TECHNICAL MANUAL FOR DVC-1310A & DVC-1312 CAMERAS

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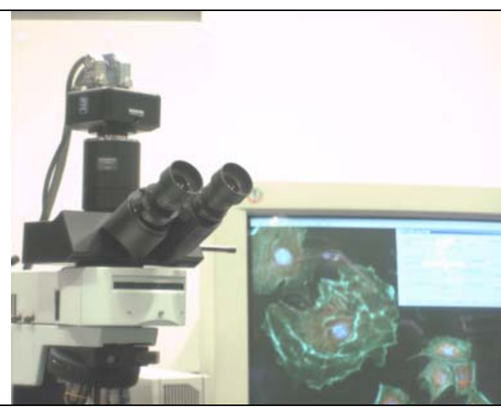

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1 INTRODUCTION

DVC Company, based in Austin, Texas, is a manufacturer of cost-effective, high performance video cameras. We thank you for purchasing from the DVC-1312 series of mega-pixel digital video cameras.

This series of cameras is based on the premise that precise image processing applications demand mega-pixel cameras that are optimized for the performance available from today's leading edge CCDs, while maintaining an acceptable price to performance ratio.

The 2/3" interline Sony ICX085 CCD imager used in the DVC-1312 cameras has a 1300(H) X 1030(V) progressively scanned image format and has a pixel size of 6.7µm X 6.7µm. The CCD sensor has a particularly high QE in the Blue-Green region of the spectrum resulting in higher sensitivity for most applications.

We manufacture a range of cameras based on the Sony ICX085 CCD imager, which includes a non cooled camera, a cooled camera, and an intensifier version. A choice of I/O cards is available: LVDS and FireWire.

Models available within this series include the DVC-1312M (monochrome) and the DVC-1312C (RGB color) cameras. This camera series also includes Intensicam, which utilizes a gated, Gen III image intensifier, fiber-optically coupled to the CCD. High-speed shuttering, long-term integration, pulse driven integration, and gain/offset control are standard features. Optional features include cooling to -20°C and removal of the sensor faceplate for UV applications. All DVC cameras come with a standard 2-year warranty and use industry-standard "C-mount" lenses.

With the LVDS version, the 12 frames/sec video data is provided in a 12 bit parallel, differential LVDS format, which is "plug-and-play" compatible with industry-standard image processors. The digital data, pixel clock, enable line, and enable frame are accessible via the DB-44 connector.

In the FireWire version of the camera, the LVDS output is replaced by an industry standard 1394A connector. The camera provides 12-bit data at 11 frames/s when used with any OHCI compliant FireWire interface card.

Computer-based control of gain offset is provided to "tune" the dynamic range of the camera to the application. This provides an optimum match between the dynamic range and sensitivity of the camera and the requirements of the application.

The CCD is physically mounted in the cavity of a high-precision opto-mechanical plate to eliminate the stability problems that are caused by using poorly mounted CCDs in vibration applications. The highly stable optical mount utilizes an adjustable C-mount coupling to provide critical system focusing adjustments. In-camera digitization using the CCD pixel clock eliminates pixel jitter, improves repeatability and brings sub-pixel accuracy to image processing applications.

CView™, a Windows GUI software package is supplied with the camera, allowing image viewing and control of all camera operations. Five user programmable, single-click software "buttons" allow the user to customize the camera to the imaging application.

This manual applies to all models of the DVC-1312 cameras.

2 INITIAL INSPECTION

2.1 UNPACKING AND RECEIVING

These items were thoroughly tested and carefully packed in the factory. Upon acceptance by the carrier, they assume responsibility for its safe arrival. Should you receive this item in a damaged condition, apparent or concealed, a claim for damage must be made to the carrier. To return the product to the factory for service, please contact the DVC Customer Service Department at (512)-301-9564 for a Return Material Authorization (RMA) Number.

If visual inspection shows damage upon receipt of this shipment, it must be noted on the freight bill or express receipt, and the notation signed by the carrier's agent. Failure to do this can result in the carrier refusing to honor the claim.

When the damage is not apparent until the unit is unpacked, a claim for concealed damage must be made. Make a mail or phone request to the carrier for inspection immediately upon discovery of the concealed damage. Keep all cartons and packing materials. Since shipping damage is the carrier's responsibility, the carrier will furnish you with an inspection report and the necessary forms for filing the concealed-damage claim.

2.2 EQUIPMENT SUPPLIED (LVDS system)

Figure 2.2-1: DVC-1312 Camera and adjustment wrench

Figure 2.2-2: Linear regulated power supply

Figure 2.2-3: PixeLYNX board

Figure 2.2-4:US version of line cord with IEC320 receptacle

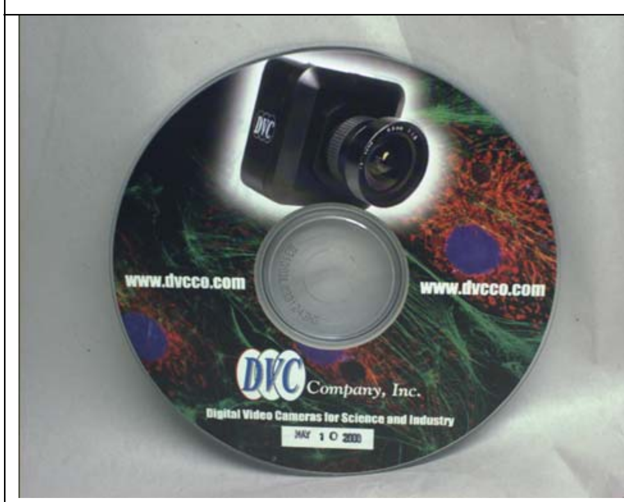


Figure 2.2-5: DVC distribution CD-ROM

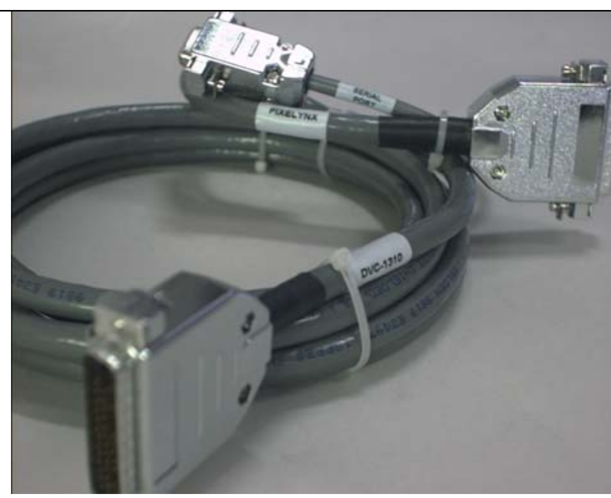


Figure 2.2-6: 10ft. interface cable, with 18" RS232 pigtail

2.3 EQUIPMENT SUPPLIED (Firewire system)

Figure 2.3-1: DVC-1312 Camera and adjustment wrench

Figure 2.3-2: Linear regulated power supply

Figure 2.3-3: Firewire cable

Figure 2.3-4:US version of line cord with IEC320 receptacle

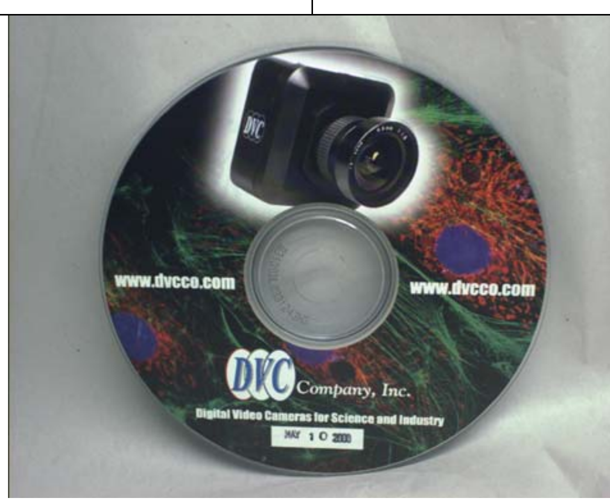


Figure 2.3-5: DVC distribution CD-ROM

2.4 OPTIONAL ITEMS

The following items are optional items and may be ordered from authorized dealers of DVC. They are not typically supplied with each Camera.

1. Lenses and/or other optical elements
2. Third party Image Analysis software, e.g. ImagePro, Adobe Photoshop®

3 MAINTENANCE

CAUTION: Only technicians familiar with video circuits and digital camera maintenance should attempt procedures in this section of the manual. This Camera contains sensitive devices that can be damaged by static discharge. Use appropriate static control methods when working inside the Camera or at connector pins when cable plugs are removed.
There are no user serviceable parts inside the camera, and, in most cases there should not be any need to open the camera.

3.1 LENS AND SENSOR FACEPLATE CLEANING

The glass faceplate of the CCD image sensor can be cleaned by wiping the surface gently with a cotton swab soaked in methyl alcohol. Never rub with a dry swab. Please note that the sensor faceplate is in the focal plane of the Camera. Any contaminants on this surface will show up in the picture. Dry pressurized air can be helpful in removing these contaminants.

3.2 CLEANING AND LUBRICATION

Carefully clean the exposed optical surfaces of the lens, and the window filter in front of the faceplate of the sensor periodically to remove accumulated dust and film.

3.2.1 When should I clean the CCD imager in my camera?

Clean the CCD imager only when absolutely necessary, to avoid damaging the delicate CCD surface. Although cleaning the CCD imager is fairly simple, you should not do so unless the dirt or debris is a noticeable problem in the image file. Any time the sensor and other delicate mechanisms are exposed to tools, they are at risk of being damaged. Use all practical safety precautions, common sense, and only the tested and approved cleaning supplies listed in this bulletin.

3.2.2 What causes the CCD imager to get dirty?

Dust and dirt are the culprits. At DVC, professional cameras are manufactured under strict conditions and assembled in a dust-free room. Before shipping, each camera is tested and checked to assure that it meets stringent specifications for cleanliness and quality. Although we take extreme care to produce a dust-free camera, changing lenses, or static can cause debris to appear on the imager.

3.2.3 What must I do before cleaning the CCD imager?

One of the first steps in the cleaning procedure is the removal of the IR filter from the camera. Use the adjustment wrench to turn the 1” format C-mount lens adaptor counter-clockwise. Then remove the lens adaptor, which will cause the attached lens to be removed, thereby exposing the IR filter.

3.2.4 How should the CCD Imager be cleaned?

1. Moisten a lint-free cotton swab with clean isopropyl alcohol. The swab should be completely moist, but not dripping. **Important:** Isopropyl alcohol is flammable and evaporates quickly. It acts as a solvent and lubricant to remove contaminants from the surface. Be sure to have your camera ready with the CCD exposed before you moisten the swab.
2. Remove a cleaner from the protective plastic sleeve. Do NOT allow the swab to come in contact with any surface that might contain dust, dirt, or other contaminants.
3. Carefully draw the **once** across the surface of the CCD glass with light, consistent pressure. Rotate the swab 180° and draw it across the CCD surface again.
If pooling or streaks occur, you may have too much alcohol on the swab.

4. Examine the CCD surface in a strong light. Take an out-of-focus picture of a flat, illuminated surface to see if any dirt or dust remains. If dust or dirt particles are present, they appear as a soft shadow or dark blemish in the image.
5. If dust spots remain, repeat this procedure using a clean moistened swab.

3.3 CAMERA POWER SUPPLY

DVC provides a power supply for use with the DVC-1312 camera. The electrical and optical specification of the camera are guaranteed only when used with DVC supplied accessories.
NOTE: The power supply is connected to line voltage. It is encapsulated for the safety of the operator. There are no user-serviceable parts inside the power supply, and it should not be opened since there are dangerously high voltages within.

3.4 INTERNATIONAL APPLICATIONS

Figure 3.4-1: Bottom view of power supply showing voltage selection switch (115V)

Figure 3.4-2: Bottom view of power supply showing voltage selection switch (220V)

Figure 3.4-3: IEC line cord with Euro-style plug

Figure 3.4-4: IEC line cord with UK-style plug

4 CAMERA SPECIFICATIONS

4.1 OPTICAL

Sensitivity @ 2850°K (measured with IR filter)	Color: 0.08fc for full-scale (min. gain); 0.005fc for full-scale (max. gain); 0.001fc for full-scale with 10-sec exposure Monochrome: 0.05fc for full-scale (min. gain); 0.003fc for full-scale (max. gain); 0.0007fc for full-scale with 10-sec exposure
Pixel size and format	6.7µm(H)X 6.7µm(V); interline format; Bayer CFA pattern used for color camera
Spectral Response	See Figures 3.1-1, 3.1-2, 3.1-3

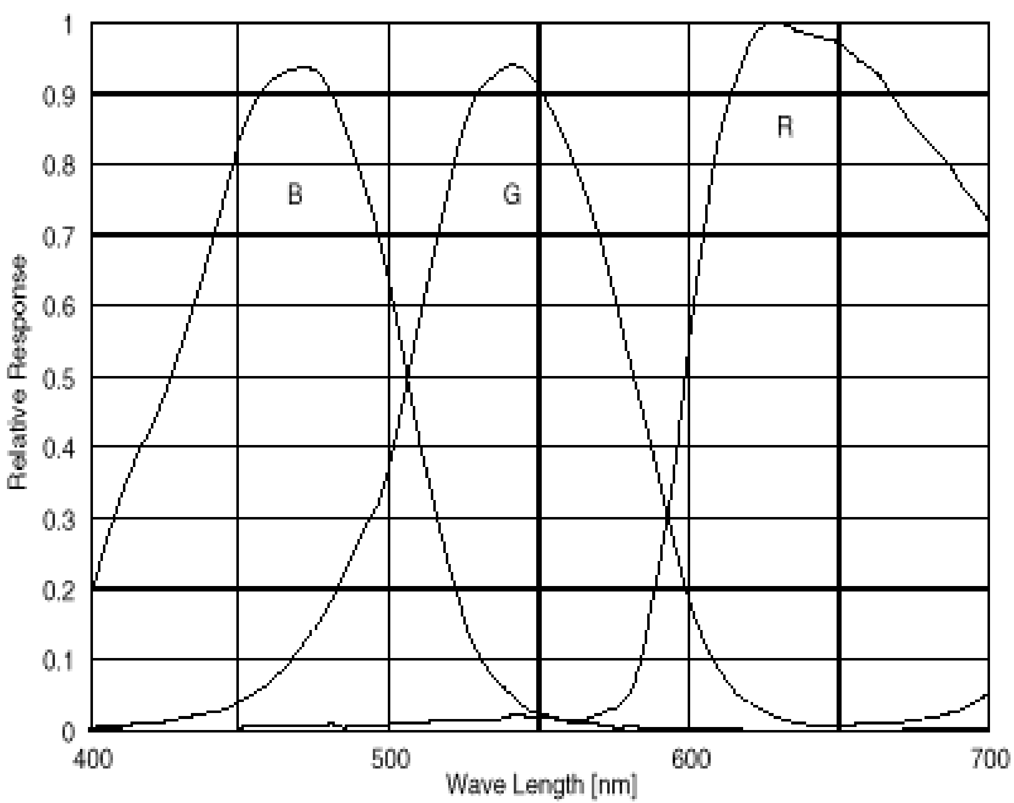


Figure 4.1-1: Color camera spectral response

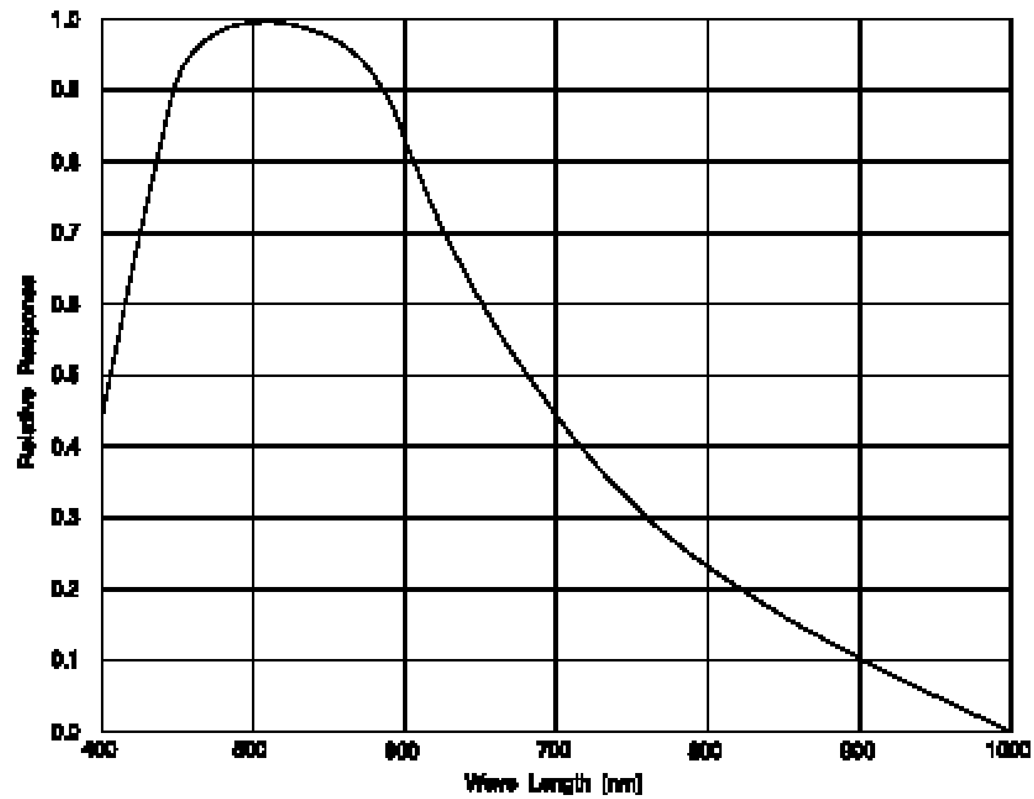


Figure 4.1-2: Monochrome camera spectral response

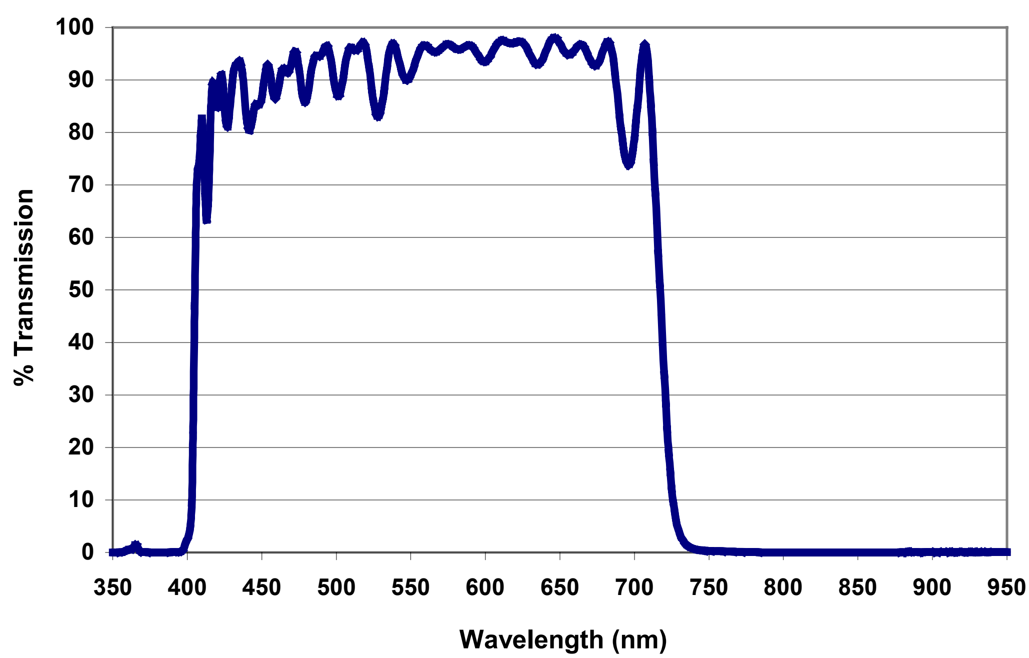


Figure 4.1-3: IR Filter Characteristics

4.2 DIGITAL VIDEO OUTPUT

4.2.1 12 Bit RS-422/RS-644 (LVDS)

