FireWire-CAM-001
FireWire-CAM-002

Manual

1st Edition

A product of a PHYTEC Technology Holding company

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1st Edition February 2005

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1 Delivery Contents

The standard scope of supply includes the following components:

- the camera
- a C/CS-mount adapter
- a tripod adapter (bolted together with the camera)
- the **software**-CD SO-221
- this manual

1.1 Accessories

For the operation of the camera you normally need some additional components.
You can obtain following material designed to be compatible with the camera from PHYTEC:

Figure 1: FireWire Connector Cable 6-Pin/6-Pin Type

- FireWire Connector Cable (6-pin/6-pin type), 1.8 m
  Order number WK096-1.8
- FireWire Connector Cable (6-pin/6-pin type), 3.0 m
  Order number WK096-3.0
- FireWire Connector Cable (6-pin/6-pin type), 4.5 m
  Order number WK096-4.5

Figure 2: Firewire Connecting Cable 6-Pin/4-Pin Type

- FireWire Connector Cable (6-pin/4-pin type), 1.8 m
  Order number WK097-1.8
- FireWire Connector Cable (6-pol/4-pin type) 3.0 m
  Order number WK097-3.0
- FireWire Connector Cable (6-pol/4-pin type), 4.5 m
  Order number WK097-4.5

Hint:

- The FireWire cables with a 4-pole plug are usually needed for connecting the camera to a laptop.
  The 4-pin FireWire connection does not provide supply voltage. When using such a cable you need a separate mains adapter for the power supply.
- Please note that the full data rate is specified for a cable length of up to 4.5 m. The usage of longer cables is possible but the data rate will be reduced according to the bus specifications. This means that you possibly cannot use the full image resolution or framerate.

- AC-adapter 12 V / 600 mA for separate power supply
  Order number SV001

- Video lenses:
  In our product range we keep a variety of high-quality lenses for several purposes. We will gladly assist you in choosing an adequate lens.

- Additional accessories:
  Depending on your application you may need further components. We are happy to assist you in case any questions should occur.

1.2 What you Need for the Initial Start-Up

For the initial basic start-up you usually need some further components besides the FireWire-CAM itself.
These are partially dependent on the computer with which you use the camera. In *Figure 3* you get a first overview of the appropriate accessories:

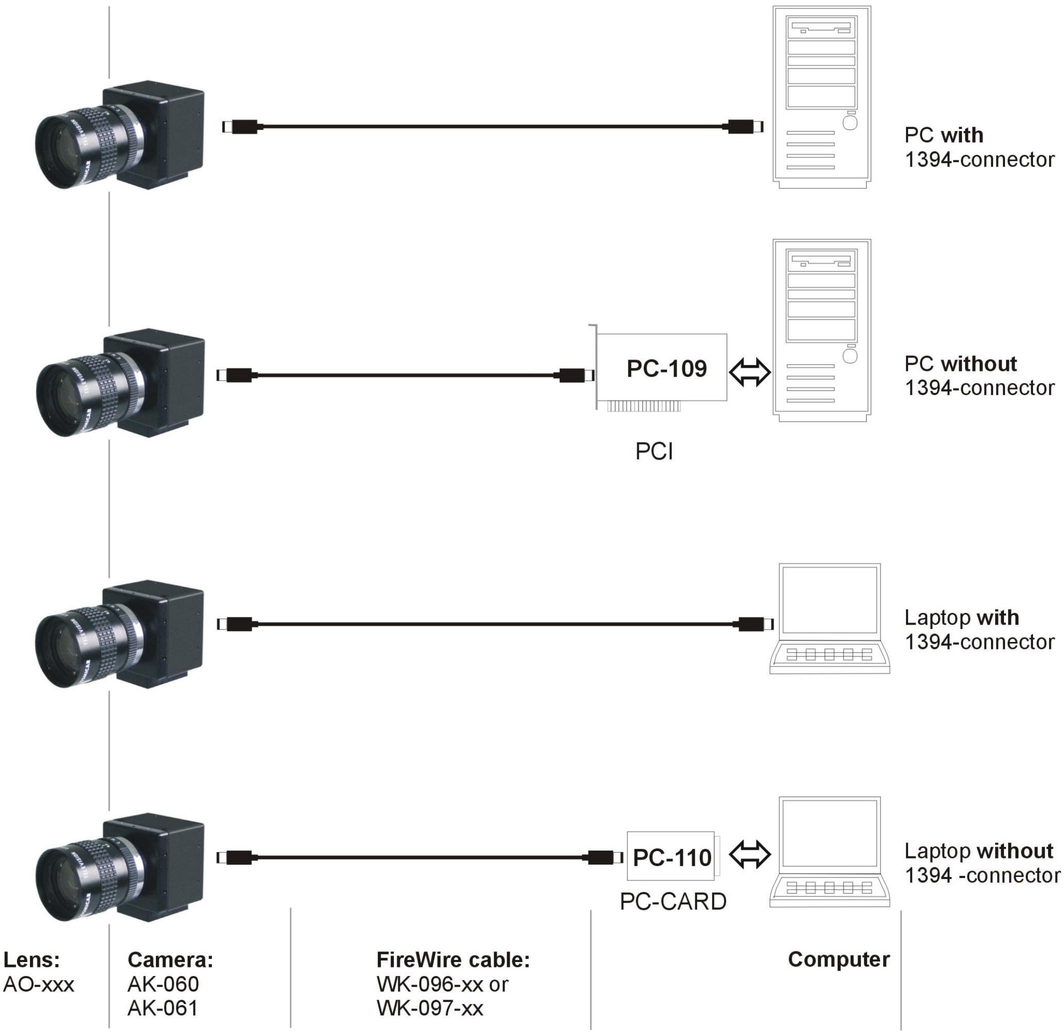

Figure 3: Components of a FireWire System

- A C- or CS-Mount lens. Please note however that the high quality of digital cameras should not be reduced by using lenses of low quality (*see section 3.6*). PHYTEC provides a wide range of compatible high-quality lenses.

- A PHYTEC FireWire camera.

- In case the IEEE 1394 bus does not provide supply voltage (which is common to almost all laptop solutions), you will need an extra mains adapter (e.g. the SV001, *see above*). You can use a stabilised quality-mains adapter of your choice alternatively if it provides 8 to 40 VDC and 500 mA. *Please read section 1.4,"Important Notes"*

- A cable for the connection between camera and IEEE 1394 bus. This will usually be the IEEE 1394 interface (host controller) of your computer. PHYTEC provides several IEEE 1394 cables. You can use any other cable alternatively if they comply with the IEEE 1394 standard. *Please read section 1.4,"Important Notes"*

- A computer (PC, laptop) that meets the following requirements

Caution!
The host computer has to meet following requirements:

- 1394 interface, compatible with the standards IEEE 1394-1995 and IEEE 1394a (OHCI), 400 MBit/s
- processor: Pentium II, 300 MHz or higher
  recommended: Pentium II, 500 MHz, 128 MB RAM or higher
  for "FireWire-SDK": PIII, 800 MHz or higher
- Graphics adaptor with 24 or 32-bit colour depth
- Operating system: Windows 2000/SP2 or Windows XP
- DirectX 8.1 or higher

Note:
In case you purchased a Starter-Kit, most components needed are already contained.
Please compare the the contents of your kit with the list of required components first.

1.3 Features of the FireWire-CAM-001 / 002

Both FireWire cameras feature following attributes:

- 1/4" progressive-scan CCD
- 640 x 480 pixel
- up to 30 images/s
- IEEE 1394a interface
- DCAM 1.04 protocol
- WDM Stream Class driver included
- PHYTEC-FireWire SDK included
- connection for C-/CS-Mount lenses (lens not included)

- **FireWire-CAM-001**: monochrome model („black/white“)
- **FireWire-CAM-002**: colour model

Notes:
- You can find the detailed technical data in *section 5.*
- In this document and in the application software, the cameras are sometimes referred to as FCAM-001 resp. FCAM-002.

1.4 Important Notes

- We hereby expressly note that, according to the product liability law, we cannot be made responsible for damages caused by our devices if they have been used or repaired inappropriately or if, in case of a component replacement resp. system construction, other parts than our original components or components approved by us have been used, and especially if the operating instructions were not correctly followed.

- Handle the camera with care. Avoid hard shocks, concussions, etc. The camera can be damaged by incorrect handling and wrong storage.

- Do not try to disassemble the camera. To avoid electric shocks, do not remove neither screws nor the case. There are no components in the camera that need user maintenance. Maintenance work may only be carried out by qualified maintenance personel.

- Never use strong or abrasive detergents (e. g. alcohol, benzene or turpentine) to clean the case of the camera. Wipe the case with a soft cloth slithtly moistened with a neutral cleanser.

- Never expose the camera to humidity, dust or dirt. This camera is intended for indoor use only. Humidity can damage the camera and cause the risk of electric shock.

- Never point the camera towards the sun or very bright objects. Otherwise this may lead to blooming and smear.

- Keep the camera shut or mount a lens to avoid getting dust on the CCD chip.

- Clean the CCD front panel carefully. Never use strong of abrasive detergents for the cleaning of the CCD front panel.

- Only use the original cable and power supply intended for the camera. The warranty expires if other cables or power supplies are used.

- If you would like to use the camera with another power supply, please note that it may only be used with a low voltage of +8 to +40 V DC (direct current). Connecting it directly to mains voltage (e.g. 230 V AC) is a danger to life!

- The mains adapter provided with the camera (depending on supply option) should not be used with other devices.

1.5 Declaration of Conformity

The cameras FireWire-CAM-001 and FireWire-CAM-002 meet the EC directive 89/336/EEC for a digital device of class B. They have been tested and thus conform to EN55024/CISPR22 and EN55024/CISPR24.
To conform to EU standards, shielded cables have to be used to connect other devices to the camera. The cameras have been tested in a typical environment complying with class B. It is therefore assumed that the cameras will also be functioning in other environments complying with class B.

1.6 Overview of Connectors and Settings

1.6.1 Connectors

Usually you only need the IEEE 1394 bus for connecting the camera. This bus transmitts the video data, the control data and the supply voltage for the camera.
In case the IEEE 1394 bus does not provide supply voltage, the camera requires an additional mains adapter.
Always connect the **In** socket directly resp. indirectly (*see Figure 5*) with the computer (PC).

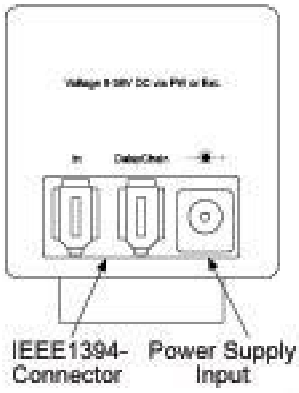

Figure 4: Rear View

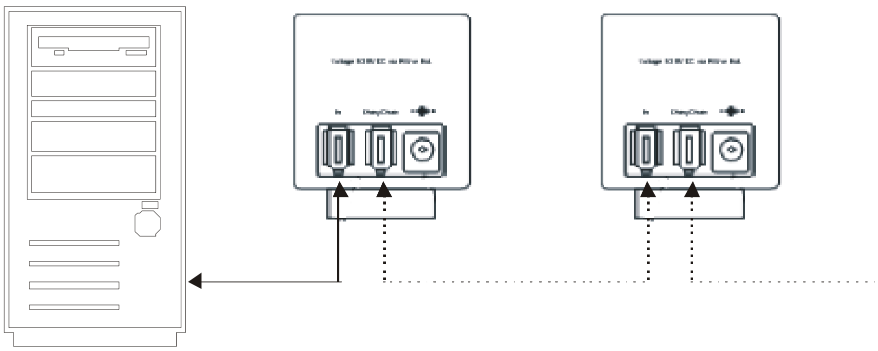

Figure 5: Connecting the FireWire Cameras with the Computer (PC)

Caution!

- The terms „In“ and „DaisyChain“ specify the direction of the feeding of the supply voltage: **In** expects a power supply by another 1394 device while **DaisyChain** supplies other 1394 devices (*see Figure 6)*
- If you have connected the camera to your computer via a 4-pole plug, your camera will not be supplied with voltage by this device. In this case you will have to connect the socket „power supply“ to an external power supply. Use for example the mains adapter SV001 from PHYTEC.

1.6.2 Settings

All parameters of the camera are adjustable via the IEEE 1394 bus. The camera is delivered with a sample application (requires Windows 2000/SP2, XP or higher and DirectX 8.1 or higher), that allows for the acquisition of images and streams of images and the adjustment of the basic parameters (*see section 2.5)*

It is, of course, possible to adjust the camera parameters independently of this program. For this purpose, PHYTEC offers a WDM Stream Class driver (*see section 4*) which allows the parameters to be set with every image processing software compatible to DirectX 8 or higher.

Alternatively the PHYTEC-SDK (DirectX wrapper) can be used. It allows for a very convenient access to all features of the FireWire-CAMs without the programmer having to become acquainted with the complexity of DirectX.The SDK includes connections to several programming interfaces:

- **.NET components:** for MS Visual Basic .NET and C# .NET
- **ActiveX Control:** for Microsoft Visual Basic 6
- **C++ Class Libary:** Microsoft Visual C++ 6 and Visual C++ .NET

For each of these interfaces the SDK provides all binaries, headers and libraries needed, a detailed help as well as sample projects and demo programs with source codes.

You will find an overview dealing with the programming in *section REF _Ref101320163 \n \h 4*. The complete specifications for the features you will find in the help files dealing with the respective programming environments on the *„Vision-Tools“-CD, SO-221.*

An outline of standardised dialogues is available in *section 2.5.3*, details on these parameters you will find in *section 3.4*.

2 First Steps

This chapter explains how to connect the FireWire camera to your computer and how to install the software needed for the first image acquisitions.The individual sections discuss the proceedure for different hardware constellations.
Please check which hardware version you are using and read on in the corresponding section:

Section 2.1: Hardware Installation on a Standard PC
Section 2.2: Laptop Installation

Section 2.3 describes the installation of the software for all hardware variants.

2.1 Hardware Installation on a Standard PC

2.1.1 The FireWire connection

Check first if your computer is already equipped with a FireWire interface.

You will usually find a 6-pole FireWire socket on your PC (*Figure 6*).

Figure 6: A 6-Pin FireWire Socket

You will be able to identify this socket by the FireWire logo (*Figure 7*):

Figure 7: FireWire and i.LINK lLgos

Note:
The FireWire interface sometimes is also called i.LINK or IEEE-1394.

