

Boson Lens Calibration

Application Note



FLIR Systems OEM & Emerging
6769 Hollister Avenue
Goleta, CA 93117
Phone: +1.805.964.9797
www.flir.com

This document does not contain any export controlled information

Document Number: 102-2013-100-02

Version: 1.0

Issue Date: August 2017

Table of Contents

1.0	Document.....	4
1.1	Revision History	4
1.2	Scope.....	4
2.0	Software Connection	5
3.0	Lens Gain Calibration	8
3.1	Requirements.....	10
3.2	Setup	11
3.3	Procedure.....	11
4.0	Supplemental Flat Field Correction (SFFC) Calibration	14
4.1	Requirements.....	17
4.2	Setup	17
4.3	Procedure.....	18
5.0	Non-Volatile Flat Field Correction.....	20
5.1	Requirements.....	20
5.2	Calibration Procedure	21
6.0	Solar Exposure Protection.....	22

This document does not contain any export controlled information

Table of Figures

Figure 1. Boson Application	5
Figure 2. COM Port Selection	6
Figure 3. Device Manager Help	7
Figure 4. USB Video.....	7
Figure 5. Analog Video	8
Figure 6. Before Lens Gain Calibration.....	9
Figure 7. After Lens Gain Calibration	9
Figure 8. Camera Software Revision	10
Figure 9. Lens Gain.....	12
Figure 10. Lens Gain Frame Capture	13
Figure 11. Effects of SFFC.....	15
Figure 12. Out-of-Field Radiation.....	15
Figure 13. SFFC Application Curve	16
Figure 14. SFFC Procedure	18
Figure 15. NVFFC Procedure	21
Figure 16. Solar Protection Coating	22

This document does not contain any export controlled information

1.0 Document

1.1 Revision History

Version	Date	Comments
1.0	August 2017	Initial release
1.1	June 2019	Updated Export footer

The FLIR website will have the newest version of this document as well as offer access to many other supplemental resources: <http://www.flir.com/cvs/cores/resources/>

There is also a large amount of information in the Frequently Asked Questions (FAQ) section on the FLIR website: <http://www.flir.com/cvs/cores/knowledgebase/>.

1.2 Scope

This document discusses the various procedures to compensate for optical characteristics such as lens transmission uniformity (roll-off) and thermal emissions, especially for lens-less core configurations and after customer-furnished items such as a lens or window have been installed. These procedures include Lens Gain Calibration, Supplemental Flat Field Correction (SFFC), and Non-Volatile Flat Field Correction (NVFFC). This document also discusses lens coating recommendations for the Boson core.

This document does not contain any export controlled information

2.0 Software Connection

The Boson camera system utilizes a Windows-based custom Graphical User Interface (GUI). It provides access to all user controls and configuration parameters. This application allows customers to perform the three calibration procedures described in this App Note: lens gain calibration, supplemental flat field correction (SFFC) calibration, and storage of non-volatile flat field correction (NVFFC). The following procedure describes how to connect to the Boson core and stream live video.

- 1) Install the FLIR Boson App (v1.4.2 or later) on your Windows® 7 or 10 computer. If you have a previous version of the application installed, you should first uninstall it using Windows Add/Remove Programs.
- 2) Connect the camera to the computer via the USB interface. Allow all camera drivers to load successfully. Drivers will only load the first time a Boson is connected to a new COM port. Open the FLIR Boson App software. The Boson Link indicator in the lower right corner of the window will show as DISCONNECTED with an orange background.

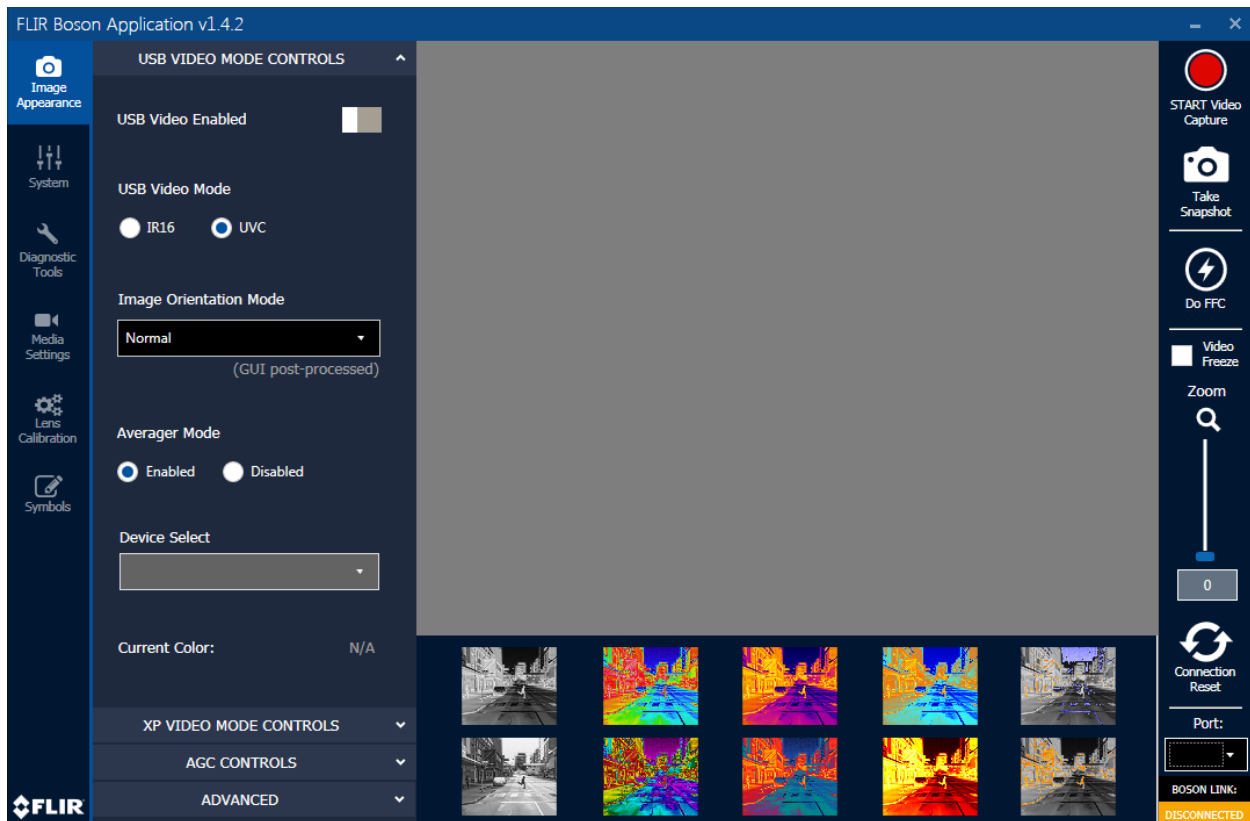


Figure 1. Boson Application

This document does not contain any export controlled information

Note: Navigation buttons along the left side of the Boson application are referred to in this document as “tabs”. Contained on each tab are “accordion panes”, referred to simply as “panes”.

