

QUICK REFERENCE

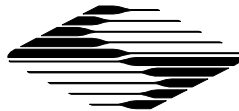
REV. 1.04 (20071030)

SUTTER INSTRUMENT COMPANY

LAMBDA SERIES

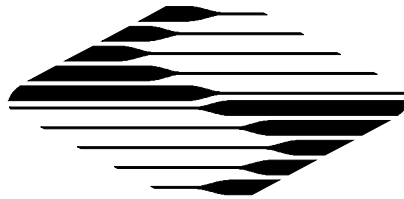
CONFIGURATION, CABLING, &
REMOTE CONTROL

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TABLE OF CONTENTS

1. CONFIGURATIONS.....	1
2. CABLING	3
2.1 MECHANICALS.....	3
2.2 PARALLEL PORT SETTINGS.....	4
2.3 LPT1 ON PRINTER ADAPTER	4
2.4 SERIAL PORT SETTINGS	7
3. REMOTE CONTROL.....	9
3.1 GENERAL	9
3.2 PARALLEL PORT CONTROL OF SHUTTERS VIA TTL LINES	9
3.3 COMMAND CODE RANGES.....	10
3.3.1 <i>Lambda 10 & 10-series</i>	10
3.3.2 <i>Lambda DG-series</i>	10
3.4 FILTER WHEEL COMMAND STRUCTURES.....	11
3.4.1 <i>Lambda 10</i>	11
3.4.2 <i>Lambda 10-2, 10-C, 10-3, & 10-B</i>	11
3.4.3 <i>Lambda DG-4</i>	12
3.5 COMMAND CODES.....	13
3.5.1 <i>Lambda 10</i>	13
3.5.2 <i>Lambda 10-2</i>	13
3.5.3 <i>Lambda 10-3</i>	14
3.5.4 <i>Lambda 10-B</i>	16
3.5.5 <i>Lambda SC</i>	18
3.5.5.1 <i>Lambda SC Timer Command Encoding</i>	20
3.5.6 <i>Lambda DG-4</i>	22
3.6 STATUS COMMAND RETURN CODES AND DATA.....	23
3.6.1 <i>Lambda 10-3</i>	23
3.6.2 <i>Lambda 10-B</i>	25
3.6.2.1 <i>Filter Wheel/Shutter Configuration</i>	25
3.6.2.2 <i>1- or 2-Shutter (no Filter Wheel) Configuration</i>	26
3.6.3 <i>Lambda SC</i>	28
3.7 GET CONTROLLER TYPE AND CONFIGURATION COMMAND RETURN CODES AND DATA	29
3.7.1 <i>Lambda 10-3</i>	29
3.7.2 <i>Lambda 10-B</i>	30
3.7.3 <i>Lambda SC</i>	30
3.8 COMPLETE COMMAND REFERENCE FOR ALL LAMBDA-SERIES PRODUCTS	31

1. CONFIGURATIONS

Table 1-1. Lambda Series Configurations.

Lambda Model	Ports			TTL				Wheels	Shutters	Smart-Shutter?
	Parallel	Serial	USB	Parallel Port		BNC Connectors				
				Input	Output	Input	Output			
10 ⁽¹⁾	✓ ⁽¹⁾			✓ ⁽¹⁾	✓	✓	✓	1 ⁽¹⁾	1 ⁽¹⁾	
10-2	✓	✓		✓				2	2	
10-C	✓	✓		✓				1	2	
10-3		✓	✓			(✓)	(✓)	3	2	✓
10-B		✓	✓			✓	✓	1	2	✓
SC		Opt.	✓			✓	✓		1	✓
LS								2 ⁽²⁾	1 ⁽²⁾	
DG-4, 5	✓	✓						⁽³⁾	⁽³⁾	1 ⁽³⁾

Note 1: In the Lambda 10, a shutter must be controlled via TTL, as no remote computer control of a shutter is possible via the parallel port. Apart from commands for 10 speeds and 10 positions for the filter wheel (X0 – X9 and 0X – 9X) no other remote commands are defined, with the exception of 238 decimal (EE hexadecimal), which is the “Go On Line” command.

Note 2: The Lambda LS is not normally equipped with filter wheels or shutters, although a drop-in filter holder is provided for manual wavelength switching. The Lambda LS can be optionally equipped with up to two filter wheels, the first mounted internally, and the second mounted externally, both externally controlled. The Lambda LS may also be equipped with a standalone SmartShutter (internally mounted, but externally controlled).

Note 3: The Lambda DG-4 and DG-5 do not use filter wheels to hold their filters; adjustable mirrors are used to change the light path to the appropriate fixed-position filter. The DG-4/5 has a built-in shutter mechanism, and can be optionally equipped with a SmartShutter.

2. CABLING

2.1 Mechanicals

Table 2-1. Controller Cabling for Mechanicals.

Configuration	Connector Type	Cable Max. Length	Cable Type
Standalone filter wheel, or filter wheel with standard shutter (same housing)	DB-15 female to DB-15 male	3 meters (approx. 10 feet)	Minimum of 26 awg stranded wire with 500 Volt.
Filter wheel with SmartShutter (same housing)	DB-25 male to DB-25 female	3 meters (approx. 10 feet)	Minimum of 26 awg stranded wire with 500 Volt.
Standalone filter wheel and standalone SmartShutter	DB-25 male split to a DB-15 male (Filter Wheel) and a DB-9 male (SmartShutter)	3 meters (approx. 10 feet)	Minimum of 26 awg stranded wire with 500 Volt.
Standalone SmartShutter	DB-25 male to DB-9 male (Lambda 10-3 or 10-B) or DB-9 female to DB-9 male (Lambda SC only)	3 meters (approx. 10 feet)	Minimum of 26 awg stranded wire with 500 Volt.
Two standalone SmartShutters	DB-25 male split to two DB-9 male	3 meters (approx. 10 feet)	Minimum of 26 awg stranded wire with 500 Volt.

Table 2-2. Controller Cables for Remote Control.

Port (Lambda model(s))		Connector Type	Cable Max. Length	Ferrite at Controller End	Cable Type
USB (10-3, 10-B, SC)		A to B	3 meters (approx. 10 feet)	None required	Dielectric separation of circuits. Foil shielding.
Serial RS-232 (10-2, 10-C, 10-3, 10-B, DG-4, DG-5)		DB-9 female to DB-9 male	3 meters (approx. 10 feet)	*Fair-Rite #0443167-251	Connected to metal faceplates of connectors on both ends.
Parallel	10	16-pin DIP header-style male to DB-25 female	3 meters (approx. 10 feet)	None required	Connected to metal faceplate of connector on remote computer end.
	10-2, 10-C, 10-3, DG-4, DG-5	DB-25 male to DB-25 female	3 meters (approx. 10 feet)	*Fair-Rite #0443167-251	Connected to metal faceplates of connectors on both ends.
TTL		BNC male to BNC male			

2.2 Parallel Port Settings

Table 2-3. PC printer adapter addresses

	Address	
	Base	Input Port
LPT1 on Graphics Adapter	956 (3BC Hex)	957 (3BD Hex)
LPT1 on Printer Adapter	888 (378 Hex)	889 (379 Hex)
LPT2 on Printer Adapter	632 (278 Hex)	633 (279 Hex)

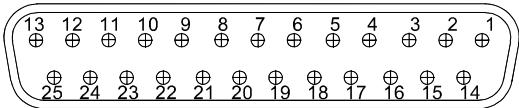


Figure 2-1. 25-Pin DSUB Parallel Port Connector

Table 2-4. PC and Lambda 10 Parallel Port Pin Assignments.

