FLIR Boson® FFC/NUC Control Application Doc

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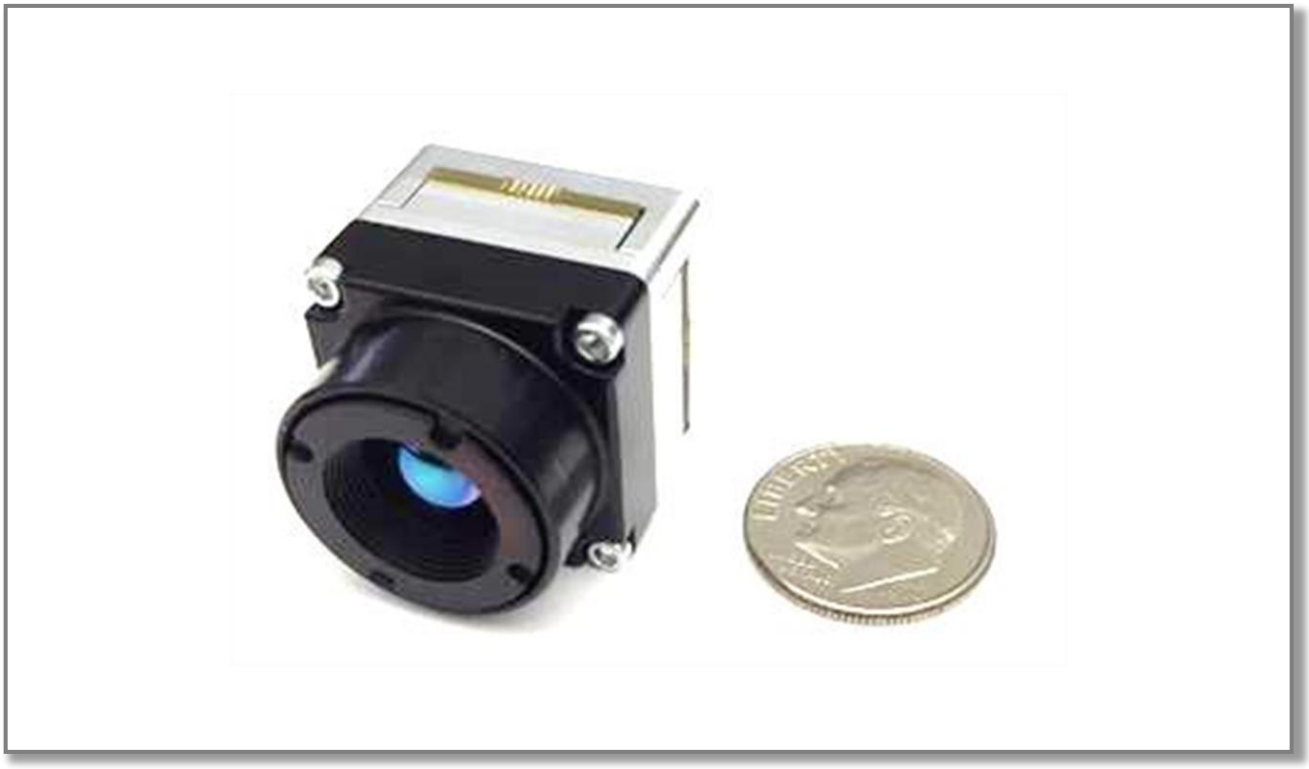

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1 Document

1.1 Revision History

Version	Date	Comments
100	1/22/2018	Initial Release
110	6/26/2018	-Clarified section 2.2, Serial Query -Renamed App note -Removed section numbers from SDK commands in section 2
120	9/21/2018	-Added information about how to operate the camera in manual FFC mode -Clarified wording in some sections -Changed "Scope" section into an "Intro" section, and added more background information -Updated proprietary statement/export control footer

1.2 Reference Documents

Ref Number	Document Number	Description
1	102-2013-43	Boson datasheet
2	102-2013-44	Boson Software IDD

1.3 Intro

This application note describes the appropriate way to control the FLIR Boson® LWIR camera while in External or Manual Flat Field Correction ("FFC) mode. The information contained within this document also applies to the Automotive Development Kit (ADK). The FFC is one of multiple correction maps that helps to optimize image quality for all LWIR thermal cameras. Changing the FFC mode from Auto-mode will allow a user to control when the FFC occurs and whether to use the internal shutter or a customer-furnished, external shutter source. Please Note: Boson does have signal processing algorithms to help improve image quality between FFC events (known as SSN), however this should not be relied upon as a method to replace the Shutter/FFC. Regular FFCs are required for Boson to meet its sensitivity specifications.

