



By S.Mazenauer ., Keller AG für Druckmesstechnik

CCS30 for the X Line

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Abstract This document is a supplement to the general description of the software CCS30.
 It contains specific information about using the CCS30 software with X-Line pressure transmitters
 (class 5.20 and 5.21)

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1 CCS30 – General information

CCS30 is software provided by KELLER for measuring, setting and configuring a wide range of KELLER products. The transmitters are connected to the PC via an RS485-RS232, RS485-USB or RS485-Ethernet interface converter. This makes it possible to communicate with one or more transmitters via the RS485 bus.

1.1 Accessing the extended area

Certain tabs and settings are not available in normal mode. The settings that can be applied via these tabs go beyond normal use and should only be changed by experienced users. This area is therefore password-protected. To enter the password, go to the main menu: Extras -> Login.

Password: **prof**

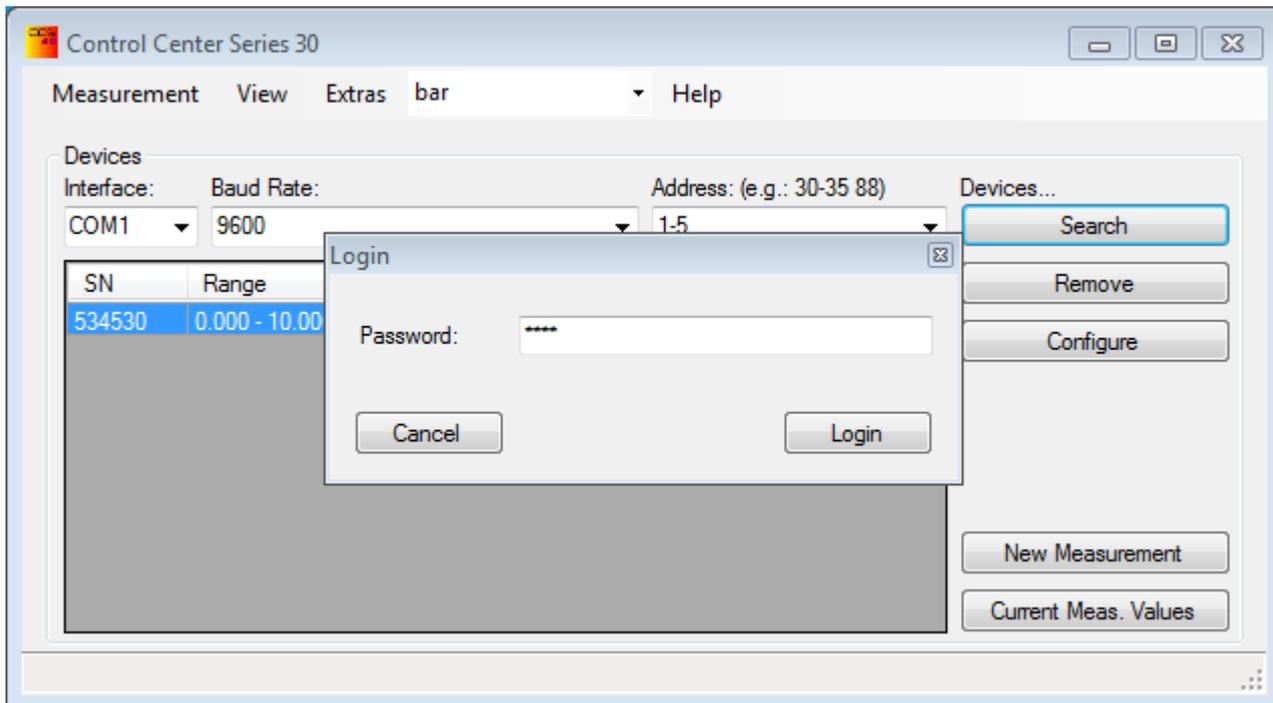


Fig.: Logging in to CCS30

Where the extended area is mentioned in this document, it is necessary to log in to activate these functions every time CCS30 is started.



2 Search

The “Search” button prompts the program to search for individual transmitters automatically and display the devices found in the list. The search process can be modified, for example by limiting the search to a specific interface (COM port) or only searching for devices with a specific communication speed (baud rate).

Limiting the search criteria can speed up the process. If a particular transmitter is expected but is not found, this could be due to the limitations on the search. Check whether the correct interfaces are being scanned, the communication speed set on the transmitter is being used and the correct address(es) of the subscriber on the RS485 bus is (are) being contacted. If you are unsure, simply set the interface, baud rate and address to “auto” to ensure that the software will search for all possible devices.

Please note: if several devices are connected to the RS485 communication lines, the search will not work with address 250 as all bus subscribers will react and respond to this address, leading to collisions in the communication. The software can only identify and contact a connected device on the bus via the general address 250. If several devices are present, the search must be limited to the correct bus addresses or address range. Unless otherwise agreed, transmitters are supplied with address = 1 and 9600 baud.

2.1 Address

If the address is not known, the address 250 can be used to contact every transmitter. However, only ONE transmitter may be connected. For multiple transmitters, the addresses may be separated by blank spaces or a range may be specified using “-” (from... to).

Examples:

Address	Explanation
1-5	Devices with addresses 1, 2, 3, 4 and 5 are searched for
4,7,9	Devices with addresses 4, 7 and 9 are searched for.

3 Remove

Use the “Remove” button to remove a marked transmitter from the list. If you want to display this transmitter again, you must conduct a new search for it using the “Search” button.



4 Current measurements

Click the button "Current measurements" to display the current measurements in a table. This opens the following window:

