



See the possibilities

User's Manual

RM/TM-1405GE **RMC/TMC-1405GE**

*Digital Monochrome/Color
Progressive Scan, Interline-Transfer GE Camera*

*Document Version: F
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CE Compliance

The RM/TM-1405GE series of cameras has been certified to conform to the requirements of Council Directive 89/336/EC for electromagnetic compatibility and to comply with the following European Standards:

EMCEN55022: 1998 + A1: 2000 CLASS A

EN55024: 1998 + A1: 2001

All JAI Inc. products bearing the CE mark have been declared to be in conformance with the applicable EEC Council Directives. However, certain factory-installed options or customer-requested modifications may compromise electromagnetic compatibility and affect CE compliance. Please note that the use of interconnect cables that are not properly grounded and shielded may affect CE compliance.

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WARNING

Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

RM/TM-1405GE Series Operation Manual

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TM-1405GE Hardware Operation Manual

1 Hardware Introduction

1.1 Product Description

The JAI TM-1405GE is a high-speed progressive scan CCD camera. The interline-type CCD permits full vertical and horizontal resolution of very high speed shutter images and applications. The electronic shutter, which has speeds to 1/21,000 second, can be reset asynchronously by external pulse control. The frame rate for a full image is 30 fps, with partial scan modes of up to 1 line. A 2:1 ratio imager format with uniform square pixels provides superior image definition in any orientation.

The TM-1405GE has a full dynamic range control function, which can be set at externally selectable look-up table (LUT) knee slopes to convert 10-bit input to 8-bit output, thereby optimizing the CCD's full dynamic range in the normal output signal range. 10-bit linear output is also selectable.

Applications for the TM-1405GE include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high security surveillance.

The TM-1405GE series consists of the RM/TM-1405GE (monochrome) and the RMC/TMC-1405GE (color). Unless otherwise noted, all information contained in this manual is relevant to both models.

1.2 Features

The TM-1405GE has the following features:

- Miniature size and light weight

The printed circuit boards in the TM-1405GE have been arranged to create modular electronics, giving the camera flexibility. In addition, the use of miniature solid-state components results in a compact, lightweight camera that is 50.8mm x 50.8mm x 83.5mm in dimensions, and weighs only 140 grams.

- Imager

The TM-1405GE uses a progressive scan interline transfer CCD that has the following features:

- Resolution of 1392 x 1040 active pixels for excellent image quality.
- 4.65 x 4.65 μm square pixels for precise dimensional measurement.
- High-speed electronic shutter capability for high dynamic resolution of moving objects that eliminates the need for a mechanical shutter.
- Progressive scan CCD eliminates interlace deterioration of image and increases ease of computer interface.
- High sensitivity and low noise at fast scanning. The CCD has an excellent S/N ratio at the default setting greater than 51dB.

- Electronic shutter

The TM-1405GE has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing.

- Asynchronous reset

The TM-1405GE captures asynchronous reset images and provides single-shot video output with single FDV. This makes it simpler for an ordinary frame grabber to capture the asynchronous reset images. The TM-1405GE's asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied to pin 6 on the Hirose, or the PLC 12-pin connector, it resets the camera's scanning and purging of the CCD.

The TM-1405GE has three modes to control the asynchronous reset and shutter speed:

- Async, no shutter. The video signal and FDV are reset by external VINIT.
- Async Programmable shutter. The shutter speed depends on the number of horizontal lines controlled by the user.
- External VINIT with pulse width. The duration between pulse edges controls the shutter speed externally.

- Output

The TM-1405GE has a 10-bit/8-bit Gigabit Ethernet output. The analog output is 714 mV p-p composite video (75 ohms) on all models.

- Warranty

Contact your factory representative for details about the warranty.

2 Installation

The following instructions will help you to set up your camera quickly and easily. JAI suggests that you read through these instructions first, before you unpack and set up your camera system.

2.1 Getting Started

2.1.1 Unpacking Instructions

JAI recommends that you save the original packing cartons for the cameras and accessories in case you need to return or exchange an item.

We also recommend that you bench-test any equipment being sent to another location for field installation to assure that everything is fully operational as a system.

2.1.2 Components

When you receive your TM-1405GE camera from JAI, the contents of the shipping box should include the camera and a document download card. If either of these items are missing, contact your JAI representative immediately. The document download card includes instructions and web locations for downloading the datasheet, manual, and camera-control software. If you do not have Internet access, contact JAI to receive this material on a CD-ROM.

2.1.3 Accessories and Options

The following additional accessories and options may be required for your application:

- PD-12U series power supply
- 12P-02S power cable
- Cat5e or cat6 shielded Ethernet cable (not supplied by JAI)
- Tripod Mounting Kit: TP-20
(for dimensions go to:
www.jai.com/EN/CameraSolutions/Products/Accessories/Pages/Home.aspx)

Check with your JAI representative before you install your camera to determine what you might need.

2.2 Camera Setup

2.2.1 Heat Dissipation

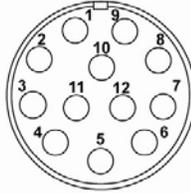
The TM-1405GE is a compact camera. Since all the electronics have been packed in a compact package, the outer case of the camera can become hot because of heat dissipation. For optimal performance, JAI recommends using a cooling fan to set up a positive air flow around the camera and following the precautions below.

- Mount the camera on a large heat sink (camera bracket) made out of a heat-conductive material like aluminum.
- Make sure the flow of heat from the camera case to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate the free flow of air.

2.2.2 Connector Pin Configurations

The TM-1405GE has a 12-pin Hirose connector for power input and signal integration as shown in Figure 1.

Figure 1. 12-Pin Connector Pinouts

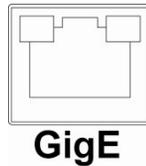


Pin #1 is Ground and pin #2 is +12V DC. Table1 shows the pin-out table.

Table 1 Table 1 12-Pin Connector

| Pin | Description | Pin | Description |
|-----|--------------------------------|-----|-------------|
| 1 | GND | 7 | VD in |
| 2 | +12V DC | 8 | Strobe |
| 3 | GND (analog) | 9 | HD in |
| 4 | Video out | 10 | Reserved |
| 5 | GND (digital) | 11 | Reserved |
| 6 | VINIT in (External_Trigger) | 12 | Reserved |

Figure 2. GigE Ethernet Connector



Use at least cat5e UTP cables (cat6 cables are preferred). JAI recommends the use of shielded cables to reduce emissions and for CE/FCC compliance. Double-shielded cables further reduce emissions.

2.2.3 Power Supplies and Power Cable Setup

2.2.3.1 Power Supplies

The TM-1405GE camera requires 12V DC power obtained through the 12-pin connector located on the rear panel of the camera. JAI, Inc. power supplies feature a 122-240V AC / 12V DC 1.2A universal voltage supply. JAI recommends the following power supplies:

| | | |
|----------|-------------------------------|---------------|
| PD-12UU | PD-12UU no 12-pin connector | US Plug |
| PD-12UUP | PD-12UU with 12-pin connector | US Plug |
| PD-12UE | PD-12UU no 12-pin connector | European Plug |
| PD-12EUP | PD-12UU with 12-pin connector | European Plug |

If you are providing power through the 12-pin connector, the PD-12P, PD-12UEP and PD-12UUP power supplies are available with the 12-pin mating connector already attached to the leads from the power supply. You can connect the PD-12UU and PD-12UE power supplies to the JAI power cable using a terminal strip or directly.

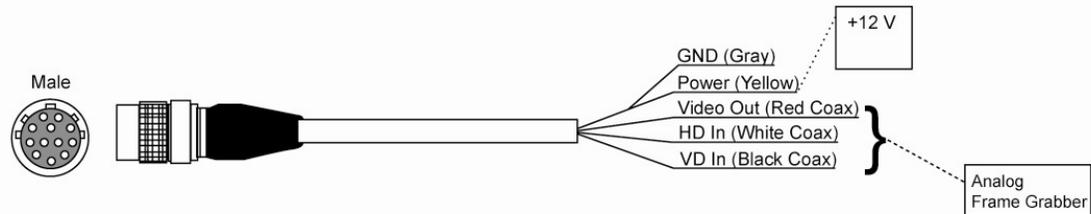
When wiring the PD-12UU and PD-12UE power supplies directly, note the following:

- Twist the lead ends together and tin-solder for strength and electrical continuity.
- Use shrink tubing or a similar insulator to prevent exposed leads from touching and shorting.
- The +12V lead is marked with a red stripe or white lettering; be sure not to reverse the leads.
- Make sure all connections are properly insulated to prevent shorting.

2.2.3.2 JAI Power Cables

If you are using JAI power cables, such as the 12P-02S, refer to the Figure 3 which shows the cable pin-out diagram and pinouts. The color-coded leads use Gray for Ground and Yellow for +12V.

Figure 3. 12P-02S Interface Cable (optional)



| 12P-02S Interface Cable | | | | | |
|-------------------------|--------------------|---------------------------|------|-------------------|----------------------|
| Pin# | Lead Color | Function | Pin# | Lead Color | Function |
| 1 | Gray | GND (Power Ground) | 7 | Black coax | TTL IN (External_VD) |
| 2 | Yellow | +12V DC (Power In) | 8 | White coax shield | TTL OUT (STROBE) |
| 3 | Red coax shield | GND (Analog Ground) | 9 | White coax | TTL IN (External_HD) |
| 4 | Red coax | VIDEO (Analog Out) | 10 | Brown | RESV |
| 5 | Orange coax shield | GND (Digital Ground) | 11 | Blue | RESV |
| 6 | Orange coax | TTL IN (External_Trigger) | 12 | Black coax shield | RESV |

Note: Make sure that the unused leads are not touching and that there is no possibility that exposed wires could cause the leads to short.

2.2.3.3 Building Your Own Power Cable

Refer to the 12-pin connector pin-out in Figure 1. Connect the Ground lead to pin #1, and the +12V DC lead to pin #2 of the 12-pin connector. Power must be DC-regulated, and of sufficient current to properly power the camera.

2.2.3.4 Attaching the Power Cable to the Connector

The 12-pin connector is keyed and will only fit in one orientation. To properly attach the power cable to the camera connector, use the following steps:

1. Rotate the connector while applying slight pressure until the keyways line up.
2. Press the connector into place until firmly seated.
3. Plug the power cord into the 100V AC socket. This powers up the camera.

Note: If using a power supply other than the standard PD-12U Series from JAI, certain characteristics are required of the power supply and the wiring in order to properly power the camera. The camera requires 12V immediately upon start-up; no slow ramps. Once power is applied, the power supply must be able to support a 2A to 2.5A in-rush current for approximately 200 μ s to prevent the voltage at the camera from dropping below the 10.8V minimum required. Dropping below this will result in the camera's internal power supply lowering its impedance in an attempt to draw more current. Since no more current will be available, the voltage at the camera will drop instead. This will result in a steady state hang-up which will damage the camera's power supply and cause the camera to cease operating or to operate in an unstable manner.

2.2.4 Attaching the Camera Lens

The TM-1405GE camera accepts 1/2" or larger format size C-mount lenses¹ to the camera, carefully engage the threads and rotate the lens clockwise until it firmly seats on the mounting ring. Do not force the lens if it does not seat properly.

Note: Some lenses with extremely long flangebacks may exceed the mounting depth of the camera.

2.2.5 Adjustable Back-Focus

Before cameras are shipped, back focus is carefully set using a collimator, oscilloscope and other specialized equipment. While the factory-set focus serves well in most cases, an adjustable back focus makes it possible to improve image sharpness when using lower-cost zoom lenses, custom optics, or in unusual parameters.

There should be an obvious need to refocus the lens before attempting to change the back focus. This is a very exacting task. Some cameras have been returned to the factory to reset the back focus after failed attempts to change the focus by customers. It might be wise to label cameras whose back focus was adjusted

1. The camera must be connected to a monitor before attempting to adjust the back focus.
2. To back focus the camera, first attach a C-mount lens in the mount. Be certain that the lens is properly seated.
3. Next set the lens focus to infinity (if the lens is a manual iris, set the iris to a high f number while still retaining a well illuminated image).
4. Loosen the three miniature hex set-screws (use a 0.9 mm hex wrench) that lock the focus ring in place (two screws for a CS-mount). Slowly turn the lens and focus ring assembly back and forth until you obtain the best image of the desired object. This sets the back focus. Once the best image is obtained, tighten the focus ring set-screws until they are snug. Do not over-tighten the screws.

Note: Mini-bayonet cameras adapted to C-mount do not have the back focus feature.

¹ C-mount to F-mount and C-mount to K-mount adapters are available for larger format lenses (35 mm). Check with local photography dealers for these lens adapters.

Figure 4. Back-Focus Set-Screw Locations

Loosen the three 2mm screws around the perimeter of the C-mount lens collar (two 2mm screws for a CS-mount) to adjust the back focus. Unless you absolutely must, do not attempt to adjust this focus.

3 Operation

3.1 Progressive Scanning

The TM-1405GE uses a state-of-the-art progressive scanning interline transfer CCD which scans all lines sequentially from top to bottom at one frame rate. Like a non-interlace computer screen, it generates a stable, crisp image without alternating lines and provides full vertical TV resolution of 1040 lines.

The interline transfer architecture is also important to generate simultaneous shuttering. This is different from full frame transfer architecture, which requires a mechanical shutter or strobe light in order to freeze the object motion.

The TM-1405GE outputs the progressive scanned image with an electronic shutter in two different formats.

- Progressive scanning digital - The CCD signal goes through A/D converters 10-bit in, 10-bit/8-bit out. The digital output is available using the Gigabit Ethernet connector.
- Analog output - The analog output is the same as 75 ohms, 714mV format available from BNC and 12-pin connector. Analog video does not conform to the RS-170 standard and is not RS-170 compatible.

3.2 Bayer Color Filter (Color Versions)

JAI AccuPiXEL series color cameras are high-resolution, high-speed progressive scan CCD cameras. The interline transfer, progressive scan CCD permits full vertical and horizontal resolution of images acquired at very high shutter speeds. The electronic shutter, which has speeds to 1/21,000 sec., can be reset asynchronously by external pulse control. Uniform square pixels provide superior image definition in any orientation. On-chip micro lenses mean increased sensitivity.

3.2.1 Color Filter Array

JAI AccuPiXEL cameras use Bayer CFA (color filter array) as their standard primary color filter. This filter provides the most popular color interpolation supported by numerous software suppliers.

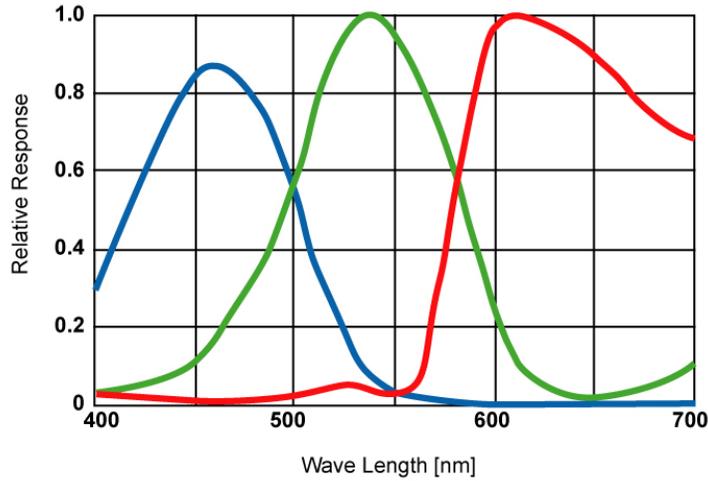
The digital format allows the camera to output accurate pixel data, including the color information. When the data is stored in the frame buffer of a frame grabber or computer, the color information is easily manipulated to restore the original color images. Because the color filter array contains only a single R, G or B color in each pixel, the restored image has to fill in colors in the missing pixel locations. The software uses neighboring pixel information to “guess” the missing colors to make smooth, clear images. This is called “color interpolation.” Today’s high-speed computers allow such color interpolation to be done almost in real time. Because these cameras do not contain internal color processing circuitry, they are smaller and less expensive than full-function color cameras.

3.2.2 Bayer Color Filter Array (CFA)

The Bayer CFA is an R, G, B primary color filter array. This is the most widely accepted CFA for the single-chip CCD progressive scan format. This type of array layout has a specific order for each color’s pixels. Since the human eye’s resolution and color recognition are highest at green, the CFA contains two greens per each red and blue.

It is critical for the frame grabber and color interpolation to know where the individual color pixels exist relative to sync (LDV and FDV) timing.

