



See the possibilities

User's Manual

RM/TM-2030GE RMC/TMC-2030GE

Progressive Scan Cameras

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Warranty

Please contact your factory representative for details about the warranty.

Certifications

CE Compliance

The RM/TM-2030GE 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.

Contact the JAI Inc. Applications Engineering Department for further information regarding CE compliance.

FCC

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case the user will be required to correct the interference at his own expense.

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-2030GE Series Operation Manual

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1. RM/TM-2030GE Series Camera Hardware

1 Hardware Introduction

1.1 Product Description

The JAI, Inc. TM-2030GE series¹ is a Gigabit Ethernet output, high-resolution 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 1/26,000 sec., can be reset asynchronously by external pulse control. The frame rate for a full image is 32 fps. A square imager format with uniform square pixels provides superior image definition in any orientation. On chip micro lenses provide increased sensitivity. 12-bit internal processing can be converted to 8-bit, 10-bit or 12-bit output.

The TM-2030GE has a full dynamic range control function, which can be set at externally selectable look-up table (LUT) knee slopes thereby optimizing the CCD's full dynamic range in the normal output signal range. As a Gigabit Ethernet output camera, the TM-2030GE has semi-auto-gain balancing functions. The camera does not have a LUT for the 12-bit output.

Applications for the TM-2030GE include machine vision, medical imaging, intelligent transportation systems, high-definition graphics, on-line inspection, gauging, character reading, archiving, and high security surveillance.

1.2 Features

- Small size and light weight

The printed circuit boards in the TM-2030GE 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 51mm x 51mm x 85mm in dimensions, and weighs only 215 grams (7.6 oz.).

- Imager

The TM-2030GE uses a dual-tap progressive scan interline transfer CCD that has the following features:

- Resolution of 1920 x 1080 active pixels for excellent image quality
- 7.4 x 7.4 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 during fast scanning. The CCD has an excellent S/N ratio at the default setting that is greater than 57dB.
- The CCD has built-in micro-lenses for increased quantum efficiency.

¹ Unless otherwise stated, all information in this manual applies to all cameras in the TM-2030GE series, the TM-2030GE, TMC-2030GE, RM-2030GE, and the RMC-2030GE.

- Electronic shutter

The TM-2030GE has a substrate drain-type shutter mechanism which provides superb pictures at various speeds without smearing.

- Asynchronous reset

The TM-2030GE captures async reset images and provides single-shot video output with single FDV (frame data valid). This makes it simpler for an ordinary frame grabber to capture the asynchronous reset images. The TM-2030GE's asynchronous reset is flexible and accepts external horizontal drive (HD) for phase locking. When the VINIT (5V) pulse is applied to CC1, it resets the camera's scanning and purging of the CCD.

The TM-2030GE has three modes to control the asynchronous reset and shutter speed:

- Async, no shutter.* The video signal and FDV are reset by external VINIT.
- Internal shutter speed control.* The speed control varies from 1/32 to 1/16,000 sec. The video signal and FDV starts with internal V reset timing related to shutter speed.
- External VINIT with pulse width.* The duration between pulse edges controls the shutter speed externally.

- Output

The TM-2030GE has a dual-tap 12-bit/10-bit/8-bit Gigabit Ethernet output.

- Dual-channel auto black level balancing and semi-auto gain balancing

The TM-2030GE, as a dual-tap output camera, has auto black level balancing and semi-auto gain balancing functions.

- Warranty

Please contact your factory representative for details about the warranty.

2 Installation

The following instructions are provided to help you to set up your camera. We suggest that you read through these instructions before you unpack and set up the camera system.

2.1 Getting Started

2.1.1 Unpacking Instructions

We recommend 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-2030GE camera from JAI, Inc., the contents of the shipping box should include the camera and a document download card. If either of these items is missing, please contact your JAI, Inc. 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, please contact JAI, Inc. to receive this material on a CD-ROM.

2.1.3 Accessories and Options

Following is a list of additional accessories and options that may be required for your application. Please check with your JAI, Inc. representative before you install your camera to determine what you might need.

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

2.2 Camera Setup

2.2.1 Heat Dissipation

The TM-2030GE is a compact 1920 by 1080 camera. Since all the electronics have been packed in a compact package, the outer case of the camera can become hot due to heat dissipation. For optimal performance, JAI, Inc. recommends using a cooling fan to set up a positive air flow around the camera and following the precautions below.

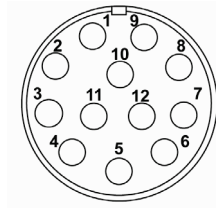
- Mount the camera on a large heat sink (camera bracket) made out of heat-conductive material like aluminum.
- Make sure the flow of heat from the camera case to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate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

2.2.2 Connector Pin Configurations

2.2.2.1 12-Pin Connector

The TM-2030GE has a 12-pin Hirose connector for power input as shown below.

Figure 1. 12-Pin Connector Pinouts



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

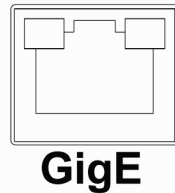
Table 1 12-Pin Connector

Pin	Description	Pin	Description
1	GND	7	VD in (CC4 equiv)
2	+12V DC	8	Strobe Output
3	GND (analog)	9	HD in (CC3 equiv)
4	Analog Video	10	Reserved
5	GND (digital)	11	Reserved
6	VINIT in (CC1 equiv)	12	Reserved

2.2.2.2 Ethernet Connector

The GigE socket, marked on the camera's back panel as GigE, is a standard RJ-45 Ethernet socket as shown in Figure 2.

Figure 2. GigE Ethernet Connector



Use at least cat5e UTP cables (cat6 cables are preferred). JAI, Inc. 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-2030GE camera requires 12V DC power that is 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 power supply. JAI, Inc. 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-12UEP	PD-12UU with 12-pin connector	European plug

For users 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. The PD-12UU and PD-12UE power supplies can be connected to the JAI, Inc. power cable either directly or using a terminal strip.

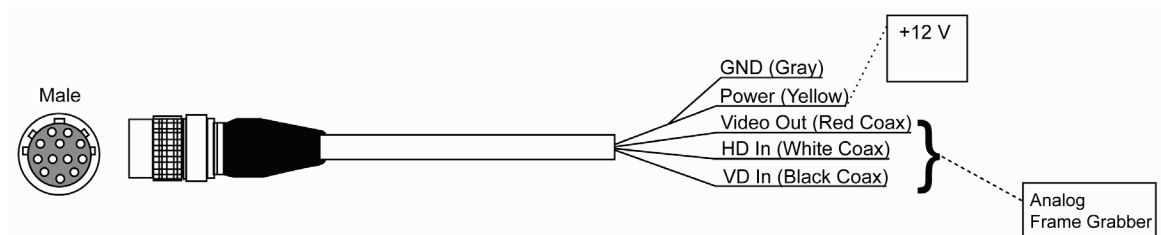
When wiring the PD-12UU and PD-12UE power supplies directly, please note the following:

- The lead ends must be twisted together and tin-soldered for strength and electrical continuity.
- Shrink tubing or a similar insulator should be used 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.
- All connections must be properly insulated to prevent shorting.

2.2.3.2 JAI, Inc. Power Cables

If you are using JAI, Inc. power cables such as the 12P-02S, please refer to the 12-pin connector pinout diagram below. The cable pin-out diagram is shown in Figure 49. 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 shield	TTL IN (External_HD)
4	Red coax	Reserved	10	Brown	Reserved
5	Orange coax shield	GND(Digital Ground)	11	Blue	Reserved
6	Orange coax	TTL IN (External_Trigger)	12	Black coax	Reserved

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. Follow these directions to properly attach the power cable to the camera connector:

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-2030GE camera accepts 1-inch or larger format size C-mount lenses. To attach the C-mount lens² 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. Some lenses with extremely long flange backs may exceed the mounting depth of the camera.

2.2.5 Adjustable Back-Focus

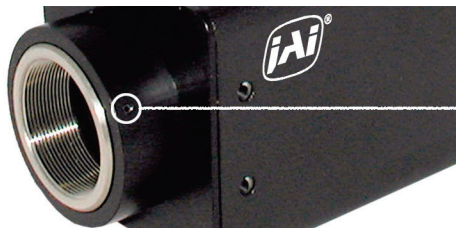
Before cameras are shipped, back focus is carefully set using a collimator, oscilloscope and other specialized equipment. While the factory-set focus serves well in most cases, an adjustable back focus makes it possible to improve image sharpness when using lower-cost zoom lenses, custom optics, or in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

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.

² C-mount to F-mount and C-mount to K-mount adapters are available for larger format lenses (35mm). Check with local photography dealers for these lens adapters.

3 Operation

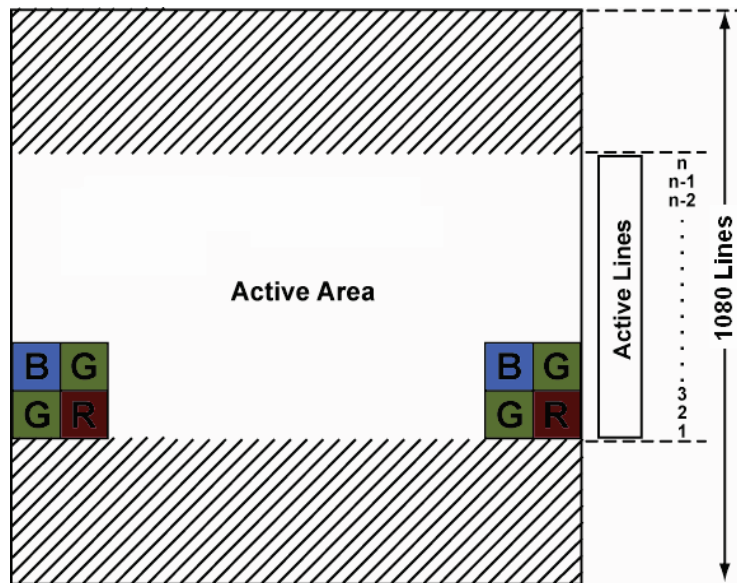
3.1 Progressive Scanning

The TM-2030GE 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 1000 lines (a normal TV monitor display may not be able to show 1000 lines due to monitor resolution of 30Hz scanning).

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.

3.1.1 Preset Scan Area

TM/TMC-2030GE has full scan mode, all active lines of the CCD sensor, 1080 lines, are transferred out line by line.



3.1.2 Full Scan Area 2x2 Binning

TM/TMC-2030GE has 2x2 binning of the full scan area. In 2x2 binning mode, pixel (i, j) includes all the information of pixel (2i-1, 2j-1), (2i-1, 2j), (2i, 2j-1) and (2i, 2j) in normal full scan mode (where $i=1, 2, \dots, 800$; $j=1, 2, \dots, 540$). In this mode vertical binning makes frame transfer faster than normal scan mode, however, due to the mixture of pixel information, the camera resolution is low in this mode, and the Bayer pattern CCD camera loses color information.

Figure 5. 2x2 Binning

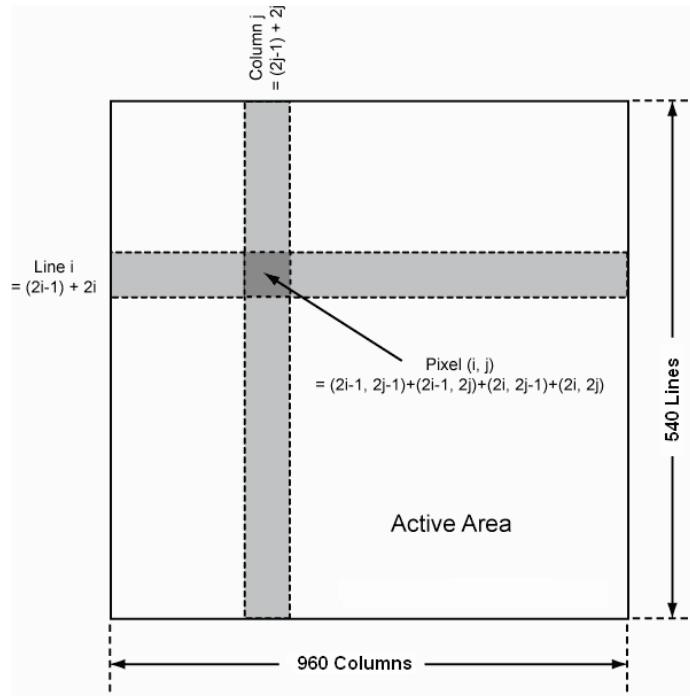


Table 2 Scan Area Modes

	Scan Area	Start Point (Line)	Effective Area (Lines x Pixels)	Frame Rate (FPS)	
				Dual Tap	Single Tap
A	Full Scan	1	1920 x 1080	32.32	16.16
T	Full Scan 2x2 Binning	1	960 x 540	58.65	30.79

3.2 Bayer Color Filter (Color Versions)

JAI, Inc. 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 up to 1/26,000 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, Inc. 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)

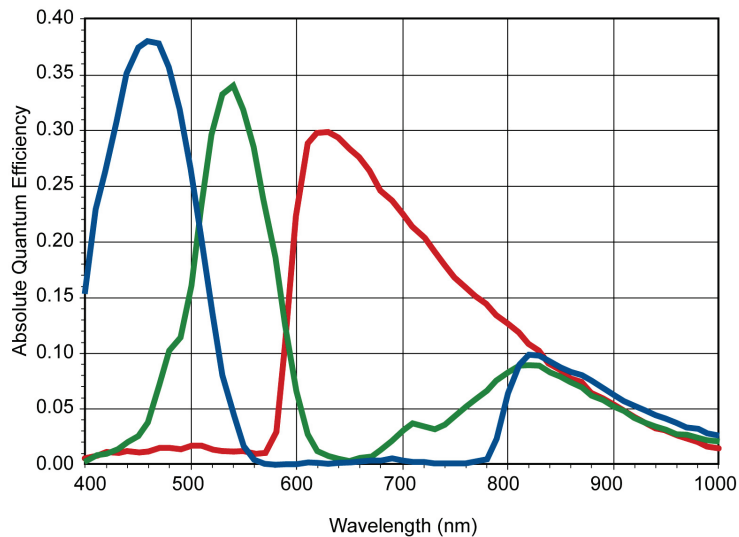
The Bayer CFA is an R, G, B primary color filter array. This is the most widely accepted CFA for the single-chip CCD progressive scan format. This type of array layout has a specific order for each color’s pixels. Since the

