FAST    OFF

```

Press F1 (BROWSE) followed by F2 to move to the first filter in the sequence. Key in the new intensity level and press F2 to move to the next filter. To leave the intensity value unchanged, press F2. Press 0 to exit the EDIT BRIGHTNESS menu after all the desired changes were done. The intensity of the filters not edited separately is automatically set to the common value.

4.2.2.1 Lamp Version and Timer

To find out the version of the lamp module installed in the unit, press 5 in the lamp menu. The lamp version will be shown on the first line of the display (the text LAMP VERSION may not be correct in some versions, but the number should be correct):

```

LAMP VERSION 0.70 L@
:8.1A 40.0C LIT 100%
W- 25MM F0 SP1
S- FAST    OFF

```

The display will automatically revert to the main information after a few seconds.

The current number of hours on the lamp is briefly shown on the first line of the display when the 6 key is pressed from the lamp menu:

```
LIT -000005,0 HRS L@
:8.1A 40.0C LIT 100%
W- 25MM F0 SP1
S- FAST    OFF
```

4.3 Filter Wheel and SmartShutter Menu

The filter wheel and shutter menu is shown on the lower two lines of the display. To toggle between the lamp and the wheel/shutter menus, use the LOCAL key. When the wheel/shutter menu is active, the @ symbol is shown at the end of line three of the display.

The keypad control allows the selection of a filter and of a filter wheel speed, manual switching between different filters, the choice of a shutter mode of operation associated with each or all filters, wheel and shutter testing and setting and resetting of the default configuration.

4.3.1 Filter and Speed Selection

After the turn-on routine is completed, the filter wheel defaults to filter 0 and speed 1, illustrated by F0 and SP1 in line three of the display. The default mode of the shutter is FAST and the shutter is closed (OFF).

To change the filter number, activate the wheel/shutter menu (press LOCAL), key in the new filter value and press F2. (In this menu, F2 plays the role of ENTER).

To change the switching speed, press the SPEED key. The following will be shown on the display:

```
LOCAL=> FOR LAMP  L@
:8.1A 40.0C LIT 100%
ENTER NEW SPEED   @
VALUE IN  0-7
```

Speed 0 is the fastest speed and speed 7 is the slowest. Enter the new speed value and press F2. The display will change to reflect the new speed value.

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

The switching time (in milliseconds) for each of the eight speeds is given in 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 or LB10-WHS4IQ).

4.3.2 Opening and Closing the Shutter

The status of the shutter, open or closed, is shown in the last line of the display as ON or OFF, respectively, following the shutter mode. Pressing the SHUTR key opens and closes the shutter (toggles between the ON/OFF states). The status screen is immediately updated with the state of the shutter.

4.3.3 The F1 functions

A series of controller functions are accessible when the F1 key is pressed from the wheel/shutter menu (the text LAMP VERSION may not be correct in some versions, but the number should be correct):

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-TTL    2-TEST    @
3-MODE   4-CONFIG

```

... where:

- **TTL** enables and disable the TTL triggering of the shutter opening and closing
- **TEST** runs shutter and wheel testing routines and also runs the demo program stored in the memory.
- **MODE** selects the shutter mode (FAST/SLOW/ND)
- **CONFIG** allows changing or reverting to the default configuration

4.3.3.1 The TTL Function

Pressing F1 followed by 1 from the wheel/shutter menu changes the display to:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-ENABLE TTL      @
2-DISABLE TTL

```

Press 1 to activate or 2 to deactivate the TTL triggering, or press 0 to exit the menu. The TTL control offers direct control of over the shutter from the TTL input on the rear of the cabinet.

4.3.3.2 The TEST Function

Press F1 followed by 2 to choose the TEST function. The display will show the following options:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-LOOP  2-SPEED  @
3-SHUTTER 4-DEMO

```

Press 1, 2 or 3 to choose one of the options, 4 to run the demo program or 0 to exit.

The **LOOP** Option performs the loop test for the interior serial port connection to the lamp. Press 0 to exit to the main menu. This is for production test only since the serial port is only used for communication between the lamp module and the controller board.

The **SPEED** Option tests the different possible speeds of the wheel with the current filter load and suggests the optimal (PREFERRED) speed. Press 0 to exit to the main menu.

The **SHUTTER** Option runs the demonstration program for the SmartShutter.

The **DEMO** Option runs the demonstration program for the SmartShutter/filter wheel combination.

4.3.3.3 The MODE Function

The MODE function allows the user to choose one of three modes of operation for the SmartShutter, which could be the same for all filters, or different for each filter. For the MODE menu, press F1 followed by 3. The following options will be listed on the display:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-FAST  2-SLOW  @
3-NEUTRAL DENSITY

```

When the FAST or the SLOW options are chosen by pressing the appropriate key, the display will change to:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
TO FILTER: 1-ALL @
2-CURRENT 3-NEW

```

Option 1 assigns the selected shutter mode to all the filters and 2 only to the current filter. If option 3 is chosen, the display will show:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
NEW FILTER NO.= @
?

```

Input the number of the filter to which you wish to associate this shutter mode and press F2.

To use the neutral density capability of the SmartShutter, press 3 from the shutter MODE menu and enter the number of steps followed by F2 when prompted:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
ENTER NUMBER 1-144 @
ND STEPS

```

The ND mode can also be assigned to all, to the current or to selected filters as above.

4.3.3.4 The CONFIG (Configuration) Function

The factory set default configuration for the filter wheel is filter 0 (F0) and speed 1 (SP1), and for the shutter the fast mode (FAST) and closed (OFF). This configuration can be modified using the CONFIG function in the MODE menu.

Press 4 in the MODE menu. The display will show the following configuration choices:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-DEFAULT @
2-SHUTTER MODE

```

Press 1 to change the default configuration. The default configuration menu will give the following options:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-SET DEFAULT @
2-RESET ALL

```

Choose 1 to change the configuration. The following selection menu will be displayed:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-SPEED 2-FILTER @
3-SHUTTER MODE

```

Press 1 again to change the switching speed and enter a value between 0 and 7 followed by F2:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
SET NEW DEFAULT @
SPEED VALUE: 0-7

```

If you wish to change more default values, press 1 when prompted and repeat the procedure, if not, press 0 to exit.

To change the default filter number, press 2 in the selection screen and enter the new filter value between 0 and 9. Then press 1 when prompted and repeat the procedure to change more default values, or press 0 to exit.

To change the shutter default, press 3 in the selection menu:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
CURRENT MODE AS @
DEFAULT? 1-Y, 0-N

```

Press 1 or 0 as needed and then again 1 or 0 if you wish, or wish not to change more default values.

To reset the current configuration to the existing default, press 2 in the DEFAULT configuration menu.

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
ARE YOU SURE TO @
RESET? 1-Y, 0-N

```

All the changes made will be shown on the display once returned to the main menu.

To change the shutter mode default, choose option 2 (SHUTTER MODE) in the configuration menu. The options displayed are:

```

LOCAL=> FOR LAMP L
:8.1A 46.0C LIT 100%
1-SAVE MODE @
2-RESTORE MODE

```

Selecting 1, saves the current shutter mode as one of three configurations, M1, M2, or M3. Selecting 2, will replace the current configuration by an existing configuration from the memory, saved previously as M1, M2 or M3.

5. OPERATIONS: EXTERNAL COMMAND CONTROL

5.1 Principles of Operation

The Lambda XL controller can be operated locally (manually) from the controller keypad as described in the previous chapter, or by issuing commands on a computer and transmitting them to the Lambda XL over a **USB** (Universal Serial Bus) connection. If the USB control is not available in the software package used, it may be possible to use the virtual com port driver from Sutter Instrument to provide serial port functionality with the USB port. These operational modes are functionally identical. Each allows the user to select:

- **Turning the lamp on and off**
- **Adjusting lamp intensity level**
- **Setting a filter by rotating the filter wheel to the appropriate position**
- **Setting the filter switching speed**
- **Opening and closing the SmartShutter**
- **Setting the SmartShutter mode**

Information needed to connect the power cord and start up the Lambda XL for first time is covered in the **INSTALLATION** chapter.

Local operation using the keypad is covered in the **OPERATIONS** chapter.

This chapter explains control of the unit from a remote device, providing a description of the 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 electrical connections are available on the rear panel of the Lambda XL. Use the USB port to connect the unit to the USB or virtual serial port of a computer.

