# Usermanual Schmidt + Haensch
# iPR FR$^2$

In-line Process Refractometer


SCHMIDT
HAENSCH
innovators by tradition since 1864

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# Symbols

The symbols used in this manual have the following meanings:

Safety advice

Special note

Emblematises your mouse cursor

# Safety advices

This manual does not claim to address all the safety aspects involved in servicing and operating an **Schmidt+Haensch** refractometer and/or handling samples. It is the customers responsibility to ensure all safety regulations and protective recautions for the persons concerned work with the device. **Schmidt+Haensch** guarantees and warrants the proper function of the refractometer only, if no unauthorized adjustments are made to mechanical parts, electronic parts and software, and the following points are adhered to. Follow all advises, warnings and instructions in the manual to ensure the correct and safe functioning of the **Schmidt+Haensch** refractometer.

The instrument must be freely accessible for installation or reinstallation and also service purposes.

The refractometer should not be installed too closely to hot pipes or other devices.

Do not open the instrument while it is in operation.

Only qualified service personnel is allowed to open the instrument.

Care must be taken to avoid sudden temperature changes because this can damage the device.

You can only transfer data from the **iPR** to your computer by interfacing these two devices with there serial ports.

Don't plug out the serial cable while data transfer. This could lead to data loss.

You can only print out your measurements with a network-compatible printer, if the **iPR** refractometer is attached to your network by using the provided adapter .

Don't plug out the ethernet cable while printing. This could lead to data loss.

Take care, that your PC covers the minimum system requirements and that your printer is network-compatible.

The **iPR** is **not** an explosion-proof instrument, and therefore must not be operated in areas where there is a danger of explosion.

Do not store inflammable material near the instrument.

Ensure that the **iPR** is located in a sufficiently ventilated area, free from inflammable gases and vapors.

Connect the **iPR** to mains power via a safety switch located a safe distance from the instrument. In an emergency, turn off the power using this switch. Do not use the **iPR** power switch.

Keep a fire extinguisher at hand.

Each of our units is subjected to an in-depth inspection prior to delivery. Signs of use caused by tests are possible and have no influence on the performance and function of the instrument.

Avoid temperature shocks in front of the prism larger than 50°C during the process, otherwise the prism could crack.

The surface of the instrument could heat up depending on the measurement temperature, so please take care not to burn your hands.

If you have any questions, call the **Schmidt+Haensch** service.

# 1 What is refractometry ?

Refractometry is generally speaking the measurement of refractive index and its interpretation under different starting points. Refractometric measurements can be used for example for purity investigations, sample recognition, dilution control or composition. It's also used for characterization of substances or for determination of substance data, especially of organic liquids.

An important area of application is the food-analysis. For example the investigation of oils or fat, sugar and sugar containing substances. Also beer and spirituous beverages belong to the material class, which are investigated by refractometry. The liquid-chromatography also relies on the capabilities of the refractometric measurement, providing quality control for process optimization.

## 1.1 Introduction to theory of refractometry

Refraction of light is caused by different propagation of speed of light in different media. If light traverses the interface between dissimilar materials, it will change its propagation direction depending on the speed difference. This phenomenon is called „ refraction". This gives to the whole subject the name „Refractometry", standing for all methods including refractive index determination for controlling substance properties. Refractive index $n_{12}$ for light changeover from $Medium$ 1 to $Medium$ 2 equals exactly to the ratio of speed of light in these two media:

$$\boxed{n_{12} = c_1 / c_2}$$

$c_1$ = Speed of light in $Medium$ 1

$c_2$ = Speed of light in $Medium$ 2

$Law\ of\ Refraction$:

$$\boxed{n_1 \cdot sin(\alpha_1) = n_2 \cdot sin(\alpha_2)}$$

$\alpha = Angle\ of\ incidence$

The refractive index is also depending on the wavelength of light. The refraction of long-waved light is higher than the refraction of short-waved light. This behaviour is called „Dispersion". That is why a correct declaration of refractive index requires also the wavelength. Normally refractive index is given for the yellow line of sodium (D-Line), which equates to a wavelength of *589,3 nm*.

If light, coming from a high refracting material, is entering a lower refractive medium under a high angle of incidence, then this will result in a striking escape of light into the second media. Further increase of the incident angle results in a totally reflected beam where the surface behaves as a perfect mirror. If one brings now a third medium onto this totally reflecting prism surface, than for certain incident angles the total reflection will be disturbed and light can enter the third medium, which normally is a liquid. In this way a sharply bounded line in the reflected light will be produced, whose position can be easily detected by a CCD-sensor and the software of the instrument. An increase of the sample refractive index will result in a movement of the borderline meaning one has a very sensitive sensor for refractive indices.

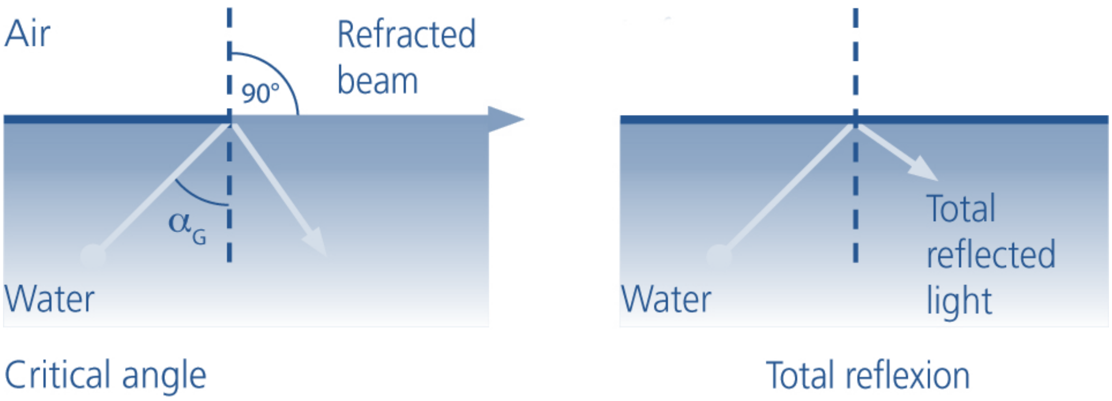


Figure 1: total reflection at the optical more dense medium

Both, theory and also praxis, shows that in case of total reflection light enters a small distance into the second medium (approximately ½ wavelength) and returns to the higher refracting medium. This behaviour results in a specific detail of this measurement system: only a very thin layer has direct contact with the measurement prism and is detected. This is important to know, because in the process refractometry the liquid should have a very good contact with the

prism and even the slightest dirt or crust on it would immediately lead to erroneous readings. This is caused by the fact that in such cases the **iPR FR2** will naturally measure these dry layers on the prism, although the process media is still flowing in the pipeline and eventually has a new refractive index value meanwhile.

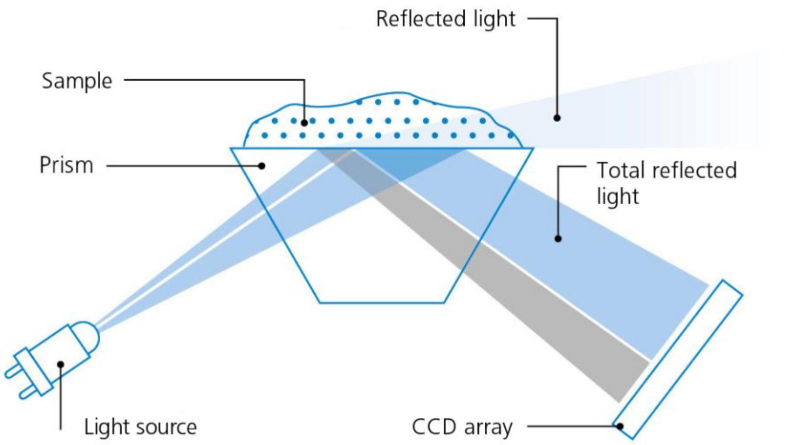


Figure 2: schematic diagram of the function of the refractometer

# 2 Installation

In the following the most important informations about the installation of the process refractometer were assorted. Figure 3 shows the most relevant dimensions of the device with a *VariVent* - flange.

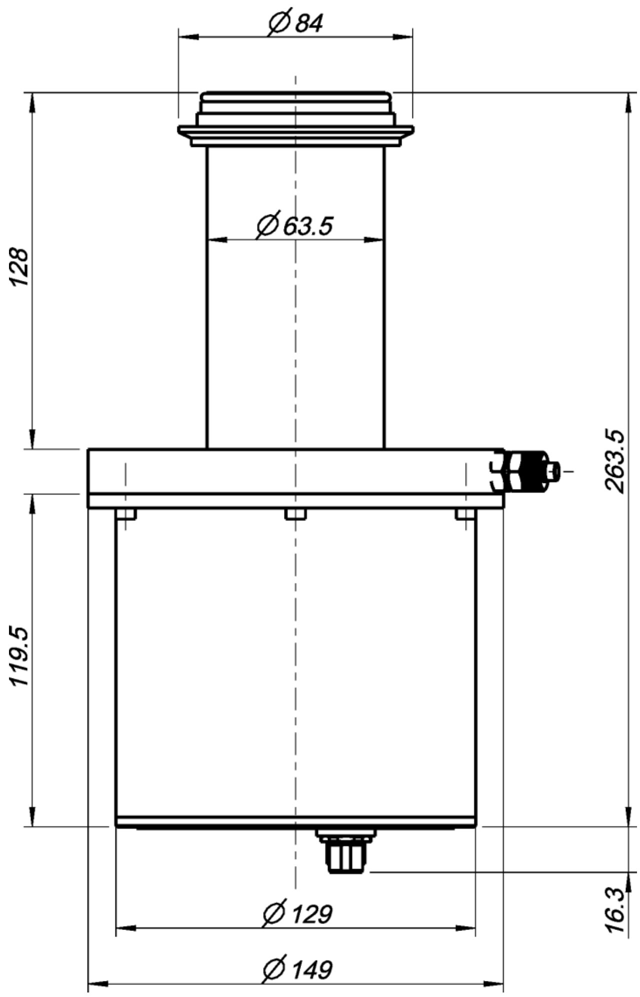


Figure 3: Process refractometer - scale drawing of the housing with flange

The measuring head will be delivered completely assembled with the specified flange. The three provided flanges are *VariVent-Inline* (GEA Tuchenhagen), *APV-Inline* (APV) and *TriClamp*. Some examples for the usage of these connectors are shown in figures 4 to 7.

