FLIR LEPTON®
Lepton vs. Lepton 3 Application Note

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Document

Revision History

Version	Date	Comments
100	2017-04-04	Published for Lepton 3 Release
101	2018-08-27	Updated EAR statement

Scope

This document summarizes the key differences between the Lepton and Lepton 3 camera modules. It is intended primarily for users familiar with Lepton who are considering Lepton 3 as an upgrade. The document is divided into 9 sections:

Summary

The primary difference between Lepton and Lepton 3 is the improved resolution of the infrared sensor. Lepton provides an output of 80x60 pixels whereas Lepton 3 outputs 160x120. Despite having four times the number of pixels, Lepton 3 maintains the form factor of its predecessor and actually consumes slightly less power (nominally 140 mW versus 150 mW). A key enabler for the improved resolution is reduction of pixel pitch from 17 to 12 microns.

Electrical Interface

Generally speaking, the electrical interface to Lepton 3 is identical to Lepton. It is intended to be installed in the same socket (Molex 105028-1001 or Molex 105028-2031), and the pinout is unchanged. All DC and logic levels, all AC characteristics, and all absolute maximum ratings are identical to Lepton (with the possible exception of the VoSPI clock frequency, as described in the video interface section). As noted in the Summary section, the power consumption of Lepton 3 is nominally 7.1% less (140 mW vs. 150 mW).

Command and Control Interface (CCI)

Lepton and Lepton 3 share a common CCI, a two-wire interface very similar to I2C (the difference relative to the true I2C standard being that only 16-bit transfers are allowed). Both Lepton and Lepton 3 use the same I2C address (0x2A), and Lepton 3 is fully backward compatible with the Lepton command set. The document which defines the interface in detail, the Software Interface Description Document (IDD) document number 110-0144-04, is common to all versions of Lepton as is the Software Development Kit (SDK).

Video Interface

Considering that Lepton 3 outputs four times as many pixels as Lepton, it is not surprising that the biggest differences between the two modules are in the Video-Over-SPI (VoSPI) interface. Regardless, much of the interface is unchanged, as summarized below:

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1) The VoSPI physical layer is identical, including the SPI mode and timing.
2) For both modules, the minimum VoSPI transaction is a packet consisting of either 164 bytes of data (Raw14 video mode) or 244 (RGB888 mode). The packet protocol, including the packet header and payload, are unchanged. However, it is worth noting a single packet represents a single 80-pixel video line for Lepton whereas it represents half of a 160-pixel video line in Lepton 3.
3) The synchronization requirements are identical with one exception. To maintain synchronization, Lepton requires each video frame to be read out prior to the next available frame. In contrast, Lepton 3 requires each *segment* to be read out prior to the next available segment, where a segment represents one-quarter of a video frame.
4) For both Lepton and Lepton 3 each unique frame is followed by two non-unique frames which must be read out to maintain synchronization. For Lepton each unique video frame is duplicated twice. For Lepton 3 each unique frame is followed by two partial, invalid frames.

The four most significant differences between the Lepton and Lepton 3 VoSPI interfaces are:

1) On Lepton, reconstructing a video frame from the individual packets requires the host to decode the packet number from each packet header. On Lepton 3, the host must decode both the packet number and the segment number.
2) The total number of bits per frame is 4X greater for Lepton 3 than for Lepton. Consequently, the minimum SPI clock rate is 4X faster. The maximum SPI clock rate for both modules is 20 MHz.
3) Both Lepton and Lepton 3 provide the option to output a sync pulse on GPIO3. The frequency of the pulse is 4X higher on Lepton 3 than on Lepton. For Lepton 3, the sync pulse represents when the next available segment is available whereas for Lepton it indicates when the next available frame is available.
4) When telemetry is enabled in Lepton, it results in three extra video lines (63 total packets per frame). When telemetry is enabled in Lepton 3, it results in 1 additional packet per segment for a total of 2 extra video lines.

A careful review of the VoSPI section of the Lepton 3 datasheet is recommended for a more complete understanding of the video interface.

