AM-IPE4k

User Manual

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AMAC ASIC- und Mikrosensoranwendung Chemnitz GmbH
Kopernikusstr. 16
D-09117 Chemnitz
Germany

Tel.: +49 371 334204 - 0
Fax: +49 371 334204 - 69
E-Mail: info@amac-chemnitz.de
Web: www.amac-chemnitz.de

Revision history

Date	Revision	Change(s)
16/10/2017	1.0	First version (preliminary)
11/05/2020	1.1	Figure 1: Block diagram updated to english Table 1: Feature overview update to the IPE4K datasheet Figure 4: Measuring system connection update figure english Table 2: Description of the input amplifier Bit CFG1/LPF to CFG2/LP Table 4: Correction register DISKSC 0x013 [1] changed to 0x013 [2] and 0x09[9] changed to 0x09[10] DISK360 0x013 [2] changed to 0x013 [1] and 0x09[10] changed to 0x09[9] Table 6: Configuration of the reference point CGFG1/Z4 changed to CFG3/Z4 Output signals RS-422 – ABZ mode reference Figure 4 changed to Figure 6 At 4.5Teach signal TEAN to TEAEN and CFG1 to CFG2. Table 11: Configuration of the digital hysteresis value corrected to length of registert 000. Figure 9: IP4k monitor – Start window english figure update. Figure 10: Interpolation measurement 1 english description added Table 21: Error LEDs ESOFF changed to offset error Figure 11: Interpolation measurement 2 Figure 12: Configuration readout english version Figure 13: Sensor parameterenglish version Figure 14: Sensor expert – CFG1 english version Figure 15: Sensor expert – CFG2 english version Figure 16: Sensor expert – CFG3 english version Figure 17: Sensor expert – CFG4 english version Figure 18: Sensor expert – SSI english version Figure 19: Sensor expert – PRE_ST english version Figure 21: Sensor expert – IUW english version Figure 21: Sensor expert – IUW english version Figure 22: Sensor expert – LDRenglish version Figure 23: Sensor expert – LDR2 english version Figure 24: Hardware – Communication english version Figure 25: Software – Display english version Figure :26 Software Streaming english version Figure 27: Oscilloscope – Time-based oscillogram english version Figure 28: Oscilloscope – XY representation english version Table 26: Hardware configuration as delivered Vss corrected to Vpp SPI sub D Table 14: Connector SUB-D 15-pin → SPI added Figures from Software updated to new version software. IP4k Monitor version 0.9.2.66 Table 21: Error LEDs ESADC and ECADC error at a large offset and high amplitude at the same time corrected. Hardware communication corrected. Updated to Software options and according circiut for IPE4k. ABZ deleted.

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List of abbreviations

AVSS	–	Ground analogue (GND)
A	–	Square wave signal A (P = positive; N = negative)
B	–	Square wave signal B (P = positive; N = negative)
COS	–	Cosine signal (P = positive; N = negative)
DNC	–	Do not connect
DVDD	–	Supply voltage digital (+ 5 V)
DVSS	–	Ground digital (GND)
EN	–	Error signal negative
EP	–	Error signal positive
MA	–	Master clock SSI (P = positive; N = negative)
REF	–	Reference signal (P = positive; N = negative)
RS-422	–	EIA-422 (line-bound differential serial data transmission)
SENSVDD	–	Supply voltage analogue (+ 5 V)
SIN	–	Sine signal (P = positive; N = negative)
SLI	–	SSI data input (P = positive; N = negative)
SLO	–	SSI data output (P = positive; N = negative)
SPI	–	Serial peripheral interface
SSI	–	Synchronous serial interface
TEACH	–	Teach signal of the AM-IP4k
TRG	–	Trigger signal of the AM-IP4k
V0	–	Mean voltage
Vpp	–	Peak-to-peak voltage
Z	–	Square wave signal Z (P = positive; N = negative)
ZER	–	Zero signal of the AM-IP4k

1 Overview

The programmable interpolation unit IPE4k is designed to increase the resolution of incremental position and angular measuring systems with sinusoidal output signals offset by 90°. It can be used with various encoder systems, which operate according to different measuring principles. The signal period is divided up to 4096 times. The interpolation unit can be used with both single-ended and differential input signals. The configuration is carried out either via USB, via SSI interface, or via the internal EEPROM of the AM-IP4k. It is possible to equip the interpolation unit with a SPI interface (3.3 V or 5 V system).
An AMAC-specific gain and offset control as well as the phase correction of the AM-IP4k inside ensure a high accuracy of measurement in industrial environments.
The interpolation unit can be connected to a standard meter or to a control (delivery status) via RS-422 interface. Alternatively, it is possible to change the configuration via USB and to connect the unit to a SSI master. The operating voltage is 5 VDC.
The interpolation unit suits perfectly the use in control systems because of the features of the interpolation circuit AM-IP4k, such as configurable low pass filter or a digital hysteresis.

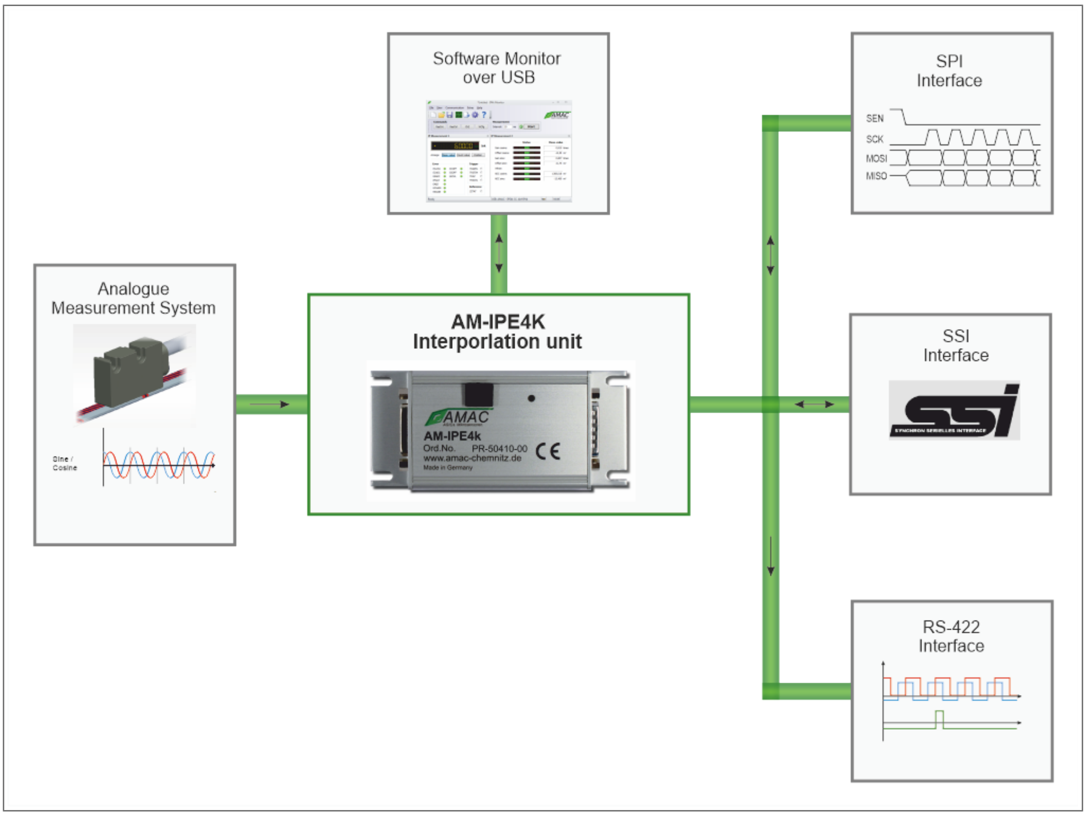


Figure 1: Block diagram

Info:
Detailed descriptions of all features can be found in the data sheet of the AM-IP4k.

2 Features

Table 1: Feature overview

Interfaces	
Analogue input	- Sine- / Cosine- / Reference signal; differential or single-ended* - Nominal amplitude configurable to 1 V_{pp} / 500 mV_{pp} / 250 mV_{pp} / 75 mV_{pp} - Maximum input frequency up to 220 kHz
ABZ	- 90° square wave sequences (A/B/Z). - Adjustable width of the index signal Z of ¼ or 1 period A/B - Error signal - Interrupt signal for µC - Additional signals for sensor adjustment
SPI[1)]	- 30 bit count value / 16 bit multi-turn value - Data rate up to to 500,000 measured values/s - 9 bit signal monitoring - Compatible with standard SPI: 16 bit, MSB first, up to 25 MHz - Signal filter for noise suppression to be enabled
SSI	- Up to 30 bit count value / 16 bit multi-turn value - SSI 20 bit or 32 bit - 2 bit signal monitoring - Gray code / Binary code - Adjustable timing - SSI ring mode
Other inputs	- Trigger signal for measured value storage - Zero signal and teach signal for sensor's zero point adjustment and storage
Current ouput	- Controlling a laser diode for optical sensors - Controlled by square of the input signal's absolute value
Configuration options	- Internal EEPROM - Serial SPI interface[1)]
Interpolation / Signal processing	
Interpolation rates	- Interpolation basis rate: 4096, 4000, 3200, 2560 - Configurable divider: 1, 2, 4, 8, 16, 32, 64, 128 additionally for basic IR 4096 (256, 512, 1024) - Interpolation rate adjustable at will via EEPROM table, default IR setting value 2560
Signal adjustment	- AMAC-specific digital controller for offset, control range ±10% of the nominal amplitude - AMAC-specific digital controller for amplitude, control range 60% … 120% of the nominal amplitude - Digital potentiometer with 64 steps for phase correction; setting range ±5° or ±10° - Input signal monitoring with configurable error indication
Signal correction	- Wobble correction for periodic errors over 360° (rotary encoder) - Signal form correction for periodic errors within one sine/cosine period (for linear encoder too) - Can be activated or deactivated separately
Interference suppression	- Adjustable low pass filter (Cut off frequencies10 kHz, 75 kHz, 250 kHz) - Digital hysteresis to suppress output edge noise - Adjustable minimum edge separation (band width limitation) at the output
Reference signal processing	- Adjustable reference position 0 … 360° - Determination of the optimum reference position via SPI or additional signals - Processing of distance coded reference marks - Measured value trigger at the reference position
Other	- 2-stage measured value trigger - Programmable timer (3.2 µs … 420 ms) - Constant delay between sampling and measurement for all resolutions (at 40 MHz) without signal correction 2.35 µs, respectively 3.95 µs with signal correction - Multi-turn counter
Main features	
Operating voltage	5 VDC
I/O voltage, digital	3.3 VDC
Temperature range	-40 … +125°C
Interface clock frequency	SPI 25 MHz (15 MHz via on-board USB-SPI-Converter), SSI 5 MHz

[1)] If the SPI option is selected

* with external adjustment (negative inputs SINN, COSN, REFN at mean voltage) respectively operating AM-IP4k at single-ended mode (CFG3_SE_VR_int=1) using VM_OUT as mean voltage for SINP, COSP and REFP (negative inputs SINN, COSN, REFN internally set directly at VM)

3 Input signals

The IPE4k requires voltage signals as input signals, having a sinusoidal dependency on the measured value (position or angle) and a 90° phase shift related to a period of the scale. A third input signal is used as reference point signal to determine the zero point at the scale. It is possible to process all three input signals as single-ended as well as differential signals.

