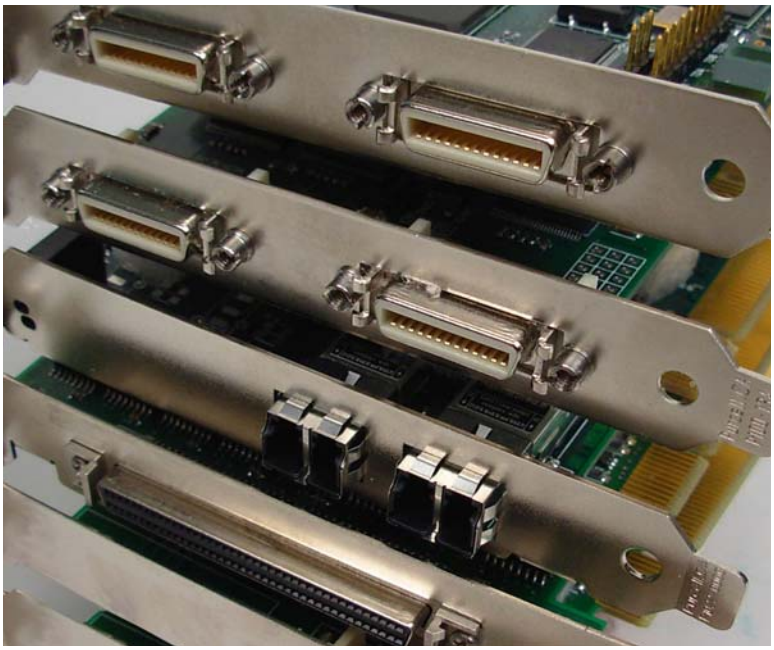
User's Guide

Camera Link PCI Express (PCIe) Gen1 Frame Grabbers



High-speed image capture for Camera Link on PCIe platforms

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Camera Link PCIe DV/DVa Frame Grabbers

Camera Link PCIe DV/DVa Frame Grabbers

Overview

This guide covers current and legacy EDT Camera Link PCI Express (PCIe) Gen1 frame grabbers, which provide fast image capture and DMA between an external Camera Link camera and a host computer.

Current products in this group are called the “DVa” series. This series includes:

PCIe8 DVa C-Link	Current standard frame grabber for PCIe Gen1 (x8)
PCIe4 DVa C-Link	Current standard frame grabber for PCIe Gen1 (x4)
PCIe4 DVa FOX	Current fiber-optic frame grabber for PCIe Gen1 (x4)

Legacy products in this group are called the “DV” (with no “a”) series. This series includes:

PCIe8 DV C-Link	Legacy standard frame grabber for PCIe Gen1 (x8)
PCIe4 DV C-Link	Legacy standard frame grabber for PCIe Gen1 (x4)

Companion products to the above (not covered in this guide – see Related Resources on page 8) include:

EDT simulators	Example: PCIe8 DVa CLS – for simulation of Camera Link image data
EDT fiber extenders	Example: RCX C-Link – to extend Camera Link 100+ kilometers over fiber
EDT coax extenders	Example: RCX C-Link Coax2 – to extend Camera Link 600 feet over coax

Included Files

For the products covered in this guide, your EDT installation package includes device drivers for supported operating systems, as well as source code and binaries for:

- GUI capture and display application (`pdvshow`)
- Standalone initialization applications (`initcam, camconfig`)
- Command-line capture and display applications (`take, simple_take, simplest_take, simple_*`)
- Command-line serial communication tool (`serial_cmd`)
- Diagnostic tools (`pciload, dvinfo, pdb`)
- API libraries (`libpdv, libedt,` and associated source files)
- Makefiles for Windows (`makefile.nt`) and Linux / Mac OS X (`makefile`)
- Camera configuration files (`camera_config/*.cfg`)
- Board firmware files (`flash/*` directories)

For detailed descriptions of selected programs, see Example and Utility Applications on page 17. For a more comprehensive list of programs, see the `README` file in your EDT installation package. For additional source code and header files, see the EDT library and API (Related Resources on page 8).

Power Over Camera Link (PoCL)

EDT PCIe DVa series frame grabbers support Power Over Camera Link (PoCL) via polyfuse technology using dedicated power.

When your board is shipped, PoCL is disabled. To enable PoCL, use the jumpers provided on the board, as shown in Appendix B: Board Diagrams on page 32.

CAUTION!

To avoid a short (shown by a red LED behind the backpanel, near the affected connector) related to the PoCL jumpers:

- If using a frame grabber (or using a CLS board as a frame grabber) with PoCL enabled, always use PoCL cables and devices, and power off all devices before connecting or disconnecting cables.
- If using a CLS board as a simulator, always disable PoCL.

For details on PoCL pin assignments, see Appendix A: Pin Assignments on page 31.

Related Resources

To find product-specific information that is related to a particular EDT product, go to www.edt.com and open the relevant product page to find links to that product's datasheet (specifications) and user's guide.

To find general technical information that is not related to a particular EDT product (for example, cable pinouts for multiple products), go to www.edt.com and look in Product Documentation.

The resources below may be helpful or necessary for your applications.

EDT Resources

Description	*Detail*	*Web link*
• Documentation for each particular product	Datasheets and user's guides	www.edt.com (find product page)
• User's guide – legacy vision products	PCI products AIA products	" (Product Documentation)
• User's guide – camera configuration (setup)	Camera configuration guide	" (Product Documentation)
• User's guide – firmware (setup)	Firmware guide	" (Product Documentation)
• User's guides for cabling and pinouts	Cabling and pinouts for PCI and PMC	" (Product Documentation)
• Application programming interface (API)	HTML and PDF versions	" (Product Documentation)
• Installation packages (Windows, Linux, and Mac OS X included; others by request	Software / firmware downloads	" (Product Documentation)

Standards / Specifications

Description	*Pertains to*	*Documentation*	*Web link*
• PCI / PCIe	PCI / PCIe bus	PCI Special Interest Group (PCI SIG)	www.pcisig.com
• Camera Link	Camera Link	Vision Online (VO)	www.visiononline.org
• IRIG-B	IRIG-B time code	Inter-Range Instrumentation Group, mod B	irigb.com

Requirements

EDT frame grabbers are high-speed DMA devices that require adequate bandwidth for reliable operation. The requirements will vary by camera (since different cameras run at different speeds), so you should select and configure your camera and system with the proper requirements in mind, as shown in Table 1.

Table 1. Requirements for I/O, bus type, throughput, cabling

	Product name	Input / output	Bus type*	Throughput	Cabling**	OS
Current series	PCIe4 DVa FOX	Camera Link in (over fiber)	PCIe x4	Up to 680 MB/s	Fiber-optic	Windows,
(“DVa”)	PCIe4 DVa C-Link	Camera Link in		Up to 510 MB/s	Camera Link	Linux,
	PCIe8 DVa C-Link		PCIe x8	Up to 1.2 GB/s		Mac OS X
Legacy series	PCIe4 DV C-Link	Camera Link in	PCIe x4	Up to 200 MB/s	Camera Link	(others by
(“DV” – no “a”)	PCIe8 DV C-Link		PCIe x8	Up to 1.2 GB/s		request)

* For bus type, follow these recommendations for optimal performance:

- Typically, these products will **not** work in a a bus slot dedicated to graphics cards.
- Typically, these products will work in a bus slot with more lanes than the number specified here, but not in a bus slot with fewer.
- Typically, although these products will work in a bus slot newer than PCIe Gen1 (such as PCIe Gen2 or Gen3), the resulting performance still will not exceed Gen1 specifications.

For details on requirements and bandwidth issues, see Problems With Bandwidth on page 28.

**Cabling (standard or PoCL, as required) can be from EDT or a third party. For further documentation on cabling and pins, see Related Resources on page 8 and Appendix A: Pin Assignments on page 31.

Installation

For Camera Link PCIe framegrabbers, EDT currently provides installation packages for these operating systems (OS):

- Windows
- Linux
- Mac OS X

NOTE For other operating systems, contact EDT or, for details on VxWorks, see Appendix D: VxWorks or go to www.edt.com/support.html.

To install your Camera Link PCIe framegrabber:

1. Uninstall any previously installed EDT installation packages.
2. To ensure you are using the latest possible installation package while avoiding version compatibility issues, do one of the following:
   — For a new application, download the latest package from the EDT installation disk (included with the product), or from www.edt.com (see Related Resources on page 8).
   — For any application running third-party software, use the version of the EDT installation package with which the software was built, or recompile / relink the application with the latest package (see Related Resources on page 8).
3. Follow the installation instructions from your camera manufacturer and your host computer manufacturer.
4. Connect the product, using the cabling specified in Requirements on page 9.
5. To verify that the driver is installed and the board is recognized, run `pciload` from the command line (for details, see Example and Utility Applications on page 17).

Application Programming Interface (API)

EDT provides a common application programming interface (API) for all supported operating systems, so an application written for one EDT product is designed to work with other EDT products with minimal modification; any exceptions – such as for various operating systems – are noted in this guide.

NOTE To interface to the Camera Link PCIe board, use subroutines from the EDT digital imaging library and, if necessary, from the EDT DMA library; routines in both libraries are documented in the EDT API.

— The EDT digital imaging library provides a C language interface to your Camera Link PCIe board, and it also handles error recovery, bookkeeping, and camera shutter triggering and timing. EDT recommends using it for all programming specific to Camera Link PCIe products.

— The lower-level EDT DMA library `edt_` subroutines should be accessed directly only when they provide needed functionality that is not provided in the EDT digital imaging library.

All of these resources are provided in your EDT installation package (see Related Resources on page 8).

Building or Rebuilding an Application

EDT's installation package includes C source and executables for all of the provided examples, diagnostics, and utilities.

NOTE Applications which access EDT boards must be compiled and linked to match the platform in use (32- or 64-bit). Applications linked with 32-bit EDT libraries will not run correctly on 64-bit systems, or vice versa. The EDT driver / software installation script detects whether the system is running 32- or 64-bit, and installs the appropriate files.

To build or rebuild a program, follow the steps below.

1. Verify that you have an appropriate compiler installed:
   - In Windows, use a C compiler (we recommend Microsoft Visual C compiler) or, to use the Linux `gcc` compiler, contact EDT.
   - In Linux, use the `gcc` compiler (typically included in the Linux installation).
2. Using the above compiler, do one of the following:
   - In Windows, run *Pcd Utilities* and enter...

     `nmake` *`file`*

     ...replacing *`file`* with the name of the example program you wish to build.
   - In Linux or Mac OS X, in a terminal window, navigate to the installation directory (by default, `/opt/EDTpcd`) and enter...

     `make` *`file`*

     ...replacing *`file`* with the name of the example program you wish to build.
3. To rebuild the examples, utilities, and diagnostics, do one of the following:
   - In Windows, navigate to the installation directory (by default, `C:\EDT\pcd`) and run...

     `nmake`

     ...for Visual Studio 6.0 or later – or use the Visual Studio 2008 projects and solutions in `projects.vs2008`.
   - For Linux, navigate to the installation directory (by default, `/opt/EDTpcd`) and run...

     `make`
4. After the build is complete, use the `--help` command line option to display usage options and descriptions.

