



IPEMOTION
Software

Beckhoff PlugIn

December 2013

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1 Important and general information

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Please follow these instructions before and during the use and application on any IPETRONIK product!

1.1.1 Safety and Warning instructions

Please follow the instructions **and** information as contained in the user manual!

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 - Tap of one or several bus systems (CAN, LIN, ETHERNET) including the required electrical connection(s) for data acquisition.
 - Communication with the vehicle's control units (ECUs), especially with such of the brake system and/or of the engine and transmission control (power train control system).
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1.2 General information

1.2.1 About this manual

This manual describes how to use the Beckhoff PlugIn together with the IPEmotion data acquisition software.

1.2.2 Version

This manual has the version number V04 released [12] [2013] © **All rights reserved !**

PlugIn version used for this documentation: V01.04.00.

1.2.3 Legend of used icons



Tip

This icon indicates a useful tip that facilitates the application of the software.



Information

This icon indicates additional information for a better understanding.



Attention!

This icon indicates important information to avoid potential error messages.

1.2.4 Support

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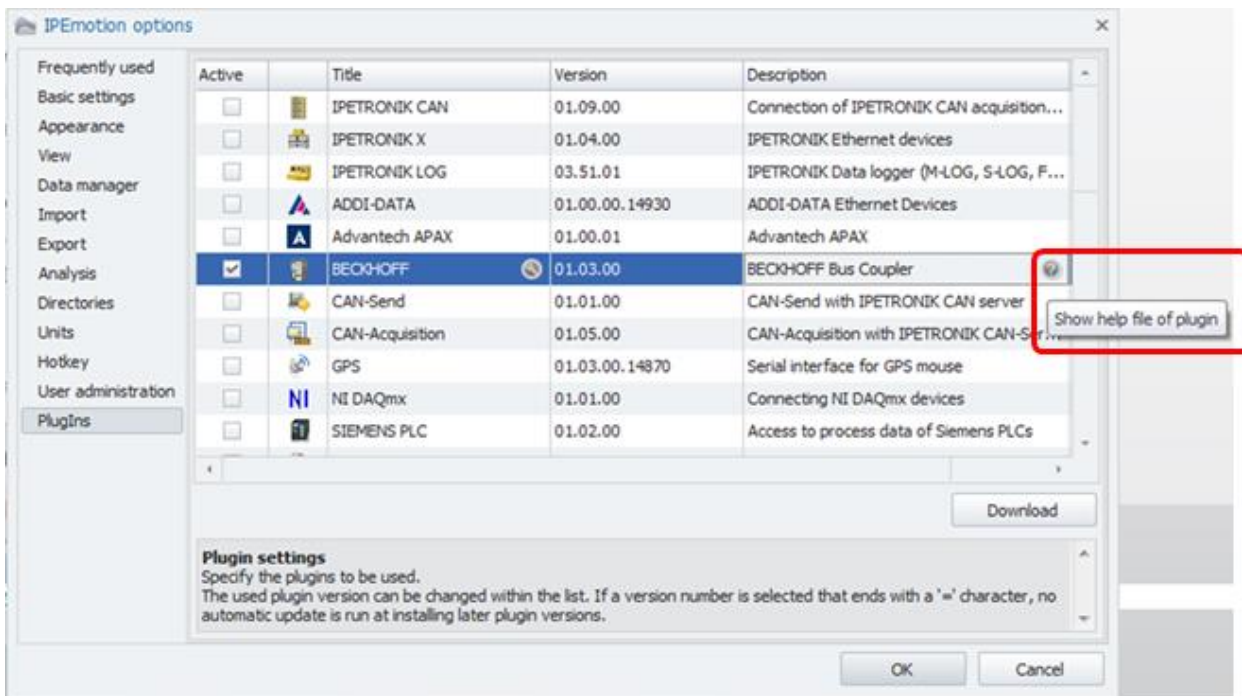
Technical support and product information

www.ipetronik.com e-mail: support@ipetronik.com

2 PlugIn Overview

2.1 PlugIn Installation

The Beckhoff PlugIn is hosted on the IPETRONIK website www.ipetronik.com. After having installed the PlugIn, you need to restart IPEmotion. A message window will notify you, telling that a new PlugIn was found. After activation, the PlugIn can be used for your data acquisition application. The PlugIns are managed in the IPEmotion options.



Direct access to the PlugIn manual.

2.2 Supported Interfaces

2.2.1 BK Bus Couplers - based on Modbus TCP

The PlugIn supports Beckhoff bus couplers based on Modbus TCP protocol. Users only deal with the configuration of the bus coupler and the IO terminals. All the details about Modbus address configuration are done automatically by the PlugIn. The PlugIn can communicate with the Beckhoff BK bus couplers without any additional Beckhoff driver or software installation.

The supported interface devices are:

- ▶ BK9000
- ▶ BK9050
- ▶ BK9100

These BK bus couplers support (KL) K-Bus IO terminals only.

2.2.2 EtherCAT - based on ADS and R3IO

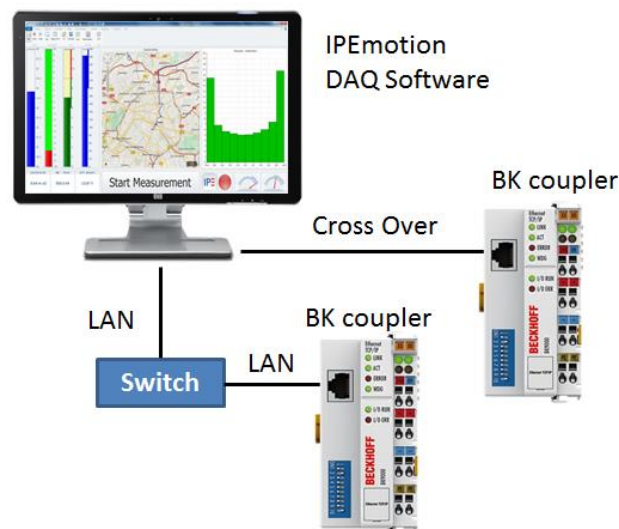
The PlugIn also supports the ADS and the R3IO interfaces. These interfaces are suitable for configuring a communication to the Beckhoff PLC system for (EL) EtherCAT IO terminals. For the communication over ADS or R3IO interfaces the Beckhoff TwinCAT System Manager must be installed together with IPEmotion and the PlugIn.