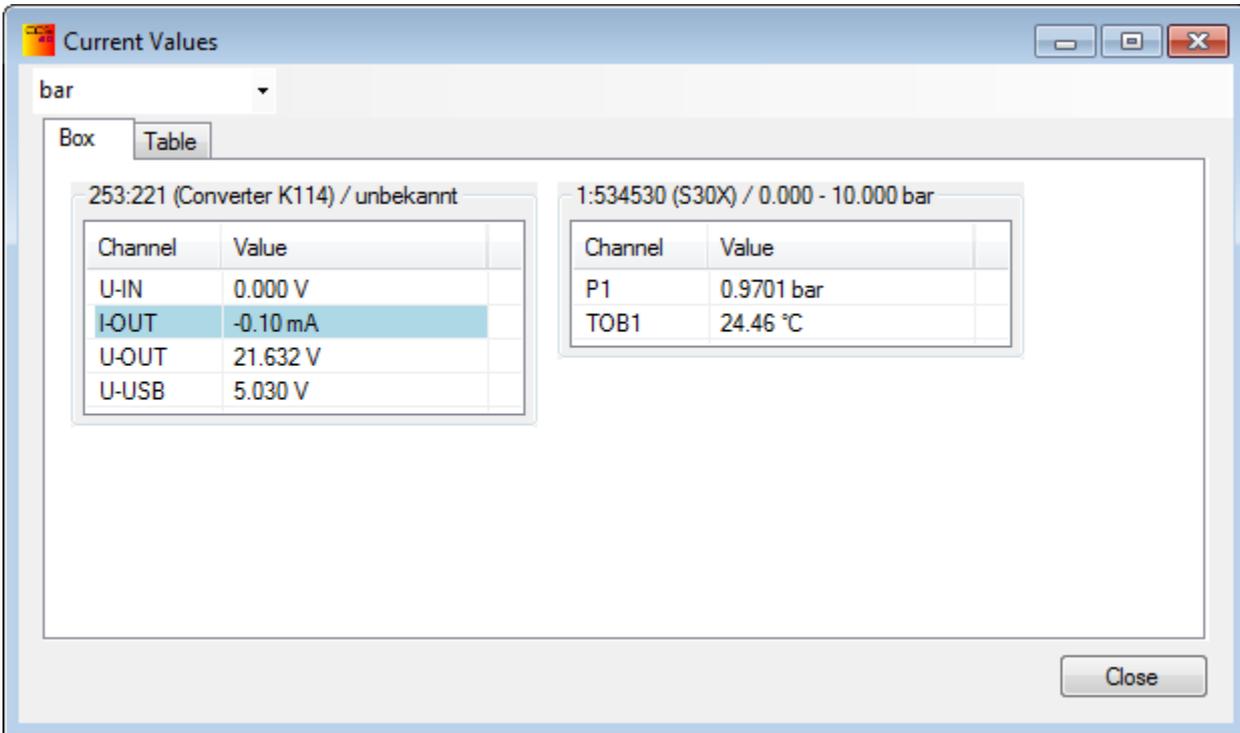


Fig.: Current measurements

A table listing the available channels with the current measurements and units is displayed for each transmitter. The precise settings and options for displaying the current measurements are described in the document [CCS30_Manual_de.pdf](#).

5 Configure

Various settings can be configured in this window. Only the options available for the transmitter type in question are shown. This chapter describes the possible configurations for X-Line transmitters of type 5.20 and 5.21.



5.1 Communication

5.1.1 Setting the baud rate

The baud rate of the transmitter can only be changed in the extended area. To do this, enter the desired baud rate in the window *Configure* -> *New Baud Rate* and write it into the transmitter via "Write". Once this command is entered, type 5.21 transmitters reset themselves automatically and restart with the new baud rate. Type 5.20 transmitters must be disconnected from the power (pull the plug out from the transmitter; do not unplug the USB cable!). The CCS30 software will also change the baud rate and will now communicate with the corresponding transmitter at the new baud rate. (If the configuration window has been closed, you must perform a new search for the transmitter so that it can be displayed with the new baud rate.)

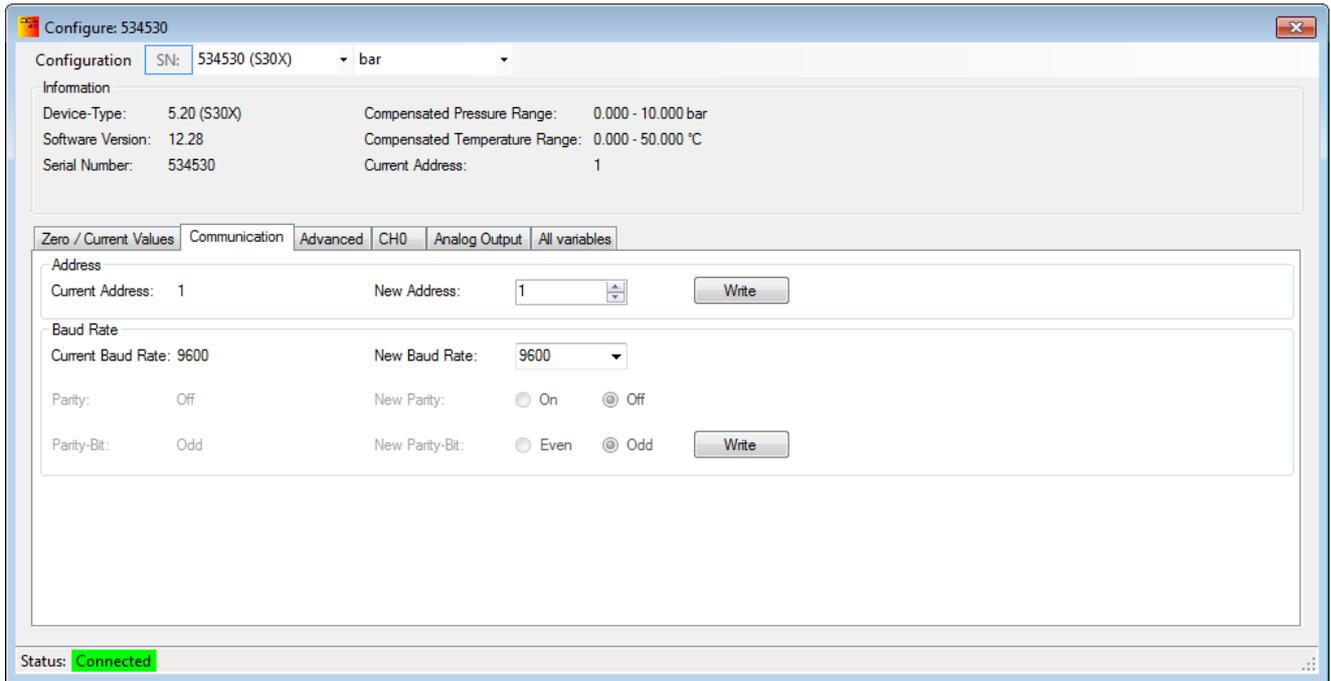


Fig.: Baud rate

Changing the parity: Only change the standard settings if absolutely necessary (e.g. in a bus with other devices). To change the parity, you must enter the password "keller45un" in the login window.

5.1.2 Switching to SDI-12 mode (type 5.21)

Type 5.21 transmitters can be switched from RS485 mode to SDI-12 mode if they have been ordered with this option. This can only be done in the extended mode of the CCS30 software. Please note that once a transmitter has been set to SDI-12 mode, an SDI-12 interface converter is required to put it back in RS485 mode. The button "Activate SDI-12" should therefore be used with caution. The RS485 interface is not accessible in SDI-12 mode (it is deactivated)!



