Merlin™

Uncooled Microbolometer Camera

User's Guide
Version 1.2
414-0060-10

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1 Introduction

- Merlin Uncooled is a long-wavelength infrared (LWIR) high-performance camera offered by Indigo Systems Corp. The camera consists of an uncooled Focal Plane Array (FPA) incorporating a 320 x 240 matrix or 'staring' array of microbolometer detectors, sensitive in the 7.0–14.0 micron range. The detector array is manufactured using micromachining techniques on a Complimentary Metal Oxide Semiconductor (CMOS) readout integrated circuit to form the IR FPA. The FPA is enclosed in an all-metal evacuated dewar assembly, and is thermally stabilized at a temperature of 313 K. The FPA incorporates internal thermal reference detectors that provide compensation for thermal drift and noise.

- Merlin's signal processing electronics control the FPA, create timing and bias signals, perform analog-to-digital conversion, non-uniformity correction, replace bad pixels, automatically control the brightness and contrast of the display video when commanded (including histogram equalization for image display enhancement), output digital and analog video data and perform interface functions with external camera components.

- By design, the Merlin is operable by a Remote Button Panel, or through the RS-232 serial port using either terminal emulator software or the Graphical User Interface (GUI). Advanced commands can only be executed through the RS-232 serial port via remote control.

- The camera chassis supports threaded quick connect/disconnect optics. Several lens options with different focal lengths are available.

- A real-time, 60 Hz, 12 bit digital data stream is one of the camera's standard output formats.

- The Merlin is capable of being synchronized to an external RS-170 composite synchronization signal. This feature is especially useful in stereoscopic applications, where two cameras are used simultaneously.

- The camera operates on a single power input of 6 VDC, which is provided by an external A/C power supply that plugs into a wall socket.

1.1 Camera Architecture

The Merlin camera operates the FPA in a single output, full frame, 6 Mpixel/sec mode. The full 320 x 240 FPA operates at a frame rate of 60 Hz in an NTSC camera configuration and at 50 Hz when operating in PAL configuration. The analog video frame rates are 30 Hz and 25 Hz for NTSC and PAL cameras, respectively. Integration time and FPA video offset are user-adjustable through the Remote Button Panel or RS-232 user interface. The camera supports both one- and two-point non-uniformity correction. There are 3 sets of non-uniformity correction (NUC) tables stored in the camera, labeled NUC 0-2.

The dewar utilizes a thermoelectric cooler to stabilize the temperature of the FPA. The standard dewar f/number for the Merlin Uncooled Microbolometer camera is f/1.4, and the aperture is 0.643 inches in diameter. See Appendix B for the Optical Interface drawing.

The back panel of the camera, shown in Figure X, supports the interfaces for the Remote Button Panel, the power on/off switch, the power input connector, video output connectors (NTSC or PAL and S-Video), the RS-232 connector, and the digital data interface connector. Power is supplied to the camera through the 6 Volt DC supply. The camera can be controlled through the Remote Button Panel or through the RS-232 output by connecting it to a computer and using the Graphical User Interface software or a terminal mode program such as HyperTerminal, described in Section 3.4.

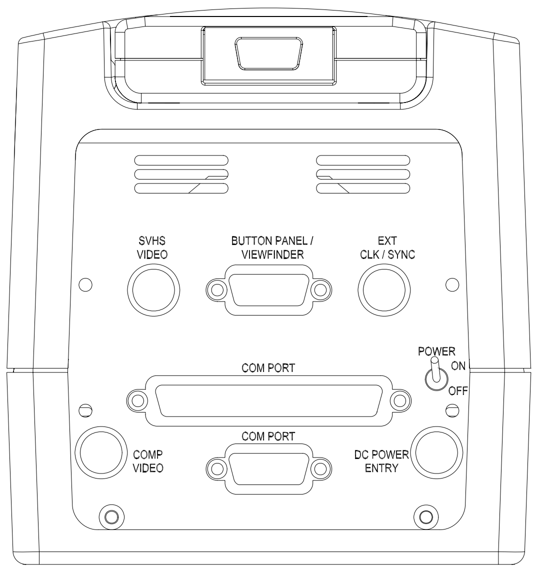


Figure 1. Camera Back Panel

1.2 Physical & Mechanical Interface

The camera body dimensions are 4.0 inches high, 4.5 inches wide, 8.0 inches long (excluding the lens). The chassis is fabricated from aluminum, and contains the sensor assembly and signal processing electronics. The camera weight is less than 3.5 lbs. The camera chassis base incorporates two tapped holes in line with the optical axis. The tapped holes are fitted with a helicoil insert to provide a 1/4" x 20 standard threaded insert. The holes are located 3.44 and 5.44 inches back from the camera's lens interface. Holes for locking pins are also available. See Appendix C for mechanical drawings of the Merlin camera.

1.2.1 Thermal Interface

Merlin's design architecture utilizes convective cooing techniques by means of an internal fan structure. The placement of internal camera components, including the mounting base plate, aids in conducting heat away from temperature-sensitive electronics. A combination of these two concepts optimizes system heat sinking.

1.2.2 Optical Interface

The lens-to-camera interface is shown in Appendix B. The mounting tolerance of the flange provides a back working distance of 1.307 ± .005 inches, as measured from the front surface of the FPA to the back of the mounting flange interface. The mounting tolerance of the flange provides a working distance of at least 0.309 inches as measured from the mounting flange interface to the front of the dewar window, in order to accommodate the insertion of a calibration flag into the optical path. The standard dewar f/number for the camera is f/1.4, and the aperture is 0.643 inches in diameter.

2 Getting Started

The following is a list of included components with the Merlin Uncooled Microbolometer Camera package:

- Camera
- Lens (25mm is standard)
- Cal Flag Assembly
- Remote Button Panel
- Remote Button Panel interface cable
- AC/DC Power Supply
- Graphical User Interface (GUI) software
- User Guide
- BNC Video Cable
- Reusable Shipping Container

Optional accessories include:

- LWIR Lens(es)
- External Synchronization Generator

The camera is delivered completely assembled. It has been preset with three non-uniformity correction (NUC) tables for imaging scenes at room temperature and above. For a detailed explanation of non-uniformity correction, see Section 2.3. The FPA requires temperature stabilization in order to operate properly. This takes about 30 seconds from power up, and during this time the image will appear non-uniform. Once a stable image appears, it is recommended that a 1-point correction be performed in order to obtain a clear, uniform image.

2.1 Warnings and Precautions

The following warnings and precautions should be followed when handling and operating your Merlin Uncooled Microbolometer camera.

- Great care should be exercised with your camera optics. The antireflection coating on the germanium optics is very easily scratched and should only be cleaned according to the procedures outlined below. Otherwise, a light dusting of air should be enough to dislodge any dust particles, although small amounts of dust will not affect image quality noticeably. If it is absolutely necessary to clean the surface, use 75% isopropyl alcohol and lens tissue, and use extremely light wiping motions. Use a fresh section of tissue with each swipe so as not to drag a piece of dirt back over the lens surface.

- Do not open your camera body for any reason. Only Indigo Systems Corporation should service the camera.

2.2 System Setup

To obtain an image with a video monitor, perform the following operations in order:

1. Connect the Remote Button Panel to the back of the camera using the cable with the 15 pin connector on each end.
2. Connect the video output to a monitor using the supplied BNC video cable.
3. Connect the AC/DC supply to the rear panel power connector.
4. Switch the back panel power switch to the ON position.

You should see a "White Hot" monochrome image appear after about a 30 second stabilization time. This is the default video setting. Refer to section 3.3.2.1 for other options. The camera will operate in Automatic Gain Control (AGC) mode when powered up. Push the Menu button on the Remote Button Panel to access the menu selection. The menu should appear on the monitor. Use the arrow keys to move through the menus, pushing the enter button to execute commands. The camera has been set up at the factory to support imaging using the three NUC tables. The camera will default to NUC0 on power up, as this is considered the factory default NUC table. Camera parameters for NUC0, such as integration time and Vreset can only be changed through the RS-232 interface, not through the button panel. Typical settings for NUC0 are:

Integration Time – 48.0 microseconds
Vreset – 110

2.3 Non-Uniformity Correction

Infrared detectors vary in their individual response to thermal or photon energy. This is commonly referred to as detector "non-uniformity". Unless some type of compensation is performed, this variation in response of the individual detectors will result in a non-uniform image. Non-uniform images appear "grainy" and unclear with possible black and/or white pixels apparent. The following narrative provides a brief description of how the correction process works, along with some representative correction methods and a tutorial on setting up the camera to perform a two-point correction. The non-uniformity correction process is sometimes, inaccurately, referred to as "calibration".

2.3.1 One-Point Correction

Improvements in detector fabrication and processing have resulted in detector gain values that are relatively stable over time. "Drift" is the term used to describe the gradual change over time of detectors from a uniform to a non-uniform state. In most cases where the camera parameters have not been changed, it is only necessary to perform an occasional offset correction, referred to as a one-point correction, to achieve a uniform image. This is done by filling the FPA's field of view with a uniform source of illumination such as a metal plate that is painted black to increase its emissivity. When commanded to perform a 1-point correction, the camera will collect data from several successive image frames of this uniform source. From this data, offset correction values will be calculated for each pixel assuming that all the pixels are being illuminated with the same flux levels. The term one-point refers to performing this correction at a single temperature reference point, updating only the offset correction coefficients.

The camera is set up at the factory to use the internal flag source to perform 1-point corrections. It is often desirable to use an external calibration source, as opposed to the internal flag. The internal flag must be disabled with the command MANFLAG sent through the RS-232 interface. In the MANFLAG (Manual Flag) mode, the user will be prompted to supply an external uniform temperature source for a 1-point correction. When the external Cal command is executed, the video monitor will display instructions for placing a correction source in the camera field of view. This source should be a uniform temperature, flat source that covers the camera's field of view. The source should be placed close to the front of the lens and remain in place according to the instructions displayed on the monitor. The camera can be put back into internal flag mode with the software command AMBFLAG (see section 3.6.2).

After power up, performing a one-point correction should provide a good image for room temperature scenes. The command for performing a one-point correction is both located at the 1-PT button on the Remote Button Panel and under the Calibration Menu. An internal motorized flag assembly is incorporated in the camera between the FPA and the camera lens. The flag is used to perform one-point non-uniformity corrections, and is at camera ambient temperature only. The control for the flag is through the RS-232 terminal mode software.

Note: There is a feature available that will automatically do a one-point correction with the flag at a period set by the software parameter CALPER.. Setting this parameter to zero disables this automatic correction feature, and this is the factory default setting. See Section 3.6.2 for more information.

There are three varieties of one-point correction you can perform:

1. 1 Point Refresh – press the 1PT button. The camera does a one-point correction using the ambient internal flag or an external source, depending on whether the camera is set to manual flag mode. As the calculated coefficients are not stored in flash memory, this correction is lost if you subsequently change NUC tables or power-cycle the camera.

2. 1 Point Update – hold the 1PT button until the following messages are displayed:

   PERFORMING 1 POINT UPDATE CALIBRATION…
   ACQUIRING DATA…

CALCULATING AND STORING COEFFICIENTS…

This option stores the correction coefficients in flash memory. If you subsequently change NUC tables, and then return to the NUC table with the one-point update, the values are saved. You can also initiate a 1 point update by going to the CALIBRATE menu, then selecting 1_PT_UPDATE, and then pressing enter.

3. Cal 1 point – this is a factory test function, which can be initiated only through the RS-232 port, and is intended for factory testing purposes only. Do not use it!

2.3.2 Two-Point Correction

Note: A two-point correction for each NUC table has been performed using high quality blackbody sources at the factory, so in most cases you will not need to repeat this process unless the integration time must be changed.

The most definitive NUC is referred to as a “two-point” or “gain and offset” correction. This type of correction is done by measuring the output voltage of each detector element at two temperature points that may be designated as “cold” and “hot”. The temperature difference is relative, and depends on the application, but should be at least 10 degrees (a few hundred A/D counts). The average pixel response at the cold and hot temperatures is first determined. Gain and offset values, also called correction coefficients, are then calculated and applied to each pixel so that the response of each pixel fits the slope of a line fitted through the cold and hot average points. The gain term is used to adjust the slope and the offset term is used to correct the DC level, both on a pixel-by-pixel basis.

During the two-point correction process “bad pixels” are identified and replaced using a nearest neighbor replacement algorithm. “Bad pixels” are identified based on a response and/or noise level outside a factory defined point from the mean response and noise level. The “bad pixels” are not replaced in the camera’s 12-bit digital data output.

