Quark™
Product Specification

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Version 100

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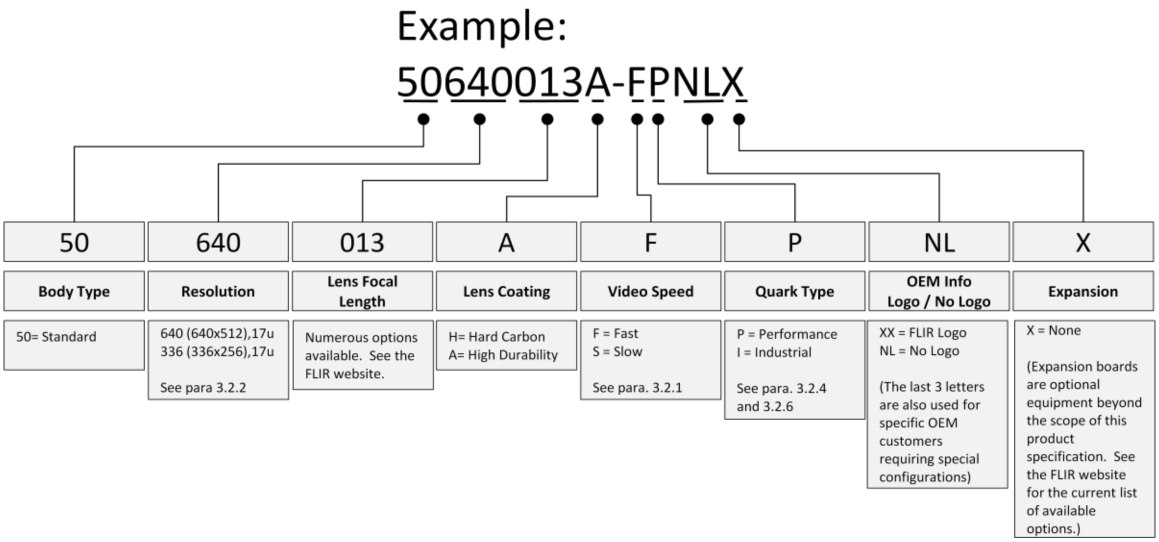
1 Document

1.1 Revision History

Version	Date	Comments
Rev 100	11/07/2011	Initial Release.

1.2 Scope

Quark is a highly miniaturized infrared imaging core from FLIR Systems®, offered in various configurations. Part numbering is as shown below.



Example:

50640013A-FPNLX

50	640	013	A	F	P	NL	X
Body Type	**Resolution**	**Lens Focal Length**	**Lens Coating**	**Video Speed**	**Quark Type**	**OEM Info Logo / No Logo**	**Expansion**
50= Standard	640 (640x512),17u 336 (336x256),17u See para 3.2.2	Numerous options available. See the FLIR website.	H= Hard Carbon A= High Durability	F = Fast S = Slow See para. 3.2.1	P = Performance I = Industrial See para. 3.2.4 and 3.2.6	XX = FLIR Logo NL = No Logo (The last 3 letters are also used for specific OEM customers requiring special configurations)	X = None (Expansion boards are optional equipment beyond the scope of this product specification. See the FLIR website for the current list of available options.)

Quark is intended to be field-upgradeable with feature improvements over time. Consequently this product specification will be updated to reflect the new features of each upgrade.

Note: A number of expansion cards intended for specific applications are available for the Quark core. In most cases, these expansion cards modify or augment the standard core functionality. This specification only applies to the standalone 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 Quark website is referenced as a source of additional information. This website can be accessed via the following URL:

www.flir.com/cvs/cores/uncooled/products/quark/

Additionally, FLIR's Applications Engineering Department is referenced as a resource for obtaining additional help or information. The department can be accessed via the following phone number: +1-805-964-9797 (or toll-free within the United States at 888-747-FLIR (888-747-3547).) Email requests can be addressed to SBA-ApplicationsEng@flir.com.

2.2 FLIR Systems Documents

102-PS241-01	Quark 2 Quick-Start Guide
102-PS241-41	Quark 2 Electrical Interface Description Document (IDD)
102-PS241-42	Tau2.0/Quark Software IDD
Various	Mechanical Interface Description Drawing (varies by part number)

2.3 External Documents

IEC 61000	Electromagnetic Compatibility (EMC)
Directive 2002/95/EC	Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)
Directive 2002/96/EC	Waste Electrical and Electronic Equipment (WEEE)
Regulation (EC) 1907/2006	Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)

2.4 Abbreviations / Acronyms

CMOS	Complementary Metal-Oxide-Semiconductor
DDE	Digital Detail Enhancement
EMC	Electromagnetic Compatibility
ESD	Electrostatic Damage
FFC	Flat Field Correction
FOV	Field of View
GUI	Graphical User Interface
I/O	Input / Output
ICD	Interface Control Drawing / Document
IDD	Interface Description Drawing / Document
IIR	Infinite Impulse Response
IP	Ingress Protection
LUT	Look-Up Table
LVDS	Low-Voltage Differential Signaling
MTBF	Mean Time Between Failure
NETD	Noise Equivalent Temperature Difference
NFOV	Narrow Field of View
NTSC	National Television System Committee
PAL	Phase Alternating Line
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
RoHS	Reduction of Hazardous Substances
ROI	Region of Interest
SDK	Software Developers’ Kit
TBD	To Be Determined
URL	Uniform Resource Locator
NVFFC	Non-volatile FFC
WEEE	Waste Electrical and Electronic Equipment
WFOV	Wide Field of View

3 Requirements

3.1 Interface Requirements

3.1.1 Mechanical Interface

3.1.1.1 Size / Weight

There are a large number of lens options for Quark, as denoted in the part number. Weight of the product varies as a function of lens type. Because new lens types are being added to the product list on a regular basis, this product specification does not list weight requirements for all configurations. Instead these requirements are specified in separate Mechanical Interface Description Drawings (IDDs) unique to each configuration. The cross section of Quark is 22.0 mm x 22.0 mm. The length is a function of lens type and is specified in the Mechanical IDD for the configuration.

Note: Current lens offerings are shown on FLIR's Quark website under the Optics tab. IDD STEP files and PDF drawings are available for download from the Quark website under the Drawings / Models tab.

3.1.1.2 Mounting

The Quark provides a number of options for mounting. The preferred approach is via four threaded holes (M1.6x0.35) on the rear surface of the core. See the relevant Mechanical IDD for more detailed information. Zinc-plated steel screws are recommended with a thread penetration of 2.4mm to 2.6mm.

3.1.2 Electrical Interface

Note: The paragraphs that follow describe high-level electrical-interface requirements. See the Quark Electrical IDD for detailed requirements.

3.1.2.1 Connector

The electrical interface to the Quark is a single high-density 60-pin connector: Samtec #ST4-30-1.50-L-D-P-TR. The recommended mating connector is Samtec #SS4-30-XXX-L-D-K-TR where XXX is either 3.00 or 3.50 for a mated stack height of 4.5mm or 5mm. See the Quark Electrical IDD for pin-out.

3.1.2.2 Input Power

The input-voltage range for the Quark is 3.3V ± 0.1V. Nominal power dissipation is approximately equal to 1.0W at room temperature. See the Quark Electrical IDD for detailed requirements regarding the power interface.

3.1.2.3 Analog Channel

The Quark provides an analog channel that can be field-configured to any of the following options:

1. NTSC
2. PAL
3. NTSC, monochrome
4. PAL, monochrome
5. Disabled (saves approximately 75 mW)

See the Quark 2 Electrical IDD for detailed requirements regarding the analog channel.

