

Setting Up Multiple GigE Cameras

Technical Application Note TAN2012004

Revised May 26, 2014

1.1 Subject

Technical Application Note (TAN2012004): Setting Up Multiple GigE Cameras

1.2 Applicable Product(s)

- All Point Grey GigE Vision Imaging Devices

1.3 Application Note Description

This application note provides information on configuring and understanding your GigE camera setup. It includes the following sections:

[Preparing for Use](#)

[Maximizing GigE Potential](#)

[Configuring Your GigE Camera](#)

[Allocating Bandwidth](#)

[Setting up Multiple Cameras](#)

[Troubleshooting](#)

1.4 Preparing for Use

Before you use your Point Grey GigE camera, we recommend that you are aware of the following resources:

Getting Started Manual for the camera—provides information on installing components and software needed to run the camera. The Getting Started manuals can be downloaded from the [Point Grey Website](#).

Technical Reference for the camera—provides information on the camera's specifications, features and operations, as well as imaging and acquisition controls. The technical references can be downloaded from the [Point Grey Downloads](#) page.

FlyCapture2 SDK—contains utilities to configure the camera (GigE Configurator and Driver Control GUI), update firmware and drivers, and check setup. As well, contains the FlyCapture2 API for use in creating your own applications. FlyCapture2 can be downloaded from the [Point Grey Downloads](#) page.

Firmware updates—ensure you are using to most up-to-date firmware for the camera to take advantage of improvements and fixes. The latest firmware can be downloaded from the [Point Grey Downloads](#) page.

1.5 Maximizing GigE Potential

Frame Buffer

All Point Grey GigE cameras include a 32 MB frame buffer that can be used for temporary image storage. This may be useful in cases such as:

- Retransmission of an image is required due to data loss or corruption.
- Multiple camera systems where there is insufficient bandwidth to capture images in the desired configuration.

All images pass through the frame buffer mechanism.

GigE link layer IP

Point Grey has implemented its own GigE link layer technology on an FPGA. This eliminates the dependency of a third party chip vendor and allows Point Grey to continuously improve the camera and firmware to ensure maximum compatibility with third party hardware.

Image Filter Driver

To reduce GigE packet load on the CPU, Point Grey provides the Image Filter Driver (pgrGigEm.inf). This driver operates between the camera and the Microsoft built-in UDP stack to filter out GigE vision stream protocol (GVSP) packets. The CPU does not process all the packets, and therefore is used less.

1.6 Configuring your GigE Camera

1.6.1 Configuring Drivers

Ensure you are using the best driver for your configuration. The Driver Control utility provided with FlyCapture2 allows you to verify which driver is in use and install a different driver if necessary.

Point Grey GigE cameras can operate by communicating directly with the Microsoft UDP stack. However, it is recommended to use the Point Grey Image Filter Driver in order to improve image streaming performance.



GigE cameras operating on Linux systems communicate directly with the drivers that come with Ubuntu distributions (i.e., no performance driver).

To open the Driver Control utility:

Start Menu→All Programs→Point Grey Research→FlyCapture2→Utilities→DriverControlGUI

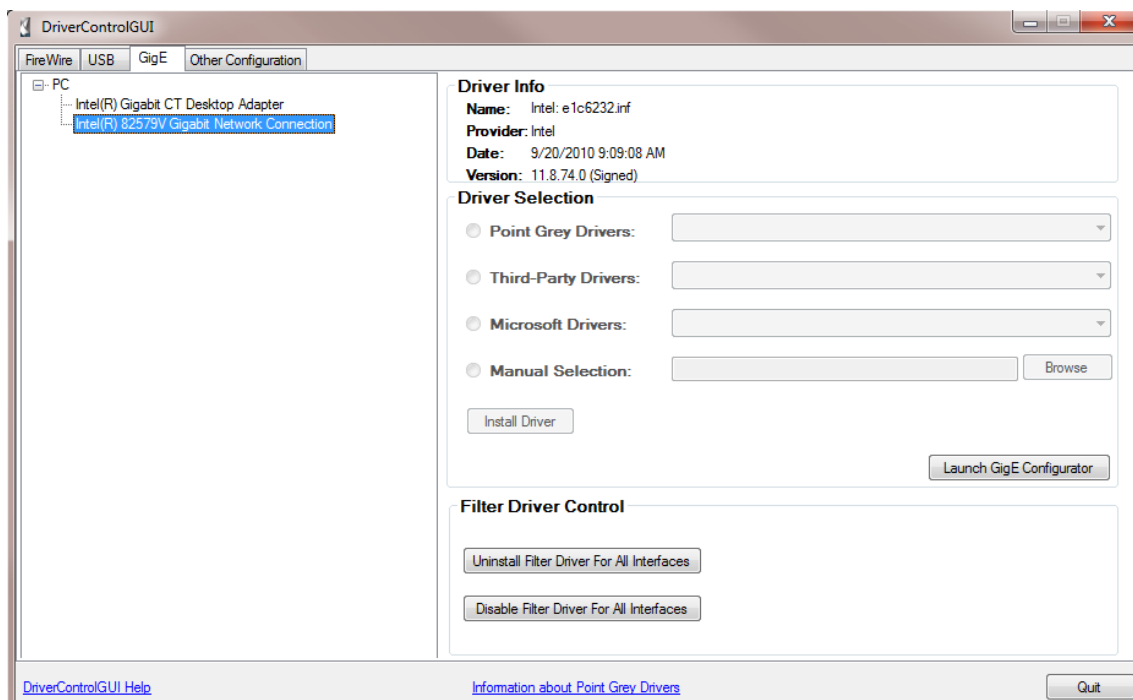


Figure 1. DriverControlGUI
(FlyCapture 2.3.1.7—Windows7, 32-bit)

1.6.2 Configuring Host Adapter and GigE Camera

The GigE Configurator is a utility that is installed with FlyCapture2 that allows you to control the configuration of your network adapter and GigE camera.

