

# Compact Hardwired Logic Controller M241 System User Guide

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All pertinent state, regional, and local safety regulations must be observed when installing and using this product. For reasons of safety and to help ensure compliance with documented system data, only the manufacturer should perform repairs to components.

When devices are used for applications with technical safety requirements, the relevant instructions must be followed.

Failure to use Schneider Electric software or approved software with our hardware products may result in injury, harm, or improper operating results.

Failure to observe this information can result in injury or equipment damage.

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# Safety Information

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## Important Information

### NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of this symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

## **DANGER**

**DANGER** indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

## **WARNING**

**WARNING** indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

## **CAUTION**

**CAUTION** indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

## **NOTICE**

**NOTICE** is used to address practices not related to physical injury.

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## PLEASE NOTE

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

## BEFORE YOU BEGIN

Do not use this product on machinery lacking effective point-of-operation guarding. Lack of effective point-of-operation guarding on a machine can result in serious injury to the operator of that machine.

### **WARNING**

#### **UNGUARDED EQUIPMENT**

- Do not use this software and related automation equipment on equipment which does not have point-of-operation protection.
- Do not reach into machinery during operation.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

This automation equipment and related software is used to control a variety of industrial processes. The type or model of automation equipment suitable for each application will vary depending on factors such as the control function required, degree of protection required, production methods, unusual conditions, government regulations, etc. In some applications, more than one processor may be required, as when backup redundancy is needed.

Only you, the user, machine builder or system integrator can be aware of all the conditions and factors present during setup, operation, and maintenance of the machine and, therefore, can determine the automation equipment and the related safeties and interlocks which can be properly used. When selecting automation and control equipment and related software for a particular application, you should refer to the applicable local and national standards and regulations. The National Safety Council's Accident Prevention Manual (nationally recognized in the United States of America) also provides much useful information.

In some applications, such as packaging machinery, additional operator protection such as point-of-operation guarding must be provided. This is necessary if the operator's hands and other parts of the body are free to enter the pinch points or other hazardous areas and serious injury can occur. Software products alone cannot protect an operator from injury. For this reason the software cannot be substituted for or take the place of point-of-operation protection.



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Ensure that appropriate safeties and mechanical/electrical interlocks related to point-of-operation protection have been installed and are operational before placing the equipment into service. All interlocks and safeties related to point-of-operation protection must be coordinated with the related automation equipment and software programming.

**NOTE:** Coordination of safeties and mechanical/electrical interlocks for point-of-operation protection is outside the scope of the Function Block Library, System User Guide, or other implementation referenced in this documentation.

## START-UP AND TEST

Before using electrical control and automation equipment for regular operation after installation, the system should be given a start-up test by qualified personnel to verify correct operation of the equipment. It is important that arrangements for such a check be made and that enough time is allowed to perform complete and satisfactory testing.

### CAUTION

#### EQUIPMENT OPERATION HAZARD

- Verify that all installation and set up procedures have been completed.
- Before operational tests are performed, remove all blocks or other temporary holding means used for shipment from all component devices.
- Remove tools, meters, and debris from equipment.

**Failure to follow these instructions can result in injury or equipment damage.**

Follow all start-up tests recommended in the equipment documentation. Store all equipment documentation for future references.

#### **Software testing must be done in both simulated and real environments.**

Verify that the completed system is free from all short circuits and temporary grounds that are not installed according to local regulations (according to the National Electrical Code in the U.S.A, for instance). If high-potential voltage testing is necessary, follow recommendations in equipment documentation to prevent accidental equipment damage.

Before energizing equipment:

- Remove tools, meters, and debris from equipment.
- Close the equipment enclosure door.
- Remove all temporary grounds from incoming power lines.
- Perform all start-up tests recommended by the manufacturer.

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## OPERATION AND ADJUSTMENTS

The following precautions are from the NEMA Standards Publication ICS 7.1-1995 (English version prevails):

- Regardless of the care exercised in the design and manufacture of equipment or in the selection and ratings of components, there are hazards that can be encountered if such equipment is improperly operated.
- It is sometimes possible to misadjust the equipment and thus produce unsatisfactory or unsafe operation. Always use the manufacturer's instructions as a guide for functional adjustments. Personnel who have access to these adjustments should be familiar with the equipment manufacturer's instructions and the machinery used with the electrical equipment.
- Only those operational adjustments actually required by the operator should be accessible to the operator. Access to other controls should be restricted to prevent unauthorized changes in operating characteristics.

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# About the Book

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## At a Glance

### Document Scope

This document describes a generic architecture based on Modicon M241 Logic Controller.

This document is intended to provide a quick introduction to the described system.

It is not intended to replace any specific product documentation, nor any of your own design documentation. On the contrary, it offers additional information to the product documentation for installing, configuring, and implementing the system.

The architecture described in this document is not a specific product in the normal commercial sense. It describes an example of how Schneider Electric and third-party components may be integrated to fulfill an industrial application.

A detailed functional description or the specification for a specific user application is not part of this document. Nevertheless, the document outlines some typical applications where the system could be implemented.

Your specific application requirements may be different and will require additional and/or different components. In this case, you will have to adapt the information provided in this document to your particular needs. To do so, you will need to consult the specific product documentation of the components that you are substituting in this architecture.

Pay particular attention in conforming to any safety information, different electrical requirements, and normative standards that would apply to your adaptation.

There are some major components in the architecture described in this document that cannot be substituted without completely invalidating the architecture, descriptions, instructions, wiring diagrams, and compatibility between the various software and hardware components specified herein.

Be aware of the consequences of component substitution in the architecture described in this document as substitutions may impair the compatibility and interoperability of software and hardware.

### Validity Note

This document has been updated with the release of SoMachine V4.1 SP1 Lexium 28 add-on.

## Related Documents

Title of Documentation	Reference Number
PowerPact Multistandard, Catalogue	LVPE212023EN
The essential guide for power supplies and transformers	DIA3ED2070412EN
Multi 9 System, Catalog	0860CT0201
Phaseo power supplies and transformers, Catalogue Pages	14082-EN
iEM3100 series / iEM3200 series, Energy Meters, User Manual	DOCA0005EN
Control and protection components	MKTED210011EN
Preventa, Machine Safety Products	MKTED208051EN
The essential guide: Preventa machine safety	DIA4ED2041204EN
ATV32 - Safety integrated functions manual	S1A45606
Magelis HMI STU 655/855, User Manual	EIO0000000614
Magelis XBT GC/XBT GK/XBTGT, SoMachine - Combo and Network Drivers	EIO0000000219 (ENG)
Harmony XB5R, ZBRN1/ZBRN2, User Manual	EIO0000001177 (EN)
Harmony XB5R, Expert Instruction Sheet	EIO0000000812 (EN)
Control and signaling components	MKTED208031EN
Modicon M241 Logic Controller, Hardware Guide	EIO0000001456 (ENG)
Modicon M241 Logic Controller, Programming Guide	EIO0000001432 (ENG)
Modicon TM3, Digital I/O Modules, Hardware Guide	EIO0000001408
Modicon TM3, Expansion Modules Configuration, Programming Guide	EIO0000001402
ConneXium Ethernet Switches, TCSESU0••F•N0, Quick Reference Guide	31007950
TeSys U, Starter-controllers, Catalogue	DIA1ED2081003EN
Altivar 32, Variable speed drives for synchronous and asynchronous motors, Installation manual	S1A28686 (ENG)
Altivar 32, Variable speed drives for synchronous and asynchronous motors, Programming manual	S1A28692 (ENG)
LXM28A and BCH2, Servo drive system, Product manual	0198441114054-EN
Detection for automation solutions OsiSense	MKTED210041EN
OsiSense XCC, Rotary Encoders, Catalog	9006CT1101
The essential guide of Detection	DIA4ED2041203EN
Transparent Ready, User Guide	31006929
Modbus Serial Line, Planning and Installation Guide	33003925
SoMachine Programming Guide	EIO0000000067 (ENG)

You can download these technical publications and other technical information from our website at [www.schneider-electric.com](http://www.schneider-electric.com).

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## Product Related Information

### **DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH**

- Disconnect all power from all equipment including connected devices prior to removing any covers or doors, or installing or removing any accessories, hardware, cables, or wires except under the specific conditions specified in the appropriate hardware guide for this equipment.
- Always use a properly rated voltage sensing device to confirm the power is off where and when indicated.
- Replace and secure all covers, accessories, hardware, cables, and wires and confirm that a proper ground connection exists before applying power to the unit.
- Use only the specified voltage when operating this equipment and any associated products.

**Failure to follow these instructions will result in death or serious injury.**

Some of the equipment constituted by the architectures presented herein have been designed to operate outside of any hazardous location. Therefore, only install the equipment herein in zones known to be free of a hazardous atmosphere.

### **DANGER**

#### **POTENTIAL FOR EXPLOSION**

Install and use this equipment in non-hazardous locations only.

**Failure to follow these instructions will result in death or serious injury.**

Consult the individual product documentation of the equipment described in the present document for specific safety information.

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## WARNING

### LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines.<sup>1</sup>
- Each implementation of this equipment must be individually and thoroughly tested for proper operation before being placed into service.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

<sup>1</sup> For additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems" or their equivalent governing your particular location.

## WARNING

### UNINTENDED EQUIPMENT OPERATION

- Only use software approved by Schneider Electric for use with this equipment.
- Update your application program every time you change the physical hardware configuration.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

### Applicable Terminology

The products described in the present document are designed to specific standards and the technical terms, terminology and the corresponding descriptions in this manual are intended to use the terms or definitions of those pertinent standards.

In the area of functional safety systems, drives and general automation, this may include, but is not limited to, terms such as "safety function", "safe state", "fault", "fault reset", "failure", "error", "error message", "dangerous", etc.

Among others, these standards include:

Standard	Description
EN 61131-2:2007	Programmable controllers, part 2: Equipment requirements and tests.
ISO 13849-1:2008	Safety of machinery: Safety related parts of control systems. General principles for design.
EN 61496-1:2013	Safety of machinery: Electro-sensitive protective equipment. Part 1: General requirements and tests.
IEC 61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: General requirements.
IEC 61508-2:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Requirements for electrical/electronic/programmable electronic safety-related systems.
IEC 61508-3:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems: Software requirements.
IEC 61784-3:2008	Digital data communication for measurement and control: Functional safety field buses.
IEC 62061:2005	Safety of machinery. Functional safety of safety-related electrical, electronic, and programmable electronic control systems
2006/42/EC	Machinery Directive
2004/108/EC	Electromagnetic Compatibility Directive
2006/95/EC	Low Voltage Directive

In addition, terms used in the present document may tangentially be used as they are derived from other standards such as:

Standard	Description
IEC 61800 series	Adjustable speed electrical power drive systems
IEC 61158 series	Digital data communications for measurement and control – Fieldbus for use in industrial control systems

Finally, the term "zone of operation" may be used in conjunction with the description of specific hazards, and is defined as it is for a "hazard zone" or "danger zone" in the EC Machinery Directive (EC/2006/42) and ISO 12100-1:2010.





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# Chapter 1

## General Information

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### What Is in This Chapter?

This chapter contains the following topics:

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## Introduction

### Overview

With **Tested Validated Documented Architectures (TVDA)**s, Schneider Electric provides complete controlling system proposals applicable for a wide range of applications.

TVDAs are meant to help you to

- quickly find cost efficient controlling solutions,
- optimize the system implementation time,
- gain a competitive advantage and optimize overall costs for your machine.

With detailed component lists, wiring diagrams, commissioning guides, controller, and HMI applications the effort to assemble and setup the system becomes significantly reduced.

For a high level of reliability and robustness each TVDA is subjected to extensive system validation. Specific performance requirements as well as installation constraints are considered in the system design.

TVDA provide a high level of openness for adaptations. With a clear separated project template structure and dedicated functions embedded in SoMachine and SoMachine Basic, required modifications can be realized quickly.

### **WARNING**

#### **UNINTENDED EQUIPMENT OPERATION**

Thoroughly read and understand any and all device manuals for the characteristics and properties of the devices employed before attempting to modify parameters that may alter those characteristics and properties.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## Deliverables

### SoMachine Project Template

The SoMachine Project Template is comprised of a ready-to-use controller project covering the complete system configuration. Within the project template, you can find preconfigured application code to operate field devices, to monitor the system status, and to handle errors that are detected.

### HMI Application

The HMI application is a ready-to-use interface that can:

- Control the main functionalities of the system
- Indicate the system status
- Visualize the system errors that are detected

### System User Guide (SUG)

The System User Guide provides:

- System documentation with a focus on installation, commissioning, and adaptation of the system
- Bill of Material (BOM), including power distribution components
- Detailed installation information for each component
- Guidance on how to commission the complete system
- Introduction of available ranges and key features of each component used within the architecture
- Guidance on how to adapt the system efficiently by making use of dedicated functions provided within SoMachine software

### Wiring Diagram

The wiring diagrams provide detailed guidance on the system wiring, and are reusable as a base to generate final technical documentation of the controlling system.

The wiring diagrams are provided for download on the Schneider Electric web page [www.schneider-electric.com](http://www.schneider-electric.com) and are available in the following file formats:

- EPLAN Electric P8 V2.4 project archive
- \*.pdf (generated with EPLAN)
- \*.dwg (generated with EPLAN)



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# Chapter 2

## System Architecture

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### What Is in This Chapter?

This chapter contains the following topics:

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## Architecture Related Safety Information

### Remote Devices

Remote control operating devices may lead to unintended equipment operation by:

- incorrect operation
- insufficient view on the machine during operation
- unintentional manipulation

The manufacturer or the operating company of the machine must take precautions to avoid unintentional equipment operation that may be caused by remote control.

### WARNING

#### UNINTENDED EQUIPMENT OPERATION

- Place operator devices of the control system near the machine or in a place where you have full view of the machine.
- Protect operator commands against unauthorized access.
- If remote control is a necessary design aspect of the application, ensure that there is a local, competent, and qualified observer present when operating from a remote location.
- Configure and install the Run/Stop input for the application so that local control over the starting or stopping of the controller can be maintained regardless of the remote commands sent to any controller.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

### Wireless Devices

Data transmission between wireless devices can be influenced by environmental conditions. Especially for portable devices, such as wireless and batteryless push-buttons, the quality of the wireless communication is changing depending on the position of the device to the receiver.

### WARNING

#### LOSS OF CONTROL

- Do not use wireless equipment as the only means of control for critical control functions such as motor start/stop or power disconnect.
- Provide separate or redundant control paths for critical control functions.
- Provide a means to achieve a safe state during and after a path failure for critical control functions such as emergency stop and overtravel stop.
- Improve the reliability of the wireless network by the use of repeater(s).

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## Communication

Fieldbuses or network communication may lead to loss of control by:

- Communication disturbance by external influences (for example wiring or EMC)
- Delay during communication
- Interruption of communication
- Inaccurate communication

### **WARNING**

#### **LOSS OF CONTROL**

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines.<sup>1</sup>
- Each implementation of this equipment must be individually and thoroughly tested for proper operation before being placed into service.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

<sup>1</sup> For additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems" or their equivalent governing your particular location.

## System Architecture

### Overview

The architecture is arranged into the optimized performance class and is distinguished by the following characteristics:

- Modicon M241 Logic Controller
- Magelis touch-panel HMI STU 855
- Energy metering
- Modbus serial line communication
- Ethernet connectivity
- Application of machine functional safety devices
- Wireless and batteryless operator push-buttons
- 46 digital inputs
- 34 digital outputs
- 8 analog inputs
- 2 analog outputs

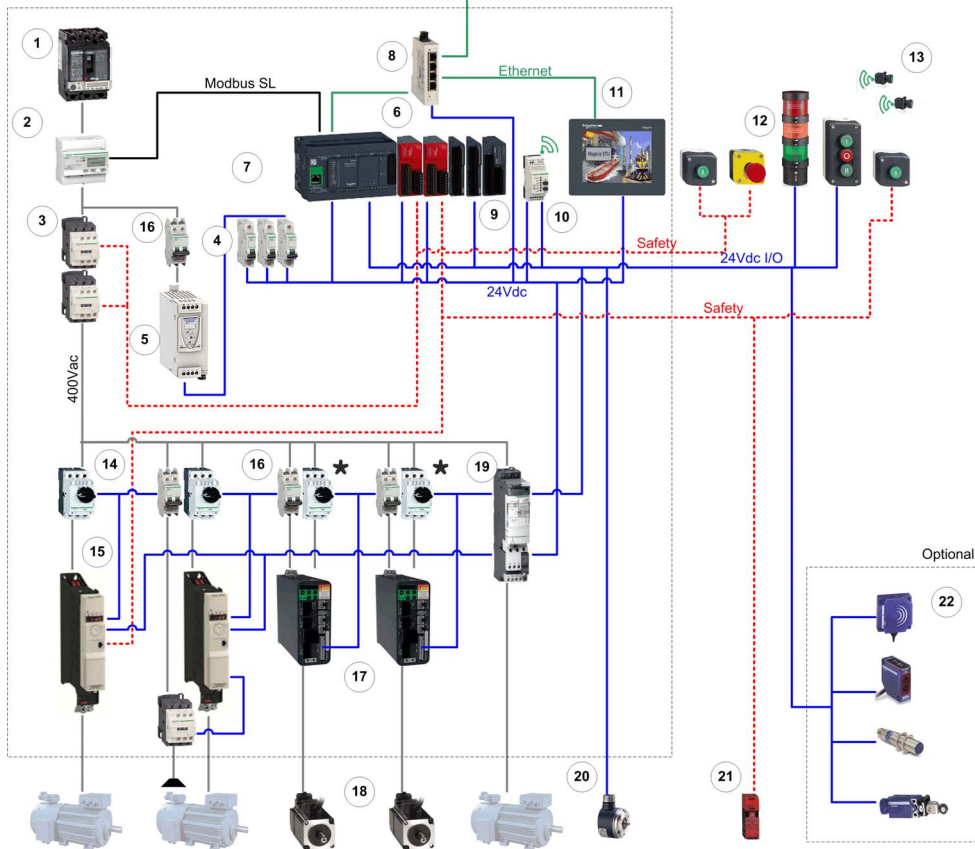
The architecture implements five coordinated drives and one incremental encoder which are linked to the local I/Os of the controller. The control and monitoring of the devices is realized with the controller via hardwired signals.

- 2 Altivar 32
- 1 TeSys U
- 2 Lexium 28
- 1 OsiSense XCC - incremental encoder



Layout

Optimized Compact hardwired logic controller M241



1	PowerPact circuit breaker	12	Harmony signaling/control devices
2	iEM3150 energy meter	13	Harmony wireless push-buttons
3	TeSys D LC1D contactor	14	TeSys GV2 motor circuit-breaker
4	Multi 9 C60 (UL1077) circuit breaker	15	Altivar 32 variable speed drive
5	Phaseo power supply	16	Multi 9 C60 (UL 489) circuit breaker
6	TM3 Preventa safety module	17	Lexium 28 servo drive
7	Modicon M241 Logic Controller	18	Lexium BCH2 servo motor
8	Ethernet switch (unmanaged)	19	TeSys U motor-starter controller
9	TM3 I/O expansion module	20	OsiSense XCC incremental encoder

10	Harmony wireless receiver (ZBRRC)	21	Preventa door-guard switch
11	Magelis HMI STU855 touch panel	22	OsiSense sensors and switches
*	Conformance to standard UL 508C requires that fuses as per UL248 or circuit breakers as per UL489 are used for the branch circuit protection in place of the motor circuit breakers depicted above in front of the Lexium servo drives. For more information, refer to LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.		

