FLIR Camera Adjustments
LWIR Video Camera

Application Note

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1.0 Document

1.1 Revision History

Version	Date	Comments
100	10/25/2011	Initial Release

1.2 Scope

This note is intended to provide a better understanding of FLIR image processing algorithms. Once these are well understood by the user, the camera can be optimized to give the best possible image for a given scenario. This document applies to the FLIR Quark, Tau 2, Tau, and Photon uncooled thermal cores. These cores can be found in most FLIR Commercial Systems products.

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
Quark Quick Start Guide	102-PS241-01	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
Quark Product Specification	102-PS241-40	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
Quark Electrical IDD	102-PS241-41	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, Camera Link, 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/. Additionally, a FLIR Applications Engineer can be contacted at 888.747.FLIR (888.747.3547).

2.0 Automatic AGC Parameters

The first thing to understand is that the detector data is directly streamed from the sensor as14-bit values for each pixel in the array. The analog image is displayed using 8-bit values and almost all commercial displays are 8-bit devices. This means that there must be some compression to get the data into a format that can be displayed. Throughout this note, there are histograms that are represented in Signal vs. Number of Pixels. A histogram is a sorting of pixel values into intensity "bins". What this means is the bit value (which increases as pixels get brighter) is on the x-axis and the number of pixels in the image that have that bit value is on the y-axis. This is a way of plotting image data in order to illustrate which are the most significant intensity values. The algorithms attempt to compress the data in a meaningful way that preserves as much of the image content as possible.

2.1 Introduction to Histograms

The following histogram is the 14-bit data taken from a Tau 320 with a cold water bottle, a mid-temperature wall, and a hot coffee mug in the scene. These three objects can be seen in the data histogram as three separate peaks. The lowest bit values, which are farthest to the left in the histogram, are the coldest pixels in the scene. The values in 14-bit space range from 0 to 16384.