Readout Rate	20 MHz, 10 MHz, 5 MHz, 2.5 MHz (user selectable via software)
Resolution/Frame Rate (Binning: Monochrome model only)	1300 x 1030 at 12 f/s (1 x 1) 1300 x 515 at 24 f/s (1 x 2) 650 x 515 at 24 f/s (2 x 2) 325 x 257 at 41 f/s (4 x 4) 162 x 128 at 65 f/s (8 x8)
Signal to noise	>65 dB, at min. gain
Sensitivity (light required for full scale output)	0.05fc@0dB gain, 12 f/sec 0.003fc@max gain, 12 f/sec 0.0007fc@0dB gain, 10 sec exposure
Gamma	1.0 (linear)

4.2.2 Firewire

Readout Rate	18 MHz, 9 MHz, 4.5 MHz, 2.25 MHz (user selectable via software)
Resolution/Frame Rate (Binning: Monochrome model only)	1300 x 1030 at 11 f/s (1 x 1) 1300 x 515 at 21 f/s (1 x 2) 650 x 515 at 21 f/s (2 x 2) 325 x 257 at 36 f/s (4 x 4) 162 x 128 at 58 f/s (8 x8)
Signal to noise	>65 dB, at min. gain
Sensitivity (light required for full scale output)	0.05fc@0dB gain, 11 f/sec 0.003fc@max gain, 11 f/sec 0.0007fc@0dB gain, 10 sec exposure
Gamma	1.0 (linear)

4.3 Intensicam

(The data shown below represents the "standard" photocathode response. Extended blue and special Gen IV versions are also available).

QE	> 35% Quantum Efficiency from 500 to 800 nm
Sensitivity	$1X10^{-8}$ fc Sensitivity (faceplate) @ 2854K, 12fps
Photocathode	GaAs photocathode, std spectral response 450 to 900 nm
Intensifier life	> 10,000 hrs @ 10^{-5} fc or lower
Geometric Distortion	< 1%
Resolution	64 1p/mm
Gating	50 ns to 83 ms

4.4 CAMERA CONTROL

RS-232C, *C-View*™ Interface Software module, standard

Gain control	30 dB
Offset control (black)	-16% to +34%
High speed shutter	LVDS: 80 µs to 83.33 ms FW: 90 µs to 94 ms
Integration control	LVDS: 83.33 ms to 15 min. FW: 94 ms to 15 min.

4.5 ELECTRICAL

Timing	Progressive scanned, non-interlaced
Power Supply Voltages & Current requirements	± 15 V DC each @ 250 mA steady state + 5 V DC @ 250 mA steady state.
Clock Rate	LVDS: 20 Mhz derived from internal crystal oscillator Firewire: 18 Mhz derived from internal crystal oscillator

4.6 MECHANICAL FOR STANDARD LVDS/FIREWIRE CAMERAS

Weight (without lens)	11.9 ounces (336.3 grams)
Temperature limits (operating)	-10°C to 50°C
Temperature limits (storage)	-30°C to 70°C
Dimensions	3.25" X 3.25" X 1.75"
Lens mount	Industry standard C- mount
Camera mount	¼ - 20 threaded holes for top/bottom mount
Digital Video Connector	LVDS:DB-44, female connector (See Appendix C) Firewire: Standard 1394A connector
Power Supply Connector	LVDS: DB-9, Male connector (see Appendix C) Firewire: Standard 1394A connector

4.7 MECHANICAL FOR COOLED CAMERAS

Weight (without lens)	27.9 ounces (792 grams)
Temperature limits (operating)	-10°C to 50°C
Temperature limits (storage)	-30°C to 70°C
Dimensions	3.90" X 3.90" X 2.80"
Lens mount	Industry Standard C-Mount
Camera mount	¼ - 20 threaded holes for top/bottom mount
Digital Video Connector	DB-44, female connector (See Appendix C)
Power Supply Connector	DB-9, Male connector (see Appendix C)

4.8 MECHANICAL FOR INTENSICAM

Weight (without lens)	27.9 ounces (606.5 grams)
Temperature limits (operating)	-10°C to 50°C
Temperature limits (storage)	-30°C to 70°C
Dimensions	
Lens mount	Industry Standard C-Mount
Camera mount	¼ - 20 threaded holes for top/bottom mount
Digital Video Connector	DB-44, female connector (See Appendix C)
Power Supply Connector	DB-9, Male connector (see Appendix C)

NOTE: See Appendix A for dimensioned mechanical diagrams.

5 CAMERA FUNCTIONAL DESCRIPTION

5.1 BLOCK DIAGRAM

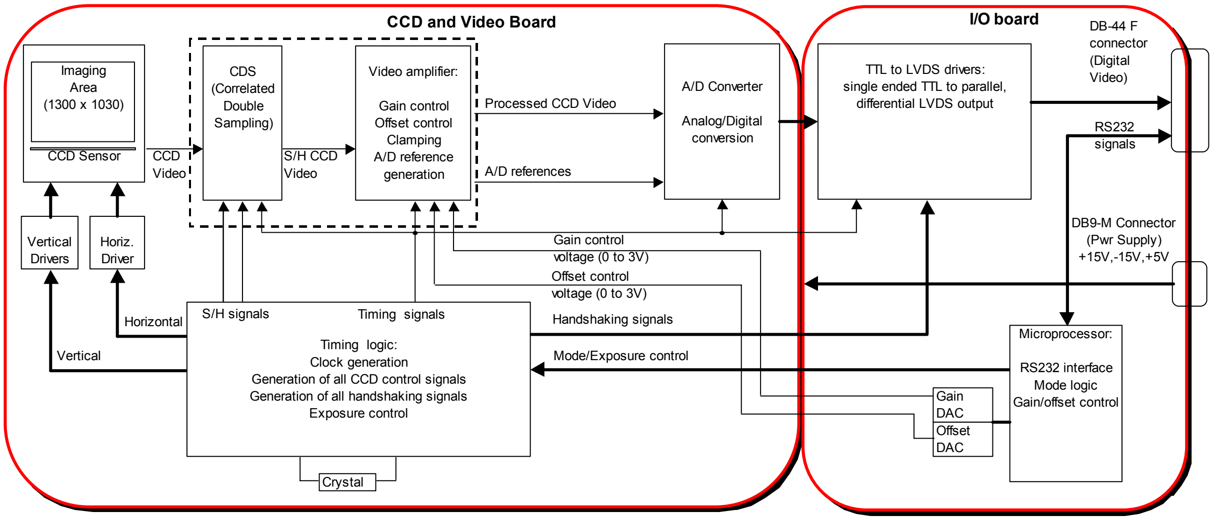


Figure 5.1-1: DVC-1312 camera block diagram (LVDS version shown)

5.2 CCD AND VIDEO BOARD

5.2.1 CCD Sensor

Light from the scene is brought into focus at the imaging plane of the CCD. A 1mm thick IR blocking optical filter blocks out the IR component of the light. The IR blocking filter is attached to the c-mount adapter ring. For non IR multi-spectral imaging applications with the DVC-1312 C Mount Adapter without an IR filter is available.

The following functions take place within the CCD:

5.2.1.1 Integration

During the integration period (1/12 sec.), charges are integrated in the active charge site wells. The amount of charge that is integrated in each active charge site well is proportional to the illumination received at each active charge site on the CCD. In the case of the color camera, each charge site has a Red, Green or Blue color filter over the field, designating it as a Red, Green or Blue pixel. The filter pattern that is used is referred to as a Bayer pattern, which is shown below:

G	B	G	B	..
R	G	R	G	..
G	B	G	B	..
R	G	R	G	..
:	:	:	:	::

Figure 5.2-1: Bayer pattern color filter array

5.2.1.2 Charge Transfer

During the Vertical blanking interval, the charge that was integrated in each active charge site during the previous exposure (normally 1/12 sec, or one frame) is shifted to an adjacent opaque storage charge site. In the figure below, active charge sites are designated by the letter "I" for integration and the opaque storage charge sites are designated by the letter "S" for storage.

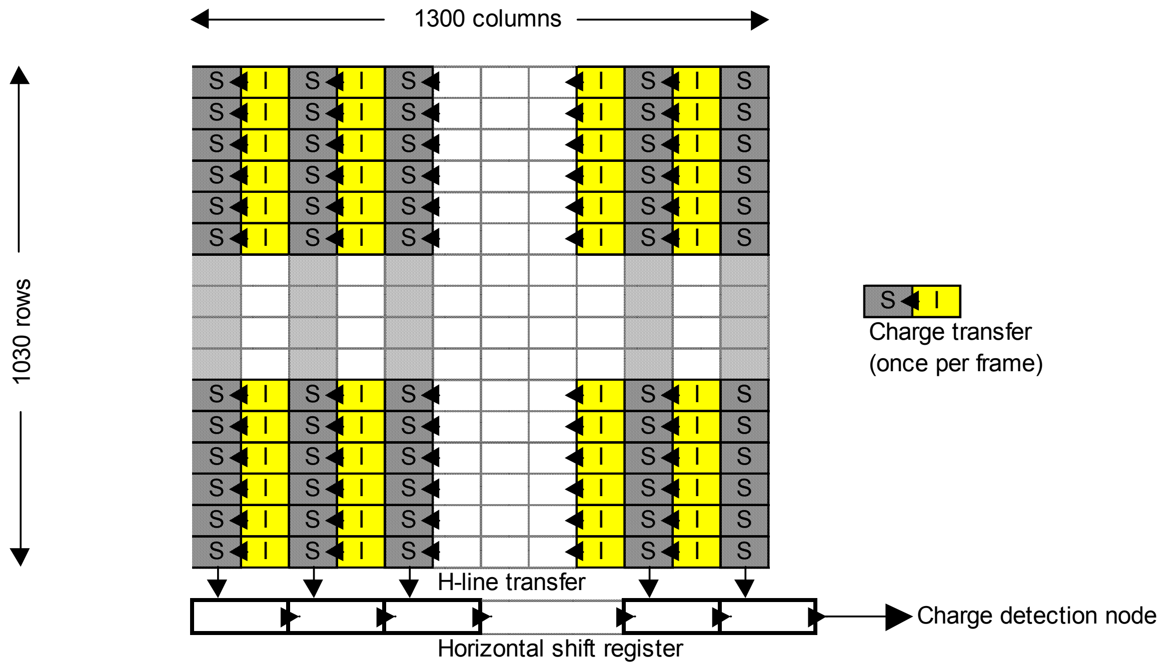


Figure 5.2-2: Block diagram of CCD

5.2.1.3 Readout

In the following adjacent frame, the charges are transferred vertically, one line at a time, from the storage charge sites of the CCD to an on-chip horizontal shift register and then sequentially to the detection node where they are made available as signal voltages. **Note:** While one frame is being read out from the opaque pixels, the next frame is being integrated in the active charge sites of the CCD.

5.2.2 Video Processing

The low-level video signal voltage from the CCD is clamped (for black reference) and fed through a high-speed CDS correlated double sampling CDS amplifier. The CDS process is required to remove a significant source of noise from the video signal. The video signal is then amplified in the next stage, which has voltage-controlled-gain and voltage-controlled-offset. The control voltages for gain and offset are 0 to 3V in range and are derived via on-board digital-to-analog converters (DACs) which are controlled via the host PC interface.

5.2.3 Video Digitization

The video signal output from the video processor is fed to a 12-bit Analog-to-Digital converter. The 12 bit digital date is available at a connector on the board.

5.2.4 Voltage Regulation

Input voltages (+15V, -15V and +5V) are converted into several positive and negative voltages required by the CCD and in the video processing circuits.

5.2.5 Timing

This logic block on the CCD and Video board performs the following functions:

- Generation of CCD timing signals
- Generation of Video & handshaking timing signals
- Asynchronous Reset function
- Mode control function
- Exposure control function

5.3 DIGITAL I/O BOARD

5.3.1 LVDS Version: TTL to LVDS Drivers

The Digital Video Data is latched and converted to an LVDS format (on the TTL2LVDS board) for transmission as a balanced, differential signal along the cable which consists of shielded twisted pairs.

5.3.1.1 RS232 Interface

This is made up of a microprocessor-based circuit, which communicates via an on-board UART with the serial port of a PC.

5.3.2 Fire Wire Version

5.3.2.1 Isochronous Data

The digital video data is latched and converted to an isochronous IEEE 1394 A (Fire Wire) format for transmission as a serial data stream on a standard Fire Wire interface cable.

5.3.2.2 Asynchronous Data

Camera control commands from the host PC are sent via the Fire Wire interface cable in the form of asynchronous data. The data is received and translated into internal camera control signals that are used to set gain, offset exposure etc. in a variety of camera modes.

6 INSTALLATION

Refer to C-View Installation and Operation

7 MODES OF OPERATION

7.1 NORMAL MODE

In each mode description, the RS232 mode commands (LVDS version only) are shown. Please refer to the RS232 details in Section 9.4.

NRR: Normal mode with reset
NOR: Normal without reset

In the normal mode of operation, the following signals are used to synchronize a digital frame grabber to the camera:

Pixel Clock: Periodic 20 MHz, square wave output which is synchronous with digitized pixel data.
Enable Frame: Periodic 12Hz (frame rate) output; the rising edge signifies the start of a valid frame and the falling edge signifies the end of a valid frame
Enable Line: Periodic 12.53 KHz (line rate) output; the rising edge signifies the start of a valid line and the falling edge signifies the end of a valid line.

The Horizontal and Vertical Drive signals are usually outputs generated by the camera.

In the timing diagram show below, charge transfer from the active (imaging) charge sites to adjacent (opaque) storage sites takes place at the beginning of a frame. In this process, all the charge that was accumulated in the imaging charge sites during the previous frame is transferred to the opaque storage sites.

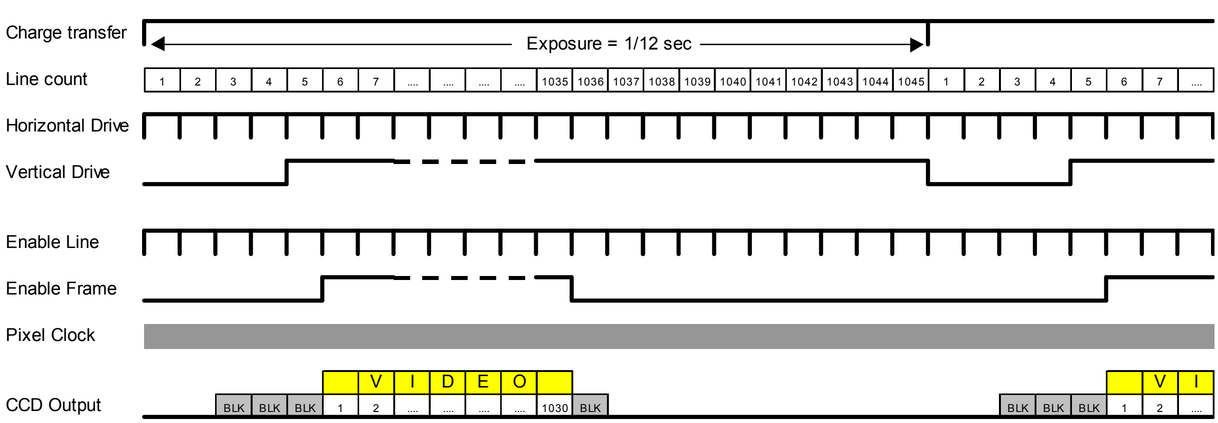


Figure 7.1-1: Timing diagram--normal mode

Every horizontal line during the next frame, one line of the charge matrix in the opaque storage sites is shifted vertically into a horizontal shift register. The horizontal shift register is clocked out, one pixel at a time, on to a charge detection node that converts it to a voltage, which can be sampled and digitized.

