

# LAMBDA SC

*SMARTSHUTTER*<sup>®</sup>  
CONTROL SYSTEM

## OPERATION MANUAL

REV. 1.20D ( 20230227)



**SUTTER INSTRUMENT**<sup>®</sup>

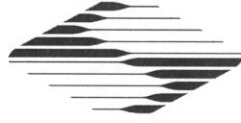
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# EU Declaration of Conformity (DoC)

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

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<b>Equipment Tested:</b>	<b>SmartShutter<sup>®</sup> motorized optical shutter and Lambda SC controller</b>		
<b>Model(s):</b>	<b>LB-SC (controller); IQ12, IQ25, IQ35, &amp; IQ50 (SmartShutter); FSWITCH &amp; FSTOGGLE (footswitch)</b>		
<b>Conforms to Standards:</b>	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 61000-4-4:2012, EN 61000-4-6:2014, EN 61000-4-11:2004	EN 61000-4-3:2011, EN 61000-4-5:2014, EN 61000-4-8:2010, & EN 61000-4-11:2004
	LVD (Safety):	EN 61010-1:2010	
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<b>Test Report(s):</b>	20120511-01C_Lambda SC_CE Report R2, 20120511-01C, 20120511-01C_Lambda SC_CE Report R3, 20120511-01RC-CE; 20200520_REACH and RoHS Compliance Statement		

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

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## DISCLAIMER

The LAMBDA SC SmartShutter Controller is designed for the specific use of controlling the open and closed state of a shutter (specifically, a SmartShutter), and no other use is recommended.

This instrument is designed for use in a laboratory environment. It is not intended for, and should not 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 operatives to use this device.

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

## SAFETY WARNINGS AND PRECAUTIONS



### Electrical


- Operate the LAMBDA SC using 110-240 V AC., 50/60 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 x 20 mm glass tube, T1.0A, 250V (219XA Series), IEC 60127-2, Sheet III  
Use only Littelfuse 0219001.XAP (219XA Series)

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

### Avoiding Electrical Shock and Fire-related Injury

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

-  Never look into the optical pathway of the high intensity light sources typically used with this instrument. Doing so can cause permanent eye damage.
-  The high-intensity light sources typically used with this instrument also produce a significant amount of heat. Direct contact with the housing of those instruments can cause serious burns.


-  **The SmartShutter is Not a Safety Shutter:** Sutter Instrument Co.'s SmartShutter is not intended to be a 'safety shutter.' A safety shutter usually closes automatically in the event of a power failure and is designed with the primary goal of ensuring that it will not allow any unintended exposure. For laser safety applications, a shutter is normally designed so that no single component failure allows an unintended exposure to the laser beam. The SmartShutter is intended for use in the controlling of light in scientific and industrial applications. The SmartShutter was designed for high performance and durability, but without certain features that would be desirable in a safety shutter application.

### Electromagnetic Interference


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

### Operational

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

- This instrument is designed for operation in a laboratory environment (Pollution Degree I).
-  **DO NOT CONNECT OR DISCONNECT THE CABLES BETWEEN THE CONTROLLER AND THE MECHANICAL UNITS WHILE POWER IS ON.**

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

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

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## 1. GENERAL INFORMATION

### 1.1 About This Manual

The Lambda SC is a *SmartShutter* control system designed for rapid aperture control of wavelength and is comprised of two subsystems: 1) a controller, and 2) one *SmartShutter* that is placed in the optical pathway of your existing experimental setup. Installation of the *SmartShutter* is discussed in the *SMARTSHUTTER* section while installation of the controller is discussed in the *CONTROLLER* section. This unit supports a single *SmartShutter*. Finally, the remote operation of the Lambda SC through its USB or RS-232 serial port is discussed in the *REMOTE CONTROL* sections.

In the next few pages, you will find unpacking instructions followed by some *quick-start* directions in the *FIRST TIME USE* section to help you get acquainted with the manual operation of the Lambda SC. Please take the time to read these instructions to assure the safe and proper use of this instrument.

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 (415-883-0128 or [info@sutter.com](mailto: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 Time) at (415) 883-0128. You may also E-mail your queries to [info@sutter.com](mailto:info@sutter.com).

**NOTE:** The RS-232 serial port is absent on early versions of the Lambda SC controller. If you have a version of the Lambda SC that does not have the serial port, and you would like to have it added, please contact Sutter Instrument Co. to arrange for an upgrade.

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## 2. ACCESSORIES

### 2.1 *SmartShutters*

SmartShutters are available in 25-, 35-, or 50-mm sizes. The 25- and 35-mm SmartShutters are completely exchangeable without requiring modification of the Lambda SC controller. When exchanging a 25- or 35-mm SmartShutter with a 50-mm version, or vice versa, the Lambda SC controller box must be returned to Sutter Instrument Co. for reprogramming.

### 2.2 Mounts

An 8-32 screw-mount hole exists on the edge of the SmartShutter opposite the motor, into which may be attached a mounting post of any desired length. When the SmartShutter is mounted on a post using this screw-mount hole, the exact center of the shutter aperture is precisely aligned with the vertical center of the post. A \_\_\_-long post is available from Sutter Instrument Co. This post, along with posts of other dimensions, as well as post holders and bases, are available from most laboratory equipment suppliers.

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

### 2.3 Adapters

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

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### 3. UNPACKING

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

- One standalone SmartShutter.
- A mounting rod and base holder for the SmartShutter are included if ordered.
- LAMBDA SC controller.
- 9-pin SmartShutter to controller connecting cable.
- USB interface cable
- Power cord.
- CD-ROM disc containing device driver and utility/configuration software for the USB interface.
- Manual.

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

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

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## 4. FIRST TIME USE

### 4.1 Some Basic Information

The Lambda SC is a microprocessor-controlled, high-speed shutter controller designed for microscopy and other applications that require rapid and accurate wavelength switching. The Lambda SC controller can control one SmartShutter and features a USB input for remote control.

The controller is designed around an embedded microcontroller, which automatically determines the equipment installed. The electronics for controlling a SmartShutter are already installed, even if you did not order that option. If you add a SmartShutter later or change the size of the SmartShutter, there are no additional electronics to buy, although you may need to have the controller reprogrammed if switching between 25- or 35-mm SmartShutter and a 50-mm one, or vice versa.

The controller runs the attached SmartShutter under remote control through a USB or RS-232 serial input using the same simple protocol as the original Lambda 10- series controllers with only minor differences. The controller is programmed with a superset of commands, based on the Lambda 10-3 and 10-B, some commands of which are unique to the Lambda SC. The controller can also be configured for it to be under basic control of an external signaling device connected to the controller's TTL IN connector.

The following instructions are meant to help you set up the Lambda SC and familiarize you with the remote mode of SmartShutter control.

The Lambda SC controller can control one *SmartShutter*. Shutters are commonly used to turn off a light source in order to prevent photo bleaching or other photo damage. In addition, they may be used to select between multiple light sources or light paths, such as transmitted light versus fluorescence excitation. SmartShutters, in particular, have the ability to be placed into one of several modes. These modes determine the way the actual shutter action works: Fast Mode, Soft Mode, and Neutral Density Mode. Fast Mode provides for the fastest open/close action of the shutter. Soft Mode is slightly slower than Fast Mode and provides for a somewhat gradual open/close action, as well as being quieter. Neutral Density Mode allows for the control of the aperture of the open state of the shutter – between 1 and 144 microsteps may be selected for the Neutral Density Mode. Neutral Density Mode also provides for the control of light intensity without affecting the wavelength.

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

## 4.2 Line Power (Mains)

The power cord provided with the Lambda SC connects to the Power Entry Module located on the back of the unit (see diagram below). This Module also includes the Line Fuse and Power Switch.

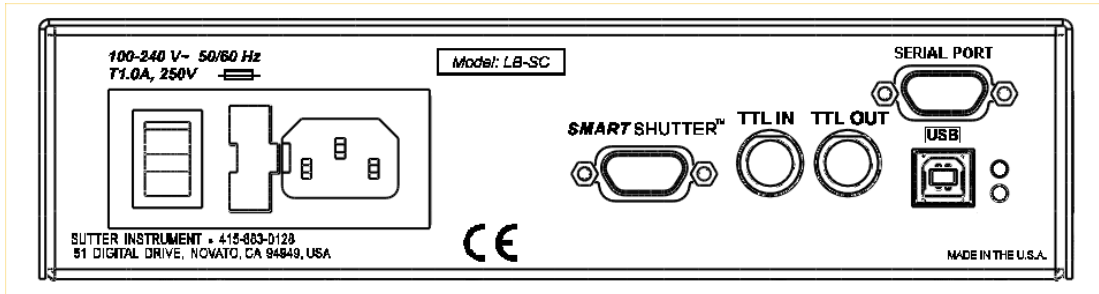


Figure 4-1. Lambda SC cabinet (rear view)

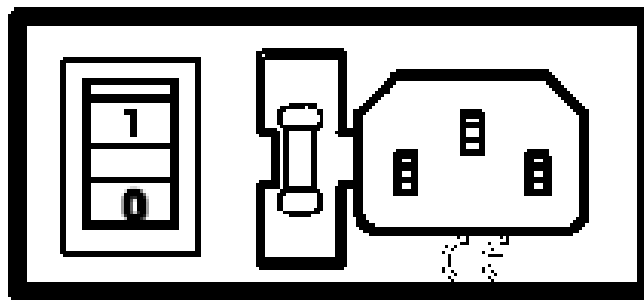


Figure 4-2. Switch, fuse, and power connection

The Lambda SC 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 SC cabinet is turned OFF. Plug the power cord provided with the Lambda SC into the Line Input socket on the Power Entry Module and then to a power source of the appropriate voltage and frequency.

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

## 4.3 Basic Operation

### 4.3.1 Initialization

At power on the Lambda SC will open or close the SmartShutter according to its internally saved configuration. Additionally, the mode of the SmartShutter (Fast, Soft, or Neutral Density (and number of microsteps)) is determined by the settings in the internally saved configuration. When powering up the Lambda SC for the first time after having received it and setting it up, the state and mode of the SmartShutter defaults to the factory settings (State = Closed, Mode = Fast; and for TTL control, Trigger = High).

The actual configuration can be verified and changed by installing the Lambda SC COM Utility software for connection to the computer’s RS-232 serial port, or the Lambda SC USB

Utility software after having installed the USB device driver. Additionally, the open/closed state of the SmartShutter can be controlled by connecting a triggering signal to the TTL Input connector on the rear of the Lambda SC box.

#### 4.5 Make It Go

1. Turn on the power using the ON/OFF switch on the back panel of the Lambda SC controller cabinet. The attached SmartShutter will automatically open and close as an indication that the unit has been powered on and has been initialized.
2. The Lambda SC will default to on-line at power-on or after a reset. If the unit is connected to a USB port with properly installed software, the USB port will be selected as the default remote control interface.
3. The Lambda SC will be on-line at power on, ready for USB port commands.
4. Send a command from the host computer to toggle the shutter open and closed (if it is connected).

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

- Install the SmartShutter into the optical pathway using the appropriate adapter.
- Establish communication between the Lambda SC and your computer.

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

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## 5. SMARTSHUTTER

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

### 5.1 Step Motor Based Shutter Advantages

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

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

The following instructions are meant to help you set up the Lambda *SmartShutter* and familiarize you with the manual mode of filter selection. More detailed discussions of controller function, filter installation and remote communications can be found in other sections of this manual.

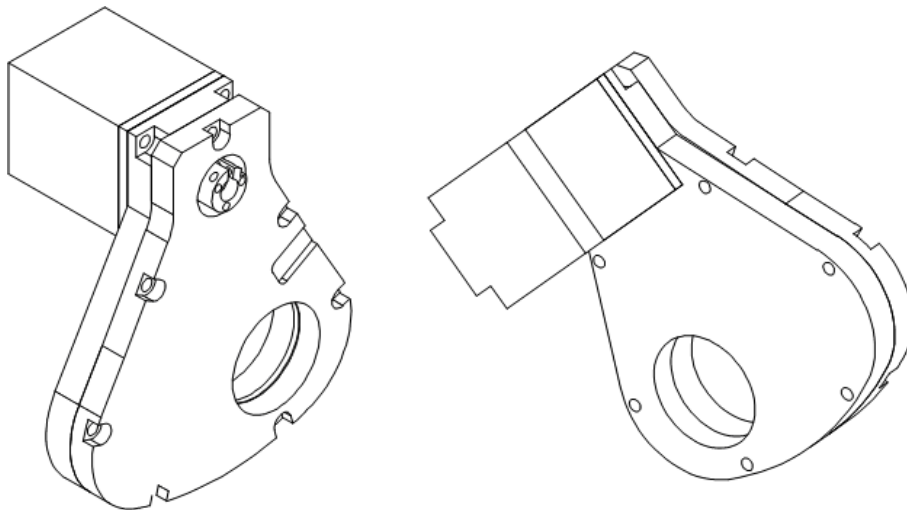


Figure 5-1. 25-mm SmartShutter.

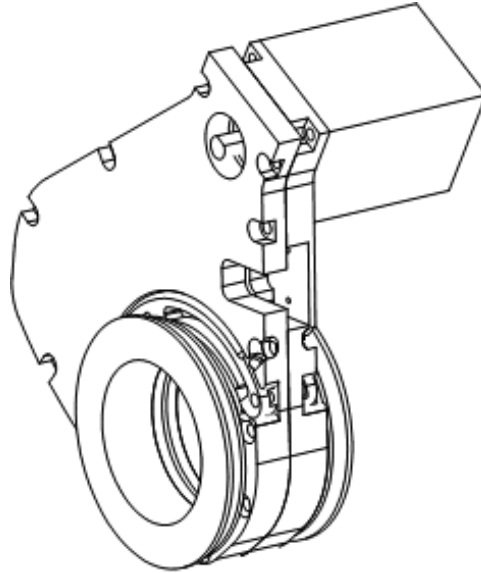


Figure 5-2. 35-mm *SmartShutter*.