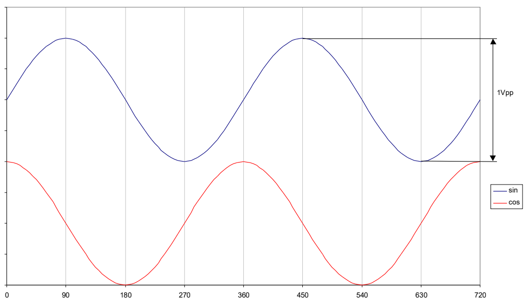


Figure 2: Input signal (single-ended)

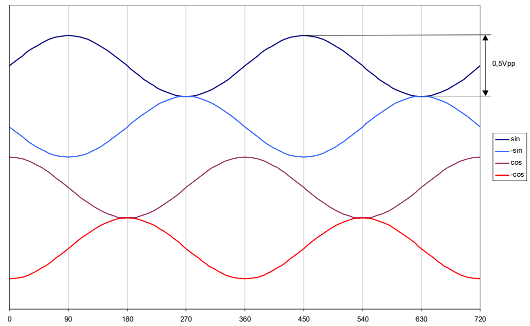


Figure 3: Input signal (differential)

3.1 Measuring system connection

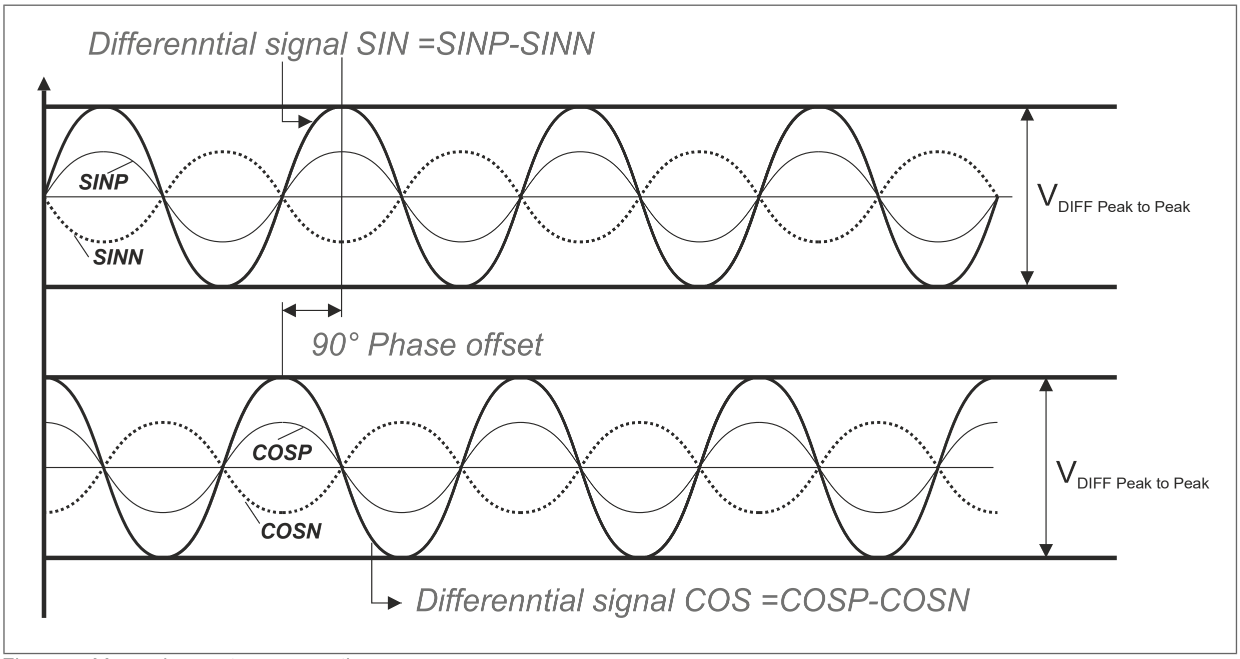


Figure 4: Measuring system connection

3.2 Description of the input amplifier

The gain can be set using the register CFG1 (see also the AM-IP4k's data sheet).

Table 2: Description of the input amplifier

CFG1/GAIN(1:0)	00	01	10	11
Input voltage for differential supply at each input (mV_{pp}) [1]	500	250	125	37.5
Input voltage for single-ended supply (mV_{pp}) [2]	1000	500	250	75
Input voltage range for interpolation V_{Diff} (mV_{pp})	600...1200	300...600	150...300	45...90
Mean voltage at input (V)	2.5	2.5	2.5	2.5
Mean voltage at SMON/CMON nominal (V)	1.1	1.1	1.1	1.1
Gain factor ($2xV_{MON}$ / V_{DIFF})[3]	1.27	2.54	5.24	16.76
Bit CFG2 / LP	recommended	recommended	recommended	necessary

[1] At each of the inputs SINP, SINN, COSP, COSN
[2] SE_AMP2 = 1, SE_HALB = 1
[3] WIDE = 0, SE_AMP2 = 0, SE_HALB = 0

3.3 Signal adjustment and correction

3.3.1 Amplitude and Offset

The input signals are subjected to an AMAC-specific gain and offset control. The amplitudes are controlled within a range between 60 % and 120 % of the nominal amplitude. The control range of the offset of both input signals is ±10 % of the nominal amplitude. The phase deviation of the input signals can be corrected statically within a range of ± 5° and ± 10° using the internal digital potentiometer.

Table 3: Signal correction

Parameter	in percent of the nominal amplitude (PEAK-PEAK)	in percent of the ADC-Maximum (PEAK-PEAK)	in mV of the standard signal (0.66 Vpp)	in V at Pin SMON or CMON (PEAK-PEAK)
Maximum value at the input ($Vmax_{pp}$)	150	100	990	1.90
Nominal value of the input signal ($Vnom_{pp}$)	100	66.7	660	1.27
Amplitude's guaranteed control range	60 ... 120	40 ... 80	400 ... 800	0.76 … 1.52
Setting range of the amplitude controller	56 ... 168 [1]	38 ... 112 [1]	370 ... 1110 [1]	0.71 … 2.13 [1]
Vector monitoring [2]	30	20	200	0.38
Offset's guaranteed control range (sensor)	±15	±10	±70	±0.133
Setting range of the offset controller	±25	±17	±165	±0.315

[1] The amplitude's setting range exceeds the ADC's dynamic range.
[2] A sum signal of sine and cosine is monitored, see chapter 7.6 bit VLOW at the data sheet of the AM-IP4k.

3.3.2 Correction of periodic errors

Two corrections can be applied to the sampled signal for periodic error compensation. The 360° correction (wobble correction) of position errors during a complete sensor rotation is suitable only for rotary encoders. In contrast, the SC correction[3] (signal form correction) analyses a single sine period of the sensor signal and therefore can be applied to linear encoders, too.

The corrections can be activated and deactivated separately, but work only with a valid EEPROM configuration loaded. Besides general settings this configuration has to contain the correction coefficients valid for a particular input signal.

Table 4: Correction register

Name	SPI-Address [Bit]	EEP-Address [Bit]	Function
DISKSC	0x13 [2]	0x09 [10]	'1' = SC correction off
DISK360	0x13 [1]	0x09 [9]	'1' = 360° correction off
Koeffizienten_360	0x40...0x5F	0xA0...0xBF	Table of coefficients for 360° correction
Koeffizienten_SC	0x60...0x7F	0xC0...0xDF	Table of coefficients for SC correction
Zahnzahl	0x1B [4:0]...0x1A[7:0]	0x0D[12:0]	Number of teeth for 360° correction
Korrekturwert SC	0x94...0x97	-	Calculated correction value SC correction
Korrekturwert 360	0x98...0x9B	-	Calculated correction value 360° correction
LDR_OUT	0x9C...0x9F	-	Output value of laser diode control

Note:
The current software release of the IP4k Monitor does not yet include the determination and calculation of the signal correction coefficients for periodic errors. These features will be part of a future software release.

3.4 Reference signal

The reference signal is usually also called index respectively zero point signal, or Z-signal. A reference point is detected as the voltage at the input pin REFP is higher than the voltage at the input pin REFN.

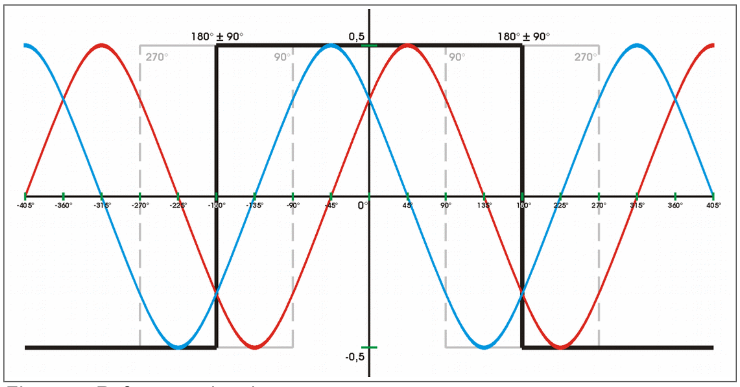


Figure 5: Reference signal

Info:
If there is no need for a reference signal at the input, the reference point processing may be switched off using the internal configuration of the IPE4k.

Table 5: Internal reference signal

Register values CFG3 / DISZ	Meaning
0	Reference signal at output active
1	Reference signal at output inactive

Info:
The shape of the Z-signal at the IPE4k's output can be adapted to different applications by configuring the IC. If an increment is selected for the width of a Z-signal, the Z-impulse at the output will correspond exactly to a quarter period of the signals A and B. The Z-impulse will last one full period if four increments are selected.