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

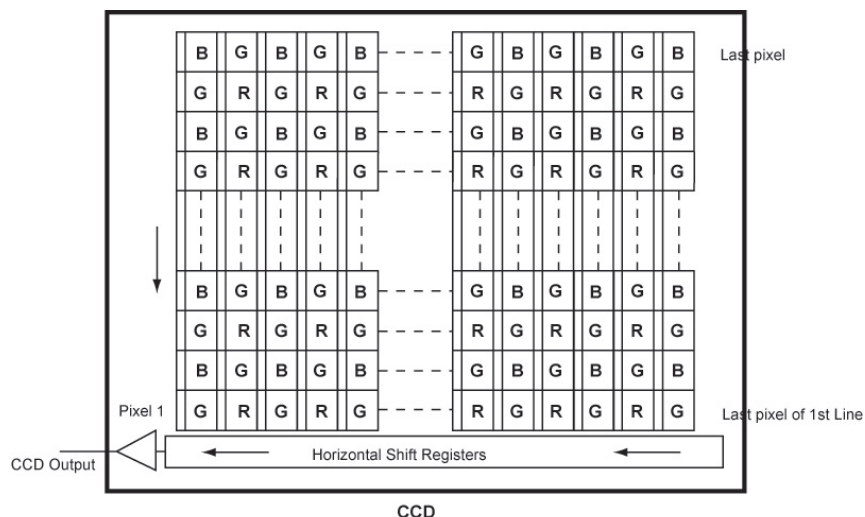
Figure 6. Bayer Color Filter Response.



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 is exactly the same. Contact JAI, Inc. for further information regarding CCD manufacturers.

Figure 7. Example of Color CCD CFA Pattern



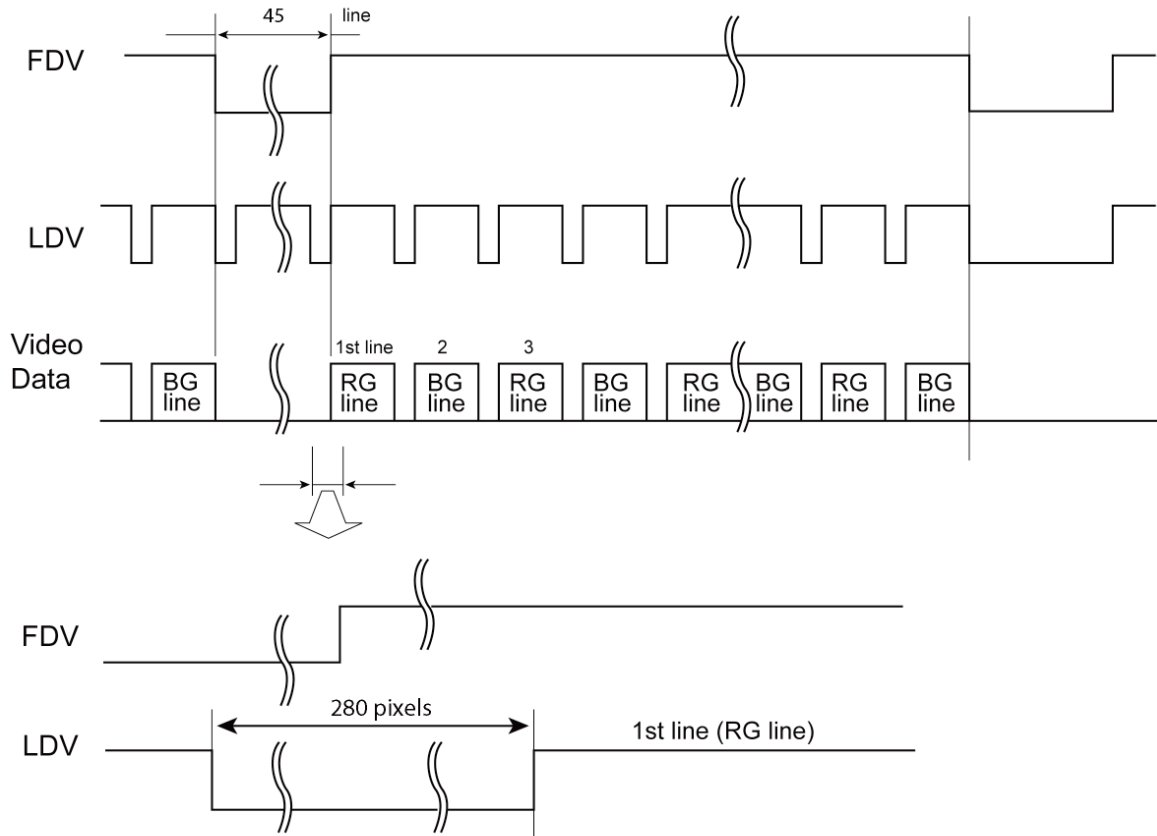
3.2.4 Sync and Data

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 monochrome cameras.

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

The following diagram is an example of the TMC-2030GE default mode. FDV and LDV are used internally for the GigE interface.

Figure 8. Example of TMC-2030GE (Same as TM-2030GE)



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 monochrome cameras.

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).

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, and so on.

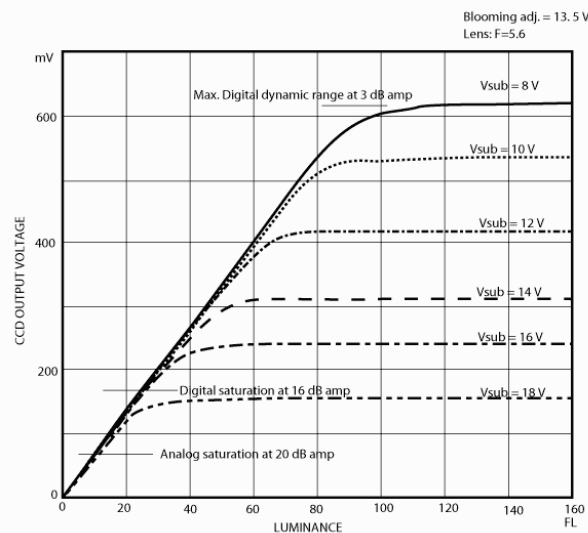
Green	Red	Green
Blue	Green	Blue
Green	Red	Green

All AccuPiXEL color cameras are carefully designed for maximum color performance. JAI, Inc. 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 Dynamic Range Control

Figure 9. Output and Blooming



The typical interline transfer CCD has fixed noise levels based on dark current (thermal or KT noise), pattern noise, and the operating clock speed. In general, the level of the 20 MHz pixel clock CCD at room temperature is around 20 to 50 electrons. The maximum capacity of CCD charges is limited by the well capacity at saturation. The range is limited by the structure and the pixel size.

The TM-2030GE uses a CCD with 7.4 μm x 7.4 μm pixels and a two-phase vertical shift register structure. The well capacity is 40,000 electrons. The theoretical dynamic range is 40,000:30 = 1333:1 (60 dB).

A typical CCD camera does not use the full dynamic range due to the nominal gain and the output specification such as RS-170. The typical CCD camera's gain is set at 16 to 22 dB and the RS-170 video level is 714 mV. Using 20 dB gain for the calculation, CCD output is limited to $714/10 = 71.4$ mV. Since the CCD's saturation voltage is 400 mV to 500 mV, it uses less than 1/5 of the full dynamic range.

Machine vision and outdoor applications cannot afford to miss image information behind the saturation, which is why the dynamic range adaptation is critical.

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

The TM-2030GE 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 12-bit A/D input so that the full dynamic range of the CCD is utilized at 12-bit references as the input and the LUT output is converted into either 8-bit or 10-bit to adjust the gamma correction. There is no 12-bit LUT.

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.

3.4 External Sync and Pixel Locking

The TM-2030GE accepts an external sync of standard HD and VD at TTL level for general locking to a system sync and clock. The frequency requirement is as follows:

Full Progressive Scan:

$f_{HD} = 36.36 \text{ KHz} \pm 2\%$

$f_{VD} = 32.32 \text{ Hz} \pm 2\%$

(Internal Master clock = 80.00 MHz,

Pixel clock = 40.00 MHz)

3.5 Electronic Shutter

The TM-2030GE has a substrate drain-type shutter mechanism which provides a superb picture at various speeds without smearing.

3.5.1 Programmable Exposure-Continuous Mode

The exposure time of TM/TMC-2030GE can be specified from one video line to a maximum of one frame using the serial communication commands in the Continuous Mode. There is overhead where the specified exposure time is n video lines, making the real exposure time equal to

$$\text{Exposure Time} = \begin{cases} (n + 1) * 27.5 \mu s + 15.6 \mu s & \text{Dual Tap} \\ (n + 1) * 55.0 \mu s + 15.6 \mu s & \text{Single Tap} \end{cases}$$

When $n=0$, the exposure time is minimum exposure time. It is equal to:

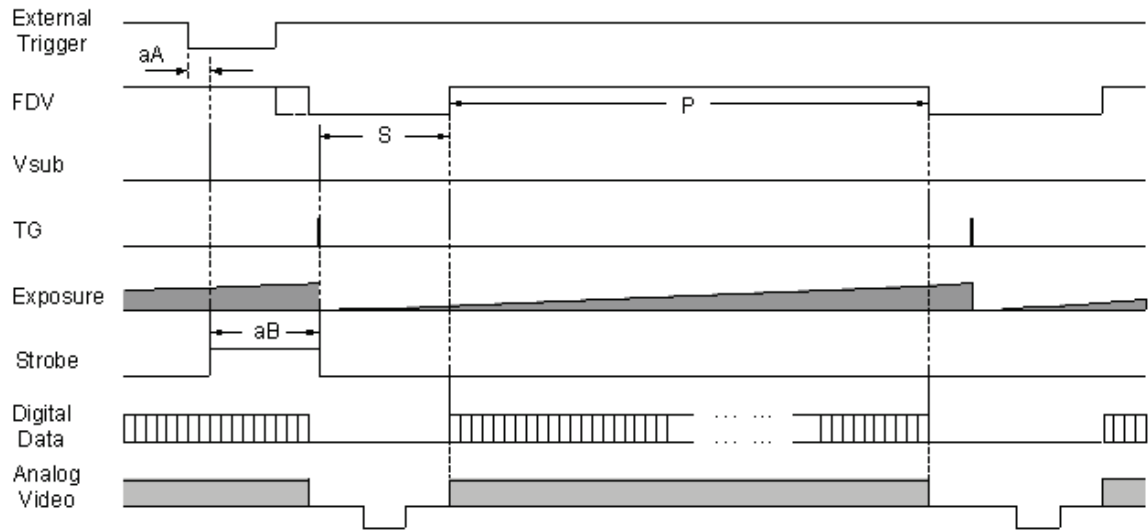
$$\text{Minimum Exposure Time} = \begin{cases} 43.1 \mu s \text{ (1/26000s)} & \text{Dual Tap} \\ 70.6 \mu s \text{ (1/14000s)} & \text{Single Tap} \end{cases}$$

In this mode the maximum exposure time is equal to the setting for one frame. If the user specified exposure time is longer than the time allowed for one frame, it will be ignored by the camera.

3.5.2 Asynchronous No Shutter Mode

In Asynchronous No Shutter Mode, applying the external trigger starts a camera scan reset. The camera finishes the line it is scanning and scans an additional 9 video lines, this charge is sent to the horizontal register.

Because the external trigger is randomly applied, the new image charge may overlap with the previous image. To prevent an existing charge accumulation from interfering with a new image, most users set up the application in a dark area and depend on a strobe light for illumination. From the time the external trigger activates until the transfer gate turns off, about 9.5 video lines are available for integration; if everything is properly configured, the strobe flashes during this time.

Figure 10. External Trigger Timing.

