FGC-101
Certified FrameGrabber Associate

Lesson Guide

Version 1.0

Contents

Module 1: Introducing the FrameGrabber Camera System

This textbook is used for all delivery formats for this course. It provides a solid foundation to the concepts needed to understand how FrameGrabber Camera systems work and how to connect the subsystem and its components. This course covers all connections needed to make the system operational, but does not cover installation planning. Installation planning is covered in the course FGC-102 Certified FrameGrabber Technician.

Resources

- *FrameGrabber System User Guide,* Chapter 1

Module Objectives

1. Identify and describe the typical use cases for FGC Camera Systems
2. Identify the three subsystems that comprise the FGC System

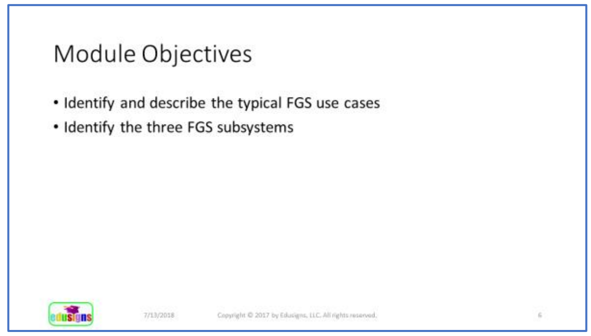
Slides

Slide 1-1

Go over the module objectives with the students. We have included the two most common use cases.

In this module, we focus on:

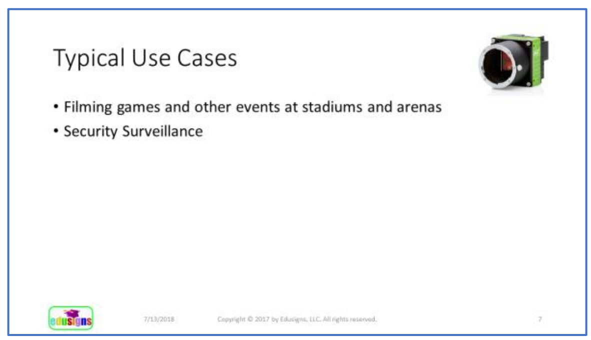
- The typical FGS use cases,
- The three FGS subsystems



Slide 1-2

This slide shows the most common use cases for FGC Camera Systems our customers have reported.

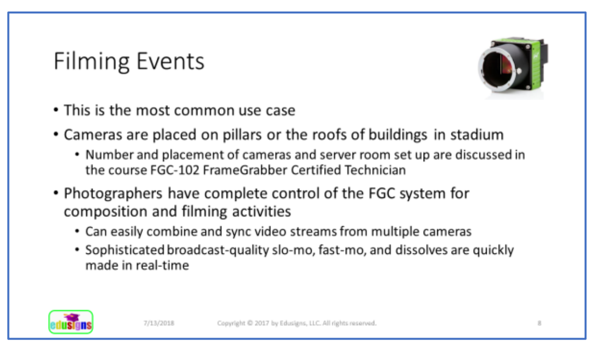
Ask the class if they have other use cases. Make a note of them and we can add them to future course revisions.

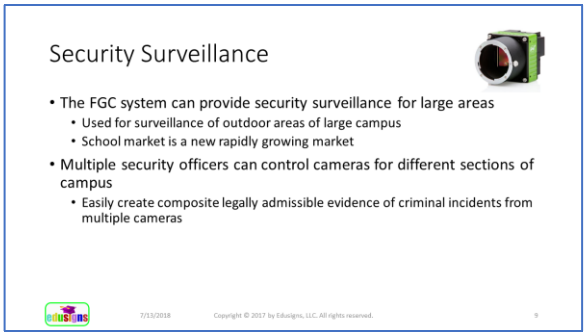


Slide 1-3

The most common use for FGS systems is filming events in stadiums. If you have seen instant replays of sporting events on TV, you have seen FGS systems in action.

Cameras are mounted on pillars or the roofs of buildings, such as the press box, to allow capture of event video from multiple angles. These are merged together by photographers. The photographers have complete control of the FGC system for composing their video and for filming activities.

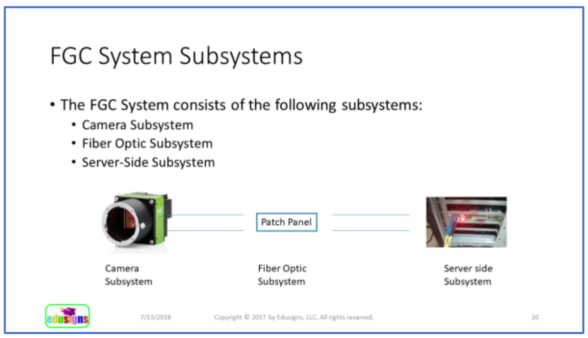




Slide 1-4

Another common use of FGS systems is security surveillance. If you already have an FGS system in use in your stadium, it only makes sense to use it as part of the stadium's security system when not filming events

FGS has noted that school campuses are a fast-growing market for FGS systems. School campuses use FGS systems for round-the-clock security surveillance even when the campus is open for business as a deterrent to theft and destruction of property.



Slide 1-5

The FGS System consists of three subsystems:

- Camera Subsystem
- Fiber Optic Subsystem
- Server-Side Subsystem

Each of these subsystems plays a major role in getting video from the stadium to the photographers for processing into composite video. Camera subsystems are located throughout the stadium for capturing video footage of events.

The Camera subsystems are connected to each other and to the Server-Side subsystem by fiber-optic cables. The fiber-optic cables comprise the Fiber-Optic Subsystem.

The Server-Side subsystem includes the Patch Panel where the Fiber-Optic Subsystem connects to the Server-Side Subsystem. The Server-Side Subsystem includes a master server and one or more slave servers. These Servers have FrameGrabber cards installed with a Camera Subsystem connected to each one of them.

We cover the details of each of these subsystems and their connections in the modules that follow.

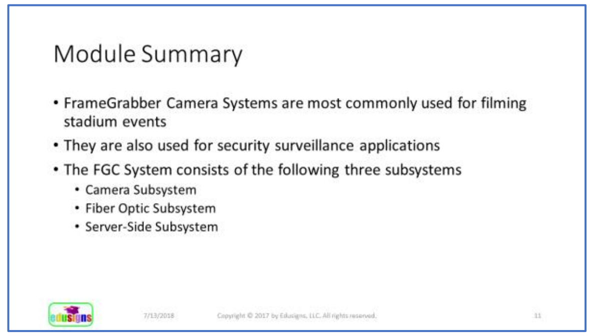
Slide 1-6

In this module, students received an introduction to FGS systems. We presented the most common use cases:

1. Filming stadium events
2. Security surveillance

We also introduced the three subsystems that comprise the FGS system:

- Camera Subsystem
- Fiber-Optic Subsystem
- Server-Side Subsystem



In the next module, we discuss the Camera Subsystem in depth. We look at its components and how they are connected to each other and to the Fiber-Optic Subsystem.

Questions

Instructors should ensure that the student answers have the main points indicated in the answers below.

1. Name the most common use case for FGC systems.

   The following are the most common use cases for FGC systems:
   - Filming stadium events
   - Security surveillance

2. The FGC system consists of three subsystems. List them below.

   The FGC system consists of the following three subsystems:

   - Camera Subsystem – one or more of these in the stadium mounted on pillars or building rooftops
   - Fiber-Optic Subsystem—connects Camera Subsystems to the Server-Side Subsystem via the Patch Panel.
   - The Server-Side Subsystem—connects Camera Subsystems to FrameGrabber Servers.