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# Chapter 3

## Safety & Safety Requirements

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### What Is in This Chapter?

This chapter contains the following topics:

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## Safety Evolution Structure for the System User Guides

### Overview

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2. Risk assessment (*see page 32*)
3. Functional safety standards overview (*see page 36*)
4. Standard EN ISO 13849-1 machinery safety (*see page 37*)
5. Standard EN/IEC 62061 machinery safety (*see page 45*)
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7. Where to get more information regarding safety (*see page 53*)
  - a. Safety guide
  - b. Sistema
  - c. Sistema library
8. Concept used on specific TVDA

## Evolution of Legal Framework

### EC Directive

Legal instrument to harmonize the legislation of the European member states

- Defines the essential health and safety requirements (EHSRs).
- Transposed into national law (act, decree, order, regulations).

### Standard

A standard is a technical specification approved by a recognized standardization body for repeated or continuous application, with which compliance is not compulsory.

### Harmonized Standard

A standard becomes harmonized when published throughout the member states.

### Presumption of Conformity

- When a product conforms to a harmonized European standard, the reference to which has been published in the official journal of the European Union for a specific directive, and which covers one or more of the essential safety requirements, the product is presumed to comply with those essential safety requirements of the directive.
- In many cases European standards (ENs) are technically similar to international (IEC or ISO) standards. However only European standards include a list of which EHSRs are covered, so only European standards can confer a presumption of conformity.

### European Directives and Safety Standards

Link between some of the main safety standards and the European directives according with the sectors of activity.

Fundamental rights from EU	Free circulation (CE mark)	Workers Protection	Environment Protection
European Union Directive	Machinery 2006/42/EC	Use of Work Equipment 89/391/EC	Seveso II 2008/99/EC96/82/EC
Sector of Activity	Machine Builder	End User System Integrator	End User System Integrator
Safety Standards	Generic Standard EN/IEC 61508	Harmonized Standards EN ISO 13849-1 EN/IEC 62061	EN ISO 13849-1 EN/IEC 62061
		EN ISO 13849-1 EN/IEC 62061	EN/IEC 61511

A list of such standards can be accessed at:

<http://www.newapproach.org/Directives/DirectiveList.asp>

### A, B and C Standards

When a type C standard deviates from one or more provisions dealt with by a type A standard or by a type B standard, the type C standard takes precedence. EN ISO 12100 is type A standards. European standards for the machinery safety form the following structure:

<p><b>Type A standards</b> Basic safety standards giving basic concepts, principles for design, and general aspects that can be applied to all machinery.</p>	
<p><b>Type B standards</b> Generic safety standards dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:</p> <ul style="list-style-type: none"> <li>● Type B1 standards on particular safety aspects (for example, safety distances, surface temperature, noise)</li> <li>● Type B2 standards on safeguards (for example, two-hand controls, interlocking devices, pressure sensitive devices, guards)</li> </ul>	
<p><b>Type C standards</b> Machine safety standards dealing with detailed safety requirements for a particular machine or group of machines.</p>	

Some examples of these types of standards are:

Name	Type	Description
EN ISO 12100	A	2010 Safety of machinery - General principles for design - Risk assessment and risk reduction
EN ISO 13850	B	Emergency stop - Principles for design
EN/IEC 62061	B	Functional safety of safety-related electrical, electronic, and electronic programmable control systems
EN ISO 13849-1	B	Safety of machinery - safety-related parts of control systems - Part 1 general principles for design
EN 349	B	Minimum gaps to avoid crushing of parts of the human body
EN ISO 13857	B	Safety of machinery - safety distances to prevent hazard zones being reached by upper and lower limbs
EN 60204-1	B	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 1088/ISO 14119	B	Interlocking devices associated with guards - Principles for design and selection

### Manufacturers' Responsibilities

Manufacturers placing machines on the market within the European Economic Area (EEA) must comply with the requirements of the machinery directive. Note that "placing on the market" includes an organization supplying a machine to itself, that is, building or modifying machines for its own use, or importing machines into the EEA.

## Users' Responsibilities

Users of machines need to ensure that newly purchased machines are CE marked, and accompanied by a declaration of conformity to the machinery directive. Machines must be used in accordance with the manufacturer's instructions.

Existing machines taken into service before the machinery directive came into force do not need to comply, although they need to comply with the regulations resulting from the use of work equipment directive and be safe and fit for purpose.

Modification of machines can be considered as manufacture of a new machine, even if for use in-house, and the company modifying a machine needs to be aware that it might need to issue a declaration of conformity and CE marking.

## Risk Assessment

### European Legislation

Machines are sources of potential risk and the machinery directive requires a risk assessment to ensure that any potential risk is reduced to less than the acceptable risk.

Standard EN/ISO 12100 defines risk as follows: risk is the severity multiplied by the possibility of occurrence. It defines an iterative process for achieving machine safety, which states that the risks for each potential hazard can be determined in 4 stages.

1. Risk assessment
2. Determination of machine limits
3. Identification of the potential hazard
4. Risk evaluation

This method provides the basis for the requisite risk reduction.

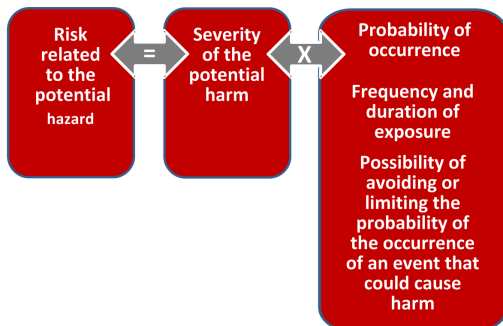
### Risk Assessment

Risk assessment consists of a series of logic steps which make it possible to analyze and evaluate machinery-related risks systematically.

Risk assessment is followed, whenever necessary, by a reduction of the risk.

This definition taken from standard EN/ISO 12100 is based on an iterative process represented in the diagram opposite.

Definition of risk





## Determination of Machine Limits

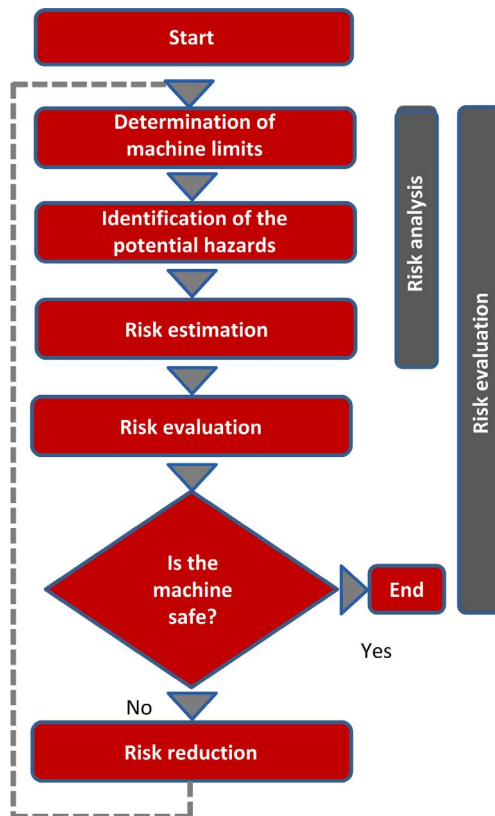
Risk assessment starts by determining the limits of the machine at all stages of its life cycle:

- Transport, assembly, installation
- Commissioning
- Use
- De-commissioning, dismantling

The use limitations must then be specified:

- Operating modes
- Level of training required
- Space limits (amplitude, movement...)
- Time limits (life cycle, frequency of maintenance...)

Logic steps for risk analysis



## Identification of the Potential Hazard

If a potential hazard exists, a hazardous phenomenon will cause harm if measures are not taken. All the tasks associated with the life cycle of a machine must be identified, such as:

- Assembly, transport, and installation
- Adjustment, testing
- Learning, programming
- Tool changing
- Feeding, removal of product from the machine
- Starting, stopping
- Emergency stops, restarting after an unexpected stop
- Maintenance, cleaning, and so on.

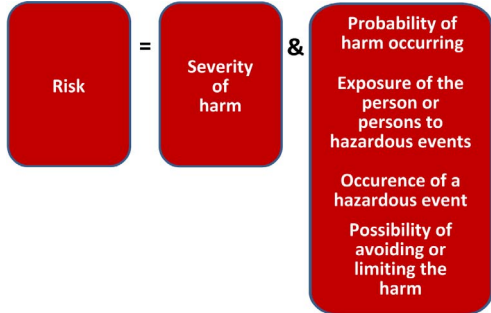
The risk is a function of the severity of the harm and the probability that this harm will occur. The severity of the harm takes into account:

- The severity of injuries (slight, serious, death)
- The extent of the harm (number of persons)

The probability of the harm occurring takes into account:

- Exposure to the hazard (nature of access, time spent in the hazardous zone, number of persons exposed, frequency of access)
- The occurrence of a hazardous event (accident history, comparison of risks, ...)
- The possibility of avoiding or limiting the harm (experience, awareness of the risk, ...)

Elements of the risk



## Risk Evaluation

Based on the risk assessment, the designer has to define the safety-related control system. To achieve that, the designer will choose one of the 2 standards appropriate to the application:

- either standard EN ISO 13849-1, which defines performance levels (PL)
- or standard EN/IEC 62061, which defines safety integrity level (SIL)

## Risk Reduction

The process of risk reduction for dangerous events starts by:

- intrinsic prevention (inherently safe design)
- definition of the appropriate protective means (guards, barriers, fences, ...)
- personnel training

If the selected preventive measure depends on a safety-related control system, the designer has to perform an iterative process for the design of the safety related control system. The first stage is to define the necessary safety-related control functions:

- either through the choice of components
- or by adapting the control system architecture. Redundancy (double circuit components), for example, significantly increases the reliability of the solution

Once the limits of available technologies have been reached; it will not be possible to further reduce the rate of dangerous failures. To achieve the required level of safety, it will be necessary to use a diagnostic system that allows dangerous failures to be detected.

## Functional Safety Standards

### Overview

The functional safety standards are intended to encourage designers to focus more on the functions that are necessary to reduce each individual risk, and on the performance required for each function, rather than simply relying on particular components. These standards make it possible to achieve greater levels of safety throughout the life of a machine.

- Under the previous standard, EN 954-1, categories (B, 1, 2, 3 and 4) dictated how a safety-related electrical control circuit must behave under fault conditions. Designers can follow either EN ISO 13849-1 or EN/IEC 62061 to demonstrate conformity with the machinery directive. These 2 standards consider not only whether a fault will occur, but also how likely it is to occur.
- This means that there is a quantifiable, probabilistic element in compliance: machine builders must be able to determine whether their safety circuit meets the required safety integrity level (SIL) or performance level (PL). Panel builders and designers should be aware that manufacturers of the components used in safety circuits (such as safety detection components, safety logic solvers, and output devices like contactors) must provide detailed data on their products.

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## Standard EN ISO 13849-1 Machinery Safety - Safety-Related Parts of Control System

### Overview

Standard EN ISO 13849-1 is an evolution of standard EN 954-1.

### Field of Application of the Standard

This standard gives safety requirements and advice relating to principles for the design and integration of safety-related parts of control systems (SRP/CS), including software design.

For these parts, it specifies the characteristics, including the performance level, needed to achieve these safety functions. It applies to the SRP/CS of all types of machine, regardless of the technology and type of energy used (electric, hydraulic, pneumatic, mechanical, and so on).

### Process

The risk assessment leads to decisions on risk reduction measures.

It defines a 6-stage design process:

1. Selection of the essential safety functions that SRP/CS must perform. For each safety function, specify the required characteristics.
2. Determine the required performance level (PLr).
3. Design and technical creation of safety functions: identify the parts that perform the safety function.
4. Evaluate the performance level PL for each safety-related part.
5. Check that the performance level PL achieved is greater than or equal to the required level (PLr).
6. Check that all requirements are satisfied.

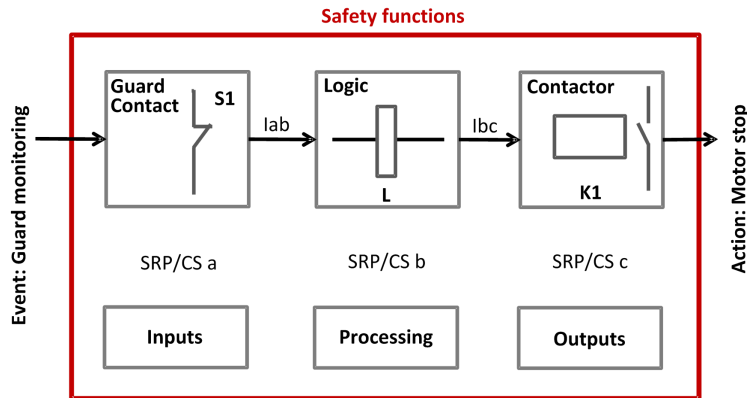
The above 6 stages will be illustrated taking as an example a safety function where a severe injury can be caused by a horizontal movement on a machine not stopping where an operator maybe exposed to this dangerous situation. The machine is sometimes accessed by production workers and monitored during operation.

### Stage 1 - Selection of Safety Functions

The diagram below shows a safety function which consists of several parts:

- The input actuated by opening of the guard (SRP/CSa)
- The control logic, limited in this example to opening or closing of a contactor coil (SRP/CSb)
- The power output that controls the motor (SRP/CSc)
- The connections (Iab, Ibc)

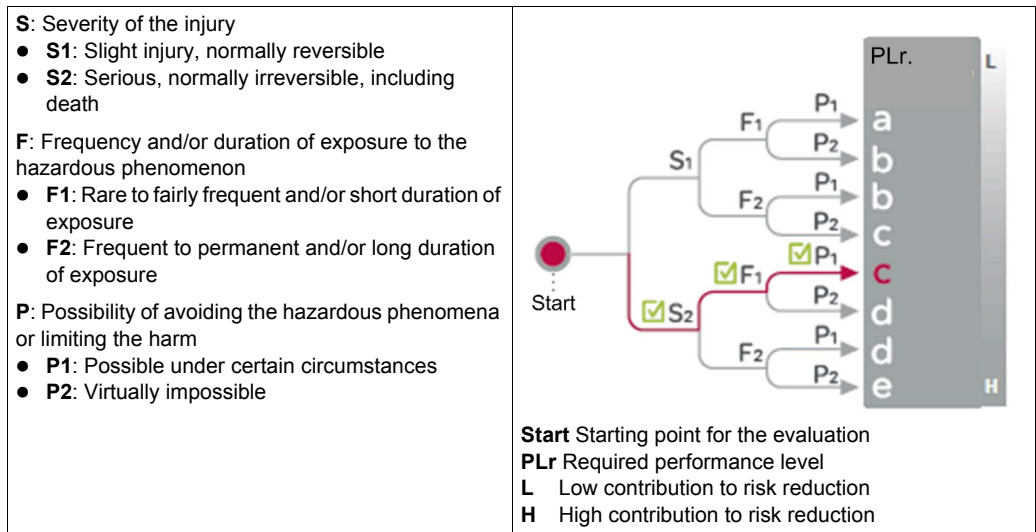
Representation of the safety function



## Stage 2 - Estimation of Required Performance Level (PLr)

Considering the example of the person coming into area where the machine is operating, the risk is estimated using the risk graph.

The parameters to be considered are:



For the example: a serious injury **S2** can be caused by being exposed near the machine as if there is no safe guarding to ensure that the movement will stop the horizontal movement with a load may continue until collision.

After considering the severity of the injury investigate the frequency and/or duration of the possible entry to the dangerous area. Here you define the frequency of exposure to the hazard is low **F1** (occasional presence).

The last step is based upon the possibility to avoid the hazard and limiting the harm. To evaluate this, take into consideration that it is possible to avoid the harm as the visibility around the dangerous machine is monitored by the operator and in this case there is a possibility to avoid the harm under certain conditions so define it as **P1**.

The result of the estimation gives a required performance level **PLr = c**.

### Stage 3 - Design and Creation of the Safety Functions

There is a need to describe the PL (performance level) calculation method.

For a SRP/CS (or a combination of SRP/CS), PL could be estimated with the figure after estimation of several factors such as:

- Hardware and software system structure (categories)
- Mechanism of failures, diagnostic coverage (DC)
- Components reliability, mean time to dangerous failure (MTTF<sub>d</sub>)
- Common cause failure (CCF)

#### Categories (Cat.) and designated architectures

Summarized system behavior in the event of a failure and the principles used to achieve the safety, for the 5 categories defined.

Category	System Behavior	Designated Architecture
B	A fault can lead to loss of the safety function.	
1	As for category B but the probability of this occurrence is lower than for the category B.	
2	A fault can lead to loss of the safety function between 2 periodic inspections and loss of the safety function is detected by the control system at the next test.	
3	For a single fault, the safety function is always ensured. Only some faults will be detected. The accumulation of undetected faults can lead to loss of the safety function.	
4	When faults occur, the safety function is always ensured. Faults will be detected in time to prevent loss of the safety function.	
<p><b>Im</b> Interconnecting means  <b>C</b> Cross monitoring  <b>I, I1, I2</b> Input device, for example sensor  <b>L, L1, L2</b> Logic  <b>m</b> Monitoring  <b>O, O1, O2</b> Output device, for example main contactor  <b>TE</b> Test equipment  <b>OTE</b> Output of TE</p>		



### MTTF<sub>d</sub> (mean time to dangerous failure)

The value of the MTTF<sub>d</sub> of each channel is given in 3 levels (see table below) and shall be taken into account for each channel (for example, single channel, each channel of a redundant system) individually.

Reliability levels of components

Index	Range
Low	3 years $\leq$ MTTF <sub>d</sub> < 10 years
Medium	10 years $\leq$ MTTF <sub>d</sub> < 30 years
High	30 years $\leq$ MTTF <sub>d</sub> < 100 years

A MTTF<sub>d</sub> of less than 3 years should never be found, because this would mean that after 1 year in operation, 30% of all those components in use would have failed to a dangerous state. The maximum value is limited to 100 years because devices dealing with a significant risk should not depend on the reliability of a single component. Additional measures such as redundancy and tests are required.

### Diagnostic coverage (DC)

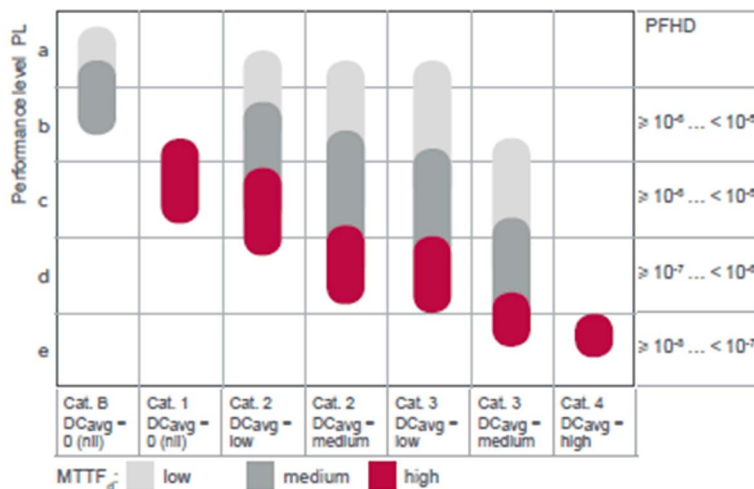
This term is expressed as a percentage and quantifies the ability to diagnose a dangerous failure.