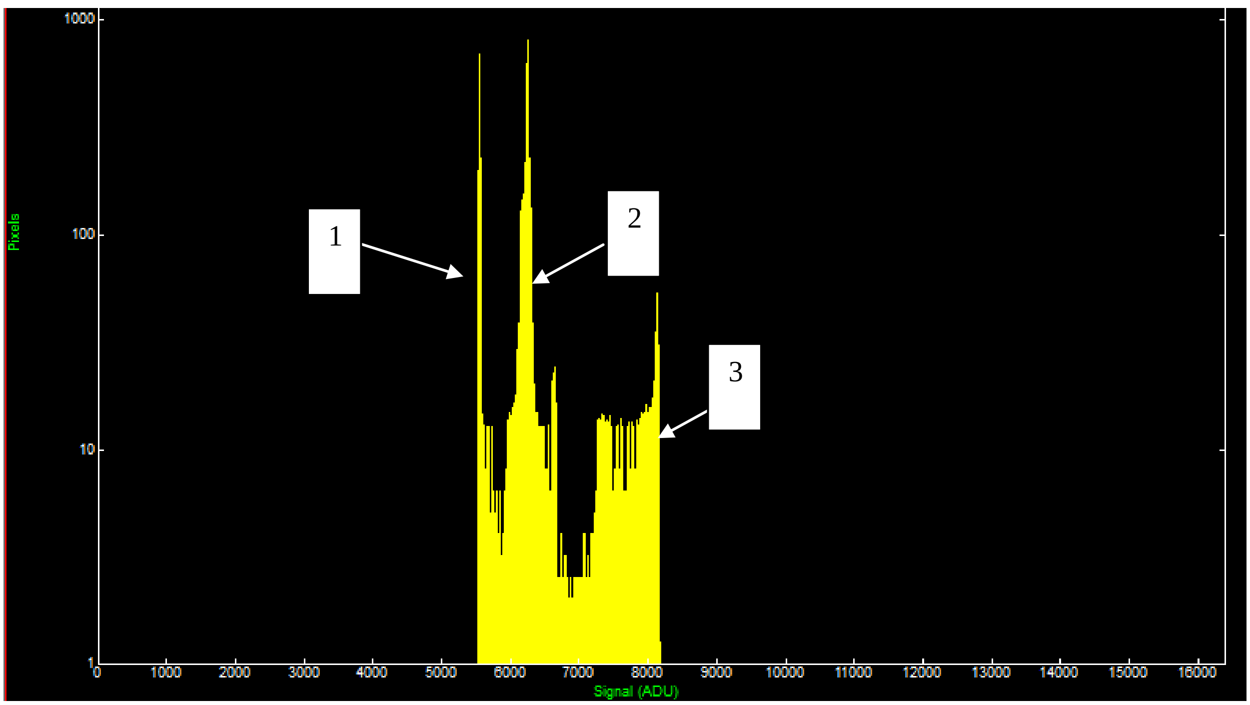

Figure 1: 14-bit Histogram

The following image is associated with this histogram. You can see the cold, black water bottle, the grey background, and the hot, white coffee mug. You can also see that the water bottle is fairly uniform and has a narrow spike whereas the mug has different temperatures in the handle and above the coffee line. For this reason, the data is more spread in the histogram at point 3.

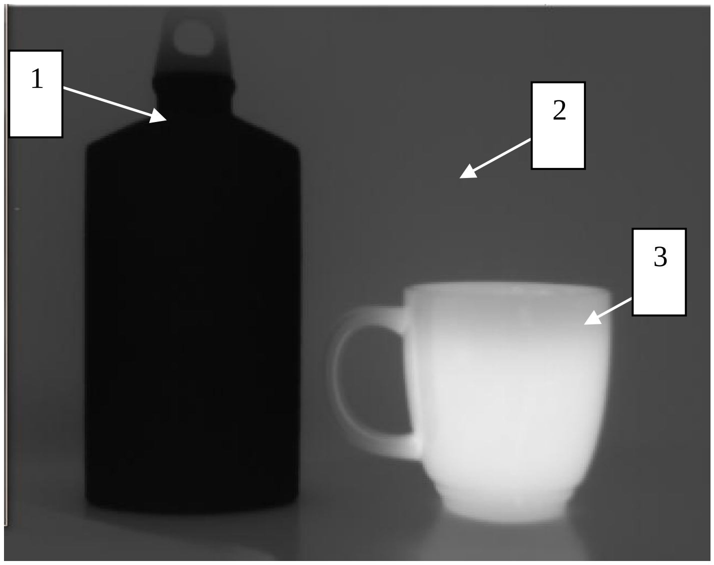

Figure 2: Image of scene

2.2 Linear Histogram

The first and simplest method to translate the data into 8-bit space is using a linear algorithm. Although this algorithm is not typically used, it will help illustrate the concept of using a transfer funciton to map from one space to another. A typical linear intensity transfer table will map the middle 90% of the histogram to 8 bit space. The bottom and top 5% are discarded. This algorithm finds the interesting portion of the data and crops above and below it. The following histogram is a representation of the same scene in 8-bit space. Notice the three peaks from the 14-bit data represented in 8-bit space and that the values on the x-axis now range from 0-255 rather than 0-16384.