2.3.3 External Correction Sources

The best non-uniformity correction results are usually achieved by using uniform temperature sources placed in front of the camera lens, as opposed to an internal flag between the lens and the FPA. Corrections performed through the lens take into account the entire optical path from the source to the FPA. This can give a superior corrected image, since reflections within the lens or other non-uniformities are corrected for as well. External cold and hot sources may be as rudimentary as a lens cap and a hand, respectively. Good results can be obtained using metal plates painted with a flat black epoxy, leaving one plate at room temperature and the other on top of a computer monitor to provide a reasonable temperature differential. Advanced IR camera operators often use calibrated, very uniform temperature sources called blackbody sources.

When using external sources it is important that they be placed close to the front of the lens. Sources must cover the entire lens area so that the FPA “sees” nothing but the source itself. If these conditions are not met, then the FPA will be exposed to stray radiation and a 1- or 2-point correction process may be compromised.

The hot and cold sources used to perform the two-point correction should bound the temperature range of the scene of interest and be within 10 – 15% of the camera's dynamic range. Therefore, imaging the hot source should produce an output at least 10 % below the saturation level, while the cold source should produce an output at least 10 % above the bottom rail.

Additional Settings:

The parameters in NUC1 and 2 (Integration time, Vreset) can be changed through the Remote Button Panel. The parameters for NUC0 can only be changed using the software interface. Using the Waveform function is helpful in setting up your parameters. This is enabled under the Calibration menu option. This function displays a waveform trace horizontally across the lower portion of the image. The trace represents the average output of each FPA row, mapped across the screen from left to right starting with average output from the FPA row on the top of the screen. When imaging a scene, the waveform trace should appear in the middle of its range if the camera parameters are adjusted properly. Parameters that are typically adjusted and affect the waveform level are integration time and Vreset. See Section 3 for more details on all the Menu functions.

2.3.4 Performing a Two-Point Correction

Each of the camera's three non-uniformity correction (NUC) tables has been preset at the factory to image typical scenes at room temperature and above. NUC0 has been set to the longest integration time available (48 microseconds), while NUC1 and NUC2 are set to shorter times. If the hottest objects in the image are saturated using the lowest sensitivity NUC (2), then you may need to reduce the integration time from the factory set value. In that case the two-point correction needs to be redone using the camera parameters for the particular scene. The integration time is the parameter to adjust. This parameter is specific for each of the three NUCs. The parameters are adjusted using the Remote Button Panel (the RS-232 interface must be used for NUC0) and selecting the CALIBRATION menu then selecting the INTG_TIME menu item. The arrow keys on the button panel increase/decrease the parameter values. The WAVEFORM command is also found under the CALIBRATION menu.

To maximize sensitivity of the Merlin camera, the longest possible integration time that does not saturate the response should be used, based on the minimum and maximum temperatures of interest in the scene to be imaged.

The following procedure assumes the camera has been powered up for at least 30 minutes according to the procedure in Section 2.2, and that the focal plane has reached a stable temperature:

Two-Point Correction Procedure:

Once the INTG_TIME (and other NUC parameters) have been set, you are can perform the two-point correction. Select the 2 PT menu function (under the CALIBRATION menu). Have your cold and hot sources ready to place in front of the camera. Follow the directions on the video monitor for placing the cold and hot sources in place. Note that when the camera is performing a one or two-point correction, the output trace of the WAVEFORM is not active, and the hot and cold sources should be checked prior to initiating the correction process.

Sequence of Events:

- The camera will prompt you to put the cold source in place.
- Press the enter button to begin executing the two-point correction.
- The camera automatically adjusts the offset so that response looking at the cold source is one-quarter full scale (~1000 counts).
- The camera takes the cold data.
- The camera prompts you to put the hot source in place.
- The camera takes hot data, and performs the NUC table computations.
- While looking at the hot data, the camera looks for noisy pixels and marks them as bad.
- Once the two-point correction is complete, a status menu appears on the display for a few seconds. This shows the A/D converter levels for the cold and hot sources, along with the number of bad pixels found during the correction process. You may want to note these values.

If the difference between the cold and the hot source was not sufficient (typically at least a few hundred counts) a message will appear on the video display stating the correction failed due to the “delta” in temperature being too small. The two-point should be repeated with sources that provide a larger difference in signal level. It is recommended to place the sources in the camera field of view and check the waveform level prior to initiating the 2PT command. The waveform trace should change by at least 1/10 of the range.

If the correction is successful, the image should appear uniform and clear. Upon completion of a 2PT correction, the camera parameters (INTG_TIME and VRESET) are stored in the camera flash memory until another 2PT is performed on this NUC.

After completion of a two-point correction if the image appears black or very blotchy the two-point correction was unsuccessful. Probable causes for the failure are:

1) Sources did not completely cover the camera field of view during the entire data collection period, particularly if there is a large portion of the image that is black or white.
2) The FPA is not at a stable temperature.
3) One of the sources came too close to or was outside the A/D converter’s range.
4) Incorrect camera NUC parameters were used.

Even if a two-point correction is successful and results in a good looking image, a grainy effect will appear when imaging scenes in which the temperature of objects is far outside the range over which the two-point correction was performed. A correction for the higher temperature conditions should be performed for imaging these scenes.
Following a successful two-point correction, there will be some drift in the output of the pixels, especially following warm-up/cool-down cycles of the FPA. This drift will appear as slight graininess in the image; sometimes a few black or white pixels will also appear. These effects can almost always be corrected by performing a 1-point correction, often referred to as an "offset correction" since only the offset coefficients in the NUC table are updated during this process. A single temperature source is used for this correction. Experience with systems such as the Merlin Uncooled Microbolometer camera has shown that for a given set of camera parameters, a 1-point correction is sufficient for periods of several months or longer.

3 Camera Control

The Merlin Uncooled Microbolometer Camera can be controlled through the Remote Button Panel or the RS-232 serial port interface using the Graphical User Interface software or a terminal mode program such as Hyperterminal. The commands accessible through the Remote Button Panel are a subset of the commands that can be entered through the serial port, and it will be necessary to use the RS-232 interface in order to access advanced camera features. A complete list of camera commands is given in Appendix A.

3.1 Remote Button Panel Control

This chapter describes how to use the Remote Button Panel (Figure 2.) to control the camera system, as well as perform functions such as changing FPA settings, performing corrections, adjusting contrast and brightness, and checking camera status.

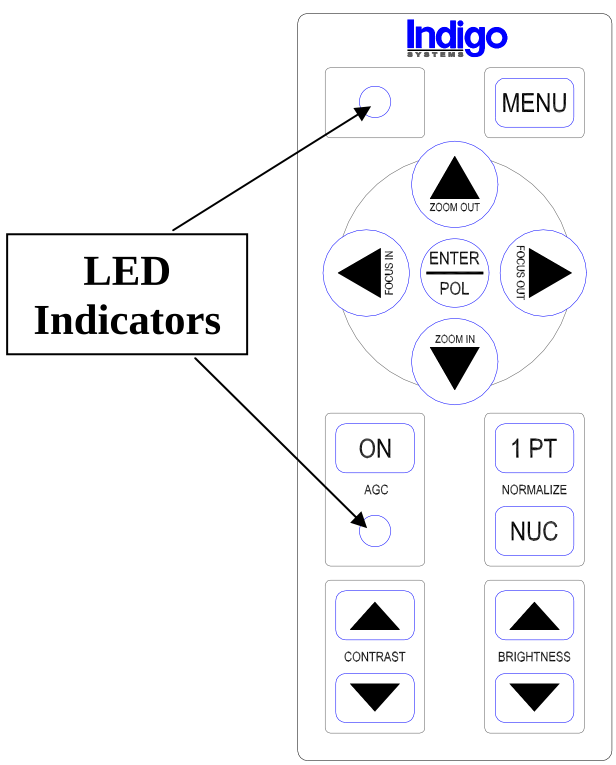


Figure 2. Button Panel Layout

The button panel interface consists of two Camera Status LED's and 13 Camera Control Buttons. The two Camera Status LED's function as follows:

Automatic Gain Control (AGC) LED:	On - AGC Enabled Off - AGC Disabled
Power LED:	On - Input Voltage Level is OK Off - Input Power Not Applied Flashing - Input Voltage is Low
Flashing Power & AGC LEDs:	Boot Error or System Error has occurred.

Note: A low input voltage may indicate a bad power supply or a power input connector that is not properly mated.

Note: If restarting the camera does not fix the boot error, contact Indigo Systems Corporation. Your camera may need service.

The 13 camera control buttons on the Remote Button Panel are shown in Figure 2. A description of their functions is listed below:

Menu: This displays the camera control menu in the upper symbology window and places the cursor (highlighted item) in the most recently selected position. Pressing the *<MENU>* button, while in the camera control menu, will cause the upper symbology window to be cleared. While in a submenu, pressing the *<MENU>* button will display the camera control menu and place the cursor (highlighted item) in the most recently selected position.

Enter: Enters the sub-menu or activates the highlighted operation when the cursor is present. If no cursor is highlighted (typically in a numeric increment/decrement menu), then pressing the *<ENT>* key will return the display to the next higher menu. If no menu is present pushing this button toggles the video polarity.

Contrast Up: Increases the contrast level when the AGC is not active, turns the AGC off if the AGC is active.

Contrast Down: Decreases the contrast level when the AGC is not active, turns the AGC off if the AGC is active.

Brightness Up: Increases the brightness level when the AGC is not active, turns the AGC off if the AGC is active.

Brightness Down: Decreases the brightness level when the AGC is not active, turns the AGC off if the AGC is active.

Once the menu is displayed these buttons are used to select sub-menu items.

Note: The Zoom in/out and Focus in/out functions indicated on the Navigator buttons are not implemented for the Merlin Uncooled camera.

Navigator Right: Moves the cursor "across to the right" within a row (if the cursor is already at the far right, it will roll over to the left most item).

Navigator Left: Moves the cursor "across to the left" within a row (if the cursor is already at the far left, it will roll over to the right most item).

Navigator Up: Moves the cursor "up" within a column (if the cursor is already at the top of a column, it will roll over to the bottom item).

Navigator Down: Moves the cursor "down" within a column (if the cursor is already at the bottom of a column, it will roll over to the top item).

AGC Enable: Enables the camera automatic gain and level control. The AGC led will turn on when AGC is enabled.

1 PT: Pressing this button perform a one-point refresh correction. A one-point refresh uses the internal flag if the camera is set to AMBFLAG mode (factory default), or else prompts the user for a reference source if set to MANFLAG mode. The camera averages eight frames of reference video, then determines new NUC offset values for each FPA pixel (while maintaining the existing gain coefficients) and new offset coefficient values are loaded into the camera hardware.

NOTE: The one-point refresh correction operation does not change the contents of the NUC flash memory.

NUC Select: Selects a non-uniformity correction table. Keeping the button depressed cycles through the three NUC tables and pressing enter within a few seconds of cycling to a NUC will enable that NUC.

ROM Boot: The button panel also supports a ROM boot operation by simultaneously pressing the Menu and Navigator Right keys at power up. This sets the camera back to NUC0 and restores the RAM memory from the flash memory.

3.2 Menu Overview

The Merlin menu structure is shown below.

MAIN MENU

- CALIBRATE
- DISPLAY
- AGC SETUP
- CAMERA SETUP

CALIBRATE NUC:*X*

- 1_PT_UPDATE
- 2_PT
- WAVEFORM
- INTG_TIME
- V_RESET
- TE_COOLER
- NUC_INIT

DISPLAY

- VID_PALETTE
  - MONO_G1.0
  - MONO_G2.2
  - RED_HOT
  - SEPIA
  - FUSION
  - NO_GREEN
  - NO_YELLOW
  - RAINBOW
  - SPARE_0
  - SPARE_1
- TEXT_COLOR
  - MONOCHROME
  - COLOR_A
  - COLOR_B
  - COLOR_C
- STATUS
  - OFF
  - ON
  - DATE TIME
  - SET
- XHAIR_0
  - OFF
  - ON
  - LOCATION : *X* *X*
  - SIZE
- XHAIR_1
  - OFF
  - ON
  - LOCATION : *X* *X*
  - SIZE
- COLOR_BAR
  - ENABLE
  - DISABLE

AGC_SETUP

- AGC_TYPE
  - LINEAR
  - HISTO EQUAL
  - LIN 2 PART
- ROI_SIZE
  - 16K
  - 32K
  - 64K

CAM_SETUP

- DIG_VID_OUT
  - UNCORRECTED
  - NUC_CORR
  - DISPLAY_VID
- SYNC_MODE
  - INTERNAL
  - EXTERNAL
- FACT_DEF

3.3 Menu Descriptions

3.3.1 CALIBRATE Submenu

The CALIBRATE submenu allows the user to set up the FPA and to perform either a one-point update or two-point correction. The CALIBRATE submenu consists of the following selections:

CALIBRATE	1PT_UPDATE	TE_COOLER
NUC: X	2PT	NUC_INIT
	WAVEFORM	
	INTG_TIME	
	V_RESET	

Where *X* is the currently active NUC table.

