USB-Messbox: CEBO-LC

USB-Messbox-CEBO-LC122.pdf

This document was automatically created.
Please visit www.cesys.com for the latest version.

Haftungsausschluss

Cesys GmbH übernimmt keinerlei Gewähr für die Aktualität, Korrektheit, Vollständigkeit oder Qualität der bereitgestellten Informationen.

Haftungsansprüche, welche sich auf Schäden materieller oder ideeller Art beziehen, die durch die Nutzung oder Nichtnutzung der dargebotenen Informationen bzw. durch die Nutzung fehlerhafter und unvollständiger Informationen verursacht wurden, sind grundsätzlich ausgeschlossen, sofern kein nachweislich vorsätzliches oder grob fahrlässiges Verschulden vorliegt.

Alle Angebote sind freibleibend und unverbindlich. Wir behalten es uns ausdrücklich vor, Teile der Seiten oder das gesamte Angebot ohne gesonderte Ankündigung zu verändern, zu ergänzen, zu löschen oder die Veröffentlichung zeitweise oder endgültig einzustellen.

Warenzeichen und Marken

Windows, Microsoft, and Visual Studio sind eingetragene Markenzeichen bzw. eingetragene Marken der Microsoft Corporation.

LabVIEW ist eine eingetragene Marke von National Instruments.

Alle anderen Marken sind das Eigentum ihrer jeweiligen Inhaber.

Disclaimer

CESYS GmbH reserves the right not to be responsible for the topicality, correctness, completeness or quality of the information provided. Liability claims regarding damage caused by the use of any information provided, including any kind of information which is incomplete or incorrect,will therefore be rejected. All offers are not-binding and without obligation. Parts of the pages or the complete publication including all offers and information might be extended, changed or partly or completely deleted by the author without separate announcement.

Trademarks

Windows, Microsoft, and Visual Studio are either trademarks or registered trademarks of Microsoft Corporation.

LabVIEW is a trademark of National Instruments.

All other trademarks are the property of their respective owners.

CESYS GmbH
Zeppelinstrasse 6A
D-91074 Herzogenaurach
Germany

[WWW.CESYS.COM](http://www.cesys.com)

May 21, 2013, 5:00 pm

CEBO-LC at a glance

CEBO-LC is a universal measurement and automation device. It has a plug-and-play USB interface which is isolated to prevent mutual interference between the computer and all the many things you want to connect to.

Its electronics is capsuled in a rugged aluminum housing, which has rubber fittings for a secure grip.

Connecting sensors and actuators can be achieved easily using the built-in screw terminals. Custom extensions can simply be plugged in to its extension DB25 connector.

There is no AC adapter required. High accuracy and extreme reliability are hallmarks of this device.

The mainboard is also available as an OEM version. You can embed it in your devices, machines or equipment and save the time and costs of designing your own electronics. Contact us to find out details.

Applications

- Measuring voltages and resistances
- Detecting sensor signals and digital states
- Automate experiments and tests,
- Control of special machines
- Monitoring of processes
- Setting analog values from a PC or Mac
- Switch of digital signals
- Event counting

Features

Analog Inputs

- 14 Single-Ended or 7 Differential or any combination
- 16 bit resolution
- Software programmable gains: x1, x10, x100, x1000
- Analog input ranges: 10V, 1V, 100mV, 10mV
- Instrumentation amplifier inputs
- SAR 65.000 - 85.000 Samples/s (depending on the number of enabled inputs)

Analog Outputs

- 2 Single-Ended
- 12 bit resolution
- 10V output swing
- 50 impedance
- Short-circuit proof

Digital I/O

- 20 general purpose I/O
- Individually configurable as Input or Output
- CMOS voltage levels (3.3V nominal)
- 5 Volt tolerant
- Short-circuit proof

Additional

- Built-in temperature sensor
- 1 Trigger Input / Output
- 1 Counter Input
- 2 Fixed Current Outputs (200A / 10A)
- 2 Power Outputs (5V)
- 2 Status LEDs

USB Interface

- USB1.1 and USB2.0 compatible

- Fullspeed (12 Mbit)
- Isolated to improve measurement performance and protect Host computer
- High retention USB connector to prevent unintented disconnection

Supported Operating Systems

- Microsoft Windows (XP, Vista, 7, 8) (32 + 64 bit, Windows XP 32 bit only)
- Mac OS X, 10.6 or higher
- Linux (PC/Desktop), tested on Ubuntu 12.04 LTS (32 + 64 bit)
- Linux on Raspberry Pi (Wheezy)

Supported Programming Languages/Interfaces

- C++
- Java
- .NET
- Python
- LabVIEW (on Windows platforms)
- ProfiLab (on Windows platforms)

CEBO-LC block diagram

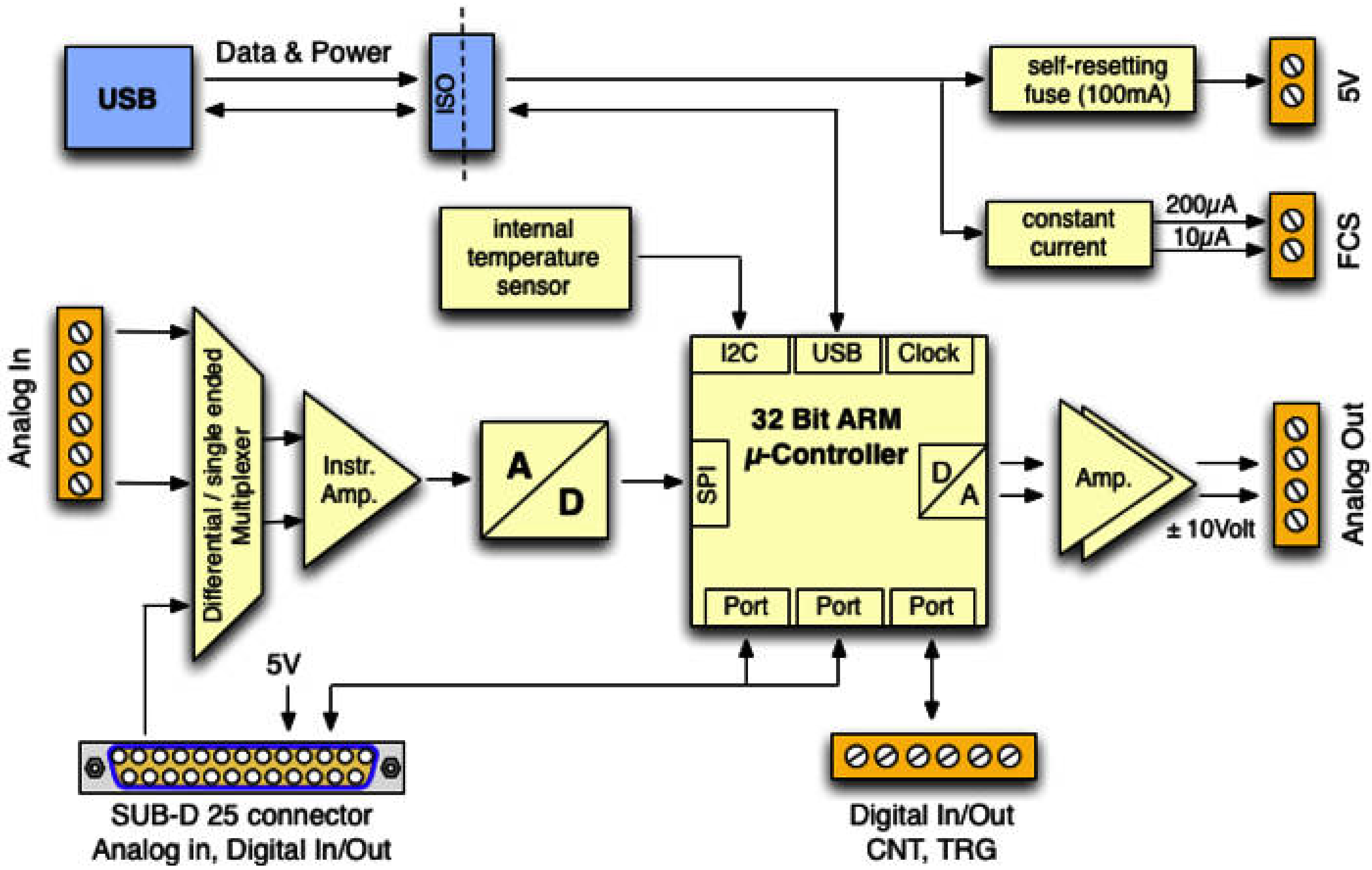


Figure: simplified block diagram

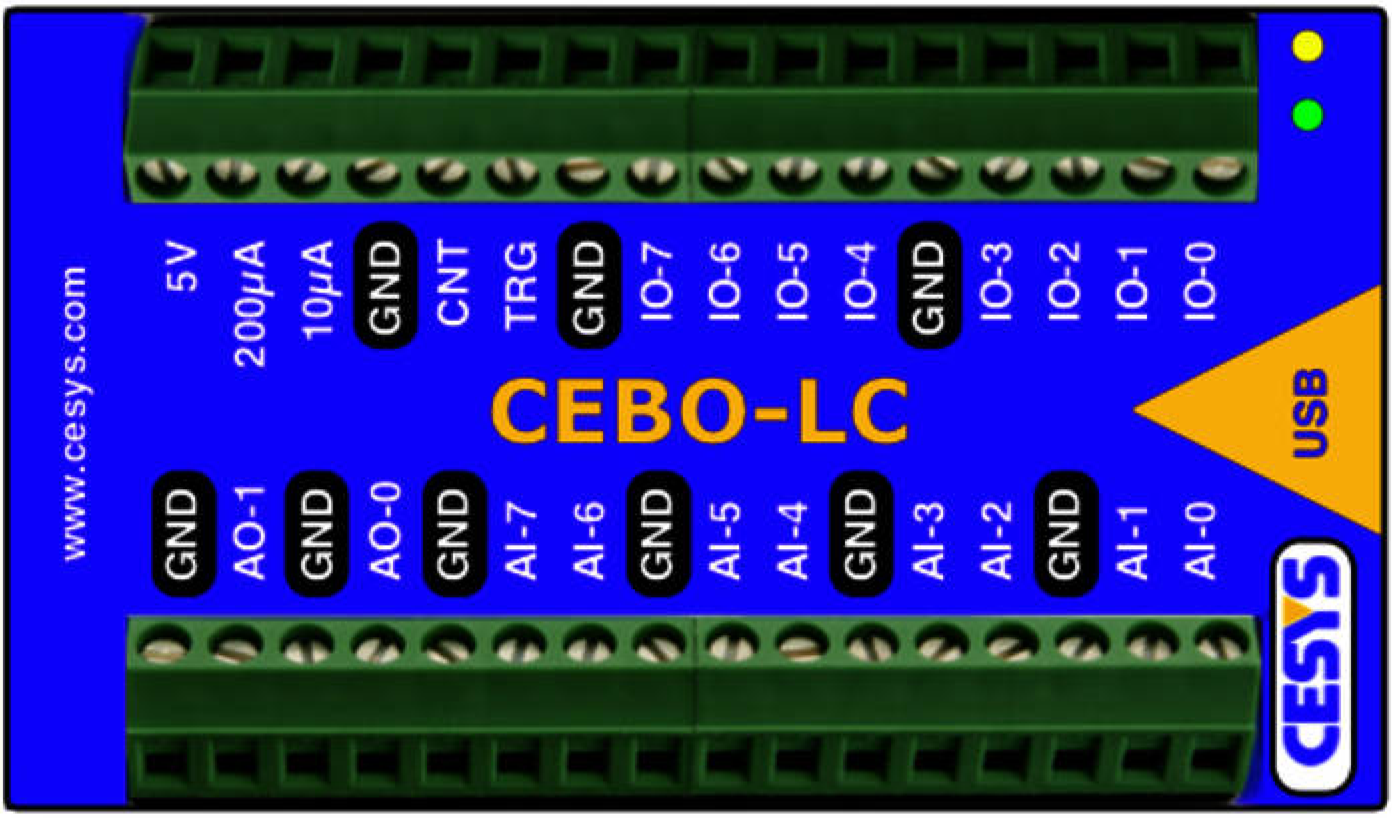
Specification - General

Parameter	Condition	Min	Typical	Max	Units
Dimensions (BxWxH)			75x113x36		mm
Operating Temperature Range			23	70	°C

Screw terminal

A selection of CEBO-LC Input/Output signals is available on industry standard 5mm screw terminals:

Position of the terminals



Terminal pin assignment

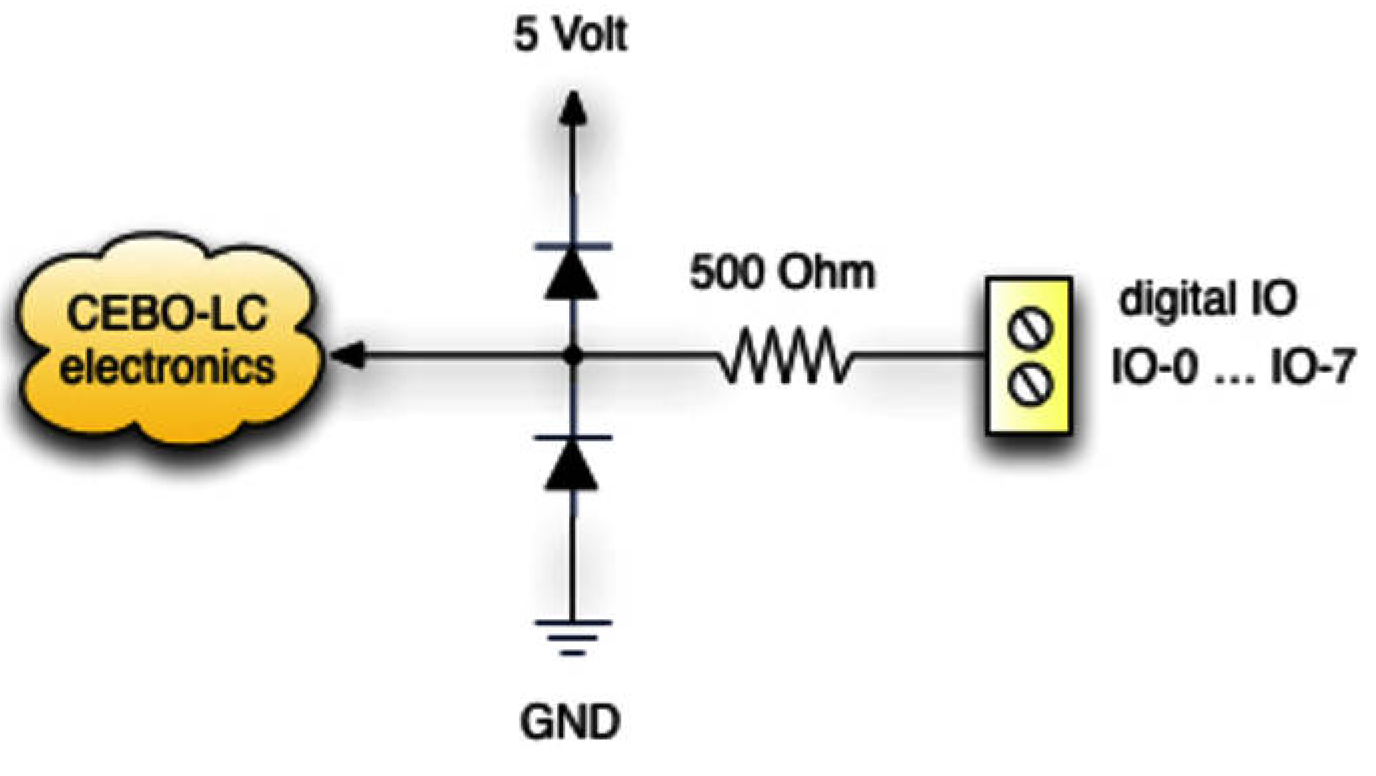
Signal	Desription	Signal	Description
GND(1)		**5V(2)**	Power Output
AO-1	Analog Output 1	**200µA**	Fixed Current Output
GND(1)		**10µA**	Fixed Current Output
AO-0	Analog Output 0	**GND(1)**	
GND(1)		**CNT**	Counter Input
AI-7	Analog Input 7	**TRG**	Trigger Input/Output
AI-6	Analog Input 6	**GND(1)**	
GND(1)		**IO-7**	Digital Input/Output 7 (Port 0, IO 7)
AI-5	Analog Input 5	**IO-6**	Digital Input/Output 6 (Port 0, IO 6)
AI-4	Analog Input 4	**IO-5**	Digital Input/Output 5 (Port 0, IO 5)

GND(1)		**IO-4**	Digital Input/Output 4 (Port 0, IO 4)
AI-3	Analog Input 3	**GND(1)**	
AI-2	Analog Input 2	**IO-3**	Digital Input/Output 3 (Port 0, IO 3)
GND(1)		**IO-2**	Digital Input/Output 2 (Port 0, IO 2)
AI-1	Analog Input 1	**IO-1**	Digital Input/Output 1 (Port 0, IO 1)
AI-0	Analog Input 0	**IO-0**	Digital Input/Output 0 (Port 0, IO 0)

1. Screw terminals labeled GND are internally connected.
2. 5V Power Outputs are internally connected. A total of 100mA can be sourced.