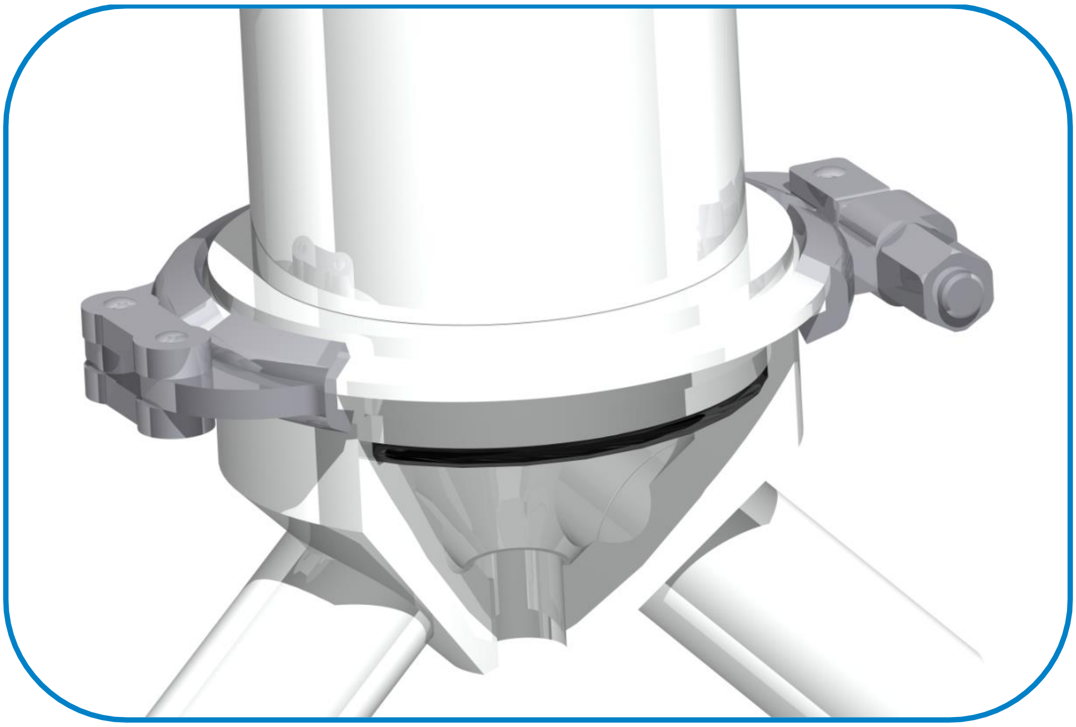

Figure 4: Tuchenhagen by- pass connection

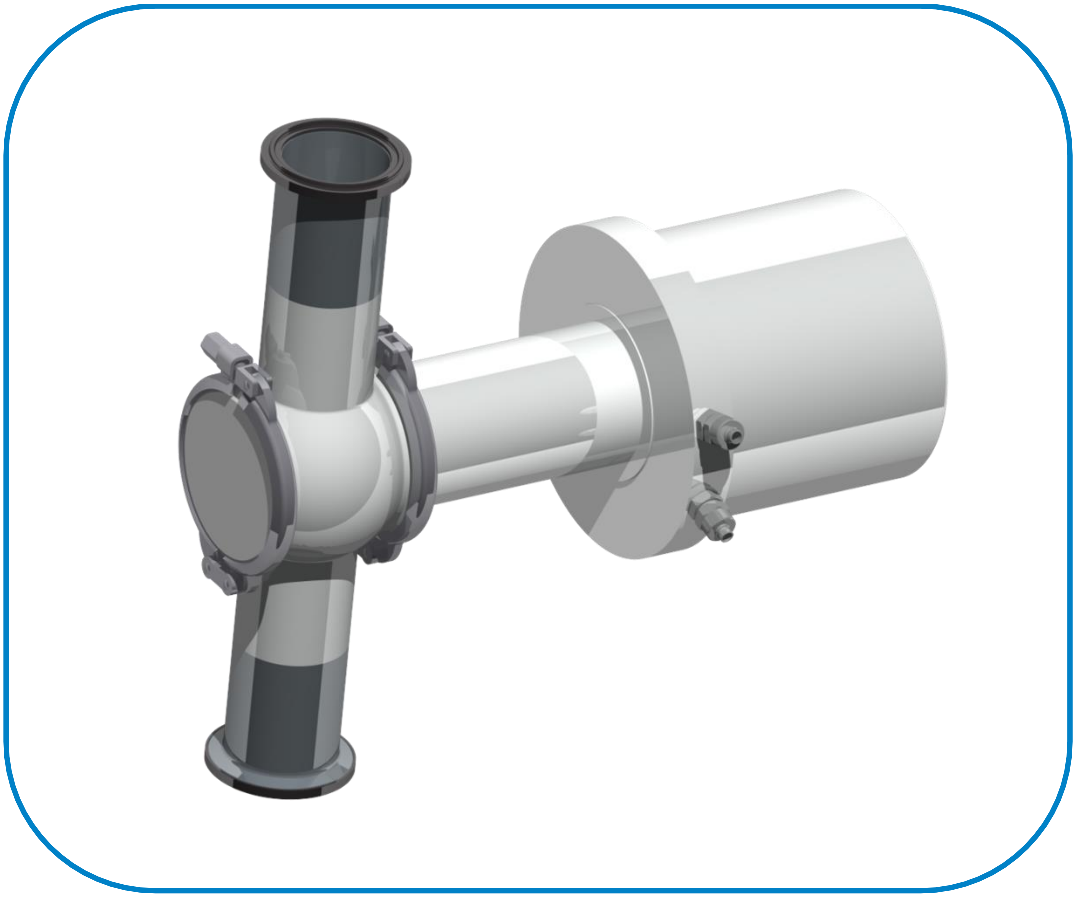

Figure 5: Varivent-inline

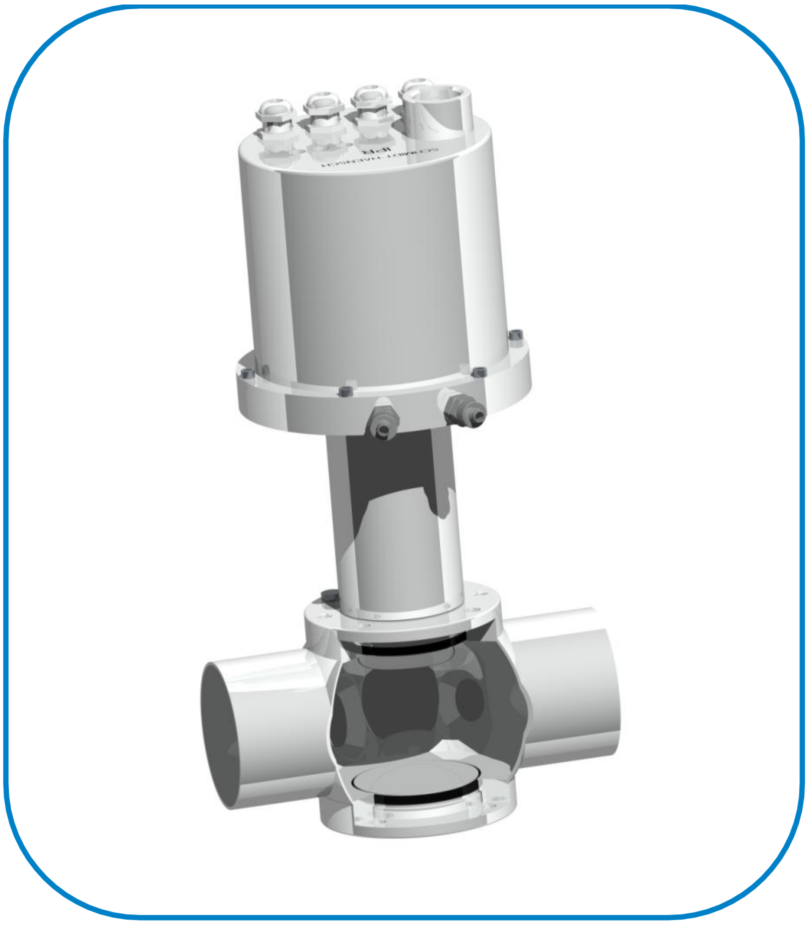

Figure 6: APV Process-inline

Figure 7: Triclamp locking ring

The instrument can operate in closed rooms and also outside in almost all climatic circumstances. But attention must be paid if the instrument has to be installed outside. Avoid excessive solar radiation and direct rain in order to keep the instrument from getting humid inside. If transparent pipelines were used, attention must be paid for avoiding stray light reaching the light sensor inside because this would result in incorrect readings.

Vibrations of the pipelines can also have negative influences on the instrument performance. Conduct arrangements for dampening strong vibrations or try another pipeline position with fewer vibrations. A mechanical support of the main body of the refractometer will help to reduce the vibration effects on the systems performance.

Installation of the refractometer should be performed at a pipeline position with high flow speed and a reliable filling of the process line. If the diameter of the process pipeline varies too much select the smallest one to assure a high speed of liquid flow.

If the refractometer is used for dilution control, select a position for installation where a reliable mixing of the components can be securely assumed.

The O-ring seal between the measuring prism and the flange has been constructed in a specific way, so that it is secured that the product flow is not affected by the prism: the surface of the flange is absolutely plane with measuring prism.

The optimal installation is also given by the technical parameters: in order to assess an optimal operation it is recommended to install the **iPR FR2** horizontally.

For an installation in a tank it is recommended to place the refractometer close to a stirrer to assure a high liquid flow and a representative measuring.

If the liquid has a high viscosity the installation should be made by using a 90° bend in order to realise a higher liquid flow and achieve a self cleaning of the prism at the same time.
It has to be avoided at any rate to install the refractometer vertically. As a consequence of that it could happen that the pipe is not full with process liquid and this could cause false measurings. Also the risk of a plate-out on the prism is higher if the prism surface is mounted at the bottom side.

In the following figure all possible configurations for installation are schematically given.

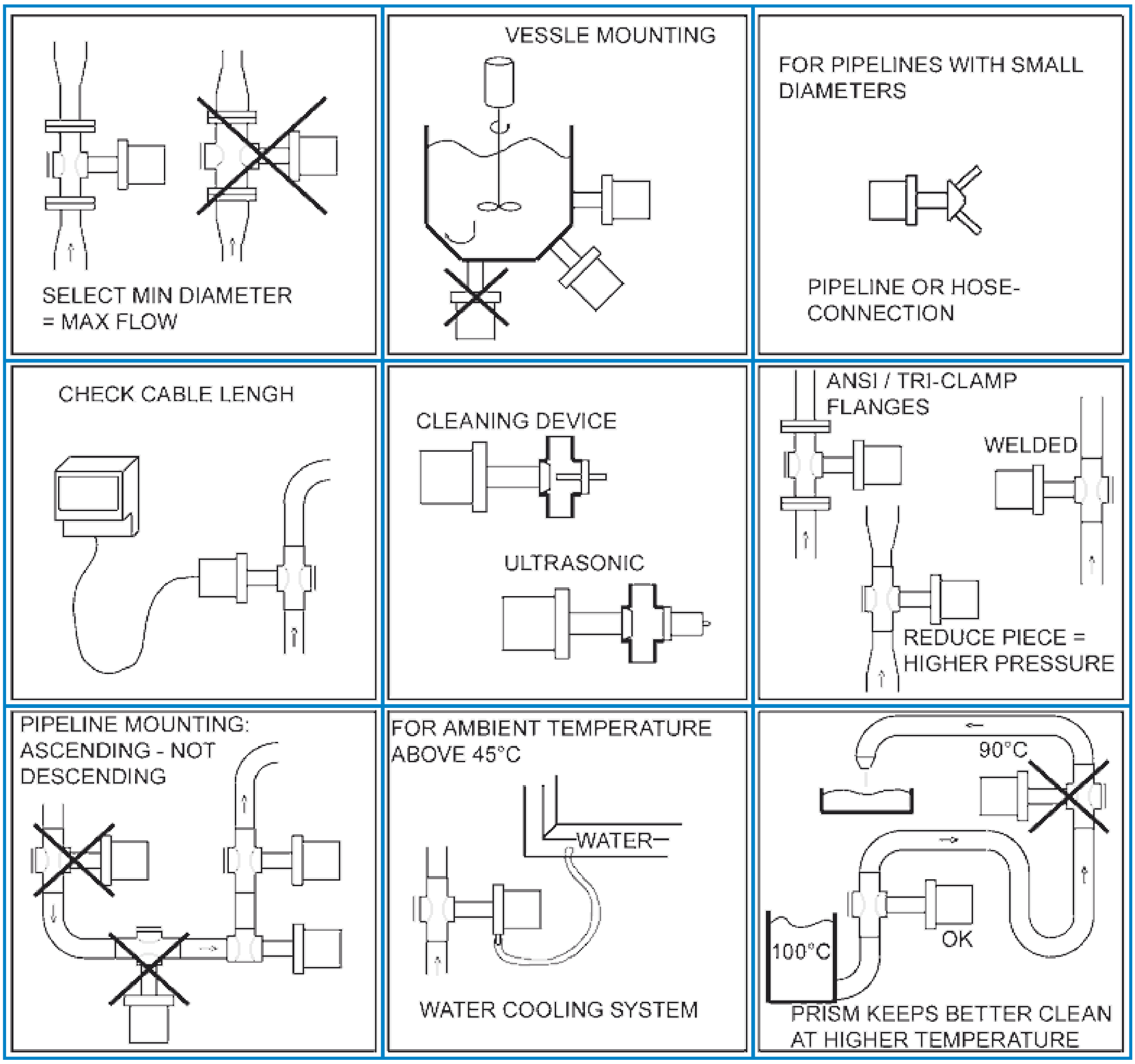


Figure 8: Installation guide lines

# 3 Operation

After the installation at the process control you can start running the refractometer with the supply voltage (*24 Volt DC*).

## 3.1 PC Programm P309

On the enclosed CD you can find the control software **P309**. Copy the application "Config.exe" and the files "Imodule.dll", "P309.ind" and "P309.lm2" to your computer.

In the following the initialisation of the program and the usage of the provided modules will be exemplified.

First of all you have to connect the **iPR FR2** with the PC by using the serial port. Now start the program **P309** on your computer.

### 3.1.1 Start software

Choose your language and decide what you want to do. You have the opportunity to login as *User read only* or *User read/write*. If you select *User read/write* you have to type in your password. The *User* profile *Service* is reserved to the *Schmidt + Haensch* customer service. Confirm your selection by clicking *OK*.