Module 2: The Camera Subsystem

The Camera Subsystem is at the heart of image acquisition. FGC camera systems have multiple Camera Subsystems installed in strategic locations throughout a stadium, typically on pillars near the action or on the roofs of buildings within the stadium

Module Objectives

3. Describe how the Camera Subsystem works
4. Identify the connections that must be made to connect the camera to the Fiber-Optic and Server-Side Subsystems

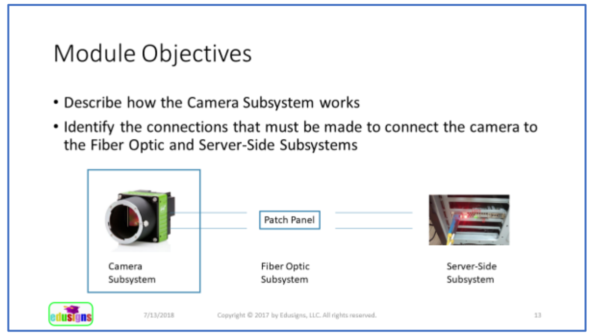
Resources

- *FrameGrabber User Guide,* Chapter 2
- JAI Spark Series Camera Manual, http://www.jai.com/ProtectedDocuments/Manuals/Manual SP-20000-PMCL.pdf
- Gidel Remote Camera Link Fiber Optic Extender, http://www.gidel.com/Corporate-Links/pdf/Remote-Camera-Extension-System.pdf

Slides

Slide 2-1

Go over the module objectives with the students. We have included the two most common use cases.

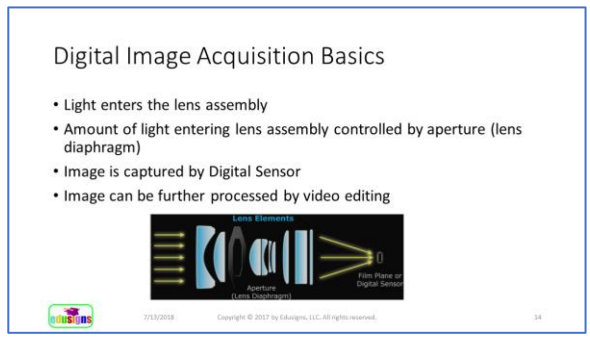


In this module, we focus on:

- How the Camera Subsystem works
- Identifying the connections that must be made to connect the camera to the Fiber-Optic and Server-Side Subsystems

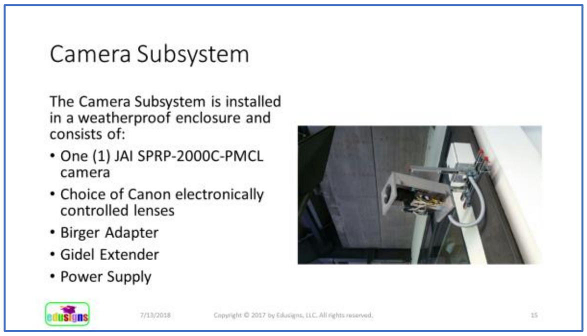
Slide 2-2

We begin with a review of basic digital image acquisition. All cameras basically work the same way whether the image is captured to film or digitally:



- Light must first enter the camera through the lens assembly
- The amount of light entering the lens assembly is controlled by the aperture (lens diaphragm)
- The image is captured by a CMOS digital sensor at the back of the camera
- The captured imaged can be further processed by video editing

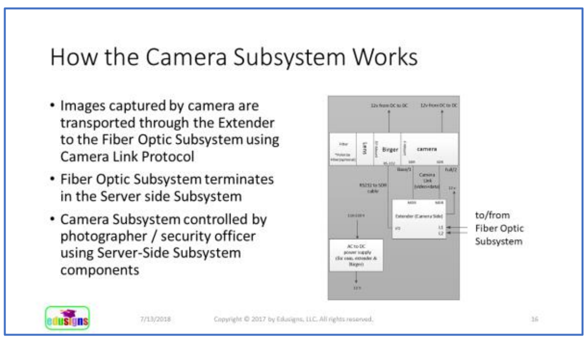
Slide 2-3



The FGC Camera Subsystem is installed in a weatherproof enclosure and consists of the following:

- One (1) JAI SPRP-2000C-PMCL camera
- Choice of Canon electronically-controlled lenses (only one can be installed at a time on the camera) – the lens is installed at time of Camera Subsystem installation in the stadium
- Birger Adapter – allows the photographer to remotely control the lens focus and aperture (f-stop) settiings
- Gidel Extender – allows Camera Link Protocol signals to be sent over Fiber-Optic Subsystem to Server-Side Subsystem
- Power Supply – provides power to all of the above components that comprise the Camera Subsystem

Slide 2-4

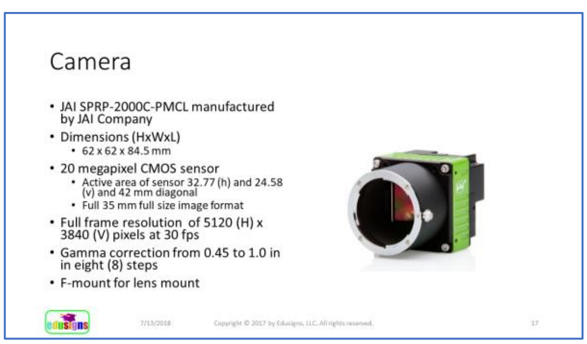


The Camera Subsystem works as follows:

Images captured by the camera are transmitted through the Extender to the Fiber-Optic Subsystem using the Camera Link protocol.

The Extender is necessary because the Camera Link protocol is not supported by fiber-optic links. The Extender converts Camera Link protocol signals to fiber-optic signals so that they can be transmitted through the Fiber-Optic Subsystem to the Server-Side Subsystem.

Slide 2-5



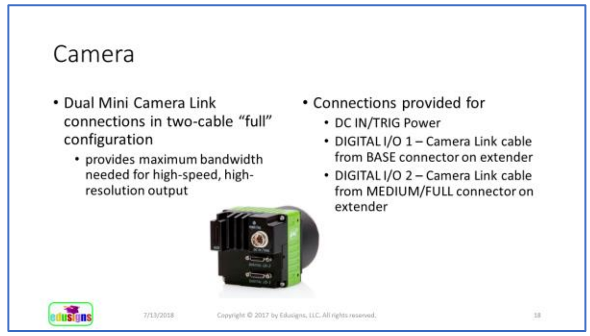
The heart of the Camera Subsystem is the camera itself.

FGC Systems use the JAI SPRP 2000-PMCL cameras manufactured by the JAI Company.

Camera specifications are provided. This camera meets the demanding specifications of FGC systems and broadcasters alike for professional-grade video streaming.

Slide 2-6

The JAI camera features dual Mini Camera Link connections in two-cable "full" Camera Link protocol configuration. We discuss the details of Camera Link protocol configuration in *Module 5: The Camera Link Protocol*.



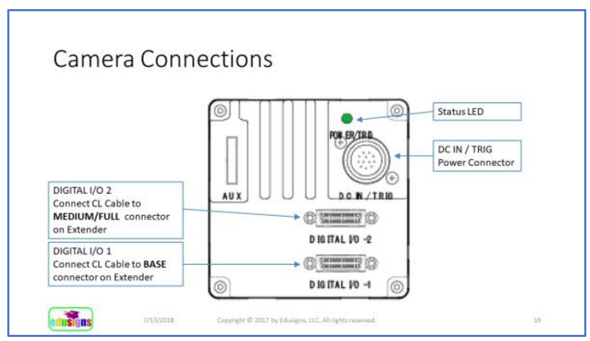
The two-cable full configuration provides the maximum bandwidth needed for high-speed, high-resolution video output.