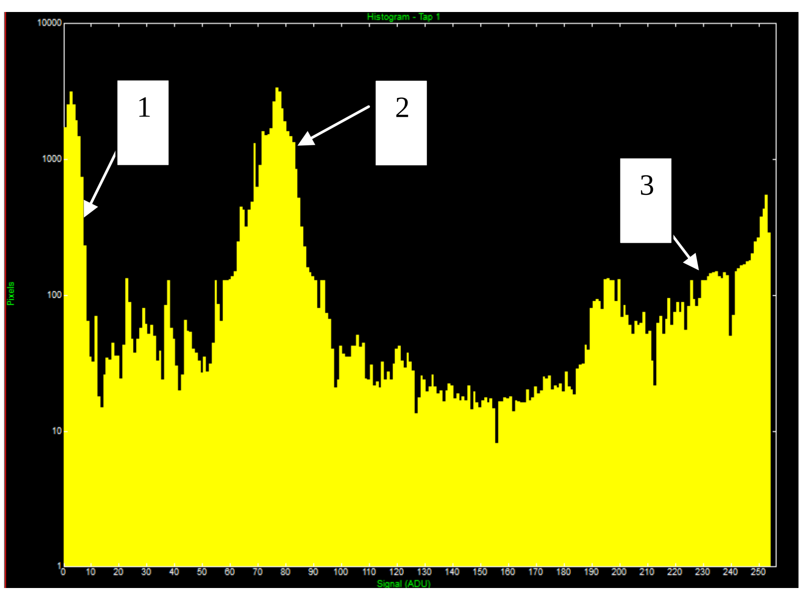

Figure 3: Linear AGC, ITT Mean: 127, Max Gain: 8

2.3 Plateau Histogram Equalization

The Plateau Histogram Equalization algorithm seeks to maximize the dynamic range available for the content of the scene. It does this using a transfer function that is based on the number of pixels that are in each bin and allocating more 8-bit range for that bin. The Plateau value is the pixels/bin limit when the transfer function is maximized. When this number is small, the Automatic AGC will approach a linear algorithm that preserves a linear mapping between the 14-bit and 8-bit data. The goal of the Automatic algorithm is to try and make each of the 255 bins have the same number of pixels in it, which should give the best contrast for the given scene. When the plateau value is higher, the algorithm is more able to redistribute the data to achieve this goal. This prevents wasted levels of grey on regions that have no scene content and can visually be seen in the histograms by noticing that peaks are much smoother and the data is spread much more evenly.

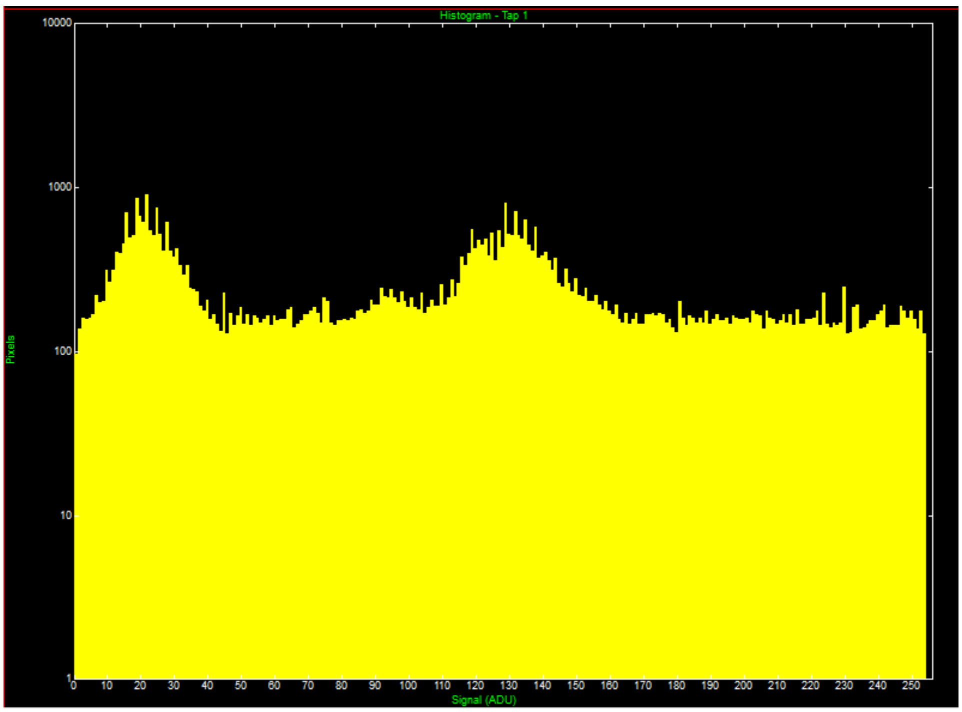

Figure 4: Plateau: 150, ITT Mean: 127, Max Gain: 8

Compare to Linear Histogram in Figure 3

The following plot shows the Image Transform Table for both Linear and Plateau Histogram Equalization. The 14-bit value on the x-axis will map to the 8-bit value on the y-axis where the conversion is plotted. In 14-bit regions with low contrast, the curve is much flatter and there are not as many 8-bit values consumed. In high detail regions, the curve is steep and more 8-bit values are used.