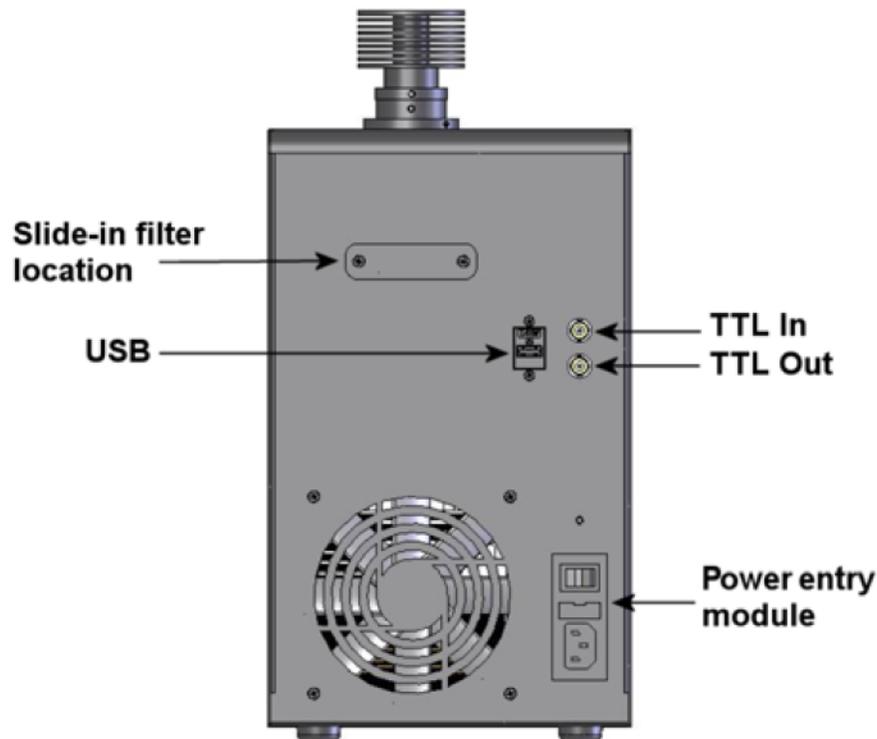


Figure 5-1. Lambda XL Rear panel electrical connections.

USB PORT – A USB Type B (device) receptacle used to connect the Lambda XL controller as a USB device to a USB port of a host computer.

POWER SWITCH –This turns on the system power.

LINE POWER –This socket is used to connect the power cord to the Lambda XL.

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.

Upon power-up, the Lambda XL goes automatically in remote control mode, indicated by the letter U in the upper right corner of the display. Use the LOCAL key to toggle between the local and the remote control.

5.2 Configuring the Lambda XL for Remote Control Interfaces and Software

5.2.1 Setting the Product Identification for Remote-Control Software

Startup screen

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
W- 25MM F0 SP1 @
S- FAST OFF

```

F1 brings up config menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1-TTL 2-TEST @
3-MODE 4-CONFIG

```

Then F2 to bring up the remote-control speed setting menu config menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1-DEVICE TYPE @
2-BAUD RATE

```

Press 1 for Device Type menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1- 10-B* @
2- LBXL

```

The star indicates the current product ID. Once a new product ID is chosen, the display will revert to the initial screen. To exit any of the menus without any changes, press 0 (zero).

Pressing 1 for “10-B” momentarily displays the following message indicating that “10-B” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT DEVICE @
TYPE IS 10-B .....

```

Pressing 2 for “LBXL” momentarily displays the following message indicating that “LBXL” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT DEVICE @
TYPE IS LBXL .....

```

5.2.2 Setting the Baud Rate of the Lambda XL's USB Chip's Serial Interface

Startup screen

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
W- 25MM F0 SP1 @
S- FAST OFF
  
```

F1 brings up config menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1-TTL 2-TEST @
3-MODE 4-CONFIG
  
```

Then F2 to bring up the remote-control speed setting menu config menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1-DEVICE TYPE @
2-BAUD RATE
  
```

Press 2 for Baud Rate menu:

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
1-9600 2-19200 @
3-115200 4-128000*
  
```

The star indicates the current baud rate. Once a new baud rate is chosen, the display will revert to the initial screen. To exit any of the menus without any changes, press 0 (zero).

Note that the baud rate 128000 is selected as the default as shipped from the factory.

9600, 19200, and 115200 should be used only with the VCP driver. It is generally safest to select 9600, since that is the universal default for serial ports. Select 19200 or 115200 only if your connecting application can select and operate with that baud rate.

Pressing 1 for “9600” momentarily displays the following message indicating that a baud rate of “9600” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT BAUD RATE @
IS 9600 .....
  
```

Pressing 1 for “19200” momentarily displays the following message indicating that a baud rate of “19200” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT BAUD RATE @
IS 19200      . . . . .

```

Pressing 1 for “115200” momentarily displays the following message indicating that a baud rate of “115200” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT BAUD RATE @
IS 115200    . . . . .

```

Pressing 1 for “128000” momentarily displays the following message indicating that a baud rate of “128000” has been selected.