Notes:

1. *To comply with the frame-rate requirements of the NTSC and PAL standards, "slow" (export-compliant) configurations duplicate each analog frame multiple times. For example, in PAL mode, the digital output frame rate of a slow configuration is nominally 8.33Hz whereas each analog frame is duplicated (total of 3 copies) to produce a 25Hz rate.*
2. *In the monochrome modes, color encoding is not used and video low-pass filtering is disabled, which results in slightly higher bandwidth data to the display system. This mode can be used to improve image sharpness when color palettes and color symbols are not required. The monochrome option applies only to analog output.*

3.1.2.4 Digital Channels

The Quark provides two simultaneous digital channels, one parallel and one serial. The parallel channel can be configured to one of the following options:

1. BT.656 (post-AGC with color palettes applied (see 3.3.2.7) and symbols overlaid (see 3.3.2.8))
2. CMOS 8-bit (post-AGC)
3. CMOS 14-bit (pre-AGC)
4. Disabled (saves approximately 10 mW)

Similarly, the serial channel can be configured to one of the following options:

1. LVDS 14-bit (pre-AGC)
2. LVDS 8-bit (post-AGC)
3. Disabled (saves approximately 10 mW)

See the Quark Electrical IDD for detailed requirements regarding each option. Note that it is possible to enable both the parallel and serial digital output as well as the analog channel simultaneously, though it is assumed that unused channels will be disabled for power savings.

3.1.2.5 Command / Control Interface

The Quark provides an RS-232 channel for command / control. See the Quark Electrical IDD for detailed requirements regarding the physical interface and the Tau 2 / Quark Software IDD for detailed requirements regarding the protocol and commands associated with the interface.

A graphical user interface (GUI) is provided to facilitate configuration of core settings. This GUI is available for download on FLIR's Quark website (see 2.1).

3.1.2.6 Discrete I/O

The Quark provides the option of user-configured discrete I/O pins that can be used as either input signals to the core (for example, to signal the core to toggle between white hot and black hot) or as output signals from the core (for example, to signal imminent FFC). Depending upon the selected digital mode (see 3.1.2.4), there are between 1 and 8 pins available as discrete I/O. The function assigned to each discrete I/O pin is defined by a control file. No file is loaded by factory default. See FLIR's Quark website for an application note further describing discrete I/O files. Table 1 lists potential signals that can be assigned to discrete I/O pins.

Table 1: Signals Available for Discrete I/O Pin Assignment

Function	Input or Output	Detail
White hot/black hot	Input	The voltage level of this pin controls the palette applied to the analog image (see 3.3.2.7). The pin has a pull-up so that the no-connection state is High (3.3V). When this pin is high (3.3V) the analog image will use the White Hot palette (palette 1 in the standard palette file). When this pin is low (0V) the analog image will use the Black Hot palette (palette 2 in the standard palette file). The camera will power up in the saved default state and switch to the discrete input defined state when the pin state is changed.
Do FFC	Input	The application of Positive going edge to this pin will perform the "Do FFC" function.
FFC imminent	Output	This pin is normally at 0V and changes to 3.3V when the FFC Imminent Icon is present on the analog display. The "FFC Warn Time" command controls both the analog icon and this output signal.
FFC Mode	Input	The voltage level of this pin controls the FFC mode. When the pin is high (also the non-connection state), the core operates in "automatic" FFC mode (see 3.3.2.1). When the signal is pulled low, the core will switch to "manual" mode. The camera will power up in the saved default state and switch to the discrete input defined state when the pin state is changed.
Palette Toggle		This function will change the color palette from the current value to the next palette in the loaded LUT table when the discrete pin transitions from the no-connection state to the low state. No LUT change happens on the transition from low to no-connection. The LUT state after LUT14 will be LUT1.

3.1.2.7 External Sync

The Quark provides an external sync channel that can be used to synchronize frame start between two Quark cores, one configured as master and the other configured as slave. It can also be used to synchronize the frame start of a Quark with that of another product. See the Quark Electrical IDD for more detailed requirements regarding the interface. Each Quark can be configured into one of three external-sync modes:

- Disabled: In "disabled" external-sync mode, the core relies on internal timing, and the external-sync channel is used as neither input nor output.
- Master: In "master" mode, the core relies on internal timing to control its own frame start but also outputs a synchronization pulse on the external-sync channel.
- Slave: In "slave" mode, the core synchronizes its frame start to a pulse received on the external-sync channel.

Note: The external-sync feature is not recommended for "slow" configurations of Quark, and correct operation is not guaranteed. See the Quark electrical ICD for more information.

3.2 Imaging Requirements

3.2.1 Output Resolution

Output resolution (i.e., number of pixels) varies by configuration as well as user-specified runtime settings, as shown in Table 2. The resolution of the configuration is encoded in the part number (see 1.2).

Table 2: Output Resolution by Configuration & Video Setting

Configuration, Resolution	Video Setting	Output Resolution, analog & BT.656	Output Resolution, LVDS & CMOS
640	NTSC	640x480	640x512
640	PAL	640x512	640x512
336	NTSC	320x240	336x256
336	PAL	320x256	336x256

3.2.2 Frame Rate

Table 3 shows digital frame rate as a function of configuration as well as two user-specified runtime settings: video setting and averager mode. In averager-enabled mode, the Quark performs automatic "smart" averaging of pairs of frames from the detector array.

Note: The averager operation is designed to reduce blur by only averaging a given pixel's output if the difference from one frame to the next is small enough to be considered noise. The 640 configuration does not provide an averager option.

Table 3: Frame Rate by Configuration & Video Setting

Configuration, Video Speed	Configuration, Resolution	Video Setting	Averager Mode	Frame Rate (Hz)
Fast	336	NTSC	Disabled	59.94 Hz
Fast	336	PAL	Disabled	50.00 Hz
Fast	336	NTSC	Enabled	29.97 Hz
Fast	336	PAL	Enabled	25.00 Hz
Fast	640	NTSC	not applicable	29.97 Hz
Fast	640	PAL	not applicable	25.00 Hz
Slow	336	NTSC	Disabled	8.56 Hz
Slow	336	PAL	Disabled	8.33 Hz
Slow	336	NTSC	Enabled	7.49 Hz
Slow	336	PAL	Enabled	8.33 Hz
Slow	640	NTSC	not applicable	7.49 Hz
Slow	640	PAL	not applicable	8.33 Hz

3.2.3 Optical Performance

Field of view (FOV) varies by lens. Because new lens types are being added to the product list on a regular basis, this product specification does not list optical requirements for all configurations. Instead the FOV for each configuration are specified in separate Mechanical IDDs unique to each configuration.

Note: Current lens offerings are shown on FLIR's Quark website under the Optics tab.

3.2.4 Sensitivity

See Appendix A. (This appendix contains proprietary performance specifications and is available to parties having a Non-Disclosure Agreement (NDA) on file with FLIR Systems. Please contact FLIR Systems to obtain this appendix.)

3.2.5 Intrascene Range

See Appendix A.

3.2.6 Operability

See Appendix A.

3.3 Functional Requirements

3.3.1 Start-Up Features

3.3.1.1 Splash Screen

At start-up, the Quark presents a splash screen (or optionally 2 splash screens, displayed one after the other) in the analog and BT.656 channel. The default splash screen is the FLIR Splash screen. It is possible to customize the splash screen in the field. (See FLIR's Quark website for an Application note describing this capability.) The timing of each splash screen (i.e., how long each is displayed) can also be adjusted via serial command.

3.3.1.2 Readiness Time

Elapsed time from application of power to output of IR video is approximately 2 sec for the 336 configurations and approximately 4 sec for 640 configurations. (This requirement only applies if splash-screen display time is set to "minimum".)

3.3.1.3 Power-On Defaults

The Quark presents capability to specify default setting to be applied at start-up. Additionally, it is possible to reset the core to factory-specified defaults. See the Tau 2 / Quark Software IDD for a list of applicable settings and factory default values.

