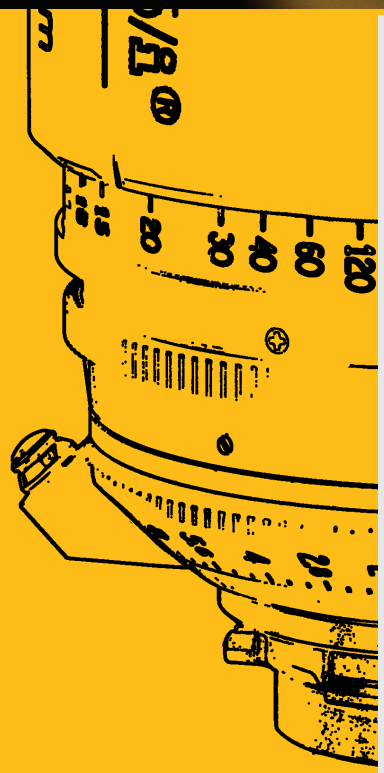
Cooke /i Technology



Cooke /i® Protocol Part I

Lens Hardware, CORE Commands

2021

cookeoptics.com

Cooke Optics /i Technology

Part I – /i Protocol

Hardware, CORE Commands

Date: 2021
Version: 5.0

Contents

Cooke /i® Technology Protocol - Introduction

Cooke Optics Limited developed the /i® Technology system to enable film and digital cameras and equipment to automatically record and display key lens data for every frame shot. Lens metadata includes information such as focal length, focus distance, T-stop, zoom, depth of field, horizontal field of view, entrance pupil position and frame rate. Script supervisors no longer need to manually write down lens setting for every frame shot. Power and data are transmitted through a camera interface, an external interface or both.

Cooke's /i² (/i® Squared) and /i³ (/i® Cubed) Technology metadata systems build on the capabilities of Cooke's /i® Technology. In additional to lens metadata, the newest features

provide inertial tracking data plus shading and distortion mapping. The position and orientation data along with all other lens data will greatly aid VFX teams with their post-production work.

1.1 Purpose

This document describes the Cooke /i® protocol.

Parts I & II are available on the Cooke Optics website and can be downloaded at http://www.cookeoptics.com/s/technicaldocumentation.html. They include the /i® Technology Communications Protocol and a Manual for Cooke lens users. The document is for Lens Technicians, /i® Technology partners and anyone interested in learning more about the /i® Technology protocols.

A Cooke /i® confidential document is available to /i® Technology partners.

1.2 Contact Information

Please email info@cookeoptics.com with questions or if you need additional information.

1.2 References

Cooke /i® Communications Protocols Version V4.0 – April 2016

2. Cooke /i® "Intelligent" Technology Overview

/i® Technology is a registered trademark of Cooke Optics Limited. It is a metadata protocol system that enables cameras and other devices to automatically record key lens data for every frame shot. Equipment identification is by serial number, lens type and manufacturer.

Cooke /i® lenses record lens settings and perform a series of calculations to provide continuous remote readout of focal length, focus distance, aperture, zoom, depth of field, hyperfocal distance, horizontal field of view, entrance pupil position, and normalized zoom in both metric and imperial units. The dynamic information is digitally recorded for every frame and stored as metadata, accessible via cable connector near the lens mount and/or contacts in the PL mount that sync with /i® compatible cameras and other equipment.

/i² (/i® Squared) and /i³ (/i® Cubed) are the most recent additions to /i® Technology. The newest functions include inertial tracking data, distortion and shading map. The shading, distortion, position and orientation data along with all other lens data will greatly aid VFX teams with their post-production work.

/i² and /i³ Technology are backward compatible with the original /i® Technology software. An inexpensive board upgrade is available for Cooke /i® lenses.

2.1 /i® Technology Open Protocol

The goal behind /i® Technology is to provide an open standard that will streamline and enhance the process of filmmaking by making equipment digitally compatible from production through post. Any product that displays the "/i®" logo, from acquisition through post, is compatible with all other /i® Technology embedded products. This means an /i® lens from Cooke can be used with any other products that conform to the /i® Technology standards.

The /i® Technology Communication protocol has two main types of commands, CORE commands and EXTENDED commands. See Figure 1. 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 documentation available on the cookeoptics.com website.

Brand specific commands, known as EXTENDED commands, are confidential. The EXTENDED commands include some PRIVATE commands used internally by each manufacturer as well as a set of EXTENDED commands that are available only to /i® Technology partners.

Users should rely on the CORE command set.

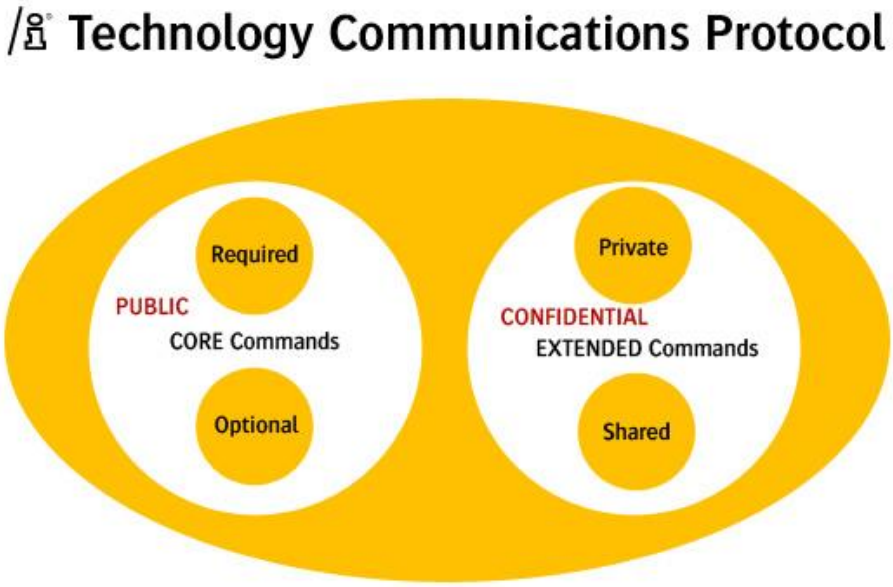


Figure 1

2.2 /i® Technology Partners

Cameras that are /i® equipped talk to /i® lenses directly via contacts in their lens mounts. /i® monitors and recorders that have built-in /i® Technology can display and record lens data in real time, providing a graphic representation of the iris, focus and depth-of-field. Metadata is passed through to VFX tools through cameras or recorders which capture Cooke's /i® metadata. A more extensive list of current /i® Technology partners can be found at https://www.cookeoptics.com/i/itechpartners.html

Table 1: Lens Types with /i® Technology

Note: The first character in the serial number is often used by /i® compatible equipment to identify lens manufacturer. /i® Technology partners should check with Cooke to verify compatibility of their unique lens' serial numbers.

TYPE	SERIAL No.	EXAMPLE
Cooke Optics Lenses (see Section 5.2 SerialNo. format change for /i®²)		
miniS4/i® Prime Lenses	8FFF-xxxx	8025-1234 = miniS4/i® 25mm
S4/i® Prime Lenses	4FFF.xxxx 4FFF-xxxx FF-xxxx	4025.1234 = S4/i® 25mm 4025-1234 = S4/i® 25mm 25-1234 = S4/i® 25mm
5/i® Prime Lenses	5FFF.xxxx 5FFF-xxxx	5025.1234 = 5/i® 25mm 5025-1234 = 5/i® 25mm
S4/i® CXX Zoom Lens	800xxx	800123 = CXX 15-40mm
Anamorphic /i® Prime Lenses	9FFF.xxxx	9025.1234 = Anamorphic /i® 25mm
Anamorphic /i® Zoom Lens	9345.xxxx 9459.xxxx	9345.1234 = 35mm-140mm 9459.1234 = 45mm-450mm
S7/i® Full Frame Plus Prime Lenses	7FFF.xxxx	7025.1234 = S7/i® 25mm
PANCHRO/i® Classic Prime Lenses	3FFF.xxxx	3025.1234 = PANCHRO/i® Classic 25mm
Anamorphic /i® Full Frame Plus Prime Lenses	7FFF.xxxx	7025.1234 = Anamorphic/i® Full Frame 25mm
h ú K Ŝ NJ a l· y˝dz Ŧ l· Ŏ ú dzNJ Ŝ NJ ă Ω [Ŝ y˝ ă Ŝ		
RED Zoom 18-50mm	600xxxx	6001234
RED Zoom 50-150mm	610xxxx	6101234
DigiOptical 18-50mm	620xxxx	6201234
DigiOptical 50-150mm	630xxxx	6301234
Angenieux OPTIMO 15-40mm	AAxxxxxxx	AA1234567
Angenieux OPTIMO 28-76mm	ABxxxxxxx	AB1234567
Angenieux OPTIMO 45-120mm	ACxxxxxxx	AC1234567
Angenieux OPTIMO DP 16-42mm	ADxxxxxxx	AD1234567
Angenieux OPTIMO DP 30-80mm	AExxxxxxx	AE1234567
Angenieux OPTIMO 17-80mm	AFxxxxxxx	AF1234567
Angenieux OPTIMO 24-290mm	AGxxxxxxx	AG1234567
Angenieux OPTIMO STYLE 25-250 (*)	AHxxxxxxx	AH1234567
Angenieux OPTIMO STYLE 16-40mm	AIxxxxxxx	AI1234567
Angenieux OPTIMO STYLE 30-76mm	AJxxxxxxx	AJ1234567
Angenieux OPTIMO 30-72 A-2Smm	AKxxxxxxx	AK1234567
Angenieux OPTIMO 56-152 A-2Smm	ALxxxxxxx	AL1234567
Angenieux OPTIMO 28-340mm	AMxxxxxxx	AM1234567
Angenieux OPTIMO 19.5-94mm	ANxxxxxxx	AN1234567