5.2 Measurement concept

5.2.1 Schematic circuit diagram

The X-Line transmitter of type 5.20 is constructed according to the principle A/D conversion → Calculation → D/A conversion. This means that there is no direct electrical connection between the sensor signal and the output signal. This provides for maximum precision as TC and lin errors can be mathematically compensated for to optimum effect and the analogue output can be scaled freely.

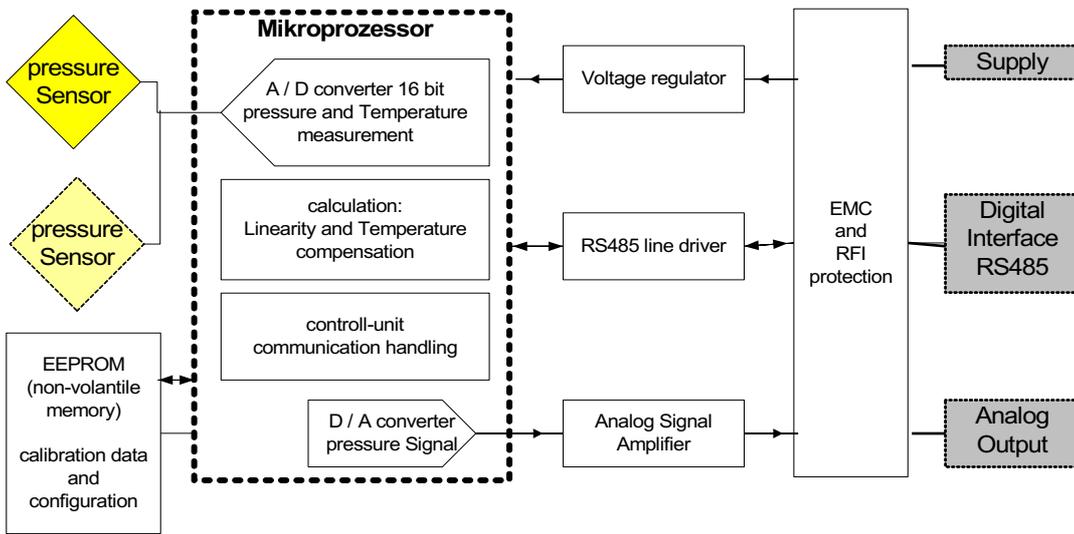


Fig.: Schematic circuit diagram 5.20

The X-Line transmitter of type 5.21 is constructed according to the principle A/D conversion → Calculation. There is no analogue output option with type 5.21. Signals are purely digital and are only available when called.

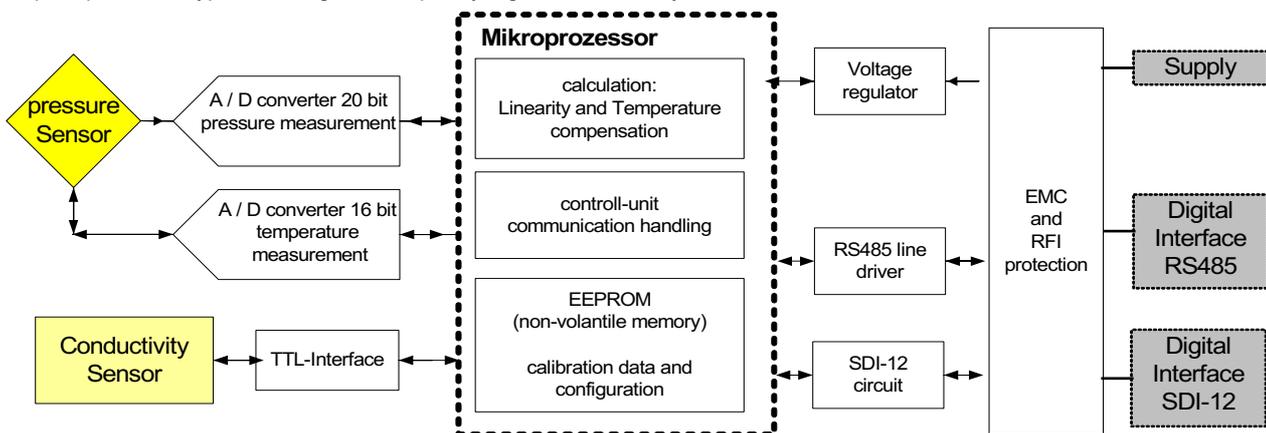


Fig.: Schematic circuit diagram 5.21



5.2.2 Time diagram: measurement and calculation

The signal processing sequence is shown in the following diagram:

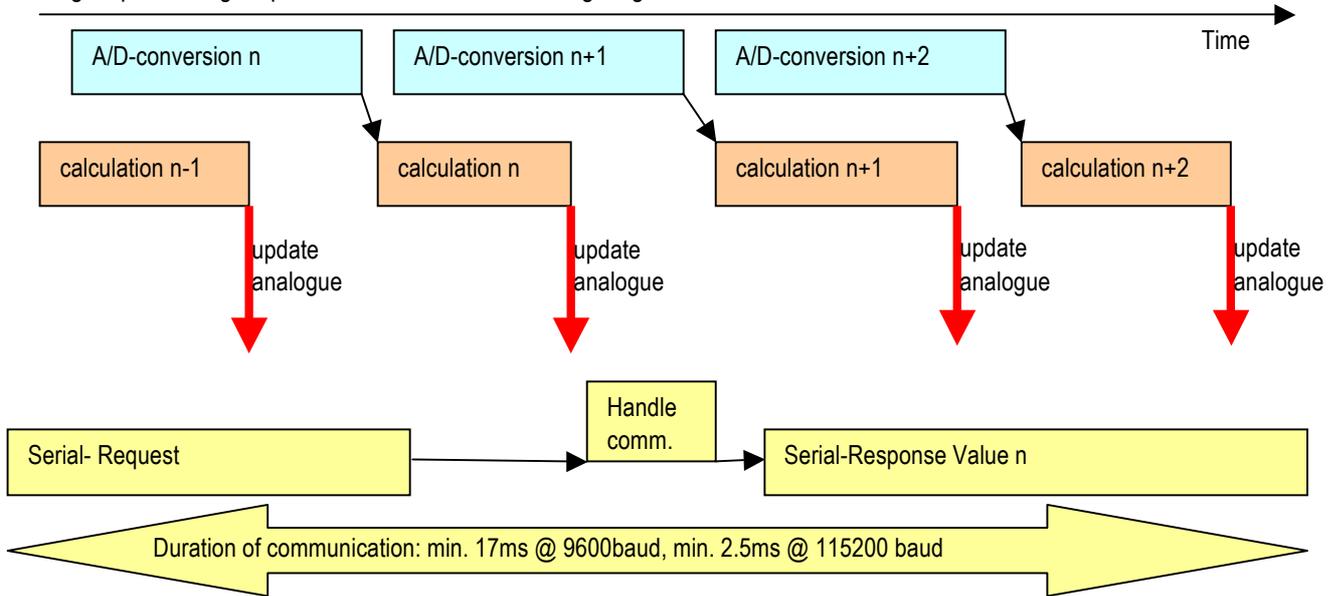


Fig.: Time diagram: measurement and calculation

The conversion time is configurable and can be set via the interface. The calculation takes approx. 1 ms and runs in parallel with the conversion. (The difference between types 5.20 and 5.21 is that no analogue output signal is generated for 5.21.) The configuration of the ADC and filter settings is described in the chapter ADC Configuration and Filters.