- 3) Above the Boson Link indicator, there is a pull-down menu that lists all active COM ports. Select the COM port associated with the Boson camera.

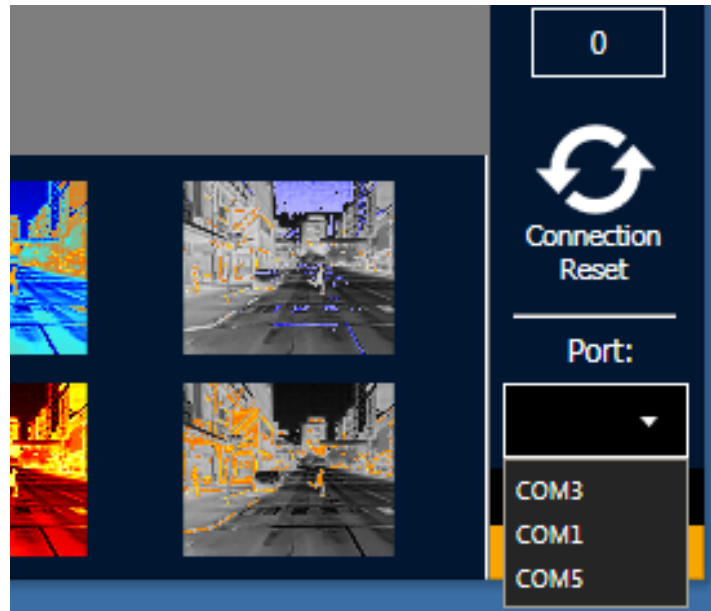


Figure 2. COM Port Selection

- 4) If the COM port is unknown, use Windows Device Manager to identify the port associated with the Boson camera. It should be listed as **FLIR Control (COM X)** where X is the COM port number of the camera. (Seen in Figure 3 on next page)

This document does not contain any export controlled information



Figure 3. Device Manager Help

For customers using multiple Boson cameras, the COM port may need to be manually changed as the Boson Application has difficulty connecting to ports greater than 28. To manually change, right-click on the FLIR Control entry in Device Manager, select Properties, then select the Port Settings tab. Locate the Advanced button on this pane and press it. Locate the COM Port Number pull-down menu. Select an appropriate port number below 28. Make sure the selected port is not currently in use by another device.

- 5) If a successful connection is made, the Boson Link indicator will turn from orange to green and show as Connected.
- 6) If USB Video is to be used, turn on the **USB Video Enable** switch and select **FLIR Video** from the **Device Select** pull-down menu.

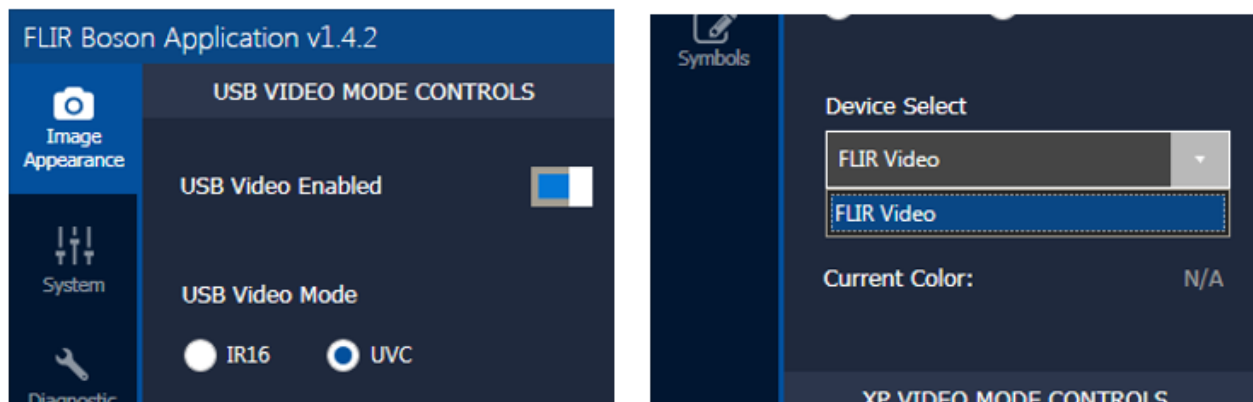


Figure 4. USB Video

This document does not contain any export controlled information

- 7) At this point, a live UVC stream should be visible in the app and you can be confident that you have established communication correctly with the Boson core. USB Video Mode can be configured between UVC and IR16 using the associated radio button.
- 8) If an analog monitor is preferred over USB video, the analog video mode must first be enabled as it is not a factory default condition. Navigate to the **XPVIDEO MODE CONTROLS** tab on the **Image Appearance** pane and select the **Analog Video** radio button. This setting can then be saved as a power-on default by selecting **SAVE POWER-ON DEFAULTS** on the **CONFIGURATION CONTROLS** pane of the **SYSTEM** tab. Note that analog video requires the FLIR USB / Analog VPC Accessory (PN 421-0061099).

