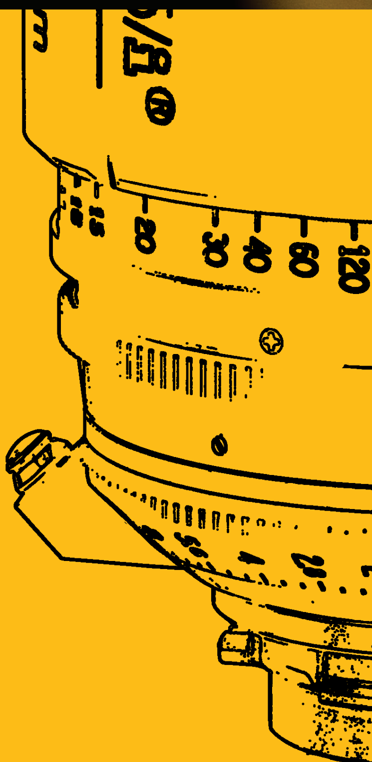

Cooke /i Lens Manual
Part II

Cooke /i Lens Types and Hardware

2021

cookeoptics.com

Cooke Optics /i Technology
Part II – /i Protocol
Cooke /i Lens Manual

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Contents

Cooke Optics /i Lens System Components

1.1 Lens System Overview

The Cooke /i Technology lens system contains resistance elements to sense ring positions, an electronics board to process and calculate lens information, and one or two serial communications interfaces to receive and send commands and data to a camera and/or other external device. Cooke 5/i lenses also have two sets of LEDs used to illuminate the focus scale. The LEDs are connected to a secondary electronics interface board.

The lens electronics board has a communication interface which connects directly to the camera and may also have a second communication interface that can be connected to an external device such as a monitor, recorder or External Data Source Unit. The camera interface operates at TTL levels and the external interface operates at RS232 levels. Each communication interface provides power supply and serial transmit and receive lines through separate 4 way connectors.

1.2 Potentiometer Connections

Cooke Prime lenses house two sensor resistance elements with wipers to sense the ring positions for focus and aperture. Cooke Zoom lenses house three sensor resistance elements, with wipers to sense the ring positions of focus, aperture and zoom. The lens electronics board connects to the resistance elements using one connector for Prime lenses and two connectors for Zoom lenses. They are supplied with power from the board and the wiper signals are fed back to the board for sensing. These current settings are interpreted using analog inputs which have 12 bit resolution. (Some of the earliest S4/i lenses had only 10 bit resolution.)

1.3 Illumination Ring

The 5/i Prime lens logic boards have an additional 4-way connector which connects to a secondary electronics board via a cable. This connector carries power plus 2 PWM current sinking signals to control the two sets of LED's and provide scale illumination. Lighting control instructions are described in Section 5.

1.4 Inertial Components

Lenses with /i2 and /i3 Technology have a 3D digital linear acceleration sensor, a 3D digital magnetic sensor and a 3D digital angular rate sensor. Sensor calibration is performed at the factory when the lenses are built. The inertial calibration coefficients are constant values unique to each lens. This data is necessary for processing of the inertial data and should be retrieved once and stored with the fixed lens metadata.

1.5 Shading and Distortion Data

The newest Cooke lenses with /i3 Technology have shading data and distortion data. The distortion data is unique to each individual lens and must be measured at the Factory. Shading and distortion data is stored in the lens and a copy of the data is made available on the Cooke website at https://cookeoptics.com/i/itech.html. The distortion and shading data can be used to speed up post processing and VFX workflows.

The Lens Metrology Database Public API.pdf document could be helpful for anyone writing plugins to automatically list and pull lens shading and distortion information.

Cooke /i System Communications

2.1 Basic Communications Format

Standard serial communication is 8 bit data without parity, 1 stop bit, in ACSII format. The lens also transmits a packed binary format response when requested, using the 8 bit no parity format, to reduce the time taken to transmit data from the lens.

Inertial data, distortion map and illumination data is transmitted using pre-defined binary data packets described in Part I.

The camera or external unit will initiate all data transfers from the lens except during Power-Up. At Power-Up, a single automatically generated string is transmitted by the lens to both channels indicating that a power-up has occurred.

All commands sent to the lens must be in ASCII format and terminate with a carriage-return character [c/r]. The carriage return character has hex value “0x0D”. Lens reply responses in ASCII format terminate with the character pair, linefeed followed by carriage return [l/f][c/r]. The linefeed carriage return pair have hex values “0x0A” and “0x0D”.

2.2 Communicating with an /i Lens

Most Cooke /i lenses have two communications channels. Cooke miniS4/i lenses have one communication channel.

Power inputs on both /i communication channels are monitored at startup and during operation to determine which channel has control. Lenses that have a single communication channel will be controlled by the camera interface. For most other /i lenses, the two channels function independently and can both receive commands and send replies at different baud rates. The exception is with older S4/i Prime and CXX Zoom lenses with older electronics boards (without inertial sensors), whose channels do not function independently. For these lenses, if power is present on the external interface, then the external interface is granted control. If power is not present on the external interface, then the camera is granted control. S4/i lenses with older electronics boards (installed prior to 2016) can receive commands on only one channel, but responses will be sent out on both channels.

Typically, a lens will start-up at a baud rate of 115k2 and send the *powerupstring*, <[l/f][c/r/], (less-than symbol followed by a linefeed and carriage return), when power is on. The lens will then wait for one second to receive an N (or NN) command from a controlling channel. If this command is not received within one second, the baud rate will drop to 9600 and the lens will issue a new power up string of <[l/f][c/r/]. The lens then waits until the N or NN command is received. The lens <u>must</u> receive an N or NN command as the first command. Once the lens has received and responded to this command, all other commands (valid for that lens type) are available to the controlling channel(s). For example, the Kbn command can be sent to the lens to revise the baud rate.

2.2.1 Connecting an /i Lens to an /i Camera

Cameras which are /i Technology compliant can automatically retrieve and record key lens data for each frame through the four contact pins built into the PL mounts. The extent of camera data made available is the choice of the camera manufacturer via their software, so check with the camera manufacturer for details. Cameras use different film sizes or Circle of Confusion values. The lens' default film size is 35 mm with Circle of Confusion value equal to 0.0250 mm. You can use the V, W or Wnn command to set the appropriate film size to match any camera. See Core commands in Part I for details.