Often customers operate the Boson in 'Auto FFC' mode, however this may not be acceptable for some applications. During FFC, the video output will be frozen for approximately 0.5 seconds and this process may occur at any time depending on the temperature and elapsed operating time of the camera. Therefore, when analytics are involved in a system, it is generally recommended to operate the camera in manual mode. This allows the analytics software to accommodate for an FFC at known time rather than become interrupted unexpectedly. One such application that may use Manual mode is the automotive

application. Manual control of the FFC allows for an automotive system to perform the FFC at a convenient time, such as when the car is stopped at a stoplight. Drones that use a gimbal is another example of an application that often uses FFC in External mode. Doing an external FFC on a dedicated black body can generate a more uniform correction than using the internal shutter, resulting in better quality imagery.

'Manual FFC' uses the internal shutter only on user command, while 'External FFC' ignores the internal shutter and instead does the FFC on the scene presented to the camera, such as an external black body. However, if you command an External FFC on a scene, then the scene's frame(s) will be the NUC applied, resulting in a 'ghost image' that is burned into the video output.

When operating in External or Manual FFC Mode, the host will need to also control the Non-uniformity calibration tables (NUC Tables) that are used by the camera to operate over the broad temperature range. This is a separate set of correction maps that are calibrated by FLIR and operate in conjunction with the FFC. Depending on the FPA temperature and gain state of the camera, one of the four calibration tables will be in use:

Table Number	Temperature Range (Degrees Celsius)	Gain Mode
0	[-40,80]	Low**
1	[-40,-20]*	High
2	[-20,60]*	High
3	[60,80]*	High

*These temperature ranges are approximate. Small variations will be seen between units.
** Only the Professional and Industrial grade Bosons will have a low-Gain NUC Table. Consumer grade Bosons do not have Low-Gain available as a feature.

Both the FFC correction and the calibration table corrections allow for optimal Boson image quality, and failure to properly manage them will result in severely reduced image quality. In manual and external mode, the HOST must control the operation. In Auto mode the Boson will handle this operation and will present a small green box in the upper right-hand corner when the camera is about to do an FFC (configurable off/on). Calibration table switching is dependent on the camera's internal temperature sensor and is achieved in conjunction with an FFC event.

2 Boot Up Behavior

The table below shows the variations in **boot up behavior** when operating in the various FFC modes (Auto, Manual, and External):

Auto FFC Mode	Manual FFC Mode	External FFC mode
Automatic FFC takes place and calibration tables are switched to the correct table based on the internal temperature sensor of the LWIR sensor. If the camera is in the correct table already the calibration table is not switched. *The host does NOT have to watch the FFC Desired and Table Switch desired flag.*	The camera will perform ONE initial FFC event at startup (approximate at 2 seconds from power on) and switch to the correct calibration table. The boson will then wait for further commands for FFC and table switching. If a NVFFC map is stored (see Section 7.6.1 of the Boson Datasheet), then the NVFFC map is loaded at start up instead of doing an FFC event. *The host must now watch the FFC Desired and Table Switch desired flag (described more below).*	The camera will NOT perform an initial FFC event at startup and will only start in table 2 (-20C to 65C). The boson will then wait for commands for external FFC and table switching. If a NVFFC map is stored (see Section 7.6.1 of the Boson Datasheet), then the NVFFC map is loaded at startup. *The host must now watch the FFC Desired and table switch desired flag (described more below).*

3 Status Bits for FFC and Calibration Table Switching

Boson has a set of status bits (or flags) that can be monitored via the Telemetry line or using the serial commands. These status bits allow a host system to determine if an FFC or Table switch is required and when those operations have completed. Each of the commands listed in ***blue italics*** are taken from the Boson software IDD (Ref 2) (more information on each command can be found in the appropriate section of that document). For a full description of all the status bits and what conditions cause them to be set, see section 6.12.3 of the Boson Datasheet (Ref 1).

Section 7.6 of the Boson datasheet describes the FFC modes in detail. In general, the logic is as follows for manual or external FFC mode:

1. Monitor the *FFC Desired* Flag and *Table Switch Desired* Flag
2. If the flag indicates that and FFC or Table switch is desired, then perform the correction using the appropriate SDK commands (see below).

3.1 Telemetry

Boson provides telemetry information on the parallel video output provided on the 80 pin connector. The entire telemetry line reference is printed at the end of this document for reference. This telemetry line can be used to watch for FFC, Table Switched desired, and NUC Table desired status. If the Boson camera is connected to the USB accessory, then telemetry is not provided. For some application it may be desired to get telemetry over USB video (ie the ADK). Contact ADAS-Support@flir.com for more information about getting telemetry in the ADK with USB.