PC Parallel Port DB-25		Lambda 10 16-Pin Header Connection	
Pin #	Def.	Def.	Pin #
1	Strobe	Not Connected (NC)	
2	Data Bit 0	Filter or Command Bit 0	9
3	Data Bit 1	Filter or Command Bit 1	10
4	Data Bit 2	Filter or Command Bit 2	11
5	Data Bit 3	Filter or Command Bit 3	12
6	Data Bit 4	Speed Bit 0 or Command Bit 4	13
7	Data Bit 5	Speed Bit 1 or Command Bit 5	14
8	Data Bit 6	Speed Bit 2 or Command Bit 6	15
9	Data Bit 7	Speed Bit 3 or Command Bit 7	16
10	ACK	NC	
11	Busy	Busy Line Output	8

PC Parallel Port DB-25		Lambda 10 16-Pin Header Connection	
Pin #	Def.	Def.	Pin #
12	PE	Error Line Output	7
13	Select	NC	
14	Autofeed	NC	
15	Error	NC	
16	Init	NC	
17	Select In	NC	
18	Ground	NC	
19	Ground	NC	
20	Ground	NC	
21	Ground	NC	
22	Ground	NC	
23	Ground	NC	
24	Ground	Ground	5
25	Ground	Ground	6

Note: Pins 1 through 4 on the Lambda 10's 16-pin header connector must not be connected.

Table 2-5. PC and Lambda 10-2, 10-C, and DG Series Parallel Port Pin Assignments.

Pin #	PC Parallel Port	10-2 & 10-C Parallel Port	DG-4 & 5 Parallel Port
1	Strobe	Not Connected (NC)	Not Connected (NC)
2	Data Bit 0	Filter or Command Bit 0	Filter or Command Bit 0
3	Data Bit 1	Filter or Command Bit 1	Filter or Command Bit 1
4	Data Bit 2	Filter or Command Bit 2	Filter or Command Bit 2
5	Data Bit 3	Filter or Command Bit 3	Filter or Command Bit 3
6	Data Bit 4	Speed Bit 0 or Command Bit 4	Hold For Trigger Bit or Command Bit 4
7	Data Bit 5	Speed Bit 1 or Command Bit 5	Command Bit 5
8	Data Bit 6	Speed Bit 2 or Command Bit 6	Command Bit 6
9	Data Bit 7	Wheel Select Bit or Command Bit 7	Command Bit 7
10	ACK	NC	NC
11	Busy	Busy Line Output	Busy Line Output
12	PE	Error Line Output	NC
13	Select	NC	NC
14	Autofeed	Shutter	NC
15	Error	NC	NC
16	Init	NC	NC
17	Select In	NC	NC
18	Ground	NC	NC
19	Ground	NC	NC
20	Ground	NC	NC
21	Ground	NC	NC
22	Ground	NC	NC
23	Ground	NC	NC
24	Ground	Ground	Ground
25	Ground	Ground	Ground

2.3 Serial Port Settings

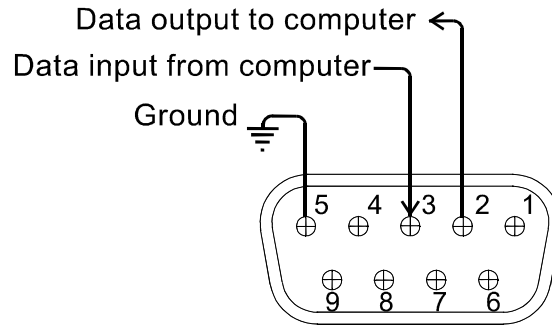


Figure 2-2. Serial port pin assignments.

Table 2-6. PC and Lambda Series Serial Port Pin Assignments.

Pin #	PC Serial Port	Lambda Serial Port
1	DCD or CD (Data Carrier Detect)	NC (not connected)
2	RXD (Receive Data)	TXD (Transmit Data)
3	TXD (Transmit Data)	RXD (Receive Data)
4	DTR (Data Terminal Ready)	NC
5	Signal Ground	Ground
6	DSR (Data Set Ready)	NC
7	RTS (Request To Send)	NC
8	CTS (Clear To Send)	NC
9	RI (Ring Indicator)	NC

Note: The outer part of the D-shell connector (metal) is connected to chassis (frame) ground.

Communication for the serial port requires the following settings:

- Baud rate 9600 (bps (bits per second))
- Data bits 8
- Parity none
- Stop bits 1
- Flow Control none

Microsoft QuickBasic open COM port syntax:

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


3. REMOTE CONTROL

3.1 General

Table 3-1. Remote Control Command Categories.

Category	Description
Filter commands	These are commands used exclusively for controlling filter wheels.
Shutter commands	These are commands used exclusively for controlling shutters (SmartShutters and/or standard shutters).
Special commands	These are commands for the general control of the Lambda 10, SC, or DG series controller, and are not necessarily specifically related to either filter wheels or shutters.

3.2 Parallel Port Control of Shutters via TTL Lines

Table 3-2. Commands for Parallel Port Control of Dedicated TTL Lines.

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

Table 3-3. Commands for Parallel Port Control of Dedicated TTL Lines (Alternate View).

Parallel Port					Shutter A	Shutter B
Value			Pins			
Decimal	Hex.	Binary	14	16		
0	0	000	High	Low	Open	Closed
2	2	010	Low	Low	Closed	Closed
4	4	100	High	High	Open	Open
6	6	110	Low	High	Closed	Open

3.3 Command Code Ranges

3.3.1 Lambda 10 & 10-series

Table 3-4. Lambda 10 Series Command Code Ranges.

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

3.3.2 Lambda DG-series

Table 3-5. DG Series Command Code Ranges.

Filter Command Ranges			Shutter and Special Command Ranges		
Hexadecimal	Binary	Decimal	Hexadecimal	Binary	Decimal
00 - 1F	00000000 00011111	0 - 25	20 - FF	00100000 11111111	26 - 255

3.4 Filter Wheel Command Structures

3.4.1 Lambda 10

Table 3-6. Lambda 10 Filter Command Structure.

Functional Bit Groups								
Byte Bit #	7	6	5	4	3	2	1	0
Group	Speed				Filter Position			
Group Bit #	3	2	1	0	3	2	1	0
Decimal Group Values	0 - 9				0 - 9			
Hexadecimal Group Values	0 - 9				0 - 9			
Binary Group Values	0000 - 1001				0000 - 1001			

Formula for encoding Lambda 10 filter wheel commands within a byte (numbers in decimal):

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

3.4.2 Lambda 10-2, 10-C, 10-3, & 10-B

Table 3-7. Lambda 10-2, 10-C, 10-3, & 10-B Filter Command Structure.

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

NOTE: For the Lambda 10-2 and 10-3, Bit 7 is used to select up to select up to two (10-2) or three (10-3) wheels: set to 0 for Wheel A (or C (10-3 only)), and set to 1 for Wheel B. To select Wheel C (10-3 only), Bit 7 is set to 0 and the entire filter command byte must be preceded by a byte containing the value of 252 decimal (FC hexadecimal). For Lambda 10-C and 10-B, Bit 7 must always be set to 0.

Formula for encoding Lambda 10- series filter wheel commands within a byte (numbers in decimal):

If Wheel A or C: 0 + (speed * 16) + position = byte value

If Wheel B: 128 + (speed * 16) + position = byte value

3.4.3 Lambda DG-4

Table 3-8. Lambda DG Series Filter Command Structure.

Functional Bit Groups								
Byte Bit #	7	6	5	4	3	2	1	0
Group	Unused			Move on Cmd. or Synch.	Filter Position			
Group Bit #				0	3	2	1	0
Decimal Group Values				0 - 1	0 - 15			
Hexadecimal Group Values				0 - 1	0 - F			
Binary Group Values				0 - 1	0000 - 1111			

Formula for encoding Lambda DG- series filter wheel commands within a byte (numbers in decimal):

If Move on Command: 0 + position = byte value

If Move on Synch: 16 + position = byte value

3.5 Command Codes

3.5.1 Lambda 10

Table 3-9. Lambda 10 Remote Control Commands.