3.3.1.1 1PT_UPDATE Function

The 1PT_UPDATE selection allows the user to perform a one-point update correction. The one-point update correction routine used the internal flag source if the camera is set to AMBFLAG mode (factory default), or if set to MANFLAG mode, prompts the user to place a reference into the sensor field-of-view. The camera averages eight frames of reference video, determines new NUC offset values for each FPA pixel and loads the new coefficient values into the camera hardware. The one-point update operation stores the new NUC coefficient tables in the NUC flash memory at the active NUC table index. The current FPA mode parameters are also saved into flash memory for restoration during a NUC table switch.

The 1PT_UPDATE function requires a 2-point NUC table to be present before correction will continue. When activating this command through the RS-232 interface, the 1PT_UPDATE function will prompt the user for permission to overwrite the “factory” table (NUC0).

3.3.1.2 2PT Function

This initiates the two-point correction as described in Section 2.3.2.

3.3.1.3 WAVEFORM Function

The WAVEFORM function allows the user to either enable or disable the waveform display window on the lower symbology screen. When enabled a waveform trace will appear across the bottom third of the video display. The waveform display allows the user to view the output of the FPA in an “oscilloscope” fashion in order to adjust FPA mode parameters for desired operation. Each point on the waveform display is the average of a row of FPA pixels. Each waveform point thus represents the average of the 320 pixels comprising an FPA row and 240 such points are shown horizontally across the display where the rightmost point on the display represents the average of the top row of FPA pixel values. If the waveform trace is near the bottom of the display, then the FPA signal is in the lower part of the A/D converter range (~ 0) and if the trace is near the top of the display the FPA output is near the top of the A/D converter’s range (~4095). In order for a two-point normalization to work well, almost all the pixels on the FPA should not approach the zero level when looking at the cold source, nor should they approach the 4095 level when imaging the hot source.

When disabled, the lower symbology screen is returned to the previous status display state.

3.3.1.4 INTG_TIME Function

Note: A two-point correction should be performed if you change this parameter.

The INTG_TIME function is used to change the FPA integration time. The factories set integration times are 48 microseconds, 36 microseconds, and 24 microseconds for NUC tables 0-2 respectively. In the Merlin Uncooled Microbolometer camera, the term "integration time" would have been more appropriately referred to as "sample time". Use the *<NUP>* button to increase the value or the *<NDN>* button to decrease the value. The integration time will change in 1 microsecond increments from 1 to 48 microseconds. The integration time value is updated in the mode structure but will not be permanently saved in flash memory unless a one-point, one-point update or two-point correction is performed.

Microbolometer cameras are different from cameras that detect individual photons through photovoltaic or photoconductive means. In a microbolometer camera, individual pixels receive different amounts of thermal radiation from the scene and heat up different amounts with respect to the bolometer array substrate. The part of each bolometer that heats up is thermally isolated from the substrate so that a very small amount of input IR power results in a measurable change in the bolometer's temperature. By selecting the thermal conductance to the substrate and also selecting the thermal mass (heat capacity) of the thermally isolated bolometer, the bolometer's thermal time constant is determined. The array substrate is held at a very stable and uniform temperature so that the bolometer heats up to a specific temperature for a specific amount of input IR radiation from the scene. The amount of heating of each pixel (and thus the intensity of the IR scene) is determined by passing a known current or known voltage through a resistive element in the thermally isolated section of the bolometer. The resistive element is made from a material that changes resistance significantly with temperature. If a known voltage is applied across the bolometer's resistor for a short time, the current generated will be related to the resistance value, which in turn is related to the temperature of the bolometer, which is a direct measure of the incident IR radiation.

The length of time that the measurement (integration) current is allowed to flow through the bolometer and be collected on some type of integrating mechanism (like an integration capacitor) is the camera's integration (or sample) time. Clearly, the amount of signal collected at an integration capacitor will be proportional to the length of integration time and also the size of the current. Since higher currents result from hotter scenes, then a shorter integration time will allow hotter scenes to be imaged without saturation of the integration capacitor. Similarly, colder scenes will generate more signal on the integration capacitor if their currents are integrated longer. The reason that integration time is kept to values that range in the microseconds for the MERLIN Uncooled camera is that passing current through the resistor of the bolometer results in temporary heating of the structure, which is desirable to minimize. Also, the integration time range is defined to best match an appropriate amount of signal to be generated on the bolometer to levels allowed by the camera electronics. This definition of integration time is fundamentally different from the integration time of a photon detector where the current to be integrated is generated directly from absorbed photons and the length of time that the photocurrent is allowed to collect on an integration capacitor is the integration time.

Unlike a camera based on a photon detector a bolometer-type camera is always receiving input power from the scene. At the time that the temperature of the bolometers is sampled by the integration current, the bolometers will have been viewing the scene for the full frame time (1/60 seconds). The bolometer's temperature right before the application of the integration current will be the result of heating that occurred over the last 16 milliseconds. So from the point of view of a photon detector camera, the bolometer camera "integrates" its input signal for the full frame time.

Note: The application of the integration current occurs on a row-by-row basis, not on the whole FPA. Therefore, bolometer cameras are rolling-mode devices, not snapshot mode (at least with the current technology).

3.3.1.5 V_RESET Function

Note: A two-point correction should be performed if you change this parameter.

The V_RESET function is used to change the FPA video offset voltage. The FPA has a larger dynamic range than the A/D converter so adjusting the V_RESET allows the FPA's range to be adjusted within the A/D converter range. The V_RESET range is 0 to 255 where 0 sets the camera to the lowest part of the FPA range. Use the *<NUP>* button to increase the value or the *<NDN>* button to decrease the value. To adjust the V_RESET range, turn on the WAVEFORM trace. Increasing the V_RESET value will cause the level of the output displayed by the WAVEFORM to move down since the camera is being adjusted to use the upper portion of the focal plane array's range.

The VRESET factor value is updated in the mode structure but will not be permanently saved in flash memory unless a one-point, one-point update or two-point correction is performed.

3.3.1.6 TE_COOLER Function

The TE_COOLER function allows the user to select between a high and low temperature setting for the FPA's thermoelectric cooler circuitry. Changing the FPA temperature to the high setting is useful if the camera's ambient temperature is higher than 35 C. The following TE_COOLER submenu will be displayed upon activation:

TE_COOLER	LOW_TEMP
	HIGH_TEMP

To change the current TE Cooler mode, activate the desired selection.

Note: The TE cooler may not be able to achieve the desired FPA setpoint temperature if the camera ambient temperature rises above 55 C. If you are operating your camera under unusual conditions, check with Indigo Systems Customer Support for help.

3.3.1.7 NUC_INIT Function

The NUC_INIT function sets the camera hardware NUC gain coefficients to unity and the offset coefficients to zero. The user will be prompted to ensure that a NUC initialization operation is desired before executing the initialization process.

Note: The NUC_INIT function does not change the flash memory. Activating a new NUC table from the button panel will restore the NUC settings from flash memory.

3.3.2 DISPLAY Submenu

The DISPLAY submenu allows the user to setup the camera display screen. The DISPLAY submenu consists of the following selections:

DISPLAY	VID_PALETTE	COLOR BAR
	TEXT_COLOR	
	STATUS	
	XHAIR_0	
	XHAIR_1	

3.3.2.1 VID_PALETTE Function

The VID_PALETTE function is used to change the color scheme of the video image on the display screen. The user may select either monochrome, gamma corrected monochrome, or any one of eight false color tables. The polarity button on the Remote Button Panel will invert any palette selected. The following VID_PALETTE submenu will be displayed upon activation:

VID_PALETTE	MONO_G1.0	NO_GREEN
	MONO_G2.2	NO_YELLOW
	RED_HOT	RAINBOW
	SEPIA	SPARE_0
	FUSION	SPARE_1

3.3.2.2 TEXT_COLOR Function

The TEXT_COLOR function is used to change the color scheme of the FPA symbology on the display screen. The user may select either monochrome or from three different color tables (A

through C). The following TEXT_COLOR submenu will be displayed upon activation:

TEXT_COLOR	MONO COLOR_A COLOR_B COLOR_C

3.3.2.3 STATUS Function

The STATUS function is used to control the status window in the lower symbology screen. The user may either disable the status display, enable full status or show date and time only. The STATUS function also allows the user to set the date and time for the camera. The following STATUS submenu will by displayed upon activation:

STATUS	OFF ON DATE_TIME SET

To completely disable the status display, activate the OFF menu selection. Note that even when the status window is disabled, the low power indicator will flash in the lower symbology screen when a low voltage condition is detected.

To enable the full status display, activate the ON menu selection. This full status display will show the following items on the lower symbology screen:

AGC:	LIN/HISTO/OFF
BRT:	Brightness in % of full scale
CON:	Contrast in % of full scale
ROI:	Region of Interest for AGC/ALC Calculations (16K, 32K, 64K)
NUC:	Active NUC Table
ASW:	Auto NUC Switch OFF or ON (Always OFF in version 2.02 or above)
POL:	NORM (White Hot) / INV (Black Hot)
DIG:	Format of Digital FPA Video Data Output (Uncorrected, Corrected, AGC/ALC Pixel Replaced)
INT:	Integration Time (Reported in Microseconds)
RST:	Vreset value (reported in bits from 0 to 255)
TEC:	Thermoelectric Cooler temperature setpoint (Low or High)
TYP:	FPA Type that installed software supports (I002 in version 2.02 or above)
CFG:	Configuration code for camera
PRM:	Current EEPROM Version
S/W:	Software revision
MO/DAY/YR	
PWR:	OK/LOW Status of input power
HR/MIN/SEC	

To enable the partial status display, activate the DATE_TIME menu selection. This enables a partial status display wherein only the current date and time are displayed in the lower symbology screen.
To change the time and date, activate the SET menu selection. This will display the following menu along with the current values for hours, minutes, month, day, and year:

SET	HOURS
	MINUTES
	MONTH
	DATE
	YEAR

To update any of the date/time values, activate the appropriate menu selection. Use the <*NUP*> button to increase the value or the <*NDN*> to decrease the value. When you are finished changing a particular field, press the <*ENT*> button to return to the SET submenu. When done changing all required date/time fields, press <*MENU*> to update the date/time in the camera real-time clock circuit and return to the main menu.

3.3.2.4 XHAIR_0/XHAIR_1 Functions

The XHAIR_0/XHAIR_1 functions allow the user to control the two hardware cross-hair generators in the camera. The user can control the location and size of the two cross hairs. The following XHAIR_x submenu will be displayed upon activation:

XHAIR_x	OFF
	ON
	LOCATION
	SIZE

To disable the cross hair, activate the OFF menu selection. To enable the cross hair, activate the ON menu selection.

Activate the LOCATION menu selection to control the crosshair locations. With the LOCATION menu item selected, the navigator buttons (<*NUP*>, <*NDN*>, <*NRT*> and <*NLT*>) control the position of the cross hair on the display. Hold the appropriate navigator button to move the cross hair in the desired direction. The horizontal and vertical position of the cross hair will be displayed while the LOCATION menu item is active. When done changing the location, press the <*ENT*> button to return to the XHAIR_x submenu or press <*MENU*> to return to the top-level menu.

To change the size of the cross hair, activate the SIZE menu selection. Use the <*NUP*> button to increase the value or the <*NDN*> to decrease the value. When done changing the size, press the <*ENT*> button to return to the XHAIR_x submenu or press <*MENU*> to return to the top-level menu.

3.3.2.5 COLOR_BAR Function:

The COLOR_BAR function is used to enable or disable the color bar from the display. The color bar appears along the top edge of the screen. The following COLOR_BAR submenu will be displayed upon activation:

COLOR_BAR	ENABLE
	DISABLE

3.3.3 AGC_SETUP Submenu

The AGC_SETUP submenu allows the user to setup the camera display screen. The AGC_SETUP submenu consists of the following selections:

AGC_SETUP	AGC_TYPE
	ROI_SIZE

3.3.3.1 AGC_TYPE Function

The AGC_TYPE function allows the user to select the automatic gain and level control mode for the camera. The following AGC_TYPE submenu will be displayed upon activation:

AGC_TYPE	LINEAR
	HISTOGRAM

The linear type AGC function uses all pixel values and maps lowest pixel value to the zero of the video DAC, and the highest pixel value to the maximum of the video DAC.