To open the GigE Configurator:

Start Menu→All Programs→Point Grey Research→FlyCapture2→Utilities→GigE Configurator

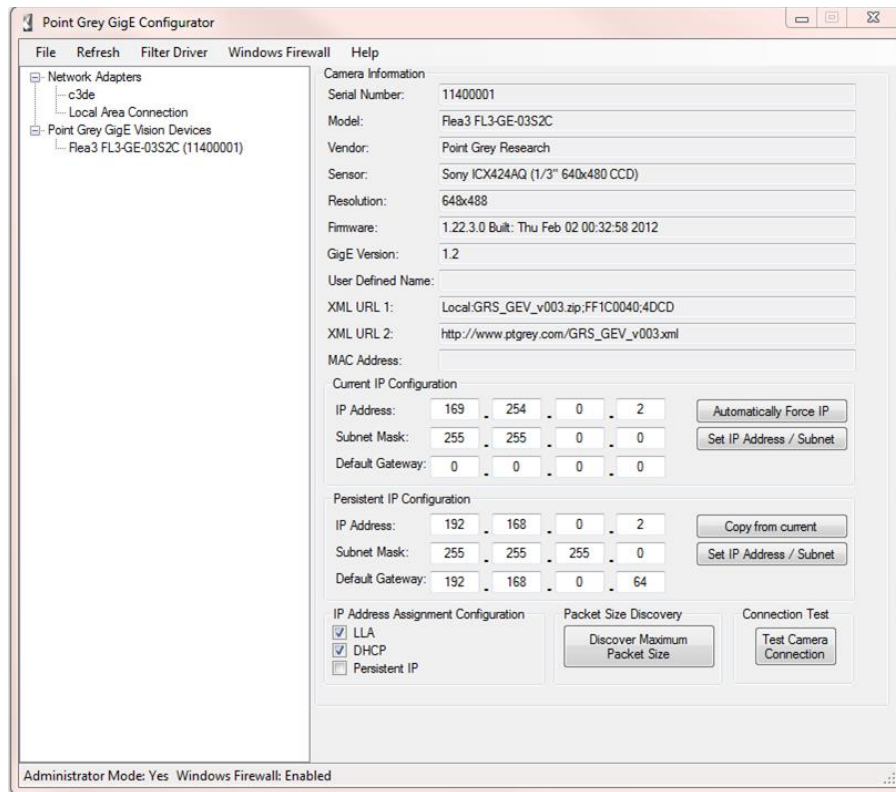


Figure 2. GigE Configurator
(FlyCapture2 v2.3.1.7—Windows7, 32-bit)

Note: The GigE Configurator can also be opened from the Driver Control utility.

The GigE Configurator lists your Network Adapters and your Point Grey GigE devices and allows you to access the following:

- Adapter and device properties
 - Manage IP addresses
 - Link speed
 - MTU (maximum transmission unit)
- Camera IP configuration options
 - DHCP protocol
 - Persistent IP

- Link-local address (LLA)
- Driver and firewall
 - Enable/disable the Point Grey image filter driver
 - Enable/disable the Windows Firewall

As well, the GigE Configurator can be used to test the camera connection and discover the maximum packet size.

1.6.3 Setting the IP Address

Both the camera and the host adapter must have an IP address on the same subnet. This can be assigned in three ways:

Persistent—Both the adapter and the camera have a fixed IP address that will not change. Generally the address is within a closed network range of 192.168.X.X. The adapter and the camera must be on the same subnet.



Persistent IP addressing is recommended for multiple cameras on multiple ports.

Dynamic (DHCP)—Both the camera and the adapter are set to automatically obtain an IP address. This means that the IP address will dynamically change (within a range) every time the camera or computer is restarted. It may take up to one minute for the IP address to resolve and the camera to enumerate.

Default (LLA)—Both the camera and the adapter use a default IP address from the link-local address block 169.254.x.x.

The camera assigns its current IP address in the following sequence:

1. Persistent—Uses the defined IP address. If not available, then;
2. DHCP—Attempts to find a dynamic IP address. If not available, then;
3. LLA—Uses the default IP address.

