Neutrino Software Interface Description Document (IDD)

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The information contained herein does not contain technology as defined by the EAR, 15 CFR 772, is publicly available, and therefore not subject to EAR.

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1 Document

1.1 Revision History

Rev. #	Date	Comments
090	02/13/2014	Initial engineering release
100	2/14/2014	initial release
110	08/13/2015	Corrected ITAR restriction statement
111	09/17/2018	Changed ITAR statement to EAR

1.2 Scope

Neutrino is an infrared imaging cooled InSb detector core from FLIR Systems®. This Interface Description Document (IDD defines software interface requirements and commands. Except where noted, all requirements / commands apply to both products, hereafter referred to generically as "the core".

2 References

The following documents form a part of this specification to the extent specified herein.

2.1 FLIR Website / Contact Information

In multiple locations throughout this document, FLIR's Tau / Quark website is referenced as a source of additional information. This websites can be accessed via the following URL:

www.flir.com/browse/camera-cores--components/thermal-camera-cores/mwir/

Additionally, FLIR's Applications Engineering Department is referenced as a resource for obtaining additional help or information. Email requests can be addressed to SBA-cores@flir.com.

2.2 FLIR Systems Documents

Ref. 1	102-2001-60	Neutrino Electrical Interface Description Document

2.3 External Documents

Ref. 5	ANSI/TIA/EIA-232 (formerly RS232)	Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

2.4 Acronyms / Abbreviations

AGC	Automatic Gain Control
CCITT	Commite' Consultatif International de Telegraphique et Telephonique. (International consultative committee on telecommunications and Telegraphy)
CRC	Cyclic Redundancy Check
DDE	Digital Detail Enhancement
FFC	Flat Field Correction
FOV	Field of View
FPA	Focal Plane Array
FW	Firmware
IDD	Interface Description Drawing / Document
LSB	Least Significant Bit
LUT	Look-Up Table
LVDS	Low-Voltage Differential Signaling
MSB	Most Significant Bit
NTSC	National Television System Committee
PAL	Phase Alternating Line
ROI	Region of Interest
SW	Software
TBD	To Be Determined
XP	eXPansion
WFOV	Wide Field of View

3 Serial Communications Protocol

The serial communication channel is a two-node, master-slave interface between an external device and the core. The external device is considered the "master" in that it initiates all communications. The core is a "slave" that generates a reply to each received message. For the purposes of this document "incoming" or "received" messages refer to those from the master device to the core, and "reply" messages refer to those from the core to the master device.

3.1 Port Settings

Table 3-1 defines the serial port settings of the serial communication interface.

Table 3-1 Serial Port Settings

Parameter	Value
Signaling polarity	Auto-detected. See 3.1.1
Baud rate	Configurable. See 3.1.2
Data bits	8
Parity	None
Start bits	1
Stop bits	1
Flow control	None
Bit order	Least significant first (after start bit)

3.1.1 Signaling Polarity

The polarity of incoming packets on the RS232 channel is automatically detected by the core. That is, the core will automatically detect whether the host is transmitting standard or inverted logic and will reply via the same. Anytime the signal level of core's RX line (i.e., the host's TX line) remains static for an entire frame period, the core assumes that the current level is the quiescent state. For example, if the quiescent state is at 3.3V as depicted in Figure 1a, the core assumes standard logic. If the quiescent state is at ground as depicted in Figure 1b, the core assumes inverted logic. At power-on, the core assumes inverted logic by default until a complete frame period elapses with no traffic on its RX line. Note that auto-polarity detection is always active and therefore signal polarity can be switched dynamically in the middle of a power cycle (though this is not expected to occur in practice).

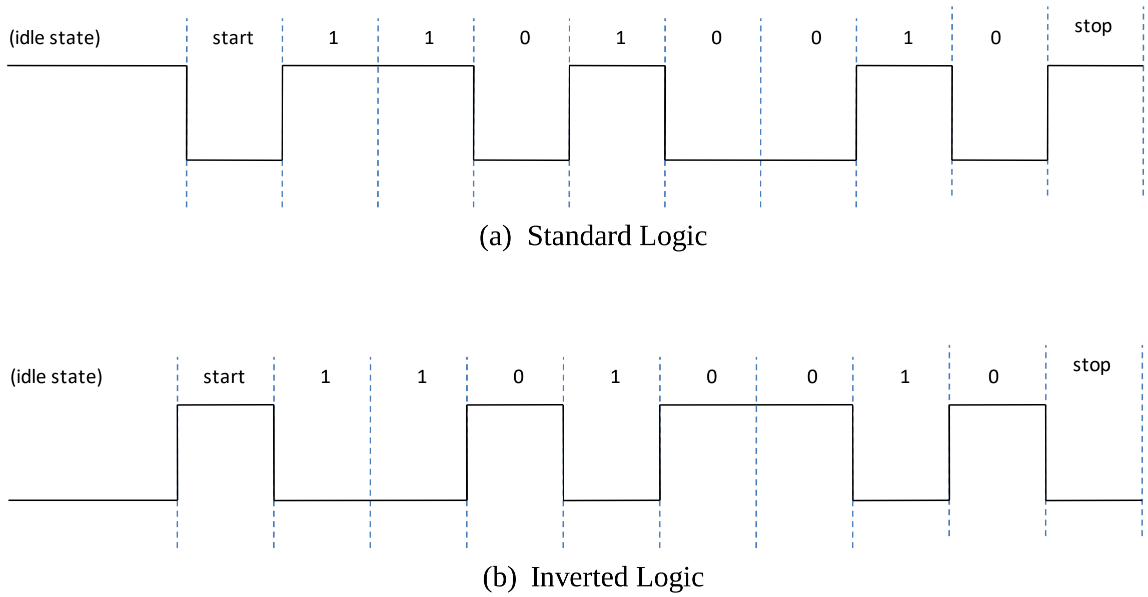

Figure 1: Example of Standard and Inverted Comm. Traffic

3.1.2 Baud Rate

The baud rate of the serial comm. channel is configurable to any of the following:

1. Auto-baud (as described below)
2. 9.6k
3. 19.2k
4. 28.8k
5. 57.6k
6. 115.2k
7. 460.8k
8. 921.6k

Note: Baud rate tolerance to incoming messages is +/- 3%. Outgoing messages are to within +/-1%.

