TECOMAT FOXTROT

PROGRAMMABLE CONTROLLERS

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CONTENT

1. INTRODUCTION TO THE TECOMAT FOXTROT PROGRAMMABLE LOGIC CONTROLLERS

1.1 INTRODUCTION

What is a programmable logic controller?

A programmable logic controller (thereinafter PLC) is a digital control electronic system designed for control of industrial machines and processes within industrial environment. Through digital or analog inputs and outputs the PLC receives and sends information from/into the unit being controlled. Control algorithms are saved in the memory of the user program that is executed cyclically.

Principles of user program execution

The control algorithm of the PLC is written in as a sequence of instructions in the user program memory. The central unit reads stepwise the individual instructions from this memory, executes corresponding data operations in the notepad memory and in the stack or eventually executes transitions in the sequence of instructions providing the instruction belongs to the group of organizational instructions. After all instructions of the required algorithm are executed, the central unit updates output variables into output peripheral modules and updates the states from input peripheral modules into the notepad memory. This process repeat itself continuously and it is called "program cycle" (Fig. 1.1, 1.2).

Unrepeated updates of the states of input variables within the whole program cycle avoid the possibility of occurance of hazardous states within the control algorithm while being solved (during the computation input variables cannot be changed).
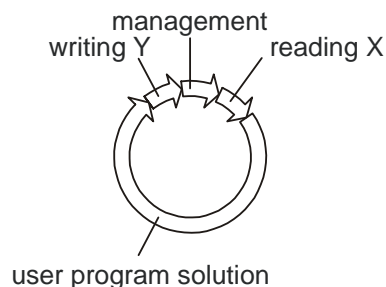
Fig.1.1   Cycle of the user program solution
Read X - transcription of values from PLC input modules into the X area in the notepad memory
Write Y - transcription of values computed by the program from the Y area into PLC output modules
Management - preparation of the PLC central unit for the next cycle program solution
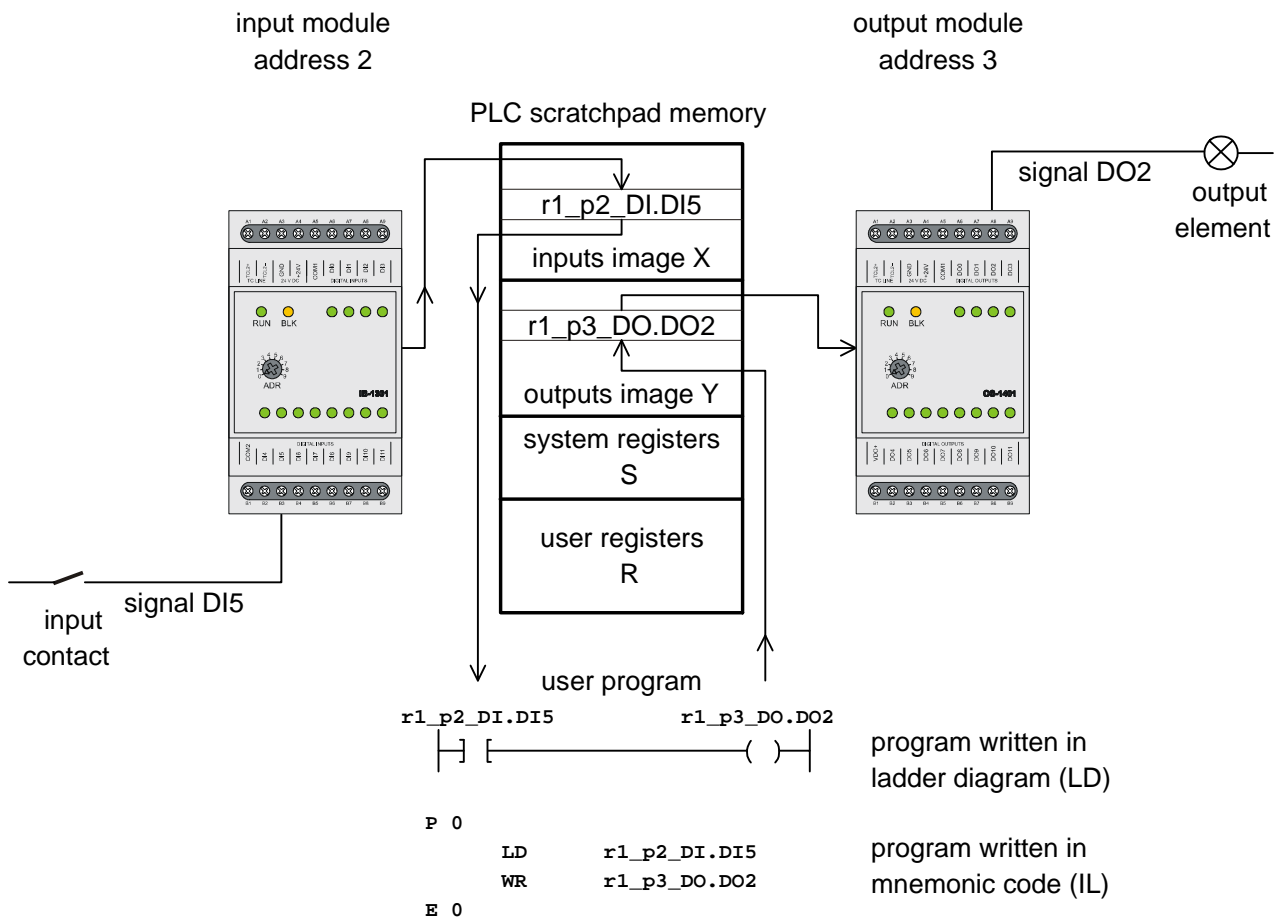
Fig.1.2   Signal processing scheme of the PLC
(symbolical signal names are automatically generated in the Mosaic
environment and the user has the opportunity to change them)

1.2   TECOMAT FOXTROT SYSTEM FEATURES

The TECOMAT FOXTROT PLCs are small and compact automatic controllers with a number of modular enhancements. They unify the advantages of compact automatic controllers in size and the advantages of modules in expandability and variability.

They are intended for technology control within various industry fields and other branches. Individual system modules are sealed in plastic protective cases which are installed onto the ČSN EN 50022 "U" bar. Due to this, it is possible to manipulate with devices without the threat of damage to the CMOS parts.

Communication

Data communication among PLCs and superior PCs, among several PLCs or among PLCs and other devices are usually realized via serial transmissions. The FOXTROT systems support basic transmissions via the Ethernet network or the EPSNET industrial network.

One asynchronous serial channel is fitted with a RS-232 interface, the second one is optionally fitted with various types of physical interfaces according to customer's specifications (RS-232, RS-485, and RS-422). When using the RS-485 interface, there can be up to 32 participants on one level of the EPSNET network with the serial line length of up to 1200 m. Optionally, other industrial protocols and buses can be supported, such as MODBUS, PROFIBUS DP, CAN, etc. Eventually, asynchronous communication

through universal transmission channels controlled directly from the user program is possible, too.

All central units are standardly equipped with a 10/100Mb Ethernet interface allowing operation of more logic connections at a time.

Creating an extensive system

Peripheral expanding modules are connected to the central unit via serial bus. Due to this individual parts of the TECOMAT FOXTROT system can be distributed so, that individual modules are placed right by the technologies in operation and thus save the power cabling.

Connection with PC

The entire system can communicate with computers of the PC standard. The computer can be thus used for monitoring of the controlled process although, it is located outside the industrial environment in a central control desk or a control centre. The computer also serves as the programming tool for PLC.

Besides the TECOMAT FOXTROT PLC series, computers of the PC standard can join the communication (via a serial interface adapter) as well as other units which fulfill EPSNET requirements (another PLC TECOMAT, operator panels, etc.).

Distributed control systems

Based on these facts, extensive systems of distributed or hierarchic control can be created. However, these systems can be also created by "sequential bottom-up steps" which means that the originally autonomous systems are gradually connected and completed with the upper level of control or with central monitoring and data collection only. Systems developed in this way usually have longer durability than the ones created in "one top-down step ".

The advantage of these distributed systems is in particular the possibility of autonomous control even during the centre failure, gradual initiation of the whole system, easier debugging, additions, cost savings and labour-saving during the installation (e.g. cabling, control boards).

Programming device

A PC can be used as a programming device. The computer configuration must be selected according to the software features (Mosaic, Reliance, ...).

The TECOMAT FOXTROT offers a number of useful system services that makes the programming more simple and user-friendly. An example can be a wide range of time data, current date and time displayed or system support of the states handling while switching on the PLC power supply.

1.3   TECOMAT FOXTROT SET

The smallest fully functional assembly PLC FOXTROT is formed by a central module containing the central unit and various combinations of number and types of inputs and outputs and in some versions also the inbuilt display 4 x 20 characters and 6 push-buttons (table 2.1). The basic module can be expanded by connecting of up to ten peripheral modules (table 3.1.).

Individual modules are connected to the basic module via the TCL2 bus. The bus interconnected via metallic cables agrees with the RS-485 interface and must be closed on

both ends. The basic module contains the bus termination and **must** always be placed at its end. The bus must be on its other end connected to the last module along with the termination unit KB-0290 (one piece is included with the basic module).
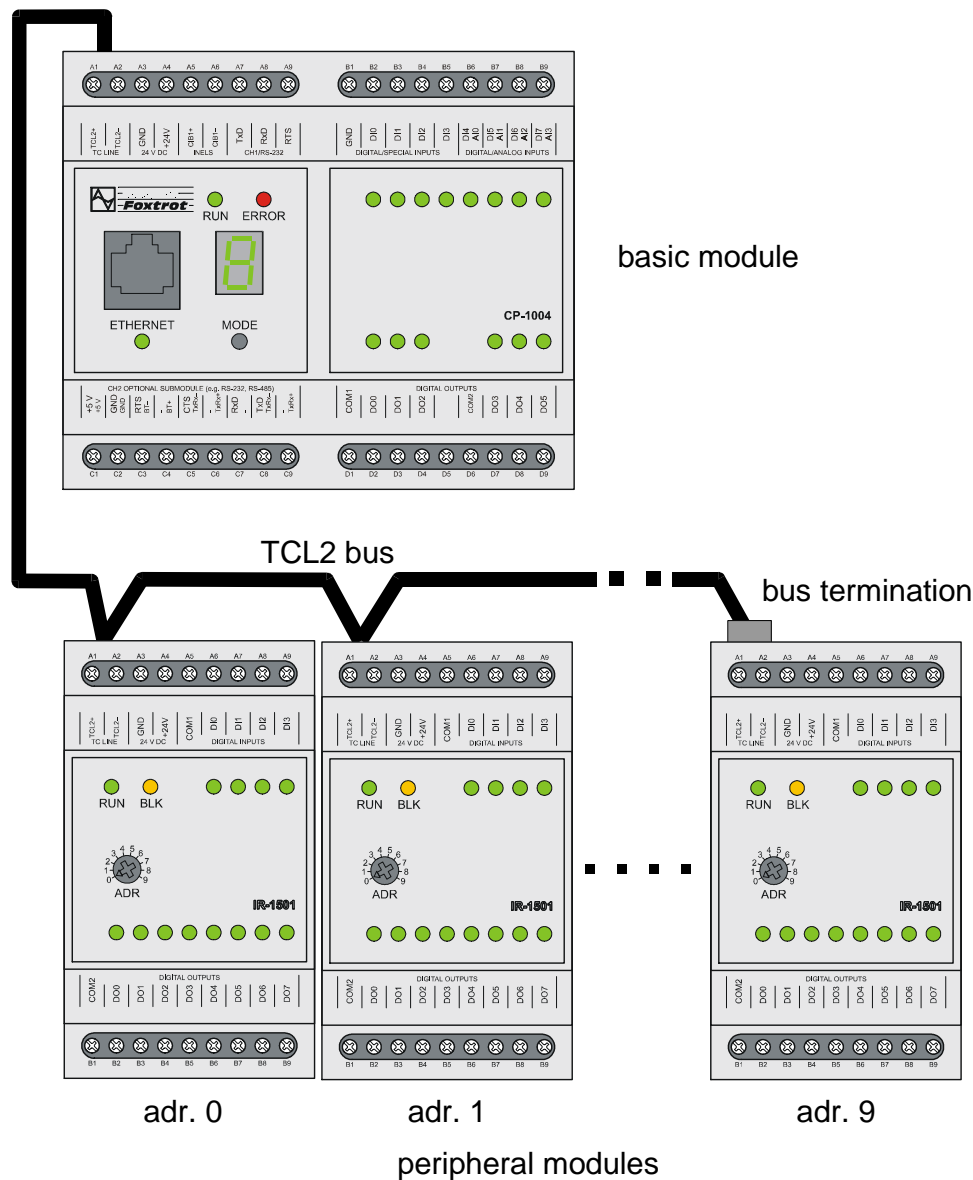
Fig.1.3   PLC TECOMAT FOXTROT set

1.4   BASIC PLC PARAMETERS

TECOMAT FOXTROT PLCs are designed to be fitted into cases and racks. The basic parameters of the PLCs can be seen in tables 1.1 to 1.5. Detailed parameters of each module are stated in the relevant chapters.

All FOXTROT PLC modules are equipped with a plastic cover and a holder for the installation on U-rail. Dimensions of a basic module are shown on Fig. 1.4. Peripheral modules has the same shape, their width is half size only.

The width of each module is a multiple of 17.5 mm marked as M. This value corresponds with the size of circuit breakers and other electrical installation elements mounted on U-rail. Then, the size of basic modules is equal to 6M and the peripheral modules to 3M.
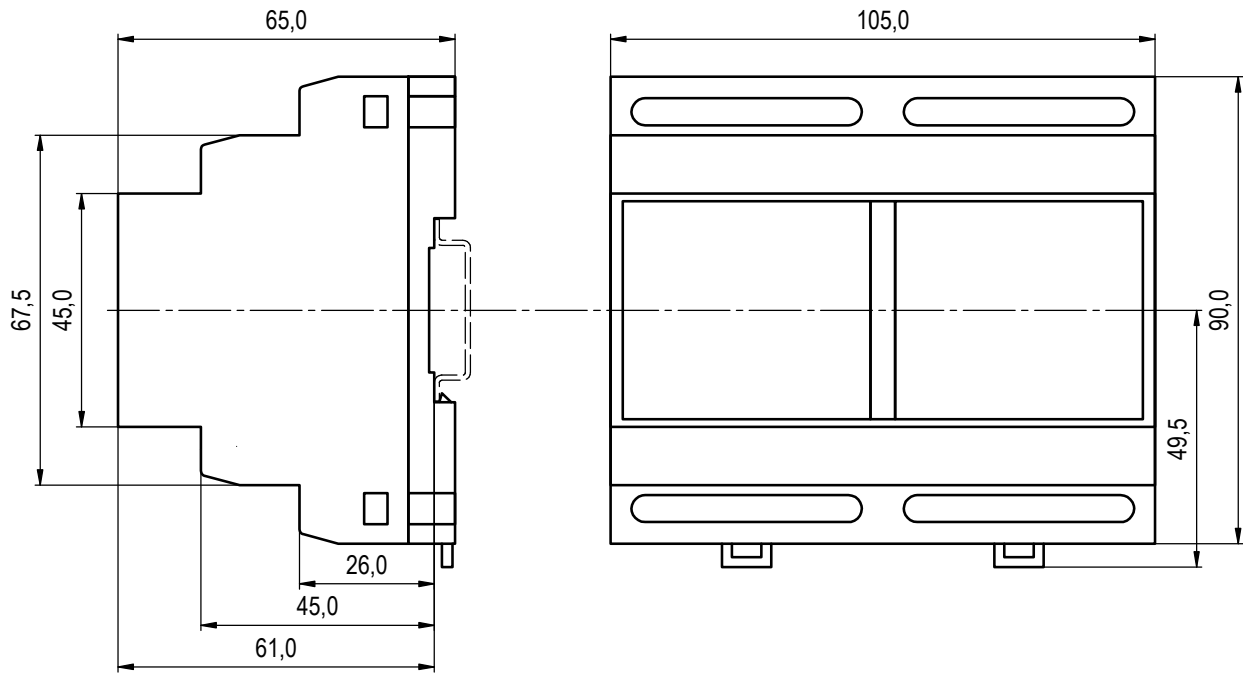
Fig..1.4   Basic module dimensions

Table1.1 Basic parameters

Product standard	ČSN EN 61131-2:2005 (idt IEC 61131-2:2003)
Electrical item protection class (ČSN EN 61131-2:2005, idt IEC 61131-2:2003)	I
Equipment type	built-in
Coverage level (ČSN EN 60529:1993, idt IEC 529:1989)	IP10B
Service life	10 years

Table 1.2 Operational conditions

Class of environment influence – ČSN 33 2000-3	Normal
Operating temperatures range	0 °C to + 55 °C
Permitted temperatures during transport	-25 °C to + 70 °C
Relative humidity	10 % to 95 % w/o condensation
Atmospheric pressure	min. 70 kPa (< 3000 m above sea level)
Degree of pollution - ČSN EN 61131-2	2
Over voltage category of installation - ČSN 33 0420-1	II
Working position	vertical
Type of operation	continuous
Vibration resistance (sinusoidal vibrations)	10 Hz to 57 Hz amplitude 0,075 mm,
Fc according to ČSN EN 60068-2-6	57 Hz to 150 Hz acceleration 1G
Electromagnetic compatibility:	
Emissions - ČSN EN 55022	class B
Immunity	table 16, ČSN EN 61131-2

Table 1.3 Storage conditions

Storage environment	dry, clean rooms without conducting dust, aggressive gases or acid vapours for the period not exceeding the guarantee period
Storage temperatures	–25 °C to +70 °C without temperature shocks
Relative humidity	max. 80% without vapour condensation

Table 1.4 Transport conditions

Transport environment	Sheltered transport mean, transport case must avoid rain and snow effects
Transport temperatures	–25°C to +70°C

Table1.5 System specification

User program execution
• Cyclic, multi-loop control with the possibility of interruption from time and error messages
User program memory
• CMOS RAM, EEPROM
Basic PLC modes
• RUN - user program execution
• HALT – termination of the user program execution, PLC programming
• Possibility to change the mode by the command through the serial channel
Output locking
• By a command through the serial channel
• Automatically after a fatal system error
Hardware diagnostics
• Processor check (watchdog)
• Power failure check, data protection during power failure
• Serial communication protection safeguard
• Data transmission via I/O bus safeguard
Software diagnostics
• User program validation check
• User program cycle time watch
• Continuous check of user program correctness (non-existing jump target, memory structure overflow, division by zero, unknown instruction, etc.)
Communication
• Serial through EPSNET, MODBUS, PROFIBUS DP, CAN
• General serial asynchronous
• Interfaces Ethernet UDP/TCP/IP, RS-232, RS-485, RS-422
Other functions
• Automatic recognition of peripheral unit configuration
• EEPROM programming for purposes of the user program backup
• Communication support of data monitoring by superior system
• Possibility of the user program execution without peripheral modules activation
• Additional memory for data archiving DataBox
• RTC circuit
• PLC variables analyzer support
• Possibility of fixation of peripheral module inputs and outputs
• Possibility to change the program during operation (on-line)
• Project archivation in PLC memory
• MMC / SD card with FAT12/FAT16/FAT32 file system
• Integrated web server

2. PLC FOXTROT BASIC MODULES

All basic modules of the FOXTROT system consist of several parts. The first part constitutes of the central unit with the main system processor, two serial channels, Ethernet interface and TCL2 system bus for communication with peripheral modules.

The second part is composed of the processor ensuring the communication within the CIB bus. It is presented under the name MI2-01 on the system bus.

The third part is peripheral and consists of the IR-1057 board (CP-1004, CP-1014) or IR-1056 board (CP-1005, CP-1015). Under this name the processor operating inputs and outputs is presented on the system bus (an older type of IR-1057 is named IR-1055).

Basic modules CP-1014 and CP-1015 contain yet another forth part which is the display and push-buttons. The processor that operates this part is presented on the system bus under the name OI-1073.

Table 2.1 shows an overview of basic FOXTROT PLC modules including their configuration. Table 2.2 shows the basic parameters connected with power supply and dimensions.

Table 2.1 Basic module options of the FOXTROT system

Type	Description	Order number
CP-1004	K series central unit 4 binary inputs 24 V useable as counter inputs 4 optional inputs - binary 24 V / analog 0-10 V (10 bits) 6 relay inputs 250 V 2 serial channels (CH1 - RS-232, CH2 - optional) 1 Ethernet 10/100 Mb interface 1 TCL2 bus line for connecting peripheral units 1 CIB / bus line possibility of fitting the submodule with binary inputs and outputs	TXN 110 04
CP-1005	K series central unit 6 optional inputs - binary 24 V / analog (unipolar voltage and current ranges, passive resistant sensors, 16 bits) 2 analog inputs 0-10 V (10 bits) 6 relay inputs 250 V 2 serial channels (CH1 - RS-232, CH2 - optional) 1 Ethernet 10/100 Mb interface 1 TCL2 bus line for connecting peripheral units 1 CIB / bus line possibility of fitting the submodule with binary inputs and outputs	TXN 110 05
CP-1014	configuration similar to CP-1004 LCD display 4 x 20 characters, 6 user push-buttons	TXN 110 14
CP-1015	configuration similar to CP-1005 LCD display 4 x 20 characters, 6 user push-buttons	TXN 110 15

While creating a new project within the Mosaic development environment, we will be asked to choose the system which we will be programming. The part of the system

selection is also a selection of the basic module. This setting is located in the Project manager in the node *Hw | PLC series selection* and can be changed anytime (fig.2.1).
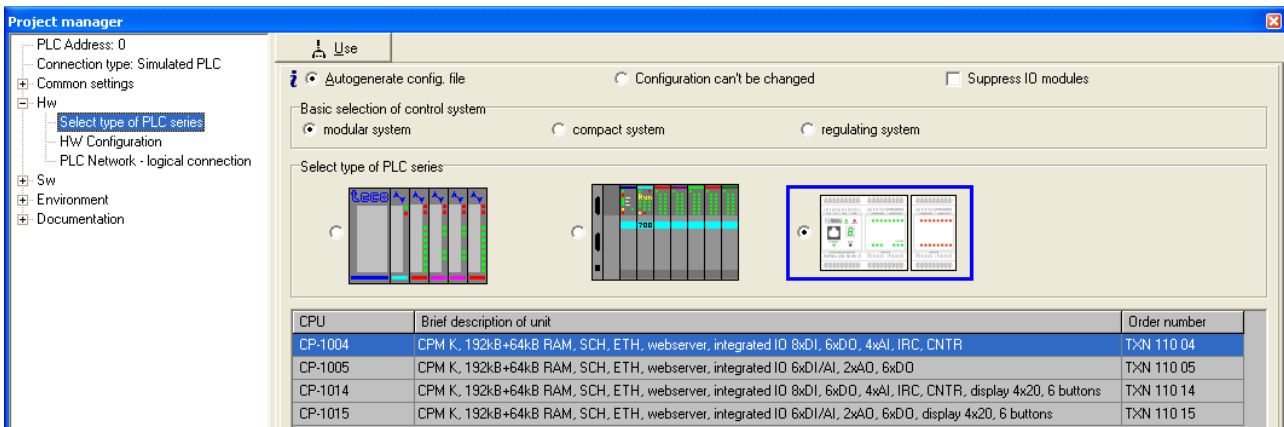
Fig.2.1   PLC series selection

Table 2.2 Basic parameters of basic modules

Type of the central unit	CP-1004	CP-1014	CP-1005	CP-1015
Power supply voltage (SELV)	24 VDC, +25%, −15%			
Internal protection	none			
Maximum input	8 W			
Connection	screw fixed terminals, max.2,5 mm^2 of the conductor on the terminal, connector RJ-45 (Ethernet)			
Galvanic separation of the power supply from internal circuits	none*			
Input number	8		6	
from which binary optional / for counters	4		-	
from which binary optional / analog	4		6	
Output relay number	6		6	
Analog output number	-		2	
User LCD display (character number)	-	4 x 20	-	4 x 20
Number of user push-buttons	-	6	-	6
The number of additional binary inputs/outputs	7 / 0 (PX-7811)			
optional on the submodule channel CH2	4 / 3 (PX-7812)			
Module dimensions	106 × 95 × 65 mm			

*   Galvanically separated are only relay outputs and serial channel CH2 depending on the submodule used realizing the interface

All basic modules are supplied by 24V which is connected to the terminals A3 and A4 within the array marked 24V DC. It is necessary to realize that internal and also peripheral circuits (except relay inputs and channel CH2) are not galvanically separated.

ATTENTION!	**The increased attention should be paid to connection of the power supply voltage. If we connect 24 V onto different terminals than the supplying ones, part of the system can be destroyed!**

Within the TC LINE array, there is on terminals A1 and A2 the system bus TCL2 outgoing section which serves for the connection of other peripheral modules (chapter 3.) The interconnection is undertaken so, that using one line we interconnect terminals TCL2+

of all modules and using a second line we interconnect terminals TCL2–. Details are described in the chapter 4.3.1.

Within the Foxtrot, there is on terminals A5 and A6 the CIB outgoing section which is operated by the internal master that is within the basic module presented under the name MI2-01.

Within the CH1, RS-232 array, there is on terminals A7, A8 and A9 the serial channel CH1 outgoing section with fixed interface RS-232 (chapter 2.2.1.). Signal ground of the RS-232 interface is connected to the terminal A3.

Table 2.3 The connection of the terminal A of PLC FOXTROT basic modules

A1	TCL2+	system bus TCL2
A2	TCL2–	system bus TCL2
A3	GND	module ground
A4	+24V	supply
A5	CIB+	line CIB
A6	CIB–	line CIB
A7	RxD	data received
A8	TxD	data sent
A9	RTS	modem sending prompt

All modules of the PLC FOXTROT set are equipped with the plastic protection case and with the holder for module fitting onto the U bar.

ATTENTION!	**Modules contain components sensitive to electrostatic charge, therefore, user guides for these circuits must be abided!** **The manipulation is undertaken on the module that is disconnected from the power supply only, this applies both for module itself as well as for input and output signals!**

2.1   CENTRAL UNIT

The central unit executes its own user program and contains basic functions necessary for the PLC. This implies that the PLC must contain a central unit. Every central unit has a character assigned which designates its series. Each series of central units has its specific features important for the translator of the user program e.g. mapping and range of a memory, range of an instruction file, etc.

The central unit contains:

- 192 KB backed up CMOS RAM memory for user programs
- 64 KB backed up CMOS RAM memory for user tables
- 256 KB EEPROM flash memory for backing up of user programs and tables
- 2 MB EEPROM flash memory for projects archiving (chapter 5.5.3.)
- 512 KB additional memory for DataBox data archiving
- 64 KB user registers
- RTC
- 2 serial channels, first one with a fixed interface (RS-232), and second one with an optional interface changeable by using submodules (RS-232, RS-485, RS-422)
- Ethernet 10/100 Mb interface
- 1 TCL2 bus line for connection of peripheral units
- 1 CIB / bus line

- slot for MMC / SD card (older basic modules that have not a hole for card plug-in on the side, supports only RS MMC - RS marking means reduced size)
- integrated Web server (chapter 5.7.)

This is a K series central unit with an instruction file the part of which are arithmetic operations with numbers with a fixed base point of the size 32 bits with or without sign within a floating point (floating point single precision - 32 bits and double precision - 64 bits), PID regulator instruction, operator panel support (TER instruction) and support of a higher programming language.

Its mode and diagnostic reports are shown on a seven segment display.

Table 2.4 Basic parameters of the central unit

Module type	CP-1004, CP-1005, CP-1014, CP-1015
Real time circuit	yes
User program and table memory	192+64 KB
EEPROM backup memory of the program	yes
Internal DataBox additional data memory	512 KB
Project archiving memory	2 MB
Slot for the MMC / SD card	yes
Backup of RAM and RTC *	
without battery	typ. 500 h
with battery	typ. 20 000 h
Cycle time of 1k of log. instructions	0,2 ms
Number of user registers	64 KB
- number of remnant registers	32 KB
Number of IEC timers	4096
Number of IEC counters	8192
Binary input and output types	130
Instruction length	2 ÷ 10 bytes
Central unit series	K
No. of serial channels *	2
Interface Ethernet 10/100 Mb	1
TCL2 bus	1
CIB / bus	1
Integrated Web server	yes

* Applies for the central unit without power supply, when power supply is switched on the battery is disconnected, the backup period is thus extended. When the power supply is switched off, the circuits are backed up by an accumulator, the battery, if fitted, is connected only after its discharging (chapter 2.1.2.). The backup accumulator allows the battery change without any data loss.

** The CH2 serial channel interface is optional using plug-in submodules MR-01xx for RS-232, RS-485 and RS-422, M-Bus, PROFIBUS DP, CAN.

Communication possibilities

Channel CH1
- Mode **PC**   - communication with superior systems via the EPSNET protocol
- Mode **PLC**- data sharing among PLCs in the EPSNET-F network
- Mode **UNI** - common channel with arbitrary asynchronous communication
- Mode **MPC** - data exchange with subordinated PLCs in the EPSNET multimaster network

- Mode **MDB** - communication with superior systems via the MODBUS protocol
- Mode **PFB** - connection of stations PROFIBUS DP slave

Channel CH2
- Mode **PC**   - communication with superior systems via the EPSNET protocol
- Mode **PLC**- data sharing among PLCs in the EPSNET-F network
- Mode **UNI** - common channel with arbitrary asynchronous communication
- Mode **MPC** - data exchange with subordinated PLCs in the EPSNET multimaster network
- Mode **MDB** - communication with superior systems via the MODBUS protocol
- Mode **PFB** - connection of stations PROFIBUS DP slave
- Mode **UPD** - operation of special parallel submodules
- Mode **DPS** - realization of the station PROFIBUS DP slave (from version sw 3.5)
- Mode **CSJ** – connection of CAN bus with SJA1000 driver

Ethernet ETH1
- Mode **PC**   - communication with superior systems via the EPSNET UDP protocol within TCP/IP network
- Mode **PLC** - data sharing among the PLCs in the TCP/IP network
- Mode **UNI** - common data exchange via UDP and TCP protocols
- Mode **MDB** - communication with superior systems via the MODBUS UDP and MODBUS TCP protocols (from sw version 3.7)

The communication parameters are set in the Mosaic development environment within the project. The setting of serial channels and the Ethernet interface can be found in the Mosaic development environment. If we press the push-button MODE on the basic module, the text with Ethernet ETH1 settings will show for the time the button is pressed.

A detailed description of communications can be found in a separate manual *Serial communication of TECOMAT PLCs - 32 bit model (order number TXV 004 03.02).*

2.1.1   Indication elements and setting options

Indication LED diodes

Basic modules contain RUN and ERR LED diodes which indicate the mode the central unit is in (see table 2.5). Under the Ethernet interface connector the LED diode is placed which, when on, indicates the physical connection to the Ethernet network (does not indicate data transfer). The rest of LED diodes located on the right side of the front panel of CP-1004 modules, indicate the excitation of inputs and outputs. Furthermore, these modules units are equipped with an unitary seven-segment display.

Basic modules CP-1014 and CP-1015 have not LED diodes to indicate inputs and outputs, nor do they have seven-segment display. Their function is executed by an integrated display. Details are described in the chapter 2.5.

Details on the central unit's behaviour are stated in chapter 5.

Table 2.5 Function overview of indication LEDs of the basic module

Name	Colour	Behaviour	Function
RUN	Green	on	central unit is working, user program is not executed (HALT / PROG mode)
		flashing	central unit is working, user program is executed (mode RUN)
ERR	Red	on	signalization of an error reported by the central unit
ETHERNET	Green	on	signalization of Ethernet ETH1 interface activity
other	Green	on	indication of excitation of DI inputs and DO outputs (CP-1004, CP-1005 only)

MODE button in CP-1004, CP-1005 modules

Basic modules are equipped with one button which basic function is the displaying of the IP address, IP mask of the Ethernet interface, IP network gateway address and further of the setting of both serial channels. All these information are displayed in the form of the rolling text during the time the button is pressed any time the central unit is in operation (HALT, RUN modes).

A change of parameters using the push-button is not possible, all changes are done through the development environment.

After switching the PLC power supply on, the push-button has several functions during the launching sequence. If we do not press the button during the launching sequence the PLC will launch one of its operation modes (RUN, HALT with an error, etc).

If we press the button before the power supply is switched on and we keep it pressed for about 3s after the system has been started, the central unit will launch the BOOT mode and await a change in firmware. (chapter 7.1.1.).

If we press the push-button after the firmware version has been shown and we keep it pressed for about 3s, the PLC will launch the HALT mode (useful for cases when the user program running has a problem).

If we press the push-button, after the power supply is switched on, for a short time before or during the firmware version is shown, the PLC will offer a memory test. That is indicated by lighting up the letter **t** on the display. These tests are designated for maintenance purposes and upon unauthorized use the PLC memory can be erased completely. Therefore, if we incidentally get into this state, we switch the PLC off and back on again

For details see chapter 5.

MODE button in CP-1014, CP-1015 modules

Basic modules CP-1014, CP-1015 are equipped with seven push-buttons. Where six buttons under the display is designated especially for an application usage, the MODE push-button placed in the line on the left end is used for switching the display between user and system mode of projection.

In the RUN mode the display is switched to the user mode and displays characters defined by the application program running. The display is switched to the system mode, by short pressing of the push-button MODE, where it displays the PLC mode and the indication of DI inputs and DO outputs excitation. Using the cursor keys we can browse among other information displays that shows IP address, IP mask of the Ethernet interface, IP network gateway address and settings of both serial channels. By another short press of the button MODE, the display will switch back to the user mode.

In other modes, when the user program is not running, the display is standardly switched to the system mode. If the user program is not operated by the display then it stays permanently in the system mode.

After switching the PLC power supply on, the button MODE has several functions during the launching sequence. If we do not press the button during the launching sequence the PLC will launch one of its operation modes (RUN, HALT with an error, etc.).

If we press the button MODE before the PLC power supply is switched on and we keep it pressed after the system has been started, the list of modes will appear on the display. Using the cursor keys we can choose among modes RUN, HALT, BOOT, by setting parameters and hardware tests. The selection is accomplished by pressing ↵ (enter) and then confirmed by another pressing of ↵ or cancelled by the push-button **C** (clear).

For details see chapter 2.5. and 5.

2.1.2 Program memory and RTC power supply backup

When switching the PLC power supply voltage off, data in the user program memory and in the remnant zone of the notepad are backed up. Backup is ensured by a Li-Ion battery.

The real time circuit and the calendar circuit (RTC) is backed up in the same way as the user program memory.

The battery does not need any maintenance. Because it is sealed in the system, an eventual replacement should be done by the producer.

When the battery is changed, all data in the user program memory and in the remnant zone of the notepad are lost. Therefore, we recommend to backup the user program to the EEPROM memory.

Booster backup battery

The Li-Ion battery has an effective life of backing up of 500 hours. If, from any reason, do we need to extend the backing up period (e. g. bypassing the period of company holiday when the power is off), we can fit into the prepared holder the additional lithium battery of CR2032 type which, after the Li-ion battery is exhausted, will start to supply the power and thus extend the backing up period up to 20 000 hours.

Consequently, in case of single-shift operation cycle, the battery discharging does not occur not even during the weekend. Moreover, while changing the floating battery that is located on the holder, the program remains backed up in the Li-ion battery, thus, it can not be deleted.

The program memory requires the backing up voltage of at least 2.1 V. This means that if the battery voltage drops below this value, the safe program and data backing up is not ensured after the floating battery is discharged. If we exchange the discharged battery for a new one by this time, the loss of content is avoided. The battery voltage reduction below the value of 2.1 V is indicated in the S35.0 bit.

The exchange of the floating battery (CR2032 type or similar, 3 V, $\varnothing$ 20 mm, width 3.2 mm) should be undertaken in the interval of 2 or 3 years. The effective lifetime of this battery is usually 5 years.

The battery is inserted in the holder located on the front board of the basic module and is accessible after boards are removed from the case. After the exchange is done, the unneeded battery should be hand over to authorized organizations to be disposed of.

ATTENTION!	**Modules contain components sensitive to electrostatic charge, therefore, user guides for these circuits must be abided!**
	The manipulation is undertaken on the module that is disconnected from the power supply only!
	No metal instrument (forceps, pliers, etc.) must be used to avoid the battery short-circuit. Mind the right polarity!

Note.: The first series of basic modules CP-1004 produced in 2007 (version hw 01) is not equipped with the holder for the floating battery.

2.2   COMMUNICATION INTERFACES

As it was mentioned above, the central unit of all versions of basic modules PLC FOXTROT contains two serial channels (chapter 2.2.1.) and one Ethernet interface (chapter 2.2.3.). The serial channel CH1 has a fixed interface RS-232, serial channel CH2 enables the selection of the interface via exchangeable submodules MR-01xx (chapter 2.2.2.).

2.2.1   Serial channels

Serial channel CH1

Serial channel CH1 has fitted a fixed interface RS-232. Within this channel, there can be set communication modes **PC**, **PLC**, **MPC**, **UNI**, **MDB** and **PFB**. Connectors wiring is stated in the table 2.6.

Table 2.6 Serial channel CH1 connection

A3	GND	ground
A7	RxD	received data
A8	TxD	sent data
A9	RTS	modem sending prompt

It is necessary to bear in mind that this serial channel is not galvanically separated.

Serial channel CH2

Serial channel CH2 enables the selection of the interface via the exchangeable submodules MR-01xx (chapter 2.2.2.). Submodules are equipped with the identification record that can be read in the Mosaic development environment. Thus, the current mounting of the basic module can be detected. If there is on the serial channel set a mode that the exchangeable submodule does not support (table 2.7), the serial channel is switched off (**OFF mode**).

2.2.2   Exchangeable submodules

Exchangeable submodules can be divided into three groups according to their function:

♦ general serial interfaces
♦ special buses sequencers
♦ binary inputs and outputs

First group submodules are used for transfer of serial data of the TTL level to levels of the corresponding interface (RS-232, RS-485, RS-422, M-Bus). Therefore, it is a standard serial communication in modes **PC**, **PLC**, **MPC**, **UNI**, **MDB** and **PFB**.

Second group submodules are used for connection of a special bus (PROFIBUS DP, CAN) to the PLC. Submodule is in this case fitted with a special sequencer that itself contains a bus and exchange actual data only with the PLC central unit. It concerns modes **DPS** and **CSJ**.

Third group submodules has basically nothing in common with serial communication, nevertheless, they use connectors and controls dedicated to the serial channel CH2. The serial channel is in this case set to the **UPD** mode. PX-78xx submodules, that enable to increase the number of inputs and outputs on the basic module, belong to this group.

All submodules are equipped with the identification record that can be read in the Mosaic development environment. Thus, the current mounting of the basic module can be detected. If there is on the serial channel set a mode that the exchangeable submodule does not support (table 2.7), the serial channel is switched off (**OFF mode**).

Table 2.7 Order numbers of exchangeable submodules

Type	Modification	Order number	Supported modes
MR-0104	interface RS-232 with galvanic isolation	TXN 101 04	PC, PLC, MPC, UNI, MDB, PFB
MR-0114	interface RS-485 with galvanic isolation	TXN 101 14	
MR-0124	interface RS-422 with galvanic isolation	TXN 101 24	
MR-0152	slave station PROFIBUS DP	TXN 101 52	DPS
MR-0158	M-Bus interface	TXN 101 58	UNI
MR-0160	pair of CAN sequencers (SJA1000)	TXN 101 60	CSJ
MR-0161	sequencer CAN (SJA1000)	TXN 101 61	
PX-7811	7 binary inputs 24 V	TXN 178 11	UPD
PX-7812	4 binary inputs 24 V, 3 binary inputs 24 V	TXN 178 12	

Optional submodules are fitted into the basic module CP-10xx on the middle board at the position described in fig.2.2.
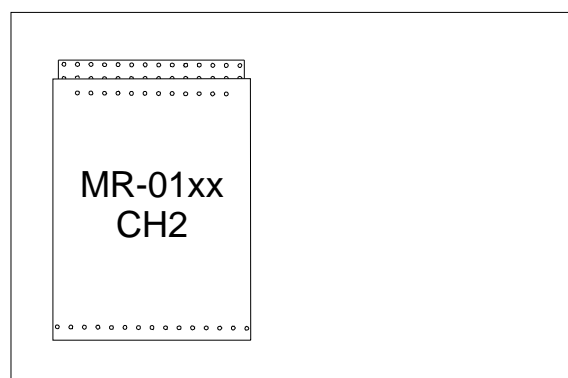
Fig.2.2   The location of the exchangeable submodule of the serial interface on the middle board of the basic module

If it is necessary to fit or change the submodule, retaining pawls of the bottom part of the case must be loosened using the screw. After the bottom part of the case is removed, we separate the board assembly from the rest part of the case. After the removal of the upper part of the board with the indication and connector for the Ethernet interface, the exchangeable submodule is accessible.

ATTENTION!	**Modules contain components sensitive to electrostatic charge, therefore, user guides for these circuits must be abided!**
	The manipulation is undertaken on the module that is disconnected from the power supply only!
	While changing submodules, it is vital to check carefully the right mounting of submodule female connectors against male connectors on the main board. Female connectors have not the location coding and when connected incorrectly, the damage on the submodule or even basic board can occur when switched back on!!!

2.2.2.1 RS-232 interface

The submodule MR-0104 ensures the transmission of the TTL signals of the serial interface to the RS-232 interface including the galvanic isolation. This interface is designated for the interconnection of two participants only, it can not be used within the network (except e.g. connection of boards ID-0x in the slave mode). It is applicable for e. g. connection of PLC TECOMAT and PC on short distances.

Table 2.8 Technical parameters of submodule MR-0104

Galvanic isolation	yes
Insulating voltage of galvanic isolation	1000 VDC
Max. transmission rate	200 kBd
Input resistance of the receiver	min. 7 kΩ
Output signal level	typ. $\pm$ 8 V
Max. length of the line connected	15 m

Table 2.9 Connection of the terminal board of the serial channel CH2 while submodule MR-0104 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	RTS	modem sending prompt
C4		
C5	CTS	modem sending readiness
C6		
C7	RxD	data received
C8	TxD	data sent
C9		

2.2.2.2 RS-485 interface

The submodule MR-0114 ensures the transmission of galvanically separated serial interface TTL signals to the RS-485 interface. This type of the interface is used for connection of several participants on one line and for communication networks creation.

To ensure correct functioning, it is necessary to terminate the line on its ends. This can be undertaken by interconnection of terminals TxRx+ s BT+ a TxRx– s BT–.

The galvanic isolation of the serial interface is provided by an in-built converter and an external power supply is not needed.

Table 2.10   Technical parameters of the submodule MR-0114

Galvanic isolation	yes
Insulating voltage of galvanic isolation	1000 VDC
Max. transmission rate	2 MBd
Receiver sensitivity	min. ± 200 mV
Output signal level	type 3,7 V
Max. length of the line connected	1200 m*

*   The maximum length applies to twisted and shielded cable and a communication rate of max. 120 kBd.

Table 2.11   Connection of the terminal board of the serial channel CH2 while submodule MR-0114 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	BT–	– line termination output RS-485
C4	BT+	+ line termination output RS-485
C5	TxRx–	data received and sent (level –)
C6	TxRx+	data received and sent (level +)
C7		
C8	TxRx–	data received and sent (level –)
C9	TxRx+	data received and sent (level +)

2.2.2.3 RS-422 interface

   The MR-0124 submodule ensures the transfer of galvanically separated serial interface TTL signals to the RS-422 interface. The interface allows the connection of two cooperating devices, consequently, it cannot be used for networks (an exception is for example the connection of ID-0x series panels).

Table 2.12   Technical parameters of the submodule MR-0124

Galvanic isolation	yes
Insulating voltage of galvanic isolation	1000 VDC
Max. transmission rate	2 MBd
Receiver sensitivity	min. ± 200 mV
Output signal level	type 3,7 V
Max. length of the line connected	1200 m*

*   The maximum length applies to twisted and shielded cable and a communication rate of max. 120 kBd.

Table 2.13   Connection of the terminal board of the serial channel CH2 while submodule MR-0124 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	CTS–	modem sending readiness (level –)
C4	CTS+	modem sending readiness (level +)
C5	RxD–	data received (level –)
C6	RxD+	data received (level +)
C7		
C8	TxD–	data sent (level –)
C9	TxD+	data sent (level +)

2.2.2.4 PLC FOXTROT connection to the CAN bus

MR-0151 submodules with the pair of drivers SJA1000 and MR-0161 with one driver SJA1000 enable the connection of the PLC FOXTROT to the CAN network with transfer rates of 1 MBd, 500, 250, 125, 50, or 20 kBd. They can only be used in **CSJ** mode.

It is necessary to terminate the communication lines on both ends to ensure correct functioning. It is undertaken by connection of terminals TxRx+ with BT+ and TxRx– s BT–.

Table 2.14   Connection of the terminal board of the serial channel CH2 while submodule
            MR-0161 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	BT–	– CAN line termination output
C4	BT+	+ CAN line termination output
C5	TxRx–	data received and sent (level –)
C6	TxRx+	data received and sent (level +)
C7		
C8	TxRx–	data received and sent (level –)
C9	TxRx+	data received and sent (level +)

Table 2.15   Connection of the terminal board of the serial channel CH2 while submodule
            MR-0160 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	BT–	– CAN line termination output*
C4	BT+	+ CAN line termination output *
C5	TxRx1–	data received and sent (level –)CAN1 line
C6	TxRx1+	data received and sent (level +) CAN1 line
C7		
C8	TxRx2–	data received and sent (level –)CAN2 line
C9	TxRx2+	data received and sent (level +) CAN2 line

* Only one line termination is brought out for one CAN line (any one of the two). If we need to terminate both lines at this place, then we terminate the second line using a 120 Ω resistor between signals TxRx+ and TxRx– of this line.

2.2.2.5 PLC FOXTROT connection to the PROFIBUS DP network

The MR-0152 submodule enables the connection of the PLC FOXTROT to the PROFIBUS DP network as a slave station with a transmission rate of up to 12 MBd. It can only be used in the **DPS** mode.

It is necessary to terminate communication lines on both ends to ensure correct functioning. It is undertaken by the connection of terminals TxRx+ with BT+ and TxRx– with BT–. Furthermore, it is important to remember that the line A of the PROFIBUS bus has – (TxRx–) level and the B line + (TxRx+) level.

Table 2.16   Connection of the terminal board of the serial channel CH2 while submodule
　　　　　　MR-0152 is fitted

C1	+5V	supply output +5V
C2	GND	signal ground
C3	BT–	– RS-485 line termination output
C4	BT+	+ RS-485 line termination output
C5	TxRx–	data received and sent (level –)
C6	TxRx+	data received and sent (level +)
C7		
C8	TxRx–	data received and sent (level –)
C9	TxRx+	data received and sent (level +)

2.2.2.6 The connection of heat meters via the M-Bus interface

The MR-0158 submodule enables the waking up of a standard M-Bus line with six slave stations. The power supply current of the line is ensured by an internal increasing stabilizer from the separating power supply converter of the TTL. The transmitter modulator can be alternatively supplied by an external power supply U_{cc3} (36 V / 50 mA), then it is possible to connect up to 20 slaves to the line. The current assessment is dynamical thus enables the change of the number of connected units without any additional configuration.

The serial channel must be set to the **UNI** mode and its own protocol must be executed via the user program.

Table 2.17   Connection of the terminal board of the serial channel CH2 while submodule
　　　　　　MR-0158 is fitted

C1		
C2	+5V	supply output +5V
C3	M–	M-Bus bus (level –)
C4	U_{cc3}	external power supply output 36 V / 50 mA
C5	M–	M-Bus bus (level –)
C6	M+	M-Bus bus (level +)
C7	M+	M-Bus bus (level +)
C8	M–	M-Bus bus (level –)
C9	M+	M-Bus bus (level +)

2.2.2.7 Expansion of further binary inputs and outputs

PX-7811 and PX-7812 submodules enable increasing of the number of binary inputs and outputs on the basic module in cases when the serial channel CH2 is not used in any other way

The PX-7811 submodule contains 7 binary inputs, the PX-7812 submodule contains 4 binary inputs and 3 binary outputs. These inputs and outputs are galvanically isolated.

It is necessary to set the serial channel to the **UPD** mode. Inputs and outputs connection to the terminal board C is shown in table 2.18 (PX-7811) and table 2.19 (PX-7812).

Table 2.18   Connection of the terminal board of the serial channel CH2 while submodule PX-7811 is fitted

C1	+24 V	inputs supply
C2	GND	inputs ground
C3	IN0	input IN0
C4	IN1	input IN1
C5	IN2	input IN2
C6	IN3	input IN3
C7	IN4	input IN4
C8	IN6	input IN6
C9	IN7	input IN7

Note: The input IN5 is not brought out due to technical purposes

Table 2.19   Connection of the terminal board of the serial channel CH2 while submodule PX-7812 is fitted

C1	+24 V	inputs and outputs supply
C2	GND	inputs and outputs ground
C3	IN0	input IN0
C4	IN1	input IN1
C5	IN2	input IN2
C6	IN3	input IN3
C7	OUT0	output OUT0
C8	OUT2	output OUT2
C9	OUT3	output OUT3

Note: The output OUT1 is not brought out due to technical purposes

Binary inputs

Binary inputs are used for connection of two-condition signals of the controlled object to the PLC. The PX-7811 submodule contains 7 binary inputs, the PX-7812 submodule contains 4 binary inputs. Inputs are galvanically separated from internal PLC circuits and are organized into a group with a common connector. The common connector of the group is minus.

Table 2.20   Basic parameters of binary inputs of submodules PX-7811 and PX-7812

Type of the submodule	PX-7811	PX-7812
Number of inputs	7	4
Number of inputs in the group	7	4
Galvanic separation from internal circuits	yes	
Common conductor	minus	
Input supply for log.0 (UL)	max. +5 V DC min. −15 V DC	
for log.1 (UH)	min. +11 V DC type +24 V DC max. +30 V DC	
Input current at log.1	typ. 3 mA	
log.0 to log.1 delay	5 ms	
log.1 to log.0 delay	5 ms	
External supply voltage of input circuits	24 V DC	
Max. power take-off from external source	27 mA	
Insulation voltage between inputs and internal circuits	500 V DC	
Submodule power loss	max. 850 mW	

Binary outputs

Binary outputs are used for control of two-condition action and signaling units of the object controlled supplied by the direct voltage of 24 V. The submodule PX-7812 contains 3 binary outputs that enable to switch the current-carrying capacity of up to 0,5 A each. Outputs are galvanically separated from internal circuits of the PLC, nevertheless, not from 4 inputs on this submodule. Inputs are organized into one group with one common connector. The common connector of the group has a plus polarity.

Table 2.21   Basic parameters of binary outputs of the submodule PX-7812

Submodule type	PX-7812
Number of outputs	3
Number of outputs in the group	3
Galvanic isolation from internal circuits	yes
Outputs type	transistor output
Common conductor	plus
Switched voltage	max. 30 V DC type 24 V DC min. 11 V DC
Switched current	max. 0,5 A
Common connector current	max. 2 A
Cut off current when opened	max 300 µA
ON-time	max. 400 µs
OFF-time	max. 400 µs
Short-circuit protection	yes
Initial peak current limitation	typ. 1,4 A
Initial peak current OFF-time	typ. 4 ms
Short-circuit current limitation	typ. 1,1 A
Polarity reversal protection	yes*
Inductive load handling	external - RC element, varistor, diode

*   The circuit will be inducted to the non-active state, loads will be switched on, the current will circulate through the protective diode of the circuit.

There is, on the fig.2.3, represented schematically the connection of switching devices while the PX-7811 submodule is fitted. There is, on the fig.2.4 represented schematically the connection of switching devices and loads while the PX-7812 submodule is fitted.
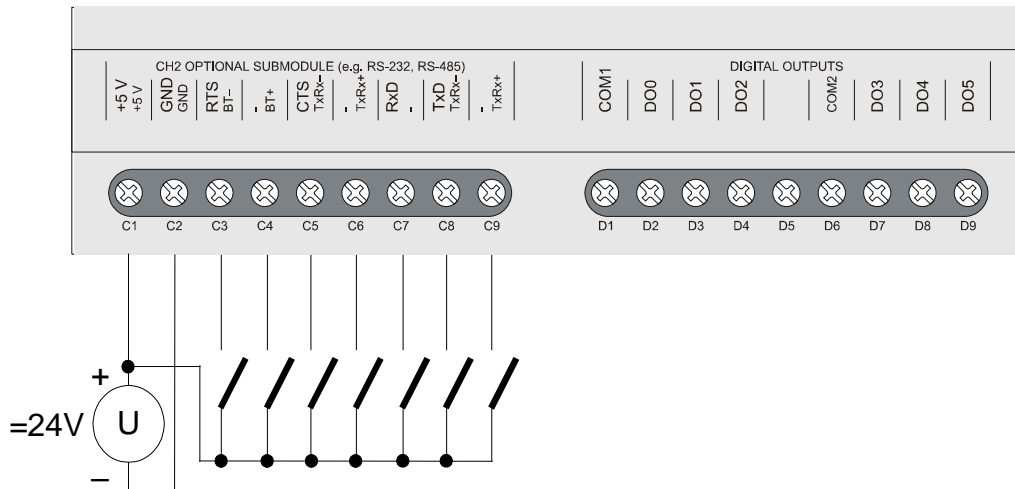
Fig.2.3   Typical example of switching devices connection to the basic module CP-10xx while the PX-7811 submodule is fitted on the CH2 channel
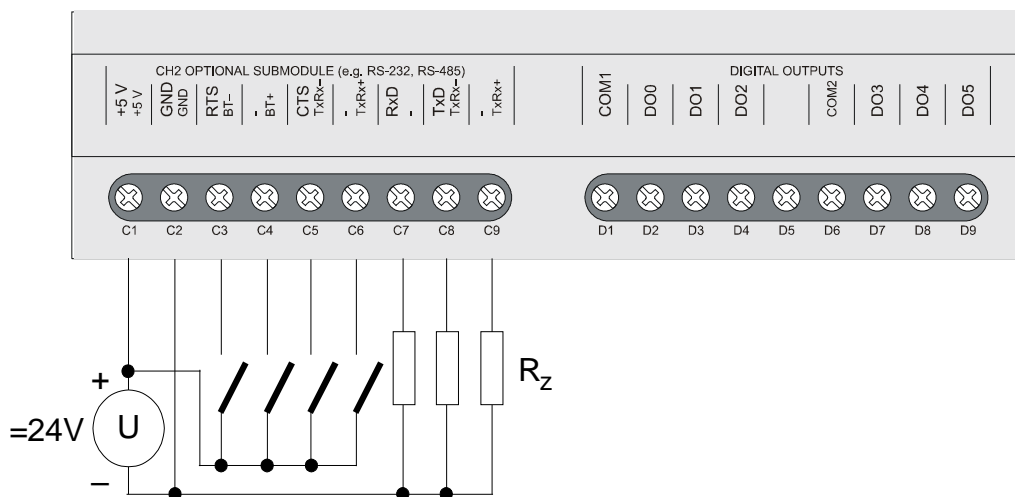
Fig.2.4   Typical example of switching devices and loads connection to the basic module CP-10xx while the PX-7812 submodule is fitted on the CH2 channel

Initialization of PX-7811 and PX-7812 submodules

Owing to the fact that PX-7811 and PX-7812 submodules engage the channel CH2 position, we treat them as a special mode of the serial channel. The **UPD** mode is concerned.

We open, in the *Project manager*, the window *HW | HW configuration*. In the tag *Central module* on the line CPU, we click on the icon 🗹.

The window *Channel parameters setting* will (fig 2.5). We select the **UDP** mode on the line of the channel CH2 and then we click on the icon 🗹 in this field.
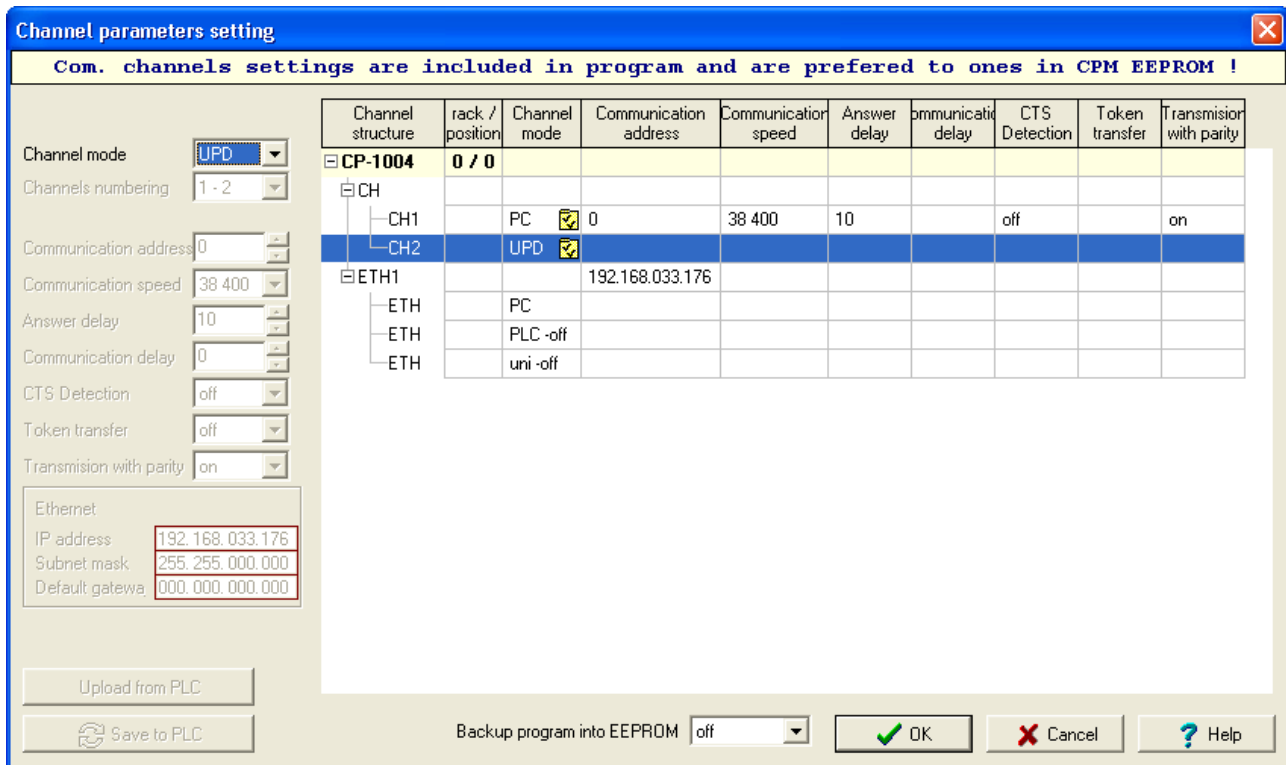
Fig. 2.5   UPD mode selection in the channel CH2

The window *Submodules selection* will appear (fig.2.6, fig.2.7). From the list we select the corresponding submodule and we name symbolically input and output data (those names will appear in the panel *Setting V/V* in the column *Alias*). Then, by pressing the button OK, we confirm the selection and the setup is finished now.
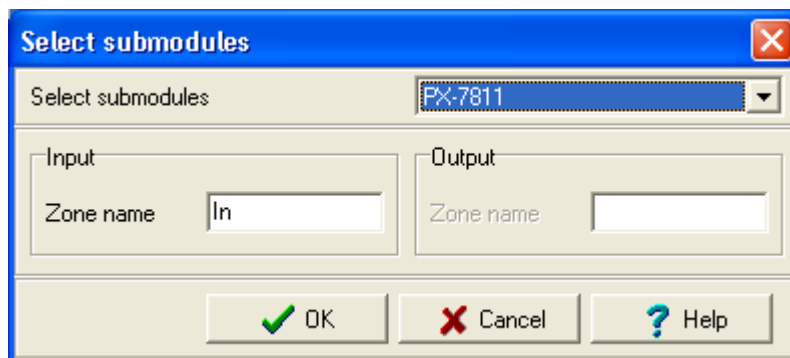
Fig.2.6   PX-7811 submodule selection
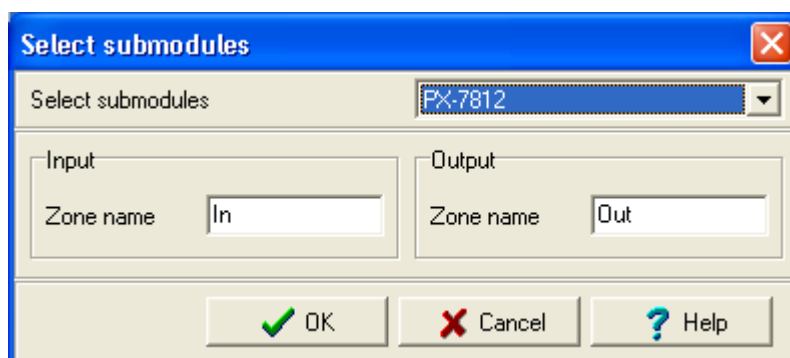
Fig.2.7   PX-7812 submodule selection

Data provided

The channel CH2 in the **UPD** mode provides information on inputs and outputs on submodules PX-7811 and PX-7812. The data structure is visible in the panel *Setting V/V* In the Mosaic environment (fig.2.8, fig.2.9) (icon 🔟).

Structure items have assigned symbolic names that always begin with characters *r0_p0_* which are assigned to the central unit. In the column *Full entry* is always presented a particular symbolic name of the item given. If we want to use data in the user program, we either use this symbolic name, or in the column *Alias* we enter our own symbolic name which can be used further. In no case do we use absolute operands since they can alter after a new compilation of the program.
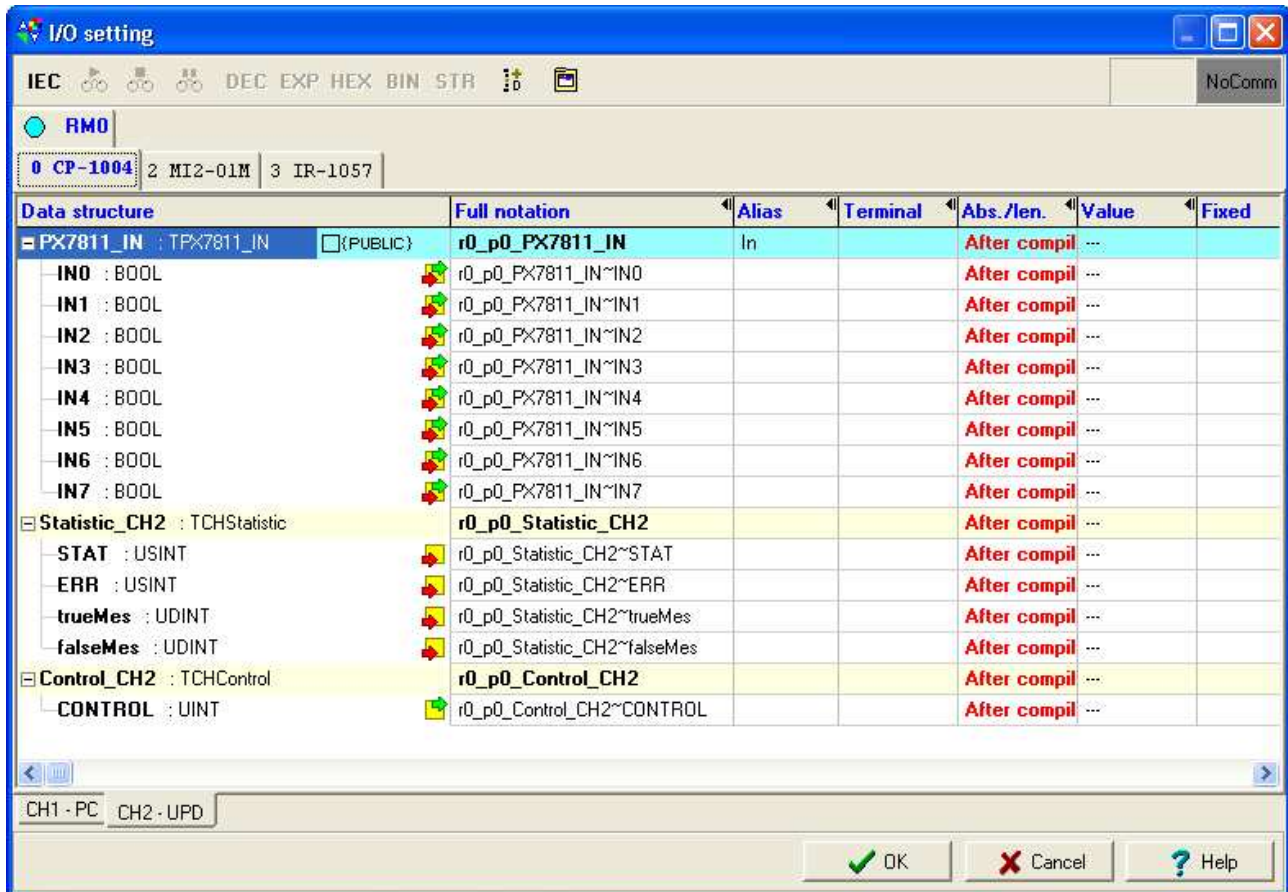
Fig.2.8   Data structure of the PX-7811submodule

PX7811_IN   - outputs binary values (8times boolean type)

IN7	IN6	0	IN4	IN3	IN2	IN1	IN0
.7	.6	.5	.4	.3	.2	.1	.0

bit

IN0 - IN7 – binary inputs
        input IN5 is not in the PLC FOXTROT physically interconnected

Status and control structures of the channel *Statistic_CH2* and *Control_CH2* are not used in this mode.
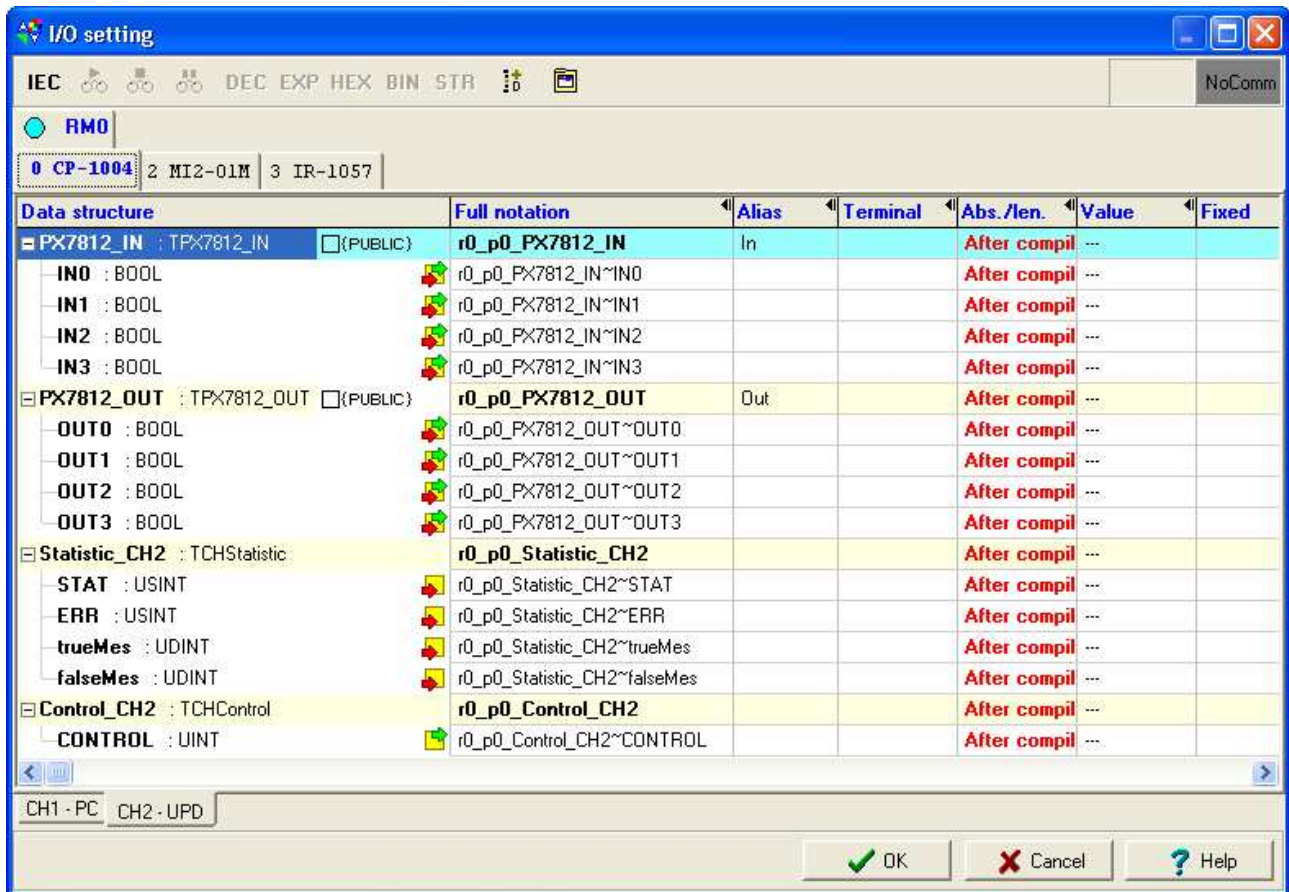
Fig.2.9   Data structure of the PX-7812 submodule

PX7812_IN   - outputs binary values (8times boolean type)

0	0	0	0	IN3	IN2	IN1	IN0
bit .7	.6	.5	.4	.3	.2	.1	.0

IN0 - IN3 – binary inputs
input IN5 is not in the PLC FOXTROT physically interconnected

PX7812_OUT - outputs binary values (8times boolean type)

0	0	0	0	OUT3	OUT2	0	OUT0
bit .7	.6	.5	.4	.3	.2	.1	.0

OUT0 - OUT3 – binary outputs
output OUT1 is not in the PLC FOXTROT physically interconnected
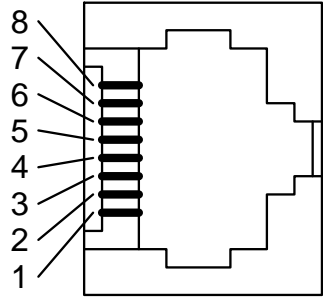
Status and control structures of the channel *Statistic_CH2* and *Control_CH2* are not used in this mode.