Angenieux OPTIMO 44-440 A-2S (*)	AOxxxxxxx	AO1234567
Angenieux 42-425 Anamorphic T Series (*)	APxxxxxxx	AP1234567
Angenieux 42-420 A-2S (*)	AQxxxxxxx	AQ1234567
Fujinon 19-90mm	F0700****	F07001234
Fujinon 85-300mm	F0701****	F07011234
Sony F3 35mm	S01Pxxxxx	S01P00001
Sony F3 50mm	S02Pxxxxx	S02P00001
Sony F3 85mm	S03Pxxxxx	S03P00001
Sony F3 Wide Zoom 11-16mm	S04Zxxxxx	S04Z00001
Sony F3 Power Zoom 18-252mm	S05Zxxxxx	S05Z00001
Canon	Qxxxxxxxx	Q93810250
Zeiss	Zxxxxxxxx	Zxxxxxxxx
Panavision	Pxxxxxxxx	Pxxxxxxxx
Leitz	Lxxxxxxxx	Lxxxxxxxx
ARRI	Rxxxxxxxx	Rxxxxxxxx
SIGMA	Gxxxxxxxx	Gxxxxxxxx

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

(*) The Angenieux OPTIMO STYLE 15-35 has internal /i Technology. For other Angenieux lenses, /i technology is supported via external motorization.

Cooke lenses with /i² and /i³ Technology use serial number format “NFFF.xxxx“. [5th character is a “dot”]

Cooke lenses before /i² and /i³ Technology use serial number format “NFFF-xxxx“. [5th character is a “dash”]

3. Hardware

3.1 Interface Requirements

Most Cooke /i® lenses have both a camera communication connector (four contacts built in the PL mount as shown in figure 2) and an external communication connector (figures 3 and 4). The only exception is with miniS4/i® lenses which have a single camera communication interface. Each interface is described in detail below.

3.2 Power

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

3.3 Camera Connector

Signal voltages on the camera interface are at TTL levels where the quiescent state of the data line is a logical high (greater than 2.4 volts).

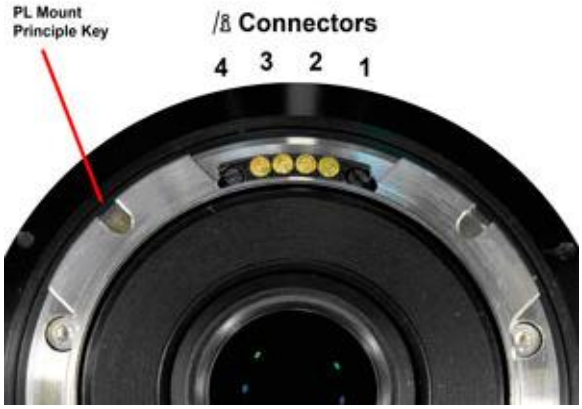


Figure 2: Viewed from rear of lens

Pin 1	Data from Lens	
Pin 2	Data to Lens	
Pin 3	0 volts	Data and Power
Pin 4	+V	Power in

Note: A pull up resistor may be needed to successfully establish communication with an ARRI camera. To detect a lens during start-up, an ARRI camera first applies a 5V test voltage and measures the voltage between RX and TX. If the voltage level is in the range of 10-80% of the applied test voltage, communication is successfully established and the camera switches on the 24V supply voltage. The pull-up resistor value will differ depending on lens hardware. Cooke i lenses use pull-up resistors in the range 300K-400K ohms. Older Cooke I boards do not need a pull-up resistor. In addition, ARRI cameras require the startup time for lens to be less than or within the range 400-500ms after power has been applied.

3.4 External Connector

Signal voltages on external connector are at RS 232 levels (+ and – with respect to 0 volts) where the quiescent state of the data line is at a negative voltage. The external connector is a standard LEMO mechanical connector with 4 pins. Maximum cable length depends on baud rate. (Refer to Table 2 on page 14.)

3.4.1 Standard LEMO Connector

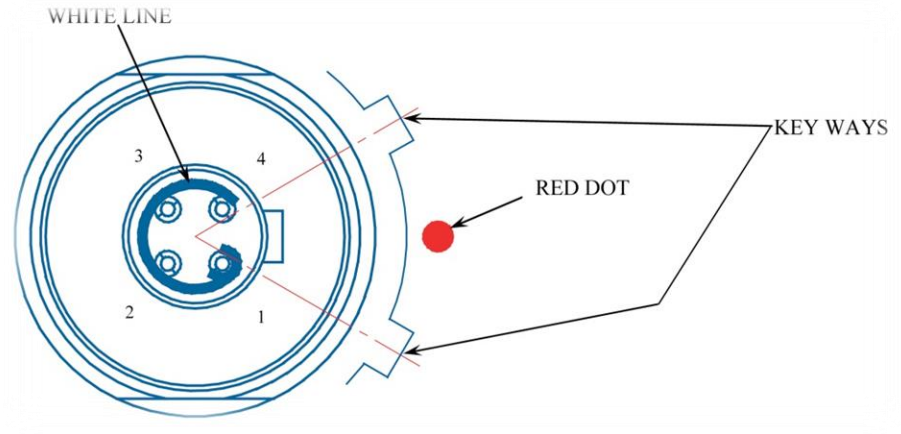


Figure 3: Rear View of LEMO socket EGB00304CLL. (This is the view of the solder buckets and the red dot marker and key way positions indicated for clarity.)

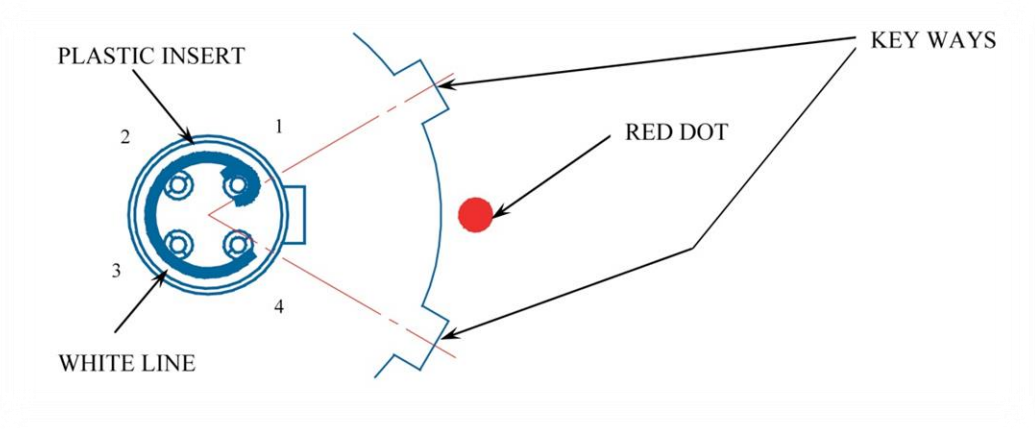


Figure 4:Rear View of LEMO PLUGS FGB00304CLAD35 or FHB00304CLAD35. (This is the view of the solder buckets and the red dot marker and key way positions are indicated for clarity.)