All signals and the supply voltage necessary for operating the camera are usually available on this socket.
Therefore only one single cable is necessary for the camera.

This cable has to feature a 6-pin plug on each end (*Figure 8*):

Figure 8: FireWire Connecting Cable 6-Pole/6-Pole Type

Depending on the desired length of the cable, you can use one of these FireWire cables for the connection:

- FireWire connection cable (6-pin/6-pin type), 1.8 m
  Order number WK096-1.8
- FireWire connection cable (6-pin/6-pin type), 3.0 m
  Order number WK096-3.0
- FireWire connection cable (6-pin/6-pin type), 4.5 m
  Order number WK096-4.5

Hints:

- In case your PC should not have a FireWire interface, you would first have to install a FireWire interface card to be able to use the camera. *Refer to section 2.1.2.*
- In case your PC should have a smaller 4-pin FireWire socket, please proceed as explained in *section 2.2, "Laptop Installation"*. If your computer features both types of sockets, we recommend the connection on the 6-pin socket.
- Please note that the full data rate is specified only for a cable length of up to 4.5 m. The use of longer cables is possible but the data rate will be reduced according to the bus specification. This means that you possibly will not be able to use the full image resolution or framerate.

The FireWire interface is „hot-plug"-capable. This means that you can connect and disconnect the camera without having to shut down your computer. Please mind however to close all programs that access the camera to avoid data loss.

To put the camera into operation, simply plug one end of the FireWire cable into the socket „In" on the back of the camera and the other end into the 6-pin FireWire socket of your computer.
Further connections are not required.

Caution!
You will have to install the respective driver software on your PC prior to the initial operation. Without the installation of the driver, the camera will not function at all or merely in a limited way.
Please read *section 2.3* how to install the driver.

2.1.2 Installation of a FireWire Interface Card (PC)

This step is necessary if your computer is not yet equipped with a FireWire interface.
In this case you require an additional PCI card with FireWire interfaces. Below we describe the installation of the PHYTEC FireWire card, ordering number PC-109.
Depending on the option of order, this card may already be included as part of your kit's delivery contents.

Caution!
For this step the computer has to be disconnected from the mains voltage supply. It is important that you are absolutely certain that the device is not receiving voltage from any source.
Be aware that if this is not the case, parts of the device can carry voltages at levels that could cause electrocution.

Remove the case of the PC (usually screwed).Choose a free PCI slot (usually the white, short parallel slots on the motherboard).

- Remove the PC housing (usually screwed).
- Choose a free PCI slot (usually the white, short parallel slots on the motherboard)
- Remove the slot bracket from the PC case (unscrew or break it off if neccesary).
- Carefully insert the FireWire interface card PC-109 into the slot (*as depicted in Figure 9*) with the slot bracket towards the outside. The card should lock firmly.
- Do not push the card into the slot with force, motherboard or card could be damaged!
- Mind that the card's golden contact stripes match the contact springs of the slot.

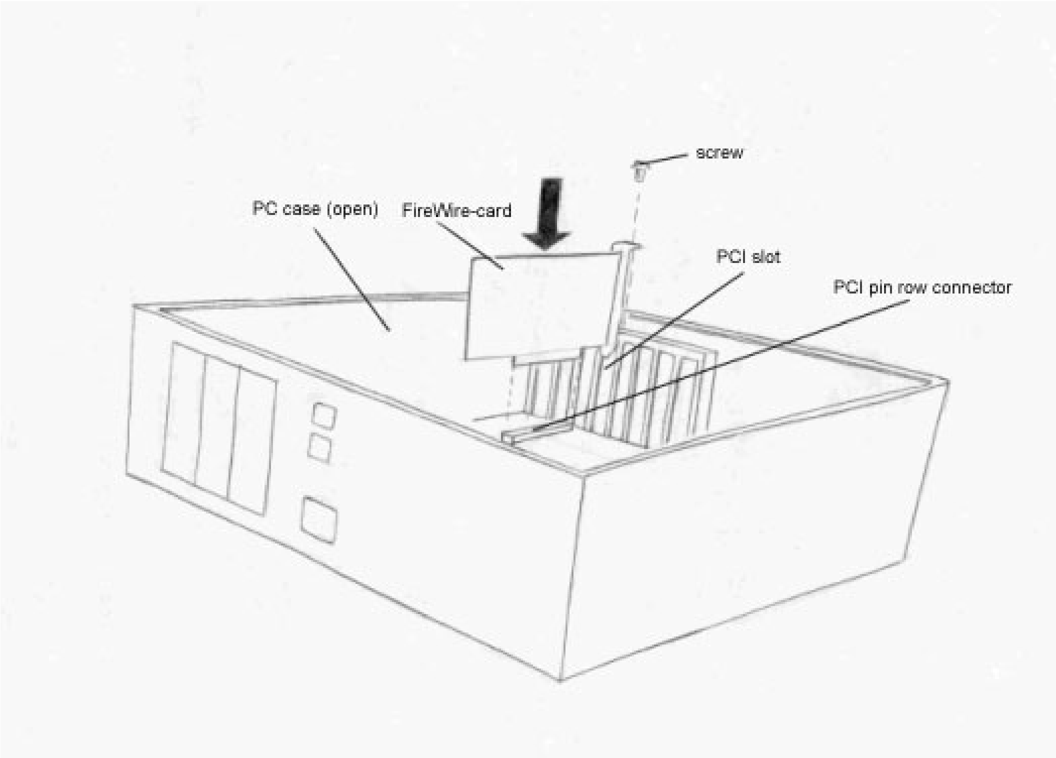

Figure 9: Insertion of the Card into the PCI Slot

- Make sure that the card is straight and that no neighboring contacts have been short circuited.

Attention!
Fix the card with a screw to the case for reasons of stability and to ensure that the card has a safe bonding to the computer case *(see Figure 9)*

- Close the computer's housing.
- Reconnect the mains supply.
- Do not yet connect the camera with the FireWire socket of the interface card.
- Now start the computer. Windows XP / Windows 2000 automatically identifies the newly installed interface card. Since the software drivers are already included in the operating system, you usually will not need an installation CD.

2.2 Laptop Installation

2.2.1 The FireWire Connection

Check first if your computer is already equipped with a FireWire interface.

A laptop usually is provided with a 4-pin FireWire socket (*Figure 10*).

Figure 10: 4-Pole FireWire Socket

You will also recognise this socket by the FireWire logo (*Figure 11*):

Figure 11: FireWire and i.LINK Logos

Note:
The FireWire interface sometimes is also called i.LINK or IEEE-1394.

The 4-pole socket – other than the 6-pole socket – transmitts data signals but no supply voltage for the camera. Therefore a seperate power supply is required to provide the camera with electricity.

This cable has to feature a 6-pole plug on one end and a 4-pin plug on the other (*Figure 12*):

Figure 12: FireWire Connecting Cable 6-Pin/4-Pin Type

Depending on the desired length of the cable, you can use one of these FireWire cables for the connection:

- FireWire Connector Cable (6-pin/4-pin-type), 1.8 m
  Order Number WK097-1.8
- FireWire Connector Cable (6-pin/4-pin-type), 3.0 m
  Order Number WK097-3.0
- FireWire Connector Cable (6-pin/4-pin-type), 4.5 m
  Order Number WK097-4.5

Hints:
In case your PC should not have a FireWire interface, you would first have to install a FireWire interface card to be able to use the camera. Most laptops offer the possibility to insert an additional card in form of a "PC-card" (resp. „PCMCIA" card). *Please read section 2.2.2 on this.*

If your laptop is equipped with a 6-pole FireWire socket, proceed as described in *section 2.1, "Hardware Installation on a Standard PC"*.

Check the manual if your laptop supplies voltage via this socket. Otherwise an additional mains adapter for the camera is required.

- Please note that the full data rate is specified only for a cable length of up to 4.5 m. The use of longer cables is possible but the data rate will be reduced according to the bus specification. This means that you possibly will not be able to use the full image resolution or frame rate.

The FireWire interface is „hot-plug"-compatible. This means that you can connect and disconnect the camera without having to shut your computer down. Please mind however to close all programs that access the camera to avoid data loss.

To connect the camera, please proceed as follows:

- First supply the camera with power. For this you can use a stabilised quality mains adapter of your choice in case it provides 8 to 40 VDC (direct current) and 500 mA. We recommend the use of the PHYTEC mains adapter SV001. Depending on the option of order, this adapter may already be included in your kit contents.

- Check the voltage setting of the adapter and select the appropriate low voltage connector (5.5 mm outer diameter). When connecting be sure that the polarity is correct! (minus outside, plus inside).
  Connect the adapter to the right socket on the back of the camera (In *Figure 13*, labelled „Power Supply Input").

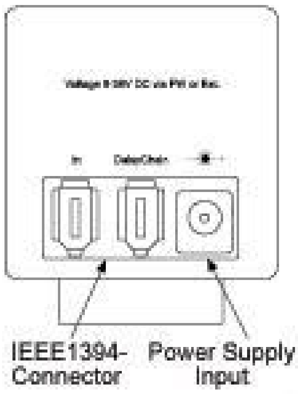

Figure 13: Camera Connectors

- You can now establish the FireWire connection. To do this insert the cables 6-pin plug into the „In“ socket on the back of the camera and the 4-pin plug into the FireWire socket on your computer.

Caution!
Before initial start up you will first need to install the corresponding software on your PC. Without the driver the camera will function in a limited capacity or not at all. *Refer to section 2.3 for installation of the driver*.

2.2.2 Installation of a FireWire Interface Card (Laptop)

This step is only required if your laptop is not equipped with a FireWire interface.
In this case you will require an interface card for FireWire. In the following paragraphs we describe the installation of the PHYTEC FireWire Card, Order Nr. PC-110.
Depending on the order option you have, this card may already be included as part of your kit contents.

The card PC-110 is an add-on card for the PC-Card receptacle socket (also identified as „Cardbus“). Your laptop must be equipped with a socket of this type.
Please note the additional system requirements listed in the card manual.

The interface card is „hot-plug“ capable. You can therefore insert it into the cardbus receptacle socket of your laptop while it is turned on. With Windows 2000/Windows XP the card is automatically recognized and installed.
In general no installation CD is required, since the software drivers are already present in the operating system.

The FireWire card is equipped with 6-pin FireWire sockets. Depending on the desired cable length, one of the following FireWire cables can be used to establish a connection:

- FireWire Connector Cable (6-pin/6-pin Type), 1.8 m Order Nr. WK096-1.8
- FireWire Connector Cable (6-pin/6-pin type), 3.0 m
  Order Nr. WK096-3.0
- FireWire Connector Cable (6-pin/6-pin Type), 4.5 m
  Order Nr. WK096-4.5

Caution!
Although the interface card has 6-pin sockets, the laptop will generally not provide a power supply for the camera. Therefore you will have to use an external power adapter for the camera.

To connect the camera proceed as described below:

- First connect the camera’s power supply. You can use a high-quality stabilized adapter of your choice, as long as it delivers 8 to 40 VDC (Direct Current) and 500 mA. We recommend that you use the PHYTEC adapter SV001. Depending on the kit option you have, this adapter may already be included on delivery.
  Check the voltage settings of the adapter and select the appropriate low voltage plug (5.5 mm outer diameter). When connecting be sure that the polarity is correct (minus outside, plus inside).
  Plug the adapter into the right socket on the back of the camera (labelled „Power Supply“ in *Figure 14*).

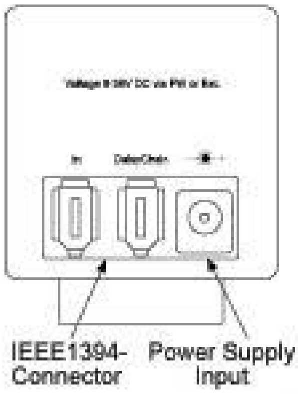

Figure 14: Camera Connectors

- You can now establish the FireWire connection. Insert one end of the FireWire cable in the socket „In" on the back of the camera and the other side in the 6-pin FireWire socket on the interface card.

Caution!
Upon initial start up you have to install the corresponding driver software on the PC. Without installing the driver, the camera will function in a limited capacity or not at all. *Refer to section 2.3 for driver installation.*

2.3 Installation of the Driver Software

The appropriate software device driver has to be installed so that the camera can be addressed by the application software.
This device can be found on the CD that is included with the camera. You can also download driver software updates from the PHYTEC website.

Caution!
Check first to see if your computer meets the following system requirements for operating the camera:

- Pentium II, 300 MHz or higher and 1394-interface
- Graphic card with 24 or 32-bit color depth
- Windows 2000/SP2 or Windows XP
- DirectX 8.1 or higher

Make sure that your computer is equipped with this software.

To install the driver software for the FireWire camera, proceed in the following manner:

Caution!
The DirectX driver must be installed prior to installation of the driver software for the FireWire camera. Otherwise not all driver functions will be supported and/or the system may crash.

- Connect the camera to your computer. To install the driver the camera must be ready for operation. Follow the instructions in the previous sections for this.
- Insert the CD SO-221 in your computer's CD-ROM drive.
- The CD should start automatically, bringing up the title menu shown in *Figure 15*.
  If the CD doesn't start automatically: open the content folder of the CD (from your desktop or using Windows Explorer) and double click on ***SO-221.exe***.

Figure 15: Title Menu of the „Vision Tools" - CD

- Click on *FireWir-CAM*. You will be taken to the installation menu for the PHYTEC FireWire Camera. Select *„FCAM-001/-002"* (*Figure 16*) and click on *Install Driver*.

Figure 16: Installation Menu for the FireWire Camera

- The installation program of the FireWire Camera's software driver (DCAM-Driver) will appear, *Figure 17*.

Figure 17: Driver Installation, Step 1

- Select the camera model that is connected to the FireWire interface. (This model should already be selected.)
  If no selection appears, check to see if the camera is connected correctly and ready for operation. This is required before the driver can be installed. Click on „*Next*".

- The driver is now installed (*Figure 18*)
  In some cases a software compatibililty warning will appear (*Figure 18*). Click on „*Continue Installation*".