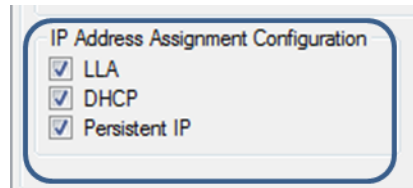
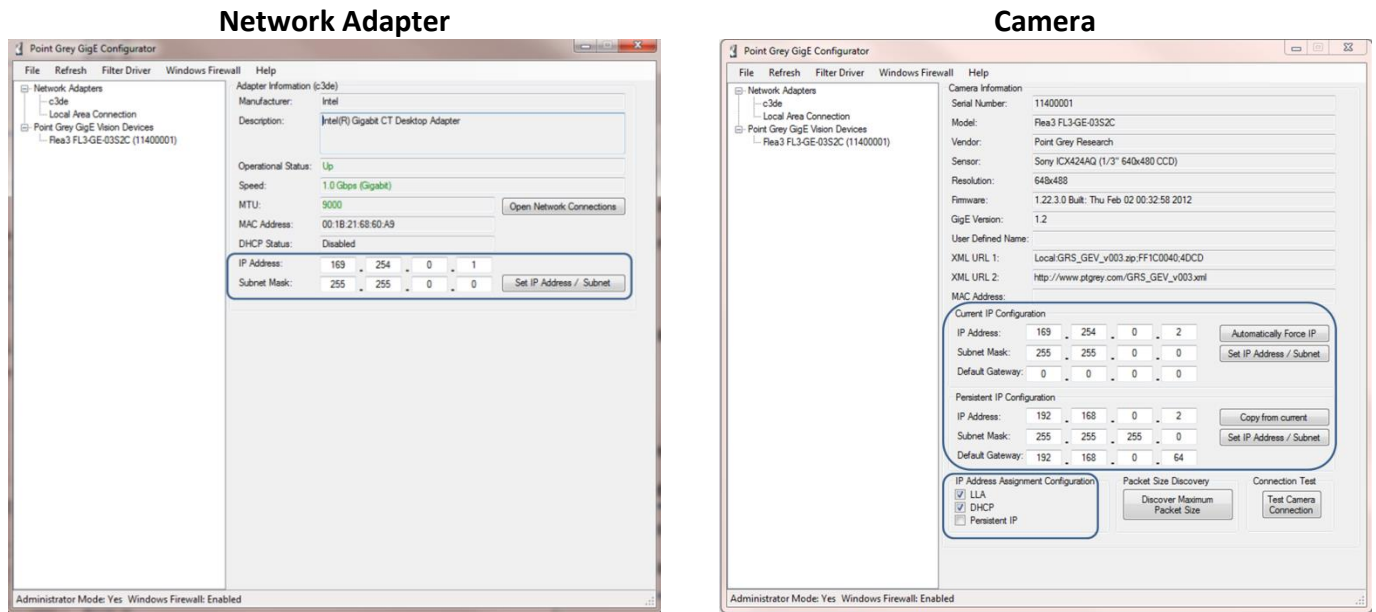


Figure 3. IP Address Assignment Configuration in GigE Configurator (FlyCapture2 v2.3.1.7—Windows7, 32-bit)

You can use the GigE Configurator to set the IP address to both the adapter and the camera. LLA cannot be deselected as an option.



**Figure 4. IP Addressing in GigE Configurator
(FlyCapture2 v2.3.1.7—Windows7, 32-bit)**

1.6.4 Multiple Host Adapter

When setting up multiple cameras using multiple host adaptors. It is important to put each host adaptor on its own subnet.

For example:

Subnet A	IP Address	Subnet Mask
Host Adaptor 1	192.168.100.1	255.255.255.0
Camera 1	192.168.100.2	255.255.255.0
Camera 2	192.168.100.3	255.255.255.0

Subnet B	IP Address	Subnet Mask
Host Adaptor 2	192.168.200.1	255.255.255.0
Camera 3	192.168.200.2	255.255.255.0
Camera 4	192.168.200.3	255.255.255.0

1.6.5 Auto Force IP

The GigE Configurator can automatically force an IP address refresh. This detects the IP address of the Network Interface card and automatically sets the camera's IP address relative to the card.

The FlyCap2 demo program can be used to test your camera settings and verify operation. From the camera selection window, you can also automatically force an IP address refresh.

1.7 Bandwidth Allocation

The User Datagram Protocol (UDP) used by the GigE Vision standard provides no guaranteed transmission or fixed timing mechanism. Therefore, bandwidth must be managed by adjusting packet size and packet delay, based on desired resolution and frame rate.

1.7.1 Packet Size

Packet size influences the number of interrupts generated which affects CPU usage. The larger the packet size, the fewer the interrupts for the same amount of data. To minimize CPU usage, increase the packet size.

The upper limit depends on your host adapter, your Ethernet switches (if used), and the camera.

From the GigE Configurator with your adapter selected, click Open Network Connections to open the Windows Adapter Properties. Adjust the packet size of your host adapter to ~9000 (the standard jumbo packet size). If your adapter does not support such a large packet (or MTU) size, then you will experience slightly higher CPU usage.

From the GigE Configurator with your camera selected, click Discover Maximum Packet Size. This will test the network to see the maximum size that can be sent and received. Set your camera's packet size to be less than or equal to this maximum.

1.7.2 Packet Delay

The Packet delay acts like a gap between packets during transmission. This delay allows the host to process the current packet before the arrival of the next one. When you increase the packet delay value from zero, you reduce the effective bandwidth assigned to the camera and thereby also reduce the possibility of dropped frames.



Increasing the packet delay is recommended when running multiple cameras through an Ethernet switch.

1.7.3 Adjusting Packet Size and Packet Delay

Packet size and packet delay for the camera are configurable using Point Grey's FlyCapture2 API or the FlyCap2 demo program.