Pin 1	Data from Lens	
Pin 2	Data to Lens	
Pin 3	0 volts	Data and Power
Pin 4	+V	Power in

Table 2: Maximum Cable Length versus Baud Rate

Baud Rate	Max Cable Length
9600	50 meters
19200	30 meters
38400	10 meters
48000	8 meters
57600	5 meters
96000	2 meters
115200	2 meters
230400	0.5 meters

The RS-232 maximum cable length depends upon baud rate.

4. System Communications

4.1 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 shading data is transmitted using pre-defined binary data packets described in Sections 5.1.28 – 5.1.35.

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”.

4.2 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 Sections 5.1.15 – 5.1.17 for details.

4.3 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 (or NN) command. The lens must receive the N (or NN) 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).

Part II describes in more detail the operation of both channels on Cooke /i lenses.

Some commands were introduced with newer firmware versions and may not be available if the firmware has not yet been upgraded. Firmware and Software Version numbers for Cooke /i lenses are listed in Part II, Appendix B.1.

Some commands reference specific lens types (such as commands to control scale illumination which pertain only to 5/i lenses) and are part of the Optional CORE command set.

For a lens to be considered an /i lens, it must respond to all the Required CORE commands such that all the fields of the response have valid data.

The Kdi and K61 commands are only available on lenses equipped with /i² and /i³ Technology. Valid distortion data is available to /i³ lenses that have been calibrated at the factory.

Zeiss Extended commands for lens shading and distortion can be found in a separate document.

Table 3: CORE Command Functions

Number	Command	CORE COMMANDS	Required vs Optional	
1	N	Retrieve Fixed Data – Required first Command	Required	
2	D	Retrieve one set of ASCII Lens Data	Required	
3	Kd	Retrieve one set of Packed Binary Lens Data	Required	
4	K3	Retrieve name of Lens Manufacturer	Optional	xx
5	K4	Retrieve name of Lens Type	Optional	xx
6	P	Retrieve board Temperature	Optional	
7	B	Retrieve board Firmware Version Number	Required	
8	Kbn	Set Baud Rate [default = 115k2 or 9.6k]	Required	
9	C	Set "Continuous Send" mode & begin transmission of ASCII Lens Data	Required	
10	Kc	Set "Continuous Send" mode & Transmit Packed Binary Lens Data	Required	
11	G	Set "Checksum" mode	Required	
12	Ka	Set "Inhibit Error Response" mode	Required	
13	X	Set Display Units to Imperial	Required	
14	Y	Set Display Units to Metric	Required	
15	V	Set "Film Size" to 35mm (default value)	Required	
16	W	Set "Film Size" to 16mm	Required	
17	Wnn	Set "Film Size" to nn (*where nn = 00-31 refers to specified film size/circl of confusion. See chart.*)	Required	
18	H	Stop "Continuous Send"; clear "Checksum"; clear "Inhibit Error Response" mode	Required	
19	OX	Set Start-Up Units to Imperial	Optional	x
20	OY	Set Start-Up Units to Metric	Optional	x
		5 /i SCALE ILLUMINATION COMMANDS Optional		
21	Kjn	Set "Scale Illumination" for both LED sets	Optional	
22	Kkn	Set "Scale Illumination" for one LED set	Optional	
		EXTERNAL INTERFACE COMMANDS [EOptional]		
23	OS	Retrieve Channel Settings for This Channel	Optional	x
24	OT	Retrieve Baud Rate, Data Type, Display Unit for Opposite Channel	Optional	x
25	OC	Commence Append of Data String	Optional	x
26	OD	Append Data String (up to 60 8-bit data values)	Optional	x
27	OH	Halt Append of Data String	Optional	x
		INERTIAL DATA COMMANDS Optional		
28	Kdi	Retrieve Binary Lens Data + Inertial Data	Optional	xx
29	K61	Retrieve Inertial Calibration Coefficients	Optional	xx
30	K8	Retrieve Picture Width	Optional	xx
31	K91	Retrieve Anamorphic Squeeze Factor	Optional	xxxx
		SHADING AND DISTORTION COMMANDS Optional		

32	KKi	Retrieve Lens Shading Data	Optional	xxxx
33	KKd	Retrieve Lens Distortion Map	Optional	xxx
34	KKid	Retrieve Lens Distortion Map and Shading Data	Optional	xxx
35	NN	New Start-up Command (includes Shading & Distortion data if available)	Optional	xxx

x: Not available on older miniS4/i, S4/i and CXX lenses.
xx: These commands are available only for lenses equipped with /i² and /i³ Technology.
xxx: These commands provide valid distortion data if they were properly calibrated for distortion data.
xxxx: These commands were not included in first /i² release.

4.4 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).

Cooke /i lens Variations are shown in Part II.

Basic Lens Response Types

Basic Lens Response	What It Means
< l/f c/r	Standard Power-On
+++< l/f c/r	Look for Bluetooth Initialization – not supported in /i²
^ l/f c/r	Channel temporarily locked out
@ l/f c/r *or* @x l/f c/r	Loss of Program - not supported in /i²
? l/f c/r	Invalid command (Note: Will not be sent if Inhibit Error Command has been issued.)
[Tag].....*data string*..... l/f c/r	Echo command that was sent followed by the requested data.
! l/f c/r	Acknowledge the command was received and implemented.

5. CORE Command Set

5.1 CORE Commands – All Lenses

Commands to a lens are in ASCII format and terminate with a carriage return character. Responses from a lens are in either an ASCII format, a packed binary or a pre-defined binary data packet format and terminate with the character pair, linefeed carriage-return: [l/f][c/r].

5.1.1 N: Retrieve Fixed Data in ASCII Format

Lenses must receive an N (or NN) command as the first command. Once the lens has received and responded to the start-up command, all other commands (valid for that lens type) are available to the controlling channel(s). [See also the NN command described in section 5.1.35 for /i³ lenses.]

Note: Some older lenses (S4/i lenses without /i² or /i³ Technology) have N command responses that vary slightly from what is shown below. Please see Part II, Appendix A.1 for details. All other Cooke /i lenses provide the following N command response. This will remain consistent for all lenses in all future development cycles.

Issue	N[C/R]	Tag = N
Response	NSs..sssOu..uuuLtNxxxMdddUbTffyyBv.vv [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) [Tag=f for S4/i Primes
M	ddd	Unspecified (Primes) or maximum focal length (Zooms)
U	b	Start-up units: I=imperial, M=metric, (b=metric or B=imperial when both available. See commands X,Y,OX,OY)
T	ff	Transmission factor
	yy	2 SPACE characters
B	v.vv	Firmware version number

Example:

Issue: N[c/r]

NS4050.0093OCooke Test Lens Body LPN050M050UIT95 B4.34[l/f][c/r]

Note: The N command returns maximum focal length=999mm (tag M) when the maximum focal length equals or exceeds 999mm.

5.1.2 D: Retrieve Pre-Defined Set of Calculated Data in ASCII Format

Please see Part II- Appendix A.1 for variations in response to D command.

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 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 z m m m m 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	Actual Aperture setting – conventional notation**
Z	f f f f	Zoom – EFL (mm) [0000 for Prime lenses]
H	a a a a a a a a	HYPERFOCAL Setting –units*
N	b 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	mmmm	Normalized Zoom Setting [0000 for Prime lenses]
S	xxxxxxxxx	Lens Serial Number

All distances are actual distances measured from the focal plane.

Example:

Issue: D[c/r]

Response:
D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093[l/f][c/r]

The units* depend on which *Display Units* have been selected. (See commands X and Y) Metric units will be in multiplies of 1mm and Imperial units will be in multiples of 0.1 inch except Zoom-EFL which will always be in mm.

The Actual Aperture setting is a multiple of 0.01 (typical values range from 1.xx to 22.xx) The Actual Aperture setting - conventional notation** is intended for display purposes and follows the ring marks using FULL STOP + n notation to indicate the nearest 1/10th STOP value.

The reference frame size used for the Horizontal Field of View is based on the dimensions for 35mm film and is specified as 12.446mm (24.892/2).

The aperture values returned by the D and Kd commands reflect the actual iris ring position.

The entrance pupil position is measured from the image plane (position of camera sensor or film). It is positive when EPP is in the object direction and negative when it is beyond the image plane.

The zoom values returned by the D and Kd commands reflect the actual zoom ring position.

Values after tags D, H, N and F are 7 digits in range 0000000-9999999, where 9999999 represents infinity.

