USB 3.0 pco camera interface

This application note "USB 3.0 camera interface" discusses features and issues of the PCO USB 3.0 interface. Included in this discussion is the configuration of recommended hardware and software.

1 Introduction

The PCO USB 3.0 interface is based on the Cypress EZ-USB FX3[1] device and it is compatible to PCO software such as the pco.camware[2] and PCO SDK[3]. To run a PCO USB 3.0 camera successfully the user should consider a number of important issues that are discussed in the following Chapters. Chapter 2 is about recommended standard USB 3.0 hardware components, e.g. USB 3.0 Hubs and PCIe USB 3.0 interface cards. In Chapter 3 required software components are mentioned. Chapters 4 and 5 provide a list of known issues and FAQs encountered during testing. All topics are presented with suggestions for troubleshooting.

2 Recommended Hardware Components

This Chapter provides an overview of various hardware components that are required for a proper operation of PCO USB 3.0 cameras. Configurations that are recommended are provided for the following components:

- Motherboard, CPU and chipset configuration (Chapter 2.1)
- USB 3.0 xHCI host controller of the PCIe USB 3.0 interface card or the onboard USB 3.0 port (Chapter 2.2)
- USB 3.0 cables (Chapter 2.3)
- USB 3.0 hubs (Chapter 2.4)

2.1 Motherboard And Chipset Configuration

It is recommended to use a Motherboard with a state of-the-art USB 3.0 host controller for the onboard USB 3.0 ports. The latest generation of the USB 3.0 xHCI host controllers manufactured by Intel, Renesas (NEC), Fresco, Via Labs, ASMedia and Texas InstrumentInc. (TI) are tested by Cypress Semiconductor Corporation. (see Cypress EZ-USB® FX3™ SDK Release Notes, Version 1.2.3, (Chapter 1.3). Currently

PCO recommends only motherboards with the following onboard xHCI host controllers:

- Renesas/NEC µPD720202 host controller (see chapter 2.2);
- Intel® USB 3.0 eXtensible Host Controller (see Chapter 2.2).

If the Motherboard does not have an onboard USB 3.0 port or the onboard USB 3.0 port does not work properly with a PCO USB 3.0 camera (see Chapter 4 'Known Issues' and Chapter 5 'FAQs'), please use an independent PCIe USB 3.0 extension card. In this case, PCO recommends the following:

- DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller),
- DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller).

2.2 USB 3.0 Extension Card With xHCI[4] Host Controller

USB 3.0 xHCI host controllers are available from the following:

- Renesas Electronics America Inc. (earlier NEC),
- Texas Instrument Inc.,
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.,
- Intel Inc.,
- AMD Inc. and
- Etron Technology, Inc.

To determine suitable manufacturers of the xHCI controller, please use the Windows Device Manager. For example, in Windows 7 drop down the "USB-Controller" entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the properties dialog, click the 'details' tab, and choose 'Vendor' in the properties pull-down box.

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[1] The Cypress EZ-USB FX3 IC has an integrated USB 3.0 and USB 2.0 physical layer (PHY), and a fully configurable, parallel, general programmable interface called GPIF II, which can connect to an external processor, ASIC, or FPGA. EZ-USB FX3 enables data transfers up to 320 MBps from GPIF II to the USB interface. Cypress also provides drivers for Linux and actual Windows OSs (http://www.cypress.com/Fx3, Application Note: AN70707).

[2] Camware is a comfortable program for camera control and image acquisition, including recording of long sequences and time laps. It is capable of controling all digital imaging cameras of pco (http://www.pco.de/categories/camera-software/camware).

[3] The software development kit (SDK) gives customers the opportunity to use pco cameras within their own software for their applications, by simply making the functionality available with an appropriate dynamic link library (DLL) for Windows. The SDK package includes demonstration programs in C and C++ to allow a fast and easy start. So camera control can be added to the software (http://www.pco.de/categories/camera-software/software-development-kit/).

[4] eXtensible Host Controller Interface (xHCI) is a computer interface specification that defines a register-level description of a host controller for USB capable of interfacing to USB 1.0, 2.0, and 3.0 compatible devices.