Command	Value (decimal, hexadecimal, binary)	Description
Set filter wheel speed and position	(See Table 3-4 for possible value ranges.)	Sets the filter wheel's speed (0 – 9) and position (0 – 9), each of which is encoded in BCD (Binary Coded Decimal). The speed uses Bits 7, 6, 5, & 4, and the position uses Bits 3, 2, 1, & 0.
Transfer Control to Computer (On Line)	238 EE 11101110	When the controller is in the local mode, the unit will be forced to go ON LINE if this code is sent.

3.5.2 Lambda 10-2

Table 3-10. Lambda 10-2 Remote Control Commands.

Command	Value (decimal, hexadecimal, binary)	Description
Set filter wheel, speed and position	(See Table 3-4 for possible value ranges.)	Sets the filter wheel (A, B, or C), the filter wheel speed (0 – 7), and the filter position (0 – 9). Bit 7 is set to 0 for Wheel A and 1 for Wheel B. The filter wheel speed is encoded in octal (base 8) using Bits 6, 5, & 4. The filter position is encoded in BCD (Binary Coded Decimal) using the least significant nibble (Bits 3, 2, 1, & 0).
Transfer Control to Computer (On Line)	238 EE 11101110	When the controller is in the local mode, the unit will be forced to go ON LINE if this code is sent. The input port from which this command is received will become active. Sending this command via one input when the other input is active will cause the unit to change remote input modes. WARNING: <u>If 238 is the current command of either input, do not send 238 via the other channel and do not attempt to go to the local mode!</u> In either case, the controller will loop between modes continuously requiring the controller to be RESET.
Batch Transfer	223 DF 11011111	The controller reads the next four commands and acts on them in quick succession before acting on any subsequent command.
Open Shutter A	170 AA 10101010	Opens Shutter A

Command	Value (decimal, hexadecimal, binary)	Description
Open Shutter A Conditional	171 AB 10101011	Opens Shutter A while Wheel A is stopped. The shutter will close each time the wheel moves and then will open again at the end of the move.
Close Shutter A	172 AC 10101100	Closes Shutter A
Open Shutter B	186 BA 10111010	Opens Shutter B
Open Shutter B Conditional	187 BB 10111011	Opens Shutter B while Wheel B is stopped. The shutter will close each time Wheel B moves and then will open again at the end of the move.
Close Shutter B	188 BC 10111100	Closes Shutter B

3.5.3 Lambda 10-3

Table 3-11. Lambda 10-3 Remote Control Commands.

Command	Value (decimal, hexadecimal, binary)	Description
Set filter wheel, speed and position	(See Table 3-4 for possible value ranges.)	Sets the filter wheel (A, B, or C), the filter wheel speed (0 – 7), and the filter position (0 – 9). Bit 7 is set to 0 for Wheel A or C, and 1 for Wheel B. For Wheel C, a byte containing a value of 252 decimal (FC hexadecimal) must precede the command byte. The filter wheel speed is encoded in octal (base 8) using Bits 6, 5, & 4. The filter position is encoded in BCD (Binary Coded Decimal) using the least significant nibble (Bits 3, 2, 1, & 0).
Open Shutter A	170 AA 10101010	Sets the state of Shutter A to open.
Open Shutter A Conditional	171 AB 10101011	Configures Shutter A to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move.
Close Shutter A	172 AC 10101100	Sets the state of Shutter A closed.

Command	Value (decimal, hexadecimal, binary)	Description
Open Shutter B	186 BA 10111010	Sets the state of Shutter B to open.
Open Shutter B Conditional	187 BB 10111011	Configures Shutter B to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move.
Close Shutter B	188 BC 10111100	Sets the state of Shutter B closed.
Batch Start	189 BD 10111101	Instructs the controller to collect the next 1 to 6 bytes representing filter wheel and shutter movement/action commands, until the Batch End command is received, whereupon the collected filter wheel and shutter commands are executed in quick succession. NOTE: This command supports filter wheels A, B, and C, and shutters A and B – it should not be confused with the Batch Transfer command, which does not support Wheel C.
Batch End	190 BE 10111110	Instructs the controller that the Batch Start command and the one to six wheel/shutter movement/action command sequence has ended -- the collected filter wheel and shutter commands are executed in quick succession.
Status	204 CC 11001100	Returns status of unit in two bytes
All Motors Power On	206 CE 11001110	Instruct the controller to power on all motors.
All Motors Power Off	207 CF 11001111	Instruct the controller to power off all motors.
Fast-mode Shutter	220 + 1 or 2 DC + 01 or 02 11011100 + 00000001 or 00000010	Sets the shutter to fast mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2).
Soft-mode Shutter	221 + 1 or 2 DD + 01 or 02 10111011 + 00000001 or 00000010	Sets the shutter to soft mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2).
Neutral Density-mode Shutter	222 + 1 or 2 + 1 – 144 DE + 01 or 02 + 01 – 90 10111100 + 00000001 or 00000010 + 00000001 - 10010000	Sets the shutter to neutral-density mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2). The third byte contains a value of 1 through 144 indicating the number of microsteps.
Batch Transfer	223 DF	Instructs the controller to collect the next four wheel/shutter commands. Once received, the four commands are executed

Command	Value (decimal, hexadecimal, binary)	Description
	11011111	in quick succession. This command was introduced in the Lambda 10-2; it is retained in the Lambda 10-3 for compatibility with applications that already have this functionality programmed. NOTE: This batch command does not support Wheel C – use the Batch Start and Batch End command sequence instead if support for Wheel C is required.
Transfer to On Line	238 EE 11101110	Puts controller on-line
Transfer to Local	239 EF 11101111	Puts controller in local mode
Reset	251 FB 11111011	Resets the controller
Get Controller Type and Configuration	253 FD 11111011	Queries the controller as to its type and configuration.

3.5.4 Lambda 10-B

Table3-12. Lambda 10-B Remote Control Commands.

Command	Value (decimal, hexadecimal, binary)	Description
Set filter wheel speed and filter position	(See Table 3-4 for possible value ranges.)	Sets the filter wheel speed (0 – 7) and the filter position (0 – 9). Note that for the Lambda 10-B, the most significant bit (Bit 7) of the command byte is always 0. The filter wheel speed is encoded in octal (base 8) using Bits 6, 5, & 4. The filter position is encoded in BCD (Binary Coded Decimal) using the least significant nibble (Bits 3, 2, 1, & 0).
Open Shutter A *	170 AA 10101010	Sets the state of Shutter A to open.
Open Shutter A Conditional *	171 AB 10101011	Configures Shutter A to open while the filter wheel is stopped. The shutter will close each time the filter wheel moves and then will open again at the end of the move.
Close Shutter A *	172 AC 10101100	Sets the state of Shutter A closed.
Open Shutter B *	186 BA 10111010	Sets the state of Shutter B to open.
Close Shutter B *	188 BC 10111100	Sets the state of Shutter B closed.

Command	Value (decimal, hexadecimal, binary)	Description
Status	204 CC 11001100	Returns status of unit in two bytes
All Motors Power On *	206 CE 11001110	Instruct the controller to power on all motors.
All Motors Power Off *	207 CF 11001111	Instruct the controller to power off all motors.
Fast-mode Shutter	220 + 1 or 2 DC + 01 or 02 11011100 + 00000001 or 00000010	Sets the shutter to fast mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2).
Soft-mode Shutter	221 + 1 or 2 DD + 01 or 02 10111011 + 00000001 or 00000010	Sets the shutter to soft mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2).
Neutral Density-mode Shutter	222 + 1 or 2 + 1 – 144 DE + 01 or 02 + 01 – 90 10111100 + 00000001 or 00000010+ 00000001 - 10010000	Sets the shutter to neutral-density mode (<i>SmartShutter</i> only). Second byte indicates Shutter A (1) or B (2). The third byte contains a value of 1 through 144 indicating the number of microsteps.
Transfer to On Line	238 EE 11101110	Puts controller on-line
Transfer to Local	239 EF 11101111	Puts controller in local mode
Reset	251 FB 11111011	Resets the controller
Get Controller Type and Configuration *	253 FD 11111011	Queries the controller as to its type and configuration.