3.5.3 Asynchronous Programmable Exposure Mode

In Asynchronous Programmable Exposure Mode, when an external trigger is applied, the exposure starts after one discharge signal (V_{sub}), which happens after the trigger's active edge is off. Because the discharge signal (V_{sub}) synchronizes with LDV in this mode, there is a maximum one video line of jitter between the trigger active edges to discharge signals (V_{sub}) off. In this mode, the exposure time from 0 video lines to 2079 video lines can be controlled through serial communication commands in one video line steps. In this mode, the minimum exposure time is equal to 0 video lines plus overhead: the maximum exposure time is equal to 2079 video lines plus overhead. Where the specified exposure time is n video lines, the real exposure time is equal to:

$$Exposure\ Time = \begin{cases} (n + 1) * 27.5\ \mu s + 15.6\ \mu s & \text{Dual Tap} \\ (n + 1) * 55.0\ \mu s + 15.6\ \mu s & \text{Single Tap} \end{cases} \quad (n = 0, 1, \dots, 2079)$$

When $n=0$, the exposure time is minimum exposure time. It is equal to:

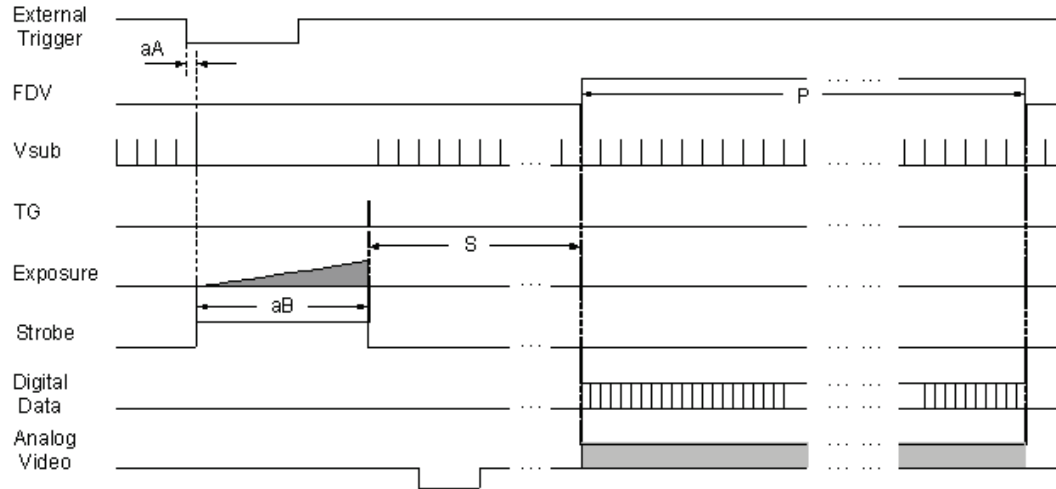
$$Minimum\ Exposure\ Time = \begin{cases} 43.1\ \mu s\ (1/26000s) & \text{Dual Tap} \\ 70.6\ \mu s\ (1/14000s) & \text{Single Tap} \end{cases}$$

When $n=2079$, the exposure time is maximum exposure time. It is equal to:

$$Maximum\ Exposure\ Time = \begin{cases} 57.22\ ms\ (1/17\ s) & \text{Dual Tap} \\ 114.42\ ms\ (1/9\ s) & \text{Single Tap} \end{cases}$$

- If the exposure time is less than one frame time ($n < 1124$), the maximum trigger frequency is equal to 1/1 frame time.
- If the exposure time is longer than one frame time ($n > 1124$), the maximum trigger frequency is equal to 1/ exposure time.
- The minimum active period of the external trigger is $5\ \mu s$.

Figure 11. Asynchronous Programmable External Trigger



3.5.4 Pulse Width Control Mode

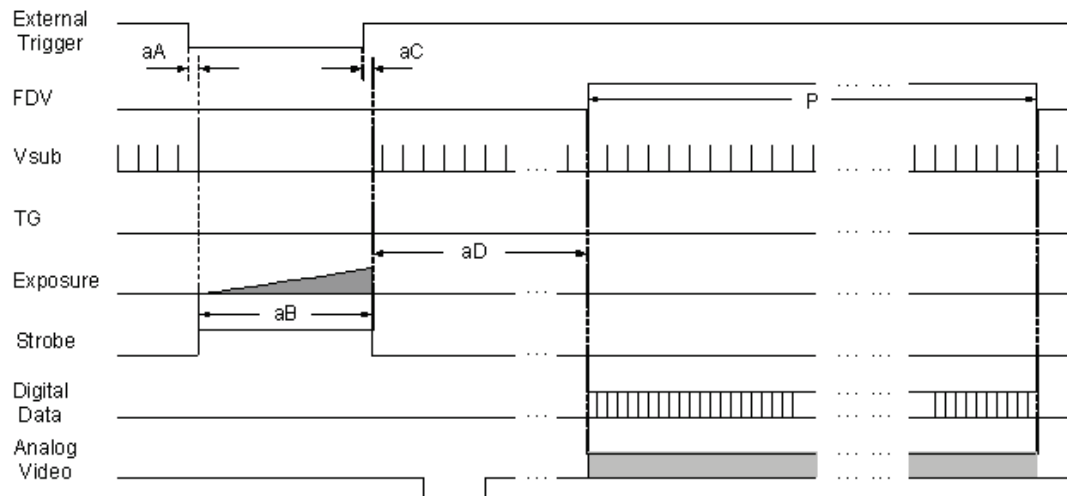
In Pulse Width Control (PWC) Mode, the exposure time is controlled by the external trigger. When an external trigger is applied, one discharge signal (V_{sub}) is generated right after the active edge of the trigger. The exposure starts when the discharge signal is in the off state. The exposure ends following the trigger active off. Exposure time is controlled by the pulse width of the external trigger. Because the CCD requires some overhead from trigger-active-off to the transfer gate event, the actual exposure time is equal to:

$$\text{Exposure Time} = \text{Pulse Width} + 12.4\mu\text{s}$$

Since one discharge signal (V_{sub}) is generated right after the active edge of the trigger, it is asynchronous with LDV, and the discharge signal may happen during an active video transfer period, causing visible reset noise to show in the current image. To avoid reset noise, the maximum trigger frequency in PWC mode should be less than $1/(\text{exposure time} + \text{one frame transferring time})$.

The minimum active period of the external trigger is $5\mu\text{s}$. Theoretically, the maximum active period of the external trigger is unlimited. But, due to the usability of images at 25°C it is recommended the active period of the external trigger be no longer than one second.

Figure 12. Pulse Width Control Trigger

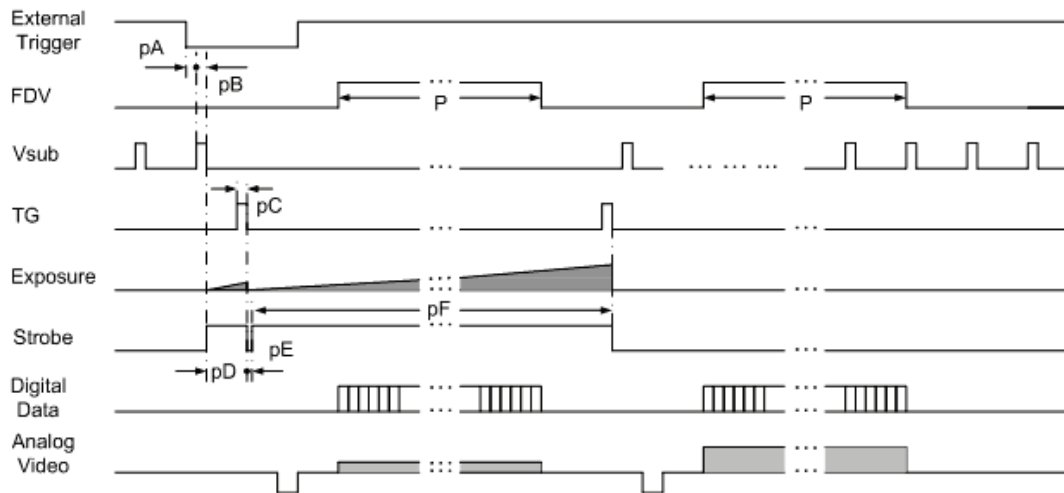


3.5.5 Particle Imaging Velocimetry Fixed Exposure Mode

In Particle Imaging Velocimetry (PIV) Fixed Exposure Mode, when an external trigger is applied, the first time exposure starts the same as in PWC mode. It lasts a very short period (8 μ s). The second time exposure starts during the transferring time of the first image. The second time exposure continues until the first image transfers completely. The second image is transferred after the second exposure. There is a short period (500ns) between the first exposure and the second exposure. In order to keep two exposure periods constant, the LDV is reset before the first image is transferred out.

The maximum trigger frequency in this mode is equal to $1 / (\text{transfer time of two frames} + 4\mu\text{s})$. The minimum active period of the external trigger is 5 μ s

Figure 13. PIV Exposure Timing Table



3.5.6 PWC PIV Mode

The PWC PIV Mode is based on PIV Fixed Exposure. In this mode, the first time exposure is controlled by the pulse width of the external trigger, which is similar to PWC mode. The real exposure time of the first image is equal to the pulse width of the external trigger.

The maximum trigger frequency in this mode is equal to $1 / (\text{transfer time of two frames} + \text{exposure time of the first image})$.

The minimum active period of the external trigger is 10 pixel clocks (250ns)

Figure 14. PWC PIV Timing Table.

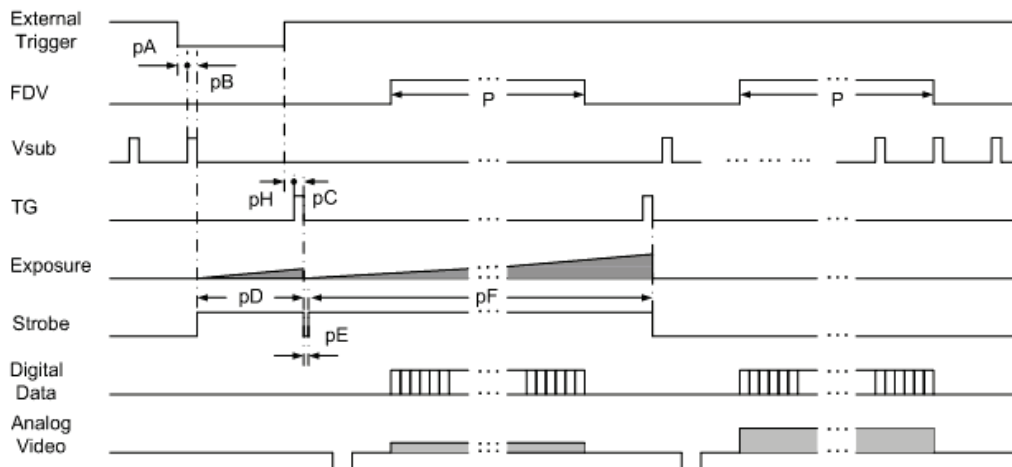


Table 3 Asynchronous Mode Chart

	Asyn No Shutter	Async Preset and Prog. Shutter	PWC
aA	<1 line	<1 line	6 clk
aB	9.5 line	(n+1) lines + 298 clk	Pulse width + 48 clk
aC			48 clk

	PIV Fixe Expo	PIV PWC	Unit
pA	6	6	Pixel
pB	70	70	
pC	200	200	
pD	320	320	
pE	20	20	
pF	1	1	Frame

3.6 Camera Timing Charts

Figure 15. Camera Timing Chart

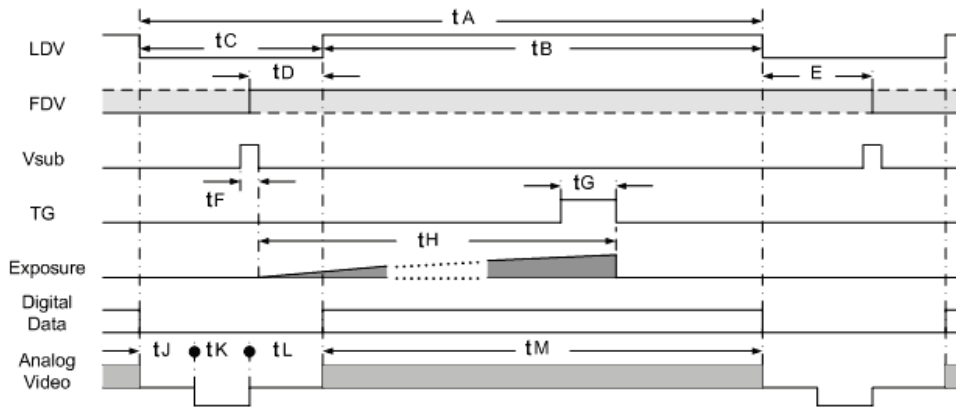


Figure 16. Digital Data Output Order for Configuration

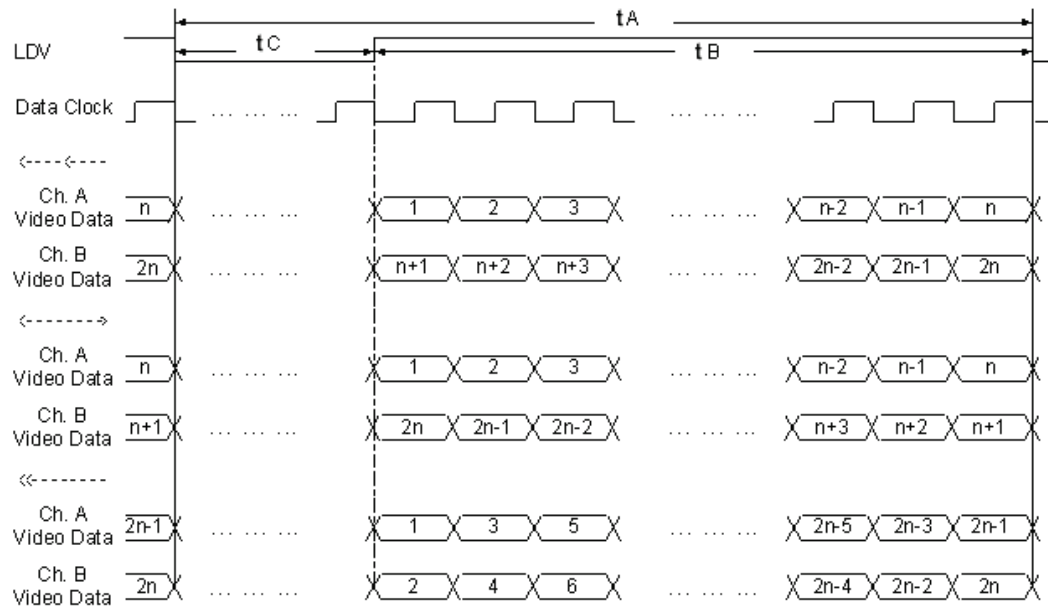
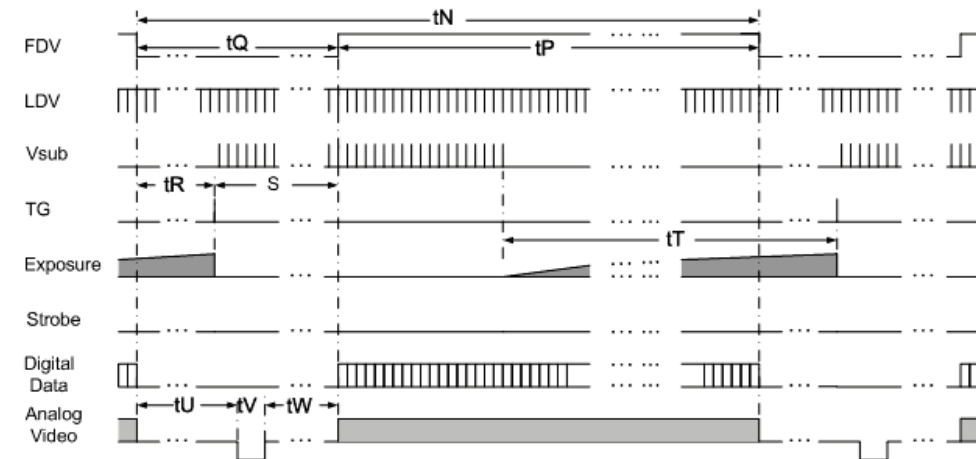


Figure 17. Field Video Timing--Continuous Mode



4 Functions and Operations

4.1 GigE Vision Standard Interface

The TM-2030GE 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-2030GE 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-2030GE cameras at the continuous mode and full scan area (1920x1080) is:

Model	Pixel Type	Frame Rate	Packet data volume required (GevSCPSPacketSize of 4040)
TM-2030GE	Mono8	32.4 fps	538 Mbit/s
	Mono10	32.4 fps	1.09 Gbit/s
	Mono10Packed	32.4 fps	817 Mbit/s
	Mono12	32.4 fps	1.09 Gbit/s
	Mono12Packed	32.4 fps	817 Mbit/s
TMC-2030GE	BayerGR8	32.4 fps	538 Mbit/s
	BayerGR10	32.4 fps	1.09 Gbit/s
	BayerGR12	32.4 fps	1.09 Gbit/s

Note: 1 The Mono10, Mono12, BayerGR10, and BayerGR12 settings at full frame rate will exceed GigE bandwidth. It is recommended to use BayerGR8, Mono10Packed or Mono12Packed for max frame rate.