Feature Set

The Lepton 3 feature set is identical to that of Lepton with two exceptions:

1) Lepton 3 provides a new command called “Set User Defaults”
2) Lepton 3 includes an improved AGC algorithm

Set User Defaults Feature

This “Set User Defaults” feature allows the user to customize all parameter settings (such as whether to output Raw14 data or RGB888 data) and then store those settings as power-on defaults. Once the parameter defaults are stored, they will take affect at every subsequent power-up and/or reset event. This feature allows the customer to customize Lepton cameras in a factory environment prior to installation in the end system. Depending upon the application, this capability may preclude the need for a Command and Control Interface in the end system. Note that “Set User Defaults” can only be sent once. The Lepton 3 will report an error if the command is sent a second time.

Improved AGC

The Lepton 3 AGC algorithm is a modified version of classic histogram equalization (HEQ) that mitigates the associated shortcomings, including poor contrast between two objects of different temperatures in bi-modal scenarios, placing too much emphasis on background clutter of lesser interest, and inducing noise in low dynamic range scenarios. One such modification is a “clip limit high” function, which clips the maximum population of any single bin, limiting the influence of heavily populated bins on the mapping function. Another feature utilized exclusively by the Lepton 3 algorithm is called “linear percent.” It adds a user-defined percentage of the total number of pixels to every non-zero bin in the histogram, resulting in additional contrast between portions of the histogram separated by gaps. The “maximum gain” function is an improvement to classic HEQ and the Lepton algorithm. It limits the amount of gain applied when the dynamic range of the 14-bit image is less than 255 bins, thus limiting the amount of noise in the output AGC image. The *Figure 1* below demonstrates the benefit of the Lepton 3 features.

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Figure 1 – Comparison of Linear AGC, Classic HEQ, and the Lepton 3 Variant of HEQ

(a) Linear AGC Histogram

(b) Classic Histogram Equalization

(c) Lepton 3's Variant of Equalization

Performance

Other than the obvious benefit of providing 4 times the pixel resolution, the performance specifications of Lepton 3 are very similar to Lepton.

NEDT: Both products have a specified Noise Equivalent Delta Temperature (NEDT) less than 50 mK with an f/1.1 lens with radiometry mode enabled.

Note: NEDT refers to the thermal resolution of the product. An NEDT of 50 mK means that when the temperature difference between two temperatures is 50 mK, than the signal-to-noise ratio is unity.

Field of View: The nominal field of view (FOV) of Lepton 3 is slightly wider than that of Lepton, as summarized in *Table 1*.

Table 1 – Field of View of the Lepton vs. Lepton 3

	Horizontal FOV	Vertical FOV	Diagonal FOV

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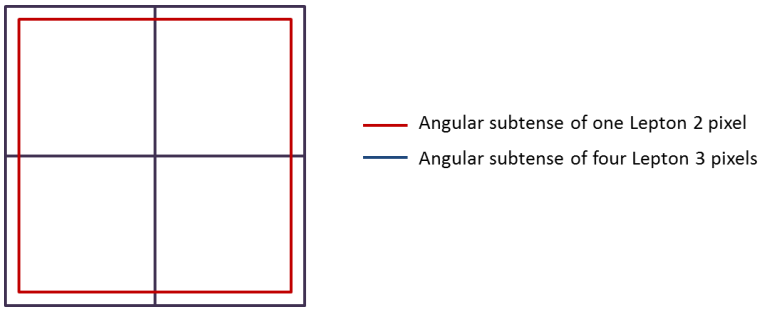
Lepton	51 degrees	38 degrees	64 degrees
Lepton 3	56 degrees	42 degrees	71 degrees

Operability: Both Lepton and Lepton 3 provide operability ≥99% (i.e., less than 1% of the pixels are defective). In both products, all defects are replaced by the average of non-defective neighbors. Lepton 3 allows two-pixel clusters, but it is worth noting that the angular subtense of a two-pixel cluster in Lepton 3 is nearly half the angular subtense of a single defect in Lepton. This fact is illustrated in the *Figure 2* below.

Figure 2 – Angular Subtense Depiction



Mechanical

In general, the mechanical interface to Lepton 3 is very similar to Lepton. The two figures below show Lepton on the left and Lepton 3 on the right. *Figure 3*Figure 1 shows the x- and y-dimensions of the shuttered configuration, and *Figure 4* compares the z-dimensional height. As described in the Electrical section, both are intended to be installed in the same socket.