Setting the Camera Model

After installing the board and its driver, configure it for the camera you will use.

Your EDT installation package provides example configuration files for various camera models; if no file is provided for your camera, or if you wish to modify the directives of an existing configuration file, consult the EDT Camera Configuration Guide (see Related Resources on page 8).

NOTE For a medium- or full-mode camera, you may need to first reprogram the flash memory for medium- or full-mode operation. For details, see Table 4 on page 24.

Next, initialize (configure) the driver for your camera model, using one of the methods in Table 2.

Table 2. Initialization Methods by Operating System

OS	PdvShow	Command line

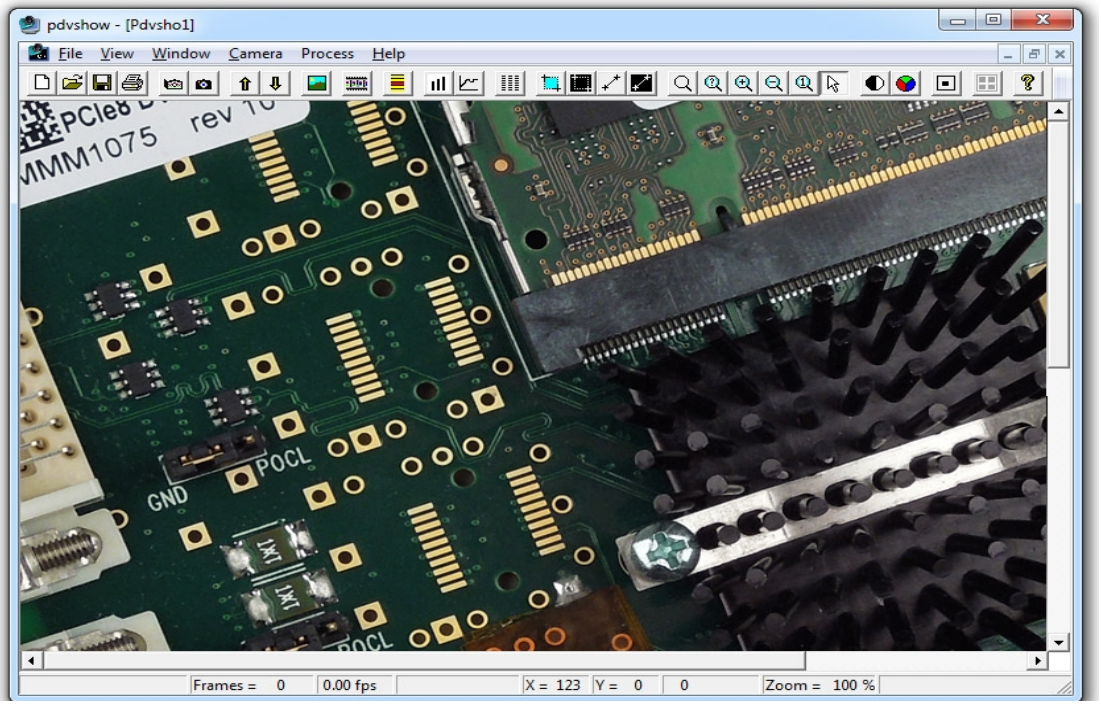
Windows	To configure the driver for your camera:
	1. Double-click the *PdvShow* desktop icon.
	2. In dialog box, select your camera model.
	3. Click *OK*.
	
	To reconfigure for a different camera or operating mode:
	1. Double-click the *PdvShow* desktop icon.
	2. Execute *Camera > Setup*.
	3. In dialog box, select your camera model.
	4. Click *OK*.
		Use the `initcam` utility. At a command prompt, enter...
		`initcam -f camera_config/file.cfg`
		...where *file* is the name of the camera configuration file that matches your camera model and operating mode.
		This utility optionally lets you specify a unit (`-u` flag) and DMA channel (`-c` flag). Thus, if you wish to configure the camera on DMA channel 1, but not the camera on DMA channel 0, enter...
		`initcam -u camera_config/file.cfg`
		`initcam -u 0 -c 1 -f camera_config/file.cfg`
		See the application `initcam` (in this guide) and the Camera Configuration Guide (Related Resources).

Linux or Mac OS X	To configure the driver for your camera: 1. Navigate to the installation directory... `/opt/EDTpdv`. 2. At the prompt, enter... `camconfig` 3. In dialog box, select your camera model. 4. Click *OK*. To reconfigure for a different camera model or operating mode, rerun `camconfig`.	Follow the above procedure for Windows. NOTE: If you do not have "." in your path, you'll need to precede commands with "`./`" as in the example below. Example: `./initcam -f camera_config/file.cfg`
VxWorks	See Appendix D: VxWorks or www.edt.com/support.html, or contact EDT.	
Other	Contact EDT.	

Image Capture and Display

For capturing and displaying images, your EDT software contains a GUI in an application called *PdvShow*. The Windows version of this GUI is shown in Figure 1.

Figure 1. Windows GUI for *PdvShow*



Running PdvShow

To run *PdvShow*...

- For Windows, double-click the *PdvShow* desktop icon, or enter `pdvshow` at a command-line prompt.
- For Linux, run `make pdvshow` to build the FLTK application, and then enter `pdvshow` at the prompt.
- For Mac OS X, there is no *PdvShow*, but you can experiment by exploring this user's guide and the `pdv_flshow` subdirectory of the main distribution directory (by default, `/opt/EDTpdv`).

The command-line invocation allows you to specify options – for example...

```
pdvshow -pdvU_C
```

...where *U* is the unit number (useful if you have more than one Camera Link PCIe device) and *C* is the DMA channel number for multichannel devices. For example...

```
pdvshow -pdv0_1
```

...runs *PdvShow* using board 0, DMA channel 1. This is useful if, for example, you are using one board with two base-mode cameras, and you want *PdvShow* to access the camera on DMA channel 1.

NOTE In Windows, the command line is a property of the icon.To use an icon to access a unit or DMA channel other than 0 (the default): copy and rename the *PdvShow* icon; then change its shortcut properties to use the command line with the option `-pdvU_C` where *U* is the unit and *C* is the DMA channel.

For demonstration or debugging purposes, you can run this application when no board is installed in the system; the image window then shows a test pattern. To do so, at the command line, enter...

```
initcam -u dmy0 -f configuration_file
pdvshow -dmy0
```

If you have not yet initialized the driver, select your camera or simulator from the list and click *OK*.

If the image window shows incorrect data (usually because the camera model has been changed since the last driver initialization), select *Camera* > *Setup* and choose the correct camera model.

To access camera controls, use the *PdvShow* toolbar and menus. For details, see *PdvShow Help*.

Compiling PdvShow

To experiment with example code in this application, use the source code indicated below.

- For Windows, look in `pdvshow` in the appropriate Visual Studio project subfolder. For details, see the `README` file in the `pdvshow` subfolder of the main distribution folder (by default, `C:\EDT\Pdv`).

NOTE The `pdvshow` executable comes already built on Windows distributions, so you need not compile it unless you wish to experiment with the source code.

- For Linux, see the source code and the `README` file in the `pdv_flshow` subdirectory of the main distribution directory (by default, `/opt/EDTpdv`).
- For Mac OS X, there is no *PdvShow*, but you can experiment by exploring the information in this guide.

For more about the cross-platform FLTK-based version of *PdvShow*, see `README` in the `pdv_flshow` subdirectory of the main distribution directory (by default, `/opt/EDTpdv`).

If the open-source FTLK library (required by `pdv_flshow`) is not installed, `make pdvshow` will try to install it. If the installation fails, you will need to install FLTK 1.1.9 by hand.

To install FLTK 1.1.9:

1. In `pdv_flshow`, open `fltk-1.1.9-source.tar.gz` and run...

   ```
   gunzip fltk-1.1.9-source.tar.gz
   tar –xf fltk-1.1.9-source.tar
   ```

   ...to install `fltk-1.1.9`.

2. In `fltk-1.1.9`, run...

   ```
   make
   make install
   ```

3. In `pdv_flshow`, run...

   ```
   make pdvshow
   ```

Units, Connectors, and Channels

This section covers how to work with multiple units, connectors, and channels, which are defined as follows:

unit	EDT product (board)
connector	physical connector (for example, a fiber-optic or MDR26 connector)
channel	DMA channel or, sometimes, simulation channel

Typically, an EDT Camera Link (C-Link) board has two MDR26 connectors and one simulation channel, while an EDT fiber-optic (FOX) board has one to four fiber-optic connectors with no simulation channel.

In base mode, each camera requires one connector on the EDT board, and each connector provides one DMA channel. Thus, in base mode, an EDT frame grabber with two connectors has two DMA channels.

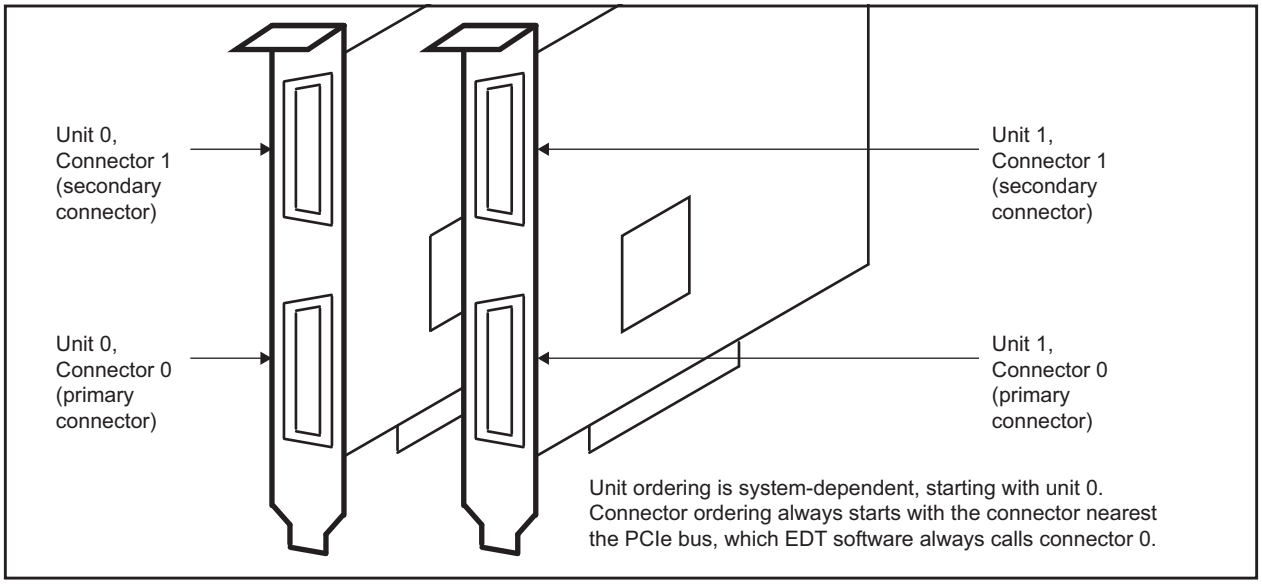
In medium or full mode, each camera requires two connectors on the EDT board. In this case, the two connectors work together to support one DMA channel.