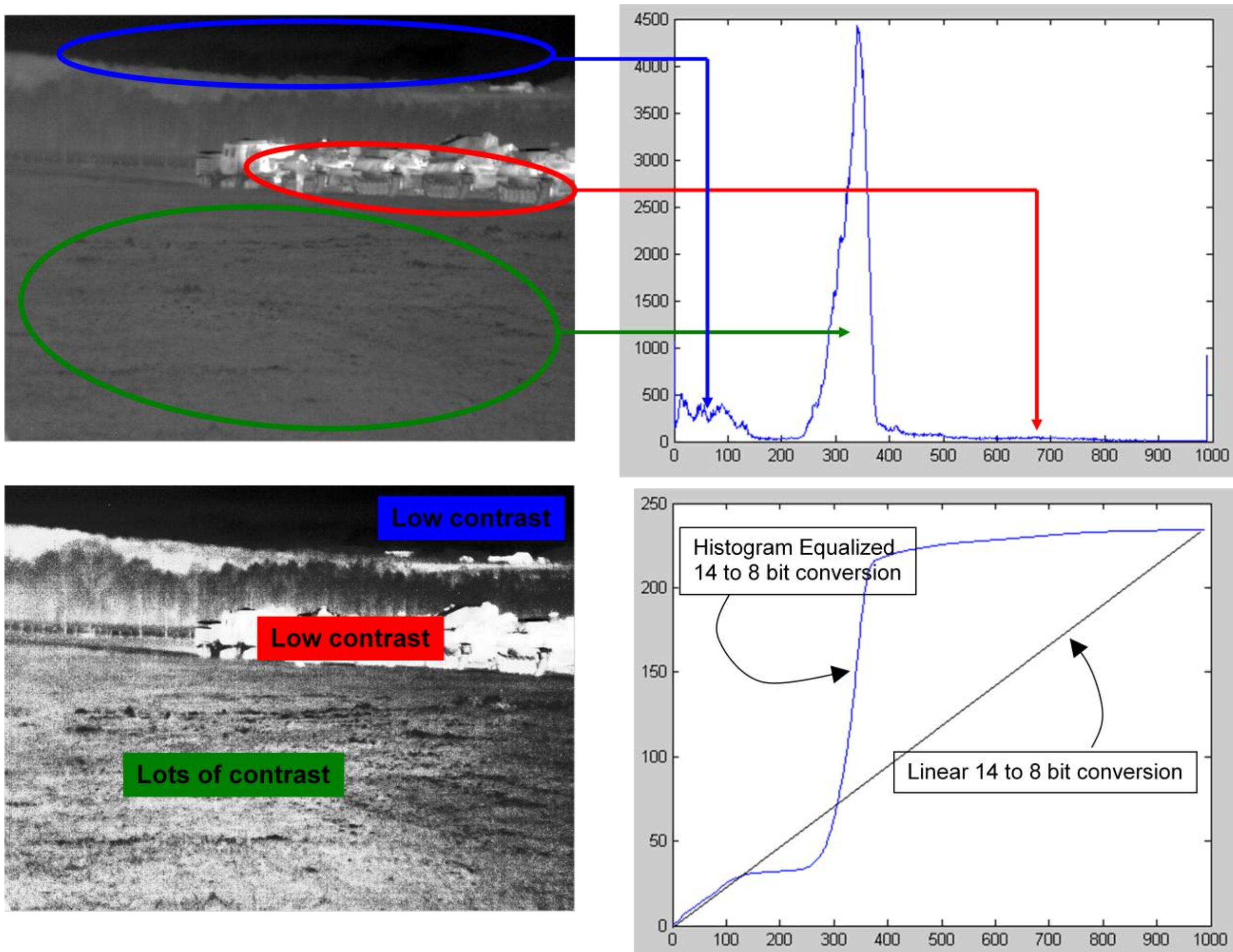

Figure 5: Image Transform Table for Linear and Plateau algorithms

In many applications, there are objects with different temperatures that all need to have contrast. In this case, the plateau value can be increased from the default setting of 150 to 250 or 300, depending on the content of the scene. This will provide the algorithm with more flexibility to generate an image with high contrast for both foreground and background targets. In applications where there is a large object of a small temperature range and the background is not important, lowering the plateau value to 100 or 50 will dedicate more contrast to the foreground object and the background will have less. This can also be done when an AGC ROI is used to discard scene content that is not important.

It is important to note that higher plateau value distorts the correlation between physical temperature of the scene and level of grey in the image, which is preserved in a linear histogram.

