Camera Interface Guide

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Video Basics

Introduction

This guide serves as an introduction to video and interfacing a camera to Matrox Imaging hardware. It will help you understand the descriptions and diagrams in your camera manual, and will enable you to get your system up and running more quickly. Depending on your knowledge level, certain sections of this guide will meet your needs more than others. The sections at the beginning describe components and timings of standard and non-standard video. **Table 1** gives an example of some of the information required when building a digitizer configuration file (DCF) using Matrox Intellicam camera interface software1. A DCF provides the video description to the digitizer in order to enable grabbing. The **Modes of Operation** section describes certain camera modes. The **Mode Reference** section, located on the inside cover, summarizes the different modes in a quick reference table. The terminology used to describe video features may vary slightly from one camera manufacturer to another and the definitions found here are as Matrox Imaging uses them.

Video Formats

All video signals conform to a particular standard or non-standard video format, which specifies information such as signal type (analog or digital), synchronization signals, number of lines, as well as other details that define the signal. RS-170A, RS-330 and RS-343 are the standard monochrome video signals used in the United States, Canada and Japan. CCIR is the monochrome standard used mainly in Europe.

The three color standards used are NTSC (United States, Canada, Japan and parts of South America), PAL (Europe) and SECAM (France, Russia and the republic states). NTSC is a 525 line, 30 frames (60 fields) per second, 2:1 interlaced system that uses YIQ color space2. PAL (Phase Alternate Line) is a modification of the NTSC specifications. To prevent color distortion, PAL consists of a line-by-line reversal of the phase of one of the color signal components. PAL is a 625 line, 25 frames (50 fields) per second, 2:1 interlaced system that uses the YUV color space2. SECAM (Sequentiel Couleur Avec Mémoire/Sequential Color with Memory) adds the hue and saturation to a monochrome signal by transmission on an alternative line to avoid any crosstalk of color information. SECAM is also a 625 line, 25 frames (50 fields) per second, 2:1 interlaced system.

Non-standard video formats usually differ from standard video in their timings and signal characteristics. Some examples of non-standard formats include high resolution, negative-going analog and digital video. High resolution video includes those cameras with spatial resolution of 1024 pixels x 1024 lines or higher; requiring a higher sampling rate (MHz) by the frame grabber. Negative-going video is an analog video signal where white or bright pixel data is represented by a more negative electrical value than a black or dark pixel. Digital video is a digitized waveform of RS-170A, NTSC, CCIR, PAL or non-standard video signals where the sync, blanking and saturation levels have been assigned a digital value. Additional discussion of non-standard video includes asynchronous reset, external exposure control and line scan.
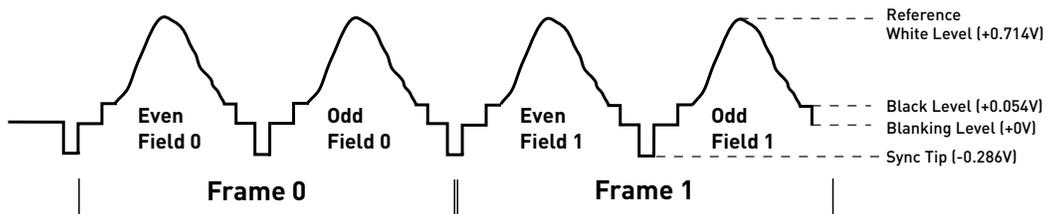
Standard analog format

Standard cameras use a CCD (charged coupled device) array as an optical sensor which reads out a single interlaced frame made up of two fields (even and odd). The even field contains only even numbered lines and the odd field contains only odd numbered lines of video information.

RS-170A is a standard monochrome composite video signal that contains both timing and image information in a single signal. This monochrome video is a 525 line system with a frequency of 30 frames (60 fields) per second. RS-170A has a 1 volt video signal amplitude, is 2:1 interlaced scan and has a standard sampling field or digitizing frequency providing a 4:3 aspect ratio. Since the video signal ranges from -0.286V to +0.714V, it has an amplitude of 1V.

The portion of the signal that lies above +0.054V, called the black level, contains active video, while the portion below +0.054V contains all sync information (e.g., blanking, horizontal and vertical). The saturation value of the RS-170A signal, called the reference white level, corresponds to a voltage of +0.714V. The reference black level corresponds to a voltage of +0.054V. An example of RS-170A video can be viewed in **Diagram 1** along with its electrical representations.

Video Basics

Diagram 1: Frames (fields) of standard RS-170A video with electrical voltage levels

Even Field 0   Odd Field 0   Even Field 1   Odd Field 1

Reference White Level (+0.714V)
Black Level (+0.054V)
Blanking Level (+0V)
Sync Tip (-0.286V)

Frame 0   Frame 1

Blanking intervals

A video signal has both vertical and horizontal blanking intervals. The vertical blanking occurs between two consecutive fields, while the horizontal blanking interval occurs between two lines. During the blanking period, the video signal is "blanked" by bringing down the voltage to a level equal to or below the black level (e.g., 0 volts for RS-170A).

Vertical blanking

Occurring between two fields, the vertical blanking interval is made up of a front and back porch (see **Diagram 2**). Each porch consists of a series of pulses (equalization pulses). Between the porches is the sync portion of the blanking interval which, depending on the signal type, will either contain a series of pulses (serration pulses) or no pulse at all (block sync). Serration pulses3 are not used in conjunction with a frame grabber when a pixel clock is provided by the camera or frame grabber (see **Pixel Clock** section for more info).
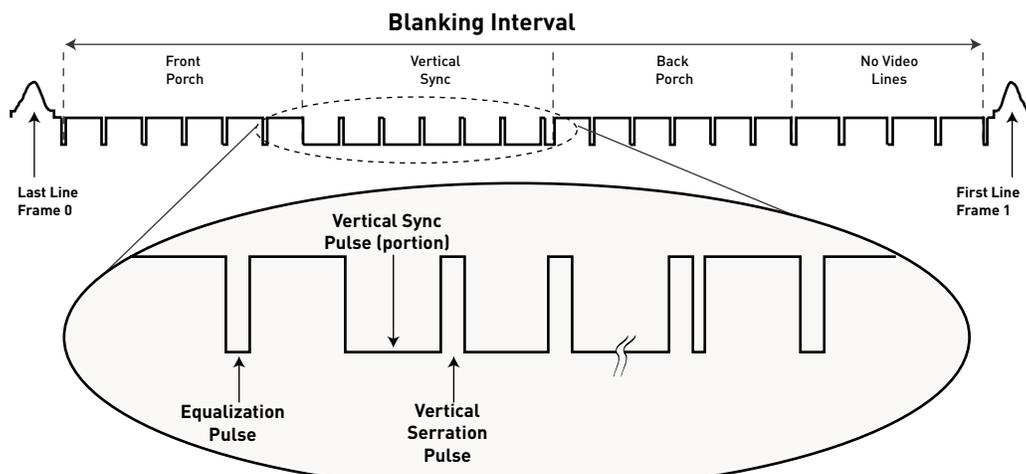
Horizontal blanking

The horizontal blanking interval occurs between two lines and consists of the front porch of the previous line, the horizontal sync (hsync) pulse and the back porch of the current line (see **Diagram 3**). DC restoring of the signal, called clamping, usually occurs during the back porch of the hsync interval, although in some cameras it may occur during the front porch or in the sync pulse.

Sync Pulses

Blanking intervals contain vertical sync (vsync) and horizontal sync (hsync) pulses. A vsync pulse separates the two frames/fields and indicates the top of the next frame/field. A hsync pulse separates each line of video and indicates the beginning of a new scan line. During this period, the RS-170A video signal drops below 0V to -0.286V (from the blanking level down to the sync tip). Individual lines and hsync pulse locations can be seen in **Diagram 4** for a RS-170A video signal.