```

LOCAL=> FOR LAMP L
:0.1A 30.0C OFF 100%
CURRENT BAUD RATE @
IS 128000    . . . . .

```

5.3 Virtual Com-Port

The Lambda XL can only be connected to a host computer through the USB port. As a result, in order to configure the Lambda XL controller in imaging software (or any control software) that supports only the serial port, it is necessary to use a Virtual Com Port (VCP) driver. The Sutter Instrument VCP driver and installation instructions are available for download on the Sutter web site (www.sutter.com). It is critical to follow these installation instructions precisely for a proper installation.

Once the VCP driver is installed correctly, it may be necessary to ensure that the imaging software is set at the same baud rate as the Lambda XL. The default baud rate for the XL is 128000. However, this baud rate can be changed by accessing the local menu. The baud rate options are 9600, 19200, 115200, and 128000. If there is no baud rate option in your software suite, it is likely the baud rate is 9600. The serial port baud rate for the Sutter Instrument Lambda 10-2, 10-B, and 10-3 filter wheel controllers is 9600 baud, so it is likely that any software that supports serial communication with these controllers will use 9600 baud.

To change the baud rate, set the instrument in manual mode and activate the wheel menu (press LOCAL twice after the instrument is turned on will accomplish this), then press the following sequence of keys: F1 -> F2 -> 2 and select the value associated with baud rate of choice.

Refer to the preceding instructions on how to change the data rate of the Lambda XL’s serial interface between its USB chip and master microcontroller. The baud rate selected will be the one that must be used with virtual serial port (COM1, COM2, etc.) created when the VCP driver was installed.

5.4 Remote Control Commands

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 the filter wheel.
Shutter commands	These are commands used exclusively for controlling the SmartShutter.
Special commands	These are commands for the general control of the Lambda XL controller, and are not specifically related to either the filter wheel or shutter.

Most of the commands described in this chapter are ones that are sent from the computer to the Lambda XL. Some of these commands will cause the Lambda XL 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 XL, 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 XL 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 the function associated with the command has completed and that the controller is now ready for another command.

5.5 Input Command Structure

5.5.1 Commands Description

Table 7-2 provides a complete list of all the remote commands for the Lambda XL.

Table 5-2. Remote Control Commands.

Command	Value (Decimal, hexadecimal, & binary)	Description
Set filter wheel speed and filter position	(See the table “Command Code Ranges” for possible value ranges.)	Sets the filter wheel speed (0 – 7) and the filter position (0 – 9). Note that for the Lambda XL, 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).
Open Shutter A	170 AA 10101010	Sets the state of Shutter A to open.

Command	Value (Decimal, hexadecimal, & binary)	Description
Open Shutter A Conditionally	171 AB 10101011	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.
Close Shutter A	172 AC 10101100	Sets the state of Shutter A closed.
Open Shutter B	186 BA 10111010	Sets the state of Shutter B to open.
Close Shutter B	188 BC 10111100	Sets the state of Shutter B closed.
Status	204 CC 11001100	Returns status of unit in two bytes
All Motors Power On	206 CE 11001110	Instruct the controller to power on all motors.
All Motors Power Off	207 CF 11001111	Instruct the controller to power off all motors.
Fast-mode Shutter	220 + 1 or 2 DC + 01 or 02 11011100 + 00000001 or 00000010	Sets the shutter to fast mode (<i>SmartShutter</i> TM only). Second byte indicates Shutter A (1) or B (2).
Soft-mode Shutter	221 + 1 or 2 DD + 01 or 02 10111011 + 00000001 or 00000010	Sets the shutter to soft mode (<i>SmartShutter</i> TM only). Second byte indicates Shutter A (1) or B (2).
Neutral Density-mode Shutter	222 + 1 or 2 + 1 – 144 DE + 01 or 02 + 01 – 90 10111100 + 00000001 or 00000010 + 00000001 - 10010000	Sets the shutter to neutral-density mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2). The third byte contains a value of 1 through 144 indicating the number of microsteps.
Transfer to On Line	238	Puts controller on-line

Command	Value (Decimal, hexadecimal, & binary)	Description
	EE 11101110	
Transfer to Local	239 EF 11101111	Puts controller in local mode
Reset	251 FB 11111011	Resets the controller
Get Controller Type and Configuration	253 FD 11111011	Queries the controller as to its type and configuration.

NOTE: Although the 10-B control board within the Lambda XL does support the “Dual-SmartShutter” configuration (no filter wheel), the internal and external peripheral interface connections have not been finalized.

Commands sent to the controller via the serial or USB interface are structured in one-byte (8-bit) signals. 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 XL 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 the shutter as well various modes in which the SmartShutter can operate.

- **Special Commands.** These commands are used to control various aspects of the controller that are not specifically related to either the filter wheel or the shutter. 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 types of Input Commands based on the bit pattern of the Command and will respond accordingly. These types of Commands are discussed in more detail in the following sections.

The following table shows the command byte value ranges for filter commands and those for shutter/special commands.

Table 5-3. Command Code Ranges.

Filter Command Ranges			Shutter and Special Command Ranges		
Hexadecimal	Binary	Decimal	Hexadecimal	Binary	Decimal
00 - 09	00000000 00001001	0 - 9	0A - 0F	00001010 00001111	10 - 15
10 - 19	00010000 00011001	16 - 25	1A - 1F	00011010 00011111	26 - 31
20 - 29	00100000 00101001	32 - 41	2A - 2F	00101010 00101111	41 - 47
30 - 39	00110000 00111001	48 - 57	3A - 3F	00111010 00111111	58 - 63
40 - 49	01000000 01001001	64 - 73	4A - 4F	01001010 01001111	74 - 79
50 - 59	01010000 01011001	80 - 89	5A - 5F	01011010 01011111	90 - 95
60 - 69	01100000 01101001	96 - 105	6A - 6F	01101010 01101111	106 - 111
70 - 79	01110000 01111001	112 - 121	7A - 7F	01111010 01111111	122 - 127
80 - 89	10000000 10001001	128 - 137	8A - 8F	10001010 10001111	138 - 143
90 - 99	10010000 10011001	144 - 153	9A - 9F	10011010 10011111	154 - 159
A0 - A9	10100000 10101001	160 - 169	AA - AF	10101010 10101111	170 - 175
B0 - B9	10110000 10111001	176 - 185	BA - BF	10111010 10111111	186 - 191
C0 - C9	11000000 11001001	192 - 201	CA - CF	11001010 11001111	202 - 207
D0 - D9	11010000 11011001	208 - 217	DA - DF	11011010 11011111	218 - 223
E0 - E9	11100000 11101001	224 - 233	EA - EF	11101010 11101111	234 - 239
F0 - F9	11110000 11111001	240 - 249	FA - FF	11111010 11111111	250 - 255

5.6 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 those models of the Lambda series of controllers that support the simultaneous connection of two filter wheels, the filter wheel bit (Bit 7) is used to select the filter wheel. The Lambda XL 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, corresponds 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 Table 5-8).

