Technical Documentation for

FM33xx - TC-Plug

Applies to all FM33xx types
SW_VERSION 0xB0FA, 2000-25-05

Version: 1.7
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BECKHOFF

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Foreword

Notes on the Documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

Liability Conditions

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. None of the statements of this manual represents a guarantee (Garantie) in the meaning of § 443 BGB of the German Civil Code or a statement about the contractually expected fitness for a particular purpose in the meaning of § 434 par. 1 sentence 1 BGB. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Safety Instructions

Safety Rules

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

State at Delivery

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH.

Personnel Qualification

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

Description of safety symbols

The following safety symbols are used in this operating manual. They are intended to alert the reader to the associated safety instructions.

Danger

This symbol is intended to highlight risks for the life or health of personnel.

Warning

This symbol is intended to highlight risks for equipment, materials or the environment.

Note

This symbol indicates information that contributes to better understanding.

Introduction

Overview

The various implementation levels of the TC-Plug differ in the number of thermocouple input channels (12 channels or 32) and in the type of thermocouple implemented (J or K type).

Technical data

Mechanical structure

Side view of the TC-Plug

Technical data (Version 1F.1 26.05.2000)	FM3312	FM3332
Dimensions	120mm x 52mm x 129mm, ,length x wide x height	
Connector Hood	Han24B (Harting)	
Connector to Thermocouples	Han24E	Han64D
Contacts	Hard gold plated	
Coding system	With coding pins in the connector	
Power supply and PROFIBUS connection	Round-Connector, DIN 45322 (series 423, 723 Binder) Shield of the Round-Connector is connected to the plug	

Electrical data

The following tables provide a summary of the electrical and fieldbus-specific data related to the TC-Plug.

Technical data (Version 1F.1 26.05.2000)	FM3312	FM3332
General technical data		
Power supply	24 V_{DC}, -15% …+20% (20.4...28.8 V)	
typical operating current	90 mA (24 V)	100 mA (24 V)
max. operating current	120 mA (24 V)	130 mA (24 V)
Power supply input protection **Reverse voltage** **Over voltage**	 min. -35V max. 35V	
Potential separation		
Thermocouples / PROFIBUS	500 V_{rms}	
Thermocouples / Supply Voltage	500 V_{rms}	
Supply Voltage / PROFIBUS	100 V_{rms}	
Ambient temperature		
Operating temperature	0...+55°C	
Storage temperature	-25...+85°C	
Type of protection	plug: IP65 (PROFIBUS-Connector: IP67)	
Vibration	EN 60068-2-6 10 Hz <= f <= 57 Hz: 0,075mm Amplitude 57 Hz <= f <= 150 Hz: 1,0 g	
Shock	EN 60068-2-27/29 15 g, 11 ms	
Vibration	conforms to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29	
EMC immunity / EMC emission	conforms to EN 61000-6-2 / EN 61000-6-4	
Approvals	CE, cULus*	
*)	For the compliance of the cULus requirements use 4 Amp. fuse or class 2 power supply!	
Thermocouple technical data		
Number of Inputs	12	32
Type of Input	Differential Input, mV measurement, high impedance grounded no electrical separation	
Connection	two wire, direct connection	
Wiring length	max. 10 meter	
Thermocouple sensor type	type K:-100...1370°C	
	type J:-100...900°C	
Common mode input voltage range	-8 V...+8 V	
Common mode rejection	typical 90 dB (independent from conversion time)	
Common mode rejection	typical 150 dB (at 50 Hz or 60 Hz Rejection)	
Normal mode rejection	typical 98 dB (at 50 Hz or 60 Hz Rejection)	
Resolution	0.1°C per digit	
Linearization Error	+-0,1°C (voltage to temperature)	

Technical data (Version 1F.1 26.05.2000)	FM3312	FM3332
Cold junction compensation Error	+- 0,1 C (voltage to temperature) +- 0,3°C (Offset and linearization)	
Calibration Error	+- 0,1°C	
Nonlinearity Error	+- 0,1°C	
Temperature Drift	+- 0,2°C	
Temperature nonlinearity	+- 0,1°C	
Cold junction compensation	Internal (temperature measurement in the plug)	
Conversation time (per channel)	Adjustable 50 ms (60 Hz Common Mode Rejection) 60 ms (50 Hz Common Mode Rejection)	
Data update time	200 ms (60 Hz) 230 ms (50 Hz)	
Wiring fail indication	Yes (Open Thermocouple)	
Back voltage indication		
Back Voltage Range	>10 V, < -10 V	
Switch off time	3 ms, max.	
Input resistance for current limitation	2400 R, typical	
Input voltage	100 Vac between TC+ and TC- of each channel	
	240 Vac above Protective Earth	
	415 Vac to other TC	
Input protection mechanism	Current limitation Channel disconnect	
Range of Input protection	240 Vac,dc	
Earth connection	The plug must be connected to protective earth with the earth-connector in the plug!	

Fieldbus-specific data

Technical data (Version 1F.1 26.05.2000)	FM3312	FM3332
Field bus protocol	PROFIBUS DP, EN50170	
Transmission rate	Max. 12Mbaud	
Address configuration	Setting via two rotary switches	
Status LED	RUN, BF (Bus Failed), ERR (Error)	
	TC Run, TC Err	

Pin assignment for the round connector

Round connectors

round connector for input

round connector for output

Pin assignment (Module)		Male Connector (Input)	Female Connector (Output)
PROFIBUS	pin 1	A = RxD / TxD-N	A = RxD / TxD-N
PROFIBUS	pin 2	B = RxD / TxD-P	B = RxD / TxD-P
PROFIBUS Termination	pin 3		GND
PROFIBUS Termination	pin 4		+5V
Power supply	pin 5	+24V	+24V
Power supply	pin 6	0V	0V

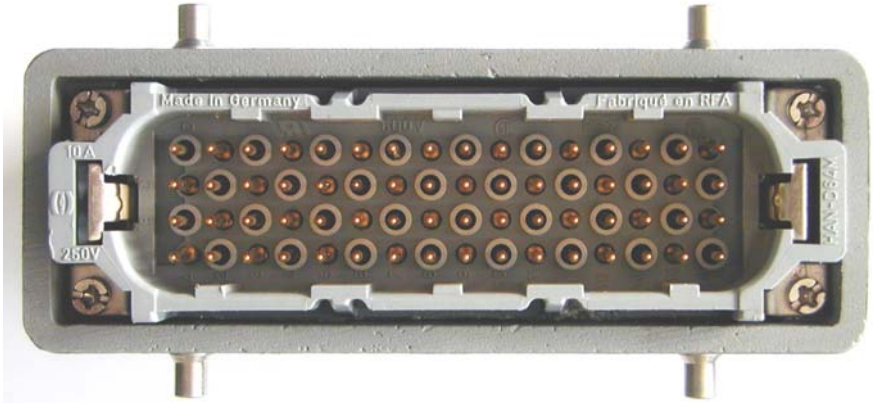
Attention

Protect the power supply (24 V) by using a fuse (max. 4 A, medium time-lag), to protect the modules in case of short circuit at the hybrid cable (PROFIBUS / Power Supply).