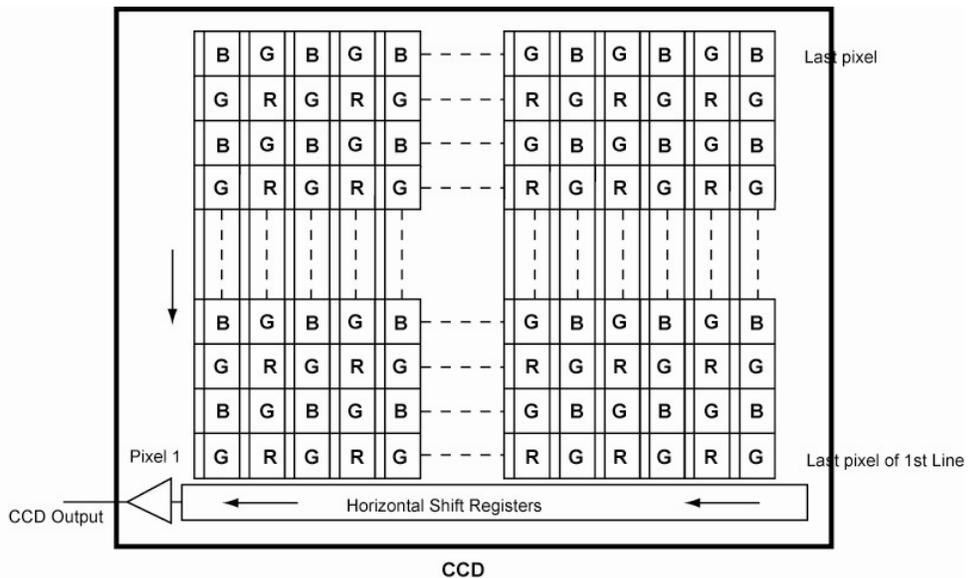
This requirement makes digital output the preferred choice, because the timing relationships are very accurate.



3.2.3 Starting Pixel Configuration

All manufacturers produce identical Bayer CFAs, but there are slight differences between the CCDs produced by different manufacturers. The first line is generally R and G. The camera timing can be adjusted to start with either G or R by skipping the very first pixels at each line. The majority of color interpolation software can select between a variety of pixel relations, such as R/G start or G/R start, as well as G/B start and B/G start. Once the correct scanning is configured, the rest of the interpolation will be exactly the same. Please contact JAI for further information regarding CCD manufacturers.

Figure 5. Example of Color CCD CFA Pattern



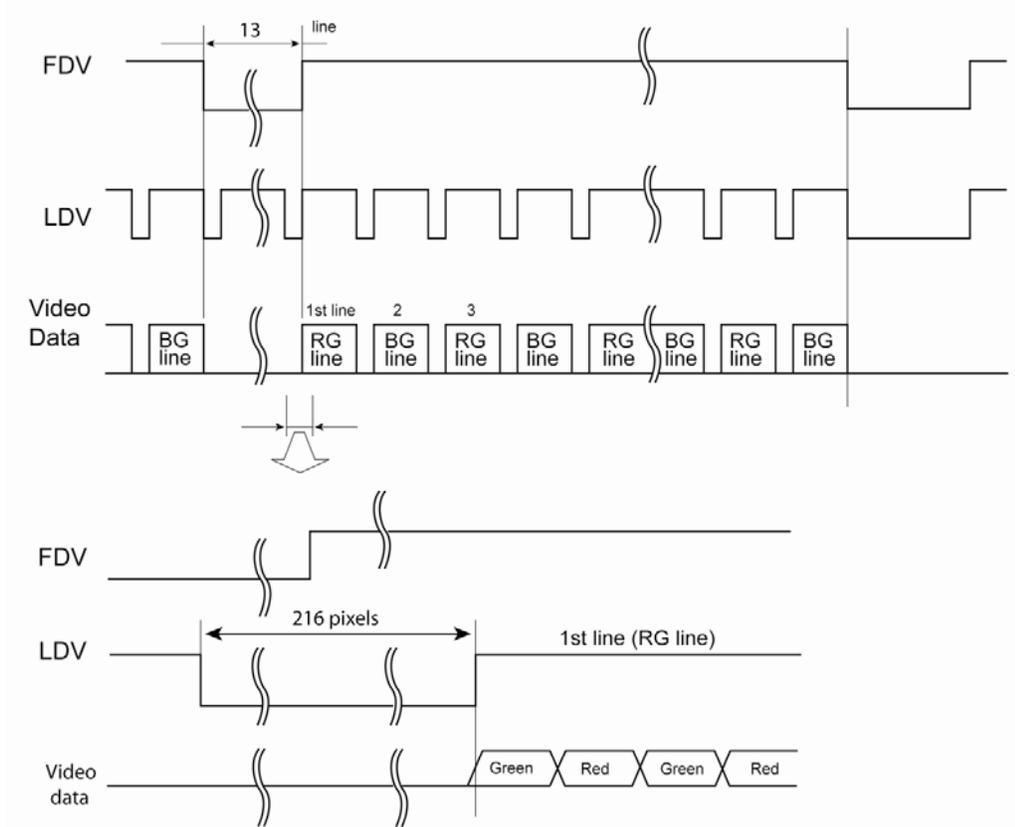
3.2.4 Sync and Data

The individual color data is exactly the same as the pixel data. This means that the timing relationships of the color cameras are also the same as of the B/W cameras.

For a detailed timing chart, please refer to each B/W camera's data sheet and manual.

The following diagram is an example of the TMC-1405GE default mode. FDV and LDV are used internally for the GigE interface.

Figure 6. Example of TMC-1405GE in Default Mode



3.2.5 Camera Functions

AccuPiXEL color cameras perform all functions the same way as monochrome cameras. However, because of color characteristics, the LUT (Look-up Table) is different. The LUT is a powerful tool to adjust the dynamic range as well as the color dynamic range. Since human color perception is non-linear, LUT selection can help optimize color contrast by selecting the LUT value. Gamma 0.45 is logarithmic and is close to human perception.

When LUT is selected, black-level adjustment must be more accurate than for B/W cameras.

For a detailed timing chart, please refer to the standard AccuPiXEL camera data sheet, or contact JAI.

3.2.6 Interpolation Software

The color interpolation can be performed in the frame grabber or by using the host computer’s CPU. Most major frame grabbers with processing capability provide tools for color interpolation. Software vision packages also provide color interpolation capability, but speed and performance may be determined by the PC’s resources and by the complexity of the interpolation routine.

3.2.7 Color Interpolation

The Bayer pattern color filter array (CFA) consists of R, G, and B primary colors. Each pixel represents one of three colors. In order to display or print color images, the signal has to be converted to RGB output, which has three independent channels (outputs) and sync signals.

Color interpolation software or firmware performs the color preprocessing by filling the missing color pixels with neighboring pixels. It then separates the stream of data, (8-bit or 10-bit) into 3 (RGB) data (8-bit x 3) and adds the color matrix to adjust and balance each of the R, G, and B channels (white balance or color balance).

| | | |
|-------|-------|-------|
| Green | Red | Green |
| Blue | Green | Blue |
| Green | Red | Green |

The image quality depends on the camera's own pixel data (including pixel data independency from neighboring pixels, noise and color filter), and interpolation of the software algorithm such as 3 x 3 interpolation, 2 x 2 interpolation, color matrix, white balance capability, etc.

All AccuPIXEL color cameras are carefully designed for maximum color performance. JAI strongly suggests that you use digital output for the best performance.

Some software is used on board (FPGA or DSP) to perform the interpolation. Other software simply uses the host computer's memory and CPU. The processing speed may vary depending on the architecture and speed of the computer.

3.3 Electronic Shutter

The TM-1405GE has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing. A built-in flexible shutter speed control selects the electronic shutter rate from 1/30 to 1/21,000.

With VINIT high (CC1), the CCD keeps discharging. With an active low pulse to VINIT, the camera resets and purges the charge momentarily. Then it starts integrating for the period of shutter control set by either an external pulse width or internal shutter control. Progressive scanning permits a full 1040 lines of vertical resolution, as compared to a conventional CCD camera which captures only half the vertical lines per shutter.

3.4 External Sync

The TM-1405GE accepts an external synchronization of standard HD and VD on CC3 and CC4 of the Gigabit Ethernet connector for general locking to an external source. The tolerance is $\pm 2\%$ horizontal frequency.

3.5 Asynchronous Reset

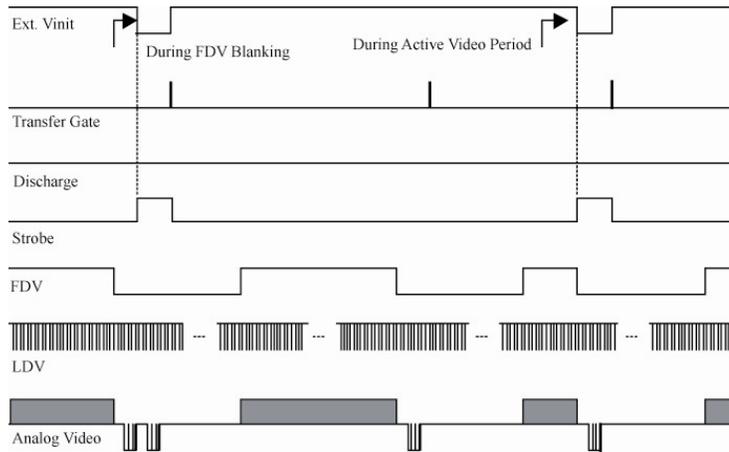
The TM-1405GE camera includes the following modes to control the asynchronous reset and shutter speed:

- Async No Shutter (recommended for strobe applications)
- Async Programmable shutter
- External VINIT with Pulse Width (No-Delay Shutter)

3.5.1 Async No Shutter

Async No Shutter allows for standard strobe and back-to-back strobing applications (strobing both before the transfer gate and right after).

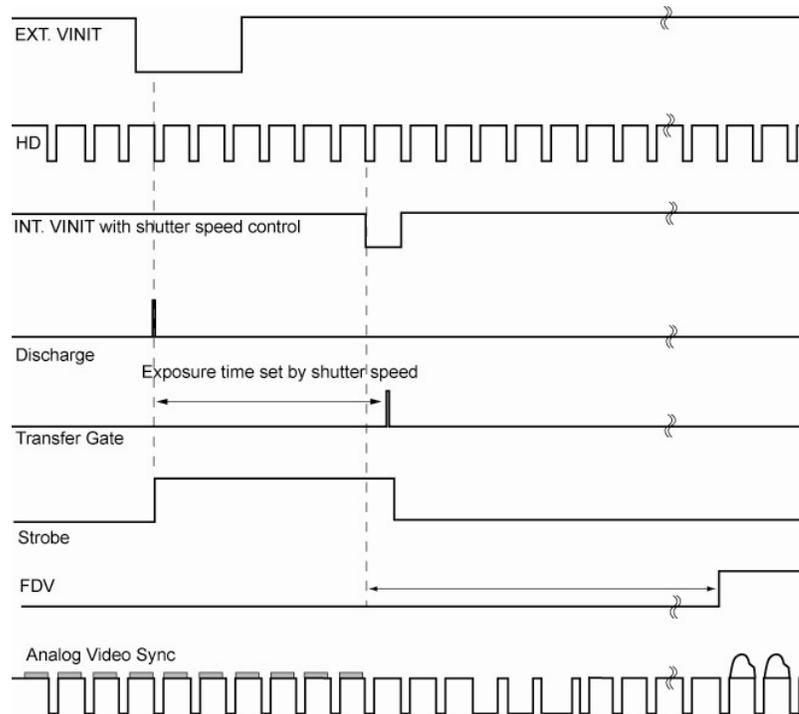
Figure 7. Async No Shutter



3.5.2 Async Programmable Shutter Speed Control

In Asynchronous Programmable Shutter mode, the video signal starts with internal VINIT. When the external VINIT pulse is applied, internal VINIT is latched to HD and the internal VINIT is delayed to set up the shutter speed period. Video output timing starts right after the internal VINIT and single shots, FDV is output at the internal VINIT timing. Shutter speed is determined by a direct shutter value entered from 1 to 1040 via the camera's control software. The shutter value equals 1.5H (horizontal line time) or 47.6 μ sec for each increment.

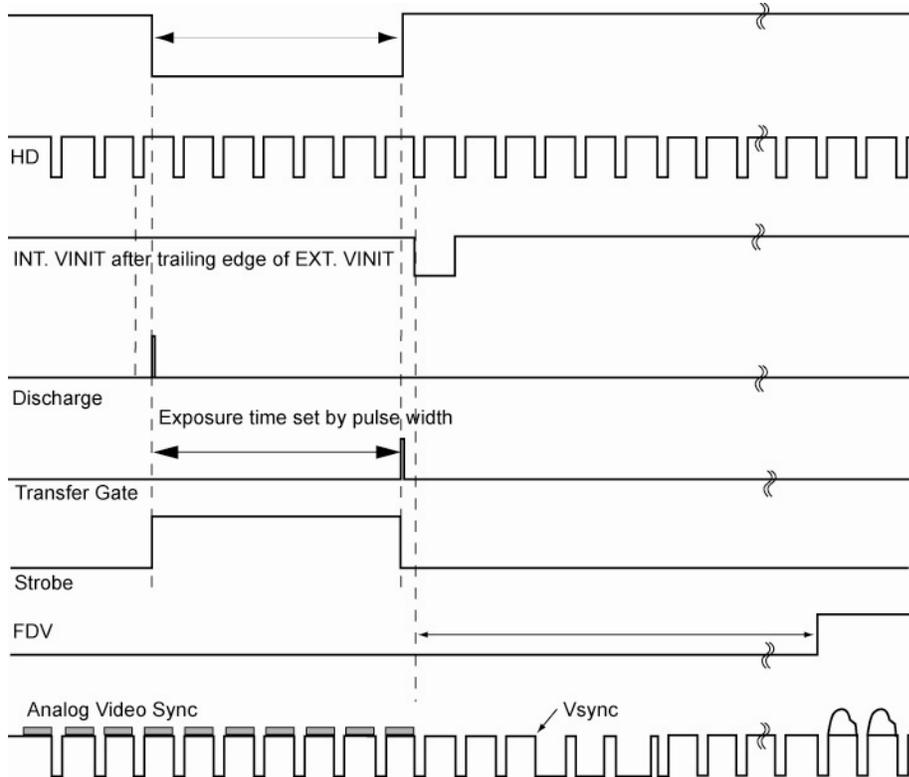
Figure 8. Async Programmable Shutter Speed Control



3.5.3 External VINIT With Pulse Width (No-Delay Shutter)

For multiple-camera applications such as 2D or 3D measurement and multi-angle inspection, simultaneous image capturing at an exact shutter timing for all cameras is a critical requirement. The TM-1405's asynchronous pulse-width control mode provides no-delay shutter as standard. Regardless of the internal pulse timing, the camera discharges at the VINIT leading edge and transfers charges at the trailing edge of the pulse. Even though each camera runs with slightly different H and data clock timing, the image capturing is exactly simultaneous.

Figure 9. No-Delay Shutter



3.6 Programmable Look-Up Table (LUT) and Knee Control

The TM-1405GE has a built-in LUT (look-up table) for dynamic range control.

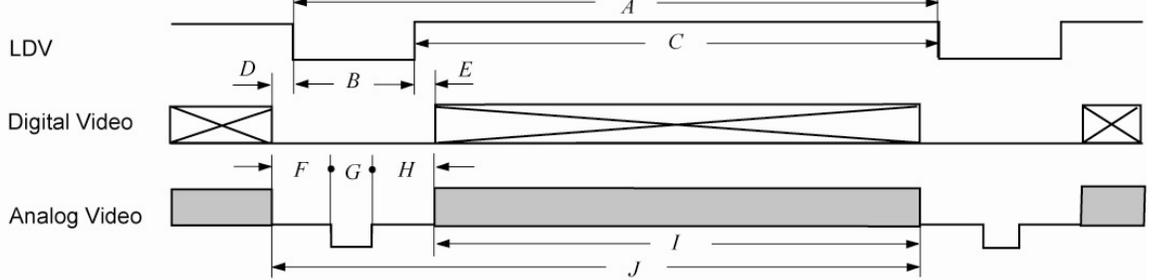
At a specific gain setting, the offset (minimum level... dark point) and A/D reference top voltage (maximum level... saturation point) are set to 10-bit A/D input so that the full dynamic range of the CCD is utilized at 10-bit references as the input and the LUT output is converted into 8-bit to adjust the gamma correction. Notice that the LUT (look-up table) is not available in the 10-bit grayscale mode.

The look-up table has two knee points (variable gamma selection) that allow the 10-bit input to be segmented into three regions. The look-up table selection can be made by knee curve direct input.