2.2.2 External Remote Readout of /i Lens Data

Continuous remote readout of the precise lens data can be obtained by connecting the lens to an external device such as the Cinematography Electronics /i Lens Display Unit or Ambient MasterLockit box. Lens metadata can be displayed and recorded on an externally connected /i compatible monitor, such as a Transvideo's Starlite HD.

2.2.3 Cooke Lenses: Serial Numbers with /i, /i2 and /i3 Technology

Please note changes to the serial number formatwith **/i2** and **/i3** Technology Lenses with /i2 & /i3 Technology will use serial number format "NFFF.xxxx" using a period instead of a dash in the middle. Cooke /i lenses that are upgraded with new /i2 & /i3 Technology boards will have serial numbers stored in memory in the new format even though the engraved serial numbers on the lens body remain in the "NFFF-xxxx" format. The N command response for S4/i lenses equipped with the newer boards, will now match the N command response for all other Cooke lenses.

Important Note: The first character in the serial number is often used by /i compatible equipment to identity lens manufacturer.

2.3 Power

Power can be supplied to the lens through either the camera connector or an external connector (if available) or both. The maximum voltage which can be supplied on either connector is 35V (DC). Minimum voltage to run older /i boards is 8 volts and minimum voltage to run /i2 and /i3 boards is 5 volts.

/i Lens Power Consumption [older boards without inertial sensors]					
Voltage	S4/i(mA)	5/i (mA)	5/i (mA)	Anamorphic/i (mA)	miniS4/i (mA)
		Lights Off	Lights On		
10	32	49	80	49	64
12	32	49	80	49	64
14	33	49	80	49	64
16	33	49	80	49	64
18	33	50	80	50	64
20	33	50	80	50	64
22	33	50	80	50	64
24	34	50	81	50	64
26	34	50	81	50	64
28	34	50	81	50	64
30	34	51	81	51	64
32	34	51	81	51	64

/i2 - /i3 Lens Power Consumption			
Voltage	5/i (mA)	5/i (mA)	S4/i, Anamorphic/i, S7/i, PANCHRO/i, AnamorphicFF/i (mA)
	Lights off	Lights On	
10	26	67	26
12	22	67	22
14	19	63	19
16	17	57	17
18	16	51	16
20	15	46	15
22	14	43	14
24	13	40	13
26	12	38	12
28	12	36	12
30	11	34	11
32	11	34	11

2.4 External Data Source Unit (EDSU)

Most Cooke lenses have additional facilities and commands which enable an external device, (called an External Data Source Unit or EDSU,) connected to the lens' external RS232 channel, to perform special operations.

Under normal operation, a command is sent to a lens to request information. The lens generates a data string and sends this information to the camera interface, the external interface or both. This data can then be stored by the camera or external device for post processing. Lenses with EDSU capabilities have the additional facility to collect a data stream from an External Data Source Unit (EDSU) and then append this data to the normally generated data string of the lens. This combined data string is then sent to the camera. At the same time that the EDSU is sending data to the lens, it can also request that the lens send the normal data stream back to it. (Commands and instructions for using the EDSU are described in Part I.)

2.5 /i Lens Types – CORE Commands and EXTENDED Commands

The /i Technology Communication protocol has two main types of commands, CORE commands and EXTENDED commands. See Figure 1 in Part I. CORE commands are used to communicate between different brands of equipment. EXTENDED commands are considered brand specific and are used primarily for updating and testing brand specific firmware.

CORE commands include both "required" and "optional" commands. These commands are available to the public and are detailed in /i documentation available on at www.cookeoptics.com. Brand specific commands, known as EXTENDED commands, are confidential and available only to /i Technology partners who support all required CORE commands.

Users should rely on the CORE command set.

Equipment from a manufacturer who adopts the /i Technology protocols and agrees to implement all required /i CORE commands, can communicate directly with any /i lens. An /i lens accepts specific commands that control the data output, including a continuous mode that can send a constantly updated data stream at up to 285 frames per second. This data can be embedded as metadata. For cameras with /i capability, the data can be stored as metadata with the image file.

When each lens is built, a careful process is undertaken to ensure each individual sensor is calibrated so that the resistance elements map correctly to their respective optical ring markings and inertial sensor coefficients are stored for post processing. This information is stored in the electronics board along with other unique lens characteristics.

A special calibration process is performed at the Cooke Factory to store angle data corresponding to ring marks used by ARRI wcu-4 wireless compact unit. Some older lenses do not have this angle data available.

The newest Cooke /i lenses have shading and distortion data. A lens that has not undergone Cooke's distortion calibration process will not have valid distortion data. Shading and distortion data can be downloaded from the Cooke website by entering a lens serial number if available. https://cookeoptics.com/i/itech.html. The Lens Metrology Database Public API.pdf document could be helpful for anyone writing plugins to automatically list and pull lens information.

A set of EXTENDED commands, unique to Cooke lenses, is used for adding and updating Cooke lens specific firmware and data. These *hidden*commands are considered confidential.

2.5.1 miniS4/i Prime Lenses

miniS4/i Prime lenses have a single channel interface for direct communication with a camera. The start-up baud rate will be 115k2 if an N command is received within one second. If no N command is received within one second, the speed will drop to 9600 baud and the lens will issue a new power up string of <[l/f][c/r]. It will then wait without timeout for an N command. Baud rate can be adjusted using the Kbn command. The CORE commands described in Part I: Sections 5.1 through 5.1.18 are available for miniS4/i lenses.

2.5.2 Older S4/i Prime and CXX 15-40mm Zoom Lenses without inertial sensors

Older S4/i lenses have two communications channels that can operate at baud rates up to 115k2. S4/i lenses without inertial sensors do not have independent channels. These lenses send the same response to both channels and can receive commands only from a single controlling channel. If power is present on the external interface, the external interface takes precedence over the camera interface and will have control. If only one interface supplies power, it will be the controlling channel. If the external interface has control, start-up will be at 115k2 baud and the standard power-on prompt, "< [l/f][c/r]", is sent. If no N command is received within one second the data rate is dropped to 9600 baud and a modified power-up string in sent, "+++<". This is a unique Bluetooth feature built into older S4/i lens only (before /i2 Technology). The modified power-up string doubles as both a Bluetooth initialization prompt, "+++", and a standard start-up prompt. Additional details on establishing a Bluetooth connection are described in Appendix A.2. Baud rate can be adjusted using the Kbn command.

