SUTTER INSTRUMENT

Lambda 10-B Optical Filter Changer System
External Control Quick Reference

Rev. 1.02 (20190605)

Table 1. Commands.

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

Byte Value			Keyboard Entry			Filter Wheel Command			Description
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	Wheel	Speed	Filter	Shutter or Special Command
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		@			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	A	4	4	
69	45	01000101	Alt-0069		E			5	
70	46	01000110	Alt-0070		F			6	
71	47	01000111	Alt-0071		G			7	
72	48	01001000	Alt-0072		H			8	
73	49	01001001	Alt-0073		I			9	
74	4A	01001010	Alt-0074		J				
-	-	-	–		–				
79	4F	01001111	Alt-0079		O				
80	50	01000000	Alt-0080		P			0	
81	51	01000001	Alt-0081		Q			1	
82	52	01000010	Alt-0082		R			2	
83	53	01000011	Alt-0083		S			3	
84	54	01000100	Alt-0084		T	A	5	4	
85	55	01000101	Alt-0085		U			5	
86	56	01000110	Alt-0086		V			6	
87	57	01000111	Alt-0087		W			7	
88	58	01001000	Alt-0088		X			8	
89	59	01001001	Alt-0089		Y			9	
90	5A	01001010	Alt-0090		Z				
-	-	-	–		–				
95	5F	01011111	Alt-0095		_				
96	60	01010000	Alt-0096		`			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	A	6	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			0	
113	71	01110001	Alt-0113		q			1	
114	72	01110010	Alt-0114		r	A	7	2	
115	73	01110011	Alt-0115		s			3	
116	74	01110100	Alt-0116		t			4	

	Byte Value		Keyboard Entry			Description			
						Filter Wheel Command			
Dec.	Hex.	Binary	Alt-keypad entry	Ctrl-char.	ASCII def./-char.	Wheel	Speed	Filter	Shutter or Special Command
117	75	01110101	Alt-0117		u			5	
118	76	01110110	Alt-0118		v			6	
119	77	01110111	Alt-0119		w			7	
120	78	01111000	Alt-0120		x			8	
121	79	01111001	Alt-0121		y			9	
122 - 127	7A - 7F	01111010 - 01111111	Alt-0122 – Alt-0127		z – ~				
128 - 169	80 - A9	10000000 - 10101001	Alt-0128 – Alt-0169						
170	AA	10101010	Alt-0170						Open Shutter A [*]
171	AB	10101011	Alt-0171						Open Shutter A conditionally [*]
172	AC	10101100	Alt-0172						Close Shutter A [*]
173 - 185	AD - B9	10101101 - 10111001	Alt-0173 – Alt-0185						
186	BA	10111010	Alt-0186						Open Shutter B [*]
187	BB	10111011	Alt-0187						
188	BC	10111100	Alt-0188						Close Shutter B [*]
189 - 203	BD - CB	10111101 - 11001011	Alt-0189 - Alt-0203						
204	CC	11001100	Alt-0204						Status
205	CD	11001101	Alt-0205						
206	CE	11001110	Alt-0206						All motors power on [*]
207	CF	11001111	Alt-0207						All motors power off [*]
208 - 219	D0 - DB	11000000 - 11011011	Alt-0208 – Alt-0219						
220	DC	11011100	Alt-0220						Fast mode
221	DD	11011101	Alt-0221						Soft mode
222	DE	11011110	Alt-0222						Neutral density mode
223 - 237	DF - ED	11011111 - 11011101	Alt-0223 – Alt-0237						
238	EE	11101110	Alt-0238						On Line
239	EF	11101111	Alt-0239						Local
240 - 250	F0 - FA	11110000 - 11111010	Alt-0240 – Alt-0250						
251	FB	11111011	Alt-0251						Reset
252	FC	11111100	Alt-0252						
253	FD	11111101	Alt-0253						Get controller type & configuration [*]
254	FE	11111110	Alt-0254						
255	FF	11111111	Alt-0255						

NOTE 1: All commands indicated with "*" are not available in early versions of the Lambda 10-B (those prior to Revision D).