7.2 HIGH SPEED SHUTTER

HDO: High speed shutter with discharge (one-shot)
HNL: High speed shutter without discharge
HDL: High speed shutter with discharge (continuous)

When one of the high-speed shutter modes is selected, the duration of exposure is set as an integral number of horizontal-line-periods. In the shutter modes, the duration of exposure can be set from 1-to-1045 horizontal lines, in 1-horizontal-line-period (approx. 80μ sec) increments.

7.2.1 Setting The Exposure Duration

DB(10:1) are exposure setting internal TTL level signals that can be set using the EXP command, e.g. EXP 0A5 sets the exposure to Hex"0A6" number of lines in all the shutter modes (HDO, HDL, HNL). The duration of exposure in the high-speed shutter modes is from 1 through 1045 horizontal line periods, represented by an 11-bit control word.

High-speed shutter mode without discharge (HNL): In this mode asynchronous resets are ignored. This mode is designed for use in applications in which the electronic shutter is used primarily as a means of light level control, i.e. as an electronic "iris" in cases where there is too much light in the field of view. This is usually done to prevent saturation of the CCD with a full frame or 1/12sec exposure. The normal sequence of timing (see fig. 7.2-1) is followed and there are no interruptions of the Enable_frame, Enable_line and Pixel Clock signals.

In the example below, exposure is set to 1/500sec; this translates to 25 horizontal-line-periods (25 x 80μ sec = 1/500sec). In order to achieve this exposure, the CCD must be exposed for 25 line periods out of the total of 1045 line periods in the frame. Since the CCD has to continuously integrate charge, the 25 line-period exposure is obtained by "dumping" the charge every line for the first 1020 line periods, and then stopping the "dumping" action for the last 25 line-periods. At the end of this "active" 25 line exposure period, the charges are transferred to the storage matrix followed by readout. This is shown graphically in the timing diagram below.

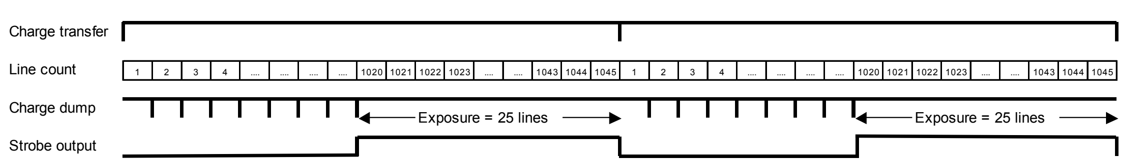


Figure 7.2-1: Timing diagram--shutter mode (HNL & HDL)

7.2.2 Strobe

In many applications, objects in the field of view can be moving too rapidly to be properly imaged under normal conditions. A combination of the high-speed shutter and a strobe may be used to stop motion. It is often desired to synchronize the strobe action with the camera exposure. For this purpose, a STROBE output pulse is generated within the camera. The STROBE output pulse allows an external strobe light to be turned on during the exposure period. Since the duration of the exposure is a user-programmable setting, the start-time (relative to the vertical timing of the camera) and the duration of the STROBE output pulse also vary, depending upon the shutter setting.

The strobe output pulse is generated to coincide with the exposure period. It is asserted (rising edge) after the last "charge dump" pulse in each frame. It goes low at the next CCD readout pulse (see above diagram). The strobe light can be activated at any time during the HIGH duration of the strobe output pulse.

7.2.3 Reset & Shutter

In some applications, it is necessary to synchronize the camera to an external event. In order to allow flexibility, two camera RESET inputs are provided. These inputs are called VRST_INT (TTL-pin39 of the DB44 connector) and INPUT1(differential LVDS-pins [34,35] of the DB-44 connector). The default level for both these signals is logic "HIGH". Within the camera, these two signals are logically AND-ed together and the resulting RESET signal is used to reset the counters within the camera-timing chip. If either the TTL (VRST_INT signal) or the differential LVDS (INPUT1) is unused it floats HIGH due to internal pull-ups. The other signal may be pulled "LOW" to cause a reset to the camera.

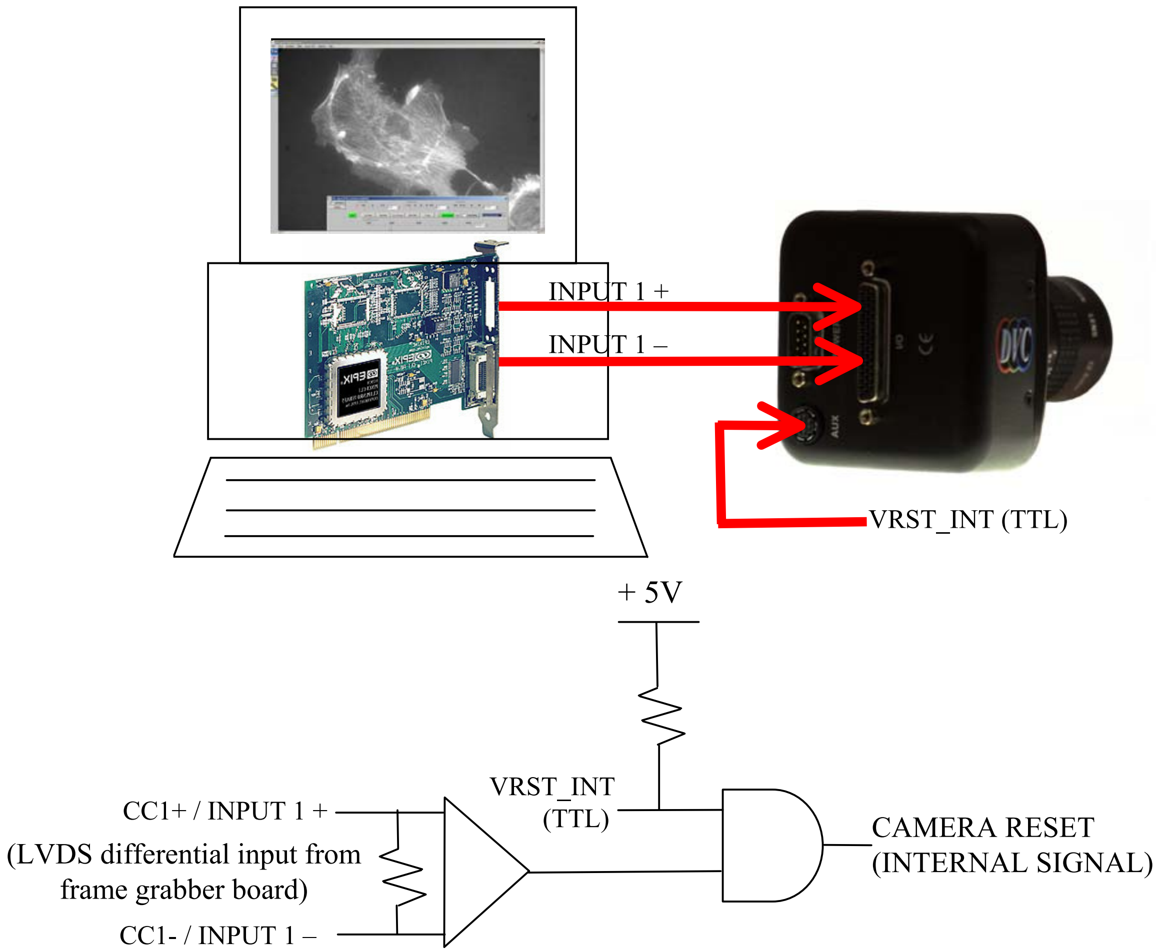


Figure 7.2-2: Asynchronous Reset

Note: frame grabbers have the ability to control the LVDS input (INPUT1+, INPUT1-) of the camera. This is facilitated by connecting them via two wires within the camera-framegrabber interface cable to differential LVDS frame grabber outputs that are driven by a General Purpose register bit that is to be controlled by host software. The TTL input (VRST_INT) is usually NOT connected via the camera-framegrabber interface cable. Therefore, in most applications, the VRST_INT signal floats HIGH - enabling resets from the framegrabber (under control of the host software). In some cases, however, users may want to feed a TTL reset signal directly to the camera, e.g. from an optical detector in an inspection application. In this case, the user must ensure that the LVDS input (INPUT1) is either driven HIGH or allowed to float HIGH.

In cameras that have an auxiliary input connection, the VRST_INT (TTL) input is available as one of the pins. In some applications, this input can be used to reset the camera directly instead of generating resets from the frame grabber.

In the HDO and HDL shutter modes, an asynchronous falling edge on the VRST_INT (TTL) or INPUT1 (LVDS) input of the camera is used to synchronize the exposure period of the camera to the outside world (the rising edge is not significant, however, the LOW duration should last at least 1µsec). Since the falling edge is truly asynchronous, in most instances it would have the effect of interrupting the readout of a previously exposed frame from the storage area elements of the CCD; a residual charge from the previous exposure therefore may exist on the storage area elements. This charge must be removed from the storage area by a "discharge" process before the next charge transfer takes place.

7.2.3.1 One Shot high speed shutter with discharge (HDO)

This mode is also referred to as the "one-shot" or "snapshot" mode. In this mode, the camera acts like a snapshot digital camera. The camera outputs no frames (and no Enable_Frame signals) until a reset signal is received (see above section related to reset signals). Once a reset signal is received, the camera immediately performs one-and-only-one exposure (with the duration determined by the previously set EXP command) resulting in one-and-only-one valid Enable_Frame signal. Note: there is no latency or delay between the falling edge of reset and the start of the exposure.

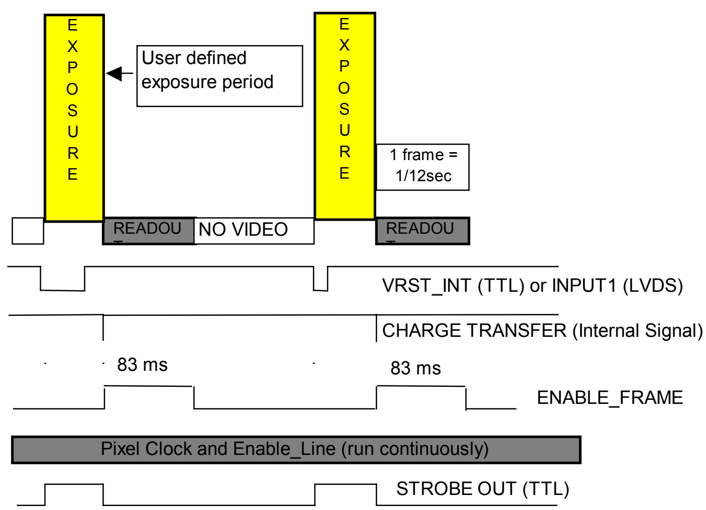


Figure 7.2-3: Timing diagram—HDO Mode

In a typical frame grabber based system, the displayed image is updated only when the reset is generated; until then, the previously captured image (resulting from the previous reset) is displayed. Therefore this mode is referred to as the asynchronous "snapshot" mode.

NOTE: The frame grabber should be capable of sustaining long periods of time without receiving an Enable-Frame signal.

The exposure is set, as in all shutter modes, via the serial EXP command with its 11-bit argument. For example, EXP 018 will set up the exposure to be equivalent to 25 lines of exposure (Hex"019" = Decimal 24 + 1); since one-line-period is 80µsec, this is the same as 25 x 80µsec = 0.002sec or 1/500sec.

7.2.3.2 High speed shutter with discharge (HDL)

If an asynchronous reset occurs while the camera is in this mode, the residual charge in the storage area from a previous exposure is flushed out (discharged) by a sequence of vertical channel transfer pulses. This period lasts for 6.8msec (see timing diagram below). Note: the discharge pulses affect only the storage area; the "charge dump" pulses that are required to clear the imaging area are generated immediately after the discharge within the 6.8mSec period. This is followed by the exposure period and then the readout of the integrated charge. As shown below in the timing diagram, the normal sequence of the Enable_frame signal is interrupted by the asynchronous reset input; It is forced LOW by the falling edge of the reset signal and remains low until the discharge and exposure periods are completed (6.8mS + user_defined_shutter_exposure). The rising edge of the Enable_frame signal signifies the start of the readout process of the synchronized frame. Note: the Enable_line and Pixel Clock signals are un-interrupted by the reset signal and run continuously.

Note: if the exposure period is greater than 80 lines, then a special condition exists, which allows a concurrent discharge and exposure, eliminating the taking period between the falling edge of reset and the start of exposure that exists in cases where the exposure period is less than 80 lines.

After the synchronized frame is readout, normal shutter operation resumes until the next falling edge of the asynchronous reset is received.

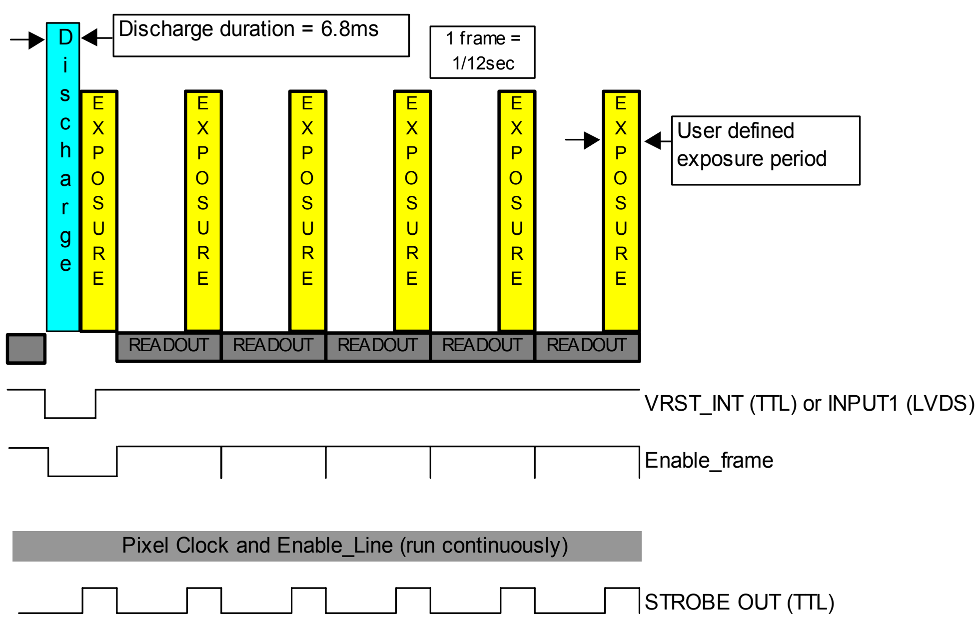


Figure 7.2-4: HDL mode

7.3 N FRAME INTEGRATION

NFR: "N" frame integration (low speed shutter)

When the low-speed shutter mode (or N Frame Integration mode) is selected, the duration of exposure is set as an integral number of frames. For the DVC-1312 camera, the duration of exposure can be set from 1-to-1024 frames, in 1-frame increments. Note: since one frame is 1/12sec or 83.33msec, the range of control is from 1/12sec to 85.5 sec.

If the exposure is set to, for example, 1 second ; this translates to 12 frame-periods (12 x 1/12sec = 1sec). In order to achieve this exposure, the CCD must be exposed for 12 frame periods between transfers. Since EXP000 corresponds to a 1-frame exposure a 12 frame exposure will result from an EXP 00B setting.

In order to maintain synchronization with a frame grabber, the pixel clock and enable line signals are un-interrupted during exposure and subsequent readout. The enable frame signal, however, is set "low" during exposure and goes "high" during readout to signify that the accumulated frame is being read out and may be captured by the frame grabber. This is shown graphically in the timing diagram below.

NOTE: The frame grabber should be capable of sustaining long periods of time without receiving an Enable-Frame signal.

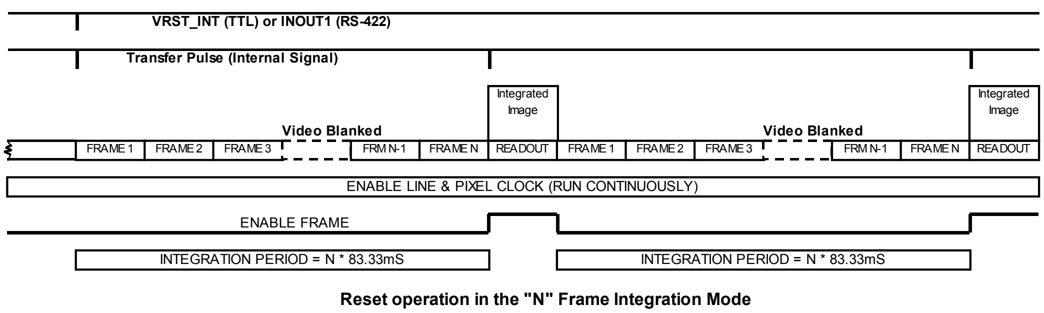


Figure 7.3-1: Timing diagram--long exposure

7.3.1 Reset Operation in N-Frame Integration Mode

During the N-Frame integration mode, a falling edge of the VRST_INT (TTL) or the INOUT1(LVDS) resets the camera and initiates a new N-frame exposure (as shown above).

7.4 ULT: ULTRA-LONG-TERM EXPOSURE

This mode is identical to the NFR mode, except that there is a x120 multiplier in the EXP argument. This means that an EXP argument of N will have the effect of setting up an integration of (N+1) x120 frames, e.g.: N=3 would result in an exposure of (3+1)X120 frames = 480 frames or 40 sec.

