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IntelliWave Notes

This document contains all my collected notes and hints how to install and use IntelliWave, for Interferometers with USB2 cameras, tested with IntelliWave 6.7.1.0999, 6.7.1.947, 6.75-04 and 6.91-07

If you find errors in this document, or if something is missing, or if you have found out any hints or tricks with IntelliWave that aren't yet included in this document, please let me know.

I'd like to include everything that might be interesting for other IntelliWave users.

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1 Software Installation for version 6.75-04 and newer

There have been some significant changes in the installation procedure, beginning with version 6.75 and newer.

The operating system on the computer should be the english version of Windows 7 Professional, or Windows 10. With other language versions (for example german) there may be problems when installing the driver for the Contec card (I got an error message while running the setup.exe for this card, see below).

1.1 Installing the Digital/Analog Card into the Computer

- Switch off computer
- Open it and install the Contec_1604 card into an empty PCI slot
- Fix it with a screw
- Close the computer

1.2 Install the manufacturer's driver

The (manufacturer) driver for the analog/digital card must be installed by running DVD:\Phase_Shifter/Contec/Setup.exe
Simply follow the instructions.

If you get an error message "The current language is not supported by the Device Driver Installation Wizard" when running the setup.exe, then don't use the setup.exe and instead install the Contec Driver from the DVD that came together with the D/A converter card. Click on "Install Development or Execution Environment" and in the next step choose "API-AIO(WDM) Advanced Analog I/O driver", then follow the instructions.

If you forget to install this driver, then you would get this error message when you start IntelliWave:
"The program can't start because CAIO.DLL is missing ..."

1.3 Install the hardware key driver

Then install the software for the USB hardware key. Simply run the Setup_Rainbow_7.6.5.exe from the DVD/Rainbow_Key_Setup folder and follow the instructions.

1.4 Install IntelliWave

Then install IntelliWave from the DVD. Simply run the DVD/Setup_IntelliWave_v6.75-04.exe and follow the instructions. When asked for the interferometer type, select "other".

1.5 Software for USB2 Cameras

It's highly recommended to install also the software for the USB2 camera from german manufacturer IDS. Download the latest version from

www.ids-imaging.de --> Support --> Downloads --> uEye_Cameras

Download the file for "Windows 7 (64-Bit)" and "USB2 uEye". I did test the version 4.90. Install this file and use the 64-bit version. When asked, choose "Install driver", "3. USB", "Install a desktop shortcut to 'uEye Cockpit' and to 'IDS Camera Manager' "

Two programs will be installed automatically:

1. "uEye_Cockpit" is a program for testing the camera. You can use it to watch live video, make adjustments to the camera settings, and save these settings in a *.ini file. More about this will follow below.
2. "IDS_Camera_manager" is a program for checking if the camera is connected correctly to the computer, and if the correct drivers are installed.

The camera type in the interferometer is UI-1240ML-M-GL. This is a monochrome USB2 camera with 1280x1024 pixels.

1.6 Cables between Computer and Interferometer

There are two cables:

- The USB2 cable for the camera must be connected to a USB2 port. A USB1 port won't work. Very important: Always use a high quality USB2 cable, as short as possible. With a cheap or too long cable you may have the problem that IDS_Camera_Manager detects a correctly connected camera, although you won't see any live video in μ Eye_Cockpit or in IntelliWave. In this case you might see this error message in μ Eye_Cockpit: "Can't open Camera - Error code 2 !". If you need a longer cable, you can use an active USB2 extension cable. I have tested a 10m cable "DELOCK 82446" and it works fine even at the highest pixel clock. It's possible that not all USB ports in the computer work with the camera. In this case, try another USB port.
- The cable from the DA converter card to the high voltage amplifier (which may be built into the interferometer) is used for sending the -10V...+10V control voltage to the amplifier. The high voltage amplifier amplifies this voltage by a factor of -40 (it's an inverting amplifier) and gives the +400V...-400V voltage to the phase shifter. The phase shifter contains 2 or 3 piezo transducers which move the reference optics in 1/4 wave increments between the individual pictures. The DA converter card has 3 output channels, but normally we use only channel 0 for all piezo transducers simultaneously.

1.7 Install the IntelliWave drivers

Now you must install the IntelliWave drivers for the camera and the phase shifter card. Please note there are two drivers required for the phase shifter card: The manufacturer driver (see above) and the IntelliWave driver (see below). Don't do this before you have installed IntelliWave from the DVD.

Copy the file C:/Program_Files_(x86)/Engineering_Syntheses_Design/IntelliWave/IntelliWaveDrivers/AcquireFringeIDS/AcquireFringe.dll to the folder C:/Program_Files_(x86)/Engineering_Syntheses_Design/IntelliWave There is already a file with the same name, you can overwrite it.

Copy the file C:/Program_Files_(x86)/Engineering_Syntheses_Design/IntelliWave/IntelliWaveDrivers/ShiftFringeContec/ShiftFringe.dll to the folder C:/Program_Files_(x86)/Engineering_Syntheses_Design/IntelliWave There is already a file with the same name, you can overwrite it.

Now start IntelliWave. If you get an error message regarding the camera, please proceed as described below in chapter "Generate or check a camera file with μ Eye_Cockpit"

Log files can be found in the folder C:\Mahr\Logbook\Automated

2 Software Installation for older versions up to 6.7.1.0999

The operating system on the computer should be the english version of Windows 7 Professional. With other language versions (for example german) there may be problems when installing the driver for the Contec card (I got an error message while running the setup.exe for this card).

Windows 10 should work, if all the hardware drivers are available. I haven't yet tested Windows 10 with these software versions myself.

The software installation is also described in ESDI's "IntelliWave Install Guide". What's described there is all right, but this file contains some additional useful informations, especially for interferometers which were refurbished with USB2 cameras. ESDI's install guides can be found on the DVD:

DVD:/Manuals/General/iw_common_installations_manual.pdf
and
DVD:/Manuals/General/iw_generic_installations_manual.pdf

The first thing to do is to install IntelliWave from the DVD. Simply follow the instructions. I recommend to make a desktop shortcut for IntelliWave. The path is
c:\Program_Files_(x86)\Engineering_Synthesis_Design\IntelliWave\IntelliWave.exe

The next step is to install the software for the USB hardware key. Simply run the Setup_Rainbow.exe from the DVD/Rainbow_key_setup folder.

2.1 Software for USB2 Cameras

It's highly recommended to install also the software for the USB2 camera from german manufacturer IDS. Download the latest version from www.ids-imaging.de --> Support --> Downloads --> uEye_Cameras

Download the file for "Windows 7 (64-Bit)" and "USB2 uEye". I did test the version 4.41. Install this file and use the 64-bit version. When asked, choose "Install driver", "3. USB", "Install a desktop shortcut to 'uEye Cockpit' and to 'IDS Camera Manager' "

Two programs will be installed automatically:

1. "uEye_Cockpit" is a program for testing the camera. You can use it to watch live video, make adjustments to the camera settings, and save these settings in a *.ini file. More about this will follow below.
2. "IDS_Camera_manager" is a program for checking if the camera is connected correctly to the computer, and if the correct drivers are installed.

The camera type in the interferometer is UI-1240ML-M-GL. This is a monochrome USB2 camera with 1280x1024 pixels.

2.2 Installing the Digital/Analog Card into the Computer

- Switch off computer
- Open it and install the Contec_1604 card into an empty PCI slot
- Fix it with a screw
- Close the computer

The (manufacturer) driver for this card must be installed by running
DVD:\Phase_Shifter/Contec/Setup.exe

Simply follow the instructions.