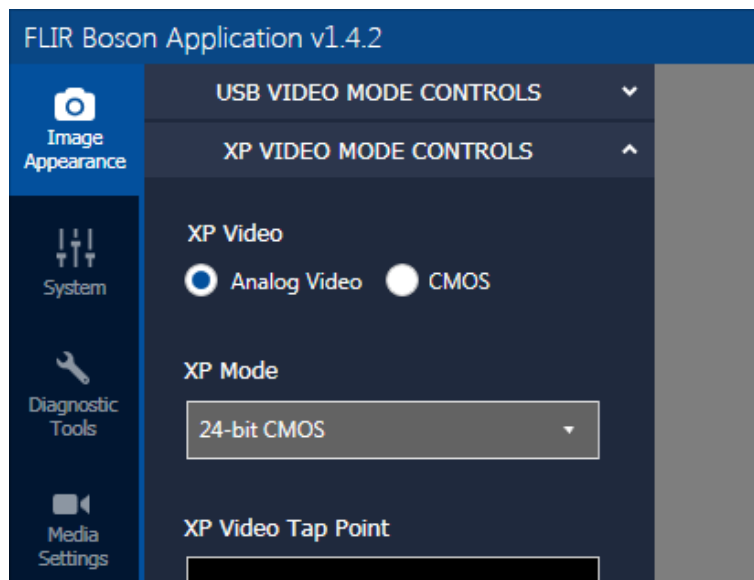


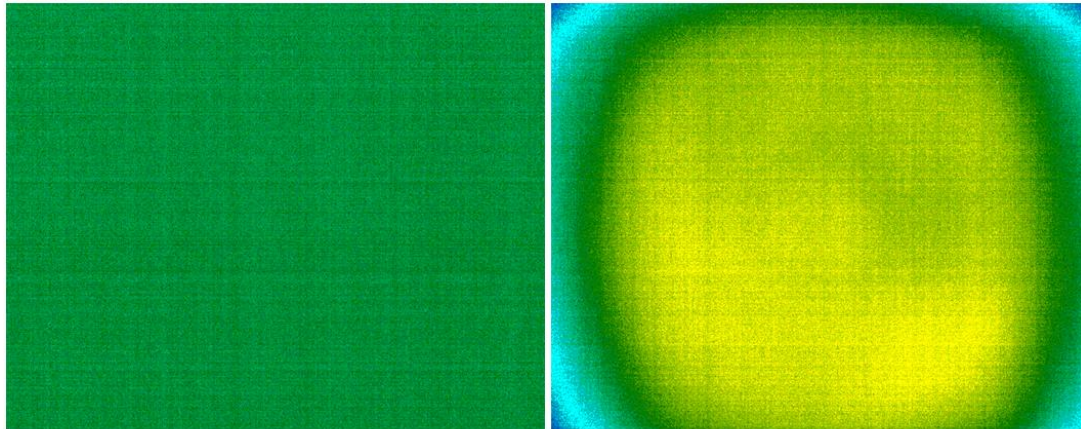
Figure 5. Analog Video

3.0 Lens Gain Calibration

If the lens gain information in the camera is incorrect for the lens that is attached to the core (which would be true if the customer has installed a new lens without performing the lens-gain calibration described in this section), imagery may appear darker or lighter in the corners, depending upon scene conditions. This is most evident with low contrast scenes and/or large uniform temperature objects like walls, ceilings, or wide area black-bodies. The root cause of this effect is that virtually every lens design produces a non-uniform illumination pattern onto the Focal Plane Array (FPA), with the corners typically receiving less thermal radiation than the center. Lens gain calibration eliminates the issue by providing more digital gain where there is less optical throughput. Figure 6 and Figure 7 illustrate the problem and corresponding correction. In each pair, the image on the left shows a uniform scene that is the same temperature as the reference used for the most recent flat field correction (FFC). The images on the right are a uniform scene, approximately 25 degrees warmer than its reference. The “Rainbow”

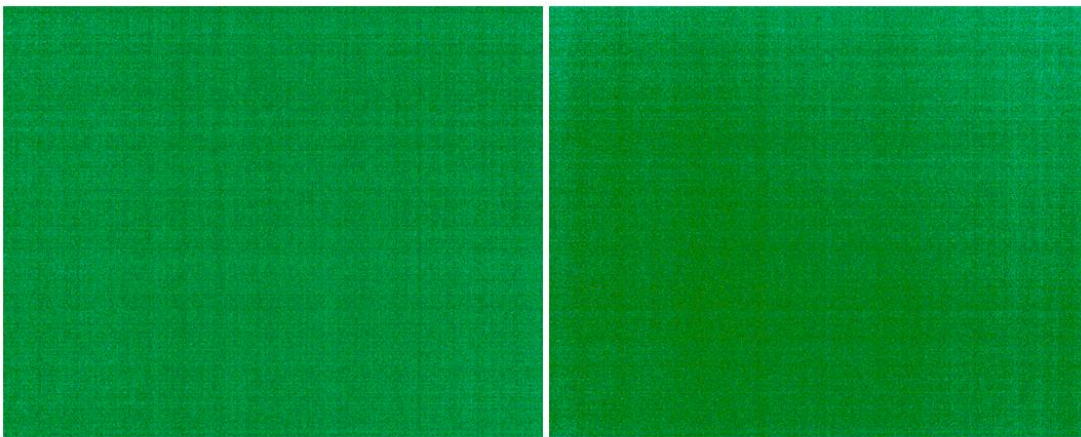
This document does not contain any export controlled information

color palette was used to emphasize the difference between the center and edges of the image. The pair in Figure 6 was taken before a lens gain calibration, and shows a noticeable difference between the two cases. The pair in Figure 7 were taken after the lens gain calibration and shows no noticeable difference between the two cases. That is because gain has been applied to correct for lower thermal radiation projected by the lens onto the edges of the FPA.



Uniform scene at FFC ref. temperature

Uniform scene at elevated temperature

Figure 6. Before Lens Gain Calibration


Uniform scene at FFC ref. temperature

Uniform scene at elevated temperature

Figure 7. After Lens Gain Calibration

This document does not contain any export controlled information

3.1 Requirements

This procedure applies to FLIR's Boson 320 and 640 camera cores, and requires access to the following:

- FLIR Boson App version 1.4.2 or higher
- Preferably two blackbodies (must be capable of subtending the entire field of view of the camera with two different scene temperatures, separated by approximately 20 to 30C). One blackbody can be used, but results will be less than optimal. Alternatively, an aluminum plate uniformly coated with a flat black paint can be used in place of the ambient blackbody. The plate should be at least ¼" thick.
- Boson 320 with Release 2 software (2.0.11863 or later) or Boson 640. It is possible to update the software on Boson 320 Release 1 cameras to enable use of this feature. Refer to the separate App Note entitled "FLIR Boson Release 2.0 Update Procedure". If the version number of the currently-installed software is in doubt, it can be checked via the "Status Panel" pane on the "Diagnostic Tools" tab, as shown in Figure 8.
- Serial communications over USB to a computer using the Boson USB/Analog Video cable (or similar)