For TM-2030GE cameras, the jumbo frame can be set at a maximum 16260 Bytes (Factory setting is 1428 Bytes). To set Jumbo Frame, refer to section 4.3.4.

To ensure the integrity of packets transmitted from the camera it is recommended to 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.

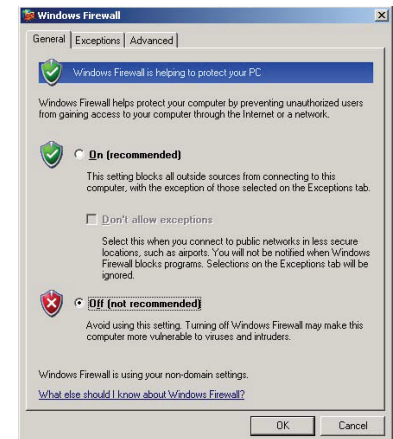
Use at least Cat5e or preferably Cat6 Ethernet cables.

Whenever possible, limit the camera output to Mono8, Mono10Packed or Mono12Packed for Monochrome cameras, and BayerGR8 for color.

4.3.3 Disable Firewalls

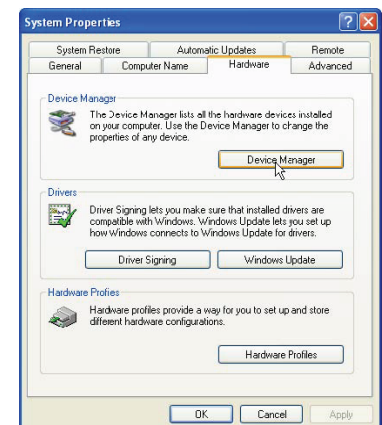
To ensure proper operation of the JAI SDK & Control Tool, all firewalls must be disabled. This also includes the Windows firewall.

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

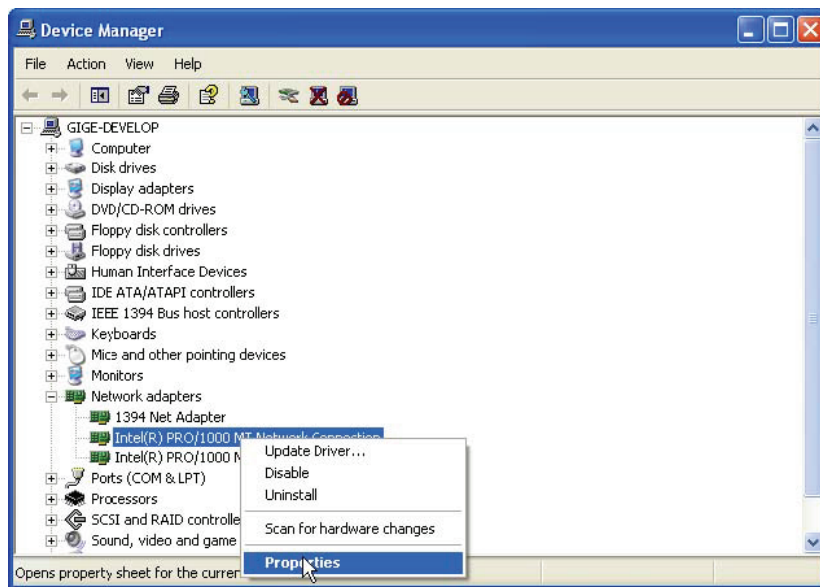


4.3.4 Enabling Jumbo Frame

- (1) Click [Start] and click [Control Panel].
- (2) Click [Performance and Maintenance].
- (3) Click [System].
- (4) Click [Hardware] tab.
- (5) Click [Device Manager]

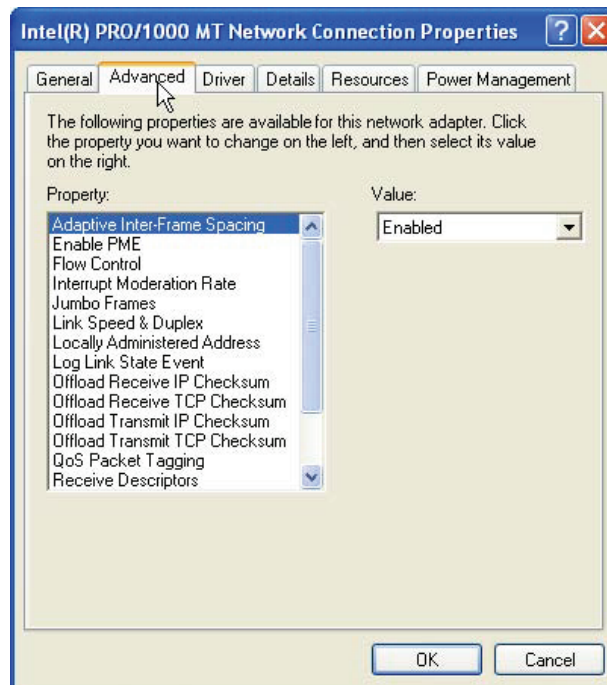


- (6) Expand [Network adapters].
- (7) Select target NIC, right-click, and click [Properties].

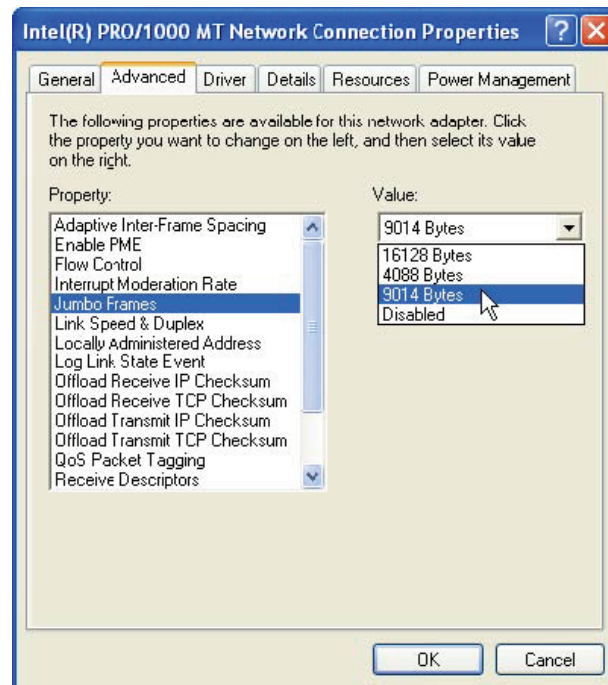


Note: The following procedure uses the Intel(R) PRO/1000 as an example. If a different NIC is used, the setup tabs will likely be different. In that case, set the item in a manner similar to what is described here.

- (8) Click [Advanced] tab.



- (9) Select Jumbo Frames under Property, and set the desired value. This setting defines the maximum GevSCPS Packet Size the camera can use.



(10)Click [OK].

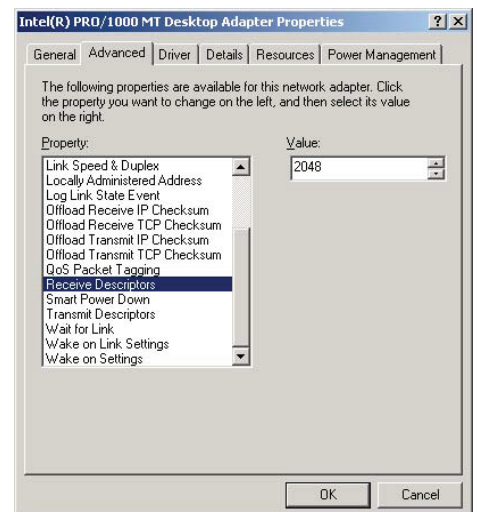
(11)Close [Device Manager].

(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.

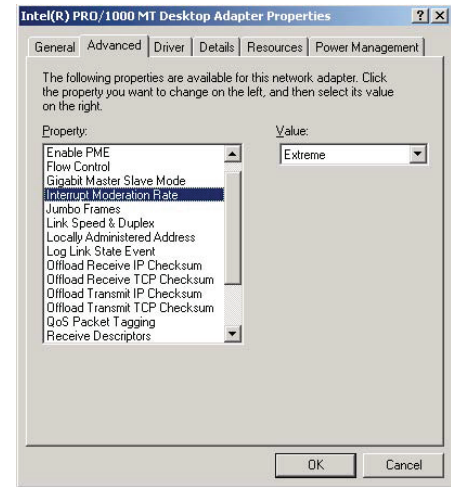
Click “OK” to save the property.



4.3.6 Interrupt Moderation rate

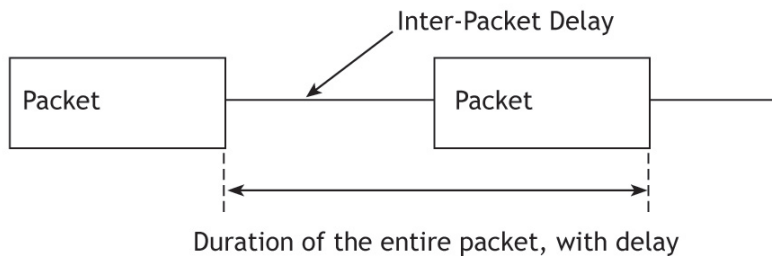
If the Network Connection Properties list contains a property called Interrupt Moderation Rate, then it is possible to set the preferred value. When it is changed from Minimal to Medium, High, and Extreme, the number of interruptions is decreased to get better performance. Set it to “Extreme.”

Click “OK” to save the property.



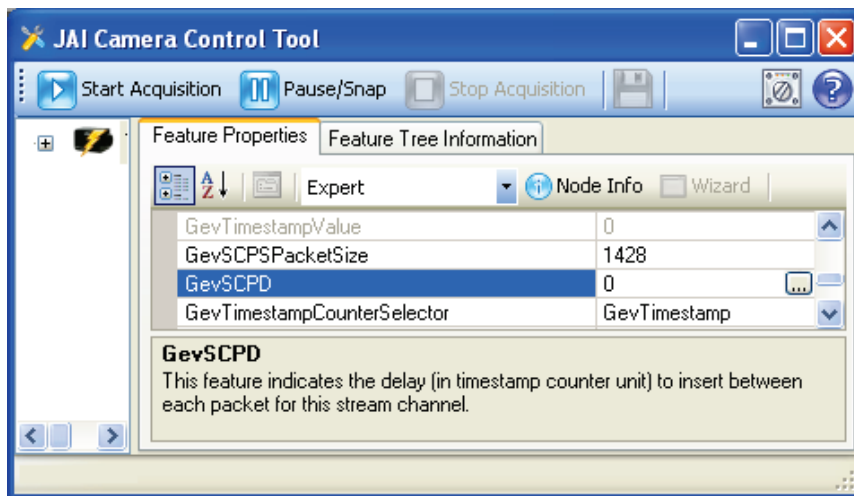
4.3.7 Calculating and setting Inter-Packet Delay

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.



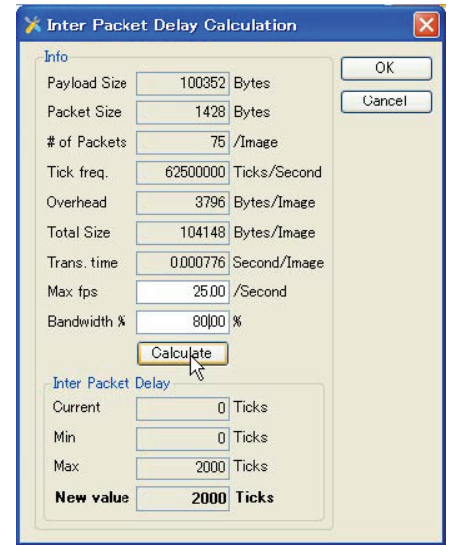
At first, type in the frame rate of the connected camera.
TM-2030GE cameras (in dual tap mode) are 32 fps.

Set the bandwidth at 80%.

Click the calculation tab.