If you forget to install this driver, you will get this error message when you start IntelliWave:
"The program can't start because CAIO.DLL is missing ..."

2.3 Cables between Computer and Interferometer

There are two cables:

- The USB2 cable for the camera must be connected to a USB2 port. A USB1 port won't work. Very important: Always use a high quality USB2 cable, as short as possible. With a cheap or too long cable you may have the problem that IDS_Camera_Manager detects a correctly connected camera, although you won't see any live video in uEye_Cockpit or in IntelliWave. In this case you might see this error message in uEye_Cockpit: "Can't open Camera - Error code 2 !". If you need a longer cable, you can use an active USB2 extension cable. I have tested a 10m cable "DELOCK 82446" and it works fine even at the highest pixel clock. It's possible that not all USB ports in the computer work with the camera. In this case, try another USB port.
- The cable from the DA converter card to the high voltage amplifier (which may be built into the interferometer) is used for sending the -10V...+10V control voltage to the amplifier. The high voltage amplifier amplifies this voltage by a factor of -40 (it's an inverting amplifier) and gives the +400V...-400V voltage to the phase shifter. The phase shifter

contains 2 or 3 piezo transducers which move the reference optics in 1/4 wave increments between the individual pictures. The DA converter card has 3 output channels, but normally we use only channel 0 for all piezo transducers simultaneously.

- Pinout of the 50-Pin connector for the Contec card: Pin 24 is Ground, Pin 25 is Signal

2.4 Installing the (IntelliWave) Drivers

Please note there are two drivers required for the phase shifter card: The manufacturer driver (see two chapters above) and the IntelliWave driver (this chapter).

Don't do this before you have installed IntelliWave from the DVD.

On the IntelliWave DVD the drivers are in the folder DVD:\IntelliWave_Drivers

You will need two drivers,

"acq_uEye.exe" for the USB2 camera, and

"ShiftA_Contec_HV400.exe" for the DA converter card Contec_1604

or alternatively "ShiftA_DT_HV400.exe" for the DA converter card from Data Translation (which was used for older IW installations).

Make a double click on the first driver, then in the next window select the destination folder which is C:\Program_Files_x86\Engineering_Synthesis_Design\IntelliWave (don't use the folder "Drivers" !) then click on "unzip" and close the small window.

Do the same for the second driver.

Please note that the ShiftA_Contec_HV400 driver will always produce a positive output voltage. Negative output voltage is impossible with this driver. If you need the full -10V...+10V output voltage range, use the ShiftA_Contec.exe driver instead. Both versions are single channel drivers.

2.5 Adjustments in IntelliWave

Start IntelliWave.

It's possible that you get this error message: "Function is_ParameterSet returned with error 50 = Can't open the file". Just click this error message away. It means that IntelliWave still has the wrong camera in its configuration file. This will be corrected in the next steps.

Now make (or check) the following adjustments:

Configuration::Hardware::Interferometer::Common_Properties

Wavelength: 0.6328 μ m (for Helium-Neon laser)

Waves/Fringe: 0.5 (for typical measurements)

Configuration::Hardware::Interferometer::General_Interferometer_Type

Select "Fizeau"

Configuration::Hardware::Phase_Shifting_Interface

Port: 1

Channel: 0

Device: Contec 1604[1][HV400]

Device Voltage: -10V...10V

Safe Voltage: 0V...9V

Configuration::Hardware::Frame_Grabber

In the "Options" group, uncheck the box "Use_Alignment_Camera" if your interferometer doesn't have a second camera.

Configuration::Hardware::Camera::Select_Camera_by_File

C:\Program_Files_x86\Engineering_Synthesis_Design\IntelliWave\Cameras\Z-Series\la_uEye_1240.ini

Options::Display_Memory_General::Memory

Click on "Get_Camera_Array_Size". If the result isn't 1024 x 1024, then you must first generate a new camera file with uEye_Cockpit, and then repeat this step. See chapter "Generate a camera file with uEye Cockpit" below.

Options::Acquisition::Configuration

Set "Time between frames" to 60ms.

Automation::Configure::Automation1

In the "Acquire Automation" group, select "Compute OPD map" and remove the tick "Post OPD Averaging".

In the "OPD Map Automation" group, select "Compute Aberrations".

In the "Aberration Automation" group, select "RMS of Aberration fit".

Tick the box at "Display Graphics Automation".

In this group, select these settings (you can change them later, but this is a good starting point):

Window 1: Interferogram / Image

Window 2: None

Window 3: OPD / Graph_2D_Color_Map

Window 4: OPD / Graph_3D_Perspective

Tick the box at "Display Spreadsheet Automation".

In this group, select "Interferogram Histogram" in the "After Acquire" field, and "None" in the "After Create OPD" field.

Dont forget to save the settings: File::Save_Configuration_as_Default

There won't be a warning if you exit IntelliWave without prior saving. Of course, you can create multiple configuration files with different file names. When you start IntelliWave the next time, the default settings will be automatically loaded.

Check out if the life video works, by clicking on the "Video" icon in the top left corner (or press F3 or F9).

You may have to adjust the camera exposure time by clicking on the small black arrow just right of the "Video" icon, and then select "Shutter Speed".

Overexposed areas in the interferogram will be displayed in red color. Make sure that there are no red areas in the video when you make a measurement. A few red pixels are acceptable, but there shouldn't be many of them close together.

2.6 Phase Shifter Calibration

- Switch on life video in the top left window (first ckllick in the top left window, then press F3 or F9).
- Adjust the interferometer so that you see fringes on the screen.
- In the top left window, define a circular mask, so that the mask is smaller than the test glass, The mask should contain 3-7 fringes and no areas without fringes.
- Make the interferogram as bright as possible, but make sure that there are no red pixels in the life video. Otherwise decrease the shutter time.
- Select Configuration::Phase_Shift_Calibration:Automatic_by_Phase
- Make sure there are no vibrations during calibration !
- Click on "Calibrate"
- The voltage difference from Frame 1 to Frame 5 should be approximately 5 Volts for Zygo MK-3 or MK-4 phase shifters. The voltages in the "Extra" fields don't care. Only Frame 1 to Frame 5 are important. The difference may differ from one instrument to another. I think it's ok if the difference is in the range from 3 to 8 Volts.
- If successful, click on "Save_as_Default"

2.7 Generate or check a camera file with uEye_Cockpit

If the USB2 camera doesn't work, the reason may be that your camera is a newer version than the *.ini file that came with IntelliWave. You can generate a new file with "uEye_Cockpit" as follows:

- Close IntelliWave
- Start uEye_Cockpit
- Click on "Monochrome"
- Start the life video by clicking on the green triangle icon in the top left corner.
- If you want to check the existing camera file, click on File::Load_parameters_from_File and select this file: C:\Program_Files_x86\Engineering_Synthesis_Design\IntelliWave\Cameras\Z-Series folder\l_a_uEye_1240.ini
- Now you should see a life video from the camera. If required adjust the interferometer so that you see some fringes.
- Click on the "Camera_Properties" icon and make the following adjustments:
- Camera::Exposure Time: Hold
- Image::Auto_Gain: off
- Image::Gain: 1x (or 2x or 4x, if required for very dark interferograms)
- Image::Gamma: off
- Size: 1024x1024
- Size::Left: center (128)
- Size::Show_only_AOI: on (This is very important, if you forget it you will see only a black screen in IntelliWave, although the video appears fine in uEye_Cockpit)
- Format: Mono_8
- Then from the File Menu save the settings to a file in the C:\Program_Files_x86\Engineering_Synthesis_Design\IntelliWave\Cameras\Z-Series folder. You can overwrite the current IntelliWave selected file "a_uEye_1240.ini".
- Close uEyeCockpit

- Run IntelliWave again
- If you have a problem with some USB2 ports, it's possible the camera is running too fast. You can change the clock and frame rate in uEye_Cockpit also.