3 Configuring a system with BK Bus Couplers

3.1 Connecting Bus Coupler to PC

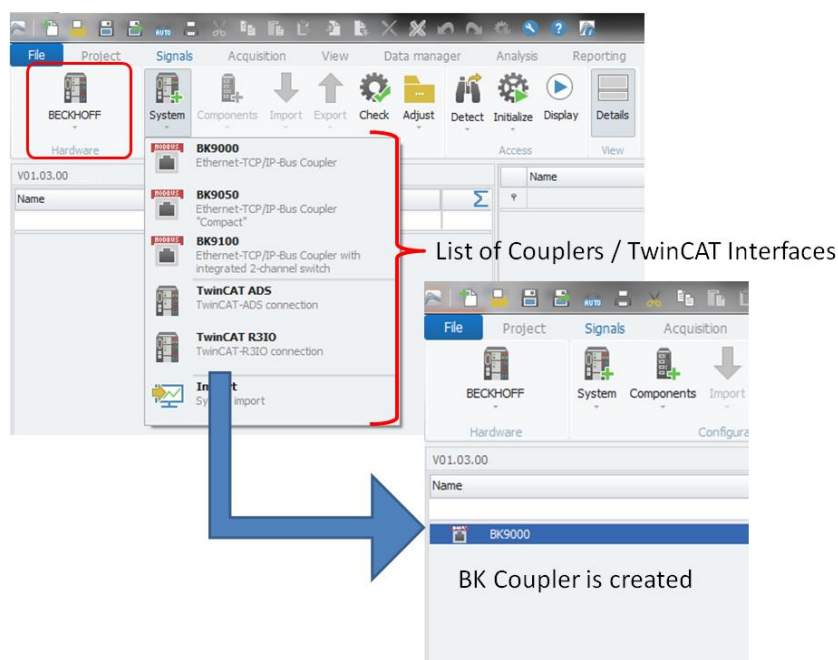
In the first step, an Ethernet connection between bus coupler and the PC with the IPEmotion software should be established. The coupler requires 24 Volt DC power supply. Please refer to the Beckhoff help manual for information on how to wire up the power input. In case you are using a direct connection between bus coupler and PC, a cross over cable is recommended. If you are using a direct connection, the computer and the coupler both need a static IP-address.

If the coupler and the PC are communicating over a network (Switch), a standard LAN cable is required. In a network environment, the computer does not necessarily need to have a static IP-address.



3.2 Creating a BK System

In order to setup a system, the Beckhoff PlugIn needs to be selected in the SIGNALS tab sheet. After selecting the PlugIn, you need to select the interface / bus coupler you would like to use for your measurement application. The selected bus coupler model in IPEmotion has to match with the coupler you use for your application.



In our example, the coupler BK9000 will be used. Several BK or TwinCAT systems can be created if needed.

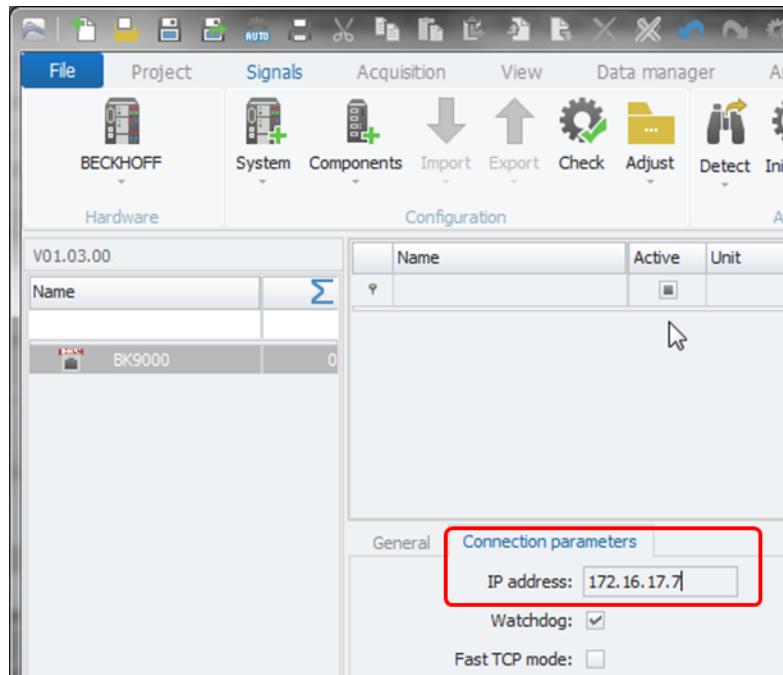
3.3 Configuring Coupler Interface Parameters

The next important step is to configure the interface parameters which consist of the following options:

- ▶ IP-address of the coupler
- ▶ Enable / disable Watchdog
- ▶ Fast Mode (supported only for coupler BK9000)

3.3.1 Entering IP address of coupler

The IP address is entered in the connection parameters tab sheet.



The factory default IP address is 172.16.17.0 (0 = if all dip switches of the coupler are in the OFF position). When all dip switches are in the ON position, the IP address is 172.16.17.255.

The modification of the last digit of the IP-address through the dip switches becomes effective, when switch 9 and 10 are in the OFF position. The following tables gives you an overview of how to change the last position of the IP-address through the dip switches No 1-8.

Dip Switch No.	1	2	3	4	5	6	7	8	9	10	
Value when Switch in ON status	1	2	4	8	16	32	64	128			
Example 1	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	IP
Last digit of IP	1	2	4	0	0	0	0	0			172.16.17. 7
Example 2	ON	ON	ON	ON	ON	ON	ON	ON			IP
Last digit of IP	1	2	4	8	16	32	64	128			172.16.17. 255
Example 3	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF			IP
Last digit of IP	0	0	4	8	0	0	0	0			172.16.17. 12

The new settings of the dip switches become effective after power OFF / ON and a new startup of the bus coupler.

If you need to reset the bus coupler to the factory settings, the following steps are required:

- ▶ Power off the bus coupler and remove all IO terminals
- ▶ Connect only end terminal KL9010 to the coupler
- ▶ Change all dip switches to the ON position
- ▶ Apply the 24 V DC power to the coupler
- ▶ After successful reset of the settings, LED *ERROR* and LED *I/O RUN* and LED *I/O ERR* are flashing
- ▶ After that you can power on the system and carry on with your software and hardware configurations

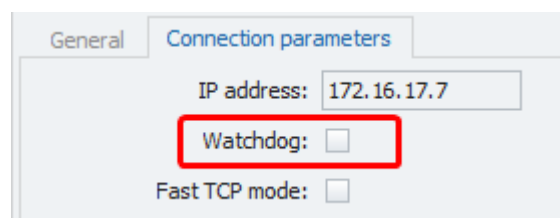
**Tip**

If you like to define any IP address for the coupler, you need to refer to the Beckhoff manual. One useful tool is Beckhoff's BootP server .

3.3.2 Enable / Disable Watchdog

The watchdog is a safety mechanism. When the LAN connection between PC and bus coupler is lost, the Beckhoff hardware is detecting the disconnection and is automatically switching analog and digital output terminals into the save status (ZERO value) to shut down actuators or emergency stops. In the default configuration, when a new coupler is created, the watchdog is activated (boxes checked).

However, there may exist applications, where it is useful to deactivate the watchdog for example when short network disconnections can be expected. When the watchdog is deactivated, the BK system behaves in a way that the terminals keep the analog or digital output value when the Ethernet communication to the PC is disconnected.

**Information**

Beckhoff recently changed the firmware and the behavior of the watchdog for the analog input terminals KL3062. When the Modbus TCP interface is used to communicate with the bus coupler, the watchdog is already activated and the KL3062 run LED is not active. If you like to activate the LEDs to show the run status of KL3062, the watchdog check box should be deactivated.