Table 6: Configuration of the reference point

Register values CFG3 / Z4	Meaning
0	1 increment = ¼ period
1	4 increments = 1 period

4 Output and input signals

The IPE4k runs two different modes. The ABZ mode is the normal counter mode with ABZ signals at the output. Operating at SSI mode (only counter mode), it is possible to read out measured values via the interface. The IPE4k will be delivered running ABZ mode, but modes can be configured by USB.

4.1 Output signals RS-422 – ABZ mode

The phase-shifted square-wave signals, to be counted by single or quadruple evaluation, typical for incremental encoders, are the output signals at ABZ mode. A synchronous Z-signal will be generated if an angle of 0° (see also figure 5) is passed through and the analogue differential input voltage between the reference signal inputs **REFP** and **REFN** is positive. If the differential input voltage is permanently positive, the reference impulse will be generated once per input signal period.

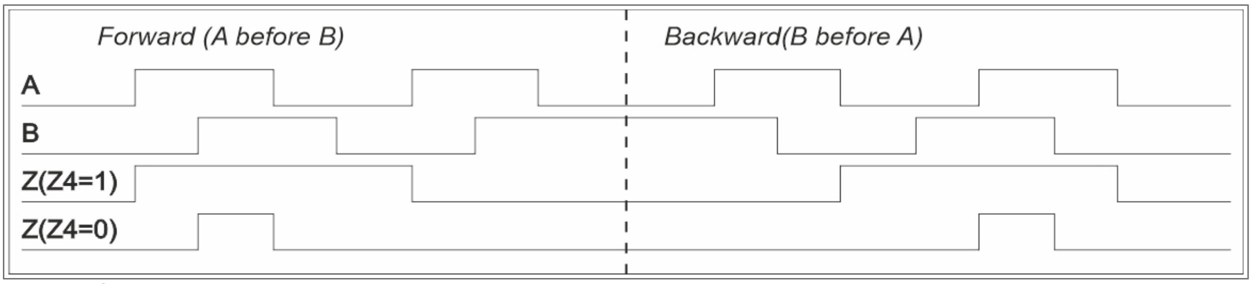


Figure 6: Output signals ABZ

Info:
The signals A, B and Z will be postponed by one increment if the digital hysteresis is activated.

4.2 Output and input signals RS-485 – SSI mode

At SSI mode measured values can be read out via the interface. The SSI interface is inactive with a connected USB.

4.2.1 SSI interface

The SSI interface of the AM-IP4k will be activated if during the IC's reset the input `SEN` is kept at the L-level. For the AM-IP4k operating via the SSI interface, the EEPROM must contain a valid configuration because the EEPROM contains some basic operating parameters. The bits `SSITO` and `RING` at the register `CFGSSI` are initialised by the user using the system parameters at the EEPROM to operate the interface.
The register `POSIT` (see the data sheet of the AM-IP4k) is transmitted with a data length of 20 or 32 bits in the data of the SSI protocol. The data contains the value of the interpolation counter (single-turn counter) and of the multi-turn counter. Additionally, two bits are assigned to error information. Setting the bit `RING` at the register `CFGSSI` enables the SSI master to force the repeated transfer of the same value by a continuous clock (SSI ring mode).

Info:
Using the multi-turn counter the interpolation rate should be set to 256, 128, 64, or 32, as the higher-level interface master usually operates only with binary resolutions.

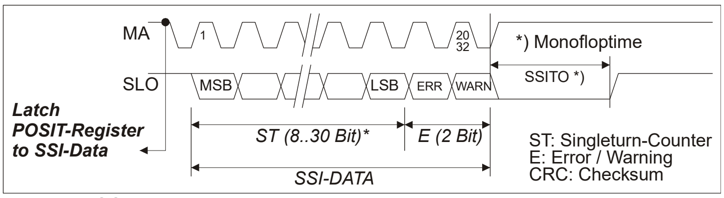


Figure 7: SSI

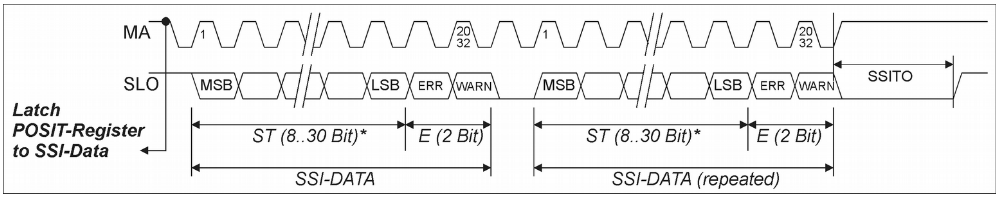


Figure 8: SSI (Ring mode)

Table 7: Register CFGSSI (SSI mode)

Bit	Meaning	Factory setting	User setting
SSITO	SSI timeout	20µs at 40 MHz	`SSITO` = (Timeout·f_{OSZ})-3
RING	SSI ring mode	Ring mode	SSI master mode
SSI20	Data length	32 bits	0 for 32 bits / 1 for 20 bits

4.3 Error signal

An error signal will be generated if the input signals are implausible. There will be an error signal too if the input frequency is that high so the square-wave signals can no longer follow or that it exceeds the maximum input frequency. In general, it is recommended to use the error signal for data processing. Further information concerning the error signal are provided in chapter 7.6 of the AM-IP4k's data sheet.

Info:
If the error signal was detected at the output, the current measurement result and all subsequent results must be discarded. After the removal of the cause of error and the reset it is necessary to cross the reference point again to be able to measure absolute values.

4.4 Trigger signal

The trigger signal can be used to save the current count value to a trigger holding register of the AM-IP4k. The respectively "oldest" value is provided from the trigger holding registers when there is a read-access to the register `MVAL`.

4.5 Teach signal

Using the teach signal a zero point position can be stored in the AM-IP4k's EEPROM. The signal has to be activated by the configuration bit TEAEN at register CFG2. For more details, see the data sheet of AM-IP4k, chapter 7.10.

4.6 Zero signal

The internal counter of the AM-IP4k and – in case of an error – the corresponding error bit can be reset by the zero signal. After doing so it is necessary to cross the reference point again to be able to measure absolute values.

5 Interpolation rate

Interpolation rates (IRATE) can be set between 4 and 4096. Interpolation rate in this context means the number of increments into which a sine or cosine input signal period can be divided.

The interpolation rate is configured at `CFG1/IR`. There are four basic interpolation rates: 4096, 4000, 3200, and 2560. The last has a factory setting value and can be reprogrammed by user. The succeeding interpolation rate values correspond to the division by 2, 4, 8, 16, 32, 64, and 128 of basic interpolation rates. Invalid values occur when result division is not an integer.

Table 8: Interpolation rate

IR(4:3) \ IR(2:0)	000	001	010	011	100	101	110	111
10	4096	2048	1024	512	256	128	64	32
00	4000	2000	1000	500	250[1)]	125[1)]	invalid	invalid
01	3200	1600	800	400	200	100	50[1)]	25[1)]
11	2560	1280	640	320	160	80	40	20

[1)] These interpolation rates should only be used while running counter mode. In these cases, ABZ signals are invalid.

It is also possible to select further interpolation rate values with an extended IR divider. The basic interpolation rates remain the same. Using configuration IRDiv2 in `CFG2` the interpolation rates 16, 8, and 4 can be selected. See Table 15.

IR_sum(3:0) = IR(2:0) + IRDiv2(2:0)

Table 9: Interpolation rate with extended IR divider

IR(4:3) \ IR_sum	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010
10	4096	2048	1024	512	256	128	64	32	16	8	4
00	4000	2000	1000	500	250[1)]	125[1)]	invalid	invalid	invalid	invalid	invalid
01	3200	1600	800	400	200	100	50[1)]	25[1)]	invalid	invalid	invalid
11	2560	1280	640	320	160	80	40	20	invalid	invalid	invalid

[1)] These interpolation rates should only be used while running counter mode. In these cases, ABZ signals are invalid.

5.1 Edge separation for ABZ signals

The minimum edge separation t_{pp} of the output signals A, B and Z can be set in binary steps between $1/f_{osz}$ and $128/f_{osz}$. Using this function, the band width of the IPE4k can be restricted to slower RS-422 counters (see for details the data sheet of the AM-IP4k, chapters 7.4.2, 7.5).

Table 10: Minimum edge separation

Minimum edge separation tpp	Register values CFG1 – TPP(2:0)
1/fosz	000 (0)
2/fosz	001 (1)
4/fosz	010 (2)
8/fosz	011 (3)
16/fosz	100 (4)
32/fosz	101 (5)
64/fosz	110 (6)
128/fosz	111 (7)

5.2 Digital hysteresis for ABZ signals

To suppress the edge noise of the output signals at low input frequencies as well as during downtime, a digital hysteresis for A, B and Z can be activated at register CFG1. Thus, switching of outputs will be prevented if static input signals occur. All output signals will be delayed by the set hysteresis value.

