MU-Thermocouple1 CAN

Configurable System for Data Acquisition and Data Processing

User Manual

Document version 1.7.0 (2020-03-20)

PEAK System

Relevant products

Product Name	Model	Part number
MU-Thermocouple1 CAN (measuring range J)	Metal-cased measuring unit with 8 measuring channels	IPEH-002205-J
MU-Thermocouple1 CAN (measuring range K)	Metal-cased measuring unit with 8 measuring channels	IPEH-002205-K
MU-Thermocouple1 CAN (measuring range T)	Metal-cased measuring unit with 8 measuring channels	IPEH-002205-T

The cover page shows the product MU-TC1 CAN with thermocouple connectors for the type K (green). Versions with assemblies for other thermocouple types have an identical casing design.

Attention! Heed the safety instructions in section 3.1 on page 13 that explain the meaning of the warning sign printed on the unit casing.

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Contents

1 Introduction

The Thermocouple1 measuring unit offers connections for 8 thermocouples for different temperature ranges (J, K, T).

Measurement data can be preprocessed and transmitted via CAN bus using a central microcontroller. Configuration work involves using Windows software on a computer connected to the same CAN bus.

1.1 Properties at a Glance

- 8 Mini sockets for thermocouple types J, K, and T (depending on the assembly of measuring modules at delivery)
- 4 galvanically isolated measuring modules, each with 2 thermocouple sockets of the same type
- Measuring ranges:
  - J: -210 to +1121 °C
  - K: -200 to +1370 °C
  - T: -200 to +400 °C
- Measurement accuracy: 0.2 %
- Accuracy of the reference sensors:
  typically ±0.5 K, max. ±1.0 K at +25 °C ambient temperature
- Resolution for temperature data at CAN communication: 1/16 °C
- High-speed CAN connection (ISO 11898-2) for data transfer and configuring, galvanically isolated up to 500 V
- Basic configuration with the Windows software Thermocouple Configuration

- Advanced configuration with the Windows software PPCAN-Editor 2
- Configurable preprocessing of readings with integrated microcontroller
- Aluminum casing with flange; DIN rail fixing option available on request
- Voltage supply from 6 to 34 V
- Extended operating temperature range of -40 to +85 °C (-40 to +185 °F)

1.2 Prerequisites

For operation:

- Power supply 12 V DC nominal (6 - 34 V possible), connected via supplied mating connector

For configuring of the measuring unit via CAN:

- Computer with Windows 10, 8.1, 7 (32/64-bit)
- PC-CAN interface of the PCAN series for the computer (e.g. PCAN-USB or PCAN-PCI)
- CAN connection between the computer and the measuring unit

1.3 Scope of Supply

- Measuring unit MU-Thermocouple1 CAN in an aluminum casing
- Mating connector for the power supply
- Configuration software Thermocouple Configuration for Windows 10, 8.1, 7 (32/64-bit)

- Configuration software PPCAN-Editor 2 for Windows 10, 8.1, 7 (32/64-bit)
- Manual in PDF format

2 Connectors

2.1 Thermocouple Sockets

The measuring unit MU-TC1 CAN supports the following types of thermocouples (according to the assembly of the measuring unit):

Type	Color (IEC 60584-1)	Temperature range
J	black	-210 - +1121 °C
K	green	-200 - +1370 °C
T	brown	-200 - +400 °C

The connection is done with a 2-pin **Mini connector** for thermocouples according to DIN EN 50212. The color of the socket shows the thermocouple type to be used according to the standard IEC 60584-1.

Note: Connecting the wrong type of thermocouple can lead to measurement errors.

Due to the different sizes of pins on a thermocouple connector a reverse polarity protection is ensured.