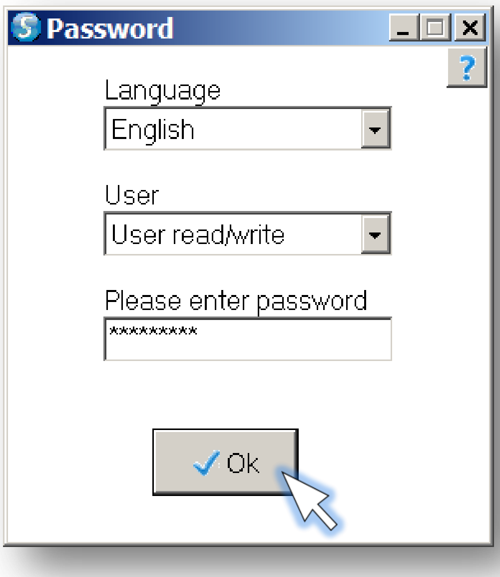


Figure 9: Start-window P309

### 3.1.2 Menu

Select the COM-Port the **iPR FR2** is connected to.

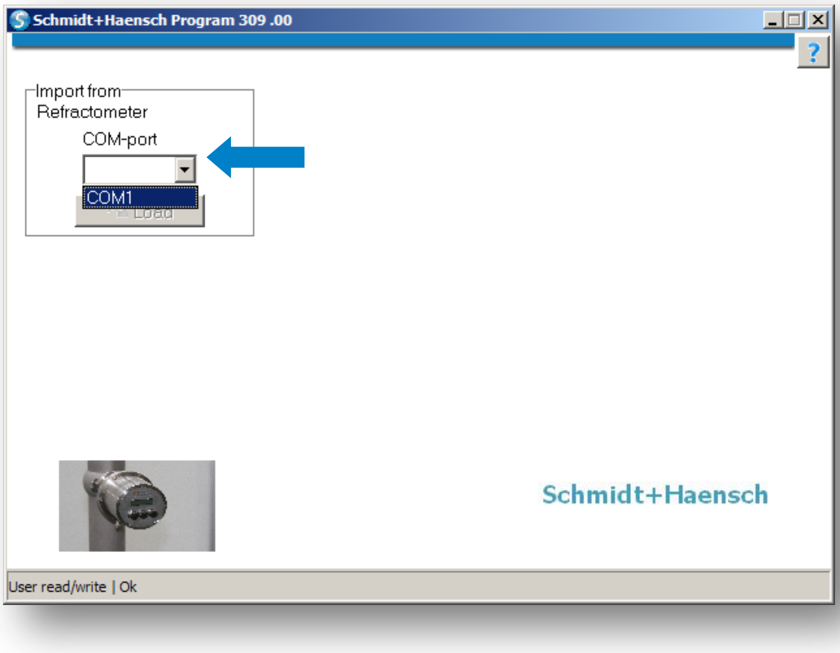


Figure 10: Menu P309

### 3.1.3 Succesful connection

If the device is connected correctly, additional fields appear at the middle of the window. They lead to the actual measuring and test functions.

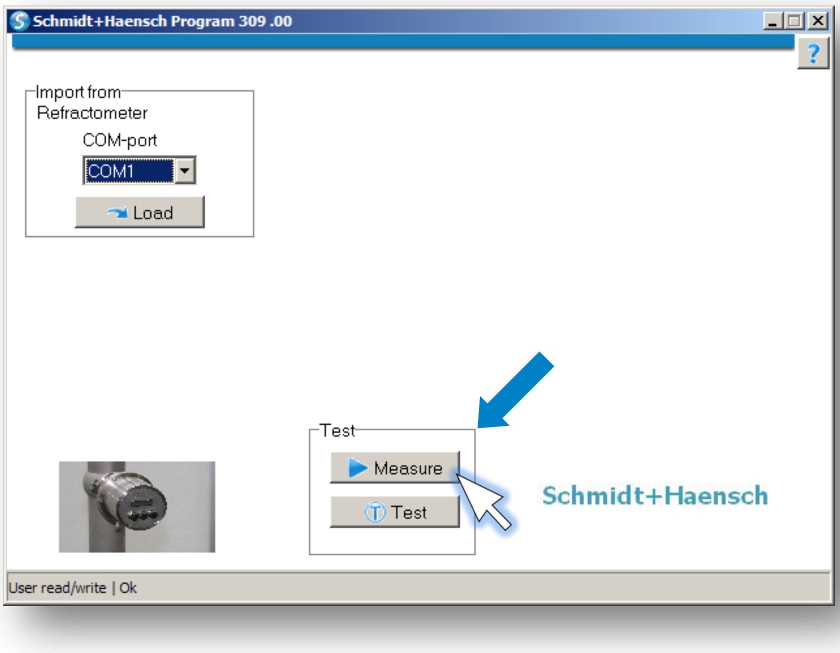


Figure 11: Loading succesful - choose Measure

### 3.1.4 Test

By clicking *Test* you enter a menu where you can test the certain currents of the device as well as the switch outputs. Just type in your designated values at *Current Output* (*mA*, q.v. 3.1.15) and *Switch* (q.v. 3.1.23) and start with clicking *Set current and switch*.

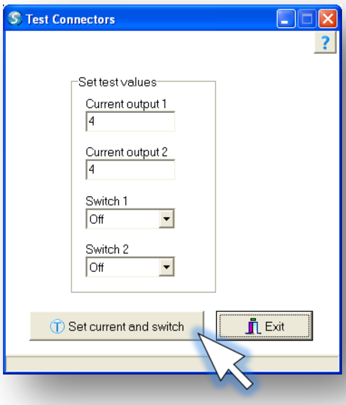


Figure 12: Self test values

### 3.1.5 Measure

If you click *Measure*, the window shown at figure 13 opens. Here you have the opportunity to adjust the frequency of measurement at the editbox *Interval*. If you type 5, it means that the refractometer measures and displays the results every 5 seconds. To start the measurement just click *Start*. After you interrupted the measuring process with *Stop*, you can save the displayed values at csv-format with *Save*. If you click *Clear*, the table with your measurements will be deleted.

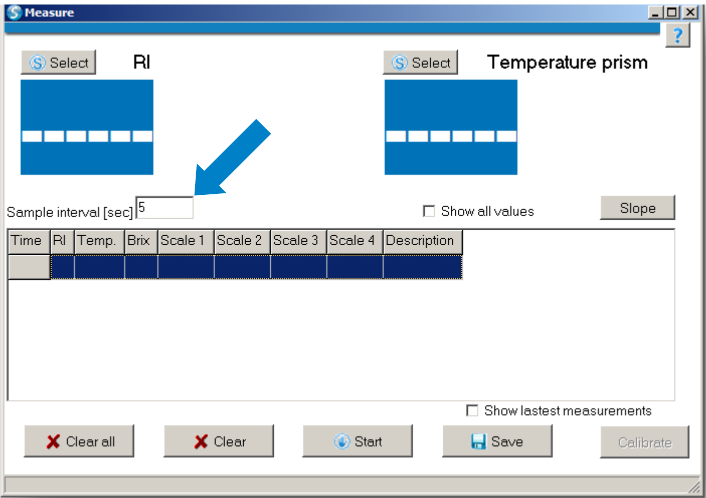


Figure 13: Choose frequency of measurement and Start measurement

### 3.1.6 Measurements without Show all values

At figure 14 you can see the output of the measurements without the checkmark at *Show all values*. At the blue fields on top of the window are the current measuring values. At the same time all measurements were shown in the table sorted by the time they were recorded.

You can choose the measuring values you want to see at *Select*. The values *Refractive index*, *Temperature*, *Brix* or *Scale* can be displayed.

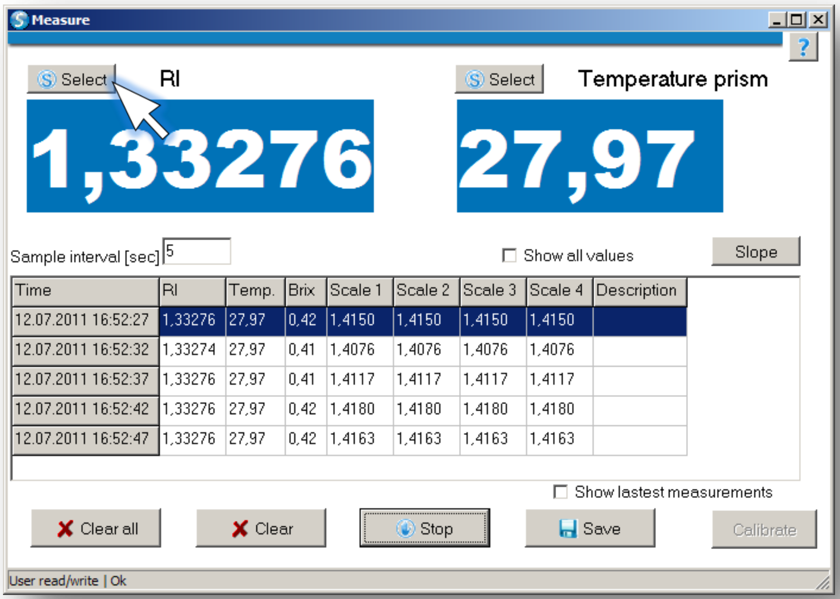


Figure 14: Measurements without Show all values

### 3.1.7 Calibrate

To activate this button, you first have to load the instrument configuration in the start menu (q.v. 3.1.10). Then you have the opportunity to execute a *1 point*- or *2-point*-calibration. The values of the *Slope* and the *Offset* will be modified here. To operate a *1 point*-calibration the *Brix* value has to be entered and confirmed with *Store*. Now you can see the measured and the expected value at *1. Sample*. To perform a *2 point*-calibration choose *2 point* and type in a second *Brix* value in the up coming field.

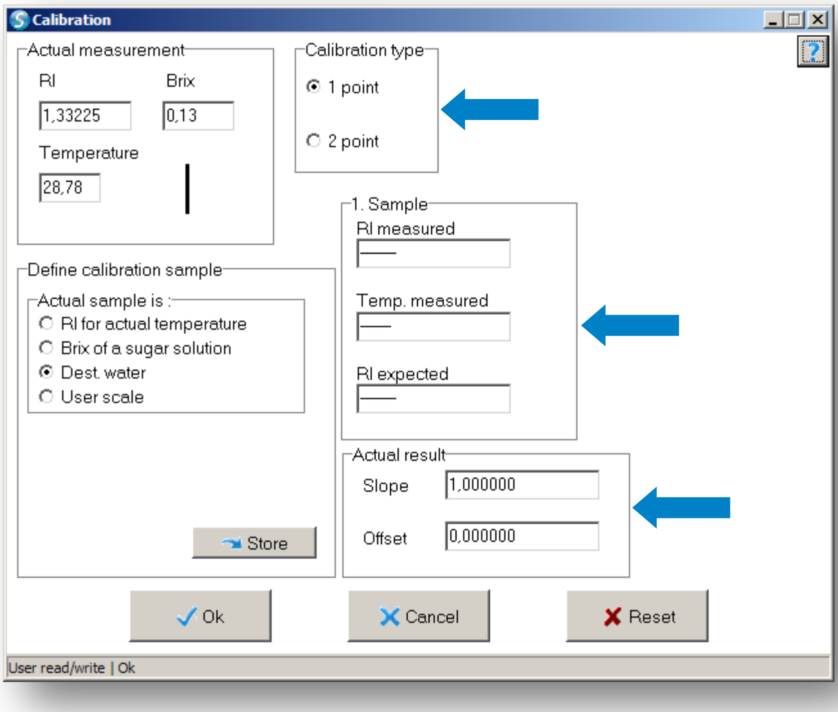


Figure 15: Calibrate

### 3.1.8 Slope

By clicking the button *Slope* you reach a function which displays you the measurements in a graph. It is feasible to grip the amplitude values graphically.