2.2.3   Ethernet interface

Basic modules are fitted with the Ethernet 10/100 Mbit interface. The Ethernet interface is fitted with a RJ-45 connector with a standard signal arrangement. The connector is ready to be used with common UTP patch cables. The interface is designed to use direct or crossed cables.

Table 2.22 Ethernet interface connection (front view of the connector on PLC)

	Pin	Signal	Conductor colour
8 7 6 5 4 3 2 1	8	not used	brown
	7	not used	white / brown
	6	RD– or TD-	green or orange
	5	not used	white / blue
	4	not used	blue
	3	RD+ or TD+	white / green or white / orange
	2	TD– or RD-	orange or green
	1	TD+ or RD+	white / orange or white / green

Note: The RD and TD signal connection options depend on the cable used (direct or crossed). The colour of the conductor enables exact identification of the signal.

2.3   PERIPHERAL PART OF MODULES CP-1004, CP-1014

Peripheral part of modules CP-1004, CP-1014 constitutes of IR-1057 (older variant IR-1055) board containing 8 multipurpose inputs and 6 relay outputs. The first four inputs DI0 - DI3 can be used as common binary inputs or as inputs for sequencers. Other four inputs DI4 - DI7 can be used as common binary inputs or as analog inputs AI0 - AI3. Under the name IR-1057 (respectively IR-1055) the processor operating these inputs and outputs presents itself within the system bus.
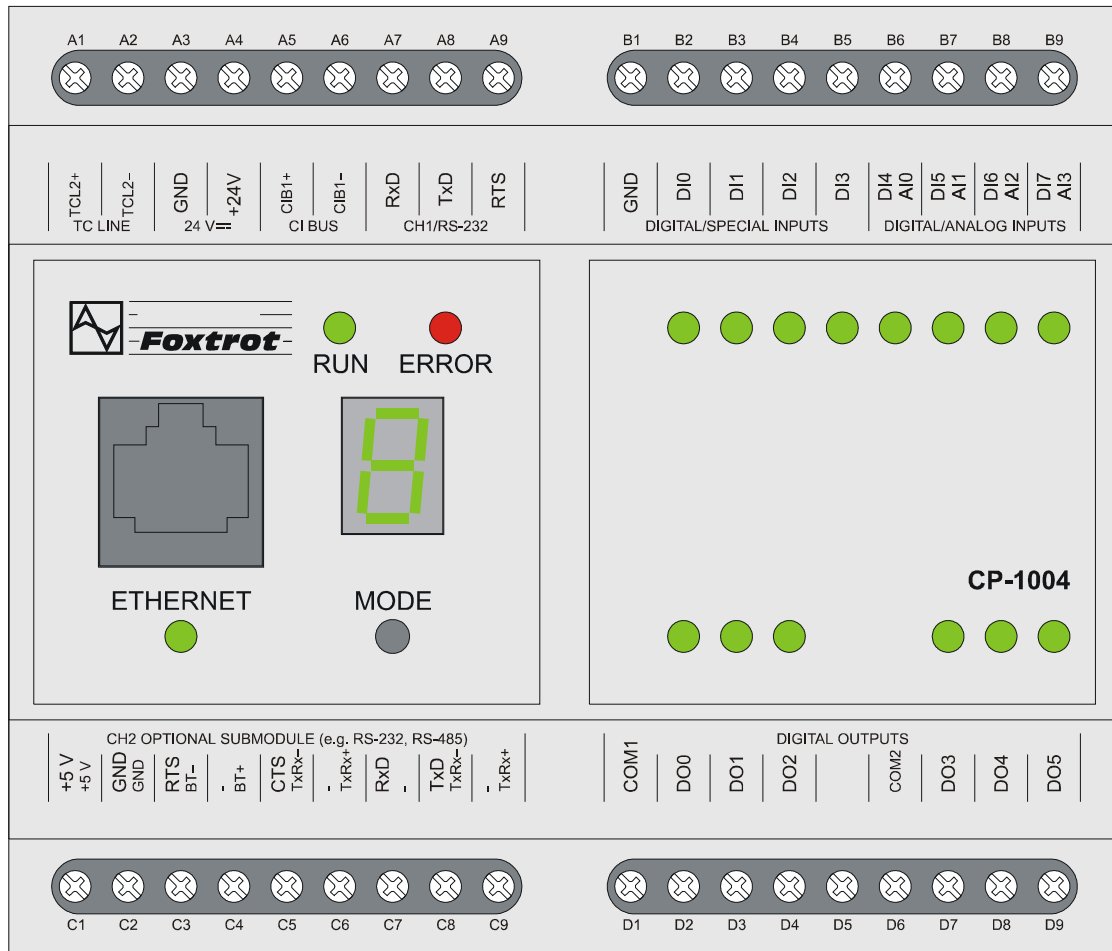
Fig.2.10   Basic module CP-1004

In the table 2.23 is described the connection of terminals in terminal boards B and D. The connection of the terminal board A is common for all basic modules and is described in the table 2.3 in the introduction to the chapter 2. The connection of the terminal board C is dependant on the submodule fitted and its options are described in the chapter 2.2.2.

Table 2.23   Connection of terminal boards B and D of CP-1004, CP-1014 modules

B1	GND	module ground
B2	DI0	binary input DI0
B3	DI1	binary input DI1
B4	DI2	binary input DI2
B5	DI3	binary input DI3
B6	DI4 / AI0	binary input DI4 / analog input AI0
B7	DI5 / AI1	binary input DI5 / analog input AI1
B8	DI6 / AI2	binary input DI6 / analog input AI2
B9	DI7 / AI3	binary input DI7 / analog input AI3
D1	COM1	digit sense line of inputs DO0 - DO2
D2	DO0	relay output DO0
D3	DO1	relay output DO1
D4	DO2	relay output DO2
D5		
D6	COM2	digit sense line of outputs DO3 - DO5
D7	DO3	relay output DO3
D8	DO4	relay output DO4
D9	DO5	relay output DO5

2.3.1   Binary inputs

Binary inputs are instrumental to the connection of two-condition signals of the controlled object to the PLC. CP-1004 and CP-1014 basic modules contain 8 binary inputs DI0 - DI7. These inputs are not galvanically isolated from the internal circuits of the PLC. The excitation (switching on) is signalized by lighting up of the relevant LED diode. All inputs have a joint minus connector. Inputs DI0 - DI3 can be used as inputs for counters, inputs DI4 - DI7 can be used as analog inputs AI0 - AI3. Even if these inputs are used as inputs for counters then still inputs DI0 – DI3 can be used as binary inputs simultaneously. Inputs DI4 - DI7 works as binary only when they are not used for analog measuring (apply to each input independently on others).

Table 2.24   Basic parameters of binary inputs

Type of module	CP-1004, CP-1014 (IR-1055, IR-1057)
Number of inputs	8
Number of inputs in group	8
Galvanic isolation from internal circuits	no
Diagnostics	Signalization of excited input on panel
Common conductor	minus
Input voltage	
for log.0 (UL)	max. +5 V DC
	min. −5 V DC
for log.1 (UH)	min. +15 V DC
	type +24 V DC
	max. +30 V DC
Input current at log.1	type 5 mA
log.0 to log.1 delay	5 µs (DI0 - DI3)
	5 ms (DI4 - DI7)
log.1 to log.0 delay	5 µs (DI0 - DI3)
	5 ms (DI4 - DI7)
Minimum width of the pulse captured	50 µs

Inputs DI0 - DI3 allow to switch on the function of short impulses capturing. This function prolongs the selected level of the input signal until the PLC cycle scan. Therefore, it is possible to ensure that individual pulses on the input which are shorter than the PLC cycle will not be lost.

Note: If the function of capturing short impulses is activated on one of the inputs, it is then forbidden to have switched on the counter which uses this input. If such a situation should occur, the function of capturing short impulses is switched off automatically.

Binary inputs are bring out onto connectors within fields DIGITAL / SPECIAL INPUTS and DIGITAL / ANALOG INPUTS. You can see a schematic overview of switchers connection on fig 2.1.3.

Attention! It is necessary to realize that connectors GND in the 24 V DC and DIGITAL / SPECIAL INPUTS fields are galvanically connected inside the system. It is not recommended to connect the GND connector in the DIGITAL / SPECIAL INPUTS field to the negative terminal of the system power supply including inputs because the cycle would be closed by the second GND connector and induction of interfering signals would be hindered.
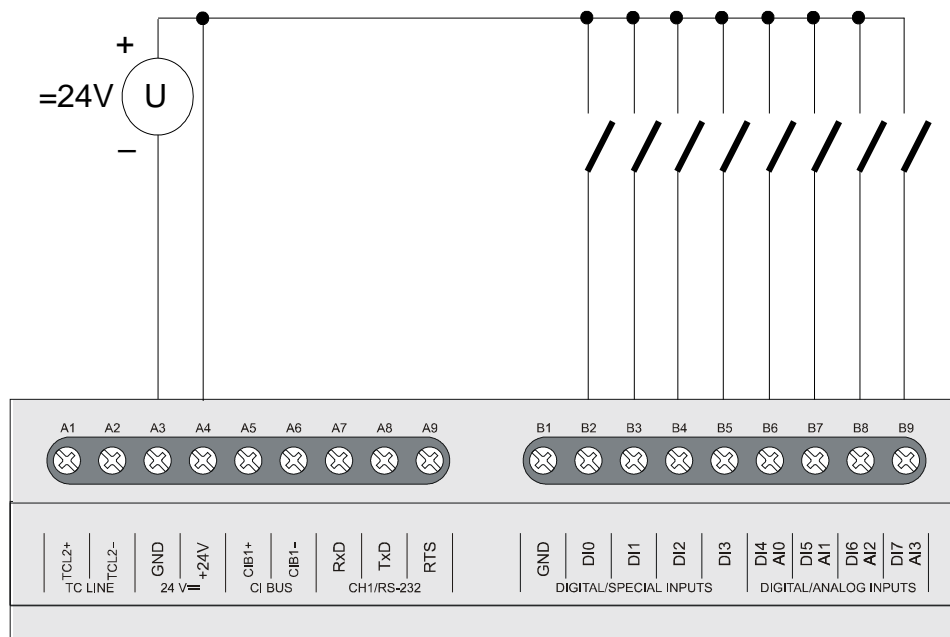
Fig.2.11   Typical example of switchers connection to the binary inputs of CP-1004, CP-1014 modules

2.3.2   Relay outputs

Relay outputs are instrumental to control of two-condition action and signaling elements of the controlled object that are supplied by alternating or direct current up to 250V. Outputs are realized by a switching voltage-free contact of the relay brought out within a group with one joint connector.

The CP-1004 basic module contains 6 relay inputs DO0 - DO5 organized in two groups of three inputs with the joint connector. Inputs are galvanically separated both from inside circuits of the PLC and between the two groups themselves. The excitation of the output is signalized by the lighting up of the relevant LED diode.

Table 2.25   Basic parameters of relay outputs

Module type	CP-1004, CP-1014 (IR-1055, IR-1057)
Number of inputs	6
Number of groups x number of outputs in group	2 x 3
Galvanic isolation from inside circuits	yes (also between groups)
Diagnostics	Signalization of output excitation on the panel
Type of outputs	Electromechanical relay, non-protected output
Contact type	switching
Switching voltage	max. 250 V min. 5 V
Switching current	max. 3 A min. 100 mA
Short-term output overload	max. 4 A
Voltage flow through the joint connector	max. 10 A
Time of contact closure	type 10 ms
Time of contact opening	type 4 ms
Threshold limits of the load switched	
for resistant load	max. 3 A at 30 V DC or 230 V AC
DC13 for inductive load	max. 3 A at 30 V DC
AC15 for inductive load	max. 3 A at 230 V AC
Switching frequency without load	max. 300 switches / min.
Switching frequency with rated load	max. 20 switches / min.
Mechanical lifetime	min. 5 000 000 cycles
Electrical lifetime at max load	
for resistant load	min. 100 000 cycles
DC13 for inductive load	min. 100 000 cycles
AC15 for inductive load	min. 100 000 cycles
Short-circuit protection	N/A
Treatment of inductive load	external - RC unit, varistor, diode (DC)
Insulation voltage	
among inputs and internal circuits	3750 V AC
among output groups	3750 V AC

Binary input contact relays are brought out to connectors in the DIGITAL OUTPUTS field. A schematic overview of the connections of loads powered by independent sources is shown in fig.2.1.4. Protection against overload and short-circuit is ensured by usage of safety fuses for each input or for each group separately. The rated voltage and type of the fuse is selected for each load and character of load differently while considering the maximum voltage and overload ability of the outputs or group of outputs. For example when using tube fuses with a T and F fuse characteristic and a switching rate of 35 A, it is possible to use a rated current of 3 A per fuse per output and fuses up to 10A when protecting a joint group conductor.

The principle of various ways how to undertake inductive load treatment, RC draft support for anti-interference members, overview of anti-interference items delivered by the PLC producers and other recommendations are stated in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02*.
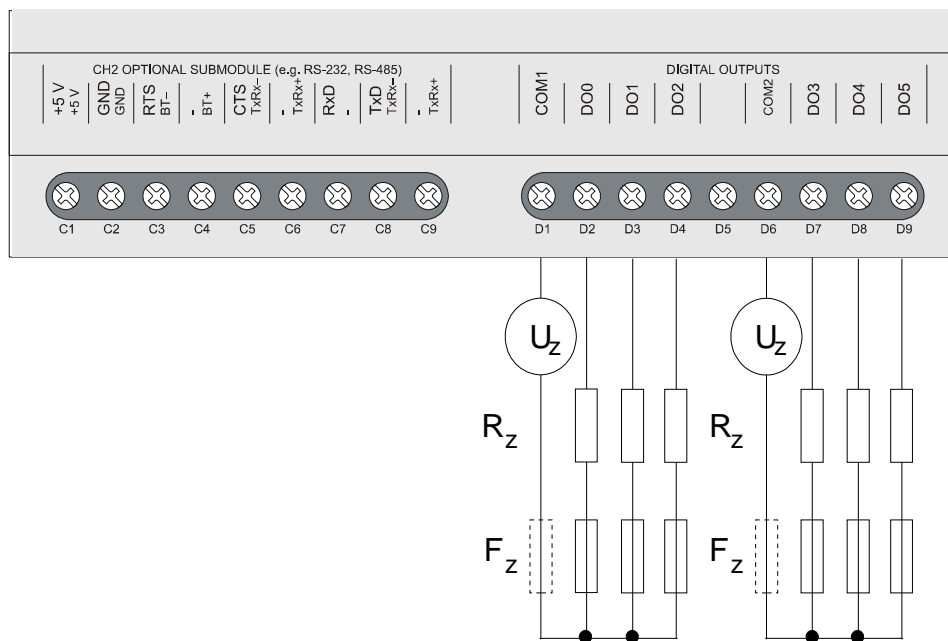
Fig.2.12 Typical example of load connection to binary relay outputs of *CP-1004, CP-1014 basic modules*

2.3.3 Analog inputs

Analog inputs are used for connection of analog signals of the controlled object to the PLC. Basic CP-1004 and CP-1014 modules contain 4 analog inputs AI0 - AI3 which are physically identical with DI4 - DI7 binary inputs. Inputs have no galvanic isolation from the PLC internal circuits. All inputs have a joint minus connector. DI0 - DI3 inputs can be used as inputs for counters and inputs DI4 - DI7 can be used as analog inputs AI0 - AI3. If the individual input from the group DI4 - DI7 / AI0 - AI3 is not used for analog measuring, then it works as a binary input.

Table 2.26   Basic parameters of analog inputs

Module type	CP-1004, CP-1014 (IR-1055, IR-1057)
Number of inputs	
Number of inputs in group	4 (joint inputs with DI0 - DI3)
Galvanic isolation of inside circuits	No
Diagnostics	Overload signalization within status word
Joint conductor	Minus
External power supply	No
Type of converter	sigma-delta
Time of conversion	350 µs
Digit differentiating ability	10 bits
Input resistance	approx. 6 kΩ
Measuring range / resolution (1 LSB)	0 to +10 V / 11,36 mV
Allowed continual overload	max. +10,5 V, min. 0 V
Analog input error	< 3 %
Maximum error at 25 ℃	± 3 % of full range
Temperature coefficient	± 0,1 % of full range / K
Linearity	± 0,2 % of full range
Repeatability at constant conditions	0,5 % of full range
Detection of unclosed input	no

Analog inputs are brought out to connectors in the field DIGITAL / ANALOG INPUTS. The fig. 2.13 shows a scheme of the signal power supplies connected to analog inputs.
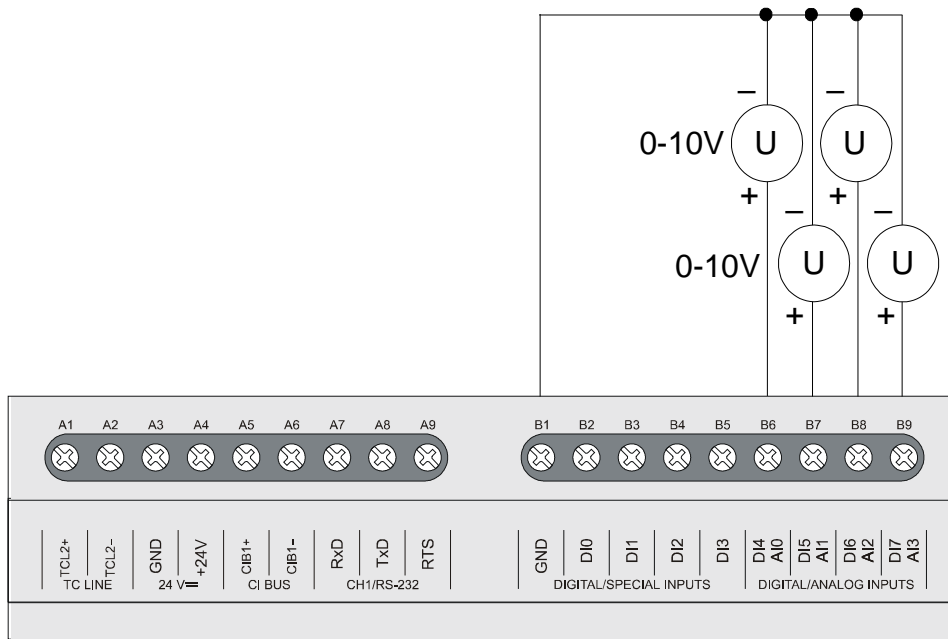
Fig.2.13   Typical example of signals connection to analog inputs of CP-1004, CP-1014 basic modules

2.3.4   Counters

Binary inputs DI0 - DI3 can be used as counter inputs. Two counter objects are available which can work in several modes (one-way counter, two-way counter, basic IRC). Each object of the counter uses two inputs by default. Moreover, the first object of the counter enables modes that use all four inputs (counter and IRC with reset and capturing). In this case the second object of the counter is switched off. Even when used for these alternative functions, inputs DI0 –DI3 are still useable as standard binary inputs. Inputs are brought out to connectors in the field DIGITAL / SPECIAL INPUTS.

Input electric parameters can be found in the table 2.24, time parameters in table 2.27. and an overview of modes in 2.28.

Table 2.27   Time parameters of counter inputs

Module type	CP-1004, CP-1014 (IR-1055, IR-1057)
Counter modes:	
Input frequency	5 kHz
Pulse width	min. 50 µs
log.0 to log.1 delay	5 µs
log.1 to log.0 delay	5 µs
Register range	0 up to 4 294 967 295 (32 bits)
Incremental counters (IRC):	
symetric signal frequency (V, G)	1.25 kHz
Pulse width (V, G, NI, MD)	min. 50 µs
log.0 to log.1 delay	5 µs
log.1 to log.0 delay	5 µs
Register range	0 up to 4 294 967 295 (32 bits)
Pulse length measuring, period and phase shift measuring:	
Input frequency	0.1 up to 5000 Hz
Pulse width	50 up to 10 000 000 µs

Table 2.28   Overview of counter modes

Counter mode	Counter object 1				Counter object 2	
signal	DI0	DI1	DI2	DI3	DI2	DI3
One one-way counter	UP	-	-	-	UP	-
Two one-way counters	UP	UPB	-	-	UP	UPB
Two-way counter	UP	DOWN	-	-	UP	DOWN
Counter with controlled direction	CLK	DIR	-	-	CLK	DIR
Basic IRC	V	G	-	-	V	G
Two-way counter with reset and capturing	UP	DOWN	CLR	CAP	-	-
Counter with controlled direction and with reset and capturing	CLK	DIR	CLR	CAP	-	-
IRC with reset and capturing	V	G	NI	MD	-	-
Pulse length measuring	input selectable during operation DI0 - DI3				-	-
Period and phase shift measuring (both function switchable during operation)	period: input selectable during operation DI0 - DI3				-	-
	phase shift: measured between DI1 and DI0				-	-

Overview of abbreviations of various signals:

UP   - pulse input for counter incrementation
UPB   - pulse input for B counter incrementation
DOWN - pulse input for counter decrementation
CLK   - pulse input for counter
DIR   - counter direction
CLR   - counter resetting
CAP   - counter capturing value
V   - IRC first track
G   - IRC second track
NI   - IRC zero pulse
MD   - measuring contact

As it can be seen in the table 2.28, both counter objects can be adjusted to different mode combinations providing the first object uses the inputs DI0 and DI1 only (first 5 modes). If the first object uses all DI0 to DI3 inputs then the second object is switched off.

According to the configuration, there are up to 4 simple one-way counters or 2 simple two-way counters / incremental encoder or 1 counter / incremental encoder including reset and capturing available.

The meaning of each function is described in chapter 2.3.6. Counter inputs are connected in the same manner as standard inputs as can be seen in fig.2.11. In fig.2.14 and 2.15 are shown examples of the IRC position sensors connection.

Attention!　　For older variant named IR-1055 pulse length measuring and period and phase shift measuring modes are assigned for periodical signals only. Since these measurings are loaded with accidental error caused by the engagement of the processor of the periphery during data exchange with the central unit. This error is eliminated so, that the resultant value of the measuring is gained through the average value of the last eight pulses captured. Therefore, it is supposed that the detected signal is represented by pulses repeated in particular period. The absolute error of the measuring is max. ± 10 µs and decrease as the PLC cycle period is increased.

For newer variant named IR-1057, more powerful processor is used. The absolute error of the measuring max. ± 10 µs is valid for each individual measuring. The result value means actual measured value. In this case we can measure non-periodical signal too.
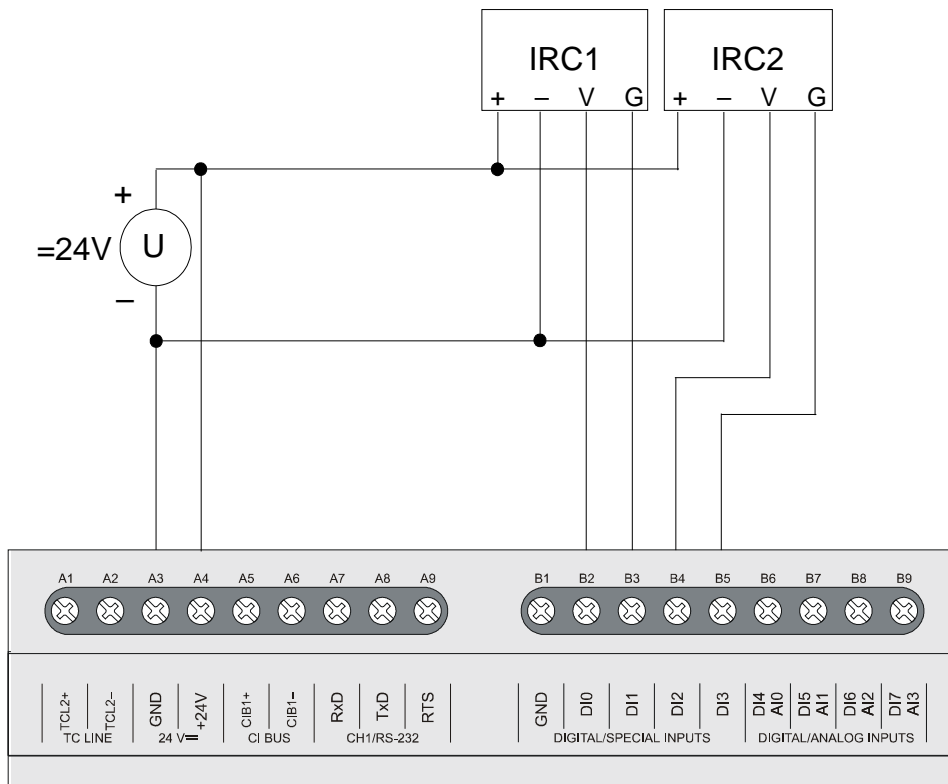
Fig.2.14　Example of the two incremental encoders (IRC) connection
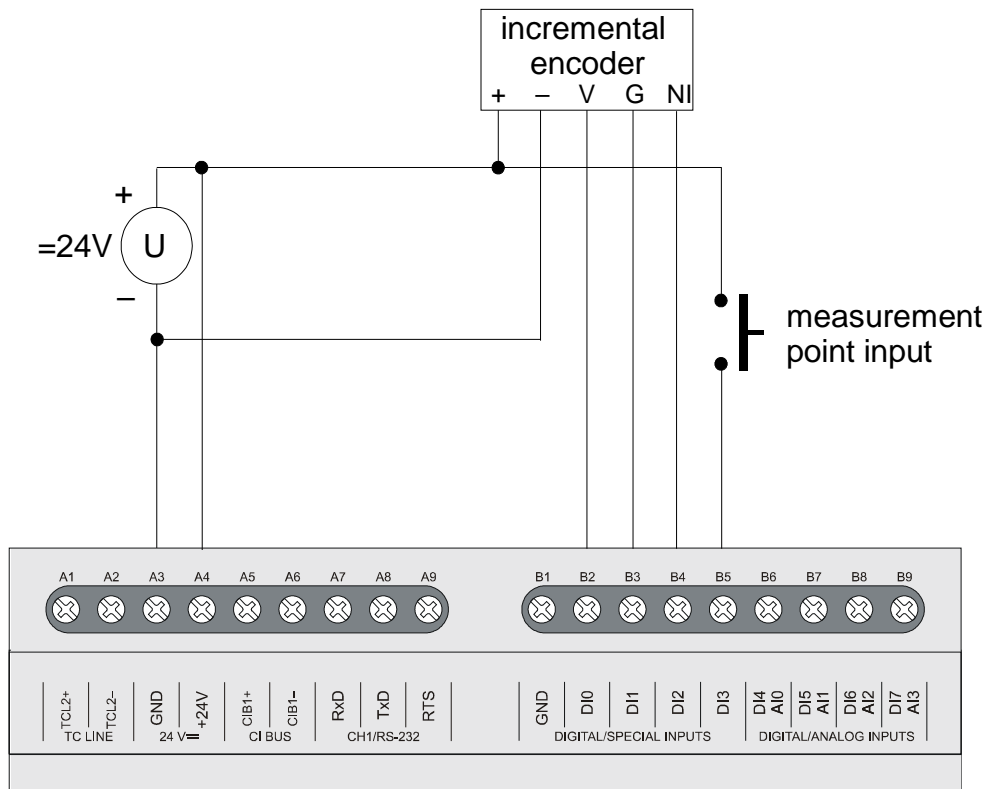
Fig.2.15   Example of the IRC incremental encoder complete connection

2.3.5   Data provided by the IR-1055, IR-1057 boards

Central units CP-1004, CP-1014 provide data connected with the serial communication (ETH1, CH1, CH2 interfaces). Details are to be found in the manual Serial communication PLC TECOMAT - model 32 bits (TXV 004 03.02).

The peripheral part of the module, IR-1055, respectively IR-1057 boards provide information on inputs and outputs. The data structure is apparent in the panel *I/O Settings* in the Mosaic development environment (Fig.2.16) (icon 10).

Structure items have assigned symbolical names which, for the IR-1055, IR-1057 boards start always with *r0_p3_* characters. In the column *Full entry,* the concrete symbolical name for the given item is always stated. If we want to use data in the user program, we use this symbolical name or in the column *Alias* we enter our own symbolical name which can then be used. In no case do we use absolute operands since they can alter after the compilation of the user program.

Fig.2.16   IR-1055, respectively IR-1057 boards data structure

Input data

DI   - binary input values (8times boolean type)

DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DI0 - DI3 - binary inputs useable for counters
DI4 - DI7 - binary inputs useable for analog measurements
     If an individual input is used for analog measuring, then the corresponding DI bit has permanently the value of 0.

DIP   - binary input values with short impulse detection (8times boolean type)

0	0	0	0	DIP3	DIP2	DIP1	DIP0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DIP0 - DIP3 - input values DI0 - DI3 with artificial prolongation of selected level during one cycle (detection of short impulses)

CNT_IN1   - counter input object 1 (*TCNTF_IN* structure)

CNT_IN1~SCNT - counter status word 1 (16times boolean type)

0	0	0	EPS	EMD	ENI	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EV   - 1 - active edge tag on DI0 (according to the mode)
EG   - 1 - active edge tag on DI1 (according to the mode)
ENI   - 1 - active edge tag on DI2 (according to the mode)
EMD   - 1 - active edge tag on DI3 (according to the mode)
EPS   - 1 - achieved preset tag
EVB   - 1 - active edge tag on DI1 (B counter)
EPSB - 1 - achieved preset tag (B counter)

CNT_IN1~VALA - first input value - interpretation according to the counter mode (udint type)
- counter value 1 (counter and IRC)
- period during which the input is in log.1 (impulse length measurement)
- period or phase shift (period measuring)

CNT_IN1~VALB - second input value - interpretation according to the counter mode (udint type)
- counter value 1B (pair of counters)
- captured value (counter and IRC with capturing and resetting)
- period during which the input is in log.0 (impulse length measurement)

CNT_IN2   - counter inputs object 2 (*TCNTF_IN* structure)

CNT_IN2~SCNT - counter status word 2 (16times boolean type)

0	0	0	EPS	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EV   - 1 - active edge tag on DI2 (according to the mode)

EG   - 1 - active edge tag on DI3 (according to the mode)
EPS   - 1 - achieved preset tag
EVB   - 1 - active edge tag on DI3 (B counter)
EPSB - 1 - achieved preset tag (B counter)

CNT_IN2~VALA - counter value 2 (udint type)

CNT_IN2~VALB - counter value 2B (pair of counters - udint type)

AI0, AI1, AI2, AI3 - analog inputs objects AI0 - AI3 (*TAI* structure)

AIn~STAT   - analog input AIn status word (16times boolean type)

0	0	0	FLS	OVF	OVR	0	0
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

bit

FLS - 1 - invalid measured value (during module launching after switch-on)
OVF - 1 - range overflow (input value exceeded the nominal range by 5%)
OVR - 1 – range exceeding (input value exceeded the nominal range)

AIn~FS   - AIn analog input value (int type)
The minimum input value matches with the value 0, the maximum value matches with the value 31500, whereas is valid that 100% of the nominal range of the analog input matches the value *FS* = 30000.

AIn~ENG   - AIn analog input value (real type)
Value of measured voltage in volts.

AIn~PCT   - AIn analog input value (real type)
The percentage relation between the measured and the nominal value of the analog input. For the value *FS* = 0 applies the value *PCT* = 0% and for the value *FS* = 30000 applies the value *PCT* = 100%.

Output data

DO   - binary output values (8times boolean type)

0	0	DO5	DO4	DO3	DO2	DO1	DO0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DO0 - DO5 - relay outputs

CNT_OUT1   - counter output object 1 (*TCNTF_OUT* structure)

CNT_OUT1~CCNT - counter control word1 (16times boolean type)

0	FMD	MD	NI	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

bit

IN1	IN0	0	MOD	FCB	SETB	RESB	ENB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EN   - 0 - counter 1 stopped
        1 - counter 1 counts
RES   - 1 - counter 1 reset and clearing
SET   - 1 - counter 1 set to the *SET* value

FC   - 0 - counter 1 runs free
          1 - clear counter 1 from the SET value gained

NI   - 1 - clear counter 1 from the signal NI

MD   - 1 - MD signal capturing approved

FMD   - 0 - clear counter 1 from MD signal
          1 - capture current value of the counter 1 into *VALB* from the MD signal

ENB   - 0 - counter 1B stopped
          1 - counter 1B counts

RESB - 1 - counter 1B reset and its clearing

SETB - 1 - setting counter 1B to the SET value

FCB   - 0 - counter 1B runs free
          1 - clear counter 1B from the SET value gained

MOD   - 0 - period measuring
          1 - phase shift measuring

IN1-IN0 - selection of measured input for impulse length or period measurements
          00 - input DI0
          01 - input DI1
          10 - input DI2
          11 - input DI3

CNT_OUT1~SET - counter 1 preset

CNT_OUT2   - counter outputs object 2 (*TCNTF_OUT* structure)

CNT_OUT2~CCNT - counter 2 control word (16times boolean type)

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	FCB	SETB	RESB	ENB
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter 2 stopped
          1 - counter 2 counts

RES   - 1 - counter 2 reset and clearing

SET   - 1 - counter 2 set to the value SET

FC   - 0 - counter 2 runs free
          1 - clear counter 2 from the *SET value* gained

ENB   - 0 - counter 2B stopped
          1 - counter 2B counts

RESB - 1 - counter 2B reset and its clearing

SETB - 1 - counter 2B set to the SET value

FCB   - 0 - counter 2B runs free
          1 - clear counter 2B from the *SET value* gained

CNT_OUT2~SET - counter 2 preset

The behaviour of individual data objects is described in the following chapter.

2.3.6 Initialization and behaviour of individual data objects of the IR-1055, IR-1057 boards

The peripheral part of modules CP-1004, CP-1014, IR-1055, respectively IR-1057 boards, contains a block of binary inputs and outputs, two counter objects and an analog input block.

The panel for parameters setting of the IR-1055, respectively IR-1057 boards can be opened from the Project manager *HW | Configuration HW* (Fig.2.17). In the folder *CPU* on the line I/O click on the ☑ icon.
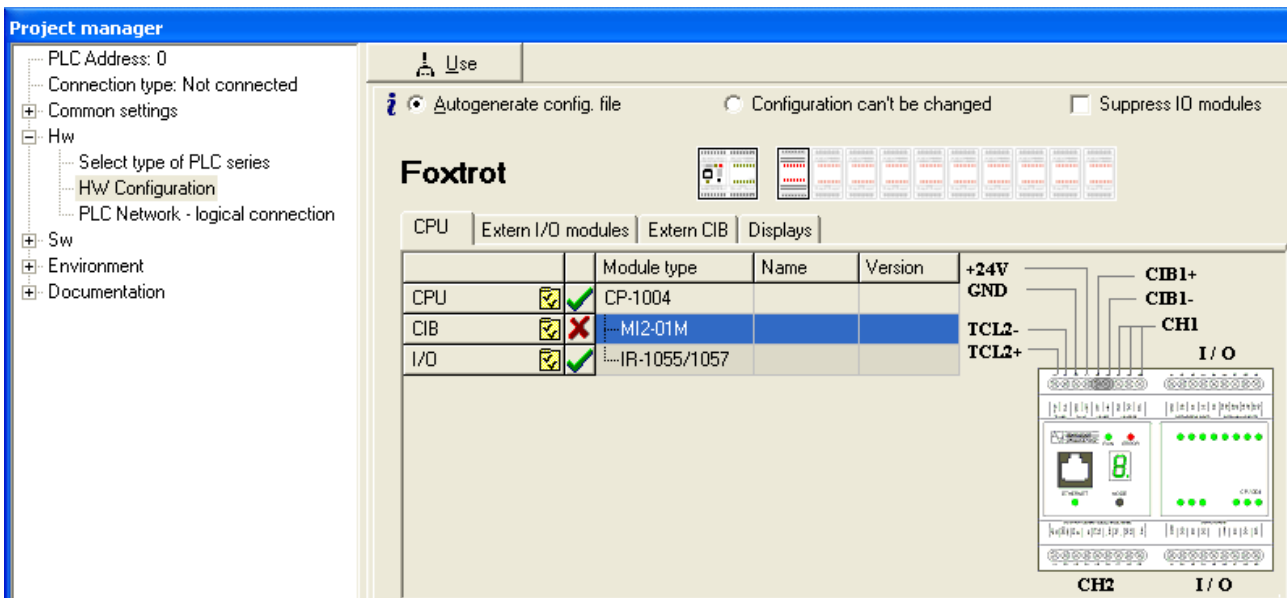
Fig.2.17   Configuration of the CP-1004 basic module

Binary inputs

Binary inputs state is contained in the DI variable. The state of all universal inputs DI0 – DI3 is valid also in cases when inputs are used for alternative functions (capturing of short impulses, inputs for counters). The status of universal inputs DI4 - DI7 is valid only in such cases when inputs are not used as analog inputs.
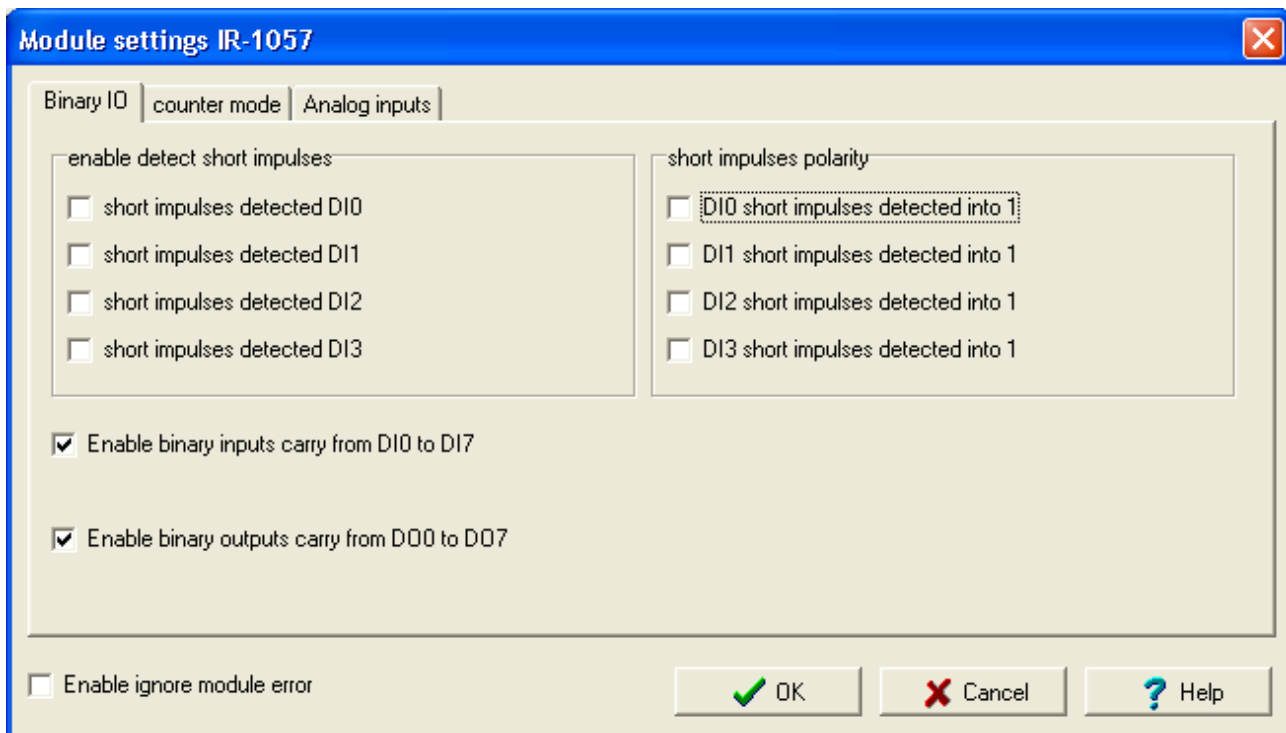
Fig.2.18   Configuration of binary inputs and outputs

If we check an item *Enable ignore module error* at the bottom side of *IR-1057 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialise the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5).

Configuration of binary inputs is located in the folder *Binary IO* (Fig.2.18). By ticking the option *Switch-on of transfer of binary inputs DI0 to DI7* we can enable the transfer of current states of all eight inputs into the PLC notepad. If this option is not ticked, the relevant values are not transferred into the PLC notepad.

This option has no influence on inputs configuration. Individual inputs DI4 - DI7 behave as binary only when they are not used as analog inputs AI0 - AI3 (in the folder *Analog inputs* the channel with the corresponding number is not ticked).

It is possible to activate the function of short impulses capturing within each input DI0 to DI3 individually. By ticking the option *short impulses are detected,* we can activate the function of capturing short impulses for the according input. If the option *short impulses detected into 1 of the correspondent inputs* is ticked, then the function of short impulses capturing into log.1 is activated, otherwise, the function of short impulses capturing into log.0 is activated. If one of the options is not available, it means that the relevant input is already occupied by a counter function.

If we have the input signal which is mainly in the state of log.1 and impulses onto log.0 occur within that are shorter then the longest possible PLC cycle period, then a loss of such impulses can occur because only such states of inputs are standardly transferred into the PLC that occur at the time of one cycle turn of the central unit. If we switch the detection of short impulses for the log.0 on, then its changes are detected on the correspondent input. If the value log.0 appears on the input during the cycle scan, then it will stay saved in the module memory until the nearest data transfer to the central unit, even though the value log.1 is on the input at the time of the data transfer.

The same applies by analogy for the input signal which is mainly in log.0 and short impulses onto log.1 appear on him. We switch the detection of short impulses for the log.1 on and the short-term value of log.1 on the input is prolonged until the cycle scan.

The input state with short impulse detection switched on is contained in *DIP* variable.
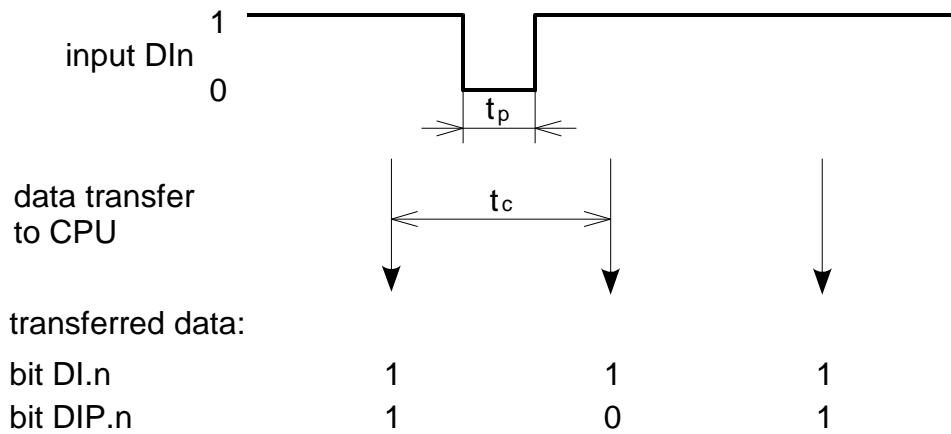
Fig.2.19   Detection of short impulses into log.0 function
            t_p -pulse width, t_c =PLC cycle period
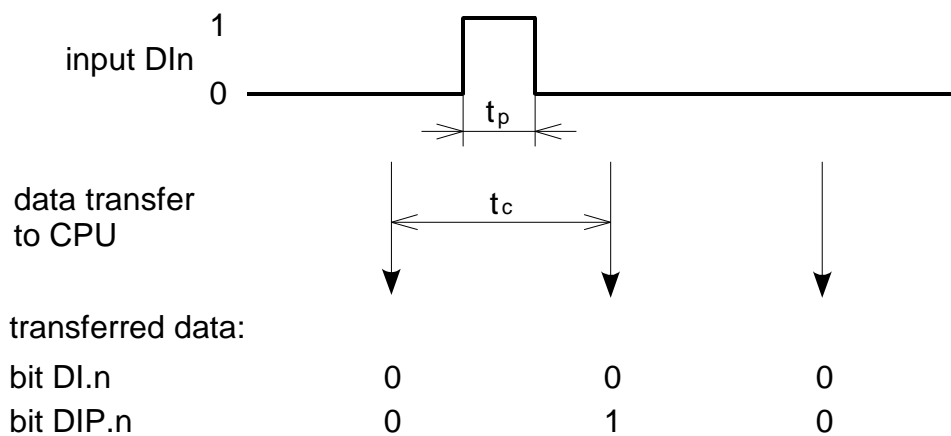
Fig.2.20   Detection of short impulses into log.1 function
            t_p -pulse width, t_c =PLC cycle period

Binary outputs

The binary outputs state is contained in the *DO* variable. The configuration of binary outputs can be found in the folder *Binary IO* (Fig.2.18). By ticking the option S*witch-on of transfer of binary inputs,* we can enable the transfer of current states of all six inputs into the PLC notepad. If this option is not ticked, the relevant values are not transferred and the outputs are not set.

Analog inputs

CP-1004, CP-1014 modules contain 4 analog inputs AI0 to AI3 that have fixed measuring range from 0 to 10 V. Each input has 4 variables *STAT*, *FS*, *ENG* and *PCT*. The *STAT* status is transferred always, among variables *FS*, *ENG* and *PCT* we choose one depending on the interpretation of measured values we require. The configuration of analog inputs can be found in the folder *Analog inputs* (Fig.2.21).
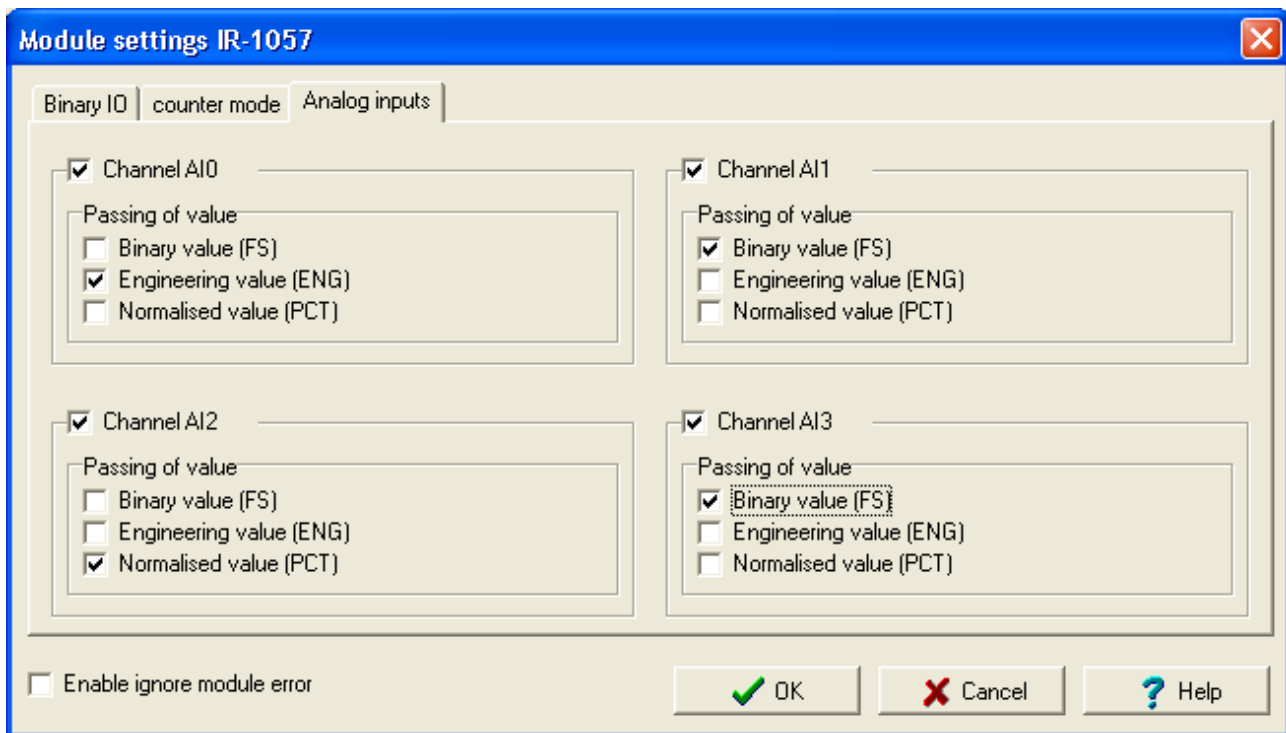
Fig.2.21   Configuration of analog inputs

It applies generally, that if we tick the box *Channel AIn*, the corresponding input will behave as an analog AIn. If the box *Channel AIn* is not ticked, the corresponding input will behave as a binary DIn+4.

The transferred value in the FS variable is an int. type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. Simultaneously, it applies that 100% of the nominal range of the analog input corresponds to *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents current in volts directly.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between the measured and nominal values of the analog input. The *PCT* variable is related to the *FS* variable. It applies that the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach the maximum value of 105% which corresponds to *FS* = 31500.
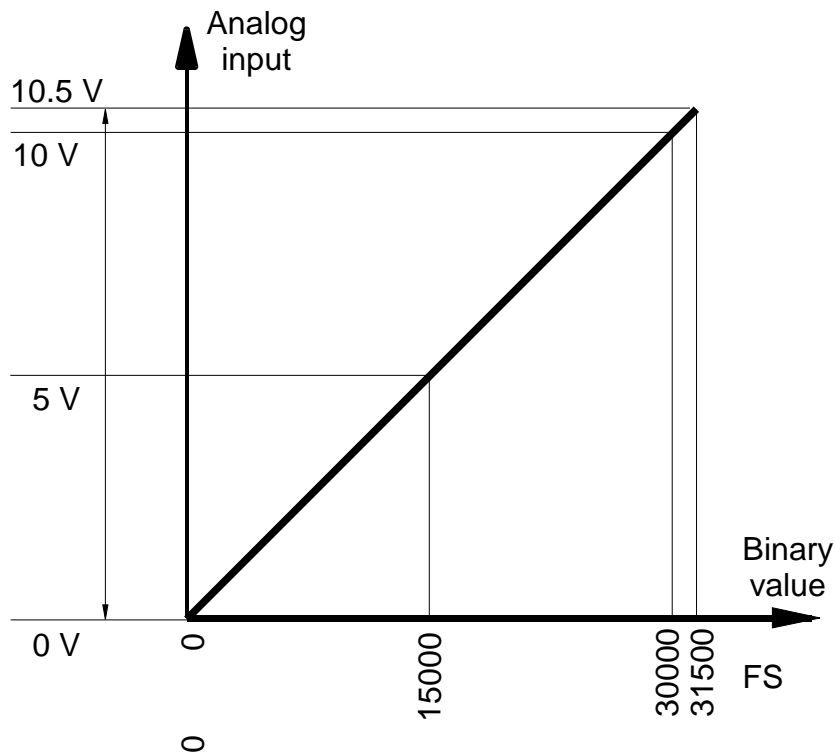
Fig.2.22   Current range of analog inputs of the modules CP-1004, CP-1014

Table 2.29   Transferred values of analog inputs of the modules CP-1004, CP-1014

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 10,5 V	$000C	31500	10,5	105	range overflow
10,5 V	$0004	31500	10,5	105	range exceeding
:	$0004	:	:	:	
10 V	$0000	30000	10	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Counters

CP-1004, CP-1014 modules contain two counter objects which use inputs DI0 to DI3 and they can be set to various operation modes. These modes can be basically divided into two groups. The first group is represented by modes that always use two inputs. The first counter object uses inputs DI0 and DI1, the second counter object uses inputs DI2 and DI3. Both counter objects can be set to a random mode within this group and each can work in a different mode.

The group of basic modes of counter objects constitutes of the following modes:

♦ No counter
♦ One one-way counter
♦ Two one-way counters
♦ Two-way counter
♦ Counter with controlled direction
♦ Basic IRC

The second group of basic modes of counter objects constitutes of the following modes:

♦ Two-way counter with resetting and capturing
♦ Counter with controlled direction and with capturing and resetting
♦ IRC with capturing and resetting
♦ Impulse length measuring
♦ Period and phase shift measuring

These modes use all four inputs DI0 to DI3 and they can be set only in the first counter object. The second counter object is always switched off. Counters configuration can be found in the folder *Counter mode* (Fig.2.23).
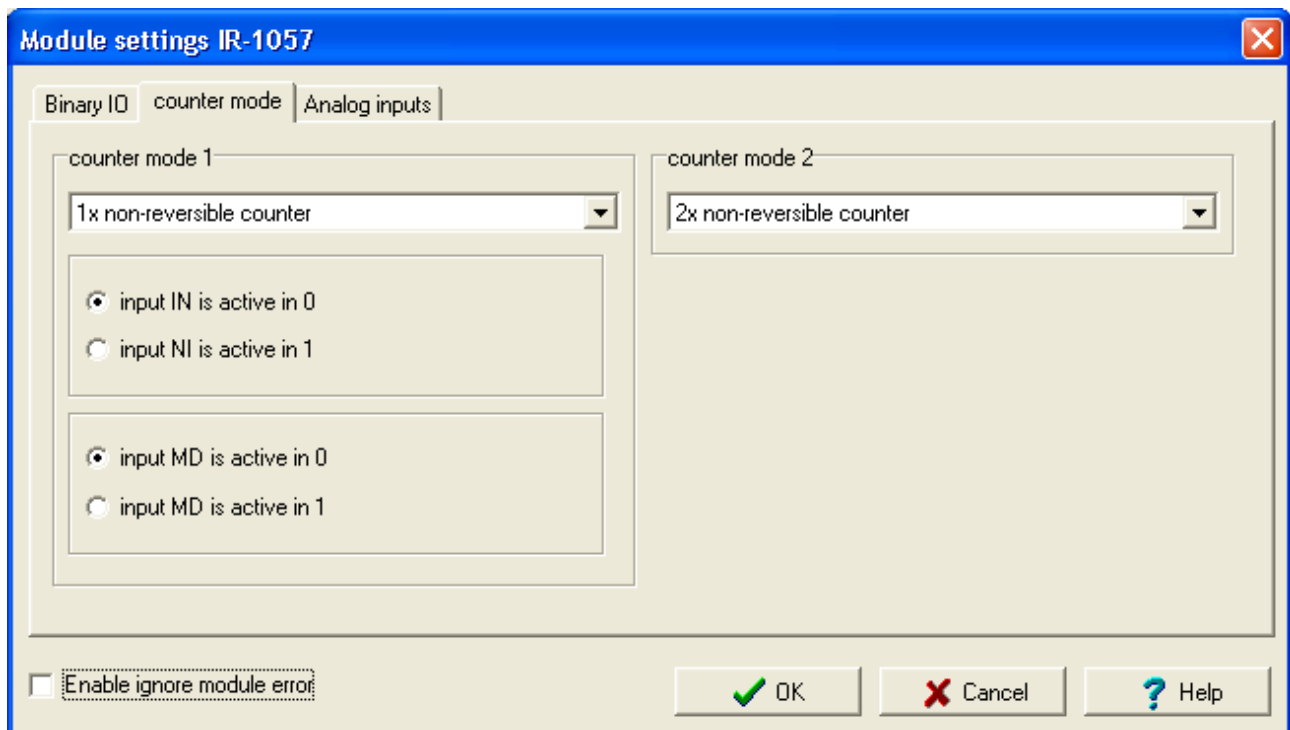
Fig.2.23   Counters configuration

For counter modes from the second group, it is possible to set the signal polarity NI and MD. If we switch the option *input NI is active in 1* on, then the transfer of the signal from state 0 to state 1 will be understood as the entering edge. If we switch the option *input NI*

is active in 0 on, then the transfer of the signal from state 1 to state 0 will be understood as the entering edge. The same applies for the MD signal.

We will now describe functions of individual counter object modes.

One one-way counter

The counter object contains one one-way counter of external events (*VALA* variable) equipped with the UP input counter (DI0 or DI2 rather) and with a preset (SET variable).

If the entering edge appears on the UP input, the counter increases its content by 1 and in the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on input. If the resultant content of the counter is the same as the *SET* variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If, simultaneously, the FC bit is set to log.1 in the control word, the counter content will be automatically reset.

The control word can also control the counter run (bit *EN*), counter reset (bit *RES*), or set its content to a SET variable value (*SET* bit entering edge).

SCNT - counter status word

0	0	0	PS	0	0	0	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV - 1 - entering edge tag on the UP input
PS - 1 - achieved preset tag

CCNT - counter control word

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN - 0 - counter stopped
        1 - counter counts
RES   1 - counter reset and its clearing
SET   1 - setting counter to the *SET* variable value
FC   0 - counter free run
        1 - clearing the counter after the variable SET value is reached

Two one-way counters

The counter object contains two one-way counters of external events (VALA and VALB variables) equipped with UP (DI0 or DI2) and UPB (DI1 or DI3) input counters and a joint preset (SET variable).

If the entering edge appears on the UP input, the counter A increases its content by 1 and in the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the resultant content of the counter A is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If, simultaneously, the FC bit is set to log.1 in the control word, the counter content will be reset automatically.

If by analogy the entering edge appears on the UPB input, the counter B increases its content by 1 and in the status word, in the EVB bit, the log.1 during one PLC cycle will show as the entering edge tag. If the resultant content of the counter B is the same as the

SET variable value, then in the status word, in the PSB bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FCB bit is set to log.1 in the control word, the counter content will be reset automatically.

The control word can also control the counters run (*EN and ENB* bit), reset the counter (*RES and RESB* bit), or set their content to a SET variable value (*SET and SETB* bit). The *SET* variable is common to both counters, however, it is possible to change it whenever during the operation.

SCNT - counter status word

0	0	0	PS	0	0	0	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	PSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input UP
PS   - 1 - achieved preset tag counter A
EVB   - 1 - entering edge tag on input UPB
PSB   - 1 - achieved preset tag counter B

CCNT - counter control word

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	FCB	SETB	RESB	ENB
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter A stopped
        1 - counter A counts
RES   1 - counter A reset and its clearing
SET   1 – setting counter A to the SET variable value
FC   0 - counter A free run
        1 – clearing counter A when SET variable value is gained
ENB   0 - B counter stopped
        1 - B counter counts
RESB   1 - counter B reset and its clearing
SETB   1 - setting counter B to the SET variable value
FCB   0 - counter B free run
        1 - clearing counter B when SET variable value is gained

Two-way counter

The counter object contains one two-way counter of external events (*VALA* variable) equipped with UP (DI0 or DI2), DOWN (DI1 or DI3) counter inputs and a preset (SET variable).

If the entering edge appears on the UP input, the counter increases its content by 1 and in the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the entering edge appears on the DOWN input, the counter decreases its content by 1 and in the status word, in the EG bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FC bit is set to log.1 in the control word, the counter content will be automatically cleared.

The control word can also control the counters run (*EN* bit), reset the counter (*RES* bit), or set its content to a SET variable value (entering edge of the *SET* bit).

SCNT - counter status word

0	0	0	PS	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input UP
EG   - 1 - entering edge tag on input DOWN
PS   - 1 - achieved preset tag

CCNT - counter control word

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped
         1 - counter counts
RES   1 - counter resetting and clearing
SET   1 - setting counter to SET variable value
FC   0 - counter free run
         1 - clearing the counter after variable SET value is gained

Counter with controlled direction

The counter object contains one two-way counter of external events (*VALA* variable) equipped with a CLK input counter (DI0 or DI2), input for assessment of the direction of counting DIR (DI1 or DI3) and a preset (SET variable).

If the entering edge appears on the CLK input, then providing that the DIR input has the value of log.1, the counter increases its content by 1, consequently, if the DIR input has the value of log.0, the counter decreases its content by 1. In the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If, simultaneously, the FC bit is set to log.1 in the control word, the counter content will be automatically cleared.

The control word can also control the counters run (*EN* bit), reset the counter (*RES* bit), or set its content to a SET variable value (entering edge of the *SET* bit).

SCNT - counter status word

0	0	0	PS	0	0	0	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input CLK
PS   - 1 - achieved preset tag

CCNT - counter control word

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped
          1 - counter counts
RES   1 - counter resetting and clearing
SET   1 - setting counter to the SET variable value
FC   0 - counter free run
          1 - clearing the counter after variable SET value is gained

Basic IRC

The counter object enables the connection of an incremental position sensor with outputs with open collectors (*VALA* variable). Both tracks V (DI0 or DI2) and G (DI1 or DI3) only can be connected. The clearing impulse is not connected. The preset (SET variable) is also available.

If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FC bit is set to log.1 in the control word, the counter content will be automatically cleared.

The control word can also control the counter run (*EN* bit), reset the counter (*RES* bit), or set its content to a SET variable value (*SET* bit).

SCNT - counter status word

0	0	0	PS	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input UP
EG   - 1 - entering edge tag on input DOWN
PS   - 1 - achieved preset tag

CCNT - counter control word

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped
          1 - counter counts
RES   1 - counter resetting and clearing
SET   1 - setting counter to the SET variable value
FC   0 - counter free run
          1 - clearing the counter after variable SET value is gained

Two-way counter with clearing and capturing

The counter object contains one two-way counter of external events (*VALA* variable) equipped with UP (DI0), DOWN (DI1) counter inputs, CLR clearing input (DI2), CAP capturing input (DI3) and a preset (SET variable). This mode can be set in the first counter object only. The second object must be switched off.

If the entering edge appears on the UP input, the counter increases its content by 1 and in the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the entering edge appears on the DOWN input, the counter decreases its contents by 1 and in the status word, in the EG bit, the log.1 during one PLC cycle will show as an entering edge tag on input. If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FC bit is set to log.1 in the control word, the counter content will be cleared automatically.

If the entering edge appears on the CLR input up to the level which has been selected during the configuration as active, the content will be cleared, by a single application, providing that in the control word is the NI bit set to log.1.

The CAP input is multipurpose. It can be used for the counter clearing or for values capturing. The *FMD* bit in the control word acts as a switch of these functions.

If the entering edge appears on the CAP input up to the level which has been selected during the configuration as active, the counter content will be copied into the *VALB* variable providing that in the control word *MD* and *FMD* bits are set to log.1.

If the entering edge appears on the CAP input up to the level which has been selected during the configuration as active, the counter content will be cleared, by a single application, providing that in the control word the *MD* bit is set to log.1 and the *FMD* bit is set to log.0.

The control word can also control the counter run (*EN* bit), reset the counter (*RES* bit), or set its content a SET variable value (*SET* bit).

SCNT - counter status word

0	0	0	PS	EMD	ENI	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input UP
EG   - 1 - entering edge tag on input DOWN
ENI - 1 - active edge tag on input CLR
EMD - 1 - active edge tag on input CAP
PS   - 1 - achieved preset tag

CCNT - counter control word

0	FMD	MD	NI	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped
       1 - counter counts
RES 1 - counter resetting and clearing
SET 1 - setting counter to the SET variable value
FC   0 - counter free run
       1 - clearing the counter after variable SET value is gained

NI   - 1 - counter clearing from the input CLR
MD   1 - approval of input CAP
FMD   0 - clear counter from the input CAP
           1 – capturing of the current value of the counter into the VALB variable from the CAP input

Counter with controlled direction with clearing and capturing

The counter object contains one two-way counter of external events (*VALA* variable) equipped with a CLK input counter (DI0), input for assessment of the direction of counting DIR (DI1), CLR clearing input (DI2), CAP capturing input (DI3) and a preset (SET variable). This mode can be set in the first counter object only. The second object must be switched off.

If the entering edge appears on the CLK input, then providing that the DIR input has the value of log.1, the counter increases its content by 1 and consequently, if the DIR input has the value of log.0, the counter decreases its content by 1. In the status word, in the EV bit, the log.1 during one PLC cycle will show as an entering edge tag on the input. If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FC bit is set to log.1 in the control word, the counter content will be cleared automatically.

If the entering edge appears on the CLR input up to the level which has been selected during the configuration as active, the counter content will be cleared, by a single application, providing that the in control word is the NI bit set to log.1.

The CAP input is multipurpose. It can be used for the counter clearing or for values capturing. The *FMD* bit in the control word acts as a switch of these functions.

If the entering edge appears on the CAP input up to the level which has been selected during the configuration as active, the current counter content will be copied into the *VALB* variable providing that in the control word *MD* and *FMD* bits are set to log.1.

If the entering edge appears on the CAP input up to the level which has been selected during the configuration as active, the content will be cleared, by a single application, providing that in the control word the *MD* bit is set to log.1 and the *FMD* bit is set log.0.

The control word can also control the counter run (*EN* bit), reset the counter (*RES* bit), or set its content to a SET variable value (*SET* bit).

SCNT - counter status word

0	0	0	PS	EMD	ENI	0	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input CLK
ENI   - 1 - active edge tag on input CLR
EMD   - 1 - active edge tag on input CAP
PS   - 1 - achieved preset tag

CCNT - counter control word

0	FMD	MD	NI	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped

	1 - counter counts
RES	1 - counter resetting and clearing
SET	1 - setting counter to the SET variable value
FC	0 - counter free run
	1 - clearing the counter after variable SET value is gained
NI	1 – counter clearing from input CLR
MD	1 - approval of input CAP
FMD	0 – counter clearing from CAP input
	1 – capturing of the current value of the counter into the VALB variable from CAP input

IRC with clearing and capturing

The counter object enables the connection of an incremental position sensor with outputs with open collectors (*VALA* variable). Both tracks V (DI0) and G (DI1), clearing impulse NI (DI2) and measuring contact MD (DI3) may be connected.

The preset (SET variable) is also available. This mode can be set in the first counter object only. The second object must be switched off.

If the resultant content of the counter is the same as the SET variable value, then in the status word, in the PS bit, the log.1 during one PLC cycle will show as an achieved preset tag. If the FC bit is set to log.1 in the control word, the counter content will be cleared automatically.

