Datasheet, 9Hz Configuration

FLIR Boson^{TM} Thermal Imaging Core < 9Hz

General Description

Boson^{TM} is a complete thermal imaging core designed to integrate easily into an Original Equipment Manufacturer's (OEMs) complete system. The core images Long Wave Infrared (LWIR) radiation and outputs a thermal video stream. A highly configurable platform, Boson provides a host of user-selectable features and interfaces for a variety of applications.

Features

- Multiple hardware configurations:
  - QVGA (320x256) and VGA (640x512) sensor array
  - Multiple field-of-view (FOV) options: 8 QVGA FOVs and 8 VGA FOVs
  - Integral shutter assembly
- Low size, weight, and power (SWAP); capability to trade feature set for power
- User-configurable I/O with multiple channels for video and command/control, including USB, parallel CMOS, and UART
- SDIO, I2C, and SPI channels for peripheral support (e.g., memory card, external GPS, gyro, digital compass, etc.); full support to be provided in an upcoming SW upgrade
- State-of-the-art signal processing, including advanced noise filters for superior sensitivity, eZoom, and colorization
- Power-safe field upgrade
- Rapid start-up, < 1.5 sec to imaging
- Designed for industrial / military environment
- RoHS compliant

Applications

- Handheld thermal-imaging systems, such as fire-service, military/paramilitary, and thermography
- Security & surveillance systems
- UAV / robotic vision
- Navigation / obstacle-avoidance
- Automotive DVE

Key Specifications

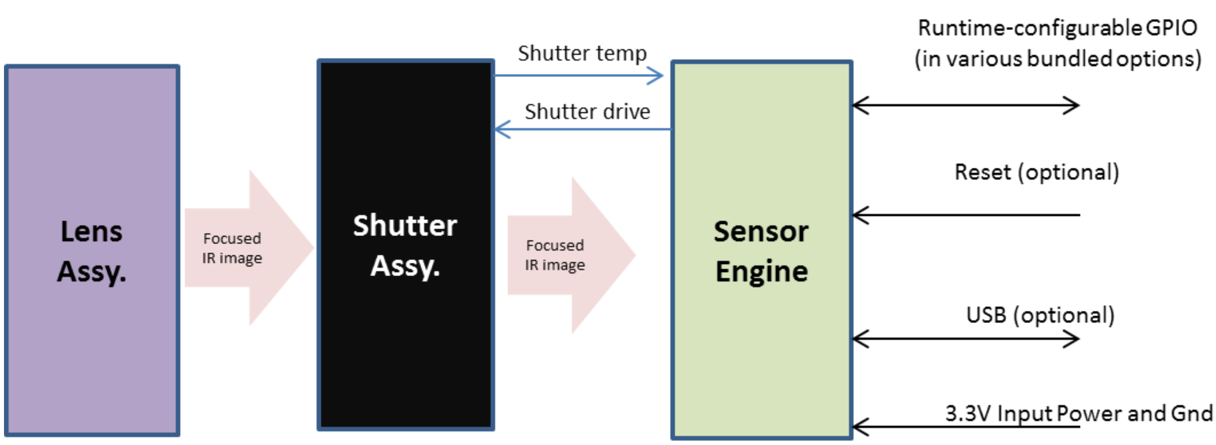
Unless otherwise stated, all specifications apply to all Boson configurations.

Imaging	
Sensor technology	Uncooled VOx microbolometer
Array format	320x256 or 640x512
Effective frame rate	<9Hz
Thermal sensitivity	Varies by configuration, as low as <40 mK
NUC	Factory calibrated, capable of operation with or without shutter
Field of view	4º to 95º HFOV, depending upon lens configuration
Solar protection	Integral
Electrical	
Input voltage	3.3V
Power dissipation	Varies by configuration, as low as 580 mW
Video channels	CMOS or USB2 (see note 1)
Control channels	UART or USB (see note 2)
Peripheral channels	I2C, SPI, SDIO (see note 3)
Mechanical	
Size	Varies by configuration, as small as 21 x 21 x 11 mm
Weight	Varies by configuration, as light as 7.5g
Environmental	
Operating temp.	-40C to 80C (varies by config.)
Shock	1500g @ 0.4msec

- Note 1: USB3, comm via I2C, and I2C, SPI, and SDIO peripheral channels are all anticipated in a future field-upgradeable SW release.

Release 100, October 2016

NOTE: All Specifications are subject to change without notice



Tasb 1: Simplified System Block Diagram

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1 DOCUMENT

1.1 Revision History

Version	Date	Comments
Rev 100	October 2016	Initial release

1.2 Product Upgrade History

The list below lists each Boson software release and a summary of the incremental features/improvements provided by each.

Software Rev #	Release Date	Comments
1.0.7405	October 2016	Initial product release.

1.3 Contact Us

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

http://www.flir.com/cores/content/?id=74595

The website also contains Frequently Asked Questions and a knowledge base:

http://www.flir.com/cvs/cores/knowledgebase/

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.

1.4 Document Conventions

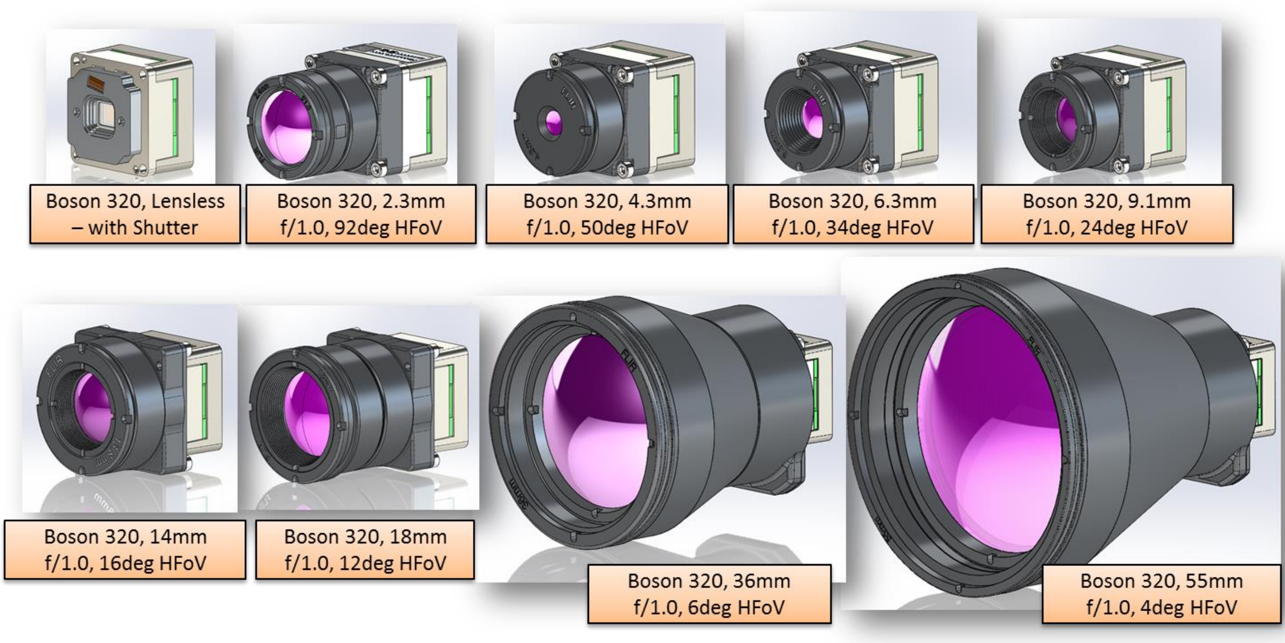
Throughout this document, modes and parameters which are user-configurable via the command and control interface (CCI) are shown in **bold font**. Status variables which can be read but not directly altered via the CCI are shown in *italic font*.

1.5 Scope

Boson^{TM} is a highly configurable thermal imaging core comprised of the following 3 major components:

- Lens assembly: Multiple fields of view are available. A lensless configuration is also available with no lens flange. The various lens options are delineated in Section 10.
- Shutter assembly: An integral shutter assembly provides best uniformity by allowing the camera to automatically perform a periodic correction (called flat-field correction) as required.
- Sensor engine: Boson provides both a QVGA (320x256/12 µm) configuration as well as a VGA (640x512/12 µm) configuration. In either case, the focal plane array (FPA) is integrated with common signal-processing electronics, providing state-of-the-art noise filtering, image enhancement, operational logic, and camera functions, as described in Sections 5, 6, and 7. The Boson sensor engine also provides all electrical I/O on a single connector, as detailed in Section 4.

Figure 2 shows some of the available hardware configurations featuring various combinations of lens assembly, shutter assembly, and sensor assemblies. See Section 10 for more information on the available lens configurations.



(a) 320 configurations

(a) 640 configurations

Figure 2: Various Configurations of Boson

Figure 3 shows the part-numbering schema for Boson.

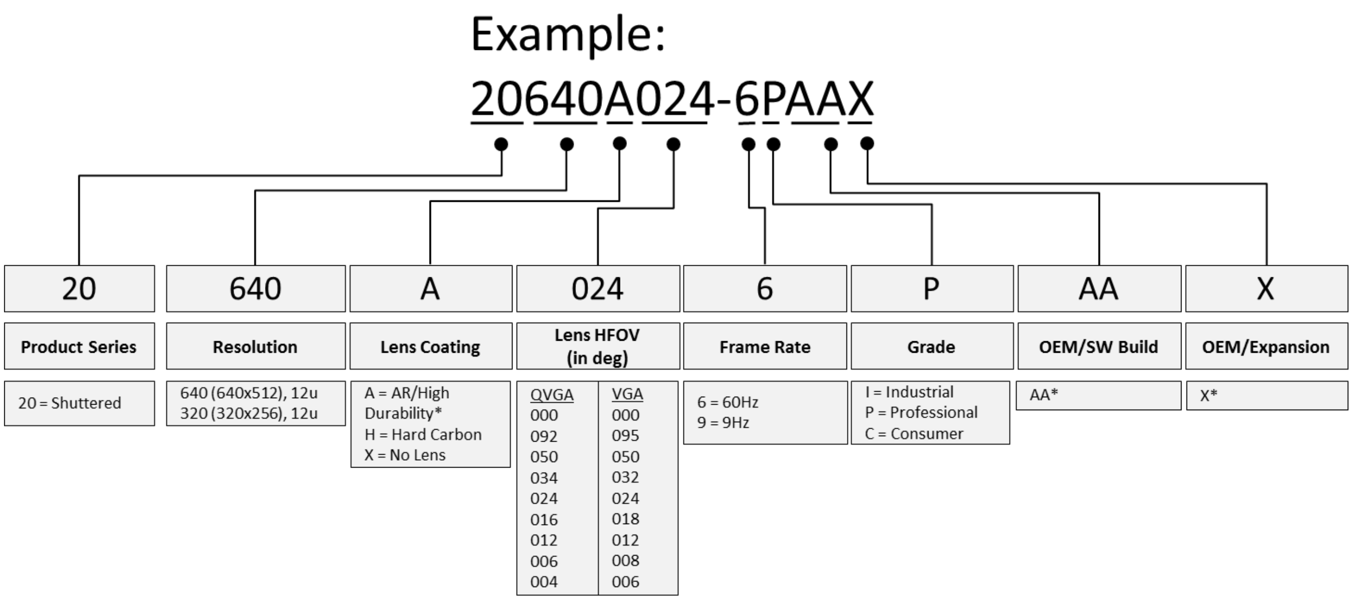


Figure 3: Boson Part-Numbering Schema

2 Key Specifications

Unless otherwise stated, all specifications apply to all Boson configurations.

NOTE: As explicitly noted below, some software features are not provided in the current product release but will be available at a later time via a field-upgradeable software update.

Table 1: Boson Key Specifications

Specification	Description
Overview	
Sensor technology	Uncooled VOx microbolometer
Pixel size	12 µm
Spectral range	Longwave infrared, nominally 8 µm to 14 µm (see Section 11.5)
Array format	320x256 or 640x512
Effective frame rate	< 9Hz configuration for export (see Section 7.9)
Thermal time constant	Nominally 8 msec
Thermal sensitivity	Varies by configuration (see Section 11.1 for more detail) • Industrial grade: ≤ 40 mK • Professional grade: ≤ 50 mK • Consumer grade: ≤ 60 mK
Operability	Varies by configuration (see Section 11.3 for more detail) • Industrial grade: ≥99%, no clusters > 3x3 • Professional grade: ≥98.5%, no clusters > 3x3 • Consumer grade: ≥98%. no clusters > 5x5
Non-uniformity corrections (NUC)	Shuttered configuration capable of automatic flat-field correction (FFC); FLIR's Silent Shutterless NUC (SSN)™ suite of scene-based NUC algorithms;
Electronic zoom	1X to 8X zoom (see Section 6.6)
Image orientation	Adjustable (vertical flip and/or horizontal flip) See note 1
Symbol overlay	Alpha blending for translucent overlay See note 1
Snapshots	Full-frame snapshot, SDIO interface to support removable media See note 1
Electrical	
Video output channel	Two options: (see Section 8.2) • CMOS • USB2 See note 2
Video output format	Three runtime-selectable options (see Section 7.7): • Data before AGC (16b, sensor resolution) • Data after AGC, before digital zoom (8b, sensor resolution) • Data after colorization (various bit-width, 640x512 resolution regardless of configuration)
Input clock	None required

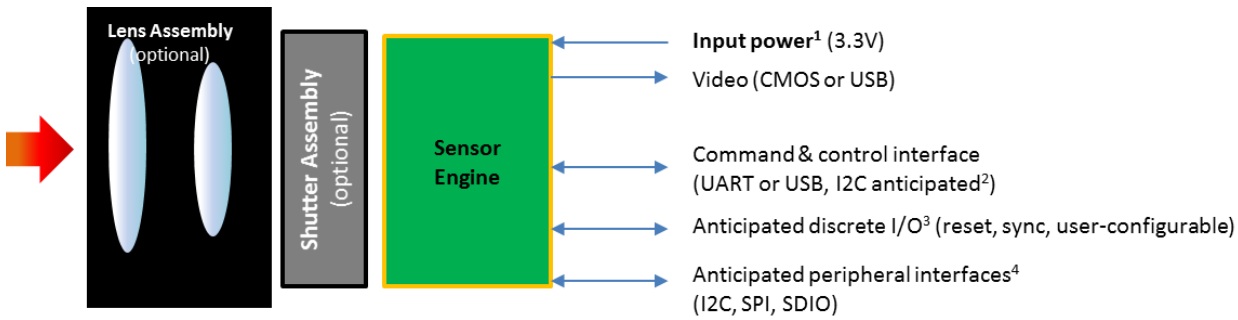
Specification	Description
Frame sync	Two runtime-selectable options: • Free-running: Frame timing internally synchronized • Slave mode: Frame timing externally synchronized See note 1
Command & Control Interface (CCI)	Three options: (see Section 8.1) • UART • USB • I2C See note 1
Command & Control API	See Boson Software Interface Description Document (IDD)
Peripheral Interfaces	• SPI (Boson as master, peripheral as slave device) See note 1 • I2C (Boson as master, peripheral as slave device) See note 1 • SDIO See note 1
Input supply voltage (nominal)	3.3V (See Section 12.1)
Power dissipation	Between 580 mW and 1060 mW, configuration and temperature dependent (See Section 12.2)
Mechanical	
Package dimensions, lens-less and shutter-less configuration	320 and 640 sensor engine: 21 mm x 21 mm x 11 mm (w x h x d) Note: dimensioned drawings for each Boson configuration are not included herein but are available on the FLIR website. STEP files available upon request. (See Section 1.3)
Weight	Varies by configuration, a low as 7.5g. (See Section 10)
Environmental (see Section 13)	
Optimum operating temperature range	-40 °C to +80 °C
Storage temperature range	-50 °C to +85 °C
Shock	1500 G @ 0.4 ms

Note 1: Feature is not provided in the current product release but is anticipated at a later time via field-upgradable software revision.

Note 2: USB3 is anticipated at a later time via field-upgradeable software revision.

3 System Architecture

A simplified architectural diagram of the Boson thermal imaging core is shown in Figure 4.



1. Only essential interface is power. All others are optional.
2. Command & Control via I2C anticipated in a future product release
3. External sync and user-configurable discretes anticipated in a future product release.
4. I2C,SPI, and SDIO are anticipated in a future product release.

Figure 4: Boson Simplified Architecture

The lens assembly focuses infrared radiation from the scene through the shutter aperture onto the sensor engine. The shutter assembly periodically blocks radiation from the scene, presenting a uniform thermal signal to the sensor array. This uniform input signal allows internal correction terms to be updated, improving image quality. For applications in which there is little to no movement of the Boson core relative to the scene (for example, fixed-mount security applications), the shutter assembly is highly recommended. For applications in which there is ample scene movement (for example, handheld applications), the shutter is less essential due to FLIR's Silent Shutterless NUC (SSN)™ technology, further described in Section 5.3. That said, the shutter is capable of improving image quality in all applications and is always recommended.

The sensor engine consists of a focal plane array (FPA) integrated with a System on a Chip (SoC). The FPA is a two-dimensional array of vanadium-oxide (VOx) microbolometers with 12-micron pitch. The QVGA configuration provides 320x256 pixels while the VGA configuration provides 640x512. The temperature of each microbolometer varies in response to incident flux. The temperature change causes a proportional change in the detector's resistance. VOx provides a high temperature coefficient of resistance (TCR) and low 1/f noise, resulting in excellent thermal sensitivity and highly stable uniformity. The microbolometer array is grown monolithically on top of a readout integrated circuit (ROIC). Once per frame, the ROIC senses the resistance of each detector by applying a bias. The resulting signal is digitized and processed by the SoC, which provides signal conditioning and output formatting. The SoC is also responsible for all camera logic as well as the Command and Control Interface (CCI). The signal pipeline is fully defined in Section 5 while the output interfaces are defined in Section 8.

4 Electrical Pinout

As shown in Figure 5, electrical interface to the Boson core is via a single 80-pin connector, Hirose DF40C-80DP-0.4V(51). The recommended mating connector is Hirose 80-pin board-to-board receptacle (socket) DF40HC-(4.0)-80DS-0.4V(51), for a mating stack height of 4.0 mm.

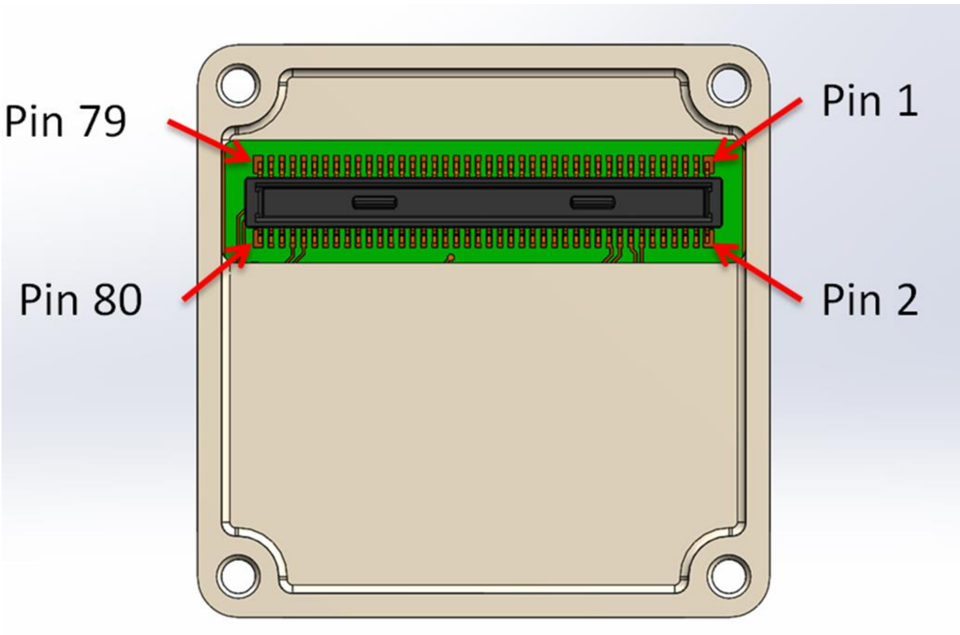


Figure 5: Boson Connector Pin Numbering

4.1 Pin Assignments

Pin assignments and description for the Boson main connector are shown in Table 2.

Table 2: Boson Pin Assignments and Pin Description

Pin #	Pin Name	Signal Type	Signal Level	Description
1, 3, 5, 7, 10, 13, 19, 20, 29, 30, 39, 40, 49, 50, 59, 60, 69, 70, 79	DGND	Power	GND	Digital Ground
2, 4, 6, 8	3V3	Power	3.3V	Input Power
11	USB_D_P	Diff Pair	USB spec compliant	USB2 data+
9	USB_D_N	Diff Pair	USB spec compliant	USB2 data-
15	USB_VBUS	Power	USB spec compliant	USB VBus
17	USB_ID	I/O	USB spec compliant	USB ID
14	USB_TX_P	Diff Pair	USB spec compliant	Reserved for USB3 transmit+ (See note 1)
12	USB_TX_N	Diff Pair	USB spec compliant	Reserved for USB3 transmit-
18	USB_RX_P	Diff Pair	USB spec compliant	Reserved for USB3 receive+
16	USB_RX_N	Diff Pair	USB spec compliant	Reserved for USB3 receive-
21, 22, 23, 25, 26, 27, 28, 31, 32, 33, 34, 35, 36, 37, 38, 41, 42, 43, 44, 45, 46, 47, 48, 51, 52, 53, 54, 55, 56, 57, 58, 61, 62, 63, 64, 65, 66, 67, 68, 71, 73, 74, 75, 76, 77, 78	GPIO	I/O	1.8V	See Table 3
24	RESET	I/O	1.8V	See Section 7.1
72	EXT_SYNC	I/O	1.8V	Reserved for external sync (See note 1)
80	No Connect		n/a	

Note 1: USB3 and external sync capability are both anticipated via a future field-upgradeable software release.

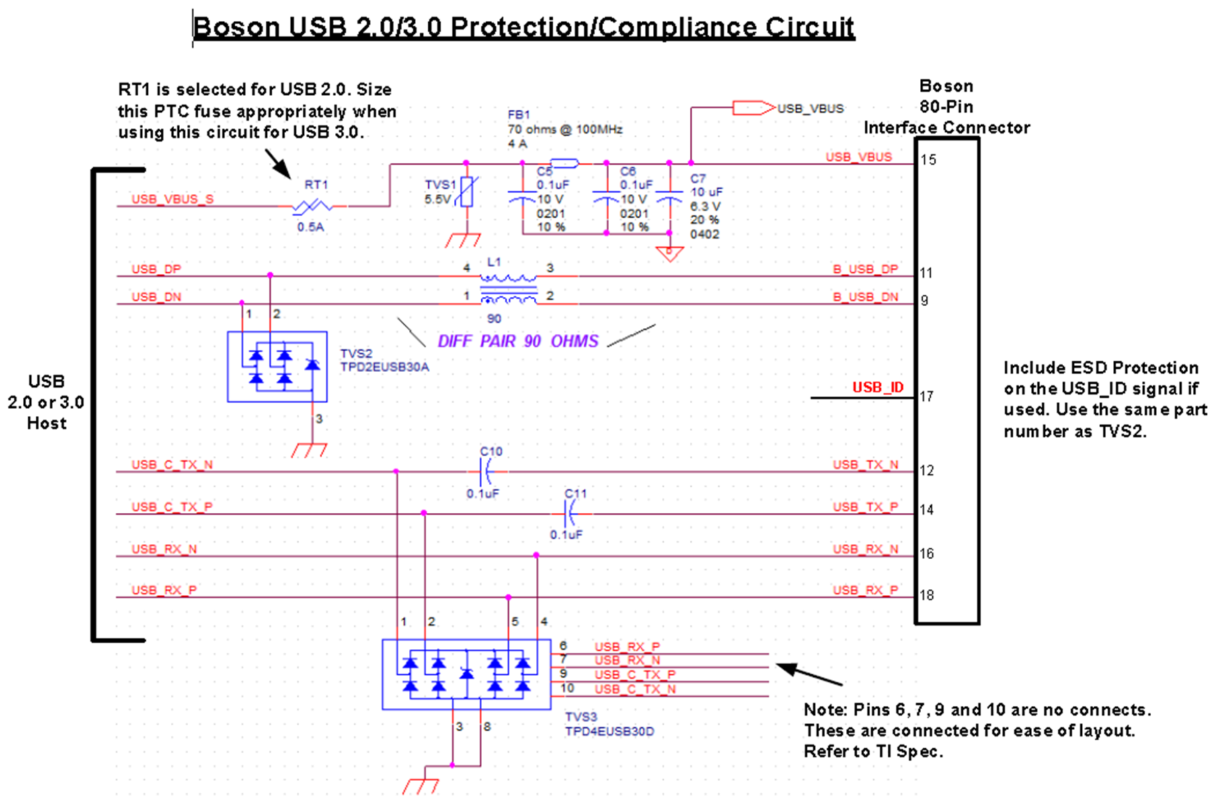
NOTE: In a future software release, the GPIO pins shown in Table 2 will be runtime-configurable into one of three optional bundles. Table 3 shows the assignments for those pins by option. The various interfaces for each bundle are described in more detail in Section 8. The current product release provides Option 1 by default.