Connections are provided for:

- DC IN/TRIG Power
- DIGITAL I/O 1 to the BASE connector on the Extender.
- DIGITAL I/O 2 to the MEDUM/FULL connector on the Extender.

Slide 2-7

Connect the camera to the Power Supply by plugging a DC power lead from the Power Supply to the DC In/TRIG power connector. The green status LED illumines to indicate camera is receiving power.



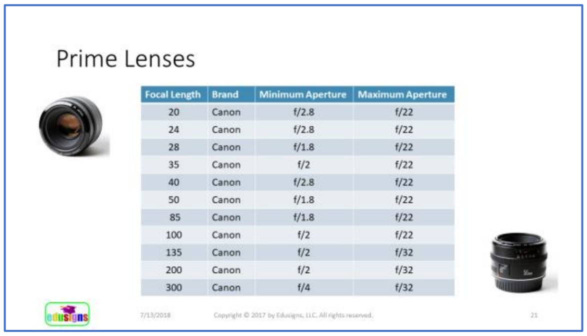
- Connect the DIGITAL I/O 1 to the BASE connector on the Extender.
- Connect the DIGITAL I/O 2 to the MEDUM/FULL connector on the Extender.
- The Camera is now connected to the Camera Subsystem. We still must choose a lens for the camera and we cover that in the next slide.

Slide 2-8

You have a wide choice of Prime or Zoom lenses.

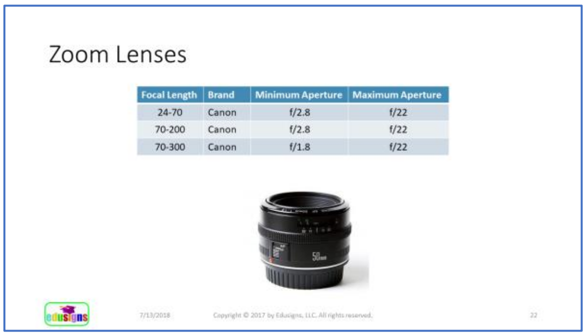
Prime lenses have a fixed focal length which cannot be changed by the user. Zoom lenses are more versatile since you can change the focal length of the lens.

Slide 2-9



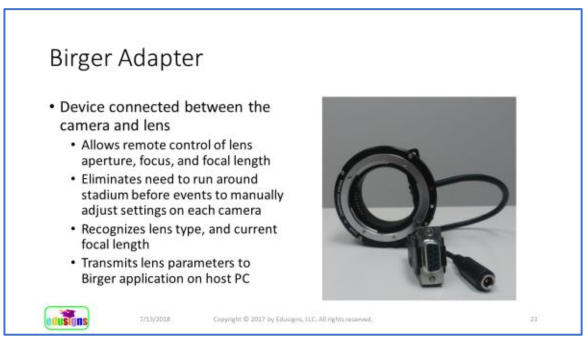
The table on this slide shows the Prime lenses your FGC system can use.

Slide 2-10



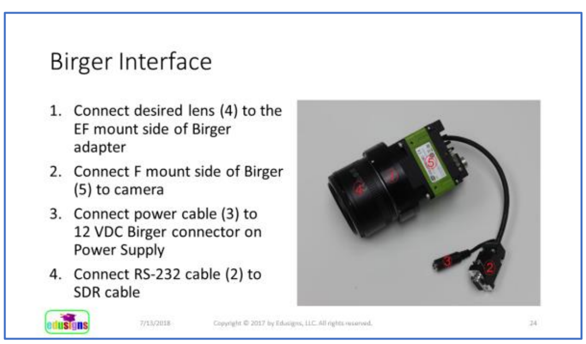
The table on this slide shows the Zoom lenses your FGC system can use.

Slide 2-11



The Birger adapter is a device that connects the camera and lens allowing the user to control the lens remotely. You can control the focus, focal length (for Zoom lenses) and aperture (f-stop). The Birger adapter eliminates the need to run around the stadium and set the lenses before the event. Lens settings are transmitted to the Birger application on the host PC.

Slide 2-12

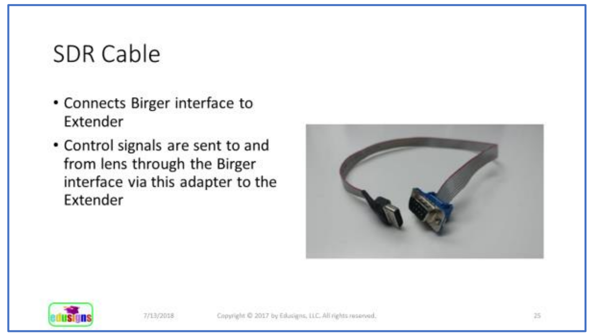


The Birger interface connects the Birger adapter and Extender:

- Connect desired lens (4) to the EF mount side of Birger adapter
- Connect F mount side of Birger (5) to camera.
- Connect RS-232 cable (2) to SDR cable

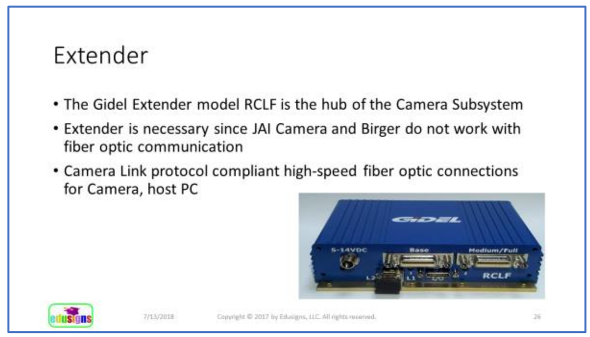
Slide 2-13 The SDR cable connects the Birger interface to the Extender.

Control signals are sent to and from the lens through the Birger interface via this adapter to the Extender.



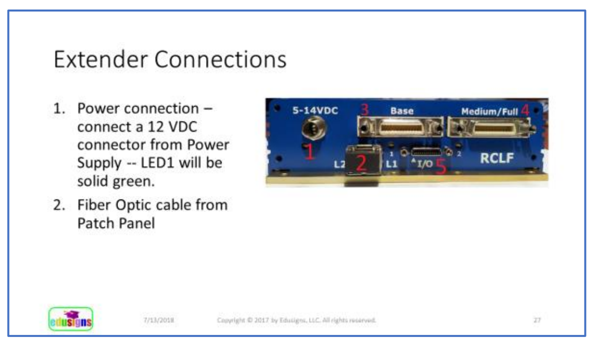
Slide 2-14 The Gidel Extender, model RCLF is the hub of the Camera Subsystem. The Extender is necessary since the JAI Camera and Birger do not work with fiber-optic communiation.

The Extender provides Camera Link protocol compliant high-speed connections for Camera and host PC.