## 5.2 Modes

The Lambda SC supports three modes of operation for the *SmartShutter*.

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

## 5.3 Special Considerations

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

### 5.3.1 Mounting

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



When a 35 mm *SmartShutter* is to be mounted to a 32 mm Lambda 10 filter wheel, a special adapter threads into the filter wheel T-mount and the *SmartShutter* mounts on this piece. The 35 mm *SmartShutter* has a receptacle for the flange on the end of this T-mount tube and this allows the *SmartShutter* to mount to the flange on the end of the tube in many different orientations. On the other side of the *SmartShutter* a similar rotating mount accepts an adapter that is used to couple to our standard microscope adapters. It is possible to install a T-mount instead, if desired.

### 5.3.2 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 both the 25 mm and the 35 mm versions operating in the fast mode. Note that the controller will not accept new commands or TTL pulses in the FAST mode for about 12 msec after a command has been received. The additional time is required for display changes and other overhead.

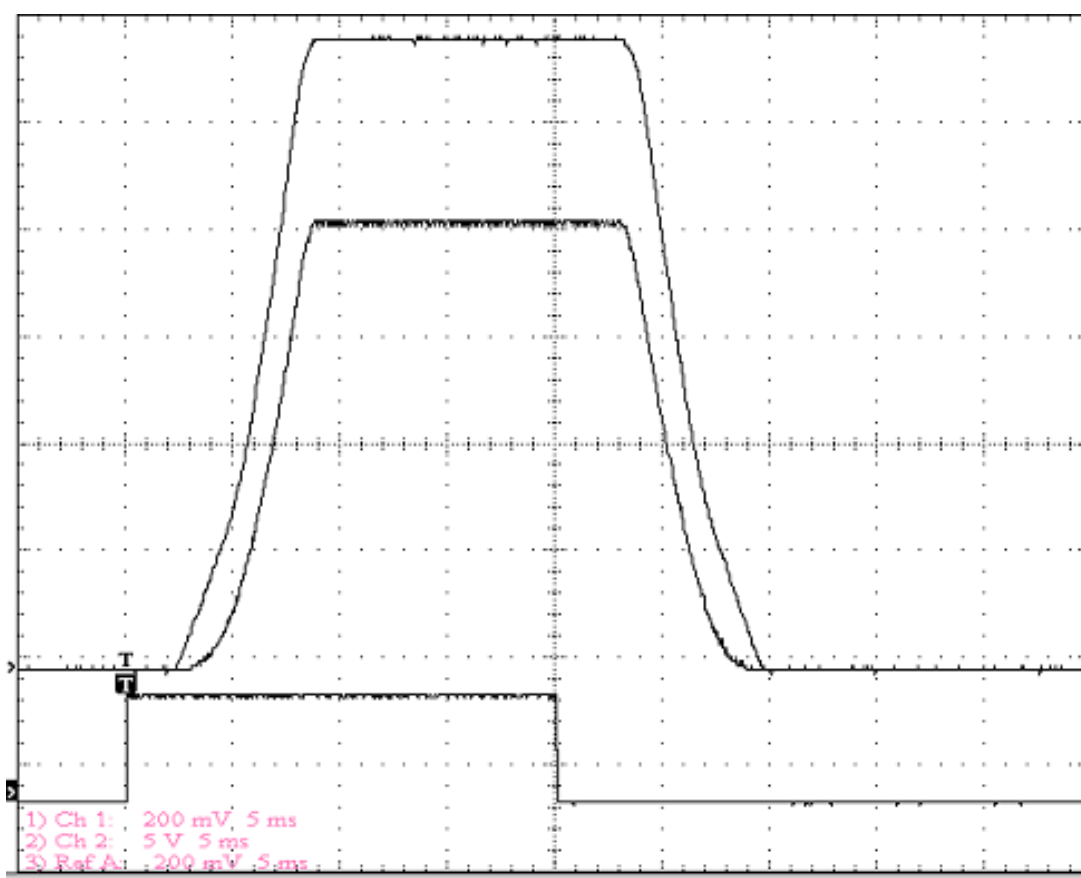


Figure 5-3. SmartShutter timing

The previous figure shows the timing of a *SmartShutter*. 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.

### **5.3.3 Repetition Rates and Duty Cycle**

Operation does not require over-driving the motor windings, so the motor windings are not damaged by frequent opening and closing over long time periods. 25 mm (one inch) versions can usually operate well at up to 20 Hz. 35 mm versions can usually operate well at up to 15 Hz. These shutters may be operated at higher rates up to 40 Hz, but there will normally be specific frequencies in 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 msec., with 12.5 msec. between open and close commands. This is close to the absolute minimum time in either the open or closed state. If you attempt to reduce the time in either state below 12 msec, the controller will not start to change the shutter state until the 12-msec minimum period is over.

## 6. CONTROLLER

### 6.1 Principles of Operation

The Lambda SC controller is operated remotely from a computer through the USB port. Remote operation allows the user to select:

- Shutter position
- Shutter mode

The remainder of this chapter provides a detailed description of the controller's rear panel connectors and front panel controls. Information needed to connect the power cord and SmartShutter is found in the FIRST TIME USE chapter. The REMOTE CONTROL chapter explains control of the unit from a remote device. Technical details, which are not required for operation, but which may help you understand the behavior of the unit, are found in APPENDIX A: Stepping Motor Operation.

### 6.2 Rear Panel Connectors and Switches

All electrical connections are all made on the rear panel of the Lambda SC. See the FIRST TIME USE chapter for details on connecting the power cord and SmartShutter cable.

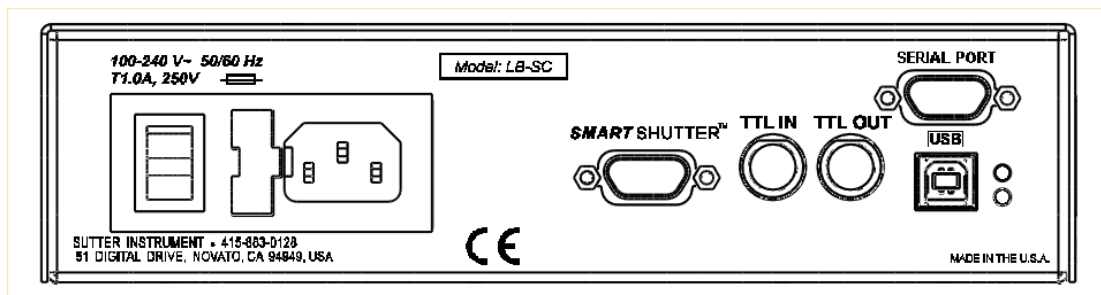


Figure 6-1. Electrical connections.

#### 6.2.1 SMARTSHUTTER

The port labeled **SMARTSHUTTER** is a 9-pin, DSUB male connector used to link the Lambda SC controller with the *SmartShutter*.

#### 6.2.2 USB Port

The port labeled **USB** is a USB B type receptacle and is designed to accept the B type connector (“device”) end of the USB cable provided. The other end of the USB cable is connected to a host computer for the purpose of remote controlling the Lambda SC.

#### 6.2.3 Serial Port

The port labeled **SERIAL** is a 9-pin, DSUB female receptacle used for establishing an RS-232 serial interface between the Lambda SC and a host computer using the cable provided.

**NOTE:** The RS-232 serial port is absent on early versions of the Lambda SC controller. If you have a version of the Lambda SC that does not have the serial port, and you would like to have it added, please contact Sutter Instrument Co. to arrange for an upgrade.

#### 6.2.4 TTL Input and Output

Two BNC receptacles are provided for TTL control of the connected SmartShutter. The receptacle labeled **TTL IN** is used for connection with a trigger source, such as a foot switch, an oscillator, or the TTL output of another device. The receptacle labeled **TTL OUT** can be used to cascade the trigger control to another device.

#### 6.2.5 Power Switch

The power switch, located near the fuse and the power socket, is used to turn the power on and off to the Lambda SC and attached SmartShutter.

#### 6.2.6 Line Power

The power socket is used to connect the supplied power cord to the Lambda SC.

#### 6.2.7 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.

#### 6.2.8 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.

### 6.3 Front Panel

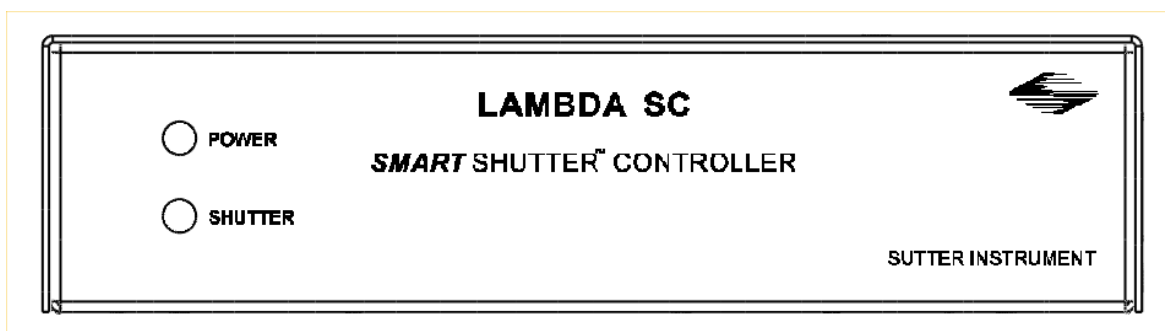


Figure 6-2. Lambda SC front panel controls.

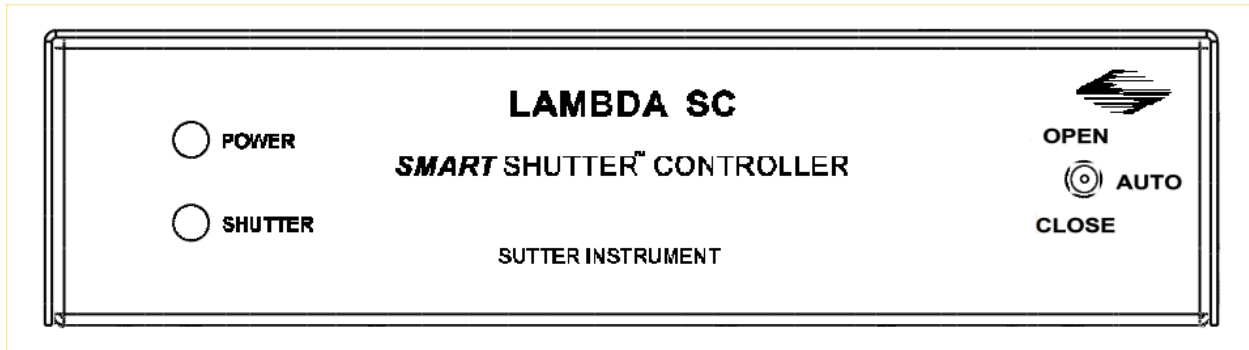


Figure 6-3. Lambda SC front panel with manual shutter control switch.

### 6.3.1 Power Light

This lamp is lit while the controller is powered on.

### 6.3.2 Shutter Light

This lamp is lit while the SmartShutter is in the open state.

### 6.3.3 Manual Shutter Control Switch

This three-position switch is used to manually open or close the SmartShutter, overriding programmed operation or external control (TTL signaling and/or remote host computer connected via RS-232 Serial or USB). The manual shutter control switch's middle position (labeled AUTO) places the Lambda SC controller into its normal mode of being under the control of its programming, under TTL control, or under the control of an externally connected host computer.

**NOTE:** The switch for manual control of the SmartShutter is absent on the front panel of early versions of the Lambda SC controller. If you have a version of the Lambda SC that does not have the switch, and you would like to have it added, please contact Sutter Instrument Co. to arrange for an upgrade.

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## 7. MANUAL CONTROL

Manual control of the Lambda SC and the attached SmartShutter can be achieved by one of two means:

1. Toggle switch on the front panel of the Lambda SC cabinet.
2. A foot switch (or other switching device) attached to the TTL IN receptacle on the rear of the Lambda SC cabinet.

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## 8. EXTERNAL COMMAND CONTROL OPERATIONS OVERVIEW

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

The following table shows how remote commands are categorized.

Table 8-1. Remote control command categories

Category	Description
Shutter commands	These are commands used exclusively for controlling the SmartShutter.
Special commands	These are commands for the general control of the Lambda SC controller and are not specifically related to shutters.

Most of the commands described in this chapter are ones that are sent from the computer to the Lambda SC. Some of these commands will cause the Lambda SC 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 SC, 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 SC controller has finished performing the task associated with a command (or command followed by one or more parameter bytes), the controller will transmit to the host computer an ASCII carriage return (CR, 13 decimal, or 0D hexadecimal) as an indication that function associated with the command has completed and that the controller is now ready for another command. This echoing back of bytes sent by the remote computer to the controller, and the return of an ASCII carriage return after a command's task is complete, is the same for both serial and USB interfaces.

### 8.1 Input Command Structure

The following table provides a complete list of all the remote commands for the Lambda SC.

### 8.2 Input Command Structure

The following table provides a complete list of all the remote commands for the Lambda SC.

