Matrox Intellicam

version 8.0

User Guide

Manual no. 10521-301-0800

May 19, 2005

PRINTED IN CANADA

Contents

Chapter 5: Concrete examples 43

Appendix A: Video specification form 65

Appendix B: Camera interface reference 73

Index

Chapter

1

Introduction

This chapter briefly describes the features of the Matrox Intellicam configuration software and how to install it.

Welcome to Matrox Intellicam

Matrox Intellicam is a high-level, 32-bit Windows-based program that provides fast camera interfacing and interactive access to all the grab features and functionalities of your Matrox frame grabber. Matrox Intellicam allows you to grab with various camera types, and see the results immediately.

You can also use Matrox Intellicam to create and/or modify digitizer configuration format files (DCF files) for use with Matrox frame grabbers that support non-standard acquisition. These files can then be used to interface with any camera supported by your Matrox frame grabber.

Installation

Matrox Intellicam is included with MIL/ActiveMIL/MIL-Lite/ActiveMIL-Lite, Matrox Inspector, and Matrox Odyssey Native Library (ONL). It is automatically installed when installing MIL/MIL-Lite or ActiveMIL/ActiveMIL-Lite. You can also install Matrox Intellicam as a stand-alone product. Refer to the manual of the accompanying software for more installation information.

During installation, you will be asked a number of questions, such as:

- The drive and folder in which to install the program.
- The port with the development hardware license-key: the parallel or the USB port.
- The type of Matrox hardware installed in your computer (for example, Matrox Solios). Note that under Windows 2000/XP, the boards should be installed before the Matrox frame grabber drivers are installed.
- Whether to install the MGA drivers. This will only be asked if you have a Matrox Imaging board with a display section or a Matrox graphics board, and the drivers to be installed are newer than the drivers already on your computer.

What you need to run Matrox Intellicam

The computer and operating system requirements for Matrox Intellicam are the same as the accompanying software with which you installed Matrox Intellicam. Refer to the user guide for the accompanying software for these requirements.

Matrox Intellicam documentation conventions

This section describes some conventions used in this manual.

Documentation conventions

This manual occasionally makes reference to a MIL-Lite function. However, anything that can be accomplished with MIL-Lite can also be accomplished with MIL, ActiveMIL, ActiveMIL-Lite, Odyssey Native Library, or Matrox Inspector.[1]

Menu conventions

This manual refers to operations, accessible through the menus, as commands, and refers to them by their menu names. For example, selecting **Validate DCF** from the **DCF** menu is referred to as the **DCF Validate DCF** command.

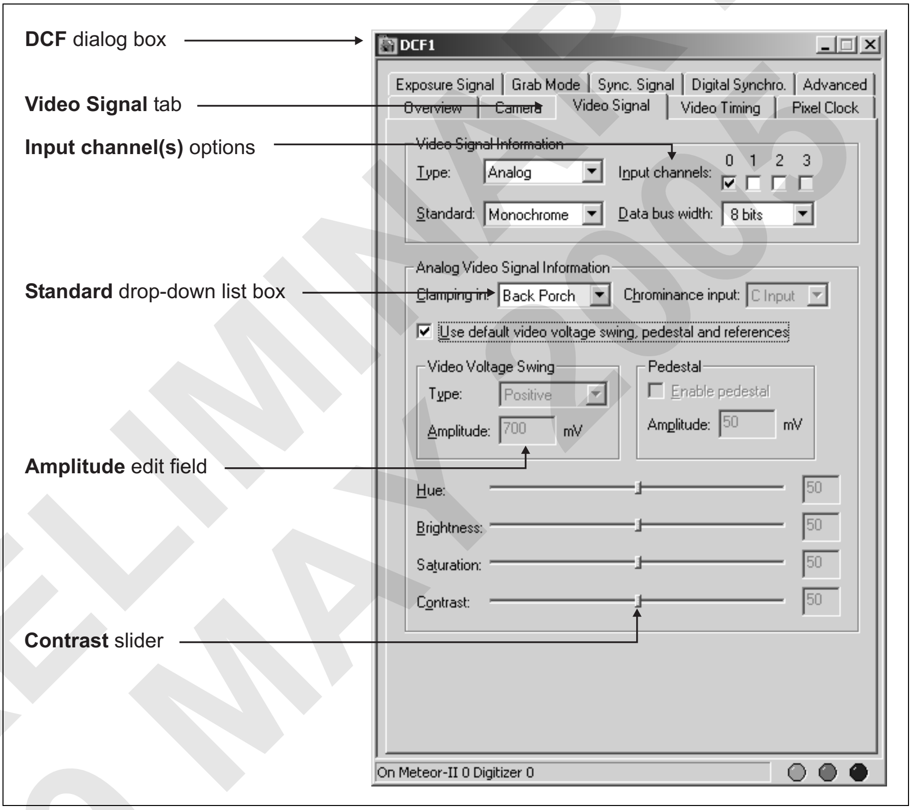
Dialog box conventions

In general, when a command is called, a dialog box appears. Dialog boxes allow you to specify how to perform the command. To use a dialog box, you might have to enter values in edit fields, select items from list boxes, specify options, adjust values using sliders, or click on buttons and selectors.

1. Most operations can be accomplished with Matrox Inspector.

Multiple tabs

Most of Matrox Intellicam's dialog boxes are actually multiple dialog boxes, that is, different dialog boxes overlaid one on top of the other. The main dialog box is referred to as a dialog box, while its internal dialog boxes (or property pages) are referred to as tabs. The tab name appears at the top of the tab.



Chapter

2

Matrox Intellicam basics

This chapter describes the Matrox Intellicam basics required to grab with standard and non-standard cameras.

Using Matrox Intellicam

This chapter describes the basics for using Matrox Intellicam. This information is required to grab images or test DCFs.

Before starting, make sure that your frame grabber is correctly installed and set up, and that your camera is properly connected. Most of the time, you will perform the basic steps:

1. Choose a system.
2. Choose a DCF that matches, as closely as possible, the data format of your camera.
3. Create an image document.
4. Continuously grab from your camera into the image document.
5. Adjust the digitizer controls and/or fine-tune your DCF. Refer to the chapter, *Customizing your DCF*, for information on fine-tuning your DCF.

Note that these are basic steps to use either standard or non-standard cameras with Matrox Intellicam.

Selecting a target system

Matrox Intellicam requires that you specify a target system before using any of its features. A system generally refers to a board with video acquisition capabilities that is installed in your computer.

Matrox Intellicam systems represent and permit access to the specified Matrox Imaging board, the Host CPU and memory, and any available graphics controller. When you specify a system, Matrox Intellicam opens communication channels and initializes the system (or hardware resources).

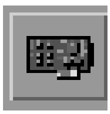
The first time that you load Matrox Intellicam, the **System Selection** window appears. From the list of available systems that appears, select the system, and either double-click on it or click on the **Make Active** button to activate it.

Virtual systems

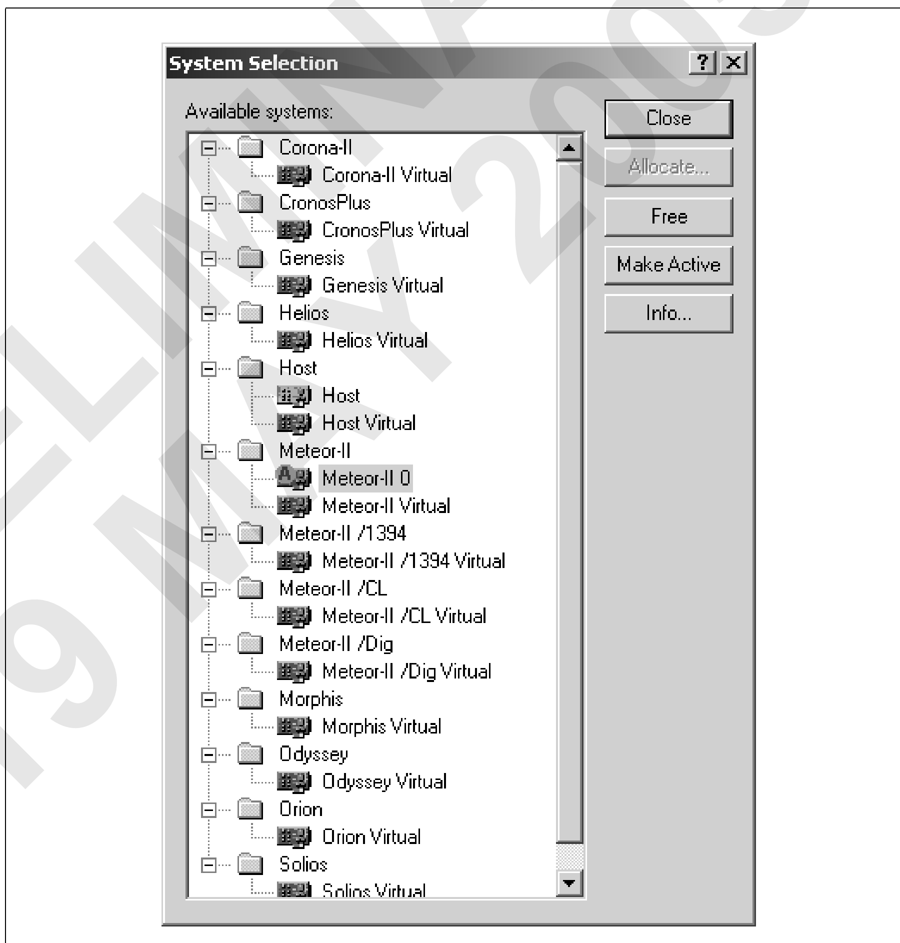
You will also notice that Matrox frame grabbers are available as virtual systems in Matrox Intellicam. You would select a virtual system to configure a DCF file for a frame grabber that is not currently installed.

❖ Note that you cannot grab using a virtual system.

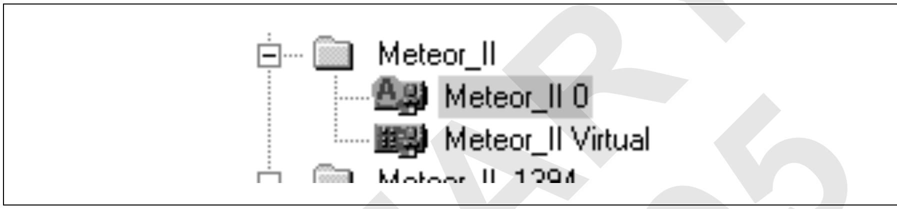
Your target system can be changed at any time. To do so:



1. Click on the **System Selection** button, or use the **Options System Selection** command. The **System Selection** dialog box opens.



2. Choose your target system (for example, **Meteor_II 0**) by double clicking on the item to make it active. This makes the selected system the default system and the icon next to your selection changes to an **A** (for Active System). The active system is the system with which to capture images and associate DCFs.



The **0** following the name of the board implies that the board is the first of several boards of the same type installed in your computer. Moreover, it indicates a physical board as opposed to a virtual one.

3. Click on **Close**. The system with the **A** icon is now the active system.

Selecting a DCF for your camera

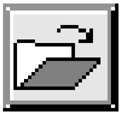
After selecting your system, you must select or create a DCF. A DCF is a *digitizer configuration format*. A digitizer is set of acquisition paths from which to acquire data from a single camera of the specified type. A DCF is a document that contains the register-level information that must be downloaded into the digitizer section of your target system before you can grab with your particular camera.To interface your frame grabber with a camera, you must specify a DCF that matches the video timings and format of that camera.

If you are using a standard camera (such as, RS-170 or CCIR), a DCF is already pre-defined for your camera. If you are using a non-standard camera, a DCF might have been pre-defined. If not, you will either have to modify an existing DCF or create a new one.

Pre-defined DCF files

Check to see if a DCF has already been created for a particular camera in the *\DCF* directory for your board in the *\DCF* sub-directory for your frame grabber in the *\Matrox Imaging\Drivers* directory. If a pre-defined DCF file is available for your camera, it should be located and opened in Matrox Intellicam. However, you can find updated and verified DCFs for most common camera manufacturers on the Matrox Imaging website and use those when available.

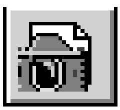
❖ Note that you should download the official and verified DCFs from the Matrox Imaging website: http://www.matrox.com/imaging/cameras/appnotes.cfm.



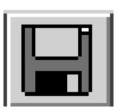
To open an existing DCF, use the **File Open** command or click on the **Open** button. The DCF opens in a Digitizer Configuration Format dialog box.

Creating your own DCF files

You can also create your own DCF from scratch, but it is easier to start from an existing DCF and change the fields that do not conform to the configuration of your particular camera.



To create a DCF, use the **File New** command or click on the **New DCF** button. This opens the **New Digitizer Configuration Format** dialog box. Select the **Digitizer Configuration Format** tab. You can either select an initial digitizer format from the presented dialog box or click on the **Browse** button to start from an existing DCF file. A DCF file is created. Refer to the *Customizing the DCF* chapter for more information on setting appropriate values.



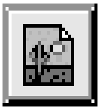
The DCF dialog box will not have the same name as the selected digitzer format; rather, it will have a temporary name (for example, DCF1). You can choose a file name when you save your DCF, using the **File Save** command or the **Save** button.

❖ Note that if you use the **Save** button when you have an existing DCF open, saving will overwrite the original file without prompting you to overwrite the file. If you want to keep the original file, use the **File Save As** command, and give it a different file name.

Target systems and DCF files are further discussed in the next chapter. Examples for interfacing a non-standard camera can be found in the *Concrete examples* chapter. If you are unfamiliar with video timing and signals, you might want to consult *Appendix B: Camera interface reference* before you begin.

Creating an image document

To grab or load an image in Matrox Intellicam, you must create an image document. An image document is a memory buffer associated with your target system, and is used to store grabbed or loaded images. Matrox Intellicam supports image documents in several image formats, including MIM, TIF, RAW, BMP, JPG, and JP2.



To create an image document, use the **File New** command or click on the **New Image** button. The **New Image** dialog box opens, which allows you to set various attributes for your image, such as the size and type.

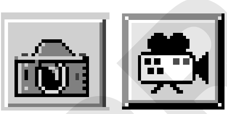
If a DCF is already open in Matrox Intellicam, any grab command will create a new image document for you. The new image document is, by default, created using the attributes specified in the DCF. To create an image with different attributes, deselect the **Fill with current digitizer sizes** option, and specify all the required information in the appropriate edit fields. When you are finished, click on the **OK** button to continue.

❖ The DCF dialog box displays the image attributes in the **Camera signal** section of the **Overview** tab.

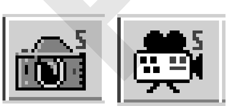
Child areas

You might want to define a child area in your image document. For example, you might want to work only on a specific region of interest within the image itself. To define such an area, double click at the child area's required point of origin in the image document and drag the child area to the required size. In MIL and ActiveMIL, child areas are referred to as child buffers and child images, respectively.

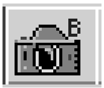
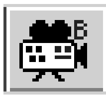
Grabbing images using Matrox Intellicam



Once you have selected a target system, DCF file, use the **Digitizer Single Grab** or the **Digitizer Continuous Grab** command to grab images and display them in the current image window. A continuous grab can be stopped with the **Digitizer Halt Grab** command.



You can also use the **Digitizer Single Safe Grab** or the **Digitizer Continuous Safe Grab** commands to grab images. In safe mode, the image is grabbed into the internal buffer of the image document, and then copied to its buffer in displayed memory, instead of being grabbed directly into displayed memory. You should use safe modes for making changes to your DCF. Performing a grab separate from the displayed memory is less likely to cause Matrox Intellicam to hang, for example, in cases where the user enters values in the DCF control that cause the camera or digitizer to malfunction.

The **Digitizer Single Bayer Grab** and the **Digitizer Continuous Bayer Grab** commands grab an image and starts a live grab (respectively) into an internal buffer then applies a Bayer conversion to the image before the image is copied to its buffer in displayed memory. Refer to the *Cameras with a Bayer filter* section for information on Bayer settings.

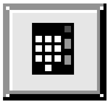
Using the digitizer control settings

The DCF specifies the number of acquisition paths and the "initial state" of these acquisition paths. To allocate a digitizer on the target system, select it from the list of digitizers from the digitizer drop-down list box. Some of the initial acquisition settings (called *digitizer controls*), as well as some other initial settings, can be dynamically modified and/or adjusted afterwards in your application, for example, using MIL-Lite functions.

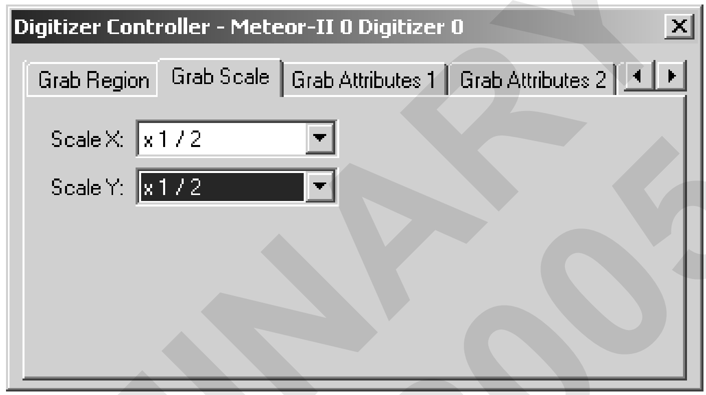
You can experiment interactively with the various dynamic digitizer controls. To do so, start a continuous grab (for example, using the **Digitizer Continuous Grab** command, or click on the **Continuous Grab** button), and experiment with the various controls provided in the **Digitizer Controller** dialog box. As you change the various control settings, you can immediately see the results of your changes in the image that you are grabbing. This allows you to become familiar with the capabilities of your board when it is initialized with a particular DCF.

❖ Note that some controls, especially triggers, exposure and switching modes. are best changed when grabbing is halted, or else they might cause Matrox Intellicam to hang.

Any adjustments made using the **Digitizer Controller** dialog box will not change the contents of the DCF, since the digitizer controls are applied "on top of" the DCF's initial state. In other words, if you specify **Channel 1** as the default data input channel in your DCF (selecting the **Input channels** options in the **Video Signal** tab of the opened DCF) and change the channel number from the **Channel** drop-down list box in the **Channel** tab of the **Digitizer Controller** dialog box to 2, your grab will be done using Channel 2. However, when you reload the DCF, Channel 1 will still be the default channel.



To open the **Digitizer Control** dialog box, click on the **Digitizer Control** button or use the **Digitizer Control** command.



The **Digitizer Control** dialog box is unique for each board, and provides digitizer control options available for your particular board. Choose among the various tabs to access the digitizer controls, such as data input channel, reference levels, or grab scale factor.

For example, the initial resolution setting for a standard RS-170 camera is 640 x 480. If you want to grab at half that size, select the **Grab Scale** tab and set the **Scaling X** and **Scaling Y** options to 1/2. All subsequent grabbing (until the DCF is reloaded) will be done using that scale factor.

❖ Note that each control in the various tabs corresponds to a digitizer setting accessible through a MIL-Lite function (for example, **MdigControl**(), **MdigReference**(), or **MdigChannel**()). Using the tabs to control the digitizer settings allows you to quickly find the exact value required for each setting, and see its effect before writing your application program.

A simple grabbing example

The following is an example of grabbing with a camera.

1. Select a system. Use the **Options System Selection** menu command, and select the required system from the lists of available systems.

2. Open the required DCF. Use the **File Open** menu command and browse to the required DCF, then click on **Open**, or click on the **Open** button.

3. Create a new image document. Use the **File New menu** command and select the **Image** tab or click on the **New Image** button. Select **Settings from the current DCF**., or select **Settings set manually** and specify the image properties.

4. Grab your image. Use the **Digitizer Single Grab**, **Digitizer Single Safe Grab**, or **Digitizer Single Bayer Grab** for single image; or use the **Digitizer Continuous Grab**, **Digitizer Continuous Safe Grab**, or **Digitizer Continuous Bayer Grab** for continuous grabs.

5. Make sure all the edges of the grabbed image appear correctly. For example, you should make sure there are no black bars at the edges of the image.

   However, if bars do appear at the edges, you might need to adjust the DCF. Refer to the sub-section, *Fine-tuning your DCF* in the section *Interfacing a non-standard camera* for further information.

6. Verify the frame rate in the status bar at the bottom right corner.

   Note that in cases where the actual frame rate might not correspond to the frame rate displayed in the **Frequency** field of the **Video timings** tab, the frame rate might not be accurate. Refer to the chapter *Customizing the DCF* for information about adjusting the DCF.

7. Click on stop. Use the **Digitizer Halt Grab** menu command or click on the **Halt Grab** button.

Example of grabbing simultaneously using two or more cameras

On frame grabbers that support it, you can use Matrox Intellicam to grab from two or more cameras at the same time. This is done by using a separate DCF for each camera.

The following is an example of grabbing a sequence using multiple cameras into an image document:

1. Select a system. Use the **Options System Selection** menu command, and select the required system from the lists of available systems.

2. Open the required DCF for the first camera.

3. From the **Overview** tab of the DCF dialog box, select the number of digitizers from the **Digitizer number** drop-down listbox.

4. Open the required DCF for the next camera.

   - Even if you use the same DCF specifications for each camera, you must save each DCF file using separate names.

5. Select the DCF with which you want to grab first to make it active. Grab your image by clicking on a grab command. The grab will open a new image document.

   - Note that clicking on one of the grab commands affects the image document or DCF dialog that is active.

6. Select the next DCF to make it active and then start the grab. The grab will open in a separate image document. Continue to select DCFs for each camera used.

7. Select the DCF on which you want to halt grabbing and click on the **Stop** button. To halt grabbing on all cameras, select each DCF individually and click on the **Stop** button.

Chapter

3

Customizing the DCF

This chapter gives you a description of how to customize a DCF.

Interfacing a non-standard camera

If your target system supports acquisition with non-standard cameras and downloadable digitizer configuration format (DCF) files, you can create and/or modify a DCF to interface with your particular camera.

Once you have tested your hardware and software by grabbing with a standard camera (see *Chapter 2: Matrox Intellicam basics*), you can connect the non-standard camera with which to interface.

Non-standard cameras include frame scan cameras and line scan cameras.

This chapter provides some important tips and points to keep in mind when working with different camera modes and settings. In the subsequent chapter, some concrete examples are provided on how to interface with some of these types of cameras.

If you are not familiar with interfacing cameras, prior to continuing with this chapter, you should refer to *Camera interface reference* for information on interfacing cameras in general. Then, you should become as familiar as possible with your camera. Read the manufacturer's documentation carefully. We recommend filling out the *Video Specification Form* provided in this manual, or send it to the camera manufacturer and ask them to fill it out for you.

When interfacing with a non-standard camera, it is a good idea to start with an existing DCF that has a configuration similar to that of your camera. Remember that you can download DCF files for your target system from the Matrox Imaging website (see the section *Selecting a DCF for your camera* in chapter 2). View the headers of the various DCF files to help you choose the most appropriate DCF.

You should also read the associated application note for your specific camera. Application notes are available on the Matrox Imaging website at http://www.matrox.com/imaging/cameras.

