Datasheet

FLIR Boson® Thermal Imaging Core

General Description

Boson® is a complete thermal imaging core designed to integrate easily into an Original Equipment Manufacturer's (OEM's) 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: 9 QVGA FOVs and 8 VGA FOVs
  - Integral shutter assembly as well as shutterless configurations
- Low size, weight, and power (SWAP); capability to trade feature set for power
- Radiometric output for select configurations (output directly proportional to scene irradiance or temperature)
- User-configurable I/O with multiple channels for video and command/control, including USB, parallel CMOS, and UART
- State-of-the-art signal processing, including advanced noise filters for superior sensitivity, eZoom, and colorization
- External-sync capability
- Power-safe field upgrade
- Quick start-up, approx. 2.5 to 3 sec, depending upon configuration and settings
- 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
Maximum effective frame rate	Fast configuration: 60Hz Slow configuration: 8.6Hz
Thermal sensitivity	Varies by configuration, as low as <40 mK @ f/1.0
NUC	Factory calibrated
Field of view	4º to 95º HFOV, depending upon lens configuration
Electrical	
Input power	3.3V
Power dissipation	Varies by configuration, as low as 500 mW
Video channels	CMOS, BT656-like, or USB3
Control channels	UART or USB
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
Shock	1500g @ 0.4msec

NOTE: All Specifications are subject to change without notice

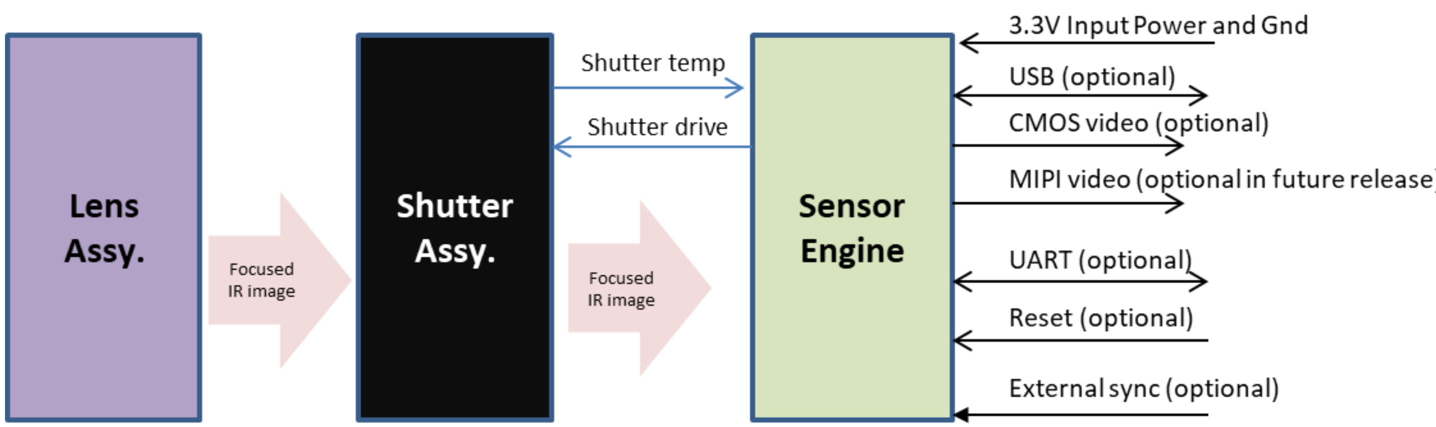

Figure 1: Simplified System Block Diagram

Doc. # 102-2013-40 Release 340, March 2021

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1 DOCUMENT

1.1 Revision History

Version	Date	Comments
Rev 100	October 2016	Initial release
Rev 200	May 2017	Updated to reflect Release 2
Rev 300	Jan. 2018	Updated to reflect Release 2.0.2 for both the 320 and 640 configurations
Rev 310	May 2018	Updated Section 1.2 (Product Upgrade History), Section 5.1 (Frame Averager), Section 7.3 (Averager Modes), Table 10 (Lens Specifications), and Section 12.2 (Power Consumption)
Rev 320	August 2018	Updated the export statement on the title page
Rev 330	October 2019	Updated to reflect Release 2.1 for both the 320 and 640 configurations Updated Optical Characteristics Table (now 2 separate tables) with diagonal FOV and new lenses Updated Signal pipeline latency metric Corrected Figure 19 Formatting improvements Boson Datasheet now covers both “Fast” and “Slow” camera configurations
Rev 340	March 2021	Updated to reflect Release 3.0 with radiometric functionality Updated Reset Voltage Note in Section 7.1 Updated External Circuitry recommendations Updated Color-Encoding Modes, RGB/BGR format correction Updated Mechanical Mounting recommendations Updated Lens Options to include New 4.5mm Boson 320 lens

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 (320 configuration only)
2.0.10715	May 2017	Release 2, 320 configuration. Key new features include: • Symbol overlay • Splash screen • Supplemental FFC (SFFC) • Non-volatile FFC (NVFFC) • Overtemperature protection • Reduced power
2.0.13137	Nov. 2017	Release 2.0.2: minor bug fixes of the 320 configuration and the initial public release of the 640 configuration.
2.0.15223	May 2018	Release 2.0.6: minor bug fixes for both the 320 and 640 configurations.
2.1.19831	May 2019	Release 2.1. Primary intent is to support new shutterless configurations. Key new features / changes include: • Improved SFFC: no longer necessary to disable SFFC after external FFC • Improved Spatial Column Noise Reduction: better ability to handle large column noise in the absence of a start-up FFC. • New Low-Frequency Shading Reduction (LFSR) algorithm. • External-sync capability • USB3 support. (Previous revisions support USB2 only.)
3.0.25868	March 2021	Release 3.0: Primary intent is to support radiometric configurations as well as other new features: • Output which is linear with scene irradiance (T-stable output) or scene temperature (T-linear output) with optional optical path corrections for select configurations • Color isotherms • Spot Meter feature • Optional telemetry line (metadata) on the USB video channel • Improved output uniformity of targets which exceed the camera's maximum scene temperature (clipping feature) • Low power frame skipping mode • Double clocked CMOS output modes • Scratchpad storage • Additional system symbols • Spot Meter Error • C-grade configurations now include low-gain mode

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:

https://www.flir.com/products/boson/

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

https://flir.custhelp.com/

Additionally, FLIR's Applications Engineering Department is referenced as a resource for obtaining additional help or information. Requests can either be submitted through *https://flir.custhelp.com/* or through the appropriate sales channel.

1.4 Document Conventions

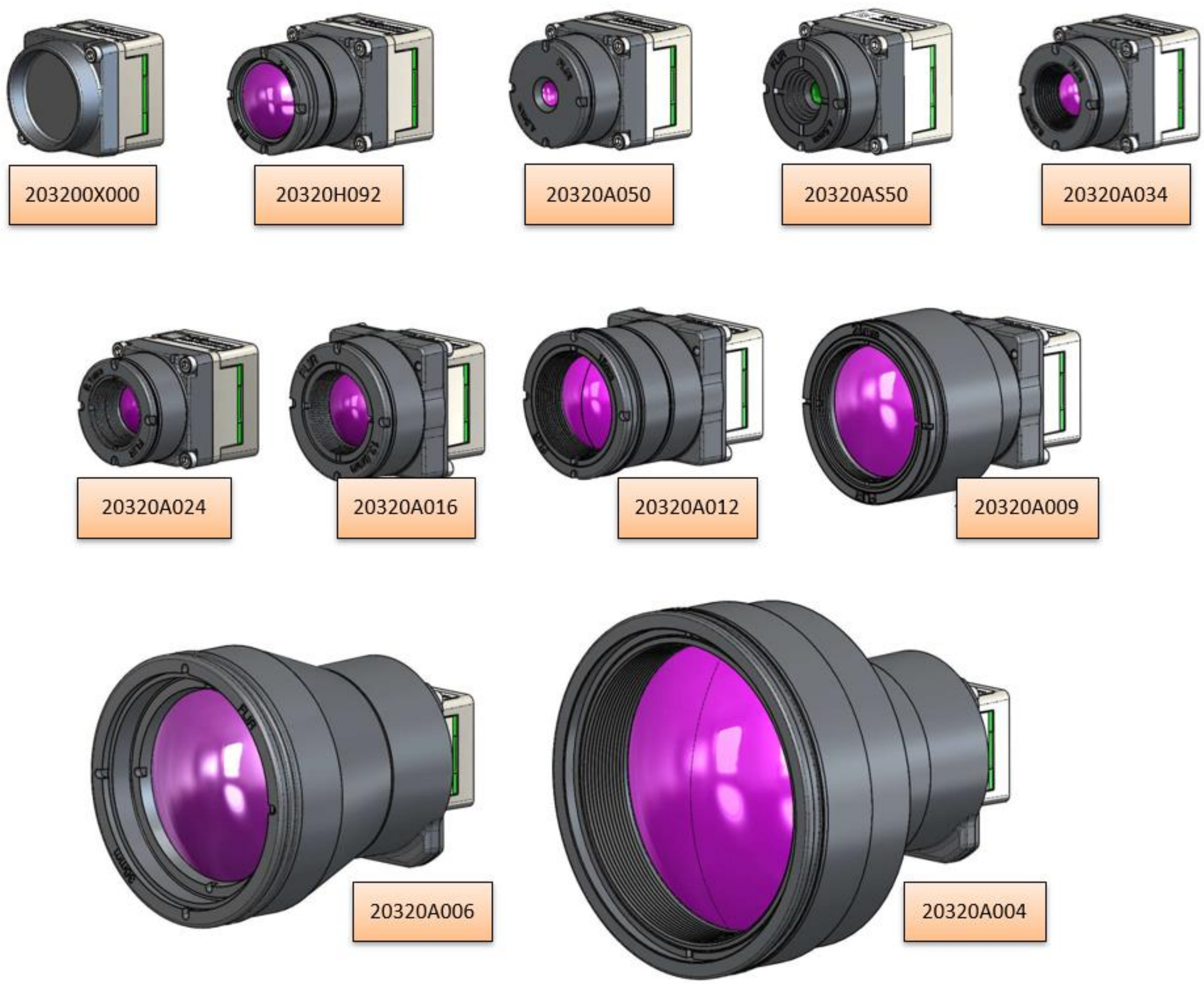
Throughout this document, modes and parameters which are user-configurable via the command and control interface (CCI) are shown in **bold font**. Status variables which can be read via the CCI (and/or via the telemetry line in some cases) but not directly altered are shown in *italic font*.

1.5 Scope

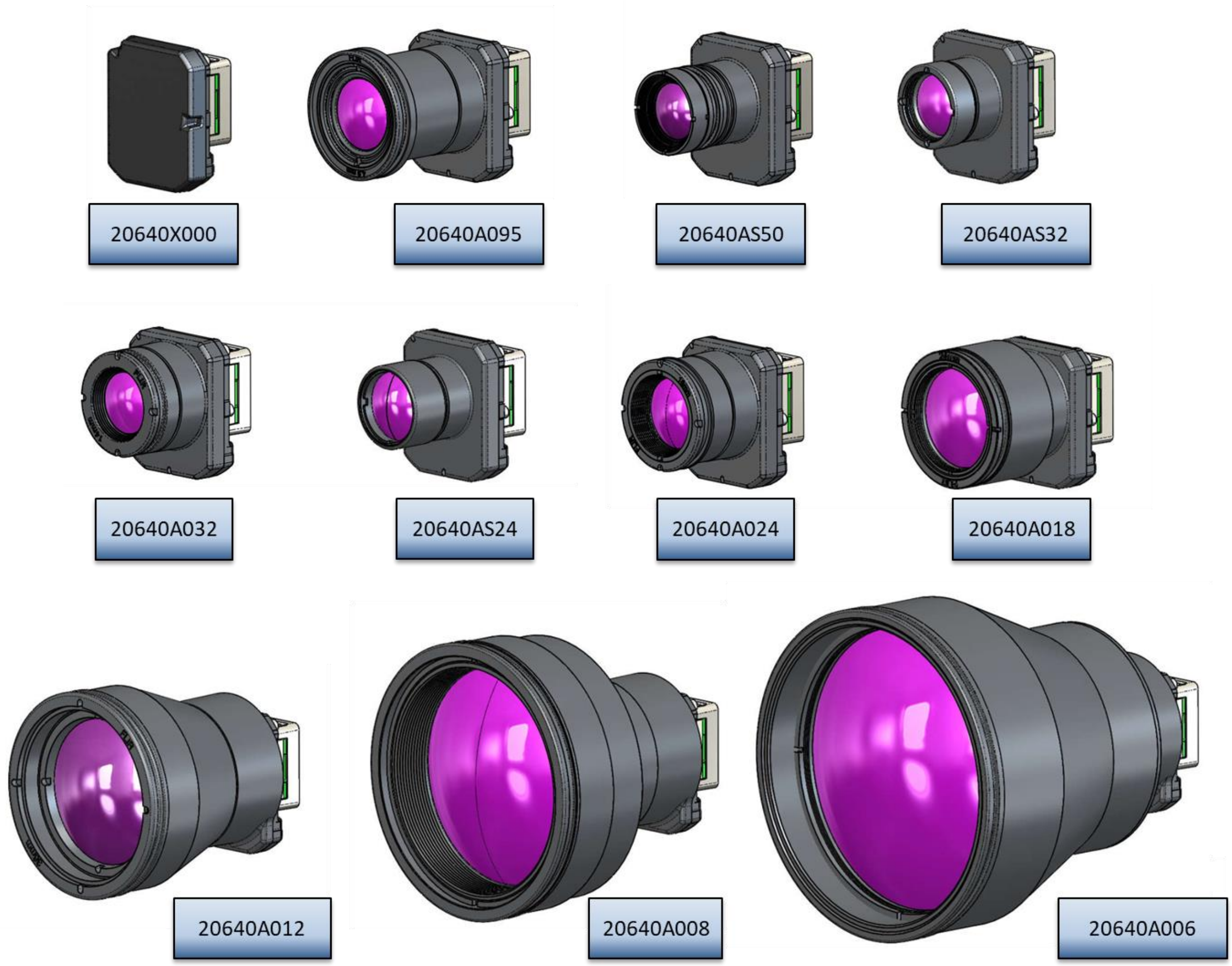
Boson™ is a highly configurable thermal imaging core comprised of the following 3 major components:

- 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. Shutterless configurations are also available.
- 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, detailed in Section 4.

Figure 2 shows most of the available hardware configurations featuring various combinations of lens assembly, shutter assembly, and sensor assemblies. (Note: no 320 configuration would be smaller without a shutter, hence no 320 shutterless configs are offered. For the same reason, the 640 configurations with large lenses (36mm and longer focal length) are not offered as shutterless.) See Section 10 for more information on the available lens configurations.



(a) 320 configurations (all with shutter)

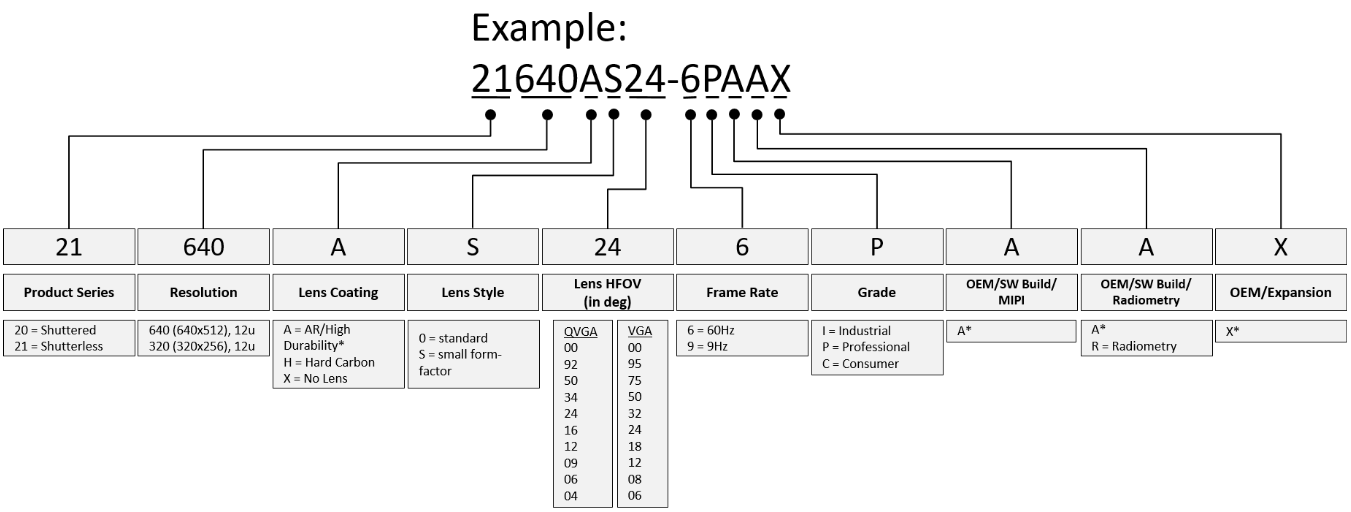


(b) 640 shuttered configurations

(c) 640 shutterless configurations

Figure 2: Various Configurations of Boson

Figure 3 shows the part-numbering schema for Boson.



* The last three digits (A, A, X) are available for customized OEM configurations.

Figure 3: Boson Part-Numbering Schema

NOTE: The Frame Rate configuration of the camera, designated by the first number in the Part-Number suffix (IE, 6PAAX or 9PAAX), indicates whether the camera is a "Fast" 60Hz configuration or "Slow" 9Hz configuration. "Slow" framerate cameras are configured to output a framerate <9Hz in order to comply with US export regulations. A "Slow" framerate camera cannot be reconfigured to become a "Fast" camera and vice versa. Please contact your FLIR sales representative or certified FLIR distributor for more information on Boson export requirements.

NOTE: Only those part numbers which contain an "R" in the second-to-last digit of the part number support radiometric output. The option to support radiometry requires additional factory calibration, and at present, not all lens types provide the option. Please contact your FLIR sales representative or certified FLIR distributor for more information on which lens types currently support radiometry.

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

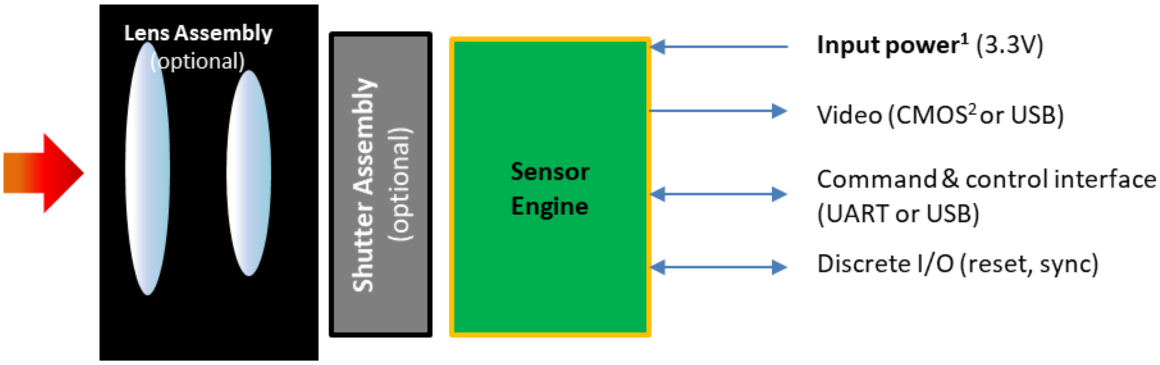
Specification	Description
Overview	
Sensor technology	Uncooled VOx microbolometer
Pixel size	12 µm
Spectral range	Longwave infrared, nominally 8 µm to 14 µm
Array format	320x256 or 640x512
Effective frame rate	Varies by configuration, Averager mode (see Section 7.3), and Frame Skip mode (see Section 7.4) Fast Configuration: • 60Hz (default). As low as 4.3Hz Slow (for export out of the USA): • 8.6Hz (default)
Thermal time constant	Nominally 8 msec
Thermal sensitivity	Varies by configuration (see Section 11.1 for more detail) • Industrial grade: $\leq$ 40 mK • Professional grade: $\leq$ 50 mK • Consumer grade: $\leq$ 60 mK
Radiometric Accuracy	Radiometric Capable Cameras only. ~ ±5°C accuracy, depending upon operating conditions. (See Section 11.5)
Operability	Varies by configuration (see Section 11.3 for more detail) • Industrial grade: $\geq$99%, no clusters > 3x3 • Professional grade: $\geq$98.5%, no clusters > 3x3 • Consumer grade: $\geq$98%. no clusters > 5x5
Non-uniformity corrections (NUC)	Shuttered configuration capable of automatic flat-field correction (FFC); all configurations capable of FLIR's Silent Shutterless NUC (SSN)™ suite of scene-based NUC algorithms (see Section 6.6)
Electronic zoom	1X to 8X zoom (see Section 6.9)
Symbol overlay	Alpha blending for translucent overlay
Bootup Time	~2.5 seconds for the 320 configuration See note 1 ~3.0 seconds for the 640 configuration See note 1

Electrical	
Video output channel	Two options: (see Section 8.2) • CMOS • USB3
Video output format	Three runtime-selectable options (see Section 7.12): • Data before AGC (16b, output resolution = sensor resolution) • Data after AGC, before digital zoom (8b, output resolution = sensor resolution) • Data after colorization (various bit-width, output resolution = 640x512 regardless of sensor resolution)
Input clock	None required
Frame sync	Two runtime-selectable options: • Free-running: Frame timing internally synchronized • External-sync: Frame timing slaved to an external pulse train
Command & Control Interface (CCI)	Three options: (see Section 8.1) • UART • USB
Command & Control API	See Boson Software Interface Description Document (IDD)
Input supply voltage (nominal)	3.3V (See Section 12.1)
Power dissipation	Between 500 mW and 1550 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 and .STEP files for each Boson configuration are not included herein but are available on the FLIR website. (See Section 1.3)
Weight	Varies by configuration, a low as 7.5g. (See Section 10)
Environmental (see Section 13)	
Operating temperature range	-40 °C to +80 °C
Storage temperature range	-50 °C to +85 °C
Shock	1500 G @ 0.4 ms
ESD	EN 61000-4-2 Level 4

Note 1: Bootup times are approximate and can be lowered for high-volume OEM configurations by removing support for symbol overlays. Please contact support through your sales channel for more information.

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. MIPI as a replacement for the CMOS video channel is planned for a future product variant

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 5.4. That said, the shutter is capable of improving image quality in all applications and is always recommended, especially at start-up.

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 one row at a time. 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 8.2.

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. Note that the correct orientation of the camera is as depicted in this figure. Rotating the camera 180 degrees such that the connector is below centerline rather than above will result in an upside-down image.

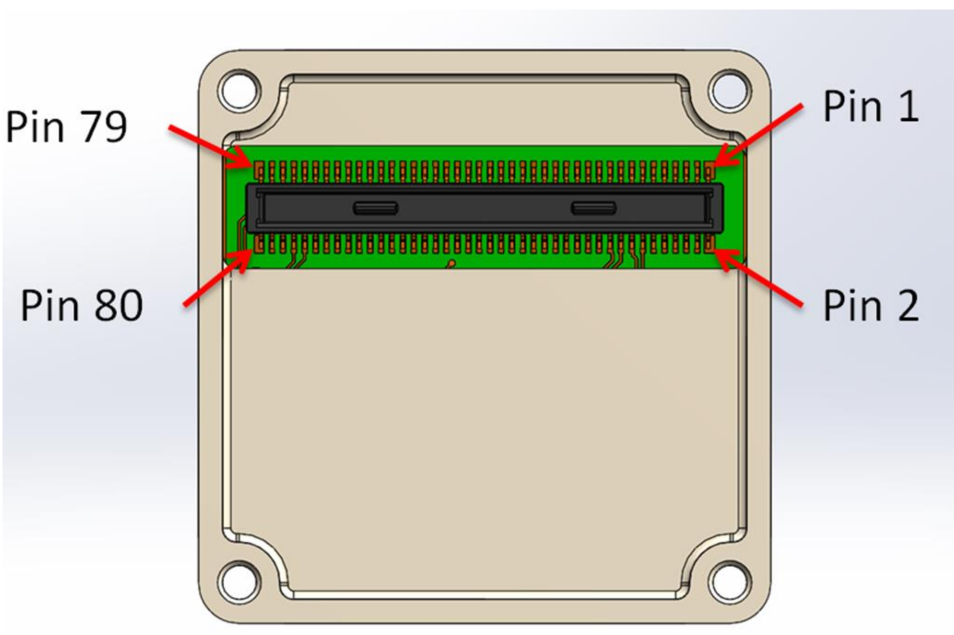


Figure 5: **Boson Connector Pin Numbering**

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4.1 Pin Assignments

Pin assignments and description for the Boson main connector are shown in Table 2 and Table 3. Any channels or signals which will not be used should be left floating.

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 (sense line only, not used to power the Boson core)
17	USB_ID	I/O	USB spec compliant	USB ID
14	USB_TX_P	Diff Pair	USB spec compliant	USB3 transmit+
12	USB_TX_N	Diff Pair	USB spec compliant	USB3 transmit-
18	USB_RX_P	Diff Pair	USB spec compliant	USB3 receive+
16	USB_RX_N	Diff Pair	USB spec compliant	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 (asserted low)	See Section 7.1
72	EXT_SYNC	I/O	1.8V	See Section 6.17
80	No Connect		N/A	

Table 3: Assignment of GPIO Pins.

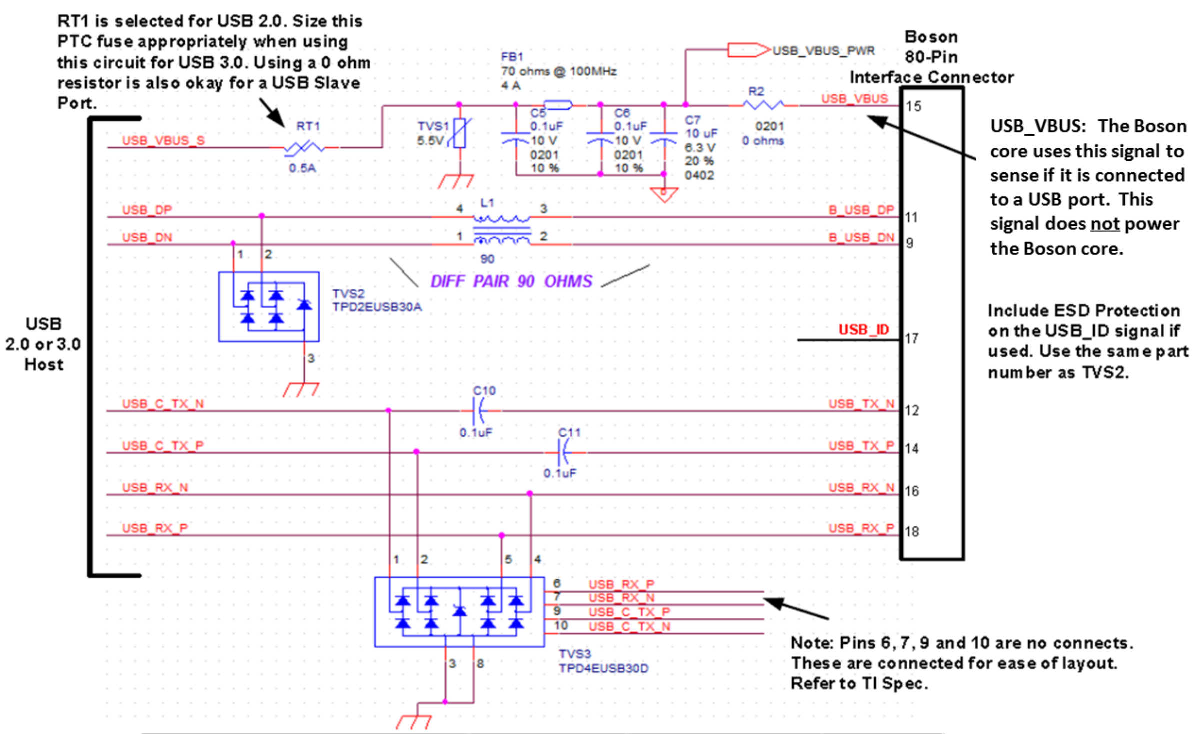
The discrete I/O pins, I2C channel, SD channel, and SPI channel are not used in any current Boson release.

Connector pin	Signal Name	Signal Description
23	GPIO	Discrete I/O pin 0
26	GPIO	Discrete I/O pin 1
33	uart_apb_sin	UART input
43	uart_apb_sout	UART output
41	cmos_data_13	CMOS bit13
21	cmos_data_14	CMOS bit14
38	cmos_data_15	CMOS bit15
34	cmos_data_16	CMOS bit16
22	cmos_data_17	CMOS bit17
42	cmos_data_18	CMOS bit18
37	cmos_data_19	CMOS bit19
52	cmos_data_20	CMOS bit20
54	cmos_data_21	CMOS bit21
35	cmos_data_22	CMOS bit22
36	cmos_data_23	CMOS bit23
58	GPIO	Discrete I/O pin 2
44	GPIO	Discrete I/O pin 3
51	cmos_data_2	CMOS bit2
56	cmos_data_3	CMOS bit3
27	cmos_data_4	CMOS bit4
28	cmos_data_5	CMOS bit5
32	cmos_data_6	CMOS bit6
31	cmos_data_7	CMOS bit7
25	cmos_data_8	CMOS bit8
46	cmos_data_9	CMOS bit9
45	cmos_data_10	CMOS bit10
48	cmos_data_11	CMOS bit11
47	cmos_data_12	CMOS bit12
55	cmos_pclk	CMOS pixel clk
53	cmos_vsync	CMOS vsync
73	cmos_hsync	CMOS hsync
78	cmos_data_valid	CMOS data valid
77	cmos_data_0	CMOS bit0
62	cmos_data_1	CMOS bit1
63	i2c_scl	I2C Clk
67	i2c_sda	I2C Data
75	sd_clk	SD clk
66	sd_cmd	SD command/response
65	sd_dat_0	SD data0
68	sd_dat_1	SD data1
61	sd_dat_2	SD data2
64	sd_dat_3	SD data3
57	spi_mosi	SPI master-out slave-in
76	spi_miso	SPI master-in slave-out
74	spi_sclk_out	SPI clk
71	spi_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 if the USB channel is utilized.
- 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.
- A pull-up resistor (4.7Kohm to 10Kohm) is recommended on connector pin 58 Discrete I/O pin 2.
- The Mg frame of the camera should be tied to ground to ensure proper EMI shielding

Boson USB 2.0/3.0 Protection/Compliance Circuit



Part Description	Vendor	Part Number	Ref Des
RES SMD 0.0 OHM JUMPER 1/20W	Venkel	CR0201-20W-000T	R2
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 optional frame averager and frame-skip features, non-uniformity correction (NUC) and defect replacement, spatial and temporal filtering, optional radiometric processing and temperature-conversion (select configurations only), automatic gain correction (AGC), electronic zoom, colorization and 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 7.12 for a full description of the video output properties at each tap.