Table 3: Assignment of GPIO Pins by Runtime-Configurable Option.

		Option 1 (24bit video)	Option 2 (16bit video)	Option 3 (8bit video)	
		SDIO	SDIO	2 SDIO	
		1 SPI	1 SPI	1 SPI	
		1 I2C	1 I2C	2 I2C	
		1 UART	1 UART	1 UART	
		3 GPIO	11 GPIO	11 GPIO	
Connector pin	Generic name	24 bit video	16 bit video	8 bit video	Description
23	GPIO_12	GPIO	GPIO	GPIO	Discrete I/O pin 0
26	GPIO_13	GPIO	GPIO	GPIO	Discrete I/O pin 1
33	GPIO_14	uart_apb_sin	uart_apb_sin	uart_apb_sin	UART input
43	GPIO_15	uart_apb_sout	uart_apb_sout	uart_apb_sout	UART output
41	GPIO_16	cmos_data_13	cmos_data_13	sd_hst1_dat_3	CMOS bit13 or SD_ch1 data3
21	GPIO_17	cmos_data_14	cmos_data_14	sd_hst1_clk	CMOS bit14 or SD_ch1 clk
38	GPIO_18	cmos_data_15	cmos_data_15	sd_hst1_cmd	CMOS bit15 or SD_ch1 command/response
34	GPIO_19	cmos_data_16	GPIO	sd_hst1_dat_0	CMOS bit16 or SD_ch1 data0
22	GPIO_20	cmos_data_17	GPIO	sd_hst1_dat_1	CMOS bit17 or SD_ch1 data1
42	GPIO_21	cmos_data_18	GPIO	sd_hst1_dat_2	CMOS bit18 or SD_ch1 data2
37	GPIO_22	cmos_data_19	GPIO	GPIO	CMOS bit19
52	GPIO_23	cmos_data_20	GPIO	GPIO	CMOS bit20
54	GPIO_24	cmos_data_21	GPIO	GPIO	CMOS bit21
35	GPIO_25	cmos_data_22	GPIO	GPIO	CMOS bit22
36	GPIO_26	cmos_data_23	GPIO	GPIO	CMOS bit23
58	GPIO_27	GPIO	GPIO	GPIO	Discrete I/O pin 2
44	GPIO_28	GPIO	GPIO	GPIO	Discrete I/O pin 3
51	GPIO_38	cmos_data_2	cmos_data_2	cmos_data_2	CMOS bit2
56	GPIO_39	cmos_data_3	cmos_data_3	cmos_data_3	CMOS bit3
27	GPIO_40	cmos_data_4	cmos_data_4	cmos_data_4	CMOS bit4
28	GPIO_41	cmos_data_5	cmos_data_5	cmos_data_5	CMOS bit5
32	GPIO_42	cmos_data_6	cmos_data_6	cmos_data_6	CMOS bit6
31	GPIO_43	cmos_data_7	cmos_data_7	cmos_data_7	CMOS bit7
25	GPIO_44	cmos_data_8	cmos_data_8	GPIO	CMOS bit8
46	GPIO_45	cmos_data_9	cmos_data_9	GPIO	CMOS bit9
45	GPIO_46	cmos_data_10	cmos_data_10	GPIO	CMOS bit10
48	GPIO_47	cmos_data_11	cmos_data_11	i2c2_scl	CMOS bit11 or I2C Ch2 Clk
47	GPIO_48	cmos_data_12	cmos_data_12	i2c2_sda	CMOS bit12 or I2C Ch2 Data
55	GPIO_29	cmos_pclk	cmos_pclk	cmos_pclk	CMOS pixel clk
53	GPIO_30	cmos_vsync	cmos_vsync	cmos_vsync	CMOS vsync
73	GPIO_31	cmos_hsync	cmos_hsync	cmos_hsync	CMOS hsync
78	GPIO_32	cmos_data_en	cmos_data_en	cmos_data_en	CMOS data enable
77	GPIO_36	cmos_data_0	cmos_data_0	cmos_data_0	CMOS bit0
62	GPIO_37	cmos_data_1	cmos_data_1	cmos_data_1	CMOS bit1
63	GPIO_60	i2c0_scl	i2c0_scl	i2c0_scl	I2C Ch0 Clk
67	GPIO_61	i2c0_sda	i2c0_sda	i2c0_sda	I2C Ch0 Data
75	GPIO_63	sd_hst0_clk	sd_hst0_clk	sd_hst0_clk	SD_ch0 clk
66	GPIO_64	sd_hst0_cmd	sd_hst0_cmd	sd_hst0_cmd	SD_ch0 command/response
65	GPIO_65	sd_hst0_dat_0	sd_hst0_dat_0	sd_hst0_dat_0	SD_ch0 data0
68	GPIO_66	sd_hst0_dat_1	sd_hst0_dat_1	sd_hst0_dat_1	SD_ch0 data1
61	GPIO_67	sd_hst0_dat_2	sd_hst0_dat_2	sd_hst0_dat_2	SD_ch0 data2
64	GPIO_68	sd_hst0_dat_3	sd_hst0_dat_3	sd_hst0_dat_3	SD_ch0 data3
57	GPIO_78	spi1_mosi	spi1_mosi	spi1_mosi	SPI master-out slave-in
76	GPIO_79	spi1_miso	spi1_miso	spi1_miso	SPI master-in slave-out
74	GPIO_80	spi1_sclk_out	spi1_sclk_out	spi1_sclk_out	SPI clk
71	GPIO_82	spi1_ss_out_in_1	spi1_ss_out_in_1	spi1_ss_out_in_1	SPI chip select

4.2 External Circuitry

- FLIR highly recommends implementing the protection circuit for the USB channel shown in Figure 6 on interfacing electronics.
- External pull-up resistors (4.7Kohm to 10Kohm) are recommended on all I2C signals if the channel is utilized.
- A pull-down resistor (4.7Kohm to 10Kohm) is recommended on the SPI chip select if the SPI channel is utilized.
- A pull-up resistor (4.7Kohm to 10Kohm) is recommended on the uart_apb_sin signal if the UART is utilized.



Part Description	Vendor	Part Number	Ref Des
CAP CER 0.1uF 10V X5R 0201	Murata	GRM033R61A104KE15D	C5,C6,C10,C11
CAP - CER 10UF 6.3V 20% X5R 0402	TDK	C1005X5R0J106M050BC	C7
PTC Resettable Fuse 6V 1.5A, SMT 0805	Littelfuse Inc.	0805L150SL	RT1
VARISTOR 7.1V 20A 0402	Littelfuse Inc.	V5.5MLA0402NR	TVS1
TVS DIODE 3.6VWM 8VC SOT3	Texas Instruments	TPD2EUSB30ADRTR	TVS2
TVS DIODE 5.5VWM 8VC 10SON	Texas Instruments	TPD4EUSB30DQAR	TVS3
CHOKE COMMON MODE USB2.0 0805	Coilcraft	0805USB-901MLC	L1
FERRITE CHIP 120 OHM 3000MA 0603	Murata Electronics	BLM18SG700TN1D	FB1

Figure 6: Recommended USB protection circuitry, to be implemented on interfacing electronics

5 Signal Pipeline

A high-level block diagram of Boson's signal pipeline is depicted in Figure 7. The pipeline includes an optional frame averager, non-uniformity correction (NUC) and defect replacement, spatial and temporal filtering, automatic gain correction (AGC), electronic zoom, colorization and (in a later software release) symbol overlay. All of these processing blocks are described in more detailed in the sections to follow. Note that video can be tapped at various locations within this pipeline. See Section 7.7 for a full description of the video output properties at each tap.

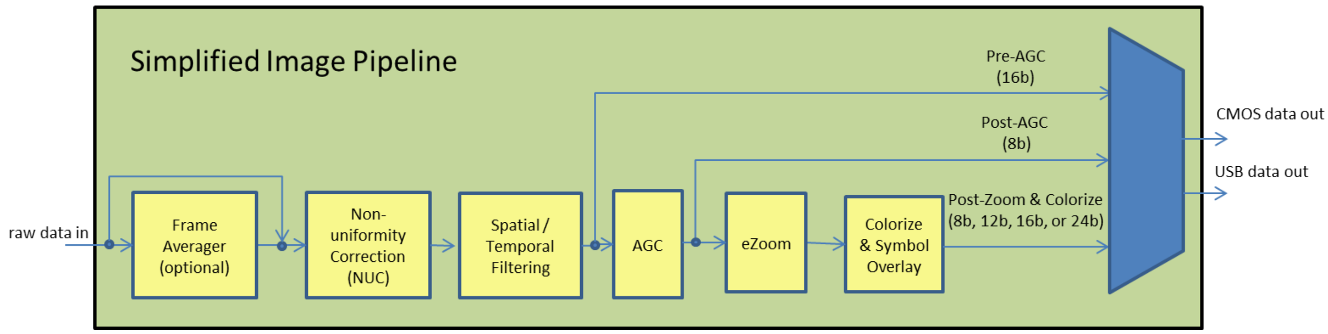


Figure 7: Boson Signal Pipeline

5.1 Frame Averager

At the beginning of the signal pipeline, Boson provides an optional frame-averager block (disabled by factory-default). When disabled, the effective output frame rate is 8.6Hz; when enabled, it is 7.5Hz. The primary benefit of enabling the averager is power reduction. Depending upon configuration, power savings approaching 100 mW can be realized. See Section 12.2. Boson utilizes a "smart averager" which minimizes blur during scene motion. Essentially whenever there is motion between the two input frames, the frame received later in time is provided as output without averaging. A comparison between a simple averager and the Boson smart averager is shown in Figure 8 below.

(a) Simple averager (a) Boson "smart averager"

Figure 8: **Boson's Smart Averager Prevents Blur in Moving Scenes**

5.2 NUC

The non-uniformity correction (NUC) block applies correction terms to ensure a uniform output from each pixel when the camera is imaging a uniform thermal scene. Factory-calibrated NUC terms are applied to compensate for temperature effects, pixel response variations, and lens-illumination roll-off. Under normal circumstances, the generation and application of NUC terms is transparent to the user and requires no external intervention or support. One notable exception is the lens-less configuration. If a non-FLIR lens is installed by the user, it is necessary to perform a one-time calibration, further described in Section 6.8.

To compensate for temporal drift and residual non-uniformity, the NUC block applies an offset term which can be periodically updated at runtime via a process called flat-field correction (FFC). The FFC process is further described in Section 6.3. The NUC block also performs replacement of any pixels identified as defective during factory or field calibration. The replacement algorithm assesses the status of neighboring pixels and calculates an optimum replacement value.

As previously stated, all terms applied by the NUC block are enabled by factory default, and most users will have no reason to ever disable them. Moreover, uniformity will degrade significantly as the result of doing so. However, it is possible to enable/disable each term independently:

- Temp-correction: a dynamic correction term which compensates for pixel-to-pixel offset variation over temperature
- Gain: a term which compensates for pixel-to-pixel responsivity variation
- FFC: a term generated during the FFC process which compensates for temporal drift and other residual non-uniformity
- Bad pixel replacement (BPR): a process whereby pixels identified as defective are replaced by nearest neighbors

5.3 Spatial / Temporal Filtering

The signal pipeline includes a number of sophisticated image filters designed to enhance signal-to-noise ratio (SNR) by reducing temporal noise and residual non-uniformity. The filtering suite includes FLIR's Silent Shutterless NUC (SSN)™ technology, which is an advanced set of scene-based NUC algorithms. SSN relies on motion within the scene to isolate fixed pattern noise (FPN), which is then removed dynamically. The filtering suite also contains algorithms optimized for reduction of row and column noise. Like the NUC block, the filtering steps performed in this block are transparent to the user and require no external intervention or support.

Below is a brief description of the various filters which are all enabled by factory default. Most users will have no reason to ever disable any of them, and generally speaking, temporal noise or uniformity will degrade as the result of doing so.

- Spatial column noise reduction (SCNR): a filter intended to minimize column noise
- Silent Shutterless NUC (SSN): a filter intended to minimize random spatial noise
- Temporal filter (TF): a filter intended to minimize temporal noise

5.4 AGC

Boson provides a highly-configurable contrast-enhancement algorithm for converting 16-bit data to an 8-bit output suitable for display. Unlike the NUC block and Spatial / Temporal Filtering block, the AGC block includes a number of user-selectable parameters which allow the image enhancement to be tailored for application, scene conditions, and subjective taste. See Section 6.5 for a complete description of the algorithm and all associated parameters.

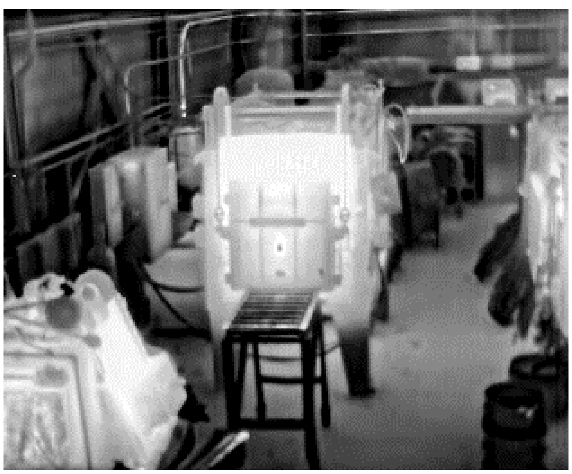
(a) Linear AGC example.

(b) Histogram-based AGC example

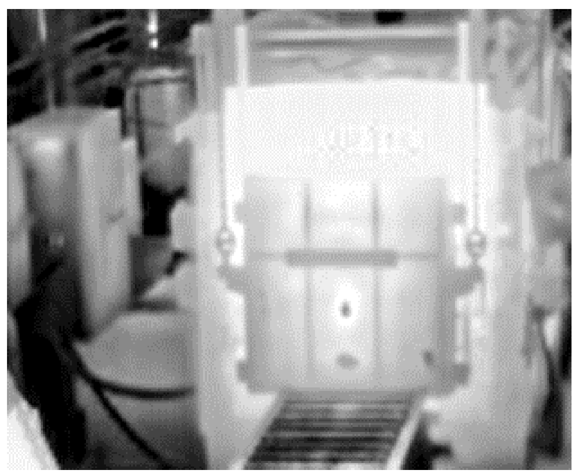
Figure 9: Example Imagery with Linear and Histogram-based Contrast Enhancement

5.5 eZoom

The electronic zoom block provides an optional interpolation of a subset of the field of view to the 640x512 resolution of the output stream. For example, it is possible to select the central 50% of the pixel area and stretch it to the full output resolution, resulting in a 2X zoom. See Section 6.6 for a more complete description of the feature and its associated parameters.



(a) 1X zoom (full FOV displayed)

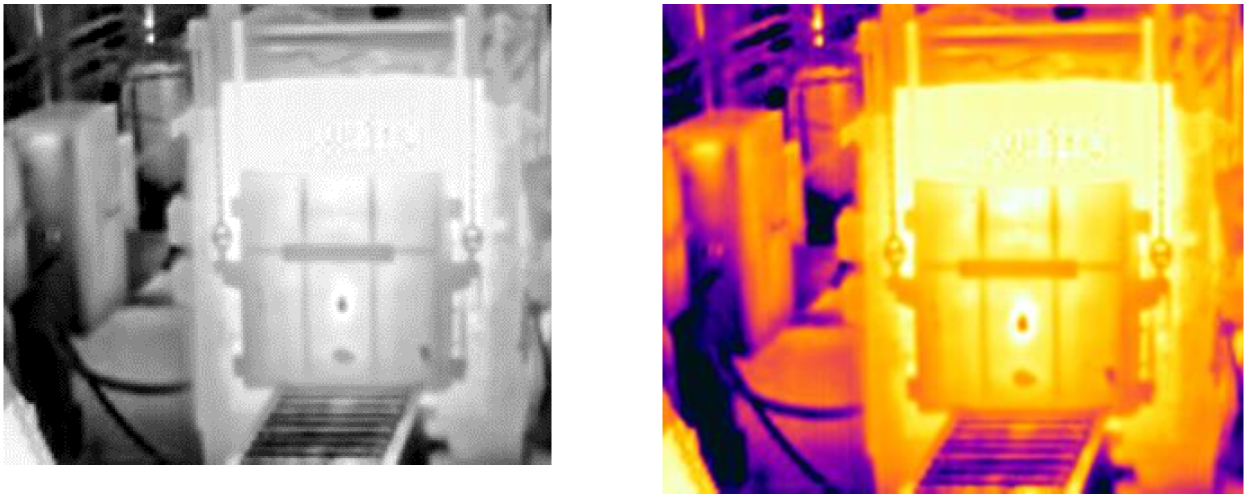


(b) 2X zoom (half FOV displayed)

Figure 10: Example Imagery Showing eZoom

5.6 Colorize

The colorize block takes the contrast-enhanced, post-eZoom thermal image as input and generates an output in which a color palette is applied. Boson provides a number of built-in color palettes, as described in Section 6.7.



(c) Monochrome Image (d) Colorized Image

Figure 11: Example Imagery Showing Colorization

5.7 Latency

Latency of the Boson signal pipeline is defined as the time difference between when the signal level of a given pixel is read from the sensor and when that signal is available as output from the camera. Referring to Figure 7, it is the amount of time for "raw data in" to be fully processed to "data out" at the selected video channel. The value varies depending upon where in the signal chain the output is tapped, as follows:

- Pre-AGC: ~108% of the frame time
- Post-AGC: ~113% of the frame time
- Post-zoom: ~222% of the frame time

For all three tap points, the output channel utilizes a multi-frame buffer as described in Section 7.9. This buffer introduces a frame of latency. For the post-zoom tap-point, the zoom operation itself also utilizes a multi-frame buffer, introducing a second frame of latency. The remaining fractions of a frame-time in the latency values provided above are processing time required by the various blocks in the signal pipeline.

NOTE: Like all thermal detectors, Boson's sensor assembly has a characteristic thermal time constant. It is not traditional to include time constant in the latency definition.

6 Camera Features

Boson provides a number of operating features, more completely defined in the sections which follow.

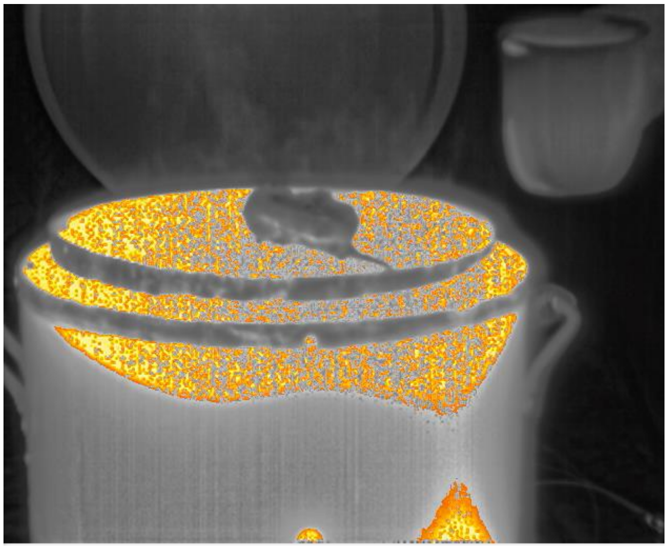
- Power-On Defaults, page 25
- Dynamic-Range Control, page 25
- Flat-field Correction, page 28
- Telemetry, page 31
- AGC, page 31
- E-Zoom, page 25
- Colorization, page 43
- Lens Calibration, page 45
- Diagnostic Features, page 45
- Upgradeability / Backward Compatibility, page 47

6.1 Power-On Defaults (User Selectable)

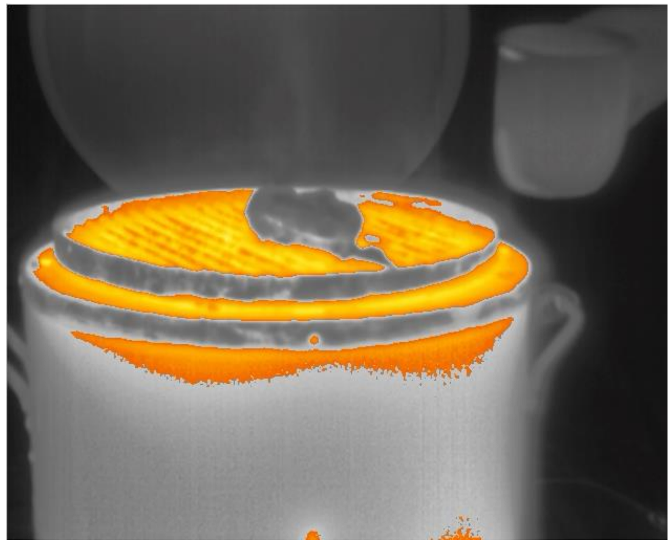
Boson provides a “save defaults” capability which allows all current mode and parameter settings to be stored as power-on defaults. Boson also provides the ability to restore the original factory default settings (which can then be re-saved as power-on defaults). See Table 6 in Section 8.1 for a list of affected modes and parameters. The table also shows the factory-default value for each setting.

6.2 Dynamic-Range Control

To support a wide range of scene temperatures while providing optimum sensitivity, the industrial and professional grades of Boson provide two gain states: high-gain and low-gain. In high-gain state, the thermal sensitivity is highest (i.e., NEDT is lowest) but hot objects in the scene (> 140C) are prone to saturation. In low-gain state, the thermal sensitivity is lower (i.e., NEDT increases by approximately 250%), but scene range is extended to approximately 500C. Figure 12 depicts example imagery for both states. In the high-gain example, it is easier to see subtle temperature differences (e.g., in the mug and in the background), but the entire surface of the grill is saturated. In the low-gain example, it is possible to resolve thermal details within the hot grill (because the pixels are not saturated), but the subtler temperature differences are harder to discern.



(a) High-gain state
(higher sensitivity, lower scene range)



(b) Low-gain state
(lower sensitivity, higher scene range)

Figure 12: Example Images, High-Gain State and Low-Gain State

NOTE: The consumer grade of Boson does not provide multiple dynamic-range-control modes and instead always operates in high-gain mode.