If the entering edge appears on the NI input up to the level which has been selected during the configuration as active, the counter content will be cleared, by a single application, providing that in the control word the NI bit is set to log.1.

The MD input can be used both for the counter clearing or for value capturing. The *FMD* bit in the control word acts as a switch of these functions.

If the entering edge appears on the MD input up to the level which has been selected during the configuration as active, the current counter content will be copied into the *VALB* variable providing that in the control word *MD* and *FMD* bits are set to log.1.

If the entering edge appears on the MD input up to the level which has been selected during the configuration as active, the counter content will be cleared, by a single application, providing that in the control word the *MD* bit is set to log.1 and the *FMD* bit to log.0.

The control word can also control the counter run (*EN* bit), reset the counter (*RES* bit), or set its content to a SET variable value (*SET* bit).

SCNT - counter status word

0	0	0	PS	EMD	ENI	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - entering edge tag on input UP
EG   - 1 - entering edge tag on input DOWN
ENI   - 1 - active edge tag on input CLR
EMD - 1 - active edge tag on input CAP
PS   - 1 - achieved preset tag

CCNT - counter control word

0	FMD	MD	NI	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - counter stopped
         1 - counter counts
RES   1 - counter resetting and clearing
SET   1 - setting counter to the SET variable value
FC   0 - counter free run
         1 - clearing the counter after SET variable is gained
NI   1 – counter clearing from input NI
MD   1 - approval of input MD
FMD   0 - counter clearing from input MD
         1 – capturing of the current value of the counter into the VALB variable from the MD input

Impulse length measurement

The counter object enables measuring of the impulse length on any of the four DI0 – DI3 inputs. This mode can be set in the first counter object only. The second object must be switched off.

The length of the log.1 level period is measured by the *VALA* variable, the length of the log.0 level period is measured by the *VALB* variable. The validity of the measured values is indicated by tags EV (valid length of the log.1 level) and EG (valid length of the log.0 level) in the status word. The measured values are stated in microseconds (the values represent the average value of the last eight measurings by IR-1055 board)

It is possible to activate the measuring (*EN* bit) and select the measured input (*IN0* and *IN1* bits) using the control word.

SCNT - counter status word

0	0	0	0	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 valid length of the log.1 level tag
EG   - 1 - valid length of the log.0 level tag

CCNT - counter control word

0	0	0	0	0	0	0	EN
.7	.6	.5	.4	.3	.2	.1	.0

IN1	IN0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - measuring deactivated
         1 - measuring activated
IN1-IN0 - selection of measured input
         00 - input DI0
         01 - input DI1
         10 - input DI2
         11 - input DI3

Period and phase shift measuring

The counter object enables measuring of a period on any of the four DI0 - DI3 inputs or of a phase shift between the inputs DII and DI0. This mode can be set in the first counter object only. The second object must be switched off.

The period length between two increasing edges of a chosen input signal or the phase shift value between two increasing edges of a chosen input signal DII and DI0 are measured within the *VALA* variable. The validity of the measured values is indicated by the EV tag in the status word. Measured values are stated in microseconds (they are represented by an average value of the last eight measurings by IR-1055 board).

It is possible to activate the measuring (*EN* bit), to switch between the measuring of period or phase shift (*MOD* bit) and to choose the measured input for period measuring (*IN0* and *IN1*).

SCNT - counter status word

0	0	0	0	0	0	0	EV
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EV   - 1 - - valid measured value tag

CCNT - counter control word

0	0	0	0	0	0	0	EN
.7	.6	.5	.4	.3	.2	.1	.0

IN1	IN0	0	MOD	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

EN   - 0 - measuring deactivated
        1 - measuring activated
MOD   0 - period measuring
        1 - phase shift measuring
IN1-IN0 - selection of measured input for the period measuring
        00 - input DI0
        01 - input DI1
        10 - input DI2
        11 - input DI3

2.4   PERIPHERAL PART OF MODULES CP-1005, CP-1015

The peripheral part of modules CP-1005, CP-1015 constitutes of the IR-1056 board containing 6 multipurpose inputs, 6 relay outputs and 2 analog outputs. Inputs can be used as binary inputs DI0 - DI5 or as analog inputs AI0 - AI5. Under the name IR-1056, the processor operating these inputs and outputs appears on the system bus.
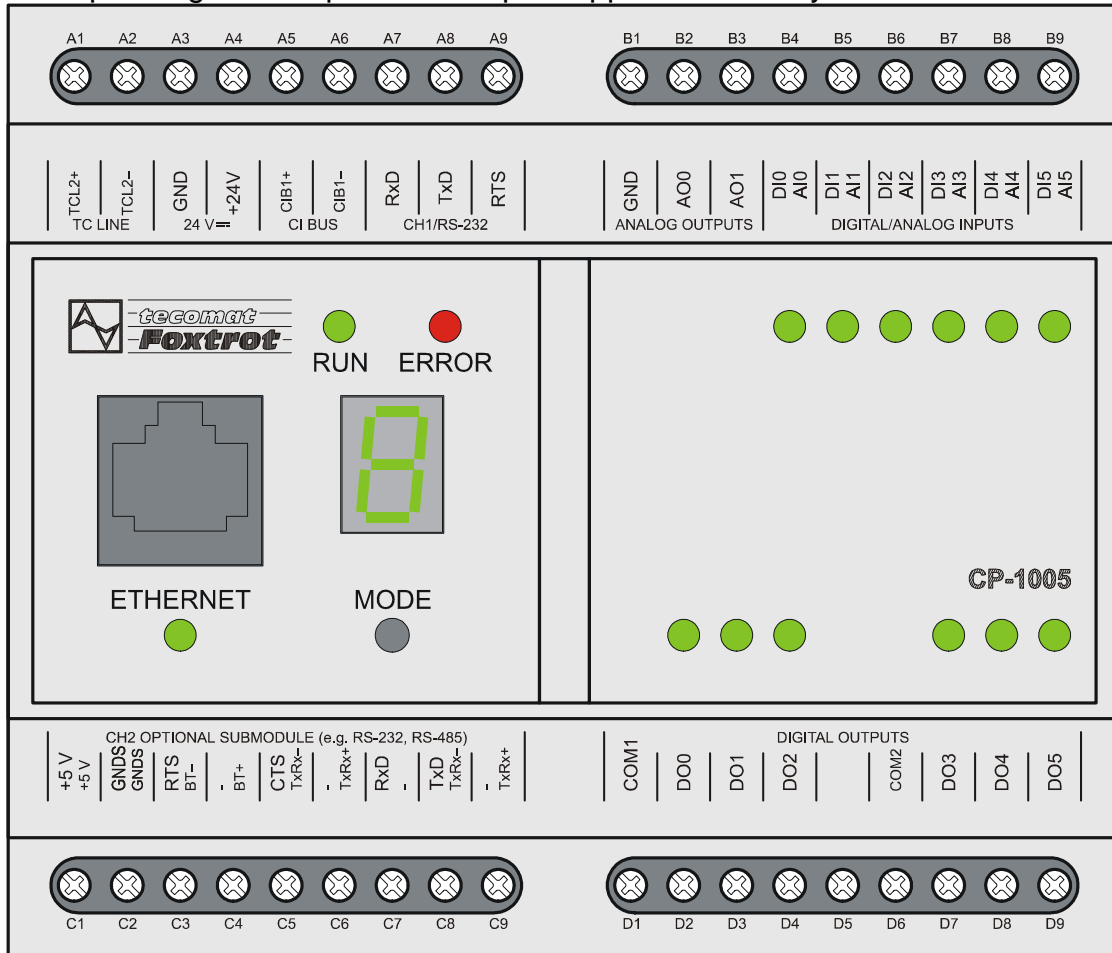

Fig.2.24   Basic module CP-1005

In the table 2.30 it is described the connection of terminals in terminal boards B and D. The integration of a terminal board A is common for all basic modules and is shown in the table 2.3 in the introduction of the chapter 2. The integration of a terminal board C is dependant on the submodule fitted and its options are described in the chapter 2.2.2.

Table 2.30   The integration of terminal boards B and D of modules   CP-1005, CP-1015

B1	GND	module ground
B2	AO0	analog output AO0
B3	AO1	analog output AO1
B4	DI0 / AI0	binary input DI0 / analog input AI0
B5	DI1 / AI1	binary input DI1 / analog input AI1
B6	DI2 / AI2	binary input DI2 / analog input AI2
B7	DI3 / AI3	binary input DI3 / analog input AI3
B8	DI4 / AI4	binary input DI4 / analog input AI4
B9	DI5 / AI5	binary input DI5 / analog input AI5
D1	COM1	common conductor of outputs DO0 - DO2
D2	DO0	relay output DO0
D3	DO1	relay output DO1
D4	DO2	relay output DO2
D5		
D6	COM2	common conductor of outputs DO3 - DO5
D7	DO3	relay output DO3
D8	DO4	relay output DO4
D9	DO5	relay output DO5

2.4.1   Binary inputs

   Binary inputs serve for the connection of two-condition signals of the controlled object to the PLC. Basic modules CP-1005, CP-1015 contain 6 binary inputs DI0 – DI5. Inputs are not galvanically isolated from internal circuits of the PLC. The excitation (switching) is signalized by lighting up of the LED diode. All inputs have a joint minus terminal.
   Inputs can be used also as analog inputs AI0 - AI5. If the individual input is not used for the analog measurement, then it works as a binary input.

Attention!   Inputs used as binary inputs **must not have any jumpers inserted** within the set array in the bottom of the basic module CP-1005 (see chapter 2.4.3.).

Table 2.31   Basic parameters of binary inputs

Module type	**CP-1005, CP-1015 (IR-1056)**
Number of inputs	6
Number of inputs in the group	6
Galvanic isolation from internal circuits	ne
Diagnostics	signalization of the excited input on the panel
Joint conductor	minus
Input voltage	
for log.0 (UL)	max. +5 V DC
for log.1 (UH)	min. +12 V DC
	typ. +24 V DC
	max. +30 V DC
Input current at log.1	type 5 mA
Delay from log.0 to log.1	1 ms
Delay from log.1 to log.0	1 ms

   Binary inputs are bring out on terminal in the array DIGITAL / ANALOG INPUTS. In the fig.2.25 there is a schematical drawing of the connection of the switchers.
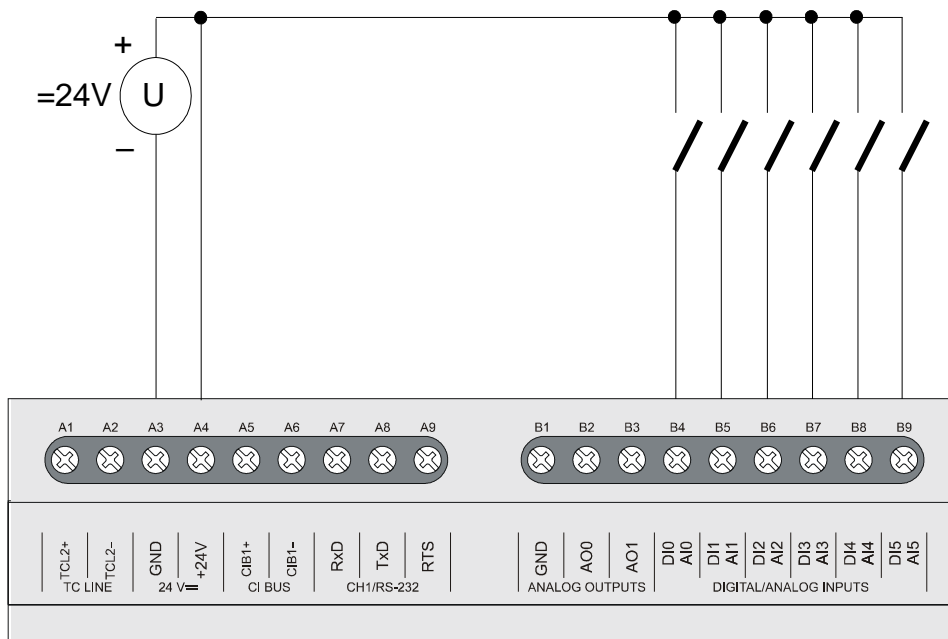
Fig.2.25   Typical example of the switchers connection to binary inputs of basic modules CP-1005, CP-1015

Attention!   It is necessary to bear in mind that terminals GND in arrays 24 V DC and ANALOG OUTPUTS are galvanically connected within inside of the system. It is not desirable to interconnect the terminal GND in the array ANALOG OUTPUTS to the negative terminal of the source of the supplying system and inputs because there would occur the closing of the loop via the second terminal GND and thus a possible induction of interfering signals could appear.

2.4.2   Relay outputs

Relay outputs serve to control two-state action and signaling elements of the controlled object supplied by alternating or direct current of up to 250V. The outputs are realized by a closing voltage-free contact relay brought out in a group with one joint terminal.

Basic modules CP-1005, CP-1015 contain 6 relay outputs DO0 - DO5 organized in two groups with three outputs each with the joint terminal. Outputs are galvanically isolated both from internal PLC circuits and also both groups between themselves. The excitation (switching) of the output is signalized by the lighting up of the relevant LED diode.

Binary input relays contacts are brought out to terminals in the DIGITAL OUTPUTS array. A schematic drawing of connections of loads powered by independent sources is shown in fig. 2.26. Protection against overload and short-circuit is undertaken using safety fuses for each input or for each group. The rated voltage and type of fuse is selected for each load and character of load differently while considering the maximum voltage and overload capacity of outputs or group of outputs. For example when using tube fuses with a T and F fuse characteristic and a switching rate of 35 A, it is possible to use a rated current of 3 A per fuse per output and fuses of up to 10A when protecting a joint group conductor.

Table 2.32   Basic parameters of relay outputs

| Module type	CP-1005, CP-1015 (IR-1056)
Number of inputs	6
Number of groups x number of outputs in group	2 x 3
Galvanic isolation from internal circuits	yes (even among groups)
Diagnostics	signalization of the excited output on the panel
Type of outputs	electromechanical relay, non-protected output
Contact type	switching
Switching voltage	max. 250 V min. 5 V
Switching current	max. 3 A min. 100 mA
Short-term overload of output	max. 4 A
Voltage through joint terminal	max. 10 A
Time of contact closure	type 10 ms
Time of contact opening	type 4 ms
Threshold limits of switched loads	
for resistant load	max. 3 A at 30 V DC or 230 V AC
DC13 for inductive load	max. 3 A at 30 V DC
AC15 for inductive load	max. 3 A at 230 V AC
Switching frequency without load	max. 300 switches / min.
Switching frequency with rated load	max. 20 switches / min.
Mechanical lifetime	min. 5 000 000 cycles
Electrical lifetime at max load	
for resistant load	min. 100 000 cycles
DC13 for inductive load	min. 100 000 cycles
AC15 for inductive load	min. 100 000 cycles
Short-circuit protection	none
Treatment of inductive load	external - RC input, varistor, diode (DC)
Insulation voltage	
between inputs and internal circuits	3750 V AC
between output groups	3750 V AC
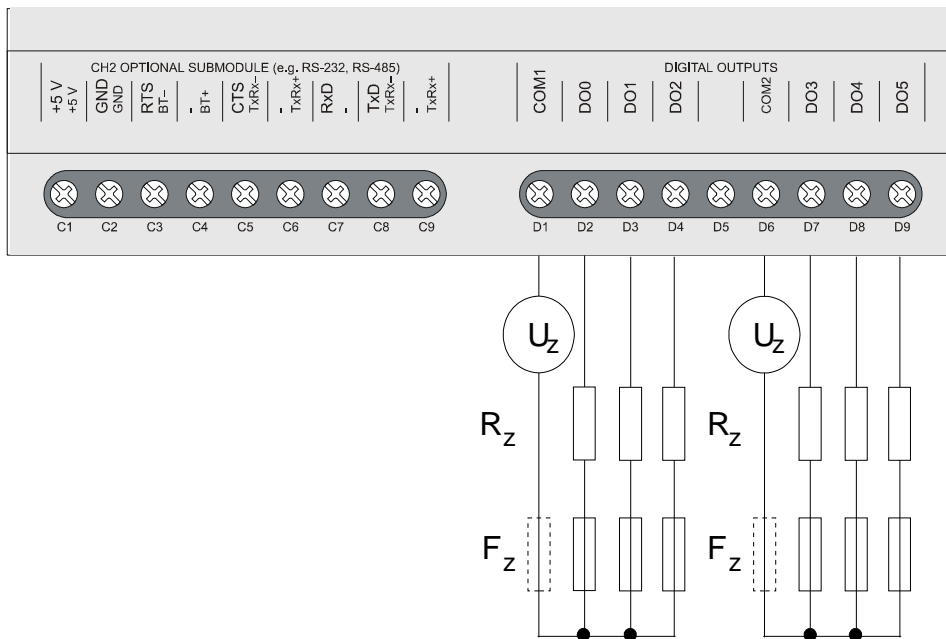
Fig.2.26   Typical example of the loads connection to relay outputs of basic modules CP-1005, CP-1015

The principle of different ways of the inductive load treatment, instruments of RC suppression elements proposal, an overview of sets of suppression elements supplied by the PLC producer and other recommendations are stated in the documentation The handbook for programmable automatons TECOMAT FOXTROT TXV 004 11.01 designing.

2.4.3   Analog inputs

Analog inputs are used for the connection of analog signals of the controlled object to the PLC. Basic modules CP-1005, CP-1015 contain 6 analog inputs AI0 – AI5 which are physically identical with DI0 – DI5 binary inputs. Inputs have no galvanic isolation from PLC internal circuits. All inputs have a joint minus terminal.

If the individual input is not used for the analog measurement, it works as a binary input.

It is necessary to configure individual inputs by jumpers within the set array in bottoms of basic modules CP-1005, CP-1015 (fig.2.27). According to use of individual inputs, we set the correspondent jumpers in conformity with the table 2.33.
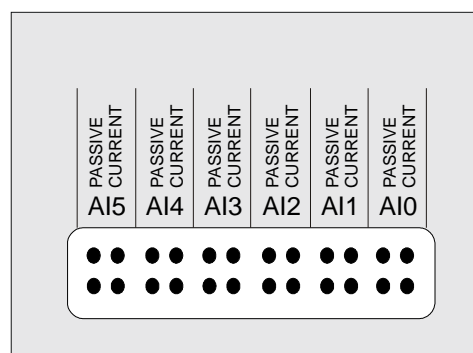

Fig.2.27   Set array in the bottom of the module CP-1005, CP-1015

Table 2.33   Inputs mode setting

Jumpers setting	Input application
PASSIVE CURRENT	
● ● ● ●	binary inputs DIn analog inputs AIn – voltage measurement
▮ ● 　 ●	analog inputs AIn – connection of passive resistor detectors
● ▮ ●	analog inputs AIn – current measurement

Analog inputs are brought out to the terminals in the array DIGITAL / ANALOG INPUTS. In the fig.2.28, there is a schematic drawing of the connection of individual sources of signals to analog inputs.

Table 2.34   Basic parameters of analog inputs

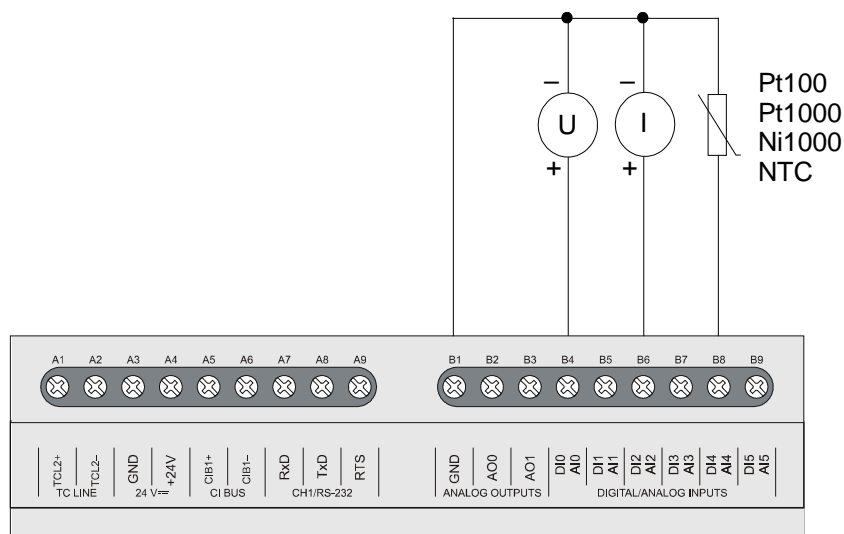| Module type	CP-1005, CP-1015 (IR-1056)
Number of inputs	6 (variant function of inputs DI0 - DI5)
Number of inputs in group	6
Galvanic isolation from internal circuits	none
Diagnostics	overload signalization in status word
Joint conductor	minus
External supply	none
Converter type	approximation
Digital display resolution	14 bits
Protection type	integrated surge guards
Insulation potential under the normal service conditions	none
Filtration	low-pass filter, digital comb filter 50/60 Hz
Internal calibration	auto calibration always after module switch-on
Measuring range / resolution (1 LSB) voltage compliance	0 up to +10 V / 1,4975 mV 0 up to +5 V / 748,75 µV 0 up to +2 V / 299,5 µV 0 up to +1 V / 149,75 µV 0 up to +0,5 V / 74,875 µV
current range	0 up to 20 mA / 2,995 µA 4 up to 20 mA / 2,995 µA
passive thermal sensor	Pt100 1,385 (−90 up to +400°C) Pt100 1,391 (−90 up to +400°C) Pt1000 1,385 (−90 up to +400°C) Pt1000 1,391 (−90 up to +400°C) Ni1000 1,617 (−60 up to +200°C) Ni1000 1,500 (−60 up to +200°C) NTC termistor 12 kΩ / 25°C (−40 up to +125°C)*
resistance transmitters	OV1000 (0 up to 1000 Ω)

*   From IR-1056 board firmware version 1.4

Fig.2.28   *Typical example of signals connection to analog inputs of basic modules CP-1005, CP-1015 (individual signal types are connectable to any analog input)*

Table 2.35   Basic parameters of input current ranges

Module type	CP-1005, CP-1015 (IR-1056)
Input impedance within the signal range	> 50 kΩ

Analog input error
  max. error at 25 ℃
  temperature coefficient
  non-linearity
  repeatability at steady-state conditions
	
	±0,3 % of full range
	±0,02 % of full range / K
	±0,08 % of full range
	0,05 % of full range

Max. allowed permanent overload (without damage)	±35 V (each terminal AI against AGND)*
Total time of system input shift	type 80 µs
Repetition period of the sample	type 480 µs
Overload signalization	in the status word
Open input detection	none

*   The jumper of the correspondent input **must not be set for current measuring.** In the measuring mode the input can endure the permanent overload of only ±5 V without a damage!

Table 2.36   Basic parameters of current input ranges

Module type	CP-1005, CP-1015 (IR-1056)
Input impedance within the signal range	100 Ω

Analog input error
  max. error at 25 ℃
  temperature coefficient
  non-linearity
  repeatability at steady-state conditions
	
	±0,4 % of full range
	±0,03 % of full range / K
	±0,07 % of full range
	0,05 % of full range

Max. allowed permanent overload (without damage)	+50 mA (each terminal AI against AGND)
Total time of system input shift	type 80 µs
Repetition period of the sample	type 480 µs
Overload signalization	in the status word
Open input detection	in the status word (range descent- only range of 4 ÷20 mA)

Table 2.37   Basic parameters of input ranges for passive resistor sensors

Module type	CP-1005, CP-1015 (IR-1056)
Input impedance within the signal range	> 50 kΩ
Reference voltage	10 V

Analog input error
  max. error at 25 ℃
  temperature coefficient
  non-linearity
  repeatability at steady-state conditions
	
	±0,5 % of full range
	±0,05 % of full range / K
	±0,09 % of full range
	0,07 % of full range

Max. allowed permanent overload (without damage)	±35 V (each terminal AI against AGND)*
Total time of system input shift	type 80 µs
Repetition period of the sample	type 480 µs
Overload signalization	in the status word
Open input detection	none
Sensor disconnection detection	in the status word(range exceeding)

- The jumper of the correspondent input **must not be set for current measuring.** In the measuring mode the input can endure the permanent overload of only ±5 V without a damage!

2.4.4   Analog outputs

Analog outputs are used for the control of analog action and signaling elements of the controlled object. Basic modules CP-1005, CP-1015 contain 2 analog outputs AO0 and AO1. Inputs are voltage inputs 0 ÷ 10V, both have one joint terminal. In terms of allowed overload of 105 %, it is possible to set the voltage of up to 10.5 V on outputs. Analog outputs are galvanically isolated from internal circuits. Joint terminals of analog inputs, analog outputs and reference voltage are interconnected.

Table 2.38 Basic parameters of analog outputs

Module type	CP-1005, CP-1015 (IR-1056)
Number of outputs	2
Number of outputs in the group	2
Output type	active voltage output
Galvanic isolation from internal circuits	none
Joint conductor	minus
External supply	none
Transmission period	10 µs
Protection type	integrated surge guards
Insulation potential under the normal service conditions	none
Digital display resolution	10 bits
Input range / resolution (1 LSB)	0 up to +10 V / 10,546 mV
Max. output value	105 % upper limits of output range
Max. allowed permanent overload (without damage)	±20 V (each terminal AO against AGND)
Max. output current	10 mA
Analog output error	
max. error at 25 ℃	±2 % of full range
temperature coefficient	±0,3 % of full range / K
non-linearity	±0,7 % of full range
repeatability at steady-state conditions	0,5 % of full range

Analog outputs are brought out to terminals in the array ANALOG OUTPUTS. In the fig.2.29, there is a schematical drawing of the load connection to analog outputs.
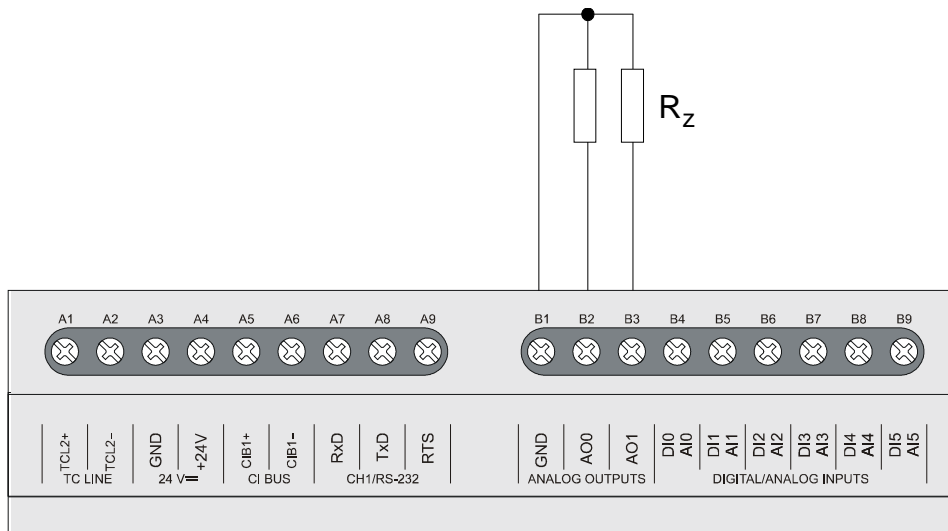
Fig.2.29   Typical example of the loads connection to analog outputs of basic modules CP-1005, CP-1015

2.4.5   Data provided by the IR-1056 board

Central units CP-1005, CP-1015 provide data regarding the serial communication (ETH1, CH1, CH2 interface). Details are to be found in the manual Serial communication PLC TECOMAT - model 32 bits (TXV 004 03.01).

The peripheral part of the module, the IR-1055 board, provides information on inputs and outputs. The structure of data is shown in the panel *I/O Settings* in the Mosaic development environment (Fig.2.30) (icon 〖IO〗).

Items in the structure have assigned symbolical names which, for the IR-1055 board start with *r0_p3_*. In the column *Full entry,* the concrete symbolical name for the given item is always stated. If we want to use data in the user program, we use either the symbolical name or in the column *Alias,* we enter our own symbolical name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.

Fig.2.30   IR-1056 board data structure

Input data

DI — binary input values (8x boolean type)

0	0	DI5	DI4	DI3	DI2	DI1	DI0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DI0 - DI5 - binary inputs
If the individual input is used for the analog measurement, then the correspondent DI bit has a permanent value of 0.

AI0, AI1, AI2, AI3, AI4, AI5 – analog inputs objects AI0 - AI5 (*TAI structure*)

AIn~STAT — status word of analog input AIn (16x boolean type)

0	0	0	FLS	OVF	OVR	UNR	UNF
.7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

bit

FLS — 1 – invalid measured value (during module initialization after the switch-on)
OVF — 1 – range reading (input quantity exceeded the nominal range of 5%)
OVR — 1 – range exceeding (input quantity exceeded the nominal range)
UNR — 1 – range descend (input quantity descended under the nominal range)
UNF — 1 – range under-flow (input quantity descended under the nominal range of 5%)

Signalization of the underrange and under-flow is active only for the range of 4 up to 20 mA, for resistor sensors of temperature and thermocouples. This function is not active for voltage and current measuring ranges.
While setting any of bits OVF and UNF into the log.1, the red LED diode relevant to the input given is lighting.

AIn~FS — analog input value AIn (int type)
The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value *FS* = 30000.

AIn~ENG — AIn analog input value (real type)
Value of measured voltage in volts.

AIn~PCT — The percentage relation between the measured and the nominal value of the analog input. For the value *FS* = 0 applies the value of *PCT* = 0% and for the value *FS* = 30000 the value *PCT* = 100%.

Output data

DO — binary output values (8x boolean type)

0	0	DO5	DO4	DO3	DO2	DO1	DO0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DO0 - DO5 - relay outputs

AO0, AO1   - analog output objects AO0, AO1 (*TAO_TC6 structure*)

AOn~FS   - AIn analog input value (int type)
               The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value *FS* = 30000.

AOn~ENG   - AIn analog input value (real type)
               Value of measured voltage in volts.

AOn~PCT   - AIn analog input value (real type)
               The percentage relation between the measured and the nominal value of the analog input. For the value *FS* = 0 applies the value of *PCT* = 0% and for the value *FS* = 30000 the value *PCT* = 100%.

The behaviour of each data object is described in the chapter below.

2.4.6   Initialization and behaviour of individual data objects of the IR-1056 board

The peripheral part of modules part (IR-1055 board) contains a block of binary inputs and outputs, two counter objects and an analog inputs block.
The panel for setting of parameters of the IR-1056 board can be opened from the project manager *HW | Configuration HW* (Fig.2.31). In the folder *Central module* on the line I/O we click on the icon.
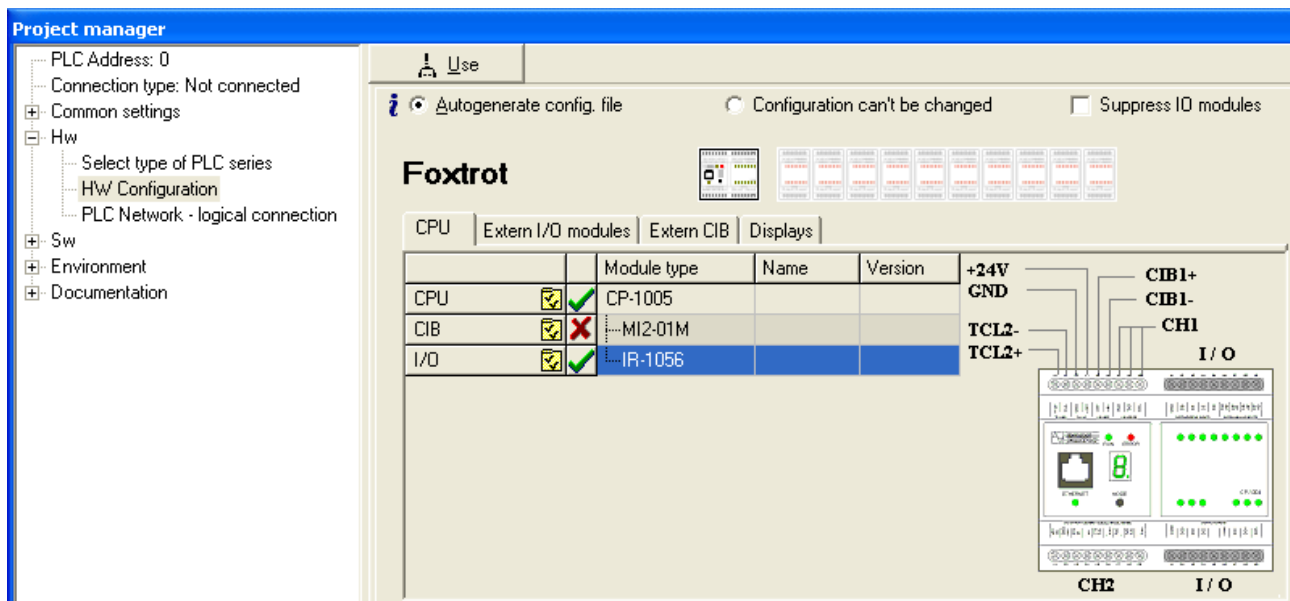
Fig.2.31   Configuration of the CP-1005 basic module

Binary inputs

The binary input state is contained in the DI variable. The state of all universal inputs is valid only in such cases when inputs are not used as analog inputs.
If we check an item *Enable ignore module error* at the bottom side of *IR-1056 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5).

Fig.2.32   Configuration of binary inputs and outputs

The configuration of binary inputs can be found in the folder *Binary IO* (Fig.2.32). By ticking the option *The switch-on of the transfer of binary inputs DI0 to DI7 we* can enable the transfer of current states of all six inputs into the PLC notepad. If this option is not ticked, the relevant values are not transferred and will not show in the PLC notepad.

This selection has no effect on the inputs configuration. Individual inputs behave as binary only when they are not used as analog inputs (in the folder *Analog inputs* the channel with the similar number is not ticked).

Binary outputs

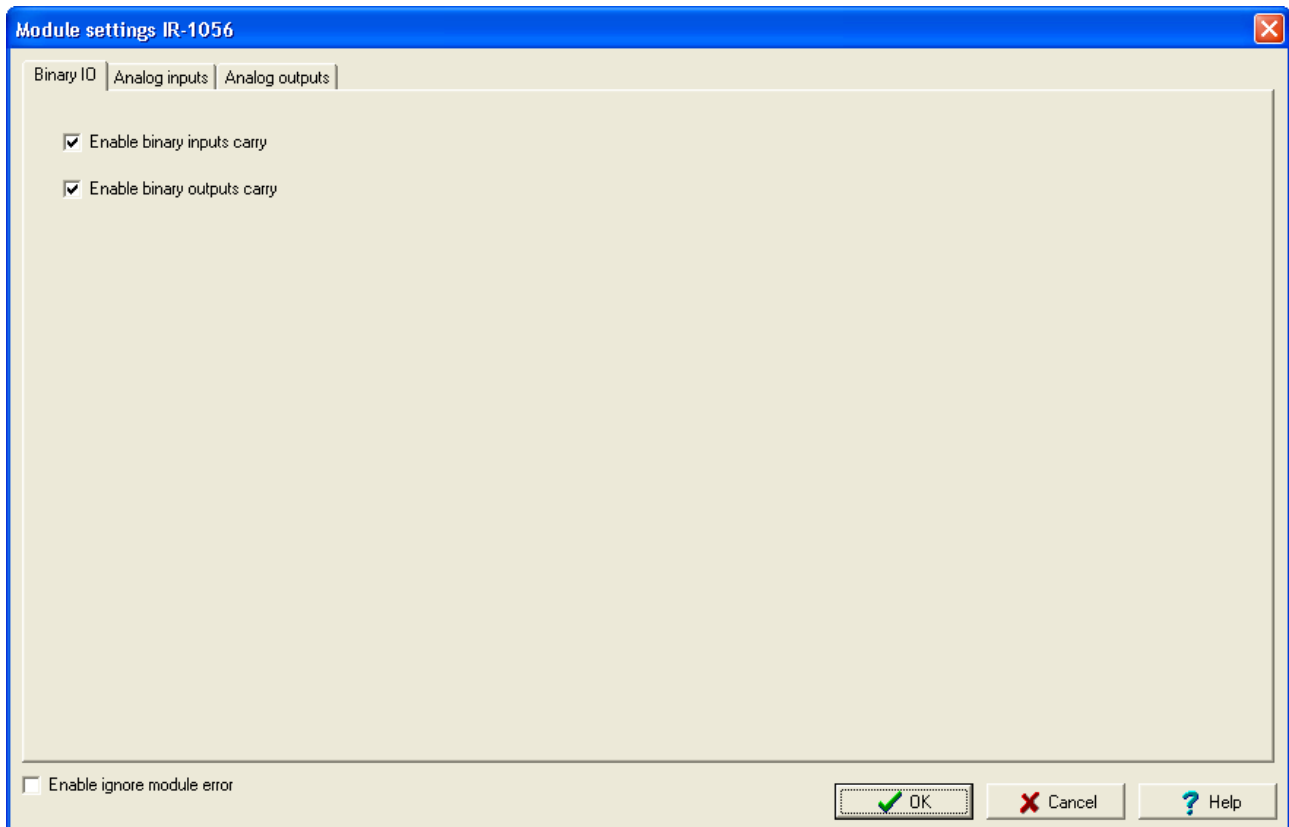Binary outputs state is contained in the DO variable. The configuration of binary outputs can be found in the folder *Binary IO* (Fig.2.32). By ticking the option The switch-on of the t*ransfer of binary inputs* we can enable the transfer of current states of all six outputs from the PLC notepad into the module. If this option is not ticked, the relevant values are not transferred and outputs are not set.

Analog inputs

The CP-1004 module contains 6 analog inputs AI0 to AI5 with an optional measuring range from 0 to 10 V. Each input has 4 variables *STAT*, *FS*, *ENG* and *PCT*. The *STAT* status is transferred every time, among variables *FS*, *ENG* and *PCT* we choose one depending on the interpretation of the measured value required. The configuration of analog inputs can be found in the folder *Analog inputs* (Fig.2.33).

It applies generally, that if we tick the *Channel AIn* box, the input n will behave as an analog AIn. If the box *Channel AIn* is left blank, then the input n will behave as a binary DIn.
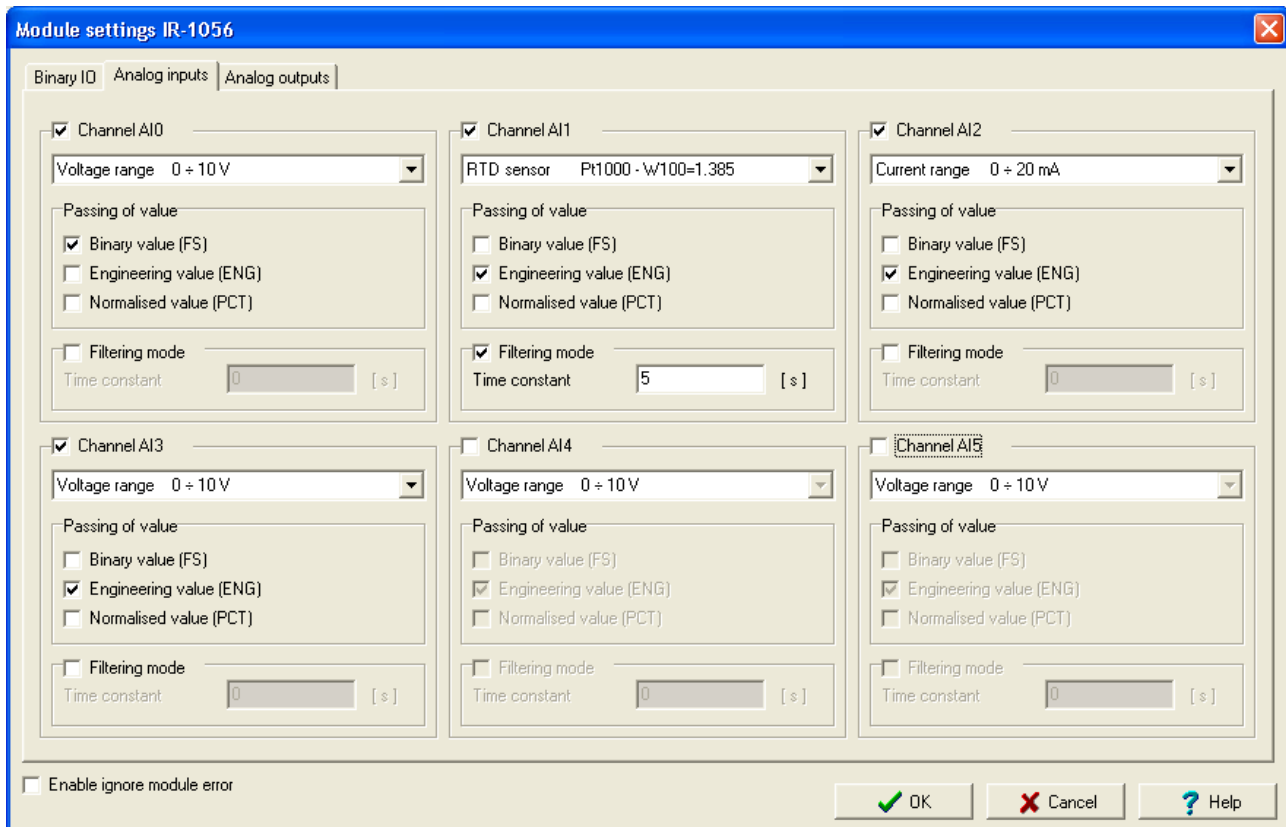
Fig.2.33   Configuration of analog inputs

The transferred value in the FS variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents the current in volts.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

If we want to filter the input analog value, we switch the filtration mode on and set the time constant. Measured values of the correspondent channel pass through the filter of the 1st grade. The filter is due to the following relation:

$$y_t = \frac{y_{t-1} \cdot \tau + x}{\tau + 1}$$

x – transferred value of the analog input
y_t - output
y_{t-1} – last output
τ - time constant of the 1st grade filter

The value of the time constant is set within the range 0.1 ÷ 25.0 s. The filtration concerns all data formats of the channel given (*FS*, *ENG* and *PCT*) and is accessible within all measuring ranges.

In following graphs and tables, there are introduced transferred values for individual ranges of analog inputs.

Fig.2.34   Current ranges of analog inputs of modules CP-1005, CP-1015

Table 2.39   Transferred values of analog inputs for 0 up to 10 V range

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 10,5 V	$000C	31500	10,5	105	range overflowing
10,5 V	$0004	31500	10,5	105	range exceeding
:	$0004	:	:	:	
10 V	$0000	30000	10	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 2.40   Transferred values of analog inputs for 0 up to 5 V range

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 5,25 V	$000C	31500	5,25	105	range overflowing
5,25 V	$0004	31500	5,25	105	range exceeding
:	$0004	:	:	:	
5 V	$0000	30000	5	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 2.41   Transferred values of analog inputs for 0 up to 2 V range

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 2,1 V	$000C	31500	2,1	105	range overflowing
2,1 V	$0004	31500	2,1	105	range exceeding
:	$0004	:	:	:	
2 V	$0000	30000	2	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 2.42   Transferred values of analog inputs for 0 up to 1 V range

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1,05 V	$000C	31500	1,05	105	range overflowing
1,05 V	$0004	31500	1,05	105	range exceeding
:	$0004	:	:	:	
1 V	$0000	30000	1	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 2.43   Transferred values of analog inputs for 0 up to 0.5 V range

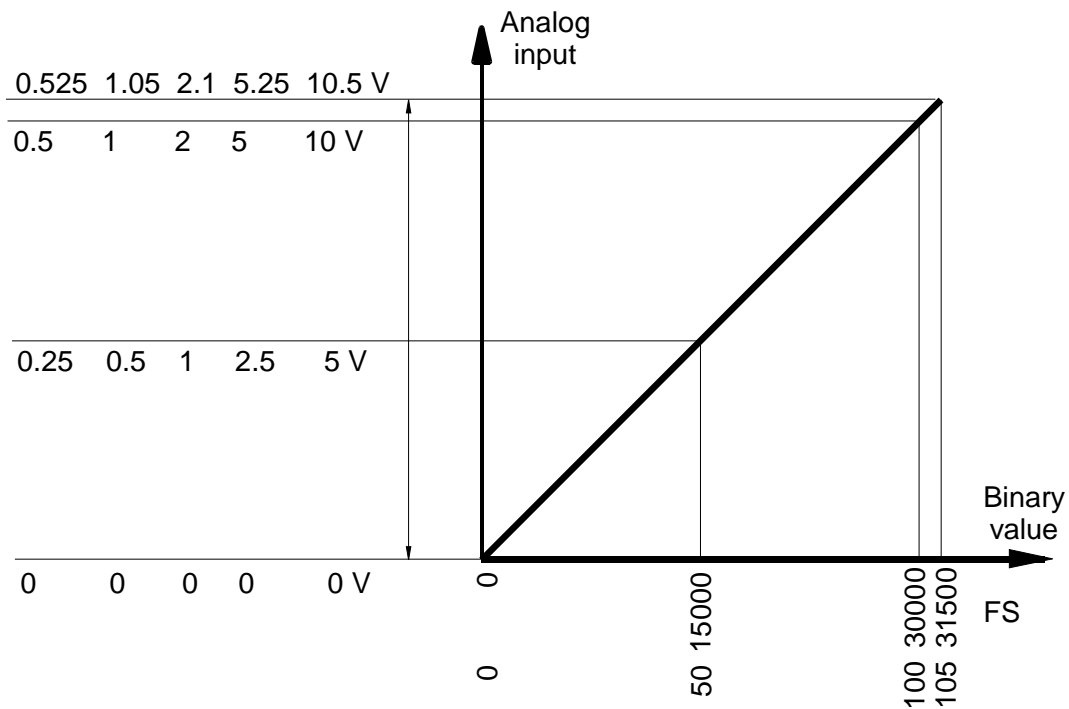| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 0,525 V	$000C	31500	0,525	105	range overflowing
0,525 V	$0004	31500	0,525	105	range exceeding
:	$0004	:	:	:	
0,5 V	$0000	30000	0,5	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Fig.2.35   Current range from 0 up to 20 mA of analog inputs of modules CP-1005, CP-1015

Table 2.44   Transferred values of analog inputs for 0 up to 20 mA range

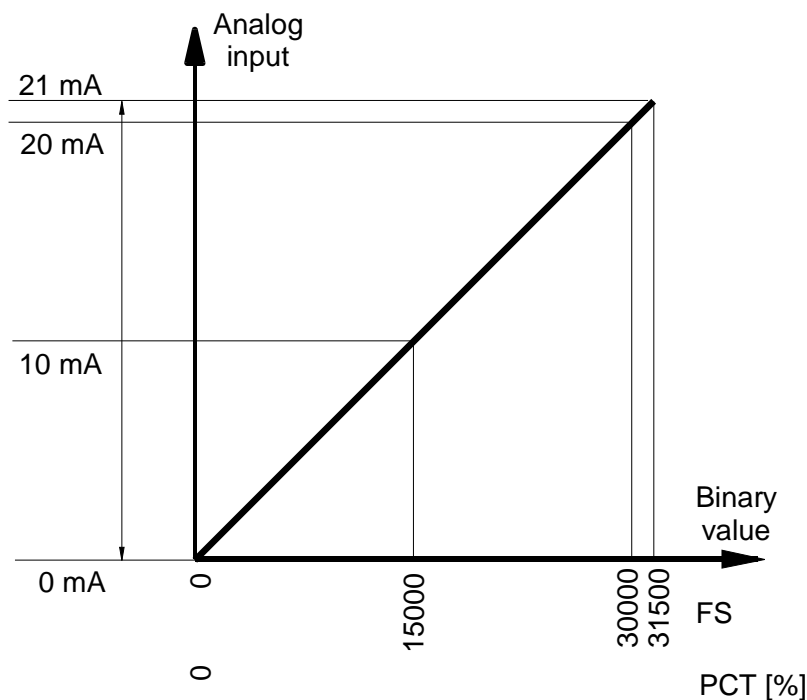| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 21 mA	$000C	31500	21	105	overflowing
21 mA	$0004	31500	21	105	range exceeding
:	$0004	:	:	:	
20 mA	$0000	30000	20	100	nominal range
:	$0000	:	:	:	
0 mA	$0000	0	0	0	
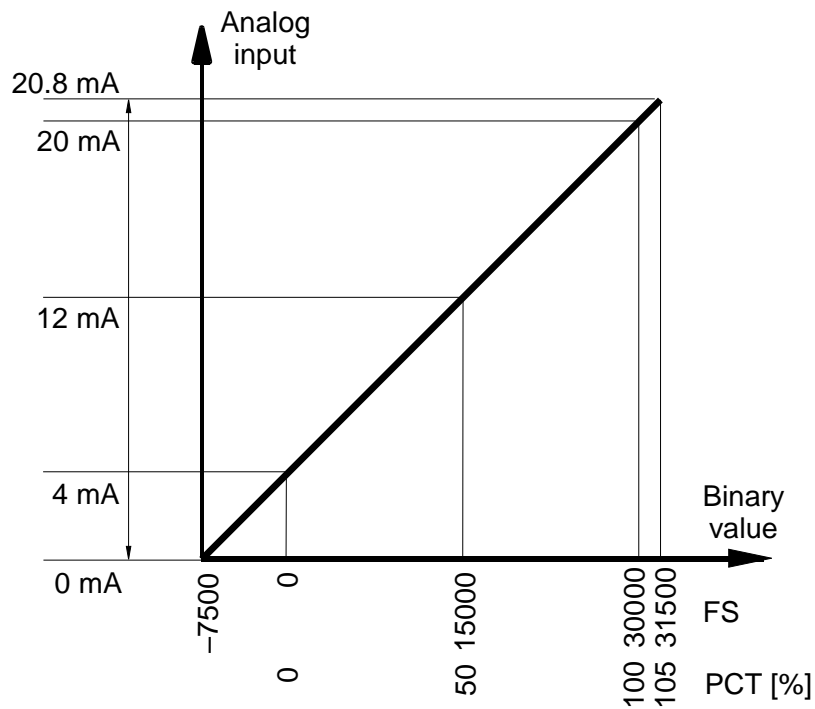
Fig.2.36   Current range from 4 up to 20 mA of analog inputs of modules CP-1005, CP-1015

Table 2.45   Transferred values of analog inputs for 4 up to 20 mA range

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 20,8 mA	$000C	31500	20,8	105	range overflowing
20,8 mA	$0004	31500	20,8	105	range exceeding
:	$0004	:	:	:	
20 mA	$0000	30000	20	100	nominal range
:	$0000	:	:	:	
4 mA	$0000	0	4	0	
:	$0002	:	:	:	range descended
3,2 mA	$0002	−1500	3,2	−5	
:	$0003	:	:	:	range underflowing
0 mA	$0003	−7500	0	−25	

Fig.2.37   Range of analog inputs of modules CP-1005, CP-1015 for resistor sensors Pt100, Pt1000, Ni1000 and NTC thermistors

Table 2.46   Transferred values of analog inputs for Pt100 and Pt1000

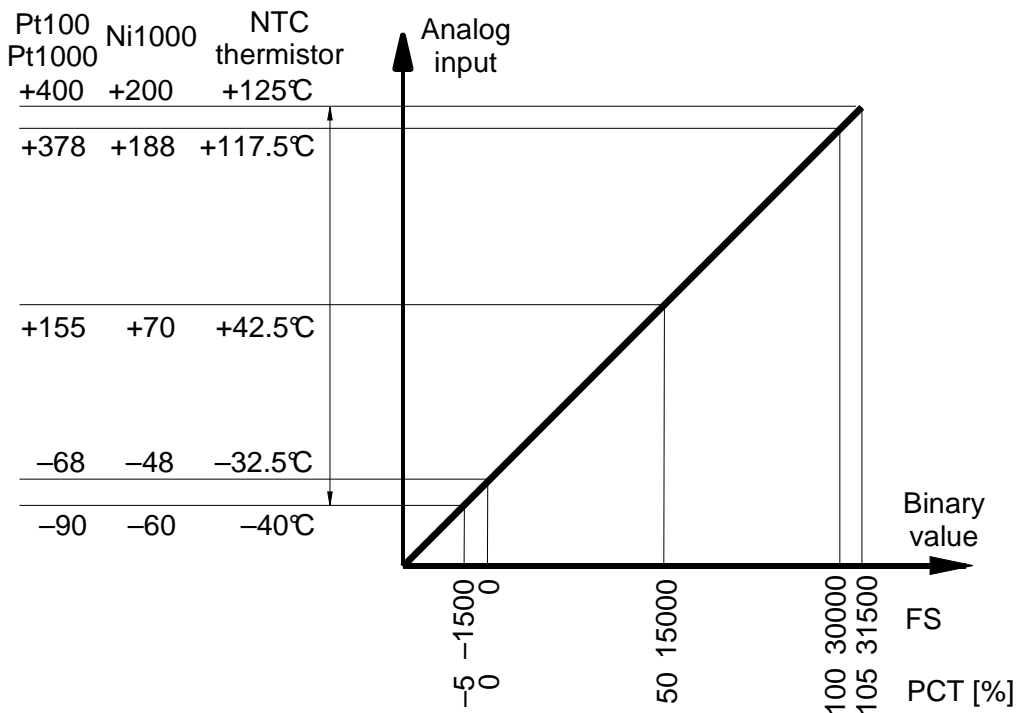| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 400 ℃	$000C	31500	400	105	range overflowing
400 ℃	$0004	31500	400	105	range exceeding
:	$0004	:	:	:	
378 ℃	$0000	30000	378	100	nominal range
:	$0000	:	:	:	
−68 ℃	$0000	0	−68	0	
:	$0002	:	:	:	range descended
−90 ℃	$0002	−1500	−90	−5	
< −90 ℃	$0003	−1500	−90	−5	range underflowing

Table 2.47   Transferred values of analog inputs for Ni1000

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 200 ℃	$000C	31500	200	105	range overflowing
200 ℃	$0004	31500	200	105	range exceeding
:	$0004	:	:	:	
188 ℃	$0000	30000	188	100	nominal range
:	$0000	:	:	:	
−48 ℃	$0000	0	−48	0	
:	$0002	:	:	:	range descended
−60 ℃	$0002	−1500	−60	−5	
< −60 ℃	$0003	−1500	−60	−5	range underflowing

Tab.2.48   Transferred values of analog inputs for NTC thermistors

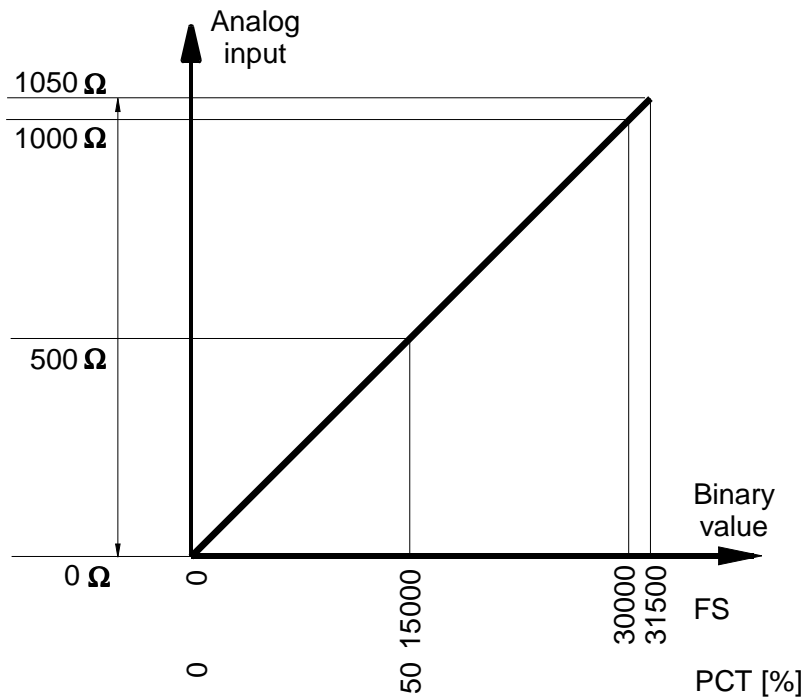| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 125 ℃	$000C	31500	125	105	range overflowing
125 ℃	$0004	31500	125	105	range exceeding
:	$0004	:	:	:	
117.5 ℃	$0000	30000	117.5	100	nominal range
:	$0000	:	:	:	
−32.5 ℃	$0000	0	−32.5	0	
:	$0002	:	:	:	range descended
−40 ℃	$0002	−1500	−40	−5	
< −40 ℃	$0003	−1500	−40	−5	range underflowing

Fig.2.38   Range of analog inputs of modules CP-1005, CP-1015 for resistor transmitters OV1000

Table 2.49   Transferred values of analog inputs for OV1000

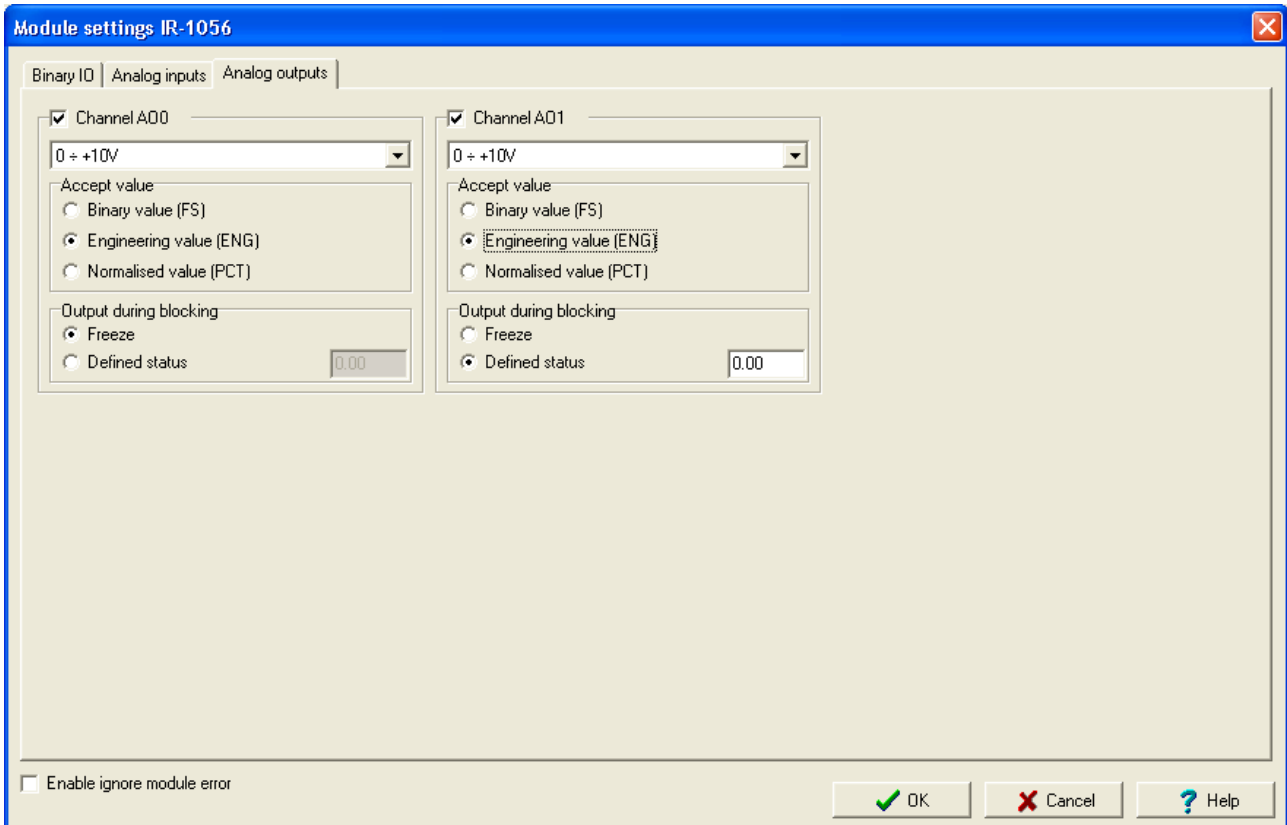| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1050 Ω	$000C	31500	1050	105	range overflowing
1050 Ω	$0004	31500	1050	105	range exceeding
:	$0004	:	:	:	
1000 Ω	$0000	30000	1000	100	nominal range
:	$0000	:	:	:	
0 Ω	$0000	0	0	0	

Analog outputs

Modules CP-1005, CP-1015 contain 2 analog outputs AO0 and AO1, which are in the range of 0 up to 10V. Each input has three variables *FS*, *ENG* and *PCT*. Among these variables we choose one according to which interpretation of the output value is required. The configuration of analog outputs can be found in the folder *Analog outputs* (fig.2.39).

The transferred value of the *FS* variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents the current in volts.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

Obr.2.39   Analog outputs configuration

The behaviour of outputs in the HALT mode can be defined in two ways. If we mark the item *Freeze,* then after the mode transition to the HALT mode, the analog output stays set to the last value entered by the user program.

If we mark the item *Defined state,* then after the mode transition to the HALT mode, on the analog output is set the value entered within the correspondent array. This entered value has a format similar to the selected transmitted variable. This means that if we use the FS format, the value is of the int type within the range 0 - 31500, if we use the ENG format, the value is of the real type within the range 0 - 10.5 V, and if we use the PCT format, the value is of the real type within the range 0 - 105%.

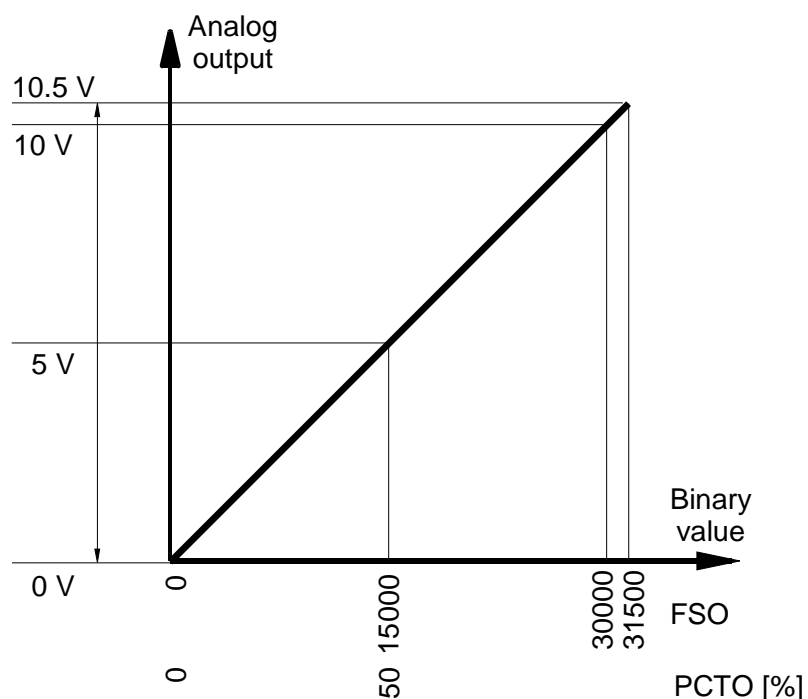After the supply switch-on, analog outputs are always set to the value of 0.

Fig.2.40   Range of analog outputs of modules CP-1005, CP-1015

Table 2.50   Transferred values of analog outputs for the range 0 up to10 V

Output value	Variable			
	FS	**ENG**	**PCT**	
10,5 V	> 31500	> 10,5	> 105	range overflowing
10,5 V	31500	10,5	105	range exceeding
:	:	:	:	
10 V	30000	10	100	nominal range
:	:	:	:	
0 V	0	0	0	

2.5   INTEGRATED DISPLAY OF MODULES CP-1014, CP-1015

Basic modules CP-1014 and CP-1015 contain an integrated LCD display of the size of 4 x 20 characters and 6 user buttons. Under the name OI-1073 the processor operating this display and buttons presents itself on the system bus.

The display is equipped with backlit which is active for 60 minutes since the user program start or the last pressing of any button. The backlit can be activated for the next 60 minutes by pressing any button or by PLC transfer to another mode (HALT, RUN). The backlit is switched on the light when PLC system error occurs too.
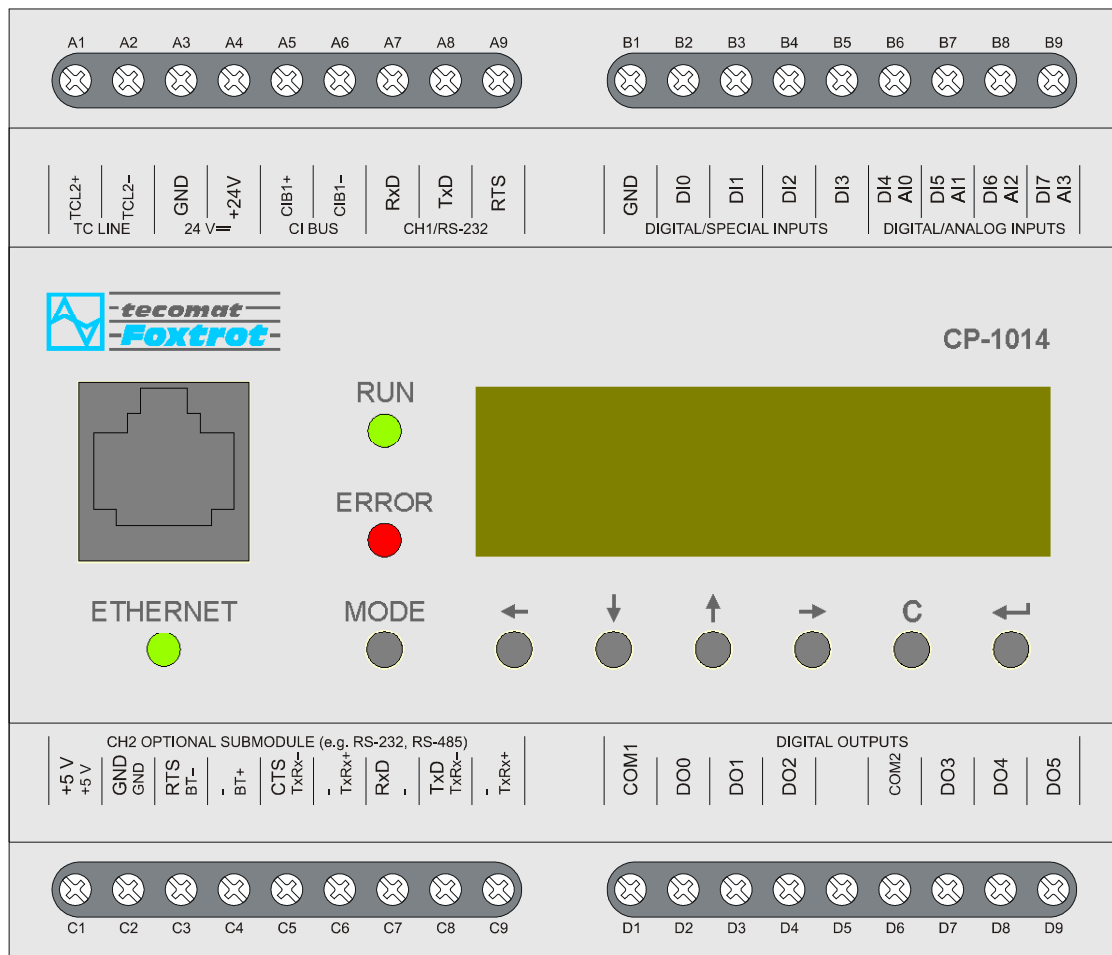
Fig.2.41   Basic module CP-1014

2.5.1   Display fonts

The display is used both for displaying of system information and for application use by the user as an operational panel. If the display is operated by the user program, then in the RUN mode it works in the user mode – I. e. it displays characters generated by the user program. Via the MODE button it is possible to switch to the system mode for the purpose of displaying the system state.

