Schleibinger Thin-Layer-Shrinkage-Measuring-System

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Contents

1 Introduction

Cementitious building materials change their volume during the hydration. This is a known phenomen resulting from structural and environmental factors. The process can take up to months and years reflected in shrinkage or expansion of materials. For the most practical applications of building materials the changing of the volume is very harmful and has to be minimized.

Many theoretical models describe the causes of shrinkage and expanding of building materials on later ages, when the material has gained adequate strength. This includes drying shrinkage when water is loosing to the environment and due to this volumetric change takes place. But also the occurrence of autogenous shrinkage which takes place without moisture transfer to the environment is of great importance for the shrinkage behaviour and thus on cracking risk of building materials.

While the autogenous shrinkage at later ages has been well documented and explained by self-desiccation behaviours there is no theoretically explanation of autogenous shrinkage at very early age during the first day of hydration. At early ages, the tensile capacity of cementitious materials is lowest and the risk of cracking is high. The mechanisms during the first hours of hydration are still not fully understood. Due to the difficulties in measurement or relatively high inaccuracy, the measurements of the volumetric changes at the early age are rarely performed. Therefore, it is more important to have suitable measuring instruments capable of measuring the volume change behaviour of the building materials from the beginning of the hydration, and on the other hand measuring equipment capable of simulating the environmental conditions from the field of application.

1.1 Taxonomy of Shrinkage Measurement Systems

The volume change of the building materials is of high interest when focusing on maintaining of durable structures. The change of the volume is often attributed to drying of the concrete over a long time period. Not only the drying shrinkage but also the thermal and particularly the autogenous shrinkage, which shows volume reduction resulting from internal chemical and structural changes, are of interest for the formation of cracks. The autogenous shrinkage for example is a big issue especially for the high strength or high perfomance concrete with the low water-to-cement ratios.

Due to the production process cementitious materials undergo different stages which are a liquid or plastic stage, intermediate stage of the setting and the hardened stage of the materials:

- fluid (F)
- setting time (S)
- hardened material (H)

For the shrinkage of cementitious materials two distinct stages can be defined which are early and later ages. The age of 24 hours and longer refer to the later age shrinkage. This is also the kind of shrinkage which is recorded by standardized measurements where a certain strength of the material is necessary.

The early stage is commonly definded as the first day while the cementitious materials are setting and starting to harden. The change of the consistency of the cementitious material implements high requirements for a measuring system. At the plastic state, usual physical test methods can not be applied showing difficulties in measuring of the fluid materials.

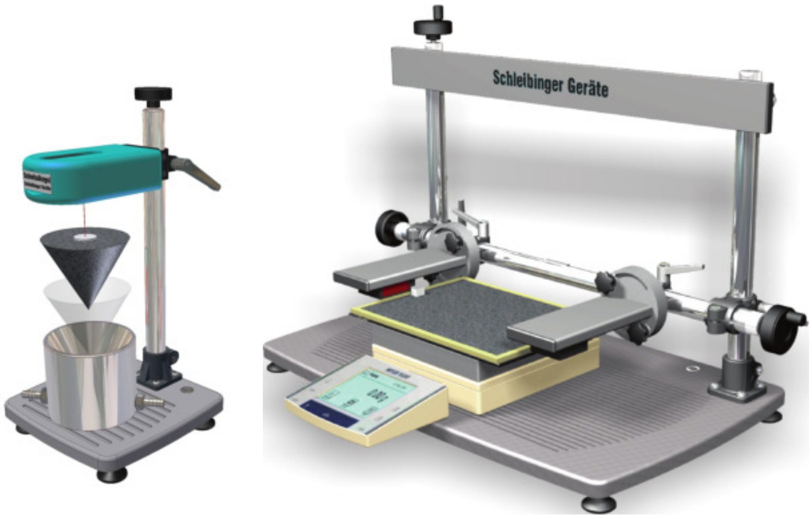
The process of hydration of cementitious materials itself is influenced by the environmental conditions like temperature (freezing and thawing), humidity, and impact of gas, or salty or acid liquids. For shrinkage investigations only the environmental conditions have to be constant. On the other side the length change of the materials due to the change of the environmental conditions can be a factor for the resistance of these materials. This will be used for example for the detection of the reactivity of the material due to the alkali silicate reaction or for examination of freeze-thaw resistance of concrete.

In addition to the free shrinkage the measurement of the blocked or restrained shrinkage provides further information about the building materials. Under restrained shrinkage the age of cracking and induced tensile stress characteristics of mortar or concrete speciment can be determined.

The company **Schleibinger Geräte** provides testing equipment for a whole range of measurement of shrinkage behaviours of building materials:

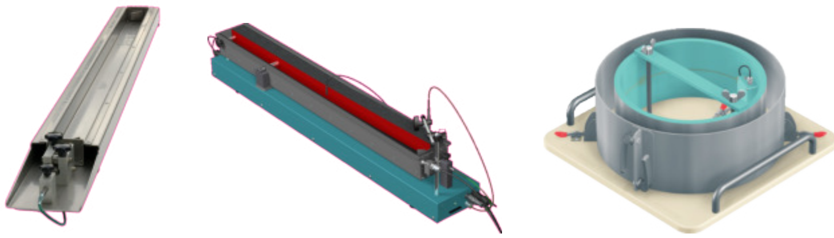
- The Schleibinger **Shrinkage-Cone** - a measurement equipment for a very early shrinkage and expansion of building materials like paste, mortar, plaster etc. A contactless laser sensor allows recording the data directly after the filling of cone-formed specimen container.
- The Schleibinger **Thin-Layer-Measurement-System** - measurement equipment for a very early measurement of the volume change of the building materials such as paste, mortar, plaster, self-leveling compounds or other materials applicated as a thin layer. Two laser units allow a contactless measurement of the shrinkage or the expansion of these materials.
- The Schleibinger **Shrinkage Drains** - for continuous measuring of shrinkage and expansion using a movable anchor.
- The Schleibinger **Bending Drain** - for measurement of the volume change and the curling of the specimen. Influence of floor heating can be simulated.
- The Schleibinger **Shrinkage Ring** - for the determination of age of cracking and induced tensile stress under restraind shrinkage (according to ASTM C1581)

Due to different stages of the building materials fluid (F), setting time (S) and hardened stage (H) different equipment for different stages can be used. Figure 1 shows the different measurement devices for the measurement of the volume change behaviours of the building materials.



(a) Shrinkage Cone

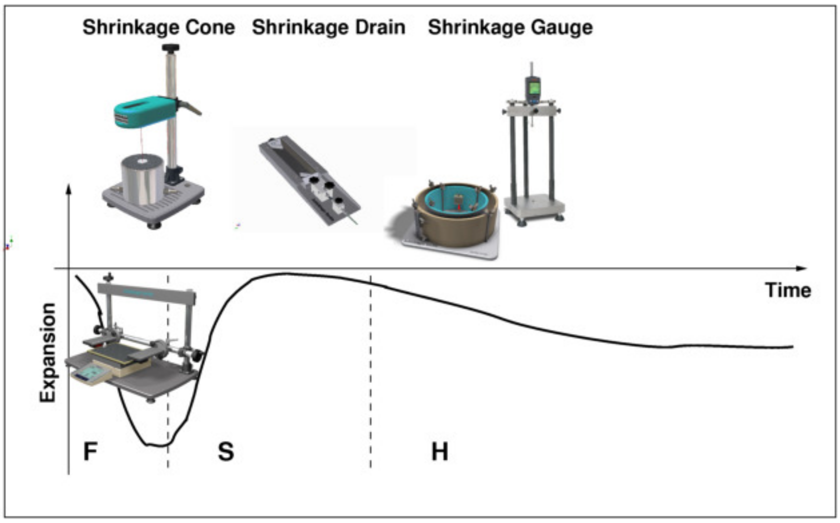
(b) Thin-Layer-Measurement-System



(c) Shrinkage Drain

(d) Bending Drain

(e) Shrinkage Ring



(f) Shrinkage over time

Figure 1: Schleibinger Shrinkage measurement equipment

2 Theory of Operation

2.1 Thin-Layer-Measurement-System (TLMS)

The application of building materials like self-leveling and flooring compounds is carried out in thin layers. These building materials show fast setting behaviours and harden within a couple of hours. Accordingly, a subsequent drying of such a thin layer is generally terminated after the first day. In order to investigate the dynamics of early shrinkage and expansion a special set-up of two LASER units, which are horizontally aligned, was developed.