NOTE In EDT hardware, the connectors are labeled 0 and 1 on some boards, but 1 and 2 on others. Regardless of the labels on the hardware, the software always counts the connectors in order as 0 (primary), 1 (secondary), and so on, with 0 being the connector nearest the PCIe bus.

If you install one board in your host system, the system will assign the default unit number (0) to that board. If you install multiple boards, the system will assign a unique unit number to each board, starting with 0 (the sequence is system-dependent). Typically, the unit number is an argument when invoking an application (such as `take` or `pdvshow`) or a parameter passed into one of the EDT subroutines.

Figure 2 shows an example of how the software enumerates the units (boards) and connectors. The default for the first unit number, connector number, and DMA channel number is always 0, with additional units, connectors, and DMA channels numbered as 1, 2, and so on.

Figure 2. Example of Unit Numbering and Connector Numbering



If you are using multiple EDT boards (units), or multiple connectors on a single EDT board, the software provides a unique handle to represent each unit and connector. Unless you specify something else, any application (either your own or EDT's) seeking access to the devices will default to unit 0, connector 0.

The way that you address the appropriate unit and DMA channel will depend on what you are doing.

- For pdvshow, use the argument `-pdv`*`U_C`*. For details, see Image Capture and Display on page 13.
- For EDT example and utility applications, use the arguments `-u` *`unit`* and `-c` *`channel`* (see Example and Utility Applications).

- For EDT API, use `pdv_open_channel(..., unit, channel)`. For each device, the open routine will return a pointer to the structure that represents the opened device (unit and DMA channel); this pointer appears in EDT examples and documentation as `pdv_p`. Each unit / channel combination can be opened and manipulated independently by passing the appropriate pointer to the library subroutines. For details, see the EDT API (Related Resources on page 8).

Serial Communication

Most cameras have a manufacturer-defined serial command set for camera control and status. To utilize this capability, EDT boards implement serial transmit and receive using standard serial lines as defined by the Camera Link specification. You can use serial communication in a number of ways, as discussed below.

At Initialization

As mentioned in Setting the Camera Model on page 11, the initialization process uses directives in a configuration file to set the board registers and the driver variables to match your camera model and your operating mode. Additional directives (especially `serial_baud, serial_init, serial_binit,` and other `serial_*` directives) can be used to send serial commands when the system is initialized. These are described in the EDT Camera Configuration Guide (see Related Resources on page 8).

EDT provides several example configuration files that contain the serial commands needed to put a camera into the desired mode. You can edit these commands or copy them to a new configuration file.

For suggestions, see comments in the example configuration files `camera_config/generic`*`X`*`cl.cfg` (where *`X`* is replaced by a specific bits-per-pixel value – for example, `generic8cl.cfg`) in the EDT installation package.

From Command Line

The command-line utility `serial_cmd,` described in serial_cmd on page 19, allows you to send serial commands to a camera and receive its response, in either ASCII or hexadecimal format. Command-line help also can be accessed by entering `serial_cmd --help.`

If you wish to incorporate this functionality in your own application, see the source code provided in `serial_cmd.c` in the EDT installation package.

From PdvShow

In the *PdvShow* application, in the *Camera* menu, select *Programming*. The resulting dialog allows you to send and receive serial commands from the camera. For details, see Image Capture and Display on page 13.

From a Camera Manufacturer's Application

Most Camera Link camera makers supply a Windows-based graphical camera control application that lets you send and receive serial commands using a board-specific serial dynamic link library (DLL). Your EDT installation package provides a DLL named `clseredt.dll` which, per the Camera Link 2.0 specification, is installed at:

- `%PROGRAMFILES%\Cameralink\Serial` (64-bit version); or
- `%PROGRAMFILES(X86)%\CameraLink\Serial` (32-bit version)

Camera GUIs typically provide some method for specifying the DLL pathname; for details, see your camera documentation.

If it becomes necessary to rename the file or copy it to a different location, be sure to recopy any newer versions of the file to the appropriate location when you reinstall the EDT installation package.

From Your Application

To see all of the routines needed for user applications to send and receive serial commands: In the EDT API (see Related Resources on page 8), follow the link to the EDT digital imaging library, and then — under Modules at the bottom of the page — to Communications / Control.

Example and Utility Applications

EDT provides a variety of example, utility, and diagnostic applications. All can be run from the command line, using Unix-style options and arguments.

To help those developing Camera Link PCIe applications, C source code is provided for all the examples. The source code file is the name of the application with a `.c` extension (e.g., "`take.c`").

For those just beginning, we recommend starting with the source for `simple_take` or `simplest_take,` as those applications are the easiest to understand.

The most commonly useful options for these programs are described below. Placeholders shown in italics should be replaced with your own values.

For a complete list of usage options, at the command line, enter the application name with the `--help` option to display the help message.

pciload

Used to query the boards or, optionally, to update and verify the board's flash PROM. After installation, you may want to run `pciload` with no arguments and review the output to help verify that the board and driver did install correctly. To use `pciload` to update and verify the flash PROM, see Firmware on page 23.

setdebug

A debug and diagnostic utility. The options shown here may be useful to you. Options not shown here, as a rule, are specific to driver internals and are useful (and safe) only with guidance from EDT engineers.

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).
`-c` *`channel`*	The DMA channel, on multichannel boards; default is 0 (first channel).
`-d 0`	Unique to `setdebug`. Displays current board register values.
`-v`	Unique to `setdebug`. Displays version information for library and driver.
`-h`	Displays full list of options.

initcam

Command-line utility that initializes the board and device driver for a specific camera. It initializes board registers; sets various parameters (width, height, depth, etc.) to specific values; and optionally sends serial initialization commands to the camera from the referenced configuration file. The EDT configuration files are in your installation directory under `camera_config`. The EDT camera selector GUI applications (e.g. `pdvshow, camconfig`) are simply wrappers to provide a way to select the correct file, then shell out to call `initcam`. To initialize from your own application code, you can use `initcam.c` as example code. For a detailed description of configuration files and directives, consult the Camera Configuration Guide (see Related Resources on page 8).

Several of the most useful options are...

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).
`-c` *`channel`*	The DMA channel, on multichannel boards; default is 0 (first channel).
`-f` *`pathname`*	The (required) name of the configuration file to use for initialization.

Example:

```
initcam -f camera_config/generic8cl.cfg
```

take

Used to acquire images and (optionally) save them to files. Though it does not display the images, it does provide many other options, making it a useful diagnostic tool. The source also shows how to change camera settings such as integration time; tune image acquisition in certain ways; and detect errors.

Several of the most useful options are:

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).
`-c` *`channel`*	The DMA channel, on multichannel boards; default is 0 (first channel).
`-b` *`file`*	The base name of the file in which to save the image, in Sun raster format on Linux or Mac OS X systems, or in Windows bitmap format on Windows systems (note – in EDT software packages later than 5.3.3.3, this option always will create files in Windows bitmap format, regardless of which operating system you are using). If only one image is taken, this is the filename; otherwise a two-digit number is appended to each file, starting with 00. The appropriate suffix is automatically added.
`-f` *`file`*	The name of the file in which to save the image, in raw format. The file includes only raw image data, with no formatting information.
`-l` *`loopcount`*	The number of consecutive pictures you wish to take. The default is one.
`-N` *`numbufs`*	The number of ring buffers (default is 1). A ring buffer is a portion of host memory preallocated for DMA and used in round-robin fashion. A setting of four optimizes pipelining — one ring buffer currently acquiring data, one ready for data, one getting ready, and one backup.
`-v`	Turns on verbose mode. The default is off.

Example: To acquire 100 images as quickly as possible using four ring buffers, without saving to files, enter:

```
take -N 4 -l 100
```

Example: If you have one PCIe8 DVa C-Link board connected to two base-mode cameras, and you wish `take` to use the camera on DMA channel 1, enter:

```
take -u 0 -c 1 -N 4 -l 100
```

simple_take

Shows how to use the API to acquire images from a camera connected to the Camera Link PCIe board and (optionally) save the images to files.

To add image acquisition to an application, EDT recommends starting with this example, which shows how to use the ring buffer routines to improve performance by pipelining image acquisition and processing.

Several of the most useful options are:

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).
`-c` *`channel`*	The DMA channel, on multichannel boards; default is 0 (first channel).
`-b` *`file`*	The base name of the file in which to save the image, in Sun raster format on Linux or Mac OS X systems, or in Windows bitmap format on Windows systems (note – in EDT software packages later than 5.3.3.3, this option always will create files in Windows bitmap format, regardless of which operating system you are using). If only one image is taken, this is the filename; otherwise a two-digit number is appended to each file, starting with 00. The appropriate suffix is automatically added.
`-l` *`loopcount`*	The number of consecutive pictures you wish to take. The default is one.
`-N` *`numbufs`*	The number of ring buffers — by default, one. (A *ring buffer* is a portion of host memory preallocated for DMA and used in round-robin fashion.) A setting of four optimizes pipelining — one ring buffer currently acquiring data, one ready for data, one getting ready, and one backup.

Example: To acquire four images as fast as possible using four ring buffers, saving each to files named `picture00.bmp` through `picture03.bmp` on Windows (or `.ras` on Linux / Mac OS X), enter...

```
simple_take -N 4 -l 4 -b picture
```

simplest_take

The simplest example application. It sets up four ring buffers and acquires a single image, with no pipelining.

`simplest_take` accepts an optional argument of a file name to which to save the image. If no name is supplied, it reports a successful image acquisition, or any errors that occurred — useful for testing.

Example: To acquire an image and save it to a file named `pic.bmp,` enter...

```
simplest_take -b pic.bmp
```

simple_sequence

Like `simple_take` but, instead of capturing and saving one file at a time, it captures a finite number of images (limited to available memory) into memory and then writes them all out at once. See `simple_take` for the most commonly used options.

simple_irig2

Example of capturing images using the IRIG2 timestamp header. Can be useful even if an IRIG time signal is not present, since it can be used to "tag" the beginning of an image with an image count and magic number – to verify that image data has not been lost (loss of sync detection). See `simple_take` for the most commonly used options.

serial_cmd

Sends serial commands to a camera through the board, using calls to routines in the API. By default, the application starts in command mode: the final argument to `serial_cmd` is the command to send to the camera. Delimit this command with either single or double quotation marks, but be consistent. For example:

```
serial_cmd "MDE?"
```

If you omit the command argument, the application enters interactive mode, in which you can type one command per line. To quit the application, enter Control-C.

Several of the most useful options are:

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).
`-c` *`channel`*	The DMA channel, on multichannel boards; default is 0 (first channel).
`-x`	Treats the command argument as a hexadecimal number, which is sent to the camera without terminating nulls or carriage returns. The default is ASCII with a terminating carriage return added.