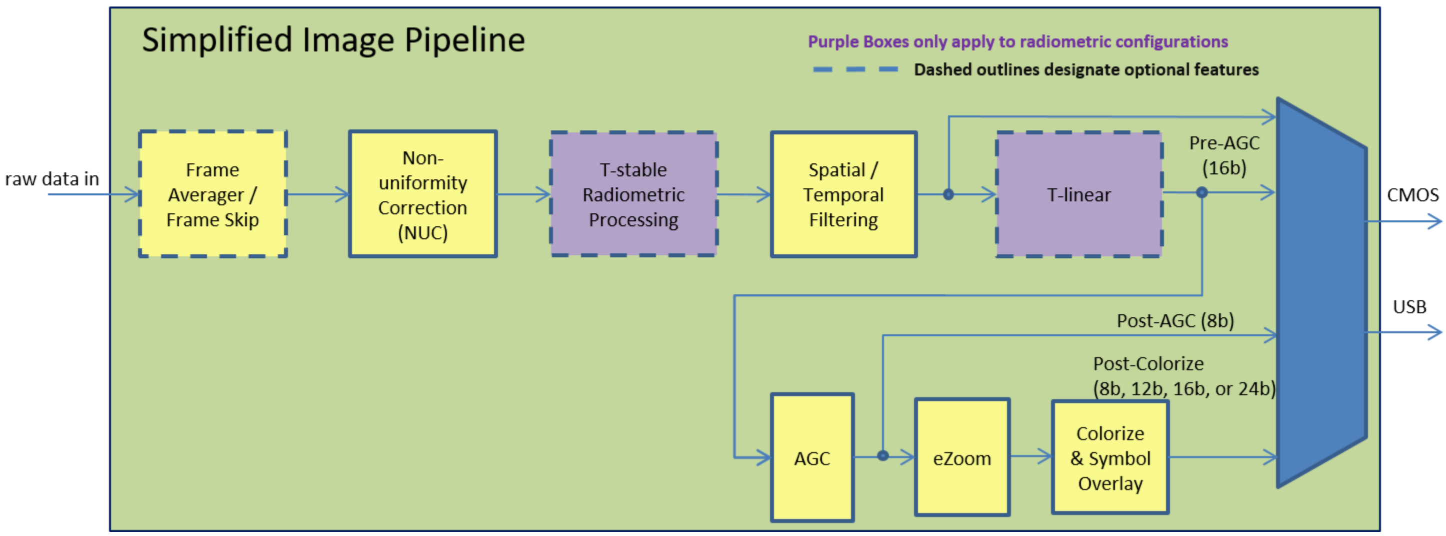


Figure 7: Boson Signal Pipeline

5.1 Frame Averager

At the beginning of the signal pipeline, Boson provides an optional frame-averager block (disabled by factory-default). On Fast cameras, the remainder of the signal pipeline operates at 60Hz frame rate when averager is disabled, whereas the data is processed at 30Hz when enabled. On Slow cameras, the effective output frame rate is 8.6Hz when disabled, whereas the output is 7.5Hz when enabled. The primary benefits of enabling the averager are power reduction and NEDT improvement. Depending upon configuration, power savings approaching 100 mW can be realized, as shown in Section 12.2. NEDT improvement is on the order of 20%. Boson utilizes a "smart averager" which minimizes blur during scene motion. Essentially whenever there is motion between the two input frames, the frame data 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

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NOTE: Intended use case is that the averager mode is specified and saved as a power-on default (see Section 6.1). Beginning with Release 2.0.6, a change to averager mode will not affect frame rate on the current power cycle. To change frame rate, the change to the averager mode must be saved as a power-on default and then the camera reset or power cycled. If the change to averager mode is not saved as a power-on default, the selection is inconsequential since it has no effect on the current power cycle.

5.2 Frame Skip

Following the optional averager function is an optional frame-skip feature which can be used for further reductions in frame rate and power dissipation. The frame skip value *fs* can be set to any integer value between 0 and 6, with the resulting output frame rate calculated as FR / (*fs* + 1), where FR = 60Hz if the averager function is disabled and 30Hz otherwise. The factory default value of fs = 0, for an output frame rate of 60Hz. Setting *fs* = 0xFFFF is a special lowest-power standby case resulting in *all* frames being skipped (i.e. 0Hz output). In this state, all functions of the CCI are still intact. The power savings metrics below should only be used as an approximation.

5.3 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 such as a blackbody plate. Factory-calibrated NUC terms are applied to compensate for temperature effects, pixel response variations, lens-illumination roll-off, and out-of-field irradiance. These terms are enabled by factory default, and most users will have no reason to ever disable them except as noted below.

- <u>FFC</u>: Unlike all the other corrections applied by the NUC block, FFC is not one-time calibrated but is instead updated periodically at runtime via a process called flat-field correction (FFC). The FFC process is further described in Section 6.6.
- <u>Temperature-correction</u>: a correction term which compensates for pixel-to-pixel offset variation over operating temperature
- <u>Gain</u>: a correction term which compensates for pixel-to-pixel responsivity variation. This term is actually the product of two components, one which compensates for variations stemming from the sensor assembly and another which compensates for variations stemming from the lens assembly. On lens-less configurations of Boson or when the Boson camera is installed behind another optical component, the latter component of the gain term (referred to as the lens-gain map) should be field calibrated by the user, as described in Section 6.14.
- <u>SFFC</u>: a correction term which compensates for out-of-field irradiance (i.e., the heat radiating from surfaces inside the camera assembly). If Boson is installed in an enclosure or environment which significantly increases or reduces camera self-heating, it is recommended that SFFC be field-calibrated by the user, as described in Section 6.14.
- <u>Bad pixel replacement (BPR)</u>: a correction process whereby pixels identified as defective are replaced by a value generated from nearest neighbors

All of the above corrections are arranged into three separate constructs:

- NUC Tables: contain the temperature-compensation terms, and the portion of the gain term which compensates for variations stemming from the sensor assembly. All NUC tables are factory-calibrated. There are up to 4 NUC tables stored within the camera:
    - NUC Table 0: NUC Table 0 is calibrated for low-gain state and spans the full operating temperature range, -40C to 80C.
    - NUC Tables 1 -3: NUC Tables 1 through 3 are calibrated for high-gain state, and each spans a portion of the total operating temperature range. NUC Table 1 is calibrated from approximately -40C to -20C, NUC Table 2 s calibrated from approximately -20C to 60C, and NUC Table 3 is calibrated from approximately 60C to 80C. At start-up, Boson automatically loads and applies the proper table, and if during operation the camera heats or cools down such that a different table is optimum, the camera switches tables automatically (if in automatic FFC mode) or signals a *Table Switch Desired* status if in manual or external FC mode. See Section 7.9 for a description of FFC modes. See Section 6.15.3 for a description of the *Table Switch Desired Status.*
- Lens Tables: the lens tables are comprised of the portion of the gain term stemming from the lens assembly, the SFFC correction, and (if field-calibrated), the NVFFC. At start-up, Boson automatically loads whichever lens table is stored as the power-on default (Lens 0 or Lens 1). The switch from one lens table to another is only via user-command. Boson configurations which include a lens are shipped with factory-calibrated lens-gain and SFFC correction terms in Lens 0, while Lens 1 is empty. As described in Section 6.14, it may be beneficial to replace the factory calibration with a field calibration, depending upon installation conditions. Lens-less configurations are shipped with both Lens 0 and Lens 1 empty, and it is necessary to perform a field calibration once a lens is installed. The decision to calibrate the NVFFC map is application-dependent, as described in Section 7.9.1.
- Defect Map: there is a single defective-pixel map, which is applied independently of NUC-table or Lens-table selection. The map is factory calibrated, but the user has the option of adding pixels to it. (This operation occurs automatically as part of the lens-calibration process described in Section 6.14.) The user also has the option to restore the factory-calibrated map in the event that non-defective pixels are inadvertently added during operation.

5.4 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 and/or uniformity will degrade as the result of doing so.

- Spatial column noise reduction (SCNR): a filter intended to minimize column noise
- Spatial row noise reduction (SRNR): a filter intended to minimize row noise
- Silent Shutterless NUC (SSN): a filter intended to minimize random spatial noise
- Low-frequency shading reduction (LFSR): a filter intended to reduce image side-to-side gradients and circularly-symmetric gradients caused by suboptimal environmental conditions
- Temporal filter (TF): a filter intended to minimize temporal noise. Note that temporal filter must be enabled if LFSR or SSN are enabled. If application of temporal filtering is not desired, set Delta NF to 255 to allow LFSR and SSN to continue to operate.

NOTE: While the spatial filtering algorithms described above are intended to minimize residual non-uniformity, FLIR always recommends using either Boson's internal shutter or an external shutter design to perform periodic FFC for highest image quality.

5.5 Radiometry

Configurations of Boson which are radiometric capable feature the ability to output a "temperature stable" output or a "temperature linear" output. In the former case, the 16b output is intended to be linear with input flux (i.e. target irradiance) and independent of the camera's own temperature. In the latter case, the input flux is translated to absolute temperature (Kelvin). That is, the output is linear with scene temperature. For temp-linear output, parameters such as target emissivity atmospheric transmission can be adjusted to reflect current imaging conditions. See Section 6.2 for a more complete description.

5.6 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 6.8 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

5.7 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 6.9 for a more complete description of the feature and its associated parameters.

(a) 1X zoom (full FOV displayed)

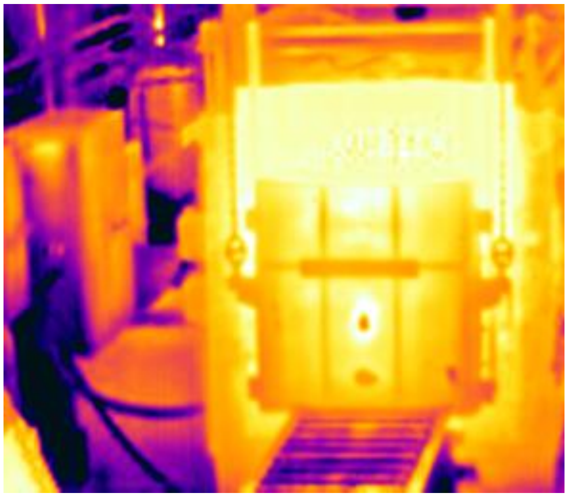
(b) 2X zoom (half FOV displayed)

Figure 10: Example Imagery Showing eZoom

5.8 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 6.10.

(c) Monochrome Image



(d) Colorized Image

Figure 11: Example Imagery Showing Colorization

5.9 Symbol Overlay

The symbol-overlay block overlays symbol patterns over the infrared image. In addition to several automatic symbols described in Section 6.11, the symbol overlay block also allows display of user-specified symbols, as exemplified in Figure 12. A full description of Boson's custom-symbol capabilities is provided in Section 0.

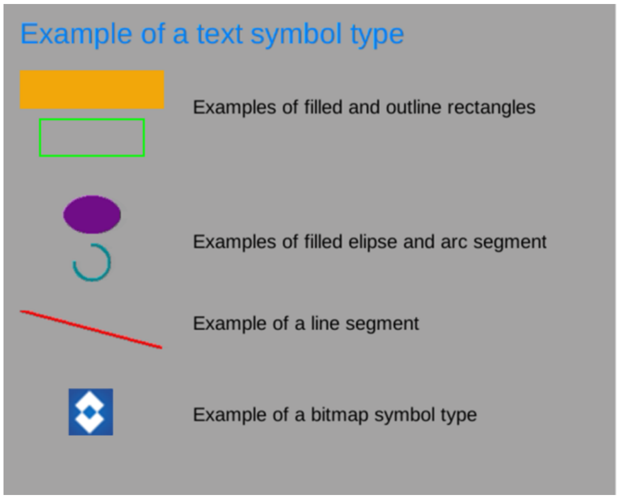


Figure 12: Examples of Boson Symbol Types

5.10 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

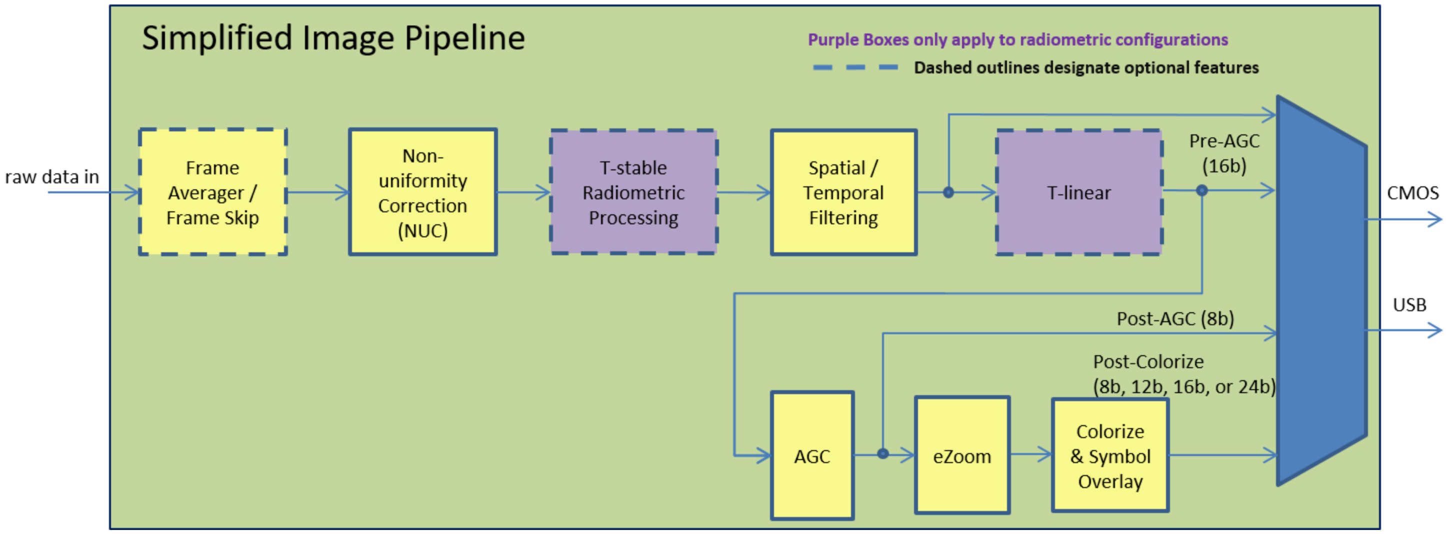


Figure 7, it is the amount of time for "raw data in" to be fully processed to "data out" at the selected video channel. The value varies depending upon where in the signal chain the output is tapped, as follows:

- Pre-AGC: ~24 msec
- Post-AGC: ~25 msec (1 msec greater than the pre-AGC tap)
- Post-zoom: ~43 msec (18 msec greater than the post-AGC tap)

For all three tap points, the output channel utilizes a multi-frame buffer as described in Section 7.14. This buffer introduces a frame of latency, which is the dominant latency source for the pre-AGC and post-AGC taps. 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 the processing time required by the various blocks in the signal pipeline.

NOTE: The averager function combines two frames of the data from the sensor. The latency numbers shown above are applicable to the second of the two frames (the later frame) when the averager is enabled.

NOTE: Boson's sensor assembly has a characteristic thermal time constant, nominally 8 msec. It is not traditional to include time constant in the pipeline-latency definition.

6 Camera Features

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

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 8 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 Radiometry

NOTE: Only those part numbers which contain an "R" in the second-to-last digit of the part number support radiometric output. The option to support radiometry requires additional factory calibration, and at present, not all lens types provide the option. Please contact your FLIR sales representative or certified FLIR distributor for more information on which lens types currently support radiometry.

Beginning with Release 3.0, some configurations of Boson provide the option of radiometric output. For such configurations, the 16b output can be configured to "temperature stable" or "temperature linear", as described below and depicted in Figure 13.

- Temperature-stable output: 16b output value is intended to be proportional to scene-flux only and independent of the camera temperature. That is, when imaging a given scene, the output image is stable even if the camera's temperature varies, as shown in the middle graph of Figure 13. By comparison, output varies significantly with camera temperature when radiometry is disabled, as illustrated in the left-most graph.
- Temperature-linear output: 16b output value is intended to be directly proportional to scene temperature. In high-gain state, the 16b output value corresponds to scene-temperature in Kelvin multiplied by 100, and in low-gain state, it corresponds to Kelvin multiplied by 50. For example, expected output in high-gain state when imaging a 20C BB is [(20C + 273.15)] * 100 = 29315, as depicted in the right-most graph of Figure 13. In practice, radiometric error prevents an output which corresponds perfectly with scene temperature. See Section 11.5 for a discussion of radiometric accuracy.

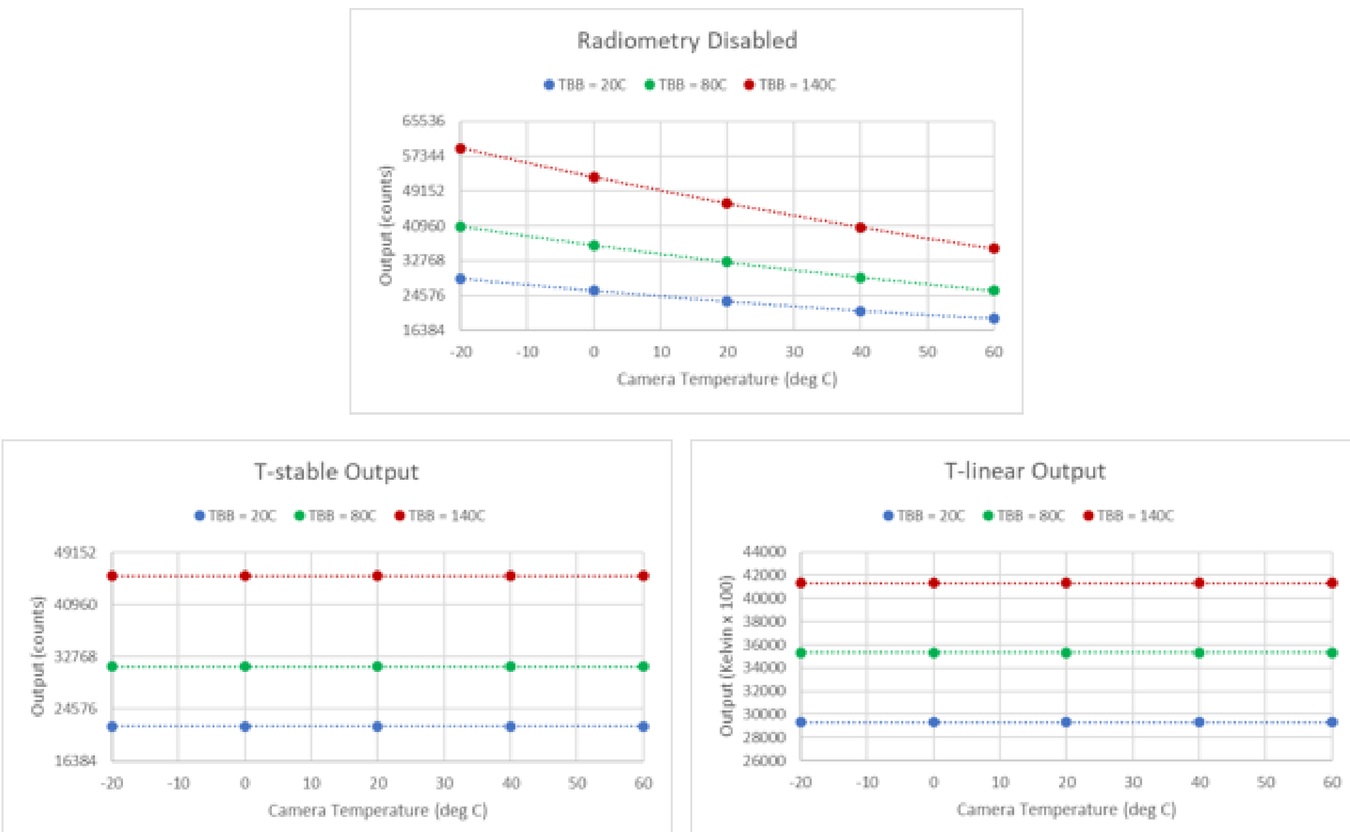


Figure 13: Output vs. Camera Temperature Comparison: Radiometry Disabled, T-Stable, and T-linear

From an image-quality standpoint, both radiometry modes produce nearly identical performance (no significant effect on NEDT), and either mode is appropriate for strict imaging applications. However, for applications in which temperature measurement is required, radiometry must be enabled.

6.2.1 Environmental Factors

It is necessary that environmental factors are properly set to achieve optimal radiometric accuracy. In the Boson App, they are available in the Radiometry Tab. The parameters are described as follows:

- **Window Temperature:** The temperature of the IR transmissive window in the optical path of the camera
- **Window Transmission:** The transmission of the IR transmissive window
- **Window Reflection:** The reflection of the IR transmissive window.
- **Window Reflection Temperature:** The reflection of the internal temperature on the camera side of the window, off the IR transmissive window.
- **Atmospheric Transmission:** Transmission of the atmosphere in the optical path between the camera and the target
- **Atmospheric Temperature:** Temperature of the Air between the camera and the target
- **Emissivity Target:** Emissivity of the target being measured
- **Background Temperature:** Temperature of the scene background being imaged. Generally, this will be near ambient.

Figure 14: Default Environmental Factors as shown in the Boson App

6.2.2 Spot Meter Accuracy

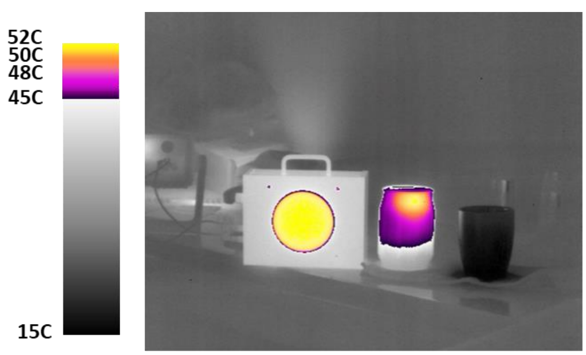
Spot Meter Accuracy represents a measure of the expected radiometric performance by reporting an integer value based on a comparison between the as-calibrated environment and the current camera conditions. A low value indicates more optimal camera conditions and therefore will occur when camera conditions are such that the camera is able to generate a more accurate temperature measurement.

Table 4: Spot Meter Accuracy look up table

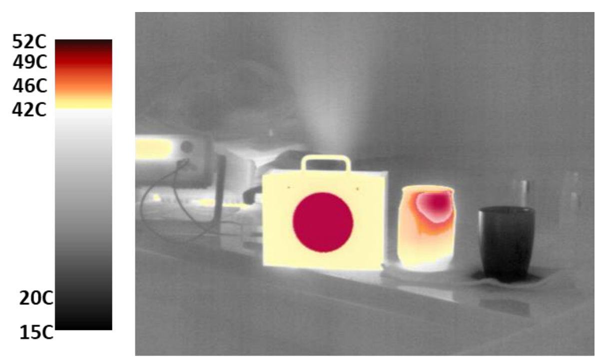
Spot Meter Accuracy	Uncertainty Factor	Description
Best	Scenario 1	Best-case conditions stated in Test Conditions 11.5.1
Good	Scenario 2	Steady-state conditions at ambient temperatures within the valid operating temperature range but outside those of Scenario 1.
Stable	Scenario 3	Thermally dynamic conditions within the valid operating temperature range with some allowance for a slow rate of temperature change.
Unstable	Scenario 4	Any condition outside of Scenario 3.
Disabled	Scenario 5	Radiometric data not relevant. Either radiometry or spot meter is disabled.

6.3 Isotherms

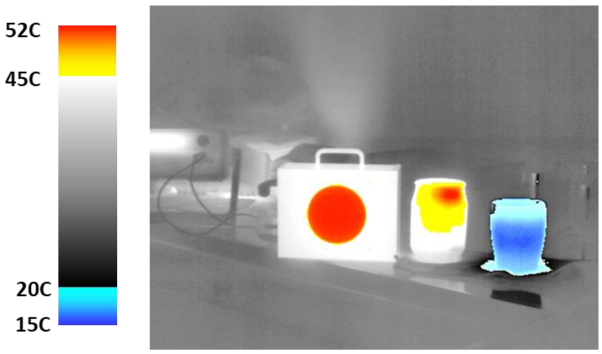
Beginning with Release 3.0, Boson provides an optional Isotherm feature, with new options for colorizing pixels at the post-colorization video tap. Figure 15 illustrates some of the potential uses of the Isotherms feature.



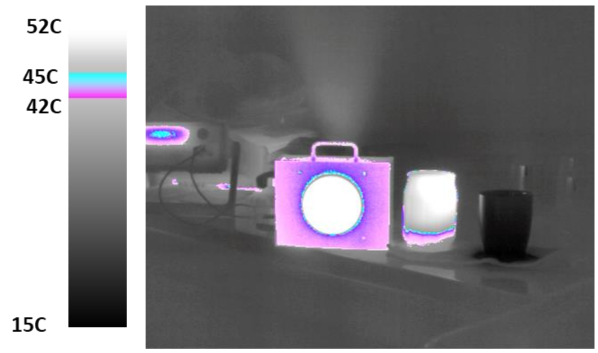
(a)Colorize hot objects



(b) Colorize hot object



(c)Colorize hot and cold objects



(d) Colorize mid-range objects

(e)Colorize hot objects, green-hot for all else

(f) Yellow-hot (monochrome) palette

Figure 15: Example Imagery with Various Isotherm Settings

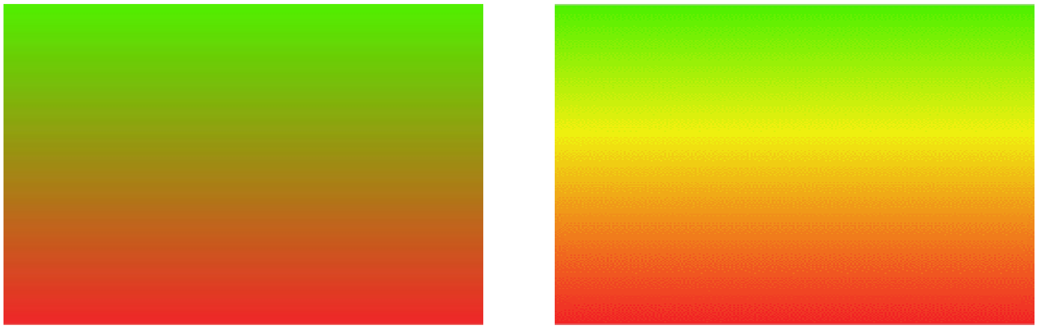
The Isotherms feature allows the full 16b range of the camera to be divided into 5 regions, and different colorization schemes can be applied to each region. The boundaries between regions are specified as a percentage of the 16b range (e.g. 0% = 0 counts, 100% = 65535). For those configurations which support radiometry, boundaries can alternatively be specified in temperature units (as illustrated in the images of Figure 15).

While using isotherms, FLIR recommends using AGC linear Percent (Section 6.8.5) at or above 90% or 0.90. This will avoid regions of the isotherm bands being disrupted by non-linear grey bands that are using a histogram equalization to set grey levels, and subsequently colors.

The Colorization mode of each Isotherm region can be independently selected from one of the following five options, all of which are shown in Figure 17:

- **Linear-RGB mode**: post-colorization output of pixels in a region with mode set to **Linear RGB** mode is linearly interpolated from two specified endpoint colors. For example, if the lower boundary is set to 30C and assigned an RGB color value of (240,240,0) and the upper boundary is set to 40C and assigned a color value of (240,0,40), then a pixel imaging a 35C object will have an output color value of (240,120,20).

- **Linear-HSV mode**: identical to **Linear-RGB** mode except that interpolation is performed in Hue Saturation Value (HSV) color space rather than in RGB color space. Use of this color space provides some color mappings which are not possible in RGB. An example is shown in Figure 16.



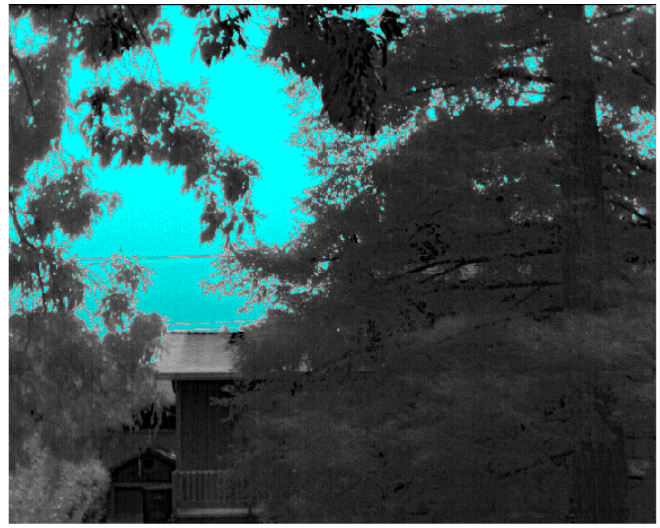
(a) RGB interpolation (b) HSV interpolation

Figure 16: Example of RGB vs. HSV interpolation.

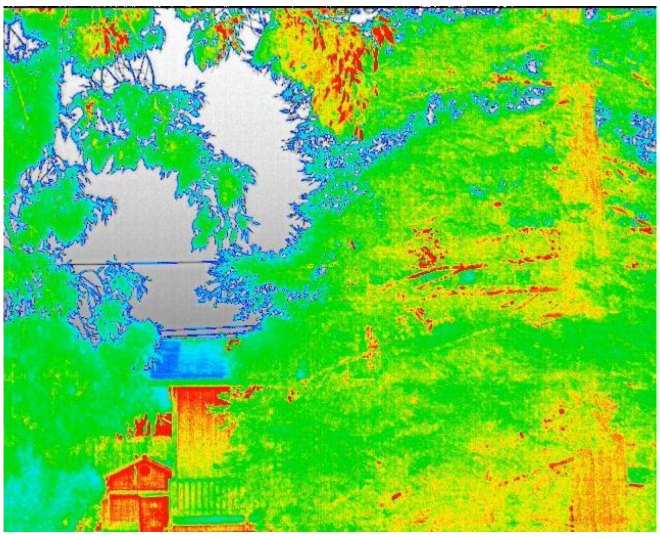
Notice the colors at the top and bottom are identical, but the interpolated colors in between are not.

- **Standard mode**: post-colorization output of pixels in a region set to **Standard** mode appear the same with isotherms enabled and they do with isotherms disabled if the same colorization LUT is chosen for each mode. That is, output value of each pixel in a **Standard** region is based strictly on the AGC algorithm and colorization LUT chosen.
- **Non-Linear mode**: post-colorization output of pixels in all such regions are mapped non-linearly between colors, independently of the palette setting and the colorization mode of other regions. This mode attempts to mimic the non-linear AGC algorithm. A potential advantage of **Non-Linear** mode over **Standard** mode is better utilization of available colors. In an image in which much of the image is in one or more regions set to **Linear RGB** mode or **Linear HSV** mode, the regions set to **Standard** mode may use only a small fraction of the grayshades, as illustrated in Figure 17c. Conversely, the regions set to **Non-Linear Gray** mode use the full spectrum of grayshades, as illustrated in Figure Figure 17d.
- **Single-Color mode**: post-colorization output of pixels in a region set to **Single-Color** mode have the same luminance value as with isotherms disabled; however, chrominance values are based on a single specified color. This mode readily supports monochrome color palettes (e.g. red hot).

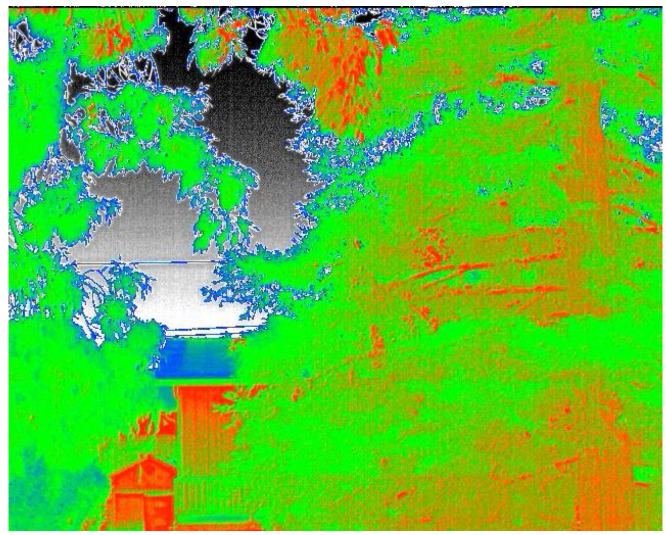
(a) Isotherms disabled, black-hot palette



(b) **Standard** mode (hotter foreground) and **Single Color** modes (cooler background)



(c) **Linear-HSV** mode(hotter foreground) and **Standard** mode(cooler background)



(d) **Linear-RGB** mode(hotter foreground) and **Non-Linear Gray** mode (cooler background)

Figure 17: Examples of each Isotherm Mode

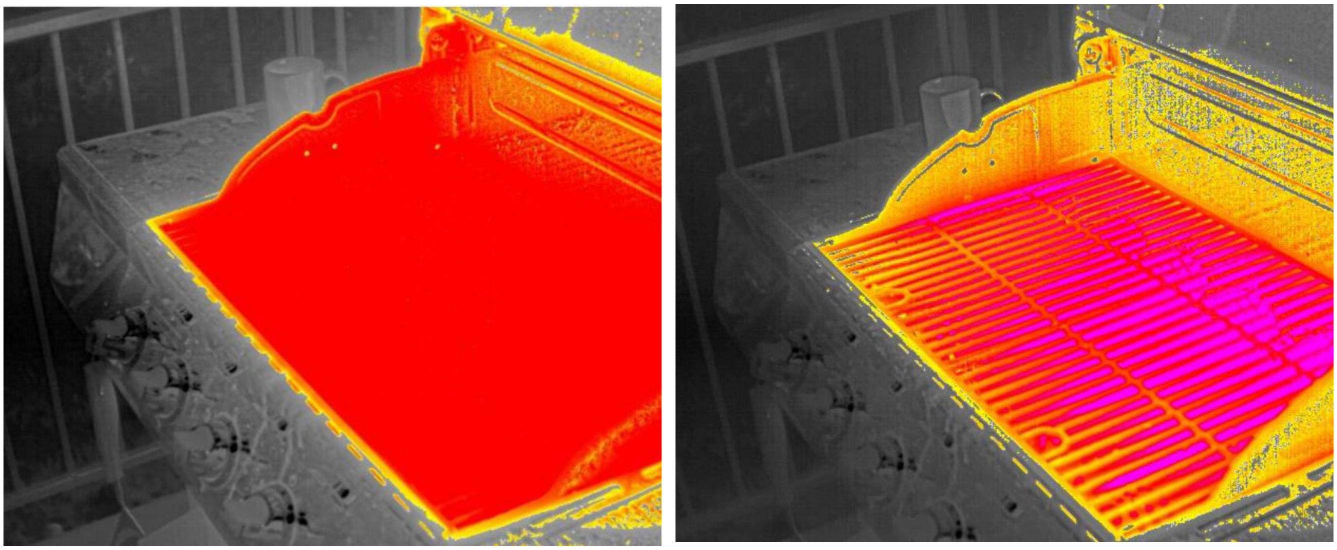
6.4 Spot Meter

Prior to Release 3.0, Boson provided an Image Statistics feature, reporting average pixel value, minimum pixel value, maximum pixel value, and standard deviation within a specified region of interest (ROI). Beginning with Release 3.0, Boson additionally provides a separate Spot Meter feature. Key differences between the Image Statistics feature and the Spot Meter feature are as follows:

- Both features report mean, standard deviation, minimum value, and maximum value upon command and via the telemetry line. The Spot Meter additionally reports the location (x,y coordinates within the sensor) of the pixel with minimum value and the pixel with maximum value.
- The Image Statistics feature collects its statistics after the Non-Uniformity Correction block in the signal pipeline. (Refer to Figure 7.) The Spot Meter feature collects its statistics at the end of the 16b pipeline. Consequently, for configurations which provide radiometric capability, the Spot Meter is for the temperature-stable signal (if Radiometry is enabled and T-linear conversion is disabled) or the temperature-linear signal (if Radiometry and T-linear conversion are both enabled). In other words, units are reported in temperature units (Kelvin x 100) if the 16b tap is configured for temperature-linear output.
- The Spot Meter mean value can be displayed on-screen as a numeric value or thermometer-style gauge. (See Section 6.11 for more information on symbol overlays).
- The regions of interest (ROI) for both the Image Statistics and Spot-Meter feature are independently configurable. For example, the Image Statistics feature can be configured to collect statistics from the full array while the Spot Meter feature is configured to collect statistics from a 16x16 pixel area in the center of the array.
- The Image Statistics mean value is the basis for gain-state switching, as described in Section 6.5.