To use the FlyCap2 demo program:

1. Start Menu→All Programs→Point Grey Research→FlyCapture→FlyCap2



You must close the GigE Configurator before opening FlyCap2.

2. In the Camera Selection window, select your camera and click Configure Selected.
3. In the Camera Configuration window, click Custom Video Modes. An estimate of the camera's bandwidth is provided.
4. The GigE Packet Size and Packet Delay parameters can be adjusted using a slider or number field. Click Apply.



Changing the video mode, pixel format, or region of interest, may require further adjustments to the packet size/packet delay.

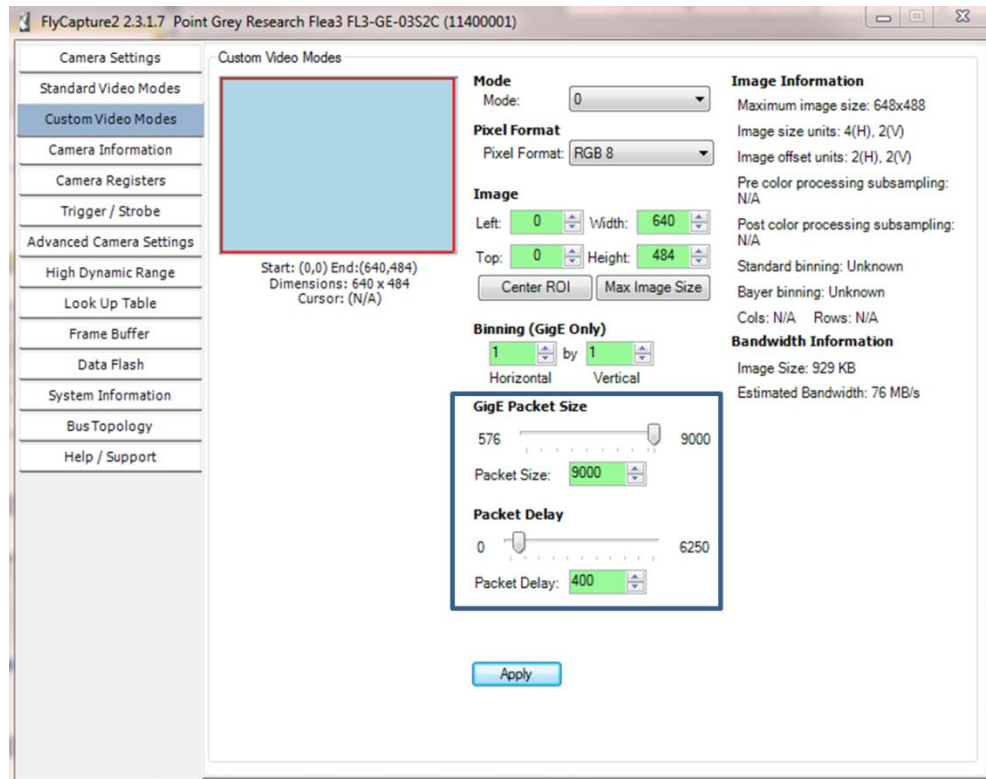


Figure 5. Packet Size and Packet Delay in the Camera Configuration window (FlyCapture 2.3.1.7—Windows7, 32-bit)

Packet size for the host adapter is configurable through Windows Device Manager, accessible from the GigE Configurator. It is identified in the GigE Configurator as MTU (Maximum Transmission Unit) and in Device Manager as Jumbo Packet.