Protective circuit of Digital I/O

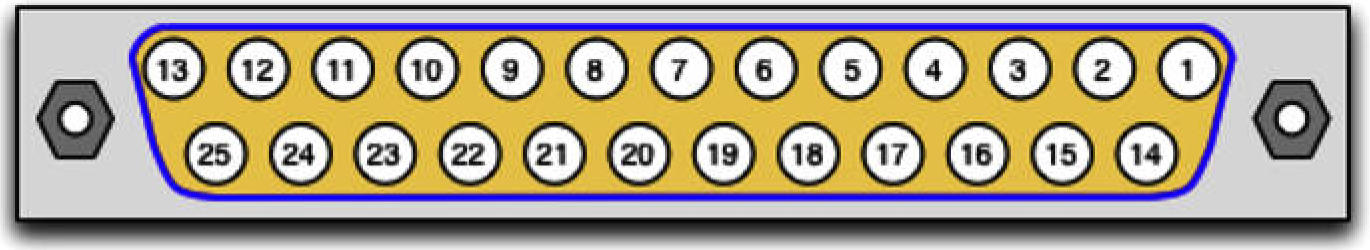
All Digital I/O terminals are short-circuit proof* and protected against overvoltage.



* Single I/O only. Total current should be limited to less than 25 mA.

Please note: the SUB-D pins have different resistor values than the ones of the screw terminals!

Expansion Connector (DB25)



Additional to the industry standard 5mm screw terminals, CEBO-LC comes with a 25pin D-SUB jack of female type. A lot of CEBO-LC Input/Output signals not available on the screw terminals are routed to this expansion connector:

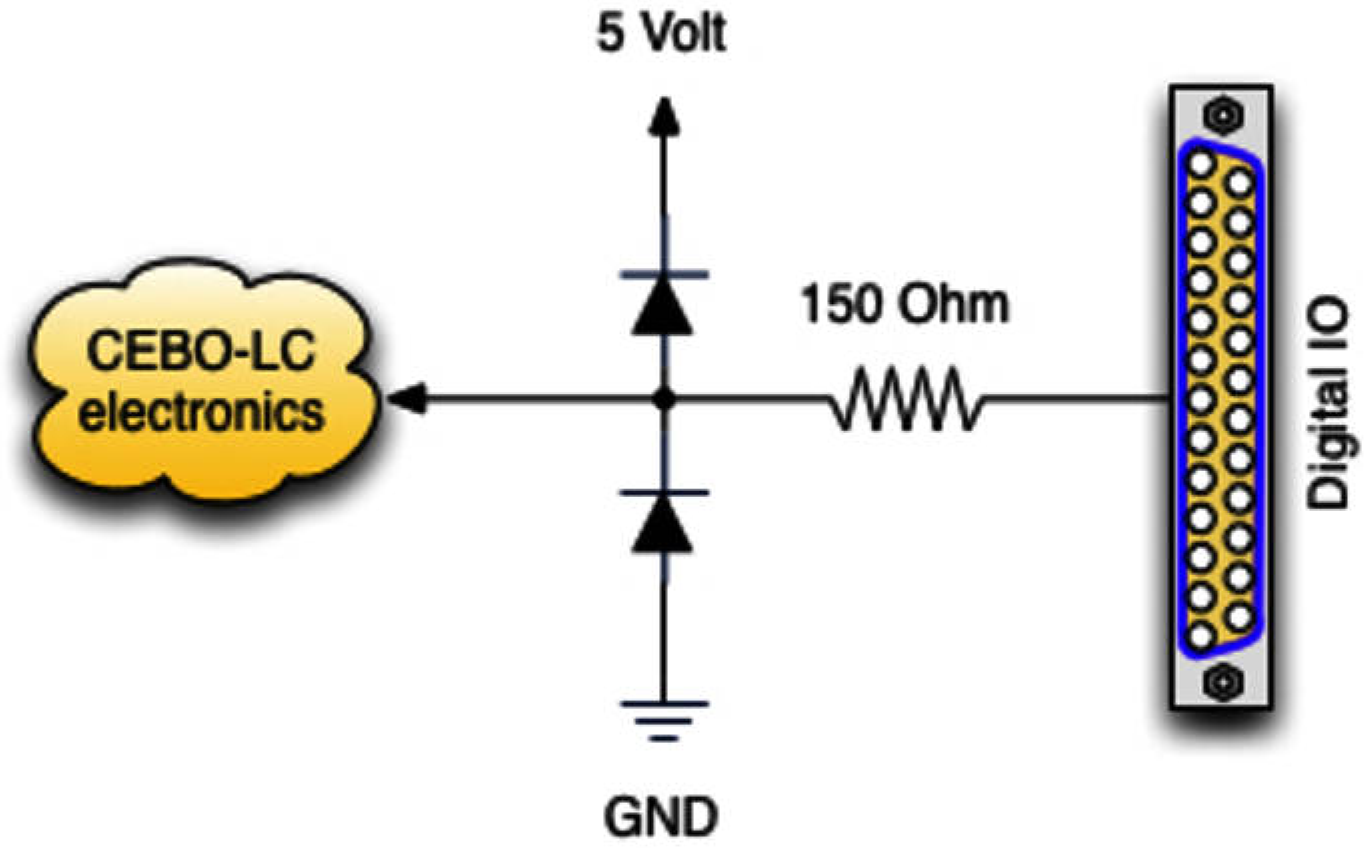
- Six Single-Ended Analog Inputs
- Twelve Digital I/O signals
- 5V Power Output
- Six GND signals

Pin	Signal	Description	Pin	Signal	Description
1	GND(1)		**14**	5V(2)	Power output
2	IO-8	Digital I/O 8 (Port 1, IO 0)	**15**	IO-9	Digital I/O 9 (Port 1, IO 1)
3	IO-10	Digital I/O 10 (Port 1, IO 2)	**16**	IO-11	Digital I/O 11 (Port 1, IO 3)
4	IO-12	Digital I/O 12 (Port 1, IO 4)	**17**	GND(1)	
5	GND(1)		**18**	IO-13	Digital I/O 13 (Port 1, IO 5)
6	IO-14	Digital I/O 14 (Port 1, IO 6)	**19**	IO-15	Digital I/O 15 (Port 1, IO 7)
7	IO-16	Digital I/O 16 (Port 2, IO 0)	**20**	IO-17	Digital I/O 17 (Port 2, IO 1)
8	IO-18	Digital I/O 18 (Port 2, IO 2)	**21**	IO-19	Digital I/O 19 (Port 2, IO 3)
9	GND(1)		**22**	GND(1)	
10	AI-13	Analog Input 13	**23**	AI-12	Analog Input 12
11	AI-11	Analog Input 11	**24**	AI-10	Analog Input 10
12	AI-9	Analog Input 9	**25**	AI-8	Analog Input 8
13	GND(1)				

1. GND pins are internally connected.
2. 5V Power Outputs are internally connected. A total of 100mA can be sourced.

Protective circuit of Digital I/O

All Digital I/O signals on DB25 connector are short-circuit proof* and protected against temporary overvoltage.



* Single I/O only. Total current should be limited to less than 25 mA.

If a Digital IO is used as output to drive a Led, no additional series resistor is needed. The internal protection resistor will act as a current limiter.

Example:
Output Voltage when "high": 3.3V
Typical forward voltage of a red Led: 1.8V (2.1V typ. for green Led)
Current flow: (3.3V - 1.8V) / 150 Ohm = 10mA

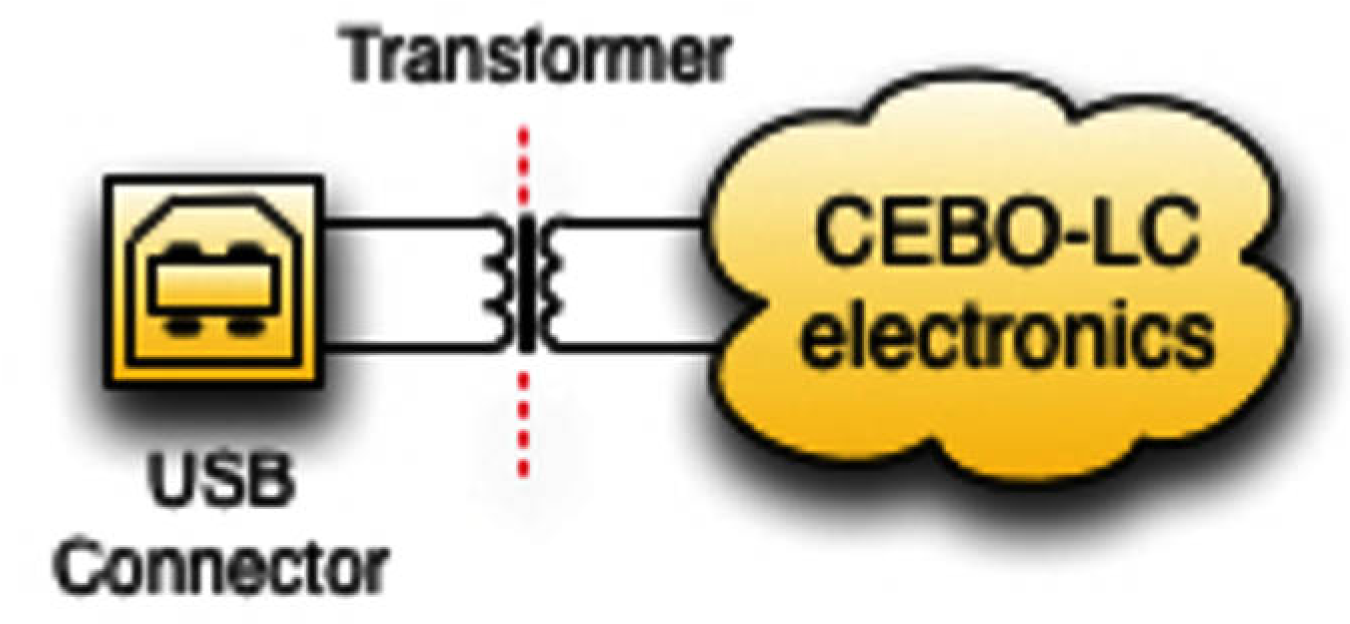
Please note that the screw terminals have different resistor values than the ones of the SUB-D pins!

USB Interface

CEBO-LC is a full-speed USB 2.0 device. USB connection provides communication and power. CEBO-LC GND signal is isolated from USB/PC ground. Hence, mutual interference between host system and CEBO LC I/O signals is avoided.

In other words: The CEBO-LC signals labeled GND are **not** connected to the host computer chassis or the host computer GND. This is a big advantage when precise and noise-free measurements are desired.

Because it is already built-in, there is no need to use an additional external USB-ISOLATOR:



The isolation is rated 500 Volt / 60Hz (1.000 VDC for one second).

Important: The device is not approved for medical use.

Power and status Leds

CEBO-LC comes with two status LEDs. A yellow LED indicates USB connection and traffic while a green LED indicates power status or helps identifying a special CEBO-LC device optically.

Green Led

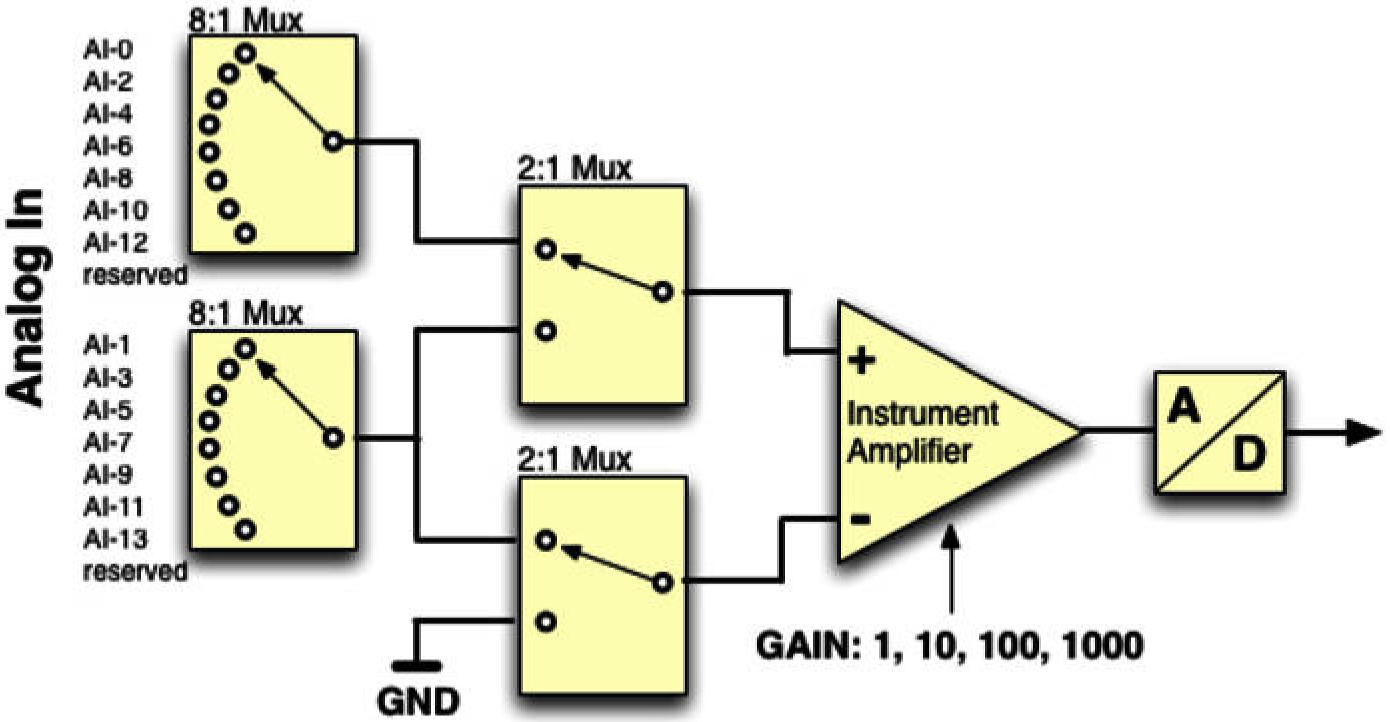
Primarily the green LED signals power supply connection status. If CEBO-LC is powered (i.e. is plugged to a host or to an USB-Hub) the LED will turn on.

Additionaly, the green LED can be switched off and on via software command. This way, when more than one device is used at a single host system, a special device can be identified optically by setting / resetting the LED.

Yellow Led

The yellow LED signals USB connection status and traffic. Default status after successfully establishing the USB link is on. With every USB transfer a short blink is initiated. Therefore blinking speed can be a measure of USB traffic.

Analog Inputs



Features:

- 8 Single-Ended (AI-0 to AI-7) or 4 Differential on screw terminals
- 6 Single-Ended (AI-8 to AI-13) or 3 Differential on expansion connector DB25
- 16 bit resolution
- Software programmable gains: x1, x10, x100, x1000
- Analog input ranges: 10V, 1V, 100mV, 10mV
- Instrumentation amplifier inputs
- SAR 65.000 - 85.000 Samples/s (depending on the number of enabled inputs)

Floating Inputs

To keep input resistance at a maximum, all Analog Inputs are left floating and are not artificially pulled to 0.0V. Readings from a floating input depend on sample rate and adjacent channels and will return undefined results.

Input Signal Range

Keep in differential-mode the "Input Common-Mode Voltage" (V_{cm}) and the "Input Voltage" (V_{in}) within the hexagons shown in the figures below. In single-ended-mode simply you have to stay in the setted range.

If you will not notice you get an invalid reading.