Diagram 2: Vertical blanking of standard RS-170A video

Blanking Interval

Front Porch   Vertical Sync   Back Porch   No Video Lines

Last Line Frame 0   First Line Frame 1

Vertical Sync Pulse (portion)

Equalization Pulse   Vertical Serration Pulse

Video Basics

Horizontal
Sync (Line 2)

Front Porch
(Line 0)

Back Porch
(Line 2)

Reference
White Level (+0.714V)

Line 0

Line 2

Black Level (+0.054V)

Blanking Level (0V)

Sync Tip (-0.286V)

**Horizontal
Blanking
Interval**

horizontal sync pulses

Line 0   Line 2   Line 4   Line 6   Line 1   Line 3   Line 5   Line 7

Even Field

Odd Field

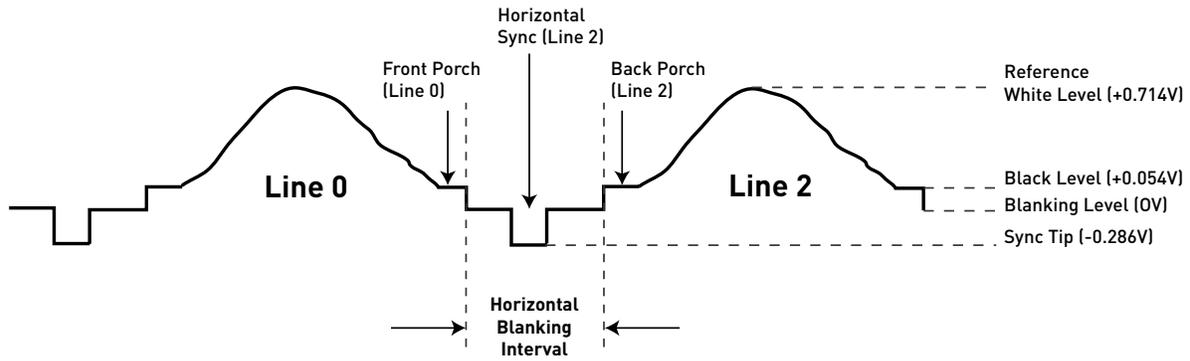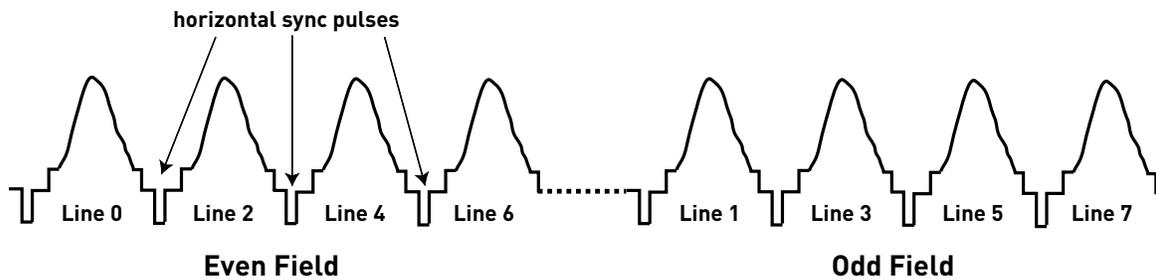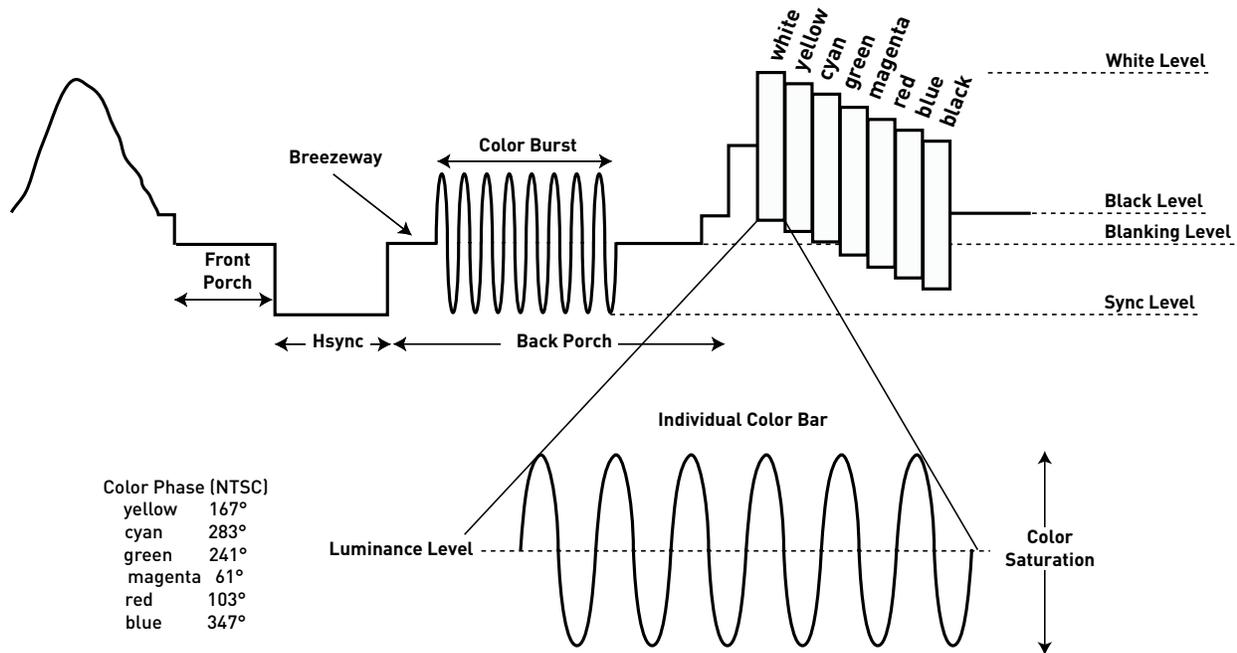### Color coding

Video timing for color standards is similar to that of monochrome standards, except that the color information must be included with the signal by way of color phase and subcarriers, as well as information on how to decode the color information (see Diagram 5).

Color phase, measured in degrees, is the timing relationship in a video signal that assures correct color hues. Color subcarrier is a clock used to run the color decoder (color burst). The subcarrier's amplitude represents the saturation of the color, while the phase angle represents hue of the color. The color burst informs the decoder how to decode the color information contained in the line of active video information that follows.

The color signal is also composed of horizontal and vertical blanking intervals, further made up of the front porch, the sync (horizontal and vertical) and the back porch. During horizontal blanking, the back porch is composed of a breezeway and the color burst. The breezeway is the portion of the video signal between the rising edge of the hsync and the start of the color burst.

Video Basics

Breezeway

Color Burst

White Level

Black Level

Blanking Level

Front Porch

Sync Level

Hsync

Back Porch

Individual Color Bar

Color Phase (NTSC)
yellow	167°
cyan	283°
green	241°
magenta	61°
red	103°
blue	347°

Luminance Level

Color Saturation

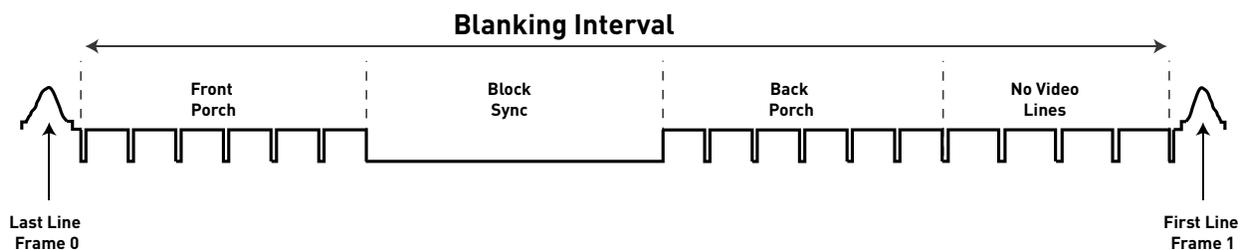white yellow cyan green magenta red blue black

RS-330, RS-343A & CCI analog video signals

RS-330 and RS-343A are monochrome video standards based on the RS-170 standard that have additional signal characteristics by way of modified timing waveforms and tighter tolerances. With the RS-330 standard, the output is a composite analog signal without serration pulses during the sync period, known as block sync4 (see **Diagram 6**). The RS-343A is for high-resolution video signals containing between 675 and 1023 lines per image frame.

The CCIR (Comité Consultatif International des Radio communications) video standard is used generally in European countries. This monochrome video standard is a 625-line system with a frame rate of 25 frames (50 fields) per second. CCIR is similar to RS-170A in that it has a 1 volt video signal amplitude, is 2:1 interlaced scan and has a standard sampling field or digitizing frequency providing a 4:3 aspect ratio. The CCIR timing for the sync signals is similar to the RS-170A, except for the absence of the pedestal (black and blanking levels are equal).

Blanking Interval

Front Porch

Block Sync

Back Porch

No Video Lines

Last Line Frame 0

First Line Frame 1

Video Basics

Video timing used for building DCFs

The respective widths of the sync pulse, back porch, active video period and front porch are known as the video timings of the camera. These timings are required when building a digitizer configuration file (DCF)5 using Matrox Intellicam camera interface software and can be read off of the timing diagrams in the camera manual. To be certain that you have a good understanding of the video characteristics (timings, etc.), complete the Video Specification Form found on our website (www.matrox.com/imaging). **Table 1** provides an example of timings used to build DCFs for RS-170A or CCIR video signals.