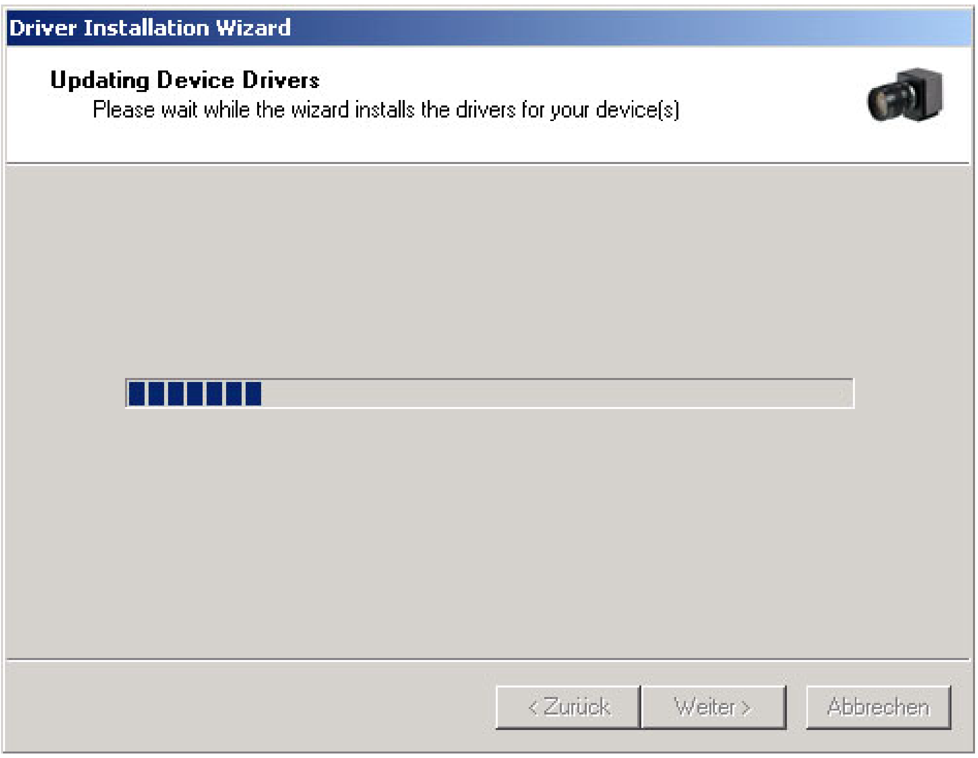

Figure 18: Driver Installation, Step 2

Figure 19: Driver Installation, Compatibility Warning

- At the end of the installation you will receive a message (*Figure 20*). Click on „*Finish*“.

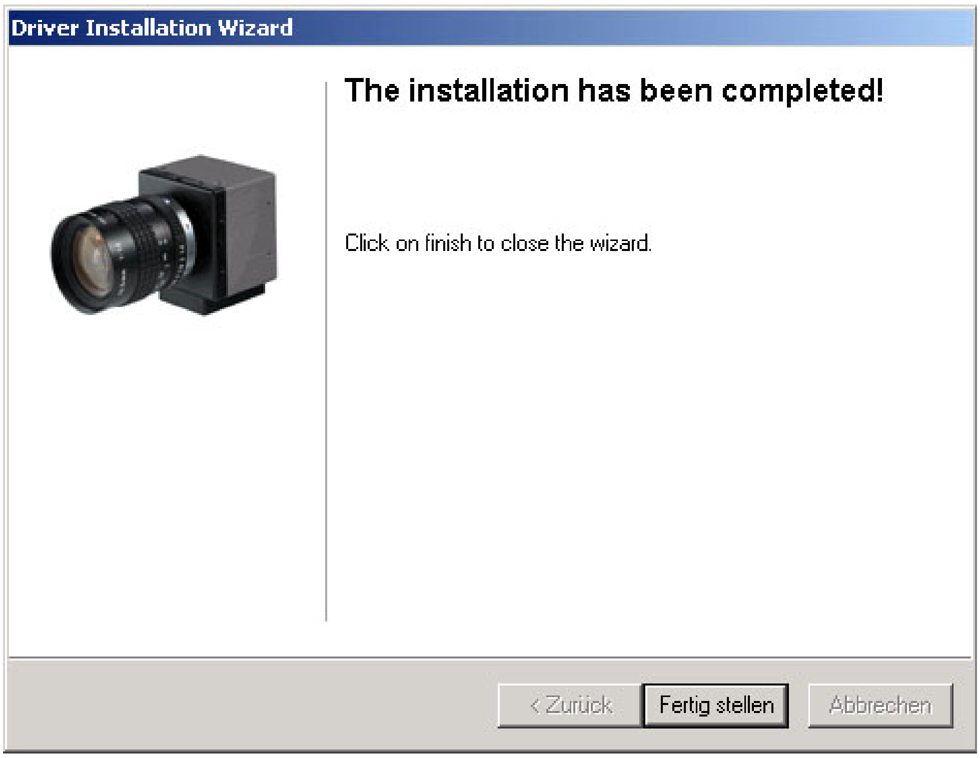

Figure 20: Driver Installation, Step 3

- Now remove the FireWire cable from the camera and wait a moment, then reconnect the cable.
- The driver installation is now complete.

Hint:

- If you would like to run multiple cameras of different types (PHYTEC FireWire CAM-001 and -002) on the same computer, you have to perform the installation procedure for both cameras.
- After the installation procedure has been performed on a computer, you can connect and disconnect the camera as often as you like. The FireWire interface automatically activates the driver.
- The driver installation procedure has to be carried out for each individual camera connected to the computer.

In the next two sections, you will be shown how to mount a lens on your camera and then how to display your first live picture on your screen.

2.4 Mounting a Lens

At first glance mounting a lens seems simple. However, when dealing with high-quality digital cameras, the selection of an appropriate lens and its correct mounting can play a decisive role in the image quality.

There are a few recommendations for selecting an appropriate lens in *section 3.2*. The following paragraphs provide instructions on the connection of a lens. The FireWire-CAM-001/002 is compatible with C- and CS-Mount lenses.
The difference between these two lens types is marginal: If you want to connect a C-Mount lens, you need to attach a CS/C-adaptor-ring between the lens and the camera. With CS-Mount lenses, this ring cannot be used.

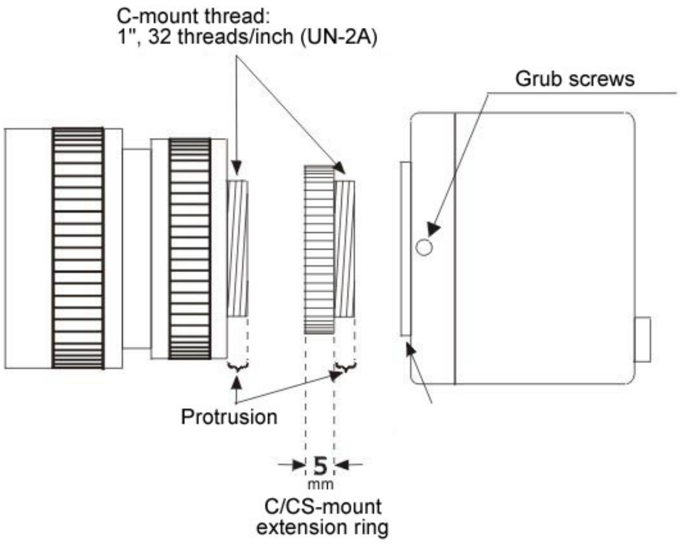

Figure 21: Lens Assembly (C-Mount)

The C/CS-Mount ring influences the so-called „flange focal distance“. This is the distance between the back of the lens and (the part that is attached to the camera) and the picture plane– in our case the surface of the CCD sensor. The pictures shown in *Figure 21* illustrate the difference.

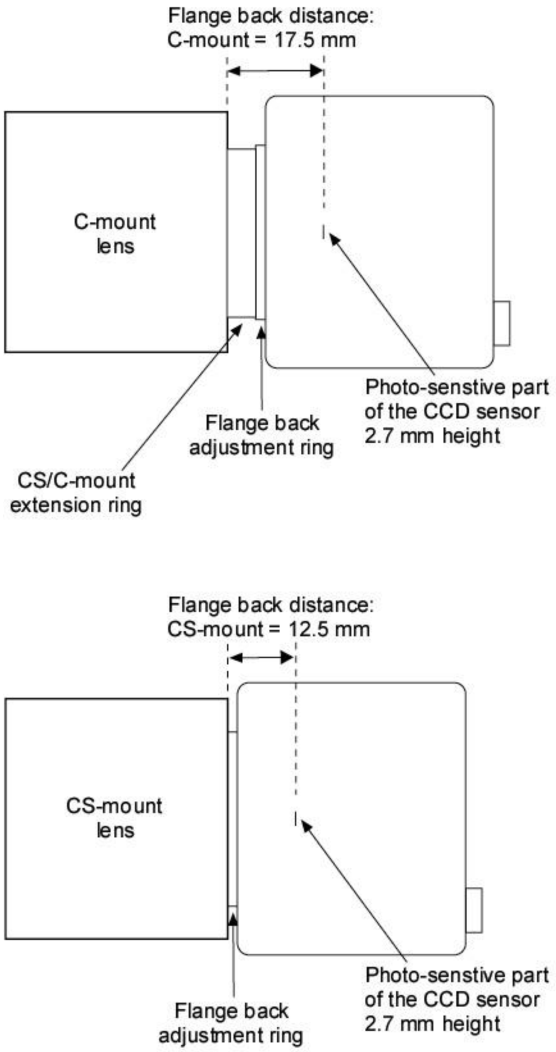

Figure 22: Flange Back Distances and Mountig of C-Mount (Top) / CS-Mount (Bottom) Lenses

In reality the mechanics of the lens and the cameras can vary slightly from one model to another, which may also influence the flange focal distance. If, for example, you are not able to set your lens to „infinite focus“, this is a typical sign of an incorrect flange focal distance.

In this case you can solve the problem with the help of the camera's flange focal distance setting ring. As shown in *Figure 21*, this ring is attached with two set-screws.

You can access these screws through two holes on the side and the bottom of the camera housing. After you have loosen the set-screws, you can adjust the camera's flange focal distance setting ring according to your requirements.

Hints:

- Adjustment of the flange focal distance is usually only required if you are having problems with focusing in „infinite" or with objects close to the lens. Since adjusting the flange focal distance can quickly lead to problems with the imaging system, it should only be done if absolutely necessary!

- If the picture is out of focus in all of the lens ranges, please check to see if you have a C-Mount lens (use adapter ring) or a CS-Mount lens (remove adapter ring).

- It is possible that the lens is not suited for the desired object distance. In this case you will be able to focus on remote objects, but not on close objects. The required minimum distance between the object and the lens is called the *minimum object distance* (M.O.D.) and is provided in the lens data. PHYTEC support will be happy to advise you on the selection of an alternative lens or on the implementation of extension rings, which reduce the M.O.D.

Caution!

Some lenses have very high insertion depth. In these cases the above portioned parts of the lens can damage the CCD and/or the filter of the same (FireWire-CAM-002). Please note that when you are using this type of lens your warranty is made void.

2.5 Starting Up the Camera with the Demo Program

2.5.1 The First Live Image

After you have established the necessary connections, installed the driver software and mounted a lens following the instructions in the previous sections, you can now start up the camera and display a live image on the screen.

For the first test, the included CD SO-221 includes the program ***amcap.exe*** from Microsoft™. You can find this program in the subfolder *FireWireCAM001_002\Demo\Amcap*.

The program does not need to be installed. You can start it simply by double-clicking on the program symbol ***amcap.exe***.

- The application will appear (*Figure 23*). In the status line at the lower window edge the camera identification „FCAM-001“ or „FCAM-002“ will appear.
  If you have installed multiple image sources on your computer, you may have to select the proper image source first. To do this go to the „Devices“ menu and select „FCAM-001“ or „FCAM-002” (*Figure 24*).
- Now select the „Preview“ option from the „Capture“ menu. To display the image the option must be checked (*Figure 25*).
- The Live image will now appear in the program window.

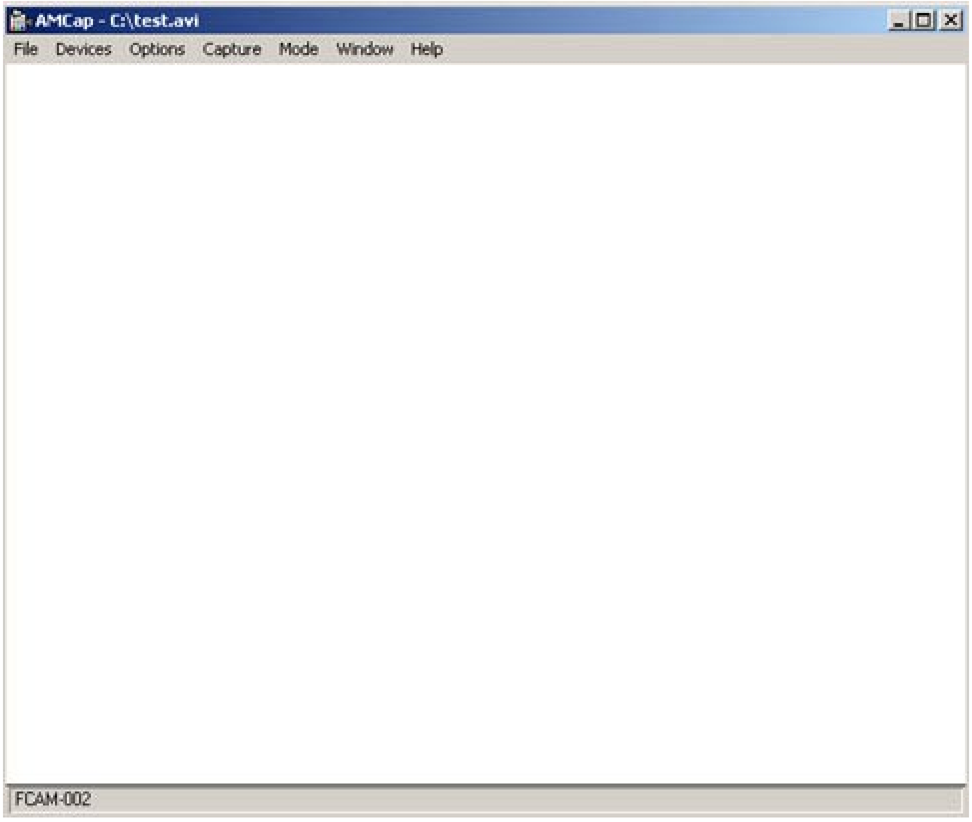

Figure 23: The Program „AMCap“

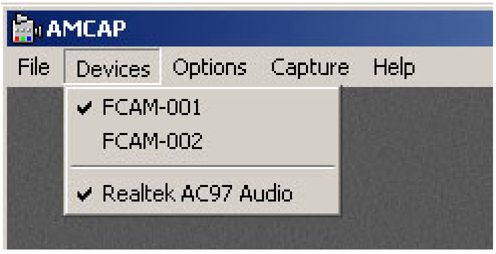

Figure 24: AMCap – Select Device

Figure 25: AMCap – Activate Preview Function

2.5.2 Problem Solving

Check the following points if the live picture is poor or doesn't appear:

- No „Video Device“ is recognized
  - Is the camera connected to the computer correctly?
  - Is the camera connected to a power supply? (use adapter if necessary)
  - Is the software driver installed?
  - Is DirectX, Version 8.1 or higher installed?