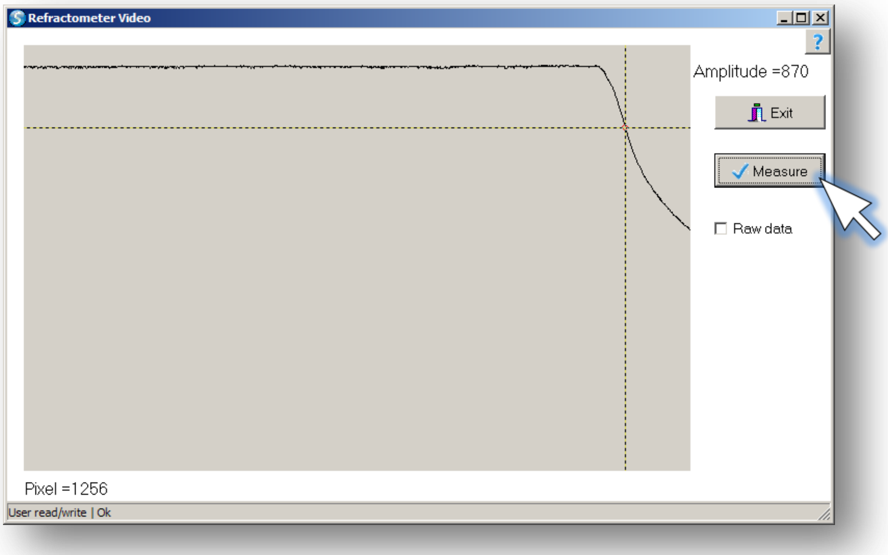


Figure 16: Refractometer Slope

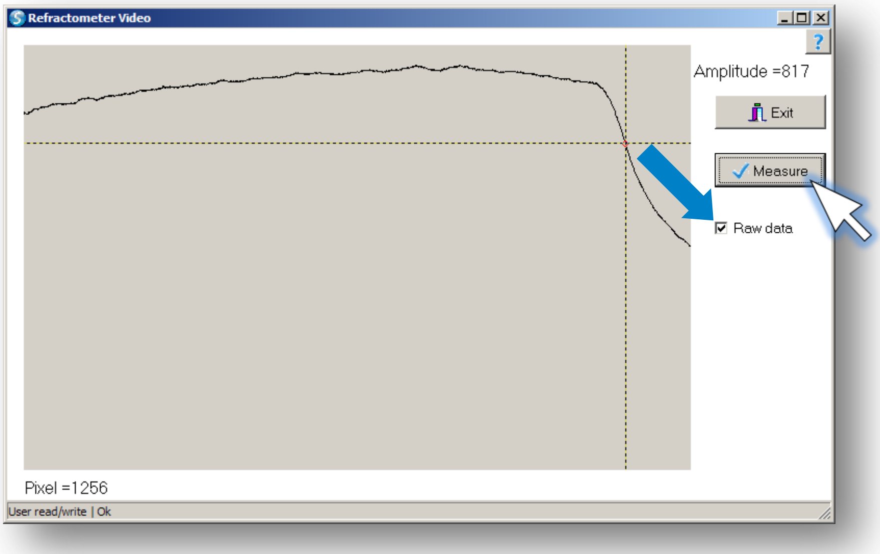


Figure 17: Refractometer Slope raw data

### 3.1.9 Measurements with Show all values

If the checkmark at *Show all values* is activated, all values the device transfers were displayed. If you click into the last column *Description* you can add more detailed information to this specific value. The last measured value is always shown and the sidebar is automatically scrolling down if you acvtivate the checkmark *Show newest*.

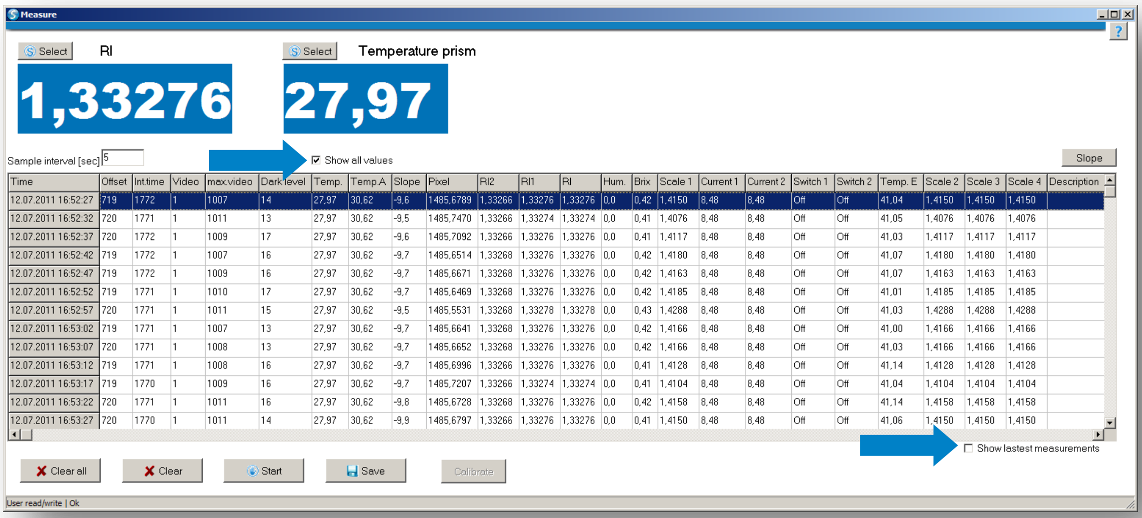


Figure 18: Measurements with Show all values

### 3.1.10 Menu options

To load the instrument configuration from the process refractometer to the PC, press *Load* under the COM-port selector. After the successful download of the settings, the serial number and the firmware version of the device will be displayed.

By using *Edit* you can take a look at the different settings and modify them if you want to. It is recommended to save the "original" configuration on your PC before changing the settings of the instrument. In the future you can restore previous settings with this saved configuration.

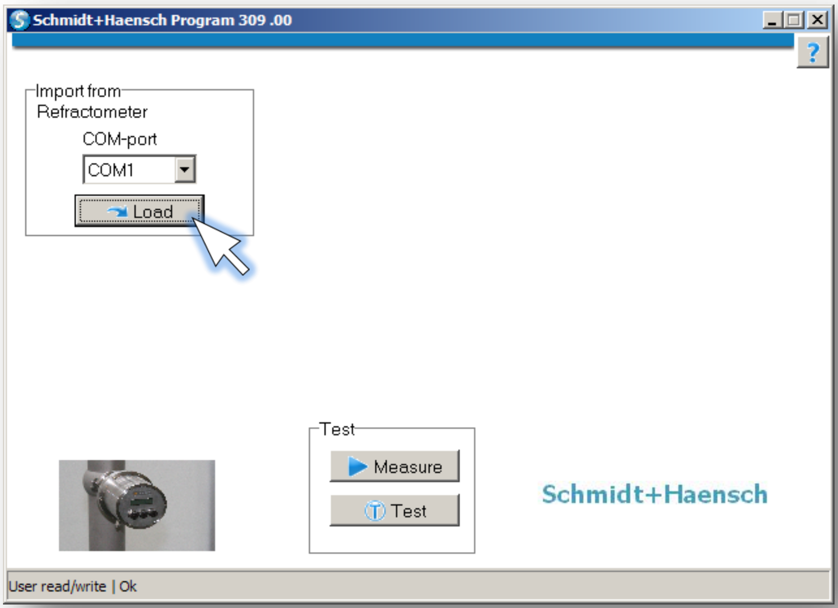


Figure 19: Edit refractometer settings

### 3.1.11 Edit configuration

Select the module which you would like to modify. The specific modules will be explained on the following pages.

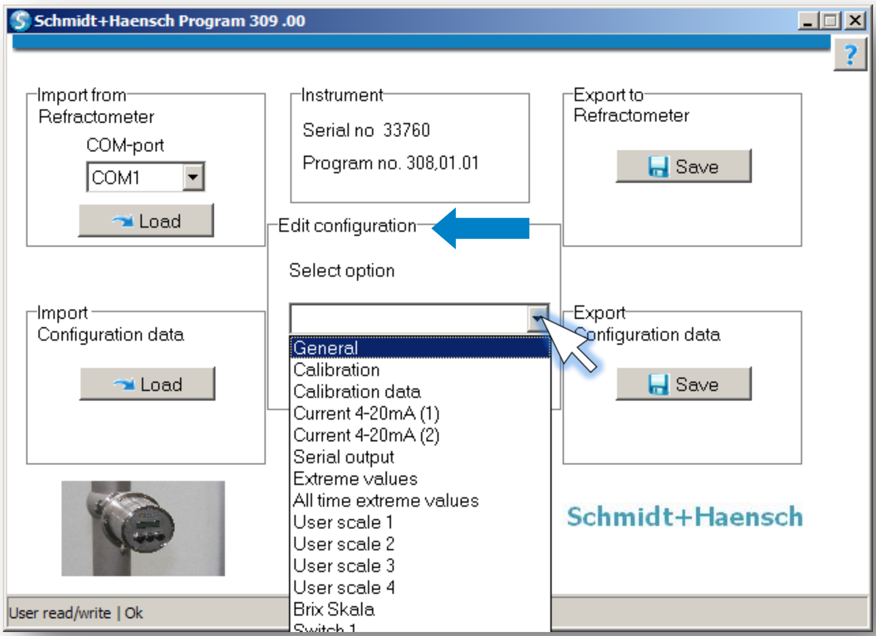


Figure 20: Edit modules

### 3.1.12 General

The module offers you an overview of the **iPR FR2** you are using. You can see the *Factory no.*, the *Serial no.* , the amount of hours the device has operated so far and the security level. All these information aren’t editable.

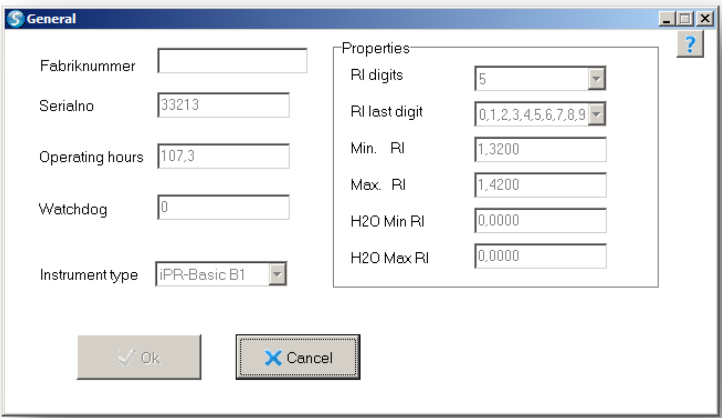


Figure 21: Module General

### 3.1.13 Calibration

The modification of the settings *Calibration slope* and *Calibration offset is reserved* to the *Schmidt + Haensch* customer service. If you like to edit them, ask *S+H* first. With slope you can adjust a dumping of the calibration curve and offset affects as a parallel adjustment of the calibration curve.

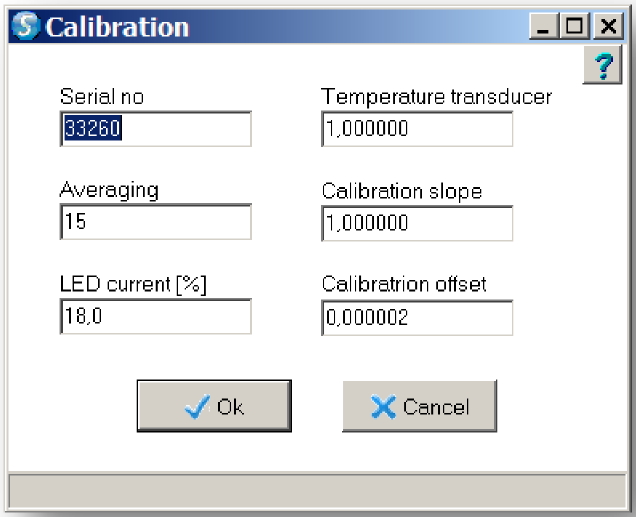


Figure 22: Module Calibration

### 3.1.14 Calibration data

All relevant data of the calibration is displayed here.

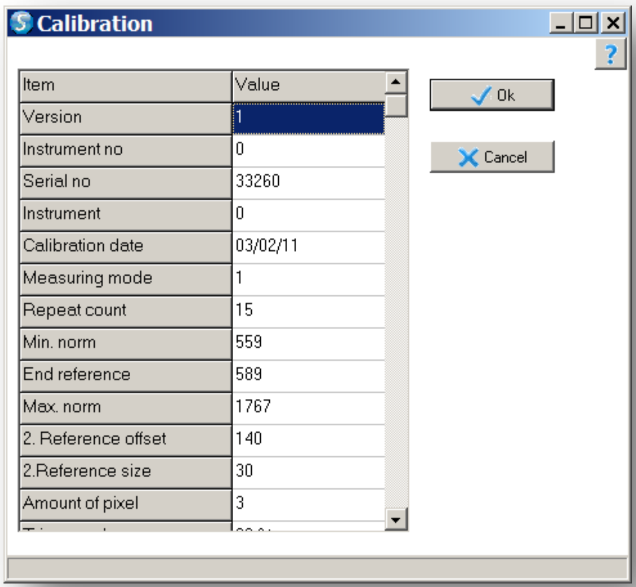


Figure 23: Calibration data

### 3.1.15 Current 4-20mA (1) and Current 4-20mA (2)

Up to two certain currents can be defined for the chosen *Measured value* (e.g. Brix). If you set a checkmark at *Test values* all the other measuring values can be chosen as well but in most cases that is just interesting during service.

In the example shown at figure 24 the *Measured value for 4mA* should be *0 Brix* and the one for *20mA* should be *100 Brix*. If an error occurs the output should be *2mA*. At *Calibration* you can set test currents at *4mA / 20mA* and re-calibrate them via the *Measured currents*.