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

3.5.5 Lambda SC

Table 3-13. Lambda SC Remote Control Commands.

Command	Value (decimal, hexadecimal, binary)	Description
Open Shutter	170 AA 10101010	Sets the state of the shutter to open.
Close Shutter	172 AC 10101100	Sets the state of the shutter to closed.
Stop the Free Run	191 BF 10111111	Stops the Free Run if it is currently running.
Status	204 CC 11001100	Returns status of unit in two bytes
All Motors Power On	206 CE 11001110	Instruct the controller to power on all motors.
All Motors Power Off	207 CF 11001111	Instruct the controller to power off all motors.
Fast-mode Shutter	220 DC 11011100	Sets the shutter to fast mode.
Soft-mode Shutter	221 DD 10111011	Sets the shutter to soft mode.
Neutral Density-mode Shutter	222 + 1 – 144 DE + 01 – 90 10111100 + 00000001 - 10010000	Sets the shutter to neutral-density mode. Second byte contains a value of 1 through 144 indicating the number of microsteps.
Transfer to On Line	238 EE 11101110	Puts controller on-line
Set Delay Timer	250 + (16 – 21) + 4 bytes FA + (10 – 15) + 4 bytes 11111010 + (00010000 – 00010101) + 4 bytes	Sets the time to when the shutter opens (0 through 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond). The 2 nd to 6 th bytes contain the delay time, as follows: 2 nd byte, lower nibble: Hours (0 through 5). 3 rd byte: Minutes (0 – 59) 4 th byte: Seconds (0 – 59) 5 th byte, upper nibble: 100s digit (0-9) for milliseconds; lower nibble: 10s digit (0-9). 6 th byte, upper nibble: 1s digit (0-9) for milliseconds; lower nibble: 0.1s digit (0-9).
Set Exposure Timer	250 + (32 – 37) + 4 bytes FA + (20 – 25) + 4 bytes	Sets the time to when the shutter opens (0 through 5 hours even (or 4 hours, 59 minutes, 59 seconds, 999.9 milliseconds + 0.1 millisecond). The 2 nd to 6 th bytes contain the delay time, as follows:

Command	Value (decimal, hexadecimal, binary)	Description
	11111010 + (00100000 – 00100101) + 4 bytes	2 nd byte, lower nibble: Hours (0 through 5). 3 rd byte: Minutes (0 – 59) 4 th byte: Seconds (0 – 59) 5 th byte, upper nibble: 100s digit (0-9) for milliseconds; lower nibble: 10s digit (0-9). 6 th byte, upper nibble: 1s digit (0-9) for milliseconds; lower nibble: 0.1s digit (0-9).
TTL IN Pulse Trigger Disabled	250 + 160 FA + A0 11111010 + 10100000	Disable TTL IN shutter triggering.
TTL IN High Triggers SmartShutter to Open	250 + 161 FA + A1 11111010 + 10100001	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.
TTL IN Low Triggers SmartShutter to Open	250 + 162 FA + A2 11111010 + 10100010	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.
TTL IN Rising Edge Triggers SmartShutter to Toggle Open/Close	250 + 163 FA + A3 11111010 + 10100011	Trigger shutter to toggle (open if closed, close if opened) on TTL IN rising edge.
TTL IN Falling Edge Triggers SmartShutter to Toggle Open/Close	250 + 164 FA + A4 11111010 + 10100100	Trigger shutter to toggle (open if closed, close if opened) on TTL IN falling edge.
TTL OUT Disabled	250 + 176 FA + B0 11111010 + 10110000	Disables TTL OUT shutter open synch signal.
Opening Shutter Sets TTL OUT to High	250 + 177 FA + B1 11111010 + 10110001	When shutter opens, TTL OUT is set to high.
Opening Shutter Sets TTL OUT to Low	250 + 178 FA + B2 11111010 + 10110010	When shutter opens, TTL OUT is set to low.
Restore Controller to the Factory-Default Configuration	250 + 192 FA + C0 11111010 + 11000000	Changes the controller's configuration to that of the factory default.
Save the Current Configuration to the Controller	250 + 193 FA + C1 11111010 + 11000001	Saves the current configuration to the controller. This saved configuration will be used next time the controller is powered up or is reset.
Set Number of Repeat Cycles for Free Run	250 + 240 + 2 bytes FA + F0 + 2 bytes	Sets the number of repeat cycles for the Free Run feature. 3 rd and 4 th 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

Command	Value (decimal, hexadecimal, binary)	Description
	11111010 + 11110000 + 2 bytes	Continuous operation (i.e., infinite repeat cycles).
Start Free Run on Power Up	250 + 241 FA + F1 11111010 + 11110001	Starts the Free Run immediately after the controller powers up. The number of repeat cycles does not need to be set beforehand.
Start Free Run on Trigger Pulse from TTL IN	250 + 242 FA + F2 11111010 + 11110010	Starts the Free Run immediately after trigger pulse is received on TTL IN. The number of repeat cycles must be set beforehand.
Start Free Run immediately	250 + 243 FA + F3 11111010 + 11110011	Starts the Free Run immediately on receiving this command. The number of repeat cycles must be set beforehand.
Reset Controller to the Last Saved Configuration	251 FB 11111011	Resets the controller and sets the configuration to the one that was last saved.
Get Controller Type and Configuration *	253 FD 11111011	Queries the controller as to its type and configuration.

3.5.5.1 Lambda SC Timer Command Encoding

Table 3-14. Lambda SC Timer Command Encoding.

Byte Number (order)	Value (decimal, hexadecimal, binary)	Upper & Lower Nibble Values (decimal, hexadecimal, & binary)	Description
1 st	250 FA 1111 1010	(Not relevant)	Lambda SC Special Command.
2 nd	10 – 15, 20 – 25 0001 0000 – 0001 0101. 0010 0000 – 0010 0101	Upper: 1 - 2 1 - 2 0001 - 0010 Lower: 0 – 5 0 – 5 0000 - 0101	1 = Set Delay Timer 2 = Set Exposure Timer Hours (0 through 5) *
3 rd	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant – all 8 bits used)	Minutes (0 through 59)
4 th	0 – 59 00 – 3B 00000000 - 00111011	(Not relevant – all 8 bits used)	Seconds (0 through 59)

Byte Number (order)	Value (decimal, hexadecimal, binary)	Upper & Lower Nibble Values (decimal, hexadecimal, & binary)	Description
5 th	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 th	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).

3.5.6 Lambda DG-4

Table 3-15. Lambda DG Series Remote Control Commands.