In software applications such as CView™, developers may choose to design a single “exposure” slider bar for long exposures. When the exposure is less than eg. 60 sec, the NFR mode may be used, with an increment of 1 frame time = 83.3 ms. For longer exposures, the ULT mode is invoked with an increment of 120 frames = 10 sec. The transition between NFR mode and ULT mode may be transparent to the user; the only real difference between the ULT and NFR mode from the user’s perspective is the “granuality” of control.

7.5 PULSE DRIVEN EXPOSURE

PDX: Pulse driven exposure (external)
PDI: Pulse driven exposure (internal, one-shot)
PDP: Pulse driven exposure (internal, periodic)

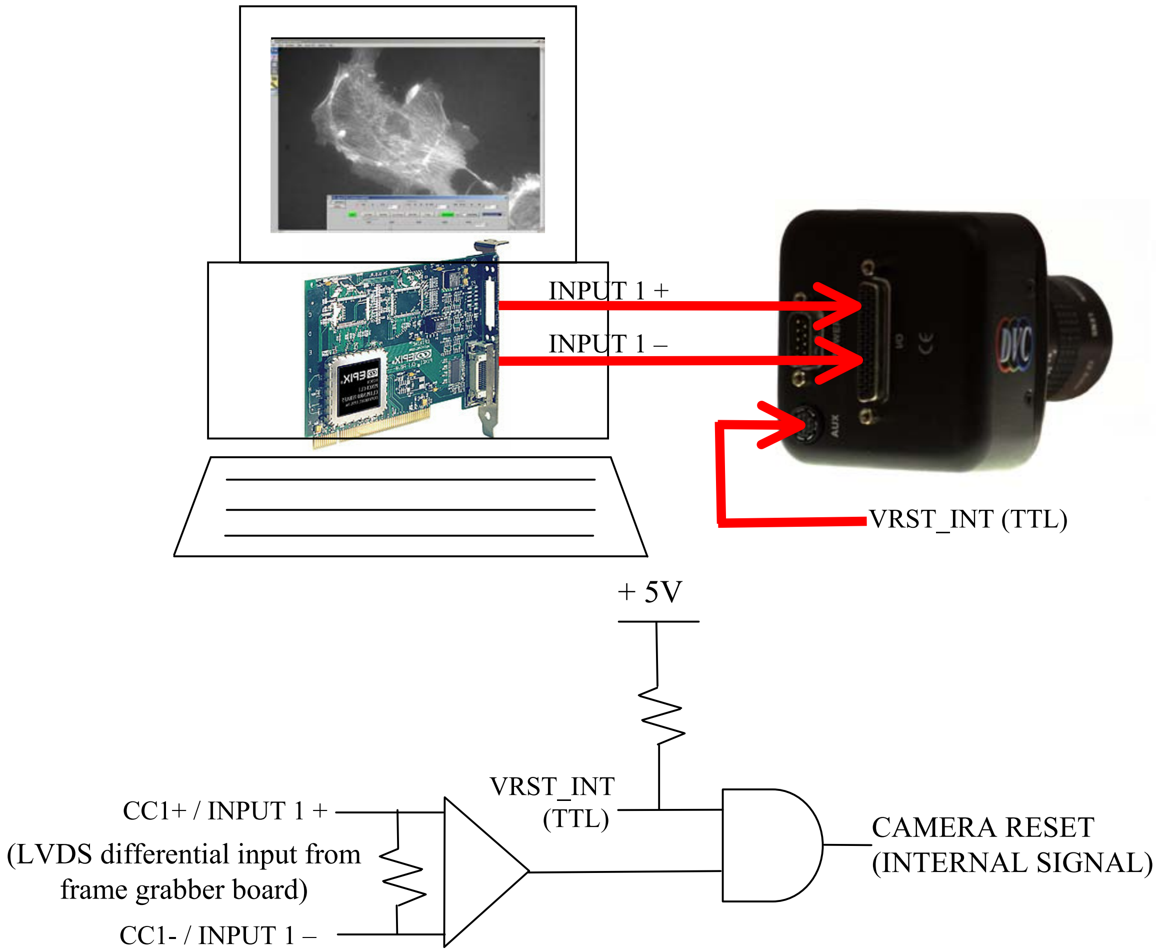


Figure 7.5-1: Asynchronous Reset

When the Pulse Driven Exposure mode is selected, the duration of exposure is set by the user via the LOW duration of an externally generated pulse. A falling edge of the pulse clears the imager and initiates exposure, a subsequent rising edge terminates exposure, resets the vertical counter within the camera and initiates readout of the acquired frame.

This pulse signal may be TTL (VRST_INT) or LVDS (INOUT1 + & INOUT1-); these two inputs are logically AND-ed within the camera, therefore one of them should normally be HIGH if the other one is to be used. There are no prescribed limits to the LOW duration; therefore this mode affords the user the most flexibility in terms of controlling the duration and the instant of exposure. For example, application software can be written to directly drive the camera between long and short exposures without any latency; some application developers choose to use the PDX mode as the sole camera mode, since this can control long and short exposure easily by controlling a single signal. The max rep rate of the driving pulse in the 1312 is limited to 1/(83.3ns+exp).

In order to maintain synchronization with a frame grabber, the pixel clock and enable line signals are un-interrupted during exposure and subsequent readout. The enable frame signal, however, is set "low" during exposure and goes "high" only during readout to signify that the accumulated frame is being read out and may be captured by the frame grabber. This is shown graphically in the timing diagram below.

NOTE: The frame grabber should be capable of sustaining long periods of time without receiving an Enable-Frame signal.

PDI and **PDP** are special cases of the Pulse driven exposure mode, in which the camera microprocessor is used (via the TIL & TIH cmd) to drive the reset pulse. These modes are of limited use except when the frame grabber does not have a well defined method of generating exposure pulses.

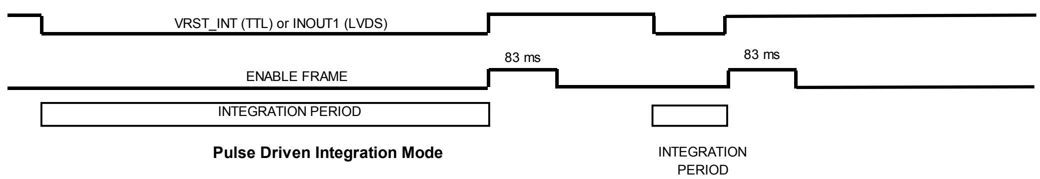


Figure 7.5-2: Pulse driven integration mode, showing long/short exposure with minimum latency

7.6 BINNING

Binning is a feature of the camera that allows the user to trade-off camera resolution in favor of frame rate and sensitivity. When one of the binning modes is selected, a selected number of contigous pixels is treated as one "super-pixel". This is illustrated below, shown in the bin 2x2 case. By means of transferring two lines into the horizontal shift register, pixels are summed vertically. These vertically summed pixels are then clocked out to the detection mode without the usual intervening reset gate signal.

Command Code	Description	Frame Size	Frame Rate
BIN 11	1 x 1 binning	1300(H) x 1030(V)	11.86f/sec (normal mode)
BIN 21	2 x 1 binning	1300(H) x 550(V)	23.63f/sec
BIN 22	2 x 2 binning	650(H) x 515(V)	23.63f/sec
BIN 44	4 x 4 binning	325(H) x 257(V)	41.1f/sec
BIN 88	8 x 8 binning	162(H) x 128(V)	64.9f/sec

Table 7.6-1: Binning commands

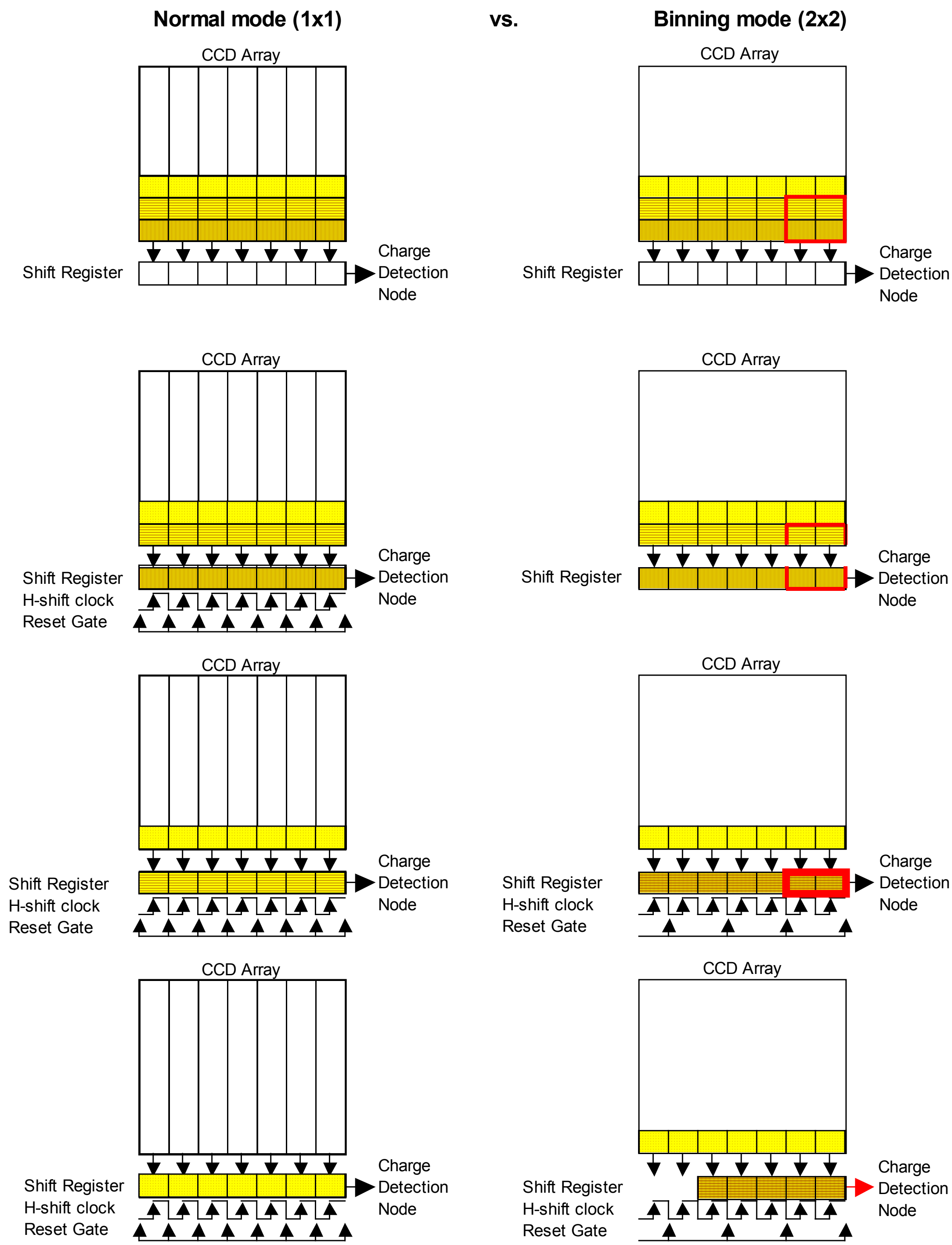


Figure 7.6-1: Bin 2x2 case

In the above figure, the pixels marked by the heavy border, are read out as one "super-pixel" value. The binning mode of the camera is set via the BIN command. There are five valid arguments to this command {11, 21, 22, 44, 88}. When one of these commands is issued by the host-side software, the mode control bits are set as shown in the table for 2µsec. The mode control bits then revert to the setting (1 x x x) just prior to the binning command.

7.6.1 Binning and Shutter:

The following table is provided as a guide for calculating the shutter mode exposure values that apply in the different binning modes.
The shutter setting for binning modes needs to be shifted with an offset, in order to get the desired amount of exposure:

mode	no exposure	1_line	2_line	max line
1x1	0	1	2	1043
2x2	520	521	522	1043
4x4	780	781	782	1043
8x8	910	911	912	1043

7.6.2 Binning and Bayer Pattern Color Filter Arrays

When binning is performed within the CCD, e.g. in the BIN 2x2 mode, the charge from a 4-pixel quad made up of 2-horizontal and 2-vertical pixels is collected into one CCD horiz-shift-register element. The charge value that is read out therefore corresponds to a summation of the 4-pixel quad.

P11 + P12
+
P21 + P22

1-data-value

In this mode, the user trades off resolution for frame rate and sensitivity.

In a Bayer-filter color camera, the 2x2 binning mechanism described above creates a quad summation which results in R+G+G+B value.

R11 + G12
+
G21 + B22

1-data-value

This R+G+G+B value does not represent any meaningful color information; however, it may be used as a luminance value. Application developers may use BIN 2x2, BIN 4x4 or BIN 8x8 modes (in a color camera) to create a fast monochrome image during focusing, fast object/image manipulation in the field-of-view etc. and then revert to a full-resolution 12f/s color image after determining an image of interest.

7.7 SLOW SCAN

Slow scan: The read noise of a CCD is significantly affected by the scanning rate. Some users wish to improve the read noise by slow-scanning the CCD. This is provided in the camera by means of a clock multiplexer scheme; the user selects which one of the four (4) clocks is to be used as the pixel clock.
Note: This selection affects all the internal clocks, since the entire timing logic runs on the selected clock. Therefore, all exposure values etc. will be scaled accordingly.
The slow-scan mode of the camera is set via the SLW command. There are four valid arguments to this command {01, 02, 04, 08}. When one of these commands is issued by the host-side software, the mode control bits are set as shown in the table for 2µsec. The mode control bits then revert to the setting (1 x x x) just prior to the slow-scan command.

Command Code	Description	Frame Rate (LVDS)	Clock (LVDS)
SLW 01	Fast pixel clock divided by 1	12f/sec	20 MHz
SLW 02	Fast pixel clock divided by 2	6f/sec	10 MHz
SLW 04	Fast pixel clock divided by 4	3f/sec	5 MHz
SLW 08	Fast pixel clock divided by 8	1.5f/sec	2.5 MHz

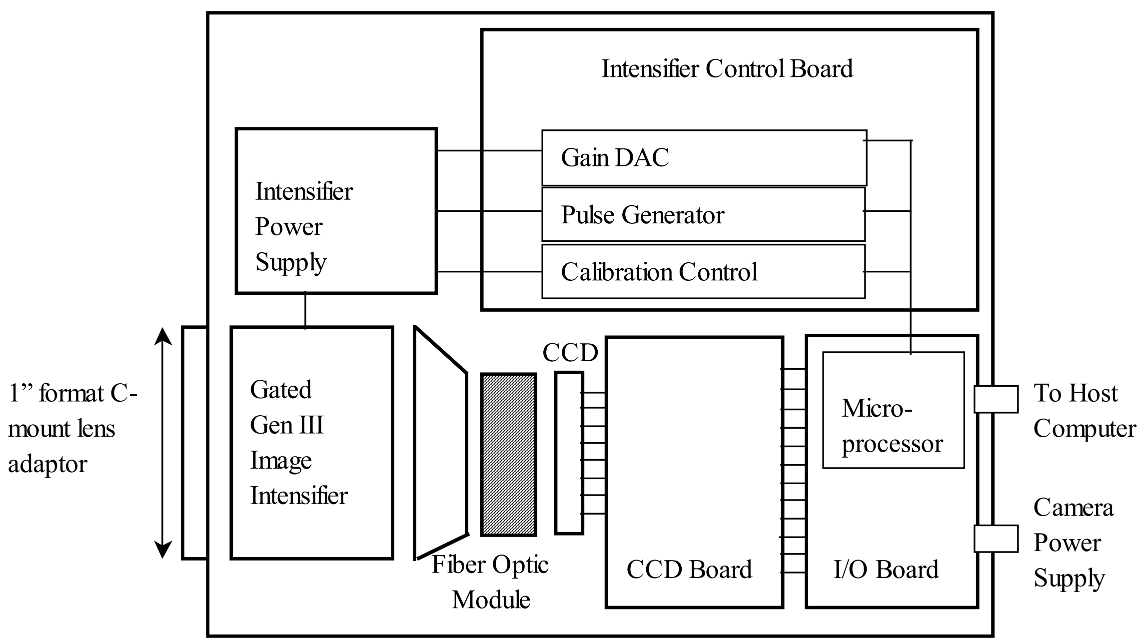
Table 7.7-1: Slow-scan mode commands

7.8 INTENSICAM

7.8.1 Introduction

The Intensicam is a special version of a 1312 camera in which a gated Gen III image intensifier is fiber-optically bonded to the front surface of the CCD. Due to the high luminous gain of the Intensifier tube, every incident photon generates thousands of electrons within the tube. Even under very low-light conditions, this results in a live image on the phosphor of the Intensifier, which is viewable by the CCD.

7.8.2 Functional Description



Fiber-optic module: This is used to couple the image that is generated on the phosphor of the image intensifier to the CCD. Since the optical format of the image intensifier is 1" and that of the CCD is 2/3", a taper is used for the reduction.

High voltage power supply: This is used to generate the voltages that are necessary for the performance of the image intensifier.

Intensifier control board: This board interfaces between the camera I/O board and the high-voltage power supply. A serial interface is used between the I/O board and the controller chipset.

{Note: Over-exposure can cause permanent damage to the Intensifier tube that is part of the Intensicam}

7.8.3 Spectral Response

Standard and enhanced coatings are available to provide different spectral characteristics (see Figure 7.8.1). The phosphor of the intensifier (which is fiber-optically coupled to the CCD) emits in the blue-green part of the spectrum, which is well matched to the peak-response of the CCD. The spectral response for the standard intensifier (and the extended blue version) are shown below; enhanced coatings are available upon request.