2.5.3 Cooke /i2 and /i3 Lenses

Cooke /i2 & /i3 lenses have two communications channels and can receive commands and send responses on these channels independently. The channels can operate at different baud rates up to 230.4K. Start-up baud rate is at 115k2 on both channels if an N (or NN) command is received within one second from either channel. If no N (or NN) command is received within one second, the speed will drop to 9600 baud and the lens will issue a new power up string of <[l/f][c/r]. It will then wait without timeout for an N command from either channel. Baud rate can be adjusted using the Kbn command.

There are two unique commands, (OX, OY), associated with a dual marked focus ring on some Cooke lenses. These allow the user to change the Start-Up units to imperial or metric and are described in Part 1 Section 5.1.19-5.1.20. See Part 2 Section 3.2.2 for a more detailed description of the dual marked focus ring.

Under normal operation, a Cooke /i lens will receive commands to generate and then send the requested data string to the camera interface, the external interface or both. This data can be stored by the camera or external equipment for recording and subsequent post processing.

A set of additional functions are available to these lenses which allow them to receive an externally generated data string and then append this received data to the normally generated data stream of the lens before it is sent to the camera. A unit which sends data to an /i lens through its external interface is called an "External Data Source Unit" or EDSU. Operation with an EDSU is described in Part 2 Section 6. Part 1 Section 5.1.23-5.1.27 defines the commands associated with the EDSU functionality.

5/i lenses are equipped with a scale illumination feature not found on any other lenses. The LED's are driven using Pulse Width Modulation to vary the intensity. Intensity settings can be controlled by using the Aperture ring. Part II Section 5 defines commands specific to the 5/i illumination feature.

2.5.4 DigiOptical, Angenieux, Fujinon, Sony, Zeiss, Leitz and Canon Lenses

As /i Technology partners, DigiOptical, Angenieux, Fujinon, Sony, ARRI, Zeiss, Leitz and Canon have agreed to support all required CORE /i Technology commands. Each manufacturer may also have unique EXTENDED command features which are considered hidden to the general user. Depending on the manufacturer, some EXTENDED commands may be available by request to /i Technology partners.

2.6 CORE Command / Response Structure

Communication with a lens is initiated by the Camera or External device and a lens replies with the requested information and/or to acknowledge the command. The only exception to this sequence is at Power-Up. A lens will automatically transmit a data string to each existing channel to indicate a power-up has occurred. The lens will then wait to receive an N command. The lens must receive the N command as its first command, after which all other commands are available to the controlling channel(s).

Each command has a specific lens response. A lens will respond with *the error response string*: "? [L/F][C/R]" to any unrecognized command, unless the *Inhibit Errors* command "Ka" has been issued.

Each of the two communication channels on most /i lenses function independently. Older S4/i lenses without inertial sensors send the same response to both channels and can receive commands only from the controlling channel. For these S4/i lenses, when power is present on the external interface, the external interface will have control. Thus, the camera interface will have control only when there is no power supplied to the external interface. miniS4/i lenses only have one communication channel.

Some commands were introduced with newer firmware versions and may not be available if their firmware has not yet been upgraded. Firmware and Software Version numbers are listed in Part II Appendix B.1. Note that commands to control scale illumination pertain only to 5/i lenses.

2.7 Start-Up Sequence

Most lenses will start-up at a baud rate of 115k2 and send the *powerupstring*, <[l/f][c/r/], (less-than symbol followed by a linefeed and carriage return), when power is detected. The lens will then wait for one second to receive an N command from a controlling channel. If no N command is received within one second, the speed will drop to 9600 baud and the lens will issue a new power up string of <[l/f][c/r]. It will then wait without timeout for an N command from either channel. The lens must receive an N command as the first command. Once the lens has received and responded to this command, all other commands (valid for that lens type) are available to the controlling channel(s). Variations are shown in the table below.

2.7.1 Table: Controlling Channel and Start-up Baud Rate

Lens Type	Interface with Power		Controlling Channel	Start-up Baud Rate
	External	Camera		
miniS4/i - up to 8.02	N/A	YES	Camera	115k2
S4/i – 0.29, 0.39, 1.29, 1.39	YES	YES	External	115k2
S4/i 0.29, 0.39, 1.29, 1.39	YES	NO	External	115k2
S4/i - 0.29, 0.39, 1.29, 1.39	NO	YES	Camera	115k2
S4/i - up to 0.28, 0.38, 1.28, 1.38	YES	YES	External	115k2
S4/i - up to 0.28, 0.38, 1.28, 1.38	YES	NO	External	115k2
S4/i - up to 0.28, 0.38, 1.28, 1.38	NO	YES	Camera	9600
All Cooke /i Lenses with inertial sensors	YES	YES	Both	115k2
All Cooke /i Lenses with inertial sensors	YES	NO	External	115k2
All Cooke /i Lenses with inertial sensors	NO	YES	Camera	115k2

Note: For older S4/i lenses without inertial sensors, both channels do not function independently.

2.7.2 Bluetooth Operation – S4/i Lenses with 1st Generation /i Boards

S4/i lenses with 1st generation /i lens boards (no inertial data) are Bluetooth capable (if the external interface has control), although this feature has been dropped from the rest of the Cooke /i lens' series and has been retired in the next generation S4/i lenses with i boards. If an S4/i lens is controlled by the external interface, its start-up baud rate will be 115k2 and the standard power-on prompt, <[l/f][c/r/], is sent to both channels. The lens will wait for one second to receive an N command from the external channel. If no response is received within one second, the data rate will drop to 9600 baud and a modified power-on string is sent: +++<[l/f][c/r/]. This string doubles as a Bluetooth initialization prompt, "+++" and a standard start-up prompt, "<". The lens at this stage will accept either the N command directly through the external interface or it will enter a series of exchanges to establish a Bluetooth connection. If the N command is received on the external interface, the lens will skip further Bluetooth operation and enter normal startup mode.

If a valid Bluetooth connection is established, the baud rate will remain at 9600 and the lens will wait for the N command. The Baud rate must remain at 9600 once a Bluetooth link is established, so any command to change baud rate at this point will receive the *error response* In the event a Bluetooth connection is not established correctly within one second, the lens will issue a standard startup string (<) and wait until an N command is received from the external interface.

The series of command and responses to establish a Bluetooth communication exchange is outlined in Part 1 Appendix A.2.