A PCIe USB 3.0 extension Card will be required if the computer Motherboard does not have an onboard USB 3.0 port (see Chapter 2.1); or, the onboard USB 3.0 port does not work properly (see Chapters 4 and 5); or, if better performance is required (see Chapter 4.5). The following extension cards with USB 3.0 host controllers manufactured by Renesas (earlier NEC) have been tested and recommended:

- DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller),
- DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller).

NOTE: USB3.0 interface cards with controllers from Etron Technology, Inc. have not yet been tested.

2.3 USB 3.0 Cables

It is recommended to use the cable included with the PCO USB 3.0 camera. The USB 3.0 standard does not specify a maximum cable length. It only describes the electrical characteristics of the cable. Currently it is possible to buy USB 3.0 cables with lengths up to 5 m. When using a cable length of 5m, (or 10m with a USB 3.0 Hub between the camera and PC), and the cable is found insufficient, PCO offers an USB 3.0 fiber optic extender. Please contact the PCO support or visit the website for detailed information.

One potential problem caused by a faulty cable could be that the camera is not properly recognized by the PC and does not appear in the Device Manager; or, appears as "unknown device". This condition could occur from time to time or even permanently when the camera is connected to the PC.

2.4 USB 3.0 Hubs

In general, PCO does not recommend using a USB 3.0 Hub to operate one or more PCO cameras. When using a Hub, PCO cannot guaranty reliability and/ or full data throughput. If a Hub has to be used for multi-device operation, the PCO USB 3.0 interface only supports USB 3.0 Hubs only - no USB 2.0 Hubs. In the case that one or more cameras are operated from one PC, it is advised to use separate DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202

host controller) extension cards for each PCO USB 3.0 camera. If the maximum camera data throughput is not a primary requirement, a single 4 port DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller) extension card can be used. PCO has only tested USB 3.0 Hubs with Renesas Electronics America Inc. (earlier NEC) host controllers. Test results with other vendors, such as Texas Instrument Inc. and VIA Labs Inc (Diamond), will follow in the next version of this UBS 3.0 application note. Also, it is not recommended use two or more USB 3.0 Hubs in series.

2.5 Overview

The following table gives an overview about tested and recommended system configurations or hardware components.

3 Recommended Software Components

Table 1 – Recommended System Configurations	
motherboard	There is no recommendation for a manufacturer. But if an onboard USB 3.0 port is used, the Renesas´s xHCI host controller µPD720202 is recommended (see chapter 2.2).
USB 3.0 extension card	• DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller), • DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller) (see chapter 2.2).
PCIe Slot of the PC	A PCIe 4x, 8x or 16x slot is recommended.
USB 3.0 Cable	USB 3.0 cable included in the packaging of your PCO USB 3.0 camera (see chapter 2.3).
USB 3.0 Hub	Not recommended.
Operating System	Windows XP 32 Bit, Win7 32 Bit / 64 Bit, Win8 32 Bit / 64 Bit
Multiple PCO USB 3.0 cameras connected to a PC	A separate DELOCK 89348 (U3-PCIE1XG202-10) extension card for each camera should be used to guaranty maximum data throughput of each camera.
FOL adapter	Please visit our homepage (www.pco.de) for actual information.
This document	Please visit our homepage (http://www. pco.de/support) to get the most recent version of this document.

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The PCO USB 3.0 driver supports Windows 7/8 (x86 or x64) and Window XP x86 operating systems.

Microsoft does not support USB 3.0 natively for Win 7 or older Windows versions. Therefore use the manufacturers' supplied xHCI host controller driver. By contrast, in Windows 8 Microsoft does provide a native generic xHCI Driver but PCO recommends using the driver from the corresponding manufacturer of the xHCI host controller. Currently there are seven different vendors producing USB 3.0 host controllers:

- Renesas Electronics America Inc. (earlier NEC),
- Texas Instrument Inc.,
- VIA Labs Inc (Diamond),
- Fresco Logic Inc.,
- Intel Inc.,
- AMD Inc and
- Etron Technology, Inc.

Please make sure that the most recent driver from the manufacturer is installed before a PCO USB 3.0 camera is connected to a USB 3.0 port of the PC. The appropriate driver for the PC's USB 3.0 port could be loaded from the homepage of the manufacturer of the USB 3.0 host xHCI controller; or, from the homepage of the USB 3.0 extension card vendor. The current driver of the extension card included in the packaging of your PCO USB 3.0 camera is added to the PCO USB Stick delivered with the PCO USB 3.0 camera.