Example (command mode usage):

```
% serial_cmd "MDE?"      (Redlake "Query Mode" command)
MDE TR                   (camera response)
%
```

Example (interactive mode usage):

```
% serial_cmd
>MDE?                    (Redlake "Query Mode" command)
MDE TR                   (camera response)
>
% serial_cmd -x           (for hexadecimal arguments)
> 03 06 02               (camera-dependent command)
> Control-C              (end the program)
```

To access a camera on DMA channel 1, enter:

```
% serial_cmd -u 0 -c 1 "MDE?"
                         (Redlake "Query Mode" command)
```

```
MDE TR                    (camera response)
%
```

dvinfo

Gathers board-specific and system-specific technical data, runs several diagnostics, and writes the results to `dvinfo.out` in the current directory. Use the resulting ASCII text file to diagnose problems yourself, or send the file to EDT for technical support.

To run `dvinfo`:

1. Connect and power on the camera.
2. If possible, initialize the board with `initcam` or `pdvshow`.
3. Make sure no other PDV applications (such as `pdvshow`) are running.
4. Run `dvinfo`.

One useful option is:

`-u` *`unit`*	The unit number, if multiple boards are installed; default is 0 (first board).

Triggering

This section describes the most common triggering methods for your Camera Link PCIe board, as well as each mode's configuration file directives, serial control commands, and software considerations. You can change trigger modes either directly in your application, or by using configuration file directives.

- For details on camera configuration directives, see the EDT Camera Configuration Guide (Related Resources on page 8).
- For details on specific serial control commands, see your camera manual.

By default, most cameras power up in continuous (also called *freerun*) mode, sending images continuously. For most cameras, EDT provides configuration files for freerun mode. For some cameras, EDT also provides configuration files for internal triggered, external triggered, or pulse-width mode. All of these modes and configuration details are described below.

Freerun (Continuous)

In this mode, the camera acquires images continuously without waiting for a trigger signal.

Configuration file directives:	`MODE_CNTL_NORM: 00` (default) `serial_init:` as needed to set freerun mode (usually not needed because most cameras power on in freerun by default)

Triggered by EDT Board

In this mode, the camera waits for a trigger signal from your EDT board before acquiring an image.

Configuration file directives:	`MODE_CNTL_NORM: 10` `serial_init:` as needed to put the camera in triggered mode (camera dependent)

Pulse-width Triggered (Controlled or Level)

In this mode, exposure duration is determined by how long the EXPOSE line is held TRUE (high).

Configuration file directives:	`MODE_CNTL_NORM: 10`
	`method_camera_shutter_timing: AIA_MCL`
	`serial_init:` as needed to put the camera in pulse-width mode (camera dependent)

API subroutine:	`pdv_set_exposure,` millisecond units, range 0–25500

For cameras with very fast shutters that accept exposure times in microseconds, another configuration file directive tells `pdv_set_exposure` to use microseconds instead of milliseconds.

Configuration file directive:	`MODE_CNTL_NORM: 10`
	`method_camera_shutter_timing: AIA_MCL_100US`
	`serial_init:` as needed to put the camera in pulse-width mode

API subroutine:	`pdv_set_exposure,` microsecond units, range 0–25500

External Trigger Direct to Camera

With this method, the trigger is sent from an external source directly to the camera, bypassing the board. The camera and board can be configured as in freerun mode; however, depending on timing, your application may time out and fail to receive images. You can avoid timeouts in either of two ways:

- If the maximum period of time between triggering signals is known, configure the `user_timeout` period in the software for a large enough value to avoid timeouts.
- If application blocking is acceptable, configure the `user_timeout` period in the software for an infinite period (`user_timeout=0`) to ensure that the application waits until an image arrives.

Configuration file directives:	`MODE_CNTL_NORM: 00` `user_timeout:` as needed to ensure that your application does not time out while waiting for an image
API subroutine:	`pdv_set_timeout,` millisecond units

Be sure to comply with Requirements on page 9. If you have trouble, consult Troubleshooting on page 26.

External Trigger Pass-through

With this method, a trigger is sent from an external device to the board, and from the board to the camera. A TTL signal is input to the board, which in turn sends out an LVDS or RS422 signal (depending on the board and its configuration) to the camera trigger line, typically CC1.

Configuration file directives:	`MODE_CNTL_NORM: A0` `CL_CFG2_NORM:` as needed to set separate or combined triggers from trigger 0 pins `user_timeout:` as needed to ensure that your application does not time out while waiting for an image
API subroutine:	`pdv_set_timeout,` millisecond units

The software timeout considerations are the same as those under External Trigger Direct to Camera.

Be sure to comply with Requirements on page 9. If you have trouble, consult Troubleshooting on page 26.

External Triggering Pins

The pins to which you connect the trigger source are shown in Appendix B: Board Diagrams.

With two cameras, trigger input 0 can trigger both cameras, or triggers 0 and 1 can trigger cameras 0 and 1 independently; for details, see configuration file directives (above).

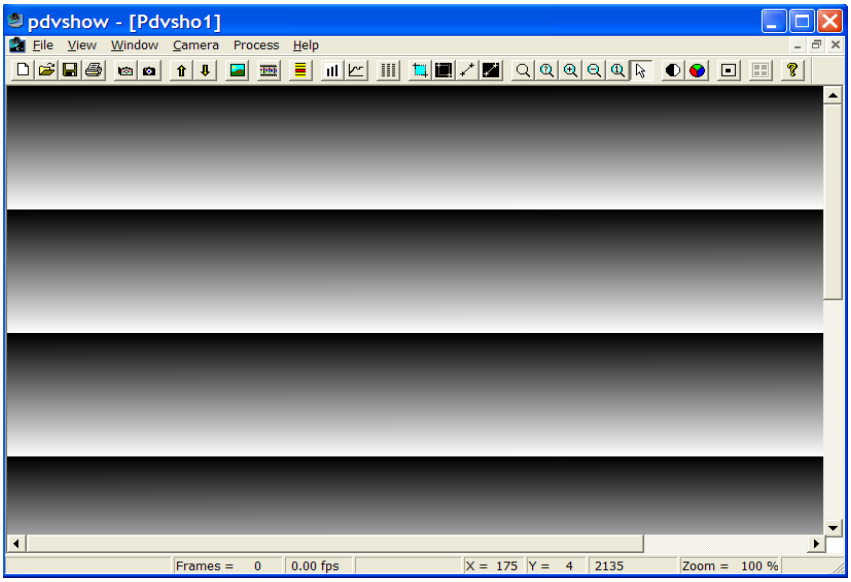
Fire the trigger by applying a TTL signal lasting at least 10 microseconds to these pins, which in turn send a signal of the appropriate level to the camera trigger line, typically CC1. The trigger cable can drive either pin high with respect to the other; no particular polarity is required.

The two pins of each trigger drive a Vishay SFH6206 optocoupler through a 130-Ω series resistor. This optocoupler is provided to allow coupling to electromechanical systems in which major ground spikes can occur when electrical devices such as motors, for example, turn on or off.

Simulation and Testing

EDT Camera Link PCIe boards (excluding the FOX boards) include a channel 2 simulator for generating sample data with no camera attached to the board (useful for testing the board hardware). This channel uses a simple counter to generate 16-bit pixel data; pixels start black and fade to white, as in Figure 3.

Figure 3. Simulated Channel 2 Test Image in *PdvShow*



Data is generated as fast as the bus speed allows:

- On a four-lane PCI Express bus, 680 MB/s;
- On an eight-lane PCI Express bus with a maximum payload of 128 bytes, 1.1–1.4 GB/s.

To use the channel 2 simulator with `pdvshow`, follow the steps below.

1. Start the application with:

   ```
   pdvshow -pdv0_2
   ```

2. Select the *Camera Setup* menu item.
3. Select the desired configuration.

To use the channel 2 simulator with your own application:

1. Use the initialization application `initcam`, specifying channel 2 and the camera configuration file for your camera. From a command prompt, enter:

   ```
   initcam -c 2 -f camera_config/yourCamera.cfg
   ```

...replacing *yourCamera* with the appropriate configuration file name for your camera and application.

NOTE For general testing, use one of the genericXXcl.cfg files provided with your board.

2. Open the device with a call to pdv_open_channel, passing it NULL for the device, your value for the unit number (board), and 2 for the channel – as in this example (showing a unit number of 0):

```
PdvDev *pdv_p = pdv_open_channel(NULL, 0, 2);
```

The pointer returned from this call points to the simulated data; any image acquisition calls, such as pdv_wait_image, that pass this pointer will access the simulated data.

Because data is generated as fast as possible, you can also use the channel 2 simulator to measure the maximum bus bandwidth, using the utility application cl_speed. This utility takes the unit number as an argument and begins channel 2 simulation on the specified board; it then reports the data speeds achieved.

Firmware

At times, you may need to reprogram the PCI / PCIe interface flash memory using pciload – for instance:

- if you want to switch from one mode to another (base, medium, full) on certain EDT boards;
- if you want to convert an EDT simulator into a frame grabber, or vice versa;
- if you need to use an FPGA configuration file that has special functionality;
- if you upgrade to a new installation package that includes a required update for your board; or
- if the firmware becomes corrupted.

To do so, follow the instructions in the sections below.

Checking and Loading the Firmware

The following procedure applies to standard firmware only. If you are running a custom firmware file and need to update it, first get a custom firmware configuation file from EDT.

NOTE Do not upgrade the firmware simply because you see a newer firmware file with a new driver; instead, consult the README file in the package, which will tell you if there is a necessary upgrade.

- For Windows, pciload is an application in \EDT\Pdv. Double-click the *Pdv Utilities* icon to bring up a command shell in the installation directory \EDT\Pdv.
- For Linux / Mac OS X, pciload is an application in /opt/EDTpdv.

To see currently installed and recognized EDT boards and firmware, enter:

```
pciload
```

The program outputs the date and revision number of the firmware in the flash memory.

To compare the PCI / PCIe firmware in the package to the firmware loaded in flash on the board, enter:

```
pciload verify
```

If the two match, the firmware on the board is the same as the firmware in the installation package. If they differ, you'll see error messages, but these do not necessarily indicate problems; if your application is working correctly, you probably do not need to upgrade the firmware.

If you do wish to update the standard firmware, enter:

```
pciload update
```

To upgrade or switch to a specific firmware file, enter:

```
pciload firmware
```

...replacing *firmware* with the filename of the desired firmware, up to but not including the .bit extension.

Example: To load full-mode firmware on a PCIe8 DVa C-Link board, run...

```
pciload pe8dvacamlk_fm
```

The board reloads the firmware from the flash memory only during powerup – so after running `pciload,` the old firmware is in the PCIe FPGA until the system has power-cycled.

NOTE Updating the firmware requires cycling power, not simply rebooting.

For a list of all `pciload` options, see the tables below or enter:

```
pciload --help
```

NOTE When using the tables below, use only Table 3 for current boards (with “DVa” in their names) and only Table 4 for legacy boards (with “DV” but no “a” in their names). The firmware is not interchangeable.

Table 3. Arguments to pciload for current boards (with “DVa” in their names)

Board name	Command	Notes
PCIe4 DVa FOX	`pciload pe4dvafox` (base mode) `pciload pe4dvafox_fm` (full mode)	EDT recommends using base / medium firmware for base / medium mode cameras. However, if you have just one frame grabber and are switching between base / medium mode and full mode, you can use full-mode firmware with one base- or medium-mode camera of 40 MHz or more.
PCIe4 DVa C-Link	`pciload pe4dvacamlk` (base or medium mode)	
PCIe8 DVa C-Link*	`pciload pe8dvacamlk` (base mode) `pciload pe8dvacamlk_fm` (medium or full mode)	

* To find and load the firmware that converts this frame grabber into a PCIe8 DVa CLS simulator, consult the EDT Simulator User’s Guide (see Related Resources on page 8).