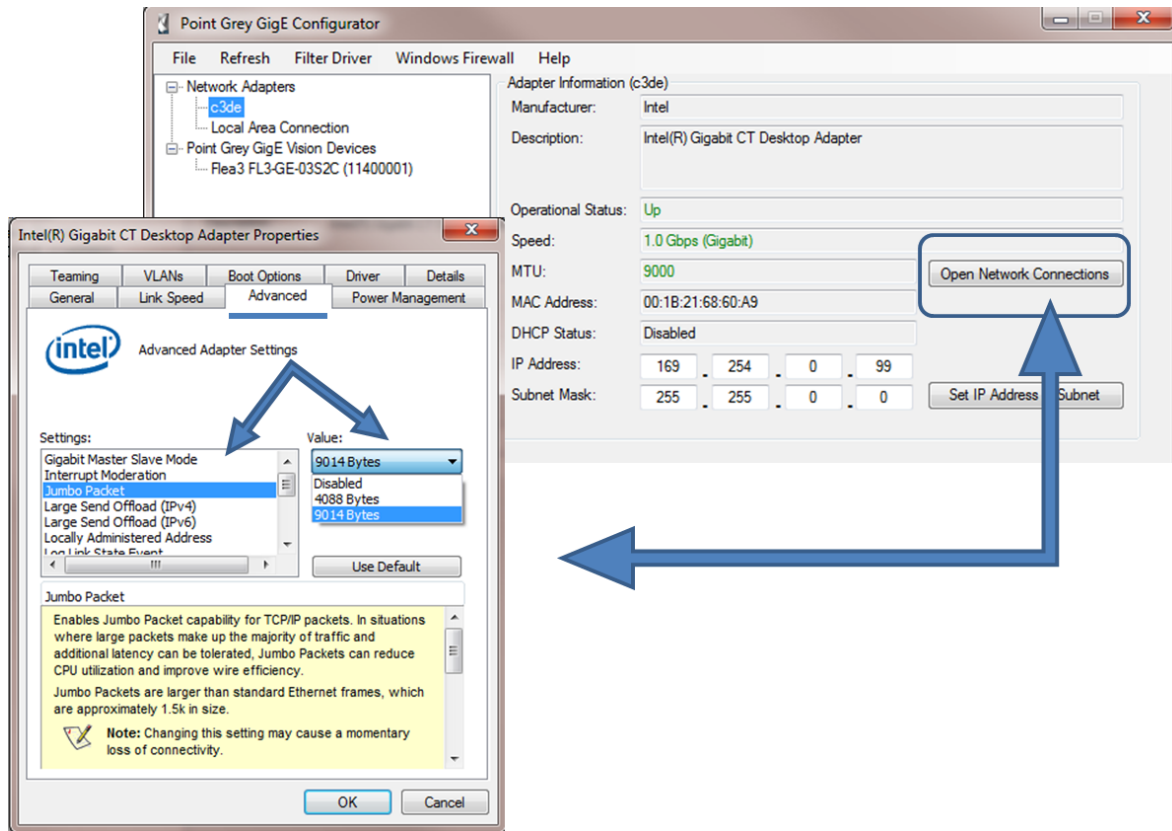


Figure 6. Setting Adapter Packet Size (MTU)
(FlyCapture2 v2.3.1.7—Windows7, 32-bit)

1.7.4 Calculating Required Bandwidth

The maximum bandwidth available is 125 MB. This includes image data, control data and image resends, which occur when frames are being dropped. Each image and each packet has a certain amount of overhead that will use some bandwidth. Therefore, when calculating your bandwidth requirements, you should not attempt to use the full maximum of 125 MB.



If the packet size and packet delay combination exceeds the available bandwidth, frames will be dropped.

To calculate your bandwidth requirements:

- Determine your required resolution, frame rate, and pixel format (bytes per pixel)
Height x Width x Frame Rate x Bytes per Pixel = Bandwidth in MB

- As an example, for an image that is VGA, 82 FPS, Mono8:
 $640 \text{ (H)} \times 480 \text{ (W)} \times 82 \text{ (FPS)} \times 1 \text{ (BPP)} = \sim 25 \text{ MB}$

FlyCap2 provides the estimated bandwidth on the Custom Video Modes tab.

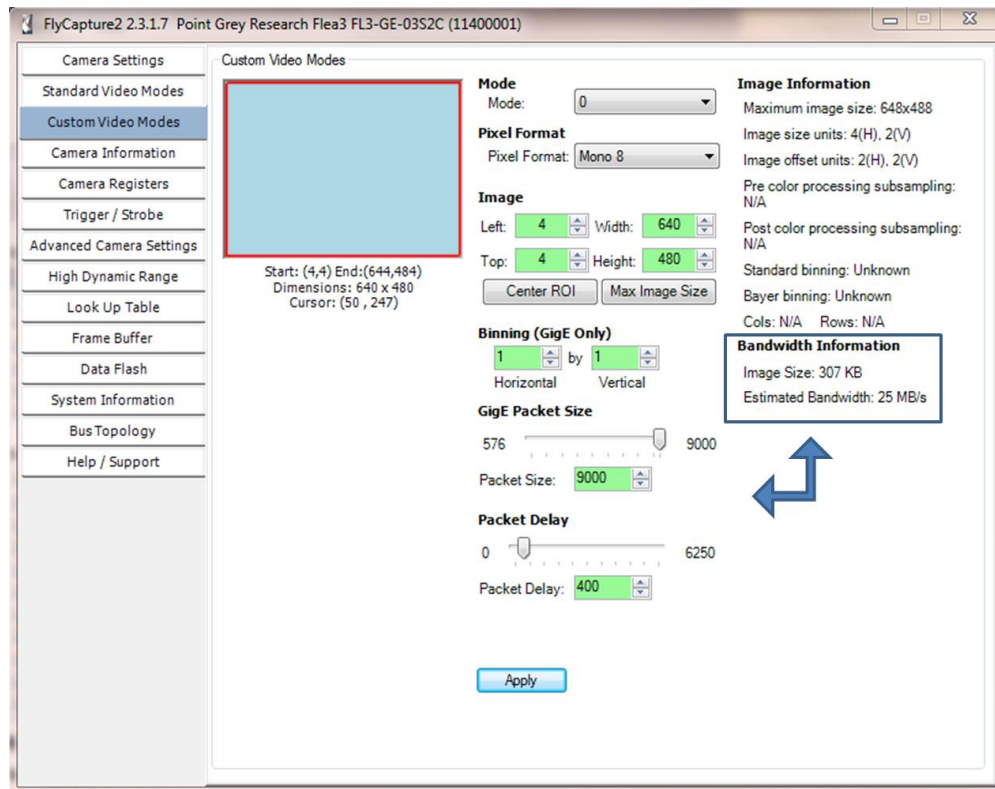


Figure 7. Estimated Bandwidth shown in the Camera Configuration window (FlyCapture 2.3.1.7—Windows7, 32-bit)



If your version of FlyCap2 does not display Estimated Bandwidth, please download the latest version from the [Point Grey Downloads](#) site.