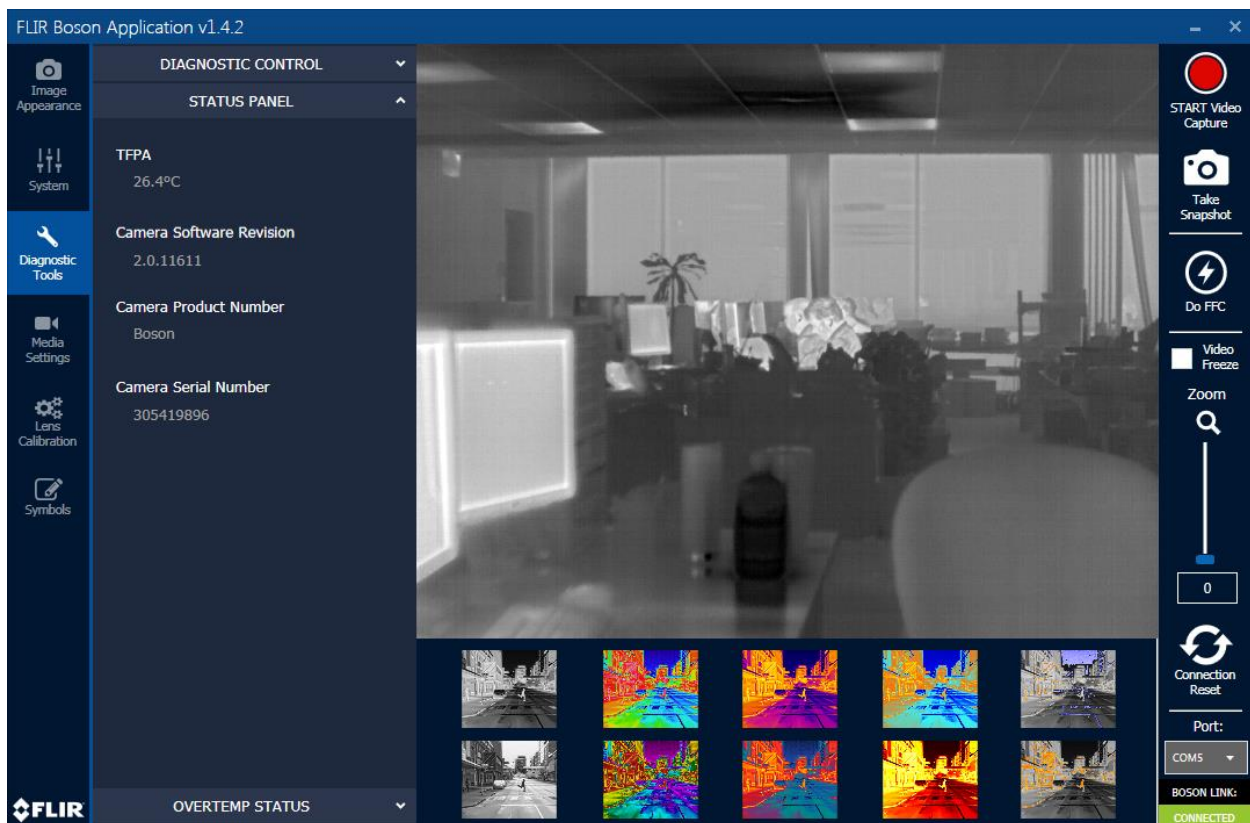


Figure 8. Camera Software Revision

This document does not contain any export controlled information

3.2 Setup

- 1) Follow the procedure listed in Section 2.0 for installing the Boson Application and connecting to the Boson camera.
- 2) If possible, install the Boson into the final assembly hardware including all optical components. The camera should be focused as it is to be used (at infinity focus, for example) and not refocused on the blackbodies.
- 3) Two temperature sources are required for this procedure. It is possible to utilize a single blackbody source, initially set to one temperature and then later to a second temperature. However, it is preferred to utilize two blackbodies such that it is possible to image both in rapid succession, thereby eliminating drift effects which can degrade the calibration. The goal is to have two uniform scenes which are separated by approximately 20 degrees C, such as 25C and 45C. The blackbodies must subtend the entire field of view of the camera.

3.3 Procedure

Important points about the lens gain process

- The camera should not be held by the cable during data collection or installed into a mounting device that will significantly alter the heat load on the system. If the Lens Gain (and SFFC, see Section 4.0) procedure cannot be accomplished while the Boson core is installed in its final assembly, use the Boson Tripod Adapter accessory (PN 261-2608-00) and secure it to a tripod or vise.
- The camera should be left focused as it is to be used, not focused on the blackbodies.
- The delay between taking the warm and cold samples should be as short as possible, but allow the image to stabilize for a second or two after the hot-to-cold source transition.
- Condensation should not be allowed to occur on the black-bodies. Do not use a black body temperature below the dew-point.
- When called for, the camera should be positioned close to the black-body so the entire camera field of view is covered (flood-filled). **It is critical that the entire FOV is covered.**
- The blackbodies should not be allowed to alter the temperature of the camera lens. Shield the camera from the blackbody when not collecting data.
- The camera video should not be inverted or reverted during this procedure.

This document does not contain any export controlled information

- 1) Navigate to the **Lens Calibration** tab in the Boson Application. All Boson cameras have two lens tables, referred to as Lens 0 and Lens 1. For cameras that are delivered with a lens installed, FLIR recommends selecting Lens 1 for the user calibration. This will preserve the factory calibration in the Lens 0 memory location. For cores delivered without a lens, there is no gain map stored in either location. In this situation, it is possible to save separate lens maps for lens 0 and lens 1 for use with dual FOV optics.
- 2) Select the **LENS GAIN CONTROLS** pane. Do not navigate away from this pane once you begin the data collection process because doing so could change camera settings required for calibration.

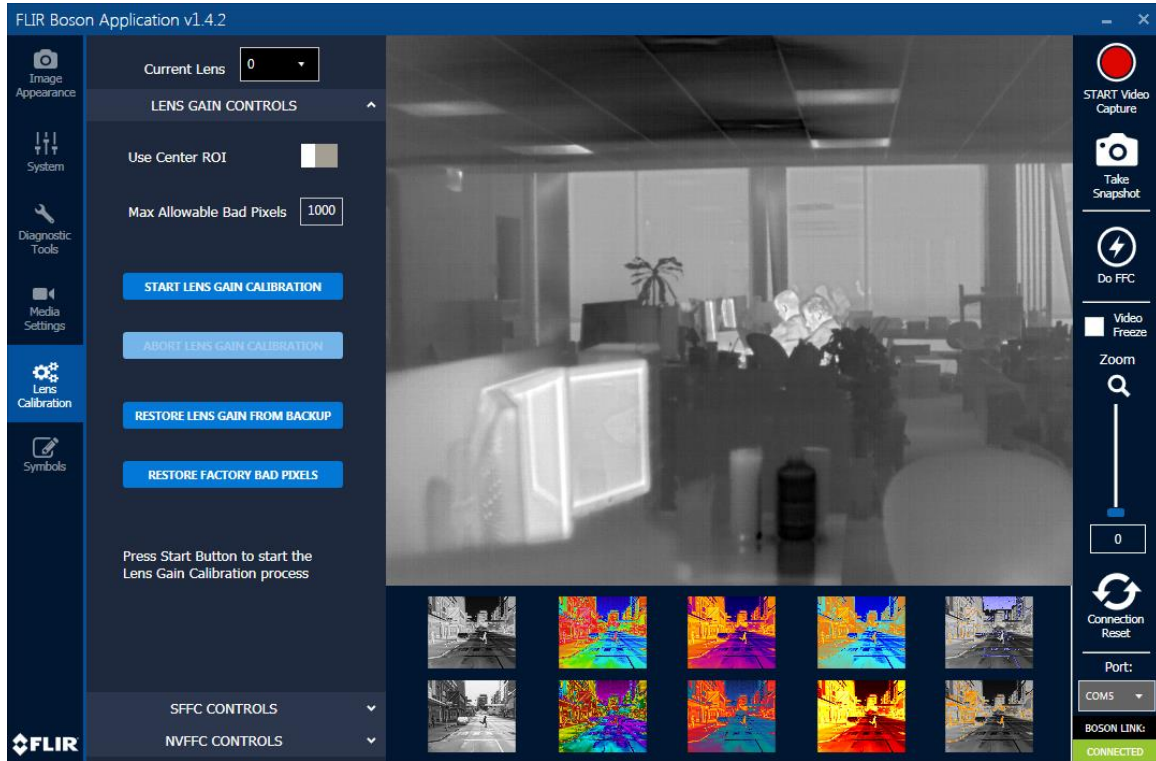


Figure 9. Lens Gain

- 3) Initiate the calibration process by pressing the **START LENS GAIN CALIBRATION** button. The app will automatically download a copy of the current gain map before it is erased in the camera. The downloaded copy is stored at C:\TEMP and can be restored at a later time if desired (see step 8).

