NUMSafe CTMS2912
Digital outputs terminals

Operating manual

M00061EN-00

Edition 08.2021

www.num.com

num
CNC HighEnd Applications

Summary

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1 Foreword

1.1 Notes on the documentation

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

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

1.1.1 Disclaimer

The documentation has been prepared with care. The products described are subject to cyclical revision. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

1.1.2 Trademarks

EtherCAT, Safety over EtherCAT® are registered trademarks of and licensed by Beckhoff Automation GmbH.

Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

1.1.3 Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

1.1.4 Copyright

1.1.5 Delivery conditions

In addition, the general delivery conditions of the company NUM apply.

1.1.6 Product features

Only the product features specified in the current user documentation are valid. Further information given on the product pages of the NUM homepage, in emails or in other publications is not authoritative.

1.2 Safety instructions

1.2.1 Delivery state

All the components are supplied in particular hardware and software configurations appropriate for the application.

Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of NUM.

1.2.2 Operator’s obligation to exercise diligence

The operator must ensure that:

- the NUMSafe products are only used as intended (see chapter Product description).
- the NUMSafe products are only operated in sound condition and in working order.
- the NUMSafe products are operated only by suitably qualified and authorized personnel.
- the personnel is instructed regularly about relevant occupational safety and environmental protection aspects, and is familiar with the operating manual and in particular the safety notes contained herein.
- the instruction manual is in good condition and complete, and always available for reference at the location where the NUMSafe products are used.
- none of the safety and warning notes attached to the NUMSafe products are removed, and all notes remain legible.

1.2.3 Description of safety symbols

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

Symbol	Meaning of the symbol
	**Serious risk of injury!** **Failure** to follow the safety instructions associated with this symbol directly endangers the life and health of persons.
	**Caution – Risk of injury!** **Failure** to follow the safety instructions associated with this symbol endangers the life and health of persons.
	**Personal injuries!** **Failure** to follow the safety instructions associated with this symbol can lead to injuries to persons.
 **Warning**	**Damage to the environment or devices** **Failure** to follow the instructions associated with this symbol can lead to damage to the environment or equipment.
 **Note**	**Tip or pointer** This symbol indicates information that contributes to better understanding.

1.3 Document revisions

Code	Edition	Evolution Index	Meaning of the major documentation evolution points	See chapter
M00061	08.2021	00	First version of the manual.	-

1.4 Version history of the NUMSafe product

This version history lists the software and hardware version numbers. A description of the changes compared to the previous version is also given.

Note

Updated hardware and software

NUMSafe products are subject to a cyclical revision. We reserve the right to revise and change the NUMSafe products at any time and without prior notice.

No claims for changes to products already delivered can be asserted from these hardware and/or software changes.

Date	Software version	Hardware version	Modifications
08.2021	01 (V01.04)	00	First release of the CTMS2912

1.5 NUM Agencies

The list of NUM agencies is given on http://www.num.com

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2 System description

2.1 NUM EtherCAT terminals

The NUM EtherCAT Terminal system is used for decentralized connection of sensors and actuators to a controller.

The components of the NUM EtherCAT Terminal system are mainly used in industrial automation and building management systems. As a minimum, a bus station consists of an EtherCAT Coupler and connected EtherCAT Terminals.

The EtherCAT Coupler forms the communication interface to the higher-level controller, while the EtherCAT Terminals form the interface to the sensors and actuators.

The whole bus station is clipped onto a 35 mm DIN mounting rail (EN 60715). The mechanical link of the bus station is established with a slot and key system on EtherCAT Couplers and EtherCAT Terminals.
The sensors and actuators are connected with the terminals via the screwless (spring-loaded) connection system.

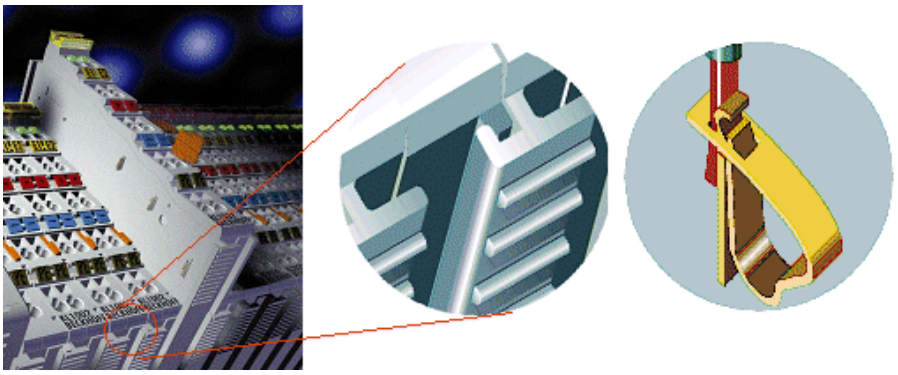

Fig.1 Slot and key system and screwless (spring-loaded) connection system

2.1.1 NUM EtherCAT Gateway

Mechanical data

Mechanical data	NUM EtherCAT Gateway
Material	Polycarbonate, polyamide (PA6.6).
Dimensions (W x H x D)	44mm x 100mm x 68mm
Mounting	On 35mm mounting rail (EN60715) with lock
Attachable by	Double slot and key connection

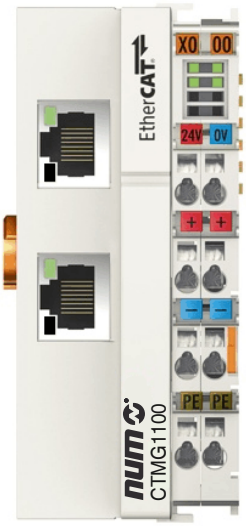

Fig.2 NUM EtherCAT Gateway

Connection technology

Connection technology	NUM EtherCAT Gateway
Wiring	Spring-loaded system
Connection cross-section	0.08 mm²... 2.5 mm², stranded wire, solid wire
Fieldbus connection	EtherCAT
Power contacts	3 spring contacts
Current load	10A
Rated voltage	$24V_{DC}$

2.1.2 NUMSafe Terminals

Mechanical data

Mechanical data	NUMSafe Terminals
Material	Polycarbonate, polyamide (PA6.6).
Dimensions (W x H x D)	12mm x 100mm x 68mm or 24mm x 100mm x 68mm
Mounting	On 35mm mounting rail (EN60715) with lock
Attachable by	Double slot and key connection

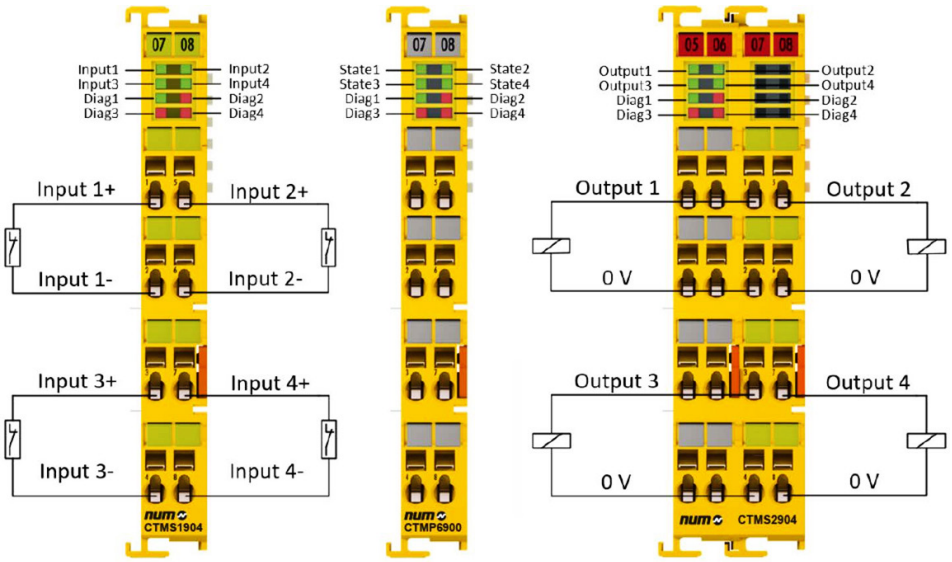

Fig.3 Overview of EtherCAT Terminals

Connection technology

Connection technology	NUMSafe Terminals
Wiring	spring-loaded system
Connection cross-section	0.08mm²... 2.5mm², stranded wire, solid wire
Fieldbus connection	E-bus
Power contacts	Up to 3 blade/spring contacts
Current load	10A
Rated voltage	Depends on NUMSafe Terminal type

2.1.3 E-bus

The E-bus is the data path within a terminal strip. The E-bus is led through from the NUM EtherCAT Gateway through all the terminals via six contacts on the terminals' side walls.

2.1.4 Power contacts

The operating voltage is passed on to following terminals via three power contacts. Terminal strip can be split into galvanically isolated groups by means of potential feed terminals as required.

The power feed terminals play no part in the control of the terminals, and can be inserted at any locations within the terminal strip.

2.2 NUMSafe

2.2.1 The I/O construction kit is extended safely

The integrated NUMSafe safety solution is the logical continuation of the open, PC-based NUM control philosophy. Due to their modularity and versatility, the NUMSafe components fit seamlessly into the NUM control system. The I/O components are available in the formats NUMSafe Terminals, EtherCAT Terminal, EtherCAT plug-in module and EtherCAT Box.

Thanks to the fieldbus-neutral safety protocol (NUMSafe/Safety-over-EtherCAT), NUMSafe devices can be integrated into any fieldbus system. They are integrated into existing networks with EtherCAT and can be used directly in the machine as IP 67 modules. These safety I/Os form the interfaces to the safetyrelevant sensors and actuators.