Pin assignment for the 24-pin connection strip

Pin assignment FM3312	pin 1	TC1+	pin 13	TC1-
	pin 2	TC2+	pin 14	TC2-
	pin 3	TC3+	pin 15	TC3-
	pin 4	TC4+	pin 16	TC4-
	pin 5	TC5+	pin 17	TC5-
	pin 6	TC6+	pin 18	TC6-
	pin 7	TC7+	pin 19	TC7-
	pin 8	TC8+	pin 20	TC8-
	pin 9	TC9+	pin 21	TC9-
	pin 10	TC10+	pin 22	TC10-
	pin 11	TC11+	pin 23	TC11-
	pin 12	TC12+	pin 24	TC12-

Pin assignment for the 64-pin connection strip



Pin assignment FM3332		A..	B..	C..	D..
	pin 1	TC1+	TC1-	TC17+	TC17-
	pin 2	TC2+	TC2-	TC18+	TC18-
	pin 3	TC3+	TC3-	TC19+	TC19-
	pin 4	TC4+	TC4-	TC20+	TC20-
	pin 5	TC5+	TC5-	TC21+	TC21-
	pin 6	TC6+	TC6-	TC22+	TC22-
	pin 7	TC7+	TC7-	TC23+	TC23-
	pin 8	TC8+	TC8-	TC24+	TC24-
	pin 9	TC9+	TC9-	TC25+	TC25-
	pin 10	TC10+	TC10-	TC26+	TC26-
	pin 11	TC11+	TC11-	TC27+	TC27-
	pin 12	TC12+	TC12-	TC28+	TC28-
	pin 13	TC13+	TC13-	TC29+	TC29-
	pin 14	TC14+	TC14-	TC30+	TC30-
	pin 15	TC15+	TC15-	TC31+	TC31-
	Pin 16	TC16+	TC16-	TC32+	TC32-

Functional description

The interfaces

The module has manual and electrical interfaces. The electrical interfaces connect the PROFIBUS cable to the termination resistor and the power supply for the fieldbus connection. For the temperature measurement, the thermocouples are wired via the 24 or 64 pin connection strips and the PE connection. The module also has a serial interface for configuration. The module's station address can be set via the manual interface. The LEDs of the visual display supply information about the current status of the TC-Plug module.

Status LEDs for the PROFIBUS-communication

Status LEDs for the thermocouple input channels

Serial configuration interface and switches for station addresses

6-pin plug and socket for fieldbus connection

PE connection

Round connector

The round 6-pin connectors are used to connect the PROFIBUS cables and the module's operating voltage. The operating voltage is fed via the module's 6-pin male connector. The operating voltage is brought out on the 6-pin female connector side to supply the next module. The supply voltage for the PROFIBUS cables is also fed in at the plug side and brought out again on the socket side. The internal 5V bus voltage is brought out on the socket side in order to supply the termination resistor. This voltage must not be used for other purposes, and must not be connected elsewhere through the cables. The screw threads on the round connector are in metallic contact with the module housing, and provide a low-resistance connection for the PE line. Grounding the screening braid on the PROFIBUS cable is therefore effective.

PE connection

The screening braids on the PROFIBUS cables are to be earthed at the modules, in accordance with the PROFIBUS specification. This requirement is satisfied by a low-resistance connection between the PE connection to the ground of the local environment (the machine). The PE connection is also responsible for the potential equalization of grounded and non-grounded thermocouples, and for thermocouples grounded at different potentials (see thermocouple measurement). The back voltage protection diverts mains voltages via the PE connection. This means that it is essential for proper earthing of the module to be guaranteed. When the module is being fitted, the PE connection should be established first. Connection of the module to the thermocouples via the connecting strip should be performed subsequently. In this way the risk of back voltage being present at the thermocouple inputs during assembly is avoided. If the earthing is inadequate the user is exposed to hazardous voltages on the housing. When the module is being dismantled, the module should, for this reason, first be disconnected from the thermocouples before the PE connection is removed.

Connecting strip for thermocouples

The thermocouples are connected to the 24-pin or 64-pin connection strips. The signal assignment and polarity must be correctly observed. Cold junction compensation is implemented on the circuit board within the module. The connection between the module electronics and the connector pins is made with the corresponding thermal material. The use of thermocouples other than those listed in the documentation is not permitted. Good thermal conduction between the module's plug and socket means that no significant thermal voltage is created by the plugged connections. Thermal insulation on the socket side of the connection should be ensured in order to avoid a large temperature error. Draughts and unevenly heated areas in particular are to be avoided.

Configuration interface

Serial interface under the screwed cover

The module has an RS232 interface at the top of the front panel under the PG threaded fitting. The miniature connector can be linked through a special cable to the serial interface of a PC. The module can be configured with the KS2000 configuration software. The interface allows the analog channels to be configured.

Switches for the station address

Two rotary switches are used to set the station address. The rotary switches are located under the screwed cover next to the serial configuration interface. The address is set as decimal number. The right-hand rotary switch is for the units, and the left-hand switch sets the tens. (Example: station address 18: left hand switch = 1, right hand switch = 8). In order for a new station address that has been set to be permanently stored in the module it must be reset (either by a brief interruption of the power supply or by means of a software reset).

Thermocouple measurement

The thermocouples consist of two different metal alloys. Voltages proportional to the temperature arise where the alloys are in contact. In the case of a type K thermocouple these voltages are typically in the range of 50 µV/°C. This means that the inputs for the thermocouples must be capable of measuring voltages in the µV and mV range. In addition to the signal measurement itself, the module performs functions related to error detection, interference suppression and protection from external voltages.

Input circuits

The module can contain up to 32 thermocouple inputs. Electrical isolation between the channels could not be implemented, for reasons of both cost and space. In order to exclude the possibility of mutual interference, every input has a high-impedance differential amplifier. This rejects interfering voltages that can be coupled into the thermocouple circuit. Voltage differences between individual thermocouples are also suppressed without them having any effect on one another. The conditioned measurement signals are digitized with a sigma-delta converter, and are then transmitted over the PROFIBUS.

Broken lead detection

Broken leads are detected as a diagnosis of the state of the thermocouple. The break is recognized through the infinite resistance of the broken thermocouple. Broken leads are detected in both grounded and ungrounded thermocouples.

Cold junction compensation

When a thermocouple is used for temperature measurement, a voltage is thermally generated at the other end of the connection as well as at the location of the measuring junction. On both the 12-pin and the 64-pin contact strips the socket contact at the module is connected to the thermal wire. Other requirements mean that it is not possible to measure directly at the socket contacts (plugging in without contact losses, and ability to withstand mains voltage). There is another cold junction on the plug side, opposite the cold junction on the socket side. Good temperature equalization between the socket and plug contacts, and thermal insulation of the socket and plug contacts, ensure that the thermal voltages on the two sides are equalized. The voltages thus cancel each other out. To achieve this structure, the connection in the module between the plug contact and the circuit board is made with the necessary thermal material in each case (J or K type). The resulting cold junction is then on the circuit board for the module electronics. At this point it is possible to perform a simple yet effective measurement of temperature in order to implement the cold junction compensation.

Back voltage protection

The back voltage protection guards against external voltages applied through the thermocouple inputs. Voltages of up to 230 V_{AC} are tolerated, or are withstood without damage to the module. Those thermocouple inputs that are not affected remain functionally operative, or are only affected for a short time. The module switches measurements from the affected channel off and disconnects the voltage, so that the unwanted voltage can remain connected to the thermocouple input for a long period. If it is possible to manage without that particular thermocouple channel, it is not necessary to rectify the fault immediately.