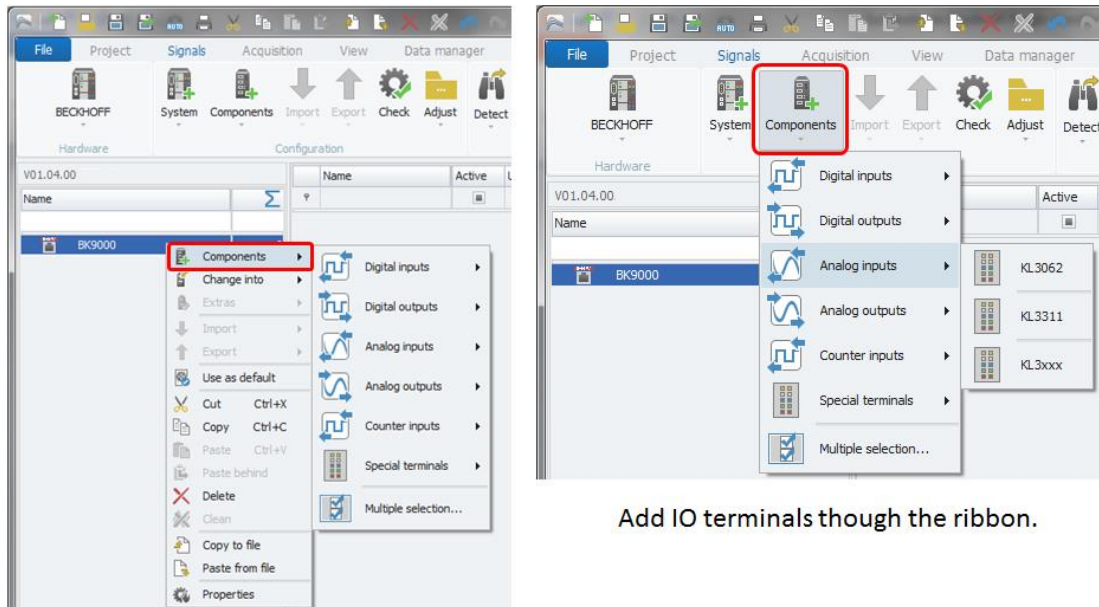
Please note: The analog input terminals KL3062 are measuring correctly even though the LEDs are showing the inactive status.

3.3.3 Fast Mode (only for coupler BK9000)

The fast mode check box can only be enabled for the BK9000 bus coupler. Compared to the other BK couplers, this device supports higher sample rates of up to 100 Hz. The sample rate is a global setting and is applied to all channels of the system.

3.4 Adding IO Terminals to the Coupler

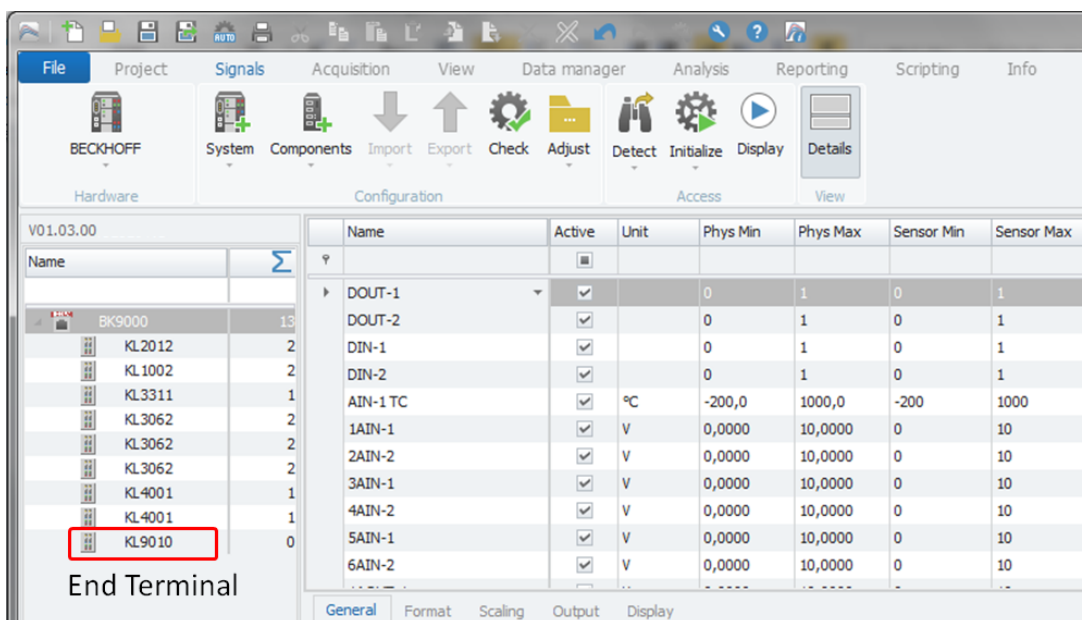
After creating the interface device (bus coupler), the IO terminals must be created. The order of the IO terminals in IPEmotion must match exactly the same order of the IO terminals and power input terminals used by the hardware setup. The physical order of the IO terminals is reflecting the Modbus address structure and the PlugIn is automatically reading the correct values from the different terminals.



Add IO terminals through the ribbon.

Add IO terminals through the context menu on device level.

The following screen shot shows a complete system with several IO terminals.



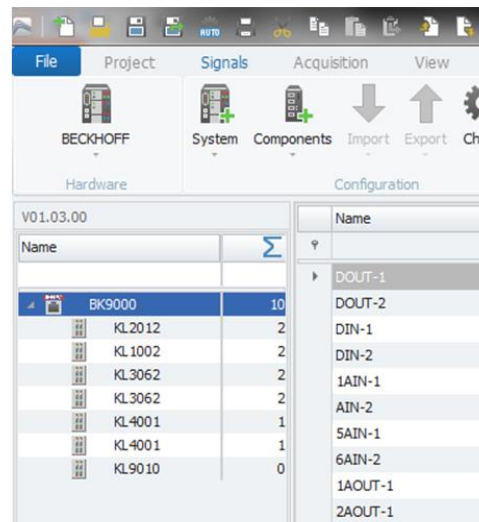
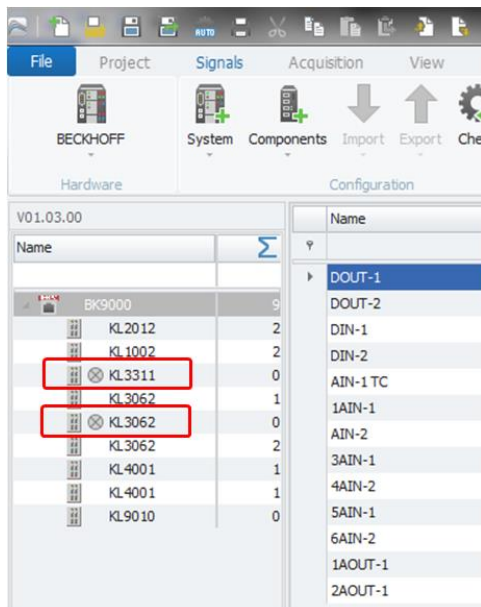
Information

The IO terminals must be initially created in the right order as used by the hardware setup. It is misleading to use a sorting function to bring the modules in the same order as used in the HW setup e.g. by renaming the IO terminals.

It is recommended to including the end terminal KL9010 in the IPEmotion process structure. For the Modbus addressing point of few it is not necessary to include the end terminal. The measurement will work correctly without an end terminal in the IPEmotion configuration.