2.8 Checking the sign of the phase map

A hill on the test surface should be displayed as a hill in the phase map. To make sure that the phase map has the correct sign, please measure a known test piece which has a hill or a depression. If the sign is wrong, go to the Automation::Configure menu and toggle "Invert_OPD".

Another method for changing the sign is in Options::Acquisition::Configuration, where you can toggle between "forward" and "backward".

Dont't forget to save this setting before you close IntelliWave, File::Save_Configuration_as_Default.

As a test piece you can use a flat glass which has a turned down edge, or you can use a glass that has a depression etched with a drop of hydroflouric acid.

3 Analog video cameras and framegrabbers

Most newer interferometers have a digital camera with USB2 interface. In these cases this chapter is irrelevant.

3.1 Which framegrabber cards can be used?

- **Matrox Meteor**
 - The manufacturer's driver is located at DVD / Frame_Grabber / Matrox
 - The IntelliWave drivers are located at DVD / InetlliWave_Drivers
- **Imaging Source "DFG/SV1/PCle"** which is marked on the card as "A052108-A3". "Imaging Source" is not written on the card.
 - The manufacturer's driver is located at DVD / Frame_Grabber / Imaging_Source / Frame_Grabber_Card
 - The IntelliWave driver is located at DVD / InetlliWave_Drivers / Acq_WDM
- And several other cards, which I haven't tested myself.

3.2 Settings for "DFG/SV1/PCle" framegrabber (Imaging Source)

It's not unusual that IntelliWave crashes while you make the following settings. Before making any settings, switch the live video off: Video[0] should be shown in the top left corner. In case of a crash, just restart IntelliWave and check all settings before you switch on the live video.

For a CCIR (50Hz interlaced) camera use these settings:

- Configuration --> Hardware --> Frame_Grabber
 - Frame_Grabber_Type: ImageSrc
 - Video Type: Pseudo Video
 - Click on "Configure Frame Grabber"
 - Device_Name: DFG/SV1/PCle
 - Video Norm: Pal_D
 - Video_Format: Y800 (768x576)
 - Frame_rate: 25
 - Advanced --> Configure_Frame_Grabber: Select the correct input channel (01 Video: Composite)
- Options --> Display/Memory/Gernal --> Memory Select "1/2 Size" = 384 x 288
This is recommended because interlaced means that the even and uneven lines aren't exposed simultaneously, and thus the phase shift isn't exactly equal for all lines, which would produce nasty artefacts.

For a EIA (RS-170, 60Hz interlaced) camera use these settings:

- Configuration --> Hardware --> Frame_Grabber
 - Frame_Grabber_Type: ImageSrc
 - Video Type: Pseudo Video
 - Click on "Configure Frame Grabber"
 - Device_Name: DFG/SV1/PCle
 - Video Norm: NTSC_M
 - Video_Format: Y800 (640x480 VGA)
 - Frame_rate: 29.97
 - Advanced --> Configure_Frame_Grabber: Select the correct input channel (01 Video: Composite)

- Options --> Display/Memory/General --> Memory Select "1/2 Size" = 320x240
This is recommended because interlaced means that the even and uneven lines aren't exposed simultaneously, and thus the phase shift isn't exactly equal for all lines, which would produce nasty artefacts.

For a Pulnix TM-9701 camera use these settings:

- Configuration --> Hardware --> Frame_Grabber
 - Frame_Grabber_Type: ImageSrc
 - Video Type: Pseudo Video
 - Click on "Configure Frame Grabber"
 - Device_Name: DFG/SV1/PCIe
 - Video Norm: NTSC_M
 - Video_Format: Y800 (640x480 VGA)
 - Frame_rate: 29.97
 - Advanced --> Configure_Frame_Grabber: Select the correct input channel (01 Video: Composite)
- Options --> Display/Memory/General --> Memory Select "Get Camera Array Size" = 640x480
This is possible because the Pulnix TM-9701 has a progressive sensor. The camera has an internal memory and an interlaced output. In this case the two half frames are exposed exactly simultaneously.

3.3 Testing the framegrabber without IntelliWave

For testing a framegrabber without IntelliWave, you can use the program "AmCap". It works with Windows 7. It can be downloaded for example here: <https://amcap.de.softonic.com/>

Under Devices you must select the "DFG/SV1/PCIe" framegrabber.

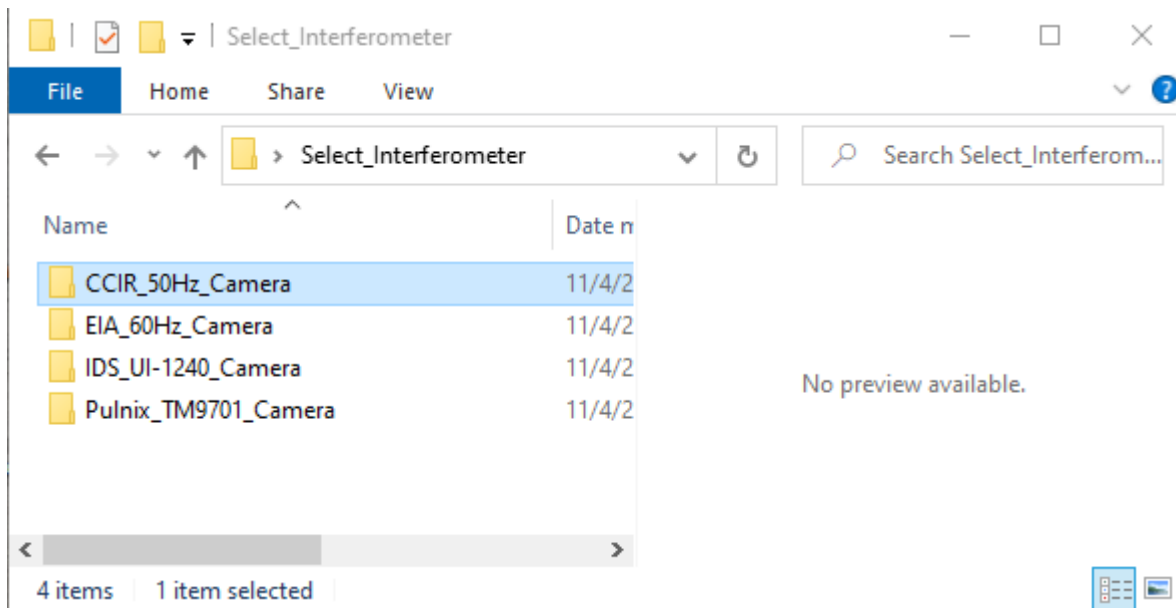
It's important that you select the correct video source: Options --> Video_Device --> Crossbar_Video_Input