Table 8-2. External control commands

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
Open Shutter A	Tx	All	1	0	170	AA	1010 1010	0170			Sets the state of Shutter A to open
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Close Shutter A	Tx	All	1	0	172	AC	1010 1100	0172			Sets the state of Shutter A closed.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Stop the Free Run	Tx	All	1	0	191	BF	1011 1111	0191			Stops the Free Run if it is currently running.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Status	Tx	All	1	0	204	CC	1100 1100	0204			Returns status of unit (see status table)
	Rx	All		13	13	0D	0000 1101		^M	<CR>	Completion indicator
All Motors Power On	Tx	All	1	0	206	CE	1100 1110	0206			Instruct the controller to power on all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
All Motors Power Off	Tx	All	1	0	207	CF	1100 1111	0207			Instruct the controller to power off all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Fast-mode Shutter	Tx	All	1	0	220	DC	1101 1100	0220			Sets fast mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Soft-mode Shutter	Tx	All	1	0	221	DD	1110 1101	0221			Sets soft mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Neutral Density-mode Shutter	Tx	All	2	0	222	DE	1110 1110	0222			Sets neutral-density mode
				1	1	01	0000 0001	0001			2 <sup>nd</sup> byte contains 1 - 144
					144	90	1001 0000	0144			indicating microsteps
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Transfer to On Line	Tx	All	1	0	238	EE	1110 1110	0238			Puts controller on-line
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Set Delay Timer	Tx	All	6	0	250	FA	1111 1010	0250			Sets time to when shutter opens (0 - 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond).
				1	16	10	0001 xxxx				Upper Nibble: <b>Set Delay Timer</b>
					21	15	xxxx 0000				Lower Nibble: Hours (0 - 5).
				2	0	00	0000 0000				Minutes (0 - 59)

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description			
					Dec.	Hex.	Binary							
				3	59	38	0011 1011				Seconds (0 – 59)			
					0	00	0000 0000							
				4	-	-	-							Upper Nibble: 100s digit (0-9) for milliseconds
					0	00	0000 xxxx							
					-	-	0009 xxxx							
					153	99	xxxx 0000							
				-	-	-								
				5	0	00	0000 xxxx							Upper Nibble: 1s digit (0-9) for milliseconds
					-	-	0009 xxxx							
					153	99	xxxx 0000							
-	-	-								Lower Nibble: 0.1s digit (0-9) for milliseconds				
-	-	xxxx 0009												
<b>Rx</b>	All		1	0	13	0D	0000 1101			<CR>	Completion indicator			
<b>Set Exposure Timer</b>	<b>Tx</b>	All	6	0	250	FA	1111 1010	0250				Sets time to when shutter remains open (0 - 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond).		
					16	10	0002 xxxx						Upper Nibble: <b>Set Exposure Timer</b>	
				1	-	-	xxxx 0000							Lower Nibble: Hours (0 - 5).
					21	15	-							
				2	0	00	0000 0000							Minutes (0 – 59)
					-	-	-							
				3	0	00	0000 0000							Seconds (0 – 59)
					-	-	-							
				4	0	00	0000 xxxx							Upper Nibble: 100s digit (0-9) for milliseconds
					-	-	0009 xxxx							
153	99	xxxx 0000								Lower Nibble: 10s digit (0-9) for milliseconds				
-	-	-												
5	0	00	0000 xxxx							Upper Nibble: 1s digit (0-9) for milliseconds				
	-	-	0009 xxxx											
	153	99	xxxx 0000								Lower Nibble: 0.1s digit (0-9) for milliseconds			
	-	-	-											
-	-	xxxx 0009												
<b>Rx</b>	All		1	0	13	0D	0000 1101			<CR>	Completion indicator			
<b>TTL IN Pulse Trigger Disabled</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Disable TTL IN shutter triggering.			
				1	160	A0	1010 0000	0160						
	<b>Rx</b>	All		1	0	13	0D	0000 1101			<CR>	Completion indicator		
<b>TTL IN High Triggers</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is normally low, which keeps			
				1	161	A1	1010 0001	0161						

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
SmartShutter to Open											shutter closed. When TTL IN goes high, shutter opens, and stays open until TTL IN goes low again.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Low Triggers SmartShutter to Open	Tx	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is normally high, which keeps shutter closed. When TTL IN goes low, shutter opens, and stays open until TTL IN goes high again.
				1	162	A2	1010 0010	0162			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Rising Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN rising edge.
				1	163	A3	1010 0011	0163			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN falling edge.
				1	164	A4	1010 0100	0164			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL OUT Disabled	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	176	B0	1011 0000	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to High	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	177	B1	1011 0001	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to Low	Tx	All	2	0	250	FA	1111 1010	0250			When shutter opens, TTL OUT is set to low.
				1	178	B2	1011 0010	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Restore Controller to the Factory- Default Configuration	Tx	All	2	0	250	FA	1111 1010	0250			Changes the controller's configuration to that of the factory default.
				1	192	C0	1100 0000	0192			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Save the Current Configuration to the Controller	Tx	All	2	0	250	FA	1111 1010	0250			Saves the current configuration to the controller. This saved configuration will be used next time the controller is powered up or is reset.
				1	193	C1	1100 0001	0193			

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Set Number of Repeat Cycles for Free Run	Tx	All	4	0	250	FA	1111 1010	0250			Sets the number of repeat cycles for the Free Run feature. 3 <sup>rd</sup> and 4 <sup>th</sup> bytes contain the number of repeat cycles as a 16-bit integer ranging from 0 to 65,000. Any number above 65,000 (65,001 to 65,535) sets up the Free Run for Continuous operation (i.e., infinite repeat cycles).
				1	240	F0	1111 0000	0240			
				2-3	0	0000	0000 0000 0000 0000				
				-	-	-	-				
				65000	FDE8	1111 1101 1110 1000					
				or 65001	or FDE9	or 1111 1101 1110 1001					
	- 65535	- FFFF	- 1111 1111 1111 1111								
Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator	
Start Free Run on Power Up	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after the controller powers up. The number of repeat cycles does not need to be set beforehand.
				1	241	F1	1111 0001	0241			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Start Free Run on Trigger Pulse from TTL IN	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after trigger pulse is received on TTL IN. The number of repeat cycles must be set beforehand.
				1	242	F2	1111 0010	0242			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Start Free Run immediately	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately on receiving this command. The number of repeat cycles must be set beforehand.
				1	243	F3	1111 0011	0243			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Reset Controller to the Last Saved Configuration	Tx	All	1	0	251	FB	11111011	0253			Resets the controller and sets the configuration to the one that was last saved.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Get Controller Type and Configuration	Tx	All	1	0	253	FD	11111101	0253			Queries the controller as to its type and configuration (see controller type & config. table)
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator

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

**Shutter Commands:** These commands control the open and closed states of shutters as well various modes in which SmartShutters can operate.

**Special Commands:** These commands are used to control various aspects of the controller that are not specifically related to either filters or shutters. Some of these commands are also used to obtain status and configuration information of the controller.

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

### 8.3 Shutter Commands

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 8-3. Shutter commands

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
Open Shutter A	Tx	All	1	0	170	AA	1010 1010	0170			Sets the state of Shutter A to open
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Close Shutter A	Tx	All	1	0	172	AC	1010 1100	0172			Sets the state of Shutter A closed.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Fast-mode Shutter	Tx	All	1	0	220	DC	1101 1100	0220			Sets fast mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Soft-mode Shutter	Tx	All	1	0	221	DD	1110 1101	0221			Sets soft mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Neutral Density-mode Shutter	Tx	All	2	0	222	DE	1110 1110	0222			Sets neutral-density mode
				1	1	01	0000 0001	0001			2 <sup>nd</sup> byte contains 1 - 144 indicating microsteps
					144	90	1001 0000	0144			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator

The following paragraphs describe the shutter commands in more detail.

### 8.3.1 Open Shutter

Changes the shutter's state to open.

### 8.3.2 Close Shutter

Changes the shutter's state to closed.

### 8.3.3 Fast-Mode Shutter

Sets the mode of the specified shutter to FAST (*SmartShutter* only).

### 8.3.4 Soft-Mode Shutter

Sets the mode of the specified shutter to SOFT (*SmartShutter* only).

### 8.3.5 Neutral Density Mode Shutter

Sets the mode of the specified shutter to NEUTRAL DENSITY (*SmartShutter* only). The command ends with a second byte, which contains a value of 1 through 144 indicating the number of microsteps.

## 8.4 Special Commands

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

Table 8-4. Special command codes

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
Stop the Free Run	Tx	All	1	0	191	BF	1011 1111	0191			Stops the Free Run if it is currently running.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Status	Tx	All	1	0	204	CC	1100 1100	0204			Returns status of unit (see status table)
	Rx	All		13	13	0D	0000 1101		^M	<CR>	Completion indicator
All Motors Power On	Tx	All	1	0	206	CE	1100 1110	0206			Instruct the controller to power on all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
All Motors Power Off	Tx	All	1	0	207	CF	1100 1111	0207			Instruct the controller to power off all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Transfer to On Line	Tx	All	1	0	238	EE	1110 1110	0238			Puts controller on-line
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Set Delay	Tx	All	6	0	250	FA	1111 1010	0250			Sets time to when shutter

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description	
					Dec.	Hex.	Binary					
Timer											opens (0 - 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond).	
				1	16 - 21	10 - 15	0001 xxxx xxxx 0000 - xxxx 0005				Upper Nibble: <b>Set Delay Timer</b>	
				2	0 - 59	00 - 38	0000 0000 - 0011 1011				Minutes (0 - 59)	
				3	0 - 59	00 - 38	0000 0000 - 0011 1011				Seconds (0 - 59)	
				4	0 - 153	00 - 99	0000 xxxx - 0009 xxxx xxxx 0000 - xxxx 0009				Upper Nibble: 100s digit (0-9) for milliseconds	
						Lower Nibble: 10s digit (0-9) for milliseconds						
				5	0 - 153	00 - 99	0000 xxxx - 0009 xxxx xxxx 0000 - xxxx 0009				Upper Nibble: 1s digit (0-9) for milliseconds	
						Lower Nibble: 0.1s digit (0-9) for milliseconds						
		<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
	Set Exposure Timer	<b>Tx</b>	All	6	0	250	FA	1111 1010	0250			
1					16 - 21	10 - 15	0002 xxxx xxxx 0000 - xxxx 0005				Upper Nibble: <b>Set Exposure Timer</b>	
2					0 - 59	00 - 38	0000 0000 - 0011 1011				Minutes (0 - 59)	
3					0 - 59	00 - 38	0000 0000 - 0011 1011				Seconds (0 - 59)	
4					0 - 153	00 - 99	0000 xxxx - 0009 xxxx xxxx 0000 - xxxx 0009				Upper Nibble: 100s digit (0-9) for milliseconds	
					Lower Nibble: 10s digit (0-9) for milliseconds							
5					0 - 153	00 - 99	0000 xxxx - 0009 xxxx xxxx 0000				Upper Nibble: 1s digit (0-9) for milliseconds	
					Lower Nibble: 0.1s digit							



Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
							- xxxxx 0009				(0-9) for milliseconds
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Pulse Trigger Disabled	Tx	All	2	0	250	FA	1111 1010	0250			Disable TTL IN shutter triggering.
				1	160	A0	1010 0000	0160			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN High Triggers SmartShutter to Open	Tx	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is normally low, which keeps shutter closed. When TTL IN goes high, shutter opens, and stays open until TTL IN goes low again.
				1	161	A1	1010 0001	0161			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Low Triggers SmartShutter to Open	Tx	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is normally high, which keeps shutter closed. When TTL IN goes low, shutter opens, and stays open until TTL IN goes high again.
				1	162	A2	1010 0010	0162			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Rising Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN rising edge.
				1	163	A3	1010 0011	0163			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN falling edge.
				1	164	A4	1010 0100	0164			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL OUT Disabled	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	176	B0	1011 0000	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to High	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	177	B1	1011 0001	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to Low	Tx	All	2	0	250	FA	1111 1010	0250			When shutter opens, TTL OUT is set to low.
				1	178	B2	1011 0010	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Restore	Tx	All	2	0	250	FA	1111 1010	0250			Changes the controller's

Command	Tx/ Delay- Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
<b>Controller to the Factory- Default Configuration</b>				1	192	C0	1100 0000	0192			configuration to that of the factory default.
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Save the Current Configuration to the Controller</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Saves the current configuration to the controller. This saved configuration will be used next time the controller is powered up or is reset.
				1	193	C1	1100 0001	0193			
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Set Number of Repeat Cycles for Free Run</b>	<b>Tx</b>	All	4	0	250	FA	1111 1010	0250			Sets the number of repeat cycles for the Free Run feature. 3 <sup>rd</sup> and 4 <sup>th</sup> bytes contain the number of repeat cycles as a 16-bit integer ranging from 0 to 65,000. Any number above 65,000 (65,001 to 65,535) sets up the Free Run for Continuous operation (i.e., infinite repeat cycles).
				1	240	F0	1111 0000	0240			
				2-3	0	0000	0000 0000 0000 0000 - - 65000 FDE8 1111 1101 1110 1000 or or or 65001 FDE9 1111 1101 1110 1001 - - 65535 FFFF 1111 1111 1111 1111				
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Start Free Run on Power Up</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after the controller powers up. The number of repeat cycles does not need to be set beforehand.
				1	241	F1	1111 0001	0241			
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Start Free Run on Trigger Pulse from TTL IN</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after trigger pulse is received on TTL IN. The number of repeat cycles must be set beforehand.
				1	242	F2	1111 0010	0242			
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Start Free Run immediately</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately on receiving this command. The number of repeat cycles must be set beforehand.
				1	243	F3	1111 0011	0243			
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Reset Controller to the Last</b>	<b>Tx</b>	All	1	0	251	FB	11111011	0253			Resets the controller and sets the configuration to the one that was last saved.