The baud rate is configured via the BAUD_RATE command (0x07) and capable of being stored as a power-on default via the SET_DEFAULTS command (0x01). The BAUD_RATE command must be sent at the current baud rate, and the core replies to the command at the specified rate. All subsequent commands must then be sent at the newly specified baud rate. For example, if the power-on default for a particular core is 460.8k and a new baud rate of 28.8k is desired, the BAUD_RATE command specifying a change to 28.8k must be sent at 460.8k. The core will reply with an acknowledgement at 28.8k. All future commands on the current power cycle must then be sent at 28.8k baud. At the next power up, the core will return to its power-on default, 460.8k, unless 28.8k was established as the new power-on default by having sent the SET_DEFAULTS command after sending the BAUD_RATE command.

Note: If the host is ignorant of the current baud rate setting, it must attempt communication at each baud rate until receiving a valid response. Caution should be exercised when storing a new baud rate as power-on default unless the host is capable of cycling through all possible baud rates.

When auto-baud is the current baud-rate setting, the core attempts to detect baud rate from the first message received via the following process:

- The elapsed time between the first 6 edges is measured on the RX line (from rise to fall or fall to rise). If the shortest of the 5 elapsed-time periods is between 0.860 usec and 1.302 usec (that is, $(921.6\ \text{kHz})^{-1} \pm 20\%$), the core sets its baud rate to 921.6k. If the shortest period is between 13.889 usec and 20.833 usec (that is, $(57.6\ \text{kHz})^{-1} \pm 20\%$), the core sets its baud rate to 57.6k. Otherwise the auto-detection process starts over again. Figure 2 illustrates the process for a transmitted byte 0x6E, which includes 6 edges and happens to be the first byte of every valid command to the core (see 3.2). Either the period marked #3 or that marked #5 in the figure will be identified as the shortest transition and therefore used to select baud rate.
    - *Note 1: Glitches on the receive line might possibly result in an erroneous detection.*
    - *Note 2: The receive logic defaults to 57.6k (i.e., data are sampled at 57.6k beginning with the first start bit). If data is sent at 921.6k, it will be incorrectly sampled until the auto-baud detection process has locked onto the correct baud rate. Consequently, a core in auto-baud will only generate a valid reply to the first message sent by the host if that message is sent at 57.6k. A message sent at 921.6k will establish the faster baud rate but will not generate a valid reply. (The second message sent at 921.6k will be the first that generates a valid reply.) For that reason, it is recommended to send a No Op command (0x00) as the first message when operating in auto-baud mode.*
    - *Note 3: The auto-baud detection only occurs once per power cycle; all communications thereafter must be at the same rate.*

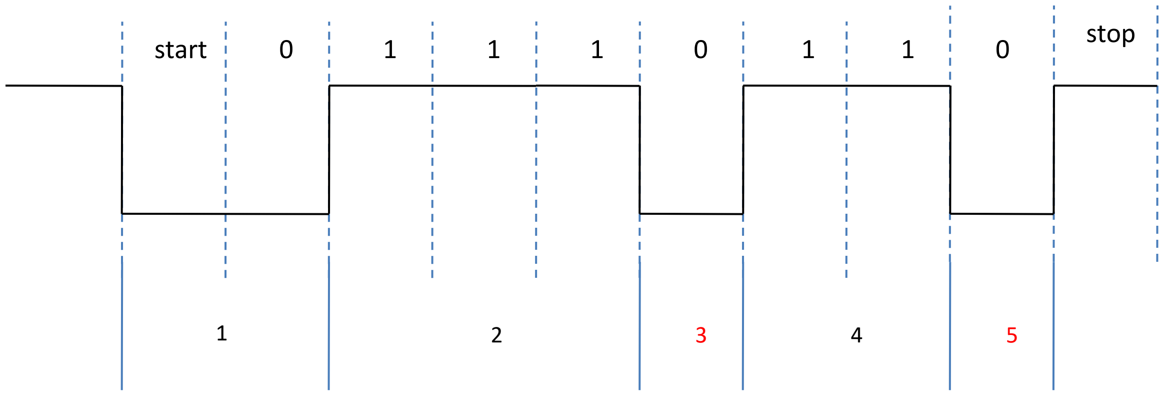

Figure 2: Illustration of Edges Used in Auto-Baud Detection Algorithm

3.2 Packet Protocol

All incoming and reply messages shall adhere to the packet protocol defined in Table 3-2 and the subparagraphs that follow.

Table 3-2 Packet Protocol

Byte #	Upper Byte	Comments
1	Process Code	Set to 0x6E on all valid incoming and reply messages
2	Status	See 3.2.1
3	Reserved	
4	Function	See 3.2.2
5	Byte Count (MSB)	See 3.2.3
6	Byte Count (LSB)	
7	CRC1 (MSB)	See 3.2.4
8	CRC1 (LSB)	
N	Argument	See 3.2.5
N+1	CRC2 (MSB)	See 3.2.4
N+2	CRC2 (LSB)	

3.2.1 Status Byte

The second byte of each incoming packet is ignored. For all reply messages, the core sets the second byte as shown in Table 3-3 to indicate status of the previous incoming message packet. The decoding of the incoming message is as follows:

1) The byte-count bytes are read to determine the expected length of the packet. If the incoming packet duration exceeds a timeout period (nominally 100 msec), CAM_TIMEOUT_ERROR is reported (status byte = 0x07).
   Note: Camera SW does not respond with a 0x07 timeout error, but the UL3-RS232.dll used in many applications does provide this message status response.
2) Once the full packet has been received, the CRC bytes are checked first (see 3.2.4). If either is incorrect, CAM_CHECKSUM_ERROR is reported (status byte = 0x04).
3) The process-code byte is then checked; if it is not equal to 0x6E, CAM_UNDEFINED_PROCESS_ERROR is returned (status byte = 0x05).
4) The function code is then checked, and if it is invalid (i.e., not one of the codes shown in Table 3-5), CAM_UNDEFINED_FUNCTION_ERROR is returned (status byte = 0x06). CAM_FEATURE_NOT_ENABLED (status byte = 0x0A) is also a possible return if the function code is not supported by the particular configuration (e.g., the command is supported in some configurations of the core, just not the particular configuration receiving the command).
5) The packet length is then checked. If the length is invalid for the function code, CAM_BYTE_COUNT_ERROR is returned (status byte = 0x09).
6) For some function codes, the range of the argument is limited. In those cases, the argument is checked, and CAM_RANGE_ERROR is returned if it is invalid (status byte = 0x03).
   Note: Any reply packet reporting an error will have no data bytes (i.e., byte count = 0).