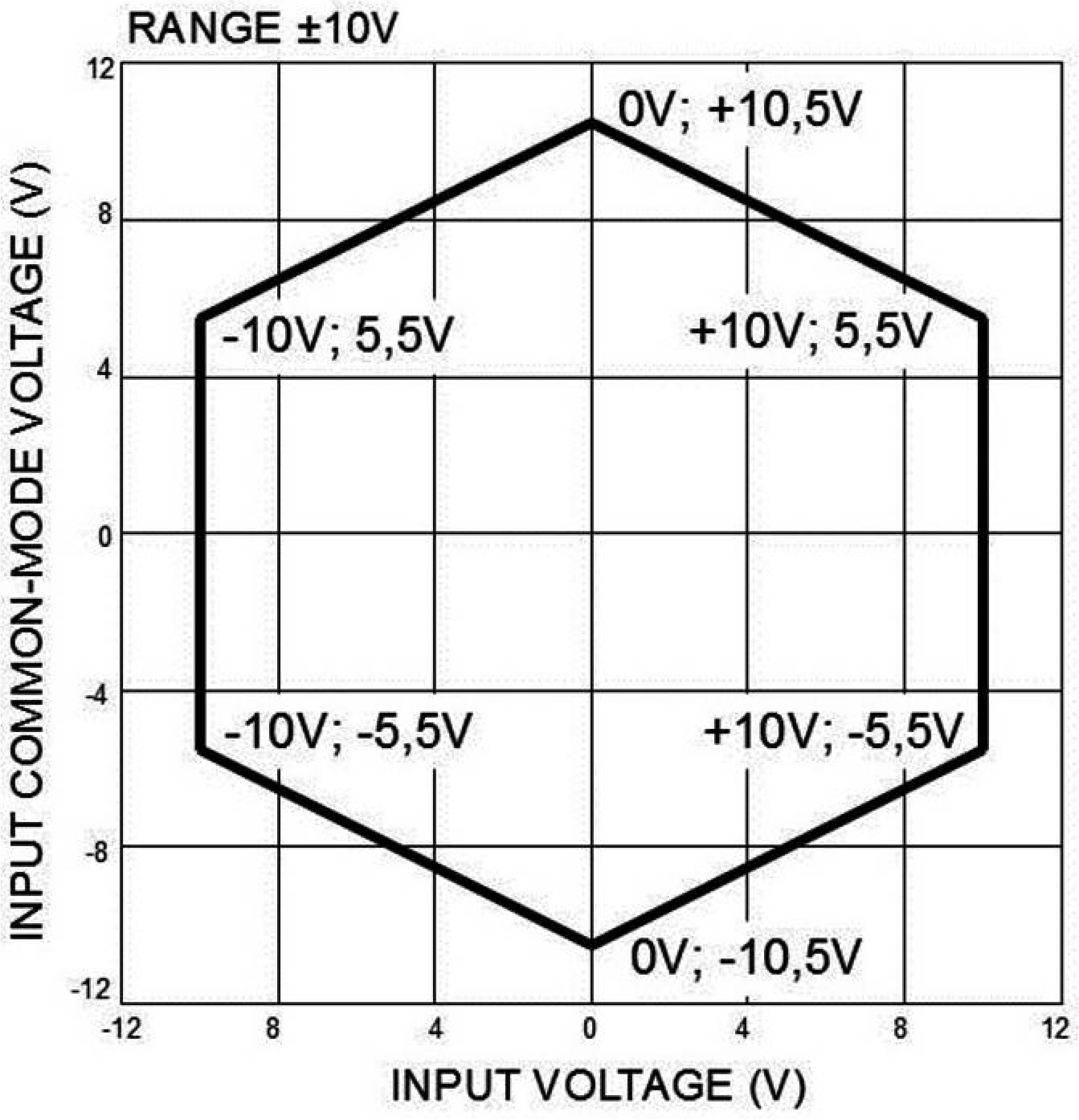
The "Input Common-Mode Voltage" is calculated as follows:

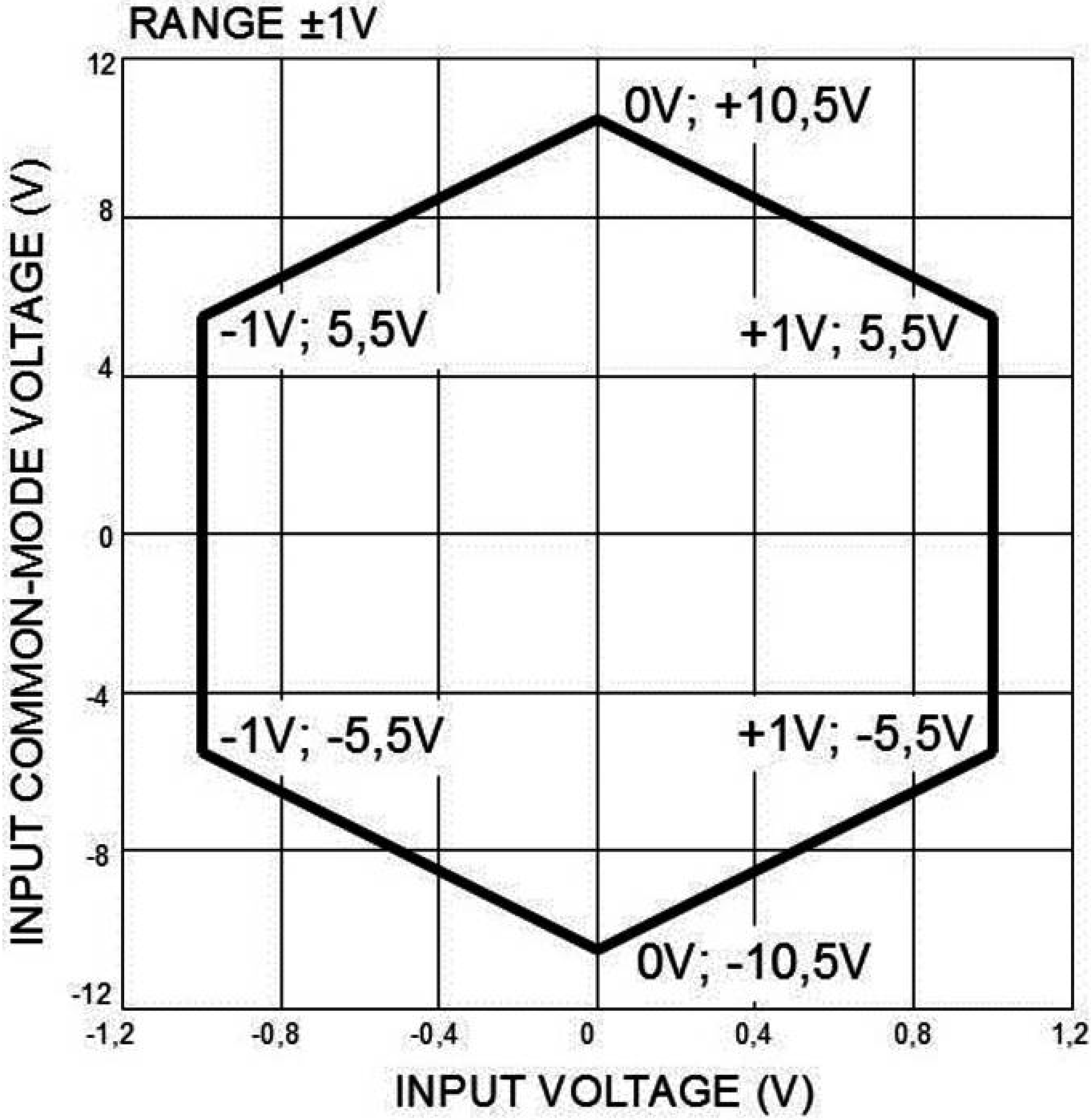
$V_{cm} = (V_{pos} + V_{neg}) / 2$

$V_{in} = V_{pos} - V_{neg}$

V_{pos} = even channel of a differential pair
V_{neg} = odd channel of a differential pair
If you measure in singel-ended the odd channel is switched to ground.

The limitation results from the amplifier circuit and its supply voltage and the ADC.





Example:
You have two voltages (5V & 11V) relating to mass.
V_{in} = 6V & V_{cm}= 8V
This point is in no figure inside the hexagon, so you get no valid reading.

Overvoltage protection

CEBO-LC Analog Inputs are rated for 10V with respect to GND. Keep voltages on any Analog Input within 12,3V to guarantee valid readings on adjacent channels. To limit current flow in case of overvoltage an internal series resistor is added at all input channels. Make sure voltages are within 20V at any time to prevent CEBO-LC from damage. This is also true if CEBO-LC is unpowered.

Settling time

In general, settling time is the time needed for the analog signal to reach a stable state at the ADC input after a step change occurred. With CEBO-LC such a step change occurs every time when input multiplexers change from one channel to another. Therefore this time is called interchannel delay time. With increasing gain settings a higher interchannel delay time may be required. With default interchannel delay times CEBO-LC meets specifications at all gains for source impedances up to 1 k at the least.

Factory preset interchannel delay times

Gain	Interchannel delay time [µs]
1	16
10	28
100	150
1000	500

All CEBO-LC specifications were measured with factory-preset interchannel delay times. Normally, there is no need to change these settlings. However, it is possible if desired. Find more information on how to achieve user defined interchannel delay times in chapter Data Acquisition Interchannel Delay.

Noise and Resolution Table

The following table provides typical noise levels measured with CEBO-LC under ideal conditions. Resolution is calculated based on these levels. If not otherwise noted, measurements were taken with Analog Input 0 connected to GND with a short wire.

Range [volts]	Peak-To -Peak Noise [24 bit counts]	Peak- To-Peak Res. [bits]	Noise- Free Res. [µV]	RMS Noise [24 bit counts]	Eff. Res. [bits]	Eff. Res. [µV]
±10	942	14,1	1123,3	219,8	16,2	262,0
±1	1252	13,7	149,2	286,0	15,8	34,1
±0,1	6252	11,4	74,5	1448,2	13,5	17,3
±0,01	19484	9,8	23,2	4039,6	12,0	4,8

For Noise-Free Resolution 128 measurements are taken, subtracting the minimum value from the maximum value.

RMS and Effective data are calculated based on the standard deviation of 128 readings.

Use equations (1) and (2) to determine signal-to-noise ratio (SNR) and corresponding effective number of bits (ENOB).

Equation (1)	$SNR_{\|dB} = 20 * \log(noise / full\text{-}scale\ input)$

Equation (2)	$ENOB_{\|BIT} = (SNR_{\|dB} - 1{,}76dB) / 6{,}02dB$

Equation (3) gives a representation of noise in counts. All counts data stated in the table above are 24 bit aligned values.

Equation (3)	$Noise_{\|counts} = 2\text{^}(24 - ENOB)$

To calculate a corresponding 16 bit value, counts data needs to be divided by 2^8.

Equation (4)	$Noise_{\|counts\_16Bit} = Noise_{\|counts\_24Bit} / 2\text{^}8$

Use equation (5) to calculate Peak-To-Peak Resolution & Effective Resolution in V:

Equation (5)	$Resolution_{\|V} = full\text{-}scale\ input / (2\text{^}Resolution_{\|BIT})$

Specifications - Analog Input

Parameter	Condition	Min	Typical	Max	Units
Typical Input Range (1)	Gain=1	-10,5		10,09	volts
Max AI Voltage to GND (2)	Valid Readings	-12,3		12,3	volts
Max AI Voltage to GND (3)	No Damage	-20		20	volts
Input Bias Current (4)		5		30	nA
Input Impedance (4)			1		G©
Source Impedance (4)			1		k©
Integral Linearity Error	Gain=1, 10, 100		t.b.d	t.b.d	% FS
	Gain=1000		t.b.d	t.b.d	% FS
Absolute Accuracy (~23±2°C)(5)	Range=±10V		±0,01		% FS
	Range=±1V		±0,01		% FS
	Range=±100mV		±0,01		% FS
	Range=±10mV		±0,04		% FS
Temperature Drift			t.b.d		ppm/°C
Noise (Peak-To-Peak)				<23,2	µV
Effective Resolution (RMS)			16,2		bits
Noise-Free Resolution			14,1		bits
Cross-talk(6)	1kHz	100			dB
	10kHz	86			dB

1. Single-Ended or Differential.
2. Maximum voltage on any Analog Input compared to GND for valid measurements on other channels. For readings on the channel itself, Single-Ended inputs are limited by the "Typical Input Range". For Differential readings consult common mode input voltage range tables.
3. Maximum voltage compared to GND on any Analog Input to prevent CEBO LC from damage. This is

also true if CEBO LC is unpowered.

4. Keep source impedance below given maximum value to ensure proper readings with default settling times. For greater source impedances You may be required to increase settling times.
5. These values were calculated as follows:
   $f_{total} = f_{measure} + f_{calibration\ device\ (max)}$
   $_{fmeasure}=(x_d - x_r) / x_r$
   f: relative error
   x_r: value from calibration device
   x_d: mean of n measurements from "Device Under Test"
   n=1000/1000/500/100 at range 10V / 1V / 100mV / 10mV
6. A sinusoidal voltage with a 10V amplitute was connected to one channel. Another channel was shorted to GND and the cross talk was measured at all ranges. No other channels was measured.

Power on behavior

When connecting CEBO-LC to a host system, a positive voltage might occur on analog outputs. Pulse length typically is about 6ms, peak voltage is about 1,5V. Maximum short-circuit current during this period is about 20mA. Please make sure that connected equipment is not negatively affected by this.

The same behavior is true when updating CEBO-LC firmware. Please remove all connections prior to initating firmware update process with CeboLab.

Specification - Analog Outputs

Parameter	Condition	Min	Typical	Max	Units
Nominal Output Range	No Load	-10		10	volts
	@±2,5mA	-9,875		9,875	volts
Resolution			12		bits
Absolute Accuracy	5% to 95% FS		±0,1		% FS
Integral Linearity Error				±4	counts
Differential Linearity Error				±2	counts
Error Due To Loading	@ 100 µA		0,16		%
	@ 1 mA		0,6		%
Souce Impedance			50		?
Short Circuit Current (1)	Max to GND		45		mA
Time Constant			t.b.d.		µs

1. Continuous short circuit will not cause damage.

Specifications - Digital Input

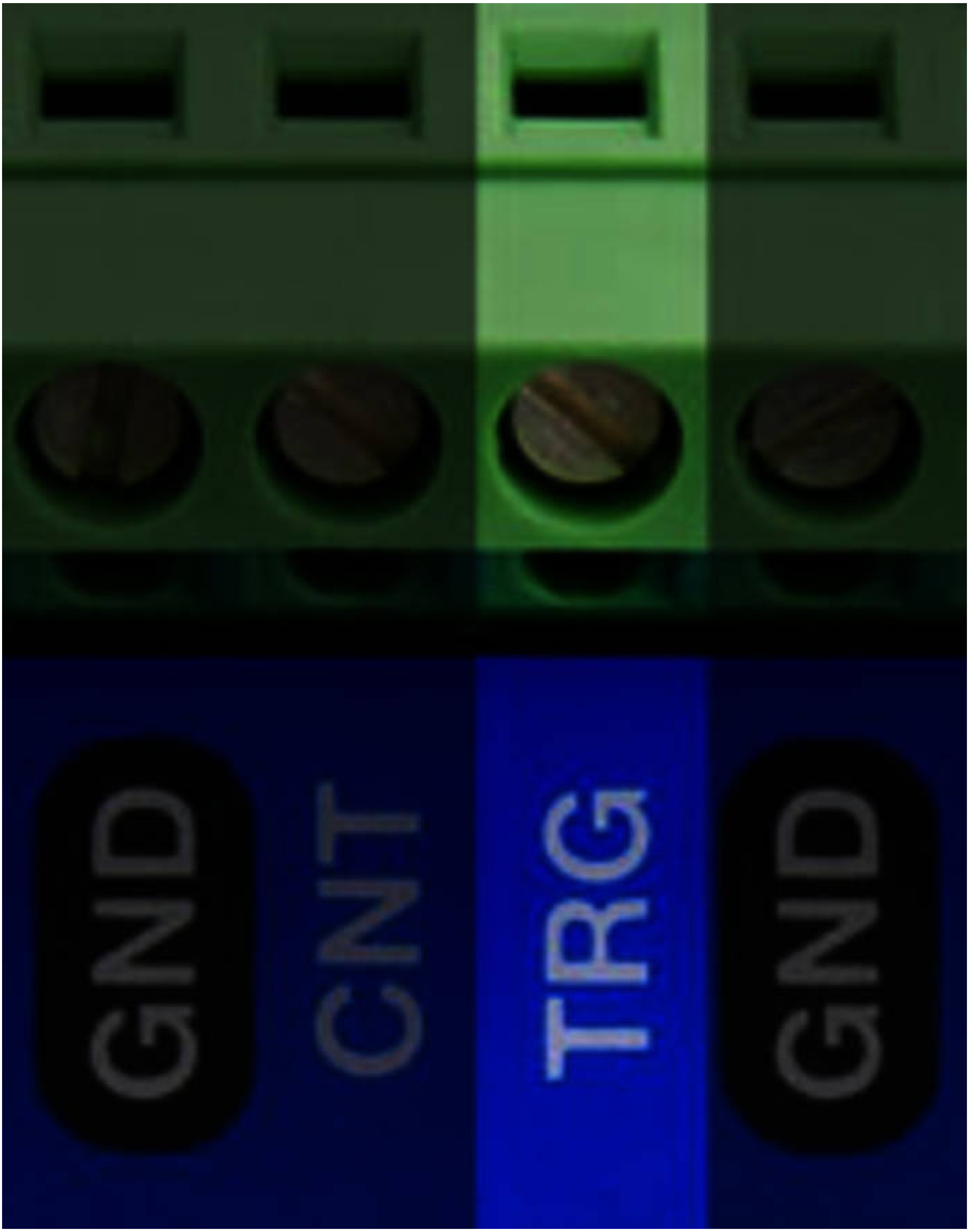
Parameter	Min	Typical	Max	Units
Low Level Input Voltage	-0,3		0,8	volts
High Level Input Voltage	2		5,8	volts
Maximum Input Voltage				
@Screw terminal(2)(3)	-10		10	volts
@DB25 connector(2)(3)	-6		6	volts

Specifications - Digital Output

Parameter	Condition	Min	Typical	Max	Units
Output Low Voltage	No Load				volts
@Screw terminal(3)	Sinking 1 mA		0,5		volts
@DB25 connector(3)	Sinking 1 mA		0,19		volts
@DB25 connector(3)	Sinking 5 mA		0,91		volts
Output High Voltage	No Load		3,3		volts
@Screw terminal(3)	Sourcing 1 mA		2,77		volts
@DB25 connector(3)	Sourcing 1 mA		3,01		volts
@DB25 connector(3)	Sourcing 5 mA		2,36		volts
Short Circut Current (1)					
@Screw terminal(3)			6,5		mA
@DB25 connector(3)			18		mA
Total Current (1)				25	mA
Output Impedance					
@Screw terminal(3)			507		?
@DB25 connector(3)			183		?