How the back voltage protection operates

The thermocouple inputs are protected within the module against voltages that are outside the permitted signal range. The permitted range is about –10V...+10V. If voltages outside this range appear, the current is limited by an internal resistance and is diverted to a protective circuit. The current-limiting function of the input circuit protects the thermocouple wires from excessive short-circuit currents, so that they are not destroyed. A protective circuit is responsible for a group of at most eight thermocouple inputs. The central protective circuit detects the excess voltage and switches off all the thermocouple inputs in the group. This process affects the current measurements being taken by the channels in this group, and those measurements will have to be made again. Monitoring and switching groups off means that the channel that is directly affected cannot be identified. The faulty thermocouple input is identified by switching on the channels that have been switched off again one by one. As soon as it is seen that the protective circuit for these thermocouple inputs is triggered again after a channel is switched on, this channel is recognized as faulty, and remains switched off. When all the channels in the group have been tested, and are either operating again or have been switched off because they are faulty channels, it is possible to continue with the normal measuring process. The fault in the channels that have been switched off is checked by switching on again after a configurable time, so that the faulty channels can be automatically brought back into operation.

Start-up procedure and diagnostics

Installation guidelines

The PROFIBUS Nutzerorganisation e.V. technical guidelines must be followed when installing and laying the PROFIBUS lead.
PROFIBUS-DP/FMS assembly guidelines
www.profibus.com

Operating modes

After being switched on, the TC-Plug carries out a self-test, and checks all the functions of its components. If there is a fault, the TC-Plug enters the "STOP" mode, but otherwise goes into the "fieldbus start" state.

Status display LEDs

The module has two groups of LEDs for the display of status. The upper group contains three LEDs and indicates the state of the PROFIBUS, while the lower group indicates the states of the thermocouple inputs.

RUN LED

The “RUN” LED is illuminated cyclically by process data exchange over the fieldbus.

BF LED

The “BF" LED indicates any fieldbus errors.

ERR LED

The “ERR" LED indicates the error code of any fieldbus error.

TC RUN

The “TC RUN” LED is illuminated cyclically by process data exchange.

TC ERR

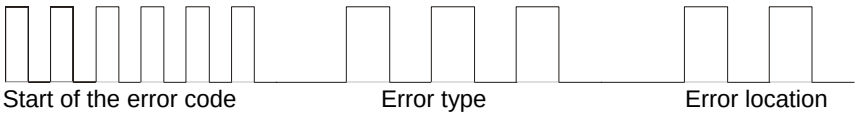
The “TC ERR” LED indicates the error code for the thermocouple inputs.

Local errors

The bottom two LEDs are used to indicate the operating status of the thermocouple inputs. The green LED lights up in order to indicate fault-free operation. The red LED blinks with two different frequencies in order to indicate an error. The error is encoded in the blinks as follows:

Blink code

Fast blinking	Start of the error code
First slow sequence	Error code
Second slow sequence	Error code argument



Error codes for the thermocouple inputs

Error code	Error code argument	Description	Remedy
1 pulse	0	EEPROM checksum error	
1 pulse	1	Inline code buffer overflow	
1 pulse	2	Unknown data type	
2 pulses	-	Programmed configuration	
3 pulses	Faulty channel number. The first faulty channel is indicated.	Back voltage	
4 pulses	Faulty channel number. The first faulty channel is indicated.	Open circuit	

Fieldbus error

The upper three LEDs indicate the operating status of the PROFIBUS. The red ERR LED flashes with two different frequencies in order to indicate an error. The sequence of flashes has the same structure as that for the "TC ERR" LED. The first slow sequence follows the fast flashing, and the second slow sequence follows this. The error is encoded in the blinks as follows:

PROFIBUS error codes

I/O-RUN	BF	DIA	Meaning	Remedy
on	off	off	Operating state: RUN Inputs are read and outputs are set.	Everything is operating correctly
on	on	off, blinking	1. Bus activity, but slave is not yet parameterized 2. Bus error in which the outputs a.) become 0 b.) remain unchanged	- Start master - Check parameters (-> Diagnostics data, DIA-LED) - Check configuration (-> Diagnostics data, DIA-LED)
off	off	off	Terminal bus cycles synchronized DP-watchdog switched off, no exchange of data	PLC is in STOP mode, start PLC
off	on	on	No bus activity	- Start master - Check bus cable
off	on	off, blinking	Bus error, reaction Terminal bus cycles are stopped	- Start master - Check parameters (-> Diagnostics data, DIA-LED) - Check configuration (-> Diagnostics data, DIA-LED)

ERR		Meaning	Remedy
1 pulse	0 n (n>0)	Not enough DP-Cfg data received. Faulty DP-Cfg data byte.	Check DP configuration.
2 pulses	0 n (n>0)	Not enough User-Prm data received. Faulty User-Prm data byte.	Check DP user parameters.

Peripheral data in the process image

One 16 bit value is supplied for each configured channel in the minimal configuration. In addition to this value there is a 32 bit value for open circuit, a 32 bit value for back voltage, and a 16 bit status word.

32 channels can be configured in the maximal configuration.

D0..D31 Temperature in 1/10 degree Celsius (16 bit signed integer per channel)

Open circuit

One bit is reserved for each channel. If the channel is deactivated this bit will always have the value zero. If a channel is activated, this bit will be set to 1 when an open circuit is detected, and this fact is indicated through the channel data by the limit value of the implemented thermocouple:

Limit values of the thermocouples for an open circuit channel

Type J: 900°C
Type K: 1370°C

Back voltage

One bit is reserved for each channel, in a procedure similar to that for open circuit. If excess voltage is detected at a channel, the corresponding bit is set and the limit value of the implemented thermocouple is displayed.

Status word

Each channel has a status word. The error bits in the status word are set when an error is detected, and have the following meaning:

Error message	Bit
OVERRANGE	0
UNDERRANGE	1
CHERROR	6

Underrange, Overrange and Error are all set if there is an open circuit. Depending on whether the thermocouple is grounded or not, the ADC value will go to 0x8000 or 0xFFFF.

I/O configuration

The TC-Plug modules can be configured with a configuration software that supports the integration of the modules via a GSD file. TC-Plug modules are slave modules conforming to PROFIBUS.

Multiplex mode and simple mode

The TC-Plug modules can be operated in two modes. Different GSD files are required, depending on whether the TC-Plug is to be configured in multiplex or simple mode. Multiplex mode enables the quantity of data transferred via the fieldbus to be minimized. In this mode, communication with the TC-Plug occurs via the status/control word, and at the same time the channel data from a maximum of 4 channels are transferred via the fieldbus (see chapter: Protocol for the cyclic transfer in multiplex mode). For most applications, the TC-Plug can be operated in simple mode. In this mode, the channel data from a maximum of 32 channels can be transferred at the same time via the fieldbus. The simple mode is easier to configure and is recommended for most applications.