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 5-4. Filter Command Structure.

Functional Bit Groups								
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 XL 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 XL 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”.

5.6.1 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 in the Lambda XL since only one filter wheel is supported)

speed = 0 through 7

position = 0 through 9

5.7 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	Value (Decimal, hexadecimal, & binary)	Description
Open Shutter A	170 AA 10101010	Sets the state of Shutter A to open.
Open Shutter A Conditional	171 AB 10101011	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.
Close Shutter A	172 AC 10101100	Sets the state of Shutter A closed.

Command	Value (Decimal, hexadecimal, & binary)	Description
Open Shutter B	186 BA 10111010	Sets the state of Shutter B to open.
Open Shutter B Conditional	187 BB 10111011	NOTE: This command is not available in the Lambda XL due to its inability to support both a filter wheel and a set of two shutters.
Close Shutter B	188 BC 10111100	Sets the state of Shutter B closed.

The following two tables described the formats for the SmartShutter mode commands in the “Wheel/Shutter” versus “Dual Shutter” configuration.

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

Command	Value (Decimal, hexadecimal, & binary)	Description
Fast-mode Shutter	220 DC 11011100	Sets the shutter to fast mode (SmartShutter only).
Soft-mode Shutter	221 DD 10111011	Sets the shutter to soft mode (SmartShutter only).
Neutral Density-mode Shutter	222 + 1 – 144 DE + 01 – 90 10111100 + 00000001 - 10010000	Sets the shutter to neutral-density mode (SmartShutter only). Second byte contains a value of 1 through 144 indicating the number of microsteps.

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

Command	Value (Decimal, hexadecimal, & binary)	Description
Fast-mode Shutter	220 + 1 or 2 DC + 01 or 02 11011100 + 00000001 or 00000010	Sets the shutter to fast mode (SmartShutter only). Second byte indicates Shutter A (1) or B (2).

Command	Value (Decimal, hexadecimal, & binary)	Description
Soft-mode Shutter	221 + 1 or 2 DD + 01 or 02 10111011 + 00000001 or 00000010	Sets the shutter to soft mode (SmartShutter only). Second byte indicates Shutter A (1) or B (2).
Neutral Density-mode Shutter	222 + 1 or 2 + 1 – 144 DE + 01 or 02 + 01 – 90 10111100 + 00000001 or 00000010 + 00000001 - 10010000	Sets the shutter to neutral-density mode (SmartShutter only). Second byte indicates Shutter A (1) or B (2). The third byte contains a value of 1 through 144 indicating the number of microsteps.

The following paragraphs describe the shutter commands in more detail.

5.7.1 Open Shutter A (or B)

Sets Shutter A or B, respectively, to the open state.

5.7.2 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.

5.7.3 Close Shutter A (or B)

Sets Shutter A or B, respectively, to the closed state.

5.7.4 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).

5.7.5 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).

5.7.6 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”.

5.8 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 XL 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 of the Lambda XL’s special commands.

Table 5-8. Special command codes.

Command	Value (Decimal, hexadecimal, & binary)	Description
Status	204 CC 11001100	Returns status of unit in two bytes
All Motors Power On	206 CE 11001110	Instruct the controller to power on all motors.
All Motors Power Off	207 CF 11001111	Instruct the controller to power off all motors.
Transfer to On Line	238 EE 11101110	Puts controller on-line
Transfer to Local	239 EF 11101111	Puts controller in local mode
Reset	251 FB 11111011	Resets the controller
Get Controller Type and Configuration	253 FD 11111011	Queries the controller as to its type and configuration.

The following paragraphs describe the special commands in more detail.

5.8.1 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 XL is in the “Filter Wheel/Shutter” configuration, whereas the second table shows the status data returned when in the “Dual Shutter” configuration.

Table 5-9. Status Command Return Codes and Data in a “Wheel/Shutter” Configuration.

Order	Num. of bytes	Category	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
1	1	Command echo		204 CC 11001100	The Status command byte code echoed back.
2	1	Filter wheel state	Wheel, Speed and Position	* 0 – 121 00 – 79 00000000 – 01111001	Filter Wheel (Bit 7): Always 0. Speed (Bits 6, 5, & 4): 0 – 7. Position (Bits 3, 2, 1, & 0): 0 – 9
				Error or no filter wheel installed	10 0A 00001010
			3	1	Shutter open/closed state
Open state is conditional	171 AB 10101011	The open state of the shutter is conditional upon the movement of the filter wheel.			
Closed	172 AC 10101100	The shutter is in the closed state.			
4	1 or 2	Shutter mode (<i>SMART-SHUTTER</i> [™] only)	<i>SMART-SHUTTER</i> [™] not connected	219 DB 11011011	Indicates that no SmartShutter is connected. No shutter is connected
			Fast mode	220 DC 11011100	Indicates that the SmartShutter is in fast mode.
			Soft mode	221 DD 10111011	Indicates that the SmartShutter is in soft mode.
			Neutral Density mode (1 byte) plus number of microsteps (1 byte)	222 + 1 – 144 DE + 01 – 90 10111100 + 00000001 - 10010000	Indicates that the SmartShutter is in neutral-density mode. A second byte contains the number of microsteps (1 – 144).

*** NOTE:** Range shown for the filter wheel command/status byte is not 100% inclusive. Please refer to Table 5-4 for an explanation of how the byte is encoded, and to Table 5-3 for a list of valid byte values.

5.8.2 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.

5.8.3 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.

5.8.4 Transfer to On Line

This command is the equivalent to pressing the ON LINE key on the Lambda XL'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.

5.8.5 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.

5.8.6 Reset

Causes the Lambda XL 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.

5.8.7 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 5-10. “Get Controller Type and Configuration” Command Return Codes and Data.

Configuration	Total num. bytes	Description			
		Category	Num. Bytes	Possible Values	
				ASCII string	Meaning
Filter Wheel with or without shutter or Single Shutter (no filter wheel) (One standalone filter wheel only, one filter wheel with one integrated shutter, or one standalone filter wheel and one standalone shutter)	14	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	LBXL	Lambda XL **
				10-B	“Lambda 10-B” **
		Filter Wheel Type	4	W-25	25mm
				W-32	32mm
				W-HS	High Speed
				W-BD	Belt Driver
				W-NC	Not Connected
				W-ER	Error
		Shutter Type	4	S-IQ	SmartShutter
S-VS	No shutter connected				
Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.		
Dual SmartShutters™ (no filter wheel) (Two shutters (SmartShutters™ only); no filter wheel)	16	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	LBXL	Lambda XL **
				10-B	“Lambda 10-B” **
		Shutter A Type	5	SA-IQ	1 st SmartShutter
		Shutter B Type	5	SB-IQ	2 nd SmartShutter
		Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.