Pixel clock

A pixel clock is a timing signal used to divide the incoming line of video into pixels. The pixel clock is derived from either the camera or the frame grabber (refer to your camera manual to determine if the camera provides a pixel clock). It may be necessary to generate a pixel clock using the frame grabber's phase-locked loop (PLL). To generate a pixel clock, the PLL uses a reference signal. The reference signal can be either the frame grabber's on-board crystal oscillator or an external line sync (i.e., hsync) when periodic.

In some situations, a clock exchange will occur between the camera and the frame grabber. Initially the frame grabber will supply a pixel clock to the camera. The camera, in return, will generate a new pixel clock and return this pixel clock along with the video data to the frame grabber to insure that the incoming video data is in phase with the pixel clock used to digitize or sample this video data. A phase difference may result from internal delays created by digital circuitry in the camera.

Pixel jitter is the timing 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). As a result of pixel jitter, the incoming video data may be digitized late or early resulting in inaccurate pixel representation (see **Diagram 7**). Generating the pixel clock from the frame grabber's PLL based on a stable reference will lower the pixel jitter to a value that will produce results well within an accurate range.

Diagram 7: Pixel Jitter

P +x ns

P = Pixels

P

P -x ns

± Xns*

HSYNC

Pixel Clock
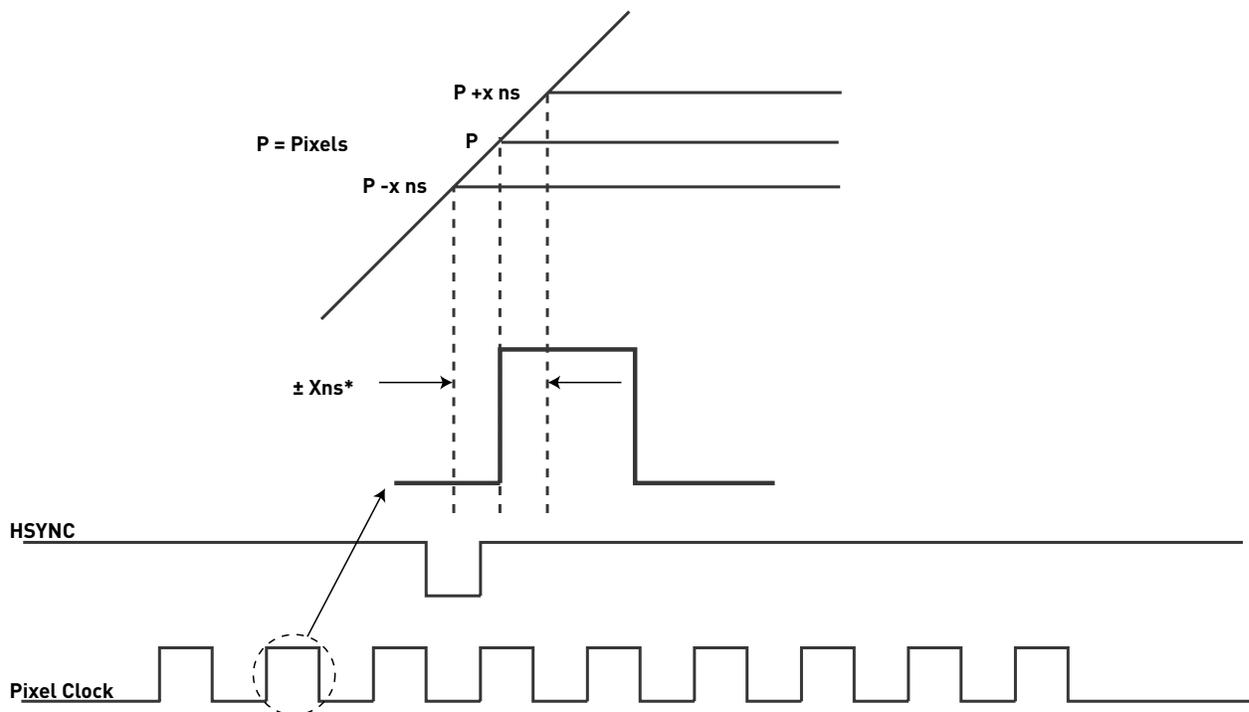
Video Basics

Table 1: RS-170A and CCIR Signal Characteristics

	RS-170A	CCIR	
# of raster lines/frame	525	625	Lines
# of raster lines/field	262.	312.5	Lines
V total displayed lines/frame	485	485	Lines
V total displayed lines/field	242.	242.5	Lines
V front porch/field	3.0	3.0	Lines
V sync/field	3.0	3.0	Lines
equalization pulse width	2.3±	2.3± 1	µs
V back porch/field	14	20	Lines
V blanking/field	20	25	Lines
line frequency	15.734	15.625	KHz
line duration	63.556	64.000	µs
line blanking	10.9 ± 0.2	12.00 ± 0.3	µs
front porch	1.5 ± 0.1	1.5 ± 0.3	µs
H sync pulse width	4.7 ± 0.1	4.7 ± 0.2	2 µs
back porch	4.7	5.8	µs
active horizontal	52.66	52	µs
nominal bandwidth	4.2	5.0, 5.5, 6.0	MHz
effective horizontal resolution	640	768	Pixels
output voltage	1.0	1.0	Vp-p
video voltage	0.7	0.7	Vp-p
sync voltage	0.3	0.3	Vp-p
impedance	75	75	ohm
pedestal	0.054	n/a	V

Non-Standard video

Non-standard video Analog progressive scan
With progressive scan video, also known as non-interlaced, the sensor reads out the entire frame (containing both even and odd components) at one time. The frame is not composed of separate fields as with standard analog video such as RS-170A.

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

Negative-going video
Negative-going video is an analog video signal where white or bright pixel data is represented by a more negative electrical value than a black or dark pixel. **Diagram 8** represents how negative-going video usually appears, however, other variations of negative-going video may exist.

Digital video
Digital video is a video signal where data-carrying-signals are restricted to either one of two voltages levels, corresponding to logic 1 or 0 (see **Diagram 9**). This type of representation of data is beneficial because it can be transmitted with a minimum of noise and distortion introduction. Each pixel in digital video is represented by a n-bit system (see **Diagram 10**), where a value between 0 and 2n represents the brightness value (e.g. , an 8-bit system will have a value between 0 and 255 to represent the brightness value of a pixel). Each additional captured bit provides more information about the pixel. For monochrome images, this means that as one increases the number of bits captured, higher shades of gray are reproduced resulting in a more accurate representation of the subject.
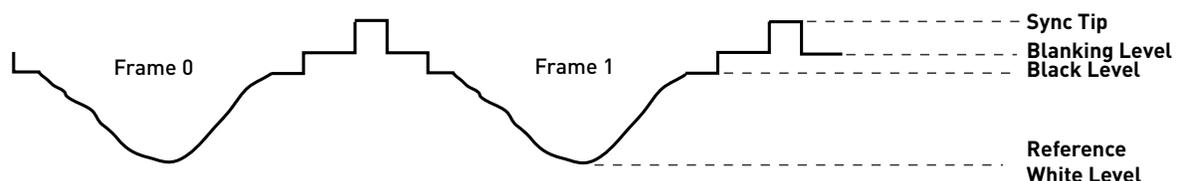
Digital video data is usually transmitted on a pixel-by-pixel basis in the form of several bits in parallel. Each bit is transmitted on an individual signal line (with TTL logic levels standard) or a pair of signal lines such as differential RS-422 or EIA -644 (LVDS) standards. Other digital formats include IEEE-1394 and Camera Link™.

TTL (Transistor-Transistor Logic) is a medium/high speed family of logic integrated circuits, while RS-422 is a medium range differential signaling pair standard. With RS-422, digital information can travel over a longer distance without the introduction of as much noise (random image information known as snow or flecks) as with a TTL signal line. EIA-644 (LVDS) is a short range standard with a high transmission speed, low noise and low power requirement.

IEEE-1394 digital serial link is a high speed, bi-directional communication for device control and video transfer. IEEE 1394 video, based on the Digital Camera (DCAM) Specification, provides video, control and camera power in a single cable design, as well as enough bandwidth to handle the video transfer demands at typical image resolutions and frame rates. IEEE-1394 provides support for two types of data transfer modes depending on the nature of the data. Asynchronous data transfer mode provides guaranteed delivery of control commands, while Isochronous data transfer mode provides guaranteed bandwidth for time-critical data such as live video.