The electronics will monitor the current potentiometer settings and from these calculate the corresponding Focus Distance (S), T stop setting (T), Aperture display value (t) and current Zoom setting (Z and z). From these values, calculation parameters and other constants the electronics will calculate the Hyperfocal setting (H), Near (N) and Far (F) distances, Horizontal Field of view (V) and Entrance Pupil Position (E) for transmission. The lens serial number is extracted from the FIXED DATA, which is stored at time of Calibration.

5.1.3 Kd: Retrieve one set of Packed Binary Data

Please see Part II- Appendix A.1 for variations in response to Kd command.

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 S x x x x x x x x x[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 Setting
nnnn	Near Focus Distance
ffff	Far Focus Distance
vv	Horizontal Field of View
ee	Entrance Pupil Position
ZZ	Normalized Zoom Value [0000 – 10000] *[This field not included in Prime lenses prior to 0.29 or 0.39*
Sxxxxxxxxx	S followed by Lens Serial Number [ASCII format]

All distances are actual distances measured from the focal plane.

Example:

Issue: Kd[c/r]

Response: d@@L^Jh??@@@A_k@@KG@@NMDQ@W@@S4050.0093[l/f][c/r]

(Typically 41 characters including termination)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
d	@	@	L	^	J	h	▫	▫	@	@	@	A	_	k	@	@	K	G	@	@	N	M	D	Q	@	W	@	@	S
64	40	40	4C	5E	4A	68	B8	85	40	40	40	41	5F	6B	40	40	4B	47	40	40	4E	4D	44	51	40	57	40	40	53

4	0	5	0	.	0	0	9	3	\n	\r
34	30	35	30	2E	30	30	39	33	0A	0D

Response Values Defined as Follows:

Note: None of these 8 bit data patterns correspond to any Control character codes.

Focus Distance:

ssss: Current Focus Distance units [1 mm] or [0.1 inch] depending on Display Units selected.

ssss represents packed binary response - 24 bits in 4 bytes (characters)

ssss	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	b23	b22	b21	b20	b19	b18
2nd	0	1	b17	b16	b15	b14	b13	b12
3rd	0	1	b11	b10	b09	b08	b07	b06
4th	0	1	b05	b04	b03	b02	b01	b00

Range: 0 to (2^24 -1) = 16777215[mm] or 0.0 to (2^24 -1) = 1677721.5[inch]
Infinity: b00 … b23 = 1 (a binary value of all 1's represents infinity)

Aperture Value

TT: Actual Aperture Setting (T Number x 100)

12 bits in 2 bytes (characters)

TT	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	b11	b10	b09	b08	b07	b06
2nd	0	1	b05	b04	b03	b02	b01	b00

Range: 144 to 2560 (1.44 to 25.60)

Aperture Ring T Stop Position

tt: Aperture Ring T Stop Integer x 10 & the 1/10th fraction

12 bits in 2 bytes (characters)

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

Range 1st: 14 to 220 for Integer x 10
Range 2st: 0 – 9 for 1/10th fraction

Zoom - EFL

zz: Current Focal Length in mm for Zoom Lenses and 0 for Prime Lenses

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 1st : 0 – 1023 [mm] for Zoom Lenses
Range 2st: b00 …b09 = 0 for Prime Lenses

Hyperfocal Distance

hhhh: Hyperfocal Distance [1 mm] or [0.1 inch] depending on Display Units selected.

24 bits in 4 bytes (characters)

hhhh	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	b23	b22	b21	b20	b19	b18
2nd	0	1	b17	b16	b15	b14	b13	b12
3rd	0	1	b11	b10	b09	b08	b07	b06
4th	0	1	b05	b04	b03	b02	b01	b00

Range: 0 to (2^^{24} -1) = 16777215[mm] or 0.0 to (2^^{24} -1) = 1677721.5[inch]
Infinity: b00 … b23 = 1 (a binary value of all 1's represents infinity)

Near Focus Distance

nnnn: Near Focus Distance [1 mm] or [0.1 inch] depending on Display Units selected.

24 bits in 4 bytes (characters)

nnnn	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	b23	b22	b21	b20	b19	b18
2nd	0	1	b17	b16	b15	b14	b13	b12
3rd	0	1	b11	b10	b09	b08	b07	b06
4th	0	1	b05	b04	b03	b02	b01	b00

Range: 0 to (2^^{24} -1) = 16777215[mm] or 0.0 to (2^^{24} -1) = 1677721.5[inch]
Infinity: b00 … b23 = 1 (a binary value of all 1's represents infinity)

Far Focus Distance

ffff: Far Focus Distance [1 mm] or [0.1 inch] depending on Display Units selected.

24 bits in 4 bytes (characters)

ffff	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	b23	b22	b21	b20	b19	b18
2nd	0	1	b17	b16	b15	b14	b13	b12
3rd	0	1	b11	b10	b09	b08	b07	b06
4th	0	1	b05	b04	b03	b02	b01	b00

Range: 0 to (2^^{24} -1) = 16777215[mm] or 0.0 to (2^^{24} -1) = 1677721.5[inch]
Infinity: b00 … b23 = 1 (a binary value of all 1's represents infinity)

Horizontal Field of View

vv: Horizontal Field of View in Degrees x 0.1

11 bits in 2 bytes (characters)

vv	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1st	0	1	0	b10	b09	b08	b07	b06
2nd	0	1	b05	b04	b03	b02	b01	b00

Range: 0 to 1800 (0.0 to 180.0)

Entrance Pupil Position

ee: Entrance Pupil Position signed 10 bit value. s=0 for positive, s=1 for negative

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

Range: 0 to 1023 (signed)

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

ZZ: Normalized Zoom Value – 0.000 to 1.000

(See Appendix A.1 for variations in response to Kd command.)

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
b00 …b09 = 0 for Prime Lenses

5.1.4 K3: Retrieve Name of Lens Manufacturer

Note: Lens will respond with the Unknown Response string: ?[L/F][C/R] if this command has not been implemented in firmware version.

Issue	K3[C/R]	Tag = K3
Response	K3 xxxxxxxxxxxxxxx [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
K3	xxxxxxxxxxxxxxx	Name of Manufacturer

15 character response string

Example:
Issue: K3[c/r]
Response: K3Cooke Optics Lt[l/f][c/r]

5.1.5 K4: Retrieve Name of Lens Type

Note: Lens will respond with the Unknown Response string: ?[L/F][C/R] if this command has not been implemented in firmware version.

Issue	K4[C/R]	Tag = K4
Response	K4 xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
K4	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	Name of Lens Type

30 character response string

Example:
Issue: K4[c/r]
Response: K4S4i-50 [l/f][c/r]

5.1.6 P: Retrieve Lens Temperature

Issue	P[C/R]	Tag = P
Response	P x x [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
P	a b	Current Temperature in degrees Celsius

Note: xx range: 00- 99; >100 degree, output 99; negative temperature, output 'FF'

Example:
Issue: P[c/r]
Response: P22[l/f][c/r]
Note: The temperature reading process takes approximately 0.5 seconds.
During this time period, all other processes are suspended.

5.1.7 B: Retrieve Firmware Version Number

Issue	B[C/R]	Tag = B
Response	B a b c d [L/F][C/R]	

Tag	Value	Definition
B	a b c d	Firmware Version Number – format X.XX

Example:
Issue: B[c/r]
Response: B 4.34[l/f][c/r]

Note: One space between B and 4.34

5.1.8 Kbn: Set New Baud Rate

Issue	Kbn[C/R]	Tag = B
Response	Kbn ! [L/F][C/R]	

Response (Unknown)	?[L/F][C/R]	

n	Baud Rate	Maximum Cable Length
0	9600	50 meters
1	19200	30 meters
2	38400	10 meters
3	48000	8 meters
4	57600	5 meters
5	96000	2 meters
6	115200	2 meters
7	230400	.5 meters Note: This rate for Camera interface only – not supported by all I lenses

Example:
Issue: Kb1[c/r]
Response: Kb1! [l/f][c/r]

Note: The Unknown response string will be issued if the value of "n" exceeds the valid range.

5.1.9 C: Set Continuous Send Mode & Transmit ASCII Lens Data

Issue	C[C/R]	
Response	! [L/F][C/R]	

Once Continuous Send Mode is set, the lens will continually measure, calculate and send values in the D command format. To end Continuous Send mode use the H command.

Note (except for S4/i through 0.29 & 0.39): This command received from one channel will only set this mode "for that channel".

