

COACHLAB II

DESCRIPTION D006

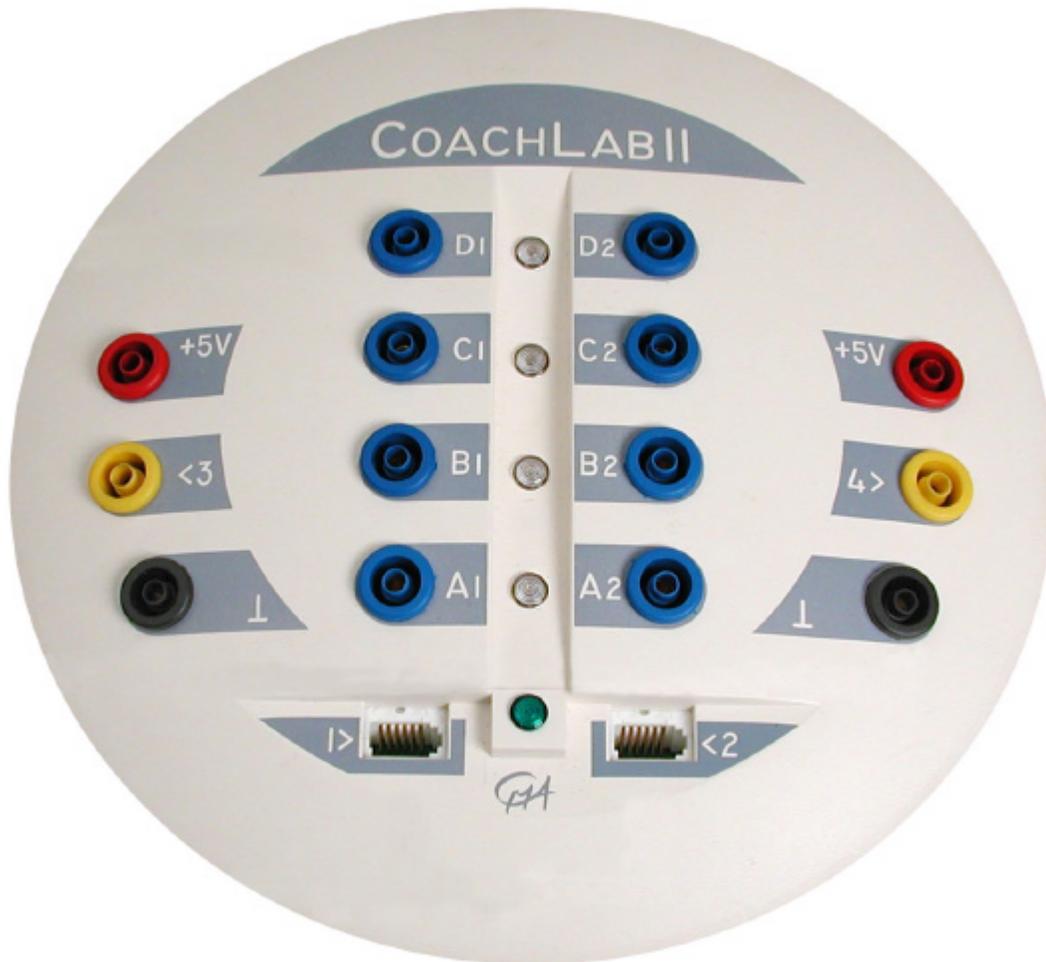


Figure 1. The CoachLab II Interface

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I. Introduction

CoachLab II is a multifunctional interface for computerized measurement and control. The interface is prepared for today's generation and future generations of fast computers, because it is provided with its own micro-controller and memory (see 'Embedded system'). CoachLab II is connected to the computer through the serial port and powered via a mains adapter (both included).

CoachLab II is provided with (see figure 3):

1. Two analog inputs (input 1 and 2) to connect sensors with BT (*British Telecom*) connectors.
2. Two analog inputs (input 3 and 4) to connect sensors with 4-mm plugs.

All inputs can also be used as a counter input^{1,2} or for event-based measurements.

3. Four 'push-pull' output channels³ to control various actuators.
4. A plug for the external mains adapter.
5. A 9-pin plug for connection of the cable to a serial port of the computer.
6. A digital channel (input 5 and 6) for connection of one or two ultrasonic motion detectors (TI-CBR™ (art. nr 0518) or the CMA Motion Detector (art. nr 03517)).
7. Four red/orange/green LEDs showing the status of each of the digital output channels.
8. A green LED which lights up when CoachLab II is properly powered.