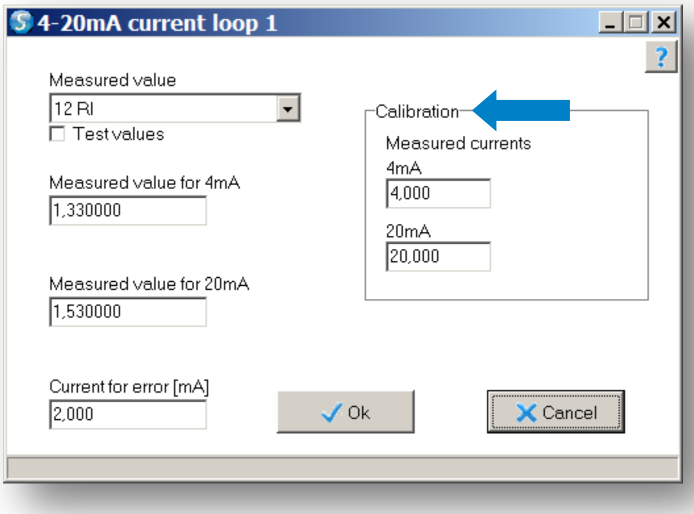


Figure 24: Current loop 1

### 3.1.16 Serial Output

At this module, you can set the serial interface parameters that were shown in columns 1 to 5. Here you can set a checkmark at *Test values* too and all provided measurement parameters will be provided again.

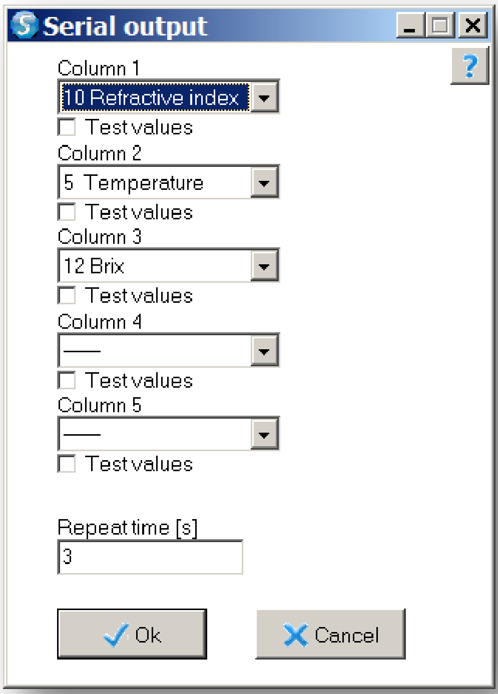


Figure 25: Module Serial Output

### 3.1.17 Extreme values

The *Extreme values* of the measured temperature and humidity can be inspected here.

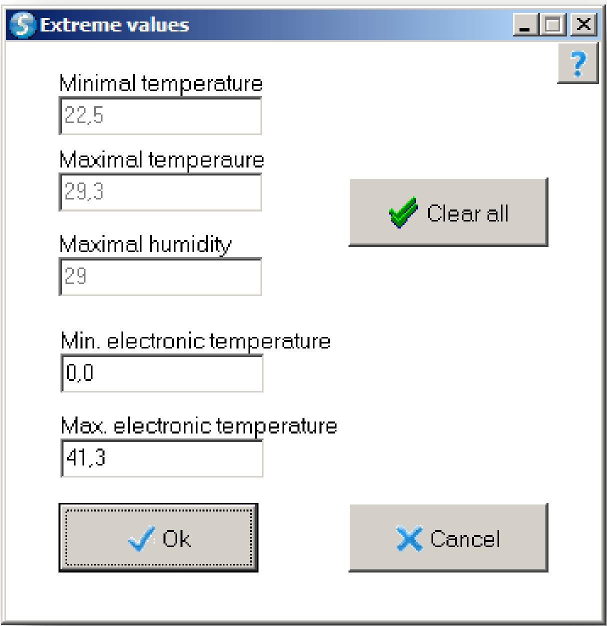


Figure 26: Extreme values of temperature and humidity

### 3.1.18 All-time extreme values

The *Extreme values* of all ever measured temperatures and humidities can be inspected here.

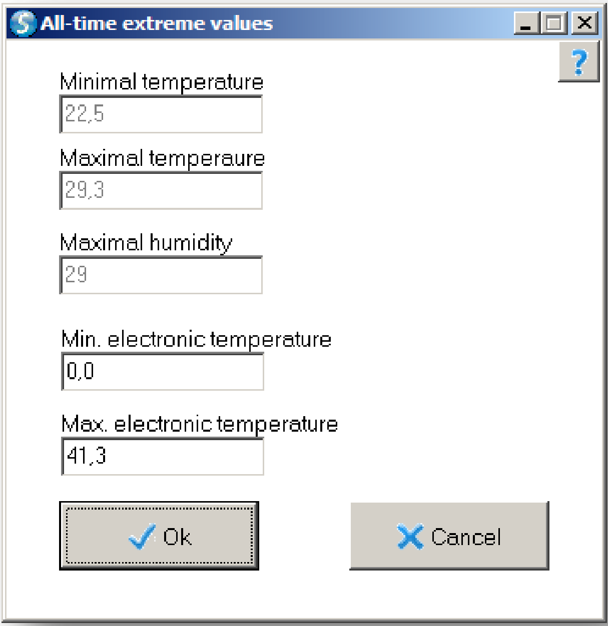


Figure 27: All-time extreme values of temperature and humidity

### 3.1.19 User Scale

It is possible to define own *User Scales* and test them as well. At *Measure value* you can select the input value you want to relate to. You can choose between *Refractive Index* and *Brix Scale*. *Min. input value* signifies the smallest input parameter, the same goes for *Max. input value*. Within the limits of *Min. temperature* and *Max. temperature* correct scale values could be computed. *Format length* and *Decimal places* allows you to set the resolution of the scale. The coefficients result from the measuremetns with known samples and were provided to you by *Schmidt +Haensch*.

You can export your generated scale with *Save*.

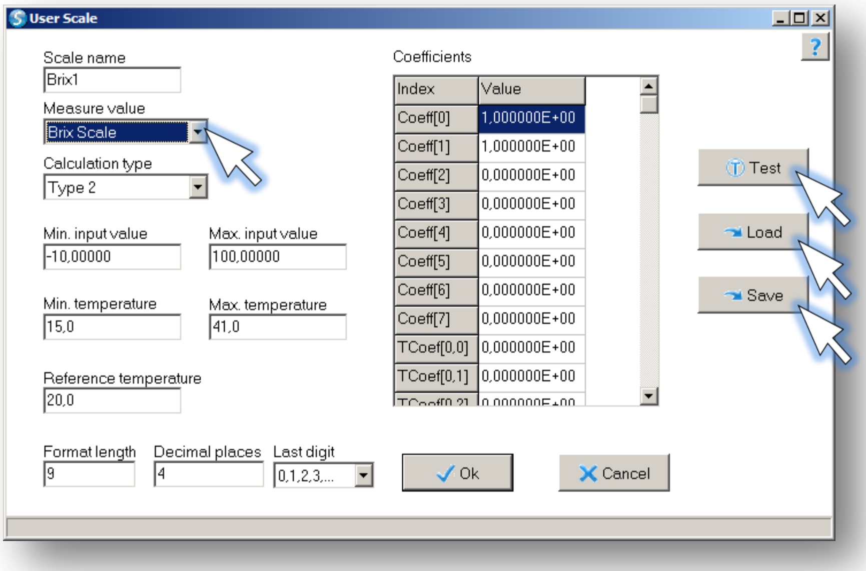


Figure 28: Configure User scale

At chapter 1, „What is refractometry ?“, was described in detail that first of all a refractometer measures a value that is not interesting on ist own: the speed of light at the measured product sample. But this value can be converted to more concrete and useful units like …

- Brix value
- Dry substance (DS)
- Oechsle scale
- Moisture content of honey

The dry substance doesn't depend on the temperature, but the refractive index changes with the temperature. Because of this it is always necessary to measure the temperature as well if you determine the refractive index. The same applies for almost every special scale that has a concrete meaning. A scale that considers the temperature is called „temperature corrected“.

Unfortunately the temperature dependency of the refractive index is substance-specific. This means, that for a certain temperature e.g. cyclohexane shows the same measuring value like a treacle with *53% DS* and at another temperature the same like a treacle with *52% DS*. Thus all temperature corrections apply only for certain substance groups. The Brix scale is defined with the concentration of sucrose in water and thats why the temperature correction of this scale is correct for sucrose dilutions. The temperature behaviour is very similiar to, for instance, the one of marmelade or orange juice, so this temperature corrected brix scale can be used for these substances as well. The temperature correction of the brix scale applies for the field where the scale is used and this is the comestible goods industry.

## Calculating of a special scale

Generally you need two values to calculate a scale value of a special scale: the refractive index and the the temperature. Because of this the conversion occurs in two steps. In the first step only the refractive index is considered and the temperature behaviour at the second one. So the result of the first step is correct for only one specific temperature. This temperature is called reference temperature.

The *Schmidt+Haensch* refractometers accomplish the first step with the help of a polynom and the second one was executed by using a matrix. This will be reconsidered in the following:

Normally you generate the scale value at the reference temperature out of the refractive index in the first step. But you can also cascade a scale, that means that instead of the refractive index a scale value can be the input value of another scale as well. This is why we generally call this input parameter „Input".

At first you define the auxiliary quantity „$r$", which results of the difference of the input parameter and the value *1.33*. Thereupon the polynom is computed with this auxiliary quantity. This method isn't straight forward, but it helps to handle the polynom itself esaier, in any case if the input parameter is the refractive index. Take a look at the second example note below.

Because of the fact, that the refractive index changes with the temperature, the result of the first step also changes with a varying temperature. This is symbolised by '$(t)$'. The two formulas in relation:

| | |
|---|---|
| $r$ = Input value - 1.33 | valid for computation type „*Type 1*" |
| $r$ = Input value | valid for computation type „*Type 2*" |

„*Type* 3" : special computation formula, details subject to *Schmidt+Haensch*

$$Scale(t) \coloneqq c_1 + c_2 \cdot r + c_3 \cdot r^2 + c_4 \cdot r^3 + c_5 \cdot r^4 + c_6 \cdot r^5 + c_7 \cdot r^6 + c_8 \cdot r^7$$

Some of the coefficients $c_1$ to $c_8$ could be zero, so do not be irritated by the complexity of the formula.

In the second step the temperature dependency is considered. This is necessarily for most of the special scales as long as a a stable temperature isn't guaranteed during a measurement. The formula uses the result of the first step as well as the temperature, which is called <input b> here. The reference temperature, the temperature that do not need any corrections, is used also.

The formulas:

$$dT \coloneqq r - referencetemperature$$

$$Scale \coloneqq Scale(t) + c_{12} \cdot dT + c_{13} \cdot dT^2 + c_{14} \cdot dT^3$$

$$+ (c_{22} \cdot dT + c_{23} \cdot dT^2 + c_{24} \cdot dT^3) \cdot Scale(t)$$

$$+ (c_{32} \cdot dT + c_{33} \cdot dT^2 + c_{34} \cdot dT^3) \cdot Scale(t)^2$$

$$+ (c_{42} \cdot dT + c_{43} \cdot dT^2 + c_{44} \cdot dT^3) \cdot Scale(t)^3$$

This formula with its twelve coefficients seems very complicated first, but as in step one they are not all quite necessary.

Examples

Let us start with a very simple example. If you want to dilute samples 1:1 before you determine the brix value with the refractometer, you have to multiply the value with two – or you create the special scale $'Bx\_2'$, which is doing that automatically. Take a look at the formula for the first step. There is a value called "Input[1]", which is normally the refractive index. But in this case it is more useful to take the brix value as the input (value) ! Since 1.33 must be subtracted from the input value (which is very annoying in this case) the conversion is:

$$Bx\_2 = 2.66 + 2.0 \cdot r$$

Remember: „$r$“ is the auxiliary quantity, so input value minus $1.33$. In order that the coefficients are:

$$c_1 = 2{,}66$$

$$c_2 = 2{,}0$$

$$c_3 = 0{,}0$$

$$\vdots$$

$$c_8 = 0{,}0$$

This was pretty easy. Take care, that the brix value considers the temperature and you do not have to apply a temperature correction.
Let us observe an example that is a little bit more exciting: the brix scale itself. For instance, you have this table with values at $20.0°C$:

| Brechungsindex | Brix |
|---|---|
| 1.332986 | 0 |
| 1.347824 | 10 |
| 1.363842 | 20 |
| 1.381149 | 30 |
| 1.399860 | 40 |
| 1.420087 | 50 |
| 1.441928 | 60 |

We call this seven values the support points of the polynomial fit.

If your calculator is able to compute a best-fit curve, it would show you the following formula:

$$\boldsymbol{Brix = 0.358 + 549.396 \cdot r}$$

So if you want to type in the coefficients for the special scale you have to use $0.358$ for $c_1$ and $549.396$ for $c_2$. The coefficients $c_3$ to $c_8$ would be zero.