Table 4. Arguments to pciload for legacy boards (with “DV” but no “a” in their names)

Board name	Command	Notes
PCIe4 DV C-Link	`pciload pedvcamlk32` (base mode) `pciload pe4dvcamlk32_mm` (medium mode)	(no full-mode firmware provided)
PCIe8 DV C-Link (rev. 10 or lower)	`pciload pe8dvcamlk` (base or medium mode) `pciload pe8dvcamlk_fm` (full mode)	EDT recommends using base / medium firmware for base / medium mode cameras. However, if you have just one frame grabber and are switching between base / medium mode and full mode, you can use full-mode firmware with one base- or medium-mode camera of 40 MHz or more.
PCIe8 DV C-Link (rev. 11 and up)	`pciload pe8dvcamlk2` (base or medium mode) `pciload pe8dvcamlk2_fm` (full mode)	

Corrupted Firmware

In rare cases, the board firmware may become corrupted. Typically, the symptom is that the board is not recognized by the operating system, or the computer itself will not boot with the board in it. In such cases, booting from the protected (backup) sector will allow the board to be seen so that you can reprogram the programmable sector.

Each EDT frame grabber has both a protected (backup) and a programmable flash memory boot sector. The sector from which the board will boot is determined by a jumper, which is preset to the programmable sector. If that sector becomes corrupted, you can move the jumper so the board will boot from the protected sector.

Most often, firmware corruption is the result of an interrupted load process or an unanticipated interaction with the host computer; if so, following the procedure below should solve the problem.

If the firmware file itself has become corrupted, first contact EDT for the current firmware you’ll need to replace it, and then follow this procedure.

To reboot from the protected sector:

1. If needed, move the new firmware file to the directory in which you installed the EDT software.
2. Power down the host and board.
3. To avoid later confusion, remove any other EDT boards from the host.

4. On the EDT board with the corrupted firmware, move the jumper from its programmable to its protected setting (to locate this setting on your board, see Firmware on page 23).
5. Power up the host and board.
6. Navigate to the directory in which you installed the EDT software.
7. At the command prompt, enter...

   ```
   pciload
   ```

   The program outputs the date and revision number of the firmware in the flash memory — in this case, the date and revision number that shipped as of your purchase date. If no errors are reported, you have successfully booted from the protected sector.
8. With the system still powered up, move the jumper back to its original position.
9. Enter...

   ```
   pciload firmware
   ```

   ...replacing *firmware* with the correct filename, as indicated in Table 3 and Table 4 (above). If the feedback shows no errors, the new firmware has been installed, although it is not yet running.
10. Power down the host and board again.
11. Power up the system.
12. Run `pciload` with no arguments to verify the board is recognized and is running with the new firmware.

Troubleshooting

The EDT installation package includes numerous diagnostic programs, the most useful of which are briefly described in Example and Utility Applications on page 17. You can use these programs to search for problems yourself or to generate output files to provide to EDT for technical support. For further technical help, visit the EDT support webpage (see Related Resources on page 8).

NOTE When contacting EDT for support, always provide output from the most relevant diagnostic programs – especially `dvinfo`, which gathers board- and system-specific information, runs tests, and writes the results to the file `dvinfo.out` in the current directory (see dvinfo on page 20).

Board Not Seen

To verify that the firmware is installed correctly and can access each board, run `pciload` (in the EDT installation package) with no arguments. You should see information on each EDT board that can be seen.

If a board is not seen by the system:

- Try uninstalling and reinstalling the EDT package (and remember to reboot after each install).
- Try moving the board to a different slot.
- Try checking for these possible problems...
  - — Typically, an EDT PCIe board will not work in a bus slot dedicated to graphics cards, or a bus slot wired for fewer lanes than the number specified – for instance, an eight-lane board will not work properly in a slot wired for only four lanes (see Requirements on page 9).
  - — EDT drivers typically will not work with “guest only” accounts, so if you are using such an account, change to an account with greater access.
  - — For Windows 7 or Windows Vista, EDT installation packages prior to version 5.3.3.1 typically will not load if your Windows User Account Control is set to the lowest (disabled) setting. In such cases, try either disabling User Account Control or updating your EDT installation package (see Installation on page 10).

See also Problems With Bandwidth on page 28 and Problems With Firmware on page 30.

Problems With Software Installation

Many software installation problems may be solved by downloading the latest EDT installation package (see Installation on page 10).

NOTE Be sure to remove any previous installation packages before installing a new or updated package.

Windows

Try any of the following:

- If a board is not recognized, use the *Windows Device Manager* to see if the board is present as an “unknown device.” If so, right-click on the unknown device and choose *Uninstall* to uninstall it; then, from the *Action* menu, select *Scan for Hardware Changes*.
- Uninstall and then reinstall your existing EDT installation package.
- Download and install the latest EDT installation package (see Installation on page 10).

NOTE Do not extract and install files by hand; doing so will circumvent the installation process, which automatically updates system files, establishes links, and creates new files. Similarly, do not remove files by hand. Instead, use the *Add or Remove Programs* facility in the Windows control panel.

Linux

Try any of the following:

- Failure during installation may be due to system package dependencies. Make sure the following packages are installed on your system...

  ```
  make
  gcc
  libtiff
  linux kernel headers
  ```

  For example, on Ubuntu, you would install the `libtiff` library by running...

  ```
  sudo apt-get install libtiff4-dev
  ```

  After all needed packages are in place, running `make` from the `/opt/EDTpdv` directory should complete installation.
- Uninstall and then reinstall your existing EDT installation package. To uninstall, use the programs in the `/opt/EDTpdv` installation directory...
  - If the package was installed using *`package`*`.run`, remove it with `./uninstall.sh.`
  - If the package was installed using `rpm --install package,` remove it with `rpm -erase` *`package`*`.`
- Download and install the latest EDT installation package (see Installation on page 10).

NOTE New Linux versions often require an updated device driver, so if you are using a new or updated Linux kernel and you have trouble with the EDT installation or device access, check to see if a new EDT installation package is available.

Mac OS X

Try any of the following:

- Verify that you are using the appropriate EDT installation package for your version of Mac OS X...
  - For versions 10.6 and higher, use EDT 5.*x* packages.
  - For versions 10.5 and lower, use EDT 4.1.9.6 package.

- Uninstall and then reinstall your existing EDT installation package. Before doing so, uninstall existing EDT installation directories by renaming or deleting them. Typically they are found at...
  - `/Applications/Edt/pdv`
  - `/Applications/Edt/pcd`
- Download and install the latest EDT installation package (see Installation on page 10). Before doing so, uninstall existing EDT installation directories by renaming or deleting them. Typically they are found at...
  - `/Applications/Edt/pdv`
  - `/Applications/Edt/pcd`

Corrupted Images, Slow Acquisition, Timeouts, Data Loss

Corrupted images, slow acquisition rates, repeated timeouts, or data loss usually indicate that the bus is too slow or the driver is misconfigured. To correct this issue:

- Verify that the camera configuration file is the correct one for your camera and operating mode; see Setting the Camera Model on page 11.
- Verify that the EDT board is in a PCIe slot that is wired electrically (not just physically) to support the number of lanes provided by the board. For example, an EDT x8 board requires a slot that is x8 or x16, while an EDT x4 board requires a slot that is x4, x8, or x16. Also, note that some motherboards will “split” lanes between two slots, so that two x8 slots will become x4 if both are occupied.
- Determine the bandwidth required by your camera, and then ensure that both the board and the host can sustain the required throughput. For fastest full-mode cameras, your frame grabber and your host bus both must support eight lanes. For multiple camera installations, the combined data rates should not exceed that of the board(s) installed.
- Verify that the firmware file you loaded is the correct one for your camera and your mode of operation (base, medium, or full mode); see Firmware on page 23.
- Eliminate other devices, if any, that may be reducing the available bus bandwidth.
- Consult Requirements on page 9 to verify that your setup meets bus and throughput requirements.
- When updating to a new device driver, always recompile and relink applications that use EDT libraries (see Firmware on page 23).

For more information, see Problems With Bandwidth.

Problems With Bandwidth

To prevent timeouts and data loss caused by bandwidth problems, you’ll need to determine the bandwidth required by your camera and verify that the board and the host system can sustain the required throughput.

Bandwidth requirements depend on the camera’s pixel clock speed, the number of bytes per pixel, the number of taps, and the number of DMA channels. To calculate bandwidth requirements, use this equation:

```
pixel clock speed * taps * bytes/pixel = total bandwidth
```

NOTE The pixel clock speed, not the frame rate, affects bandwidth requirements. If data loss is a problem, increasing the delay between frames probably will not help.

Cameras that output 10–16 bits per pixel will require two bytes per pixel of bandwidth. Therefore, a camera that has a 40 MHz pixel clock, two taps, and 12 bits per pixel requires system bandwidth of:

```
40 * 2 * 2 = 160 MB per second
```

You can ease this constraint by running the camera in a less demanding mode — for example, you can often run two-tap cameras in single-tap mode, or 12-bit cameras in 8-bit mode.

Other tips on solving bandwidth problems include:

- Consult Requirements on page 9 to verify that your setup meets bus and throughput requirements.

- Consider the number of cameras and the speed of the cameras you are using. The bus bandwidth may be adequate for some configurations, but inadequate for configurations with more or faster cameras.
- Consider the number of frame grabbers or other devices connected to the bus; using multiple devices on a single bus can reduce bandwidth, sometimes considerably.
- Verify that your bus has the required number of (fully connected and usable) lanes: at least four lanes for the 4-lane boards, and at least eight lanes for the 8-lane boards.
- Note that the legacy PCIe4 DV C-Link has a maximum bandwidth of about 200 MB/s (due to bridging issues between PCI and PCIe). If you have bandwith problems with this legacy “DV” board, consider upgrading to a newer “DV**a**” version – either x4 (PCIe4 DV**a** C-Link) or x8 (PCIe8 DV**a** C-Link).

Problems Acquiring Images With EDT Applications

If you have problems with image acquisition when using EDT applications, try the suggestions below.

- Verify that the camera device is on and is receiving power.
- Verify that all interface cable connections are working properly: Turn off the camera, unplug the cable at both ends, reattach the cable at both ends, and turn on the camera again.
- Try a different cable, if available.
- Try a different camera, if available.
- Verify that the EDT installation package was installed correctly and that the driver is running and can see the board. To do so, in the EDT installation directory, go to the command line and enter:

  ```
  pciload
  ```

  If you see no information about your EDT board, then a problem occurred during installation.

  To resolve it, one at a time, try:

  — cycling system power;

  — moving the board to a different slot;

  — uninstalling and reinstalling the driver.

For best performance, install your EDT board in a bus that is not shared with any other devices and that meets the board’s speed requirements, as discussed in Requirements on page 9.