Decimal	Hexa-decimal	Binary	Keyboard	Command	
0 – 15	00 – 0F	00000000 – 00001111	Alt-0000 – Alt-0015	Move, on command, to Filter Position 0 – 15.	Upper and Lower nibble (0000 <u>XXXX</u>) values
16 – 31	10 – 1F	00010000 – 00011111	Alt-0016 – Alt-0031	Move, on sync, to Filter Position 0 – 15.	Upper and Lower nibble (0001 <u>XXXX</u>) values
170	AA	10101010	Alt-0170	Open Shutter: Returns to the filter position that was active when the close shutter command was last issued	
171	AB	10101011	Alt-0171	Marker In Remote N.D. Adjustment: DAC value. Send between each command for changing N.D. through adjustment of galvo.	
172	AC	10101100	Alt-0172	Close Shutter: Selects Filter Position 0 and stores filter value for return using Open Shutter command 170	
186	BA	10111010	Alt-0186	Activates Turbo-Blanking	
188	BC	10111100	Alt-0188	Inactivates Turbo-Blanking	
202	CA	11001010	Alt-0202	Selects triggered by strobe line as the ring buffer mode	
203	CB	11001011	Alt-0203	Deselects triggered by strobe line	
204	CC	11001100	Alt-0204	Selects triggered by video synch as the ring buffer mode	
205	CD	11001101	Alt-0205	Deselects triggered by video sync	
206	CE	11001110	Alt-0206	Selects triggered by video sync gated by strobe line as the ring buffer mode	
207	CF	11001111	Alt-0207	Deselects triggered by video sync gated by strobe line as the ring buffer mode	
218	DA	11011010	Alt-0218	Freeze Display: Stops updating the display in order to allow the highest frequency of filter changes	
219	DB	11011011	Alt-0219	Turn Display On: Restores normal updating of the display	
223	DF	11011111	Alt-0223	Start Loading Ring Buffer: Places the controller in a mode that allows a series of filter values to be loaded in the ring buffer	
234	EA	11101010	Alt-0234	Start Remote Change Of N.D. Setting: Places the controller in the N.D. adjust mode. In this mode the output galvo position for the selected filter value can be changed as a fine adjustment for output intensity.	
235	EB	11101011	Alt-0235	Increase Value Of Galvo DAC (by 1 unit)	
236	EC	11101100	Alt-0236	Decrease Value Of Galvo DAC (by 1 unit)	
237	ED	11101101	Alt-0237	End N.D. Adjustment And Save: Saves the new galvo DAC value and returns to the normal on-line mode.	
238	EE	11011110	Alt-0238	Set controller to On Line: Transfers control to the computer.	
240	F0	11110000	Alt-0240	End Loading Ring Buffer: Sent after the final value to be loaded in the ring buffer. New ring buffer values are saved..	
241	F1	11110001	Alt-0241	Run From Ring Buffer (RB): Causes filter value to be controlled by the RB. Controller steps through RB, advancing to next filter for each trigger or sync pulse. One of the three triggering modes must be selected first.	
242	F2	11110010	Alt-0242	End Run From Ring Buffer: Returns to normal on-line mode.	

Note 1: Filter Position 0 is not a true filter position, but rather a position that is located away from the filters. This has the effect of closing a shutter over the lamp light path.

3.6 Status Command Return Codes and Data

3.6.1 Lambda 10-3

Table 3-16. Lambda 10-3 Status Command Return Codes and Data.

Order	Num. of bytes	Category	Sub Category	Value (decimal, hexadecimal, & binary)	Description
1	1	Command echo		204 CC 11001100	The Status command byte code echoed back.
2	1	Filter Wheel A status	Wheel, Speed and Position	Encoded command byte: 0 – 121 00 – 79 00000000 – 01111001 *	Filter Wheel (Bit 7): 0
					Speed (Bits 6, 5, & 4): 0 – 7.
					Position (Bits 3, 2, 1, & 0): 0 – 9
3	1	Filter Wheel B status	Wheel, Speed and Position	Encoded command byte: 128 – 249 80 – F9 10000000 – 11111001 *	Filter Wheel (Bit 7): 1
					Speed (Bits 6, 5, & 4): 0 – 7.
					Position (Bits 3, 2, 1, & 0): 0 – 9
4	2	Filter Wheel C status	Wheel, Speed and Position	1 st byte = Wheel C indicator byte: 252 FC 11111100 2 nd byte = encoded filter wheel status byte: 0 – 121 00 – 79 00000000 – 01111001 *	Filter Wheel (Bit 7): 0 NOTE: Preceding byte containing 252 decimal (FC hexadecimal), indicates Wheel C.
					Speed (Bits 6, 5, & 4): 0 – 7.
					Position (Bits 3, 2, 1, & 0): 0 – 9
5	1	Shutter A open/-closed state	Open	170 AA 10101010	Shutter A is in the open state.
			Open state is conditional	171 AB 10101011	The open state of Shutter A is conditional upon the movement of the Filter Wheel A.
			Closed	172 AC 10101100	Shutter A is in the closed state.
6	1	Shutter B open/-closed state	Open	186 BA 10111010	Shutter B is in the open state.
			Open state is conditional	187 BB 10111011	The open state of Shutter B is conditional upon the movement of the Filter Wheel B.

Order	Num. of bytes	Category	Sub Category	Value (decimal, hexadecimal, & binary)	Description
			Closed	188 BC 10111100	Shutter B is in the closed state.
7	2 or 3	Shutter A mode (<i>SMART</i> - SHUTTER only)	<i>SMART</i> - SHUTTER not connected	219 + 1 DB + 01 11011011 + 00000001	Indicates that no <i>SmartShutter</i> is connected to Port A. Either no shutter is connected or a Vincent shutter is connected.
			Fast	220 + 1 DC + 01 11011100 + 00000001	Indicates that <i>SmartShutter</i> A is in the fast mode.
			Soft	221 + 1 DD + 01 10111011 + 00000001	Indicates that <i>SmartShutter</i> A is in the soft mode.
			Neutral Density (1 byte) plus number of microsteps (1 byte)	222 + 1 + 1 – 144 DE + 01 + 01 – 90 10111100 + 00000001 + 00000001 - 10010000	Indicates that <i>SmartShutter</i> A is in the neutral-density mode. A third byte contains the number of microsteps (1 – 144).
8	2 or 3	Shutter B mode (<i>SMART</i> - SHUTTER only)	<i>SMART</i> - SHUTTER not connected	219 + 2 DB + 02 11011011 + 00000010	Indicates that no <i>SmartShutter</i> is connected to Port B. Either no shutter is connected or a Vincent shutter is connected.
			Fast	220 + 2 DC + 02 11011100 + 00000010	Indicates that <i>SmartShutter</i> B is in the fast mode.
			Soft	221 + 2 DD + 02 10111011 + 00000010	Indicates that <i>SmartShutter</i> B is in the soft mode.
			Neutral Density (1 byte) plus number of microsteps (1 byte)	222 + 2 + 1 – 144 DE + 02 + 01 – 90 10111100 + 00000010 + 00000001 - 10010000	Indicates that <i>SmartShutter</i> B is in the neutral-density mode. A third byte contains the number of microsteps (1 – 144).

3.6.2 Lambda 10-B

3.6.2.1 Filter Wheel/Shutter Configuration

Table 3-17. Lambda 10-B Status Command Return Codes and Data in a Filter Wheel/Shutter Configuration.

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

3.6.2.2 1- or 2-Shutter (no Filter Wheel) Configuration

Table 3-18. Lambda 10-B Status Command Return Codes and Data in a 1- or 2-Shutter (no Filter Wheel) Configuration.

Order	Num. of bytes	Category	Sub Category	Value (decimal, hexadecimal, & binary)	Description
1	1	Command echo		204 CC 11001100	The Status command byte code echoed back.
2	1	Shutter A open/closed state	Open	170 AA 10101010	Shutter A is in the open state.
			Open state is conditional	171 AB 10101011	The open state of Shutter A is conditional upon the movement of the filter wheel.
			Closed	172 AC 10101100	Shutter A is in the closed.
3	2 or 3	Shutter A mode (<i>SMART</i> -SHUTTER only)	<i>SMART</i> -SHUTTER not connected	219 + 1 DB + 01 11011011 + 00000001	Indicates that no <i>SmartShutter</i> is connected to Port A. Either no shutter is connected or a Vincent shutter is connected.
			Fast	220 + 1 DC + 01 11011100 + 00000001	Indicates that <i>SmartShutter</i> A is in the fast mode.
			Soft	221 + 1 DD + 01 10111011 + 00000001	Indicates that <i>SmartShutter</i> A is in the soft mode.
			Neutral Density (1 byte) plus number of microsteps (1 byte)	222 + 1 + 1 – 144 DE + 01 + 01 – 90 10111100 + 00000001 + 00000001 - 10010000	Indicates that <i>SmartShutter</i> A is in the neutral-density mode. A third byte contains the number of microsteps (1 – 144).
4	1	Shutter B open/closed state	Open	186 BA 10111010	Shutter B is in the open state.
			Closed	188 BC 10111100	Shutter B is in the closed state.
5	2 or 3	Shutter B Mode (<i>SMART</i> -SHUTTER only)	<i>SMART</i> -SHUTTER not connected	219 + 2 DB + 02 11011011 + 00000010	Indicates that no <i>SmartShutter</i> is connected to Port B. Either no shutter is connected or a Vincent shutter is connected.