- The picture is black
  - Is the iris of the lens open?

- The picture is only black and white (gray levels)
  - Do you have the color version FCAM-002?
  - Is the software driver installed?
  - Is the correct camera model selected?
  - Was a color format selected with the settings?
  - Is your graphics card configured for more than 256 colors?
  - Is DirectX, Version 8.1 or higher installed?

- The picture quality is poor
  - Is the iris of the lens opened sufficiently?
  - Is the illumination sufficient?
  - Is your graphic card configured for more than 256 colors?
  - Try to adapt the camera parameters or set them to their „default“ values (see next section)

- The image is not focussed/cannot be focussed
  - Check the lens setting
  - Has the minimum object distance (M.O.D.) been met?
  - Does the extension ring need to be removed/mounted?
  - If necessary adjust the flange focal length (**Caution!**).

- The image display is too slow / flickers
  - You can set the display speed (*see next section*)
  - It is possible that your computer's processor performance is too low
- The picture flickers under artificial lighting
  - Adjust the picture frequency to the frequency of the artificial lighting. The maximum camera frequency is 30 Hz, which results in interference with the 50 Hz mains frequency in Europe. Use the setting „Frame Rate Reduction“ in the dialog „Advanced Settings“ (*see next section*).

2.5.3 Adjusting Camera Settings

The FireWire-CAM-001 and -002 offer a large number of setting options, which can be adjusted via software from the computer.
The setting options are grouped in multiple dialogs (menus).
Depending on the application the call of the dialogs can occur at various locations.
This section provides a brief overview of the setting options and the call of the dialogs in the program AMCap. A complete description of the functions can be found in *section 3.4*

- Setting the Video Format

> Setting in AMCap:
> Options4Video Capture Pin...

Here you can make basic settings for the image format and color depth. The highest picture quality can be achieved by setting the color depth to RGB24 (for FCAM-002) or Y800 (for FCAM-001).
In addition to this you can mirror the picture horizontally and/or vertically, set the picture size and the picture refresh rate (these settings are not effective in all applications).

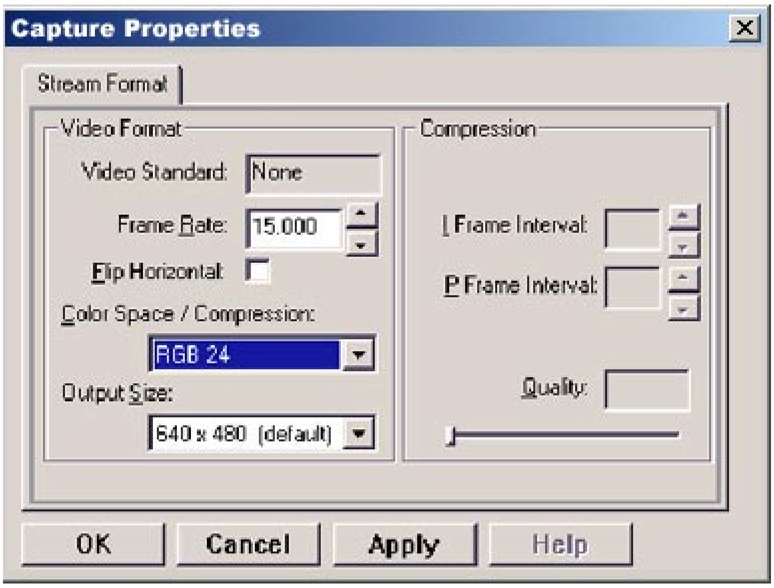

Figure 26: Camera Setting „Stream Format“

Hint:
The maximum display rate in the program AMCap is independent of the setting „Frame Rate“ in the menu „Capture“ (Capture4Set Frame Rate...4Frame Rate). Set this setting to a higher value (e.g. 30) if the picture refresh rate appears to be too low.

- Changing the Capture Settings

> Setting in AMCap:
> Options4Video Capture Filter...4Video Control

This dialog enables you to adjust the image capture precisely to your image capture specifications.
In the camera's default setting all parameters are regulated automatically. In order to make the settings manually remove the „Auto“ check from behind the desired parameter (☑ → ☐) and set the desired value with the sliding control.
Please note that depending on the camera model not all setting options can be selected.

Hint FireWire-CAM-001:

Activate the gamma correction to achieve a more balanced image:
☑ Gamma

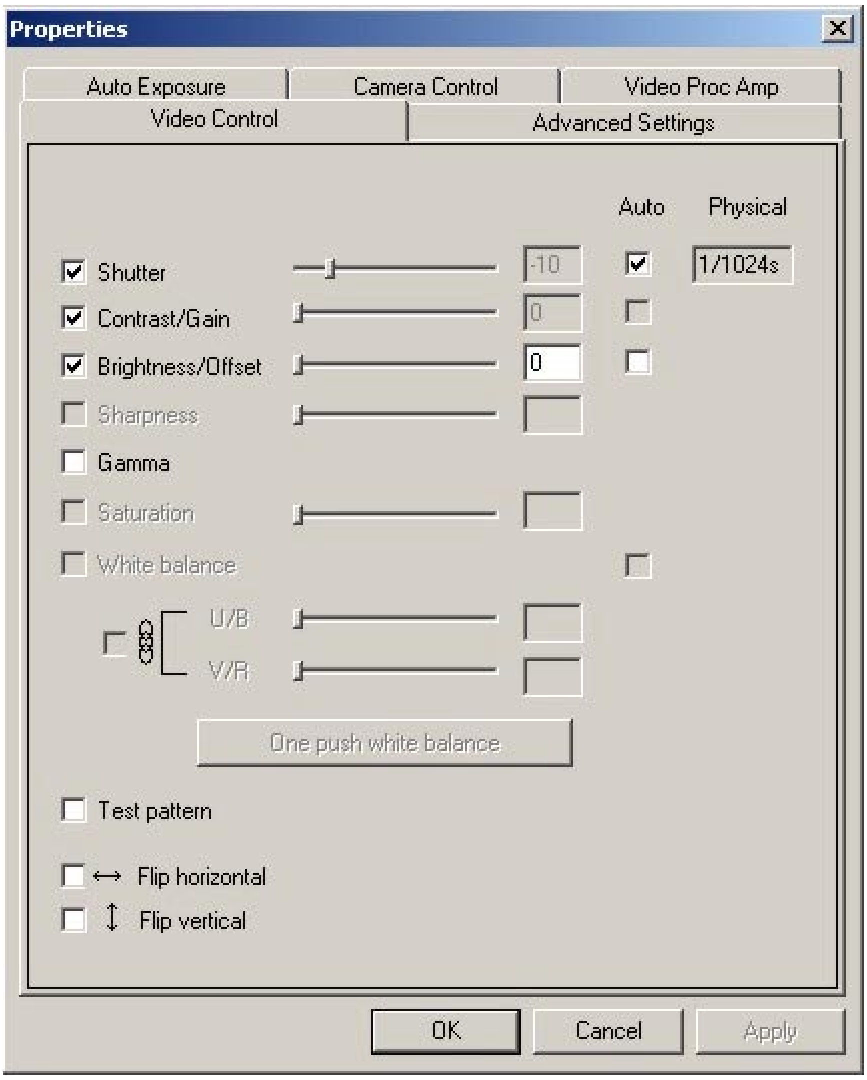

Figure 27: Camera Setting „Video Control“

- Configuring the automatic exposure

> Setting in AMCap:
> Options4Video Capture Filter...4Auto Exposure

In this dialog you can set the reference value for the auto exposure. This allows the general lighting impression to be adjusted to the application.

With *Backlight Correction* the auto exposure can also be adapted to unfavorable lighting conditions. This is particularly advantageous if an object is sitting before a light background and is therefore underlit. By selecting an appropriate mask the measuring range of the auto exposure can be adjusted so that the background brightness is ignored.

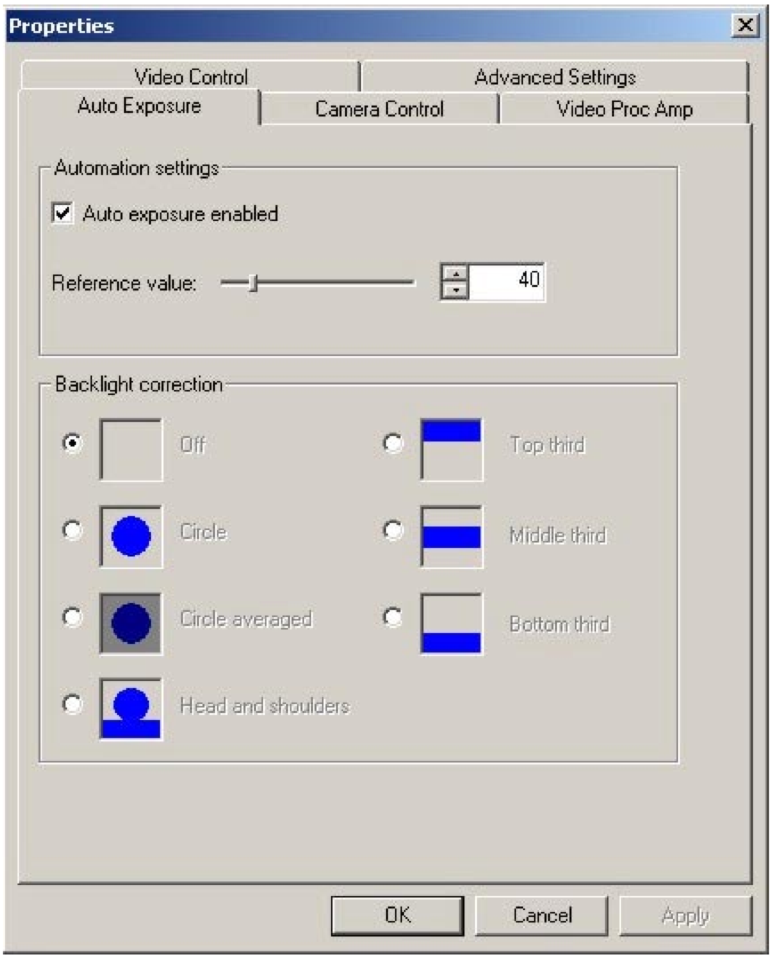

Figure 28: Camera Setting „Auto Exposure“

- Advanced Settings

> Call in AMCap:
> Options4Video Capture Filter...4Advanced Settings

The **Advanced Settings** dialog allows access to a few special parameters of the signal processor.
Here you can determine if and how the sensor's defective pixels (so-called „dead“ pixels) should be handled, which may be visible in the picture in rare cases.
You can also determine in which format the input of the exposure time should occur (any modifications require a restart of the driver).

One important setting option is the *Frame Rate Reduction.* The camera's refresh rate (image capture frequency) is usually 30 Hz. With an artificial light source, interference can result at this rate.
This occurs because light from lamps powered by mains frequency is not constant, rather it pulses with the mains frequency. This is particularly noticeable with fluorsecent lamps. Since in Europe the network frequency is not a whole multiple of the 30 Hz – capture frequency, zebra stripes or flickering can occur in the image.
In this case activate the function *Frame Rate Reduction:*

☑ Frame Rate Reduction

This will reduce the refresh rate to around 25 Hz, which is a reduction to approximately 83.3 % of the original value. Thus the interference can be avoided.

Hint:

- The occurance of interference at 30 Hz is not a defect. Standard TV cameras in Europe always operate at the lower frequency of 25 Hz to avoid this interference.
- The exposure time is (usually) independent of the picture frequency. Therefore the settings do not influence each other.

3 The Camera in Detail

3.1 Camera Connections

- **Power Supply**

If the IEEE 1394 Bus does not deliver the operating voltage (this also applies for nearly all laptop solutions) then the camera requires an additional power adapter such as the PHYTEC SV001. Alternatively you can use a stable, high-quality adapter of your choice, as long as it delivers 8 to 40 VDC and 500 mA. Please read the *section 1.4, "Important Notes"*.

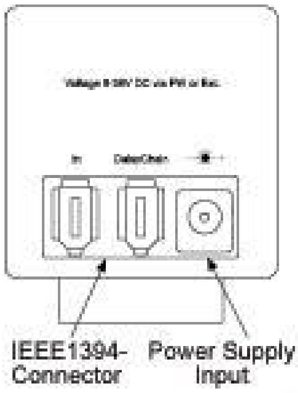

Figure 29: Camera Connections

Caution!
The identifiers „In“ and „DaisyChain“ describe the supply direction of the operating voltage: **In** expects a voltage supply from another 1394 device while **DaisyChain** supplies other 1394 devices. Despite these identifiers the data flow is always bidirectional.

- **IEEE 1394 Interface**

The camera is equipped with two IEEE 1394-1995/1394a, 6-pin, 400 Mb/s connectors. PHYTEC offers a variety of suitable IEEE 1394 cables. As an alternative you can use other cables, as long is they meet the IEEE 1394 standard. Please refer the section *1.4, "Important Notes"* before proceeding.

3.2 Connecting the Lens

The camera supports lenses with C-Mount or CS-Mount connectors.
Refer to section 2.4 for instructions on connecting the lens.

Hints for Selecting the Lens

In order to take full advantage of the quality and the features of the camera, it is important that you select a lens that is optimized to your application. In the following section we have provided some helpful hints on how to proceed in the selection of a suitable lens.