Optionally you can even determine a parabola with the least-squares method, the formula would look like that:

$$\boldsymbol{Brix = -1.90 + 682.773 \cdot r - 1167.678 \cdot r^2}$$

Results compared to the set values:

| refractive index | brix | | |
|---|---|---|---|
| | set value | straight line | parabola |
| 1.332986 | 0 | 2.0 | 0.1 |
| 1.347824 | 10 | 10.2 | 9.9 |
| 1.363842 | 20 | 19.0 | 19.9 |
| 1.381149 | 30 | 28.5 | 30.0 |
| 1.399860 | 40 | 38.7 | 40.1 |
| 1.420087 | 50 | 49.9 | 50.1 |
| 1.441928 | 60 | 61.9 | 59.9 |

Therefore one can say neither straigt lines nor parabola are adequate for a device that should reach a precision of $0.01\,Bx$ !

With a third-order function the maximum error at the seven support points would be only $0.01\,Bx$.

But be careful ! The result of a measuring of a $65 - Bx$-sample would be $65.04\,Bx$ with a third-order function. It is a general problem of all polynomal fits that they are unsteady beyond the support points. If you only have values from $0$ to $60\,Bx$, it means, that the scale is only secured up to $60\,Bx$.

Let us take a look to the temperature correction. If you are using a manual Abbe-refractometer with a defined brix scale, you also got a table with temperature corrections that came with it. According to this table the measured value is changed per degree Centigrade about $0.06\,Bx$ at water and about $0.08\,Bx$ at $60\,Bx$. Since the parabola do not provide good results anyway, a linear correction of $0.07\,Bx\,/\,°C$ is adequate. But please consider that this linear correction is not good enough for a refractometer that should guarantee a precision of $0.04\,Bx$ !

Therewith $c_{12}$ would be $0.07$ and all the other coefficients zero in this simplified case.

This example shows that the calculation of a special scale is not that simple. Many users probably have a calculator that is able to determine a best-fit curve. But in the example shown above you saw that this was not sufficient, because you can achieve an accuracy range of $2\,Bx$.

Starting point of all calculations is respectively a table with values that the refractometer should show (set values) and the corresponding refractive indexes (or also brix values). Such a table can also be computed with a formula you find in technical literature. For a number of particular cases we provide you already calculated coefficients.

Comment

In the paragraph above you read that using the auxiliary quantity „$r$“ makes it easier to handle the polynom. For the sake of completeness the coefficients for the third-order polynoma with the auxiliary quantity „$r$“ are listed in the following:

$$c_1 = -2.093 \quad c_2 = 707.774 \quad c_3 = -1736.434 \quad c_4 = 3301.961$$

… all others are zero

Accordingly, if you compute with using the refractive index:

$$c_1 = -11783.327 \quad c_2 = 22849.207 \quad c_3 = -14911.260 \quad c_4 = 3301.961$$

… all others are zero

Not only that the coefficients are more „unhandy“, bigger numbers are used as well. If you, by way of example, calculate the two polynoms step by step you will get for the one with the auxiliary quantity $r = 0.051149$

$$\boldsymbol{Brix = -2.093 + 36.202 - 4.543 + 0.442 = 30.008}$$

And for the one with the according refractive index $ri = 1.381149$

$$\boldsymbol{Brix = -11783.327 + 31558.159 - 28444.310 + 8699.485 = 30.007}$$

### 3.1.20 Test Scale / Load Scale

At *Test* you can test your new generated scale. Type in an *Input value* for a known refractive index. At the field below the prevailing temperature is required. If you click *Calculate* the *Scale result* will be computed.

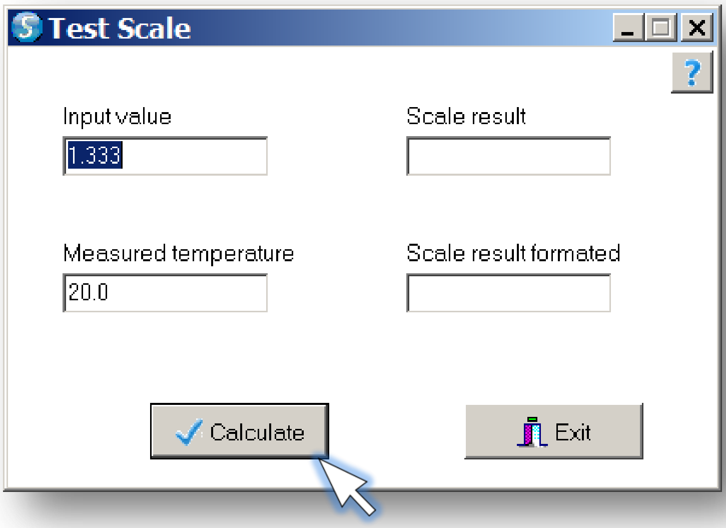


Figure 29: Test new Scale

If you click *Load*, you can load a pre-generated scale on your device.

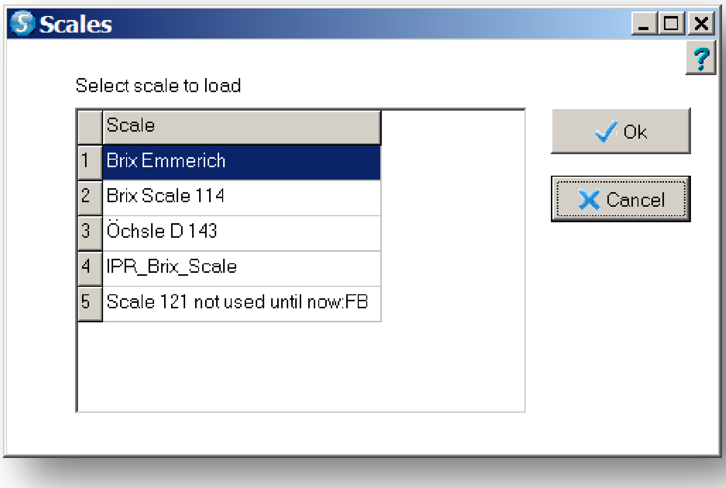


Figure 30: Load scale

3.1.21 Brix Scale

The *Brix Scale* is defined on the **iPR FR2**. Because of this fact you can't edit the coefficients. The other values can be changed by the user for individual configuration. *Min. input value* signifies the smallest input parameter, the same goes for *Max. input value*. Within the limits of *Min. temperature* and *Max. temperature* correct scale values could be computed. *Format length* and *Decimal places* allow you to set the resolution of the scale. The coefficients result from the measuremetns with known samples and were provided to you by *Schmidt + Hanesch*.

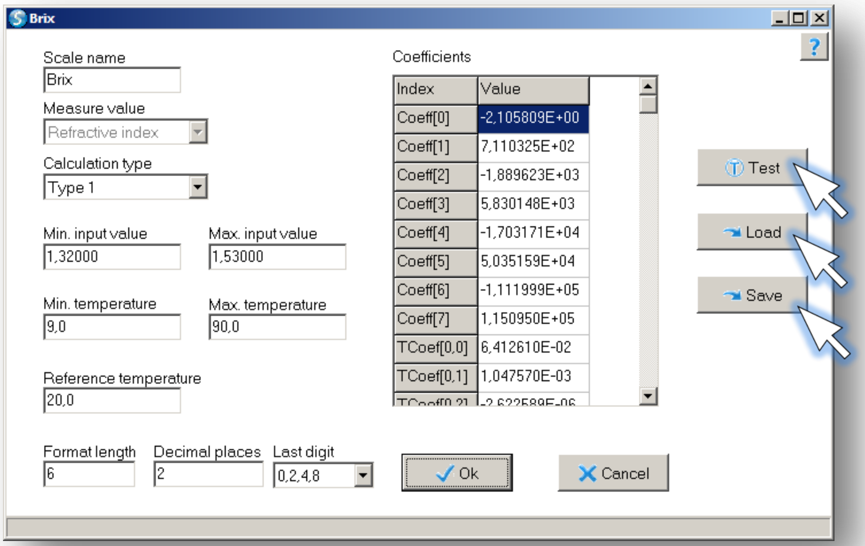


Figure 31: Brix scale

### 3.1.22 Test Brix scale

For simulation of the scale behaviour and temperature dependency, this test option is available. Type in an *Input value* for a known refractive index and the prevailing temperature. If you click *Calculate* the *Scale result* will be computed.

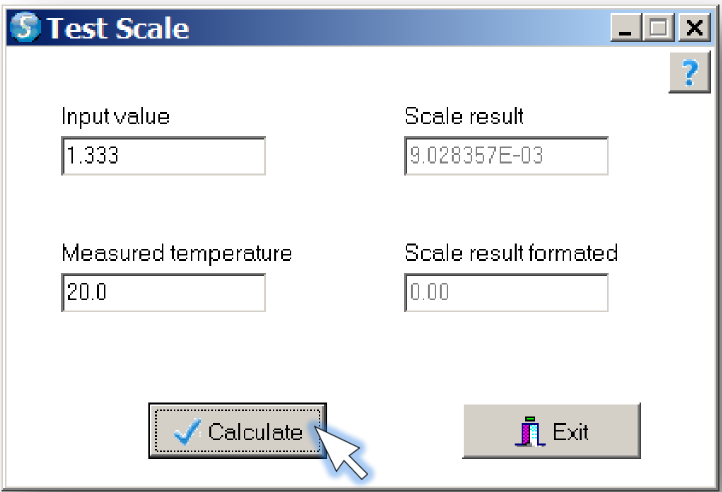


Figure 32: Test Brix scale

### 3.1.23 Switch 1 and Switch 2

The **iPR FR2** is equipped with two *Switch* outputs to run, for example, a connected valve (max. *1 A, 24V DC*) or a relay. With this feature it is possible to control the cleaning of a measuring head of a magnetic valve in constant time intervals depending on the measuring value, for instance.

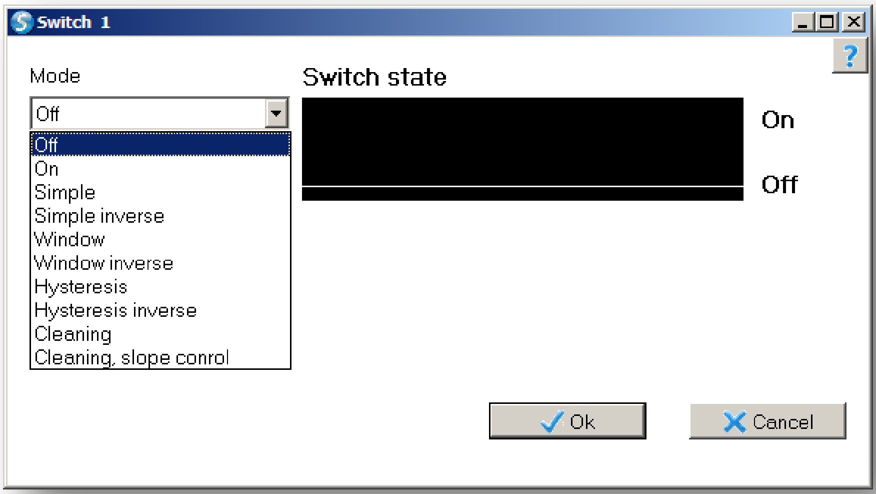


Figure 33: Switch state Off

There are different operation modes offered for the *Switch* function. The *Switch state* is also shown graphically to understand the function better. At figure 33 the horizontal direction shows the measuring value and not the time. If you set a checkmark at *Test values* you have a bigger assortment of parameters to control the *Switch*.

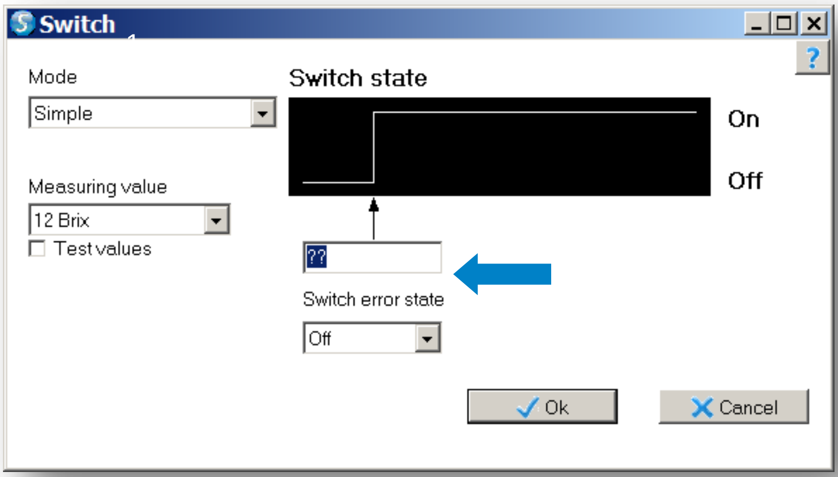


Figure 34: Switch function Simple (1)

This example (figure 34 and 35) shows a switch function where the switch exchanges to state *On* if the measuring value, in this case Brix reaches a certain Brix value. So if the value reaches for example 10, the switch is turned on.