Figure 1: Mini socket for a thermocouple

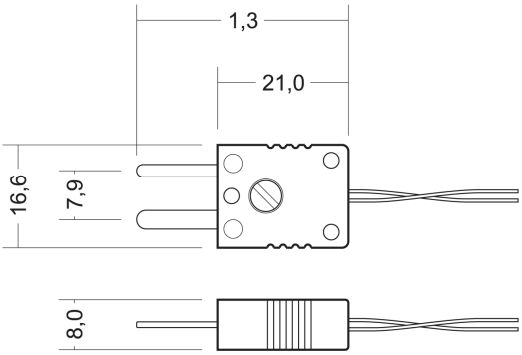

Figure 2: Dimension drawing Mini thermocouple plug

2.1.1 Measuring Accuracy

The absolute measuring accuracy consists of the accuracy of the thermocouples and the reference sensors. The measurement of the thermocouples results in a differential temperature between the measuring point and the temperature of the measuring socket. Only the reference sensors can convert this differential temperature into an absolute temperature.

The accuracy of the reference sensors is defined as follows:

- ±1 K at 0 - +70 °C
- ±2 K at -20 - +85 °C
- ±3 K at -40 - +125 °C

The accuracy of the thermocouples is 0.2 %.

Example of the determination of the total accuracy:

At an ambient temperature of the module of about 40°C the basic accuracy is +/-1 K. For the calculation of the error caused by the thermocouple, the difference between the temperature measurement and the ambient temperature of the measuring

module is relevant. The following overall accuracy results from the ambient temperature of 40°C and a measured value of 100°C:

(100 - 40) °C x 0.2 % = 60 K x 0.2 % = 0.12 K

0.12 K + 1 K = +/-1.12 K (total accuracy)

Note: The ambient temperature should change only slowly so that the contact point of the thermocouple in the socket actually corresponds to the measured reference temperature (the reference temperature sensor is located near the socket).

2.2 CAN (D-Sub Connector)

A High-speed CAN bus (ISO 11898-2) is connected to the 9-pin D-Sub connector. The pin assignment corresponds to the specification CiA® 102.

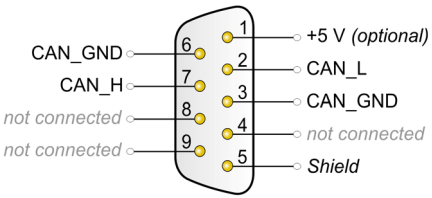

Figure 3: Pin assignment High-speed CAN bus
(view onto the male D-Sub connector of the measuring unit)

The CAN connection is not terminated internally. Therefore, the measuring unit must be connected to a terminated CAN bus (120 Ω between CAN_L and CAN_H on both ends of the CAN bus).

2.3 Supplying External Devices via the CAN Connector

A 5-Volt supply can be routed to pin 1 of the D-Sub CAN connector by setting a solder jumper on the controller board of the measuring unit. Thus external devices with low power consumption (e.g. bus converters) can be directly supplied via the CAN connector.

The 5-Volt supply is connected to the power supply of the measuring unit and is not fused separately. For galvanic isolation the measuring unit contains an interconnected DC/DC converter. Therefore, the current output is limited to 100 mA.

Attention! Risk of short circuit! The measuring unit's electronics or connected electronics may be damaged.

If the option described in this section is activated, you may only connect or disconnect CAN cables or peripheral devices (e.g. bus converters) to or from the measuring unit while it is disconnected from the power supply (de-energized).

Do the following to activate the 5-Volt supply at the CAN connector:

Attention! Electrostatic discharge (ESD) can damage or destroy components in the measuring unit. Take precautions to avoid ESD when handling the boards.

1. Take off any connected cable from the measuring unit.
2. Remove the two screws of the D-Sub connector.
3. Remove the four screws on the front panel in order to detach it.
4. Pull out the right board (has the D-Sub connector) of the casing.

5. On the bottom side of the board set a solder jumper on the position as marked in the following figure. During this procedure take especially care not to produce unwanted short circuits on the board.