The Histogram type AGC function does histogram equalization on the image data. This increases the noise of the image, but is useful when the intensity distribution is very uneven in a scene. For example, suppose there is a very hot object in the center of a scene. The linear AGC algorithm can lead to an image where everything but the hot object appears dark, because the high intensity of the hot object skews the AGC. The Histogram AGC routine will correct for this hot object.

To change the current AGC mode, activate the desired selection.

3.3.3.2 ROI_SIZE Function

The ROI_SIZE function allows the user to select the region-of-interest size over which to compute automatic gain and level control statistics. The following ROI_SIZE submenu will be displayed upon activation:

ROI_SIZE	16K
	32K
	64K

To change the current region-of-interest size, activate the desired selection. The region-of-interest size is selected in image pixels and the region-of-interest is centered in the camera field-of-view. The shape of the region is square, but it is not shown as an overlay box on the screen.

3.3.4 CAM_SETUP Submenu

The CAM_SETUP submenu allows the user to setup the camera display screen. The CAM_SETUP submenu consists of the following selections:

CAM_SETUP	DIG_VID_OUT
	SYNC_MODE
	FACT_DEF

3.3.4.1 DIG_VID_OUT Function

The DIG_VID_OUT function allows the user to select the type of digital video output onto the camera's 12 bit digital data output port. The following DIG_VID_OUT submenu will be displayed upon activation:

DIG_VID_OUT	UNCORRECTED
	NUC_CORR
	DISPLAY_VID

To set the digital output video to a particular format, activate the desired selection. The UNCORRECTED entry outputs 12-bit uncorrected video (no defective pixels replaced, marked a 0) onto the digital output port. The NUC_CORR entry outputs 12-bit corrected video (no defective pixels replaced, marked a 0) onto the digital output port. The DISPLAY_VID entry outputs 8-bit corrected, contrast adjusted, defective pixel replaced video onto the digital output port. This function does not affect the data output on the NTSC (PAL) or S-Video outputs.

3.3.4.2 SYNC_MODE Function

The SYNC_MODE function allows the user to select either internal or external frame synchronization for the camera. The following SYNC_MODE submenu will be displayed upon activation:

SYNC_MODE	INTERNAL
	EXTERNAL

To set the synchronization mode video to a particular value, activate the desired selection. The INTERNAL mode uses the timing generator within the camera for display frame synchronization. The EXTERNAL mode requires the Indigo Systems external sync option (part number 421-0001-00 for NTSC, 421-0001-00 option 01 for PAL) for display frame synchronization.

3.3.4.3 FACT_DEF Function

The FACT_DEF function sets the camera to NUC255, an invalid state. Pressing the NUC button returns the user to NUC0, the factory default table. If the parameters for NUC0 had previously been changed via the RS-232 interface and a two-point correction performed, the FACT_DEF command returns to these most recent settings.

After initiating this command the AGC will be turned off.

3.4 RS-232 Serial Interface

Merlin accepts remote control functions and provides operating status via an RS-232 serial interface. A straight-through RS-232 cable should be connected between the RS-232 connector on the camera back panel and the appropriate COM port on the computer. The camera is capable of transmitting and receiving serial data for distances up to 50 feet.

The camera can be remotely controlled through the RS-232 serial port using either a terminal program (e.g. HyperTerminal) or the Graphical User Interface software provided with the camera. The PC-based graphical interface application runs under Windows NT through the RS-232 port. This software program is supplied with each camera that contains the executable and any necessary support files needed for remote camera control. An exception to this requirement may be a subset of camera commands for which Indigo may decide to charge a premium. In this event, selected camera commands are made available by means of a software-based password protection scheme or other method that does not require the return of the camera to the factory.

The terminal mode program should be setup as follows:

3.4.1 COM Port Connection Properties

To operate the camera through the RS-232 port, select the appropriate COM port and settings.

Port Settings:

Baud: 38400
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: None

COM Port Properties - Settings:

Function, Arrow, Control Keys – terminal keys
Emulation – VT100
Backscroll buffer lines - 500

ASCII Setup:

ASCII Sending – disable “send line ends with line feeds”
– disable “echo typed characters locally”
ASCII Receiving – enable “append line feeds to incoming line ends”
– enable “wrap lines that exceed terminal width”

The camera default baud rate is 38.4K baud. Symbology is overlaid on the video monitor and contains information regarding the status and operational modes of the camera.
The camera supports field updates of camera application software or Xilinx FPGA configuration files, uploaded using the terminal mode program.

The COM0 serial port is fully functional (without user intervention) shortly after a power cycle or reset has been performed. This can be verified by connecting the terminal software before resetting the hardware. After a reset the camera outputs the following strings:

FORMAT NTSC *(or PAL)*
EXPANSION FLASH PRESENT *(if so configured)*
INSTRUMENTATION ADC PRESENT *(if so configured)*
BEGIN MAIN LOOP

This process takes approximately 5 seconds. Commands may be entered after this point in the boot up process.

The terminal mode operation supports a basic command set, advanced command set and serial packet protocol interface (this interface requires a separate "front end" software application to be developed by the end user to meet specific requirements). A summary of the basic commands is provided in Section 3.6.1. Please contact Indigo Systems Corporation Customer Support for more information on this interface.

3.4.2 COM Port File Upload

A file upload for the purpose of updating the camera control software or Xilinx FPGA configuration files can be performed as follows:

a) Connect external computer running communications software to the camera's COM0 port.

b) Power up the system (or reboot) while simultaneously holding down the *<MENU>* and *<NRT>* buttons on the button panel, or wait until the camera has completed the boot up sequence and type the "PROGRAM" command via COM0.

c) The camera will output the following message -

   INPUT ACTION OR FILE TYPE TO BE LOADED
   (1) RESTORE CAMERA TO FACTORY DEFAULTS
   (2) CODE UPGRADE
   (3) XILINX UPGRADE
   (X) CONTINUE WITHOUT ACTION

d) Enter '1' to boot the hardware and reset the values in non-volatile memory and mode configuration structure to factory defaults. Choose '2' for code update, '3' for Xilinx FPGA update, or 'X' to continue without any action. If the COM port does not receive one of these characters it will retransmit the message and wait for user action.

e) Once a selection has been made for upload then use the communications software to send the proper file using the XMODEM-CRC format. This is a 128 byte per packet format with a cyclic redundancy check. The camera system will send the start download character ('C') approximately every 5 seconds until transmission begins.

f) After completion of file transmission the camera electronics will write the data to its FLASH memory. If a Code Update is performed, the upload message is output again for the purpose of complete board programming. After a Xilinx file is uploaded the system will continue with the booting process.

3.5 Serial Packet Protocol

The serial packet protocol interface is used to operate the camera electronics remotely. This interface requires a separate "front end" software application to be developed by the end user to meet specific requirements.

For details on this interface as well as a complete list of commands please request a copy of the "Serial Command Protocol" interface document for this version of the software.

3.6 COM Port Commands

The following is a list of commands that can be issued through the COM0 port, along with a brief description of each command.

NOTE: All commands should be entered in capital letters (<CAPS LOCK> on. Otherwise the camera software will not understand them. If you type HELP, *you will get a complete list of commands.*

3.6.1 Basic Command Set

AGCHISTO:	Selects histogram equalization mode for AGC/ALC.
AGCLIN:	Selects linear mode for AGC/ALC.
AGCLIN2:	Selects linear 2 part mode for AGC/ALC.
AGCOFF:	Disables AGC/ALC control.
AGCON:	Enables AGC/ALC control.
BRIGHT:	Allows input of brightness value (0 - 4095).
CAL1PT:	Performs an offset calibration.
CAL1PTRF:	Performs an offset calibration while maintaining previous gain data (Does not store coefficients to FLASH memory).
CAL1PTUP:	Performs an offset calibration while maintaining previous gain data.
CAL2PT:	Performs an offset and gain calibration.
CAMID:	Display a listing of the current camera identification numbers. See paragraph 3.6.1.1 for a more complete description.
CAMMODE:	Display a listing of the current camera configuration settings. See following paragraph for details.
CLEAR:	Clears any user-entered text on symbology screens.

CLRBAROFF:	Disables the color bar on the display.
CLRBARON:	Enables the color bar on the display.
COLFLIP:	Enables FPA flipped column readout.
COLNORM:	Enables normal FPA column readout.
CONT:	Allows input of contrast value (0 - 4095).
CTIABIAS:	Allows input of CTIA bias adjust value (0 - 7). [ISC9809 Only]
CTIABW:	Allows input of CTIA bandwidth factor (0 - 3). [ISC9809 Only]
DETBIAS:	Allows input of detector bias adjust value (0 - 127). [ISC9705 Only]
DIGCOR:	Selects NUC corrected data output to the digital port.
DIGDSPL:	Selects pixel replaced display data output to the digital port.
DIGUNCR:	Selects uncorrected data output to the digital port.
EXTSYNC:	External sync enabled.
FACTDEF:	Resets all values stored in non-volatile and configuration structure memory to factory presets.
FOCUSIN:	Pulses focus motor to near for user specified length (100ms default).
FOCUSOUT:	Pulses focus motor to far for user specified length (100ms default).
FPAMODE:	Outputs the current FPA mode settings. See paragraph 3.6.1.3 for details.
HELP:	Outputs a complete list of the Basic Command Set.
HIGHTEC:	Selects the high TE Cooler operation temperature (I32R electronics only).
INTEG:	Allows input of integration time value (in microseconds).
INTSYNC:	Internal sync enabled.
ITRON:	Enables short integration then read timing. [ISC9809 Only]
ITROFF:	Enables normal integration timing. [ISC9809 Only]
LOWTEC:	Selects the low TE Cooler operation temperature (I32R electronics only).
MEMTEST:	Performs memory test and outputs results.
MSTRCURR:	Allows input of the master current bias value (0 – 7).
NOISE:	Performs noise calculation and outputs results.
NUCSWOFF:	Disables automatic NUC table switching.
NUCSWON:	Enables automatic NUC table switching.
OPTEST:	Performs operational tests and outputs results.
OVLPAL*X*:	Sets overlay video palette (*X* is 0 for monochrome; 1 thru 3 for color tables).
POLINV:	Inverts input polarity (“Black Hot”);
POLNORM:	Normal input polarity (“White Hot”);
PROGRAM:	Calls routine to perform uploads of application or Xilinx files.
PWRADJ:	Allows input of the power adjust value (0 – 3).
ROI16K:	Sets AGC/ALC ROI window (for calculation purposes) to center 16K pixels.
ROI32K:	Sets AGC/ALC ROI window (for calculation purposes) to center 32K pixels.
ROI64K:	Sets AGC/ALC ROI window (for calculation purposes) to center 64K pixels.
ROWFLIP:	Enables FPA flipped row readout.
ROWNORM:	Enables normal FPA row readout.
SETDATE:	Allows input of date.

SETGAIN:	Allows input of gain factor (0 – 3 for ISC9705, 0 – 1 for ISC9809).
SETNUC:	Allows input of NUC table number to be activated.
SETTIME:	Allows input of time.
SKIMOFF:	Disables skimming mode.
SKIMON:	Enables skimming mode.
STR:	Allows user to input text to be displayed on the symbology screens. See paragraph 3.6.1.4 for details.
STSOFF:	Disables on-screen status display (All).
STSON:	Enables on-screen status display (Full Status).
STSTIME:	Enables on-screen status display (Partial Status - Date/Time).
VDETCOM:	Allows input of Vdetcom bias voltage.
VIDPAL*X*:	Sets image video palette (*X* is 0 or 1 for monochrome; 2 thru 9 for psuedocolor tables).
VIDOFST:	Allows input of Vidoffset bias voltage.
VOS:	Allows input of Vos bias voltage.
WAVEOFF:	Disables the waveform display in lower symbology window.
WAVEON:	Enables the waveform display in lower symbology window.
XH0HOR:	Allows input of cross hair 0 horizontal location.
XH0OFF:	Disables cross hair 0.
XH0ON:	Enables cross hair 0.
XH0SIZE:	Allows input of cross hair 0 size (radius in pixels).
XH0VER:	Allows input of cross hair 0 vertical location.
XH1HOR:	Allows input of cross hair 1 horizontal location.
XH1OFF:	Disables cross hair 1.
XH1ON:	Enables cross hair 1.
XH1SIZE:	Allows input of cross hair 1 size (radius in pixels).
XH1VER:	Allows input of cross hair 1 vertical location.

3.6.1.1 CAMID COM Port Command

The following is a typical result of the CAMID command.