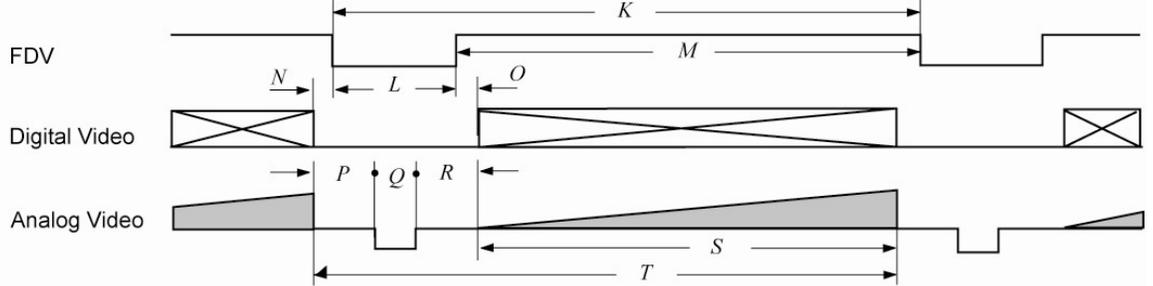
3.7 Camera Timing Charts

1. Video Output

>> Line Video Timing

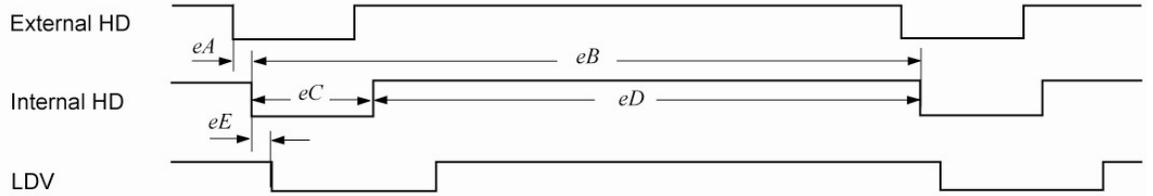


>> Field Video Timing

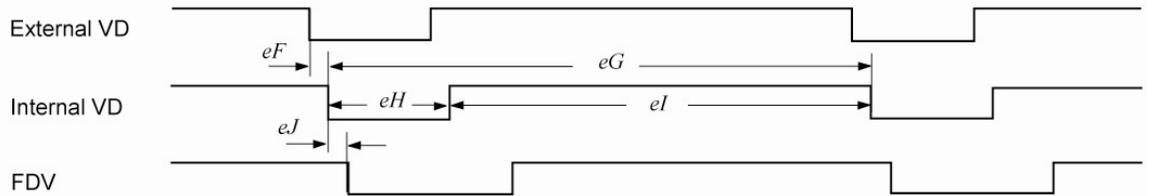


2. External HD Locking & External VD Reset

>> External HD Locking

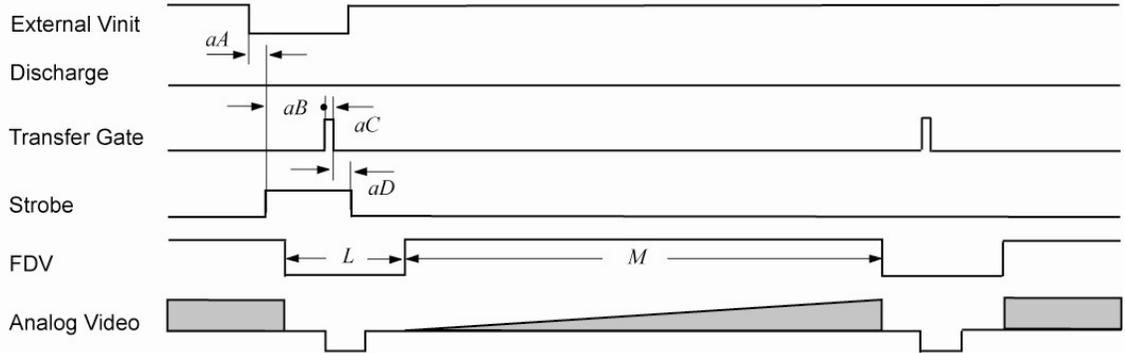


>> External VD Reset

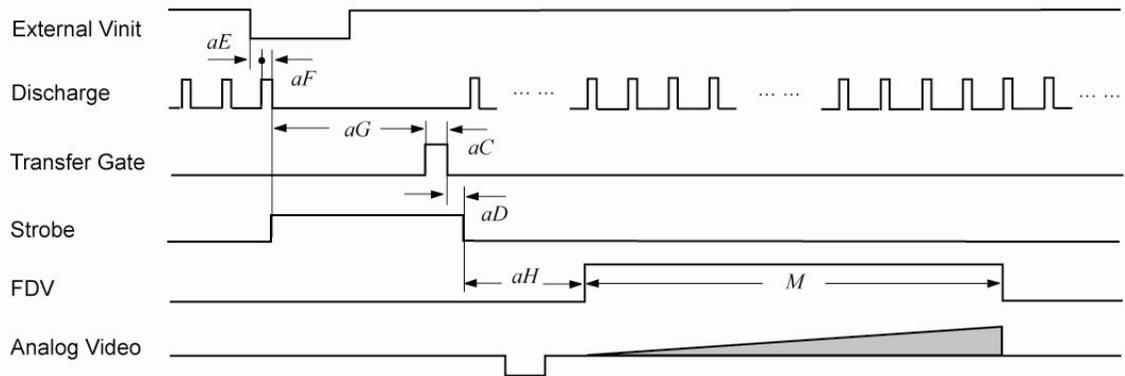


3. Async Reset

>> Async No Shutter (async shutter 0)



>> Async Direct Shutter & Async No-delay Shutter



3.8 Video Output

Table 2 Video Output (Horizontal Timing)

| Horizontal Timing | | |
|-------------------|------------------|------------------|
| | Number of pixels | 30fps (μ s) |
| A | 1608 | 32.16 |
| B | 216 | 4.32 |
| C | 1392 | 27.84 |
| D | 0 | 0 |
| E | 0 | 0 |
| F | 48 | 0.96 |
| G | 61 | 1.22 |
| H | 107 | 2.14 |

Table 3 Video Output (Vertical Timing)

| Vertical Timing | | | | |
|-----------------|-----------------|------------|-----------------------------|------------------------|
| | Full Scan Area | | User Scan Area (SP:x, TL:y) | |
| | Number of lines | 30fps (μs) | Number of lines | 30fps (μs) |
| J | 1053 | 33864.48 | (nfp+11)+nrp+y | ((nfp+11)+nrp+y)*32.12 |
| K | 13 | 418.08 | (nfp+11)+nrp | ((nfp+11)+nrp)*32.16 |
| L | 1040 | 33446.40 | y | y*32.16 |
| M | 0 | 0 | 0 | 0 |
| N | 0 | 0 | 0 | 0 |
| P | 3 | 96.48 | nrp+6 | (nrp+6)*32.12 |
| Q | 3 | 96.48 | 3 | 96.48 |
| R | 7 | 225.12 | nfp+5 | (nfp+5)*32.16 |

Where

$$n_{fp} = \begin{cases} \text{int}\left(\frac{x+11}{6}\right) & \text{remainder of } \frac{x+11}{6} = 0 \\ \text{int}\left(\frac{x+11}{6}\right)+1 & \text{remainder of } \frac{x+11}{6} \neq 0 \end{cases}$$

$$n_{rp} = \begin{cases} \text{int}\left(\frac{1042-x-y}{6}\right) & \text{remainder of } \frac{1042-x-y}{6} = 0 \\ \text{int}\left(\frac{1042-x-y}{6}\right)+1 & \text{remainder of } \frac{1042-x-y}{6} \neq 0 \end{cases}$$

3.9 External HD Locking and External VD Reset

Table 4 External HD Locking and External VD Reset (Horizontal Timing)

| Horizontal Timing | | |
|-------------------|------------------|------------|
| | Number of pixels | 30fps (μs) |
| eA | <1 | <0.02 |
| eB | 160 | 3.20 |
| eC | 1448 | 28.96 |
| eD | 15 | 0.30 |

Table 5 External HD Locking and External VD Reset (Vertical Timing)

| Vertical Timing | | | | |
|-----------------|-----------------|------------|-----------------------------|-----------------------|
| | Full Scan Area | | User Scan Area (SP:x, TL:y) | |
| | Number of lines | 30fps (μs) | Number of lines | 30fps (μs) |
| eE | <1 | <32.16 | <1 | <32.16 |
| eF | 9 | 289.44 | 9 | 289.44 |
| eG | 1404 | 45152.64 | (nfp+2)+nrp+y | ((nfp+2)+nrp+y)*32.16 |
| eH | 0 | 0 | 0 | 0 |

3.10 Asynchronous Reset

Table 6 Asynchronous Reset

| | (L: lines) (P: pixels) | 30 fps (μ s) |
|----|---------------------------|----------------------|
| aA | <1L | <32.16 |
| aB | 9L + 960P | 308.64 |
| aC | 160P | 3.20 |
| aD | 9L | 289.44 |

Table 7 Asynchronous Direct Shutter and Pulse-Width Control

| | Asynchronous Direct Shutter (ADS=n) | | Pulse-Width Control (Pulse Width=z) | |
|----|--|-------------------|--|-------------------|
| | (L: lines) (P: pixels) | 30 fps (μ s) | (L: lines) | 30 fps (μ s) |
| aE | <1L | <32.16 | <10P | <0.2 |
| aF | 53P | 0.972 | 36P | 0.72 |
| aG | (n+1)L+960P | (n+1)*32.16+1.92 | z+960P | z+1.92 |
| aH | K-1 | (K-1)*32.16 | K-1 to K | (K-1 to K)*32.16 |

4 Functions & Operations

4.1 GigE Vision Standard Interface

The TM-1405GE series cameras are designed in accordance with the GigE Vision standard. Digital images are transmitted over Cat5e or Cat6 Ethernet cables. All camera functions are also controlled via the GigE Vision interface.

The camera can operate in continuous mode, providing an endless stream of images. For capturing individual images, related to a specific event, the camera can also be triggered. For precise triggering, it is recommended to use a hardware trigger applied to the Hirose 12-pin connector. It is also possible to initiate a software trigger through the GigE Vision interface. However, when using a software trigger, certain latency inherent to the GigE interface must be anticipated. This latency, that manifests itself as jitter, greatly depends on the general conditions and traffic on the GigE connection. The frame rate described in this manual is for the ideal case and may deteriorate depending on conditions.

When using multiple cameras (going through a switch and/or a single path) or when operating in a system with limited transmission bandwidth the Delayed Readout Mode and Inter-Packet Delay functions can be useful.

4.2 GigE Vision-Aware Software

A GigE Vision camera can be controlled by any software that understands the protocol. At JAI we provide the JAI GigE Vision SDK and Control Tool to interface with our cameras. The remainder of the manual will show screenshots of the JAI Control Tool but other 3rd party software will provide similar functionalities.

4.3 Recommended Network Configurations

Although the TM-1405GE series cameras conform to Gigabit Ethernet (IEEE 802.3) not all combinations of network interface cards (NICs) and switches/routers are suitable for use with the GigE Vision compliant camera.

4.3.1 Verified Network Interface Cards (NICs)

At the time of publishing this document these combinations have been verified:

NIC: Intel Pro/1000MT, Pro/1000GT, Pro/1000PT.

CPU: Intel Core 2 Duo 1.84Ghz.

Memory: 2 GB

Video Card: video card on PCI Express bus with at least 256MB of VRAM.

Functions such as screen saver and power save should not be used. Unnecessary applications such as Word, Excel or others should not be used.

4.3.2 Video data rate (network bandwidth)

The video bit rate for TM-1405GE series cameras at the continuous mode and full scan area. is:

| Model | Pixel Type | Frame Rate | Packet data volume (GevSCPSPacketSize of 4040) |
|------------|--------------|--------------------|---|
| TM-1405GE | Mono8 | 30 fps | 352.2Mbit/s |
| | Mono10 | 30fps ₁ | 704.3Gbit/s |
| | Mono10Packed | 30 fps | 541.4Mbit/s |
| TMC-1405GE | BayerRG/GB8 | 30fps | 352.2Mbit/s |
| | BayerRG/GB10 | 30fps ₁ | 704.3Gbit/s |

Note: The Mono10, and BayerRG/GB10 settings at full frame rate will exceed GigE bandwidth. It is recommended to use Mono8 Mono10Packed or BayerRG/GB8 for max frame rate.

For TM-1405GE series cameras, the jumbo frame can be set at a maximum 16260 Bytes (Factory setting is 1428 Bytes). To set Jumbo Frames, refer to section 4.3.4.

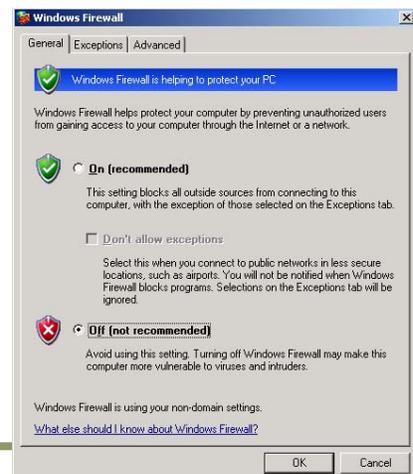
To ensure the integrity of packets transmitted from the camera it is recommended that you follow these simple guidelines:

- Whenever possible use a peer-to-peer network.
- When connecting several cameras going through a network switch, make sure it is capable of handling jumbo packets and that it has sufficient memory capacity.
- Configure inter-packet delay to avoid congestion in network switches.
- Disable screen saver and power save functions on computers.
- Use high performance computers with multi-CPU, hyper-thread and 64-bit CPU, etc.
- Only use Gigabit Ethernet equipment and components together with the camera.
- Use at least Cat5e or preferably Cat6 Ethernet cables.
- Whenever possible, limit the camera output to Mono8 or Mono10Packed for Monochrome cameras, and BayerRG/GB8 for color.

4.3.3 Disable Firewalls

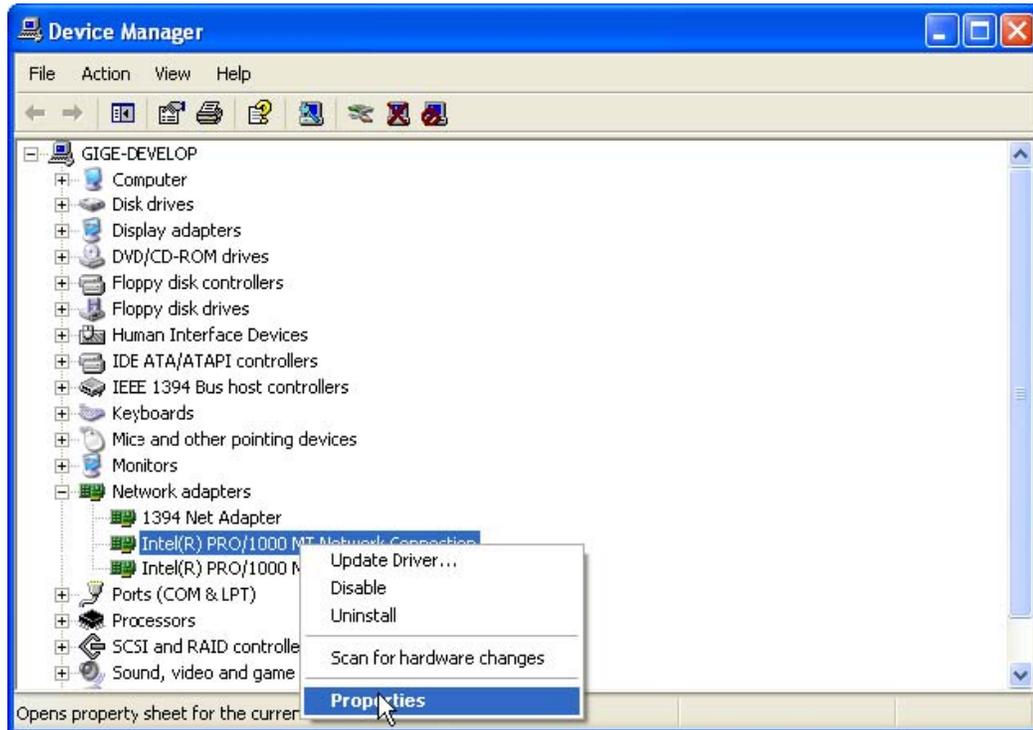
To ensure proper operation of the JAI SDK & Control Tool, all firewalls must be disabled. This also includes the Windows firewall.

Click [Start], [Control Panel] for accessing the Windows firewall configuration.