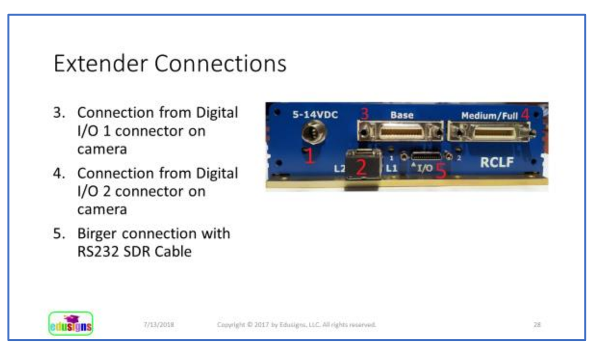
Slide 2-15 The following connections are required:

1. Power supply connection from 12 VDC power connection. LED1 is solid green to show Extender is receiving power.
2. Fiber Optic cable from patch panel



Slide 2-16 The following Camera connections are required:

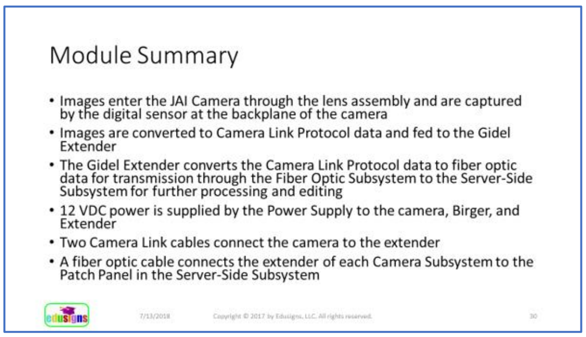
3. Connection from DIGITAL I/O 1 connector on camera.
4. Connection from DIGITAL I/O 2 connector on camera.
5. Birger connection with RS-232 SDR Cable.



Slide 2-17

The Power Supply provides connections for Camera, Birger, and Extender.

Connect the 110-240 VAC connector to an electrical outlet. The Power Supply has auto-voltage sensing and adjusts accordingly.
All components in the Camera Subsystem receive their power from the Power Supply



Slide 2-18

In this module, we began with review of images are acquired by cameras.

Images from the camera are converted to Camera Link protocol data and fed to the Gidel Extender.

The Gidel Extender converts the Camera Link protocol data to fiber optic data for transmission through the Fiber-Optic Subsystem to the Server-Side Subsystem for processing and editing.

12 VDC power is provided by the Power Supply to the camera, Birger, and Extender.

Two Camer Link cables connect the camera to the Extender in a “full” configuration for maximum throughput and resoultion.

A fiber-optic cable connects the Extender of each Camera Subsystem to the Patch Pabel in the Server-Side Subsystem.

Questions

Instructors should ensure that the student answers have the main points indicated in the answers below.

1. Describe how the camera works.

   The camera acquires images when:

   - Light enters the lens
   - An aperture (or diaphragm) allows the photographer to adjust the exposure of the image
   - The image is captured at the back of the camera by CMOS sensor and transmitted to the Extender.

2. Describe the connections from the camera to the Extender.

   The camera connections to the Extender are:
   - Connection from DIGITAL I/O 1 connector on camera to Base connector on Extender
   - Connection from DIGITAL I/O 2 connector on camera to Medium/Full connector on Extender
   - RS-232 connection to Birger using SDR cable

   Camera uses Camera Link protocol to send image data to the Extender.

3. Describe how the Extender works. Why is it needed?

   The Extender connects the Camera Subsystem to the Fiber-Optic Subsystem. The camera uses the Camera Link protocol to transmit images. The camera and Birger do not work with fiber-optic communication. The Extender provides an interface between the Camera Link protocol used by the camera and Birger and the fiber-optic communication protocol.

4. What are the specifications of the Power Supply? Which devices of the Camera Subsystem need power connections?

   The Power Supply needs 110-240 VAC input. It outputs 12 VDC. The camera, Birger, and Extender all need 12 VDC connections from the Power Supply to operate.

5. How many Camera Link cables must you connect from the camera to the Extender?

   Two cables are connected from the camera to the Extender. One goes from the DIGITAL I/O 1 connector on the camera to the Base connector on the Extender. The other goes from the DIGITAL I/O 2 connector on the camera to the Medium/Full connector on the Extender.

Supplemental Resources

Canon Birger-Controlled Lenses

JAI and FrameGrabber Systems have tested the following Canon Birger-Controlled lenses to ensure compatibility with your FrameGrabber Camera System. We provide listings of

- Prime lenses
- Zoom lenses

Prime lenses have a fixed focal length. They are probably the most commonly used lenses on FrameGrabber Camera systems:

Focal Length	Brand	Minimum Aperture	Maximum Aperture
20	Canon	f/2.8	f/22
24	Canon	f/2.8	f/22
28	Canon	f/1.8	f/22
35	Canon	f/2	f/22
40	Canon	f/2.8	f/22
50	Canon	f/1.8	f/22
85	Canon	f/1.8	f/22
100	Canon	f/2	f/22
135	Canon	f/2	f/32
200	Canon	f/2	f/32
300	Canon	f/4	f/32

Zoom lenses have a variable focal length and can provide added versatility to your system. These zoom lenses are compatible with your FrameGrabber System:

Focal Length	Brand	Minimum Aperture	Maximum Aperture
24-70	Canon	f/2.8	f/22
70-200	Canon	f/2.8	f/22
70-300	Canon	f/1.8	f/22

Module 3: The Fiber Optic Subsystem

The Fiber Optic Subsystem connects all the Camera Subsystems to the Server-Side Subsystem components. The three subsystems of the FGC Camera System are connected to form a high-speed fiber optic network.

Module Objectives

5. Describe how the Fiber Optic Subsystem works
6. Identify the connections that must be made to connect the Camera and Server-Side Subsystems to the Fiber Optic Subsystem

Resources

- *FrameGrabber User Guide,* Chapter 3.
- *Gtek Product Manual,* http://www.10gtek.com/templates/wzten/pdf/PRODUCT_MANUAL-10Gtek.pdf

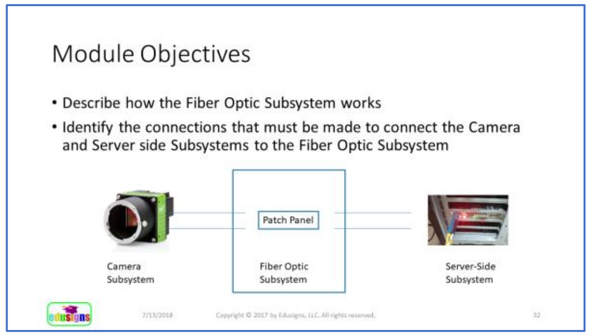
Slides

Slide 3-1

Go over the module objectives with the students.

In this module, we focus on:

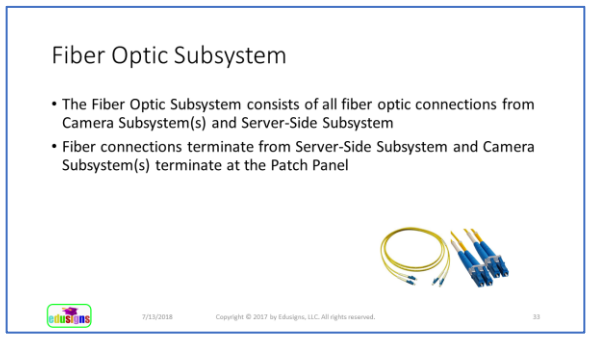
- Describe how the Fiber Optic Subsystem works
- Identify the connections that must be made to connect the Camera and Server-Side Subsystems to the Fiber Optic Subsystem



Slide 3-2

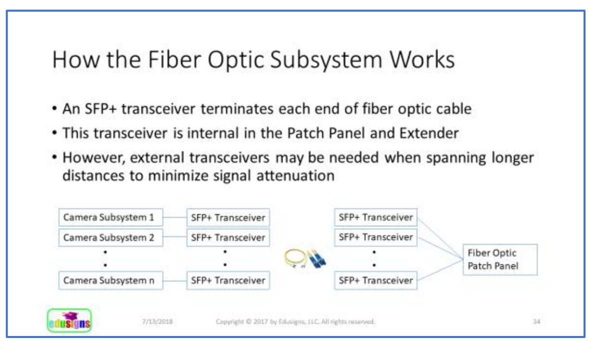
The Fiber Optic Subsystem consists of all the fiber optic connections from the Camera Subsystem(s) and Server-Side Subsystem.