6.5 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 are prone to saturation. In low-gain state, the thermal sensitivity is lower, but scene range is significantly higher. (See Sections 11.1 and 11.2, respectively, for NEDT and intrascene range in both gain states.) Figure 18 depicts example imagery for both states. In the high-gain example, it is easier to see subtle temperature differences (e.g., the smoke rising from the grill), 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 18: 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.

Boson provides an automatic gain-switch mode in which the camera automatically selects the optimum gain state based on scene content and a number of user-specified parameters. The logic for automatic gain-state switching is shown in Figure 19. The associated parameters are described in more detail in the paragraphs which follow.

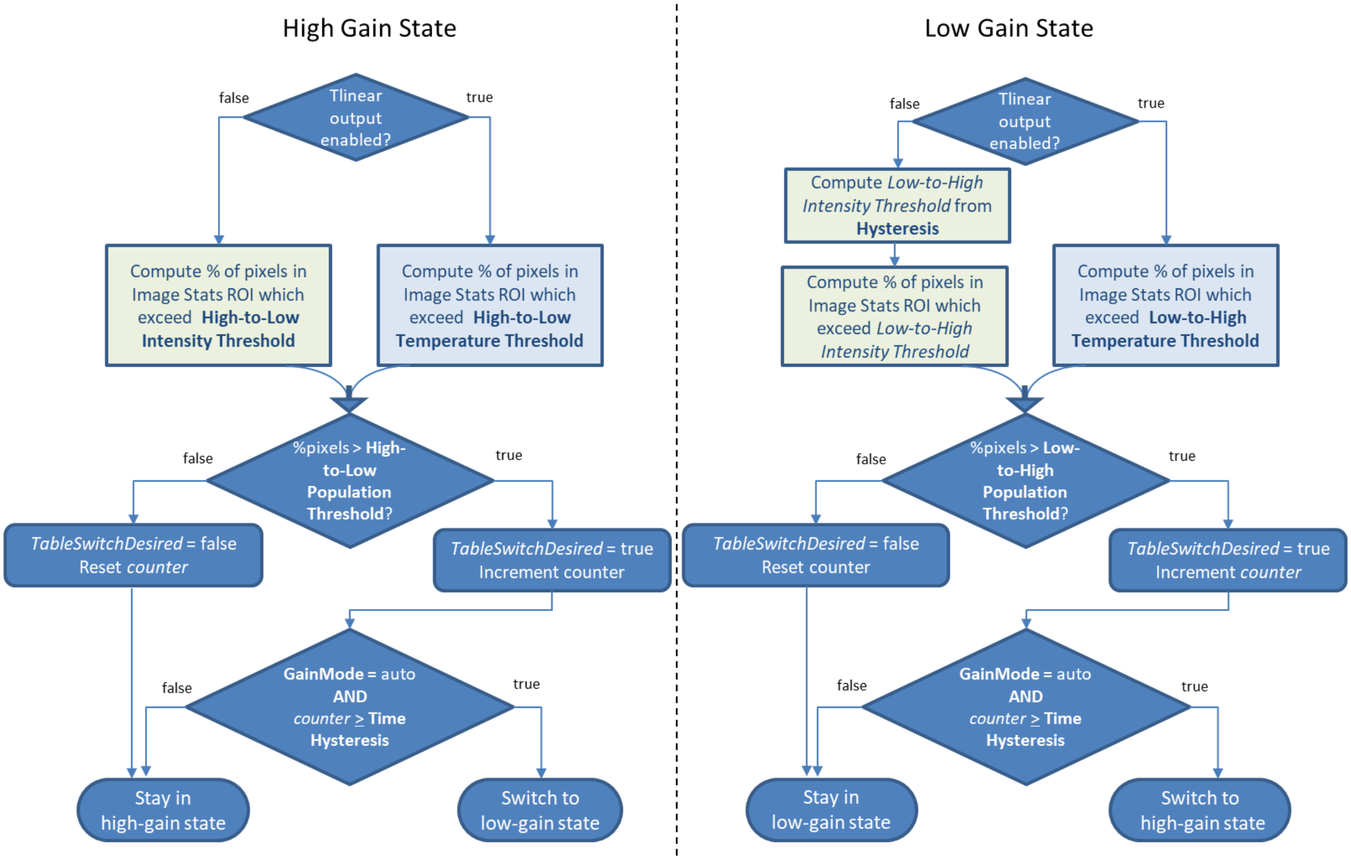


Figure 19: Automatic-Gain-Switch Logic

- **Gain Mode** (high-gain, low-gain, or automatic): determines whether or not Boson automatically determines the optimum gain state based on current scene conditions. See Section 7.7 for a detailed description of these modes. Default value is high-gain. None of the remaining parameters listed below have any effect except when in automatic gain mode. Note: for shutterless operation, automatic gain mode is not recommended because several noise filters described in Section 5.4 are reset at each gain switch, which can result in poor image quality when toggling often between the two gain states.

- **High-to-Low Intensity** or **High-to-Low Temperature Threshold:** In conjunction with the parameter **High-to-Low Population** described below, either the **High-to-Low Intensity** or **High-to-Low Temperature Threshold** parameter defines the scene conditions which result in the camera determining that a switch from high-gain state to low-gain state is desired. **High-to-Low Temperature Threshold** only applies in those configurations which support radiometry and only if temperature-linear output is enabled. Otherwise, **High-to-Low Intensity Threshold** is used. The thresholds represent the flux level (expressed as a percentage of that required to achieve maximum output value) or scene temperature (expressed in Celsius) 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 of **High-to-Low Intensity Threshold**, 90% represents 90% of the maximum output value and is recommended under most operating conditions. For those configurations which support radiometry, the factory-default value of **High-to-Low Temperature Threshold** is 120C.)
- **High-to-Low Population Threshold:** In conjunction with **High-to-Low Intensity Threshold** or **High-to-Low Temperature Threshold** described above, the **High-to-Low Population** defines the scene conditions which result in a desired change from high-gain state to low-gain state. It represents the percentage of the pixel population which must exceed the intensity or temperature threshold to signal a desired switch to low-gain state. The factory-default value is 5%. A larger value requires a larger percentage of pixels to be imaging hot objects to produce that result.
- **Low-to-High Population Threshold:** In conjunction with the **Hysteresis** or **High-to-Low Temperature Threshold** parameters described below, **Low-to-High Population Threshold** defines the scene conditions which result in the camera determining that a switch from low-gain state to high-gain state is desired. The **Low-to-High Population Threshold** represents the percentage of the pixel population which must fall below the intensity or temperature threshold to signal a desired switch to high-gain state. The factory-default value is 98%. The value cannot be set to less than (100% - **High-to-Low Population Threshold**) to avoid scene conditions which might result in oscillation between gain states.

- **Hysteresis** or **Low-to-High Temperature Threshold:** In conjunction with the **Low-to-High Population Threshold** parameter described above, either the **Hysteresis** or **Low-to-High Temperature Threshold** parameter defines the scene conditions which result in the camera determining that a switch from low-gain state to high-gain state is desired. **Low-to-High Temperature Threshold** only applies in those configurations which support radiometry and only if temperature-linear output is enabled. Otherwise, **Hysteresis** is used to calculate the internal variable *Low-to-High Intensity Threshold*. The resulting thresholds represent the signal level (expressed as a percentage of maximum flux level in high-gain state) or scene temperature (expressed in Celsius) below which a pixel is scored as being one which would benefit from transition to high-gain state. In either case (whether using **Hysteresis** or **Low-to-High Temperature Threshold**) the lower the value, the cooler the scene must be to result in a switch to high-gain state. (The factory-default value of **Hysteresis**, 95% represents a flux level that is 95% of that required for a pixel to exceed **High-to-Low Intensity Threshold** when operating in high-gain state. The factory-default value of **Low-to-High Temperature Threshold** is 100C.)
- **Gain Switch Hysteresis (Frames):** Beginning with Release 3.0, **Gain Switch Hysteresis Frames** denotes the number of consecutive frames for which a desired gain switch must signaled before an automatic gain switch takes place.
- **Gain Switch Hysteresis (Seconds):** Beginning with Release 3.0, **Gain Switch Hysteresis Seconds** denotes the time interval which must lapse before an automatic gain switch takes place.

In addition to the user-selectable parameters associated with the dynamic-range control feature, Boson provides three status variables reported via the telemetry line (see Section 6.7) or by status request on the CCI (see Section 8.1):

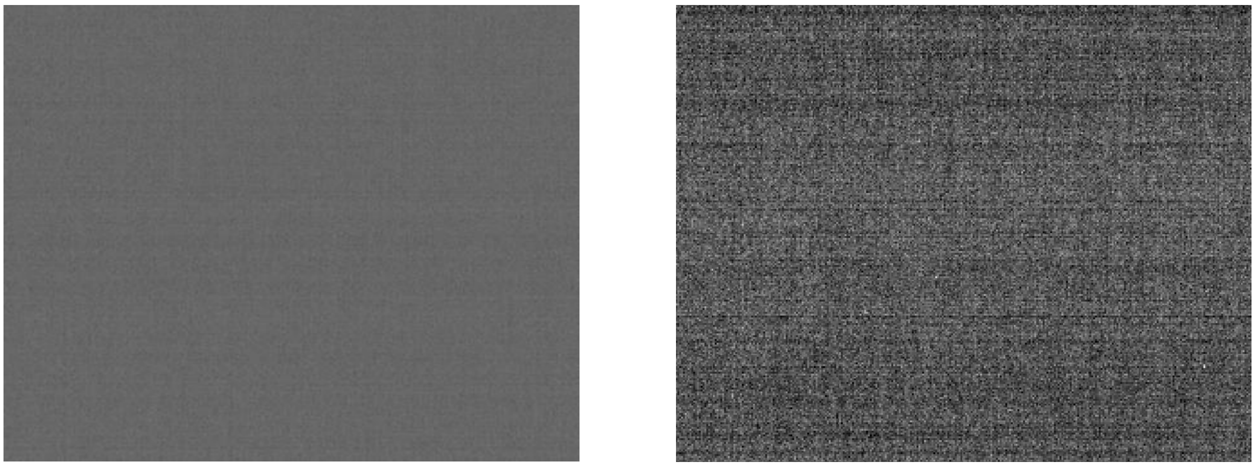
- *Current NUC Table*: The *Current NUC Table* variable has a value of 0 when operating in low-gain state and a value greater than 0 (either 1, 2, or 3) when operating in high-gain state. For an explanation of NUC Tables, see Section 5.2.

- *Desired NUC Table*: The *Desired NUC Table* variable is automatically set based on ambient temperature, scene conditions and the selectable parameters described above. When in automatic gain mode, an automatic NUC table switch takes place whenever *the Desired NUC Table* value does not match the value indicated via *Current NUC Table.* In manual or external FFC mode, a table switch only occurs in response to "Table Switch" command. (See note below.) If *Current NUC Table* = 0, and *Desired NUC Table* > 0, a NUC table switch (automatic or commanded) causes the camera to switch from low-gain state to high-gain state. Conversely, if *Current NUC Table* > 0, and *Desired NUC Table* = 0, a table switch causes the camera to switch from high-gain state to low-gain state. Note that the "Table Switch" command has no effect when *Current NUC Table = Desired NUC Table.* That is, no table switch occurs under that condition.
- *Table Switch Desired*: The *Table Switch Desired* flag is set whenever *Desired NUC Table* is not equal to *Current NUC Table*. When in automatic FFC mode, this flag is never set because instead an automatic table switch takes place. When in manual or external FFC mode, commanding a table switch when this flag is set will cause the switch to take place. (See note below.) Commanding a table switch when the flag is not set has no effect. By factory default, a red circle will appear in a location which circumscribes the *FFC Desired* symbol whenever the *Table Switch Desired* flag is set. (See Figure 37 in Section 0.)

NOTE: FLIR System's Tau® camera core, a predecessor to Boson, automatically switches NUC tables without performing FFC when operating in external FFC mode. Beginning with Release 2.1, Boson provides capability to configure external FFC mode to behave the same as Tau (automatic table switch) rather than setting *Table Switch Desired* and requiring the host to explicitly command a table switch.

6.6 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 20a. However, drift over long periods of time can degrade uniformity, resulting in imagery which appears more grainy (Figure 20b). 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 20: 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 7.9, Boson can be configured to perform 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 which control when FFC events occur. Each 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 7.9 for a detailed description of these modes. Factory-default is “automatic” for configurations which include a shutter, which means FFC events are triggered by:
  - Start-up
  - Expiration of internal timer with period specified by **FFC Period** (see below)
  - Temperature change beyond **FFC Temp Delta** (see below)
  - Change in NUC table (see Section 5.3)
  - Explicit command

  For configurations which do not include a shutter, factory default is “external”. For such cameras, no automatic FFC ever takes place.
- **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 2, 4, 8 or 16. Utilizing fewer frames 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 21 quantifies the benefit. The factory-default value is 8 frames for cameras which include a shutter, 16 frames for shutterless. Note that with averager enabled (i.e., 30Hz output rather than 60Hz output), a value of *n* frames represents twice as much time as with averager disabled since frame period is twice as long.
- **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 300 represents a 300 second (5 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. This can be independently controlled for High and Low-gain modes.

- **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 10 represents a 1 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. This can be independently controlled for High and Low-gain modes.
- **FFC Start-up Period**: When Boson is first powered, it experiences rapid self-heating in the first few minutes of operation. During this time, it benefits from more frequent FFC events than required during steady-state operation. **FFC Start-up Period** specifies a period of time (in seconds) after power-up during which the camera triggers FFC in response to temperature change equal to one-third of the value of **FFC Temp Delta**. For example, if **FFC Temp Delta** is set to its factory-default value, which results in an FFC event every 1 degree when at steady-state, then an FFC event occurs every 1/3rd degree from start-up until a time period equal to **FFC Start-up Period**. The value of **FFC Start-up Period** is user-selectable, but it is not recommended to change the factory-default value, 90 seconds.
- **FFC Warn Time**: Prior to any automatic FFC event, Boson enters an “FFC Imminent” state, which is signaled via the telemetry line and via an on-screen warning. (See Section 7.9 for more detail regarding the “FFC Imminent” state.) The time that the camera remains in “FFC Imminent” state is user-selectable via the **FFC Warn Time** parameter. The factory-default value is 2 seconds.

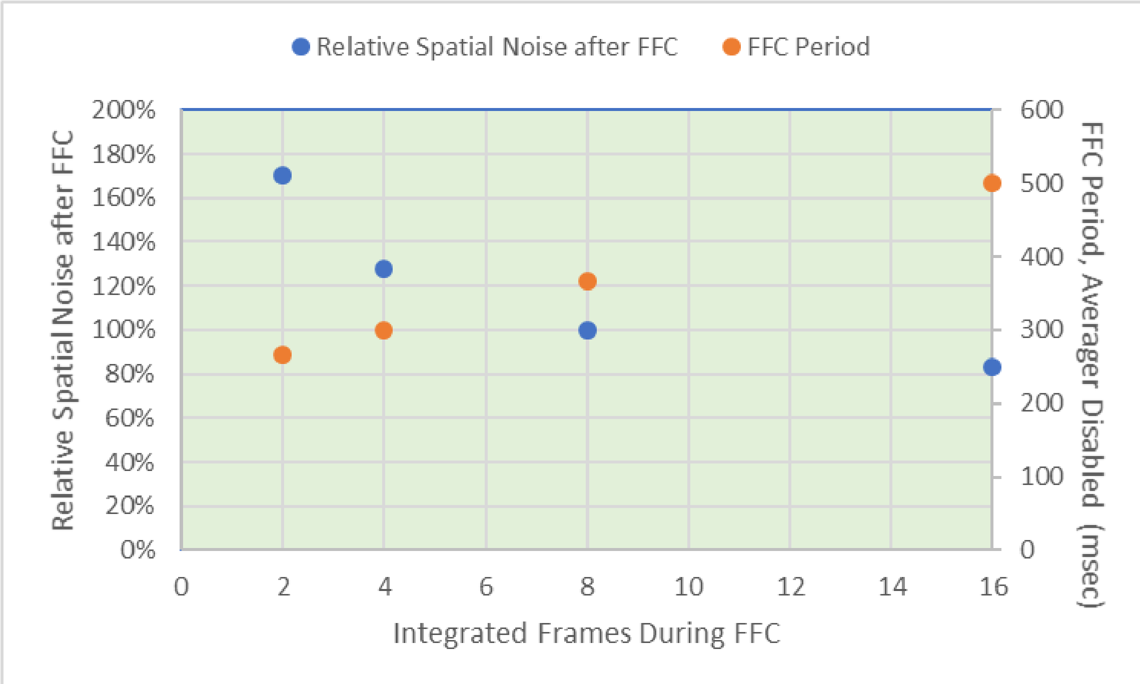


Figure 21: Relative Spatial Noise after FFC vs. Number of Integrated Frames (factory-default = 8)

In addition to the user-selectable parameters associated with the FFC process, Boson provides two status variables reported via the telemetry line (see Section 6.7):

- *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 7.9 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 7.9 for detailed description of these conditions.

NOTE: For shutterless configurations, it is recommended to perform an external FFC whenever the *FFC Desired* flag is set.

6.7 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 5.

Table 5: Telemetry Line Encoding

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
0	0	2	Telemetry Revision	0001 for Release 1 0002 for Release 2 0003 for Release 3
1	2	4	Camera serial number	
3	6	4	Sensor serial number	
5	10	20	Camera part number	ASCII encoded
15	30	14	Reserved	
22	44	12	Camera software revision	Bytes 44-47: SW major revision # Bytes 48-51: SW minor revision # Bytes 52-55: SW patch revision #
28	56	2	Frame rate	This is the actual data rate of the video output channel (in frames per second) when in continuous mode. For some configurations, frames are duplicated to generate an *effective* frame rate which is less than the value shown in this field. Similarly, when external sync is used to affect the frame rate of the readout integrated circuit, the resulting value is not represented by this field.
29	58	8	Image Stats ROI	
33	66	2	MeanInROI	
34	68	2	minInROI	
35	70	2	MaxInROI	

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
36	72	2	stdDev	
37	74	2	Units for ROI stats	
38	76	8	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 Bit 7: Low-power state Bit 8: Overtemp state All other bits reserved.
42	84	4	Frame Counter	Rolling counter of output frames since start-up.
44	88	4	Frame Counter at last FFC	Value of the frame counter at the last FFC event
46	92	2	Tfpa (counts)	FPA temperature in counts
47	94	2	Camera temperature	In Kelvin x 10 (e.g., 3001 = 300.1K)
48	96	2	Camera temperature at last FFC	In Kelvin x 10 (e.g., 3001 = 300.1K)
49	98	12	Reserved	

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
55	110	4	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 = SSN (SPNR) enable/disable Bit 7 = BPR enable/disable Bit 9 = SFFC enable/disable Bit 13 = SRNR enable / disable Bit 17 = LFSR enable / disable All other bits reserved
57	114	2	Number of frames to integrate at next FFC	
58	116	42	Reserved	
79	158	2	Current NUC Table	See note 2 of Table 7 in Section 7.9
80	160	2	Desired NUC Table	See note 2 of Table 7 in Section 7.9
81	162	4	Core Temp	In Celsius x 1000 (e.g., 30021 = 30.021C)
83	166	4	Overtemp event counter	
85	170	4	ROI Population Below Low-to_High Threshold	
87	174	4	ROI Population Below High_to_Low Threshold	
89	178	6	Toggling pattern (intended as check of stuck CMOS signals)	Bytes 178-179: 0x5A5A Bytes 180-181: 0xA55A Bytes 182-183: 0xA5A5
92	184	4	Zoom factor	
94	188	4	Zoom X-center	Row number
96	192	4	Zoom Y-center	Column number
98	196	84	Reserved	
140	280	4	Time stamp in msec	

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
142	284	28	Reserved	
156	312	2	External sync mode	0 = free running, 1 = slave
157	314	60	Reserved	
187	374	2	agcContrast	
188	376	4	agcBrightnessBias	
190	380	2	agcBrightness	
191	382	2	Valid Image	
192	384	2	reserved	
193	386	4	Spot Meter Accuracy	Radiometry Spot Meter Accuracy
194	388	2	Reserved	
240	480	2	gainSwitchFrameCount	Frames since last gain mode switch
241	482	4	gainSwitchTimestampMs	Timestamp of last gain mode Switch
243	486	2	spotmeterMeanCounts	
244	488	2	spotmeterDeviation	Standard deviation of spot meter
245	490	2	spotmeterMinCount	
246	492	2	spotmeterMinRow	
247	494	2	spotmeterMinColumn	
248	496	2	spotmeterMaxCounts	
249	498	2	spotmeterMaxRow	
250	500	2	spotmeterMaxColumn	

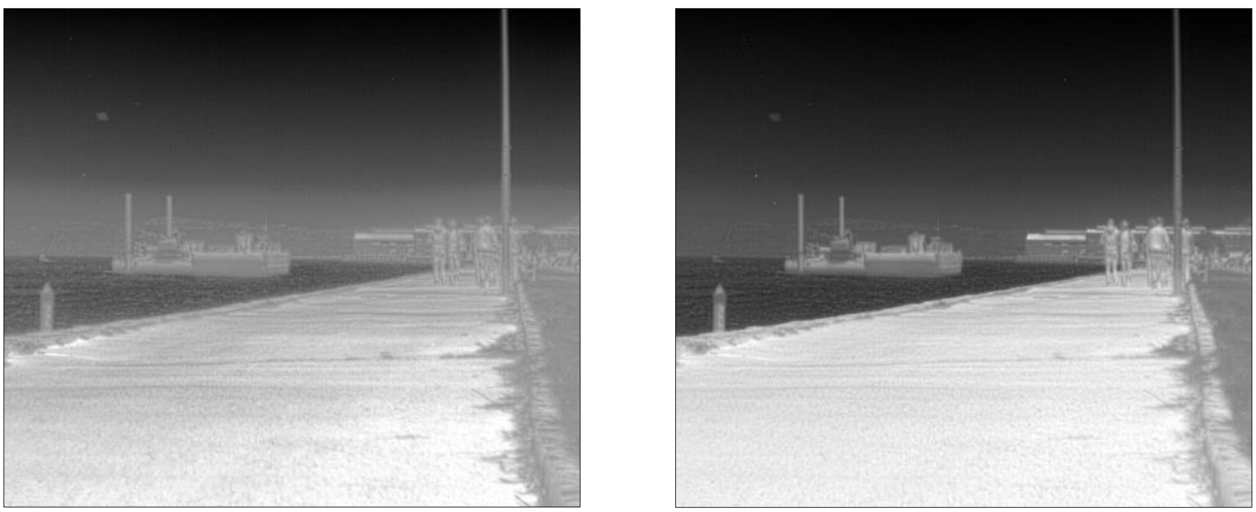
6.8 AGC

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**
- **Linear Percent**
- **Adaptive Contrast Enhancement (ACE)**
- **Digital Detail Enhancement (DDE)**
- **Smoothing Factor**
- **Region of Interest (ROI)**
- **Damping Factor**

6.8.1 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 22 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 22: Example Images Showing Both AGC Modes

6.8.2 Plateau Value

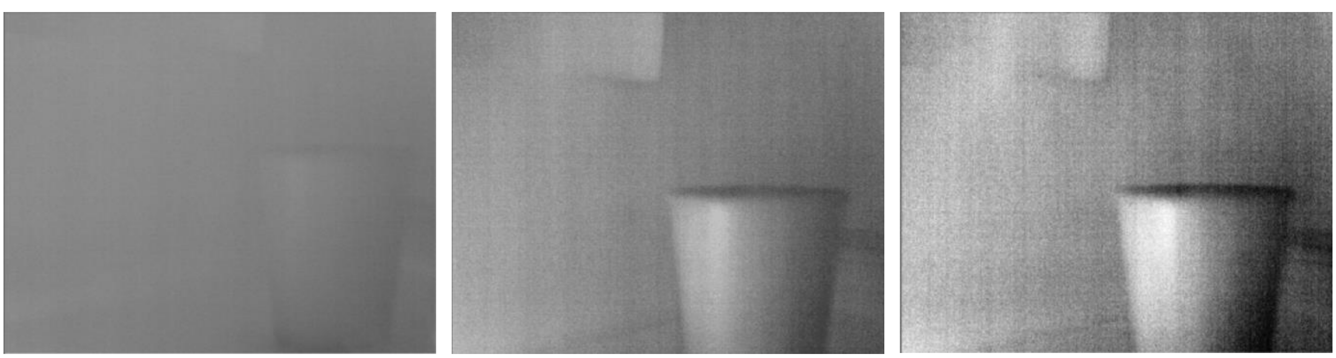
As mentioned above, one of the characteristics of classic HEQ is that it will devote grayshades proportionally to histogram population, meaning that large, mostly uniform portions of a scene will receive a large percentage of the grayshades. This characteristic can lead to those portions of the scene 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%. Note that because the parameter value is expressed as a percentage, it is not required to modify the value if the Region of Interest (see Section 6.8.9) is modified.

6.8.3 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%. Tail rejection can be modified by using outlier-cut balance, which shifts ignored outliers more to one side of the histogram. The default for this setting is 1 which designates an even distribution between low and high values being cut off as outliers.

6.8.4 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 23 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 23: Example Images Showing Three Different Max Gain Values

6.8.5 Linear Percent

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. **Linear Percent** 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 24, a higher value leads to more "separation" in gray shades between the person and the hot furnace in the image. The default value of **Linear Percent** is 20%, but like **Max Gain**, the optimal value varies with application and personal preference.

(a) **Linear Percent** = 0%

(b) **Linear Percent** = 30%

Figure 24: Example Images Showing Different Values of Linear Percent

6.8.6 Adaptive Contrast Enhancement (ACE)

ACE provides contrast adjustment dependent on relative scene temperature. The scale of values ranges from 0.5-4.0. In white-hot polarity, an **ACE** value less than one darkens the image, increasing contrast in hotter scene content, while an **ACE** value greater than one will do the opposite. Figure 25 shows the of **ACE** effect on the transfer function, and Figure 26 shows an example image with 3 different values. The factory-default is 0.97.

NOTE: When toggling between white-hot and black-hot, it is suggested to toggle the **ACE** value between 1-X and 1+X. For example, if a value of 0.90 is utilized in white-hot mode, a value of 1.10 is suggested in black-hot mode.

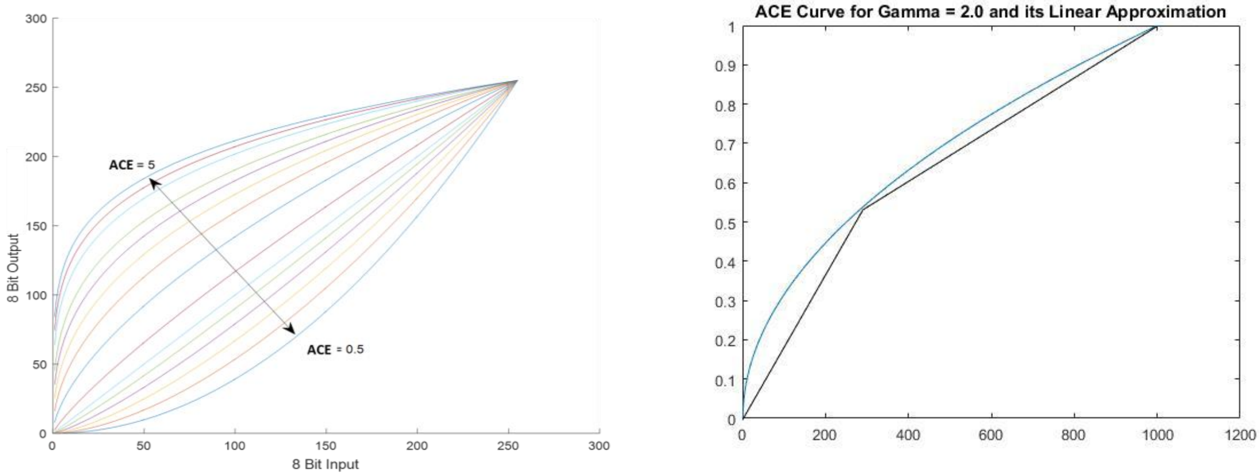


Figure 25: **Graphical Illustration of ACE and a corresponding example of the piece wise approximation of the ACE curve that is implemented.**

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

Figure 26: **Example Images Showing Different Values of ACE**

6.8.7 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 27. The factory-default value is 0.95.

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

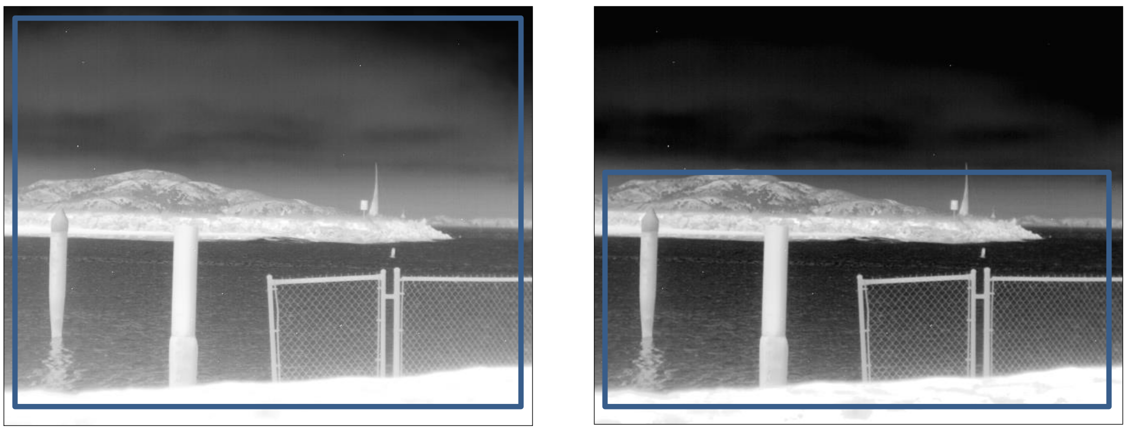
Figure 27: Example Images Showing Different Values of DDE

6.8.8 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.

6.8.9 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 28. 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 for the 320 configuration or 639 for the 640 configuration, **End Row** = 255 for the 320 configuration or 511 for the 640 configuration).