Problems With Your Applications

A mismatch between driver and library software versions can cause application or system failures in your applications that use EDT libraries. When updating to a new device driver, always recompile and relink applications that use EDT libraries.

Use the PDVDEBUG and EDTDEBUG environment variables to enable debug console output from the EDT libraries. Both libraries are documented on the EDT website.

Applications that use the EDT digital imaging library can set the PDVDEBUG environment variable to 1 or 2. A value of 1 turns on call trace information from most (though not all) library routines; a value of 2 enables more verbose trace information. A value of 0 turns off debug output. Setting the EDTDEBUG environment variable to one or two will provide even more detailed debug output from the underlying EDT DMA library.

The EDT message handler library provides generalized error- and message-handling for EDT software libraries and can be helpful for debugging your programs. See the EDT message handler library in the API for specific routines and usage.

Before calling for technical support, reproduce the problem with one of our applications, such as `take`, `simple_take`, or `pdvshow`, if possible. If you cannot reproduce the problem with an EDT application, compare your code with ours to see if you can spot the difficulty.

A simple example program that demonstrates the problem is also helpful.

Problems With Threads

The driver and libraries for your Camera Link PCIe product use threads. If you are using third-party software that is not thread-safe, contact your third-party vendor to determine if a thread-safe version is available.

Problems With Firmware

You may need to update the PCIe interface flash memory with `pciload` under these conditions:

- If you install a new device driver or switch to an FPGA configuration file with special functionality;
- If your firmware becomes corrupted;
- If the board is not seen in the system or is missing functionality that is in newer boards;
- If the firmware loaded on the board does not match the camera mode.

For details, see Firmware on page 23.

Appendix A: Pin Assignments

Table 5 shows the MDR26 pin assignments for Camera Link signals.

Table 5. Pinout – MDR26 Connector

Camera or simulator end	Frame grabber end	Camera Link signal (base mode, primary connector)	Camera Link signal (medium mode, secondary connector)	Camera Link signal (full mode, secondary connector)
1*	1*	inner shield / ground*	inner shield / ground*	inner shield / ground*
14*	14*	inner shield / ground*	inner shield / ground*	inner shield / ground*
2	25	X0–	Y0–	Y0–
15	12	X0+	Y0+	Y0+
3	24	X1–	Y1–	Y1–
16	11	X1+	Y1+	Y1+
4	23	X2–	Y2–	Y2–
17	10	X2+	Y2+	Y2+
5	22	Xclk–	Yclk–	Yclk–
18	9	Xclk+	Yclk+	Yclk+
6	21	X3–	Y3–	Y3–
19	8	X3+	Y3+	Y3+
7	20	SerTC+	unused	100 ohms
20	7	SerTC–	unused	terminated
8	19	SerTFG–	unused	Z0–
21	6	SerTFG+	unused	Z0+
9	18	CC1–	unused	Z1–
22	5	CC1+	unused	Z1+
10	17	CC2+	unused	Z2–
23	4	CC2–	unused	Z2+
11	16	CC3–	unused	Zclk–
24	3	CC3+	unused	Zclk+
12	15	CC4+	unused	Z3–
25	2	CC4–	unused	Z3+
13*	13*	inner shield / ground*	inner shield / ground*	inner shield / ground*
26*	26*	inner shield / ground*	inner shield / ground*	inner shield / ground*

* For PoCL, pins 1 and 26 change to +12V DC power, while pins 13 and 14 change to +12V DC power return.

CAUTION!

To avoid a short (shown by a red LED behind the backpanel, near the affected connector) related to the PoCL jumpers:

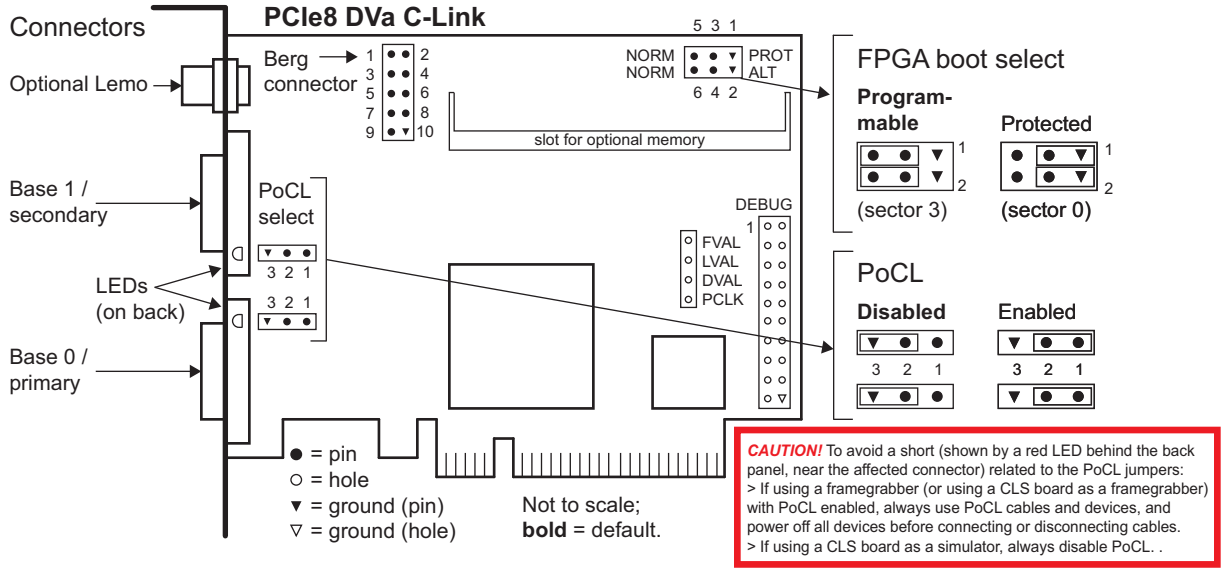
- If using a frame grabber (or using a CLS board as a frame grabber) with PoCL enabled, always use PoCL cables and devices, and power off all devices before connecting or disconnecting cables.
- If using a CLS board as a simulator, always disable PoCL.

Appendix B: Board Diagrams

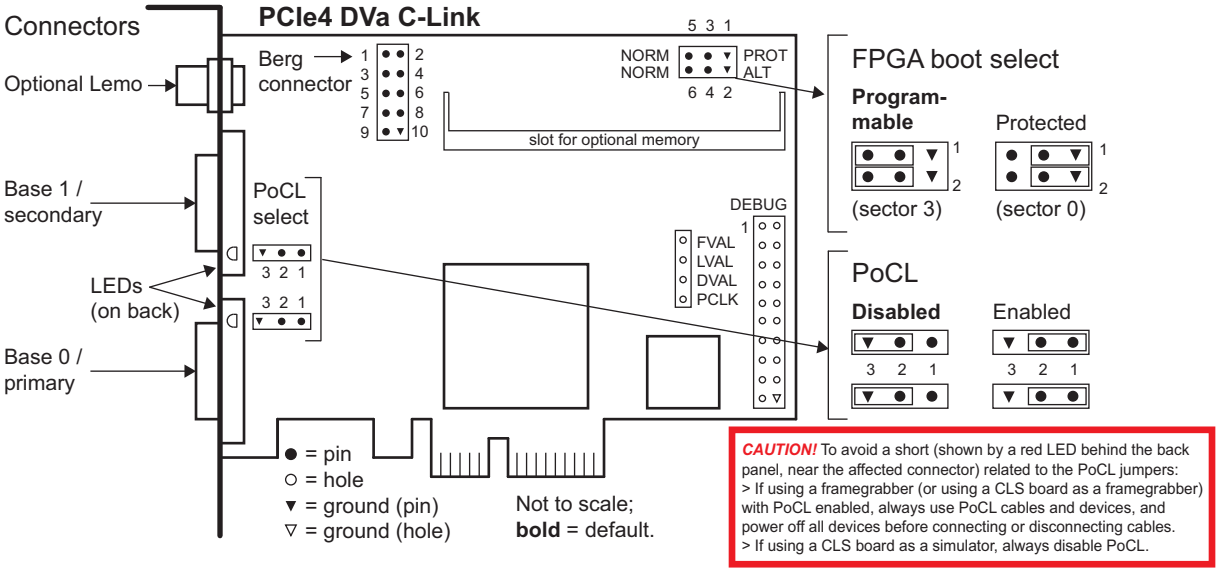
This section shows diagrams and key features for the various Camera Link PCIe boards.

Standard and Fiber-Optic (FOX) Frame Grabbers, PCIe DVa series

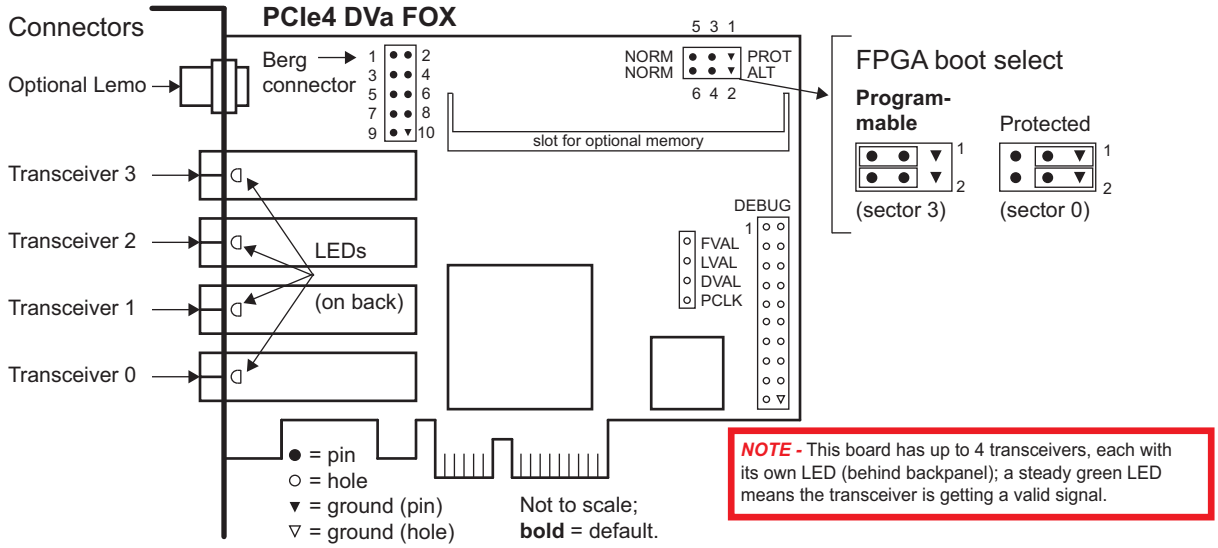
PCIe8 DVa C-Link (or PCIe8 DVa CLS, when used as a frame grabber)