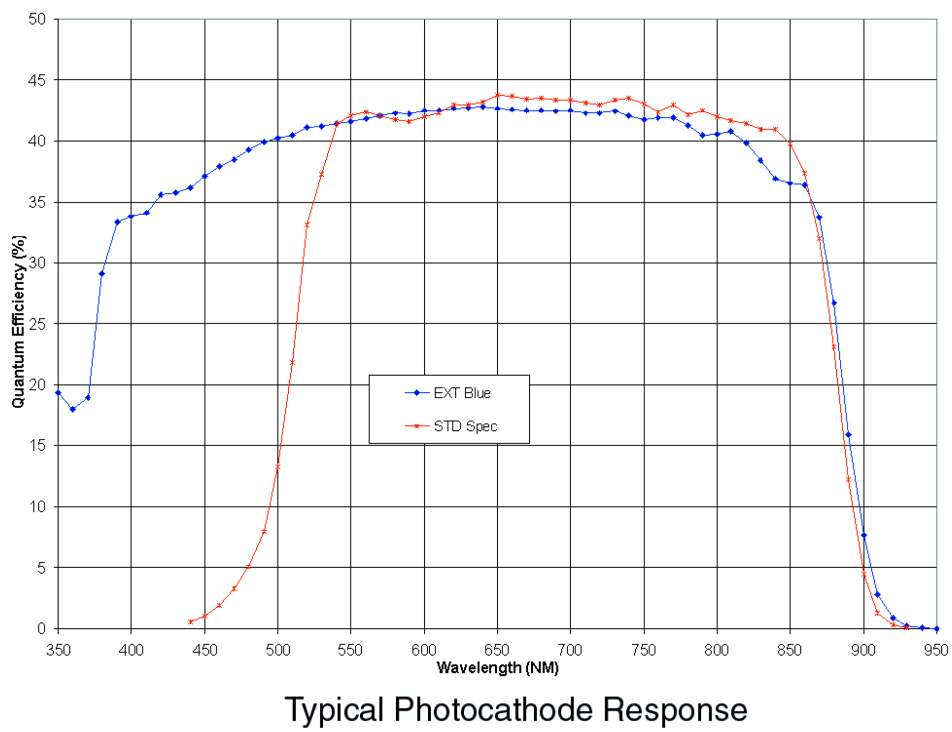


Figure 7.8-1: Intensicam spectral response

7.8.4 Intensicam & CView™

1) In CView, there is an "Intensify" button on the control panel that is (by default) RED in color. As long as this button is RED, the Intensifier is gated OFF (to protect the camera). Although the camera is connected (and a frames/sec counter is visible in the LHS of the viewing window), the image will remain black.

2) The user must press the RED button, turing it GREEN, to turn on the Intensifier. {**Note: Over-exposure can cause permanent damage to the Intensifier tube that is part of the Intensicam}**. It is the user's responsibility to ensure that the light settings of the microscope or optics are appropriate for use with this camera. If an overload is detected (in the form of an overexposed white image), the user should IMMEDIATELY press the GREEN button, turning it RED and turning OFF the Intensifier. Then, after readjusting the optics, the process may be repeated until suitable viewing conditions exist.

3) The button marked "Control" that is to the RHS of the RED/GREEN button may be pressed to activate the controls of the Intensifier.

4) The Intensifier Gain slider bar appears at the bottom of the standard control panel, when activated, and may be retracted when not required, to minimize the screen space that is occupied by the control panel.

5) The Intensifier modes may be selected from the modes list-box; if a short mode is selected, then the appropriate Intensifier-control slider bar appears in the place of the camera exposure bar.

6) By default the Intensifier is set to "OFF" when the 5 user defined buttons are used. The 5 "user defined" buttons along the bottom of the control panel should be re-programmed for use with the Intensifier. This is done for purposes of protecting the camera from inadvertant over-exposure.

7) To re-program a button, set the camera into a desired mode (any combination of Camera/Intensifier settings, e.g. Camera gain=0dB, Camera Offset = 0%, Intensifier Gain = 10000); then right-click the desired button, e.g. "Normal" and type in a new name, e.g. "Gain=10K", and press "Enter". The button will now be renamed to "Gain=10K"

8 APPLICATION NOTES

8.1 BAYER FILTER DECODING ALGORITHM

8.1.1 Introduction

The following information is provided to assist software developers to create a high-resolution color image from the digitized data that is provided by the DVC-1312C Camera.

1) The electronics within the camera are the same for the monochrome as well as for the R-G-B version of the camera. For this reason, all the timing signals, including digitized video data, clock, enable-line and enable-frame are the same for both cameras. Also, all modes of operation that are described for the monochrome version of the camera apply to the R-G-B version. These modes include the electronic shutter modes, asynchronous reset mode, and pulse driven integration modes.

2) The color-filter-array (CFA) of the color imager follows the commonly used "Bayer pattern". This pattern (shown below) is based on the premise that the human eye derives most of the luminance data from the green content of a scene; and it is the resolution of this luminance data that is perceived as the "resolution" of an image. Therefore, by ensuring that more of the pixels are "green", a image of higher perceived resolution can be created--compared with an alternating R-G-B color filter array with equal numbers of Red, Green and Blue pixels.

G	B	G	B	..
R	G	R	G	..
G	B	G	B	..
R	G	R	G	..
:	:	:	:	::

Figure 8.1-1: Bayer Pattern CFA

8.1.2 Color Pixel Processing

The following steps are required for processing the color pixels

8.1.3 White Balance

Depending on the "color temperature" of the light source, a white object may generate different values for its R, G and B pixel values. For example, when the camera is pointed at a uniformly diffused white object that fills the entire field of view, the resulting R, G and B values may form the following matrix:

300	200	300	200	. .
110	300	110	300	. .
300	200	300	200	. .
110	300	110	300	. .
:	:	:	:	: :

R=110, G=300, B=200

300	110	300	110	. .
200	300	200	300	. .
300	110	300	110	. .
200	300	200	300	. .
:	:	:	:	: :

R=200, G=300, B=110
(fluorescent lighting)
(incandescent lighting)

Figure 8.1-2: Examples of Bayer Pattern values for fluorescent and incandescent light

Both cases require correction, because a white object should have R=G=B data values. The simplest correction would involve "equalizing" the data - if the Green pixel values are kept unchanged and the Red and Blue pixel values are multiplied by appropriate "gain" coefficients.

In the case of the "fluorescent lighting" example, Red Gain (Rg) should be 300/115 = 2.6 and Blue Gain (Bg) should be 300/200 = 1.5

In the case of the "incandescent lighting" example, Rg (or Red Gain) should be 300/200 = 1.5 and Bg should be 30/115 = 2.6

As shown in the above examples, the Rg and Bg coefficients depend on the type or the color temperature of the illumination that is used. Therefore, a "white balance" operation is required each time that the scene illumination or color temperature is changed.

The procedure for a white balance operation is as follows:

- the software instructs the user to point the camera at a uniform white object e.g. a sheet of white paper.
- the software instructs the user to press the "white-balance " button.
- the software examines the ratios G/R and G/B and determines the average value of Rg and Bg over a predetermined region. It is usually a good idea to keep the reasonably small.
- the software then stores the computed average Rg and Bg values and uses them as coefficients to generate color corrected Red and Blue pixel values from the "raw" Red and Blue pixel values.

In some applications, it may be possible to store some frequently observed combinations of Rg and Bg to simplify this operation. For example, if the camera is used under the same lighting conditions at all times, the user should be able to perform the white balance operation once and then store the Rg and Bg values. A typical software user interface might have three choices under Preset White Balance options: "Typical Fluorescent", "Typical Incandescent" and "User Setting."

8.1.4 Gamma Correction

In order to compensate for the non-linearity of monitors, a gamma correction curve needs to be applied to the color corrected digitized pixel values. A default value of 0.6 may be provided, although in some applications, this may need to be a user-supplied number.

8.1.5 Color Coding

For each digitized pixel value (after color correction AND gamma correction) it is necessary to generate the remaining two values to complete that pixel's representation in the R-G-B color space. This can be done in several ways - it might be a good idea to provide all the following implementations and then allow the user to select the one that best suits the application.
In the following example, the G11, B11 … represent color-corrected and gamma-corrected digitized pixel values. Several different color-coding algorithms are possible:

G11	B12	G13	B14	. .
R21	G22	R23	G24	. .
G31	B32	G33	B34	. .
R41	G42	R43	G44	. .
:	:	:	:	: :

Figure 8.1-3: Bayer Pattern CFA (color coding example)

8.1.6 Suggested Algorithm

"Green pix" PIX22 = Avg(R21, R23); G22; Avg(B12, B32)
"Red pix" PIX23 = R23; Avg(G13, G22, G33, G24); Avg(B12, B32, B34, B14)
"Blue pix" PIX32 = Avg(R21, R41, R43, R23); Avg(G31, G42, G33, G22); B32
For pixels on the edge of the imager, the following algorithm can be used:
PIX11 = R21; G11; B12
LHS column
PIX21 = R21; Avg(G11, G22, G31); Avg(B12, B32)
PIX31 = Avg(R21, R41); G31; B32
Top row:
PIX12 = Avg(R21, R23); Avg(G11, G13); B12
PIX13 = R23; G13; Avg(B12, B14)
A similar approach can be taken with pixels on the bottom row and the RHS column.

9 RS-232 interface definition for DVC1310A / 1312A cameras (LVDS Cameras Only)

9.1 INTRODUCTION

The following is a definition of the RS-232 interface for the DVC-1310A/1312A cameras. RS-232 control is standard within all DVC131X cameras that use LVDS outputs to connect with suitable frame grabber boards; it can be controlled via a communication program (such as Windows HyperTerminal) or within a larger program, such as C-View™.

9.2 PHYSICAL DESCRIPTION

The RS-232 interface is physically designed as a microprocessor-based circuit that is present on-board the DVC-131X camera. The microprocessor has an on-board UART which communicates with the serial port of the PC via an RS232 interface chip. The microprocessor is configured to have two data ports: a 4-bit data output register that controls the camera modes and an 11-bit data output register that controls the exposure of the camera. In addition to the data ports, a dual digital-to-analog converter (DAC) is used to control the camera gain and offset by creating two 0-to-3V analog control voltages. The microprocessor decodes valid camera commands and creates the user specified combination of the two data ports and the two analog control voltages.

9.3 COMMUNICATION PROTOCOL

Serial communication protocol: the camera uses a full duplex UART type asynchronous system, using standard non-return-to-zero (NRZ) format (one start bit, eight data bits, one stop bit, no parity). The baud rate is fixed at 9600. The character code is based on the ASCII standard. Character flow protocol: None

Command Syntax: the camera will recognize a command as three command characters, followed by a space character, followed by an argument that consists of two characters, ended by the carriage return character.

Query Syntax: the camera will recognize a query as three command characters followed by the question mark character, then ended by the carriage return character. The camera responds to a query with three command characters, followed by a space character, followed by an argument that consists of three characters, then ended by the carriage return character.

Error messages: the camera responds to an erroneous command or query in one of three possible ways.

ERROR MESSAGE	EXPLANATION
E-SYN	The camera cannot understand the command
E-ARG	The camera can understand the command, but the argument is either out-of-range or not understood e.g. an alpha character embedded in a numeric string
E-XMT	The camera detects a transmission error e.g. buffer overflow, parity or framing.
E-HRT	The HRT command was issued in a mode in which Hardware Reset is illegal.

9.4 CAMERA CONTROLS

The camera has the following parameters that can be controlled or queried via the RS232 port:

9.4.1 Gain

The camera gain is controlled by means of an analog voltage (0-to-3VDC). This parameter is supplied by the host PC as a two digit hex data argument to the command GAI and converted to an analog voltage using an 8-bit Digital-to-Analog converter (DAC). A gain command with the syntax "GAI 9A" would set the gain to the maximum value.

1) The power on Gain value is 29 "Hex", corresponding to the 0dB point.

2) Software designers may wish to design a "Gain Slider bar" based on the following table:

Hex	Gain (dB)
00	-8.2
29	0.0 (power-on default)
9A	+22.6

Table 9.4-1: Gain Table

9.4.2 Offset (or black level)

The camera offset is controlled by means of an analog voltage (0-to-3VDC). This parameter is supplied by the host PC as a two digit hex data argument to the command OFS and converted to an analog voltage using an 8-bit Digital-to-Analog converter (DAC). An offset command with the syntax "OFS 9A" would set the offset to the maximum value.

1) In cameras that have a firmware revision prior to 6.0, the power-on default value of OFS is 31 (hex); In cameras that have a firmware revision of 6.0 or higher, the power-on default value of OFS is 18 (hex).

2) Software designers may wish to design an "Offset Slider bar" based on the following tables, while using the VER command (see section 5.0, "Special Commands"):

Hex	Offset (%)
00	-7.5%
18	0%(power-on default)
9A	40%

Table 9.4-2: Offset Table

Hex	Offset (%)
00	-15%
31	0%(power-on default)
9A	32%

Table 9.4-3: Before Rev 6.0

9.4.3 Exposure

The argument of the EXP command sets the camera exposure by controlling an internal "exposure bus" which is made up of 11 data bits DB[10:0]. The power-on default value of EXP is 7FF. An exposure command with the syntax "EXP 7FF" would set the exposure to the maximum value (all bits set "High"). The argument of the EXP command has different increments depending on the mode of the camera: in hi-speed shutter exposure modes, the EXP increments are one-H-line-period: in NFR mode, the increments are one-frame-periods; in ULT mode the increment is 10 seconds.
Note: the argument of the EXP command is offset by 1 in all modes.

For example, EXP 00 in NFR mode gives 1-frame exposures
EXP 00 in hi-speed shutter modes gives 1-line exposures
EXP 00 in ULT mode gives a 10-sec exposure.

9.4.4 Modes

The camera modes are set via 4 internal TTL level signals, corresponding to MC3, MC2, MC1, MC0. The syntax for the MDE command is "MDE XYZ" where XYZ can be any of the nine three character codes shown in the second column of the table below. The DB[10:0] signals are driven by EXP{arg} in all modes. The MC[3:0] signals are set as shown by the table below:

MC 3 2 1 0	**Code**	**Description**	**VRST_INT**
0 0 0 0		2:1 Binning; BIN 21	Hi Z
0 0 0 1		2:2 Binning; BIN 22	Hi Z
0 0 1 0		4:4 Binning; BIN 44	Hi Z
0 0 1 1		8:8 Binning; BIN 88	Hi Z
0 1 0 0		Slow scan, divide PIXCLK by 2; SLW 02	Hi Z
0 1 0 1		Slow scan, divide PIXCLK by 4; SLW 04	Hi Z
0 1 1 0		Slow scan, divide PIXCLK by 8; SLW 08	Hi Z
0 1 1 1		Unlock slow-scan & binning; SLW 01 OR BIN 11	Hi Z
1 0 0 0	NRR	Normal mode with reset	Hi Z
1 0 0 1	HDO	High speed shutter with discharge (one-shot)	Hi Z
1 0 1 0	HNL	High speed shutter without discharge	Hi Z
1 0 1 1	HDL	High speed shutter with discharge (continuous)	Hi Z
1 1 0 0	ULT	Ultra-long-term exposure	Hi Z
1 1 0 1	NFR	"N" frame integration (low speed shutter)	Hi Z
1 1 1 0	PDI	Pulse driven exposure (internal, one-shot)	Int. ‾‾‾____‾‾‾ sets exposure
1 1 1 0	PDP	Pulse driven exposure (internal, periodic)	Int. ‾‾‾____‾‾‾ sets exposure
1 1 1 0	PDX	Pulse driven exposure (external)	Hi Z
1 1 1 1	NOR	Normal without reset	Hi Z

Pulse Driven Exposure (external): this is a "special" mode of operation in which the exposure of the camera is set via a user-determined pulse. In the external (PDX) version of this mode, the user supplies an external VRST_INT pulse – at the falling edge, the camera starts to integrate charge on the CCD. When the pulse goes "High", the vertical counter within the camera is reset and frame readout begins (it is the user's responsibility to ensure that the "high" duration lasts for at least one frame read-out (83 msec).

Pulse Driven Exposure (internal): this is a "special" mode of operation in which the exposure of the camera is set by the low-duration of a user-determined pulse.

In the PDP internal version of this mode, the microprocessor that controls the RS232 interface generates a periodic pulse with a user-defined "low" duration (TIL command) and a user-defined "high" duration (TIH command).

In the PDI internal version of this mode, the microprocessor that controls the RS232 interface generates a one-shot pulse on the user's command with a user-defined "low" duration (TIL command) followed by a "high" state until the next command.

Binning: The binning mode of the camera is set via the BIN command. There are five valid arguments to this command {11, 21, 22, 44, 88}. When one of these commands is issued by the host-side software, the mode control bits are set as shown in the table for 2µsec. The mode control bits then revert to the setting (1 x x x) just prior to the binning command.

Command Code	Description	Frame Size	Frame Rate
BIN 11	1 x 1 binning	1300(H) x 1030(V)	11.86f/sec (normal mode)
BIN 21	2 x 1 binning	1300(H) x 515(V)	23.63f/sec
BIN 22	2 x 2 binning	650(H) x 515(V)	23.63f/sec
BIN 44	4 x 4 binning	325(H) x 257(V)	41.1f/sec
BIN 88	8 x 8 binning	162(H) x 128(V)	64.9f/sec

Slow scan: The slow-scan mode of the camera is set via the SLW command. There are four valid arguments to this command {01, 02, 04, 08}. When one of these commands is issued by the host-side software, the mode control bits are set as shown in the table for 2µsec. The mode control bits then revert to the setting (1 x x x) just prior to the binning command.