Embedded system

Operating systems such as Windows 95/98, Windows 2000, Windows NT4.0 have the disadvantage that "real time" measurements can be interrupted at any time for very short periods by other tasks the operating system has to perform (multitasking). This is especially a problem with high sample frequencies. A solution for this is to control the measurement process by a separate micro-controller and to store the data in a corresponding memory.

CoachLab II uses this technique. It has its own processor and memory. When the software sends a measurement command to CoachLab II, it carries the measurement out independently, and stores the data in its local memory. The data are sent to the computer via the serial port. If this process is interrupted by other tasks of the operating system, the data are not lost, they only appear with a little delay on the screen. CoachLab II can be called an embedded system. The same kinds of systems are applied nowadays at large scale in apparatus like washing machines, video recorders, etc.

¹ One input can serve as a counter at a time. The other inputs can serve as normal analog inputs during the same measurement.

² Counter behavior of an analog input: CoachLab II has the possibility to adjust a threshold of an analog input. If an analog sensor signal crosses this threshold in a predefined direction, the counter will be incremented by one.

³ A 'push- pull' output channel is a two-wired output. Each wire can be switched to one of the poles of the power supply (+12V and Ground). By this one can choose the direction of the current through the actuator. This results in four controllable states per output.

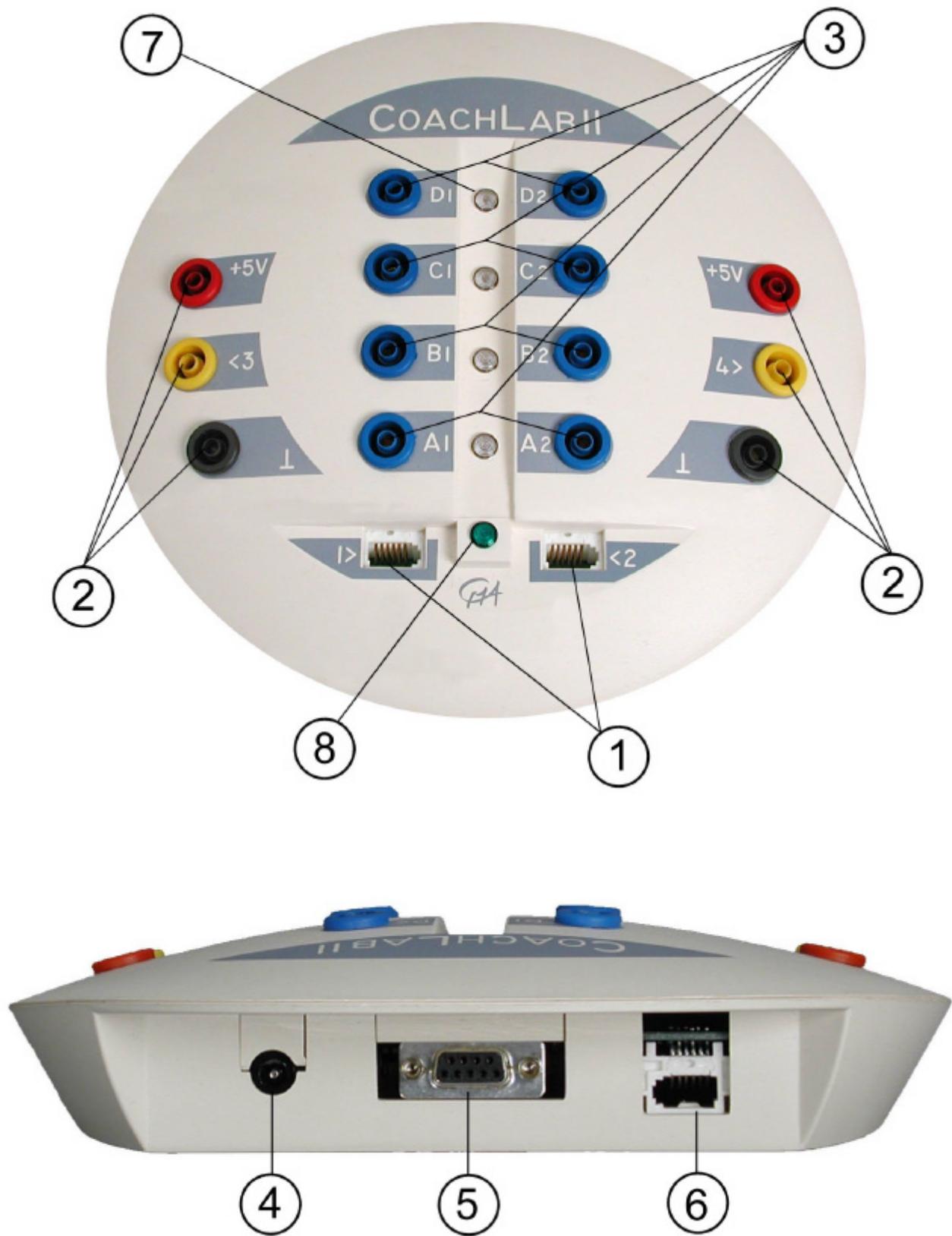


Figure 2. The different parts of CoachLab II (top view & rear view). The numbers refer to the text.

II. Using the CoachLab II interface

1. Computer and software requirements

To use CoachLab II you need Coach⁴ software running on a PC computer with a processor which can be compared with Intel 80486, with Windows 95/98/2000 or NT system software with at least 4 MB RAM (8 MB RAM recommended) and unused serial (or USB port⁵). Computer running Windows 3.1 may also work. See the 'Guide to Coach 5' manual or other Coach 5 software manuals for details.

2. Serial connection to the computer

The CoachLab computer connection is located on the rear side of the interface (figure 2, ⑤).

- Connect the 9-pin plug of the serial cable to CoachLab II.
- Connect the other 9-pin plug to the serial port of your computer.⁶

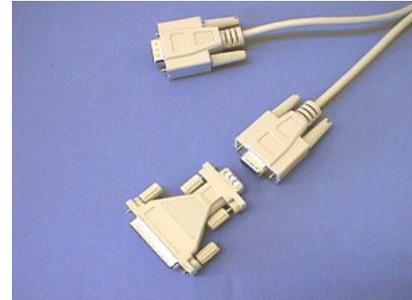


Figure 3. 9-pin serial cable and 9 to 25-pin adapter plug (included).

2.1. Serial port settings

CoachLab II supports the following baudrate: 9600, 19200, 38400, 57600 and 115200. Each time the power is switched on, the baudrate will be set to 9600 baud (default setting). If you want to change the baudrate or the COM port number, you can do it in the main menu of the Coach software under *Tools>Install hardware drivers* (or during the installation of Coach).