Table 3-3 Status Byte Definition

Status Byte Value (hex)	Definition	Description
0x00	CAM_OK	Message received
0x03	CAM _RANGE_ERROR	Argument out of range
0x04	CAM _CHECKSUM_ERROR	Header or message-body checksum error
0x05	CAM _UNDEFINED_PROCESS_ERROR	Unknown process code
0x06	CAM _UNDEFINED_FUNCTION_ERROR	Unknown function code
0x07	CAM _TIMEOUT_ERROR	Timeout executing serial command
0x09	CAM _BYTE_COUNT_ERROR	Byte count incorrect for the function code
0x0A	CAM _FEATURE_NOT_ENABLED	Function code not enabled in the current configuration

3.2.2 Function Byte

The function-code byte is used to specify the function of an incoming message. For all reply messages, the camera will echo back the function-code byte. A list of all valid Tau 2 / Quark commands is shown in Table 3-5. For most of these commands, the core replies *after* it has executed the specified function. Such commands are referred to as “synchronous” or “blocking”. For a few select commands, the core replies to acknowledge receipt of the message *before* execution of the command is complete. For example, the core replies immediately to the DO_FFC command rather than delaying the response until the FFC operation is complete. Such commands are referred to as “asynchronous” or “non-blocking”, and all are noted explicitly in Table 3-5 (and additionally listed in Table 3-4 below). Some non-blocking commands such as those which result in writing the core’s non-volatile memory have an associated status message that can be used to poll the core for progress. This information is also explicitly noted in Table 3-5.

Table 3-4 List of Non-blocking Commands

ID	Function Code	Command
1	0x01	SET_DEFAULTS
12	0x0C	DO_FFC
37	0x25	TEST_PATTERN
47	0x2F	SYMBOL_CONTROL
130	0x82	TRANSFER_FRAME
198	0xC6	WRITE_NVFFC_TABLE

3.2.3 Byte Count Bytes

The byte-count bytes are used to specify the number of argument bytes in the packet (not the total number of bytes in the packet). The byte count will typically be an even number, with range between 0 and 0x0106 (262 decimal). See Table 3-5 for the expected byte count associated with each function-code byte. Note that the byte-count of an incoming message is not necessarily equal to the byte count of the reply message. Note also in Table 3-5 that many function bytes are overloaded (i.e., have different behavior depending upon byte-count). For example, if the BAUD_RATE command (0x07) is sent with a byte count of 0, the core replies with the current baud rate without modifying it. If sent with a byte count of 2, the core changes the baud rate to the value specified by the 2-byte argument. (This type of command is referred to as a set/get since it can be used for either purpose.)

3.2.4 CRC Bytes

On all incoming and outgoing messages, two cyclical redundancy checks (CRCs) are calculated using CCITT-16 initialized to 0. (Polynomial = $x^{16} + x^{12} + x^5 + 1$.) CRC1 is calculated using only the first 6 bytes of the packet. CRC2 is calculated using all previous bytes in the packet (i.e. bytes 0 through N). Below is an example showing a CRC calculation for the single byte 0x6E.

Data = 0x6E = 01101110 (binary); Polynomial = 10001000000100001 (binary)

```
   011011100000000000000000        [data is right-padded with 16 zeros]
⊕ 010001000000100001
--------------------------------------
   001010100000100001000000
⊕ 0010001000000100001
--------------------------------------
   000010000000110001100000
⊕ 00010001000000100001
--------------------------------------
   000010000000110001100000
⊕ 000010001000000100001
--------------------------------------
   000000001000110101101000
⊕ 0000010001000000100001
--------------------------------------
   000000001000110101101000
⊕ 00000010001000000100001
--------------------------------------
   000000001000110101101000
⊕ 000000010001000000100001
--------------------------------------
  000000001000110101101000    = 0x8D68
```

3.2.5 Argument Bytes

The argument bytes (also called data bytes) are used to encode the argument of a message packet. The number of argument bytes is typically an even number. See Table 3-5 for the argument definition for each message. Two's-complement numbering is used for all signed values. Big-endian ordering is employed:

Byte 0, Byte 1, Byte 2, etc.

3.2.6 Serial Command List

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
0	0x00	NO_OP	No operation	Cmd:0 Reply:0	None	The typical use of this command is to verify proper communication via a valid reply from the core.
1	0x01	SET_DEFAULTS	Sets all current settings as power-on defaults This command is non-blocking (see 3.2.2). The MEMORY_STATUS command (ID #196) is the associated status command.	Cmd:0 Reply:0	None	See Table 3-6 for a list of all affected parameters.
2	0x02	CAMERA_RESET	Commands a camera reset / reboot	Cmd:0 Reply:0	None	
3	0x03	RESTORE_ FACTORY_ DEFAULTS	Reverts settings to factory defaults.	Cmd:0 Reply:0	None	See Table 3-6 for a list of all affected parameters. This command "undoes" any parameter changes (including those stored as power-on defaults), restoring all to factory-default values. This command must be followed by the SET_DEFAULTS command (0x01) to restore the factory settings as power-on defaults.
4	0x04	SERIAL_NUMBER	Gets the serial number of the camera and sensor	Cmd: 0	None	
				Reply: 8	Bytes 0-3: Camera serial number Bytes 4-7: Sensor serial number	
5	0x05	GET_REVISION	Gets the firmware / software version	Cmd: 0	None	
				Reply: 8	Bytes 0-1: SW major version Bytes 2-3: SW minor version Bytes 4-5: FW major version Bytes 6-7: FW minor version	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
7	0x07	BAUD_RATE	Gets or sets the baud rate of the serial comm. channel	Get Cmd: 0 (Reply: 2)	None	See 3.1.2 for further explanation.
				Set Cmd: 2 & Reply: 2	0x0000: Auto baud 0x0001: 9600 baud 0x0002: 19200 baud 0x0003: 28800 baud 0x0004: 57600 baud 0x0005: 115200 baud	
12	0x0C	DO_FFC	Commands FFC This command is non-blocking (see 3.2.2). There is no associated status command.	Cmd:0 Reply:0	None	See para. 3.3.2.1 of Ref. 1 / Ref. 3 for explanation of short FFC and long FFC.
15	0x0F	VIDEO_MODE	Gets or sets the video signal mode, enabling analog channel to be enabled/disabled and allowing freeze frame or real-time data. Note: Bits 2, 3, and 4 are valid for selecting 1X, 2X, 4X, or 8X zoom provided that bit 9 is set to 0. When bit 9 is set to 1, bits 2-4 are ignoredThe new EZOOM_CONTROL command will not causes on-screen icons to be displayed.	Get Cmd: 0 (Reply: 2)	None	See para. 3.1.2.3 and 3.3.2.4 of Ref. 1 / Ref. 3 for definition of each mode.
				Set Cmd: 2 & Reply: 2	Video mode: bit 0: 0 = real-time 1 = freeze bit 1: 0 = analog enabled 1 = analog disabled bit 2: 0 = 2X off, 1 = 2X enabled bit 3: 0 = 4X off, 1 = 4X enabled bit 4: 0 = 8X off, 1 = 8X enabled bit 9: 0 = zoom bits valid 1 = zoom bits ignored	
16	0x10	VIDEO_PALETTE	Gets or sets the video palette	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 29
				Set Cmd: 2 & Reply: 2	Palette number	See para. 3.3.2.7 of Ref. 1 / Ref. 3 for explanation of the parameter
17	0x11	VIDEO_ ORIENTATION	Gets or sets the video orientation	Get Cmd: 0 (Reply: 2)	None	See para. 3.3.2.3 of Ref. 1 / Ref. 3 for definition of each mode.