This document does not contain any export controlled information

- 4) The app will monitor the camera's internal temperature and verify stability. If the camera has not been running long enough, the app will delay the calibration until temperature stability has been achieved. If the stability process takes more than five minutes, ensure the camera's working environment is not changing. If necessary, place an enclosure around the camera and blackbody to reduce air currents.
- 5) Once the app determines the camera's temperature is sufficiently stable, it will download a copy of the current lens gain map, erase the current gain map, disable all correction terms in the camera, and prompt the user to place the hot source in the camera's field of view. Once in place, click the **HOT CAPTURE** button. Keep the hot source in front of the camera until prompted to replace it with the cold source.

Note: The order in which the two blackbodies are imaged is important. The calibration will fail if the cold source is imaged when prompted for the hot source or vice versa. The **ABORT LENS GAIN CALIBRATION** button can only be used during the camera temperature stability testing period. If the process is interrupted for any reason after the app prompts for the Hot Capture, the lens gain will either need to be reloaded from the backup file or the lens gain process completed.

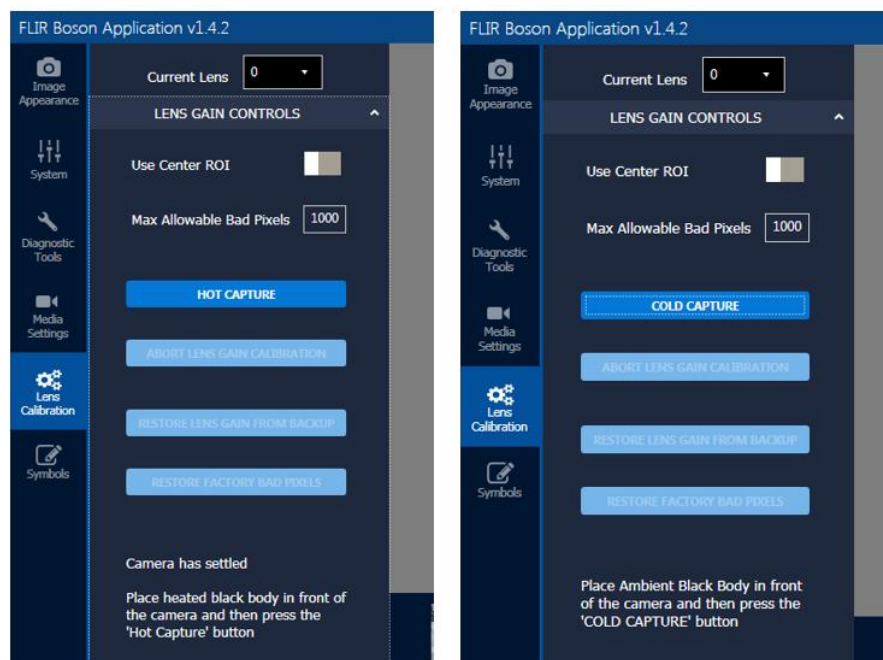


Figure 10. Lens Gain Frame Capture

- 6) Replace the hot source with the cold source and click **Cold Capture**. The application will take some time to record the data. Keep the camera pointed at the blackbody until the entire process is finished. The software will then automatically calculate the new gain, detect bad pixels, and perform an FFC. Once the entire process is complete, the camera will apply the new

This document does not contain any export controlled information

gain map to the image. The quality of the calibration and resultant image can then be assessed. The **Gain Correction** slider switch located on the Advanced tab of the Image Appearance pane can be used to help assess the effectiveness of the newly created lens gain

- 7) At this point, the Hot and Cold captures have been uploaded, the gain map computed, the gain map saved, and the camera returned to its original state. If the lens map number was changed prior to the calibration (as recommended in step 1 for cameras with a factory-installed lens), the user may wish to save the power-on defaults such that the camera will default to the newly calibrated map at each subsequent start-up. This is accomplished by selecting **SAVE POWER-ON DEFAULTS** on the **CONFIGURATION CONTROLS** pane of the **SYSTEM** tab.

To test the new gain map, the user may perform the following procedure:

- Perform an external FFC while imaging the cold black body
 - Move the hot black body into the field of view of the camera and verify the image is still uniform
 - If the image is uniform, the gain calibration is valid. If the image is not uniform, try the lens calibration procedure again. Intermediate temperatures can also be used to evaluate image quality.
- 8) The **RESTORE LENS GAIN FROM BACKUP** button can be used to re-load a previously generated lens gain. Files are stored on the PC at C:\Temp.

4.0 Supplemental Flat Field Correction (SFFC) Calibration

Supplemental Offset, or Supplemental Flat Field Correction (SFFC), is a correction term intended to compensate for non-uniformity which occurs as the result of self-emission of camera components. SFFC can also help reduce Image Non-Uniformities (INUs) caused by defects or debris in the optical path. (See the separate INU App Note for a better understanding of this phenomenon.) The correction is associated with the installed lens / optical path, and Boson cameras support terms for up to 2 lenses / optical paths. The non-uniformity corrected by SFFC is caused by out-of-field radiation and is seen even immediately after a shutter-based FFC, as depicted in Figure 11. This is because the internal shutter paddle is not generally at the exact same temperature as other internal camera components, such as the lens housing. Because the shutter blocks irradiance from those camera components, as shown in Figure 12, thermal irradiance from those surfaces are not adequately corrected during an internal FFC. The SFFC correction map is calibrated by taking the difference between an internal FFC (using the internal shutter) and an external FFC through the lens.