The LASERs are arranged opposite to each other. A fresh sample is placed between the LASERs. The light-weight reflectors are placed on the surface of fresh sample in a way the LASER beams are reflecting (2]. The measurements can start immediately after placing of the fresh sample and adjusting of the Laser beams. The measurement is made by recording the length change between the reflectors with an accuracy of 0.15 μm.

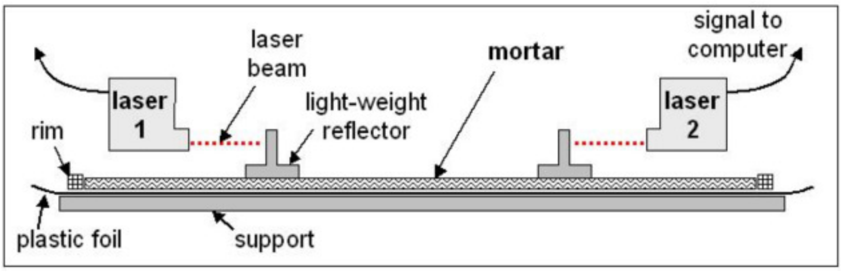


Figure 2: Measurement setup at TLMS (with courtesy by Dr. Zurbriggen, elotex, Schweiz)

This set-up allows to investigate the different formulation parameters and their influences onto the different stages of shrinkage and expansion, namely the plastic shrinkage, setting expansion and drying shrinkage.

The most important issues, which occur due to the application of such building materials in thin layers, are:

- a high surface-to-volume ratio causes a surface drying effect which becomes the dominant mechanism for strong and rapid physical shrinkage.
- the intense hydration reaction can cause a chemical shrinkage or strong expansion in case of Ettringite formation.

Additional, a synchronous recording of environmental conditions (temperature and humidity) are possible. The temperature of the sample during the measurement can be recorded as well. For the detection of weight changes of the measured sample a balance (Sartorius, Mettler or Kern) can be connected to the system. The measured data are stored as a standard ASCII file on a data logger which is supplied with the system. The logger has a network interface (Ethernet) and can be easily integrated into a local Intranet. Data readout and visualizing can be done by a standard web browser or can be saved as a txt-file for further data handling via e.q. Microsoft Excel, LibreOffice or any other similar program. No special computer or special software is necessary.

3 Hardware Installation

3.1 Important Safety Hints - TLMS

The Laser of the TLMS is working at the wavelength of 670 nm. The maximum output power is 1mW. Laser protection is class 2 according to DIN EN 60825-1:2008-05.

Don't look into the laser beam! Laser protective eyewear are urgently recommended!

Please use the laser only according to your national laws.

3.2 Requirements

The Shrinkage Cone, the TLMS, the Bending Drain, the Shrinkage Drain and the Shrinkage Ring are delivered with a data logger. The data logger records the measurement values for several months depending on recording interval (sampling rate) and the amount of channels connected. The data sets are stored nonvolatile in the data logger. The logger is equipped with a network interface.

It may be integrated in a local intranet as well as into the worldwide Internet. As user interface PC with an actual Internet browser like Firefox 24+, Internet Explorer 9+, Microsoft Edge, Chrome 25+, Opera 15+, ... will be used. No special operating system of the computer is needed. Even a tablet with Android or iOs system can be used.

The computer must be equipped with an Ethernet network interface running the TCP/IP protocol. During the measurement no running computer is needed. The configuration is described in detail in section 3.4.

In addition to the http protocol the file transfer protocol (ftp) can be used for readout of the data. The username for the ftp protocol and the password are `ftp`.

For debugging purposes it is possible to login with the telnet protocol. The username and the password are `tel`.

3.3 Installation of the Data Logger for the TLMS

- Connect the Laser heads to the data logger with a cable.
- Connect the thermocouple and the temperature and humidity sensor to the data logger.
- If needed connect the balance. Be sure that the serial interface of the balance is activated (chapter 3.7).
- Turn on the balance. The balance should always be turned on before the data logger.
- The data logger will be delivered with a 240 V / 50 Hz power supply. Connect the power supply with the data logger (Fig. 3, 4). After some seconds the data logger is running and the LED indicator should blink.
- Configure the network interface as described in chapter 3.4.
- The data logger requires a free IP address. The logger is delivered with the address written on a label on the bottom-side of the data-logger. Please use the Windows program Chiptool.exe (delivered with the data logger) to change the IP address. For more information, please, visit: **http://schleibinger.com/chiptool/**

Figure 3: Data logger for TLMS (front side and back side)

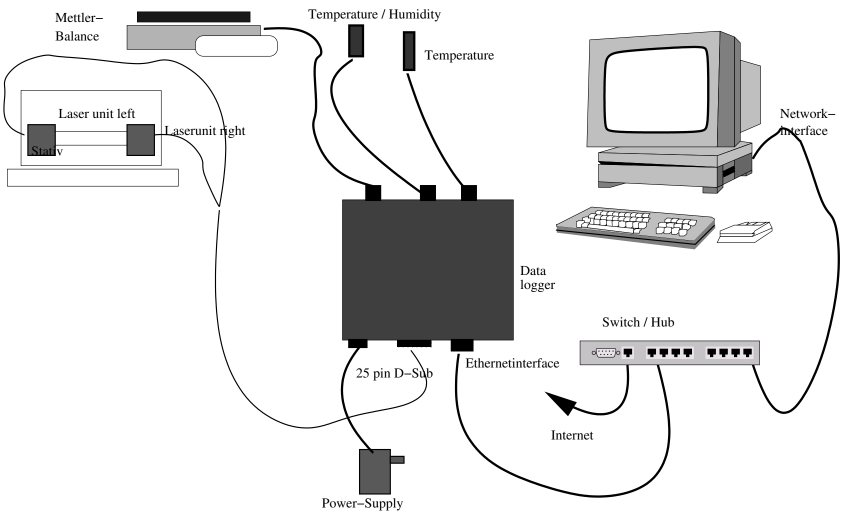


Figure 4: Wiring the TLMS

3.4 Configuration of the Network access

The Schleibinger data logger, the Slabtester and the CDF machine are equipped with a *100 BaseT* network interface. It can be integrated within a local Intranet or globally into the Internet. The network configuration can be done with the program Chiptool which can be found on USB stick delivered with the equipment or downloaded from the page:

`www.schleibinger.com/chiptool`.

Example of Default Settings:

```
Device: Data logger for the shrinkage cone
Customer:  Miximaxi AG
Serial Nr: 201312324
MAC-ID: 00:30:56:90:7D:C3
Hostname: Scone_201312324
[]   Obtain an IP-Address automatically
[]   Use the following IP-Addresse: IP addresse:.......
Subnet mask:.......
```

3.4.1 Network configuration between data logger and PC

There are two options for the network configuration of the data logger and PC available:

- by automatically getting an IP address = default setting at time of delivery
- by using a static IP address

Automatically getting IP address

Connection of the data logger into a local network with DHCP- and DNS-Server is the simplest and fastest method.

- Connect the data logger with your local network (switch) using the network cable which was delivered with the device and switch on the data logger (24V adapter)
- Enter the host name into the address line of your browser in a form "**http://...**" (Fig. 5.)

A DHCP-Server assigns a free IP address to the data logger. You can access the data logger via the default host name using the DNS (Fig. 5).

Hint: DHCP server are scanning the network from time to time assigning a IP address and a symbolic name to all computers in the network. This procedure may take some time. So please wait some minutes until you try to access the data logger with its host name.

Alternatively, in the case the host name - DNS-server does not work or supported in your network the connection with the data logger can be done by using of the assigned IP address. This IP address can be found from the program Chiptool, mentioned above (Fig. 6).

Make sure the data logger always getting the same IP address from the DHCP server. Enter the IP address assigned by the DHCP server into the address line of the browser instead of the host name (Fig. 7).