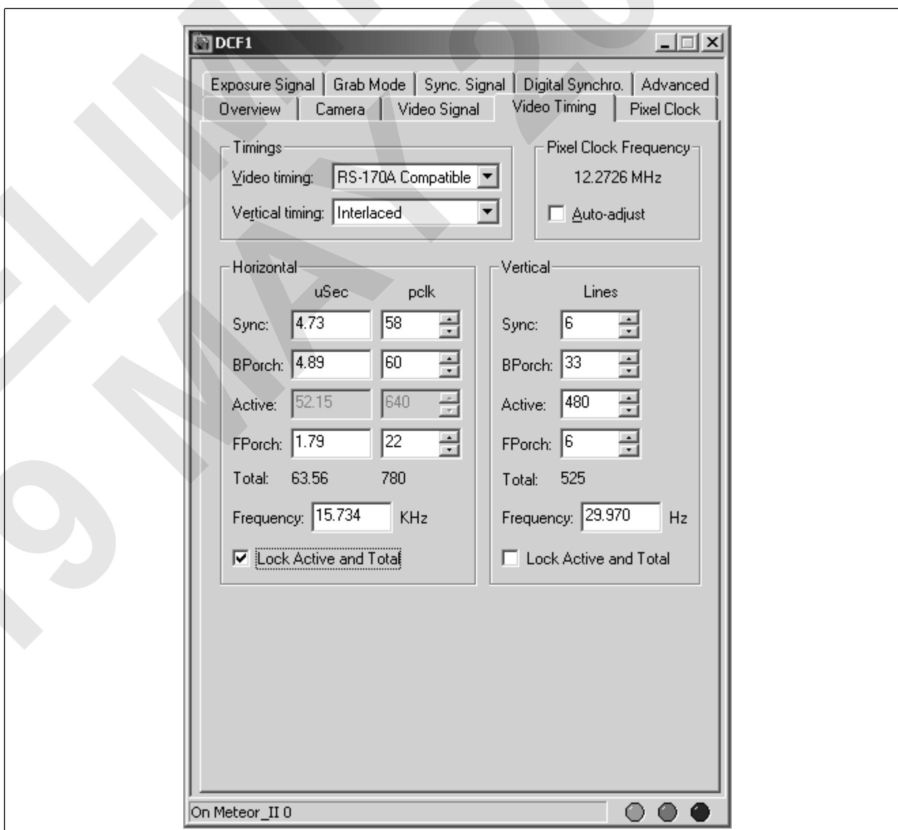
Fine-tuning your DCF

Once you have a selected a DCF that has a configuration similar to that of your camera, you can fine-tune the settings to best suit your requirements. For example, a typical adjustment for analog cameras is if the active video is not properly centered, it is likely that the back porch specified in the DCF is a little too narrow; to adjust the alignment, you will have to make the back porch a little wider.

❖ The *horizontal back porch* is the blank region at the left of the grabbed image. This blank region might be visible if the back porch specified in the DCF is wider than the value entered in the Horizontal **BPorch** field.

To adjust the back porch:

1. Click on the **Video Timing** tab of the DCF while grabbing continuously.



- Typically, you should not select the **Auto-adjust** option while grabbing, unless you want to change the aspect ratio of your grabbed image. For this example, make sure the option is not selected.

2. Select the **Lock Active and Total** option in the **Horizontal** section to keep the original total horizontal timings and have Matrox Intellicam automatically calculate the front and back porch values.

   - Note that, based on the features of your camera, it is possible that one or more state are not present in the camera video timings, particularly for digital cameras. If a specific state is missing, set its corresponding timing value to zero or to the minimum allowed by your frame grabber. For more information, refer to the definition for **video timings**.

   - The above also applies to **Vertical** timings.

3. To change the setting for your back porch, type in the new value in the **Horizontal BPorch** edit field and press **Enter**. Otherwise, click on the current value of the back porch, and then click on the up or down arrows located to the right of the edit field. When you click on the up arrow, the black stripe on the left of the grabbed image will disappear as the image is moved to the left. You will immediately see the results of the changes on the image. Continue to make adjustments until you are satisfied with the results.

❖ You can specify **Horizontal** timings in either microseconds (μsec) or pixel clock cycles (pclk).

❖ If your continuous grab stops or becomes unstable, you might want to adjust your synchronization values. If you set synchronization values that are well outside a reasonable range, the hardware will not be able to synchronize properly and will stop your grab or make it unstable.

The only way to get around this is to stop your grab completely and reload your DCF. Typing in your values rather than using the arrows will increase your chances of the values being accepted without a problem. If you are changing all or most of your timings, you might try to stop your grab, change your timings and then re-start your grab.

You can save your new DCF by clicking on the **Save As** button or by using the **File Save As** menu command.

Using non-standard cameras

Different non-standard cameras can support various modes and features. A camera is considered non-standard when its video signals do not conform to one of the internationally accepted video standards, such as CCIR, RS-170, NTSC, or PAL.

Non-standard cameras can support some of the following characteristics:

- Interlaced or non-interlaced mode.
- Frame scan or line scan capabilities.
- Various resolutions.
- Analog or digital video signals.
- Adjustable pixel clock frequency.
- Asynchronous reset mode (useful when grabbing upon a trigger).
- External exposure shutter control.
- Multiple taps.
- Varying bits per pixel.
- RGB color.
- Bayer filters.
- Slave or master mode (in a slave mode, the frame grabber is master while the camera is slave).

The remainder of this chapter gives you recommendations on configuring your DCF for most of these characteristics.

You can read about triggered grabs and asynchronous reset, and user-defined signals in the chapter *Using exposures, triggers, and user-defined signals*.

Interlaced and non-interlaced modes

Some cameras can transmit video in interlaced mode, non-interlaced mode, or in either mode. When creating or modifying a DCF, you must specify in which of these two modes the camera will be transmitting video, using the **Camera** tab of the DCF dialog box. Selecting the frame scan camera option will allow you to choose between interlaced and non-interlaced modes (modes that require vertical timing), whereas there is no vertical timing involved when using a line scan camera.

You must select whether the vertical timing for the video signal is interlaced or non-interlaced using the **Video Timing** tab.

If during a continuous grab using an analog camera, the lines become skewed at the top of the image, try selecting the **Block synchronization type enable** option in the **Sync. Signal** tab of the DCF dialog box. This will configure the board so that it expects a block synchronization pulse (that is, one without serration pulses).

In chapter 5, the examples for interfacing with a frame scan camera deal primarily with non-interlaced mode. Refer to chapter 5 for more details.

Frame scan modes

When using cameras that support frame scan modes, you must specify that the camera is a frame scan type of camera using the **Camera** tab of the DCF dialog box when creating or modifying a DCF.

There are several variations of frame scan camera modes. The following are points to retain when using Matrox Intellicam with frame scan cameras:

- **Continuous frame scan**. A camera that uses continuous frame scan transmits continuous video, that is, the camera is *free-running*. The camera uses its internal exposure control. The frame rate is fixed and depends on the camera's settings.

- **Pseudo-continuous frame scan**. A camera that supports pseudo-continuous frame scan provides continuous video, however, the camera is in triggered mode. Typically, these cameras use exposure control. The frame rate is a function of the external trigger and of the exposure time.

- **Asynchronous reset mode**. A camera equipped with asynchronous reset mode provides video on-demand. The exposure control can be internal or external (via the camera's settings, or controlled by the frame grabber). In addition, the frame rate is a function of the exposure signal frequency.

- **Long exposure mode**. This type of frame scan camera mode uses video on-demand. The exposure control can be internal or external (exposure can be much longer than frame time). Frame time is a function of the exposure time and the output rate.

The examples in chapter 5 illustrate acquiring analog data and digital data with frame scan cameras. Refer to chapter 5 for more details.

Line scan modes

When using cameras that support line scan mode, you must specify that the camera is a line scan type camera using the **Camera** tab of the DCF dialog box when creating or modifying a DCF.

Line scan cameras can be operated at a fixed line scan rate, at a variable line scan rate, at a fixed line scan rate with a frame trigger, at a variable line scan with frame trigger (both line and frame triggers), at a fixed line scan rate with a variable frame size (using frame triggers), and also at a variable line scan rate with a variable frame size (using line and frame triggers).

For further information about the specifics of each mode, refer to *Appendix B: Camera interface reference*.

The following are some points to retain when using Matrox Intellicam with line scan cameras:

- **Fixed line scan mode**. Also called *free-running* mode. You should use a fixed line scan mode when you know that objects are moving past the camera at a constant speed or vice versa. This mode is useful for determining if the camera functions properly, but might not be practical for determining the height of the object in the image. You must specify the fixed line scan mode using the **Grab Mode** tab of the DCF dialog box.

- **Fixed line scan rate with frame trigger**. DCFs can support fixed line scan rates with frame triggers. This mode allows you to grab at a fixed line scan rate with the additional advantage of supporting a frame trigger. The frame trigger indicates when to start grabbing a specified number of lines or frames. Select the fixed line scan mode with a hardware trigger using the **Grab Mode** tab of the DCF dialog box.

- **Fixed line scan rate with variable frame size**. DCFs can support fixed line scan rate with variable frame size. This mode is useful for applications that require fixed line scan, but need the flexibility to change frame size, meaning you can vary the number of lines in the image. Select the fixed line scan mode with a a variable frame size on the **Grab Mode** tab of the DCF dialog box.

- **Variable line scan mode**. DCFs can support variable line scan mode, where the grab is synchronized to an external event. In contrast to the fixed line scan mode, the aspect ratio is less likely to be distorted when grabbing because the external trigger signals when to grab using a motion encoder. This mode is used primarily for inspecting continuous materials such as sheets of metal or paper, and not typically used for discreet objects. Select the variable line scan mode using the **Grab Mode** tab of the DCF dialog box.

- **Variable line scan rate with frame trigger**. DCFs can support variable line scan rates with frame triggers. This mode is useful for discreet objects that moves past the camera at constant or at a variable rate, because the grab is triggered by the moving object. Select the variable line scan mode with a hardware (or software) trigger using the **Grab Mode** tab of the DCF dialog box.

- **Variable line scan rate with variable frame size.** DCFs can support variable line scan rates with variable frame size. This mode is useful for applications that require variable line scan, but also has the advantage of using and external signal to start and stop the grab. Select the variable line scan mode with a a variable frame using on the **Grab Mode** tab of the DCF dialog box.

Some examples in chapter 5 deal with interfacing with line scan cameras, such as grabbing digital data with a Camera Link line scan camera and using asynchronous reset with a Camera Link line scan camera. Refer to chapter 5 for further information.

Changing resolutions

You can change resolutions on some cameras by using *binning*, by using a partial scan, or using a region of interest (child area). Using Matrox Intellicam, you can change resolutions for the grab.

Binning (sometimes called integration) is a process where many adjacent pixels in a CCD are combined to form a "larger pixel". Binning can be used where higher frame rates are required and higher sensitivity at the cost of lower resolution. Note that the aspect ratio will be affected by binning if the x and y factors are not the same. Binning is available on certain cameras and increases the frame rate by reducing the amount of lines or pixels being output from the camera.

In Matrox Intellicam, you can change the resolution by changing the value of the **Active** field for the number of lines for the vertical synchronization using the **Video Timing** tab.

❖ When adjusting resolutions, you always want to match the camera's output resolution to that in Matrox Intellicam.

Partial scan

You can use a partial scan on some cameras to change resolutions which can increase the frame rate on the camera because fewer lines or pixels per frame are sent to the digitizer.

Regions of interest

On some cameras (including IEEE-1394 cameras with format 7), you can create a region of interest with a lower resolution which can be used like a lower resolution camera. This usually means that only a part of the image will be output. The frame rate, however, usually remains the same as the one for the original resolution. The region of interest can also be controlled by the frame grabber using the **Grab Region** tab of the **Digitizer Controller** dialog. Also you can use the **Image Child Area** command to specify the destination pixels in the image.

Acquiring analog or digital data

You can use Matrox Intellicam to verify that your camera is set up properly, whether it be analog or digital.

For most standard analog cameras, the DCFs provided by Matrox should be sufficient to grab. However, for non-standard analog cameras or digital cameras (aside from Camera Link cameras), you will mostly likely need to modify an existing DCF to suit the cameras.

All the information required to customize a DCF for your camera should be available in the documentation for the camera, including video timings, pixel clock frequencies, and maximum resolutions.

Analog data

When acquiring analog data, you will usually need to build a custom cable to get the camera to function properly, which might be simple to set up. You can use Matrox Intellicam to verify whether the cabling is correct by performing test grabs.

For analog data, you usually only need one signal which contains composite (horizontal and vertical) synchronization signals, along with the video information. Sometimes, you might also have separate horizontal and/or vertical synchronization signals. Analog video is converted to digital data by the frame grabber. You can also have RGB analog data where each component (red, green or blue) is a separate signal.

Digital data

Because there are no standards for digital cables, a custom cable must be built for each camera. This can get complex for digital setups, though image quality is better than for analog signals.

Using Matrox Intellicam, you can start off with a pre-defined DCF for a camera similar to yours and customize it to your requirements. In general, when receiving digital data and synchronization signals, the signals you need to connect are a pixel clock, horizontal synchronization, vertical synchronization, and data signals.

❖ Note that Matrox does not have DCFs which support IEEE-1394 compliant cameras directly. You can use an existing DCF which most closely matches the IEEE-1394 camera and modify it to meet specific requirements.

Pixel clock frequency

If required, you can adjust the pixel clock frequency for your grab on the **Pixel Clock** tab of the DCF dialog box. For example, you might want to change pixel clock frequency to adjust the aspect ratio. Increasing the pixel clock frequency to changes the number of pixels sampled per line and increase resolution. Also, if you do not know the correct pixel clock frequency for the camera, you can adjust the frequency until it best suits the input from your camera.

The frame rate is directly proportional to the pixel clock frequency. For example, if your pixel clock frequency is set at 40 MHz (resulting in 30 frames per second (fps)), and the pixel clock frequency is halved, the frame rate will be approximately 15 fps (excluding blanking and synchronization).

❖ Note that you should use the recommended pixel clock frequency specified in the documentation for the camera; you should adjust the pixel clock values of the DCF only when necessary.

If the acquired image seems to have "salt and pepper" noise, try adjusting the pixel clock delay using the slider bar on the **Pixel Clock** tab of the DCF dialog box until the noise disappears. Occasionally, the pixel clock does not sample the digital signal at a "stable state". By adding a slight delay, this ensures that the sampling is performed at the correct time. You can add the delay in the **Delay** fields of the required pulses of the **Timer 1** or **Timer 2** sub-tabs of the **Exposure Signal** tab.

This can also work to compensate for propagation delays when grabbing with longer cables; you can try adding 2 nanoseconds (nsec) per meter of cable.

Pixel depth (bits per pixel)

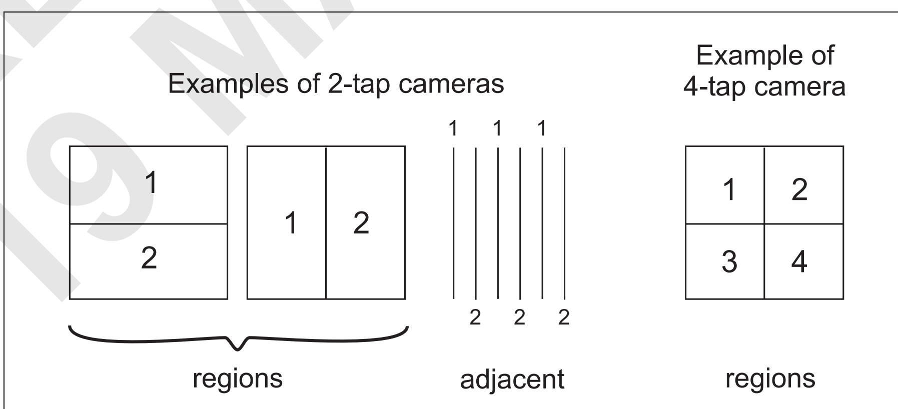
Most digital cameras can output at 8 bits per pixel although some are capable of outputting at higher bit modes such as 10- or 12-bit cameras. RGB cameras typically output at 3 x 8 bits (for 24 bits color depth in total). Bayer color cameras typically support 10-bit images. See the section *Cameras with a Bayer filter* for more information.

You can set the number of bits that will be digitized (or sent to memory). To do so, change data bus width on the **Video Signal** tab of the DCF dialog box. You might want to reduce the pixel depth (bits per pixel) to gain speed, or to simply test to see if your camera outputs video properly.

Analog cameras provide an analog signal which can be digitized at any available amount of bits per pixel (dependent on the frame grabber), but the most common is 8 bits per pixel, as there is little advantage in digitizing an 8-bit source into a 10-bit image because you do not gain any precision in doing so.

Multiple tap cameras

Some cameras can send multiple simultaneous outputs, two or more parts (taps) of an image for a higher frame rate; ouputting two taps simultaneously provides twice the bandwidth as a single-tap camera.



❖ RGB cameras can also be considered 3-tap cameras but are usually simply referred to as RGB cameras.

You can specify the number of taps transmitted from your camera using the **Tap Configuration** sub-tab of the **Camera** tab, found in the **DCF** dialog box. Once the taps are specified, you can click the corners of the tap region(s) to change the direction of the tap(s). The arrowhead indicates the direction of the tap.

Some tap arrangements are more common than others. Tap arrangements are usually specific to the camera. When specifying tap arrangements, you should consult the specifications for your camera.

In chapter 5, there are two examples that deal with cameras with taps: grabbing using a single-tap camera, and grabbing using a multi-tap camera. Refer to chapter 5 for more details.

RGB cameras

Some cameras support RGB color definition. For applications that require color detail, it is advantageous to use a RGB camera. If using a color camera, specify its RGB video signal information by selecting the video standard from the **Standard** drop-down list box from the **Video Signal** tab.

RGB color from an analog source is transmitted along three analog signals (red, green and blue) with either composite, or typically on the green signal, or separate synchronization signals.

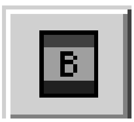
RGB 8 bit color from a digital source typically consists of 24 digital signal pairs. Synchronization and pixel clock signals are separate.

Cameras with a Bayer filter

Cameras that feature a Bayer color filter (sometimes referred to as a Bayer camera) can be used with Matrox Intellicam to provide a cost-effective method for grabbing color images: the camera outputs a single-band color-encoded image, and then you can convert it to a multi-band color image. The image typically has the same size and width as its 3-band equivalent. However, intensity and color information of each of its pixels is shared by 4 neighboring pixels.

When using Bayer filters in Matrox Intellicam, you need to specify the Bayer filter pattern. To do so, select the **Camera** sub-tab from the **Camera** tab of the DCF dialog. From the **Bayer mode** drop-down list box, select the required pattern.

❖ Note that when applying a Bayer filter with Matrox Intellicam, even if you use a frame grabber with built in Bayer capabilities, the camera you are using must still be equipped with a Bayer filter. The Bayer pattern specified in the camera is the one that will be used in the DCF. To specify the Host Bayer pattern, use the **Digitizer Bayer Settings** command; to specify the camera Bayer pattern, use the **Bayer mode** drop-down listbox from the **Camera** sub-tab of the **Camera** tab of the **DCF** dialog.



When grabbing with a Bayer filter, be sure to calibrate the white balance prior to your grab, otherwise the color settings will not be optimal. You can calibrate the white balance of your images from the **Configure Bayer Settings** dialog which you access by clicking on the **Bayer** button. Refer to the MIL User Guide for further information about Bayer filters.

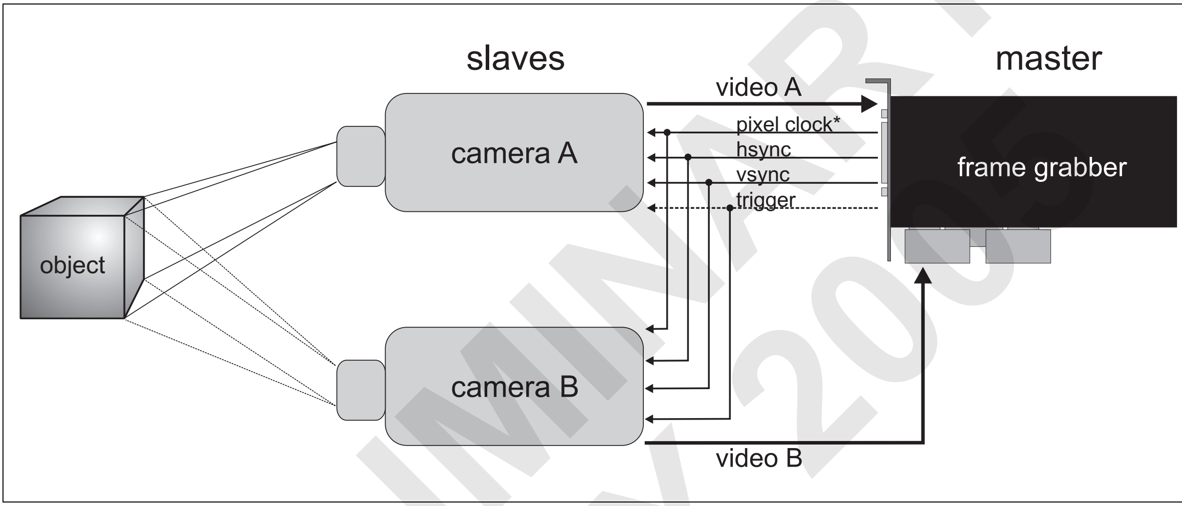
Frame grabber master/camera slave mode

Some cameras can operate in master or slave mode. In a typical digital camera set up, the camera provides the pixel clock and therefore acts as the synchronization source and master; then, the frame grabber synchronizes to the camera. In the mode where the camera acts as the slave, the frame grabber provides the pixel clock and the synchronization signals to the camera.

❖ Note that the limitations of the camera still dictate the signals that the frame grabber sends (for example, the pixel clock frequency). Also, the pixel clock and synchronization signals must match the camera specifications.

The frame grabber master/camera slave mode is useful for applications that require precision, for example, from two or more cameras as a single source; these set-ups are referred to as using the *genlock system*.

When multiple video sources are used, and precise synchronous acquisition is required, the frame grabber can act as the master by outputting the pixel clock and synchronization signals to the cameras, where the cameras are configured as slave.



Chapter

4

Using exposures, triggers, and user-defined signals

This chapter explains using exposures, hardware and software triggers, as well as user-defined signals.

Introduction to exposures, triggers, and user-defined signals

This chapter discusses how to create a DCF to generate exposure signals, to grab upon a trigger signal, and to send and receive user-defined signals with Matrox Intellicam.

Using external exposure controls

In controlled exposure mode, you can dynamically control the camera exposure shutter using an exposure signal. Take note that when grabbing fast-moving images, using longer exposure periods might cause the image to be blurred; therefore, you should make sure to set your lighting accordingly to provide optimal exposure.

To set exposure signals in Matrox Intellicam, you specify the settings on the sub-tabs of the **Exposure Signal** tab.

User-defined signals

Some cameras must be set using configuration control line inputs. User-defined outputs can be use to set the mode for the camera. User-defined outputs might vary depending on the frame grabber.

❖ Note that not all frame grabbers support user-defined signals.

To set user-defined signals in Matrox Intellicam, you specify the settings on the sub-tabs of the **Other** tab.

Performing a simple triggered grab

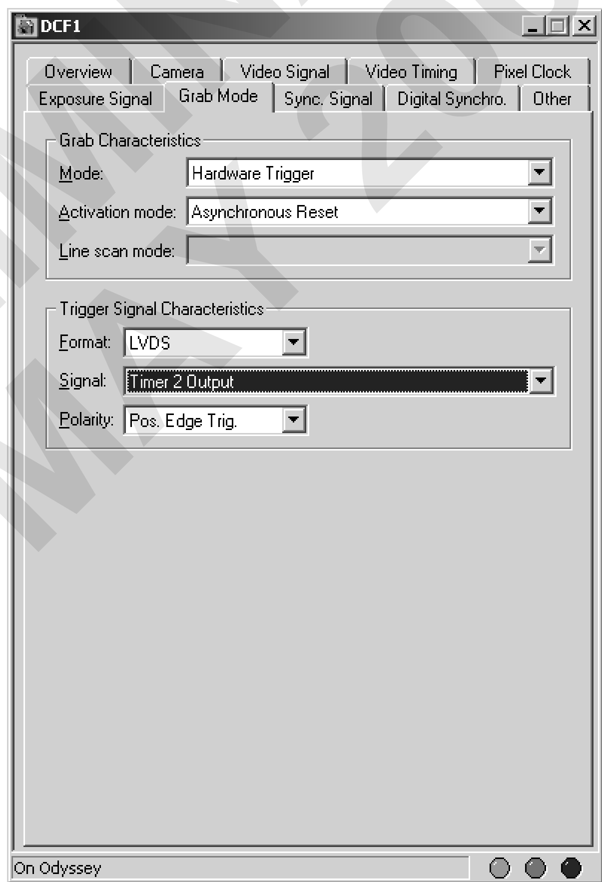
You can create a DCF to perform a simple triggered grab. In a triggered grab, the frame grabber is set to wait for an external trigger. When the frame grabber receives the signal (the hardware trigger), the frame grabber will then signal the camera to send the next available frame.

If the frame grabber and the camera support it, the frame grabber can send a reset signal to the camera upon receiving the trigger signal.