Command	Tx/- Delay/- Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
<b>Saved Configuration</b>	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Get Controller Type and Configuration</b>	Tx	All	1	0	253	FD	11111101	0253			Queries the controller as to its type and configuration (see controller type & config. table)
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator

**NOTE:** The “TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close” command was introduced in versions of the Lambda SC programmed with Version 1.08 or later of the firmware. Before attempting to use this command, it is strongly advised that the version of the firmware with which the connected Lambda SC is programmed is checked by first issuing the “Get Controller Type and Configuration” command.

The following paragraphs describe the special commands in more detail.

#### 8.4.1 Status

The Status command is used to return information about the state and mode of the attached SmartShutter.

Table 8-5. Status command return codes and data

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
1	<b>Command echo</b> (1 byte)	1	204 CC 11001100	The Status command byte code echoed back.
2	<b>Shutter Open/Closed State</b> (1 byte)	2	170 AA 10101010	<b>Open:</b> Shutter is in the opened state.
			172 AC 10101100	<b>Closed:</b> Shutter is in the closed state.
3	<b>Shutter Mode</b> (1 byte)	3	219 DB 11011011	<b>Not Connected:</b> Indicates that no SmartShutter is connected.
			220 DC 11011100	<b>Fast:</b> Indicates that the SmartShutter is in fast mode.

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
			221 DD 10111011	<b>Soft:</b> Indicates that the SmartShutter is in soft mode.
			222 DE 10111100	<b>Neutral Density:</b> Indicates that the SmartShutter is in neutral-density mode. A second byte follows with number of microsteps (1 – 144).
<b>NOTE: From this point onwards in this table, byte numbers shown in parenthesis are true only if Shutter Mode (Byte 3) = Neutral Density (222 decimal (DE hexadecimal)).</b>				
4	<b>Neutral Density Microsteps</b> (1 byte)	(4)	1 – 144 01 – 90 00000001 - 10010000	<b>Neutral Density Microsteps:</b> Contains the number of microsteps (1 through 144) for the SmartShutter’s neutral density mode. <b>Note that this byte is present (and at this position) in Status structure only if the Shutter Mode (Byte 3) contains the value for Neutral Density (222 decimal (DE hexadecimal)).</b>
5	<b>Lead-in byte for Lambda SC Special commands</b> (1 byte)	4/(5)	250 FA 11111010	Lead-in byte for all Lambda SC-specific special commands (TTL IN, TTL OUT, Timers, and Free Run). This lead-in byte is expressed only once in the status return data structure, and this is where it occurs.
6	<b>TTL IN Setting</b> (1 byte)	5/(6)	160 A0 10100000	<b>Disabled:</b> Trigger/toggle control of the shutter via TTL IN is turned off.
			161 A1 10100001	<b>Trigger on High:</b> Shutter is normally closed; opens while high signal is present on TTL IN.
			162 A2 10100010	<b>Trigger on Low:</b> Shutter is normally open; closes while high signal is not present on TTL IN.
			163 A3 10100011	<b>Toggle on Rising Edge:</b> On the rising edge of TTL IN going high, shutter opens if closed and closes if open.
			164 A4 10100100	<b>Toggle on Falling Edge:</b> On the falling edge of TTL IN going low, shutter closes if open and opens if closed.
7	<b>TTL OUT Setting</b> (1 byte)	6/(7)	176 B0 10110000	<b>Disabled:</b> TTL OUT synch signal is disabled.

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
			177 B1 10110001	<b>High on Shutter Open:</b> TTL OUT is set to high when shutter opens.
			178 B2 10110010	<b>Low on Shutter Open:</b> TTL OUT is set to low when shutter opens.
8	<b>Delay Timer</b> (Time to when shutter opens; 5 bytes)	7/(8)	0 or 1 0x or 1x 0000xxxx or 0001xxxx	<b>Enabled/Disabled (Upper Nibble):</b> If 0 (disabled), all five Delay Timer bytes can be ignored. If 1 (enabled), remaining five bytes (and respective nibbles where applicable) may contain values for hours, minutes, seconds, and milliseconds.
			0 – 5 x0 – x5 xxxx0000 – xxxx0101	<b>Hours (Lower Nibble):</b> Hours (0 – 5).
		8/(9)	0 – 59 00 – 38 00000000 - 00111011	<b>Minutes:</b> (0 – 59)
		9/(10)	0 – 59 00 – 38 00000000 - 00111011	<b>Seconds:</b> (0 – 59)
		10/(11)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 100s Digit (Upper Nibble):</b> 0 – 9
			0 – 9 x0 – x9 xxxx0000 – xxxx1001	<b>Milliseconds 10s Digit (Lower Nibble):</b> 0 – 9.
		11/(12)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 1s Digit (Upper Nibble):</b> 0 – 9.
			0 – 9 x0 – x9 xxxx0000 – xxxx1001	<b>Milliseconds 0.1s Digit (Lower Nibble):</b> 0 – 9.

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
9	<b>Exposure Timer</b> (Time <u>during</u> <u>which the shutter</u> <u>remains open</u> ; 5 bytes)	12/(13)	0 or 1 0x or 1x 0000xxxx or 0001xxxx	<b>Enabled/Disabled (Upper Nibble):</b> 0 (disabled) or 1 (enabled).  If disabled, all five Exposure Timer bytes can be ignored. Otherwise, the remaining five bytes (and respective nibbles where applicable) may contain values for hours, minutes, seconds, and milliseconds.
			0 – 5 x0 – x5 xxxx0000 – xxxx0101	<b>Hours (Lower Nibble):</b> (0 – 5).
		13/(14)	0 – 59 00 – 38 00000000 - 00111011	<b>Minutes:</b> (0 – 59)
		14/(15)	0 – 59 00 – 38 00000000 - 00111011	<b>Seconds:</b> (0 – 59)
		15/(16)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 100s Digit (Upper Nibble):</b> 0 – 9.
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	<b>Milliseconds 10s Digit (Lower Nibble):</b> 0 – 9.
		16/(17)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 1s Digit (Upper nibble):</b> 0 – 9.
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	<b>Milliseconds 0.1s Digit (Lower Nibble):</b> 0 – 9.
		10	<b>Free Run</b> (3 bytes)	17/(18)
242 F2 11110010	<b>Run On Trigger Pulse</b>			
243 F3 11110011	<b>Run Now</b>			

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
		18/(19)	(Upper Byte) 0 - 255 00 - FF 00000000 - 11111111	<b>Number of repeat cycles for Free Run.</b> These two contiguous bytes combined (joined) contain the number of repeat cycles as a 16-bit integer ranging from 0 to 65,000. Above 65,000 (65,001 to 65,535), Free Run is set up for Continuous operation (i.e., infinite repeat cycles).
		19/(20)	(Lower Byte) 0 - 255 00 - FF 00000000 - 11111111	
11	<b>Terminator</b> (1 byte)	20/(21)	13 0D 00001101	<b>Terminator:</b> ASCII CR (Carriage Return) used to indicate the end of the status data.

#### 8.4.2 All Motors Power On

This command is used to instruct the controller to switch ON electrical power to the SmartShutter's motor.

#### 8.4.3 All Motors Power Off

This command is used to instruct the controller to switch OFF electrical power to the SmartShutter's motor.

#### 8.4.4 Transfer to On Line

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

#### 8.4.5 Set Delay Timer

Sets the time to when the shutter opens.

#### 8.4.6 Set Exposure Timer

Sets the time to how long the shutter remains in the opened state.

#### 8.4.7 More Information on Timers:

The Set Delay Timer and Set Exposure Timer commands both have their times expressed in terms of hours (0 – 5), minutes (0 – 59), seconds (0 – 59), and milliseconds (0 – 999.9). The maximum time that can be specified is 5 hours (exactly 5:00:00:000.0), or 4:59:59:999.9 + 0:00:00:000.1. Each timer command makes use of multiple bytes, and the byte format is the same for both. The time specified for a timer is encoded in such a way to minimize the number of bytes required for the entire command. The following table shows how time is encoded on both timer commands:

Table 8-6. Timer command time encoding

Byte Num.	Byte Value (Decimal, hexadecimal, & binary)	Upper & Lower Nibble Values (Decimal, hexadecimal, & binary)	Description
1 <sup>st</sup>	250 FA 1111 1010	(Not relevant)	Lambda SC Special Command.
2 <sup>nd</sup>	10 – 15, 20 – 25 0001 0000 – 0001 0101. 0010 0000 – 0010 0101	1 - 2 1 - 2 0001 - 0010	1 = Set Delay Timer 2 = Set Exposure Timer
		0 – 5 0 – 5 0000 - 0101	Hours (0 through 5) *
3 <sup>rd</sup>	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant)	Minutes (0 through 59)
4 <sup>th</sup>	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant)	Seconds (0 through 59)
5 <sup>th</sup>	0 – 9, 16 – 25, 32 – 41, 48 – 57, 64 – 73, 80 – 89, 96 – 105, 112 – 121, 128 – 137, 144 – 153. 00 – 09, 10 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, 80 – 89, 90 - 99 0000 0000 – 0000 1001, 0001 0000 – 0001 1001 0010 0000 – 0010 1001, 0011 0000 – 0011 1001 0100 0000 – 0100 1001, 0101 0000 – 0101 1001 0110 0000 – 0110 1001, 0111 0000 – 0111 1001 1000 0000 – 1000 1001, 1001 0000 – 1001 1001	0 – 9 0 – 9 0000 - 1001	Milliseconds: 100s digit (0 through 9)
		0 – 9 0 – 9 0000 - 1001	Milliseconds: 10s digit (0 through 9)
6 <sup>th</sup>	0 – 9, 16 – 25, 32 – 41, 48 – 57, 64 – 73, 80 – 89, 96 – 105, 112 – 121, 128 – 137, 144 – 153. 00 – 09, 10 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, 80 – 89, 90 - 99 0000 0000 – 0000 1001, 0001 0000 – 0001 1001 0010 0000 – 0010 1001, 0011 0000 – 0011 1001 0100 0000 – 0100 1001, 0101 0000 – 0101 1001 0110 0000 – 0110 1001, 0111 0000 – 0111 1001 1000 0000 – 1000 1001, 1001 0000 – 1001 1001	0 – 9 0 – 9 0000 - 1001	Milliseconds: 1s digit (0 through 9)
		0 – 9 0 – 9 0000 - 1001	Milliseconds: 0.1s digit (0 through 9)

\* NOTE: If hours are set to 5, then all other time fields must be set to zero. In other words, 5 hrs. 0 min. 0 sec. 0.0 ms is the maximum time for the timer commands (or 4 hrs., 59 min., 59 sec., 999.9 ms PLUS 0.1 ms).



#### **8.4.8 TTL IN Pulse Trigger Disabled**

Disables the use of TTL IN for controlling the state of the shutter.

#### **8.4.9 TTL IN High Triggers SmartShutter to Open**

When the signal coming in on TTL IN goes high, the shutter opens. Once the signal goes low again, the shutter closes (the low signal keeps the shutter closed, and the high signal keeps the shutter open).

#### **8.4.10 TTL IN Low Triggers SmartShutter to Open**

When the signal coming in on TTL IN goes low, the shutter opens. Once the signal goes high again, the shutter closes (the high signal keeps the shutter closed, and the low signal keeps the shutter open).

#### **8.4.11 TTL IN Rising Edge Triggers SmartShutter to Toggle**

On the rising edge of the signal coming in on TTL IN, the shutter opens if closed or closes if open (toggles its state).

#### **8.4.12 TTL IN Falling Edge Triggers SmartShutter to Toggle**

On the falling edge of the signal coming in on TTL IN, the shutter opens if closed or closes if open (toggles its state).

#### **8.4.13 TTL OUT Synch Signal Disabled**

Disables the synchronization signal on TTL OUT.

#### **8.4.14 Opening Shutter Sets TTL OUT to High**

When the shutter goes to the open state, the synchronization signal on TTL OUT goes high.

#### **8.4.15 Opening Shutter Sets TTL OUT to Low**

When the shutter goes to the open state, the synchronization signal on TTL OUT goes low.

#### **8.4.16 Restore Controller to the Factory-Default Configuration**

Causes the current configuration to revert to that of the factory default (i.e., the configuration the controller had when it shipped).

#### **8.4.17 Saves the Current Configuration to the Controller**

Causes the current configuration to be saved to the controller. The next time the controller is powered up or is reset, the last saved configuration will be used.

#### **8.4.18 Set Number of Repeat Cycles for Free Run**

Sets the number of repeat cycles for the Free Run feature. The 3<sup>rd</sup> and 4<sup>th</sup> bytes of the command stream contain the number of repeat cycles. Both bytes should be treated as a single 16-bit integer. The number of repeat cycles ranges from 0 to 65,000. Any number above 65,000 (65,001 to 65,535) sets up the Free Run for **Continuous** operation (i.e., infinite repeat cycles).

#### 8.4.19 Start Free Run on Power Up

Configures Free Run to start immediately after the controller powers up. The number of repeat cycles does not need to be set beforehand.

#### 8.4.20 Start Free Run on Trigger Pulse from TTL IN

Configures Free Run to start immediately upon receiving a trigger pulse on TTL IN. The number of repeat cycles **must** be set beforehand.

#### 8.4.21 Start Free Run Immediately

Starts the Free Run immediately on receiving this command. The number of repeat cycles **must** be set beforehand.