- **Focal Length**

  With the focal length you determine the visible screen window, or image portion captured by the camera.
  The focal length depends on the size of the CCD chip, the distance from the object and the focal length of the lens being used.
  The screen window should be optimized so that the object being captured is always fully visible on the screen, and also so that the amount of unused screen space surrounding the object is minimized. Otherwise the object would be displayed unnecessarily small and the camera's resolution would not be fully utilized.

  The FireWire-CAM-001/-002 are both equipped with a ¼" – CCD-sensor. The following formula can be used to calculate the required focal length f from the desired frame width B and the distance between the object and the lens (L) (all values in millimeters):

$$f = \frac{3.6mm}{B} \cdot L$$

  Round the resulting value up to the next available focal distance. This will give you a slightly bigger screen window than necessary but it ensures that the entire object will be captured on the screen.

The image height H is calculated from the image width B based on the following relationship:

$$H = \frac{3}{4} \cdot B$$

Please note that wide angle lenses will produce some edge distortion, which can have a detrimental effect during image capture or analysis. In this case try increasing the distance to the object and set a larger focal length.

Reference points for selecting focal length:

Focal Length	**Lens Type**
< 8mm	Wide Angle
8 ... 16 mm	Normal Range
> 16 mm	Telephoto Lens

A selection of standard lens focal lengths can be found in our catalog and on our web site. Please ask us about other available focal lengths.

- **Resolution**

How good will the picture resolution be for a given focal length? This depends on the picture size (size of the screen window) and the number of pixels the sensor has.
The FireWire-CAM-001 / -002 have a pixel count of 640 x 480 pixels (height x width).
You can now begin to determine the spacial resolution by dividing the picture width in mm by the number of horizontal pixels (640) (corresponding vertically).

Example:
You have a screen window that is 100 mm x 75 mm.
The maximum resolution that can be achieved is
100 mm : 640 = 0.15625 mm horizontal or
75 mm : 480 = 0.15625 mm vertical

The actual resolution that can be achieved is usually smaller, since the quality of the lens and some technical characteristics of the camera (e.g. the band width of the analog amplifier) also play a role. With color cameras in single chip tecnology, you must also consider that the pixels have color filters, which also reduce the resolution (primarily the local resolution of the color information).
The actual resolution of a system (lens – camera) can be determined automatically and is given in terms of so-called *TV-lines*. This is the number of perpendicular black/white lines per screen window that can be differentiated.

- **Minimum Object Distance**

The minimum object distance (M.O.D.) determines the minimum distance between the object and the lens at which the picture can be rendered in focus.
The M.O.D. value is given in the lens data.
An input M.O.D. =0.3m means that the object has to be at least 30 cm from the lens.
Often the camera has to be brought closer to the object than the M.O.D. will allow for technical reasons. In this case you can use an extension ring. The extension ring is inserted between the camera and the lens and reduces the M.O.D. value. Since it is difficult to calculate the required length of the extension ring, Extension ring sets are available (PHYTEC Order Number AZ005), that can be used to achieve the required value in application.

- **Aperture**

A lens with a manually adjustable aperture (iris) offers two advantages:

1. The depth of field can be adjusted. By closing the aperture the distance range in which objects are shown in focus is increased. This is of particular importance if the object distance is very small. However the amount of light allowed through by the lens is reduced which means that exposure times will increase and/or the picture will be noisy.

2. The amount of light allowed through the lens can be controlled. This makes sense primarily in applications where there is a lot of light, which could result in overexposure or blooming.
   In some cases a fixed exposure time may be desired for an application. In this case you can enter the exposure time manually (in the camera dialog) and set the aperture so that the image is properly lit.
   In normal cases the aperture should only be closed as much as necessary to prevent noise in the picture.

In industrial applications it usually makes sense to be able to lock the selected aperture setting. For this purpose some lenses are equipped with fixing screws.

3.3 Mechanical Attachment

The camera is equipped with a mounting plate with three threaded screw holes (*Figure 30*). The middle hole has a ¼“ – photo thread. This enables the camera to be attached to all standard tripods.
The two outer holes have a metric M6 threads. They can be used to attach the camera to a device or in a system without requiring special screws.
Please note that the maximum screw depth is 8 mm.

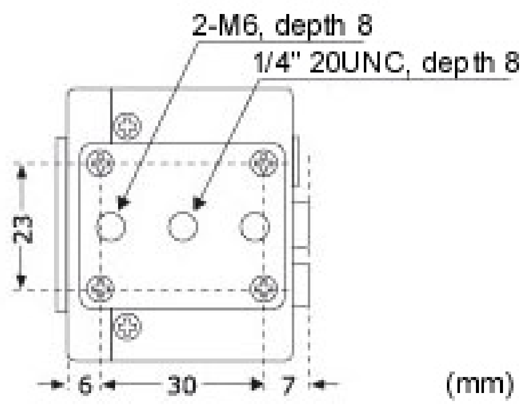

Figure 30: Mounting Plate

The mounting plate is attached to the camera with four screws (*Figure 31*). It can be connected to any side of the camera (*Figure 32*). The attachment is therefore very flexible and can be easily adapted to a given application.

Figure 31: Attachment of the Mounting Plate

Figure 32: Mounting Options of the FireWire-CAM

3.4 Camera Settings

The settings described in the following section influence the various function blocks of the camera. The camera is depicted schematically in *Figure 32*.

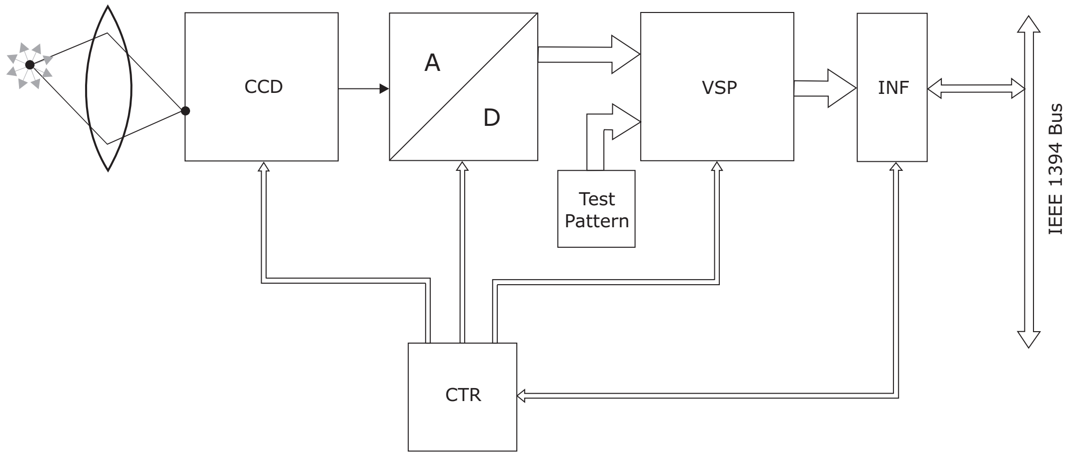

Figure 33: Block Diagram of the FireWire-CAM-001/002

The processing chain begins with the light that is reflected from the object. This light shines through the lens and hits the CCD.
The analog picture signal is sent to an A/D converter. The converter gives the „raw“ digital representation of the picture formed by the reflected light rays.
This picture now has to be prepared by a video signal processor (VSP).
A control unit (CTR) establishes communication between the processing units and the IEEE 1394 Bus interface and also makes the parameter settings described in the following sections.

3.4.1 Camera Settings: Standards

One of the most interesting properties of the FireWire-CAM-001/002 is that they are based on standards that are widely circulated. One of these standards is called ***DCAM***. It describes the parameters and the data structures of IEEE 1394 cameras that do not feature audio processing and transmit the picture data uncompromised. Additional information on DCAM can be found in *section 4, “The Software Concept”*.

Hint:
Please note that the FireWire-CAM-001/002 offer setting options in addition to these DCAM parameters, which can be very useful in certain applications, but are not (yet) included in the DCAM specification. In the following sections the DCAM-conformant parameters are marked.

3.4.2 Camera Settings in Detail

All camera parameters can be set over the IEEE 1394 Bus. In order to access these, install the camera and the included software as described in the *section 2, „First Steps“*.
In the following section the individual setting options and their effects are described in detail.

3.4.2.1 Camera Settings – Data Stream Format

The dialog **Data Stream Format** *(Figure 26)* offers you the selection between the various resolutions and frame rates, therefore defining the basic structure of the video signal.

You will achieve the highest picture quality if you use RBG24 (for FireWire-CAM-002) and Y800 (for FireWire-CAM-001) for the **color space** and select 640 x 480 as the **output size**.

However, these operating modes also require the highest bandwidth.

All parameters are DCAM-conformant.
For addtional information refer to section 3.6, “How to Maximize Image Quality”.

3.4.2.2 Camera Settings – Video Control

The dialog **Video Control** gives you access to all basic parameters that can be used to set the function blocks of the camera described in the introduction.

For additional information refer to *section 3.6," How to Maximize Image Quality".*

Shutter (DCAM): sets the exposure time.
This parameter can be set manually or automatically (along with the amplification **Gain**; *see below*).
Technically this parameter is based on an internal feedback loop. This loop takes 4048 gray level samples from the picture and calculates a average brightness level from them.
The image range that the samples are taken from determines the current setting of the backlight correction. This parameter can be set over the dialog **Auto Exposure** (*see section 3.4.2.3*).

Gain and shutter influece the picture in a similar manner. A reduction in the gain can be compensated by an increase in the shutter and vice versa. There are therefore many combinations of gain and shutter that will result in an identical picture.

The gain, however, is the electrical amplification of the image signal, while the shutter influences the exposure *time*.
A higher gain value will result in a noisy image. For this reason the gain should not be set unnecessarily high.
On the other hand, longer exposure times may result in motion blur and other picture distortions.
Typically speaking, a balance between the two settings is preferable.
If satisfactory image quality cannot be achieved, a brighter light source may be required.

Gain/Contrast (DCAM): The amplification gain (also called contrast) influences the electrical output signal of the CCD. This is an electrical amplification of the image signal. *More details are provided in the shutter description above.*

Offset/Brightness (DCAM): The offset (also called brightness) influences the direct voltage offset of the CCD output signal directly. Visually this is perceived to be an adjustment of the picture brightness. As opposed to the contrast setting, the brightness setting does not change the relationship of dark to light.
This parameter can be set manually or automatically.

Sharpness (DCAM): The sharpness setting changes the sharpness of the video picture.
This mechanism can be used to compensate for lowpass effects (that may result from spacial color interpolation) (*see section 3.5*). You can shut off this function if it is not required.

Gamma (DCAM): If gamma correction is switched on the camera will output the gray levels adapted to the non-linear characterstics of picture tube based monitors.
With activated gamma correction the image looks richer in contrast – expecially with monochrome cameras.

Saturation (DCAM, only with FireWire-CAM-002): This parameter allows the manual setting of color saturation from black and white to extremely saturated colors. This allows the picture display to be adapted to color sensitivity or the picture environment.
You can shut off this function if it is not required.

White Balance (DCAM, only with FireWire-CAM-002): U/R (red/green) and V/B (green/blue) influence the red and blue portions of the picture. You can therefore set the camera to the applied light to achieve a color-neutral impression. In most cases the automatic white balance is the preferable setting. For color evaluation tasks, the automatic white balance must be shut off.

In manual operation both parameters can be linked to quickly find an initial setting. Depending on the lighting, some fine tuning may be required. To do this the parameter link must be broken.

Test Pattern: The test pattern can be used to trace the cause of problems back to the lighting, optics and the CCD or the signal processor.
The test pattern shows changes to the parameters *Saturation, White Balance, Sharpness and Gamma.* It is not effected by *Shutter, Gain* or *Backlight Correction.*

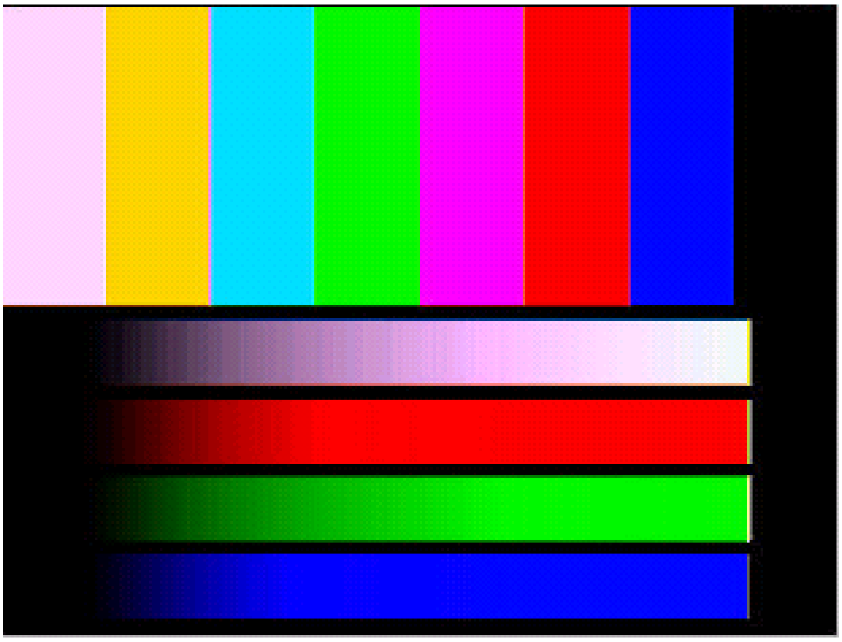

Figure 34: Test Pattern

Flip Horizontal/Vertical: With these options the picture can be flipped horizontally and vertically. This function is useful if the camera and image orientation are different or if mirrors have to be used for taking a picture.

3.4.2.3 Camera Settings – Auto Exposure

The Dialog **Auto Exposure** gives you access to parameters that determine the behavior of the control loop in the Shutter/Gain automatic mode.
You are therefore able to adjust the behavior of the automatic exposure control and adapt it to your application's requirements.

For further information refer to section 3.6," How to Maximize Image Quality".

Exposure Reference (DCAM): The automatic Shutter/Gain mode is based on a control loop, which takes 4048 grayscale samples from the picture and calculates an average brightness from them. This average value is then compared to the exposure reference and if the Shutter or Gain do not match then it is modified. The image area that the samples are taken from is determined by the current setting of the Backlight Correction.
With this value you can set the average brightness level (reference brightness) value of the image in automatic mode.