Example:
Issue: C[c/r]
Response:

!<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>D0000798T0680t5.6+5Z0000H0006123N0000711F0000909V027.3E+023z0000S4050.0093<\n><\r>

....

5.1.10 Kc: Set Continuous Send Mode & Transmit Packed Binary Data

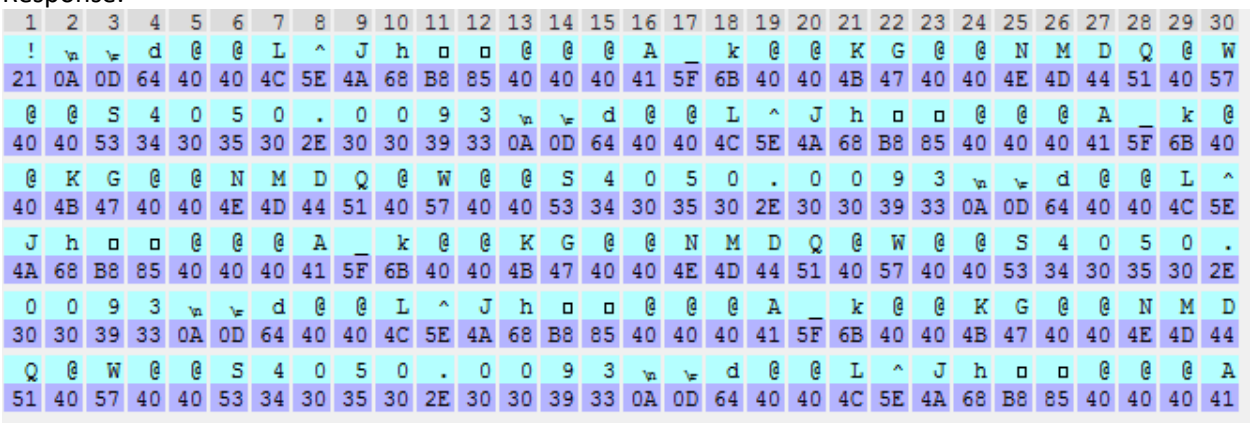
Issue	Kc[C/R]	Tag = d
Response	d s s s s TT t t z z h h h h n n n n f f f f v v e e Z Z S x x x x x x x x x x [L/F][C/R]	

Once Continuous Send Mode is set, the lens will continually measure, calculate and send values in the Kd command format. This mode is unset by using the H command.

Example:

Issue: Kc[c/r]

Response:



This command sets the retrieved data format to packed binary (as described by the Kd command) and sends data in continuous mode. The data content and format is the same as the Kd command data content and format. This mode is unset by using the H command.

Each data packet is defined under the Kd command above.

5.1.11 G: Set Checksum Mode

Issue	G [C/R]	No Tag
Response	!MN [L/F][C/R]	

The checksum consists of two characters which are added to the response string between the contents of the message and the termination character pair: [L/F]{C/R].

The checksum is formed by setting an 8 bit checksum value to all 1's and then performing an "exclusive or" operation between the existing checksum value and each character of the response string in turn, until all the characters are processed. The resulting 8 bit checksum is then converted into two separate characters.

In checksum mode, two characters are added to the response string between the message string and the termination sequence, (l/f)(c/r). The checksum is formed by setting an 8 bit checksum value to all 1's and then performing an exclusive or operation (XOR) between the existing checksum value and each character of the response string in turn, until all the characters are processed. The resulting 8 bit checksum is then converted into two separate characters as shown below.

Checksum value:	c7 c6 c5 c4 c3 c2 c1 c0
First checksum character to be transmitted:	0 1 0 0 c7 c6 c5 c4
Second checksum character to be transmitted:	0 1 0 0 c3 c2 c1 c0

These two characters are appended to the response string followed by the termination sequence. Use the H command to turn the checksum mode off.

Example:
Issue: G[c/r]
Response: !MN[l/f][c/r]

Responses of N and B commands when Checksum mode is on:
Issue: N [c/r]
Response: NS4050.0093OCooke Test Lens Body LPN050M050UIT95 B4.34OC[l/f][c/r]
Issue: B [c/r]
Response: B 4.34H@[l/f][c/r]

5.1.12 Ka: Set Inhibit Error Response Mode

Issue	Ka[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Once the Error Response Mode is set, the lens will simply ignore any bad or invalid message it receives rather than send the ?[L/F][C/R] response to a command it does not recognize.
Note: The response unknown: ?[L/F][C/R] will be issued by some early lens (S4/ǻ versions prior to 0.22, 0.35, 1.23, 1.31) which did not implement this command.

Example:

Issue: Kb9 [c/r] *before Ka sent*
Response: ?[L/F][C/R]

Issue: Ka[l/f]
Response: ! [l/f][c/r]

Issue: Kb9 [c/r] *after Ka sent*
Response: *no response sent*

5.1.13 X: Set Display Units to Imperial

Issue	X[C/R]	Tag = X
Response	X [L/F][C/R]	

Note: This command will change the display units on both channels for older S4/i® lenses with the original /i® Technology but will change only the display units for the channel which issued the command for all other two channel lenses, including all /i² Technology lenses. See Part II for additional information regarding operation of X and Y commands.

Example:
Issue: X[c/r]
Response: X[l/f][c/r]

5.1.14 Y: Set Display Units to Metric

Issue	Y[C/R]	Tag = Y
Response	Y [L/F][C/R]	

Note: This command will change the display units on both channels for older S4/i® lenses with the original /i® Technology but will change only the display units for the channel which issued the command for all other two channel lenses, including all /i² Technology lenses. See Part II for additional information regarding operation of X and Y commands in Cooke lenses.

Example:
Issue: Y[c/r]
Response: Y[l/f][c/r]

5.1.15 V: Set 35mm Mode

Issue	V[C/R]	Tag = V
Response	V 0.0 b b b [L/F][C/R]	

Tag	Value	Definition
V	b b b	Circle of Confusion value in mm for 35mm film

Example:
Issue: V[c/r]
Response: V0.0250[l/f][c/r]

5. 1.16 W: Set 16mm Mode

Issue	W[C/R]	Tag = W

Response	W 0.0 b b b [L/F][C/R]	

Tag	Value	Definition
W	b b b	Circle of Confusion value in mm for 16mm film

Example:
Issue: W[c/r]
Response: W0.0125[l/f][c/r]

5.1.17 Wnn: Set Film Size Extended Mode

Issue	Wnn[C/R]	Tag = W
Response	W 0.0 b b b [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
W	b b b	Circle of Confusion value in mm

Example:
Issue: W08[c/r]
Response: W0.0191[l/f][c/r]

nn	Film Size	Circle of Confusion Value
00	35 mm	0.0250
01	16 mm	0.0125
02	4096 x 2304	0.0211
03	3072 x 1728	0.0159
04	2048 x 1152	0.0106
05	AATON 3 perf	0.0238
06	ATON 2 perf	0.0222
07	4480 x 1866, 4.5K	0.0218
08	2764 x 2304, 4K Anamorphic	0.0191
09	Sony APS-C01	0.0105
10	ALEXA 65 (54.12x25.58)	0.0499
11	Arriflex 765	0.0475
12	Phantom 65	0.0467
13	Hasselblad H5D	0.0458
14	Leica S	0.045
15	Panavision Primo 70	0.0434
16	Alexa 65 (42.24x23.76)	0.0404
17	RED VV8K / Panavision DXL	0.0386
18	VistaVision	0.0375

19	35mm Full Frame	0.0361
20	UniVisium FF 35	0.0335
21	RED Dragon	0.0292
22	RED 8K Helium	0.0282
23	ALEXA XT	0.0275
24	Super35	0.0259
25	Sony F65	0.0233
26	UniVisium Super 35	0.0223
27	Super16	0.0121
28	16mm	0.0106
29	2/3" Video	0.0092
30	Super8	0.0058
31	8mm	0.0047

Note: The Unknown response string will be issued if the value of “nn” exceeds the valid range.

Lenses power up with default film size 35mm. The value can be changed by issuing V, W or Wnn commands from either the PL connector or the External connector. However, once the Camera (PL) channel sets the film size, the External channel is inhibited from changing the film size. At that point, if the External channel issues a command to change the film size, the response will be to return the current set film size (not the requested change)

5.1.18 H: Unset Continuous Mode

Issue	H[C/R]	No Tag
Response	! [L/F][C/R]	

This command causes received channel to stop transmitting continuous data after a C or Kc command. It also unsets the Checksum Mode and the Inhibit Error Response Mode. This command received from one channel will only set this mode for that channel.