New value is calculated.

Click OK. The displayed value is automatically transferred
to the Packet Delay column of the Control Tool.

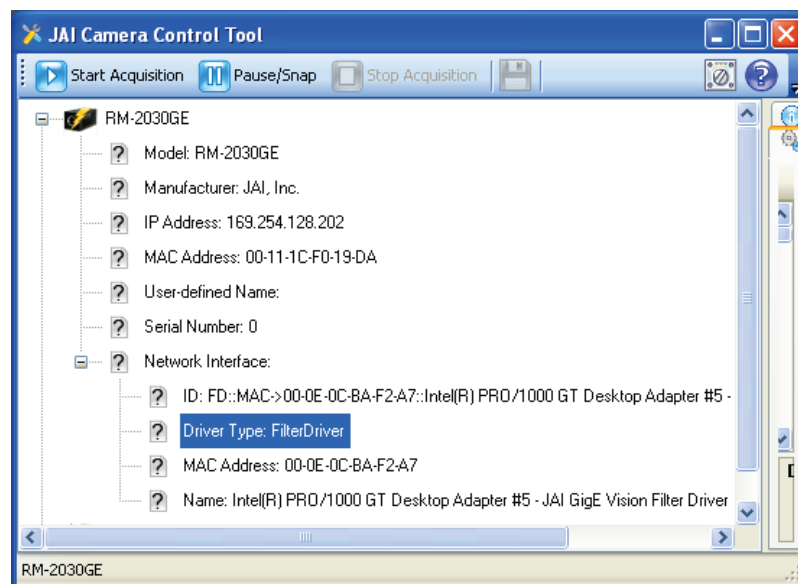


4.3.8 Confirm the Filter Driver is used

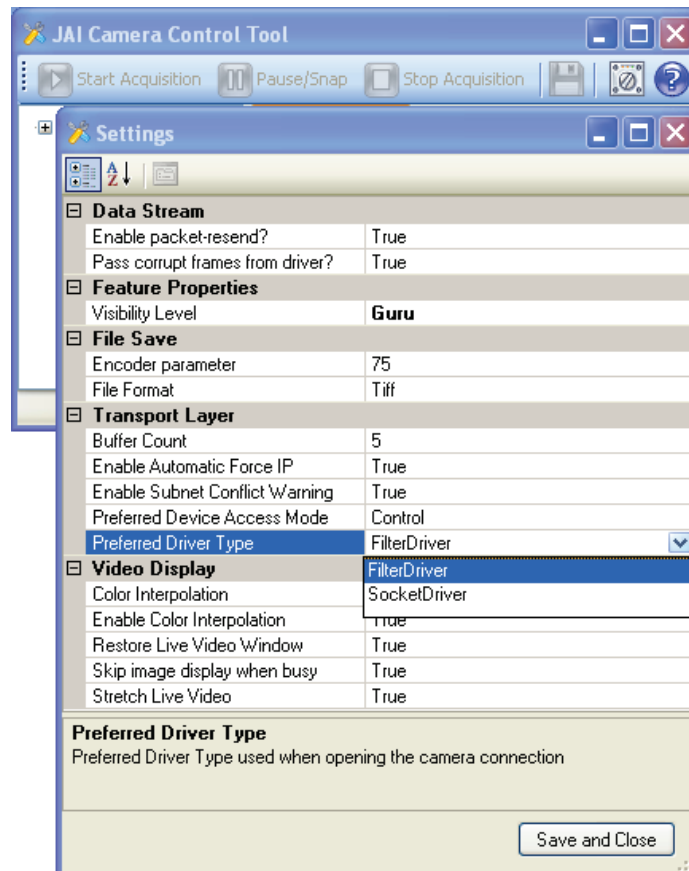
The filter driver is installed as an optional function when JAI SDK is installed. If the filter driver is not installed at that time, it can be installed from, All Programs ⇒ JAI SDK ⇒ GigE Vision Filter Driver ⇒ Install GigE Vision Filter Driver.



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.



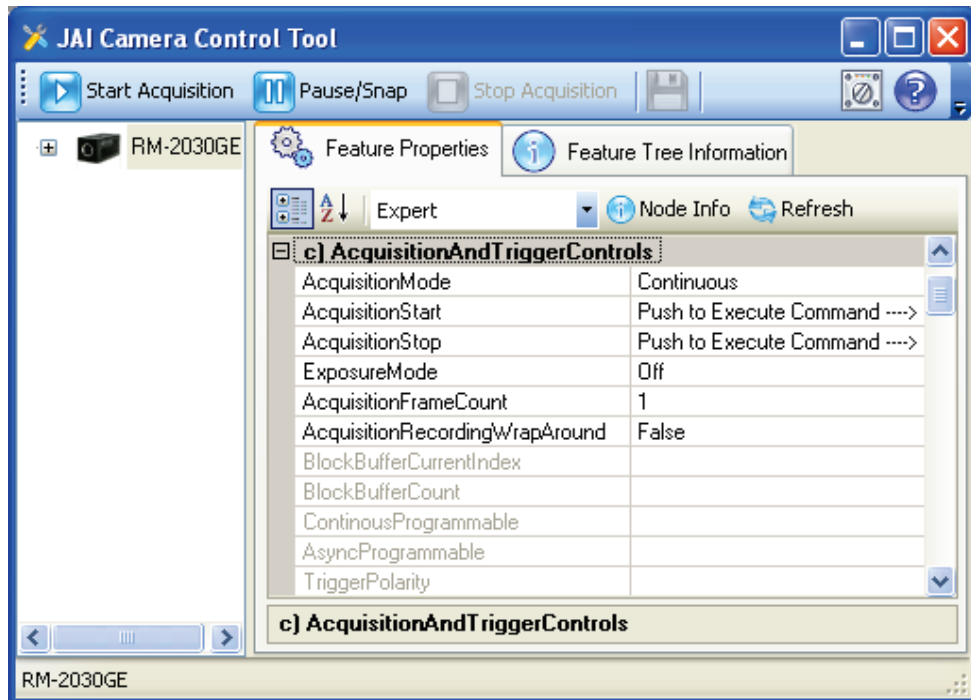
5 Configuring the Camera

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 18. 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 if AcquisitionRecordingWrapAround is False.
- ContinuousReadout: Images will be read continuously from the camera's onboard memory. When no more images are available, timeouts will occur.
- SingleFrameRecording: Acquire a single image and store onto the onboard memory.
- SingleFrameReadout: A single image will be read from the onboard memory. If no frames are available, a timeout will occur. To receive the next image simply execute AcquisitionStart once.

AcquisitionStart: tells the camera to start acquiring images in the mode as specified by AcquisitionMode. This also tells the camera to send one more image while in SingleFrameReadout.

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. When the buffer is full the oldest recorded image will be overwritten by the newest image.

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” section 5.9.7 for 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
- FixedExposurePIV
- PulseWidthControl_PIV
- 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.

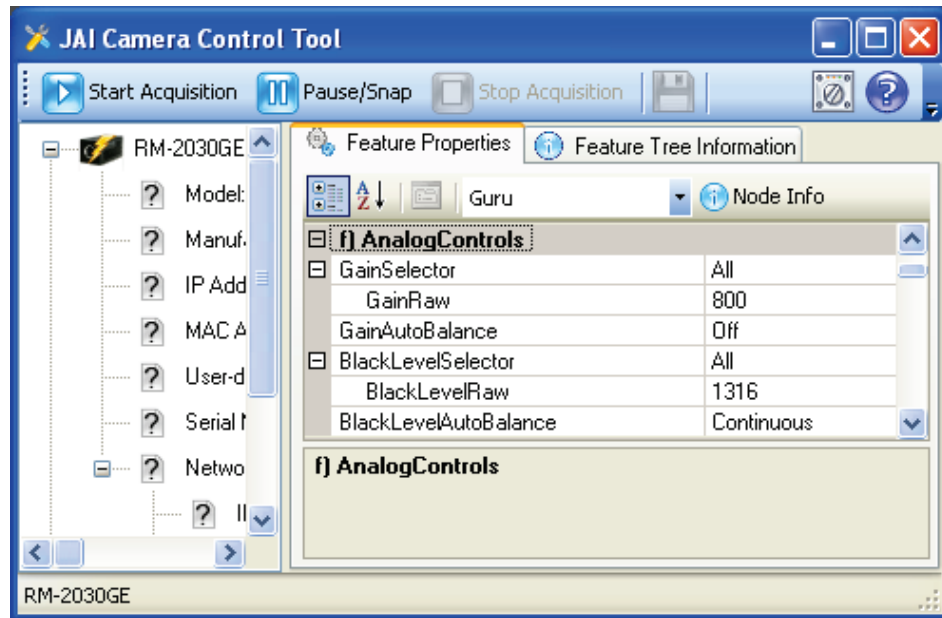
TriggerPolarity: this feature selects which signal state, high or low, of the trigger signal will initiate an image capture for triggered ExposureModes.

5.2 AnalogControls

These controls allow you to make adjustment to image intensities (Gain), Black Level, and channel balancing.

The camera image sensor is read out via two channels called Taps. Each channel's Gain, and Black Level can be independently adjusted.

Figure 19. AnalogControls Category



GainSelector: select the video channel that GainRaw will affect.
Available choices:

- All: entire image.
- Tap2: right channel.

GainRaw: controls the Gain value.

GainAutoBalance: use this feature to balance the left and right channel's Gain values. Make sure the camera is pointing at a uniform light source. The balance is done once and may be repeated if needed. This process may take a long time (~3min), during which the value will stay at "Once". Programmatically, the developer should poll the value to check status after turning on the feature to Once.

- Off: auto balance is not active.
- Once: auto balance is active.

BlackLevelSelector: select the video channel that BlackLevelRaw will affect.
Available choices:

- All: entire image.
- Tap2: right channel.

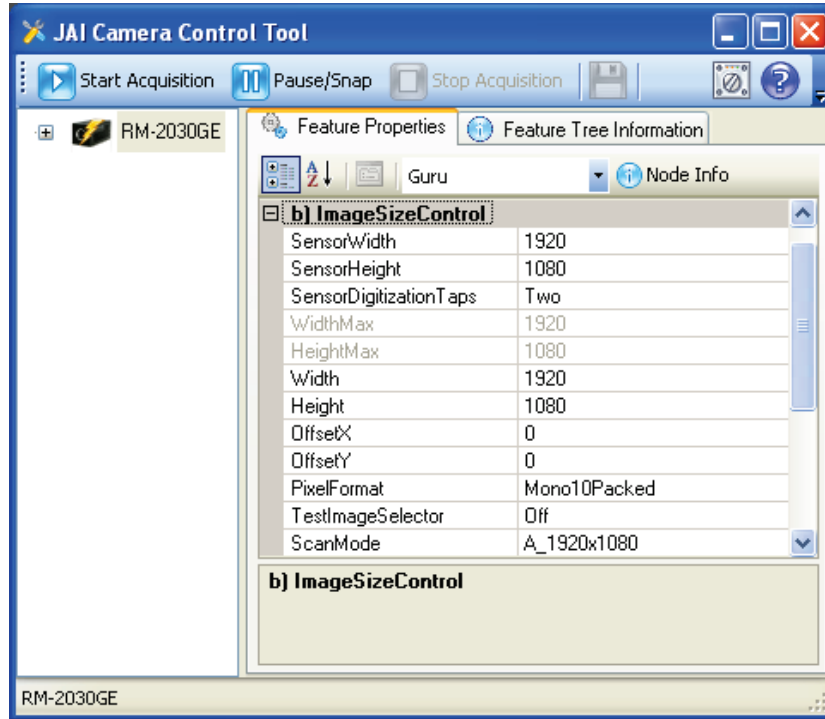
BlackLevelRaw: controls the black level as a raw integer value.

BlackLevelAutoBalance: use this feature to continuously auto balance the channels' Black Level.

5.3 Image Size Controls

These controls allow you to make adjustment to the image's size, scan mode, and tap selection. Please see Table 2 - Scan Area Start Modes for a table of possible image sizes and modes.

Figure 20. ImageSizeControl category



SensorDigitizationTaps: the camera can be configured to read out from the image sensor using either one or two channels. Possible options:

- One: Single Tap. This mode will use one channel to read out images. The image will have a uniform intensity but results in slower frame rate.
- Two: Dual Tap. This mode uses two channels to read out images. Since two different electronic channels are used, the image needs to be balanced by using GainAutobalance and BlackLevelAutobalance.

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.

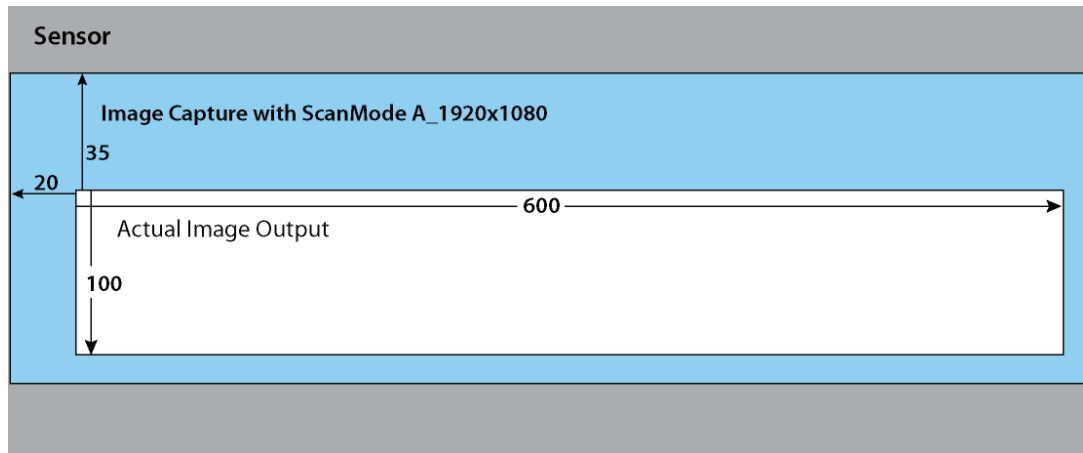
Height: sets the height of the output image. When ScanMode is changed it is necessary to set this value to equal to or less than HeightMax.