NOTE 2: The Lambda 10-B supports only one filter wheel (Wheel A). Therefore, Bit 7 should always be set to 0.

NOTE 3: The "ASCII def./char." column for codes 128 through 255 (80 through FF hex) is left blank, since there are no ASCII character definitions for the codes in this range. However, many computers and operating systems do support characters within this range, although there is no single standard across all platforms. Furthermore, many operating systems, such as Microsoft Windows and Apple Mac OS X, have several "code pages" (character sets), many of which are country/language specific, from which the user can select. Therefore, this part of the table is left blank – if you wish, you may write in the characters defined in the character set you use on a regular basis.

Table 2. Filter command structure.

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

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

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

... where *speed* = 0 through 7 and *position* = 0 through 9. The Wheel Bit is not included in the formula because in the Lambda 10-B it is always set to 0 (Wheel A).

Table 3. "Get Status" command return data in a "Wheel & Shutter" configuration.

Total Num. Bytes	Category	Byte Offset	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
5 or 6*	Command echo	0		204 CC 11001100	"Get Status" command echoed back.
	Filter wheel state	1	Wheel, Speed and Position	0 0 0xxx xxxx	Filter Wheel (Bit 7): Always 0 for Wheel A.
				0-7 N/A x000 xxxx – x111 xxxx	Speed (Bits 6, 5, & 4): 0 – 7.
				0 - 9 0 - 9 xxxx 0000 – xxxx 1001	Position (Bits 3, 2, 1, & 0): 0 – 9
			Error or no filter wheel installed	10 0A 00001010	Either no filter wheel is installed or there is an error on the 15-pin wheel port.

Total Num. Bytes	Category	Byte Offset	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
	Shutter open/closed state	2	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.
	SmartShutter mode (1 or 2 bytes)	3	SmartShutter not connected	219 DB 11011011	Indicates that no SmartShutter is connected. Either no shutter is connected or a Vincent shutter is connected.
			Fast mode	220 DC 11011100	Indicates that the SmartShutter is in fast mode.
			Soft mode	221 DD 10111011	Indicates that the SmartShutter is in soft mode.
			Neutral Density mode	222 DE 10111100	Indicates that the SmartShutter is in neutral-density mode.
		(4)*	Number of microsteps for neutral density mode.	1 – 144 01 – 90 00000001 - 10010000	Number of microsteps (1 – 144) for neutral density mode. **NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)).**
	Return data terminator	4 or (5)*		13 0D 00001101	ASCII CR (carriage return).

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

Table 4. "Get Status" command return data in a "Dual-SmartShutter" configuration.

Total Num. Bytes	Category	Byte Offset	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
8, 9, or 10	Command echo	0		204 CC 11001100	"Get Status" command echoed back.

Total Num. Bytes	Category	Byte Offset	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
	Shutter A open/closed state	1	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.
	Shutter B open/closed state	2	Open	186 BA 10111010	Shutter B is in the open state.
			Closed	188 BC 10111100	Shutter B is in the closed state.
	Shutter A mode (SmartShutter only)	3	SmartShutter A not connected	219 DB 11011011	Indicates that no SmartShutter is connected to Port A. Either no shutter is connected or a Vincent shutter is connected.
			Fast	220 DC 11011100	Indicates that SmartShutter A is in the fast mode.
			Soft	221 DD 10111011	Indicates that SmartShutter A is in the soft mode.
			Neutral Density	222 DE 10111100	Indicates that SmartShutter A is in the neutral-density mode.
		4	Device A designator	1 01 00000001	Designates Shutter A
		5	Number of microsteps for Neutral Density	1 – 144 01 – 90 00000001 - 10010000	A third byte contains the number of microsteps (1 – 144). **NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter A Mode is set to Neutral Density (Offset 3 = 222 (0xDE)).**
	Shutter B Mode (SmartShutter only)	5 or 6	SmartShutter B not connected	219 DB 11011011	Indicates that no SmartShutter is connected to Port B. Either no shutter is connected or a Vincent shutter is connected.
			Fast	220 DC 11011100	Indicates that SmartShutter B is in the fast mode.
			Soft	221 DD 10111011	Indicates that SmartShutter B is in the soft mode.