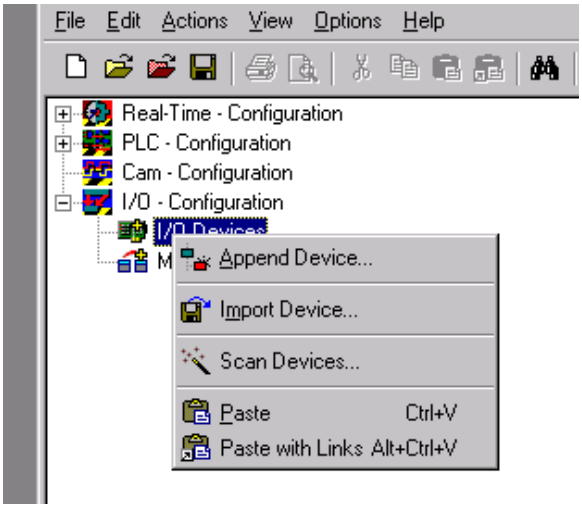
Configuration in the TwinCAT System Manager

This section describes the configuration of the TC-Plug modules with the TwinCAT System Manager. A PROFIBUS master card such as the CP5412A2 from Siemens can be used as the master. The configuration of a TC-Plug module with the CP5412A2 is described below.

Configuring the PROFIBUS master

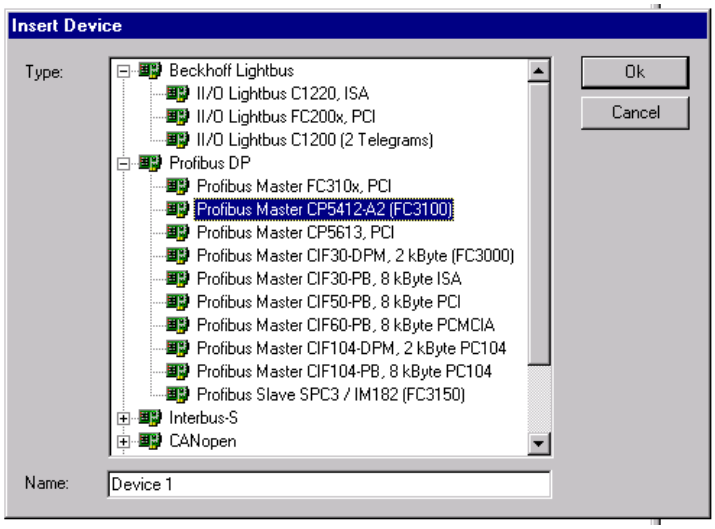
If the right mouse button is clicked on the *I/O Devices* branch in the TwinCAT System Manager, the following context menu appears.

Add a PROFIBUS master



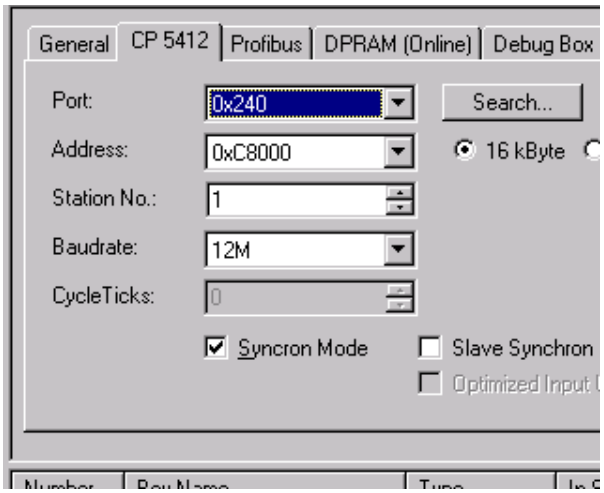
Using the menu command *Append Device…* a PROFIBUS master can be inserted into the configuration. The PROFIBUS master card can be selected in the dialog box which then opens.

Available PROFIBUS master cards



After you have confirmed with OK the master card appears in the branch that shows the configured I/O devices. A mouse click on the CP5412 will open a dialog box on the right with the master's configuration settings

Configuring the master card

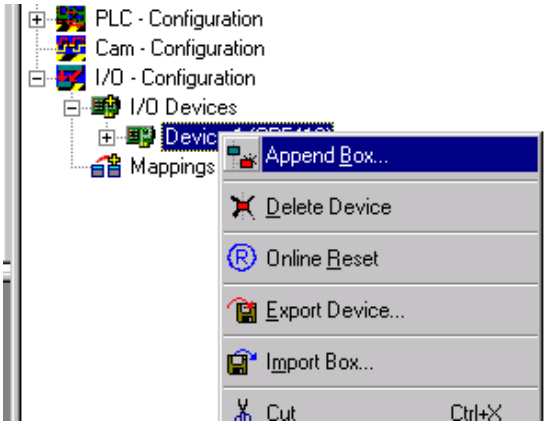


The port number, address range and baud rate must be set on the *CP 5412* tab. Baud rates up to 12 Mbaud are supported by the TC-Plug, and the port number can be found automatically with the *Search..* menu command. The address range should be selected in such a way that no conflict with other hardware is caused.

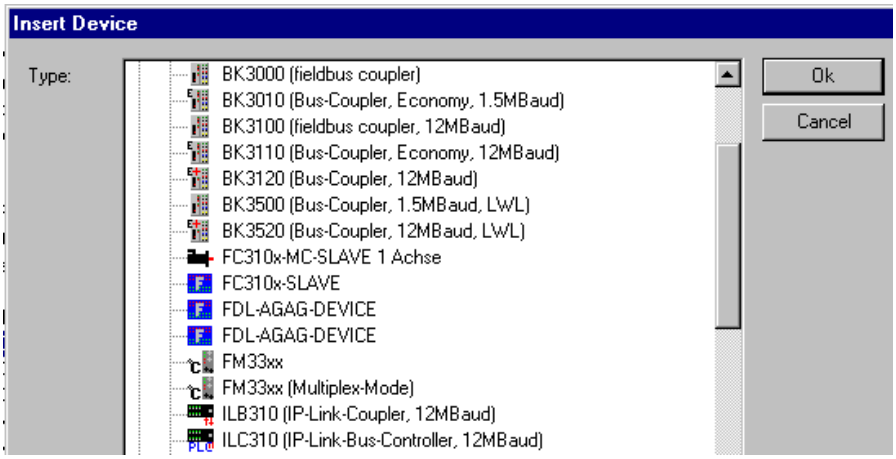
Linking of the TC-Plug

Clicking with the right mouse button on the CP5412A2 master card causes the following context menu to appear in the TwinCAT System Manager:

Adding of the PROFIBUS slaves



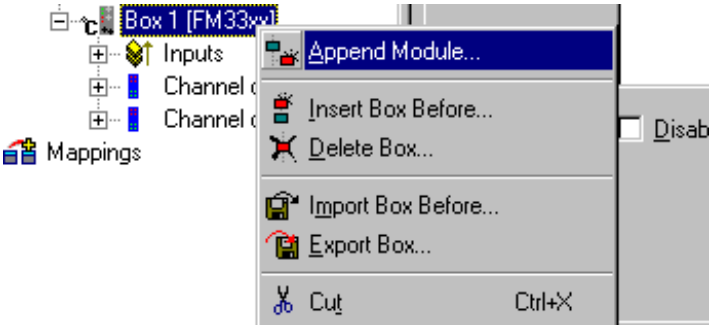
The menu command *Append Box…* opens a dialogue with all the available PROFIBUS slaves.