3.3.1.4 Fault-Tolerant Upgradeability

The 336 configuration of Quark provides the capability to safely upgrade firmware / software. In the event of power loss or data corruption during the upgrade process, the core will continue to provide at least the minimum functionality required for the upgrade process to be repeated. The 640 configuration provides fault-tolerant software upgrade but not fault-tolerant firmware upgrade.

Note: The 336 configuration of Quark reserves a portion of non-volatile memory referred to as the "upgrade" block. FLIR recommends writing only to the upgrade block and not to the "factory" block when upgrading firmware. Fault-tolerant upgrade is not ensured when writing the factory block. When the upgrade block is written, boot-up time increases by approximately 300 msec. The 640 configuration does not provide an upgrade block. Caution should be exercised when upgrading firmware.

3.3.1.5 Backward Compatibility

All future releases of Quark firmware / software will be backwards compatible with all fielded versions of Quark. In other words, upgrading the core in the field with an authorized firmware / software release will not result in a loss of function or performance.

Note: Not all feature improvements planned for later releases will necessarily work when a fielded Quark is upgraded because some may require factory calibration to function properly. However, in those cases, the new feature will simply not function rather than causing the upgraded core to behave erroneously.

3.3.2 Image Processing Features

3.3.2.1 FFC

All configurations of the Quark are delivered with factory-calibrated correction terms that provide uniform pixel response. Flat-field correction (FFC) is a process whereby one of the correction terms, referred to as the FFC map, is updated periodically in the field to improve image quality. Recalibrating the FFC map corrects for temporal pixel drift.

While it is possible for the Quark to operate over long periods of time without FFC, performance can be maintained at the highest possible level by performing FFC often, for example:

- At power-up
- When the ambient temperature has changed by several degrees since the last FFC

  Note: An internal temperature sensor is readable by command. See 3.3.4.3.
- When several minutes have elapsed since the last FFC

It is not essential to repeat the FFC process as often as recommended above, but superior image quality will be maintained as a result of doing so.

Recalibration of the FFC map is typically executed by subtending the entire field of view by a uniform source (such as by closing a shutter mechanism over the lens or by pointing the core to a uniform scene) and then initiating the FFC process via command. The Quark does not include a shutter or other internally-controlled mechanism that presents a uniform temperature required to complete the FFC process. Therefore, it is assumed that one of the following conditions is true:

- The Quark is integrated with an external shutter assembly capable of being controlled by means of control signals SHUTTER0 and SHUTTER1 from the Quark. (See 3.3.2.1.2.)
- External logic commands the Quark to perform FFC at appropriate opportunities (such as when the external logic has driven an external shutter closed or when the Quark is known to be imaging a uniform source such as a lens cap).
- The Quark is operated in stable temperature conditions such that the small degradation in image quality resulting from not performing periodic FFC is acceptable. *Note: Even when the Quark is operated in stable conditions, it is highly recommended that FFC be performed whenever possible. Even if the application does not support the possibility of performing FFC at each power cycle, it should be performed whenever possible and saved to the non-volatile memory, as further described below.*

The FFC process takes nominally 0.4 seconds to complete, depending upon the user-specified parameters, Shutter Close Time and Shutter Open Time (see 3.3.2.1.2). The digital output data (CMOS and LVDS) is frozen throughout, and a warning symbol consisting of a square in the upper-right corner is displayed in the analog and BT.656 video. The FFC process can be initiated via command at any time.

It is possible to save the currently-applied FFC map to non-volatile memory. The saved map, referred to as the non-volatile FFC (NVFFC) map, will be applied at the next power-up. (Note that recalibrating the FFC map and storing it as the NVFFC map are two separate operations, each initiated by command.) Every Quark is delivered with a factory-calibrated NVFFC map that is applied at start-up. After each commanded FFC recalibration, the newly-generated map is applied in lieu of the NVFFC map. However, the new map is lost after power cycling *unless* it is saved as the NVFFC map (in which case, it overwrites the previous NVFFC map). If possible, a new NVFFC map should be stored at each power cycle. (The older the stored NVFFC map, the less effective it is because of temporal pixel drift).

Note: It is not recommended to erase the NVFFC map without replacing it. If there is no NVFFC map to apply, image quality at start-up may be severely degraded.

The Quark provides three user-selectable FFC modes:

- Automatic: In automatic FFC mode, the stored NVFFC map is applied at start-up. 5 seconds after start-up, the core automatically initiates the FFC recalibration process. Thereafter, the core autonomously initiates periodic FFC recalibration events as triggered by elapsed time or temperature change or both. (The elapsed time period and the amount of temperature change that trigger a new FFC event are both parameters that can be specified by the user. In automatic mode, the user can also command an FFC event at any time rather than waiting for the automatic event.) Automatic FFC mode is not recommended unless the Quark is interfaced to a shutter assembly that it signals to open / close automatically via the logic signals SHUTTER0 and SHUTTER1. (See 3.3.2.1.2).
- Manual: In manual mode, the stored NVFFC map is applied at start-up. However, the FFC process is only initiated via command, never automatically / autonomously by the core. (See the one exception in the note below.) In manual mode, the core signals shutter close / open via the signals SHUTTER0 and SHUTTER1 (see 3.3.2.1.2).
- External: External mode is essentially identical to manual mode except that the signals SHUTTER0 and SHUTTER1 are not used. That is, even if the Quark is interfaced to a shutter assembly that responds to logic signals from SHUTTER0 and SHUTTER1, the core will not exercise it when NVFFC is commanded. The assumption in external mode is that the core is imaging an external uniform source when FFC is initiated.

  Note: If the NVFFC map is erased and not replaced (which is not recommended, as described in a previous note), Quark initiates an automatic FFC immediately after start-up when in automatic or manual mode (but not in external mode).

3.3.2.1.1 Long FFC

When the Quark is heated or cooled across its full operating temperature range, it may occasionally require a “long” FFC process depending upon the FFC mode. The long FFC operation takes approximately 0.1 sec longer than the normal “short” FFC operation and allows the core to automatically load calibration terms that are appropriate for the current operating temperature range. A status flag readable via serial command indicates when the core is awaiting a long FFC command. (See the Tau 2 / Quark Software IDD.) When operating in automatic FFC mode, the long FFC process takes place automatically. When operating in external FFC mode, calibration terms are loaded automatically without requiring an FFC process. (Image quality may appear slightly worse until FFC is commanded.) When operating in manual FFC mode, the core awaits a long FFC command before loading new calibration terms.

Note: Nominally long FFC is required whenever the Quark core is heated / cooled through approximately 0C, 40C, and 65C. For example, if the core temperature is 35C when first powered on and then heated to 45C, it will normally require long FFC. If the core is then cooled back down to 35C, a second long FFC will again be signaled.

3.3.2.1.2 Shutter Control

Quark provides two logic signals, SHUTTER0 and SHUTTER1, intended to signal an external shutter-drive circuit when to open / close an external shutter device during the FFC process. (These signals are logic signals only and are not intended to directly drive a shutter assembly.) Table 4 depicts a truth table to be implemented by the shutter-drive circuit.

Table 4: Shutter-Signals and Intended Shutter Response

SHUTTER0	SHUTTER1	Intended Shutter-Circuit Action
Low	Low	Idle
High	Low	Drive shutter closed
Low	High	Drive shutter open
High	High	(Quark never signals this state.)