This document does not contain any export controlled information

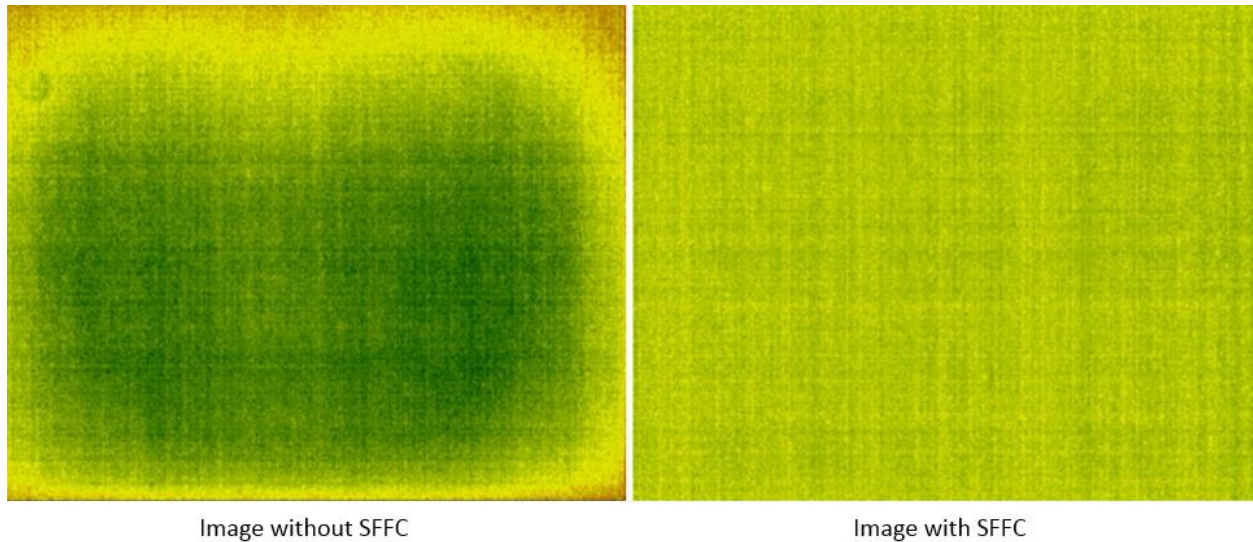


Figure 11. Effects of SFFC

Note: when using “external FFC” mode, the SFFC offset should be disabled. This is because each time external FFC is performed, it compensates for the out-of-field irradiance which SFFC is intended to correct. Leaving SFFC offset enabled after an external FFC essentially causes the out-of-field irradiance to be corrected twice, resulting in overcompensation (i.e., poor uniformity).

For all Boson configurations except lens-less, the camera is delivered with a factory-calibrated SFFC map. However, it is highly recommended to recalibrate SFFC when the Boson is installed by the user in its final enclosure with all heatsinking in place. That is because the internal heating of the camera will differ in this condition compared to the factory-calibration conditions.

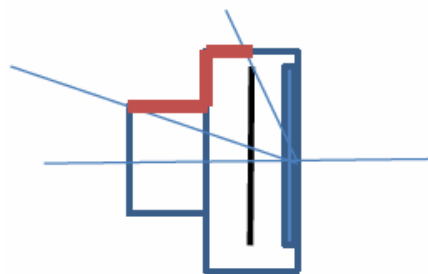


Figure 12. Out-of-Field Radiation

The supplemental flat field correction is applied as a scaled factor that is inversely proportional to the rate of change of camera temperature at start-up. In other words, when the camera temperature is stable, the correction will be applied at 100% and it will be applied less and less as the camera

This document does not contain any export controlled information

temperature is changing. The following plot is meant to be demonstrative only and does not represent an actual LUT from a camera.

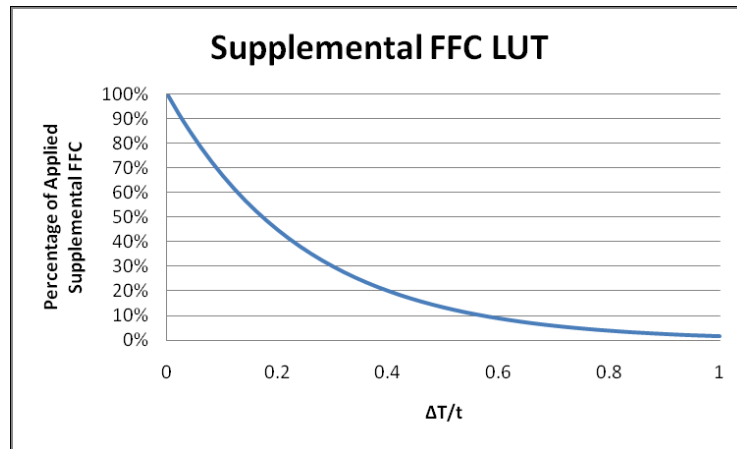


Figure 13. SFFC Application Curve

Note: For lens-less Boson cores, it is necessary to thermally couple the lens and the sensor together. Separating the sensor from the lens or providing a poor thermal conduction path can lead to substandard performance even with SFFC calibration. FLIR ships lens-less cores with a plastic dust cover which should only be removed in a clean-room environment to prevent exposure of the sensor to microscopic debris. It is up to the customer to design their own lens interface. The lens-less configuration is only intended for advanced users with the capability to implement an adequate mating flange and to follow clean room procedures.

This document does not contain any export controlled information

4.1 Requirements

This procedure applies to FLIR's Boson 320 and 640 camera cores, and requires access to the following:

- FLIR Boson App version 1.4.2 or higher
- A blackbody at ambient temperature capable of subtending the entire field of view of the camera.
- Boson 320 with Release 2 software (2.0.11863 or later) or Boson 640. It is possible to update the software on Boson 320 Release 1 cameras to enable use of this feature. Refer to the separate App Note entitled "FLIR Boson Release 2.0 Update Procedure". If the version number of the currently-installed software is in doubt, it can be checked via the "Status Panel" pane on the "Diagnostic Tools" tab, as shown in Figure 8.
- Serial communications over USB to a computer using the Boson USB/Analog Video cable (or similar)

4.2 Setup

- 1) Follow the procedure listed in Section 2.0 for installing the Boson Application and connecting to the Boson camera.
- 2) If possible, install the Boson into the final assembly hardware including any enclosures, optical components, convection fans, heat-loads and heatsinks. If this is not possible, set up the Boson so that the heat load on the camera simulates as closely as possible the final assembly.
- 3) Lens gain must be calibrated prior to SFFC calibration. See Section 3.0. The lens focus should not be changed between the lens-gain calibration and the SFFC calibration.
- 4) A single blackbody source temperature is required for this procedure. It must subtend the entire field of view. **Note:** SFFC calibration is performed with the lens gain map enabled (which is why lens gain must be performed prior to SFFC), so in theory, the temperature of the blackbody used for SFFC calibration shouldn't matter. In practice, it isn't unusual to have some small residual gain error even after lens calibration, and therefore it is recommended to utilize a source temperature similar to what will be imaged during normal operation. For most users, an aluminum plate coated with flat-black paint at ambient temperature will be an adequate source.

This document does not contain any export controlled information

4.3 Procedure

- 1) Navigate to the **Lens Calibration** tab in the Boson Application. As described in Section 3.0, all Boson cameras have two lens tables, referred to as Lens 0 and Lens 1. For cameras that are delivered with a lens installed, FLIR recommends selecting Lens 1 for the user calibration. This will preserve the factory calibration in the Lens 0 memory location. For cores delivered without a lens, there is no SFFC map stored in either location. In this situation, it is possible to save separate lens maps for lens 0 and lens 1 for use with dual FOV optics.