Backlight Correction: In automatic Shutter/Gain mode 4048 grayscale samples are taken from the image and are used to calculate a average brightness level. The configuration of the backlight correction determines the location of the samples. The average brightness value is then used to adapt the auto exposure to special lighting situations. This is primarily necessary for very bright or very dark picture areas, such as with backlit objects or with very bright objects set before a dark background.

3.4.2.4 Camera Settings – Advanced Settings

The Dialog **Advanced Settings** allows access to a few special parameters of the signal processor.

For additional information refer to *section 3.6, "How to Maximize Image Quality".*

Dead Pixel Compensation: Even now CCDs are not completely free from irregularities which in some cases may be visible as „dead pixels". These pixels will appear to be stuck at black or white. The dead pixel compensation offers two mechanisms for eliminating such abnormalities in individual pixels:

The **median filter** compares the gray level of the current pixel with the values of the neighboring pixels to the right and left and replaces this gray level with a median value of all three.
The filter for **non-linear interpolation** also compares the current pixel with its neighboring pixels. If the gray level of the current pixel varies from its neighboring pixels by a value greater than that given in the field **max graylevel deviation** then it will be replaced by the average level of the neighboring pixels.

If you compare the results of both methods, the median filter is more effective in eliminating white pixels, but results in a greater reduction of image clarity than non-linear interpolation.

Physical units: Display of the exposure time based on the definition of DirectShow. Please note when switching this option on or off that the change only takes effect after a restart. A restart can be achieved by removing and then re-inserting the 1394 cable.

Frame rate reduction: Reduces the current refresh rate to about 83.3 %. Thus a refresh rate of 30 frames/s would reduce to 25 frames/s. It is therefore possible to reduce the flicker of 50 Hz-based lighting.
Flickering is due to the fact that light from lamps that are connected to a mains frequency is not constant, but instead pulses with the mains frequency. This is particularly obvious with phosphorescent lamps. Since in Europe the mains frequency is not a whole number multiple of the 30 Hz – frame rate, the result can be zebra striping or brightness irregularites (flickering) in the image.

Note:
- The occurance of interference at 30 Hz is normal. Standard TV cameras in Europe always operate with the lower picture frequency of 25 Hz to avoid this type of interference.
- The *exposure time* is (generally) independent of the picture requency. The settings therefore do not influence eachother.

3.5 Spectral Behavior

3.5.1 FireWire-CAM-001 (monochromatic)

Figure 35 shows the spectral behavior of the monochromatic FireWire-CAM-001.
Please note that this camera is not equipped with an IR-band elimination filter. Therefore you can use the IR-sensitivity of these cameras in various applications.

In some applications it is a good idea to block certain ranges of wave length. You can do this by attaching a special filter to the lens. We will be happy to advise you in the selection of an appropriate filter.

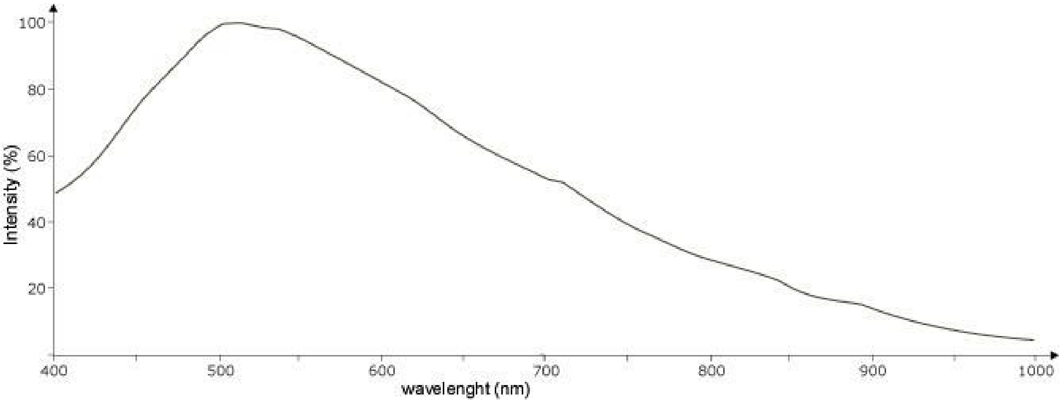

Figure 35: Spectral Response (FireWire_CAM-001)

3.5.2 FireWire-CAM-002 (Color)

Simply put, the CCD-Chip converts photons to electrons. Three color filters (red, green, and blue) are used for color display. With these three color levels it is possible to create the picture colors. With single-chip cameras (like the FireWire-CAM-002) very small filter elements of the three colors are placed alternatingly in front of the individual pixels of the CCD chip (called Mosaic or Bayer filters).
Figure 36 demonstrates the function of this filter.

The small picture below shows a red field and a blue field with a green border. This picture was taken without the usual preparation (we will go into more detail about this later). That is why it appears a bit „raw“.
The larger picture is an enlarged section of the smaller picture. The letters R (Red), G (Green) and B (Blue) show the structure of the color filter, whlie the gray value represents the brightness of the individual pixels.

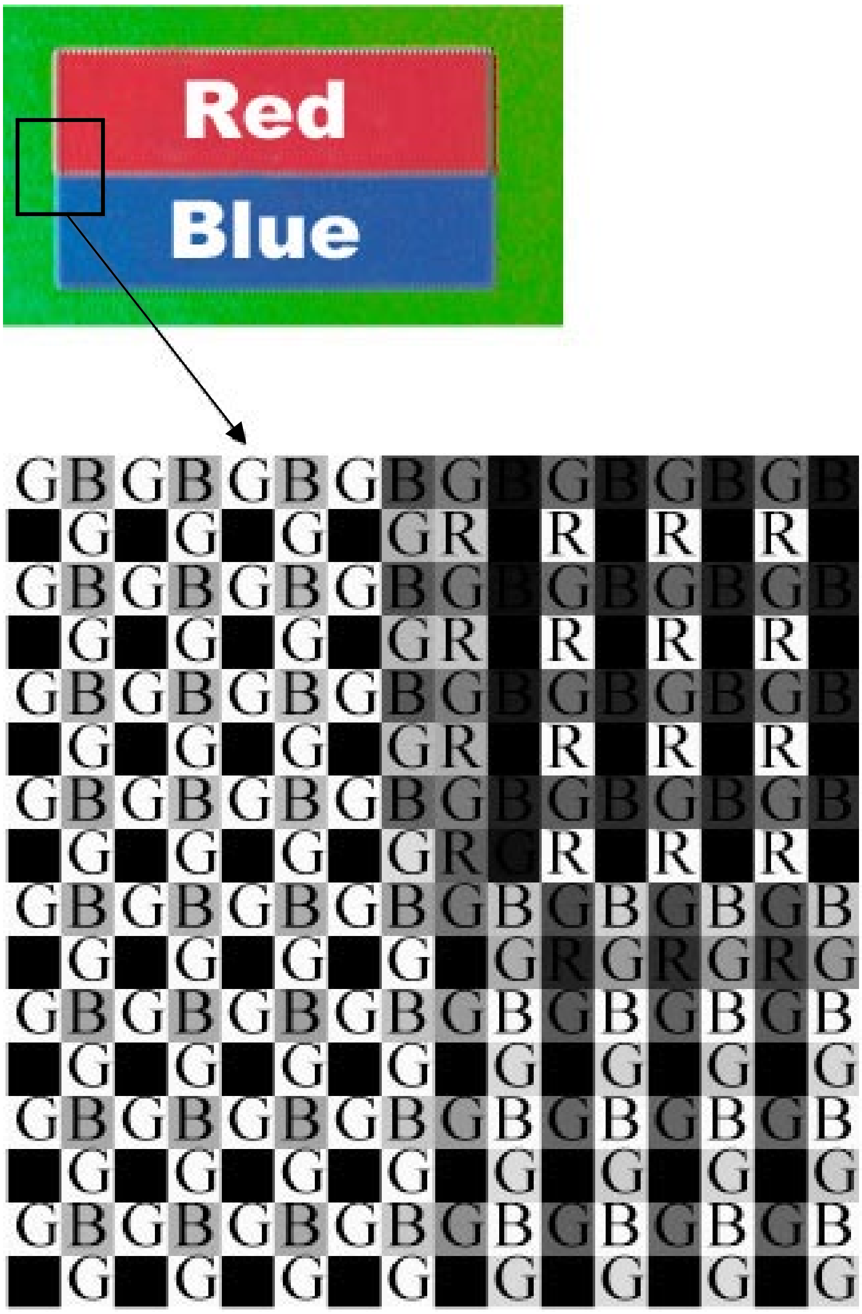

Figure 36: Bayer Pattern Filter (ColorSensor)

Figure 37 shows which spectral ranges actually represent the values R, G and B. If, for example, a G-Pixel has a high brightness level, this means that the light that hit this point was made up mostly of wavelengths between approximately 500 and 600 nm.

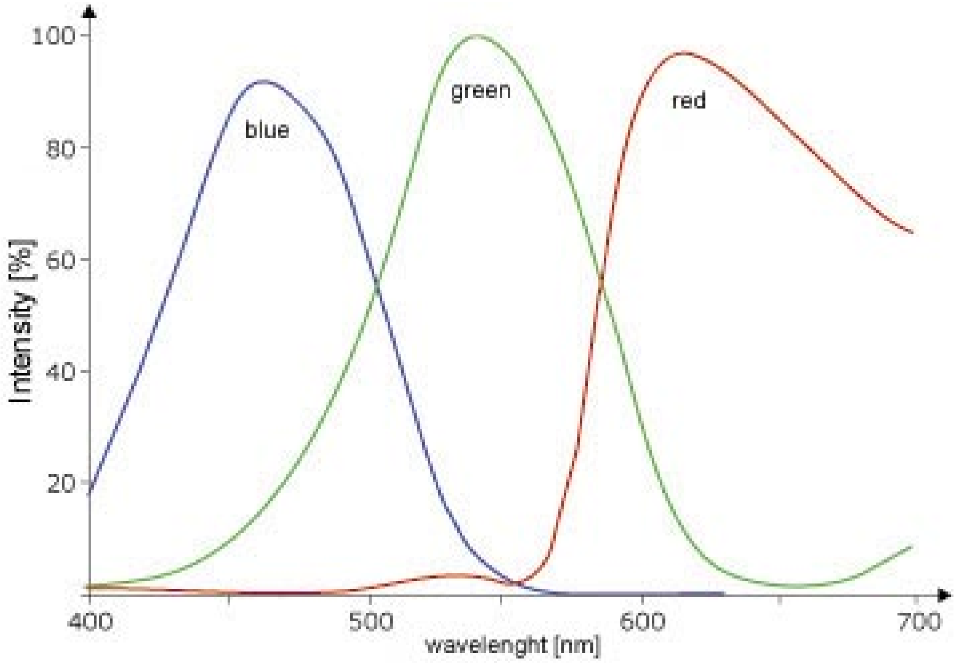

Figure 37: Spectral Filter Characteristics (FireWire-CAM-002)

Please note that with a G-pixel it is impossible to say anything about the red or blue portion of the light. Wavelengths between 400 and 500 nm can only be measured with B-pixels. Wavelengths between 600 and 700 nm can only be measured with R-pixels.
The problem is therefore that a pixel can only measure one of the three colors, while we require all three color values at each pixel position for an RGB image.
The Bayer pattern model uses the „spatial color interpolation" to generate an RGB image from the neighboring color pixels.
Let's assume that we have an R-pixel and we require the missing G- and B-values. The interpolation algorythm estimates these values based on the neighboring pixels of the R-pixel. If it finds a neighboring B-pixel with a high gray value and a G-pixel with a low gray value, then it is quite probable that the R-pixel is probably pale violet or lilac colored.
For each pixel we have one measured and two estimated color values. As with all modern cameras this interpolation is carried out in the FireWire-CAM-002 by a signal processor. *It is described in the introduction to section 3.4.*

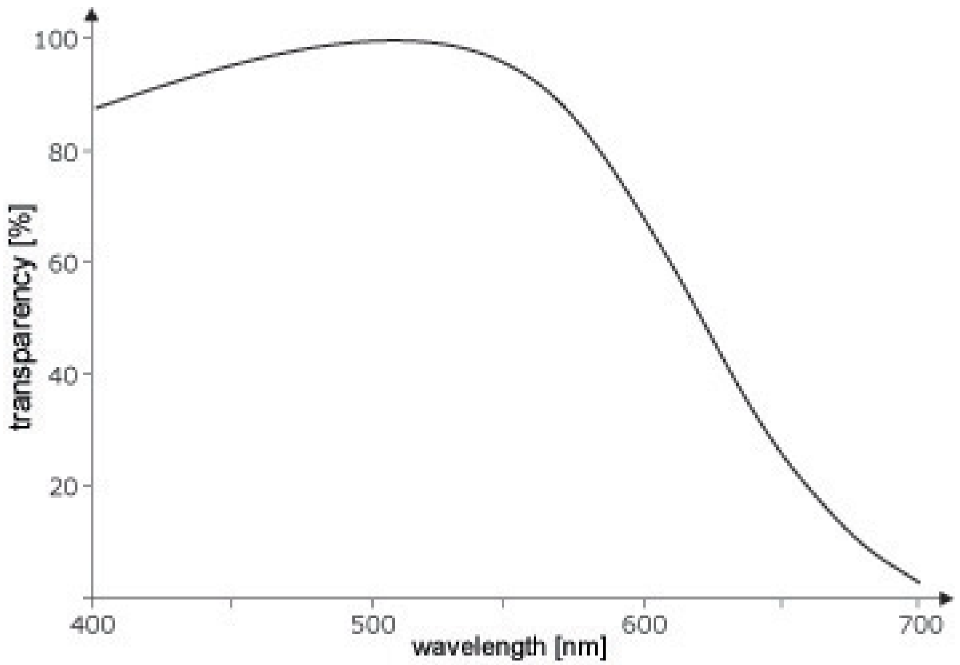

Figure 38: FireWire-CAM-002 Band Elimination Filter

3.6 How to Maximize Image Quality

„Image Quality“ is always a relative term. However, the definition of quality really depends on the requirements of the application in question.

3.6.1 Lens

The video lens has a significant influence on the picture quality. *Refer to section 3.6 for selection of an appropriate lens.*
In any case you should use a high quality lens.
PHYTEC offers high-quality lenses from Pentax.
If you have a special requirement profile we recommend lenses from Schneider Kreuznach.
We will be happy to advise you on the selection of an appropriate lens.