The possibility to transmit the safety-relevant signals over a standard bus system gives rise to substantial advantages in terms of planning, installation, operation, maintenance, diagnostics and costs.
The safety application is configured or programmed respectively in the Flexium Tools.
This application is then transferred via the bus to a NUMSafe logic component. These form the heart of the NUMSafe system.

All safety devices in the system communicate with this logic component. Due to the enormous flexibility of the system, several NUMSafe logic components can also be operated simultaneously in a network.

2.2.2 Safety concept

NUMSafe: Safety and I/O technology in one system
- Extension of the familiar NUM I/Os system with NUMSafe EtherCAT Terminals
- Freely selectable mix of safe and standard signals
- Logical link of the I/Os in the CTMP6900 NUMSafe Logic Terminal
- Safety-relevant networking of machines via bus systems.

NUMSafe protocol (Fail Safe over EtherCAT - FSoE)
- Transfer of safety-relevant data via any media (“genuine black channel”)
- IEC 61508:2010 SIL 3 compliant.

Configuring instead of wiring:
- Configuration of the NUMSafe system via “CODESYS Safety for EtherCAT Safety Module” programming system
- System Manager for editing and displaying all bus parameters
- Certified function blocks such as emergency stop, operation mode, etc.
- Simple handling
- Typical function blocks for machine safety.

NUMSafe Logic Terminal CTMP6900
- Link unit between NUMSafe input and output terminals
- Configuration of a simple, flexible, cost-effective, decentralized safety controller
- No safety requirements for higher-level control system
- NUMSafe Logic Terminal enables networks with up to 65535 NUMSafe devices
- NUMSafe Logic Terminal can establish up to 128 connections (NUMSafe connections).
- Several NUMSafe logic terminals are cascadable in a network
- Safety functions such as emergency stop, protective door etc. are already included suitable for applications up to SIL 3 according to IEC 61508:2010 and DIN EN ISO 13849-1:2006 (Cat 4, PL e).

NUMSafe I/O components
- All current safety sensors can be connected
- Operation with a NUMSafe Logic Terminal
- CTMS1904 with 4 fail-safe inputs for sensors (24VDC) with floating contacts
- CTMS2904 with four safe channels for actuators (24VDC, 0.5A per channel)
- conforming to IEC 61508:2010 SIL 3 and DIN EN ISO 13849-1:2006 (Cat 4, PL e) requirements.

2.2.3 The fail-safe principle (Fail Stop)

The basic rule for a safety system such as NUMSafe is that failure of a part, a system component or the overall system must never lead to a dangerous condition.

 CAUTION	**Safe state!** The safe state of the NUMSafe system is always the switched-off and de-energized state.

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3 Product description

3.1 CTMS2912 - NUMSafe terminal with two fail-safe outputs

The CTMS2912 is a safe output terminal with two fail-safe outputs, each with 2 A (24 VDC).
The CTMS2912 meets the requirements of the following standards:

- EN 61508:2010 (SIL 3)
- EN 62061:2005/A2:2015 (SIL CL 3)
- EN ISO 13849-1:2015 (Cat. 4, PL e).

The NUMSafe terminal has the typical design of a 12 mm EtherCAT Terminal. The outputs use the voltage of the power contacts. In addition, the voltage of the power contacts is applied to terminal points 2/6 and 3/7.

The terminal points GND1, GND2 and GND UP (terminal points 3/7) are directly connected internally.

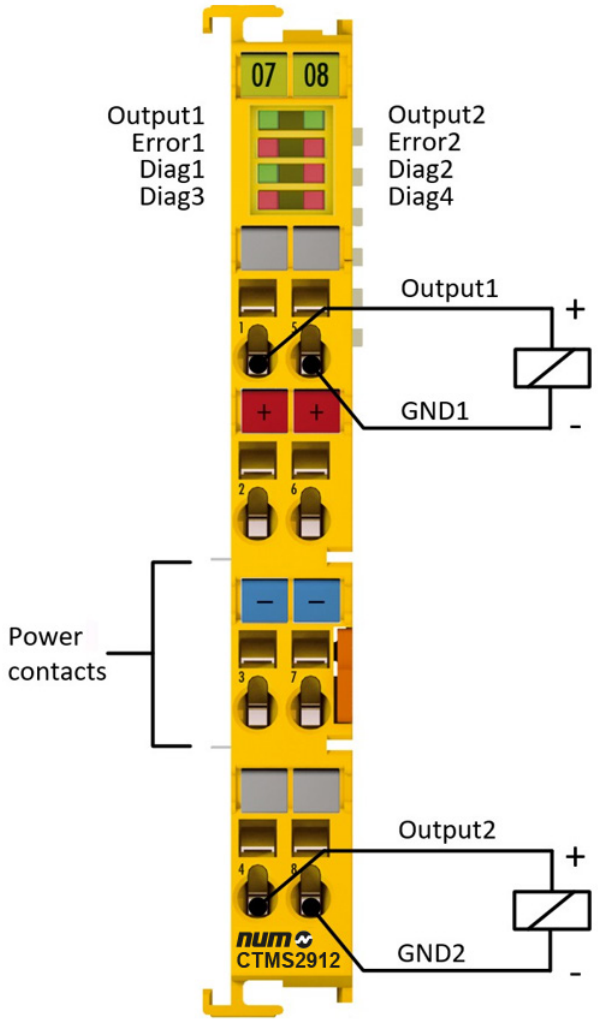

Fig.4 CTMS2912 - NUMSafe terminal with two fail-safe outputs

3.2 Intended use

 WARNING	**Caution – Risk of injury!** NUMSafe terminals may only be used for the purposes described below!

The NUMSafeTerminals expand the application area of NUM EtherCAT terminals system with functions that enable them to be used for machine safety applications.

The NUMSafeTerminals are designed for machine safety functions and directly associated industrial automation tasks. They are therefore only approved for applications with a defined fail-safe state. This safe state is the switched-off and de-energized state. Fail- safety according to the relevant standards is required.

The NUMSafe terminals enable connection of:

- 24 V_{DC} sensors such as
  emergency stop push-buttons, rope pull switches, position switches, two-hand switches, safety switching mats, light curtains, light barriers, laser scanners, etc.
- 24 V_{DC} actuators such as
  contactors, protective door switches with tumbler, signal lamps, servo drives, etc.

 Note	**Test pulses** When selecting actuators please ensure that the test pulses of the NUMSafe component do not lead to switching of the actuator or a diagnostic message of the NUMSafe component.

The following NUMSafe components were developed for these tasks:

- The CTMS1904 is an EtherCAT Terminal with 4 digital fail-safe inputs
- The CTMS2904 is an EtherCAT Terminal with 4 digital fail-safe outputs
- The CTMP6900 is an EtherCAT Terminal with integrated NUMSafe logic

These NUMSafe components are suitable for operation on the

- NUM CTMGxxxx series Bus Couplers

 WARNING	**System limits** The TÜV SÜD certificate applies to this NUMSafe component, the function blocks available in it, the documentation and the engineering tool. Flexium Tools and the NUMSafe Loader are permitted as engineering tools. Any deviations from these procedures or tools, particularly externally generated xml files for NUMSafe import or externally generated automatic project creation procedures, are not covered by the certificate.

 WARNING	**Power supply from SELV/PELV power supply unit!** The NUMSafe components must be supplied with 24 V_{DC} by an SELV/PELV power supply unit with an output voltage limit Umax of 36 V_{DC}. Failure to observe this can result in a loss of safety.

 WARNING	**Commissioning test** Before the CTMS2912 can be used for safety-related tasks, a commissioning test must be carried out by the user so that faulty sensor wiring can be ruled out.

Follow the machinery directive!

The NUMSafe components may only be used in machines as defined in the machinery directive.

Ensure traceability!

The buyer has to ensure the traceability of the device via the serial number.

3.3 Technical data

Product name	**CTMS2912**
Number of outputs	2
Status display	4 (one green and one red LED for each output)
Fault response time	≤ watchdog times
Output current per channel	max. 2 A (at 24 V_{DC})
Actuators	When selecting actuators please ensure that the CTMS2912 test pulses do not lead to actuator switching.
Cable length between actuator and terminal	Unshielded max. 100 m Shielded max. 100 m
Wire cross section	min. 0.75 mm^2
Input process image	6 bytes
Output process image	6 bytes
CTMS2912 supply voltage (SELV/PELV)	24 V_{DC} (–15% / +20%) (A 10 A fuse should be provided for the potential group)
Current consumption from the E-bus	Approx. 200 mA
Power dissipation of the terminal	Typically 1.7 W
Electrical isolation (between the channels)	NO
Electrical isolation (between the channels and the E-bus)	YES
Insulation voltage (between the channels and the E-bus, under common operating conditions)	Insulation tested with 500 V_{DC}
Dimensions (W x H x D)	12 mm x 100 mm x 68 mm
Weight	Approx. 55 g
Permissible ambient temperature (operation)	-25 °C to +55 °C (note chapter Temperature measurement)
Permissible ambient temperature (transport / storage)	-40°C to +85°C
Permissible air humidity	5% to 95%, non-condensing
Permissible air pressure (operation / storage / transport)	750 hPa to 1100 hPa (this corresponds to an altitude of approx. -690 m to 2450 m above sea level, assuming an international standard atmosphere)
Climate category according to EN 60721-3-3	3K3 (the deviation from 3K3 is possible only with optimal environmental conditions and also applies only to the technical data which are specified differently in this documentation)
Permissible level of contamination according to EN 60664-1	level of contamination 2 (note chapter Maintenance)
Unacceptable operating conditions	NUMSafe Terminals must not be used under the following operating conditions: • under the influence of ionizing radiation (exceeding the natural background radiation) • in corrosive environments • in an environment that leads to unacceptable soiling of the Bus Terminal
EMC immunity/emission	Conforms to EN 61000-6-2 / EN 61000-6-4 (EMC Zone B)
Vibration resistance	Conforms to EN 60068-2-6 5 Hz ≤ f < 8.4 Hz (3.5 mm peak) 8.4 Hz ≤ f < 150 Hz (10 m/s^2 peak)
Shock resistance	conforms to EN 60068-2-27 15 g with pulse duration 11 ms in all three axes
Protection class	IP20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection class IP54 according to IEC 60529
Permissible installation position	See chapter Installation position and minimum distances
Approvals	CE, TÜV SÜD

Derating table for altitudes above 2000 m

The derating table (table 8) from the IEC 61131-2:2017 standard can be referred to for the use of the NUMSafe components above the specified maximum altitude.