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_1920x1080
- Width sets to 600 and Height to 100.
- OffsetX is then set to 20.
- OffsetY is then set to 35.
- The resulting image is of size 600x100 with the upper left pixel offset by 20 pixel horizontally and 35 vertically

Figure 21. 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.
- Mono12: 12-bit monochrome image with 1 pixel needing 2 bytes.
- Mono12Packed: 12-bit monochrome image with 2 pixels packed into 3 bytes.

Bayer: BayerBG patterns are used for OffsetY with odd values.

- BayerGR8: 8-bit Bayer pattern with Green and Red pixels in first row.
- BayerBG8: 8-bit Bayer pattern with Blue and Green pixels in first row.
- BayerGR10: 10-bit Bayer pattern with Green and Red pixels in first row.
- BayerBG10: 10-bit Bayer pattern with Blue and Green pixels in first row.
- BayerGR12: 12-bit Bayer pattern with Green and Red pixels in first row.
- BayerBG12: 12-bit Bayer pattern with Blue and Green 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):

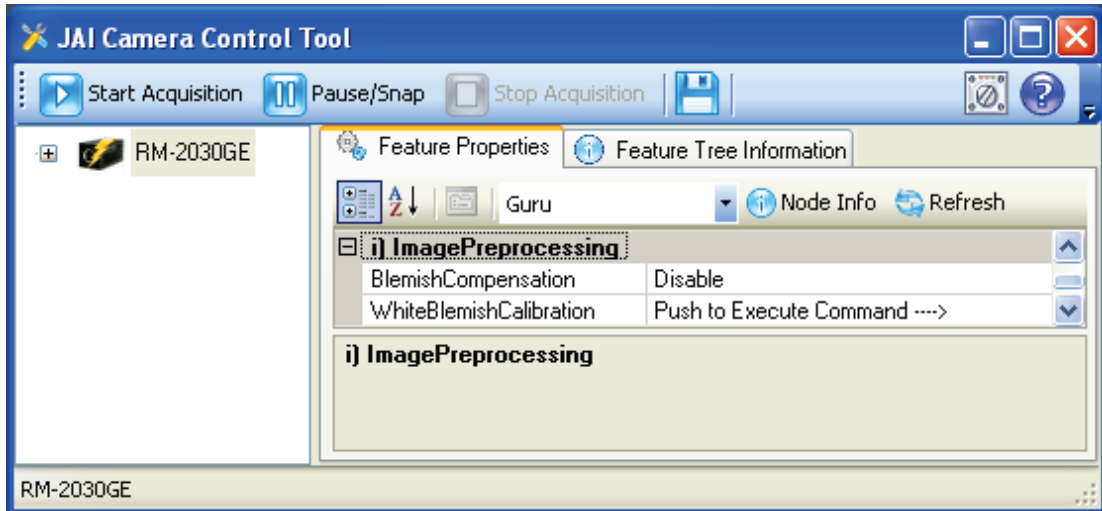
- A_1920x1080
- T_2x2Binning

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 Image Preprocessing

As temperature changes the image sensor can produce defective pixels in images, this feature will attempt to compensate this phenomenon and produce a cleaner image. Run the White Blemish Calibration before using Blemish Compensation.

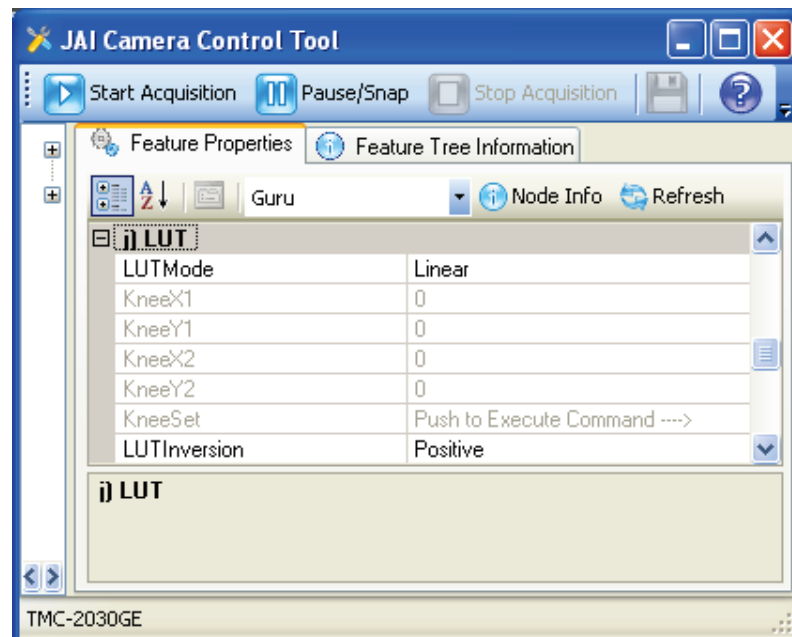


- *BlemishCompensation*: enables or disables Blemish Compensation.
- *WhiteBlemishCalibration*: this is done to calibrate the camera so Blemish Compensation can be run. This is only necessary after a camera has been powered off and restarted. Cover the lens with the lens cap before calibrating.

5.5 LUT (Look Up Table)

The camera's Lookup Table is used for dynamic range control when the camera is in 8, or 10-bit output mode.

Figure 22. 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.

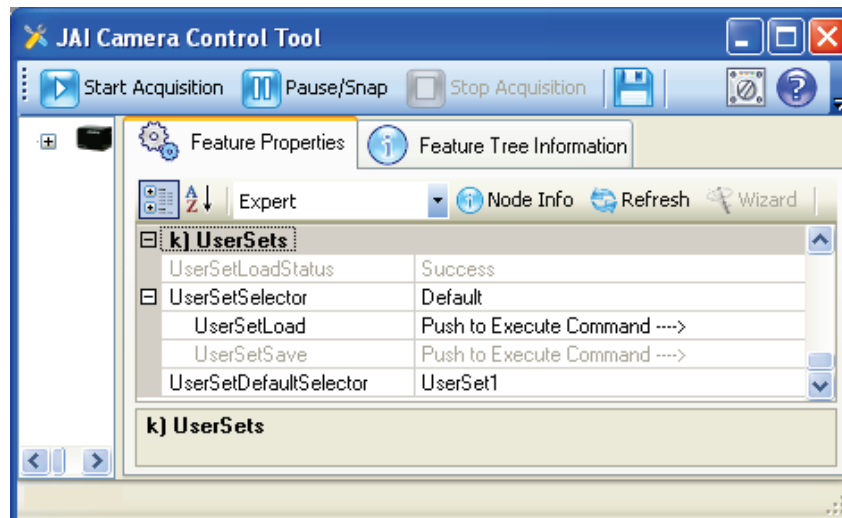
KneeSet: after you have changed the values of the knee points click KneeSet to apply the setting. The camera will take a few seconds to calculate the LUT table. It is recommended to stop image acquisition during this time.

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

5.6 UserSets

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

Figure 23. 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).

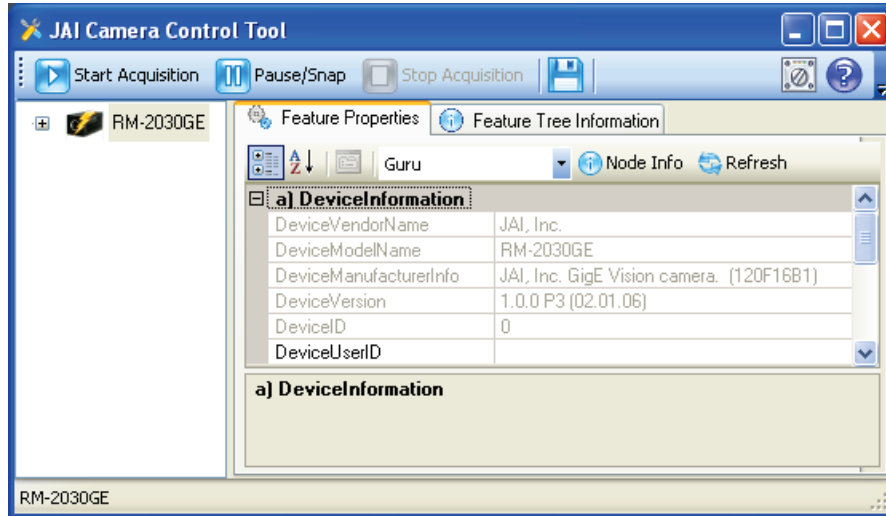
UserSetLoad: load the camera settings from the selected memory page.

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

5.7 DeviceInformation

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

Figure 24. 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.

5.8 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.

5.8.1 Persistent IP

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

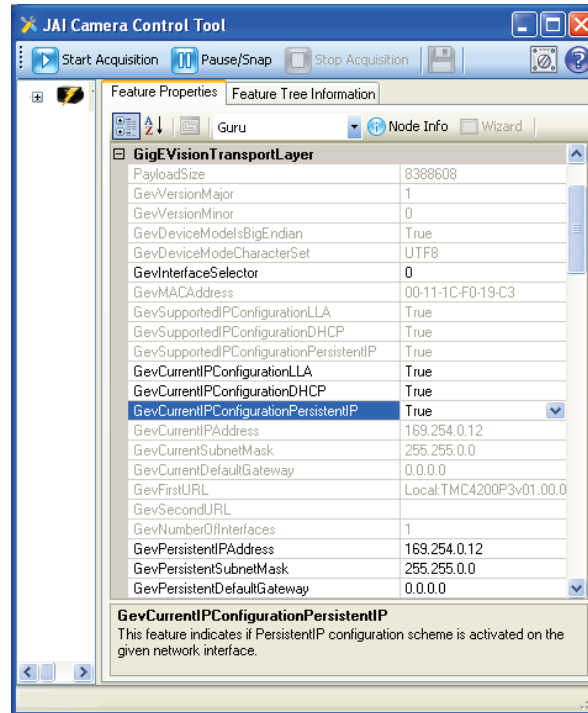
1. Persistent IP
2. DHCP: a DHCP server on the network will assign the camera an IP Address.
3. Link-Local Address (LLA): an IP Address in the 169.254.X.X ranged is assigned.

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:

1. Set Visibility to at least Expert.
2. Set `GevCurrentIPConfigurationPersistenIP` to True.
3. Set `GevPersistentIPAddress` to the IP Address of your choosing. (Ex: 169.254.0.11)
4. 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.
5. Set `GevPersistentDefaultGateway` to the IP Address of your gateway. (Ex: 0.0.0.0)

Figure 25. GigEVisionTransportLayer Persistent IP



5.8.2 Stream Channel Packet Size

GevSCSPacketSize: 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 1428 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 **GevSCSPacketSize** to a desired value.

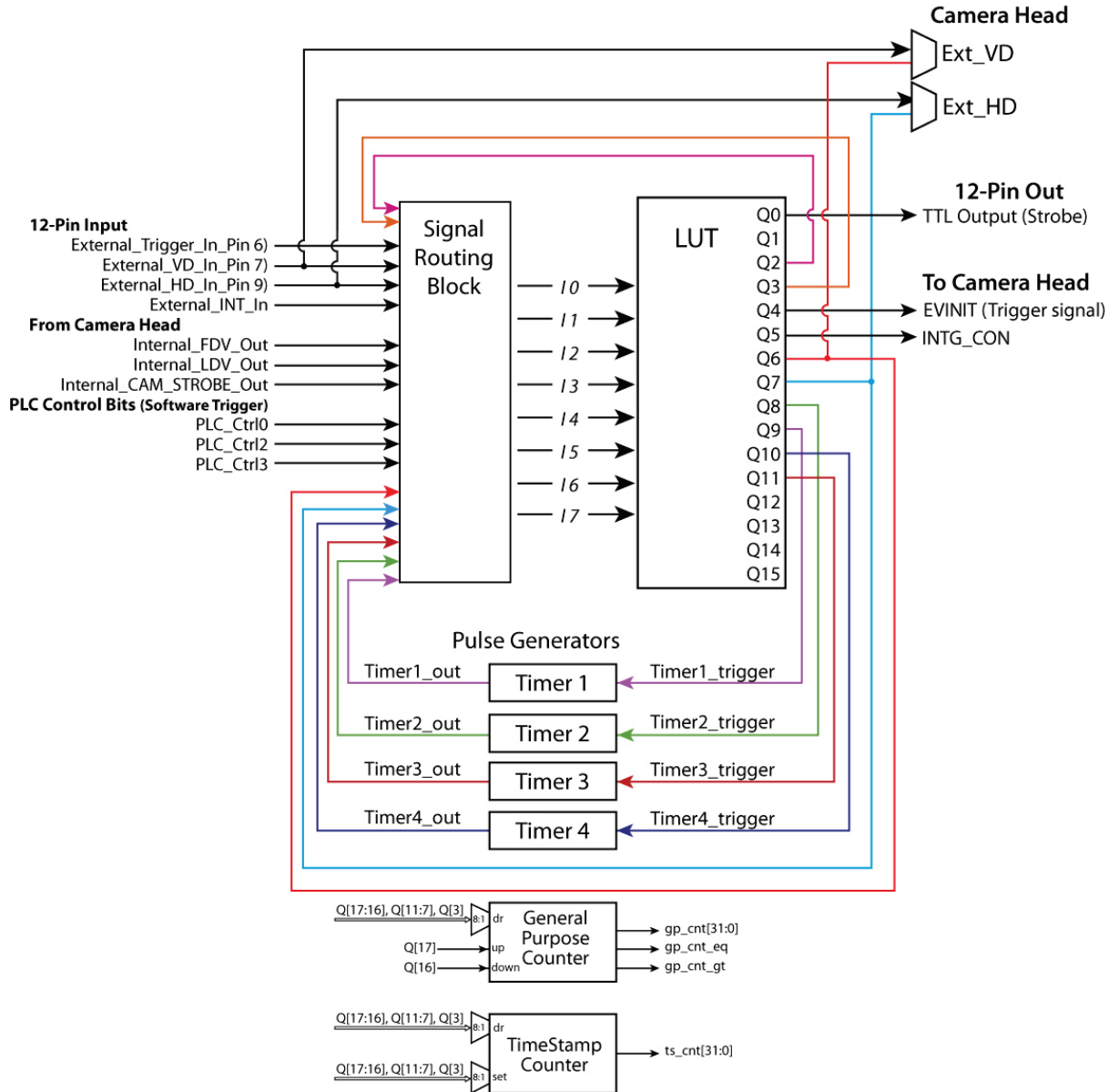
GevHeartbeatTimeout: specifies the current heartbeat timeout in milliseconds. Available only in Guru visibility mode. The host software must send at least one command to the camera during this period otherwise it loses control of the camera. This is usually handled by the control tool.