Measurement and Calculation Units

3.1 Measured Values and Calculated Values

Cooke /i lenses measure the lens settings (focus, aperture, zoom) and use these values to calculate focal length, hyperfocal distance, near focus distance, far focus distance, horizontal field of view, entrance pupil position, normalized focus distance and normalized zoom setting. Distance values are expressed in either millimeters or in multiples of 0.1 inch with the exception of the Zoom – EFL value, which is always expressed in millimeters. All distances are actual distances measured from the focal plane.

Every Cooke /i lens stores a unique set of calibration tables, individually determined by a special calibration process, and preloaded into the lens before it leaves the Cooke factory. The calibration tables provide reference values that correspond to the focus, aperture and zoom (if applicable) ring. Some lenses are calibrated in both imperial and metric units, while others are calibrated only in metric or only in imperial units. The N and NN command response string provides information to indicate which calibration table(s) is stored in the lens and which units are defaults for display purposes. (See Part 1 Section 5.1)

Users can request metric units (by issuing Command Y) or imperial units (by issuing Command X) regardless of how the lens was calibrated. Note that the two channels on Cooke lenses with inertial sensors function independently while the two channels on S4/i lenses without the inertial data are not independent. These commands will change the display units on both channels for older S4/i lenses but will change only the display units for the channel which issued the command for lenses with fully independent channels.

To make use of the inertial tracking data for VFX, users should retrieve the Inertial Calibration Coefficients using the K61 command or the NN command. See Part 1 Section 5.1.29.

New to /i2 and /i3, lenses can now be calibrated at the factory to store angle data corresponding to each ring position. Commands to retrieve angle data are confidential and available only to /i Partners.

3.2 Start-Up Units – How to Interpret the N Command after Tag Response

3.2.1 Prime & Zoom Lenses

If the value after Tag U in the N command response is an ‘I’, the calibration table stores focus distances in imperial units only. If the value after Tab U is an ‘M’, the calibration table stores focus distances in metric units only. If the value after Tag U is a ‘B’, the calibration table stores focus distances in both imperial and metric units with the default display units set as imperial. If the value after Tag U is a ‘b’, the calibration table stores focus distances in both imperial and metric units with the default display units set as metric.

3.2.2 Cooke Lens Units - Special Start-Up Units Commands

Some Cooke lenses have a dual marked focus ring that can be reversed to show either imperial or metric units. These lenses have been factory calibrated in both imperial and metric units and the factory set Start-Up Units should match the focus ring units.

The Start-Up Units can be checked by issuing the N Command or the OS Command. The value after Tag U for a lens with dual marked focus ring will always be either a ‘B’ or ‘b’, where B indicates the default focus distance values are in imperial units and b indicates the default units are metric. (See also Commands X and Y and specific commands, OS, OX and OY.)

Commands OX and OY switch between the stored imperial and metric calibration tables, change the default units on both channels (by changing the ‘B’ to a ‘b’ or changing the ‘b’ to a ‘B’) which change the display units. Commands X and Y change only the current display units on the channel the command was sent.

Note: miniS4/i® and older S4/i® lenses do not recognize the OX and OY commands.

Baud Rates and Response Times

4.1 Implementation – Cooke /i Lenses without inertial sensors

Message transmission time is affected by the length of the data stream and baud rate. Earlier S4/i Prime and Zoom lenses with 10-bit ADC have slower clock speeds than the later S4/i Primes lenses with 12-bit ADC.

4.1.1 Table: Compare Calculation Time to Lens Type – Older Cooke /i Lenses without /i2 and /i3 Technology

Lens Type	ADC Type	Calculation Time
5/i Prime	ALL	3.2 msec
miniS4/i Prime	ALL	12 msec
S4/i Prime	12-bit	10 msec
S4/i Prime	10-bit	20 msec
S4/i Zoom	12-bit	12 msec
S4/i Zoom	10-bit	12 msec

4.1.2 Table: Compare Repeat Rate (frames/second) to Lens Type – Older Cooke /i Lenses without inertial sensors

Lens Type	Command	Repeat Rate (Frames/sec)		
		Baud Rate 9600	Baud Rate 115200	Baud Rate 230400
5/i Prime	D	11.8	97.1	144.9
	Kd	21.6	140	185
miniS4/i Prime	D	11	53	N/A
	Kd	17	66	N/A
S4/i Prime (12-bit)	D	11	60	N/A
	Kd	19	73	N/A
S4/i Prime (10-bit)	D	9	37	N/A
	Kd	16	42	N/A
S4/i Zoom	D	11	53	N/A
	Kd	17	63	N/A

Lens Type	Command	Repeat Rate (Frames/sec)		
		Baud Rate 9600	Baud Rate 115200	Baud Rate 230400
5/i® Prime-1 channel	C	12.3	147	285.7
	Kc	23.4	277	285.7
5/i® Prime -2 channel	C	12.3	147	263
	Kc	23.4	263	263
miniS4/i® Prime	C	11	53	N/A
	Kc	18	64	N/A
S4/i® Prime (12-bit)	C	11	60	N/A
	Kc	20	75	N/A
S4/i® Prime (10-bit)	C	10	37	N/A
	Kc	17	43	N/A
S4/i® Zoom	C	11	53	N/A
	Kc	18	64	N/A

4.2 Timing on a /i2 & /i3 Board with Firmware Version X.35 & X.75

In this section, “One channel” indicates that a lens receives commands from either the Camera or the External channel only. “Two channels” indicates that the lens receives commands from both channels. (Worst case is when two channels receive commands at the same time. In this case, the second channel waits for the first one to finish, which maximizes processing time.)

Lens command processing time: Calculation time + formatting time

Commands	One channel only	Two Channels
D	3.5ms	7ms
Kd	2.5ms	5ms
Kdi	3ms -6.5ms	5ms-8.5ms

Lens command total response time: The time between camera sending a command and camera receiving the whole lens response.

4.21 Table: Lens total response time and rate of Command D

Baudrate	Total response time(s)		Total response rate	
	One channel	Two channels	One channel	Two channels

115200	0.010270833	0.013770833	97.36308316	72.6172466
230400	0.006885417	0.010385417	145.2344932	96.2888666

4.22 Table: Lens total response time and rate of Command Kd

Command Kd	Total response time(s)		Total response rate	
	One channel	Two channels	One channel	Two channels
115200	0.006319444	0.008819444	158.2417582	113.3858268
230400	0.004409722	0.006909722	226.7716535	144.7236181

The length of the Kdi response varies with the frame rate. This means the Kdi command response times will differ depending on how many inertial packets are included in the response. The table below lists the total response time with the packet numbers.