***NOTE:** The character shown in the “ASCII string” column for the command echo 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:** The text returned for “Controller Type” is “LBXL” by default. This text can be changed to “10-B” (for Lambda 10-B) in cases where the remote control software being used to control the Lambda XL issues the Get Controller Type and Configuration command to identify the product but does not recognize “LBXL” as a supported product. The Controller Type text is changed via the Lambda XL’s keypad and display menus in local mode, as described earlier in this chapter.

5.9 Shutter Control via the Dedicated TTL Line

The Special Commands shown above can be sent to the controller via 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.

5.10 External Control Command Programming

This section describes some suggested tips and techniques when writing programs on the remote control computer for communicating with the Lambda XL via the USB (Universal Serial Bus) port or the RS-232/virtual com 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 the USB port. The programming specifics for the USB port 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.

5.10.1 Preparing the Command Byte

All remote control command codes for the Lambda XL require no more than one byte (8 bits) of storage for each command. If using a programming language that makes 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 or 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.

5.10.1.1 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.

5.10.1.2 Shutter or Special Commands

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

5.10.2 **Command Transmission Protocol**

The Lambda XL does not use any of the standard protocols commonly used for USB communications between computers or between a computer and a peripheral device. The Lambda XL 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 USB port connections.

5.10.2.1 Confirmation Command Echo

When the host computer sends a command to the Lambda XL, 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 XL sends a confirmation byte (described next) that indicates the operation associated with the command completed.

5.10.2.2 Command Completion Indicator

When the Lambda XL 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 XL 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.

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6. REMOTE CONTROL: USB PORT

The Lambda XL can communicate with the computer via the Universal Serial Bus (USB) port. The remote computer must be equipped with the necessary USB hardware and its operating system must be properly configured to recognize and work with the USB interface. Of all the USB ports available on the remote computer, be they part of the computer itself or part of a USB hub, one port must be available for use with the Lambda XL.

There are some basic differences in the physical connections and the modes by which USB and serial data are transmitted to the controller. The command code structures, however, are identical. The connection and command structure required to control the Lambda XL via the USB port are discussed in this chapter.

6.1 Installing the Lambda XL as a USB Device on a Windows System

The Lambda XL can be used as a USB device with a remote computer that is installed with the necessary USB hardware and is running one of the following versions of Microsoft Windows.

1. Windows 98¹ and Windows 98 SE (Second Edition)
2. Windows ME (Millennium Edition)
3. Windows 2000 (Professional, Server, and Advanced Server)
4. Windows XP (all editions)²
5. Windows Vista (all editions)³
6. Windows 7 (all editions)

6.1.1 Installation Steps

To install the Lambda XL as a USB device on a remote computer running one of the above-listed versions of the Microsoft Windows operating system, follow these steps.

1. Make sure that the Lambda XL 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 Lambda XL. Of the two connectors on the supplied USB cable, the one that is square-shaped is the one that connects the USB device. The device connector is shown in the following figure.

¹ **Windows 95 and USB:** With the exception of the last releases of Windows 95 prior to the release of Windows 98, Windows 95 does NOT support USB hardware. Those releases of Windows 95 that do support USB will generally have “With USB Support” as part of the operating system’s title. However, none of Sutter Instrument’s USB-equipped products have not been tested on such systems.

² **32-bit and 64-bit Versions of Windows:** The USB device driver for the Lambda XL is designed to work with 32-bit versions of the Windows operating systems listed above. This driver is not intended for use with any 64-bit version of Windows.

³ **Windows Vista:** The current USB device driver for Lambda XL has been tested under Windows Vista (32-bit version only). Because Windows Vista’s security architecture has been significantly enhanced over previous versions of Windows, you will find that the installation process (described next) will frequently prompt you for permission to proceed to subsequent steps.

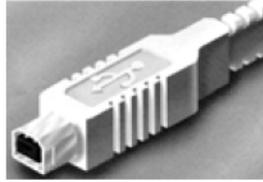


Figure 6-1 -- The USB cable device connector.

Moreover, the receptacle in the rear of the Lambda XL into which the “device” connector of the USB cable connects is shown in the following figure.



Figure 6-2 -- The Lambda XL USB receptacle.

Turn the power switch in the back of the Lambda XL to ON.

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, if the driver/software for the hub has already been installed and the hub is functioning properly. The “host” USB receptacle and connector are rectangular-shaped, as shown in the following figures.

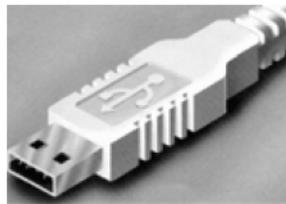


Figure 6-3 -- Host connector end of USB cable.



Figure 6-4 -- 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.

6.1.2 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 6-5 -- New USB device detected message box.

The above message box will display for a period of time, 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 XL 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 10-3, a Lambda SC, an MPC-200, or even another Lambda XL) is already connected and configured with your computer. If this is the first time the Lambda XL USB device drivers are being installed, it is then quite likely that Windows will display the dialog box shown in the following figure.



Figure 6-6 -- Digital Signature dialog box.

Do not be concerned that Windows is unable to find a Microsoft digital signature for the Lambda XL as shown in the previous figure. Simply press the “Yes” button to continue to the next step. The next figure shows the dialog box that Windows displays when it is ready ask you for the location of the Lambda XL USB device drivers.

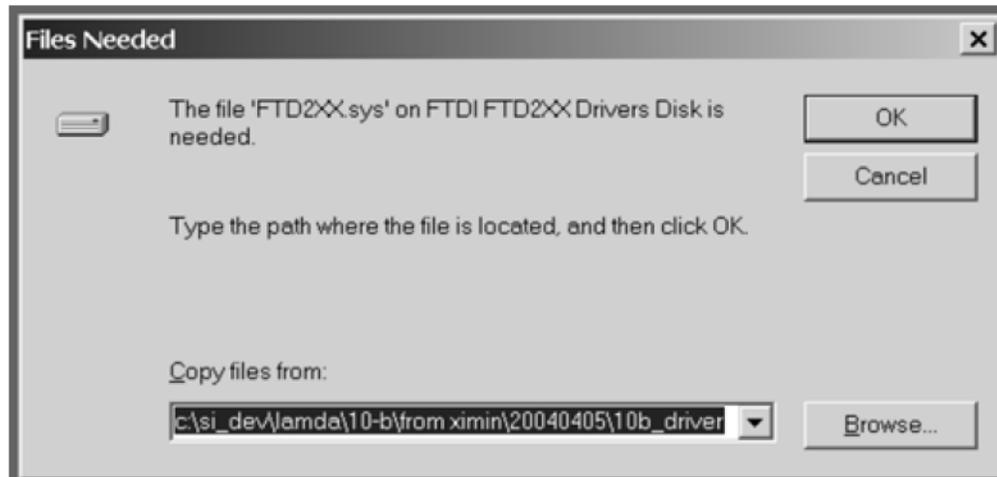


Figure 6-7 -- Specifying location of driver files.

In the previous figure, 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 XL USB interface installation. You have the following three choices for this dialog box:

1. Enter a path in the “Copy files from” combo box and then press OK.
2. Alternatively, 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.
3. Finally, 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 XL 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.

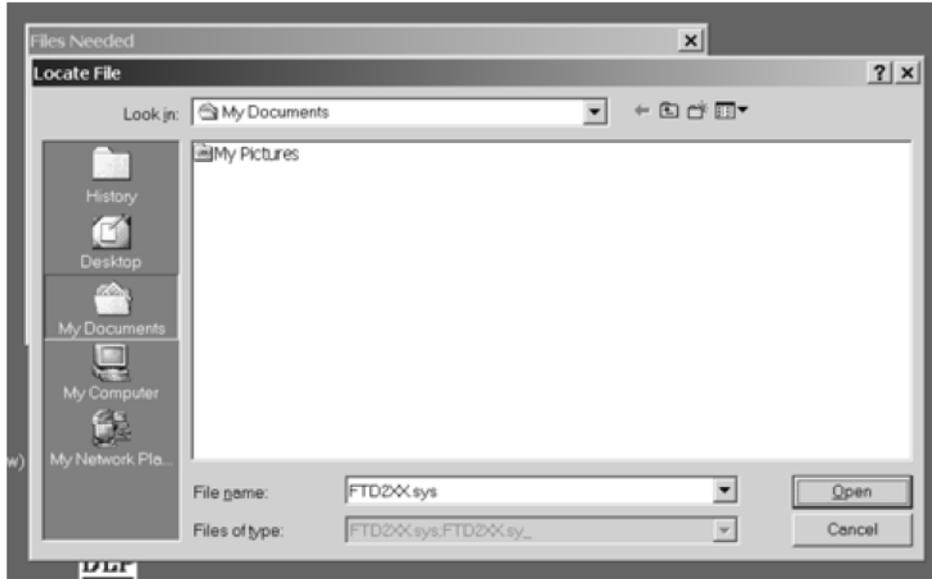


Figure 6-8 -- Browsing for the driver file needed.