The following is an example of a simple triggered grab.

1. Start with a DCF that best matches the camera you are using, that specifies a continuous grab in the **Grab Mode** tab.

2. On the **Grab Mode** tab, make sure that the grab mode is set to asynchronous reset. Also, make sure that the trigger signal format is set to the correct type (LVDS or TTL, according the application note), and that the signal is set to the correct connector to which the trigger is connected. Ensure that the trigger signal's polarity matches the polarity specified on the **Timer 1** and/or **Timer 2** sub-tabs of the **Exposure Signal** tab.



3. Activate the grab by clicking on the **Grab** button.

4. Send a trigger. Note that it will time out after only a few seconds once a grab is started and a trigger is not received.

   ❖ The default value for the timeout period is specified in MIL. Refer to the MIL documentation for further details.

5. Verify the frame rate at the right of the status bar.

6. Click on the **Stop** button on the main toolbar to stop grabbing.

Using asynchronous reset trigger and automatic exposure control

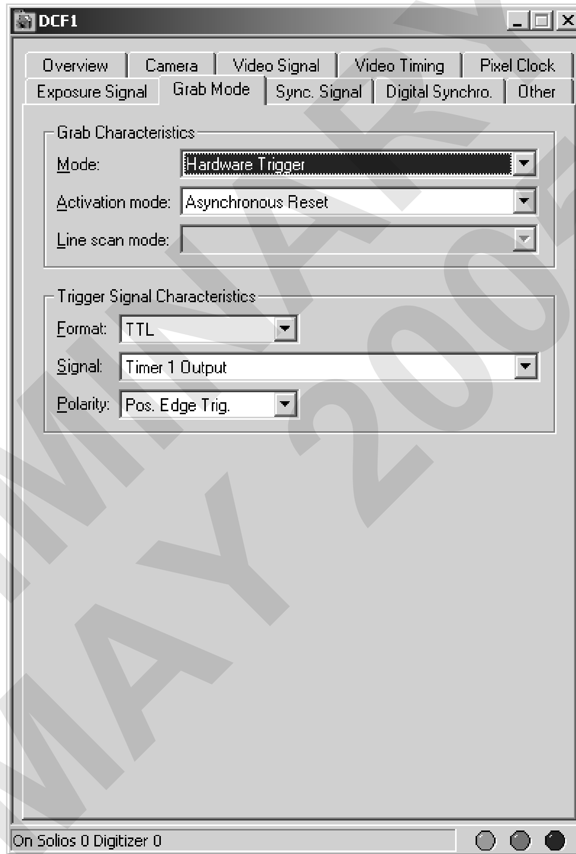
In a triggered grab using asynchronous reset mode, the frame grabber receives an external trigger, sends the exposure signal to the camera's trigger input, then immediately afterwards, the camera sends the valid frame, which is acquired by the frame grabber.

Only frame grabbers that support non-standard cameras allow for asynchronous reset operations. When you supply a trigger to the frame grabber, make sure to set the correct options in the **Grab Characteristics** area of the **Grab Mode** tab in the DCF dialog box. Select the

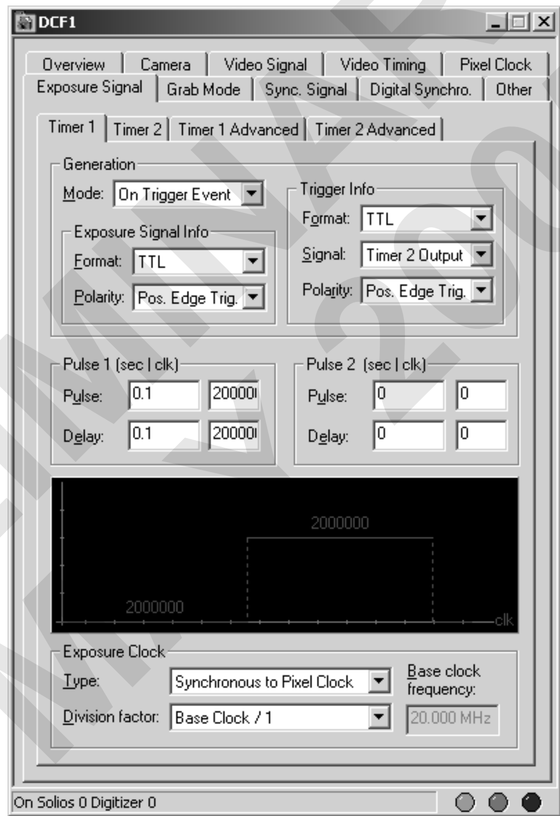
When using asynchronous reset mode in Matrox Intellicam, make sure to specify asynchronous reset mode by setting the activation mode to **Asynchronous Reset** on the **Grab Mode** tab of the DCF dialog box.

If the camera is set to asynchronous reset mode with an internal exposure control, the timer will be used as a trigger. If the camera is set to asynchronous reset mode with an external exposure control, the timer will be used to control the camera's exposure.

Ensure that you select the correct trigger source for the required timer on the **Exposure signal** tab.



❖ Most interfaces only require one timer to generate the exposure signal (for example, exposure1) to send to the camera as a trigger input. Set the timer mode to **On Trigger Event** in the **Generation** section on the **Timer** sub-tab of the **Exposure Signal** tab in the DCF dialog box. Set the trigger format to an external signal in the **Trigger Info** area.



Also ensure that you set up the video timings on the **Video Timing** tab, according to the specifications for the camera.

You should make sure the cables are connected properly. Send the corresponding exposure signal to the camera trigger input. For a Camera Link camera, make sure you set the camera control signals.

Once the DCF is set up, you can save the DCF and use it to grab images.

Chapter

5

Concrete examples

This chapter outlines a few examples using Matrox Intellicam.

Matrox Intellicam examples

In the following examples, you will find step-by-step descriptions of how to interface a non-standard frame scan camera and a line scan camera with different frame grabbers using various settings.

Interfacing a frame scan camera

This example will deal with interfacing a non-standard frame scan camera. Our target non-standard camera is the fictitious FSCAM. The FSCAM's specifications are as follows:

- Input: high-resolution non-interlaced mode (1024 x 1024 at 20 MHz, 15 frames per second).
- Output: analog data.
- Both continuous scan (normal) and asynchronous reset trigger modes are supported.

Acquiring analog data using frame scan cameras

For this example, the Matrox Helios XA is used to grab analog data, using a frame scan camera.

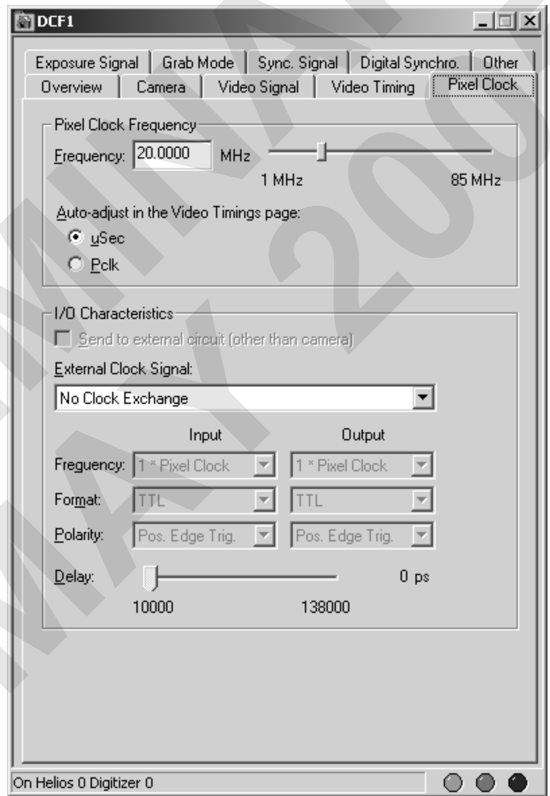
The following outlines the steps for this setup:

1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the frame scan camera using the **File Open** command. Ensure that the DCF specifies frame scan camera.

   If you are unsure which DCF to use, refer to Application Notes on the Matrox Imaging website, and browse to Camera Interface Application Notes in the Interfacing Cameras menu. You can select the application note by camera manufacturer, then select the camera model according to the Matrox Imaging hardware; or you can select the application note by Matrox Imaging hardware, then select the camera manufacturer and model.

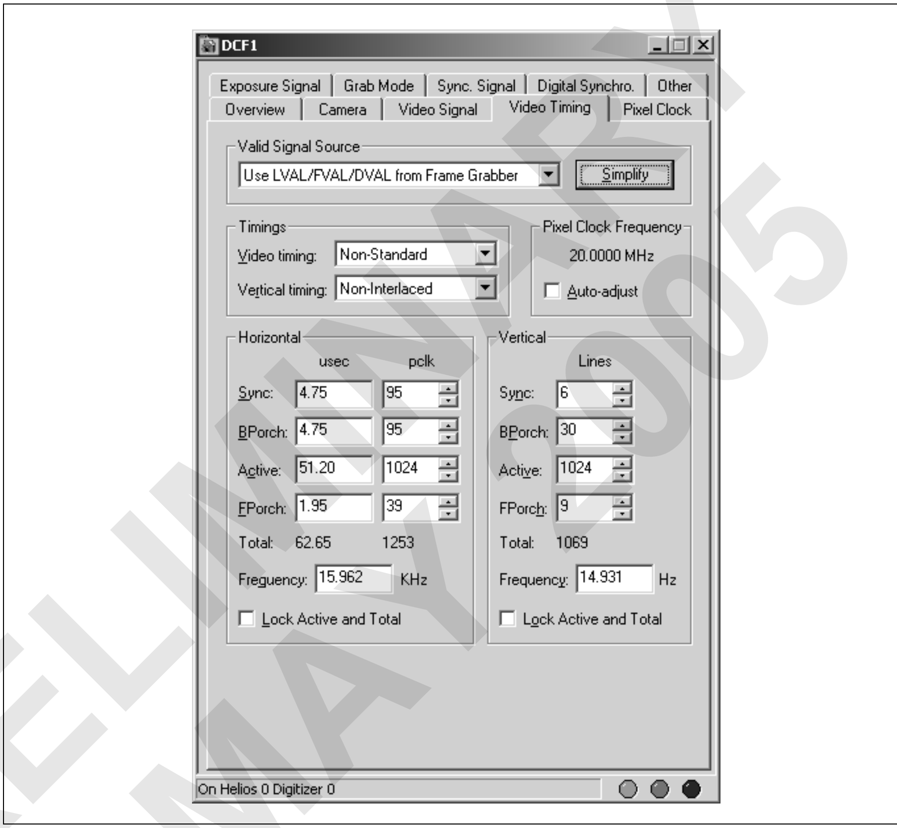
To determine which DCF to use, you can refer to the **General Information** section of the **Overview** tab in the DCF dialog for a summarization of the DCF, including camera resolution, timings, and the pixel clock value. This will help you determine which DCF to use that best corresponds to the frame scan camera to use.

2. Refer to the documentation for the camera to set the pixel clock frequency. Set the appropriate pixel clock frequency in the **Pixel Clock** tab of the DCF dialog.



3. Set the video timings of the active period signal, as well as the horizontal and vertical timing values on the **Video Timing** tab. If the fields do not appear on the tab, click on the **Advanced** button to display the **Horizontal** and **Vertical** areas. Make sure the **Lock Active and Total** options are not selected; this option is used to shift the active values around inside the total value to get rid of black bars that might appear on the edges, instead of changing the duration of the signal, and consequently changing its frequency.

be used for disabling changes to the active values for the indicated synchronization signal and locking the total value.



4. Make sure the number of taps is also specified on the **Camera** tab; note that the value of the **Active** field is the result of the total active value divided by the number of taps used.

5. Verify the options on the **Video Signal** tab. Make sure there are no errors (that is, the **Error Report** dialog does not appear).

6. Use the **File Save** or **File Save As** command to save the DCF. Furthermore, you can take a snapshot of the DCF dialog boxes to recall the settings for the DCF. You might need them should you ever change the saved values in the DCF and want to recall the values originally saved.

Acquiring digital data using frame scan cameras

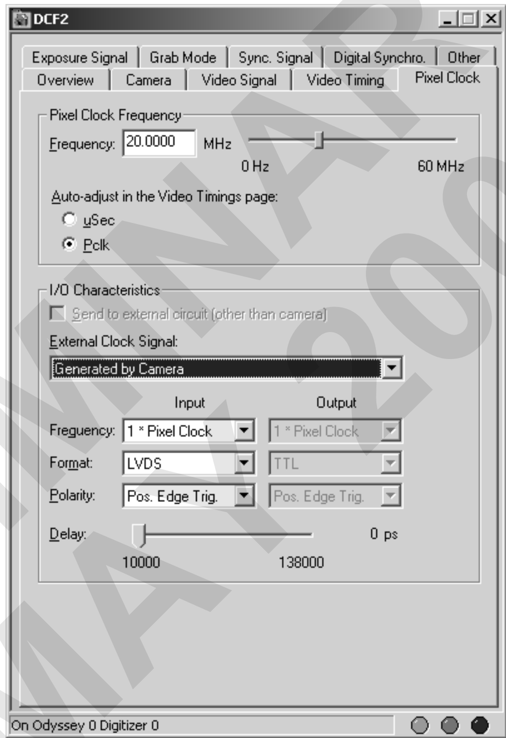
For this example, the Matrox Odyssey XD will be used to grab digital data, using a frame scan camera.

Note that a total of 4 taps can be used in frame scan cameras when grabbing digital data; however, by connecting an optional digital module to the Matrox Odyssey, you can use an additional 4 taps, for a total of 8 taps. The number of bits that the frame scan camera can output is 8 bits, though with this set up, you can acquire at higher bit modes (for example, 10- or 12- bit).

The following outlines steps for this setup:

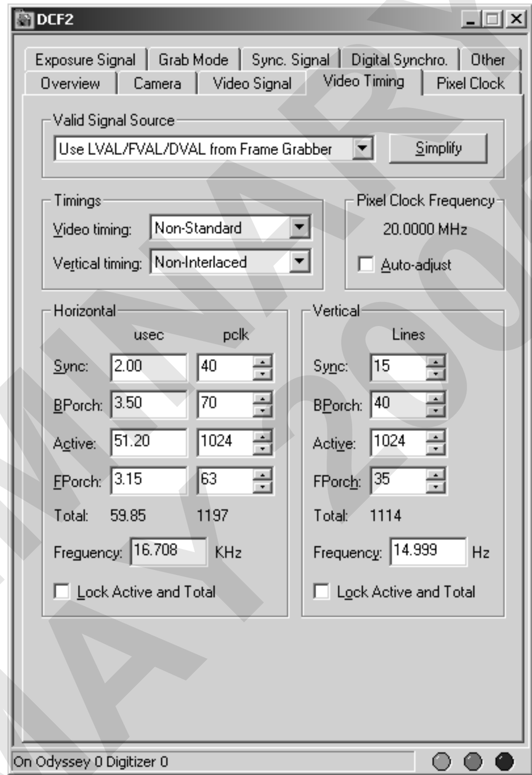
1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the frame scan camera. Ensure that the DCF specifies frame scan camera.

2. Refer to the documentation for the camera to establish the pixel clock frequency of the camera. Generally the pixel clock will be generated by the camera, therefore, select **Generated by the Camera** option from the **External Clock Signal** drop-down list box on the **Pixel Clock** tab.

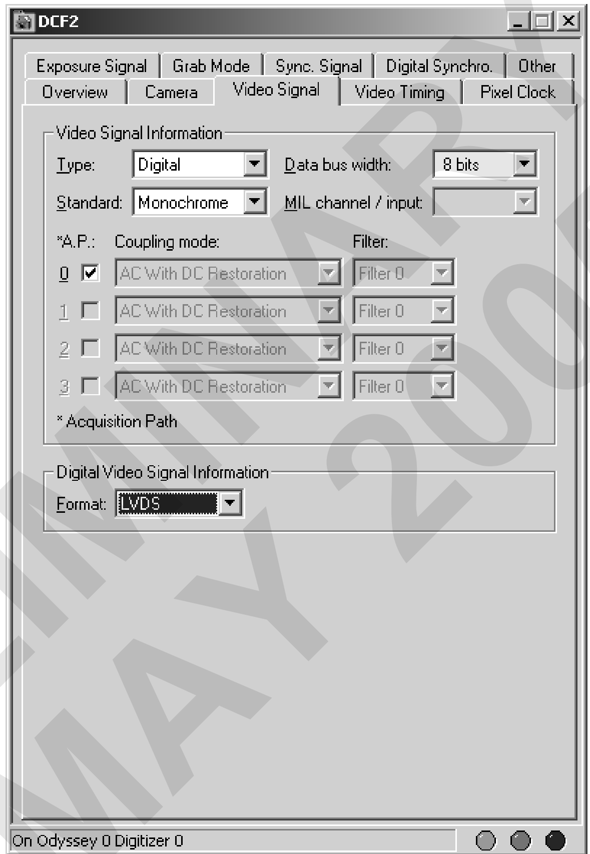


❖ Note that Matrox Odyssey XD can provide the pixel clock. Specify this option in the **Pixel Clock** tab in the **I/O Characteristics** area.

3. Set the video timings of the active period signals, as well as the horizontal and vertical timing values using the **Video Timing** tab.

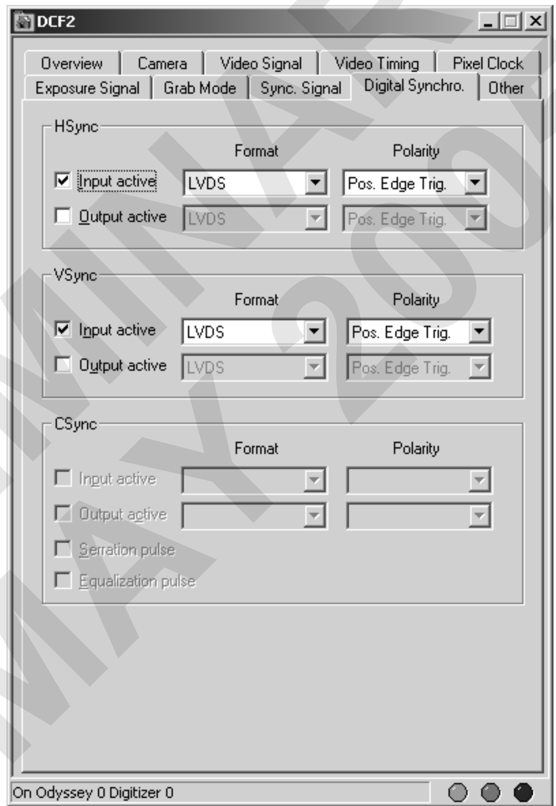


4. On the **Video Signal** tab, ensure that video signal type is set to **Digital**.



5. On the **Sync. Signal** tab, ensure the **Synchronization signal available** field specifies the available synchronization signals, in this case, **HSync & VSync**.

6. Make sure the settings for the horizontal synchronization and the vertical synchronization are set to active. Unless the frame grabber is set as the master, synchronization signals will come from the camera, and the default value for the synchronizations signals is not enabled. You enable these options in the **Digital Synchro**. tab.



If the digitizer is selected as the synchronization signal source, you should enable the output synchronization signals on the **Digital Synchro.** tab. If the camera is selected as the synchronization signal source, you should enable the input synchronization signals on the **Digital Synchro.** tab. By default the camera is selected as the synchronization signal source.

7. Adjust the other DCF settings according to the specifications for the camera.

8. Save the DCF using the **Save As** command.

Interfacing a line scan camera

This section describes examples interfacing with a line scan camera. Some will be dealing with different target frame grabbers.

Acquiring digital data using Camera Link line scan cameras

For this example, the dual-Base version of Matrox Odyssey XCL will be used with a line scan camera.

The following outlines steps for this setup:

1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the Camera Link line scan camera.

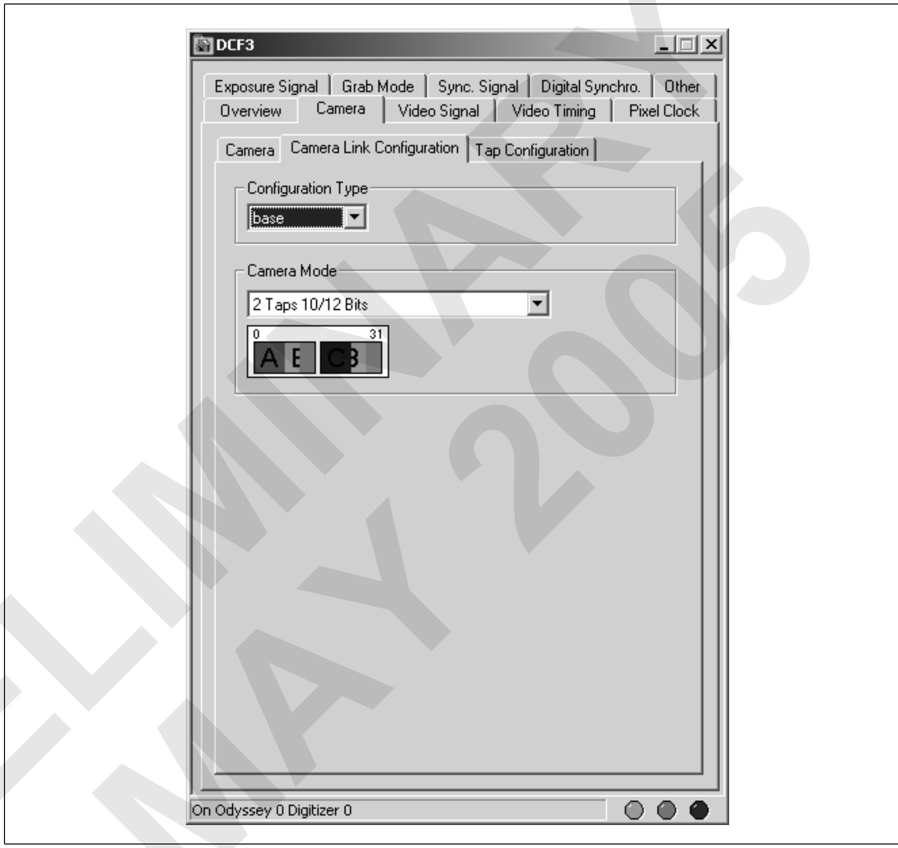
   If you are unsure which DCF to use, refer to Application Notes on the Matrox Imaging website.

2. On the **Camera** sub-tab of the **Camera** tab, set the type of camera to **Line Scan**.

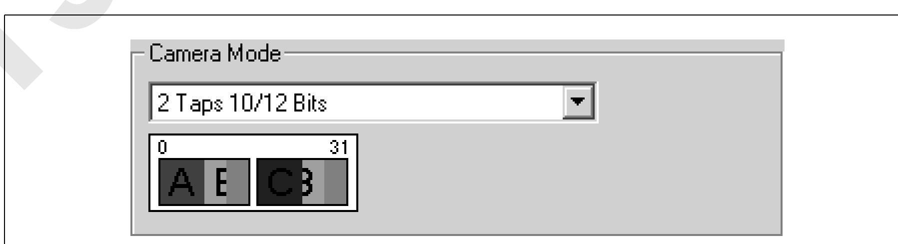
3. Specify the number of taps using the **Camera** sub-tab of the **Camera** tab.

   - Note that the **Error Report** dialog might appear, with a description of an error or warning. You can usually ignore the message if you are just setting up your DCF, particularly when changing tap configurations and data depth values. Once you have corrected the error or warning, the **Error Report** dialog will close automatically. However sometimes, the message will close only once you have corrected the error or warning and switched tabs in the DCF dialog.

4. Set the required Camera Link configuration on the **Camera Link Configuration** sub-tab. Set the appropriate configuration type and camera mode.