3.6.2 Lighting

With image processing applications the selection of the right lighting plays a major role.
Ideally the lighting will illuminate the object evenly and with high contrast. Undesired structures (shadow, and overexposed areas) should therefore occur as little as possible in the picture.
Correct lighting can drastically reduce processing times in many applications. For industrial image processing a series of special lighting techniques have been developed that can increase picture display quality in various applications.

In this section we briefly describe a few lighting procedures.

- **reflected-light method**

The reflected light method is one of the most commonly used lighting methods.
In this method a light source (e.g. a standard lamp or a special ring light, *see Figure 39*) is pointed at the object from above.
This lighting technique is used if structures need to be recognizable on the object, such as print, dirt, color (in this case a color-stable lighting is recommended) or mounted parts (attendance monitor or position monitor). There are different variations of this method.
Problems that may occur with this procedure are uneven lighting, reflection (particularly on shiny surfaces) and shadows.

Figure 39: PHYTEC Ring Light Order No.: VZ-001-x, VZ-002-x

- **Diffuse Lighting**

With diffuse lighting no direct light rays hit the viewed object. This reduces problems with reflections and overexposed areas.
The Ring Light (*Figure 39*) can generate diffuse lighting if a corresponding filter ring is attached, thereby solving this problem.
For especially critical appliactions, such as highly reflective surfaces, special shapes are available that shine the light on the object indirectly over a dome shaped lighting bell.

- **Light-Field or Dark-Field Lighting**

These two methods differ from one another considerably in terms of the camera position in relation to the object. The positon of the lighting source in relation to the object remains the same.

The light field lighting leaves the ranges of interest dark (e.g. a drill hole in a workpiece). The dark field lighting functions in the opposite manner (*Figure 40*).

The type of lighting should be selected based on the object surface. If necessary tests should be performed with both variants to determine which method displays the structures of interest the best.

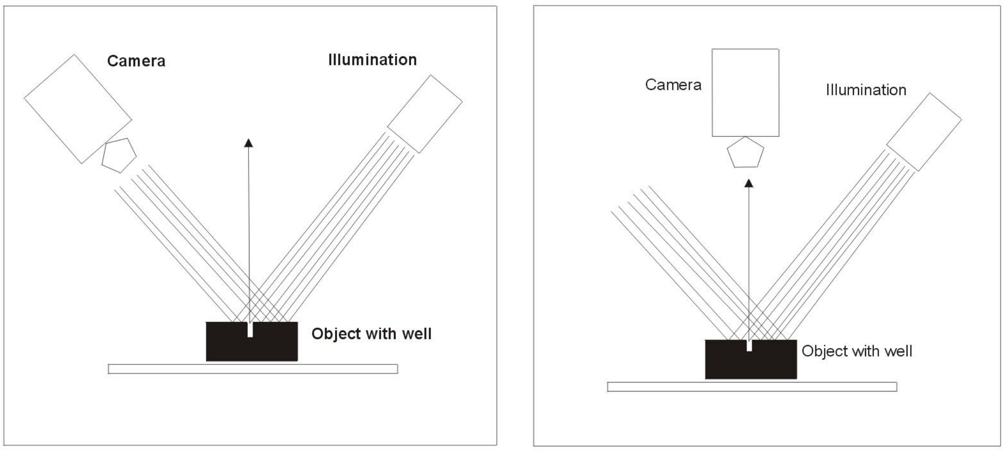

Figure 40: Light-Field- (Left) and Dark-Field-Lighting (Right)

- **Shadow Projection**

If object areas and their background are similar in terms of their gray value, the object border can be difficult to discern (contrast problems). If the background isn't too dark, you can measure the object's cast shadow instead of the object edge (*Figure 41*).

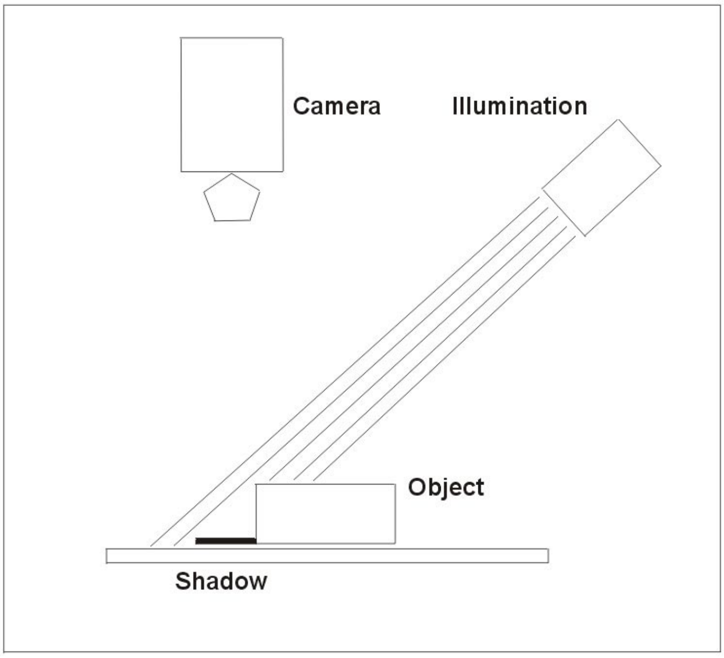

Figure 41: The Shadow Projection

- **Structured Light**

In place of the homogenous light described up to this point it is also possible to use a special structured light. This structured light makes it possible to mesaure the height of an object with a light band or crosshairs (e.g. from a laser). This is an expansion of the shadow projection.

The light line (band) is projected at a known angle α toward the object. The camera is positioned perpendicular to the object. The picture therefore contains two parallel lines, that are a distance *d* from one another. This distance can be easily measured by the image processing software and converted to height *h* using the angle α (*Figure 42*).

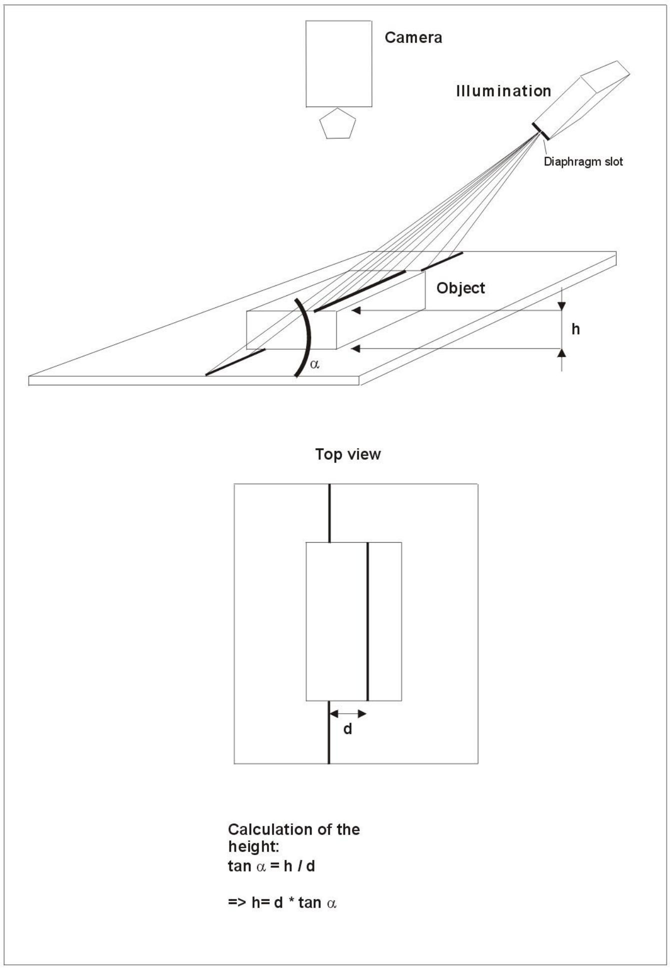

Figure 42: The Structured Light

- **Silhouette Projection**

This method is very useful if you are only interested in the outline of a flat object (e.g. for measurement purposes).
It generates high contrast pictures and is not dependent on the surface of the object.
With the silhouette projection the object is placed before a luminescent plate. It is a diffuse lighting surface that lights the object from below. The camera is pointed at the object from the front, i.e. toward the light source (*Figure 43*).

The result is a grayscale image. The bright pixels are the background, the dark pixels are the object.

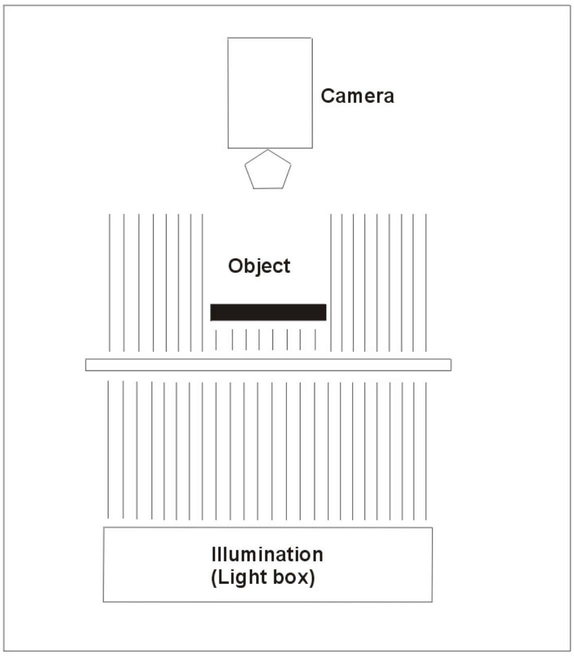

Figure 43: The Silhoutte Projection

- **Transmitted Light Method**

The transmitted-light-method (transillumination) can be very useful with transparent objects like glass. The transillumination makes the inner structures visible (*Figure 44*).
It is possible, for example, to depict the steel wire inside a security glass or the liquid level within a bottle. X-ray images in medical technology are also an example of transillumination.

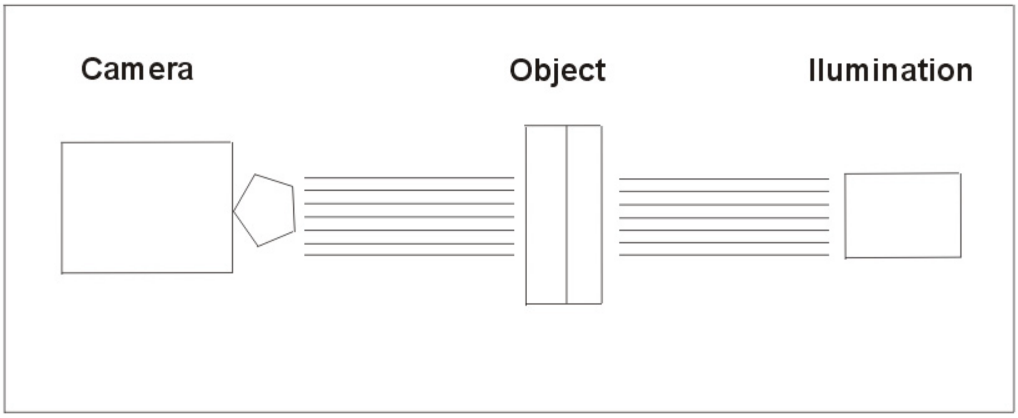

Figure 44: Transillumination

3.6.3 Camera Setup

The FireWire-CAM offers a wide range of setting options that enable it to be optimally adapted to the picture requirements.
The individual parameters are listed in *section 3.4, „Camera Settings"*.
In the following paragraphs the settings used for typical automation and visualization applications are described.
With visualization applications the focus of optimization is primarily the picture as it is seen by the viewer (e.g. remote monitoring, security applications). Automation usually requires constant environmental conditions set according to the given task. The general visual impression is therefore usually a secondary consideration. Instead it is more important that the recognizable features for the subsequent image processing are easily and reliably discernable.
Of course in practicle applications there may be instances where a mixture of both requirement profiles is needed.

3.6.3.1 Setting for Visualization with Stable Lighting

The typical camera for these purposes is the FireWire-CAM-002. Under the assumption that there are stable lighting conditions we recommend the following settings (*see Windows dialogues in section 2.5.3):*

Shutter and **Gain**: Keep Gain as low as possible and Shutter as high as possible, since Gain not only amplifies the picture signal but also amplifies image noise.
High Shutter values (longer exposure times) can also lead to motion blur. Determine through calculation or experimentation the highest reasonable value and set the *Gain* accordingly, so that the picture brightness is optimized. If necessary adjust the lens aperture to improve the image.

Brightness: Keep the Brightness setting as low as possible. This guarantees the highest gray value dynamic.

Sharpness: Adjust the sharpness of the picture according to the visual impression that it makes. Be aware that too high of a Sharpness setting will also show noise more clearly and may have an unnatural effect on the image. Before adjusting the Sharpness setting, be sure that focus and aperture (=depth of field) settings on the lens are optimized.

Gamma: If you are displaying the pictures on a tube monitor, Gamma should be active. For most other cases Gamma should be shut off.
Select the setting according to the visual impression you desire.

Saturation: For a „realistic“ image, in most cases it is recommended that the color saturation adjustment is deactivated. Otherwise a value between 50 and 80 will usually deliver the best results.

White Balance: Use the switch **One Push White Balance** to get a base value. With some slight adjustments afterwards you should easily be able to find the optimal setting.
In most cases the automatic white balance („Auto“) does an adequate job.

3.6.3.2 Visualization Applications with Variable Lighting

Shutter and **Gain** usually have to be operated automatically. In this case the dialog **Auto Exposure** offers the following two parameters that you can use to influence the behavior of the Shutter/Gain regulation.

Exposure Reference: The presetting of this reference value for the automatic lighting is 30. Do not change this value by more than 10. Otherwise it could result in instabilities.

Backlight Correction: If this parameter is set to **OFF**, then the automatic exposure control measures the brightness value of the entire image. If the lighting conditions between the various image portions are considerably different, then you can compensate for this effect with another method of measurement.
This enables you to limit the measuring range to the relevant picture area.

Brightness: Try to avoid using the automatic setting. It is better to keep this value as low as possible. This guarantees the highest gray value dynamic.

Sharpness: Adjust the sharpness to achieve the desired picture effect. As described in the previous section, the proper lens and its correct connection can also be decisive for picture sharpness.