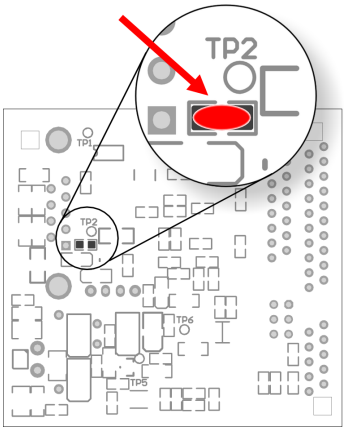

Figure 4: Position of the solder jumper on the bottom side of the controller board

6. Put the measuring unit back together in the reverse order.

2.4 Power Supply Socket

The measuring unit is operated with 12 V DC, 6 to 34 V are possible. The connection is done with the supplied mating connector for fastening cable strands. The polarity is as follows:

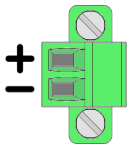

Figure 5: Mating connector for the power supply, connection at the lower right part of the front panel

3 Use

3.1 Safety Instructions

Attention! Danger due to electric shock! Risk of destroying the measuring unit!

You may only measure temperatures on energized parts when these are not directly connected with the mains voltage (measuring category CAT I). The measuring unit must not be used in the measuring categories CAT II, CAT III, or CAT IV.

Never apply a voltage higher than 30 V between thermocouples or between a thermocouple and earth.

Attention! Risk of burns!

At ambient temperatures of +70 °C (+158 °F) and above a protection against contact must be ensured for the measuring unit, i.e. the surface may no longer be tangible.

3.2 Operation with Default Configuration

At delivery the measuring unit is provided with a default configuration which allows you to start measuring and acquire the measuring data via CAN instantly without further adaptations.

Tip: If you have advanced demands, you can reconfigure the measuring unit (see chapter 4 on page 15).

3.2.1 CAN Data

With the default configuration the measuring values of the eight measuring channels and, for information purposes, the measuring values of the four reference sensors are transmitted via CAN as follows:

Property	Value
CAN IDs	100h, 101h, 102h
Data bytes	2 per measuring channel/reference sensor (8 per CAN message)
Contents per measuring channel	16-bit value: 1/16 °C
Data mode	Intel (Little Endian) signed
CAN bit rate	500 kbit/s
Transmission period	300 ms

Data byte in ID 100h	Measuring channel
1 - 2	1A
3 - 4	1B
5 - 6	2A
7 - 8	2B

Data byte in ID 101h	Measuring channel
1 - 2	3A
3 - 4	3B
5 - 6	4A
7 - 8	4B

Data byte in ID 102h	Reference sensor
1 - 2	1
3 - 4	2
5 - 6	3
7 - 8	4

3.2.2 Status LEDs

LED position	The LED …	Meaning
Thermocouple socket	shines red	An intact thermocouple is connected. If despite an connected thermocouple the corresponding LED should not shine, the cable or the thermocouple may not be all right.
Power supply socket	blinks green (1 Hz)	Normal operation of the microcontroller unit
	blinks green quickly (2 Hz)	Missing configuration. Send a configuration to the measuring unit via CAN (see the following chapter *Configuring the Measuring Unit*).

4 Configuring the Measuring Unit

If the default configuration for measuring data transmission as described in section 3.2 does not fit your needs, you can configure the measuring unit MU-TC1 CAN with Windows software via a CAN connection.

Here you have two options:

- Basic configuration with Thermocouple Configuration
- Advanced configuration with the PPCAN-Editor 2

The programs can be found on the provided DVD. You can also retrieve a current version of each program from our website.

The configuration options are described in the following sections.