4.23 Table: Lens total response time and rate of command Kdi for one channel

Commands		Baud rate							
Kdi		115200				230400			
Process time 6.5ms	Packet no	0	2	4	6	0	2	4	6
	Response time (s)	0.011447917	0.020302083	0.02915625	0.038010417	0.008973958	0.013401042	0.01782813	0.022255208
	Response rate	87.35213831	49.25602873	34.29796356	26.30857769	111.4335461	74.6210649	56.09114812	44.93330213

4.24 Table: Lens total response time and rate of command Kdi for two channels

Commands		Baud rate							
Kdi		115200				230400			
Process time 8.5ms	Packet no	0	2	4	6	0	2	4	6
	Response time(S)	0.013447917	0.022302083	0.03115625	0.040010417	0.010973958	0.015401042	0.01982813	0.024255208
	Response rate	74.3609605	44.83886035	32.09628887	24.99349128	91.12482202	64.93067298	50.43341214	41.22825854

Illumination Scale – 5/i Lenses

5.1 Overview

5/i lenses are equipped with two sets of LED's which can controlled to illuminate the scales in low light situations. The brightness level of one set can be altered while the other is OFF, or both sets can be altered in unison. Manual Control of the brightness levels is achieved using the Aperture Ring. The brightness levels can also be controlled remotely by issuing the Kjn or Kkn Commands.

5.1.1 5/i Manual Scale Illumination Instructions

At Power up, the LED's will be OFF and consume minimum power.

To alter the brightness of both sets of LEDs, move the Aperture ring to the aperture setting T22 end-stop and move it away towards T1.4, then repeat that process twice more within 0.5 second.

This will cause the LED's to be set to fully ON for 0.3 sec, then fully OFF for 0.3 sec and then fully ON. The operator can now adjust the desired level by moving the Aperture scale up (towards T22) or down (towards T 1.4). If there is a half second period during which "no change of Aperture setting" is detected, the "set illumination level" is retained. During this illumination setting process, /i lens operations continue to function normally.

To alter the brightness of one set of LEDs, move the Aperture ring to the aperture setting T1.4 end-stop and move it away towards T22, then repeat that process twice more within 0.5 second.

This will cause the LED's to be set to OFF for 0.3 sec, then ON for 0.3 sec, then OFF again. The operator can now adjust the desired level by moving the Aperture scale up (towards T22) or down (towards T 1.4). If there is a half second period during which "no change of Aperture setting" is detected, the "set illumination level" is retained. During this illumination setting process, /i lens operations continue to function normally.

To turn off LEDs, move the Aperture ring to the aperture setting T1.4 end-stop and move it away towards T22, then repeat that process twice more within 0.5 second.

This will cause the LED's to be set to OFF for 0.3 secs, then ON for 0.3 secs, then OFF again. The operator can now wait a half second and the "off-set illumination level" is retained. During this illumination setting process, /i lens operations continue to function normally.

External DATA Source Unit (EDSU)

6.1 Overview

All Cooke Anamorphic /i and 5/i lenses and all Cooke lenses with /i^2 & /i^3 Technology have additional capabilities and commands which enable an external device, (called an External Data Source Unit or EDSU,) connected to the external RS232 channel of the lens, to perform special operations.

Under normal operation, when a command is sent to a lens requesting information, the lens generates a data string and sends this information to the camera interface, the external interface or both. This data can then be stored by the camera or external device for post processing. EDSU capable lenses have the additional facility to collect a data stream from an External Data Source Unit (EDSU) and then append this data to the lens' normally generated data string.

During the "append" operation, the EDSU generated data stream is stored within the lens and then appended to every data block that is sent to the Camera. The EDSU can turn the append operation "ON" and "OFF". The lens has space to store a single EDSU STRING, and this same string is used for every data block until it is updated by the EDSU or the append function terminated. The data rate from the EDSU does not need to match the data rate between camera and lens. If data strings from the EDSU (which are to be appended) arrive slower than the rate of data strings being generated by the lens for the camera, then multiple strings to the camera will have the same EDSU append string added.

At the same time the EDSU is sending data to the lens, it can also request that the lens send the normal data stream back to it.

6.2 Principals of Operation

1. EDSU issues OS command to determine settings for current channel.
2. EDSU issues OT command to determine settings for opposite channel.
3. EDSU establishes format of data and data rate to send to lens.
4. EDSU issues OC command and verifies response from lens. (An internal EDSU buffer for the EDSU data in the lens will be cleared.)
5. Data sent to the opposite (camera) interface will now append the contents of EDSU buffer to the normal data stream. (If buffer remains empty, no data will be appended.)

6. Each time EDSU generates new data, it issues OD command to send data. This data is stored in lens in EDSU buffer. (When new string is received by lens, it replaces existing EDSU contents with new string.)
7. The lens generates data strings at whatever rate is required (single or continuous) and uses the latest EDSU data to append.
8. To terminate the process, the EDSU sends OH command.

EDSU can also request lens operate in Continuous data send mode (ASCII or Binary) so lens data is available to EDSU for use internally or passed through to secondary unit.

9. In this mode, data from lens is mixed with responses from OD commands issued by the EDSU, (response will be first string sent by lens after receipt of any OD command so will not be confused with next continuous data string.)

6.3 EDSU Dependencies – Blocking Requirements for Pass-Through Operation

If EDSU has a secondary unit attached, and it allows commands from the secondary unit to be passed to the lens, (and corresponding response passed back), certain commands should be blocked to prevent corruption of the communication process.

Table 6: Valid Commands - Allowed & Blocked Recommendations with EDSU

Command	Function	Recommendation
B	Retrieve firmware version	Allowed
C	Set Continuous send ASCII data	Allowed (unless EDSU using Kd or Kc)
D	Retrieve single ASCII data string	Allowed (unless EDSU using C or Kd or Kc)
D	Retrieve single ASCII string	Allowed (unless EDSU extracts single block and passes through to secondary unit)
G	Set checksum mode ON	Beware
H	Unset optional modes	Beware
Kbn	Set/Change baud rate	Blocked (unless EDSU follows baud rate change)
Kc	Set continuous send Binary data	Allow (unless EDSU using C or D)
Kd	Request single Binary data string	Allow (unless EDSU using C or D)
Kjn	Set both illumination levels	Allow
Kkn	Set single illumination level	Allow
N	Retrieve Fixed data block	Allow
OC	EDSU only command	Block
OD	EDSU only command	Block
OH	EDSU only command	Block
OS	EDSU only command	Block
OT	EDSU only command	Block

P	Retrieve board temperature	Allow
V	Set/Change film size	Beware (Interlock exists for Camera priority)
Wnn	Change film size	Beware (Interlock exists for Camera priority)
X	Change units to Imperial	Beware
Y	Change Units to Metric	Beware

To avoid potential conflicts that may arise if commands are issued by multiple sources, the EDSU should monitor any commands allowed to pass-through to the lens to verify commands meet lens specifications and do not cause conflict with current EDSU operation.