4 Using IntelliWave with multiple different interferometers

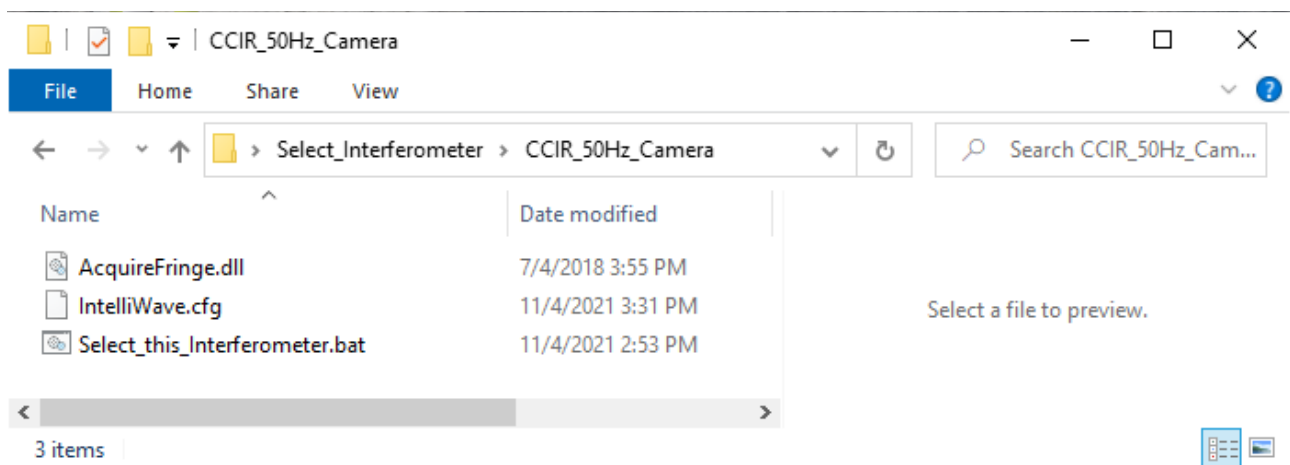
When you want to use IntelliWave for several different interferometers, these files must be updated before you start IntelliWave:

- The configuration file IntelliWave.cfg, which is in the folder
C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave\Configuration Files
- The file AcquireFringe.dll which is in the folder
C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave
However if all interferometers are using the same camera type, then it's not necessary to update this file. You must only connect the correct camera to the computer.
- The file ShiftFringe.dll which is in the folder
C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave
However if all interferometers are using the same D/A converter card, then it's not necessary to update this file. You can connect the output of the D/A converter card to all interferometers simultaneously. It's not necessary to use switches.

I recommend to create a folder "Select_Interferometer" on the desktop, which contains a sub-folder for each interferometer (or for each camera type):



Each of these sub-folders contains three files:



The batch file **Select_this_Interferometer.bat** has this content:

```
copy IntelliWave.cfg "C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave\Configuration Files"  
copy AcquireFringe.dll "C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave"  
pause
```

Each sub-folder contains the same batch file, and the files **AcquireFringe.dll** and **IntelliWave.cfg**.

At first glimpse you might ask “how can that work if it’s all the same?”.

Well, the files **AcquireFringe.dll** and **IntelliWave.cfg** have the same filenames in each sub-folder, but they aren't the same files.

The **IntelliWave.cfg** files contain different informations for frame grabber source and image size.

The **AcquireFringe.dll** files come from different sources:

- If the **IDS UI-1240** camera is used, the file comes from the folder
C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave\IntelliwaveDrivers\AcquireFringeIDS
- If the **ImagingSource** framegrabber is used with an analog camera, then the file comes from the folder
C:\Program Files (x86)\Engineering Synthesis Design\Intelliwave\IntelliwaveDrivers\AcquireFringeImageScr

When you want to switch to another interferometer, follow these steps:

- **Exit IntelliWave**
- **Open one of the sub-folders and execute the batch file by double-clicking it.**
- **A console window will open, and you should check that two files were copied. There should be no error messages. The reason for the “pause” command at the end of the batch file is that you can see error messages. Without the pause command the window would close immediately.**
- **Start IntelliWave**
- **When you save a new configuration file from within IntelliWave, you must of course copy it to the correct sub-folder.**

5 Making Measurements with IntelliWave

5.1 Help

IntelliWave has two built-in help functions:

1. Help::Help This will open the help in an IntelliWave window. The drawback is that IntelliWave won't accept any input until you have closed the help window.
2. Help::Help_Advanced This will open the help file in your browser. This is better, because you can click it into the background and use it simultaneously with IntelliWave.

5.2 Waves per Fringe Constant

In IntelliWave it's called "Waves/Fringe" and can be found in Configuration::Hardware::Interferometer::Common_Properties. In Zygo's MetroPro software it's called "Scale Factor", and in 4D Technology's 4Sight software it's called "Wedge Factor".

Three different names for the same thing !

This parameter must be set according to the type of measurement:

Use 1.0 if you want to measure the error in a reflected wavefront.

Use 0.5 if you want to measure the surface error of a glass surface. This is the default setting.

Use 0.5 if you want to measure a wavefront error in a double-pass configuration.

Use 0.25 if you want to measure a surface error in a double-pass configuration (for 0° angle of incidence).

Very important: If you set this parameter incorrectly, your result will be off by a factor of 0.5 or 2.

Example 1: If you measure the surface error of a flat test piece against a transmission flat, the value must be set to 0.5. The same is also valid for measuring lens surfaces against a transmission sphere.

Example 2: Let's assume you have a transmission flat, a perfect return flat, and a glass window in between. If you want to measure the window in transmission, you must also set the value to 0.5. This is because the light passes twice through the window, this is called a double-pass configuration.

5.3 How to have the life video always visible

It's recommended to show the life video in window 2, this is the upper right window (not the upper left window !). Click on the upper right window, then click on the "Video" icon to switch on life video (or press F3 or F9).

It is important that you don't have anything specified in the Automation menu for this window (Window 2: None).

Then the life video will always stay on, even after an acquisition. This won't work if you have the life video in the top left window.

5.4 Keyboard shortcuts

F1 = Acquire

F2 = Compute OPD

F3 = Toggle Live Image

F4 = Alignment Video (if the interferometer has a second USB camera for alignment)

F9 = Toggle Life Image (same as F3)

5.5 Possible sources of vibrations and air currents

During the measurement (which takes about 2-3 seconds) you must avoid all possible sources of vibrations. If you use averaging, then the time is longer, of course. Use the live video screen to check if there are any vibrations.

Possible sources of vibrations:

- Don't touch the interferometer table during the measurement.
- The computer and the mouse must be on another table.
- Use a vibration isolation table. Make the table as heavy as possible. Mass helps to reduce vibrations. The center of gravity of the whole table must not be too high, otherwise the vibration isolation system may become unstable and oscillate.
- Do not walk on the floor during the measurement.
- Do not open or close doors during the measurement.
- Switch off any nearby machines that may produce vibrations.
- If traffic on a nearby road is the source of the vibrations, you may have to make the measurement at night.