5.3 Zeroing the pressure and setting the sensitivity (zeroing/current values)

The pressure value of the transmitter can be zeroed or set to any desired value. The amplification can also be adjusted in extended mode. This option is intended for calibration purposes and should never be used to adjust the unit of the pressure signal. This should be done in the readout electronics for digitally read out measurements and via scaling of the output signal for analogue outputs. The scaling that can be performed in this window has an effect on the digital and analogue value. All of the channels available in this transmitter are shown in this window.

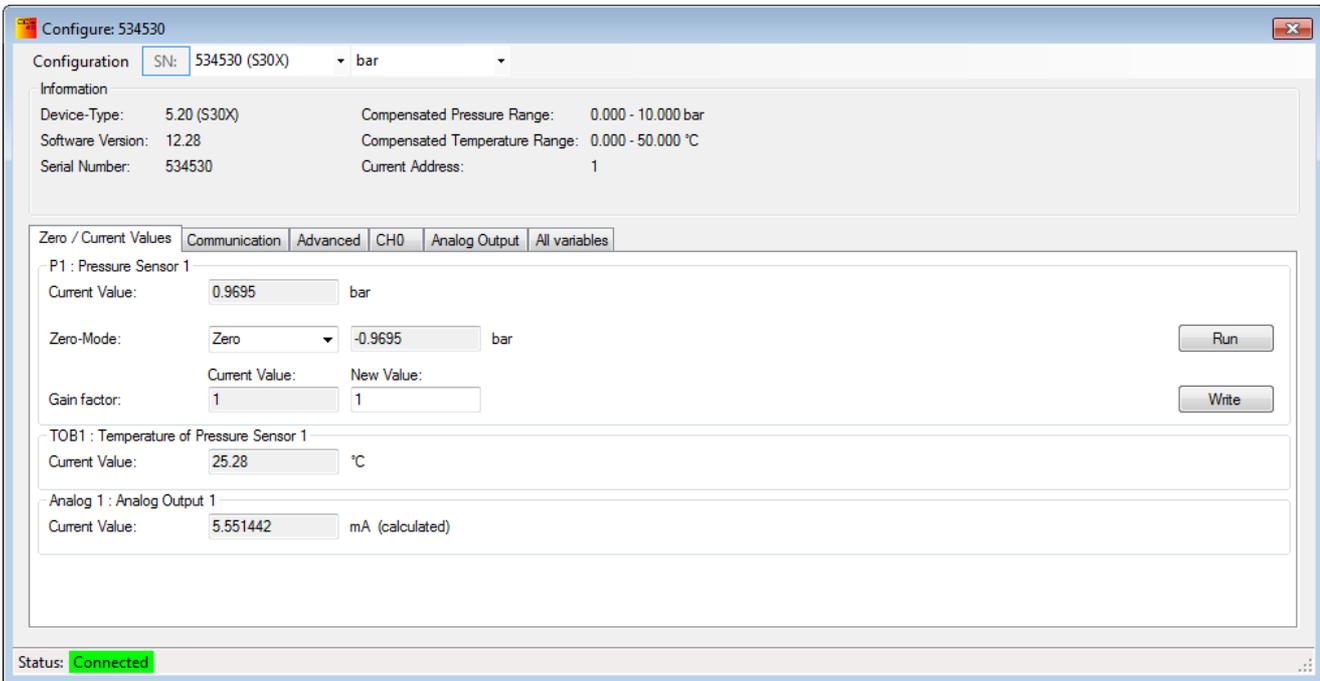


Fig.: Zeroing/current values window

The following settings are available in zeroing mode:

- Zeroing The zero point is set such that zero is shown for the currently measured value.
- Set to The zero point is set such that the specified target value is shown for the currently measured value.
- Standard value The zero point is restored to the factory settings.

5.4 ADC Configuration and filter settings (extended area)

The front end and the AD converter are different in types 5.20 and 5.21. Type 5.20 has a PGA and a 16-bit AD converter in the microcontroller, while type 5.21 uses the differential amplifier and the 20-bit AD converter for the pressure and the 16-bit AD converter for the temperature as a separate component.

All the settings described in this chapter are only available in the extended area.



5.4.1 ADC settings for pressure channel

5.4.1.1 Type 5.20

Samples per Average

A single AD conversion is structured as follows (example with number of measurements per averaging = 2):

Elem. conversion 1	Elem. conversion 2
--------------------	--------------------

Two elementary conversions are averaged. 2, 4 or 8 converter values can be averaged.

The length of the elementary conversion is determined by the setting "Elementary Conversion Time". This should not be changed as it has a slight effect on the sensitivity.

Total conversion time

The total conversion time is influenced by the number of measurements per averaging and the selected baud rate. At a baud rate of 9600 baud, the CPU frequency is slower and an AD conversion therefore takes longer. At a baud rate of 115,200 baud, the CPU frequency is increased by a factor of 1.6 and the AD conversion is correspondingly quicker.

If the elementary conversion time is changed, the zero point and the amplification have to be readjusted. Therefore, it is advisable where possible only to change the number of averagings for the filtering and noise suppression.

The total conversion time is calculated as follows:

$$T_{total_Convert} = Samples_per_Average \cdot T_{convert} (baud)$$

$$T_{convert} (9600) = 1ms \quad T_{convert} (115200) = 0.7ms$$

$$Samples_per_Average = 2 \text{ (default Wert)}$$

An additional time for the calculations in the microcontroller follows the total conversion time before a pressure change becomes visible on the sensor at the analogue output of the transmitter. This calculation takes just under 1 ms without DA conversion and just under 1.5 ms with it. At a baud rate of 115,200 baud and with averaging across two values, the duration is therefore 1.4 ms (elementary conversion time) + 1.4 ms (calculation and DA output time) = 2.8 ms before a signal change at the input is visible at the output.