Command Code	Description	Frame Rate
SLW 01	Fast pixel clock divided by 1	12f/sec
SLW 02	Fast pixel clock divided by 2	6f/sec
SLW 04	Fast pixel clock divided by 4	3f/sec
SLW 08	Fast pixel clock divided by 8	1.5f/sec

9.5 SPECIAL COMMANDS

Version: The VER (followed by a carriage return) command queries the camera and returns the characters DVC and a two byte hex code representing a "major revision" and a "minor revision". A typical response to the command VER is DVC6.0.

Camera Type: the CAM command (followed by a carriage return) command queries the camera as to its "type". In versions prior to 6.0, the CAM command (followed by a carriage return) returns one of the following parameters: 1312M (for a DVC-1312 monochrome camera) OR 1312C (for a DVC-1312C color camera).

In version 6.0 and future versions, there are more valid responses to the CAM command, to accommodate the following models:

1312AM
1312AC
1310AM
1310AC

Note: since this is a new command, older versions of the camera will respond to this query with an error msg.

The INT command (followed by a carriage return) command queries the camera as to whether the image-intensifier option (Intensicam) is installed. Note: since this is a new command, older versions of the camera will respond to this query with an error msg. (which should be interpreted as equivalent to "no intensifier installed". Valid responses are 00: no intensifier installed {default} and 01: intensifier installed.

The following commands apply only to intensified cameras:

CMD Code	*Description*	*Range of argument*	*Output signals controlled {default}*
IGN	Intensifier Gain	00 ≤ two digit hex value ≤ FF	Int_Gain DAC {00}
IPO	Intensifier Pulse "ON" Duration	000 ≤ three digit hex value ≤ FFF	SPI Latch {00}
IPD	Intensifier Pulse Delay	00 ≤ two digit hex value ≤ FF	SPI Latch {00}
IMD XYZ	Intensifier mode (see below)	IOF, ION, PON, SON, PEX	INT_PULSE {IOF}
IMD IOF	Turn off intensifier	See below	
IMD ION	Turn on intensifier in Gain mode	See below	INT_PULSE {LOW}
IMD PON	Turn on intensifier in Pulse mode	uses IPO & IPD; see below	INT_PULSE {HIGH}

9.5.1 Intensifier Control

The luminous gain of Intensifier tube is controlled in a log-linear fashion via the serial port (IGN parameter). The intensifier may also be gated to provide duty-cycle control of its "on" time--the gating is internally derived but controlled via the serial port (IPO and IPD parameters) in several different modes (set by the IMD parameter).

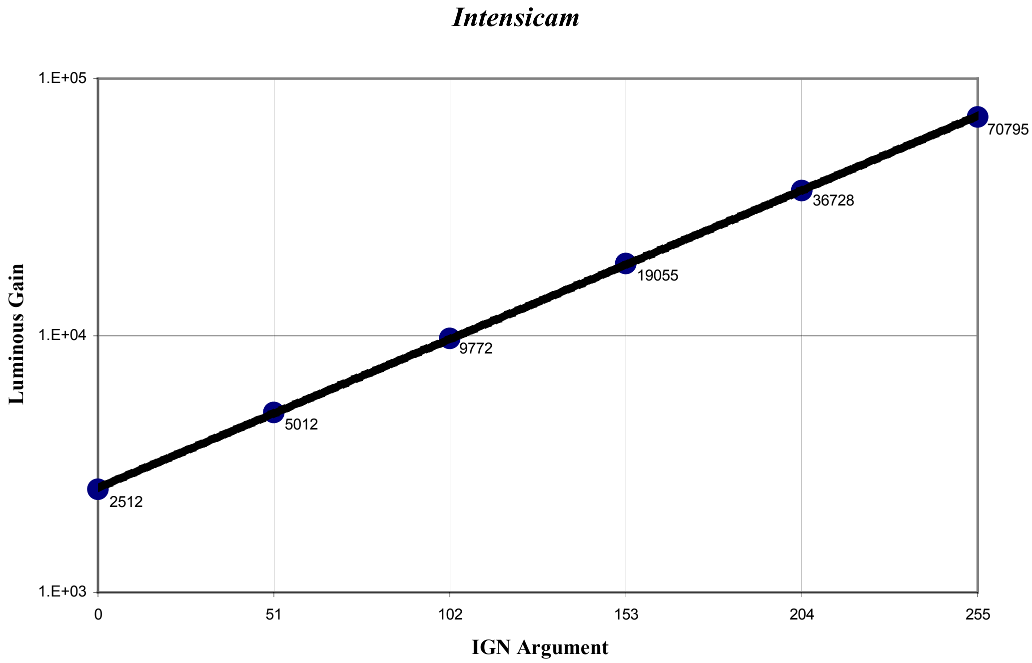


Figure 9.5-1: Luminous Gain versus IGN Argument

9.5.2 Notes on Intensifier Operation

CAUTION: Do NOT point the intensifier at bright lights or permanent damage to the intensifier tube may result.

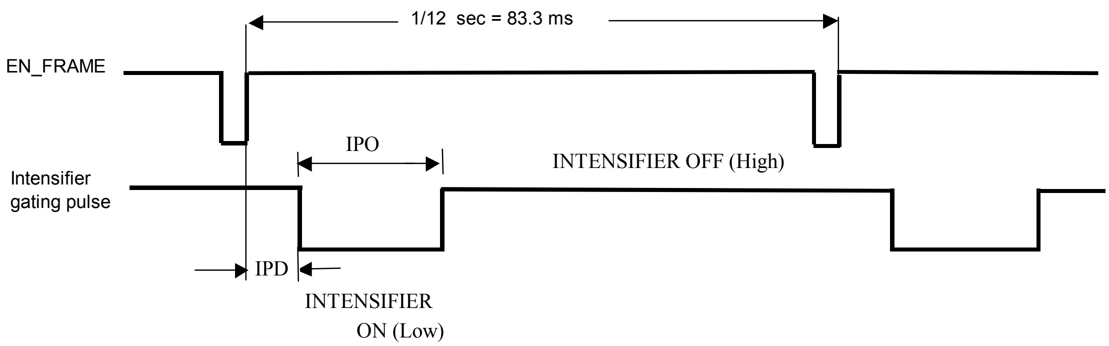
- The INT_PULSE (which is a camera-internal signal) controls the intensifier gate and follows negative logic, i.e. the Intensifier is "off" when this pulse is HIGH; the Intensifier is "on" when this pulse is LOW. This pulse is used under software control either to control the "duty cycle" of the Intensifier (IMD PON or IMD SON) or to protect the Intensifier against “photon overload” damage by gating it OFF (IMD IOF).

- The power on default setting of the INT_PULSE is HIGH. This will ensure that on power-up all light to the camera is cut-off. This protects the Intensifier, since it is quite likely that a user may power up the camera before connecting the cable required to view an image and may accidentally cause damage to the Intensifier by pointing to a bright source of light. Software will have to be enabled to turn on the intensifier, by using the ION command (see below), or others. Some apps will do this on "connect" others may follow a more elaborate process, asking the user to "enable" the intensifier.

- Command "IMD IOF": sets the INT_PULSE to be always HIGH; this will turn OFF the Intensifier. It is recommended that the application sets the Intensifier to this state prior to disconnecting or terminating operation. This is also the power-on default mode.

- Command "IMD ION": sets the INT_PULSE to be always LOW; this will set the Intensifier in the ON state, allowing its gain to be adjusted using the IGN command. Pulse control of the Intensifier gate is not possible in this mode. IPO and IPD settings are ignored.

- Intensifier Gate Control Pulse Command "IMD PON" and "IMD SON": Sets the Intensifier in the pulse mode; toggling the signal INT_PULSE once per frame, with a delay IPD (from the falling edge of ENF) and low duration IPO.



- IPO parameter range in IMD PON mode: range is from 10us to 10ms, with 10us increments requiring a three digit hex argument ranging from 000(10us) to FFF (10ms).

- IPO parameter range (in IMD SON mode) Intensifier gating pulses will be generated from (50ns, 100ns, 150ns…204.8µs) depending on IPO parameter (same three digit Hex from 000 to FFF, but now with a 50ns increment).

- IPD (In both IMD PON and IMD SON modes): range is from 50ns to 10µs, with 50ns increments requiring a two digit hex argument from 00(50ns) to FE(10µs). Note: FF is not valid.

- Application software developers are advised to send out the IMD IOF command before exiting (or disconnecting) the app. program, to protect the Intensifier at times when it isn't being used to make an image.

- Applications may be developed to add "Auto" features, such as AutoBrite (CView terminology). Also AutoShut (which will quickly shut off the intensifier under overbright conditions, then attempt to gradually increase IPO to 10µs, 20µs, 30µs pulses) while monitoring the image intensity level.

- IMD PEX (Intensifier mode: External Pulse), which will tristate the camera-internal pulse, allowing the user to drive the Intensifier gate. IPO and IPD values are ignored. An “auxiliary connector” is provided which allows the user to feed the pulse VRST_INT from an external source (see Appendix for details).

9.6 COMMAND SUMMARY

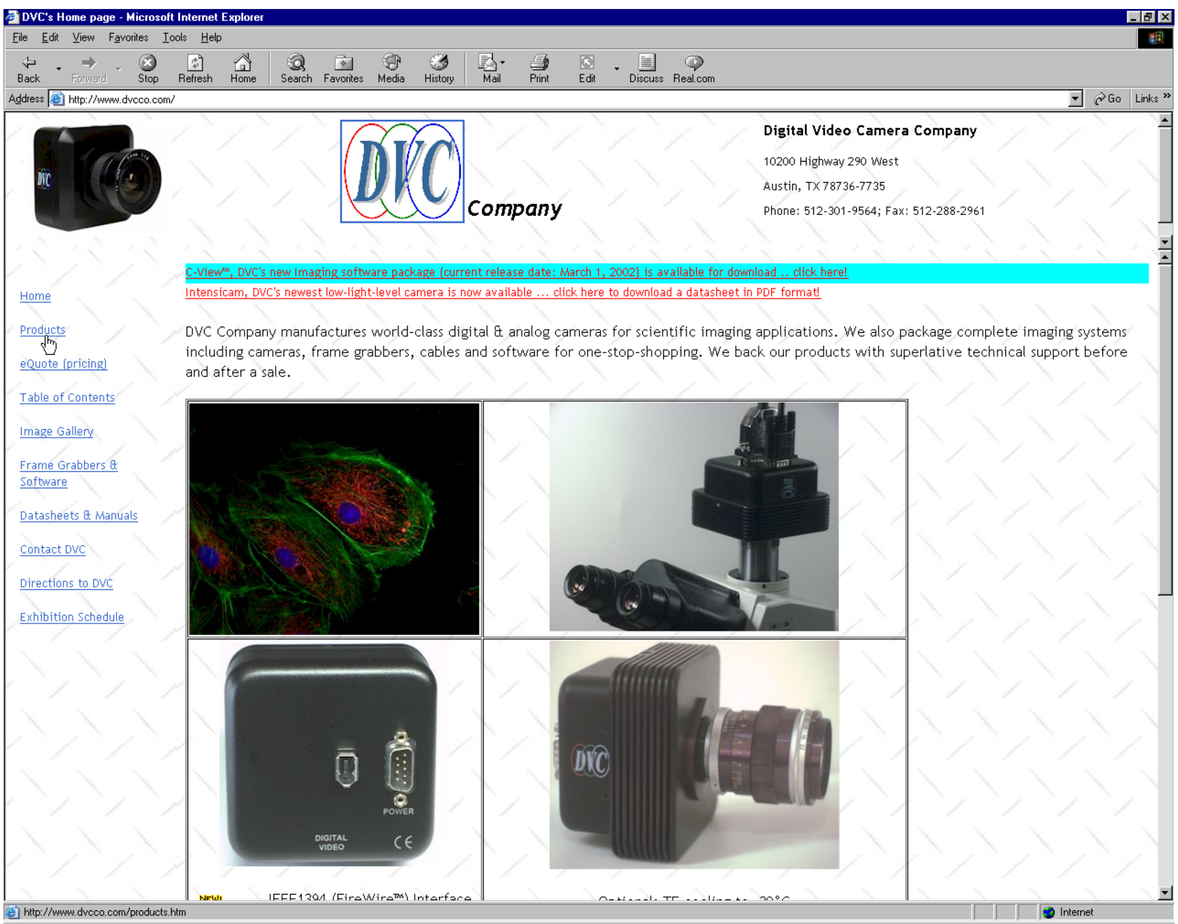
CMD code	Description	Range of arguments (all other arguments will result in an error msg.)	Output signals controlled {default}
MDE	Mode	See table	MC[3:0] {NOR}
GAI	Gain control (0-to-3VDC)	00 ≤ two digit hex value ≤ 9A	Gain {29}
OFS	Offset control (0-to-3VDC)	00 ≤ two digit hex value ≤ 9A	Offset {see section 4.0}
BIN	Binning mode	11, 21, 22, 44, 88	MC[3:0] {11}
SLW	Slow scan mode	01, 02, 04, 08	MC[3:0] {01}
EXP	Exposure in hi-spd shutter modes Exposure in NFR mode Exposure in ULT mode	000 ≤ three digit hex value ≤ 414 000 ≤ three digit hex value ≤ 7FF 000 ≤ three digit hex value ≤ 7FF	DB[10:0]] {200} DB[10:0] {00C} DB[10:0] {001}
TIL	Low duration of VRST_INT; 50ms to 10sec in 50ms increments	01 ≤ two digit hex value ≤ C8	VRST_INT (in PDI, PDP modes) {14}
TIH	High duration of VRST_INT; 50ms to 10sec in 50ms increments	01 ≤ two digit hex value ≤ C8	VRST_INT (in PDP mode) {14}
HRT	Hardware reset, 100µsec low on VRST_INT	No arguments (see “section 5.0)	VRST_INT
RST	Software reset to default values	No arguments (see “section 5.0)	All
VER	Version request	No arguments (see “section 5.0)	None
INT	Intensifier query (see section 5.0 for more Intensifier commands)	No arguments (see “section 5.0)	None
ALL	Modify all camera parameters	TBD	TBD
CAM	Camera Type Query	No arguments (see “section 5.0)	None
STA	Status request	No arguments (see “section 5.0)	None

10 INFORMATION AND SUPPORT RESOURCES

You can obtain product information at http://www.dvcco.com
For tech support, please contact DVC at (512)-301-9564 or e-mail eng@dvcco.com
Our mailing address is the following:
DVC Company
10200 Highway 290 West
Austin, TX 78736

Our address in Europe is the following:
DVC Europe
12, Kingswood Court
Maidenhead, Berks SL6 1DD, England
Phone: +44-1628 625342; Fax: +44-1628 625485

Please obtain the most current information from DVC's website at http://www.dvcco.com