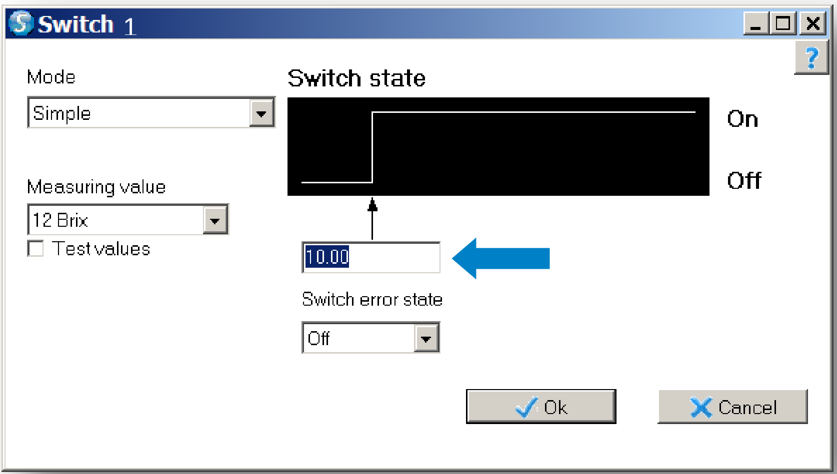


Figure 35: Switch function Simple (2)

In the following the operation modes of the switch will be considered in more detail:

**Off:** The switch is always off.

**On:** The switch is always on.

**Simple:** The switch turns on automatically at a certain value.

**Simple inverse:** The switch turns off automatically at a certain value.

**Window:** The switch stays on within a defined measurement region.

**Window inverse:** The switch stays off within a defined measurement region.

**Hysteresis:** You can define two switchpoints where the switch is applied depending on the previous history of the measurements. With this procedure you can avoid too fast and unsteady movements of the switch with the help of a generously proportioned measurement region.

**Hysteresis inverse:** Works the same as *Hysterese*, but the switch function is vice versa.

**Cleaning:** It is possible, independently from the measuring value, to initiate a cleaning of the prism with the help of the *Switch*. With the *Cleaning time* you can define, how long the switch stays on. The parameter *Waiting time* allows to set a period of time and after the expiration of this interval the switch is activcated automatically.

**Cleaning, slope control:** At certain types of samples the parameter slope can be used to trigger a valve. In this way you can achieve a dilution or admixture of another product ingredient by turning on a valve, if, for example, the slope is getting to high caused by rising haze of the product. This guarantees a more constant product quality. Enter a minimum slope for the product where it does not meet the target values. Choose this slope depending on your previous experiences. For this purpose, it is recommended to determine a clear relationship between the slope and the sample condition on the basis of detailed measurements and the primary measured variable (refractive index / Brix) first.

### 3.1.24 Display

The LCD display on the rear side of the refractometer can be configured to display up to two values for easy process information. Select from the scroll bar two values to be shown on each line. Default settings are refractive index for the first value and temperature for the second value. It is also possible to adjust the contrast of the display and again you can set a checkmark at *Test values* to choose from all measurement parameters.

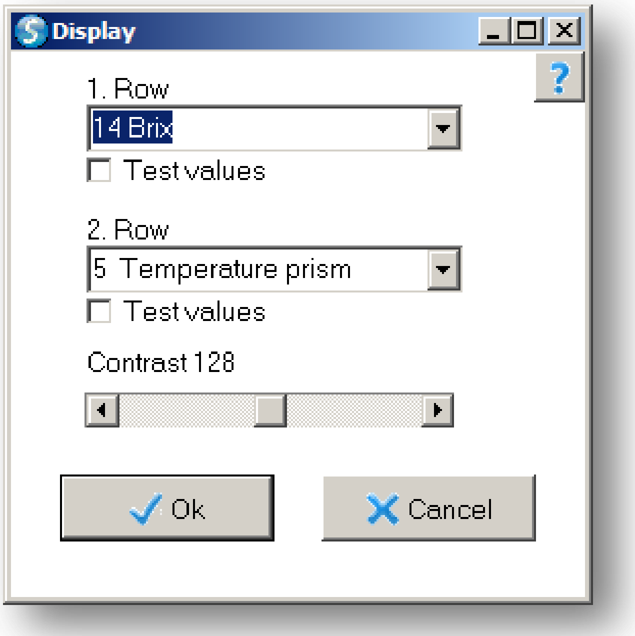


Figure 36: Configure LCD display

### 3.1.25 Save data

You have the opportunity to save your edited data. You can *Save* them on your *iPR FR2* and configure the device in this way. It is also possible to save the configuration at a file, so you can *Load* it at a later date.

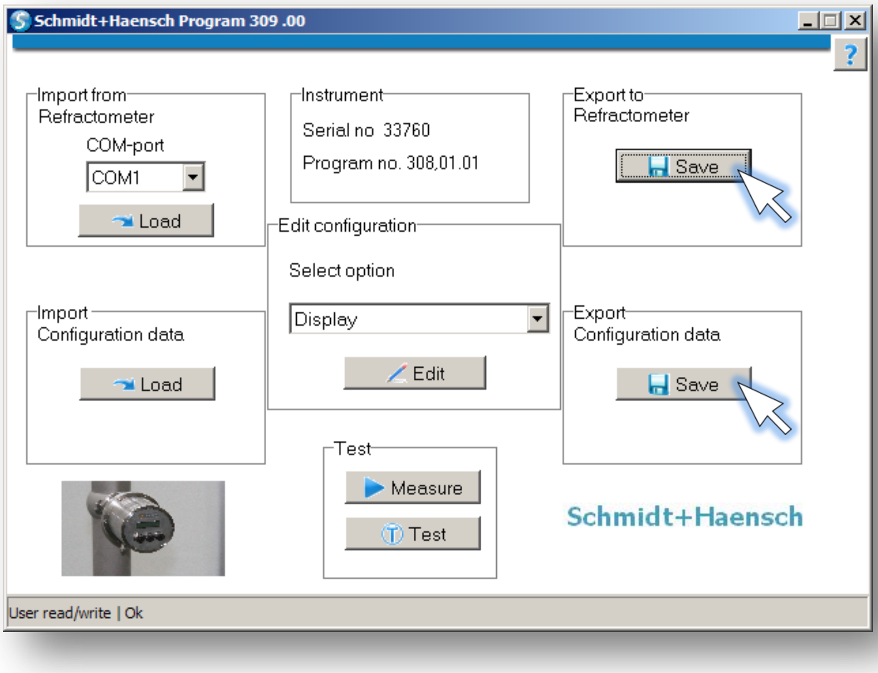


Figure 37: Save data

## 3.2 Terminal Program

Of course, the **iPR FR2** is able to communicate via a terminal program to the computer. In this way you can transfer measurements directly to the PC. Connect the **iPR FR2** with the PC by using the serial port. Now start the program *HyperTerminal* on your computer. You can find it at "Start / All Programs / Accessories / Communication".

### 3.2.1 Start HyperTerminal

After starting the application you have to type in a significant name for the new connection.


Figure 38: Choose name for new HyperTerminal connection

### 3.2.2 Settings

Then select the COM-Port the **iPR FR2** is connected to .


Figure 39: Choose COM-Port for HyperTerminal connection

### 3.2.3 Set parameter for communication

Adjust the field *Bits per second* to *9600*. The fields *Parity* and *Handshake* must be set to *none*. These are the default settings, but please make sure, that they match with the settings of the instrument.

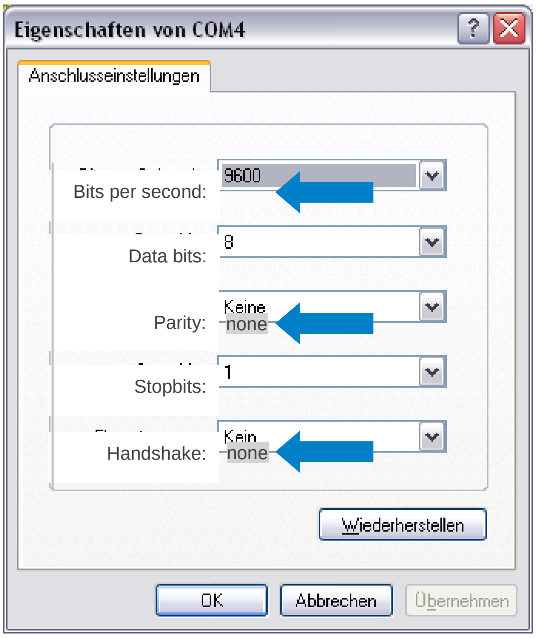


Figure 40: Set communication parameter

## 3.2.4 Default HyperTerminal output

Figure 40 shows the default output of the HyperTerminal.

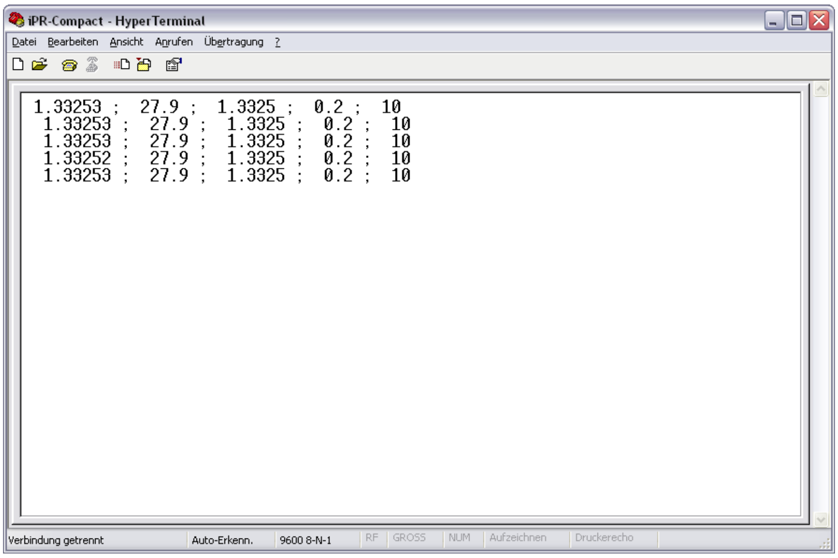


Figure 41: Default output of Terminal

Key f

The key „f“ gives you the opportunity to read out the error storage.

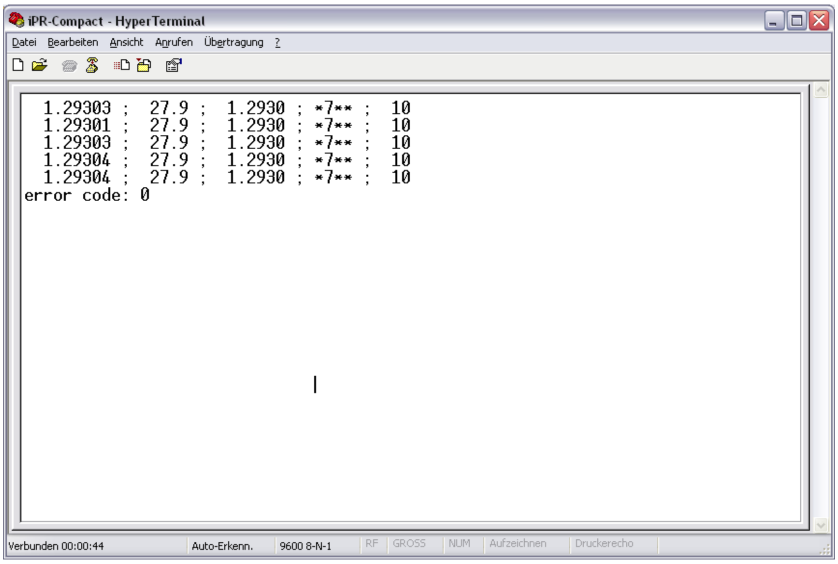


Figure 42: Readout with "f"

Keys m,M,n,N

These keys were used to readout a row with chosen measuring values.