Fiber connections terminate from the Server-Side Subsystem and Camera Subsystem(s) at the Patch Panel.

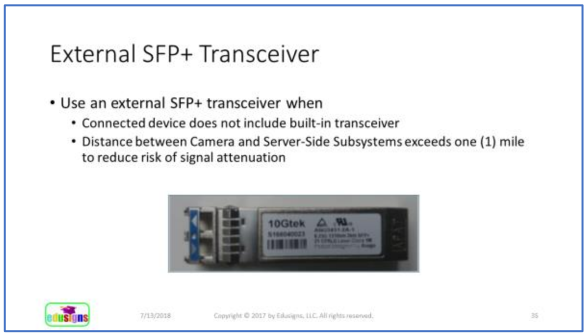


Slide 3-3

The Fiber Optic Subsystem requires that an SPF+ transceiver terminate each end of the Fiber Optic cable. The transceiver is internal in the Patch Panel and Extender so you don't need to use an external transceiver for those connections.



However, you may need an external transceiver when spanning longer distances to minimize signal attenuation. You may also need a transceiver to connect to a host PC's FrameGrabber card.

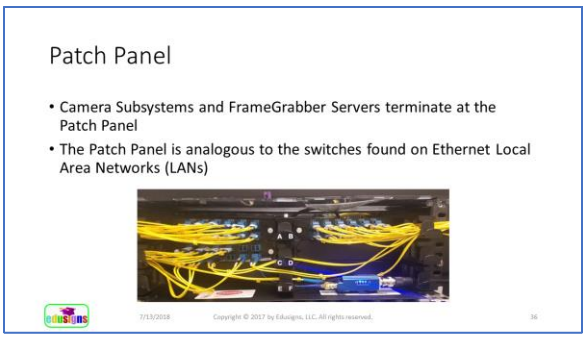


Slide 3-4

This slide shows a typical SPF+ transceiver. This one is made by 10Gtek. You must use a transceiver when the connected device does not include a built-in transcevier.

Both ends of the fiber optic cable require a transceiver: either a built-in transceiver or an external one must be provided.

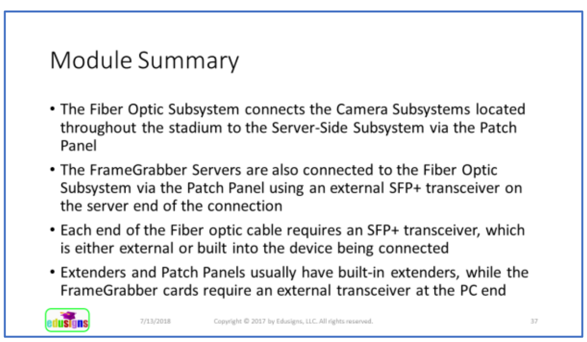
To reduce the risk of signal attenuation, the distance between Camera and Server-Side Subsystems should not exceed one (1) mile.



Slide 3-5

The Patch Panel is sthe termination point for all connections from the Camera Subsystems and from FrameGrabber Servers that comprise the Server-Side Subsystem.

Think of the Patch Panel as you would a network switch found on Ethernet Local Area Networks (LAN). The Patch Panel serves the same function: connect all the components together.



Slide 3-6

In this module, we covered the Fiber Optic Subsystem. The Fiber Optic Subsystem connects the Camera Subsystems and Server-Side Subsystem via the Patch Panel.

FrameGrabber Servers are also connected to the Fiber Optic Subsystem via the Patch Panel using an external SPF+ transceiver on the server end of the conn

Each end of the fiber optic cable must be terminated by a transceiver. It can be internal or external.

Questions

Instructors should ensure that the student answers have the main points indicated in the answers below.

3. What is the purpose of the Fiber Optic Subsystem? What connects to the Fiber Optic Subsystem?

   The purpose of the Fiber Optic Subsystem is to form a high-speed fiber optic network to connect:
   a. Camera Subsystems
   b. Server-Side Subsystem components

   The Camera Subsystems and Server-Side Subsystem components connect to the Patch Panel.

4. Describe how fiber optic cabling works.

   Fiber optic cabling uses pulses of laser light to represent data.

   A transceiver at each end of the cable sends and receives data in the form of laser light down the cable.

5. What is a transceiver and when do you need to use an external transceiver? Which devices usually have built-in transceivers and which ones need external transceivers?

   A transceiver is a device that allows receiving and transmitting of fiber optic signals over a fiber optic cable. A transceiver is needed at both ends of the cable.

   The transceiver can be built into the device. If the device you are connecting does not have a built-in transceiver you must use an external transceiver.

   Patch Panels and Extenders usually have built-in transceivers. FrameGrabber cards used in the Servers require an external transceiver.

Module 4: The Server-Side Subsystem

The Server-Side Subsystem servers two functions. It allows the photographer to control all the Camera Subsystems in the stadium and allows the photographer to synchronize multiple video streams into a composite stream.

Module Objectives

This module introduces you to the Server-Side Subsystem. In this module, you:

1. Describe how the Server-Side Subsystem works
2. Identify the connections that must be made to connect the components of the Server-Side Subsystem.

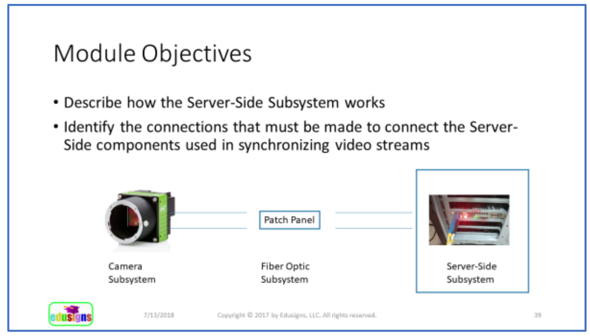
Resources

FrameGrabber User Guide, Chapter 4

Slides

Slide 4-1

Go over the module objectives with the students. We have included the two most common use cases.

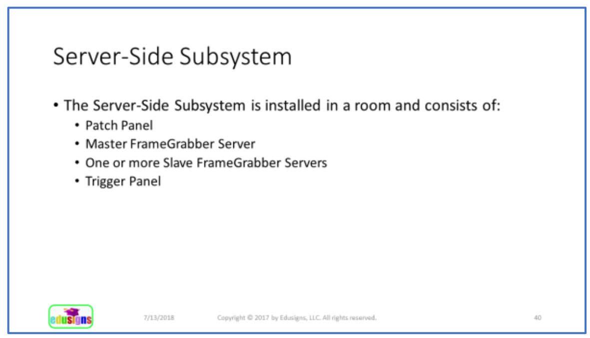


In this module, we focus on:

- Describe how the Server-Side Subsystem works
- Identify the connections that must be made to connect the Server-Side components used in synchronizing video streams.

Slide 4-2

Most students are familiar with the idea of a server room for a data network such as the one in their home or office.