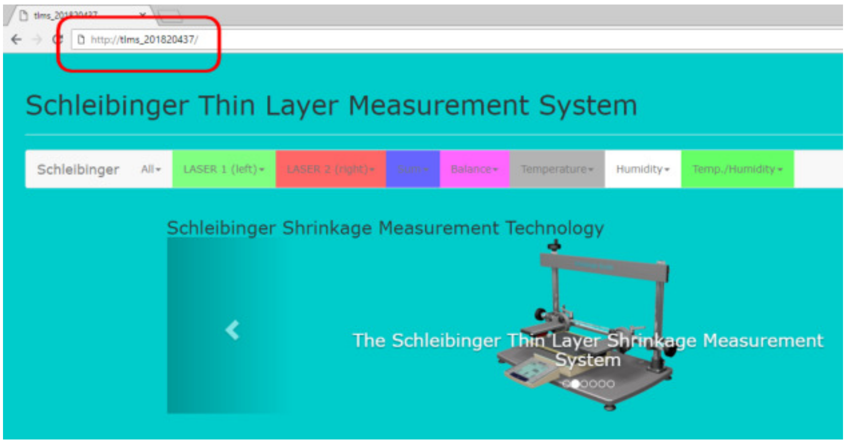
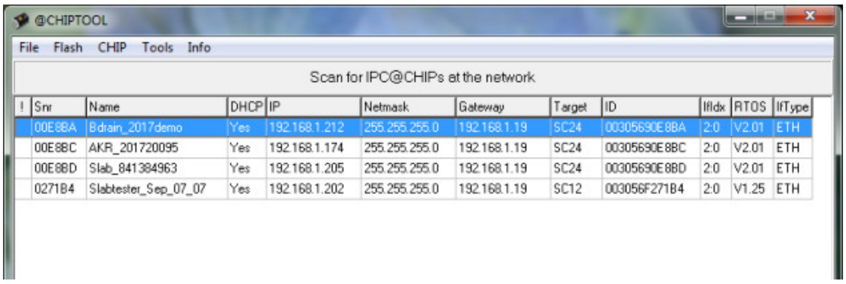


Figure 5: Accessing the data logger with a symbolic server name.



!	Snr	Name	DHCP	IP	Netmask	Gateway	Target	ID	IfIdx	RTOS	IfType
	00E8BA	Bdrain_2017demo	Yes	192.168.1.212	255.255.255.0	192.168.1.19	SC24	00305690E8BA	2:0	V2.01	ETH
	00E8BC	AKR_201720095	Yes	192.168.1.174	255.255.255.0	192.168.1.19	SC24	00305690E8BC	2:0	V2.01	ETH
	00E8BD	Slab_841384963	Yes	192.168.1.205	255.255.255.0	192.168.1.19	SC24	00305690E8BD	2:0	V2.01	ETH
	0271B4	Slabtester_Sep_07_07	Yes	192.168.1.202	255.255.255.0	192.168.1.19	SC12	003056F271B4	2:0	V1.25	ETH

Figure 6: Readout the IP address to the data logger with the program chiptool.

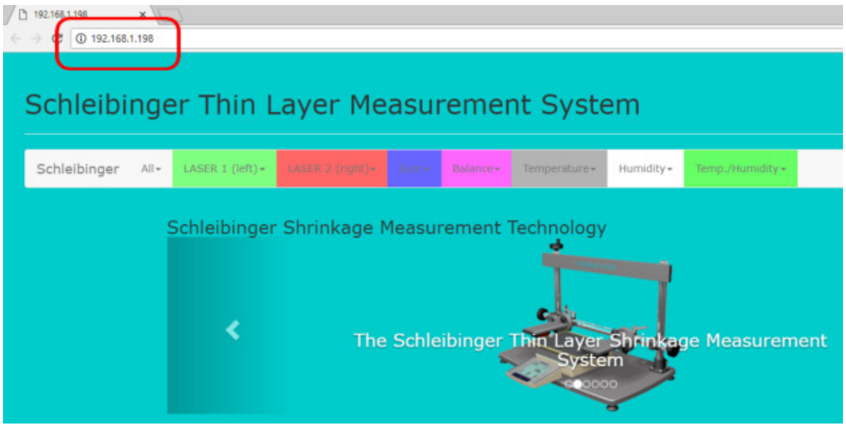


Figure 7: Accessing the data logger with a fix IP address.

using static IP address

If no network avaliable or you are not allowed to connect a measurement device into your local network, the Schleibinger data logger can be connected directly to a PC, e.g. with an older notebook. Most of the PCs are configured in a way, that they take an IP address automatically assigned by the DHCP server. In case of a direct connection between data logger and PC, both peers are missing the DHCP server. For this chase use a static IP address.

a) set static IP address on the computer:

Open `Control Panel` → `Network and Internet` → `LAN-Connection` → `Properties` and set a static IP-address from the so called private area e.g. `192.168.1.1` and a sub net mask `255.255.255.0`. Gateway doesn't has to be set. See figure 8

b) set static IP address on the data logger:

Connect the data logger and the PC with the static IP address with a cross-wired Ethernet cable (Cat5, RJ45)- not delivered with the equipment, and start the program chiptool. The program is searching for the data logger and if the PC is configured correctly and the right connection cable is used, the Schleibinger device appears in the window of the program. Click with the right mouse button on the entry within the window and choose IP configuration. A small window appears. Enter an other static IP address from the same private area as well [Fig. 9). This IP address has to be different from one of PC e.g. `192.168.1.2` and the same sub net mask. Finally click on `Config`.

Enter the new IP address of the data logger in the header of the browser. The main page of the data logger should appear.

For the integration of the data logger into the network infrastruction, please, ask your network administrator.

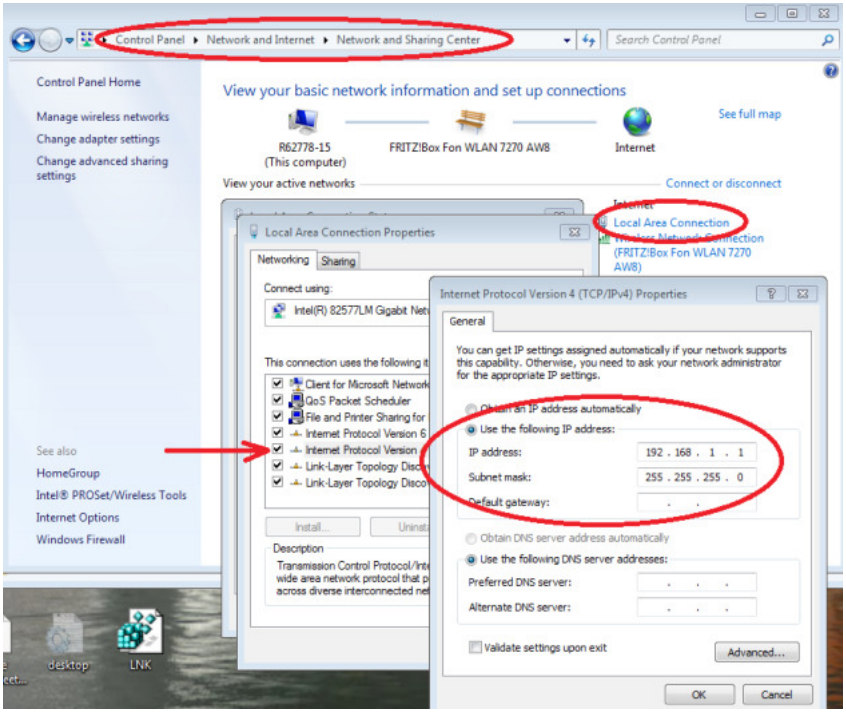


Figure 8: Configuration of PC for a direct connection with data logger.