#### 8.4.22 Reset (to Last Saved Configuration)

Causes the Lambda SC 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.

#### 8.4.23 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 8-7. "Get Controller Type and Configuration" command return codes and data

Total num. bytes	Category	Byte Offset	Length	Value (Decimal, hexadecimal, & binary)	ASCII Char. Seq.	Possible Values
14	Command echo back	0	1	253 <sub>10</sub> , FD <sub>16</sub> , 11111101 <sub>2</sub>	ý	"Get Controller Type & Config." command echoed back. *
	Controller Type and firmware version	1	8		SC-vV.SS	Lambda SC, with firmware version V and subversion SS (e.g., "SC-v1.05").
	Shutter Type	7	4		S-IQ	SmartShutter
	Command return data terminator	13	1	13 <sub>10</sub> , 0D <sub>16</sub> , 00001101 <sub>2</sub>	<CR>	ASCII CR (carriage return).

**\*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 "Batch Transfer of Commands" and batch-related commands are not supported in the Lambda SC controller.

## 8.5 Shutter Control without Remote Control Commands via the Dedicated TTL Line

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

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

## 8.6 *SmartShutter* Movement Errors: Causes and Solutions

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

### 8.6.1 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 40 Hz, which normally provides solid operation.

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

It is possible, then, to experience movement errors after changing only the delay interval between moves. If you are making moves with a short delay interval and errors are produced, it might be desirable to adjust the interval to obtain the most secure result. Experiment with small changes in the delay to find the best value and then keep the delay at that value. If you do see errors in movement, try using a long time interval (1 second) between moves to test whether the length of the interval is contributing to the error rate.

## 8.7 Remote Control Command Programming

This section describes some suggested tips and techniques when writing programs on the remote control computer for the purpose of communicating with the Lambda SC via either the serial RS-232 port or the USB (Universal Serial Bus) port. The following paragraphs and the code examples deal with remote control command programming in a general manner,

abstracted from telecommunications medium. The discussions and examples are applicable to either the serial RS-232 port or the USB port. The programming specifics for either the serial or USB ports are covered in the respective chapters, following this chapter. The discussions and examples are also relatively platform independent. The code samples written in the C programming language, for example, are written in a fairly 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.

### 8.7.1 Preparing the Command Byte

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

```
unsigned char command_byte;
```

...where “command\_byte” is the name, the programmer chooses to give the variable.

### 8.7.2 Command Transmission Protocol

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

#### 8.7.2.1 Confirmation Command Echo

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

#### 8.7.2.2 Command Completion Indicator

When the Lambda SC 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”).

## 9. EXTERNAL COMMAND CONTROL: SERIAL PORT

The Lambda SC microprocessor sets the serial RS-232C port, by default, as the input source upon startup. An appropriate command from the remote computer through the serial port will automatically set that port as the active input source and the display on the controller will reflect that change on its bottom line. The serial port will remain active until an appropriate command is sent from a remote computer through the USB port. There are, obviously, some basic differences in the physical connections and the modes by which serial and USB data are transmitted to the controller. The command code and return code structures are, however, for the most part, the same. The connection and command structure required to control the Lambda SC via the Serial port are discussed in this chapter.

**NOTE: The RS-232 serial port is absent on early versions of the Lambda SC controller. If you have a version of the Lambda SC that does not have the serial port, and you would like to have it added, please contact Sutter Instrument Co. to arrange for an upgrade.**

### 9.1 Connecting to the Serial Port

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

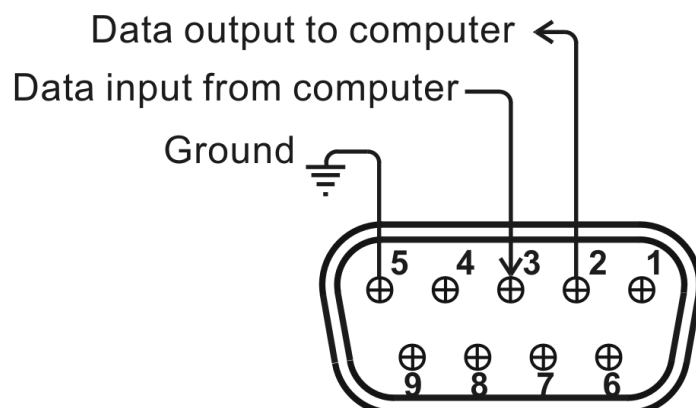


Figure 9-1. Serial port pin assignments

Communication for the serial port requires the following settings:

- Baud rate            9600
- Data bits            8
- Parity                none
- Stop bits            1
- Flow Control:      none

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

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

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

## 9.2 Input Command Set and Protocol

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

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

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

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

## 10. EXTERNAL COMMAND CONTROL: USB PORT

Controlling the Lambda SC externally via computer is accomplished by sending commands between the computer and the equivalent connector on the rear of the controller.

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

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

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

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

Table 10-1. USB interface serial port settings.

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

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

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

1. Ver. 1.06.02 is for use with Windows 98, 98 SE, ME, and 2000 and 32-bit edition only of Windows releases after that. This version supports only the direct D2XX mode of operation VCP (Virtual COM Port) mode is not supported).
2. Ver. 2.06.00 is for use with Windows 2000 and 32-bit and 64-bit editions of Windows released after that. This version is a Combined Driver Model (CDM) that can be installed for either direct D2XX or VCP (Virtual COM Port) modes of operation. Following the

section on installing the standard device driver (next), is the section that describes downloading and installing the CDM device driver.

3. Ver. 2.10.00 supports Windows XP on up.
4. Ver. 2.12.24 supports Windows 7 on up.

## 10.1 Installation Steps

To install the Lambda SC as a USB device on a remote computer, follow these steps.

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

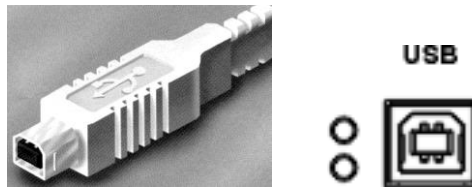


Figure 10-1. The USB cable device connector and device USB receptacle.

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

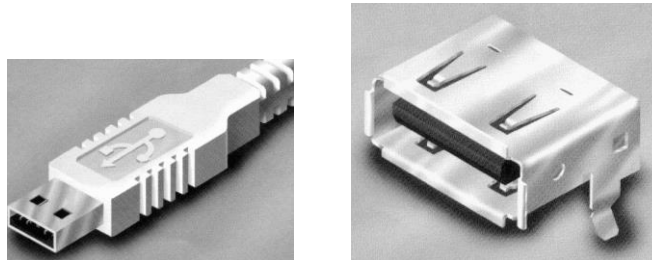


Figure 10-2. Host connector end of USB cable and USB host receptacle on remote computer.

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

## 10.2 Installing the Lambda SC as a USB Device on a Windows System using the Standard Device Driver

The Lambda SC can be used as a USB device running one of the following versions of Microsoft Windows: Windows Interactive USB Device Driver Installation



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

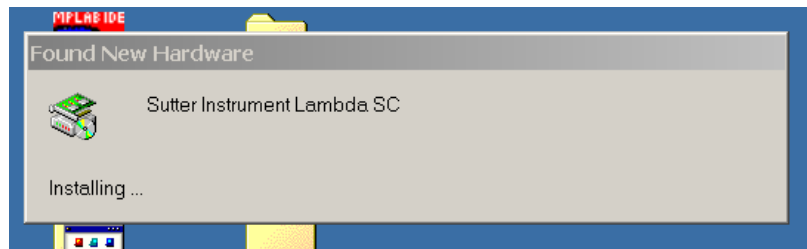


Figure 10-3. New-USB device detected message box.

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

If the Lambda SC USB device drivers have already been installed on this computer, then Windows will usually find them and automatically reactivate them. If the drivers had been previously installed and then removed (uninstalled), it is possible that Windows is still able to locate the drivers and automatically reinstall them. Windows may also automatically install the appropriate drivers if another Sutter Instrument Company instrument with a USB interface (such as a Lambda 10-B, a Lambda 10-3, an MPC-200, or even another Lambda SC) is already connected and configured with your computer. If this is the first time the Lambda SC USB device drivers are being installed, it is then quite likely that Windows will display the dialog box shown in the following figure.

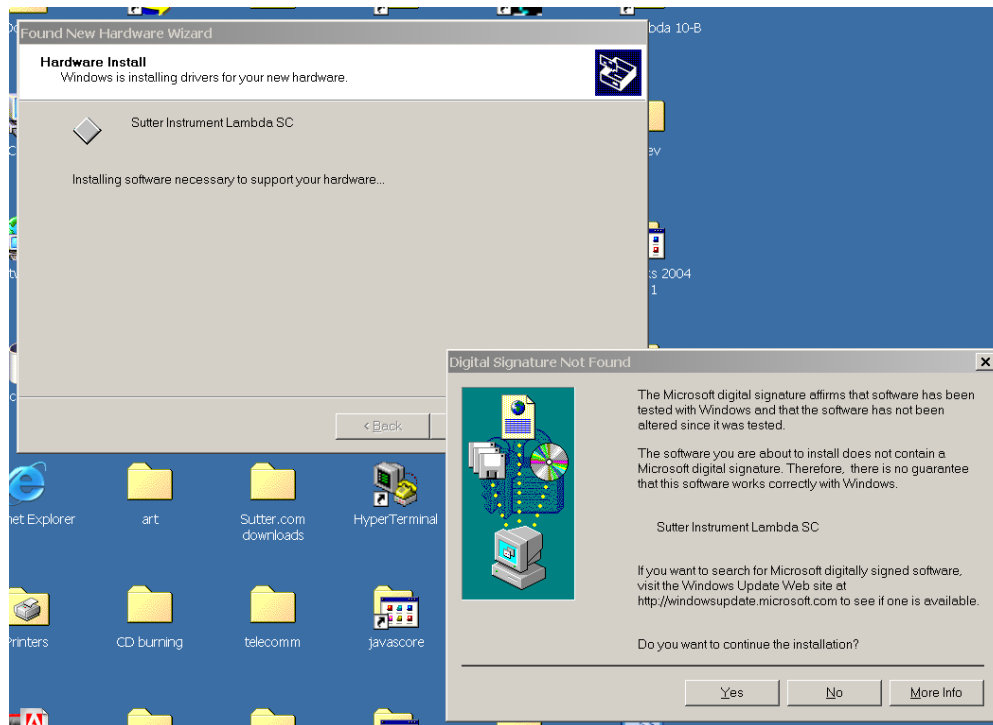


Figure 10-4. Digital Signature dialog box.

Do not be concerned that Windows is unable to find a Microsoft digital signature for the Lambda SC as shown in 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 SC USB device drivers.

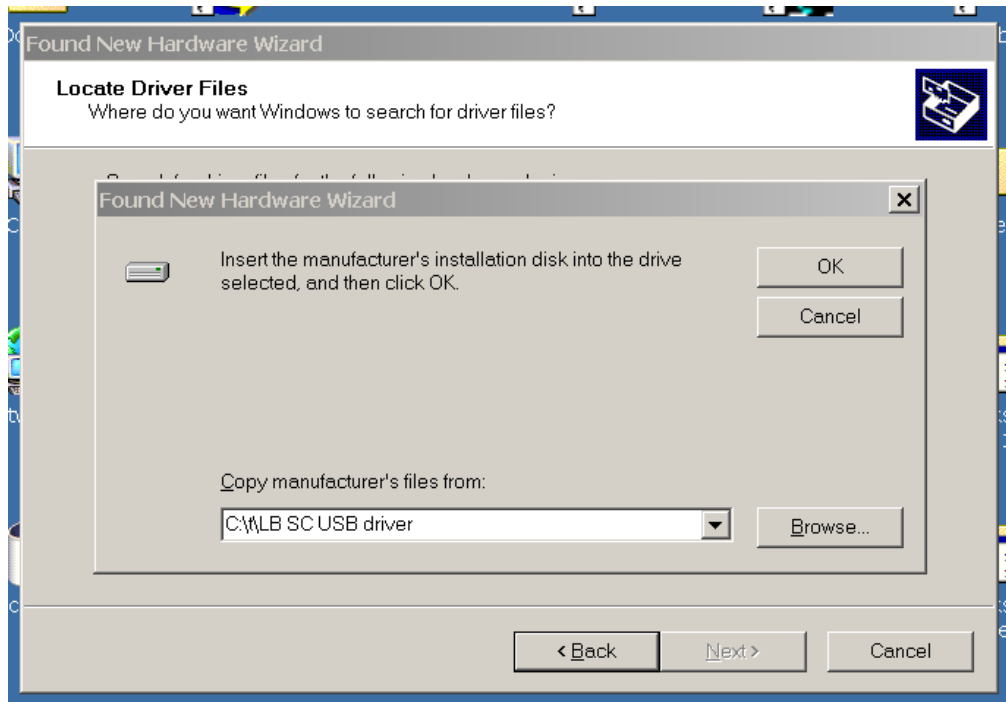


Figure 10-5. Specifying location of driver files.

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 SC 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. 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. Alternatively, clicking the Browse button displays another dialog that allows you to navigate through your system’s drives and folders for the location containing the needed Lambda SC 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.