1. Short-circuit proof single I/O only. Total current should be limited to less than 25 mA.
2. Keep voltages on Digital I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
3. Protective circuit of Digital I/O on the screw terminals differs from that on the Sub-D jack.

Trigger



CEBO-LC has one Trigger Input/Output which is located at the TRG terminal. With firmware releases 1.x, the trigger is available for Multi Frame DAQ modes only. With the trigger signal, you can use an external event to start data acquisition or you can synchronize multiple CEBO-LC devices.

After startup TRG is configured as input signal, but inactive. To use TRG as a trigger, the corresponding peripheral needs to be enabled first. This is done by software calls (API).

An example about using TRG terminal as Trigger Input/Output is provided in Programming Reference => C++ => Trigger.

Trigger Input

In Trigger Input mode, an external signal must be supplied to the TRG terminal. CEBO-LC supports three different ways of trigger recognition.

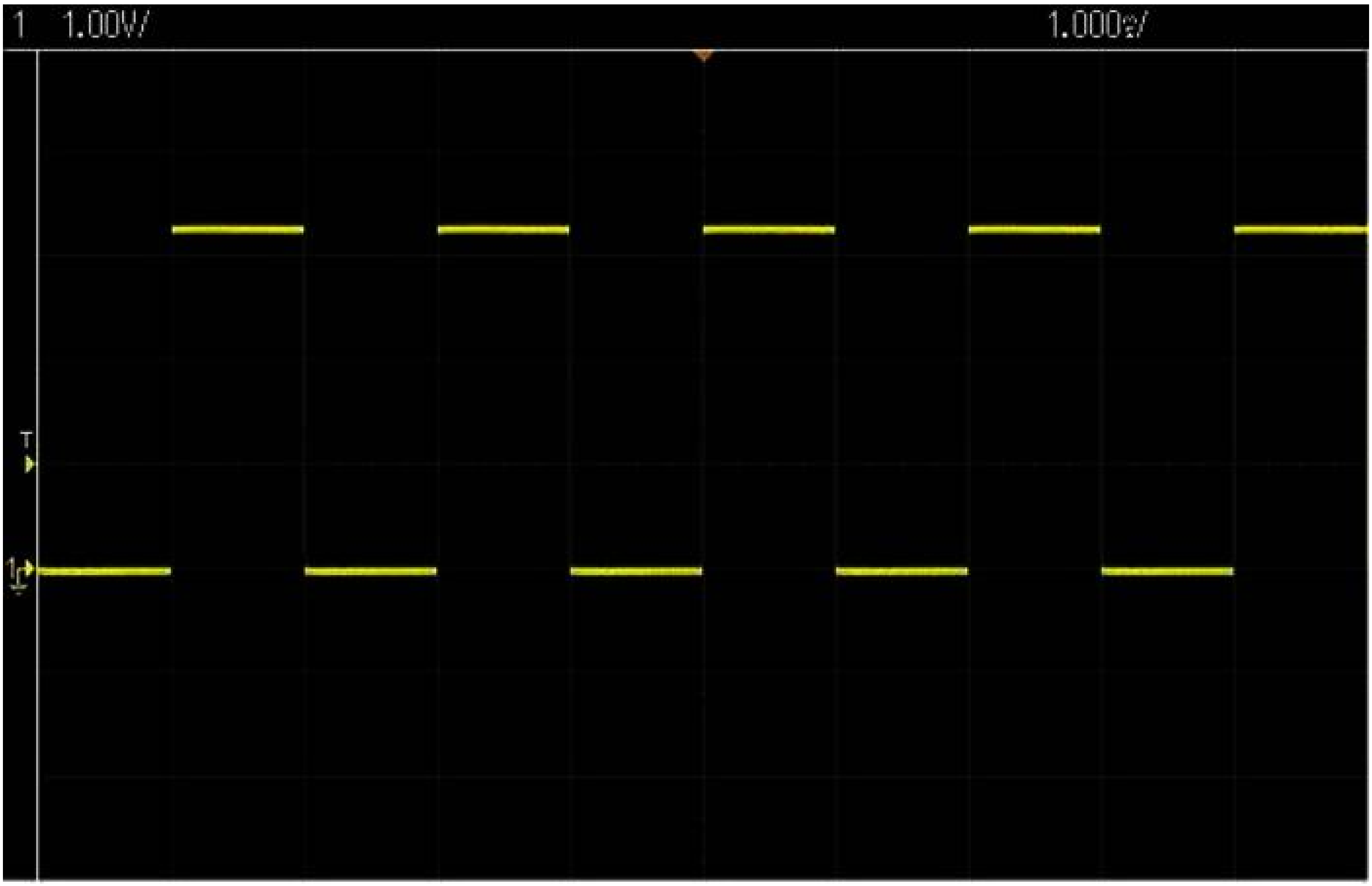
Rising edge:
In rising edge mode, every transition from low to high on the TRG terminal is a trigger event.

Falling edge:
In falling edge mode, every transition from high to low on the TRG terminal is a trigger event.

Alternating:
In alternating mode, both edges are trigger events.

Trigger Output

You can use trigger output for hardware timed DAQ modes. The TRG signal becomes an actively driven output. Depending on your settings (pulse mode, alternating mode) it toggles or pulses on every acquisition of a frame.



Alternating Mode

In alternating mode, every acquisition of a frame toggles the level of the TRG output signal. Consequently, the resulting signal is a square wave with 50% duty cycle and half the frequency of the data acquisition frame rate.

Pulse Mode

In Pulse Mode every trigger event initiates a pulse of several 100ns on TRG terminal. In this mode TRG signal rate equals the frame rate used for data acquisition, but duty cycle depends on frame rate and will be less than 50%.

Trigger application example

To get higher frame rates or channel counts, you can use two ore more CEBO-LC devices in parallel. In many cases, an identical acquisition rate is required for all devices. Then, "alternating mode" is the first choice.

To setup for this scenario, connect all the TRG terminals of all devices together. Because CEBO-LC is isolated from host ground, additionally connect the GND terminals.

Configure one device for Alternating Trigger Output mode (master) and all others for Alternating Trigger Input mode (slaves).

With every frame start, the master will toggle the level of the TRG signal, tripping a trigger on the slave devices.

An example how to accomplish master/slave configurations for CEBO-LC is provided in Programming Reference => C++ => Trigger.

Specifications - Trigger

Parameter	Condition	Min	Typical	Max	Units
Low Level Input Voltage		-0,3		0,8	volts
High Level Input Voltage		2		5,8	volts
Maximum Input Voltage (1)		-10		10	volts
Output Low Voltage				0,8	volts
Output High Voltage		2	3,3		volts
Output Impedance (2)			257		?
Input Total Edge Rate (3)	No Stream				edges/s
	While Streaming (4)			75.000	edges/s
Latency (5)	Trigger Input to conversion start (6)		10,5		us
	Trigger Input to conversion start (7)		21,5		us
	Trigger Output to conversion start (8)		9,5		us

1. Keep voltages on Trigger I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
2. Protective circuit of TRG terminal uses lower resistor value than normal Digtial I/O.
3. Keep the total number of edges below this limit, to avoid missing edges.
4. Input frame consisting of Analog Input 0.
5. Time interval from edge of Trigger signal to ADC conversion start signal for the first analog input in the InputFrame.
6. External timed data acqusition.
7. Hardware timed data acquisition with Trigger set to rising edge input mode.
8. Hardware timed data acquisition with Trigger set to alternating output mode.

Counter

CEBO-LC has an external counter input. It is located at the screw terminal labeled CNT.

On every rising edge on CNT, a 32 bit register is incremented. This counter requires the firmware to jump to a small interrupt service routine on each rising edge. Therefore maximum edge rate without missing counts depends on available processing resources. When the CNT counter is used exclusively, maximum input edge rate will be in the range of t.b.d. Samples/s. With Multi Frame DAQ enabled at the same time, maximum input edge rate will be less. And since each rising edge on CNT needs processing time, maximum Multi Frame DAQ input frame rate will be reduced, too.

By default CNT counter is disabled and the counter register is set to 0. Prior to counting, the peripheral needs to be enabled by software. In chapter Programming Reference => C++ => Counter you find further information on how to enable/disable or reset CNT counter by software.

Specifications - Counter

Parameter	Condition	Min	Typical	Max	Units
Low Level Input Voltage		-0,3		0,8	volts
High Level Input Voltage		2		5,8	volts
Maximum Input Voltage (1)		-10		10	volts
Input Total Edge Rate (2)	Without reading (3)			300.000	edges/s
	Continuously polling Counter value			35.000	edges/s
	Mutli Frame DAQ @ 1 kHz (4)			25.000	edges/s
	Mutli Frame DAQ @ 25 kHz (4)			5.000	edges/s

1. Keep voltages on Trigger I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
2. Keep the total number of edges below the Max limit, to avoid missing edges.
3. Counter value is only checked, after counting events have been disabled.
4. Input frame consisting of Analog Input 0 & counter value.

Temperature Sensor

Inside the CEBO-LC device, the IC temperature sensor ADT7410 from Analog Devices is used to provide 0,5C accurate, 16 bit digital data.

Reading the temperature is initiated by an API (software) call. A 16 bit value is returned immediately. Temperature data is not available while streaming.
See chapter Programming Reference => C++ => Info for further details on how to access temperature data.

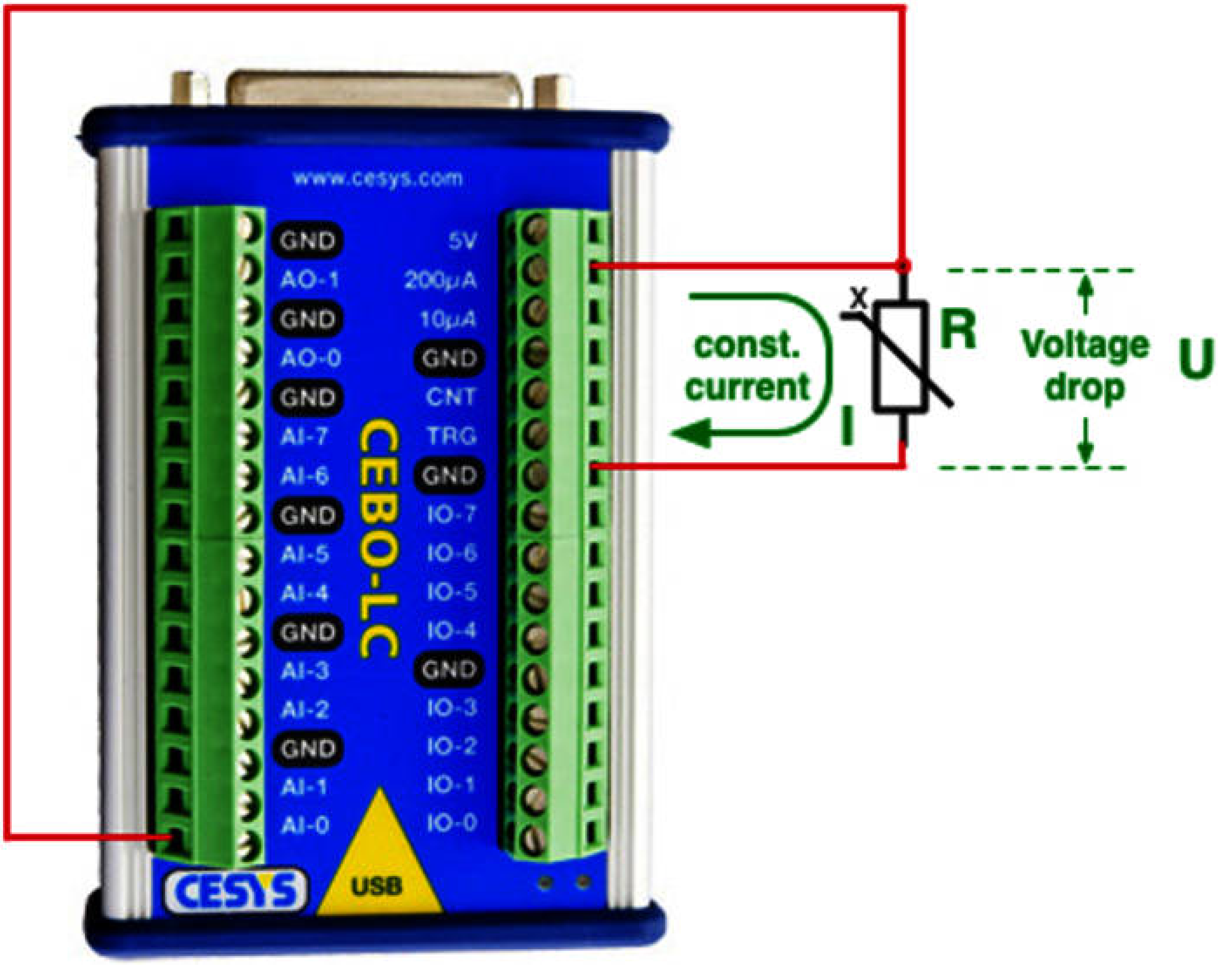
Because the temperature sensor resides inside CEBO-LCs enclosure, temperature readouts deliver values that are somewhat higher than the temperature of the screw terminals. Typically this offset is about 1-2 C at room temperature.

Constant-current sources

CEBO-LC has two accurate built-in current sources (200A / 10A). Both are available on screw terminals.

The exact values of the Fixed Current Outputs are measured during factory calibration process and stored in flash. You can find more information on how to access calibration data for the Fixed Currend Outputs in chapter Programming References => C++ => Info.

Application example



To measure a resistor value, connect one terminal of the resistor to the Fixed Current Output and the other to CEBO-LC GND.
Then, measure the voltage drop across the resistor with one of the Analog Inputs of CEBO-LC. In this example: AI-0

Because all GND terminals are internally connected, you don't have to wire one GND screw terminal externally to another one.

The resistor value R is calculated with Ohm's law:

R = Voltage drop / Fixed Current Output = U / I

Resistive sensors are very common to measure various physical quantities.
With the help of a temperature-dependent resistor (PTC, NTC), a temperature can be measured indirectly by measuring the voltage drop across the resistor.

The constant current sources can output a maximum voltage of about 3 Volt.
This puts a limit to the usable measurement range.
For the 200A source, it is about 15 kOhm (= 3 Volt / 200A).
For the 10A source it is about 300 kOhm (= 3 Volt / 10A).

Reading more than one analog-in-channel

If you measure more than one analog-in-channel it is necessary to increase the interchannel delay to >1000s (1500s is recommended), because the source has a high impedance and because of some switching effects.