> To determine the driver currently in use for the xHCI controller, use the Windows Device Manager. For example in Windows 7, drop down the "USB-Controller" entry and find the USB 3.0 host xHCI controller of the USB 3.0 device in the sub-tree. Then right-click to open the Properties dialog, click the 'driver' tab and choose 'driver details'.

If the PCO USB 3.0 camera is turned on and is connected to the USB 3.0 port of the PC, the OS will automatically try to recognize the device and will try to install the correct PCO USB 3.0 driver.

3.1 Windows 7 and 8 PCO´s driver installation
The PCO´s USB 3.0 driver is installed with a dialog-based installer.

3.1.1 First Installation
In the case no PCO USB 3.0 driver is available; a message box will inform you that the driver installation has failed. In this case the Windows Device Manager will show an 'unknown device' called 'USB3'. Please download the PCO driver installer from http://www.pco.de/drivers and install the driver following the instructions provided. If the installation is successful, the PCO USB camera will be listed in the Device Manager at the 'PCO camera' entry with the name 'pco.camera with USB 3.0'.

3.1.2 Updating The Driver
In the case a PCO USB 3.0 driver is already installed and available, the PCO USB camera will be listed in the Device Manager at the 'PCO camera' entry with the name 'pco camera with USB 3.0'. To update the PCO USB 3.0 driver, please download the most recent driver installer from http://www.pco.de/drivers, and install the driver following the instructions provided.

3.2 Windows XP PCO´s driver installation
Installation of files manually.

3.2.1 First Installation
In the case when no PCO USB 3.0 driver is available, a dialog box will appear and ask where the driver is located. (This is similar to the installation of USB 2.0 devices). Choose the 'PCOUSB.inf' file from the downloaded after unpacking the driver zip-file. The zip-file can be downloaded from http://www.pco.de/drivers.

If no dialog box appears, please open the Property window of the 'unknown device' looking for 'PCO GigE/USB Interface' in the Windows Device Manager.

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The 'update driver' button on the Driver tab should then be clicked and the 'PCOUSB.inf' file from the unpacked driver zip-file should then be chosen. If the installation is successful, the PCO USB camera will then be listed in the Device Manager at the 'PCO camera' entry with the name 'pco.camera with USB 3.0'.

3.2.2 Updating The Driver

In case the PCO USB 3.0 driver is already installed and available, the PCO USB camera will be listed in the Device Manager in the 'PCO camera' entry with the name 'pco.camera with USB 3.0'. To update the PCO´s USB 3.0 driver, please download the most recent driver installer from http://www.pco.de/drivers, as follows:

- For Windows XP, the driver is packed in a zip-file which has to be unpacked into a local folder first. Then connect the camera to the PC and open the Windows Device Manager.
- Open the Property window of the 'PCO GigE/USB Interface' device in the 'pco.camera with USB 3.0' entry.
- Click the 'update driver' button on the Driver tab and then choose the 'PCOUSB.inf' file from the downloaded and unpacked driver zip-file.

4 Known Issues

Each of the USB 3.0 hardware and software components will have an effect on the performance of the PCO USB 3.0 interface. So each component, e.g. the Motherboard, USB 3.0 PCIe extension card and its driver, USB 3.0 Hub, etc., could be the reason why a PCO USB 3.0 camera might fail to be properly connected. The most common issues are discussed below.

4.1 USB 3.0 camera is not enumerated by Windows OS

Please make sure the operating system is Windows 7/8 (x86 or x64) or Window XP x86. The PCO USB 3.0

interface will only support these operating systems. Known reasons why a USB 3.0 camera is not recognized by the Windows OS and does not appear in the Device Manager are as follows:

- The USB 3.0 xHCI host controller of the Motherboard´s onboard port or the extension card does not work properly with the Cypress EZUSB® FX3™. Or, the driver of the USB 3.0 xHCI host controller is incorrect or outdated (see Chapter 3).
- The spread spectrum clocking5 generated by the chipset of the Motherboard disturbs the Cypress EZ-USB® FX3™. Some xHCI host controllers allow a too wide a clock spectrum, which the Cypress EZUSB® FX3™ cannot handle.
- A faulty USB 3.0 cable is being used (see Chapter 2.3).