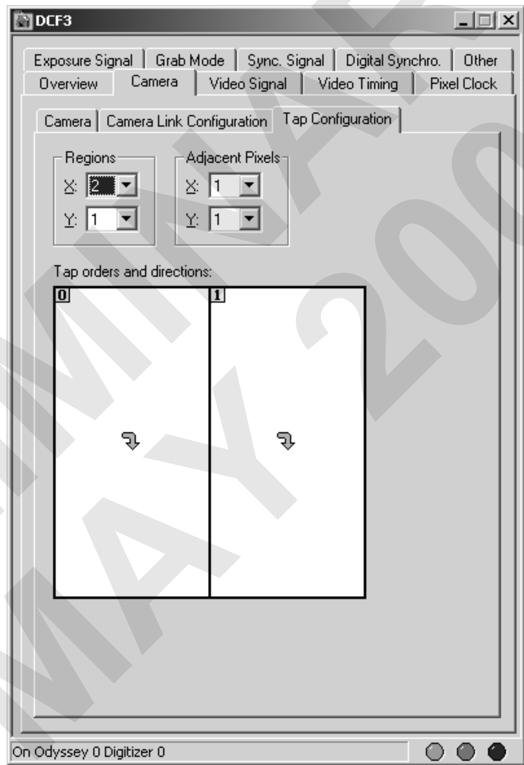


You can view the Camera Link bit configuration in the **Camera Mode** area on the **Camera Link Configuration** sub-tab.



Refer to *Appendix B: Camera interface reference* for further details on the Camera Link standards and a brief explanation of the camera mode data lines grouping.

5. Using the **Tap Configuration** sub-tab of the **Camera** tab, ensure that the configuration is set up for multiple taps. Arrange the tap destinations as required.



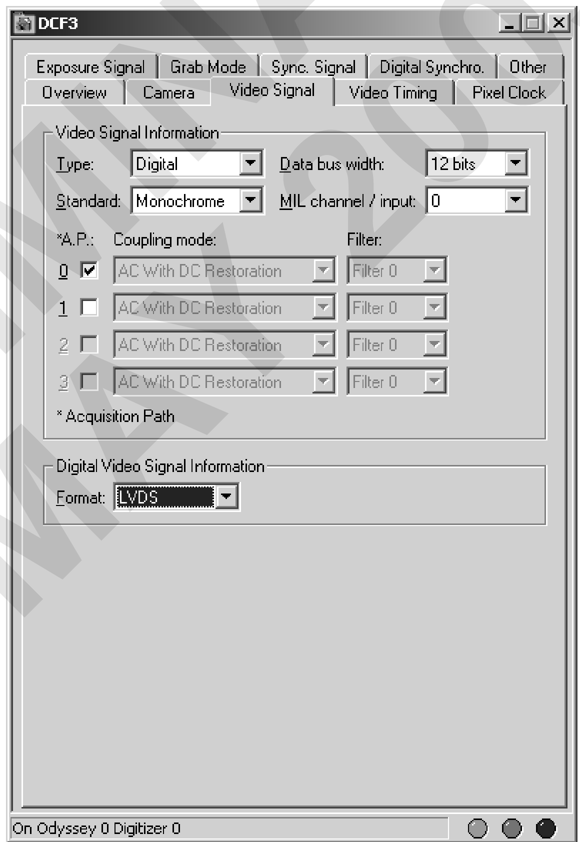
By clicking on any of the corners of a tap region in the **Tap orders and directions** area, you can change the direction of the tap. The direction of the arrow indicates the direction and order of the tap.

6. Refer to the documentation for the camera to establish the pixel clock frequency for the camera. Set the appropriate pixel clock frequency in the **Pixel Clock** tab of the DCF dialog. The pixel clock frequency is generated by the camera.

7. You can adjust the values for the front and back porch to 0 for a Camera Link camera if required. On the **Video Timing** tab, click on the **Advanced** button to display the advanced properties of the **Video Timing** tab. You can set these values in the **FPorch** and **BPorch** fields.

8. Set the video timings of the active period signal, as well as the horizontal and vertical timing values on the **Video Timing** tab.

9. On the **Video Signal** tab, ensure that video signal type is set to **Digital**.



10. Adjust the other DCF settings according to the specifications for the camera.

11. Save the DCF using the **Save As** command.

Using single-tap cameras

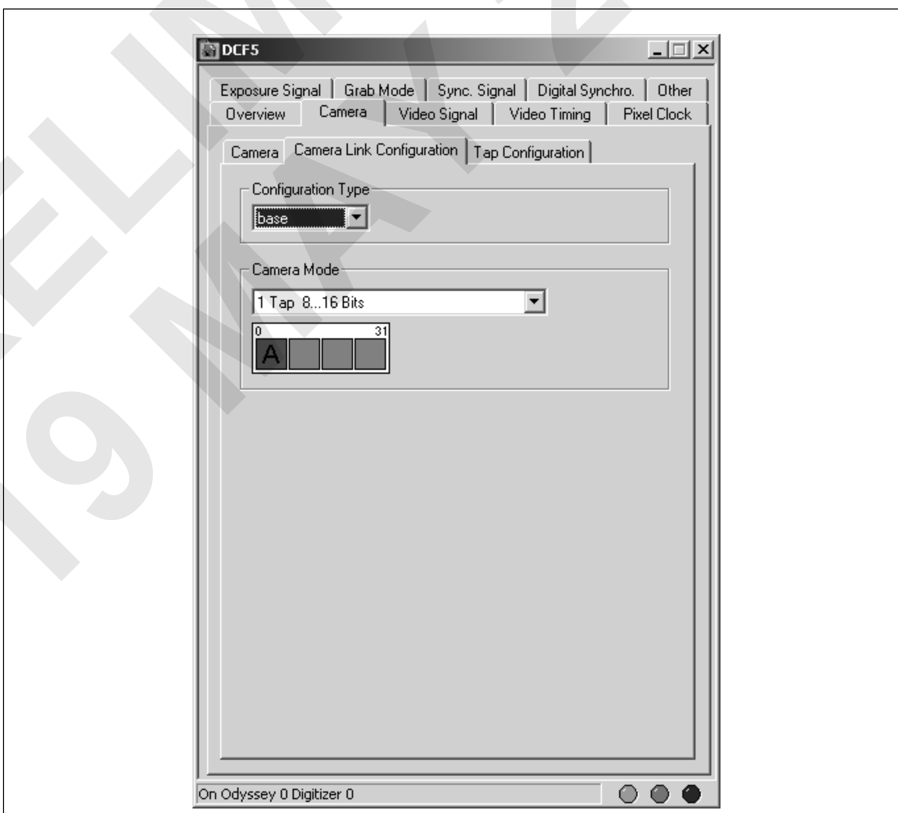
For this example, the single-Full version of the Matrox Odyssey XCL will be used with a single-tap camera. Single-tap cameras are more common than multi-tap cameras.

The following outlines the steps for this setup.

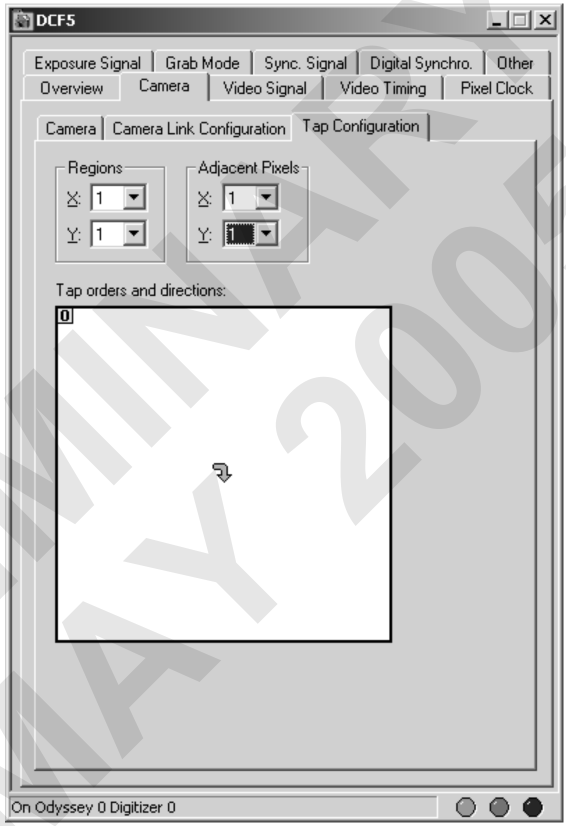
1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the single-tap camera.

2. In the **Camera** sub-tab of the **Camera** tab, select the **1 Tap** option in the **Number of taps** drop-down list box.

3. In the **Camera Link configuration** sub-tab of the **Camera** tab, select the mode **1 Tap 8...16 bits** from the **Camera Mode** drop-down list box. This selects both the number of taps and the configuration type.



4. In the **Tap Configuration** sub-tab of the **Camera** tab, ensure that the configuration is set up for only one tap (as specified in step 2).



5. Adjust the video timing settings on the **Video Timing** tab according to the specifications for the camera.

6. Save the DCF using the **Save As** command.

Using multi-tap cameras

To take advantage of a multi-tap camera's multiple outputs (which allow for the simultaneous transfer of two or more pixels), using multi-tap cameras allows for faster frame rates without increasing the pixel clock frequency. This setup, however, requires more data lines.

For this example, the single-Full version of the Matrox Odyssey XCL will be used with a multi-tap camera.

The following outlines the steps for this setup:

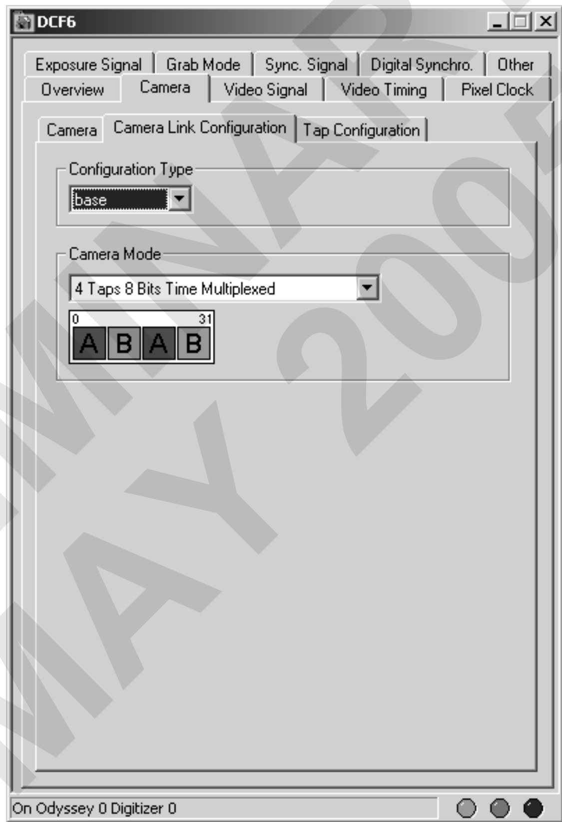
1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the multi-tap camera.

2. Make sure to specify a Camera Link board from the drop-down list-box using the **Overview** tab.

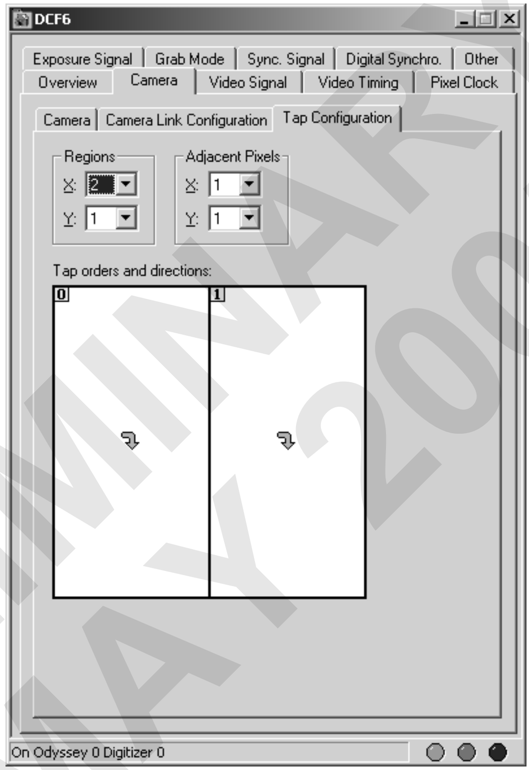
3. From the **Camera** sub-tab of the **Camera** tab, select the required number of taps from the **Number of taps** drop-down list box.

4. Specify the number of taps in the **Camera** sub-tab of the **Camera** tab.

5. In the **Camera Link configuration** sub-tab of the **Camera** tab, select the required mode from the **Camera Mode** drop-down list box (for example, select the **2 Taps 10/12 Bits** option for a 2-tap camera using 10- or 12-bit images). This selects both the number of taps and the configuration type.



6. In the **Tap Configuration** sub-tab of the **Camera** tab, ensure that the configuration is set up for multiple taps. Arrange the tap destinations.



7. Adjust the video timing settings on the **Video Timing** tab, according to the specifications for the camera.

   ❖ Note that values indicated for the **Active** fields for both Horizontal and Vertical signals are for each tap.

8. Save the DCF using the **Save As** command.

Using asynchronous reset with a Camera Link line scan camera

In asynchronous reset mode with a Camera Link line scan camera, the frame grabber resets the camera on external events (such as an object passing in front of a light beam to detect its presences, or a conveyor belt stopping). The difference between using asynchronous reset with a non-Camera Link camera and with a Camera Link camera is the cables involved. Cables for Camera Link cameras are standardized and therefore easier to use, as opposed to having to create a custom cable for a non-Camera Link camera. Routing for trigger signals and exposure signals is built into the cable for Camera Link cameras.

For this example, the Matrox Helios XCL will be used to grab, using a Camera Link camera.

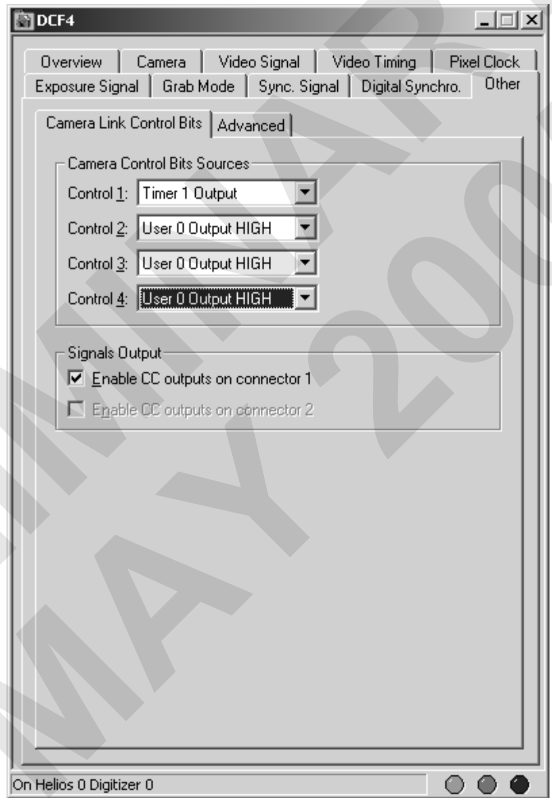
The following outlines the steps for this setup:

1. In Matrox Intellicam, locate and open the DCF that corresponds the closest to the Camera Link camera.

2. On **Camera** sub-tab of the **Camera** tab, select the required number of taps (for example, 2 taps).

3. On the **Camera Link Configuration** sub-tab of the **Camera** tab, select the configuration type and the required camera mode (according to the number of taps specified on the **Camera** sub-tab). On the **Tap Configuration** sub-tab of the **Camera** tab, arrange the tap destinations (if required).

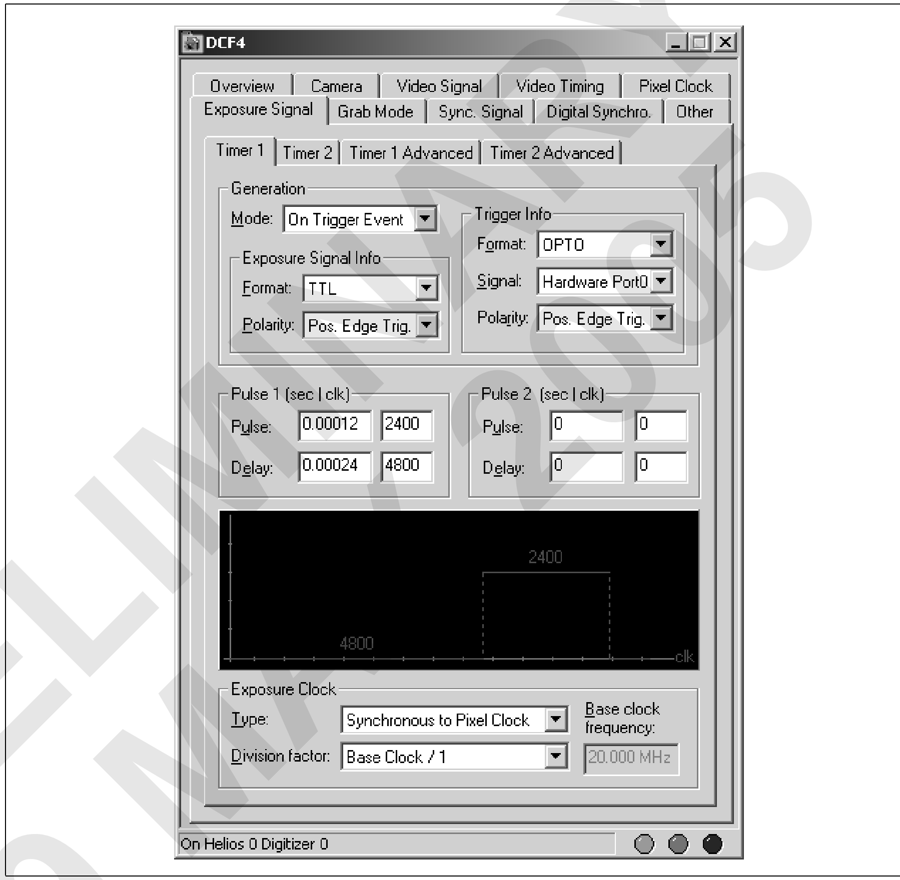
4. From the **Camera Link Control Bits** sub-tab of the **Other** tab, enable the **Enable CC outputs on connector 1** option. Select the required settings for each camera control signal from the respective drop-down list box in the **Camera Control Bit Sources** area.



- You should set the camera control signals that are not used by the exposure timers to **User 0 Output HIGH** because setting them to any other settings can cause problems with some cameras.

5. Adjust the video timing settings on the **Video Timing** tab, according to the specifications for the camera.

6. Adjust the settings for the exposure signals using the **Exposure Signal** tab. Make sure that the **Timer 1** sub-tab specifies **On Trigger Event**. Adjust the pulse and delay values as required.



- Note that some cameras might use two pulses, therefore, adjust the values accordingly.

7. Save the DCF using the **Save As** command.

Appendix A: Video specification form

This appendix contains a video specification form to help you with the configuration of your digitizer.

Providing us with your video specifications

The purpose of the video specification form is two-fold:

- You can use it to help identify and document the various features of your video source, making it easier for you to create your DCF.

- You can use it to provide us with information about your video source in the event you need help creating your DCF.

  If you are having trouble getting your DCF to work properly, we would be glad to help you with it.

- Forward a copy of the completed form and any other relevant documentation to the **Matrox Imaging Applications Department**, either by fax or email. Refer to the customer support contact numbers found at the back of this manual, or refer to the Matrox Imaging website at http://www.matrox.com/imaging/ for further information on how to contact us.

- Answer all questions in Sections I through IV directly on the form that follows. Since your camera might support several modes, your answers should reflect the required mode of operation. Enter N/A for any non-applicable entries.

- If your camera manufacturer has provided you with detailed documentation, include a photocopy of this documentation with your completed form.

- Refer to the manual for your specific frame grabber to know if you must take any grab limitations into account.

❖ The information contained in the form is the **minimum** required to determine compatibility between Matrox's imaging hardware and a specific video source.

For more details on any of the terms used in this form, refer to the glossary.

Video specification form

Please fill out the following video specification form with as many details as possible. You can also obtain a copy of this form on Matrox Imaging's website.

Section I: Acquisition requirements

Use the space provided below to enter a detailed description of your desired camera operation and acquisition system. Refer to the specific modes available for your camera. Use diagrams and add extra pages as necessary.

This information is important to allow us to choose the best way to interface your camera with our hardware.

____

____

____

____

____

Section II: General information

Please fill out the following:

1. **Camera manufacturer**: ____

2. **Model#**: ____

3. **Camera type**:
   [ ] Area scan (for example, RS-170 camera) (aperiodic)
   [ ] Frame scan (periodic)
   [ ] Line scan
   [ ] Other, specify: __________________________________

4. **Video data rate**: ______ MHz and ______ frames/sec

5. **Desired acquisition resolution**: _____ H x _____ V

6. **Scanning format**:
   [ ] Interlaced (2 fields per video frame)
   [ ] Non-interlaced (1 field per pass/video frame)

7. **Video format**:
   [ ] Analog   Amplitude _______ V (p-p)
   Swing type (select only one):
   [ ] positive
   [ ] negative
   [ ] both-swing

   [ ] Digital ____ bits
   Format
   [ ] TTL
   [ ] RS-422
   [ ] LVDS
   [ ] Camera Link/Channel Link
   [ ] IEEE-1394

8. **Synchronization format** (skip this question for Camera link and IEEE-1394):
   [ ] Analog
   [ ] Composite video (video/synchronization on same wire)
   [ ] Video and composite sync (video and synchronization separate)
   [ ] Serrated synchronization
   [ ] Block synchronization

   [ ] Digital
   [ ] Csync
   [ ] Hsync and Vsync
   [ ] Vsync only
   [ ] Hsync only

Synchronization digital format: [ ] TTL [ ] RS-422

Csync or Hsync polarity:
- [ ] positive going polarity
- [ ] negative going polarity
- [ ] N/A

Vsync polarity:
- [ ] positive going polarity
- [ ] negative going polarity
- [ ] N/A

9. **Pixel clock**

clock rate: _______ MHz [ ] TTL [ ] RS-422 [ ] LVDS

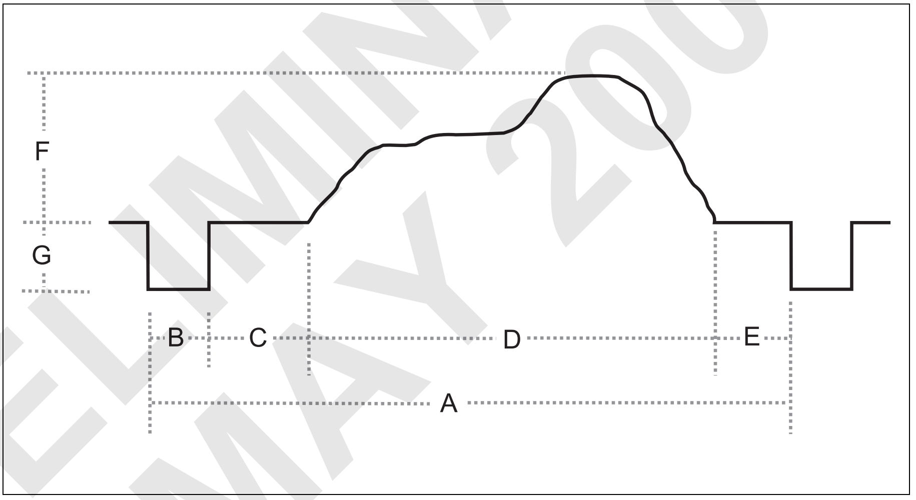
❖ Note that if a pixel clock value is not specified in the documentation for the camera, you can probably probe for it.

Section III: Timings specifications

When you have, for example, an camera with incomplete documentation, or there is no DCF available which matches the camera closely, and the camera cannot be sent into Matrox Imaging for testing, fill in the information requested below, or include the timing specification documentation provided by your camera manufacturer. **Refer to the manual for your particular frame grabber for possible grab limitations.**

Horizontal timings

Although the following diagram shows a composite video waveform, the timings also apply to separate video and synchronization sources.