Advice: try the highest value. If this gives problems switch back to a lower value.

3. USB connection to the computer

With help of a USB to serial port adapter it is possible to connect CoachLab II to the USB port. There are many different brands of 'USB - to serial port' adapters available on the market. In general, a USB to serial port adapter requires the installation of a software driver. During installation of this driver an extra COM port is created. For example if the computer has installed already two ports COM1 and COM2 then the software add extra port called COM3. This port has to be selected in the hardware

⁴ The following Coach software products support the CoachLab II interface: 'Coach 5', Coach 5 Junior, 'Coach 5 for CMA Interfaces'.

⁵ For USB connection a USB to serial port adapter is needed (not included).

⁶ If the computer has only a 25-pin serial port connector available (e.g. when a mouse is connected to the 9-pin serial port connector), connect the cable using the 9 to 25-pin adapter plug, which is included.

settings in Coach (during installation of Coach or in the main menu under *Tools>Install hardware drivers*).

4. Power supply of CoachLab II

- Put the round plug of the 12-V power supply into the bus (4) on the rear side of CoachLab II.
- Connect the mains adapter.
- The green LED (8) lights up indicating that the interface is powered properly and a test program starts. During the test all LEDs between outputs (7) successively light up.



Figure 4. The CoachLab II mains adapter (included).

5. Resetting CoachLab II⁷

It may happen that the communication between CoachLab II and the computer is lost. If this is the case reset CoachLab II. This can be done in two ways (in the Coach software):

1. When there is no communication on opening of a Coach activity/results and the program displays the message that the panel CoachLab II can not be initialized then:
 - If the interface is connected properly to the computer (i.e. it did work before)⁸, reset the interface by disconnecting and reconnecting the plug of the external mains adapter.
 - Press *Retry* in Coach.
2. When the communication with the interface is lost while working in a Coach activity/result then:
 - Right click the CoachLab II screen panel.
 - Select the *Reset Hardware* option.
This option is only available if the CoachLab II panel is active in Coach.

6. Connecting sensors and counters

All inputs of CoachLab II can be used simultaneously.

6.1. Connecting analog sensors

Analog sensors can be connected to the analog inputs of CoachLab II. Two kinds of analog inputs are available:

- two inputs (input 1 and 2) for sensors with BT (British Telecom) - style plugs with right-hand connectors;

⁷ For more detailed problem descriptions see 'IV. Troubleshooting'.