Camera Link™ is based on National Semiconductor's Channel Link technology that combines traditional low-voltage differential signal (LVDS) with serial digital data flow. It offer high-speed data transfer rates of up to 2.38 Gbit/s with transmission speeds up to 85 MHz. Camera Link™ supports bi-directional communication for camera control and serial communication, as well as video data over cable lengths as long as 10 meters (32.8 feet).

Diagram 8: Negative-going Video

Frame 0   Frame 1

Sync Tip
Blanking Level
Black Level

Reference
White Level

Non-Standard video

Diagram 9: Equivalence between analog composite and digital video

Hsync

Front Porch   Back Porch

Line n   Line n+1

Analog
Composite
Video

Hsync (separate)

Pixel Data
(all bits*)

Digital
Video

Diagram 10: 8-bit digital video

Line Valid

Bit 0

Bit 1

Bit 2

Bit 3

Bit 4

Bit 5

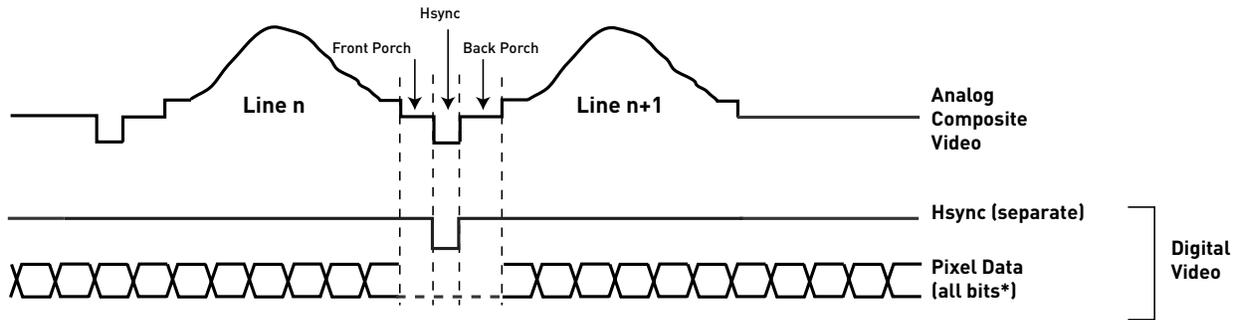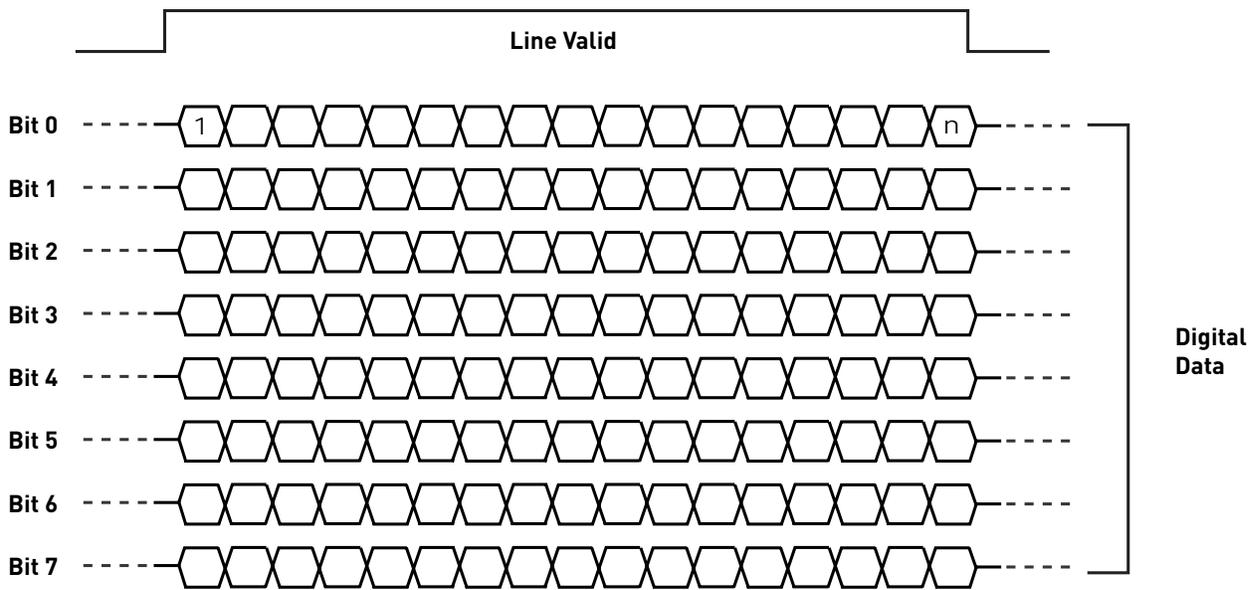Bit 6

Bit 7

Digital
Data

Modes of operation

Typically cameras can be operated in one of several different modes. For area scan cameras, modes include continuous, pseudo-continuous, trigger, asynchronous reset, control and long exposure (integration). Line scan cameras may be operated in fixed line scan rate, variable line scan rate mode, and line scan rate and variable frame size mode. The connections mentioned in the discussion of modes are general. Some cameras may require additional connections for signals such as auxiliary control, external trigger, etc. All required connections should be specified in the camera manual. The use of "internal" in this discussion refers to the camera's end and "external" refers to the board's end. Horizontal sync and vertical sync is referred to as hsync and vsync respectively. Bi-directional signals represent those that can be supplied by either the frame grabber or the camera. Terminology varies from one manufacturer to another, so the definitions found here are as Matrox Imaging uses them.
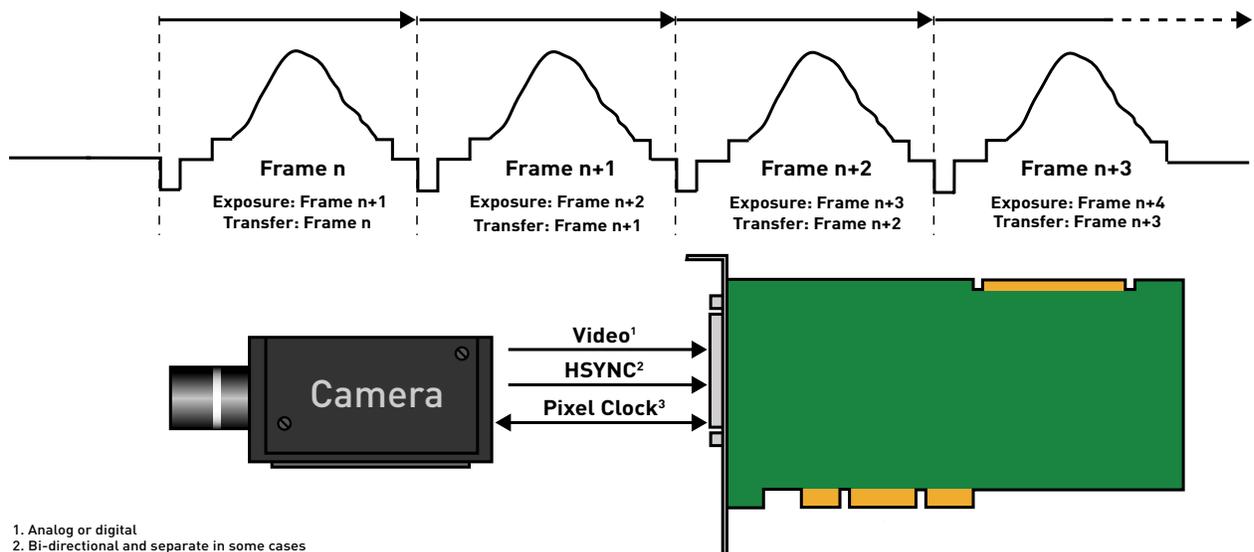
Area Scan Modes

1. Continuous (Diagram 11)

The camera continuously outputs images at a fixed frame rate, usually 30 frames (60 fields) per second or 25 frames (50 fields) per second being North American and European timings respectively. In general, the exposure time is the reciprocal of the frame rate. If supported by the camera, it may also be possible to decrease the exposure period. The frame rate, however, is fixed and cannot be changed. Exposure of the current frame and transfer of the previous frame occur concurrently in continuous mode. Therefore, exposure time in this mode cannot exceed the reciprocal of the frame rate (i.e., frame transfer time.