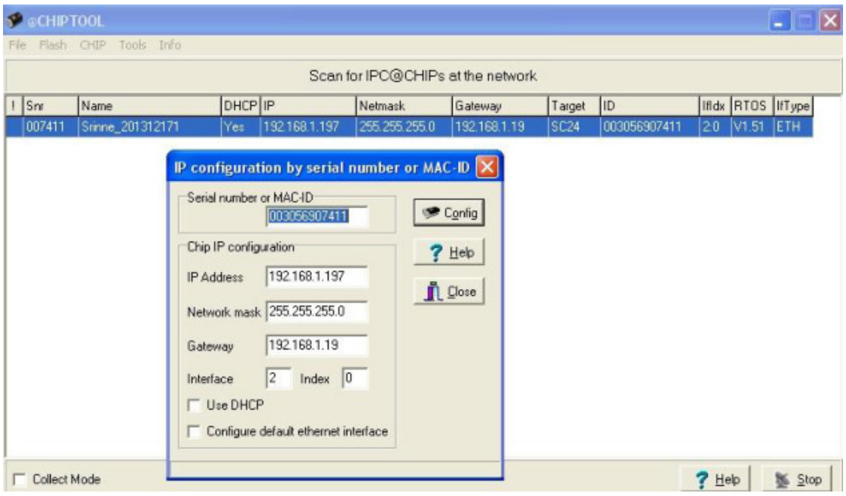


Figure 9: Configuration of the data logger for direct connection using program chiptool.

3.5 Thermocouples

As an option thermocouples can be connected to the data logger or the strain gage amplifier of the Shrinkage Rings for measuring the specimen temperature.

A thermocouple is a temperature-measuring device consisting of two dissimilar conductors that contact each other at one or more spots, where a temperature differential is experienced by the different conductors (or semiconductors). It generates a voltage when the temperature of one of the spots differs from the reference temperature at other parts of the circuit. Thermocouples are a widely used type of temperature sensor for measurement and control. Commercial thermocouples are inexpensive, interchangeable, supplied with standard connectors, and can measure a wide range of temperatures. The main limitation of the thermocouples is their accuracy: system errors of less than one degree Celsius (℃) can be difficult to achieve.

There are different types of thermocouples on the market available. Type K (chromel / alumel) is the most common thermocouple type with a sensitivity of approximately $41\mu V/C$ (chromel positive relative to alumel when the junction temperature is higher than the reference temperature) (Fig. 10]. This type K of thermocouple is cost-effective and available in a wide variety of probes with the temperature range from -200 ℃ to +1350 ℃.[1]

Attention: Please, use Type K thermocouples with the Schleibinger data logger only. Otherwise the results will be incorrect!

After the measurement, the thermocouple can be simply pulled out of the sample. If it is not possible, cut it off. Thermocouple can be reused by removing the insulation from the cable head and twisting the cables.

please note!

If no thermocouple is connected or it is brocken, the temperature will still displayed on the device. This temperature is the temperature or the cold spot at the temperature plug of the data logger.

[1] Text partly from: Wikipedia contributors. "Thermocouple." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 31 May. 2015. Web. 5 Jun. 2015.

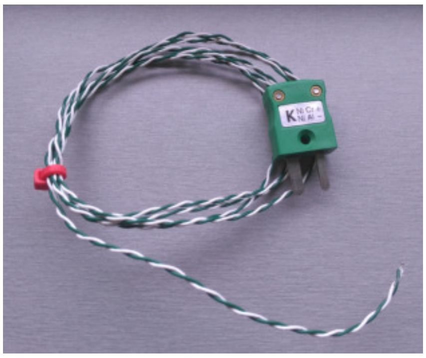


Figure 10: Thermocouple type K

3.6 Combined Humidity and Temperature Sensor

A combined relative humidity and temperature sensor (SHT75) for the measurement of the environmental conditions can be connected to the data logger as well (Fig. 11). This sensor integrate sensor elements plus signal processing in compact format and provide a fully calibrated digital output. A capacitive sensor element is used for measuring relative humidity while temperature is measured by a band-gap sensor. Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit. This results in good signal quality, a fast response time and insensitivity to external disturbances (Fig.12) [2]).

Figure 11: combined humidity and temperature sensor

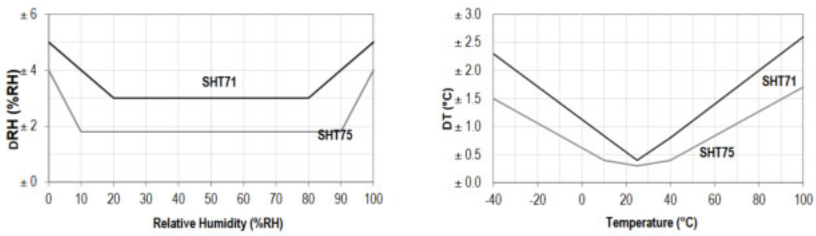


Figure 12: SHT75 sensor used with maximal RH-tolerance at 25 ℃ (left) and maximal T-tolerance (right)

[2] Text partly from: Datasheet SHT7x, Humidity and Temperature Sensor IC.

3.7 Balance Interface

Drying shrinkage is defined as the contracting of a hardened concrete mixture due to the loss of capillary water. This shrinkage causes an increase in tensile stress, which may lead to cracking, internal warping, and external deflection, before the concrete is subjected to any kind of loading. Portland cement based concrete undergoes drying shrinkage or hydral volume change. The consideration of the volume change of concrete is particularly important for an engineer and the building designe.

Drying shrinkage can occur in slabs, beams, columns, bearing walls, prestressed members, tanks, and foundations (source: The Pennylvenia State Univ.).

Water loss associated with the drying shrinkage can be measured by a balance. The balance can be placed under the sample and connected to the data logger (Fig. 3). Current three manufacturers are supported: Kern, Mettler-Toledo and Sartorius. A RS232 interface is used. For the USB connection a interface cable from the balance manufacturer is required.

Setting parameters of the balance:

- serial interface
- 9600 band, 8bit-1-N adjustment
- automatic calibration is set to "OFF"
- for the connection with the data logger, balance should be switched on first.

4 Handling

4.1 TLMS

4.1.1 Measurement of thin layer

The preparation for the measurement with the Thin-Layer-Measurement-System can be done as following:

- Prepare a form for the liquid sample. For example: take a thin PE or PP hosehold-foil with a size of approx. 200 x 300 mm. Glue a strip of Tesa Moll at the ends of the foil to prepare a border around the foil and to produce a kind of sample container. Place the foil on some coreboard (for example a glas plate)
- Fill the sample container with the liquid sample
- Place the sample on the balance or a rigid underground between two LASER beams of TLMS.
- Adjust the sensor position of the LASERs nearly to the sample border.
- Place the reflectors on the surface of the liquid sample in the way the LASER beam will be reflected and the light on the each sensor is lighting yellow/green. Make sure the height of the LASER beam is ok and each LASER meets the reflector in the middle.

The adjustments of the LASER positions will be done by a hand wheels:

- The height of the LASER sensor position will be adjusted by turning the upper hand wheel on the top of the TLMS for both sensors sumultaneously.
- The distance between the LASER sensors will be adjusted by turning the lateral hand wheel on each side of the TLMS for each sensor separately.

The LASER triangulation sensor has to be placed in the middle of the measuring range which is about 32750 of raw value (Fig. 13). The procedure for the finding of the correct sensor position should be performed as follows:

- Find the meausring range of the LASER sensor:

  - Shift the left laser head by turning on the left hand wheel on the left side of the TLMS untill green LED on the sensor comes on.

  - Turning the sensor in the opposite direction untill the red LED comes on.

- Go back to place the LASER in the middle of the measuring range. The LED switching from green to yellow/green.
- Do the same for the right laser head.

The measurements can be started (Fig. 14). For starting the measurement **Quickstart** is recommended (see also chapter 5.2.4).

Please note: Due to thermal stabilisation of the TLMS the system should be put into operation about 20 minutes before the start of the measurement.