⁸ If a COM port setting in Coach software is not correct then the CoachLab II interface is not detected and the message 'Coach can not initialize Panel CoachLab II' appears.

- two inputs (input 3 and 4) for sensors with 4-mm plugs (old style CMA sensors).

Adapter cables are available to convert a BT input to a 4-mm input (art. nr 0520) and to convert a 4-mm input to a BT input (art. nr 0519).

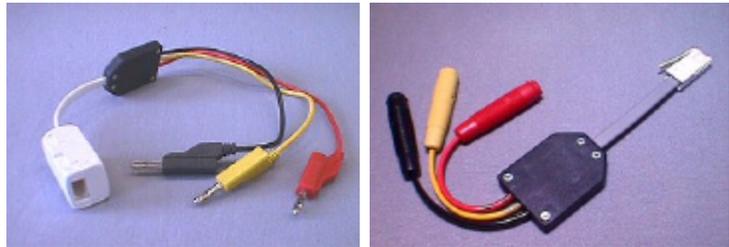


Figure 5. Adapters art. nr 0520 (left) and 0519 art. nr (right).

6.2. Connecting digital sensors

Up to two ultrasonic motion detectors with BT - style plugs with left-hand connectors can be connected to the digital channel (inputs 5 and 6)⁹ of CoachLab II.

For measurements with two motion detectors the special splitter cable (art. nr 0706) is required (not included).

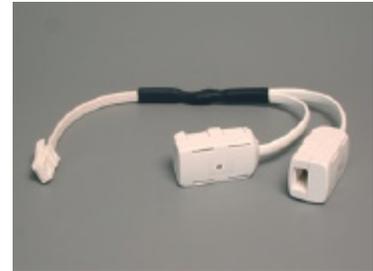


Figure 6. Splitter cable art. nr 0706.

6.3. Connecting an analog sensor as a counter

Sometimes one is not interested in the value of a signal but in the numbers per second the signal fluctuates up and down. E.g. to determine how often the monitor screen of your computer is refreshed by using a light sensor or to measure the rate of your heart beats by using a heart rate sensor.

With CoachLab II it is possible to use an analog sensor as a counter to count 'pulses'. To do so you have to define in the Coach software:

- a *Threshold*: the value the signal has to pass to be counted; and
- a *Direction*: should the threshold be passed *Upwards* (increasing signal values) or *Downwards* (decreasing signal values).

If an analog sensor signal crosses a specified threshold in a predefined direction, the counter will be incremented by one. The minimal time whereby two samples will be detected independently is 100 μ s. (See also Coach Help, Keyword 'Analog sensor'.)

6.4. Connecting counters

All analog inputs can also be used as a counter input or for event-based measurements. One input can serve as a counter at a time. The other inputs can serve as regular analog inputs during the same measurement. CoachLab II has the possibility to adjust the counter threshold. If a counter signal crosses this threshold in the predefined direction, the counter will be incremented by one. (See also Coach Help, Keyword 'Counter'.)

⁹ Input 6 is available only when the splitter cable (art. nr 0706) is used.

7. Connecting actuators to CoachLab II

Each of the output channels A to D is provided with a push-pull channel driver, which can be set in four controllable states. The output LED indicates the states of the output channel by means of different colors: Green, Orange, Red, Off.

The maximum output current of each channel is 0.6 A. The total output current of all channels together is maximally 1.2 A.

For instance, it is possible to drive two bi-directional motors of 0.5 A each.

The output channels can be set to 16 different power levels. Power is reduced by switching the 12 V on and off at a rate of 625 Hz.¹⁰

E.g. at level 1, an output channel is switched on for 1/16th of the cycle time and switched off for the remaining cycle time. The cycle is repeated with the mentioned frequency of 625 Hz. This is called PWM - Pulse Width Modulation.

¹⁰ The maximum power level for an actuator can be adjusted by the software.

III. Technical specifications of CoachLab II

1. Connection to the computer

For data transmission CoachLab II is connected via a 9-pin serial cable (male-female, 1 to 1, (a 0 modem cable will not work!)) to the computer.

Always use the included cable to prevent malfunction.

At the computer side a 25-pin plug can be obtained by using the standard 9-pin to 25-pin adapter plug (included). The pin configuration of the 9-pin serial cable is described in the table below.