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
				Set Cmd: 2 & Reply: 2	0x0000 = Normal 0x0001 = Invert 0x0002 = Revert 0x0003 = Invert + Revert	
18	0x12	DIGITAL_ OUTPUT_MODE	Gets or sets the digital output channel modes, depending upon byte count and arguments value.	Get Cmd: 0 (Reply: 2)	None	See para. 3.1.2.4 of Ref. 1 / Ref. 3 for definition of the various digital output modes. Note: In Tau 1.X, it was not possible to set bit depth of the CMOS and LVDS channels independently. Both had to be set to either 8bit or 14bit mode. For Tau 2, the command has been modified to allow a different bit depth to be specified for each channel.
				Set Cmd: 2 & Reply: 2	Common disable (affects both the LVDS and XP channels) 0x0000 = enabled 0x0002 = disabled	
			Gets the CMOS (XP) Mode	Get Cmd: 2	Byte 0: 0x02 Byte 1: don't care	
				Reply: 2	Bytes 0-1: XP Mode 0x0000 = disabled 0x0001 = BT656 0x0002 = CMOS	
			Sets the CMOS (XP) Mode	Set Cmd: 2 & Reply: 2	Byte 0: 0x03 Byte 1: 0x00 = disabled 0x01 = BT656 0x02 = CMOS	
			Gets the CameraLink (LVDS) Mode	Get Cmd: 2	Byte 0: 0x04 Byte 1: don't care	
				Reply: 2	Bytes 0-1: LVDS enable 0x0000 = disabled 0x0001 = enabled	
			Set the CameraLink (LVDS) Mode	Set Cmd: 2 & Reply: 2	Byte 0: 0x05 Byte 1: 0x00 = disabled 0x01 = enabled	
			Sets the CMOS mode Bit Depth (8 or 14bit)	Set Cmd: 2 & Reply: 2	Byte 0: 0x06 Byte 1: 0x00 = 14bit 0x01 = 8bit	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
			Sets the CameraLink (LVDS) mode Bit Depth (8 or 14bit)	Set Cmd: 2 & Reply: 2	Byte 0: 0x07 Byte 1: 0x00 = 14bit 0x01 = 8bit	
			Gets the CMOS mode Bit Depth (8 or 14bit)	Get Cmd: 2	Byte 0: 0x08 Byte 1: don't care	
				Reply: 2	0x0000 = 14bit 0x0001 = 8bit	
			Gets the CameraLink (LVDS) mode Bit Depth (8 or 14bit)	Get Cmd: 2	Byte 0: 0x09 Byte 1: don't care	
				Reply: 2	0x0000 = 14bit 0x0001 = 8bit	
				Resp:2	Bytes 0-1: Bayer Order 0x0000=GR, 0x0001=GB, 0x0002=BG, 0x0003=RG	
19	0x13	AGC_TYPE	Gets or sets the AGC algorithm	Get Cmd: 0	None	See para. 3.3.2.6 of Ref. 1 / Ref. 3 for definition of each algorithm.
				Set Cmd: 2 & Reply: 2	0x0000 = plateau histogram 0x0001 = once bright 0x0002 = auto bright 0x0003 = manual 0x0004 = not defined (returns error) 0x0005 = linear AGC 0x0008 = CLAW 0x0009 = Plateau+entropy 0x000A = entropy	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
			getEBThreshold	Get Cmd: 2 & Reply: 2	Bytes 0-1 Const: 0x0300 Reply bytes 0-1 (0-255)	
			setEBThreshold	Set Cmd: 4	Bytes 0-1 = const: 0x0300 Bytes 2-3 = value 0-255	
			getLinearPercent	Get Cmd: 2 & Reply: 2	Bytes 0-1 Const: 0x0400 Reply bytes 0-1 (0% -100%)	
			setLinearPercent	Set Cmd: 4	Bytes 0-1 = const: 0x0400 Bytes 2-3 = value 0% - 100%	
20	0x14	CONTRAST	Gets or sets the contrast value used by once-bright, auto-bright, and manual AGC algorithms	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 255
				Set Cmd: 2 & Reply: 2	Contrast value	See para. 3.3.2.6.3 – 3.3.2.6.5 of Ref. 1 / Ref. 3 for explanation of this parameter. It is not applicable to all AGC algorithms.
21	0x15	BRIGHTNESS	Gets or sets the AGC brightness value used by the manual and auto-bright AGC algorithms	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 16383
				Set Cmd: 2 & Reply: 2	Brightness value	See para. 3.3.2.6.3 and 3.3.2.6.4 of Ref. 1 / Ref. 3 for explanation of this parameter. It is not applicable to all AGC algorithms.
24	0x18	BRIGHTNESS_BIAS	Gets or sets the brightness bias value used by the once-bright AGC algorithm	Get Cmd: 0 (Reply: 2)	None	Range: -16384 to 16383
				Set Cmd: 2 & Reply: 2	Brightness bias value	See para. 3.3.2.6.5 of Ref. 1 / Ref. 3 for explanation of this parameter. It is not applicable to all AGC algorithms.
32	0x20	READ_SENSOR	Gets various data from the core, depending upon argument of incoming message	Cmd: 2 & Reply: 2 Reply: 2	Incoming arg. | Outgoing response 0x0000 | FPA temp in deg. C*10 0x0001 | FPA temp in raw counts 0x0002 – 0009 | unused 0x000A | Housing temp, deg. C x 100 0x000C – 0x0010 | reserved 0x0018: camTicFreq	See 3.3.4.3 of Ref. 1 / Ref. 3 Integration period is expressed a number of 1/CamTicFreq Default camTicFreq = 52800000