Example:
Issue: H[c/r]
Response: ![l/f][c/r]

5.1.19 OX: Set Start-Up Units to Imperial

Issue	OX[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

This command will set the Start-Up Units character to B, changing the current “Display Units” selection for both channels to Imperial. See Part II for additional details. This command not available in older miniS4/i, S4/i and CXX lenses.

Example:
Issue: OX[c/r]
Response: ![l/f][c/r]

Note: The Unknown response string will be issued if command not recognized.

5.1.20 OY: Set Start-Up Units to Metric

Issue	OY[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

This command will set the Start-Up Units character to b, changing the current “Display Units” selection for both channels to Metric. See Part II for additional details. This command not available in older miniS4/i, S4/i and CXX lenses.

Example:
Issue: OY[c/r]
Response: ![l/f][c/r]

Note: The Unknown response string will be issued if command not recognized.

5/i SCALE Illumination Commands - Optional

Additional details for operating the 5/i Scale Illumination feature are described in Part II.

5.1.21 Kjn: Set Scale Illumination Level for Both LED Sets - 5/i Lenses Only

Issue	Kjn[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

The value of n is between 0 and 9, where 0 sets illumination to OFF and 9 is at maximum brightness.

Example:
Issue: Kj5[c/r]

Response: ![l/f][c/r]

Note: The Unknown response string will be issued by all non-5/i lenses or if the value of "n" is any character that is not 0 to 9.

5.1.22 Kkn: Set Scale Illumination Level for One LED Sets - 5/i Lenses Only

Issue	Kkn[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

The value of n is between 0 and 9, where 0 sets illumination to OFF and 9 is at maximum brightness. (The second LED set is turned off.)

Example:
Issue: Kk5[c/r]
Response: ![l/f][c/r]

Note: The Unknown response string will be issued by all non-5/i lenses or if the value of "n" is any character that is not 0 to 9.

Commands for External Interface [EDSU] - Optional

All Cooke Anamorphic /i and 5/i lenses, (and lenses with /i² and /i³ Technology), allow users to append additional external data (up to 60 8-bit values) onto the data stream normally generated inside the lens. External data is retrieved through the external communication interface and then appended to the D, C, Kd or Kc response stream. The appended string must consist of 8 bit characters which do not include the [l/f] or [c/r] character, and no other ASCII control character (hex 00 to hex 1F).

Additional details describing the EDSU operation are provided in Section II.

5.1.23 OS: [EDSU] Retrieve Current Channel Settings

Issue	OS[C/R]	Tag = O
Response	OrRdUC0.0cccWnninlSssssssssBx.xx[L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition

O		Tag
r	R	Focus Scale Ring Type currently fitted on lens: I = Imperial M = Metric
d	U	Display Units currently selected: I = Imperial M = Metric
C	0.0ccc	Film Size/ Circle of Confusion (CoC) Value (mm)
W	nn	Number Associated with Film Size (CoC) Value – *see Wnn Command*
i	nI	Illumination Level [n=1 for 1 LED, n=2 for 2 LEDs, I = 0(min) – 9(max)
S	sssssssss	Lens Serial Number
B	x.xx	Firmware Version Number

Example:
Issue: OS[c/r]
Response: OrIdIC0.0250W00Si00S4050.0093B4.34 [I/f][c/r]

Note: The Unknown response string will be issued when command not recognized.

5.1.24 OT: [EDSU] Retrieve Baud Rate, Data Type, Opposite Channel Display Units

Issue	OT[C/R]	Tag =Ot
Response	OtBbFfUu [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
Ot		Tag
B	b	Baud Rate of Opposite Channel: b=0 -7 [see Kbn Command]
F	f	f = A (ASCII), f = B (Binary)
U	u	Display Units currently selected: u=I (Imperial), u=M (Metric)

Example:
Issue: OT[c/r]
Response: OtB0FAUI [I/f][c/r]

Note: The Unknown response string will be issued when command not recognized.

5.1.25 OC: [EDSU] Commence Append of Data String

Issue	OC[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Example:

Issue: OC[c/r]
Response: ! [l/f][c/r]

Note: The Unknown response string will be issued when command not recognized.

5.1.26 OD: [EDSU] Append Data String (up to 60 8-bit values)

Append Data String (dddd……d) to the D, C, Kd or Kc Response String

Issue	ODddd…….d[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

ddd…..d = a string of up to 60 data values which terminate with the [C/R] character. These can be any 8 bit values except a [C/R] or [L/F].

Example:
Issue: OD abc1237&^$ [c/r]
Response: ! [l/f][c/r]
Note: The Unknown response string will be issued when command not recognized.

5.1.27 OH: [EDSU] Halt Append of Data String

Issue	OH[C/R]	No Tag
Response	! [L/F][C/R]	
Response (Unknown)	?[L/F][C/R]	

Example:
Issue: OH[c/r]
Response: ! [l/f][c/r]

Note: The Unknown response string will be issued when command not recognized.

NEW /i² Technology Commands

The response to the Kdi command includes new inertial data plus all the same lens metadata returned when issuing the Kd command. (To reduce transmission time, use baud rate 115,200 or above.)

5.1.28 Kdi: Retrieve Lens plus Inertial Tracking Data

Issue	KdiX[C/R]
Response	[section1][section2][section3][section4][section5][section6] [section7][section8][section9][L/F][C/R]
Response (Unknown)	?[L/F][C/R]

Response	Values	Description	Offset
section1	i	size=1 byte	0
section2	X	size=1 byte; 00-ff : sequence number of Kdi command used for synchronization	1
section3	nn	size=2 bytes; 0000-ffff : length of Kdi response, the whole response from i X nn …data, excluding [l/f][c/r] big endian: [2] = MSB, [3] =LSB	2
section4	lens metadata	size=38 bytes; (same response as Kd response) 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 S x x x x x x x x x x see page 18-22 in Cooke Manual for more details	4
section5	time stamp of frame	size=2 bytes; t00-t15; time when Kdi command is received Bit7 Bit6 Bit5 Bit4 Bit3 Bit2 Bit1 Bit0 1st t15 t14 t13 t12 t11 t10 t09 t08 2nd t07 t06 t05 t04 t03 t02 t01 t00	42
section6	Magnetometer data	size=6 bytes; X (mx0-mx15), Y(my0-my15), Z(mz0-mz15) 1st mx15 mx14 mx13 mx12 mx11 mx10 mx09 mx08 2nd mx07 mx06 mx05 mx04 mx03 mx02 mx01 mx00 3rd my15 my14 my13 my12 my11 my10 my09 my08 4th my07 my06 my05 my04 my03 my02 my01 my00 5th mz15 mz14 mz13 mz12 mz11 mz10 mz09 mz08 6th mz07 mz06 mz05 mz04 mz03 mz02 mz01 mz00	44
section7	data sample packet ID	size=1 byte; gyro data : 1; accelerometer data : 2	50
section8	time stamp of data sample packet	size=2 bytes; t00-t15; time when gyro/acc FIFO reaches its water mark Bit7 Bit6 Bit5 Bit4 Bit3 Bit2 Bit1 Bit0 1st t15 t14 t13 t12 t11 t10 t09 t08 2nd t07 t06 t05 t04 t03 t02 t01 t00	51
section9	accelerometer or gyro data packet	size of 1 sample=6 bytes; size of 8 samples =48 bytes 1st bx15 bx14 bx13 bx12 bx11 bx10 bx09 bx08 2nd bx07 bx06 bx05 bx04 bx03 bx02 bx01 bx00 3rd by15 by14 by13 by12 by11 by10 by09 by08 4th by07 by06 by05 by04 by03 by02 by01 by00 5th bz15 bz14 bz13 bz12 bz11 bz10 bz09 bz08 6th bz07 bz06 bz05 bz04 bz03 bz02 bz01 bz00	53

The total length of one accelerometer/gyro data packet is 51 bytes.

Number of inertial packets in KdiX response (includes Magnetometer data)	0	1	2	3	4	5	6	7	8
Length of Kdi response (excluding [l/f][c/r])	50	101	152	203	254	305	356	407	458

Each time the lens receives a KdiX command, it reads out the data from the buffer and clears it. The total length of the KdiX response string varies according to the frame rate. The maximum depth of the inertial data buffer is currently set to 8. It holds the latest 8 inertial data packets if the buffer overflows.