Adaptive low-pass filter

This is a low-pass filter that can be adjusted. It can distinguish between noises and signal changes and adapt accordingly. The device reacts immediately in the event of a pressure jump. If the signal then remains stable, however, the low-pass filter is activated. The filter is therefore ideal for quasi-static measurements but is not recommended for dynamic ones. This filter can be used in combination with the fixed low-pass filter.

Low-pass filter

Low-pass filter for pressure channels P1 and P2 (if active). The filter operates as follows:

$$P_O(n) = \frac{(2^{LowpassFilter} - 1) * P_O(n-1) + P_I(n)}{2^{LowpassFilter}}$$

PO(n): new filtered value
 PI(n): currently measured value
 PO(n-1): last filtered value

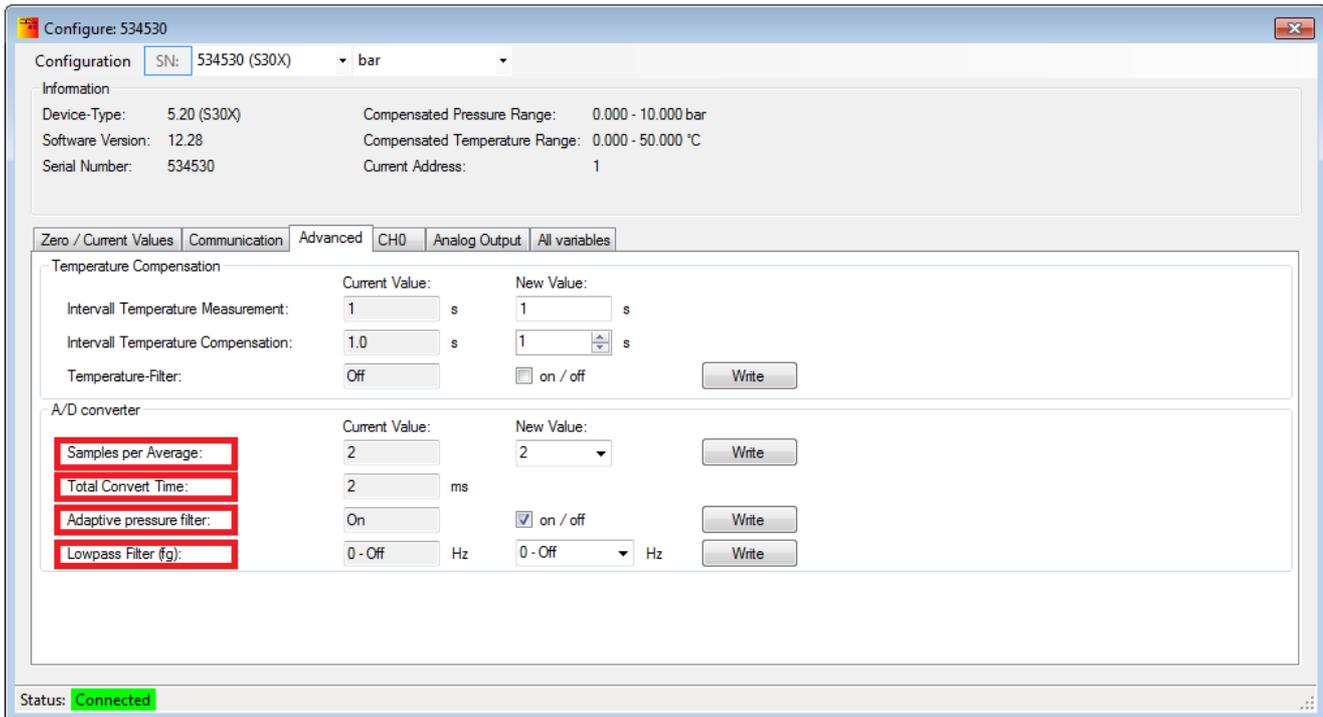


Fig.: Analogue/digital converter configuration 5.20

Filter behaviour and interaction

If a low-pass filter setting of >3 is selected, the adaptive low-pass filter then has virtually no impact as the low-pass filter (fg) is dominant.

Recommendations:

- Standard application: Adaptive low-pass filter active and low-pass filter = 0.
This results in minimal noise (< 20 ppm FS = $1/50,000$ of the measurement range) and a fast reaction to pressure changes.
- Analogue output only: If the measurement signal is filtered adequately at the A/D card, both of these filters can be activated.
- Filtering the pressure signal: Set the low-pass filter according to the application.
- For dynamic measurements, the adaptive pressure filter must be switched off as it can distort the signals.

If the measurement is read out via the RS485 interface, the low-pass filter must be set such that no downsampling occurs. E.g. Read-out rate = 100 Hz \rightarrow Low-pass filter = 3.



5.4.1.2 Type 5.21

The external AD converter of the 5.21 can measure the pressure at three different speeds: 480 SPS, 240 SPS and 120 SPS. The total conversion time is calculated on the basis of this setting in each case. Please note that the calculation time in the microcontroller has to be added on to the conversion time in the AD converter. At a sampling rate of 240 SPS, a new pressure value is measured every 4.17 ms; however, the additional calculation time means that a change in the pressure signal is only visible at the output approximately 5.5 ms after it occurs at the input. As this transmitter can only read out digitally, the time it takes for the signal to be read out is dependent on the read-out time and the baud rate.

When selecting the AD conversion time, it should be noted that the lower the conversion time, the better the noise suppression. Furthermore, an especially high sampling rate is not practical as the data cannot be picked up at all by the Modbus RTU or Keller bus provided at 9,600 or 115,200 baud.

Adaptive low-pass filter

This is a low-pass filter that can be adjusted. It can distinguish between noises and signal changes and adapt accordingly. The device reacts immediately in the event of a pressure jump. If the signal then remains stable, however, the low-pass filter is activated. The filter is therefore ideal for quasi-static measurements but is not recommended for dynamic ones. This filter can be used in combination with the fixed low-pass filter.

Low-pass filter

Low-pass filter for pressure channels P1 and P2 (if active). The filter operates as follows:

$$P_O(n) = \frac{(2^{\text{LowpassFilter}} - 1) * P_O(n-1) + P_I(n)}{2^{\text{LowpassFilter}}}$$

PO(n): new filtered value
PI(n): currently measured value
PO(n-1): last filtered value



Configure: 533885

Configuration SN: 533885 (S30X2) bar

Information

Device-Type: 5.21 (S30X2)	Compensated Pressure Range: 0.800 - 2.300 bar
Software Version: 16.20	Compensated Temperature Range: -20.000 - 80.000 °C
Serial Number: 533885	Current Address: 1

Zero / Current Values | Communication | **Advanced** | All variables

Temperature Compensation

Temperature-Filter: Off on / off Write

A/D converter

	Current Value:	New Value:	
Sampels per Second:	240	240	Write
Total Convert Time:	4 ms	4 ms	
Adaptive pressure filter:	On	<input checked="" type="checkbox"/> on / off	Write
Lowpass Filter (fg):	0 - Off Hz	0 - Off Hz	Write

Status: **Connected**

Fig.: Analogue/digital converter configuration 5.21



5.4.2 Temperature measurement and compensation

The temperature measurement is necessary for these products in order to compensate for the temperature characteristics of the pressure sensor.