Table 11: Configuration of the digital hysteresis

Register values CFG1 DH(2:0)	Meaning
000	Digital hysteresis deactivated
001 to 111	Digital hysteresis activated and setting of the hysteresis value

6 Characteristic values

Table 12: Characteristic values

Operating conditions	Min.	Nom.	Max.	Unit
Operating voltage	4.75	5.0	5.5	V
Current consumption		110	230	mA
Internal supply voltage		3.3		V
Mean voltage at VM_OUT		2.5		V
Output current at VM_OUT			30	mA
Operating temperature	- 40		85	°C
Input section	**Min.**	**Nom.**	**Max.**	**Unit**
Input frequency			220	kHz
Phase shift between SIN and COS		90		°
Amplitude SINN ⇔ SINP / COSN ⇔ COSP	0.075	1.0	1.2	V_{pp}
Phase correction	4.5 / 9	5 / 10	9 / 11	°
Oscillator frequency f_{osz}		40		MHz
Interpolation	**Min.**	**Nom.**	**Max.**	**Unit**
Interpolation rate	4 … 4096			
Minimum interval time t_{pp} A / B signal	1 / fosz		128 / fosz	ns
Interpolation accuracy		± 0.7		
Delay time (A / B / Z)	155 / fosz		187 / fosz	ns
Other characteristics	**Housing made of extruded profile**			
Degree of protection	IP20			
Connectors	SUB-D, 15-pin			
Dimensions	55 mm x 80 mm x 20 mm			

7 Configuration of the connectors

7.1 Pin assignment of connector X1, ABZ/ SPI

Table 13: Connector SUB-D 15-pin → ABZ

Pin	Name	Signal	Meaning
1	AP	Output	Square-wave signal A positive
2	VSS	Input	GND
3	BP	Output	Square-wave signal B positive
4	VDD	Input	Supply voltage 5 V
5	EP	Output	Error signal E positive
6	nTEACH	Input with pull-up	Teach signal; falling edge active
7	ZN	Output	Square-wave signal Z negative
8	nTRIG	Input with pull-up	Trigger signal; falling edge active
9	AN	Output	Square-wave signal A negative
10	VSS	Input	GND
11	BN	Output	Square-wave signal B negative
12	VDD	Input	Supply voltage 5 V
13	nZERO	Input with pull-up	Zero signal; falling edge active
14	ZP	Output	Square-wave signal Z positive
15	EN	Output	Error signal E negative

Table 14: Connector SUB-D 15-pin → SPI

Pin	Name	Signal	Meaning
1	MISO	Output	SPI master in salve out
2	VSS	Input	GND
3	SEN	Output	SPI SEN signal
4	VDD	Input	Supply voltage 5 V
5	EP	Output	Error signal E positive
6	nTEACH	Input with pull-up	Teach signal; falling edge active
7	ZN	Output	Square-wave signal Z negative
8	nTRIG	Input with pull-up	Trigger signal; falling edge active
9	MOSI	Output	SPI master out slave in
10	VSS	Input	GND
11	SCLK	Output	SPI clock
12	VDD	Input	Supply voltage 5 V
13	nZERO	Input with pull-up	Zero signal; falling edge active
14	ZP	Output	Square-wave signal Z positive
15	EN	Output	Error signal E negative

7.2 Pin assignment of connector X1, SSI mode

Table 15: Connector SUB-D 15-pin → SSI

Pin	Name	Signal	Meaning
1	SLOP	Output	Signal SLO positive
2	VSS	Input	GND
3	SLIP	Input	Signal SLI positive
4	VDD	Input	Supply voltage 5V
5	SENN	Input	Signal SEN negative 1)
6	nTEACH	Input with pull-up	Teach signal; falling edge active
7	MAN	Input	Signal MA negative
8	nTRIG	Input with pull-up	Trigger signal; falling edge active
9	SLON	Output	Signal SLO negative
10	VSS	Input	GND
11	SLIN	Input	Signal SLI negative
12	VDD	Input	Supply voltage 5V
13	nZERO	Input with pull-up	Zero signal; falling edge active
14	MAP	Input	Signal MA positive
15	SENP	Input	Signal SEN positive 1)
1) Signals do not have to be connected. Interface configuration using the SEN signal is done internally.			

7.3 Pin assignment of connector X2

Table 16: Connector X2 test signals sine / cosine of the analogue input of the AM-IP4k

Pin	Name	Signal	Meaning
1	SMON	Output	Test signal of the sine channel of the analogue input of the AM-IP4k
2	CMON	Output	Test signal of the cosine channel of the analogue input of the AM-IP4k
3	GND	Input	Analogue ground for measurements

7.4 USB interface X4

Table 17: USB interface X4

Pin	Name	Meaning
1	+ USB	+ 5 V
2	USBD -	Data -
3	USBD +	Data +
4	ID	–
5	- USB	GND

7.5 Pin assignment of female connector X6

Table 18: Female connector SUB-D 15-pin

Pin	Name	Signal	Meaning
1	SINP	Input	Sine positive
2	AVSS	Output	GND
3	COSP	Input	Cosine positive
4	SENSVDD	Output	Supply voltage 5 V (equipment variant with 3,3V)
5	–	–	–
6	–	–	–
7	REFN	Input	Reference signal negative
8	–	–	–
9	SINN	Input	Sine negative
10	AVSS	Output	GND
11	COSN	Input	Cosine negative
12	SENSVDD	Output	Supply voltage 5 V (equipment variant with 3,3V)
13	VM_OUT	–	SENSVDD/2
14	REFP	Input	Reference signal positive
15	–	–	–

7.6 LED

Table 19: LED

LED	Signal	Meaning
nERR LD4 LD6	Red (LD6 off)	An error occurred
	Green (LD4 off)	Normal operation
Power LED LD3	Off	IPE4k not active
	Green	IPE4k active

8 Configuration of AM-IP4k

8.1 Configuration of AM-IP4k using "IP4kApp.exe"

After a reset of the IC AM-IP4k all registers will be initialised with their default values. If the IPE4k was connected to a PC via USB according to the instructions, the AM-IP4k could be easily set using the PC software "IP4k-Monitor". Furthermore, the active interface at X1 can be selected by this program. The program is available for download on our website **www.amac-chemnitz.de**.

Note:
To avoid difficulties in communicating with the PC, the hardware address of the IPE4k is set at 0x00 and must not be modified in the software.

9 Software – IP4k-Monitor

9.1 Overview

The IP4k-Monitor-Software allows to visualise and control the parameters and characteristics of the AM-IP4k, which is built in the IPE4k. The software is designed for Windows operating systems and has to be connected by USB (USB to SPI on the board).

9.2 System requirements

To ensure the proper running of the program the PC or notebook should meet the following minimum system requirements:

- **Hardware:**
  - Processor: 2 GHz or faster (a multi-core processor is recommended)
  - at least 512 MB of RAM
  - at least 1 GB available hard-disc space (for measured values)
  - Graphics card with 24-bit colour (32-bit recommended)
  - 1024 x 768 display or higher
  - available USB interface

- **Operating system[1)]:**
  - Microsoft Windows® Server 2003
  - Microsoft Windows® Vista
  - Microsoft Windows® 7
  - Microsoft Windows® 8.1
  - Microsoft Windows® 10 and above

[1)] Microsoft and Windows® are registered trademarks of Microsoft Corporation in the US and other countries.

9.3 Installation

The software and USB drivers are installed using the executable file 50410-SW-x-x-IP4k-monitor Setup.exe.

9.4 Program structure

The configuration program's graphical interface is organised in a dialogue bar, a status bar and two sectors displaying the measured values. Below the tool bar, there is the dialogue bar to start taking measurements and to select the time interval for queries or to trigger reset commands for e.g. the counter. The measured values and the status information of the AM-IP4k are shown in the two measurement parts of the window, provided that a measurement was started via the dialogue bar. The measured values are updated within the specified time interval.

After starting the application, shown in figure 9, the software checks the hardware availability. If any hardware is detected, its identifier will appear in the status bar. If the IC is properly connected and activated, the circuit's name will appear in the status line (e.g. "IC: AM-IP4k"). In case no circuit is detected, "unknown" will appear.

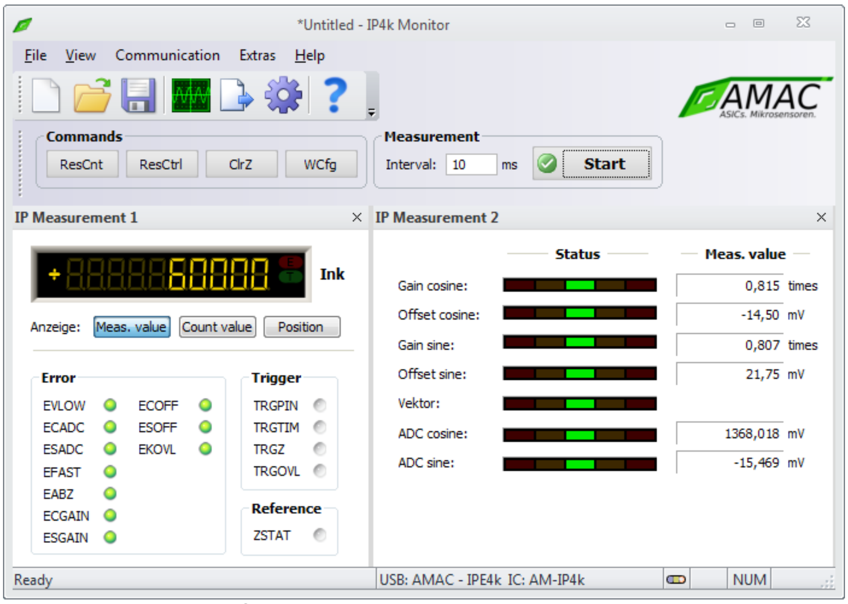
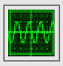


Figure 9: IP4k monitor – Start window

9.5 Menu bar

Table 20: Menu bar – Symbols

Symbol	Name	Meaning
	New document	Creates a blank configuration file.
	Open document	Opens an existing file and reads the configuration settings.
	Save document	Saves the configuration settings to a file.
	Oscilloscope view	Opens the oscilloscope view, see chapter 9.9.
	Export data	Exports the measured data to a file.
	Configuration	Opens the configuration window, see chapter 9.8.
	Information	Shows information about the program and about the connected hardware.

9.6 Support

During the development of the configuration program special attention was paid to a clear and self-explanatory graphic interface. Many elements of the interface show further information by mousing over (tooltip or status text). The setting made in this program can be saved to a setup-file with the extension ".ip4k" and retrieved again.

9.7 Measurement

Once an AM-IP4k is connected to the PC and detected by the software, a live measurement can be taken by pressing the start button. The displays in the two measurement windows are updated within the specified time interval with the selected time value of the interval being an approximate value. The real value of the interval depends on configuration of the software and the interface plus of the performance and capacity of the PC.