Understanding your required bandwidth helps you determine what kind of configuration you need for setting up multiple cameras (see [Setting Up Multiple Cameras](#)).

Once you have calculated your required bandwidth, you can allocate an amount to each camera by adjusting the packet size and packet delay. Allocating a specific amount to each camera helps to avoid dropped packets due to a data burst. You would do this in a set up with multiple cameras, or in a situation where the system bandwidth might be limited or shared due to hardware architecture.

Here are some packet size/packet delay combinations you can use with any image size, pixel format combination. Frame rate will be limited depending on total bandwidth.

To allocate 25 MB ~20% of bandwidth	To allocate 55 MB ~ 45% of bandwidth
Packet Size = 9000 Packet Delay = 5900	Packet Size = 9000 Packet Delay = 1800
Packet Size = 1400 Packet Delay = 900	Packet Size = 1400 Packet Delay = 255

1.8 Setting up Multiple Cameras

There are two methods of setting up multiple cameras.

1.8.1 Single camera connected directly to a single Ethernet Port



Figure 8. Single camera connected directly to a host adaptor

System Description

Component	Description
CPU	Intel Core i3-2100
Motherboard	Intel BLH6710H.86A
RAM	2GB
Network adapter	Intel PRO 1000 PCIe Card (ACC-01-1100)
Cabling	Cat5e
Operating system	Windows 7 x86
Driver	Point Grey GigE Filter Driver 2.3.3.22
Software	FlyCapture2 Release 2.3.2.14 x86
Camera firmware	1.24.3.0

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
GS2-GE-50S5M-C	Mono16	2448 x 2048	11	9000	10	110
Total Bandwidth						110 MB/s

1.8.2 Multiple cameras connected to a single Ethernet Port through a switch

With a single Ethernet port, multiple cameras are connected to the host adaptor via a switch. This set up combines the bandwidth from each camera onto a single cable; therefore, the sum of bandwidth used by all cameras cannot exceed 125 MB. (See [Calculating Required Bandwidth](#) above.)

If you see frames being dropped on an individual camera, increase the packet delay for each camera to reduce the total bandwidth.



If possible, the switch should be configured to accept large packet sizes. You may need to adjust the camera's packet size to suit the switch's capabilities.

Any method of IP addressing (Persistent, Dynamic, or LLA) can be used for this set up.

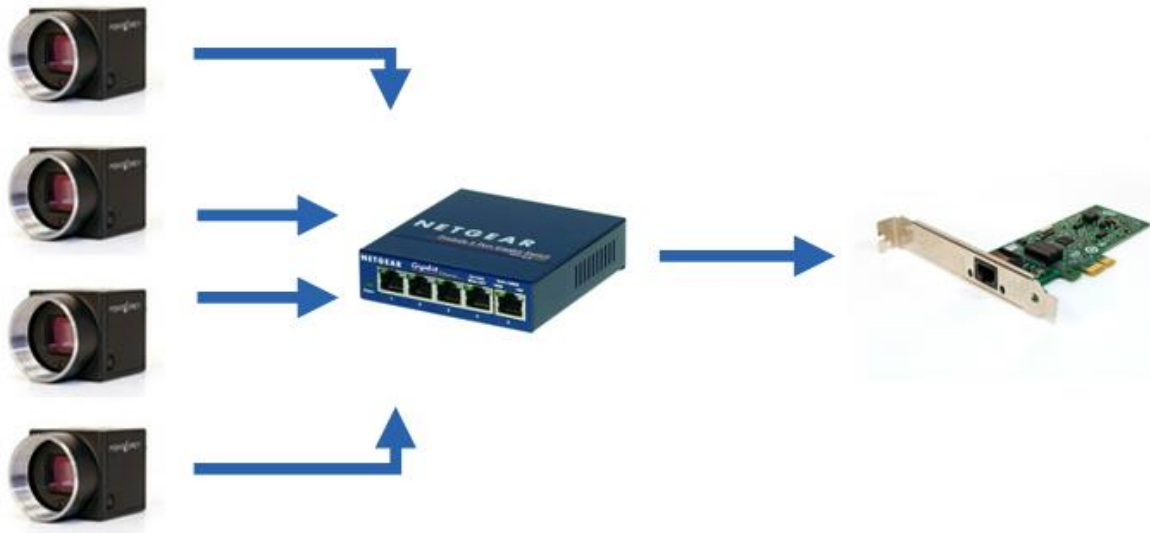


Figure 9. Multiple cameras connected to a host adaptor via switch

System Description

Component	Description
CPU	Intel Core i3-2100
Motherboard	Intel BLH6710H.86A
RAM	2GB
Network adapter	Intel PRO 1000 PCIe Card (ACC-01-1100)
Network switch	Netgear GS105 5-Port Gigabit Switch
Cabling	Cat5e
Operating system	Windows 7 x86
Driver	Point Grey GigE Filter Driver 2.3.3.22
Software	FlyCapture2 Release 2.3.2.14 x86
Camera firmware	1.24.3.0

Example A – Two cameras connected to a switch

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
FL3-GE-03S1C-C	Raw16	648 x 488	62	1400	250	54
FL3-GE-03S1M-C	Mono16	648 x 488	62	1400	250	54
Total Bandwidth						108 MB/s

