Supplemental FFC

Application Note

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1.0 Document

1.1 Revision History

Version	Date	Comments
100	10/14/2011	Initial Draft
110	7/31/2013	Updated Procedure
120	7/28/2014	Added manual calibration procedure

1.2 Scope

Supplemental Offset or Supplemental Flat Field Correction (SFFC) is a correction term intended to compensate for non-uniformity that occurs in thermally dynamic scenarios (for example, at start-up or when the camera is rapidly heated / cooled). The correction is associated with the installed lens, and some cameras support terms for up to 2 lenses.

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/ Here is a sample of some of the resources that can be found:

Document Title	Document Number	Description
Tau Quick Start Guide	102-PS242-01	Quick Start Guide for first-time use
FLIR Camera Controller GUI User's Guide	102-PS242-02	Detailed Descriptions for functions and adjustments for FLIR cameras using the FLIR Camera Controller GUI
Tau 2 Product Specification	102-PS242-40	Product specification and feature description
Tau 2 Electrical IDD	102-PS242-41	Written for Electrical Engineers to have all necessary information to interface to a Tau 2 camera
Tau 2/Quark Software IDD	102-PS242-42	Written for Software Engineers to have all necessary information for serial control of Tau 2 and Quark
Assorted Mechanical Drawings and Models	Various	There are drawings and 3D models for various camera configurations for mechanical integration
Application Notes	Various	Written for Systems Engineers and general users of advanced features such as Gain Calibration, Supplemental FFC Calibration, NVFFC Calibration, Bad Pixel Killing, detailed use of Camera Link, Camera Link Accessory Modifications, On-Screen Symbology, AGC/DDE explanation, Camera Mounting, Spectral Response, Optical Interface for lens design, and others.

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/.

2.0 Requirements:

Supplemental FFC is supported on the following cameras:

- Tau 320 (minimum software version 2.78)
- Tau 640
- Tau 2
- Quark 2 (not Quark 1)

The camera software revision can be verified in the FLIR Camera Controller GUI by clicking Help→About. The software will be described as "Main app" and the last two values are reported above. It is possible to update the software on a Tau 320 to enable the use of this feature. Consult a FLIR Applications Engineer for more details.

The latest version (GUI Framework v1.0.0.112) of the FLIR Camera Controller GUI can be obtained at http://www.flir.com/cvs/cores/resources/software/tau/. Refer to the FLIR Camera Controller GUI User's Guide for information on installing the FLIR Camera Controller GUI or connecting to the camera.

3.0 Supplemental FFC Operation

The Supplemental FFC (Supplemental Offset) is a correction factor intended to compensate for non-uniformity that occurs in thermally dynamic scenarios. This non-uniformity is typically caused by out-of field radiation and is seen in the form of dark or light corners. The correction factor is determined by taking the difference between an internal FFC with the shutter and an external FFC through the lens. This capability is not typically required unless the lens is changed after delivery from FLIR. It is important that the camera is installed in the final system and the system is in thermal equilibrium before the calibration occurs.

The SFFC algorithm is intended to correct the non-uniformity caused by out-of-field irradiance. This is caused by the difference of an internal and external FFC. With the shutter being close to the sensor, as opposed to being outside the aperture, out-of-field radiation from the housing and lens holder is not subtracted after an internal FFC.

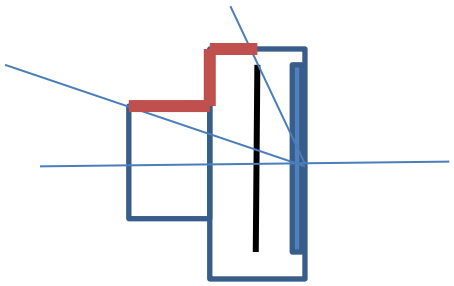


Figure 1: Radiation from the parts in red is not subtracted after an internal FFC.

Supplemental FFC_V1

The correction is applied as a scaled factor that is inversely proportional to the rate of change of the camera temperature. 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 temperature is changing. The following plot is meant to be demonstrative only and does not represent an actual LUT from a camera.