4.1 Prerequisites for Configuring via CAN

- Computer with Windows 10, 8.1, 7 (32/64-bit)
- CAN interface of the PCAN series for the computer (e.g. PCAN-USB or PCAN-PCI)
- CAN connection between the computer and the measuring unit

4.2 Configuring Multiple Measuring Units at a Single CAN Bus

If you want to configure multiple measuring units at the same CAN bus, you must assign a separate ID in the range of 0 to 15 to each measuring unit. This is done on by 4 switches on the controller

board, where each switch represents a bit of a binary number. As a result, the measuring units can be distinguished by the configuration software.

Do the following to set the ID of the measuring unit:

Attention! Electrostatic discharge (ESD) can damage or destroy components in the measuring unit. Take precautions to avoid ESD when handling the boards.

1. Take off any connected cable from the measuring unit.
2. Remove the two screws of the D-Sub connector.
3. Remove the four screws on the front panel in order to detach it.
4. Pull out the right board (has the D-Sub connector) of the casing.
5. In the switch block S1, set the ID with the four DIP switches. Each switch is a bit of a four-digit binary number (see Figure 7).

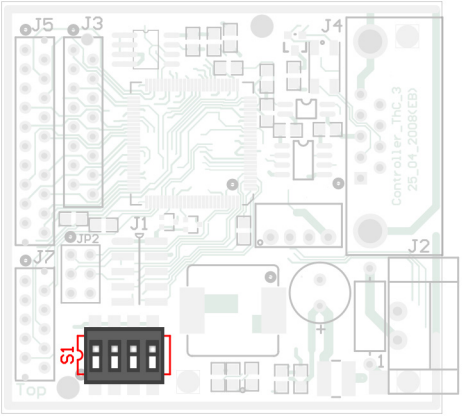

Figure 6: DIP switches on the controller board for setting the ID

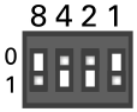

Figure 7: Values of the individual switches
(example setting binary 1001 corresponds to ID 9)

6. Put the measuring unit back together in the reverse order.

4.3 Basic configuration with Thermocouple Configuration

With the help of the supplied Windows program Thermocouple Configuration you can easily change the following settings regarding the measuring data:

- Block-wise assignment of CAN IDs to the measuring channels 1A to 2B and 3A to 4B
- Transmission periods for both CAN IDs
- Data type and format for each measuring channel (signed/unsigned, Intel/Motorola)
- Scaling of measuring values for each measuring channel (scale, offset)
- CAN bit rate
- The mentioned configuration options also for the four measuring values of the reference sensors in the measuring unit

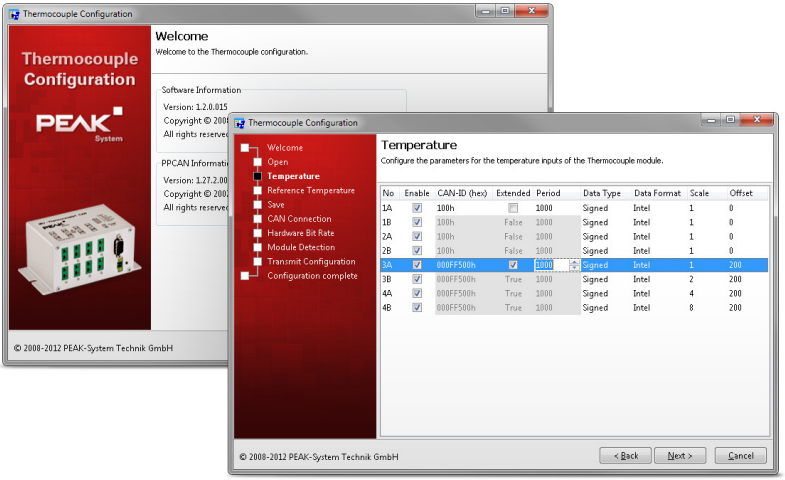

Figure 8: Views of the Windows program Thermocouple Configuration

4.3.1 Starting Thermocouple Configuration

The program does not require an extra installation and can directly be started from the supplied DVD.