There are a number of user-selectable parameters associated with Boson's dynamic range control feature, each of which is described below.

- **Gain Mode** (high-gain, low-gain, or automatic): determines whether or not Boson automatically transitions between gain states based on scene conditions. See Section 7.4 for a detailed description of these modes. Default value is high-gain.

NOTE: Automatic gain mode and AGC Information-Equalization enabled mode are mutually exclusive options. To enable automatic gain mode, it is necessary to first disable Information-Equalization mode. Likewise, to enable AGC Information-Equalization mode, it is necessary to first select either high-gain mode or low-gain mode (not automatic mode).

- **High-to-Low Intensity Threshold:** In conjunction with the parameter **High-to-Low Population**, the **High-to-Low Intensity Threshold** parameter defines the scene conditions which cause the *Table Switch Desired* flag to be set and which cause the *Desired NUC Table* status to be set to the low-gain NUC table (table 0). (The *Desired NUC Table* flag is defined below.) The **High-to-Low Intensity Threshold** represents the intensity above which a pixel is scored as being one which would benefit from transition to low gain state. It is typically set to a value near high-gain saturation. (The factory-default value, 90% represents 90% of the maximum output value and is recommended under most operating conditions.)
- **High-to-Low Population Threshold:** represents the percentage of the pixel population which must have intensity exceeding **High-to-Low Intensity Threshold** before *Table Switch Desired* is set and *Desired NUC Table* = 0. The factory-default value is 5%.
- **Low-to-High Population Threshold:** represents the percentage of the pixel population which must have intensity below the *Low-to-High Intensity Threshold* before *Table Switch Desired* is set and *Desired NUC Table* is set to one of the high-gain tables (1, 2, or 3, depending upon ambient temperature). The factory-default value is 98%. The value cannot be set to less than (100% - **High-to-Low Population Threshold**). Such a value could result in a condition in which the *Desired NUC Table* status could be a high-gain table or the low-gain table simultaneously (i.e., a scene condition which would cause the camera to toggle back and forth between gain states when operating in automatic gain mode).

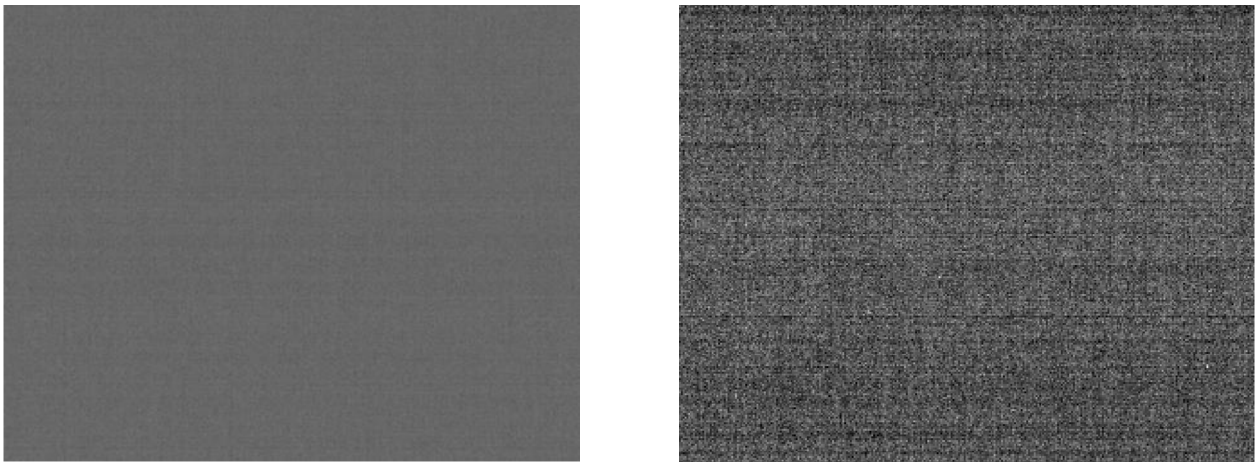
NOTE: The variable *Low-to-High Intensity Threshold* is calculated automatically based on the value of **High-to-Low Intensity Threshold**. The calculated value corresponds to a scene temperature just below that which corresponds to **High-to-Low Intensity Threshold**.

In addition to the user-selectable parameters associated with the dynamic-range control feature, Boson provides two status variables reported via the telemetry line (see Section 6.4) or by status request on the CCI (see Section 8.1):

- *Current NUC Table*: The *Current NUC Table* variable has a value of 0 when operating in low-gain state and a value greater than 0 (either 1, 2, or 3) when operating in high-gain state.
- *Desired NUC Table*: The *Desired NUC Table* variable is automatically set based on scene conditions and the selectable parameters described above. When in automatic gain mode, an automatic gain toggle takes place whenever *the Desired NUC Table* value does not match the current gain state as indicated by the *Current NUC Table* variable. Gain switch does not require an FFC event and takes place within a single frame.

6.3 Flat-Field Correction

Boson is factory calibrated to produce output imagery which is highly uniform when viewing a uniform-temperature scene, such as shown in Figure 13a. However, drift over long periods of time can degrade uniformity, resulting in imagery which appears more grainy (Figure 13b). Operation over a very wide temperature range (for example, powering on at -20 °C and heating to 60 °C) can also lead to a grainier image.



(a) Uniform image (b) Grainy image

Figure 13: Examples of Good and Grainy Images

For scenarios in which there is ample scene movement, such as most handheld applications, Boson is capable of automatically compensating for drift effects with FLIR's Silent Shutterless NUC (SSN) suite of algorithms. However, for use cases in which the scene is essentially stationary, such as fixed-mount applications, SSN is less effective. In those scenarios, it is recommended to periodically perform a flat-field correction (FFC). FFC is a process whereby the NUC terms applied by the camera's signal processing engine are recalibrated to produce optimal image quality. The sensor is briefly exposed to a uniform thermal scene, and the camera updates the NUC terms to ensure uniform output. The entire process takes less than a second. As described in Section 7.5, Boson can be configured to perform a FFC automatically or only upon command via the CCI. Furthermore, Boson can be configured to use its internal shutter or to use an external scene as the uniform source. In the latter case, the camera must be viewing the uniform scene before FFC is commanded.

NOTE: If FFC is performed in "External" FFC mode while imaging a non-uniform scene, the scene will be "burned in" to the correction map, resulting in severe image artifacts.

There are a number of user-selectable parameters associated with the FFC process, each of which is described below.

- **FFC Mode** (automatic, manual, or external) determines whether or not Boson performs FFC automatically and whether or not it uses the internal shutter during an FFC event. See Section 7.5 for a detailed description of these modes. Factory-default is “automatic”.
- **FFC Period:** When the camera is in automatic FFC mode, **FFC Period** defines the maximum elapsed time between automatic FFC events. When the camera is in manual or external FFC mode, this parameter defines the maximum elapsed time before the *FFC Desired* flag is enabled. (See below.) **FFC Period** is specified in seconds (e.g., the factory-default value of 900 represents a 900 second (15 minute) maximum time between successive FFC events). A specified value of 0 is an exception which disables the time-based trigger. The factory-default value is recommended under most operating conditions.
- **FFC Temp Delta:** When the camera is in automatic FFC mode, **FFC Temp Delta** defines the maximum temperature change of the FPA between automatic FFC events. When the camera is in manual or external FFC mode, this parameter defines the temperature change which triggers the *FFC Desired* flag to be set. **FFC Temp Delta** is specified in tenths of a Celsius degree (e.g., the factory-default value of 30 represents a 3 deg temp change between successive FFC events). A specified value of 0 is an exception which disables the temp-based trigger. The factory-default value is recommended under most operating conditions.
- **FFC Integration Period**: During each FFC event, the camera automatically integrates *n* frames of sensor data to generate the resulting correction term. **FFC Integration Period** specifies the value of *n*, either 4, 8 or 16. Utilizing fewer frames obviously decreases the FFC period (with diminishing returns due to overhead) whereas utilizing more frames provides greater reduction of spatial noise (also with diminishing returns due to 1/f noise). Figure 14 quantifies the benefit. A value of 8 is the factory-default value.

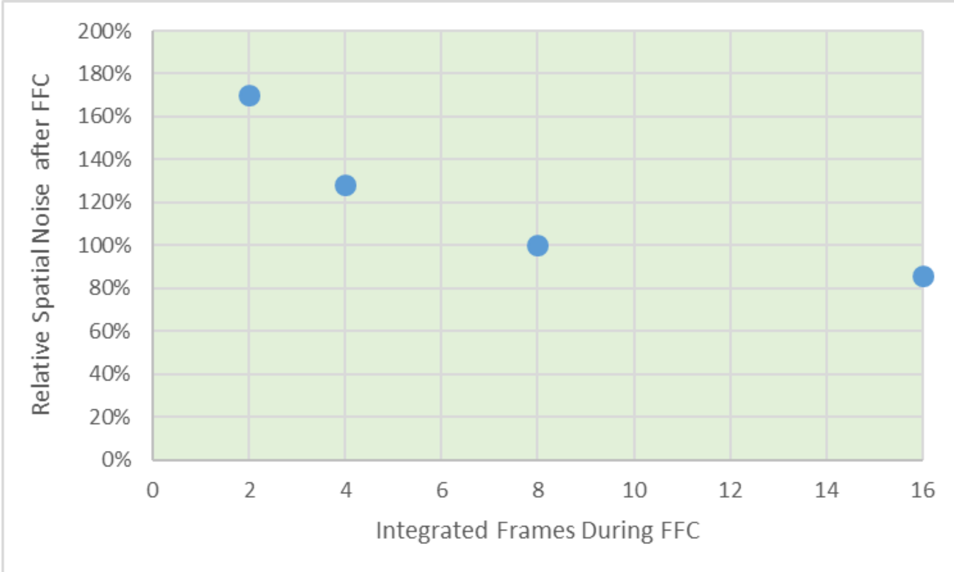


Figure 14: Relative Spatial Noise after FFC vs. Number of Integrated Frames (default = 8)

In addition to the user-selectable parameters associated with the FFC process, Boson provides two status variables reported via the telemetry line (see Section 6.4):

- *FFC State*: provides information about the FFC event (i.e., has it been initiated since start-up, is it imminent, is it in progress, is it complete). Section 7.5 defines each of the FFC states.
- *FFC Desired*: In manual and external FFC modes, the *FFC Desired* flag is used to signal the user to command FFC at the next possible opportunity. In automatic FFC mode, the flag is never set because the same conditions which cause it in manual and external FFC instead cause an automatic FFC. See Section 7.5 for detailed description of these conditions.

6.4 Telemetry

Boson provides the option to enable a single line of telemetry as either the first or last line in each frame. The telemetry line contains metadata describing the image stream and the camera. A complete list of the telemetry-line contents is provided in Table 4. Note that all telemetry data is encoded in big endian format. The two variables associated with the telemetry line are as follows:

- **Telemetry enable** is either true or false. Factory-default value is true.
- **Telemetry location** determines whether the telemetry line is provided on the first row (as a header) or on the last row (as a footer) of each video frame. Factory-default value is header.

NOTE: Telemetry mode only affects the CMOS output as telemetry is not an option for the USB video channel. Each telemetry datum is 16-bits wide.

Table 4: Telemetry Line Encoding

Word start	Word End	Number of 16-bit Words	Name	Notes
0	0	1	Telemetry Revision	Format = major (byte 1), minor rev (byte 0).
1	2	2	Camera serial number	
3	4	2	Sensor serial number	
5	14	10	Camera part number	ASCII encoded
15	21	7	Reserved	
22	27	6	Camera software revision	Words 22-23: SW major revision # Words 24-25: SW minor revision # Words 26-27: SW patch revision #
28	28	1	Frame rate	This is the actual data rate of the data channel in frames per second. For some configurations, frames are duplicated to generate an *effective* frame rate which is less than the value shown in this field.

Word start	Word End	Number of 16-bit Words	Name	Notes
29	37	9	Reserved	
38	41	4	Status bits	Bits 0-1: FFC state (00 = never started, 01 = imminent, 10 = in progress, 11 = complete) Bits 2-4: Gain mode (000 = high gain, 001 = low gain, 010 = automatic, 011 – 111 = reserved) Bit 5: FFC Desired Bit 6: Table Switch Desired
42	43	2	Frame Counter	Rolling counter of output frames since start-up.
44	45	2	Frame Counter at last FFC	Value of the frame counter at the last FFC event
49	46	1	Reserved	
47	47	1	Camera temperature	In dK (i.e, 3001 = 300.1K)
48	48	1	Camera temperature at last FFC	
49	64	6	Reserved	
55	56	2	Pipeline enable bits	Bit 0 = FFC offset enable/disable Bit 1 = Gain enable/disable Bit 2 = Temp compensation en/dis Bit 3 = Averager enable/disable Bit 4 = Temporal filter en/dis Bit 5 = SCNR enable/disable Bit 6 = SPNR enable/disable Bit 7 = BPR enable/disable All other bits reserved

Word start	Word End	Number of 16-bit Words	Name	Notes
57	57	1	Number of frames to integrate at next FFC	
58	78	21	Reserved	
79	79	1	Current NUC Table	See Section 7.5
80	80	1	Desired NUC Table	See Section 7.5
81	319	239	Reserved	

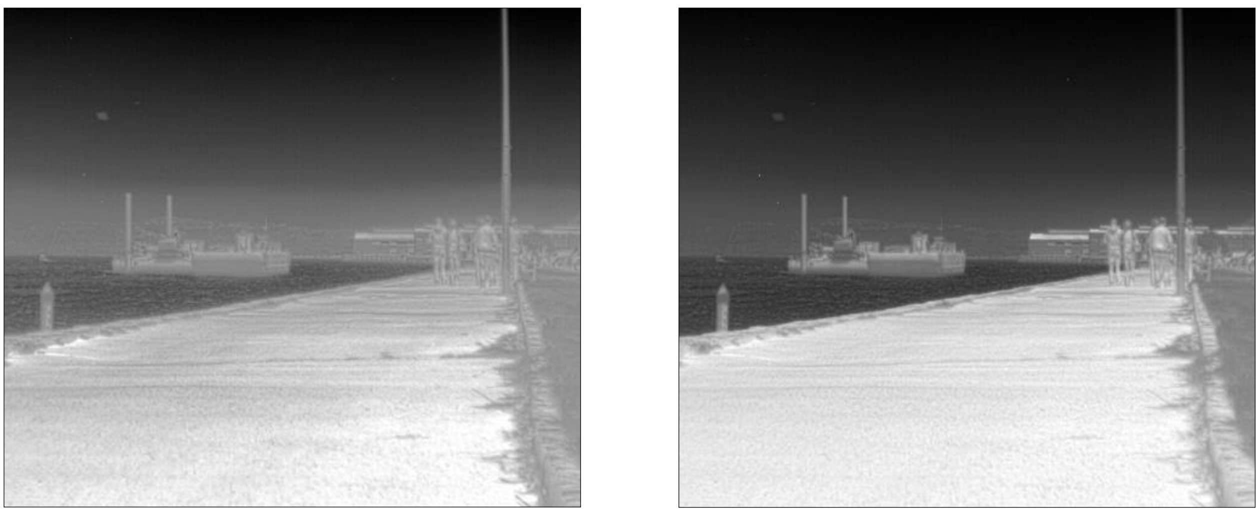
6.5 AGC

Automatic gain correction (AGC) is the process whereby the 16-bit resolution of the signal pipeline is converted an 8-bit signal suitable for a display system. Boson provides a sophisticated AGC algorithm which is highly customizable via a large number of parameters. It is a variant of classic histogram equalization (HEQ), which uses the cumulative histogram as the transfer function. (For a detailed explanation of histograms and AGC in general, refer to FLIR's Camera Adjustments Application Note, available from the Boson website linked in Section 1.3.) In classic HEQ, an image with 60% sky will devote 60% of the available 8-bit values (referred to as grayshades here forward) to the sky and leave only 40% for the remainder of the image. Boson's algorithm provides a number of parameters intended to allocate the grayshades more optimally according to user preferences. The AGC signal-processing block also incorporates FLIR's Digital Detail Enhancement (DDE) algorithm, which is capable of accentuating details. A list of the 10 AGC parameters is provided below, and a more detailed explanation of each one follows.

- **AGC Mode**
- **Plateau Value**
- **Tail Rejection**
- **Max Gain**
- **Linearity Factor**
- **Adaptive Contrast Enhancement (ACE)**
- **Digital Detail Enhancement (DDE)**
- **Smoothing Factor**
- **Region of Interest (ROI)**
- **Dampening Factor**

6.5.1 AGC Mode

AGC Mode (Information-Based Equalization enabled/disabled) determines the weighting of pixels when the histogram is generated. Many scenes are comprised of a small number of objects superimposed against a fairly uniform background (or perhaps two backgrounds such as sky and ground). In classic HEQ, the background dominates the histogram for such scenes and is therefore allocated a large percentage of the 8-bit gray shades, leaving few for the foreground details. In Information-Based Equalization Enabled mode, the scene data is segregated into details and background using a High-Pass (HP) and Low-Pass (LP) filter. Pixel values in the HP image are weighted more heavily during the histogram-generation process, resulting in details being allocated more 8-bit gray shades and thus benefiting from higher contrast in the output image. When Information-Based Equalization is disabled, every pixel is weighted equally. The factory-default value of **AGC Mode** is "Information-Based Equalization enabled". Figure 15 shows an example image for both modes. With Information-Based Equalization disabled, the sky and pavement are assigned more grayshades, whereas when enabled, the ship and people receive more emphasis. Note that not all of the images shown in this section of the datasheet were acquired using a Boson camera.



(a) Information-Based Equalization Disabled

(b) Information-Based Equalization Enabled

Figure 15: Example Images Showing Both AGC Modes

6.5.2 Plateau Value

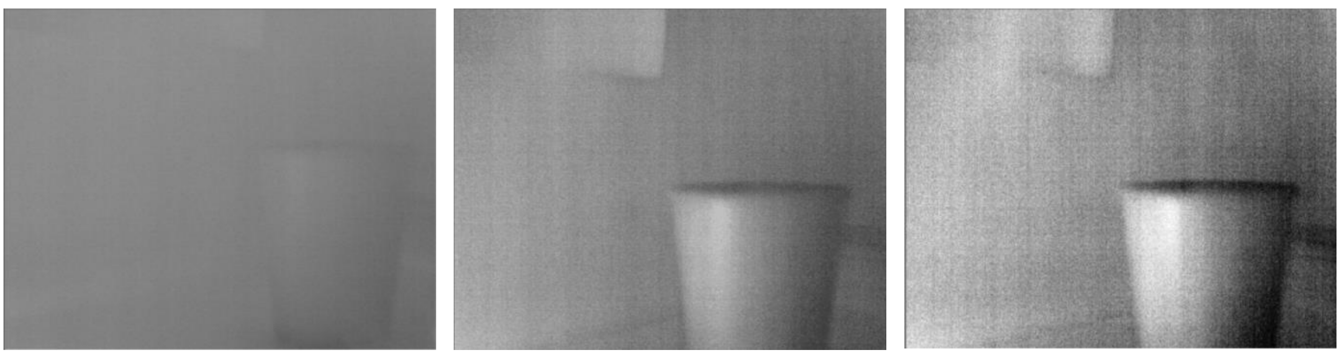
As mentioned above, one of the characteristics of classic HEQ is that it will devote grayshades proportionally to histogram population, meaning that large, mostly uniform portions of a scene will receive a large percentage of the grayshades. This characteristic can lead to those portions of the scene receiving excessive contrast (i.e., appearing noisy) while small objects are washed out due to getting a small allocation of gray shades. The **Plateau Value** parameter can reduce this effect by clipping the maximum value of any histogram bin. The factory-default value is 7%.

6.5.3 Tail Rejection

Tail Rejection determines what percentage of histogram outliers to ignore when generating the transfer function between 16b and 8b. For example, if the value is set to 2%, the mapping function ignores the bottom 2% of the histogram as well as the top 2%, optimizing the mapping function for the central 96%. Any pixels in the lower rejected tail are mapped to minimum gray value, and any in the upper rejected tail are mapped to maximum gray value. The factory-default value of **Tail Rejection** is 0%.

6.5.4 Max Gain

Max Gain determines the maximum slope of the transfer function between 16b and 8b. In scenes with very little thermal contrast (i.e., narrow histograms), an unconstrained transfer function can allocate essentially all 256 grayshades to a small number of 16b values. While this does enhance the displayed contrast, it also makes image noise more obvious. Limiting the maximum slope of the transfer function can result in images which are more pleasing to the eye in that they appear less grainy. Figure 16 shows an example image with 3 values of **Max Gain**, illustrating the pros and cons of low and high values. The factory-default value is 1.38, but perhaps more than any other AGC parameter, the optimal value varies with application and personal preference.

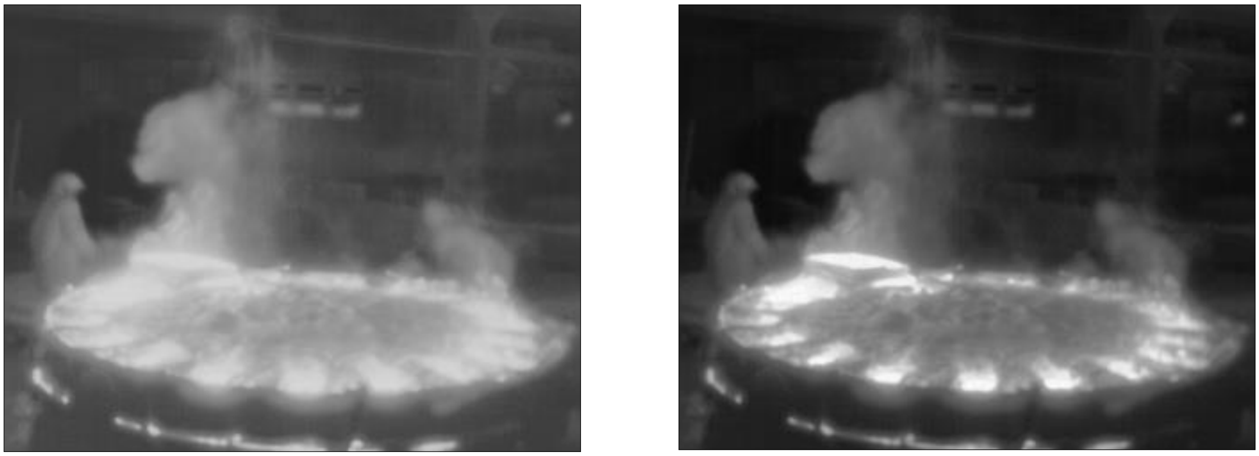


(a) Low value of **Max Gain** (b) Mid value of **Max Gain** (c) High value of **Max Gain**

Figure 16: Example Images Showing Three Different Max Gain Values

6.5.5 Linearity Factor

One of the benefits of non-linear AGC algorithms is efficient mapping of grayshades. Consider a scene containing a single hot object against a cold background. The resulting histogram is bimodal, with a large unpopulated region separating the two modes. A linear mapping function causes one of those modes to be mapped to very dark shades and the other to very bright shades; all of the mid-level shades are wasted since the unpopulated bins between the two modes map to them. A non-linear transfer function solves the problem by essentially collapsing the two modes of the input histogram together, preventing any empty bins between them in the resulting output histogram. However, this too can be non-ideal in some scenes. Consider for example a scene with a person standing in front of a wall. Even if the person is significantly warmer than the wall, the contrast in the displayed image between the two objects might collapse to nearly zero as the result of a non-linear mapping. **Linearity Factor** provides a compromise between true linear AGC and a non-linear AGC by defining the percentage of the histogram which will be allotted to linear mapping. As shown Figure 17, a higher value leads to more "separation" in gray shades between the person and the hot furnace in the image. The default value of **Linearity Factor** is 20%, but like **Max Gain**, the optimal value varies with application and personal preference.