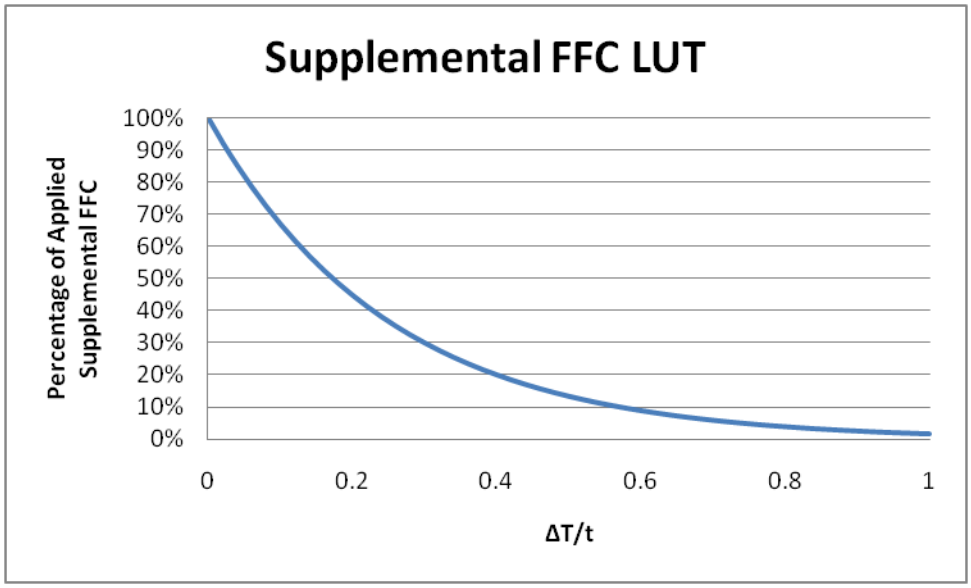


Figure 2: Example shape of Supplemental FFC LUT

This correction can be extremely useful for cameras that do not have a shutter and use either NVFFC, which applies a stored FFC on startup, or perform a single External FFC at startup. In this case, the camera temperature will be changing quickly at first and Supplemental FFC will not be applied. As the camera temperature begins to stabilize, a higher percentage of the Supplemental FFC will be applied. Since the Supplemental FFC was calibrated at steady state temperature of the camera, it will apply more correction as it becomes a closer match to the needed FFC.

4.0 GUI Calibration Procedure

4.1 Accessing Advanced Tab

To calibrate a Supplemental FFC, access to the Advanced Tab in the FLIR Camera Controller GUI is required.

The Advanced Tab contains many features that can be considered to be for advanced users. For this reason, a special keystroke and password is required to display the Advanced Tab. The keystroke is **Ctrl+Shift+a** and the password is www.flir.com. After the keystroke is performed, the following dialog will appear. Note that the text in the following image is added and a password typed will display as asterisks.