If the EDSU is not logging data but only generating OD data, then Commands D, C, Kd, Kc can be allowed without conflict. In general, control of film size and data append functions should come from a single source to avoid conflicts. Similarly, changes to Baud rate or checksum mode have “difficult to follow” implication and it may be simpler to block all such commands. To block a command, the EDSU should respond to the command from the secondary device using the standard error response “?[l/f][c/r]”.

The EDSU data string can be made up of any 8 bit values (up to 60 values total) which terminate with the [c/r] character. These can be any 8 bit values except [c/r][l/f]. Care should be taken if the string includes any other ASCII control characters, (Hyperterminal , PuTTY or other data interpretation programs might recognize them as formatting commands and attempt to implement them).

7. Troubleshooting – Possible Errors and How to Fix Them

7.1 Loss of Program – Cooke Lenses without /i^2 Technology

In the unlikely event that a lens experiences a loss of program, the start-up prompt will appear as a @[l/f][c/r] or @x[l/f][c/r] . If this occurs, the lens will need its program to be reloaded. Please contact your service provider.

7.2 Loss of Program – Cooke Lenses with /i^2 and /i^3 Technology

If there is no power-up string from a lens with /i^2 or /i^3 Technology, it will need its program to be reloaded. Please contact your service provider.

Appendix A

A.1 Command/Response VARIATIONS - earlier software versions

Note: You can retrieve the version number by issuing the B command.

A.1.1 D Command Variations:

Retrieve Pre-Defined Set of Calculated Data in ASCII Format

Note: Data length for v0.30 is 62 characters while data length for v0.39 and v4.21 is 76 characters.

S4/i® Prime Lens versions [0.21 – 0.28 (10 bit) 0.34 - 0.38 (12 bit)]

Issue	D[C/R]	Tag = D
Response	D s s s s s s s T a a a a t b b b b b Z f f f f H a a a a a a a N b b b b b b b F c c c c c c c V v v v . v E s e e e S x x x x x x x x x [L/F][C/R]	

Tag	Value	Definition
D	s s s s s s s	actual focus distance – units
T	a a a a	actual Aperture setting
t	b b b b b	calibration ring Aperture value
Z	f f f f	Zoom – EFL (mm)
H	a a a a a a a	HYPERFOCAL setting -units
N	b b b b b b b	NEAR FOCUS distance – units
F	c c c c c c c	FAR FOCUS distance – units
V	v v v . v	Horizontal Field of view - degrees
E	s e e e	Entrance Pupil Position – units [Tag: s is a + or - sign]
S	xxxxxxxxx	Lens Serial Number

Note: The Zoom – EFL value = 0000 for all Prime lenses.

S4/i® Zoom Lens versions up to and including [1.22, 1.30]

Issue	D[C/R]	Tag = D
Response	D s s s s s s s T a a a a t b b b b b Z f f f f H a a a a a a a N b b b b b b b F c c c c c c c V v v v . v E s e e e S x x x x x x x x x [L/F][C/R]	

Tag	Value	Definition
D	s s s s s s s	actual focus distance – units
T	a a a a	actual Aperture setting
t	b b b b b	calibration ring Aperture value
Z	f f f f	Zoom – Effective Focal Length (mm)
H	a a a a a a a	HYPERFOCAL setting -units
N	b b b b b b b	NEAR FOCUS distance – units
F	c c c c c c c	FAR FOCUS distance – units
V	v v v . v	Horizontal Field of view - degrees
E	s e e e	Entrance Pupil Position – units [Tag: s is a + or - sign]
Z	mmm	Normalized Zoom Setting
S	xxxxxxxxx	Lens Serial Number

Note: The normalized zoom setting value resolution was [0.00 to 1.00] for S4/i Zoom lens versions up to and including 1.22, 1.30 and is displayed as 000 to 100. The resolution for all subsequent versions is [0.000 to 1.000] and is displayed as 0000 to 1000.

A.1.2 N Command Variations:

Retrieve Fixed Data in ASCII Format The first command a lens receives must be the N command.

Response for all Anamorphic /i, 5/i, miniS4/i, S7/i, PANCHRO/i Prime lens and for S4/i lenses with /i^2 and /i^3 Technology:

Issue	N[C/R]	Tag = N
Response – Prime Lens	NSs..sssOu..uuuLPNxxxMdddUbTffyyBv.vv [L/F][C/R]	

Response for S4/i Prime lens versions 0.25 – 0.29 (10-bit board) and 0.35 – 0.39 (12-bit board):

Issue	N[C/R]	Tag = N
Response – Prime Lens	NSs..sssOu..uuuLPfxxxNdddUbEseeeBv.vv [L/F][C/R]	

Example:
Issue: N [l/f][c/r]
Response: NS4075-0123OCooke Optics LPf027N077UIE+088B4.22

Response for S4/i Prime lens versions before 0.25 (10-bit board) and 0.35 (12-bit board):

Issue	N[C/R]	Tag = N
Response – Prime Lens	NSs..sssOu..uuuLPfxxxNdddUbEseee y [L/F][C/R]	

Response for S4/i Zoom lens versions 1.26 – 1.29 (10-bit board) and 1.36 – 1.39 (12-bit board):

Issue	N[C/R]	Tag = N
Response – Zoom Lens	NSs..sssOu..uuuLZNxxxMdddUbTff yy Bv.vv [L/F][C/R]	

Example:
Issue: N [l/f][c/r]
Response: NS8000123 OCooke Optics LZN015M040UIT92 B1.39

Response for S4/i Zoom lens in earlier versions:

Issue	N[C/R]	Tag = N
Response – Zoom Lens	NSs..sssOu..uuuLZNxxxMdddUbTff yyy [L/F][C/R]	