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
33	0x21	EXTERNAL_SYNC	Gets or sets external sync mode	Get Cmd: 0 (Reply: 2)	None	See para. 3.1.2.7 of Ref. 1 / Ref. 3 for definition of each mode.
				Set Cmd: 2 & Reply: 2	0x0000 = disabled 0x0001 = slave (ATFR) 0x0002 = master 0x0003 = slave (AIWR)	
37	0x25	TEST_ PATTERN	Gets or sets the test pattern mode This command is non-blocking (see 3.2.2). There is no associated status command. Note: If the command is sent more than once without disabling the test pattern in between, the core is automatically placed in manual FFC mode, manual gain mode.	Get Cmd: 0 (Reply: 2)	None	See para. 3.3.4.2 of Ref. 3 for definition of each test pattern.
				Set Cmd: 2 & Reply: 2	0x0000 = test pattern off 0x0001 = 14-bit ascending ramp 0x0003 = big vertical 0x0004 = horizontal shade 0x0005 = factory use 0x0006 = color bars 0x0008 = ramp with steps	
44	0x2C	DDE_GAIN	Enables / disables DDE and gets or sets the gain value for DDE in manual mode	Get Cmd: 0 (Reply: 2)	None	Range: 0 – 255 See para. 3.3.2.5 of Ref. 1 / Ref. 3 for definition of this parameter. *Note: Set capability has no effect in automatic DDE mode. (See SPATIAL_THRESHOLD, 0xE3.)*
				Set Cmd: 2 & Reply: 2	Gain value	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
49	0x31	SPLASH_CONTROL	Gets/sets the Splash Screen delay parameters	Get Cmd: 0 (Reply: 4)	Bytes 0-1: Splash Screen # (0-1)	Range: 0 – 6000 (in video fields)
				Set Cmd: 4 & Reply: 4	Bytes 0-1: Splash Screen # (0-1) Bytes 2-3: Timeout period	See para. 3.3.1.1 of Ref. 1 / Ref. 3 for explanation of this parameter.
50	0x32	EZOOM_CONTROL	Continuous Zoom Controls	Get Cmd: 0		Width and increment / decrement value in pixels
				Reply: 2	Bytes 0-1: Current zoom width	
				Get Cmd: 2	Bytes 0-1: 0x0000: zoom width 0x0004: max. zoom width	
				Reply: 2	Bytes 0-1: requested value	
				Set Cmd: 4 (Reply: 0)	Bytes 0-1 0x0001: Set zoom width to specified value 0x0002: Increment zoom by specified value 0x0003: Decrement zoom by specified value Bytes 2-3: Specified value	
62	0x3E	AGC_FILTER	Gets or sets the AGC filter value	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 255
				Set Cmd: 2 & Reply: 2	AGC filter value (0 = immediate)	See para. 3.3.2.6.1 of Ref. 1 / Ref. 3 for explanation of this parameter.
63	0x3F	PLATEAU_LEVEL	Specifies the plateau level for the Plateau AGC algorithm.	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 4095
				Set Cmd: 2 & Reply: 2	Plateau level	See para. 3.3.2.6.1 of Ref. 1 / Ref. 3 for explanation of this parameter. It only applies to the plateau AGC algorithm.

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
76	0x4C	AGC_ROI	Gets or sets the Region of Interest (ROI) used by some of the AGC algorithms in normal and zoom modes. Assumes signed coordinates relative to center value of (0,0), and coordinates are expressed as percentages (-512 = -50%, +512 = +50%). See para. 3.3.2.4 of ref. 3 for a more complete explanation. Note: Unlike Tau 2.0, only a single ROI is defined for Tau 2.1. It is applied whether video is zoomed or unzoomed.	Get Cmd: 0	None	Range: ±512 (±50%) The setting is referenced to full frame. Software automatically scales for eZoom.
				Reply: 8	Bytes 0-1: Left Bytes 2-3: Top Bytes 4-5: Right Bytes 6-7: Bottom	
85	0x55	AGC_MIDPOINT	Gets or sets the AGC midpoint offset, a parameter used by the Plateau-Equalization, CLAW, Auto+Entropy and Entropy algorithms	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 255 See para. 3.3.2.6.1 of Ref. 1 / Ref. 3 for explanation of this parameter. It does not apply to all AGC algorithms.
				Set Cmd: 2 & Reply: 2	AGC midpoint	
101	0x65	SERIAL_NUMBER	Gets the serial number of the camera and sensor.	Get Cmd: 0	None	This command is redundant with 0x04 and is left to maintain backward compatibility.
				Reply: 8	Bytes 0-7: Serial number	
102	0x66	CAMERA_PART	Gets the camera part number	Get Cmd: 0	None	
				Reply: 32	Bytes 0-31: Part number (ASCII)	
104	0x68	READ_ARRAY_ AVERAGE	Reads the mean of the current frame. This value is not ROI-dependent.	Get Cmd: 0	None	
				Reply: 4	Bytes 0-1: Mean in counts (+/-4 counts of rounding error) Bytes 2-3: histogram width in counts (+/- 4 counts of rounding error)	
106	0x6A	MAX_AGC_GAIN	Gets or sets the max-gain parameter for Plateau AGC	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 2047 See para. 3.3.2.6.1 of Ref. 1 / Ref. 3 for explanation of this parameter. It only applies to the plateau-equalization AGC algorithm.
				Set Cmd: 2 & Reply: 2	Max-AGC-gain parameter	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
112	0x70	PAN_AND_TILT	Gets or sets the pan (x axis) and tilt position (y axis) for the zoom window relative to the center of the unzoomed window.	Get Cmd: 0 (Reply: 4)	None	
				Set Cmd: 4 & Reply: 4	Bytes 0-1: Tilt position in rows Bytes 2-3: Pan position in columns	Limited to a range of -40 to +40 For advanced users, the pan/tilt range limits can be removed. Contact FLIR Applications Engineering for further details.
114	0x72	VIDEO_STANDARD	Gets or sets the video standard (affects frame rate)	Get Cmd: 0 (Reply: 2)	None	See para. 3.1.2.3 and 3.2.2 of Ref. 1 / Ref. 3 for explanation of these modes. Not all configurations support the 60Hz / 50Hz modes.
				Set Cmd: 2 & Reply: 2	0x0000 = NTSC, 30Hz 0x0001 = PAL, 25Hz	
116	0x74	NUC_TABLE_LOAD	Loads NUC from flash to DRAM	Cmd: 2	Bytes 0-1 nucNum	0x0000 to 0x0003
130	0x82	TRANSFER_FRAME	Captures a snapshot to a specified buffer location. (Capture operations must be sequential.) This command is non-blocking (see 3.2.2). There is no associated status command.	Cmd: 4 & Reply: 4	Byte 0: type 0x08 = 14-bit snapshot 0x16 = 8bit bitmap capture 0x17 = 8bit bitmap playback Byte 1: snapshot number Byte 2-3: 0x0001 For type 17, set bytes 2-3 to 0x0000 to resume live imagery.	The primary purpose of this command is to support the snapshot feature, described in para. 3.3.2.9 of Ref. 1 / Ref. 3. See FLIR's Tau website for an Application Note that provides a detailed explanation of the command sequences required to execute snapshot capture, playback, and download.
131	0x83	CALC_GAIN	Computes and applies the gain terms from first and second captured frames	Cmd: 0		
		CALC_GAIN	setOffsetOfGain	Cmd: 2	Bytes0-1 offsetOfGain	0 to 16383, 8192=normal
		CALC_FRAME_DIFF	Bytes 0-1: const 0X0000 Bytes 2-3: diff_Frame_Num Bytes 4-5: hot_Frame_Num Bytes 6-7: cold_Frame_Num	Cmd: 8 Reply: 2	Bytes 0-1: Mean_average_of_Diff_Frame	
		CALC_GAIN_FRAME	Bytes 0-1: const 0X0001 Bytes 2-3: Gain_Frame_Num Bytes 4-5: Diff_Frame_Num Bytes 6-7: Mean_average			