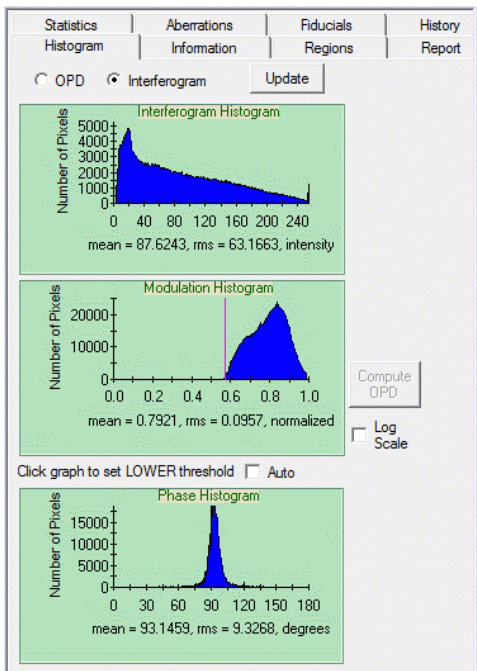
Possible sources of air currents:

- Close all windows and doors.
- No air conditioning.
- No heating in the room.
- Not too many people in the room. Each person is a 100W heat source.
- Do not walk around before or during the measurement. Walking around in the room would also move the air and bring warmer air in the light path.
- Make sure the floor, all walls, and the ceiling of the room have the same temperature.
- Do not let the sun shine in the room. It will heat up some surfaces.
- Make sure the test piece has the same temperature as the air. If it comes directly from the polishing machine, it may be too warm.
- It may also be too warm if you have touched it with your fingers. If you don't believe me, make this test: Put a piece of paper on a glass surface and press your thumb on it for 30 seconds. Remove the paper and make a measurement as fast as possible. You will see a hill where the thumb has warmed up the glass.
- If you have air currents, it may help to isolate the optical path with a tunnel of styrofoam plates, especially if you have a long optical path from the reference surface to the test piece.
- Slow air currents can be compensated by averaging many measurements.

5.6 Now let's make the first measurement

- Switch on the live video.
- Make sure that the interferometer has warmed up at least 15 minutes. The fringes in the interferogram should be stable and not move faster than about one fringe per minute. If this is not the case, wait.
- Switch the interferometer to "Align" mode.
- If required, adjust the shutter speed, so that you can see the crosshair. Click on the small black arrow just right of the "Video" icon, and then select "Camera Control". A small window will open where you can change the shutter speed. You can leave this window always open.
- Another way to change the exposure time is to click on the small black arrow just right of the "Video" icon, then select "Shutter Speed" and then choose one of the 10 speeds.
- If you have already a test piece in front of the interferometer, block the light path with a piece of paper, or tilt the test piece so that it doesn't reflect any light back to the interferometer.
- Tilt the transmission flat or the transmission sphere until the brightest dot is in the center of the crosshair. From now on, do not change this setting.
- Remove the piece of paper.
- Adjust the test piece. The test piece will also produce a dot. If you see more than one dot, use the brightest one. Adjust the test piece until the dot is also in the center of the test piece.

- Switch the interferometer to "View" mode. Now you should see an interferogram.
- Define a circular mask. Click on the small triangle just right of the "Mask" icon and click on "Circular Mask". Then move the mouse over the top left corner of the round interferogram, press the left mouse button and move the mouse to the bottom right corner, then release the mouse button. Now you should see a blue circle, and a window opens. Don't change anything in this window and click on "ok". When you move the mouse pointer over the blue circle, the mouse pointer changes to a small circle. When you now press the left mouse button, four white dots appear around the mask. With these white dots you can change the size of the mask with the mouse.
- If required, adjust the shutter speed, so that the interferogram doesn't contain overexposed (red) areas. If only a few pixels are red, that doesn't matter.
- Make some fine adjustments of the test piece, until the number of fringes is as small as possible. That means you want to test the part exactly on the optical axis. This is especially important if you are testing fast spherical surfaces. If you see several fringes, then the optical path is tilted and you will get some Coma in the result.
- Now wait until you don't see any vibrations or air currents in the live video.
- Make a left click in Window 1 (top left window) to make sure that the measurement will be shown in this window. (If you don't do that, you may accidentally have window 2 selected, and then you wouldn't see the live video after the measurement).
- Then click on "Acquire" or press F1, to make a measurement.
- Now let's have a look at the spreadsheet (on the left side of the screen). Click on "Histogram" and then on "Interferogram". You will see three graphics:



At the top you see the "Interferogram Histogram". It describes how many pixels of each brightness are present in the interferogram. The X axis is the brightness from 0 to 255. The Y axis is the number of pixels. The histogram shown at left is a good one. You see that the whole brightness range from 0 to 255 is used. The small peak at 255 means that there are a few overexposed pixels, but this number is just acceptable. Make sure that this peak isn't much higher than shown here. If it is higher, use a faster shutter speed. If the histogram shows only pixels with lower brightness, for example all pixels are below X=120, then you could make the shutter speed slower.

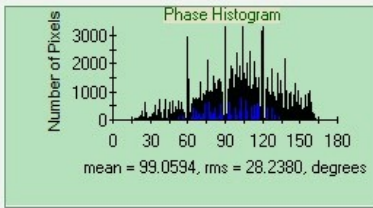
In the middle you see the "Modulation Histogram". It describes how much the brightness of a pixel has changed within the 5 pictures. The modulation should be as high as possible. If you have areas in the interferogram which don't reflect light (for example an obstruction), then these areas will have a very small modulation.

The histogram shown here is a good one, because all pixels have a high modulation. You see the red line in the histogram. It can be moved with the mouse. This line defines the "Modulation Threshold", which means that all pixels left of the red line will not be used for analysis. Try different settings of the threshold and click on the "OPD" icon to see how the resulting OPD map changes.

At the bottom you see the "Phase Histogram".

This histogram should have a peak near 90 degrees. Everything between 80 and 100 degrees is acceptable. The histogram shown here is a good one. If the peak is always below 80 or always above 100 degrees, then something with your phase shifter calibration is wrong. In this case repeat the phase shifter calibration.

If the peak is much broader than shown here, or if you have several peaks, or if the peak is jumping around from one measurement to the next, then you probably have too much vibration during the measurement. Or the phase shifter is not working at all. Check the cables.



This is an example for a very bad phase histogram. It could have one of the following reasons:

1. The interferogram is much too dark, for example if all pixels in the "interferogram histogram" (that's the histogram at the top) are in the range [0..30]. Use a longer exposure time to make the interferogram brighter.

2. It's possible that the phase shifter doesn't work at all. Check all cables and connectors in the signal chain: The [-10V..+10V] signal comes from the DA card in the PC. From there it goes to the high voltage amplifier. This amplifier is internal in the MK-3 and MK-4 interferometers, or external if you have a modernized GPI interferometer. The amplifier has a gain of -40, so that the output voltage is in the range [-400V..+400V]. The gain factor is negative because it's an inverting amplifier. The amplified voltage goes from the output of the amplifier to the phase shifter. The phase shifter contains two or three piezo transducers, which move the reference optics by a small amount (less than a micrometer).

You can check the [-10V..+10V] signal as follows:

Connect a digital voltmeter (20V DC range) to the cable, which comes from the DA card. Start IntelliWave, click on Configuration::Phase_Shift_Calibration, then click on "Manual Control". Now you can manually change the voltage by clicking the up/down arrows.

If this test is successful, the next step is to measure the output voltage of the amplifier. Please note that at this point you have a dangerous voltage in the [-400V..+400V] range. You must never touch this voltage with your hand! Use a voltmeter (500V DC range) to measure this voltage. The output voltage should be the input voltage multiplied by factor -40.

If you have the correct input voltage, but no output voltage, then check the fuse of the amplifier. It's a 0.1A fuse for the 230V version, or a 0.16A fuse for the 115V version.

Another possible test (without having to connect a voltmeter) is to use a frequency generator at the input of the amplifier. Use a frequency between 400Hz and 1500Hz, and set the RMS voltage to 5V or smaller. If the amplifier works correctly, you should hear the sound from the phase shifter. You can use sine wave or rectangular wave. Rectangular will make a stronger sound. You can also set the generator to a very low frequency, for example 0.1Hz, and observe the live video on the computer screen.