Figure 3 – X and Y Dimensions, (Left) Lepton, (Right) Lepton 3

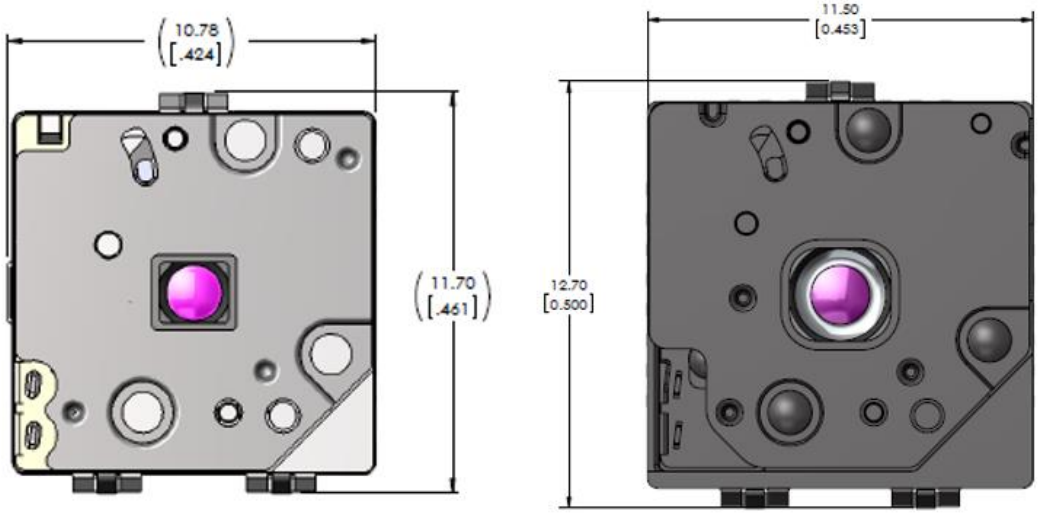


Figure 4 – Z-Dimensions, (Left) Lepton, (Right) Lepton 3

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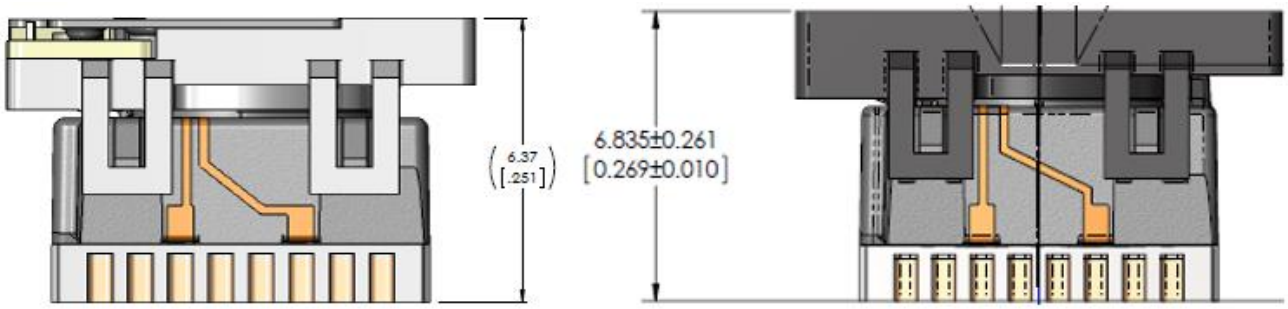

Environmental

The same environmental requirements specified for Lepton apply also to Lepton 3. These specifications are summarized in *Table 2* below.

Table 2 – Environmental Specifications

Stress	Maximum Rating
Operating Temperature Range	-10° C to 65° C (-20° C to 75° C with some possible performance degradation)
Maximum Operating Temperature	80 °C[1]
Shutter Operating Temperature	-10° C to 65° C[2]
Storage Temperature	-40° C to 80° C
Altitude (pressure)	12 km altitude equivalent
Relative Humidity	95%
Thermal Shock	Air-to-air across operating temp. extremes (-10° C to 65° C, 65° C to -10° C)
Mechanical Shock	1500 g, 0.4 msec
Vibration	Transportation profile, 4.3 grms
ESD	Human Body Model (HBM), 2kV Charged Device Model (CDM), 500V

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Note(s)

1. Lepton 3 contains an automatic shutdown feature when its internal temperature exceeds the maximum safe operating value.
2. Lepton 3 contains an automatic shutter lockout feature that prevents the shutter from operating when its internal temperature is outside the range of -10° C to 65° C.

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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.

The information contained herein does not contain technology as defined by the EAR, 15 CFR 772, is publicly available, and therefore, not subject to EAR. NSR (6/14/2018).
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