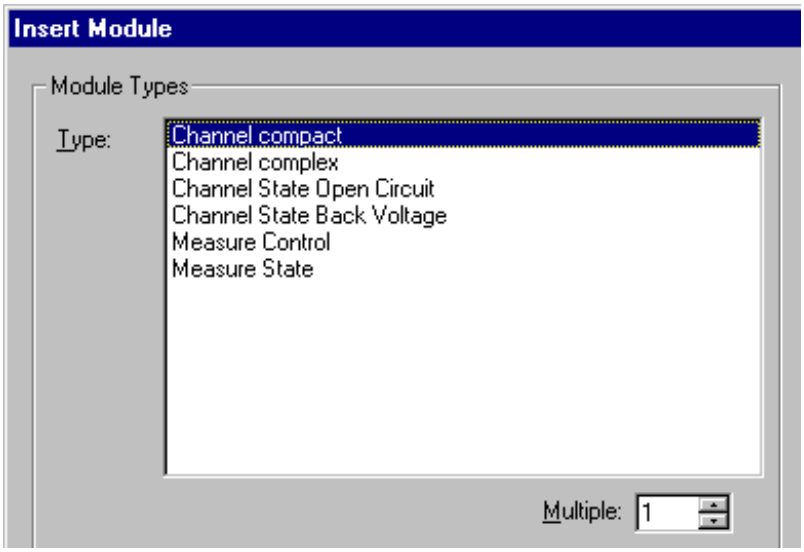
FM33xx or *FM33xx* (*multiplex* mode) is selected from the list, depending on whether the TC-Plug is to be operated in simple or multiplex mode. Select *FM33xx* (simple mode) from the list and confirm with OK. A new box (slave) will be added to the configuration tree.

In the next step, the individual modules are appended. Click with the right mouse button on the FM3xx box and select *Append module...* from the context menu.

add TC-Plug modules



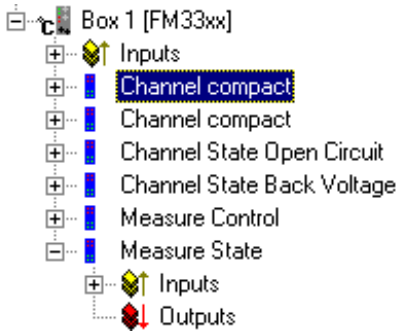
A dialogue with the available modules will appear.



The modules are added in the following order:

- Add *Channel compact.* Repeat n times for n channels;
- Add *Channel State Open Circuit;*
- Add *Channel State Back Voltage;*
- Add *Measure Control;*
- Add *Measure State;*

TC-Plug example configuration in simple mode with 2 channels

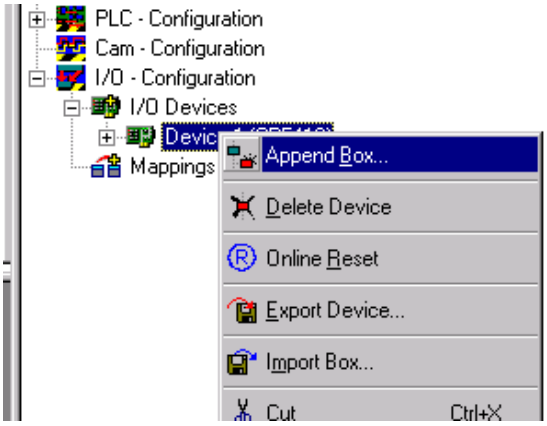


TC-Plug example configuration in multiplex mode

Linking the TC-Plug modules using the GSD file

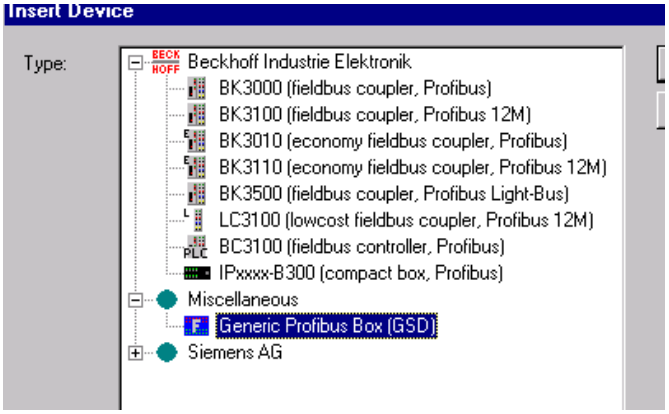
The TC-Plug modules can be linked into the TwinCAT System Manager through a GSD file. A GSD file can configure any PROFIBUS slave in the TwinCAT System Manager. Clicking with the right mouse button on the CP5412A2 master card causes the following context menu to appear in the TwinCAT System Manager:

Adding a TC-Plug module to the I/O configuration



The menu command *Append Box…* opens a dialogue with all the available PROFIBUS modules.

Linking a slave using the GSD file



If the *Generic Profibus Box* is selected, a *File Open* dialog box appears. The corresponding TC-Plug GSD file can be selected in this dialog window. Once you have confirmed with OK, the TwinCAT System Manager reads the device-specific parameters from the GSD file and inserts the TC-Plug into the existing configuration.

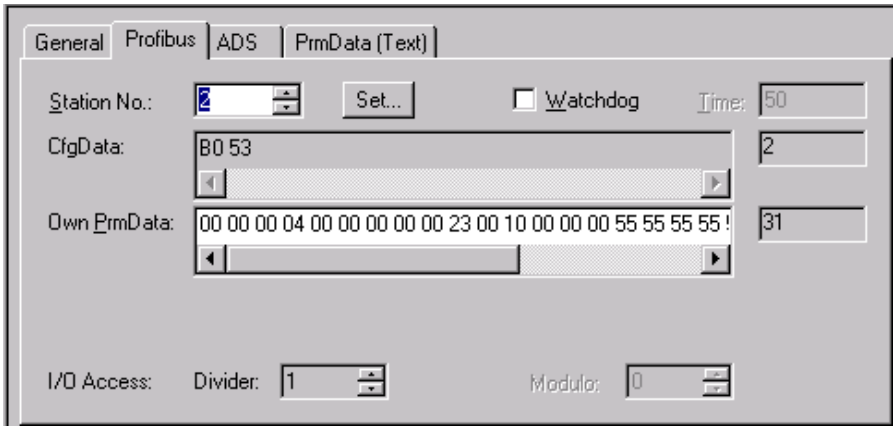
Linking into the Simatic Manager

The following steps are required for linking the TC-Plug into the Simatic Manager in simple mode and for configuring it.

- Install the GSD file in the Simatic Manager, add the module in the hardware configuration and set the PROFIBUS address;
- Data format: MOTOROLA; *Connection Channel 0: Channel connected;* set;
- n times for n channels: Add *Channel compact*, set the required I-addresses for the data;
- Append *Channel State Open Circuit;*
- Append *Channel State Back Voltage;*
- Append *Measure Control;*
- Append *Measure State;*
- Download the configuration into the station;
- Start master;
- Reset TC-Plug by switching it on and off (power is removed);

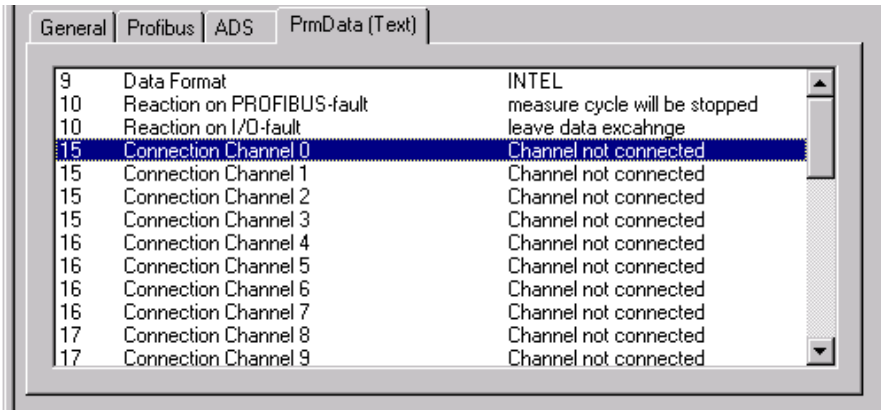
Configuration of the TC-Plug modules

Clicking with the mouse on a TC-Plug module in the I/O configuration tree permits the necessary configuration settings to be made on the tabs:



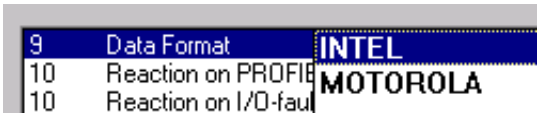
The station number of the TC-Plug module must correspond to the station number physically set with the rotary switches.