The fringes should move with the selected frequency, for example 5 seconds in one direction and then 5 seconds in the other direction, if the frequency is 0.1Hz (= 10 seconds cycle time).

In the presence of vibrations it's difficult to make a successful phase shifter calibration. But a manual calibration is always possible as follows:

Select the "linear" phase shift calibration mode and enter a suitable value in the "volts/wave" field. Typical values are in the 1.5 - 4 range. Then click on "calibrate". This is not a real calibration. It just calculates the voltages for the required number of steps. Now make a measurement, and look at the phase histogram. If the peak is above 90°, then your volts/wave value was too large. Repeat the calibration with a lower value and find the best value by try and error.

5.7 Averaging multiple measurements

In order to reduce artefacts from vibrations or from air currents, you can average multiple measurements. Go to Automation::Configure::Automation1 and tick the box "Post OPD Averaging", and enter the number of measurements. This number will also be shown below the "Acquire" icon.

Before you average multiple measurements, it's always a good idea to have a look at several (non-averaged) OPD maps, and check if they don't differ too much. If some OPD maps look very different from others (for example due to spikes or unwrapping errors), then it doesn't make sense to average multiple measurements. You should solve the problem first and get better OPD maps which don't differ too much.

During averaging, you can also apply a quality check to the phase maps before they are averaged, and too bad phase maps will be rejected. Do this as follows:

1. On the "Statistics" spreadsheet select "Interferogram" radio button.
2. Enter the Min and Max acceptable values, for example
Phase_Step_Average 88 to 92
Phase_Step_RMS 0 to 10
Modulation_Average 0.5 to 1.0
3. Check the QC box for each of the above.
4. In "Automation Configure" check the "Acquire_Automation:Quality_Control" box
5. Now perform averaging as normal. All acquisitions that do not match the specs will be rejected.

5.8 Removing unwanted Spikes in the OPD Map

If a measurement has an unusual high PV value, the reason may be spikes in the OPD map, which possibly are so small that you don't see them. Such spikes can be removed in the Options::Image_processing::Filters menu, where in the group "Clip_OPD_Spikes" you can select for example "Clip_by_Histogram / 98%".

5.9 How to calibrate the OPD map in Millimeters

Because of the optical zoom, the image size can be anything. So the user must calibrate image size to mm.

There are two ways:

1. Select Tools::Calibrate Image, then draw line across fringe area, and then enter dimensions and select units
2. Draw a data mask around fringe area. Right click on the mask and select Units on bottom right. Enter dimensions and units (image and display).

5.10 Save a mask for default use

Masks are stored in data file, not configuration file. However, if you want the same mask to be loaded when you run IW, then save the mask, then from the Mask Menu, select Save_Mask_as_Default.

5.11 Masks

All types of masks (including lines) can only be drawn in the upper left window.

If you want a circular mask with a fixed aspect ratio, there is a workaround to do this:

Create an elliptical mask. In the "Object Properties" window, select "Fixed Aspect" and manually set the X and Y sizes to the same value, then click on "ok". When you now change the size of the mask with the mouse, the aspect ratio won't change. I know this is counter-intuitive. You have to use an ellipse when you really need a circle, and when you use a circle you can change its size into an ellipse... this is clearly something that could be improved.

Left click on a mask to highlight it. Then use page up/down to resize, or arrows to move.

Is it possible to set the diameter of the aperture mask automatically to 90% of the test piece diameter?

Yes and no. Any mask can be saved and opened later or automatically when IW opens. If you want the mask to be 90% of the parts diameter in real world units, one must first calibrate the image. Click on "Tools", then "Calibrate Image Units", draw a line that is matching the parts diameter and enter the parts diameter in mm. Now all mask drawn will be relative in size to the part.

How to define a polygon mask? Set the corner points with left mouse clicks, and use a right mouse click to close the polygon. Single corner points can be moved by holding the "ctrl" key while moving the point with the left mouse button.

How to change the size of a polygon mask? Left click the polygon to highlight it, then press PageUp/PageDown to resize.

How to exclude a border with fixed width from a mask? Use Erode in the Options::Image_Processing menu to eliminate border pixels.

5.12 Problems and Solutions

I saw this problem only one time and could not reproduce it again:

Apparently the phase shifts between the 5 interferograms were much different from another, and definitely not 90°. To check this you can show the first interferogram in a window, and by double clicking on it you can switch to the next interferogram. This way you can inspect all five interferograms and check if the phase shift is approximately 90°. The 5th interferogram should look like the first interferogram, because $4 * 90^\circ = 360^\circ$. If you have this error, shut down IntelliWave and check the camera signal with uEye_Cockpit. If uEye_Cockpit fails to show the live video, then shut down the computer and restart it. Restart IntelliWave and check if it works again.

5.13 Measuring the surface error of flat windows

This is difficult, because the window makes two reflections, one from each side. It helps if the window has a small wedge angle, so that the other side produces such a high fringe density that the camera can't resolve it.

For smaller wedge angles, or for nearly parallel plates, you must decrease the reflection from the unwanted side. This can be done by painting the back side with black ink. I prefer "Edding T100 refill ink for permanent marker". It dries within a few minutes, and can easily be washed off the glass with alcohol.

For testing the window's front side against the transmission flat, paint the back side with black ink.

For testing the window's back side against the transmission flat, turn the window around so that the back side faces the transmission flat. The other side should again be painted with black ink.

You can also test the front side against the back side. In this case you remove the transmission flat. The resulting fringes represent a combination of the errors from both surfaces and also the inhomogeneity of the glass. Please note that in this case you can't make a phase shift analysis, because there is no transmission flat mounted on the phase shifter. If you try to make a phase shift measurement, the resulting phase histogram will look like the example in the above picture (This is an example for a very bad phase histogram...)

5.14 CaliBall Test, how to average multiple measurements with pauses between them

The CaliBall is used for calibrating a transmission sphere. A silicon nitride ball is tested several times with the transmission sphere, and between the measurements the ball is turned by hand to a new random position. This means you need a pause between the measurements for turning the ball and for waiting until air movements have stabilized again. That's why the "Post OPD Average" feature in the Automation1 menu can't be used in this case. Instead there are three ways how this can be done:

1. Create a folder and save the individual measurements in this folder. Typically you make about 10 measurements. Then press the drop arrow next to the OPD icon and select "Average OPD files". Select the files you wish to average and press "open".
2. Or use the "Average Manually" function from the OPD icon drop down menu.
3. Write a script to do this. Will only work with PE version, not with LE-2 version. There are script functions to add delays or user prompts.

5.15 Window Sizes

Can be changed manually.

How to make smaller (quadratic) sub-windows on a large screen? If you have a large screen (1920x1080), IW will fill the whole screen when started, and the four sub-windows will have an aspect ratio of about 2:1 (which doesn't make much sense, because normally the test pieces are round). When the IW window is reduced in size, you will get a horizontal scroll bar and the sub-windows don't become smaller. To make them smaller, use IW menu item Window::Tile to rearrange the sub-windows.

5.16 Interferogram is too dark or too bright

Too dark:

- Increase shutter time.
- Increase Camera Gain, see chapter about uEye_Cockpit above.
- Remove gray filter in front of camera objective.
- If the field is unevenly illuminated, an adjustment of the spatial filter may be required. This is difficult, if you haven't done it before. It's easy to make a too big adjustment, and then you don't see any illumination at all. Then it's very time-consuming to correct this error. Before you try to adjust the spatial filter, know exactly what you do!