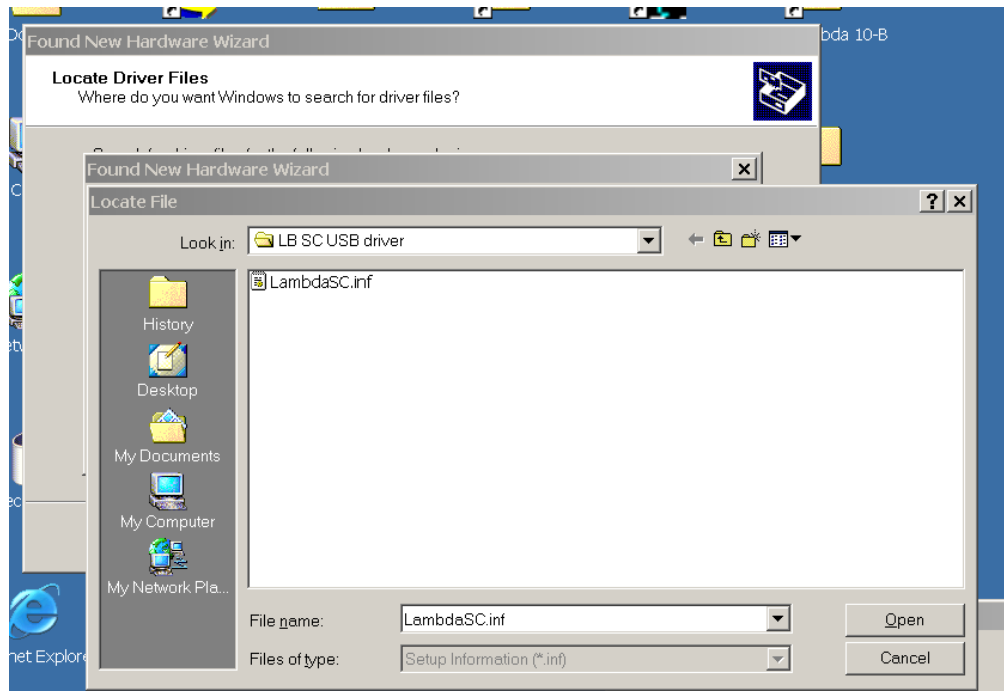


Figure 10-6. Browsing for the driver file needed.

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

This completes the description for installing the Lambda SC as a USB device connected to a Windows system.

### 10.3 Installing the Lambda SC as a USB Device on a Windows System using CDM (Combined Driver Model) Device Driver

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

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

To install the CDM device driver for the Lambda SC, first download the device driver and installation instructions from the following links:

[http://www.sutter.com/SOFTWARE/SI\\_CDM\\_vx\\_xx\\_xx.zip](http://www.sutter.com/SOFTWARE/SI_CDM_vx_xx_xx.zip)

and the installation instructions at

[http://www.sutter.com/SOFTWARE/CDM\\_driver\\_Install\\_Guide.pdf](http://www.sutter.com/SOFTWARE/CDM_driver_Install_Guide.pdf)

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

## 10.4 Installing the USB interface for non-Windows systems

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

1. Linux drivers and tools:

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

2. Apple Macintosh drivers, tools, and information:

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

## 10.5 Verifying USB Communication between Remote Computer and Lambda SC

Once the Lambda SC 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 SC 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 SC as a USB device. The USBTest program is provided on a 3.5-inch HD floppy diskette or CD-ROM, shipped with the Lambda SC or it can be downloaded from Sutter Instrument Co.’s web site ([www.sutter.com](http://www.sutter.com)). The files that make up the distribution of the USBTest program include the Setup program. Simply run this setup program to install USBTest on your system (Windows-based systems only).

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

[https://www.sutter.com/SOFTWARE/Lambda\\_Test.zip](https://www.sutter.com/SOFTWARE/Lambda_Test.zip)

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

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

## 10.6 Uninstalling the USB Driver for the Lambda SC

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

1. Open the *Control Panel* (click on *Start* to bring up the main Windows menu, then click on *Settings*, and then *Control Panel* in the submenu).

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

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

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

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

## 10.7 Remote Commands and the USB Interface

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

## 10.8 Command Sequence Formatting and Protocol:

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

### **10.8.1 Confirmation Command Echo**

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

### **10.8.2 Command Completion Indicator**

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

## 11. EXTERNAL COMMAND CONTROL: LOGIC LEVEL (TTL) INPUT FOR SHUTTER CONTROL

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

### 11.1 TTL IN Modes

The SmartShutter connected to the Lambda SC can be controlled via a signaling or switch device attached to TTL IN in the following ways. In all cases, refer to the table of commands in the Remote Control chapter for the specific command byte values needed to enable each mode or to disable TTL IN control.

#### 11.1.1 Trigger on High

Signal on TTL IN is normally low, which keeps shutter closed. When TTL IN goes high, shutter opens, and stays open until TTL IN goes low again.

#### 11.1.2 Trigger on Low

Signal on TTL IN is normally high, which keeps shutter closed. When TTL IN goes low, shutter opens, and stays open until TTL IN goes high again.

#### 11.1.3 Toggle on Rising Edge

Trigger shutter to toggle (open if closed, close if opened) on TTL IN rising edge.

#### 11.1.4 Toggle on Falling Edge

Trigger shutter to toggle (open if closed, close if opened) on TTL IN falling edge.

#### 11.1.5 Triggering the Start of a Free Run of Timer Cycles

The Lambda SC can be configured to start the Free Run of configured timers for a preset number of cycles by triggering on high on TTL IN.

#### 11.1.6 Disabling Triggering/Toggling Control

The Lambda SC can be configured so that signaling on TTL IN is ignored.

### 11.2 Using the PC's Parallel Port for Shutter Control

The parallel port has been used extensively for control of shutters through logic level signals. The output available at Pin 14 of the 25-pin parallel port is usually employed. Pin 14 corresponds to the bit that encodes the value 2. 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 0.

Table 11-1. Commands for PC parallel port control of SmartShutter via TTL IN

	<b>PC Parallel Port Pin 14</b>	
<b>Byte value</b>	0	2
<b>TTL level</b>	High	Low



## 12. PAIRED SHUTTERS FOR SHORT EXPOSURE TIMES

The coordinated movement of two shutters in series in the optical path can be configured to produce shorter exposure times than is possible with a single shutter. A single shutter will require about 8 msec with the shutter completely open before the shutter blade can start covering the aperture. With two shutters in series this limitation can be eliminated. Starting with one shutter open and one shutter closed, the exposure begins by opening the closed shutter. The exposure ends when the shutter that was originally open closes. The exposure time is determined by the delay between the start of the first shutter's opening movement and the second shutter's closing movement so long as the time to open and the time to close are essentially the same. With a reduced aperture, such as 3 mm, it takes less than 1 msec to go from closed to open or from open to closed. There is a delay of about 5 msec between the TTL signal and the shutter state.

If the sequence is controlled by direct commands or separate TTL signals, the timing is under the user's control. If the user cannot produce the direct commands or the TTL signals required, the Lambda SC can be adapted to work with a single TTL signal. One of the controllers is set to open on TTL high, which is the default mode of operation. The second Lambda SC controller can then be programmed to produce a closing move on the falling edge of the TTL command signal followed automatically by a move to reopen the second shutter. The result with a reduced aperture, such as 3 mm, is a shutter open time that is essentially the same as the TTL pulse duration, but delayed by about 5 msec.

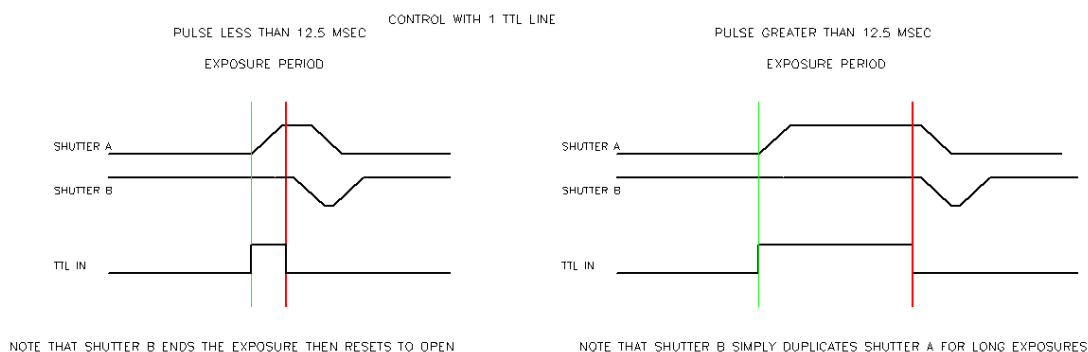


Figure 12-1. Two-shutter configuration showing exposure times

For long exposure times the second shutter simply closes at the same time as the first shutter and then reopens, so it is not required. At exposure times less than about 12.5 msec the second shutter will begin to close as soon as the TTL line goes low. The first shutter cannot begin to close until about 12.5 msec after the time the TTL signal went high, so if the TTL signal goes low in less than 12.5 msec after going high, the second shutter will respond immediately while the first shutter will not close until the 12.5 msec period is over. In other words, while the paired shutters are capable of producing a very short exposure duration in the sub-millisecond range, the paired shutters cannot produce high repetition rates because the normally open shutter must have time to reset itself back to the open state before the next exposure. The time it takes to reset should be on the order of approximately 21-24 Ms, so the system cannot respond to a second trigger pulse in less than 21-24 Ms from the falling edge of the preceding pulse.

In order to configure two Lambda SC controllers for this mode of operation, one controller is operated in the default mode, which is open on TTL high. The second controller is

programmed to be normally open at power on and to trigger on the falling edge of the TTL signal. This can be done using the Lambda SC utility.

## 13. MAINTENANCE

Routine cleaning of the Lambda SC system is required to prevent excessive dust accumulations – wipe all exterior surfaces with a dry, soft, cotton cloth.

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

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

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## APPENDIX A. LIMITED WARRANTY

Sutter Instrument Company, a division of Sutter Instrument Corporation, limits the warranty on this instrument to repair and replacement of defective components for one year after the 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.

Limited warranty work will be performed only at the factory.

The cost of shipment both ways is to be borne by the user.

The limited warranty is as stated above and no implied or inferred liability for direct or consequential damages is intended.

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

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## APPENDIX B. ACCESSORIES

### B.1. SmartShutter

<b>IQ12-SA</b>	12.5mm SmartShutter with standalone housing.
<b>IQ12-AN</b>	12.5mm hard anodized SmartShutter.
<b>IQ25-SA<sup>1</sup></b>	25mm SmartShutter with standalone housing.
<b>IQ25-W<sup>2</sup></b>	25mm SmartShutter with housing to fit a 25mm filter wheel.
<b>IQ25-WU<sup>2</sup></b>	25mm SmartShutter to retrofit non-shuttered filter wheel.
<b>IQ25-LS</b>	25mm SmartShutter with housing designed for installation into a Lambda LS system.
<b>IQ25-DG</b>	25mm SmartShutter with housing designed for installation into a Lambda DG-4 or DG-5 system.
<b>IQ35-W</b>	35mm SmartShutter with housing to fit 32mm filter wheel.
<b>IQ35-SA</b>	35mm SmartShutter with standalone housing.
<b>IQ50-SA</b>	50mm SmartShutter with standalone housing.

<sup>1</sup> If vignetting is an issue, a 35mm shutter is recommended instead.

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

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

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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 C-2. To remove the spare fuse, press down on the end of the compartment to push it out of the other end. The old fuse can serve as a convenient tool for pushing the spare fuse compartment out. Replace the active fuse with the spare and re-install the fuse holder and power cord. If the controller fails to power up with the new fuse installed, call Sutter Instrument technical support personnel for assistance.

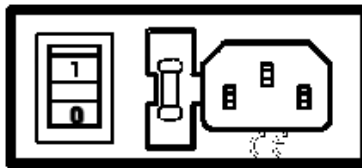


Figure C-1. Power entry module

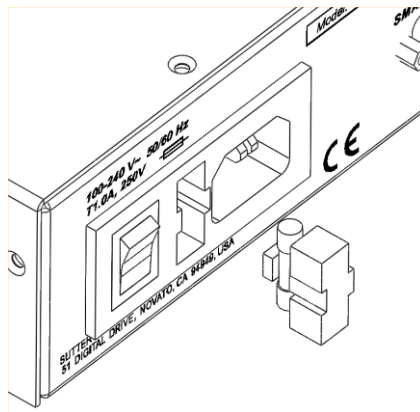


Figure C-2. Fuse holder



The type and rating of both fuses are as follows:

**5 x 20 mm glass tube, IEC 60127-2, Sheet III,  
T1.0A, 250V (219XA Series)  
(use only Littelfuse 0219001.XAP (219XA Series))**

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## APPENDIX D. TECHNICAL SPECIFICATIONS



### Dimensions (H x W x D):

**Controller** 5.38" x 5.86" x 8.25"  
13.67 cm x 14.88 cm x 20.96 cm

#### 25 mm (1") *SmartShutter*:

**Height (from motor top to shutter bottom):** 3.88" H  
9.86 cm H

#### **Width and depth:**

**Motor end (top):** 1.06" W x 1.88" D  
2.69 cm W x 4.78 cm D

**Shutter end (bottom):** 2.88" W x 0.66" D  
7.32 cm W x 1.68 cm D

#### 35 mm (1.38") *SmartShutter*:

**Height (from motor top to shutter bottom):** 4.25" H  
10.80 cm

#### **Width and depth:**

**Motor end (top):** 1.38" W x 2.31" D  
3.51 cm W 5.87 cm D

**Shutter end (bottom):** 3.13" W x 0.88" D  
7.95 cm W x 2.24 cm D

### Weight:

**Controller** 2.55 lb. (2 lb., 9 oz.)  
1.16 kg.

**25 mm *SmartShutter*:** 0.6 lb. (9.6 oz)  
0.27 kg

35 mm *SmartShutter*.0.75 lb. (12 oz)  
0.34 kg**Electrical:****Input voltage (Mains)**115 V, 60 Hz  
230 V, 50 Hz**Power cord**

10A, 250V, with safety ground plug

Table D-1. Lambda SC controller cables

	Connector Type	Cable Type	Cable Max. Length
<b>SmartShutter</b>	DB-9 male to DB-9 female	Minimum of 26 awg stranded wire with 500 Volt. Two ferrites are attached, one at each end.	10 feet (approx. 3 meters)
<b>Serial</b>	DB-9 female to DB-9 male	Connected to metal faceplates of connectors on both ends. One ferrite is attached at one end.	
<b>USB</b>	A to B	Dielectric separation of circuits. Foil shielding.	