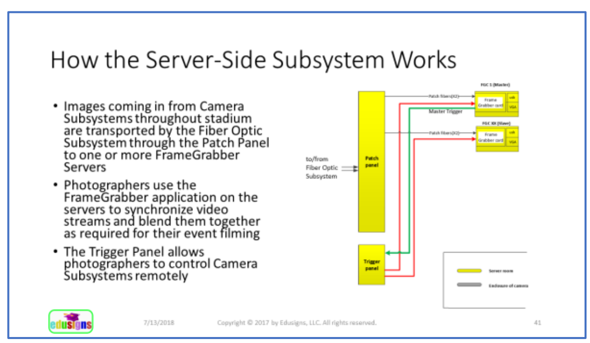


The Server-Side Subsystem is located in a room like a server room and consists of similar components:

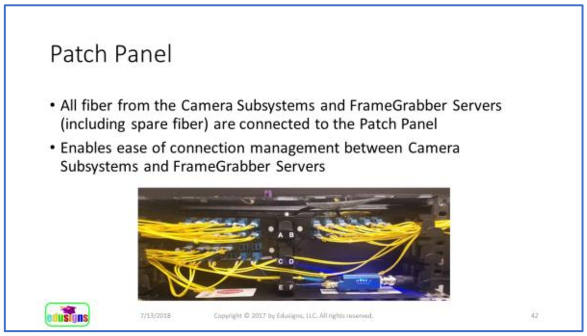
- Patch Panel
- Master FrameGrabber Server
- One or more Slave FrameGrabber Servers
- Trigger Panel

Slide 4-3

The Server-Side Subsystem processes images coming from the Camera Subsystems located throughout the stadium. The images are transmitted from the Camera Subsystems through the Fiber-Optic Subsystem to the Server-Side Subsystem.



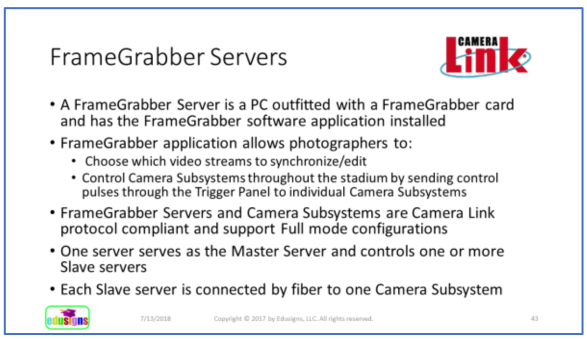
Using the FrameGrabber software application and the Trigger panel, photographers can synchronize video streams and blend them together to form composite streams as required for their event filming. The FrameGrabber Application focuses on stream composition and synchronization while the Trigger Panel allows remote control of the Camera Subsystems.



Slide 4-4

We mentioned earlier that all the Camera Subsystems throughout the stadium are connected by Fiber Optic cables that comprise the Fiber-Optic Subsystem. The Fiber-Optic Subsystem cables terminate at the Patch Panel.

The Patch Panel also connects the Server-Side components to facilitate controlling the Camera Subsystems and allow photographers to interact with incoming video streams. For details regarding the FrameGrabber software application, please refer to the course FGP-101 *Certified FrameGrabber Photographer.*



Slide 4-5

FrameGrabber Servers are PCs outfitted with FrameGrabber cards and have the FrameGrabber software application installed on them.

The FrameGrabber software application allows photographers to:

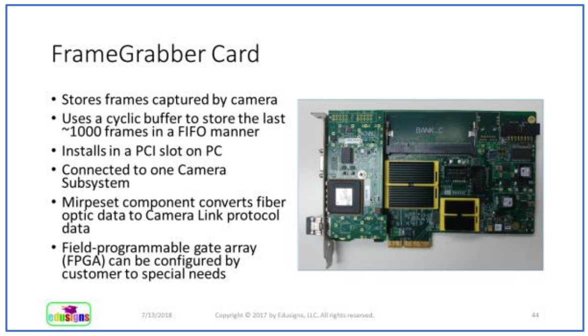
- Choose which video streams to synchronize and blend to form composite video streams.
- Control individual Camera Subsystems throughout the stadium by sending control pulses through the Trigger Panel to each Camera Subsystem.

FrameGrabber Servers and Camera Subsystems are Camera Link protocol compliant and support Full mode configurations for maximum resolution and maximum data transmission.

One FrameGrabber Server serves as the Master Server and controls one or more Slave servers. It can also control a Camera Subsystem, though this is not usually done in practice.

Each Slave server is connected by fiber to one (and only one) Camera Subsystem. Instructors should emphasize that only one Camera Subsystem can be connected to a server.

Slide 4-6



Earlier, we mentioned that each Frame Grabber Server is outfitted with a FrameGrabber card. The card stores image frames captured by the camera. Recall that cameras connect with components in the Camera Subsystem that allow transmission of the image frames by fiber-optic cable to the server. The main component of interest is the Extender which converts Camera Link protocol data from the camera to fiber-optic data for transmission to the Server-Side Subsystem.

The card installs into a PCI slot on the PC. Both older and late-model PC motherboards have at least a couple of PCI slots, making this process a simple plug and play operation. The Mirpeset component on the card converts incoming fiber-optic data back to Camera Link protocol data that the FrameGrabber Software application and Trigger Panel can use for camera control and video synchronization.

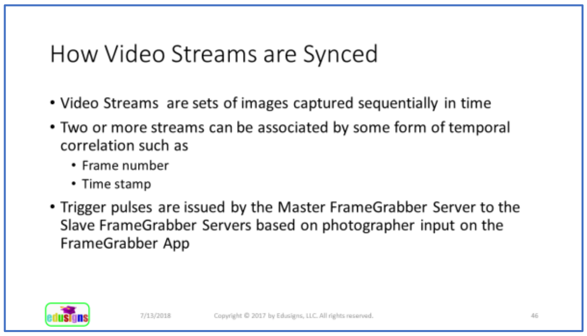
FrameGrabber cards come with field-programmable gate array (FPGA) that can be configured by the customer to meet their special needs.

Slide 4-7

Each FrameGrabber Server is connected to the Trigger Panel. Usually the Master Server is configured as FGC01. The Slave Servers are configured as FGC02, FGC03, etc.

The Master Server processes trigger pulses for Slave FrameGrabber Servers. Pulses are used to create synchronized video streams.

Each Trigger Panel can support up to 28 Camera Subsystems.



Slide 4-8

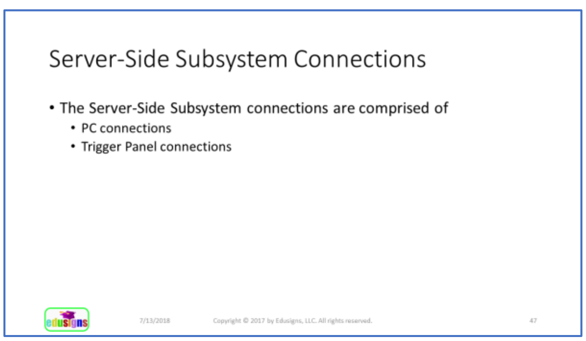
Video Steams are sets of images caputred by each Camera Subsystem sequtentially in time.

Before you can sync streams, you need to associate them by some form of temporal correlation. The most common are the automated IDs provided by the camera:

- Frame number
- Time stamp

Trigger pulses are issued by the Master FrameGrabber Server to the Slave FrameGrabber Servers based on photographer input using the FrameGrabber software application. The photographer can also use the Trigger cable connected to the master input on the trigger panel and FrameGrabber SDR connection.

The Patch Panel also connects the Server-Side components to facilitate controlling the Camera Subsystems and allow photographers to interact with incoming video streams. For details regarding the FrameGrabber software application, please refer to the course FGP-101 *Certified FrameGrabber Photographer.*



Slide 4-9

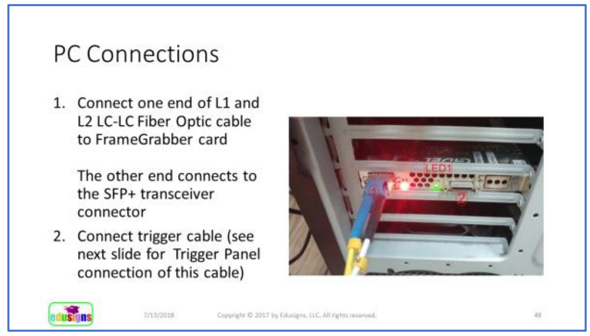
To set up your Server-Side Subsystem, you must connect your:

- FrameGrabber Server PCs to the Patch Panel and
- Trigger Panel

We cover these connections in the next few slides.