The "User Parameter Data" can easily be configured in a dialog box on the *PrmData(Text)* tab.



The dialog box displays the most important TC-Plug PROFIBUS parameter data in textual form, and this can be configured by the user. A double mouse-click on one of the parameters will open a selection menu showing the available parameters.

Data format

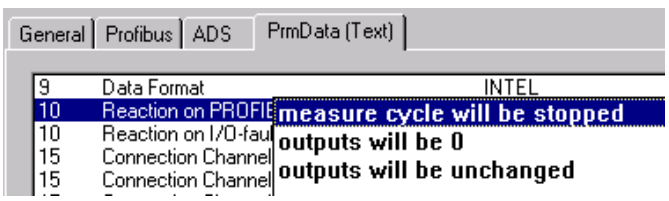


The analog thermocouple inputs can be evaluated either in Intel or in Motorola format.

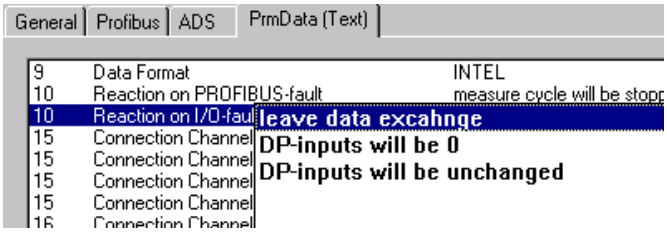
s

The reaction to a fieldbus or I/O error can be configured through associated parameters.

Reaction on PROFIBUS-fault



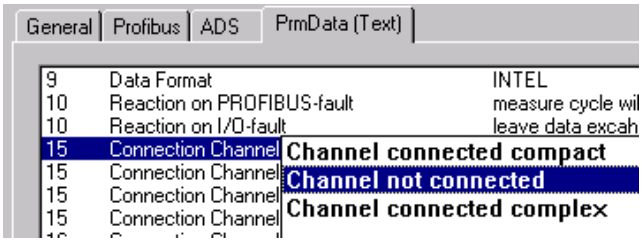
Reaction on I/O-fault



Channel settings for the TC-Plug modules

The number of active analog channels can be configured by means of the channel settings. Only the data of the channels that are associated are transmitted over the fieldbus and can be evaluated. At least one channel must be associated in the minimal configuration. A maximum of 32 channels can be associated through the configuration. If a channel is to be associated, the user can choose between complex or compact mapping of the channel data. Only compact mapping is presently supported. This means that 16 data bits are transmitted over the fieldbus for each channel.

Configuring the channels



At least one channel must be configured in the minimal configuration. This means that a compact association must be configured for at least one channel.

Channel configuration by means of DPV1 services

Channel configuration over the fieldbus

The channels of the TC-Plug module can be activated or deactivated over the fieldbus by means of the DPV1 Services. Once the configuration was changed, the vendor settings can only be set back with the configuration software KS2000. The module holds the new configuration settings after TwinCAT restart and after the Power-Off of the TC-Plug module. You can call the DPV1-Services from the PLC by means of the ADSWRITE function block. The ADSWRITE function block can be found in the PLC library PlcSystem.Lib. The Ads parameters have following values:

If you use CP5412A2 as master:
NETID = NetId of the TwinCAT System;
PORT = Port number from the TC-Plug -> Ads tab in the TwinCAT System Manager;
IDXGRP = 0x0;
IDXOFFS = 0x1;
LEN = 1 until max. 16 Byte configuration data;
SRCADDR =Pointer to the data buffer with the configuration data;

If you use FC310x as Master:
NETID = NetId of the FC310x card in the TwinCAT System Manager;
PORT = 0x1000 + Station number of the TC-Plug module;
IDXGRP = 0x0;
IDXOFFS = 0x1;
LEN = 1 until max. 16 Byte configuration data;
SRCADDR =Address of the data buffer with the configuration data;

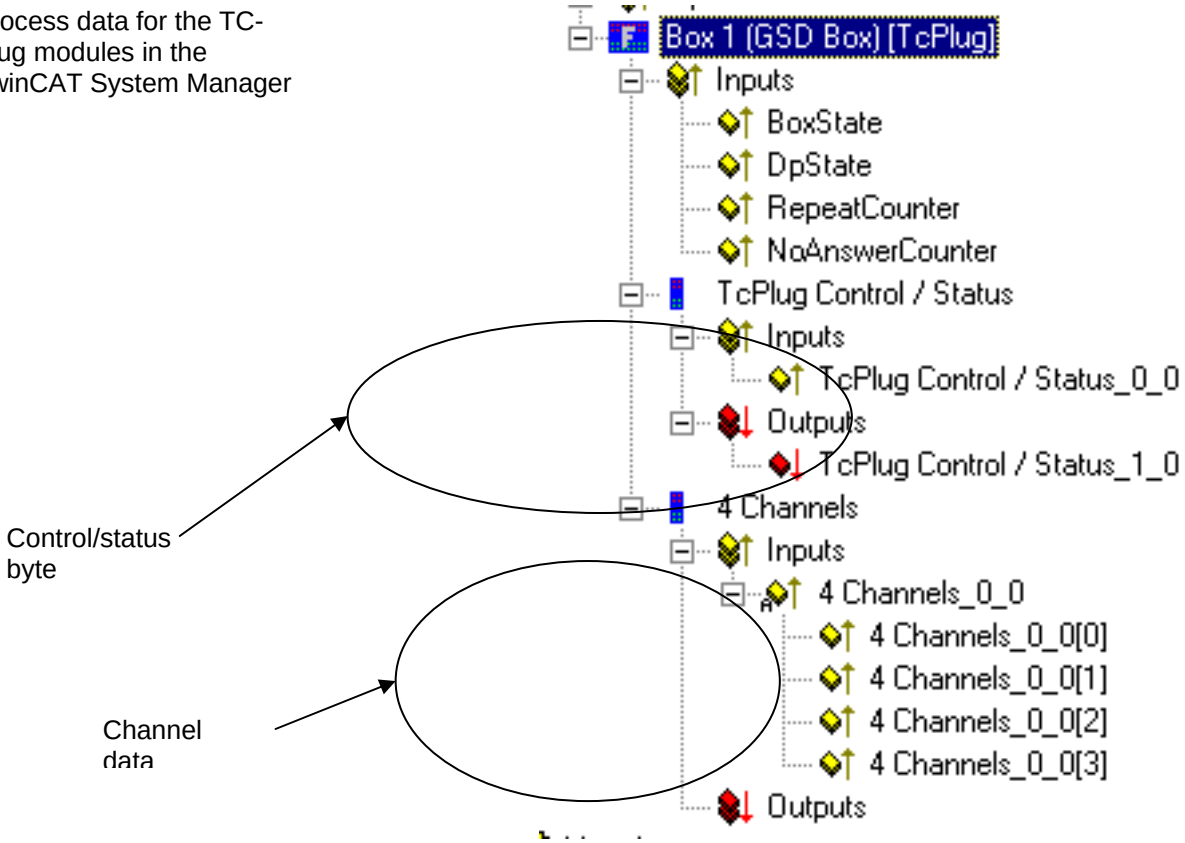
Maximal 4 channels can be switched on or off by the means of one byte in the configuration data. Every channel uses 2 bits of configuration data which tells if its activated or not. The channel is deactivated if one of the two bits is 1 and activated if both bits are zero. The thermo outputs are set to zero during the change of the TC-Plug configuration.