For example, in the event of welding of a N/C contact in a relay, the state of the N/O contact could incorrectly indicate the opening of the circuit, unless the relay has mechanically linked N/O and N/C contacts, when the fault can be detected.

The standard recognizes 4 levels:

Denotation	Range
Nil	DC < 60%
Low	60% $\leq$ DC < 90%
Medium	90% $\leq$ DC < 99%
High	99% $\leq$ DC

The relationship between categories, DC and  $MTTF_d$  of each channel and PL.



Using the above chart you can now select the most appropriate architecture, the required diagnostic coverage as well as ensure the products selected have the right  $MTTF_d$  values.

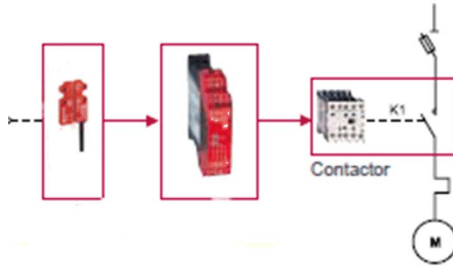
As the example requires PL=c the chart states as a minimum a category 1 architecture with a diagnostic coverage of 0 (Nil) and a  $MTTF_d$  of high is required.

It is possible to use architectures with higher categories to solve the safety function needs.

You start with determining the architecture required to solve the function. Use the following category 1 architecture:

Category	System Behavior	Designated Architecture
1	As for category B but the probability of this occurrence is lower than for the category B.	<pre> graph LR     Event[Event] --&gt; Input[Input]     Input --&gt; Processing[Processing]     Processing --&gt; Output[Output]     Output --&gt; Action[Action]             </pre>

Knowing the architecture it is now possible to select the most appropriate products. Using the offer catalogs you define the products as illustrated below.



The selection of the right products may take several iterations as it is only possible to ensure that the right products are selected after calculations have been made.

#### Stage 4 - Evaluate the Performance Level (PL) for Each Safety-Related Part

Typically the data needed for the calculation of the performance level is being provided by the components supplier.

For safety processing devices the  $MTTF_d$ , DC and performance level values are provided.

For other non-safety components such as contactors, limit switches, and so on, which wear primary as a result of their mechanical actuation,  $B_{10d}$  values are provided by the supplier in some cases. When the  $B_{10d}$  values are not available, the annex C from the 13849-1 standard can be used.

Example	$B_{10d}$ (Where 10% of the Population Fail to Dangerous Failure Mode)	$MTTF_d$	DC
SRP/CS <sub>a</sub> : Magnetic switch	50000000	1578.28	-
SRP/CS <sub>b</sub> : XPS AXE safety module	-	457	99.99%
SRP/CS <sub>c</sub> : TeSys contactor	1369863	194	99%

To estimate the performance level of a safety function, the condition is that the  $MTTF_d$ , the DC, and the category from each component are known. The procedure to follow:

- Calculation of  $MTTF_d$  and DC of the complete system
- Analysis of the category

For electromechanical products:

- The  $MTTF_d$  is calculated based on the total number of operations that the product can perform, using  $B_{10d}$  values.

In this case, the machine operates for 220 days per year, 8 hours per day with a cycle of 90 s

- $N = 220 \times 8 \times (3600 / 90) = 70,400$  operations/year
- $MTTF_d = B_{10d} / (0.1 \times N)$

For the magnetic switch:

- The  $MTTF_d = 1578$  years

For the contactors:

- The  $MTTF_d = (1,369,863) / (0.1) \times 70,400 = 194$  years
- The  $MTTF_d$  for each channel will then be calculated using the formula:

$$\frac{1}{MTTF_d} = \frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}}$$

that is, 284 years

A similar formula is used to calculate the diagnostic capability:

$$DC_{avg} = \frac{\frac{DC_a}{MTTF_{da}} + \frac{DC_b}{MTTF_{db}} + \frac{DC_c}{MTTF_{dc}}}{\frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}}}$$

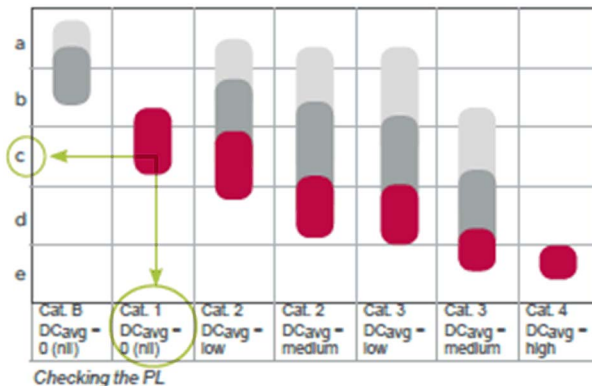
The DC in the example is < 60%, for example nil.

### Stage 5 - Checking That Required Performance Level Is Achieved

The result of the above calculations is summarized below:

- An architecture: category 1
- A mean time to failure > 30 years:  
high  $MTTF_d \gg$  a diagnostic capability < 60% (nil)

Looking at this table, confirms that PL level c is achieved:



### Stage 6 - Validation of the Required Performance Level

The design of SRP/CS must be validated and must show that the combination of SRP/CS performing each safety function satisfies all the applicable requirements of EN/ISO 13849.

## Standard EN/IEC 62061 Machinery Safety - Safety-Related Parts of Control System

### Overview

This standard is specific to the machine sector according to EN/IEC 61508. It gives rules for the integration of subsystems designed in accordance with EN/ISO 13849. It does not specify the operating requirements of non-electrical control components in machines (for example: hydraulic, pneumatic).

### Functional Approach to Safety

As with EN/ISO 13849-1, the process using the EN/IEC 62061 starts with analysis of the risks (EN/ISO 12100) in order to be able to determine the safety requirements.

A particular feature of this standard is that it prompts you to make a functional analysis of the architecture; then split it into subfunctions and analyze their interactions before deciding on a hardware solution for them (the SRECS).

A functional safety plan must be drawn up and documented for each design project. It must include a specification of the safety requirements for the safety functions (SRCF) that is in 2 parts:

- Description of the functions and interfaces, operating modes, function priorities, frequency of operation, and so on.
- Specification of the safety integrity requirements for each function, expressed in terms of SIL (safety integrity level).

The structured and documented design process for safety-related electrical control systems (SRECS):

- The procedures and resources for recording and maintaining appropriate information.
- The process for management and modification of the configuration, taking into account organization and authorized personnel.
- The verification and validation plan

The decisive advantage of this approach is that of being able to offer a failure calculation method that incorporates all the parameters that can affect the reliability of electrical systems, whatever the technology used.

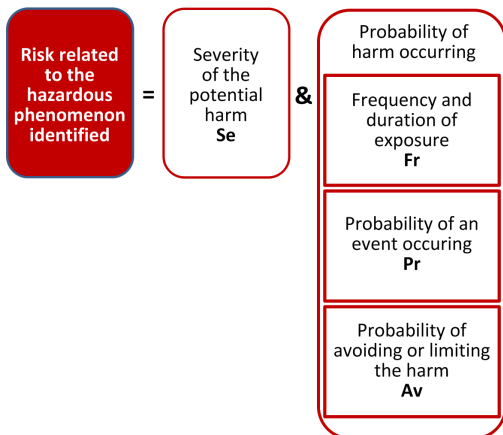
The method consists of assigning a SIL to each function, taking into account the following parameters:

1. The probability of a dangerous failure of the components ( $PFH_d$ )
2. The type of architecture; with or without redundancy, with or without diagnostic device making it possible to avoid some of the dangerous failures
3. Common cause failures (power cuts, overvoltage, loss of communication network, and so on) (CCF)
4. The probability of a dangerous transmission error where digital communication is used
5. Electromagnetic interference (EMC)

### Process

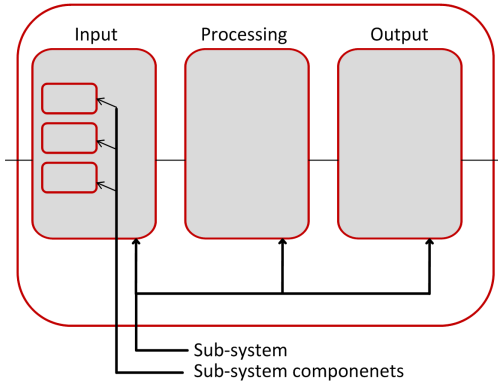
Designing a system is split into 5 stages after having drawn up the functional safety plan:

1. Based on the safety requirements specification (SRS), assign a safety integrity level (SIL) and identify the basic structure of the safety-related electrical control system (SRECS), describe each related function (SRCF)
2. Break down each function into a function block structure (FB)
3. List the safety requirements for each function block and assign the function blocks to the subsystems within the architecture
4. Select the components for each subsystem
5. Design the diagnostic function and check that the specified safety integrity level (SIL) is achieved



### Stage 1 - Assign a Safety Integrity Level (SIL) and Identify the Structure of the SRECS

Based on the risk assessment performed in accordance with standard EN/ISO 12100, estimation of the required SIL is performed for each hazardous phenomenon and is broken down into parameters, see illustration below.



#### Severity Se

The severity of injuries or damage to health can be estimated by taking into account reversible injuries, irreversible injuries, and death.

Consequence	Severity Se
Irreversible: death, loss of an eye or an arm	4
Irreversible: shattered limb, loss of a finger	3
Reversible: requires the attention of a medical practitioner	2
Reversible: requires first aid	1

#### Probability of the harm occurring

Each of the 3 parameters Fr, Pr, Av must be estimated separately using the most unfavorable case. It is strongly recommended that a task analysis model is used in order to ensure that estimation of the probability of the harm occurring is correctly taken into account.

#### Frequency and duration of exposure Fr

The level of exposure is linked to the need to access the hazardous zone (normal operation, maintenance ...) and the type of access (manual feeding, adjustment...). It must then be possible to estimate the average frequency of exposure and its duration.

Frequency of Dangerous Exposure	Fr
≤1 hour	5
> 1 hour...≤1 day	4
>1 day=< 2 weeks	3

Frequency of Dangerous Exposure	Fr
2 weeks ≤ year	2
> 1 year	1

**Probability of occurrence of a hazardous event Pr**

2 basic concepts must be taken into account:

- The predictability of the dangerous components in the various parts of the machine in its various operating modes (normal, maintenance, troubleshooting), paying particular attention to unexpected restarting
- The behavior of the persons interacting with the machine, such as stress, fatigue, inexperience, and so on.

Probability of Occurrence of a Dangerous Event	Pr
Very High	5
Probable	4
Possible	3
Almost impossible	2
Negligible	1

**Probability of avoiding or limiting the harm Av**

This parameter is linked to the design of the machine. It takes into account the suddenness of the occurrence of the hazardous event, the nature of the dangerous component (cutting, temperature, electrical) and the possibility for a person to identify a hazardous phenomenon.

Probability of Avoiding or Limiting the Harm	Av
Impossible	5
Almost impossible	3
Probable	1

**Assignment of the SIL**

Estimation is made with the help of the table below. In the example, the degree of severity is 4 because there is a risk of death; this value is shown in the first column of the table.

All the other parameters must be added together in order to select one of the classes (vertical columns in the table below), which gives:

- Fr = 5; access between 1 hour and a day
- Pr = 2; low probability of occurrence of the hazardous event (for example, operator monitoring)
- Av = 3; probability of avoiding almost impossible

Therefore a class  $CI = 5 + 2 + 3 = 10$



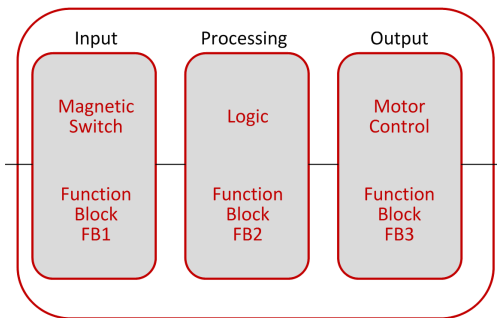
A level of SIL 2 must be achieved by the safety-related electrical control systems (SRECS) on the machine.

Se	Class Cl				
	3-4	5-7	8-10	11-13	14-15
4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3
3	-	-	SIL 1	SIL 2	SIL 3
2	-	-	-	SIL 1	SIL 2
1	-	-	-	-	SIL 1

### Basic structure of the SRECS

Without going into detail about the hardware components to be used, the system is broken down into subsystems. In the example, you find the 3 subsystems that will perform the input, processing, and output functions.

The figure below illustrates this stage, using the terminology given in the standard.



### Stage 2 - Break down Each Function into a Function Block Structure (FB)

A function block (FB) is the result of a detailed breakdown of a safety-related function. The function block structure gives an initial concept of the SRECS architecture. The safety requirements of each block are deduced from the specification of the safety requirements of the system's function.

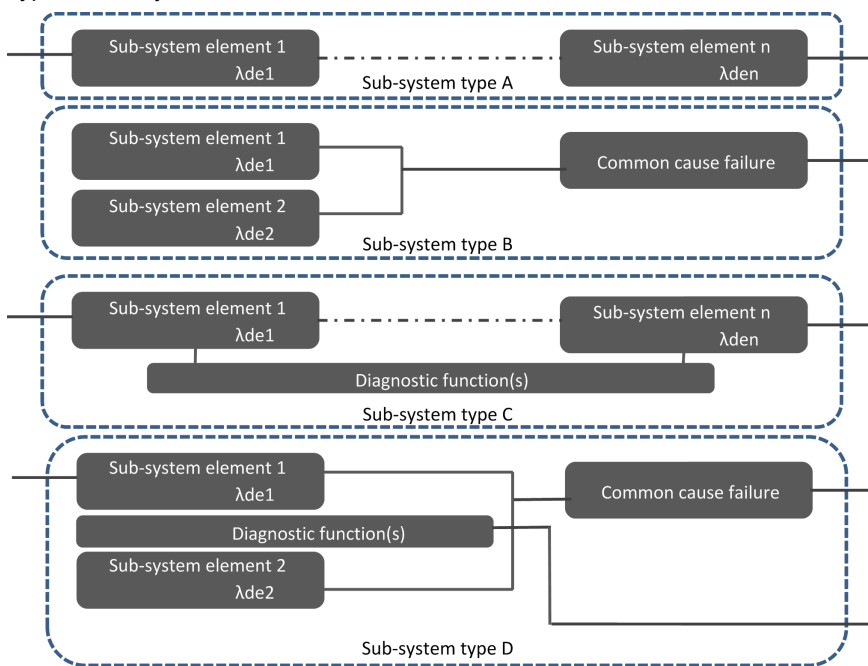
### Stage 3 - List the Safety Requirements for Each Function Block and Assign the Function Blocks to the Subsystems

Each function block is assigned to a subsystem in the SRECS architecture. A failure of any subsystem will lead to the failure of the safety-related control function.

More than one function block may be assigned to each subsystem. Each subsystem may include subsystem elements and, if necessary, diagnostic functions in order to ensure that anomalies can be detected and the appropriate action taken.

These diagnostic functions (D) are considered as separate functions; they may be performed within the subsystem, by another internal or external subsystem.

### Types of subsystem architectures



### Stage 4 - Select the Components for Each Subsystem

As the safety integrity level required in the example mentioned above is SIL 2, each of the components must achieve this level. Once the targeted SIL is determined, the components constructing the system from safety-related subsystems (sensor/switch, logic, actuator) have to be selected. The components must have  $PFH_d$  (probability of dangerous failure per hour) equal to the required SIL rating needed.

### Stage 5 - Design the Diagnostic Function

The SIL of the subsystem depends not only on the components, but also on the architecture selected. In EN 62061, a safety integrity requirement is expressed as a target failure value for the probability of dangerous failure per hour ( $PFH_d$ ) of each safety-related control function (SRCF).

This can be calculated from reliability data for each component or subsystem, and is related to the SIL as shown in table 3 of the standard.

Relationship between SIL and PFH<sub>d</sub> values

SIL	Probability of Dangerous Failures Per Hour (PFH <sub>d</sub> )
3	$\geq 10^{-8} < 10^{-7}$
2	$\geq 10^{-7} < 10^{-6}$
1	$\geq 10^{-6} < 10^{-5}$

For each of the 4 logical architectures A to D presented above, there is a different formula to calculate the PFH<sub>d</sub>. The calculation method is complex and will not be presented here (see EN/IEC 62061 for the formula and the parameters taken into account).

## Selecting the Applicable Standard

### Overview

In order to be able to select the applicable standard, a common table in both standards gives indications which are summarized below:

Technology Used	EN ISO 13849-1 Maximum PL	EN/IEC 62061 Maximum SIL
Non-electric only, for example, hydraulic	e	Not covered
Including some electromechanical, example: relays, and/or complex electronics	e (for designated architectures only)	3
Including complex electronics, for example programmable	D	3

Relationship between the performance level (PL) and the safety integrity level (SIL):

PL	SIL	Probability of Dangerous Failures Per Hour (1/h)
a	No correspondence	$\geq 10^{-5} < 10^{-4}$
b	1	$\geq 3 \times 10^{-6} < 10^{-5}$
c	1	$\geq 10^{-6} < 3 \times 10^{-6}$
d	2	$\geq 10^{-7} < 10^{-6}$
e	3	$\geq 10^{-8} < 10^{-7}$

## More Information Regarding Safety

### Overview

To know more about the relevant regulations, take a look to the safety guide:



<http://www.schneider-electric.com/download/ww/en/details/10101698-Machine-safety-guide/?reference=DIA4ED1100102EN>

### Sistema

For support in creating the safety-related calculations in accordance to EN ISO 13849-1, refer to the free software as well as the related Schneider Electric Sistema offer library.

Sistema:

<http://www.dguv.de/bgja/en/prs/softwa/sistema/index.jsp>

Sistema library:

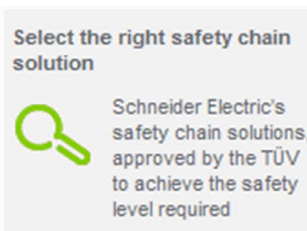
[http://www2.schneider-electric.com/documents/original-equipment-manufacturers/SCHNEIDER-ELECTRIC-SAFETY-EN\\_2012\\_09.zip](http://www2.schneider-electric.com/documents/original-equipment-manufacturers/SCHNEIDER-ELECTRIC-SAFETY-EN_2012_09.zip)

### Safety Chain Solutions

Schneider Electric offers a library of certified safety chain solutions.

Safety chain solutions provide you with a complete document explaining the concept, the used cases, the architecture, wiring diagram as well the complete calculation.

Each of the safety chain solutions is certified by TÜV enabling you to reuse the architectures for your machine and reusing the Sistema calculations as well as the documentation to help certify the machine to the European legislation.