If the output of the camera is an analog video signal, where both the hsync and the vsync are combined with video data to form a composite video signal, then that signal alone is required by the frame grabber for operation in continuous mode. While not typical, some cameras may output an analog video signal where only the hsync is composite. In this case, a separate digital vsync signal (e.g., a frame enable or a trigger signal) is required and supplied by the camera to the frame grabber or vice-versa. Separate digital syncs may also be used when the output of the camera is a fully composite analog signal. The analog syncs included in the video signal are simply ignored.

If the output of the camera is a digital video signal, both the hsync and the vsync are usually separate digital signals provided by the camera or frame grabber. Some cameras combine the hsync and the vsync into a single digital composite sync. Finally, a pixel clock may 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 previous section, Pixel Clock).

Diagram 11: Continuous mode

Frame n	Frame n+1	Frame n+2	Frame n+3
Exposure: Frame n+1	Exposure: Frame n+2	Exposure: Frame n+3	Exposure: Frame n+4
Transfer: Frame n	Transfer: Frame n+1	Transfer: Frame n+2	Transfer: Frame n+3

Camera

Video[1]

HSYNC[2]

Pixel Clock[3]

1. Analog or digital
2. Bi-directional and separate in some cases
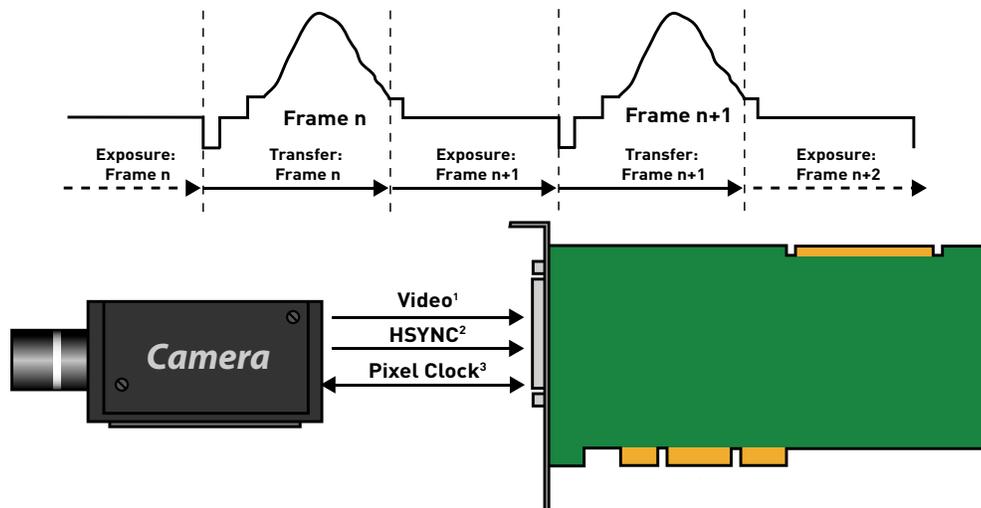3. Internal or external pixel clock

Area Scan Modes

2. Pseudo-continuous (Diagram 12)

The camera continuously outputs images at a frame rate that is determined by the exposure time and the frame transfer time. The frame rate is usually less than 30 frames (60 fields) or 25 frames (50 fields) per second for North American and European formats respectively. The exposure time may be selected by adjusting the camera, however, the frame transfer time is fixed and is characteristic of the camera. Exposure and transfer of a frame occurs sequentially (see diagram 12). Exposure of a new frame only starts once the previous frame has been fully transferred, therefore, 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. Unlike continuous mode, the exposure time can be much longer than the frame transfer time. The signals involved in this mode are the video output (analog or digital) and syncs. As with continuous mode, these signals may be combined with video data (composite) or separate digital syncs can be used.

Diagram 12: Pseudo-continuous mode

Frame n Frame n+1

Exposure: Frame n | Transfer: Frame n | Exposure: Frame n+1 | Transfer: Frame n+1 | Exposure: Frame n+2

Camera

Video[1]
HSYNC[2]
Pixel Clock[3]

1. Analog or digital
2. Bi-directional and separate in some cases
3. Internal or external pixel clock

3. Trigger (Diagram 13)

The camera continuously outputs images at a fixed frame rate as in continuous mode, however an external trigger signal is provided to the frame grabber. The external trigger signal causes the frame grabber to grab on the next vsync of the video signal, thereby acquiring the next frame. Any additional external trigger signals will be ignored until the current frame period is over.

To ensure the capture of an image, the shortest time between external trigger signals should 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 syncs are provided

to the frame grabber. The trigger mode is used to capture a single image or a sequence of images. In general, exposure time details are similar to those described in Continuous mode.

4. Asynchronous reset (Diagram 14)

Either an external trigger signal is provided to the frame grabber or the frame grabber has an internal trigger which can be periodic or aperiodic (software controlled). The frame grabber in turn triggers the asynchronously resettable camera to initiate exposure.

Area Scan Modes

4. Asynchronous reset (continued)

The trigger signal from the frame grabber to the camera is referred to as the exposure signal and is controlled through the DCF file in Matrox Intellicam. The camera is resynchronized on the arrival of the exposure signal. The delay from the time the frame grabber is triggered to the time it starts exposing is programmable.
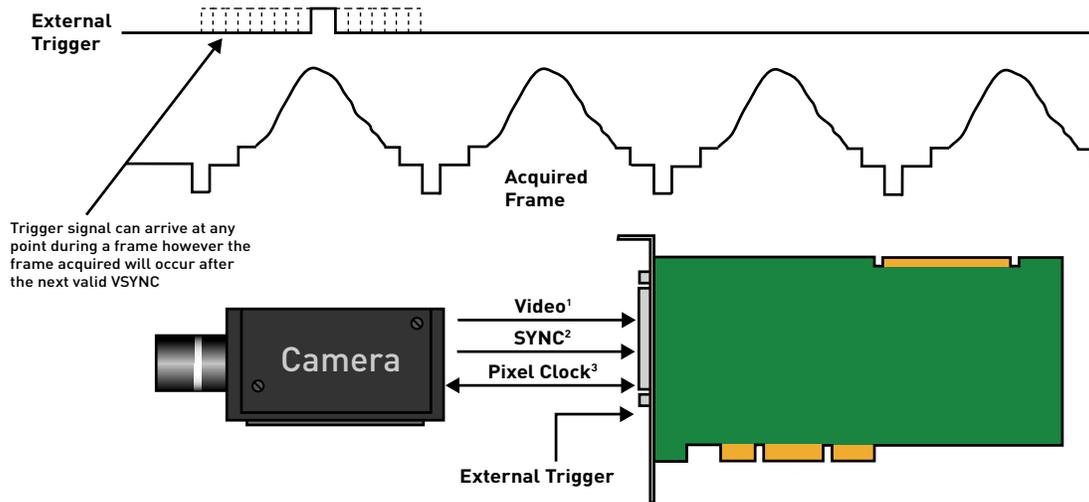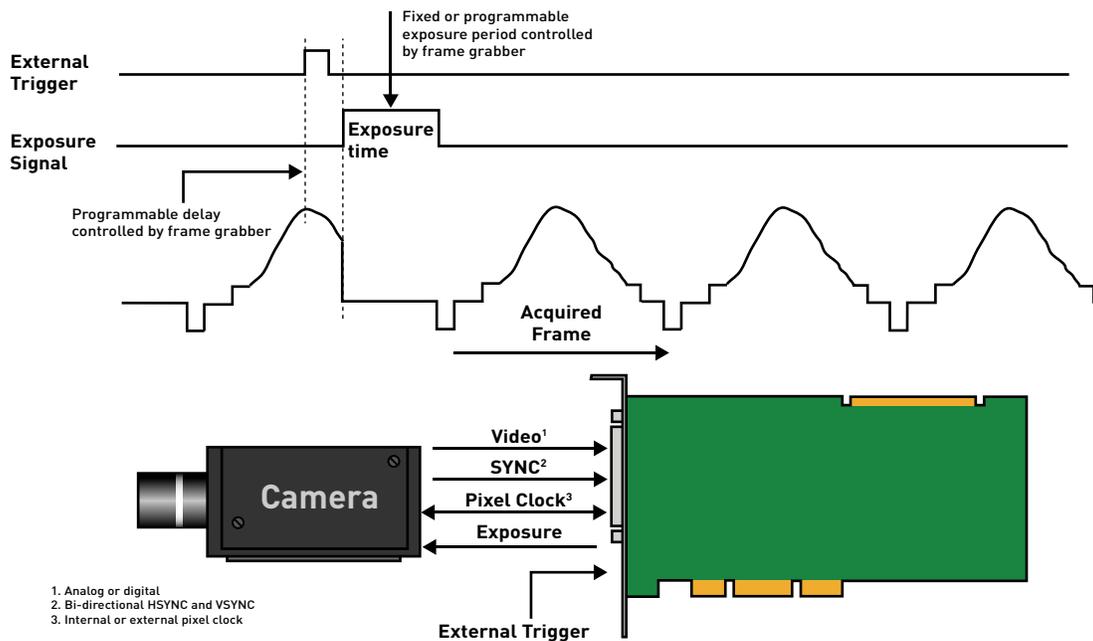
Diagram 13: Trigger mode