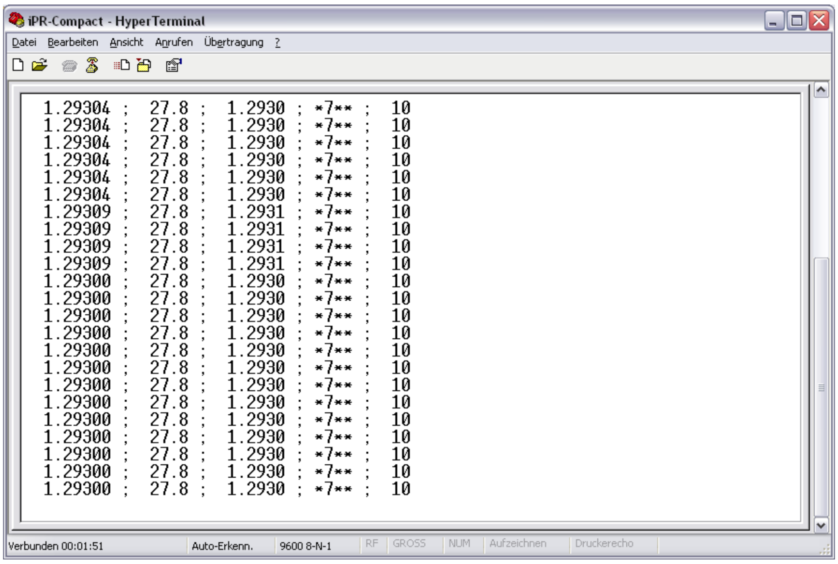


Figure 43: Output measurement values with "m,M,n,N"

Keys s,S

If you type the keys „s,S“ measured values were read out.

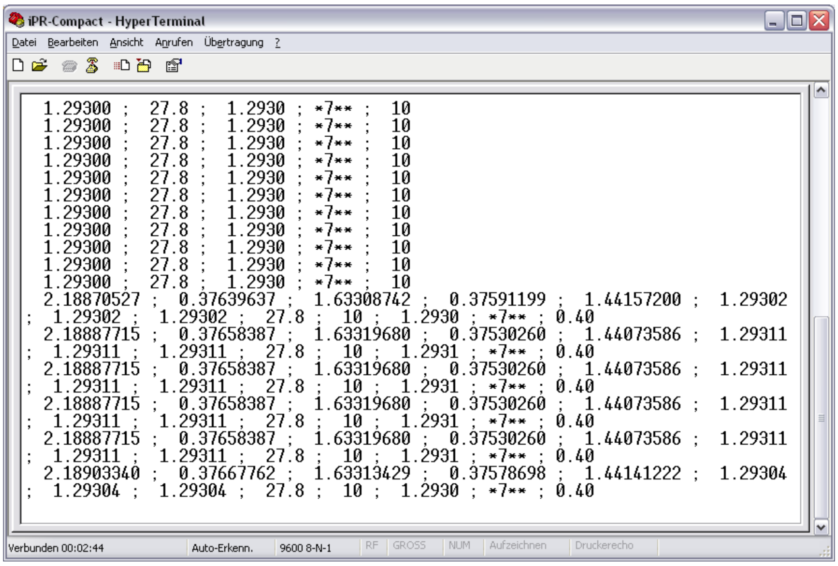


Figure 44: Output of all measured values with "s,S"

Keys Esc,x,X

With the keys „Esc,x,X“ the output continues. With „Esc“ every action can be cancelled.

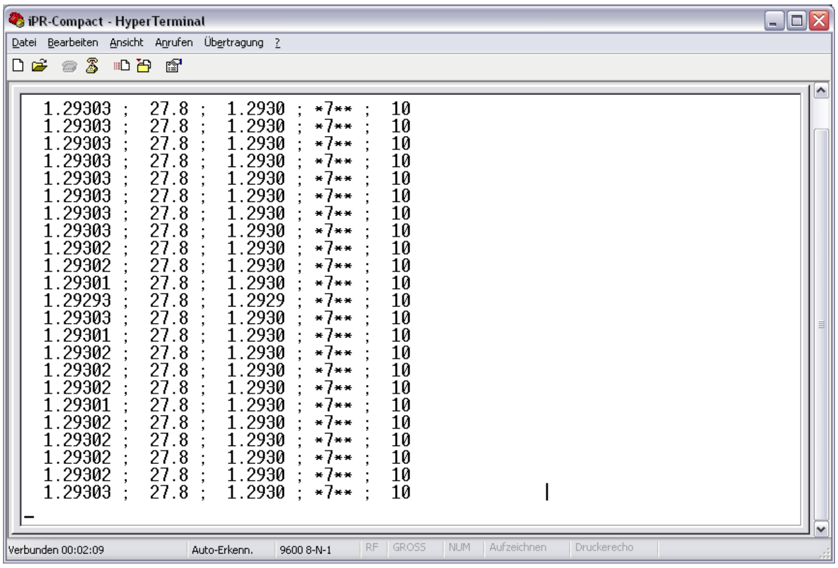


Figure 45: Interrupt with "Esc,x,X"

## 3.3 Error list

| Error number | Error number | |
|---|---|---|

| internal | external (Display) | |
|---|---|---|
| E401 | **1** | EEprom-Error: at least one set has not been loaded |
| E402 | **2** | No video data, offset can not be set.<br>e.g. stray light reaching CCD sensor |
| E403 | **3** | Not enough light intensity on CCD sensor |
| E404 | **4** | Too much light intensity on CCD sensor |
| E405 | **5** | Temperature below limit |
| E406 | **6** | Temperature above limit |
| E407 | **7** | Humidity sensor (HIH4000) is not working |
| E408 | **8** | Calculated Pixel too low |
| E409 | **9** | Calculated Pixel too large |
| E410 | **10** | Scale input value too small |
| E411 | **11** | Scale input value too large |
| E412 | **12** | Temperature too low for the scale |
| E413 | **13** | Temperature too high for the scale |
| E414 | **14** | Scale input value wrong |
| E415 | **15** | Slope positive or too shallow > -4 |
| E416 | **16** | Refractive index too small, < 1,3 |
| E417 | **17** | Refractive index too high, > 1,6 |
| E420 | **20** | 20 mA- interface highly resistive |

# 4 Maintenance and calibration

The **iPR FR2** process refractometer is designed for continuous operation without maintenance. Because of the fact, that it operates without any moving parts, regular maintenance is not necessary. A drying cartridge inside the unit provides dry air. The built-in sensor measures humidity additionally and would indicate if the drying cartridge has to be exchanged.

Nevertheless it is possible that a review of the unit could be necessary:

- If there has a coating on the prism: The instrument measures wrong refractive index or concentration.
- The device displays the rising humidity.

## 4.1 Maintenance intervals

It is appropriate to extract the unit from the line to clean the prism and storing it in a dry place when there are long breaks in the process. These periods may, for example, campaigns in the sugar industry. To ensure safe operation of the device, it is advisable to send them even without the occurrence of errors every two years to the service to get the best performance guaranteed.

## 4.2 Maintenance works

The best way to inspect the device is to remove it form the process line. It is advised to clean the device after removing. Especially the flange and the prism must be absolutely devoid of material residua. Now the instrument can be checked with distilled water and calibrated if necessary at room temperature. If the deviations are higher than the specified values, please contact the **Schmidt + Haensch** – customer service.

# 5 Technical specifications

## 5.1 Mechanical

| | |
|---|---|
| Refractive index range | 1,3300 – 1,5300 |
| Resolution refractive index | 0,00001 |
| Measurement range Brix | 0 – 100 $Brix$ (Automatic Temperature-correction 15°$C$ – 40°$C$) |
| Resolution Brix | 0,01 $Brix$ |
| Precision | $\pm$ 0,00007 $RI$ / $\pm$ 0,05 $Brix$ |
| Temperature accuracy | $\pm 0.2°C$ |
| Temperature resolution | $\pm 0.01°C$ |
| Process temperature | $-10°C$ to $+150°C$ |
| Ambient temperature | $-10°C$ to $+40°C$ |
| Max pressure | $1MPa$ (10 $bar$) |
| Wetted parts | YAG, stainless steel 1.4404 AISI 316L<br>Viton® O-ring (DIN FPM or ISO FKM) |
| Power supply | $24V\ DC\ < 120mA$ ($20V$ – $28V$) |
| Light source | 589 $nm$ LED |
| Display | LCD display-2 Lines |
| Analog data output | $4 - 20\ mA$ - active output [ 500Ω |
| Digital output | Serial communication with RS232,<br>RS422 (switchable) and USB |
| Software | Configuration program:<br>serial output, analog output,<br>monitoring of measurements and save data |
| Process connection | optional: *VariVent-Inline* (Tuchenhagen) or *APV-Inline (APV)* or *TriClamp* |
| Other options | Cleaning units |

| | |
|---|---|
| Dimensions | *264 mm x 149 mm* (length x diameter) |
| Weight | *5300 g* |

## 5.2 Electrical

The **iPR FR2** needs only three cables to operate:

- Power Supply: 5 pin male
- Switch: 5 pin female
- Configuration and serial communication: 8 pin female

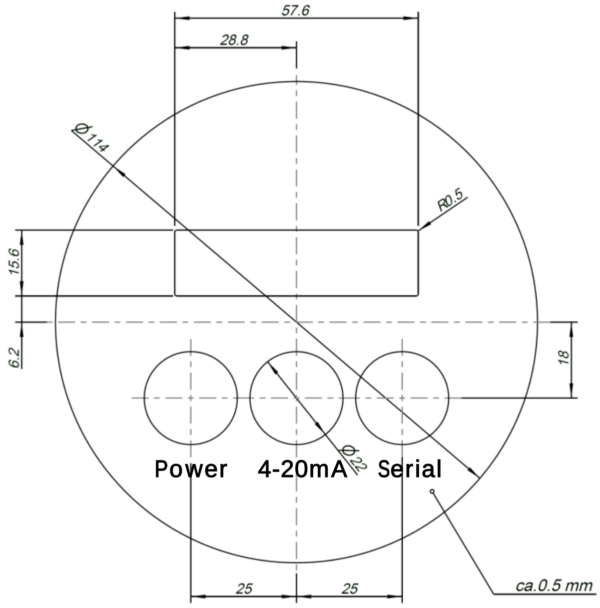


Figure 46: Dimensions rear side iPR FR2

### 5.2.1 Power supply and Switch

| Pin | CIR-Power-Kabel Farbe | Signal |
|---|---|---|
| 1 | brown | Ub (+24V) |
| 2 | white | Switch 1 ( 1A ) |
| 3 | blue | Switch 2 ( 1A ) |
| 4 | black | GND |

### 5.2.2 4 – 20 mA Current Interface

| Pin | CIR-Power-Kabel Farbe | Signal |
|---|---|---|
| 2 | white | 4 – 20 mA (1) |
| 3 | blue | GND |
| 4 | black | 4 – 20 mA (2) |
| 5 | grey | GND |

### 5.2.3 Configuration cable RS232

| Sub-D 8-pol Pin | CIR-Com-Cable Color | Signal |
|---|---|---|
| 1 | white | RxD (RXD + RS422) |
| 2 | brown | TxD (TXD + RS422) |
| 3 | green | RTS (TXD + RS422) |
| 4 | yellow | CTS (RXD - RS422) |
| 5 | grey | RS422 |
| 6 | rose | GND |

To activate the RS422-function of the interface please cut and isolate the Pin5 of the Sub-D-interface.

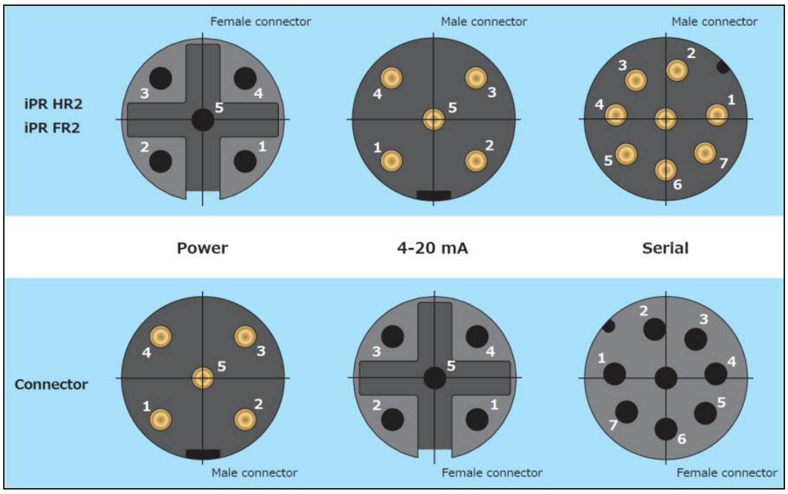


Figure 47: Overview connecting leads

# 6 Minimum system requirements

| | |
|---|---|
| Processor | Pentium 4 - 2,0 GHz |
| Diskspace | 2 GB |
| Memory | 512 MB of RAM |
| Operating system | Windows 2000 and above |
| Interface | 1x RS232 serial, USB to serial |

Version 2 – Revision 1 – January 2017

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