Altitude in m	**Derating factor for the temperature**[1]
0 to 2000[2]	1.0
3000	0.9
4000	0.8
5000	0.7

Note:
Linear interpolation is permissible between the altitudes

1. Ambient temperature of the device at an altitude of 2000 m
2. The air pressure and air density increase as the altitude decreases. Therefore the derating factor for 0 to 2000 m (1.0) is used for altitudes below sea level.

Calculation example

In the following example the calculation is performed for a NUMSafe component at an operating altitude of 4000 m.
Permissible ambient temperature up to 2000 m above sea level = 55 °C
Permissible ambient temperature up to 4000 m above sea level = 55 °C * 0.8 = **44 °C**

 **CAUTION**	**Compliance with the temperature limits** The NUMSafe component has a maximum internal temperature at which a switch-off takes place. This is designed for the maximum permissible ambient temperature. If the derating factor for the temperature for higher altitudes is used, the user is solely responsible for ensuring that the calculated maximum ambient temperature is complied with.

3.4 Safety parameters

Characteristics numbers	CTMS2912
Lifetime [a]	20
Prooftest Intervall [a]	Not requiered [1]
PFH_D	2.88 E-09
PFD	2.55 E-05
$MTTF_D$	High
DC	High
Performance level	PL e
Category	4
HFT	1
Element Classification [2]	Type B

[1] No special proof tests are required during the entire service life of the CTMS2912.

[2] Classification according to IEC 61508-2:2010 (chapter 7.4.4.1.2 and 7.4.4.1.3)

The CTMS2912 EtherCAT Terminal can be used for safety-related applications within the meaning of EN 61508:2010 up to SIL3 and EN ISO 13849-1:2015 up to PL e (Cat 4).

Further information on calculating or estimating the $MTTF_D$ value from the PFH_D value can be found in the NUMSafe Application Guide or in EN ISO 13849-1:2015, Table K.1.

In terms of safety-related parameters, the Safety-over-EtherCAT communication is already considered with 1% of SIL3 according to the protocol specification.

3.5 Safe output

The safe outputs are implemented as a single channel per module. It is essential to pay attention to the following note if two or more outputs run in a common sheathed cable.

DANGER

Clocked signals inside a sheathed cable

If clocked signals from different modules are used inside a single sheathed cable, then a module error such as a cross-circuit or external power supply must lead to the switch-off of all of these modules.

This is achieved by setting the Module Fault Link active parameter for all modules involved.

This parameter is set to TRUE by default.

3.6 Fuse

Power supply of the power contacts

The safe outputs are supplied from the power contacts. The current carrying capacity of the power contacts is limited to 10 A.

The power supply of the power contacts for each potential group must be protected with a 10 A fuse.

3.7 Dimensions

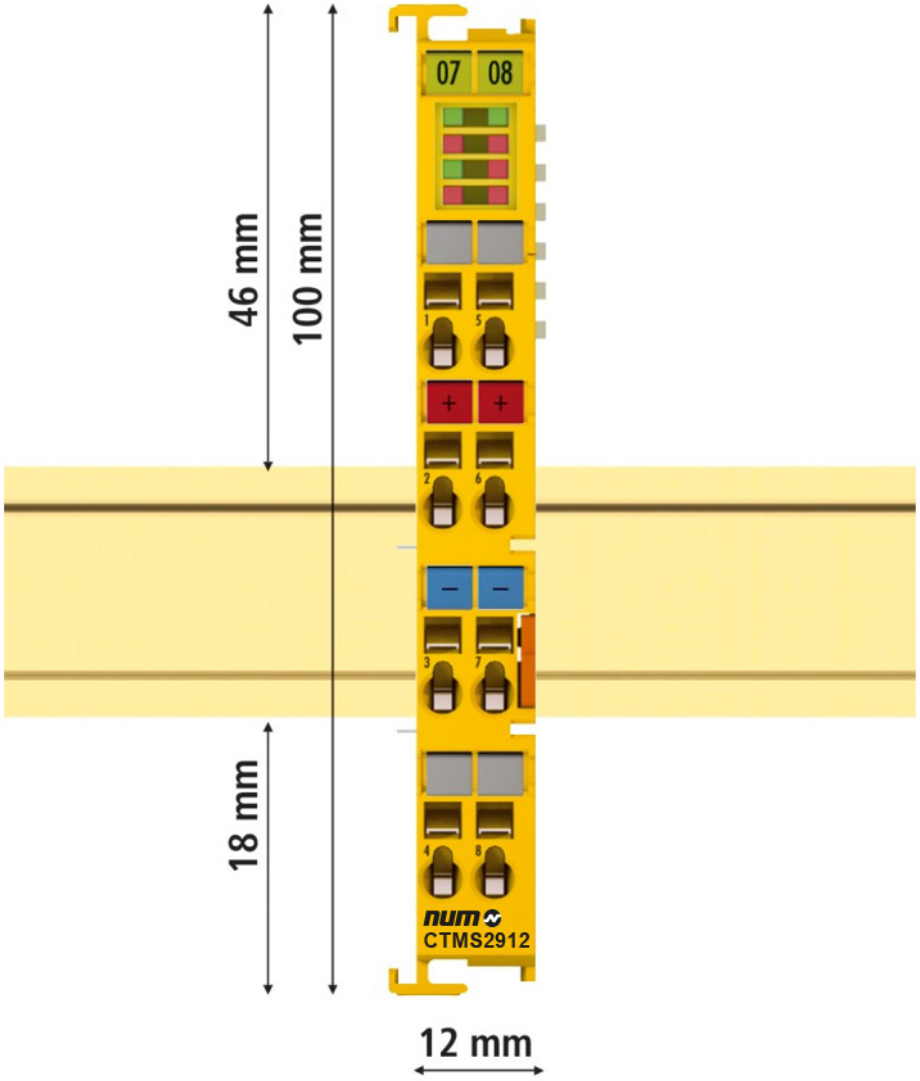

Fig.5 CTMS2912 - Dimensions

- Width: 12 mm (side-by-side installation)
- Height: 100 mm
- Depth: 68 mm

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4 Operation

4.1 Environmental conditions

Please ensure that the NUMSafe terminals are only transported, stored and operated under the specified conditions (see technical data)!

 WARNING	**Risk of injury!** The NUMSafe terminals must not be used under the following operating conditions: • under the influence of ionizing radiation • in corrosive environments • in an environment that leads to unacceptable soiling of the EtherCAT terminal.

 Warning	**Electromagnetic Compatibility** The NUMSafe components comply with the current standards on electromagnetic compatibility with regard to spurious radiation and immunity to interference in particular. However, in cases where devices such as mobile phones, radio equipment, transmitters or high-frequency systems that exceed the interference emissions limits specified in the standards are operated near NUMSafe components, the function of the NUMSafe components may be impaired.

4.2 Installation

4.2.1 Safety instructions

Before installing and commissioning the NUMSafe terminals please read the safety notes in the foreword of this documentation.

4.2.2 Transport / storage

Use the original packaging in which the components were delivered for transporting and storing the NUMSafe components.

 CAUTION	**Note the specified environmental conditions** Please ensure that the digital NUMSafe terminals are only transported and stored under the specified environmental conditions (see technical data).

4.2.3 Mechanical installation

DANGER	**Risk of injury!** Bring the bus system into a safe, de-energized state before starting installation, disassembly or wiring of the EtherCAT terminals!

4.2.3.1 Instructions for ESD protection

STOP **Warning**	**Devices can be destroyed by electrostatic charging!** The devices contain electrostatically sensitive components which can be damaged by improper handling. • Please ensure you are electrostatically discharged when handling the components; also avoid touching the spring contacts directly (see illustration). • Avoid contact with highly insulating materials (synthetic fibers, plastic films etc.) • When handling the components, ensure good grounding of the environment (workplace, packaging and persons) • Each bus station must be terminated on the right side with the CTMT9011 end cap to ensure the protection class and ESD protection.

Fig.6 Spring contacts of NUM EtherCAT I/O components

4.2.3.2 Control cabinet / terminal box

The NUMSafe terminals must be installed in a control cabinet or terminal box with IP54 protection class according to IEC 60529 as a minimum.

4.2.3.3 Installation position and minimum distances

For the prescribed installation position the mounting rail is installed horizontally and the mating surfaces of the CTMx terminals point toward the front (see illustration below).