External Trigger

Trigger signal can arrive at any point during a frame however the frame acquired will occur after the next valid VSYNC

Acquired Frame

Camera

Video[1]

SYNC[2]

Pixel Clock[3]

External Trigger

Diagram 14: Asynchronous reset mode

Fixed or programmable exposure period controlled by frame grabber

External Trigger

Exposure Signal

Exposure time

Programmable delay controlled by frame grabber

Acquired Frame

Camera

Video[1]

SYNC[2]

Pixel Clock[3]

Exposure

1. Analog or digital
2. Bi-directional HSYNC and VSYNC
3. Internal or external pixel clock

External Trigger

Area Scan Modes

4. Asynchronous reset (continued)
There are three versions of the asynchronous reset mode utilized by cameras; vertically asynchronously resettable, vertically and horizontally asynchronously resettable and fully asynchronously resettable. A camera can be identified as:

- vertically asynchronously resettable when only the vertical timings are reset on the exposure pulse;

- vertically and horizontally asynchronously resettable if both the vertical timings and the horizontal timings are reset on the exposure pulse;

- and fully asynchronously resettable when the vsync, the hsync and the pixel clock are reset on the exposure signal.

Examine the timing diagrams that are found in the camera manual to determine which of the three cases corresponds to the asynchronous reset mode of your particular camera.

In this mode, the exposure time is controlled by way of the camera or the frame grabber. Some cameras will ignore an exposure signal that arrives before the current frame period is over, while others will resynchronize on this new signal, discarding all current video information. Generally, the shortest time between external trigger signals should be greater than the sum of the exposure signal width, the exposure time and the frame transfer time to avoid loss of information. The signals utilized in this 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 syncs.

5. Control (Diagram 15)
The exposure time is controlled externally, by way of the frame grabber. In most cases, the camera is triggered by an asynchronous reset signal, which is initiated by an external trigger source by way of the frame grabber. The asynchronous reset signal is referred to as the exposure signal. The delay from the time the camera is triggered to the time it starts exposing is programmable. The delay between exposure and frame transfer is fixed and is a characteristic of the camera.

In this mode, the camera is resynchronized on the exposure signal. The width of the exposure signal determines the exposure time and is controlled in the DCF file through Matrox Intellicam. Some cameras will ignore an exposure signal that arrives before the current frame period is over, while others will resynchronize on this new signal and discards all current information. To avoid loss of information, the shortest time between external trigger signals should be greater than the

sum of the exposure signal width and the frame transfer time. The signals utilized in this mode are an external trigger signal provided to the frame grabber, an exposure signal supplied by the frame grabber to the camera, the video output (analog or digital) and syncs. Control mode is employed for user control over the start and exposure time of an image.

5. Long exposure or integration (Diagram 16)
The exposure time can be controlled by the camera or the frame grabber. In this mode, an external trigger signal is provided to the frame grabber, which in turn triggers the camera. The trigger signal from the frame grabber to the camera is referred as the exposure signal and is controlled in the DCF file through Matrox Intellicam.

With most cameras the exposure signal is latched on the horizontal sync and is used to initiate frame transfer on the video's next vertical sync. The exposure time is generally specified in terms of an integer number 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; one field time is half of a frame time. This mode can be used when an exposure time greater than one frame time is desired. Most cameras will ignore the end of an exposure signal that arrives before the current frame period is over, while others will latch onto the signal and initiate the next exposure immediately afterward.

To ensure the capture of an image:

- if the exposure is controlled by the camera, the shortest time between external trigger signals should be greater than the sum of the exposure signal width, the exposure time and the frame transfer time;

- if the exposure is controlled by the frame grabber, the shortest time between external trigger signals should be greater than the sum of the exposure signal width and the frame transfer time.

The width of the exposure signal determines the exposure time and is adjusted in the DCF file through Matrox Intellicam. 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, the video output (analog or digital) and syncs.
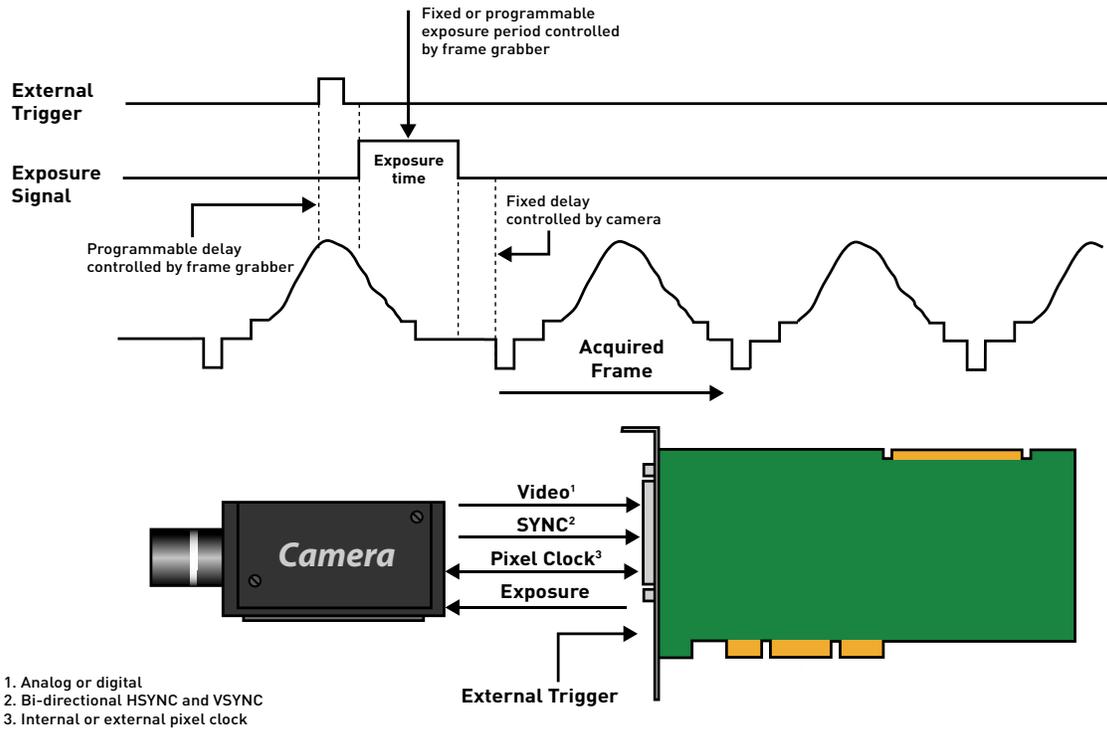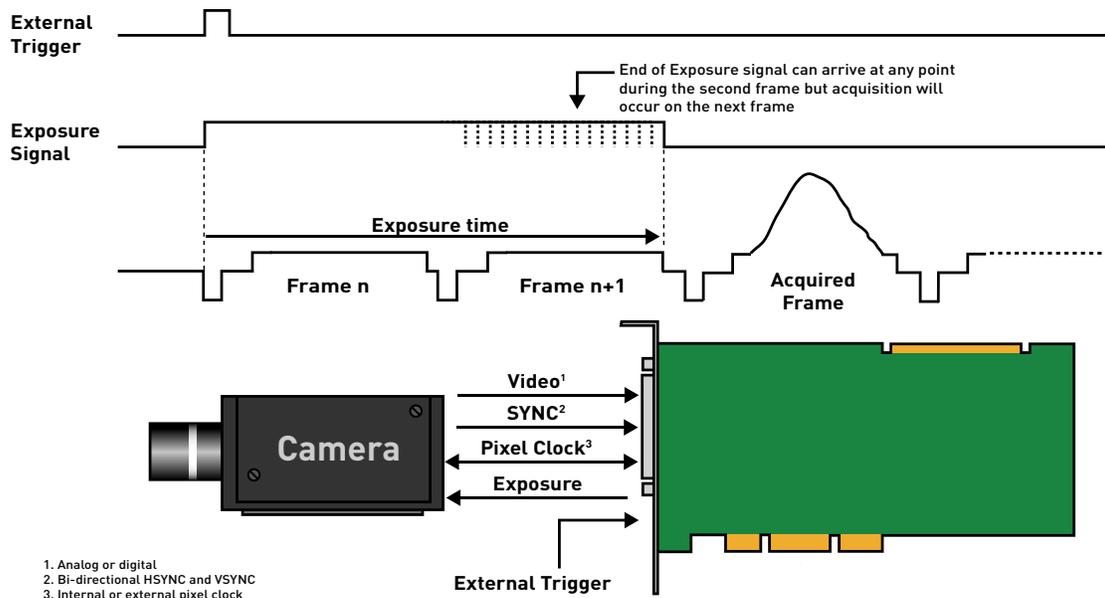
Area Scan Modes