9.7.1 IP measurement 1

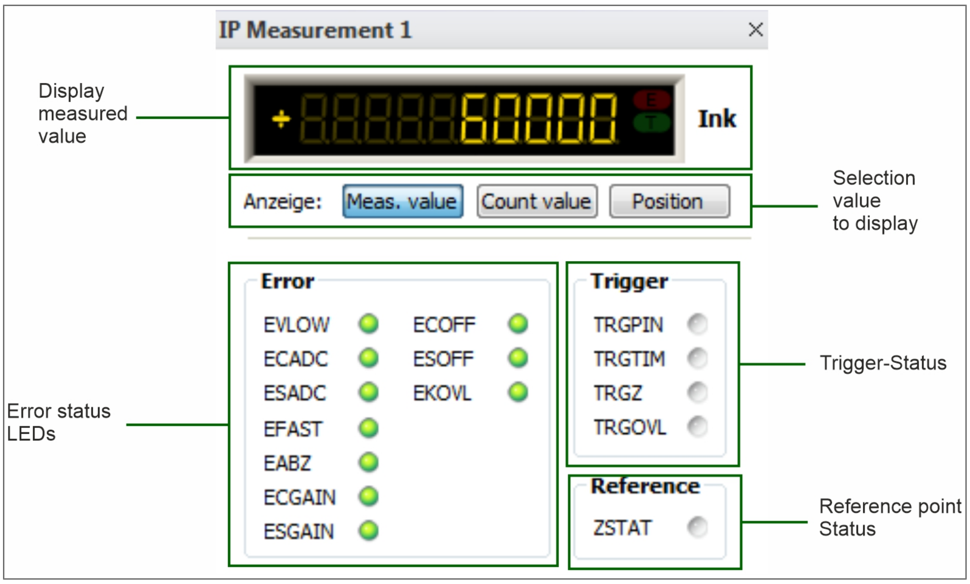


Figure 10: Interpolation measurement 1

During a measurement, the current count value is shown in the window IP measurement 1. It is possible to choose between measured value (register MVAL of the AM-IP4k), count value (register CNT) and position (register POSIT; see the description of the registers at the AM-IP4k's data sheet). By choosing position, single and multi-turn information can be displayed depending on the circuit configuration (registers CFGSSI/MTBIT, CFGSSI/STBIT).

The signalling of the error LEDs depends on the circuit configuration. The error events can be activated, deactivated or stored permanently at the configuration register CFG1. The behaviour of the LEDs will be adapted accordingly. The LEDs for error, trigger and reference point status correspond to the information at the status register STAT of the AM-IP4k. The meaning of the error LEDs is given in table 21; the status LEDs are described in table 22.

Table 21: Error LEDs

LED	Meaning
EVLOW	Green: No vector error. Red: The signal vector generated from the sine and cosine signal is too small, caused mostly by a partially or totally disconnected sensor. Another cause of error may be input signals with a very large offset and a low amplitude at the same time.
ECADC	Green: No ADC error at the cosine signal. Red: The AD converter for the cosine signal is overdriven, caused by a signal amplitude being too high. Another cause of error may be input signals with a very large offset and a high amplitude at the same time.
ESADC	Green: No ADC error at the sine signal. Red: The AD converter for the sine signal is over-driven, caused by a signal amplitude being too high. Another cause of error may be input signals with a very large offset and a high amplitude at the same time.
EFAST	Green: No speed error. Red: The input frequency is too high to generate A/B signals or to detect the direction. The monitored frequency differs in the use of the internal counter and of the square-wave outputs A/B/Z.
EABZ	Green: No error at A, B, Z. Red: The signals A, B and Z are invalid because of the input frequency being too high. The monitored frequency depends on the set minimum edge separation t_{pp}. This error will occur too if the interpolation rate or the minimum edge separation t_{pp} are changed. The detection of this error will be deactivated automatically using the internal counter.
ECGAIN	Green: No amplitude error at cosine signal. Red: The gain controller for the cosine signal has reached its limit, caused either by a signal amplitude being too low or by a partially or totally disconnected sensor.
ESGAIN	Green: No amplitude error at sine signal. Rot: The gain controller for the sine signal has reached its limit, caused either by a signal amplitude being too low or by a partially or totally disconnected sensor.
ECOFF	Green: No offset error at cosine signal. Red: The offset controller for the cosine signal has reached its limit, caused by a signal offset being too large, by an invalid value for the initialisation of the offset controller or by a partially or totally disconnected sensor.
ESOFF	Green: No offset error at sine signal. Red: The offset controller for the sine signal has reached its limit, caused by a signal offset being too large, by an invalid value for the initialisation of the offset controller or by a partially or totally disconnected sensor.
EKOVL	Green: No error at correction value calculation. Red: The calculated correction value is invalid, caused by a wrong configuration of the correction coefficients. The sensor should be calibrated again.

Table 22: Status LEDs

LED	Meaning
TRGPIN	Trigger status (Pin) active: The next measured value read from register MVAL was triggered by Pin TRG. inactive: Register MVAL contains the current position value (Register POSIT).
TRGTIM	Trigger status (Timer) active: The next measured value read from register MVAL was triggered by timer. inactive: Register MVAL contains the current position value (Register POSIT).
TRGZ	Trigger status (Reference point) active: The next measured value read from register MVAL was triggered by reference signal. inactive: Register MVAL contains the current position value (Register POSIT).
TRGOVL	Trigger overflow active: Overflow of the trigger holding register. A trigger event was lost. inactive: No overflow of the trigger holding register. At the most two trigger events will be stored.
ZSTAT	Reference point status active: The reference mark of the scale was passed; AM-IP4k and scale work synchronously. inactive: Reference mark of the scale was not yet passed or the relation between count value and reference mark was lost due to an error.

9.7.2 IP measurement 2

The quality of the sensor signals is illustrated with LED bars of the controller parameter in the window IP measurement 2. Additionally, the input voltage at the AD converters is monitored; thus, a possible overload of the ADC will be visualised by the software. The meaning of the displayed elements is shown in the tables 23 and 24.

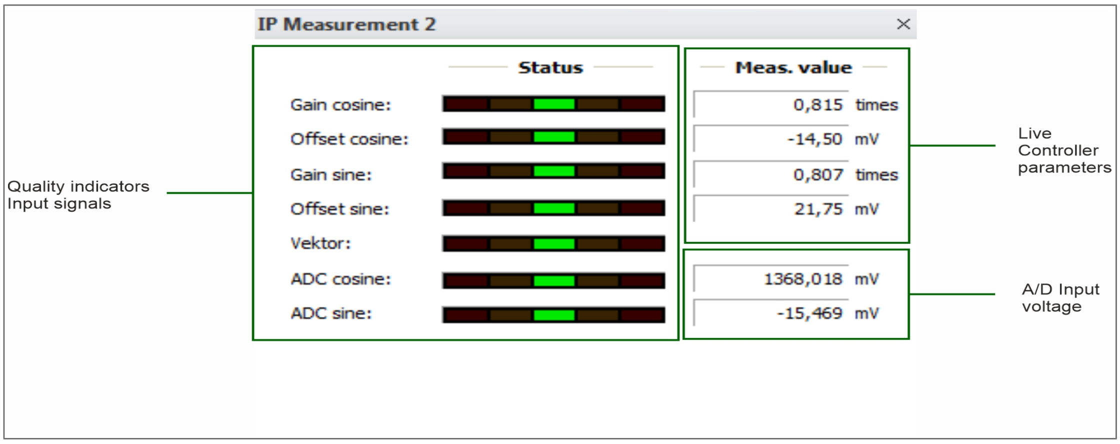


Figure 11: Interpolation measurement 2

Table 23: Sensor monitoring

Name	Type	Meaning
Gain cosine Gain sine	LED bar	Controller correction value for the signal amplitude.
	Measured value	Controller value for the input signal amplification.
Offset cosine Offset sine	LED bar	Offset correction value of the controller.
	Measured value	Controller value for the offset correction.
Vector	LED bar	Vector magnitude of the input signals.
ADC cosine ADC sine	LED bar	Range of values of the AD converter.
	Measured value	Current input voltage at the AD converter.

Table 24: Range of values of the sensor monitoring

Display	Meaning
LED bar green yellow on the left yellow on the right red on the left red on the right	Value ... ... is within the permissible range ... is too small, sensor signal should be aligned ... is too big, sensor signal should be aligned ... is too small, measured value is incorrect ... is too big, measured value is incorrect

9.8 Configuration

The software reads out the current configuration after detecting the circuit. The user’s possibilities are to confirm that or to create a new configuration (File → New; symbolised as a blank sheet). In addition, a previously saved configuration with the extension *.ip4k can be loaded (File → Open; symbolised as folder).

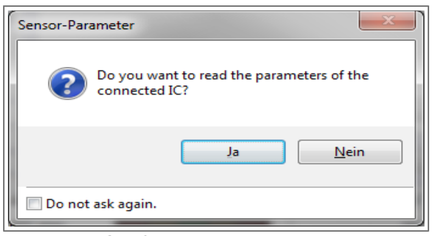


Figure 12: Configuration readout

The configuration window can be opened via the menu (Tools → Configuration) or via the tool bar. There are several tabs for the basic and the advanced configuration of the circuit as well as for software settings.
As the configuration is stored to the circuit's internal EEPROM and validated automatically, it can be loaded from the EEPROM at the power-on or the reset of the IC and can be used. The validity of the configuration is stored to EEPROM address 0x00. If the circuit is supposed to be used with the default settings, the content of the EEPROM must be validated first by using a button in the configuration window (Sensor – Expert). Additionally, the validity of the EEPROM is displayed. With an external configuration of the circuit (`CFGPIN`) the default settings are used for all characteristics not configured by pins and the programmed EEPROM content is not applied to the configuration.

9.8.1 Sensor - Parameter / Expert

At the configuration menu's first tab "Sensor – Parameter" basic settings as interpolation rate and input amplitude can be adjusted, which makes it possible to adapt the AM-IP4k's basic settings without much effort.
To save the selected settings to the EEPROM of the AM-IP4k the button "Program" has to be pressed. The button "Verify" is used for comparing the data of the software with those of the EEPROM and returns a result of the comparison. If there are differences, the EEPROM values can be checked using the "Read" button and shown in the software's display.

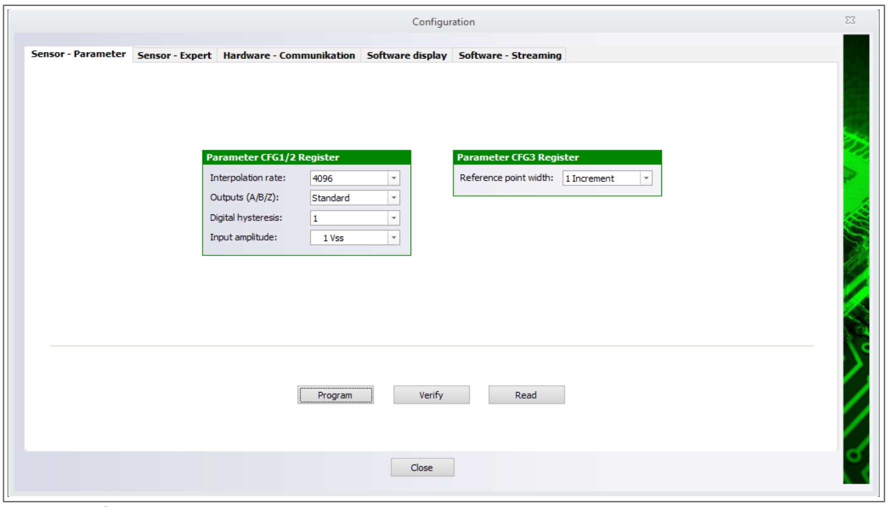


Figure 13: Sensor parameter

For further adjustments of the AM-IP4k the tab "Sensor – Expert" is intended to be used. This tab is based on the definitions of the configuration registers CFG1-4, CFGSSI, PRE_ST, PRE_MT, CFGIUW, CFGLDR, and CFGLDR2, which can be programmed individually using this tab. A detailed description and explanation can be found in the data sheet. The tasks "Program", "Verify", and "Read" can be executed as described above.