The highest priority is given to measuring, calculating and outputting the pressure. The linearity is calculated using a third-degree polynomial. The coefficients of the polynomial for linearisation are temperature-dependent and are recalculated after the temperature measurement.

5.4.2.1 Type 5.20

As the temperature only changes slowly, it is measured less often than the pressure. For type 5.20, the temperature measurement interval can be set and the number of temperature measurements after which a compensation calculation should be performed can also be specified.

As type 5.20 only has one AD converter, one pressure measurement value is omitted at the time of the temperature measurement.

Fig.: Temperature compensation 5.20

Standard settings: as shown.

The temperature measurement values can also be filtered using a low-pass filter (temperature filter). If this filter is active, the temperature measurement interval should be set as low as possible (= 1 s).

$$T_O(n) = \frac{3 \cdot T_O(n-1) + T_I(n)}{4}$$

Formula for the temperature low-pass filter: (cumulative moving average)

$T_O(n)$ current filtered temperature value

$T_O(n-1)$ old filtered temperature value

$T_I(n)$ current measured temperature value



5.4.2.2 Type 5.21

Type 5.21 measures pressure and temperature in parallel. It has two independent external AD converters, one faster one for pressure measurement and one slower one for temperature measurement. The temperature is measured at a fixed interval of 14 SPS and a temperature compensation calculation is performed after every measurement. The temperature can be filtered using a low-pass filter. However, this is not usually necessary as the AD converter is very low-noise for the temperature measurement.

$$T_o(n) = \frac{3 \cdot T_o(n-1) + T_i(n)}{4}$$

Formula for the temperature low-pass filter: (cumulative moving average)

- TO(n) current filtered temperature value
- TO(n-1) old filtered temperature value
- TI(n) current measured temperature value

5.4.3 Settings for conductivity measurements (type 5.21)

For a type 5.21 transmitter that is equipped with a conductivity sensor, the CCS30 software can be used to turn this conductivity sensor on and off. This can be useful for saving energy. Turning off the conductivity sensor reduces power consumption by more than half. (Consumption of the conductivity sensor: approx. 8.5 mA.) However, it must be borne in mind that starting up the conductivity sensor takes approximately 3 seconds, during which time the sensor does not deliver any measurements (NAN).

The conductivity range in which measurements are to be taken, the temperature compensation method and the conductivity temperature coefficient can also be adjusted. It must be ensured that the conductivity to be measured is always within the specified range.

The conductivity sensor can be calibrated. The specified values can be displayed using the CCS30 software but not changed. Separate software is available for calibrating the individual ranges and can be downloaded from the KELLER website: [ConductivityCalibrationTool](#).



Configure: 533885

Configuration SN: 533885 (S30X2) bar

Information

Device-Type: 5.21 (S30X2)	Compensated Pressure Range: 0.800 - 2.300 bar
Software Version: 16.20	Compensated Temperature Range: -20.000 - 80.000 °C
Serial Number: 533885	Current Address: 1

Zero / Current Values | Communication | **Advanced** | All variables

Conductivity Sensor

Conductivity Sensor Version 18 0/2 2

Conductivity Sensor Enabled Write

Measuring Range Conductivity Sensor

Current Measuring Range	New Measuring Range
Range2-> 0..2000uS/cm (2ms/cm)	Range2-> 0..2000uS/cm (2ms/cm) Write

Gain

	Current Value:	Date of Calibration
Range 1:	<input type="text" value="1"/>	17.08.2016 16:01:52
Range 2:	<input type="text" value="1"/>	17.08.2016 16:01:52
Range 3:	<input type="text" value="1"/>	17.08.2016 16:01:52
Range 4:	<input type="text" value="1"/>	17.08.2016 16:01:52

Conductivity Temperature Compensation Method according DIN/EN27888

Current Method	New Method	Write
Linear Temperature Compensation @25°C	<input type="text"/>	

Conductivity Temperature Coefficient % 1/K

Current Value % :	New Value % :	Write
<input type="text" value="2.2"/>	<input type="text"/>	

Conductivity Cell-Constant

Current Value:

Status: **Connected**

Fig.: Conductivity configuration



5.5 Configuring channel 0 (CH0) (type 5.20)

For type 5.20 transmitters, a calculated channel 0 (CH0) can be generated and can be output when configured accordingly, including on the analogue output.

no.	Pressure	Value
0	0	0
1	1.25	2
2	2.5	3.8
3	3.75	5.4
4	5	6.6
5	6.67	8
6	8.33	9.2
7	10	10.2

Fig.: CH0 configuration

The measured pressure value can be converted using preset mathematical formulae. This can be used e.g. to “measure” the flow rate or the fill level in a tank.

Mathematical functions available for the channel CH0:

- 1 P1 - P2 Differential pressure between two absolute cells (PD-39X)
- 3 Root of (P1) Flow rate calculation for relative differential pressure (PD-33X)
- 5 Root of (P1-P2) Flow rate calculation for differential pressure between two absolute cells (PD-39X)
- 14 Curve fitting with straight lines

(Depending on the transmitter, not all calculations are available for the channel 0 (CH0))

Version 5.21 transmitters currently do not have a calculated channel 0 (CH0).



5.6 Analogue output (type 5.20)

Depending on the version of type 5.20, the transmitter has an analogue current output (4 ... 20 mA) or a voltage output (0 ... 10V or 0 ... 2.5 V). This analogue output range can now be assigned to a pressure range so that the current pressure value can be read out via the analogue signal.

The measurable pressure range is defined by the compensated pressure range $\pm 10\%$. However, the scaling of the analogue signal is not limited: only a partial range can be output, the signal can be defined as inversely proportional or a pressure range that is larger than the compensated pressure range can be set. In this final case, only a part of the analogue output range is then used: for example, a 0 ... 10 V output can be changed to 0 ... 5 V.

The available settings are identical in the standard area and extended area. In the extended area, it is also possible to output the signal of the channel 0 (CH0) at the analogue output, if it is active.