Diagram 15: Control mode

Fixed or programmable
exposure period controlled
by frame grabber

**External
Trigger**

**Exposure
Signal**

**Exposure
time**

Fixed delay
controlled by camera

Programmable delay
controlled by frame grabber

**Acquired
Frame**

Camera

Video[1]
SYNC[2]
Pixel Clock[3]
Exposure

External Trigger

1. Analog or digital
2. Bi-directional HSYNC and VSYNC
3. Internal or external pixel clock

Diagram 16: Long exposure or integration mode

**External
Trigger**

End of Exposure signal can arrive at any point
during the second frame but acquisition will
occur on the next frame

**Exposure
Signal**

Exposure time

Frame n   **Frame n+1**

**Acquired
Frame**

Camera

Video[1]
SYNC[2]
Pixel Clock[3]
Exposure

External Trigger

1. Analog or digital
2. Bi-directional HSYNC and VSYNC
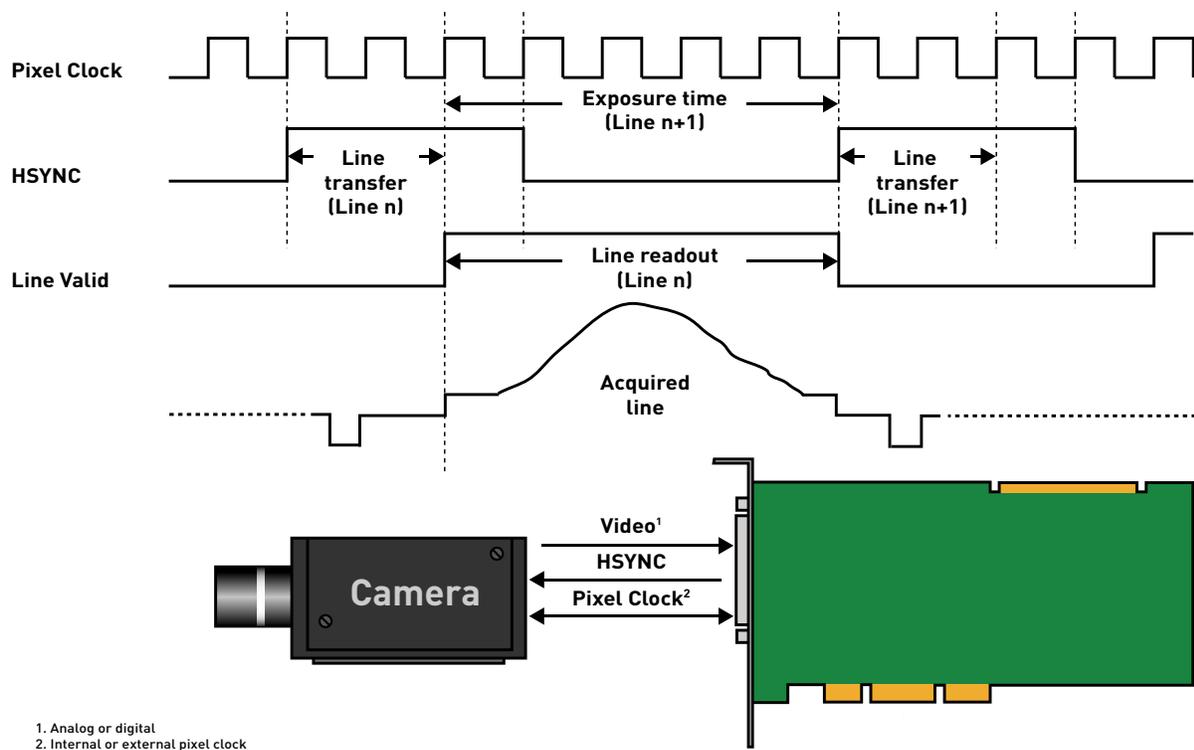3. Internal or external pixel clock

Line Scan Camera Modes

1. Fixed (Continuous) line scan rate (Diagram 17)
An hsync signal is supplied to the line scan camera by the frame grabber with a frequency that determines the line scan rate. The line transfer period is initiated upon the rising edge of the hsync and is followed by the line readout period. Unless the camera features exposure control, the exposure time is the reciprocal of or inversely proportional to the line scan rate.

A pixel clock is usually supplied to the camera by the frame grabber. There are some cameras that return an additional clock (strobe) that is derived from the first clock. This clock is used as the real pixel clock and are known as a clock exchange. The signals utilized in this mode are a pixel clock, hsync, a returned strobe signal (with some cameras) and video output (analog or digital).

Diagram 17: Fixed (Continuous) lines scan rate mode

Pixel Clock

Exposure time
(Line n+1)

HSYNC

Line transfer
(Line n)

Line transfer
(Line n+1)

Line Valid

Line readout
(Line n)

Acquired line

Video[1]

HSYNC

Camera

Pixel Clock[2]

1. Analog or digital
2. Internal or external pixel clock

2. Variable line scan rate (Diagram 18)
An external trigger signal is provided to the frame grabber, which in turn triggers the camera to initiate line readout. The trigger from the frame grabber to the camera is called an exposure signal. The frequency of the external trigger signal determines the line scan rate and it must be greater than the exposure time and the line transfer time.

- With external exposure control, the length of the exposure signal will specify the exposure time.
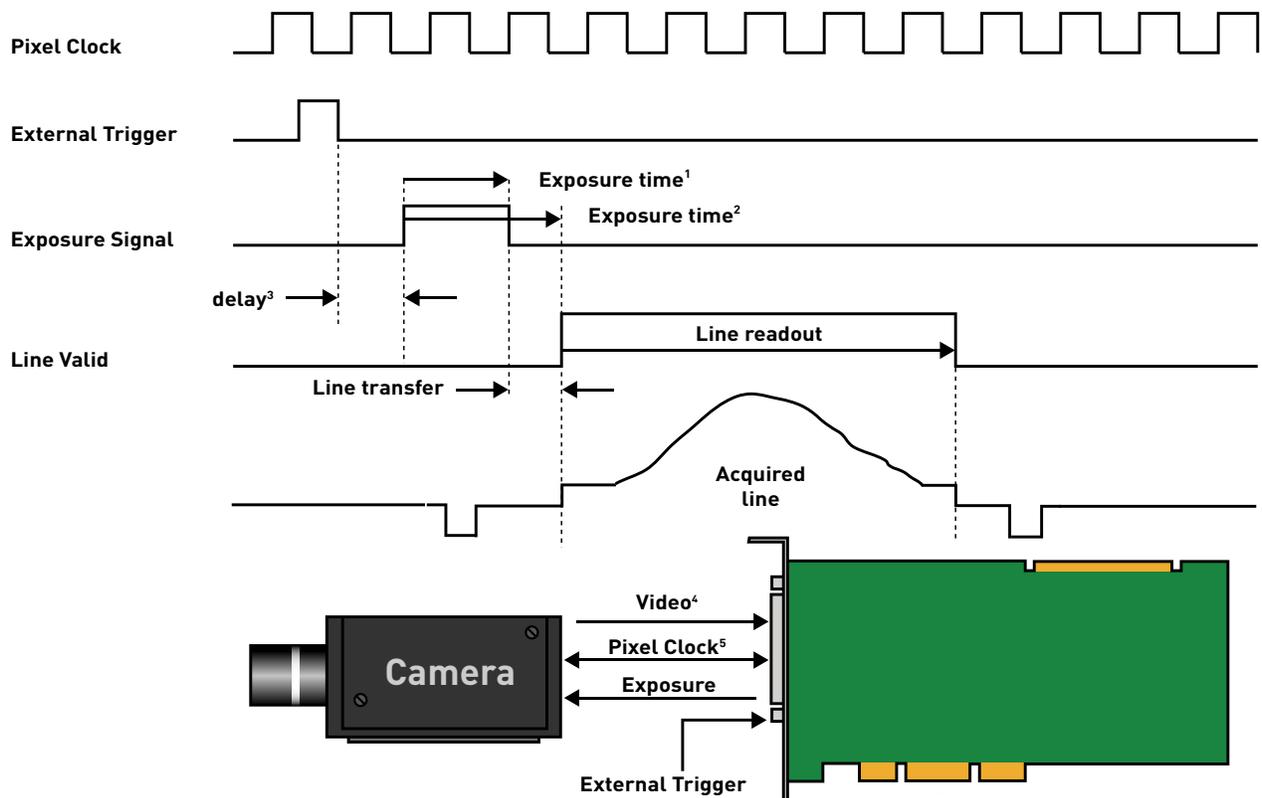
- With internal exposure control, exposure time is set on the camera (through switches or control bits) and is specified by the exposure signal period plus line transfer delay.