PCIe4 DVa C-Link

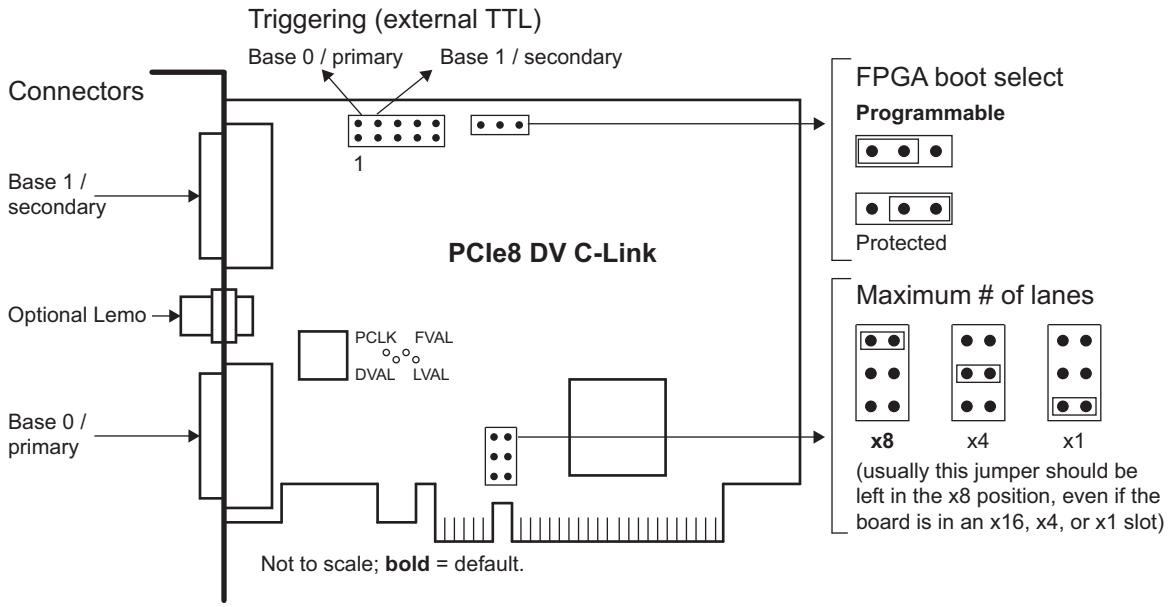


PCIe4 DVa FOX

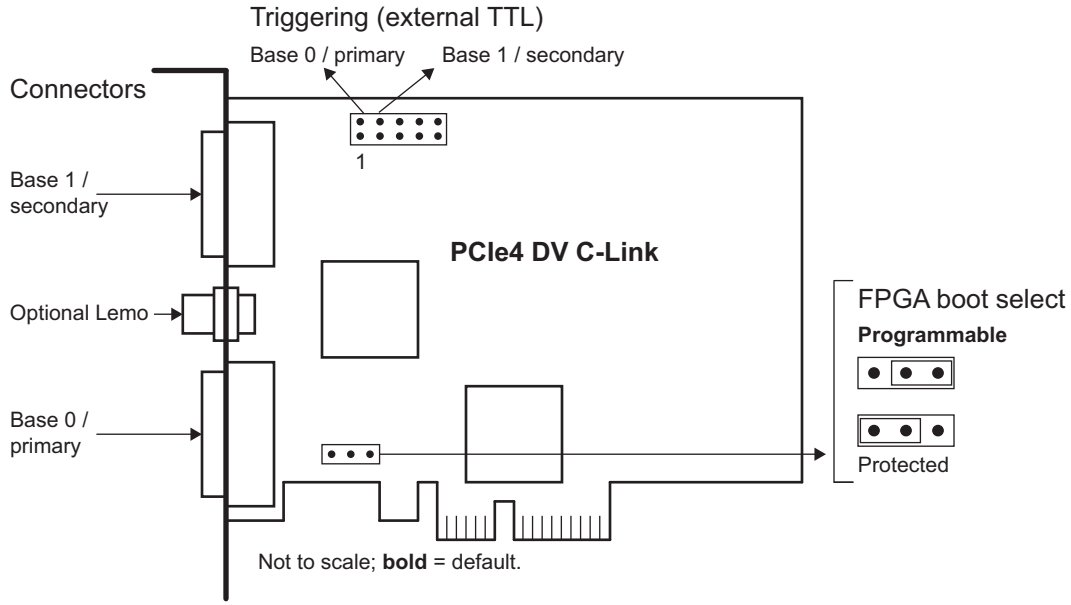


Legacy Frame Grabbers, PCIe DV series

PCIe8 DV C-Link



PCIe4 DV C-Link

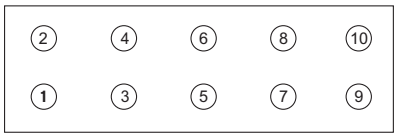


Additional External Inputs

Via Berg Connector or Optional Lemo Connector

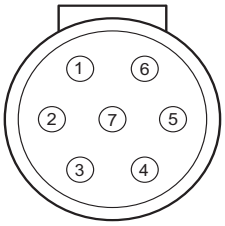
All Camera Link PCIe boards have two connectors that can be used for external control (triggers and other inputs): a Berg connector, or an optional seven-pin Lemo connector. Pin assignments are shown below.

BERG CONNECTOR:



Pin	PCIe DVa series (all)	Legacy PCIe4 DV C-Link	Legacy PCIe8 DV C-Link
1	Trigger 0+	Trigger 0+	Trigger 0+
2	Trigger 0-	Trigger 0-	Trigger 0-
3	Trigger 1+	Trigger 1+	Trigger 1+
4	Trigger 1-	Trigger 1-	Trigger 1-
5	IRIG-B	IRIG-B	IRIG-B
6	3.3V	Reserved	Reserved
7	Reserved	Ground	Ground
8	Reserved	Reserved	Reserved
9	Reserved	Reserved	Reserved
10	Ground	Ground	Ground

LEMO CONNECTOR:



Pin	PCIe DVa series (all)	Legacy PCIe4 DV C-Link	Legacy PCIe8 DV C-Link
1	Trigger 1+	Trigger 0+	Trigger 1+
2	3.3V	Trigger 0-	Reserved
3	Trigger 0+	Trigger 1+	Trigger 0+
4	Trigger 0-	Trigger 1-	Trigger 0-
5	IRIG-B	IRIG-B	IRIG-B
6	Trigger 1-	Reserved	Trigger 1-
7	Ground	Ground	Ground

Via Optional Cable Assembly

For the PCIe8 DV / DVa C-Link and the PCIe4 DVa C-Link, there is an optional EDT-built cable assembly for triggering, timestamping, or both; below are the pin assignments (see also Appendix C: Timestamping).

Table 6. Pin assignments – Current EDT cable assembly for triggering, timestamping, or both

EDT p/n 016-13840 (June 2010):	*[color]*	*Lemo*	*D9*	*Function*	*BNC*	*BNC Label*
	green	1	2	trigger 1+	center conductor	TRIG 1
	red	2	9	reserved	–	–
	orange	3	7	trigger 0+	center conductor	TRIG 0
	brown	4	8	trigger 0-	shield	TRIG 0
	white	5	4	IRIG IN	center conductor	IRIGB
	blue	6	3	trigger 1-	shield	TRIG 1
	black	7	5	ground	shield	IRIGB

For length, Lemo to D9 = 1 ft.; three BNCs out to D9 = each 6 in. or less.

Below is a legacy version of the cable, which is supported only for legacy applications that still use it.

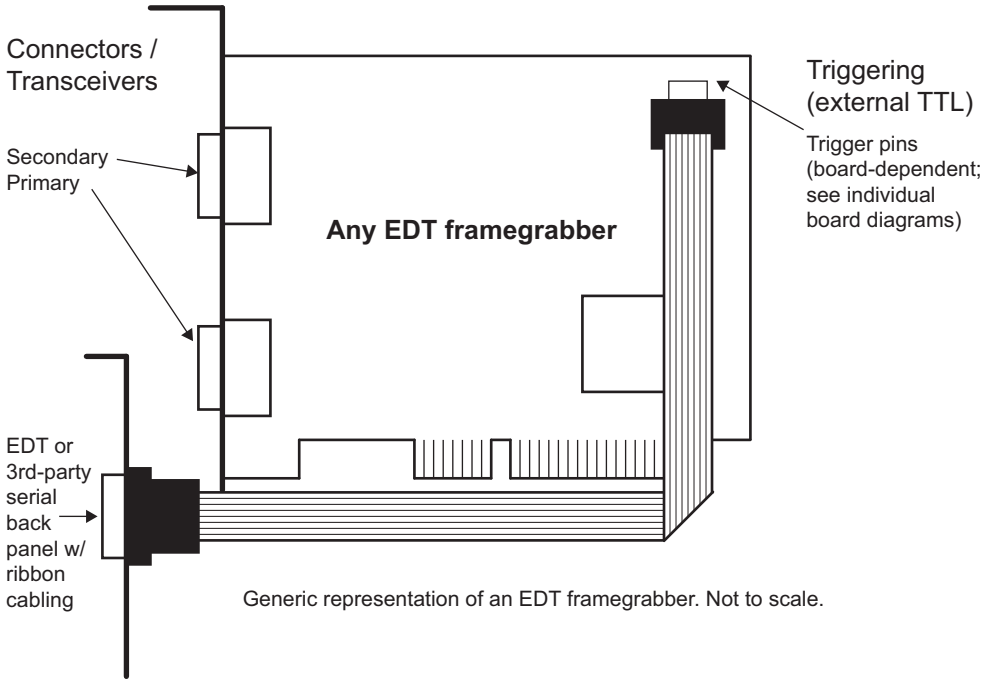
Table 7. Pin assignments – Legacy EDT cable assembly for triggering, timestamping, or both

EDT p/n 016-02894 (legacy):	*[color]*	*Lemo*	*Function*
	green	1	–
	red	2	–
	orange	3	–
	brown	4	–
	white	5	(to center conductor of coaxial cable)
	blue	6	–
	black	7	(to shield of coaxial cable)

For length, Lemo cable = 2 ft.; BNC cable = approximately 36 in.

Via Ribbon Cabling and D9 Connectors

If you do not have the optional Lemo connector, you can use a serial backpanel equipped with ribbon cabling and one or two 9-pin D-connectors. The diagram below illustrates the single D-connector setup.



Generic representation of an EDT framegrabber. Not to scale.

Appendix C: Timestamping

This appendix covers the timestamping function, which is provided through the optional Lemo connector on the PCIe8 DV / DVa and the PCIe4 DVa C-Link frame grabbers.

This function enables a precise IRIG-B timestamp to be inserted, directly into the data, for each image frame at the moment of capture. The timestamp is included in a 32-byte footer after the end of the image data; no image data is overwritten. For example, a camera with 1000 x 1000 8-bit pixels would produce 1,000,032 bytes of DMA data.

Although the footer is at the end of the DMA data, the time is captured at the beginning of the frame on the rising edge of the frame valid signal. The time thus captured combines the time derived from an IRIG-B input with a high-resolution counter for computing fractional seconds.

NOTE EDT's current IRIG-B format (IRIG2) is the second such format used for Camera Link PCIe boards. EDT's former IRIG-B format (IRIG1) is now obsolete.

In addition to the IRIG time value, the footer contains a frame counter, as well as space for a 64-bit timestamp computed as Unix seconds and fractional seconds.

For information on cable connectors and pinouts, see Additional External Inputs on page 35.

