FLIR Lepton with Radiometry Quickstart Guide

Document Number: 102-PS245-76 Rev 121

FLIR® | The World's Sixth Sense™

Table of Contents

Revision History

Version	Date	Comments
100	December 8, 2016	Initial Release
110	June 16, 2017	Updated to include equations required for calibration herein
120	June 16, 2018	Corrected equation for calculation of windows transmission
121	August 28, 2018	Updated EAR statement

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).

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 integrated systems 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 7-14µm. 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 single temperature and relating it to the temperature sensors included in the Lepton module.

For best radiometric accuracy, it is recommended 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
- 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_{1NoWin}.

11) Calculate the average percent transmission reduction due to the window with the following equation:

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

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.

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

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

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

$$W(T) = \frac{R}{\exp(B/T_K) - F} + O$$

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

The World's Sixth Sense™

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}(measured) is determined in Step 7 and T_{Win} (measured) is determined in Step 12:

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

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

Note: 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 the i2c interface.

The World's Sixth Sense™

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.

FLIR® | The World's Sixth Sense™