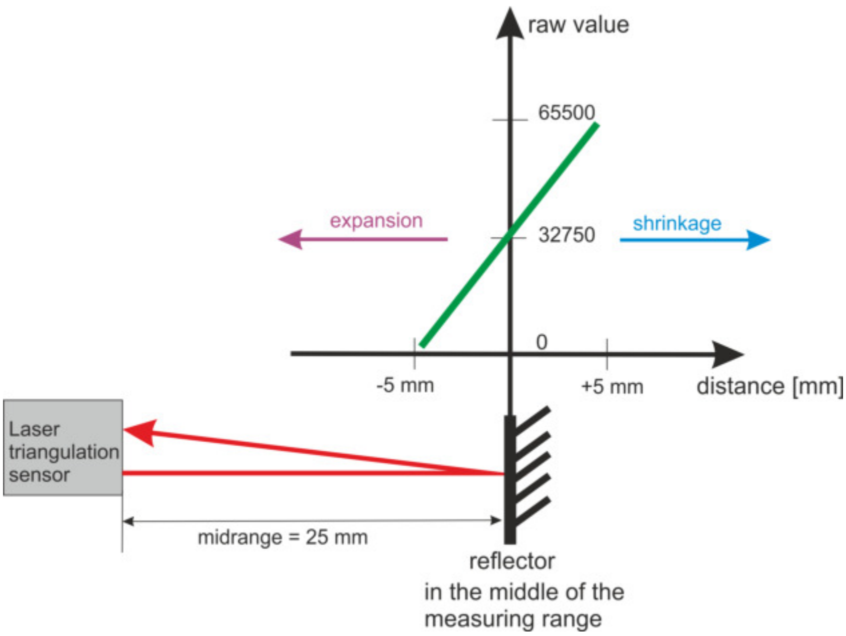


Figure 13: Adjustment of the LASER triangulation sensor for TLMS

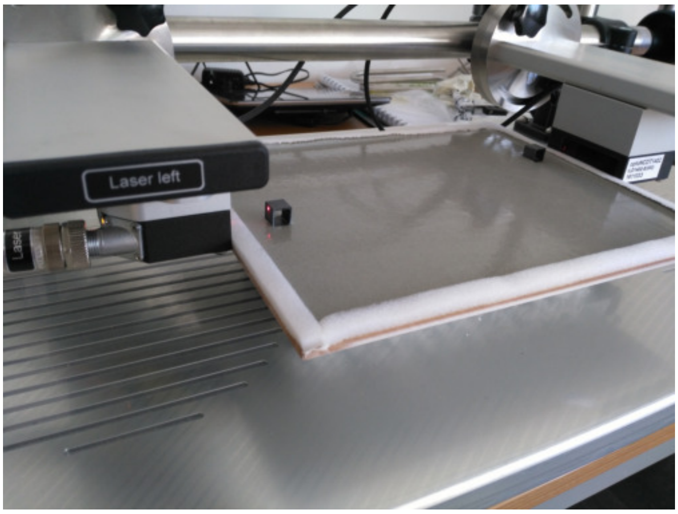


Figure 14: TLMS measurement on thin layer

4.1.2 Measurement with Shrinkage Cone

In addition to measurement of thin layers TLMS system can be used for the measurements with the Schleibinger **Shrinkage Cone** container. Both LASER units can be rotated by 90 degrees. At that position one or maximum two **Shrinkage Cone** containers can be placed under the LASER units and the investigation of the shrinkage behaviour of liquid building materials can be done (Fig. 15).

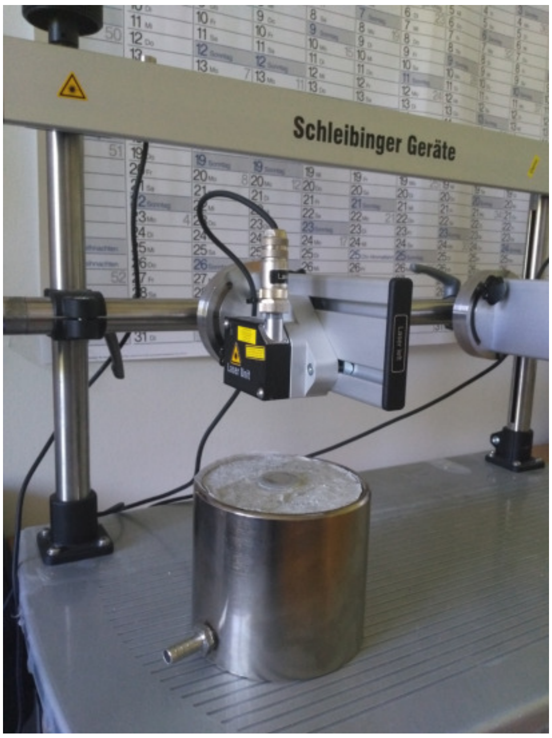


Figure 15: TLMS with Shrinkage Cone container

5 The Software

The software is quite similar for all shrinkage test systems.

5.1 Recording Data

As soon the data logger get power, data acquisition starts. This is shown by blinking of the green LED "OK" at the front-side of the data logger and a LED from the measuring sensor lights up if connected. The PC is only required for setup and data transfer.

5.2 Software Handling

The operation of the devices will be done by a Web-Browser-Software. To communicate with the data logger start at your PC your web browser. Enter the host name or the IP address at the address line of your browser. The start screen will appear in the browser (Fig. 16).

In the header of the page on the left the drop down menu **All** is shown. From this menu all channels will be controlled in the same way. For example starting the measurement, set up of the real time clock, showing all data numerical and graphical (Fig. 17).

The single channels are listed from the buttom **All** on the right side. Depending on installed options these are the single sensors like LASER sensors for the TLMS or Shrinkage Cone, LVDT sensors for the Shrinkage Drain and Bending Drain, Temperature sensor, combined relative humidity and temperature sensor and a balance signal.

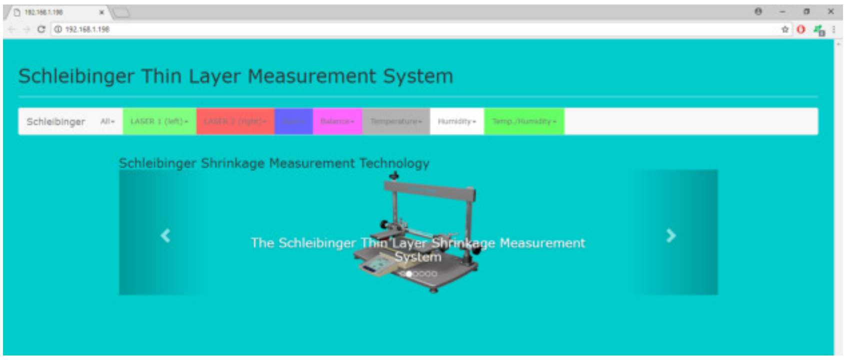


Figure 16: Start screen

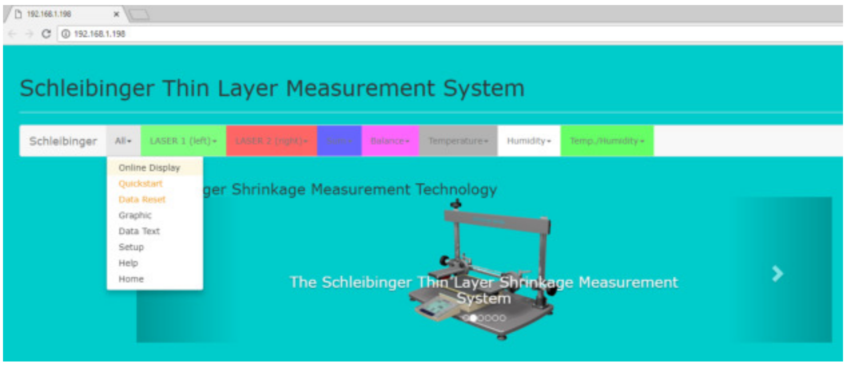


Figure 17: Main menu

5.2.1 Singel Channel Setup

The configuration of the measurement can be done from the **Setup** (Fig. 18). For each channel:

- Recording interval (**Sampling Rate**) can be selected from 10 seconds to 10 minutes (Fig. 18]. The appropriate measurement values are recorded according to the set interval.
- **Limit** value for each channel can be specified. If the **Limit** set to `infinitely` the data will be collected according to the set recording interval of the sampling rate. If the LIMIT is set to for example n=5 the data logger will record the additional data where the difference of the measured value between two measurement points bigger than 5. This gives the possibility to record the changes in the measured value independend from the set recording interval. The unit of the LIMIT is due to the channel selected.
- **Time Format** of the recording interval can be selected. The **Time Format** can be choosen between `Time/s` and `n*smaplingrate/s`. When selecting `Time/s` and a sampling rate of for example 30s the data logger will record data at 30s, 61s, 90s, 119s . . . . The reason for this are small deviations in the response time of the several software processes running on data logger. If this is not desired please select `n*smaplingrate/s` for the **Time Format** Setup or in the Excel worksheet. From this the actual measuring time is rounded sown to the recording interval from the sampling rate.