CAM TYPE: I003
SER NUM: 9900600
CFG CODE: 0XR0
PROM VER: 2.01
S/W VER: 2.02

3.6.1.2 CAMMODE COM Port Command

The following is a typical result of the CAMMODE command.

NUC TABLE: 2
STATUS DISPLAY: FULL

XH0 CONFIG:	100	120	8	
XH1 CONFIG:	220	120	8	
AGC CONFIG:	ON	LIN	64K	
MANUAL GAIN:	100%	0	97%	128
VIDEO PALETTE:	MONO_G1.0			
PROC VIDEO:	CORRECTED			
OVERLAY PALETTE:	MONO			
REF SETTINGS:	140	170		
SERVO FACTORS:	10	17		
CAL FLAG:	MANUAL			
SYNC ENABLE:	INTERNAL			

The XH0/1 CONFIG display values: horizontal location, vertical location, and radius.

The AGC CONFIG displays values: status, type, region of interest window size.

The MANUAL GAIN display values: brightness percent, brightness value, contrast percent, and contrast value.

The VIDEO PALETTE values are MONO_G1.0, MONO_G2.2, and PSEUDO_*X*.

The REF SETTINGS display values: cold and hot.

The SERVO FACTORS display values: open and closed.

3.6.1.3 FPAMODE COM Port Command

The following is a typical result of the FPAMODE command.

VID OFST: 40
V DETCOM: 182
V OS: 85
INTEG: 5000
GAIN: 1
PWR ADJ: 0
MSTRCURR: 3
DET BIAS: 64
SKIMMING: 0
LINE RPT: 0
ROW READ: 0
COL READ: 0
TEC COLD: 140
TEC HOT: 170

3.6.1.4 FPA String Command Details

STR,RR,CC,F,B,MM,TEXT: Displays user entered text string on symbology screen at location and appearance specified.

STR - Identifies command as user string.

, - Delimiters.

RR - Indicates symbology row (00 - 04) upper window and (05 - 09) lower window.

CC - Indicates starting column (00 - 35). Note: strings that extend beyond the 35^{th} column will be adjusted to fit.

F - Foreground or text color. See table below.

B - Background color. See table below.

MM - Mode information. Currently not implemented.

TEXT - User defined text string (up to 36 characters). See character map below. Characters that do not fall into the Merlin defined character map will be replaced with a "space".

3.6.2 Advanced Command Set:

Note: HELPADV *gives you a list of advanced commands. Please use caution when using these commands, as many of them are intended for test purposes only. Consult Customer Service at ISC if you have any questions.*

AGCPUPOFF: Disables automatic AGC on power up.

AGCPUPON: Enables automatic AGC on power up.

AMBFLAG: Sets calibration flag type to "AMBIENT".

CLEARREF: Sets the TEC reference to normal value, clearing value set with SETREF command.

CLOSEFCTR: Allows user to input servo "closed" factor.

COUNT: Forces a ramp count input to the system.

DUALFLAG: Sets calibration flag type to "DUAL TEMPERATURE".

FOCUSDUR: Sets the time, in milliseconds, of the focus motor pulse duration.

FORCE0: Forces a "0" input for all pixel values.

FORCE1: Forces a "1" input for all pixel values.

HAGCPT: Sets the AGC high limit point. See paragraph 3.6.2.2 for details on setting limit.

HELPADV: Outputs a complete list of the Advanced Command Set.

HPERCENT: Sets the auto NUC switching high-end saturation percentage. See paragraph 3.6.2.1 for details on the auto NUC switching feature.

HSATPT: Sets the auto NUC switching high-end saturation count. See paragraph 3.6.2.1 for details on the auto NUC switching feature.

LAGCPT: Sets the AGC low limit point. See paragraph 3.6.2.2 for details on setting limit.

LIN2BRK: Sets the percentage of the 256 colors mapped to the background (low end). See paragraph 3.6.2.3 for details.

LPERCENT: Sets the auto NUC switching low-end saturation percentage. See paragraph 3.6.2.3 for details on the auto NUC switching feature.

LSATPT: Sets the auto NUC switching low-end saturation count. See paragraph 3.6.2.1 for details on the auto NUC switching feature.

MANFLAG: Sets calibration flag type to "MANUAL".

MAXAGCCON: Sets the maximum gain of the AGC routine to "0" - 4095, "1" - 2, "2" - 1, or "3" - 0.5.

MERGENUC0: Copies over (adds) NUC Table 0 defective pixels to current active NUC table. See paragraph 3.6.2.1 for details.

NUCOFF: Sets Unity Gain and Zero Offset bits disabling calibrated coefficients from being applied.

NUCON:	Clears Unity Gain and Zero Offset bits enabling calibrated NUC coefficients to be applied.
OPENFCTR:	Allows user to input servo “open” factor.
PIXDSPL:	Enables display of cross hair pixel location count value.
PRPLOFF:	Disables bad pixel replacement.
PRPLON:	Enables bad pixel replacement.
RATEFULL:	Enables full video frame rate for the digital port. (Enables video DAC)
RATEHALF:	Enables 1/2 video frame rate for the digital port. (Disables video DAC)
RATEQTR:	Enables 1/4 video frame rate for the digital port. (Disables video DAC)
REFCOLD:	Allows input of reference TEC Cold bias setting. Stores value in mode structure and is not applied until a calibration is performed.
REFHOT:	Allows input of reference TEC Hot bias setting. Stores value in mode structure and is not applied until a calibration is performed.
REMNOISY:	Allows removal of noisy pixels based on user input values.
SERVO:	Allows input of servo pulse factor (0 - 63). NOTE: This is for test purposes only; damage to the cal flag mechanism may occur if values are entered beyond its physical constraints. Limits are set by proper Camera Configuration code.
SETREF:	Allows input of reference TEC bias setting for test purposes.
SINGFLAG:	Sets calibration flag type to “SINGLE TEMP”
TESTOFF:	Clears/resets the COUNT, FORCE0, and FORCE1 commands.

3.6.2.1 BAUD115/56/38 Commands:

The BAUDXXX commands allow the user to set the controller’s COM 0 serial port bit rate. The camera will always default to 38,400 baud on power up.

These commands are intended for special application use. Once a command to change the baud rate has been sent to the camera the user will need to adjust the baud rate of the terminal or front-end application. In HyperTerminal the open connection will need to be closed and then reconnect at the new baud rate. Please use this command with caution.

3.6.2.2 Automatic NUC Table Switching Configuration Commands:

Note: This feature is not yet available, but your Merlin camera software will be upgraded to have these capabilities in the future.

Several commands are used to configure the electronics to perform an automatic NUC table switch for varying conditions. If the low saturation conditions are met, the active NUC table will decrement (if not already at lowest table). If the high saturation conditions are met, the active NUC table will increment (if not already at highest table.

The low saturation conditions are met when the specified percentage of pixels (in ROI window) is at or below the low saturation count value.

The high saturation conditions are met when the specified percentage of pixels (in ROI window) is at or above the high saturation count value.

To configure the camera for auto NUC switching, enter the appropriate settings as described below and then enable the feature with the NUCSWON command.

The LSATPT and HSATPT are used to set the saturation count points. Valid input values are between 0 and 4080. The actual and stored values will be calculated using the following formulas:

(1) SaturationPointStored = InputValue / 16

(2) SaturationPoint = SaturationPointStored * 16

The result of equation (1) will yield a 'rounded' byte wide value. This is done so to conserve space in non-volatile RAM. Therefore, if the user enters a value of 3100, the actual saturation point count will be:

SaturationPointStored = 3100 / 16 = 193

SaturationPoint = 193 * 16 = 3088

The LPERCENT and HPERCENT are used to set the pixel saturation percentage. Valid input values are between 15 and 90, and it represents a percentage of the total region of interest pixels. The actual and stored values will be calculated using the following formulas:

(1) PercentStored = (90 - InputValue) / 5

(2) Percent = 90 – (PercentStored * 5)

The result of equation (1) will yield a 'rounded' nibble wide value. This is done so to conserve space in non-volatile RAM. Therefore, if the user enters a value of 68 for 68%, the actual percentage used will be:

PercentStored = (90 – 68) / 5 = 4

Percent = 90 – (5 * 4) = 70

It is important to note that the saturation settings are independent of the NUC tables. Therefore, to keep the electronics from jumping/skipping tables, it will probably be necessary adjust the integration time and/or biases for each mode.

3.6.2.3 LAGCPT/HAGCPT COM Port Commands:

The LAGCPT/HAGCPT commands are used to enter AGC limit factors. The input factors are stored in nonvolatile memory and used in subsequent boots. A factor of "0" disables the associated limit.

During the AGC loop, all pixel intensities above the high AGC set point will get mapped to color 255 (typically white), and all pixel intensities below the low AGC set point will get mapped to color 0 (typically black).

Valid input values are between 0 and 4080. The actual and stored values will be calculated using the following formulas:

(1) AgcLimitStored = InputValue / 16

(2) AgcLimit = SaturationPointStored * 16

The result of equation (1) will yield a 'rounded' byte wide value. This is done so to conserve space in non-volatile RAM. Therefore, if the user enters a value of 3100, the actual AGC limit count will be:

AgcLimitStored = 3100 / 16 = 193

AgcLimit = 193 * 16 = 3088

3.6.2.4 LIN2BRK COM Port Command:

The LIN2BRK command is used to enter a percentage of the 256 colors to be mapped to the pixel counts below the histogram peak value for the 2 part linear AGC mode. Thus allowing the background (low end) of the image to be enhanced. Valid input values are between 10 through 45.

All entered values between the limits will be accepted but will be rounded to a multiple of five using the equation below. The factor is what gets stored in non-volatile RAM.

(1) Lin2FactorStored = (InputValue – 10)/5

Lin2FactorStored	Mapped to Low End
"0"	10%
"1"	15%
"2"	20%
"3"	25%
"4"	30%
"5"	35%
"6"	40%
"7"	45%

3.6.2.5 MERGENUC0 COM Port Command:

The MERGENUC0 command is used in conjunction with 2-pt correction to find defective pixels.

The MERGENUC0 command will add/copy defective pixels from NUC0 to the existing NUC table list. NUC0 will typically hold a factory correction that has under gone both a noisy and nonlinear pixel removal. This will allow a user to generate a very effective NUC table with just a 2-pt correction and merge command.

The user will have an opportunity to view the defective pixels and determine whether or not to save the updated table to FLASH memory. If the user chooses not to save the updated table the previous table will be restored.

3.6.2.6 REMNOISY/REMNONLIN COM Port Command:

The REMNOISY and REMNONLIN commands are used to find/add/replace additional defective pixels.

The REMNOISY command will query the user for the number of passes to be performed (1 – 32). Then the user will be prompted to enter a threshold factor. The threshold factor (1 – 1000) represents a percentage (.01% – 10%). During each pass, a frame will be 'grabbed' and a frame average will be computed. Then each pixel of that frame will be compared against the average of the frame. Any pixels that fall outside of the average plus or minus the threshold percent will be marked as defective. The user will have an opportunity to view the defective pixels and determine whether to save the updated table to FLASH memory. If the user chooses not to save the updated table the previous table will be restored.

The REMNONLIN command will only ask the user for a threshold factor. The nonlinear pixel removal process adjusts the V_{reset} bias slightly before doing a frame grab. Only a single pass will be performed. Any pixels that fall outside of the average plus or minus the threshold percent will be marked as defective. Again, the user will have an opportunity to view the defective pixels and determine whether to save the updated table to FLASH memory. If the user chooses not to save the updated table the previous table will be restored.

3.7 Foreground/Background Tables

Number	Monochrome	Color_A	Color_B	Color_C
Alpha_0	Transparent	Transparent	Transparent	Transparent
Alpha_1	Black	Black	Black	Blue
Alpha_2	Gray	Blue	Green	Yellow
Alpha_3	White	Green	Yellow	Green
Xhair_0	Dk. Gray	Yellow	Red	Red
Xhair_1	Lt. Gray	Red	Blue	Purple

3.8 Character Map

Hexadecimal	ASCII Character	Merlin Character
0x2D	-	-
0x2E	.	.
0x2F	/	/
0x30	0	0
0x31	1	1

0x32	2	2
0x33	3	3
0x34	4	4
0x35	5	5
0x36	6	6
0x37	7	7
0x38	8	8
0x39	9	9
0x3A	:	:
0x3B	;	;
0x3C	<	<
0x3D	=	=
0x3E	>	>
0x3F	?	_
0x40	@	SPACE
0x41	A	A
0x42	B	B
0x43	C	C
0x44	D	D
0x45	E	E
0x46	F	F
0x47	G	G
0x48	H	H
0x49	I	I
0x4A	J	J
0x4B	K	K
0x4C	L	L
0x4D	M	M
0x4E	N	N
0x4F	O	O
0x50	P	P
0x51	Q	Q
0x52	R	R
0x53	S	S
0x54	T	T
0x55	U	U
0x56	V	V
0x57	W	W
0x58	X	X
0x59	Y	Y
0x5A	Z	Z

3.9 Thermography Option

A thermography option is now available for the Merlin Uncooled. The thermography option includes moveable crosshairs, or "spotmeters" that provide a real-time temperature display. User inputs are available for target emissivity and reflected background temperature. Calibrated digital data is provided for use with Talon, Indigo's data acquisition and analysis system.