Do the following to start Thermocouple Configuration:

1. Insert the supplied DVD into the appropriate drive of the computer.
2. The navigation program starts automatically after a short moment. If not, start the program `Intro.exe` from the root directory of the DVD manually.
3. Under **English** > **Tools** > **Thermocouple Configuration** select the command **Start**.

Alternatively, you can copy the contents of the DVD directory `\Tools\Thermocouple Configuration` to an arbitrary place of a local hard disk and execute the program `TCconfig.exe` from there.

4.3.2 Creating a Basic Configuration

The program Thermocouple Configuration guides you through the configuration procedure step by step. The created configuration may not only be sent to the measuring unit but also saved on a data carrier (CANdb format). Furthermore, you can use a saved configuration as basis for a new one, or send it without any changes to the measuring unit.

4.4 Advanced Configuration with the PPCAN-Editor 2

Some functions of the measuring unit may also be configured more detailed. For example, you can apply hysteresis functions, characteristic curves, and other simple as well as more complex conversion and composition functions to the measuring values of the thermocouple inputs and the reference sensors. Furthermore, there are options for individually activating the LEDs and for adapting the transmission parameters of the CAN bus to special applications.

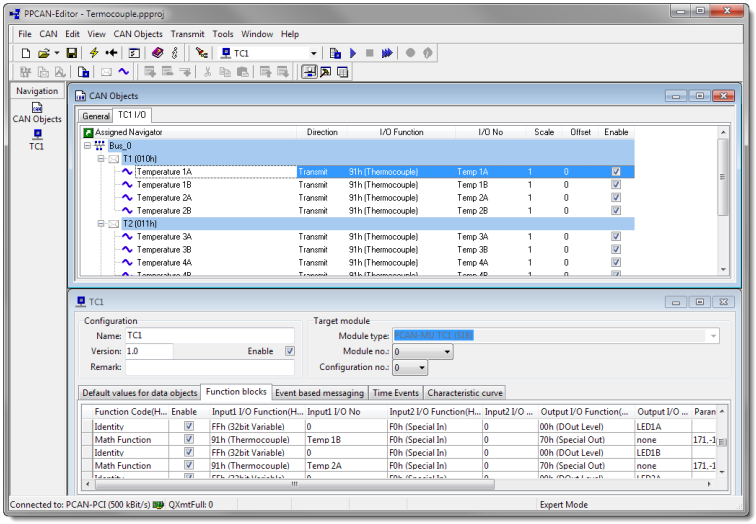

Figure 9: PPCAN-Editor with a configuration

Install the PPCAN-Editor under Windows (e.g. from the supplied DVD) in order to use it.

Tip: For general notes on operation, use the program help or take a look at our tutorial videos.

Furthermore you will find numerous examples in the configuration tutorial, which you can download from the MU-Thermocouple1 CAN product page under **Download**.

5 Technical Specifications

Measuring modules	
Count	4
Connectors	2 Mini sockets for thermocouples (DIN EN 50212) per module, 8 altogether
Galvanic isolation	each measuring module internally against the supply voltage, up to 500 V
Supported thermocouple types (IEC 60584-1)	J (-210 - +1121 °C) K (-200 - +1370 °C) T (-200 - +400 °C) (according to the used module)
Measurement accuracy[1] of the thermocouple inputs	±0.2 %
Influence of ambient temperature	10.5 ppm/K
Reference sensors	4 (1 per measuring module)
Measurement accuracy[1] of the reference sensors	±1 K at 0 - +70 °C ±2 K at -20 - +85 °C ±3 K at -40 - +125 °C
Measuring category	CAT I (only electric circuits that are not connected to the mains)

Controller module	
Microcontroller	NXP LPC2366
Resolution for temperature data at CAN communication	1/16 °C
Sampling rate of the sensors	3 Hz

[1] In chapter 2.1.1 on page 9 measuring accuracy is explained in more detail.