The ITT Mean sets the midpoint of the Image Transform Table and is applied after the histogram equalization on the 8-bit data. This can be thought of as an offset that shifts the entire distribution to the left or the right and directly affects the brightness of the image. It is important to notice that when the data is shifted, it is cropped and it is not stretched to fill the 8-bit range. This means that you are losing data by shifting, but the data on the top and bottom may not be the most important. Increasing the Plateau Value, as seen above, typically raises the perceived brightness of the scene. This could be counteracted by lowering the ITT Mean from the default of 127 to 120.

It is also important to note that changes in levels of grey are more perceptible to a human observer at lower levels of illumination. This is because a change from 5 to 10 counts is 100% and a change from 245 to 250 is about 2%. By lowering the ITT Mean, you can shift the luminance to a lower value so that a human observer will be more capable of seeing small changes in the scene. If you are using analytics, the performance will not likely be improved by this change and the default setting of 127 is recommended.

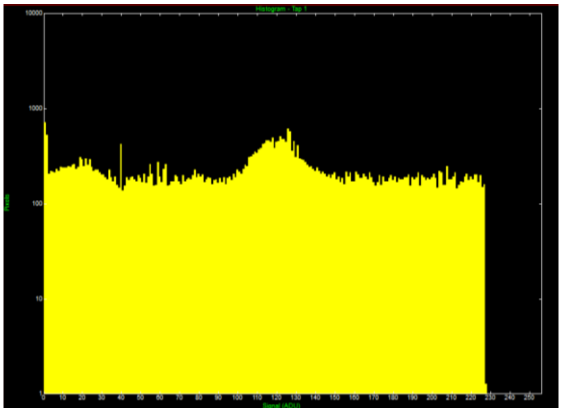

Figure 6: Plateau: 250, ITT: 110, Max Gain: 8

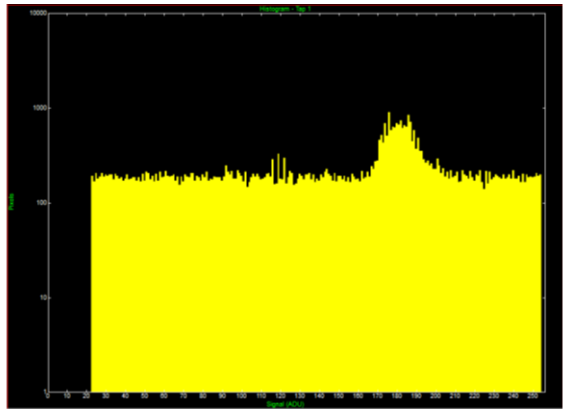

Figure 7: Plateau: 250, ITT: 150, Max Gain: 8

The final AGC parameter is the Max Gain. To demonstrate this, it will be better to look at a scene with very low contrast. The scene used was a uniform wall with an empty paper cup that was slightly warmer than the wall. Notice the very narrow spike in the 14-bit data and the very small bump just to the right of the spike.

Figure 8: Low contrast scene in 14-bit space.

The large spike from the wall is the same value as in initial histogram.

The following histogram shows the 8-bit data with the default Max Gain setting of 8. Notice that there is a large amount of unused levels of grey on the left and right of the signal. The maximum gain setting sets the upper limit of gain that the algorithm can use as it attempts to stretch the data to fill the full 8-bit range. If the scene has a high level of contrast, it will use much less gain than the maximum gain setting. In typical applications, this value can be increased from the default of 8 to 12 or 15. Analytics that are not affected by spatial noise might tolerate higher values around 25 or 30. Values below are used for demonstration and do not represent typical settings.