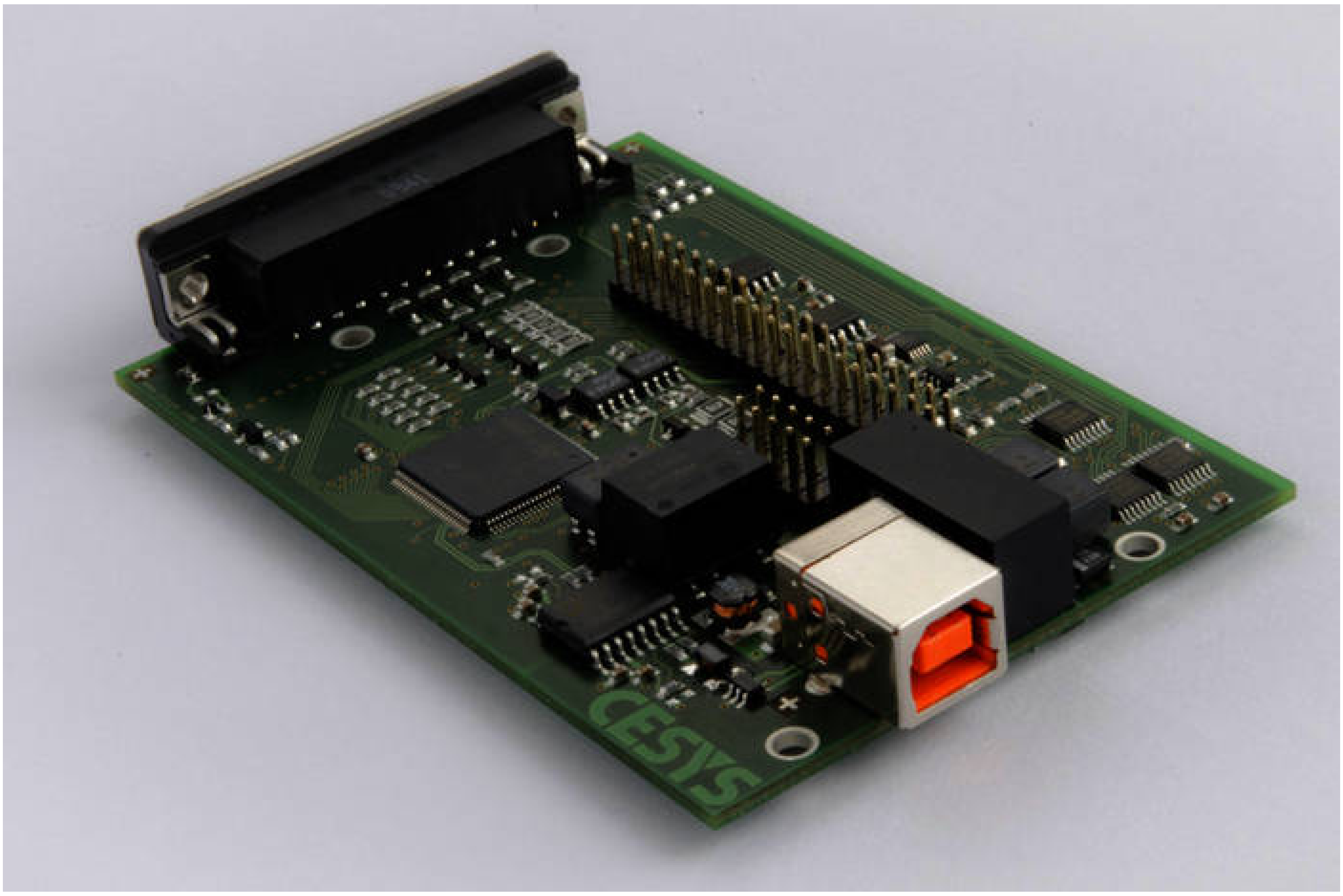
Specifications - Constant Current Source 200µA

Parameter	Condition	Min	Typical	Max	Units
Absolute Accuracy(1)	~25°C; R**Specifications - Constant Current Source 10µA**				
Parameter	Condition	Min	Typical	Max	Units
Absolute Accuracy(1)	~25°C; R(1) Compared to calibration data stored in flash.**5 Volt power supply output**CEBO LC has two 5V power supply outputs. You can use them to supply sensors, signal conditioners or any other circuit to save an additional battery or wall-plug. One is located at the "5 Volt" screw terminal, the other is available at pin 14 of the 25pin D-Sub connector. Both 5V outputs are internally connected and fused by a self-resetting 100mA fuse. The 5 Volts do not come from the USB plug directly. There is an isolated DC/DC converter inside CEBO LC. The GND reference is the level of the CEBO-LC GND signals. The PC GND is isolated. **Do not try to connect a 5 Volt source to this output. CEBO-LC is sourced from USB and does not need an additional power supply.** **Specifications - 5 Volt Output**				
Parameter	Condition	Min	Typical	Max	Units
Typical Voltage			5		volts
Output Voltage Accuracy			±5		%

Load Voltage Regulation(10% to 100% full load)				15	%
Output Ripple and Noise			50		mV
Maximum Current (1)	-40°C		140		mA
	-20°C		120		mA
	0°C		110		mA
	23°C		100		mA
	40°C		80		mA
	50°C		70		mA

(1) A resettable 100mA fuse prevents overcurrent on 5V Power Outputs.

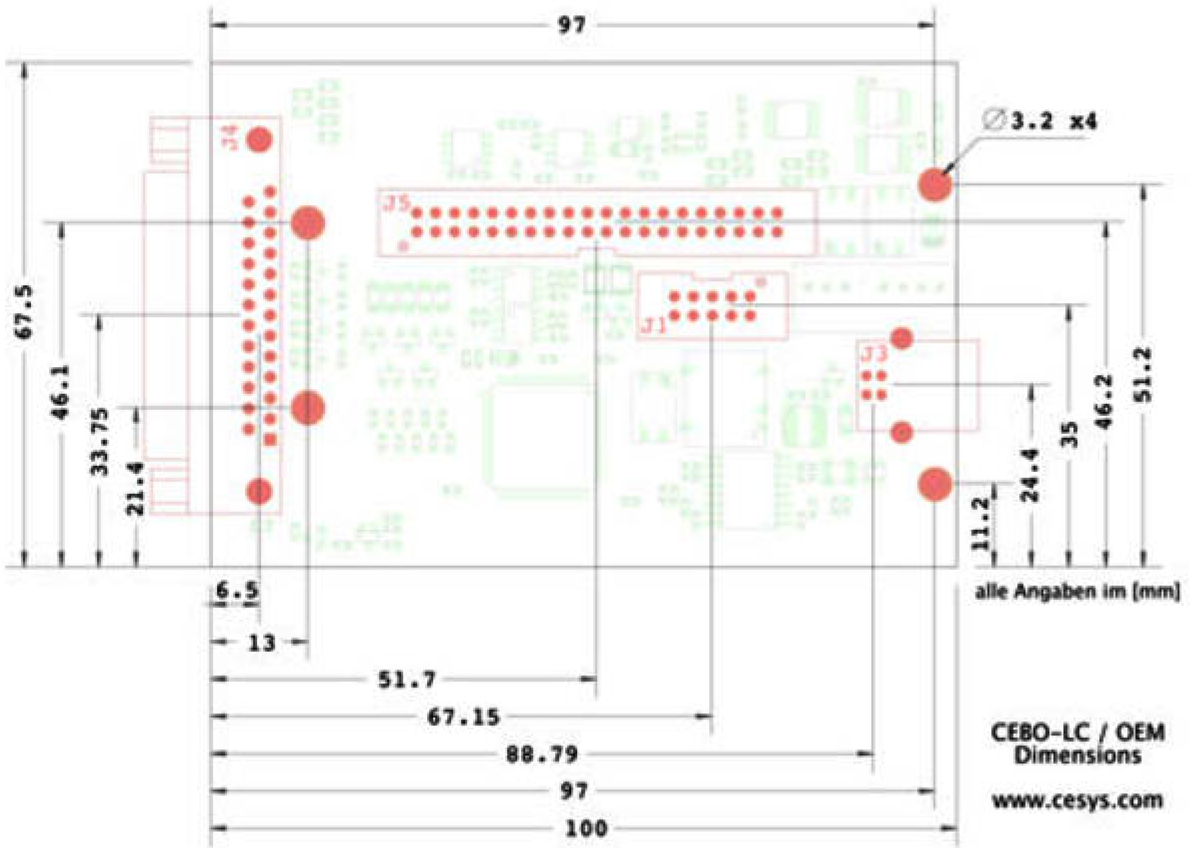
CEBO-LC/OEM



CEBO-LC is also available as "OEM-version" without the enclosure and without screw terminals. The screw-terminal signals are on a 2x20 pin standard 0,1" (2,54 mm) header instead.
Use the OEM version to embed CEBO-LC functionality into your machines or devices.

There is a minimum order quantity of 10 pieces.

Dimensions of the OEM board



OEM Connector

Pin	Signal	Description	Pin	Signal	Description
1	GND(1)		**2**	5V(2)	Power Output
3	10µA	constant current output	**4**	200µA	constant current output
5	GND(1)		**6**	CNT	Counter Input
7	TRG	Trigger Input/Output	**8**	IO-7	Digital Input/Output 7
9	IO-6	Digital Input/Output 6	**10**	IO-5	Digital Input/Output 5
11	GND(1)		**12**	IO-4	Digital Input/Output 4
13	IO-3	Digital Input/Output 3	**14**	IO-2	Digital Input/Output 2
15	IO-1	Digital Input/Output 1	**16**	IO-0	Digital Input/Output 0
17	GND(1)		**18**	GND(1)	
19	AO-1	Analog Output 1	**20**	GND(1)	
21	AO-0	Analog Output 0	**22**	GND(1)	
23	AI-6	Analog input 6	**24**	AI-7	Analog input 7
25	AI-4	Analog input 4	**26**	AI-5	Analog input 5
27	GND(1)		**28**	GND(1)	
29	AI-2	Analog input 2	**30**	AI-3	Analog input 3
31	AI-0	Analog input 0	**32**	AI-1	Analog input 1
33	GND(1)		**34**	GND(1)	
35	VCC	+12V	**36**	VSS	-12V

37	GND(1)		**38**	T-LED(3)	USB status and traffic LED
39	P-LED(3)	Power supply status and indicator LED	**40**	GND(1)	

1. GND pins are internally connected.
2. 5V Power Outputs are internally connected. A total of 100mA can be sourced.
3. T-LED and P-LED are general purpose digital I/Os directly connected to the microcontroller. With normal firmware, these are used to drive status LEDs on the IO-Board through a series resitor located on the IO-Board.

Specifications - Vcc/Vss-Output

Parameter	Conditions	Min	Typical	Max	Units
Typical Voltage	No-load		±12		volts
	@ 2,5mA		±???		volts
Maximum Current			???		mA

Data acquisition

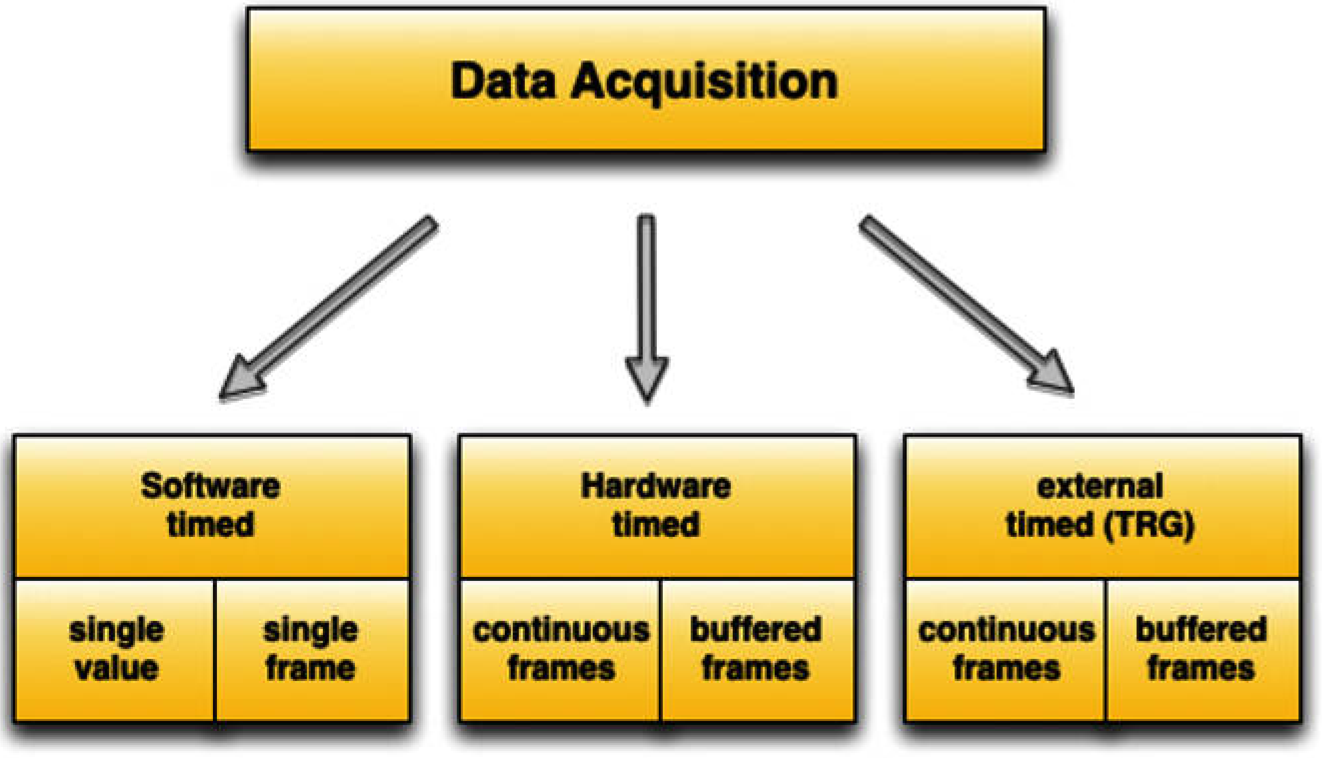
The process of measuring data is called "Data acquisition". It is abbreviated DAQ.
There are several ways to collect data with the CEBO-LC. We call them "DAQ modes".

In this section, you will learn the basics of data acquisition with CEBO-LC.

Data acquisition modes

Some measurement problems require more effort than reading one single input.

Depending on the circumstances, a fixed number of measurements with well defined timing or an endless stream of measurements is desired. Sometimes, data acquisition should take place only when there is a trigger event (i.e. a external digital signal switches from low to high).



Software timed - one single frame

Capture and return one frame. The time when the frame is captured is not exactly defined. It depends on the timing, the system needs to process the request, send it to the CEBO-LC device and process it there.

Hardware timed - continuous frames

Capture and return a unlimited number of frames. The frame acquisition frequency is generated by an internal hardware timer of the CEBO-LC. The Frame data is endlessly streamed to the host system.

The maximum frame acquisition frequency is limited by the data transfer rate between the CEBO-LC and the host system.

Hardware timed - buffered frames

Capture and return a fixed number of frames. The frame acquisition timing is generated by an internal hardware timer of the CEBO-LC. Frame data is stored in an internal buffer of the CEBO-LC before it is sent to the host.

When **external trigger** is enabled, an edge on the TRG input is required to start capturing.

This acquisition mode allows it, to capture data at a higher rate than in continuous mode under some circumstances (i.e. slow PC or heavy loaded CPU). The number of acquisitions is limited by the buffer size of the CEBO-LC.

External timed - continuous frames / buffered frames

This acquisition modes are like the comparable hardware-timed modes with one difference: There is no hardware-timer.

Edges on the TRG input trigger the acquisition of one frame. Falling, rising or both edges can be used to trip trigger events.

Frames

CEBO-LC has various sources and sinks of data. Besides the analog inputs and outputs there are digital signals and counter values.

One way to access them individually, would be to assign a unique address to each. Then, communication between the host and CEBO-LC would have some significant overhead to transmit and decode address data.