(a) **Linearity Factor** = 0% (b) **Linearity Factor** = 30%

Figure 17: Example Images Showing Different Values of Linearity Factor

6.5.6 Adaptive Contrast Enhancement (ACE)

ACE provides contrast adjustment dependent on relative scene temperature. The scale of values ranges from 0.5-4.0. An **ACE** value less than unity darkens the image, increasing contrast in hotter scene content, while an **ACE** value greater than unity will do the opposite. Figure 18 shows the of **ACE** effect on the transfer function, and Figure 19 shows an example image with 3 different values. The factory-default is 0.97.

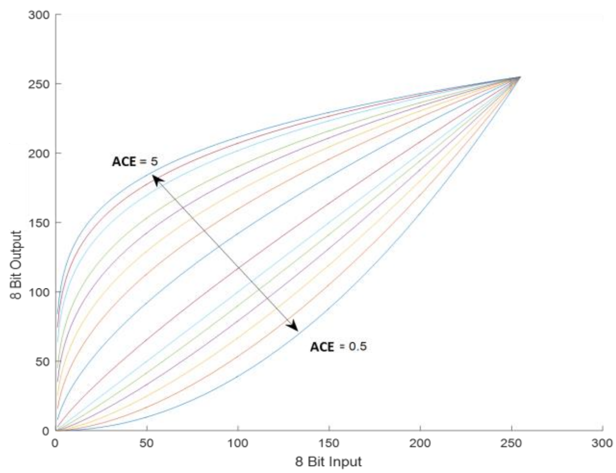


Figure 18: **Graphical Illustration of ACE**

(a) **ACE** = 0.9 (b) **ACE** = 1.0 (c) **ACE** = 1.3

Figure 19: **Example Images Showing Different Values of ACE**

6.5.7 Digital Detail Enhancement (DDE)

The **DDE** parameter either attenuates (values less than unity) or amplifies (values greater than unity) the HP content of the scene. Examples are shown in Figure 20. The factory-default value is 0.95.

(a) **DDE** = 0.8 (b) **DDE** = 1.3%

Figure 20: Example Images Showing Different Values of DDE

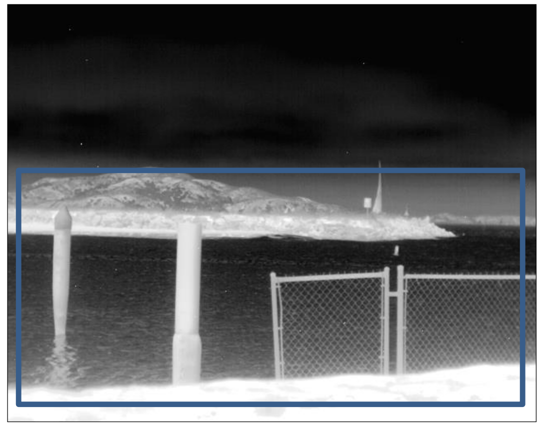
6.5.8 Smoothing Factor

The **Smoothing Factor** parameter defines which spatial frequencies are included in the HP image and which are in the LP image, both of which are relevant to the Information-Based-Equalization Enabled mode of operation and to the DDE algorithm.. A higher value results in more frequencies being included in the HP portion of the image. The factory-default value of **Smoothing Factor** is 1250, and for almost every use cases, FLIR recommends using this value.

6.5.9 Region of Interest (ROI)

In some scenarios, it may be desirable to optimize the AGC for some subset of the total field of view, such as the central portion of the scene. Or perhaps for a fixed-mount application, it may be beneficial to exclude some portion of the scene, as illustrated in Figure 21. The ROI provides this capability. It is actually comprised of four parameters (**Start Column**, **Start Row**, **End Column**, **End Row**), which define the corners of a rectangle. The default ROI is the full sensor array (**Start Column** = 0, **Start Row** = 0, **End Column** = 319, **End Row** = 255).

(a) ROI = Full Image



(b) Sky excluded from ROI

Figure 21: Example Image for 2 Different ROI

6.5.10 Dampening Factor

The AGC algorithm computes the optimum transfer function for each new frame of incoming data. However, it is not always beneficial to allow the applied transfer function to change rapidly. Consider when a mid-sized hot object enters an otherwise bland scene. The new object will be allocated brighter grayshades, resulting in the background migrating towards darker shades. If this transition happens suddenly from one frame to the next, it can be disconcerting to a viewer, appearing as an image flash. Boson provides a temporal filter which can mitigate against a sudden flash by limiting how quickly the AGC can react to a change in scene conditions. A higher value of the **Dampening Factor** parameter allows the algorithm to react quicker. A value of 100% results in no filtering at all, and a value of 0% causes the AGC transfer function to stops updating altogether. The factory-default value is 85%.

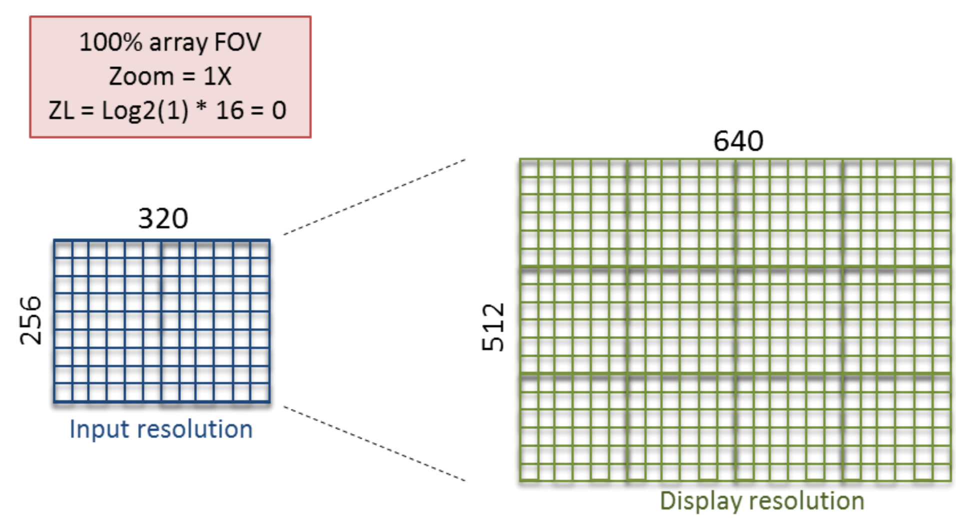
6.6 Ezoom

Boson provides a digital zoom capability in which a zoom window (either the full sensor-array data or some cropped subset) is interpolated to the 640x512 resolution of the post-zoom output stream, as exemplified in Figure 22. For the 320 configuration, the maximum size of the zoom window is 320x256, which in effect means the minimum interpolation factor is 2:1 (640x512 output from 320x256 input). However, using the classical definition of digital zoom, sensor FOV divided by displayed FOV, the minimum zoom is 1X. That is the definition of zoom used herein. The zoom function provides 49 discrete zoom levels (0 – 48). The transfer function between zoom and specified **Zoom Level**, ZL, is as follows:

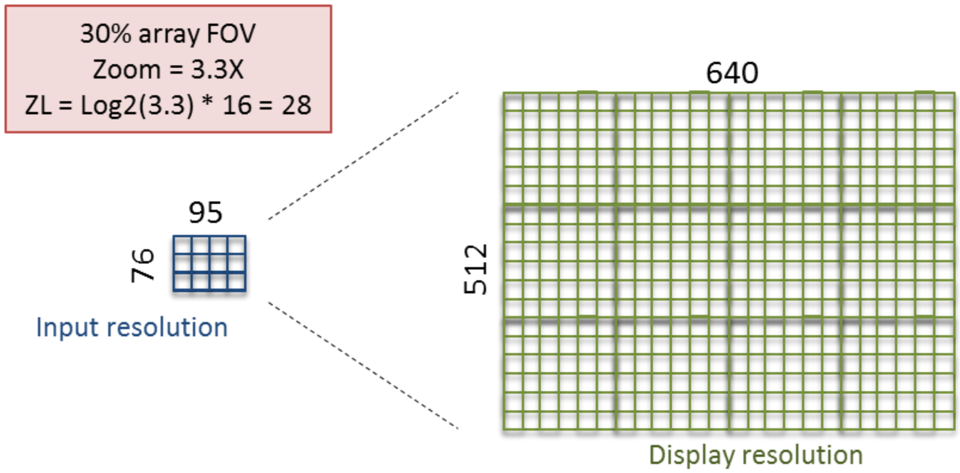
$$\text{Zoom} = 2 \wedge (ZL/16)$$

This transfer function is depicted graphically in Figure 23. Note that the maximum zoom is $2^3 = 8X$.

By factory default, the cropped "zoom window" is concentric with the center of the array. However, it is possible to specify the center of the zoom window to be any valid row/column in the sensor array, a feature known as "pan and tilt" of the zoom window. This feature is illustrated in Figure 24 for a 2X zoom window (ZL=16). The left-hand pane of the figure shows the default location of the zoom window relative to the full sensor array, and the right-hand pane shows the zoom window panned and tilted to the upper left. The camera automatically range checks the specified center row and column of the zoom window and will disallow an invalid value (i.e., one which would cause the zoom window to extend outside the edge of the sensor array). For example, if **Zoom Level** is set to 16, the column used for center of the zoom window is automatically constrained to values between 80 and 240.



(a) 1X zoom (Displayed FOV = 100% of Camera FOV)



(b) 3.3X zoom (Displayed FOV = 30% of Camera FOV)

Figure 22: Visualization of Zoom Function

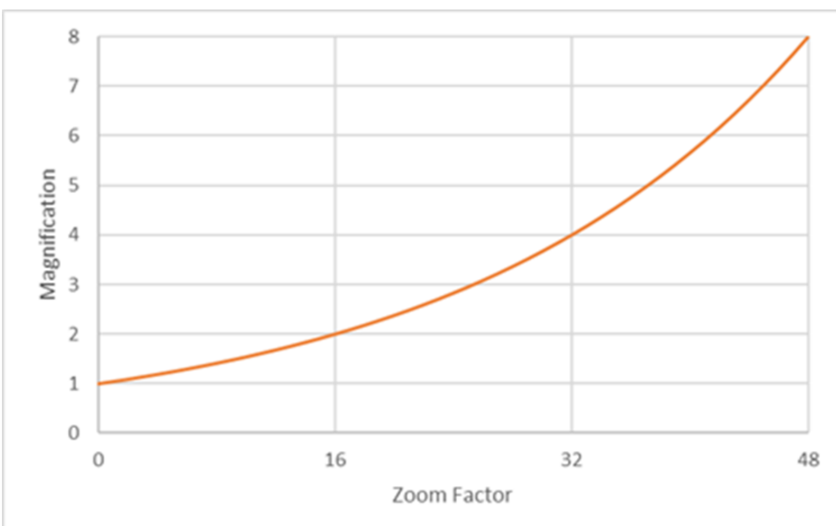
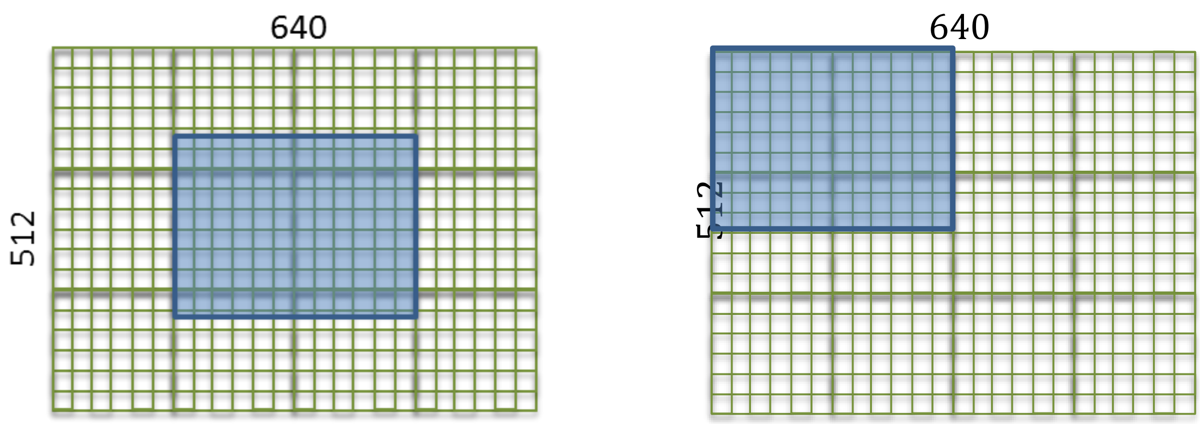


Figure 23: Zoom (Relative Magnification) as a function of specified Zoom Level



(a) Centered Zoom Window
- Center row = 128
- Center column = 160

(b) Panned and Tilted Zoom Window
- Center row = 64
- Center column = 80

Figure 24: Illustration of "Pan and Tilt",

In summary, the following parameters provide full control of the zoom function:

- **Zoom Level** is a variable between 0 and 48 which determines the applied zoom according the equation:

  $$Zoom = 2 \wedge (ZL/16)$$

  The factory-default value of **Zoom Level** is 0.

- **Zoom Center Column** is the x-coordinate of the sensor array at which the zoom window is centered. For maximum zoom (width of zoom window = 40 rows), valid values range between 20 and 300. However, the valid range automatically shrinks as the zoom window grows to prevent it from spilling outside the sensor array. For example, for minimum zoom (width of zoom window = 320 columns), the only valid value for **Zoom Center Column** is 160. The factory-default value is 160.

- **Zoom Center Row** is the y-coordinate of the sensor array at which the zoom window is centered. For maximum zoom (height of zoom window = 32 rows), valid values range between 16 and 240. However, the valid range automatically shrinks as the zoom window grows to prevent it from spilling outside the sensor array. For example, for minimum zoom (height of zoom window = 256 rows), the only valid value for **Zoom Center Row** is 128. The factory-default value is 128.

NOTE: None of the zoom parameters (**Zoom Level**, **Zoom Center Column**, or **Zoom Center Row**) have any effect on the video signal if it is tapped prior to zoom. See Section 7.7.

6.7 Colorization

As shown in Figure 25, Boson provides a number of factory-installed palettes, also referred to as color look-up tables or LUTs. (In these illustrations of the palettes, the upper left corner represents the color associated with an 8-bit input value of 0, and the lower-right represents the color associated with a value of 255.) Figure 26 and Figure 27 show two sample images with each palette applied. In a later software release, Boson will additionally provide the option to replace the factory-installed palettes with custom palettes defined by the user. Changing the parameter **Color Palette** causes the applied palette to change. The factory-default value is “white hot”.

NOTE: The selected **Color Palette** has no effect on the video signal if it is tapped prior to colorization. See Section 7.7.

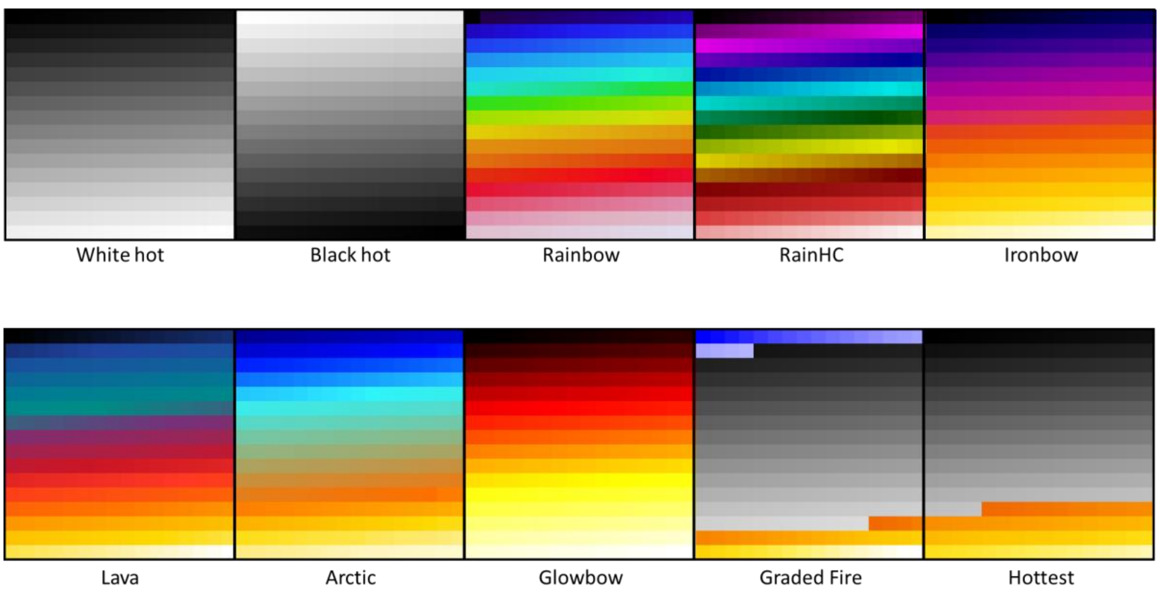


Figure 25: Boson’s Factory-Loaded Color Palettes

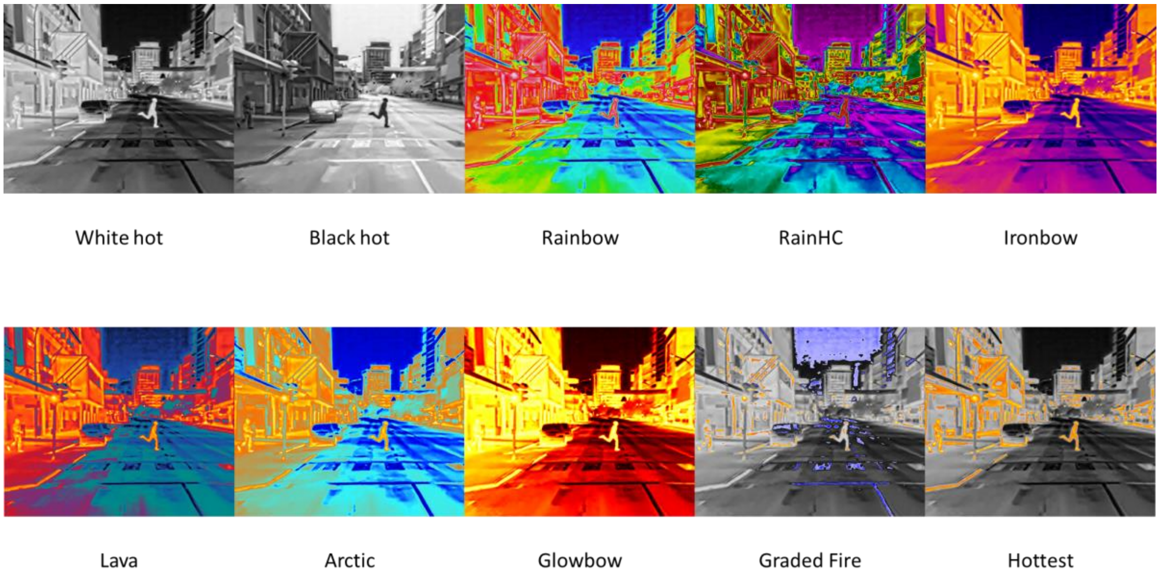


Figure 26: Sample Image1 With Boson's Color Palettes

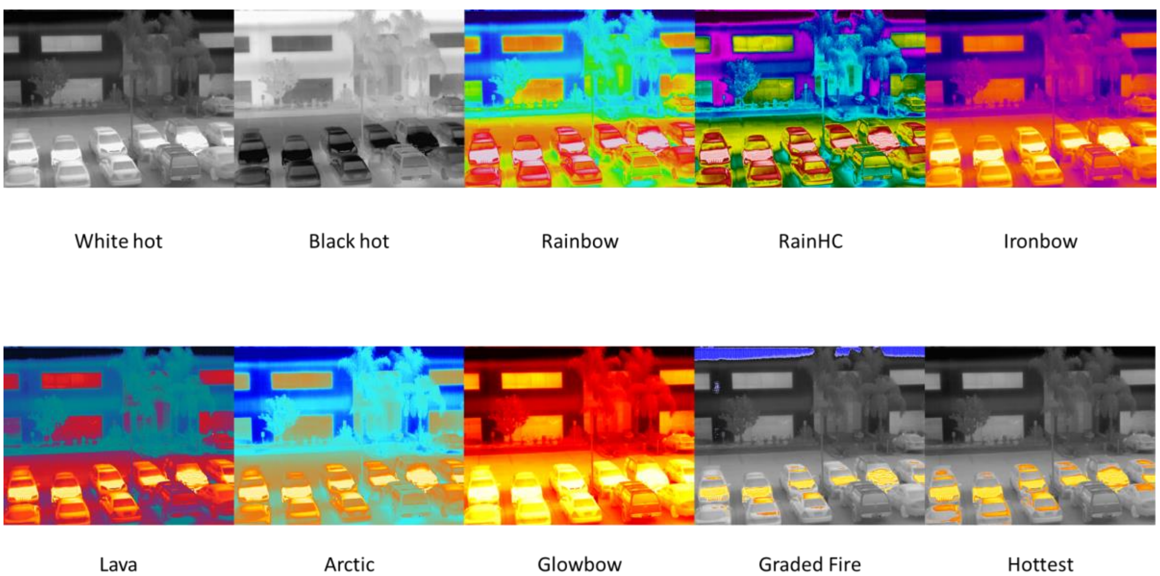


Figure 27: Sample Image2 with Boson's Color Palettes

6.8 Lens Calibration

Most configurations of Boson include a set of factory-calibrated NUC terms which compensate for temperature effects, pixel response variations, and lens-illumination roll-off. For such configurations, the generation and application of NUC terms is transparent to the user and requires no external intervention or support. However, one notable exception is the lensless configuration or a Boson sold with multiple lens options. If a non-factory-installed lens is used, it is necessary to perform a one-time calibration. The process requires exposing the camera to two different blackbody temperatures (e.g., room temperature and 20C above room temperature). The lens calibration process utilizes a FLIR-supplied graphical user interface (GUI), which sequences all the steps required to calibrate the lens. A screenshot of the GUI is provided in Figure 28. For a detailed tutorial on using this GUI, refer to FLIR's Lens Calibration Application Note, available from the Boson website linked in Section 1.3.

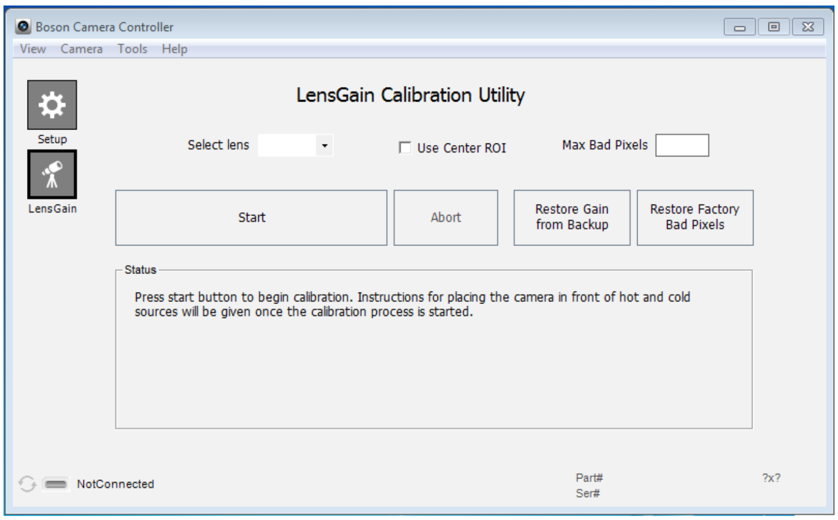


Figure 28: FLIR Lens-Calibration Graphical User Interface (GUI)

6.9 Diagnostic Features

Boson provides a number of diagnostic features, more completely defined in the sections that follow.