To find more information regarding the safety chain solutions:

<http://www2.schneider-electric.com/sites/corporate/en/solutions/oem/machine-safety/safety-selector.page>

Using the safety chain solutions provided by Schneider Electric to solve the existing architecture:


Step	Action	Comment
1	Perform a risk assessment of your machine.	A required performance level ( <b>PLr</b> ) must be specified for each intended safety function following a risk assessment in accordance to the standard EN ISO 12100.
2	Use the <b>Safety Chain Selector</b> * to find the most appropriated pre-certified architecture.	By answering the questions the most appropriated architectures will be proposed by the tool.
3	Adapt the proposed architecture to meet the needs of your machine risk assessment.	Select other devices to substitute those in the proposed architecture by examining the safety catalog.
4	Create the <b>Systema</b> file based on the used architecture within the <b>Systema</b> tool.	Each architecture, which is provided with the <b>Safety Chain Selector</b> is available as a template in the <b>Systema</b> tool.
5	Adapt the template in the <b>Systema</b> tool based on the adaptations to the architecture and/or substitution of devices done in step 3.	The safety library within the <b>Systema</b> tool contains numerous devices with all required parameters for the calculation.
6	Adapt the number of machine operations within the <b>Systema</b> file for your machine.	Within the template, default values were set and these have to be adapted in order to match the machine requirements.
7	Re-evaluate the achieved performance level.	Verify that the attained performance level by the control system is greater than or equal to the required performance level resulting from the risk assessment in step 1.
8	Document the relevant changes in the <b>Systema</b> file.	Specific information about the machine, the author, and so on, must be documented.
9	Print the <b>Systema</b> file to be used as part of the machine documentation.	It is necessary to provide the documentation about the risk assessment and the calculation of the machine.
* <b>Safety Chain Selector:</b> <a href="http://www2.schneider-electric.com/sites/corporate/en/solutions/oem/machine-safety/safety-selector.page">http://www2.schneider-electric.com/sites/corporate/en/solutions/oem/machine-safety/safety-selector.page</a>		

## Functional Safety Measures Implemented in this Architecture

### Overview

Within the described architecture, there are 2 safety functions covering different risks. These are described in the following sections.

**NOTE:** The safety functions proposed in this architecture do not provide a preferred safety chain solution for your machine. These are proposals as to how a safety function could be realized.



## WARNING

**UNINTENDED EQUIPMENT OPERATION**

Ensure that a risk assessment is conducted and respected according to EN/ISO 12100 during the design of your machine.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

### Emergency Stop

In this TVDA, the safety function emergency stop is applied to disconnect the main power supply of all drives.

This safety architecture is conforming to category 4 EN ISO 13849-1:2008 and is using the stop category 0 in accordance with the standard IEC/EN 60204-1.

The architecture achieves a performance level (PL) of **e** and a safety integrity level (SIL) of **3**.

Used devices:



Device	Description
Input	2 channel emergency stop button Harmony XAL K
Logic	TM3 safety module TM3SAF5R
Output	2 redundant contactors with feedback loop LC1D

## Protective Door Monitoring

In this TVDA, the safety function protective door monitoring is applied to stop the motor driven by an Altivar 32. The uncontrolled stop of the motor is realized using the safety-related input STO (Safe Torque Off) of the Altivar 32.

The safety function STO (Safe Torque Off) only removes power to the motor. However, the drive itself remains under power. Further, the DC bus voltage is still present. If the door monitoring has been triggered because of, for example, the intention to do maintenance, you will need to remove main power even though power has been removed from the motor.

**⚡ ⚠ DANGER**

**ELECTRIC SHOCK, EXPLOSION OR ARC FLASH**

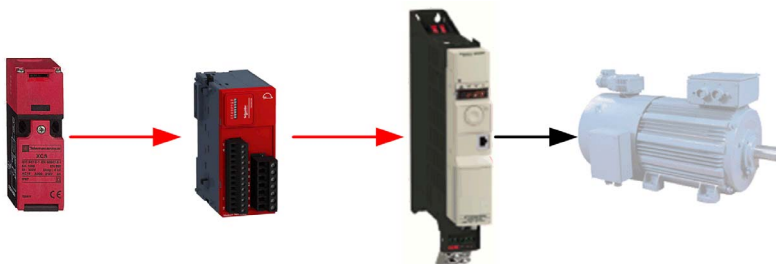
- Turn off the mains voltage using an appropriate switching device to remove power from the drive.
- After removing power, wait for 15 minutes to allow the DC bus capacitors to discharge in the drives.

**Failure to follow these instructions will result in death or serious injury.**

This architecture is conforming to category 3 EN ISO 13849-1:2008 and is using the stop category 0 in accordance with the standard IEC/EN 60204-1.

The architecture achieves a performance level (PL) of **d** and a safety integrity level (SIL) of **2**.

Used devices:





---

Device	Description	Comment
Input	2 channel guard switch Preventa XCS	-
Logic	TM3 safety module TM3SAF5R	-
Output	Variable speed drive Altivar 32 with safety-related input	STO (Safe Torque Off) input of Altivar 32 to disconnect the power stage of the drive

**NOTE:** In this architecture the single channel input with safety function on the Altivar 32 is used. In order to reach a category 3 architecture, it is necessary to use a shielded cable for the wiring. The cable shield must be connected to the protective earth ground. Follow the wiring guidelines from the drive user manual.

The Altivar 32 drive incorporates additional safety-related functions which are not applied in this TVDA. For more information refer to ATV32 - Safety integrated functions manual, S1A45606.



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# Chapter 4

## Hardware

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### Overview

This chapter provides general information about the hardware.

### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
4.1	Electrical Distribution and Monitoring	60
4.2	Safety Modules	72
4.3	HMI	77
4.4	Controller	84
4.5	Communication	92
4.6	Motor Control	94
4.7	Detection	115

## Section 4.1

### Electrical Distribution and Monitoring

---

#### What Is in This Section?

This section contains the following topics:

Topic	Page
PowerPact H-Frame Circuit Breaker - Hardware	61
Multi-9 C60 (UL 1077) Circuit Breaker - Hardware	63
Multi-9 C60 (UL 489) Circuit Breaker - Hardware	65
Phaseo Power Supply Universal - Hardware	66
iEM31xx Energy Meter Series - Hardware	68

## PowerPact H-Frame Circuit Breaker - Hardware

### Front View

PowerPact H-Frame circuit breaker (15...150 A)



### Description

The PowerPact multistandard circuit breakers are designed to help protect electrical systems from damage caused by overloads and short circuits.

Multistandard circuit breakers are available with either thermal-magnetic or Micrologic electronic trip units. Multistandard circuit breakers with thermal-magnetic trip units contain individual thermal (overload) and immediate (short circuit) sensing elements in each pole.

PowerPact multistandard circuit breakers offer high performance and a wide range of interchangeable trip units to protect most applications. Electronic trip units provide highly accurate protection with wide setting ranges and can integrate measurement, metering, and communication functions. They can be combined with the front display module (FDM121) to provide functions similar to a power meter.

Industry-leading multistandard-compliant circuit breakers provide unrivalled reliability for heavy-duty applications. Common catalog numbers, standardized ratings, and a full range of field-installable accessories make product selection, installation, and maintenance easier than ever.

Features	<ul style="list-style-type: none"> <li>● Rated current 15...600 A</li> <li>● Breaking capacity from 18...65 kA at 480 Vac</li> <li>● 3-pole versions</li> <li>● 3 frame sizes: PowerPact H (15...150 A), PowerPact J (150...250 A), and PowerPact L (250...600 A)</li> <li>● Thermal-magnetic and electronic protection available for the entire range</li> <li>● Common accessories and auxiliaries with Compact NSX range</li> <li>● Suitable for isolation</li> <li>● Switch-disconnector versions available</li> <li>● Compliance with IEC 60947-2 and UL 489</li> <li>● Certifications: UL, CSA, CCC</li> </ul>
Benefits	<ul style="list-style-type: none"> <li>● Multistandard compliant: IEC, UL, CSA, CCC</li> <li>● Worldwide available with unique global part numbers</li> <li>● Flexible and simple offer, with proven performance</li> <li>● With direct access to energy metering and energy efficiency thanks to the Micrologic control units</li> </ul>
Applications	<p>Feeder protection and circuit disconnect solutions when a multistandard approach for one global design machine is needed.</p> <ul style="list-style-type: none"> <li>● International &amp; global multi-site OEMs applications</li> <li>● Regional OEMs exporting to USA, with production in different countries, and in need of local support/maintenance.</li> </ul>

For more information, refer to PowerPact Multistandard, Catalogue, LVPED212023EN.

## Multi-9 C60 (UL 1077) Circuit Breaker - Hardware

### Front View

Multi-9 C60 (UL 1077) miniature supplementary protectors



### Description

The Multi-9 supplementary protector line from Schneider Electric is a modular system of supplementary protectors, accessories, and installation equipment that makes up the most complete product offering in its class.

These UL 1077 recognized supplementary protectors provide overcurrent protection in applications where branch circuit protection is either already provided or is not required.

- 0.5...63 A at 480Y/277 Vac
- Up to 10 k AIR
- 1-, 2-, 3-, and 4-pole versions
- Common tripping of all poles
- B-curve 3...5 in. (76.2...127 mm), C-curve 7...10 in. (177.8...254 mm), D-curve 10...14 in. (254...355.6 mm)
- Current limiting capability is standard
- Full line of accessories
- Only 0.71 in. (18 mm) width per pole
- Flush, surface, or DIN rail mountable
- UL 1077, IEC 60947-2, and CE marked

New accessories with UL ratings include the following:

- Comb bus bars - UL recognized comb bus bars for UL 1077 supplementary protectors simplify wiring. They are available in 1-, 2-, and 3-phase versions. They are fixed length of 12 poles and cannot be cut. (A wide variety of IEC rated comb bus bars is also available).
- Tooth caps for the unused teeth of the comb bus Bar are also available. They come in bags of 4 strips of 5 (for a total of 20 poles), but can be snapped apart to be used individually.
- Ring tongue terminal Kit: A field-installable kit provides isolation barriers and ring terminals to convert a standard box lug Multi-9 C60 (UL 1077) miniature supplementary protector.

For more information, refer to Multi 9 System, Catalog, 0860CT0201.



## Multi-9 C60 (UL 489) Circuit Breaker - Hardware

### Front View

Multi-9 C60 (UL 489) miniature circuit breakers



### Description

The Multi-9 C60 (UL 489) miniature circuit breaker is a UL 489 version of the Schneider Electric Multi-9 C60 family of DIN rail mountable circuit protection devices.

UL 489 devices provide branch circuit protection while UL 1077 supplementary protectors do not.

Designed to meet global applications and code requirements, the UL listed Multi-9 breakers are the first product to carry UL 489, IEC 947-2, and CSA C22.2 ratings as well as the CE mark.

The Multi-9 breaker family features an extensive array of accessories.

- 1-, 2-, and 3-pole configurations
- 17 UL 489 ratings 0.5 A...35 A
- 2 trip curves available: C curve (7...10 times handle rating); D curve (10...14 times handle rating)
- Small size: less than 19.05 mm (0.75 in.) wide per pole
- Interrupting ratings 10K AIR standard
- System voltages include 120/240 Vac and 240 Vac; also DC ratings of 60 Vdc (1P) and 125 Vdc (2P)
- Ring terminals available (with finger-safe option)
- Padlock attachments for locking in the "OFF" position only
- Common tripping of all poles
- Variety of accessories including shunt trip, auxiliary switch, and under-voltage release. Same accessories can be used on both UL 1077 and UL 489 devices.
- Mounting base for 12...60 poles.

For more information, refer to Multi 9 System, Catalog, 0860CT0201.

## Phaseo Power Supply Universal - Hardware

### Front View

Phaseo ABL8RPS24100 power supply



### Description

The Phaseo electronic switch mode power supply is designed to provide the DC voltage necessary for the controller and automation system equipment control circuits.

Conforming to IEC standards and UL, CSA, TÜV and C-Tick certified, they are suitable for industrial use.

The ABL8RPS/8WPS range of Phaseo power supplies covers power ratings 72...960 W in 24 Vdc and adapts to most power distribution systems used throughout the world. The same power supply can thus be connected phase to neutral or phase to phase for line supplies ranging 100...500 Vac nominal.

- Local or remote diagnostic functions
- Current limiting or stop in event of an overload
- Function modules to ensure continuity of service
- Power reserve for absorbing the transient current peaks

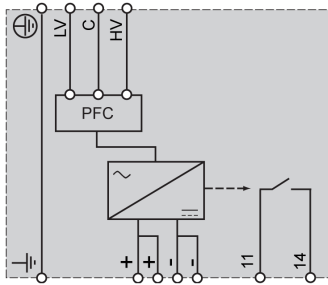
Standards and certifications	UL, CSA, TÜV, C-Tick
Power range	72...960 W
Voltage range	Input: 100...500 Vac Output: 24 Vdc
Degree of protection	IP 20 conforming to IEC 60529
Dimensions	6 different types (W x H x D): 44...165 x 143 x 120...155 mm (1.73...6.5 x 5.63 x 4.72...6.1 in.)

For more information, refer to :

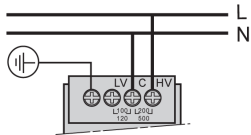
- The essential guide for power supplies and transformers, DIA3ED2070412EN
- Phase0 power supplies and transformers, Catalogue Pages, 14082-EN

## Wiring

Connection overview ABL8RPS24100



Wiring example: 200...500 V single phase



## iEM31xx Energy Meter Series - Hardware

### Front View

The graphic shows the front view of the energy meter iEM3110:



### Description

The Acti 9 iEM3100 Energy Meter series offers a cost-attractive, competitive range of DIN rail-mounted energy meters ideal for subbilling and cost allocation applications. Combined with communication systems such as Smart Link, the Acti 9 iEM3100 series makes it easy to integrate electrical distribution measurements into your facility management systems. The Acti 9 iEM3100 series contains 8 versions of energy meter (for example, iEM3110 and iEM3150) to satisfy basic to advanced applications for buildings and industry, data centers, and networks, infrastructure, and so on.

- Graphical display for easy viewing
- Self-powered meters
- Direct measurement up to 63 A
- Onboard Modbus, LON, M-Bus or BACnet communication
- Commissioning safely with ease
- Compact size

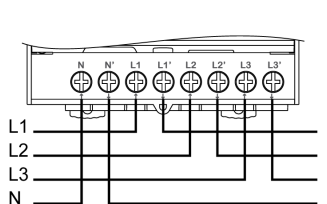
Standards and certifications	IEC 61557-12, IEC 61036, IEC 61010, IEC 62053-21/22 class 1 and 0.5S, IEC 62053-23, EN50470-3
Current (max)	63 A
Models	iEM3100, iEM3110, iEM3115, iEM3135, iEM3150, iEM3155, iEM3165, iEM3175

Functions (depending on the model)	<ul style="list-style-type: none"> <li>● Active energy measurement</li> <li>● Electrical measurements such as I, V, P, and so on.</li> <li>● Alarm</li> <li>● Digital output for pulse</li> <li>● MID (legal metrology certification)</li> </ul>
Degree of protection	<ul style="list-style-type: none"> <li>● front panel: IP40</li> <li>● casing: IP20</li> </ul>
Dimensions	W x H x D: 90 x 95 x 69 mm (3.54 x 3.74 x 2.72 in.)

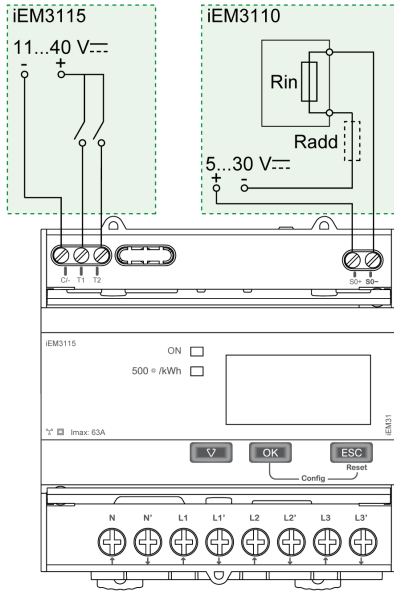
For more information, refer to iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN.

## Wiring

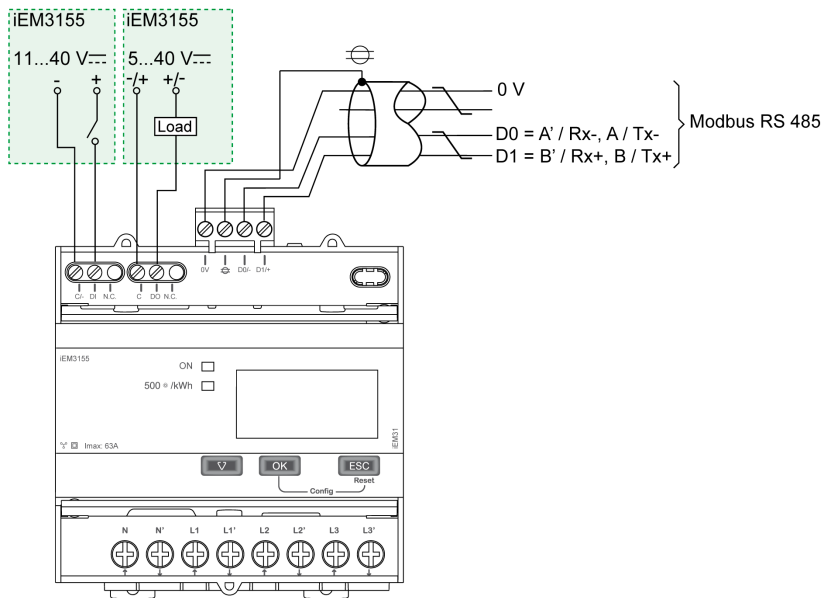
The graphic shows the wiring on three-phase systems for direct measurement of iEM31••



The graphic shows the connection diagram of iEM3100 / iEM3110 / iEM3115:



The figure shows the connection diagram of iEM3150 / iEM3155:



## Section 4.2

### Safety Modules

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#### What Is in This Section?

This section contains the following topics:

Topic	Page
Modicon TM3 Safety Module - Hardware	73
Preventa Detection and Dialog - Hardware	76



## Modicon TM3 Safety Module - Hardware

### Front View

Modicon TM3 safety module



### Description

The Modicon TM3 modular I/O system provides flexible and scalable configuration of expansions by direct connection with M221, M241, and M251 controllers. Characterized by easy wiring and maintenance, this modular I/O system offers a wide variety of modules that enables you to meet your desired configuration for reduced costs and simplification.

The Modicon TM3 modular I/O system contains a range of TM3 safety modules. These Modicon TM3 safety modules contain inputs and relay outputs to manage one safety function at a time. The safety function is realized in the module itself and the monitor and control functions are processed by the controller via the TM3 I/O bus.

There are several types of Modicon TM3 safety modules supporting multiple functions. The achievable Performance Level (PL) according to EN/ISO 13849-1:2008 reaches from PL **d** up to PL **e** and is dependent on the selected module type and the application.

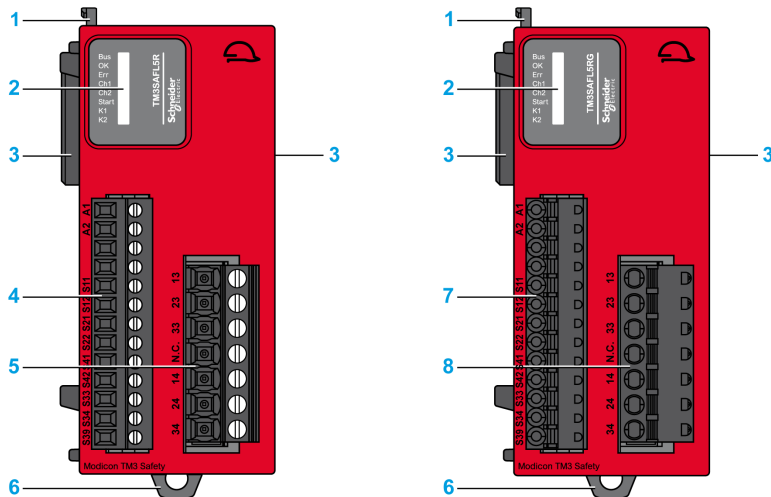
The module used in the described architecture is the TM3SAF5R. The main characteristics are described in the table below.

