

# FLIR Lepton with Radiometry Quickstart Guide

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## Table of Contents

Revision History .....	1
Scope .....	1
Compensation for Final System Integration.....	2
Background .....	2
Application.....	2
Requirements .....	2
Procedure .....	3

## Revision History

Version	Date	Comments
100	December 8, 2016	Initial Release

## Scope

This document describes a simplified subset of the parameter updates necessary for integrating the Lepton with Radiometry configuration (80x60 part number: 500-0763-01) into a final system. For a more in depth discussion of the radiometry background principles and sources of error, please refer to the Advanced Radiometry Application Note (document number 102-PS245-75).

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102-PS245-76, Lepton with Radiometry Quickstart Guide, Rev:100



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## Compensation for Final System Integration

### Background

The Lepton with Radiometry is calibrated at the factory for accurate measurement of a scene with 100% emissivity in close proximity to the camera. Factors such as scene emissivity and unwanted signal from sources other than the scene will influence the measurement accuracy of a real scene. Compensation for the factors that enter as a result of integrating the Lepton in a complete system is the subject of this document.

The Lepton with Radiometry calibrated values and parameter defaults assume no window or 100% window transmission, but typical systems in which the Lepton is integrated include a window which needs to be characterized to achieve accurate radiometry. The window must be transmissive in the long wave infrared (LWIR) band, specifically 7-14microns. Typical materials include Ge, ZnS, and Si where the average transmission across the LWIR band would be provided by the window supplier or preferably characterized for best accuracy as described in the subsequent section. The temperature of the window should also be characterized to determine the additional irradiance it adds to the system. In use, the window temperature will vary as a function of the environment temperature which can be compensated for by either run-time measurement (i.e. including a temperature sensor) or simply characterizing the value at a particular temperature and relating it to the temperature sensors included in the Lepton module.

For best radiometric accuracy, it is recommended that instead of utilizing the transmission values provided by the supplier, that the window transmission and window temperature are characterized on a small sample set in the final system to be applied to all systems using the same configuration. The window transmission should be characterized first, then the window temperature at a single ambient temperature point at a minimum. Note that the window temperature measurement error is high when the window transmission is very high, but in this case the impact of this parameter is lower. The following section discusses the procedure for characterizing the window parameters which are effectively correcting all gain (e.g. window transmission) and offset (e.g. reflection and/or irradiance from the window) errors in the final system.

### Application

#### Requirements

- Two black body sources with known temperatures and emissivity, e.g. 20°C and 60°C
- Software interface to communicate with Lepton over i2c

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102-PS245-76, Lepton with Radiometry Quickstart Guide, Rev:100

# FLIR Lepton with Radiometry Quickstart Guide

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- Video interface to view VoSPI
- Final enclosure with the window

## Procedure

- 1) Power on the Lepton within the final system (including the window).
- 2) Align the camera with the black body source such that the surface of the black body subtends at a minimum the 10x10 center pixels. Ensure the black body is far enough away to be in focus. If the black body source is relatively hot, this can cause undesired camera heating affects, so a shield may be used until the data collection starts.
- 3) Ensure the black body source is stable in temperature. Ensure the camera temperature is stable. For example, to verify the camera temperature is stable, read back the FPA temperature via the `LEP_GetSysFpaTemperatureKelvin()` C-SDK command multiple times over the course of 10 seconds.
- 4) Change the Flat Field Correction (FFC) mode to “Manual” to ensure no FFCs occur during the calibration via the `LEP_SetFfcShutterModeObj()` C-SDK command.
- 5) Perform an FFC via the `LEP_RunSysFFCNormalization()` C-SDK command and wait at least one minute prior to data collection.
- 6) Set the TLinear state to disabled via the `LEP_SetRadTLinearEnableState()` C-SDK command.
- 7) Capture a frame or record the mean of the center pixels. The mean output of the center region of interest, ideally smaller than the black body (e.g. 6x6), is variable  $S_{1Win}$ . Record the FPA temperature ( $T_{FPA}$ ) in degrees Celsius at the time of this measurement (either in the telemetry data or via i2c query).
- 8) Move the camera to view the second, hotter black body source.
- 9) Capture a frame or record the mean of the center pixels. The mean output of the center ROI is variable  $S_{2Win}$ .  
*Note: Alternatively, both black body sources can be viewed simultaneously and the captured frame analyzed with the appropriate region of interest for each of the  $S_{1Win}$  and  $S_{2Win}$  measurements.*
- 10) Remove the window and repeat the previous steps where the new measurements without the window are variables  $S_{1NoWin}$  and  $S_{2NoWin}$ .
- 11) Calculate the average percent transmission reduction due to the window with the following equation:

$$\tau_{Win} = \epsilon \cdot \frac{S_{2Win} - S_{1Win}}{S_{2NoWin} - S_{1NoWin}}$$

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102-PS245-76, Lepton with Radiometry Quickstart Guide, Rev:100



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12) Calculate the window temperature with the following equations. The flux due to the window temperature  $W(T_{Win})$  must first be calculated before converting to temperature  $T_{Win}$  with the RBFO parameters that were calibrated at the factory on a per-camera basis; the RBFO parameters can be read from the camera software via the `LEP_GetRadRBFOExternal0()` C-SDK command. The background temperature  $T_{Bkg}$  must be assumed and the corresponding flux  $W(T_{Bkg})$  calculated using the RBFO function. The expected blackbody signal  $W(T_{BB})$  must also be calculated with the known black body temperature and the RBFO function.

$$W(T_{Win}) = \frac{S_{1Win} - \tau_{Win}\{\epsilon W(T_{BB}) + (1 - \epsilon)W(T_{Bkg})\}}{(1 - \tau_{Win})}$$

$$T_{Win} = B / \ln\left(\frac{R}{W(T_{Win}) - O} + F\right)$$

where

- $\epsilon$  = emissivity of the black body
- $S_{1Win}$  = measured signal against black body 1
- $\tau_{Win}$  = characterized window transmission
- $W(T_{BB})$  = expected signal against the black body
- $W(T_{Bkg})$  = flux due to background temperature
- $R, B, F,$  and  $O$  = camera specific constants readable via CCI

13) Write the characterized external scene parameters  $\tau_{Win}$  and  $T_{Win}$  to camera software via the `LEP_SetRadFluxLinearParams()`.

14) Verify accuracy against both black body sources to confirm the newly characterized parameters.

15) If it is not practical to measure the window temperature in use, it can be estimated by using nearby known temperatures such as that of the focal plane array ( $T_{FPA}$ ) plus an offset determined experimentally. This constant offset may be determined with the room temperature ambient data described above, where  $T_{FPA}(\text{measured})$  is determined in Step 7 and  $T_{Win}(\text{measured})$  is determined in Step 12:

$$\text{Offset} = T_{Win}(\text{measured}) - T_{FPA}(\text{measured})$$

$$T_{Win}(\text{runtime}) = T_{FPA}(\text{runtime}) + \text{Offset}$$

Note that updating the window temperature in runtime based on  $T_{FPA}$  or an additional temperature sensor requires constant update of the  $T_{Win}$  parameter in software via `i2c`.

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102-PS245-76, Lepton with Radiometry Quickstart Guide, Rev:100



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