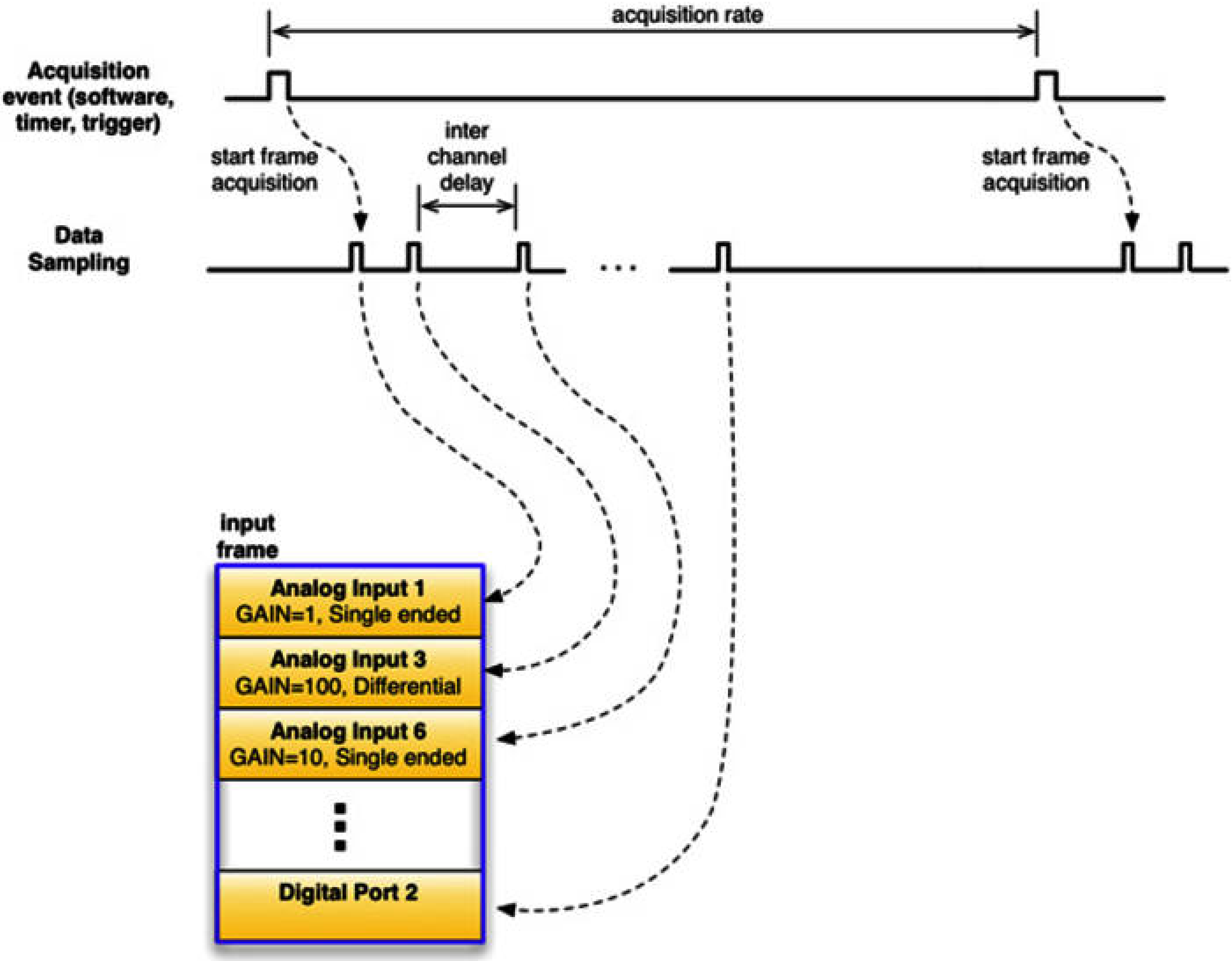
This is why data flow to and from CEBO-LC is organized in blocks of data. They have known sizes and structures and are called "frames".

Depending on the transmission direction, there are **InputFrames** and **OutputFrames**. An **InputFrame** contains the results of data acquisition, while an **OutputFrame** contains data that is sent to outputs or internal registers like counters.

Before you can use a frame, you have to define it by using the methods setupInputFrame respectively setupOutputFrame.

After setting values in an OutputFrame and before reading values from an InputFrame, you must actively communicate with the device to send or receive the frame(s).

Data acquisition example



DAQ Timing

Data acquisition of all channels takes place sequentially in a fixed order. The settling time after switching channels can be adjusted. It is called "Interchannel Delay".
The shorter the interchannel delay is, the more frames per second you can get - but with less accuracy.

Input Frame

Setting up an input frame is a two step process.

First, build a list of inputs that should be measured. This can be any analog input (single ended and/or differential), digital port, counter or trigger. Every input can be in the list only once. The order of the inputs in the list does not matter.

Second, set up the frame using this list calling **setupInputFrame()** of the class instance.

Output Frame

The output frame is set up by defining a list of all outputs that should be set using a single write. Output frames can be a list of analog outputs and digital ports (do not forget to set their output enable masks).

Call **setupOutputFrame()** using this list.

Interchannel delay

In general, settling time defines the time needed for an analog signal to reach a stable state after a step change occured. With CEBO-LC such step changes occur, whenever a input multiplexer switches from one channel to another. To reduce impacts on measurement accuracy when switching between different analog input channels, a minimum dead time needs to be waited between subsequent measurements. This time is called the interchannel delay. Increasing interchannel delay time might enhance measurement accuracy, but will on the other hand reduce achievable maximum frame-rate. There always is a tradeoff between speed and accuracy.

With the default interchannel delay times CEBO-LC meets specifications at all gains for source impedances up to 1 k at the least. Normally, there is no need to change interchannel delays manually. However, it is possible if desired. For example, if speed is more important than actual accuracy. Interchannel delay is one of several parameters that can be set for each of the various analog inputs, independently. See corresponding programming references to get details on how to set parameters for analog inputs.

Factory preset interchannel delay times

Gain	Interchannel delay time [µs]
1	16
10	28
100	150
1000	500

Single Value IO

Single value I/O is the most basic form to sample an input or modify an output. The call is synchronous, so invoking a method processes the request always immediately, which means:

- In case of sampling: The result of the called method is the sampled value, the method call lasts as long as sampling and data transmission from device to host is active.
- In case of modify: The method call sends the value to the peripheral directly and returns*.

*In reality, the method returns earlier than the output will show the result, there is some latency from host to the devices periphery.

Specifications - Command/Response Speed

Condition	Min	Typical	Max	Units
Analog (1)		1,4	6,1	ms
Digital (1)		0,93	4,0	ms

(1) Depends on the computer, USB peripheral and Interchannel Delay.

Intention

The idea behind this feature is that handling multiple inputs and outputs concurrently has some benefits:

- Sampling order and input to input sample distance of a selected group of inputs is always constant.
- Data transfer between host and device can be optimized to a maximum.
- Very easy handling when working with more than one input or output.

Single InputFrame Procedure

Use single frame reading if you want to read more than one input directly. First, specify the inputs to read. Do this by creating a list of the inputs and call method **setupInputFrame()** of the device in use (The list type varies between the different programming languages, refer to the specific language documentation for more detail).

All subsequent calls to **readFrame()** will sample the specified inputs and return an instance of type **InputFrame**, which contains the sampled values. **InputFrame** has convenient methods to access these values.

Single OutputFrame Procedure

If you have the requirement to update various outputs, this method technique should be your choice. Similar to the input direction, you must define the API about the involved outputs. Call method **setupOutputFrame()** using the list of these outputs at first.

Method **createOutputFrame()** creates an instance of type **OutputFrame**, whose metrics fits to respective device. Calling the various methods of **OutputFrame** to fill the structure with the values you intent to output.

Call method **writeFrame()** on the device instance to update all previously specified outputs.

Specifications - Command/Response Speed

Condition	Min	Typical	Max	Units
1xAnalog (1)		0,9-1,0	4,0	ms
1xDigital (1)		0,9-1,0	4,0	ms
complete frame (1)		1,15	4,0	ms

(1) Depends on the computer, USB peripheral and Interchannel Delay.

Multi Frame DAQ

The principles and mechanics of the previous topic are the base to understand the description in this section.

Multi frame DAQ is a configurable method to sample a set of inputs in either a static frequency or using external events cyclically. Captured frames are stored in a device site buffer which can be read out from host side.

Methods

There are different multi DAQ methods:

The main difference is the event to capture the individual frames. One mode captures a frame in a given time interval (hardware timed), the other mode does this for every external trigger (external timed).

The second difference is either continuous or buffered mode. Continuous will capture without any limit. The host must read the frames as fast as possible, otherwise the device onboard buffer will overflow. Buffered mode requires a limit from you. Frames are than captured until this count of frames has been reached. This limit can't be larger than the amount of frames that fit into the device buffer (which varies between different frame setups).

Flow

Multi Frame DAQ can be used by doing the following steps:

- Open device.
- Setup the input frame using setupInputFrame().
- Call one of the start DAQ methods:
  - startBufferedDataAcquisition()
  - startBufferedExternalTimedDataAcquisition()
  - startContinuousDataAcquisition()
  - startContinuousExternalTimedDataAcquisition()
- Read the captured frames using readBlocking() or readNonBlocking().
- Stop the data acquisition using stopDataAcquisition().

Specifications - Max Sample Rate

Condition	Max	Units
1xSingleEnded	70.000	frames per second
2xSingleEnded	39.000	frames per second
3xSingleEnded	27.000	frames per second
4xSingleEnded	21.000	frames per second
5xSingleEnded	17.000	frames per second
6xSingleEnded	14.000	frames per second
7xSingleEnded	12.000	frames per second

8xSingleEnded	10.000	frames per second
9xSingleEnded	9.000	frames per second
10xSingleEnded	8.500	frames per second
11xSingleEnded	7.500	frames per second
12xSingleEnded	7.000	frames per second
13xSingleEnded	6.500	frames per second
14xSingleEnded(all)	6.000	frames per second
1xDigitalPort	90.000	frames per second
2xDigitalPort	71.000	frames per second
3xDigitalPort	41.000	frames per second
1xAnalog & all digital	41.000	frames per second
all (1)	4.000	frames per second

These values were measured with the range of 10V and an Interchannel Delay of 11s. They are dependent on the PC and the USB port.

(1) All means all 14x SingleEnded, 7x Differential, 3x DigitalPort, 1x Counter, 1x Trigger

Digital Ports

Single IO signals are grouped in digital ports. To define a frame, add whole ports, not single signals.

You can individually define the direction of every signal. As default, all I/O signals are inputs.

Calibration

CEBO devices come factory calibrated. All corrective calculations are performed by the API internally.

This includes the setting of analog output voltages and measurement of analog inputs.

The exact value of both fixed current sources is measured and stored in the device's flash memory during calibration.

Firmware-Update

The firmware can be updated using CeboLab. How you can patch a device is described in detail here.

Firmwares can be found on our download site.

Application Software

The generic Software CEBOLAB and the APIs for various languages are common for all CEBO devices.

There are two applications specially made for CEBO-LC. They are Executables (*.exe) for Windows operating systems (sorry no Mac or Linux version).

Instrument-panel

Data-recording

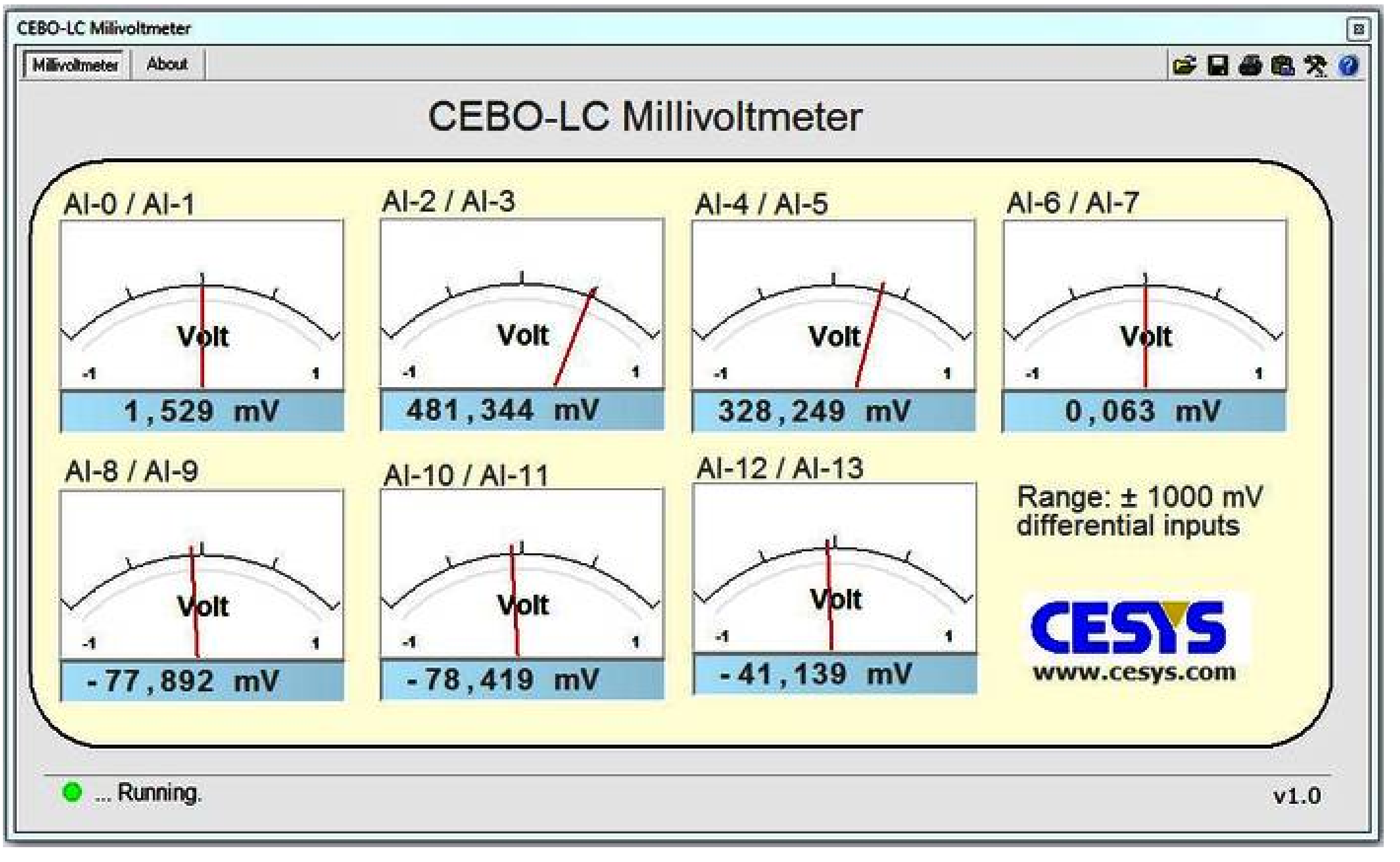
CEBO-LC Control and measurement software

With these new applications, the CEBO-LC measurement laboratory is now easier to use. Download the free CEBO LC data recorder to capture and export values to spreadsheet or word processing. Use CEBO-LC Millivoltmeter or Microvoltmeter to precisely measure multiple voltages. With the LC-CEBO pen plotter you get a pen recorder with up to 4 channels.

CEBO-LC Millivoltmeter and CEBO-LC Microvoltmeter

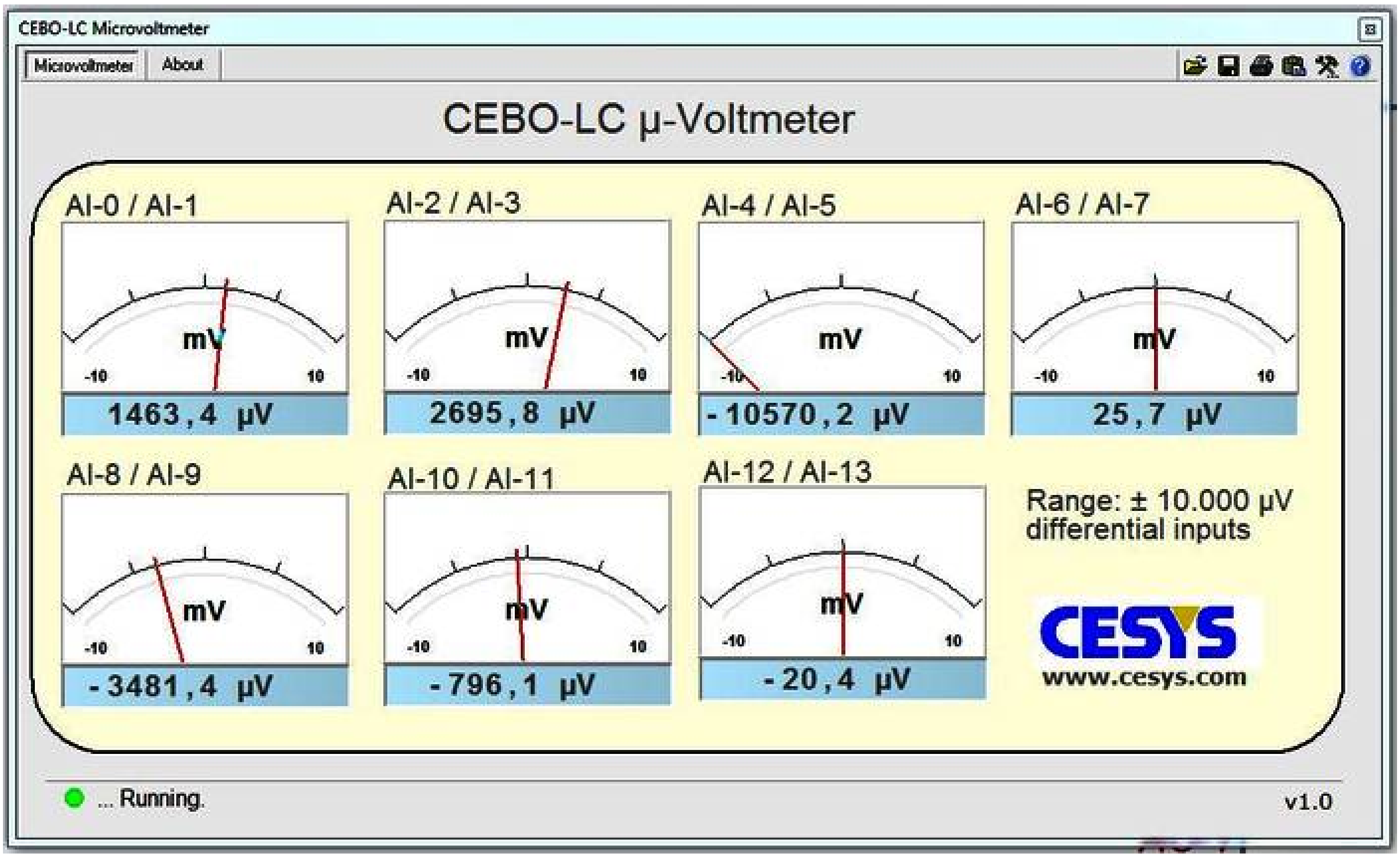
This two applications set the CEBO-LC analog inputs to differential mode. To get stable readings the inputs are sampled multiple times. The mean value of the measurements is calculated and displayed.