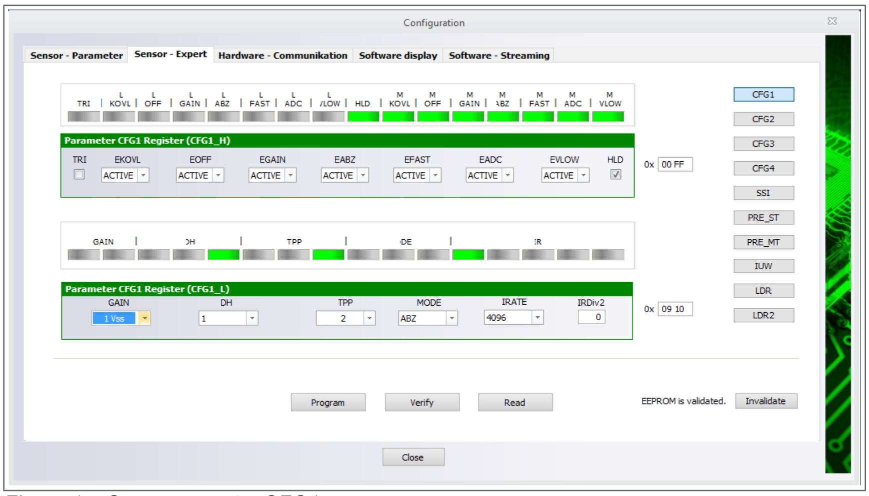


Figure 14: Sensor expert – CFG1

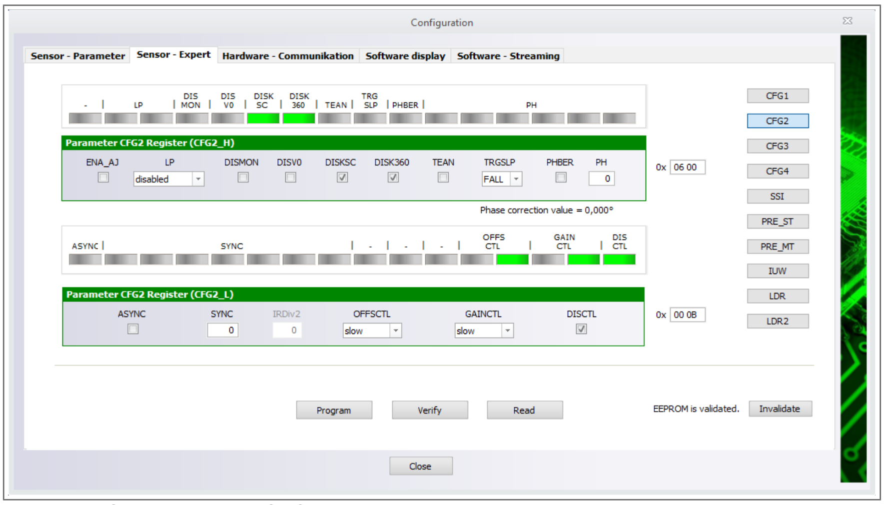


Figure 15: Sensor expert – CFG2

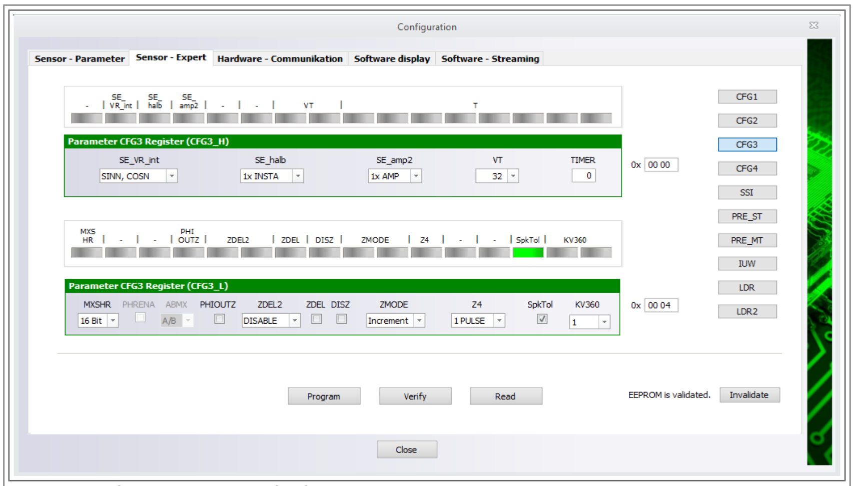


Figure 16: Sensor expert – CFG3

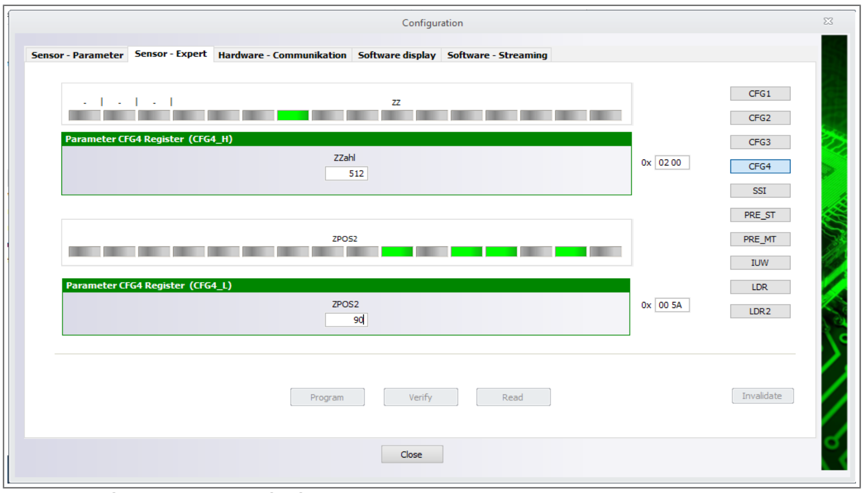


Figure 17: Sensor expert – CFG4

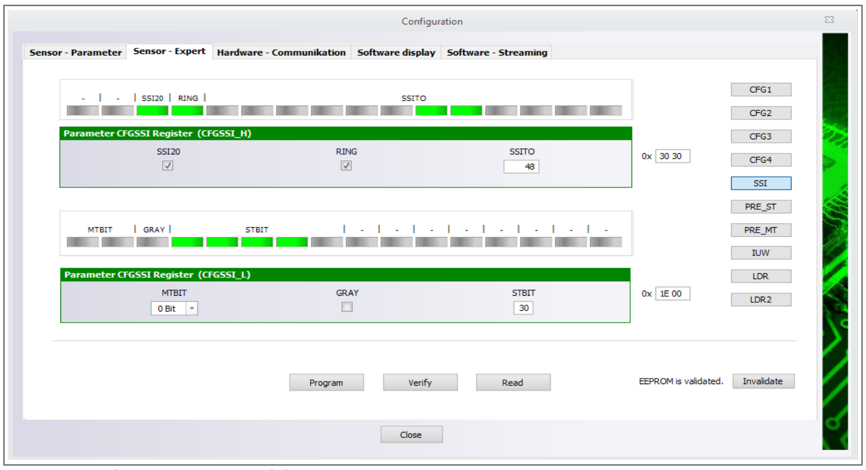


Figure 18: Sensor expert – SSI

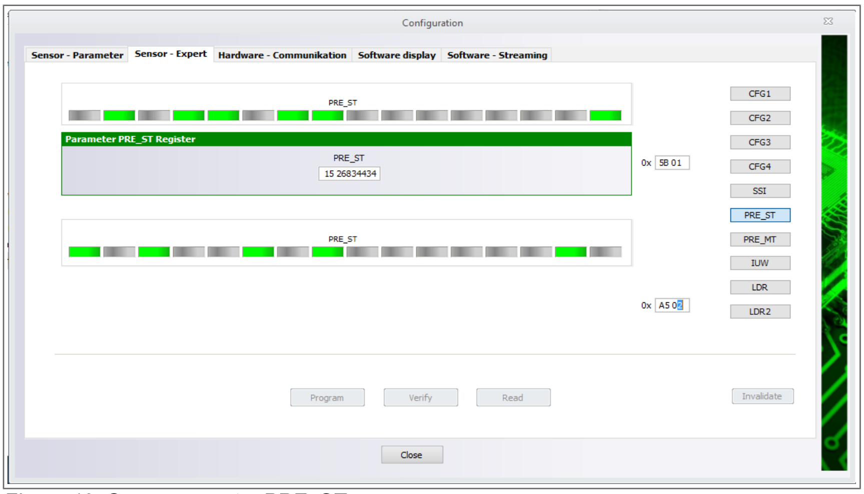


Figure 19: Sensor expert – PRE_ST

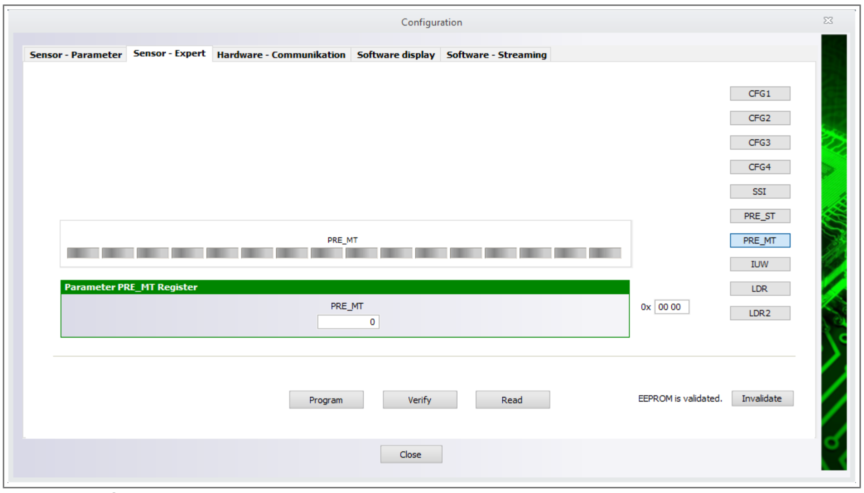


Figure 20: Sensor expert – PRE_MT

Note:

The use of the AM-IP4k's laser diode control is not possible in the current hardware release of the AM-IPE4k.