3.5 Removing and Deactivating IO Terminals

If your hardware configuration is changing, e.g. terminals are physically removed you need to **delete** these terminal from the IO list also. The Modbus addresses are only updated when the IO terminals are deleted. When you **deactivate** an IO terminal, the address mapping remains and only the measurement of these inputs is deactivated.



Deleting terminals:
Modbus address settings are updated.

Deactivating terminals:
Is not changing the Modbus address settings.
> No measurements of these inputs.

3.6 Supported KL IO Terminals

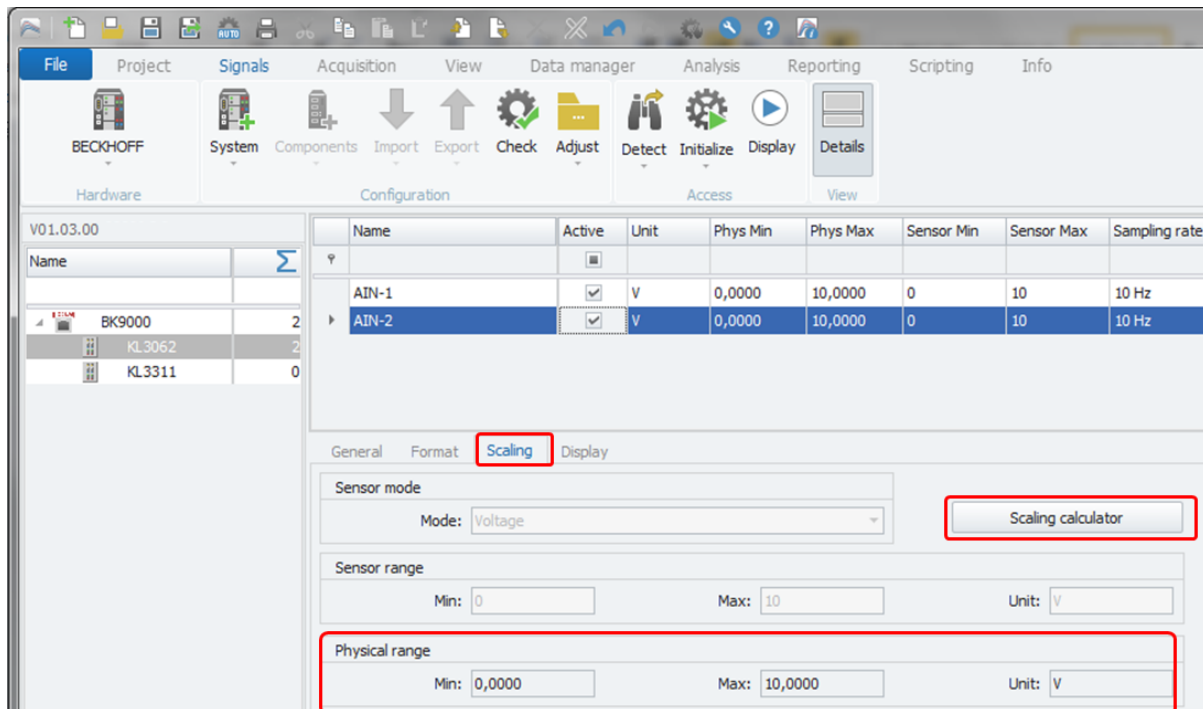
This PlugIn version supports the following KL IO terminals. The list of terminals is growing along with customer projects and new requirements.

IPEmotion: Components selection - BK9000				
Count	Symbol	Type	Description	
0		KL1Group	Digital input terminal	
0		KL1xxx	Digital input terminal	
0		KL2xxx	Digital output terminal	
0		KL3xxx	Analog input terminal	
0		KL4xxx	Analog output terminal	
0		KL9xxx	System terminal	
0		KL1002	2-channel digital input terminal 24 V DC	
0		KL1512	2-channel up/down counter, 24 V DC	
0		KL1808	8-channel digital input terminal 24 V DC	
0		KL2012	2-channel digital output terminal 24 V DC	
0		KL2442	2-channel digital output terminal 24 V DC, 2x 4 A	
0		KL2521	1 channel-Pulse-Train output terminal RS422/24 V DC	
0		KL2808	8-channel digital output terminal 24 V DC	
0		KL3062	1-channel analog input terminal 0...10 V	
0		KL3311	1-channel thermocouple input terminal with open-circuit recognition	
0		KL4001	1-channel analog output terminal 0...10 V	
0		KL9010	Bus end terminal	

The terminals indicated e.g. KL1xxx are generic terminals which can be used to create new terminals. The process is explained in the next section.

3.7 Channel Scaling

For the channel scaling you select a channel and switch to the SCALING tab sheet. In this tab sheet you can scale all analog and digital input and output channels. Basic scaling operations can be defined directly in the tab sheet by entering the physical range (engineering units) to the system. However, if you need a more sophisticated scaling input with factor offset- scaling or self-developed linearization tables you may use the Scaling calculator.



Channel scaling for engineering units.

3.8 Adding generic IO terminals – from template terminals

Beckhoff offers a large range of IO terminals and not all terminal types are implemented in the PlugIn, yet. However, the PlugIn provides generic terminals which give users the possibility to create their own terminals individually.

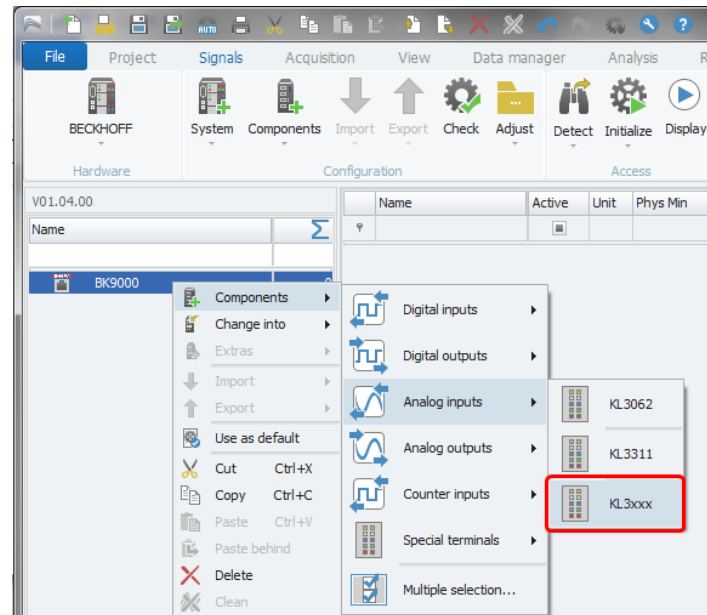
- ▶ KL 1xxx Generic Digital input terminal
- ▶ KL 2xxx Generic Digital output terminal
- ▶ KL 3xxx Generic Analog input terminal
- ▶ KL 4xxx Generic Analog output terminal
- ▶ KL 9xxx Generic special terminal

If a specific terminal is missing in the PlugIn you can easily create a terminal from the five main IO terminals by your own. In the following example a two channel high precision analog input terminal (KL 3172) with a 0 - 2 Volt measurement range is created.



Information

Not all IO terminals can be created through the generic templates. If you require a special IO terminal please contact IPETRONIK for support.