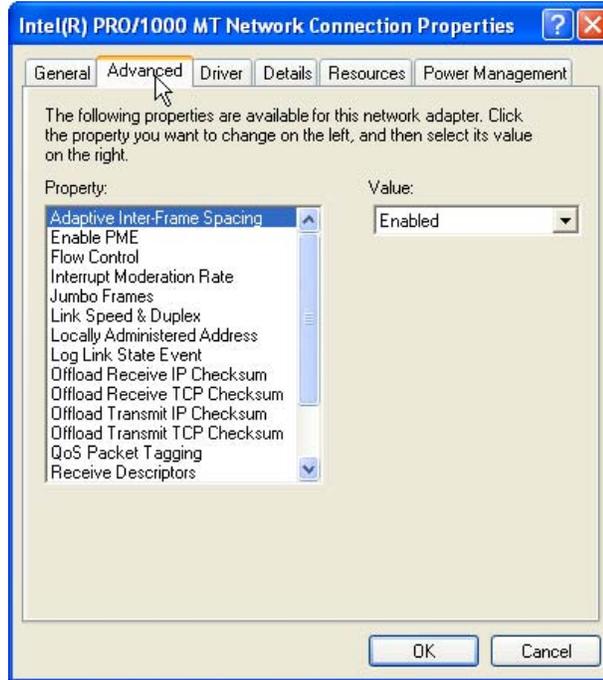
4.3.4 Enabling Jumbo Frames

- (1) Click [Start] and click [Control Panel].
- (2) Click [Performance and Maintenance].
- (3) Click [System].
- (4) Click [Hardware] tab.
- (5) Click [Device Manager]
- (6) Expand [Network adapters].
- (7) Select target NIC, right-click, and click [Properties].

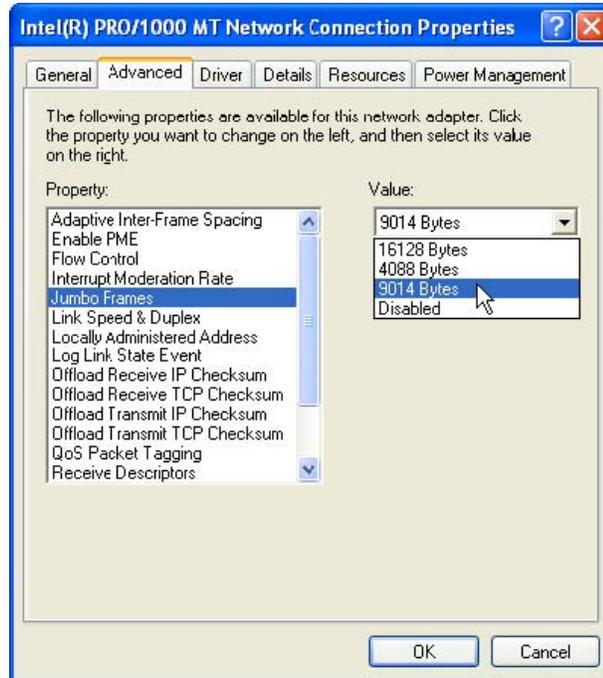


Note: The following procedure uses the Intel(R) PRO/1000 as an example. If a different NIC is used, the setup tabs will likely be different. In that case, set the item in a manner similar to what is described here.

(8) Click [Advanced] tab.



(9) Select Jumbo Frames in the Property list, and select the desired Value. This setting defines the maximum GevSCPS Packet Size the camera can use.



(10) Click [OK].

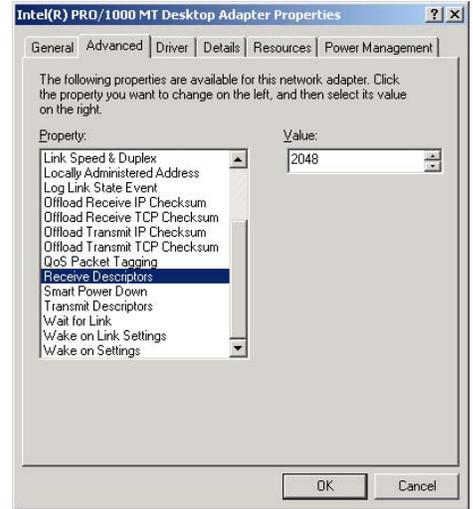
(11) Close [Device Manager].

(12) Close [System Properties] clicking [OK].

4.3.5 Setting Receive Descriptors

If the Network Connection Properties list contains a property called Receive Descriptors, then change its property to the maximum value supported by the NIC installed in the computer.

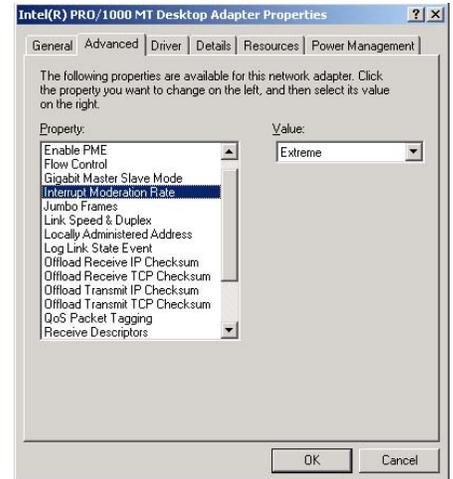
Click “OK” to save the property.



4.3.6 Interrupt Moderation rate

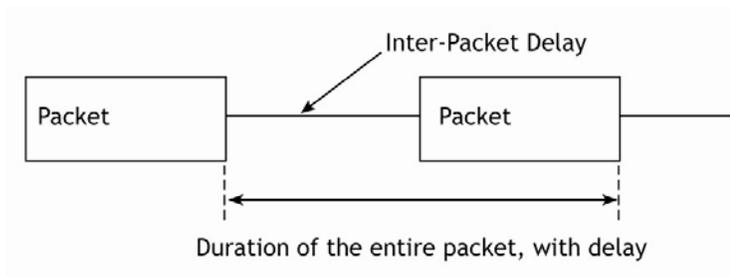
If the Network Connection Properties list contains a property called Interrupt Moderation Rate, then it is possible to set the preferred value. When it is changed from Minimal, M High and Extreme, number of interruption is decreased to get better performance. Set it to “Extreme.”

Click “OK” to save the property.



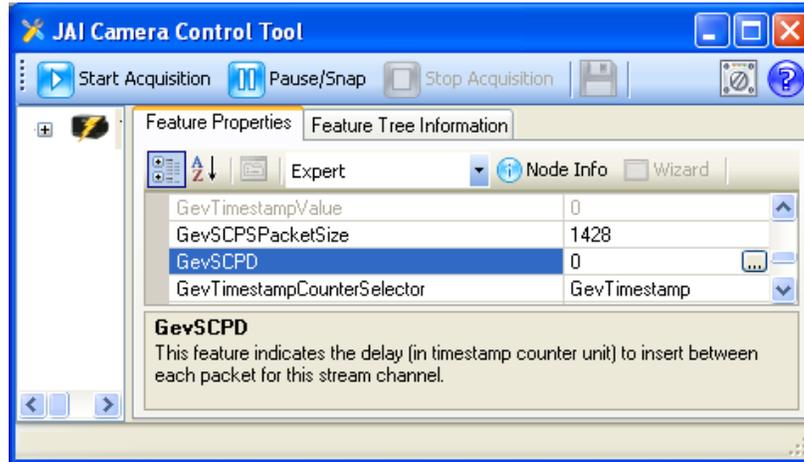
4.3.7 Calculating and setting Inter-Packet Delay

When connecting several cameras to one network interface card via a switching hub, it is important to optimize the Inter-Packet Delay of the cameras to avoid congestion in the switch. A sure sign of congestion is the loss of packets.



Since increasing the inter-packet delay also adds overhead to the data transfer it is important to calculate the optimal setting in order to make best use of the video bandwidth.

JAI Control Tool has a built in wizard for calculating Inter-Packet Delay. When the Inter-Packet Delay function is activated, a button appears on the right hand side of the bar. Click the button to open the calculation wizard window.



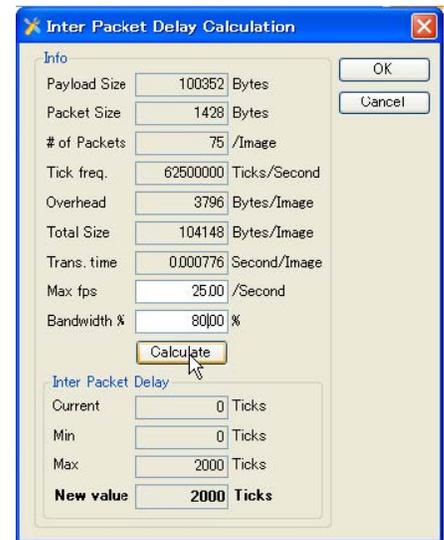
At first, type in the frame rate of the connected camera. TM-1405GE series cameras are 30 fps.

Set the bandwidth at 80%.

Click the calculation tab.

New value is calculated.

Click OK. This shown value is automatically transferred to the Packet Delay column of the Control Tool.



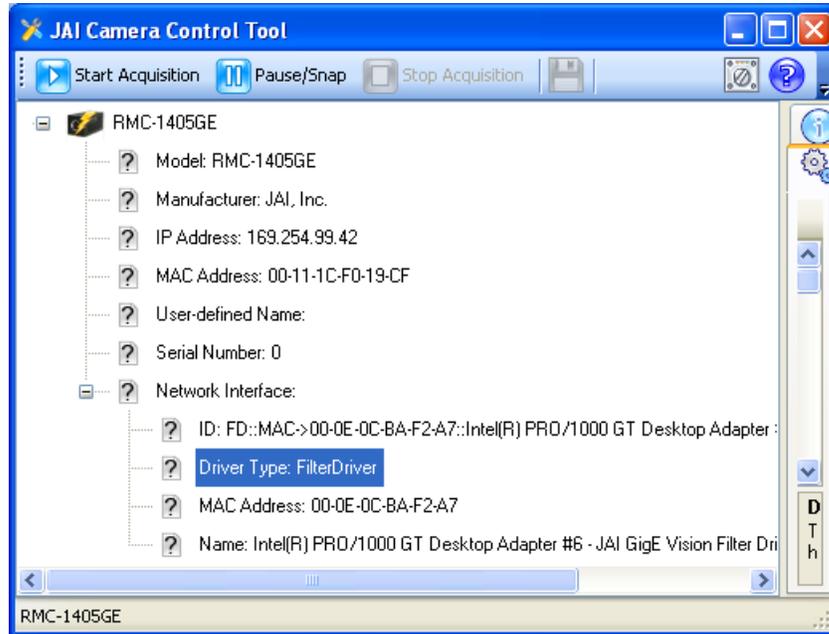
4.3.8 Confirm the Filter Driver is used

The filter driver is installed as an optional function when JAI SDK is installed. If the filter driver is not installed at that time, it can be installed from All Programs => JAI SDK => GigE Vision Filter Driver => Install GigE Vision Filter Driver.

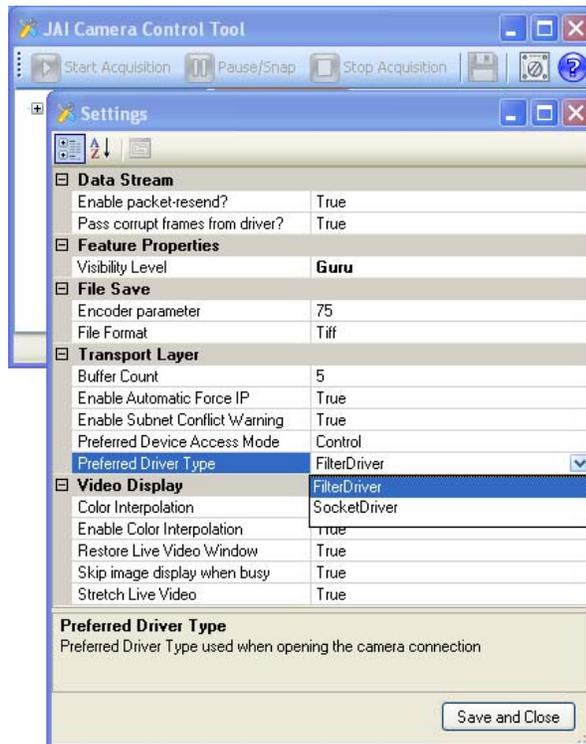


RM/TM-1405GE Series

If the Filter Driver is installed properly, the Camera Control Tool indicates “Driver Type Filter Driver” in the Network Interface.



If it is not shown, confirm the setting in the “Settings” window. Access the “Settings” window by clicking on the icon to the left of the blue question mark icon. Refer to the “Getting Started Guide” provided with the JAI GigE Vision SDK and Control Tool for more information about controls in the “Settings” window.



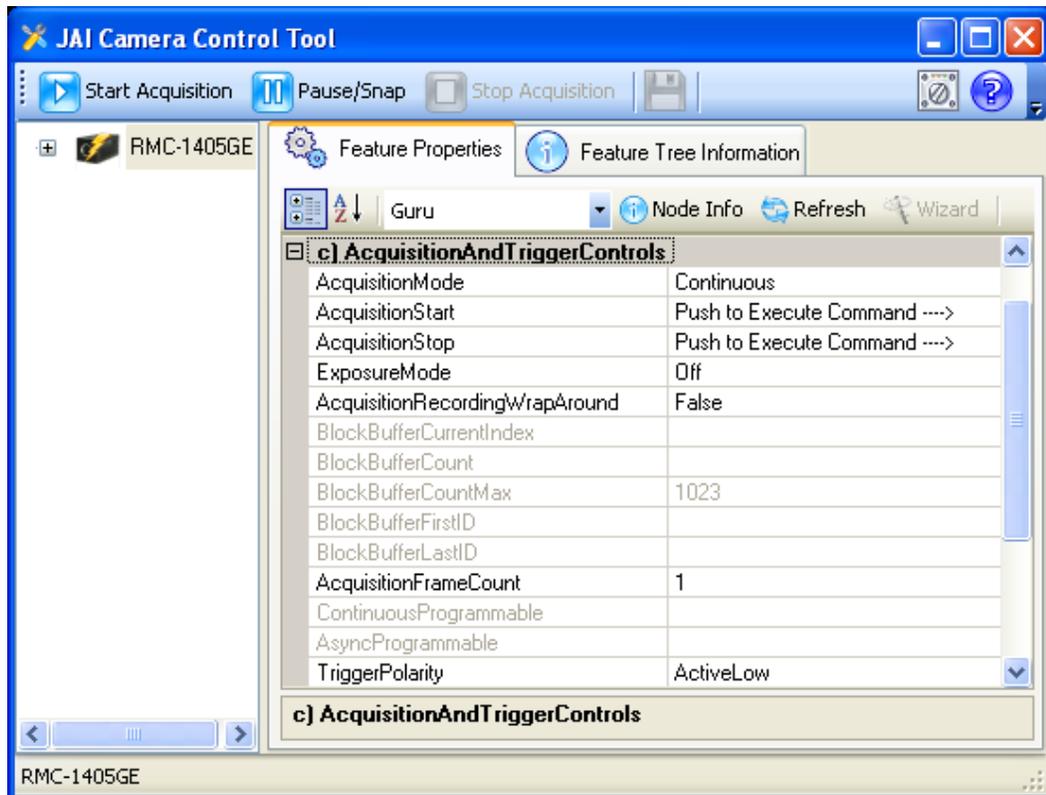
5 Configuring the Camera

The following sections describe the various features of the camera.

5.1 Acquisition and Trigger Controls

These controls affect exposure mode, exposure time, and image acquisition operations.

Figure 10. Acquisition And Trigger Controls Category



AcquisitionMode: controls how the camera behaves during image acquisition.

The possible options are:

- Continuous: Images will be acquired continuously.
- SingleFrame: A single image will be acquired.
- MultiFrame: the camera acquires the number of images as specified by AcquisitionFrameCount feature (see next page).
- ContinuousRecording: The camera will continuously acquire and store images onto the onboard memory. Acquisition is stopped when the onboard memory capacity is reached unless AcquisitionRecordingWrapAround is set to True. Images can be read from the camera using either ContinuousReadout or SingleFrameReadout.
- ContinuousReadout: recorded images will be read continuously from the camera's onboard memory. When no more images are available, timeouts may occur in some software.

- **SingleFrameRecording:** Acquire a single image and store onto the onboard memory. Images can be read from the camera using **SingleFrameReadout**.
- **SingleFrameReadout:** A single image will be read from the onboard memory. If no frames are available, a timeout may occur in some software. To retrieve the next image simply execute **AcquisitionStart** once.

AcquisitionStart: tells the camera to start acquiring images in the mode as specified by **AcquisitionMode**.

AcquisitionStop: tells the camera to stop acquiring images.

AcquisitionFrameCount: specifies the number of frames to be acquired in the **MultiFrame Acquisition** mode. Valid range is from 1 to 255.

AcquisitionRecordingWrapAround: for use with **ContinuousRecording** mode. Possible options:

- **True:** when the recording buffer is full the oldest recorded image will be overwritten by the newest image.
- **False:** continuous recording will stop when buffer is full.