The behaviour of the display in the system mode is described in the chapter 4.

The display is operated in the character mode. It enables to display 256 characters of the character set selected during the initialization of the user program. There are following Windows character sets available:

CP1250 (WinLatin2 – central European)
CP1251 (WinCyrillic – Cyrillic alphabet)
CP1252 (WinLatin1 – western European)
CP1253 (WinGreek – Greek alphabet)

All mentioned character sets have identical coding of the first 128 characters. Codes 0 - 31 contain graphical characters for creating of lines and bar graphs and for displaying of key characters. Codes 32 - 127 correspond to the standard ASCII coding. Codes 128 - 255 differs according to the selected code page and contain characters of national alphabets and other characters.

Individual characters and their coding are shown in following tables.

Tale 2.51 Code table of ASCII characters 0 - 127 ($00 - $7F)

code	$0x	$1x	$2x	$3x	$4x	$5x	$6x	$7x
$x0		│		0	@	P	`	p
$x1	─	┐	!	1	A	Q	a	q
$x2	⊏	┐	"	2	B	R	b	r
$x3	⊏	└	#	3	C	S	c	s
$x4	⊏	⊥	$	4	D	T	d	t
$x5	■	⊤	%	5	E	U	e	u
$x6	■	├	&	6	F	V	f	v
$x7	■	─	'	7	G	W	g	w
$x8	⌐	↑	(	8	H	X	h	x
$x9	□	↓	)	9	I	Y	i	y
$xA	▯	→	∗	:	J	Z	j	z
$xB	▮	←	+	;	K	[	k	{
$xC	■	┼	,	<	L	\	l	|
$xD	↵	┘	–	=	M	]	m	}
$xE	-1	┌	.	>	N	^	n	~
$xF	∞		/	?	O	_	o	■

Table 2.52   Code table of ASCII characters 128 - 255 ($80 - $FF) for the code page CP1250 (central European)

code	$8x	$9x	$Ax	$Bx	$Cx	$Dx	$Ex	$Fx
$x0	€			°	Ŕ	Đ	ŕ	đ
$x1		'		±	Á	Ń	á	ń
$x2	,	'			Â	Ň	â	ň
$x3		"	Ł	ł	Ă	Ó	ă	ó
$x4	„	"	¤		Ä	Ô	ä	ô
$x5	…	•	Ą	µ	Ĺ	Ő	Í	ő
$x6	†	-	¦	¶	Ć	Ö	ć	ö
$x7	‡	—	§	·	Ç	×	ç	÷
$x8	ˆ	˜			Č	Ř	č	ř
$x9	‰			ą	É	Ů	é	ů
$xA	Š	š	Ş	ş	Ę	Ú	ę	ú
$xB	‹	›	«	»	Ě	Ű	ë	ű
$xC	Ś	ś	¬	Ľ	Ë	Ü	ě	ü
$xD	Ť	ť	–		Í	Ý	í	ý
$xE	Ž	ž		ľ	Î	Ţ	î	ţ
$xF	Ź	ź	Ż	ż	Ď	ß	ď	■

Table 2.53 Code table of ASCII characters 128 - 255 ($80 - $FF) for the code page CP1251 (Cyrillic alphabet)

code	$8x	$9x	$Ax	$Bx	$Cx	$Dx	$Ex	$Fx
$x0	Ђ	ђ		°	А	Р	а	р
$x1	Ѓ	'	ў	±	Б	С	б	с
$x2	‚	'	ў	І	В	Т	в	т
$x3	ѓ	"	Ј	і	Г	У	г	у
$x4	„	"	¤	ґ	Д	Ф	д	ф
$x5	…	•	Ґ	µ	Е	Х	е	х
$x6	†	-	¦	¶	Ж	Ц	ж	ц
$x7	‡	—	§	·	З	Ч	з	ч
$x8	€		Ё	ё	И	Ш	и	ш
$x9	‰			№	Й	Щ	й	щ
$xA	Љ	љ	Є	є	К	Ъ	к	ъ
$xB	<	>	«	»	Л	Ы	л	ы
$xC	Њ	њ	¬	ј	М	Ь	м	ь
$xD	Ќ	ќ	–	Ѕ	Н	Э	н	э
$xE	Ћ	ћ		ѕ	О	Ю	о	ю
$xF	Џ	џ	Ї	ї	П	Я	п	я

Table 2.54 Code table of ASCII characters 128 - 255 ($80 - $FF) for the code page CP1252 (western European)

code	$8x	$9x	$Ax	$Bx	$Cx	$Dx	$Ex	$Fx
$x0	€			°	À	Ð	à	đ
$x1		'	¡	±	Á	Ñ	á	ñ
$x2	‚	'	¢	²	Â	Ò	â	ò
$x3	ƒ	"	£	³	Ã	Ó	ã	ó
$x4	„	"	¤		Ä	Ô	ä	ô
$x5	…	•	¥	µ	Å	Õ	å	õ
$x6	†	—	¦	¶	Æ	Ö	æ	ö
$x7	‡	—	§	·	Ç	×	ç	÷
$x8	ˆ	˜			È	Ø	è	ø
$x9	‰			¹	É	Ù	é	ù
$xA	Š	š	ª	º	Ê	Ú	ê	ú
$xB	<	>	«	»	Ë	Û	ë	û
$xC	Œ	œ	¬	¼	Ì	Ü	ì	ü
$xD			–	½	Í	Ý	í	ý
$xE	Ž	ž		¾	Î	Þ	î	þ
$xF		Ÿ	¯	¿	Ï	ß	ï	ÿ

Table 2.55 Code table of ASCII characters 128 - 255 ($80 - $FF) for the code page CP1253 (Greek alphabet)

code	$8x	$9x	$Ax	$Bx	$Cx	$Dx	$Ex	$Fx
$x0	€			°	ΐ	Π	ΰ	π
$x1		'		±	Α	Ρ	α	ρ
$x2	‚	'	Ά	²	Β		β	ς
$x3	ƒ	"	£	³	Γ	Σ	γ	σ
$x4	„	"	¤		Δ	Τ	δ	τ
$x5	…	•	¥	µ	Ε	Υ	ε	υ
$x6	†	–	¦	¶	Ζ	Φ	ζ	φ
$x7	‡	—	§	·	Η	Χ	η	χ
$x8	^	~		Έ	Θ	Ψ	θ	ψ
$x9	‰			Ή	Ι	Ω	ι	ω
$xA			ª	Ί	Κ	Ϊ	κ	ϊ
$xB	<	>	«	»	Λ	Ϋ	λ	ϋ
$xC			¬	Ό	Μ	ά	μ	ό
$xD			–	½	Ν	έ	ν	ύ
$xE				Ύ	Ξ	ή	ξ	ώ
$xF			‾	Ώ	Ο	ί	ο	■

2.5.2   Keybuttons coding

There are 6 buttons designated for the use in the application that are marked with arrow tools, sign ↵ (enter) and **C** (clear). These buttons are coded according to the table 2.56. The system supports the function autorepeat (periodic transmission of the button code when pressed for a long time) and the possibility of switching on the transmission of so-called terminal character generated by the release of the pressed button.

Table 2.56   Keybuttons coding

code	button
$00	none button pressed
$0D	↵
$18	↑
$19	↓
$1A	→
$1B	←
$7F	C
$FF	terminal character (release of the pressed button)

The button MODE serves for switching of the display between system and user mode of displaying and it can not be used for the application. Conversely, in the system mode of the display, buttons marked by arrow tools are used for listing between system screens. Codes of pressed buttons are not in the system mode transferred into the PLC notepad.

2.5.3   Data provided by the OI-1073 display

The display OI-1073 enables the characters entry on the display and capturing of user keys. Data structure can be found in the panel *I/O Settings* In the Mosaic environment (fig.2.42) (icon).

Stricture items have assigned symbolic names that for the OI-1073 display start always with the characters *r0_p1_*. In the column *Full entry* there is always a concrete symbolic name shown for the item given. If we want to use data in the user program, we use either this symbolic name or in the column *Alias* we enter our own symbolic name that we can then use. In no case do we use absolute operands since they can alter after a new compilation of the user program.

Fig.2.42   Data structure of the OI-1073 display

Input data

OI1073_UserKeyb   - pressed button code (usint type)

If no button is pressed, the value transferred is $00. While the button is pressed, its code (chapter 2.5.2., table 2.56) is transferred by a single application (in one cycle of the user program). Repeated transfer of the code of the pressed button is activated only after the autorepeat delay expiration (if the autorepeat is set). After the release of the pressed button, the terminal character $FF is broadcasted by a single application (if the broadcasting of the terminal character is set).

Output data

OI1073_VideoRam - ASCII array of characters designated for displaying (80x usint type)

The display processor firstly decodes the text according to the set character set and afterwards displays relevant characters on the display. Characters sets available are described in the chapter 2.5.1.

2.5.4   Initialization of the OI-1073 display

The panel for the OI-1073 display parameters setting can be open in the Project manager in the tag *HW | HW configuration* (fig.2.43). In the folder *Central module,* on the line panel, we click the icon .
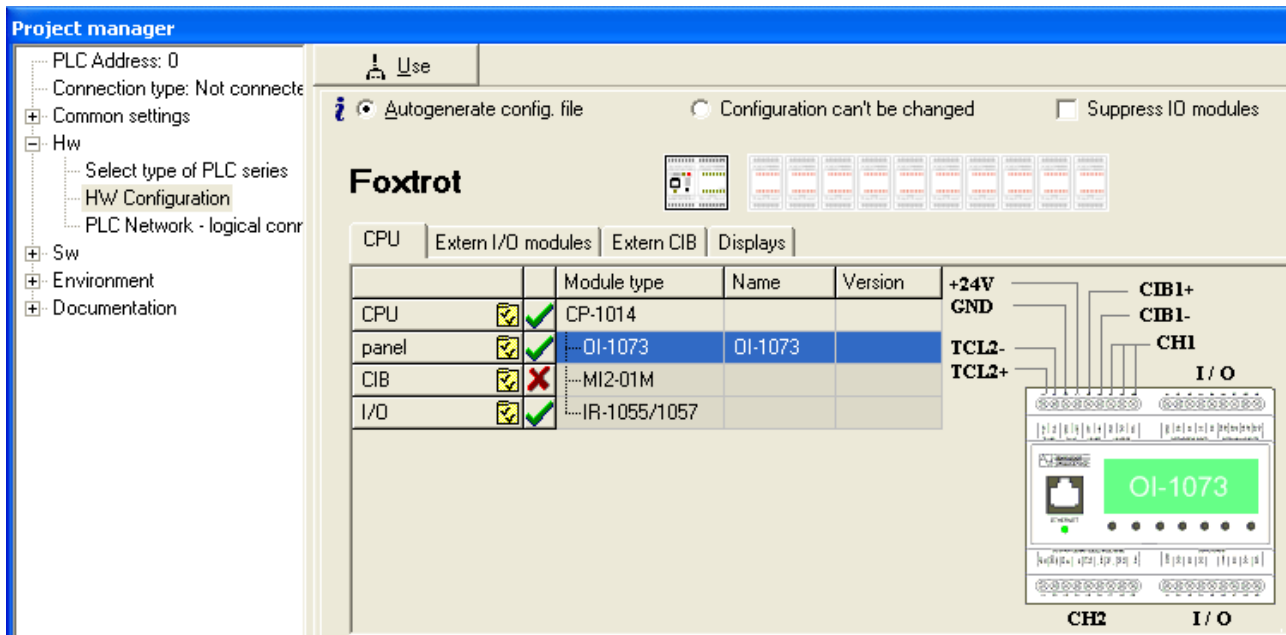
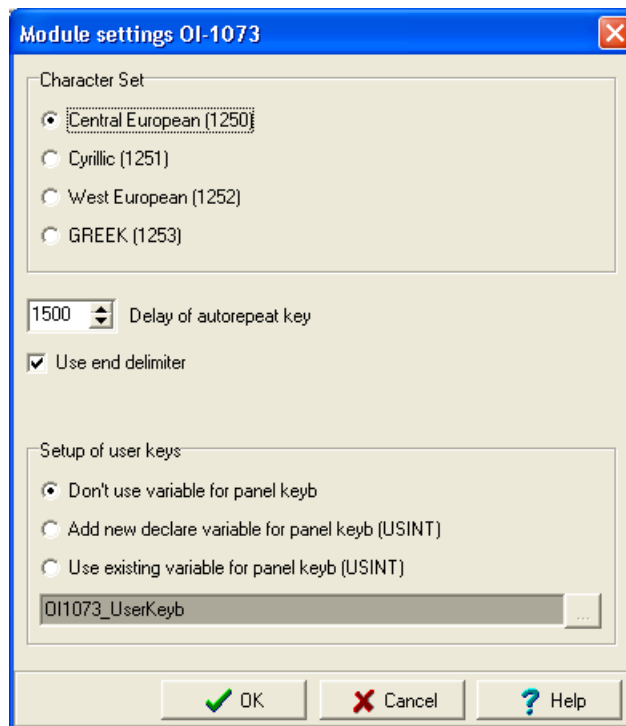*Fig.2.43   Basic module CP-1014 configuration*

Fig.2.44   The OI-1073 display configuration

In the top section we select the character set according to which the display will decode the displayed text. Available are:

♦ Windows central European (CP1250)
♦ Windows Cyrillic (CP1251)
♦ Windows western European (CP1252)
♦ Windows Greek (CP1253)

The item *Keyboard autorepeat delay* determines the time delay after which, during the long-term press of the button, the button autorepeat is activated, i. e. the state when the pressed button code is continuously transferred until it is released. The autorepeat delay

can be set within the range of 0 up to 1500 ms, in the step after 100 ms. If we want to switch the autorepeat off, we set the delay value to 0.

By ticking the item *Use the terminal character,* the function of the terminal character transfer ($FF code) is activated after the pressed button is released. This function is useful in particular while using the autorepeat function and is used for short and long keystroke recognition.

Setup of user keys item determines the manner in which pressed key code is accessed. This setting has a meaning for PanelMaker.

The option *Don't use variable for panel key* means that the pressed key processing is completely done by PanelMaker and we will not process it in the user program.

The option *Add new variable declaration for panel key* allows entering a name of new variable in which we want to publish pressed key code for next processing to the field below this option.

The option *Use existing variable for panel key* allows entering a name of an existing variable in which we want to publish pressed key code for next processing to the field below this option. The variable can be selected from the list which is displayed after … button pressing.

3.   TECOMAT FOXTROT PLC PERIPHERAL MODULES

There is an overview of peripheral modules PLC FOXTROT in the table 3.1. The table 3.2 contains an overview of other modules that can be connected to the basic module PLC FOXTROT via the TCL2 bus.

Table 3.1 Peripheral modules variants of the FOXTROT system

Type	Description	Order number	Chapter
IB-1301	12 binary inputs 24 V, 4 of them usable as counters inputs	TXN 113 01	chap.3.1.1
OS-1401	12 binary transistor outputs 24 V	TXN 114 01	chap.3.2.1
IR-1501	4 binary inputs 24 V usable as counters inputs 8 relay outputs	TXN 115 01	chap.3.3.1
IT-1601	8 analog inputs (unipolar voltage and current ranges, passive resistor sensors (16 bits) 2 analog unipolar voltage outputs (10 bits)	TXN 116 01	chap.3.4.1
IT-1602	8 analog inputs (bipolar low-voltage ranges, thermocouples, 16 bits) 2 analog bipolar voltage outputs (10 bits)	TXN 116 02	chap.3.4.2

Table 3.2 Alternatives of other modules connectable to the FOXTROT system

Type	Description	Order number	Chapter
MI2-02	2 lines of the bus CIB	TXN 131 28	chap.3.5.1
ID-14	display 4x20 characters, 25 key-buttons	TXN 054 33	chap.3.5.2

All PLC FOXTROT modules are equipped with the plastic protection case and with a holder for the module mounting on to the U bar.

ATTENTION!	**Modules contain components sensitive to electrostatic charge, therefore, user guides for these circuits must be abided!** **The manipulation is undertaken on the module that is disconnected from the power supply only as well as on input and output signals!**

3.1   BINARY INPUT MODULES

These modules contain binary inputs and are connected to the basic module via the bus TCL2.

3.1.1   IB-1301 module

Peripheral module IB-1301 contains 12 binary inputs 24 V DC. The first four inputs DI0 - DI3 can be used as a common binary inputs or as counters inputs. All inputs are galvanically isolated. The module is supplied from the supply voltage of z 24 V DC that is not galvanically isolated from internal circuits.
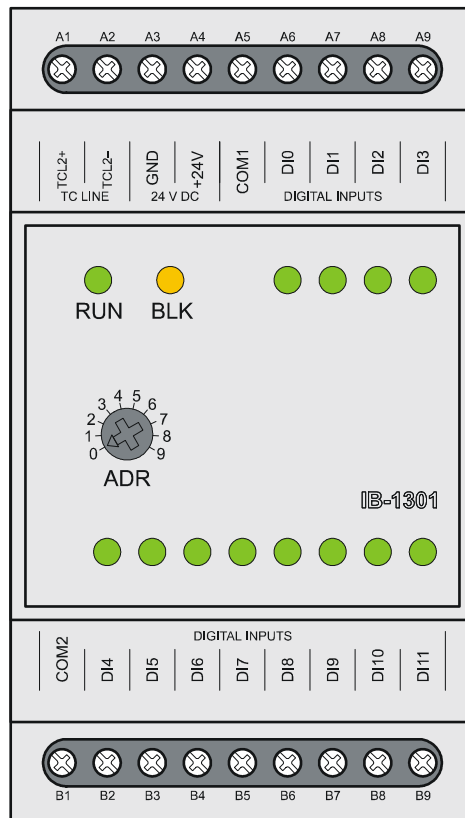

Fig.3.1.1   Peripheral module IB-1301

Table 3.1.1   Basic parameters of the IB-1301 module

Module type	IB-1301
Supply voltage (SELV)	24 VDC, +25%, −15%
Internal protection	none
Max. input power	2,5 W
Connection	Fixed screw terminals, max.2,5 mm^2 of the conductor on the terminal
Supply galvanic isolation from internal circuits	none
Number of inputs	12
From which optional binary / for counters	4
Size	53 x 95 x 65 mm

There is shown the connection of terminals of the IB-1301 module in the table 3.1.2

Table 3.1.2   Connection of terminal boards A and B of the IB-1301 module

A1	TCL2+	System bus TCL2
A2	TCL2–	System bus TCL2
A3	GND	Module ground
A4	+24V	Supply
A5	COM1	Common conductor of inputs DI0 - DI3
A6	DI0	Binary input DI0
A7	DI1	Binary input DI1
A8	DI2	Binary input DI2
A9	DI3	Binary input DI3
B1	COM2	Common conductor of inputs DI4 - DI11
B2	DI4	Binary input DI4
B3	DI5	Binary input DI5
B4	DI6	Binary input DI6
B5	DI7	Binary input DI7
B6	DI8	Binary input DI8
B7	DI9	Binary input DI9
B8	DI10	Binary input DI10
B9	DI11	Binary input DI11

3.1.1.1 Binary inputs

Binary inputs serve for the connection of two-condition signals of the controlled object to the PLC. The IB-1301 peripheral module contains 12 binary inputs DI0 – DI11. Inputs have galvanic isolation from PLC internal circuits. The excitation (switching) is signalized by lighting of the LED diode up. Inputs are in two groups with a joint terminal. The first group contains inputs DI0 - DI3 and the second group contains inputs DI4 - DI11. The joint terminal can be plus or minus for each group. DI0 - DI3 inputs can be used as inputs for counters. Even if these inputs are used alternatively as described, they still can be used as binary inputs.

DI0 – DI3 inputs enable to switch on the function of the short impulses capturing. This function extends the selected level of the input signal until the next PLC turn. Therefore, it can be ensured that individual pulses on the input which are shorter than the PLC cycle will not be lost.

Note: If the function of the short impulses capturing is activated on one of the inputs, it is forbidden to have the counter object which uses this input switched on. If such a situation occurs, the function of the short impulses capturing is automatically switched off.

Table 3.1.3   Basic parameters of binary inputs of the IB-1301 module

Module type	IB-1301
Number of inputs	12
Number of inputs in group	4 + 8
Galvanic isolation from internal circuits	yes
Diagnostics	Signalization of the excited input on the panel
Joint conductor	minus / plus
Input voltage	
for log.0 (UL)	max. +5 V DC
	min. −5 V DC
for log.1 (UH)	min. +15 V DC
	type +24 V DC
	max. +30 V DC
Input current at log.1	type 10 mA (DI0 - DI3)
	type5 mA (DI4 - DI11)
Delay from log.0 to log.1	5 µs (DI0 - DI3)
	5 ms (DI4 - DI11)
Delay from log.1 to log.0	5 µs (DI0 - DI3)
	5 ms (DI4 - DI11)
Minimum width of captureable pulse	50 µs

Binary inputs are brought out to terminals within arrays DIGITAL INPUTS. You can see a schematic overview of switchers connection in the fig 3.1.2.
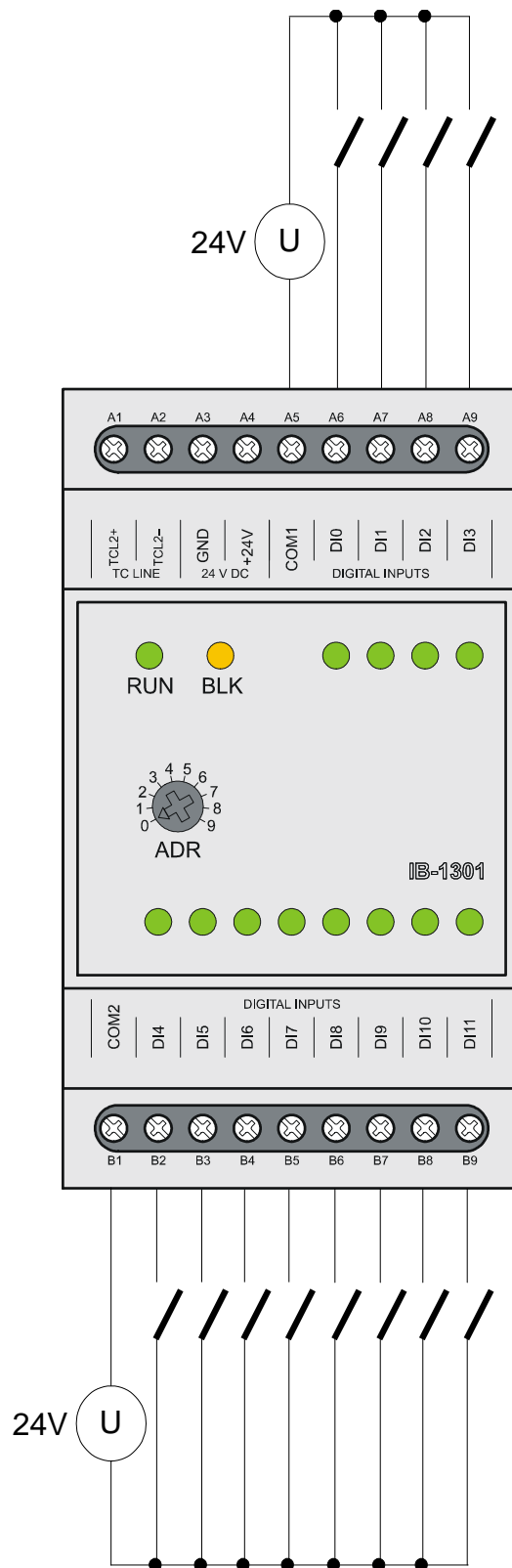
Fig.3.1.2   Typical example of switches connection to binary inputs of the IB-1301 module

3.1.1.2 Counters

Binary inputs DI0 - DI3 can be used as counter inputs. Two counter objects are available that can work in several modes (one-way counter, two-way counter, basic IRC). Each counter object uses standardly two inputs. Moreover, the first counter object enables

modes that use all four inputs (counter and IRC with resetting and capturing, impulse length measuring, period and phase shift measuring). In this case the second counter object is switched off. Even when used for these alternative functions, inputs DI0 –DI3 are useable also as standard binary inputs. Inputs are brought out to terminals within the top array DIGITAL INPUTS.

Electric parameters of inputs are stated in the table 3.1.3, time parameters in the table 3.1.4. and a modes overview in the table 3.1.5.

Table 3.1.4   Time parameters of counters inputs of the module IB-1301

Module type	IB-1301
Counters modes:	
Input frequency	5 kHz
Pulse width	min. 50 µs
Delay from log.0 to log.1	5 µs
Delay from log.1 to log.0	5 µs
Register range	0 up to 4 294 967 295 (32 bits)
Incremental sensors (IRC):	
Symmetric signal frequency (V, G)	1,25 kHz
Pulse width (V, G, NI, MD)	min. 50 µs
Delay from log.0 to log.1	5 µs
Delay from log.1 to log.0	5 µs
Register range	0 up to 4 294 967 295 (32 bits)
Impulse length measuring, period and phase shift measuring:	
Input frequency	0,1 up to 5000 Hz
Pulse width	50 up to 10 000 000 µs

Table 3.1.5   Overview of counter modes

Counter mode	Counter object 1				Counter object 2	
signal	DI0	DI1	DI2	DI3	DI2	DI3
One one-way counter	UP	-	-	-	UP	-
Two one-way counters	UP	UPB	-	-	UP	UPB
Two-way counter	UP	DOWN	-	-	UP	DOWN
Counter with controlled direction	CLK	DIR	-	-	CLK	DIR
Basic IRC	V	G	-	-	V	G
Two-way counter with reset and capturing	UP	DOWN	CLR	CAP	-	-
Counter with controlled direction and with reset and capturing	CLK	DIR	CLR	CAP	-	-
IRC with reset and capturing	V	G	NI	MD	-	-
Impulse length measuring	Input optional during the operation DI0 - DI3				-	-
Period and phase shift measuring (both functions switcheable during the operation)	period: Input optional during the operation DI0 - DI3				-	-
	Phase shift: Measured between DI1 and DI0				-	-

Abbreviations of various signals overview:
UP   - impulse input for counter incrementation
UPB   - impulse input for B counter incrementation

DOWN - impulse input for counter decrementation
CLK - impulse input for counter
DIR - counter direction
CLR - counter reset
CAP - capturing of the counter value
V   - first track IRC
G   - second track IRC
NI   - clearing pulse IRC
MD   - measuring contact

As can be seen in the table 3.1.5, both counter objects can be adjusted to different mode combinations providing that the first object uses only inputs DI0 and DI1 (first 5 modes). If the first object uses all DI0 to DI3 inputs, then the second object is switched off.

According to the configuration we can have available up to 4 simple one-way counters or 2 simple two-way counters / IRC or 1 counter / IRC including reset and capturing.

Modes of impulse length measuring and period and phase shift measuring are designated for periodic signals only. These measurements are loaded by a live error arising due to occupance of the periphery processor during the data transmission with the central unit. This error is eliminated so, that the resultant value of the measuring is gained as an average of the last eight pulses captured. Thus, it is supposed that the detected signal is presented by impulses repeated with a certain periodicity. An absolute error of the measurement is max. ± 10 µs and decrease in connection to the PLC cycle time extension.

The meanings of each function are described in the chapter 2.3.6. Counter inputs are connected similarly to standard inputs as shown in the fig.3.1.2. In fig.3.1.3 and fig.3.1.4 you can see examples of the IRC position sensors connection.
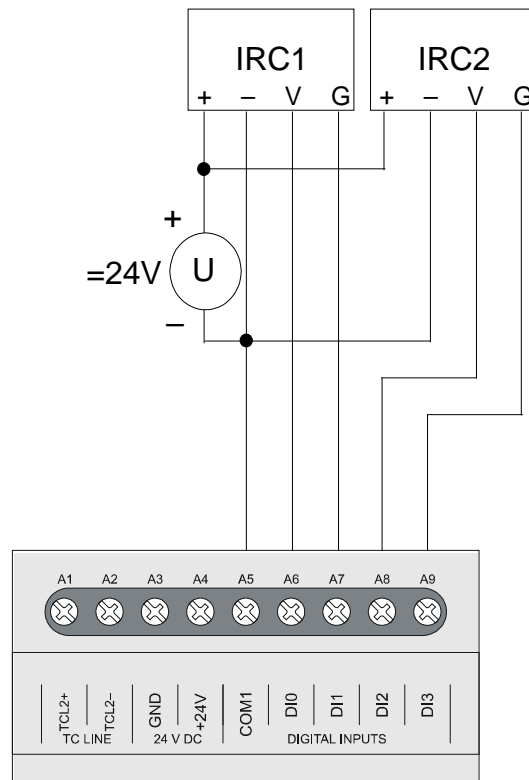
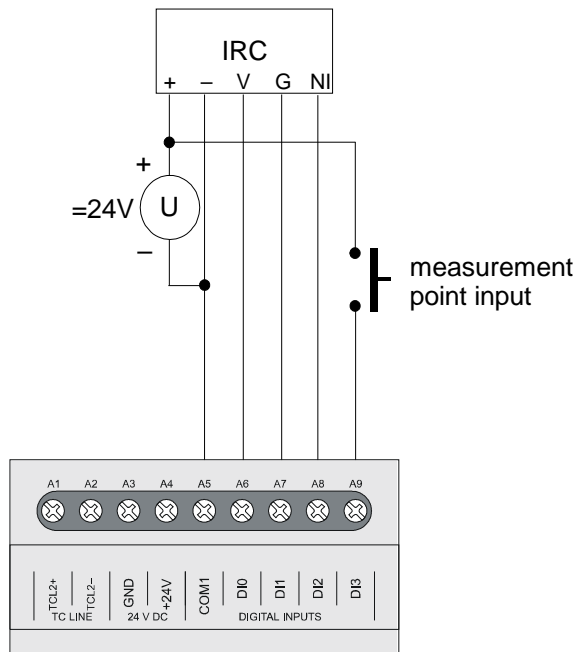*Fig.3.1.3 Example of two IRC incremental encoders connection*

Fig.3.1.4   Example of a complete connection of the IRC position sensor

3.1.1.3 Data provided by the IB-1301 module

The IB-1301 peripheral module provides information on inputs. Data structure can be seen in the panel *I/O Settings* in the Mosaic development environment (Fig.3.1.5) (icon ▣).

Structure items have assigned symbolic names which always start with *r1_px_* where x is the number correspondent to the adjusted address on the rotating switch. In the column *Full entry* the concrete symbolic name for the given item is always stated. If we want to use data in the user program we use either this symbolic name or in the column *Alias* we enter our own symbolic name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.
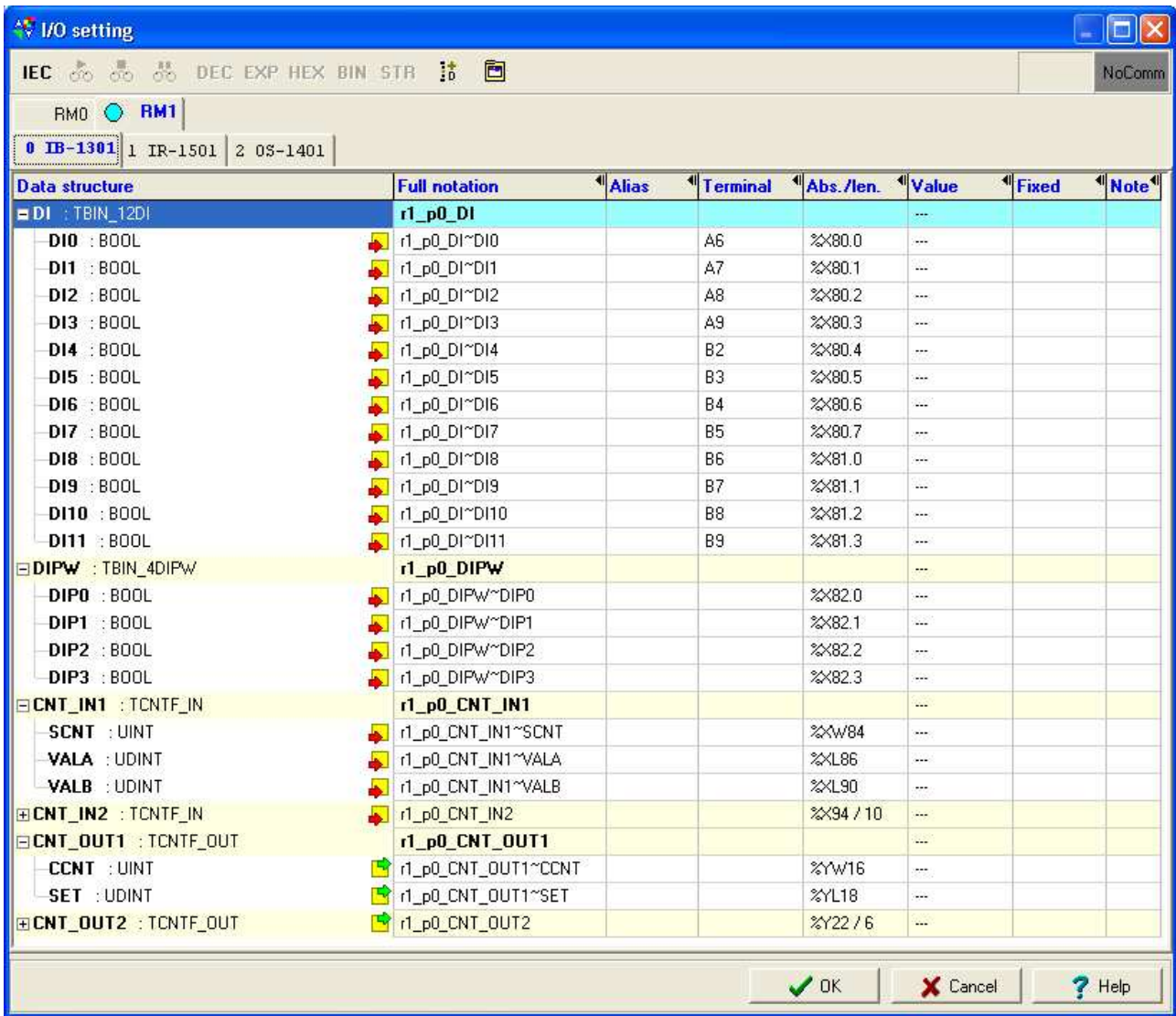
Fig.3.1.5   IB-1301 module data structure

Input data

DI   - binary input values (16x boolean type)

	DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0
bit	.7	.6	.5	.4	.3	.2	.1	.0

	0	0	0	0	DI11	DI10	DI9	DI8
bit	.15	.14	.13	.12	.11	.10	.9	.8

DI0 - DI3 - binary inputs useable for counters
DI4 - DI11 - standard binary inputs

DIP   - binary input values with short impulse detection (16x boolean type)

	0	0	0	0	DIP3	DIP2	DIP1	DIP0
bit	.7	.6	.5	.4	.3	.2	.1	.0

	0	0	0	0	0	0	0	0
bit	.15	.14	.13	.12	.11	.10	.9	.8

DIP0 - DIP3 – input values DI0 - DI3 with artificial extension of the selected
level into one cycle(detection of short impulses)

CNT_IN1   - counter input object 1 (*TCNTF_IN structure*)

CNT_IN1~SCNT – counter status word 1 (16x boolean type)

0	0	0	EPS	EMD	ENI	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

    EV   - 1 - active edge tag on DI0 (according to the mode)
    EG   - 1 - active edge tag on DI1 (according to the mode)
    ENI   - 1 - active edge tag on DI2 (according to the mode)
    EMD   - 1 - active edge tag on DI3 (according to the mode)
    EPS   - 1 - achieved preset tag
    EVB   - 1 - active edge tag on DI1 (B counter)
    EPSB - 1 - achieved preset tag (B counter)

CNT_IN1~VALA – first input value - interpretation according to the counter mode (udint type)
- counter value 1 (counter and IRC)
- period during which the input is in log.1 state (impulse length measurement)
- period or phase shift (period measuring)

CNT_IN1~VALB – second input value - interpretation according to the counter mode (udint type)
- counter value 1B (pair of counters)
- captured value (counter and IRC with reset and capturing)
- period during which the input is in log.0 state (impulse length measurement)

CNT_IN2   - counter inputs object 2 (*TCNTF_IN structure*)

CNT_IN2~SCNT – counter status word 2 (16x boolean type)

0	0	0	EPS	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

    EV   - 1 - active edge tag on DI2 (according to the mode)
    EG   - 1 - active edge tag on DI3 (according to the mode)
    EPS   - 1 - achieved preset tag
    EVB   - 1 - active edge tag on DI3 (B counter)
    EPSB - 1 - achieved preset tag (B counter)

CNT_IN2~VALA – counter value 2 (udint type)

CNT_IN2~VALB – counter value 2B (pair of counters – udint type)

Output data

CNT_OUT1 - counter 1 output object (*TCNTF_OUT* structure)

CNT_OUT1~CCNT – counter 1 control word (16x boolean type)

	0	FMD	MD	NI	FC	SET	RES	EN
bit	.7	.6	.5	.4	.3	.2	.1	.0

	IN1	IN0	0	MOD	FCB	SETB	RESB	ENB
bit	.15	.14	.13	.12	.11	.10	.9	.8

EN - 0 - counter 1 stopped
      1 - counter 1 counts
RES - 1 - counter 1 reset and clearing
SET - 1 - counter 1 set to the SET value
FC - 0 - counter 1 runs free
      1 - clear counter 1 after the SET value is gained
NI - 1 - approved signal capturing NI
MD - 1 - approved signal capturing MD
FMD - 0 - clear counter 1 from MD signal
      1 - capture current value of counter 1 into *VALB* from MD signal
ENB - 0 - counter 1B stopped
      1 - counter 1B counts
RESB - 1 - counter 1B reset and clearing
SETB - 1 - set counter 1B to the SET value
FCB - 0 - counter 1B runs free
      1 - clear counter 1B after the SET value is gained
MOD - 0 - period measuring
      1 - phase shift measuring
IN1-IN0 - selection of measured input for impulse length or period measurements
      00 - input DI0
      01 - input DI1
      10 - input DI2
      11 - input DI3

CNT_OUT1~SET - counter 1 preset

CNT_OUT2 - counter 2 outputs object (*TCNTF_OUT* structure)

CNT_OUT2~CCNT - counter 2 control word (16x boolean type)

	0	0	0	0	FC	SET	RES	EN
bit	.7	.6	.5	.4	.3	.2	.1	.0

	0	0	0	0	FCB	SETB	RESB	ENB
bit	.15	.14	.13	.12	.11	.10	.9	.8

EN - 0 - counter 2 stopped
      1 - counter 2 counts
RES - 1 - counter 2 reset and clearing
SET - 1 - counter 2 set to the SET value
FC - 0 - counter 2 runs free
      1 - clear counter 2 after the SET value is gained
ENB - 0 - counter 2B stopped
      1 - counter 2B counts

RESB - 1 - reset counter 2B and its clearing
SETB - 1 - counter 2B set to the *SET2* value
FCB   - 0 - counter 2B runs free
                    1 - clear counter 2B after the *SET2* value is gained

CNT_OUT2~SET - counter 2 preset

The behaviour of individual data objects is described in the following chapter.

3.1.1.4 Initialization and behaviour of individual data objects of the IB-1301 module

The IB-1301 peripheral module contains a block of binary inputs and outputs and two counter objects.

The panel intended for module parameters setting can be opened in the project manager in the node *HW | HW configuration* (Fig.3.1.6). In the folder *External I/O modules* click on the icon on the relevant line.
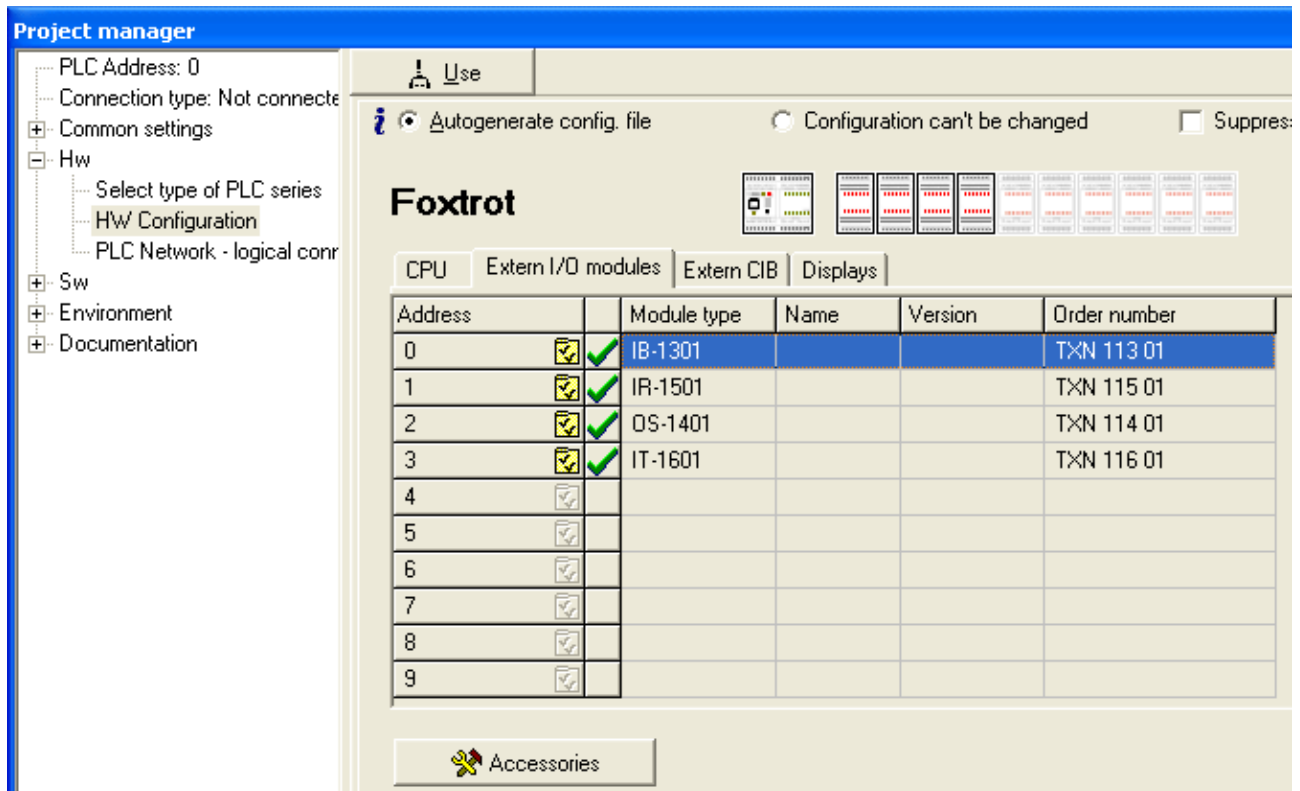
Fig.3.1.6   Configuration of peripheral modules

Binary inputs

The binary input state is contained in the DI variable. The state of all twelve inputs is valid even in cases when inputs are used for alternative functions (short impulses capturing, inputs for counters).

The binary inputs configuration can be found in the folder *Binary IO* (Fig.3.1.7). By ticking the option *Switch-on the transfer of binary inputs DI8 to DI11* we can enable the transfer of current states of all four inputs into the PLC notepad. If this options are not ticked, relevant values are not transferred and do not appear in the PLC notepad.
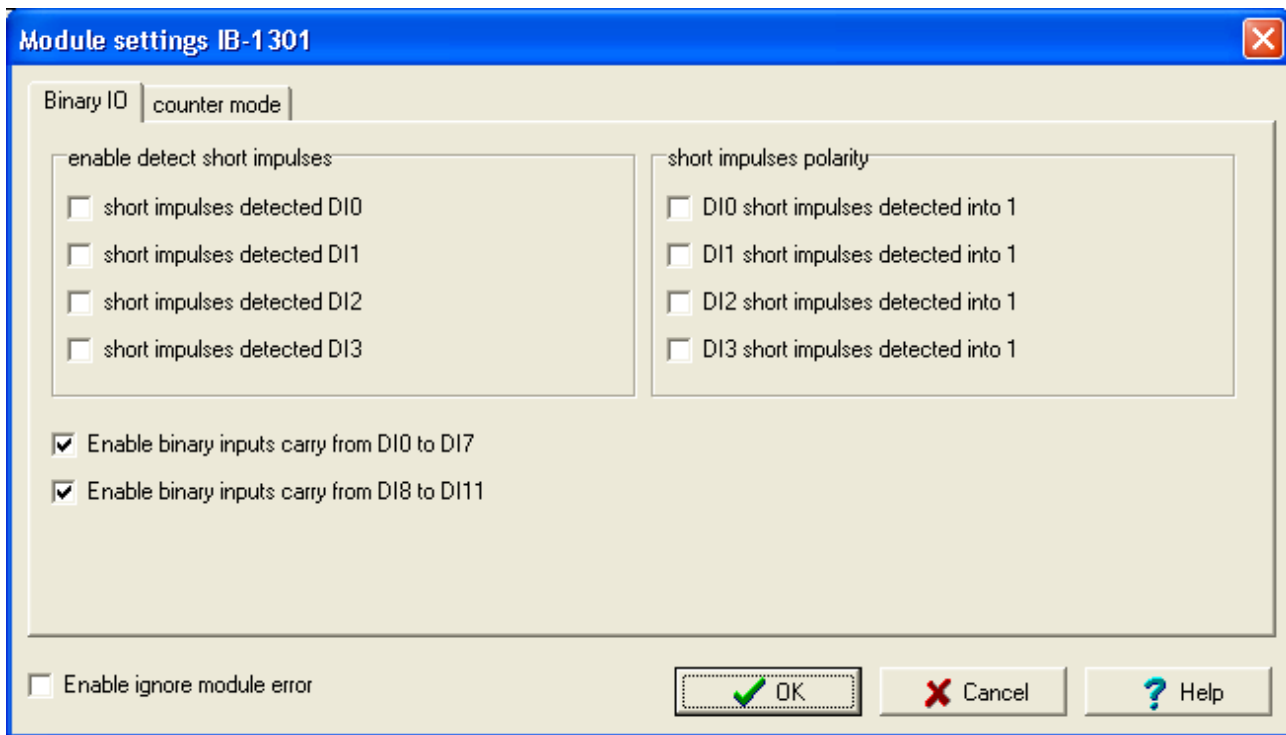
Fig.3.1.7   Configuration of binary inputs

If we check an item *Enable ignoring module error* at the bottom side of *IB-1301 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5). This function can be used in case we want to keep PLC running even if peripheral module power supply is switched off.

It is possible to activate the function of short impulses capturing on each input DI0 to DI3 individually. By ticking the option *short impulses are detected* we can activate the function of short impulses capturing for the correspondent input. If the option *short impulses detected into 1 of the according inputs* is checked, then the function of capturing short impulses into log.1 is activated, otherwise, the function of capturing short impulses into log.0 is activated. If one of the options is not available, it means that the appropriate input is already occupied by a counter function.

If we have an input signal which is mainly in the log.1 state and impulses into log.0 occur on it that are shorter then the longest possible PLC cycle period, then a loss of such impulses can occur because only states of inputs appearing at the time of the central unit cycle turn are standardly transferred into the PLC. If we switch on the detection of short impulses for the log.0 state, then its changes are detected on the relevant input. If the value log.0 appears on the input during the cycle period, then it will stay recorded in the module memory until the nearest data transfer to the central unit is undertaken, even though the value log.1 is on the input at the time of the data transfer.
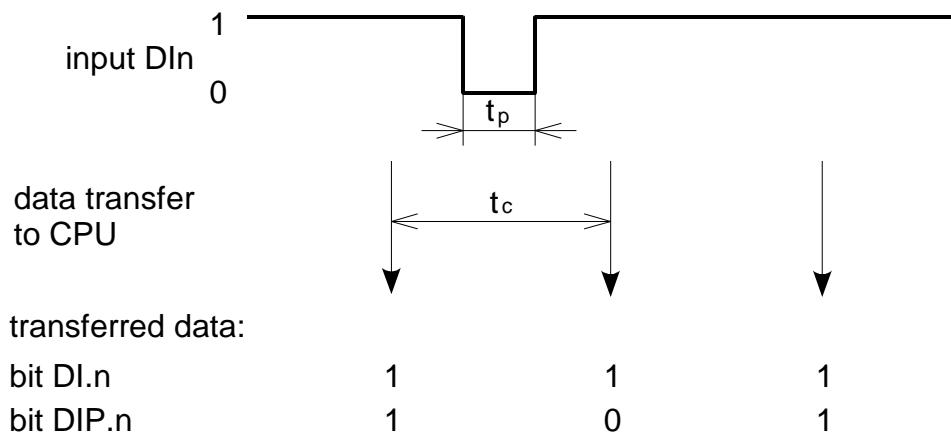
Fig.3.1.8 Detection of short impulses into log.0 function
t_p -pulse width, t_c =PLC cycle period

The same applies by analogy for an input signal which is mainly in log.0 state and short impulses to log.1 appear within. We switch the detection of short impulses for the log.1 state on and the short-term value log.1 at the input is extended until the cycle turn.

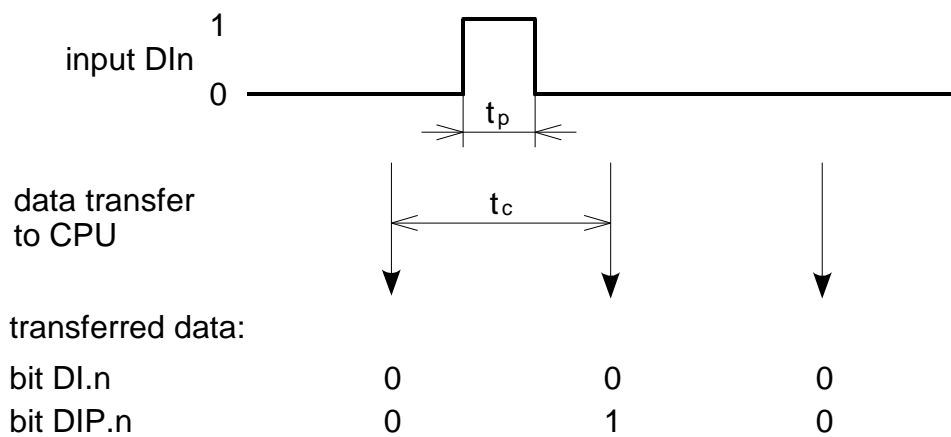The inputs state with switched on short impulse detection is contained in the DIP variable.

Fig.3.1.9 Detection of short impulses into log.1 function
t_p -pulse width, t_c =PLC cycle period

Counters

The IB-1301module contains two counter objects which use inputs DI0 to DI3 and they can be set to several operation modes. These modes can be divided into two groups. The first group is represented by modes that always use two inputs. The first counter object uses inputs DI0 and DI1, the second counter object uses inputs DI2 and DI3. Both counter objects can be set to a random mode from this group and each can work in a different mode.

The group of basic modes of counter objects consists of the following modes:

♦ No counter
♦ One one-way counter
♦ Two one-way counters
♦ Two-way counter
♦ Counter with controlled direction
♦ Basic IRC

The second group of basic modes of counter objects consists of the following modes:

♦ Two-way counter with reset and capturing
♦ Counter with controlled direction and with reset and capturing
♦ IRC with reset and capturing
♦ Impulse length measuring
♦ Period and phase shift measuring

These modes use all four inputs DI0 to DI3 and they can be set in the first counter object only. The second counter object is always switched off. The counters configuration can be found in the folder *Counter mode* (Fig.3.1.10).

Fig.3.1.10 Counters configuration

For counter modes from the second group, it is possible to set the signal polarity NI and MD. If we switch the option *input NI is active in 1* on, then the transfer of the signal from state 0 to state 1 will be understood as the entering edge. If we switch the option *input NI is active in 0* on, then the transfer of the signal from state 1 to state 0 will be understood as the entering edge. The same applies for the MD signal.

The counter object modes are identical to those of IR-1055 board of CP-1004 module and are described in detail in chapter 2.3.6.

3.2 BINARY OUTPUT MODULES

These modules contain binary outputs and are connected to the basic module via the TCL2 bus.

3.2.1 OS-1401 module

The peripheral OS-1401 module contains 12 binary 24 V DC outputs. All inputs have galvanic isolation. The module is powered by 24 V DC which has no galvanic isolation from the internal circuits.
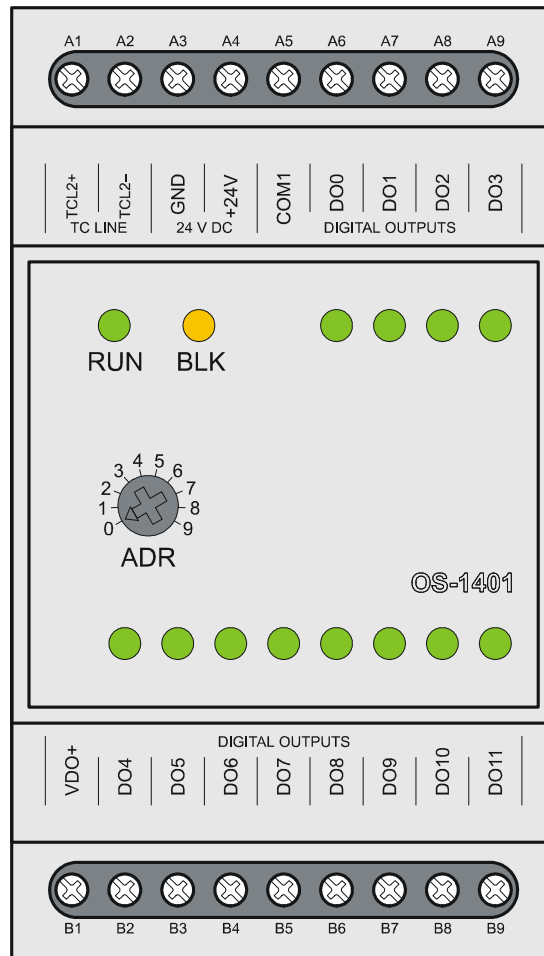

Fig.3.2.1   OS-1401 peripheral module

Table 3.2.1   OS-1401 basic module parameters

Module type	OS-1401
Power supply voltage (SELV)	24 VDC, +25%, −15%
Internal protection	none
Maximum input	2,5 W
Connection	Fixed screw terminals, max.2,5 mm^2 conductor per terminal
Galvanic isolation of power supply from internal circuit	none
Number of inputs	12
Size	53 x 95 x 65 mm

The connection of terminals of the OS-1401 module is shown in the table 3.2.2.

Table 3.2.2   Connection of terminal boards A and B of the OS-1401 module

A1	TCL2+	system bus TCL2
A2	TCL2–	system bus TCL2
A3	GND	module ground
A4	+24V	supply
A5	VDO+	common conductor of outputs DO0 - DO11
A6	DO0	binary output DO0
A7	DO1	binary output DO1
A8	DO2	binary output DO2
A9	DO3	binary output DO3
B1	COM1	outputs power supply + 24 V DC
B2	DO4	binary output DO4
B3	DO5	binary output DO5
B4	DO6	binary output DO6
B5	DO7	binary output DO7
B6	DO8	binary output DO8
B7	DO9	binary output DO9
B8	DO10	binary output DO10
B9	DO11	binary output DO11

3.2.1.1 Binary outputs

Binary outputs serve for controlling two-condition action and signaling elements of the controlled object powered by a 24V direct current. The OS-1401 peripheral module contains 12 binary outputs DO0 – DO11. Outputs DO0 - DO3 enable the switching of the current load of up to 2 A each (together max 4,4 A). Outputs DO4 - DO11 enable the switching of the current load of up to 0,5 A each. Outputs have galvanic isolation from internal circuits of the PLC. The output excitation (switching) is signalized by lighting up of the LED diode. There is one group of outputs using a common terminal. The common terminal has a negative polarity.

Table 3.2.3   Basic parameters of binary outputs of the OS-1401 module

Module type	OS-1401
Number of inputs	12
Number of groups	12
Galvanic isolation from internal circuits	yes
Diagnostics	Signalization of excited input on panel
Type of outputs	Transistor output
Joint conductor	Plus
Switching voltage	9,6 to 28,8 V DC
Switching current	max. 2 A (DO0 - DO3)
	max. 0,5 A (DO4 - DO11)
Current through the joint terminal	max. 4,4 A (sum of DO0 - DO3)
	max. 9 A (sum of DO0 - DO11)
Residual current while the contact is open	max 300 µA
Time of contact closure	max. 400 µs
Time of contact opening	max. 400 µs
Short-circuit protection	yes
Limitation of launch peak current	type 7,5 A
Time of disconnection of launch peak current	type 4 ms
Limitation of short-circuit current	type 4 A
Protection against the reversal of poles	yes*
Treatment of inductive load	External RC unit, varistor, diode

* The circuit will become inactive, loads will be switched and current will run through the protective circuit diode.

Binary outputs are brought out to terminals in the DIGITAL OUTPUTS array. A schematic overview of the loads connection powered by independent sources is shown in fig.3.2.2. Outputs are realized by semiconductor switches with internal protection against current and heat overload. To increase the resistivity and lifetime it is necessary to include anti-interference elements to the switched load. The 24V DC power supply connected to the VDO+ terminal and COM1 is necessary for the correct functioning of the output switches!

The principle of various ways how to undertake inductive load treatment, support for RC anti-interference members draft, overview of anti-interference sets delivered by the PLC producer and other recommendations are stated in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02*.
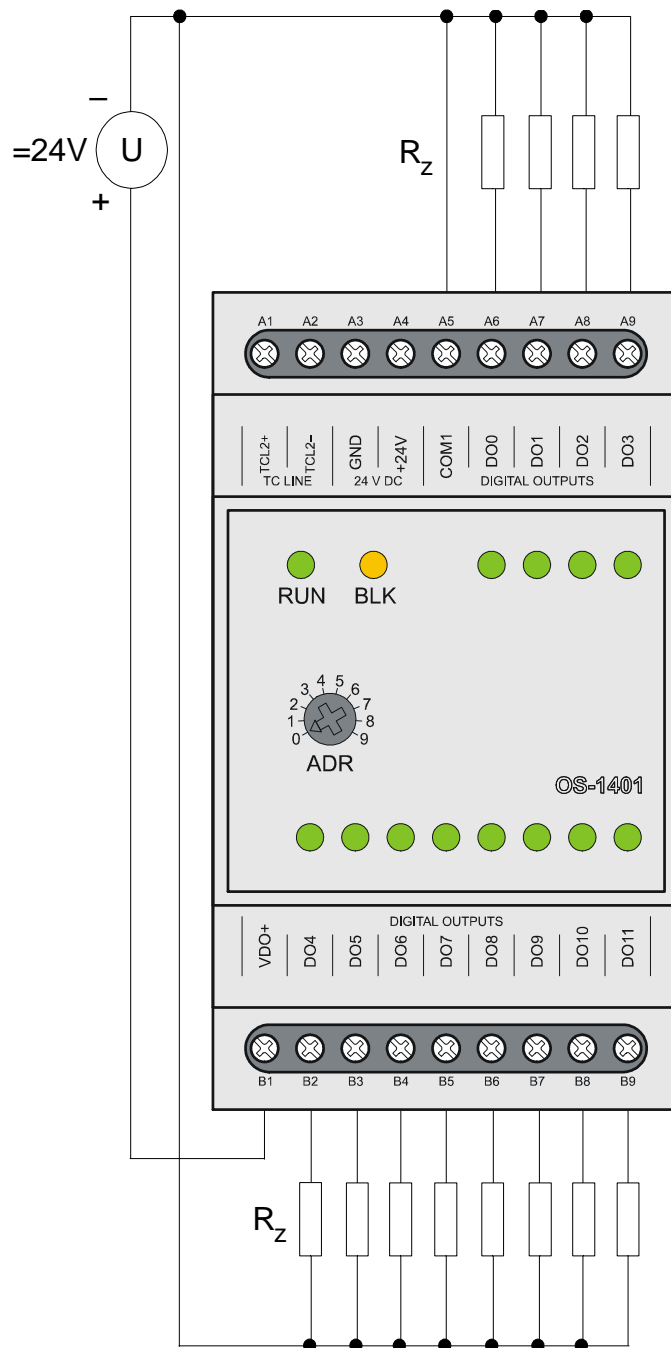
Fig.3.2.2   Typical example of loads connection to binary inputs of the OS-1401 module

3.2.1.2 Data provided by the OS-1401 module

The OS-1401 peripheral module provides information on outputs. Data structure is apparent from the panel *I/O Settings* in the Mosaic development environment (Fig.3.2.3) (icon 🔟).

Items in the structure have assigned symbolic names which always start with *r1_px_* characters where x is the number correspondent to the set address on the rotary switcher. In the column *Full entry* the concrete symbolical name for the given item is always stated. If we want to use data in the user program, we use either this symbolic name or in the column *Alias* we enter our own symbolic name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.
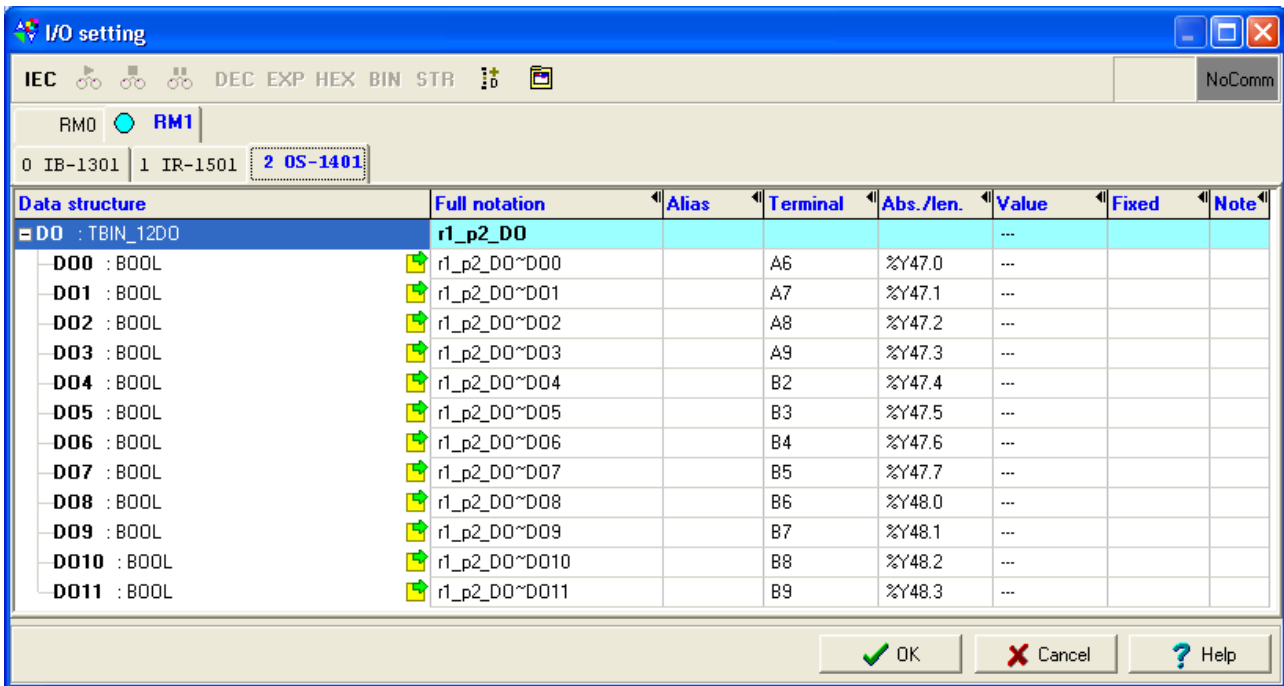
Fig.3.2.3   OS-1401 module data structure

Output data

DO   - binary output values (16x boolean type)

DO7	DO6	DO5	DO4	DO3	DO2	DO1	DO0
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	0	DO11	DO10	DO9	DO8
.15	.14	.13	.12	.11	.10	.9	.8

bit

DO0 - DO11 - binary outputs

The behaviour of individual data objects is described in the chapter below.

3.2.1.3 Initialization and behaviour of individual data objects of the OS-1401 module

The OS-1401 peripheral module contains a block of binary outputs.

The panel for the module parameters setting can be opened from the project manager *HW | HW configuration* (Fig.3.2.4). In the folder *External I/O modules* click on the icon on the relevant line.
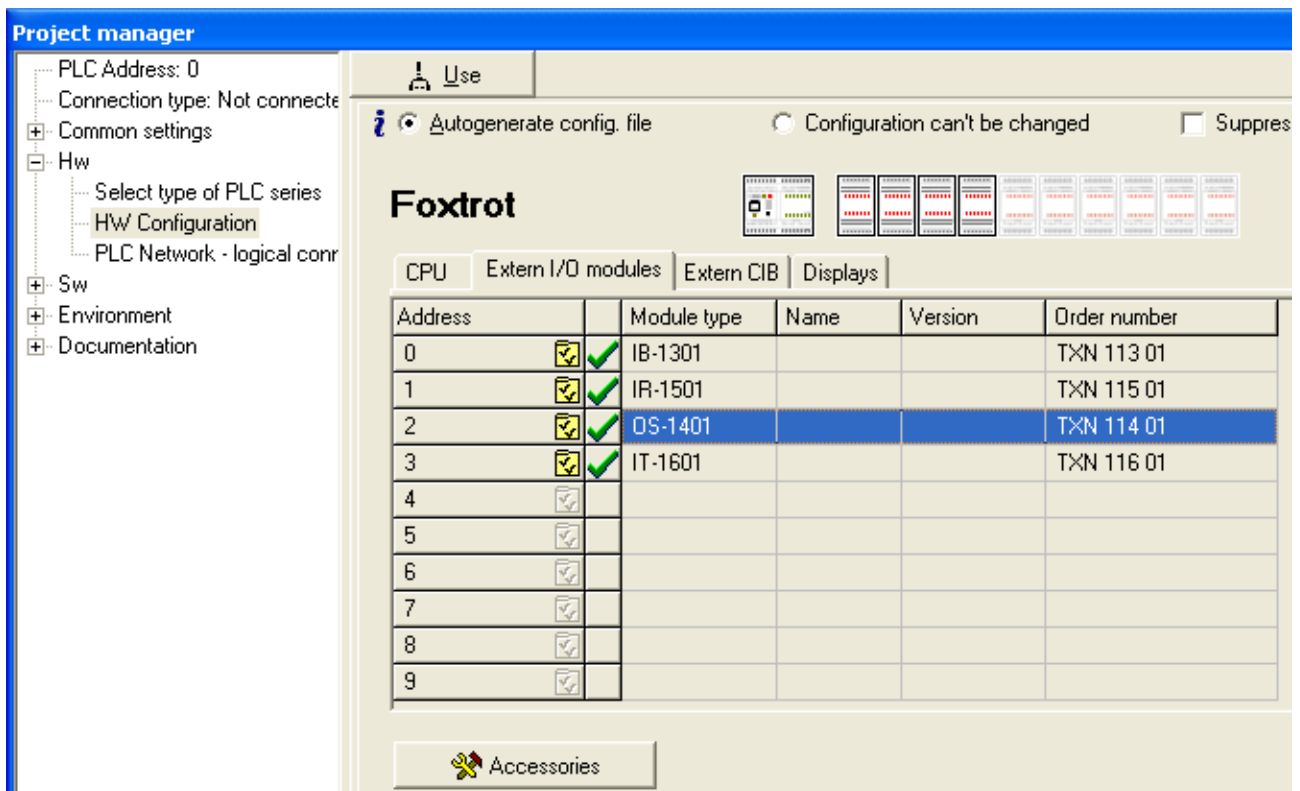
Fig.3.2.4   Configuration of peripheral modules

Binary outputs

The binary outputs state is contained in the DO variable. Configuration of binary outputs can be found in the folder *Binary IO* (Fig.3.2.5). By ticking the option *Switch-on of the transfer of binary outputs DO0 to DO7* we can enable the transfer of current states of the first eight outputs into the PLC notepad. By ticking the option *Switch-on of the transfer of binary inputs DO8 to DO11* we can enable the transfer of current states of the four remaining outputs into the PLC notepad. If this option is not ticked, relevant values are not transferred and relevant outputs are not set.
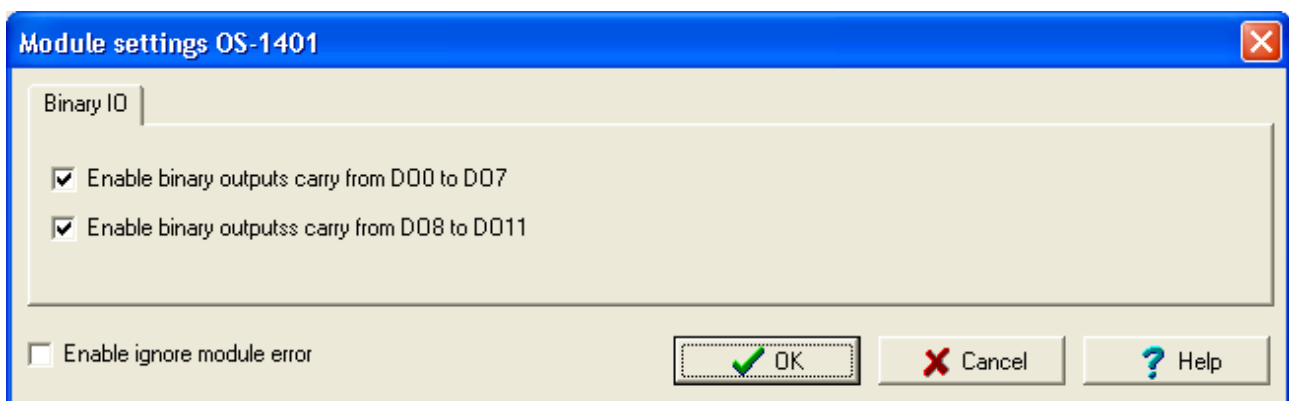
Fig.3.2.5   Configuration of binary outputs

If we check an item *Enable ignoring module error* at the bottom side of *OS-1401 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5). This function can be used in case we want to keep PLC running even if peripheral module power supply is switched off.