CEBO-LC Millivoltmeter



The CEBO-LC Millivoltmeter has 7 differential inputs. The measurement range is 1 Volt.

CEBO-LC Microvoltmeter



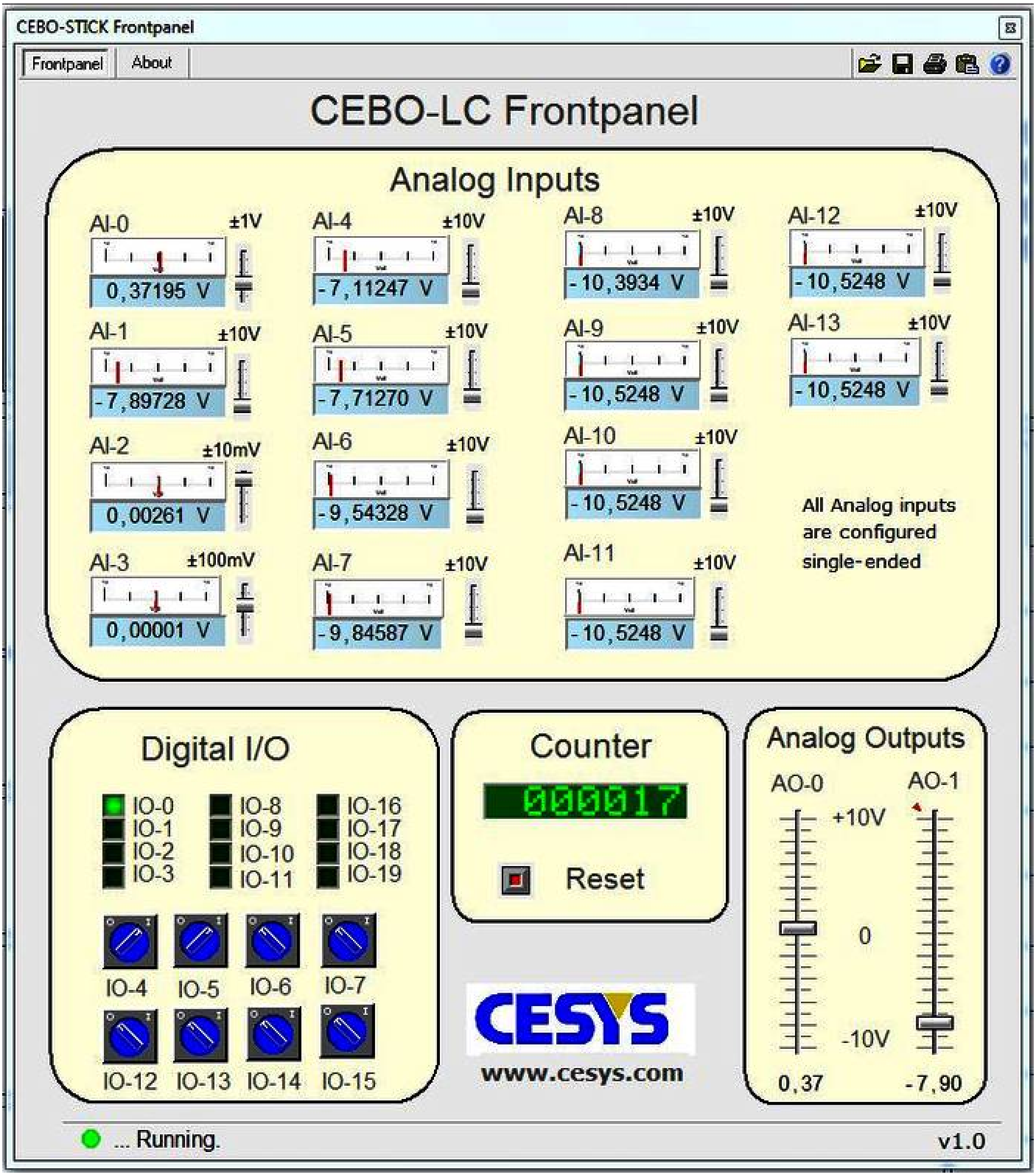
The CEBO-LC Microvoltmeter has 7 differential inputs. The measurement range is 10 mV.

CEBO-LC Frontpanel

This application displays 14 single-ended analog inputs, the actual counter value and 12 digital I/Os. The range of each analog input is selectable individually.

8 digital I/Os are configured as outputs. Their state (high/low) is controlled by switches.

Two sliders control the voltage on the two analog outputs. The range is -10V to +10V.

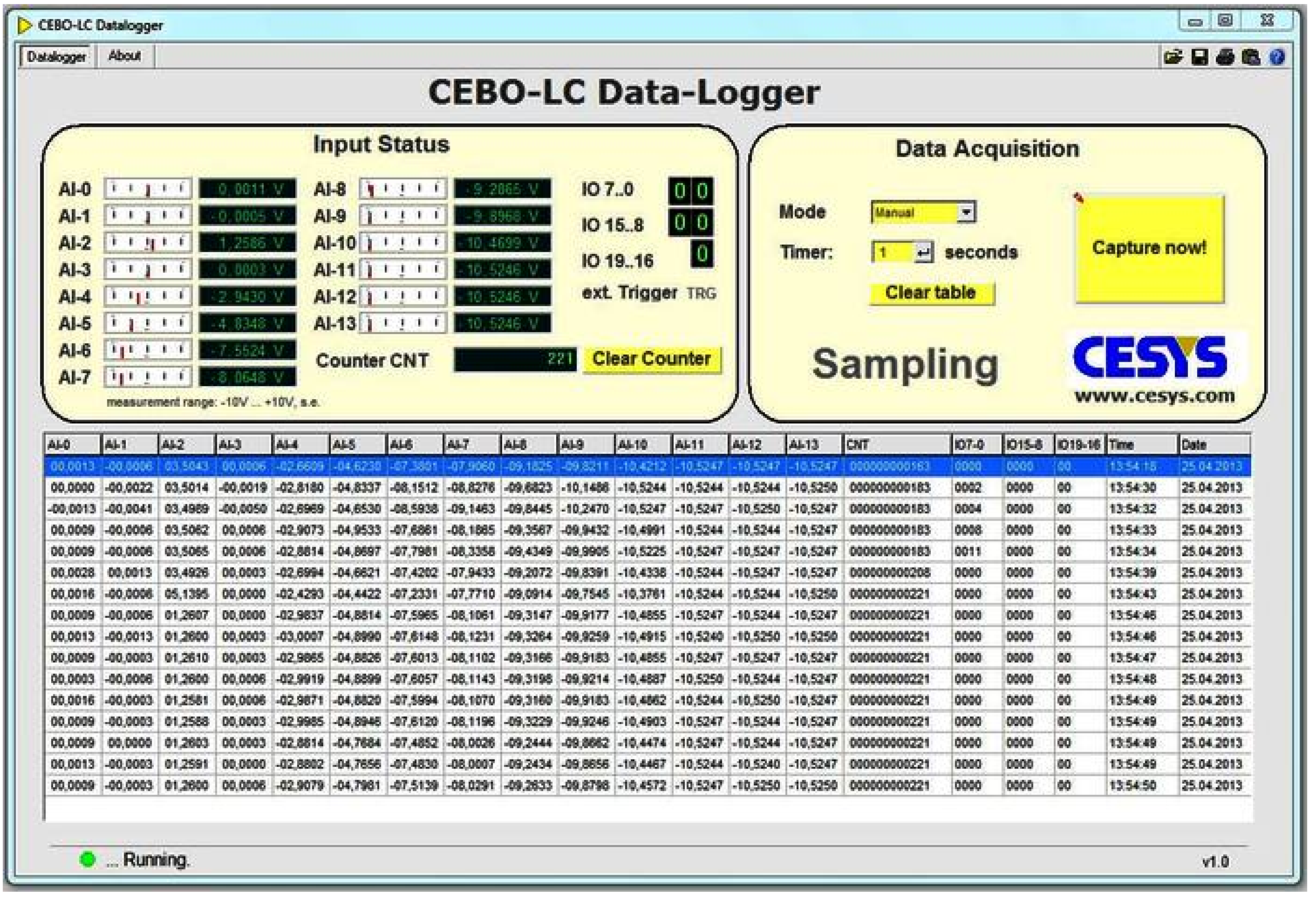


CEBO-LC Datalogger

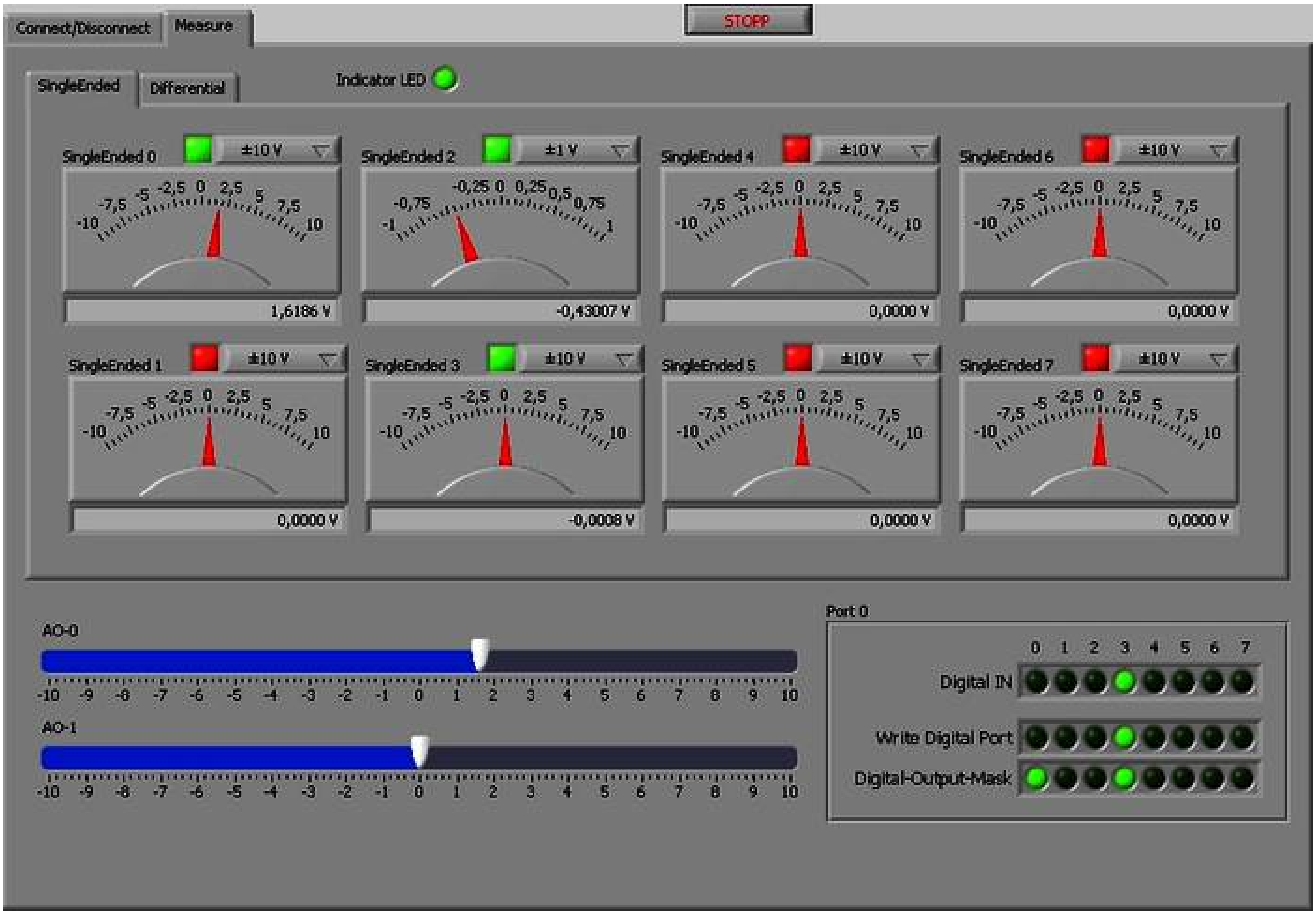
The CEBO-LC Datalogger captures the voltage levels on all 14 analog inputs, the counter value and the state of all 20 digital inputs. The information is saved in a table together with the current date and time.

Capturing is triggered by clicking on a button, by a timer or by an edge on the external trigger-input "TRG".

Captured data can be saved in a file for further processing with Excel, Word or other external programs.



Labview - Demo1



This is a small tool and LabView-Demo for

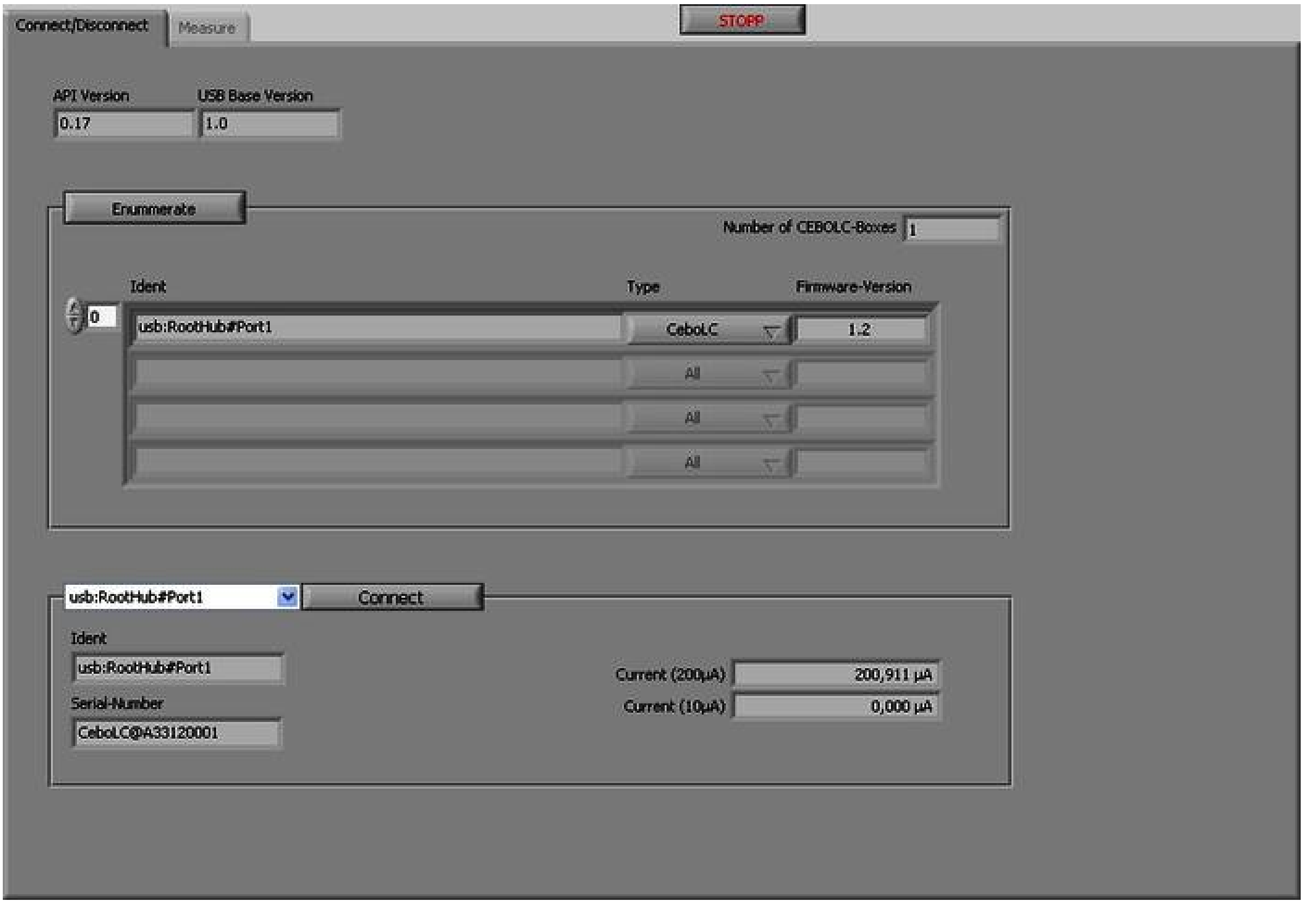
- measuring voltage (scew terminal only)
  - SingleEnded
  - Differential
- voltage output
- controlling the digital IO (scew terminal only)
- setting the indicator LED