Max. Performance Level (PL) / Safety Integrity Level (SIL)	Category 4, PL "e" according to EN/ISO 13849-1: 2008, SIL 3 according to IEC/EN 61508-1:2010
Safety function	2 channel operation with cross circuit detection either with monitored or non-monitored start
Standards and certifications	CE For more information on the standards and certifications, refer to the Modicon TM3 Safety Modules, Hardware Guide.
Power supply	24 Vdc (-15...+20 %)
Power consumption	3.6 W (power supply), 0.2 W (TM3 I/O bus)

Input channels	2 safety inputs and 1 start input (monitored or non-monitored)
Output channels	3 relay outputs normally open controlled together, AC-15: 230 V, 5 A per output DC-13: 24 V, 4 A per output
Degree of protection	IP 20

### Components

Modicon TM3 safety module with removable screw or spring terminal block

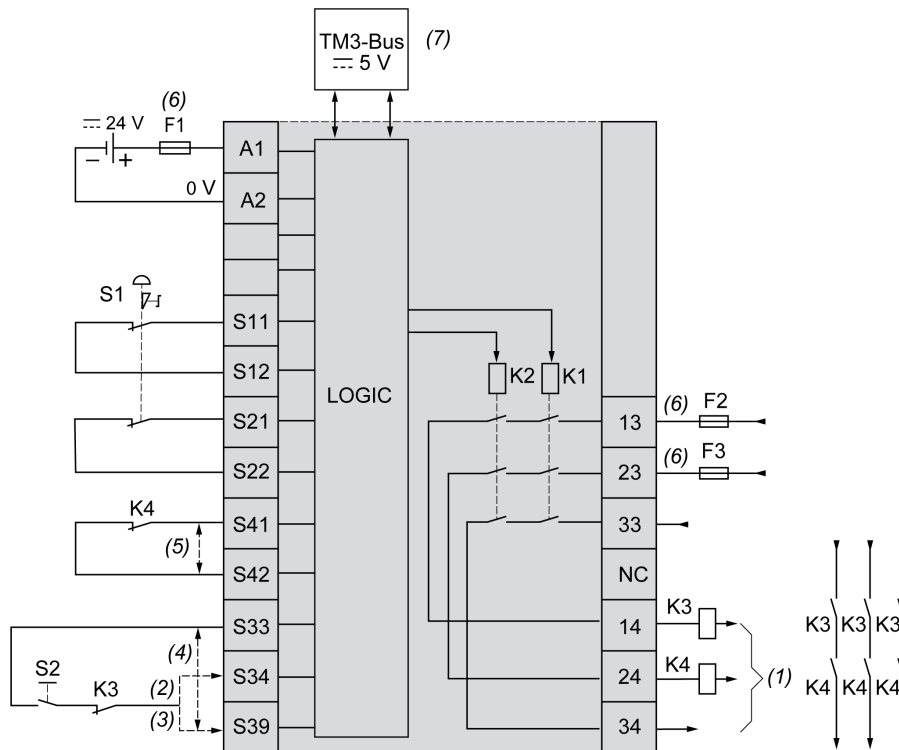


1	Locking device for attachment to the previous module
2	Status LEDs
3	Expansion connector for I/O bus (one on each side)
4	Power supply and input removable screw terminal block with a 3.81 mm (0.15 in) pitch
5	Relay output removable screw terminal block with a 5.08 mm (0.20 in) pitch
6	Clip-on lock for 35 mm (1.38 in.) DIN-rail
7	Power supply and input removable spring terminal block with a 3.81 mm (0.15 in) pitch
8	Relay output removable spring terminal block with a 5.08 mm (0.20 in) pitch

For more information, refer to Modicon TM3 Safety Modules, Hardware Guide, EIO000001831.

## Wiring

Wiring example of emergency stop connection to a TM3SAF5R• module



S1	Emergency stop switch
S2	Start switch
(1)	Safety outputs
(2)	Monitored start
(3)	Non-monitored start
(4)	For automatic start, directly connect <b>[S33]</b> and <b>[S39]</b> terminals
(5)	Second external device monitoring channel. Connect <b>[S41]</b> and <b>[S42]</b> terminals if not used.
(6)	Fuses: Power supply max. 4 A (gG), output max. 4 A (gG) or 6 A (F)
(7)	Non-safety related I/O bus communication with logic controller

## Preventa Detection and Dialog - Hardware

### Front View

Preventa product range



### Description

The Preventa product range, offered under the Telemecanique Sensors brand, consists of safety detection products, safety dialog products, safety motor control products, safety automation products, and so on.

Preventa modules help to easily reach the required safety machinery and standards level in conformance with directives and standards.

The Preventa product range includes: Safety switches, limit switches, light curtains, emergency stop, foot switches, safety modules, and so on.

For more information, refer to

- Preventa solutions for efficient machine safety - catalogue, MKTED2140201EN
- The essential guide: Preventa machine safety, DIA4ED2041204EN

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## Section 4.3

### HMI

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#### What Is in This Section?

This section contains the following topics:

Topic	Page
Magelis HMI STU	78
Harmony XB5R ZBRRC Wireless Access Point - Hardware	81
Harmony Control and Signaling - Hardware	83

## Magelis HMI STU

### Front View

The graphic shows the front of the Magelis HMI STU:



### Description

The Magelis STU panels enhance the Magelis small panel range and thus provide more flexibility, more communication, and easy and fast revolutionary mounting system. The Magelis STU panels are powered by Vijeo-Designer software and bring a cost-effective solution to all machine builders.

Magelis STU terminals are available in 2 sizes and help to enhance the productivity of your machine.

Magelis STU provides the following features:

- High definition color screen TFT QVGA with LED backlight
- 2 screen sizes: 3.5" (HMI STU655) and 5.7" (HMI STU855)
- Tool free mounting with the Schneider Electric 22 mm (0.86 in.) push-button system
- Connectivity via Ethernet (Modbus TCP, Ethernet IP, and PROFINET protocols)
- Interfaces to allow easy maintenance and good peripheral links
- Remote access via WebGate browser and e-mail service

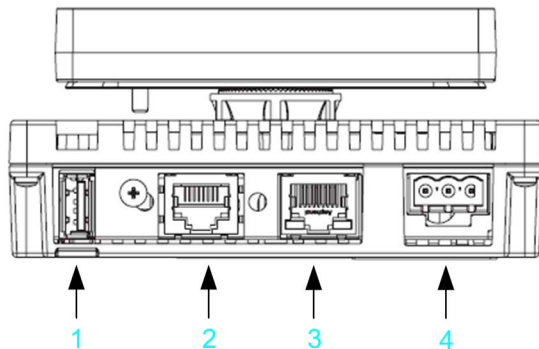
Conformity to standards	EN, IEC, UL 508, ISA 12, CSA, Marine Bridge & Deck, GOST
Power supply	24 Vdc with removable connector
Degree of protection	IP 65

Interfaces	<ul style="list-style-type: none"> <li>● Ethernet port: 1x RJ45</li> <li>● Serial line: 1x RJ45 (COM1: RS 232C / RS-485)</li> <li>● USB: 1x mini-B (2.0) + 1x Type-A (2.0)</li> </ul>
Protocols	<ul style="list-style-type: none"> <li>● Modbus TCP</li> <li>● Ethernet IP</li> <li>● Modbus SL</li> <li>● Uni-Telway</li> </ul>
Display	320 x 240 pixels, 65,536-color TFT
Memory	<ul style="list-style-type: none"> <li>● Application/Backup: 32 Mb/64 Kb</li> <li>● Extension: via USB stick only</li> </ul>
Functions	<ul style="list-style-type: none"> <li>● Real time clock: Access to controller real-time clock</li> <li>● Variables: max. 8000</li> </ul>
Dimensions (W x H x D)	<ul style="list-style-type: none"> <li>● Front 3.5": 98 x 81 x 6 mm (3.858 x 3.188 x 0.629 in.)</li> <li>● Front 5.7": 163 x 129.5 x 17.5 mm (6.42 x 5.09 x 0.69 in.)</li> <li>● Rear module: 118 x 98 x 30 mm (4.64 x 3.85 x 1.18 in.)</li> <li>● Cut-out (diameter: 22 mm / 0.86 in.)</li> </ul>

For more information, refer to , Magelis HMI STU 655/855, User Manual, EIO0000000614.

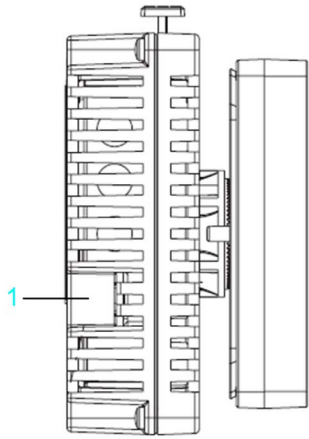
## Wiring

Bottom view of the connector:



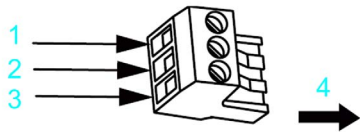
- 1 Standard A USB port connector
- 2 Serial I/F (host I/F 8-pin RJ45)
- 3 Ethernet interface (LAN)
- 4 Power input terminal block

Side view of the connector:



1 Mini-B USB port connector

The graphic shows the power plug:



- 1 + / 24 Vdc
- 2 - / 0 Vdc
- 3 FG / grounded terminal connected to the unit chassis
- 4 Insertion direction



## Harmony XB5R ZBRRC Wireless Access Point - Hardware

### Front View

Harmony ZBRRC receiver



### Description

Harmony XB5R wireless and batteryless push buttons are used for remote control with an access point. This allows more flexibility and simplicity in the installation.

The control is realized via radio transmission. Each transmitter is equipped with a generator that converts the mechanical energy produced by pressing the push button into electrical energy.

A radio-coded message with a unique ID code will be sent in a single pulse to one or more receivers. These receivers can be located several tens of meters away.

The access point processes the received radio frequency inputs and provides them via 4 transistor outputs as a 24 Vdc signal.

Wireless and batteryless push-button technology reduces the wiring and hence the cost of installation. They have a wide range of industrial and building applications such as:

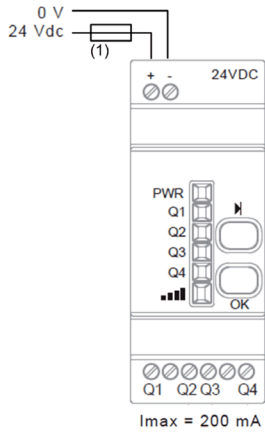
- packing lines
- automatic doors in logistic centers
- automobile industries
- bag filling in cement industries
- office lighting for efficient usage of the power

Standards and certifications	BT2006/95EC, CE: R:TTE1999/5/EC, EMC2004/108/EC, C-Tick, UL, CSA, CCC, Gost, RSS, ANATEL, SRRRC, FCC, ICASA, ARIB T66
Rated voltage	24 Vdc
Degree of protection	IP 20
Dimensions	W x H x D: 36 x 108 x 70.66 mm (1.42 x 4.25 x 2.78 in.)

For more information, refer to Harmony XB5R, Expert Instruction Sheet, EIO000000812 (EN).

## Wiring

### Wiring example Harmony XBRRC



(1) 500 mA fuse fast-blow

## Harmony Control and Signaling - Hardware

### Front View

Harmony product range



### Description

Schneider Electric offers a comprehensive range for control and signaling in industrial and commercial applications. All aspects of control and signaling needs are catered for including pilot devices such as push-buttons, indicator lamps, selector switches, and joysticks for standard hole cutouts.

For more information, refer to Control and signaling components, MKTED208031EN.

## Section 4.4 Controller

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### What Is in This Section?

This section contains the following topics:

Topic	Page
Modicon M241 Logic Controller - Hardware	85
Modicon TM3 Modules - Hardware	90

## Modicon M241 Logic Controller - Hardware

### Front View

Modicon M241 Logic Controller



### Description

The Modicon M241 Logic Controller is a control system that offers an all-in-one solution with optimized configurations and an expandable architecture.

The Modicon M241 Logic Controller has various powerful features and can service a wide range of applications. Software configuration, programming, and commissioning are accomplished with the SoMachine software.

Thanks to the SoMachine software platform it offers optimized solutions for speed control, counting, axis control and communication functions.

The SoMachine software, used to configure and program the Modicon M241 Logic Controller, supports the following IEC61131-3 programming languages for use with these controllers:

- IL: Instruction List
- LD: Ladder Diagram
- ST: Structured Text
- FBD: Function Block Diagram
- SFC: Sequential Function Chart

SoMachine software can also be used to program this controller using CFC (Continuous Function Chart) language.

The following communication functions, depending on the model, are supported by the controllers:

- Ethernet
- USB programming
- Serial line
- CANopen Master

The following embedded I/O types are available, depending on the controller reference:

- Regular inputs
- Fast inputs associated with counters
- Regular transistor outputs
- Fast sink/source transistor outputs associated with pulse generators

All controllers support up to 21 application program tasks with the following limits:

- 4 cyclic tasks: one is configured by default (MAST)
- 1 freewheeling task
- 8 software event driven tasks
- 8 hardware event driven tasks

Standards and certifications	IEC/EN 61131-2, UL 508
Rated voltage	24 Vdc
Degree of protection	IP 20 with protective covers in place
Memory	RAM: 64 Mbytes (to execute the application) Flash: 128 Mbytes (to save in case of power outage)
Dimensions	Device-dependent (W x H x D): 150/190 x 94.5 x 87.5 mm (5.9/7.48 x 3.72 x 3.45 in.)
Options	<ul style="list-style-type: none"> <li>● TM2 modules</li> <li>● TM3 modules</li> <li>● TM4 modules</li> <li>● TMC4 cartridges</li> </ul>

For more information, refer to :

- Modicon M241 Logic Controller, Hardware Guide, EIO0000001456 (ENG)
- Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG)

## Interfaces

Device	CAN	USB Prg	Ethernet	Serial Line
TM241C24T	0	1	0	2
TM241C24U	0	1	0	2
TM241CEC24T	1	1	1	2
TM241CE24U	0	1	1	2
TM241C40T	0	1	0	2
TM241CE40U	0	1	0	2
TM241CE40T	0	1	1	2
TM241CE40U	0	1	1	2
TM241CE24T	0	1	1	2
TM241CEC24U	1	1	1	2

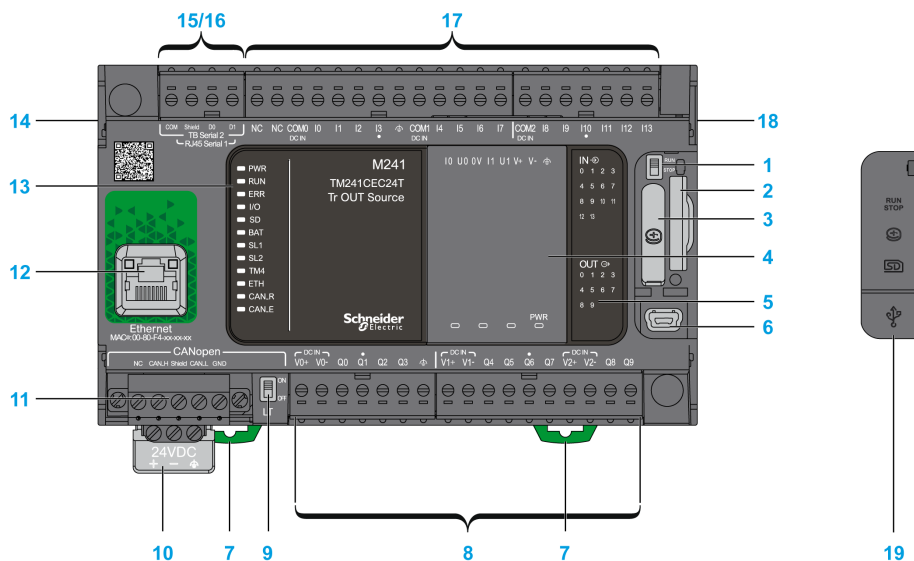
## Embedded I/Os

Device	Fast Inputs	Fast Outputs	Digital Regular Inputs	Digital Regular Transistor Outputs
TM241C24T	8	4	6	6
TM241C24U	8	4	6	6
TM241CEC24T	8	4	6	6
TM241CE24U	8	4	6	6
TM241C40T	8	4	16	12
TM241CE40U	8	4	16	12
TM241CE40T	8	4	16	12
TM241CE40U	8	4	16	12
TM241CE24T	8	4	6	6
TM241CEC24U	8	4	6	6

You can expand the number of I/Os for your controller by adding expansion I/O modules.

## Controller Components

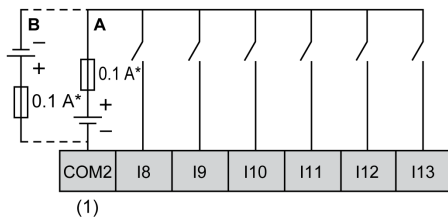
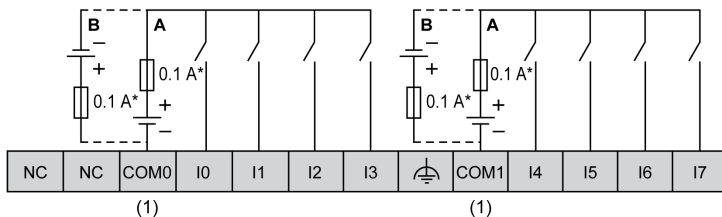
### TM241CEC24T



1	Run/Stop switch	11	CANopen / screw terminal block type
2	SD card slot	12	Ethernet / type RJ45 (RS-232 or RS-485)
3	Battery	13	Status LED
4	Removable cartridge cover	14	TM4 bus connector
5	I/Os status LEDs	15	Serial line port 1 / type RJ45 (RS-232 or RS-485)
6	USB mini-B programming port / for terminal connection to a programming PC (SoMachine)	16	Serial line port 2 / screw terminal block type (RS-485)
7	Clip-on lock for 35 mm (1.38 in.) top hat section rail (DIN-rail)	17	Embedded digital inputs, input removable terminal block
8	Embedded digital outputs Output removable terminal block	18	TM3/TM2 bus connector
9	Link termination switch	19	SD card slot, Run/Stop switch, and USB mini-B programming port protective cover
10	24 Vdc power supply	-	-

### Wiring

Connection of the inputs of the controller to the sensors



\* Type T fuse

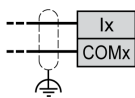
(1) The COM0, COM1, and COM2 terminals are **not** connected internally

**A** Sink wiring (positive logic)

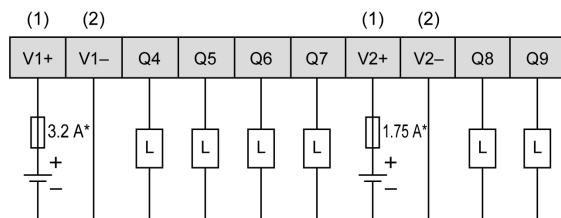
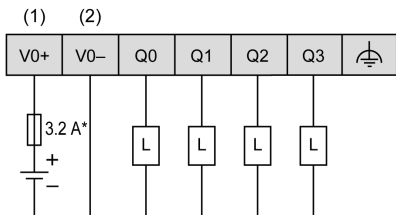
**B** Source wiring negative logic



Fast input wiring for I0...I8



Connection of the outputs of the controller to the pre-actuators

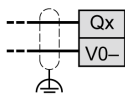


\* Type T fuse

(1) The V0+, V1+ and V2+ terminals are **not** connected internally.