3.3 COMBINED MODULES OF BINARY INPUTS AND OUTPUTS

These modules contain binary inputs and outputs and are connected to the basic module via the TCL2 bus.

3.3.1 IR-1501 module

The IR-1501 peripheral module contains 4 binary 24 V DC inputs and 8 relay outputs. Inputs can be used as standard binary inputs or inputs for counters. All inputs and outputs have galvanic isolation. The module is powered by 24 V DC which has no galvanic isolation from the internal circuits.
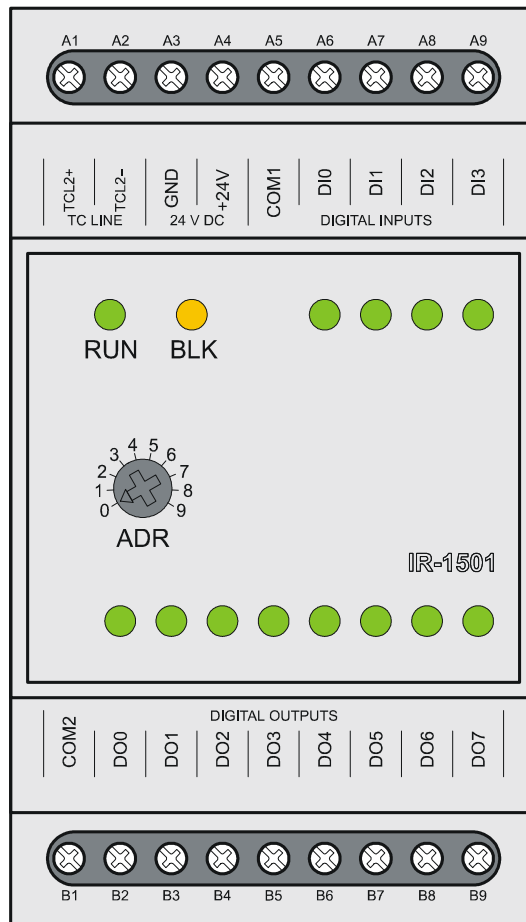

Fig.3.3.1   IR-1501 auxiliary module

Table 3.3.1   Basic parameters of the IR-1501 module

Module type	IR-1501
Power supply voltage (SELV)	24 VDC, +25%, −15%
Internal protection	none
Maximum input	2,5 W
Connection	fixed screw terminals, max.2,5 mm^2 conductor per terminal
Galvanic isolation of supply from internal circuits	none
Number of inputs	4
Number of outputs	8
Size	53 x 95 x 65 mm

The connection of terminals of the IR-1501 module is shown in the table 3.3.2.

Table 3.3.2   Connection of terminal boards A and B of the IR-1501 module

A1	TCL2+	system bus TCL2
A2	TCL2–	system bus TCL2
A3	GND	module ground
A4	+24V	supply
A5	COM1	common conductor of inputs DI0 - DI3
A6	DI0	binary input DI0
A7	DI1	binary input DI1
A8	DI2	binary input DI2
A9	DI3	binary input DI3
B1	COM2	common conductor of inputs DO0 - DO7
B2	DO0	binary input DO0
B3	DO1	binary input DO1
B4	DO2	binary input DO2
B5	DO3	binary input DO3
B6	DO4	binary input DO4
B7	DO5	binary input DO5
B8	DO6	binary input DO6
B9	DO7	binary input DO7

3.3.1.1 Binary inputs

Binary inputs serve for the connection of two-condition signals of the controlled object to the PLC. The IR-1501 peripheral module contains 4 binary inputs DI0 – DI3. Inputs have galvanic isolation from internal circuits of the PLC. The input excitation (switching) is signalized by lighting up of the LED diode. Inputs are organized into a group with a joint terminal. The joint terminal can be plus or minus for each group. Inputs can be used as inputs for counters, too. Even if these inputs are used for alternative functions as described, they can still be used as binary inputs.

Inputs enable to switch the function of short impulses capturing on. This function extends the selected level of the input signal until the next PLC turn is undertaken. Consequently, it is ensured that individual pulses on the input which are shorter than the PLC cycle will not be lost.

Note: If the function of capturing short impulses is activated on one of the inputs, it is forbidden to have the counter object, which uses this input, switched on simultaneously. If such a situation occurs, the function of capturing short impulses is switched off automatically.

Table 3.3.3   Basic parameters of binary inputs of the IR-1501 module

Module type	IR-1501
Number of inputs	4
Number of inputs in group	4
Galvanic isolation from internal circuits	yes
Diagnostics	Signalization of excited input on panel
Joint conductor	minus / plus
Input voltage	
for log.0 (UL)	max. +5 V DC
	min. –5 V DC
for log.1 (UH)	min. +15 V DC
	type +24 V DC
	max. +30 V DC
Input current at log.1	type 10 mA
Delay from log.0 to log.1	5 µs
Delay from log.1 to log.0	5 µs
Minimum width of the pulse captured	50 µs

Binary inputs are brought out to terminals in the DIGITAL INPUTS array. You can see a schematic overview of the switchers connection in fig 3.3.2.
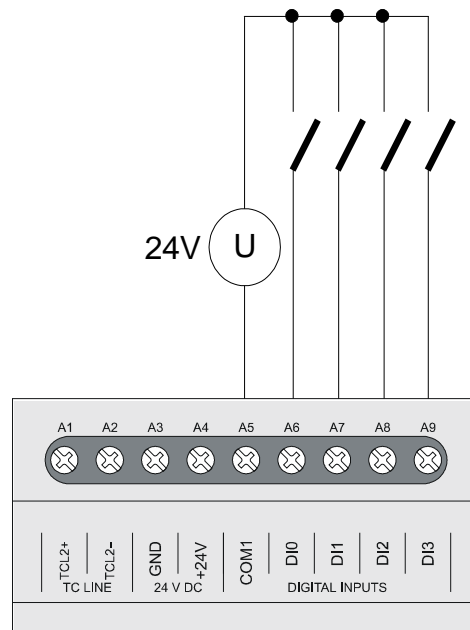
Fig.3.3.2   Typical example of the switches connecting to binary inputs of the IR-1501 module

3.3.1.2 Relay outputs

Relay outputs serve to control two-state action and signaling elements of the controlled object supplied by alternating or direct current of up to 250V. Outputs are realized by a closing voltage-free contact relay brought out to a group with one joint terminal.

The IR-1501 peripheral module contains 8 relay outputs DO0 - DO7 organized into a group with a joint terminal. Outputs have galvanic isolation from internal PLC circuits. Outputs excitation is signalized by lighting up of a relevant LED diode.

Table 3.3.4   Basic parameters of relay outputs of the IR-1501 module

Module type	IR-1501
Number of inputs	8
number of outputs in group	8
Galvanic isolation from internal circuits	yes
Diagnostics	Signalization of excited output on panel
Type of outputs	electromechanical relay, unprotected output
Contact type	switching
Switching voltage	max. 250 V
	min. 5 V
Switching current	max. 3 A
	min. 100 mA
Short-term overload of output	max. 4 A
Current through joint terminal	max. 10 A
Time of contact closure	type 10 ms
Time of contact opening	type 4 ms
Threshold limits of switched loads	
for resistive load	max. 3 A at 30 V DC or 230 V AC
DC13 for inductive load	max. 3 A at 30 V DC
AC15 for inductive load	max. 3 A at 230 V AC
Switching frequency without load	max. 300 switches / min.
Switching frequency with rated load	max. 20 switches / min.
Mechanical lifetime	min. 5 000 000 cycles
Electrical lifetime at max load	
for resistive load	min. 100 000 cycles
DC13 for inductive load	min. 100 000 cycles
AC15 for inductive load	min. 100 000 cycles
Short-circuit protection	external
Treatment of inductive load	External RC unit, varistor, diode (DC)
Insulation voltage	
between inputs and internal circuits	3750 V AC
between output groups respectively	3750 V AC

Binary input relay contacts are brought out to terminals in the DIGITAL OUTPUTS array. A schematic drawing of connections of loads powered by independent sources is shown in fig. 3.3.3. Protection against overload and short-circuit is undertaken using safety fuses for each input or for each group. The rated voltage and type of fuse is selected for each load and character of load differently considering the maximum voltage and overload capacity of outputs or group of outputs. For example when using tube fuses with a T and F fuse characteristic and a switching rate of 35 A, it is possible to use a rated current of 3 A per fuse per output and fuses of up to 10A when protecting a joint group conductor.

The principle of various ways how to undertake inductive load treatment, support for RC anti-interference members draft, overview of anti-interference items delivered by the PLC producer and other recommendations are stated in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02*.
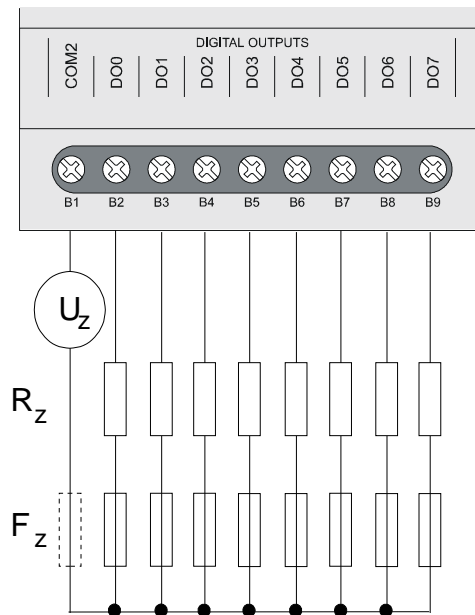
Fig.3.3.3 Typical example of the switches connection to binary inputs of the IR-1501 module

3.3.1.3 Counters

Binary inputs DI0 - DI3 can be used as counter inputs. Two counter objects are available working in several modes (one-way counter, two-way counter, basic IRC). Every counter object standardly uses two inputs. The first counter object enables modes that use all four inputs (counter and IRC with reset and capturing, impulse length measuring, period and phase shift measuring). In this case the second counter object is switched off. Even when used for these alternative functions, inputs DI0 –DI3 are still useable as standard binary inputs. Inputs are brought out to terminals in the DIGITAL INPUTS array.

Input electric parameters can be found in the table 3.3.3, time parameters in the table 3.3.5 and an overview of modes in 3.3.6.

Table 3.3.5   Time parameters of counter inputs of the IR-1501 module

Module type	IR-1501
Counter modes:	
Input frequency	5 kHz
Pulse width	min. 50 µs
Delay from log.0 to log.1	5 µs
Delay from log.1 to log.0	5 µs
Registers range	0 to 4 294 967 295 (32 bits)
Incremental sensors (IRC):	
Symmetric signal frequency (V, G)	1,25 kHz
Pulse width (V, G, NI, MD)	min. 50 µs
Delay from log.0 to log.1	5 µs
Delay from log.1 to log.0	5 µs
Registers range	0 to 4 294 967 295 (32 bits)
Pulse length measuring, period and phase shift measuring:	
Input frequency	0,1 to5000 Hz
Pulse width	50 to 10 000 000 µs

Table 3.3.6   Overview of counter modes

Counter mode		Counter object 1				Counter object 2	
	signal	DI0	DI1	DI2	DI3	DI2	DI3
One one-way counter		UP	-	-	-	UP	-
Two one-way counters		UP	UPB	-	-	UP	UPB
Two-way counter		UP	DOWN	-	-	UP	DOWN
Counter with controlled direction		CLK	DIR	-	-	CLK	DIR
Basic IRC		V	G	-	-	V	G
Two-way counter with reset and capturing		UP	DOWN	CLR	CAP	-	-
Counter with controlled direction and with reset and capturing		CLK	DIR	CLR	CAP	-	-
IRC with reset and capturing		V	G	NI	MD	-	-
Pulse length measuring		selectable during operation DI0 - DI3				-	-
Period and phase shift measuring (both functions switcheable during operation)		period: input selectable during operation DI0 - DI3				-	-
		phase shift: measured between DI1 a DI0				-	-

Overview of various signals abbreviations:
UP   - impulse input for counter incrementation
UPB   - impulse input for B counter incrementation
DOWN - impulse input for counter decrementation
CLK   - impulse input for counter
DIR   - counter direction
CLR   - counter reset
CAP   - capturing counter value
V   - IRC first track
G   - IRC second track
NI   - IRC clearing pulse
MD   - measuring contact

As results from the table 3.3.6, both counter objects can be set to different mode combinations providing that the first object uses inputs DI0 and DI1 (first 5 modes) only. If the first object uses all DI0 to DI3 inputs, then the second object is switched off.

According to the configuration we can have up to 4 simple one-way counters or 2 simple two-way counters / IRC or 1 counter / IRC including reset and capturing available.

Modes of impulse length measuring and period and phase shift measuring are designated for periodic signals only. These measurements are loaded with a libe error arising during the occupance of the periphery processor while exchanging data with the central unit. This error is eliminated so, that the resultant value of the measurement is gained as an average of the last eight pulses captured. Therefore, it is supposed that the signal detected is represented by pulses repeating with a certain period. The absolute error of the measurement is max. ± 10 µs and decrease in relation to the PLC cycle extension.

The meaning of each function are described in detail in chapter 2.3.6. Counter inputs are connected in the same manner as standard inputs as shown in fig.3.3.2. In fig.3.3.4 and 3.3.5 examples of the IRC position sensors connection can be seen.
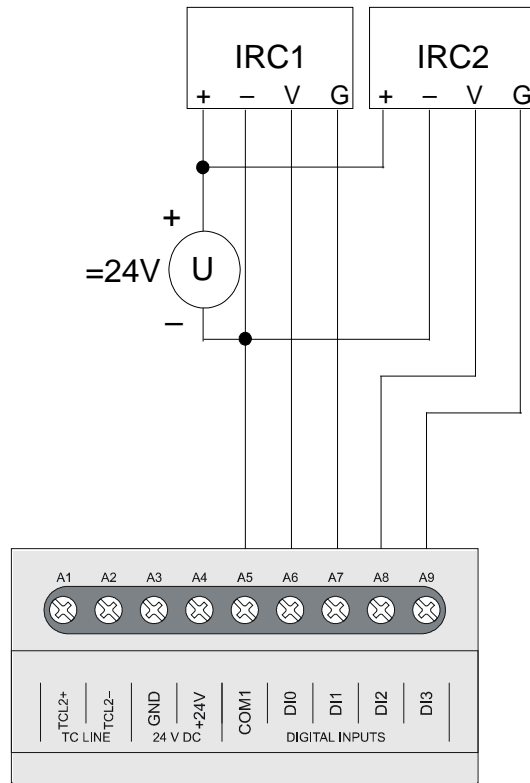
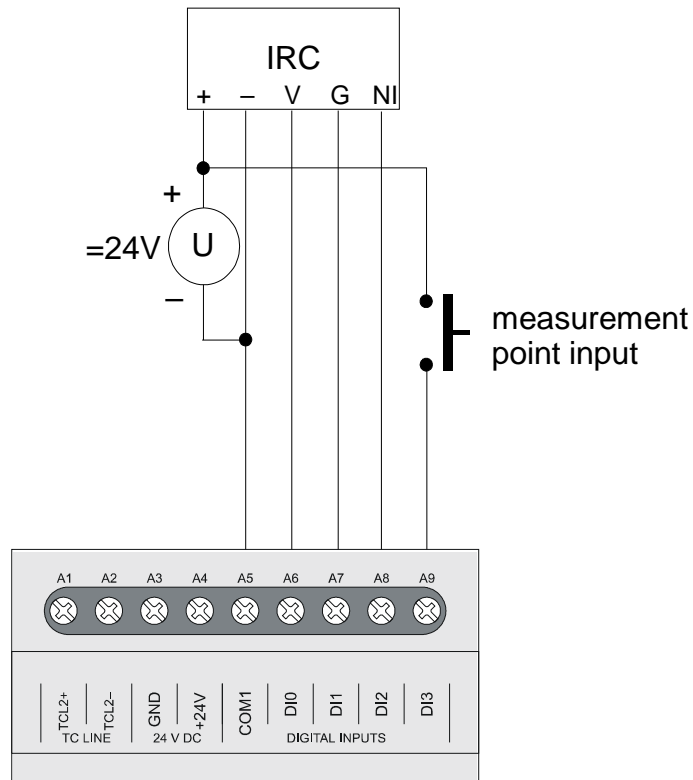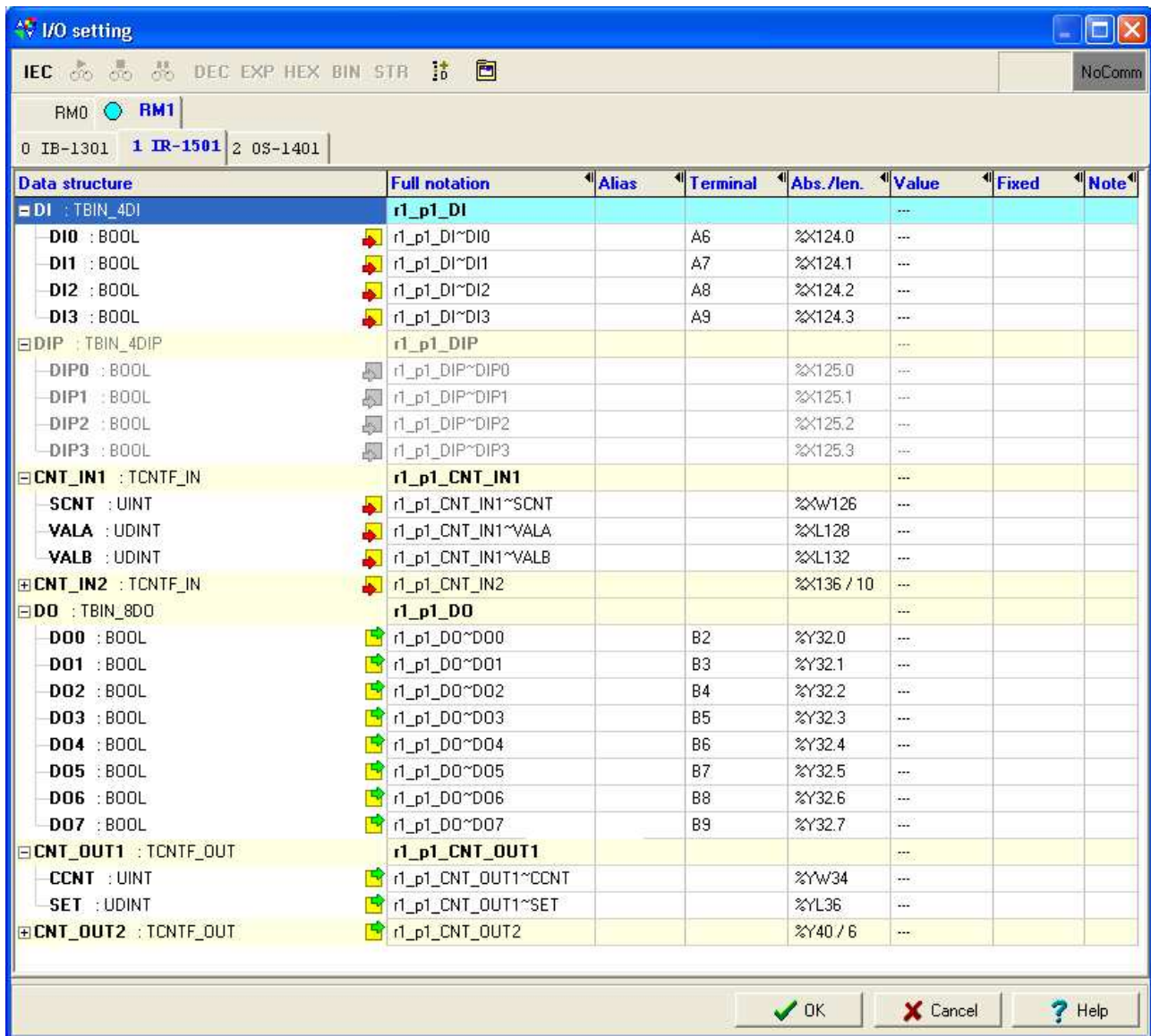*Fig.3.3.4   Example of two IRC position sensors connection*

Fig.3.3.5   Example of complete connection of IRC position sensor

3.3.1.4 Data provided by the IR-1501 module

The IB-1501 peripheral module provides information on inputs and outputs. The data structure is apparent from the panel *I/O Settings* in the Mosaic development environment (Fig.3.3.6) (icon 🔟).

Items in the structure have assigned symbolic names which, for the IR-1055 board, start always with *r1_px_* characters where x is the number correspondent to the set address on the rotary switch. In the column *Bull entry* the concrete symbolic name for the given item is always stated. If we want to use data in the user program, we use either this symbolical name or in the column *Alias* we enter our own symbolic name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.

Fig.3.3.6   IR-1501 module data structure

Input data

DI   - binary input values (8x boolean type)

0	0	0	0	DI3	DI2	DI1	DI0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DI0 - DI3 - binary inputs useable for counters

DIP   - binary input values with short impulse detection (8x boolean type)

0	0	0	0	DIP3	DIP2	DIP1	DIP0
.7	.6	.5	.4	.3	.2	.1	.0

bit

DIP0 - DIP3 - input values DI0 - DI3 with artificial extension of the selected level into one cycle(detection of short impulses)

CNT_IN1   - counter 1 input object (*TCNTF_IN structure*)

CNT_IN1~SCNT – counter 1 status word (16x boolean type)

0	0	0	EPS	EMD	ENI	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EV   - 1 - active edge tag on DI0 (according to the mode)
EG   - 1 - active edge tag on DI1 (according to the mode)
ENI   - 1 - active edge tag on DI2 (according to the mode)
EMD   - 1 - active edge tag on DI3 (according to the mode)
EPS   - 1 - achieved preset tag
EVB   - 1 - active edge tag on DI1 (B counter)
EPSB - 1 - achieved preset tag (B counter)

CNT_IN1~VALA - first input value - interpretation according to the counter mode (udint type)
- counter value 1 (counter and IRC)
- period during which the input is in log.1 state (impulse length measurement)
- period or phase shift (period measuring)

CNT_IN1~VALB - second input value - interpretation according to the counter mode (udint type)
- counter value 1B (pair of counters)
- captured value (counter and IRC with reset and capturing)
- period during which the input is in log.0 state (impulse length measurement)

CNT_IN2   - counter input object 2 (*TCNTF_IN* structure)

CNT_IN2~SCNT - counter status word 2 (16x boolean type)

0	0	0	EPS	0	0	EG	EV
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	EPSB	0	0	0	EVB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EV   - 1 - active edge tag on DI2 (according to the mode)
EG   - 1 - active edge tag on DI3 (according to the mode)

        EPS   - 1 - achieved preset tag

        EVB   - 1 - active edge tag on DI3 (B counter)

        EPSB - 1 - achieved preset tag (B counter)

CNT_IN2~VALA - counter value 2 (udint type)

CNT_IN2~VALB - counter value 2B (pair of counters – udint type)

Output data

DO   - binary output values (8x boolean type)

	DO7	DO6	DO5	DO4	DO3	DO2	DO1	DO0
bit	.7	.6	.5	.4	.3	.2	.1	.0

        DO0 - DO7 - relay outputs

CNT_OUT1   - counter output object 1 (*TCNTF_OUT* structure)

CNT_OUT1~CCNT - counter control word1 (16x boolean type)

	0	FMD	MD	NI	FC	SET	RES	EN
bit	.7	.6	.5	.4	.3	.2	.1	.0

	IN1	IN0	0	MOD	FCB	SETB	RESB	ENB
bit	.15	.14	.13	.12	.11	.10	.9	.8

        EN   - 0 - counter 1 stopped

                 1 - counter 1 counts

        RES   - 1 - counter 1 reset and clearing

        SET   - 1 - counter 1 set to the SET value

        FC   - 0 - counter 1 runs free

                 1 - clear counter 1 after the SET value is gained

        NI   - 1 - approved signal capturing NI

        MD   - 1 - approved signal capturing MD

        FMD - 0 - clear counter 1 from the MD signal

                 1 - capture current value of counter 1 into *VALB* from MD signal

        ENB   - 0 - counter 1B stopped

                 1 - counter 1B counts

        RESB - 1 - counter 1B reset and clearing

        SETB - 1 - setting counter 1B to the SET value

        FCB - 0 - counter 1B runs free

                 1 - clear counter 1B after the SET value is gained

        MOD - 0 - period measuring

                 1 - phase shift measuring

        IN1-IN0 - selection of measured input for impulse length or period measurements

                 00 - input DI0

                 01 - input DI1

                 10 - input DI2

                 11 - input DI3

CNT_OUT1~SET - counter 1 preset

CNT_OUT2   - counter 2 output object (*TCNTF_OUT* structure)

CNT_OUT2~CCNT – counter 2 control word (16x boolean type)

0	0	0	0	FC	SET	RES	EN
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	0	FCB	SETB	RESB	ENB
.15	.14	.13	.12	.11	.10	.9	.8

bit

EN   - 0 - counter 2 stopped
         1 - counter 2 counts
RES   - 1 - counter 2 reset and clearing
SET   - 1 - counter 2 set to the SET value
FC   - 0 - counter 2 runs free
         1 - clear counter 2 after the SET value is gained
ENB   - 0 - counter 2B stopped
         1 - counter 2B counts
RESB   - 1 - counter 2B reset and clearing
SETB   - 1 - counter 2B set to the SET value
FCB   - 0 - counter 2B runs free
         1 - clear counter 2B after the SET value is gained

CNT_OUT2~SET - counter 2 preset

The behaviour of individual data objects is described in the chapter below.

3.3.1.5 Initialization and behaviour of individual data objects of the IR-1501 module

The IR-1501 peripheral module contains a block of binary inputs and outputs and two counter objects.
The panel for module parameters settings can be opened from the project manager *HW | HW configuration* (Fig.3.3.7). In the folder *External I/O modules* click on the icon on the relevant line.
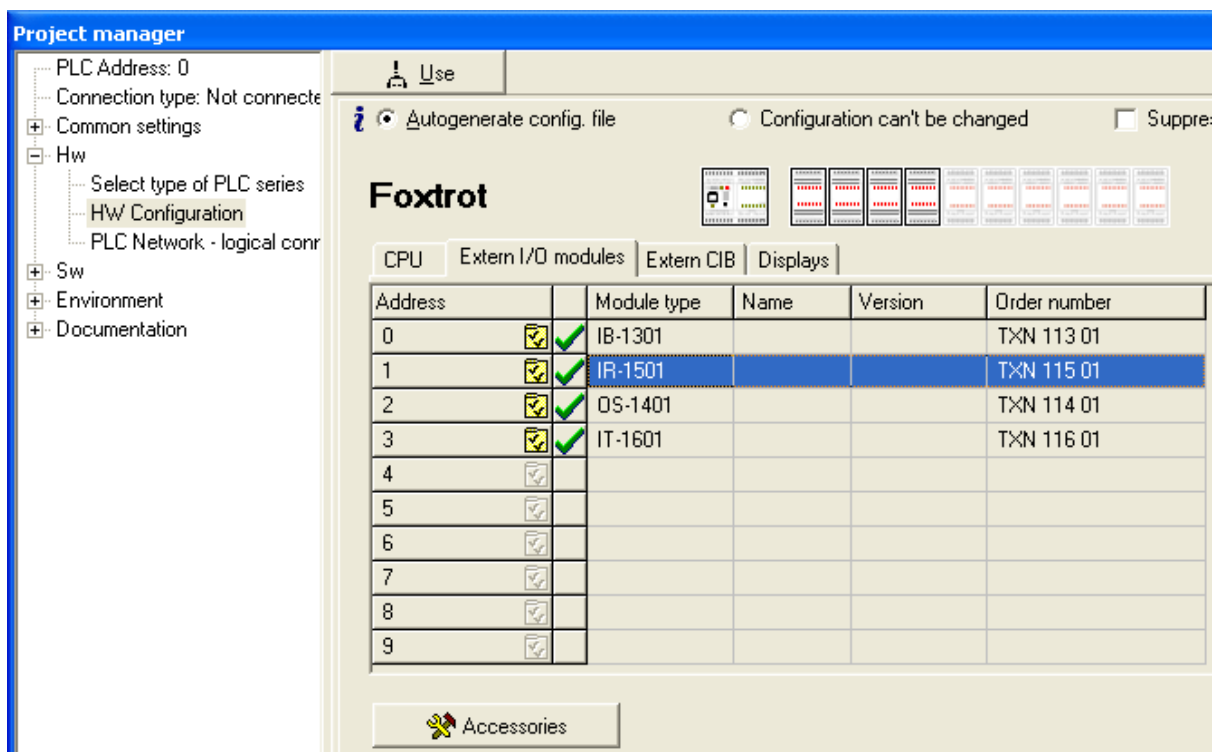

Fig.3.3.7 Configuration of peripheral modules

Binary inputs

The binary input state is contained in the DI variable. The state of all four inputs is valid even in cases when inputs are used for alternative functions (short impulses capturing, inputs for counters).
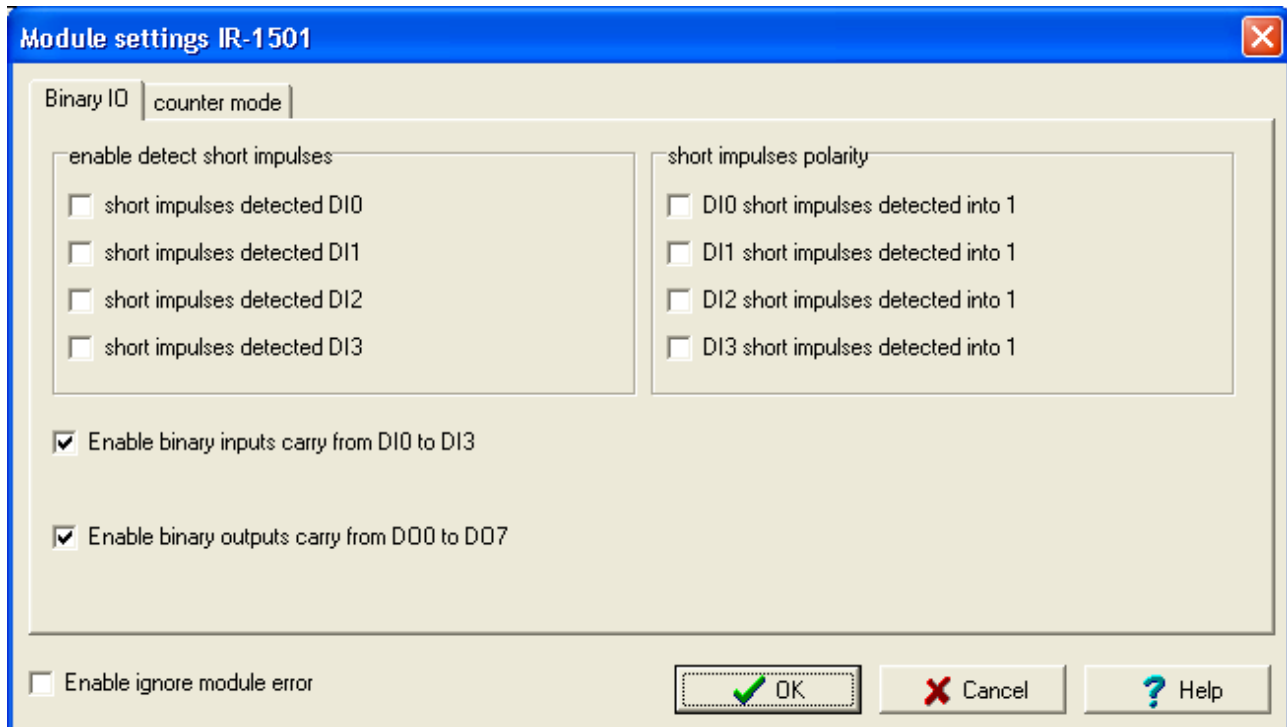

Fig.3.3.8   Configuration of binary inputs and outputs

If we check an item *Enable ignoring module error* at the bottom side of *IR-1501 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5). This function can be used in case we want to keep PLC running even if peripheral module power supply is switched off.

Configuration of binary inputs can be found in the folder *Binary IO* (Fig.3.3.8). By ticking the option *Switch-on the transfer of binary inputs DI0 to DI7 switched on* we can enable the transfer of current states of all four inputs into the PLC notepad. If this option is not ticked, relevant values are not transferred and do not appear in the PLC notepad.

It is possible to activate the function of capturing short impulses on each input DI0 to DI3 individually. By ticking the option *short impulses are detected* we can activate the function of short impulses capturing for the relevant input. If the option *short impulses detected into 1 of the correspondent inputs* is checked, then the function of capturing short impulses into log.1 is activated, otherwise, the function of capturing short impulses into log.0 is activated. If one of the options is not available, it means that the relevant input is already occupied by a counter function.

If we have an input signal which is mainly in the log.1 state and impulses into log.0 occur within which are shorter then the longest possible PLC cycle period, then a loss of such impulses can occur because only states of inputs appearing at the time of the central cycle turn are standardly transferred into the PLC. If we switch the detection of short impulses for the log.0 state on, then its changes are detected on the relevant input. If the value log.0 appears on the input during a cycle, then it will stay recorded in the module memory until the nearest data transfer to the central unit is undertaken, even though the value log.1 is on the input at the time of the data transfer.

The same applies by analogy for the input signal which is mainly in log.0 state and short log.1 impulses appear within. If we switch the detection of short impulses for the log.1 state on, then the short-term value log.1 is extended until the next cycle turn.

The inputs state with the short impulse detection switched on is contained in the DIP variable.
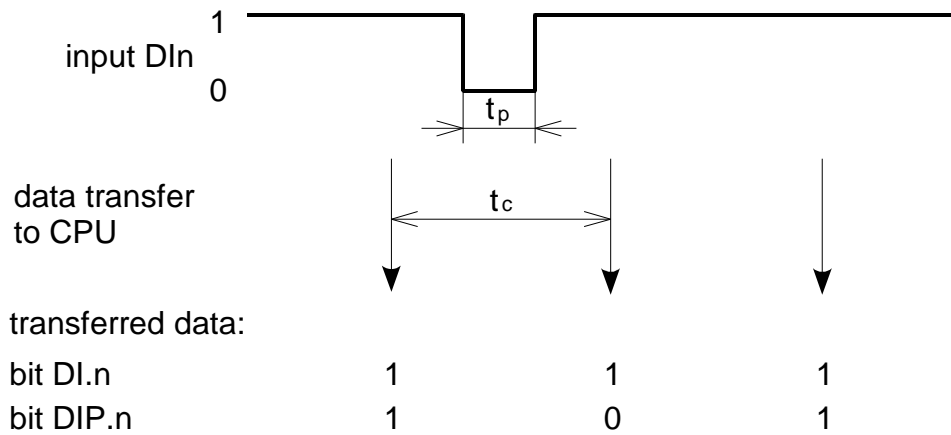
Fig.3.3.9   Detection of short impulses into log.0 function
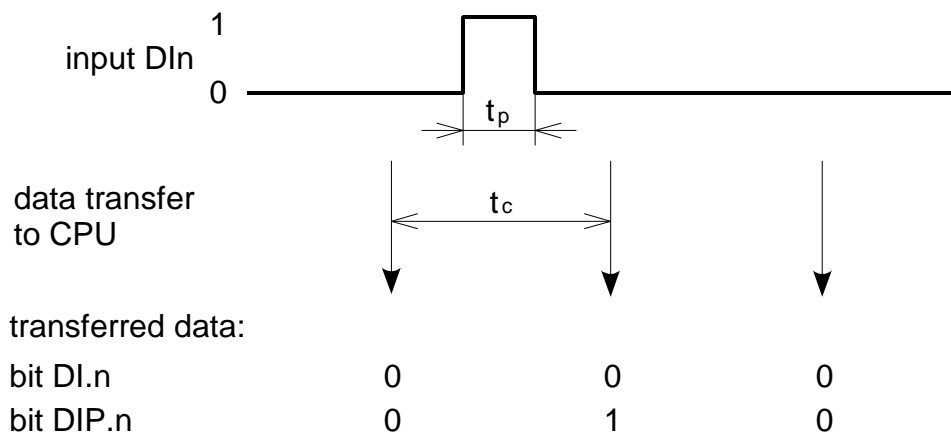t_p -pulse width, t_c =PLC cycle period

Fig.3.3.10 Detection of short impulses into log.1 function
t_p -pulse width, t_c =PLC cycle period

Binary outputs

The binary inputs state is contained in the DO variable. The configuration can be found in the folder *Binary IO* (Fig.3.3.8). By ticking the option *Switch-on the transfer of binary inputs* we can enable the transfer of current states of all six inputs into the PLC notepad. If this option is not ticked, relevant values are not transferred and outputs are not set.

Counters

The IR-1501 module contains two counter objects that use inputs DI0 to DI3 and they can be set to several operation modes. These modes can be divided into two groups. The first group is represented by modes that always use two inputs. The first counter object uses inputs DI0 and DI1, the second counter object uses inputs DI2 and DI3. Both counter objects can be set to a random mode from this group and each can work in a different mode.

The group of basic modes of counter objects consists of the following modes:

- ◆ No counter
- ◆ One one-way counter
- ◆ Two one-way counters
- ◆ Two-way counter
- ◆ Counter with controlled direction
- ◆ Basic IRC

   The second group of basic modes of counter objects consists of the following modes:

- ◆ Two-way counter with reset and capturing
- ◆ Counter with controlled direction and with reset and capturing
- ◆ IRC with reset and capturing
- ◆ Impulse length measurement
- ◆ Period and phase shift measuring

   These modes use all four inputs DI0 to DI3 and they can be set in the first counter object only. The second counter object is always switched off. The counters configuration can be found in the folder *Counter mode* (Fig.3.3.11).
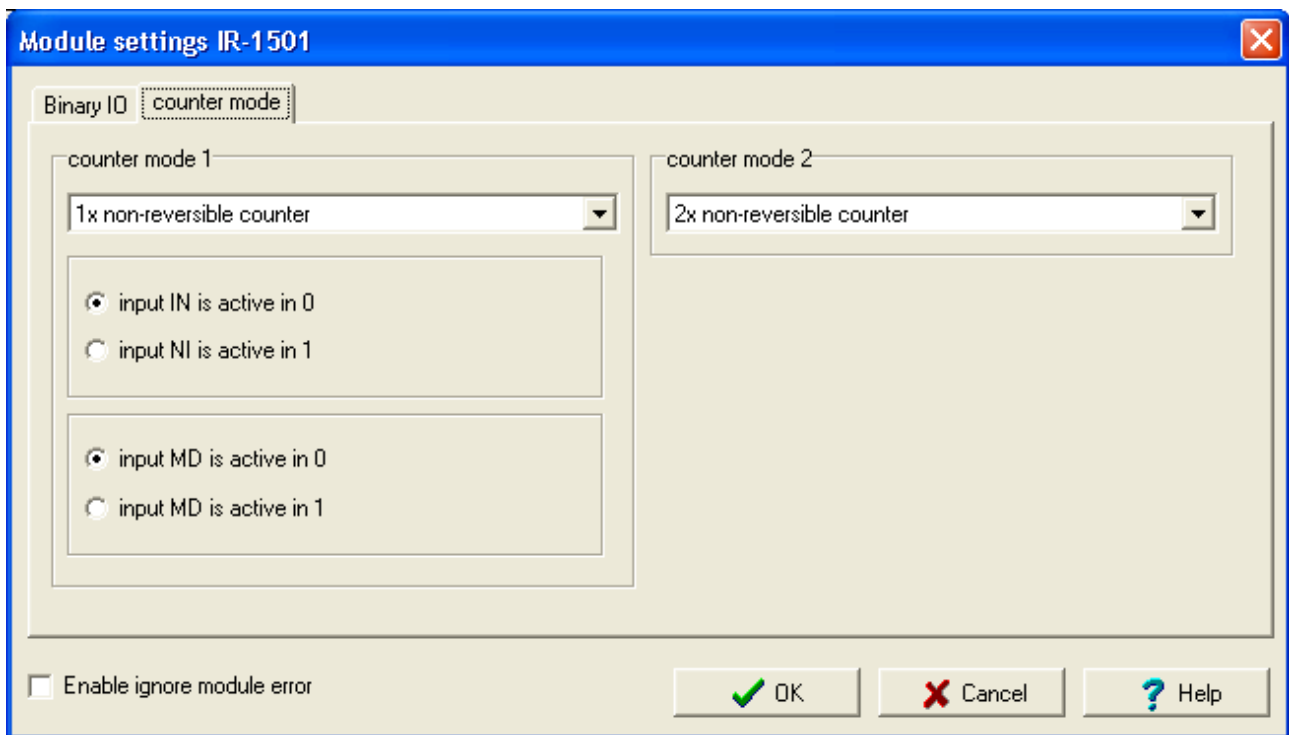

Fig.3.3.11 Counters configuration

   For counter modes from the second group, it is possible to set the signal polarity NI and MD. If we switch the option *input NI is active in 1* on, then the transfer of the signal from state 0 to state 1 will be understood as the entering edge. If we switch the option *input NI is active in 0* on, then the transfer of the signal from state 1 to state 0 will be understood as the entering edge. The same applies for the MD signal.

   The individual counter object modes are identical to those of IR-1055 board of the CP-1004 module and are described in detail in the chapter 2.3.6.

3.4   ANALOG MODULES

These modules contain analog inputs and outputs and are connected to the basic module via the TCL2 bus.

3.4.1   IT-1601 module

The IT-1601 peripheral module contains 8 analog inputs and 2 analog outputs. All inputs and outputs have galvanic isolation. The module is powered by 24 V DC which has no galvanic isolation from internal circuits.
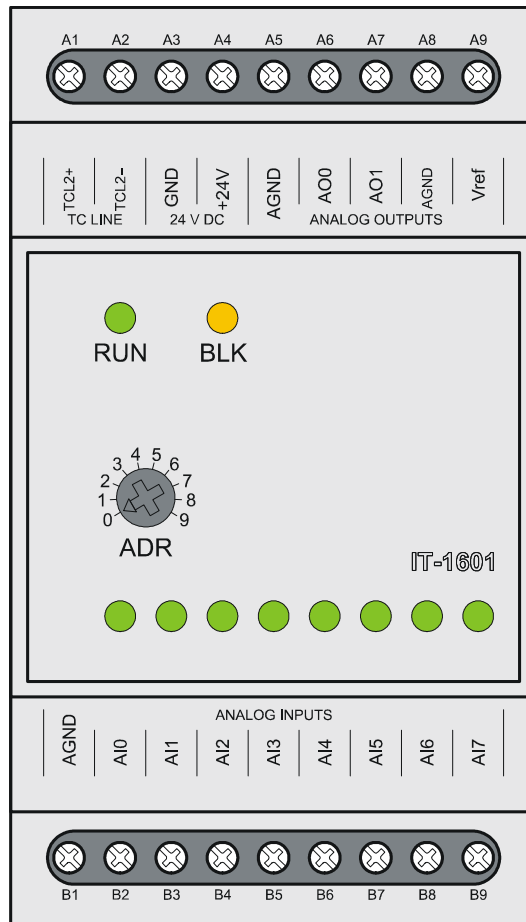

Fig.3.4.1   IT-1601 peripheral module

Table 3.4.1   Basic parameters of the IT-1601 module

Module type	IT-1601
Power supply voltage (SELV)	24 VDC, +25%, −15%
Internal protection	ne
Maximum input	4,5 W
Connection	fixed screw terminals, max.2,5 mm^2 conductor per terminal
Galvanic isolation of supply from internal circuits	between internal circuits and terminals, supply and bus 500 V DC
Number of analog inputs	8
Number of analog outputs	2
Size	53 x 95 x 65 mm

The terminals connection of the IT-1601 module is shown in the table 3.4.2.

Table 3.4.2   Connection of terminal boards A and B of the IT-1601 module

A1	TCL2+	system bus TCL2
A2	TCL2−	system bus TCL2
A3	GND	module ground
A4	+24V	supply
A5	AGND	analog ground
A6	AO0	analog output AO0
A7	AO1	analog output AO1
A8	AGND	analog ground
A9	VREF	reference voltage
B1	AGND	analog ground
B2	AI0	analog input AI0
B3	AI1	analog input AI1
B4	AI2	analog input AI2
B5	AI3	analog input AI3
B6	AI4	analog input AI4
B7	AI5	analog input AI5
B8	AI6	analog input AI6
B9	AI7	analog input AI7

3.4.1.1 Analog inputs

Analog inputs are used for the connection of analog signals of the controlled object to the PLC. The IT-1601 peripheral module contains 8 analog inputs AI0 – AI7. Inputs are universal, independently configurable as voltage inputs, current inputs and two wire connection of passive resistance sensors.

Table 3.4.3   Basic parameters of analog inputs of the IT-1601 module

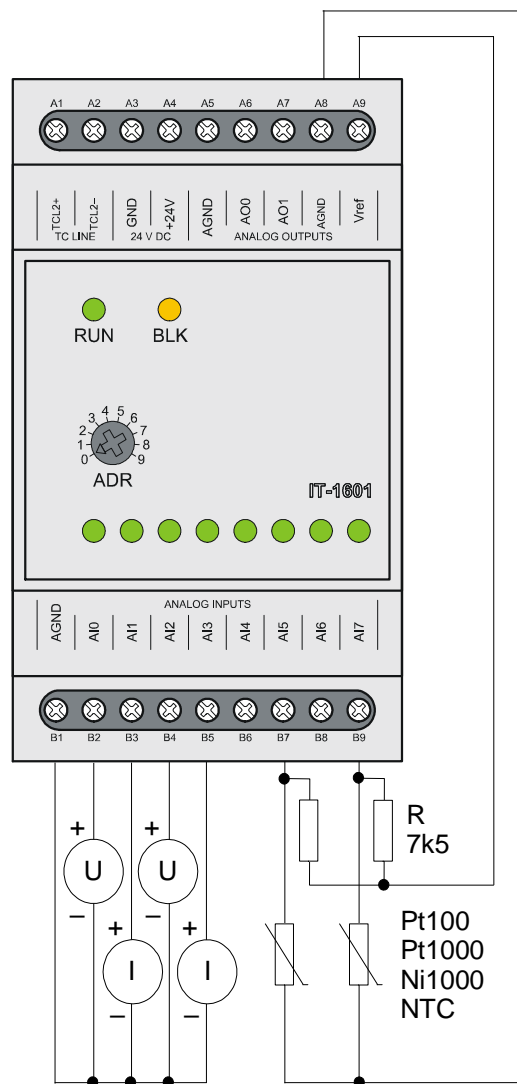| Module type	IT-1601
Number of inputs	8
Number of inputs in group	8
Galvanic isolation from internal circuits	yes
Diagnostics	Overload signalization in status word and by LED diode on the front panel
Joint conductor	minus
External power supply	none
Type of converter	sigma-delta
Digital display resolution	16 bits
Protection type	integrated surge guards
Insulation potentials at normal operating conditions	none
Filtration	low pass filter, digital comb filter 50/60 Hz
Internal calibration	autocalibration always after module switch-on
Measuring range / resolution (1 LSB) voltage ranges	0 to +10 V / 162,8 µV 0 to +5 V / 81,38 µV 0 to +2 V / 39,06 µV 0 to +1 V / 19,53 µV
current ranges	0 to 20 mA / 0,3906 µA 4 to 20 mA / 0,3906 µA 0 to 5 mA / 0,0977 µA
passive thermal sensors	Pt100 1,385 (−90 to +400°C) Pt100 1,391 (−90 to +400°C) Pt1000 1,385 (−90 to +400°C) Pt1000 1,391 (−90 to +400°C) Ni1000 1,617 (−60 to +200°C) Ni1000 1,500 (−60 to +200°C) NTC termistor 12 kΩ / 25°C (−40 to +125°C)*
resistance transmitters	OV100 (0 to 100 Ω) OV1000 (0 to 1000 Ω)

* From IT-1601 module firmware version 1.6

All inputs have one joint terminal and are galvanically isolated from internal circuits. Joint terminals of analog inputs, analog outputs and reference voltage are interconnected.

Each input is equipped by a red LED diode indication the state when the value of the input signal is outside the measuring range (overload or unloading, possibly input disconnection).

Analog inputs are brought out to terminals in the ANALOG INPUTS array. Reference voltage for resistance sensors connection is brought out to terminals in the ANALOG OUTPUTS array. There is schematic drawing of the connection of various signal sources to analog outputs in the fig.3.4.2.

Examples of sensors connection and requirements on wiring are described in the documentation *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02.*

*Obr.3.4.2 Typical example of signals connection to analog inputs of the IT-1601 module
(particular signal types are connectable to any input)*

Table 3.4.4   Basic parameters of voltage input ranges

Module type	IT-1601
Input impedance within the signal range	> 100 kΩ (ranges 1 V and 2 V)
	> 20 kΩ (ranges 5 V and 10 V)

Analog input error
  max. error at 25 °C
  thermal coefficient
  non-linearity
  repeatability at steady conditions
	
	±0,3 % of full range
	±0,02 % of full range / K
	±0,08 % of full range
	0,05 % of full range

Max. allowed permanent overload (without damage)	±35 V (each terminal AI against AGND)
Total time of the system input transfer	type 65 ms
Sample repeating time	type 500 ms
Overload signalization	in status word and LED diode on the front panel
Input disconnection detection	none

Table 3.4.5   Basic parameters of current input ranges

Module type	IT-1601
Input impedance within the signal range	100 Ω

Analog input error
  max. error at 25 ℃
  thermal coefficient
  non-linearity
  repeatability at steady conditions
	±0,4 % of full range
	±0,03 % of full range / K
	±0,07 % of full range
	0,05 % of full range

Max. allowed permanent overload (without damage)	+30 mA (each terminal AI against AGND)
Total time of the system input transfer	type 65 ms
Sample repeating time	type 500 ms
Overload signalization	in status word and LED diode on the front panel
Input disconnection detection	in status word and LED diode on the front panel (range nonfulfilment – only range 4 ÷20 mA)

Table 3.4.6   Basic parameters of input ranges for passive resistance sensors (when using the supplied resistor 7k5)

Module type	IT-1601
Input impedance within the signal range	> 100 kΩ
Reference voltage	10 V

Analog input error
  max. error at 25 ℃
  thermal coefficient
  non-linearity
  repeatability at steady conditions
	±0,5 % of full range
	±0,05 % of full range / K
	±0,09 % of full range
	0,07 % of full range

Max. allowed permanent overload (without damage)	±35 V (each terminal AI against AGND)
Total time of the system input transfer	type 70 ms
Sample repeating time	type 600 ms
Overload signalization	in status word and LED diode on the front panel
Input disconnection detection	none
Max. allowed permanent overload (without damage)	in status word and LED diode on the front panel (range exceeding)

3.4.1.2 Analog outputs

Analog outputs serve for control of analog action and signaling elements of the controlled object. The IT-1601 peripheral module contains 2 analog outputs AO0 and AO1. They are voltage outputs 0 ÷ 10V, both have one joint terminal. In terms of allowed overload of 105 %, it is possible to se the voltage of up to 10,5 V on outputs. Analog outputs are galvanically isolated from internal circuits. Joint terminals of analog inputs, analog outputs and reference voltage are interconnected.

Table 3.4.8 Basic parameters of analog inputs of the IT-1601 module

Module type	IT-1601
Number of outputs	2
Number of outputs in group	2
Output type	active voltage output
Galvanic isolation from internal circuits	yes
Joint conductor	minus
External supply	none
Transfer time	10 µs
Protection type	integrated surge guards
Insulation potentials at normal operating conditions	none
Digital display resolution	10 bits
Output range / resolution (1 LSB)	0 to +10 V / 10,546 mV
Max. output value	105 % upper limit of input range
Max. allowed permanent overload (without damage)	±20 V (each terminal AO against AGND)
Max. output current	10 mA
Analog output error	
max error at 25 °C	±2 % of full range
thermal coefficient	±0,3 % of full range / K
linearity	±0,7 % of full range
repeatability at steady conditions	0,5 % of full range

Analog outputs are brought out to terminals in the ANALOG OUTPUTS array. There is a schematic drawing of the connection of the load to analog outputs in fig.3.4.3.
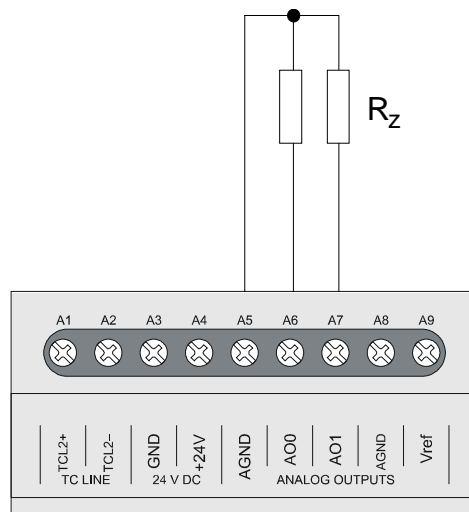

Fig.3.4.3 Typical example of load connection to analog outputs of the IT-1601module

3.4.1.3 Data provided by the IT-1601 module

The IT-1601 peripheral module provides information on inputs and outputs. The data structure is apparent from the panel *I/O Settings* in the Mosaic development environment (fig.3.4.4) (icon ▣).

Items of the structure have assigned symbolic names which always start with *r1_px_* characters where x is the number correspondent to the set address on the rotary switch. In the column *Full entry* the concrete symbolic name for the given item is always stated. If we

want to use data in the user program, we use either this symbolical name or in the column *Alias* we enter our own symbolic name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.
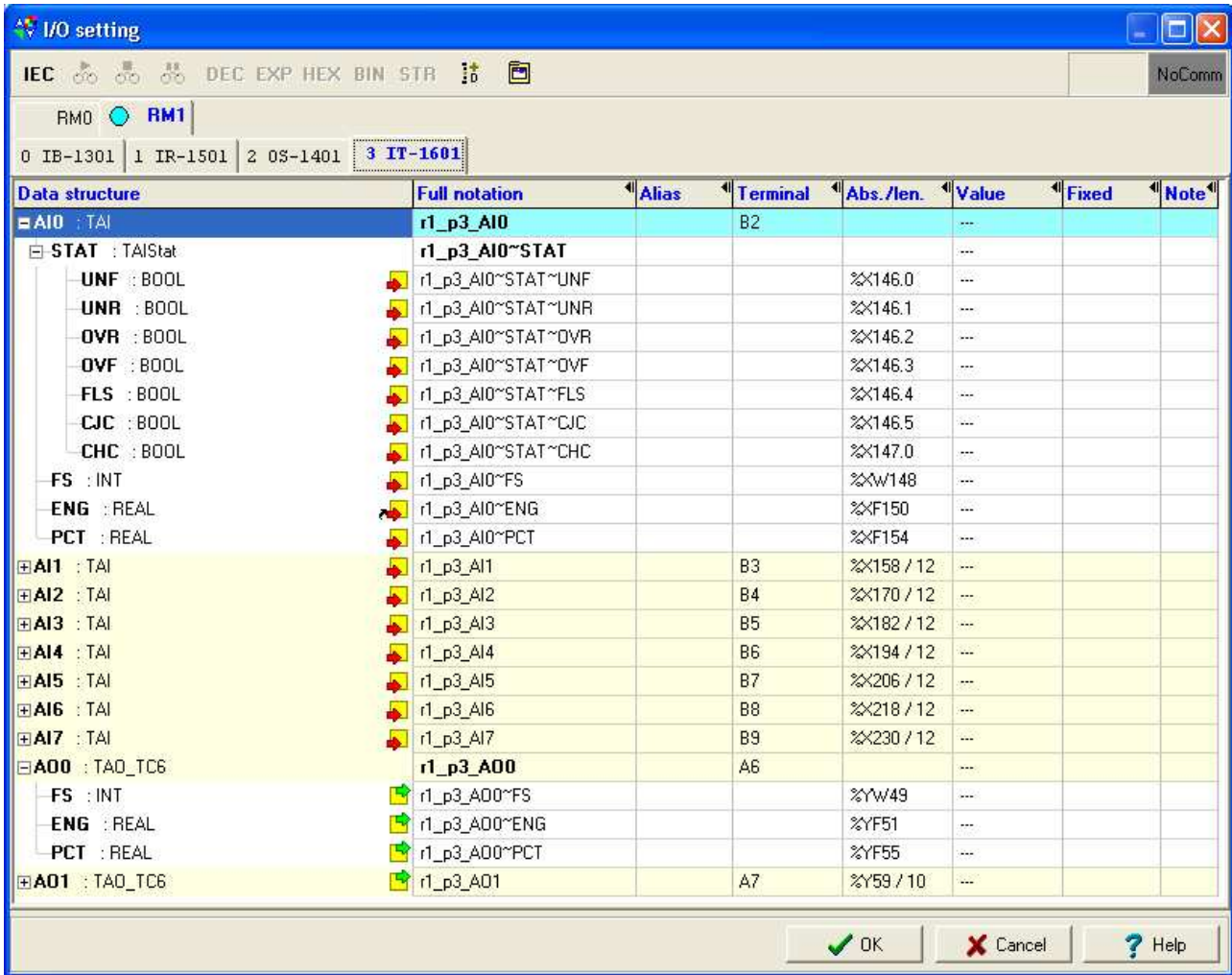

Fig.3.4.4 IT-1601 module data structure

Input data

AI0, AI1, AI2, AI3, AI4, AI5, AI6, AI7 – analog outputs objects AI0 - AI7 (*TAI structure*)

AIn~STAT   - analog input AIn status word (16x boolean type)

0	0	0	FLS	OVF	OVR	UNR	UNF
bit .7	.6	.5	.4	.3	.2	.1	.0

0	0	0	0	0	0	0	0
bit .15	.14	.13	.12	.11	.10	.9	.8

FLS - 1 – invalid value of the measurement (during module initiation after the switch-on)

OVF - 1 – range overflow (input quantity exceeded the nominal range at 5%)

OVR - 1 – range exceeding (input quantity exceeded the nominal range)

UNR - 1 – range nonfulfilment (input quantity did not reach the nominal range)

UNF - 1 – range underflow (input quantity did not reach the nominal range at 5%)

The signalization of range nonfulfilment and underflow is active for the range of 4 to 20 mA only and for resistance sensors of the temperature. This function is not active for other voltage and current measuring ranges. While setting any of the bits OVF and UNF to log.1, the red LED diode correspondent to the input given lights up.

AIn~FS - analog input AIn value (int type)
The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value $FS = 30000$.

AIn~ENG - AIn analog input value (real type)
Value of measured quantity in engineering units.

AIn~PCT - AIn analog input value (real type)
The percentage relation between the measured and the nominal value of the analog input. For the value $FS = 0$ applies the value of $PCT = 0\%$ and for the value $FS = 30000$ the value $PCT = 100\%$.

Output data

AO0, AO1 - analog inputs objects AO0, AO1 (*TAO_TC6 structure*)

AOn~FS - AOn analog input value (int type)
The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value $FS = 30000$.

AOn~ENG - AOn analog input value (real type)
Value of measured voltage in volts.

AOn~PCT - AOn analog input value (real type)
The percentage relation between the measured and the nominal value of the analog input. For the value $FS = 0$ applies the value of $PCT = 0\%$ and for the value $FS = 30000$ the value $PCT = 100\%$.

The behaviour of individual data objects is described in the following chapter.

3.4.1.4 Initialization and behaviour of individual data objects of the IT-1601 module

The IT-1601 peripheral module contains a block of analog inputs and outputs.
The panel for parameters setting can be opened from the project manager in the node *HW | Configuration HW* (fig.3.4.5). In the folder *External I/O modules* we click on the icon on the relevant line.
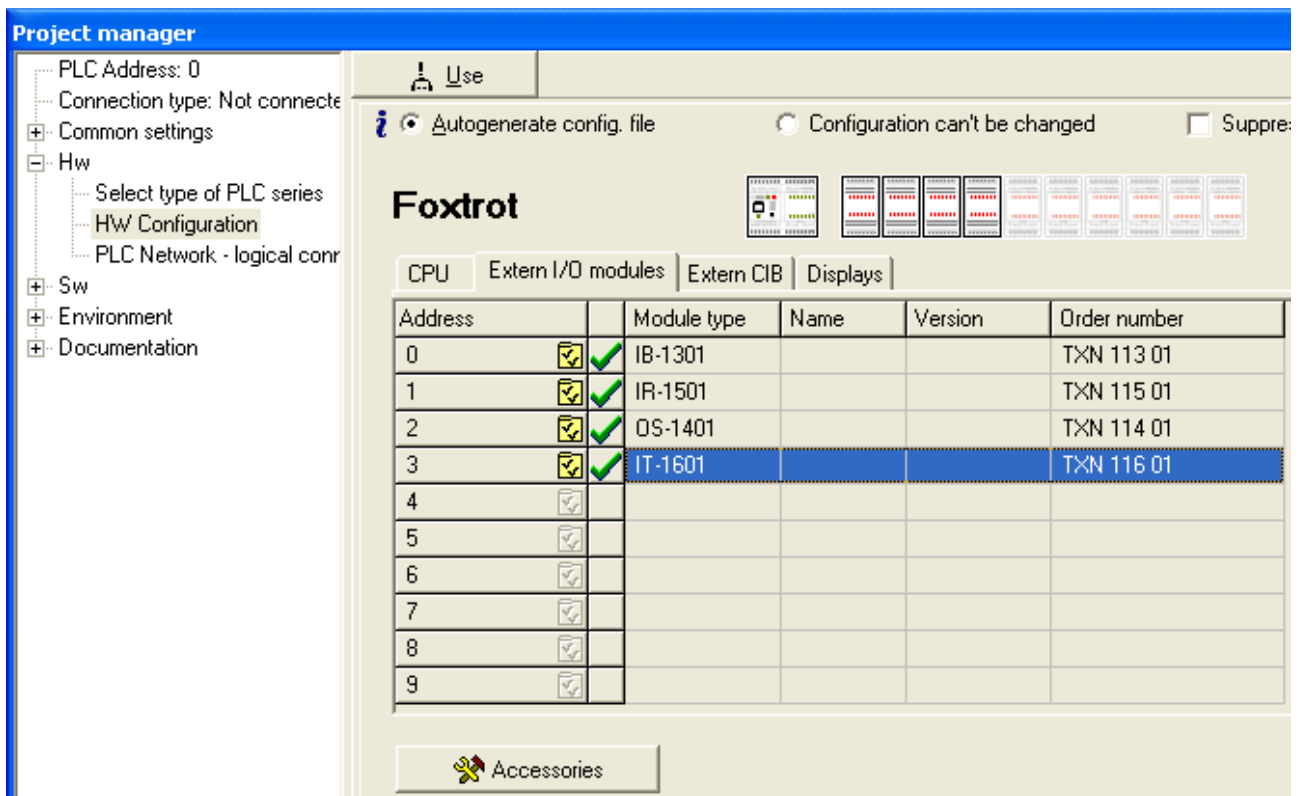
Fig.3.4.5   Peripheral modules configuration

Analog inputs

The IT-1601 module contains 8 analog inputs AI0 to AI7 which have various measuring ranges. Each input has four variables *STAT*, *FS*, *ENG* and *PCT*. State *STAT* is always transferred, among variables *FS*, *ENG* and *PCT* we choose one depending on the interpretation of the measured value required. The configuration of analog inputs can be found in the folder *Analog inputs* (fig.3.4.6).

The transferred value in the FS variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents directly the value in engineering units according to the measuring range selected.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

If we want to filter the input analog value, we switch the filtration mode on and set the time constant. Measured values of the correspondent channel then go through the 1st grade filter. The filter is due to the following relation:

$$y_t = \frac{y_{t-1} \cdot \tau + x}{\tau + 1}$$

x – Converted value of the analog input
y_t - output
y_{t-1} – last output
τ - time constant of the 1st grade filter

The time constant value is set in the range 0,1 ÷ 25,0 s. The filtration concerns all data formats of the channel given (*FS, ENG* and *PCT*) and is accessible within all measuring ranges.
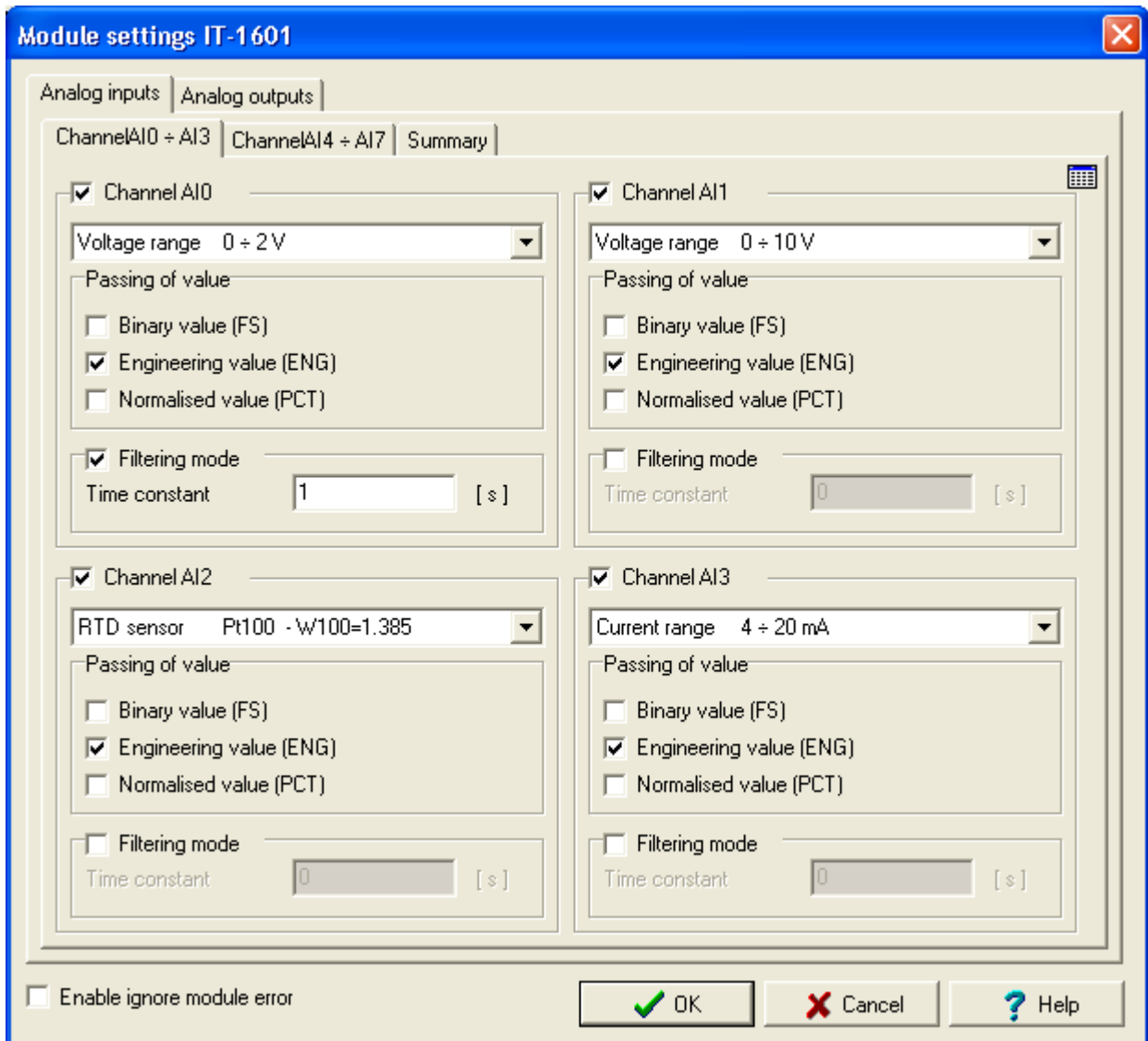

Fig.3.4.6   Analog inputs configuration

If we check an item *Enable ignoring module error* at the bottom side of *IT-1601 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5). This function can be used in case we want to keep PLC running even if peripheral module power supply is switched off.