6.9.1 Test Patterns

Boson provides capability to display a programmable test pattern, shown in Figure 29. This is intended primarily to adjust display properties and/or for diagnostic purposes (for example, to verify the core is providing a valid output).

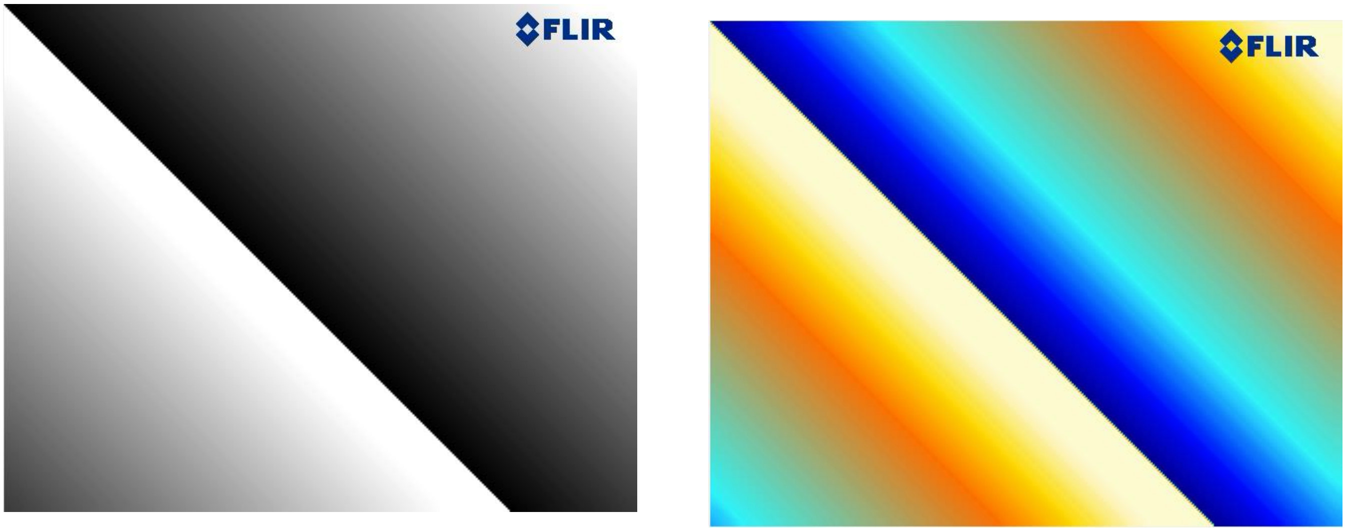


Figure 29: Boson test pattern (shown in both White-Hot and Rainbow palettes)

6.9.2 Camera Temperature

Boson provides capability to report internal core temperature via the *Camera Temperature* status variable. Accuracy of the measurement is ±5C°.

6.9.3 Status Indicators

Boson provides a number of status indicators, reported via the telemetry line (see Section 6.4) and via the CCI. These indicators are listed below. See the referenced sections for context and/or more detailed information.

- *FFC State*: The *FFC State* variable provides information about the FFC event (i.e., has it been initiated since start-up, is it imminent, is it in progress, is it complete). Section 7.5 defines each of the FFC states.
- *FFC Desired*: When operating in manual or external FFC mode, the *FFC Desired* flag is used to signal the user to command FFC at the next possible opportunity. In automatic FFC mode, the flag is never set because an automatic FFC takes place instead. See Section 7.5 for detailed description of the conditions which cause the flag to be set.
- *Table Switch Desired*: When operating in manual or external FFC mode, the *Table Switch Desired* flag is set when the camera is operating outside the range of the current NUC table. (See Section 7.5 for more details.) When in automatic FFC mode, this flag is never set because instead an automatic table switch and automatic FFC take place.

- *Current NUC Table*: The *Current NUC Table* variable indicates the current NUC table in which the camera is operating. See Section 7.5 for more details. A value of 0 indicates Boson is in low-gain state. A value of 1, 2, or 3 indicates Boson is in high-gain state.
- *Desired NUC Table*: The *Desired NUC Table* variable indicates the NUC table the camera will switch to upon receipt of the Table Switch command. See Section 7.5 for more information regarding the Table Switch command.

6.10 Upgradeability / Backward Compatibility

Boson can be updated with new software releases via the CCI. The upgrade is easily accomplished using the Boson Graphical User Interface (GUI). A more detailed Boson Software Upgrade Application Note provides step-by-step directions for those users who wish to update Boson's software from their own host platform rather than via the Boson GUI. This App Note is available from the Boson website linked in Section 1.3.

Boson provides fault-tolerant software upgradeability, meaning that if power to the core is disrupted during an upgrade event, the core is capable of rebooting with the functionality required to repeat the upgrade process. All future releases of Boson software will be backwards compatible with all production versions of Boson. In other words, upgrading a production core with an authorized 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 core is upgraded because some may require factory calibration to function properly. However, in all cases, a new feature will at worst simply not function rather than causing an upgraded core to behave erroneously.

7 Operating States and Modes

Boson provides a number of operating states and modes, more completely defined in the sections which follow. Generally speaking, modes of operation are user-selectable (i.e., the camera operates this way or that way depending upon user selections) whereas states are camera behaviors or operating conditions which take place automatically.

- Start-Up States, page 48
- Frame-Rate Modes, page 49
- Telemetry Modes, page 49
- Gain Modes and States, page 50
- FFC Modes and States, page 49
- CMOS Video-Tap Modes, page 54
- USB-Video Modes, page 55
- AGC Modes, page 54
- CMOS Color-Encoding Modes, page 55
- CMOS Output Modes, page 57

7.1 Start-Up States

Boson provides four power states. In most cases, the transitions between states are the result of explicit action from the user, indicated by **bold text** in Figure 30. The transition from “booting” to “fully booted” is automatic, requiring no user intervention. The four states and the transitions between them are described in more detail below.

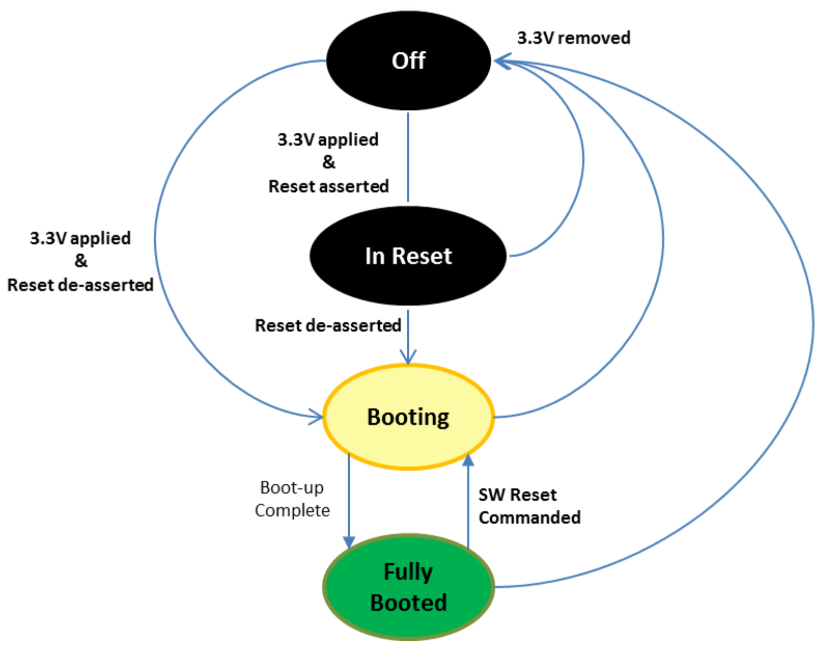


Figure 30: Boson Start-Up States

- **Off**: When no voltage is applied, Boson is in the Off state. In the off state, no camera functions are available, and the camera consumes no power.
- **In Reset**: When voltage is applied but the reset pin asserted, Boson is in the "In Reset" state. In the "In Reset" state, no camera functions are available, and the camera consumes minimal power (~65mW).
- **Booting**: In the "Booting" state, Boson is loading its program and initializing itself for full operation.
- **Fully Booted:** In the "Fully-booted" state, Boson is fully functional, producing optimal imagery, and capable of responding to commands via the CCI. Typical start-up time to the fully booted state is $\leq$1.5 sec.

7.2 Frame-Rate Modes

Boson provides two frame-rate modes affecting the video output signal:

- **Disabled mode (factory default)**
- **Enabled mode / averager enabled**

The mode is selected using the **Averager Enable** command. As described in Section 5.1, the primary benefit of enabling the averager is power reduction for those applications which do not require a high frame rate.

7.3 Telemetry Modes

Boson provides three telemetry modes affecting the CMOS output signal:

- **Telemetry disabled (factory default)**
- **Telemetry as header**
- **Telemetry as footer**

These modes are selectable via the parameters **Telemetry Enable** and **Telemetry Location**. See Section 6.4 for a complete description of the telemetry line.

NOTE: In the current product release, telemetry mode only affects the CMOS output as telemetry is not an option for the USB video channel. It is anticipated that telemetry will be optional on the USB channel in a later field-upgradeable software release.

7.4 Gain Modes and States

As described in Section 6.2, Boson provides two gain states: high and low. However, there are 3 gain *modes* which determine in which gain state it operates:

- **High-gain mode (factory default)**: Boson operates in high-gain state only, regardless of the scene.
- **Low-gain mode**: Boson operates in low-gain state only, regardless of the scene.
- **Automatic gain mode:** Boson automatically transitions between high-gain state and low-gain state based on scene conditions and user-specified parameters. See Section 6.2 for a detailed description of the parameters. They are all adjustable via the CCI; however, the default values are recommended under most operating conditions.

NOTE: Automatic gain mode and AGC Information-Equalization mode are mutually exclusive, and an error will result from trying to enable one while the other is already enabled. Since Information-Equalization mode is a factory-default, it is necessary to deselect it before attempting to enable automatic gain mode.

7.5 FFC Modes and States

Boson provides three different FFC modes:

- **Automatic (factory default):** The camera periodically performs automatic FFC in response to a number of conditions, as described in more detail in Table 5. (See Section 6.3 for a more general description of the FFC feature.)
- **Manual:** The camera performs automatic FFC at start-up only. Thereafter, it only performs FFC upon command. The camera sets an *FFC Desired* flag under a number of conditions described in Table 5.
- **External:** The camera *never* performs FFC except upon receipt of the "Do FFC" command. Moreover, it does not utilize the internal shutter for FFC but instead must be imaging a uniform external source before FFC is commanded. The camera sets an *FFC Desired* flag under a number of conditions described in Table 5.

Table 5: Camera behavior in each FFC Mode in response to various operating conditions

Condition	Behavior in Auto FFC mode	Behavior in Manual FFC mode	Behavior in External FFC mode
Start-up	Automatic FFC take place		*FFC Desired* flag is set
Commanded FFC (**Do FFC**)	FFC takes place	FFC takes place; *FFC Desired* is cleared	
Frame Counter – Frame Counter at Last FFC ≥ **FFC Period** (see note 1)	Automatic FFC takes place	*FFC Desired* is set	
|*Camera Temp* – Camera *Temp at Last FFC*| ≥ **FFC Delta Temp** (see note 1)	Automatic FFC take place	*FFC Desired* is set	
Camera is outside the range of the current high-gain NUC Table while in high-gain state (see note 2)	Automatic NUC Table switch take place, followed by automatic FFC	*Table Switch Desired* is set. *Desired NUC Table* is set to a value different from *Current NUC Table*.	
While in automatic gain switch mode, scene conditions are sufficient to trigger a gain-state change (i.e., from high to low or vice versa). See Section 6.2.	Automatic gain switch takes place. See note 3.	*Table Switch Desired* is set. *Desired NUC Table* set to a value different from *Current NUC Table*.	
Table Switch Commanded while *Table Switch Desired* is set.	n/a	NUC table switch takes place and *Table Switch Desired* is cleared, possibly followed by automatic FFC. See note 3.	NUC table switch takes place and *Table Switch Desired* is cleared, possibly followed by *FFC Desired* being set. See note 3.
Commanded switch to low-gain mode while in high-gain state or commanded switch to high-gain mode while in low-gain state.	Gain switch takes place, possibly followed by automatic FFC. See note 3.		Gain switch takes place, possibly followed by *FFC Desired* flag being set. See note 3.

- Note 1: *Frame Counter*, *Frame Counter at Last FFC*, *Camera Temp*, *Camera Temp at Last FFC* are all status variables which are provided via the telemetry line (see Section 6.4) or via command on the CCI. **FFC Period** and **FFC Delta Temp** are both user-selectable parameters which can be specified via the CCI, as further described in Section 6.3.
- Note 2: When in high-gain state, the camera operates in one of three different non-uniformity correction (NUC) tables. NUC Table 1 spans from approximately -40C to -20C, NUC Table 2 from approximately -20C to 60C, and Table 3 from approximately 60C to 80C. There is only a single table, NUC Table 0, which spans the entire temperature range when in low-gain state.
- Note 3: Boson is capable of transitioning between high-gain and low-gain state without an intervening FFC operation. Separate FFC maps are maintained for high-gain and low-gain states, as well as separate values of *Frame Counter at Last FFC* and *Camera Temp at Last FFC*. When transitioning between gain states, whether the result of an automatic switch or commanded switch, an automatic FFC or setting of the *FFC Desired* flag only occurs if elapsed time since FFC in that state and/or temperature change since the last FFC in that state dictate that an FFC take place. See the example below.

Example:

- Boson powers up in high-gain mode (see Section 7.4) and manual FFC mode. **FFC Temp Delta** is set to 3.0C. Automatic FFC takes place at start-up, and *Camera Temperature at Last FFC* = 300.0K.
- When *Camera Temperature* = 301.0K, the camera is commanded into low-gain mode. Gain switch takes place, and now *Camera Temperature at Last FFC* = 0.0K since FFC has never been performed in low-gain state. Consequently, automatic FFC takes place, and now *Camera Temperature at Last FFC* = 301.0K.
- When the camera is at 302.0K, the camera is commanded back into high-gain mode. Gain switch takes place, and *Camera Temperature at Last FFC* = 300.0K again. No FFC takes place and *FFC Desired* is not set since |*Camera Temperature* - *Camera Temperature at Last FFC*| < **FFC Temp Delta**.
- When the camera is at 303.0K, it is commanded back to low-gain state. Gain switch takes place, and *Camera Temperature at Last FFC* = 301.0K again. No FFC takes place and *FFC Desired* is not set since |*Camera Temperature* - *Camera Temperature at Last FFC*| < **FFC Temp Delta**.
- The camera continues to heat while in low-gain state until it reaches 304.0K. Now *FFC Desired* is set because |*Camera Temperature* - *Camera Temperature at Last FFC*| = **FFC Temp Delta**. Assuming FFC is commanded, now *Camera Temperature at Last FFC* = 304.0K and *FFC Desired* is cleared.
- With temperature still at 304.0K, the camera is commanded back to high-gain state. Now *Camera Temperature at Last FFC* = 300.0K, and automatic FFC takes place because |*Camera Temperature* - *Camera Temperature at Last FFC*| > **FFC Temp Delta**.

While the FFC mode defines when and how Boson performs FFC, the FFC state pertains to the FFC event itself. There are four FFC states, as illustrated in Figure 31.

1. *FFC not initiated* (power-on default): In this state, Boson applies no FFC terms. In automatic and manual FFC modes, this state is never seen because Boson performs automatic FFC at start-up.

2. *FFC imminent*: The camera only enters this state when it is operating in automatic FFC mode. The camera enters "FFC imminent" state at a user-specified period prior to initiating an automatic FFC (factory default = 2 sec). The intent of this status is to warn the user that an FFC is about to occur.

NOTE: In the current product release, the FFC Imminent state has not yet been implemented. It will be implemented in a later software release.

3. *FFC in progress*: Boson enters this state when FFC is commanded from the CCI or when an automatic FFC event is initiated. During each FFC event, the shutter is closed (if in automatic or manual FFC mode), a number of frames of sensor data are collected to generate the correction map, the shutter is opened, and the new FFC map is applied.

   Boson's video output is "frozen" throughout the "FFC in progress" state. That is, the last valid frame prior to entering "FFC in progress" is repeated throughout the event. (The telemetry line is not frozen, only the thermal image.)

4. *FFC complete*: Boson automatically enters this state whenever a commanded or automatic FFC is completed.

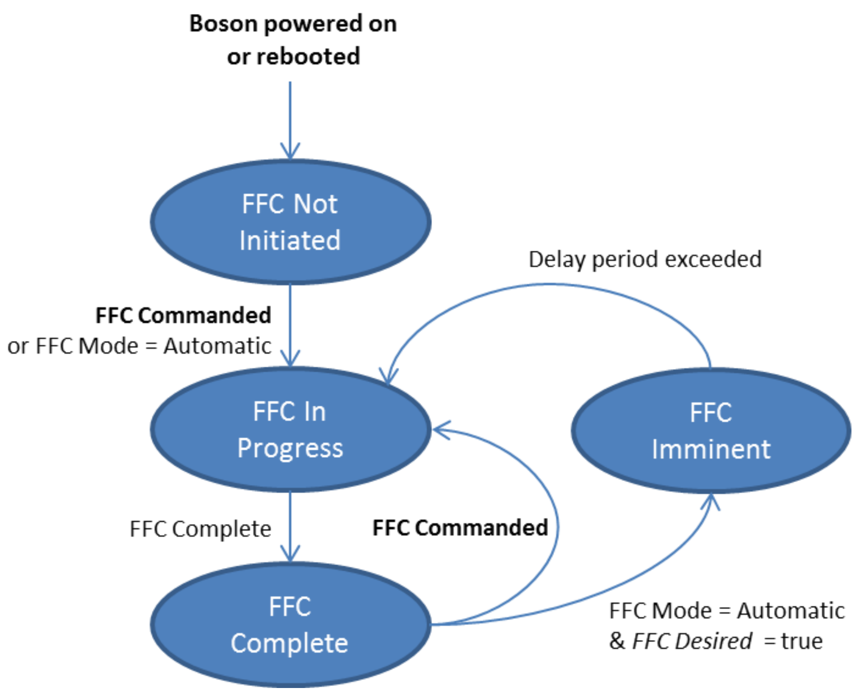


Figure 31: Boson FFC States

FFC Imminent is not implemented in the current product release.

7.6 AGC Modes

As described in Section 6.5, Boson provides two AGC modes:

- **Information-Equalization Enabled mode (factory default)**: AGC transfer function is based on the amount of information in the scene. That is, portions of the scene which contain variations (e.g., foliage) are weighted more heavily than portions which only vary gradually (e.g., sky).
- **Information-Equalization Disabled mode**: AGC transfer function weights all pixels equally.

NOTE: Automatic gain mode and AGC Information-Equalization Enabled mode are mutually exclusive, and an error will result from trying to enable one while the other is already enabled. That is, if automatic gain mode is already enabled, it is necessary to select a different gain mode before attempting to select Information-Equalization mode.

7.7 CMOS Video-Tap Modes

As described in Section 5 and shown again in Figure 32, there are multiple locations in the signal pipeline where video can be tapped for output on the CMOS channel. Boson provides the following CMOS video-tap modes:

- **Pre-AGC (16-bit) (factory default)**: The output is linearly proportional to incident irradiance; output resolution is the same as FPA resolution (e.g., 320x256 or 640x512). Data is provided on CMOS_Data[0:15]. Note that AGC settings, zoom settings, and color-encoding settings have no effect on the output signal at this tap point.
- **Post-AGC / Pre-Zoom (8-bit)**: The output is contrast enhanced via the AGC algorithm; output resolution is the same as FPA resolution. Data is provided on CMOS_Data[0:7]. Note that zoom settings and color-encoding settings have no effect on the output signal at this tap point.
- **Post-Zoom, Post-Colorize (various bit-width options depending upon color-encoding mode, see Section 7.8)**: The output is stretched to 640x512 resolution regardless of array format, and the displayed field of view is a function of the user-specified zoom parameters. The output is transformed to color space using the specified color palette (see Section 6.7) and specified color encoding mode (see Section 7.8).

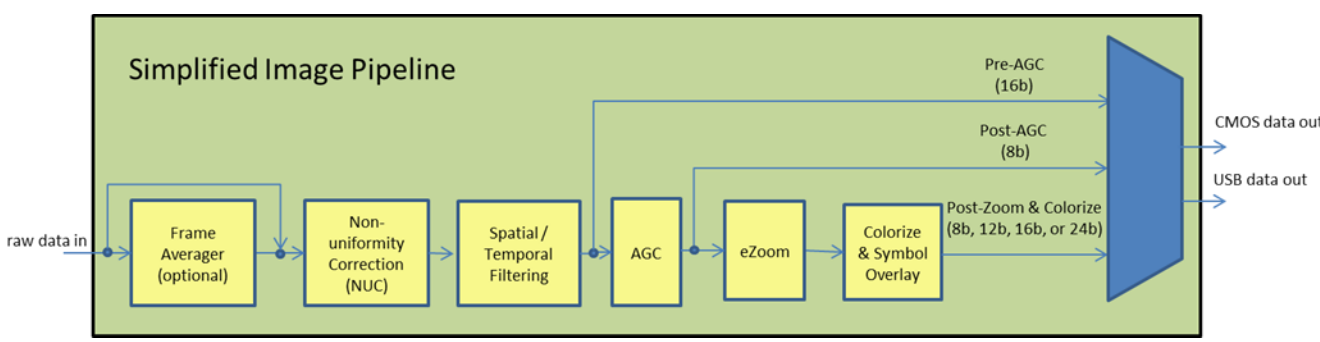


Figure 32: Boson Signal Pipeline

7.8 CMOS Color-Encoding Modes

Boson provides the following color-encoding modes which affect formatting of the output video signal when the post-colorize tap is selected:

- **YCbCr 4:2:2 (16-bit per pixel) (factory-default)**: The signal consists of a luminance channel (8 bits per clock on CMOS_Data[0:7]), a blue chrominance channel (8 bits on each even clock cycle on CMOS_Data[8-15]), and a red chrominance channel (8 bits on each odd clock cycle on CMOS_Data[8-15]).
- **YCrCb 4:2:2 (16-bit per pixel)**: The signal is identical to YCbCr except the red and blue chrominance channels are swapped. That is, the red chrominance channel is provided on the even clock cycle and the blue chrominance channel on the odd clock cycle.

NOTE: Only YCbCr 4:2:2 and YCrCb 4:2:2 are implemented in the current software release. All remaining options shown below are anticipated in a future software release.