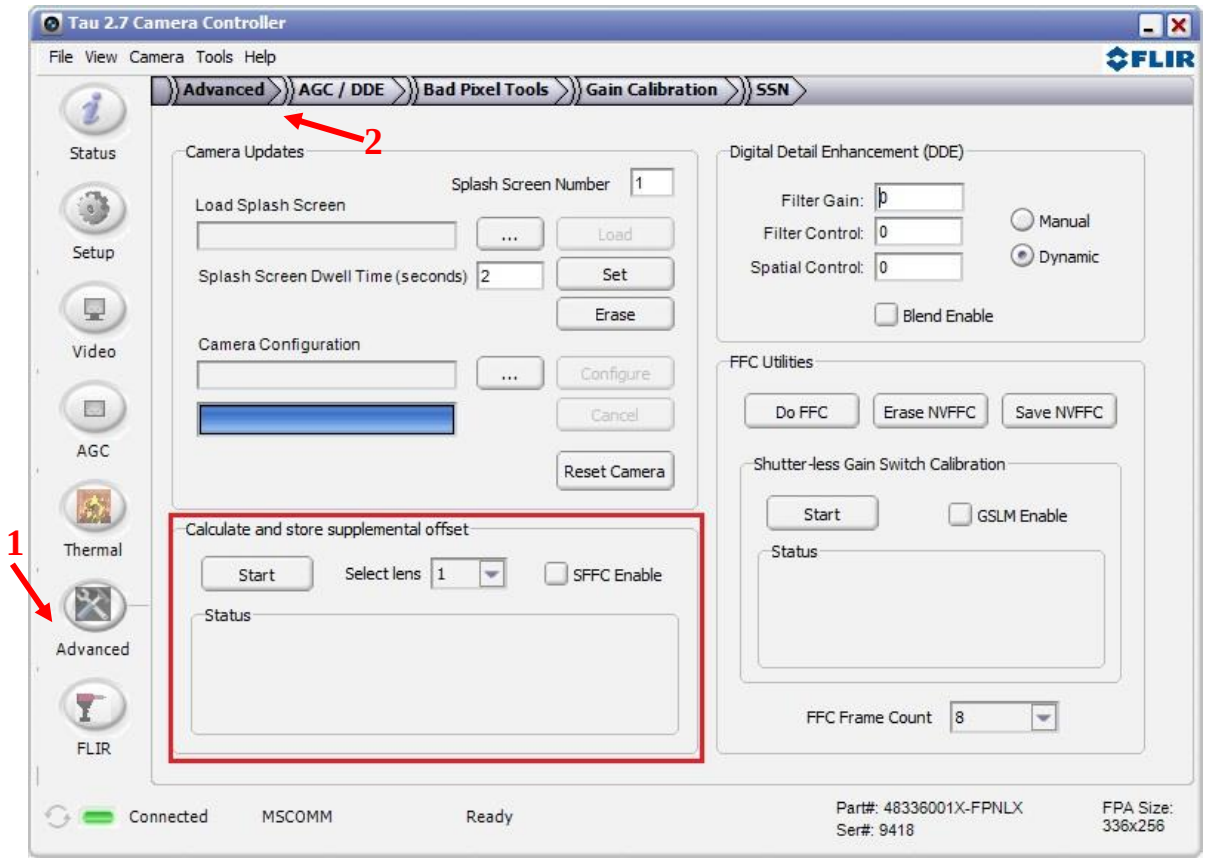
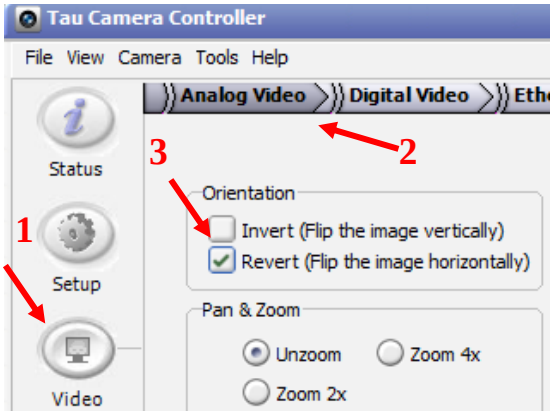


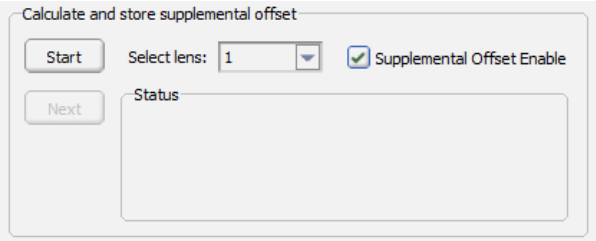
Figure 3: FLIR Camera Controller GUI – Advanced Tab

4.2 Calibration Procedure

Some configurations may use Invert and or Revert found on the Analog Video Tab. The user will need to ensure that for calibration purposes only that the Invert and Revert options are disabled. After calibration of supplemental FFCs the user may return the camera orientation to Invert and or Revert if that is the desired camera configuration. Navigate to this tab and disable (or uncheck) the Invert and Revert options (#3 in the image to the right). The user is now ready to navigate to the Advanced Tab that was made accessible in the previous section.