The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. The direction indication “down” corresponds to the direction of positive acceleration due to gravity.

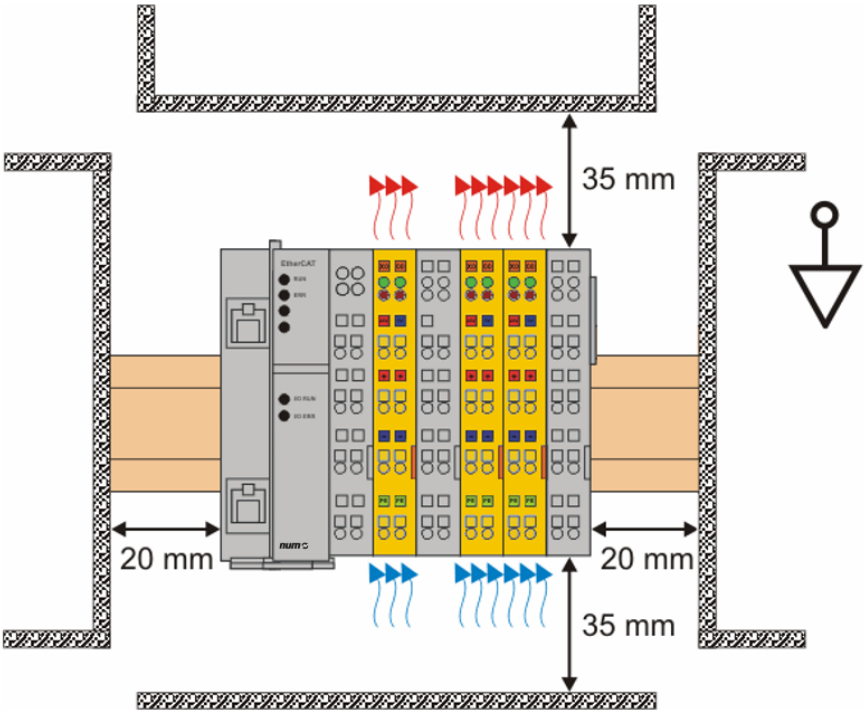

Fig.7 Installation position and minimum distances

In order to ensure optimum convection cooling, the distances to neighboring devices and to control cabinet walls must not be smaller than those shown in the diagram.

4.2.3.4 Temperature measurement

The temperature measurement consists of an CTMG1100 EtherCAT Gateway, to which EtherCAT Terminals are attached, based on the typical distribution of digital and analog signal types at a machine. On the CTMP6900 a safety project is active, which reads safe inputs and enables safe outputs during the measurement.

 **Warning**	**External heat sources / radiant heat / impaired convection** The maximum permissible ambient temperature of 55°C was checked with the example configuration described above. Impaired convection, an unfavorable location near heat sources or an unfavorable configuration of the EtherCAT Terminals may result in overheating of the NUMSafe components. The key parameter is always the maximum permitted internally measured temperature of 110°C, above which the NUMSafe components switch to safe state and report an error. The internal temperature can be read from the NUMSafe components via CoE.

4.2.3.5 Notes on the configuration of NUMSafe components

The following notes illustrate favorable and unfavorable terminal arrangements from a thermal perspective.

Components with higher waste heat are identified with a red symbol  , components with lower waste heat are identified with a blue symbol  .

CTMG1100 EtherCAT Gateway and CTMT9410 power supply terminal
The more terminals are attached after an EtherCAT Gateway or a power supply terminal, the higher the E-bus current that their power supply units have to supply. With increasing current the waste heat from the power supply units also increases.

CTMP6900
The CTMP6900 emits a relatively high amount of waste heat, since it has a high internal clock rate and high logic performance.

CTMS2904/CTMS2912
The CTMS2904/CTMS2912 emits a relatively high amount of waste heat due to the potentially high output current of the connected actuators.

CTMS1904
The CTMS1904 also emits a relatively high amount of waste heat, despite the fact that the external load due to clock outputs and safe inputs is relatively low.

Thermally unfavorable arrangement of the NUMSafe terminals

The following arrangement is rather unfavorable, as terminals with relatively high waste heat are attached directly to the EtherCAT Gateway or the power supply terminal with high E-bus load.

The additional external heating of the NUMSafe terminals by the adjacent power supply units increases the internal terminal temperature, which can lead to the maximum permissible temperature being exceeded. This leads to the diagnosis “Overtemperature” message.

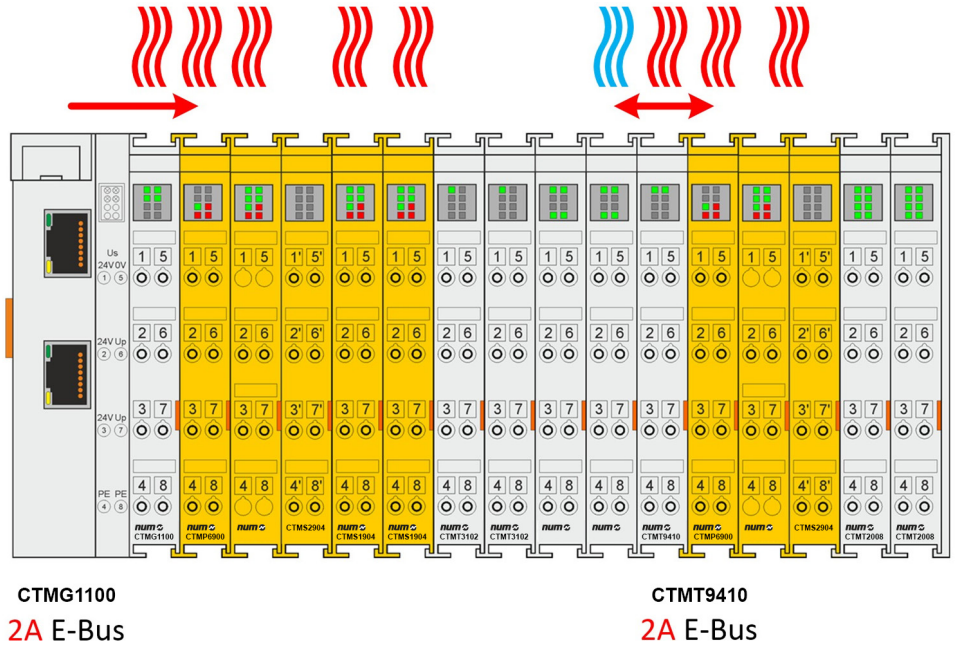

Fig.8 Thermally unfavorable arrangement of the NUMSafe terminals.

Thermally favorable arrangement of the NUMSafe terminals

The following arrangement is thermally optimized, as terminals with low current consumption and therefore low waste heat are attached between the EtherCAT Gateway / power supply terminal and terminals with higher waste heat.

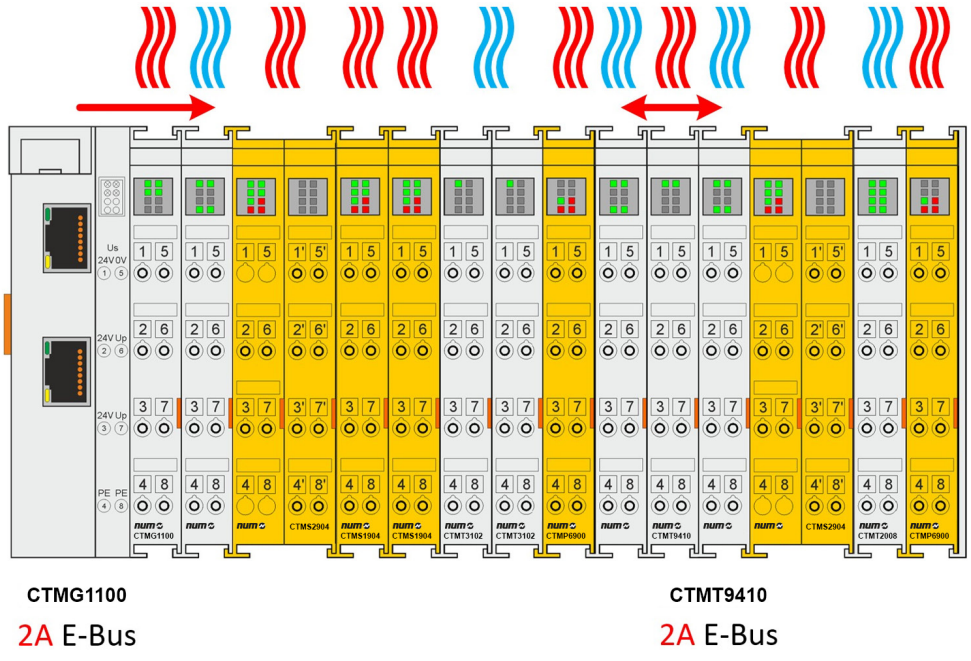

Fig.9 Thermally favorable arrangement of the NUMSafe terminals.

4.2.3.6 Installation on mounting rails

WARNING	**Risk of electric shock and damage of device!** Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the Bus Terminals!