Tag	Value	Definition
S	s .. sss	Serial Number – 9 characters
O	u.. uuu	Owner Data – 31 characters
L	t	Lens Type: t=P for Prime, Z for Zoom
N	xxx	Focal length (Primes) or minimum focal length (Zooms)
f	xxx	Focal length - S4/i Prime only Tag = f (instead of N)
M	ddd	unspecified (Primes) or maximum focal length (Zooms)
N or n	ddd	Infinity Nodal distance: N or n indicates sign plus 3 digits-*S4/i Prime only*
s (+/ -)	eee	Entrance Pupil Position: + or – sign plus 3 characters - *S4/i Prime only*
U	b	Start-up units: I=imperial, M=metric, b (metric start) or B (imperial start) [both available]
T	ff	Transmission factor (not yet available in S4/i Primes)
	y..y	SPACE characters
B	v.vv	Firmware version number

A.1.3 Kd Command Variations:

Retrieve Pre-Defined Set of Calculated Binary Data Packets
Response for lens versions BEFORE 0.21, 0.34, .22 and 1.31:

Issue	Kd[C/R]	Tag = d
Response	d s s s s TT t t z z h h h h n n n n f f f f v v e e Z Z [L/F][C/R]	

Response Values	Definition
d	Tag
ssss	Focus Distance
TT	Aperture Value – Actual Aperture Setting
tt	Aperture Ring T Stop Integer x 10 & the 1/10th fraction
zz	Zoom - EFL (mm) [0000 for Prime lenses]
hhhh	Hyperfocal Distance
nnnn	Near Focus Distance
ffff	Far Focus Distance
vv	Horizontal Field of View
ee	Entrance Pupil Position
Z or ZZ	Normalized Zoom Value – (see version #s below for format) [This field not included in these early versions of S4/i® Prime lenses]

Response Values d, sss, TT, tt, zz, hhhh, nnnn, ffff, vv, ee are the same as those described in Section 5.1.3.

Normalized Zoom Value ZZ: (Note: Response depends on Lens Version #)

ZZ: Normalized Zoom Value – 0.000 to 1.000 for S4/i® Zoom versions after 1.21, 1.30.

10 bits in 2 bytes (characters)

ZZ	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	0	0	b09	b08	b07	b06
2nd	0	1	b05	b04	b03	b02	b01	b00

Range: 0 – 1000 for Zoom Lenses
[This field not included in these early versions of S4/i® Prime lenses]

Normalized Zoom Value Z: (Note: Response depends on Lens Version #)

Z: Normalized Zoom Value – 0.00 to 1.00 for S4/i® Zoom versions up to and including 1.21, 1.30

7 bits in 1 byte (character)

Z	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1nd	1	b06	b05	b04	b03	b02	b01	b00

Range: 0 – 100 for Zoom Lenses
[This field not included in these early versions of S4/i Prime lenses]

Response for lens versions AFTER 0.21, 0.34, .22 and 1.31:

Issue	Kd[C/R]	Tag = d
Response	d s s s s TT t t z z h h h h n n n n f f f f v v e e Z Zxxxxxxxxx [L/F][C/R]	

Response Values	Definition
d	Tag
ssss	Focus Distance
TT	Aperture Value – Actual Aperture Setting
tt	Aperture Ring T Stop Integer x 10 & the 1/10th fraction
zz	Zoom - EFL (mm) [0000 for Prime lenses]
hhhh	Hyperfocal Distance
nnnn	Near Focus Distance
ffff	Far Focus Distance
vv	Horizontal Field of View
ee	Entrance Pupil Position
Z or ZZ	Normalized Zoom Value – (see 10 bit and 12 bit ADC versions below for format) [This field not included in these early versions of S4/i Prime lenses]
xxxxxxxxxx	Lens Serial Number [ASCII format]

Response Values d, sss, TT, tt, zz, hhhh, nnnn, ffff, vv, ee are the same as those described in Section 5.1.3.

Normalized Zoom Value ZZ: (Note: Response depends on Lens Version #)

ZZ: Normalized Zoom Value – 0.000 to 1.000 for S4/i Zoom versions after 1.21, 1.30

10 bits in 2 bytes (characters)

ZZ	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	0	0	b09	b08	b07	b06
2nd	0	1	b05	b04	b03	b02	b01	b00

Range: 0 – 1000 for Zoom Lenses
[This field not included in these early versions of S4/i Prime lenses]

Normalized Zoom Value Z: (Note: Response depends on Lens Version #)

Z: Normalized Zoom Value – 0.00 to 1.00 for S4/i Zoom versions up to and including 1.21, 1.30

7 bits in 1 byte (character)

Z	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1nd	1	b06	b05	b04	b03	b02	b01	b00

Range: 0 – 100 for Zoom Lenses
[This field not included in these early versions of S4/i Prime lenses]

A.2 Bluetooth Communication Exchange

The series of command and responses to establish a Bluetooth communication exchange as described in Section 4.7.2.1. [Note: The **string* sent is the lens Serial Number.]

BOARD SENDS:	BLUETOOTH SENDS:
+++< c/r	l/f OK c/r l/f or c/r l/f ERROR c/r l/f
AT c/r	c/r l/f OK c/r l/f or c/r l/f ERROR c/r l/f
ATZ c/r	c/r l/f OK c/r l/f
AT+BTNAME="…**string**…"c/r	c/r l/f OK c/r l/f
AT+BTSCAN c/r	c/r l/f OK c/r l/f followed by: c/r l/f CONNECTED c/r l/f

Appendix B

B.1 Firmware Version Number System

Cooke /i lens Firmware Current Version Numbers

Lens type	/i (10 bit)	/i (12 bit)	1st /i2	2nd /i2	3rd /i2	1st /i3	2nd /i3
			Inertial data	Expanded film size + shading data	Angle data	Distortion data for spherical lenses	Distortion data for anamorphic lenses
S4/i	0.29	0.39	4.21	4.22	4.23	4.33-4.34	4.35
CXX Zoom	1.29	1.39					
5/i		5.03	5.21	5.22	5.23	5.33-5.34	5.35
miniS4/i		8.02					
Anamorphic /i		5.03	9.21	9.22	9.23		9.35
Anamorphic /i SF			9.21	9.22	9.23		9.35
Panchro/i Classic			3.21	3.22	3.23	3.33-3.34	3.35
S7/i			7.21	7.22	7.23	7.33-7.34	7.35
Anamorphic /i 35-140			9.61	9.62	9.63		9.75
Anamorphic /i 45-450			9.81	9.82	9.83		
Anamorphic /i Full Frame Plus					7.63		7.75
Anamorphic /i SF Full Frame Plus					7.63		7.75

Note: Items shown in red have not been released as of this publishing.