(a) ROI = Full Image

(b) Sky excluded from ROI

Figure 28: Example Image for 2 Different ROI

6.8.10 Damping 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 lower value of the **Damping Factor** parameter allows the algorithm to react quicker. A value of 0% results in no filtering at all, and a value of 100% causes the AGC transfer function to stop updating altogether. The factory-default value is 85%.

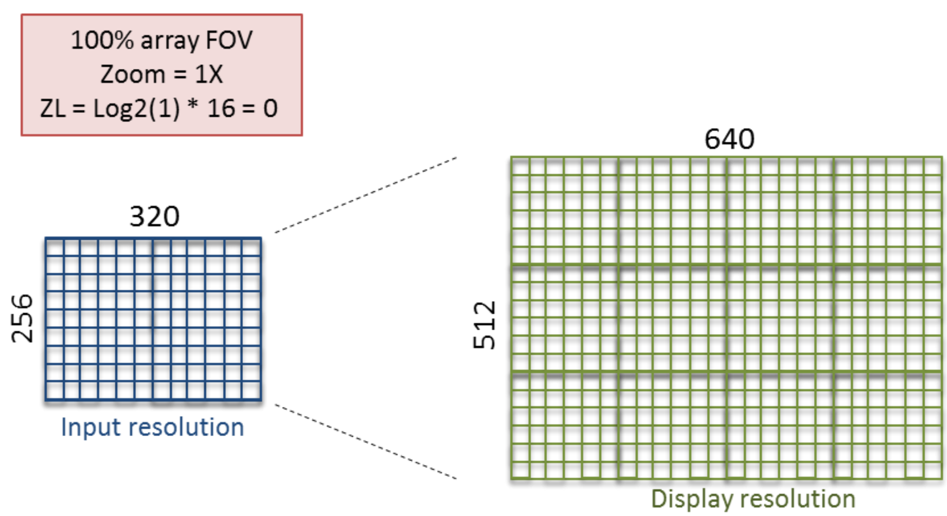
6.9 Ezoom

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 29. 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:

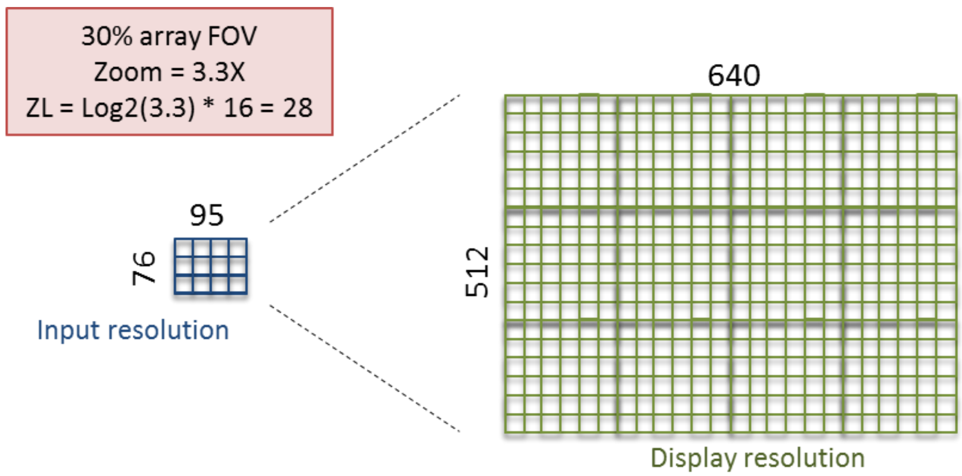
$$\text{Zoom} = 2 \wedge (ZL/16)$$

This transfer function is depicted graphically in Figure 30. 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 31 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. **Zoom Level** does not effect the on screen position of symbols.



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



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

Figure 29: Visualization of Zoom Function

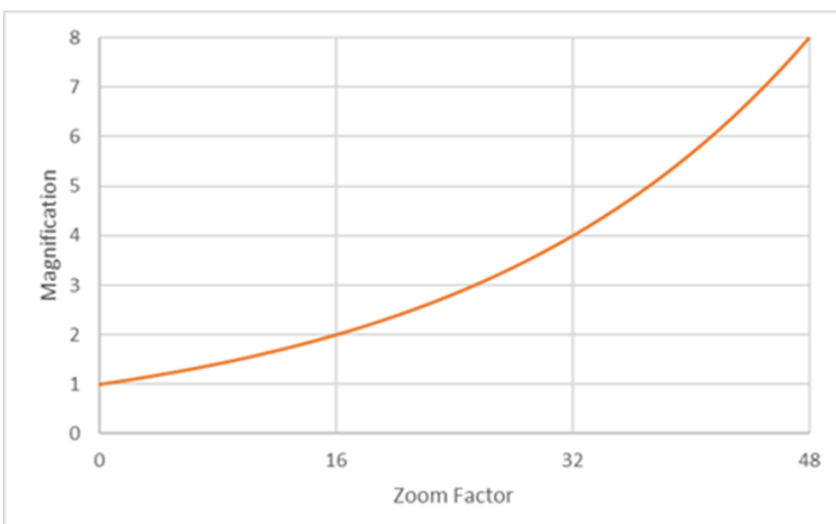
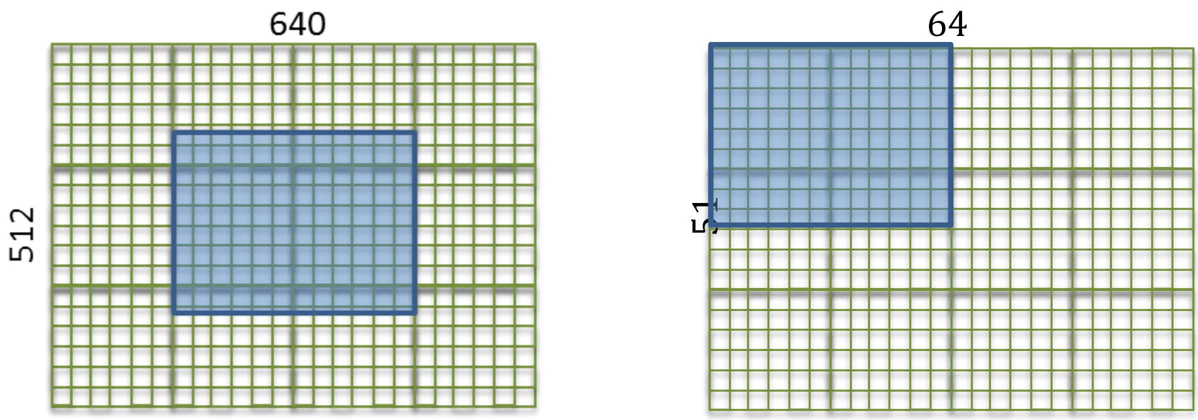


Figure 30: Zoom (Relative Magnification) as a function of specified Zoom Level



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

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

Figure 31: 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:

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

  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 7.12 for more information.

6.10 Colorization

As shown in Figure 32, 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 33 and Figure 34 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. For now, an alternative option is to use the Isotherms feature to achieve a similar effect, see Section 6.3. 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 7.12.

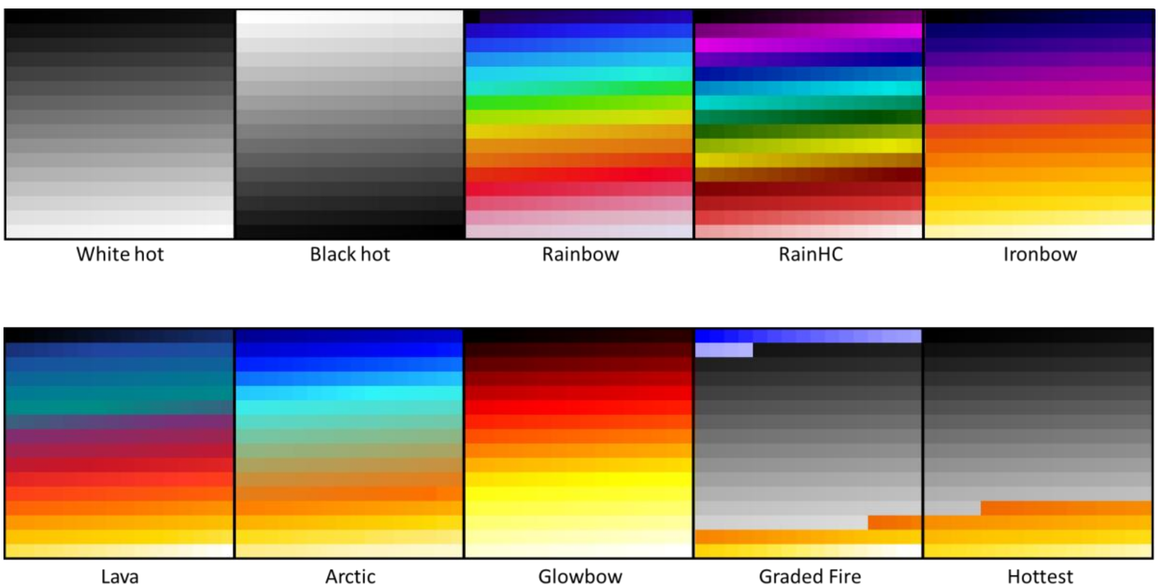


Figure 32: Boson's Factory-Loaded Color Palettes

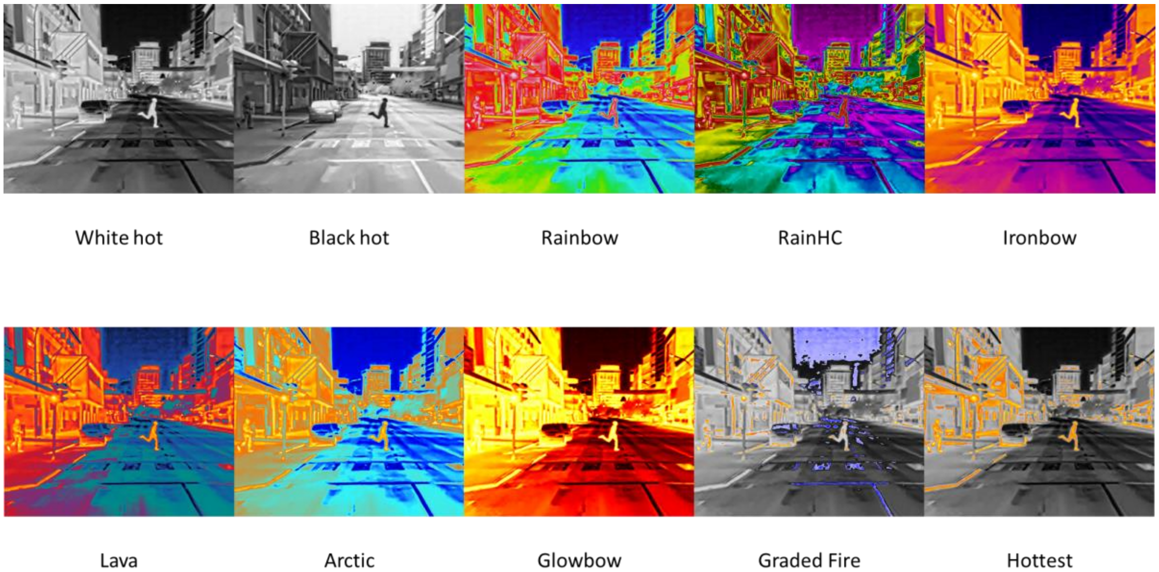


Figure 33: Sample Image1 With Boson's Color Palettes

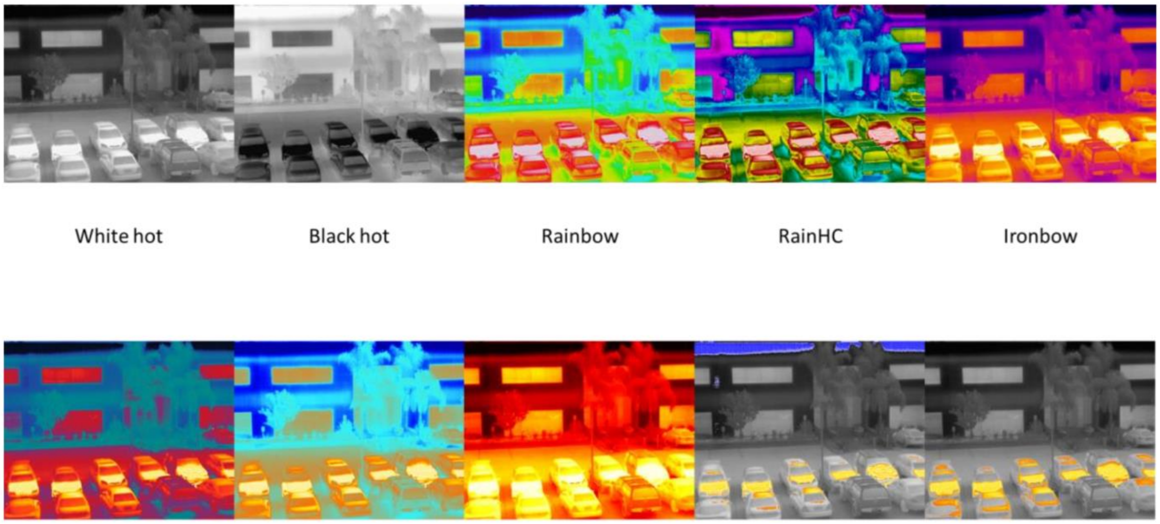


Figure 34: Sample Image2 with Boson's Color Palettes

6.11 Automatic Symbols

The Boson Release 3 configurations provides 7 symbol overlays which are automatically enabled or disabled in response to various system states and conditions, as described below. An override is provided for each. (For example, it is possible to override automatic display of the overtemp symbol while leaving all other symbols unaffected.) Additionally, it is possible to globally disable the display of *all* symbol overlays, which includes the automatic symbols described in this section as well as any custom symbols described in the next section.

- FFC In Progress: By factory default, the symbol shown in Figure 35 is displayed whenever the FFC State = "FFC Imminent" or "FFC in Progress". (See Section 7.9 for full description of the FFC states.)
- FFC Desired: By factory default, the symbol shown in Figure 36 is displayed whenever the "FFC Desired" flag is set. (See Section 6.15.3 and Section 7.9.)
- Table-Switch Desired: By factory default, the symbol shown in Figure 37 is displayed whenever the "Table-Switch Desired" flag is set. (See Section 6.15.3 and Section 7.9.).
- Low-Gain State: By factory default, the symbol shown in Figure 38 is displayed whenever the camera is operating in low-gain state. (See Section 6.5 for a full description of this state.)
- Overtemp State: By factory default, the symbol shown in Figure 39 is displayed whenever the camera is in the overtemp state. (See Section 7.2 for full description of this state.)

- Isotherm Bar: By factory default, the symbol shown in Figure 40 is displayed whenever the camera has isotherms enabled. It displays the current color LUT (See Section 6.3 for full description of this feature.)
- Spot Meter: By factory default, the symbol shown in Figure 41 is displayed whenever the camera has spot meter enabled. (See Section 6.4 for full description of this feature.) Four components make up this automatic symbol:
  - Spot Meter ROI: 25x25 square grouping bounded by a purple box
  - Spot Meter ROI statistics: Display the min, max and mean value for the spot meter ROI
  - Mean Value Bar: Graphical display of the mean ROI value in relation to the temperature markers with radiometry enabled, and a relative value with radiometry disabled.
  - Temperature Markers: Display the designated reference temperature values. Only available with radiometry enabled cameras

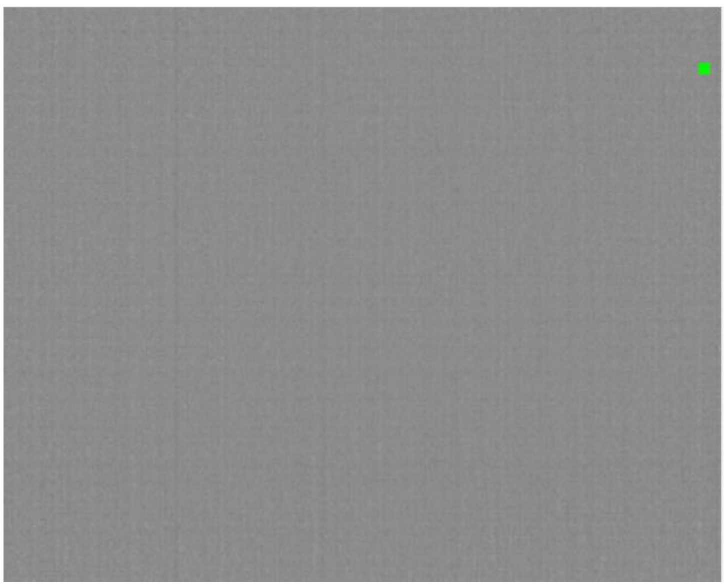


Figure 35: "FFC Imminent / In Progress" Symbol (Factory-Default); upper right corner

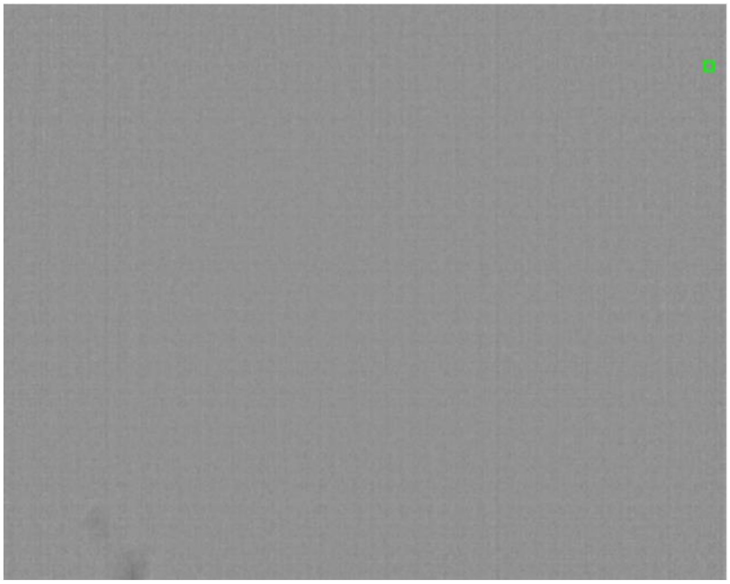


Figure 36: "FFC Desired" Symbol (Factory-Default); upper right corner

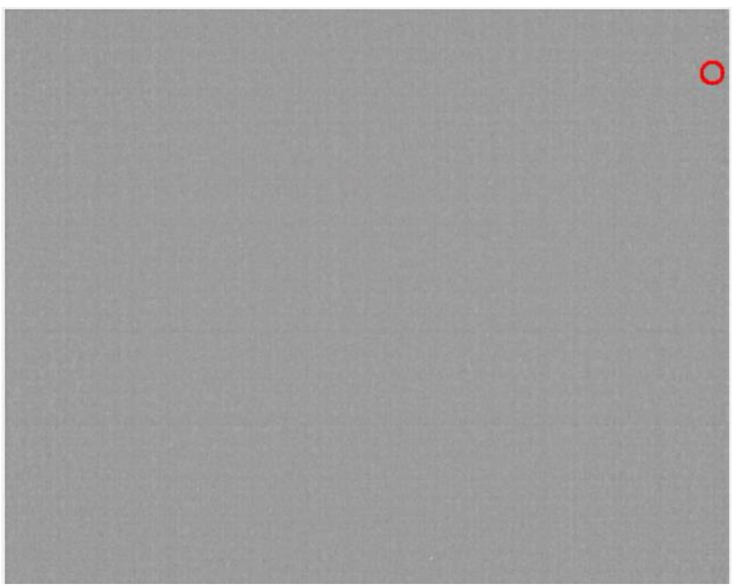


Figure 37: "Table-Switch Desired" Symbol (Factory-Default); upper right corner

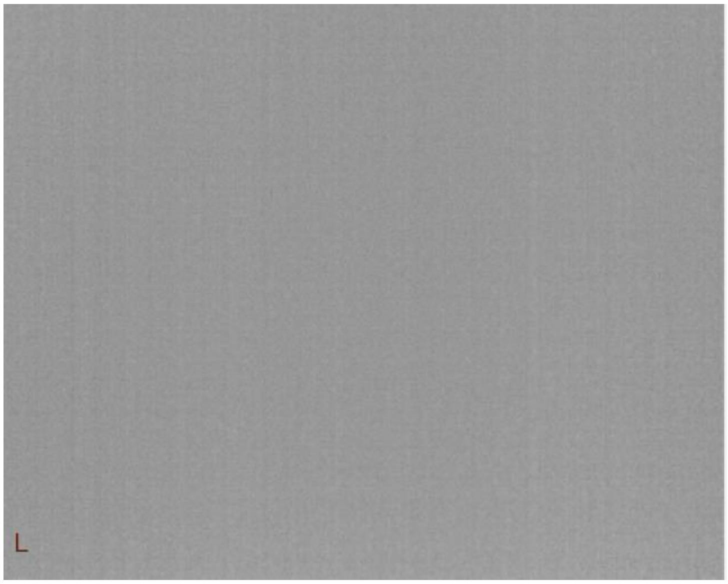


Figure 38: "Low-Gain" Symbol (Factory-Default); lower left corner

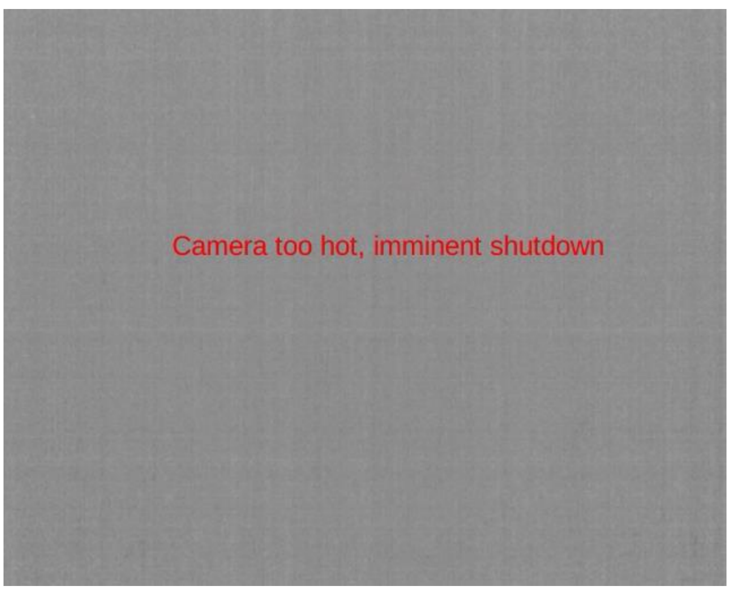


Figure 39: "Overtemp" Symbol (Factory-Default)

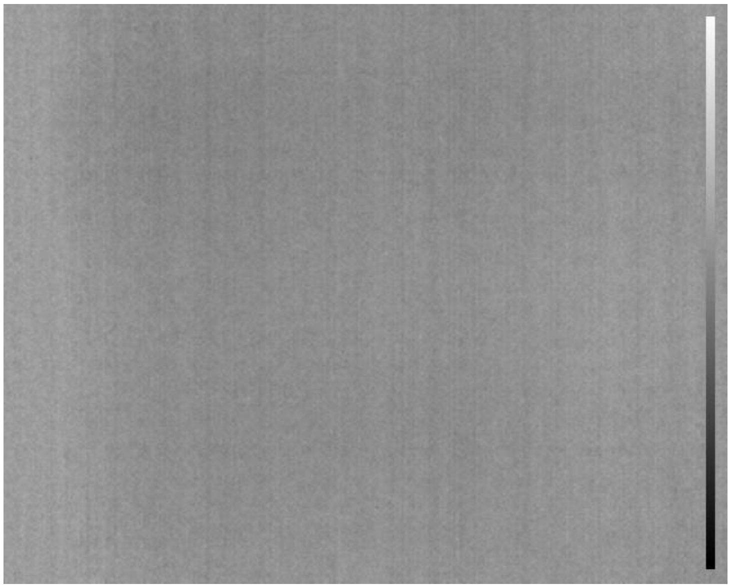


Figure 40: "Isotherm" Symbol

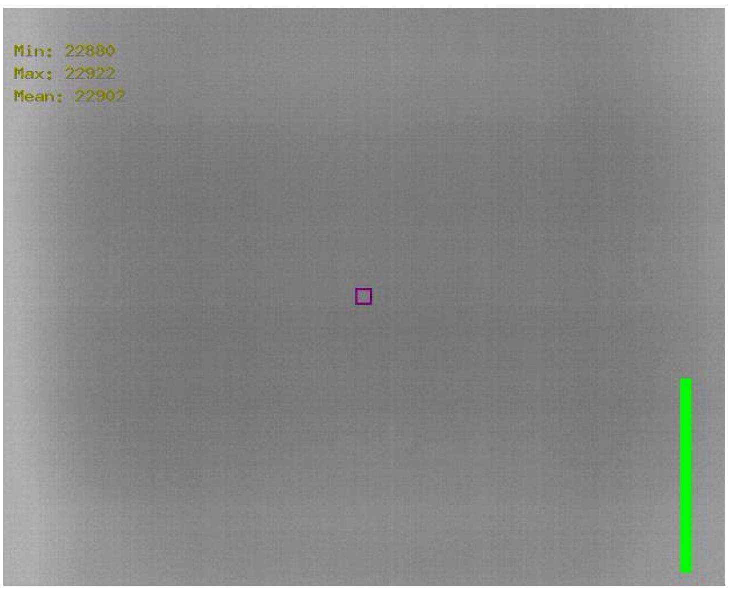


Figure 41:"Spot Meter" Symbol (Non-Radiometric 640 config.)

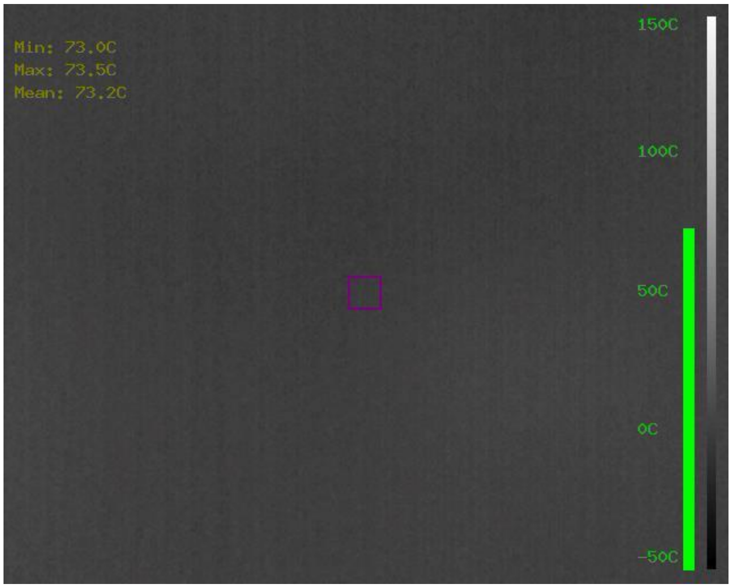


Figure 42: "Isotherms and Spot Meter" Radiometry Enabled 320 config.

The factory-default attributes of all 5 automatic symbols are shown in Table 6 below. (See Section 0 for descriptions of the various attributes.) A separate Boson Symbols Application Note, available from the Boson website linked in Section 1.3, provides more information on this advanced topic for modification of automatic symbols. The Isotherm and Spot meter symbols should not be modified in this way, and require the explanation I the symbology app note.

Table 6: Factory-default attributes of the automatic symbols

	FFC Imminent	FFC Desired	Table-Switch Desired	Low-gain	Overtemp
ID#	10	11	12	13	14
Element Type	Filled Rectangle	Outlined Rectangle	Arc	Text	Text
X Position	620	620	614	10	150
Y Position	50	50	45	470	200
Width	10	10	22	20	400
Height	10	10	22	20	25
Color	0000FF00	0000FF00	00FF0000	00762710	00FF0000
Z-position	0	0	0	0	0
Start Angle			0		
End Angle			0		
Font				1	1
Size				24	24
Alignment				TOP LEFT	TOP LEFT
ASCII Text				L	Camera too hot, imminent shutdown

6.12 Customized Symbols

The Boson Release 2 configurations provide the option to specify custom symbol overlays. The camera supports several built-in symbol types, including rectangles, elliptical arcs, text, and lines, as exemplified in Figure 43. In addition to built-in symbols types, the camera also allows bitmaps to be uploaded to the camera for display. Width of the bitmap must be an integer multiple of 8.

NOTE: The Boson Graphical User Interface (GUI) is capable of opening PNG, BMP, and JPEG files and converting them into the correct bitmap format.

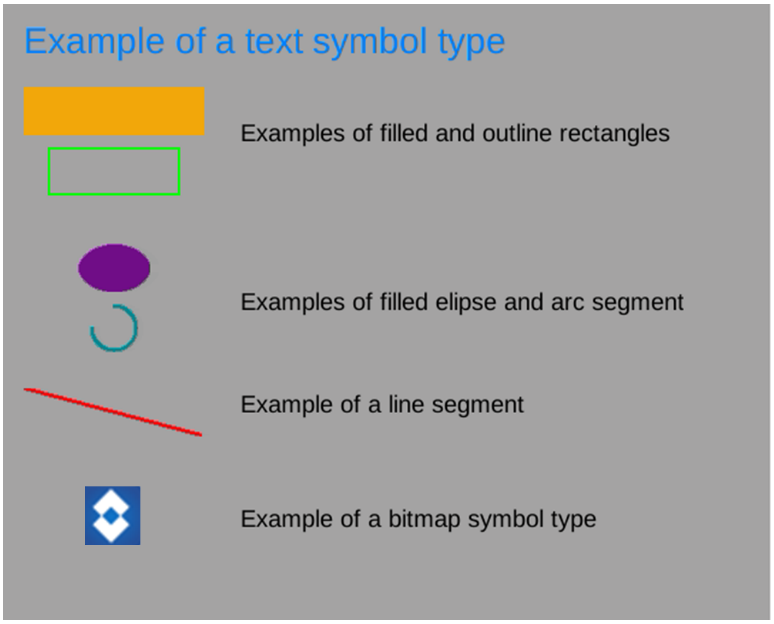


Figure 43: Examples of Boson Symbol Types

Each symbol type has a variety of user-specified attributes, as listed below.

Symbol attributes common to every symbol type:

- Symbol ID# (0 to 254): a handle for addressing the symbol when changing its attributes. Note that ID numbers 10 to 14 are pre-allocated for automatic symbols such as the FFC imminent icon. (See Section 6.11.) Changing the attributes of any of these symbol IDs will alter the appearance of the associated built-in symbol. See Table 6 for the ID# and other attributes of each automatic symbol.
- Symbol enable: 0 = not currently drawn, 1 = currently drawn

- X and Y coordinates, where x=0, y=0 is the upper left of the image and x=639, y=511 is the lower right. The upper-left corner of the symbol is placed at the specified coordinates. Note the symbol map/canvas is always 640x512 since symbol overlay occurs at the post-colorization tap in the pipeline, and that tap has 640x512 size regardless of sensor resolution. (See Section 7.12) It is not permissible to specify a location such that a portion of a symbol is outside the 640x512 canvas. (Attempting to do so will result in an error.)
- Transparency, where a value of 0 represents an opaque symbol and a value of 127 represents a completely transparent symbol. (Transparency values of 127-255 are invalid, and have undefined behavior.) Setting a transparency value greater than 0 allows a symbol to be shown without completing hiding the infrared imagery (or other symbols) behind it, as illustrated in Figure 44.
- Z-position, indicating a background (z=0) or foreground plane (z=1-255), used to determine precedence in the event of overlapping symbols. For example, a symbol with 0% transparency on the n^{th} plane will completely hide a symbol located on the n-1 plane, as illustrated in Figure 44. (If two overlapping symbols both have the same z-position, the behavior is undefined.)
- Group number, from 1 to 19. It is possible to place multiple symbol ID#s into a common group. Doing so allows the entire group to be enabled/disabled and/or moved simultaneously. Moving a group causes the X/Y location of each symbol within the group to be updated automatically.