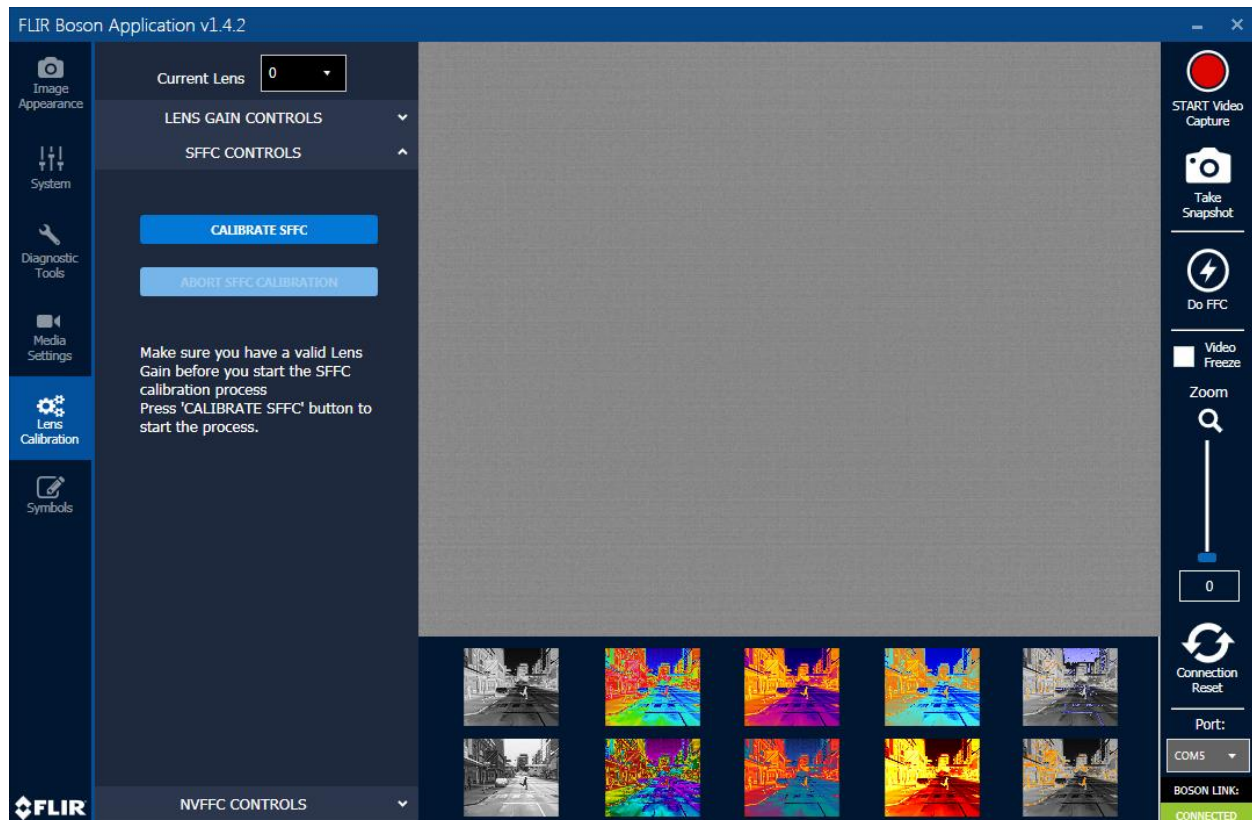


Figure 14. SFFC Procedure

- 2) Select the **SFFC CONTROLS** pane. Do not navigate away from this pane once you begin the data collection process because doing so could change camera settings required for calibration.
- 3) Initiate the SFFC Calibration process by pressing the **CALIBRATE FFC** button shown in Figure 14.
- 4) The app will monitor the camera's internal temperature and verify stability. If the camera has not been running long enough, the app will delay the calibration until temperature stability has been achieved. The larger the lens, the longer it will take to stabilize. It is not unreasonable to have to wait up to 10 minutes. If the stability process takes more than 10 minutes, ensure the camera's working environment is not changing.

This document does not contain any export controlled information

- 5) Once the app determines the camera's temperature is sufficiently stable, it will prompt the user to place the uniform source in the camera's field of view. Once in place, click the **CAPTURE** button. Keep the source in front of the camera until the app reports that calibration is complete.
- 6) If the lens map number was changed prior to the calibration (as recommended in step 1 for cameras with a factory-installed lens), the user may wish to save the power-on defaults such that the camera will default to the newly calibrated map at each subsequent start-up. This is accomplished by selecting **SAVE POWER-ON DEFAULTS** on the **CONFIGURATION CONTROLS** pane of the **SYSTEM** tab.

Upon completion of SFFC calibration, the app automatically enables the application of the SFFC map. To test the new SFFC map, the user may perform the following procedure:

- Perform a manual FFC while imaging the source used during SFFC calibration.
- If the image is uniform, the SFFC calibration is valid. If the image is not uniform, try the calibration procedure again.

This document does not contain any export controlled information

5.0 Non-Volatile Flat Field Correction

Non-Volatile Flat Field Correction (NVFFC) is a stored FFC map that is applied to the image automatically at the next power-up. 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 stores the FFC map to non-volatile memory, it also stores the value of “Camera temperature at last FFC” as well as the current NUC table. 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.
- External FFC: If the stored NVFFC map was generated in the same gain state as the start-up gain state, 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.

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.

5.1 Requirements

This procedure applies to FLIR’s Boson 320 and 640 camera cores, and requires access to the following:

- FLIR Boson App version 1.4.2 or higher.
- Boson 320 with Release 2 software (2.0.11863 or later) or Boson 640. It is possible to update the software on Boson 320 Release 1 cameras to enable use of this feature. Refer to the separate App Note entitled “FLIR Boson Release 2.0 Update Procedure”. If the version number of the currently-installed software is in doubt, it can be checked via the “Status Panel” pane on the “Diagnostic Tools” tab, as shown in Figure 8.

This document does not contain any export controlled information

5.2 Calibration Procedure

- 1) Navigate to the **Lens Calibration** tab in the Boson Application. As described in Section 3, all Boson cameras have two lens tables, referred to as Lens 0 and Lens 1. For cameras that are delivered with a lens installed, FLIR recommends selecting Lens 1 for the user calibration. This will preserve the factory calibration in the Lens 0 memory location. For cores delivered without a lens, there is no SFFC map stored in either location. In this situation, it is possible to save separate lens maps for lens 0 and lens 1 for use with dual FOV optics.