- **RGB 8:8:8 (24-bit per pixel)**: The signal consists of a red channel (8 bits per clock on CMOS_Data[0:7]), a green channel (8 bits per clock on CMOS_Data[8-15]), and a blue channel (8 bits per clock on CMOS_Data[16-23]).
- **BGR 8:8:8 (24-bit per pixel):** The signal is identical to RGB 8:8:8 except the blue and red channels are swapped. That is, the blue channel is provided on CMOS_Data[0:7] and the red channel on CMOS_Data[16:23].
- **YCbCr 4:2:2 muxed (16-bit per pixel, 2 clocks per pixel):** The luminance and chrominance channels are time-multiplexed on CMOS_Data[0:7]. Specifically, the luminance is provided on clock cycles *n* and *n*+2, the blue chrominance channel on clock cycle *n*+1, and the red chrominance channel on clock cycle *n*+3, for *n* = 0, 4, 8…. The CMOS pixel clock rate is doubled when in this mode.
- **YCrCb 4:2:2 muxed (16-bit per pixel, 2 clocks per pixel):** The signal is identical to YCbCr 4:2:2 muxed except the order of the red and blue chrominance channels are swapped. That is, the red chrominance channel is provided on clock cycles *n*+1 and the blue chrominance channel on cycles *n*+3. The CMOS pixel clock rate is doubled when in this mode.
- **RGB 8:8:8 muxed (24-bit per pixel, 2 clocks per pixel):** The red, green, and blue color channels are time-multiplexed on CMOS_Data[0:11]. Specifically, on even clocks cycles the red channel is provided on CMOS_Data[0:7] and the 4 LSBs of the green channel are provided on CMOS_Data[8:11]. On odd cycles, the MSBs of the green channel are provided on CMOS_Data[0:3] and the blue channel is provided on CMOS_Data[4:11]. The CMOS pixel clock rate is doubled when in this mode.
- **BGR 8:8:8 muxed (24-bit per pixel, 2 clocks per pixel):** The signal is identical to RGB 8:8: muxed except the blue and red channels are swapped. That is, the blue channel is provided on CMOS_Data[0:7] on even cycles and the red channel on CMOS_Data[4:11] on odd cycles. The green channel encoding is unchanged. The CMOS pixel clock rate is doubled when in this mode.

For reference, the color encoding of each mode is depicted graphically in Figure 33. Note the CMOS color-encoding mode has no effect on the video signal unless CMOS video-tap mode is “post colorize”.

<table>
<tr><th rowspan="2">Color Mode</th><th rowspan="2">Clk</th><th colspan="24">CMOS_Data</th></tr>
<tr><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="2">YCbCr 4:2:2</td><td>0</td><td colspan="8">Unused</td><td colspan="8">Cb[7:0]</td><td colspan="8">Y0[7:0]</td></tr>
<tr><td>1</td><td colspan="8">Unused</td><td colspan="8">Cr[7:0]</td><td colspan="8">Y1[7:0]</td></tr>
<tr><td rowspan="2">YCrCb 4:2:2</td><td>0</td><td colspan="8">Unused</td><td colspan="8">Cr[7:0]</td><td colspan="8">Y0[7:0]</td></tr>
<tr><td>1</td><td colspan="8">Unused</td><td colspan="8">Cb[7:0]</td><td colspan="8">Y1[7:0]</td></tr>
<tr><td>RGB 8:8:8</td><td></td><td colspan="8">B[7:0]</td><td colspan="8">G[7:0]</td><td colspan="8">R[7:0]</td></tr>
<tr><td>BGR 8:8:8</td><td></td><td colspan="8">R[7:0]</td><td colspan="8">G[7:0]</td><td colspan="8">B[7:0]</td></tr>
<tr><td rowspan="4">YCbCr 4:2:2 muxed</td><td>0</td><td colspan="16">unused</td><td colspan="8">Y0[7:0]</td></tr>
<tr><td>1</td><td colspan="16">unused</td><td colspan="8">Cb[7:0]</td></tr>
<tr><td>2</td><td colspan="16">unused</td><td colspan="8">Y1[7:0]</td></tr>
<tr><td>3</td><td colspan="16">unused</td><td colspan="8">Cr[7:0]</td></tr>
<tr><td rowspan="4">YCrCb 4:2:2 muxed</td><td>0</td><td colspan="16">unused</td><td colspan="8">Y0[7:0]</td></tr>
<tr><td>1</td><td colspan="16">unused</td><td colspan="8">Cb[7:0]</td></tr>
<tr><td>2</td><td colspan="16">unused</td><td colspan="8">Y1[7:0]</td></tr>
<tr><td>3</td><td colspan="16">unused</td><td colspan="8">Cr[7:0]</td></tr>
<tr><td rowspan="2">RGB 8:8:8 muxed</td><td>0</td><td colspan="12">unused</td><td colspan="4">G[3:0]</td><td colspan="8">R[7:0]</td></tr>
<tr><td>1</td><td colspan="12">unused</td><td colspan="8">B[7:0]</td><td colspan="4">G[7:4]</td></tr>
<tr><td rowspan="2">BGR 8:8:8 muxed</td><td>0</td><td colspan="12">unused</td><td colspan="4">G[3:0]</td><td colspan="8">B[7:0]</td></tr>
<tr><td>1</td><td colspan="12">unused</td><td colspan="8">R[7:0]</td><td colspan="4">G[7:4]</td></tr>
</table>

Figure 33: Boson's Various Color-Encoding Modes

Modes which are highlighted in gray are not provided in the current product release but are anticipated for a later field-upgradeable software release.

7.9 CMOS Output Modes

The final stage in the Boson signal pipeline is a multi-frame buffer. The CMOS output channel reads the front buffer while the signal pipeline writes a background buffer. Boson provides two CMOS output modes which affect the behavior of the CMOS channel in relation to the multi-frame buffer:

- **Continuous (factory-default):** In this mode, the CMOS channel provides data at a regular cadence (i.e., exact same clocks per frame period without exception). If the background buffer is still being written when the front buffer has been fully read out, the front buffer is read out again, resulting in a duplicated frame. This mode of operation is preferred for interfacing to a display system which requires data at a regular interval.

  For slow configurations (< 9Hz), the actual frame rate in continuous mode is either 60Hz (averager disabled, see Section 5.1) or 30Hz (averager enabled). However, each output frame is duplicated multiple times. The effective frame rate is the rate at which new frames of data are provided on the output channel. With the averager disabled, each frame is duplicated six times for an effective frame rate of 60 / 7 = 8.6Hz. With averager enabled, each frame is duplicated three times for an effective frame rate of 30 / 4 = 7.5Hz. The frame counter in the telemetry line increments by 7 with the averager disabled and by 4 with in enabled. As mentioned above, the presence of duplicated frames can be detected via the frame counter in the telemetry line since it does not increment on a duplicated frame.

- **One-shot:** In this mode, the CMOS channel inserts idle time between successive frames in those instances where there is not a back buffer ready for readout when the front buffer has been completely read. Consequently, the number of clocks per frame period is not a constant but can instead vary slightly. This mode of operation is preferred for interfacing to a frame grabber which can tolerate slight frame-rate jitter.

  For slow configurations, the actual frame rate matches the effective frame rate, and there are no duplicated frames. As described above, the frame rate is 8.6Hz and the frame counter increments by 7 with averager disabled. With averager enabled, the frame rate is 7.5Hz and the frame counter increments by 4.

NOTE: The CMOS Output mode has no effect on the USB video channel. The USB video channel always operates in one-shot mode.

8 Interface Descriptions

This section describes the primary electrical interfaces to the camera:

- Command and Control Interface, page 58
- Video Interfaces, page 61

8.1 Command and Control Interface

Boson provides two options for a command and control interface (CCI): over a UART (for asynchronous serial interfaces such as RS232) or via USB. Each interface is fully described in a separate document, the Boson Software Interface Description Document (IDD), FLIR document #102-2013-42. Generally speaking, all commands issued through the CCI take the form of a "get" (reading data), a "set" (writing data), or a "run" command (executing a function). Table 6 shows a partial list of modes, parameters, and operations which are controllable through the CCI. A graphical user interface (GUI) which provides full command and control is available for download on FLIR's Boson website. (See Section 1.3).

Table 6: Partial List of Modes, Parameters, and Operations Controllable through the CCI

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
Mode Controls			
Averager Mode	Disabled	7.2	28
Telemetry Mode	Enabled	7.3	n/a
Gain Mode	High	7.4	38
FFC Mode	Automatic	7.5	n/a
AGC Mode	Information-Based Equalization enabled	7.6	n/a
CMOS Video-Tap Mode	Pre-AGC	7.7	n/a
CMOS Color-Encoding Mode		7.8	n/a
CMOS Output Mode	One-shot	7.9	n/a
Parameter Controls			
Telemetry Location	Header	7.3	n/a
Gain-switch High-to-Low Temperature Threshold	90	6.2	n/a

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
Gain-switch High-to-Low Population Threshold	5	6.2	n/a
Gain-switch Low-to-High Population Threshold	98	6.2	n/a
FFC Period	900 (900 seconds)	6.3	n/a
FFC Delta Temp	30 (3.0 Celsius degrees)	6.3	n/a
FFC Integration Period	8 (8 frames)	6.3	57
Plateau Value	7%	6.5.2	n/a
Tail Rejection	0	6.5.3	n/a
Max Gain	1.38	6.5.4	n/a
Linearity Factor	20%	6.5.5	n/a
ACE	0.97	6.5.6	n/a
DDE	0.95	6.5.7	n/a
Smoothing Factor	1250	6.5.8	n/a
ROI Start Row	0	6.5.9	n/a
ROI Start Col	0	6.5.9	n/a
ROI End Row	255	6.5.9	n/a
ROI End Col	319	6.5.9	n/a
Dampening Factor	85%	6.5.10	n/a
Zoom Factor	0	6.6	n/a
Zoom-Center Column	160	6.6	n/a
Zoom-Center Row	128	6.6	n/a
Color Palette	White Hot	6.7	n/a

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
Operations			
SW Reset	n/a	7.1	n/a
Set Defaults	n/a	6.1	n/a
Restore Factory Defaults	n/a	6.1	n/a
Perform FFC	n/a	7.2, 6.3	n/a
Get Part Number	n/a		5-14
Get Serial Number	n/a		1-2
Read SW Revision	n/a		21-26

8.2 Video Interfaces

Boson provides two separate channels for output video:

1. CMOS
2. USB

NOTE: It is possible to provide simultaneous output on both channels. For example, CMOS can be configured to provide 16-bit data prior to AGC while USB provides the post-colorization video tap.

8.2.1 CMOS

Boson provides the option of a digital data protocol resembling that of a typical CMOS camera. Specifically:

1. The CMOS video channel is comprised of a pixel clock, up to 24 parallel bits of data, a vertical sync, a horizontal sync, and a data-valid signal. The channel utilizes 1.8V logic levels. See Table 3 in Section 4.1 for pin assignments. The vertical sync and horizontal sync are asserted low. The data-valid and all data lines are asserted high.
2. Each frame period consists of three distinct sections, as illustrated in Figure 34:
    a. The vertical sync period, during which the vertical sync, *cmos_vsync*, is asserted. The width of the vertical sync pulse, *vsw*, varies depending upon whether or not telemetry is enabled, as depicted in Table 7.
    b. A period during which successive rows of data are provided. The total number of rows during each frame, *nr*, varies depending upon settings, as shown in Table 7.
    c. A variable blank period between the end of the last row period and the next vertical sync. This variable blank period is only present in “one shot” CMOS output mode. (See Section 7.9.) In “continuous” CMOS output mode, this period is always 0 clocks. The difference in frame timing between the two modes is defined in Table 8.
3. Each row period consists of four distinct sections, as depicted in Figure 35:
    a. The horizontal sync period, during which the horizontal sync, *cmos_hsync*, is asserted. The width of the horizontal sync pulse, *hsw*, is always 7 clocks, as depicted in Table 7.
    b. A blanking period between the horizontal sync and the start of valid data referred to as the front porch. The width of the front porch, *fp*, varies depending upon the CMOS tap point, as shown in Table 7.
    c. The period during which valid data is provided on *cmos_data[0:23]* and during which *cmos_data_valid* is asserted. The number of pixels (i.e., number of clocks) in the data valid period, *ppr*, varies depending upon the CMOS tap point, as shown in Table 7.
    d. A blanking period between the end of valid data and the end of the row period, referred to as the back porch. The width of the front porch, *bp*, varies depending upon the CMOS tap point, as shown in Table 7.

4. All signals in the CMOS channel are latched on the rising edge of the pixel clock, *cmos_pclk*, as illustrated in Figure 36. As shown in Table 8, the period of the pixel clock is either 27.000 MHz or 13.500 MHz, depending upon whether or not the averager feature is enabled (see Section 7.2).
5. The output frame rate is also dependent upon whether or not the averager is enabled and the CMOS output mode. In continuous mode, output frame rate is always 30.0Hz (averager enabled) or 60.0Hz (averager disabled), but frames are duplicated to produce an *effective* frame rate below 9Hz. For example, if the averager is enabled, each unique frame is followed by 3 duplicates, for an effective frame rate of 30.0Hz/4. Similarly, if the averager is disabled, each unique frame is followed by 6 duplicates, for an effective frame rate of 60.0Hz/7. In one-shot mode, actual frame rate of a slow-configuration is either 8.6Hz (averager disabled) or 7.5Hz (average enabled).
6. As described in Section 7.7 and Section 7.8, the number of valid data bits piped out the CMOS channel is either 8, 16, or 24, depending upon the CMOS video-tap mode and possibly on the colorization mode (if and only if video-tap mode = post-colorization). The CMOS channel encoding for each tap-mode / color-encoding mode is repeated in Figure 37 below.

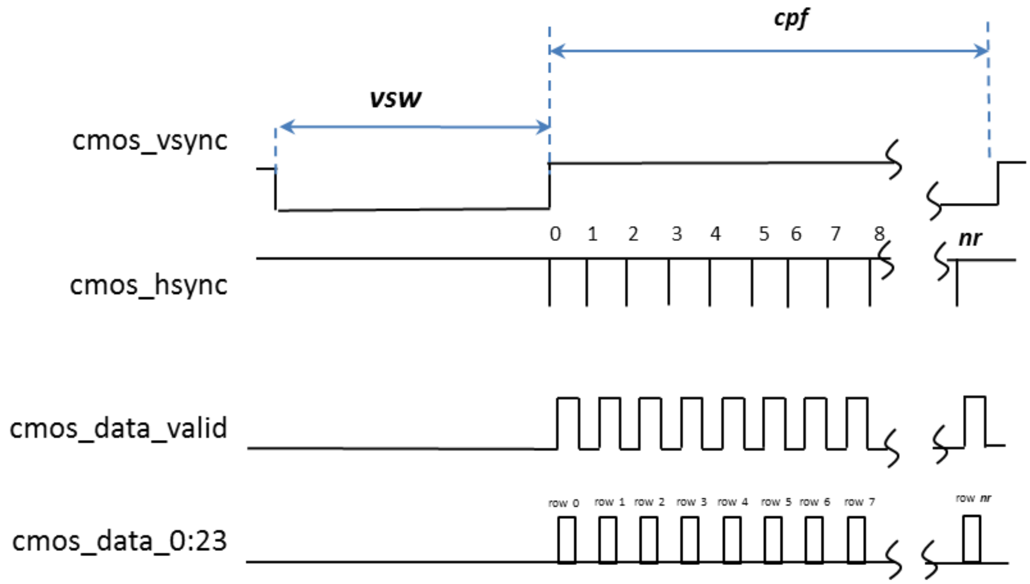


Figure 34: Frame Timing of the CMOS Output Channel

See Table 7 for the values of *vsw* and *nr*. See Table 8 for the value of *cpf*,

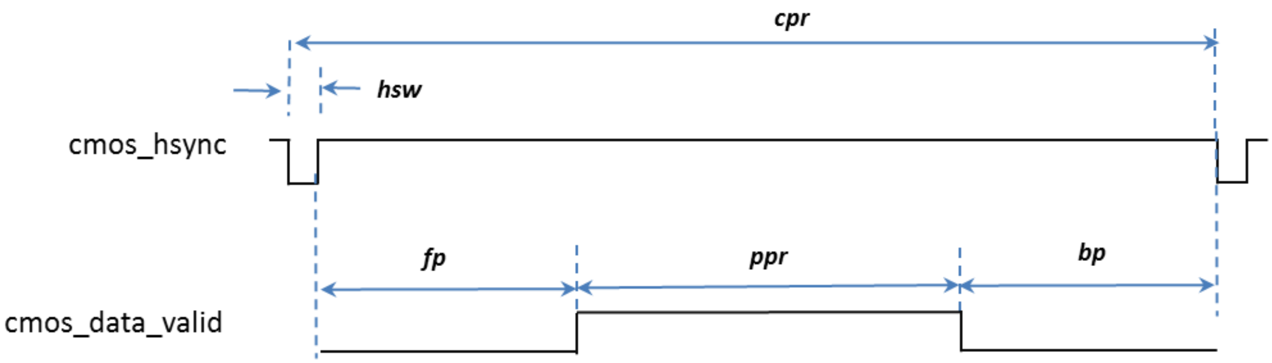


Figure 35: Line Timing of the CMOS Output Channel

See Table 7 for the values of *hsw*, *cpr*, *fp*, *ppr*, and *bp.*

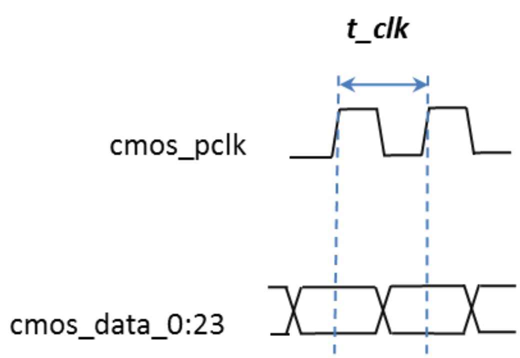


Figure 36: Phase of Pixel Clock relative to CMOS Data

See Table 7 for the value of *t_clk.*

Table 7: Timing of the CMOS channel as a function of camera settings, values common to continuous and one-shot modes

CMOS Tap Point	Pre-AGC Or Post-AGC / Pre-zoom		Post-Zoom / Post-Colorization	
Telemetry	Disabled	Enabled	Disabled	Enabled
Vertical sync width, *vsw* (in row periods)	7	6	7	6
Valid rows per frame, *nr*	256	257	512	513
Row periods per frame (*vsw* + *nr*)	263		519	
Horz sync width, *hsw* (in clocks)	7			
Front porch, *fp* (in clocks)	692		110	
Back porch, *bp* (in clocks)	692		110	
Pixels per row, *ppr*	320		640	
Clocks per row period, *cpr* (*hsw* + *fp* + *pp r*+ *bp*)	1711		867	

Table 8: Timing of the CMOS channel as a function of camera settings, values which differ between continuous and one-shot modes

(a) Continuous mode settings

CMOS Tap Point	Pre-AGC Or Post-AGC / Pre-zoom		Post-Zoom / Post-Colorization	
Averager	Disabled	Enabled	Disabled	Enabled
Clocks per frame, cpf (*cpr* x (*vsw* + *nr*))	449993		449973	
Clock rate, (1/*t_clk*) (in MHz)	27.000	13.5	27.000	13.5
Frame rate = 1/(*cpf* x *t_clk*)	60.000	30.000	60.000	30.000

(b) One-shot mode settings

CMOS Tap Point	Pre-AGC Or Post-AGC / Pre-zoom		Post-Zoom / Post-Colorization	
Averager	Disabled	Enabled	Disabled	Enabled
Clocks per frame, cpf (*cpr* x (*vsw* + *nr*)) See note 1	Varies, ≥ 3149951	Varies, ≥ 1799972	Varies, ≥ 3149811	Varies, ≥ 1799892
Clock rate, (1/*t_clk*) (in MHz)	27.000	13.5	27.000	13.5
Frame rate = 1/(*cpf* x *t_clk*)	≤ 8.57	≤7.50	≤ 8.57	≤7.50

Note 1: Additional clock periods of blanking are inserted as necessary at the end of the last row of valid data. The next vertical sync appears as soon as the next frame is ready.

Mode	Clk	CMOS_Data 23–16	CMOS_Data 15–12	CMOS_Data 11–8	CMOS_Data 7–4	CMOS_Data 3–0
Pre-AGC		unused	Data[15:0]			
Post-AGC / Pre-Color		unused			Data[7:0]	
YCbCr 4:2:2	0	unused	Cb[7:0]		Y0[7:0]	
	1	unused	Cr[7:0]		Y1[7:0]	
YCrCb 4:2:2	0	unused	Cr[7:0]		Y0[7:0]	
	1	unused	Cb[7:0]		Y1[7:0]	
RGB 8:8:8		B[7:0]	G[7:0]		R[7:0]	
BGR 8:8:8		R[7:0]	G[7:0]		B[7:0]	
YCbCr 4:2:2 muxed	0	unused			Y0[7:0]	
	1	unused			Cb[7:0]	
	2	unused			Y1[7:0]	
	3	unused			Cr[7:0]	
YCrCb 4:2:2 muxed	0	unused			Y0[7:0]	
	1	unused			Cb[7:0]	
	2	unused			Y1[7:0]	
	3	unused			Cr[7:0]	
RGB 8:8:8 muxed	0	unused		G[3:0]	R[7:0]	
	1	unused		B[7:0]		G[7:4]
BGR 8:8:8 muxed	0	unused		G[3:0]	B[7:0]	
	1	unused		R[7:0]		G[7:4]

Figure 37: Encoding of the CMOS Output Channel for each Video-Tap Mode / Color-Encoding Mode

Modes which are highlighted in gray are not supported in the current product release but are anticipated for a later field-upgradeable software release.

NOTE: The CMOS color-encoding mode has no effect on the video signal unless CMOS video-tap mode is "post colorize".

8.2.2 USB

Boson is capable of providing digital data as a USB Video Class (UVC) compliant device. Two output options are provided. Note the options are *not* selected via the CCI but rather by selecting one of the enumerated video-format options over the UVC service. The options are:

- **Pre-AGC (16-bit)**: The output is linearly proportional to the flux incident on each pixel in the array; output resolution is 320x256. Note that AGC settings, zoom settings, and color-encoding settings have no effect on the output signal at this tap point. This option is identified with a UVC video format 4CC code of "Y16 ".
- **Post-Colorize, YCbCrb**: The output is transformed to YCbCr color space using the specified color palette (see Section 6.7). Resolution is 640x512. This option is identified with a UVC video format 4CC code of "I420".

9 Mechanical Considerations

9.1 Mounting

Boson provides two primary mounting options:

- **Rear Mounting**: The rear cover of the Boson assembly provides 4 threaded holes (M1.6x0.35). See the relevant Mechanical IDD for more detailed information. Zinc plated screws with thread penetration of 2.5 to 3.5mm are recommended.
- **Lens Mounting:** Generally speaking, Boson should be supported at its lens for all Boson configurations in which the mass of the lens assembly is greater than the mass of the sensor engine. This condition is true for the following configurations:
  - 320 with 12° HFOV
  - 320 with 6° HFOV
  - 320 with 4° HFOV
  - 640 with 24° HFOV
  - 640 with 18° HFOV
  - 640 with 12° HFOV
  - 640 with 8° HFOV
  - 640 with 6° HFOV

  Each of the lens assemblies listed above provides suitable features for mounting and sealing, as summarized in Figure 38. It is worth noting that even configurations which are mounted via the lens features require heatsinking via the rear surface.