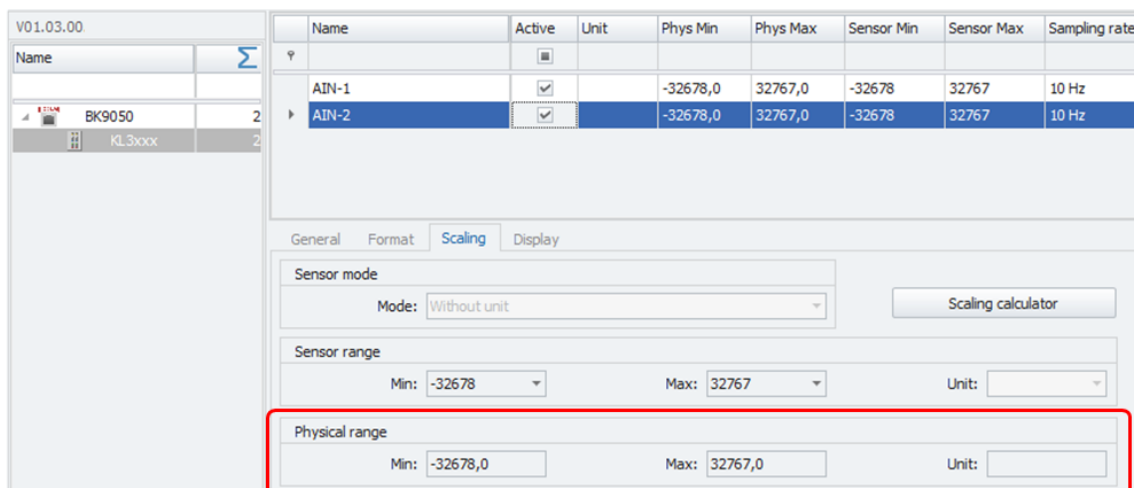
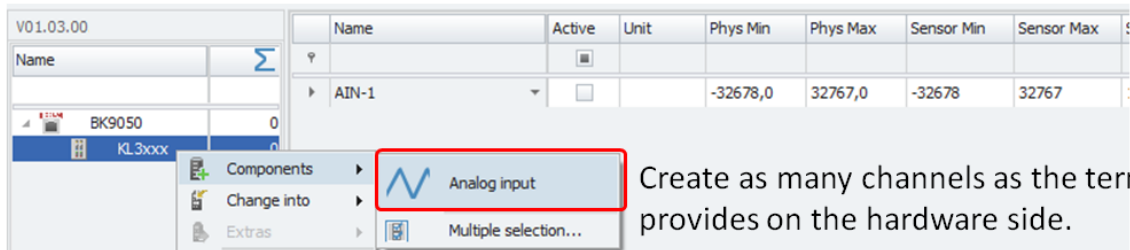
Select and add the generic terminal
for analog inputs KL 3xxx

After creating a generic input terminal KL 3xxx, the analog input channels need to be created. The KL 3172 has 2 analog inputs. Therefore, 2 input channels are created.



Information

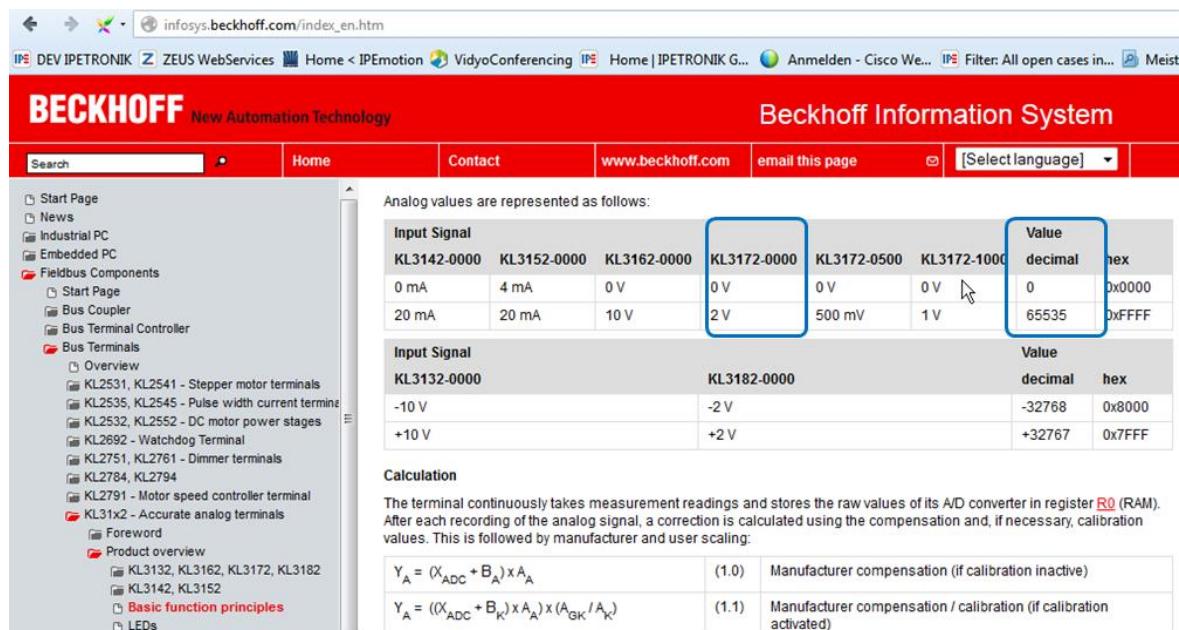
Even if you like to measure only one input e.g. of KL3172, it is still required to create as many channels (2 inputs) on the software side as provided by the terminal in order to set up the correct Modbus address register.



Define sensor scaling – see Beckhofs's technical manual of the IO terminal.

In the final step the channel scaling has to be defined. For the correct channel scaling you need to refer to the technical manual of the terminal to see the decimal values of sensor range and the physical range.

For KL3172 the decimal range of a 0 - 2V measurement is: 0 – 65535.



Analog values are represented as follows:

Input Signal	KL3142-0000	KL3152-0000	KL3162-0000	KL3172-0000	KL3172-0500	KL3172-1000	Value decimal	hex
0 mA	4 mA	0 V	0 V	0 V	0 V	0 V	0	0x0000
20 mA	20 mA	10 V	2 V	500 mV	1 V		65535	0xFFFF

Input Signal

KL3132-0000	KL3182-0000	Value decimal	hex
-10 V	-2 V	-32768	0x8000
+10 V	+2 V	+32767	0x7FFF

Calculation

The terminal continuously takes measurement readings and stores the raw values of its A/D converter in register **R0** (RAM). After each recording of the analog signal, a correction is calculated using the compensation and, if necessary, calibration values. This is followed by manufacturer and user scaling:

$$Y_A = (X_{ADC} + B_A) \times A_A \quad (1.0) \quad \text{Manufacturer compensation (if calibration inactive)}$$