The Viewer Software displays both the base firmware and software version numbers. The base firmware defines the board type and is that part of the program code (stored on the electronics board in the lens) which is fully protected and cannot be erased or altered when a new program is uploaded. New firmware is occasional offered by the manufacturer to update data processing facilities in the lens. Uploading new firmware should only be conducted by authorized lens service providers using Cooke software (Program Uploader). This software ensures updates are correctly managed and verified.

Evolution of S4/i Prime 10 bit ADC Upgrade SW Versions

V0.05 to 0.19	Early versions: most do not exist
V0.20	See specification issues up to version 2.22
V0.21	Specification issue 2.23. Addition of Serial number to lens data string
V0.22	Addition of Ka command
V0.22 to 25	skipped
V0.26	Addition of board SW version to end of N command response string
V0.27	Addition of more film formats (Wnn command + modify responses to P & Kbn commands
V0.28	Add CoC values W07 and W08
V0.29	Add dummy normalized zoom to data field & change startup to standardized sequence. Start-up Baud increase from 9600 to 115k2.

Evolution of S4/i Prime 12 bit ADC Upgrade SW Versions	
V0.30/31	See specification issues up to version 2.22
V0.33	Operation as per v0.21
V0.34	Addition of Serial number to lens data string
V0.35	Addition of Ka command
V0.36	Addition of board SW version to end of N command response string
V0.37	Addition of more film formats (Wnn command) + modify responses to P & Kbn commands
V0.38	Add CoC values W07 and W08
V0.39	Add dummy normalized zoom to data field & change startup to standardized sequence. Start-up Baud increase from 9600 to 115k2.

Evolution of S4/i Prime -/i2 and /i3 Technology	
V4.21	New lens board – /i2 Technology includes inertial tracking data
V4.22	/i2 Technology + expanded Film Size list + shading data
V4.23	/i2 Technology + expanded Film Size list + shading data + Angle data
V4.33	/i3 Technology includes spherical distortion data
V4.34	/i3 Technology includes spherical distortion data + NN response - fix camera mount
V4.35	/i3 Technology – improved timing.

Evolution of CXX Zoom 10 bit ADC Upgrade SW Versions	
V1.21	See specification issues up to version 2.22
V1.22	Specification issue 2.23. Addition of Serial number to lens data string + Increase Normalized zoom resolution
V1.23	Addition of Ka command
V1.23 to 25	skipped
V1.26	Addition of board SW version to end of N command response string

V1.27	Addition of more film formats (Wnn command) + modify responses to P & Kbn commands
V1.28	Add CoC values W07 and W08
V1.29	Change startup to standardized sequence. Start-up Baud increase from 9600 to 115k2.

Evolution of CXX Zoom 12 bit ADC Upgrade SW Versions	
V1.30	See specification issues up to version 2.22
V1.31	Specification issue 2.23. Addition of Serial number to lens data string. Increase Normalized zoom resolution. Addition of Ka command
V1.31 to 35	Skipped
V1.36	Addition of board SW version to end of N command response string
V1.37	Addition of more film formats (Wnn commands) Modify responses to P and Kbn commands
V1.38	Add CoC values W07 and W08
V1.39	Change startup to standardized sequence. Start-up Baud increase from 9600 to 115k2.

Evolution of 5/i 12 bit ADC Upgrade SW Versions	
V5.01	Factory Test version with base firmware "b"
V5.02 & 5.03	Software start-up units operation

Evolution of 5/i Prime - /i2 and /i3 Technology	
V5.21	New lens board – /i2 Technology includes inertial data
V5.22	/i2 Technology + expanded Film Size list + shading data
V5.23	/i2 Technology + expanded Film Size list + shading data + Angle data
V5.33	/i3 Technology includes spherical distortion data
V5.34	/i3 Technology includes spherical distortion data + NN response - fix camera mount
V5.35	/i3 Technology – improved timing.

Evolution of miniS4/i [Panchro/i] 12 bit ADC Upgrade SW Versions	
V8.01	Factory Test version
V8.02	Production Release version to spec 2.40

Evolution of Anamorphic /i Prime – 12 bit ADC Version	
V5.03	First release - /i Technology (without inertial data)

Evolution of Anamorphic /i Prime - /i2 and /i3 Technology	
V9.21	New lens board – /i2 Technology includes inertial data
V9.22	/i2 Technology + expanded Film Size list + shading data
V9.23	/i2 Technology + expanded Film Size list + shading data + Angle data
V9.35	/i3 Technology – improved timing. Anamorphic distortion data

Evolution of Anamorphic /i 35-140mm - /i2 and /i3 Technology	
V9.61	New lens board – /i2 Technology includes inertial data
V9.62	/i2 Technology + expanded Film Size list + shading data
V9.63	/i2 Technology + expanded Film Size list + shading data + Angle data
V9.75	/i3 Technology – improved timing. (Zoom distortion data not yet available.

Evolution of S7/i Prime -/i2 and /i3 Technology	
V7.21	/i2 Technology includes inertial tracking data
V7.22	/i2 Technology + expanded Film Size list + shading data
V7.33	/i3 Technology includes distortion data
V7.34	/i3 Technology includes spherical distortion data + NN response - fix camera mount
V7.35	/i3 Technology – improved timing.

Evolution of PANCHRO/i Classic Prime -/i2 and /i3 Technology	
V3.21	/i2 Technology includes inertial tracking data
V3.22	/i2 Technology + expanded Film Size list + shading data
V3.33	/i3 Technology includes distortion data
V3.34	/i3 Technology includes spherical distortion data + NN response - fix camera mount
V3.35	/i3 Technology – improved timing.

Evolution of Anamorphic /i Full Frame Plus Prime -/i2 and /i3 Technology	
V7.63	/i2 Technology + expanded Film Size list + shading data + Angle data
V7.75	/i3 Technology – improved timing. Anamorphic distortion data

Note: Items shown in red have not been released as of this publishing

B.3 /i Accessories

AC Power Supply for /i lenses
with external connector

XLR Power Connection for /i lenses
with external connector

Cooke /i Update Base

/i USB to Serial Cable with lemo connector

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