Camera Configuration Directives

To enable the IRIG timestamp, add to a camera configuration file:

```
method_header_type: IRIG2
```

To enable packed BCD timestamps in the configuration file, use:

```
irig_raw: 1
```

To specify that this board is using input from another board rather than direct input, use:

```
irig_slave: 1
```

Footer Format

The IRIG2 footer is 32 bytes appended to the image data transferred by DMA from the PCIe8 DV / DVa C-Link. It includes a frame counter and a timestamp from IRIG input.

Time values down to the microsecond are counted using the 40 MHz oscillator on the board. The time is latched at the beginning of transfer from the camera when the board sees the rising edge of frame valid.

After frame capture, the time in Unix seconds is computed, including the fractional time determined by dividing the current 40 MHz count by the number of 40 MHz clocks in a second. The IRIG time is determined on the board as either Unix seconds, or as the IRIG BCD values packed into a 32-bit integer.

Table 8 shows the structure elements of the IRIG2 footer.

Table 8. Elements of IRIG2 Footer, part 1 of 2

Element	Offset	Size	Type	Notes
Magic	0	4	u_int	This should be ASCII "EDT" followed by 01 (or 0x45445401).
Frame	4	4	u_int	This is the frame counter, which is reset when reset_intfc bit is cleared – normally at the start of acquisition.
IRIG time	8	4	One of two types: packed raw BCD, or Unix seconds. Type is indicated by a bit in the status register.	For IRIG time, the raw format is: 6 bits seconds 6 bits minutes 5 bits hours 9 bits days 6 bits years Unix seconds = seconds since 1/1/1970 (without leap seconds)

Table 8. Elements of IRIG2 Footer, part 2 of 2

Element	Offset	Size	Type	Notes
40 MHz count	12	4	u_int	Counts using onboard 40 MHz clock since last pulse per second
40 MHz maximum ticks at last pulse	16	4	u_int	Counts at last pulse per second (pps).
Status	20	1	u_char	Status bits: 0–3 = footer type (3 = Unix seconds; 5 = IRIG BCD) 4 = has valid IRIG data 5 = is synched with pps 6 = has seen IRIG error 7 = has seen pps error
Reserved	21	3	u_char	Reserved.
Monotonic Unix time with fractional seconds	24	8	double	This value is computed and filled in by the library after DMA. Fractional time is the 40 MHz count divided by 40 MHz max count

The following C++ struct encapsulates this footer structure, including showing the struct with bit fields representing the packed BCD values from the IRIG signal.

```
// ts_raw_t is defined in libedt_timing.h
// Packed BCD from IRIGB
typedefstruct { // Raw timecode format
u_long seconds:6;
u_long minutes:6;
u_long hours:5;
u_long days:9; // days in the year
u_long years:6;
} ts_raw_t;
// This structure is defined in pdv_irig.h
typedef struct Irig2Record {
u_int magic; /* magic */
u_int framecnt; /* starts at 0 */
/* There are two modes - seconds from 1970 (Unix time) or BCD mode, in which the BCD
values from IRIG are packed into 32 bits in the raw structure */
union {u_int seconds;
ts_raw_t raw;
} t;
u_int clocks; /* how many 40 MHz ticks in last second */
u_int tickspps; /* 40 MHz ticks since last second */
struct { /* status bits */
u_char type: 4;
u_char irig_ok:1;
u_char pps_ok:1;
u_char had_irig_error:1;
u_char had_pps_error:1;
} status;
u_char reserved[3];
double timestamp; /* holds a 64-bit unix seconds time */
/* This must be filled in by software */
} Irig2Record;
```

IRIG API

In the EDT digital imaging library routines, extra data added by the board or software (outside of the defined image) typically is called a *header*. In this case, however, such data is at the end, so it is called a *footer*.

EDT's software development kit for the IRIG option includes various files and library routines specific to IRIG, including but not necessarily limited to those described below.

simple_irig2.c

Example application that shows how to access IRIG information from frames captured using IRIG configuration.

libpdv.c

In addition to subroutines and functions for other purposes, `libpdv.c` includes the IRIG functions below.

To return the full size of the DMA (image data plus the 32-byte IRIG footer):

```
int pdv_get_dmasize(PdvDev *pdv_p)
```

To return the footer's byte offset from the beginning of the image data:

```
int pdv_get_header_offset(PdvDev *pdv_p)
```

For the IRIG footer, this will be:

```
image width x height x bytes per pixel
```

NOTE The PCIe DVa series boards require the DMA size to be a multiple of 8 bytes. Therefore, with or without the IRIG option enabled, the image size must be a multiple of 8 bytes.

To automatically enable IRIG functionality, you can use `pdv_set_header_type`:

```
int pdv_set_header_type(PdvDev *pdv_p, int header_type, int irig_slave, int irig_off-
set, int irig_raw)
```

Example:

```
int ret = pdv_set_header_type(pdv_p, HDR_TYPE_IRIG2, 1, 2, 0);
```

See the `simple_irig2.c` source code file for example code that shows how to use this functionality.

pdv_irig.c, pdv_irig.h

The functions below are included in `pdv_irig.c`.

To reset the frame counter to 0:

```
int pdv_reset_dma_framecount(PdvDev *pdv_p)
```

To set the IRIG format to packed BCD values if the value *bcd* is not zero (otherwise the format is Unix seconds since 1/1/1970):

```
int pdv_irig_set_bcd(PdvDev *pdv_p, int bcd)
```

To compute the offset of the IRIG footer and return a pointer to its memory (since this in the DMA stream from the board, this pointer will be overwritten when this buffer is used again):

```
irig2Record *pdv_irig_get_footer(PdvDev *pdv_p, u_char *imagedata)
```

To compute the Unix time from the counts values in the footer and places the result in footer > timestamp (and the timestamp value is also returned by the function):

```
double pdv_irig_process_time(Irig2Record *footer)
```

To clear the error flags `had_irig_error` and `had_pps_error` (“sticky” bits, indicating respective errors in the IRIG transfer or the 1 pps signal):

```
void pdv_irig_reset_errors(PdvDev *pdv)
```

To set the board in slave mode to use 1 pps or IRIG-B values received from another EDT board, rather than from the Lemo connector (note – this function requires a special cable from EDT):

```
void pdv_irig_set_slave(PdvDev *pdv_p, int onoff)
```

To use the direct register access to the current time value to fill in an Irig2Record structure (with the valid elements being counts, tickspps, status, and the IRIG seconds / bcd values):

```
void pdv_irig_get_current(PdvDev *pdv_p, Irig2Record *footer)
```

irigdump.c

The EDT PDV driver also contains a simple example program named `irigdump.c.` This program, based on `simple_take.c,` exercises most of the functions described above.

To display the command line arguments, run `irigdump -help.`

Appendix D: VxWorks

To run EDT products on VxWorks, you'll need to contact EDT for instructions customized for your setup.

NOTE VxWorks requires program arguments to be enclosed in double quotes (“ ”). Otherwise, all EDT command-line applications, utilities, and examples work the same as on other operating systems.

Initialization

The program `edtInstall` initializes the driver. To initialize the board for your camera, run `camconfig` and select your camera model.

Applications With and Without File Systems

EDT's VxWorks software can be configured to run with or without a file system.

If your target system has a file system, all programs work as for other operating systems, as described in the rest of this manual.

If your target system does not have a file system, build the required camera configuration files into the kernel module at the time of compilation. To save images to disk, you must set up a remote (e.g., FTP) connection to your development host. However, even with no file system, you can test whether image acquisition is working by running:

`camconfig` (if you have not yet initialized the board)

`take "-l 10"` (to acquire 10 images and store them in main memory until the program exits).

Display Applications

Because VxWorks applications typically include hardware-dependent code, EDT's GUI applications (such as `pdvshow`) do not work with VxWorks out of the box. However, EDT provides source code for `pdvshow` and the FLTK/OpenGL version `pdv_flshow` for developing a GUI.

If you wish to write your own image acquisition application, start with the example on the first page of the EDT digital imaging library in the EDT API (see Related Resources on page 8). If not, simply use `take` to capture images and transfer the images to your PC for display.

Portability

If you want to develop a cross-platform application (for example, to develop and test a program on Windows or Linux before deploying it on VxWorks), be aware that for VxWorks, the operating system, applications, and libraries are linked together into one binary that is loaded into memory and run as a single process, so applications cannot have a `main()` function.

To address this, your application can check whether the `NO_MAIN` name is defined and, if it is, replace `MAIN` with the application name. VxWorks passes the command line as a single string, so the code should use `opt_create_argv()` to split the string into an argument array and count.

Example (from `xtest.c`):

```
#ifdef NO_MAIN

  #include "opt_util.h"

  int xtest(char *command_line)

 #else

  int main(int argc, char **argv)
```

```
#endif
{
 #ifdef NO_MAIN
     char **argv  = 0 ;
     int argc = 0 ;
     opt_create_argv("xtest",command_line,&argc,&argv);
 #endif
```

The rest of the code in the `xtest.c` file deals with `argv` and `argc` and works the same on VxWorks as on other operating systems.

Note also these other portability issues:

- Stack size is set by the user; it does not grow automatically as it would in other operating systems.
- To prevent namespace conflicts, application functions should be declared static.
- Global variables should not be used; if they are used, declare them static.

Any globals and statics will have correct values only the first time the program is run; after that, the variables are still present and if nothing resets them, problems will occur when the program runs again.

Example: If global `init_done = 0` and `my_prog()` sets the global `init_done = 1,` then next time the program is run, `init_done` will be 1. Thus, `my_prog()` should reset `init_done = 0` right before exit.

Revision Log

Below is a history of modifications to this guide.

Date	By	Rev.	Pp	Detail
20150713	PH	next	All	Added “/DVa” to title: “Camera Link PCIe DV/DVa Frame Grabbers.”
20141111	PH	next	Title	Deleted unused document #(008-04053-[rev#]).
20141111	PH	next	All	Conformed “framegrabber” and “fiberoptic” to “frame grabber” and “fiber-optic.”
20141111	PH	next	11	Building or Rebuilding an Application: Added Note re. 32- vs. 64-bit applications.
20131218	PH	next	27	In Firmware > Checking and Loading the Firmware, after “Example: To load full-mode firmware on a PCIe8 DVa C-Link board, run...” – changed “pciload pe8dvacamlk” to “pciload pe8dvacamlk_fm.”
20130523	PH	next	11	• Under “Building or Rebuilding an Application,” step 3, changed last line(s) to: “...or, onWindows, as an alternative you can use the included Visual Studio 2008 projects and solutions in the subfolder `projects.vs2008`.”
20130521	PH	next	7, 34-35	• In PoCL subsection, updated Caution about PoCL. • In Appendices A (Pin Assignments) and B (Board Diagrams), updated Caution about PoCL and, in the latter, also the note on PCIe4 DVa FOX diagram.
20120914	PH	next	16-17	• Under “Example Applications and Utilities,” added `setdebug`.
20120515	PH	next	All	• Repaginated to use continuous arabic numerals from title page to end. • Implemented new terminology: Changed “digital video” to “vision” or “digital imaging.”
20120316	PH,RH	01	All	• Created this new guide for PCIe frame grabbers by moving all pre-PCIe frame grabbers into their own guide (for PCI, cPCI, and PMC).