When using a Supplemental Offset (FFC) in the field the correction must be enabled. The correction term should also be on during calibration. Once this term is enabled for calibration the user should use the drop down menu and select the desired lens to be calibrated.



Before a Supplemental FFC can be performed, the camera temperature must stabilize. Click the Start button, and the GUI will monitor the camera for temperature stability. Once the test is passed, it will prompt for a uniform target to be placed in front of the camera and the Next button will become active.

An optimal target will be a uniform blackbody that is approximately the same temperature as the FPA temperature. This does not need to be precise, but it would be best not to use a 500C blackbody if the camera will be looking at a parking lot. Click Next and wait for the calibration to complete.

The camera will perform an Internal FFC and an External FFC and then calculate the Supplemental FFC to store. The camera will disable the Supplemental map after performing an external FFC since the map is only needed when using the internal FFC. If normal operations use the Supplemental FFC, then the map should be re-enabled after the SFFC calibration is performed.

Note: The camera will not apply the Supplemental FFC unless the Enable box is checked. If the final configuration is intended to have the Invert or Revert options enabled on the Analog Video Tab, now is the time to re-enable those options and save settings on the Setup Tab to keep these settings power cycle persistent.

5.0 Manual Calibration Procedure

The GUI provides a user friendly way to calibrate a supplemental FFC. Any calibration process of a thermal camera is almost always best when performed in its final enclosure. A pass through mode to a PC and the FLIR camera controller GUI is not always an option. This may also be used by customers with custom shutters they install behind their lens. This section will provide the steps that are needed to perform a SFFC calibration using serial communication on Tau 2.1.1, Quark 2.0 and later. The software commands are described below and may be found in the SWIDD.

- The camera temperature needs to stabilize before performing this calibration process
    - Periodically query the camera for FPA temp

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
32	0x20	***READ_SENSOR***	Gets various data from the core, depending upon argument of incoming message	Cmd: 2 & Reply: 2	Incoming arg. | Outgoing response 0x0000 | FPA temp in deg. C*10 0x0001 | FPA temp in raw counts	

- While waiting for the camera to stabilize, record the initial states of DDE and SSN (Tau 2.7 and Quark 2.0) to be restored after the SFFC calibration
- Disable DDE by setting the spatial threshold to zero and disable the blend mode if it is enabled
    - See SW IDD
- Disable SSN (available in Tau 2.7 and Quark 2.0 releases and later) and disable the SFFC correction before calibration

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
177	0xB1	***CORRECTION_MASK***	Sets Correction Mask	Cmd: 2 & Reply: 2	Valid arguments: 0x0063 (all corrections enabled, except no SFFC, non-advanced radiometry [AR], no SSN) 0x007F (all corrections enabled, non-AR, no SSN) 0x087F (all corrections enabled, Non-AR) 0x023F (all corrections enabled, With AR, no SFFC, no SSN) 0x027F (all corrections enabled, advanced, no SSN) 0x0A7F (all corrections enabled, with AR)	

- Ensure the camera is **not** in Invert or Revert mode
- When the camera is stabilized, DDE/SSN/SFFC are disabled, and the camera is not in Invert or Revert mode, point the camera at a uniform target
    - An optimal target will be a uniform blackbody that is approximately the same temperature as the FPA temperature. This does not need to be precise, but it would be best not to use a 500C blackbody if the camera will be looking around a room
    - Continue to leave the camera pointing at the uniform target until the procedure is complete
- Set the FFC mode to manual mode
    - Set with the FFC_MODE_SELECT (0x0B) command in the SWIDD
- When the camera is pointing at the uniform target, perform an internal FFC
    - An internal FFC will occur when in manual and the 0x0C command is sent
- Close the shutter
    - Set using the SHUTTER_POSITION (0x79) command in the SWIDD
- Save a snapshot to buffer #2 using the transfer frame command
    - Command and argument bytes: 0x82 0002
    - This is the internal frame capture