Mounting

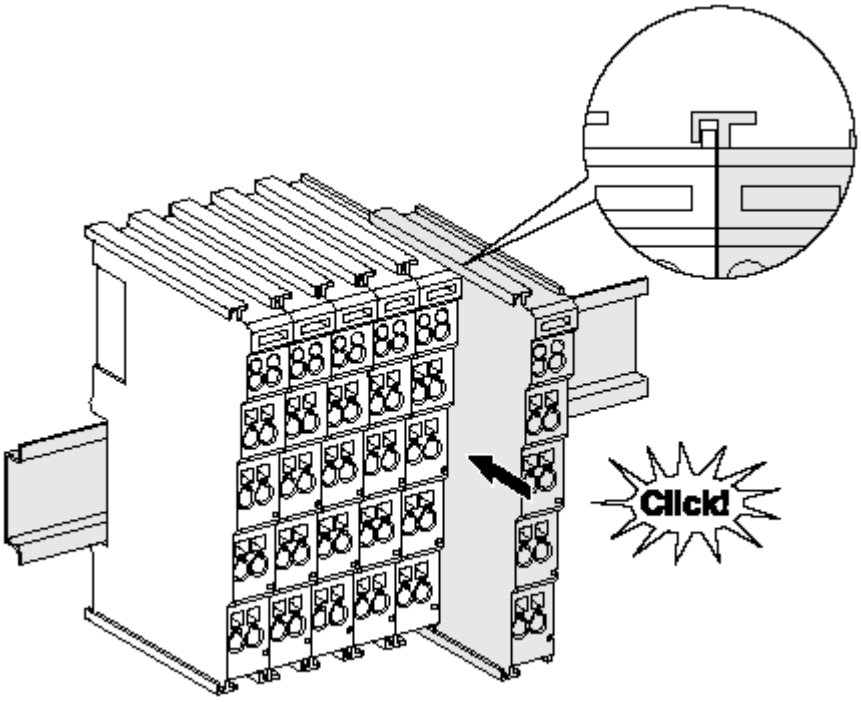

Fig.10 Installation on the mounting rail

The EtherCAT Gateways and Bus Terminals are attached to commercially available 35 mm mounting rails (DIN rail according to EN 60715) by applying slight pressure:

1. First attach the EtherCAT Gateway to the mounting rail.
2. The EtherCAT Terminals are now attached on the right-hand side of the EtherCAT Gateway.
   Join the components with slot and key and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.
   If the terminals are clipped onto the mounting rail first and then pushed together without slot and key, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

Note	**Fastening of mounting rails** The locking mechanism of the terminals and couplers protrudes into the profile of the mounting rail. When installing the components, make sure that the locking mechanism doesn't come into conflict with the fixing bolts of the mounting rail. For fastening mounting rails with a height of 7.5 mm under the terminals and couplers, use flat fastening components such as countersunk head screws or blind rivets.

Disassembly

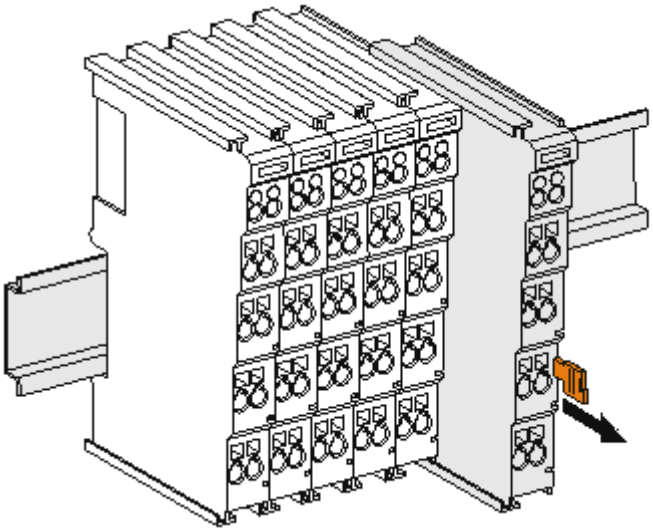

Fig.11 Removal from mounting rail

Each EtherCAT terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull down the terminal at its orange-colored straps from the mounting rail by approx. 1 cm. The rail locking of this terminal is automatically released, and you can now pull the terminal out of the EtherCAT Terminal block with little effort.
2. To do this, grasp the unlocked terminal simultaneously at the top and bottom of the housing surfaces with your thumb and index finger and pull it out of the EtherCAT Terminal block.

4.2.4 Electrical installation

4.2.4.1 Connections within a EtherCAT Terminal block

The electric connections between the EtherCAT Gateway and the EtherCAT Terminals are automatically realized by joining the components:

Spring contacts (E-bus)

The six spring contacts of the E-bus deal with the transfer of the data and the supply of the EtherCAT Terminal electronics.

 **Warning**	**Observe the E-bus current** Observe the maximum current that your EtherCAT Gateway can supply to the E-bus! Use the CTMT9410 Power supply terminal if the current consumption of your terminals exceeds the maximum current that your EtherCAT Gateway can feed to the E-bus supply.

Power contacts

The power contacts deal with the supply for the field electronics and thus represent a supply rail within the EtherCAT Terminal block. The power contacts are supplied via terminals on the EtherCAT Gateway.

 **Note**	**Note the connection of the power contacts** During the design of a EtherCAT Terminal block, the pin assignment of the individual EtherCAT Terminals must be taken account of, since some types (e.g. analog EtherCAT Terminals or digital 4-channel EtherCAT Terminals) do not or not fully loop through the power contacts. Potential supply terminals (CTMT91xx) interrupt the power contacts and thus represent the start of a new supply rail.

PE power contact
The power contact labelled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125A.

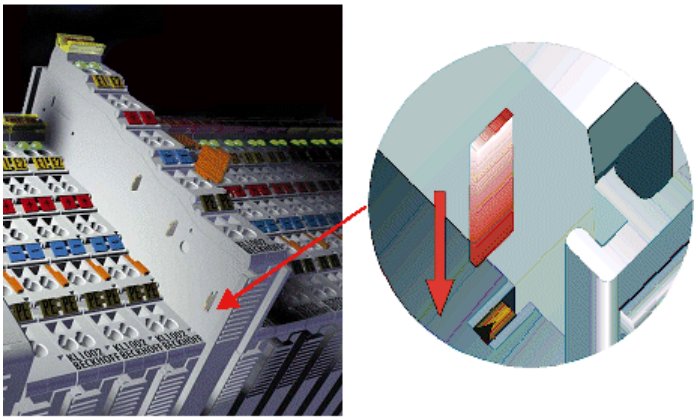

Fig.12 PE power contact

CAUTION	**Insulation tests** Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a rated voltage of 230V). For insulation testing, disconnect the PE supply line at the EtherCAT Gateway or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10mm from the group of terminals.

DANGER	**Serious risk of injury!** The PE power contact must not be used for other potentials!

4.2.4.2 Overvoltage protection

If protection against overvoltage is necessary in your plant, provide a surge filter for the voltage supply to the EtherCAT Terminal blocks and the NUMSafe terminals.

4.2.4.3 Wiring

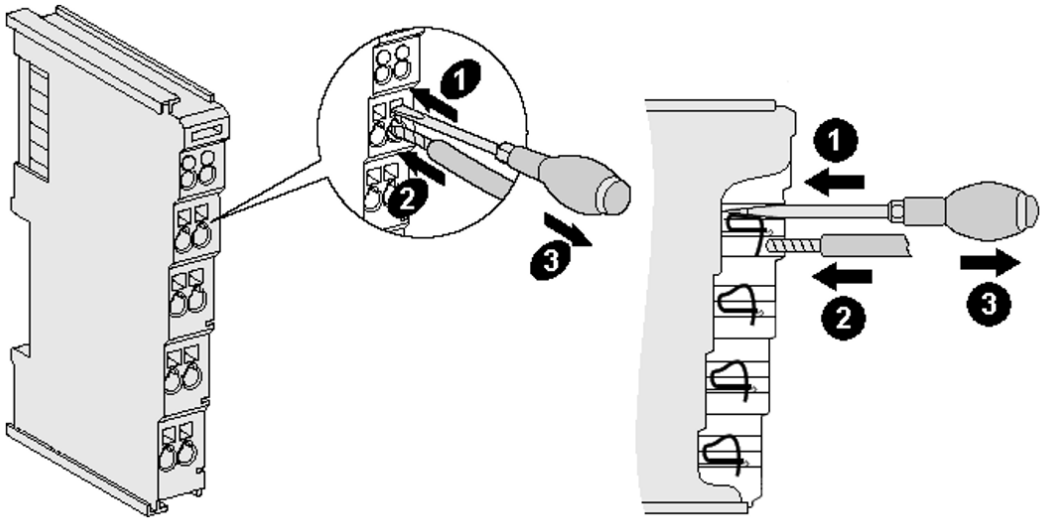

Fig.13 Connection of a cable to a terminal point.

Up to eight connections enable the connection of solid or finely stranded cables to the EtherCAT Terminals. The terminals are implemented in spring force technology.

Connect the cables as follows:

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal closes automatically when the pressure is released, holding the wire safely and permanently.

See the following table for the suitable wire size width.