Measure

At the "Measure"-tab you can

- enable/disable the analog inputs (SingleEnded/Differential)
- change the range of that channels
- set the analog outputs
- define the digital pins as output or input
- set/clear the digital outputs

Connect/Disconnect



The "Connect/Disconnect"-tab shows you:

- API version whitch is used
- USB Base Version

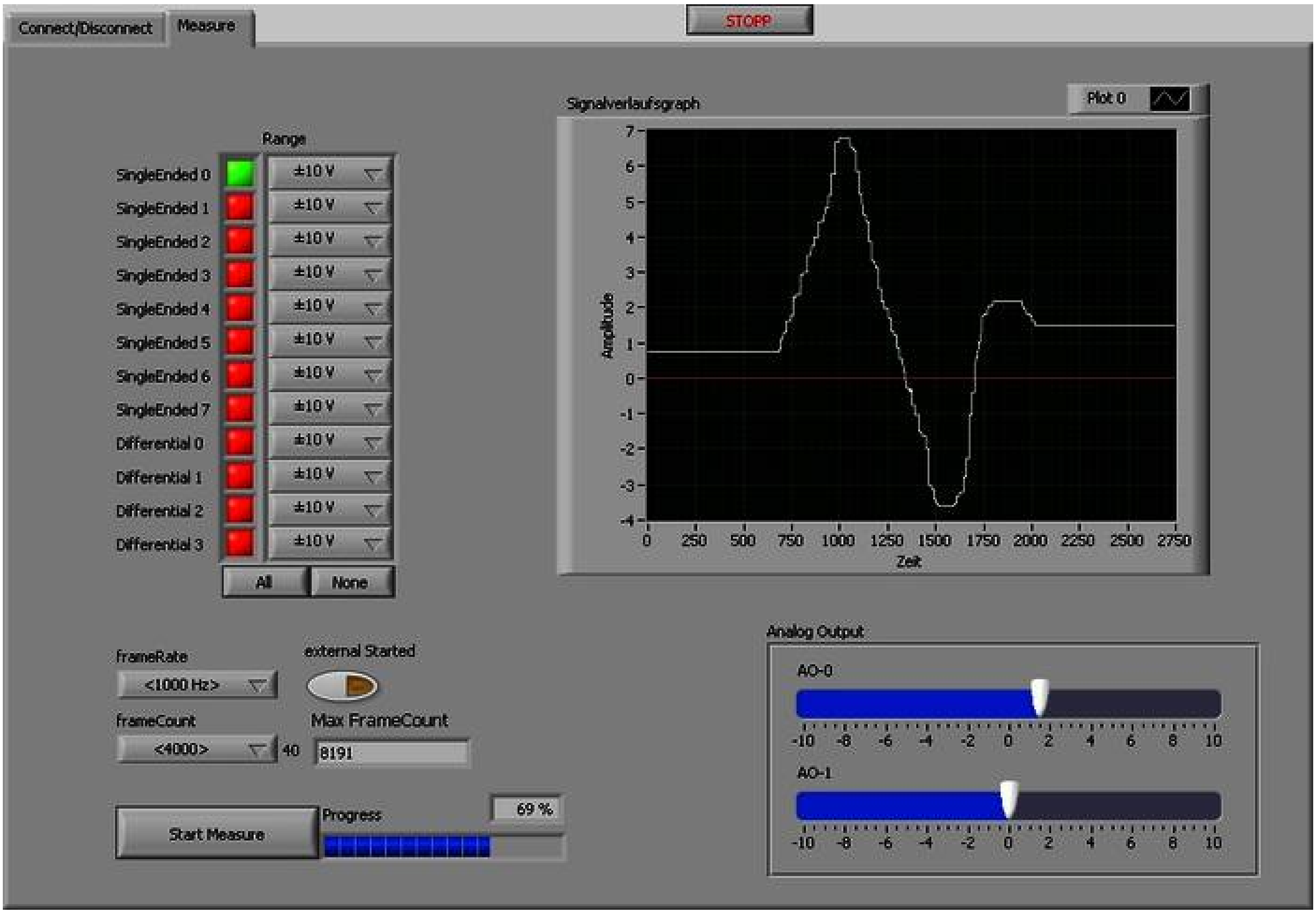
If you click at the "Enumerate"-button, you see a list and the number of all Cebo devices you can connect.

To connect a device you must select it (beside the "Connct"-button) and click the "Connct"-button.

After connecting some information about the device appears:

- Ident
- Serial-Number
- Calibration data of the constant current sources

LabView - Demo 2



This is a small tool/LabView Demo for

- measuring analog inputs (screw terminal only) in MultiFrame mode
- exporting the measurments to a file
- setting analog outputs

Measure

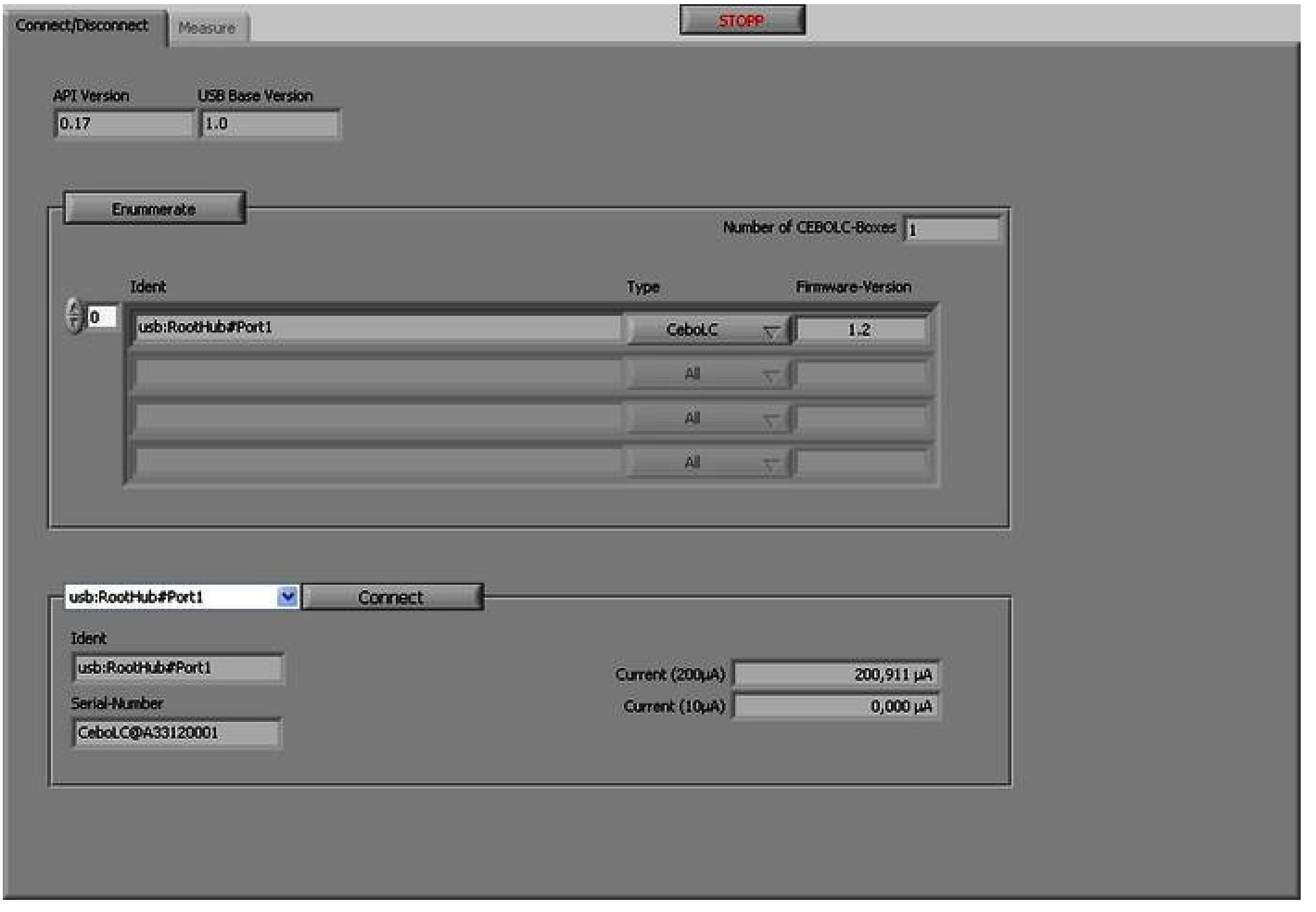
At the "Measure"-Tab you can

- enable/disable the analog channels
- select the range
- select frameRate
- select if the measure is external started
- select frameCount
- set the analog output

When the measurement is finished a dialog appears which asks you to enter a file name.

This file is text based with the extention ".lvm" and a tabulator devider. You can open it with a standard text editor, MS Excel, Open Office Calc or with a compareable program.

Connect/Disconnect



The "Connect/Disconnect"-tab shows you:

- API version whitch is used
- USB Base Version

If you click at the "Enumerate"-button, you see a list and the number of all Cebo devices you can connect.

To connect a device you must select it (beside the "Connct"-button) and click the "Connct"-button.

After connecting some information about the device appears:

- Ident
- Serial-Number
- Calibration data of the constant current sources

Specification - General

Parameter	Condition	Min	Typical	Max	Units
Dimensions (BxWxH)			75x113x36		mm
Operating Temperature Range			23	70	°C

Specifications - Analog Input

Parameter	Condition	Min	Typical	Max	Units
Typical Input Range (1)	Gain=1	-10,5		10,09	volts
Max AI Voltage to GND (2)	Valid Readings	-12,3		12,3	volts
Max AI Voltage to GND (3)	No Damage	-20		20	volts
Input Bias Current (4)		5		30	nA
Input Impedance (4)			1		G©
Source Impedance (4)			1		k©
Integral Linearity Error	Gain=1, 10, 100		t.b.d	t.b.d	% FS
	Gain=1000		t.b.d	t.b.d	% FS
Absolute Accuracy (~23±2°C)(5)	Range=±10V		±0,01		% FS
	Range=±1V		±0,01		% FS
	Range=±100mV		±0,01		% FS
	Range=±10mV		±0,04		% FS
Temperature Drift			t.b.d		ppm/°C
Noise (Peak-To-Peak)				<23,2	µV
Effective Resolution (RMS)			16,2		bits
Noise-Free Resolution			14,1		bits
Cross-talk(6)	1kHz	100			dB
	10kHz	86			dB

1. Single-Ended or Differential.
2. Maximum voltage on any Analog Input compared to GND for valid measurements on other channels. For readings on the channel itself, Single-Ended inputs are limited by the "Typical Input Range". For Differential readings consult common mode input voltage range tables.
3. Maximum voltage compared to GND on any Analog Input to prevent CEBO LC from damage. This is also true if CEBO LC is unpowered.
4. Keep source impedance below given maximum value to ensure proper readings with default settling times. For greater source impedances You may be required to increase settling times.
5. These values were calculated as follows:
   $f_{total} = f_{measure} + f_{calibration\ device\ (max)}$
   $_{fmeasure}=(x_d - x_r) / x_r$
   f: relative error
   x_r: value from calibration device
   x_d: mean of n measurements from "Device Under Test"
   n=1000/1000/500/100 at range 10V / 1V / 100mV / 10mV
6. A sinusoidal voltage with a 10V amplitude was connected to one channel. Another channel was shorted

to GND and the cross talk was measured at all ranges. No other channels was measured.

Specification - Analog Outputs

Parameter	Condition	Min	Typical	Max	Units
Nominal Output Range	No Load	-10		10	volts
	@±2,5mA	-9,875		9,875	volts
Resolution			12		bits
Absolute Accuracy	5% to 95% FS		±0,1		% FS
Integral Linearity Error				±4	counts
Differential Linearity Error				±2	counts
Error Due To Loading	@ 100 µA		0,16		%
	@ 1 mA		0,6		%
Souce Impedance			50		?
Short Circuit Current (1)	Max to GND		45		mA
Time Constant			t.b.d.		µs

1. Continuous short circuit will not cause damage.

Specifications - Digital Input

Parameter	Min	Typical	Max	Units
Low Level Input Voltage	-0,3		0,8	volts
High Level Input Voltage	2		5,8	volts
Maximum Input Voltage				
@Screw terminal(2)(3)	-10		10	volts
@DB25 connector(2)(3)	-6		6	volts

Specifications - Digital Output

Parameter	Condition	Min	Typical	Max	Units
Output Low Voltage	No Load				volts
@Screw terminal(3)	Sinking 1 mA		0,5		volts
@DB25 connector(3)	Sinking 1 mA		0,19		volts
@DB25 connector(3)	Sinking 5 mA		0,91		volts
Output High Voltage	No Load		3,3		volts
@Screw terminal(3)	Sourcing 1 mA		2,77		volts
@DB25 connector(3)	Sourcing 1 mA		3,01		volts
@DB25 connector(3)	Sourcing 5 mA		2,36		volts
Short Circut Current (1)					
@Screw terminal(3)			6,5		mA
@DB25 connector(3)			18		mA

Total Current (1)				25	mA
Output Impedance					
@Screw terminal(3)			507		?
@DB25 connector(3)			183		?

1. Short-circuit proof single I/O only. Total current should be limited to less than 25 mA.
2. Keep voltages on Digital I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
3. Protective circuit of Digital I/O on the screw terminals differs from that on the Sub-D jack.

Specifications - Trigger

Parameter	Condition	Min	Typical	Max	Units
Low Level Input Voltage		-0,3		0,8	volts
High Level Input Voltage		2		5,8	volts
Maximum Input Voltage (1)		-10		10	volts
Output Low Voltage				0,8	volts
Output High Voltage		2	3,3		volts
Output Impedance (2)			257		?
Input Total Edge Rate (3)	No Stream				edges/s
	While Streaming (4)			75.000	edges/s
Latency (5)	Trigger Input to conversion start (6)		10,5		us
	Trigger Input to conversion start (7)		21,5		us
	Trigger Output to conversion start (8)		9,5		us

1. Keep voltages on Trigger I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
2. Protective circuit of TRG terminal uses lower resistor value than normal Digtial I/O.
3. Keep the total number of edges below this limit, to avoid missing edges.
4. Input frame consisting of Analog Input 0.
5. Time interval from edge of Trigger signal to ADC conversion start signal for the first analog input in the InputFrame.
6. External timed data acqusition.
7. Hardware timed data acquisition with Trigger set to rising edge input mode.
8. Hardware timed data acquisition with Trigger set to alternating output mode.

Specifications - Counter

Parameter	Condition	Min	Typical	Max	Units
Low Level Input Voltage		-0,3		0,8	volts
High Level Input Voltage		2		5,8	volts
Maximum Input Voltage (1)		-10		10	volts

Input Total Edge Rate (2)	Without reading (3)			300.000	edges/s
	Continuously polling Counter value			35.000	edges/s
	Mutli Frame DAQ @ 1 kHz (4)			25.000	edges/s
	Mutli Frame DAQ @ 25 kHz (4)			5.000	edges/s

1. Keep voltages on Trigger I/O below Maximum Input Voltage to prevent CEBO-LC from damage. This is also true, if CEBO-LC is unpowered.
2. Keep the total number of edges below the Max limit, to avoid missing edges.
3. Counter value is only checked, after counting events have been disabled.
4. Input frame consisting of Analog Input 0 & counter value.

Specifications - Constant Current Source 200µA

Parameter	Condition	Min	Typical	Max	Units
Absolute Accuracy(1)	~25°C; R**Specifications - Constant Current Source 10µA**				
Parameter	Condition	Min	Typical	Max	Units
Absolute Accuracy(1)	~25°C; R(1) Compared to calibration data stored in flash.**Specifications - 5 Volt Output**				
Parameter	Condition	Min	Typical	Max	Units
Typical Voltage			5		volts
Output Voltage Accuracy			±5		%
Load Voltage Regulation(10% to 100% full load)				15	%
Output Ripple and Noise			50		mV
Maximum Current (1)	-40°C		140		mA
	-20°C		120		mA
	0°C		110		mA
	23°C		100		mA
	40°C		80		mA

	50°C		70		mA

(1) A resettable 100mA fuse prevents overcurrent on 5V Power Outputs.

Specifications - Vcc/Vss-Output

Parameter	Conditions	Min	Typical	Max	Units
Typical Voltage	No-load		±12		volts
	@ 2,5mA		±???		volts
Maximum Current			???		mA