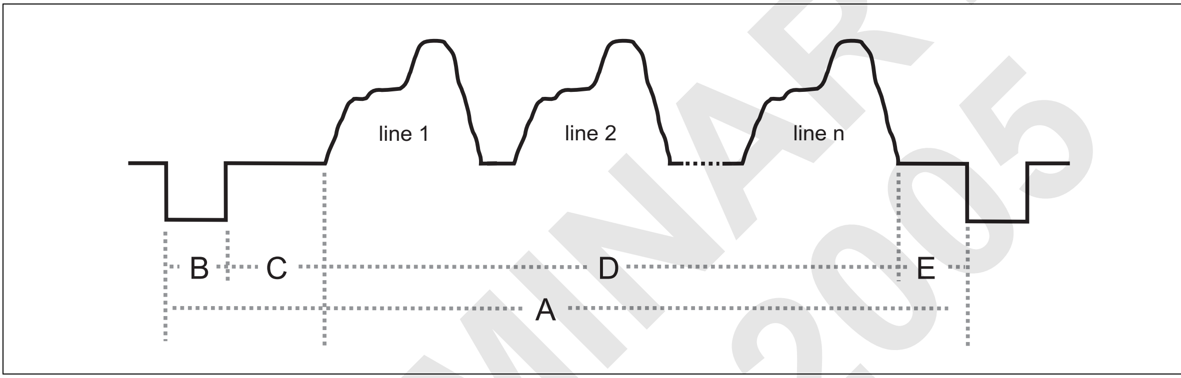


(specify whether the value is in *μ*sec or pixels per line)

A. Horizontal total line time	______ /line
B. Horizontal synchronization pulse width	______ /line
C. Horizontal back porch	______ /line
D. Horizontal total active line time	______ /line
E. Horizontal front porch	______ /line
Horizontal values given in	[ ]μsec [ ] pixels
F. Active video amplitude	______ V - p.p.
G. Synchronization pulse amplitude	______ V - p.p.

Vertical timings

For interlaced video sources, vertical timings can be expressed as the number of lines per frame or number of lines per field. For non-interlaced video sources, they should be expressed as the number of lines per frame. Note that horizontal synchronizations are not shown in the diagram below.



	Horizontal synchronization pulses/field (interlaced only)	Horizontal synchronization pulses/frame (interlaced & non-interlaced)
A. Vertical total line time	______ lines	______ lines
B. Vertical synchronization pulse width	______ lines	______ lines
C. Vertical back porch	______ lines	______ lines
D. Vertical total active time	______ lines	______ lines
E. Vertical front porch	______ lines	______ lines

Section IV: Cable specification

Skip this question for Camera link and IEEE-1394. Use the space provided below to describe all signals accessible from your video source, including the type and gender of each physical connector on the video source (for example, female BNC connector for video; male DB-25 connector for pixel clock and synchronization). If you prefer, draw a diagram.

This information will allow us to describe the necessary cable to interface your video source with our hardware.

Estimate the minimum cable length required: ______ (feet)

____

____

____

____

____

Appendix B: Camera interface reference

This appendix will help you understand the descriptions and diagrams in your camera manual, and allow you to get your system up and running more quickly.

Interfacing overview

This chapter serves as an introduction to video and interfacing a camera to Matrox hardware. It will help you understand the descriptions and diagrams in your camera manual, and allow you to get your system up and running more quickly.

Depending on your level of knowledge, certain sections might be more useful to you than others:

- **Video formats**. Identifies the various standard and non-standard video formats.
- **Standard analog video signal**. Describes how a standard analog video signal is produced, and also explains the various components of the video signal. This section also introduces some digitization-specific topics: *pixel clock*, *AC coupling* and *DC restoration*.
- **Color timing**. Describes basic concepts specific to a color video signal.
- **Non-standard video formats**. Describes some non-standard video formats.
- **Camera modes of operation**. Discusses the modes of operation for frame scan and line scan cameras.

Video formats

All video signals conform to a particular video format. The video format specifies such information as the type of video signal (analog or digital), synchronization signals, and number of lines in an image. There are standard and non-standard video formats.

Standard video formats

The RS-330 and RS-343 standards (used in the United States, Canada, and Japan) are monochrome video formats based on the RS-170 standard but have additional signal characteristics by way of modified timing waveforms and more restrictive tolerances. The CCIR video standard (used in Europe) is also a monochrome video standard similar to the RS-170 standard except that it lacks a pedestal (black and blanking levels are equal).

The standard color video formats are NTSC (United States, Canada, Japan, and parts of South America), PAL (Europe), and SECAM (France, Russia, and the republic states).

The following table summarizes the characteristics of the RS-170, CCIR, NTSC, and PAL video formats.

RS-170	• North American monochrome video format standard
	• 640 pixels x 480 lines
	• analog, interlaced
	• 525 lines per frame, 485 active lines per frame
	• line time: 63.556 μs, active line time: 52.66 μs
	• line scan frequency: 15.734 kHz
	• pixel clock frequency: 12.2727 MHz
CCIR	• European monochrome video format standard
	• 768 pixels x 572 lines
	• analog, interlaced
	• 625 lines per frame, 575 active lines per frame
	• line time: 64 μs, active line time: 52 μs
	• line scan frequency: 15.62 kHz
	• pixel clock frequency: 14.75 MHz
NTSC	• North American color video format standard
	• 640 pixels x 480 lines
	• analog, interlaced
	• 525 lines per frame, 485 active lines per frame
	• line time: 63.556 μs, active line time: 52.66 μs
	• line scan frequency: 15.734 kHz
	• pixel clock frequency: 12.2727 MHz
PAL	• European color video format standard
	• 768 pixels x 572 lines
	• analog, interlaced
	• 625 lines per frame, 575 active lines per frame
	• line time: 64μs, active line time: 52 μs
	• line scan frequency: 15.625 kHz
	• pixel clock frequency: 14.75 MHz

Non-standard video formats

Non-standard video formats include digital video, high resolution video, and negative-going video.

- Digital video is a digitized video waveform, where the synchronization and intensity (luminance) levels have been assigned a digital value. Digital video can be of any resolution, from very low to very high.

- High resolution video includes any camera with a spatial resolution of 1024 pixels x 1024 lines and higher. The difference between this type of analog video signal and a standard analog video signals is the difference in the timing specifications and the signal period, along with the increased sampling rates required by the frame grabber.

- Negative-going video is an analog video signal where white or bright pixel data is represented by a more negative voltage than black or dark pixel data.

Data exchange protocols

There are several data exchange protocols including LVDS, RS-422 and Camera Link. The data exchange protocol of choice is Camera Link. Camera Link is a high speed communications interface. You can download a copy of the Camera Link specifications from the Automated Imaging Association website (http://www.machinevisiononline.org). Refer to the sub-section *Camera Link standards* for further details.

Analog video signals

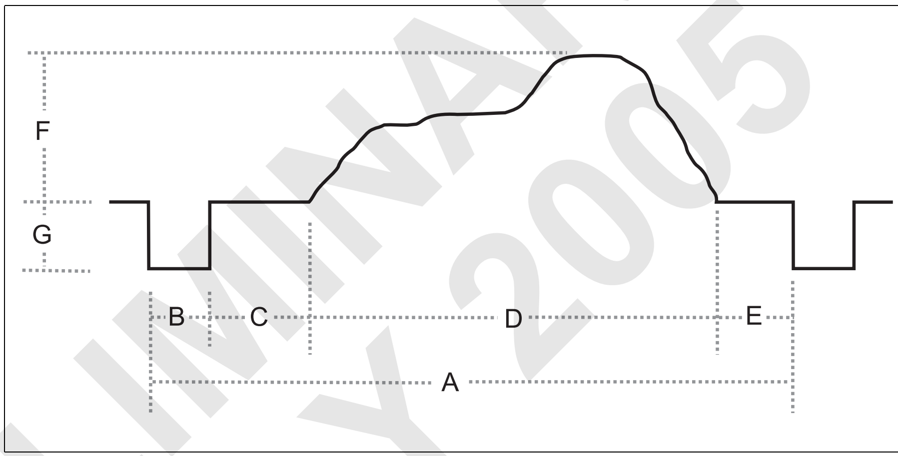
This section describes how analog video signals are produced, and explains the various components of the video signal.

How the video signal is produced

A video camera contains a two-dimensional area of photosensors (such as a charge-coupled device). These photosensors convert the energy of incident light particles into equivalent electrical charges. The charge of each sensor is then scanned out of the camera, in a left-to-right, top-to-bottom fashion, producing a continuous analog video signal that will eventually be digitized.

Video timings determine how an analog or digital input signal is organized into lines, fields and frames, and where the various synchronization signals are placed. The settings which include: synchronization pulse width, back porch, active period and front porch. These settings are valid on a line basis (horizontal timings) or a field/frame basis (vertical timings).

For a typical line, these settings refer to the following:



A. Total time for a line in a field/frame (time per line)

B. Horizontal synchronization pulse width

C. Horizontal back porch

D. Active line time (amount of pixels that contains actual video information)

E. Horizontal front porch

F. Active video amplitude

G. Synchronization pulse amplitude

Video timings and DCFs

The respective widths of the synchronization pulse, the back porch, the active video period, and the front porch are known as the video timings of the camera; these signals describe how to interpret the analog video signal (each of these timings is defined later). These timings are required when creating a DCF file, using Matrox Intellicam, and can be found in the timing diagrams of your camera manual.

The following definitions are valid for both lines (horizontal timings) or fields/frames (vertical timings):

Sync (synchronization) pulse width: This is the state that indicates the beginning of a line (horizontal synchronization) or the beginning of a field or frame (vertical synchronization). During this state, the video information is not valid.

Back porch: This is the state following the synchronization period and preceding the active video period. During this state, the video information is still not valid.

Active period: This state follows the back porch period and contains the valid video information (pixels or line) generated by the camera. During this state, the digitizer grabs the video information and places it into memory.

Front porch: This is the last state in a line/field/frame. It follows the active video period and precedes the start of the next line/field/frame. During this state, the video information is not valid.

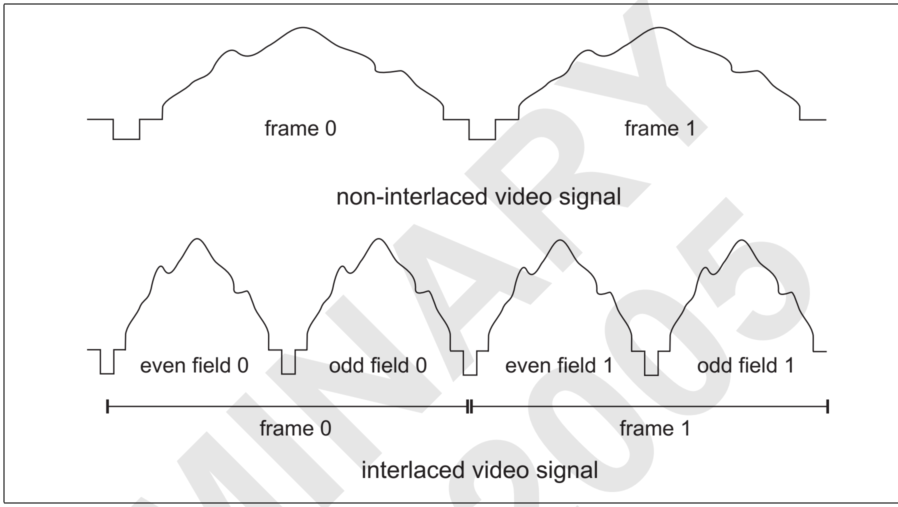
Note that, based on your camera type, it is possible that one or more of the above states are not present in the camera video timings. If a specific state is missing, set its corresponding timing value to zero, or the minimum allowed by Matrox Intellicam.

Interlaced and non-interlaced signals

In an *interlaced* video signal, the image frame is divided into two fields: an even field and an odd field. Even fields consist of even-numbered lines and odd fields consist of odd-numbered lines. As such, the frame is read out of the sensor in an odd/even or even/odd fashion.

In a *non-interlaced* video signal, the entire image frame is read out of the sensor using progressive scanning, that is, the entire frame is read out of the sensor one line at a time. The frame is not composed of separate fields.

The following illustrates interlaced and non-interlaced video signals:



Composite video signal

A *composite video signal* is an analog signal that contains both timing (that is, synchronization) and video data in a single signal. Composite video signals are usually in a standard format such as NTSC, PAL, or SECAM. The RS-170 monochrome video signal is an example of this type of video signal.

Synchronization

Synchronization indicates the end of a line or frame and the start of a new one. In composite signals, two types of pulses are needed to determine where every pixel should be "placed" in the final digital image. These pulses are the *horizontal synchronization* (hsync) and *vertical synchronization* (vsync).

A hsync pulse separates each video line and indicates where the beginning of the next scan line is to occur. A vsync pulse separates two frames (or fields) and indicates where the top of the next frame (or field) is.

During a horizontal or vertical synchronization, the video signal drops below the *blanking* level (explained later) to the *sync tip* level. For a RS-170 signal, the synchronization tip level is -0.286V.

Amplitude and reference levels

A video signal has a definite voltage range that defines the *amplitude* of that signal. For example, since the RS-170 video signal ranges from -0.286V to +0.714V, it has an amplitude of 1V.

The voltage of a black pixel is referred to as the *black level* or *black reference level*, and the voltage of a white pixel is referred to as the *saturation level* or *white reference level*. In the RS-170 video signal, the black level is +0.054V and the saturation level is +0.714V.

Active video

The portion of the video signal above the black level contains the *active video* (that is, the part of the video waveform that is actually visible on the display screen), while the portion of the video signal below the black level contains all the synchronization information.

Blanking periods

A video signal has both *vertical* and *horizontal blanking* periods. The blanking period is the portion of a video signal after the end of a frame (*vertical blanking*) or line (*horizontal blanking*), and before the beginning of a new frame or line. During the blanking period, the video signal is "blanked" so that the path of the scan beam in CRT displays cannot be seen while it returns to the beginning of the next frame or line. To blank the video signal, the voltage is brought down to a *blanking voltage*, that is, equal to or below the black level.

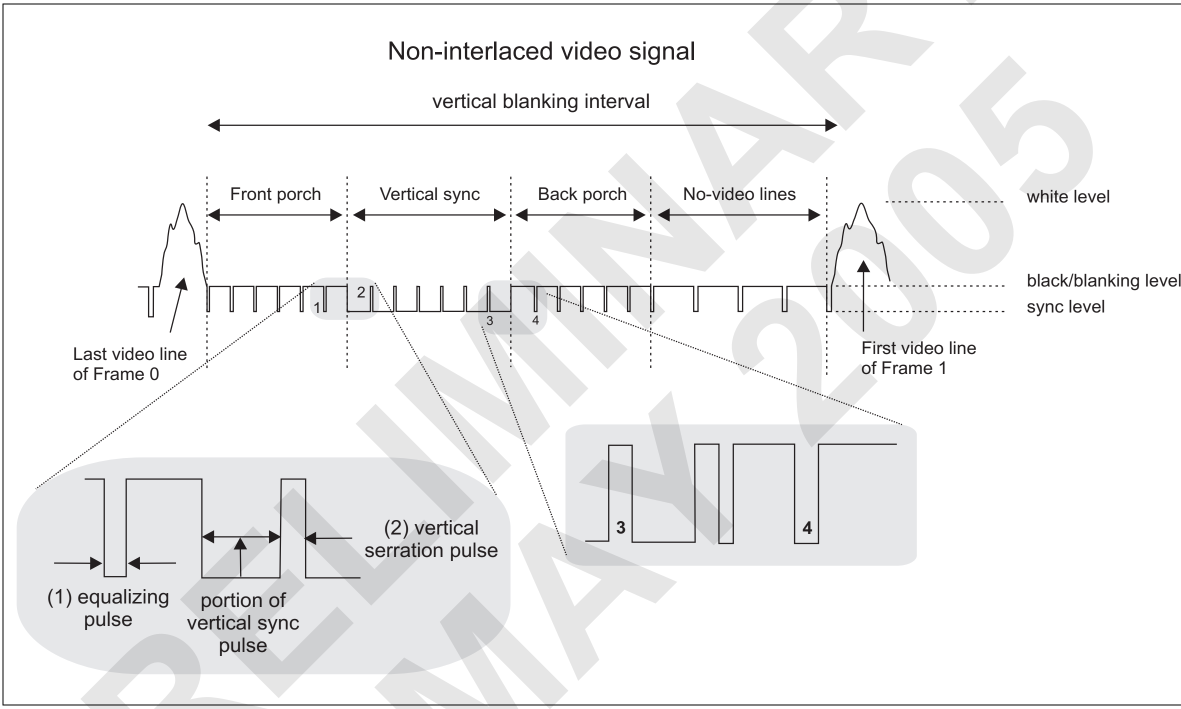
❖ The video information during a blanking period does not contain any valid image data.

Back and front porch

A vertical or horizontal blanking period is made up of a *front porch* period, a *back porch* period, and a synchronization pulse. The back porch period precedes the active video period, whereas the front porch period follows the active video period and precedes the next synchronization pulse.

Vertical blanking

The vertical blanking interval occurs between two consecutive fields in interlaced video standards, and between two consecutive frames in non-interlaced (progressive) video standards. and consists of a front porch, a vertical synchronization (vsync) pulse, a back porch, and a *no-video lines* period, as shown:



The front porch, vertical synchronization, and back porch (as shown in the above figure) have been discussed previously. The "no-video lines" period is the part of the back porch that precedes the next frame of video information. The no-video lines period does not contain *serration pulses*.

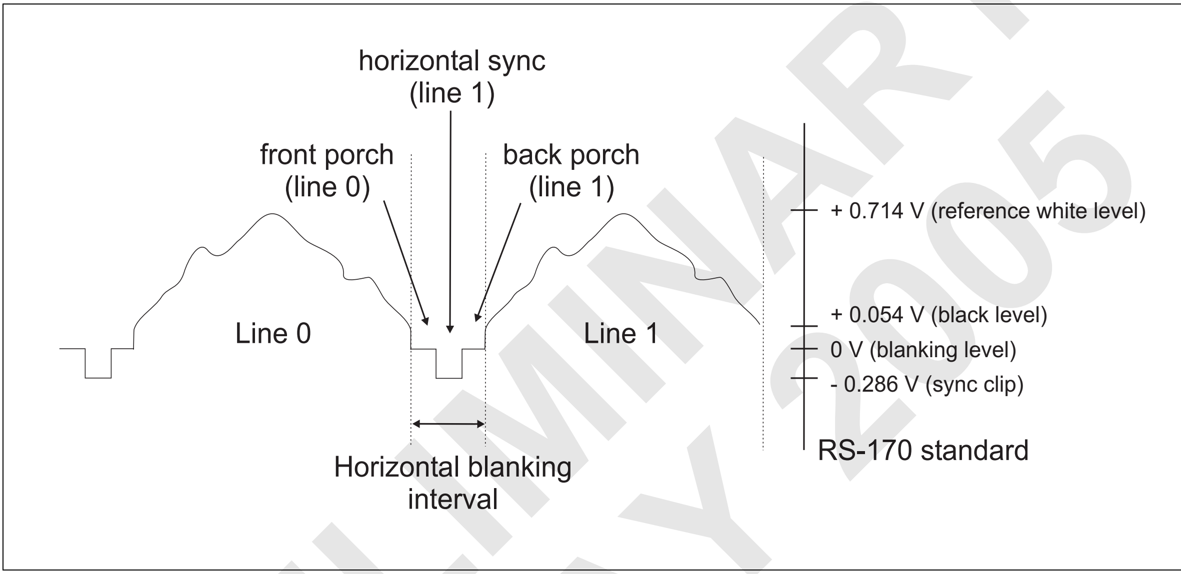
Serration pulses

Serration pulses, which might occur during the vertical synchronization interval, are pulses used to synchronize video equipment. These pulses have a frequency equal to twice the normal horizontal scan rate, usually in encoded color signals.

❖ As illustrated in the previous diagram, the polarity of the synchronization pulses in the vertical synchronization period are inverted.

Horizontal blanking

The horizontal blanking interval occurs between two consecutive lines and consists of the front porch of the previous line, a horizontal synchronization (hsync) pulse, and the back porch of the current line, as shown:



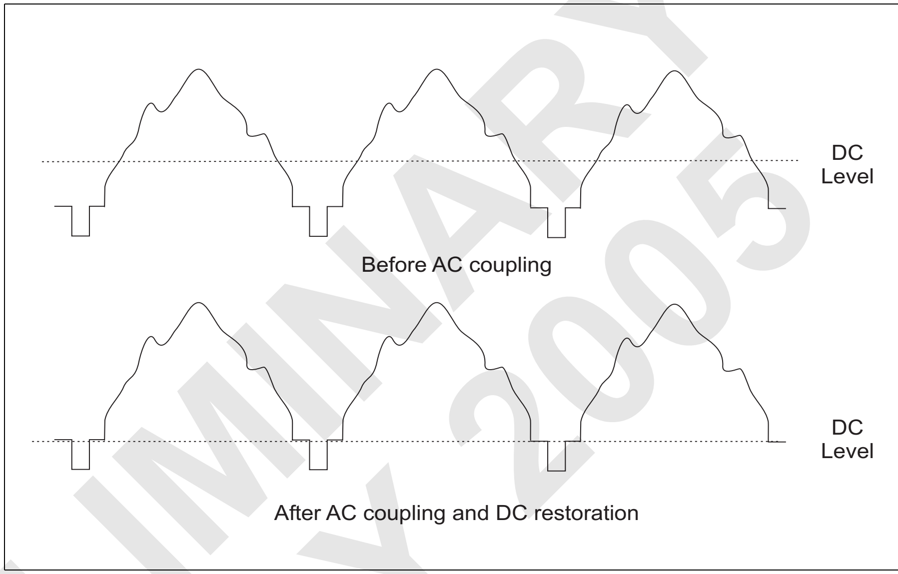
Clamping

DC restoration of the signal, called *clamping*, usually occurs during the back porch of the hsync interval, though for some cameras, it might occur during the front porch in the synchronization pulse.

The *clamping period* is the period during which the reference voltage level (or DC offset) of an analog signal is determined.

If the video signal is DC-coupled, the location of the actual image information is known. Therefore, the signal can be properly digitized since a pixel's brightness can be determined by comparing its voltage against a fixed voltage reference.

If the DC offset of a video signal is not known, the location of the actual image information is not known. Therefore, the DC offset is removed using a process known as *AC coupling*. Then, a known DC offset is added to the video signal using a process known as *DC restoration* or *clamping*. *DC restoration* or *clamping* uses DC line clamps to set the signal's black reference signal level in the analog-to-digital (A/D) converter to a stable level and a known starting point. This defines a reference point and, as such, the video signal can be properly digitized. Each pixel's brightness can be determined by comparing its voltage against a fixed voltage reference. The effects of AC coupling and DC restoration are illustrated below:



Pixel clock

To produce the digital image, you must specify a sampling rate, called the *pixel clock*, which determines how many pixels will be extracted from the active portion of the analog signal. In other words, the pixel clock is used to divide the incoming horizontal line of video into separate pixels by specifying the exact location, in time, of each pixel.

The pixel clock is derived from either the camera or your frame grabber. Refer to your camera's operating manual to determine if the camera provides a pixel clock.

Your frame grabber can generate a pixel clock from its *phase-locked loop* (PLL). Here, the PLL locks itself to a reference signal, either the frame grabber's on-board crystal oscillator, or an external line synchronization (the hsync) when periodic. This ensures that the number of pixels in each line remains constant.