3.9.1 Temperature Ranges

Only the first three NUC tables are calibrated for temperature measurement. NUC 0 (integration time 48 µsec) should be used for measuring temperatures from about 0 to 120° Celsius (30 to 250° Fahrenheit). NUC 1 (integration time 13 µsec) should be used for measuring temperatures from about 70 to 250° Celsius (150 to 500° Fahrenheit). NUC 2 (integration time 3.5 µsec) should be used for measuring temperatures from about 200 to 500° Celsius (400 to 1000° Fahrenheit). The rest of the 18 available NUC tables will be used for high temperature filters and/or other lenses (at this time, only the standard 25 mm lens has been calibrated).

The camera (without a filter installed) should never be pointed at an object or scene with a temperature significantly greater than 500° Celsius (1000° Fahrenheit) for more than a few seconds or the FPA will be temporarily damaged. The effect shows up as a ghost image, and may occur to a lesser extent even at temperatures less than 500° C if the camera stares at the object for an extended period. If the damage is not too great, it will repair itself over time (hours or days). If the camera is pointed at the sun or a laser with emission between 7 and 15 microns (even instantaneously), permanent damage could result.

3.9.2 Non-uniformity Correction

Once the camera has been calibrated, only the one-point refresh correction should be used. This is the correction available from either the remote button panel 1 PT button (not the on-screen menus), the terminal mode CAL1PTRF command, or through the Windows GUI "Command 1-Point" correction with the "Save to Flash" option NOT checked.

Caution: Performing a new 2-point NUC, a 1-point Update, or changing any of the settings in the CALIBRATE menu will invalidate the calibration for that particular NUC table.

It is recommended that the automatic 1-point correction be enabled, with a period of 10 to 30 minutes depending on the stability of the camera's ambient temperature. This is enabled at the factory, with a setting of 20 minutes. It can also be set through the GUI, or by using the terminal mode CALPER command.

3.9.3 Temperature Measurement

3.9.3.1 Setting Crosshairs

The two measurement crosshairs can be independently enabled or disabled, as well as moved and sized using the XHAIR commands on the button panel DISPLAY menu. These functions can also be performed through the terminal mode. The commands are XhnON, XHnOFF, XHnHOR, XHnVER, and XHnSIZE (where n is 0 or 1 for the two crosshairs). The terminal mode PIXDSPL command allows three choices: 0 disables the temperature display, 1 enables temperature display, and 2 allows display of raw A/D counts for each crosshair.

3.9.3.2 Emissivity and Background Temperature

Along with the selection for temperature display in Celsius or Fahrenheit, there are separate emissivity settings for each crosshair found in the button panel CAM_SETUP menu. The corresponding terminal mode commands are XHnEMIS, CELSIUS, and FAHREN.

For temperature measurement of objects or scenes with emissivity less than one, the reflected background becomes an important part of the signal. The background temperature may be input (in the currently selected temperature units, Celsius or Fahrenheit) using the BKG_TEMP selection on the CAM_SETUP menu. The terminal mode command is BKGTEMP.

3.9.3.3 Lens Temperature Correction

Another important correction is made for the temperature of the lens, using internal temperature sensors. For most accurate results, wait a few minutes for the camera and lens temperatures to stabilize when either the camera is initially powered up or when there is a significant change in ambient temperature. The current temperatures reported by the sensors can be retrieved using the terminal mode TEMP0 and TEMP1 commands.

The terminal mode command XHnVAL will return the currently displayed temperature for crosshair n.

3.9.3.4 Other Commands

The terminal mode command CAMMODE can be used to display the current settings for the crosshairs and background temperature, as well as other camera configuration settings.

Parameters returned by the FPAMODE command are used by Indigo Systems for factory configuration of calibration tables.

The terminal mode command HELPRAD gives the syntax for the various radiometric commands.

Warning: Do not use the Factory Default Reset command (on the CAM_SETUP menu) or the FACTDEF terminal mode command unless directed by Indigo personnel. This could require the camera to be returned to the factory for recalibration.

4 Imaging Electronics

The system operates an uncooled microbolometer FPA in single output mode at a 6.125 megapixel/second output rate and at 60/50 hertz field rate (NTSC/PAL 2:1 interlace). The electronics in the Merlin Uncooled Microbolometer camera perform all functions required to operate an FPA, including:

- FPA clock/bias/power generation
- FPA analog video conditioning
- Analog-to-digital conversion (12-bit)
- FPA non-uniformity correction (one or two point)
- Automatic gain and level control (AGC/ALC)

- Linear/non-linear, lookup table based contrast enhancement (including histogram equalization)
- Defective pixel replacement (selected from 8-by-8 nearest neighbor kernel)
- Monochrome and color display modes
- Standard format analog video generation (NTSC/PAL/SVHS)
- Interpolated horizontal remapping
- Color partial screen bit-mapped symbology overlay onto video output
- Remote Button Panel and RS-232 interface
- DC-to-DC power supply (6 VDC input)

4.1 Electronics

The camera electronics consist of the five printed circuit boards listed in the following paragraphs.

4.1.1 FPA Buffer Board

The FPA package is mounted on the FPA Buffer Board using pin receptacles. The primary functions of the Buffer board are: to buffer and digitize the FPA output; perform the 10 bit pixel offset correction; provide buffers and level shifters for the clock signals; and supply the FPA bias voltages.

4.1.2 FPA Support Board

The FPA Support Board and the FPA Buffer Board are interconnected by high-density board-to-board connectors, and, along with the FPA may be considered the “front end” of the Merlin Uncooled Camera. The FPA Support Board is connected to the Camera Controller Board via a short 50-conductor cable. The FPA Support Board generates timing, computer control of certain FPA biases, provides TEC temperature control, and calibration flag control.

4.1.3 Camera Controller Board

The camera controller board receives raw digital FPA video from the FPA Support Board, performs gain and offset correction, bad pixel replacement, and generates NTSC or PAL video. An embedded 386EX microprocessor provides camera control and the user interface via a button panel or serial link. The camera software is stored in flash memory and factory default settings are stored in non-volatile RAM.

4.1.4 Power Supply Board

The power supply board uses a DC-to-DC converter and a linear regulator to provide the various DC voltages required by the camera. The nominal input voltage required by the board is 6V; the output supplied to the camera is +6, -6, and +9 volts. In normal operation, the input current is approximately 2.0 amps. Peak current draw of 3.5 amps occurs for about 20 seconds during power up. This additional current is drawn by the FPA temperature stabilizer while the FPA is reaching operating temperature.

4.1.5 Back Panel Board

The back panel board contains the Merlin camera interface connectors and the on-off switch.

4.2 Camera Electrical Interfaces

The primary Merlin camera system electrical interface is through separate connectors located on the rear panel of the camera chassis. The signals and connector definition is given in Table 1. The camera rear panel supports connectors for the NTSC(PAL) and S-Video, DC Power input, Digital Data output, RS-232 Serial Port, Remote Button Panel, and Power on/off switch. A drawing of the rear panel is shown in Figure 2 below.

Signal Description	Connector Type	Mating Part Number
Input power, 6 volts at 2.0 amps nominal, 3.5 amps peak	5 pin DIN female 2 pin Fischer S102 A051-130	CUI Stack SD-50 2 pin Fischer connector
RS-232C serial command and control	9 Pin Subminiature D Socket DE9S	AMP 747904-2
Remote Button Panel	15 Pin HD D-Sub DE15S	AMP 748364-1
Analog video output in NTSC or PAL format	BNC Jack	AMP 413589-2
External Clock/Sync	5 Pos. Mini DIN Receptacle (A/D Electronics AMDC-115)	5 Pos. Mini DIN Plug (CUI Stack MD-50)
S-Video output	4-pin Mini-DIN female, receptacle	CUI Stack MD-40
Digital video output data in 12-bit parallel RS422 format	37 Pin D-Sub, female	AMP 747916-2

Table 1. Electrical Interface Definitions

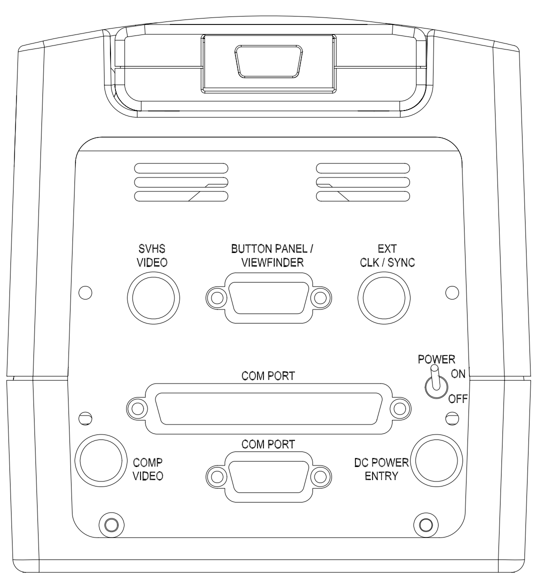


Figure 3. Merlin Uncooled Microbolometer Camera Rear Panel

4.2.1 Signal Descriptions and Pinouts

4.2.1.1 Input Power

Input voltage range for Merlin Uncooled Microbolometer Camera is 5.8 to 7.0 volts, with 6 VDC being the nominal value. The current draw is 2.0 amps nominal, 3.5 amps peak. Raw input power is supplied to Merlin's Power Supply PCB electronics and then distributed to the other PCBs. Merlin power dissipation is 12 Watts nominal. The pinouts for the two styles of input power connectors are shown in Figure 4a below. The new style is a two-pin locking connector.

Pin 3 - Power In (6 VDC)
Pin 4 - Ground

Pin 1 - +6 VDC
Pin 2 - Ground

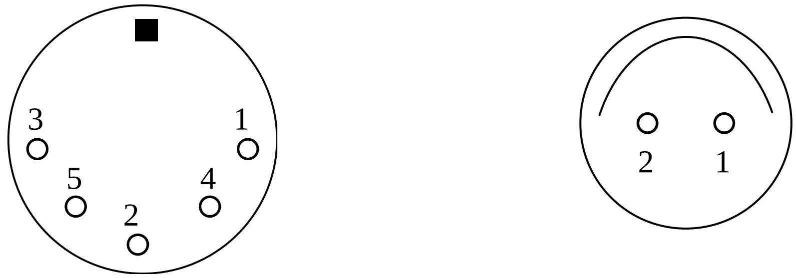


Figure 4a. Two Styles of DC Power Entry Connector (2 pin Fischer)

4.2.1.1.1 AC Power Converter

An AC to DC power converter is supplied with the Merlin Uncooled Microbolometer camera. The converter provides 6 VDC at 2.1 amps for input to the camera. The dimensions of the converter are 4.5 inches long by 3 inches wide by 2 inches high. Weight of the converter is less than 1 pound.

4.2.1.2 Analog Composite Video

The Merlin camera generates composite video in NTSC or PAL format. The video signal is brought out to a BNC connector. The selection of NTSC or PAL video is enabled in the electronics hardware configuration at the factory. Standard video levels of 1.0 V peak to peak are obtained when the camera video output is terminated with 75 ohms to ground. A 75 ohm BNC cable is provided with the camera. The center pin (pin 1) is the encoded NTSC or PAL video and the connector body (pin 2) is the video ground (shell).

4.2.1.2.1 NTSC

True NTSC format provides 484 active lines per frame, and 242 lines per field. All 240 rows of the FPA are displayed at the 59.97 Hz update rate. Merlin's analog video data (NTSC) is output at 29.985 frames per second. Each frame consists of two interlaced fields of 640x240 video data. The field rate is 59.97 Hz, so the effective size of the actual video image is 640x480 at 29.985 Hz, where FPA pixels are replicated in both the horizontal and vertical direction to map into the video display format.