The shutter-drive profile can be programmed to match the characteristics of the external shutter. For example, a shutter with a return spring will typically need to be driven closed constantly for it to remain closed whereas a bistable shutter will typically remain in its current state (open or closed) when the drive circuit is idle. Both the close profile and the open profile are specified via a 32-entry look-up table (LUT), where each 4-bit entry represents one video field (1/60th of a second in NTSC mode, 1/50th in PAL mode). The upper two bits of each entry are not used; bit 1 represents the intended state of SHUTTER0, and bit0 represents the intended state of SHUTTER1. The last entry in the table represents the “repeat” state, which is repeated until a specified timeout period. (The timeout period is from 0 to 7000 fields and is included to mitigate against burnout of the shutter motor in the event that the repeat state is “drive shutter closed” and the shutter is left in the closed position.) Figure 1 provides an example of a shutter close profile for a shutter with a return spring and another for a bi-stable shutter.

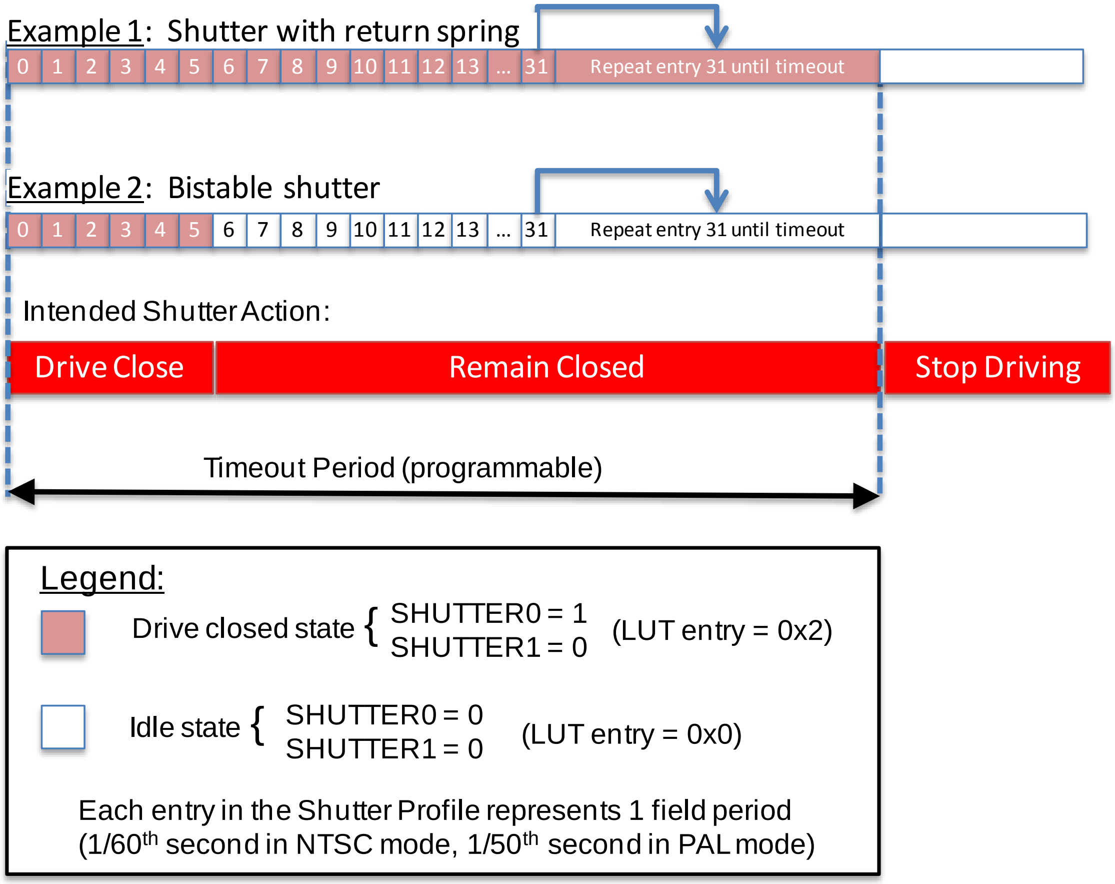


Figure 1: Two Examples of a Shutter Close Profile

Figure 2 shows the timeline for the FFC process, which consists of three distinct periods:

- The FFC Close Period is programmable in units of video frames. The FFC Close Period should be set to a value which represents the time required to completely close the shutter once the Shutter Close Profile is initiated plus a minimum of 3 frames. (The extra 3 frame periods represent the time for the pixel elements to fully respond to a change in incident radiation. The time constant of the Quark detector array is approximately 12 msec, so 3 frames represents approximately 8 time constants. If the FFC Close Period is set too low, the resulting FFC map may include some residual influence from whatever scene the Quark was imaging at the time the FFC was initiated, particularly if there are very hot or very cold items in the scene.)
- The FFC Acquire Period is not adjustable. It represents the time during which the core is integrating frames used to update the correction map and is always 4 frame periods.
- The FFC Open Period is programmable and should be set to a value equal to the time required for the shutter to fully open plus 2 frames.

Note that in automatic and manual FFC mode, SHUTTER0 and SHUTTER1 are signaled according to the specified close and open profiles described above.