Other attributes for built-in symbol types

- Color, specified as an RGBA index. This is a required attribute for all symbol types except bitmaps.
- Height / Width, specified in number of rows (1 to 512)_ / number of columns (1 to 640). This is a required attribute for filled rectangles, outline rectangles, elliptical arc segments, filled ellipses, and text symbol types. For text symbols, the height and width refer to the bounding box for the text. If actual text width exceeds specified width, wrapping will be applied (potentially exceeding specified height).
- Start radius / end radius, from 0 to 360. This attribute applies to the arc segment symbol type only. It specifies the starting angle and ending angle, where angle = 0 is to the right and angle = 180 is to the left. The arc between the starting angle and ending angle is drawn clockwise. For example, the arc segment shown in Figure 43 has starting radius = 270 and ending radius = 180.
- Start point / end point, each specified as an x/y coordinate. This attribute applies to line segment symbol type only.
- Font type. 1 = built in font (Chrome Croscore Arimo font, used under authority of the Apache License, Version 2.0), 2 = user replaceable font file. This attribute applies to text symbol type only. All of the text shown in Figure 43 was generated with the built-in font.
- Font size. This attribute applies to text symbol type only and controls the nominal height of each character of text, in rows. For example, a font size of 32 results in a character height which consumes ~1/8th of the total image height.

- Justification. This attribute applies to text symbol type only, and the valid options are
    - LEFT_TOP
    - CENTER_TOP
    - RIGHT_TOP
    - LEFT_MIDDLE
    - CENTER_MIDDLE
    - RIGHT_MIDDLE
    - LEFT_BOTTOM
    - CENTER_BOTTOM
    - RIGHT_BOTTOM
- Text, in UTF-8 characters. The text string is a fixed-width, null-terminated buffer containing exactly 128 bytes. This attribute applies to text symbol type only.

Both squares have transparency = 0%.
The z-position of both squares = 2.
Both circles have transparency = 50%.
The z-position of the upper circle is 1, the lower circle = 3

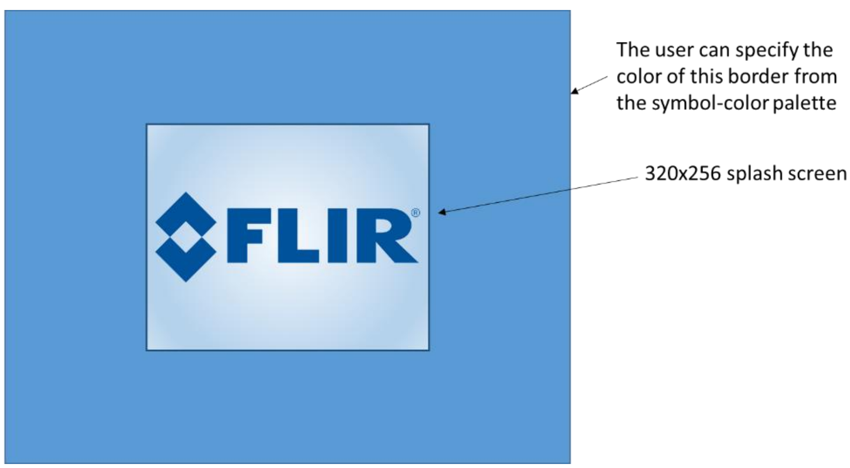
Figure 44: Examples of Overlapping Symbols, Illustrating Transparency and Z-Location

A separate Boson Symbols Application Note, available from the Boson website linked in Section 1.3, provides many more examples and more detailed treatment of the custom-symbols feature.

6.13 Start-up Splash Screen

Release 2 configurations of Boson provide the option of outputting one or two user-specified splash screens at start-up, such as a company logo and camera configuration data. The splash screens are displayed consecutively, Splash Screen 1 first, possibly followed by Splash Screen 2 if one has been uploaded to the camera. The lengths of time that each splash screen is displayed, **Splash1 Duration** and **Splash2 Duration**, are variable in millisecond increments from 0 to 120,000 msec. If the sum of **Splash1 Duration** and **Splash2 Duration** is less than the time required for the camera to transition out of "booting" state to a fully-operational state (see Section 7.1 for a description of start-up states), display of the final splash screen is automatically extended. By factory-default, a uniform black splash screen is displayed for the minimum booting time, and there is no second splash screen.

Splash screens can be uploaded to the camera in .PNG format in either 320x256 or 640x512 resolution. If a 320x256 splash screen is provided, it will be centered within a 640x512 color border, as exemplified in Figure 45. The border color, **Splash1 Background Color** and/or **Splash2 Background Color**, is user-selectable.



(a) Example 320x256 splash screen, centered within a color border

(b) Example 640x512 splash screen (output with no border)

Figure 45: Example splash-screens, 320x256 and 640x512 resolution

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NOTE: Splash screens are only properly displayed on video channels configured for post-colorization output. The post-colorization output tap has 640x512 size regardless of the sensor resolution. (See Section 7.12.)

6.14 Field Calibration

Most configurations of Boson include a set of factory-calibrated NUC terms which compensate for temperature effects, pixel response variations, lens-illumination roll-off, and out-of-field irradiance. For such configurations, the generation and application of NUC terms is transparent to the user and requires no external intervention or support. However, there are three notable exceptions to the above, each of which benefit from a one-time calibration process performed by the user:

a) The Boson lens-less configuration
b) A Boson installed behind a window or other optical assembly, resulting in a change to the illumination pattern onto the focal plane array.
c) A Boson installed in an environment which significantly affects self-heating, for example in an insulative enclosure or in a convective air flow. As a rule of thumb, re-calibration is recommended if the installation of the camera in the operating environment causes its steady state temperature to be more than one Celsius degree hotter or cooler than it would otherwise be when operated in the same ambient temperature in still-air with no enclosure.

NOTE: Exposing any thermal camera to rapid thermal transients will reduce the effectiveness of the calibration and the quality of the image. For best results, the Boson camera should be isolated from the thermal effects of window heaters, variable fans, power circuits, electric motors, or similar intermittent thermal sources, as noted in Section 9.4.

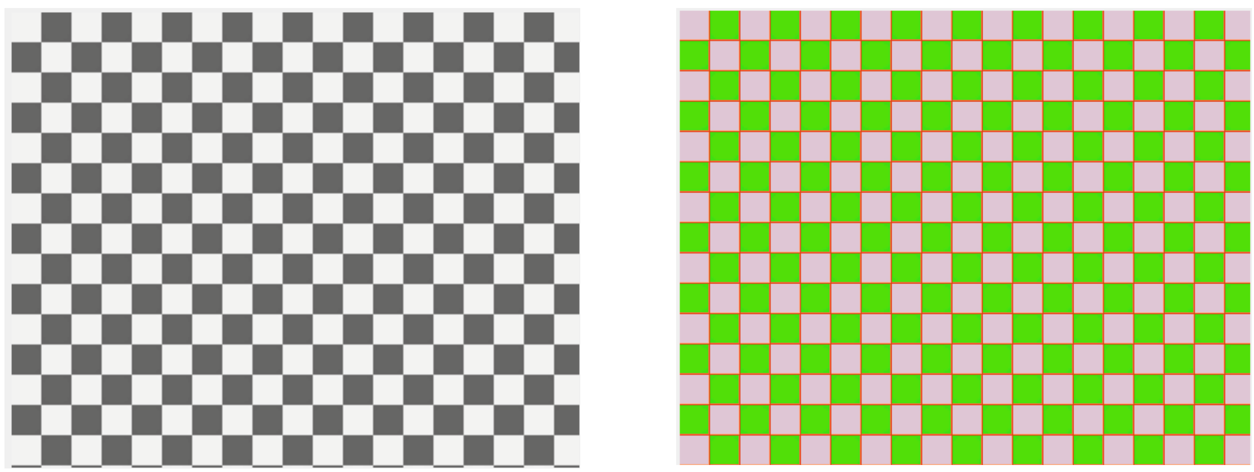
The calibration process requires exposing the camera in its final installation condition (e.g., in enclosure behind a window if applicable) to two different blackbody temperatures (e.g., room temperature and 20C above room temperature). The Boson Graphical User Interface (GUI) sequences all the steps required to complete the calibration process. For a detailed tutorial on using the GUI, refer to FLIR's Lens Calibration Application Note, available from the Boson website linked in Section 1.3.

6.15 Diagnostic Features

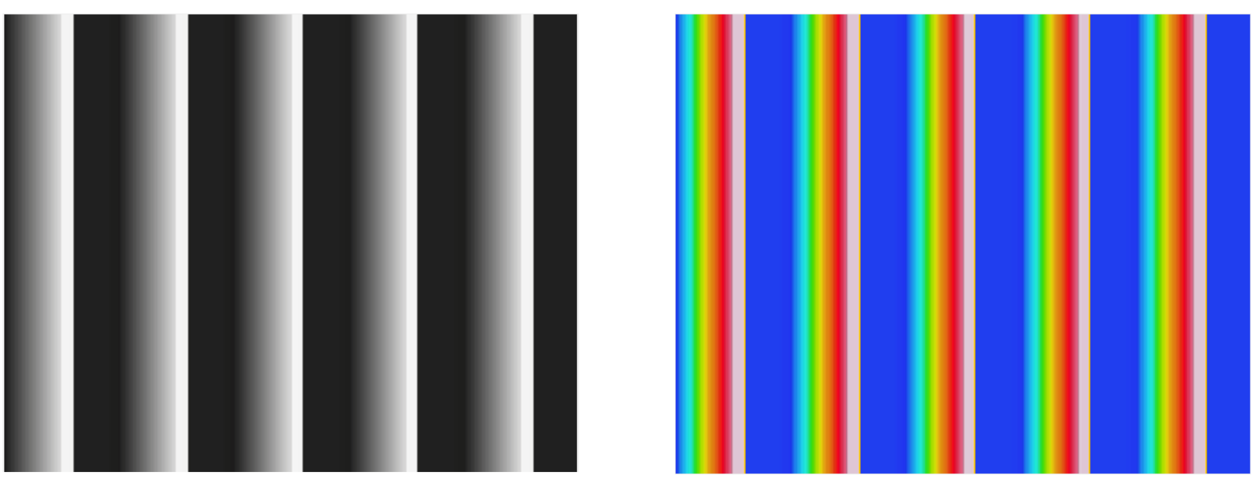
Boson provides a number of diagnostic features, more completely defined in the sections that follow.

6.15.1 Test Patterns

Boson provides capability to display a number of test patterns, two of which are illustrated in Figure 46. The test patterns are intended primarily to adjust display properties and/or for diagnostic purposes (for example, to verify the core is providing a valid output). Only a select few test patterns are available via the Boson GUI, and most must be accessed via the SDK.



(a) Checkerboard test pattern



(b) Vertical-shade test pattern

Figure 46: Two of the Boson test patterns (shown in both White-Hot and Rainbow palettes)

Because the test pattern replaces the sensor data at the beginning of the pipeline, its appearance is affected by filters and AGC settings. The Boson App does automatically disable pipeline features below. For reproduceable test patterns which appear as intended, the following configuration changes are required: **see below*

- Set external FFC (to prevent an automatic FFC event from taking place while the test pattern is enabled): bosonSetFFCMode(FLR_BOSON_FFCMODE_E.FLR_BOSON_EXTERNAL_FFC)
- Disable application of NUC terms and pipeline filters:
  - FFC: gaoSetFfcState(FLR_ENABLE_E.FLR_DISABLE)
  - Gain: gaoSetGainState(FLR_ENABLE_E.FLR_DISABLE)
  - Temperature Correction: gaoSetTempCorrectionState(FLR_ENABLE_E.FLR_DISABLE)
  - SFFC: gaoSetSffcState(FLR_ENABLE_E.FLR_DISABLE)
  - Bad Pixel Replacement: bprSetState(FLR_ENABLE_E.FLR_DISABLE)
  - Row filter, SRNR: srnrSetEnableState(FLR_ENABLE_E.FLR_DISABLE)
  - Column filter, SCNR: scnrSetEnableState(FLR_ENABLE_E.FLR_DISABLE)
  - Silent Shutterless NUC: spnrSetEnableState(FLR_ENABLE_E.FLR_DISABLE)
  - Temporal Filter: tfSetEnableState(FLR_ENABLE_E.FLR_DISABLE)
  - Low-Frequency Shading Reduction: lfsrSetApplyOffsetEnableState(FLR_ENABLE_E.FLR_DISABLE)
  - Radiometric cameras only:
    - T-linear TLinearSetControl(FLR_ENABLE_E.FLR_DISABLE)
    - radiometrySetTempStableEnable(FLR_ENABLE_E.FLR_DISABLE)

For post-AGC output (i.e. 8bit), the following AGC settings are additionally recommended: **see below*

- AGC Mode = Information-Based Equalization Disabled: agcSetUseEntropy(FLR_ENABLE_E.FLR_DISABLE)
- Plateau Level = 100% agcSetPercentPerBin(100)
- Tail Rejection = 0: agcSetDetailHeadroom(0)
- Max Gain = 8: agcSetMaxGain(8)
- Linear Percent = 100%: agcSetLinearPercent(100)
- Adaptive Contrast Enhancement (ACE) = 1: agcSetGamma(1.0)
- DDE = 1: agcSetd2br(1.0)
- Damping Factor = 0%: agcSetdf(0)

**AGC settings and other filters disabled above should be returned to their previous state to resume standard operation of the Boson core. This is automatically done in the Boson App GUI.*

6.15.2 Camera Temperature

Boson provides capability to report its temperature via the *Camera Temperature* status variable. Accuracy of the measurement is ±5C°. This temperature represents that of the sensor and is the value used to determine the proper NUC table (see Section 5.2) and to trigger FFC (see Section 6.6Flat-Field Correction).

Boson also provides capability to report the temperature of its internal signal-processing engine via the *Core Temperature* status variable. This temperature is the value used by the overtemp logic described in Section 7.2.

6.15.3 Status Indicators

Boson provides a number of status indicators, reported via the telemetry line (see Section 0), via the CCI, and in some cases as optional symbol overlays on the video signal. These indicators are listed below. See the referenced sections for context and/or more detailed information.

NOTE: The text below describes the factory-default location and appearance of each symbol overlay, but it is possible to change any attribute of these status-indicating symbols. For example, rather than a solid green rectangle appearing in the upper right of the video signal during FFC, it is possible to configure Boson to display text or any other symbol (including an uploaded bitmap file) at any location. It is also possible to disable any or all of the status-indicating symbols such that they do not appear.

- *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 7.9 defines each of the FFC states. By factory default, a small solid green square will appear in the upper right of the post-colorization video signal when FFC state = “FFC imminent” or “FFC In Progress”. (See Figure 35 in Section 6.11.)
- ***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 7.9 for detailed description of the conditions which cause the flag to be set. By factory default, a small unfilled square (green border) will appear in the upper right of the post-colorization video signal whenever the *FFC Desired* flag is set. (See Figure 36 in Section 6.11.)

- *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 5.2 for more details.) When in automatic FFC mode, this flag is never set because instead an automatic table switch takes place. By factory default, a red circle will appear in a location which circumscribes the *FFC Desired* symbol whenever the *Table Switch Desired* flag is set. (See Figure 37 in Section 6.11.)
- *Current NUC Table*: The *Current NUC Table* variable indicates the current NUC table in which the camera is operating. As described in Section 5.2, a value of 0 indicates Boson is in low-gain state while a value of 1, 2, or 3 indicates Boson is in high-gain state. There is no symbol overlay symbol to indicate this status directly. However, when Boson is operating in low-gain state, a purple "L" will appear by factory-default in the lower-left of the post-colorization video signal. (See Figure 38 in Section 6.11.)
- *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 6.5 and Section 7.9 for more information regarding the Table Switch command. There is no symbol overlay symbol to indicate this status. However, when *Desired NUC Table* differs from *Current NUC Table*, the *Table Switch Desired* flag described above is set.
- *Overtemp*: The *Overtemp* flag indicates the camera has exceeded its maximum operating temperature and will automatically enter Low-Power state. See Section 7.2 for more information regarding the Overtemp feature and Low-Power state. By factory default, a text warning will appear in the center of the display whenever the *Overtemp* flag is set. (See Figure 39 in Section 6.11.)
- *Low-Power State*: The *Low-Power* flag indicates the camera is in Low-Power state, typically the result of an overtemp event. See Section 7.2 for more information regarding the Overtemp feature and Low-Power state. There is no symbol overlay associated with Low-Power State because the video signal is disabled when in this state. The telemetry line will enable the Low-Power flag one frame before Boson enters the Low-Power state.

6.15.4 Scratchpad (Jffs2 storage location)

Boson allows up to 2.5 MB of file storage in the jffs2 MEM location within the camera's non-volatile memory. Nearly any file type can be loaded into this space if written and read according to the guidelines specified in Boson Software IDD. The Scratchpad feature shares space used by symbology, so the more custom symbols that are saved, the less space remains for scratchpad storage. The write process can be time-consuming (e.g. >90 seconds to write a 2.5MB file), and it is not recommended for routine use.

6.16 Upgradeability / Backward Compatibility

Fielded Boson cameras can be updated with new software releases via the CCI; however, at the time of writing, updates to R3.0 are not supported. It is anticipated this limitation will be overcome in the near-future by a revised update procedure. Because radiometric capability requires a factory-calibration process, it will not be possible to upgrade a fielded camera to radiometrically capable via a software upgrade.

Boson provides fault-tolerant software upgradeability, meaning that if power to the camera 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 camera 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.

NOTE: While upgrading a core to a newer release is always guaranteed, downgrading a core to an older release (even to a version used prior to a field upgrade) is not.

6.17 External Synchronization

Beginning with Release 2.1, Boson provides capability to either:

- Slave its frame rate to a pulse train received on the EXT_SYNC pin (Sync Mode = Slave)
- Generate its own frame timing, nominally 60.0Hz (Sync Mode = Master or Disabled)
    - Optionally transmit a pulse train on the EXT_SYNC pin intended to facilitate synchronizing frame rate of another camera (Sync Mode = Master).

By factory-default, Boson operates in “Disabled” Sync mode, in which case it neither responds to an input signal nor generates an output signal on EXT_SYNC.

Figure 47 illustrates the relationship between EXT_SYNC and camera’s input and output timing when in Master mode or Slave mode. In Master mode, the camera *generates* the EXT_SYNC pulse, while in Slave mode, the camera *responds* to an externally-generated EXT_SYNC pulse. In both cases, the start of readout from the sensor occurs 0.5 msec after the rising edge of EXT_SYNC. Readout from the sensor is the input to Boson’s signal-processing pipeline; the lag between that and the output from the pipeline is referred to as latency and is described in Section 5.10.

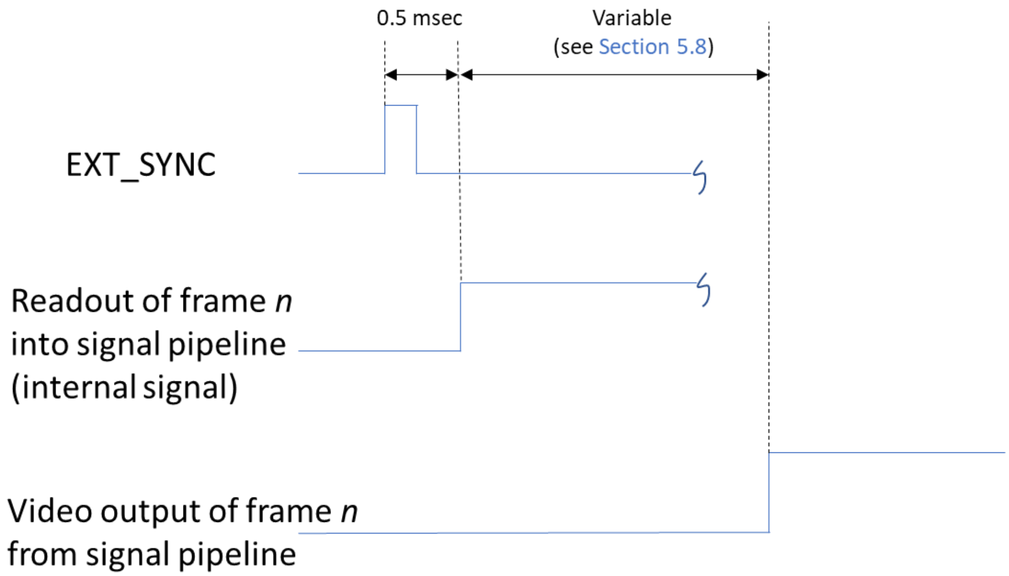


Figure 47: Timing relationship between EXT_SYNC and video output

There are several noteworthy caveats regarding Sync mode:

- Only fast Boson configurations provide Master and Slave capability. The command to specify Sync mode is invalid for slow Boson configurations (<9Hz frame rate).
- In Slave mode, Boson responds to the rising edge of an externally-generated EXT_SYNC pulse. Recommended pulse width is ≥90 nsec. In master mode, the output pulse width is nominally 4 row periods.
- Boson's sensor assembly is factory-calibrated in free-running mode at a frequency of 60.0Hz. As is generally the case for most thermal cameras, operating Boson's sensor in Slave mode at a frequency vastly different than that used for calibration can result in degraded image quality. FLIR has validated image quality to be comparable to that in free-running mode for frequency in the range 60.0 ±0.25Hz.
    - Much lower external-sync frequencies are possible; however, performance is expected to be significantly compromised as frame rate is reduced outside the recommended range, particularly non-uniformity as camera temperature is varied. More frequent FFC is recommended when operating in this manner. It is also worth noting that if EXT_SYNC is provided in "bursts" (e.g. a nominal frequency near 60Hz but with occasional long gaps between pulses), image quality may be compromised for several seconds after the pulse train resumes while the sensor returns to its steady-state temperature.
    - The highest supported sync frequency is 60.4Hz. Any EXT_SYNC pulse sent ≤16.56 msec after a previous pulse will be ignored. For example, if a pulse train is sent at a rate of 60.5 Hz (= 16.53 msec between pulses), every other pulse will be ignored, resulting in readout rate of 30.25Hz (= 33.06 msec between output frames).
- When operating in Averager-enabled mode (see Section 5.1 and Section 7.3), EXT_SYNC rate in Master mode will continue to be 60.0Hz even though output frame rate is 30.0 Hz. Similarly, in Slave mode, EXT_SYNC must be provided at twice the expected output rate. For example, if an output frame rate of 30.0Hz is expected, EXT_SYNC pulses should be provided at a rate of 60.0Hz. This is because Boson's sensor must generate two input frames for each output frame from the Averager function when it is enabled.
- In either Master mode or Slave mode, CMOS Output mode should be set to "one-shot" (see Section 7.14) if it is intended for the CMOS frame rate to match the frequency of the EXT_SYNC pulse train. In "continuous" CMOS-Output mode, CMOS frame rate is locked at 60.00Hz (even if sensor frame rate is not 60.00Hz) by duplicating or dropping frames as necessary.

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
- Overtemp and Low-Power States
- Averager Modes
- Frame-Skip Modes
- Isotherms Modes
- Telemetry Modes
- Radiometry Modes
- Gain Modes and States
- FFC Modes and States
- Lens Modes
- AGC Modes
- CMOS Video-Tap Modes
- CMOS Color-Encoding Modes
- CMOS Output Modes
- Analog Modes
- Sync Modes

7.1 Start-Up States

Boson provides four start-up states. In most cases, the transitions between states are the result of explicit action from the user, indicated by **bold text** in Figure 48. 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.

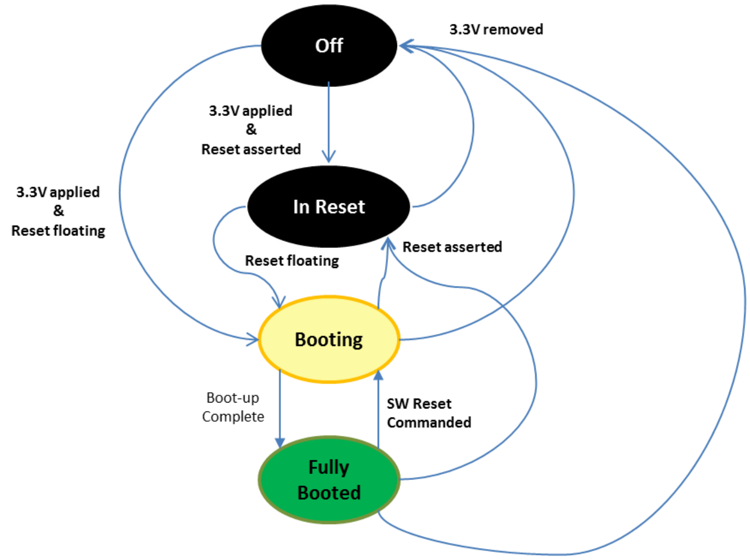


Figure 48: Boson Start-Up States

- **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). Note that the Reset pin is asserted low.
- **Booting**: In the "Booting" state, Boson is loading its program and initializing itself for full operation. Note that the reset pin must be floating for Boson to exit from the "Booting" state to the "Fully-booted" state.
- **Fully Booted:** In the "Fully-booted" state, Boson is fully functional, producing imagery, and capable of responding to commands via the CCI.

NOTE: It is not strictly necessary to connect the reset pin to power on the Boson camera, but it must be floating when the camera is in the "Booting" state, not tied to 1.8V or ground.

NOTE: It is recommended to avoid sending commands via the CCI while the camera is in any state other than 'fully booted'. This is indicated by output of imagery on the CMOS and/or USB channels.

NOTE: Avoid using the reboot command in the CCI to trigger a Boson reset. Using the reset pin or a full power cycle is advised.

7.2 Overtemp Modes and States

Release 2 configurations of Boson provides two overtemp shutdown modes:

- **Enabled (factory default):** The camera automatically transitions to a low-power state when internal core temperature exceeds the maximum safe value. The camera is capable of responding to commands in the low-power state, but the image pipeline is deliberately disabled to reduce power dissipation and thereby reduce core temperature. As illustrated in Figure 49, the transition between the normal imaging state and the low-power state is via a temporary "overtemp" state, as described below.
- **Disabled:** The camera transitions to the overtemp state but not to the low-power state in response to core temperature exceeding the maximum safe value. This mode is provided strictly for mission-critical applications (such as firefighting) in which it is essential to extend mission life as much as possible, even at risk of permanent damage to the core. Because of the high risk of damage resulting from extended operation in the overtemp state, operation in the "Overtemp Shutdown Disabled" mode voids the camera warranty.

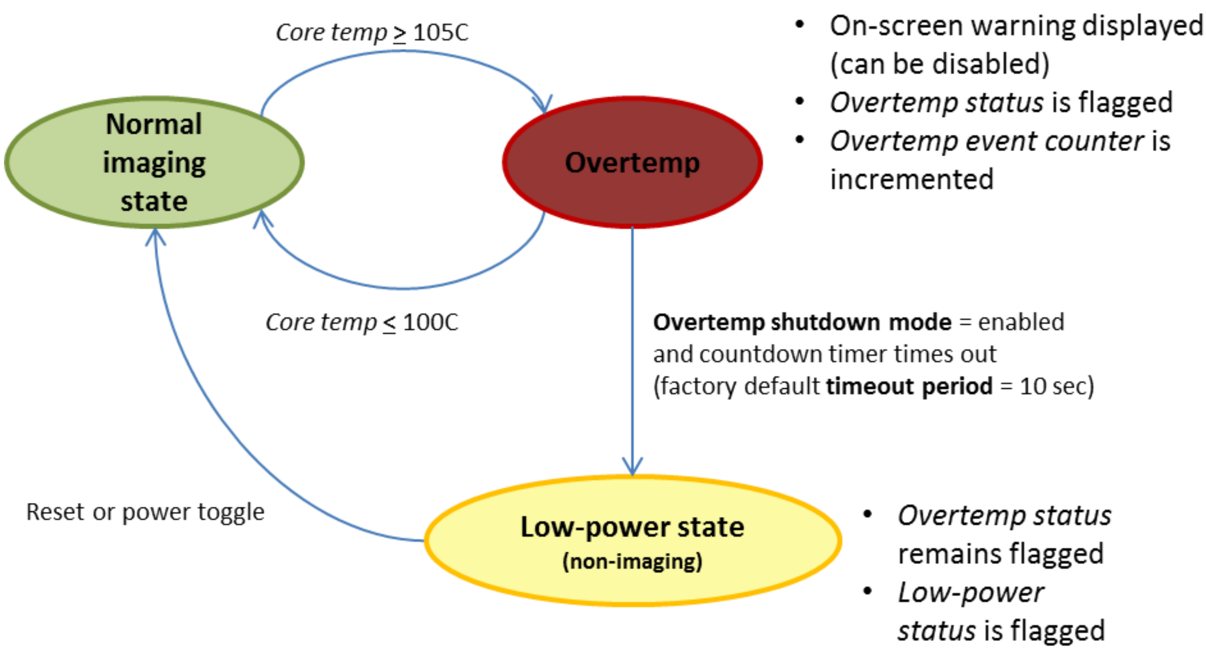


Figure 49: Boson Overtemp and Low-power States

- **Normal Imaging State to Overtemp State**: When the camera's internal core temperature exceeds its maximum safe value, 105C, the camera automatically transitions to the overtemp state. In this state, an *overtemp status flag* is set (Bit 8 of the status bits provided in columns 38 – 41 of the telemetry line, see Section 0), an *overtemp event counter* is incremented (columns 83 and 84 of the telemetry line), and the on-screen warning shown in Figure 39 is provided on the post-colorize / symbol overlay video tap. (It is possible to disable the display of the on-screen warning. See Section 6.11.) A countdown timer starts when the camera first enters the overtemp state. The factory-default **timeout period** of the countdown timer is 10 seconds.
- **Overtemp State to Normal-Imaging State**: If core temperature falls into a safe operating range (≤ 100C) while the camera is still in overtemp state, a transition back to normal-imaging state takes place. The *overtemp status f*lag is cleared, the on-screen warning is removed, and the countdown timer is stopped and restored to its starting value.
- **Ovetemp State to Low-Power State**: Unless **overtemp shutdown mode** has been set to "disabled" (as described above), the camera automatically transitions from overtemp to the low-power state when the overtemp countdown timer times out. In low-power state, the camera continues to respond to commands sent over the CCI, but the image-processing pipeline is disabled, causing no further output frames to be provided at the

video channels. The fact that the camera is in the low-power state can be ascertained via a *low-power status flag* readable via the CCI. The same status is also provided in the telemetry line (Bit 7 of the status bits provided in columns 38 – 41 of the telemetry line) on the very last frame before the camera transitions from overtemp state to low-power state. It is also worth noting that the camera's *core temperature* value can be read via the CCI while in the low-power state.

- **Low-Power State to Normal Imaging State**. The only exit from the low-power state is by toggling camera power or by reset (by asserting the reset signal or via a reset command). Note that if the camera's core temperature is still above maximum safe value after reset, the entire process will start over again. That is, the camera will immediately transition back into the overtemp state.

The factory default value of the **timeout period** of the overtemp countdown timer is 10 sec, but it can be varied between 0 and 20 seconds. A value of 0 is treated as an exception. Instead of causing the camera to immediately transition from overtemp to non-imaging state (i.e., a zero-second stay in the overtemp state), a value of 0 causes the camera to *never* transition to the low-power state. That is, a value of 0 is effectively treated as infinity and is therefore an alternative means of preventing automatic transition to low-power state.

NOTE: It is highly recommended to leave the **overtemp shutdown mode** at "enabled" and the **timeout period** of the overtemp countdown timer to a value between 1 and 20 seconds. Setting **overtemp shutdown mode** to "disabled" and/or setting the **timeout period** to 0 seconds (which is treated as an exception, as described above) voids the camera warranty.

NOTE: See Section 6.15.2 for the distinction between *Camera Temperature* and *Core Temperature*. The latter is the relevant variable for triggering the overtemp and low-power states.

NOTE: See Section 9.1 for recommended heatsinking practices to avoid an overtemp condition.

7.3 Averager Modes

Boson provides two averager modes affecting the video output signal:

- **Averager disabled (factory default)**
- **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.

NOTE: Intended use case is that the averager mode is specified and saved as a power-on default (see Section 6.1). Beginning with Release 2.0.6, a change to averager mode will not affect frame rate on the current power cycle. To change frame rate, the change to the averager mode must be saved as a power-on default and then the camera reset or power cycled. If the change to averager mode is not saved as a power-on default, the selection is inconsequential since it has no effect on the current power cycle.

7.4 Frame-Skip Modes

Boson provides 7 Frame-Skip settings affecting the output frame rate:

fs value	Output Frame rate (fps) (assuming Averager disabled)
0 (factory default)	60
1	30
2	20
3	15
4	12
5	10
6	~8.6

As described in Section 5.2, the primary benefit of frame skipping is power reduction for those applications which do not require a high frame rate. Relative power savings are shown in Figure 71.

7.5 Isotherms Modes

Beginning with Release 3.0, Boson provides two Isotherms modes:

- **Isotherms Disabled (factory default)**
- **Isotherms enabled**

For the Isotherms feature to provide the desired post-colorization output, each Isotherm region for each gain state (high-gain and low-gain) must be properly configured by specifying up to 39 parameters:

- Boundary Units: Percentage, Kelvin, Celsius, and Fahrenheit
- 8 Boundary Values: Lower-Boundary for Regions 1 -4 in high-gain state and in low-gain state.