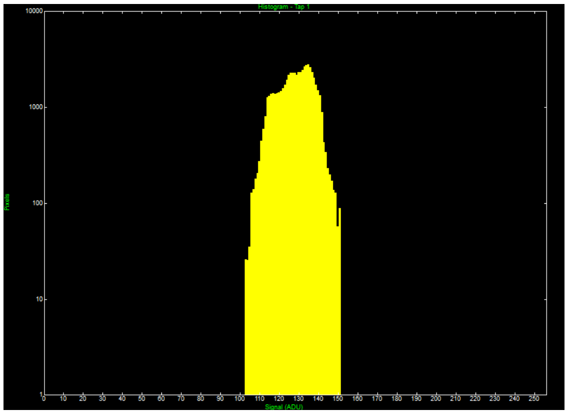

Figure 9: Plateau: 250, ITT: 127, Max Gain: 8

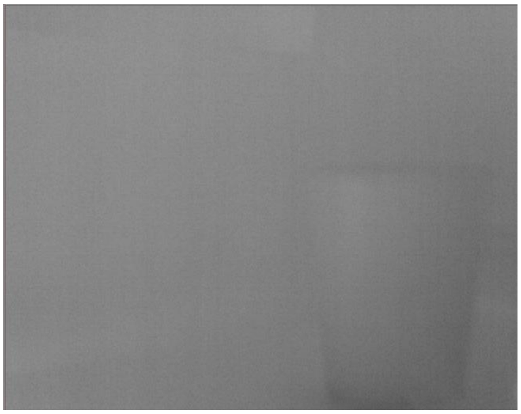

Figure 10: Low contrast Scene: default settings

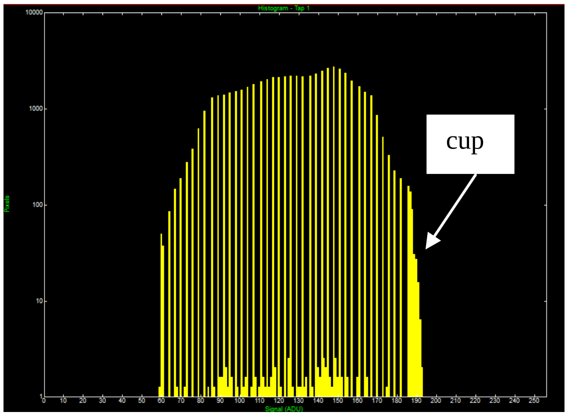

Figure 11: Plateau: 250, ITT: 127, Max Gain: 25

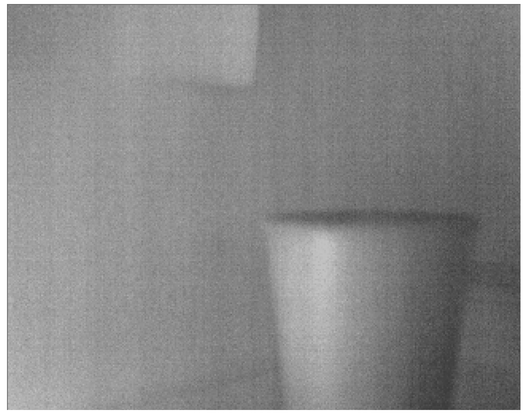

Figure 12: Low contrast scene: high gain

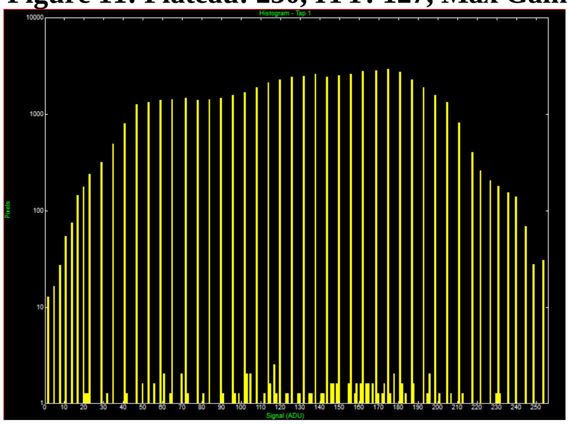

Figure 13: Plateau: 250, ITT: 127, Max Gain: 50

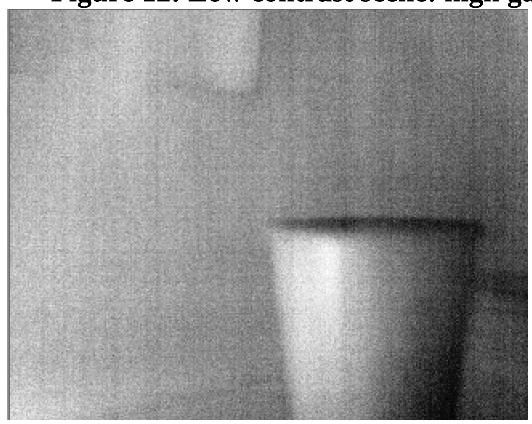

Figure 14: Low Contrast Scene: very high gain

3.0 AGC ROI

The AGC ROI sets the region of interest for the AGC to use for its calculation. If the installation is static, there are likely parts of the image that may need to be excluded. Since the AGC algorithm looks for the number of pixels with a given value and distributes those pixels evenly, disregarding unimportant pixels will have a large affect on the output. An example situation of this would be excluding the sky, which is very cold and uniform. Having a large portion of the scene containing the sky will drastically change the output of the AGC algorithm. The same is true for bodies of water, large items that are particularly hot or cold, etc.