There are shown transferred values for individual ranges of analog inputs in the following graphs and tables.
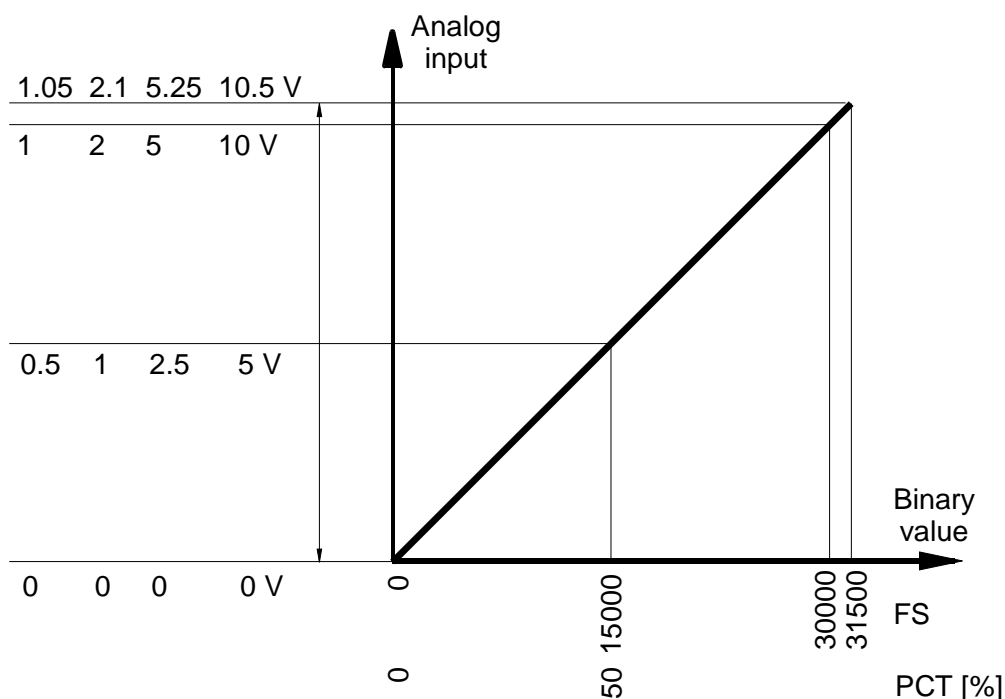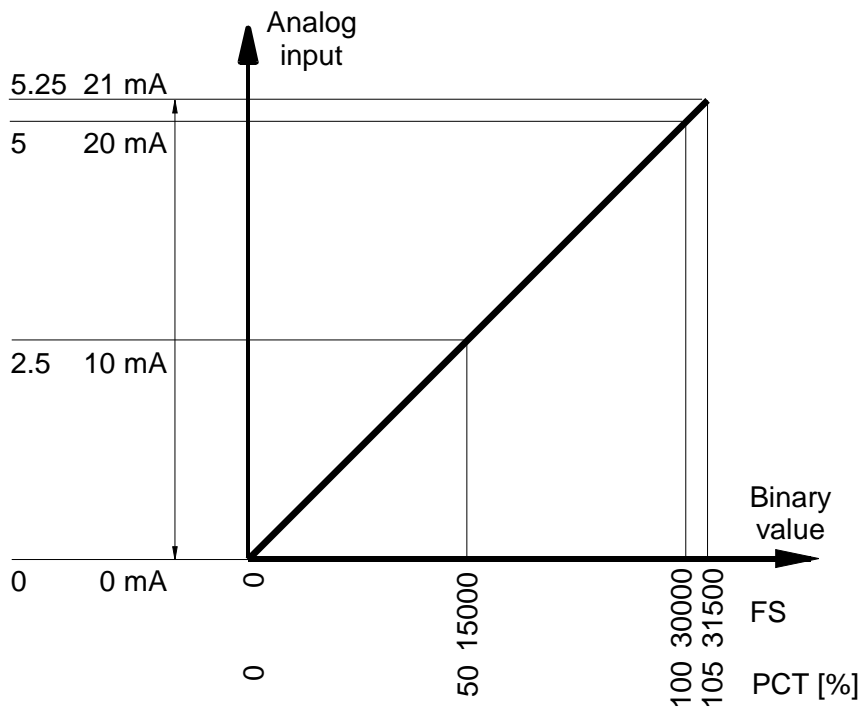
Fig.3.4.7   Voltage ranges of analog inputs of the IT-1601 module

Table 3.4.8   Transferred values of analog inputs for the range 0 to 10 V

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 10,5 V	$000C	31500	10,5	105	range overflowing
10,5 V	$0004	31500	10,5	105	range exceeding
:	$0004	:	:	:	
10 V	$0000	30000	10	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 3.4.9   Transferred values of analog inputs for the range 0 to 5 V

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 5,25 V	$000C	31500	5,25	105	range overflowing
5,25 V	$0004	31500	5,25	105	range exceeding
:	$0004	:	:	:	
5 V	$0000	30000	5	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 3.4.10 Transferred values of analog inputs for the range 0 to 2 V

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 2,1 V	$000C	31500	2,1	105	range overflowing
2,1 V	$0004	31500	2,1	105	range exceeding
:	$0004	:	:	:	
2 V	$0000	30000	2	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Table 3.4.11 Transferred values of analog inputs for the range 0 to 1 V

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1,05 V	$000C	31500	1,05	105	range overflowing
1,05 V	$0004	31500	1,05	105	range exceeding
:	$0004	:	:	:	
1 V	$0000	30000	1	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	

Fig.3.4.8   Current ranges 0 to 5 and 0 to 20 mA of analog inputs of the IT-1601 module

Table3.4.12 Transferred values of analog inputs for the range 0 to 20 mA

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 21 mA	$000C	31500	21	105	range overflowing
21 mA	$0004	31500	21	105	range exceeding
:	$0004	:	:	:	
20 mA	$0000	30000	20	100	nominal range
:	$0000	:	:	:	
0 mA	$0000	0	0	0	

Table 3.4.13 Transferred values of analog inputs for the range 0 to 5 mA

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 5,25 mA	$000C	31500	5,25	105	range overflowing
5,25 mA	$0004	31500	5,25	105	range exceeding
:	$0004	:	:	:	
5 mA	$0000	30000	5	100	nominal range
:	$0000	:	:	:	
0 mA	$0000	0	0	0	

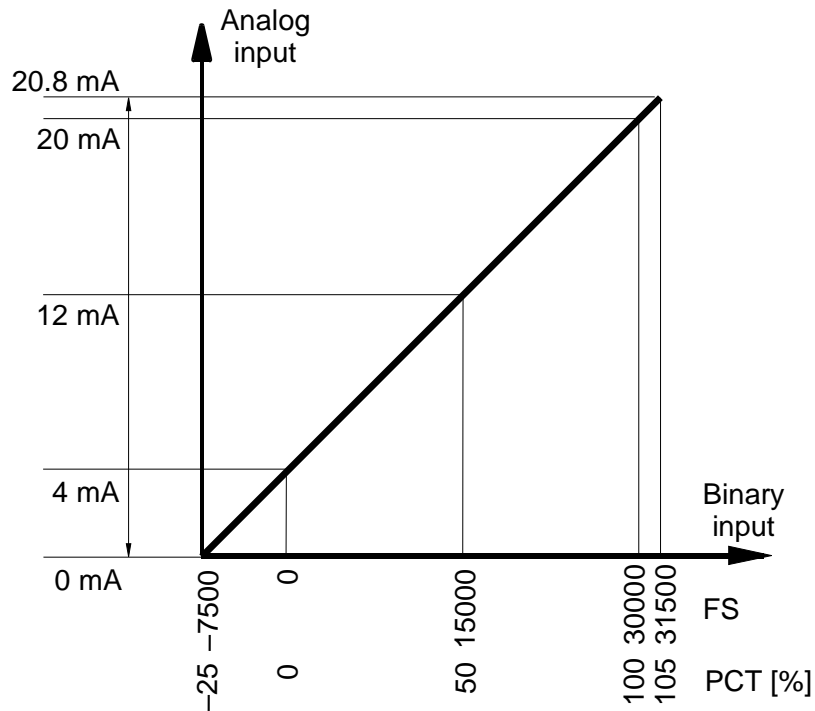*Fig.3.4.9   Current range 4 to 20 mA of analog inputs of the IT-1601 module*

Table 3.4.14 Transferred values of analog inputs for the range 4 to 20 mA

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 20,8 mA	$000C	31500	20,8	105	range overflowing
20,8 mA	$0004	31500	20,8	105	range exceeding
:	$0004	:	:	:	
20 mA	$0000	30000	20	100	nominal range
:	$0000	:	:	:	
4 mA	$0000	0	4	0	
:	$0002	:	:	:	range descended
3,2 mA	$0002	−1500	3,2	−5	
:	$0003	:	:	:	range underflowing
0 mA	$0003	−7500	0	−25	

Fig.3.4.10 Analog inputs range of the IT-1601 module for resistance sensors Pt100, Pt1000, Ni1000 and NTC thermistors

Table 3.4.15 Transferred values of analog inputs for Pt100 and Pt1000

Measured	Variable				
value	STAT	FS	ENG	PCT	
> 400 ℃	$000C	31500	400	105	range overflowing
400 ℃	$0004	31500	400	105	range exceeding
:	$0004	:	:	:	
378 ℃	$0000	30000	378	100	nominal range
:	$0000	:	:	:	
−68 ℃	$0000	0	−68	0	
:	$0002	:	:	:	range descended
−90 ℃	$0002	−1500	−90	−5	
< −90 ℃	$0003	−1500	−90	−5	range underflowing

Table 3.4.16 Transferred values of analog inputs for Ni1000

Measured	Variable				
value	STAT	FS	ENG	PCT	
> 200 ℃	$000C	31500	200	105	range overflowing
200 ℃	$0004	31500	200	105	range exceeding
:	$0004	:	:	:	
188 ℃	$0000	30000	188	100	nominal range
:	$0000	:	:	:	
−48 ℃	$0000	0	−48	0	
:	$0002	:	:	:	range descended
−60 ℃	$0002	−1500	−60	−5	
< −60 ℃	$0003	−1500	−60	−5	range underflowing

Table 3.4.17 Transferred values of analog inputs for NTC thermistors

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 125 ℃	$000C	31500	125	105	range overflowing
125 ℃	$0004	31500	125	105	range exceeding
:	$0004	:	:	:	
117.5 ℃	$0000	30000	117.5	100	nominal range
:	$0000	:	:	:	
−32.5 ℃	$0000	0	−32.5	0	
:	$0002	:	:	:	range descended
−40 ℃	$0002	−1500	−40	−5	
< −40 ℃	$0003	−1500	−40	−5	range underflowing

Fig.3.4.11 Analog inputs range of the IT-1601 module for resistance transmitters OV100 and OV1000

Table 3.4.18 Transferred values of analog inputs for OV100

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 105 Ω	$000C	31500	105	105	range overflowing
105 Ω	$0004	31500	105	105	range exceeding
:	$0004	:	:	:	
100 Ω	$0000	30000	100	100	nominal range
:	$0000	:	:	:	
0 Ω	$0000	0	0	0	

Table 3.4.19 Transferred values of analog inputs for OV1000

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1050 Ω	$000C	31500	1050	105	range overflowing
1050 Ω	$0004	31500	1050	105	range exceeding
:	$0004	:	:	:	
1000 Ω	$0000	30000	1000	100	nominal range
:	$0000	:	:	:	
0 Ω	$0000	0	0	0	

Analog outputs

The IT-1601 module contains 2 analog outputs AO0 and AO1 which have a range of 0 to 10V. Each output has three variables *FS*, *ENG* and *PCT*. Among these variables we choose one according to what type of interpretation of the input value is required. The configuration of analog outputs can be found in the folder *Analog outputs* (fig.3.4.12).

Fig.3.4.12 Analog outputs configuration

The transferred value in the FS variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the

maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents directly the value of output voltage in volts.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

Outputs behaviour in the HALT mode can be defined by two alternatives. If we mark the item *Freeze,* then after the transmission to the HALT mode the analog output stays set to the last value entered by the user program.

If we mark the item *Defined state*, then after the transmission to the HALT mode the value set in the relevant field will be set to analog output. This set value has the format identical to the selected transmitted variable. This means that if we use the FS format, the value is of an int type within the range 0 - 31500, if we use the ENG format, the value is of a real type within the range 0 - 10,5 V, and if we use the PCT format, the value is of a real type within the range 0 - 105%.

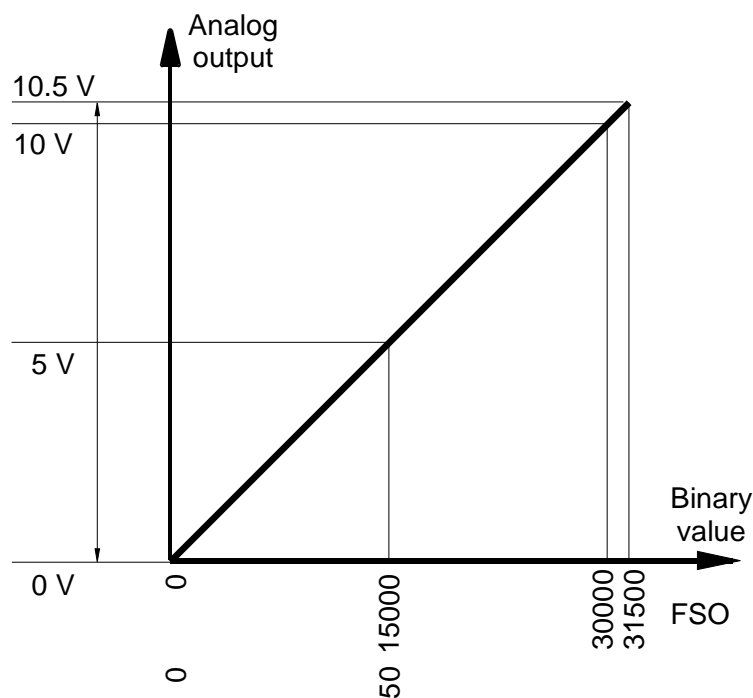After the supply switch-on, analog outputs are always set to the value of 0.

Fig.3.4.13 Analog outputs range of the IT-1601 module

Table 3.4.20 Transferred values of analog inputs for the range 0 to 10 V

Output value	Variable			
	FS	ENG	PCT	
10,5 V	>31500	>10,5	>105	range overflowing
10,5 V	31500	10,5	105	range exceeding
:	:	:	:	
10 V	30000	10	100	nominal range
:	:	:	:	
0 V	0	0	0	

3.4.2 Module IT-1602

The IT-1602 peripheral module contains 8 analog inputs and 2 analog outputs. All inputs and outputs have galvanic isolation. The module is powered by 24 V DC which has no galvanic isolation from internal circuits.
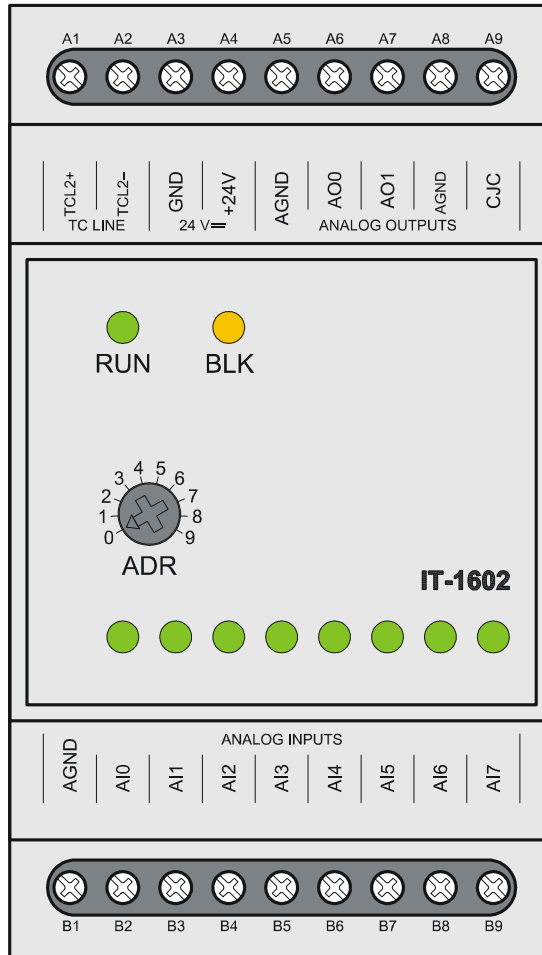

Fig.3.4.14 The IT-1602 peripheral module

Table 3.4.21 Basic parameters of the IT-1602 module

Module type	IT-1602
Power supply voltage (SELV)	24 VDC, +25%, −15%
Internal protection	none
Maximum input	2.5 W
Connection	fixed screw terminals, max.2.5 mm^2 conductor per terminal
Galvanic isolation of supply from internal circuits	none
Number of analog inputs	8
Input for measuring of cold junction	1
Number of analog outputs	2
Size	53 x 95 x 65 mm

The terminals connection of the IT-1602 module is shown in the table 3.4.22.

Table 3.4.22 Connection of terminal boards A and B of the IT-1602 module

A1	TCL2+	system bus TCL2
A2	TCL2−	system bus TCL2
A3	GND	module ground
A4	+24V	supply
A5	AGND	analog ground
A6	AO0	analog output AO0
A7	AO1	analog output AO1
A8	AGND	analog ground
A9	CJC	input for measuring of cold junction
B1	AGND	analog ground
B2	AI0	analog input AI0
B3	AI1	analog input AI1
B4	AI2	analog input AI2
B5	AI3	analog input AI3
B6	AI4	analog input AI4
B7	AI5	analog input AI5
B8	AI6	analog input AI6
B9	AI7	analog input AI7

3.4.2.1 Analog inputs

Analog inputs are used for the connection of analog signals of the controlled object to the PLC. The IT-1602 peripheral module contains 8 analog inputs AI0 – AI7. Inputs are independently configurable as voltage inputs for low values or as inputs for connection of thermocouples with external cold junction. All inputs are bipolar.

All inputs have one joint terminal and are galvanically isolated from internal circuits. Moreover, each input is equipped with a red LED diode indication the state when the signal value on the input is outside the measuring range (overloading or unloading of the input).

Cold junction temperature measuring is realized via a special input CJC using an external sensor Ni1000 1,617.

Table 3.4.23 Basic parameters of analog inputs of the IT-1602 module

Module type	IT-1602
Number of inputs	8
Number of inputs in group	8
Galvanic isolation from internal circuits	yes
Diagnostics	signalization of the out of range value in the status word and by LED diode on the front panel
External supply	none
Converter type	sigma-delta
Digital display resolution	16 bits
Protection type	integrated surge guards
Insulation potentials at normal operation conditions	500 V DC between input and internal circuits
Filtration	low-pass filter, digital comb filter50/60 Hz
Internal calibration	autocalibration always after module switch-on

Measuring range / resolution (1 LSB)
  voltage ranges
 	
  thermocouples
	−1 to +1 V / 39.06 µV
	−0.1 to +0.1 V / 4.88 µV
	J (−210 to +1200℃)
	K (−200 to +1372℃)
	R (−50 to +1768℃)
	S (−50 to +1768℃)
	B (+250 to +1820℃)

All inputs have one joint terminal and are galvanically isolated from internal circuits. Joint terminals of analog inputs, analog outputs and non-fusion end are interconnected.

Each input is equipped by a red LED diode indicating the state when the signal value on the input is outside the measuring range (overloading or unloading of the input).

Analog inputs are brought out to terminals in the ANALOG INPUTS array. The input for cold junction measuring CJC is brought out to terminals next to outputs. There is a schematic drawing of the connection of various signal sources to analog inputs in fig. 3.4.15.

Thermocouples, except B type ones, require the connection of a passive sensor Ni 1000 1,617 for cold junction measuring.

Examples of sensors connection and requirements on wiring are described in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02.*
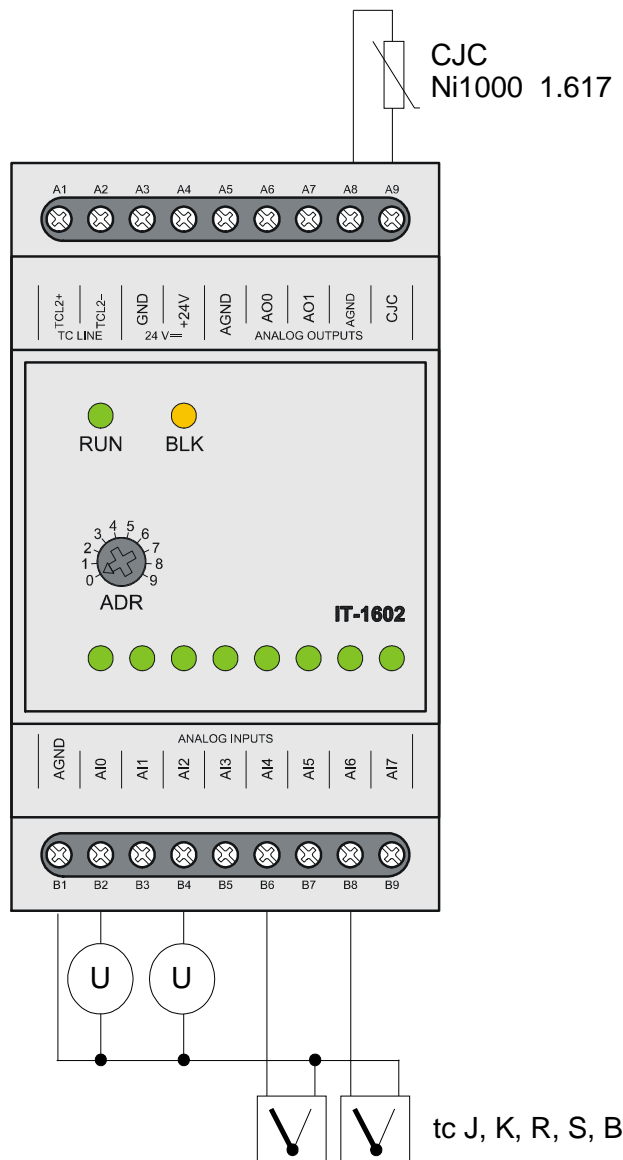
Fig.3.4.15 *Typical example of signal connection to analog inputs of the IT-1602 module*
(individual signal types are connectable to any input)

Table 3.4.24 Basic parameters of voltage input ranges

Module type	IT-1602
Input impedance within the signal range	> 1 MΩ

Analog input error
  max error at 25 ℃
  thermal coefficient
  non-linearity
  repeatability at steady conditions
	
	±0,3 % of full range
	±0,03 % of full range / K
	±0,08 % of full range
	0,03 % of full range

Max. allowed permanent overload (without damage)	±20 V (each terminal AI against AGND)
Total time of the system input transfer	type 65 ms
Sample repeating time	type 500 ms
Overload signalization	in the status word and by LED diode on the front panel
Disconnected input detection	none

Table 3.4.25 Basic parameters of input ranges for thermocouples

Module type	IT-1602
Input impedance within the signal range	> 1 MΩ
Analog input error	
max error at 25 ℃	±0,5 % of full range
thermal coefficient	±0,05 % of full range / K
non-linearity	±0,09 % of full range
repeatability at steady conditions	0,05 % of full range
Max. allowed permanent overload (without damage)	±20 V (each terminal AI against AGND)
Total time of the system input transfer	max. 100 ms
Sample repeating time	max. 800 ms
Overload signalization	in the status word and by LED diode on the front panel
Disconnected input detection	none
Disconnected sensor detection	in the status word and by LED diode on the front panel (range exceeded)

3.4.2.2 Analog outputs

Analog outputs serve for control of analog action and signaling elements of the controlled object. The IT-1602 peripheral module contains 2 analog outputs AO0 and AO1. They are voltage bipolar $0 \div \pm 10V$, both have one joint terminal. In terms of allowed overload of ±105 %, it is possible to set the voltage of up to +10,5 V, respectively -10,5 V on outputs. Analog outputs are galvanically isolated from internal circuits. Joint terminals of analog inputs, analog outputs and reference voltage are interconnected.

Table 3.4.26 Basic parameters of analog outputs of the IT-1602 module

Module type	IT-1602
Number of outputs	2
Number of outputs in group	2
Output type	active voltage output
Galvanic isolation from internal circuits	yes
External supply	none
Transfer time	10 µs
Protection type	integrated surge guards
Insulation potentials at normal operating conditions	500 V DC between output and internal circuits
Digital display resolution	10 bits
Output range / resolution (1 LSB)	−10 V to +10 V / 21,074 mV
Max. output value	+105 % upper limits of output range
Min. output value	−105 % lower limits of output range
Max. allowed permanent overload (without damage)	±14 V (each terminal AO against AGND)
Max. output current	10 mA
Analog output error	
max error at 25 ℃	±2 % of full range
thermal coefficient	±0,3 % of full range / K
linearity	±0,7 % of full range
repeatability during steady conditions	0,5 % of full range

Analog outputs are brought out to terminals in the ANALOG OUTPUTS array. There is a schematic drawing of the overload connection to analog outputs in fig. 3.4.16.
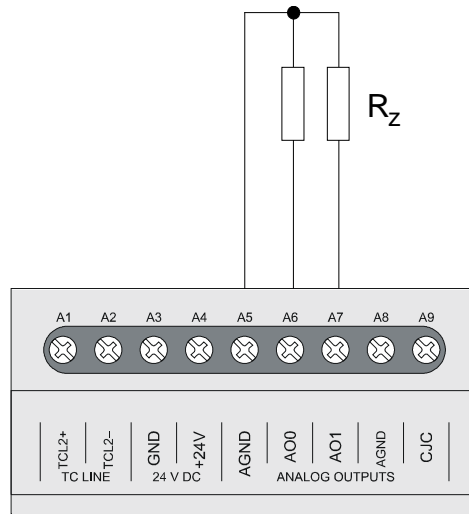

Fig.3.4.16   Typical example of overload connection to analog outputs of the IT-1602 module

3.4.2.3 Data provided by the IT-1602 module

The IT-1602 peripheral module provides information on inputs and outputs. The data structure is apparent from the panel *I/O Settings* in the Mosaic development environment (fig.3.4.17) (icon **IO**).
Items of the structure have assigned symbolic names which always start with *r1_px_* characters where x is the number correspondent to the set address on the rotary switch. In the column *Full entry* the concrete symbolic name for the given item is always stated. If we want to use data in the user program, we use either this symbolical name or in the column *Alias* we enter our own symbolic name which can then be used. In no case do we use absolute operands since they can alter after the new compilation of the user program.
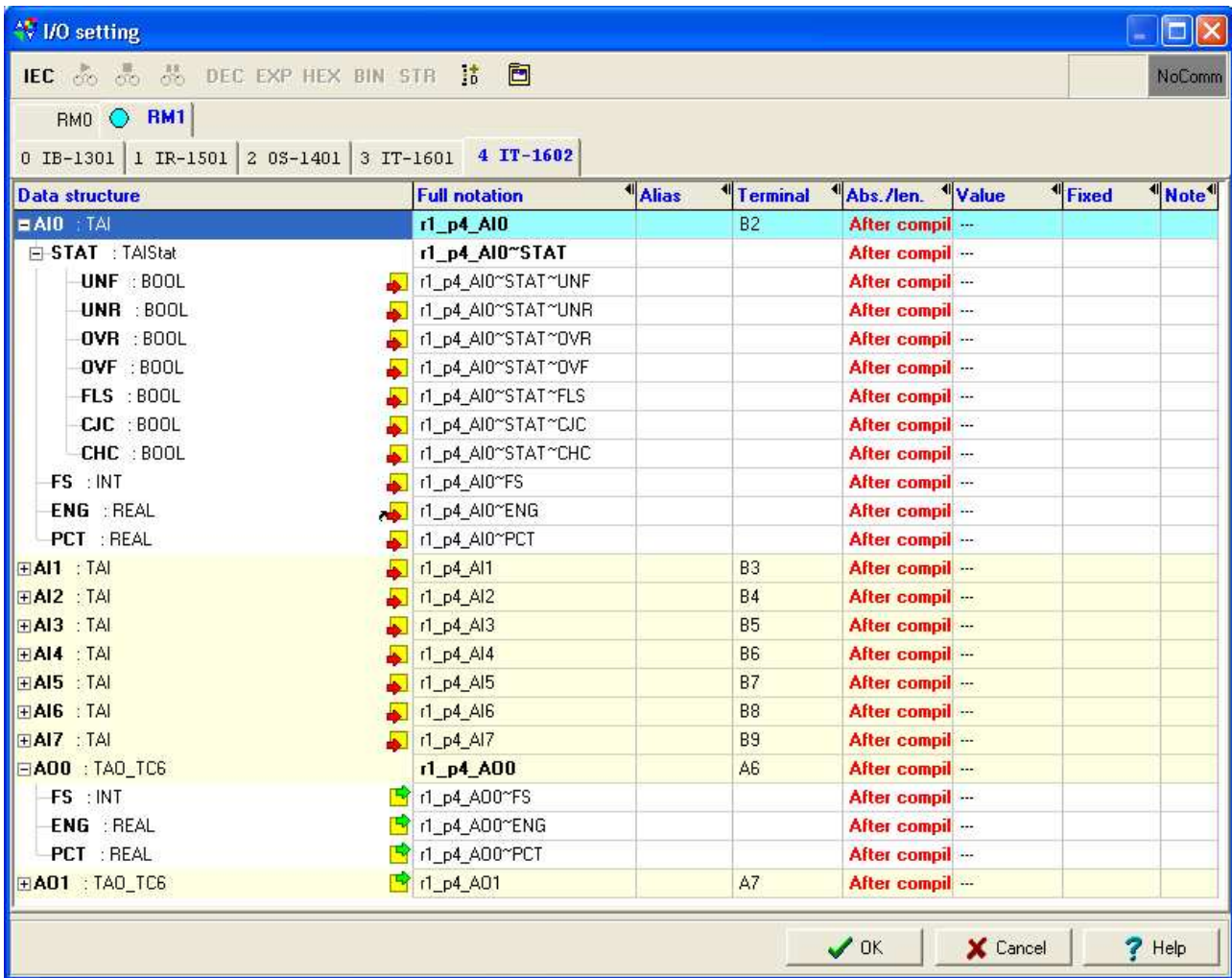
Fig.3.4.17 IT-1602 module data structure

Input data

AI0, AI1, AI2, AI3, AI4, AI5, AI6, AI7 – analog inputs objects AI0 - AI7 (*TAI structure*)

AIn~STAT — - AIn analog input status word (16x boolean type)

0	0	CJC	FLS	OVF	OVR	UNR	UNF
.7	.6	.5	.4	.3	.2	.1	.0

bit

0	0	0	0	0	0	0	0
.15	.14	.13	.12	.11	.10	.9	.8

bit

CJC - 1 – non-fusion end measuring error – temperature measured by the thermocouple is not compensated (it corresponds to the value measured at the temperature of the non-fusion end 0°C)

FLS - 1 - invalid value of the measurement (during module initiation after the switch-on)

OVF - 1 – range overflow (input quantity exceeded the nominal range at 5%)

OVR - 1 – range exceeding (input quantity exceeded the nominal range)

UNR - 1 – range nonfulfilment (input quantity did not reach the nominal range)

UNF - 1 – range underflow (input quantity did not reach the nominal range at 5%)

While setting any of the bits OVF and UNF to log.1, the red LED diode correspondent to the input given lights up.

AIn~FS - analog input AIn value (int type)
The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value *FS* = 30000.

AIn~ENG - AIn analog input value (real type)
Value of measured quantity in engineering units.

AIn~PCT - AIn analog input value (real type)
The percentage relation between the measured and the nominal value of the analog input. For the value *FS* = 0 applies the value of *PCT* = 0% and for the value *FS* = 30000 the value *PCT* = 100%.

Output data

AO0, AO1 - analog inputs objects AO0, AO1 (*TAO_TC6 structure*)

AOn~FS - AOn analog input value (int type)
The minimum input value matches the value 0, the maximum value matches 31500, by which it is valid that 100% of the nominal range of the analog input matches the value *FS* = 30000.

AOn~ENG - AOn analog input value (real type)
Value of measured voltage in volts.

AOn~PCT - AOn analog input value (real type)
The percentage relation between the measured and the nominal value of the analog input. For the value *FS* = 0 applies the value of *PCT* = 0% and for the value *FS* = 30000 the value *PCT* = 100%.

The behaviour of individual data objects is described in the following chapter.

3.4.2.4 Initialization and behaviour of individual data objects of the IT-1602 module

The IT-1602 peripheral module contains a block of analog inputs and outputs.

The panel for parameters setting can be opened from the project manager in the node *HW | Configuration HW* (fig.3.4.18). In the folder *External I/O modules* we click on the ☑ icon on the relevant line.
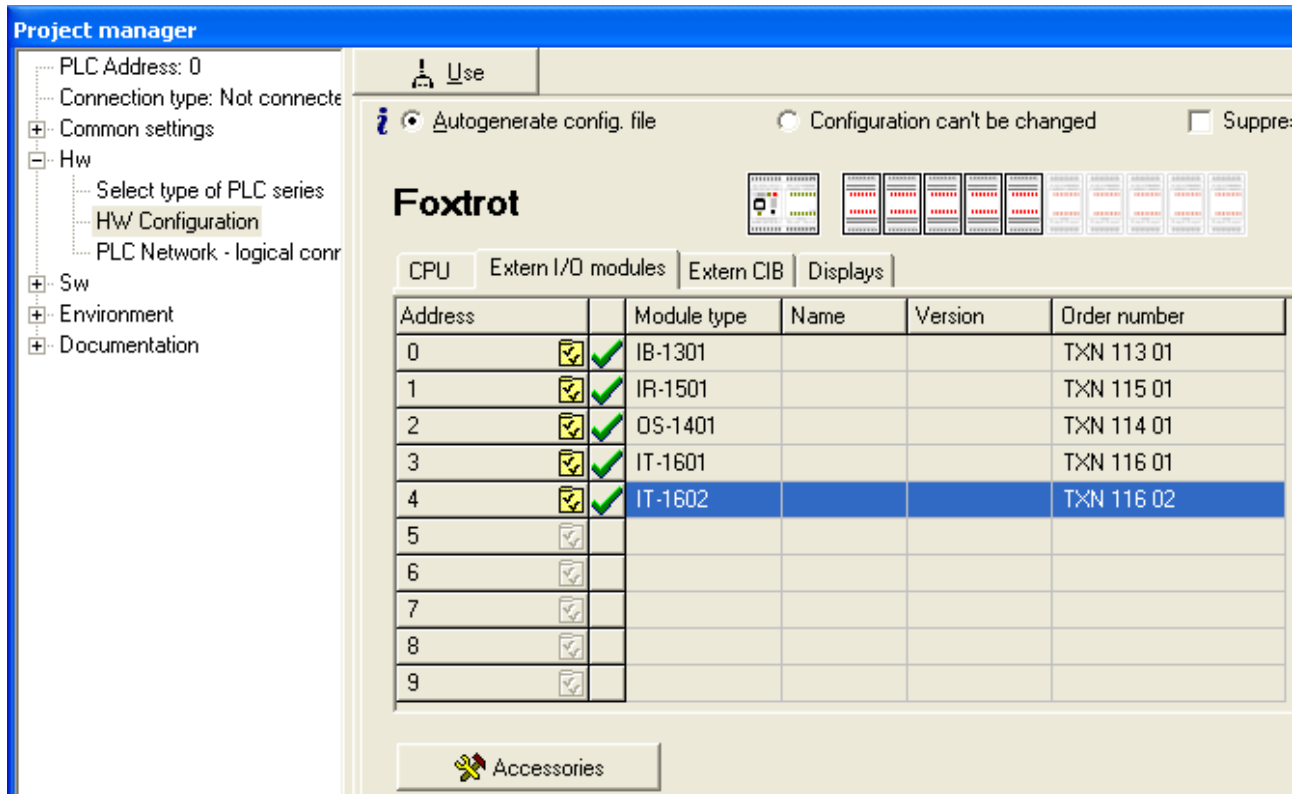

Fig.3.4.18 Peripheral modules configuration

Analog inputs

The IT-1602 module contains 8 analog inputs AI0 to AI7 which have various measuring ranges. Each input has four variables *STAT*, *FS*, *ENG* and *PCT*. State *STAT* is always transferred, among variables *FS*, *ENG* and *PCT* we choose one depending on the interpretation of the measured value required. The configuration of analog inputs can be found in the folder *Analog inputs* (fig.3.4.19).

The transferred value in the FS variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents directly the value in engineering units according to the measuring range selected.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

If we want to filter the input analog value, we switch the filtration mode on and set the time constant. Measured values of the correspondent channel then go through the 1st grade filter. The filter is due to the following relation:

$$y_t = \frac{y_{t-1} \cdot \tau + x}{\tau + 1}$$

x - Converted value of the analog input

y_t - output

y_{t-1} – last output

τ - time constant of the 1st grade filter

The time constant value is set in the range $0,1 \div 25,0$ s. The filtration concerns all data formats of the channel given (*FS*, *ENG* and *PCT*) and is accessible within all measuring ranges.
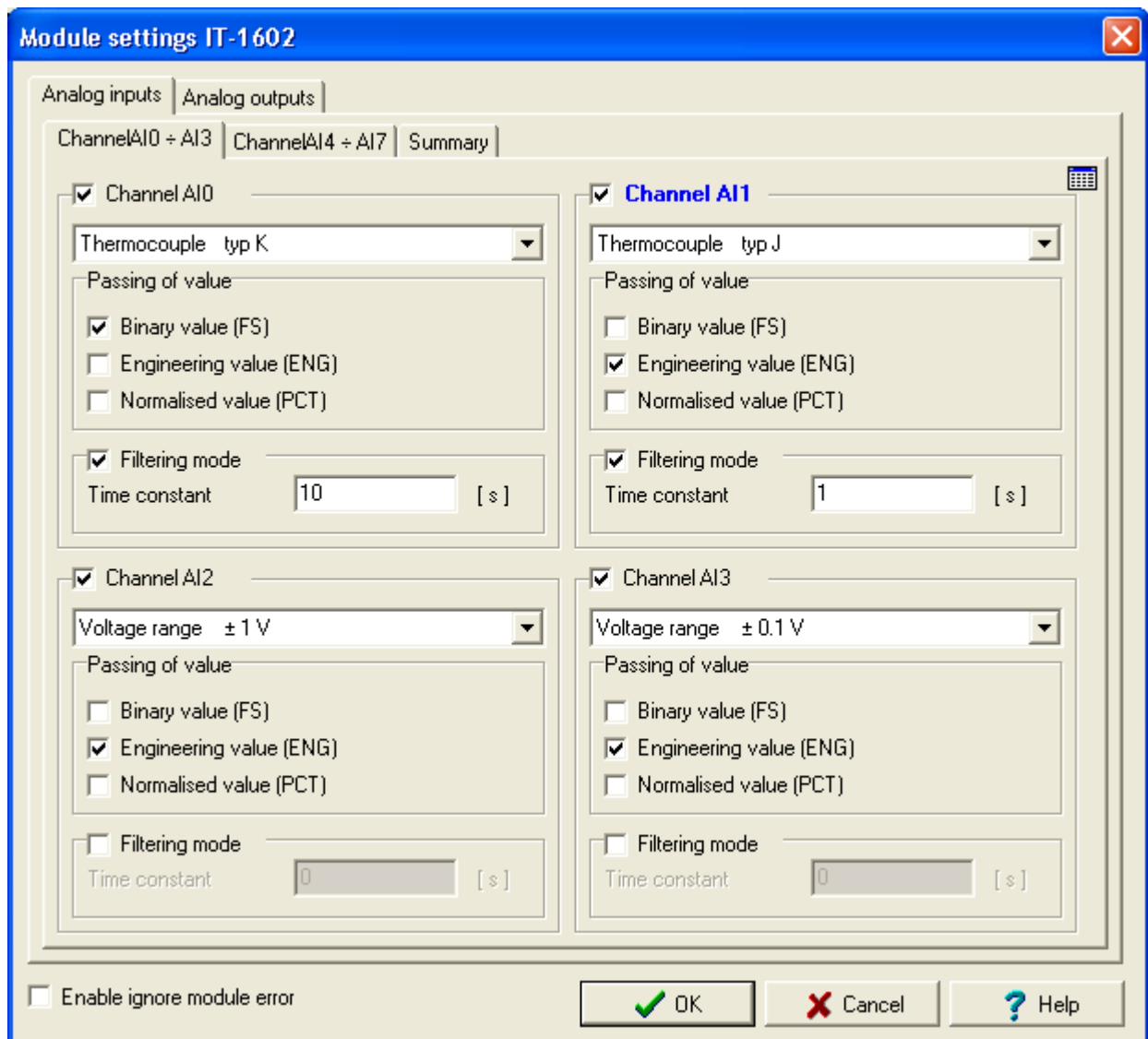

Fig.3.4.19 Analog inputs configuration

If we check an item *Enable ignoring module error* at the bottom side of *IT-1602 Module settings* pane, CPU doesn't stop user program performing even when the fatal error of data exchange with this module occurs but it tries to reinitialize the module and renew the communication. The actual module status and the validity of data can be found in peripheral system status zone. (chap. 6.5). This function can be used in case we want to keep PLC running even if peripheral module power supply is switched off.

There are shown transferred values for individual ranges of analog inputs in the following graphs and tables.
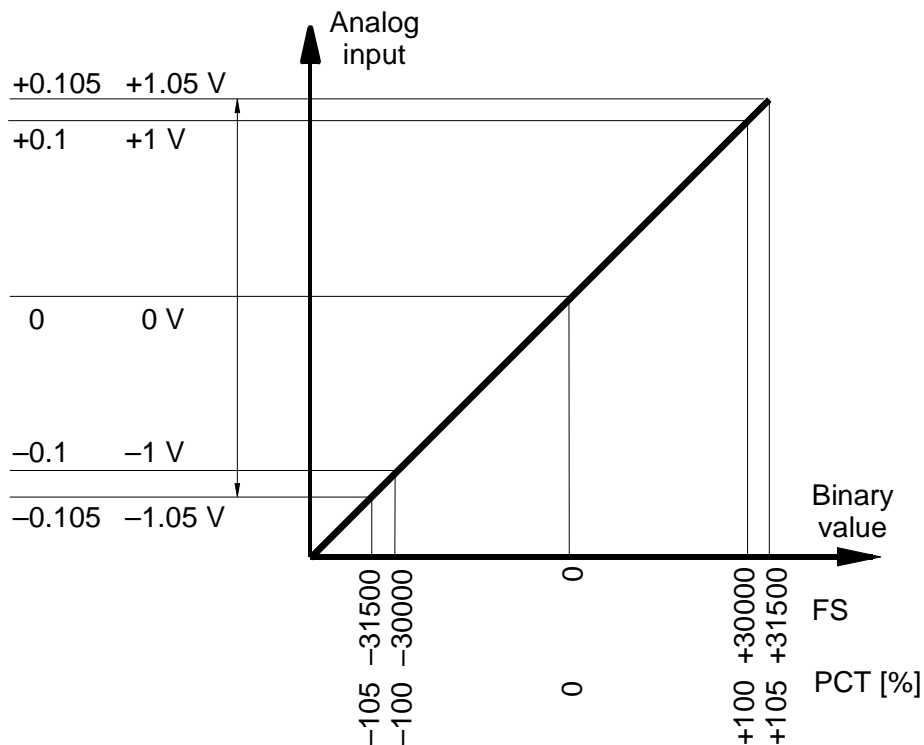
Fig.3.4.20 Voltage ranges of analog inputs of the IT-1602 module

Table 3.4.27 Transferred values of analog inputs for the range 0 to ±1 V

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1,05 V	$000C	31500	1,05	105	range overflowing
1,05 V	$0004	31500	1,05	105	range exceeding
:	$0004	:	:	:	
1 V	$0000	30000	1	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	
:	$0000	:	:	:	
−1 V	$0000	−30000	−1	−100	
:	$0002	:	:	:	range descended
−1,05 V	$0002	−31500	−1,05	−105	
< −1,05 V	$0003	−31500	−1,05	−105	range underflowing

Table 3.4.28 Transferred values of analog inputs for the range 0 to ±0,1 V

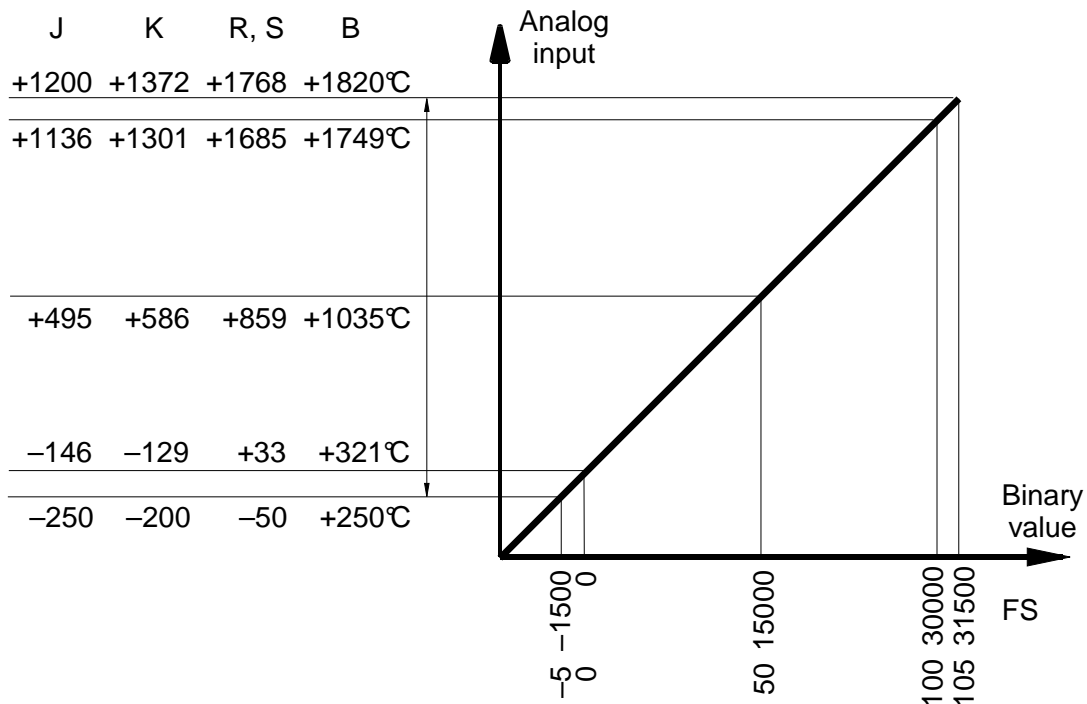| Measured value	Variable				
	STAT	FS	ENG	PCT	
> 0,105 V	$000C	31500	0,105	105	range overflowing
0,105 V	$0004	31500	0,105	105	range exceeding
:	$0004	:	:	:	
0,1 V	$0000	30000	0,1	100	nominal range
:	$0000	:	:	:	
0 V	$0000	0	0	0	
:	$0000	:	:	:	
−0,1 V	$0000	−30000	−0,1	−100	
:	$0002	:	:	:	range descended
−0,105 V	$0002	−31500	−0,105	−105	
< −0,105 V	$0003	−31500	−0,105	−105	range underflowing

Fig.3.4.21 Analog inputs range of the IT-1602 module for thermocouples

Tab.3.4.29 Transferred values of analog inputs for a thermocouple J

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1200 ℃	$000C	31500	1200	105	range overflowing
1200 ℃	$0004	31500	1200	105	range exceeding
:	$0004	:	:	:	
1136 ℃	$0000	30000	1136	100	nominal range
:	$0000	:	:	:	
−146 ℃	$0000	0	−146	0	
:	$0002	:	:	:	range descended
−250 ℃	$0002	−1500	−250	−5	
< −250 ℃	$0003	−1500	−250	−5	range underflowing

Table 3.4.30 Transferred values of analog inputs for a thermocouple K

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1372 ℃	$000C	31500	1372	105	range overflowing
1372 ℃	$0004	31500	1372	105	range exceeding
:	$0004	:	:	:	
1301 ℃	$0000	30000	1301	100	nominal range
:	$0000	:	:	:	
−129 ℃	$0000	0	−129	0	
:	$0002	:	:	:	range descended
−200 ℃	$0002	−1500	−200	−5	
< −200 ℃	$0003	−1500	−200	−5	range underflowing

Table 3.4.31 Transferred values of analog inputs for thermocouples R and S

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1768 ℃	$000C	31500	1768	105	range overflowing
1768 ℃	$0004	31500	1768	105	range exceeding
:	$0004	:	:	:	
1685 ℃	$0000	30000	1685	100	nominal range
:	$0000	:	:	:	
33 ℃	$0000	0	33	0	
:	$0002	:	:	:	range descended
−50 ℃	$0002	−1500	−50	−5	
< −50 ℃	$0003	−1500	−50	−5	range underflowing

Table 3.4.32 Transferred values of analog inputs for a thermocouple B

Measured value	Variable				
	STAT	FS	ENG	PCT	
> 1820 ℃	$000C	31500	1820	105	range overflowing
1820 ℃	$0004	31500	1820	105	range exceeding
:	$0004	:	:	:	
1749 ℃	$0000	30000	1749	100	nominal range
:	$0000	:	:	:	
321 ℃	$0000	0	321	0	
:	$0002	:	:	:	range descended
250 ℃	$0002	−1500	250	−5	
< 250 ℃	$0003	−1500	250	−5	range underflowing

Analog outputs

The IT-1601 module contains 2 analog outputs AO0 and AO1 which have a range of 0 to ±10V. Each output has three variables *FS*, *ENG* and *PCT*. Among these variables we choose one according to what type of interpretation of the input value is required. The configuration of analog outputs can be found in the folder *Analog outputs* (fig.3.4.22).

The transferred value in the FS variable is an int type variable. The value 0 corresponds to the minimum value of the input unipolar value and the value 31 500 corresponds to the maximum value. It applies that 100% of the nominal range of the analog input corresponds to the value of *FS* = 30000.

The transferred value in the *ENG* variable is a real type variable and represents directly the value of output voltage in volts.

The transferred value in the *PCT* variable is a real type variable and represents the percentage relation between nominal and measured value of the analog input. The *PCT* variable is related to the *FS* variable. It applies that for the value *FS* = 0 is the *PCT* = 0% and for the value *FS* = 30000 the *PCT* = 100%. The *PCT* variable can reach a maximum value of 105% which corresponds to *FS* = 31500.

Outputs behaviour in the HALT mode can be defined by two alternatives. If we mark the item *Freeze,* then after the transmission to the HALT mode the analog output stays set to the last value entered by the user program.
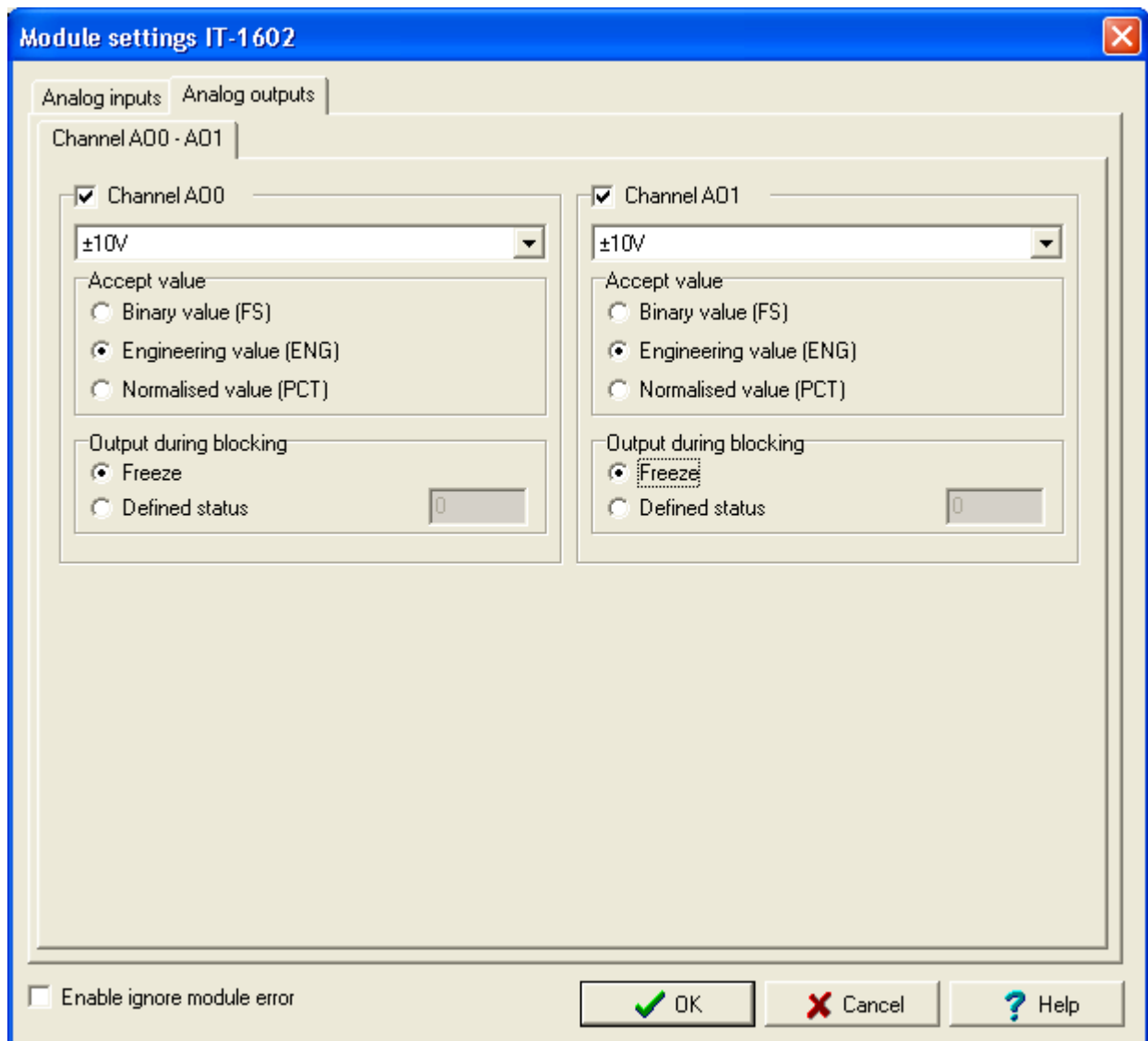
Fig.3.4.22 Analog outputs configuration

If we mark the item *Defined state*, then after the transmission to the HALT mode the value set in the relevant field will be set to analog output. This set value has the format identical to the selected transmitted variable. This means that if we use the FS format, the value is of an int type within the range -31500 - 31500, if we use the ENG format, the value is of a real type within the range -10,5 - 10,5 V, and if we use the PCT format, the value is of a real type within the range -105% - 105%.

After the supply switch-on, analog outputs are always set to the value of 0.
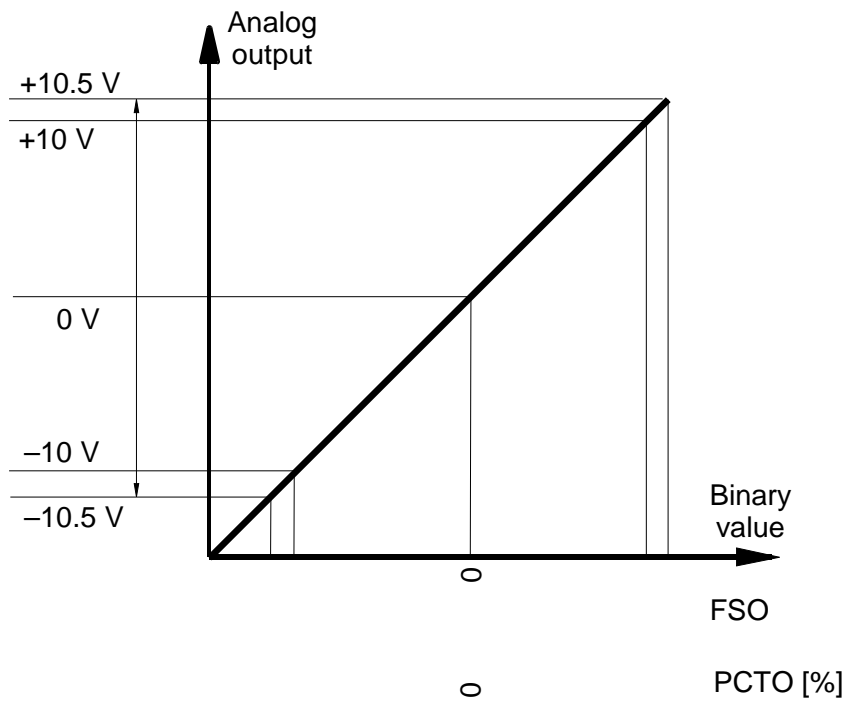
Fig.3.4.23 Analog outputs range of the IT-1602 module

Table 3.4.33 Transferred values of analog outputs for the range 0 to ±10 V

Output value	Variable			
	FS	**ENG**	**PCT**	
10,5 V	> 31500	> 10,5	> 105	range overflowing
10,5 V	31500	10,5	105	range exceeding
:	:	:	:	
10 V	30000	10	100	
:	:	:	:	
0 V	0	0	0	nominal range
:	:	:	:	
−10 V	−30000	−10	−100	
:	:	:	:	range descended
−10,5 V	−31500	−10,5	−105	
−10,5 V	< −31500	< −10,5	< −105	range underflowing

3.5   SPECIAL MODULES

All other modules which are connected to the basic module via the TCL2 bus belong to this group.

3.5.1   CIB MI2-02 external master bus

The MI2-02 module contains 2 lines of the CIB bus onto which units of system can be connected. Characteristics of both lines are identical to the integrated line of the basic module CP-10xx.

3.5.2   ID-14 operator panel

The ID-14 operator panel contains the display of 4 x 20 characters and 25 buttons. The display supports Windows CP1250 (WinLatin2 – central European), CP1251 (WinCyrillic – Cyrillic alphabet) and CP1252 (WinLatin1 – western European) fonts.

The ID-14 panel is connected to the basic module PLC FOXTROT via the bus TCL2, so in the same manner as common peripheral modules. Up to four panels of this type can be connected to one basic module. In the set mode we select the type *CPU Foxtrot* and then we must set the panel address (position address) in the range of 8 to 11 (in the case of more panels on one bus, each panel must understandably have a different address). The item rack address must always be 0.

The ID-14 operator panel enables the installation of a short U bar where the basic module PLC FOXTROT can be fitted to. A compact PLC with a display and keyboard is easily obtained by this method.

Detailed information on the ID-14 panel connection and its operation are described in the manual ID-14 operator panel TXV 002 33.01.

4. TRANSPORTATION, STORAGE AND INSTALLATION OF PLCS

4.1 TRANSPORTATION AND STORAGE

The modules are packed according to internal packing instructions into cardboard boxes. Basic documentation is enclosed in the packaging. The external packaging is undertaken according to the order quantity and the method of transportation into a shipping container labeled and containing all necessary data for transportation.

The goods is transported from the producer's facilities as agreed when placing an order. Transportation of the goods by the customer must be realized by covered transport means and in the position as is indicated on the packaging. The shipping container must be fixed in such a way to avoid accidental spontaneous movement and damage of the external container.

During transportation and storage, the product must not be exposed to direct climatic influences. Transportation of the product is permitted within temperature range of -25 °C to 70 °C and relative humidity of 10 % to 95 % (withou t condensation).

The product must be stored only in clean spaces free from conductive dust, aggressive gases and vapours. The optimum storage temperature is 20 °C. When storing the central unit for more than a half year, it is recommended to take out or isolate the battery to avoid its discharging.

4.2 SUPPLY OF PLC

Individual components of the PLC FOXTROT are delivered in the separate packaging. The assemblage is undertaken by the customer.

System assemblage is accomplished according to the following chapter.

4.3 SYSTEM ASSEMBLY

4.3.1 Interconnection of individual modules

Individual modules assembly

If optional submodules, which are delivered individually (serial interfaces), are necessary to be added to the module, then these submodules will be delivered in a separate packaging and the customer will mount them according to the directions stated in the documentation provided with these modules (chapter 2.2.2.).

Modules interconnection principles

All modules of one PLC FOXTROT set (i.e. all peripheral modules controlled by one basic module) must be interconnected via the bus interconnection which is connected to terminals on the top left corner of each module (TCL2 bus and optionally a power supply).Terminal with an identical labeling are interconnected within all modules.

The interconnection of modules must be done linearly (that means that modules are interconnected in a series one after the other and a branch line cannot be realized); the

basic module must be at one end of the bus and a terminating 120 Ω resistor must be placed on the other end between TCL2+ and TCL2– signals. For easy installation the terminator KB-0290 is included to the basic module. This member contains a terminating resistor and is designed to be inserted into the TCL2 bus terminal. During the assemblage, we insert first the terminator into terminals, then the conductor for interconnection of the bus and then tighten terminals. The terminator can be ordered separately under the number TXN 102 90.

Individual modules are interconnected via cables intended for the RS-485 bus. If the bus length exceeds 10m, we connect the TCL2 bus through the whole length without a power supply. Because the bus in not galvanically isolated, **it is vital to interconnect the grounds** of all sources that supply these modules to ensure the equilibration of potentials.

Modules can be interconnected via optical cables, too, or by a combination of optical and metallic cables. For interconnection via the optical cable the converter KB-0552 (chapter 4.3.2.) must be used. Modules are interconnected via standard ST-ST patch cables. The optical converter does not contain a metallic bus termination (120 Ω resistor), thus it does not need to be always at the end of the metallic line. If it is at the end of the metallic line, then the KB-0290 terminator must be used.

It results from the above mentioned that by using optical converters it is possible to create a random bus star branching by individual linear metallic lines interconnection via optical converters. We must not forget that all metallic bus parts must be terminated at both ends (the basic module has a built in terminator but all other modules do not)!

The optical cable ensures a galvanic isolation, therefore, for the powering of the following module an independent power supply is vital. Naturally, we do not interconnect the ground of this source with the ground of sources supplying modules „beyond" the optical cable.

Attention!   Any physical handling with interconnecting cables between individual modules may be done solely when the PLC power supply is switched off!

Three basic module connection types arise from the above mentioned:

1. Modules are interconnected via the metallic cable including the power supply. This is a standard method of interconnection suitable for sets with several modules in one distribution box. This method is limited by the maximum bus length (power supply cabling).
2. Modules are interconnected via the metallic cable without the power supply. This method is used in case of greater distances between modules – the control system is distributed into several cases within the technology, etc. Each module (or several modules together) must then have their own power supply. Any cable fulfilling RS-485 bus requirements can be used for interconnection of the TCL2 bus.
3. Modules are interconnected via the optical cable. This type of interconnection is intended for long distances. Due to the fact that the lengths of individual segments are summarized, we can achieve bus length that is several kilometers long. The optical cable ensures the galvanic isolation and thus to the module (or group of modules) that is connected via the optical cable must be an independent power supply connected. Detailed description of calculation of the maximum cable lengths can be found in chapter 4.3.2.

Attention!   The metallic communication bus between modules must not be led through an outside environment or between separately standing buildings (regardless the environment)!

> After a near lightning bolt stroke a direct threat caused by an electromagnetic field or a significant difference of potentials of the individual buildings can occur. In both cases the destruction of all parts connected to the bus can occur.
> **In such cases an optical interconnection must always be used regardless the bus length!**

The overall characteristics of the FOXTROT modules interconnection types to assemblies are stated in the table 4.1.

The stated possibilities can be mutually combined:

Table 4.1 Possibilities of FOXTROT modules interconnection

Versions	1	2	3
Additional hw	-	-	KB-0552
Transfer medium	Metallic cable (2x twisted pair)	Metallic cable (Twisted pair + GND, 2x twisted pair)	Optical cable
Power supply distribution	yes	no	no
Bus galvanic isolation	no	no	yes
Cable used	RS-485 specification	RS-485 specifications	Standard ST-ST patch cable
Connector	Screw terminals	Screw terminals	2x ST
Attenuation approx.	-	-	3,5 dB/km
Frequency length	-	-	820 nm
Fiber type	-	-	glass multimode 62.5/125 µm
Max. number of I/O modules for one CPU	10	10	10
Max. length of one bus segment	10 m	200 m	max. 1,7 km
Max. total bus length	10 m	200 m	according to segment number

Peripheral modules addressing

The addressing of peripheral modules is undertaken via a rotary switch on the module front panel.

Peripheral modules can be divided into three groups according to their addressing:

♦ common peripheral modules (IB-130x, OS-140x, IR-150x, IT-160x)
♦ ID-14 operator panels
♦ external masters of buses CIB - (MI2-02)

These three groups are in terms of addressing independent on each other. When addressing the rule applies that each module of one group must have a different address set. If two or more modules of the same group with the same address are connected to the bus, then transfer errors will occur and the system will not be functional.

Contrariwise, the identical address of two modules, each from a different group, is not in the way. Therefore, we can operate e.g. modules IB-1301 and ID-14, on the address 8 both.

4.3.2   Optical interconnection of peripheral modules

Optical interconnection modules

KB-0552 optical interconnection modules are intended for connection of optical cables to ST type optical connectors. The module doesn't contain a termination of metallic line

(resistance 120 Ω) therefore it may not be at the end of metallic line. If it is placed at the end of metallic line KB-0290 termination element must be used everytime.

Modules are interconnected via a duplex glass optical cable (with two fibres – one for each direction of transfer) 62.5/125 μm or 50/125 μm on a distance of up to1750 m. Eventually it is possible to use two single-fibre optical cables. Parameters of modules are stated in table 4.2.