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

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

Stepping motors are also made with multiple poles on both the rotor and stator; the exact arrangement determines the number of steps per revolution. The motor used in the **LAMBDA SC** 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. There are some limitations that 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. MOUNTING A *SMART*SHUTTER IN A LAMBDA LS

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

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

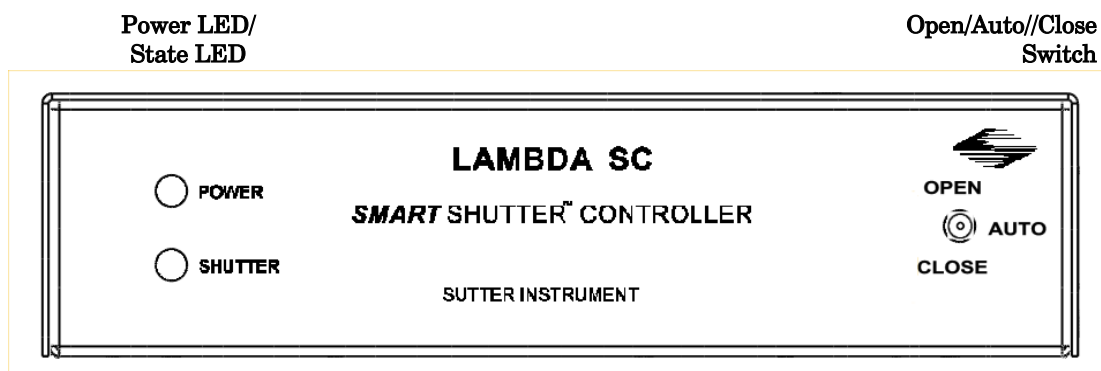
Since the Lambda LS does not have any inherent capability of controlling the *SmartShutter*, an externally positioned Lambda SC (or another Lambda model capable of controlling a *SmartShutter*) can be used to control the *SmartShutter*.

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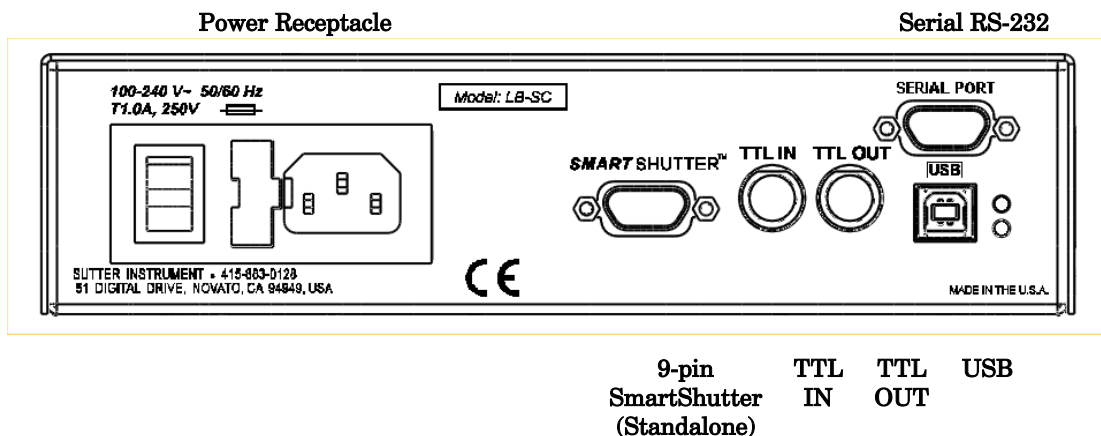


## APPENDIX G. EXTERNAL CONTROL COMMAND REFERENCE

### Manual Operation



### Configuration



### External Control

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

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

**The USB Interface:** Controlling the externally via computer is accomplished by sending commands over the USB interface between the computer and the USB connector on the rear panel of the Lambda SC. The USB device driver for Windows is downloadable from Sutter Instrument’s web site ([www.sutter.com](http://www.sutter.com)). The device requires USB CDM (Combined Driver

Model) Version 2.10.00 or higher. The CDM device driver consists of two device drivers: 1) USB device driver, and 2) VCP (Virtual COM Port) device driver. Install the USB device driver first, followed by the VCP device driver. The VCP device driver provides a serial RS-232 I/O interface between a Windows application and the device. Although the VCP device driver is optional, its installation is recommended even if it is not going to be used. Once installed, the VCP can be enabled or disabled.

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

it be disabled. The second method requires that the VCP be installed and enabled.

**Virtual COM Port (VCP) Serial Port Settings:**

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

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

Table G-1. Serial and USB- interface serial port settings.

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

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

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

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

that describes downloading and installing the CDM device driver.

3. Ver. 2.10.00 supports Windows XP on up.
4. Ver. 2.12.24 supports Windows 7 on up.

**Command Sequence Formatting and Protocol:**

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

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

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

**Command Reference:** The following table lists all the external-control commands for the Lambda SC.

Table G-2. Complete Lambda SC external-control command reference

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
Open Shutter A	Tx	All	1	0	170	AA	1010 1010	0170			Sets the state of Shutter A to open
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Close Shutter A	Tx	All	1	0	172	AC	1010 1100	0172			Sets the state of Shutter A closed.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Stop the Free Run	Tx	All	1	0	191	BF	1011 1111	0191			Stops the Free Run if it is currently running.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Status	Tx	All	1	0	204	CC	1100 1100	0204			Returns status of unit (see status table)
	Rx	All		13	13	0D	0000 1101		^M	<CR>	Completion indicator
All Motors Power On	Tx	All	1	0	206	CE	1100 1110	0206			Instruct the controller to power on all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
All Motors Power Off	Tx	All	1	0	207	CF	1100 1111	0207			Instruct the controller to power off all motors.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Fast-mode Shutter	Tx	All	1	0	220	DC	1101 1100	0220			Sets fast mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Soft-mode Shutter	Tx	All	1	0	221	DD	1110 1101	0221			Sets soft mode
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Neutral Density-mode Shutter	Tx	All	2	0	222	DE	1110 1110	0222			Sets neutral-density mode
				1	1	01	0000 0001	0001			2 <sup>nd</sup> byte contains 1 - 144 indicating microsteps
				144	90	1001 0000	0144				
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Transfer to On Line	Tx	All	1	0	238	EE	1110 1110	0238			Puts controller on-line
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Set Delay Timer	Tx	All	6	0	250	FA	1111 1010	0250			Sets time to when shutter opens (0 - 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond).
				1	16	10	0001 xxxx			Upper Nibble: <b>Set Delay Timer</b>	
					-	-	xxxx 0000			Lower Nibble: Hours (0 - 5).	
				21	15	xxxx 0005					
2	0	00	0000 0000			Minutes (0 - 59)					

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
					-	-	0011 1011				
				3	0	00	0000 0000				Seconds (0 – 59)
					-	-	0011 1011				
				4	0	00	0000 xxxx				Upper Nibble: 100s digit (0-9) for milliseconds
					-	-	0009 xxxx				
					153	99	xxxx 0000				Lower Nibble: 10s digit (0-9) for milliseconds
					-	-	xxxx 0009				
				5	0	00	0000 xxxx				Upper Nibble: 1s digit (0-9) for milliseconds
					-	-	0009 xxxx				
					153	99	xxxx 0000				Lower Nibble: 0.1s digit (0-9) for milliseconds
					-	-	xxxx 0009				
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>Set Exposure Timer</b>	<b>Tx</b>	All	6	0	250	FA	1111 1010	0250			Sets time to when shutter remains open (0 - 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond).
				1	16	10	0002 xxxx				Upper Nibble: <b>Set Exposure Timer</b>
					-	-	xxxx 0000				Lower Nibble: Hours (0 - 5).
					21	15	xxxx 0005				
				2	0	00	0000 0000				Minutes (0 – 59)
					-	-	0011 1011				
				3	0	00	0000 0000				Seconds (0 – 59)
					-	-	0011 1011				
				4	0	00	0000 xxxx				Upper Nibble: 100s digit (0-9) for milliseconds
					-	-	0009 xxxx				
					153	99	xxxx 0000				Lower Nibble: 10s digit (0-9) for milliseconds
					-	-	xxxx 0009				
				5	0	00	0000 xxxx				Upper Nibble: 1s digit (0-9) for milliseconds
					-	-	0009 xxxx				
					153	99	xxxx 0000				Lower Nibble: 0.1s digit (0-9) for milliseconds
					-	-	xxxx 0009				
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>TTL IN Pulse Trigger Disabled</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Disable TTL IN shutter triggering.
				1	160	A0	1010 0000	0160			
	<b>Rx</b>	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
<b>TTL IN High</b>	<b>Tx</b>	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is

Command	Tx/ Delay/ Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
Triggers SmartShutter to Open				1	161	A1	1010 0001	0161			normally low, which keeps shutter closed. When TTL IN goes high, shutter opens, and stays open until TTL IN goes low again.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Low Triggers SmartShutter to Open	Tx	All	2	0	250	FA	1111 1010	0250			Signal on TTL IN is normally high, which keeps shutter closed. When TTL IN goes low, shutter opens, and stays open until TTL IN goes high again.
				1	162	A2	1010 0010	0162			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Rising Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN rising edge.
				1	163	A3	1010 0011	0163			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close	Tx	All	2	0	250	FA	1111 1010	0250			Trigger shutter to toggle (open if closed, close if opened) on TTL IN falling edge.
				1	164	A4	1010 0100	0164			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
TTL OUT Disabled	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	176	B0	1011 0000	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to High	Tx	All	2	0	250	FA	1111 1010	0250			Disables TTL OUT shutter open synch signal.
				1	177	B1	1011 0001	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Opening Shutter Sets TTL OUT to Low	Tx	All	2	0	250	FA	1111 1010	0250			When shutter opens, TTL OUT is set to low.
				1	178	B2	1011 0010	0176			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Restore Controller to the Factory- Default Configuration	Tx	All	2	0	250	FA	1111 1010	0250			Changes the controller's configuration to that of the factory default.
				1	192	C0	1100 0000	0192			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Save the Current Configuration to the Controller	Tx	All	2	0	250	FA	1111 1010	0250			Saves the current configuration to the controller. This saved configuration will be used next time the controller is
				1	193	C1	1100 0001	0193			

Command	Tx/ Delay- Rx	Ver.	Total Bytes	Byte Offset (Len.)	Value			Alt- key- pad #	Ctrl- char	ASCII def./- char.	Description
					Dec.	Hex.	Binary				
											powered up or is reset.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Set Number of Repeat Cycles for Free Run	Tx	All	4	0	250	FA	1111 1010	0250			Sets the number of repeat cycles for the Free Run feature. 3 <sup>rd</sup> and 4 <sup>th</sup> bytes contain the number of repeat cycles as a 16-bit integer ranging from 0 to 65,000. Any number above 65,000 (65,001 to 65,535) sets up the Free Run for Continuous operation (i.e., infinite repeat cycles).
				1	240	F0	1111 0000	0240			
				2-3	0	0000	0000 0000 0000 0000				
				-	-	-	-				
				65000	FDE8	1111 1101 1110 1000					
				or	or	or					
				65001	FDE9	1111 1101 1110 1001					
-	-	-									
				65535	FFFF	1111 1111 1111 1111					
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Start Free Run on Power Up	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after the controller powers up. The number of repeat cycles does not need to be set beforehand.
				1	241	F1	1111 0001	0241			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Start Free Run on Trigger Pulse from TTL IN	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately after trigger pulse is received on TTL IN. The number of repeat cycles must be set beforehand.
				1	242	F2	1111 0010	0242			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Start Free Run immediately	Tx	All	2	0	250	FA	1111 1010	0250			Starts the Free Run immediately on receiving this command. The number of repeat cycles must be set beforehand.
				1	243	F3	1111 0011	0243			
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Reset Controller to the Last Saved Configuration	Tx	All	1	0	251	FB	11111011	0253			Resets the controller and sets the configuration to the one that was last saved.
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator
Get Controller Type and Configuration	Tx	All	1	0	253	FD	11111101	0253			Queries the controller as to its type and configuration (see controller type & config. table)
	Rx	All	1	0	13	0D	0000 1101			<CR>	Completion indicator

**NOTE:** The “TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close” command exists in versions of the Lambda SC programmed with Version 1.08 or later of the firmware. Before attempting to use this

command, it is strongly advised that the version of the firmware with which the connected Lambda SC is programmed is first checked by issuing the “Get Controller Type and Configuration” command.

Table G-3. Timer command time encoding.