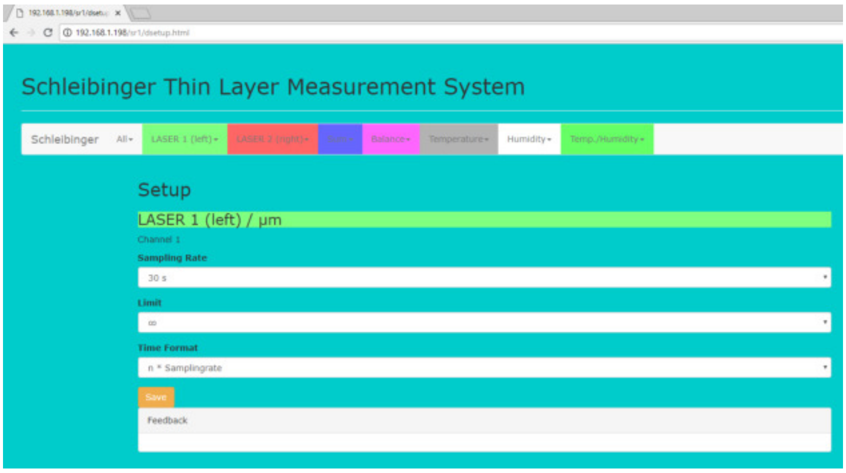


Figure 18: Channel setup

5.2.2 All Setup

The data logger uses the 24-hour clock setting.

The setup of date and time from the system time or your own time can be done [Fig. 19). Be careful, the European time format is used.

day.month.year:hour:min for example `26.03.03:12:11`.

Press the **Set Date and Time** button for confirmation.

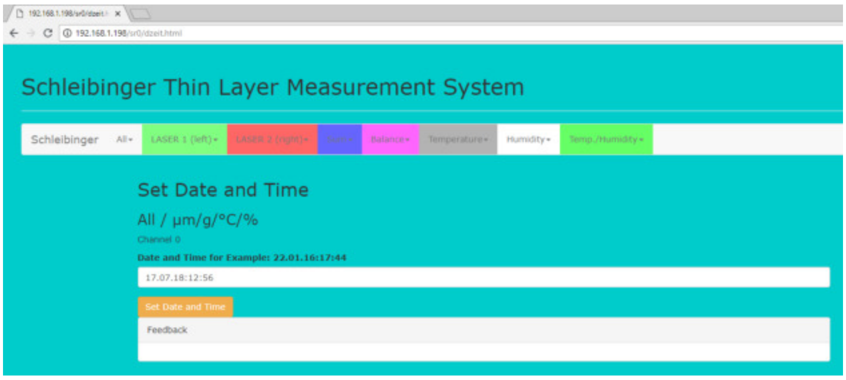


Figure 19: Setup of date and time

5.2.3 Start Measurement of single sensor

It is possible to start the measurements for each sensor separately. Starting the measurement can be done as follows:

- Adjust the LASER position as described in chapter 4
- Select the appropriate channel in the header line
- Check the Laser position by displaying the raw values with: **All - Online Display** and press **Start** (Fig. 20). The raw value from the Laser sensors should be in the range of **32500 to 33000**.
- Check the raw values for channel 1 (LASER 1, left) and/or channel 2 (LASER 2, right).

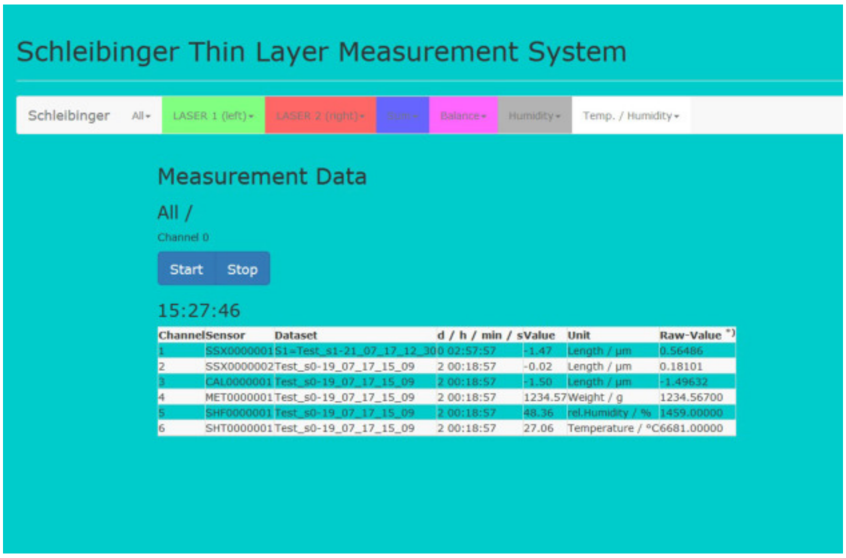


Figure 20: Measurement values in a numerical format

- Select **Offset** and press the button **Offset=0**. The measured values are set to zero (Fig. 21).

By offseting only the measured values of the channel will set to zero. The time of the measurement will still continue.

please note: For temperature and combined temperature and humidity sensors no offset is possible.

- Select **Start** for measurement start. Enter the filename (optional) and click on **Start** for setting the time to zero (Fig. 22).
- Select **Data Reset** for emptying the data file.
- Click on **Erase** Fig. 23

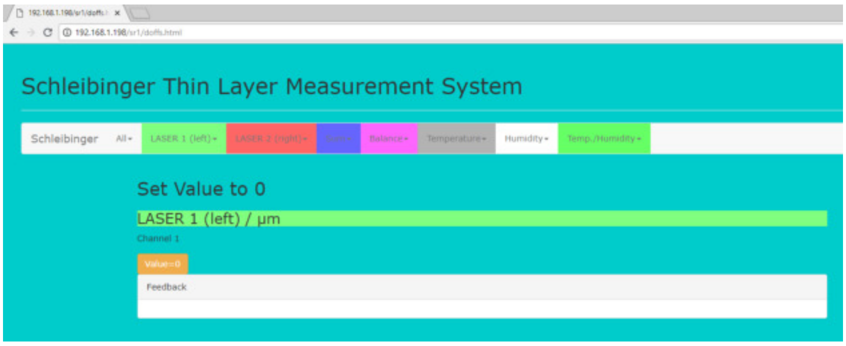


Figure 21: Offset zero

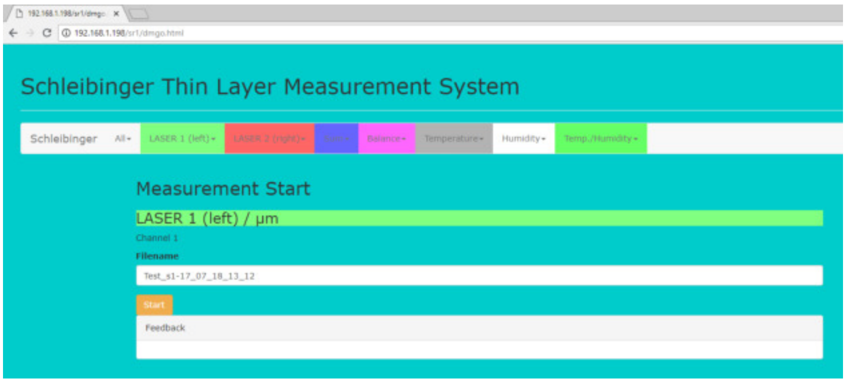


Figure 22: Measurement start

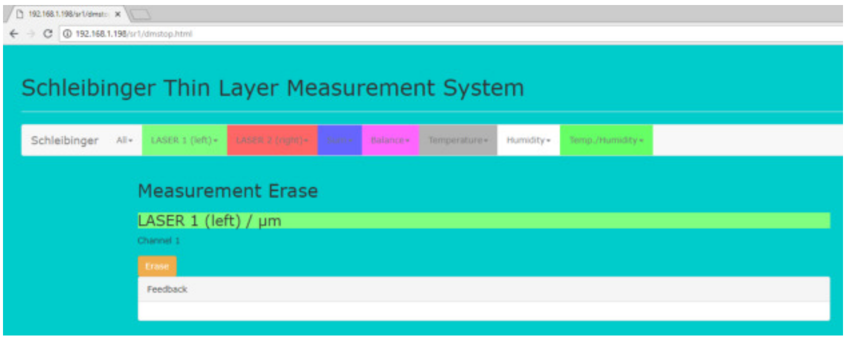


Figure 23: Data reset of single channel

5.2.4 Start Measurement with Quickstart

The start of the measurement can be done for each sensor individually or for all sensors at the same time.