BlockBufferCount: shows the number of images recorded. The number of available Block Buffers depends on image size, **GevSCSPacketSize**, and **GrbCh0AcqCfgMemoryWaterLevel**. It is recommended to use at least 1440 for **GevSCSPacketSize**. See “PLC Grabber Features” in section 5.8.7 for a description of **GrbCh0AcqCfgMemoryWaterLevel**.

BlockBufferCurrentIndex: for use with **ContinuousReadout** and **SingleFrameReadout** modes. Sets the index of the image that would be delivered next when **AcquisitionStart** or **Start Acquisition** is executed. Index 0 refers to the oldest image. Subsequent **AcquisitionStart** commands automatically increment this value. It is a write only register so you will not see the value change.

ExposureMode: specifies mode of operation for the exposure control (or shutter). All **Async** modes, and **PulseWidthControl** require a trigger signal. The possible options are:

- **Off:** No shutter.
- **ContinuousProgrammable:** Puts the camera into **ContinuousProgrammable** mode and enables the **ContinuousProgrammable** value feature below.
- **AsyncNoShutter:** this mode is meant to be used in a dark environment in conjunction with strobe light. This setting and all settings below require a trigger signal.
- **PulseWidthControl**
- **AsyncProgrammable:** Puts the camera into **AsyncProgrammable** mode and enables the **AsyncProgrammable** value feature below.

ContinuousProgrammable: user defined shutter time in unit of scan lines. Available only when **ExposureMode** is in **ContinuousProgrammable**.

AsyncProgrammable: user defined shutter time in unit of scan lines. Available only when **ExposureMode** is in **AsyncProgrammable**. Requires trigger signal.

TriggerPolarity: this feature selects which signal state, high or low, of the trigger signal will initiate an image capture for triggered **ExposureModes**.

5.2 AnalogControls

These controls allow you to make adjustment to image intensities (**Gain**), **Black Level**, and **auto black level**.

Figure 11. AnalogControls Category



GainRaw: controls the Gain value.

VTop: affects digital gain. Decreasing the value results in a brighter image. It is recommended to use values below 220.

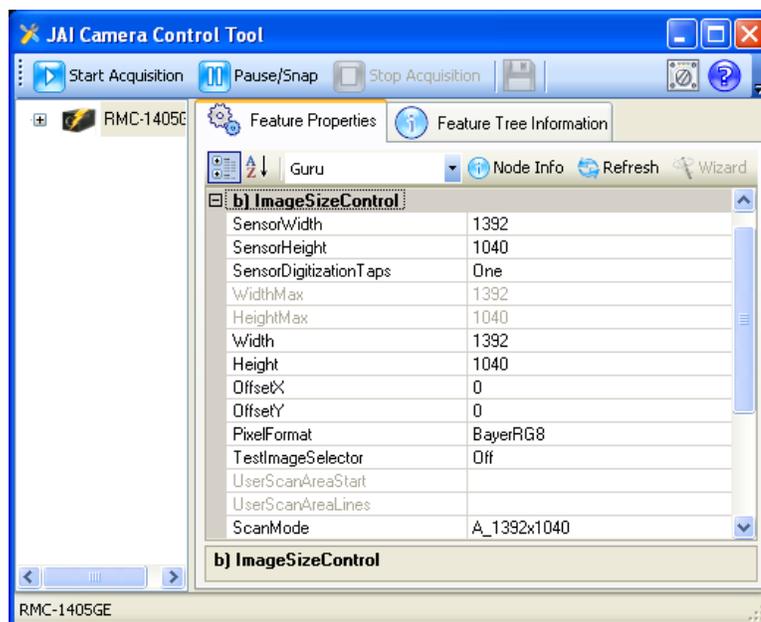
VBottom: adjusts the black level of the image. Increasing the value will increase the black level and darken the image. Available only when AutoBlackLevel is disabled.

AutoBlackLevel: adds tiny positive or negative voltages to both Vtop and Vbottom to compensate black level changes due to temperature. The camera will use AutoBlackLevelRaw as the target. Enabling this will disable VBottom adjustment.

AutoBlackLevelRaw: sets the Auto Black Level target value. Available when AutoBlackLevel is enabled.

5.3 Image Size Controls

These controls allow you to make adjustment to the image’s size, and scan mode. ImageSizeControl category



SensorDigitizationTaps: the TM-1405GE is a single tap camera and uses one channel to read out images from the image sensor.

WidthMax: shows the current valid maximum value for Width.

HeightMax: shows the current valid maximum value for Height.

Width: sets the width of the output image. When ScanMode is changed it is necessary to set this value to equal to or less than WidthMax.

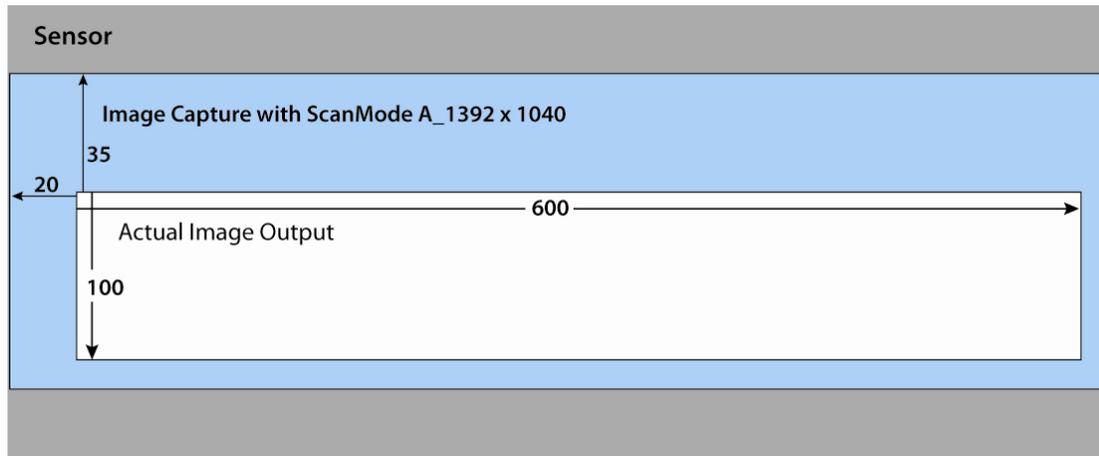
Height: sets the height of the output image. When ScanMode is changed it is necessary to set this value to equal to or less than HeightMax.

OffsetX: specify the offset from the left edge of the image captured by the sensor to be sent out of the camera. Width must be set lower than WidthMax before this value can be increased.

OffsetY: specify the offset from the top of the image captured by the sensor to be sent out of the camera. Height must be set lower than HeightMax before this value can be increased.

- Offset Example:
- ScanMode is set to A_1392x1040
- Width to 600 and Height to 100.
- OffsetX can have a range of 0 to 40. OffsetX is then set to 20.
- OffsetY can have a range of 0 to 80. OffsetY is then set to 35.
- The resulting image is of size 600x100 with the upper left pixel offset by 20 pixels horizontally and 35 vertically

Figure 12. Image Output Example.



PixelFormat: specifies the image type captured from the image sensor. Available options:

Monochrome:

- Mono8: 8-bit monochrome image.
- Mono10: 10-bit monochrome image with 1 pixel needing 2 bytes.
- Mono10Packed: 10-bit monochrome image with 2 pixels packed into 3 bytes.

Bayer: BayerGB patterns are used for Programmable User Scan Area with odd numbered starting row.

- BayerRG8: 8-bit Bayer pattern with Red and Green pixels in first row.
- BayerGB8: 8-bit Bayer pattern with Green and Blue pixels in first row.
- BayerRG10: 10-bit Bayer pattern with Red and Green pixels in first row.

- BayerGB10: 10-bit Bayer pattern with Green and Blue pixels in first row.

ScanMode: controls the image size captured by the image sensor. By changing to a smaller size you can achieve a faster frame rate. After changing *ScanMode* it is necessary to adjust the Width and Height value to a valid value. Available options (expressed in unit of Width x Height pixels):

- A_1392x1040
- UserProgrammable: user programmable scan area via *UserScanAreaStart* and *UserScanAreaLines* features.

UserScanAreaStart: sets the starting line of the User Programmable scan area. First line has a value of 0 and corresponds to the top of the image sensor. For color cameras (TMC/RMC-1405GE) this value changes the Bayer pattern of the captured image. Sets *PixelFormat* to BayGB for odd value, and BayerRG for even value.

UserScanAreaLines: sets the number for the height of the User Programmable scan area.

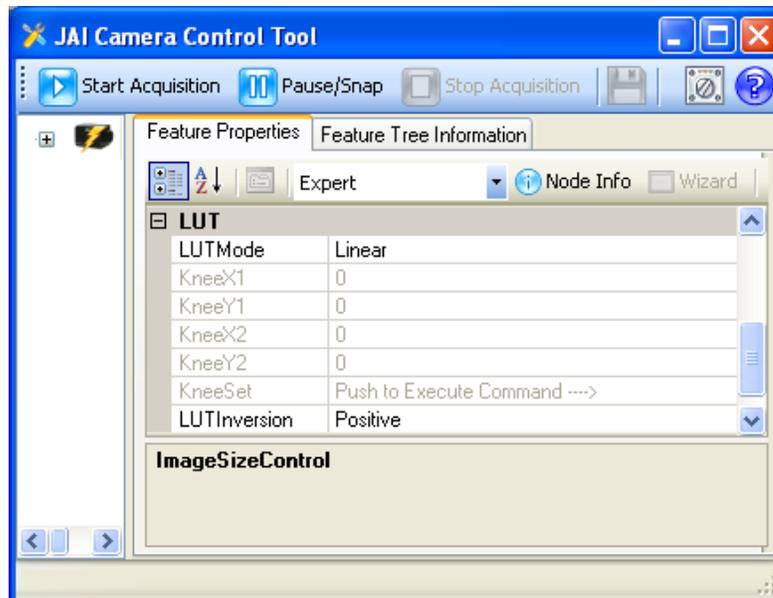
TestImageSelector: shows a software generated test pattern. Use this feature for debugging purposes. Available options are:

- Off: turn off test pattern generator and resume normal operation.
- DeviceSpecific: shows diagonal lines on black background. Generated by the camera's CPU.
- IPEngineTestPattern: shows horizontal striped gradients running right to left.

5.4 LUT (Look Up Table)

The camera's Lookup Table is used for dynamic range control when the camera is in 8-bit output mode.

Figure 13. LookUp Table



LUTMode: controls which LUT table to use. There are 2 predefined tables and 1 user configurable table. Available options:

- Linear: a linear mapping
- Gamma45: also known as Gamma 0.45.
- Knee: you can specify the curve by controlling two points. The camera will calculate the table base on the Knee values below.

KneeX1: controls the X value of first Knee point.

KneeY1: controls the Y value of first Knee point.

KneeX2: controls the X value of second Knee point. This value must be greater than KneeX1.

KneeY2: controls the Y value of second Knee point.

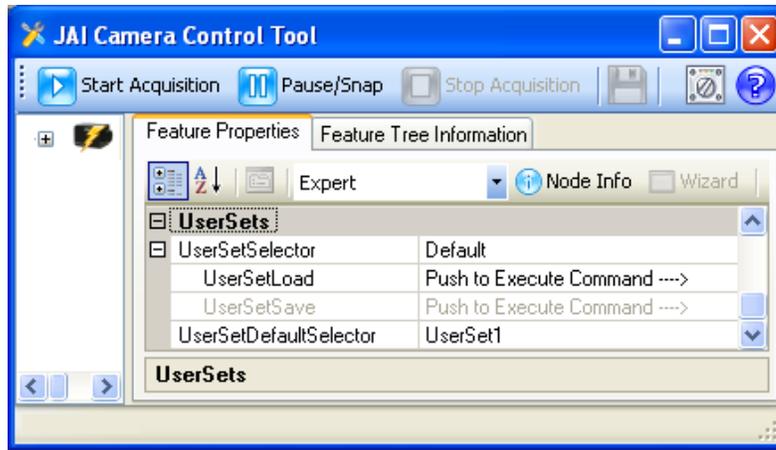
KneeSet: after you have changed the values of the knee points click KneeSet to apply the setting. The camera will take a few seconds to calculate the LUT table. It is recommended to stop image acquisition during this time.

LUTInversion: invert the current LUT table. This creates the negative of image.

5.5 UserSets

These controls are for saving camera settings to the onboard memory and selection of which setting will be used during bootup.

Figure 14. UserSets Category



UserSetSelector: selects which memory page to load, or save.

Available options:

- Default: contains factory settings.
- UserSet1: contains saved user settings.
- ...
- UserSet6: contains saved user settings.

UserSetSave: save the camera settings to the currently selected memory page. If Default is selected in UserSetSelector then UserSetSave is grayed out (Default factory settings won't be overwritten).

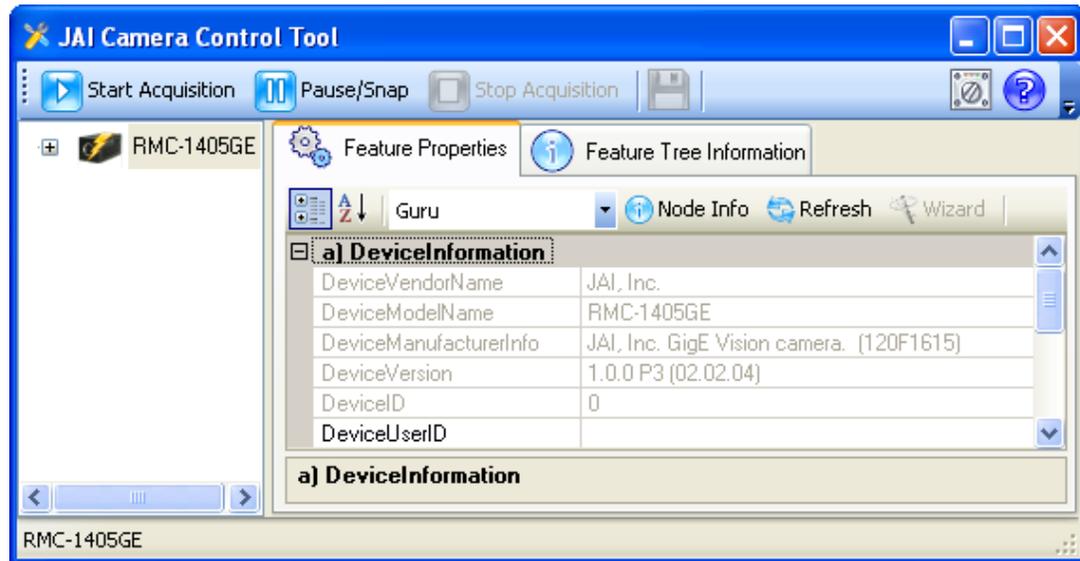
UserSetLoad: load the camera settings from the selected memory page.

UserSetDefaultSelector: chooses which memory page the camera will use as setting during boot up.

5.6 DeviceInformation

Show camera's general information such as version, model, and serial number.

Figure 15. DeviceInformation Category



DeviceVendorName: shows JAI, Inc.

DeviceModelName: shows the camera model name.

DeviceVersion: shows the current camera version.

DeviceID: the device serial ID. This is set at the factory and only available in Expert and Guru visibility modes.

DeviceUserID: User's modifiable ID. You can enter any character string up to a limit of 16 characters.

5.7 GigEVisionTransportLayer

More advanced controls for setting IP Address, GigE Vision Stream Channel settings, etc...

A complete explanation of GigE is out of the scope of this manual therefore the user should seek out various online guides about: Persistent/Static IP, DHCP, LLA, IP Address, Subnet Mask, and networking.

5.7.1 Persistent IP

When powered up and connected to the network the camera will use the following sequence to obtain an IP Address:

1. Persistent IP
2. DHCP: a DHCP server on the network will assign the camera an IP Address.
3. Link-Local Address (LLA): an IP Address in the 169.254.X.X ranged is assigned.

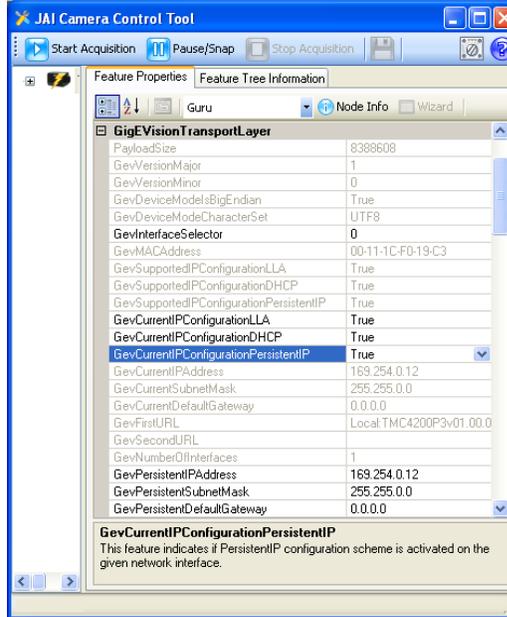
By default only DHCP and LLA are enabled. LLA will always be enabled. To disable DHCP mode set `GevCurrentIPConfigurationDHCP` to false.