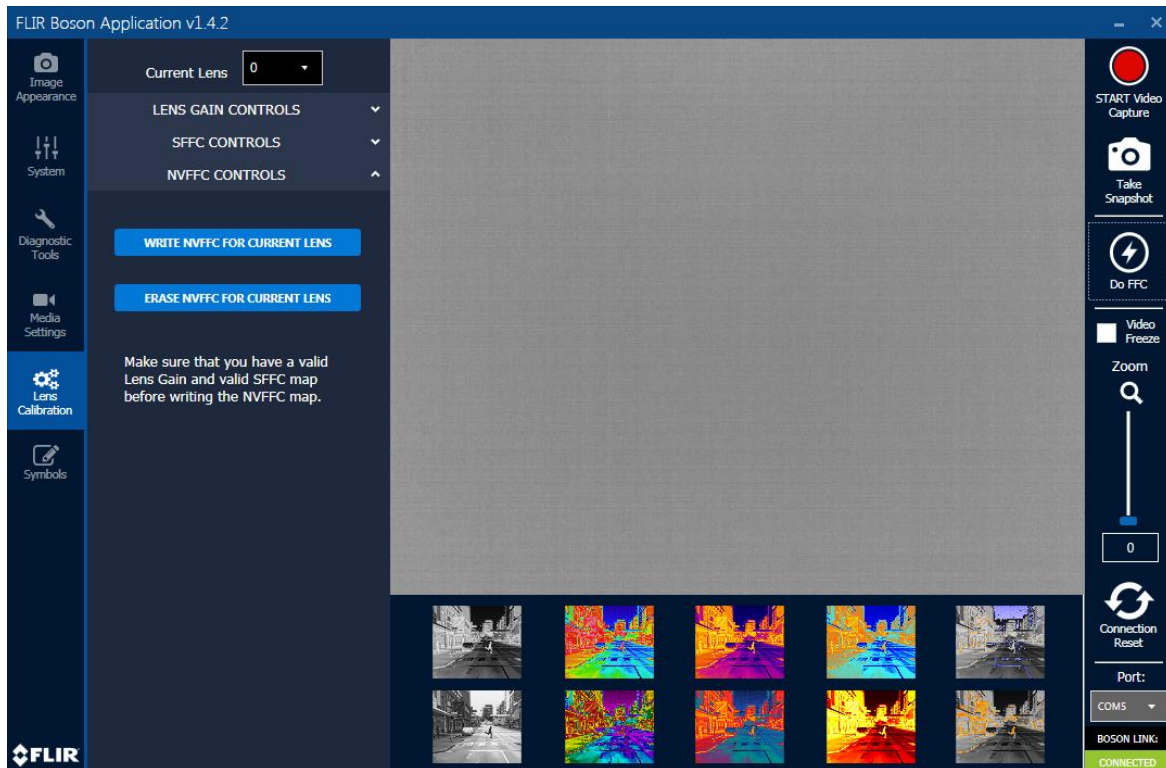


Figure 15. NVFFC Procedure

- 2) Select the **NVFFC CONTROLS** pane, shown in Figure 15.
- 3) Perform an FFC (manual/auto/external) using the **Do FFC** button on the far right of the GUI.
- 4) Press the **WRITE NVFFC FOR CURRENT LENS** button.

This document does not contain any export controlled information

6.0 Solar Exposure Protection

FLIR's uncooled detectors operate in the long wave infrared spectrum from 7.5-13.5 micrometers. Although radiation from the sun peaks at approximately 500 nanometers (the color green in the visible light spectrum), there is still plenty of energy that reaches the longer wavelengths of the Boson. Cutting off the shorter wavelengths (by use of a filter or lens coating) decreases the energy allowed to reach the detector. All standard Boson lens assemblies (320 and 640) come equipped with a solar-blocking filter. The core itself does not have a short wavelength cut-on filter on the sensor window. For any application where it is possible for the sun to enter the FOV, FLIR recommends that customers who purchase lens-less Boson cores plan to include some means for blocking solar radiation (a lens element coating, a protective front window, an internal filter assembly, etc.).

Boson lenses were designed such that out-of-band rejection will be used to minimize transmission below 7 microns. Average transmission between 1.1 and 2.1 microns is less than 5%. Average transmission between 2.1 and 5.0 microns is less than 10%.

The next page is an example of this type of protective coating.

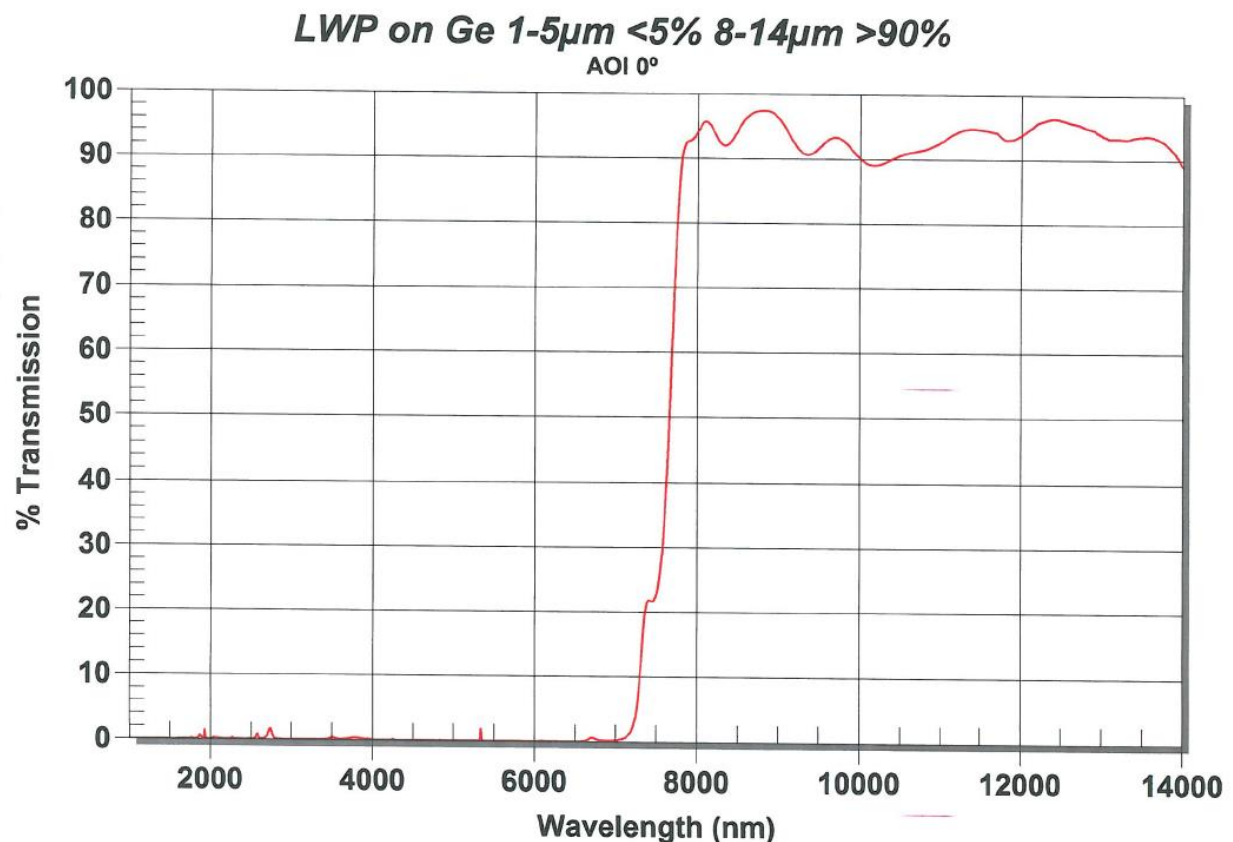


Figure 16. Solar Protection Coating

This document does not contain any export controlled information



While FLIR has taken steps to lessen the effects of the sun on our uncooled cameras, visible effects may be observed when a camera images the sun. A 'ghost' image of the sun is the most pronounced effect seen after prolonged exposure. The pixels that view the sun absorb higher levels of energy such that there is still a ghost image after the sun has moved. This is normal, temporary behavior. The length of time the ghost remains is dependent on the properties of the solar block filtering, the focal length of the lens, the duration of exposure, and the number of Flat Field Calibrations (FFCs) that occur after exposure.

This document does not contain any export controlled information