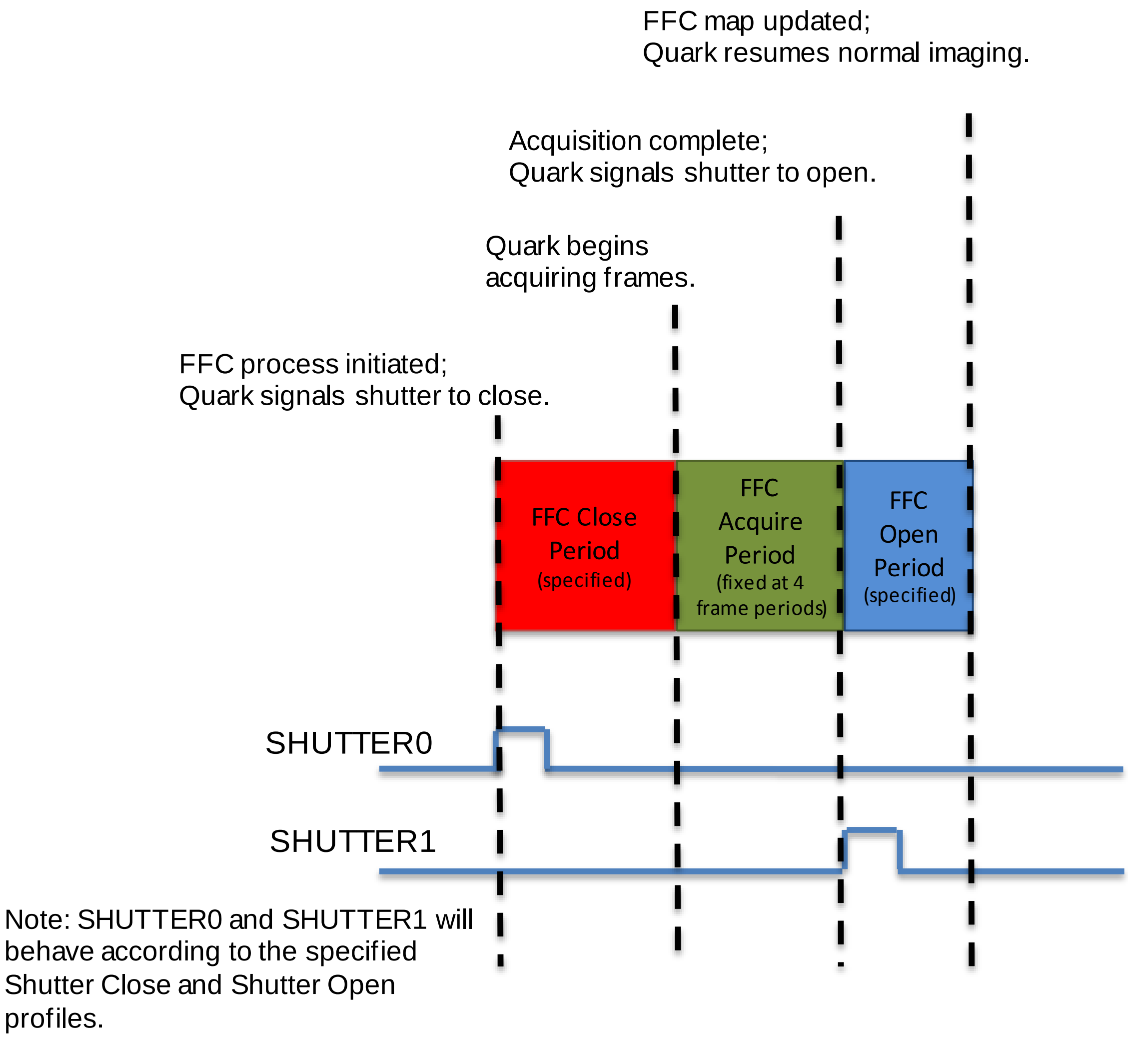


Figure 2: Illustration of FFC Timeline

3.3.2.2 Gain State

To be specified in a later release. The current release of Quark supports a high-gain state only.

3.3.2.3 Image Orientation

The Quark provides four image-orientation modes, described below and illustrated in Figure 3:

- Normal
- Invert + revert: flips image vertically and horizontally. This is the recommended mode when the core is mounted upside-down.
- Invert: flips image vertically. This is the recommended mode when the core images the scene via a vertical fold mirror.
- Revert: flips image horizontally. This is the recommended mode when the core images the scene via a horizontal fold mirror or when used in a rear-facing application intended to simulate the view through a rear-view mirror.

Invert and revert settings apply to all data channels (LVDS, CMOS, BT.656, and analog video).

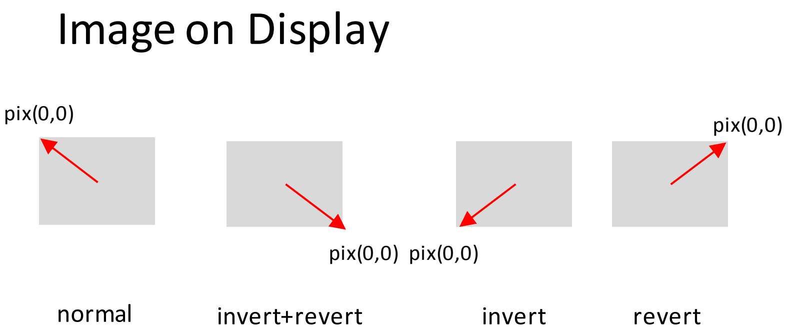


Figure 3: Illustration of Image-Orientation Modes

3.3.2.4 Zoom

The Quark provides an optional zoom capability. The maximum zoom factor varies depending upon configuration as shown in Table 5. The zoom algorithm applies to the analog and BT.656 output data (not to the CMOS or LVDS output data). A zoom symbol indicating the zoom factor is displayed (in the analog and BT.656 channels) when in zoom mode. As described in 3.3.2.6.1, a separate AGC ROI is applied for each zoom factor.

Table 5: Max Zoom vs. Array Size

Configuration, Resolution	Max Zoom
640	8X
336	4X

3.3.2.5 Digital Data Enhancement (DDE)

The Quark provides an optional “digital-data-enhancement” (DDE) algorithm which can be used to enhance image details and/or suppress fixed pattern noise. Two modes are available, “manual” and “dynamic”. The descriptions of each mode are as follows:

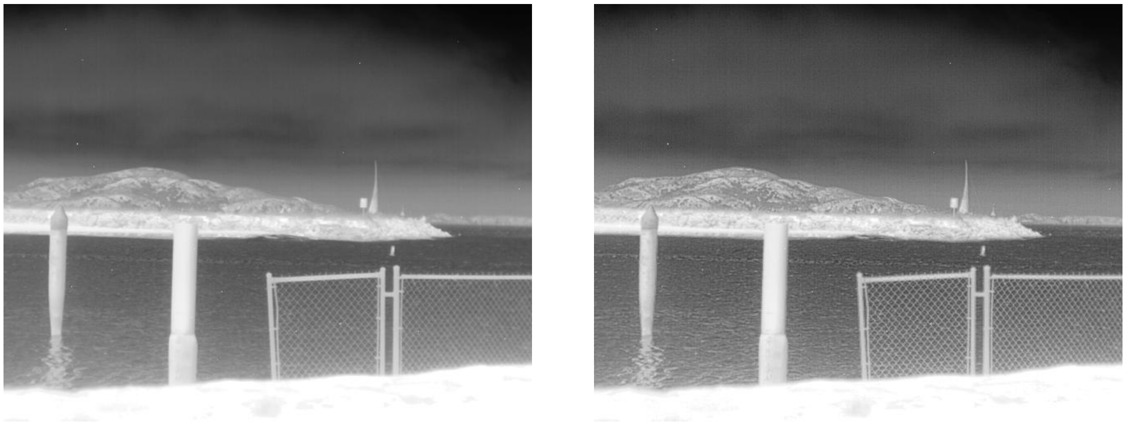
- Dynamic mode: DDE parameters are computed automatically based on scene contents. DDE index (which supplants the spatial-threshold parameter used in the manual algorithm) is the only controlling parameter and ranges from 0 to 63, with higher values representing higher degrees of detail enhancement. If no enhancement is desired, the value should be set to 17. Values less than 17 soften the image and filter fixed pattern noise, as exemplified in Figure 4. Values greater than 17 sharpen the details in the image, as shown in Figure 5.


(a) DDE index = **17**

(b) DDE index = **8**

Figure 4: Illustration of Noise Suppression with DDE

(Notice fixed pattern noise is reduced in the image on the right.)



(a) DDE index = **17**

(b) DDE index = **24**

Figure 5: Illustration of Detail Enhancement with DDE

(Notice details such as the links in the fence are sharper in the image on the right.)

Note: The recommended DDE mode is "dynamic". "Manual" is provided for customers of previous FLIR cores that have familiarly with the manual DDE mode.

- Manual mode: The following three parameters are user-specified:
    - DDE Gain: ranges from 0 to 255 and represents the magnitude of high-frequency boost (scaled by 16)
        - For gain = 0, DDE is disabled
        - For gain > 0, details are enhanced by gain/16. In other words, a value of 1 represents a 1/16 attenuation of details whereas a value of 64 represents a 4X enhancement of details.
    - DDE threshold: ranges from 0 to 255 and represents the maximum detail magnitude that is boosted. Details with magnitude exceeding the threshold are not enhanced. Values greater than 255 will place the camera in Dynamic DDE mode with a DDE index of x-255. In this case, DDE Gain and DDE spatial threshold are adjusted dynamically.
    - DDE spatial threshold: ranges from 0 to 15, and represents the threshold of the pre-filter (smoothing filter) applied to the signal prior to high-frequency boost. The pre-filter prevents low-magnitude fixed-pattern noise from being amplified. Note that the DDE spatial threshold also represents the DDE index when in automatic DDE mode.