Example:
We want to change the configuration for the first 4 channels of the TC-Plug module. From the PLC we write one byte of configuration data (10000001 binary) to the TC-Plug module. After that the channels 1 and 4 are deactivated and channels 2 and 3 are activated. The configuration of all other channels stays unchanged.
Remark: channel no. 1 is the very first TC channel connected to Pin 1 .

Multiplex mode channel data in the TwinCAT System Manager

The channel data of a TC-Plug module is mapped and displayed as follows in the TwinCAT System Manager, independently of the number of channels that are configured (associated):

Process data for the TC-Plug modules in the TwinCAT System Manager



Control/status byte and channel data for the 4 thermocouple inputs

In order to reduce the quantity of data that has to be transferred over the fieldbus, the thermocouple input data for a maximum of 4 channels only (e.g. for channels 0 to 3) is transferred over the fieldbus in any one fieldbus cycle. The control/status byte can be used to request the analog values of another 4 channels (e.g. for channels 4 to 7, 8 to 11 etc.).

Protocol for the cyclical data transfer in multiplex mode

The following protocol has been specified for communication with the TC-Plug module in order to reduce the quantity of data transferred over the fieldbus.

Appropriate *channel selection request bits* are set by the PLC in the control byte. The *channel selection request bits* select the 4 channels that are to be transferred. The TC-Plug copies the corresponding data in the input bytes [1-8] and confirms it in the *channel confirmation bits* of the status byte. If the control byte == status byte, then the data is valid.

Control byte	Value	Description
Channel Selection Request Bits 0-3	**0**	no channel selected
	1	Channel 0-3 in Input Data [1..8]
	2	Channel 4-7 in Input Data [1..8]
	3	Channel 8-11 in Input Data [1..8]
	4	Channel 12-15 in Input Data [1..8]
	5	Channel 16-19 in Input Data [1..8]
	6	Channel 20-23 in Input Data [1..8]
	7	Channel 24-27 in Input Data [1..8]
	8	Channel 28-31 in Input Data [1..8]
	9	Status (Open circuit Channel 0-31 in Input Data [1..4] and Back Voltage in Input Data [5..8])
Bit 4-6	**-**	Reserved for future use
Bit 7	**1/0**	Toggle-Bit Measure Control

Status byte	Value	Description
Channel Selection Confirmation Bits 0-3	**0**	no channel selected
	1	Channel 0-3 in Input Data [1..8]
	2	Channel 4-7 in Input Data [1..8]
	3	Channel 8-11 in Input Data [1..8]
	4	Channel 12-15 in Input Data [1..8]
	5	Channel 16-19 in Input Data [1..8]
	6	Channel 20-23 in Input Data [1..8]
	7	Channel 24-27 in Input Data [1..8]
	8	Channel 28-31 in Input Data [1..8]
	9	Status (Open circuit Channel 0-31 in Input Data [1..4] and Back Voltage in Input Data [5..8])
Bit 4-6	**-**	Reserved for future use
Bit 7	**1/0**	Toggle-Bit Measure Status

The AD conversion of the thermocouple input data in the TC-Plug module can be initiated by the PLC by toggling bit 7 in the control byte. After the bit has been toggled, the status and control bytes have different values in bit 7. When the measuring cycle in the TC-Plug module has been completed the TC-Plug will also toggle bit 7 in the status byte. The toggled bits in the status and control bytes then have the same value.

By setting the appropriate *channel selection request bits* the PLC can then request the current thermocouple input data. Every request in the control byte is appropriately acknowledged in the status byte by the TC-Plug.

During a conversion procedure the TC-Plug converts all its active configured channels. Once completed, the PLC can request the channel data over a number of cycles.

The *open circuit* and *back voltage* status information is also requested in a similar manner by means of the *channel selection control bits*. When these have been confirmed in the status byte the status information can be read from the data for the 4 channels. For each channel that is registering open circuit, one bit is set in bytes 1 to 4, while bits are set in bytes 5 to 8 for channels registering back voltage.

Register description

The TC-Plug can be configured via the serial interface using the KS2000 configuration software. The individual thermocouple input channels are represented in the configuration software as complex terminals.

Each logical thermocouple input channel has its own set of registers. Various operating modes and functionalities can be set for each channel by means of the registers.

The "General Description of Registers" explains those register contents that are the same for all complex terminals.

The terminal-specific registers are explained in the following section.

The registers for a channel can be written to if the code word 0x1235 is entered in R31 (register 31). The data is only permanently stored when the code word is cleared and the module is reset.

General description of registers

Complex terminals that possess a processor are able to exchange data bi-directionally with the higher-level controller. These terminals are referred to below as intelligent Bus Terminals. These include the analog inputs (0-10 V, -10-10 V, 0-20 mA, 4-20 mA), the analog outputs (0-10 V, -10-10 V, 0-20 mA, 4-20 mA), the serial interface terminals (RS485, RS232, TTY, data exchange terminals), counter terminals, encoder interface and SSI interface terminals, PWM terminals and all the terminals that can be parameterized.

The main features of the internal data structure are the same for all the intelligent terminals. This data area is organized as words and includes 64 memory locations. The important data and parameters of the terminal can be read and set through this structure. It is also possible for functions to be called by means of corresponding parameters. Each logical channel in an intelligent terminal has such a structure (so a 4-channel analog terminal has 4 sets of registers).

The structure of a register set is divided into the following areas:

Range	Address
Process variables	0-7
Type register	8-15
Manufacturer parameters	16-30
User parameters	31-47
Extended user region	48-63

Process variables

R0-R7 Registers in the terminal's internal RAM:
The process variables can be used in addition to the actual process image. Their function is specific to the terminal.

R0-R5: The function of these registers depends on the type of terminal.

R6: Diagnostic register
The diagnostic register can contain additional diagnostic information. Parity errors, for instance, that occur in a serial interface during data transmission are indicated here.

R7: Command register
High-Byte_Write = function parameter
Low-Byte_Write = function number
High-Byte_Read = function result
Low-Byte_Read = function number

Type register

R8-R15 Registers in the terminal's internal ROM:
The type and system parameters are hard programmed by the manufacturer, and the user can read them but cannot change them.

R8: Terminal type:
The terminal type in register R8 is needed to identify the terminal.

R9: Software version X.y
The software version can be read as a string of ASCII characters.

R10: Data length
R10 contains the number of multiplexed shift registers and their length in bits.
The Bus Coupler sees this structure.

R11: Signal channels
Related to R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length
The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control/status byte is not absolutely necessary for the terminal's function, and if the coupler is appropriately configured it is not transferred to the controller.