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
130	0x82	***TRANSFER_FRAME***	Captures a snapshot to a specified buffer location. (Capture operations must be sequential.)	Cmd: 4 & Reply: 4	Byte 0: 00 Byte 1: snapshot number	

- Return the shutter position to open
    - Set using the SHUTTER_POSITION (0x79) command in the SWIDD
- Set FFC mode to external FFC
    - Set using the FFC_MODE_SELECT (0x0B) command found in the SWIDD
- Perform an external FFC while imaging the uniform target
    - An external FFC will occur when in external FFC mode and the 0x0C command is sent
- Save a snapshot to buffer #3 using the transfer frame command described above
    - Command and argument bytes: 0x82 0003
    - This is the external frame capture

Math will need to be performed on these two frames using the calculate SFFC command different subcommands are used and highlighted and unlined in their respective section.

- Calculate the difference in these two frames and place them in buffer #4
    - Command and argument bytes: 0x84 0000 0003 0002 0004

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
132	0x84	***CALC_SFFC***	Calculates the supplemental FFC	Cmd: 8 & Reply: 0	Bytes 0-1: const_0x0000; Bytes 2-3: External_frame_number; Bytes 4-5: Internal_frame_number; Bytes 6-7: Diff_frame_number;	

- Perform first operation on buffer #4 and place result in buffer #5
  - Command and argument bytes: 0x84 0001 0004 0005 0000

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
132	0x84	***CALC_SFFC***	Calculates the supplemental FFC	Cmd: 8 & Reply: 0	Bytes 0-1: const_0x0001; Bytes 2-3: Source_frame_number; Bytes 4-5: Destination_frame_number; Bytes 6-7: const_0x0000;	

- Perform a second operation on buffer #5 and record the result that is returned
  - Command and argument bytes: 0x84 0002 0005 0006 0000
  - The reply will be a two bytes response that will be used in the next step (0x84 XYZW)

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
132	0x84	***CALC_SFFC***	Calculates the supplemental FFC	Cmd: 8 & Reply: 2	Bytes 0-1: const_0x0002; Bytes 2-3: Source_frame_number; Bytes 4-5: Destination_frame_number; Bytes 6-7: const_0x0000;	

- Calculate the final frame
  - Command and argument bytes: 0x84 0003 0005 XYZW 0000
  - XYZW is from previous step

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
132	0x84	***CALC_SFFC***	Calculates the supplemental FFC	Cmd: 8 & Reply: 0	Bytes 0-1: const_0x0003; Bytes 2-3: Source_frame_number; Bytes 4-5: Returned bytes from previous section; Bytes 6-7: const_0x0000;	

- Save the supplemental FFC
    - Command and argument bytes: 0xC5

ID	Function Code (hex)	Command	Description	Byte Count	Argument (i.e, Data Bytes) (hex)	Notes
197	0xC5	***WRITE_SFFC***	Writes the supplemental FFC table to flash	Cmd: 0 & Reply: 0	N/A	

- Query the camera for flash status using the 0xC4 command found in the SWIDD
    - The camera takes about five seconds to save this to flash
    - Do not interrupt power to the camera during a flash write
    - Do not alter or change the camera until the flash status returns complete
- Return DDE and SSN (If it applies to the cameras configuration) to initial settings
- Enable SFFC
- If the final state of the camera uses Invert or Revert mode, return those to their initial states
    - Invert and Revert should be enabled after SFFC has been enabled
- Save settings, restart the camera and verify quality of the map by slowly toggling the map on and off

If you have questions that are not covered in this manual, or need service, contact FLIR Commercial Systems Customer Support at 805.964.9797 for additional information prior to returning a camera.

This documentation is 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.