Gamma: If you display the image on a tube monitor then Gamma should be active. For most other cases Gamma should be shut off. Select the setting that gives you the best image in your opinion.

Saturation: For a „realistic“ picture, the deactivation of the color saturation setting is recommend.
Otherwise values between 50 and 80 should deliver the best results.

White Balance: Variable lighting doesn't only result in changes in brightness but also results in spectral variation (changes in color tone). Since the human eye is capable of adapting to these types of variations, we rarely notice even relatively major color variations in light in the course of a day. The camera can also adapt to color variations with the help of the Automatic White Balance.

If only the brightness values change (e.g. if an artificial light source is obscured), then the White Balance can be set manually. By clicking on the switch **One Push White Balance** you will establish a base setting. If necessary you can make slight adjustments afterwards to achieve the optimal setting.

3.6.3.3 Setting for Automated Applications

Automated applications usually require stable lighting and therefore manual parameter settings (*see dialog in section 2.5.3).*

Shutter and **Gain:** Keep the Gain setting as low as possible and the Shutter setting as high as possible, since Gain not only amplifies the image signal but also the noise.
High Shutter values (longer exposure times) can result in motion blur. Determine through calculation or experimentation the highest sensible value and then set the Gain to achive the optimal picture brightness.
If necessary adjust the lens aperture to improve the picture.

Brightness: Keep the brightness as low as possible. This guarantees the highest gray value dynamic.

Sharpness: Adjust the image sharpness to the level you desire. In automated applications you should try to set the sharpness to the lowest possible value to avoid noise.
Before adjusting the sharpness setting, be sure that the focus and aperture (sharpness depth) settings on the lens are optimized.
Since the sharpness function cannot compensate for a low quality lens, you should be sure to use a lens that is suitable for your application.

Gamma: With some automated applications a linear brightness characteristic may be desired. In this case the Gamma correction should be deactivated.
Usually the Gamma correction should be set so that the picture output is optimized for the application in question.
Therefore with applications that involve object recognition it makes sense to work with the Gamma correction switched on.

4 The Software Concept

One of the most interesting properties of the PHYTEC FireWire-CAM in terms of software is that it can run with standardized interfaces.
This makes the FireWire-CAM-001/002 compatible to the existing Windows driver models.

4.1 Layers Standards of the FireWire-CAM Series

Hardware/Protocol

At the hardware layer the standard IEEE 1394 (FireWire) is used. Since IEEE 1394 defines a data bus certain protocols are required that establish the data exchange between the devices.
With **DCAM** (described in the specification DCAM V1.3) The PHYTEC cameras use a protocol that defines the transmission of uncompressed image data streams as well as the camera parameter settings (e.g. exposure time).

Driver

The protocol is realized on the processor end with the help of a WDM Stream Class driver. WDM stands for „Windows Driver Model". For mice, keyboards, drives etc. this is standard for a long time. For automated image processing, practical application with support of the FireWire interface with Windows 2000 or better or DirectX 8 is recommended.

Software Interface

Application software should ideally access the operating system functions and not the hardware itself. Windows offers **DirectX** for image and audio processing. Since the PHYTEC FireWire-CAM only delivers image data streams, only the portion **DirectShow** is required. DirectShow automatically recognizes the WDM Stream Class driver. Therefore when using the FireWire-CAM no additional software is required (excluding the actual application software).

Consequence for the Application Software

a) If you want to use a ready-made application software, it must be compatible with DirectX (nearly all multimedia products fulfill this requirement).

b) If you plan on creating your own application software and already have experience programming with DirectX, you can access the PHYTEC FireWire-CAM WDM driver directly with DirectX. The corresponding programming description is available in the DirectX-SDK from Microsoft. The functions made available by the PHYTEC FireWire-CAM are described in *section 3.4, "Camera Settings"*.

c) If instead you are accustomed to programming frame grabbers (such as the PHYTEC pciGrabber-4*plus*), then the enormous complexity of DirectX is a hurdle that shouldn't be underestimated. Therefore PHYTEC offers a *DirectX-Wrapper* in the **FireWire-SDK** which enables easy access to all of the FireWire-CAM's functions without requiring that the programmer become familiar with the complexities of DirectX.

The SDK includes the connections to various programming interfaces:
- **NET Components:** for MS Visual Basic .NET and C# .NET
- **ActiveX Control:** for Microsoft Visual Basic 6
- **C++ Class Libary:** Microsoft Visual C++ 6 and Visual C++ .NET

Note:
The FireWire-SDK is included with the camera package. *You will find it on the „Vision Tools"-CD SO-221.*
You can install it in the CD's FireWire dialog *(see Figure 16).* For each of these interfaces the SDK makes all required binaries, Headers and Libraries available, including an extensive help menu as well as example projects and demo programs with source code.

The DirectX-Wrapper reduces the complexity of DirectX and makes a logically simple interface available to the programmer.

4.2 Accessing the Camera Driver

Section 4.1 describes the standard layer in terms of the PHYTEC FireWire-CAM-001/002.

A progammer sees these cameras at the layer of a WDM Stream Class driver. The communication between this type of driver and an application software is defined by the standard called DirectX / DirectShow.

There are three typical ways of accessing a WDM Stream Class driver.

- Programmers who have experience using DirectX can acces these drives directly using DirectX.
  Programmers who are not experienced with DirectX can access the driver with the help of the PHYTEC FireWire-SDKs. The SDK allows easy access from standard Windows programming environments. In terms of software the camera behaves similarly to a standard camera-framegrabber unit.
  The FireWire-SDK with the DirectX-Wrapper is included with the PHYTEC FireWire-CAM-001/002. *It can be found on the CD SO-221 along with the detailed descriptions of the functions*.

- If you would rather avoid programming entirely, you can use the Filter Graph Editor to parameter WDM Steam Class drivers.

4.3 Working with the Filter Graph Editor

The following sections are a brief introduction to the Filter Graph Editor.
With the Filter Graph Editor you can graphically program and test (multimedia-) applications completely or partially.
The functions shown as „DirectShow Filters“ are available to you for this purpose.

4.3.1 How to Get the Filter Graph Editor

The Filter Graph Editor (also called „graphedit“ or ***„graphedt.exe“***) is a component of Microsoft’s DDK, that can be downloaded for free from www.microsoft.com/ddk/.
It is also part of Microsoft’s DirectX SDK, which is available at www.msdn.microsoft.com/downloads/default.asp (once on that page click on „Downloads by Topic“, „Graphics and Multimedia“, „DirectX“ and „DirectX 9.0b SDK“).
Please note that Microsoft does not include the Filter Graph Editor source code or permit redistribution.

4.3.2 Working with the Filter Graph Editor

The Filter Graph Editor is a limited tool. It consists only of the executable program ***graphedt.exe*** and is therefore easy to locate in the DDK/SDK-Kit. No special installation is required. ***graphedt.exe*** can be started easily from any folder.
A detailed description of the Filter Graph Editor is available in program’s help function.

4.3.3 How the Camera Appears in the Filter Graph Editor

In the „Graph“ menu select „Insert Filters...“. You will be shown a list of *Filters*, that are available in the operating system.
The camera’s WDM Stream Class driver is also considered a filter of this type and is located in the folder „Video Capture Sources“.

The filter parameters (i.e. the camera settings) can be modified by right-clicking on the name of the filter in question. In our case this is either FCAM-001 or FCAM-002. By selecting „Filter Properties...“ you will be taken to the setting dialog shown in *section 3.4.*

Please note that the camera parameters are not stored in the camera but rather in the registry of the computer that the camera is connected to.

5 Technical Data

Characteristic Data	
Video-Format	320 x 240 YUV (4:2:2) – only AK061 640 x 480 YUV (4:1:1) – only AK061 640 x 480 YUV (4:2:2) – only AK061 640 x 480 RGB (24 Bit) – only AK061 640 x 480 monochromatic (Y, 8-bit)
Refresh Rate	3,75 / 7,5 / 15 / 30 frames/s reduceable to 83,3 %: 3,12 / 6,25 / 12,5 / 25 frames/s
Sensitivity	AK-060: 0,8 lx AK-061: 4,0 lx (Exposure time 1/30s, Gain 0 dB)
Gamma	0.41 / 1 selectable
Dynamic Range	ADC: 10-bit Output: 8-bit
S/N – Ratio	ADC: 9-bit (25°C, Gain 0 dB)

Optical Data	
Image Sensor	AK060: Sony ICX 098BL AK061: Sony ICX 098BQ
Type	CCD Interline-Transfer Progressive Scan
Sensor-Format	1/4"
Resolution	640 x 480 (H x V)
Pixel Size	5,6µm x 5,6µm
Lens Attachment	C / CS – Mount

Electrical Interfaces	
Power Supply	8 ... 40 V DC
Current Consumption	90 mA approx. (at 12 V)
Data Interface	IEEE 1394a (FireWire / i.LINK)
Remote Control (Input)	IEEE 1394a
Synchronization (Input)	IEEE 1394a
Synchronization (Output)	IEEE 1394a
Video (Output)	IEEE 1394a
Connections:	Data: 6-pin IEEE 1394 - socket Daisy-Chain: 6-pin IEEE 1394 - socket Power: Coaxial Power Plug ∅ 5,5mm (optional)

Mechanical Data	
Dimensions	50,5 mm x 50,5 mm x 47 mm (HxWxD)
Housing	Aluminum, black
Attachment	Mounting plate with photo thread 1/4" x 8mm (max.) and M6 x 8mm Dimensions:37,5 x 35 x 8 mm Mountable on 4 sides (with M2 x 6) alternative direct mounting on 4 mounting holes M2 Spacing 23 x 30 mm (BxT) Insertion depth max. 2 mm
Weight	approx. 165 g

Setting Options (manual, over IEEE 1394a – Bus)	
Exposure Time	1/3300 ... 1/30 s
Gain	0 ... 36 dB
Offset	0 ... 511
Sharpness	0 ... 255
Gamma	0,45 / 1
Color Saturation (only AK061)	0 ... 100 %
White Balance (only AK061)	2600 ... 9000 °K
Backlight Correction	none / circle / averaged circle / head and shoulders / upper third / lower third / middle third
Dead pixel - correction	none / median / non-linear interpolation

Automatic Operation	
Exposure Time (AEC)	1/3300 ... 1/30 s
Gain Control (AGC)	0 ... 36 dB
Offset	0 ... 511
White Balance (only AK061)	2600 ... 9000 °K

Environmental Conditions	
Operating Temperature	-5 °C ... 45 °C
Storage Temperature	-20 °C ... 60 °C
Max. Humidity	90% no condensation

We reserve the right to change these conditions

AK060 = FireWire-CAM-001 = FCAM-001= s/w-Model
AK061 = FireWire-CAM-002 = FCAM-002 = Color-Model

6 Dimensions

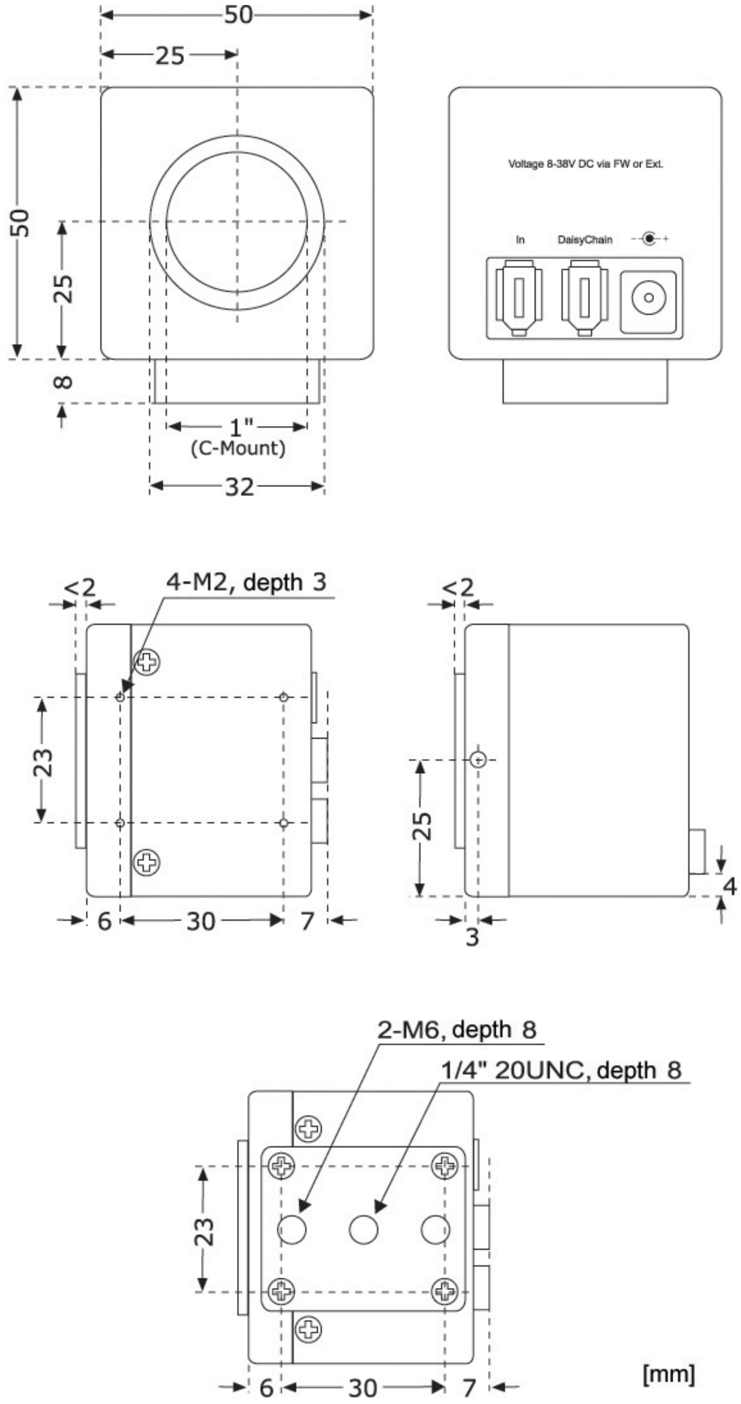

Figure 45: Dimensions

Document: FireWire-CAM-001 / 002
Document Number: L-661e_1, 1. Edition

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Published by

Ordering No. L-661e_1
Printed in Germany