To keep the Boson in the appropriate NUC table, the following procedure is recommended:

1.) Once per second, read the Telemetry Status bits for the "Table Switch Desired" bit
2.) If Table Switch Desired is set, stop all other serial communications to Boson
3.) Use command ***bosonCheckForTableSwitch():*** this will start the NUC Table switch (will take around 2 seconds).
    a. If using Manual FFC Mode, then the Boson may perform an FFC as described by Note 1 below.
    b. If using External FFC Mode, then the Boson will set the FFC Desired flag as described by Note 1 below.
4.) Read the telemetry data to ensure that "Current NUC Table" is set the same as "Desired NUC Table". This indicates that the table switch has completed
5.) Once the NUC Table switch is complete, other serial communications may be resumed

To determine if the Boson needs an FFC:

1.) Once per second, read the Telemetry Status bits for "FFC Desired"
2.) Stop all other serial communications to Boson
3.) Use command ***bosonRunFFC()***
4.) Read the Telemetry Status bits to check for when the FFC state returns "complete"
5.) Once the FFC is complete, other serial communications may be resumed

3.2 Serial Query

If an application is unable to monitor the telemetry line, a good alternative would be to use serial commands to query the same status bits.

To keep the Boson in the appropriate NUC table, the following procedure is recommended:

1.) Once per second, read ***bosonGetTableSwitchDesired()*** to determine if a Table Switch is needed
2.) If Table Switch Desired is set, stop all other serial communications to Boson
3.) Use command ***bosonCheckForTableSwitch():*** this will start the NUC Table switch (will take around 2 seconds). See Boson SWIDD for more information on the command.
    a. If using Manual FFC Mode, then the Boson may perform an FFC as described by Note 1 below.
    b. If using External FFC Mode, then the Boson May set the FFC Desired flag as described by Note 1 below.
4.) Read ***bosonGetDesiredTableNumber()*** and ***bosonGetTableNumber()*** to ensure that "Current NUC Table" is set the same as "Desired NUC Table". This indicates that the Table Switch has completed.
5.) Once the NUC Table switch is complete, other serial communications may be resumed

To determine if the Boson needs an FFC:

1.) Once per second, read ***bosonGetFfcDesired()***
2.) Stop all other serial communications to Boson
3.) Use command ***bosonRunFFC()***
4.) Read ***bosonGetFfcStatus()*** to check for when the FFC status returns "complete"
5.) Once the FFC is complete, other serial communications may be resumed

Note 1: Switching Gain state (HIGH GAIN and LOW GAIN) will require a table switch, and 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, commanded switch, automatic FFC, or a set of the *FFC Desired* flag—an FFC 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 examples below.

Examples of FFC behavior when transitioning between gain states or NUC Tables:

• 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**.

4 Specific Examples

The following section provides a set of specific examples of how the camera will operate in Auto, Manual, and External FFC Mode.

Condition	Behavior in Auto FFC mode	Behavior in Manual FFC mode	Behavior in External FFC mode
Start-up	Automatic FFC take place	If a valid NVFFC map is stored (see Section 7.6.1), it is loaded. Otherwise, automatic FFC takes place.	If a valid NVFFC map is stored (see Section 7.6.1), 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 Temp** (see note 1 and note 2)	Automatic FFC take place	*FFC Desired* is set	
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*).	
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 6.2.	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*).	
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.

5 Telemetry Reference

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
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 data 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.
29	58	18	Reserved	

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
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	Reserved	
47	94	2	Camera temperature	In Kelvin x 10 (e.g., 3001 = 300.1K)
48	96	2	Camera temperature at last FFC	
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 = SPNR enable/disable Bit 7 = BPR enable/disable Bit 8 = reserved Bit 9 = SFFC 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 6 in Section 7.6 of the Boson Datasheet
80	160	2	Desired NUC Table	See note 2 of **Error! Reference source not found.** in Section 7.6 of the Boson datasheet
81	162	4	Core Temp	In Celsius x 1000 (e.g., 30021 = 30.021C)
83	166	4	Overtemp event	
85	170	4	ROI Population Below Low-to_High Threshold	
87	174	4	ROI Population Below High_to_Low Threshold	

Word start (16b mode)	Byte Start (8b mode)	Number of Bytes	Name	Notes
89	178	6	Toggling pattern (intended as check of stuck CMOS signals)	Bytes 178-179: 0x5A5A Bytes 180-181: 0xA5A5 Bytes 182-183: 0x5A5A
92	184	4	Zoom factor	
94	188	4	Zoom X-center	Row number
96	192	4	Zoom Y-center	Column number
98	196	444	Reserved	

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