Example B – Three cameras connected to a switch

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
FL3-GE-03S1C-C	Raw8	648 x 488	55	1400	550	35
FL3-GE-03S1C-C	Raw8	648 x 488	55	1400	550	35
FL3-GE-03S1M-C	Mono8	648 x 488	55	1400	550	35
Total Bandwidth						105 MB/s

Example C – Four cameras connected to a switch

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
FL3-GE-03S1C-C	Raw8	648 x 488	40	1400	850	25
FL3-GE-03S1C-C	Raw8	648 x 488	40	1400	850	25
FL3-GE-03S1M-C	Mono8	648 x 488	40	1400	850	25
FL3-GE-03S1M-C	Mono8	648 x 488	40	1400	850	25
Total Bandwidth						100 MB/s

1.8.3 Multiple Ethernet Ports

With multiple Ethernet ports, multiple cameras are connected directly to a dedicated port. In this set up, each camera is able to use the full 125 MB bandwidth.

The host can have:

- One card with multiple ports
- Multiple cards each with a single port
- Multiple cards each with multiple ports

Persistent IP addressing is recommended for this set up. Each camera should have a unique IP address on the subnet of its port. Each port should be on a different subnet.

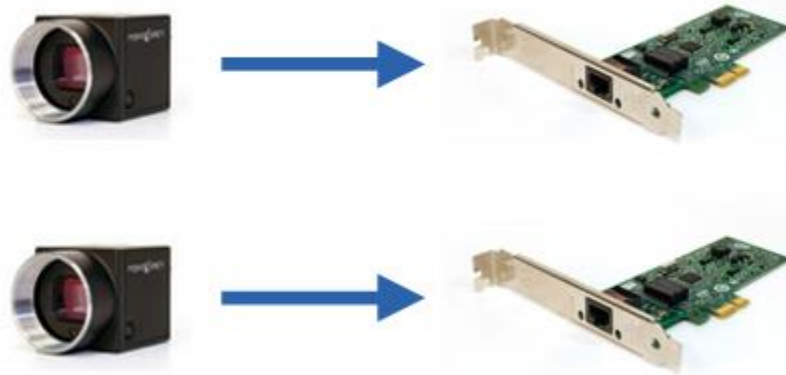


Figure 10. Two cameras each connected directly to a host adaptor

Port	Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
A	GS2-GE-50S5M-C	Mono16	2448 x 2048	10	9000	100	100
B	FL3-GE-50S5M-C	Raw16	2448 x 2048	8	9000	300	80
Total Bandwidth							180 MB/s

1.8.4 Cameras connected to multiple Ethernet ports and multiple switches

Using multiple Ethernet ports and multiple switches, you can increase the number of cameras connected on the host system. For this setup each Ethernet port will allow a maximum of 125MB bandwidth, which will be shared by the cameras that are connected to the port through a switch.



Jumbo packets need to be enabled for the switch to allow the camera to send larger image packets.

Example A – Fourteen cameras connected to two Ethernet ports (7 cameras on each switch)



Figure 11. 14 cameras connected to two host adaptor via two 8 port switches

System Description

Component	Description
CPU	Intel Core i3-530
Motherboard	Intel Desktop Board HDH55HC
RAM	2GB
Network adapter	Intel PRO 1000 PCIe Card (2x) (ACC-01-1100)
Network switch	Netgear GS110TP 8-Port Gigabit POE Smart Switch (2x)
Cabling	Cat5e
Operating system	Windows 7 x86
Driver	Point Grey GigE Filter Driver 2.3.3.54
Software	FlyCapture2 Release Candidate 2.5.2.3 x86
Camera firmware	1.21.3.0

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
BFLY-PGE-13E4C (3x)	Raw8	1280 x 1024	10.5	9000	62500	14
BFLY-PGE-13E4M (4x)	Mono8	1280 x 1024	10.5	9000	62500	14
BFLY-PGE-09S2C (4x)	Raw8	1288 x 728	14	9000	62500	14
BFLY-PGE-05S2M	Mono8	808 x 608	29	9000	62500	14
Total Bandwidth						196 MB/s

Example B – Eighteen cameras connected to two Ethernet ports (7 and 11 cameras connected per switch)

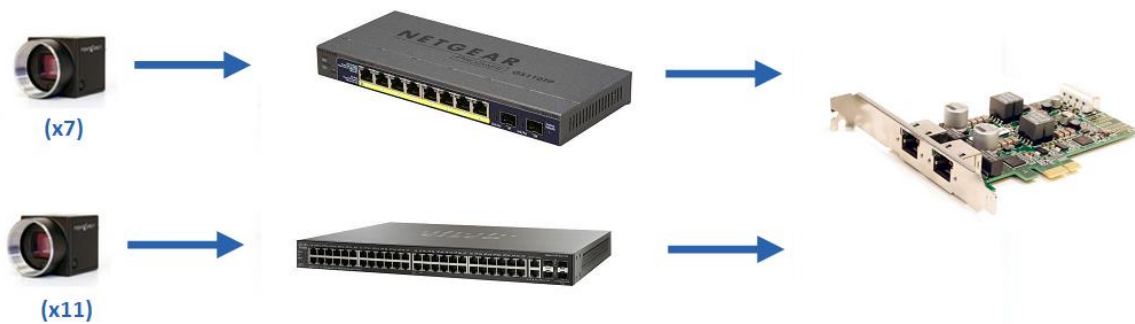


Figure 12. 18 cameras connected to two host adaptor via 8 port switch and 52 port switch