You can also assign a static IP Address to the camera so the camera will always boot up with this IP Address. To do so follow these instructions:

4. Set Visibility to at least Expert.

5. Set `GevCurrentIPConfigurationPersistenIP` to True.
6. Set `GevPersistentIPAddress` to the IP Address of your choosing. (Ex: 169.254.0.11)
7. Set `GevPersistentSubnetMask` to the subnet mask of your choosing (Ex: 255.255.0.0)
Subnet Mask must match the device to which the camera is communicating.
8. Set `GevPersistentDefaultGateway` to the IP Address of your gateway. (Ex: 0.0.0.0)

Figure 16. GigEVisionTransportLayer Persistent IP



5.7.2 Stream Channel Packet Size

GevSCSPPacketSize: Images are sent via the StreamChannel in GigE Vision terminology. The camera is able to adjust the size of the data packets sent on this channel. The minimum value of 1440 is required to get images without dropped packets. It is recommended that a value of 4040 or higher is used. If setting to above 1428, the network to which the camera is connected must be able to support Jumbo Frames. To change the stream channel packet size, follow these instructions:

1. Stop image acquisition.
2. Switch Visibility to at least Expert.
3. Set `GevSCSPPacketSize` to a desired value.

GevHeartbeatTimeout: specifies the current heartbeat timeout in milliseconds. Available only in Guru visibility mode. The host software must send at least one command to the camera during this period otherwise it loses control of the camera. This is usually handled by the control tool.

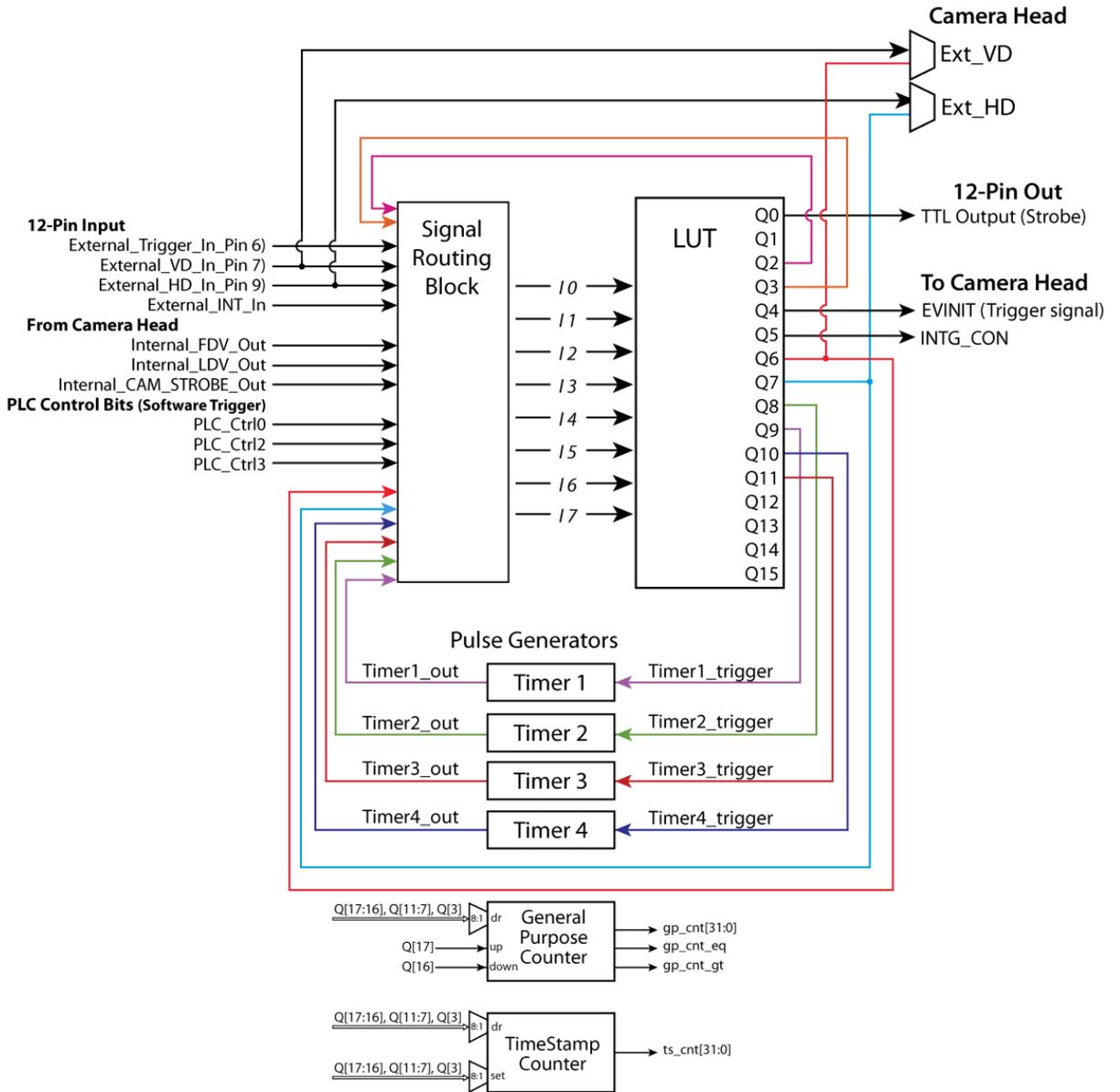
5.8 IPEngine

The camera is sectioned into two logical modules: a camera head and the IPEngine. The camera head contains the components to capture images, while the IPEngine takes care of interfacing to the outside world and transmitting captured images. The IPEngine contains the Programmable Logic Controller (PLC) and the Grabber.

The Grabber is responsible for image transmission. All input and output signals pass through the Programmable Logic Controller (PLC). The PLC contains a Signal Routing Block, Control Bits, and Lookup Table. The PLC also contains 4 Pulse Generators and 1 general purpose counter. By GenICam naming convention the Pulse Generators are called Timers. The Counter and Timers are controlled

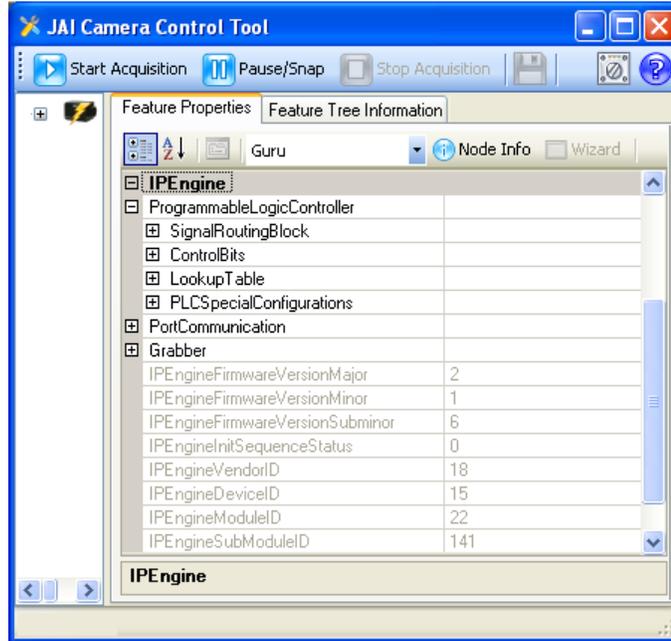
under the CountersAndTimersControls category, and the other parts are controlled under the IPEngine category.

Figure 17. PLC LUT Diagram



Note: Ext_VD, EXT_HD, EVINIT and INTG_CON all go the camera head. TTL Output (Strobe) goes outside the camera via Pin 8 of the 12-Pin cable.

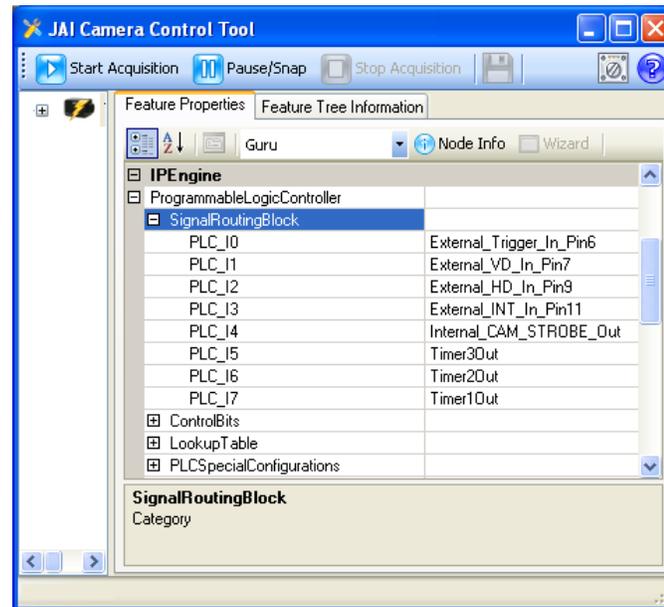
Figure 18. PLC



5.8.1 SignalRoutingBlock

The Signal Routing Block is a group of switches that lets you route signals to the PLC Lookup Table. There are a total of 8 input lines, numbered from I0 to I7. Each input line can accept a number of different signals. The input signals can be from the camera head, externally from the 12-Pin cable, or the PLC itself.

Figure 19. SignalRoutingBlock



Here are the possible input signals into the PLC:

| Signal Source | Signal Name / Input Pin | Description |
|-----------------|--------------------------|--|
| 12 Pin | External_Trigger_In_Pin6 | External trigger signal. |
| 12 Pin | External_VD_In_Pin7 | External vertical drive signal. |
| 12 Pin | External_HD_In_Pin9 | External horizontal drive signal. |
| 12 Pin | External_INT_In | External Integration Control / Read Out Inhibit signal. |
| Camera | Internal_FDV_Out | Frame Data Valid output signal generated by camera head. |
| Camera | Internal_LDV_Out | Line Data Valid output signal generated by camera head. |
| Camera | Internal_CAM_STROBE_Out | Strobe output signal generated by the camera head. |
| PLC | PLC_ctrl0 | True / False (High/Low) switch used for software trigger. (1) |
| PLC | PLC_ctrl2 | True / False (High/Low) switch used for software trigger. (1) |
| PLC | PLC_ctrl3 | True / False (High/Low) switch used for software trigger. (1) |
| PLC | PLC_Q2 | PLC output that can be routed back to the PLC. |
| PLC | PLC_Q3 | PLC output that can be routed back to the PLC. |
| PLC | PLC_Q6 | PLC output. This signal is also connected to the EXT_VD that goes to the camera head. Please see the PLCSpecialConfigurations section below. |
| PLC | PLC_Q7 | PLC output. This signal is also connected to the EXT_HD that goes to the camera head. Please see the PLCSpecialConfigurations section below. |
| Counter | Counter1Gt | Counter1's output signaling when the current count value is greater than some user defined value. Please see Counter section below. |
| Counter | Counter1Eq | Counter1's output signaling when the current count value equals some user defined value. Please see Counter section below. |
| Pulse Generator | Timer1Out | Pulse Generator 1 output signal. |
| Pulse Generator | Timer2Out | Pulse Generator 2 output signal. |
| Pulse Generator | Timer3Out | Pulse Generator 3 output signal. |
| Pulse Generator | Timer4Out | Pulse Generator 4 output signal. |

Note: (1) There is no PLC_ctrl1.

This table show possible signals each input line can accept (“(D)” specifies factory defaults):

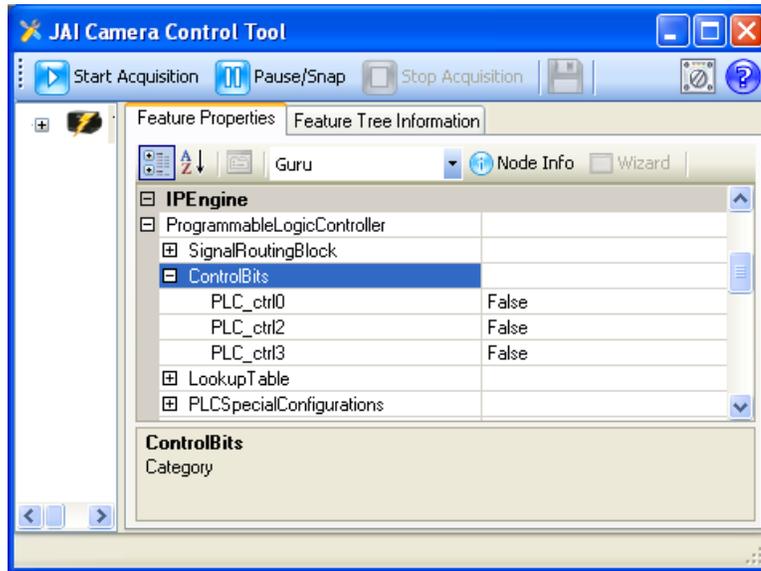
| Signal Name / Input Pin | I0 | I1 | I2 | I3 | I4 | I5 | I6 | I7 |
|--------------------------|------|------|------|------|------|------|------|------|
| External_Trigger_In_Pin6 | X(D) | X | X | X | X | X | X | X |
| External_VD_In_Pin7 | X | X(D) | X | X | X | X | X | X |
| External_HD_In_Pin9 | X | | X(D) | | X | | | |
| External_INT_In | | X | | X(D) | | X | | X |
| Internal_FDV_Out | X | X | X | | | X | X | X |
| Internal_LDV_Out | X | X | | X | X | | | X |
| Internal_CAM_STROBE_Out | X | X | X | X | X(D) | | X | X |
| PLC_ctrl0 | X | X | X | X | | X | | X |
| PLC_ctrl2 | X | | | X | X | | X | |
| PLC_ctrl3 | | X | X | | | X | | |
| PLC_Q2 | X | | X | | X | | X | |
| PLC_Q3 | | X | | X | | X | | X |
| PLC_Q6 | X | | X | | X | | X | |
| PLC_Q7 | | X | | X | | X | | X |
| Counter1Gt | | | | X | | X | | X |
| Counter1Eq | | | X | | X | | X | |
| Timer1Out | X | | X | | X | | | X(D) |
| Timer2Out | X | | X | | X | | X(D) | |
| Timer3Out | | X | | X | | X(D) | | X |
| Timer4Out | | X | | X | | | X | |

5.8.2 ControlBits

There are 3 Control Bits: PLC_ctrl0, PLC_ctrl2, and PLC_ctrl3. Note that PLC_ctrl1 is not available. The control bits can be used as software triggers by toggling between two states: True and False. True sets the signal High, while False sets the signal to Low.

When a bit is toggled on the host software, a Write Register command is sent to the camera. The arrival time of the packet depends on current network traffic therefore is varied. These are recommended for testing purposes. For more precise trigger usage please use an external input trigger signal thru the 12-Pin connector. For a constant periodic trigger signal please use the Pulse Generators (Timers).

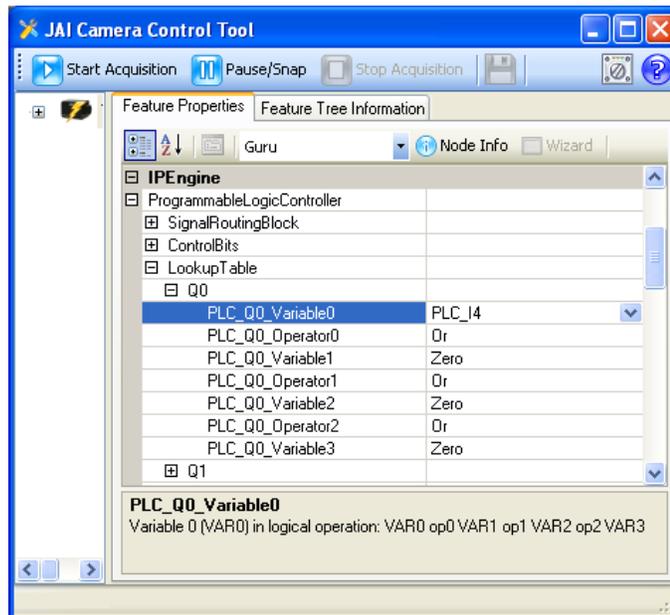
Figure 20. ControlBits



5.8.3 PLC LookupTable

The PLC Lookup Table lets you connect any input signal I0-I7 to any Lookup Table output signal Q0-Q17. You can manipulate your inputs using simple or complex Boolean operations. Each Q output results from the Boolean operations of 4 input variables and 3 Boolean operators.