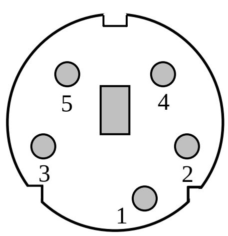
4.2.1.2.2 PAL

PAL (phase alternation by line) format displays a 240 line image centered in the active display space at a 50 Hz update rate. PAL is a television signal standard (575 active lines, 50 Hz, 220 V primary power) used in most of Europe, some Middle East and Asian countries, several African countries, Australia, New Zealand, and other Pacific island countries.

4.2.1.3 External Clock/Sync

Indigo offers a Merlin External Sync Generator as an option to the camera. This sync generator allows the video output of up to three cameras to be synced together on a frame-by-frame basis, an application that is very useful for applications such as stereoscopic imaging. The camera must be set to external sync mode through the RS-232 serial port interface. The outputs of the Merlin External Sync Generator can also be used to trigger a laser or other device through an appropriate interface. The ISC part number is 421-0001-00, and the generator is available in NTSC or PAL video format. The pinout of the external clock/sync connector is shown in Figure 4b.

Note: The Merlin External Sync Generator is the master oscillator for any system composed of Merlin cameras and other devices such as lasers, etc. The Merlin cameras ***cannot*** *be triggered by an external device other than the Sync Generator, which is a free-running oscillator. Put another way, you cannot trigger the acquisition of an image frame off a randomly firing laser, for example. Both the laser and the camera must be triggered by the Sync Generator.   Please contact Customer Support at 805-964-9797 for more information.*

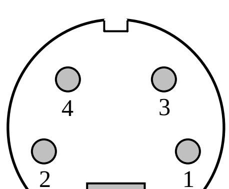


Pin 1 - Master Oscillator Disable
Pin 2 - External Master Clock Ground
Pin 3 - External Master Sync Ground
Pin 4 - External Master Clock
Pin 5 - External Master Sync

Figure 4b. External Sync Connector

4.2.1.4 Analog S-Video

An S-Video output interface is provided. S-Video (short for Super-Video) is a method of transmitting analog video signals over a cable by dividing the video information into two separate signals: one for color (chrominance), and the other for brightness (luminance). When sent to a television, this produces sharper images than composite video, where the video information is transmitted as a single signal over one wire. This is because televisions are designed to display separate Luminance (Y) and Chrominance (C) signals. (The terms Y/C video and S-Video are the same.) To take advantage of Merlin's S-Video output, the display device receiving the signals must have an S-Video input jack. An S-Video cable is provided to connect the Merlin to an S-Video capable display. The S-Video connector pinout is shown in Figure 4c:



Pin 1 - SVHS Yvid Ground
Pin 2 - SVHS Cvid Ground
Pin 3 - SVHS Luminance Video
Pin 4 - SVHS Chrominance Video

Figure 4c. S-Video Connector Pin Definition

4.2.1.5 Parallel Digital Video

A parallel digital data output interface is provided. Digital data is selectable as either 12-bit uncorrected data, 12-bit non-uniformity corrected data, or 8-bit non-uniformity corrected data with bad pixel replacement. The 8-bit corrected mode provides contrast and brightness adjusted data.

The output is parallel 12-bit wide differential data, driven with RS-422 line drivers at a nominal rate of 6.25 MHz. The data timing conforms to digital NTSC or PAL. Clock, vertical sync, and line sync control signals are supplied along with the digital data. The digital video is capable of being transmitted up to 50 feet without degradation. Figure 4d shows the digital data output interface connector pinout:

Pin 1	Ground		
Pin 2	N/C	Pin 20	N/C
Pin 3	Processed FPA Video Bit 0 – (LSB)	Pin 21	Processed FPA Video Bit 0 + (LSB)
Pin 4	Processed FPA Video Bit 1 –	Pin 22	Processed FPA Video Bit 1 +
Pin 5	Processed FPA Video Bit 2 –	Pin 23	Processed FPA Video Bit 2 +
Pin 6	Processed FPA Video Bit 3 –	Pin 24	Processed FPA Video Bit 3 +
Pin 7	Processed FPA Video Bit 4 –	Pin 25	Processed FPA Video Bit 4 +
Pin 8	Processed FPA Video Bit 5 –	Pin 26	Processed FPA Video Bit 5 +
Pin 9	Processed FPA Video Bit 6 –	Pin 27	Processed FPA Video Bit 6 +
Pin 10	Processed FPA Video Bit 7 –	Pin 28	Processed FPA Video Bit 7 +
Pin 11	Processed FPA Video Bit 8 –	Pin 29	Processed FPA Video Bit 8 +
Pin 12	Processed FPA Video Bit 9 –	Pin 30	Processed FPA Video Bit 9 +
Pin 13	Processed FPA Video Bit 10 –	Pin 31	Processed FPA Video Bit 10 +
Pin 14	Processed FPA Video Bit 11– (MSB)	Pin 32	Processed FPA Video Bit 11 + (MSB)
Pin 15	+5 Volts (DO NOT USE)	Pin 33	Ground
Pin 16	+5 Volts (DO NOT USE)	Pin 34	Ground
Pin 17	Processed FPA Vertical or Field Sync –	Pin 35	Processed FPA Vertical or Field Sync +
Pin 18	Processed FPA Horizontal Sync –	Pin 36	Processed FPA Horizontal Sync +
Pin 19	Processed FPA Video Clock –	Pin 37	Processed FPA Video Clock

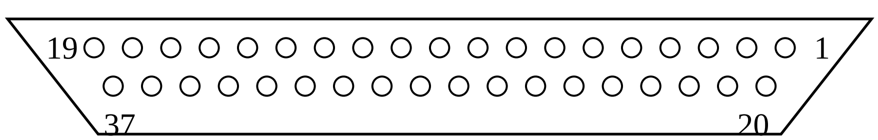


Figure 4d. Parallel Digital Video Connector Pin Definition

4.2.1.6 Remote Button Panel

Merlin can be operated via the Remote Button Panel, and/or by a host PC interface using RS-232 through a graphical user interface or terminal mode program (e.g. Hyperterminal). The Remote Button Panel allows the user to navigate through the camera menus and execute commands.

Section 3 provides details on the camera menus. Figure 4e shows the button panel interface connector pinout:

Pin 1 Button Panel AGC Indicator
Pin 2 Button Panel Contrast Down Switch
Pin 3 Button Panel Menu Switch
Pin 4 No Connect
Pin 5 Encoded NTSC or PAL Video
Pin 6 Button Panel Ground
Pin 7 Button Panel Brightness Down Switch
Pin 8 Button Panel Contrast Up Switch
Pin 9 Button Panel Select (Enter) Switch
Pin 10 +5 Volt View Finder Power
Pin 11 Button Panel Power Indicator
Pin 12 Button Panel Brightness Up Switch
Pin 13 +5 Volt Button Panel Power
Pin 14 View Finder Termination Disable
Pin 15 View Finder Ground

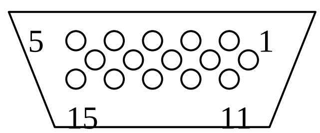


Figure 4e. Remote Button Panel Connector Pin Definition

4.2.1.7 RS-232 Remote Serial Interface

Merlin accepts remote control functions and provides operating status via an RS-232 serial interface. The camera is capable of transmitting and receiving serial data for distances up to 50 feet. The camera can be factory configured for RS-232 or RS-422 communications standards.

The camera can be remotely controlled through the COM0 serial port using either a terminal program (e.g. Hyperterminal) or the Graphic User Interface software provided with the camera. The PC-based graphical interface application runs under Windows NT through the RS-232 port. This software program is supplied with each camera that contains the executable and any necessary support files needed for remote camera control. An exception to this requirement may be a subset of camera commands for which Indigo may decide to charge a premium. In this event, selected camera commands are made available by means of a software-based password protection scheme or other method that does not require the return of the camera to the factory. Figure 4f shows the RS-232 remote serial interface connector pinout:

Pin 1 No Connect
Pin 2 Transmit – (RS-232/422)
Pin 3 Receive – (RS-232/422)
Pin 4 No Connect
Pin 5 Ground
Pin 6 Transmit + (RS422 Only)
Pin 7 Receive + (RS422 Only)
Pin 8 No Connect

Pin 9 No Connect

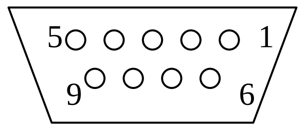


Figure 4f. RS-232 Remote Serial Interface Connector Pin Definition

4.3 Digital Data Output Timing

A timing diagram of the digital data output is shown in Figure 5.

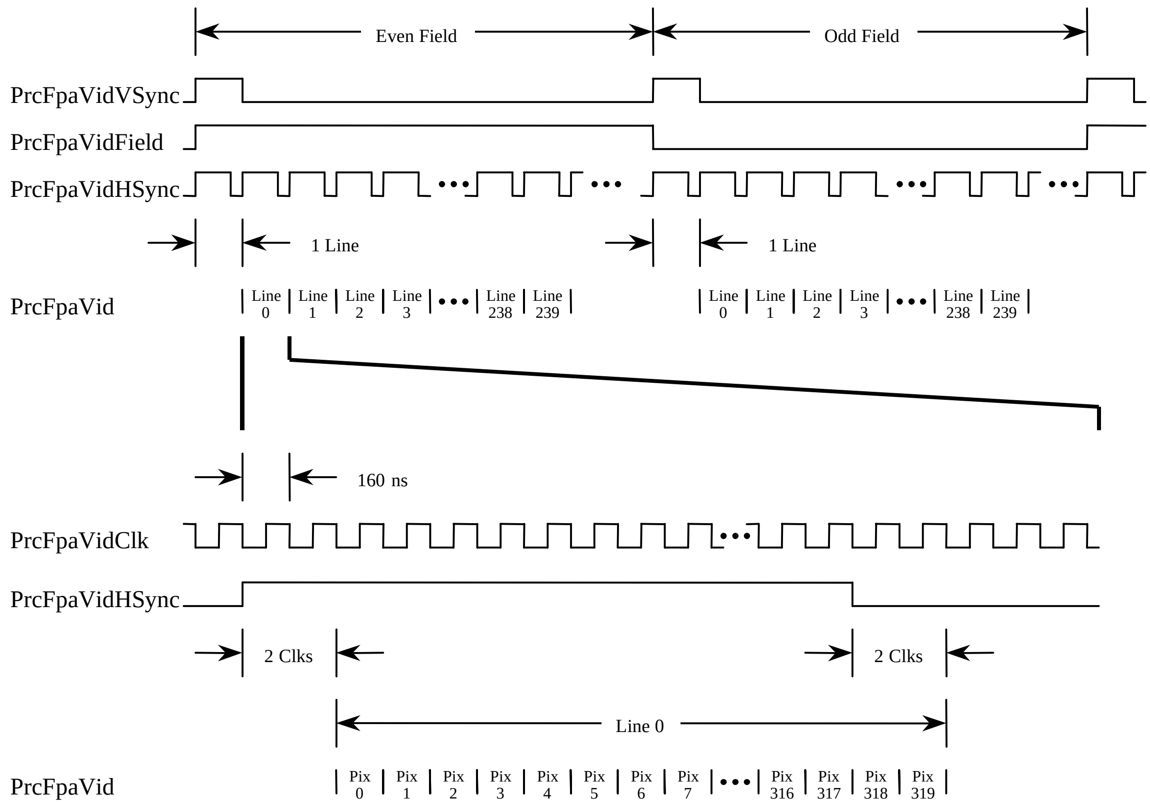


Figure 5. Digital Data Output Timing

Note:

1. PrcFpaVidVSync and PrcFpaVidHSync transition high at the same time. PrcFpaVidVSync also transitions low at the same time as PrcFpaVidHSync transitions high. The width of the PrcFpaVidVSync signal is exactly one video line (400 PrcFpaVidClk cycles).
2. The dead time between the end of line 239 and the rising edge of PrcFpaVidVSync is fixed. There is always a large amount of “dead time” (approximately 22 line times, which equates to approximately 1.4 milliseconds vertical dead time).
3. The low period of the PrcFpaVidHSync signal is 80 clock cycles.
4. In the case where there is no need to distinguish between or analyze data with respect to the "even" and "odd" fields shown in Figure 5, the digital data acquisition system can ignore the PrcFpaVidField signal, and accept any PrcFpaVidVSync pulse as a valid "start of acquisition."

5 Environmental Specifications

5.1 Temperature

Merlin operating temperature range is –20 °C to +55 °C (ambient temperature).

Merlin non-operating temperature range is -40 °C to +85 °C (ambient temperature).

5.2 Relative Humidity

0–95% RH non-condensing.