The TXN 105 52 set always contains two modules for connection of duplex optical cables.
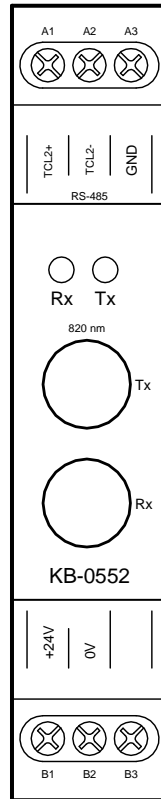
Fig.4.1   Optical interconnection module KB-0552

Table 4.2 Basic parameters of the modules optical interconnection of the bus KB-0552

Module type	KB-0552
Product standard	ČSN EN 61131-2
Electric item protection level ČSN 33 0600	III
Connection	Screw-type terminals
	Duplex 2×ST
Power supply	24 V DC
Power input	1.2 W
Frequency length of optical device	820 nm
Operation temperature	0℃ to +55 ℃
Minimum bridgeable attenuation	min. 8 dB, type 15 dB
Average lifetime at environmental temperature 55℃ (–3 dB performance)	33 years
Average lifetime at environmental temperature 40℃ (–3 dB performance)	68 years

Transceiver	symbol	min.	type	max.
		\[dBm\]		
Transceiver optical performance at 25 ℃	$P_{T\ (max)}$	–15,0	–12,0	–10,0
Total optical performance		0,355 mW		

Receiver	symbol	min.	type	max.
		\[dBm\]		
Input optical performance "log.0" 0 up to +70℃	$P_{RL(max)}$	–24,0		–10,0
Input optical performance "log.0" at 25℃	$P_{RL(max)}$	–25,4		–9,2
Input optical performance "log.1"	P_{RH}			–40,0

Interconnecting optical cables

We accomplish the cable connection in such a way that we remove dust shields from the module by pulling and insert ST connectors of optical cables. In the fibre connection transmitter (Tx) must always be connected with receiver (Rx) of the opposite module.

Table 4.3 Basic parameters of optical cables with glass multi mode fiber

Optical connection connector	Duplex 2× ST
Frequency length of optical device	820 nm
Fiber type	glass multimode 62.5/125 mm or 50/125 μm
Operating temperature	–40℃ to +85 ℃
Installation temperature	0 ℃ to +70℃
Attenuation of 1 km cable length	α	3,5 dBm
Max. short-term load in tension (< 30 min.)	500 N
Delay given by distribution speed	5 ns/m
Max. continuous tension load	1 N
Max. permanent bend radius	35 mm
External diameter of a cover of one fiber (2x)	3 to 6 mm

⚠	**Handling is undertaken when the whole FOXTROT system is switched off only! Handling when switched on can damage the modules!**

⚠	**Every time the optical cable is removed it is necessary to use the rubber covers and always blind the optical transceiver and receiver. Otherwise, damage caused by dust can occur!**

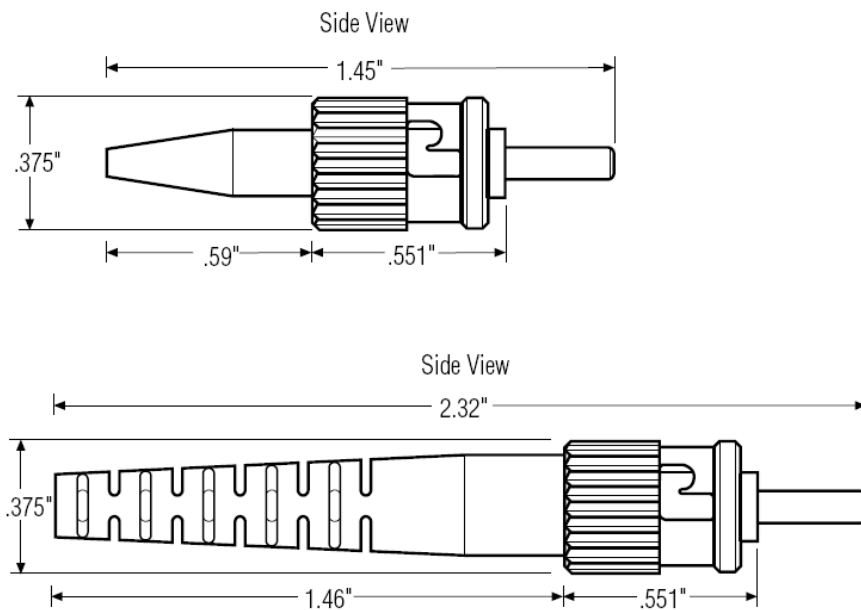| ⚠	**The product is a source of light radiation of the CLASS 2 in accordance with IEC 60825-1.** **Do not look intently into the emitter. Eyesight could be damaged!**

Fig.4.2   Mechanical dimensions of the ST optical connector

The maximum cable length depends on the optical output emitted, receiver's sensitivity and the attenuation of the used cable:

$$L_{(max)} = (P_{T\ (max)} - P_{RL(max)}) / \alpha \quad [m]$$

$L_{(max)}$	maximum length
$P_{T\ (max)}$	smallest optical output value of emitter
$P_{RL(max)}$	biggest value of input optical output for log.0
α	attenuation value of cable at 1 m of length

Transceiver output is also dependent on the temperature.

$$P_{T\ (t)} = P_{T\ (25°C)} + \Delta P_T/\Delta T \text{ x } (t - 25°C)$$

The cable attenuation is also dependent on the temperature.

$$\alpha_{(t)} = \alpha + \Delta \alpha_T/\Delta T \text{ x } (t - 25°C)$$

4.4   PLC INSTALLATION

PLC FOXTROT units are designed to be mounted onto the U bar corresponding to ČSN EN 50022. In cases without a forced ventilation the PLC must be placed in a distance of a minimum of 100 mm between the top and bottom part of the PLC and the top and bottom of the case. If a good natural ventilation can not be ensured, then it is necessary to ensure ventilation using an internal ventilator. The maximum allowed air temperature entering the PLC is 55°C.

PLCs are designed for the pollution level 2. The installation must be undertaken in such a manner, that conditions of the II. surge category will not be exceeded.

The size and design of the case must be chosen with respect to the power input of the i devices installed and with respect to the permitted operation temperature of the PLC surrounding environment (chapter 1.5.). It is necessary to take into account also performance losses that arise on inputs and outputs switched to the active state (it is necessary to base the calculations on the number of simultaneously activated inputs and outputs, on the load and type of each output). Performance losses on one input, or on the PLC output in the active state rather, can be found in table 4.4 and 4.5.

Table 4.4 Performance loss within one input

Module type	Rated current	Performance loss per 1 input
CP-1004, CP-1014 (IR-1055, IR-1057)	24 V DC	0,09 W
CP-1005, CP-1015 (IR-1056)	24 V DC	0,09 W
IB-1301, IR-1501	24 V DC / AC	0,20 W
PX-7811, PX-7812	24 V DC	0,09 W

Table 4.5 Performance loss within one output

Module type	Rated current	Output current	Performance loss per 1 output
OS-1401	24 V DC	2 A (DO0-DO3)	0,30 W
		0,5 A (DO4-DO11)	0,10 W
PX-7812	24 V DC	0,5 A	0,10 W

PLC modules can be located in the case on each other. In this case a minimum distance (between upper and lower module surface) of 90mm must be kept to ensure the air ventilation. In cases that do not have a forced ventilation, the mounting of the rack must be done so, that the distance between the case top and the upper module surface is a minimum of 90 mm. The distance between the bottom of the case and the lower module surface must be kept at minimum of 90 mm, too.

The grounding terminal of the PLC must be connected in the shortest possible way to the main grounding terminal of the case via the conductor of the profile of min. 2,5 mm^2 according to the ČSN 33 2000-5-54. The connection of the PLC supply and the connection of PLC inputs and outputs must correspond to the requirements stated in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02*.

Interference accident prevention

To reduce the level of interference in the distributing frame with the installed PLC, all inductive loads must be equipped with suppression components. Interference elimination sets are supplied for this purpose (table 4.6, 4.7).

The interference elimination set serves also for protection of the binary DC and AC input PLC modules against voltage peaks arising primarily during the inductive load control. Protection must be undertaken directly on the load due to the maximum elimination of interference spread as a source of possible failures. As protective members varistors or RC-members are supplied, whereas the highest efficiency can be reached by combination of both protection types. Of course, the set can be used anywhere within controlled technologies to protect contacts or for protection against interferences arising during control processes.

An example of connection of the protection element is illustrated in fig. 4.3. The principles of interference elimination in the position of its source as close as possible (load) must be taken into consideration.
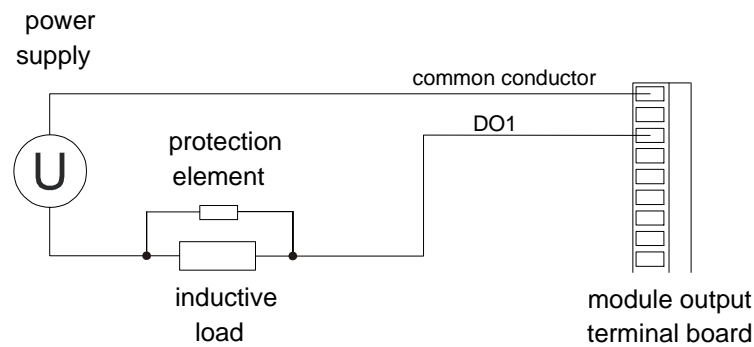
Fig.4.3   *Parallel connection of the protection element to the load*

Table 4.6 Interference elimination sets

Interference elimination set content	For load of	Set order number
8x varistor 24 V	24 V DC / AC	TXF 680 00
8x varistor 230 V	230 V AC	TXF 680 03
8x RC unit - R = 10Ω, C = 0,47μF	24 - 48 V DC / AC	TXF 680 04
8x RC unit - R = 47Ω, C = 0,1μF	115 - 230 V AC	TXF 680 05

Table 4.7 Parameters of varistors used in interference elimination sets

Energy that can be captured by the varistor I^2t (t is time of duration of the extinction pulse - in ms)	< 80 J
Current through the varistor I	< 25 A
Average value of output power loss P	< 0,6 W

Further information on interference elimination can be found in the *Manual for designing of TECOMAT FOXTROT PLCs TXV 004 11.02*.

4.5   POWER SUPPLY REQUIREMENTS

Detailed information on requirements and realization of power supplies can be found in the *Manual for designing of TECOMAT FOXTROT PLCs TXV 004 11.02*.

4.5.1   PLC power supply

The PLC power supply must be in the overvoltage category II in accordance with the ČSN 66 0420-1. If a computer (Ethernet, RS-485 interface, etc.) is connected to the PLC or if it is required that the PLC circuits (besides relay inputs) are in compliance with safety separated circuits (SELV), then the power supply must fulfill the SELV requirements in accordance with the ČSN 33 2000-4-41.

Between the primary and secondary winding of the transformer, a Cu shielding foil must be wound, connected to the inside grounding terminal of the case or the windings must be arranged is such a manner that the capacity between them is minimized.

It is recommended to add a switch to the joint PLC power supply (to be able to switch off the power supply when adjusting programs, during the maintenance, repairs, etc.). Power supplies must be realized via screened cables. The cable screening must be connected to the main terminal board of the case on the side of the transformer only. The minimum conductor diameter of cables interconnected to the main grounding terminal of the case must be 2,5 mm^2.

Attention!	24 V DC +25%, -15% voltage is used as a power supply of the PLC. Be careful not to confuse the polarity when connecting the supply because it would cause a short-circuit! In no case 24 V voltage can be connected to the TCL2 bus terminals, as this could damage circuits of the serial interface of the bus!

4.5.2 Power supply of input and output circuits

The input circuits switches of peripheral modules can be supplied by the same power supply as these modules. Then indeed, they have no galvanic isolation.

Input circuits of basic modules are always supplied from the same power supply as these modules are. The power supply must be dimensioned according to the specific power drain of the modules and power losses on input circuits (table 4.4).

Circuits switched by binary outputs must be supplied by an independent power supply or at least by an independent transformer winding. The supply source must be dimensioned according to the concrete input of the load and performance losses of input circuits (table 4.5).

4.6 SERIAL COMMUNICATION

The FOXTROT PLC is connected to other systems using serial lines. The CH1 serial channel has a fixed RS-232 interface. The CH2 channel has an optional interface. For the interface selection MR-01xx plug-in submodules are used allowing connection via interfaces RS-232, RS-485 or RS-422. Another possible connection to other systems represents the Ethernet 10/100 Mb interface.

For connection of FOXTROT system components to other systems (e.g. to PC) via the serial line, any of the interfaces being offered can be used (chapter 2.2.2). The interface is selected according to the type of interface contained in the system being connected. If this interface with its parameters is not satisfactory (longer distance, higher level of interference, low speed, connection of more participants at a time), a corresponding serial interface converter must be used on the side of the system being connected.

Table 4.8 Order numbers of cables for connection of the PLC to other participants

Type	Modification	Order number
KB-0205	cable UTP Ethernet 10/100 Mb, standard (direct)	TXN 102 05.xx*
KB-0206	cable UTP Ethernet 10/100 Mb, crossed	TXN 102 06.xx*

*   identification of the cable length (table 4.9)

Table 4.9 Order numbers of cables according to the length

Length [m]	KB-0205	KB-0206
0,5	TXN 102 05.02	TXN 102 06.02
1	TXN 102 05.04	TXN 102 06.04
2	TXN 102 05.08	TXN 102 06.08
5	TXN 102 05.20	TXN 102 06.20

Note: Different lengths can be agreed with the business department.

Detailed information on realization of communication connections and networks can be found in the *Manual for designing of programmable logic controllers TECOMAT FOXTROT TXV 004 11.02*.

5.   PLC OPERATION

5.1   INSTRUCTIONS FOR SAFE OPERATION

With PLC supply on and with power supply of input and output PLC circuits on, it is not permitted to disconnect or connect either power supply conductors or signal or bus conductors connected to PLC modules terminals.

When programming PLC control algorithms, the possibility of an error in the user program cannot be eliminated, which could result in an unexpected behaviour of the object being controlled, the consequence of which could be an emergency situation or in the worst case could be hazardous to persons. When operating the PLC, especially during trial runs and while debugging of new user programs with the controlled object, it is unconditionally necessary to pay a high attention to this.

> **The object being controlled must be adjusted so, that zero values of the control signals (PLC without power supply) ensure a stable and collision-free state of the object controlled!**

5.2   SETTING THE PLC IN OPERATION

First PLC setting in operation procedure

When setting the PLC in operation for the first time, it is necessary to adhere to the following procedure:

a) Check the connection of the network power supply of power supply modules.
b) Check the connection of grounding terminals to the main grounding terminal of the switchgear or of the case.
c) Check the mutual interconnection of PLC modules.
d) Check whether the PLC configuration and module addressing corresponds to the application given.
e) Check the correctness of the connection of PLC module power supply circuits (violation of the prescribed power supply voltage parameters can cause the destruction of input or output circuits).
f) Switch the PLC power supply on.
   The power supply of all modules must be switched on either at once or in the following sequence:
   - first the power supply of peripheral modules (in the random order),
   - eventually, CP-100x basic modules must be switched on.
Any other procedure is not permitted.

Signalization of the PLC activity after switching the power supply on

Inputs are blocked after the PLC is switched on. This is indicated by the LED diodes OFF on the peripheral modules. If, after switching the power supply on, the indication of blocking of some inputs or outputs lights up on some input or output modules for a short period of time, it is not a problem, since after switching the power supply on, the system program ensures clearing of inputs and outputs and LEDs being on will go out after a while.

This intermediate state caused by supply voltage surge does not show up on the outside since outputs are always locked immediately after the switching of power supply on and they unlock after the PLC is switched to the RUN mode (if not set up otherwise by the user).

Basic modules CP-1004 and CP-1005 are equipped with unitary seven-segment display while basic modules CP-1014 and CP-1015 are equipped with the display of 4 x 20 characters size. If we will mention in the following text about a display without any further details, then both types of display are meant.

5.3   PLC SWITCHING SEQUENCE

5.3.1   Basic modules CP-1004, CP-1005

Table 5.1 Switching sequence of central units CP-1004, CP-1005

Central unit activity OK – no errors ER - error	LED indication	Display
1. Basic initialization and hw unit testing OK - transfer to next activity	RUN on	sw version **v3_5**
ER - error in launching or in main firmware rather, switching sequence is stopped, PLC cannot be operated	ERR on	**?** or **E**
TEST – short button stroke during the power supply switch-on - transfer into testing mode	RUN on	**t**
BOOT - when the button is continuously pressed during the power supply switch-on and about 3s after –transfer into BOOT state, possibility to change the firmware	RUN on	**boot**
2. Initialization of system software processor	RUN on	**–**
3. Bus initialization (when button is pressed continuously during steps 2 and 3 for about 3s a different action will take place in step 9)	RUN on	**=**
4. SD / MMC card connection	RUN on	**=**
5. Initialization of the file system and Web server	RUN on	**=**
6. System hw configuration detection - waiting for set expansion elements readiness (buses CIB)	RUN on	**l**
OK - transfer to next activity	RUN on	**=**
ER - error is written to the error stack	RUN and ERR on	last error **E–xx–xx–xxxx**
7. PLC initialization according to the user program OK - transfer to next activity	RUN on	**=**
ER - error is written to the error stack	RUN and ERR on	last error **E–xx–xx–xxxx**

Table 5.1 Switching sequence of central units CP-1004, CP-1005

8. Activation of communication with the superior system	RUN on	**=**
9. PLC mode setup OK - switching to RUN mode and start of the user program	RUN flashing	**G**
OK - when button was pressed for about 3s in steps 2 or 3, switching to HALT mode, user program is not started	RUN on	**H**
ER – when an error occurred during switching sequence, switching to HALT mode, user program is not started	RUN and ERR on	last error **E–xx–xx–xxxx**

PLC operation after the power supply switch-on

   Immediately after switching the power supply on, the PLC performs activities shown in table 5.1. Further, this state is called PLC switching sequence. The purpose of the switching sequence is to test the PLC hardware and software and to set the PLC to the defined initial state. The table also explains the behaviour of the signalization LED diodes and of the display during the switching sequence.

Switching sequence termination

   The switching sequence can be terminated in three possible ways. If everything is O.K., then after the switching sequence is terminated, the PLC starts executing the user program and controlling the technology connected. Should the PLC diagnostics evaluate a critical error during the switching sequence, the PLC will stay in the HALT mode and signalize the error.

   If we press the button after the firmware version is displayed and we hold it for about 3s, the PLC will switch to the HALT mode where the user program is not executed, PLC outputs stay locked and the PLC expects commands from the superior system. The user program can be initiated either by the superior system, or by switching the power supply off and on. This function is useful when trouble occurs with the already running user program.

5.3.2   Basic modules CP-1014, CP-1015

PLC operation after the power supply switch-on

   Immediately after switching the power supply on, the PLC performs activities shown in table 5.2. Further, this state is called PLC switching sequence. The purpose of the switching sequence is to test the PLC hardware and software and to set the PLC to the defined initial state. The table also explains the behaviour of the signalization LED diodes and of the display during the switching sequence.

   The switching sequence can be terminated in three possible ways. If everything is O.K., then after the switching sequence is terminated, the PLC starts executing the user program and controlling the technology connected. Should the PLC diagnostics evaluate a critical error during the switching sequence, the PLC will stay in the HALT mode and signalize the error. The third possibility is to prohibit the user program execution via the option described below. PLC stays in the HALT mode after the switching sequence is accomplished.

Table 5.2 The standard switching sequence of central units CP-1014, CP-1015

Central unit activity OK – no errors ER - error	LED indication

1. System switch-on
 	
``
    s y s t e m
 	
    s t a r t i n g
``
	RUN on

2. Basic initialization and hw unit testing
OK - transfer to next activity
 	
``
    s y s t e m
 	
    s t a r t i n g   ■
``
	RUN on

ER - error in launching or in main firmware rather of the central unit, switching sequence is stopped, PLC cannot be operated
 	
``
        s w i t c h   c o d e
        i s n ' t   v a l i d ,
 t o   c o n t i n u e   t o   B O O T
  m o d e   p r e s s   a n y   k e y
``
``
  f i r m w a r e   i n   E E P R O M
        i s n ' t   v a l i d ,
 t o   c o n t i n u e   t o   B O O T
  m o d e   p r e s s   a n y   k e y
``
	ERR on

Menu - when the MODE button is continuously pressed during the power supply switch-on, the menu will appear
 	
``
 s e l e c t   i t e m ,   p l e a s e :
⤷R U N   m o d e   H A L T   m o d e
  s e t   p a r .   B O O T   m o d e
  t e s t   h w .
``
	RUN on

3. Initialization of the bus and system software processor, displaying of the basic module type and of versions of the central unit sw and hw
 	
``
    F O X T R O T   C P - 1 0 1 4
    s w   v 3 . 5   h w   v 0 2 0 0
 	
    s t a r t i n g   ■ ■
``
	RUN on

Table 5.2 The standard switching sequence of central units CP-1014, CP-1015

Central unit activity OK – no errors ER - error	LED indication
4. SD / MMC card connection ``` F O X T R O T C P - 1 0 1 4 s w v 3 . 5 h w v 0 2 0 0 s t a r t i n g ■ ■ ■ ```	RUN on
5. Initialization of the file system and Web server ``` F O X T R O T C P - 1 0 1 4 s w v 3 . 5 h w v 0 2 0 0 s t a r t i n g ■ ■ ■ ■ ```	RUN on
6. System hw configuration detection OK - transfer to next activity ER - error is written to the error stack ``` Err x x - x x - x x x x error description ```	RUN on RUN and ERR on
7. PLC initialization according to the user program OK - transfer to next activity ER - error is written to the error stack ``` Err x x - x x - x x x x error description ```	RUN on RUN and ERR on
8. Activation of communication with superior system	RUN on
9. PLC mode setup OK - switching to RUN mode and start of the user program ``` Run D I 0 1 2 3 4 5 6 7 D O 0 1 2 3 4 5 ```	RUN flashing

Table 5.2 The standard switching sequence of central units CP-1014, CP-1015

Central unit activity OK – no errors ER - error	LED indication
OK - when the MODE button was pressed during the power supply switch-on and the HALT mode was selected in the menu (table 5.3), user program is not started **Halt** **B L K**	RUN on
ER - if an error occurred during switching sequence, switching to HALT mode, user program is not started **Err** **x x - x x - x x x x** *Error description*	RUN and ERR on

PLC mode selection after the power supply switch-on

   If we press and hold the button MODE during the power supply switch-on, the menu of possible modes will appear on the display:

```
s e l e c t   i t e m ,   p l e a s e :
➜ R U N   m o d e     H A L T   m o d e
  s e t   p a r .     B O O T   m o d e
  t e s t   h w .
```

   Using cursor keys we indicate by the cursor ➜ the required item and press the button ↵. The system will call upon us to confirm the selection. E.g. after the selection of the item HALT mode, the following will appear:

```
      y o u   s e l e c t e d
      H A L T   m o d e
  p r e s s   ↵   t o   c o n t i n u e
  p r e s s   C   t o   c a n c e l
```

   By another stroke of the button ↵ , we confirm the selection and run the required action. If we selected by a mistake a different item, we press the button **C** that returns us back to the menu.

RUN mode   - run the user program (RUN mode)
                    If we select this item, PLC will continue in the switching sequence from the step 3, table 5.2. After the switching sequence termination, the user program will be executed.

HALT mode - does not run the user program (HALT mode)

If we select this item, PLC will continue in the switching sequence from the step 3, table 5.2. After the switching sequence termination, the user program will not be executed, the PLC will stay in the HALT mode, outputs will stay blocked and PLC will expect commands from the superior system. The user program can be activated either via the development environment or by the power supply switch-off and on. This function is useful when trouble occurs with the already running user program.

set par. - central unit parameters setup

If we select this item, the menu of central unit parameters that can be changed will appear:

```
parameters  settings:
➔IP  addr.    exit
 IP  mask
 gateway
```

Using cursor keys we indicate by the cursor ➔ the required parameter and we press the button ↵. The value of the parameter with the possibility of editing is invoked by this action:

```
module  IP  address

 192.168.134.176
 ↑
```

Using buttons ➔ and ← we move the cursor and by buttons ↑ and ↓ we increase, or decrease the digit value on the position indicated by the cursor. By pressing the button ↵ , we return back to the menu.

Following parameters can be set:

IP addr. - IP address of the basic module
IP mask - IP mask of the basic module
gateway - IP address of the local network gate

By selecting the item **exit**, the termination of the setting mode will be required:

```
 exit  setting  mode:
       press
↵  for  save  and  exit
C  for  exit  only
```

By pressing the button ↵ , we accomplish the saving of the change parameters into the EEPROM central unit. If we don not want to change parameters, we press **C**. The system will then proceed the reset and start the switching sequence according to table 5.2.

BOOT mode - special mode enabling the central unit firmware change (chapter 7.1.1.)

test hw. - extended test of the central unit hardware for the service purposes

5.4   PLC OPERATIONING MODES

The FOXTROT PLC can be operated in several operating modes. These are named RUN, HALT and PROG. Their indication is described in table 5.3.

At any of these operating modes (except PROG), it is possible to find out the setting of the Ethernet and serial channels CH1 and CH2 on the display of the central unit.

If, in basic modules CP-1004 and CP-1005, we press and hold the button MODE, parameters of Ethernet ETH1 channel are displayed, then of the CH1 and at last of the CH2. This information is displayed repeatedly for the duration when the button is pressed. The displaying of the parameters has no effect on the system operation.

In basic module CP-1014 and CP-1015 these data can be displayed on the display if they are in the system mode for displaying, it means that the PLC mode and inputs and outputs state is displayed. Then, using the cursor keys, we list through screens informing about the setting of channels and other parameters as it is shown on following examples (number and viewed information can differ from following examples according to PLC type and actual firmware version):

1. Ethernet ETH1 channel parameters
   - active communication modes
   - IP ... IP address
   - IM ... IP mask
   - GW ... local network gateway IP address

```
E T H 1    :    P C
I P    =    1 9 2 . 1 6 8 . 1 3 4 . 1 7 6
I M    =    2 5 5 . 2 5 5 . 0 0 0 . 0 0 0
G W    =    1 9 2 . 1 6 8 . 1 3 4 . 2 0 0
```

2., 3. Serial channel CH1 and CH2 parameters
   - active communication mode
   - A ... channel address
   - S ... transmission rate [kBd]
   - T ... response delay [ms]
   - P ... transmission delay in 100 ms
   - B ... maximum gap between two received characters in ms
   - TR ... idle time between received messages in bytes
   - TT ... idle time between transmitted messages in bytes
   - CTS ... CTS signal detection
   - RTS ... RTS signal mode
   - MT ... token mode
   - transferred data format in the form a-b-c, where:
       a is number of data bits (8 or 7)
       b is parity bit type (E – even parity, D - odd parity, N - no parity, 0 – 0 parity, 1 – 1 parity)
       c is stop bit number (usually 1)
   - serial channel interface (on CH1 fixed RS-232, on CH2 submodule type)

```
C H 1    :    P C
A - 0    S - 3 8 , 4    T - 1 0
C T S - o f f    B - 0    8 - E - 1
i n t e r f a c e    R S - 2 3 2
```

```
C H 2   :   o f f
n o   i n t e r f a c e


```

4. Additional memory
   - user program back-up EEPROM activation (off / on)
   - size of DataBox memory
   - size of memory card and size of free space on the card

```
E E P R O M   o f f
D A T A B O X   5 1 2 K B
m e m o r y   c a r d   5 1 2 M B
-   f r e e   m e m o r y   3 5 5 M B
```

5. Information about user program
   - name and version of the user program
   - date of compilation
   - size of user code and percentual occupation of user program memory
   - size of user tables and percentual occupation of memory for tables

```
      P R O G R A M , 1 . 0
  1 3 : 1 4   2 0 0 9 - 0 1 - 0 7
 1 2 2 1 8 B   (   6 % )   c o d e
   2 5 4 B   (   1 % )   t a b l e
```

6. Version of CPU firmware (firmware, boot, switch, system www pages)

```
C P - 1 0 1 4         v 4 . 1
B o o t   C P 1 0 1 4     v 2 . 7
S w i t c h   1 0 1 4     v 2 . 5
s y s t e m _ w w w      v 1 . 4
```

Detailed information on serial communications can be found in the manual *Serial communication of TECOMAT PLCs – 32 bit model TXV 004 03.02*.

If the display is in the user mode of displaying (it displays characters defined by the user program), we will switch it to the system mode by short stroke of the button MODE. While displaying in the system mode, codes of the pressed buttons are not sent for processing to the user program and thus none unwanted interference occurs within. By another short stroke of the button MODE we return back to the user mode. The display will start displaying characters defined by the user program and transfer codes of pressed buttons to the user program again.

RUN mode

In the RUN mode, the PLC reads values of input signals from input units, executes instructions from the user program and enters the calculated values of output signals into the output units. The RUN mode is signalized by flashing of the RUN LED diode on the central unit. If the RUN diodes on peripheral modules operated are flashing too, it indicates that a data transfer between the central unit and peripheral modules is running. LED ERR diodes are off. The "**G**" lights on the seven-segment indicator and the sign **Run** is displayed in the left top corner.

If the analyzer is running which is the part of the GraphMaker component in the Mosaic development environment, the seven-segment indicator does not indicate this fact, it is indicated on the display behind the sign **Run** by a small **A** character.

If the fixation of signals of peripheral modules is active, which is accessible in the Mosaic development environment in the panel *Setting V/V*, the "**F**" lights on the seven-segment indicator and on the display behind the sign **Run** a small character **F** is displayed.

HALT mode

The HALT mode is mainly used for activities connected with the user program editing. At this mode neither the user program nor the data transmission between the central unit and peripheral units is executed. The green RUN LED diodes on the central unit and peripheral modules are on permanently, the ERR LED diodes are off. On the seven-segment display, the letter **H** is on and in the left top corner the sign **Halt** is displayed.

PROG mode

In the PROG mode, CPU is during the user program saving into the back-up EEPROM. At this mode neither the user program nor the data transmission between the central unit and peripheral units is executed. The green RUN LED diodes on the central unit and peripheral modules are on permanently, the ERR LED diodes are off. On the seven-segment display, the letter **P** is on and on the display in the left top corner the sign **Prog** is displayed.

Behaviour of the PLC during a critical error

An exception from the above mentioned is a situation when a critical error occurs in the PLC that inhibits control activities. In this case, a mechanism for critical error treatment is activated that treats the critical error in light of control security and **always** switches the PLC to the HALT mode. The green RUN LED diode stops flashing and the red ERR LED diode is on, indicating an error state. The code of the error that caused the PLC suspension is displayed on the seven-segment display while besides the **Err** sign and the full error code, the error description is displayed on the last two lines. A detailed description of the PLC behaviour during various errors occurance, possible causes and troubleshooting is given in chapter 6.

Behaviour of the PLC during the power failure

In case of a power failure (either by intentional power supply switch-off, or caused by a defect of power supply lines or by a PLC power supply part defect), the central unit is informed on voltage drop in advance, so that defined system shutdown is performed, including ensuring of the correct content of user tables if the writing process was just performed, and ensuring correct content of the remnant zone.

Afterwards, the central unit is stopped and the "**O**" character appears on the display. In case of a short-term power drop, when power supply was not completely off ("drop out"), the central unit performs reset after approx. 1,5 s and the system executes the switching sequence (see chapter 5.3).

If the following notice will appear on the display

```
Err        c o m m u n i c a t i o n
              w i t h    C P U
              w a s    l o s t
```
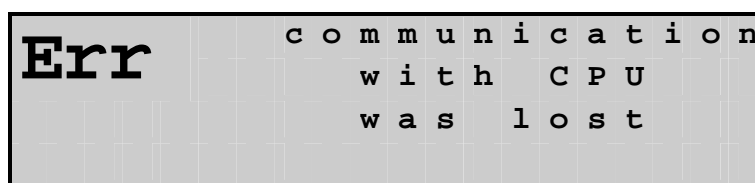
the loss of connection between the display and the central unit occurred. This can happen during the short-term power failure. After the restitution of the connection, the display will
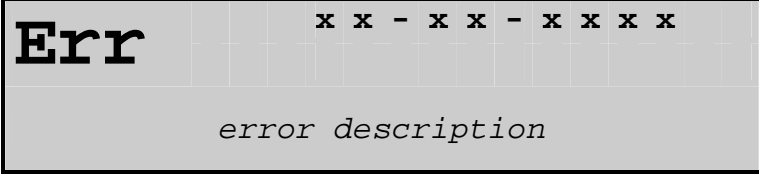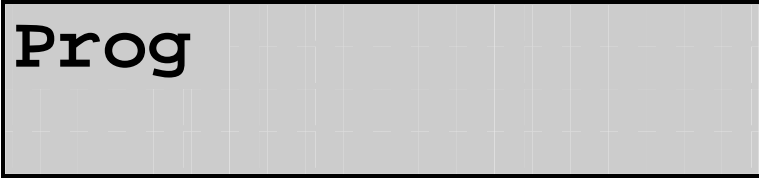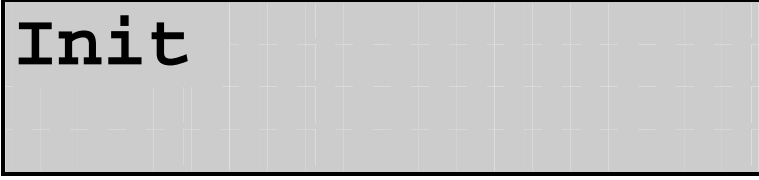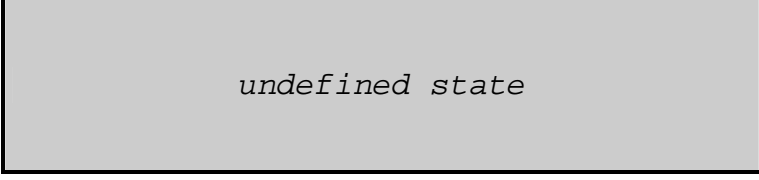
display data sent by the central unit again.

Table 5.3 Indication of operating mode of central units

Central unit state	Display CP-1004, CP-1005	LED indication
Display CP-1014, CP-1015		
RUN mode	**G**	RUN flashing
RUN mode – outputs blocked	**G**	RUN flashing
RUN mode – analyzer runs	**G**	RUN flashing
RUN mode – signal fixing active	**F**	RUN flashing
RUN mode - signal fixing active, analyzer runs	**F**	RUN flashing
HALT mode	**H**	RUN on

Table 5.3 Indication of operating mode of central units

Central unit state	Display CP-1004, CP-1005	LED indication
Display CP-1014, CP-1015		
HALT mode – PLC critical error	**E–xx–xx–xxxx**	
Err x x - x x - x x x x *error description*		RUN and ERR on
PROG mode	**P**	
Prog		RUN on
Peripheral system initialization proceeded	**I**	
Init		RUN on
PLC switch-off proceeded – power failure	**O**	
undefined state		RUN on

5.4.1 Change of PLC operation modes

The change of PLC modes can be undertaken using the superior system (master computer) that is connected to the serial channel or the Ethernet interface.

Typically, a standard PC represents this superior system serving as a programming device or as a monitoring or visualization workplace for the operation of the object controlled.

When changing PLC operating modes, some activities are executed standardly and some are optional. Generally, the change of a PLC operating mode is an activity requiring a higher concentration of the operator since in many cases it significantly influences the state of the object controlled. An example can be the change from the RUN to the HALT mode when the PLC stops the user program execution and the object connected is not controlled anymore. Therefore, we recommend reading the following text very carefully.

5.4.2 Standardly performed activities during the PLC mode change

Switching from HALT to RUN

When switching from the HALT to the RUN mode the following activities are executed:

- User program integrity test
- Software configuration of peripheral units test that is stated in the user program (chapter 5.5.2)
- User program execution starts

Switching from RUN to HALT

When switching from the RUN the HALT mode the following activities are executed:

- The execution of the user program is stopped;
- Blockage (disconnection) of PLC outputs

If during the change from one operating mode to the other a critical error occurs, the PLC sets the HALT mode, indicates the error on the central unit display and waits for the error cause deletion.

Warning:	**Control suspension using the HALT mode is designated for PLC program debugging purposes only. This feature does not replace the CENTRAL STOP function in any way. CENTRAL STOP circuits must be connected in such a way, that their function is independent of the PLC work!**

5.4.3 Optionally performed activities during the PLC mode change

Options during state transition from HALT to RUN

When switching from HALT to RUN, the following activities are optional:

- PLC error reset
- Warm or cold restart
- Output blocking during the user program execution

Options during state transition from RUN to HALT

When switching from RUN to HALT, the following activities are optional:

- PLC error reset
- PLC outputs reset

When resetting the PLC error, the entire PLC error stack is reset, including error stacks of peripheral modules.

The request on output blockage causes that the program will be executed with disconnected outputs, only the signalization of output states on the LED diodes of the output modules will be active. Output blocking is indicated by the OFF LED diode on peripheral modules and on basic modules CP-1014 and CP-1015 by the **BLK** abbrev. on the display (in the system mode of displaying). Blank squares indicate output of the basic module to log.1 instead of full squares. During outputs reset, all PLC binary output units will be reset.

5.4.4   User program restarts

Restart is an activity of the PLC, the task of which is to prepare the PLC for execution of the user program. Under normal conditions, restart is executed at every change of the user program.

FOXTROT systems differentiate two types of restart, warm and cold. The warm restart enables to holdback values in the registers even during power supply is off (remnant zone - chapter 5.5.1.). The cold restart always performs full memory initialization.

Activities during restart

During restart, the following activities are performed:

* User program integrity test
* Reset of the entire PLC notepad
* Remnant zone reset (cold restart only)
* Setting of backed up registers (warm restart only)
* Initialization of system registers S
* Initialization and check of the PLC peripheral system

Starting the user program without restart

The user program is also possible to be run without restart. In this case only the user program integrity test and PLC peripheral system check is performed.

User processes during restart

Depending on the type of restart, runs also the scheduler of user processes P . If warm restart is executed within HALT $\rightarrow$ RUN switching, user process P62 is executed as the first one after switching to the RUN mode (if it is programmed). In case of cold restart, user process P63 is executed as the first one. If no restart is executed during the switching to the RUN mode, process P0 is executed as the first one after the switching.

5.4.5   Change of the program while the PLC is in operation

The Mosaic development environment enables a so called online program change which is a change of the user program undertaken while the PLC is in operation. This can be tried out on the PLC simulator in the Mosaic development environment.

The on-line change of the program is a feature of the central unit which allows performing changes to the user program without stopping the technology under the control, i.e. without a necessity to shut down the technology controlled, when modifying the PLC program.

This feature gives the programmer using the FOXTROT system a possibility to make changes to the PLC program while the PLC is running. It is, of course, the programmer who is responsible for the correctness of modifications being made on-line. The PLC central unit together with the Mosaic development environment ensures safe execution of these changes at one time so, that the continuity of control is not threatened.

To explain the basic principle let us use the following example. Let us assume that the FOXTROT PLC controls a technology which shut down would mean a very high economic loss, e.g. a calciner, and the programmer was ordered to make changes to the PLC program used. It is not important at this moment, whether it is a correction of an incorrect

control algorithm or addition of a new function (e.g. baking of a new product). It is necessary to make changes to the PLC program and the calciner working must not be stopped. The on-line change of the program can be a solution to this situation. The programmer performs the corresponding changes of the PLC program and the central unit ensures swapping from the old program to the new one in such a way that the n-th cycle of computation is fully executed according to the original program and the following cycle will be performed according to the new program. The central unit also ensures necessary activities connected with the changes of variables in such a way that the continuity of control is not affected.

The on-line change of the program can be enabled in the Mosaic development environment in the *Project manager* in the folder *Environment / PLC Control* where we enable the option *Enable 'On-line changes'*. If the central unit does not support the on-line changes, this mode cannot be activated in the Mosaic development environment.

The enabled support of the on-line changes is signalized in the Mosaic development environment on the menu bar by the flower symbol . If the icon is coloured, the support of the on-line changes is on. If the flower icon is grey, the on-line changes are off and each change to the program will result in stopping of the control when loading the new program to the PLC.

Detailed information on the on-line changes can be found in the Help of the Mosaic development environment.

Possibilities of on-line changes

When using the on-line change, the programmer can modify the following parts of the program:

♦ Program code, i.e. any modifications of all parts of the program;
♦ Modifications of variables, i.e. insertion and deleting of all types of variables such as modification of the field size;
♦ Modifications of data types, e.g. changes to structures, adding of new data types and deleting data types not being used;
♦ Modifications of the size of the remnant zone.

The following modifications cannot be performed within the on-line change of the program:

♦ Changes to hw configuration of the system, such as addition of I/O modules or changes to I/O module types;
♦ Changes to I/O modules settings;
♦ Changes to settings of communication parameters for serial channels;
♦ Changes to PLC network.

5.5   PROGRAMMING AND DEBUGGING OF THE PLC PROGRAM

PLC programming

Programming of control algorithms and testing of the program correctness for the FOXTROT PLCs is carried out on computers of a PC standard. For connection with the PLC a common serial channel of these computers or the Ethernet interface is used.

For each PLC a CD ROM with the installation of the MOSAIC development environment in the version Mosaic Lite is supplied.

Mosaic development environment

The Mosaic development environment is a complex development tool for programming of PLC TECOMAT applications and TECOREG controllers that provides a user-friendly application for a program creation and debugging. It is a product running under the Windows 2000 / XP platform where a large number of modern technologies are employed. The following versions are available:

Mosaic Lite   non-key version with a possibility to program a PLC with three declarations #modules

Mosaic Compact enables programming of compact TECOMAT PLC controllers of the range TC400, TC500, TC600, TC650, FOXTROT and TECOREG regulators without limitations

Mosaic Profi   designated for all systems of Teco company without limitations

The environment contains a text editor, xPRO mnemocode translator, debugger, PLC communication module, PLC configuration module and a system help. Further, it contains tools for designing of operator panel desktops (PanelMaker), tool for working with PID regulators (PIDMaker), graphic on-line analysis of monitored variables or offline analysis of archived data (GraphMaker). A part of the environment is also a ID-07 / ID-08 / ID-14 operation panel simulator and OI-1073 integrated display simulator (CP-1014, CP-1015).

The environment contains the programming support according to the IEC 61131-3 standard in a structured text (ST), in instructions (IL), in the relay scheme language (LD), or in function blocks (FBD).

5.5.1   Configuration constants in the user program

Configuration constants are generated automatically during the compilation of the user program and are integral part of it. They carry information on the requested PLC mode and its use. Constants can be set via menus of the MOSAIC development environment before the compilation itself is performed (*Project manager*, folder *Sw | Cpm*) (fig. 5.1).

Default values are set after pressing the button *Basic.*

Configuration constants contain the following services:

PLC start after the switch-on - type of a restart after switching PLC power supply on. It specifies whether the warm or cold restart will be performed (chapter 5.4.4.). By default cold restart is preset.

Protected tables - specification of the user program backup range at EEPROM. It is defined here whether the entire user program including T-tables is backed up or whether T-tables are opt out and remain in the original state at backed up RAM (the option is enabled - useful in such cases when the tables are modified by the user program). By default, the entire user program is backed up (option disabled).

First warning - time of the release of the warning that the maximum permissible cycle time could be exceeded. If the cycle time of the user program processing is longer than the period of time defined by this constant, PLC system services set the bit S2.7 as a flag that the time set was exceeded during the program processing at this cycle. At the same time, the code of the soft error is set in the system register S34. By default, the value is 150 ms.

- *Cycle error* - time of monitoring of the maximum permissible cycle time
  If the user program processing cycle is longer than the maximum permissible period of cycle time, the PLC reports the critical error of cycle time exceeding, blocks outputs and interrupts the cyclic execution of the user program. This constant defines the   longest permissible period of time, during which the controlled object can stay without any intervention. The default value is 250 ms, the recommended maximum value is 500 ms.

- *Backed up registers* - number of backed up registers R (remnant zone).
  Setting of the number of backed up registers R, values of which will be saved during PLC power failure, protected by the check character and restored in case of warm restart of the PLC. The registers are saved in order beginning with the register R0, the state of the registers is backed up after the last cycle of the user program is fully completed . The default value is 0.
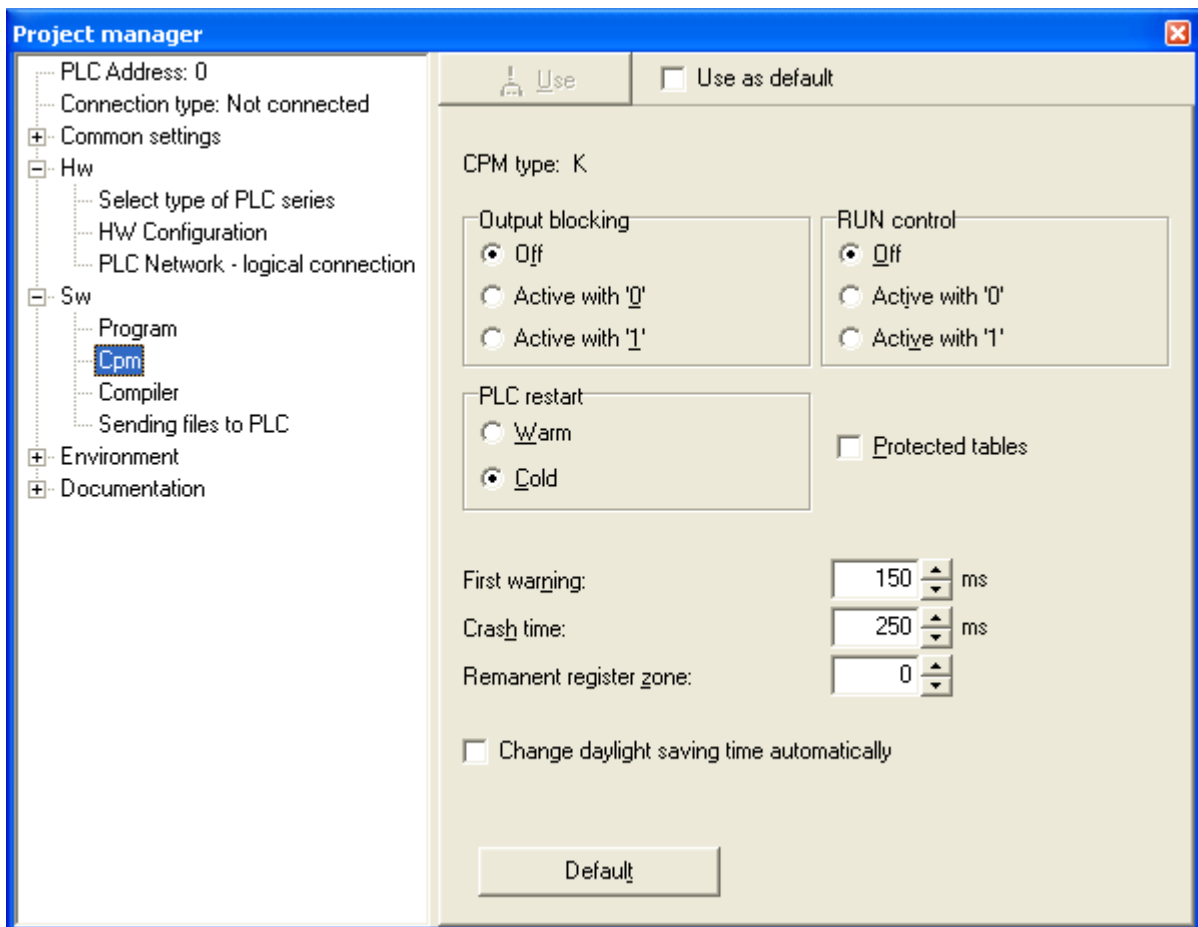
Fig.5.1   Configuration constants setting

- *Automatic switching to the daylight saving time*
  This setup causes that the system will switch the system time automatically to the daylight saving time in phase from the last March Sunday 02:00 a.m. to the last October Sunday 03:00 a.m. Time indication is accessible on the bit S35.6 (0 - winter time, 1 - daylight saving time). The bit S35.7 indicates the function activity (1 - on).
  By default this function is off.

5.5.2   PLC configuration

The configuration of peripheral modules describes the PLC set and is integral part of the user program. This description is compared to the reality found during the PLC switching sequence before the initialization of the user program execution. At the MOSAIC development environment, the configuration is entered by filling in of the forms and based on them, the environment generates directives *#module*. Generally, these directives contain the following information on each operated PLC peripheral module:

- Module address
- Information on e.g. assignment of the serial channel number CHn to a particular communication module
- Number of transmitted input and output bytes of modules
- Position in the PLC notepad where the read / sent data from / to the module are displayed (start of the continuous zone in the area X, Y)
- Reference to the T-table containing initialization data

These information allows checking the readiness of the entire PLC to perform control activities before program initialization.

The Mosaic development environment enables manual and automatic FOXTROT PLC configuration. First, in the *Project manager* select the FOXTROT modular system in the folder *Hw / PLC series selection* and choose a basic PLC module type (fig. 5.2). Then, we can configure the PLC (fig. 5.3., fig 5.4) in the folder *Hw / HW configuration* in the *Project manager*.
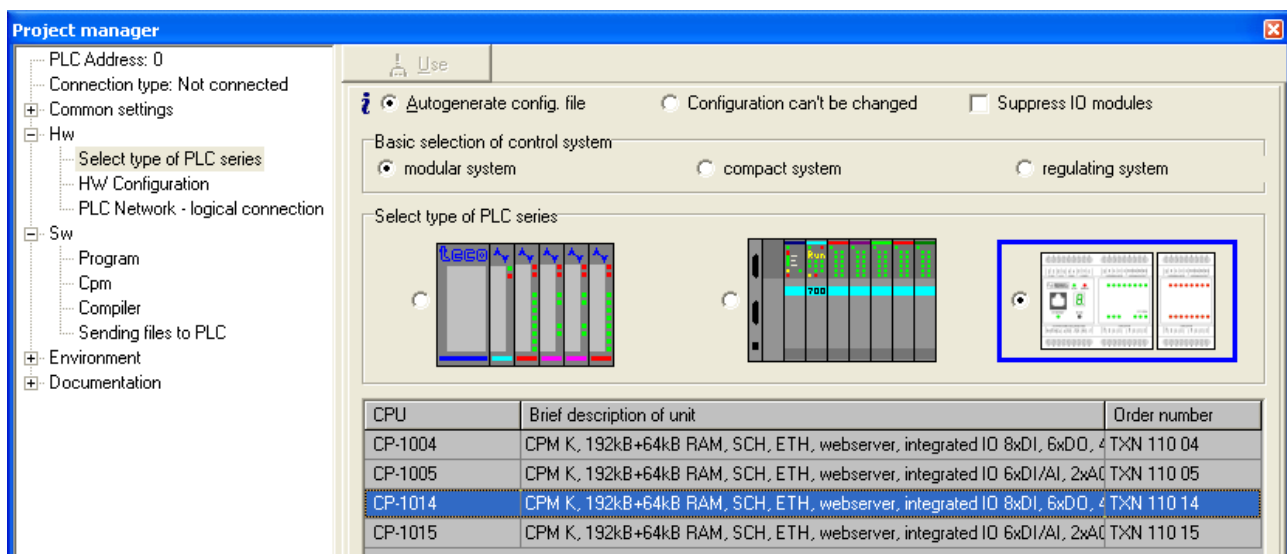
Fig.5.2   PLC series selection

Manual configuration of PLC

You can configure the PLC manually if the concrete PLC unit is not physically available. In the *Central module* (Fig.5.3) folder we can change the type of the basic module by clicking the right mouse button in the column *Module type*. We can then choose the requested module from the menu.

In the *External I/O modules* (Fig.5.4) folder we can add further peripheral modules by clicking the right mouse button on the selected place in the form in the column *Module type.* We can then choose the requested module from the menu. Its name appears at the required position of the form.

By clicking the left mouse button on the icon ⚙, a panel opens, allowing to configure the concrete module. Detailed information on the possibilities of configuration can be found in related chapters.

Automatic PLC configuration

If we have the PLC assembly, which we want to configure, physically available, we switch the PLC power supply on and establish communication with the PLC. Then we go back to the folder *Hw / HW configuration* and press the button *Load from the PLC* (fig. 5.3).
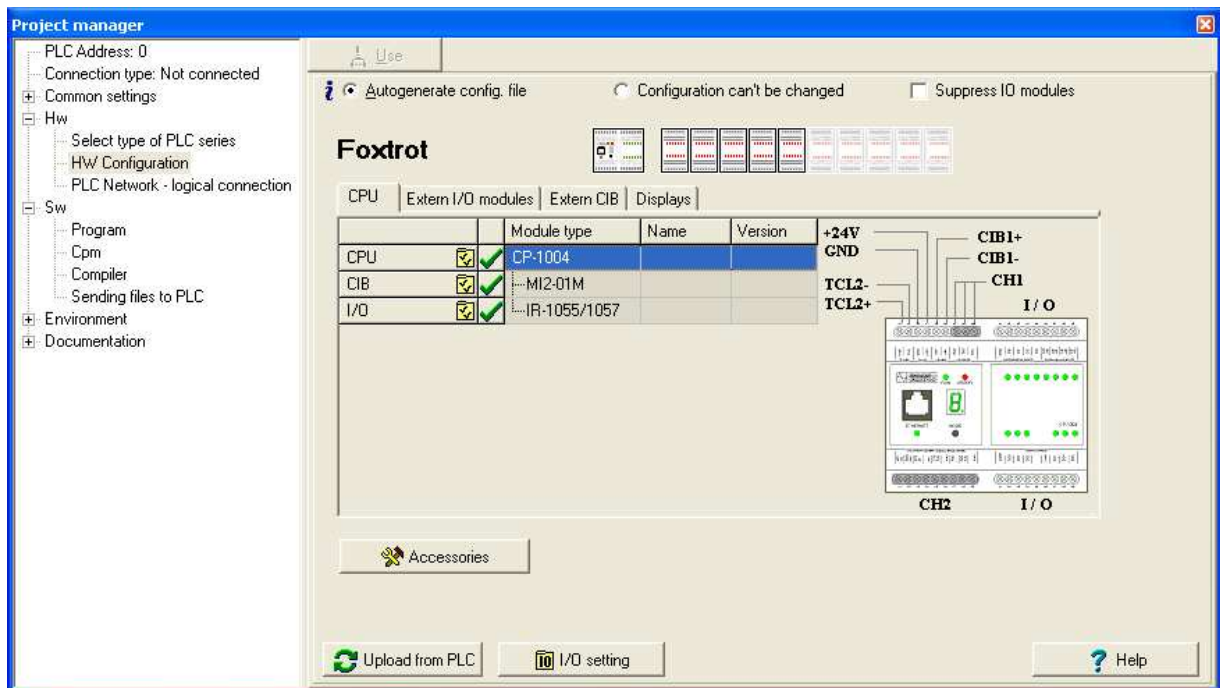
Fig.5.3   PLC FOXTROT configuration settings- basic module
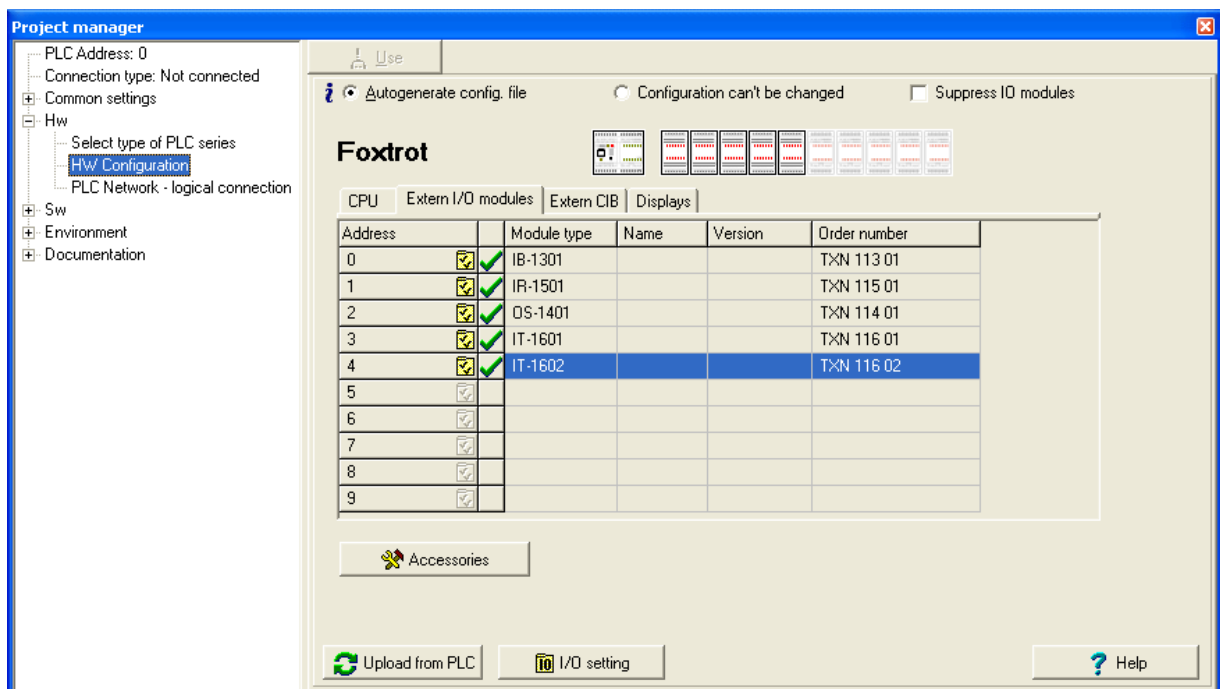
Fig.5.4   PLC FOXTROT configuration settings- peripheral module

Based on data in the central unit, a list of found modules is produced (fig.5.5.). The option *Keep original setting of imported modules* allows the correction of the configuration or adding to it without a loss the original setting. If the option is enabled, then modules, that have been already configured and found at the same positions, will keep their settings. The other newly found or modified modules (another type at the same position) have their configuration set to initial values. If this option is disabled, all the modules will have their configuration set to their initial values. Any possible previous setting will be lost.

If we do not want to include some of the found modules to the configuration, we click on the ticked square on the left edge of the line with the name of this module. By pressing the button *Apply,* the list offered will be accepted. Consequently, individual configuration dialogues for all modules are automatically offered. After this operation is finished, the object is ready for debugging with the concrete PLC set which is available.

	Rack	Position	Module type	Version	Note	
☑✓	0	0	CP-1004	43H0100	CPM K, 192kB+64kB RAM, SCH, ETH, webserver	
☑✓	1	0	OS-1401	12H0100	12xDO	
☑✓	1	1	IR-1501	12H0100	4xDI, 8xDO, counters	
☑✓	1	3	IB-1301	12H0100	12xDI, counters	
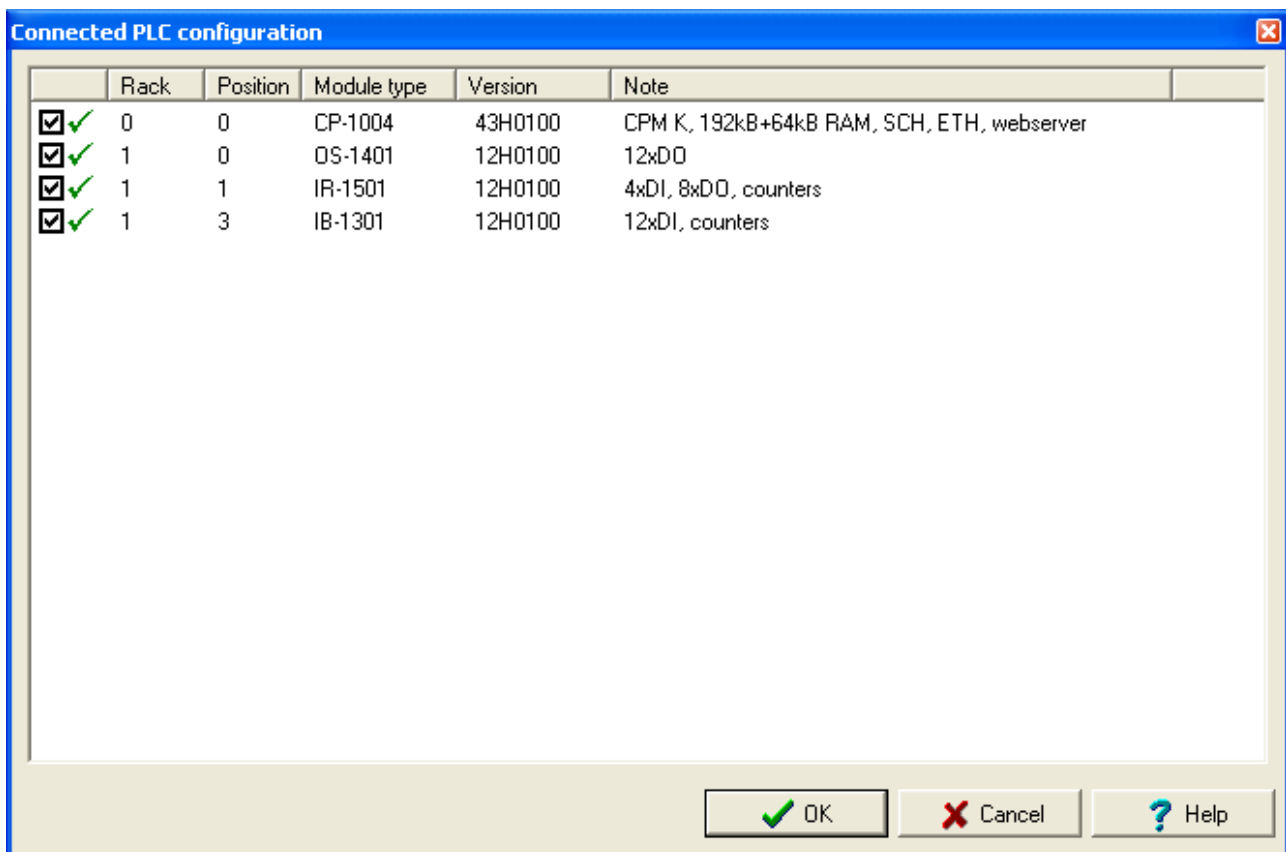
Fig.5.5   Download of configuration from PLC

As it can be understood from the above mentioned, the automatically set PLC configuration can be modified manually at any time and vice versa.

Disconnection of the peripheral module operation

The operation of any of peripheral modules can be disconnected, without the necessity of taking it out of the rack, in the MOSAIC development environment by double-click on the field exactly in the front of the name of the module in the *Project manager* in the folder *Hw / HW configuration*. The green sign indicates that the module will be operated, the red cross informs that the module will not be operated.

Execution of the user program with disconnected peripheral modules

If there is no software configuration entered in the user program, the program will be executed above the PLC working memory only and the PLC inputs and outputs will not be operated. The output modules will be blocked in this case.

We can achieve the same result if we select the option *Suppress IO modules operation* in the *Hw / HW configuration* folder in the Project manager. The translator will then ignore the set configuration and the program will be, after the compilation and launching, executed above the notepad memory only.

Monitoring of data provided by the peripheral module

By pressing the button *Setting V/V,* a panel with data structure provided by the specified module appears with its generated symbolic name that can be changed arbitrarily, and with current data values. Description of the content of this panel is always given in the description of the concrete module.

5.5.3   Project archivation in the PLC

The FOXTROT PLC enables to archive user projects directly into the central unit. This feature is useful when servicing the system and connected technologies when we have access to the source files of the user program which the central unit works with. In this manner we can avoid problems when after several years application source files cannot be found or it is not obvious which version is uploaded in the central unit.

The whole project is saved in the central unit as a zip file protected with a password. The complete process of archivation and restoring is done in the Mosaic environment.

Project archivation

Choose the item *File | Archivation | Archivation of the project to the PLC* in the menu in the Mosaic environment which will open the panel *Archive project group into the PLC)* (Fig.5.6).
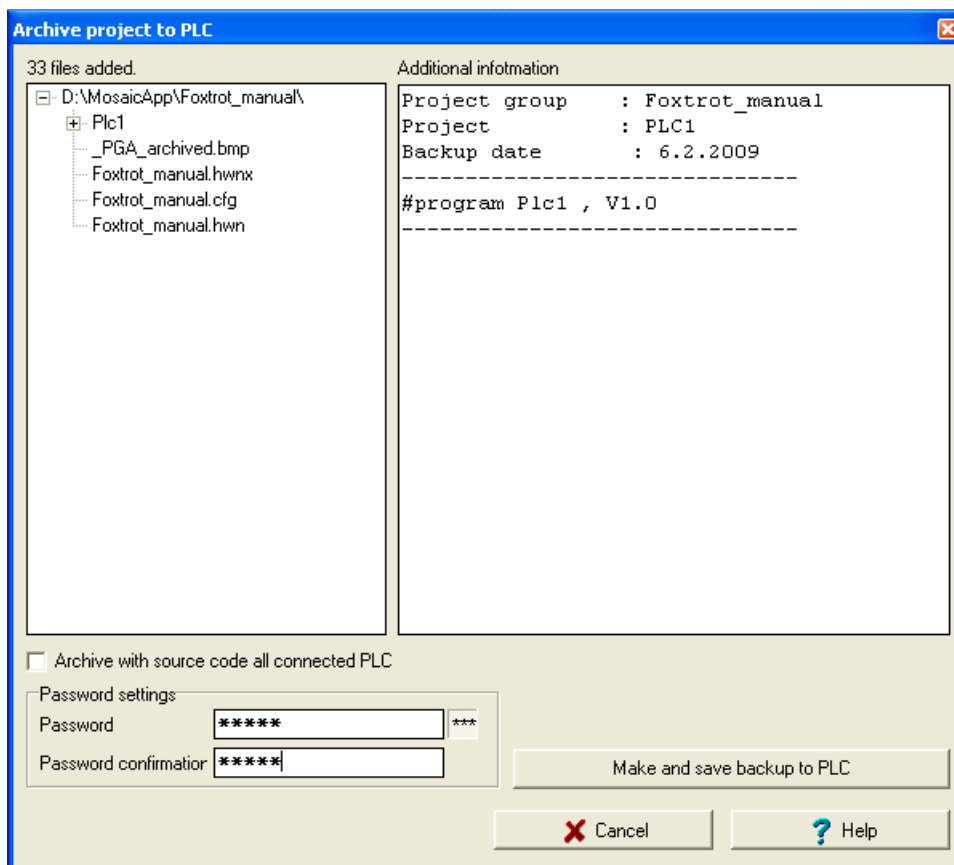
Fig.5.6   Archiving a project into the PLC

The left field shows a tree of archived files. We can enter a random text into the right field to describe the archived project.

All files of the actual project are saved in the central unit. If we select the option *Archive including source codes of connected PLCs,* then, besides the relevant project, also projects from all other PLCs from the project group which are in any way connected to this PLC *will be saved, too. (*in the project manager in the folder *Hw|PLC network - logic interconnection).*

Input a password into the field *Password* and input the same password into *Password check.* If we want to see what we are writing, we can switch off the character masking by pressing the button ***. By pressing it again the masking will be renewed. The maximum password length is 20 characters.

Then press the button *Create and save the backup to the PLC* and Mosaic will create an archive and save it to the central unit. If another project has been already saved into the central unit, then a window will appear stating its name and time of archivation and will ask you to confirm the overwriting of the former project.

Project restoration

In the Mosaic environment choose from the menu *File | Archiving|Restore the project from the PLC* and the panel *Project group restoration from the PLC* (Fig.5.7) will appear.

The description of the saved project that we entered during its archivation will appear in the right field.

Input the password into the field *Password.* If you want to see what you are writing, you can switch off the character masking by pressing the button ***. By pressing it again the masking will be renewed. After pressing the button *Download from the PLC,* the PLC archive is downloaded to the computer.