Slide 4-10

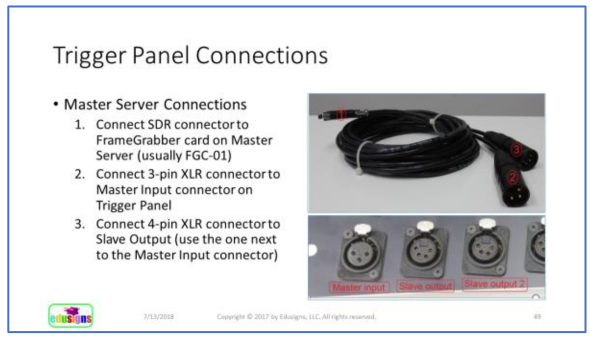
Each FrameGrabber Server is connected to the Patch Panel using L1 and L2 LC-LC Fiber Optic cable. The PC end of the Fiber Optic cable connects to the FrameGrabber card using an external SPF+ transceiver



A trigger cable is connected from the trigger cable connection on the FrameGrabber card to the Trigger Panel.

Slide 4-11

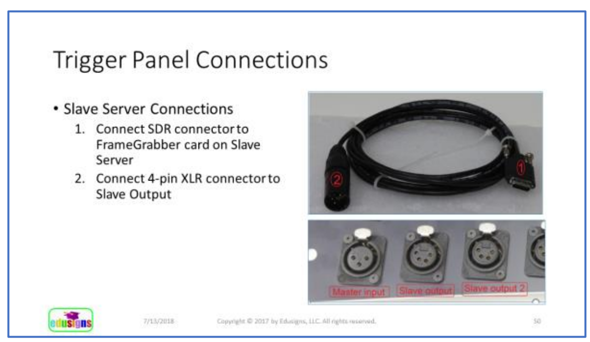
Connect the Master Server Trigger Cable:



1. Connect the SDR connector to FrameGrabber card on the Master Server (usually FGC01)
2. Connect the 3-pin XLR connector to the Master Input connector on the Trigger Panel
3. Connect the 4-pin XLR connection to the Slave Output (use the one next to the Master Input connector).

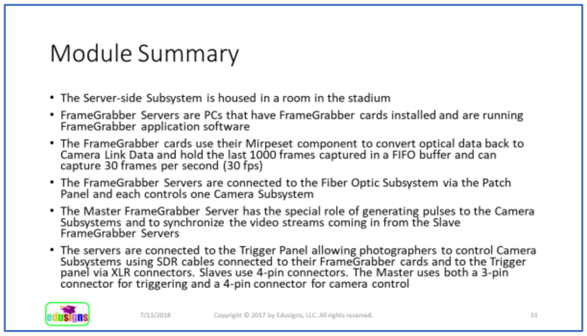
Slide 4-12

Connect the Slave Server Trigger Cable. There is one cable per slave server.



1. Connect the SDR connector to FrameGrabber card on the Slave Server.
2.
3. Connect the 4-pin XLR connection to the Slave Output.

Instructors should remind the students that the Slave Server cables have no 3-pin XLR connector. It is a common error to use a Master trigger cable to connect a Slave Server.



Slide 4-13

In this module, we covered how the Server-Side Subsystem works and the connections needed to connect the FrameGrabber Servers to the Fiber-Optic Subsystem and to the Trigger Panel. The process consists of:

- Installing a FrameGrabber card into a PCI slot on the server PC.
- Connect the server to the Fiber-Optic Subsystem using an L1 L2LC-LC Fiber-Optic cable. An external SPF+ transcevier is required on the PC end of the cable. The Patch Panel already includes a bult-in transceiver.
- Connect the SDR , 3-pin XLR connector, and -pin XLR connector to the appropriate Master Input connections on the Trigger Panel.
- For each Slave Server, connect the SDR, and 4-pin XLR connectors to the appropriate Slave Server connections on the Trigger Panel.

Up to 28 Camera Subsystems can be connected to one Trigger Panel.

Questions

Instructors should ensure that the student answers have the main points indicated in the answers below.

1. Describe how the Server-Side Subsystem works.

   The Server-Side Subsystem provides two functions:
   - Remote control of Camera Subsystems
   - Synchronization of video streams

2. Describe the connections from the Patch Panel to the PC servers.

   A Fiber Optic cable (specifically an L1 L2 LC-LC cable) connects from the Patch Panel to an external SFP+ transceiver. The transceiver connects to the FrameGrabber card installed in a PCI slot of the host PC. The host PC can be configured as a Master or Slave server.

3. Describe how the trigger cables are connected to the Trigger Panel and PC.

   Two kinds of trigger cables are available:

   The Master Server trigger cable has three connectors:
   - An SDR connector
   - A 3-pin XLR connector for sending trigger signals to Slave Servers
   - A 4-pin XLR connector for connecting a Camera Subsystem

   The Slave Server trigger cable has two connectors:

   - An SDR connector
   - A 4-pin XLR connector for connecting a Camera Subsystem

   Only one Master Server can be connected to the Server-Side Subsystem. It is customarily named FGC01 (though this is not necessary). Its trigger cable is plugged into the Master Input XLR connectors on the Trigger Panel. The SDR end of the cable plugs into the FrameGrabber card on the server.

   Each Slave server is connected to the Server-Side Subsystem via Slave Inputs on the Trigger Panel. The SDR connector plugs into the FrameGrabber card on the server.

Module 5: The Camera Link Protocol

The cameras used with the FGC Camera System communicate with the Server-Side Subsystem using the Camera Link Protocol, an industry standard camera control protocol. Camera Link is used with a wide variety of cameras and framegrabber cards. Its full protocol is used by FrameGrabber Systems to ensure the highest possible throughput and data transfer rates. FrameGrabber Systems are designed for the most demanding stadium broadcasting applications. We chose the Canera Link protocol for its robust capabilities.

Module Objectives

This module introduces you to the Camera Link Protocol. In this module, you:

3. Describe the Camera Link Protocol and how it is used to connect cameras, extenders, and frame grabber cards from multiple manufacturers.
4. Identify the three Camera Link protocol configurations and which one is used by FrameGrabber Systems

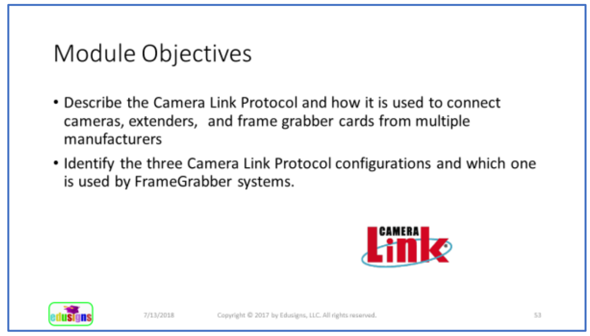
Resources

- *FrameGrabber User Guide*, Chapter 5
- *Camera Link*, https://en.wikipedia.org/wiki/Camera_Link
- *The Camera Link Camera Interface*, http://www.volkerschatz.com/hardware/clink.html

Slides

Slide 5-1

Go over the module objectives with the students. We have included the two most common use cases.