5.9 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.

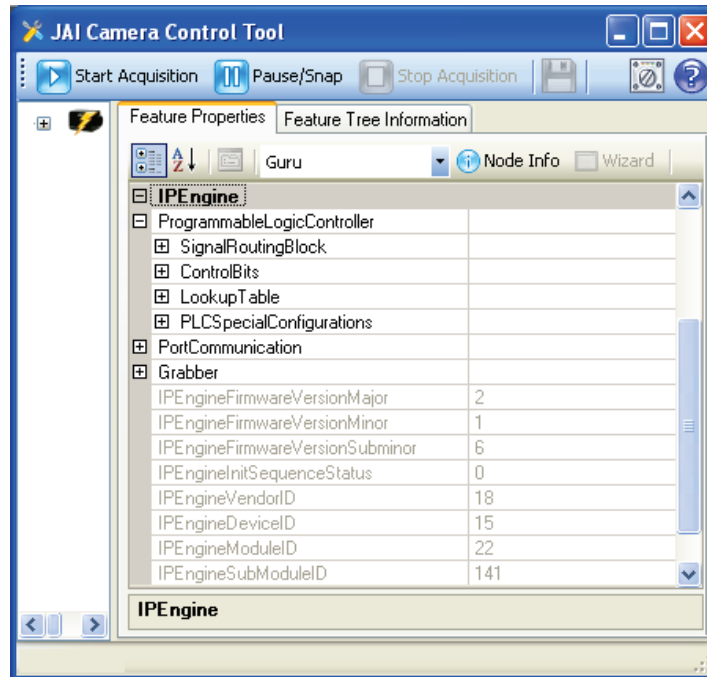
The Grabber is responsible for image transmission. All input and output signals pass through the Programmable Logic Controller (PLC). The PLC contains a Signal Routing Block, Control Bits, and Lookup Table. The PLC also contains 4 Pulse Generators and 1 general purpose counter. By GenICam naming convention 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 26. 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.

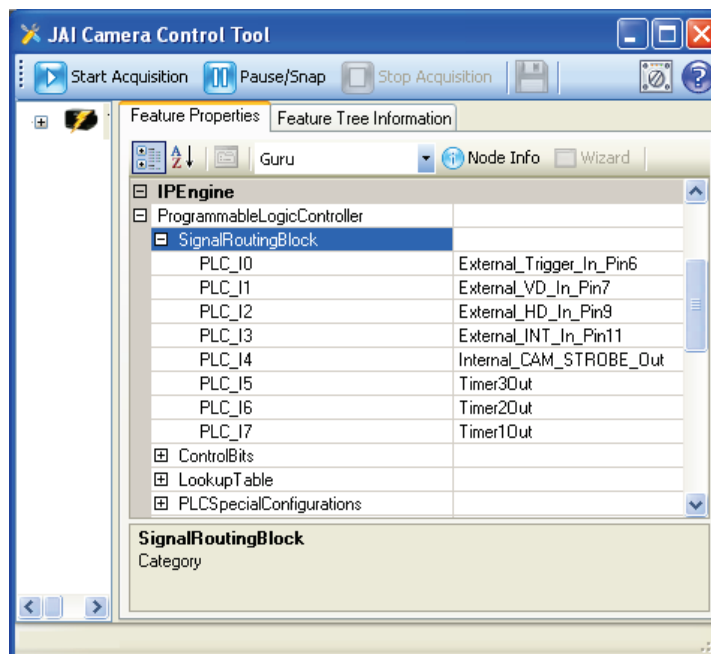
Figure 27. PLC



5.9.1 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 28. 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

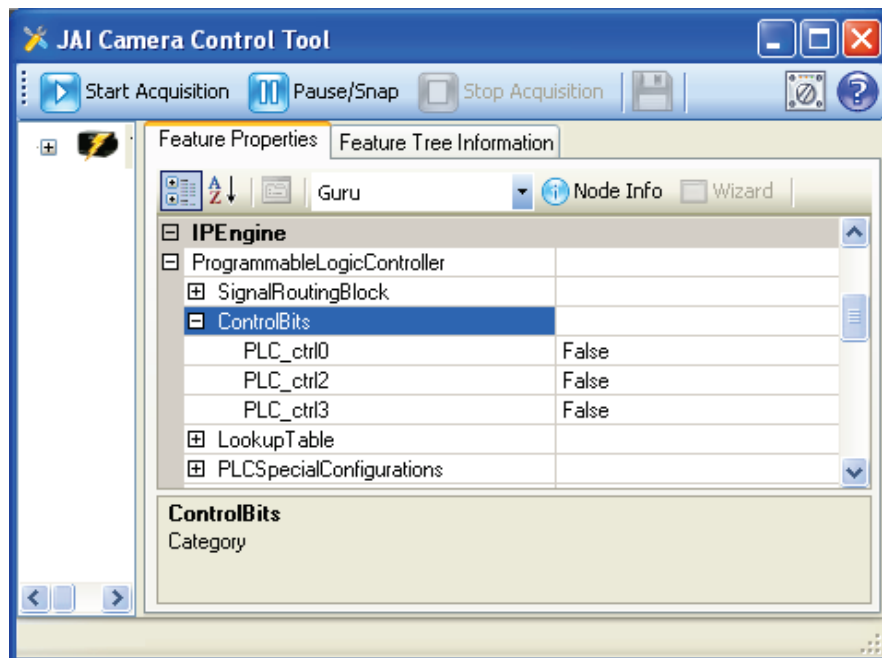
PLC_ctrl0	X	X	X	X		X		X
PLC_ctrl2	X			X	X		X	
PLC_ctrl3		X	X			X		
PLC_Q2	X		X		X		X	
PLC_Q3		X		X		X		X
PLC_Q6	X		X		X		X	
PLC_Q7		X		X		X		X
Counter1Gt				X		X		X
Counter1Eq			X		X		X	
Timer1Out	X		X		X			X(D)
Timer2Out	X		X		X		X(D)	
Timer3Out		X		X		X(D)		X
Timer4Out		X		X			X	

5.9.2 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).

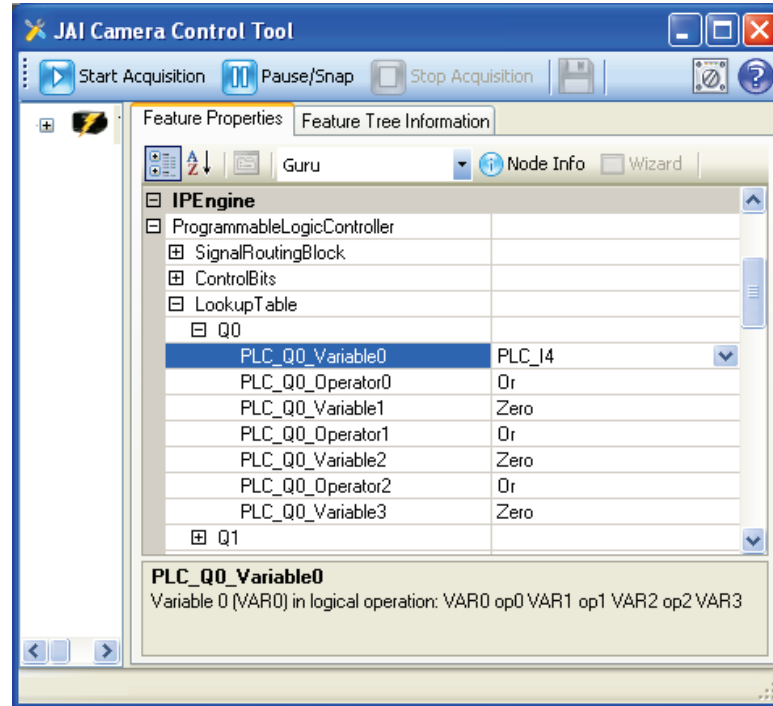
Figure 29. ControlBits



5.9.3 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 30. 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

5.9.4 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 31. PLC Special Configurations

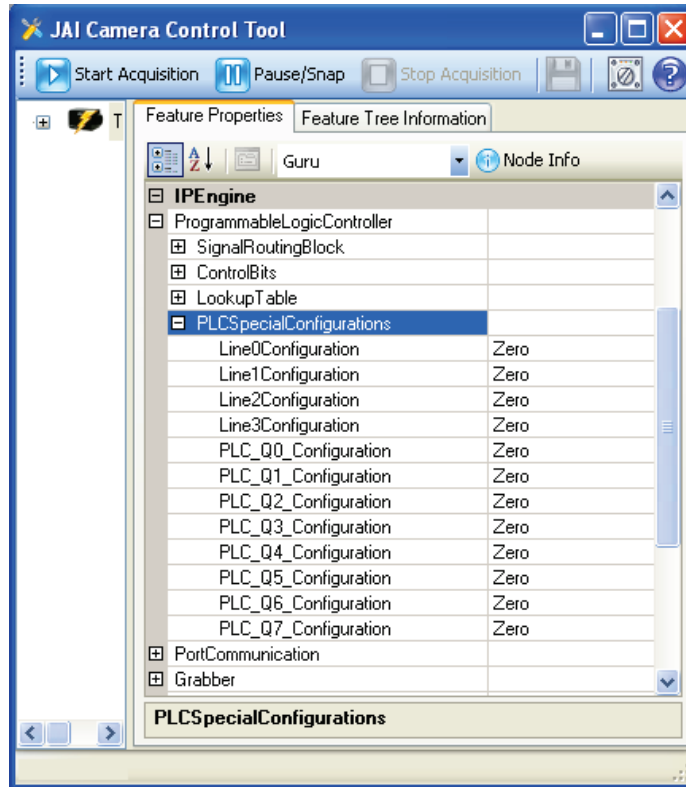
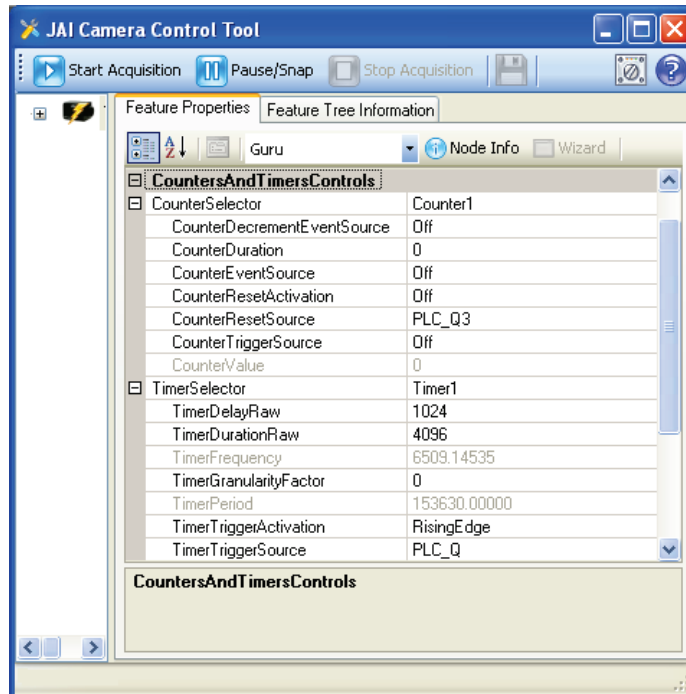
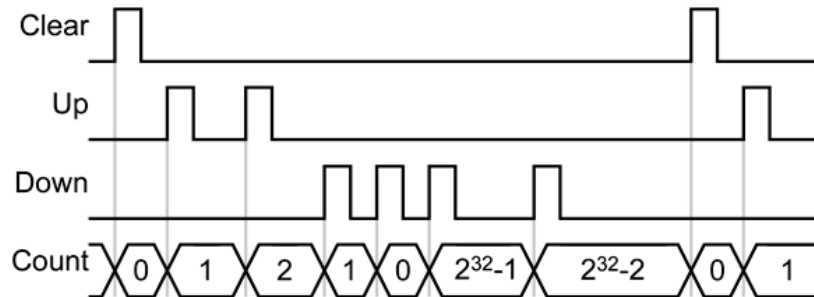


Figure 32. CountersAndTimersControls

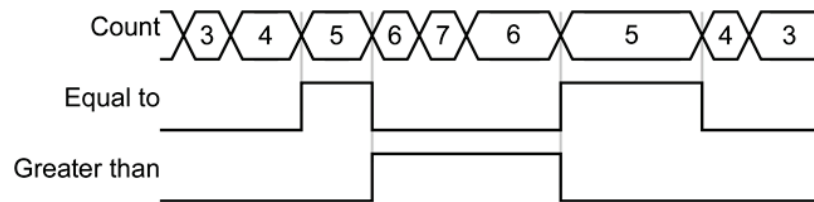


5.9.5 Counters

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:

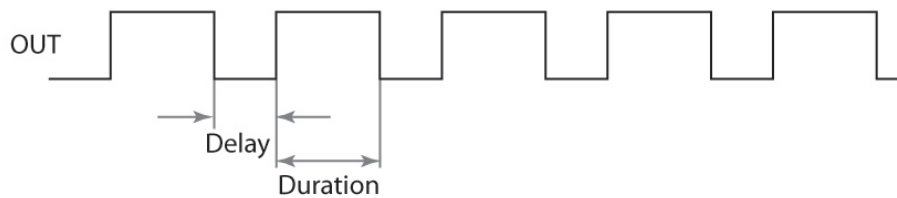
- PLC_Q3
- PLC_Q7
- PLC_Q8
- PLC_Q9
- PLC_Q10
- PLC_Q11
- PLC_Q16
- PLC_Q17

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.