Figure 21. PLC Q Output



The Q output allows the following Boolean operations:

- Variable0 Op0 Variable1 Op1 Variable2 Op2 Variable3
- (Variable0 Op0 Variable1) Op1 Variable2 Op2 Variable3
- Variable0 Op0 Variable1 Op1 (Variable2 Op2 Variable3)

- (Variable0 Op0 Variable1) Op1 (Variable2 Op2 Variable3)

All Q# controls follow this format:

- PLC_Q#_Variable0: the first input signal.
- PLC_Q#_Operator0: a Boolean operator.
- PLC_Q#_Variable1: the second input signal.
- PLC_Q#_Operator1: a Boolean operator.
- PLC_Q#_Variable2: the third input signal.
- PLC_Q#_Operator2: a Boolean operator.
- PLC_Q#_Variable3: the fourth input signal.

Each Variable has this selection:

- Zero: low signal.
- One: high signal.
- PLC_I0
- ...
- PLC_I7
- PLC_I0_Not: a Not operation is applied to the signal.
- ...
- PLC_I7_Not: a Not operation is applied to the signal.

Operator0 and Operator2 can have the following Boolean operations:

- And
- Or
- Xor
- AndParenthesis: creates a “(Variable0 & Variable1)”, or “(Variable2 & Variable3)” operation.
- OrParenthesis: creates a “(Variable0 | Variable1)”, or “(Variable2 | Variable3)” operation.
- XorParenthesis: creates a “(Variable0 XOR Variable1)”, or “(Variable2 XOR Variable3)” operation.

Operator1 can have the following Boolean operations:

- And
- Or
- Xor

5.8.4 PLCSpecialConfigurations

Switch Visibility mode to at least Expert to get access to these controls. There are two controls of interest in this category: PLC_Q6_Configuration and PLC_Q7_Configuration. These two controls affect which signal source the EXT_VD and EXT_HD come from.

PLC_Q6_Configuration: affects the EXT_VD signal.

- Set to Zero to get the signal from the PLC_Q6 output.
- Set to One to bypass the PLC LUT and get the signal directly from external 12-Pin cable.

PLC_Q7_Configuration: affects the EXT_HD signal.

- Set to Zero to get the signal from the PLC_Q7 output.
- Set to One to bypass the PLC LUT and get the signal directly from external 12-Pin cable.

Note: If the EXT_VD and EXT_HD are not being used set PLC_Q6_Configuration and PLC_Q7_Configuration to Zero to prevent spurious signals. Improper setting can result in black lines across captured images.

Figure 22. PLC Special Configurations

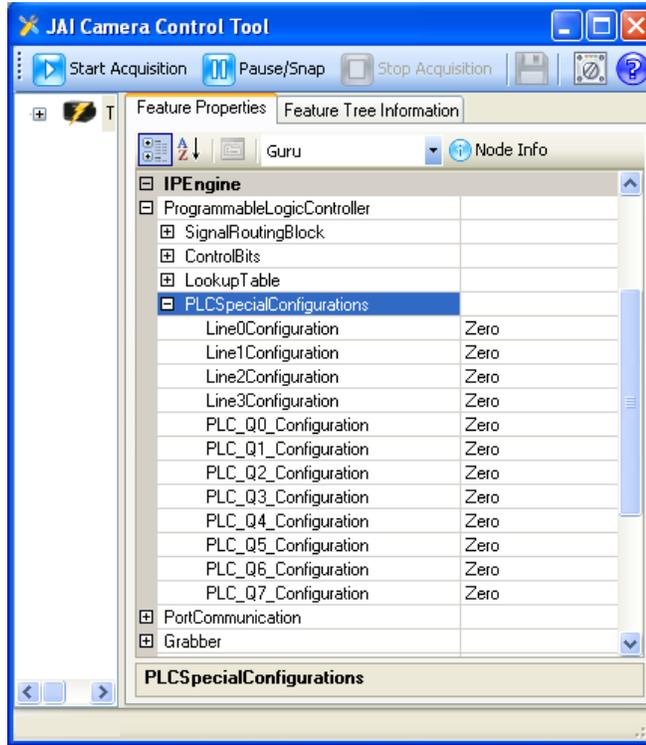
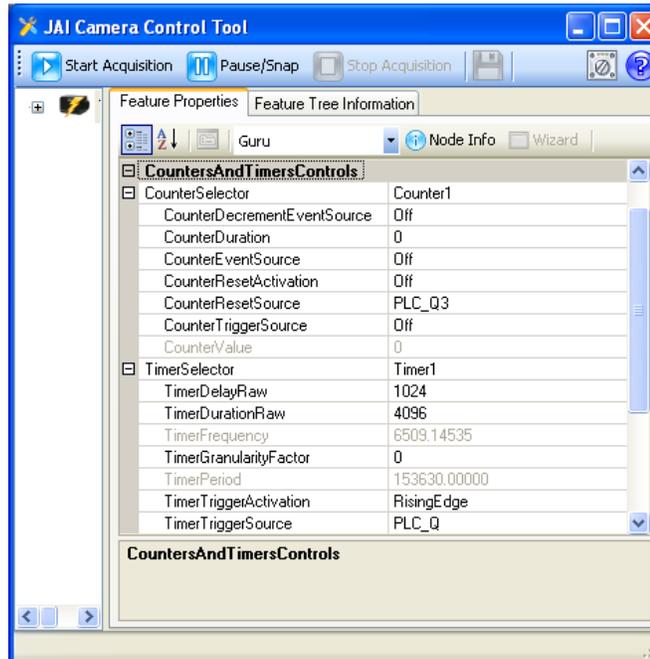
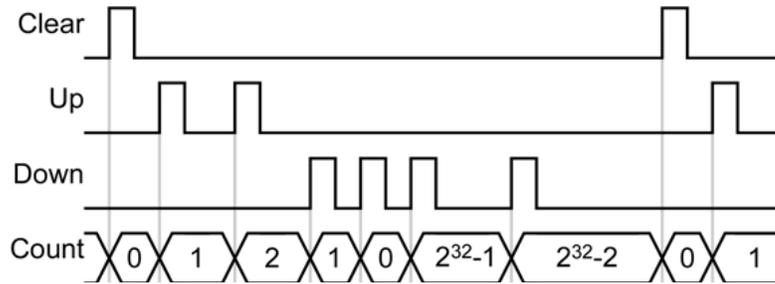


Figure 23. CountersAndTimersControls

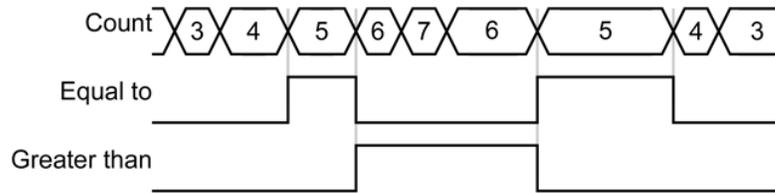


5.8.5 Counters

The General Purpose Counter lets you maintain a count between 0 and $2^{32}-1$ (long integer). You can use different inputs to increment, decrement, or clear the counter value.



The General Purpose Counter outputs two separate signals that indicate when the count is equal to and greater than the compare value that you set: Counter1Gt and Counter1Eq. These signals are available on the Input lines in the Signal Routing Block.



(Compare value of 5)

CounterSelector: selects which counter to configure. There is only 1 counter called Counter1.

CounterDecrementEventSource: selects the events that will decrement the counter. This signal comes from the Q16 pin of the PLC LUT.

Available options:

- Off: no decrement events
- PLC_Q16_RisingEdge: decrement when the signal goes from Low to High
- PLC_Q16_FallingEdge: decrement when the signal goes from High to Low.
- PLC_Q16_AnyEdge: decrement on any Falling or Rising Edge.
- PLC_Q16_LevelHigh: decrement when the signal is at the High section.
- PLC_Q16_LevelLow: decrement when the signal is at the Low section.

CounterDuration: sets the value that the CounterValue will be compared to. When the CounterValue and CounterDuration are equal, the Counter1Eq signal will go high and stay high as long as the values are equal. When the CounterValue is greater than CounterDuration, the Counter1Gt signal will go high.

CounterEventSource: selects the signal event type that will increment the counter. This signal comes from the Q17 pin of the PLC LUT.

Available options:

- Off: no increment events
- PLC_Q17_RisingEdge: increment when the signal goes from Low to High
- PLC_Q17_FallingEdge: increment when the signal goes from High to Low.
- PLC_Q17_AnyEdge: increment on any Falling or Rising Edge.
- PLC_Q17_LevelHigh: increment when the signal is at the High section.
- PLC_Q17_LevelLow: increment when the signal is at the Low section.

CounterResetActivation: select the signal event type that will reset the counter. The counter will be reset to 0.

Available options:

- Off: no decrement events
- RisingEdge: increment when the signal goes from Low to High
- FallingEdge: increment when the signal goes from High to Low.
- AnyEdge: increment on any Falling or Rising Edge.
- LevelHigh: increment when the signal is at the High section.
- LevelLow: increment when the signal is at the Low section.

CounterResetSource: selects the source for the reset signal.

Available options:

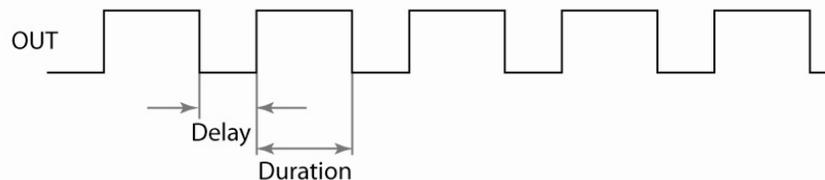
- PLC_Q3
- PLC_Q7
- PLC_Q8
- PLC_Q9
- PLC_Q10
- PLC_Q11
- PLC_Q16
- PLC_Q17

CounterTriggerSource: select the source signal to start the counter. Currently it is set to Off, meaning always on.

CounterValue: the read only value showing the current counter value.

5.8.6 Pulse Generators controls

The Pulse Generator lets you create a pulsed digital signal with a configurable frequency. They can be configured to emit a continuous (periodic) pulse. One use of this feature is to create a periodic trigger signal. The low section of the signal is called Delay, and the high is called Duration.



TimerSelector: chooses which Timer to configure.

TimerDelayRaw: configures the raw value of the low section of the output signal. The formula to calculate actual time is:

$$\text{Duration of Low (nsec)} = (\text{Granularity} + 1) * (\text{TimerDelayRaw} + 1) * 30$$

TimerDurationRaw: configures the raw value of the high section of the output signal. The formula to calculate actual time is:

$$\text{Duration of High (nsec)} = (\text{Granularity} + 1) * \text{TimerDurationRaw} * 30$$

TimerFrequency: a read-only field that shows the frequency of the pulse in Hz.

TimerGranularityFactor: a multiplier value used to scale the Delay and the Duration in increments of 30 nsec.

TimerPeriod: shows the timer's period in units of nsec.

TimerTriggerActivation: select the signal state of the TriggerSource to start the Timer.

- RisingEdge: starts when the trigger signal goes from Low to High
- LevelHigh: starts when the trigger signal is at the High state.
- FallingEdge: starts when the trigger signal goes from High to Low.
- AnyEdge: starts on any Falling or Rising Edge.
- LevelLow: starts when the trigger signal is at the Low state.

TimerTriggerSource: select the source of trigger to start the Timer.

- PLC_Q: the trigger source comes from the PLC Q output. Each Timer has their source from different Q output port:
 - Timer1 trigger comes from PLC_Q9
 - Timer1 trigger comes from PLC_Q8
 - Timer1 trigger comes from PLC_Q11
 - Timer1 trigger comes from PLC_Q10
- Continuous: the Timer is always running.

5.8.7 PLC Grabber Features

IPEngine -->Grabber --> Channel0 -->AcquisitionConfiguration

GrbCh0AcqCfgMemoryWaterLevel: the camera has 16MB of memory for frame buffer. Water level setting specifies how much of that memory to use with the AcquisitionMode's recording features. Once the buffer is full no more images will be stored. Possible settings are:

- Level50: 50%
- Level75: 75%
- Level87Point5: 87.5%
- Level100: 100%

GrbCh0AcqCfgInvertPixelData: invert pixel data turning the image into a negative image.

- True: turn on pixel inversion.
- False: turn off pixel inversion.

IPEngine -->Grabber --> Channel0 --> TriggerConfiguration

GrbCh0TrigCfgFrameToSkip: set the number of images to discard for every one it keeps from the camera head.

5.8.8 IPEngine Examples:

Example 1: Setting the camera to accept external trigger signal:

Set ExposureMode to one of the Asynchronous modes.

Setup SignalRoutingBlock

- Goto IPEngine > ProgrammableLogicController > SignalRoutingBlock
- Set Trigger Input line by setting PLC_I0 to External_Trigger_In_Pin6
- Set Camera Strobe Output by setting PLC_I4 to "Internal CAM_STROBE_Out".

Setup the PLC to route the external trigger signal to the camera's trigger line.

- Goto IPEngine > ProgrammableLogicController > LookupTable > Q0/Q4/ Q5
 - Set PLC_Q0_Variable0 to PLC_I4 (Strobe output)
 - Set PLC_Q4_Variable0 to PLC_I0 (Trigger Line)

- iii. Set PLC_Q5_Variable0 to One. (Integration signal always on.)

Example 2: Setting the camera to accept internal trigger signal generated via Timer 1:

Set ExposureMode to one of Asynchronous modes.

Setup the Timer (Pulse Generator)

- a. Set TimerSelector to Timer1.
- b. Set TimerTriggerSource to Continuous.
- c. Set TimerDurationRaw, TimerDelayRaw, TimerGranularityFactor according to values below.
 - i. These are example values only; other combinations can also be used.
 - ii. TimerFrequency tells you the rate of the trigger, hence frame rate.

| | <0.5 fps | 1 fps | 5 fps |
|------------------------|----------|-------|-------|
| TimerDurationRaw | 200 | 200 | 200 |
| TimerDelayRaw | 10000 | 4550 | 750 |
| TimerGranularityFactor | 7000 | 7000 | 7000 |

Setup SignalRoutingBlock

- a. Goto IPEngine > ProgrammableLogicController > SignalRoutingBlock
- b. Set PLC_I4 to “Internal CAM_STROBE_Out”.
- c. Set PLC_I7 to Timer1Out.

Setup the ProgrammableLogicController (PLC) to route the Timer1 output to the camera’s trigger line.

- a. Goto IPEngine > ProgrammableLogicController > LookupTable
 - i. Set Q4 > PLC_Q4_Variable0 to PLC_I7 (Trigger Line)
 - ii. Set Q0 > PLC_Q0_Variable0 to PLC_I4 (Strobe output)
 - iii. Set Q5 > PLC_Q5_Variable0 to One. (Integration signal always on.)

Example 3: Setting up Integration Signal routing from external source:

Goto IPEngine > ProgrammableLogicController > SignalRoutingBlock

Set PLC_I3 to External_INT_In

Goto IPEngine > ProgrammableLogicController > LookupTable

Set Q5 > PLC_Q5_Variable0 to PLC_I3. (Integration signal always on.)