The ' X ' in KdiX acts as a tag to synchronize command and response. The ' X ' is a byte value ranging from 0x00 to 0xff. It is assigned by the requester and is included in the response so that the response can be tied to the command that prompted it. To receive the inertial data, a recorder or camera can issue command sequence: Kdi0, Kdi1, Kdi2, …Kdi255, continually.

5.1.29 K61: Retrieve Inertial Calibration Coefficients

Inertial calibration coefficients are obtained through board inertial calibration process and are constant values unique to each lens. This data is necessary for post-production processing of the inertial data.

Issue	K61[C/R]
Response	K61nnaa..aagg..ggmm..mm…[L/F][C/R]
Response (Unknown)	?[L/F][C/R]

Value	Definition
nn[3-4]	size=2 bytes (big endian); 0000-ffff: length of the K61 response excluding [l/f][c/r] nn = 180 + 5 = 0x 00B5
aa…aa[5-52]:	48 bytes (little endian): 12 accelerometer coefficients as IEEE single precision floating point values
gg…gg[53-136]:	84 bytes (little endian): 21 gyroscope coefficients as IEEE single precision floating point values
mm…mm[137-184]:	48 bytes (little endian): 12 magnetometer coefficients as IEEE single precision floating point values

Note: nn and aa…aa, gg…gg, and mm…mm are binary format.

Example:
Issue: K61[c/r]
Response:
4B 36 31 00 B9 93 94 12 BA 94 37 65 39 19 2F EF 36 93 36 63 39 60 E6 11 3A E9 40 A6 B6 BD 21 AD 36 C7 EF 72 36 C0 B1 1C 3A CB 78 E9 3C D8 1A 50 3C EE 86 A6 3E 88 99 9B B9 D7 F6 F5 38 EF 65 95 B4 75 A5 EE 38 E2 16 98 39 AA 0C 93 B6 14 09 1A 36 15 61 CF 34 1C 4D A0 39 B0 80 1D AF 92 19 4F AE 19 10 A8 AE BA 1F 4F AE FC D1 64 2D 05 FA DD 2C 0C E2 84 2C 3F 83 2D 2D BE 78 20 2D F7 45 A9 3D FE D7 88 BC 60 4C 6B BC D5 45 87 32 7D 67 C1 B1 52 80 9C B0 9A E5 FD 31 A3 EF 7E 32 0B DA 98 B0 B7 FF BA AF B0 8E 24 30 5D 89 7D 32 E7 04 DD B6 A1 13 83 B8 A4 50 81 38 0A 0D
4B 36 31: "K61"
00 B9: length 185
93 94…A6 3E: accelerometer coefficients
88 89…6B BC: gyroscope coefficients
D5 45 81 38: magnetometer coefficients

5.1.30 K8: Retrieve Picture Width

Issue	K8[C/R]	Size
Response	K8mmmmmcccccdddd [L/F][C/R]	14 bytes
Response (Unknown)	?[L/F][C/R]	

Value	Definition
mmmmm [2-6]	size=5 bytes; measured picture width mmx10, for example: "10045" represents 1004.5mm
ccccc [7-11]	size=5 bytes; coverage mmx10, for example: "10080" represents 1008 mm
dddd [12-16]	size=4 bytes; projector distance, for example: "2000" represents 2000 mm

Example:
Issue: K8[c/r]
Response: K808420085302000[l/f][c/r]

5.1.31 K91: Retrieve Anamorphic Squeeze Factor

Issue	K91[C/R]	Size
Response	K91abc [L/F][C/R]	6 bytes
Response (Unknown)	?[L/F][C/R]	

Tag	Value	Definition
K91	abc	size=3 bytes; Squeeze Factor Spherical lenses: 1.0 Anamorphic lenses: 1.3, 1.5, 1.6 and 2.0 etc

Example:
Issue: K91[c/r]
Response: K911.0 [l/f][c/r]

5.1.32 KKi: Retrieve Shading Data

Issue	KKi[C/R]
Response	KKinnTRmmdddd…[L/F][C/R]
Response (no illumination data)	KKi? [L/F][C/R]
Response(Unknown)	?[L/F][C/R]

Values	Description	Offset
KKi	size=3 byte: Tag "KKi"	0
nn	size=2 bytes; 0000-ffff : length of KKi response excluding [l/f][c/r] (big endian)	3
T	size = 1 byte: lens type 01: spherical 02: spherical zoom 03: anamorphic 04: anamorphic zoom	5
R	Size = 1 byte free	6
mm	Size = 2 bytes (big endian) Length of shading coefficients data in bytes = 4 * the number of coefficients Spherical: number of coefficients = 12, mm = 12*4 = 48 = 0x30 Anamorphic: number of coefficients = 19, mm = 19*4 = 76 = 0x 4C Zoom: number of coefficients = 52, mm = 52*4 = 208 = 0xD0	7
dddd….	shading coefficients in single-precision floating point, little endian (details described in Vignette Documentation)	9

Example:
Issue: KKi[c/r]
Response:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
K	K	i	\n	9	□	□	\n	0	□	}	□	=	x	□	9	□	□	□	□	□	□	□	□	=	□	'	□	?	=
4B	4B	69	00	39	01	01	00	30	16	7D	17	3D	78	B3	39	BB	D8	E7	C1	BA	9F	CC	E3	3D	0F	27	A4	3F	3D
□	%	?	□	□	b	□	.	□	□	=	t	□	V	?	:	/	□	?	h	z	□	□	\n	\n	p	A	\n	\r	
80	25	3F	82	E6	62	BE	2E	CA	8B	3D	74	D2	56	3F	3A	2F	AC	3F	68	7A	1A	BF	00	00	70	41	0A	0D	

NEW /i³ Technology Commands

The response to the KKi, KKd, KKdi and NN command includes new distortion and/or shading data plus all the same lens metadata returned when issuing the Kd or N command.

5.1.33 KKd: Retrieve Distortion Map

Issue	KKd[C/R]
Response	KKdnntrppeeee …[L/F][C/R]
Response (no distortion data)	KKd? [L/F][C/R]
Response(Unknown)	?[L/F][C/R]

Values	Description	Offset
KKd	size=3 byte: Tag "KKd"	0
nn	size=2 bytes; 0000-ffff : length of KKd response excluding [l/f][c/r]	3
t	size = 1 byte: lens type 01: spherical 02: spherical zoom 03:anamorphic 04: anamorphic zoom	5
r	Size = 1 byte free	6
pp	Size = 2 bytes (big endian) [7] = MSB, [8] =LSB added Length of distortion coefficients data in bytes = 4 * number of coefficients Spherical: number of coefficients = 42, mm = 42*4 = 168 = 0xA8 Anamorphic: no of coefficients = 130, mm = 130*4 = 520 = 0x0208 Zoom: number of coefficients = n/a,	7
eeee….	distortion coefficients in single-precision floating point values, little endian	9

Example:

Issue: KKd[c/r]

Response:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
K	K	d	\n	□	□	\n	\n	□	\n	\n	H	C	\n	\n	□	A	□	□	□	A	[	□	□	?	E	□	_	>	□
4B	4B	64	00	B1	01	00	00	A8	00	00	48	43	00	00	F0	41	11	A0	93	41	5B	BD	14	3F	45	1E	5F	3E	B3
6	□	>	\n	\n	\n	\n	□	□	'	>	[	□	□	□	\r	o	`	>	\n	\n	\n	\n	□	□	□	>	Q	□	□
36	8E	3E	00	00	00	00	B6	A1	27	3E	5B	EC	86	BE	09	6F	60	3E	00	00	00	00	19	D3	8E	3E	51	C4	17
□	□	□	□	>	□	*	□	=	□	T	□	:	□	□	o	□	l	□	\b	<	□	□	□	□	□	□	□	:	□
BF	F8	B1	F6	3E	18	2A	B2	3D	9E	54	FF	3A	CB	FA	6F	BC	31	BE	08	3C	04	9A	0B	BD	19	B1	A4	3A	8C
\n	□	<	□	□	G	□	□	□	k	□	□	□	□	:	□	□	□	□	□	□	□	□	;	-	□	D	8	□	□	□
00	99	3C	C3	17	47	BC	A7	8B	6B	BC	BB	DD	B9	3A	90	13	07	BB	BC	CF	95	3B	2D	0F	44	38	E0	B6	0E
:	□	□	□	□	^	"	3	:	□	<	□	:	□	Y	□	:	□	@	□	□	□	□	s	:	□	□	d	□	□
3A	FB	E6	81	BA	5E	22	33	3A	B8	3C	01	3A	02	59	0E	3A	DE	40	A0	BA	1D	C7	73	3A	F6	CC	64	BE	9C
7	□	@	U	}	O	□	$	□	□	A	□	□	□	□	h	\r													
37	CE	40	55	7D	4F	C1	24	15	06	41	86	A0	9B	C0	68	0D													
□	□	~	Q	V	A	S	"	□	□	\n	\r																		
C2	C0	7E	51	56	41	53	22	07	C1	0A	0D																		