Wire size width (single core wires)	0.08 ... 2.5mm^2
Wire size width (fine-wire conductors)	0.08 ... 2.5mm^2
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm^2
Wire stripping length	8 ... 9 mm

4.2.4.4 CTMS2912 pin assignment

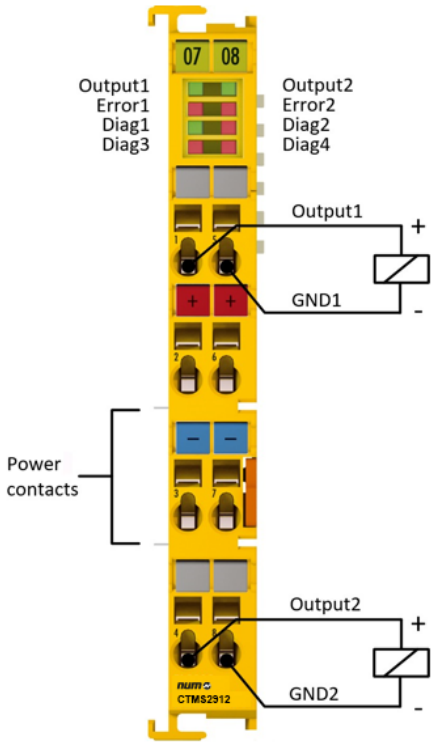

Fig.14 CTMS2912 - connection

Terminal point	Input / Output	Signal
1	Output1	Output 1 (+ 24 V_{DC})
2		24V_{DC} U_P
3		GND U_P
4	Output2	Output 2 (+ 24 V_{DC})
5	GND1	Output 1 GND (directly connected to GND U_P)
6		24V_{DC} U_P
7		GND U_P
8	GND2	Output 2 GND (directly connected to GND U_P)
Power contact (top)		24V_{DC} U_P
Power contact (low)		GND U_P

4.2.4.5 Signal cables

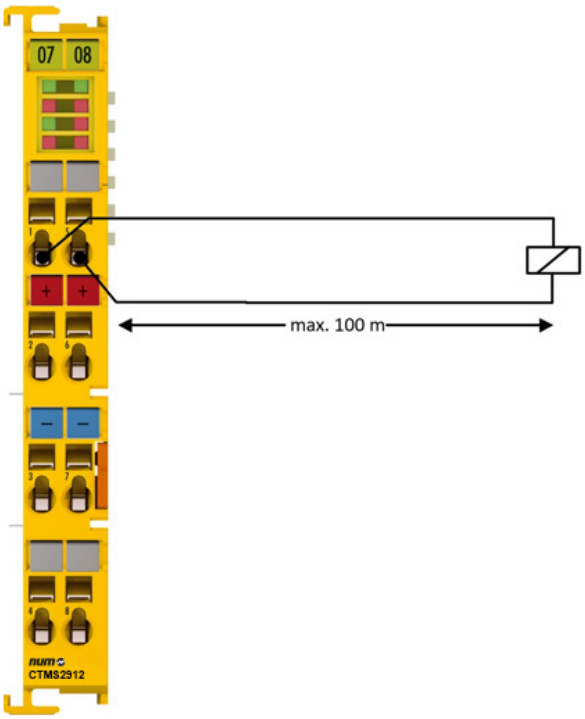

Fig.15 Max. cable length CTMS2912

When connecting a single switch contact via its own continuous cabling (or via a non-metallic sheathed cable), the maximum permitted cable length is 100m.

The use of contact points, connectors or small cable cross-sections in the wiring reduces the maximum expansion.

Cable routing

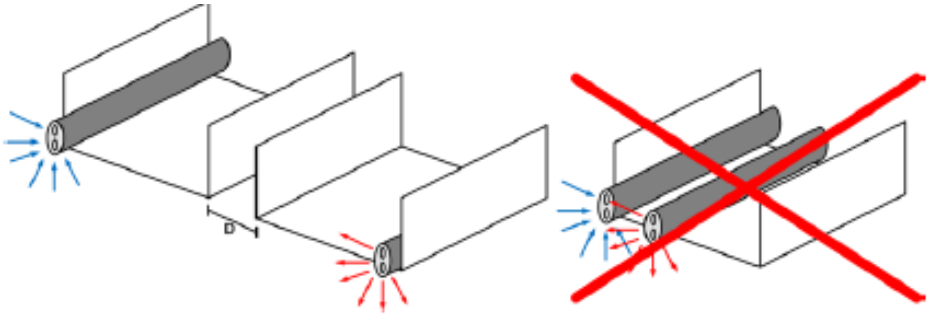

Fig.16 Cable routing

STOP **Warning**	**Route the signal cable separately** The signal cable must be routed separately from potential sources of interference, such as motor supply cables, 230 VAC power cables etc.! Interference caused by cables routed in parallel can influence the signal form of the test pulses and thus cause diagnostic messages (e.g. sensor errors or OpenLoad errors). D: Distance between the cable ducts should be as large as possible blue arrows: signal line red arrows: potential source of interference

The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages.

4.3 CTMS2912 with “CODESYS Safety for EtherCAT Safety Module”

Configuration

CAUTION	**Do not change CoE objects!** Do not change any of the CoE objects in the NUMSafe terminals. Any modifications (e.g. via Flexium Tools) of the CoE objects will permanently set the terminals to the Fail-Stop state or lead to unexpected behavior of the terminals.

4.3.1 Inserting a NUM gateway

See NUM EtherCAT terminals CTMG and CTMT Operating manual M00032.

4.3.2 Inserting a EtharCAT Terminal

See NUM EtherCAT terminals CTMG and CTMT Operating manual M00032.

4.3.3 Adding an CTMS2912

An CTMS2912 is added in exactly the same way as any other NUM EtherCAT Terminal. Open NUMSafe Terminals item in the list and select the CTMS2912.

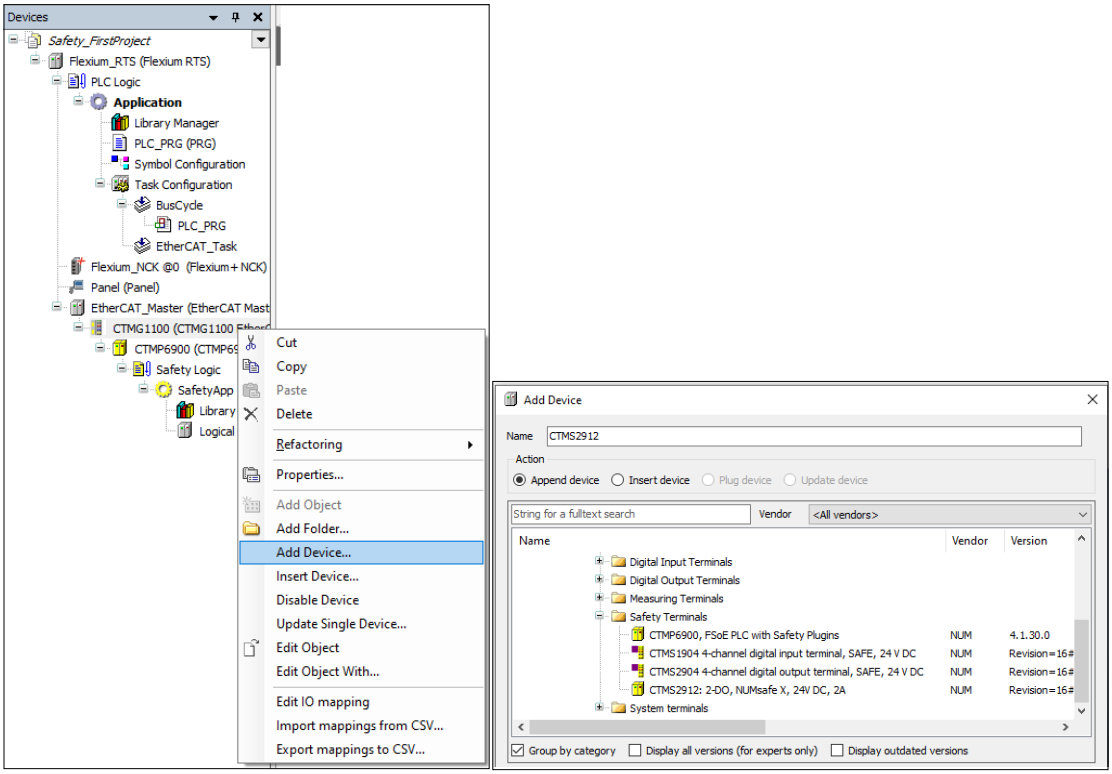

Fig.17 Adding an CTMS2912

4.3.4 Address settings of the NUMSafe terminals with 1023 possible addresses

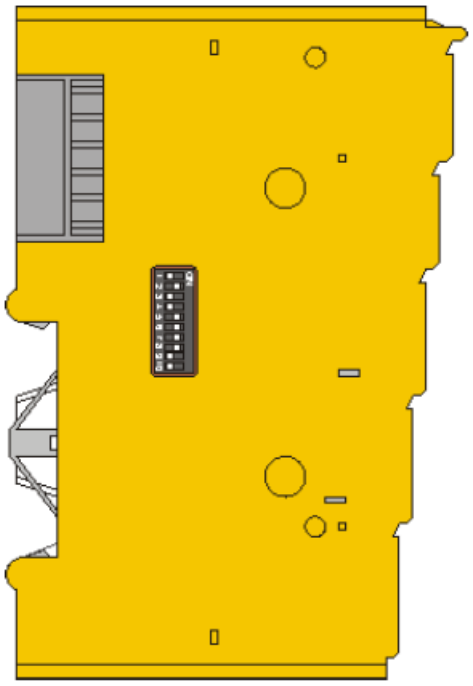

Fig.18 Address settings on NUMSafe terminals with 1023 possible addresses.

The NUMSafe address of the NUMSafe terminal is set via the 10-way dip switches on the left-hand side of the NUMSafe terminal. NUMSafe addresses between 1 and 1023 are available.

DIP switch										**Address**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**0**
ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**1**
OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**2**
ON	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**3**
OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**4**
ON	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**5**
OFF	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**6**
ON	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**7**
...	...	...	...	...	...	...	...	...	...	**...**
ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**1023**

NUMSafe address

Each NUMSafe address may only be used once within a network / a configuration!