System Description

Component	Description
CPU	Intel Core i5-4750
Motherboard	ASUS Z87-Deluxe
RAM	8GB
Network adapter	Dual port Intel 82574L PCIe card (GIGE-PCIE-2P02)
Network switch	Netgear GS110TP 8-Port Gigabit POE Smart Switch, Cisco SG500-52P 52-Port Gigabit POE Managed Switch
Cabling	Cat5e
Operating system	Windows 7 x64
Driver	Point Grey GigE Filter Driver 2.3.3.61
Software	FlyCapture2 Release 2.6.3.2 x64
Camera firmware	1.21.3.0

Seven cameras connected to Netgear GS110TP 8-Port Gigabit POE Smart Switch

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
BFLY-PGE-13E4M	Mono8	1280 x 1024	12	9000	51000	17
BFLY-PGE-05S2M	Mono8	808 x 608	34	9000	51000	17
BFLY-PGE-05S2C	Raw8	808 x 608	34	9000	51000	17
BFLY-PGE-09S2C (4x)	Raw8	1288 x 728	17	9000	51000	17
Total Bandwidth						119 MB/s

Eleven cameras connected to Cisco SG500-52P 52-Port Gigabit POE Managed Switch

Camera Model	Pixel Format	Resolution	Frame Rate	Packet Size (Byte)	Packet Delay	Bandwidth (MBytes/s)
BFLY-PGE-13E4M (5x)	Mono8	1280 x 1024	7	6250	65535	10
BFLY-PGE-13E4C (3x)	Raw8	1280 x 1024	7	6250	65535	10
BFLY-PGE-05S2M (3x)	Mono8	808 x 608	19	6250	65535	10
Total Bandwidth						110 MB/s

1.9 Troubleshooting

Solving Enumeration Problems

If your camera is not showing up as a device consider the following:

Is the camera powered?

- Check that the camera LED is on
- Power is provided via GPIO on Flea3 and Grasshopper2; power is provided via PoE or GPIO on Zebra2 and Blackfly

Is there an IP conflict?

- Ensure the camera is using a unique IP address
 - The camera and host adapter must be on the same subnet
- See [IP Addressing](#)

Is the firewall blocking FlyCapture?

- Add FlyCap2 to your firewall program's exceptions list or disable the firewall

Is other network traffic blocking your camera?

- Use a dedicated adapter for the camera and a separate adapter for the Internet or other devices

Is GigE enumeration enabled?

- Use the Registry Control utility to enable enumeration

Start Menu→All Programs→Point Grey Research→FlyCapture→Utilities→Registry Control

Is your camera showing up as "BAD" in the GigE Configurator?

This is usually caused by unmatched subnet address between the camera and the network adapter.

- Auto-force IP and Refresh
 - or
 - Manually change the IP address of the camera to match the subnet of the adapter
- See [IP Addressing](#)

Eliminating Image Consistency Errors

Image consistency errors are often caused by dropped packets. Ethernet is asynchronous in nature and capable of bursting data to peak bandwidth. A sudden burst in data transfer can create a packet collision and lead to image consistency errors.

If you're experiencing image consistency errors, consider the following:

Is the correct driver installed?

- Install Point Grey's image filter driver to reduce the packet load on the CPU.
See [Configuring Drivers](#)

Are all network components able to handle the packet size?

- In GigE Configurator, click the Discover Maximum Packet Size button to view the maximum size the network can handle.
- Use FlyCap2 to set camera's packet size to be equal to or less than the maximum packet size.
- The packet size for the host adapter can be increased from the device manager.
- Ensure any switches in the network are also able to handle the packet size.
See [Packet Size](#)

Is the packet delay too low?

- Increase the packet delay to slow down the average camera transfer rate. This can help with slower networks, less capable host computers, or for multiple cameras.
See [Packet Delay](#)

Is the computer able to handle the data?

- Free up system resources by ending unnecessary programs or processes.

1.10 Additional Downloads and Support

Point Grey Research Inc. endeavors to provide the highest level of technical support possible to our customers. Most support resources can be accessed through the [Support](#) section of our website.

Creating a Customer Login Account

The first step in accessing our technical support resources is to obtain a Customer Login Account. This requires a valid name and email address. To apply for a Customer Login Account go to the [Downloads](#) page.

Knowledge Base

Our [Knowledge Base](#) contains answers to some of the most common support questions. It is constantly updated, expanded, and refined to ensure that our customers have access to the latest information.

Product Downloads

Customers with a Customer Login Account can access the latest software and firmware for their cameras from our [Downloads](#) page. We encourage our customers to keep their software and firmware up-to-date by downloading and installing the latest versions.

Contacting Technical Support

Before contacting Technical Support, have you:

1. *Read the product documentation and user manual?*
2. *Searched the Knowledge Base?*
3. *Downloaded and installed the latest version of software and/or firmware?*

If you have done all the above and still can't find an answer to your question, contact our [Technical Support](#) team.