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 XL as a USB device connected to a Windows system.

6.2 Installing the USB Interface for Non-Windows Systems

The Lambda XL can be connected with the 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>

6.3 Verifying USB Communication between Remote Computer and Lambda XL

Once the Lambda XL 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 XL 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 XL as a USB device. The USBTest program is provided on a 3.5-inch HD floppy diskette or CD-ROM, shipped with the Lambda XL 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: Windows 98, 98 SE, ME, 2000 and XP).

The USBTest program has only one screen, and appears as shown in the following figure.

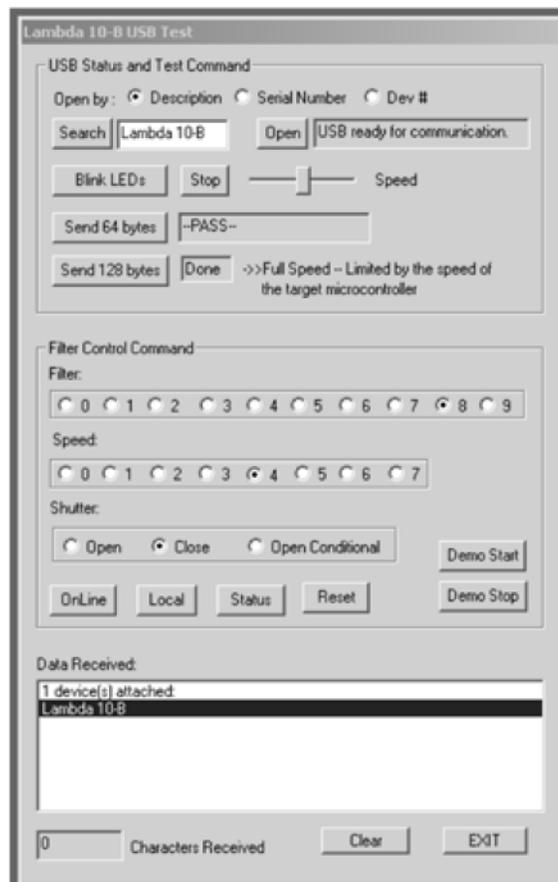


Figure 6-9 -- USBTest main screen.

Once you have the program up and running, and the screen in the previous figure is displayed, you can use the program to first identify whether or not one or more Lambda XL units are installed as USB devices. This is accomplished by first clicking the Search button which causes USBTest to scan the USB for the device requested. The search criterion is dependent on which one of the three radio buttons following "Open by:" is selected: Description, Serial Number, or Dev #. The results of the search are displayed on the "Data Received:" text field: highlight the item displayed there ("Lambda XL", serial number, or device number) and then click on it to select it. The selected item is then automatically copied to the text field associated with the Search button. Finally, click the Open button to open the Lambda XL USB device for communication. The text field associated with the Open button will be updated with a message indicating that the USB device has been successfully opened. To verify communications with the Lambda XL, click on different filter-wheel radio buttons, at different speeds - you should be able to see and hear the filter wheel move.

The source code for the USBTest program is also available upon request. The source code consists of all source, resource, and library files, including all necessary project files for

building the program with Microsoft Visual C++/Studio Version 6.0. The application is written in C and C++ for the Microsoft Windows platform, and it makes use of the Win32 and MFC (Microsoft Foundation Classes) libraries included with Microsoft Visual C++. The USBTest program also makes use of a library called FTDIXXX.DLL that is freely available from FTDI, the manufacturer of the USB chip set used in the Lambda XL and which gets installed on your system when the USB device driver for the Lambda XL is installed. The FTDIXXX.DLL is “bound” to the USBTest program via two files that are included with the USBTest program source code: FTDIXXX.H, a C/C++ header file that gets included at compile time, and FTDIXXX.LIB, the FTDIXXX.DLL interface library file, which gets linked to the project at link time. All three files are freely downloadable from FTDI’s web site: www.ftdichip.com.

Alternatively, a custom program can be written to verify the installation and for sending commands to the Lambda XL. Although providing the source code for an entire ready-to-run program is beyond the scope of this manual, the following paragraphs describe the key elements such a custom program should have in order to identify, connect with, and transmit to the Lambda XL as a USB device. Accompanying these paragraphs are listings containing snippets of code written in the C programming language that may prove of further use should it be desired to create a custom program. Note that the code examples assume that the FTDIXXX.LIB and FTDIXXX.H files described previously are being used. You may download these files directly from FTDI’s web site.

Listing 2. Opening the located USB device.

6.4 Uninstalling the USB Driver for the Lambda XL

Normally, the device drivers installed on your system that enable communications with the Lambda XL 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 XL (e.g., the Lambda XL will no longer be used with the system in question), the following steps can be followed for Windows 98, Windows ME, Windows 2000, Windows XP, or Vista.

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 XL, 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 completed, the FTD2XX entry in the Add/Remove list should now be gone.

Note that although the above procedure will remove the Lambda XL USB device driver from active use, not all related files on your system are actually deleted. Should you decide to

reinstall the USB driver for the Lambda XL 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.

In order to completely remove the USB driver and related files from the system, either manually delete the file FTD2XX.sys from the “system32” directory in your Windows directory, or 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.

6.5 Remote Commands and the USB Interface

The set of commands and the command structure described in Chapter 7. Computer/Remote Control is available for use when the Lambda XL is connected to a computer as a USB device.

7. OPERATIONS: EXTERNAL LOGIC LEVEL (TTL) INPUT FOR SHUTTER CONTROL

In addition to the control of the shutter via the keypad and USB 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.

7.1 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 XL, 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 7-1. 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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8. MAINTENANCE

8.1 Routine Maintenance

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

 **CAUTION:** *For maintaining proper cooling of the lamp module and the electronic components inside the cabinet, keep the mesh screens covering the intake vents free of dust and place the unit away from any objects that could block the flow of cool air to the vents or deflect the flow of hot air back towards the vents.*

8.2 Changing the Light Bulb

The light bulb in the Lambda XL is not field or customer serviceable. If the bulb requires replacement, the entire Lambda XL system must be returned to Sutter Instrument Company, whereupon the bulb will be replaced and system recalibrated, and then shipped back to the installation site.

8.3 Filter Wheel and SmartShutter® Maintenance

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

 **CAUTION:** *The filter wheel and SmartShutter are precision-machined parts, each mounted on a stepper motor shaft. As such, they DO NOT REQUIRE LUBRICATION. Attempting to lubricate any part of the filter wheel or SmartShutter assembly will void the warranty and may harm the motor or the device it is driving.*

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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

LLG/XL	Liquid light guide (2 meters, 3mm diameter), lens and lens tube.
LLG/5XL	Liquid light guide (2 meters, 5mm diameter), lens and lens tube (provides a larger field of view but with less intensity per unit area).
LLG/XL380	Liquid light guide (2 meters, 3mm diameter), lens and lens tube (allows higher output into the near IR).
LLG/5XL380	Liquid light guide (2 meters, 5mm diameter), lens and lens tube (allows higher output into the near IR).
IQ25-XL	25mm SmartShutter with housing to fit a Lambda XL .
LB10-NWIQ/XL	10 position 25mm filter wheel with SmartShutter for mounting in a Lambda XL .