CAN	
Specification	ISO 11898-2, High-speed CAN 2.0A (Standard format) and 2.0B (Extended format)
Bit rates	40 kbit/s - 1 Mbit/s Lower bit rates on request
Transceiver	NXP TJA1040T
Connection	D-Sub (m), 9-pin, assignment according to specification CiA® 303-1 Optional 5-Volt supply at pin 1 for external devices (e.g. bus converters), max. 100 mA Galvanic isolation up to 500 V
Termination	none

Power supply	
Supply voltage	Nominal 12 V DC (6 - 34 V possible)
Mating connector type	Phoenix Contact MC1,5/2-STF-3,81
Current consumption	ca. 100 mA at 12 V

Measures	
Size (incl. mounting plate and connectors)	130 x 60 x 73 mm (W x H x D) See also dimension drawings in Appendix B on page 24
Weight	420 g

Environment	
Operating temperature	-40 - +85 °C (-40 - +185 °F)
Temperature for storage and transport	-40 - +100 °C (-40 - +212 °F)
Relative humidity	15 - 90 %, not condensing
Safety	EN 61010-1 + Amendments 1 and 2
Ingress protection (IEC 60529)	IP20

Conformity	
EMV	Directive 2014/30/EU DIN EN 61326-1:2013-07
RoHS 2	Directive 2011/65/EU DIN EN 50581 VDE 0042-12:2013-02

Appendix A CE Certificate

EU Declaration of Conformity

This declaration applies to the following product:

Product name: MU-Thermocouple1 CAN

Item number(s): IPEH-002205-K/-J/-T

Manufacturer: PEAK-System Technik GmbH
Otto-Roehm-Strasse 69
64293 Darmstadt
Germany

We declare under our sole responsibility that the mentioned product is in conformity with the following directives and the affiliated harmonized standards:

EU Directive 2011/65/EU (RoHS 2)

DIN EN 50581 VDE 0042-12:2013-02
Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances;
German version EN 50581:2012

EU Directive 2014/30/EU (Electromagnetic Compatibility)

DIN EN 61326-1:2013-07
Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements (IEC 61326-1:2012);
German version EN 61326-1:2013