Order	Num. of bytes	Category	Sub Category	Value (decimal, hexadecimal, & binary)	Description
			Fast	220 + 2 DC + 02 11011100 + 00000010	Indicates that <i>SmartShutter</i> B is in the fast mode.
			Soft	221 + 2 DD + 02 10111011 + 00000010	Indicates that <i>SmartShutter</i> B is in the soft mode.
			Neutral Density (1 byte) plus number of microsteps (1 byte)	222 + 2 + 1 – 144 DE + 02 + 01 – 90 10111100 + 00000010 + 00000001 - 10010000	Indicates that <i>SmartShutter</i> B is in the neutral-density mode. A third byte contains the number of microsteps (1 – 144).

3.6.3 Lambda SC

Table3-19. Lambda SC Status Command Return Codes and Data.

Order	Num. of bytes	Category	Sub Category	Value (decimal, hexadecimal, & binary)	Description
1	1	Command echo		204 CC 11001100	The Status command byte code echoed back.
2	1	Shutter open/closed state	Open	170 AA 10101010	The shutter is in the open state.
			Closed	172 AC 10101100	The shutter is in the closed state.
3	1 or 2	Shutter mode	<i>SMART</i> - SHUTTER not connected	219 DB 11011011	Indicates that no <i>SmartShutter</i> is connected.
			Fast mode	220 DC 11011100	Indicates that the <i>SmartShutter</i> is in fast mode.
			Soft mode	221 DD 10111011	Indicates that the <i>SmartShutter</i> is in soft mode.
			Neutral Density mode (1 byte) plus number of microsteps (1 byte)	222 + 1 – 144 DE + 01 – 90 10111100 + 00000001 - 10010000	Indicates that the <i>SmartShutter</i> is in neutral-density mode. A second byte contains the number of microsteps (1 – 144).

3.7 Get Controller Type and Configuration Command Return Codes and Data

3.7.1 Lambda 10-3

Table 3-20. Lambda 10-3 “Get Controller Type and Configuration” command return codes and data.

Total num. bytes	Description			
	Category	Num. Bytes	Possible values	
			ASCII string	Meaning
29	Controller Type	4	10-3	Lambda 10-3
	Filter Wheel A Type	5	WA-25	25mm
			WA-32	32mm
			WA-HS	High Speed
			WA-BD	Belt Driver
			WA-NC	Not Connected
			WA-ER	Error
	Filter Wheel B Type	5	WB-25	25mm
			WB-32	32mm
			WB-HS	High Speed
			WB-BD	Belt Driver
			WB-NC	Not Connected
			WB-ER	Error
	Filter Wheel C Type	5	WB-25	25mm
			WB-32	32mm
			WB-HS	High Speed
			WB-BD	Belt Driver
			WB-NC	Not Connected
			WB-ER	Error
	Shutter A Type	5	SA-IQ	<i>SmartShutter</i>
			SA-VS	Vincent Shutter
	Shutter B Type	5	SB-IQ	<i>SmartShutter</i>
			SA-VS	Vincent Shutter

3.7.2 Lambda 10-B

Table 3-21. Lambda 10-B “Get Controller Type and Configuration” command return codes and data.

Configuration	Total num. bytes	Description			
		Category	Num. Bytes	Possible Values	
				ASCII string	Meaning
Single Shutter (One standalone filter wheel only, one filter wheel with one integrated shutter, or one standalone shutter only)	14	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	10-B	Lambda 10-B
		Filter Wheel Type	4	W-25	25mm
				W-32	32mm
				W-HS	High Speed
				W-BD	Belt Driver
				W-NC	Not Connected
				W-ER	Error
		Shutter Type	4	S-IQ	<i>SmartShutter</i>
				S-VS	Vincent Shutter (or no shutter connected)
Dual Shutters (Two shutters (<i>SmartShutters</i> only); no filter wheel))	16	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type	4	10-B	Lambda 10-B
		Shutter A Type	5	SA-IQ	<i>SmartShutter</i>
				SA-VS	Vincent Shutter
		Shutter B Type	5	SB-IQ	<i>SmartShutter</i>
		Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.

3.7.3 Lambda SC

Table 3-22. Lambda SC “Get Controller Type and Configuration” command return codes and data.

Configuration	Total num. bytes	Description			
		Category	Num. Bytes	Possible values	
				ASCII string	Meaning
One SmartShutter	14	Command echo back	1	ý	253 decimal; FD hexadecimal. *
		Controller Type and firmware version	8	SC-vV.SS	Lambda SC, with firmware version V and subversion SS (e.g., “SC-v1.05”).
		Shutter Type	4	S-IQ	<i>SmartShutter</i>
		Command return data terminator	1		ASCII carriage return; 13 decimal, 0D hexadecimal.

3.8 Complete Command Reference for all Lambda-series Products

Table 3-23. All Lambda Series Remote Control Commands.

Byte Value			Keyboard Entry			Lambda Model								Description			
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10	10	10	10	S	D	G	Wheel Command		Filter	Shutter or Special Command
														10 only	DG only		
														W h e e l	S p e e d	Move on Cmd. or Sync	
0	00	00000000	Alt-0000	^@	(NUL)	✓	✓	✓	✓	✓				A/C ⁰	0		0
1	01	00000001	Alt-0001	^A	(SOH)	✓	✓	✓	✓	✓				A/C ⁰	0		1
2	02	00000010	Alt-0002	^B	(STX)	✓	✓	✓	✓	✓				A/C ⁰	0		2
3	03	00000011	Alt-0003	^C	(ETX)	✓	✓	✓	✓	✓				A/C ⁰	0		3
4	04	00000100	Alt-0004	^D	(EOT)	✓	✓	✓	✓	✓				A/C ⁰	0		4
5	05	00000101	Alt-0005	^E	(ENQ)	✓	✓	✓	✓	✓				A/C ⁰	0		5
6	06	00000110	Alt-0006	^F	(ACK)	✓	✓	✓	✓	✓				A/C ⁰	0		6
7	07	00000111	Alt-0007	^G	(BEL)	✓	✓	✓	✓	✓				A/C ⁰	0		7
8	08	00001000	Alt-0008	^H	(BS)	✓	✓	✓	✓	✓				A/C ⁰	0		8
9	09	00001001	Alt-0009	^I	(HT)	✓	✓	✓	✓	✓				A/C ⁰	0		9
10	0A	00001010	Alt-0010	^J	(LF)							✓					10
11	0B	00001011	Alt-0011	^K	(VT)							✓					11
12	0C	00001100	Alt-0012	^L	(FF)							✓					12
13	0D	00001101	Alt-0013	^M	(CR)							✓					13
14	0E	00001110	Alt-0014	^N	(SO)							✓					14
15	0F	00001111	Alt-0015	^O	(SI)							✓					15
16	10	00010000	Alt-0016	^P	(DLE)	✓	✓	✓	✓	✓				A/C ⁰	1		0
17	11	00010001	Alt-0017	^Q	(DC1)	✓	✓	✓	✓	✓				A/C ⁰	1		1
18	12	00010010	Alt-0018	^R	(DC2)	✓	✓	✓	✓	✓				A/C ⁰	1		2
19	13	00010011	Alt-0019	^S	(DC3)	✓	✓	✓	✓	✓				A/C ⁰	1		3
20	14	00010100	Alt-0020	^T	(DC4)	✓	✓	✓	✓	✓				A/C ⁰	1		4
21	15	00010101	Alt-0021	^U	(NAK)	✓	✓	✓	✓	✓				A/C ⁰	1		5
22	16	00010110	Alt-0022	^V	(SYN)	✓	✓	✓	✓	✓				A/C ⁰	1		6
23	17	00010111	Alt-0023	^W	(ETB)	✓	✓	✓	✓	✓				A/C ⁰	1		7