5.9.6 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.

5.9.7 PLC Grabber Features

IPEngine → Grabber → Channel0 → AcquisitionConfiguration

GrbCh0AcqCfgMemoryWaterLevel: the camera has 16MB of memory for frame buffering. 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.

5.9.8 IPEngine Examples:

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

Set ExposureMode to one of the Asynchronous modes.

Setup SignalRoutingBlock

- a. Goto IPEngine > ProgrammableLogicController > SignalRoutingBlock
- b. Set Trigger Input line by setting PLC_I0 to External_Trigger_In_Pin6
- c. 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.

- d. Goto IPEngine > ProgrammableLogicController > LookupTable > Q0/Q4/ Q5
 - i Set PLC_Q0_Variable0 to PLC_I4 (Strobe output)
 - ii 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.)

5.10 Register Map

Category / Feature	Read/Write	Value Range	Default Value	Visibility Level
AcquisitionAndTriggerControls				
AcquisitionMode	RW	Continuous SingleFrame MultiFrame ContinuousRecording ContinuousReadout SingleFrameRecording SingleFrameReadout	Continuous	Beginner
AcquisitionFrameCount	RW	1-255	1	Beginner
AcquisitionStart	RO	Execute Command		Beginner
AcquisitionStop	RO	Execute Command		Beginner
AcquisitionRecordingWrapAround	RW	True False	False	Expert

Category / Feature	Read/Write	Value Range	Default Value	Visibility Level
BlockBufferCount	RO			Expert
BlockBufferCurrentIndex	WO	0 to BlockBufferCount-1		Expert
ExposureMode	RW	Off ContinuousProgrammable AsyncNoShutter PulseWidthControl FixedExposurePIV PWC_PIV AsyncProgrammable	Off	Beginner
AsyncProgrammable	RW	0-2079	Factory Set	Beginner
ContinuousProgrammable	RW	ScanMode Limited 0 - 1180 (A) 0 - 640 (Binning 2x2)	Factory Set	Beginner
TriggerPolarity	RW	ActiveLow ActiveHigh	ActiveLow	Beginner
AnalogControls				
GainSelector	RW	All Tap2	All	Beginner
GainRaw	RW	0 - 4095	Factory Set	Beginner
GainAutoBalance	RW	Off Once	Off	Beginner
BlackLevelSelector	RW	All Tap2	All	Expert
BlackLevelRaw	RW	0 - 4095	Factory Set	Expert
BlackLevelAutoBalance	RW	Off Continuous	Continuous	Expert
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		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 -	000.000.000.000	Expert

Category / Feature	Read/Write	Value Range	Default Value	Visibility Level
		255.255.255		
GevPersistentDefaultGateway	RW	000.000.000.000 - 255.255.255	000.000.000.000	Expert
GevCurrentIPConfigurationPersistenIP	RW	On Off	Off	Beginner
ImageSizeControl				
SensorDigitizationTaps	RW	One Two	Two	Expert
WidthMax	RO	0 - 1920		Beginner
HeightMax	RO	0 - 1080		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 Mono12 Mono12Packed Bayer: BayerGR8 BayerBG8 BayerGR10 BayerBG10 BayerGR12 BayerBG12	Monochrome: Mono8 Bayer: BayerGR8	Beginner
ScanMode	RW	A_1920x1080 T_2x2Binning	A_1920x1080	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

Category / Feature	Read/Write	Value Range	Default Value	Visibility Level
KneeX2	RW	0 - 255	255	Beginner
KneeY2	RW	0 - 255	255	Beginner
LUTInversion	RW	Execute Command		Beginner
UserSets				
UserSetSelector	RW	Default UserSet1 ... UserSet6	UserSet1	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
- Power cables
- Main power source
- Shutter control
- Async mode
- Lens
- Digital output cable
- 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

6.1.4 Symptom: Notebook Computer Driver Installation Problems

Remedies: The IBM T-42 laptop is unable to properly install.

6.1.5 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

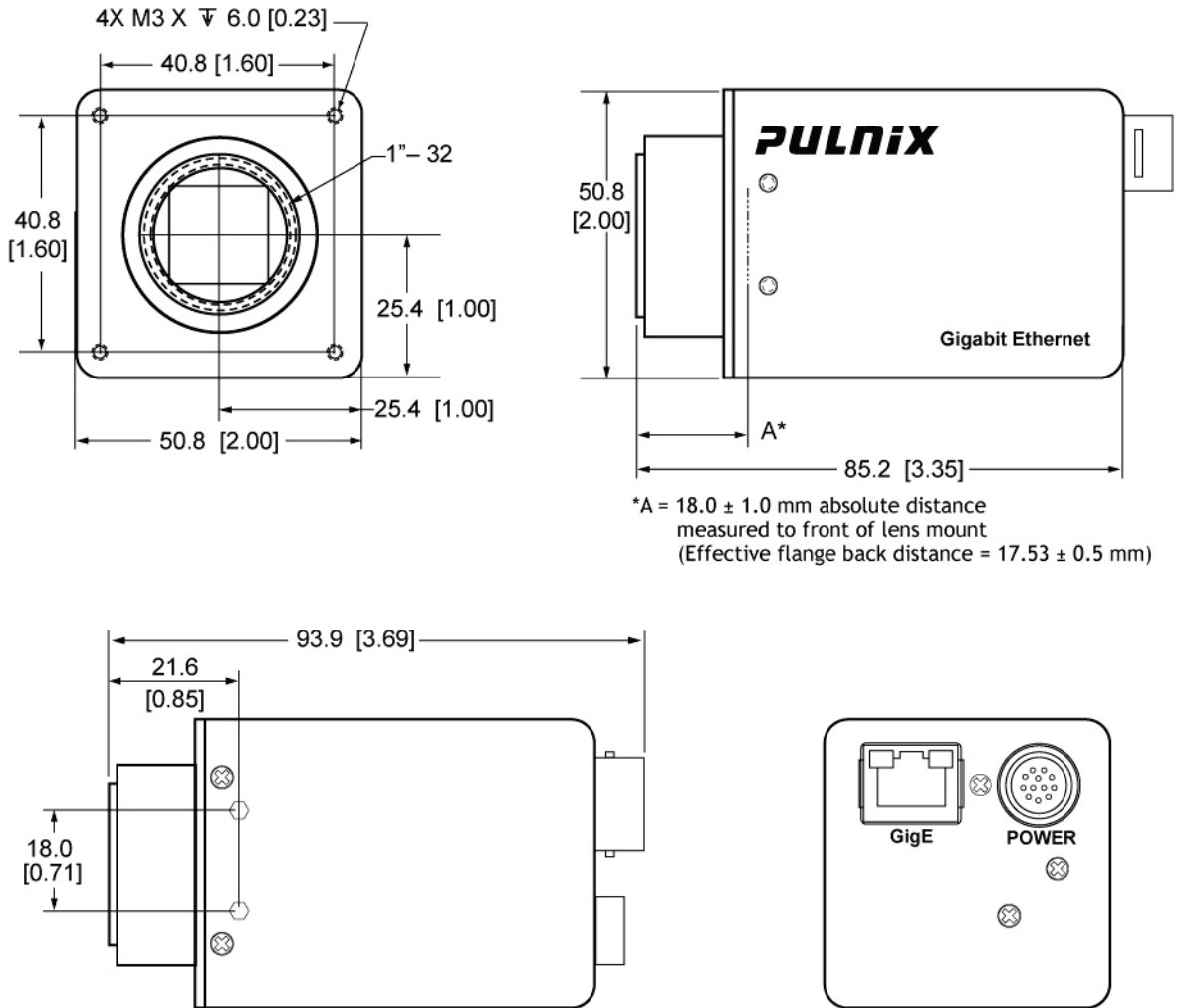
Table 4 TM-2030GE Camera Specifications Table

Feature	TM-2030GE
Sensor	1" progressive scan interline transfer CCD (KAI-2093)
Active Area	14.2mm x 8.0mm
Active Pixels	1920 (H) x 1080 (V)
Cell Size	7.4μm x 7.4μm
Readout Mode (Active Pixels)	1920 (H) x 1080 (V) @ 32 Hz (dual tap) or 16 Hz (single tap) selectable
Sync	Internal/External auto switch HD/VD, 4.0 Vp-p impedance 4.7 K ohms VD=32.32 ±2%, non-interlace HD=36.36 kHz ±2%
Data Clock Output	40.00 MHz
Resolution	Digital: 1920 (H) x 1080 (V), (Analog: over 800 TV lines (H) x 1600 TV lines (V))
S/N Ratio	>57dB min.
Min. Illumination	Monochrome: 0.45 lux. Color: 3.6 lux. f = 1.4 (no shutter) @ 32 fps. Sensitivity: 14μV/e-
Video Output	Digital output: 8-bit / 10-bit /12-bit Gigabit Ethernet selectable
Gamma	Programmable LUT (1.0 std.)
Lens Mount	C-mount (use 1" format lenses or larger)
Power Requirement	12V DC, ±10%, 800mA (typical at 25°C)
Operating Temp.	-10°C to 50°C*
Vibration	7 g (10Hz to 2000Hz) Random
Shock	70G, 11 ms half sine
Size (W x H x L)	51mm x 51mm x 85mm
Weight	215 grams (7.5 oz.) without tripod
Optional Functions	OP3-1 Internal IR Filter Added; OP3-2 Optical Filter Removal (color only); OP21 Glassless CCD Imager; OP21-1UV Ultraviolet Imager (monochrome only);
Optional Accessories	
Power Cable	12P-02S
Power Supply	PD-12UUP series (includes power connector)
Tripod Mounting Kit	TP-20

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

7.1.1 TM-2030GE Physical Dimensions

Figure 33. Physical Dimensions



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 34. Monochrome Spectral Response

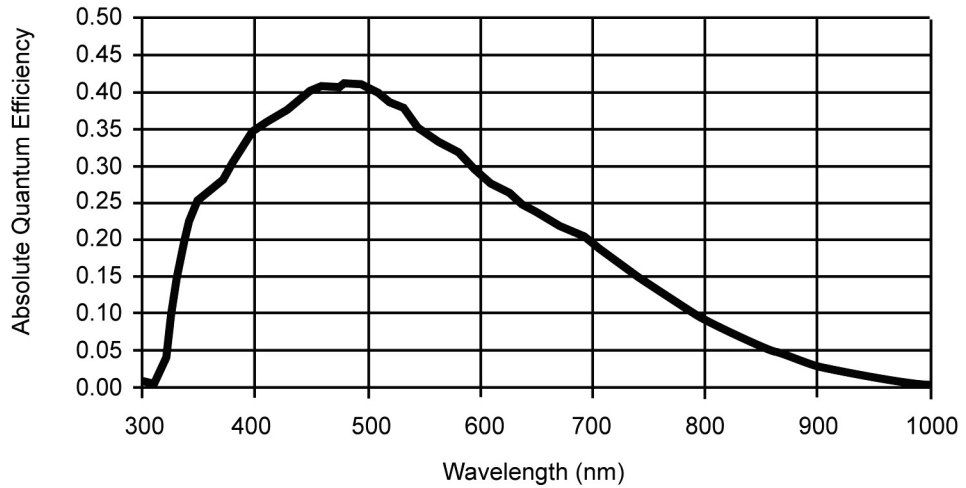
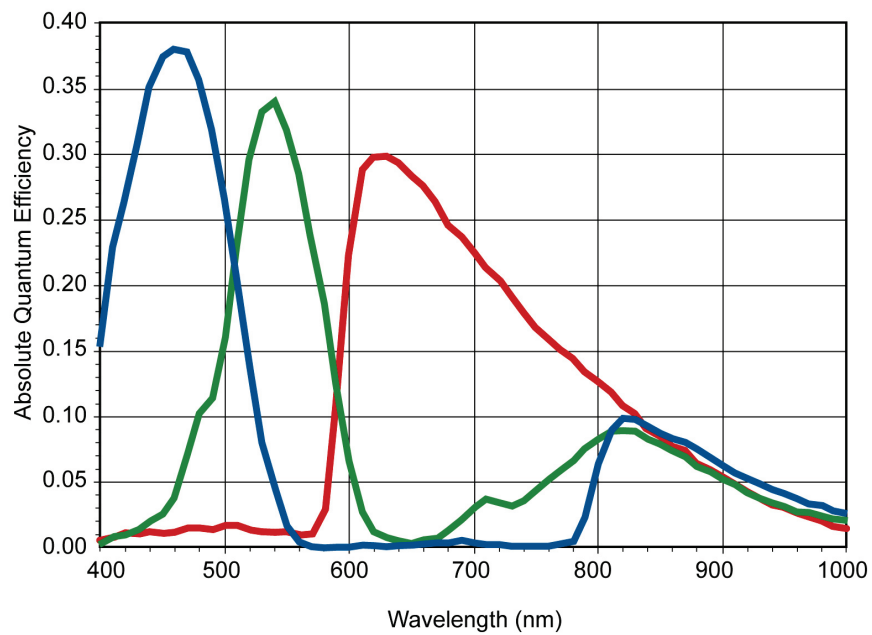


Figure 35. Color Spectral Response




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。)						



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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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