Too bright:

- Decrease shutter time.
- Decrease Camera Gain, see chapter about uEye_Cockpit above.
- Insert gray filter in front of camera objective.

5.17 Testing mild aspheres

In IntelliWave PE version there is a wizard for defining the asphere. See http://www.esdimetrology.com/pdfs/Mahr-ESDI_Marsurf-FI-2100-AS_OV.pdf

But you can also test mild aspheres with any phase-shifting interferometer with the LE-2 version. It's not as comfortable as the PE version, but it works. With a "mild" asphere I mean an asphere which deviates only a few microns from the sphere, so that the camera can still resolve the fringes without aliasing. Please note that there may be re-tracing errors, which may affect the result.

1. Adjust the asphere in front of the transmission sphere so that the fringe density becomes a minimum.
2. Make a measurement.
3. Now create an artificial phase map, which describes the theoretical difference between the asphere and sphere. Use the same data mask aperture as that for the measured data. From the "Aberrations" spreadsheet click the "Theo" button. Enter your coefficients. Click "Generate OPD" and send to Reference.
4. Reload the measured data from the file, and subtract the reference.

5.18 PVr

PVr is not available yet, but it can be computed by generating an OPD from current aberrations and displaying the PV.

5.19 How to make screenshots and save them as PDF

Unfortunately IntelliWave cannot save PDF's directly. Here is a possible workaround:

-- Install the graphics viewer IrfanView (<https://www.irfanview.com/>). You need to install both "IrfanView" and "IrfanView all plugins".

-- In IntelliWave, press CTRL-PRINT

-- Open IrfanView and click on Edit --> Paste

-- Then click on File --> Save_as where you can save the image in many different graphics file formats, including JPG, GIF, PNG and PDF.

This procedure can also be automated as follows:

-- Open IrfanView and click on Options --> Capture/Screenshot

-- Select one of the 7 possible capture areas.

-- Select a hot key, for example CTRL-F11

-- Remove the option "Include mouse cursor"

-- Select "Save captured image as file" and use the suggested default file name.

-- Choose a destination directory.

-- In the "save as" field select "PDF".

-- Then click on "Start".

-- Do not close IrfanView. It must remain open, but you can click it in the background.

-- IrfanView will save these settings automatically. When you use this feature the next time, you must only start IrfanView and click on Options --> Capture... --> Start

-- In IntelliWave (or any other application) just press CTRL-F11 when you want to make a screenshot. You will hear a short sound and a PDF will automatically be added to the destination folder.

5.20 How to save Zernike coefficients

There are two ways:

1. You can save a measurement as a *.esd file with File --> Save (or File --> Save_as). This is a big file which contains all data of a measurement. You can later open this file and analyze it again. So you can also calculate the Zernikes again. It's also possible to analyze with different settings, for example with a different mask. But this file can only be opened with IntelliWave.

2. Another way to save Zernike coefficients is to make a right click in the aberrations spreadsheet and then use "save". It will create a *.abb file which is readable with a text editor.

5.21 How to measure the radius of curvature of an (almost) flat surface

Make sure that the "waves per fringe" constant is set to 0.5, so that you are measuring the surface error. This constant can be set under Configuration / Hardware / Interferometer / Common_Properties

Create a circular mask and make a measurement. The diameter D of the mask must be known in Millimeters. If the mask is smaller than the test piece, then D is smaller than the diameter of the test piece.

At the left side under "Aberrations" you can see the Zernike coefficients. We need the Z3 value which is "Focus". This is a little bit misleading because the numbering begins at 1 instead of 0, which is more common. That's why Z3 is written in the 4th line. Anyway, we need the value in the line where "Focus" is written.

The corresponding Zernike polynomial is: $2 * r^2 - 1$

Where r is the normalized radius in the range [0...1].

At $r = 0$ (in the center of the test piece) the value of the polynomial is -1, and at $r = 1$ (at the edge of the test piece) the value is +1. That means the peak to valley value of the polynomial is 2.

Let's assume the shown "Focus" value is $1\mu\text{m}$. Then the height over the normalized radius can be calculated as follows:

$Y = 1\mu\text{m} * (2 * r^2 - 1)$ with $r = [0...1]$

The height difference from the center to the edge is $2\mu\text{m}$.

If the surface error consists only of pure curvature, with other words if all Zernike coefficients except Z3 are zero, then the PV value of the surface is exactly twice the Z3 value.

Now we must convert the PV value to Millimeters.

-- If "Focus" was given in "waves": Multiply by 0.000633mm

-- If "Focus" was given in " μm ": Multiply by 0.001

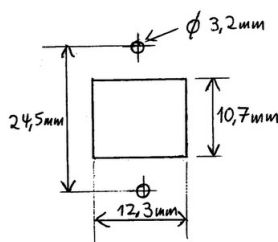
Now we know the PV value and the diameter D, and both are in Millimeters. The radius of curvature can be calculated as follows: $R = D^2 / (8 * PV)$

Summary: Multiply the "Focus" value by 2, convert it to Millimeters, and then calculate the radius of curvature with the above formula.

to be continued ...

6 Upgrading a Zygo MK-3 or MK-4 interferometer from analog to USB camera

1. Disconnect the mains power cable from the interferometer.
2. Open the top lid of the interferometer.
3. Disconnect both cables from the analog camera.
4. Remove the old camera power cable. You won't need it for the USB camera. The USB camera is powered through the USB cable.
5. The cable for the analog camera's gain and exposure time regulators has a connector in the middle, where you can disconnect it. You don't need this cable for the USB camera.
6. Remove the aluminium plate from the back side of the interferometer (6 screws), and remove the analog video connector.
7. Remove the analog camera from the interferometer. It is possible that one of the screws has a nut below the bottom plate. To access this nut, you must also remove the bottom lid of the interferometer.
8. Remove the objective from the analog camera and install it to the USB camera. If there is a gray filter on the objective, leave it there.
9. Check if the objective is focused to infinity distance, and the f/stop is fully open.
10. Install the USB camera in the interferometer. Use the old screws..
11. Now you must use a file and make the hole in the aluminium plate rectangular, and drill two bores, as shown in the below drawing.
12. Take care that the filing chips don't fall into the interferometer!
13. Install the USB adapter into this rectangular hole, and fix it with the two M3 screws.
14. Mount the aluminium plate to the interferometer.
15. Power on the interferometer and computer, use μ Eye Cockpit for viewing the image from the camera.
16. Check if the interferogram is centered in the screen.
17. If the interferogram is shifted left or right, you can correct this by turning the camera to the left or right. The small aluminium plate where the camera is mounted to, is fixed with 4 nuts. If you loosen these nuts, you can turn the whole plate a few degrees.
18. If the interferogram is shifted up or down, you must tilt the camera up or down. You can do this by putting some M3 washers below the small aluminium plate, either under the front nuts or under the rear nuts.
19. If the interferogram is centered, close the interferometer lid.
20. Then begin with the software installation, as described at the top of this website.
If you have any questions, please ask me !



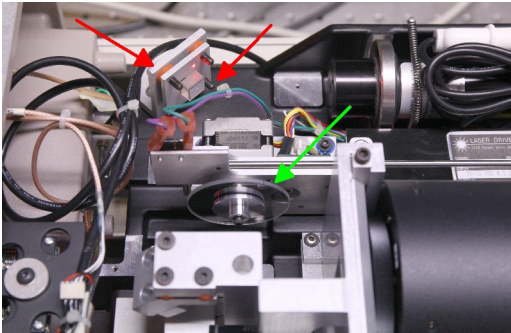
7 Instructions for refurbished Zygo GPI interferometers

-- IntelliWave software 6.75-04 and newer does no longer come on a CD-ROM. It's now on the USB stick which also serves as a hardware dongle. If you got the computer form me, then the software is already installed and tested together with the interferometer.