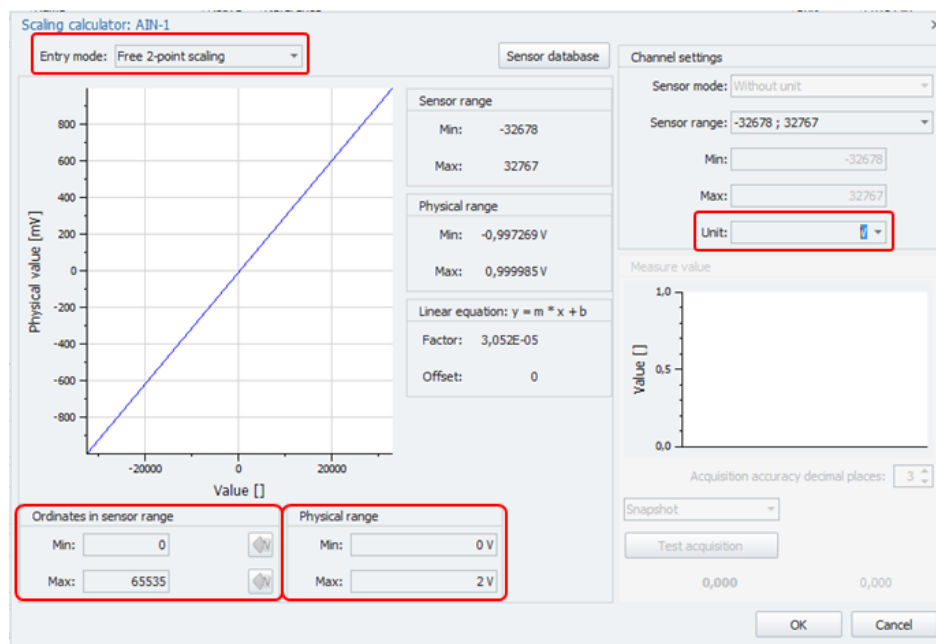
$$Y_A = ((X_{ADC} + B_K) \times A_A) \times (A_{GK} / A_K) \quad (1.1) \quad \text{Manufacturer compensation / calibration (if calibration activated)}$$

As you can see from the scaling calculator above, the IPEmotion default scaling of the generic KL3xxx terminal is -32.678 – 32767 and this not matching to the required scaling of the KL 3172 terminal.

Physical value KL 3172	Decimal value of KL 3172	IPEmotion default scaling of KL 3xxx
0 Volt	0	-32.678
2 Volt	65.535	32.767

In order to scale this terminal correctly the scaling mode “**Free 2-point scaling**” is required. The scaling is defined for the ordinate (x-axis) in the range of the KL3172 IO terminal from 0 - 65535.

The physical value (y-axis) is configured according to the input measurement range of 0 - 2 Volt.



Scaling calculator: ABN-1

Entry mode: Free 2-point scaling

Sensor database

Channel settings

Sensor mode: Without unit

Sensor range: -32678 ; 32767

Min: -32678

Max: 32767

Unit: V

Measure value

Value []

Acquisition accuracy decimal places: 3

Snapshot

Test acquisition

0,000 0,000

OK Cancel

Physical value [mV]

Value []

Linear equation: $y = m \cdot x + b$

Factor: 3,052E-05

Offset: 0

Physical range

Min: -0,997269 V

Max: 0,999985 V

Ordinates in sensor range

Min: 0

Max: 65535

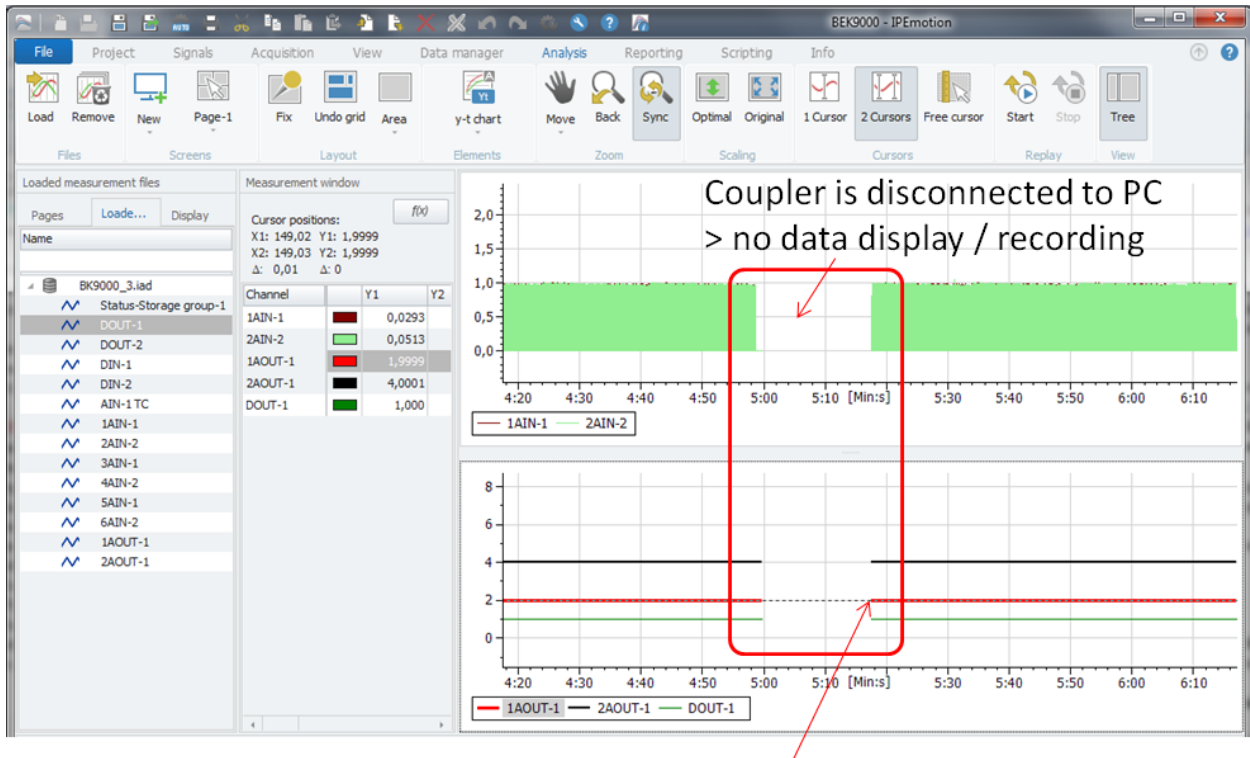
Physical range

Min: 0 V

Max: 2 V

3.9 Automatic Reconnect to the Bus Coupler

The PlugIn is supporting an auto connect function and tries to reconnect to the coupler in case the communication was stopped. If the connection (coupler –PC) is working again, the system continues with the measurements of input terminals and operation of the output terminals.

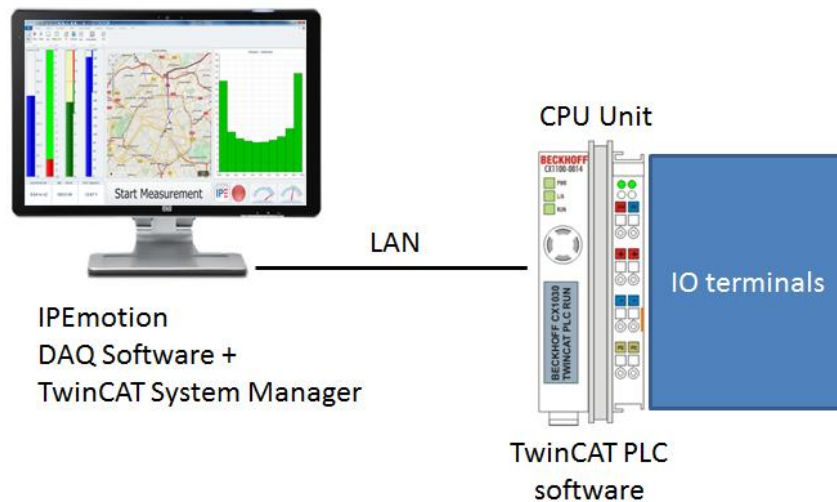


The PlugIn is permanently trying to reconnect to the bus coupler to continue with the data recording.