LB10-WHS4IQ/XL	4 position filter wheel with SmartShutter for mounting in a Lambda XL .
O800110³	Replacement lamp and power supply (requires installation and re-alignment at Sutter Instrument).
Microscope mounting adapters	Mounting adapters for Leica, Nikon, Olympus, and Zeiss microscopes are available. Please refer to the Microscope Adapters section at Sutter Instrument's web site (www.sutter.com) or contact Sutter Instrument for further information.

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APPENDIX C. FUSE REPLACEMENT

In the event that 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 located 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 8-1. 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.

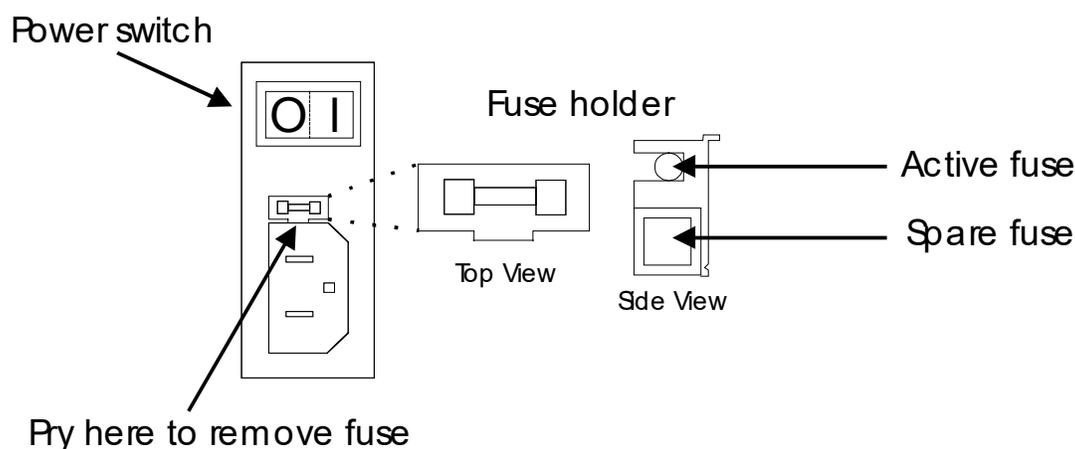


Figure 8-1. Fuse replacement.

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 the figure. To remove the spare fuse, press down on the end of the compartment and 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 lamp fails to power up with the new fuse installed, call Sutter Instrument technical support personnel for assistance.

Replace with:

5 Amp, 250V, 5 x 20mm, Time Delay fuse (EIC 60127-2, Sheet III).

**(Examples: Bussmann S506-5-R (RoHS), or
Littelfuse 218.005.P (RoHS))**

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APPENDIX D. TECHNICAL SPECIFICATIONS



Output Range:	320 to 600 nm
Lamp Type:	238-Watt Electroless Lamp
Expected Lamp Life:	10,000 hours (50% of original brightness)
Color Temperature:	7700 K (5mm aperture, NA=0.5)
Time to Brightness:	10 seconds (typical), 4 minutes (maximum) (from turn-ON to 90% brightness)
Dimensions (W x H x D):	13 x 7.75 x 9.5 in (33 x 20 x 24 cm)
Weight:	7.5 Kg (16.5 lb)
Electrical:	
Input voltage (Mains)	100 – 240 V_{ac}, 50/60 Hz
Mains fuse (rear of cabinet)	5 x 20 mm glass tube, T5.0A, 250V, IEC 60127-2, Sheet III, RoHS Compliant (such as Bussmann S506-5-R or Littelfuse 218 005.P)
Power Consumption	375 Watts max
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
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)		

APPENDIX E. 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 a stepping motor, 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 two 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 XL** 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. As long as 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 four 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. In order 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.

APPENDIX F. VIBRATIONS

The Lambda filter wheel system was designed to produce fast filter changes with a minimum of vibration. With the filter wheel mounted in the XL cabinet and connection to the microscope via a light guide, any residual vibration should not be transmitted to the microscope. 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 XL 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 XL 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 two 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.

We recommend that the Lambda XL should be placed on a solid surface that is separate from surface upon which the microscope is mounted. The best cure for vibration is isolation. If the microscope is on an air table, do not place the XL cabinet on the same air table.

F.1. SmartShutter Movement Errors: Causes and Solutions

The *SmartShutter*[™] is optimized for the fast shutter action. One element of the overall design of the SmartShutter 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.

F.1.1 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

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.

F.2. Filter Wheel - Error Detection and Recovery

The **LAMBDA XL** 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.

F.2.1 Movement Errors: Causes and Solutions

Filter Weight vs. Speed: The **LAMBDA XL** is optimized for the fastest exchange of 2 filters in research applications. One element of the **LAMBDA XL**'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

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 XL** 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.

stepping the motor near the resonance frequency (see Appendix A). Selecting a higher or lower speed will generally solve this problem.

F.2.1 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.

F.2.1 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 XL** 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.

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APPENDIX G. DISPLAY MENU NAVIGATION

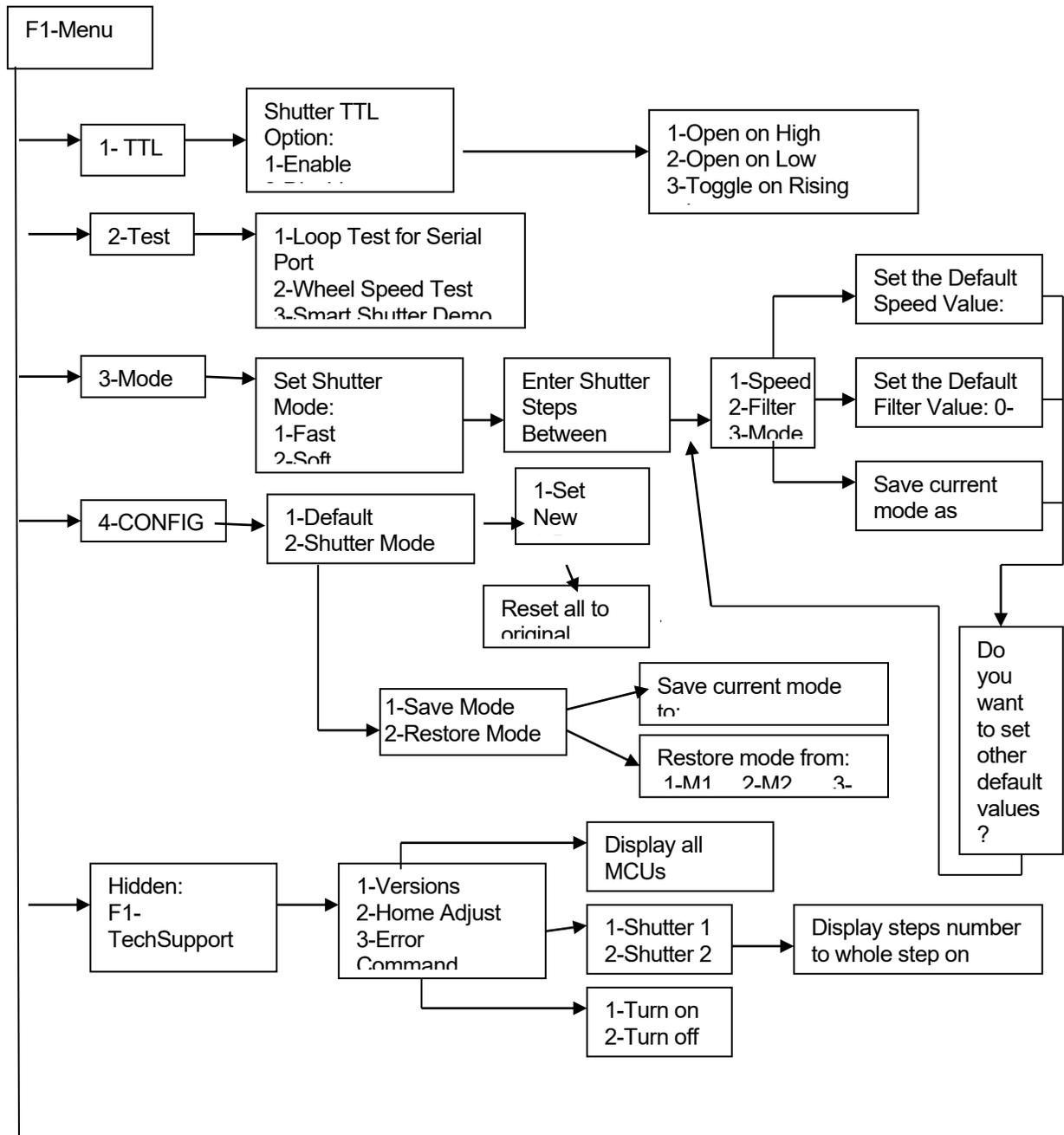
F1 KEY – Bring up the Menu.

F2 KEY – Enter key for any data input (such as neutral density steps, Lamp dim value..)

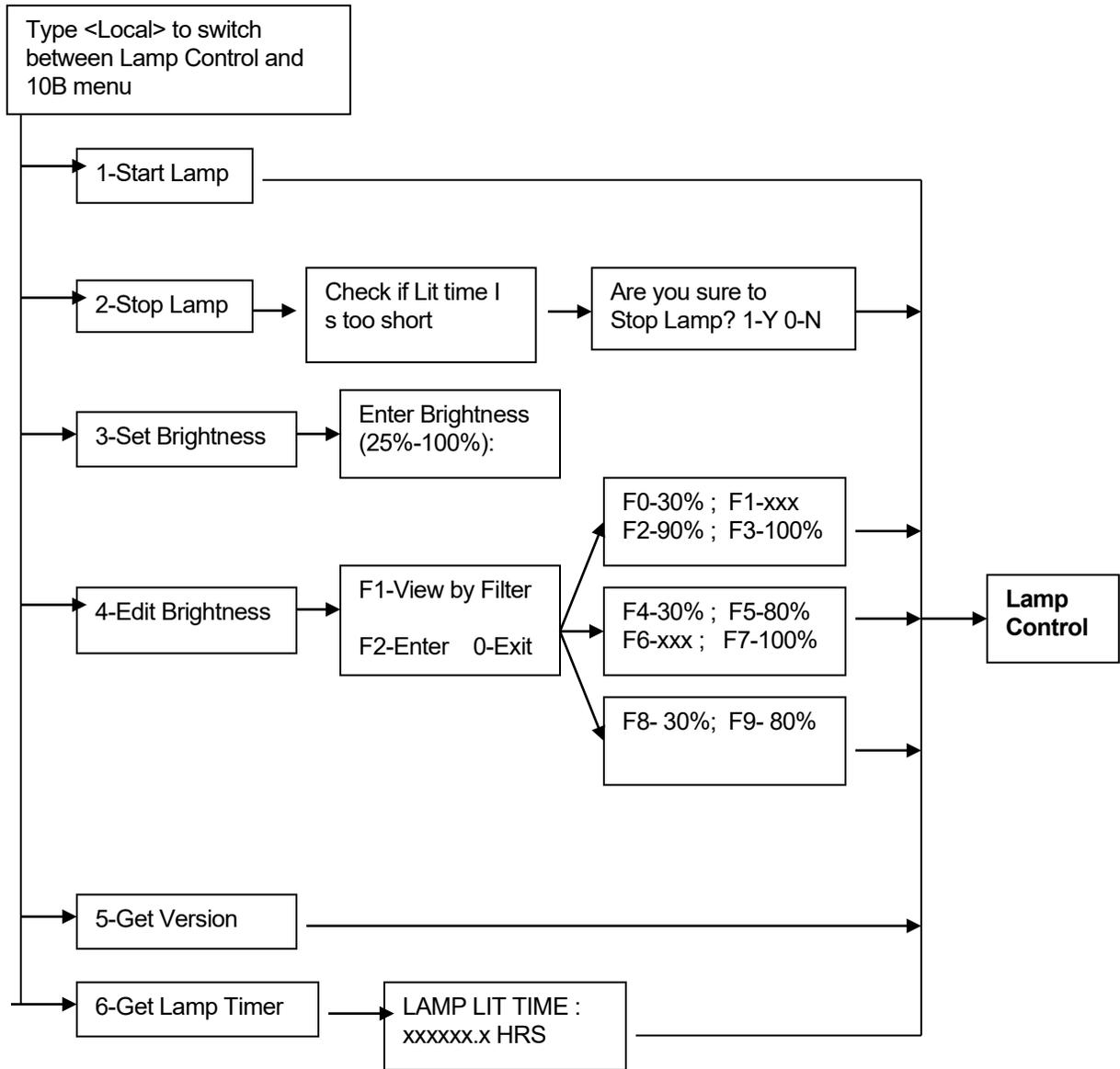
LOCAL KEY – Local mode, press this key to switch between 10B Filter Wheel & Shutter Control and Lamp Control menus.

Default – Means saved configuration will be loaded when power on next time

10B Filter Wheel & Shutter Control Menu



Lamp Control Menu



APPENDIX H. EXTERNAL CONTROL COMMAND REFERENCE

This appendix provides a complete list of remote control commands and return values.

Table H-1. Complete Command Reference.

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	Shutter or Special Command				
						e	e	t					
						e	d	r					
0	00	0000 0000	Alt-0000	^@	(NUL)	A	0	0					
1	01	0000 0001	Alt-0001	^A	(SOH)			1					
2	02	0000 0010	Alt-0002	^B	(STX)			2					
3	03	0000 0011	Alt-0003	^C	(ETX)			3					
4	04	0000 0100	Alt-0004	^D	(EOT)			4					
5	05	0000 0101	Alt-0005	^E	(ENQ)			5					
6	06	0000 0110	Alt-0006	^F	(ACK)			6					
7	07	0000 0111	Alt-0007	^G	(BEL)			7					
8	08	0000 1000	Alt-0008	^H	(BS)			8					
9	09	0000 1001	Alt-0009	^I	(HT)			9					
10	0A	0000 1010	Alt-0010	^J	(LF)								
-	-	-	-	-	-								
15	0F	0000 1111	Alt-0015	^O	(SI)								
16	10	0001 0000	Alt-0016	^P	(DLE)					A	1	0	
17	11	0001 0001	Alt-0017	^Q	(DC1)							1	
18	12	0001 0010	Alt-0018	^R	(DC2)	2							
19	13	0001 0011	Alt-0019	^S	(DC3)	3							
20	14	0001 0100	Alt-0020	^T	(DC4)	4							
21	15	0001 0101	Alt-0021	^U	(NAK)	5							
22	16	0001 0110	Alt-0022	^V	(SYN)	6							
23	17	0001 0111	Alt-0023	^W	(ETB)	7							
24	18	0001 1000	Alt-0024	^X	(CAN)	8							
25	19	0001 1001	Alt-0025	^Y	(EM)	9							
26	1A	0001 1010	Alt-0026	^Z	(SUB)								
-	-	-	-	-	-								
31	1F	0001 1111	Alt-0031	^_	(US)								
32	20	0010 0000	Alt-0032		(space)					A	2	0	
33	21	0010 0001	Alt-0033		!							1	
34	22	0010 0010	Alt-0034		"	2							
35	23	0010 0011	Alt-0035		#	3							
36	24	0010 0100	Alt-0036		\$	4							
37	25	0010 0101	Alt-0037		%	5							
38	26	0010 0110	Alt-0038		&	6							
39	27	0010 0111	Alt-0039		'	7							
40	28	0010 1000	Alt-0040		(8							
41	29	0010 1001	Alt-0041)	9							
42	2A	0010 1010	Alt-0042		*								
-	-	-	-		-								
47	2F	0010 1111	Alt-0047		/								
46	30	0011 0000	Alt-0048		0	A	3	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	
49	31	0011 0001	Alt-0049		1			1	Shutter or Special Command
50	32	0011 0010	Alt-0050		2			2	
51	33	0011 0011	Alt-0051		3			3	
52	34	0011 0100	Alt-0052		4			4	
53	35	0011 0101	Alt-0053		5			5	
54	36	0011 0110	Alt-0054		6			6	
55	37	0011 0111	Alt-0055		7			7	
56	38	0011 1000	Alt-0056		8			8	
57	39	0011 1001	Alt-0057		9			9	
58	3A	0011 1010	Alt-0058		:				
-	-	-	-		-				
63	3F	0011 1111	Alt-0063		?				
64	40	0100 0000	Alt-0064		@			0	Shutter or Special Command
65	41	0100 0001	Alt-0065		A			1	
66	42	0100 0010	Alt-0066		B			2	