5.3 Shock & Vibration

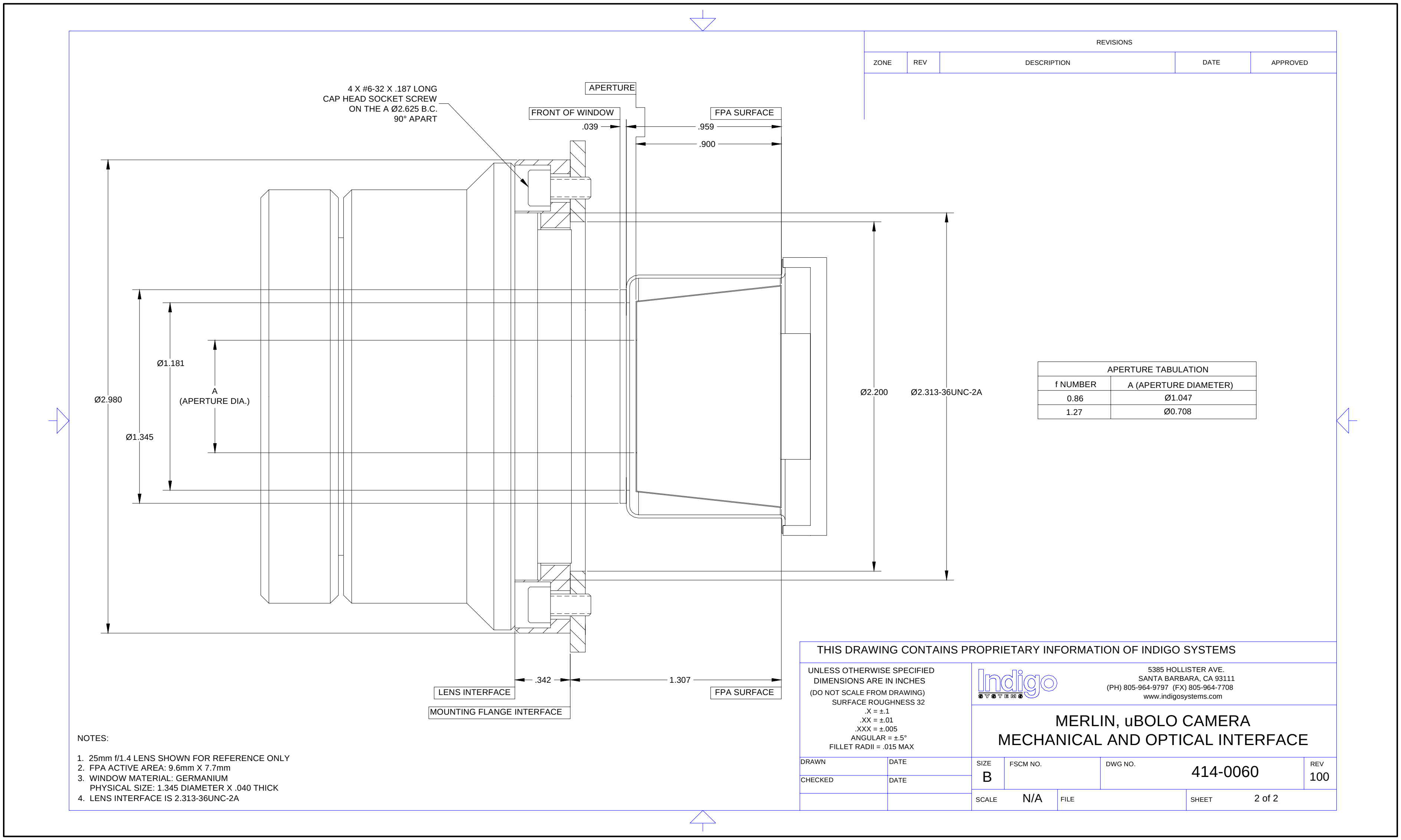
Operating shock:	> 100g/10ms, 3 axis, 2 per axis
Operating vibration:	+3 dB per octave from 20 Hz to 80 Hz 0.06 g^2/Hz from 80 to 350 Hz -3 dB per octave from 350 Hz to 500 Hz 4.1 G rms overall 3-axis, 60 minutes per axis

6 Appendix A Combined COM Port and Menu Command List

COMMAND TYPE	COM PORT COMMAND	DESCRIPTION	BUTTON PANEL DIRECT	MENU
Basic	AGCHISTO	Set AGC type to histogram equalization		Yes
Basic	AGCLIN	Set AGC type to linear		Yes
Basic	AGCLIN2	Set AGC type to linear (2 part)		Yes
Basic	AGCON	Enables AGC	Yes	
Basic	AGCOFF	Disable AGC	Yes	
Basic	BRIGHT	Adjust brightness	Yes	
Basic	CAL1PT	Performs an offset calibration, Sets gains to 1		Yes
Basic	CAL1PTRF	Begin 1 point refresh correction	Yes	
Basic	CAL1PTUP	Performs offset cal while maintaining previous gain data		Yes
Basic	CAL2PT	Performs offset and gain calibration		Yes
Basic	CAMID	Returns camera identification numbers		
Basic	CAMMODE	Displays a list of the current camera configuration settings		
Basic	CLEAR	Clears user-entered text on symbology screen		
Basic	CLRBAROFF	Disables color bar overlay		Yes
Basic	CLRBARON	Enables color bar overlay		Yes
Basic	COLFLIP	Flips FPA data column order (Mid and NIR only)		Yes
Basic	COLNORM	Enables normal FPA data column order		Yes
Basic	CONT	Allows input of contrast value	Yes	
Basic	CTIABIAS	Allows input of CTIA bias adjust value (ISC9809 only)		
Basic	CTIABW	Allows input of CTIA bandwidth factor (ISC9809 only)		
Basic	DETBIAS	Allows input of detector bias (ISC97905 only)		
Basic	DIGCOR	Set digital port to NUC corrected data		Yes
Basic	DIGDSPL	Set digital port to pixel replaced data		Yes
Basic	DIGUNCR	Set digital port to uncorrected data		Yes
Basic	EXTSYNC	Enable external sync		Yes
Basic	FACTDEF	Restores factory default settings.		Yes
Basic	FOCUSIN	Not Enabled	N/A	N/A
Basic	FOCUSOUT	Not Enabled	N/A	N/A
Basic	FPAMODE	Report current FPA mode settings		
Basic	HELP	Outputs a complete list of basic COM port commands		
Basic	HIGHTEC	Select high TE cooler operation temp (Microbolometer and NIR only)		
Basic	INTEG	Set integration time value		Yes
Basic	INTSYNC	Enable internal sync		Yes
Basic	ITRON	Enables short integration then read timing (ISC9809 only)		
Basic	ITROFF	Enables normal integration time (ISC9809 only)		
Basic	LOWTEC	Select low TE cooler operation temp (Microbolometer and NIR only)		
Basic	MEMTEST	Performs memory test and outputs results		Yes
Basic	MSTRCURR	Allows input of the master current bias value (Mid and NIR only)		
Basic	NOISE	Performs noise calculation and outputs results		Yes
Basic	NUCSWOFF	Disable Auto NUC switching		N/A
Basic	NUCSWON	Enables Auto NUC switching		N/A
Basic	OPTEST	Perform operational tests and outputs results		Yes
Basic	OVLPAL	Sets overlay text color		Yes
Basic	POLINV	Sets output video to inverted (black hot)		Yes
Basic	POLNORM	Sets output video to normal (white hot)		Yes
Basic	PROGRAM	Calls routine to perform uploads of application or Xilinx files	Yes	
Basic	PWRADJ	Allows input of power adjust value (Mid and NIR only)		
Basic	ROI16K	Set AGC window size to center 16K		Yes
Basic	ROI32K	Set AGC window size to center 32K		Yes
Basic	ROI64K	Set AGC window size to center 64K		Yes
Basic	ROWFLIP	Flips FPA data row order (Mid and NIR only)		
Basic	ROWNORM	Enables normal FPA data row order.		
Basic	SETDATE	Sets date		Yes
Basic	SETGAIN	Allows input of gain factor (0-3 for ISC9705, 0-1 for 9809)		
Basic	SETNUC	Sets active NUC table	Yes	Yes
Basic	SETTIME	Sets time		Yes
Basic	SKIMOFF	Disables skimming mode (Mid and NIR only)		

COMMAND TYPE	COM PORT COMMAND	DESCRIPTION	BUTTON PANEL DIRECT	MENU
Basic	SKIMON	Enables skimming mode (Mid and NIR only)		
Basic	STR	Displays user string on symbology window		
Basic	STSOFF	Disables on-screen status display		Yes
Basic	STSON	Enables full on-screen status display		Yes
Basic	STSTIME	Enables on-screen partial (date/time) status display		Yes
Basic	VDETCOM	Allows input of VDETCOM bias voltage (Mid and NIR only)		
Basic	VIDPAL	Sets image video palette		Yes
Basic	VIDOFST	Allows input of VIDOFST bias voltage (Mid and NIR only)		
Basic	VOS	Allows input of VOS bias voltage		
Basic	WAVEOFF	Disable waveform display in lower symbology window		Yes
Basic	WAVEON	Enable waveform display in lower symbology window		Yes
Basic	XH0HOR	Set Cross Hair 0 horizontal location		Yes
Basic	XH0OFF	Disable Cross Hair 0		Yes
Basic	XH0ON	Enable Cross Hair 0		Yes
Basic	XH0SIZE	Set Cross Hair 0 size (radius)		Yes
Basic	XH0VER	Set Cross Hair 0 vertical location		Yes
Basic	XH1HOR	Set Cross Hair 1 horizontal location		Yes
Basic	XH1OFF	Disable Cross Hair 1		Yes
Basic	XH1ON	Enable Cross Hair 1		Yes
Basic	XH1SIZE	Set Cross Hair 1 size (radius)		Yes
Basic	XH1VER	Set Cross Hair 1 vertical location		Yes
Adv.	AGCPUPOFF	Disable automatic AGC on power up		
Adv.	AGCPUPON	Enable automatic AGC on power up		
Adv.	AMBFLAG	Set calibration flag type to “AMBIENT”		Yes
Adv.	CLEARREF	Set TEC reference to normal value, clears SETREF cmd.		
Adv.	CLOSEFCTR	Allows input of flag servo “closed” factor.		
Adv.	COUNT	Forces a ramp count to the system		
Adv.	DUALFLAG	Set calibration flag to “DUAL TEMPERATURE” (Mid and NIR only)		N/A
Adv.	FOCUSDUR	Sets focus motor control pulse duration. Not enabled.		N/A
Adv.	FORCE0	Forces a “0” input for all pixel values		
Adv.	FORCE1	Forces a “1” input for all pixel values		
Adv.	HAGCPT	Set AGC high limit point.		
Adv.	HELPADV	Reports advanced COM port commands		
Adv.	HPERCENT	Set auto NUC high end saturation percent		N/A
Adv.	HSATPT	Set auto NUC high saturation count point		N/A
Adv.	LAGCSP	Sets the AGC low limit point		
Adv.	LIN2BRK	Set percentage of 256 colors mapped to the background		
Adv.	LPERCENT	Set auto NUC low end saturation percent		N/A
Adv.	LSATPT	Set auto NUC low saturation count		N/A
Adv.	MANFLAG	Set calibration flag type to manual		
Adv.	MERGENUC0	Copies over NUC0 defective pixels to current active NUC table		
Adv.	NUCON	Clears Unity Gain and Zero Offset bits enabling calibrated NUC coefficients to be applied.		
Adv.	NUCOFF	Sets Unity Gain and Zero Offset bits disabling calibrated NUC coefficients from being applied.		
Adv.	OPENFCTR	Set calibration flag servo open factor		
Adv.	PIXDSPL	Enables display of cross hair pixel location count value		
Adv.	PRPLOFF	Disables bad pixel replace		
Adv.	PRPLON	Enables bad pixel replace		
Adv.	RATEFULL	Enables full video frame rate for the digital port		
Adv.	RATEHALF	Enables 1/2 video frame rate for the digital port		
Adv.	RATEQTR	Enables1/4 video frame rate for the digital port		
Adv.	REFCOLD	Allows input of reference TEC cold bias setting (Mid and NIR only)		
Adv.	REFHOT	Allows input of reference TEC hot bias setting		
Adv.	REMNOISY	Allows removal of noisy pixels based on user input values		
Adv.	SERVO	Tests entered servo pulse factor		
Adv.	SETREFF	Allows input of reference TEC bias setting for test purposes (Mid and NIR only)		
Adv.	SINGFLAG	Sets calibration flag type to “SINGLE TEMP”		N/A
Adv.	TESTOFF	Clears/resets COUNT, FORCE0 and FORCE1 commands		

7 Appendix B Optical Interface Drawing



8 Appendix C Mechanical Drawing