3.3.2.6 Automatic Gain Correction (AGC)

The Quark provides multiple AGC algorithms used to transform 14-bit data to 8-bit. These options include the following, with associated parameters shown below each algorithm:

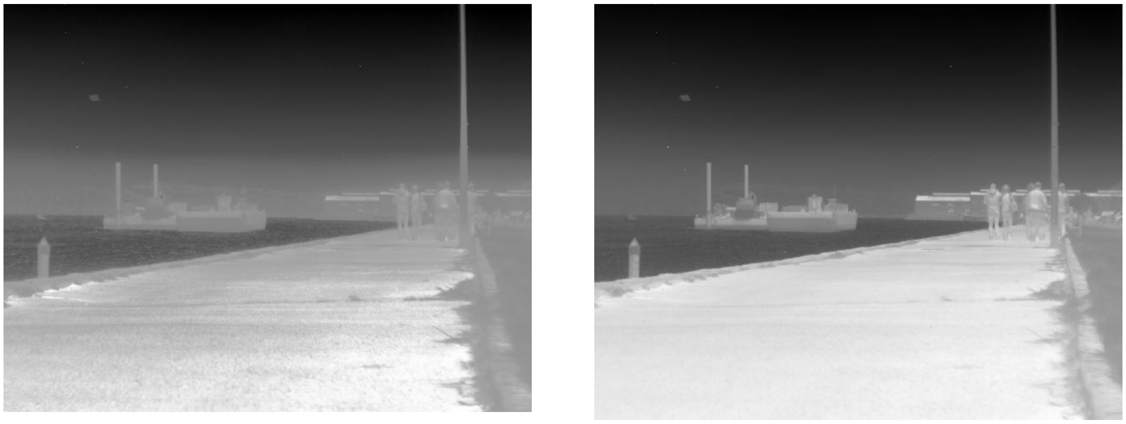
- Plateau equalization (see 3.3.2.6.1)
    - Plateau value
    - Maximum gain
    - ITT midpoint
    - Region of Interest (ROI)
    - IIR filter
- Linear histogram (see 3.3.2.6.2)
    - ITT midpoint
    - ROI
    - IIR filter
- Manual (see 3.3.2.6.3)
    - Brightness
    - Contrast
    - IIR filter
- Auto-bright (see 3.3.2.6.4)
    - Brightness
    - Contrast
    - IIR filter
- Once-bright (see 3.3.2.6.5)
    - Brightness bias
    - Contrast
    - IIR filter

Note: FLIR highly recommends that each customer optimize AGC settings for each particular application. "Preferred" AGC settings are highly subjective and vary considerably depending upon scene content and user preferences. Generally speaking, FLIR recommends the plateau equalization algorithm, but there are scenarios where each of the other algorithms may be better suited.

3.3.2.6.1 Plateau Equalization

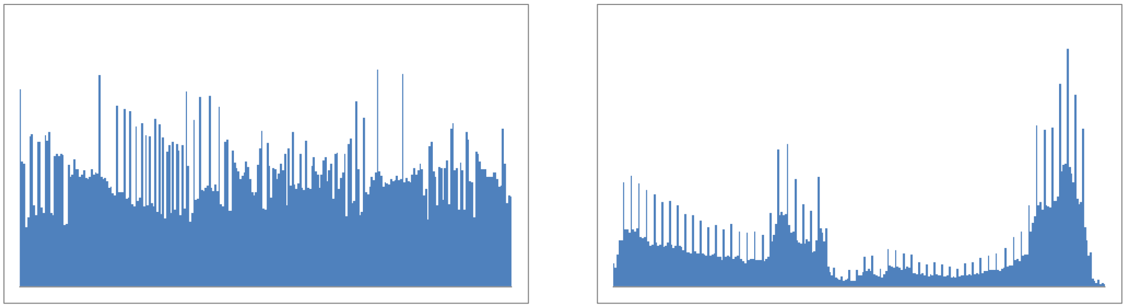
The plateau equalization algorithm performs a non-linear transformation from 14-bit to 8-bit based on image histogram. It is a variant of classic histogram equalization, an algorithm that maps 14-bit to 8-bit using the cumulative histogram of the 14-bit image as the mapping function. In classic histogram equalization, an image comprised of 60% sky will devote 60% of the available 8-bit shades to the sky, leaving only 40% for the remainder of the image. Plateau equalization limits the maximum number of grayshades devoted to any particular portion of the scene by clipping the histogram (via the plateau value) and limiting the maximum slope of the mapping function (via the maximum gain value). It also provides an ITT midpoint value that allows mean brightness of the8-bit image to be specified. The description below provides explanation of each of these three parameters.

Plateau value. When plateau value is set high, the algorithm approaches the behavior of classic histogram equalization – grayshades are distributed proportionally to the cumulative histogram, and more grayshades will be devoted to large areas of similar temperature in a given scene. On the other hand, when plateau value is set low, the algorithm behaves more like a linear AGC algorithm – there is little "compression" in the resulting 8-bit histogram. Figure 6 illustrates both of the cases.



(a) Plateau Value = **1000**

(b) Plateau Value = **10**



(c) 8bit Histogram for Plateau Value = **1000**

(d) 8-bit Histogram for Plateau Value = **10**

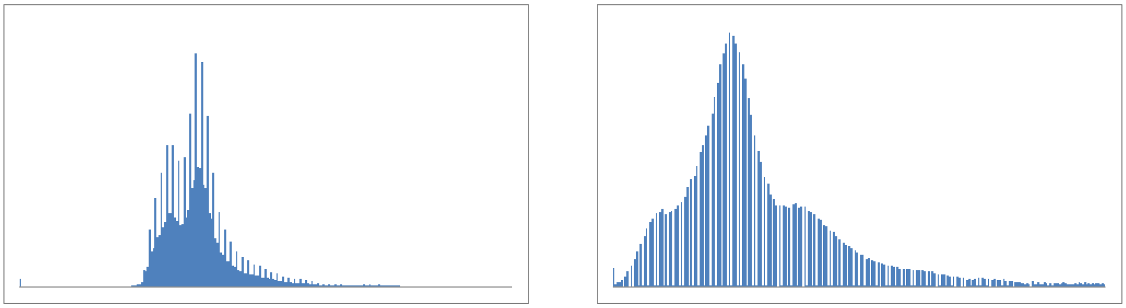
Figure 6: Illustration of Plateau Value

(Notice details in the sidewalk in the left image whereas more grayshades are available for the pedestrians in the right image.)

<ins>Maximum Gain</ins>. For scenes with high dynamic range (that is, wide 14-bit histogram), the maximum gain parameter has little effect. For a very bland scene, on the other hand, it can significantly affect the contrast of the resulting image. Figure 7 provides an example.

(a) Maximum Gain = **6**

(b) Maximum Gain = **24**



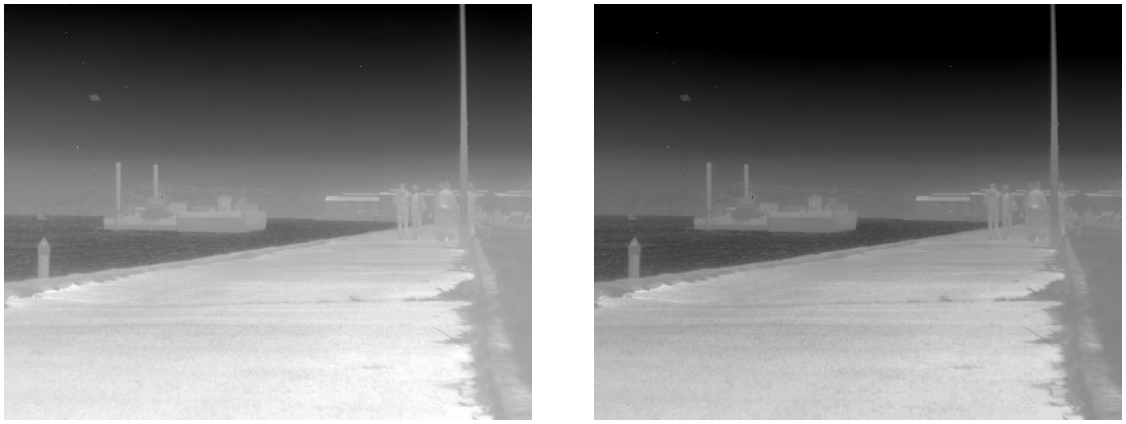
(c) 8bit Histogram for Max. Gain = **6**