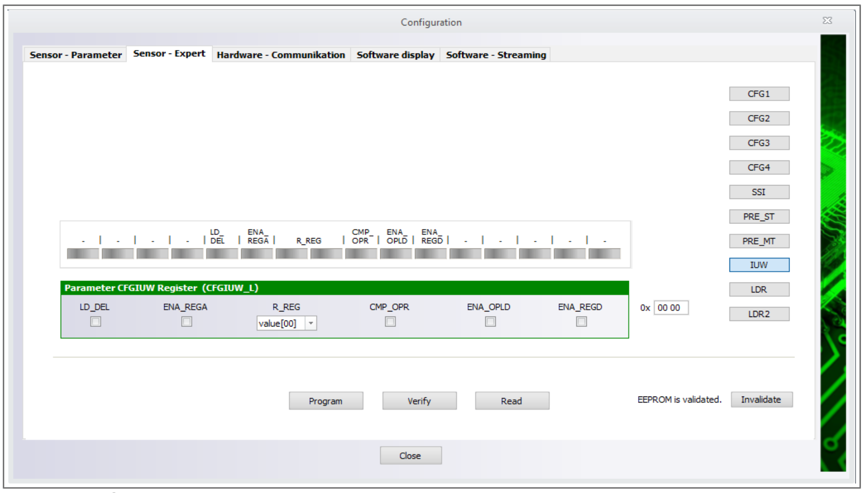


Figure 21: Sensor expert – IUW

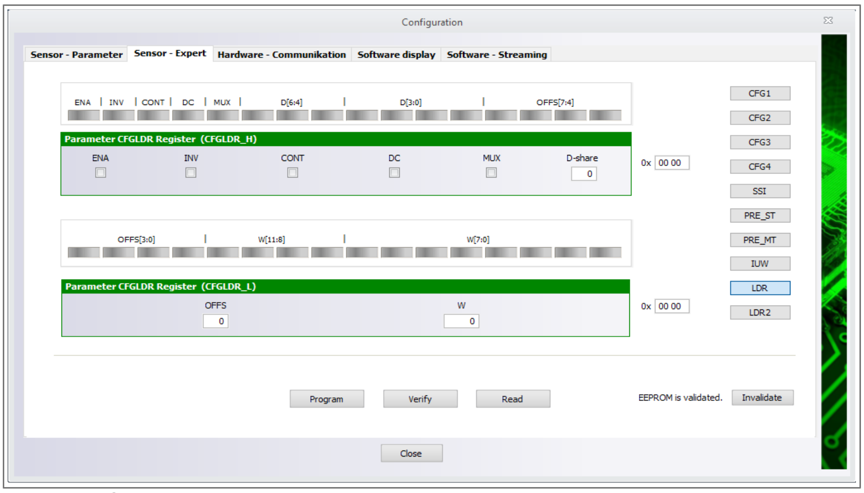


Figure 22: Sensor expert – LDR

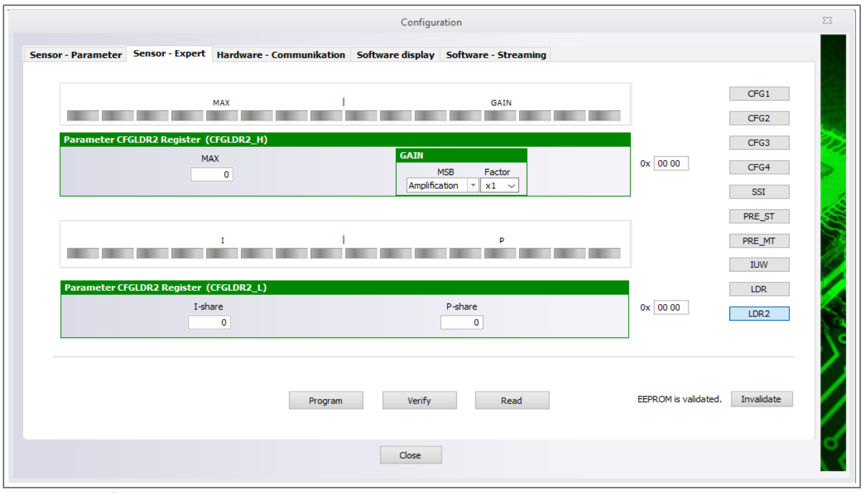


Figure 23: Sensor expert – LDR2

9.8.2 Hardware – Communication

The communication via interfaces is set at this tab, including setting the clock divisor for communication via SPI interface. The waiting time after a read-access can be determined for the SPI interface (for further information see the data sheet of the AM-IP4k). Output signals (SSI or SPI) to connector X1 can be selected at the “Config. Output” sector.

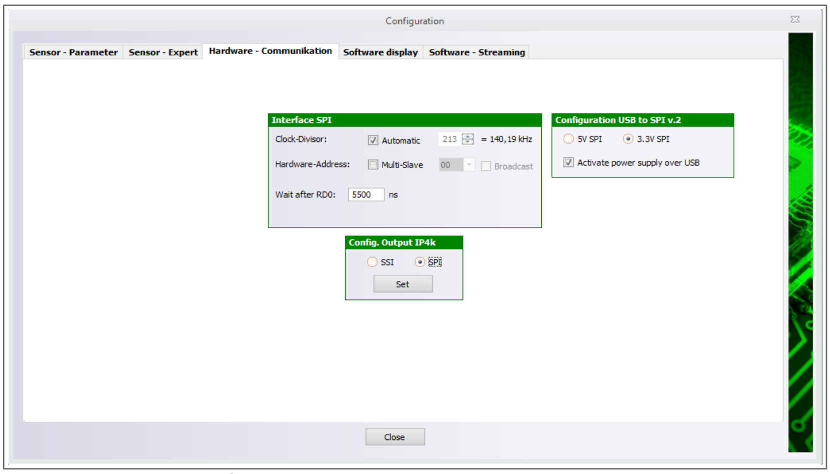


Figure 24: Hardware – Communication

9.8.3 Software – Display

At the tab "Software – Display" the unit of measurement and the scale for displaying measured values with the software can be changed (IP measurement 1, Display: Measured value). Furthermore, warnings or other kind of notes, which were blanked by the user, could be enabled again.

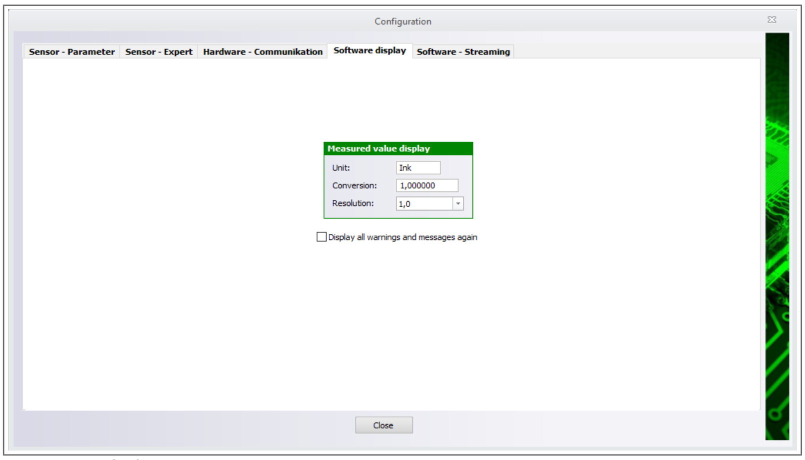


Figure 25: Software – Display

9.8.4 Software – Streaming

To record continuously the parameters of AM-IP4k, such as corrected and uncorrected ADC values, PHI, BQ, the tab "Software – Streaming" can be used. The data as measured or raw data can be transferred by the export function as CSV or MatLab data (Tools → Export; symbolized as a blank page with an arrow). Thus, the subsequent analysis and further processing of data and generating a documentation is made possible.

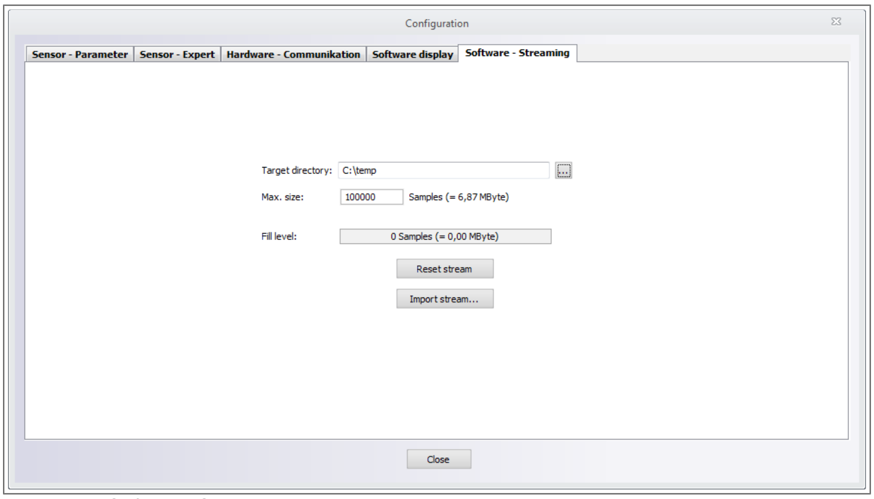


Figure :26 Software Streaming

9.9 Oscilloscope

The software also provides a graphical display of variables, e.g. ADC values or parameters of the AM-IP4k. In general, it can be chosen between the time-based oscillogram and the one showing a XY representation.