(2) The V0-, V1-, and V2- terminals are **not** connected internally

Fast output wiring for Q0...Q3



## Modicon TM3 Modules - Hardware

### Front View

Modicon TM3 Modules



### Description

The Modicon TM3 modular I/O system provides flexible and scalable configuration of expansions by direct connection with M221, M241, and M251 controllers. Characterized by easy wiring and maintenance, this modular I/O system offers a wide variety of modules that enables you to meet your desired configuration for reduced costs and simplification.

Flexible and scalable I/O configuration:

- Local or remote expansion via the local TM3 expansion bus on M221, M241, and M251 controllers.
- Wide range of I/O expansion modules:
  - Digital I/O modules
  - Analog I/O modules
  - Expert I/O modules
  - Safety I/O modules
  - Transmitter and receiver modules

Simplified maintenance installation:

- Embedded diagnostics for local and distant supervision
- Wiring simplicity: spring terminals, removable terminal blocks

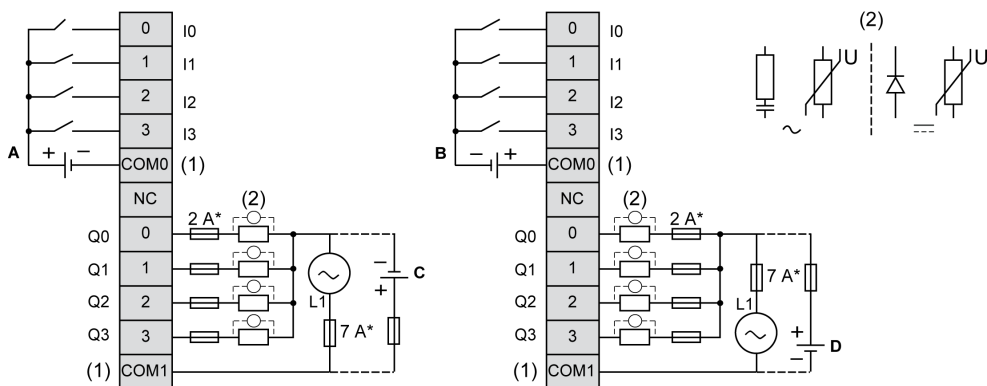
Standards and certifications	IEC/EN 61131-2 ed. 3 2007, UL 508, CSA 22.2 No. 142, CE
Power supply	24 Vdc or 120 Vac* * only TM3DI8A
Degree of protection	IP 20

Dimensions	One assembled integral module (W x H x D): 21.4...42.9 x 94.5...95 x 81.3...88.1 mm (0.84...1.69 x 3.72...3.74 x 3.2...3.47 in.)
------------	---

For more information, refer to Modicon TM3, Expansion Modules Configuration, Programming Guide, EIO0000001402.

## Wiring

### Wiring example TM3DM8R



\* Type T fuse

(1) The COM0 and COM1 terminals are **not** connected internally.

(2) To improve the life time of the contacts, and to protect from potential inductive load damage, you must connect a free wheeling diode in parallel to each inductive DC load or an RC snubber in parallel of each inductive AC load.

**A** Sink wiring (positive logic)

**B** Source wiring (negative logic)

**C** Source wiring (positive logic)

**D** Sink wiring (negative logic)

## Section 4.5 Communication

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### ConneXium Ethernet Switch (Unmanaged) - Hardware

#### Front View

5-port TCSESU053FN0 Ethernet switch (unmanaged)



#### Description

The ConneXium unmanaged Ethernet switch range offers you a smart and flexible way to integrate Ethernet solutions into your operation, from the device level to the control network and to your corporate network.

Unmanaged devices are those which there is no possibility to configure or control any of the parameters of the devices. They support Ethernet 10 Mbit/s and Fast Ethernet 100 Mbit/s.

Furthermore the switch modules support switched Ethernet networks in accordance with IEEE standard 802.3 or 802.3u using copper and fiber optic technology.

All switches are mounted on a standard DIN rail.

- Multi-address capability
- Storage and rerouting of received data
- Data packets with VLAN tags are transmitted unchanged (IEEE 802.1 Q)
- Automatic negotiation of 10/100 Mbit/s and duplex mode

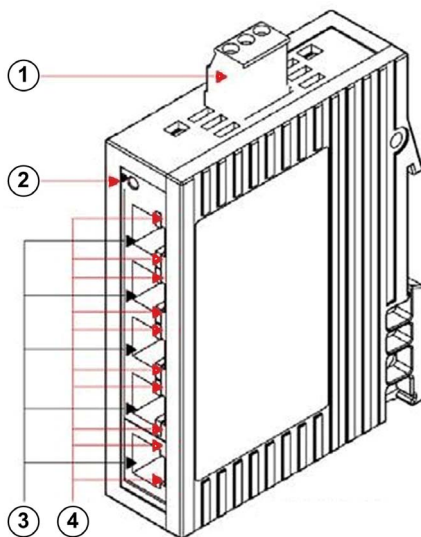
- Automatic change of polarity
- Low-cost wiring solution

Standards and certifications	UL508, CSA 22.2 No.142, CE
Power supply	24 Vdc
Operating voltage	9.6...32 Vdc
Ports	3, 4, 5,8
Degree of protection	IP 30
Dimensions	W x H x D: 25 x 114 x 79 mm (0.98 x 4.49 x 3.1 in.) (TCSESU053FN0)

For more information, refer to *ConneXium Ethernet Switches, TCSESU0••F•N0, Quick Reference Guide, 31007950*.

## Wiring

TCSESU053FN0 connector overview



- 1 3-pin terminal block for power supply
- 2 Power indicator
- 3 10/100 base-TX (RJ45) connectors
- 4 Port ACT/LNK LEDs

## Section 4.6

### Motor Control

---

#### What Is in This Section?

This section contains the following topics:

Topic	Page
TeSys D Contactor - Hardware	95
TeSys GV2 Motor Circuit Breakers - Hardware	97
TeSys U LU2B Motor Starter- Hardware	99
Altivar 32 Variable Speed Drive - Hardware	103
Lexium 28 Servo Drive - Hardware	107

## TeSys D Contactor - Hardware

### Front View

TeSys D-LC1D contactor



### Description

TeSys D-LC1D contactors are designed for all power switching, control applications, and integration into control systems.

They conform to standard IEC 60947-4-1, for utilization categories AC6b, as well as to UL/CSA standards.

This product constitutes a ready-to-use solution and offers you quick simple setup.

TeSys D contactors can be used to create motor starters for any type of application.

- AC, DC, and low-consumption DC control circuit
- All types of starter: reversing or non-reversing, star/delta, by auto-transformer, and so on.
- Various connectors: spring terminal, EverLink terminal block, screw clamp, ring-type connection, faston connector
- Easy and simple direct mounting between contactor and circuit breaker, according to EverLink terminal block (40...65 A)

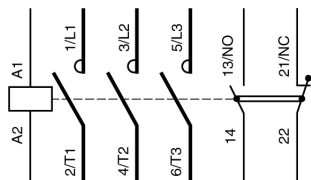
Standards and certifications	IEC/EN 60947-4-1, IEC/EN 60947-5-1, UL 508, CSA C22.2 n° 14, UL, CSA, CCC, GOST, GL, DNV, RINA, VB, LROS
Rated operational current (Ie) in AC-3 (Ue max. 440 V)	9...150 A
Rated control circuit voltage (Uc)	12(24*)...690(500*) Vac 12(24*)...440 Vdc *D115 and D150
Degree of protection (front face)	IP 20 (conforming to IEC 60529)
Protective treatment	"TH" (conforming to IEC 60068-2-30)

Dimensions	19 different types without add-on blocks or cover (WxHxD): 45...155 x 77...158 x 84...132 mm (1.77...6.1 x 3.0...6.22 x 3.3...5.2 in.)
Options	Various connector types, wide range of auxiliary contact blocks and modules, power connection accessories, suppressor modules

For more information, refer to Control and protection components, MKTED210011EN.

### Wiring

TeSys D09...150 3-pole contactors wiring diagram





## TeSys GV2 Motor Circuit Breakers - Hardware

### Front View

TeSys GV2 P motor circuit breaker



### Description

The large TeSys motor circuit-breakers range GV2, GV3 and GV7 is categorized according to their level of performance and functions. Due to its diverse characteristics, only the GV2 P is presented and integrated into the TVDA.

The TeSys GV2 P motor circuit-breakers are three-pole thermal-magnetic circuit-breakers designed for the control and protection of motors.

The motor protection is provided by the thermal-magnetic elements incorporated in the industrial motor circuit-breaker.

The magnetic elements (short-circuit protection) have a non-adjustable tripping threshold, which is equal to 13 times the maximum setting current of the thermal trips.

The thermal elements (overload protection) include automatic compensation for ambient temperature variations. The addition of an under voltage trip allows the circuit-breaker to be de-energized in the event of an under voltage condition.

- Motor and personnel protection
- Live parts are protected from direct finger contact
- Compact size
- Easy to install: screw mounting or clip-on mounting
- Control by rotary knob
- Connection by screw clamps

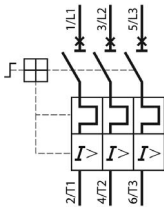
Standards and certifications	IEC 60947-1, 60947-2, 60947-4-1, EN 60204, UL508, CSA C 22.2 n° 14-05, NF C 63-650, 63-120, 79-130, VDE 0113, 0660, UL*, CSA, PTB, EZU, GOST, TSE, DNV, LROS, GL, BV, RINA, CCC, ATEX  *UL508 type E for GV2 P••H7 (line spacer included)
Operational voltage	690 V

Degree of protection	IP 20
Dimensions	W x H x D: 44.5 x 89 x 97 mm (1.75 x 3.5 x 3.82 in.)
Options	<ul style="list-style-type: none"> <li>● Combination block</li> <li>● Sets of 3-pole busbars</li> <li>● Protective end cover</li> <li>● Terminal blocks</li> <li>● Padlock able external operator</li> <li>● Contact blocks: Error signaling contact and immediate auxiliary contacts</li> <li>● Undervoltage/Shunt trips</li> <li>● Padlocking devices</li> </ul>

For more information, refer to Control and protection components, MKTED210011EN.

### Wiring

TeSys GV2 P contactors wiring diagram



## TeSys U LU2B Motor Starter- Hardware

### Front View

TeSys U LU2B\*\* motor starter



### Description

The TeSys U starter-controller is a Direct On Line (D.O.L.) starter which performs the following functions:

- Protection and control of single-phase or three-phase motors:
  - isolation and breaking function
  - overload and short-circuit protection
  - thermal overload protection
  - power switching
- Control of the application:
  - protection function indication
  - application monitoring (running time, number of errors detected, motor current values, and so on)
  - logs (last five errors detected are saved, along with motor parameter values)

These functions can be added by selecting control units and function modules which clip into the power base. This late customization is also possible after power and control circuit wiring has been completed.

From design through to operation, TeSys U offers advantages and simplifies the selection of components in comparison with a traditional solution.

- The braking, isolation, and contactor functions are incorporated in a single block. Therefore, there are fewer references to be ordered and selection is easy because a single reference covers most needs up to 15 kW.
- The control unit has a wide setting range. It can operate on a DC or an AC supply.

The compact components in the TeSys U range are mounted on a single rail, optimizing the amount of space required in enclosures. As power wiring between the circuit-breaker and contactor is not needed, TeSys U reduces installation times.

Setting-up accessories simplify or eliminate wiring between components, and allow easy selection and ordering.

With a capacity of up to 32 A/15 kW, TeSys U consists of:

- One 45 mm (1.77 in.) power base: two ratings, reversing or non-reversing, circuit-breaker function, and built-in interference suppression
- One clip-on control unit:
  - Standard CU: protection against overloads and short-circuits
  - Expandable CU: additional alarm and error differentiation
  - Multifunction CU: real-time control of motor load, local or remote diagnostics and parameter setting
- One clip-on automation control module: Modbus SL RS-485 2-wire, CANopen, AS-Interface, PROFIBUS DP, Ethernet, DeviceNet, Fipio, Interbus S via Advantys STB module or a simple parallel link
- Two optional 45 mm (1.77 in.) power functions: limiter-isolator and changeover relay

Standards and certifications	IEC/EN 60947-6-2, CSA C22-2 N° 14, Type E, UL508 type E: with phase barrier LU9SP0, UL, CSA, CCC, Gost, ASEFA, ABS, BV, DNV, GL, LROS, ATEX
Power range	0...15 kW at 400 V
Rated insulation voltage	<ul style="list-style-type: none"> <li>● Conforming to IEC/EN 60947-1, overvoltage category III: 690 V</li> <li>● Conforming to UL508, CSA C22-2 n° 14: 600 V</li> </ul>
Degree of protection	<ul style="list-style-type: none"> <li>● Front panel outside connection zone: IP 40</li> <li>● Front panel, wired terminals, and other faces IP 20</li> </ul>
Dimensions	W x H x D: LUB: 45 x 154 (224*) x 135 mm (1.77 x 6.1 (8.8*) x 5.3 in.) *LU2B (reversible)

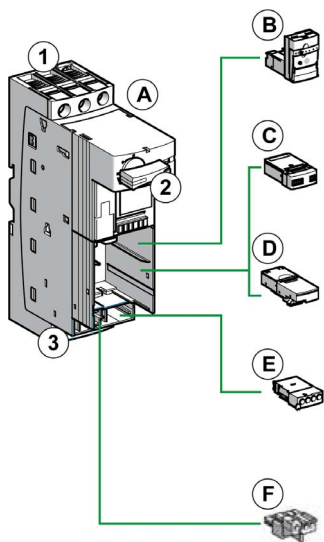
Options	<ul style="list-style-type: none"> <li>● Four different control units</li> <li>● Error signaling modules</li> <li>● Communication modules</li> <li>● Auxiliary contact modules</li> <li>● Load level modules</li> <li>● Reverser block</li> <li>● Plug-in terminal blocks</li> <li>● Control circuit pre-wiring system</li> </ul>
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For more information, refer to :

- Control and protection components, MKTED210011EN
- TeSys U, Starter-controllers, Catalogue, DIA1ED2081003EN

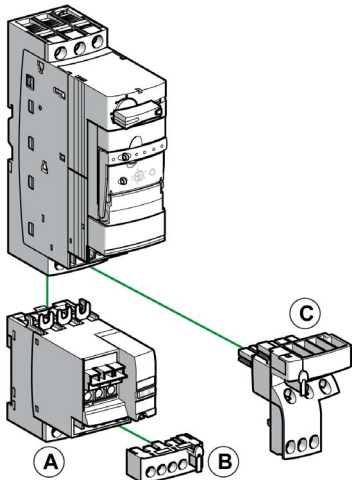
## Components

TeSys U - non-reversing



- 1 Power supply terminal block
  - 2 On/Off/Reset control handle
  - 3 "Motor" terminal block
- A Power base
- B Control units
- C Auxiliary contact modules (LUF), thermal overload signaling, error signaling modules, or load level modules
- D Communication modules
- E Auxiliary contact module (LUA)
- F Terminal block

### TeSys U - reversing

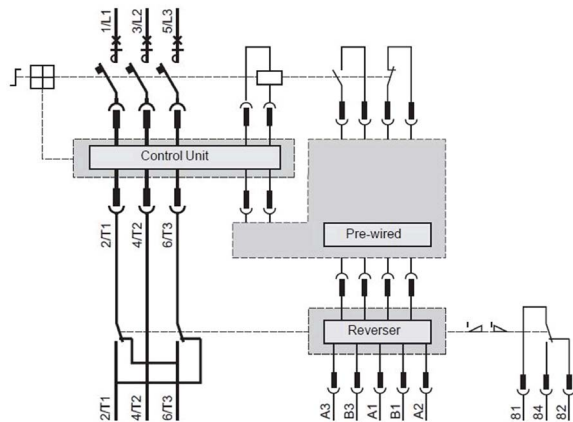


- A Reverser block
- B Plug-in terminal blocks
- C Control circuit pre-wiring system

A preassembled reversing power base can be ordered by a specific part number.

### Wiring

#### TeSys U - reversing



## Altivar 32 Variable Speed Drive - Hardware

### Front View

Altivar 32 variable speed drive



### Description

The Altivar 32 drive is a frequency inverter for 200...500 V three-phase asynchronous and synchronous motors rated from 0.18 kW to 15 kW which includes a various motor control profile.

In combination with synchronous motors, Altivar 32 variable speed drives offer optimized energy efficiency.

It features more than 150 functions. It is robust, compact, and easy to install.

The Altivar 32 drive incorporates functions which are suitable for the most common applications, including: hoisting, material handling, packaging, and special machines (like wood working machines, metal processing, and so on).

- Compact book format
- Integrated Modbus SL RS-485 2-wire
- Open: communication cards available as options
- integrated protection
- Simple setup
- Integrated programmable logic functions
- Energy saving: control of energy efficient permanent magnet synchronous motors

Standards and certifications	IEC 61800-5-1, IEC 61800-3 (environments 1 and 2, category C2), ISO/EN13849-1/-2 (category 3, PL d), IEC 61508 (parts 1 & 2), IEC 60721-3-3 (environments 3C3 and 3S3, classes 3C3 and 3S2), UL508c, CSA, NOM, GOST, C-Tick
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Power range	0.18...15 kW
Voltage range	<ul style="list-style-type: none"> <li>● single-phase 200...240 V (0.18 to 2.2 kW)</li> <li>● three-phase 380...500 V (0.37 to 15 kW)</li> </ul>
Output frequency	0.1...599 Hz
Transient overtorque	170...200 % of the nominal motor torque
Communication	<ul style="list-style-type: none"> <li>● integrated: Modbus SL RS-485 2-wire and CANopen, Bluetooth link</li> <li>● optional: DeviceNet, PROFIBUS DP V1, Modbus SL RS-485 2-wire, EtherNet/IP, Modbus TCP, EtherCAT</li> </ul>
Functions	<ul style="list-style-type: none"> <li>● standard or customizable configurations</li> <li>● factory or OEM settings</li> <li>● application-specific functions</li> <li>● adjustable switching frequency</li> <li>● HMI and dialog or configuration tools</li> <li>● uploads and downloads with drive on or off</li> </ul>
Protections	<ul style="list-style-type: none"> <li>● STO: Safe Torque Off</li> <li>● SLS: Safely Limited Speed</li> <li>● SS1: Safe Stop 1</li> </ul>
I/Os	<ul style="list-style-type: none"> <li>● 3 analog inputs - response time: 3 ms, resolution 10 bits</li> <li>● 6 logic inputs - response time: 8 ms, configurable in PTC and IN PWM</li> <li>● 1 analog input - updating time: 2 ms</li> <li>● 1 logic output - sampling time: 2 ms, configurable as voltage or current</li> <li>● 2 relay outputs</li> </ul>
Degree of protection	IP 20
EMC filter	<ul style="list-style-type: none"> <li>● integrated: C2 EMC</li> <li>● optional: C1 EMC</li> </ul>
Dimensions	<p>4 types (WxHxD)</p> <ul style="list-style-type: none"> <li>● 45 x 317 x 245 mm (1.77 x 12.48 x 9.65 in.)</li> <li>● 60 x 317 x 245 mm (2.36 x 12.48 x 9.65 in.)</li> <li>● 150 x 308 (232*) x 232 mm (5.9 x 12.13 (9.13*) x 9.13 in.)</li> <li>● 180 x 404 (330*) x 232 mm (7.1 x 15.9 (13*) x 9.13 in.)</li> </ul> <p>* = EMC plate not installed</p>
Options	<ul style="list-style-type: none"> <li>● SoMove and SoMove Mobile setup software</li> <li>● simple and multi-loader configuration tool</li> <li>● remote display terminals</li> <li>● communication cards in cassette format</li> <li>● optimized offer for connection to the CANopen bus</li> <li>● quick connect for a TeSys GV2 circuit breaker</li> </ul>

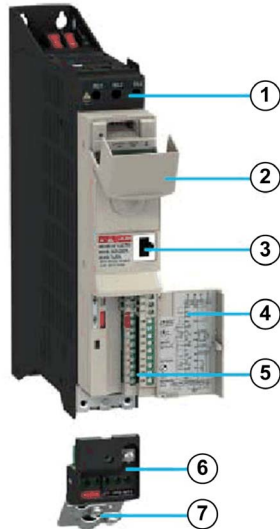


For more information, refer to :

- Altivar 32, Variable speed drives for synchronous and asynchronous motors, Installation manual, S1A28686 (ENG).
- Altivar 32, Variable speed drives for synchronous and asynchronous motors, Programming manual, S1A28692 (ENG).