Byte Value			Keyboard Entry			Lambda Model								Description				
														Wheel Command			Shutter or Special Command	
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10	10	10	10	S	D	10 only	DG only	F			
						0	0	0	0	0	C	G	W h e e l	S p e e d	M o v e o n C m d. o r S y n c	i l t e r		
24	18	00011000	Alt-0024	^X	(CAN)								A/C [•]	1		8		
															Sync.			
25	19	00011001	Alt-0025	^Y	(EM)								A/C [•]	1		9		
															Sync.			
26	1A	00011010	Alt-0026	^Z	(SUB)										Sync.	10		
27	1B	00011011	Alt-0027	^[	(ESC)											11		
28	1C	00011100	Alt-0028	^\	(FS)											12		
29	1D	00011101	Alt-0029	^]	(GS)											13		
30	1E	00011110	Alt-0030	^^	(RS)											14		
31	1F	00011111	Alt-0031	^_	(US)											15		
32	20	00100000	Alt-0032		(space)								A/C [•]	2		0		
33	21	00100001	Alt-0033		!												1	
34	22	00100010	Alt-0034		“												2	
35	23	00100011	Alt-0035		#												3	
36	24	00100100	Alt-0036		\$												4	
37	25	00100101	Alt-0037		%												5	
38	26	00100110	Alt-0038		&												6	
39	27	00100111	Alt-0039		‘												7	
40	28	00101000	Alt-0040		(										8			
41	29	00101001	Alt-0041		)										9			
42	2A	00101010	Alt-0042		*													
-	-	-	-		-													
47	2F	00101111	Alt-0047		/													
46	30	00110000	Alt-0048		0								A/C [•]	3		0		
49	31	00110001	Alt-0049		1												1	
50	32	00110010	Alt-0050		2												2	
51	33	00110011	Alt-0051		3												3	
52	34	00110100	Alt-0052		4												4	
53	35	00110101	Alt-0053		5												5	
54	36	00110110	Alt-0054		6												6	
55	37	00110111	Alt-0055		7												7	
56	38	00111000	Alt-0056		8										8			
57	39	00111001	Alt-0057		9										9			
58	3A	00111010	Alt-0058		:													
-	-	-	-		-													
63	3F	00111111	Alt-0063		?													
64	40	01000000	Alt-0064		@								A/C [•]	4		0		
65	41	01000001	Alt-0065		A												1	
66	42	01000010	Alt-0066		B												2	
67	43	01000011	Alt-0067		C												3	
68	44	01000100	Alt-0068		D												4	
69	45	01000101	Alt-0069		E												5	

Byte Value			Keyboard Entry			Lambda Model								Description			
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10	10	10	10	S	D	G	Wheel Command			Shutter or Special Command
														10 only	DG only	F i l t e r	
						2	-	C	3	B	C	-	4 / 5	W h e e l	S p e e d	M o v e o n C m d. o r S y n c	
70	46	01000110	Alt-0070		F	✓	✓	✓	✓	✓						6	
71	47	01000111	Alt-0071		G	✓	✓	✓	✓	✓						7	
72	48	01001000	Alt-0072		H	✓	✓	✓	✓	✓						8	
73	49	01001001	Alt-0073		I	✓	✓	✓	✓	✓						9	
74	4A	01001010	Alt-0074		J												
-	-	-	-		-												
79	4F	01001111	Alt-0079		O												
80	50	01000000	Alt-0080		P	✓	✓	✓	✓	✓				A/C •	5		0
81	51	01000001	Alt-0081		Q	✓	✓	✓	✓	✓							1
82	52	01000010	Alt-0082		R	✓	✓	✓	✓	✓							2
83	53	01000011	Alt-0083		S	✓	✓	✓	✓	✓							3
84	54	01000100	Alt-0084		T	✓	✓	✓	✓	✓							4
85	55	01000101	Alt-0085		U	✓	✓	✓	✓	✓							5
86	56	01000110	Alt-0086		V	✓	✓	✓	✓	✓							6
87	57	01000111	Alt-0087		W	✓	✓	✓	✓	✓							7
88	58	01001000	Alt-0088		X	✓	✓	✓	✓	✓							8
89	59	01001001	Alt-0089		Y	✓	✓	✓	✓	✓							9
90	5A	01001010	Alt-0090		Z												
-	-	-	-		-												
95	5F	01011111	Alt-0095		-												
96	60	01010000	Alt-0096		`	✓	✓	✓	✓	✓				A/C •	6		0
97	61	01010001	Alt-0097		a	✓	✓	✓	✓	✓							1
98	62	01010010	Alt-0098		b	✓	✓	✓	✓	✓							2
99	63	01010011	Alt-0099		c	✓	✓	✓	✓	✓							3
100	64	01010100	Alt-0100		d	✓	✓	✓	✓	✓							4
101	65	01010101	Alt-0101		e	✓	✓	✓	✓	✓							5
102	66	01010110	Alt-0102		f	✓	✓	✓	✓	✓							6
103	67	01010111	Alt-0103		g	✓	✓	✓	✓	✓							7
104	68	01011000	Alt-0104		h	✓	✓	✓	✓	✓							8
105	69	01011001	Alt-0105		i	✓	✓	✓	✓	✓							9
106	6A	01011010	Alt-0106		J												
-	-	-	-		-												
111	6F	01011111	Alt-0111		o												
112	70	01110000	Alt-0112		p	✓	✓	✓	✓	✓				A/C •	7		0
113	71	01110001	Alt-0113		q	✓	✓	✓	✓	✓							1
114	72	01110010	Alt-0114		r	✓	✓	✓	✓	✓							2
115	73	01110011	Alt-0115		s	✓	✓	✓	✓	✓							3
116	74	01110100	Alt-0116		t	✓	✓	✓	✓	✓							4
117	75	01110101	Alt-0117		u	✓	✓	✓	✓	✓							5
118	76	01110110	Alt-0118		v	✓	✓	✓	✓	✓							6
119	77	01110111	Alt-0119		w	✓	✓	✓	✓	✓							7
120	78	01111000	Alt-0120		x	✓	✓	✓	✓	✓							8

Byte Value			Keyboard Entry			Lambda Model										Description			
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10	10	10	10	S C	D G	Wheel Command		F i l t e r	Shutter or Special Command			
													10 only	DG only					
													W h e e l	S p e e d	M o v e o n C m d. o r S y n c				
121	79	01111001	Alt-0121		y	✓	✓	✓	✓	✓						9			
122	7A	01111010	Alt-0122		z														
127	7F	01111111	Alt-0127		~														
128	80	10000000	Alt-0128			✓							A	8		0			
							✓						B	0					
129	81	10000001	Alt-0129			✓							A	8		1			
							✓						B	0					
130	82	10000010	Alt-0130			✓							A	8		2			
							✓						B	0					
131	83	10000011	Alt-0131			✓							A	8		3			
							✓						B	0					
132	84	10000100	Alt-0132			✓							A	8		4			
							✓						B	0					
133	85	10000101	Alt-0133			✓							A	8		5			
							✓						B	0					
134	86	10000110	Alt-0134			✓							A	8		6			
							✓						B	0					
135	87	10000111	Alt-0135			✓							A	8		7			
							✓						B	0					
136	88	10001000	Alt-0136			✓							A	8		8			
							✓						B	0					
137	89	10001001	Alt-0137			✓							A	8		9			
							✓						B	0					
138	8A	10001010	Alt-0138																
143	8F	10001111	Alt-0143																
144	90	10010000	Alt-0144			✓							A	9		0			
							✓						B	1					
145	91	10010001	Alt-0145			✓							A	9		1			
							✓						B	1					
146	92	10010010	Alt-0146			✓							A	9		2			
							✓						B	1					
147	93	10010011	Alt-0147			✓							A	9		3			
							✓						B	1					
148	94	10010100	Alt-0148			✓							A	9		4			
							✓						B	1					
149	95	10010101	Alt-0149			✓							A	9		5			
							✓						B	1					
150	96	10010110	Alt-0150			✓							A	9		6			
							✓						B	1					