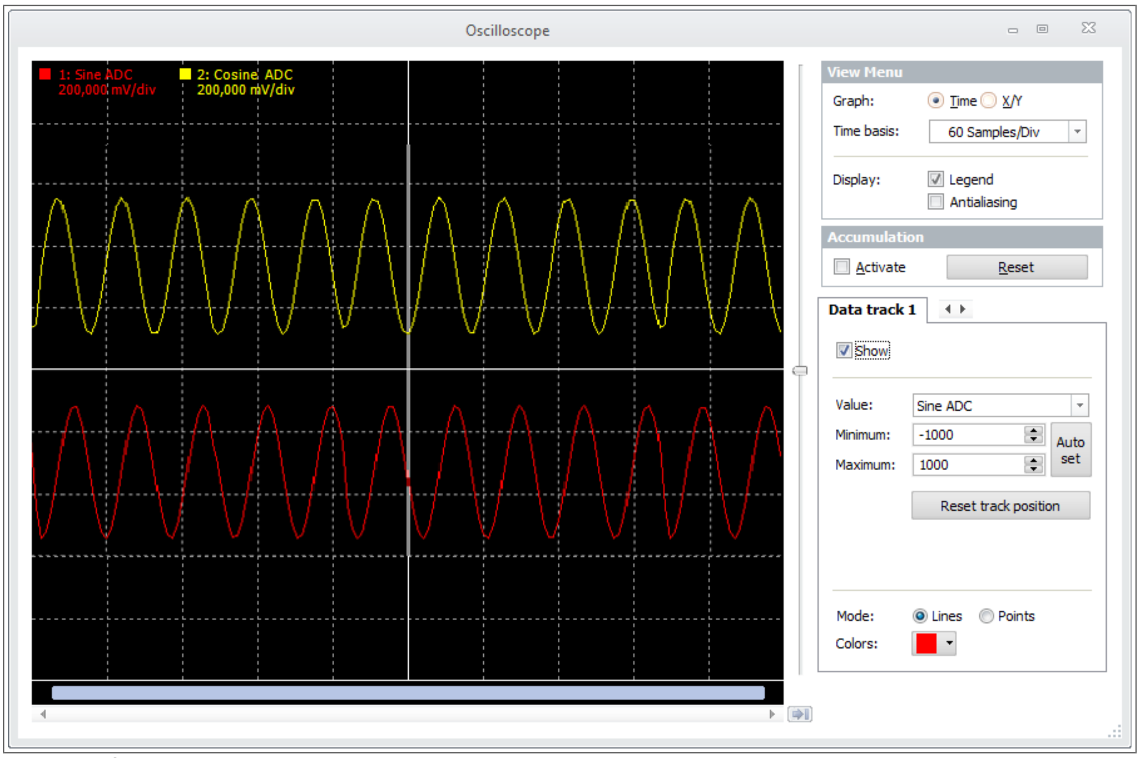


Figure 27: Oscilloscope – Time-based oscillogram

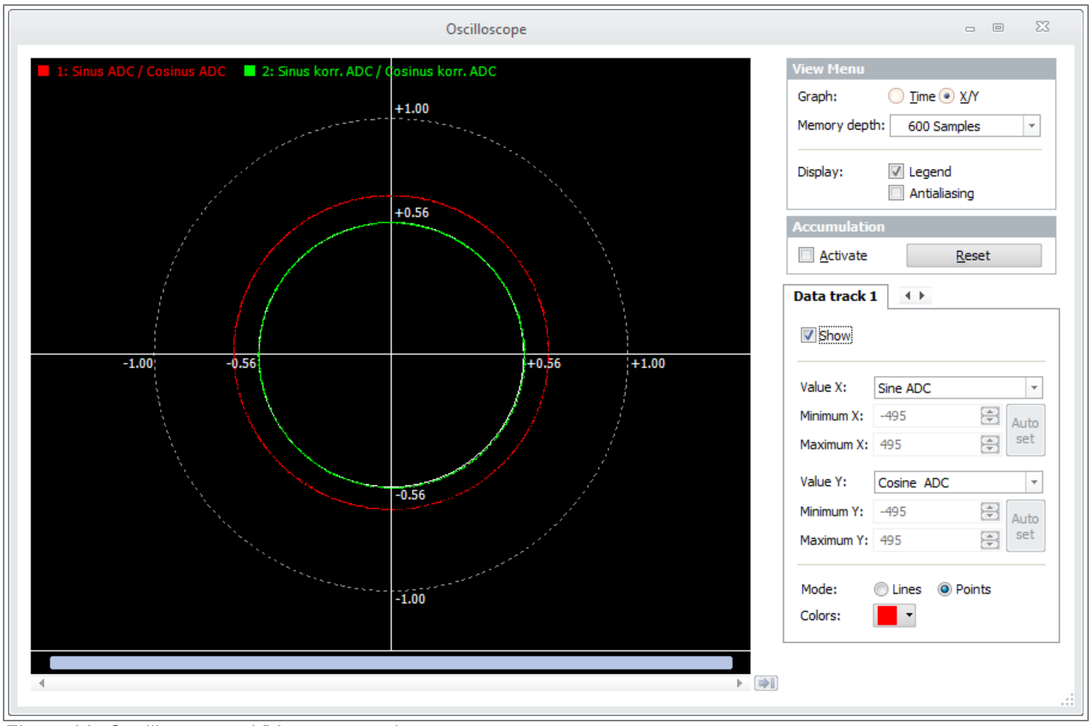


Figure 28: Oscilloscope – XY representation

10 Ordering information

Table 25: Ordering information IPE4k

Product type	Description	Article number
IPE4k	Interpolation unit with AM-IP4k (Standard configuration ABZ)	PR-50410-00

10.1 Configuration as delivered

Table 26: Hardware configuration as delivered

Interface	Description
Sensor input	Differential input signals with $1V_{pp}$, terminating impedance unpopulated
Output signals	ABZ

Table 27: Software configuration as delivered

Parameter	Configuration
Interpolation rate	4096
Reference point detection	Active
Reference point width	1 increment
Output signals	ABZ
Digital hysteresis	Active
Low pass at input	Inactive
Error signals	Active, errors will be stored (Bit `HLD` at register `CFG1` of AM-IP4k set)

11 Hardware overview

11.1 Connections and test points

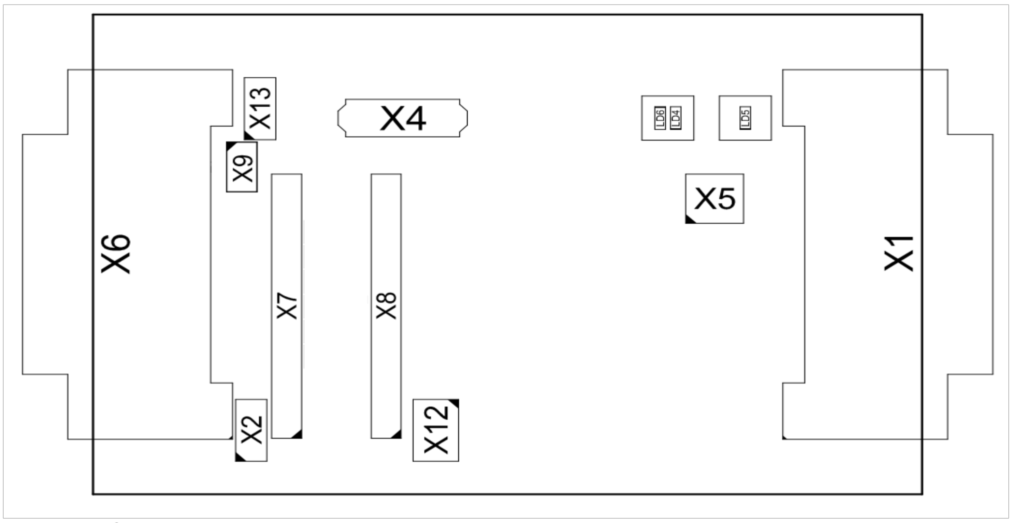


Figure 29: Connections and test points

11.2 Dimensions

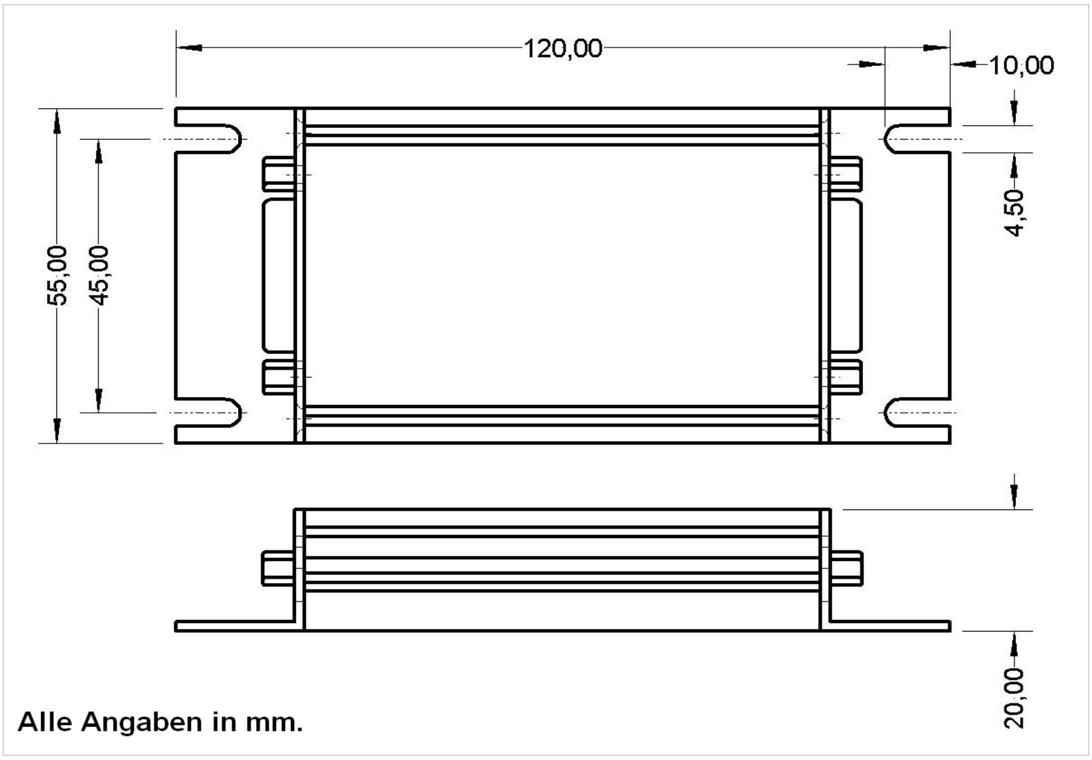


Figure 30: Dimensions

12 Notes