Darmstadt, 22 February 2019

Uwe Wilhelm, Managing Director

Appendix B Dimension Drawings

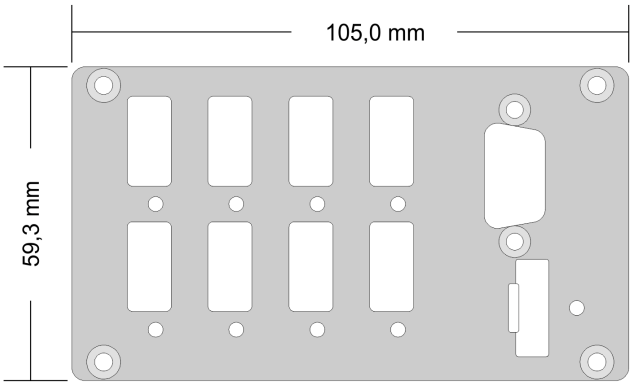

Figure 10: Front panel size

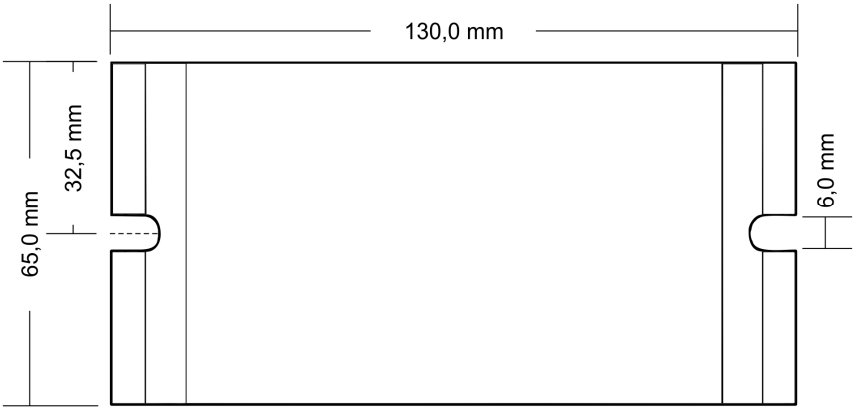

Figure 11: Mounting plate size

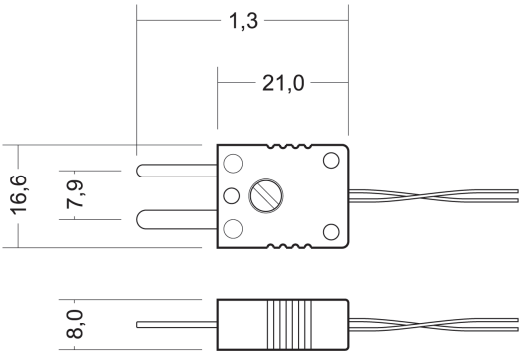

Figure 12: Mini thermocouple plug
(dimensions in mm)

The figures do not show the original size.

Appendix C Temperature Unit Configuration

This appendix describes how the scale and offset values must be set to measure in 1/16 degrees Celsius, whole degrees Celsius and whole Fahrenheit. By default, the temperature resolution is set to 1/16 degree Celsius.

Do the following to configure Scale and Offset in the wizard:

1. To measure in 1/16th of a degree Celsius, you must set Scale to 1 and Offset to 0.
2. To measure in whole degrees Celsius, Scale must be set to 0.0625 and Offset to 0.
3. To measure in whole degrees Fahrenheit, set Scale to 0.1125 and Offset to 32.

With the first option (Scale: 1, Offset: 0) the monitoring software (e.g. PCAN-Explorer) can interpret the signal values as follows:

- Celsius: Scale 0.0625 and Offset 0
- Fahrenheit: Scale 0,1125 and offset 32

With the other options the monitoring software (e.g. PCAN-Explorer) must interpret the signal values with Scale = 1 and Offset = 0.

Appendix D Device Resources

The table lists all the logical resources of the measuring unit which can be used for an advanced configuration with the PPCAN-Editor. The resources are sorted by I/O functions (column “I/O Function”) and the respective I/O numbers (column “I/O Number”).

I/O Function	I/O Number	Value range	Connection	Function
DOut Level (00h)				
	LED 1A (30)	0: off, 1: on	LED 1A	Switch on or off the LED for a measuring channel
	LED 1B (31)		LED 1B	
	LED 2A (62)		LED 2A	
	LED 2B (63)		LED 2B	
	LED 3A (94)		LED 3A	
	LED 3B (95)		LED 3B	
	LED 4A (126)		LED 4A	
	LED 4B (127)		LED 4B	
DOut Frequency (01h)				
	LED 1A (30)	0 - 100 (0 - 10 Hz, resolution 0.1 Hz)	LED 1A	Let the LED for a measuring channel blink
	LED 1B (31)		LED 1B	
	LED 2A (62)		LED 2A	
	LED 2B (63)		LED 2B	
	LED 3A (94)		LED 3A	
	LED 3B (95)		LED 3B	
	LED 4A (126)		LED 4A	
	LED 4B (127)		LED 4B	
DOut Ratio (03h)				
	LED 1A (30)	0 - 255 (255 = 100 %)	LED 1A	Generates a PWM signal with variable duty cycle and configurable frequency. The frequency is determined by the I/O function DOut Frequency (01h).
	LED 1B (31)		LED 1B	
	LED 2A (62)		LED 2A	
	LED 2B (63)		LED 2B	
	LED 3A (94)		LED 3A	
	LED 3B (95)		LED 3B	
	LED 4A (126)		LED 4A	
	LED 4B (127)		LED 4B	