9-pin male (CoachLab II)		9-pin female (Computer)	
2	TD (Transmitted Data)	2	RD (Received Data)
3	RD (Received Data)	3	TD (Transmitted Data)
5	GND (Signal Ground; common)	5	GND (Signal Ground; common)
6	+8 V	6	DSR (Data Set Ready)
All other pins are not connected in CoachLab II.			

2. External power supply

CoachLab II is powered by a mains adapter with a 2.5 mm DC-plug. This power supply also feeds the output channels.

Maximal voltage: 12 V (recommended); Minimal voltage: 9 V.

The power supply is fused by a fast fuse 2 A (5x20 mm) on the CoachLab II's circuit board.

3. Sampling frequency

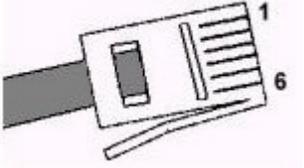
The sampling frequency depends on the used numbers of channels and how they are used. The following table gives an overview:

Number of inputs used	Maximal sample frequency
One analog input	40 kHz
Two analog inputs	20 kHz
Three analog inputs	3.33 kHz
Four analog inputs	2.5 kHz
One counter	10 kHz
One counter + one analog input	5 kHz
One motion detector	50 Hz
Two motion detectors	25 Hz

4. Inputs

4.1. BT inputs

Inputs 1 and 2 are used for analog sensors with right-hand BT connectors with the following pin-outs:

Pin	Analog Input 1 and 2
	 <p>Right-hand connector</p>
1	Vin
2	Ground
3	Vres ¹
4	Auto-ID ²
5	+5 V DC
6	Vin-low

Note:

The BT plug has two signal pins Vin (pin 1) and Vin-low (pin 6). The input range of pin 1 is -10V to +10V, and pin 6 is 0 to +5V.

In the Coach software is possible to select the range i.e. select the pin of which signal will be taken (see the Coach help keyword 'Input range'). Standard range is 0 to +5 V (pin 6).

This applies to sensors with BT plugs connected to input 1 and 2 of CoachLab II. For connecting sensors with 4-mm plugs via adapter art. nr 0519 the standard range 0 to +5 V (pin 6) is taken regardless of the software settings.

(In this adapter there is no connection between the yellow lead and pin 1).

	Vin	Vin-low
Inputs	Input 1, Input 2	Input 1, Input 2
Input signal	Analog data	Analog data
Input range	-10 to +10 V	0 to +5 V
Resolution (12 bit)	4.9 mV	1.2 mV
Input impedance	100 k Ω	100 k Ω

¹ Vres - Output reference voltage (pull-up resistance 15 k Ω) for resistance measurements.

² Auto ID (pull-up resistance 10 k Ω) - Auto ID sensor detection data input. The BT inputs have the possibility for automatic sensor recognition. Most sensors however, are not prepared for automatic recognition.

4.2. 4-mm inputs

Inputs 3 and 4 are used for analog sensors with 4-mm plugs with the following connectors:

4-mm lead	Analog Input 3 and 4
Red	+ 5 V DC
Yellow	V _{in}
Black	Ground (common for all inputs)

	V _{in}
Inputs	Input 3, Input 4
Input signal	Analog data
Input range	-10 to +10 V or 0 to +5 V (software controlled)
Resolution (12 bit)	4.9 mV (-10 to +10V range) or 1.2 mV (0 to +5V range)
Input impedance	100 k Ω

Note: The 4-mm inputs allow direct measurement of any voltage between -10 and +10 V or between 0 and +5 V (depending on software settings).

For connecting sensors with BT plugs to input 3 and 4 adapter art. nr 0520 has to be used. In this adapter the pins 1 and 6 of the BT plug are connected to each other and both signals 0 to +5 V and -10 to +10 V can be measured (without extra settings).

4.3. Counter input

One of the analog inputs can be software selected to function as a counter or as input for event-based measurements.

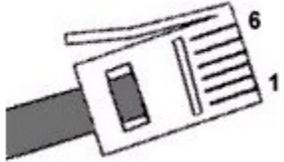
In case of event-based measurements, time stamps of the measurement points are also available from the CoachLab's memory (time resolution: 0.1 ms). The maximum signal frequency is 5kHz.

4.4. Sonic inputs

Input 5 and 6 are used for connection of one or two ultrasonic motion detectors with a left-hand BT connector (the TI-CBR™ (art. nr 0518) or the CMA Motion Detector (art. nr 03517)). For measurements with two motion detectors the splitter cable (art. nr 0706) has to be used.