    - The lower boundary of Region 0 is always min value.
    - The upper boundary of Regions 0 – 3 are the lower boundaries of Regions 1 – 4.
    - The upper boundary of Region 4 is always max value.
- 10 Colorization Modes: Mode for Regions 0-4 in high-gain state and in low-gain state. See Section 6.2.1 for a description of the Colorization Modes.
- Up to 20 Color Values: Color 1 and Color2 for Regions 0 -4 in high-gain state and low-gain state. Note that some Colorization modes require less than 2 colors. (Some require none.) For those modes, the unused Color Values can be left at factory-default values or set to any value.

7.6 Telemetry Modes

Boson provides three telemetry modes affecting the CMOS output signal:

- **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.
- **Telemetry encoding** determines how the telemetry line is provided on the CMOS pins:
    - **16b mode**: In this mode, the factory-default, each telemetry datum is provided as a 16b word on cmos_data[0-15].
    - **8b mode**: In this mode, each telemetry datum is provided as two consecutive bytes (big-endian order) on cmos_data[0-7]. Consequently, twice as many clock periods are required to transmit the data, so each datum takes up twice as many “pixels” compared to 16b mode.
    - **8b-swapped mode (“Y”mode)**: This mode is identical to 8b mode except bytes are provided in little-endian order (least-significant byte provided first).

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.

7.7 Radiometry Modes

For radiometrically capable configurations, Boson provides three radiometric output modes:

- **Radiometry Disabled (T-linear Enable/Disable has no effect on output):** 16b output varies with both scene flux and camera temeprature.
- **Radiometry Enabled, T-linear Disabled:** 16b output value is intended to be proportional to scene-flux only and independent of the camera temperature.
- **Radiometry Enabled, T-linear Enabled:** 16b output value is intended to be proportional to scene-temperature.

See Section 6.2 for a more detailed description of each radiometry mode.

NOTE: For non-radiometric configurations, it is not possible to enable radiometry.

7.8 Gain Modes and States

As described in Section 6.5, 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 and does not signal *Table Switch Desired* in response to scene conditions.
- **Low-gain mode**: Boson operates in low-gain state only and does not signal *Table Switch Desired* in response to scene conditions.
- **Automatic gain mode:** In automatic FFC mode and (see Section 7.9), Boson automatically transitions between high-gain state and low-gain state based on scene conditions and user-specified parameters. In manual and external FFC mode, *Table Switch* Desired is set based on scene conditions and user-specified parameters. See Section 6.5 for a detailed description of the parameters.

7.9 FFC Modes and States

Boson provides four different FFC modes:

- **Automatic (factory default for configurations with a shutter):** The camera periodically performs automatic FFC in response to a number of conditions, as described in more detail in Table 7. (See Section 6.6 for a more general description of the FFC feature.)
- **Manual:** The camera may perform automatic FFC at start-up, depending upon whether or not a valid non-volatile FFC map is stored (as described in Section 7.9.1). Thereafter, it only performs FFC upon command. The camera sets an *FFC Desired* flag under a number of conditions described in Table 7.
- **External (factory default for shutterless configurations):** 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 uniform source must be held in place until the FFC State changes from *FFC In Progress to FFC Complete*, as described below.) The camera sets an *FFC Desired* flag under a number of conditions described in Table 7.
- **External with Auto Table Switch:** The FFC behavior is the same as External, however the camera will switch temperature tables automatically when a desired. Boson does not automatically perform an FFC when the new table is loaded and does not signal *Table Switch Desired* in response to scene conditions.

Table 7: 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	Behavior in External with Auto Table Switch
Start-up	Automatic FFC take place	If a valid NVFFC map is stored (see Section 7.9.1), it is loaded. Otherwise, automatic FFC takes place.	If a valid NVFFC map is stored (see Section 7.9.1), it is loaded. Otherwise *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**	Automatic FFC take place	*FFC Desired* is set		

Condition	Behavior in Auto FFC mode	Behavior in Manual FFC mode	Behavior in External FFC mode	Behavior in External with Auto Table Switch
Camera is outside the temp span of the current high-gain NUC Table while in high-gain state (see Section 5.2)	Automatic NUC Table switch takes place, followed by automatic FFC	*Table Switch Desired* is set. *Desired NUC Table* is set to the optimal NUC-table value (which will differ from *Current NUC Table)*. See note 4.		Automatic NUC Table switch takes place; *FFC Desired* is set
While in automatic gain mode, scene conditions are sufficient to trigger a gain-state change (i.e., from high to low or vice versa). See Section 6.5.	Automatic gain switch takes place, possibly followed by automatic FFC as described in note 3.	*Table Switch Desired* is set. *Desired NUC Table* set to the optimal NUC-table value (which will differ from *Current NUC Table*).		Automatic gain switch takes place, possibly followed by *FFC Desired* flag being set as described in note 3.
Table Switch Commanded while *Table Switch Desired* is set.	n/a (*Table Switch Desired* is never set.)	NUC table switch takes place and *Table Switch Desired* is cleared, possibly followed by automatic FFC as described in note 3.	NUC table switch takes place and *Table Switch Desired* is cleared, possibly followed by *FFC Desired* being set as described in 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 as described in note 3.		Gain switch takes place, possibly followed by *FFC Desired* flag being set as described in 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 0) 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 **Error! Reference source not found.**
- Note 2: From start-up until a time specified by **FFC Start-up Period**, the condition is instead |*Camera Temp* – Camera *Temp at Last FFC*| ≥ **FFC Delta Temp** / 3, as described in Section 6.6.
- 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, automatic FFC or a set 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.
- Note 4: FLIR System's Tau® camera core, a predecessor to Boson, automatically switches NUC tables without performing FFC when operating in external FFC mode. Beginning with Release 2.1, Boson provides capability to configure external FFC mode to behave the same as Tau (automatic table switch) rather than setting Table Switch Desired and requiring the host to explicitly command a table switch.

Examples of FFC behavior when transitioning between gain states:

- With the camera in automatic FFC mode and high-gain mode, FFC is commanded while *Camera Temperature* has a value of 3000 (300.0K). Following FFC, *Camera Temperature at Last FFC* = 3000 (300.0K). **FFC Temp Delta** is at its factory-default value, 30 (3.0C).
- When *Camera Temperature* = 301.0K, the camera is commanded into low-gain mode for the first time. Gain switch takes place, and now *Camera Temperature at Last FFC* = 0 since FFC has never been performed in low-gain state. Consequently, automatic FFC takes place, and now *Camera Temperature at Last FFC* = 3010 (301.0K).
- When the camera is at 302.0K, the camera is commanded into high-gain mode. *Camera Temperature at Last FFC* = 3000 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* = 3010 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 an automatic FFC takes place because |*Camera Temperature* - *Camera Temperature at Last FFC*| ≥ **FFC Temp Delta**. Following FFC, *Camera Temperature at Last FFC* = 3040 (304.0K) and *FFC Desired* is cleared.
- With temperature still at 304.0K, the camera is commanded to high-gain mode. Now *Camera Temperature at Last FFC* = 3000, and another 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 50.

1. *FFC not initiated* (power-on default): In this state, Boson applies no FFC terms. In automatic FFC mode, this state is never seen because Boson always 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.

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), 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.

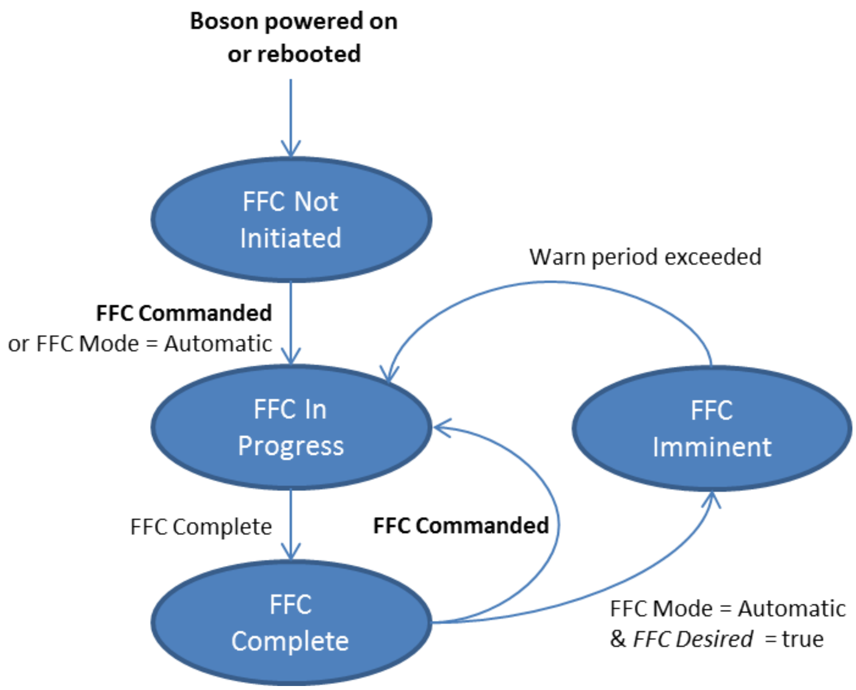


Figure 50: Boson FFC States

7.9.1 Non-volatile FFC

The Boson Release 2 configuration provides the option to store the current FFC map to non-volatile memory. The intent of the feature is to support a faster transition from start-up to useable imagery, particularly in those cases where the camera has only been powered down briefly since the last FFC.

When the camera receives the command to store the current FFC map, it also stores the value of "Camera temperature at last FFC" (the same value reported in the telemetry line, as shown in Table 5 of Section 0) as well as the current NUC table. (See note 2 of Table 7 for a description of NUC tables.) The next time the camera powers up, the decision to utilize the stored NVFFC map depends upon FFC mode, as described below.

- Automatic FFC: The camera does not load the stored NVFFC map but always performs automatic FFC instead. If the option of a faster start-up is desired, the power-on default FFC mode should be set to manual mode instead.
- Manual FFC: If the stored NVFFC map was generated in the same NUC table as the start-up NUC table, then it is loaded and applied. Otherwise, an automatic FFC takes place under the assumption that the stored map is invalid for the current conditions (i.e., will result in sub-optimal image quality). If the map is loaded, the value of “Camera temperature at last FFC” will be set to the value stored with the NVFFC map, and the value of “Frame counter at last FFC” will be set to 0. Note that the *FFC Desired* flag may be set immediately after the NVFFC map is loaded, assuming the difference between current camera temperature and “Camera temperature at last FFC” exceeds the value of **FFC Delta Temp**, as depicted in Table 7.
- External FFC: If the stored NVFFC map was generated in the same gain state as the start-up gain state (see Sections 6.2 and 7.7), then it is loaded and applied. Otherwise, no FFC offset is applied (and the *FFC Desired* flag will be set) under the assumption that the stored map is invalid for the current conditions. If the map is loaded, the value of “Camera temperature at last FFC” will be set to the value stored with the NVFFC map, and the value of “Frame counter at last FFC” will be set to 0. Note that the *FFC Desired* flag may be set immediately after the NVFFC map is loaded, assuming the difference between current camera temperature and “Camera temperature at last FFC” exceeds the value of **FFC Delta Temp**, as depicted in Table 7.

NOTE: Generally speaking, it is always preferred to generate a fresh FFC map at start-up rather than relying on a stored, potentially stale NVFFC map. The NVFFC feature is intended primarily for the case in which a camera has only been powered down briefly since the previous FFC. Use of the NVFFC feature does not replace the recommendation to perform FFC at start-up, even for shutterless configurations.

7.10 Lens Mode

Boson provides two lens modes:

- **Lens 0 (factory default)**
- **Lens 1**

The primary intent of multiple lens modes is to support a dual-FOV lens assembly. For such a lens, the illumination pattern and the out-of-field irradiance may differ between the two FOVs, in which case better image quality can be obtained by switching the applied correction terms when switching the

FOV. This can be accomplished by toggling the lens mode, which causes the following terms to be swapped:

- Lens-gain map. (See Section 5.2)
- SFFC map. (See Section 5.2)
- NVFFC map. (See Section 7.9.1) The NVFFC map is only loaded at start-up, and the power-on default selection of lens mode determines which of the two will be loaded. Switching lens mode after start-up will *not* cause the other NVFFC map to load. Instead, the current FFC map will continue to be applied.

NOTE: For any Boson configuration which includes a factory-installed lens, Lens 0 is factory-calibrated and Lens 1 is empty. For lensless configurations, both Lens 0 and Lens 1 are empty, as it is intended that a lens-calibration procedure will be performed by the user after installing a lens assembly.

7.11 AGC Modes

As described in Section 6.8, Boson provides two AGC modes:

- **Information-Based Equalization Mode Enabled (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-Based Equalization Mode Disabled**: AGC transfer function weights all pixels equally.

NOTE: Unlike Release 1, automatic gain mode and AGC Information-Based Equalization are *not* mutually exclusive in a Release 2 Boson. That is, it is possible to enable automatic gain mode and Information-Based Equalization mode simultaneously.

7.12 CMOS Video-Tap Modes

As described in Section 5 and shown again in Figure 51, 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. Note that the Radiometry Modes described in Section 7.7 affect the Pre-AGC output tap.
- **Radiometry Enabled Pre-AGC (16-bit) (factory default with Radiometry enabled)**: On Radiometry enabled cameras the T-stable or T-linear tap point is available. See Figure 51 below, as well as Section 7.7.
- **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 7.13)**: 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 6.10) and specified color encoding mode (see Section 7.13).

NOTE: USB and CMOS video can access different tap points simultaneously. This is especially useful when Radiometric and Post-AGC data are required.

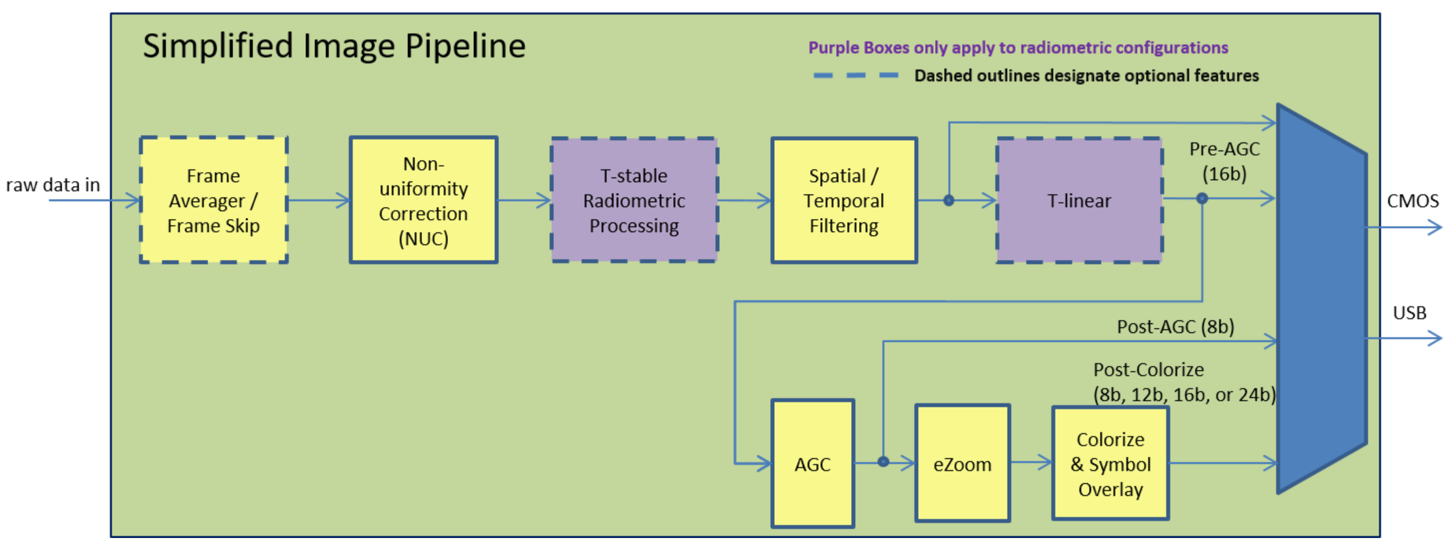


Figure 51: Boson Signal Pipeline

7.13 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 validated in the current software release. All remaining options shown below are capable of being selected but are not currently validated. FLIR does not recommend relying on any of these without thoroughly testing in the end application.

- **CrCbY 4:2:2 (16-bit per pixel)**: The signal is identical to YCrCb, but the CMOS_Data channels are swapped.
- **CbCrY 4:2:2 (16-bit per pixel)**: The signal is identical to YCbCr, but the CMOS_Data channels are swapped.
- **RGB 8:8:8 (24-bit per pixel)**: The signal consists of a red channel (8 bits per clock on CMOS_Data[n+1), a green channel (8 bits per clock on CMOS_Data[n]), and a blue channel (8 bits per clock on CMOS_Data[n+2]) where *n* = 0, 3, 6…
- **BGR 8:8:8 (24-bit per pixel):** The signal consists of a red channel (8 bits per clock on CMOS_Data[n+2), a green channel (8 bits per clock on CMOS_Data[n]), and a blue channel (8 bits per clock on CMOS_Data[n+1]) where *n* = 0, 3, 6…
- **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.

For reference, the color encoding of each mode is depicted graphically in Figure 52. Note the CMOS color-encoding mode has no effect on the video signal unless CMOS video-tap mode is “post colorize”.

Color Mode	Clk	CMOS_Data																							
		23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	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]							
CbCrY 4:2:2	0	Unused								Y0[7:0]								Cb[7:0]							
	1	Unused								Y1[7:0]								Cr[7:0]							
CrCbY 4:2:2	0	Unused								Y0[7:0]								Cr[7:0]							
	1	Unused								Y1[7:0]								Cb[7:0]							
RGB 8:8:8		R 0	B 0	G 0	R 1	B 1	G 1	R 2	B 2	G 2	R 3	B 3	G 3	R 4	B 4	G 4	R 5	B 5	G 5	R 6	B 6	G 6	R 7	B 7	G 7
BGR 8:8:8		B 0	R 0	G 0	B 1	R 1	G 1	B 2	R 2	G 2	B 3	R 3	G 3	B 4	R 4	G 4	B 5	R 5	G 5	B 6	R 6	G 6	B 7	R 7	G 7
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]							

Modes which are highlighted in gray are implemented but have not been validated in the current product release. Use is discouraged without thorough testing

Figure 52: Boson's Various Color-Encoding Modes

7.14 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:

- **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. In this mode of operation, every frame is unique. That is, the output frame rate is equal to the effective frame rate. This mode of operation is preferred for interfacing to a frame grabber which can tolerate slight frame-rate jitter. It is also the preferred mode when in external-sync (slave) mode. For Slow configurations, with averager disabled, the frame rate is 8.6Hz and the frame counter increments by 7. 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.

- **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 frame data at a regular interval.

NOTE: For Slow configurations, the output 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 to reduce the effective frame rate. The effective frame rate is the rate at which new frames of the sensor and frame rate of data are provided on the output channel are nominally identical. 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 it enabled. 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.

NOTE: For Fast configurations, since the effective frame rate and the output frame rate are nominally identical in free-running mode, it is very uncommon to find duplicated frames in continuous mode. The presence of a duplicated frame can be detected via the frame counter in the telemetry line since the frame counter does not increment for a duplicated frame.

7.15 Analog Modes

Boson provides the option of outputting a BT.656 signal using the pins normally used to provide the CMOS video channel. This capability is utilized by the the FLIR USB / Analog VPC Accessory (see Section 16.2) to obtain analog video output. There are three “analog modes”:

- **Analog Disabled (factory default)**: The CMOS channel is configured to output video according to the timing and logic described in Section 8.2.1.
- **NTSC:** The CMOS channel is configured for BT.656 output at 60Hz frame rate, outputting 525 lines per frame (525/60).
- **PAL:** The CMOS channel is configured for BT.656 output at 50Hz frame rate, outputting 625 lines per frame (626/50).

When the CMOS channel is configured for BT.656 output, cmos_vsync, cmos_hsync, and cmos_data_valid are unused, as are cmos_data[8-23]. That is, only cmos_pclk and cmos_data[0-7] are utilized, with the most-significant bit provided on cmos_data7, and the least significant bit provided on cmos_data0. Clock rate remains 27 MHz when the channel is configured for BT.656 output.

There are several noteworthy caveats regarding Boson’s BT.656 output signal:

- The output is single-ended, not differential.
- Digital line alignment does not follow the BT.656 standard exactly. Specifically, in a strictly-compliant implementation, each video line begins with an EAV code, then blanking, then SAV code, then Video Data. In Boson, digital alignment is achieved by observing EAV/SAV pairs only when only the “H’ bit is changing, making it a non-standard implementation. FLIR has not seen any resulting problems from this.
- No scaling of BT.656 output (vertical or horizontal) is supported in Boson Release 1 and 2.
- FLIR has observed some image pulsing on older CRT monitors. LCD monitors are recommended for optimal analog display.
- BT.656 limits output to values within the range 16 to 235. Because the BT.656 channel and the USB channel both receive data from a common output buffer, the post-AGC USB video format will also be limited to values within the range 16 to 235 when Analog mode is set to NTSC or PAL.

When Boson is mated with the FLIR USB / Analog VPC Accessory, it automatically detects a video encoder on the accessory and will not normally allow the NTSC or PAL modes to be selected unless this video encoder is detected. It is possible (and necessary) to override this automatic detection feature for applications which intend to utilize the BT.656 output without installing the FLIR USB / Analog VPC Accessory. This override is accomplished via command over the CCI.

NOTE: When analog mode is set to NTSC or PAL, Boson automatically sets the CMOS Video-Tap Mode to Post Colorization (see Section 7.12), the CMOS Color-Encoding Mode to YCbCr 4:2:2 only (see Section 7.13), and the CMOS Output Mode to Continuous (see Section 7.14). These are required settings, and changing any of them will prevent the BT.656 channel from functioning properly. It is not recommended to operate in External Sync (slave) mode (see Section 7.16) when analog mode is set to NTSC or PAL.

NOTE: When the averager mode is set to enabled, the BT.656 output channel continues to provide data at either 60Hz (NTSC mode) or 50Hz (PAL mode) by duplicating every frame at the output.

7.16 Sync Modes

Boson provides 3 different Sync modes:

- **Disabled Mode (factory default):** The camera generates its own timing and ignores any externally-generated sync signal provided on EXT_SYNC. Furthermore, no output signal is provided on EXT_SYNC.
- **Master Mode:** The camera generates its own timing and ignores any externally-generated sync signal provided on EXT_SYNC. However, it outputs a pulse on EXT_SYNC corresponding to the start of readout from the sensor of each new frame.
- **Slave Mode:** The camera only generates new frames in response to a sync pulse provided on EXT_SYNC.

See Section 6.17 for a more complete description and associated requirements of each Sync Mode.

NOTE: Only fast configurations support Master and Slave Modes. Slow configurations only operate in "Disabled" Mode.

8 Interface Descriptions

This section describes the primary electrical interfaces to the camera:

- Command and Control Interface, page 106
- Video Interfaces, page 110

8.1 Command and Control Interface

Boson provides two options for a command and control interface (CCI):

- UART (for asynchronous serial interfaces such as RS232), 921600/8-N-1 (921.6kBaud, 8 data bits, no parity bit, 1 stop bit)
- USB virtual serial port

Each interface is described in a separate document, the Boson Software Interface Description Document (IDD), FLIR document #102-2013-42. For both CCI channels, the Boson core is a "slave" device which never transmits a message without first receiving one and always transmits a reply to a received message. 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 8 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).

Note: Table 7 to be updated for Release 3.0 in a later revision.

Table 8: 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			
Overtemp Mode	Enabled	7.2	n/a
Averager Mode	Disabled	7.3	28
Telemetry Mode	Enabled	7.4	n/a
Isotherm Mode	Disabled	7.5	n/a
Gain Mode	High	7.7	38
FFC Mode	Automatic (shuttered configs), External (shutterless configs.)	7.9	n/a

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
AGC Mode	Information-Based Equalization enabled	7.9.1	n/a
Lens Mode	Lens 0	0	n/a
CMOS Video-Tap Mode	Pre-AGC	7.12	n/a
CMOS Color-Encoding Mode	Continuous	7.13	n/a
CMOS Output Mode	Continuous	7.14	n/a
Sync Mode	Disabled (Free-Running)	7.16	156
Parameter Controls			
Telemetry Location	Header	7.4	n/a
Telemetry Encoding	16b	7.4	n/a
Gain-switch High-to-Low Temperature Threshold	90	6.2	n/a
Gain-switch High-to-Low Population Threshold	5	6.2	n/a
Gain-switch Low-to-High Population Threshold	98	6.2	n/a
Hysteresis	95	6.2	n/a
FFC Period	1200 (20 minutes)	6.6	n/a
FFC Delta Temp	30 (3.0 Celsius degrees)	6.6	n/a
FFC Integration Period	8 (8 frames)	6.6	57
FFC Warn Period	20 (2 seconds)	6.6	n/a
FFC Start-Up Period	150 (2.5 minutes)	6.6	n/a
Plateau Value	7%	6.8.2	n/a
Tail Rejection	0	6.8.3	n/a

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
Max Gain	1.38	6.8.4	n/a
Linear Percent	20%	6.8.5	n/a
ACE	0.97	6.8.6	n/a
DDE	0.95	6.8.7	n/a
Smoothing Factor	1250	6.8.8	n/a
AGC ROI Start Row	0	6.8.9	n/a
AGC ROI Start Col	0	6.8.9	n/a
AGC ROI End Row	255	6.8.9	n/a
AGC ROI End Col	319	6.8.9	n/a
Damping Factor	85%	6.8.10	n/a
Zoom Factor	0	6.9	n/a
Zoom-Center Column	160	6.9	n/a
Zoom-Center Row	128	6.9	n/a
Color Palette	White Hot	6.10	n/a
Specify Symbol Attributes	n/a	0	n/a
Splash 1 Duration / Splash 2 Duration	0 (min time)	6.13	n/a
Splash 1 Background Color / Splash 2 Background Color	n/a	6.13	n/a
Operations			
SW Reset	n/a	7.1	n/a

Mode, Parameter, or Operation	Factory Default	Section in this Document	Telemetry Line Location
Set Defaults	n/a	6.1	n/a
Restore Factory Defaults	n/a	6.1	n/a
Perform FFC	n/a	7.9	n/a
Get Part Number	n/a		5-14
Get Serial Number	n/a		1-2
Read SW Revision	n/a		21-26
Write NVFFC	n/a	7.9.1	n/a
Erase NVFFC	n/a	7.9.1	n/a
Upload Symbol Bitmap	n/a	0	n/a
Upload Splash Screen	n/a	6.13	n/a
Erase Splash Screen	n/a	6.13	n/a

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. This is recommended for customers who require a visually pleasing image and radiometric data in parallel.

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 53:
    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 9. The value can be requested via command over the CCI. Note: in one-shot mode, it is possible that the width of *vsw* can vary slightly from the values shown in Table 9.
    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 9. Note that the number of *cmos_hsync* pulses during a frame will typically exceed *nr* because, as illustrated in Figure 53, *cmos_hsync* continues to be output at a regular interval even during the vertical sync and the blanking periods (i.e. even when cmos_data_valid is not being asserted).
    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 7.14.) In "continuous" CMOS output mode, this period is always 0 clocks.
3. Each row period consists of four distinct sections, as depicted in Figure 54:
    a. The horizontal sync period, during which the horizontal sync, *cmos_hsync*, is asserted. The width of the horizontal sync pulse, *hsw*, is 8 clocks, as depicted in Table 9. The value can be requested via command over the CCI.

b. A variable 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*, is not guaranteed, but its value can be requested via command over the CCI.

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 9.

d. A variable blanking period between the end of valid data and the end of the row period, referred to as the back porch. Like the front porch, the width of the back porch, *bp*, is not guaranteed but its value can be requested via command over the CCI. Given that *fp* and *bp* can vary, it is imperative that receiving electronics monitor *cmos_data_valid* to ascertain the start of valid pixel data on a row.

4. All signals in the CMOS channel are latched on the rising edge of the pixel clock, *cmos_pclk*, as illustrated in Figure 55. As shown in Table 10, 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. As shown in Table 10, The output frame rate is dependent upon CMOS Output mode (continuous or one-shot) and Averager mode (enabled or disabled). For Fast cameras, this would equate to a framerate of 30Hz or 60Hz respectively. For slow cameras, the output framerate is also 30Hz or 60Hz, 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 is either 8.6Hz (averager disabled) or 7.5Hz (average enabled), and no frames are duplicated.

6. As described in Section 7.12 and Section 7.13, 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

Color Mode	Clk	CMOS_Data

		23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	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]							
CbCrY 4:2:2	0	Unused								Y0[7:0]								Cb[7:0]							
	1	Unused								Y1[7:0]								Cr[7:0]							
CrCbY 4:2:2	0	Unused								Y0[7:0]								Cr[7:0]							
	1	Unused								Y1[7:0]								Cb[7:0]							
RGB 8:8:8		R 0	B 0	G 0	R 1	B 1	G 1	R 2	B 2	G 2	R 3	B 3	G 3	R 4	B 4	G 4	R 5	B 5	G 5	R 6	B 6	G 6	R 7	B 7	G 7
BGR 8:8:8		B 0	R 0	G 0	B 1	R 1	G 1	B 2	R 2	G 2	B 3	R 3	G 3	B 4	R 4	G 4	B 5	R 5	G 5	B 6	R 6	G 6	B 7	R 7	G 7
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]							
RBG 8:8:8Muxed	0									G[3:0]								R[7:0]							
	1									B[7:0]								G[7:4]							
RGB 5:6:5 Muxed	0									G[2:0]								R[4:0]							
	1									B[4:0]								G[5:3]							

7. Figure 56 below.

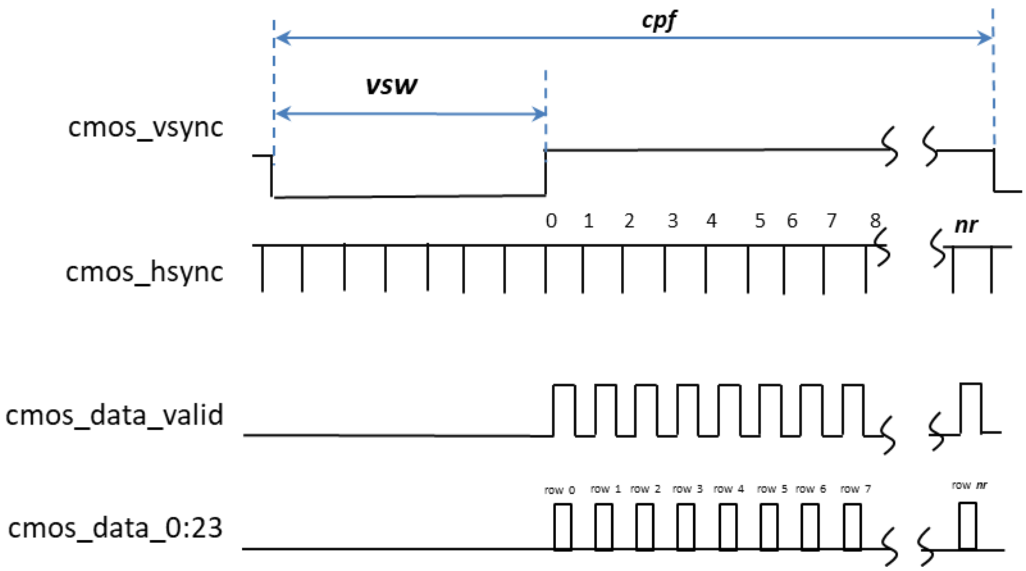


Figure 53: Frame Timing of the CMOS Output Channel

See Table 9 for the values of *vsw* and *nr*. See Table 10 for the value of *cpf*.

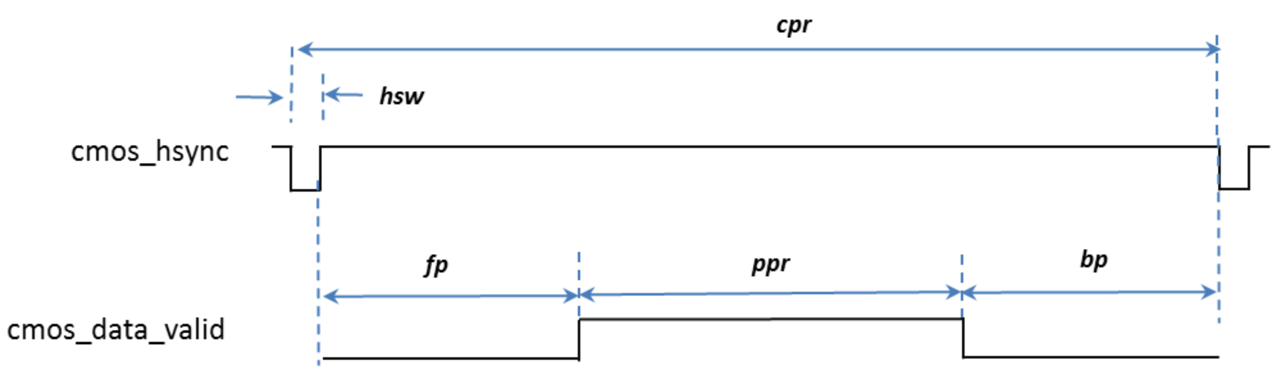


Figure 54: Line Timing of the CMOS Output Channel

See Table 9 for the values of *hsw*, *cpr*, and *ppr*. *fp* and *bp* are configuration dependent.