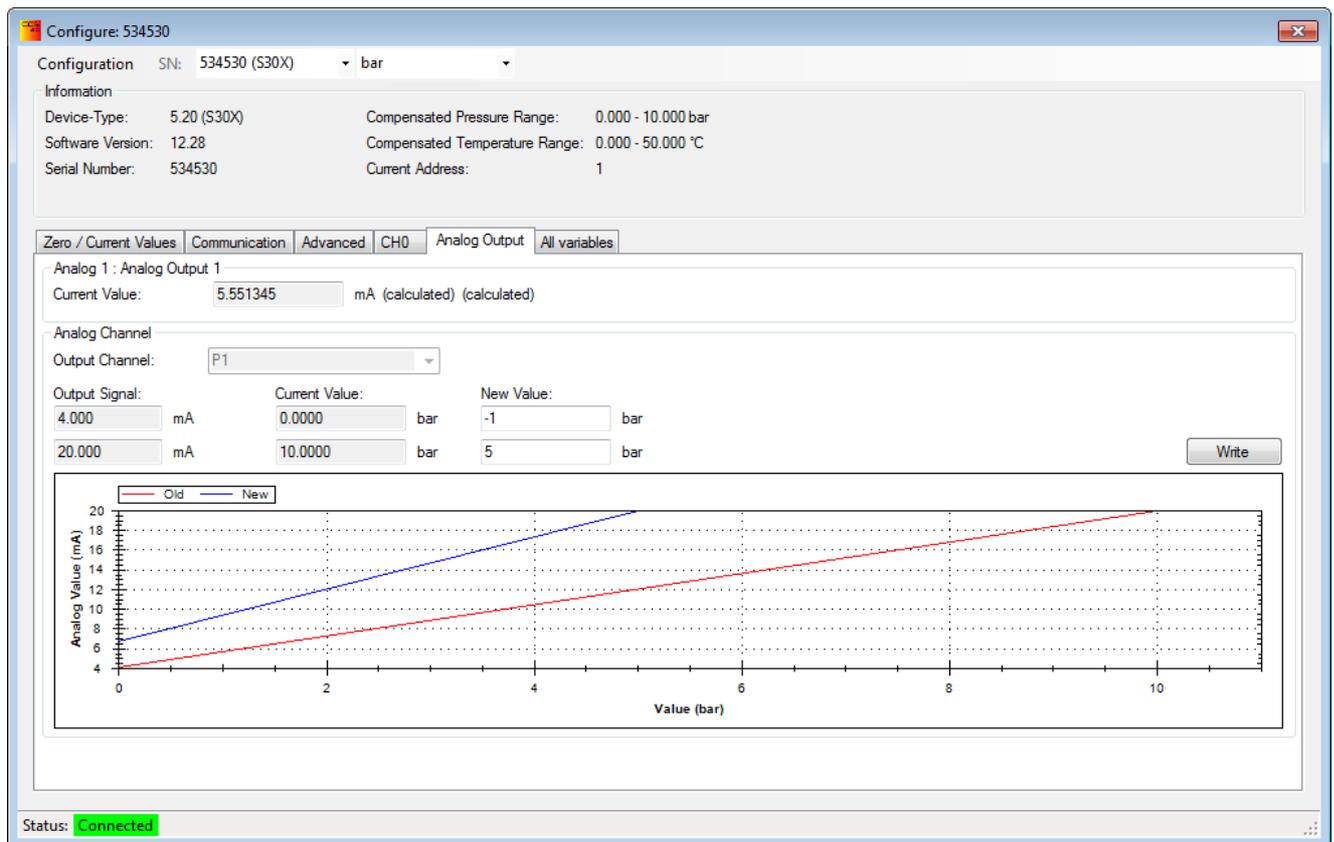


Fig.: Analogue output settings

Type 5.21 transmitters do not have an analogue output – they can only be read out digitally.



5.6.1 Analogue output limits

The graph below shows the transfer function of the pressure on the analogue output signal (in this example, the analogue signal is a function of the pressure P , but the calculated channel CH0 can also be output at the analogue output).

The analogue signal has a nominal range value of Sig_min to Sig_max which lies slightly above/below the limits Sig_uvl and Sig_ovl , respectively.

If the pressure is at the range limits (compensated pressure range $\pm 10\%$), the digital is output as $\pm Inf$ and the analogue value is set to Sig_uvl or Sig_ovl , respectively.

An internal error (e.g. measuring cell failure) is displayed digitally as NaN and at the analogue output with the value Sig_error .