The digital channel can also be used for connection of an up/down counter (e.g. a bi-directional pulley or a spirometer).

The left-hand BT connector has the following pin-outs:

Pin	Sonic Input 5 and 6 ¹
	 <p>Left-hand connector</p>
1	Echo (input) ²
2	Init (output) ³
3	Not applicable
4	+5 V DC
5	Ground
6	Not applicable

¹ Sonic input 6 is only available when splitter cable (art. nr 0507) is used.

² Echo - Ultrasonic motion detector input, TTL signal

³ Init - Distance initialization signal, TTL signal

5. Outputs

The outputs are used for connecting actuators with 4-mm wires. The output channels are provided with push-pull drivers. The outputs can deliver current up to 0.6 A per channel (continuously). Maximum current for all output channels together is 1.2 A (continuously). There are 16 power levels available. Power is reduced by switching the 12 V on and off periodically at a rate of 625 Hz.

Note: To minimize the risk of damaging by overloading the outputs of CoachLab II do not have any power when no actuator icon is placed on the screen panel in Coach software.

6. Indicator LED's

The green LED indicates that CoachLab II is properly being powered by the mains. The Red/Orange/Green LEDs indicate the status of the output channels.

7. Dimensions

Size: Ø approx. 21 cm, height: approx. 3.5 cm;

Weight: approx. 400 g

8. Warranty

CoachLab II is guaranteed completely for product quality during 12 months after the date of purchase. Any damage caused by operation contrary to the prescriptions in this manual is excluded from this guarantee.

IV. Troubleshooting

Problem which appears when working with the Coach software	Solution
<p>Coach is not able to communicate with the connected CoachLab II interface on opening a Coach activity or result. This is the case when:</p> <ol style="list-style-type: none"> 1. the hardware settings in Coach software are not correct; 2. there is no interface connected to the computer; 3. the activity/result is developed for another interface than CoachLab II; 4. the communication between interface and computer is lost. <p>A dialog box tells you that 'Coach cannot initialize Panel CoachLab II'.</p>	<ol style="list-style-type: none"> 1. In Coach click the Install-Hardware button to check the settings of the CoachLab II driver (coachlb2.dll): the selected serial port and baudrate. Note: If CoachLab II is not detected by Coach at all, check whether it is connected with the original delivered cable and mains adapter (12V). 2. Connect CoachLab II to the computer. 3. Click the button 'Select other' and select 'CoachLab II' from the list. Note: If the activity author did not defined 'Alternative panels' then this button does not appear. In this case click 'Ignore' and switch the panel in the activity (see the Coach help keyword 'Select other Panel'). 4. Reset CoachLab II by briefly disconnecting it from the mains and reconnecting it. The test cycle will run (the LEDs will flash). Open the activity/result again.
<p>Coach is not able to communicate with CoachLab II in an Activity (you can see that the values on the Sensor icons do not change at all for a longer period of time. Normally, these values always fluctuate a little bit due to noise.)</p>	<p>Reset CoachLab II.</p> <ul style="list-style-type: none"> • Right click the screen Panel and select the option 'Reset Hardware'. • You may combine this with resetting CoachLab II (see point 4 described above).
<p>The measurement values displayed on the Sensor icon or in a Window are not realistic.</p>	<p>You have probably used a Sensor icon, which does not correspond to the actual sensor, connected to CoachLab II.</p> <ul style="list-style-type: none"> • Check the ToolTip with the description of the Sensor icon, or look up the sensor information in the CMA Hardware help. • Replace the Sensor icon.

<p>When measuring, the values do not appear on the screen in real time, but after the measurement run is finished.</p>	<ol style="list-style-type: none"><li data-bbox="678 205 1458 352">1. The measurement frequency is too high or the baudrate setting is too low. If you want to receive the values in real time set the Measurement frequency to a lower value or baudrate to higher value.<li data-bbox="678 373 1458 625">2. The measurement is carried out in Quick mode, i.e. the screen is not updated during the run. This happens among others when you start a measurement with the shortcut <Ctrl>+<F9>. When the Activity stays running in Quick mode (also after starting the measurement with the Start button). Quick mode has to be turned off in the Activity options in Author mode.
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Appendix 1. Components of CoachLab II

1. Introduction

Microcontrollers have memory and a range of devices for peripheral functions like timers, A/D converters and PWM¹¹s combined onto a single chip. Microcontroller based systems do not need an operating system and the ‘firmware’ can be (re)programmed easy. The most recent trend in embedded microcontrollers is away from large complex devices towards simpler, low-end RISC¹² machines. RISC-based microcontrollers have simpler architecture than conventional microcontrollers, resulting in compressed register-to-ALU cycle time and hence faster operation. They are very common in small electronic systems developed during the last few years.