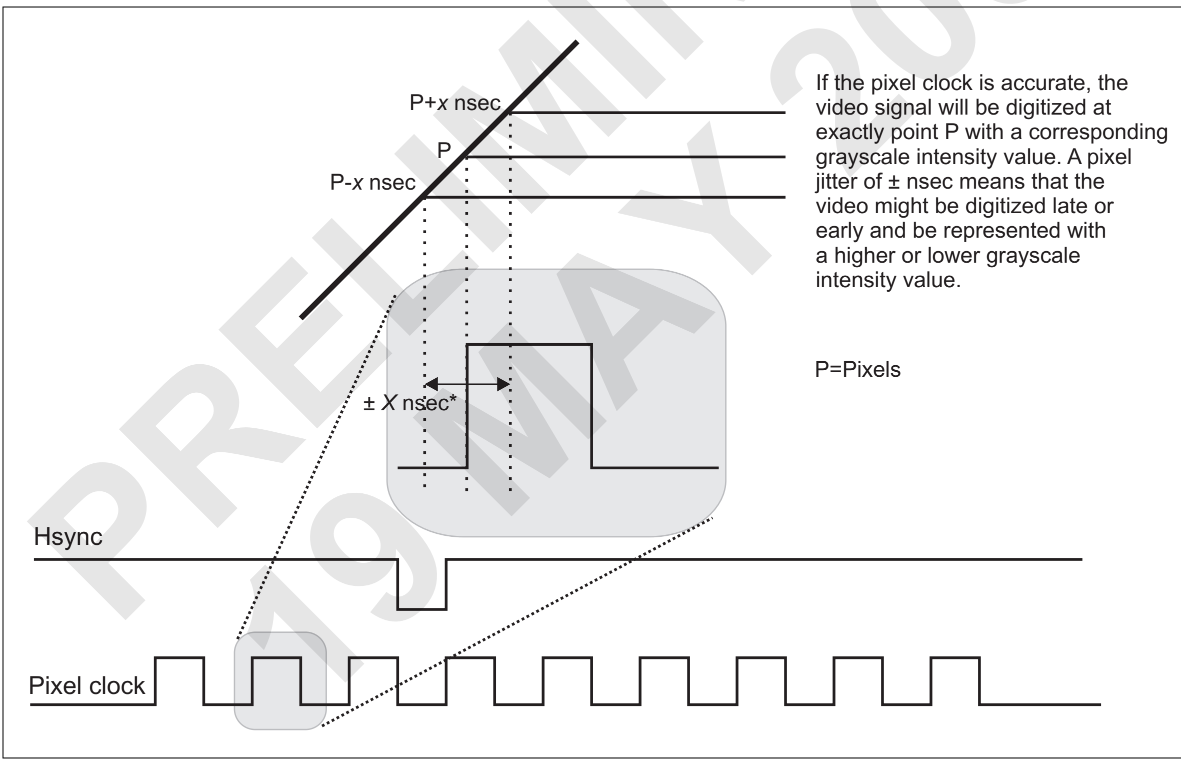
❖ In general, an external pixel clock can support very high digitization rates and allows for exact pixel location.

Clock exchange

As a general rule, if the camera has a pixel clock input, a pixel clock can be supplied to it. Sometimes, the internal workings of a camera dictate that, from the pixel clock sent by the frame grabber, the camera must generate and send back a strobe of a different frequency that corresponds to the rate at which data is being read out. This is called *clock exchange*.

Pixel jitter

Pixel jitter is the measure of accuracy of the pixel clock, measured in nanoseconds by the variance in the rising edge of the pixel clock with respect to the falling edge of the hsync. Pixel jitter is introduced by either the camera (in the pixel clock or the hsync generated from the camera) or by the frame grabber's PLL (which can introduce additional pixel jitter). Incoming video data might be digitized late or early, rendering inaccurate pixel representation, as a result of pixel jitter, as illustrated below.

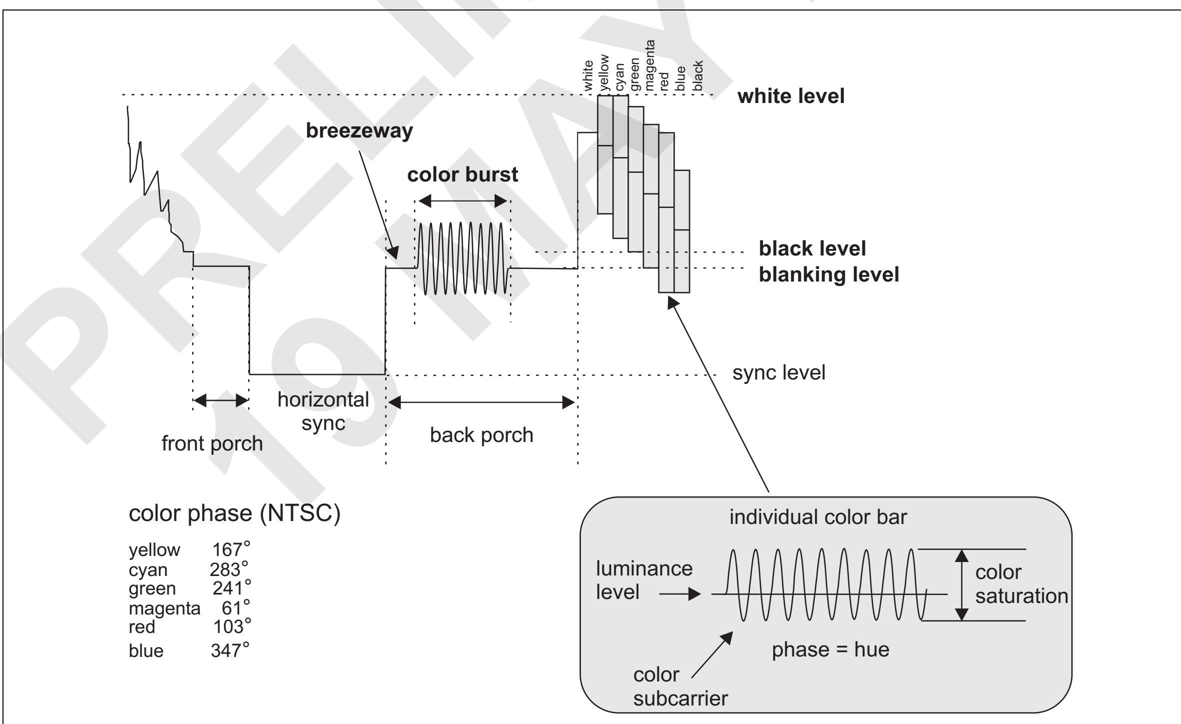


Color timing

Video line timing for composite color standards is similar to that of monochrome standards, except that color information must be included with the signal. For example, the NTSC format is a modified RS-170 video signal that includes color information, and PAL format is a modified CCIR video signal.

A composite video signal's color information is encoded in a subcarrier signal. The subcarrier is a high frequency signal that is continuously phase-shifted to represent color values across a line of active video. The angle of the phase shift is measured in degrees. The color subcarrier is a clock used to run the color decoder; this signal is superimposed on the luminance level and the subcarrier's amplitude represents saturation. See the diagram for shifts of particular hues. The amplitude of the subcarrier determines the saturation levels of the color.

To accurately determine color from phase, you need a good reference signal with no phase shift. This is provided by the *color burst*, which occurs after the horizontal synchronization, during the back porch. The period preceding the color burst is known as the *breezeway*, as shown:

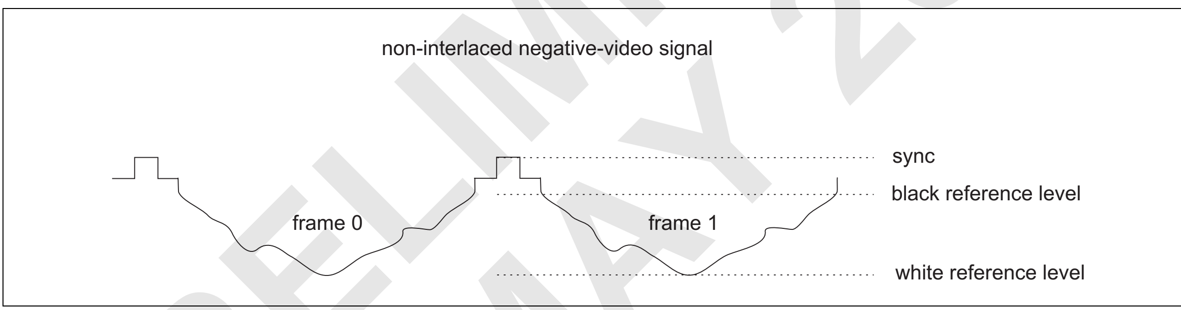


If the luminance and chrominance are mixed into a single signal, the signal is a *composite color signal*. To decode a composite color signal, the chrominance and luminance first have to be separated. The chrominance can be isolated using a *chroma bandpass* filter, or the luminance can be isolated using a *chroma trap*. Better quality color signals are sometimes provided by putting the luminance (referred to as the Y component) on a single wire, and the chrominance information on the "C" signal. This is referred to as YC video, and is often supplied through a DIN connector.

Then, the colors can be properly decoded for output, using a *chroma demodulator*.

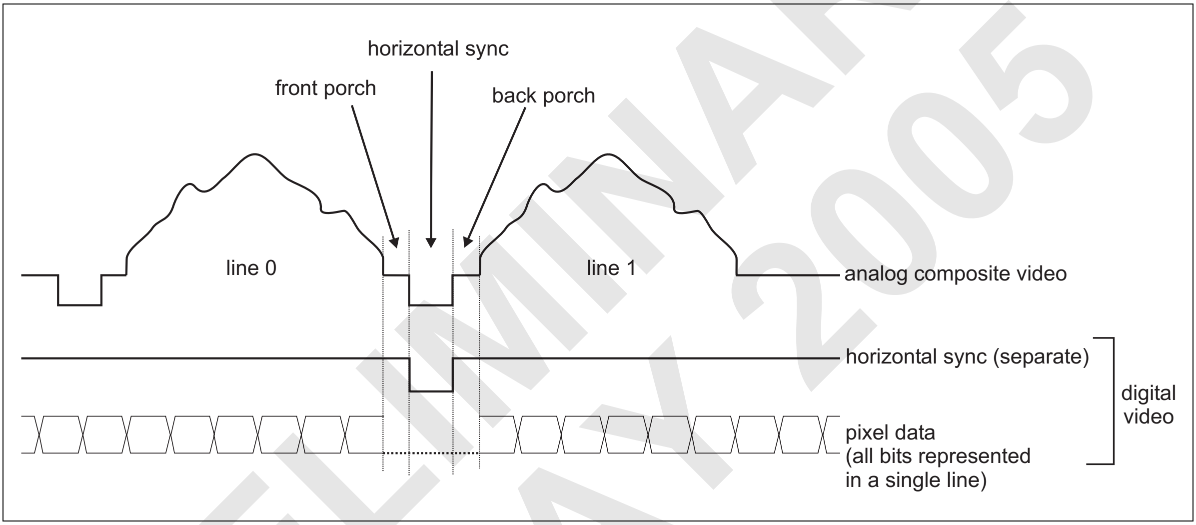
Negative-going video

Negative-going video is an analog video signal where white or bright pixel data is represented by a more negative voltage than black or dark pixel data. In general, a negative-going video signal can be represented as follows:



Digital video signals

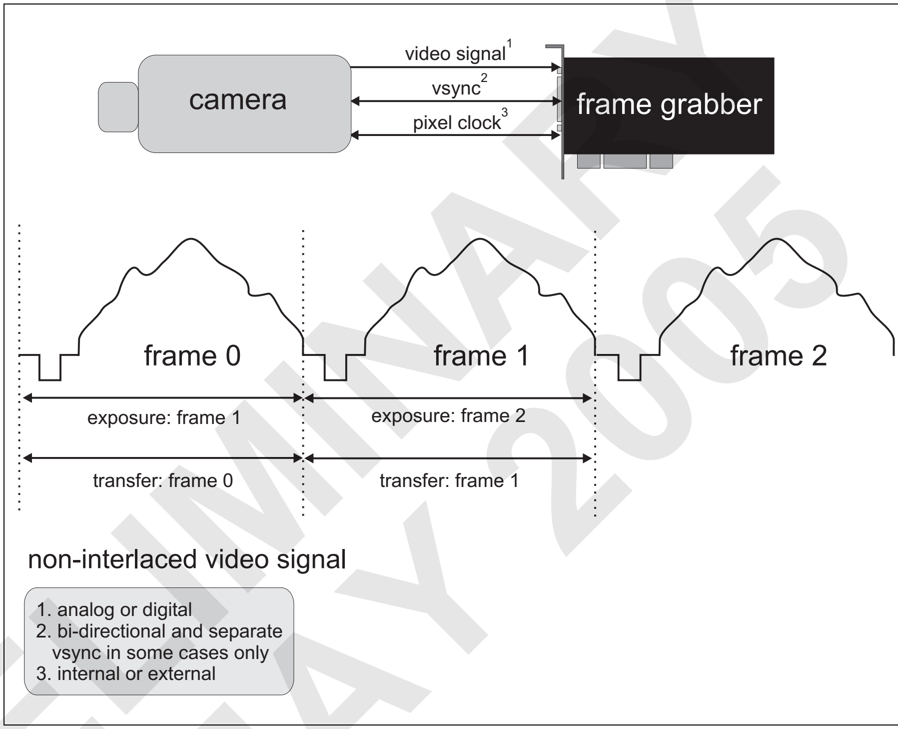
Digital composite video is essentially the same waveform as the analog composite RS-170 video signal, except that instead of varying voltages on one signal line, the values are represented as digitized values carried on multiple signal, and the data-carrying signals are restricted to one of two voltage levels: logic 1 or 0.



Representing data in digital form is useful since the waveform can be regenerated with minimum noise and distortion as it is being transferred.

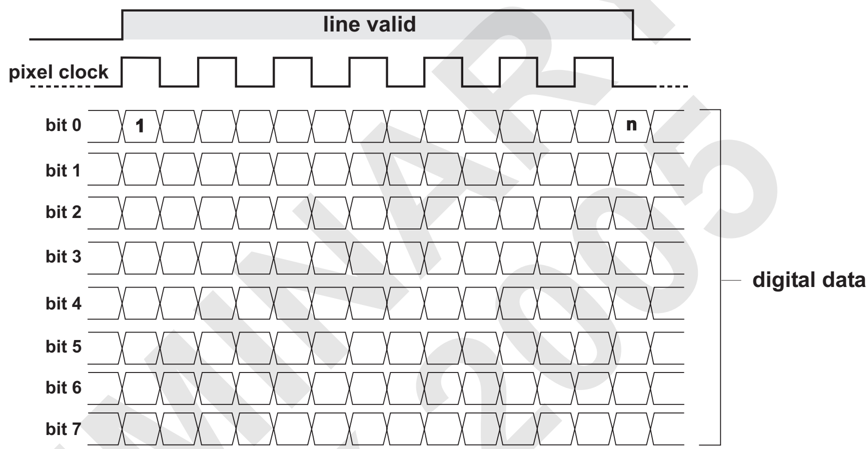
Digital data formats

The following figure illustrates an analog composite video waveform:



In digital video, pixel values are represented by an *n*-bit system, where a value between 0 and 2^{n-1} represents the brightness value. For example, in an 8-bit system, pixels can have 256 possible values, ranging from 0 to 255. As *n* increases, image information increases. For monochrome images, as *n* increases, more shades of gray are available, which results in a more accurate representation of the grabbed image. The following illustrates 8-bit digital data:

Each pixel is defined by the sampling of a single line at a certain point in time. In this 8-bit example, the pixel is represented with 256 brightness values (**2^8 = 256**).



Digital video data is usually transmitted on a pixel-by-pixel basis in the form of several bits in parallel. Each bit is transmitted on an individual SIGNAL line, using the TTL logic levels standard, or on a pair of signal lines, using differential RS-422 or EIA-644 (LVDS) standards. Other digital formats includes Camera Link.

RS-422

With RS-422, digital information can travel over a longer distance without the introduction of as much noise as with TTL. It is a medium-range differential-signaling pair signal standard.

In differential signalling, both positive and negative voltages are used. It determines binary values based on polarity and not on absolute voltage values. Therefore a signal can be clearer even with a lot of degradation.

TTL

TTL (transistor-transistor logic) is a common type of digital circuit. The TTL format signal is characterized by the voltage levels of 0 Volts representing the logical 0, and 5 Volts representing the logical 1; however, with noise and longer transmission distances, the signal can be downgraded so that determining the 0/1 is from the voltage left is erroneous.

LVDS

LVDS (low voltage differential signaling) is an electrical standard used when communicating at high speeds over wires. There are several industry standards that define LVDS including ANSI/TIA/EIA-644 (EIA-644). EIA-644 is more application independent and is used for more general purposes. EIA-644 provides a high bandwidth from higher transmission speeds with low noise and power consumption.

Camera Link

Camera Link is a high speed digital communication interface camera-to-frame grabber standard that combines low-voltage differential signal (LVDS) with serial digital data flow. Camera Link supports various real-time signals such as asynchronous reset, horizontal synchronization, and vertical synchronization.

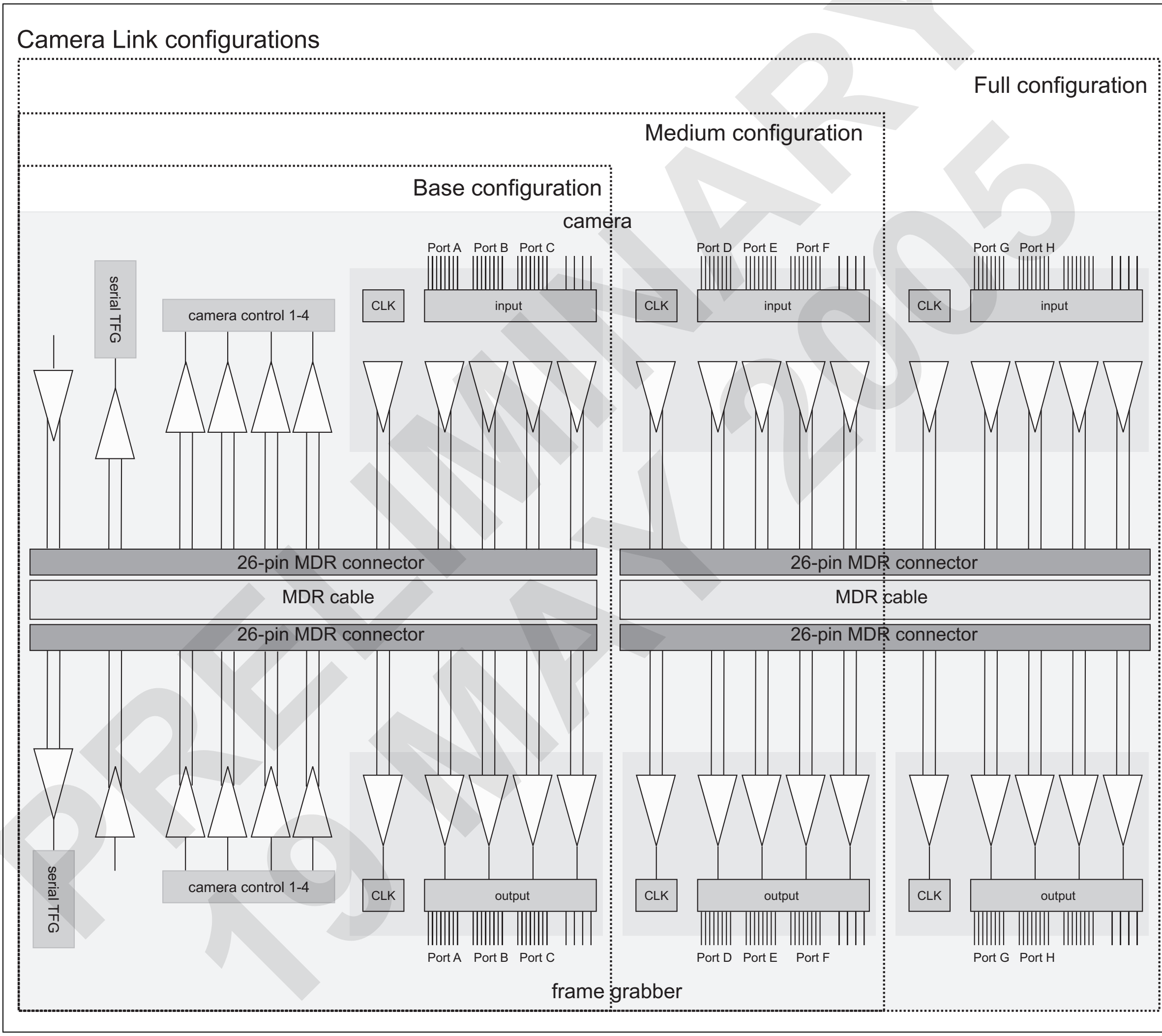
Camera Link standards

Camera Link's connectivity standards are based on National Semiconductor's Channel Link digital data transmission technology used in frame grabbers. Channel Link combines LVDS with serial transmission using a standardized cabling format. The Camera Link cable specifications provide standardized transmission rates of up to 2.38 Gbits per second over distances of up to 10 meters (32 feet).

As a result, Camera Link data transfer in base configuration can handle 1.2Gbps and in full configuration at 3.6 Gbps, which is faster than IEEE-1394 standards (up to 400 Mbps). Digital cameras equipped with a Camera Link interface do not require custom cables, making it more cost-efficient, as well as the cables are smaller and more flexible than custom cables required by early digital cameras, making them less prone to breakage and simpler to use.

The following is an illustration of the various Camera Link configurations (base, medium and Full) available for Camera Link cameras and how taps are divided. Each set of 8 bits (data lines, or ports) is represented by a letter, from A to H. Each

each set of bits is assigned independently. There are also four LVDS pairs are reserved for general camera control lines (camera control bits), primarily for exposure signals.



Using Matrox Intellicam with Camera Link standards, you can configure the acquisition paths (channels) from which you want to grab. You can also set your camera control signals to use camera control bits, which is typically used to control exposure timers on the frame grabber. You can also control serial line configurations through an application supplied by the camera manufacturer, a terminal emulator application, or software that communicates to the serial port.

Choosing between analog and digital formats

Depending on the type of application, you can choose between analog or digital cameras to best suit your needs.

For instance, analog signals are very sensitive to electromagnetic noise. Noise will directly affect the image (for example, cyclical noise might appear as periodic vertical distortion). Analog video signals might be carried over a single wire. If you require a cost-effective multiple-camera setup, such as for security applications, you might use analog cameras.

Digital cameras are less sensitive to noise and are increasing in popularity because they support high frame rates, more accuracy, and large image sizes; however, they are generally less cost-effective than analog cameras. Cables for digital signals are slightly more complex than for analog signals. The advantage over analog signals is that digitization is directly carried out in the camera, unlike for analog signals.

There are two types of digital cameras that are most common: "parallel-data" digital cameras and Camera Link cameras. Parallel-data digital cameras require one wire pair per data bit. Parallel-data digital cameras are typically referred to simply as digital cameras.

There is no standard for analog or digital cables, whereas there are established standards for Camera Link. This means that a custom cable must be built for each different type of analog or digital camera, whereas Camera Link formats use standard cabling.

Camera modes of operation

Typically, cameras can be operated in any one of several modes. This section discusses these modes. Note that camera terminology varies from one manufacturer to another, so the definitions found here reflect Matrox Imaging terminology.

Note that "internal" refers to the camera end and "external" refers to the frame grabber end. In addition, connections mentioned in the following sections are general ones. Particular cameras might require additional connections for auxiliary control signals. All required connections are specified in the camera manual.

Frame scan cameras

Frame scan cameras can be used for capturing 2-dimensional images. Frame scan cameras can be operated in any of the following modes: continuous mode, pseudo-continuous mode, trigger mode, asynchronous reset mode, control mode, and long exposure (integration) mode.

Continuous mode

In continuous mode, the camera continuously outputs images at a fixed frame rate, for RS-170 and NTSC standards, is 30 frames or 60 fields per second (North American timings) or for CCIR and PAL standards, 25 frames or 50 fields per second (European timings). In general, the exposure time is the reciprocal of the frame rate. By adjusting the camera, you might be able to use a shorter exposure time. The frame rate, however, does not change. In continuous mode, exposure of the current frame and transfer of the previous frame occur concurrently. Therefore, in this mode, exposure time cannot exceed the reciprocal of the frame rate.