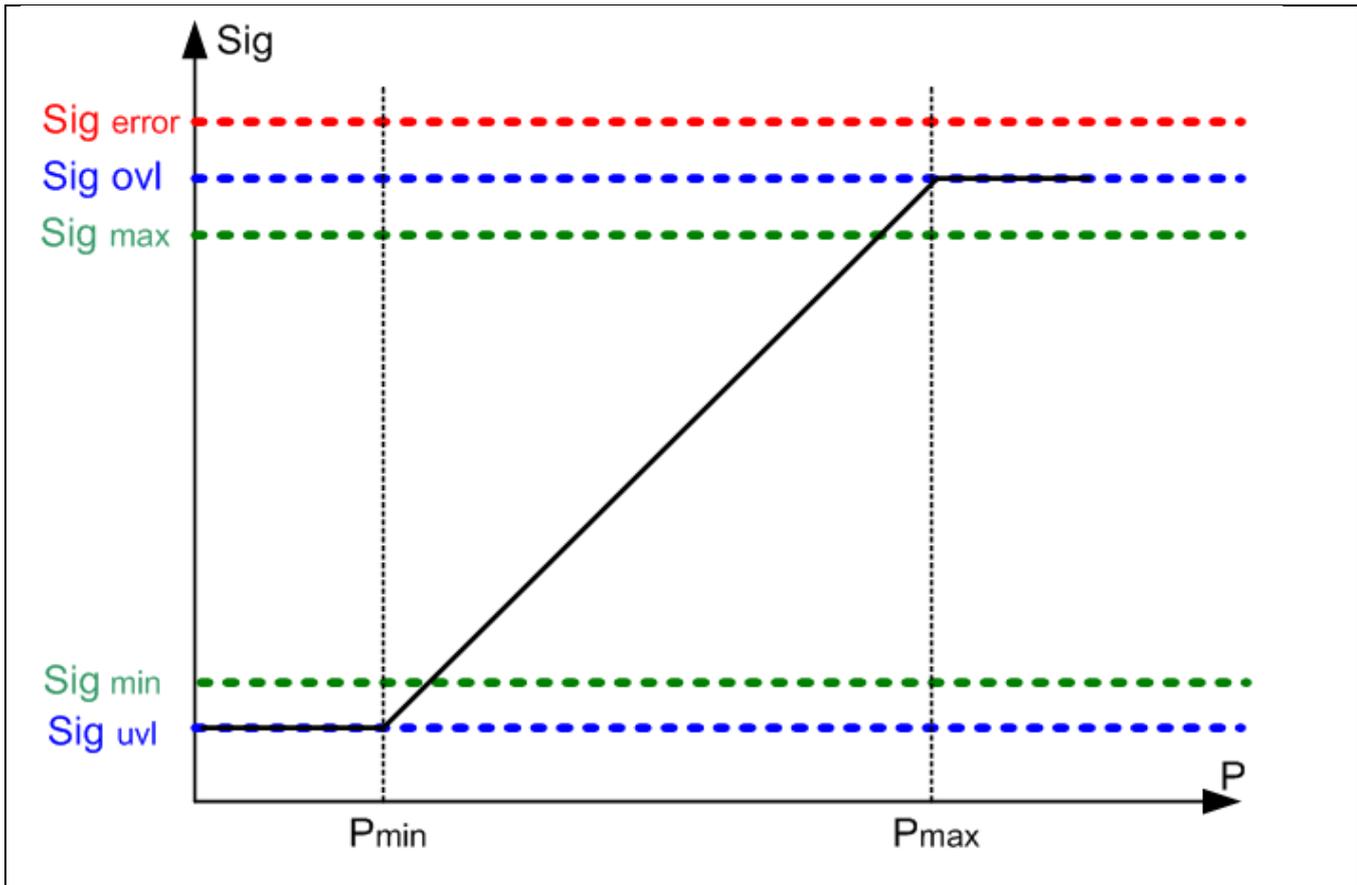


Fig.: Analogue output range limits

Output signals for the various analogue signal variants.

	0-10 V, (0..5V)	0-2.5 V	4-20 mA	Digital value
Sig_{error}	11.6 V	2.9 V	22.5 mA	NaN
Sig_{ovl}	11 V	2.75 V	21.8 mA	+Inf
Sig_{max}	10 V	2.5 V	20 mA	value
Sig_{min}	0 V	0 V	4 mA	value
Sig_{uvl}	-1 V	-0.3 V	3.3..3.6 mA	-Inf



6 New measurement

Various measurements can be recorded and represented graphically in this window. The values can also be saved in a *.csv file if configured accordingly. "Start" begins a measurement and "Stop" ends it. The recorded values can be deleted via the button "Delete measurements".

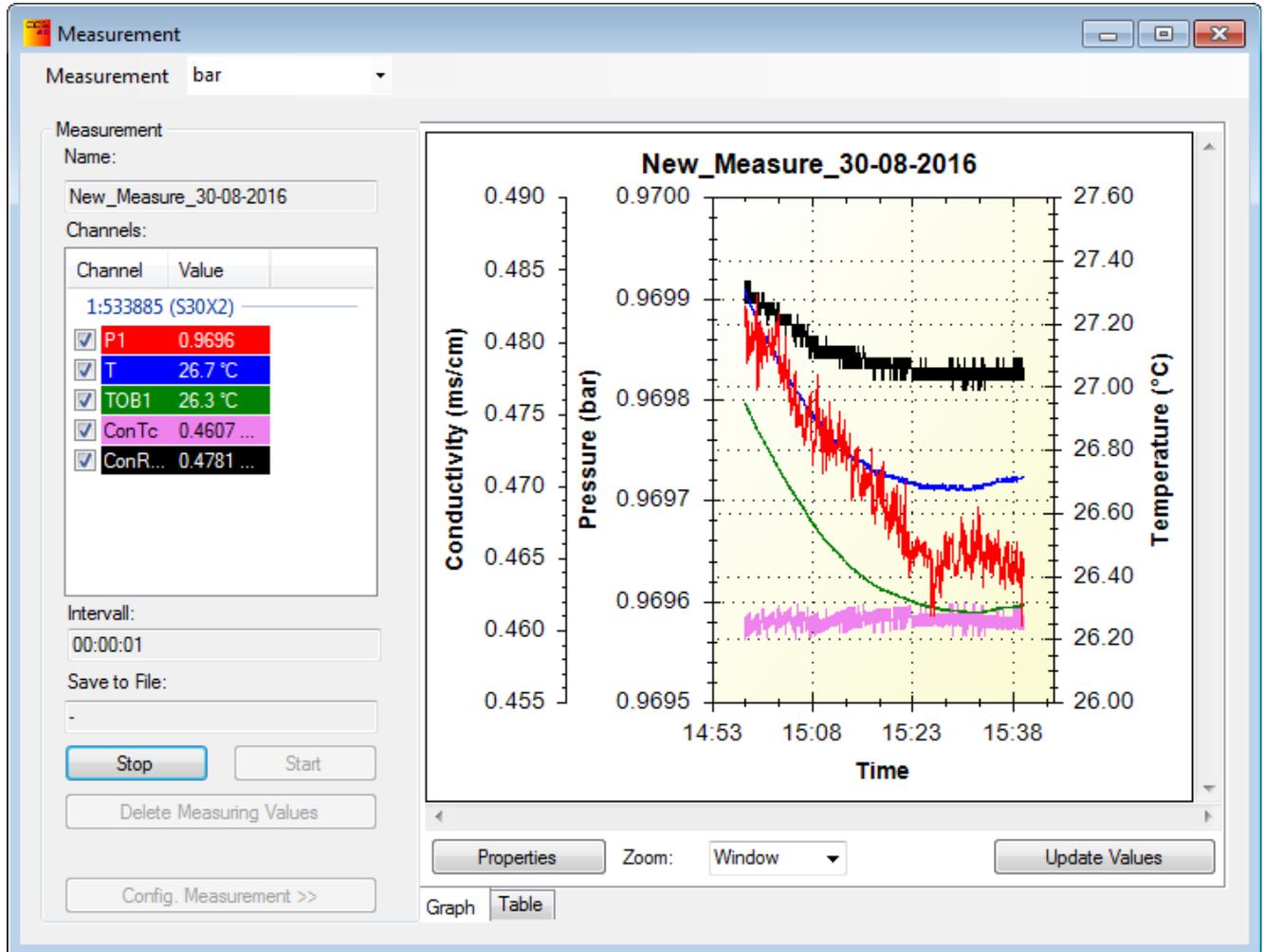


Fig.: Measurement

The precise settings and options for recording the measurements are described in the document CCS30_Manual_de.pdf.



7 Annex

7.1 Modifications

- **Document version 1.0:** First release

7.2 Support

KELLER AG für Druckmesstechnik

St. Gallerstrasse 119

CH-8404 Winterthur

T+41 52 235 25 25

www.keller-druck.com