Total Num. Bytes	Category	Byte Offset	Sub Category	Value (Decimal, hexadecimal, & binary)	Description
		6 or 7	Neutral Density	222 DE 10111100	Indicates that SmartShutter B is in the neutral-density mode.
			Device B designator	2 02 00000010	Designates Shutter B
		7 or 8	Number of microsteps for Neutral Density	1 – 144 01 – 90 00000001 - 10010000	Number of microsteps (1 – 144) for Neutral Density. **NOTE: The number of neutral density microsteps is present at this byte offset only if Shutter B Mode is set to Neutral Density (Offset 5 or 6 = 222 (0xDE)).**
	Return data terminator	7, 8, or 9		13 0D 00001101	ASCII CR (carriage return).

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

Table 5. "Get Controller Type and Configuration" command return data in a <u>wheel & shutter</u> configuration.

Total num. bytes	Category	Byte Offset	Length	Value (Decimal, hexadecimal, & binary)	ASCII Character Sequence	Description
14	Command echo back	0	1	253_{10} FD_{16} 11111101_2	ý	"Get Controller Type & Configuration" command echoed back. *
	Controller Type	1	4		10-B	Lambda 10-B **
	Filter Wheel Type	5	4		W-25	25 mm
					W-32	32 mm
					W-HS	High Speed
					W-BD	Belt Driven
					W-NC	Not Connected
					W-ER	Error
	Shutter Type	9	4		S-IQ	SmartShutter
					S-VS	Vincent Shutter (or no shutter connected)
	Command return data terminator	13	1	13_{10} $0D_{16}$ 00001101_2	<CR>	ASCII CR (carriage return).

Table 6. "Get Controller Type and Configuration" command return data in a <u>dual-SmartShutter</u> configuration.

Total num. bytes	Category	Byte Offset	Length	Value (Decimal, hexadecimal, & binary)	ASCII Character Sequence	Possible Values
16	Command echo back	0	1	253_{10} FD_{16} 11111101_2	ý	"Get Controller Type & Configuration" command echoed back. *
	Controller Type	1	4		10-B	Lambda 10-B **
	Shutter A Type	5	5		SA-IQ	1st SmartShutter (A)
	Shutter B Type	10	5		SB-IQ	2nd SmartShutter (B)
	Command return data terminator	15	1	13_{10} $0D_{16}$ 00001101_2	<CR>	ASCII CR (carriage return).

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

**NOTE: Other Sutter Instrument Lambda-series instruments can be configured by the user to identify themselves as "10-B"so they can be treated as compatible by existing software. These instruments are: Lambda XL and Lambda VF series. With the Lambda XL, the data returned by the "Get Controller Type & Configuration" and "Get Status" commands are identical to an actual Lambda 10-B, with the exception that "Controller Type" in the previous two tables can be either "10-B" or "LBXL". In the case of the Lambda VF series, the data returned by both commands differs

considerably from what is returned by an actual Lambda 10-B, and differences further exist between Lambda VF series models (Lambda VF-5, Lambda VF-1 (Single-Channel configuration), and Lambda VF-1 (Dual-Channel configuration). It is strongly recommended to anyone writing code to identify a connected Lambda 10-B that the exceptions just discussed are considered so as to avoid confusing an actual Lambda 10-B from a Lambda VF-5 or VF-1 that is configured to appear as a Lambda 10-B. Please consult the manual for the Lambda VF-5 or VF-1 for specifics of the data structures returned by both commands.