5.9 Register Map

| Category / Feature | Read/Write | Value Range | Default Value | Visibility Level |
|--------------------------------------|------------|---|---------------|------------------|
| AcquisitionAndTriggerControls | | | | |
| AcquisitionMode | RW | Continuous SingleFrame MultiFrame ContinuousRecording ContinuousReadout SingleFrameRecording SingleFrameReadout | Continuous | Beginner |

| Category / Feature | Read/Write | Value Range | Default Value | Visibility Level |
|----------------------------------|------------|---|---------------|------------------|
| AcquisitionFrameCount | RW | 1-255 | 1 | Beginner |
| AcquisitionStart | RO | Execute Command | | Beginner |
| AcquisitionStop | RO | Execute Command | | Beginner |
| AcquisitionRecordingWrapAround | RW | False True | False | Expert |
| BlockBufferCount | RO | Depends on image size. | | Expert |
| BlockBufferCurrentIndex | WO | 0 to (BlockBufferCount - 1) | | Expert |
| ExposureMode | RW | Off ContinuousProgrammable AsyncNoShutter PulseWidthControl AsyncProgrammable | Off | Beginner |
| AsyncProgrammable | RW | 0 - 2079 | Factory Set | Beginner |
| ContinuousProgrammable | RW | 0 - 1052 | Factory Set | Beginner |
| TriggerPolarity | RW | ActiveLow ActiveHigh | ActiveLow | Beginner |
| AnalogControls | | | | |
| GainRaw | RW | 71 - 231 | Factory Set | Beginner |
| VTop | RW | 0 - 255 (Max 220 recommended) | Factory Set | Guru |
| VBottom | RW | 0 - 255 | Factory Set | Guru |
| AutoBlackLevel | RW | Enable Disable | Factory Set | Guru |
| AutoBlackLevelRaw | RW | 0 - 255 | Factory Set | Guru |
| CountersAndTimersControls | | | | |
| TimerSelector | RW | Timer1 Timer2 Timer3 Timer4 | Timer1 | Beginner |
| TimerDelayRaw | RW | 1-65535 | 1024 | Beginner |
| TimerDurationRaw | RW | 1-65535 | 4096 | Beginner |
| TimerGranularityFactor | RW | 1-65535 | 0 | Beginner |
| TimerTriggerActivation | RW | RisingEdge LevelHigh FallingEdge AnyEdge LevelLow | RisingEdge | Beginner |
| TimerTriggerSource | RW | PLC_Q Continuous | PLC_Q | Beginner |

| Category / Feature | Read/Write | Value Range | Default Value | Visibility Level |
|---------------------------------|------------|--|-----------------|------------------|
| CounterSelector | RW | Counter1 | Counter1 | Beginner |
| CounterDecrementEventSource | RW | Off PLC_Q16_RisingEdge PLC_Q16_FallingEdge PLC_Q16_AnyEdge PLC_Q16_LevelHigh PLC_Q16_LevelLow | Off | Beginner |
| CounterDuration | RW | 0-4294967295 | 0 | Beginner |
| CounterEventSource | RW | Off PLC_Q17_RisingEdge PLC_Q17_FallingEdge PLC_Q17_AnyEdge PLC_Q17_LevelHigh PLC_Q17_LevelLow | Off | Beginner |
| CounterResetActivation | RW | Off RisingEdge FallingEdge AnyEdge LevelHigh LevelLow | Off | Beginner |
| CounterResetSource | RW | PLC_Q3 PLC_Q7 PLC_Q8 PLC_Q9 PLC_Q10 PLC_Q11 PLC_Q16 PLC_Q17 | PLC_Q3 | Beginner |
| CounterTriggerSource | RW | Off | Off | Beginner |
| CounterValue | RO | 0 - 4294967295 | | Beginner |
| DeviceInformation | | | | |
| DeviceVendorName | RO | | | Beginner |
| DeviceModelName | RO | | | Beginner |
| DeviceManufacturerInfo | RO | | | Beginner |
| DeviceVersion | RO | | | Beginner |
| DeviceID | RO | | | Expert |
| DeviceUserID | RW | User definable string. Maximum 16 characters. | | Beginner |
| GigEVisionTransportLayer | | | | |
| GevSCPSPacketSize | RW | 72 - 16260 | 1428 | Expert |
| GevPersistentIPAddress | RW | 000.000.000.000 - 255.255.255 | 000.000.000.000 | Expert |
| GevPersistentSubnetMask | RW | 000.000.000.000 - 255.255.255 | 000.000.000.000 | Expert |

RM/TM-1405GE Series

| Category / Feature | Read/Write | Value Range | Default Value | Visibility Level |
|---------------------------------------|------------|--|--|------------------|
| GevPersistentDefaultGateway | RW | 000.000.000.000 - 255.255.255 | 000.000.000.000 | Expert |
| GevCurrentIPConfigurationPersistentIP | RW | On Off | Off | Beginner |
| ImageSizeControl | | | | |
| SensorDigitizationTaps | RW | One | One | Expert |
| WidthMax | RO | 0 - 1392 | | Beginner |
| HeightMax | RO | 0 - 1040 | | Beginner |
| Width | RW | 0 to (WidthMax - OffsetX) | | Beginner |
| Height | RW | 0 to (HeightMax - OffsetY) | | Beginner |
| OffsetX | RW | WidthMax - Width | | Beginner |
| OffsetY | RW | HeightMax - Height | | Beginner |
| PixelFormat | RW | Monochrome: Mono8 Mono10 Mono10Packed Bayer: BayerRG8 BayerGB8 BayerRG10 BayerGB10 | Monochrome: Mono8 Bayer: BayerRG8 | Beginner |
| ScanMode | RW | A_1392x1040 UserProgrammable | A_1392x1040 | Beginner |
| UserScanAreaStart | RW | 0 to (1040 - UserScanAreaLines - 1) | 0 | Beginner |
| UserScanAreaLines | RW | 0 to (1040 - UserScanAreaStart) | 500 | Beginner |
| TestImageSelector | RW | Off DeviceSpecific IPEngineTestPattern | Off | Beginner |
| LUT | | | | |
| LUTMode | RW | Linear Gamma45 Knee | Linear | Beginner |
| KneeX1 | RW | 0 - 255 | 255 | Beginner |
| KneeY1 | RW | 0 - 255 | 255 | Beginner |
| KneeX2 | RW | 0 - 255 | 255 | Beginner |
| KneeY2 | RW | 0 - 255 | 255 | Beginner |
| LUTInversion | RW | Execute Command | | Beginner |

| Category / Feature | Read/Write | Value Range | Default Value | Visibility Level |
|------------------------|------------|--|---------------|------------------|
| UserSets | | | | |
| UserSetLoadStatus | RO | InProgress Failure Success | | Expert |
| UserSetSelector | RW | Default UserSet1 ... UserSet6 | | Beginner |
| UserSetLoad | RW | Execute Command | | Beginner |
| UserSetSave | RW | Execute Command | | Beginner |
| UserSetDefaultSelector | RW | Default UserSet1 ... UserSet6 | UserSet1 | Expert |

6 Troubleshooting

6.1 Problems and Solutions

Following are troubleshooting tips for common problems. In general, the problems listed in this section are solved by following these instructions. If there is no solution listed to the problem you are encountering, contact a JAI Inc. representative.

6.1.1 Symptom: No Video

Remedies: Check that the following are properly connected and operational.

| | |
|-------------------|----------------------|
| Power supplies | Async mode |
| Power cables | Lens |
| Main power source | Digital output cable |
| Shutter control | Analog video cable |

6.1.2

Symptom: Dark Video

Remedies: Check that the following are properly connected and operational.

Shutter selection

Iris opening on the lens

6.1.3 Symptom: Non-Synchronized Video

Remedies: Check that the following are properly connected and operational.

Proper mode output

Frame grabber software camera selection

6.2 Information and Support Resources

For further information and support:

North American Technical Support

Phone 408-383-0300
E-Mail: camerasupport.americas@jai.com

European Technical Support

Phone: +45 4457 8950
E-Mail: camerasupport@jai.com

Japan/Asia Technical Support

Phone +81 45 440 0154
E-Mail: camerasupport@jai.com



Mailing Address

Mail: JAI, Inc.
Sales Department
625 River Oaks Parkway
San Jose, CA 95134
ATTN: Video Applications

Web Site: www.jai.com

7 Appendix

7.1 Specifications

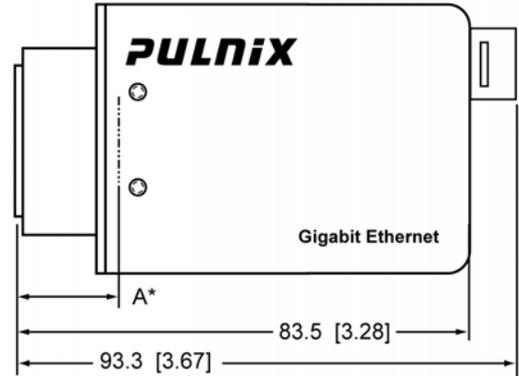
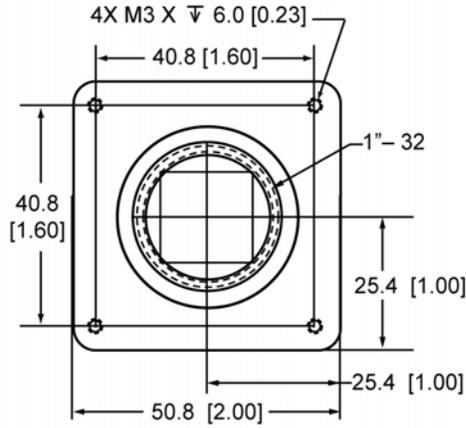
Table 8 TM-1405GE Camera Specifications Table

| | |
|------------------------------|---|
| Feature | TM-1405GE |
| Imager | 1/2" progressive scan interline transfer CCD (ICX205AL/AK) |
| Active Area | 6.47mm x 4.84mm |
| Active Pixels | 1392 (H) x 1040 (V) |
| Cell Size | 4.65µm x 4.65µm |
| Display Mode (Active Pixels) | 1392 (H) x 1040 (V) @ 30 Hz |
| Sync | Internal/External auto switch HD/VD, 4.0 Vp-p impedance 4.7 K Ω VD=30.00 Hz ±5%, non-interlace HD=31.1 kHz ±5% |
| Data Clock Output | 50.00 MHz |
| Resolution | Digital: 1392 (H) x 1040 (V) |
| S/N Ratio | 51dB min. |
| Min. Illumination | Monochrome = 0.8 lux; Color = 6.0 lux f = 1.4 without IR cut filter (no shutter) |
| Video Output | Analog: 714 mV, 75 Ω, (750 mV white clip) Digital output: Gigabit Ethernet (8- or 10-bit selectable) |
| Gamma | Programmable LUT (1.0 std.) |
| Lens Mount | C-mount (use >1/2" format lenses or larger) |
| Power Requirement | 12V DC ±10%, 420mA (typical at 25 °C) |
| Operating Temp. | -10 °C to 50 °C* |
| Vibration | 7 Grms (10 Hz to 2000 Hz) Random |
| Shock | 70G, 11 ms half sine |
| Size (W x H x L) | 50.8mm x 50.8mm x 83.5mm |
| Weight | 212 grams (7.47 oz.) without tripod |
| Optional Functions | OP 3-1, Internal IR filter added; OP 3-2, optical filter removal (color only); OP 7-5, configure to 15 fps; OP21-1QUV, glassless CCD imager with Quartz window (color) |
| Optional Accessories | |
| Power Cable | 12P-02S |
| Power Supply | PD-12U series |
| Tripod Mounting Kit | TP-20 |

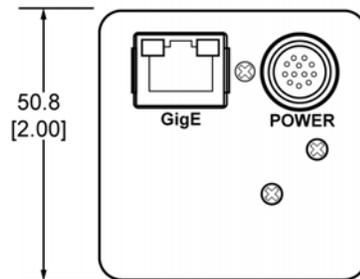
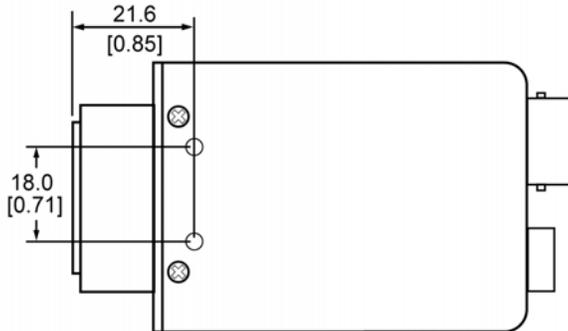
*. Refer to Section 2.2.1 for information on camera heat dissipation. Image quality degrades with increasing temperature.

7.1.1 TM-1405GE Physical Dimensions

Figure 24. Physical Dimensions



*A = 18.0 ± 1.0 mm absolute distance measured to front of lens mount (Effective flange back distance = 17.53 ± 0.5 mm)



Caution: When mounting the camera to any fixture, do not use screws that extend more than 5 mm into the camera housing to avoid possible damage to the internal circuitry. For attaching the tripod mounting plate, only the supplied screws should be used.

7.1.2 Spectral Response

Figure 25. Monochrome Spectral Response

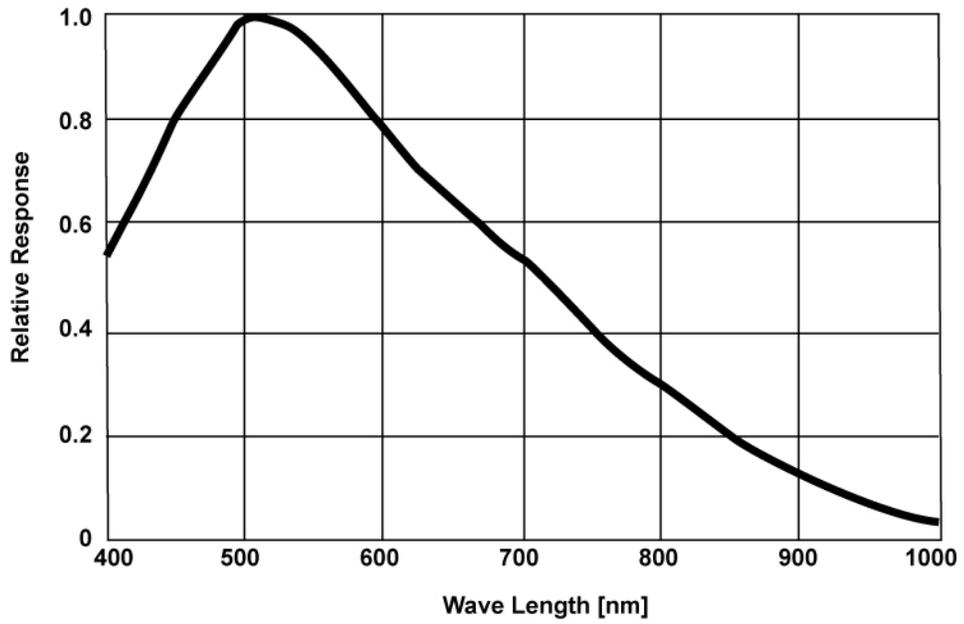
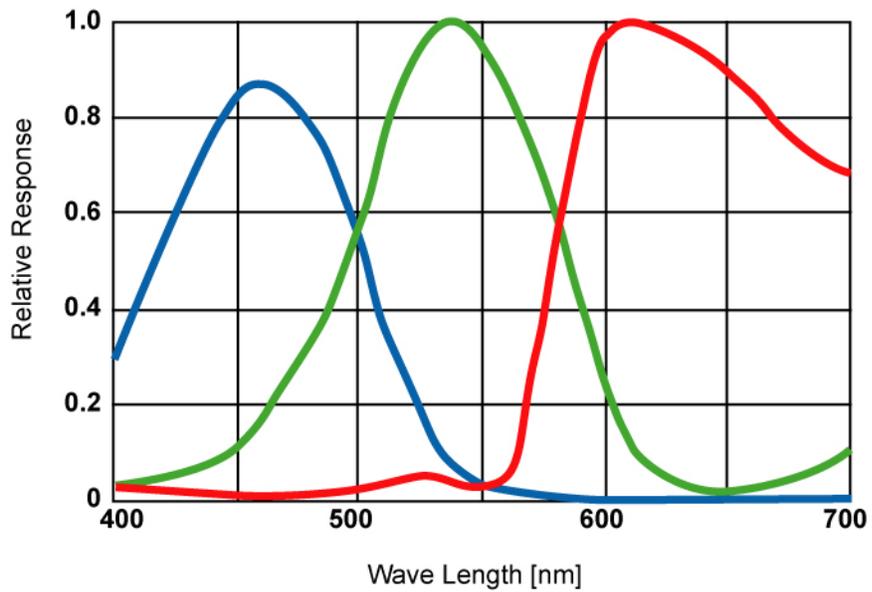


Figure 26. Color Spectral Response



Supplement

This applies to cameras in this manual that are RoHS compliant, which are noted by RM or RMC.

The following statement is related to the regulation on “Measures for the Administration of the control of Pollution by Electronic Information Products”, known as “China RoHS”. The table shows contained Hazardous Substances in this camera.

 mark shows that the environment-friendly use period of contained Hazardous Substances is 15 years.

重要注意事项

有毒，有害物质或元素名称及含量表

根据中华人民共和国信息产业部『电子信息产品污染控制管理办法』，本产品《有毒，有害物质或元素名称及含量表》如下。

| 部件名称 | 有毒有害物质或元素 | | | | | |
|-------|-----------|-----------|-----------|-----------------|---------------|-----------------|
| | 铅 (Pb) | 汞 (Hg) | 镉 (Cd) | 六价铬 (Cr(VI)) | 多溴联苯 (PPB) | 多溴二苯醚 (PBDE) |
| 外壳 | × | ○ | ○ | ○ | ○ | ○ |
| 光学滤色镜 | × | ○ | × | ○ | ○ | ○ |
| | | | | | | |

○：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006规定的限量要求以下。
 ×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006规定的限量要求。
 （企业可在此处、根据实际情况对上表中打“×”的技术原因进行进一步说明。）



环保使用期限

电子信息产品中含有的有毒有害物质或元素在正常使用的条件下不会发生外泄或突变、电子信息产品用户使用该电子信息产品不会对环境造成严重污染或对基人身、财产造成严重损害的期限。

数字「15」为期限15年。

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