I/O Function	I/O Number	Value range	Connection	Function
Special Out (70h)				
	CAN Bitrate Raw (216)		CAN	Sets a user-defined CAN bit rate (on request at PEAK-System).
	CAN Bitrate 10 kbit/s (219)	1		Sets a CAN bit rate. The value indicates the CAN channel to be configured; for the measuring unit this is always CAN channel 1. Note: The smallest possible transmission rate depends on the CAN transceiver. See technical specifications.
	CAN Bitrate 20 kbit/s (220)			
	CAN Bitrate 33.3 kbit/s (221)			
	CAN Bitrate 47.6 kbit/s (222)			
	CAN Bitrate 50 kbit/s (223)			
	CAN Bitrate 83.3 kbit/s (224)			
	CAN Bitrate 95.2 kbit/s (225)			
	CAN Bitrate 100 kbit/s (226)			
	CAN Bitrate 125 kbit/s (227)			
	CAN Bitrate 250 kbit/s (228)			
	CAN Bitrate 500 kbit/s (229)			
	CAN Bitrate 1 Mbit/s (230)			
	none (255)			Sets the CAN bit rate to 500 kbit/s so that a communication is still possible.
Thermocouple (91h)				
	Temp 1A (0)	32 bits signed (resolution 1/16 °C)	1A	Temperature value of a connected thermocouple (1/16 °C)
	Temp 1B (1)		1B	
	Temp 2A (2)		2A	
	Temp 2B (3)		2B	
	Temp 3A (4)		3A	
	Temp 3B (5)		3B	
	Temp 4A (6)		4A	
	Temp 4B (7)		4B	
	RefTemp 1 (16)	32 bits signed (resolution 1/16 °C)	(internally)	Temperature value of a reference sensor in a measuring module with two connectors (1/16 °C), for information purposes (about ambient temperature)
	RefTemp 2 (17)			
	RefTemp 3 (18)			
	RefTemp 4 (19)			
Const (CCh)				
	(See list in the PPCAN-Editor)	(Diverse values)		Diverse constants Read only; can be used as input constants.

I/O Function	I/O Number	Value range	Connection	Function
Positive Const (CDh)				
	0 to 255	(0 to +255)		Positive constants Read only; can be used as input constants.
Negative Const (CEh)				
	0 to -255	(0 to -255)		Negative constants Read only; can be used as input constants.
Special In (F0h)				
	ConfVerMain (1)	0 - 255		Main version number of the configuration Version of the configuration; can be specified in the PPCAN-Editor during the module-specific settings
	ConfVerSub (2)	0 - 255		Secondary version number of the configuration
	FW VerMain (3)	0 - 7		Main version number of the firmware For information purposes; read only
	FW VerSub (4)	0 - 31		Secondary version number of the firmware
	FW BuildNo (5)	0 - 255		Build version number of the firmware
	Module ID (16)	0 - 15		Module ID Settings of the corresponding DIP switches on the controller board; ID must be unique within the CAN net.
	MainCycleCounter (40)	0 - 65535		Count of computation cycles of the firmware since the last call; read only
	MainCycleTime Max (41)			Maximum duration in ms for a computation cycle since the last call; read only
	MainCycleTime Avg (42)			Average duration in µs for a computation cycle since the last call; read only
	none (255)			No function Can be used as place-holder if the corresponding input or output has no function.
Extension Board (F1h)				
	Slot 1 (0)	0 - 31 (5 bits) 15: Thermocouple Type K 16: Thermocouple Type J 17: Thermocouple Type T	Slots for measuring modules 1 to 4 in the casing of the measuring unit	Module type that is present in the corresponding slot
	Slot 2 (1)			
	Slot 3 (2)			
	Slot 4 (3)			
32-bit variable (FFh)				
	0 to 255	32 Bit signed		Internal 32-bit variable Temporary memory for values of function blocks and CAN variables