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
		FIND_BAD_PIXELS	Bytes 0-1: const 0x0002 Bytes 2-3: gain_Frame_Num Bytes 4-5: LowLimitPercent Bytes 6-7: highLimitPercent	Cmd: 8 Reply: 4	Bytes 0-: num of new Bad Pixels found	Lowlimit: 0 - 16383 highLimit 0 - 16383
		FIND_OUT_OF_RANGE	BYTE 0-1: Const 0X0006 BYTES 2-3: FrameNum BYTES 4-5: lowLimit BYTES 6-7: highLimit	Cmd: 8 Reply: 4	Bytes 0-3: number of bad pixels	
		REPORT_TOTAL_BAD_PIXEL_COUNT	Bytes 0-1: const 0x0007 Bytes 2-3: const 0x0000 Bytes 4-5: const 0x0000 Bytes 6-7: const 0x0000	Cmd: 8 Reply: 4	Bytes 0-3: number of bad pixels	
161	0xA1	GET_INT_TIME		Cmd: 0 Reply: 4	Byte 0: bits 31-24 Byte 1: bits 23-16 Byte 2: bits 15-8 Byte 3: bits 7-0	32 bit word based on Pixel clock frequency Integration period =N/Freq(mc)
		SET_INT_TIME	Byte 0: bits 31-24 Byte 1: bits 23-16 Byte 2: bits 15-8 Byte 3: bits 7-0	Cmd: 4		
	0xBE	ERASE_NUC_TABLE	Bytes 0-1: NUC number	Cmd:2		Valid numbers 0, 1, 2 & 3
	0xC2	WRITE_NUC_HEADER		Cmd: 0		Use to write active NUC to flash
196	0xC4	MEMORY_STATUS	Gets the status for several non-blocking write / erase commands	Cmd: 0	None	For various commands that involve writing or erasing non-volatile memory (e.g. SET_DEFAULTS, WRITE_NVFFC_TABLE, ERASE_MEMORY) this command returns status. Power should not be removed from the core until the command reports that the memory operation is complete.
				Reply: 2	Bytes remaining to be written 0x0000 = complete 0xFFFF = erase error 0xFFFE = write error	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
226	0xE2	DDE_THRESHOLD	Gets or sets the threshold of the DDE filter	Get Cmd: 0 (Reply: 2)	None	Range: 0 to 255
				Set Cmd: 2 & Reply: 2	Threshold value	See para. 3.3.2.5 of Ref. 1 / Ref. 3 for definition of this parameter. Note: Set capability has no effect in automatic DDE mode. (See SPATIAL_THRESHOLD, 0xE3.)
227	0xE3	SPATIAL_ THRESHOLD (AUTO_DDE)	Gets or sets the spatial threshold of the DDE filter and the DDE mode (auto or manual)	Get Cmd: 0 (Reply: 2)	None	See para. 3.3.2.5 of Ref. 1 / Ref. 3 for definition of this parameter.
				Set Cmd: 2 & Reply: 2	Bytes 0 -1: 0x0000 – 0x000F = manually specified threshold 0x0100 – 0x013F automatic threshold (0 to 63)	

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
229	0xE5	LENS_RESPONSE_ PARAMS	Gets and sets the lens parameters for the calculated responsivity. Note: not all configurations support advanced radiometry	Get cmd: 2	Bytes 0-1: Lens #	0=Lens #0, 1=Lens #1
				Resp: 4	Bytes 0-1: F/#	4096-65535 (0.5-7.9999)
					Bytes 2-3: Transmission	4096-8192 (0.5-1.0)
				Set cmd: 6 (Resp: 0)	Bytes 0-1: Lens #	0=Lens #0, 1=Lens #1
					Bytes 2-3: F/# 0xFFFF doesn't "set"	4096-65535 (0.5-7.9999)
					Bytes 4-5: Transmission 0xFFFF doesn't "set"	4096-8192 (0.5-1.0)
			Gets and sets the scene parameters for radiometric calculations Note: not all configurations support advanced radiometry	Get cmd: 2	Bytes 0-1: Parameter	0x0100=RAD_EMISSIVITY
				Resp: 2	Bytes 0-1: Value	4096-8192 (0.5-1.00)
				Set cmd: 4 (Resp: 0)	Bytes 0-1: Parameter	0x0100=RAD_EMISSIVITY
					Bytes 2-3: Value	4096-8192 (0.5-1.00)
				Get cmd: 2	Bytes 0-1: Parameter	0x0101=RAD_TBKG_X100
				Resp: 2	Bytes 0-1: Value	S15.0 (-50.00-327.67)
				Set cmd: 4 (Resp 0)	Bytes 0-1: Parameter	0x0101=RAD_TBKG_X100
					Bytes 2-3: Value	S15.0 (-50.00-327.67)
				Get cmd: 2	Bytes 0-1: Parameter	0x0102=RAD_TRANSMISSION_WIN
				Resp: 2	Bytes 0-1: Value	4096-8192 (0.5-1.0)
				Set cmd: 4 (Resp 0)	Bytes 0-1: Parameter	0x0102=RAD_TRANSMISSION_WIN
					Bytes 2-3: Value	4096-8192 (0.5-1.0)
				Get cmd: 2	Bytes 0-1: Parameter	0x0103= RAD_TWIN_X100
				Resp: 2	Bytes 0-1: Value	S15.0 (-50.00-327.67)
				Set cmd: 4	Bytes 0-1: Parameter	0x0103= RAD_TWIN_X100
				Resp: 0	Bytes 2-3: Value	S15.0 (-50.00-327.67)
				Get cmd: 2	Bytes 0-1: Parameter	0x0104= RAD_TAU_ATM
				Resp: 2	Bytes 0-1: Value	4096-8192 (F3.13 0.5-1.0)
				Set cmd: 4	Bytes 0-1: Parameter	0x0104=RAD_TAU_ATM