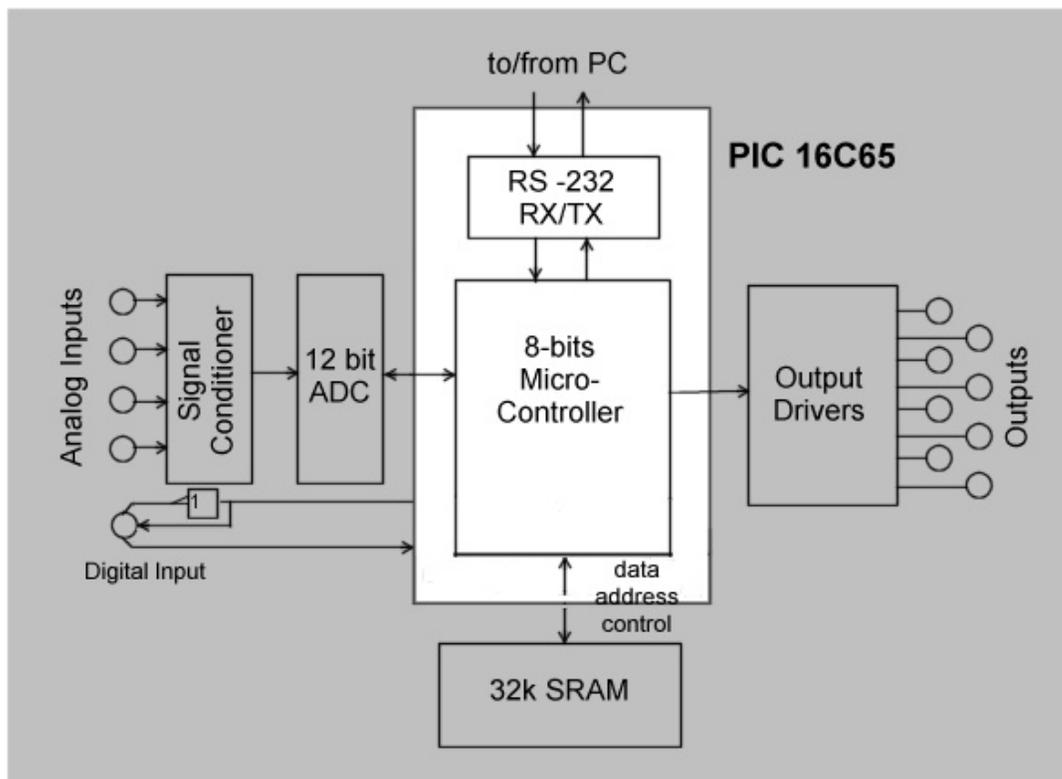


Figure 7. Block diagram of the CoachLab II interface.

2. PIC Microcontroller

The microcontroller applied in the CoachLab II interface is the 16C65 eight bit controller of Microchips PIC family. The chosen PIC device has RISC architecture,

¹¹ PWM - Pulse Width Modulation

¹² Reduced Instruction Set Computer

4k flash program memory, 3 timers, 33 multi-functional I/O lines, 2 CCPs¹³ and a USART¹⁴. One of the timers executes the interrupt-based measurement routines. Each of the CCPs combined with another timer is used for capturing the time difference between a send-pulse and the accompanying reflected pulse when using a sonar sensor. PWM for steering the four output channels is realized by software. The USART carries out the serialization of parallel data and the insertion of the start, parity and stop bits to communicate via a COM port of a PC conform the RS232 standard. The third timer is used to set the baud rate of this communication process.

3. Analog to Digital Converter

The TLC2543 12 bit AD converter from Texas Instruments accomplishes Analog to Digital conversion. An on chip input multiplexer can select any of 11 analog-signal inputs. The conversion time is 10 μ s. It is based on the successive approximation method. It has an on-chip system clock and communicates with the microcontroller via a serial protocol.

4. Data buffer

For measurements with high sample frequencies the generated data stream can be higher than the maximum transmission speed of the serial port. Therefore the sampled data is written to a 32 kb RAM buffer in CoachLab II in which 16,000 analog samples can be stored after conversion by the ADC.