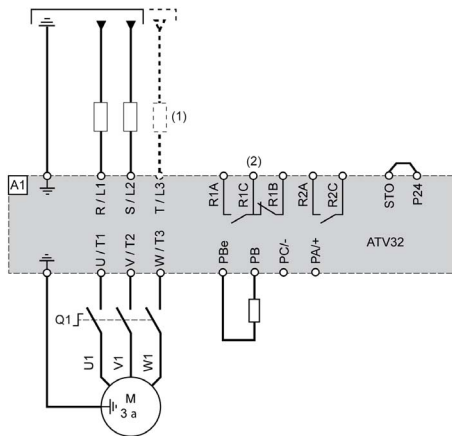
## Wiring

Altivar 32 connector overview



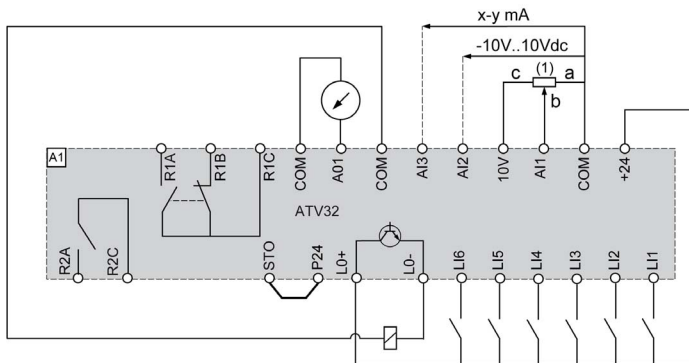
- 1 Power terminals
- 2 Protective cover
- 3 RJ45 Modbus SL RS-485 2-wire
- 4 Protective cover
- 5 Control terminals
- 6 Removable motor power terminal block
- 7 EMC mounting plate

Wiring example power supply and motor



- (1) Line choke (if used)
- (2) Relay contacts signifying detected errors

Wiring example control terminals



- (1) Reference potentiometer SZ1RV1202 (2.2 kΩ) or similar (10 kΩ maximum)

## Lexium 28 Servo Drive - Hardware

### Front View

Lexium 28 servo drive



### Description

The Lexium 28 is an all-purpose AC servo drive. Together with series BCH2 servo motors as well as a comprehensive portfolio of options and accessories, the drives are ideally suited to implement compact, high performance drive solutions for a wide range of power requirements.

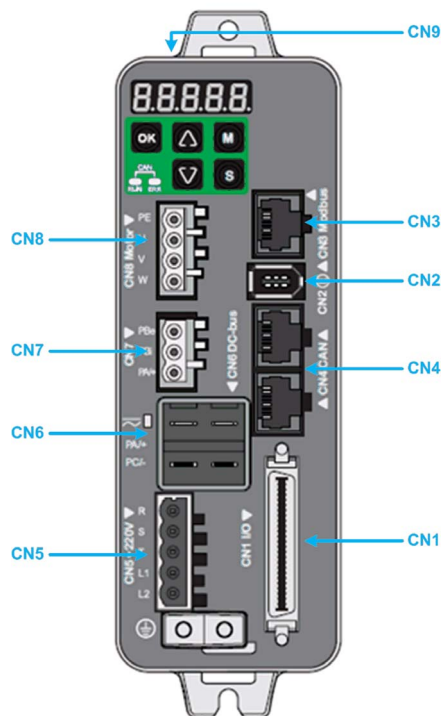
- Integrated CANopen / CANmotion communication
- Integrated safety function STO (Safe Torque Off)
- I/O interface with numerous digital and analog I/Os
- Numerous servo drive functions supported such as positioning, speed, and torque control
- Compact size
- Easy to configure and set up with SoMove configuration software and the auto-tuning function

Power range	50 W...4.5 kW
Voltage range	1 or 3 phase, 200 – 10%...230 + 10% Vac
Speed	Up to 5000 rpm
Torque	Up to 28.65 Nm
Communication	<ul style="list-style-type: none"> <li>• CANopen, CANmotion machine bus</li> <li>• Modbus for commissioning</li> </ul>

Operating modes	<ul style="list-style-type: none"><li>● Speed control mode</li><li>● Position control mode</li><li>● Torque control mode</li><li>● Jog mode</li><li>● Homing</li></ul>
Safety-related functions	STO (Safe Torque Off) function as per IEC 61800-5-2
Inputs/outputs	<ul style="list-style-type: none"><li>● 8 digital inputs</li><li>● 5 digital outputs</li><li>● 2 analog inputs <math>\pm 10</math> V</li><li>● 2 analog outputs <math>\pm 10</math> V</li><li>● 1 output for ESIM (encoder simulation)</li><li>● 1 PTI (Pulse Train Input) with high or low speed inputs</li></ul>
Degree of protection	IP20
Dimensions	6 types (W x H x D) 55...117.4 x 173.2...194.5 x 152.7 mm (2.16...4.62 x 6.82...7.66 x 6.01 in.)
Options	<ul style="list-style-type: none"><li>● Commissioning software SoMove</li><li>● Cables and connectors</li><li>● External mains filters</li><li>● DC bus accessories</li></ul>

## Physical Description

Front view of the Lexium 28

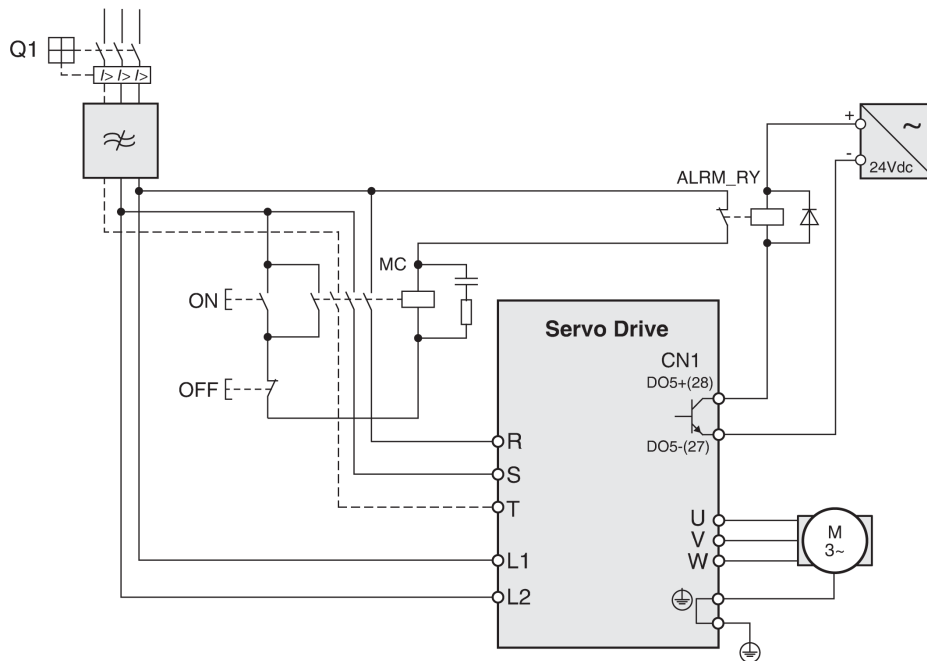


Connector	Description
CN1	I/O interface connector
CN2	Motor encoder connector
CN3	RJ45 connector – Modbus (commissioning interface)
CN4	RJ45 dual port connector (in/out) - CAN interface
CN5	<ul style="list-style-type: none"> <li>● R/S/T: Power stage supply</li> <li>● L1/L2: Controller power supply</li> </ul>
CN6	DC bus connector for parallel operation
CN7	External braking resistor
CN8	Motor phases
CN9	STO (Safe Torque Off) connector

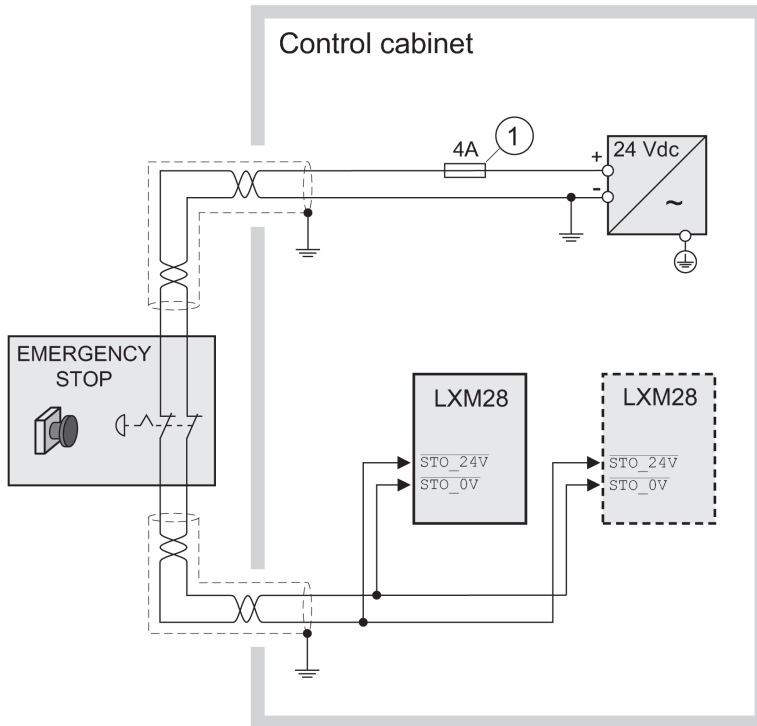
## Wiring

In this section, a selection of wiring examples is depicted to provide an overview on how to install the Lexium 28 servo drive in an automation system. For detailed information on wiring and installation of the Lexium 28 servo drive, refer to the document LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.

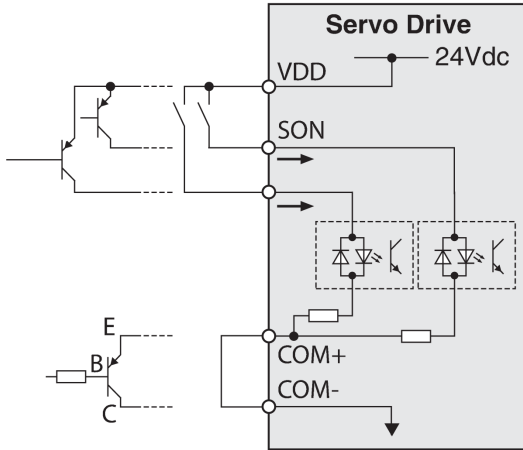
Wiring example power stage and controller power supply



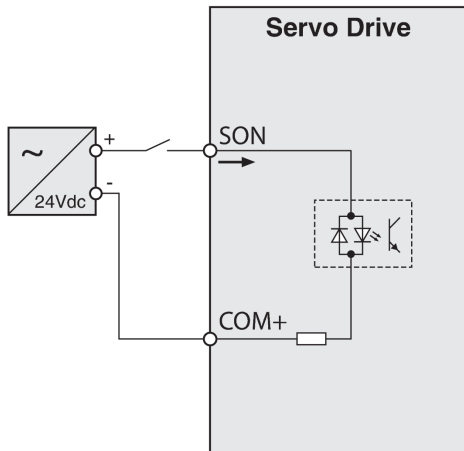
## Wiring example STO with category 0 stop (IEC 60204-1)



Wiring example digital input (logic type 1) with internal power supply

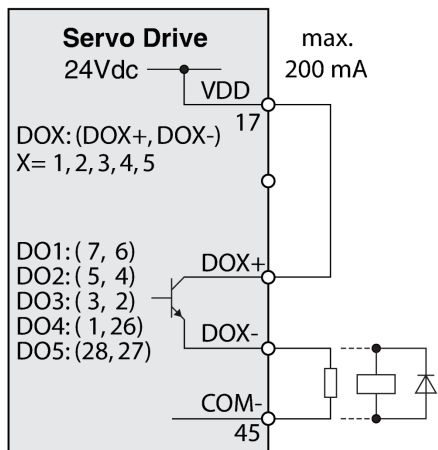


Wiring example digital input (logic type 1) with external power supply

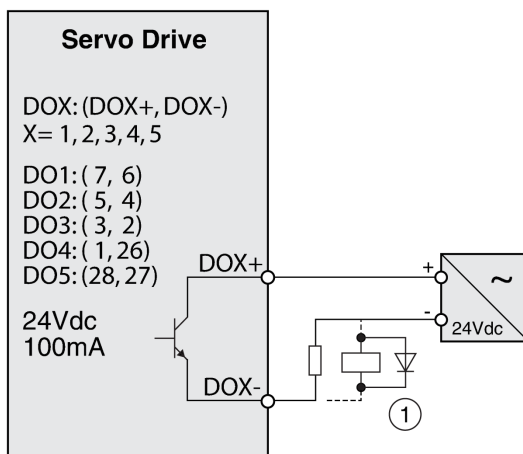




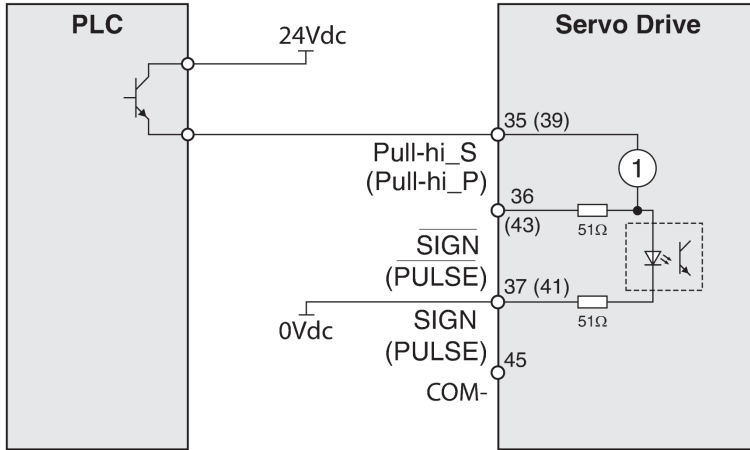
## Wiring example digital output (logic type 1) with internal power supply



## Wiring example digital output (logic type 1) with external power supply



Wiring example pulse input (open collector) with external power supply.



---

## Section 4.7

### Detection

---

#### What Is in This Section?

This section contains the following topics:

Topic	Page
OsiSense XCC Encoder - Hardware	116
OsiSense Industrial Sensors - Hardware	118

## OsiSense XCC Encoder - Hardware

### Front View

OsiSense XCC encoders



### Description

The rotary encoder is an angular position sensor, which is mechanically coupled to a driving spindle of a machine. A wide range of opto-electronic rotary encoder types is offered under the Telemecanique Sensors brand. These are the incremental encoders and the absolute encoders in single-turn and multi-turn model.

Incremental encoders provide counting indication (A, B and index signal) and can be applied for counting, positioning by counting and speed evaluation.

Absolute encoders provide an absolute position within each revolution in terms of binary or Gray code. The multi-turn encoders indicate in addition to the position value the number of revolutions. They can be applied for absolute positioning.

Encoders are offered with M23 connectors or as pre-cabled versions with 2 m long shielded cables. Preferred machines for the integration of the encoders are: Packaging, cranes, automatic dispensers, and so on.

Certifications	CE
Output type	<p>Incremental encoders:</p> <ul style="list-style-type: none"> <li>● 5 Vdc output driver RS422</li> <li>● Push-pull output driver (based on supply voltage)</li> </ul> <p>Single-turn absolute encoders:</p> <ul style="list-style-type: none"> <li>● Push-pull output driver, 11...30 Vdc, binary code, or gray code</li> <li>● SSI output without parity, 13-bit clock, 11...30 Vdc, binary code, or gray code</li> </ul> <p>Multi-turn absolute encoders:</p> <ul style="list-style-type: none"> <li>● SSI output without parity, 25-bit clock, 11...30 Vdc, binary code, or gray code</li> </ul>

Supply voltage	Incremental encoders: <ul style="list-style-type: none"> <li>● Push-pull: 5 or 11...30 Vdc</li> <li>● RS422: 4.5...5.5 Vdc or 4.75...30 Vdc</li> </ul> Absolute encoders: <ul style="list-style-type: none"> <li>● 11...30 Vdc</li> </ul>
Degree of protection	Based on the selected type: IP 52, IP 54, IP 66, IP 67 or IP 69 K
Maximum resolution	Incremental encoders: <ul style="list-style-type: none"> <li>● 100...10.000 points</li> </ul> Absolute encoders: <ul style="list-style-type: none"> <li>● 8192 points/4096 turns</li> <li>● 4096 points/8192 turns</li> </ul>
Maximum rotational speed	Diameter of shaft <12 mm (0.47 in.): 9000 rpm Diameter of shaft ≥12 mm (0.47 in.): 6000 rpm
Type of shaft	Solid shaft or through shaft
Diameter of shaft	6...30 mm (0.24...1.18 in.)
Diameter of housing	40 mm*, 58 mm, or 90 mm (1.57 in.*, 2.28 in., or 3.54 in.) *only incremental encoders
Options	Cables, connectors, deserialization jumper cables, mounting and mounting accessories

For more information, refer to OsiSense XCC, Rotary Encoders, Catalog, 9006CT1101.

## OsiSense Industrial Sensors - Hardware

### Front View

OsiSense industrial sensors product range



### Description

Under the Telemecanique Sensors brand, the latest innovations in the field of sensors for industrial detection operations are offered.

The OsiSense product range consists of safety and limit switches, pressure control sensors, ultrasonic sensors, inductive and capacitive proximity sensors, and so on.

For more information, refer to [Detection for automation solutions OsiSense, MKTED210041EN](#).

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# Chapter 5

## Communication Topology and Wiring Guide

---

### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
5.1	Introduction to System Communication	120
5.2	Ethernet Network	121
5.3	Modbus Serial Line Network	128

# Section 5.1

## Introduction to System Communication

---

### Introduction

#### Overview

The TVDA (Tested Validated Documented Architecture) includes two different communication networks.

- Ethernet  
The Ethernet network is used for the communication between the Modicon M241 Logic Controller and the Magelis HMI STU panel. The communication is based on the SoMachine network protocol. Both devices are connected via an Ethernet switch. In addition, a PC can be connected to the Ethernet for downloading and online monitoring of the application.
- Modbus SL  
The Modbus SL RS-485 2-wire network is used for the communication between the Modicon M241 Logic Controller (Master), and the energy meter iEM3150 (slave).