Table 3-5 Function Byte Codes, All Commands

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
				Resp: 0	Bytes 2-3: Value	4096-8192 (F3.13 0.5-1.0)
				Get cmd: 2	Bytes 0-1: Parameter	0x0105= RAD_TATM_X100
				Resp: 2	Bytes 0-1: Value	S15.0 (-50.00-327.67)
				Set cmd: 4	Bytes 0-1: Parameter	0x0105=RAD_TATM_X100
				Resp: 0	Bytes 2-3: Value	S15.0 (-50.00-327.67)
				Get cmd: 2	Bytes 0-1: Parameter	0x0106=RAD_ REFL _WIN
				Resp: 2	Bytes 0-1: Value	0- RAD_TAU_WIN (F3.13 0.0-τ_{win})
				Set cmd: 4	Bytes 0-1: Parameter	0x0106=RAD_REFL_WIN
				Resp: 0	Bytes 2-3: Value	0- RAD_TAU_WIN (F3.13 0.0-τ_{win})
				Get cmd: 2	Bytes 0-1: Parameter	0x0107=RAD_ TREFL _X100
				Resp: 2	Bytes 0-1: Value	S15.0 (-50.00-327.67)
				Set cmd: 4	Bytes 0-1: Parameter	0x0107=RAD_ TREFL _X100
				Resp: 0	Bytes 2-3: Value	S15.0 (-50.00-327.67)

3.3 Summarized Command Lists

The lists below are subsets of Table 2-4, each showing all the commands related to a particular aspect of Neutrino operation.

List of FFC-related commands:

ID	Function Code (hex)	Command
12	0x0C	DO_FFC

List of commands related to Analog Video / BT.656 digital video and AGC:

ID	Function Code (hex)	Command
15	0x0F	VIDEO_MODE
16	0x10	VIDEO_PALETTE
19	0x13	AGC_TYPE
20	0x14	CONTRAST
21	0x15	BRIGHTNESS
24	0x18	BRIGHTNESS_BIAS
37	0x25	TEST_ PATTERN
38	0x26	VIDEO_COLOR_MODE
43	0x2B	SPOT_DISPLAY
47	0x2F	SYMBOL_CONTROL
49	0x31	SPLASH_CONTROL
50	0x32	EZOOM_CONTROL
62	0x3E	AGC_FILTER
63	0x3F	PLATEAU_LEVEL
76	0x4C	AGC_ROI
85	0x55	AGC_MIDPOINT
106	0x6A	MAX_AGC_GAIN
112	0x70	PAN_AND_TILT
114	0x72	VIDEO_STANDARD

List of DDE-related commands:

ID	Function Code (hex)	Command
44	0x2C	DDE_GAIN
226	0xE2	DDE_THRESHOLD
227	0xE3	SPATIAL_ THRESHOLD (AUTO_DDE)

List of snapshot-related commands:

ID	Function Code (hex)	Command
130	0x82	TRANSFER_FRAME
196	0xC4	MEMORY_STATUS
210	0xD2	READ_MEMORY
212	0xD4	ERASE_MEMORY_ BLOCK
213	0xD5	GET_NV_MEMORY_SIZE

ID	Function Code (hex)	Command
214	0xD6	GET_MEMORY_ ADDRESS

Note: See FLIR's Tau website for an Application Note that provides a detailed explanation of the proper command sequences to implement snapshot capture, playback, and download.

3.4 Example format of a serial message

The packet depictions below illustrate the incoming message when the FFC_MODE_SELECT command (0x0B) is issued to get current setting and the reply message assuming the current FFC mode is "automatic" (argument = 0x0001):

Incoming message:

Process Code	Status	Reserved	Function	Byte Count	CRC	Data	CRC
0x6E	0x00	0x00	0x0B	0x0000	0x2F4A		0x0000

Reply message:

Process Code	Status	Reserved	Function	Byte Count	CRC	Data	CRC
0x6E	0x00	0x00	0x0B	0x0002	0x0F08	0x0001	0x1021

3.5 Parameters Affected by SET_DEFAULTS & RESTORE_FACTORY_DEFAULTS

Table 3-6 shows the list of parameters that can be modified by the customer and then stored as power-on defaults via the SET_DEFAULTS command (0x01). It is also possible to restore factory-default values (i.e., the original power-on defaults selected by FLIR) via the RESTORE_FACTORY_DEFAULTS command (0x03). The factory-default values are also shown in Table 3-6.

Note: RESTORE_FACTORY_DEFAULTS does not restore parameter values as power-on defaults, only as currently applied settings. If it is desired to restore factory defaults as power-on defaults, the RESTORE_FACTORY_DEFAULTS command should be followed by the SET_DEFAULTS command.