(d) 8bit Histogram for Max. Gain = **24**

Figure 7: Illustration of Maximum Gain in a Bland Image

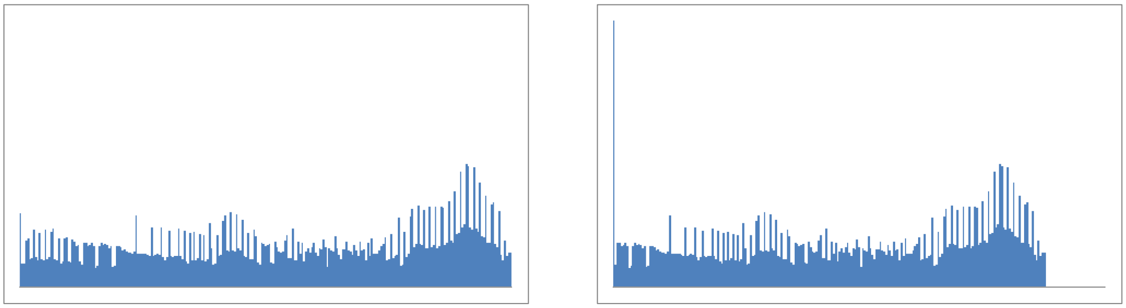
(Notice more details but also greater fixed-pattern noise in the right image.)

<u>ITT Midpoint</u>. The ITT Midpoint can be used to shift the 8-bit histogram darker or brighter. The nominal value is 128. A lower value causes a darker image, as shown in Figure 8. A darker image can help improve the perceived contrast, but it is important to note that more of the displayed image may be railed (8bit value = 0 or 255) by moving the midpoint away from 128. This can be seen in the histogram of Figure 8d.



(a) ITT Midpoint = **127**

(b) ITT Midpoint = **96**



(c) 8bit Histogram for ITT Midpoint = **127**

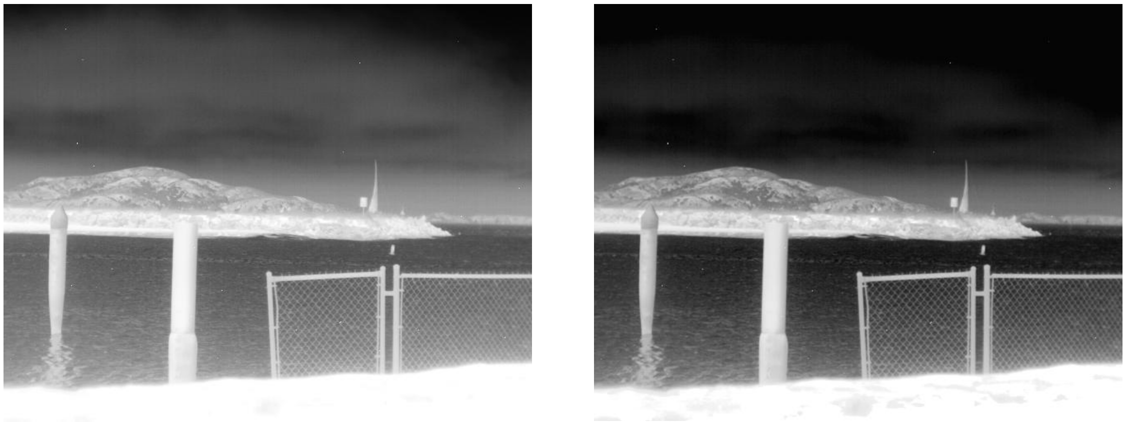
(d) 8bit Histogram for ITT Midpoint = **96**

Figure 8: Illustration of ITT Midpoint

(Notice image on the right is darker. Notice in the histogram on the right that far more pixels have a value of 0 and that no pixels have a value between 224 and 255.)

Region of Interest (ROI). In some situations, it is desirable to have the AGC algorithm ignore a portion of the scene when collecting the histogram. For example, if the Quark is rigidly mounted such that the sky will always appear in the upper portion of the image, it may be desirable to leave that portion of the scene out of the histogram so that the AGC can better optimize the display of the remainder of the image. This is illustrated in Figure 9. Similarly for a hand-held application, it may be desirable to optimize the display of the central portion of the image. For those applications, it is possible to specify a region of interest (ROI) beyond which data is ignored when collecting the image histogram. Any scene content located outside of the ROI will therefore not affect the AGC algorithm. (Note: this does not mean the portion outside of the ROI is not displayed, just that the portion outside does not factor into the optimization of the image.) Separate ROI are automatically applied for un-zoom, 2X, 4X, and 8X zoom. Coordinates for the ROI are as follows:

- Top / Bottom: 0 = center of the display, negative values are above center, positive values are below center
- Left / Right: 0 = center of display, negative values are left of center, positive values are right of center



(a) ROI = Full Image

(b) Sky excluded from ROI

Figure 9: Illustration of ROI

(Notice the image on the right has more contrast in the portion of the image below the sky.)

IIR Filter. The IIR filter is used to adjust how quickly the AGC algorithm reacts to a change in scene or parameter value. The filter is of the form

$$n' = n * \alpha/256 + n'-1 * (256-\alpha)/256$$

where:

n' = actual filtered output value for the current frame

n = unfiltered output value for the current frame

$n'-1$ = actual filtered output value for the previous frame

α = filter coefficient, user-selectable from 0 to 255

If the IIR filter value is set to a low value, then if a hot object enters the field of view, the AGC will adjust more slowly to the hot object, resulting in a more gradual transition. In some applications, this can be more pleasing than a sudden change to background brightness.

3.3.2.6.2 Linear Histogram

The linear histogram algorithm performs a linear transformation from 14-bit to 8-bit of the form:

$$8bit_i = m * 14bit_i + b$$

The slope of the transformation is computed automatically based on the ROI histogram:

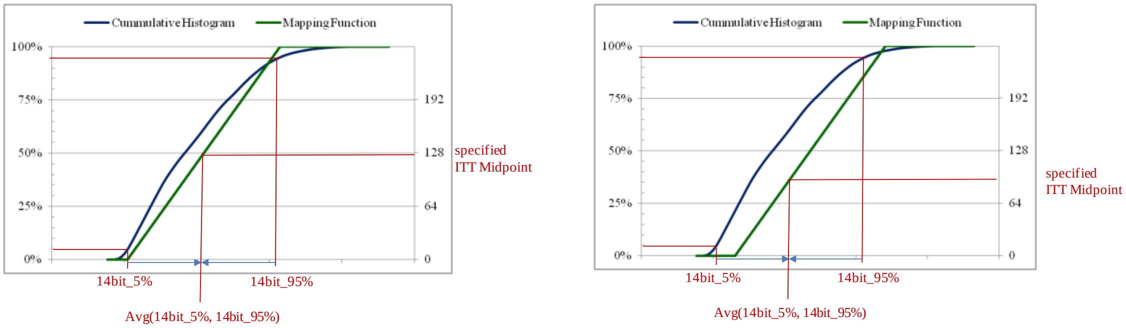
$$m = 255 / (14bit\_95\% - 14bit\_5\%),$$

where 14bit_5% is the 14-bit value corresponding to the 5% point on the cumulative ROI histogram and 14bit_95% is the value corresponding to the 95% point.

The offset is then computed as

$$b = \text{ITT midpoint} - \text{avg}(14bit\_5\%, 14bit\_5\%) * m$$

In other words, the algorithm attempts to map the midway point between the 5% and 95% points on the cumulative histogram to the specified ITT midpoint, as shown in Figure 10. The 8-bit values resulting from the above equations are clipped to a minimum value of 0 and a maximum value of 255.