Byte Value			Keyboard Entry			Lambda Model								Description				Shutter or Special Command
														Wheel Command				
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10-2	10-C	10-3	10-B	S-C	D-G-4/5	10 only		DG only	Filter		
													Wheel	Speed	Move on Cmd. or Sync			
188	BC	10111100	Alt-0188				✓		✓	✓							Close Shutter B	
												✓					Inactivates Turbo-Blanking	
189	BD	10111101	Alt-0189						✓								Batch Start (followed by up to 6 shutter & wheel command bytes, then followed by Batch End)	
190	BE	10111110	Alt-0190						✓								Batch End (ends command byte sequence started by Batch Start)	
191	BF	10111111	Alt-0191															
192	C0	11000000	Alt-0192				✓		✓				B	4		0		
193	C1	11000001	Alt-0193				✓		✓							1		
194	C2	11000010	Alt-0194				✓		✓							2		
195	C3	11000011	Alt-0195				✓		✓							3		
196	C4	11000100	Alt-0196				✓		✓							4		
197	C5	11000101	Alt-0197				✓		✓							5		
198	C6	11000110	Alt-0198				✓		✓							6		
199	C7	11000111	Alt-0199				✓		✓							7		
200	C8	11001000	Alt-0200				✓		✓							8		
201	C9	11001001	Alt-0201				✓		✓							9		
202	CA	11001010	Alt-0202									✓					Selects Triggered By Strobe Line As The Ring Buffer Mode	
203	CB	11001011	Alt-0203									✓					Deselects Triggered By Strobe Line	
204	CC	11001100	Alt-0204						✓	✓	✓						Status	
											✓	Selects Triggered By Video Synch As The Ring Buffer Mode						
205	CD	11001101	Alt-0205									✓					Deselects Triggered By Video Sync	
206	CE	11001110	Alt-0206						✓	✓	✓						All Motors Power On	
											✓	Selects Triggered By Video Sync Gated By Strobe Line As The Ring Buffer Mode						
207	CF	11001111	Alt-0207						✓	✓	✓						All Motors Power Off	
											✓	Deselects Triggered By Video Sync Gated By Strobe Line As The Ring Buffer Mode						
208	D0	11010000	Alt-0208				✓		✓				B	5		0		
209	D1	11010001	Alt-0209				✓		✓							1		
210	D2	11010010	Alt-0210				✓		✓							2		
211	D3	11010011	Alt-0211				✓		✓							3		
212	D4	11010100	Alt-0212				✓		✓							4		

Byte Value			Keyboard Entry			Lambda Model								Description				
														Wheel Command			Shutter or Special Command	
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10-2	10-C	10-3	10-B	S-C	D-G-4/5	10 only		DG only	Filter		
													Wheel	Speed	Move on Cmd. or Sync			
213	D5	11010101	Alt-0213				✓		✓								5	
214	D6	11010110	Alt-0214				✓		✓								6	
215	D7	11010111	Alt-0215				✓		✓								7	
216	D8	11011000	Alt-0216				✓		✓								8	
217	D9	11011001	Alt-0217				✓		✓								9	
218	DA	11011010	Alt-0218									✓						Freeze Display
219	DB	11011011	Alt-0219									✓						Turn Display On
220	DC	11001100	Alt-0220						✓	✓	✓							SmartShutter Fast mode
221	DD	11001101	Alt-0221						✓	✓	✓							SmartShutter Soft mode
222	DE	11001110	Alt-0222						✓	✓	✓							SmartShutter Neutral Density Mode
223	DF	11011111	Alt-0223				✓		✓									Batch Transfer (followed by 2 shutter & 2 wheel commands)
											✓						Start Loading Ring Buffer	
224	E0	11100000	Alt-0224				✓		✓				B	6			0	
225	E1	11100001	Alt-0225				✓		✓								1	
226	E2	11100010	Alt-0226				✓		✓								2	
227	E3	11100011	Alt-0227				✓		✓								3	
228	E4	11100100	Alt-0228				✓		✓								4	
229	E5	11100101	Alt-0229				✓		✓								5	
230	E6	11100110	Alt-0230				✓		✓								6	
231	E7	11100111	Alt-0231				✓		✓								7	
232	E8	11101000	Alt-0232				✓		✓								8	
233	E9	11101001	Alt-0233				✓		✓								9	
234	EA	11101010	Alt-0234									✓						Start Remote Change Of N.D. Setting
235	EB	11101011	Alt-0235									✓						Increase Value Of Galvo DAC
236	EC	11101100	Alt-0236									✓						Decrease Value Of Galvo DAC
237	ED	11101101	Alt-0237									✓						End N.D. Adjustment And Save
238	EE	11011110	Alt-0238			✓	✓		✓	✓	✓	✓						Set controller to On Line
239	EF	11011111	Alt-0239						✓	✓								Set controller to Local (off line)
240	F0	11110000	Alt-0240				✓		✓				B	7			0	
											✓						End Loading Ring Buffer	
241	F1	11110001	Alt-0241				✓		✓				B	7			1	
											✓						Run From Ring Buffer	
242	F2	11110010	Alt-0242				✓		✓				B	7			2	
											✓						End Run From Ring Buffer	
243	F3	11110011	Alt-0243				✓		✓				B	7			3	
244	F4	11110100	Alt-0244				✓		✓								4	

Byte Value			Keyboard Entry			Lambda Model								Description				
														Wheel Command			Shutter or Special Command	
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	10	10-	10-C	10-3	10-B	SC	DG-4/5	10 only		DG only	Filter		
													Wheel	Speed	Move on Cmd. or Sync			
245	F5	11110101	Alt-0245				✓		✓								5	
246	F6	11110110	Alt-0246				✓		✓								6	
247	F7	11110111	Alt-0247				✓		✓								7	
248	F8	11111000	Alt-0248				✓		✓								8	
249	F9	11111001	Alt-0249				✓		✓								9	
250	FA	11111010	Alt-0250								✓						Lead byte for special Lambda SC commands (see detailed table): •Set delay/exposure timers •TTL trigger/sync. controls •Save/restore configurations •Free-run repeat cycles	
251	FB	11111011	Alt-0251						✓	✓	✓						Reset	
252	FC	11111100	Alt-0252						✓								Wheel C First Byte (See Note 1)	
253	FD	11111101	Alt-0253						✓	✓	✓						Get Controller Type & Configuration	
254	FE	11111110	Alt-0254															
255	FF	11111111	Alt-0255															

NOTE 1: In the Lambda series (except the 10, DG-4/5, and SC), Bit 7 of the command byte is used to select the filter wheel (A, B, or C), as follows:

- **Lambda 10:** Bit 7 is the most significant bit of the upper nibble of the command byte; all four bits of which are used to define speeds 0 through 9.
- **Lambda 10-C and 10-B:** Bit 7 must always be set to 0, since only one wheel is supported.
- **Lambda 10-2:** Bit 7 is set to 0 for Wheel A and 1 for Wheel B.
- **Lambda 10-3:** Bit 7 is set to 0 for Wheel A or C, and to 1 for Wheel B. When selecting Wheel C, the entire encoded filter wheel command byte must be preceded by a byte containing the value of 252 decimal (FC hexadecimal, 11111011 binary).

NOTE 2: The “ASCII char.” column for codes 128 through 255 (80 through FF hex) is left blank, since there are no ASCII character definitions for the codes in this range. However, many computers and operating systems do support characters within this range, but there is no single standard across all platforms. Furthermore, many operating systems, such as Microsoft Windows and Apple Mac OS X, have several “code pages” (character sets), many of which are country/language specific, from which the user can select. Therefore, this part of the table is left blank – if you wish, you may write in the characters defined in the character set you use on a regular basis.