4 EtherCAT interface

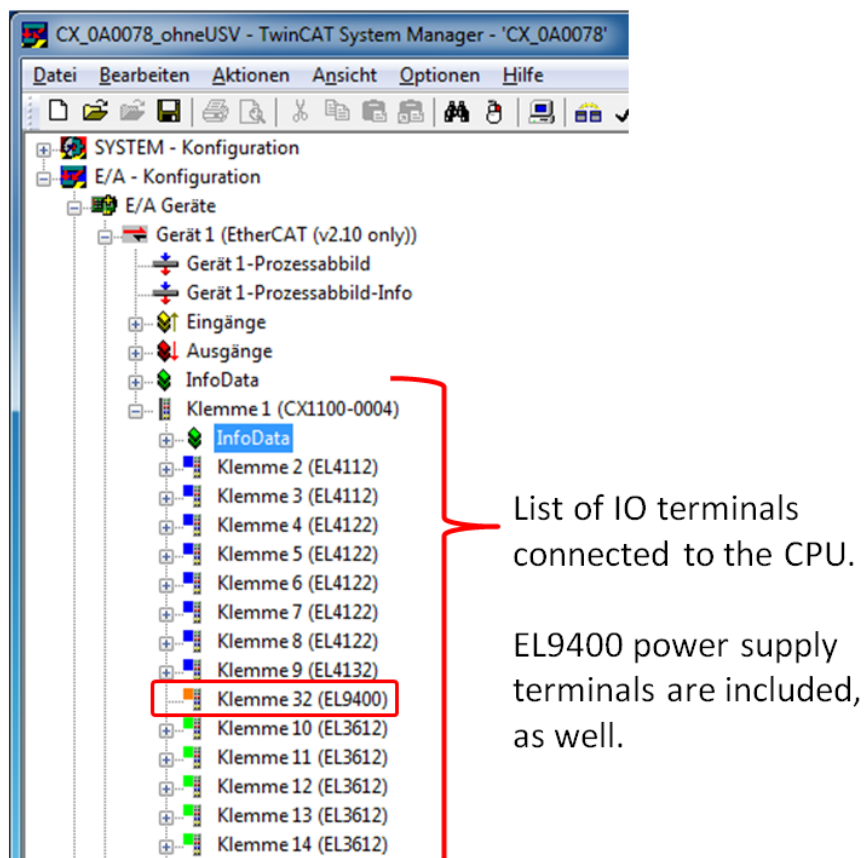
4.1 System architecture

The PlugIn is also supporting the direct data communication to Beckhoff CPU systems. For this architecture the ADS or R3IO interface is used to get the measurements from the Beckhoff CPU system integrated to IPEmotion.



4.2 TwinCAT - Beckhoff CPU configuration

On the CPU (e.g. CX1100) all the IO terminals are configured using the TwinCAT System Manager software. The IO terminals are listed exactly in the same order as they are physically connected to each other.



4.3 TwinCAT – Task configuration

In order to setup a data communication between the Beckhoff CPU and the IPEmotion PC a separate TwinCAT System manager installation on the IPEmotion PC is required. In this TwinCAT System Manager a new process task is defined which included all or only a subset of IO terminals you like to interface to IPEmotion.

The image consists of two screenshots from the TwinCAT System Manager and IPEmotion software, illustrating the configuration of a task and its connection to IPEmotion.

Top Screenshot (TwinCAT System Manager): Shows the configuration of a task named "Task 1". The "Port" field is set to "301". The "Options" section includes "I/O am Taskanfang", "Disable", "Symbole erzeugen", "Incl. externe Symbole", and "Extern synchronisieren". The "List of IO terminals included in Task 1" is shown in the left pane, listing terminals from In1_Ch1 to In9_Ch1. A red box highlights the "Task 1" entry in the left pane.

Bottom Screenshot (IPEmotion): Shows the "Configuration" window. The "Connection parameters" section is highlighted, showing "Port: 301". The "General" tab is selected. The "Name" column lists "TwinCAT" and "EL3102". The "Active" column shows checkboxes. The "Unit" column shows "V". The "Phys Min" column shows "-10,0000".

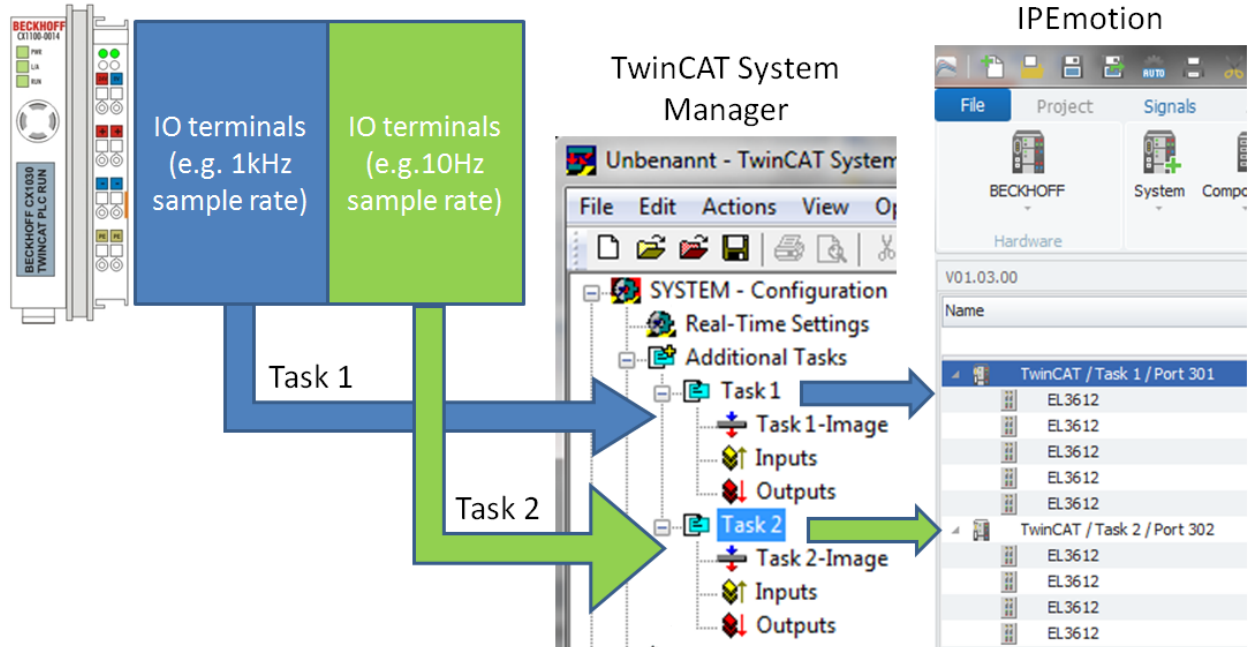
Annotations:

- Define Task & Port Number:** Points to the "Port: 301" field in the TwinCAT System Manager.
- List of IO terminals included in Task 1:** Points to the list of IO terminals in the TwinCAT System Manager.
- Same IO terminal order between Task 1 & IPEmotion:** Points to the "TwinCAT" and "EL3102" entries in the IPEmotion configuration window.
- Connect to Port: 301 of Task 1:** Points to the "Port: 301" field in the IPEmotion configuration window.