11 APPENDIX

11.1 APPENDIX A: MECHANICAL DIMENSIONS DIAGRAM

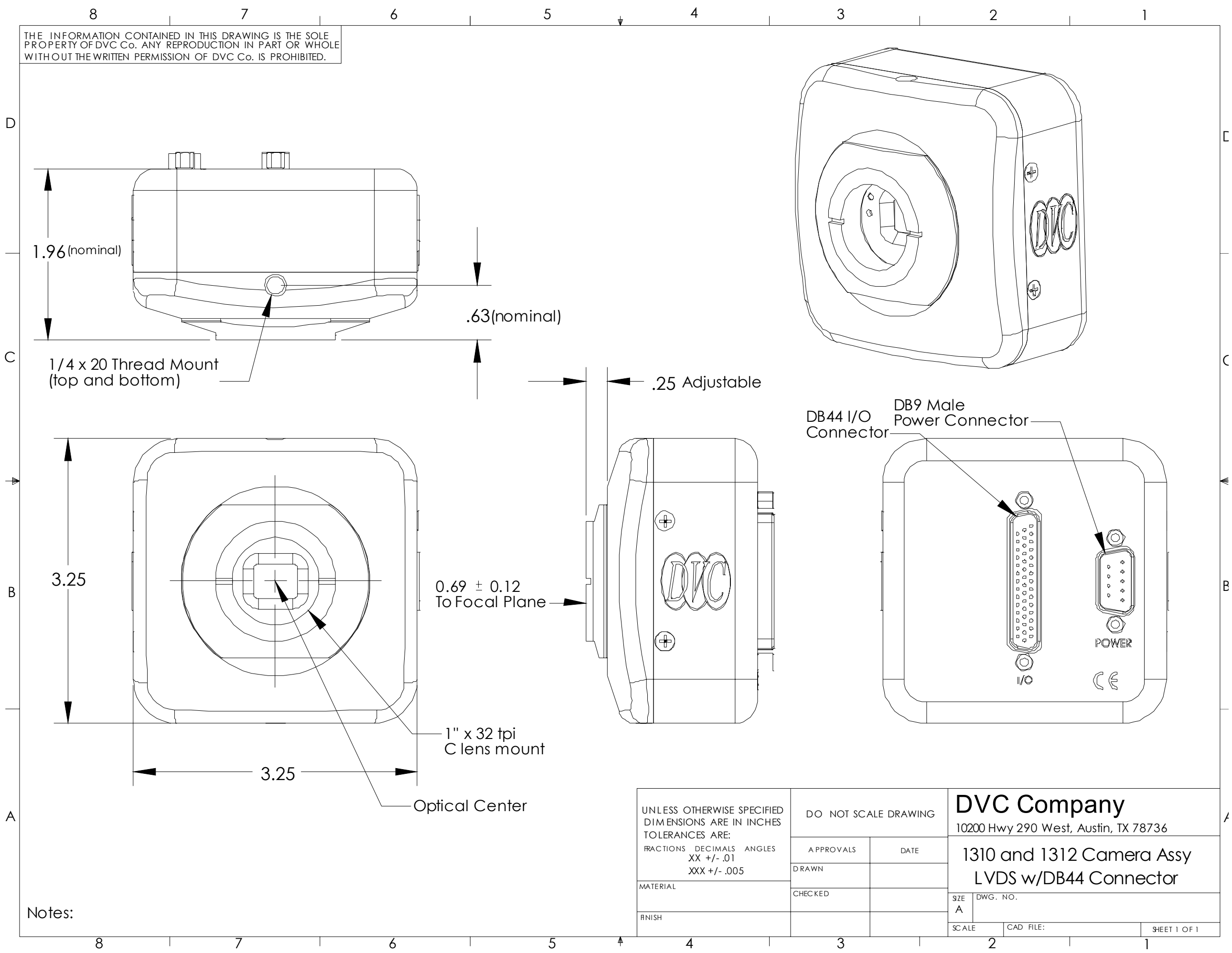


Figure 11.1-1: 1310 and 1312 with LVDS connector

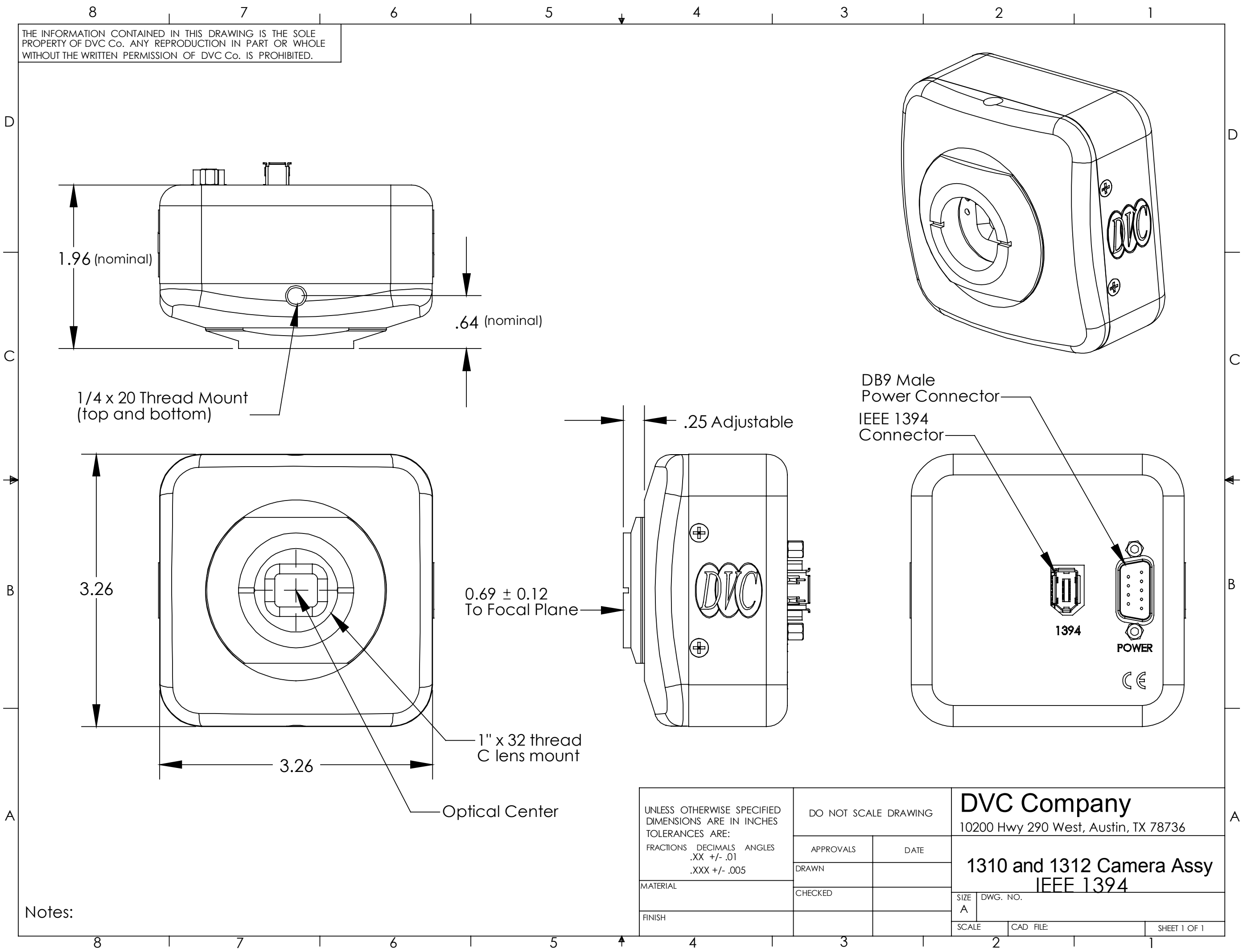


Figure 11.1-2: 1310 and 1312 Camera with 1394 Connector

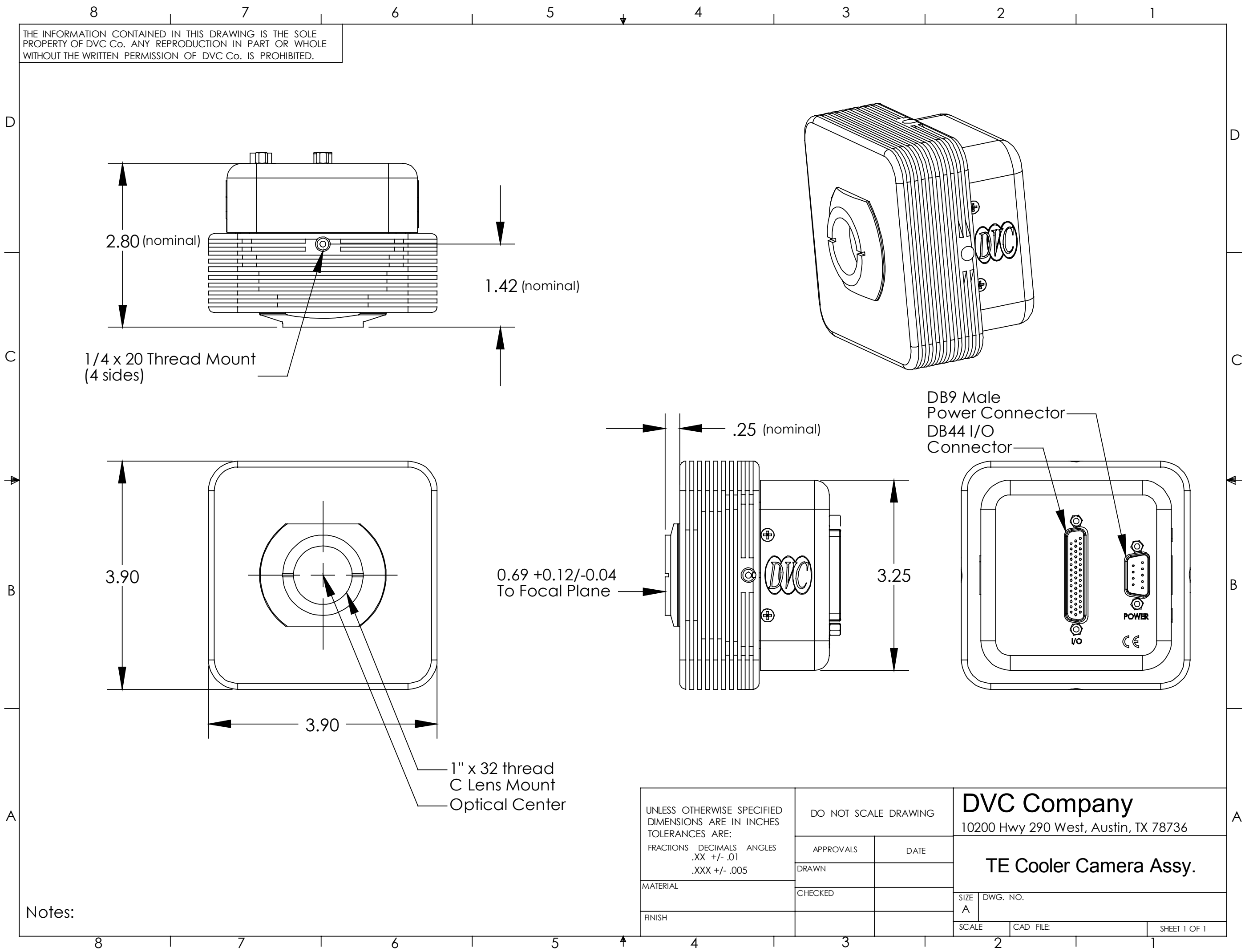


Figure 11.1-3: TE Cooler Camera

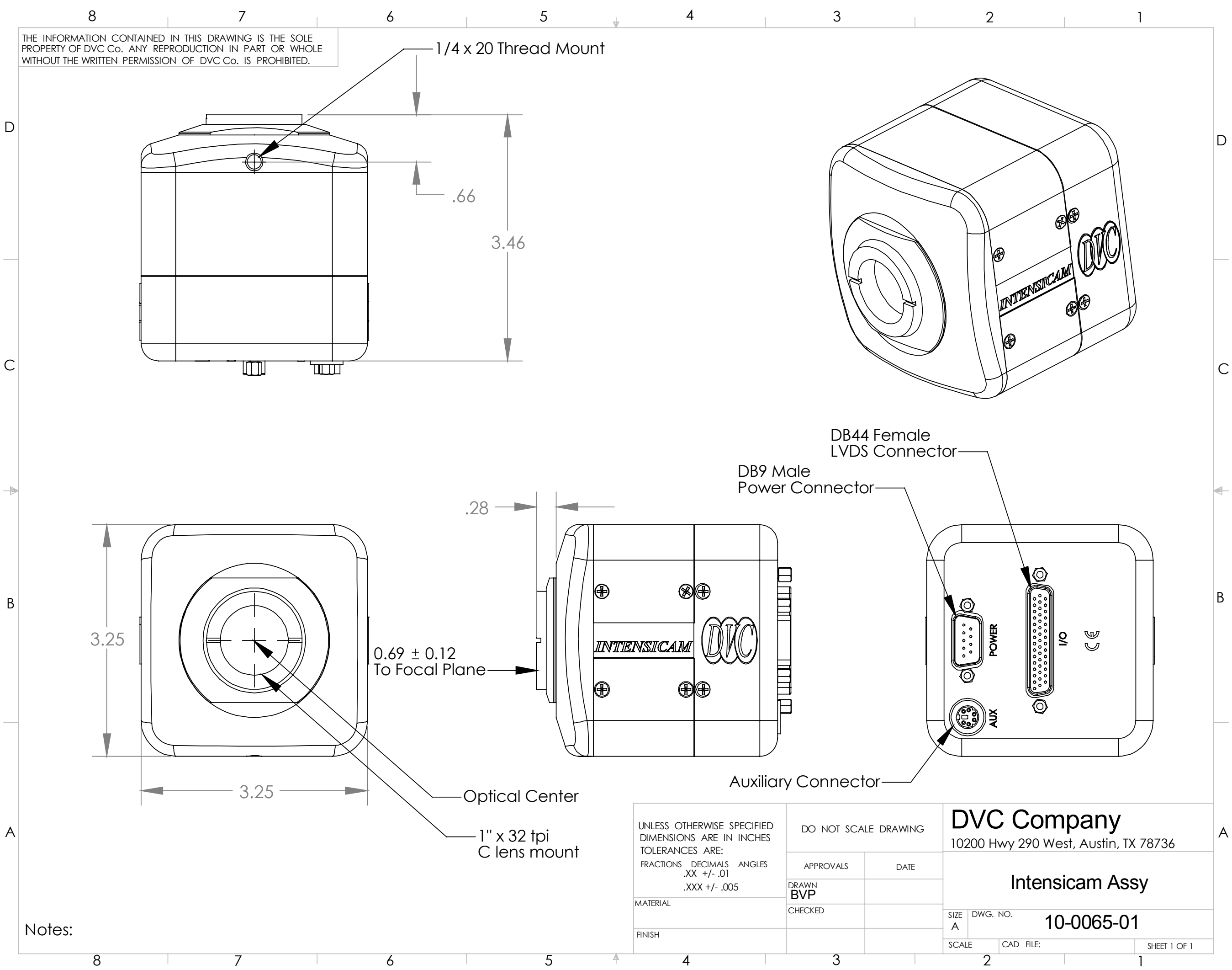


Figure 11.1-4: Image Intensifier Camera

11.2 APPENDIX B: CABLE DRAWINGS

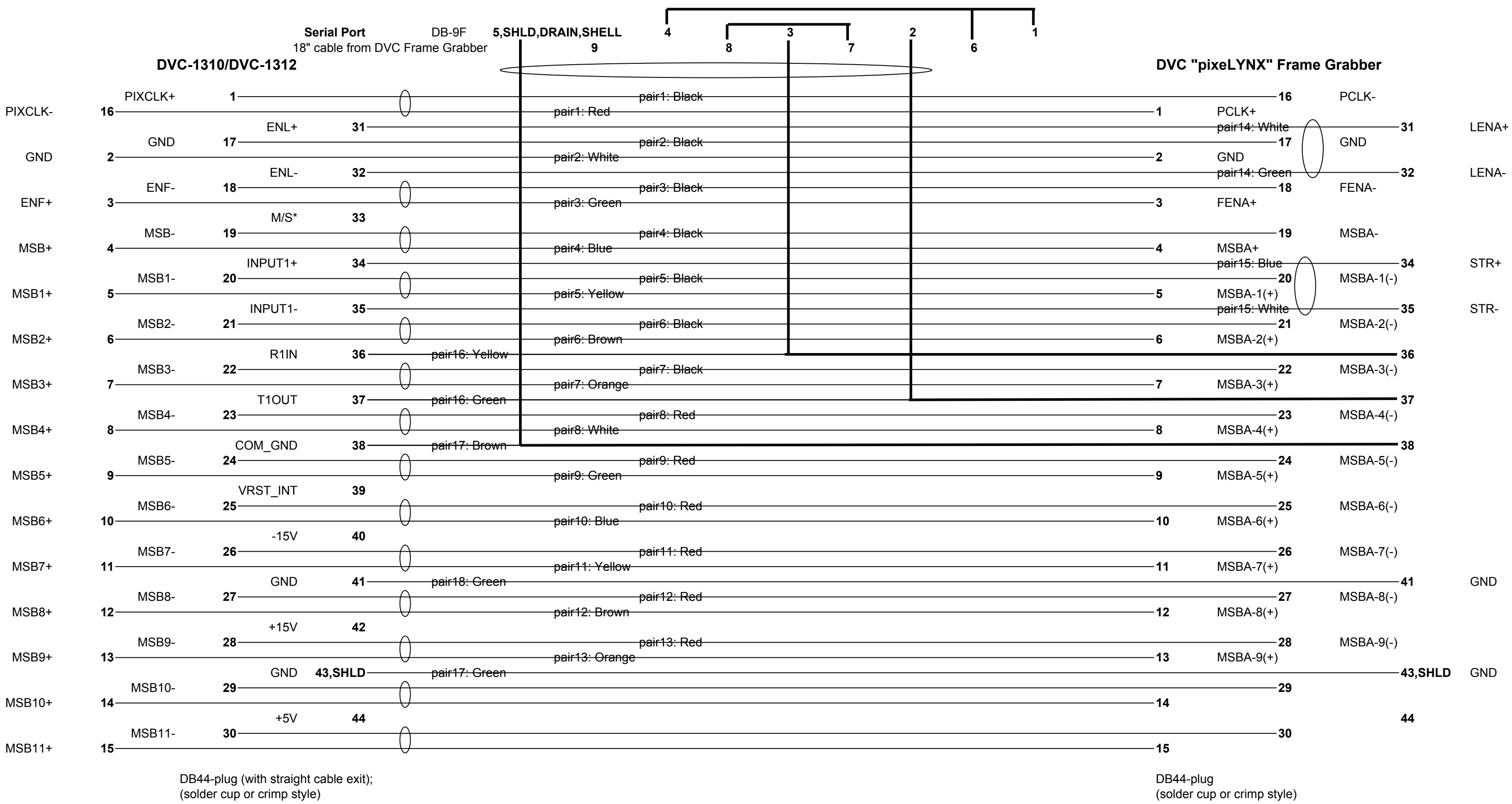


Figure 11.2-1: DVC-1312-to-pixeLNYX cable

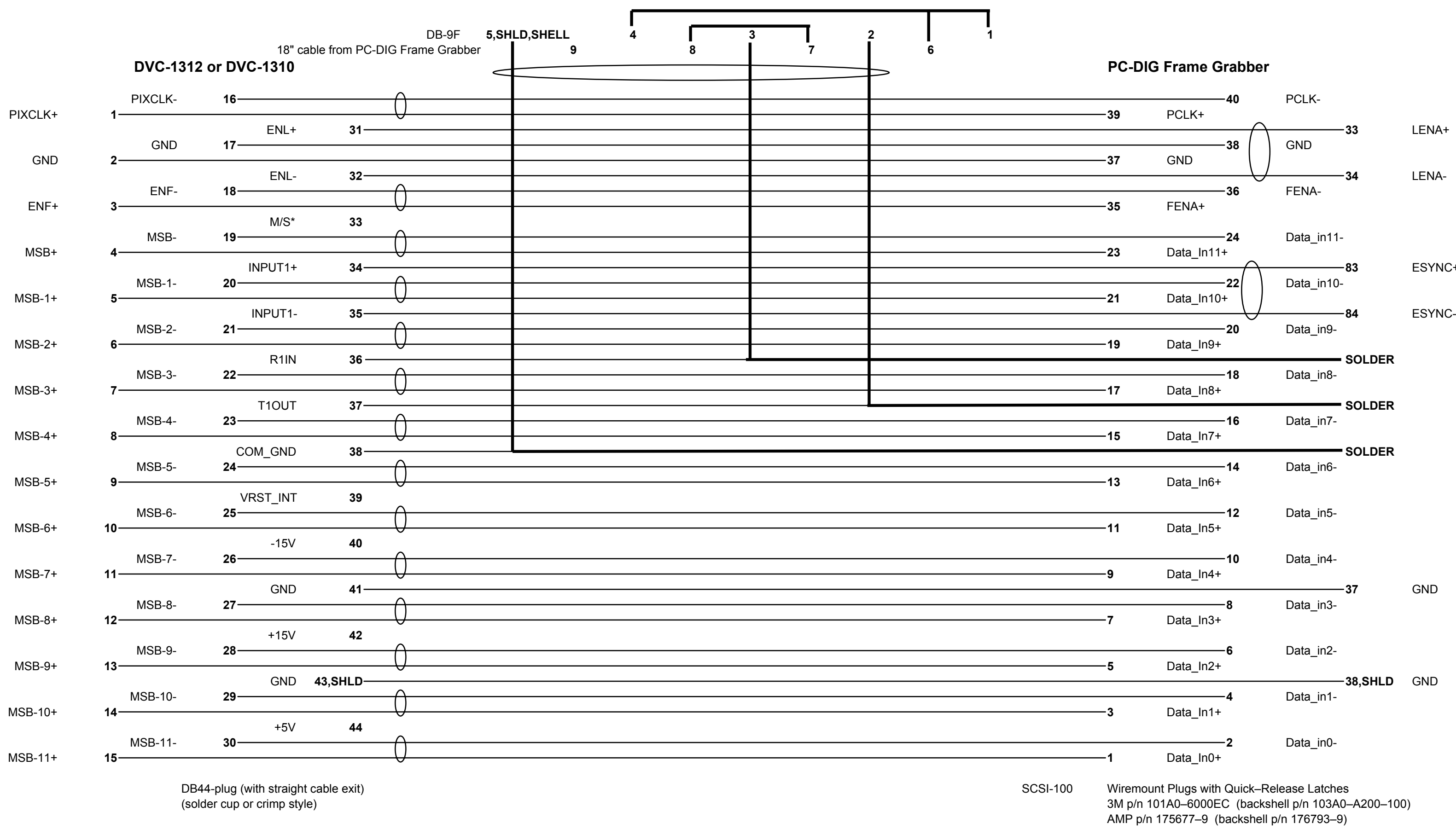


Figure 11.2-2: DVC-1312-to-PIXCI-D cable

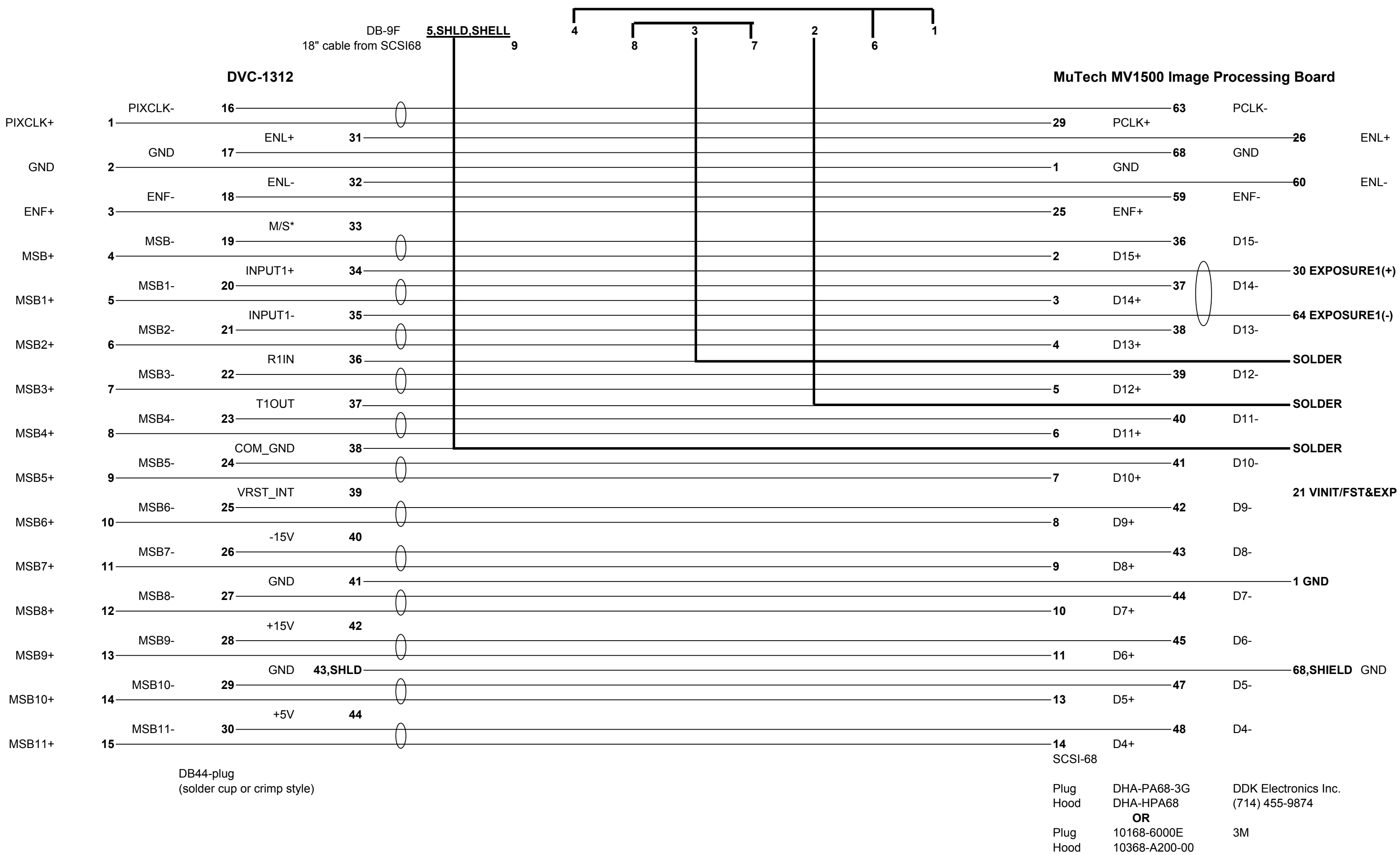


Figure 11.2-3: DVC-1312-MV1500 cable

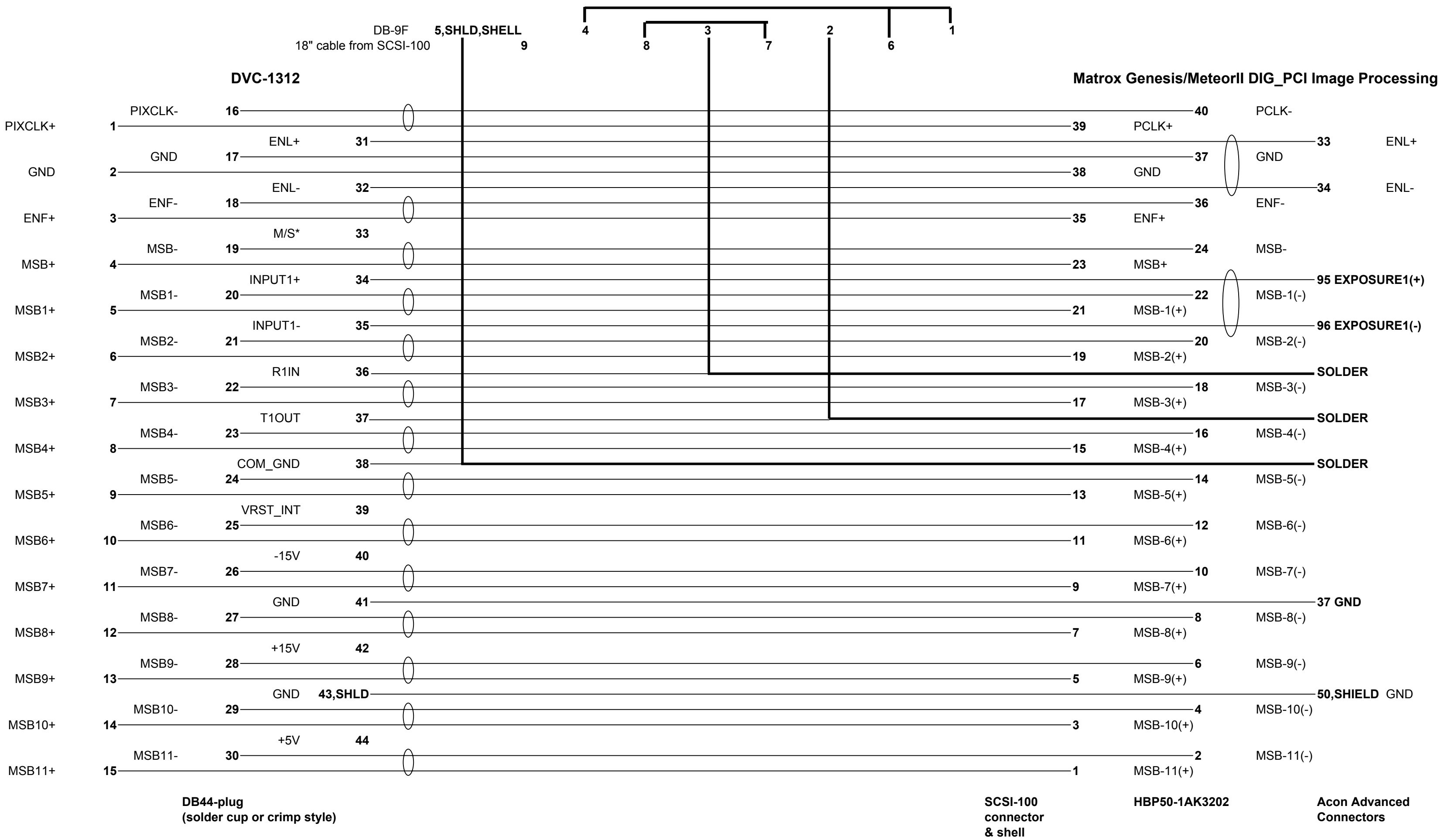


Figure 11.2-4: DVC-1312-to-Matrox Meteor II DIG (PCI) cable

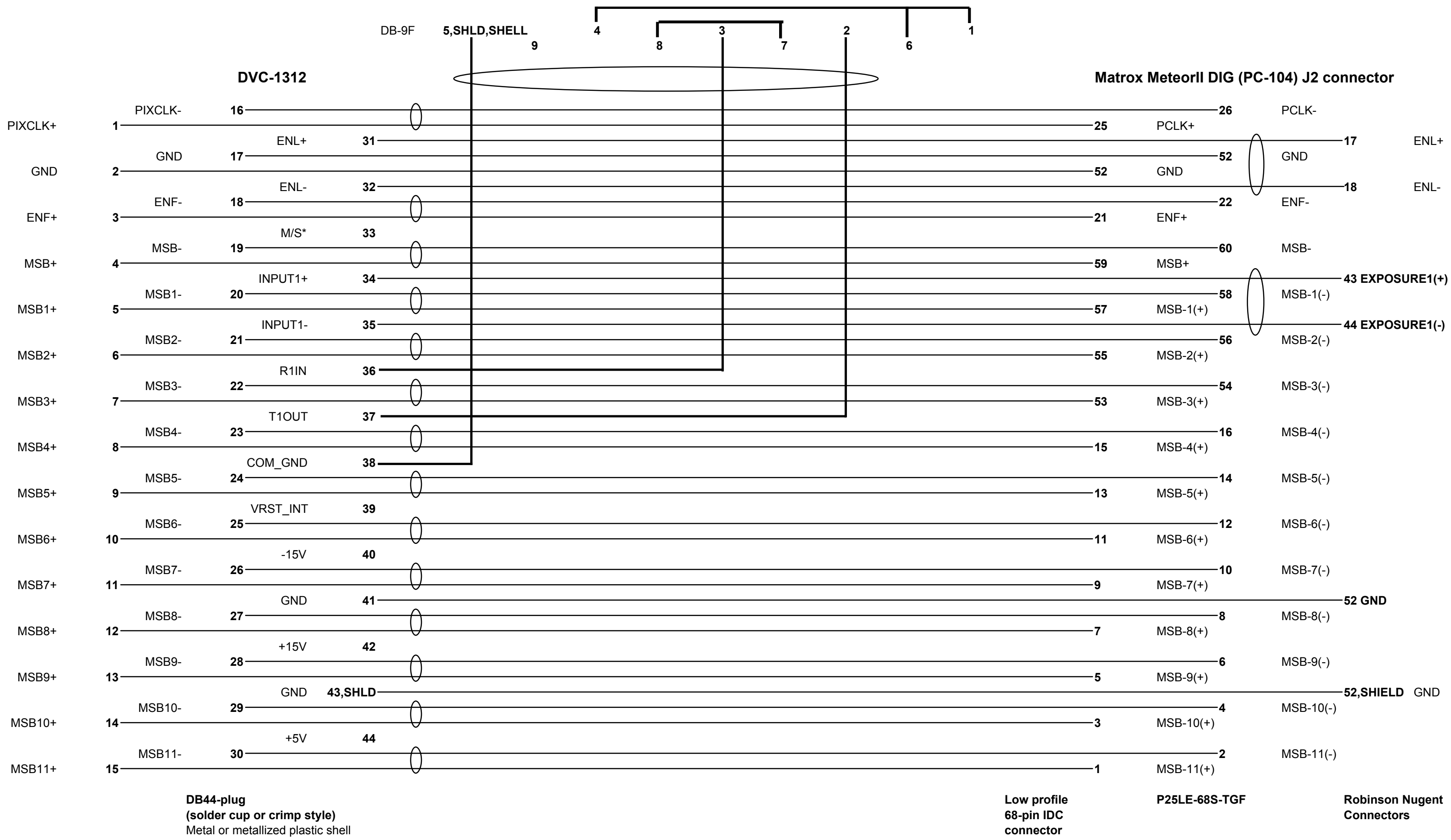


Figure 11.2-5: DVC-1312-to-Matrox II DIG_PC104 cable

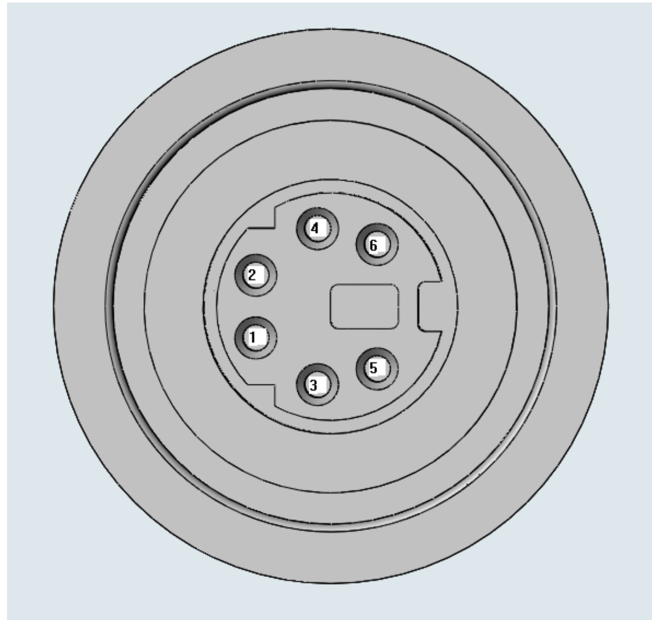
11.3 APPENDIX C: DVC-1312 CAMERA CONNECTORS

Figure 11.3-1: Camera rear view showing connector pin numbers (LVDS connections shown)

11.3.1 Auxiliary Connector

pin# Signal

----
1 HD (O)
2 INPUT1 (O)
3 VRST_INT (I)
4 GND
5 EN_FRAME (O)
6 STROBE/INT-PULSE (O)