5. Signal conditioning

Two signal amplifiers are necessary to realize both input ranges 0 to +5V and -10 to +10V for each analog input. Four inputs need another mean eight signal amplifiers individually connected to one of the inputs of the ADC. The input impedance of the inputs is 100 k Ω . The frequency of the input-signal is limited to 20 kHz (-3dB). Another two inputs of the ADC are kept apart for sensor recognition.

6. Output Drivers

Two 'standard' Push-Pull output channel drivers (type L293) are used to drive the 4 output channels. The L293 accepts standard TTL-logic levels and drives inductive loads, such as relays, solenoids/coils, DC motors and step motors.

To control the power of output channels the L293 in CoachLab II is switched periodically with a frequency of 625 Hz.

The maximum current for each channel is 0.6 A. Due to the maximum power dissipation the maximum current of the four output channels together is limited 1.2 A. When the outputs are used as 8 1-bit outputs, then the maximum output current is

¹³ Capture/Compare/PWM modules

¹⁴ Universal Synchronous and Asynchronous Receiver and Transmitter

2.4 A. Due to the specifications of the power supply included with CoachLab II, the maximum available current is 1.0 A.

Appendix 2. Measurement and control with CoachLab II

1. Measurement methods

The following measurement techniques are implemented in CoachLab II:

Single reading

A direct sample (data point) from a given channel is collected.

Time-based measurements

Data from each connected channel (analog and/or digital) are collected at a regular time interval. The sampling frequency and total measurement time can be selected. One of the channels can serve as a trigger channel. The pre-trigger time, trigger level and trigger direction can be predefined.

For measurements with selected pre-trigger time before it is checked or the signal fulfils the trigger conditions the measured data are stored in the pre-trigger buffer. Because of this the data collected during the pre-trigger time are always available.

Event-based measurements

Before an event-based measurement can be performed a counter must be assigned to an analog or a digital input. Data from all connected channels are collected each time an external event is registered by the counter. Next to the sensor values also time stamps are recorded (with a resolution of 100 μs).

The measurement process stops after a specified number of events.

Start-stop measurement

By using the event-based mode it is possible to perform time measurements for example when a falling object passes across two light gates.

Response-time measurement

This method is used for measurements with ultrasonic motion detectors. The distance between an object and a motion detector is determined in the following way. CoachLab II initiates a measurement by sending a trigger pulse to an ultrasonic motion detector. At the same moment the 16-bits timer of the micro-controller is reset and the ultrasound detector sends an ultrasonic pulse. When the sensor detects the pulse reflected from an object the time is recorded. Based on the time and the speed of sound in air the distance between the detector and the object is determined. The resolution of the measured time is 12.8 μs . This corresponds to a resolution of 2.17 mm in the determination of the distance.

Counting 'events' /pulses'

In this method a counter is incremented by one unit when an event is registered at an analog or a digital channel. The counting range is 0 - 65535.

Up/down counter

There are sensors (e.g. a bi-directional pulley) that generate two digital, symmetric voltage values, in which both signals have the same frequency but one signal is 90° behind the other one. The direction of rotation of the sensor can be determined from the phase relation of these voltages and depending on this the counter is increased or decreased by one unit. The counting range lies between -32768 and 32767.

Frequency measurement

The frequency value of an analog or a digital signal is returned after one second. The frequency range is from 0 to 5 kHz.

2. Control commands

Analog or digital actuators can be controlled through the outputs of CoachLab II. For this purpose the following commands are implemented:

SetOutputs On/Off

All outputs are set in the specified state at the same time

SetBit(s)

One or more outputs (specified by the parameter *s*) are set to 'High' at the same time.

ResetBit(s)

One or more outputs (specified by the parameter *s*) are reset to 'Low' at the same time.

GetOutputs

Returns the actual state of the outputs.

SetPowerLevel

Sets the power level of an output to one of the 16 available levels. The power is reduced by switching the 12 V on an output channel on and off at a rate of 625 Hz for certain part of the time period (ranging from 1/16 to 16/16 period). This is called PWM - Pulse Width Modulation.

OnFor (one-shot)

An output can be switched on for a given time interval. Time resolution is 0.8 ms.

Maximum time is 52 s.

Flash

An output can be periodically switched on or off. Maximum period time is 13 s.

When two outputs, which are adjusted to the same power level, are combined as one analog channel, it is possible to control for example a DC motor, which turns in two directions.

3. Measurement and control at the same time

All control commands can be executed while a measurement is running for sampling frequencies up to 10 kHz.

Note:

It is possible to develop own software (for example in LabView or Java) to control CoachLab II. For this reason the description of command list and the data formats for CoachLab II are available on request by CMA.

This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

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