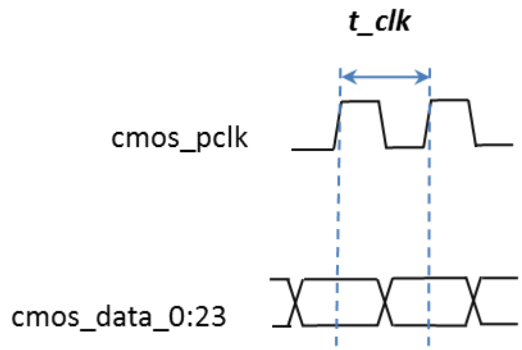


Figure 55: Phase of Pixel Clock relative to CMOS Data

See Table 10 for the value of *t_clk.*

Note: updated timing for frame-skip > 0 to be added in a later revision.

Table 9: Timing of the CMOS channel as a function of camera settings, values common to continuous and one-shot modes

CMOS Tap Point	320 Configuration: Pre-AGC and Post-AGC taps		320 Configuration: Post-Zoom / Post-Colorization tap 640 Configuration: All CMOS Tap Modes	
Telemetry	Disabled	Enabled	Disabled	Enabled
Vertical sync width, *vsw* (in row periods)	44	43	88	87
Vertical sync width, *vsw* (in clock periods)	66,000 [1]	64,500 [1]	66,000 [1]	65,250 [1]
Valid rows per frame, *nr*	256	258	512	514
Row periods per frame (*vsw* + *nr*)	300		600	
Horz sync width, *hsw* (in clocks)	8			
Pixels per row, *ppr*	320		640	
Clocks per row period, *cpr* (*hsw* + *fp* + *ppr*+ *bp*)	1500		750	

Note 1: Numbers are exact in Continuous mode. In One-Shot mode, the vertical sync width may be longer than shown due to idle time.

Table 10: Timing of the CMOS channel as a function of camera settings and configuration. Values differ between continuous and one-shot modes.

(a) Continuous mode settings, fast and slow configurations

CMOS Tap Point	320 Configuration: Pre-AGC and Post-AGC taps		320 Configuration: Post-Zoom / Post-Colorization tap 640 Configuration: All CMOS Tap Modes	
Averager	Disabled	Enabled	Disabled	Enabled
Clocks per frame, cpf (*cpr* x (*vsw* + *nr*))	450,000			
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) Fast Configuration, One-shot mode settings

CMOS Tap Point	320 Configuration: Pre-AGC and Post-AGC taps		320 Configuration: Post-Zoom / Post-Colorization tap 640 Configuration: All CMOS Tap Modes	
Averager	Disabled	Enabled	Disabled	Enabled
Clocks per frame, cpf (*cpr* x (*vsw* + *nr*)) See note 1	Varies, ≥450,000		Varies, ≥450,000	
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

Note 1: Additional clock periods of blanking are inserted as necessary at the end of the last row of valid data.

(c) Slow Configuration, One-shot mode settings

CMOS Tap Point	320 Configuration: Pre-AGC and Post-AGC taps		320 Configuration: Post-Zoom / Post-Colorization tap 640 Configuration: All CMOS Tap Modes	
Averager	Disabled	Enabled	Disabled	Enabled
Clocks per frame, cpf (*cpr* x (*vsw* + *nr*)) See note 1	Varies, ≥ 3,150,000	Varies, ≥ 1,800,000	Varies, ≥ 3,150,000	Varies, ≥ 1,800,000
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

Color Mode	Clk	CMOS_Data																							
		23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	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]							
CbCrY 4:2:2	0	Unused								Y0[7:0]								Cb[7:0]							
	1	Unused								Y1[7:0]								Cr[7:0]							
CrCbY 4:2:2	0	Unused								Y0[7:0]								Cr[7:0]							
	1	Unused								Y1[7:0]								Cb[7:0]							
RGB 8:8:8		R 0	B 0	G 0	R 1	B 1	G 1	R 2	B 2	G 2	R 3	B 3	G 3	R 4	B 4	G 4	R 5	B 5	G 5	R 6	B 6	G 6	R 7	B 7	G 7
BGR 8:8:8		B 0	R 0	G 0	B 1	R 1	G 1	B 2	R 2	G 2	B 3	R 3	G 3	B 4	R 4	G 4	B 5	R 5	G 5	B 6	R 6	G 6	B 7	R 7	G 7
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]							

Modes which are highlighted in gray are implemented but have not been validated in the current product release. Use is discouraged until a later field-upgradeable software release in which all modes are fully validated.

Figure 56: Encoding of the CMOS Output Channel for each Video-Tap Mode / Color-Encoding Mode

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 the video capture or viewing software selected by the user. 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 or 320x258 (if telemetry is desired) for the 320 configuration, 640x512 for the 640 configuration or 640x514 with telemetry. Telemetry is enabled by requesting two extra rows. Note that AGC settings, zoom settings, and color-encoding settings have no effect on the output signal at this tap point. Telemetry location can be altered to the top or bottom of the frame via the CCI. This option is identified with a UVC video format 4CC code of "Y16 " (16-bit uncompressed greyscale image). Three different output formats can be streamed from the Pre-AGC tap point, which are configurable via the CCI:
    - IR16: Standard 16-bit Pre-AGC tap point, default for non-radiometric cameras. T-stable tap point on radiometric cores.
    - T-linear: Direct T-linear tap point, only available on radiometric cores. See Section 6.2
- **Post-Colorize, YCbCr**: The output is transformed to YCbCr color space using the specified color palette (see Section 6.10). Resolution is 640x512 for both the 320 and 640 configurations. As described above, telemetry can be viewed by requesting a frame size two rows larger, 640x514. Three options are provided, identified via the UVC video format 4CC code:
    - I420: 8 bit Y plane followed by 8 bit 2x2 subsampled U and V planes
    - NV12: 8-bit Y plane followed by an interleaved U/V plane with 2x2 subsampling
    - NV21: same as NV12 except reverse order of U and V planes

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. This is the preferred mounting for radiometric capable cameras.

- **Lens Mounting:** Generally speaking, Boson should be supported at its lens for all Boson configurations for which the mass of the lens assembly is greater than the mass of the sensor engine. This condition is true for every lens which uses the M24 or M34 flange. (See Table 11 in Section 10). Each of those lens assemblies provides suitable features for mounting and sealing, as summarized in Figure 57. It is worth noting that even configurations which are mounted via the lens features require heatsinking via the rear surface. It is also worth noting that the correct orientation of the camera is with the connector located above centerline, as depicted in Figure 5. Rotating the camera 180 degrees such that the connector is below centerline rather than above will result in an upside-down image

NOTE: It is important that the lens does not experience consistent external force in the optical axis towards the sensor assembly. This can result in loss of focus.

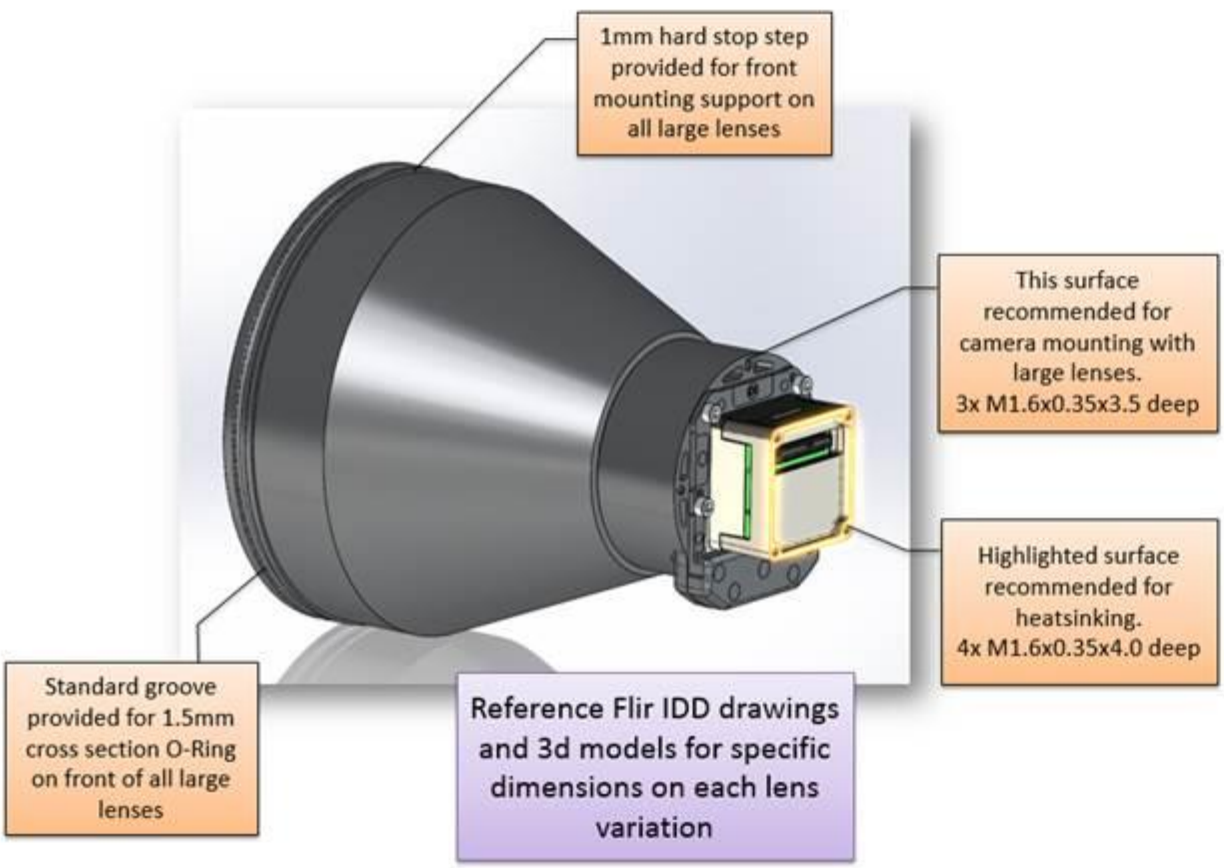


Figure 57: Mounting Guidance for Large-Lens Configurations

9.2 Sealing

Two options exist for environmentally sealing the camera – protruding the lens assembly through the enclosure (depicted in Figure 58a) and encapsulating the entire camera behind an LWIR-transparent window (depicted in 48b). To facilitate the option shown in Figure 58a, all Boson lens assemblies are rated to IP67 using the appropriate sealing interface. The larger lens configurations include an o-ring groove on the lens barrel, and the smaller lens configurations without this groove are intended to be sealed by inserting the camera through an o-ring groove in the enclosure. Refer to the lens variant specific mechanical IDD for details on this o-ring seal interface. It is important that this assembly process does not leave residual force compressing the lens towards the camera body.

For use in an abrasive or marine environment, the fully-enclosed sealing option (that shown in Figure 58b) is highly recommended. That is primarily because almost all the Boson lens assemblies provide a high-durability anti-reflection (HAR) coating qualified against mild abrasion (MIL-C-675C section 4.5.11, Moderate Abrasion) but not intended to withstand harsh abrasion (e.g., blowing sand) or salt fog. (The lone exception is the Boson 320 configuration with 92 deg HFOV. The lens installed on that configuration provides a diamond-like coating (DLC) qualified against harsh abrasion and $\geq$ 240 hours exposure to salt-fog.) The fully-enclosed option is also recommended in applications which are subject to highly dynamic temperature conditions (e.g., thermal shock, solar loading, convection currents, and other forms of non-symmetrical heat-loading / heatsinking). And the fully-enclosed option is also preferred when system de-icing is required. That is because heating a window is far less likely to produce thermal gradients within the camera compared to heating the camera's lens assembly. See FLIR's INU Application Note, available from the Boson website linked in Section 1.3, for more guidance on integrating the Boson camera into an end system.

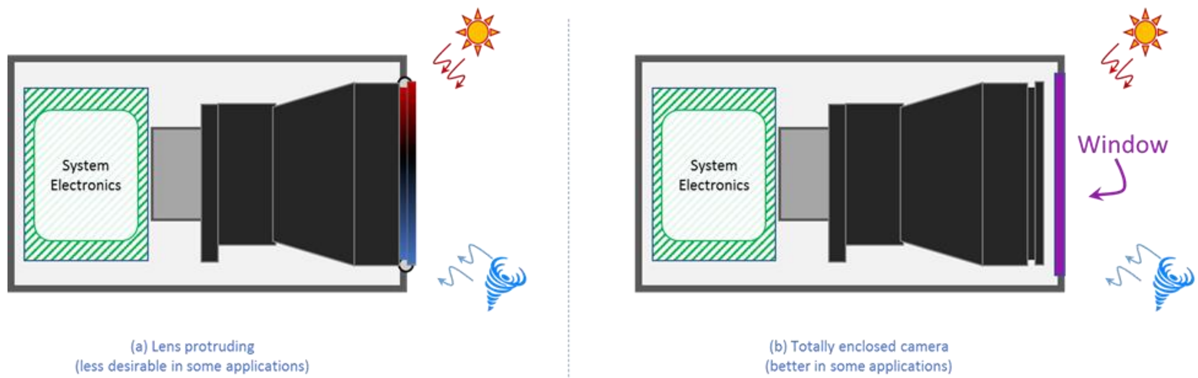


Figure 58: Two Camera-Enclosure Options

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 when exposed to humidity. 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 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 Section 1.3 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 (highlighted surface in Figure 57) must be maintained at a temperature at or below 80C at all times. If the camera's internal core temperature exceeds its maximum safe temperature, Boson signals an overtemp condition, and by factory-default, enters a low-power non-imaging state 10 seconds later. See Section 7.2 for a detailed description of this feature.

To the extent possible, Boson should be insulated from rapid thermal transients. Extreme thermal shock will reduce the effectiveness of calibration and degrade the quality of the image. For best results, the camera should be isolated from the thermal effects of window heaters, variable fans, and other intermittent thermal loads. It is particularly important to minimize temperature gradients across the camera, especially in the axes perpendicular to the optical line of sight. Avoid mounting conditions which expose the camera to asymmetric heating from heaters, high-powered devices, and other thermal loads. If convective cooling is required, airflow should be constant and as symmetric as possible about the optical line of sight.

9.5 Radiometric Implications

The thermal characteristics of the camera and its environment influence the out of field irradiance from the lens assembly, shutter assembly, and other internal components of the camera. Out of field irradiance is spurious signal not representative of the scene being imaged. Radiometric configurations of Boson undergo a factory-calibration process which includes compensation for out-of-field irradiance. However, operating the camera in a method substantially different than the configuration during calibration will degrade the quality of the compensation. All of the thermal considerations described in Section 9.4 are important not just for good image quality, but also for good radiometric accuracy. Consider the following for best radiometric results:

1) Provide adequate heatsinking to keep camera temperatures well under the operational maximum, preferably from the rear surface of the camera only.
2) Minimize conduction from any other camera surface other than the rear.
3) Minimize airflow across the camera assembly. If possible, utilize a non-insulative enclosure.
4) Avoid embedding the camera in insulative materials (e.g. foam). Doing so affects the self-heating and relative temperature of internal camera components.
5) If using an enclosure with a window, specify its parameters such that attenuation effects and unwanted radiation reflected/emitted from it can be compensated using the camera's environmental factors correction feature in Section 6.2.1.

10 Optical Characteristics

As summarized in Figure 59 and more fully described in Table 10 and Table 11, numerous lens options are provided for both QVGA and VGA, ranging from very wide field of view (FOV) to very narrow. All lens assemblies are athermalized for stable focus quality across the full operating temperature range. Note that in some cases, there are two VGA configurations providing identical or nearly identical field of view. That situation is due to the introduction of several newer lens designs smaller than the original designs, usually resulting in higher cost and/or slightly reduced performance, as summarized in Table 10 and Table 11. For example, the smaller version of the 24-deg lens has slightly slower f/#. All of the smaller lens configurations are denoted with a S preceding the FOV in the part number (e.g. 21640AS32 instead of 21640A032).

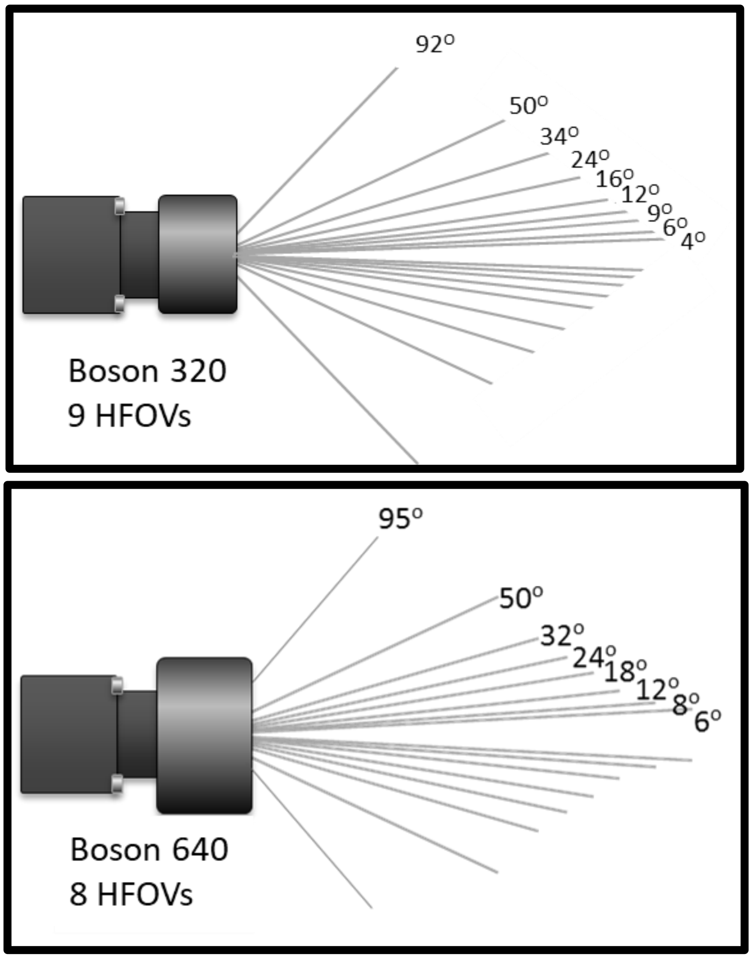


Figure 59: Various Horizontal Fields of View Supported by Boson

Table 11: Lens Optical Specifications

Config. see note 1	FOV (HxV) (deg)	FOV (Diag) (deg)	f/#	Focal length (mm)	Near-focus distance w/out refocus & with refocus (m) see note 2	Avg. Transmission, τ	MTF (nominal at Nyquist, on-axis, 20C)	Distortion (%)
20320 H092	91.9 x 74.0	124.8	1.00	2.3	0.55 / 0.03	87%	42%	<43%
20320 A050	50.0x40.0	65.9	1.00	4.3	1.9 / 0.10	93%	42%	<12%
20320 AS50	50.0x40.0	65.0	1.1	4.5	1.0 / 0.10	93%	31%	< 14%
20320 A034	34.1x27.3	43.6	1.01	6.3	4.0 / 0.20	94%	43%	< 1%
20320 A024	24.1x19.2	30.6	1.02	9.1	8.5 / 0.30	82%	42%	< 1%
20320 A016	16.0x12.8	20.4	1.01	13.8	19 / 0.50	84%	46%	< 3%
20320 A012	12.2x9.7	15.7	1.04	18.0	33 / 1.0	90%	43%	< 1%
20320 A009	9.0x7.2	11.6	1.00	24.3	58 / 1.5	89%	41%	< 2%
20320 A006	6.1x4.9	7.9	1.00	36.0	130 / 4.0	90%	40%	< 1%
20320 A004	4.0x3.2	5.2	1.01	55.0	300 / 10	86%	40%	< 1%
20640 A095	95.0x77.0	126.3	1.10	4.9	2.5 / 0.10	88%	38%	< 50%
20640 AS95	95.0x77.0	130.5	1.1	4.9	2.5 / 0.10	90%	34%	< 56%
20640 AS50	49.9x39.3	65.9	1.01	9.2	7.5 / 0.3	90%	42%	<18%
20640 A032	32.0x25.6	42.0	1.00	14.0	20 / 0.50	92%	42%	< 3%
20640 AS32	32.0x25.6	40.7	1.01	13.6	20 / 0.50	90%	42%	3%
20640 A024	24.3x19.5	31.3	1.04	18.0	33 / 1.0	90%	43%	< 2%
20640 AS24	24.3x19.2	31.3	1.09	18.0	33 / 1.0	90%	42%	< 2%
20640 A018	18.0x14.4	23.1	1.00	24.0	58 / 1.5	89%	41%	< 2%
20640 A012	12.2x9.8	15.7	1.00	36.0	130 / 4.0	90%	40%	< 1%
20640 A008	8.0x6.4	10.3	1.01	55.0	300 / 10	89%	40%	< 2%
20640 A006	6.0x4.8	7.7	1.05	72.8	550 / 17	89%	38%	< 1%

Note 1: Shutterless configurations (IE, 21640A032) have the same optical specification as their shuttered counterparts

Note 2: the first value in the column represents the closest distance at which objects will be in good focus on new cameras. This distance is slightly further away than a typically calculated hyperfocal distance. The second value represents the closest distance at which objects will be in good focus if the user adjusts the focus. Note that a focus tool is required to adjust focus of the smaller lenses (focal length ≤ 18.0mm). See Section 16.6.

Table 12: Lens Mechanical Specifications

Config.	Thread pitch	Lens Max. Diam. (mm)	Camera Length (mm)	Camera Weight (grams)
20320 H092	M18x0.5	21.0	33	24
20320 A050	M18x0.5	21.0	27	18
20320 AS50	M18x0.5	21.0	27	16
20320 A034	M18x0.5	21.0	27	17
20320 A024	M18x0.5	21.0	27	16
20320 A016	M24x0.5	26.0	28	24
20320 A012	M24x0.5	27.6	38	38
20320 A009	M24x0.5	37.0	45	49
20320 A006	M34x0.5	51.0	64	129
20320 A004	M34x0.5	68.4	75	192
20640 A095	M24x0.5	32.0	50	59
21640 A095	"	"	"	55
20640 AS95	M18x0.5	20.0	28	20
20640 AS50	M18x0.5	20.0	40	36
21640 AS50	"	"	"	31
20640 A032	M24x0.5	26.0	35	39
21640 A032	"	"	"	36
20640 AS32	M18x0.5	21.0	33	28
21640 AS32	"	"	"	23
20640 A024	M24x0.5	27.6	38	41
21640 A024	"	"	"	37
20640 AS24	M18x0.5	21.0	37	31
21640 AS24	"	"	"	27
20640 A018	M24x0.5	37.0	45	52
21640 A018	"	"	"	49
20640 A012	M34x0.5	51.0	64	132
20640 A008	M34x0.5	68.4	75	193
20640 A006	M34x0.5	82.0	100	398

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 13 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 averager disabled, in free-running mode, imaging a 30C background. (See Section 5.1 for a description of the averager. NEDT values with averager enabled are approximately 20% lower than shown in the table.)

For the 320 configuration, NEDT requirements in low-gain state are 250% of the values shown in Table 13. (See Section 6.5 for a description of high-gain and low-gain states. Only industrial and professional-grade configurations provide a low-gain state.) For the 640 configuration, NEDT requirements in low-gain state 300% of the values shown in Table 13.

Table 13: 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 10.

For reference, Figure 60 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 also changes with camera temperature, a greater NEDT 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.

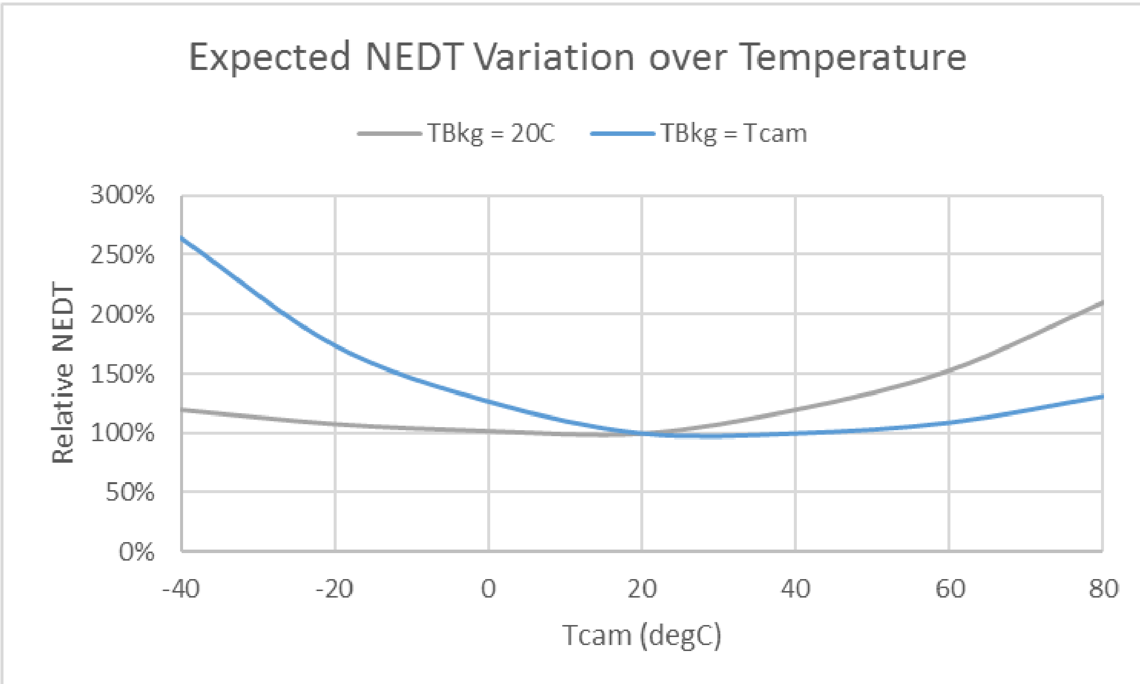


Figure 60: Expected NEDT variation over temperature

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 61 shows the maximum scene temperature of the 320 configuration as a function of camera temperature when in high-gain state, and Figure 62 shows the same for the 640 configuration. Both figures depict typical values as well as the worst-case value expected of every camera. Maximum scene temperature in low-gain state is shown for the 320 configuration in Figure 63 and for the 640 configuration in Figure 64. Radiometry enabled cameras output is not capped in high or low gain mode and will generally follow these trends.

Minimum scene temperature is at least -40C for both configuration in both gain states across the full operating temperature range. (While FLIR has not tested Boson with scene temperatures below -40C , analysis supports a capability to image temperatures approaching absolute zero when in low-gain state.)

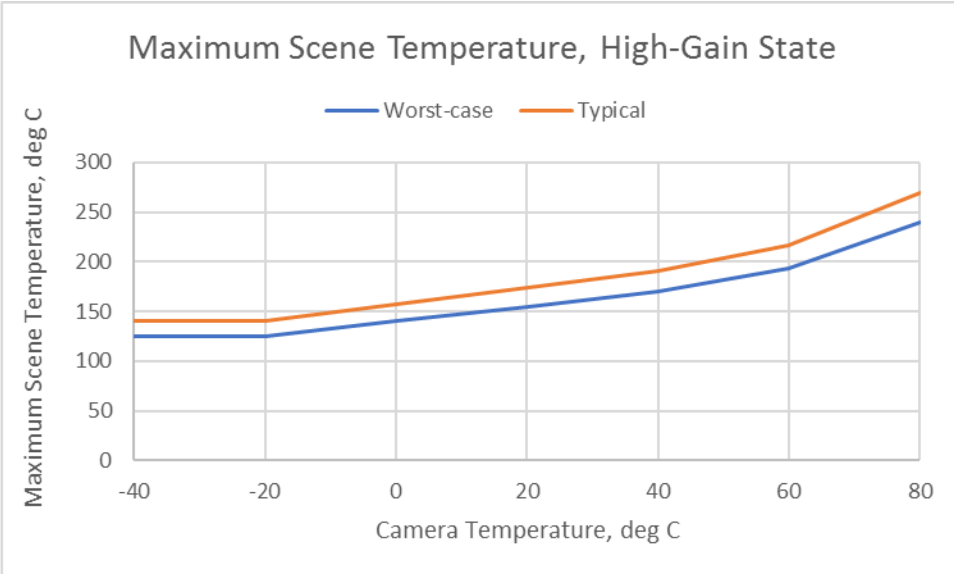


Figure 61: **Expected maximum scene temperature vs. camera temperature, high-gain state, 320 configuration**

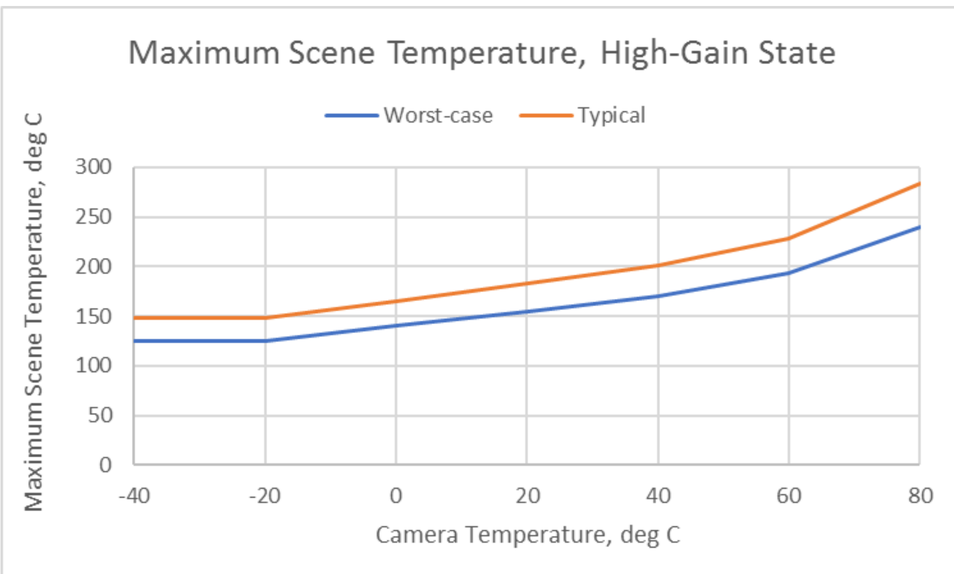


Figure 62: **Expected maximum scene temperature vs. camera temperature, high-gain state, 640 configuration**

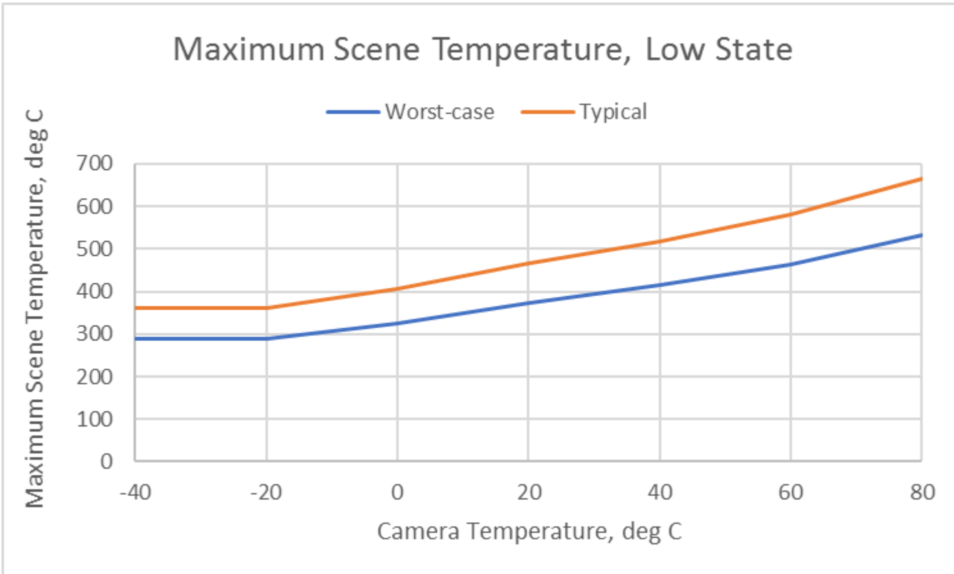


Figure 63: **Expected maximum scene temperature vs. camera temperature, low-gain state, 320 configuration**

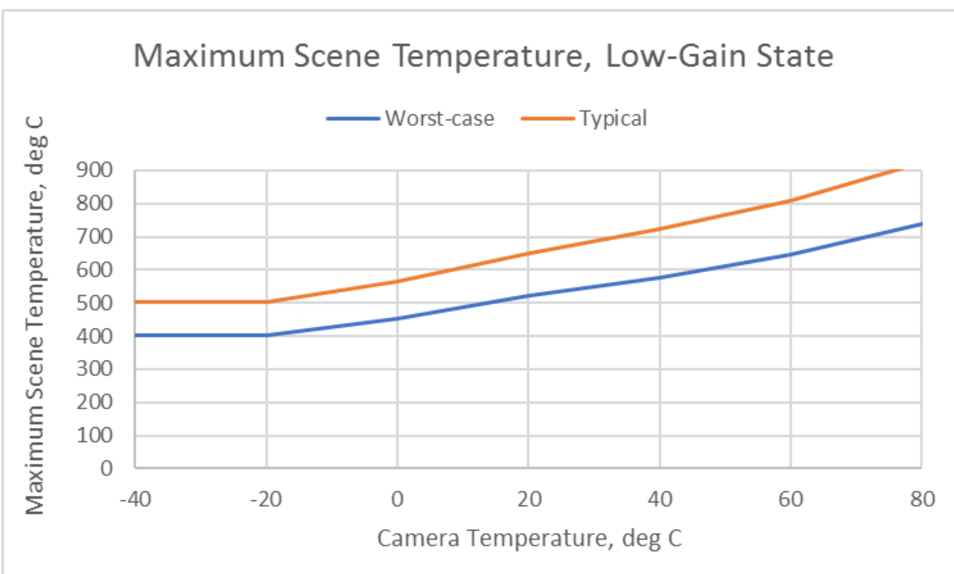


Figure 64: **Expected maximum scene temperature vs. camera temperature, low-gain state, 640 configuration**

11.3 Operability

Operability refers to requirements pertaining to the number and location/grouping of non-operable pixels. Table 14 defines the operability requirements for the 320 configuration as a function of camera grade, and Table 15 provides the same for the 640 configuration. By factory-default, all defective pixels are replaced in the output-video stream by data from adjacent non-defective pixels.