The region of interest can be set as a rectangle by defining the location of the upper left and bottom right corners using Cartesian coordinates. This means that the center of the array is (0,0), the top left corner of a 640x512 camera is (-320,256), and the bottom right corner is (320,-256).

4.0 DDE

DDE is Digital Detail Enhancement and it works to better define edges in the image and its application is dynamically proportional to the number of bins occupied in the image histogram. In a high dynamic range scene the gain will be higher than in a low dynamic range scene. This allows faint details to be visible in high dynamic range scenes without increasing temporal and fixed pattern noise in low dynamic range scenes.

The DDE is applied to the 14-bit data before the AGC and so the performance of the AGC is improved by working on an image with more clearly defined edges. DDE is factory set in Dynamic Mode which dynamically determines the amount of enhancement to apply. This prevents enhancing edges on noise in low contrast scenes.

The valid range of Dynamic DDE setting is from 1 to 63 with 17 being the neutral setting where the filter has no effect. Settings below 17 will smooth the image reducing the appearance of sharp edges. Higher DDE settings will enhance all image non-uniformities resulting in a very detailed but grainy picture, especially in high dynamic range scenes. Typical factory settings are between 22 and 30. Settings from 18 to 39 are normal imaging modes where the edge enhancement can be tuned for the scene. Use the slider to adjust the setting, or select the text field and type in the desired setting. Avoid using setting 16.

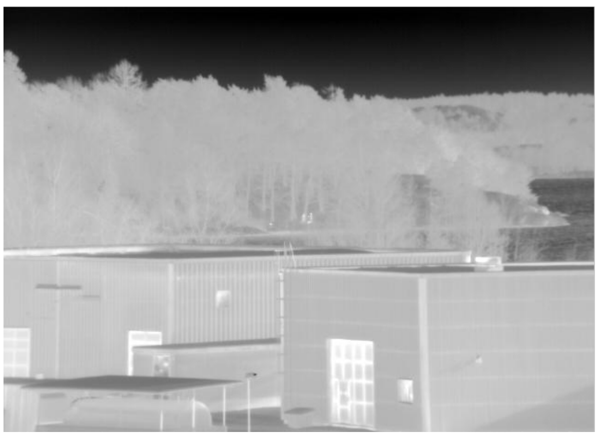

Figure 15: No DDE

Figure 16: DDE applied

5.0 LUT Palettes and Polarity

Another topic to discuss is the image LUT (Lookup Table). There are a number of lookup tables that make the image colored. This is called false color, or pseudocolor. The color is not actually related to wavelengths of light, but rather the grayscale intensity. The most useful might be the option for White Hot and Black Hot, which is also called the polarity of the image. The Black Hot palette is a pure inversion of the 8-bit data where zero becomes the hottest and 255 becomes the coldest. There are some applications where a Black Hot image allows for more perceived contrast in the image. This is primarily due to concept discussed earlier about low luminance changes.

Figure 17: White Hot

Figure 18: Black Hot

6.0 FFC Warning Indicator

The camera displays an on-screen symbol called the Flat Field Imminent Symbol prior to performing an automatic FFC operation. It can be seen in the image below as the blue square in the upper right of the video output. This symbol is displayed in the analog video and the BT.656 digital output. By default, it is displayed 2 seconds (60 frames) prior to the FFC operation. The duration of the FFC Imminent Symbol can be set in the FLIR Camera Controller GUI using the FFC Warn Time setting in the Analog Video Tab. Setting the Warn Time to less than 15 frames turns off the warning. When using analytics, this warning might induce false alarms and it is recommended to either disable this feature or create a region to ignore this area.

Figure 19: FFC Warning