In some applications one or two further extension cards should solve this problem (see Chapter 2.2). PCO recommends the following extension cards:

- DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x (µPD720202 host controller),
- DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x (µPD720202 host controller).

4.2 Data transfer problem with USB 3.0 Hubs

In general, PCO does not recommend the use of USB 3.0 Hubs. If more than one camera is required to be connected to a PC, please use a separate DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x extension card for each PCO USB 3.0 camera. If the cameras' data throughput is not important, a single 4 port DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x extension card could be used (see Chapter 2.4).

4.3 The PCO USB 3.0 driver cannot be installed

The PCO USB 3.0 driver supports the operating systems Windows 7/8 (x86 or x64) and Window XP x86. If the PCO USB 3.0 camera is turned on and is connected to the USB 3.0 port of the PC, the OS will automatically try to recognize the device and will try to install the appropriate PCO USB 3.0 driver.

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[5]spread-spectrum techniques are methods by which a signal generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth. These techniques are used for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference, noise and jamming, to prevent detection, and to limit power flux density.

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Windows 7 and 8 driver installation:
In the case no PCO USB 3.0 driver is available; a message box will inform that the driver installation has failed. In this case the Device Manager will list an 'unknown device' called 'USB3'. Please download the PCO driver installer from http://www.pco.de/drivers and install the driver following the instructions in the software dialog. If the installation is successful, the PCO USB camera will be listed in the Device Manager at the 'PCO camera' entry with the name 'pco camera with USB 3.0'.

Windows XP driver installation:
In case no PCO USB 3.0 driver is available, a dialog box will appear and ask where the driver is located. (This is the same procedure as when installing USB 2.0 devices). Choose the PCO USB 3.0 driver downloaded from http://www.pco.de/drivers. If the installation is successful, the PCO USB camera will be shown in the Device Manager in the 'PCO camera' entry with the name 'pco camera with USB 3.0'. If the camera is turned on and the camera is not listed in the Device Manager; and, no dialog box appears to ask for the location of the driver, there could be a hardware or software problem. To solve this problem please check the following:

• Verify the most recent driver for the USB 3.0 host controller installed (see Chapter 4);
• Check whether any of the other USB 3.0 ports available on the PC perform better;
• If available, try another USB 3.0 PCIe extension card (see Chapter 2.2).

4.4 Data Transfer Problems, If More Than One Camera Is Connected

With the PCO USB 3.0 interface, up to eight USB 3.0 cameras can be operated together on one PC. If there are any I/O errors during an image transfer, the problem could be the performance of the active xHCI host controller. In this case, the DELOCK 89325 (U3X4-PCIE4XE101) PCIe 4x extension card is recommended to get the best performance (see Chapter 2.4 for detailed information).

4.5 How To Increase The Performance

The minimum data throughput of a USB 3.0 connection should be 130 MB/s. Most of the PCO USB 3.0 cameras depending on the camera settings, e.g. Pixel Clock Rate, number ADCs, resolution, etc., can provide this data throughput. The maximum data throughput of the PCO USB 3.0 interface is approximately 340 MB/s. For example, if a PCO USB 3.0 camera provides a data throughput of 180 MB/s but only 130 MB/s are transferred to the PC, the xHCI host controller of the PC is acting as the bottleneck. To increase the performance of the host PC, it is advised to use one of the extension cards recommended in Chapter 2.2. The recommended extension cards should have a PCIe 1x or PCI 4x interface to the PC.

To make sure the full data-throughput of the camera is realized to the PC RAM, it is highly recommended to use a PCIe 4x, 8x or 16x slot in the PC. In case Windows 8 is used, poor performance could be caused by the automatically installed Microsoft generic xHCI USB 3.0 driver. In this is the case, load and install the driver from the manufacturer`s xHCI host controller. Please read Chapter 3 for more detailed information.

If more than one PCO USB 3.0 camera is used please note that the extension cards have a maximum bandwidth. For example, if the DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card is connected to a PCIe 16x slot in the PC, the effective bandwidth will be approximately 360 MB/s. In the case of two PCO USB 3.0 cameras connected to two ports of the extension card, the accumulated data throughput from both cameras cannot exceed 360 MB/s. In this case it is recommended to use a second dedicated DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card connected to a second PCIe 16x slot of the PC controlling the second PCO USB 3.0 camera.