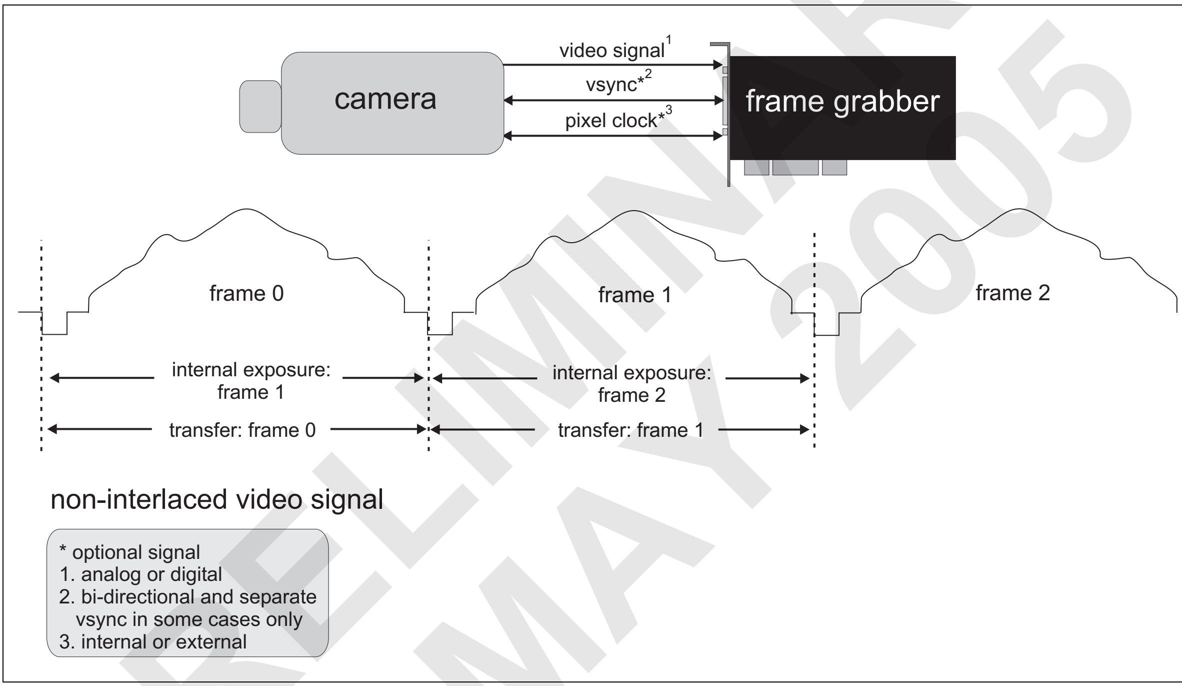
If the camera outputs an analog video signal where both the horizontal and vertical synchronization signals are combined with video data (composite video signal), then that signal alone is required by the frame grabber to operate in continuous mode. Some cameras can output an analog video signal where only the horizontal synchronization signal is merged with the video signal, although this is not typical. In such a case, a separate digital vertical synchronization signal (for example, a frame enable or a trigger signal) is supplied by the camera to the frame grabber or vice-versa.

There is also another case in which the horizontal and vertical synchronization signals are generated separately.

❖ Separate digital synchronization signals can also be used even when the camera outputs a fully composite analog signal.

If the camera outputs a digital video signal, both the hsync and vsync are usually separate digital signals provided by the camera or supplied by the frame grabber. Some cameras combine the hsync and vsync to form a single digital composite synchronization signal. Finally, a pixel clock might be provided by the camera or supplied by the frame grabber, if required. They can be supplied by both in the case of clock exchange (see the subsection on clock exchange in the *Pixel clock* section).

The following illustrates output and timings in continuous mode:



Pseudo-continuous mode

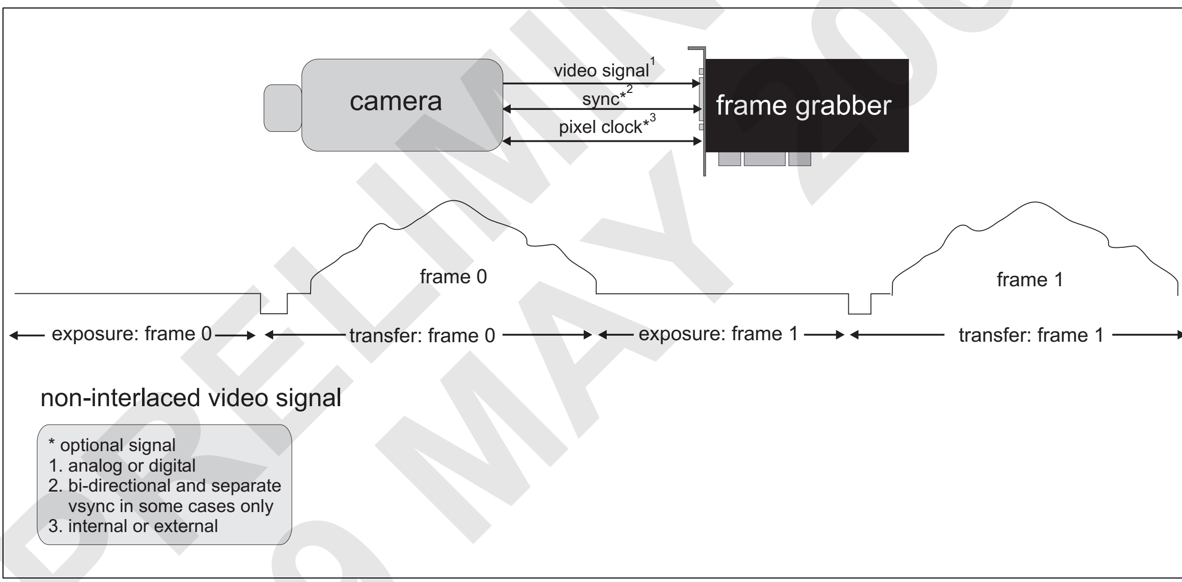
In pseudo-continuous mode, the camera continuously outputs images at a frame rate that is determined by the exposure time and the frame transfer time.

The exposure time might be selectable by adjusting the camera; however, the frame transfer time is fixed and is a characteristic of the camera. As can be seen in the timing diagrams in the manual of some cameras that operates in this mode, exposure and transfer of a frame occur sequentially, and exposure of a new frame only starts once the previous frame has been fully transferred. As such, the frame rate is the reciprocal of the sum of the exposure time and the frame transfer time. The camera sets an upper limit on the exposure time but, as opposed to continuous mode, the exposure time can be much longer than the frame transfer time.

❖ Some cameras however, are capable of integrating while outputting the previous frame. Refer to the documentation for the camera for further information.

The signals involved in this mode are the video output and synchronization signals. As with continuous mode, these signals might be combined with video data (composite) or separate digital synchronization signals can be used.

The following illustrates the timings for pseudo-continuous mode.



Trigger mode

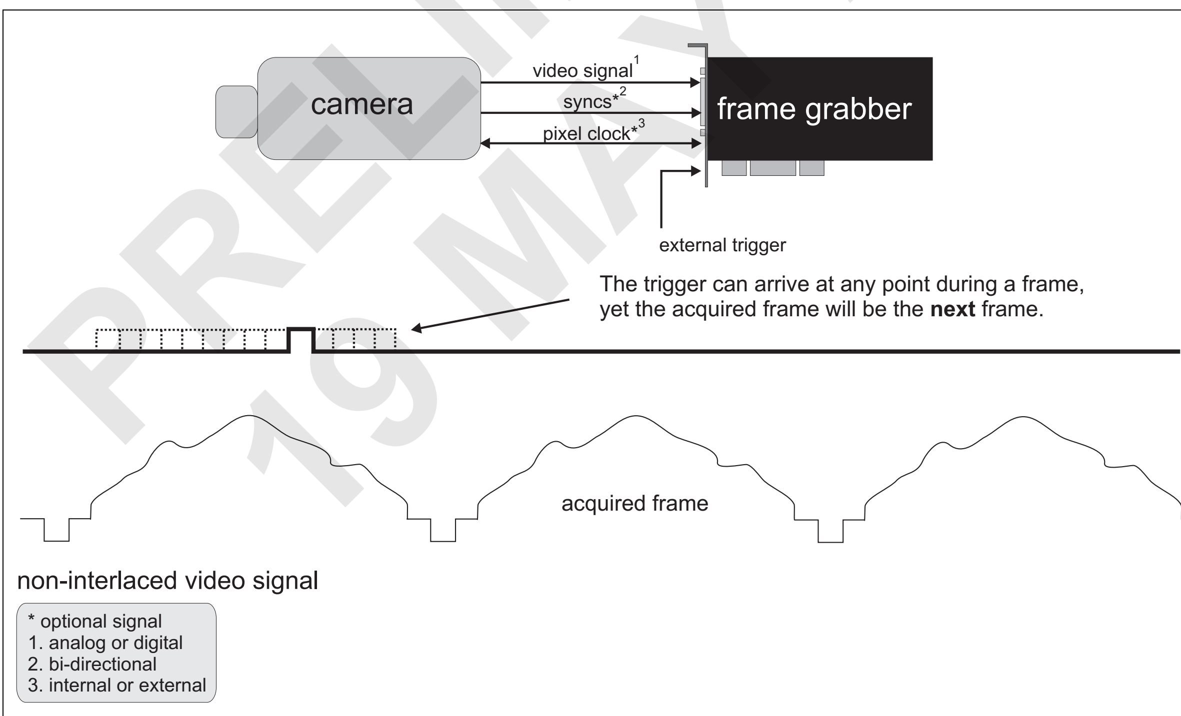
The trigger mode is used to capture a single image or a sequence of images at a certain moment in time.

In trigger mode, as in continuous mode, the camera continuously outputs images at a fixed frame rate. However, to grab a frame, the frame grabber must receive an external trigger signal.

Note that the frame grabber will ignore an external trigger pulse that arrives before the completion of the current frame period has finished grabbing the frame. Therefore, to ensure that all required frames are captured, the shortest time between external trigger pulses must be greater than the sum of the exposure time and the frame transfer time.

In addition to the external trigger signal, the video output and synchronization signals are provided to the frame grabber.

The following illustrates the timings for trigger mode:



Asynchronous reset mode

To grab a frame in asynchronous reset mode, either an external trigger signal is provided to or an internal trigger is generated by the frame grabber. An internal trigger can be periodic or aperiodic (controlled by software). The frame grabber, in turn, triggers the asynchronously resettable camera to initiate exposure. The trigger signal from the frame grabber to the camera is referred to as the exposure signal. The camera is resynchronized on the exposure pulse. The delay from the time the frame grabber is triggered to the time it sends an exposure signal is programmable.

There are three types of asynchronous reset modes used by cameras, as follows:

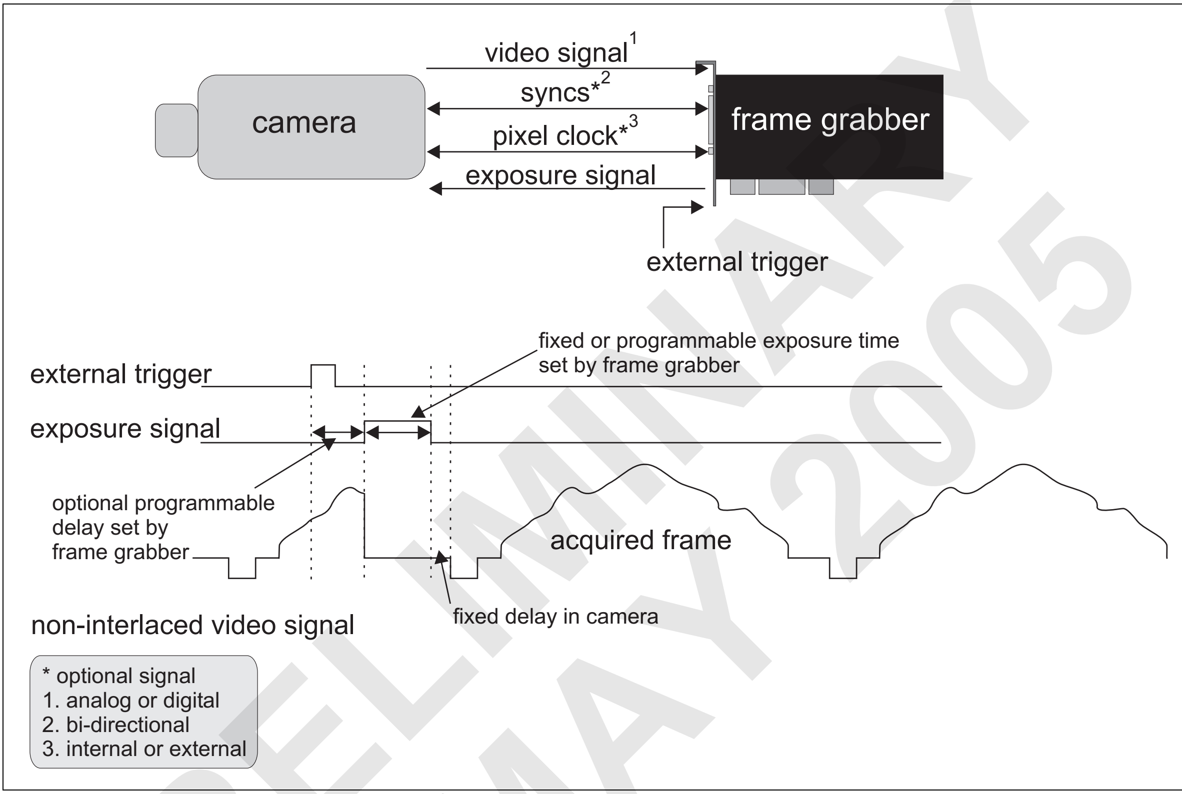
- **Vertically asynchronously resettable:** The vertical timings are reset on the exposure pulse.
- **Vertically and horizontally asynchronously resettable:** Both the vertical and horizontal timings are reset on the exposure pulse.
- **Fully asynchronously resettable:** The vertical and horizontal timings and the pixel clock are reset on the exposure pulse.

❖ Refer to the timing diagrams found in your camera's manual to determine which of the three cases corresponds to your particular camera's asynchronous reset mode.

In asynchronous reset mode, the exposure time can be adjusted on the camera itself, or determined by the frame grabber's exposure output. Some cameras will ignore an exposure pulse that arrives before the current frame period is over, while others will resynchronize on this new pulse, discarding all current information. In general, to avoid losing information, the shortest time between external trigger pulses should be greater than the sum of the exposure pulse width, the exposure time, and the frame transfer time.

The signals used in asynchronous reset mode are an external trigger signal provided to the frame grabber, an exposure signal supplied from the frame grabber to the camera, the video output (analog or digital) and synchronization signals provided to the frame grabber.

The following illustrates the timings for asynchronous reset mode:



Control mode

In control mode, the exposure time is controlled by the frame grabber. Usually, the camera is triggered asynchronously. An external trigger signal is provided to the frame grabber. The frame grabber sends an exposure signal to the camera.

Control mode is similar to asynchronous reset mode except in this mode, the camera is resynchronized on the exposure signal. The width of the exposure signal determines the exposure time.

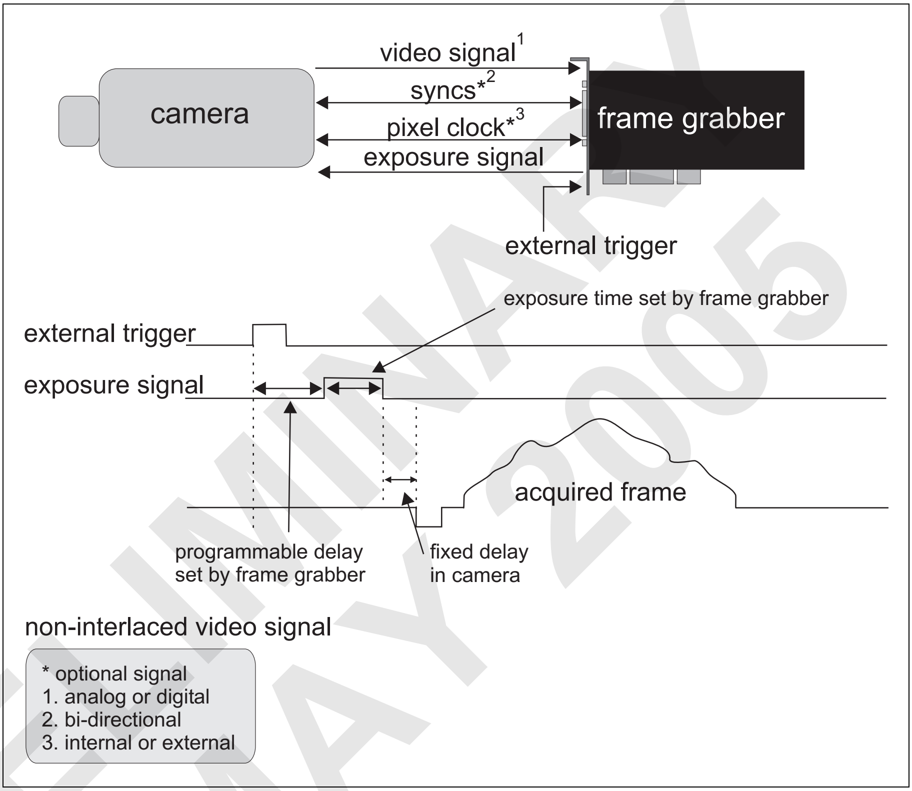
❖ You can adjust the width of the exposure signal on the frame grabber, using Matrox Intellicam to modify the DCF file or using MIL.

Some cameras will ignore an exposure signal that arrives before the current frame period is over, while others will resynchronize on this new pulse, discarding all current information. To avoid losing information, the shortest time between external trigger pulses should be greater than the sum of the exposure signal width and the frame transfer time.

The signals used in this mode are an external trigger signal provided to the frame grabber, an exposure signal supplied by the frame grabber to the camera, and the video output and synchronization signals provided to the frame grabber.

❖ Use the control mode when control over the start and exposure time of an image is required.

The following illustrates the timings for control mode:



Long exposure or integration mode

In long exposure or integration mode, the exposure time is controlled internally via switches on the camera, or externally by way of the frame grabber. In this mode, an external trigger signal is provided to the frame grabber which, in turn, activates the camera. In this mode, the signal from the frame grabber to the camera is referred to as the exposure signal.

With most cameras, the exposure pulse is latched to the horizontal synchronization signal (hsync). The camera uses this horizontal synchronization signal to initiate frame transfer on its next vertical synchronization signal. In general, the exposure time must be specified as a multiple of fields or frames, where one frame time (the frame transfer time) is equal to the reciprocal of the frame rate of the camera when operated in continuous mode. Note that one field time is half of one frame time.

❖ Use long exposure or integration mode when an exposure time greater than one frame time is required. Most cameras will ignore the end of an exposure pulse that arrives before the current frame period is over, while others will latch to the pulse and initiate the next exposure directly afterward.

To ensure capturing an image:

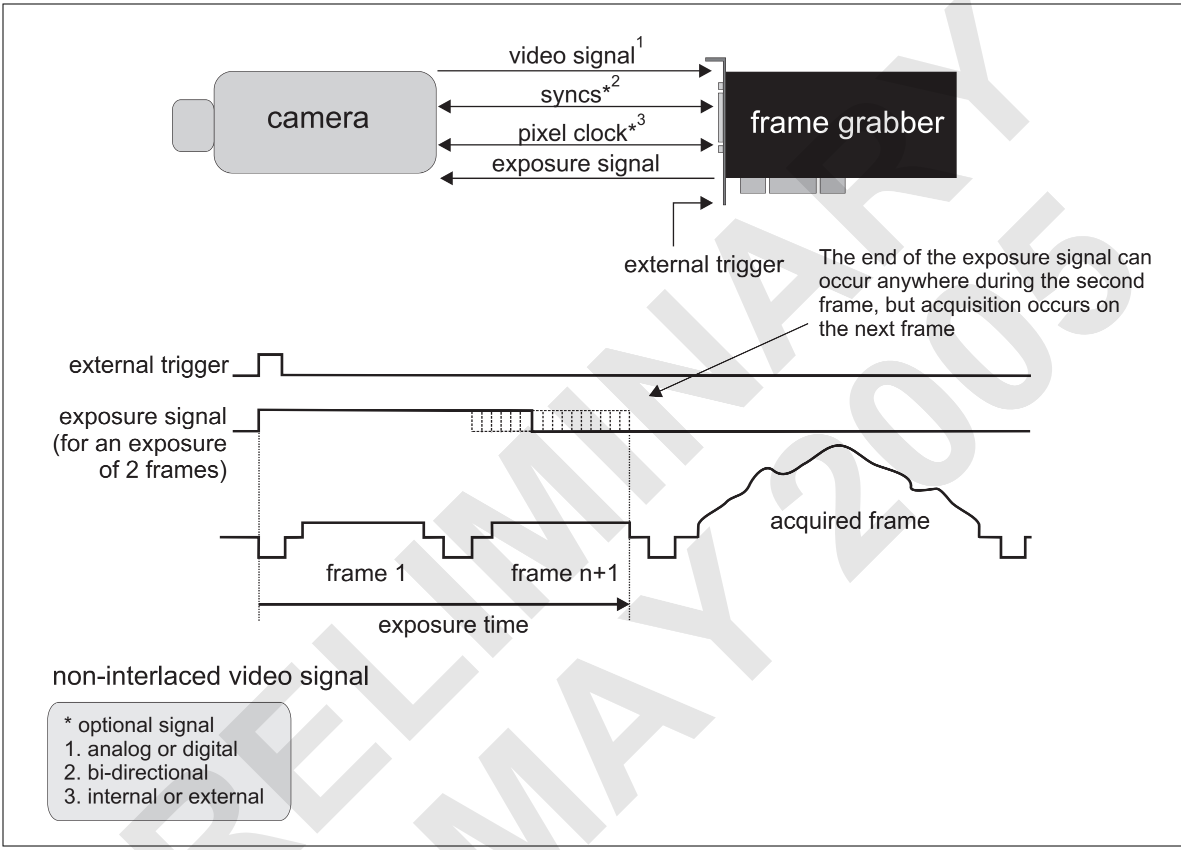
- If the exposure is *internally controlled*, the shortest time between external trigger pulses should be greater than the sum of the exposure pulse width, the exposure time, and the frame transfer time.

- If the exposure is *externally controlled*, the shortest time between external trigger pulses should be greater than the sum of the exposure pulse width and the frame transfer time.

  ❖ The width of the exposure pulse determines the exposure time and is adjusted on the frame grabber using Matrox Intellicam or MIL.

The signals used in this mode are an external trigger signal provided to the frame grabber, an exposure signal supplied by the frame grabber to the camera, and the video output (analog and digital) and synchronization signals provided to the frame grabber.

The following illustrates the timings for long exposure (integration mode):



Line scan cameras

Line scan cameras are useful for capturing moving objects, such as on a conveyor belt. Typically, line scan cameras are used for capturing 1-dimensional images, at high speeds using continuous grabs.

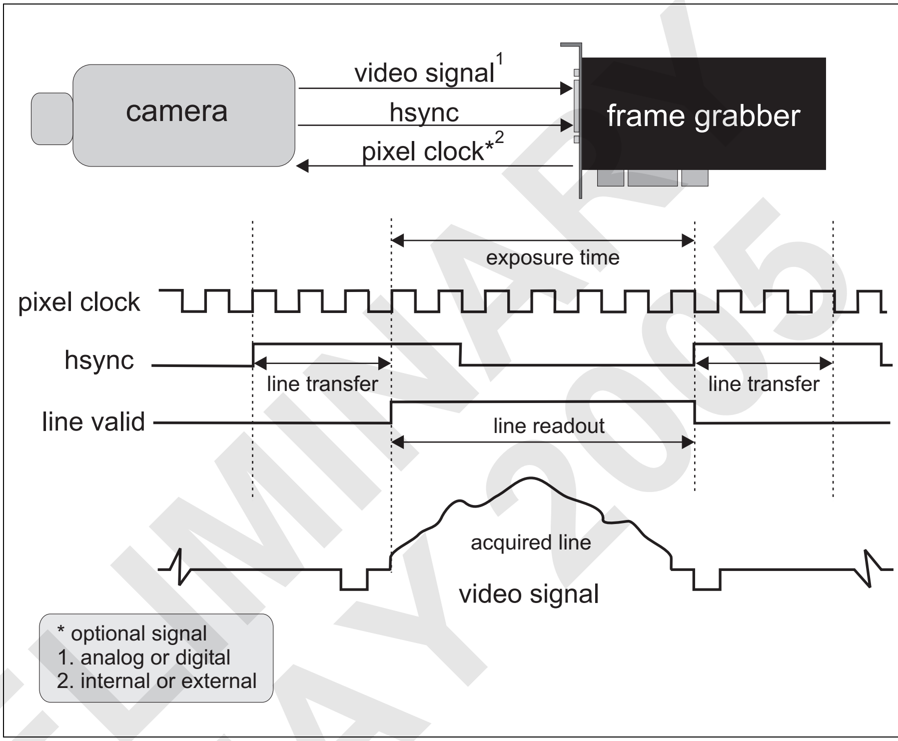
Line scan cameras can be operated in one of the following modes: fixed line scan, fixed line scan rate with frame trigger, fixed line scan rate with variable frame size, variable line scan mode, variable line scan rate with frame trigger, or variable line scan rate with variable frame size.