The address 0 is not a valid NUMSafe address!

4.3.5 Entering the FSoE addresses and parameters

The FSoE address set at the DIP switch must also be entered under the Safe configuration tab (FSoE_Address entry).

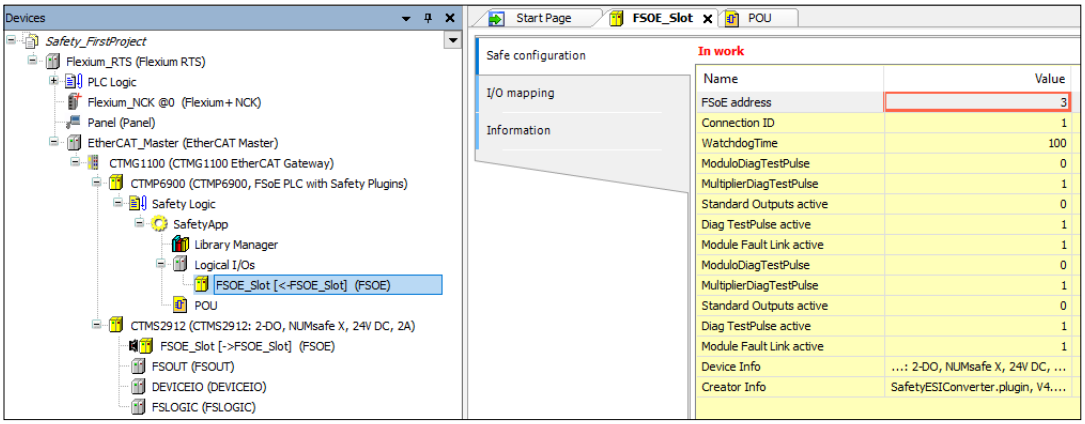

Fig.19 Entering NUMSafe addresses

The CTMS2912 parameters are set under the respective logical I/Os device in the Safe configuration tab.

Parameter overview

Name	Meaning	Values
ModuloDiagTestPulse	"Modulo value for the frequency of the generation of a test pulse. 0 -> every time 1 -> every 2nd time …"	0 … 255
MultiplierDiagTestPulse	Length of the test pulse in multiples of 400 µs	1 … 255
Standard outputs active	"In addition the safe output can be switched off from the standard PLC. Activation of the logical AND operator of the safe and standard outputs of the module"	True / false
Diag TestPulse active	Activation of test pulses for the corresponding output module	True / false
Module Fault Link active	If a module error occurs in this module, a module error is also set for all other modules of this NUMSafe component for which this parameter is set to TRUE.	True / false

4.3.6 CTMS2912 process image

The process image of the CTMS2912 consists of 6 bytes process data in the input and 6 bytes process data in the output.

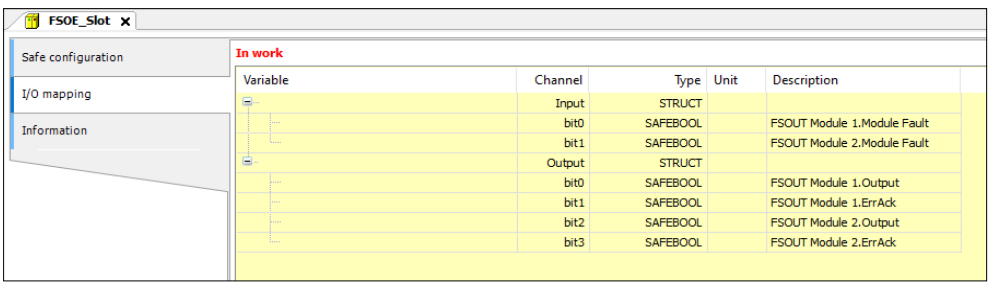

Fig.20 CMTS2912 process image

4.4 NUMSafe reaction times

The NUMSafe terminals form a modular safety system that exchanges safety-oriented data via the Safety over-EtherCAT protocol. This chapter is intended to help you determine the system's reaction time from the change of signal at the sensor to the reaction at the actuator.

Typical response time
The typical response time is the time required for transferring a piece of information from the sensor to the actuator, when the whole system operates normally, without error.

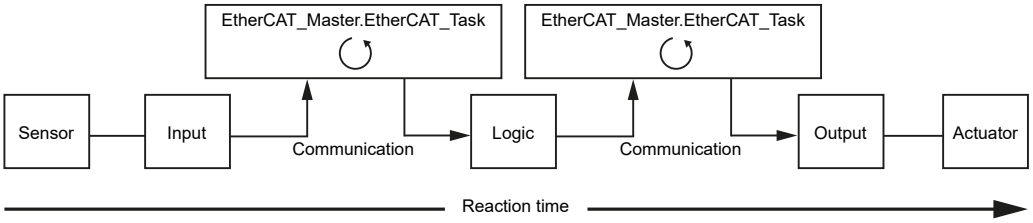

Fig.21 Typical response time

Definition	Description
RT_{Sensor}	Response time of the sensor, until the signal is made available at the interface. Typically provided by the sensor manufacturer.
RT_{Input}	Response time of the safe input, e.g. CTMS1904. This time can be found in the technical data. In the case of the CTMS1904 it is 4 ms.
RT_{Comm}	Response time of the communication. This is typically 3 times the EtherCAT cycle time, since a new Safety-over-EtherCAT telegram has to be generated before new data can be sent. These times depend directly on the higher-level standard controller (cycle time of the PLC).
RT_{Logic}	Response time of the logic terminal. This is the cycle time of the logic terminal and typically ranges from 500 µs to 10 ms for the CTMP6900, depending on the size of the safety project. The actual cycle time can be read from the terminal.
RT_{Output}	Response time of the output terminal. This is typically between 2 and 3 ms.
$RT_{Actuator}$	Response time of the actuator. This information is typically provided by the actuator manufacturer.
WD_{Comm}	Watchdog time of the communication.

The typical response time is based on the following formula:

$$ReactionTime_{typ} = RT_{Sensor} + RT_{Input} + 3*RT_{Comm} + RT_{Logic} + 3*RT_{Comm} + RT_{Output} + RT_{Actuator}$$

with

$$ReactionTime_{typ} = 5ms + 4ms + 3*1ms + 10ms + 3*1ms + 3ms + 20ms = 48ms$$

Worst case response time

The worst-case response time is the maximum time required for switching off the actuator in the event of an error.

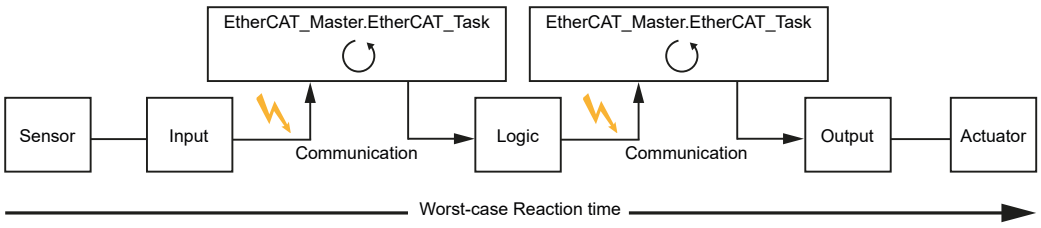

Fig.22 Worst case response time

It is assumed that a signal change takes place at the sensor, and that this is passed to the input. A communication error occurs just at the moment when the signal is to be passed to the communication interface.

This is detected by the logic once the watchdog time of the communication link has elapsed. This information should then be passed on to the output, resulting in a further communication error. This fault is detected at the output once the watchdog time has elapsed, resulting in shutdown.

This results in the following formula for the worst-case response time:

$$ReactionTime_{max} = WD_{Comm} + WD_{Comm} + RT_{Actuator}$$

with

$$ReactionTime_{max} = 2 * 15ms + 20ms = 50ms$$

4.5 Diagnostics

4.5.1 Status LEDs

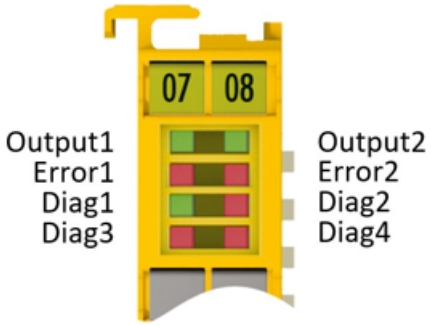

Fig.23 CTMS2912 - Status and diagnostic LEDs

LED	Color	Description
Output 1	green	Status and error display for the respective output
Error 1	red	LED lights up: Output/error is set
Output 2	green	LED not lit: Output is not set or there is no error
Error 2	red	

4.5.2 Diagnostic LEDs

LED	lit	flashes	off
Diag 1 (green)	Environment variables, operating voltage and internal tests are in the valid range • If Diag 2 flashes, a logic error code applies	-	Environment variables, operating voltage and internal tests are outside the valid range • If Diag 2 flashes, an environment error code applies
Diag 2 (red)	Together with Diag 3 and 4: Global shutdown[1)] has occurred. (see diag history of the NUMSafe components)	Logic or environment error code according to Diag1 and tables below is output	Together with Diag 3 and 4: Global fault[1)] has occurred. (see diag history of the NUMSafe components)
Diag 3 (red)	Global fault or global shutdown on µC1[1)]	-	No global fault or global shutdown on µC1[1)]
Diag 4 (red)	Global fault or global shutdown on µC2[1)]	-	No global fault or global shutdown on µC2[1)]
Diag Out (red)	Module error in the output module.	-	No error in the output module

1) A global fault permanently disables the NUMSafe component, so that it has to be replaced. A global shutdown temporarily disables the NUMSafe component. The error can be reset by switching off and back on again.