On the IPEmotion side the whole IO structure of the task needs to be created, as well. The interface between IPEmotion and the Task is established over the Port number.

A nice function of the TwinCAT System Manager is that IO terminals can be allocated to several task classes which are related e.g. to different sample rates. When you have defined several task classes with individual port numbers these task classes can be integrated into IPEmotion.

CX11xx CPU Unit



4.4 Supported EtherCAT IO Terminals

This PlugIn supports the following EL IO terminals. The list of terminals is growing along with customer projects and new requirements.

Count	Symbol	Type	Description
0		EL1xxx	Digital input terminal
0		EL2xxx	Digital output terminal
0		EL3102	2-channel analog input terminal -10...+10 V, Differential input, 16 Bit
0		EL3122	2-channel analog input terminal 4...20 mA, Differential input, 16 Bit
0		EL3612	2-channel analog input terminal 0...20 mA, Differential input, 24 Bit
0		EL3xxx	Analog input terminal
0		EL4112	2-channel analog output terminal 0...20 mA, 16 Bit
0		EL4122	2-channel analog output terminal 4...20 mA, 16 Bit
0		EL4132	2-channel analog output terminal -10...+10 V, 16 Bit
0		EL4xxx	Analog output terminal
0		EL5101	Inkremental-Encoder-Interface
0		EL9010	Bus end terminal
0		EL9xxx	System terminal

4.4.1 Adding generic IO terminals – from template terminals

Beckhoff offers a large range of IO terminals and not all terminal types are yet implemented in the PlugIn. However, the PlugIn provides generic terminals which give users the possibility to create their own terminals, individually.

- ▶ EL 1xxx Generic Digital input terminal
- ▶ EL 2xxx Generic Digital output terminal
- ▶ EL 3xxx Generic Analog input terminal
- ▶ EL 4xxx Generic Analog output terminal
- ▶ EL 9xxx Generic special terminal

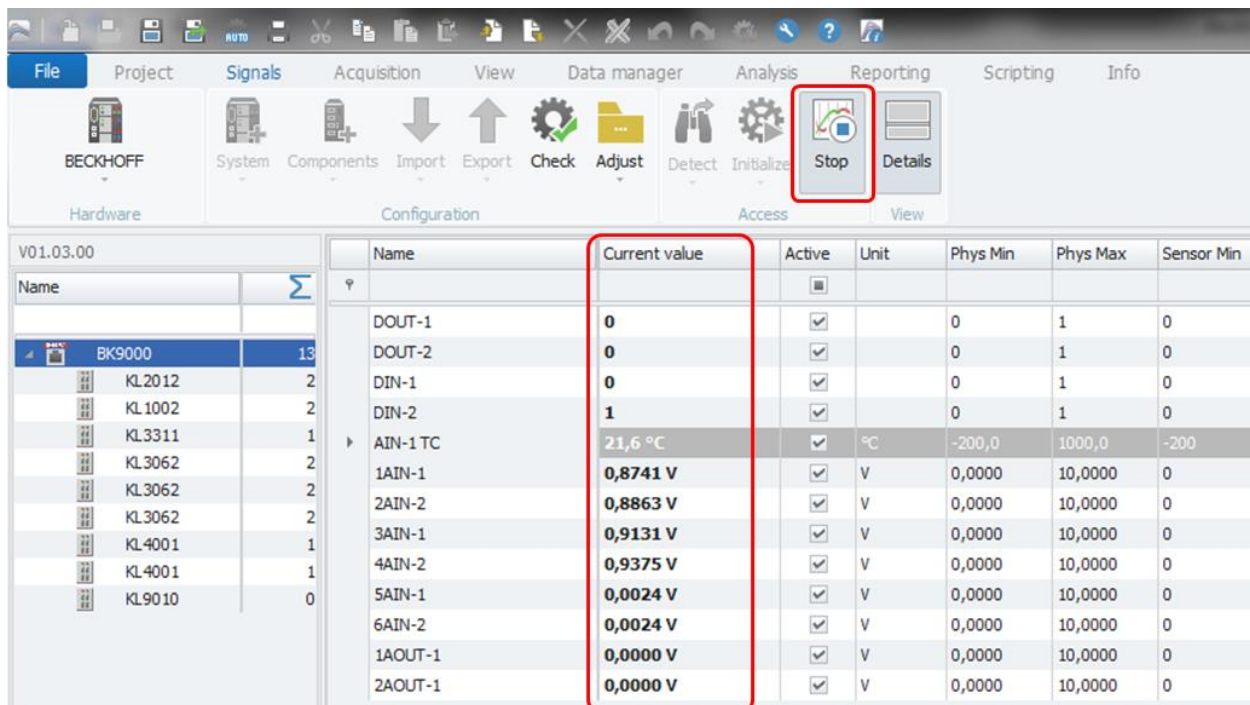
Creating a new terminal over the templating process is working with EtherCAT terminals in the same way as discussed in chapter 3.

**Information**

Not all IO terminals can be created through the generic templates. If you require a special IO terminal please contact IPETRONIK for support.

5 Starting Measurement

In order to start measurement and to test the communication you just need to run the start display button. The online measurements are directly displayed.



The screenshot shows the IPETRONIK software interface. In the top toolbar, the 'Stop' button (represented by a square with a diagonal line) is highlighted with a red box. Below the toolbar, the main window displays a table of online readings. The table has columns: Name, Current value, Active, Unit, Phys Min, Phys Max, and Sensor Min. The 'Current value' column is highlighted with a red box. The table lists various digital and analog inputs and outputs, including DOUT-1, DOUT-2, DIN-1, DIN-2, AIN-1 TC, and several AIN and AOUT channels.

Name	Current value	Active	Unit	Phys Min	Phys Max	Sensor Min
DOUT-1	0	☒		0	1	0
DOUT-2	0	☒		0	1	0
DIN-1	0	☒		0	1	0
DIN-2	1	☒		0	1	0
AIN-1 TC	21,6 °C	☒	°C	-200,0	1000,0	-200
1AIN-1	0,8741 V	☒	V	0,0000	10,0000	0
2AIN-2	0,8863 V	☒	V	0,0000	10,0000	0
3AIN-1	0,9131 V	☒	V	0,0000	10,0000	0
4AIN-2	0,9375 V	☒	V	0,0000	10,0000	0
5AIN-1	0,0024 V	☒	V	0,0000	10,0000	0
6AIN-2	0,0024 V	☒	V	0,0000	10,0000	0
1AOUT-1	0,0000 V	☒	V	0,0000	10,0000	0
2AOUT-1	0,0000 V	☒	V	0,0000	10,0000	0

Start measurement – online readings.