In the part *New project group* we enter, to the field *Name of new project group,* the name under which the project group containing the archived projects will be created. After pressing the button *Create and open* the project group will be created and opened according to the name entered and it will contain all projects that were downloaded from the PLC archive.
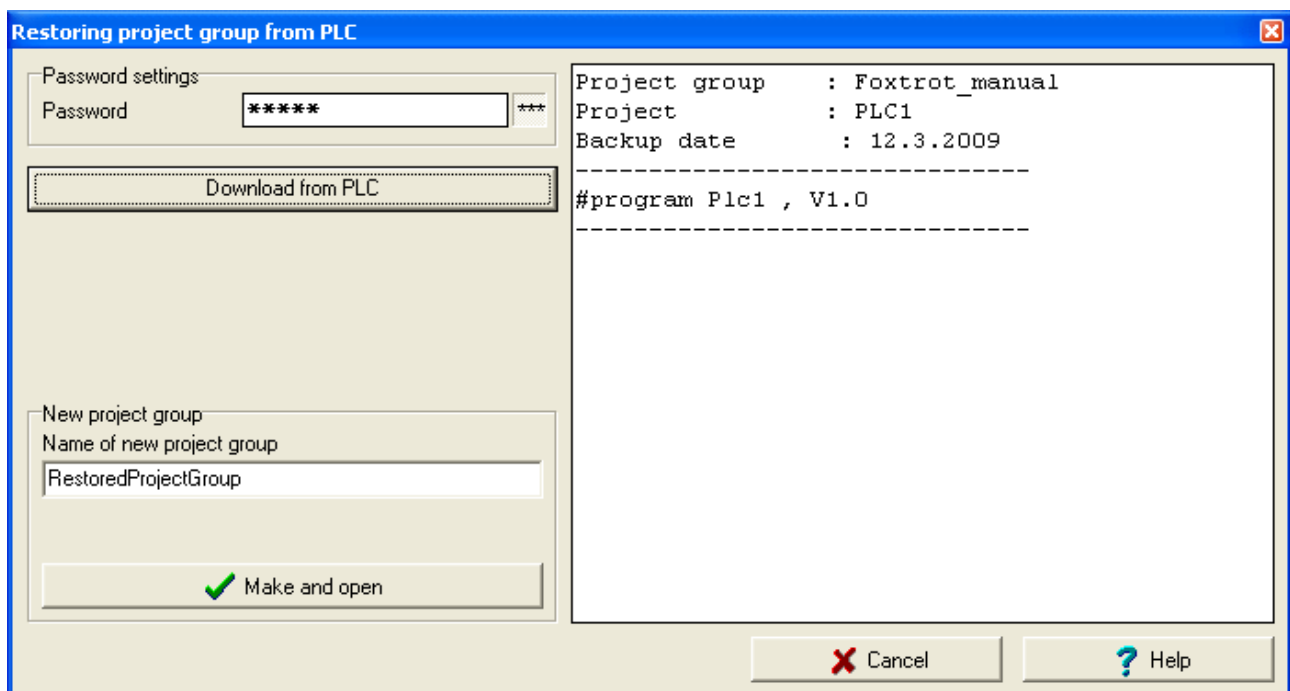
Fig.5.7   Project restoration from the PLC

5.6   TESTING OF I/O SIGNALS CONNECTED TO THE PLC

For the basic testing of input and output signals connected to the PLC, it is sufficient to create an empty program containing only software configuration of the PLC being tested and instructions P 0 and E 0 which create an empty basic process.

Thereafter, using debugging means of the MOSAIC development environment, we can monitor the states of connected inputs and set any values on PLC outputs. This easy but very effective method is recommended to be undertaken before the user program debugging since the entire path from input members (terminal switches, ...) through input units to the PLC working memory and back from the notepad memory through output units to action members will be tested.

 Hereby, errors arisen during the PLC connection to the object controlled will be cleared. Searching for such errors is significantly more difficult at the stage of the control program debugging.

Testing of input and output signals can also be done using the so called "fixation" which is accessible in the Mosaic in the panel *Setting V/V*. This procedure is applicable at any time at the stage of the user program debugging and later during the servicing of connected technologies. The fixed value keeps its set value regardless of the user program and serial communication, too. The state of fixation is indicated on the display of the central unit (see table 5.3).

5.7   FILE SYSTEM AND WEB SERVER

Basic modules CP-10xx contain a slot for a memory card of the MMC and SD types. Individual files on cards can be saved in file systems FAT12, FAT16 or FAT32. Older basic modules CP-10xx that have not a hole for card plug-in on the side support reduced size MMC only.

Cards must be formatted beforehand (the card cannot be formatted in the PLC) and if possible clear (the card can be also used for archivation of other files connected with the application but with the increasing number of files, the access to the card is slowed down). It is also important to take into consideration the card´s lifetime which is round 100 000 entries.

Memory card application

The Mosaic enables the entry of files to the memory card inserted in the central unit via the option *PLC | File system PLC*. All files transferred via the Mosaic are saved on the card into the directory (folder) ROOT. Within this folder other directories can be created by the user alone. Files saved on the card outside of the directory ROOT are not visible in the Mosaic environment.

Furthermore, the memory card is used by the Webmaker by the help of which web pages for the display of the PLC user program variables can be created. These files are saved in the folder ROOT / WWW.

Library FileLib functions used in the PLC user program enable data transfer between the memory card and the PLC notepad in both directions and other file operation. The library is supplied as a part of the Mosaic environment installation from the version 2.6.0.

Directories structure

The root directory for file operations within the PLC is called ROOT. The PLC programmer can work with those files and directories only that are located in the ROOT

directory. Other files and directories are not accessible from the user program. Consequently, the ROOT directory is for the PLC programmer the current directory.

File names

The file system support file names in the convention DOS 8.3. The file name consists of the file name itself (max. 8 characters) and of the file name extension (max. 3 characters). These two parts are separated by a dot. No punctuation symbols, spaces and symbols *, ? can be used in file names. Characters of national alphabets are not supported in names. Capital and small letters are not distinguished. Substituting characters (e.g. *.*) are not supported.

File path

The file path determines the file location on the disc in relation to the ROOT directory. Consequently, the file path contains names of directories where the file is saved. Same rules apply to the directory names as apply to file names. Individual directory names in the path are separated by the / (slash). The PLC file system supports absolute paths only. Relative paths or even current directory change are not supported.

Maximum file name length including the path is limited to 65 characters.

5.7.1   Memory card handling

The slot for the memory card is accessible through the hole on the basic module left side. In older basic modules that have not this hole yet the slot is accessible after the basic module case removal only and it is located on the middle board.

Memory card insertion

After the memory card is inserted to the slot, its automatic connection will take place immediately after the system power switch-on. It has no meaning to insert a card to the running system because it will not be connected.

Memory card removal

The memory card can be removed from the shut down system only when we are sure that **no entry on the card was in action during the system power switch-off.** If the power failure occurs during the data entry on the card, the currently opened file will not close and the file system is disturbed. After the power switch-on the central unit detects this problem and repairs it without any consequences. However, should we remove the card with such disturbed content from the system and we try to read it on a different device, all data can be lost!

This risk can be safely avoided so, that we switch the central unit to the HALT mode before we switch the PLC off (e.g. from the Mosaic environment). The central unit will cease the use program operation and close all opened files on the memory card. Then it is possible to switch the PLC off and remove safely the memory card.

ATTENTION!   **Modules contain components sensitive to electrostatic charge, therefore, user guides for these circuits must be abided! The manipulation is undertaken on the module and inputs and outputs that are disconnected from the power supply only!**

5.7.2   Web server

The central unit contains a Web server that enables the technology state viewing via the common internet browsers as is for example Internet Explorer, Firefox, etc. Individual pages are created in the XML language.

In Mosaic the Webmaker is used for pages creation that contains graphic editor allowing the insertion of pictures, texts and PLC user program variables.

Files created are saved on the memory card in the folder ROOT / WWW. As a consequence, the memory card must be inserted in the central unit to ensure the functioning of the Web server.

Files for the Web server are part of the PLC project. If we send the user program from Mosaic to the PLC, then after the program is loaded, the check of files for the Web server on the memory card in the PLC is undertaken and if any change in comparison with files saved on the PC is detected, PLC files will be updated. This automatic check can be switched off in the Project manager in the node *SW | File sending to the PLC* where we disable the option *Send newer files to the PLC automatically.*

5.8   INSTRUCTION FILE

Central units of the FOXTROT PLC K series are equipped with the stack of 32 bit width. They contain an instruction file, which is, when following certain conditions are kept, compatible with other TECOMAT PLCs.

The instruction set contains the following items:

- Data load and entry instructions with direct and indirect addressing;
- logic operations of 1, 8, 16 and 32 bits widths;
- Operations of counters, timers, shift registers;
- Arithmetic instructions, conversions and comparison of 8, 16 and 32 bits width with / without sign;
- Limit functions, value shift;
- Organizational instructions and transfers in programs;
- Conditional jumps according to comparison flags;
- Table instructions above tables in the user memory which allow an optimal realization of complicated combinational and sequential functional blocks, decoders, time and sequential controllers, sequential generators, and they also facilitate the realization of diagnostic functions, recognition of error states, sequential record of events, process protocols, diagnostic reports of type „black box";
- Table instructions above the variable space allow the index variables operation, the realization of delay lines, long shift registers; conversions into the code "1 of n", variable selection, step sequencers, event records and various stack structures;
- Table instructions with structured access;
- Sequential controller instructions;
- The system contains 8 user stacks and instructions for their switching - useful for passing of more parameters between functions that do not follow immediately one after each other, immediate state of the stack saving, etc.;
- A useful tool is the set of system variables where the system time, system time units and their edges, communication variables, flag and command variables and system messages are realized;

♦ For reduction of the response time and to facilitate the programming, so called multiprogramming (multi-loop control), including interruption processes is used;
♦ Arithmetic instructions with floating point with single precision as well as double precision;
♦ PID controller instructions;
♦ Operator panel operation instructions.

The full description of the instruction file is stated in the manual *Instruction set for TECOMAT PLC - 32 bit model,* order number TXV 004 01.02.

The system can also be programmed in ST, IL, LD and FBD languages in accordance with the international standard IEC 61131. The language description can be found in the manual *Programming of TECOMAT systems in accordance to IEC 61131-3,* order number TXV 003 21.02.

6. DIAGNOSTICS AND TROUBLESHOOTING

The diagnostic system of the FOXTROT PLC is a part of standard software and hardware of the PLC and its main task is to ensure a trouble-free and precisely defined function of the PLC in any situation. In case of PLC failure, the diagnostic system must primarily avoid the possibility of emergency states in the technology being connected to the PLC. Further task of the diagnostic system is to facilitate the clearing of faults arisen to maintenance workers or users. The diagnostic system is active from switching of the PLC power supply on and works independently from the user.

Generally, it is possible to say that the diagnostic system continuously monitors all essential parts and functions of the PLC and at the moment of an error it ensures that the error state is treated and provides information on the fault. Thus, the control safety is ensured and quick corrective actions can be taken if a PLC fault occurs. Another function of the diagnostic system is to inform the user on possible mishandling or wrong procedures undertaken while operating the PLC, so that working with PLC becomes easier and more efficient.

6.1 CONDITIONS FOR THE CORRECT OPERATION OF THE PLC DIAGNOSTICS

Correct functioning of the supply modules of the FOXTROT system is the essential condition for error-free PLC operation and for correct functioning of its diagnostics.

After switching the power supply on, the central unit performs the basic check of the hardware (see table 5.2). If a hardware error is reported, we would recommend a specialized repair to be performed.

6.2 ERROR INDICATION

The central unit has an error stack containing 8 last errors reported by the diagnostics of the entire PLC. The errors in the main error stack have the length of 4 bytes.

Error indication

The content of the error stack can be read using the MOSAIC development environment. The last critical error that stopped the PLC run is displayed on the seven-segment display of central units CP-1004, CP-1005 in the following form:

<p align="center">

E–80–09–0000

</p>

E–   - followed by an error code in hexadecimal form (digits 0 to F)
80-09-0000 - error code

On the display of central units CP-1014, CP-1015 the errors are displayed as follows:

```
Err             80 - 09 - 0000

Program  is  compiled
for  another  series
```

Concerning errors beginning with the number 9, the central units display the error code extended by two digits.

E–95–00–014212

```
Err              9 5 - 0 0 - 0 1 4 2 1 2

M a x i m u m   c y c l e   t i m e
e x c e e d e d
```
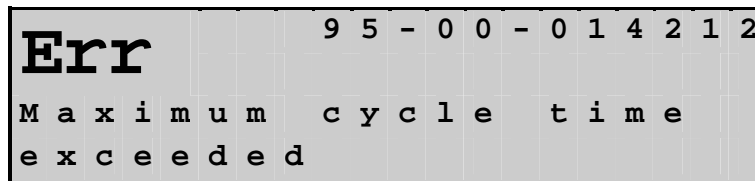
Errors in the error stack relate generally to PLC programming and the status of peripheral modules. States of the central unit indicated during the switching sequence are given in chapter 5.3. The indication of operating modes can be found in chapter 5.4.

Error division according to severity

Errors that can occur in PLC can be divided according to their severity into two groups:

a) Critical errors making an error-free control impossible
LED diodes ERR and RUN are on, the PLC switches to the HALT mode and block outputs, the last error is displayed.

b) Other errors not affecting significantly the control itself
The ERR LED is not on, the LED diode RUN is flashing, the PLC remains at the RUN mode, the error code is written to registers S48 to S51 and is available for processing by the user program, the interrupt process P43 initiated by this error can also be used.

6.3   FATAL ERRORS

In cases that a fatal error occurs, the diagnostic system first of all blocks outputs, interrupts the user program execution and identifies the fault. Information on the fault can be found either on the display of the central unit (last error only) or it can be reproached from the error stack to the superior system (PC).

The indication of the error can be cancelled by the command from the superior system or by switching the PLC power supply off and on.

6.3.1   User program and central unit hardware errors

Errors are reported by the central unit.
The user program map is the main control structure generated by the compiler.
Numerical codes are in hexadecimal form, as they are displayed.

User program saving errors

80 01 0000	invalid map length of the user program at EEPROM
80 02 0000	invalid protection character (CRC) of the user program map at EEPROM
80 03 0000	invalid protection character (CRC) of the entire program at EEPROM
80 04 0000	no user program at EEPROM

There is a fault at EEPROM memory or the user program is designated for another series of central units or it was not loaded into EEPROM at all. It is necessary to load a new user program into EEPROM, or disconnect the EEPROM memory and load the user program into RAM.

80 05 0000   invalid map length of the user program at RAM
80 06 0000   invalid protection character (CRC) of the user program map at RAM
80 07 0000   invalid protection character (CRC) of the entire program at RAM

There is a memory fault or the user program is designated for another series of central units. It is necessary to load a new user program into RAM.

80 08 0000   editing intervention to the user program while EEPROM connected

If the EPROM memory is connected, its content is loaded into the RAM memory of the central unit after switching the system on. The central unit checks the integrity of the program copy from EEPROM. In case of editing intervention, the error is reported at the moment of switching the PLC into the RUN mode. If the editing intervention is contrived, the EEPROM memory must be disconnected or reprogrammed. If the editing intervention is unintentional, it is sufficient to switch the PLC off and on again, the original program will be downloaded from EEPROM.

80 09 0000   program is compiled for another series of central units

The compiler was set to another series of central units, therefore, it is necessary to select the correct series of the central unit in the compiler menu and compile the user program again. When the compiler was set correctly, then it is designated for a higher version of system software than the version in the central unit of your PLC. This has to be cleared either by using an older compiler version or by replacing the system software in the central unit.

80 0A 0000   attempt to program non-existing EEPROM

The EEPROM backup memory is disconnected.

80 0B 0000   EEPROM programming failed

Data saved at the EEPROM backup memory does not comply with data being entered. An EEPROM fault could be a possible cause of this problem.

Central unit hardware errors

80 0C 0000   RTC error

The real time circuit (RTC) does not run which results in a failure of all PLC time functions. It means more than likely that the backup battery is exhausted and must be replaced or charged. If the backup battery is not exhausted, than the central unit must be repaired by a specialist.

80 44 0001   identification error - the record cannot be read
80 44 0002   identification error - no record
80 44 0003   identification error - invalid record length
80 44 0004   identification error - invalid record data

Reading of the identification record failed. A repair by a specialist is necessary.

80 45 0000	communication with RTC error

Time reading or writing to RTC was unsuccessful.

Programming errors

pc - address of the instruction which the error occurred in (program counter)

80 1B t t t t	invalid T-table configuration (t t t t is for table number)

The check sum of values of the T-table used by this instruction does not agree. The user program must be reloaded.

90 00 pcpcpc	return address stack overflow

The maximum number of subroutines nesting was exceeded. By nesting we understand the calling of another subroutine within the subroutine being already executed.

90 40 pcpcpc	return address stack underflow

A subroutine (CAL, CAD, CAC, CAI) call was not undertaken before a return instruction from the subroutine (RET, RED, REC).

90 80 pcpcpc	non-zero stack of return addresses after process termination

There is a different number of instructions for subroutine call (CAL, CAD, CAC, CAI) in the user program than the number of return instructions from the subroutine (RET, RED, REC).

91 00 pcpcpc	label not declared

A jump or call instruction with a label number was used which is not used anywhere in the user program.

91 40 pcpcpc	label number is greater than the maximum value

The instruction label number for call or jump is greater than the greatest number of the label used in the user program.

91 80 pcpcpc	T-table not declared

The T-table used in this instruction is not entered into the user program, it must be added.

91 C0 pcpcpc	unknown instruction code

The instruction used is not implemented in this central unit

92 00 pcpcpc	the range of the field or string is exceeded

During an indirect addressing in the ST language, the value of the index computed by the user program exceeded the size of the field or the string, into which the index is directed.

92 40 pcpcpc	stack range exceeding during indirect addressing

During the indirect addressing by means of instructions LDIB, LDI, LDIW, LDIL, LDIQ, WRIB, WRI, WRIW, WRIL and WRIQ, the stack range was exceeded.

92 80 pcpcpc   BP instruction nesting error

The BP instruction cannot be used in processes P50 to P57 (call of P5n debugging process in another process P5m).

92 C0 pcpcpc   the process for BP operation is not programmed

The P5n debugging process called by the BP instruction is not programmed. It must be added to the user program.

93 00 pcpcpc   user program fault found during the current check

System internal error.

93 40 pcpcpc   DP cannot be set - stack range exceeded
93 80 pcpcpc   SP cannot be set - system stack range exceeded
93 C0 pcpcpc   FP cannot be set - system stack range exceeded

The reason of this error can be the recursive calling of the same function in the ST language, or incorrect operation with the system stack via instructions PSHB, PSHW, PSHL, PSHQ and POPB, POPW, POPL, POPQ.

94 80 pcpcpc   unsupported functional block

The programmed functional block is not supported by the central unit.

95 00 pcpcpc   maximum cycle time exceeded

The cycle time is longer than the set value.

95 40 pcpcpc   maximum time of the interrupted process exceeded

The interrupt process execution time exceeded 5 ms or the cycle time was exceeded during the interrupt process execution (see error 95 00 pcpcpc).

6.3.2   Communication channel operation errors

The errors are reported by the central unit.
The numerical codes are in hexadecimal form.
The character cc stands for serial channel numbers (01 and 02 - CH1 and CH2, E1 - Ethernet).

83 cc 3701   serial channel initialization table length is invalid

The initialization table is either broken or designated for another type of module or another version of module.
Usually, the reason of this error is that the serial channels does not allow setting of the required mode and sets itself to the **off** mode, thus, it switches off. Special submodules requiring special operation are identified by the central unit automatically and only such modes can then be set on

the serial channel that are permitted for the given module. On the contrary, if this submodule is not identified, then it is not possible to set the mode required by this submodule, too.

83 cc 3702   non-existing auxiliary table

The auxiliary table, the initialization table adverts to, does not exist. The table must be declared, a new compilation must be made and the corrected user program must be loaded into the PLC again. Auxiliary tables are used in the for example **PFB** mode.

83 cc 3801   invalid speed in the initialization table of the serial channel

This communication speed cannot be used in the given mode of the serial channel.

83 cc 3802   station address collision

There is a subordinated station with the same address as the address of the superior station entered in the **MPC** or **PFB** mode. One of these addresses must be changed. In the **MPC** or **PFB** mode, a station with an address outside the permitted range was entered.

83 cc 3803   invalid number of network participants at **MPC**, **PLC** or **PFB** modes, incorrect number of data blocks in the **UPD** mode

The maximum permitted number of network participants in **MPC**, **PLC** or **PFB** modes was exceeded.
The maximum number of data blocks offered by the submodule was exceeded in the **UPD** mode. In the initialization, the number of the data blocks must be harmonized with the type of the submodule. Also an incorrect or illegible configuration record in the submodule can be a cause of this problem.

83 cc 3804   number of network participants in the **MPC**, **PLC** or **PFB** modes exceed the number of lines

Information on the number of participants does not correspond with following data in the initialization table. This error is generated by the number of network participants 1 or 0, too. Check the correctness of the content of the initialization table or use the configuration using the Mosaic development environment.

83 cc 3810   non-permissible number of the local port

The number of the local port was set within the range 61680 – 61699 via the Ethernet interface in the **UNI** mode. These values are reserved for system use of in-built protocols. It is necessary to use a number outside this range.

83 cc 3811   unknown Ethernet interface protocol

An unknown protocol (UDP, TCP, etc.) was set via the Ethernet interface in the **UNI** mode. It is necessary to set the correct protocol or to update the software version of the relevant communication module.

83 cc 3815   false connection

The false connection index was set via the Ethernet interface in the **UNI** mode. It is necessary to check the maximum possible number of connections within the relevant communication module. This error occurs even in case when the number of connections was increased in the newer firmware version only, than in the one loaded in this communication module. The module firmware must be re-loaded.

83 cc 4204   communication channel is not in the required mode

The serial channel is set to another mode than the initialization is designated for. The reason of this error is usually caused by the fact that the serial channel does not allow the setting of the required mode and sets itself to the **off** mode, thus, it switches off.
Special submodules requiring special operation are identified by the central unit automatically and only such modes can then be set on the serial channel that are permitted to the module given. On the contrary, if this submodule is not identified, then it is not possible to set the mode required by this submodule, too.

83 cc 4206   maximum volume of transmitted data within one network or one participant exceeded

The specified volume of transmitted data in the network in **MPC** or **PLC** modes exceeded the maximum value. One network allows data transfer of a total volume of approx. 32 KB. A second reason of this fault can be that the specified volume of transmitted data with one participant exceeded the maximum value.
For other modes the specified volume of data transmitted exceeded the maximum size which the communication submodule is able to transmit in some of data areas.

83 cc 4207   serial channel cannot be assigned – permanently occupied by another module

The number we want to assign to the serial channel, is already occupied

83 cc 4208   non-permissible mode of the communication channel

The required mode cannot be set on this communication channel. The reasons can be as follows:
- the selected communication channel does not support the required mode;
- the selected communication channel is fitted with a submodule that does not support the required mode;
- the selected communication channel is not fitted with a submodule supporting the required mode.
     Please check the correctness of the submodule fitted in the channel or select another mode or use another communication channel.

Ar pp 3402   incorrect notepad address

Exceeded notepad range in the declaration of peripheral modules controlled by the expander.

Ar pp 3411   an empty list of variables

The list of variables transferred between CPU and peripheral module is not created. It is necessary to check up the correctness of the corresponding peripheral module configuration setting, eventually to check the memory card functionality.

Ar pp 3412   file with variables cannot be open

The file with variables cannot be open. It is necessary to check up the correctness of the corresponding peripheral module configuration setting, eventually to check the memory card functionality.

Ar pp 3413   error in variable list

The list of variables is made wrong. It is necessary to check up the correctness of the corresponding peripheral module configuration setting.

Ar pp 3414   graphical display working zone is overcrowded

The list of variables for graphical display is too big. It is necessary to lower a number of variables.

Ar pp 3415   number of screen got over declared maximum

The list of variables is made wrong. It is necessary to check up the correctness of the corresponding peripheral module configuration setting.

Ar pp 3421   error at graphical display project opening
Ar pp 3422   graphical display project is not accessible
Ar pp 3423   error at graphical display project header reading
Ar pp 3424   error at graphical display project reading
Ar pp 3425   file stated in graphical display project does not exist
Ar pp 3426   information about file stated in graphical display project can not be found
Ar pp 3427   the length of file does not correspond to data in graphical display project
Ar pp 3428   time of file modification does not correspond to data in graphical display project
Ar pp 3429   names in the graphical display project file are too long
Ar pp 3430   error in the graphical display project file
Ar pp 3431   small space in the stack for graphical display communication driver
Ar pp 3432   small space in the stack for synchronization of file with display
Ar pp 3433   graphical display project is empty (it does not contain any file)
Ar pp 3434   invalid folder of graphical display project

It is necessary to check up the correctness of the corresponding graphical display configuration setting, eventually to check the memory card functionality.

Ar pp 3700   invalid length of received initialization table in the module
Ar pp 3701   invalid length of declared initialization table in the module

The initialization table is either broken or designated for another type of module or another version of module. It is necessary to verify the correctness of configuration setup of the particular serial channel, undertake a new compilation and load the repaired user program into the PLC again.

Ar pp 3803   incorrect number of participants of the CIB network

The maximum allowed number of participants of the CIB network was exceeded.

Ar pp 3805   incorrect number of communication channel

Attempt to initialize the communication channel which is not available within this module. Check the correctness of communication channel configuration.

Ar pp 3806   invalid mode of communication channel

Attempt to initialize the communication channel which is not available within this module. Check the correctness of communication channel configuration.

Ar pp 3807   invalid combination of activated variables

The peripheral module reports an illegal combination of required data. For example, some data cannot be transmitted at the same time or the volume of data transmitted is limited or, on the other hand, it might be necessary to transmit a whole file of required data. It is necessary to verify the correctness of configuration setup of the particular peripheral module, undertake a new compilation and load the repaired user program into the PLC again.

Ar pp 3808   invalid length of activated variable

The peripheral module reports an invalid length of a variable. The vast majority of variables has a fixed size given by the type of variable. If the variable represents a field with a variable length, then either too short or too long length of variable was entered in the configuration. It is necessary to verify the correctness of configuration setup of the particular peripheral module, undertake a new compilation and load the repaired user program into the PLC again.

Ar pp 3809   unsupported type of analog channel

The required type of the analog channel is not supported by the peripheral module. It is necessary to verify the correctness of configuration setup of the particular peripheral module, undertake a new compilation and load the repaired user program into the PLC again. This error also occurs in a situation when the required function is added to a newer firmware version than the one loaded in this peripheral module.

Ar pp 3813   unsupported data conversion type

The requested data conversion type is not supported by the central unit. The data conversion, during which the error occurred, is undertaken during the information exchange with the peripheral module address of which is a part of the error code. This error occurs when the requested data conversion type was included only in the new firmware version that was not uploaded into the central unit. It is necessary to update the central unit firmware.

Ar pp 3814   invalid counter mode

The required counter mode is not supported by the peripheral module. It is necessary to verify the correctness of configuration setup of the particular peripheral module, undertake a new compilation and load the repaired user program into the PLC again. This error also occurs in a situation when the required function is added to a newer firmware version than the one loaded in this peripheral module. It is necessary to upload the module firmware.

Ar pp 4301   non-existing module

In the hardware configuration such module operation is set that does not exist in a real unit. Set the configuration in compliance with the reality either manually or by loading the data from the PLC.

Ar pp 4302   non-corresponding module type – initialization intended for another type

In the hardware configuration such module operation is set that does not exist in a real unit. Set the configuration in compliance with the reality either manually or by loading the data from the PLC.

Ar pp 4303   invalid address, higher than the maximum possible

In the hardware configuration the module operation is set outside the possible addressable range. Set the configuration in compliance with the reality either manually or by loading the data from the PLC.

Ar pp 4304   module with an unknown operation

In the hardware configuration is set an operation of the module which the central unit is not able to communicate with. Set the configuration in compliance with the reality either manually or by loading the data from the PLC.

Ar pp 4401   module identification reading error - the record cannot be read
Ar pp 4402   module identification reading error - no record
Ar pp 4403   module identification reading error - invalid record length
Ar pp 4404   module identification reading error - invalid record data

Reading of the identification record of the peripheral module failed. The repair by a specialist is necessary to be done.

Ar pp 4502   hw module configuration error - no data for configuration
Ar pp 4503   hw module configuration error - invalid data about configuration
Ar pp 4504   hw module configuration error - invalid configuration data

Configuration of the peripheral module hardware failed. The repair by a specialist is necessary to be done.

Ar pp 50ss   the module did not reply to communication service ss

The peripheral module did not respond to the communication service within the specified period of time. The reason is a high level of interference, missing or non-functional bus termination or a PLC fault.

Ar pp 5103   initialization not finished

Running initialization of the peripheral module was not finished.

Ar pp 52ss   the bus did not react to the communication service ss
Ar pp 53ss   bus is not free after communication service ss
Ar pp 54ss   module responded to the communication service ss using invalid data

The peripheral module did not respond to the communication service within the specified period of time. The reason is a high level of interference, missing or non-functional bus termination or a PLC fault.

Ar pp 5501   data exchange unknown mode

The peripheral module requires an operation mode that is not supported by the central unit. It is necessary to update the central unit firmware.

Ar pp 6000   communication with the central unit interrupted

Peripheral modules are equipped with a check timer monitoring that monitors the bus in the RUN mode. The central unit sets the timer to a period of time a little longer than the maximum permitted PLC cycle time is. If there is no communication with any of the network participants detected on the serial line during this period of time, communication is claimed interrupted and the peripheral module switches to the HALT mode independently.

The reason is a high level of interference, missing or non-functional bus termination or a PLC fault.

Ar pp 6001   peripheral module receives no data

Peripheral modules are equipped with a check timer monitoring the frequency of data exchange with the central unit in the RUN mode. If there is no data exchange between the peripheral module and the central unit within the cycle period, the communication is claimed interrupted and the peripheral module switches to the HALT mode independently.
The reason is a high level of interference, missing or non-functional bus termination or a PLC fault.

Ar pp 6201   data cannot be transmitted in the HALT mode

The peripheral module, which is in the HALT mode, cannot perform data exchange with the central unit. The reason, why the module did not switch to the RUN mode as commanded by the central unit, is that the initialization of peripheral modules failed, or a high level of interference occurred or there is missing or non-functional bus termination or a PLC fault occurred. The failed initialization is usually reported by more specified error message.

Ar pp 6202   non-available bus service
Ar pp 6203   non-available bus service - hw module failure
Ar pp 6204   unknown bus service

Data exchange via system bus errors. The reason is a high level of disturbance, missing or non-functional termination of the bus or a PLC fault. Another reason can be an older version of the software of the central unit or of the corresponding module.

Ar pp 6401   Incorrect software of peripheral module

The peripheral module does not support the required function. The firmware version of this module must be changed.

Ar pp 7005   low power voltage of peripheral module

The power voltage of the peripheral module dropped beneath an acceptable limit thus limiting the correct functioning of the module.

Ar pp kkkk   Other errors reported by the peripheral module are described in the documentation for such module.

6.3.4   System errors

FF kk kkkk   central unit system error (kk - any number specifying the error type)

Central unit malfunction, please contact the manufacturer.

6.4   OTHER ERRORS

If another error occurs that does not influence the control itself significantly, the diagnostic system only identifies the error and process control is still in progress. Information on the error is disclosed in the register S34 (the first byte) that can then be used for user-handling of these errors, and in registers S48 - S51 (full code). The error can also be found by reading of the error stack by the superior system (PC).

6.4.1   System errors

According to requirements, these errors can be treated via the user program using registers S48 to S51, where the last error is saved.

pc   - instruction address where the error occurred (program counter)
cc   - communication channel (F2 - system bus)

02 cc 1200   address error
02 cc 15hh   error of service byte hh
02 cc 16ss   invalid parameters of communication service ss
02 cc 1809   protection error

Data exchange via the system bus errors. The reason is a high level of interference, missing or non-functional bus termination or a PLC fault. These errors do not cause an immediate PLC suspension, however, their occurrence means a problem that could result in a critical bus error which then causes the PLC suspension.

07 00 0000   remnant zone check error

The backed up part of the notepad, the so called "remnant zone", has an incorrect check sum. The zone will be deleted and a cold restart will be performed. The cause of this problem is RAM user memory backup fault on the central unit, most likely on the backup battery.

08 00 0000   exceeding of the first limit of cycle time monitoring

The cycle period was longer than the preset value for warning.

20 00 pcpc   user program fault during continuous check found

System internal error.

6.4.2   User program errors

According to requirements, these errors can be treated within the user program either by eliminating the cause using the input parameters check before the execution of the particular instruction or by treating the consequence using registers S48 to S51 where the last error is saved.

10 00 0000   division by zero

> In the instruction the divider was 0.

13 00 0000   table instruction above the notepad exceeded its range

> The table defined by the table instruction above the notepad exceeded its range, the instruction will not be executed.

14 00 0000   source data block defined out of range

> The data source block for the transfer instruction was defined out of range of the notepad, data or table. The instruction will not be executed.

15 00 0000   data destination block defined out of range

> The target source block for the transfer instruction was defined out of range of the notepad or table. The instruction will not be executed.

6.4.3   Errors during the on-line change

These errors are reported during the on-line change of the user program. If some of these errors occur, the new user program is denied by the central unit and the technology is hereafter controlled without an interruption according to the original program.

The r character represents the occurrence zone (0 – basic module, 1-peripheral module, 3 – external CIB master bus), the pp character represents the module address (0 to 9).

The cc character represents the communication channel (01 to 10 - CH1 to CH10, D1 - USB, E1 and E2 - Ethernet 1 and Ethernet 2).

70 05 0000   invalid map length of the new user program
70 06 0000   invalid protection character (CRC) of the map of the new user program map at RAM
70 07 0000   invalid protection character (CRC) of the entire new user program at RAM

> An error occurred during the new user program entry to the central unit. It is necessary to repeat the process.

70 09 0000   program is compiled for another series of central units

> The compiler was set for a different series of central units, it is necessary to select the correct series of the central unit in the compiler menu and compile the user program again. If the compiler was set correctly, this compiler is designated for a higher version of system software than the version in the central unit of your PLC is. This must be cleared either by using an older compiler version or by replacing the system software in the central unit.

70 0B 0000   EEPROM programming failed

An error of the new user program entry to EEPROM of the central unit occurred.

70 24 0000   list of on-line changes missing
70 25 0000   list of on-line changes has invalid CRC

An error of the new user program entry to EEPROM of the central unit occurred. It is necessary to repeat the process.

70 31 r r pp   initialization table missing

The initialization table necessary for the operation of all peripheral modules is missing in the user program. It is necessary to verify the correctness of configuration setup of the particular serial channel, undertake a new compilation and load the corrected user program into the PLC again.

70 34 r r pp   maximum variable size exceeded

The maximum size of the variable of the field type was exceeded in terms of the data exchange with the peripheral module. It is necessary to verify the correctness of configuration setup of the particular serial channel, undertake a new compilation and load the corrected user program into the PLC again.

70 43 r r pp   invalid address, higher than the maximum possible

The module operation is set outside the possible addressable area in the hardware configuration. Set the configuration in compliance with the reality either manually or by loading data from the PLC.

70 51 r r pp   unfinished initialization

Initialization of the peripheral module in progress was not finished.

70 64 r r pp   invalid software of peripheral module

The peripheral module does not support required function. The firmware version of this module must be changed.

70 A1 r r pp   non-existing module

In the hw configuration the module operation, that does not exists in the real set, is set. Set the configuration in compliance with the reality either manually or by loading data from the PLC.

70 A2 r r pp   module type in disagreement – initialization is intended for another type

In the hw configuration an operation of a different module is set, than in the real set is fitted on this position. Set the configuration in compliance with the reality either manually or by loading data from the PLC.

70 A3 r r pp   module does not support this type of on-line change

The module does not enable to change required parameters in running. This situation can be, generally, superseded by the module firmware update. (chapter7.1.2.).

70 C5 r r pp   communication channel number error

Attempt of initialization of the communication channel that is not accessible in this module. Check the correctness of communication channels configuration.

70 C6 r r pp   communication channel mode error

Attempt of initialization of the communication channel that is not accessible in this module. Check the correctness of communication channels configuration.

73 cc 3701   invalid length of initialization table of communication channel

The initialization table is either damaged or is designed for another channel mode or another type or version of module. Please check the correctness of the configuration setting of the corresponding communication channel, undertake a new compilation and load the corrected user program to the PLC again.

73 cc 3702   non-existing auxiliary table

The auxiliary table that the initialization table refers to, does not exist. The table must be declared, a new compilation must be made and the corrected user program must be loaded to the PLC again. Auxiliary tables are used, for example, in the **PFB** mode.

73 cc 3801   invalid speed in the initialization table of serial channel

This communication speed cannot be used in the given mode of the serial channel.

73 cc 3802   station address collision

At the **MPC** or **PFB** mode, there is a subordinated station entered with the same address as the address of the superior station is. One of these addresses must be changed. In the **CAN** or **PFB** mode, a station with an address outside the permitted range was entered.

73 cc 3803   invalid number of network participants in the mode **MPC**, **PLC** or **PFB**, invalid number of data blocks in the **UPD** mode

The maximum number of network participants permitted in modes **MPC**, **PLC** or **PFB** was exceeded.
The maximum number of data blocks offered by the submodule was exceeded in the **UPD** mode. In the initialization, the number of the data blocks must correspond to the type of submodule. Also an invalid or illegible configuration record in the submodule can be a cause of this problem.

73 cc 3804   the number of network participants in the mode **MPC**, **PLC** or **PFB** exceeds the number of lines

Information on the number of participants does not correspond with data following in the initialization table. This error is generated also by the number of network participants 1 or 0. Check the correctness of the content of the initialization table or use the configuration using the Mosaic development environment.

73 cc 3810   non-permissible number of the local port

In the **UNI** mode via the Ethernet interface, there was set the number of the local port in the range 61680 - 61699. These values are reserved for the system use by in-built protocols. It is necessary to use a number out of this range.

73 cc 3811   unknown protocol of Ethernet interface

In the **UNI** mode via the Ethernet interface, there was the unknown protocol set (UDP, TCP, etc.). It is necessary to set the correct protocol or to update the software version of the correspondent communication channel.

73 cc 3815   error connection

In the **UNI** mode via the Ethernet interface, there was an error index of the connection set. It is necessary to check the maximum possible number of connections within the relevant communication channel. This error occurs also when the number of connections was increased in the newer version of the firmware than the one loaded in this communication module. The module firmware must be re-loaded.

73 cc 4204   serial channel is not in required mode

The serial channel is set to a different mode than the initialization is designated for. The reason is, generally, that the serial channel does not allow the setting of the required mode and sets itself to the **OFF** mode, thus, it switches off. Special submodules requiring special operation are identified by the central unit automatically and only such modes can then be set on the serial channel that are permitted for the relevant module. On the contrary, if this submodule is not identified, then, also, it is not possible to set the mode required by this submodule.

73 cc 4206   maximum volume of data transmitted within network or participant exceeded

The specified volume of data transmitted within the network in modes **MPC** and **PLC** exceeded the maximum value. One network allows transmission of data with a total volume of approx. 32 KB. A second reason of this fault can be that the specified volume of data transmitted with one participant exceeded the maximum value.
For other modes, the specified volume of data transmitted exceeded the maximum size which the communication submodule is able to transmit within some data areas.

73 cc 4207   serial channel cannot be assigned – permanently occupied by another module

The number of the serial channel that we want to assign to the serial channel is already occupied.

73 cc 4208   non-permissible mode of communication channel

The required mode cannot be set on this communication channel. The reasons can be as follows:
- the required communication channel does not support the required mode;
- the selected communication channel is fitted with a submodule that does not support the required mode;
- the required communication channel is not fitted with a submodule supporting the required mode.
Please check the correctness of the submodule fitted in the channel or select another mode or use another communication channel.

6.5   PERIPHERAL SYSTEM STATUS ZONE

Registers S100 to S227 contain the status zone of the peripheral system that informs on the immediate status of each peripheral module. This is important especially in situations when hot-swap of the peripheral module is allowed (the possibility to switch peripheral module power supply off and on under the module running) and the user program requires information whether data read from the module are valid. This zone can also be used for a detailed PLC diagnostics realized by the superior system.

Each module corresponds to one register which index is assigned as follows:

S100 - central unit (part of CP-10xx basic module)
S101 - in-built display (part of CP-101x basic module)
S102 - internal master bus CIB (part of CP-10xx basic module)
S103 - peripheral part of the CP-10xx basic module
S108 - S111 – operator panels with addresses 8 to 11
S116 - S125 – peripheral modules with address 0 to 9
S148 - S163 - external master bus CIB

All registers of the status zone have the following structure:

Sn.7	Sn.6	Sn.5	Sn.4	Sn.3	Sn.2	Sn.1	Sn.0
POS	OTH	DEC	ERR	0	0	DATA	ECOM

Sn.0 (ECOM)   - status of communication with module
                    0 - communication is OK
                    1 - module stopped communicating
Sn.1 (DATA)   - validity of transmitted data
                    0 - data in the notepad are not up-to-date, data exchange is not in progress
                    1 - data in the notepad are up-to-date, data exchange is in progress
Sn.4 (ERR)   - module reports an error
                    0 - module runs without any error
                    1 - module reports a critical error causing data exchange impossible
Sn.5 (DEC)   - module operation is declared
                    0 - module is not operated by the user program

	1 - module is operated by the user program
Sn.6 (OTH)	- invalid type of module
	0 - module required by declaration is fitted in the position
	1 - another type of module than declared is fitted in the position
Sn.7 (POS)	- occupied position
	0 - position is not occupied
	1 - module found on the position

The content of the status register of the selected module is also available in the Mosaic development environment at the top part of the panel *Setting V/V* or after selecting *PLC | HW configuration* in the tag *Additional information*.

Examples of individual states of peripheral modules operation

In the table 6.2, there are the most frequent states of peripheral modules operation and their indication in the status zone.

Table 6.2 Most frequent states of peripheral modules operation

Status register Sn value	Status of peripheral module operation
$00	position is not occupied, operation off
$21	operated module does not communicate, data invalid - hot-swap status
$31	operated module stopped communicating, critical error reported, data invalid - hot-swap status
$80	position is occupied, operation off
$90	error occurred when trying to search for information on module
$A0	module operation running, data temporarily invalid, communication runs trouble-free - a short-term status during fitting the module in the position under run when module initialization is performed.
$A2	module operation running, data valid - normal status
$B0, $B1	module reported a critical error that stopped the user program execution
$E1	another type of module than declared by the user program was found during module initialization after power supply switch on

6.6   COMMUNICATION WITH THE MASTER SYSTEM TROUBLESHOOTING

Connection of the PLC to the superior system, usually a PC, is necessary since each PLC must be programmed. If there are problems in communication between the PLC and PC, proceed according to the following instructions:

PLC check

1. Is a power supply brought onto the PLC?
   No   Make correction.
   Yes   Proceed as specified at point 2.

2. Was the switching sequence of the central unit completed and is the unit in RUN or HALT mode (see chapter 5.3.)?
   No   The central unit reports a hardware error (see table 5.2), communication is not possible.
   Yes   Proceed as specified at point 3.

3. *For serial channels:*
   Are LED diodes of the particular channel flashing during communication on the central unit?
   No LED is flashing
   > a) The submodule of the MR-01xx interface on the particular channel is not fitted (if the interface is optional), or a submodule for another interface is fitted.
   > b) The error is within the PC, cable or adapter of the serial interface (RS-485).
   > If you use the adapter, proceed as specified at point 11.
   > If you do not use the adapter, proceed as specified at point 21.

   Only RxD is flashing
   > Channel parameters of the central unit are set incorrectly (mode, speed, address, CTS detection).

   RxD and TxD with RTS flashing alternatively
   > Communication in the direction PC → PLC is correct. Proceed as specified at point 6.

   Another state
   > Most likely, a submodule for another interface is fitted, or the cable is connected incorrectly.

   For Ethernet
   Are the ETHERNET LED diodes on the central unit or the communication module on during communication?

   No LED is flashing
   > The error is in the cables (including devices of hub or switch type)

   Ethernet LED is on
   > The Ethernet connection is correct. IP address and IP mask settings of the central unit or PC can be incorrect. It is valid, generally, that IP addresses of both participants must be identical in positions where the IP mask has non-zero values. The IP mask should be identical for both participants, for example:

PC		PLC	
IP address:	192.168.1.1	IP address:	192.168.1.2
IP mask:	255.255.255.0	IP mask:	255.255.255.0

   or:

PC		PLC	
IP address:	192.168.12.1	IP address:	192.168.25.8
IP mask:	255.255.0.0	IP mask:	255.255.0.0

   > If the problem is still not solved carry on with point 4.

4. Do you want to program the PLC using the MOSAIC development environment?
   Yes   Proceed as specified at point 5.
   No, this is communication with visualization software, etc.
   > If you use the adapter of the serial interface, proceed as specified at point 11.
   > If you do not use the adapter of the serial interface, proceed as specified at point 21.

5. Is the Mosaic development environment or any other software using PLC system services already connected through any interface?
   No   If you use the serial interface adapter, proceed as specified at point 11.

If you do not use the adapter of the serial interface, proceed as specified at point 21.

Yes   PLC system services cannot be used through more interfaces at the same time. Terminate the communication of all other software using system services, wait 5 seconds and retry to establish the required communication.

Serial interface adapter check

11. Are channel LED diodes flashing on the adapter of the serial interface (RS-232 / RS-485) during communication?

The adapter is not equipped with indication

Consider all possibilities mentioned below.

No LED is flashing

a) Adapter power supply does not work or the adapter is defective.

b) **T**he PC or cable between the PC and adapter is defective.

Proceed as specified at point 21.

Only TxD is flashing, RTS lighting permanently or not at all

The fault is either within the RTS signal between the PC and the adapter, or the PC software does not support the RTS signal control necessary for the RS-485 interface (not necessary for RS-232).

If the PC software does not support the RTS signal, the adapter must be set to the mode of automatic switching of communication directions and a sufficient response time must be set on the central unit.

The Mosaic development environment and some visualizations support the RTS signal.

Only TxD with RTS is flashing

The output part of the adapter or the cable between the adapter and PLC is defective.

TxD with RTS and RxD is flashing alternatively

Communication is correct; the problem is in the cable between the adapter and the PC or within the PC. Proceed as specified at point 21.

Cable check

21. Is the cable in the PC in the right COM, or USB or Ethernet port?

No   Make corrections.

Yes   Proceed as specified at point 22.

22. Are correct cables used?

No   Make corrections.

Yes   If possible, use another cable of the same type.

Proceed as specified at point 31.

PC check

31. Are there other drivers (mouse driver, IR port driver, etc.) installed on the serial port COM that you use?

Yes   There is a collision of drivers even when a device requiring this driver is not connected. Communication through another COM port must be used or the driver must be uninstalled.

No   Some programs running under Windows do not manage to switch quickly enough from transmission to reception. This problem can be easily solved by setting a sufficiently long response time of the PLC central unit or by reducing the communication speed.

7. PLC MAINTENANCE

According to this chapter, the PLC maintenance is undertaken while in operation. The worker undertaking the maintenance must be at least trained and have appropriate electro-technical qualification.

Correct input and output connection check

The tightness of screws and the flawlessness of the conductor insulations are checked. Cable connection is checked as well.

Voltage for supplying inputs and outputs check

A voltmeter is used to check the power supply voltage for input and output units. Correct values and thresholds are stated in the documentations of the used units.

Grounding terminals interconnection check

The resistance between a random part of the metal PLC frame and the main grounding terminal of the case in which the PLC is located in is measured using a precise measuring device for small resistances. The measured resistance must always be smaller than 0,1 Ω.

Cleaning the PLC

If units are full of dust, it is necessary to take them out of the rack and clean them using the air or with a brush. This must be done very carefully to avoid the switching of any of the switches or the unit damage.

After mounting the PLC back on, it is recommended to check the connection of the cables (be careful not to interchange them!).

Recommended measuring devices

1. a voltmeter for altering currents measuring, precision class 1,5 or better
2. a voltmeter for direct currents measuring, precision class 1 or better
3. a meter for small resistances OMEGA III or a similar type

The floating battery replacement

The floating battery, if fitted, is accessible after the removal of the case on the middle board. The back-up function and the battery replacement procedure is described in the chapter 2.1.2. After the replacement is done, it is necessary to forward the unwanted battery to the authorized organization to be disposed of. There can be the battery of the CR2032 type placed in the holder fitted in basic modules with the minimum lifetime of 5 years

7.1 FIRMWARE CHANGE

The TECOMAT FOXTROT system enables the firmware change of all processors without the necessity of removal. Changes are undertaken via the central unit. The upgrading programs needed and individual firmwares are accessible on the Internet - www.tecomat.com.

7.1.1   Central unit firmware change

For the firmware change (company system software) in central units of the TECOMAT FOXTROT system, the program Firmup1c.exe is used (similar program is used also for systems TC650 and TC700). The change can be undertaken via the serial line or the Ethernet.

The Firmup1c.exe program is a consol application that can be run under Windows 2000 and Windows XP operation systems. This program requires for the functioning the SimplePlcCom.dll library which must be located in the same folder as the program Firmup1c.exe is.

The central unit firmware consists of several files whereas some can be changed by the Teco maintenance workers only. In case of the TECOMAT FOXTROT system, the user can change the firmware of the central unit itself that is saved in the file stated in the table 7.1.

Systems have the IP address 192.168.134.176 preset from the producer. This address is set even in a case when the integrity of the record of communication parameters in EEPROM of the central unit was disturbed.

Table 7.1 Names of files with the firmware for central units of the TECOMAT FOXTROT system

module	firmware file	home IP address set in production
CP-1004	teco1004.tfw	192.168.134.176
CP-1005	teco1005.tfw	192.168.134.176
CP-1014	teco1014.tfw	192.168.134.176
CP-1015	teco1015.tfw	192.168.134.176

Central unit IP address setting

If we need to change IP address we can use next procedure suitable mainly for basic modules CP-1004 and CP-1005 that are not equipped with built-in display OI-1073 and do not allow to set IP address directly using buttons on the module.

Switch system off and on again. During power supply switching on hold button MODE pushed until CPU comes to BOOT mode. On the display there are shown boot version and MAC address that is unique number given to the central unit for Ethernet access. Copy this number and use it as parameter according to the following example.

Suppose that MAC address of the central unit is 00-0A-14-02-3F-F1 and we request to set IP address 192.168.1.10.

On the computer connected to Foxtrot system write to command line the following commands:

```
arp -s 192.168.1.10 00-0A-14-02-3F-F1
ping 192.168.1.10
```

These commands set IP address of central unit to 192.168.1.10.

Firmup1c.exe program parameters

The Firmup1c.exe program is run via the command line (e.g. *Start | Run*) and it requires for its functioning the following parameters to be set:

```
FIRMUP1C.EXE P1 P2 P3 P4 [P5] [P6] [P7] [Px] [Py] [Pz]
```

P1	- 1, 2, 3, 4	number of COM port, serial communication
	- E	communication via Ethernet
P2	- 600, 1200, ..., 38400	serial communication speed
	- xxx.xxx.xxx.xxx	IP address PLC, communication via Ethernet

P3   - 0, ..., 99   address for communication
P4 / P5 / P6 / P7 - *.tfw   names of files with firmware
Px   - /V   display current versions of firmwares in the processor
Py   - /P   program, even if the current versions of firmware is
                                     the same or higher
Pz   - /C or /E   language (Czech or English)

The Firmup1c.exe program can also be run from the batch file (*.bat).

If we run the Firmup1c.exe without a parameter /C or /E, the following query will be displayed:

```
!!! Select language / Vyberte jazyk
    English (E) / Cesky (C)  :
```

By pressing the key E or C we select the language which the following dialogues will be displayed in.

Launching of the program Firmup1c.exe examples

Load the new firmware via COM2 at a speed of 38400 kBd to CP-1004 with the address 0, after the communication establishment display actual firmware versions in the processor, program dialogues will be in Czech

```
Firmup1c.exe 2 38400 0 teco1004.tfw /V /C
```

Load the new firmware via Ethernet to CP-1014 with the address 192.168.33.160, after the communication establishment display actual firmware versions in the processor, program dialogues will be in Czech

```
Firmup1c.exe E 192.168.33.160 0 teco1014.tfw /V /C
```


The procedure of a new firmware version upload

1. Switch the PLC power supply on and wait till it switches to the RUN or ERR mode.
2. Connect the communication cable (serial communication cable or Ethernet cable).
3. The current communication parameters setting can be detected by the button stroke on the front panel of the central unit.
4. Terminate all other communications with the central unit before running the Firmup1c.exe program (esp. communication with the Mosaic). If we did not do so, the Firmup1c.exe program will notify that it is not possible to establish contact with the central unit. Communication can be terminated, for example, by disconnection of all other communication cables from the central unit.
5. Run the Firmup1c.exe program on the PC with corresponding parameters or the prepared batch. In the window that will open during the run, there is information on the central unit connected and on the type of connection displayed:

```
Firmware Upgrade Utility for TECOMAT systems
  version 2.7 (c) 2002,...,2007 Teco a.s.


System address              : 192.168.33.160
Communication pc channel    : Ethernet 10M
Identification string       : 100 CP1004K V2.4

Current version FW          : Switch 1004 v1.7
                            : Testy CP-1004 v1.4
                            : Boot CP1004 v1.9
                            : CP-1004 v2.4
```

```
     !!! System SW runs !!! Run BOOT (Y/N) ??? :
```

If we press the key N, the Firmup1c.exe program will be terminated and no changes to the firmware will be done. Hereby, versions of all firmware parts of the central unit can be detected. By pressing the key Y, we initiate the process of the firmware re-loading. Then we must answer the following query:

```
     !!! Program with verification (Y/N) ??? :
```

If we press the key N, the firmware programming will be undertaken without an additional verification of programmed blocks. The time needed for programming will be shorter than in case of pressing the key Y when apart from the positive acknowledgement after the programming of each block, the block will be loaded from the PLC back to the PC and compared with the file programmed.
The programming progress will be displayed as follows:

```
     Identification string              : 100  BOOT C 1.9

     Upgrade of FW processor initiated  : 11:32:39

     File programming in progress       : teco1004.tfw
     File version in Flash              : v2.4
     Programmed file version            : v2.5
     Approx. file size                  :  442.8 [KB]
                                    342.8 [KB] programmed
```

After the programming is finished, the following report will appear:

```
     Upgrade of FW processor finished : 11:34:18

     The new firmware is programmed in the system
     After the termination of the FirmUp1C program, the firmware will
   be run !

         ... Press any key ...
```

By pressing any key, the firmware upgrade will be terminated. The central unit will reset and run again under the new firmware version that is displayed during the switching sequence on the central unit indication.

7.1.2 Other processors firmware change

Changes of firmware of peripheral modules and peripheral parts of the basic unit are executed via the central unit connected through the Ethernet interface using the Flasher program.
All other communications with the central unit must be terminated before the activation of the Flasher program (esp. communication with Mosaic). If we did not do so, the Flasher would notify that it is not possible to establish the connection with the central unit. Communications can be terminated, for example, by disconnection of all other communication cables from the central unit.
After execution of the flasher.exe program, the following window will appear:
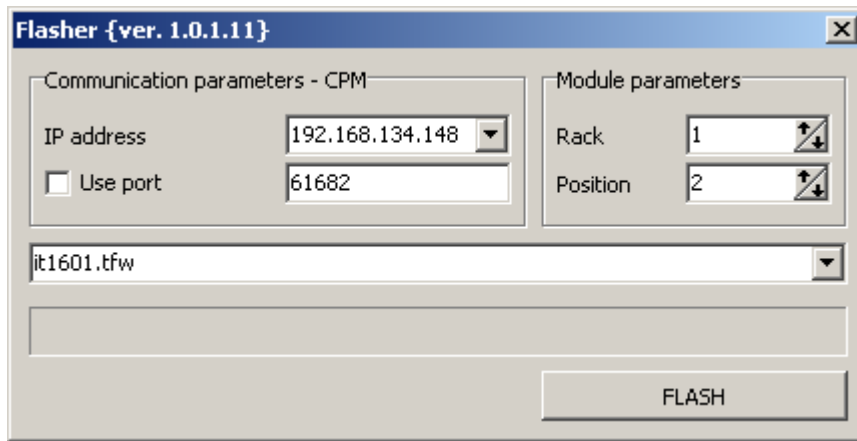
Fig.7.1   Flasher program window

In the *Communication parameters - CPM* section we set the IP address of the PLC. The port number must always be 61682 (do not tick the item *Use port*).

In the *Module parameters* section we set the group number (item *Rack*) and module address (item *Position*). Within TECOMAT FOXTROT systems rules for addressing according to the table7.2 apply.

Table 7.2 Rules for module addressing of TECOMAT FOXTROT system

Module	Module part	firmware file	Rack parameter	Position parameter
CP-1014, CP-1015	OI-1073	oi1073.tfw	0	1
CP-1004, CP-1005, CP-1014, CP-1015	MI2-01	mi2-02m.tfw	0	2
CP-1004, CP-1014	IR-1055	ir1055.tfw	0	3
CP-1005, CP-1015	IR-1056	ir1056.tfw	0	3
CP-1004, CP-1014	IR-1057	lr1057.tfw	0	3
ID-14	-	id14.tfw	0	address (8 to 11)
IB-1301	-	ir1xxx.tfw	1	address
OS-1401	-	ir1xxx.tfw	1	address
IR-1501	-	ir1xxx.tfw	1	address
IT-1601	-	it1601.tfw	1	address
IT-1602	-	it1602.tfw	1	address
MI2-02	line 0	mi2-02m.tfw	3	address
	line 1	mi2-02m.tfw	3	address + 1

Here is to be noticed that parts of the basic module have the *Rack* value always 0 and the *Position* value is fixed according to the component type. Peripheral modules have the *Rack* value always 1 and the *Position* value corresponds to the value set on the rotary address switch.

Panels ID-14 have the *Rack* value always 0 and the *Position* value is given by the panel address setting within the range 8 to 11.

External master modules of the CIB bus contain two processors. The *Rack* value must be 3 and the *Position* value corresponds to the value set on the rotary address switch for the processor operating the line 0. For the processor operating the line 1 the *Position* value higher by 1 is set.

The name of the firmware file is chosen according to the table 7.2. Files *.taw can be located in the folder *firmware* that is located in the same folder as the file flasher.exe, or they can be located in the same folder as flasher.exe.

After parameters are set, we press the button *FLASH*. If the PLC was in the RUN mode, then in switches to the HALT mode and discontinue all communications on the bus which results in, for example, „freezing" of system information on the in-built display of basic modules CP-1014 and CP-1015.

If the required module is found, a window will appear with the description of the current firmware version that we intend to program. We press the button *Yes* and thus initiate the process of firmware programming. The process is displayed by a blue array in the bottom part of the window.

When it is finished, the notice will appear informing on firmware entry which we confirm using the button *OK*. Afterwards, the Flasher is ready for further use. We can change parameters and re-load other firmware versions of other module or close the Flasher.

Discontinued communication on the PLC bus will be restored automatically after approx. ten seconds from the programming termination.

The Flasher program can be also run from the branch according to the following example:

```
flasher.exe /TFW IR1055.tfw /IP 192.168.33.150 /PORT 61682 /RACK 0 /POS 3
/AUTOMAT
```

> /TFW   - file name *.tfw
> /IP   - IP address of the central unit of the PLC
> /PORT - port (always 61682)
> /RACK - group
> /POS   - address
> /AUTOMAT - the program use as a console application

After the batch is run, the Flasher window will appear where already set values are assumed from the batch parameters. Therefore, it is sufficient to press the button *FLASH* only. Further behaviour corresponds to the previous description. After the programming termination we can alter parameters in the window (usually the change of the module address) or we close the program and run it again using another batch.

APPENDIX

Overview of errors saved to the main error stack of the central unit

Used symbols:

cc   - communication channel number
kk   - error code
pc   - address of instruction which an error occurred in(program counter)
pp   - position number in rack
r   - rack number
t t   - number of T table

The numerical codes are in hexadecimal form.

Error code	Error specification
02 cc 1200	address error
02 cc 15hh	hh service byte error
02 cc 16ss	invalid parameters of communication service ss
02 cc 1809	protection error
07 00 0000	remnant zone check error
08 00 0000	exceeding of the first limit of cycle time monitoring
10 00 0000	division by zero
13 00 0000	table instruction above the notepad exceeded its range
14 00 0000	source data block defined out of range
15 00 0000	data destination block defined out of range
20 00 pcpc	user program fault during continuous check found
70 05 0000	invalid map length of the new user program
70 06 0000	invalid protection character (CRC) of the map of the new user program map at RAM
70 07 0000	invalid protection character (CRC) of the entire new program at RAM
70 09 0000	program is compiled for another series if central units
70 0B 0000	EEPROM programming failed
70 24 0000	list of on-line changes missing
70 25 0000	list of on-line changes has incorrect CRC
70 31 r r pp	initialization table missing
70 34 r r pp	maximum variable size exceeded
70 43 r r pp	invalid rack address, higher than the maximum possible
70 51 r r pp	initialization not finished
70 64 r r pp	invalid software of peripheral module
70 A1 r r pp	non-existing module
70 A2 r r pp	module type in disagreement – initialization designated for a different type
70 A3 r r pp	module does not support these on-line changes
70 C5 r r pp	invalid communication channel number
70 C6 r r pp	invalid communication channel mode
73 cc 3701	invalid length of initialization table of serial channel
73 cc 3702	non-existing auxiliary table
73 cc 3801	invalid speed in the initialization table of serial channel
73 cc 3802	station address collision
73 cc 3803	invalid number of participants of network or data blocks
73 cc 3804	the number of participants of network exceeds the number of lines
73 cc 3810	non-permissible number of the local port
73 cc 3811	unknown protocol of the Ethernet interface
73 cc 3815	error connection
73 cc 4204	serial channel is not in required mode
73 cc 4206	maximum quantity of transmitted data within the network or for a participant exceeded
73 cc 4207	serial channel cannot be assigned - permanently occupied by another module
73 cc 4208	non-permissible mode of communication channel

Error code	Error specification
80 01 0000	invalid length of the map of the user program at EEPROM
80 02 0000	invalid protection character (CRC) of the map of the user program at EEPROM
80 03 0000	invalid protection character (CRC) of the entire program at EEPROM
80 04 0000	no user program at EEPROM
80 05 0000	invalid length of the map of the user program at RAM
80 06 0000	invalid protection character (CRC) of the map of the user program at RAM
80 07 0000	invalid protection character (CRC) of the entire program at RAM
80 08 0000	editing intervention into the user program with EEPROM connected
80 09 0000	program is compiled for another series of central units
80 0A 0000	attempt to program the switched off EEPROM
80 0B 0000	EEPROM programming failed
80 0C 0000	RTC failure
80 1B t t t t	incorrect T table configuration
80 44 0001	identification error - record cannot be read
80 44 0002	identification error - no record
80 44 0003	identification error - invalid record length
80 44 0004	identification error - invalid record data
80 45 0000	communication with RTC error
83 cc 3701	serial channel initialization table length is invalid
83 cc 3702	non-existing auxiliary table
83 cc 3801	invalid speed in initialization table of serial channel
83 cc 3802	station address collision
83 cc 3803	invalid number of network participants
83 cc 3804	number of network participants exceeds the number of lines
83 cc 3810	non-permissible number of local port
83 cc 3811	unknown Ethernet interface protocol
83 cc 3815	serial channel is not in required mode
83 cc 4204	maximum volume of transmitted data within network or for participant exceeded
83 cc 4206	serial channel cannot be assigned - permanently occupied by another module
83 cc 4207	non-permissible mode of communication channel
83 cc 4208	serial channel initialization table length is invalid
90 00 pcpcpc	return address stack overflow
90 40 pcpcpc	return address stack underflow
90 80 pcpcpc	non-zero stack of return addresses after process termination
91 00 pcpcpc	label not declared
91 40 pcpcpc	label number is higher than the maximum value
91 80 pcpcpc	T table is not declared
91 C0 pcpcpc	unknown instruction code
92 00 pcpcpc	the range of the field or string is exceeded
92 40 pcpcpc	stack range exceeding with indirect addressing
92 80 pcpcpc	error of nesting of instructions BP
92 C0 pcpcpc	process for BP operation is not programmed
93 00 pcpcpc	user program fault during continuous check found
93 40 pcpcpc	DP cannot be set - stack range exceeded
93 80 pcpcpc	SP cannot be set - system stack range exceeded
93 C0 pcpcpc	FP cannot be set - system stack range exceeded
94 80 pcpcpc	unsupported function block
95 00 pcpcpc	maximum cycle time exceeded
95 40 pcpcpc	maximum time of interrupt process exceeded
Ar pp 1200	address error
Ar pp 15hh	error of service byte hh
Ar pp 16ss	invalid parameters of communication service ss
Ar pp 1705	acceptance area overflow
Ar pp 1809	protection error
Ar pp 3100	initialization failed
Ar pp 3101	initialization table missing
Ar pp 3401	maximum size of the variable is exceeded
Ar pp 3402	invalid address in working memory
Ar pp 3411	empty list of variables
Ar pp 3412	file with variables cannot be open
Ar pp 3413	error in the list of variables

Error code	Error specification
Ar pp 3414	graphical display working zone is overcrowded
Ar pp 3415	number of screen got over declared maximum
Ar pp 3421	error at graphical display project opening
Ar pp 3422	graphical display project is not accessible
Ar pp 3423	error at graphical display project header reading
Ar pp 3424	error at graphical display project reading
Ar pp 3425	file stated in graphical display project does not exist
Ar pp 3426	information about file stated in graphical display project can not be found
Ar pp 3427	the length of file does not correspond to data in graphical display project
Ar pp 3428	time of file modification does not correspond to data in graphical display project
Ar pp 3429	names in the graphical display project file are too long
Ar pp 3430	error in the graphical display project file
Ar pp 3431	small space in the stack for graphical display communication driver
Ar pp 3432	small space in the stack for synchronization of file with display
Ar pp 3433	graphical display project is empty (it does not contain any file)
Ar pp 3434	invalid folder of graphical display project
Ar pp 3700	invalid length of received initialization table in the module
Ar pp 3701	serial channel initialization table length is invalid
Ar pp 3803	incorrect number of communication channel
Ar pp 3805	invalid mode of communication channel
Ar pp 3806	invalid combination of activated variables
Ar pp 3807	invalid length of activated variable
Ar pp 3808	non-supported type of analog channel
Ar pp 3809	unsupported data conversion type
Ar pp 3813	incorrect number of communication channel
Ar pp 3814	error counter mode
Ar pp 4301	non-existing module
Ar pp 4302	non-conforming module type - initialization for another type
Ar pp 4303	invalid rack address, higher than the maximum possible
Ar pp 4304	module with unknown operation
Ar pp 4401	module identification read error - the record cannot be read
Ar pp 4402	module identification read error - no record
Ar pp 4403	module identification read error - invalid record length
Ar pp 4404	module identification read error - invalid record data
Ar pp 4502	hw module configuration error - no data for configuration
Ar pp 4503	hw module configuration error - invalid configuration data
Ar pp 4504	hw module configuration error - invalid configuration data
Ar pp 50ss	module did not respond to communication service ss
Ar pp 5103	initialization is not finished
Ar pp 52ss	the bus did not return any reaction to communication service ss
Ar pp 53ss	the bus is not free after communication service ss
Ar pp 54ss	module responded with invalid data to communication service ss
Ar pp 5501	data exchange unknown mode
Ar pp 6000	communication interrupt with central unit
Ar pp 6001	peripheral module receives no data
Ar pp 6201	data cannot be transmitted at the HALT mode
Ar pp 6202	non-available bus service
Ar pp 6203	non-available bus service - hw module failure
Ar pp 6204	unknown bus service
Ar pp 6401	invalid software of peripheral module
Ar pp 7005	Peripheral module power supply low
Ar pp kkkk	other errors reported by the peripheral module are described in the documentation for this module
FF kk kkkk	central unit system error (kk - any number specifying error type)