Quickstart is recommend for the measurement of thin layers in which all sensors should be started at the same time.

Before starting measurement the TLMS system has to be prepared as discribed in chapter 4. Subsequently, the LASER values have to be checked:

- Select TLMS system from your web browser
- Check if both LASERS are in the middle of the measuring range by displaying the raw values as described in chapter 5.2.3
- The raw value from the LASER beam should be approximately 32500 - 33000 which means the reflector is placed in the middle of the measurement range of the LASER sensor (Fig. 13).
- Continue with **Quickstart**.

Quickstart can be carried out as follows:

Attention: All data from all channels will be erased!

- Check the range for each sensor (see also chapter 4)
- Click on **All**
- Select **Quickstart** (Fig. 24).
- Enter the filename (optional). The filename will only appear in the column DATASET from **All - Online Display** (Fig. 20)
- Click **Start**

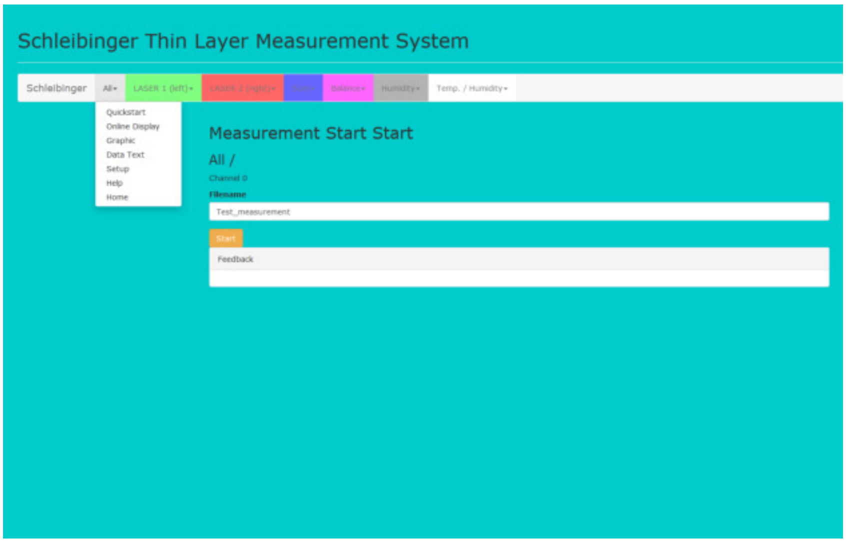


Figure 24: Quickstart for TLMS

5.3 Transferring the datasets

The measurement will be stored localy on the data logger. The memory is non-volatile. For the download of the measured data web browser can be used.

5.3.1 Data file

For each channel text data file is available. For the first channel **data**1**.txt**, for the second channel **data**2**.txt** and for the following channal (**data**n**.txt**) accordingly will be generated.

5.3.2 Data Text single channels

- Select the appropriate channel on the header of the page
- Select **Data Text** and press **Load**
- All measuring data values will be displayed (Fig. 25)
- In the first column seconds since start of the measurement are shown. In the second column the measured values are displayed. The unit of the measured values corresponds to the channel was used and is shown under the header line.
- All columns are separated by tabs.

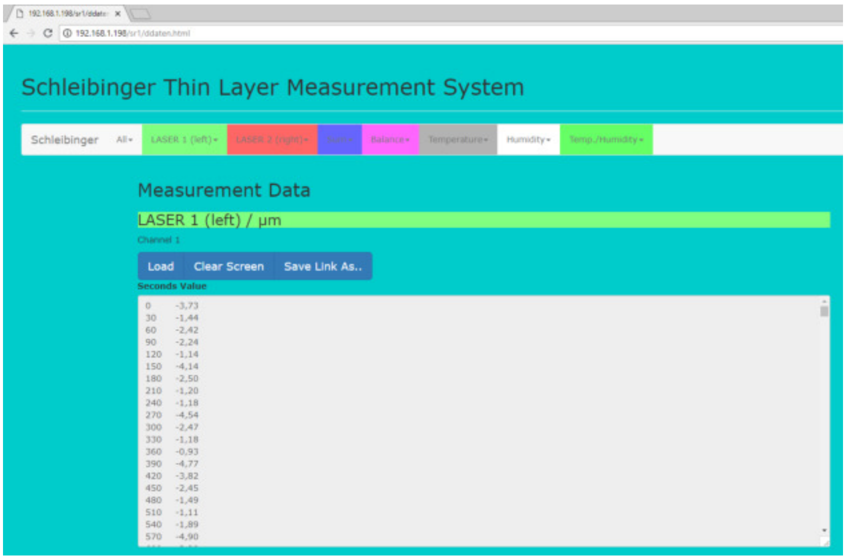


Figure 25: Measurement values of single channel as text file

The data can be copy to the other program like Excel using the clipboard or directly by selecting **Save Link As..**.

For displaying the data in Excel the browser address from the text file should be copied for example: `http://192.168.1.40/daten/data1.txt`.

Open a new Excel sheet and insert the data as following: **data - extern data - data from web**. Insert the copied address, click **import** and follow the import wizard. The data are imported.

5.3.3 All Channels

The data file generated for **All** contains all data from all channels in one (Fig. 26). The format is as follows:

Date	Time	Excel-Time	Channel 1	Channel 2
12.08.04	10:40:32	38211,444815	3999,6	-221,0

please note: The recording interval is 10 times lower compared to the channel 1.

The Excel Time is shown the internal Excel time format. The digits before the comma show the number of days since January, 1st, 1900. The digits after the comma show the fractal part of one day. For example noon time means 0.50000 and 6a.m. means 0.2500. Correct date and time will be shown after import the data into Excel and formating it as date and time. For displaying the data in Excel the browser address from the text file should be copied for example:

`http://192.168.1.40/daten/data0.txt`

Open a new Excel sheet and insert the data as following: **data - extern data - data from web**. Insert the copied address, click **import** and follow the import wizard. The data are imported. Alternative, the data file can be saved by selecting **Save Link As...**.

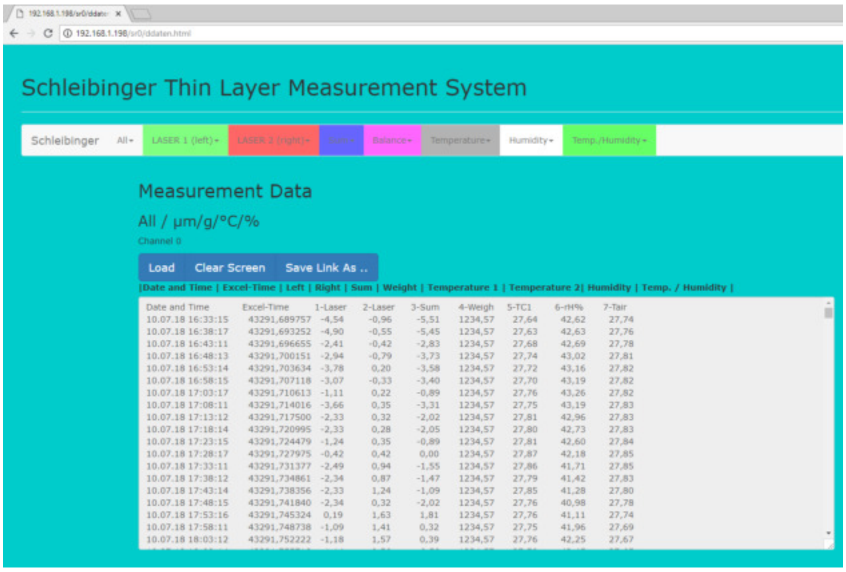


Figure 26: All channels data as text file

5.3.4 FTP

The power user can also use FTP for data transfer. Login name is `ftp`, password is also `ftp` The datasets are in `/httpd/htdocs/daten`. Don't use the Internet-Explorer for this. Its is not according to the ftp standard. We recommend Filezilla (free software), wise-ftp or similar programs.