Fixed line scan rate mode

In a fixed line scan mode (also called continuous line scan rate mode, or free-running mode), the camera is set to continuous mode and does not require synchronization signals from the frame grabber. The camera continuously outputs lines. The frequency depends on the exposure signal and frame rate settings on the camera.

The pixel clock can be provided by either the camera or the frame grabber. Some cameras that require a pixel clock be provided as well as a clock exchange mechanism.

The following illustrates the timings for fixed line scan rate mode:



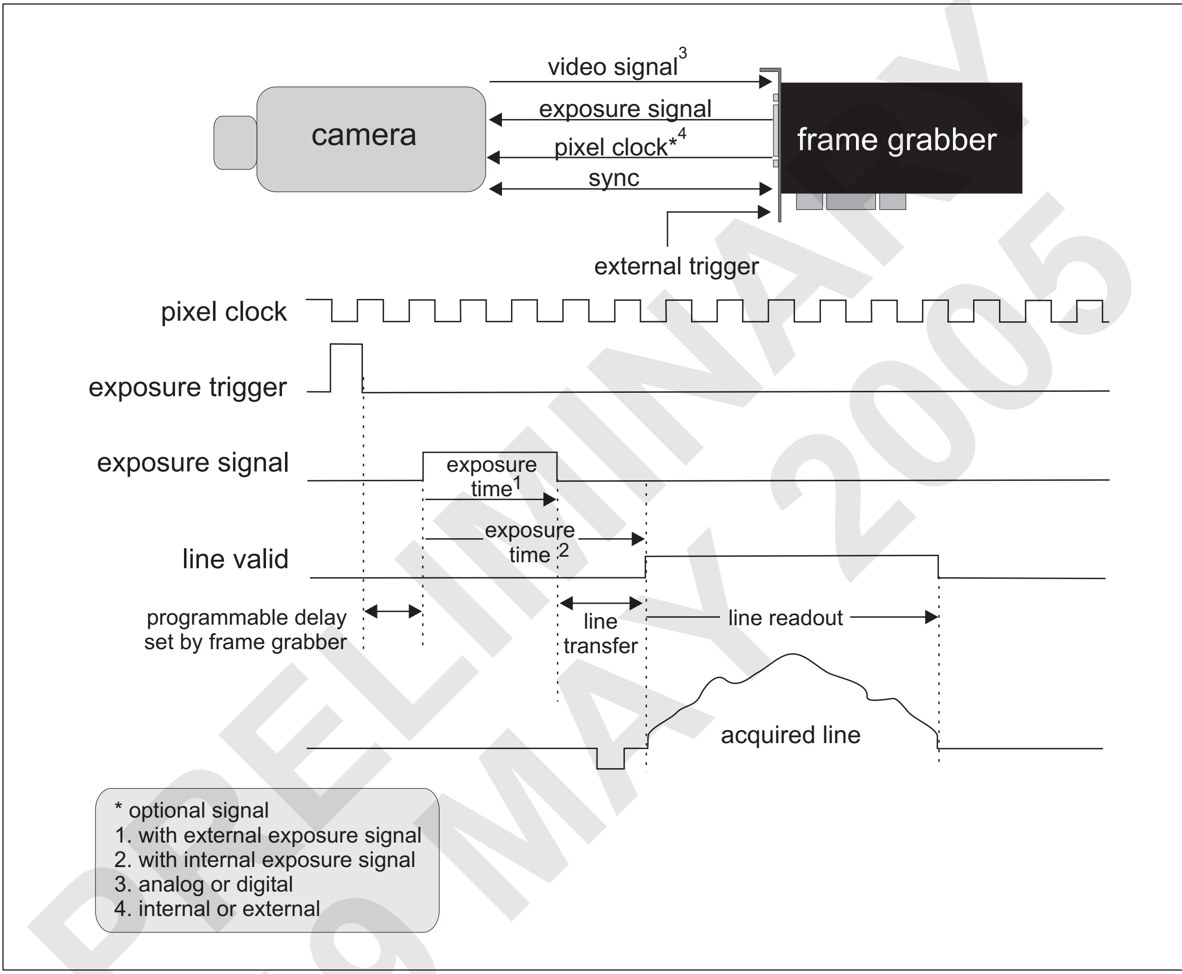
Variable line scan rate mode

In variable line scan rate mode, an external trigger signal is provided to the frame grabber which sends an exposure signal to the camera to initiate line readout.

The time interval between the exposure output pulses determines the line scan rate. This mode can use internal or external exposure time controls. The time interval between trigger signals must be greater than the sum of the exposure time and the line transfer time. With external exposure control, the length of the exposure signal determines the exposure time; without exposure control, the exposure duration is the reciprocal of the line scan rate. With internal exposure control, the exposure time is set from the camera. On cameras that support this feature, the exposure signal's pulse width might control the exposure duration.

The signals used in this mode are an external trigger (line trigger) signal (provided to the frame grabber), a pixel clock and exposure signal (supplied by the frame grabber to the camera), synchronization signals from camera to frame grabber or from the frame grabber to the camera (if the camera is in slave mode) and a video output that can be analog or digital from the camera to the frame grabber.

The following illustrates the timings for variable line scan rate mode:



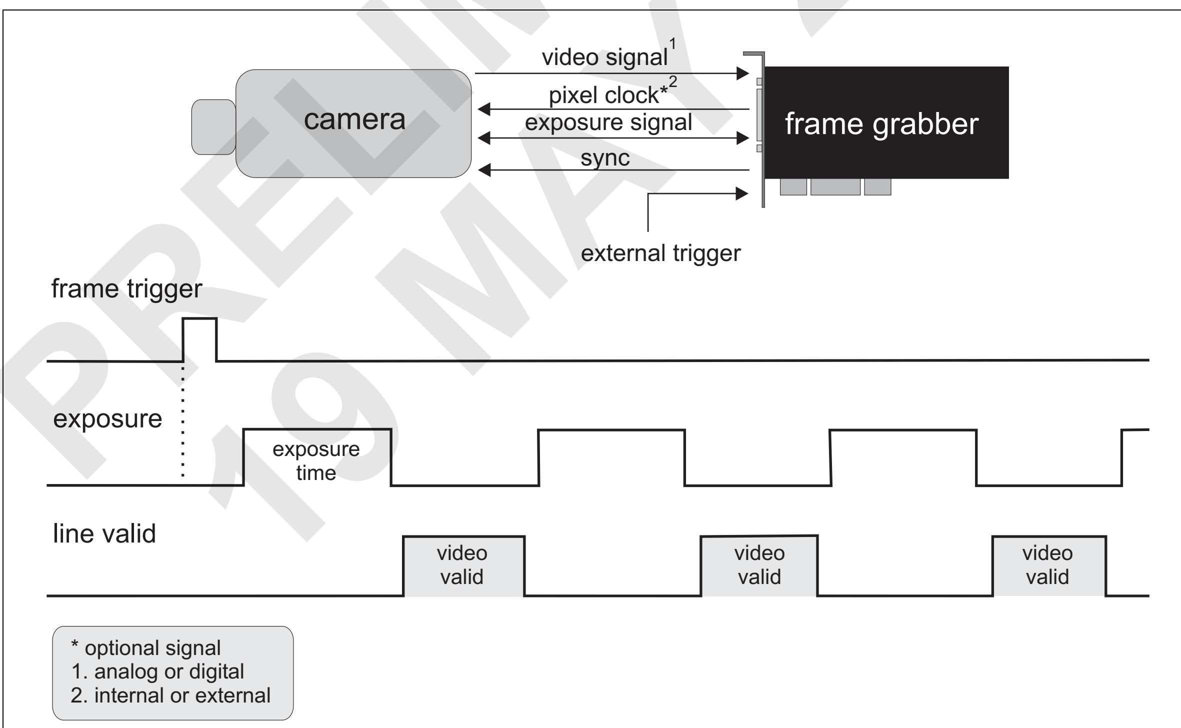
Fixed line scan rate with frame trigger mode

In a fixed line scan rate mode with a frame trigger, the line scan rate is controlled by the period of the exposure signal. The frame rate is variable, and controlled by the frequency of the external frame trigger; the external trigger period, however, must always be greater than the total time of the number of lines captured. The camera can use internal or external exposure time controls. The frame size is determined by the line number in the vertical timing specified in the DCF.

The number of lines per frame is fixed and determined by the vertical timing of the DCF. The grab starts on the rising edge of the frame trigger signal.

The required connections when using this mode are external trigger signal to frame grabber, exposure signal to the camera, and the video and synchronization signals from the camera to the frame grabber.

The following diagram illustrates the timings for fixed line scan modes with frame triggers:

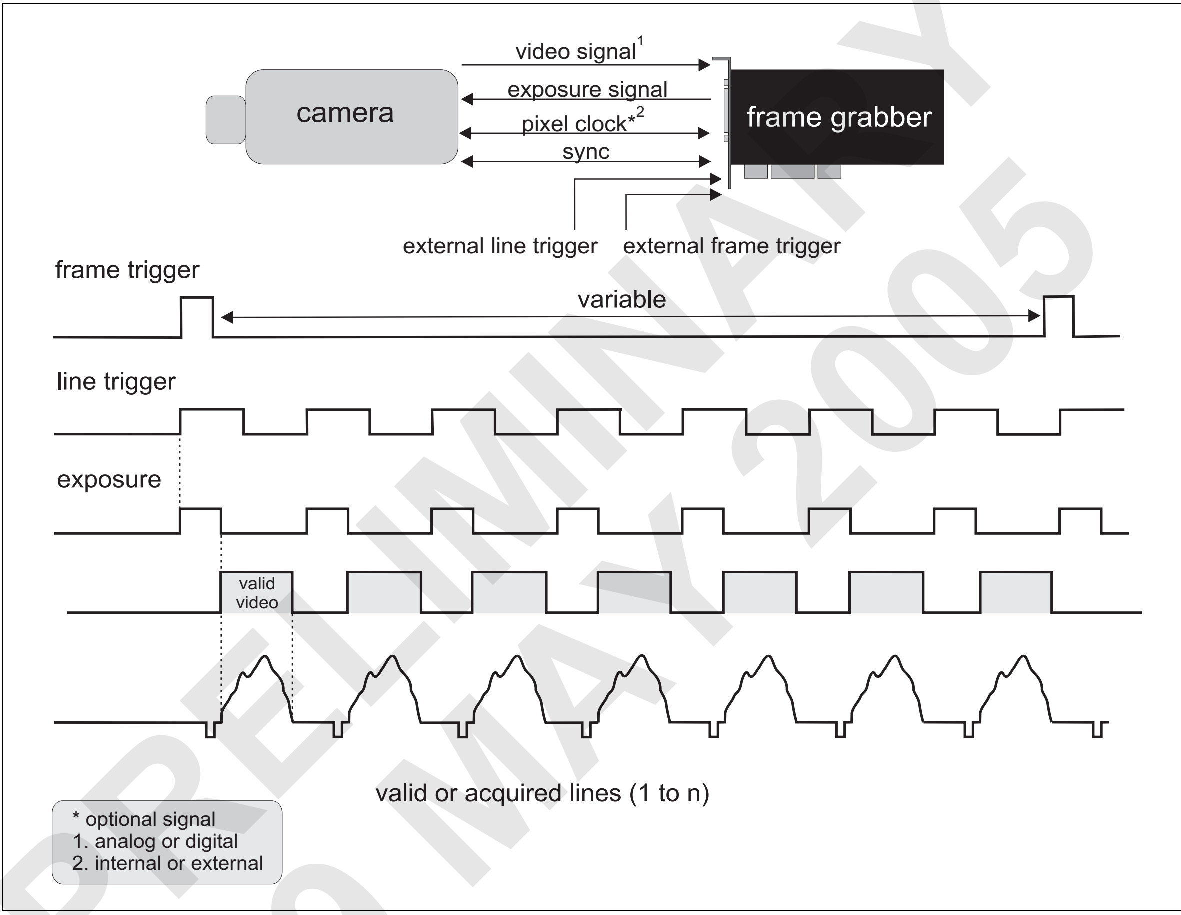


Variable line scan rate with frame trigger mode

In variable line scan rate with frame trigger mode, the frame grabber receives two external triggers: a line trigger and a frame trigger. The line trigger is continuous; however, it has a variable rate. The line trigger tells the frame grabber to send an exposure pulse to the camera to start reading out a line. When the frame trigger occurs, a specified number of lines are acquired. The frequency of the external trigger signal determines the line scan rate and must be greater than the exposure time and the line transfer time.

The signals used in this mode are external line and frame trigger signals (both provided to the frame grabber); an exposure signal (supplied by the frame grabber to the camera); a synchronization signal; and a video output.

The following illustrates the timings for variable line scan rate with frame trigger mode:



In this mode, the line scan rate is determined by the time between external trigger pulses; it can use internal or external exposure time control.

In a variable line scan mode with line and frame triggers, the camera is set to transmit video-on-demand. The line rate is a function of the line trigger; the frame capture is initiated by the frame trigger.

The required connections when using this mode are frame trigger signal, and the line trigger signal to frame grabber. To connect the exposure from frame grabber to the camera, the synchronization signals from the camera to the frame grabber or from the frame grabber to the camera (if the camera is in slave mode), and the video signal from the camera to the frame grabber.

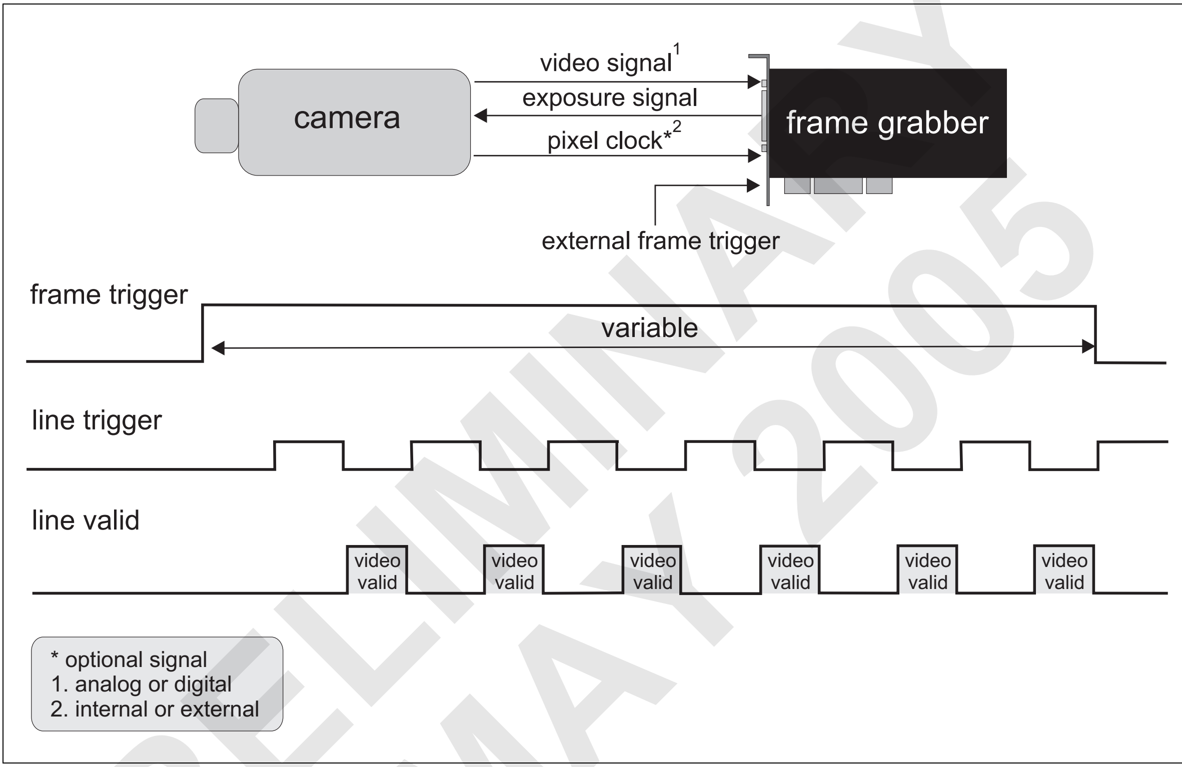
Fixed line scan rate mode with variable frame size

In a fixed line scan rate mode with variable frame size, the line rate is controlled by the period of the exposure signal. Exposure time can be internal or external. The frame capture is initiated by the frame trigger and the frame size is a function of the frame triggers active level duration. The number of lines per frame is variable and is controlled by the frame trigger signal.

The frame grabber captures lines during the high level of the frame trigger signal. The maximum number of lines captured can be adjusted by changing the number of active lines in the active vertical timing period in the DCF file. The line capture starts with the rising edge of the frame trigger signal.

The required connections when using this mode are the frame trigger and line trigger signals to frame grabber, and the periodic line resets signal (with optional exposure) from the frame grabber to the camera. You also need to connect the synchronization signals from the camera to the frame grabber, or from the frame grabber to the camera. The video signals also needs to be connected from the camera to the frame grabber.

The following illustrates timings for fixed line scan rate mode with variable frame size mode:

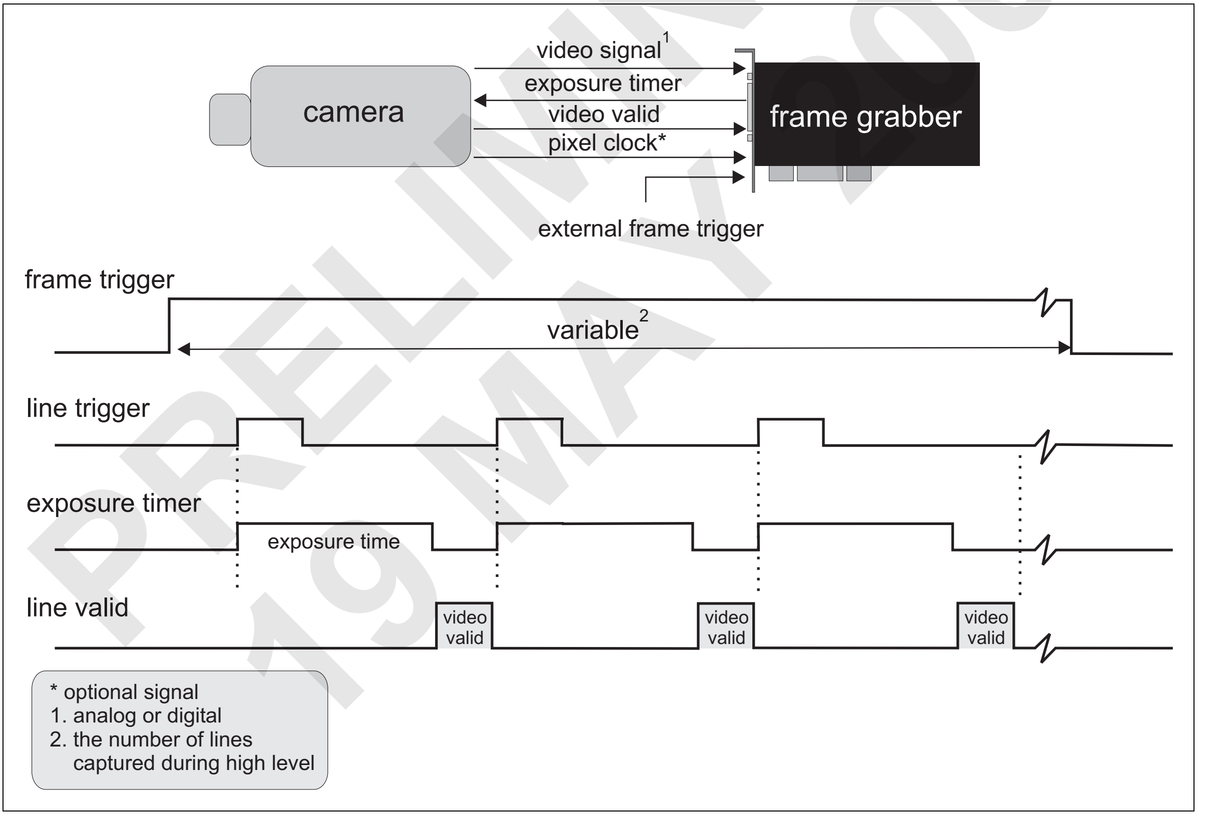


Variable line scan rate mode with variable frame size

In a variable line scan mode with variable frame size, the line rate is controlled by an external line trigger frequency. The number of lines per frame is variable and controlled by the frame trigger signal.

The frame grabber captures lines during the high level of the frame trigger. The maximum number of lines captured can be changed by changing the active vertical timing period in the DCF file. The line capture starts with the rising edge of the frame trigger signal and ends with the falling edge.

The following illustrates the timings for variable line scan mode with variable frame size:



In a variable line scan rate with variable frame size, the camera is set to transmit video-on-demand, using internal or external exposure time control. The line rate is a function of the line trigger; the frame capture is initiated by the frame trigger. The frame size is a function of the frame trigger's active level duration up to a maximum of *n* lines, as defined in the DCF.

The required connections when using this mode are from the frame trigger signal to the frame grabber as well as the line trigger signal to the frame grabber. The exposure from the frame grabber to the camera. You also need to connect the synchronization signals from the camera to the frame grabber, or the frame grabber to the camera, and the video signal from the camera to the frame grabber.

Summary of camera modes

The following tables summarize the various camera modes for frame scan and line scan cameras. Note that "internal" refers to the camera end and "external" refers to the frame grabber end.

Frame scan cameras

Camera Modes	Connections
Continuous mode: • Continuous video. • Internal exposure control. • Exposure time cannot exceed frame transfer time. • Fixed frame rate is independent of exposure time.	• Video and synchronization signals between camera and frame grabber (synchronization signals can be provided by the frame grabber).
Pseudo-continuous mode: • Continuous video. • Internal exposure control. • Exposure time can be much longer than frame transfer time. • Frame rate is a function of exposure time.	• Video and synchronization signals between camera and frame grabber.
Asynchronous reset mode: • Internal exposure control. • External trigger.	• Video, synchronization, and exposure (frame grabber acting as asynchronous reset) signals connected between camera and frame grabber. • External trigger signal connected to frame grabber.
Control mode: • External exposure control. • External trigger.	• Video, synchronization, and exposure (frame grabber acting as asynchronous reset in addition to actual exposure) signals connected between camera and frame grabber. • External trigger signal connected to frame grabber.
Long exposure or integration mode: • Internal or external exposure control. • Exposure times longer than one frame. • External trigger.	• Video, synchronization, and exposure (trigger) signals connected between camera and frame grabber. • External trigger signal connected to frame grabber.

Line scan cameras

Camera Modes	Connections
Continuous line scan rate mode: • Line scan rate determined by the frequency of the hsync signal.	• Video and synchronization signals between camera and frame grabber (synchronization signals can be provided by the frame grabber).
Variable line scan rate mode: • Line scan rate determined by time between external trigger pulses. • Internal or external exposure time control.	• Video, synchronization and exposure (trigger) signals connected between camera and frame grabber. • External trigger signal connected to frame grabber.
Fixed line scan rate with frame trigger mode: • Line scan rate determined by time between external trigger pulses. • Internal or external exposure time control.	• Video, synchronization, and exposure (trigger) signals connected between camera and frame grabber. • External line and frame trigger signals connected to frame grabber.
Variable line scan rate with frame trigger mode: • Line scan rate determined by time between external trigger pulses • Internal or external exposure time control.	• Video, synchronization, and exposure (trigger) signals connected between camera and frame grabber. • External line and frame trigger signals connected to frame grabber.
Fixed line scan rate with variable frame size: • Line scan rate determined by time between external trigger pulses. • Internal or external exposure time control.	• Video, synchronization, and exposure (trigger) signals connected between camera and frame grabber. • External line and frame trigger signals connected to frame grabber.
Variable line scan rate with variable frame size: • Line scan rate determined by time between external trigger pulses. • Internal or external exposure time control.	• Video, synchronization, and exposure (trigger) signals connected between camera and frame grabber. • External line and frame trigger signals connected to frame grabber.

Index

A

B

C

D