Table 3-6 Parameters Affected by SET_DEFAULTS and RESTORE_FACTORY_DEFAULTS

Parameter	Factory Default	Command Used to Set Parameter	Cmd ID#
Baud Rate	0x0000 (Auto baud)	BAUD_RATE	7
Gain Mode	Varies by configuration.	GAIN_MODE	10
FFC Mode	Varies by configuration	FFC_MODE_SELECT	11
FFC Interval (High-Gain State)	0x0E10 (3600 frames)	FFC_PERIOD	13
FFC Interval (Low-Gain State)	0x0546 (1350 frames)	FFC_PERIOD	13
FFC Temp Interval (High-Gain State)	0x000A (1.1C)	FFC_TEMP_DELTA	14
FFC Temp Interval (Low-Gain State)	0x000A (1.1C)	FFC_TEMP_DELTA	14
Video Palette	0x0000 (Palette 0 = white hot)	VIDEO_PALETTE	16
Video Mode	0x0000 (Real-time, unzoomed)	VIDEO_MODE	15
Video Orientation	0x0000 (Normal orientation)	VIDEO_ORIENTATION	17
Digital Output Modes	Varies by configuration	DIGITAL_OUTPUT_MODE	18
AGC Algorithm	0x0000 (Plateau Equalization)	AGC_TYPE	19
Contrast	0x0020 (32)	CONTRAST	20
Brightness	0x2000 (8192)	BRIGHTNESS	21
Brightness Bias	0x0000 (0)	BRIGHTNESS_BIAS	22
Lens Number	0x0000 (0)	LENS_NUMBER	30
Spot Meter Mode	Varies by configuration	SPOT_METER_MODE	31
External Sync Mode	0x0000 (Disabled)	EXTERNAL_SYNC	33

Parameter	Factory Default	Command Used to Set Parameter	Cmd ID#
Isotherm Mode	Varies by configuration	ISOTHERM	34
Lower Isotherm Threshold	0x005A (90%)	ISOTHERM_ THRESHOLDS	35
Middle Isotherm Threshold	0x005C (92%)	ISOTHERM_ THRESHOLDS	35
Upper Isotherm Threshold	0x005F (95%)	ISOTHERM_ THRESHOLDS	35
Video Color Mode	0x0001 (Color enabled)	VIDEO_COLOR_MODE	38
Spot Display Mode	Varies by configuration	SPOT_DISPLAY	43
DDE Gain	n/a (auto)	DDE_GAIN	44
Ezoom Width	Max value (varies by config.)	EZOOM_CONTROL	50
FFC Warn Time	0x003C (60 frames)	FFC_WARN_TIME	60
AGC Filter	0x0040 (64)	AGC_FILTER	62
Plateau Level	0x0096 (150)	PLATEAU_LEVEL	63
Spot Meter Coordinates	Varies by configuration	GET_SPOT_METER_ DATA	67
ROI Coordinates	Top: -50% Left: -50% Bottom: +50% Right: +50%	AGC_ROI	76
AGC Midpoint	0x007F (127)	AGC_MIDPOINT	85
Max. Gain	0x000C (12)	MAX_AGC_GAIN	106
Pan / Tilt Coordinates	0,0	PAN_AND_TILT	112
Video Standard	Varies by configuration	VIDEO_STANDARD	114
TLinear Enable	Varies by configuration	TLIN_COMMANDS	142
TLinear Resolution	Varies by configuration	TLIN_COMMANDS	142
Shutter Profile	Varies by configuration	SHUTTER_POSITION	121
Correction Mask	0x003F (all enabled)	CORRECTION_MASK	177
Gain Switch, High-to-Low Temperature Threshold	0x008C (140C)	GAIN_SWITCH_PARAMS	219
Gain Switch, Low-to-High Temperature Threshold	0x0064 (100C)	GAIN_SWITCH_PARAMS	219
Gain Switch, High-to-Low Population Threshold	0x005F (95%)	GAIN_SWITCH_PARAMS	219
Gain Switch, Low-to-High Population Threshold	0x0014 (20%)	GAIN_SWITCH_PARAMS	219
DDE Threshold	n/a (default mode is automatic)	DDE_THRESHOLD	226

Parameter	Factory Default	Command Used to Set Parameter	Cmd ID#
DDE Mode / Spatial Threshold	0x0119 (25, automatic mode)	SPATIAL_THRESHOLD	227
Lens Response Parameters	Varies by configuration	LENS_RESPONSE_ PARAMETERS	229

If you have questions that are not covered in this manual, or need service, contact FLIR Commercial Systems Customer Support at SBA-Cores@flir.com for additional information prior to returning a camera.

This documentation and the requirements specified herein are subject to change without notice.

This equipment must be disposed of as electronic waste.
Contact your nearest FLIR Commercial Systems, Inc. representative for instructions on how to return the product to FLIR for proper disposal.

FCC Notice. This device is a subassembly designed for incorporation into other products in order to provide an infrared camera function. It is not an end-product fit for consumer use. When incorporated into a host device, the end-product will generate, use, and radiate radio frequency energy that may cause radio interference. As such, the end-product incorporating this subassembly must be tested and approved under the rules of the Federal Communications Commission (FCC) before the end-product may be offered for sale or lease, advertised, imported, sold, or leased in the United States. The FCC regulations are designed to provide reasonable protection against interference to radio communications. See 47 C.F.R. §§ 2.803 and 15.1 et seq.

Industry Canada Notice. This device is a subassembly designed for incorporation into other products in order to provide an infrared camera function. It is not an end-product fit for consumer use. When incorporated into a host device, the end-product will generate, use, and radiate radio frequency energy that may cause radio interference. As such, the end-product incorporating this subassembly must be tested for compliance with the Interference-Causing Equipment Standard, Digital Apparatus, ICES-003, of Industry Canada before the product incorporating this device may be: manufactured or offered for sale or lease, imported, distributed, sold, or leased in Canada.

Avis d'Industrie Canada. Cet appareil est un sous-ensemble conçu pour être intégré à un autre produit afin de fournir une fonction de caméra infrarouge. Ce n'est pas un produit final destiné aux consommateurs. Une fois intégré à un dispositif hôte, le produit final va générer, utiliser et émettre de l'énergie radiofréquence qui pourrait provoquer de l'interférence radio. En tant que tel, le produit final intégrant ce sous-ensemble doit être testé pour en vérifier la conformité avec la Norme sur le matériel brouilleur pour les appareils numériques (NMB-003) d'Industrie Canada avant que le produit intégrant ce dispositif puisse être fabriqué, mis en vente ou en location, importé, distribué, vendu ou loué au Canada.

EU Notice. This device is a subassembly or component intended only for product evaluation, development or incorporation into other products in order to provide an infrared camera function. It is not a finished end-product fit for general consumer use. Persons handling this device must have appropriate electronics training and observe good engineering practice standards. As such, this product does not fall within the scope of the European Union (EU) directives regarding electromagnetic compatibility (EMC). Any end-product intended for general consumer use that incorporates this device must be tested in accordance and comply with all applicable EU EMC and other relevant directives.