-- The original Zygo GPI has two analog cameras inside, one for view mode (interferogram) and the other for align mode (crosshair). In the original remote control is an "Align/View" button for toggling between these two modes. In the refurbished interferometer, the main camera (for the interferograms) has been replaced by a 1024x1024 pixel USB2 camera. The align camera is still the old analog camera. You can see both images simultaneously and no toggling is required. The interferogram is visible on the computer screen within IntelliWave, and the alignment crosshair is visible on the analog video monitor.

-- If the interferogram has uneven illumination, for example if the left half is brighter than the right half, you can adjust the illumination with two screws (red arrows in below picture). Only small adjustments are required, less than 45°.

-- If the interferogram is too bright (red areas shown in IntelliWave live view) or too dark, and if this can't be solved by adjusting the exposure time in IntelliWave, then open the interferometer and rotate the variable ND filter by hand (green arrow in below picture). In the original Zygo GPI, the camera's exposure time is fixed, and the variable ND filter is the only way to change the interferogram's brightness. However in the refurbished interferometer, the exposure time can be adjusted in IntelliWave, and there is no need for a variable ND filter. The stepper motor at the ND filter must be disconnected, because the original electronics doesn't know how bright the image is (because it doesn't get the USB2 signal from the camera).



7.1 Now let's make the first measurement with a refurbished Zygo GPI

- Make all connections: USB2 cable from interferometer to PC, BNC cable for phase shifter from interferometer to PC, BNC cable for alignment video from interferometer to alignment monitor, connect the remote control to the interferometer, and of course connect the mains voltage to all components.
- Switch on all components. It doesn't care in which order.
- You should see the crosshair on the alignment monitor.
- Install the transmission flat on the interferometer's bayonet mount. Fix it by tightening the small black thumb screw by hand.
- Now you should see one or two bright dots on the alignment screen. The brightest one is the reflection from the reference surface, and the dimmer one is the reflection from the (AR coated) back side.
- If you have already a test piece in front of the interferometer, block the light path with a piece of paper, or tilt the test piece so that it doesn't reflect any light back to the interferometer
- Tilt the transmission flat (with the two large knobs on top) until the brightest dot is in the center of the crosshair. From now on, do not change this setting.
- Remove the piece of paper.
- Adjust (tilt) the test piece. The test piece will also produce a bright dot. If you see more than one dot, use the brightest one. Adjust the test piece until the dot is also in the center of the crosshair. If your test piece is a window with parallel surfaces, use black paint on the back side. See also the chapter "Measuring the surface error of flat windows" above.
- Switch on the "Live video" in IntelliWave. Now you should see an interferogram.
- Make sure that the interferometer has warmed up at least 15 minutes. The fringes in the interferogram should be stable and not move faster than about one fringe per minute. If this is not the case, wait.
- Make sure that there are no vibrations or air currents from the environment. That's described in more detail above.
- If required, adjust the shutter speed, so that the interferogram doesn't contain overexposed (red) areas. If only a few pixels are red, that doesn't matter.
- Define a circular mask. Click on the small triangle just right of the "Mask" icon and click on "Circular Mask". Then move the mouse over the top left corner of the round interferogram, press the left mouse button and move the mouse to the bottom right corner, then release the mouse button. Now you should see a blue circle, and a window opens. Don't change anything in this window and click on "ok". When you move the mouse pointer over the blue circle, the mouse pointer changes to a small circle. When you now press the left mouse button, four white dots appear around the mask. With these white dots you can change the size of the mask with the mouse.
- Make some fine adjustments of the test piece, so that the number of fringes becomes as small as possible. That means you want to test the part exactly on the optical axis. This is especially important if you are testing fast spherical surfaces. If you see several fringes, then the optical path is tilted and you will get some Coma in the result.
- Now wait until you don't see any vibrations or air currents in the live video.
- Make a left click in Window 1 (top left window) to make sure that the measurement will be shown in this window. (If you don't do that, you may accidentally have window 2 selected, and then you wouldn't see the live video after the measurement).
- Then click on "Acquire" or press F1, to make a measurement. Of course, the mouse and keyboard must not be on the same table as the interferometer. Otherwise you would produce a vibration by pressing the key, just in the moment when you don't want any vibrations.
- Now let's have a look at the spreadsheet... (this is already explained in this document, scroll up)

8 Instructions for the small EYOYO 5" TFT monitor

This monitor has 5 buttons on the back side. One is the on/off button. You don't need this button if you switch on the monitor by applying the 12V voltage (either from a power supply, or from the interferometer).

With the O button you can select the input: VGA, HDMI, YPbPr, AV, BNC. For interferometers, you normally use the BNC input.

For changing the settings you need the + = - O buttons.

- To switch off the timeout of the menu: Press ≡ O O O - O O (now repeat pressing + until "OFF" is shown) O ≡ ≡
- To set the aspect ratio: Press ≡ O O - O O O + (now repeat pressing O until the small arrow points to 4:3 or 16:9) ≡ ≡ ≡
- To switch the crosshair on/off: Press ≡ O O - O - (now repeat pressing O until the small arrow points to ON or OFF) - ≡ ≡
- To adjust the brightness: Press ≡ O O O O - (now adjust the brightness with the + - buttons) ≡ ≡
- To adjust the contrast: Press ≡ O O O O - O O (now adjust the contrast with the + - buttons) ≡ ≡

9 Instructions for CMOS camera modules N3125-V3, N4191-V1 and N417R-V1

Press the button to enter the menu:

```
1. LENS ..... MANUAL DC
2. EXPOSURE ... 1. SHUTTER ... AUTO 1/25 1/50 FLK 1/200 1/400 1/1000 1/2000 1/5000 1/10000 1/50000
x2 x4 x6 x8 x10 x15 x20 x25 x30
    2. AGC .... 0-15 (0 means AGC off)
    3. SENS-UP
    4. BRIGHTNESS
    5. D-WDR (Wide Dynamic Range?)
    6. DEFOG
    7. RETURN
3. BACKLIGHT
4. WHITE BAL
5. DAY&LIGHT .. EXT AUTO COLOR B/W
6. NR
7. SPECIAL .... 1. CAM TITLE
                2. D-EFFECT ..... 1. FREEZE
                3. MOTION                2. MIRROR ... OFF MIRROR V-FLIP ROTATE
                4. PRIVACY                3. NEG. IMAGE
                5. LANGUAGE                4. RETURN
                6. DEFLECT
                7. RS 485
                8. RETURN
8. ADJUST ..... 1. SHARPNESS AUTO OFF
                2. MONITOR
                3. LSC
                4. VIDEO.OUT PAL NTSC
                5. COMET
                6. RETURN
9. EXIT SAVE&END
```

Recommended settings for interferometers:

```
LENS = MANUAL EXPOSURE/SHUTTER = (select a suitable exposure time, not AUTO)
EXPOSURE/AGC = 0
DAY&LIGHT = B/W
SPECIAL/D-EFFECT/MIRROR = ROTATE, if required
ADJUST/SHARPNESS = OFF
ADJUST/VIDEO.OUT = PAL or NTSC
At last use EXIT SAVE&END to save all settings
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