Byte Num.	Byte Value (Decimal, hexadecimal, & binary)	Upper & Lower Nibble Values (Decimal, hexadecimal, & binary)	Description
1 <sup>st</sup>	250 FA 1111 1010	(Not relevant)	Lambda SC Special Command.
2 <sup>nd</sup>	10 – 15, 20 – 25 0001 0000 – 0001 0101. 0010 0000 – 0010 0101	1 - 2 1 - 2 0001 - 0010	1 = Set Delay Timer 2 = Set Exposure Timer
		0 - 5 0 - 5 0000 - 0101	Hours (0 through 5) *
3 <sup>rd</sup>	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant)	Minutes (0 through 59)
4 <sup>th</sup>	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant)	Seconds (0 through 59)
5 <sup>th</sup>	0 – 9, 16 – 25, 32 – 41, 48 – 57, 64 – 73, 80 – 89, 96 – 105, 112 – 121, 128 – 137, 144 – 153. 00 – 09, 10 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, 80 – 89, 90 - 99 0000 0000 – 0000 1001, 0001 0000 – 0001 1001 0010 0000 – 0010 1001, 0011 0000 – 0011 1001 0100 0000 – 0100 1001, 0101 0000 – 0101 1001 0110 0000 – 0110 1001, 0111 0000 – 0111 1001 1000 0000 – 1000 1001, 1001 0000 – 1001 1001	0 – 9 0 – 9 0000 - 1001	Milliseconds: 100s digit (0 through 9)
		0 – 9 0 – 9 0000 - 1001	Milliseconds: 10s digit (0 through 9)
6 <sup>th</sup>	0 – 9, 16 – 25, 32 – 41, 48 – 57, 64 – 73, 80 – 89, 96 – 105, 112 – 121, 128 – 137, 144 – 153. 00 – 09, 10 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, 80 – 89, 90 - 99 0000 0000 – 0000 1001, 0001 0000 – 0001 1001 0010 0000 – 0010 1001, 0011 0000 – 0011 1001 0100 0000 – 0100 1001, 0101 0000 – 0101 1001 0110 0000 – 0110 1001, 0111 0000 – 0111 1001 1000 0000 – 1000 1001, 1001 0000 – 1001 1001	0 – 9 0 – 9 0000 - 1001	Milliseconds: 1s digit (0 through 9)
		0 – 9 0 – 9 0000 - 1001	Milliseconds: 0.1s digit (0 through 9)

**NOTE: If hours are set to 5, then all other time fields must be set to zero. In other words, 5 hrs. 0 min. 0 sec. 0.0 ms is the maximum time for the timer commands (or 4 hrs., 59 min., 59 sec., 999.9 ms PLUS 0.1 ms).**

Table G-4. Status command return codes and data.

Byte Offset	Label	Byte Value			Description	Bit Values	
		Dec.	Hex.	Binary		Dec./-Hex	Binary
0	Command echo	204	CC	11001100	The Status command byte code echoed back.		
1	Shutter open/closed state	170	AA	10101010	Open		
		172	AC	10101100	Closed		
2	SmartShutter mode (1 or 2 bytes)	219	DB	11011011	<b>Not Connected:</b> Indicates no SmartShutter is connected.		
		220	DC	11011100	Fast Mode		
		221	DD	10111011	Soft Mode		
		222	DE	10111100	Neutral Density Mode		
		<b>NOTE: From this point onwards in this table, byte numbers shown in parenthesis are true only if Shutter Mode (Byte 3) = Neutral Density (222 decimal (DE hexadecimal)).</b>					
(3)*	Neutral Density Microsteps	1 - 144	01 - 90	00000001 - 10010000	Number of microsteps (1 – 144) for neutral density mode. <b>Note that this byte is present (and at this position) in Status structure only if the Shutter Mode (Byte 3) contains the value for Neutral Density (222 decimal (DE hexadecimal)).</b>		
3/(4)	Lead-in byte for Lambda SC Special commands	250	FA	10100000	Lead-in byte for all Lambda SC-specific special commands (TTL IN, TTL OUT, Timers, and Free Run). This lead-in byte is expressed only once in the status return data structure, and this is where it occurs.		
4/(5)	TTL IN Setting	160	A0	10100000	<b>Disabled:</b> Trigger/toggle control of the shutter via TTL IN is turned off.		
		161	A1	10100001	<b>Trigger on High:</b> Shutter is normally closed; opens while high signal is present on TTL IN.		
		162	A2	10100010	<b>Trigger on Low:</b> Shutter is normally open; closes while high signal is not present on TTL IN.		
		163	A3	10100011	<b>Toggle on Rising Edge:</b> On the rising edge of TTL IN going high,		



Byte Offset	Label	Byte Value			Description	Bit Values	
		Dec.	Hex.	Binary		Dec./Hex	Binary
					shutter opens if closed and closes if open.		
		164	A4	10100100	<b>Toggle on Falling Edge:</b> On the falling edge of TTL IN going low, shutter closes if open and opens if closed.		
5/(6)	<b>TTL OUT Setting</b>	176	B0	10110000	<b>Disabled:</b> TTL OUT synch signal is disabled.		
		177	B1	10110001	<b>High on Shutter Open:</b> TTL OUT is set to high when shutter opens.		
		178	B2	10110010	<b>Low on Shutter Open:</b> TTL OUT is set to low when shutter opens.		
6/(7)	<b>Delay Timer</b> (Time to when shutter opens; 5 bytes) and <b>Hours</b>	0 or 1	0x or 1x	0000xxxx or 0001xxxx	<b>Enabled/Disabled (Upper Nibble):</b> If 0 (disabled), all five Delay Timer bytes can be ignored. If 1 (enabled), remaining five bytes (and respective nibbles where applicable) may contain values for hours, minutes, seconds, and milliseconds.		
		0 – 5	x0 – x5	xxxx0000 – xxxx0101	<b>Hours (Lower Nibble):</b> Hours (0 – 5).		
7/(8)	<b>Minutes</b>	0 – 59	00 – 38	00000000 – 00111011	<b>Minutes:</b> (0 – 59)		
8/(9)	<b>Seconds</b>	0 – 59	00 – 38	00000000 – 00111011	<b>Seconds:</b> (0 – 59)		
9/(10)	<b>Milliseconds 100s and 10s Digit</b>	0 – 9	0x – 9x	0000xxxx – 1001xxxx	<b>Milliseconds 100s Digit (Upper Nibble):</b> 0 – 9		
		0 – 9	x0 – x9	xxxx0000 – xxxx0000	<b>Milliseconds 10s Digit (Lower Nibble):</b> 0 – 9		
10/(11)	<b>Milliseconds 1s and 0.1s Digit</b>	0 – 9	0x – 9x	0000xxxx – 1001xxxx	<b>Milliseconds 1s Digit (Upper Nibble):</b> 0 – 9		
		0 – 9	x0 – x9	xxxx0000 – xxxx0000	<b>Milliseconds 0.1s Digit (Lower Nibble):</b> 0 – 9		
<*>							
4 or (5)*	Return data terminator	13	0D	00001101	ASCII CR (carriage return).		

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
1	<b>Command echo</b> (1 byte)	1	204 CC 11001100	The Status command byte code echoed back.
2	<b>Shutter Open/Closed State</b> (1 byte)	2	170 AA 10101010	<b>Open:</b> Shutter is in the opened state.
			172 AC 10101100	<b>Closed:</b> Shutter is in the closed state.
3	<b>Shutter Mode</b> (1 byte)	3	219 DB 11011011	<b>Not Connected:</b> Indicates that no SmartShutter is connected.
			220 DC 11011100	<b>Fast:</b> Indicates that the SmartShutter is in fast mode.
			221 DD 10111011	<b>Soft:</b> Indicates that the SmartShutter is in soft mode.
			222 DE 10111100	<b>Neutral Density:</b> Indicates that the SmartShutter is in neutral-density mode. A second byte follows with number of microsteps (1 – 144).
			<b>NOTE: From this point onwards in this table, byte numbers shown in parenthesis are true only if Shutter Mode (Byte 3) = Neutral Density (222 decimal (DE hexadecimal)).</b>	
4	<b>Neutral Density Microsteps</b> (1 byte)	(4)	1 – 144 01 – 90 00000001 - 10010000	<b>Neutral Density Microsteps:</b> Contains the number of microsteps (1 through 144) for the SmartShutter's neutral density mode. <b>Note that this byte is present (and at this position) in Status structure only if the Shutter Mode (Byte 3) contains the value for Neutral Density (222 decimal (DE hexadecimal)).</b>
5	<b>Lead-in byte for Lambda SC Special commands</b> (1 byte)	4/(5)	250 FA 11111010	Lead-in byte for all Lambda SC-specific special commands (TTL IN, TTL OUT, Timers, and Free Run). This lead-in byte is expressed only once in the status return data structure, and this is where it occurs.
6	<b>TTL IN Setting</b> (1 byte)	5/(6)	160 A0 10100000	<b>Disabled:</b> Trigger/toggle control of the shutter via TTL IN is turned off.

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
			161 A1 10100001	<b>Trigger on High:</b> Shutter is normally closed; opens while high signal is present on TTL IN.
			162 A2 10100010	<b>Trigger on Low:</b> Shutter is normally open; closes while high signal is not present on TTL IN.
			163 A3 10100011	<b>Toggle on Rising Edge:</b> On the rising edge of TTL IN going high, shutter opens if closed and closes if open.
			164 A4 10100100	<b>Toggle on Falling Edge:</b> On the falling edge of TTL IN going low, shutter closes if open and opens if closed.
7	<b>TTL OUT Setting</b> (1 byte)	6/(7)	176 B0 10110000	<b>Disabled:</b> TTL OUT synch signal is disabled.
			177 B1 10110001	<b>High on Shutter Open:</b> TTL OUT is set to high when shutter opens.
			178 B2 10110010	<b>Low on Shutter Open:</b> TTL OUT is set to low when shutter opens.
8	<b>Delay Timer</b> (Time to when shutter opens; 5 bytes)	7/(8)	0 or 1 0x or 1x 0000xxxx or 0001xxxx	<b>Enabled/Disabled (Upper Nibble):</b> If 0 (disabled), all five Delay Timer bytes can be ignored. If 1 (enabled), remaining five bytes (and respective nibbles where applicable) may contain values for hours, minutes, seconds, and milliseconds.
			0 – 5 x0 – x5 xxxx0000 – xxxx0101	<b>Hours (Lower Nibble):</b> Hours (0 – 5).
		8/(9)	0 – 59 00 – 38 00000000 - 00111011	<b>Minutes:</b> (0 – 59)
		9/(10)	0 – 59 00 – 38 00000000 - 00111011	<b>Seconds:</b> (0 – 59)
		10/(11)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 100s Digit (Upper Nibble):</b> 0 – 9

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	Milliseconds 10s Digit (Lower Nibble): 0 – 9.
		11/(12)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	Milliseconds 1s Digit (Upper Nibble): 0 – 9.
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	Milliseconds 0.1s Digit (Lower Nibble): 0 – 9.
9	<b>Exposure Timer</b> (Time <u>during</u> <u>which the shutter</u> <u>remains open</u> ; 5 bytes)	12/(13)	0 or 1 0x or 1x 0000xxxx or 0001xxxx	<b>Enabled/Disabled (Upper Nibble):</b> 0 (disabled) or 1 (enabled).  If disabled, all five Exposure Timer bytes can be ignored. Otherwise, the remaining five bytes (and respective nibbles where applicable) may contain values for hours, minutes, seconds, and milliseconds.
			0 – 5 x0 – x5 xxxx0000 – xxxx0101	<b>Hours (Lower Nibble):</b> (0 – 5).
		13/(14)	0 – 59 00 – 38 00000000 - 00111011	<b>Minutes:</b> (0 – 59)
		14/(15)	0 – 59 00 – 38 00000000 - 00111011	<b>Seconds:</b> (0 – 59)
		15/(16)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 100s Digit (Upper Nibble):</b> 0 – 9.
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	<b>Milliseconds 10s Digit (Lower Nibble):</b> 0 – 9.
		16/(17)	0 – 9 0x – 9x 0000xxxx – 1001xxxx	<b>Milliseconds 1s Digit (Upper nibble):</b> 0 – 9.

Order	Category	Byte Num.	Value (Decimal, hexadecimal, & binary)	Description
			0 – 9 x0 – x9 xxxx0000 –xxxx1001	Milliseconds 0.1s Digit (Lower Nibble): 0 – 9.
10	Free Run (3 bytes)	17/(18)	241 F1 11110001	Run On Power On
			242 F2 11110010	Run On Trigger Pulse
			243 F3 11110011	Run Now
		18/(19)	(Upper Byte) 0 - 255 00 – FF 00000000 - 11111111	Number of repeat cycles for Free Run. These two contiguous bytes combined (joined) contain the number of repeat cycles as a 16-bit integer ranging from 0 to 65,000. Above 65,000 (65,001 to 65,535), Free Run is set up for Continuous operation (i.e., infinite repeat cycles).
19/(20)	(Lower Byte) 0 - 255 00 – FF 00000000 - 11111111			
11	Terminator (1 byte)	20/(21)	13 0D 00001101	Terminator: ASCII CR (Carriage Return) used to indicate the end of the status data.

Table G-5. "Get Controller Type and Config." command return codes and data

Total num. bytes	Category	Byte Offset	Length	Value (Decimal, hexadecimal, & binary)	ASCII Char. Seq.	Possible Values
14	Command echo back	0	1	253 <sub>10</sub> , FD <sub>16</sub> , 11111101 <sub>2</sub>	ý	"Get Controller Type & Config." command echoed back. *
	Controller Type and firmware version	1	8		SC-vV.SS	Lambda SC, with firmware version V and subversion SS (e.g., "SC-v1.05").
	Shutter Type	7	4		S-IQ	SmartShutter
	Command return data terminator	13	1	13 <sub>10</sub> , 0D <sub>16</sub> , 00001101 <sub>2</sub>	<CR>	ASCII CR (carriage return).

**\*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.

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## NOTES