In this module, we focus on:

- Describe how the Camera Link Protocol and how it is used to connect cameras, extenders, and frame grabber cards from multiple manufacturers
- Identify the three Camera Link protocol configurations and which one FrameGrabber Camera Systems uses.

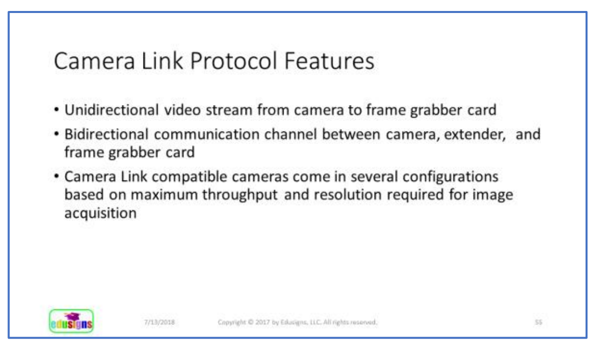
Slide 5-2

Camera Link is a robust communications protocol that uses a dedicated cable connection and standardized serial communications.

Provides a hardware specification standard that standardizes the communication between cameras, extenders, and frame grabber cards.

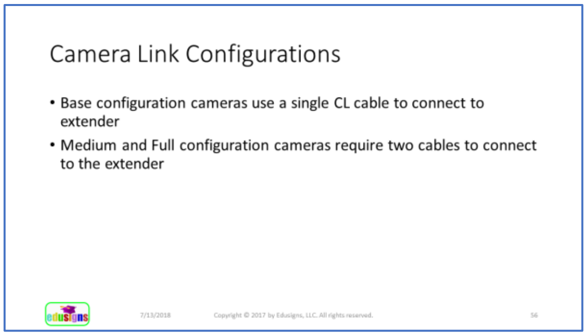
Slide 5-3

The Camera Link protocol provides a unidirectional video stream from camera to frame grabber card.



It also provides a bidirectional communication stream between camera, extender, and frame grabber card to facilitate remote control of the camera.

Camera Link-compatible cameras come in several available configurations based on maximum throughput required for image acquisition. .

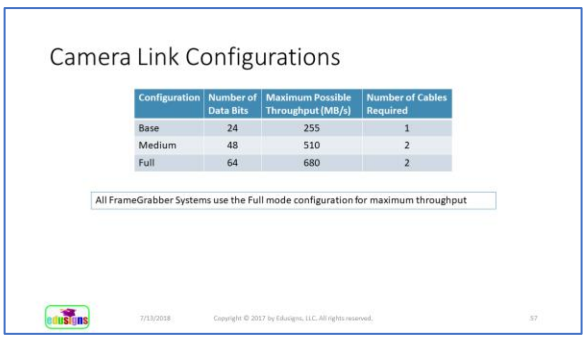


Slide 5-4

Camera Link supports three available configurations:

3. A Base configuration which uses one CL cable to connect the camera to the extender
4. Medium and Full configurations which require two CL cables to connect the camera to the extender.

We also introduced the three subsystems that comprise the FGS system: The Full configuration provides maximum throughput and image resolutions.



Configuration	Number of Data Bits	Maximum Possible Throughput (MB/s)	Number of Cables Required
Base	24	255	1
Medium	48	510	2
Full	64	680	2

Slide 5-5

The table shows the three available Camera Link configurations. This table is also reproduced in the supplementary material for this module.

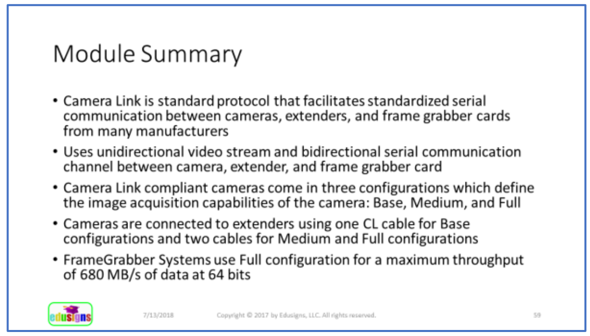
The key takeaway is that all FrameGrabber Camera Systems use the Full Camera Link protocol configuration for maximum data throughput and image resolution.

Slide 5-6

Camera Link (CL) cables connect the camera to the extender.

Since FrameGrabber Camera Systems use the Full configuration, two cables must be used to connect the camera to the extender.

Slide 5-7



In this module, we provided an overview of how the Camera Link protocol is used to connect cameras, extenders, and frame grabber cards from multiple manufacturers.

Camera Link is a robust communications protocol that provides a unidirectional video stream from camera through extender to frame grabber card. It provides a bidirectional standard serial communications channel for controlling the camera.

Camera Link-compatible cameras come in several available configurations based on maximum throughput required for image acquisition. They are Base, which requires one Camera Link (CL) cable to connect the camera to the extender, Medium, and Full. Medium and Full configurations require two CL cables to connect the camera to the extender. The Full configuration provides the maximum possible throughput and image resolution. Full configuration is used by all FrameGrabber Camera Systems.

Slide 5-8

Congratulations! You have completed the course *FGC-101 Certified FrrameGrabber Associate!*

Your next steps are to:

- Take and pass the FGC-101 Certified FrameGrabber Associate certification exam. A score of 80% or better is required to pass the examination and attain certification.
- Enroll in the course *FGC-102 Certified FrameGrabber Technician*.

Questions

1. Describe how the basic features of the Camera Link Protocol and why it is a popular way to connect cameras, extenders, and server-side components.

   The Camera Link protocol provides a robust standard method for cameras, extenders, and frame grabber cards to communicate. Camera Link provides a unidirectional video stream from camera through extender to frame grabber card. A bidirectional standard serial channel is provided for controlling the camera.

2. What are the three Camera Link Protocol camera configurations?

   The Camera Link protocol supports three configurations:

   - Base – uses only one CL cable and provides the lowest throughput and image resolution
   - Medium – uses two CL cables and provides improved throughput and image resolution over Base configuration
   - Full – also uses two CL cables; however, it provides the maximum possible throughput and image resolution.

3. Which Camera Link configuration do FrameGrabber Systems use and why? Include benefits, if any of the configuration you chose.

   All FrameGrabber Camera Systems use the Full Camera Link Protocol configuration for maximum throughput and image resolution. This configuration requires two CL cables to connect the camera to the extender.

Supplemental Resources

The Camera Link Protocol

About Camera Link

Camera Link™ is an interface protocol that includes standardized interconnects between cameras and framegrabbers. It is based on an implementation of National Semiconductor's Channel Link™ technology. The Camera Link standard was developed with the participation of several camera, frame grabber, and cable manufacturers, and defines a standard connector for both the frame grabber and the camera, which ensures that products bearing the Camera Link logo are interchangeable.

The Camera Link specification defines standard signals for clock, line, and frame, dedicated control and serial signals, and data width in various configurations of number of bits per pixel and pixels per clock. The Camera Link specification does not define a minimum and maximum clock speed; however, the Channel Link parts' 20-85 MHz is the de-facto standard.

EDT's Camera Link solutions include high-speed DMA frame grabbers as well as innovative extenders that shatter Camera Link's inherent 10-meter cable length limitation by converting the Camera Link signal to fiberoptic or coaxial for up to 10 kilometers of range in standard configurations, or up to 100 Kilometers using custom transceiver options. All EDT Camera Link products come with support for Windows and Linux.

EDT's Camera Link products are certified to the 2.0 version of the Camera Link specification. Our driver/SDK packages include frame grabber configuration files for a large variety of cameras (click here for a partial list), but virtually any Camera Link camera can be supported, usually by modifying a simple ASCII-text configuration file.

The Camera Link specification can be acquired through Machine Vision Online