5.1.34 KKid: Retrieve Lens Distortion Map and Shading Data

Issue	KKid[C/R]
Response	KKidnnTRmmdddd…trppeeee…[L/F][C/R]
Response (no distortion or shading data)	KKid? [L/F][C/R]
Response (Unknown)	?[L/F][C/R]

Values	Description	Offset
KKid	size=4 byte: Tag “KKid”	0
nn	size=2 bytes; 0000-ffff : length of KKid response excluding [l/f][c/r] (big endian)	4
T	size = 1 byte: lens type 01: spherical 02: spherical zoom 03:anamorphic 04: anamorphic zoom	6
R	Size = 1 byte free	7
mm	Size = 2 bytes (big endian) Length of shading coefficients data in bytes = 4 * number of coefficients Spherical: number of coefficients = 12, mm = 12*4 = 48 = 0x30 Anamorphic: number of coefficients = 19, mm = 19*4 = 76 = 0x 4C Zoom: number of coefficients = 52, mm = 52*4 = 208 = 0xD0	8
dddd….	shading coefficients in single-precision floating point, little endian	10
t	Same as T	10 + mm
r	Same as R	10+mm+1
pp	Size = 2 bytes (big endian)	12+mm

	Length of distortion coefficients data in bytes = 4 * number of coefficients Spherical: no of coefficients = 42, mm = 42*4 = 168 = 0xA8 Anamorphic: no of coefficients = = 130, mm = 130*4 = 520 = 0x0208 Zoom: no of coefficients = n/a,	
eeee….	distortion coefficients in single-precision floating point, little endian	14+mm

5.1.35 NN: New (Optional) Start-up Command with Shading and Distortion Data

Issue	NN[C/R]
Response	NN[nn_1][$dd…d_1$]S[nn_2][$dd…d_2$]D[nn_3][$dd…d_3$]I[nn_4][$dd…d_4$]Q[n_5][$dd…d_5$]W[n_6][$dd…d_6$][L/F][C/R]
Response from lenses which don't support NN command	N command response

Value	Definition	offset
NN	Tag "NN"	0
nn_1	length of the whole response excluding [l/f][c/r] size=2 bytes: 0000-0xffff (big endian)	2
$dd…d_1$	N command response: Sssss…. … Bv.vv (ASCII format) Size = 64 bytes	4
S	Tag 'S' for shading coefficients	68
nn_2	length of the section of [$dd…d_2$] size=2 bytes: 0000-0xffff (big endian) 0: shading coefficients are not available 52: spherical lenses 80: anamorphic 212: zoom	69
$dd…d_2$	shading coefficients (binary format) [lensType][resv][mm][data…] mm: 2 bytes, Length of illumination data in bytes See details in KKi section	71
D	D tag for distortion coefficients	71+ nn_2
nn_3	length of the section of [$dd…d_3$] size=2 bytes: 0000-0xffff (big endian) 0: distortion data are not available 172: spherical lenses 524: anamorphic n/a: zoom	72+ nn_2
$dd…d_3$	distortion data (binary format)	74+ nn_2

	[lensType][resv][pp][data…] pp: 2 bytes, Length of distortion data in bytes See details in KKd section	
I	Tag 'I' for inertial coefficients	74+ nn_2 +nn_3
nn_4	length of the section of [dd…d_4] size=2 bytes: 0000-0xffff (big endian) 0: inertial data are not available 180: any lenses	75+ nn_2 +nn_3
dd…d_4	Inertial coefficients (binary format)	77+ nn_2 +nn_3
Q	Q tag for squeeze factor	77+ nn_2 +nn_3 + nn_4
n_5	length of the section of [dd…d_5] size=1 byte: 00-0xFF 0: squeeze factor is not available 3: squeeze factor is available	78+ nn_2 +nn_3 + nn_4
dd…d_5	Squeeze factor in ASCII format For example: "1.8"	79+ nn_2 +nn_3 + nn_4
W	Tag 'W' for picture width	79 + nn_2 +nn_3 + nn_4 + n_5
n_6	length of the section of [dd…d_6] size=1 byte: 00-0xFF 0: picture width is not available 14: picture width is available	80 + nn_2 +nn_3 + nn_4 + n_5
dd…d_6	picture width in ASCII format For example: "10048100482000"	81 + nn_2 +nn_3 + nn_4 + n_5 + n_6
[L/F][C/R]	End of the response	81 + nn_2 +nn_3 + nn_4 + n_5 + n_6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
N	N	□	B	S	4	0	5	0	.	0	0	9	3	O	C	o	o	k	e		T	e	s	t		L	e	n	s
4E	4E	01	42	53	34	30	35	30	2E	30	30	39	33	4F	43	6F	6F	6B	65	20	54	65	73	74	20	4C	65	6E	73
	-		P	G												L	P	N	0	5	0	M	0	5	0	U	B	T	9
20	2D	20	50	47	20	20	20	20	20	20	20	20	20	20	20	4C	50	4E	30	35	30	4D	30	35	30	55	42	54	39
5			B	4	.	3	5	S	\n	4	□	□	\n	0	□	}	□	=	x	□	9	□	□	□	□	□	□	□	□
35	20	20	42	34	2E	33	35	53	00	34	01	01	00	30	16	7D	17	3D	78	B3	39	BB	D8	E7	C1	BA	9F	CC	E3
=	□	'	□	?	=	□	%	?	□	□	b	□	.	□	□	=	t	□	V	?	:	/	□	?	h	z	□	□	\n
3D	0F	27	A4	3F	3D	80	25	3F	82	E6	62	BE	2E	CA	8B	3D	74	D2	56	3F	3A	2F	AC	3F	68	7A	1A	BF	00
\n	p	A	D	\n	□	□	\n	\n	□	\n	\n	H	C	\n	\n	□	A	□	□	□	A	[	□	□	?	E	□	_	>
00	70	41	44	00	AC	01	00	00	A8	00	00	48	43	00	00	F0	41	11	A0	93	41	5B	BD	14	3F	45	1E	5F	3E
□	6	□	>	\n	\n	\n	\n	□	□	'	>	[	□	□	□	\r	o	`	>	\n	\n	\n	\n	□	□	□	>	Q	□
B3	36	8E	3E	00	00	00	00	B6	A1	27	3E	5B	EC	86	BE	09	6F	60	3E	00	00	00	00	19	D3	8E	3E	51	C4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
□	□	□	□	□	>	□	*	□	=	□	T	□	:	□	□	o	□	l	□	\b	<	□	□	□	□	□	□	□	:
17	BF	F8	B1	F6	3E	18	2A	B2	3D	9E	54	FF	3A	CB	FA	6F	BC	31	BE	08	3C	04	9A	0B	BD	19	B1	A4	3A
□	\n	□	<	□	□	G	□	□	□	k	□	□	□	□	:	□	□	□	□	□	□	□	□	;	-	□	D	8	□	□
8C	00	99	3C	C3	17	47	BC	A7	8B	6B	BC	BB	DD	B9	3A	90	13	07	BB	BC	CF	95	3B	2D	0F	44	38	E0	B6
□	:	□	□	□	□	^	"	3	:	□	<	□	:	□	Y	□	:	□	@	□	□	□	□	s	:	□	□	d	□
0E	3A	FB	E6	81	BA	5E	22	33	3A	B8	3C	01	3A	02	59	0E	3A	DE	40	A0	BA	1D	C7	73	3A	F6	CC	64	BE
□	7	□	@	U	}	O	□	$	□	□	A	□	□	□	□	h	\r												
9C	37	CE	40	55	7D	4F	C1	24	15	06	41	86	A0	9B	C0	68	0D												
□	□	~	Q	V	A	S	"	□	□	I	\n	\n	Q	□	1	.	0	W	□	0	8	4	2	0	0	8	5	3	0
C2	C0	7E	51	56	41	53	22	07	C1	49	00	00	51	03	31	2E	30	57	0E	30	38	34	32	30	30	38	35	33	30
2	0	0	0	\n	\r																								
32	30	30	30	0A	0D																								

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