5.4 Plotting the Measurement Data in HTML5

The web interface of the data logger is offering a modern method to display the measurement data in a graphical way.

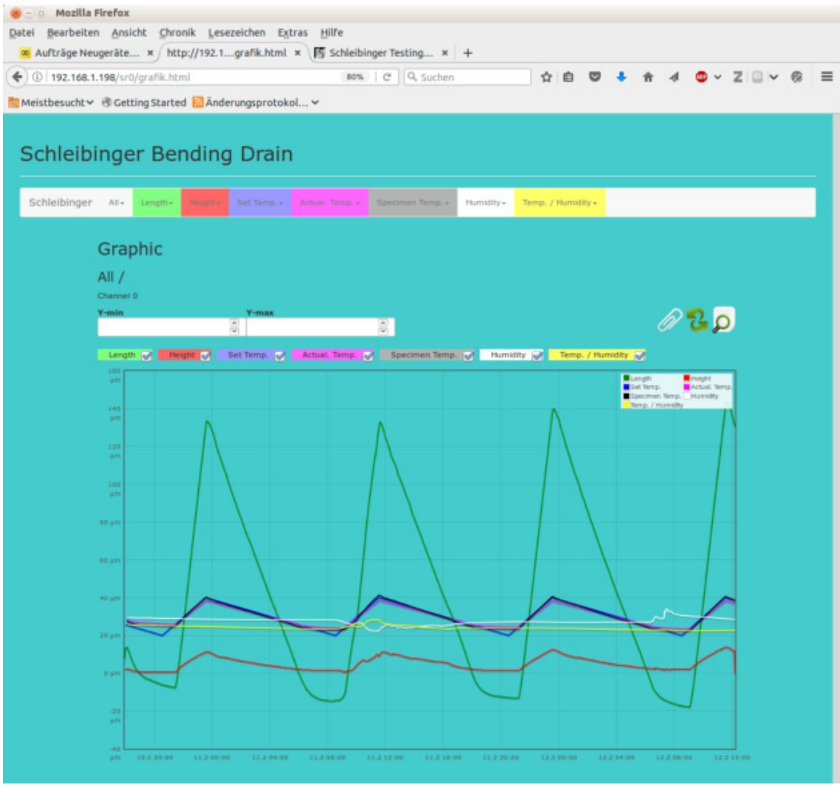


Figure 27: plotting a measurement curve in the Web-Browser

5.4.1 Channel Selection

In the upper area you may see check boxes where you may select the channels that should be shown. The color of the curves are the same then the background color of the channel names.

After selecting the required channels, you have to click on the icon with the two green arrows to reload and draw the data.

5.4.2 Zooming the Y-axis

The FLOT software is trying to find an optimal y-range for the data. You can select the range by putting in valid numbers in the min: and max: input fields.

5.4.3 Zooming the Time Axis

Please press the left mouse button and move the mouse over the region of interest in the time range. The background will change to light yellow. If you If release the mouse button again the plot will be refreshed. If you click on the magnifier icon the whole time range will be shown again.

5.4.4 Insert a Legend

Clicking on the paper-clip icon will open an input field for a text legend, shown in the graph.

5.4.5 Printing the Graph

Firefox: please use the print function of the browser. Select actual frame in the in the printing options dialog of the browser to print the graph without the menus around.

5.5 Interpretation of the results

After the measurement was done the results can be viewed from the Web browser or imported into a Excel file where the data can be further processed.

In general, the shrinkage or expansion of the sample will be given in millimeter (mm) length change per meter (m) of the sample (mm/m). The TLMS provides data of the length change in mikrometer which has to be converted to the millimeter.

From the TLMS the data of LASER 1, left, LASER 2, right and a sum channel 3, **Sum**, can be obtained. The **Sum** channel describes the sum of the channel 1 and the channel 2: the measured values of these channels are summed up. For both channels, channel 1 and channel 2, increasing measuring vallues means the reflector moves away from the LASER and decreasing values means the reflector moves to the LASER [Fig. 28). Therefore increasing values showing shrinkage and decreasing values represent expansion behaviours of the sample measured.

For the analysis of the results the measured values from the **Sum** channel have to be converted into the milimeter and the distance in meter between the reflectors (more precisely between the reflected surfaces) has to be measured. After dividing the measured values from the **Sum** channel by the distance obtained between the reflectors the data can be shown as a graph from the length change of the sample in dependence of time (Fig. 29).

Depending on the setting point of the sample used a pseudo expansion or a pseudo shrinkage within the first hour(s) could appear. The reason for this is the swimming of the reflectors on the sample surface as it spreads. Therefore this period of time must be considered critically.

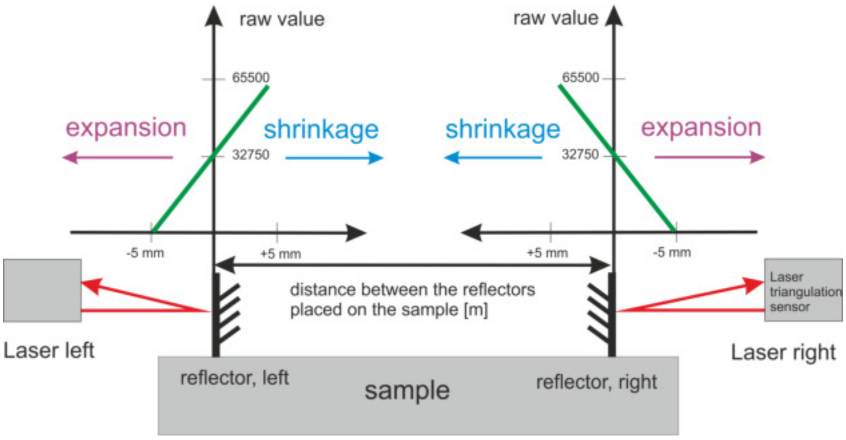


Figure 28: TLMS - schematic representation

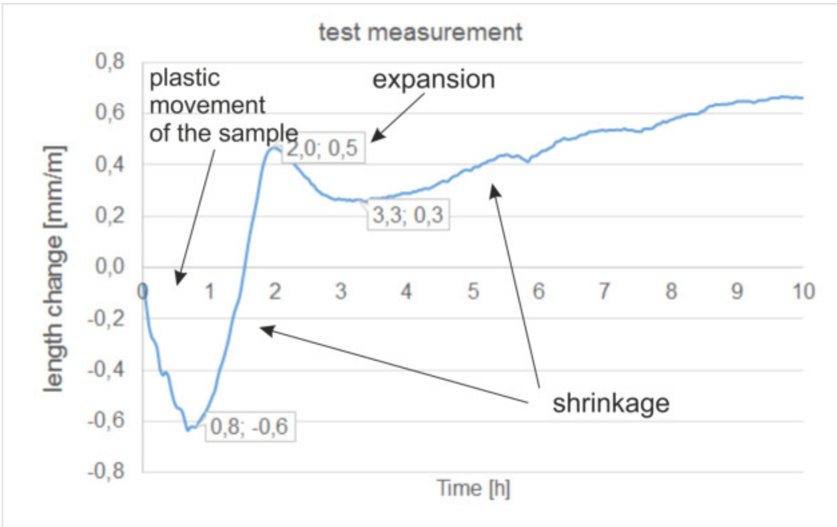


Figure 29: TLMS - Evaluation of the results

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