- With no exposure control, the exposure time will be equal to the reciprocal of the line rate. If the line rate varies over time, the exposure time will also vary causing intensity variations over time.

Line Scan Camera Modes

A pixel clock is usually supplied to the camera by the frame grabber. Certain cameras return an additional clock (strobe) to the frame grabber for use as the real pixel clock (clock exchange), which is derived from the pixel clock generated by the frame grabber. The signals utilized in this mode are an external trigger signal provided to the frame grabber, a pixel clock and exposure signal both supplied by the frame grabber to the camera, a returned strobe signal (in some cameras), and a video output (analog or digital). The camera can also return a line valid signal.

Diagram 18: Variable line scan rate mode

Pixel Clock

External Trigger

Exposure time[1]

Exposure time[2]

Exposure Signal

delay[3]

Line readout

Line Valid

Line transfer

Acquired line

Video[4]

Pixel Clock[5]

Camera

Exposure

External Trigger

1. With external exposure control
2. With internal exposure control
3. Programmable delay controlled by frame grabber
4. Analog or digital
5. Internal or external pixel clock

Line Scan Camera Modes

3. Line scan rate and variable frame size (Diagram 19)
Two external trigger signals (line and frame) are provided to the frame grabber, which in turn triggers the camera to initiate line and frame (virtual) readout. The trigger from the frame grabber to the camera is called the exposure signal. The line trigger is continuous with a variable rate. The line trigger provided to the frame grabber in turn triggers the camera to initiate the line readout. At the arrival of the frame trigger, which may also may be variable, a specified number of lines are captured to create a virtual frame.

A pixel clock is usually supplied to the camera by the frame grabber. The signals utilized in this mode (see Diagram 19) are external line and frame trigger signals provided to the frame grabber, a pixel clock and exposure signal both supplied by the frame grabber to the camera, a returned strobe signal (in some cameras), and a video output (analog or digital).

Diagram 19: Line scan rate and variable frame size mode

1. Analog or digital
2. Internal or external pixel clock
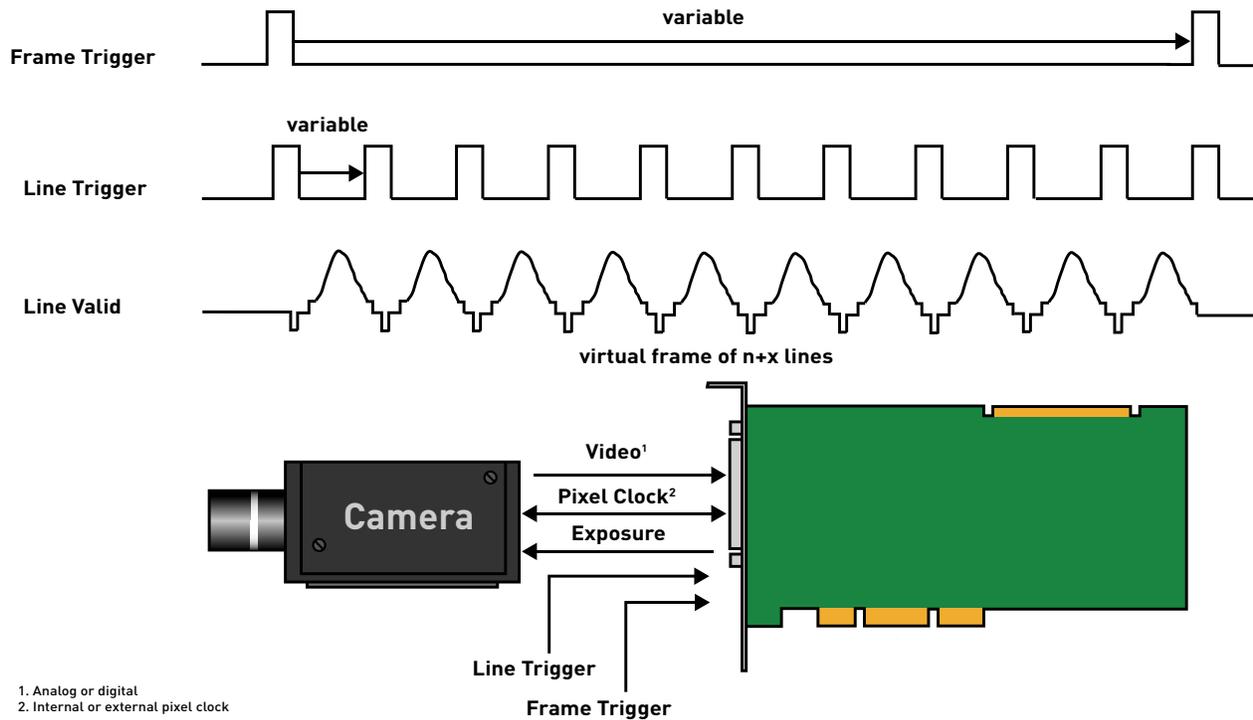
Endnotes

1. Matrox provides predefined DCFs for RS-170, CCIR, and many non-standard formats, which can be used as is or modified to meet specific requirements.

2. YIQ is the color space used in the NTSC color system, where the Y component is the black and white portion of the image; and the I and Q parts are the color components. With YUV (used by the PAL color system) the Y component is the black and white portion of the image; and the U and V parts are the color components.

3. These pulses were used to ensure correct 2:1 interlacing in earlier television video signals.

4. This characteristic of RS-330 video can prevent a frame grabber from locking onto a video source. Consult with Matrox to see if your camera is compatible with our frame grabbers.

5. Matrox provides predefined DCFs for RS-170, CCIR, and many non-standard formats, which can be used as is or modified to meet specific requirements.

Mode Reference

	Camara	Connections
Area Scan Cameras	**1. Continuous** – continuous video – internal exposure control – exposure time cannot exceed frame transfer time – fixed frame rate is independent of exposure time	– video and sync signals between camera and frame grabber (syncs can be provided from frame grabber)
	2. Pseudo-continuous – Pseudo-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 sync signals between camera and frame grabber
	3. Trigger – internal exposure control – external trigger – video and sync signals connected between camera and frame grabber – external trigger signal connected to frame grabber	– video and sync signals connected between camera and frame grabber – external trigger signal connected to frame grabber
	4. Asynchronous reset – internal or external exposure control – internal or external trigger	– video, sync and exposure (frame grabber acting has asynchronous reset) – signals connected between camera and frame grabber – external trigger signal connected to frame grabber
	5. Control – external exposure control – external trigger	– video, sync and exposure (frame grabber acting has asynchronous reset plus actual exposure) signals connected between camera and frame grabber – external trigger signal connected to frame grabber
	6. Long exposure or integration – internal or external exposure control – exposure times longer than one frame – external trigger	– video, sync and exposure (trigger) signals connected between camera and frame grabber – external trigger signal connected to frame grabber
	Camara	**Connections**
Line Scan Cameras	**1. Fixed (Continuous) line scan rate** – line scan rate determined by frequency of horizontal sync signal – internal exposure control	– video and sync signals between camera and frame grabber (sync can be provided from frame grabber)
	2. Variable line scan rate – line scan rate determined by time between external trigger pulses – internal or external exposure time control	– video, sync and exposure (trigger) signals connected between camera and frame grabber – external trigger signal connected to frame grabber
	3. Line scan rate and variable frame size – external line and frame triggers – line scan rate determined by time between external trigger pulses – internal or external exposure time control	– video, sync and exposure (trigger) signals connected between camera and frame grabber – external line and frame trigger signal connected to frame grabber

NOTE: The use of INTERNAL refers to the camera's end and EXTERNAL to the frame grabber's end.

For more information, please call: 1-800-804-6243 (toll free in North America) or (514) 822-6020
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