R13: Data type register

Data type register	
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure 1 byte n bytes
0x03	Word array
0x04	Structure 1 byte n words
0x05	Double word array
0x06	Structure 1 byte n double words
0x07	Structure 1 byte 1 double word
0x08	Structure 1 byte 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure 1 byte n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure 1 byte n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure 1 byte n double words with variable logical channel length

R14: reserved

R15: Alignment bits (RAM)
The analog terminal is placed on a byte boundary in the terminal bus with the alignment bits.

Manufacturer parameters

R16-R30 is the region for the "manufacturer parameters" (SEEROM)
The manufacturer parameters are specific for each type of terminal. They are programmed by the manufacturer, but can also be modified by the controller. The manufacturer parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out.
These registers can only be altered after the code word has been set in R31.

User parameters

R31-R47 is the "application parameters" region (SEEROM)
The application parameters are specific for each type of terminal. They can be modified by the programmer. The application parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out. The application region is write-protected by a code word.

Note

R31: Code word register in RAM
The code word **0x1235** must be entered here so that parameters in the user area can be modified. If any other value is entered into this register, the write-protection is active. When write protection is not active, the code word is returned when the register is read. If the write protection is active, the register contains a zero value.

R32: Feature register
This register specifies the terminal's operating modes. Thus, for instance, a user-specific scaling can be activated for the analog I/Os.

R33 - R47
Registers that depend on the terminal type

Extended application region

R47 - R63
Extended registers with additional functions.

TC-Plug - channel-specific register description

Process variables

R0: Unprocessed ADC value X_R
This register contains the unprocessed ADC value.

R1: Unprocessed ADC value for the cold junction compensation

R2: Temperature of the cold junction compensation
Unit: 1/10 degree Celsius, 16-bit signed int

R6: Diagnostic register
High byte: reserved
Low byte: status byte

R7: Command register

Commands:
0x0101
Offset adjustment with short-circuited input. An automatic offset adjustment is carried out. At the same time the unprocessed ADC value with which the cold junction compensation was carried out is kept in R23. The corresponding inputs are to be short-circuited.

0x0102
Gain adjustment at 30 mV. An automatic gain adjustment is carried out on the assumption that 30 mV is present at the corresponding input.

0x0103
Adjustment for temperature drift with short-circuited input. An offset adjustment should be carried out at room temperature. This function is called in order to take account of temperature drift. The comparison temperature is entered into R24, and the corresponding coefficient into R22.

R17: Calibration offset

In order to carry out a calibration, a zero is entered into R32 and R17, and a comparison with 0 V is made. The process data value (in microvolts) is multiplied by -1.9074, and entered into R17.

R18: Calibration gain
Value: [4096]

R19: Manufacturer scaling offset
Value: [0x0000]

R20: Manufacturer scaling gain
Fixed point number /256, so that 1 corresponds to a value of 256

R21: Cold junction compensation adjustment
Unit: 1/10 degree Celsius, 16-bit signed int

There are 8 cold junction compensations, and these are distributed as follows. The cold junction compensation is purely an offset adjustment.

Comp[0] Channel0 R21
Comp[1] Channel4 R21
Comp[2] Channel8 R21
Comp[3] Channel12 R21
Comp[4] Channel16 R21
Comp[5] Channel20 R21
Comp[6] Channel24 R21
Comp[7] Channel28 R21

The cold junction compensation for a channel is calculated as follows:

Cold junction compensation =
(((~channel) & 0x7) * U_compensation [(channel>>3)<<1]+(channel & 0x7) *U_compensation[((channel>>3)<<1)+1])/7;

e.g., for channel 20:
4/7*U_compensation[5]+3/7*U_compensation[4]

R26: Number of hardware channels valid
12 with the number of channels 0 - 12

the hardware is different => the two outer boards are inserted
all values != 12 result in a standard version

R32: Feature register

R32.0 **1** User scaling active
0 User scaling inactive

R32.1 **1** Manufacturer scaling active
0 Manufacturer scaling inactive

R32.2 **1** Cold junction compensation is active
0 Cold junction compensation is inactive

R32.7...R32.4 **0x0000** Output in 2 microvolts / digit
R32.7...R32.4 **0x0001** Type K active
R32.7...R32.4 **0x0010** Type J active
R32.7...R32.4 **0x1110** Output the unprocessed ADC value in the process data. Default output in 2 microvolts / digit.

R33: User scaling offset

R34: User scaling gain
Fixed point number /256,
so that 1 corresponds to a value of 256.

R37: Filter register

with the following possible entries:

The changes can only be made by way of the first channel, and are adopted after a reset.

Entry – Conversion time – Suppression

0x0C	191 ms with 4.9 MHz	50 Hz filter
0x0D	160 ms with 4.9 MHz	60 Hz filter
0x0E	46 ms with 4.9 MHz	250 Hz filter
0x0F	30 ms with 4.9 MHz	500 Hz filter

R38: Back voltage reset time

Unit is seconds. Minimum value is 10 seconds. If an error occurs, another attempt is made to activate the channel after the specified interval. Measurement is then not carried out for one cycle.

Register table

Register set

Address	Description	Default value	R/W	Memory medium
R0	Unprocessed ADC value	Variable	R	RAM
R1	Unprocessed ADC value for the cold junction compensation	Variable	R	
R2	Temperature of the cold junction compensation Unit: 1/10 degree Celsius, 16-bit signed int	0x0000	R	
R3	reserved	0x0000	R	
R4	reserved	0x0000	R	
R5	reserved	0x0000	R	
R6	Diagnostic register	Variable	R	RAM
R7	Command register	Variable	R	
R8	reserved	0x0000	R	ROM
R9	reserved	0x0000	R	ROM
R10	reserved	0x0000	R	ROM
R11	reserved	0x0000	R	ROM
R12	reserved	0x0000	R	ROM
R13	reserved	0x0000	R	ROM
R14	reserved	0x0000	R	
R15	reserved	0x0000	R/W	RAM
R16	reserved	0x0000	R/W	SEEROM
R17	Calibration offset	0x0000	R/W	SEEROM
R18	Calibration gain	app. 0x1ED8	R/W	SEEROM
R19	Manufacturer scaling offset	[0x0000]	R/W	SEEROM
R20	Manufacturer scaling gain	[0x0100]	R/W	SEEROM
R21	Cold junction compensation adjustment	Specific	R/W	SEEROM
R22	reserved	0x0000	R/W	SEEROM
R23	reserved	0x0000	R/W	SEEROM
R24	reserved	0x0000	R/W	SEEROM
R25	reserved	0x0000	R/W	SEEROM
R26	Number of hardware channels valid	Specific	R/W	SEEROM
R27	reserved	0x0000	R/W	SEEROM
R28	reserved	0x0000	R/W	SEEROM
R29	reserved	0x0000	R/W	SEEROM
R30	reserved	0x0000	R/W	SEEROM
R31	Code word	Variable	R/W	RAM
R32	Feature register	Variable	R/W	SEEROM
R33	User scaling offset	[0x0000]	R/W	SEEROM
R34	User scaling gain	[0x0100]	R/W	SEEROM
R35	reserved	0x0000	R/W	SEEROM
R36	reserved	0x0000	R/W	SEEROM
R37	Filter register	0x000D	R/W	SEEROM
R38	Back voltage reset time	0x000A	R/W	SEEROM

Appendix

Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!
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