Connector Name	On Camera	Interface Cable
Power Supply Connector	DB9M	DB9F; e.g. AMP P/N: 205203-1 with 66504-3 pins
Digital Video Connector	DB44F	DB44M; e.g. AMP P/N: 748366-1 with 748333-2 pins
Auxiliary Connector	Mini-Din-6 receptacle	Mini-Din Male; e.g. AMP P/N 750329-2

Table 11.3-1: Camera connector information

Pin No.	Signal Name	Signal Name	Pin No.
6	GND	+5VOLTS DC	1
7	STROBE (TTL)	RESERVED	2
8	GND	-15VOLTS DC	3
9	HD (TTL)	VD (TTL)	4
		+15VOLTS DC	5

Table 11.3-2: Power supply connector pinout

Pin no.	Signal	Pin no.	Signal	Pin no.	Signal
		16	PIXCLK-		
1	PIXCLK+			31	ENL+
		17	GND		
2	GND			32	ENL-
		18	ENF-		
3	ENF+			33	Not used
		19	MSB-		
4	MSB+			34	INPUT1+
		20	(MSB-1)-		
5	(MSB-1)+			35	INPUT1-
		21	(MSB-2)-		
6	(MSB-2)+			36	R1 IN
		22	(MSB-3)-		
7	(MSB-3)+			37	T1 OUT
		23	(MSB-4)-		
8	(MSB-4)+			38	COM GND
		24	(MSB-5)-		
9	(MSB-5)+			39	VRST_INT
		25	(MSB-6)-		
10	(MSB-6)+			40	Reserved
		26	(MSB-7)-		
11	(MSB-7)+			41	GND
		27	(MSB-8)-		
12	(MSB-8)+			42	Reserved
		28	(MSB-9)-		
13	(MSB-9)+			43	GND
		29	(MSB-10)-		
14	(MSB-10)+			44	Reserved
		30	(MSB-11)-		
15	(MSB-11)+				

Table 11.3-3: LVDS Digital video connector pinout

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