Table 14: Operability Requirements by Camera Grade, 320 Configuration

Camera Grade	Total Defects	Bad columns / rows (see note below)	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

Table 15: Operability Requirements by Camera Grade, 640 Configuration

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%	≤ 4 total (non-adjacent) ≤1 in central 320x256	No 3x3 clusters
Consumer	≤ 2%	≤ 6 total (≤2 adjacent) ≤2 in central 320x256	No 5x5 clusters ≤ 1 3x3 cluster, none in the central 320x256

Note: Number of bad columns / rows shown is total allowance. 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 65.

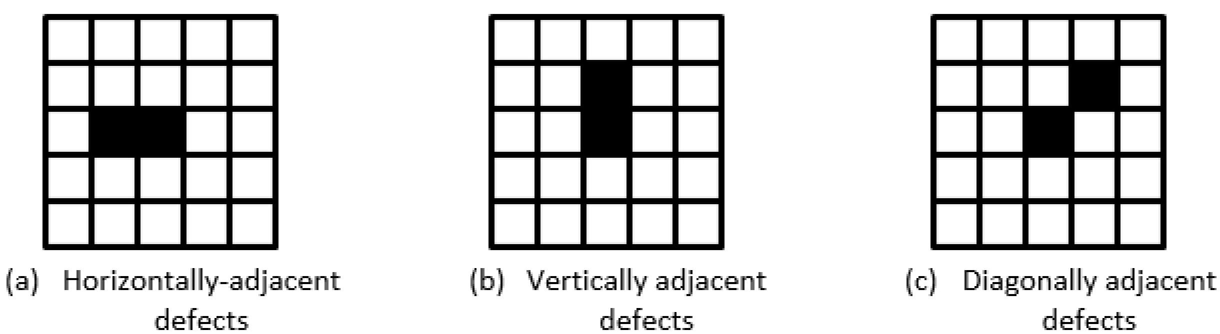


Figure 65: Examples of 2-pixel clusters

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 neighbors under certain imaging conditions, as exemplified in Figure 66 and Figure 67. 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.

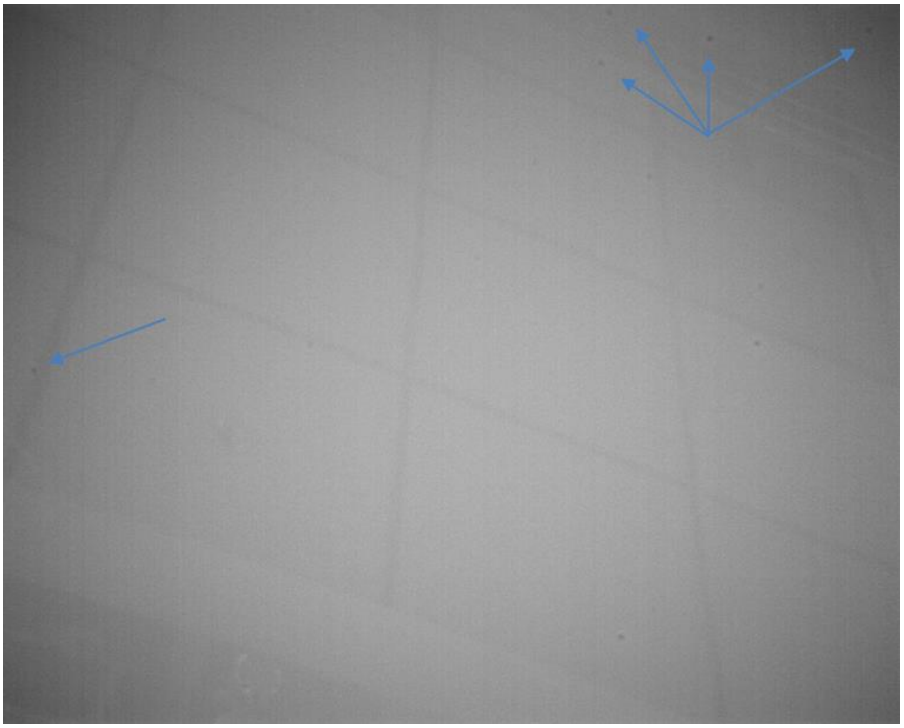


Figure 66: Example of Type A INUs

Figure 67: Examples of a Type-B INU

Table 16 defines the allowed number of INUs for each camera grade. A type A INU has a radius $\leq$ 10 pixels while a Type B INU is one with radius >10 pixels.

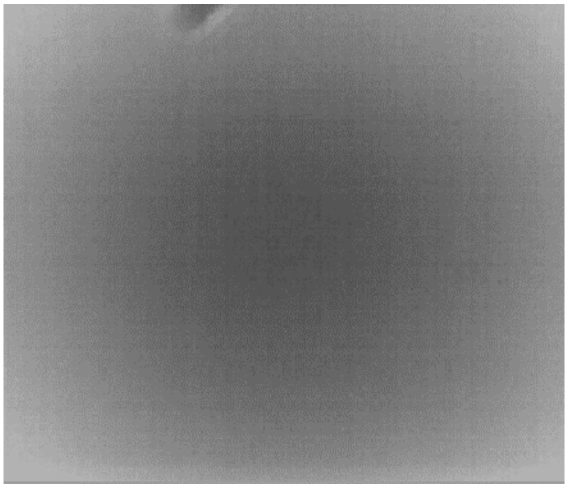
Table 16: Allowed Number of INUs by Camera Grade, 320 Configuration

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

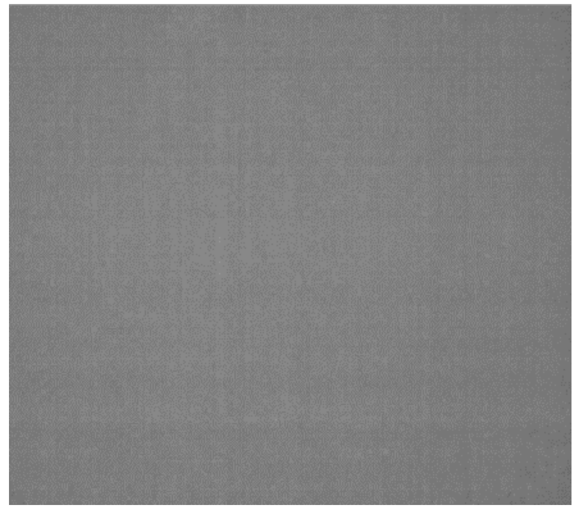
Table 17: Allowed Number of INUs by Camera Grade, 640 Configuration

Camera Grade	In Central 320x240	Outside Central 320x240
Industrial	0	≤2 Type A ≤2 Type B
Professional	0	≤2 Type A ≤2 Type B
Consumer	≤6 Type A ≤2 Type B	≤6 Type A ≤4 Type B

The SFFC feature provided in Release 2 configurations of Boson helps to reduce the appearance of INUs in most imaging conditions. Figure 68 compares an image with and without SFFC. (The INU shown in this image is considered objectionable and not representative of one which would be seen on a delivered camera. It is shown for illustration only to highlight the ability of SFFC to improve the appearance of INUs.) Note that even cameras delivered with Release 1 software can be upgraded to Release 2 and benefit from SFFC after performing the calibration process described in Section 6.14.



(a) Without SFFC



(b) With SFFC

Figure 68: Example Imagery with and without Supplemental FFC (SFFC

11.5 Radiometric Accuracy

Radiometric accuracy is dependent upon many variables, including the following:

- Target temperature
- Target emissivity and factors in the optical path affecting the signal, such as atmospheric absorption.
- Target location in the field of view
- Target distance / subtense
- Camera temperature and temperature stability
- Change in temperature since previous FFC
- FFC type (internal vs. external)
- Mounting / installation considerations (see Section 9.5)

Consequently, accuracy requirements vary depending upon test conditions. Additional radiometric optimization may need to be done to achieve peak accuracy in different system level assemblies.

11.5.1 Test Conditions

For the test conditions defined below, radiometric accuracy shall be as follows:

- Steady-state operation (δTfpa/δt < 0.1C / min)
- Target is within the Central ROI of the FOV
- Tscene between 5C and 120C (high-gain state), 5C and 500C (low-gain state)

- TfpaK within 0.2C of value at previous FFC
- Camera heatsunk from the rear only (no other thermally conductive contacts to camera)
- No window, aperture, or other attenuating material (except air) between camera and target, >99% atmospheric transmission in 8-14 micron spectral band.
- Blackbody emissivity > 98%

Table 18: High-Gain Radiometric Accuracy

High-Gain		T Ambient [C]			
		-20	0	25	50
T Scene [C]	10	+/- 3 C	+/- 3 C	+/- 3 C	+/- 5 C
	50	+/- 3 C	+/- 3 C	+/- 3 C	+/- 5 C
	100	+/- 4 C	+/- 3 C	+/- 3 C	+/- 4 C

Table 19: Low-Gain Radiometric Accuracy

Low-Gain		T Ambient [C]			
		-20	0	25	50
T Scene [C]	30	+/- 4 C	+/- 3 C	+/- 3 C	+/- 5 C
	50	+/- 4 C	+/- 3 C	+/- 3 C	+/- 5 C
	100	+/- 4 C	+/- 3 C	+/- 3 C	+/- 4 C

Table 20: Low-Gain, High Scene Temperature Radiometric Accuracy

Low-Gain		T Ambient [C]			
		-20	0	25	50
T Scene [C]	250	--	--	+/- 5 C	--
	500	--	--	+/- 10 C	--

12 Electrical Specifications

12.1 DC and Logic Level Specifications

Table 21: 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	560 / 1030 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 first number shown is for the 320 configuration, the second for the 640 configuration. In either case, the value shown is during shutter actuation.

12.2 Power Consumption

Boson power consumption is dependent upon five primary variables:

- Camera operating temperature
- Whether the frame averager function is enabled (see Section 5.1)
- Whether the frame skip function is enabled; disabled for measurements below (see Figure 71)
- Whether the USB channel is streaming video (see Section 8.2.2)
- Which filters are enabled / disabled (see Section 5.4)

Figure 69 shows typical power consumption of the 320 Release 3.0 configuration over the full operating temperature range with and without the frame averager enabled and with and without the USB channel streaming video. Power consumption for the 640 Release 3.0 configuration is depicted in Figure 70. All curves assume all filters are enabled.

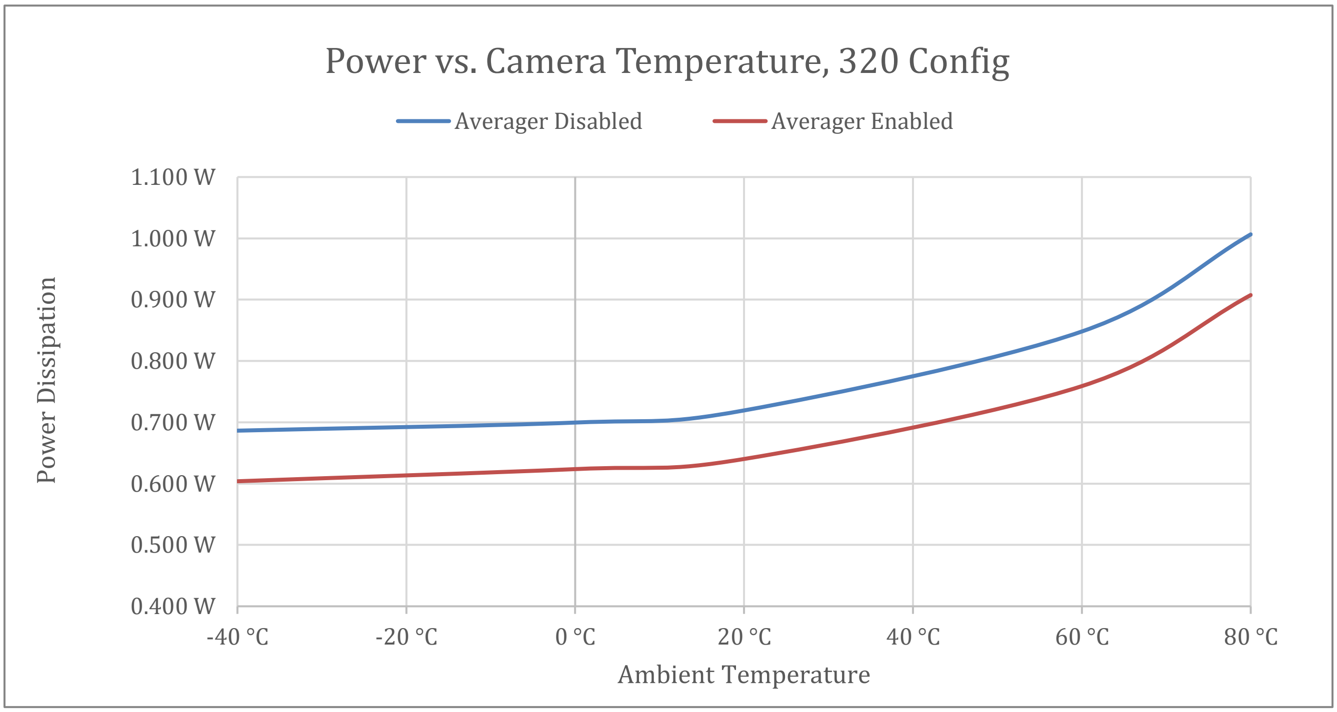


Figure 69: Typical Power Variation of the 320 Release 3.0 Configuration over Temperature

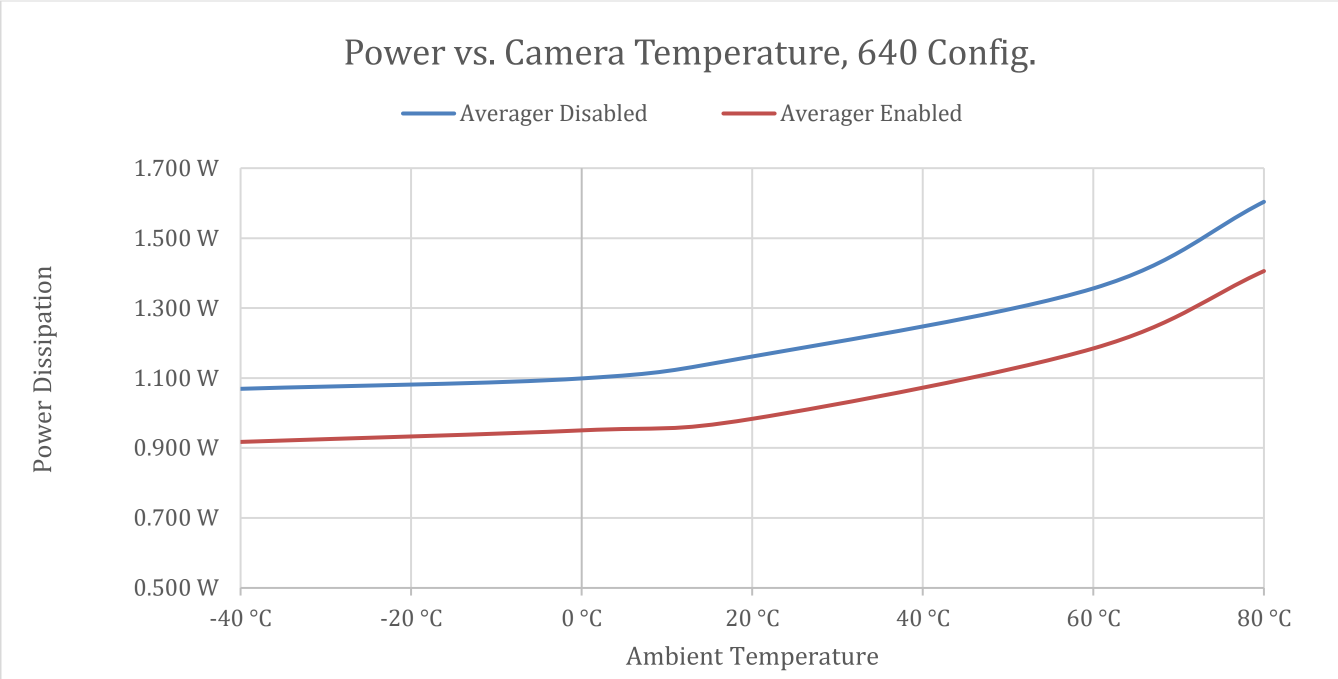


Figure 70: Typical Power Variation of the 640 Release 3.0 Configuration over Temperature

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NOTE: The power curves shown in the figures above are average values. The instantaneous power when the camera's internal shutter is actuated will be higher. For the 320 configuration, the current draw increases by as much as 315 mA during a shutter event, and for the 640 configuration, the increase is as much as 550 mA. These values are included in the max. current supply values listed in Table 21.

In power constrained applications, it may be desired to temporarily or permanently disable image processing filters to reduce power consumption. Table 22 depicts the expected power savings at room temperature which result from various filter settings. Power savings will vary slightly with temperature, generally being slightly lower than shown at temperatures below room temperature and slightly higher at temperatures above room temperature. Features should be considered additive in power savings and more helpful when combined over temperature, since the steady state system temperature will ultimately be lower with less overall power consumption.

Table 22: Power Implications of Disabling Various Filters and USB video

Filter Configurations	Power Delta, 320 Config. (mW)	Power Delta, 640 Config., (mW)
All off (SCNR, SRNR, SSN, LFSR, TF, T-linear, USB video)	-115	-150
LFSR & Radiometry disabled (e.g. similar to R2.0.6)	-55	-80
USB video disabled	-50	-70
All on (SCNR, SRNR, SSN, LFSR, TF, T-linear, USB video)	baseline	baseline

The relative power draw from the camera with the frame-skip feature enabled is shown below. Averager is disabled in this case, but can be enabled for further power savings with an additional reduction in framerate.

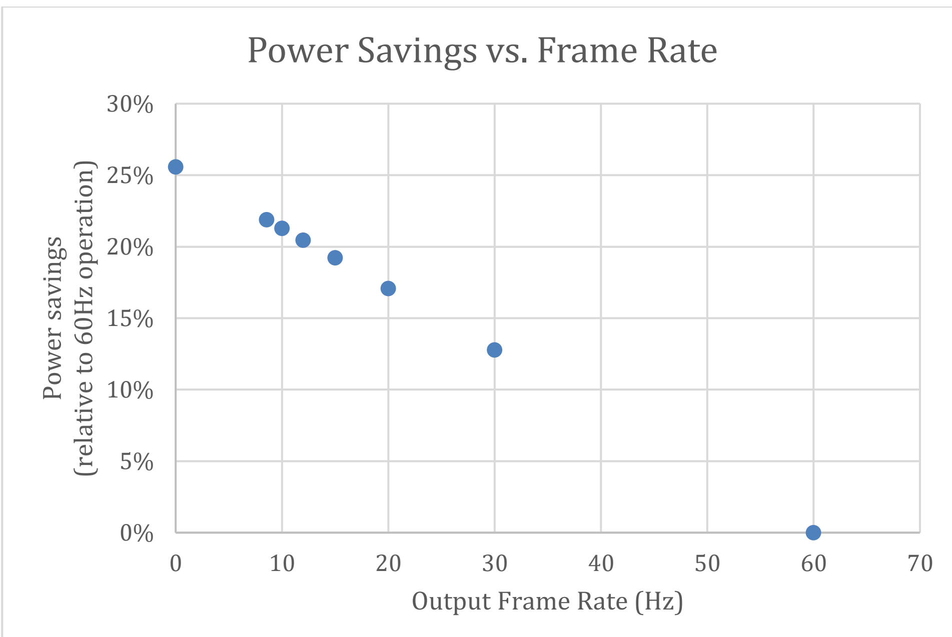

Figure 71: Power Savings as a function of frame rate

12.3 Absolute Maximum Ratings

Electrical stresses beyond those listed in Table 23 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 21 is not implied. Exposure to absolute-maximum-rated conditions for extended periods of time may affect device reliability.

Table 23: 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
Core temperature during operation	105C

13 Environmental Specifications

Environmental stresses beyond those listed in Table 24 may cause permanent damage to the device. Exposure to absolute-maximum-rated conditions for extended periods of time may affect device reliability.

Table 24: Environmental Specifications

Stress	Maximum Rating
Operating Temperature Range[1]	-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 Half-sine, all 6 axes
Vibration	Transportation profile, 4.3 grms
Salt Fog[2,3]	HAR configs: unspecified DLC configs: 240 hours per MIL-STD-810G Method
IP Rating[2]	IP67 per IEC 60529
Abrasion[3]	HAR configs: MIL-C-675C (section 4.5.11) moderate abrasion DLC configs: RSRE TS1888 Windscreen Wiper Test
ESD[4]	EN 61000-4-2 Level 4 • 8kV direct discharge • 15 kV air-gap discharge

Note(s)

1. Temperature refers to that at the rear mounting surface of the camera
2. Salt fog and IP rating only applies to the portion of the lens assembly in front of the sealing surface (i.e., the o-ring groove on large lens configurations, the cylindrical portion of the lens flange for smaller-lens configurations).
3. 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.
4. 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 72, facilitates full interface to the camera via a single USB2 connection providing power, digital video, and comm. The kit includes a 3-foot USB-A to USB-C cable.

NOTE: As of this writing, the USB VPC kit only supports USB2. FLIR is in the process of redesigning the USB VPC kit to support USB3.

16.2 USB / Analog VPC Kit

The USB / Analog VPC kit, depicted in Figure 73, 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 72: Boson VPC Kit (shown in conjunction with the Boson Tripod Accessory)

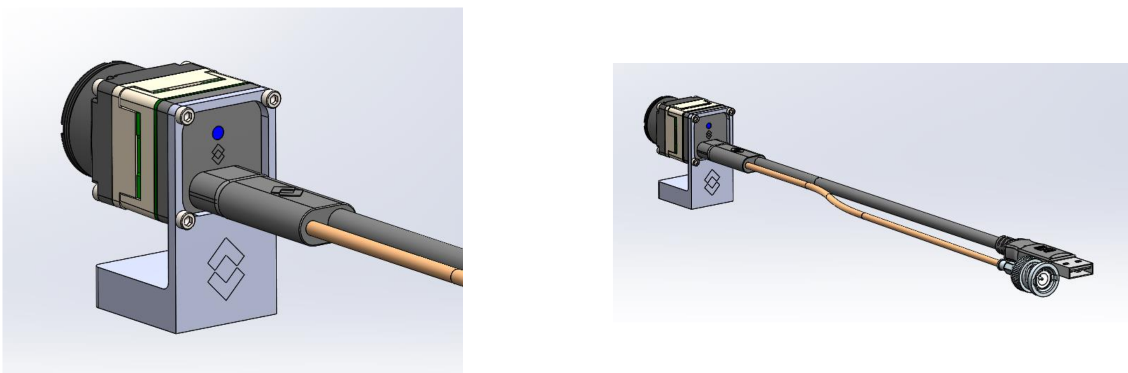

Figure 73: Boson VPC / Analog Kit (shown in conjunction with the Boson Tripod Accessory)

NOTE: Cable lengths shown in Figure 73 and Figure 72 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 74, 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, but then USB3 video is not supported.

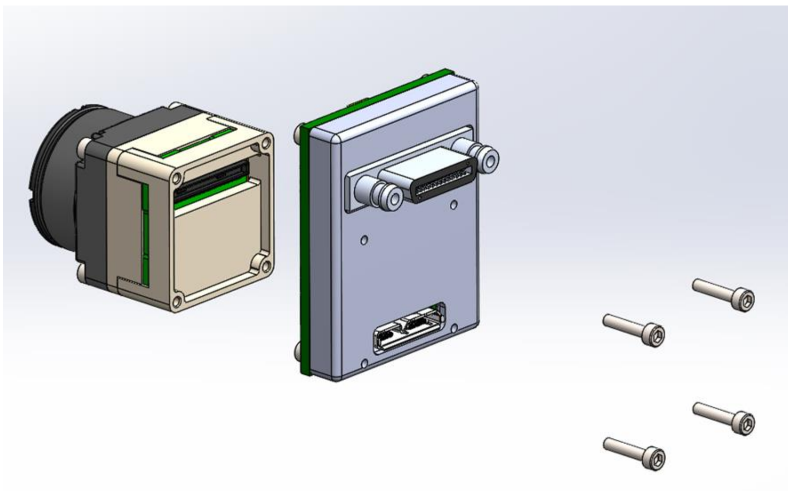

Figure 74: Boson Camera Link accessory

16.4 Boson Dev Board

The Boson Development Board, shown in Figure 75, 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

The SDIO card slot, the I2C header, and the SPI header are to support future Boson features not currently offered in the latest Boson software release.

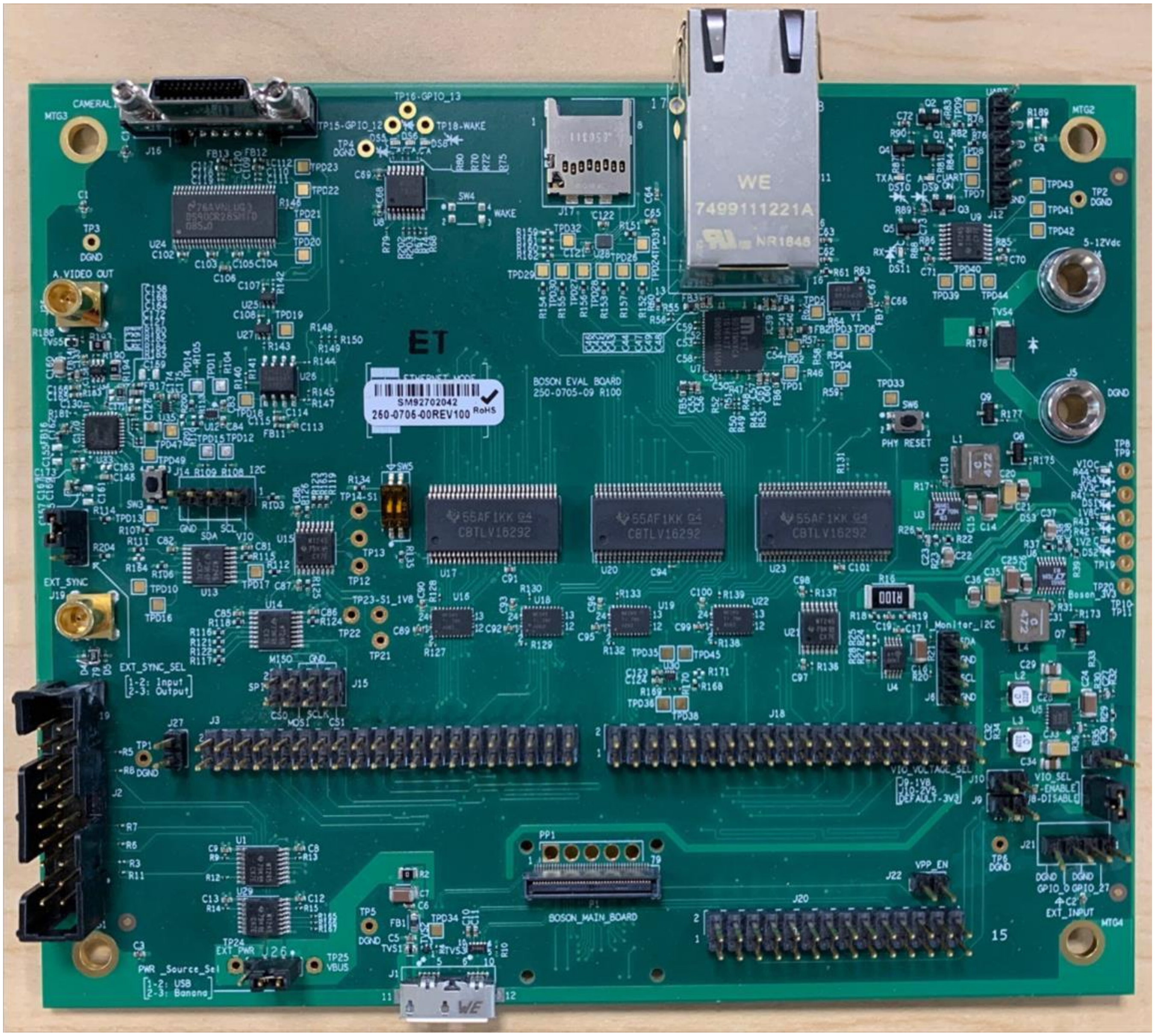

Figure 75: **Boson Dev Board**

16.5 Tripod-Mount Accessory

The Tripod-mount accessory, previously shown in Figure 73 and also shown in Figure 76, 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 76: Boson Tripod-mount accessory

16.6 Focus-Tool Accessory

The focus-tool accessory, shown in Figure 77, 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 ≥25mm and 4.9mm, do not require a focus tool since focus is achieved by simply turning the outer barrel of the lens assembly by hand.

Figure 77: Boson Focus-tool accessory

17 References

17.1 FLIR Documents

Document Number	Document Title
102-2013-01	Boson Quick-Start Guide
102-2013-42	Boson Software IDD
Various	Mechanical Interface Description Drawing (varies by part number)
102-2013-100-XX	Various Boson Application Notes

**Please visit flir.custhelp.com for all Boson related documentation, including Application Notes and Mechanical IDDs*

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 61000-4-2	Electromagnetic Compatibility (EMC) Testing and Measurement Techniques, ESD Immunity Test
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)
LFSR	Low-Frequency Shading Reduction
LUT	Look-Up Table

Abbreviation/ Acronym	Components
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
NVFFC	Nonvolatile FFC
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
SBNUC	Scene-Based Non-Uniformity Correction
SDIO	Secure Digital Input Output
SDK	Software Developers' Kit
SFFC	Supplemental FFC
SNR	Signal-to-Noise Ratio
SoC	System on a Chip
SSN	Silent Shutterless NUC (also called Spatial Pattern Noise Reduction, SPNR)
SWAP	Size, Weight, and Power
TBD	To Be Determined
TCR	Temperature Coefficient of Resistance
UART	Universal Asynchronous Receiver / Transmitter
UAV	Unmanned Aerial Vehicle
USB	Universal Serial Bus

Abbreviation/ Acronym	Components
UVC	USB Video-Device Class
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 at flir.custhelp.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.