67	43	0100 0011	Alt-0067		C			3	
68	44	0100 0100	Alt-0068		D	A	4	4	
69	45	0100 0101	Alt-0069		E			5	
70	46	0100 0110	Alt-0070		F			6	
71	47	0100 0111	Alt-0071		G			7	
72	48	0100 1000	Alt-0072		H			8	
73	49	0100 1001	Alt-0073		I			9	
74	4A	0100 1010	Alt-0074		J				Shutter or Special Command
-	-	-	-		-				
79	4F	0100 1111	Alt-0079		O				
80	50	0100 0000	Alt-0080		P			0	Shutter or Special Command
81	51	0100 0001	Alt-0081		Q			1	
82	52	0100 0010	Alt-0082		R			2	
83	53	0100 0011	Alt-0083		S			3	
84	54	0100 0100	Alt-0084		T	A	5	4	
85	55	0100 0101	Alt-0085		U			5	
86	56	0100 0110	Alt-0086		V			6	
87	57	0100 0111	Alt-0087		W			7	
88	58	0100 1000	Alt-0088		X			8	
89	59	0100 1001	Alt-0089		Y			9	
90	5A	0100 1010	Alt-0090		Z				Shutter or Special Command
-	-	-	-		-				
95	5F	0101 1111	Alt-0095		-				
96	60	0101 0000	Alt-0096		`			0	Shutter or Special Command
97	61	0101 0001	Alt-0097		a			1	
98	62	0101 0010	Alt-0098		b			2	
99	63	0101 0011	Alt-0099		c			3	
100	64	0101 0100	Alt-0100		d	A	6	4	
101	65	0101 0101	Alt-0101		e			5	
102	66	0101 0110	Alt-0102		f			6	
103	67	0101 0111	Alt-0103		g			7	
104	68	0101 1000	Alt-0104		h			8	

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	
105	69	0101 1001	Alt-0105		i			9	Shutter or Special Command
106	6A	0101 1010	Alt-0106		j				
-	-	-	-		-				
111	6F	0101 1111	Alt-0111		o				
112	70	0111 0000	Alt-0112		p	A	7	0	
113	71	0111 0001	Alt-0113		q			1	
114	72	0111 0010	Alt-0114		r			2	
115	73	0111 0011	Alt-0115		s			3	
116	74	0111 0100	Alt-0116		t			4	
117	75	0111 0101	Alt-0117		u			5	
118	76	0111 0110	Alt-0118		v			6	
119	77	0111 0111	Alt-0119		w			7	
120	78	0111 1000	Alt-0120		x			8	
121	79	0111 1001	Alt-0121		y			9	
122	7A	0111 1010	Alt-0122		z				
-	-	-	-		-				
127	7F	0111 1111	Alt-0127		~				
128	80	1000 0000	Alt-0128						
-	-	-	-						
169	A9	1010 1001	Alt-0169						
170	AA	1010 1010	Alt-0170					Open Shutter A	
171	AB	1010 1011	Alt-0171					Open Shutter A conditionally	
172	AC	1010 1100	Alt-0172					Close Shutter A	
173	AD	1010 1101	Alt-0173						
-	-	-	-						
185	B9	1011 1001	Alt-0185						
186	BA	1011 1010	Alt-0186					Open Shutter B	
187	BB	1011 1011	Alt-0187						
188	BC	1011 1100	Alt-0188					Close Shutter B	
189	BD	1011 1101	Alt-0189						
-	-	-	-						
203	CB	1100 1011	Alt-0203						
204	CC	1100 1100	Alt-0204					Status	
205	CD	1100 1101	Alt-0205						
206	CE	1100 1110	Alt-0206					All motors power on	
207	CF	1100 1111	Alt-0207					All motors power off	
208	D0	1100 0000	Alt-0208						
-	-	-	-						
219	DD	1100 1011	Alt-0219						
220	DC	1100 1100	Alt-0220					Fast mode	
221	DD	1100 1101	Alt-0221					Soft mode	
222	DE	1100 1110	Alt-0222					Neutral density mode	
223	DF	1101 1111	Alt-0223						
-	-	-	-						
237	ED	1110 1101	Alt-0237						
238	EE	1110 1110	Alt-0238					On Line	
239	EF	1110 1111	Alt-0239					Local	

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	
240	F0	1111 0000	Alt-0240			e	e	l	Shutter or Special Command
-	-	-	-						
250	FA	1111 1010	Alt-0250						
251	FB	1111 1011	Alt-0251					Reset	
252	FC	1111 1100	Alt-0252						
253	FD	1111 1101	Alt-0253					Get controller type & configuration	
254	FE	1111 1110	Alt-0254						
255	FF	1111 1111	Alt-0255						

NOTE 1: The Lambda XL supports only one filter wheel (Wheel A). Therefore, Bit 7 should always be set to 0.

NOTE 2: 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.

Table H-2. Filter command structure.

Functional Bit Groups								
Nibble	Upper				Lower			
Byte Bit #	7	6	5	4	3	2	1	0
Command Parameter Bit Group	Wheel	Speed			Filter Position			
Group Bit #	0	2	1	0	3	2	1	0
Bit Group Value Range	0	0 – 7 (000 – 111 binary)			0 – 9 (0000 – 1001 binary)			
Group Bit Position Multiplier	128	16			0			

Encoding filter wheel commands into a single byte (all numbers are in decimal):

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

... where *speed* = 0 through 7 and *position* = 0 through 9. The Wheel Bit is not included in the formula because in the Lambda XL it is always set to 0 (Wheel A).

Table H-3. Status Command Return Codes and Data in a “Wheel/Shutter” Configuration.

Order	Num. of bytes	Category	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
1	1	Command echo		204 CC 11001100	The Status command byte code echoed back.
2	1	Filter wheel state	Wheel, Speed and Position	* 0 – 121 00 – 79 00000000 – 01111001	Filter Wheel (Bit 7): Always 0. Speed (Bits 6, 5, & 4): 0 – 7. Position (Bits 3, 2, 1, & 0): 0 – 9
			Error or no filter wheel installed	10 0A 00001010	Either no filter wheel is installed or there is an error on the 15-pin wheel port.
3	1	Shutter open/closed state	Open	170 AA 10101010	The shutter is in the open state.
			Open state is conditional	171 AB 10101011	The open state of the shutter is conditional upon the movement of the filter wheel.
			Closed	172 AC 10101100	The shutter is in the closed state.
4	1 or 2	Shutter mode (<i>SMART-SHUTTER</i> only)	<i>SMART-SHUTTER</i> not connected	219 DB 11011011	Indicates that no <i>SmartShutter</i> is connected. Either no shutter is connected or a Vincent shutter is connected.
			Fast mode	220 DC 11011100	Indicates that the <i>SmartShutter</i> is in fast mode.
			Soft mode	221 DD 10111011	Indicates that the <i>SmartShutter</i> is in soft mode.
			Neutral Density mode (1 byte) plus number of microsteps (1 byte)	222, 1 – 144 DE, 01 – 90 10111100, 00000001 - 10010000	Indicates that the <i>SmartShutter</i> is in neutral-density mode. A second byte contains the number of microsteps (1 – 144).

* **NOTE:** Range shown for the filter wheel command/status byte is not 100% inclusive. Please refer to Table 5-4 for an explanation of how the byte is encoded, and to Table 5-3 for a list of valid byte values.

Table H-4. “Get Controller Type and Configuration” Command Return Codes and Data.

Configuration	Total num. bytes	Description			
		Category	Num. Bytes	Possible Values	
				ASCII string	Meaning
Filter Wheel with or without shutter or Single Shutter (no filter wheel) (One standalone filter wheel only, one filter wheel with one integrated shutter, or one standalone filter wheel and one standalone shutter)	14	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	LBXL	Lambda XL **
				10-B	“Lambda 10-B” **
		Filter Wheel Type	4	W-25	25mm
				W-32	32mm
				W-HS	High Speed
				W-BD	Belt Driver
				W-NC	Not Connected
Shutter Type	4	S-IQ	SmartShutter		
		S-VS	No shutter connected		
Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.		
Dual SmartShutters™ (no filter wheel) (Two shutters (SmartShutters™ only); no filter wheel)	16	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	LBXL	Lambda XL **
				10-B	“Lambda 10-B” **
		Shutter A Type	5	SA-IQ	1 st SmartShutter
		Shutter B Type	5	SB-IQ	2 nd SmartShutter
Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.		

***NOTE:** The character shown in the “ASCII string” column for the command echo 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:** The text returned for “Controller Type” is “LBXL” by default. This text can be changed to “10-B” (for Lambda 10-B) in cases where the remote control software being used to control the Lambda XL issues the Get Controller Type and Configuration command to identify the product but does not recognize “LBXL” as a supported product. The Controller Type text is changed via the Lambda XL’s keypad and display menus in local mode, as described in Chapter 5 (OPERATIONS: EXTERNAL COMMAND CONTROL).

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