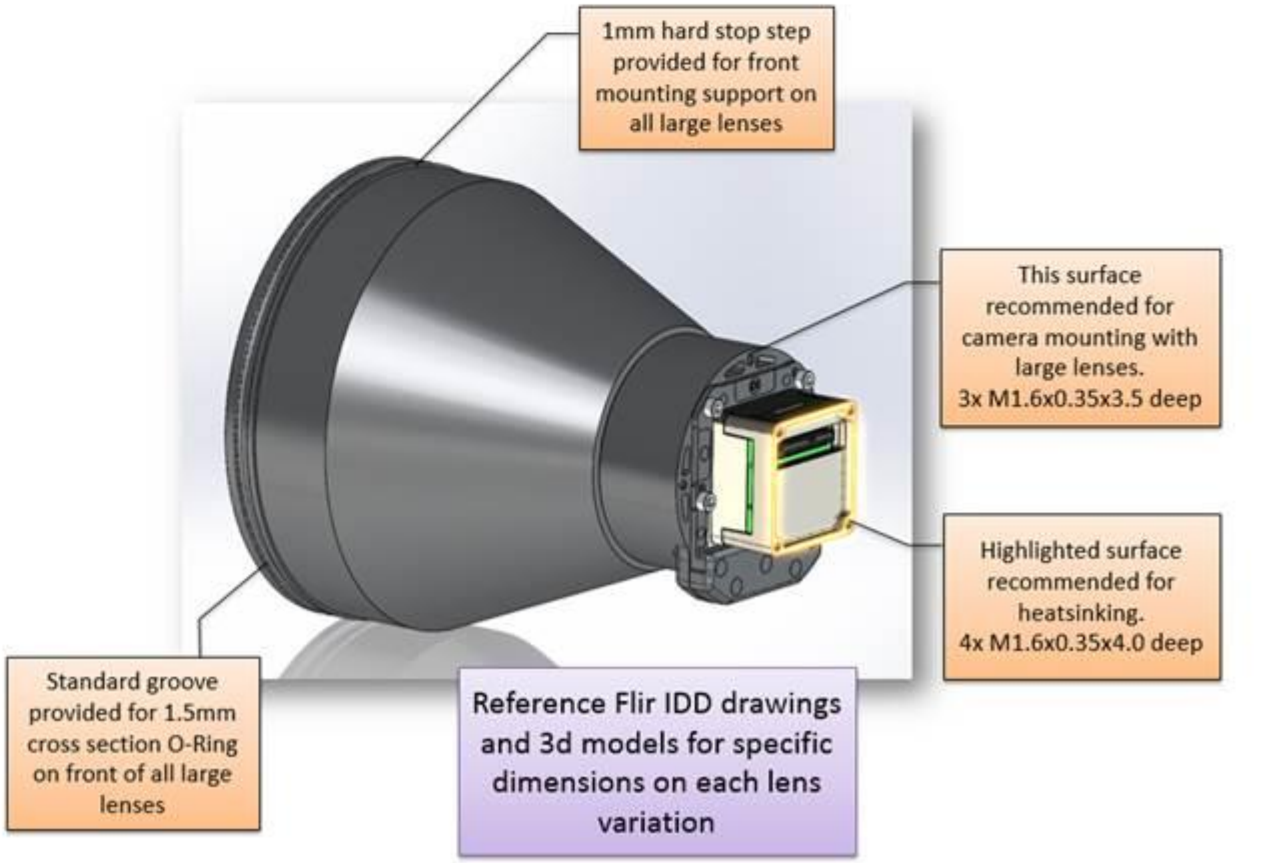


Figure 38: Mounting Guidance for Large-Lens Configurations

9.2 Sealing

Two typical use scenarios for Boson are envisioned:

- Abrasive environment (e.g., blowing sand): Boson should be installed inside a sealed enclosure behind an LWIR-transparent window.
- Non-abrasive environment: Boson should be installed in an enclosure which seals against the Boson lens barrel. All Boson lens assemblies are sealed at the front element and rated to IP67. Furthermore, all lens assemblies have been qualified against exposure to $\geq$ 240 hours of salt-fog. The 2.3mm lens (92 deg) provides a diamond-like coating (DLC) qualified against harsh abrasion (RSRE TS1888 Windscreen Wiper Test). All other lens assemblies provide a high-durability anti-reflection (HAR) coating qualified against mild abrasion (MIL-C-675C section 4.5.11, Moderate Abrasion).

For use in dry, benign environments, a sealed enclosure is not absolutely essential. However, it should be noted that the Boson core utilizes a magnesium-alloy housing and rear cover, both of which are susceptible to corrosion particularly when exposed to salt spray / salt fog. Furthermore, the edge of a circuit-card assembly (CCA) is exposed on the Boson core and is susceptible to failure and permanent damage when exposed to moisture.

9.3 Disassembly

Removal of the lens assembly is not recommended except for the purpose of swapping out an alternative lens. Removing the lens (or removing the protective cap which is factory-installed on lens-less configurations) should *only* be performed in a certified clean room (Class 1000 / ISO 6 or cleaner). When the lens is removed, extreme care must be exercised to avoid exposing the interior of the core to contamination or damage from foreign objects. Even microscopic debris is problematic and prone to causing image blemishes. Exposing the interior of the camera to forced air and/or any cleaning agents is likely to damage or further contaminate the unit and will void the warranty. Consequently, debris removal should not be attempted, and instead a contaminated unit should be returned to FLIR. In the event of contamination, contact FLIR to arrange a Return Merchandise Authorization (RMA).

NOTE: Disassembly of the Boson core for any purpose other than swapping out a lens will void the warranty.

9.4 Thermal Considerations

Adequate heatsinking must be provided to prevent the Boson core from overheating, particularly when operated in temperatures approaching the upper temperature range of the device. The rear camera cover must be maintained at a temperature below 80C at all times.

It is important to minimize any temperature gradient across the camera, particularly in the axes perpendicular to the optical line of sight. Avoid mounting conditions which expose the camera to uneven heat loads, such as directly adjacent to heaters, high-powered devices, and other heat sources.

10 Optical Characteristics

As summarized in Figure 39, both the QVGA and VGA configurations of Boson provides 8 lens options ranging from very wide field of view to very narrow field of view (FOV). All lens assemblies are athermalized for stable focus quality across the full operating temperature range. Table 9 summarizes key specifications unique to each lens assembly.

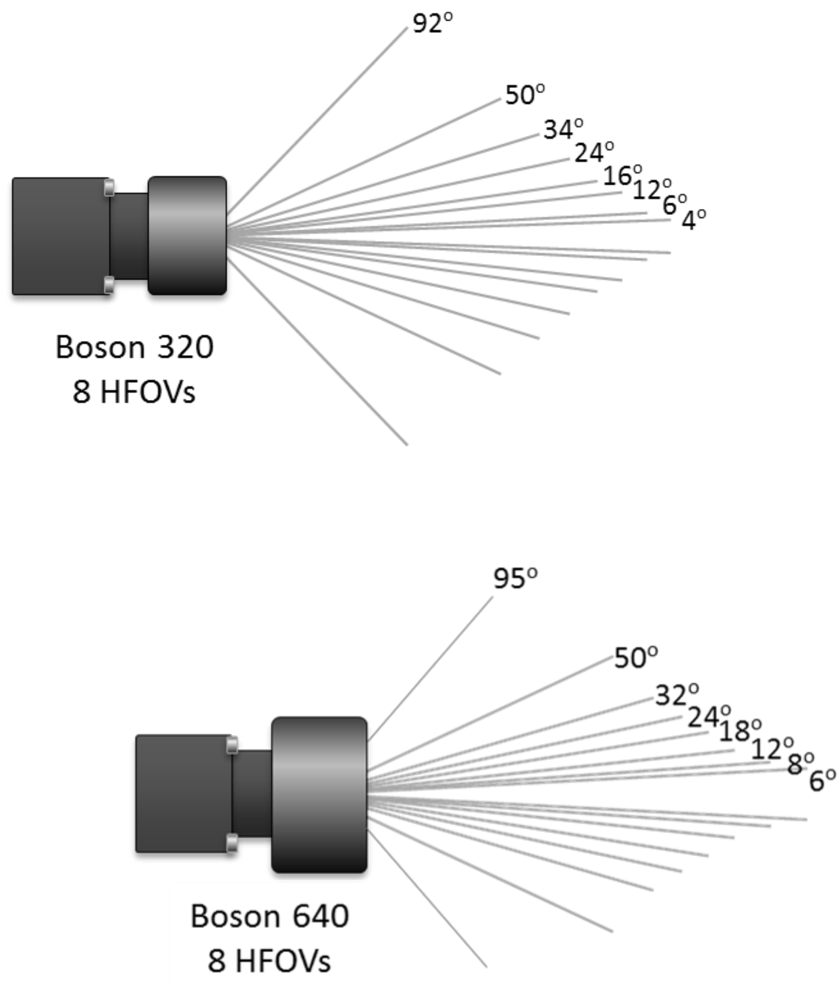


Figure 39: Various Horizontal Fields of View Supported by Boson

Table 9: Lens Specifications

Config.	HFOV (deg)	VFOV (deg)	f/#	Focal length (mm)	Trans-mission, τ	MTF (nominal at Nyquist, on-axis, 20C)	Distortion (%)	Thread pitch	Max. Diam. (mm)	Camera Length (mm)	Camera Weight (grams)
320 92 deg	91.9	74.0	1.00	2.3	87%	42%	<46%	M18x0.5	20.0	35	25
320 50 deg	50.0	40.0	1.00	4.3	93%	40%	<12%	M18x0.5	20.0	27	18
320 34 deg	34.1	27.3	1.01	6.3	94%	45%	< 1%	M18x0.5	20.0	27	15
320 24 deg	24.1	19.2	1.02	9.1	82%	42%	< 1%	M18x0.5	20.0	27	15
320 16 deg	16.0	12.8	1.01	13.8	84%	46%	< 3%	M24x0.5	26.0	28	38
320 12 deg	12.2	9.7	1.04	18.0	90%	42%	< 1%	M24x0.5	27.6	38	39
320 6 deg	6.1	4.9	1.00	36.0	90%	40%	< 1%	M34x0.5	51.0	64	132
320 4 deg	4.0	3.2	1.00	55.0	89%	40%	< 1%	M34x0.5	71.0	87	256
640 95 deg	95.0	77.0	1.10	4.9	88%	38%	< 50%	M24x0.5	34.6	50	91
640 50 deg	50.0	40.0	1.00	8.7	90%	40%	< 11%	M24x0.5	26.0	40	38
640 32 deg	32.0	25.6	1.00	14.0	92%	42%	< 3%	M24x0.5	26.0	35	38
640 24 deg	24.3	19.5	1.04	18.0	90%	42%	< 2%	M24x0.5	27.6	38	35
640 18 deg	18.0	14.4	1.20	25.0	89%	38%	< 2%	M34x0.5	37.0	51	78
640 12 deg	12.2	9.8	1.00	36.0	90%	40%	< 1%	M34x0.5	51.0	64	133
640 8 deg	8.0	6.4	1.00	55.0	89%	39%	< 2%	M34x0.5	71.0	87	257
640 6 deg	6.0	4.8	1.05	72.8	89%	36%	< 1%	M34x0.5	82.0	97	320

All configurations above have a standard high-durability AR coating on the outermost lens surface. The lone exception is the 320 92-degree configuration, which has a diamond-like coating (DLC) on its outermost surface.

11 Image Characteristics

11.1 Sensitivity

Table 10 shows sensitivity as a function of configuration, normalized to f/1.0. The specified requirements are when operating in the high-gain state at 20C, with the average disabled, imaging a 30C background. (See Section 5.1 for a description of the averager. NEDT values with averager disabled are approximately 20% lower than shown in the table.)

In low-gain state, NEDT requirements are 250% of the values shown in Table 10. See Section 6.2 for a description of high-gain and low-gain states. Only industrial and professional-grade configurations provide a low-gain state.

Table 10: Temporal NEDT in high-gain state

Camera Grade	Random temporal noise (σ_{tvh})	Column noise (σ_{th})	Row noise (σ_{tv})
Industrial	$\leq$ 40 mK	$\leq$ 14 mK	$\leq$ 14 mK
Professional	$\leq$ 50 mK	$\leq$ 18 mK	$\leq$ 18 mK
Consumer	$\leq$ 60 mK	$\leq$ 21 mK	$\leq$ 21 mK

NEDT values shown are acceptance-test limits representing the lensless configuration with an f/1.0 aperture installed. With a lens installed, test limits are scaled by $(f/\#)^2 / \tau$, where f/# and τ are as shown in Table 9.

For reference, Figure 40 illustrates the expected variation in sensitivity as a function of camera temperature. Two curves are shown in the figure, one in which scene temperature is assumed to be 20C regardless of camera temperature and one in which scene temperature is equal to camera temperature. When scene temperature is constant, the NEDT variation over temperature is due to the fact that noise and responsivity of the camera vary at different rates over temperature (i.e., $\delta\sigma / \delta T \neq \delta\mathcal{R} / \delta T$). When scene temperature varies, a greater variation is seen due to the fact that the differential radiance versus temperature (i.e., $\delta W / \delta T$) increases with temperature. That is, the difference in infrared energy is significantly higher for an 80C target relative to a 79C background than that from a -39C target relative to a -40C background.

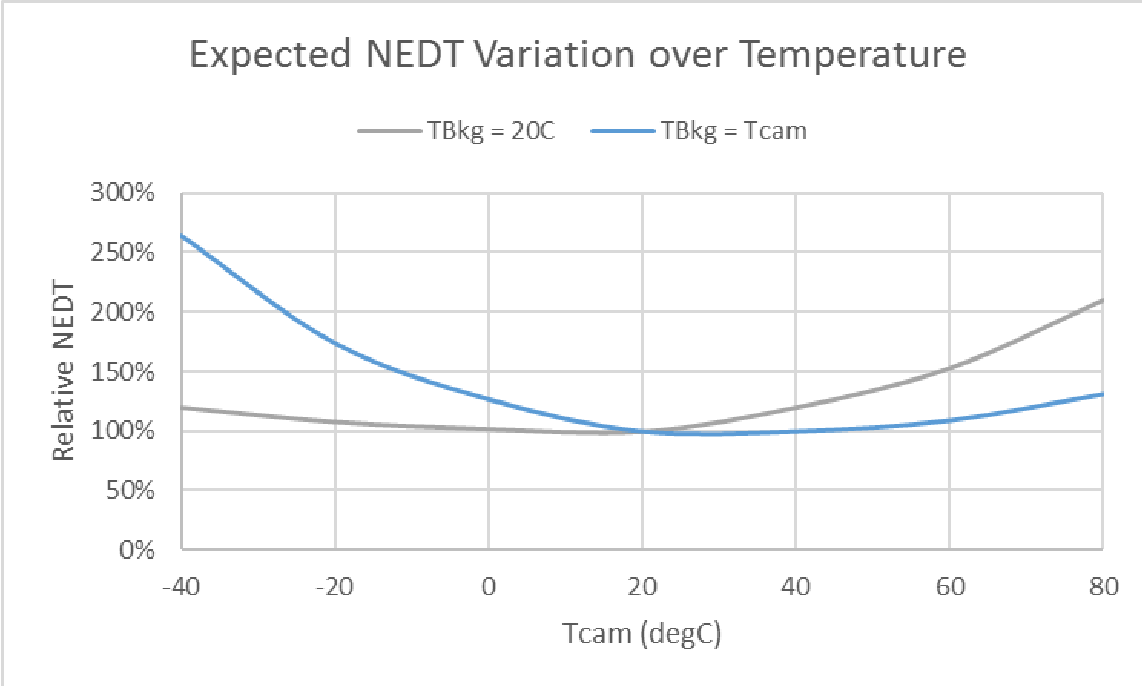


Figure 40: Expected NEDT variation over temperature

11.2 Intrascene Temperature

Intrascene temperature refers to the span of scene temperatures which map to the camera's 16-bit output range (i.e., the temperatures which can be imaged without railing the output). Figure 41 shows the maximum scene temperature as a function of camera temperature when in high-gain state. Figure 42 shows the same for low-gain state (applicable to industrial and professional-grade configurations only, not consumer grade).

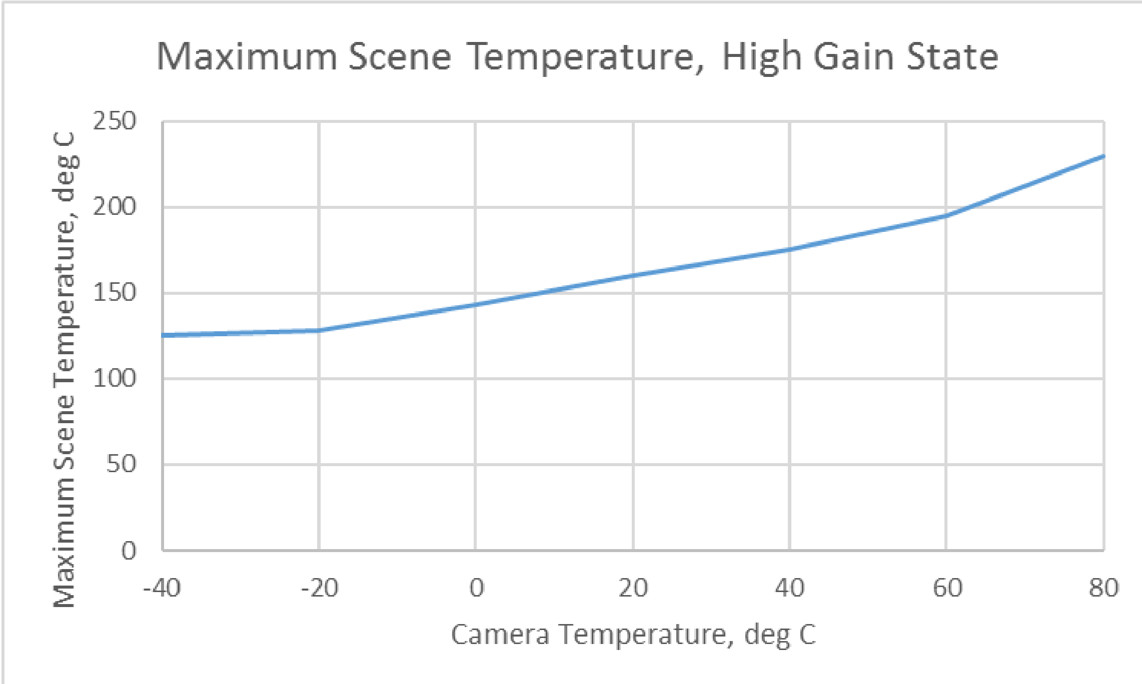


Figure 41: Expected maximum scene temperature vs. camera temperature, high-gain state

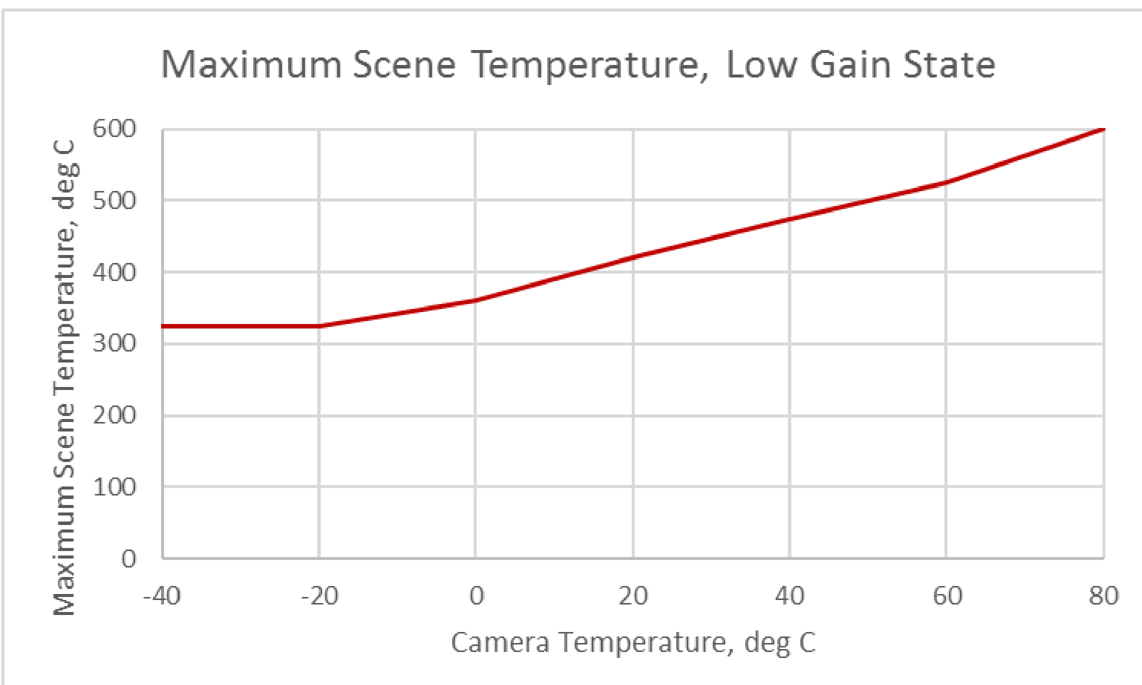


Figure 42: Expected maximum scene temperature vs. camera temperature, low-gain state

11.3 Operability

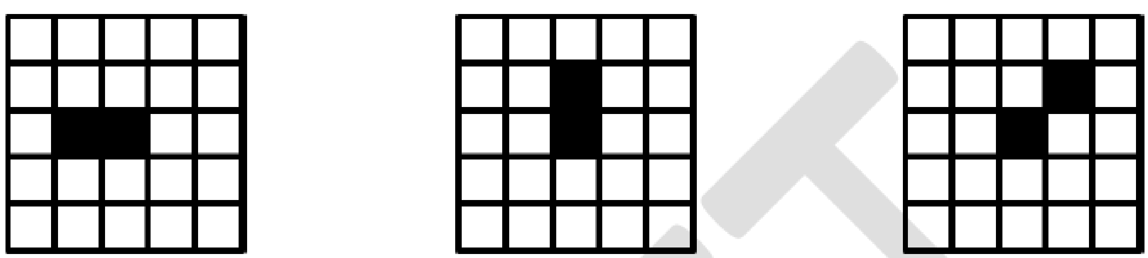
Operability refers to requirements pertaining to the number and location/grouping of non-operable pixels. Table 11 defines the operability requirements as a function of camera grade. By factory-default, all defective pixels are replaced in the output-video stream by data from adjacent non-defective pixels.

Table 11: Operability Requirements by Camera Grade

Camera Grade	Total Defects	Bad columns / rows (see note 1)	Defect Clusters
Industrial	≤ 1%	0	No 3x3 clusters (see Section 11.3.1)
Professional	≤ 1.5%	≤ 2 total (non-adjacent) ≤1 in central 160x128	No 3x3 clusters
Consumer	≤ 2%	≤ 4 total (≤2 adjacent) ≤2 in central 160x128	No 5x5 clusters ≤ 1 3x3 cluster, none in the central 160x128

Note 1: Number shown is total allowance for defective columns and rows. For example, if the requirement is ≤2, then the array is permitted to have 2 bad columns OR 2 bad rows OR 1 bad column and 1 bad row.

A defective cluster is defined as any grouping of adjacent defective pixels. Two pixels are considered adjacent if they have a common side or corner. Various examples of 2-pixel clusters are shown in Figure 43.



(a) Horizontally-adjacent defects (b) Vertically adjacent defects (c) Diagonally adjacent defects

Figure 43: Examples of 2-pixel clusters

11.3.1 3x3 Cluster Definition

A 3x3 cluster refers to any grouping of defective pixels in which there is a defective pixel which does not have at least 1 adjacent neighbor which is non-defective. For example, a 3x3 neighborhood in which all pixels are defective is a 3x3 cluster since the center pixel does not have a non-defective neighbor adjacent to it. Furthermore, a defective pixel on the edge of the array for which all 5 adjacent neighbors are defective also constitutes a 3x3 cluster, as does a defective pixel in a corner of the array for which all 3 adjacent pixels are defective.

11.3.2 5x5 Cluster Definition

A 5x5 cluster refers to any grouping of defective pixels in which there is a defective pixel which does not have at least 1 neighbor within ±2 rows or columns which is non-defective. For example, a 5x5 neighborhood in which all pixels are defective is a 5x5 cluster since the center pixel does not have any neighbor within 2 rows or 2 columns which is non-defective. As with a 3x3 cluster, a 5x5 cluster which contains less than 25 defective pixels is also possible if located on the edge or corner of the array.