5 FAQs

• ***Can I use USB2.0 PC components?***
If the USB Port, the USB Cable, or the USB Hub

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does not support USB 3.0, a USB 3.0 PCO camera will not operate properly. The camera will be recognized in the Device Manager as a USB2.0 device. Operation of the PCO camera using camware or one of the PCO SDK camera related functions will fail and the following message box will appear:

"Please make sure your camera is connected to a USB 3.0 port. If your camera is connected to a USB 3.0 port, please read the application note APL_USB3_xxx.pdf".

• ***How to identify the manufacturer of the USB 3.0 host controller?***
If a driver for the onboard USB3.0 port or an independent PCIe USB3.0 interface card is already installed, open the Windows Device Manager. Then extend the 'USB-Controller' entry and find the USB 3.0 host controller of the specific USB 3.0 device in the sub-tree. Right click to open the Properties dialog and then click the 'details' tab which will allow you to identify the correct manufacturer of the USB 3.0 controller.

• ***Why can't the PCO USB 3.0 camera be opened with camware or the PCO SDK?***
In case a PCO USB 3.0 camera is connected to your PC and the camware software starts in "Demo Mode"; or, the Camera Open Function of the PCO SDK returns an error, the explanation could be:

– The PCO USB 3.0 driver is not installed to your system and the PCO USB 3.0 device is listed as "unknown device" in the Device Manager. If so, right click the "unknown device" to open the properties dialog and install the PCO USB 3.0 driver. The driver can be downloaded from our website at "http://www.pco.de/drivers/". If the PCO USB 3.0 driver is properly installed, there will be a "PCO cameras" entry with a 'pco.camera with USB 3.0' device listed in the Device Manager.

– Another issue could be that the USB 3.0 camera is not recognized by the OS and it does not appear in the Device Manger, meaning it is even not shown as 'unknown device'. In this case

please refer to Chapter 4.1 and follow the instructions provided.

• ***Why was the PCO USB 3.0 camera not recognized by the OS?***
There could be a problem with the USB 3.0 xHCI host controller of the Motherboard or with the extension card installed in the PC. Additionally, a bad USB 3.0 cable could be the problem. Please refer to Chapter 4.1 for detailed information.

• ***How to increase the performance of the USB 3.0 data transfer?***
To make sure the full data-throughput of the camera can be transferred to the PC's RAM, it is recommended to use a PCIe 4x, 8x or 16x slot in the PC. Please refer to Chapter 4.5 for detailed information.

• In the case of using Windows 8, poor performance could be caused by the Microsoft`s automatically installed generic xHCI USB 3.0 driver. In this case please load and install the driver of the manufacturer`s xHCI host controller. Please refer to Chapter 3 for detailed information.

• If more than one PCO USB 3.0 camera is operated on a single PC, please note that extension cards have maximum bandwidths that with two or more cameras are being exceeded. There exists a maximum bandwidth of an extension card, e.g. if the DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card is connected to a PCIe 16x slot of the PC the effective bandwidth is about 360 MB/s. If two PCO USB 3.0 cameras are connected to both ports of the extension card, the accumulated data throughput of both cameras cannot exceed this 360 MB/s maximum. In this case it would help to use a second DELOCK 89348 (U3-PCIE1XG202-10) PCIe 1x card connected to a second PCIe 16x slot of the PC for the second PCO USB 3.0 camera.

• ***How many PCO USB 3.0 cameras can be connected to and operated with one PC? How many PCO USB 3.0 cameras are supported by the PCO USB 3.0 driver?***
The PCO USB 3.0 driver supports up to eight cameras using one PC (See Chapter 4.4).

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- ***The USB 3.0 PCO Driver Installer does not work.***
    - The installer will return a warning that the current OS is not supported. The installer supports the 32-bit and 64-bit versions of Windows 7 and Windows 8.
    - If the installer file is executed and a no dialog-window appears:
      Please try to install the driver manually using the Windows Device Manager. Contact our support team to get the driver files for manual installation.
    - The driver is correctly installed, but the USB 3.0 PCO camera does not appear in the Device Manager:
        * Make sure the PCO USB 3.0 camera is ready, the power switch is turned on, and the camera is connected to the PC (see Chapter 4.1).
        * Note that while installing the camera to the PC that during the USB 3.0 driver installation it could take a minute or more until the PCO USB 3.0 device recognized and is available for use.

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