Environment error codes of LED Diag 2 (if LED Diag 1 is off)

Flashing Code	Meaning
1	Maximum supply voltage µC1 exceeded
2	Supply voltage µC1 below minimum value
3	Maximum supply voltage µC2 exceeded
4	Supply voltage µC2 below minimum value
5	Maximum internal temperature exceeded
6	Internal temperature below minimum value
7	Valid temperature difference between µC1 and µC2 exceeded
8	reserved
9	reserved
10	General error

4.5.3 Flash code display

LED	Display	Description
flashing		400 ms ON / 400 ms OFF 1 second pause between the flash codes
flickering		50 ms ON / 50 ms OFF

Fig.24 Description LED display

4.5.4 Diagnostic objects

Do not change CoE objects!

Do not change any of the CoE objects in the NUMSafe terminals.
Any modifications (e.g. via the “CODESYS Safety for EtherCAT Safety Module”) of the CoE objects would permanently set the terminals to the Fail-Stop state or result in unpredictable behaviour of the Modules.

Index $F984_{hex}$: Device Info Data C1

CoE object $F984_{hex}$ currently displays internal temperature and voltage values for the NUMSafe component.

Index	Name	Meaning	Flags	Default
F984:01	Voltage C2	Voltage µC2	RO	0_{dec}
F984:02	Temperature C1	Temperature µC1	RO	0_{dec}
F984:03	Firmware CRC C1	CRC of the firmware on µC1	RO	-
F984:04	Vendor data CRC C1	CRC of the vendor data on µC1	RO	-

Index $F985_{hex}$: Device Info Data C2

CoE object F985hex currently displays internal temperature and voltage values for the NUMSafe component.

Index	Name	Meaning	Flags	Default
F985:01	Voltage C1	Voltage µC1	RO	0_{dec}
F985:02	Temperature C2	Temperature µC2	RO	0_{dec}
F985:03	Firmware CRC C2	CRC of the firmware on µC2	RO	-
F985:04	Vendor data CRC C2	CRC of the vendor data on µC2	RO	-

Diagnostics history

Any errors, which occur during operation of the NUMSafe component, such as overtemperature or undervoltage, are entered in the diagnostics history with a corresponding timestamp.

4.5.5 Diagnosis History

The diagnostic messages are saved by the NUMSafe device in a dedicated CoE object under 0x10F3 and can be read out by the application or by Flexium+.

Both the control entries and the history itself can be found in the CoE object 0x10F3. The entry Newest Message (0x10F3:02) contains the subindex of 0x10F3, which contains the latest diagnostic message, e.g. 0x06 for diagnostic message 1.

Index $10F3_{hex}$ Diagnosis History

Index (hex)	Name	Meaning	Data type	Flags	Default
10F3:0	Diagnosis History				
10F3:01	Maximum Messages	Maximum number of stored messages. A maximum of 64 messages can be stored. After that the respective oldest messages are overwritten.	UINT8	RO	0x40 (64dec)
10F3:02	Newest Message	Subindex of the latest message	UINT8	RO	0x00 (0dec)
10F3:03	Newest Acknowledged Message	Subindex of the last confirmed message	UINT8	RW	0x00 (0dec)
10F3:04	New Messages Available	Indicates that a new message is available	BOOLEAN	RO	0x00 (0dec)
10F3:05	Flags	Set via the startup list. If set to 0x0001, the diagnostic messages are additionally sent by emergency to the EtherCAT master	UINT16	RW	0x0000 (0dec)
10F3:06	Diagnosis Message 001	Diagnosis message 1	BYTE[32]	RO	{0}
...	...	...	...	...	...
10F3:45	Diagnosis Message 064	Diagnosis message 64	BYTE[32]	RO	{0}

Structure of the diagnosis messages

- DiagCode (4 bytes) – in this case always 0x 0000 E000.
- Flags (2 bytes) - diagnosis type (info, warning or error), time stamp and number of parameters contained (see the following table).
- Text ID (2 bytes) – ID of the diagnosis message as a reference to the message text from the ESI/ XML Time stamp (8 bytes) – local slave time in ns since switching on the NUMSafe device.
- dynamic parameters (16 bytes) – parameters that can be inserted in the message text (see following table).

Flags in diagnosis messages

Data type	Offset	Description	
UINT16	Bit 0…3	DiagType (value)	
		0	Info message
		1	Warning message
		2	Error message
		3...15	reserved
	Bit 4	If the bit = 1, the time stamp contained in the message is the local time stamp of the NUMSafe device. The age of the diagnosis message can be deduced by calculation with the current time stamp from the CoE object 0x10F8.	
	Bit 5…7	reserved	
	Bit 8…15	Number of parameters in this diagnosis message	

Dynamic parameters in the diagnosis messages

Type	Data type	Description	
Flags parameter 1	**UINT16**	**Describes the type of parameter 1**	
		Bit 12…15 = 0	**Bit 0…11 = data type of parameter 1** **0x0001 - BOOLEAN** **0x0002 - INT8** **0x0003 - INT16** **0x0004 - INT32** **0x0005 - UINT8** **0x0006 - UINT16** **0x0007 - UINT32** **0x0008 - REAL32** **0x0011 - REAL64** **0x0015 - INT64** **0x001B - UINT64**
Parameter 1	**Data type in accordance with flags**	**Value of parameter 1**	
Flags parameter 2	**UINT16**	**see Flags parameter 1**	
Parameter 2	**Data type in accordance with flags**	**Value of parameter 2**	
...			

4.6 Maintenance

The NUMSafe terminals are maintenance-free!.

Environmental conditions

 WARNING	**Observe the specified environmental conditions!** Please ensure that the NUMSafe terminals are only stored and operated under the specified conditions (see technical data).

If the terminal is operated outside the permitted temperature range it will switch to *Global Fault* state see the chapter Diagnosis.

Cleaning

Protect the NUMSafe terminal from unacceptable soling during operation and storage!

If the NUMSafe Bus Terminals were subjected to unacceptable soiling they may no longer be operated!

 WARNING	**Have soiled terminals checked!** Cleaning of the NUMSafe terminal by the user is not permitted! Please send soiled terminals to the manufacturer for inspection and cleaning!

4.7 Service life

The NUMSafe terminals are designed for a service life of 20 years.

Due to the high diagnostic coverage within the lifecycle no special proof tests are required.

The NUMSafe modules have a Date Code structured as follows:

Date code: CW YY SW HW	
Legend:	Sample: Date Code 17 11 05 00
CW: Calendar week of manufacture	Calendar week: 17
YY: Year of manufacture	Year: 2011
SW: Software version	Software version: 05
HW: Hardware version	Hardware version: 00

In addition the NUMSafe modules have a unique serial number.

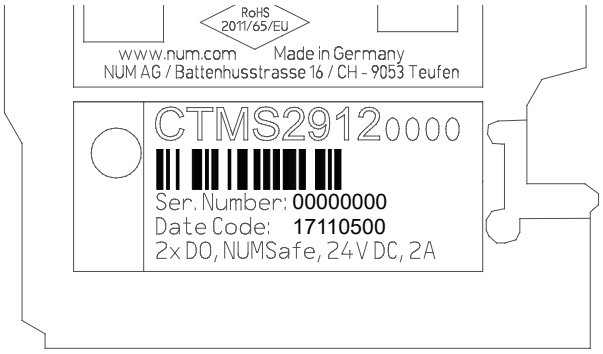

Fig.25 Unique serial number of a NUMSafe terminal

4.8 Decommissioning

STOP **Warning**	**Risk of electric shock!** Bring the bus system into a safe, de-energized state before starting disassembly of the EtherCAT Terminals!

Disposal

In order to dispose of the device, it must be removed and fully dismantled.

- Housing components (polycarbonate, polyamide (PA6.6) are suitable for plastic recycling.
- Metal parts can be sent for metal recycling.
- Electronic parts such as disk drives and circuit boards must be disposed of in accordance with national electronics scrap regulations.

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Summary

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5 Appendix

5.1 NUM Support and Service

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

5.1.1 NUM branches and partner companies NUM Support

Please contact your NUM branch office or partner company for local support and service on NUM products!
The contact addresses for your country can be found in the list of NUM branches and partner companies: www.num.com. You will also find further documentation for NUM components there.

ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 083009 0012 Rev. 00

Holder of Certificate: **NUM AG**
Battenhusstrasse 16
9053 Teufen
SWITZERLAND

Certification Mark:

Product: **Safety components**

Model(s): **CTMS2912**

Parameters:

Supply voltage:	24VDC (-15%/+20%)
Ambient temperature:	-25°C...+55°C
Protection class:	IP20

Tested according to:
2006/42/EC
EN 61508-1:2010 (SIL1-3)
EN 61508-2:2010 (SIL1-3)
EN 61508-3:2010 (SIL1-3)
EN 62061:2005/A2:2015 (SIL CL3)
EN ISO 13849-1:2015 (Cat 4, PL e)

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. This certificate is valid until the listed date, unless it is cancelled earlier. All applicable requirements of the testing and certification regulations of TÜV SÜD Group have to be complied. For details see: www.tuvsud.com/ps-cert

Test report no.: NT97450T

Valid until: 2024-07-25

Date, 2021-08-27

(Peter Weiß)

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