11.4 Image Uniformity

Image uniformity is a metric of the variation in the output image when the camera is imaging a uniform scene, such as a blackbody. An image non-uniformity (INU) is defined as a group of pixels which are prone to varying slightly from their local neighborhood under certain imaging conditions, as exemplified in Figure 44 and Figure 45. For more examples as well as a detailed explanation of INU's and the conditions under which they are most observable, see FLIR's INU Application Note, available from the Boson website linked in Section 1.3.

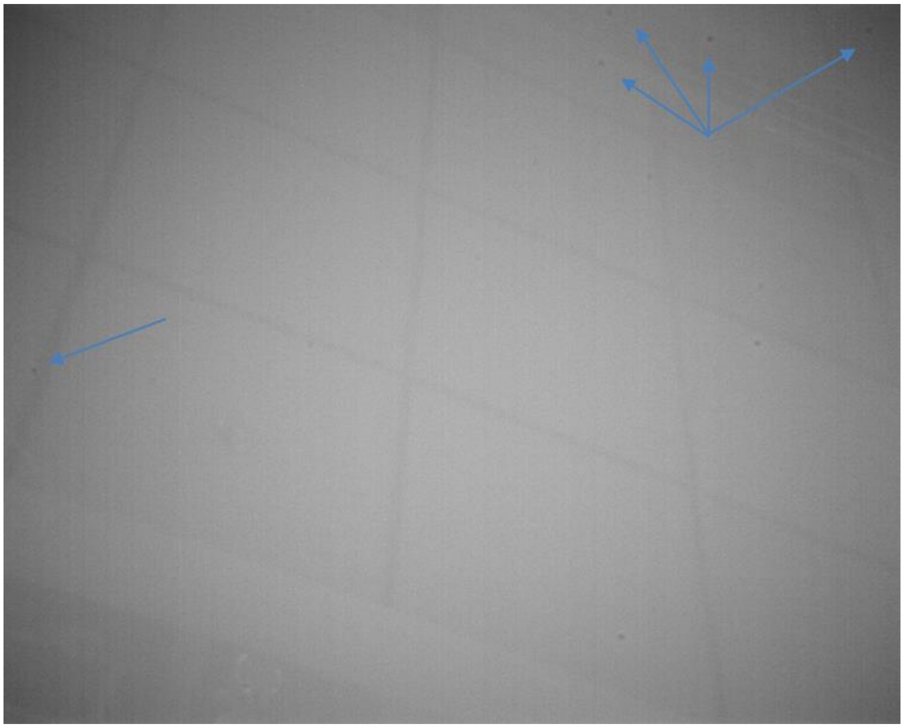


Figure 44: **Example of Type A INUs**

Figure 45: **Example of a Type B INU**

Table 12 defines the allowed number of INUs for each camera grade. A type A INU has a radius < 10 pixels while a Type B INU is one with radius >10 pixels.

Table 12: Allowed Number of INUs

Camera Grade	In Central 160x120	Outside Central 160x120
Industrial	0	<1 Type A <1 Type B
Professional	0	<1 Type A <1 Type B
Consumer	<3 Type A <1 Type B	<3 Type A <2 Type B

11.5 Spectral Response

For reference only, Figure 46 depicts the nominal spectral response of the lens-less Boson camera. The relative response for a configuration which includes a lens assembly varies by configuration.

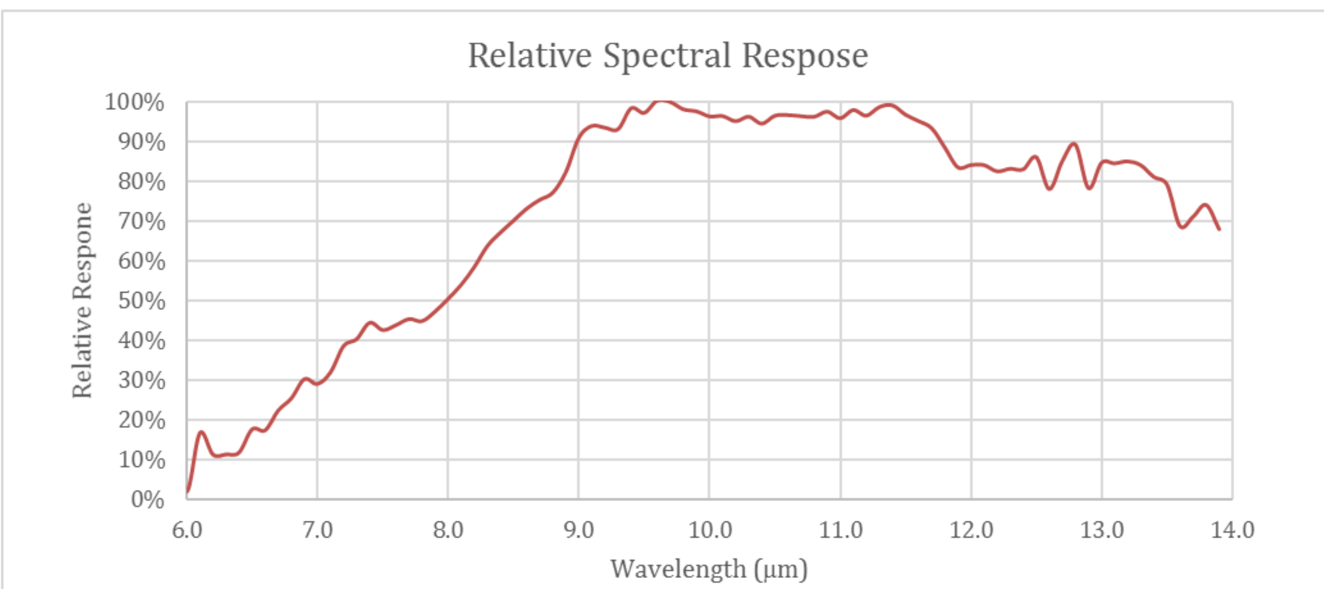


Figure 46: Relative Spectral Response of the Lens-less Boson Configuration

12 Electrical Specifications

12.1 DC and Logic Level Specifications

Table 13: DC and Logic Levels

Parameter	Description	Min	Typ	Max	Ripple, p-p max	Units
3V3	Core Voltage (primary power for the Boson core)	3.14 See note 1	3.30	3.46	0.060	Volts
USB_VBUS	USB Power	4.40	5.00	5.25	--	Volts
I_3V3	Primary supply current for Boson core	--	See note 2	520 See note 3	n/a	mA
I_VBUS	Supply current for USB	--	--	0.130	n/a	mA

Note(s)

1. 3V3 rise time from 0V to minimum voltage shall not exceed 1 msec.
2. Typical current varies with settings. See Section 12.2.
3. The maximum value shown is during shutter actuation. During other times, maximum value is 300 mA.

12.2 Power Consumption

Boson power consumption is dependent upon three primary variables:

- Camera operating temperature
- Whether the frame averager function is enabled (see Section 5.1)
- Whether the USB channel is streaming video (see Section 8.2.2)

Figure 47 shows typical power consumption over the full operating temperature range with and without the frame averager enabled and with and without the USB channel streaming video.

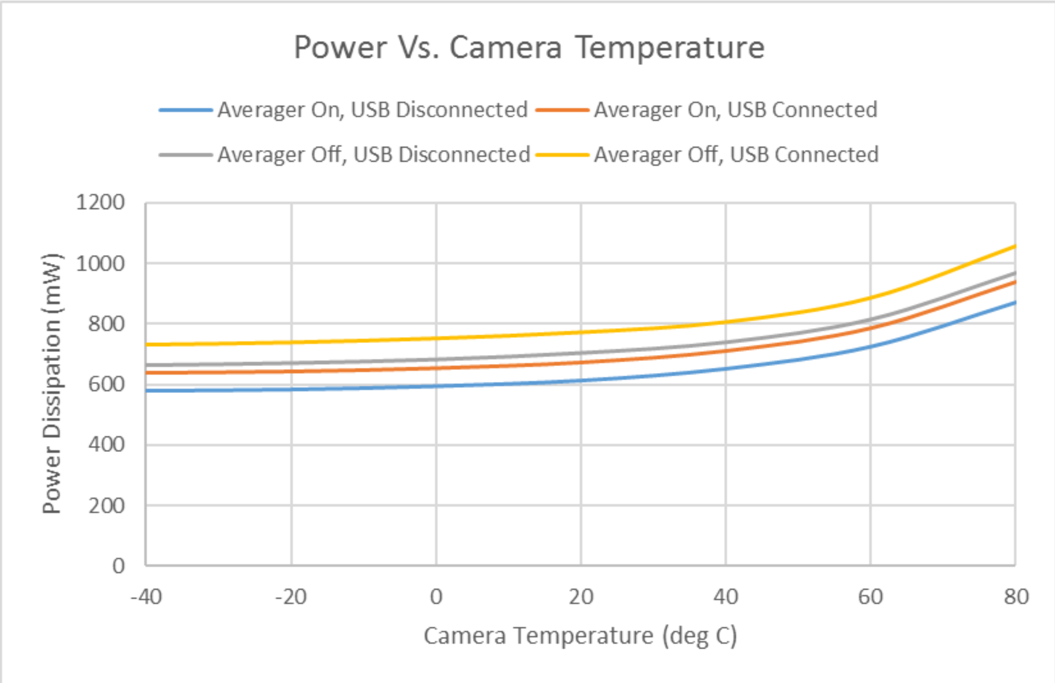


Figure 47: Typical Power Variation over Temperature

12.3 Absolute Maximum Ratings

Electrical stresses beyond those listed in Table 14 may cause permanent damage to the device. These are stress rating only, and functional operation of the device at these or any other conditions beyond those indicated under the recommended operating conditions listed in Table 13 is not implied. Exposure to absolute-maximum-rated conditions for extended periods of time may affect device reliability.

Table 14: Absolute Maximum Ratings

Parameter	Absolute Maximum Rating
Core Voltage (3V3)	3.63V
USB VBUS	5.25V
Voltage on any GPIO pin	1.98V
Voltage on any USB signal pin	5.25V

13 Environmental Specifications

Environmental stresses beyond those listed in Table 15 may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods of time may affect device reliability.

Table 15: Environmental Specifications

Stress	Maximum Rating
Operating Temperature Range	-40° C to 80° C
Storage Temperature	-50° C to 85° C
Altitude (pressure)	12 km altitude equivalent
Relative Humidity	93% non-condensing
Thermal Shock	Air-to-air, between 20C and storage temp. extremes (i.e., 20° C to -50° C, -50° C to 20° C, 20C to 85C, 85C to 20C))
Mechanical Shock	250g, 1.5 msec 500g, 0.8 msec 1500 g, 0.5 msec
Vibration	Transportation profile, 4.3 grms
Salt Fog[1]	240 hours per MIL-STD-810G Method 509.4
IP Rating[1]	IP67 per IEC 60529
Abrasion[2]	HAR configs: MIL-C-675C (section 4.5.11) moderate abrasion DLC configs: RSRE TS1888 Windscreen Wiper Test
ESD[3]	• 1.5 kV Human Body Model (HBM) per JEDEC JS-001-2012 • 200V Machine Model (MM) per JEDEC JESD22-A115C • 500V Charged-Device Model (CDM) per JESD22-C101E

Note(s)

1. Salt fog and IP rating apply to the portion of the lens assembly in front of the o-ring groove.
2. Most Boson lens assemblies have a high-durability AR (HAR) coating. The 92 deg (2.3mm) lens configuration has a Diamond-Like Coating (DLC). See Section 10.
3. Proper ESD packaging and handling procedures are required to protect the Boson Core from ESD Damage. Additionally, it is highly recommended for host electronics to incorporate the protection circuitry shown in Section 4.2.

14 Compliance with Environmental Directives

Boson complies with the following directives and regulations:

- Directive 2011/65/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)

15 Reliability

Section to be added in next release, pending life testing currently in progress.

16 Accessories

A number of accessories have been designed for use with Boson. These are listed below and described in more detail in the sections to follow.

- Boson USB VPC Kit (421-0061-00)
- Boson USB / Analog Video Power Connector (VPC) Kit (421-0062-00)
- Boson Camera Link Accessory (250-0609-00)
- Boson Dev Board (250-0593-00)
- Boson Tripod Mount (261-2608-00)
- Boson Lens Focus Tool (421-2609-00)

16.1 USB VPC Kit

The USB VPC kit, depicted in Figure 48, turns the Boson camera into a webcam. Power, digital video, and comm are all via USB2. The kit includes a 3-foot USB-A to USB-C cable.

16.2 USB / Analog VPC Kit

The USB / Analog VPC kit, depicted in Figure 49, is identical to the USB VPC kit except that includes a custom 6-foot cable with a BNC pigtail providing an additional analog video signal (NTSC-compliant).

Figure 48: Boson VPC Kit (shown in conjunction with the Boson Tripod Accessory)

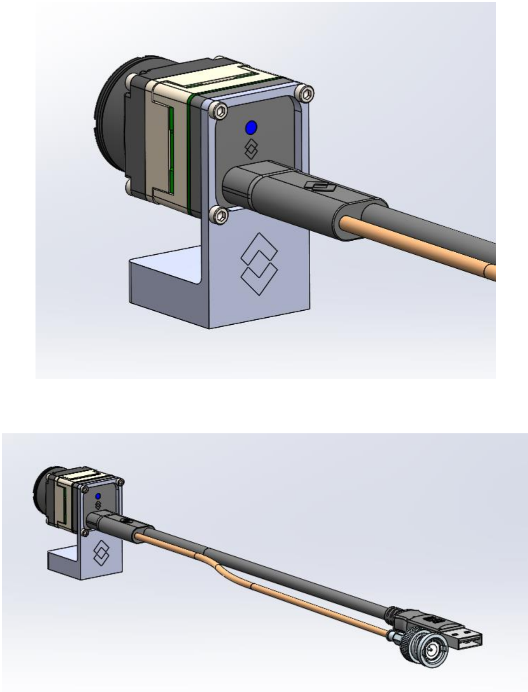


Figure 49: Boson VPC / Analog Kit (shown in conjunction with the Boson Tripod Accessory)

NOTE: Cable lengths shown in Figure 49 and Figure 48 are not to scale. Actual length is 0.9m (3.0ft) for the VPC kit and 1.8m (6.0 ft) for the VPC / Analog kit.

16.3 Camera Link Accessory

The Camera Link accessory, depicted in Figure 50, converts Boson's CMOS video signal into a Camera-Link-compliant output, with physical interface via a standard SDR-26 receptacle. Communication and power to the Boson is provided via a standard USB-3 micro-B (Super Speed) receptacle. Note that a USB-2 micro-B cable is an acceptable alternative to a USB-3 micro-B cable for communication and power.

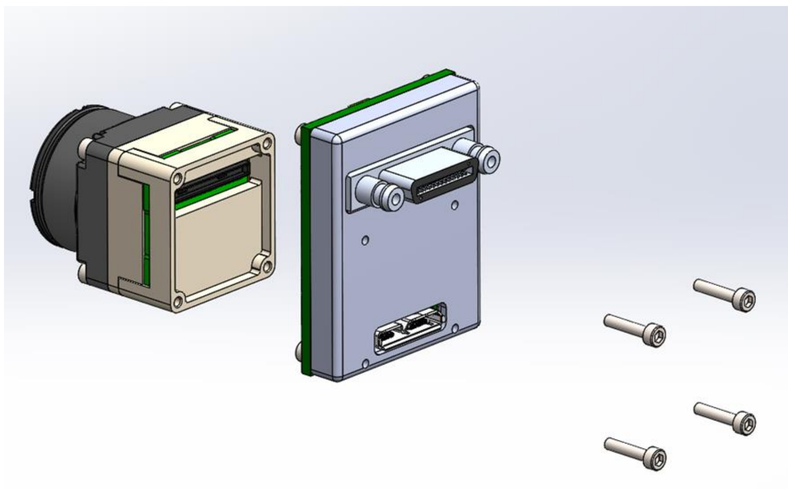


Figure 50: Boson Camera Link accessory

16.4 Boson Dev Board

The Boson Development Board, shown in Figure 51, is intended to support the electronics developer integrating the Boson into an end system. It provides full access to the Boson 80-pin connector with a number of fan-out connectors:

- standard USB-3 micro-B (Super Speed) receptacle
- standard SDR-26 receptacle with Camera-Link compliant output
- SDIO card slot
- UART header
- I2C header
- SPI header
- Power jacks

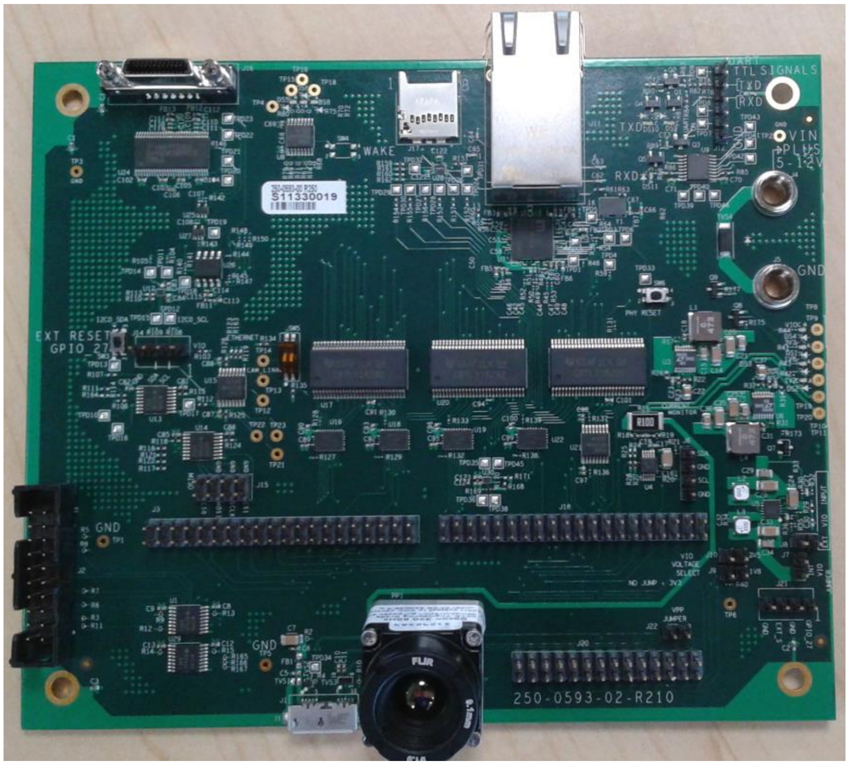


Figure 51: **Boson Dev Board (with Boson)**

16.5 Tripod-Mount Accessory

The Tripod-mount accessory, previously shown in Figure 49 and also shown in Figure 52, provides a means to mount a Boson assembly (or a Boson configured with either the VPC Accessory or the Camera Link Accessory) to a tripod via a standard 1/4-20 thread. It is designed to interface to the rear of the Boson via 4xM1.6 screws.

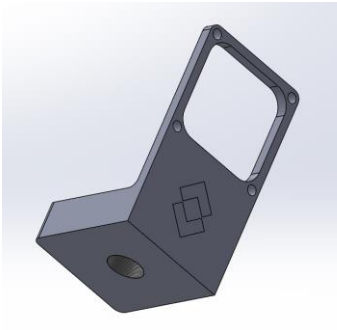


Figure 52: **Boson Tripod-mount accessory**

16.6 Focus-Tool Accessory

The focus-tool accessory, shown in Figure 53, allows any FLIR Boson lens which cannot be focused by hand to be focused by engaging the appropriate slots on the lens barrel such that it can be rotated inside the lens flange. (The focus tool has been properly sized such that no vignetting results when it engages the slots on the lens barrel.) Note that lens configurations with focal length $\geq$25mm do not require a focus tool since focus is achieved by simply turning the outer barrel of the lens assembly by hand.

Figure 53: Boson Focus-tool accessory

17 References

17.1 FLIR Documents

Document Number	Document Title
102-PS242-01	Boson Quick-Start Guide
102-PS242-43	Boson Software IDD
Various	Mechanical Interface Description Drawing (varies by part number)

17.2 External Documents

Document Number	Document Title
Directive 2011/65/EC	Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)
IEC 60529	Degrees of protection provided by enclosures (IP Code)
JESD22-A115C	Electrostatic Discharge Sensitivity Testing, Machine Model (MM)
JESD22-C101E	Field-Induced Charged-Device Model Test Method for Electrostatic Discharge Withstand Thresholds of Microelectronic Components
JEDEC JS-001-2012	Electrostatic Discharge Sensitivity Testing, Human Body Model (HBM) -- Component Testing
MIL-C-675C	Coating of Glass Optical Elements (Anti-reflection)
MIL-STD-810G	DoD Test Method Standard: Environmental Engineering Considerations and Laboratory Tests

17.3 Abbreviations / Acronyms

Abbreviation/ Acronym	Components
4CC	Four Character Code
ACE	Adaptive Contrast Enhancement
AGC	Automatic Gain Control
API	Application Program Interface
AR	Anti-Reflection
CCI	Command and Control Interface
CDM	Charged-Device Model
CMOS	Complementary Metal-Oxide-Semiconductor
CRC	Cyclical Redundancy Check
DDE	Digital Detail Enhancement
DVE	Driver's Vision Enhancer
EMC	Electromagnetic Compatibility
ESD	Electrostatic Damage
FFC	Flat Field Correction
FOV	Field of View
FPA	Focal Plane Array
FPN	Fixed Pattern Noise
GPIO	General Purpose Input / Output
GUI	Graphical User Interface
HBM	Human Body Model
HEQ	Histogram Equalization
HFOV	Horizontal Field of View
I2C	Inter-Integrated Circuit
IDD	Interface Description Drawing / Document
IIR	Infinite Impulse Response
IP	Ingress Protection (also Intellectual Property)
LUT	Look-Up Table
LWIR	Long Wave Infrared
MISO	Master In / Slave Out

MM	Machine Model
MOSI	Master-Out / Slave In
MTBF	Mean Time Between Failure
MTF	Modulation Transfer Function
NETD	Noise Equivalent Temperature Difference
NFOV	Narrow Field of View
NUC	Non-Uniformity Correction
QVGA	Quarter VGA, Quarter Video Graphic Array
REACH	Registration, Evaluation, Authorization, and Restriction of CHemicals
RGB	Red, Green, Blue (color space used to represent digital video)
RoHS	Reduction of Hazardous Substances
ROI	Region of Interest
ROIC	Readout Integrated Circuit
UART	Universal Asynchronous Receiver / Transmitter
USB	Universal Serial Bus
UVC	USB Video-Device Class
SBNUC	Scene-Based Non-Uniformity Correction
SDIO	Secure Digital Input Output
SDK	Software Developers' Kit
SNR	Signal-to-Noise Ratio
SSN	Silent Shutterless NUC
SWAP	Size, Weight, and Power
UAV	Unmanned Aerial Vehicle
USB	Universal Serial Bus
TBD	To Be Determined
TCR	Temperature Coefficient of Resistance
SoC	System on a Chip
VGA	Video Graphic Array
VOx	Vanadium Oxide
WEEE	Waste Electrical and Electronic Equipment
WFOV	Wide Field of View
YCrCb	Luma, Red Chrominance, Blue Chrominance (color space used to represent digital video)

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 contact FLIR Commercial Systems Customer Support (SBA-Cores@flir.com) for additional information. Contact Customer Support for questions related to the use of open-source software in this product. And contact Customer Support prior to returning a camera which is in need of service.

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.