(b) ITT Midpoint = **128**

(b) ITT Midpoint = **96**

Figure 10: Illustration of the Linear-Histogram Mapping Function

3.3.2.6.3 Manual

The “manual” algorithm performs a linear transformation from 14-bit to 8-bit, with slope based solely on a specified contrast value and offset based solely on a specified brightness value as shown below:

$$m = \text{specified contrast} / 64$$

$$b = 127 - (\text{brightness}) * m.$$

3.3.2.6.4 Auto Bright

The auto-bright algorithm is identical to the “manual” algorithm except that brightness value is automatically and dynamically updated to equal array mean. In other words, the array mean is automatically mapped to an 8-bit value of 127.

3.3.2.6.5 Once Bright

The “once bright” algorithm is identical to the “auto-bright” algorithm except that the offset of the linear transformation, b, is computed only at the time the algorithm is selected and is not dynamically updated. It is computed as

$$b = 127 - (\text{frame mean} - \text{brightness bias}) * m,$$

where brightness bias is a user-specified parameter.

3.3.2.7 Palette

The Quark provides up to 15 user-selectable palettes (also referred to as look-up tables or LUTs). The palette selection applies to the analog and BT.656 output data.

3.3.2.8 Symbol Overlay

The Quark provides symbol-overlay capability in which arbitrary text, rectangles (filled or outline), or bitmaps may be specified via run-time commands for on-screen display. Symbol resolution is 640x512 for all configurations. Each symbol may be displayed in 1 of 256 colors / translucency shades. The symbol overlay capability, including built-in icons such as the FFC warning indicator (3.3.2.1) and zoom symbol (see 3.3.2.4), apply to the analog and BT.656 output data. The LVDS and CMOS channels do not include symbol overlay data.

3.3.2.9 Snapshot

The 336 configuration of Quark provides snapshot capability in which 14-bit frames of data can be stored in non-volatile memory and downloaded via the serial-com. interface. The available capacity is reported upon command, and also all stored snapshots can be erased upon command. The 640 configuration does not provide capability to store a snapshot to non-volatile memory. (To support the calibration routines accessible via the GUI, snapshots can be stored temporarily to volatile memory.)

3.3.3 Radiometric Features

To be specified in a later release. The current release of Quark does not provide radiometric features.

3.3.4 Diagnostic / Status Features

3.3.4.1 Scratch Pad

The 336 configuration of Quark provides capability to store arbitrary data (up to 128 kbytes) to non-volatile memory upon command. (It is envisioned that this scratch pad can be used to log operational data in the field.)

3.3.4.2 Test Patterns

The Quark provides capability to display various test patterns. These are intended primarily to adjust display properties and/or for diagnostic purposes (for example, to verify the core is providing a valid output).

3.3.4.3 Temperature Measurement

The Quark provides capability to report internal core temperature. Accuracy of the measurement is $\underline{+}5\mathrm{C}^{o}$.

3.4 Environmental Requirements

3.4.1 Operating Temperature

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation when operated in conditions in which the core frame is within the range -40°C to +80°C.

3.4.2 Storage Temperature

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation after storage within the range -50°C to +85°C.

3.4.3 Relative Humidity

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation when operated in non-condensing humidity in the range 5% to 95%.

3.4.4 Thermal Shock

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation after extreme thermal shock from one extreme of the operating temperature range to the other.

Note: During extreme thermal shock, image quality may be temporarily compromised.

3.4.5 Mechanical Shock

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation after exposure to shock pulses of 250 g (1.5msec half-sine) and 500g (0.8msec half-sine) along any axis.

3.4.6 Vibration

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation after exposure to random vibration along any axis up to 4.3 grms per the profile specified in Table 6 (also shown graphically in Figure 11).

Table 6: Random Vibration Profile

Frequency (Hz)	Acceleration density (G^2/Hz)
10	0.040
20	0.100
100	0.100
800	0.002
1000	0.002

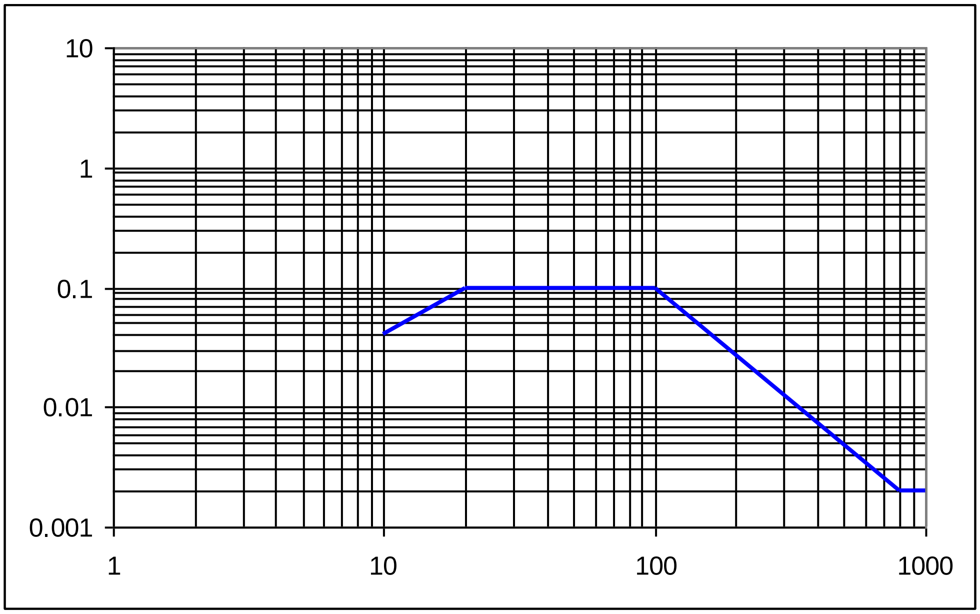


Figure 11: Random Vibration Profile

3.4.7 Altitude

The Quark meets all requirements of this specification and exhibits no damage or permanent degradation after exposure to pressure equivalent to 12 km above sea level.

Note: The Blowing Sand (3.4.8) and IP Rating (3.4.9) requirements that follow each assume the Quark lens barrel is sealed to a bulkhead via an o-ring. Neither requirement applies to the portion of the core behind the o-ring seal, only to the protruding lens barrel. Exposure of the rearward portion of the core to these environmental conditions will cause permanent damage.

3.4.8 Blowing Sand

After bulkhead mounting via an o-ring seal to the lens barrel, the protruding portion of the Quark withstands up to 90 minutes of blowing sand at normal incidence, rate of 18 m/sec. Following exposure, responsivity of the core will be degraded by no more than 10%.

Note: This requirement applies only to those configurations of the Quark with hard-carbon coating (as denoted in the part number – see 1.2).

3.4.9 IP Rating

After bulkhead mounting via an o-ring seal to the lens barrel, the protruding portion of the Quark provides ingress protection rating no less than IP67.

3.4.10 EMC

To be specified in a later release, pending formal qualification.

3.5 Design and Assembly requirements

3.5.1 Reliability / Design Life

The Quark was designed to meet all the requirements of this specification with a mean time between failure (MTBF) ≥30,000 hrs operation and a service life (including storage) in excess of 7 years.

3.5.2 ROHS / WEEE / REACH

The Quark complies with the following directives / regulations:

- Directive 2002/95/EC, “Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)”
- Directive 2002/96/ EC, “Waste Electrical and Electronic Equipment (WEEE)”.
- Regulation (EC) 1907/2006, “Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)”

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This product is protected by patents, design patents, patents pending, or design patents pending.

If you have questions that are not covered in this manual, or need service, contact FLIR Commercial Systems Customer Support at 805.964.9797 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.