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## Section 5.2

### Ethernet Network

---

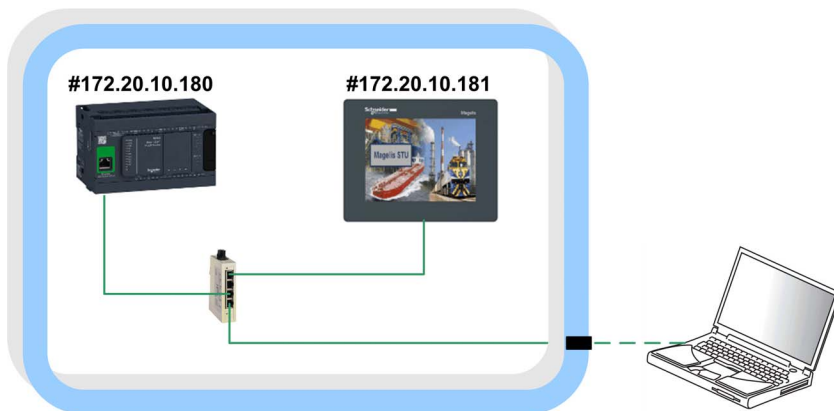
#### What Is in This Section?

This section contains the following topics:

Topic	Page
Ethernet Network Topology	122
Ethernet Wiring	123
Modicon M241 Logic Controller - Ethernet Wiring	125
Magelis HMI STU 655/855 - Ethernet Wiring	127

## Ethernet Network Topology

### Ethernet Topology



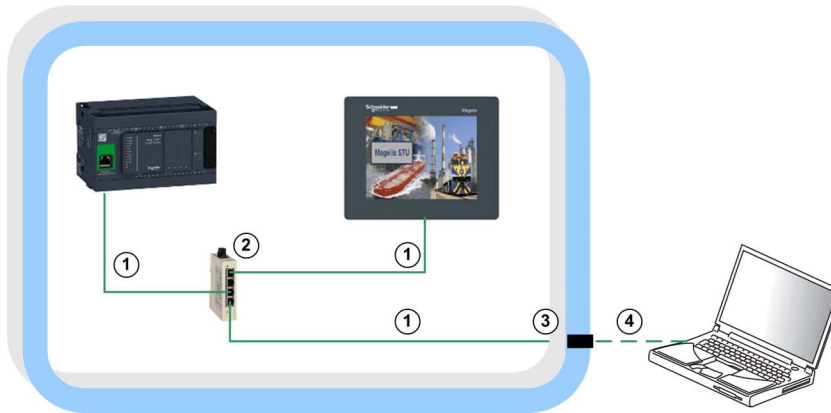
#... IP address

The subnet mask is: 255.255.0.0.

Optionally a PC can be linked to the Ethernet network.

## Ethernet Wiring

### Overview Ethernet



For more information, refer to Transparent Ready, User Guide, 31006929.

### Wiring Accessories

N°	Reference	Designation	Description	Cable Length
1	490NTW00002	Ethernet ConneXium cable - shielded twisted-pair straight cord	one RJ45 connector at each end	2.0 m (6.56 ft)
	490NTW00005			5.0 m (16.40 ft)
3	TCSEAAF11F13F00	ConneXium M12 to RJ45 Ethernet adapter	adapter for panel mounting	-
4	TCSECL1M3M3S2	Ethernet ConneXium cable - shielded twisted pair	1 x IP 67, M12, 4-pin (D- coded) connector and 1 x RJ45 connector	3.0 m (9.84 ft)

### Switch

N°	Reference	Designation	Description
2	TCSESU053FN0	Ethernet TCP/IP unmanaged switch	10BASE-T/100BASE-TX - 5x RJ45 ports copper cable

### ConneXium Ethernet Adapter

TCSECL1M3M3S2



M12 Connector (D-Coded)	M12 Pin	Signal	Description	RJ45 Pin	RJ45 Connector
	1	TD+	transmit data +	1	
	2	RD+	received data +	3	
	3	TD-	transmit data -	2	
	4	RD-	received data -	6	
	-	-	not connected	4	
	-	-	not connected	5	
	-	-	not connected	7	
	-	-	not connected	8	

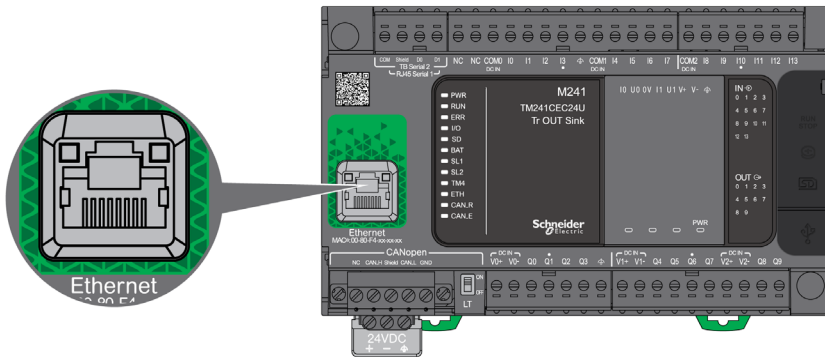
### ConneXium Ethernet Cable



M12	Signal		Signal	RJ45
1	TD +		TD +	1
3	TD -	TD -	2	
2	RD +	RD +	3	
4	RD -	RD -	6	

## Modicon M241 Logic Controller - Ethernet Wiring

### Ethernet Port

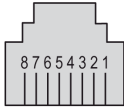


Characteristic	Description
Standard	Ethernet
Connector type	RJ45
Baud rate	Supports Ethernet "10BaseT" and "100BaseTX" with auto-negotiation
Automatic cross-over	MDI / MDIX
Services supported	<ul style="list-style-type: none"> <li>● Modbus TCP client/server</li> <li>● Ethernet/IP device</li> <li>● FTP server</li> <li>● Web server</li> <li>● SNMP</li> <li>● Modbus TCP slave device</li> <li>● IEC VAR ACCESS</li> </ul>
IP address negotiation type supported	<ul style="list-style-type: none"> <li>● DHCP</li> <li>● BOOTP</li> <li>● Fixed IP</li> </ul>
Power over Ethernet	No

For more information, refer to Modicon M241 Logic Controller, Hardware Guide, EIO000001456 (ENG).

## Pin Assignment

RJ45 Ethernet connector



RJ45 Pin	Signal	Description
1	TD+	transmit data +
2	TD-	transmit data -
3	RD+	received data +
4	-	no connection
5	-	no connection
6	RD-	received data -
7	-	no connection
8	-	no connection

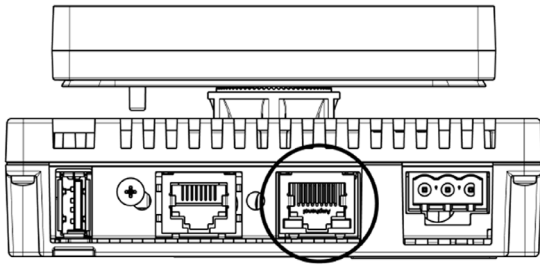
**NOTE:** The controller supports the MDI/MDIX auto-crossover cable function. It is not necessary to use special Ethernet crossover cables to connect devices directly to this port (connections without an Ethernet hub or switch).

## Magelis HMI STU 655/855 - Ethernet Wiring

### Ethernet Port

The HMI STU 655/855 comes equipped with an IEEE802.3 compliant Ethernet interface that transmits and receives data at 10 Mbit/s or 100 Mbit/s.

The graphic shows the Ethernet port of Magelis HMI STU:



Do not confuse the RJ45 Ethernet connector with the RJ45 COM1/COM2 serial port.

1:1 connections must be made with a hub or a switch. It is possible to use the 1:1 connection with a cross cable depending on the connected PCs and network cards

For more information, refer to Magelis HMI STU 655/855, User Manual, EIO000000614.

## Section 5.3

### Modbus Serial Line Network

---

#### What Is in This Section?

This section contains the following topics:

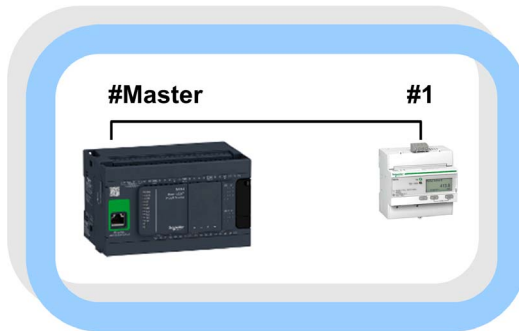
Topic	Page
Modbus SL Network Topology	129
Modbus SL Wiring	130
Modicon M241 Logic Controller - Modbus SL Wiring	131
iEM31xx Energy Meter - Modbus SL Wiring	133



## Modbus SL Network Topology

### Modbus SL Topology

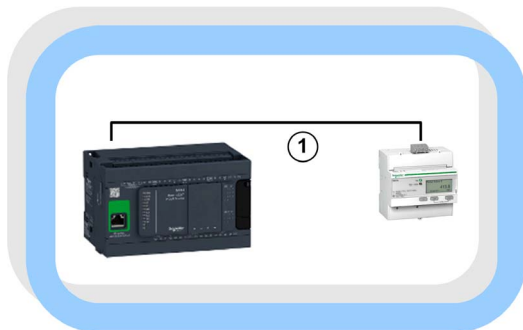
- Baud rate 19.2 kbps
- Parity even
- 1 stop bit



#... node address

## Modbus SL Wiring

### Modbus SL Overview



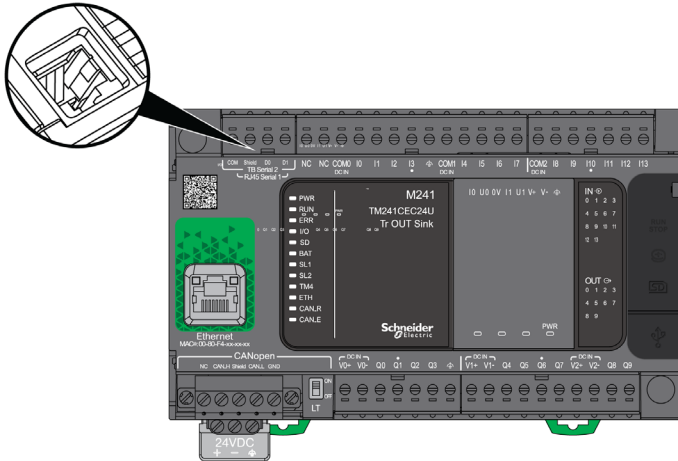
For more information, refer to Modbus Serial Line, Planning and Installation Guide, 33003925.

### Cable

N°	Reference	Designation	Description	Cable Length
1	VW3A8306D30	Modbus SL drop cable	1 RJ45 connector and one end stripped	3.0 m (9.8 ft)

## Modicon M241 Logic Controller - Modbus SL Wiring

### Modbus SL Port (Serial Line 1)



The serial line 1

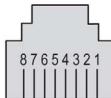
- is used to communicate with devices supporting the Modbus protocol as either master or slave, ASCII protocol (printer, modem...), and SoMachine protocol (HMI,...)
- provides a 5 Vdc power distribution

For more information, refer to Modicon M241 Logic Controller, Hardware Guide, EIO0000001456 (ENG).

### Pin Assignment (Serial Line 1)

For this architecture, the port is configured as an RS-485.

Pins for RS-485 and RS-232



Pin	Signal RS-485	Signal RS-232	Description
1	-	RxD	RS-232: Receive data line
2	-	TxD	RS-232: Transmit data line
3	-	-	-
4	D1	-	Modbus SL: D1 (+/B) RS-485 2-wire
5	D0	-	Modbus SL: D0 (-/A) RS-485 2-wire

Pin	Signal RS-485	Signal RS-232	Description
6	-	-	-
7	VP5S	-	power over Modbus SL: 5 V / max. 200 mA supply
8	SNG	Common	Modbus SL signal ground / reference to VP5S

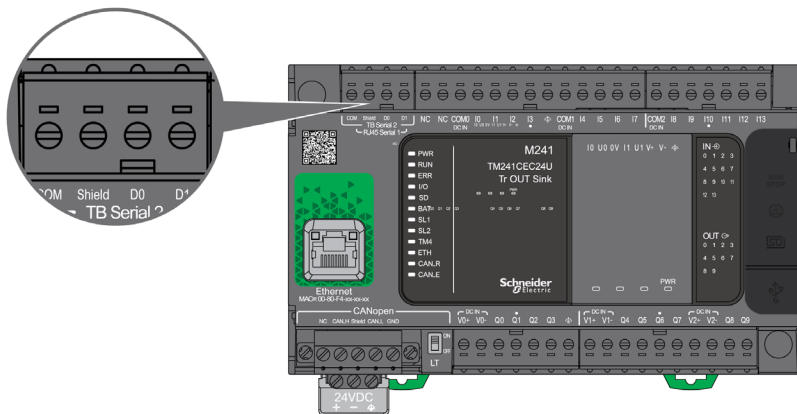
## ⚠ WARNING

### UNINTENDED EQUIPMENT OPERATION

Do not connect wires to unused terminals and/or terminals indicated as “No Connection (N.C.)”.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

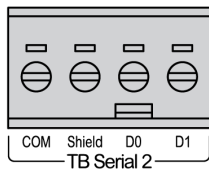
### Modbus SL Port (Serial Line 2)



The serial line 2 is used to communicate with devices supporting the Modbus protocol as either master or slave and ASCII protocol (printer, modem...), and supports RS-485 only.

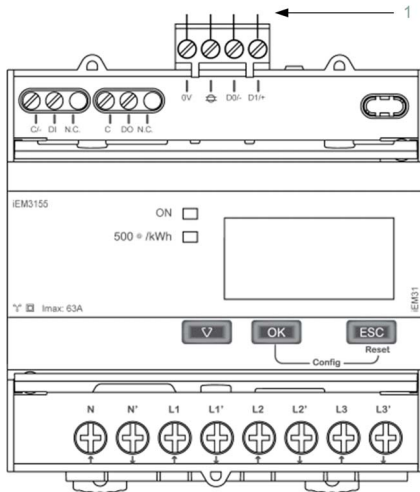
### Pin Assignment (Serial Line 2)

Pin assignment of the removable terminal block



## iEM31xx Energy Meter - Modbus SL Wiring

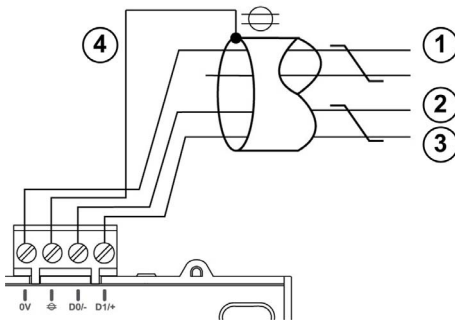
### Modbus SL Port



1 Modbus SL RS-485 2-wire port

For more information, refer to iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN.

### Pin Assignment



Item	Signal	Description
1	SNG	Modbus SL signal ground
2	D0	Modbus SL: D0 (-/A) RS-485 2-wire

Item	Signal	Description
3	D1	Modbus SL: D1 (+/B) RS-485 2-wire
4	SHLD	Modbus SL shield

### Communication Settings

The Modbus SL port of the energy meter has to be configured via the local HMI on the front.

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# Chapter 6

## Implementation

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### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
6.1	Software Requirements	136
6.2	Access the SoMachine Project Template	137
6.3	Project	138

# Section 6.1

## Software Requirements

---

### Software Requirements

#### Overview

The software required to open and to edit the project template is SoMachine V4.1 SP1 including the LXM28 add-on or later.

The following components must be installed together with SoMachine:

- SoMachine Components
  - LogicBuilder, including LogicBuilder Lexium28
  - Vijeo-Designer
  - Gateway
- Auxiliary tools
  - Controller Assistant
- Controllers
  - M241
- Repository
  - OptimizedRepository
- Documentation
  - Tested, Validated and Documented Architectures (TVDA), including TVDA for Lexium 28
- Add-ons / patches
  - Add-on Lexium 28 for SoMachine V4.1 SP1

The SoMachine Configuration Manager, which is part of the SoMachine installation, allows you to verify the installation. In addition you can add, remove, or update components of your SoMachine installation.



## Section 6.2

### Access the SoMachine Project Template

#### Access the SoMachine Project Template

##### Overview

The SoMachine project related to the described architecture is available in terms of a project template.

It is tested and validated and includes the complete and executable application with program code and device configurations.

Also part of the SoMachine project is the Vijeo-Designer application which is ready to run on the defined Magelis panel for this architecture.

You can use the project template as basis for your own application.

##### Procedure

You can access the project template as described below.

Step	Action
1	Launch SoMachine. The <b>Get started</b> dialog box of SoMachine Central is displayed.
2	Click <b>New</b> . The <b>New Project</b> dialog box is displayed.
3	Click <b>Templates</b> . The <b>New Project Assistant - Templates</b> dialog box is displayed.
4	Enter a <b>Project Name</b> .
5	Select a template from the list.
6	Click the <b>Create Project</b> button. A new project based on the selected template is opened in SoMachine Logic Builder.
7	Now you can adapt ( <i>see page 172</i> ) your new project according to your requirements.

# Section 6.3

## Project

---

### What Is in This Section?

This section contains the following topics:

Topic	Page
Controller	139
HMI	142
Devices	143
Application	148
Vijeo-Designer	150

---

## Controller

### Overview

The controller in this architecture is the M241C24T/U, which is assigned to the category of optimized logic controller of Schneider Electric.

The mandatory settings for the controller are described below.

The parameter values depicted in this document relate to the template project and the test equipment used during development.

### Ethernet

The Ethernet network in this architecture is used for the communication between the HMI and the controller.

In addition, the network provides the possibility for a remote connection with the controller or the HMI.

The Ethernet settings are performed in the device editor of the Ethernet interface. To open the device editor, double-click the **Ethernet\_1** node in the **Devices tree**.

The settings for this architecture are:

- Fixed IP address
  - IP address: 172.20.10.180
  - Subnet mask: 255.255.0.0

For the other parameters, the default settings have been used for the present template. The Ethernet configuration becomes effective after a download of the application to the controller.

For more information about the Ethernet settings, refer to Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG).

### Serial Line

The serial line 1 in this architecture is used for the communication between the controller and the energy meter.

Therefore, a **Modbus Manager** has been added under the **Serial\_Line\_1** interface. To add the **Modbus Manager**, select the command **Add Device** from the context menu of the **Serial\_Line\_1** node in the **Devices tree**. Select the **Modbus Manager** in the **Add Device** dialog box and click **Add Device**.

**NOTE:** Per default the SoMachine network manager is placed here, but this can be removed.

The serial line settings are performed in the device editor of the serial line interface. To open the device editor, double-click the **Serial\_Line\_1** node in the **Devices tree**.

The settings for this architecture are:

- Baud rate: 19200
- Parity: even
- Data bits: 8

- Stop bits: 1
- Physical medium:
  - Modbus SL RS-485 2-wire
  - Polarization resistor: Yes

The Modbus settings are performed in the device editor of the **Modbus Manager**. To open the device editor, double-click the **Modbus Manager** node in the **Devices tree**.

The settings for this architecture are:

- Transmission mode: RTU
- Addressing: Master
- Time between frames: 10 ms

For more information about the serial line configuration, refer to Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG).

## Pulse Generators

In this architecture, 2 pulse generators with name **LXM28\_1** and **LXM28\_2** are used to control the 2 Lexium 28 servo drives in pulse control mode. The pulse generator function for both pulse generators is set to PTO (Pulse Train Output) with output mode pulse/direction.

The PTO settings are performed in the device editor of the pulse generator. To open the device editor, double-click the **Pulse\_Generator** node in the **Devices tree**.

The settings for this architecture are:

- **Pulse generation function: PTO**
- **General** →Instance name: **LXM28\_1** and **LXM28\_2**
- **General** →Output Mode: **A Pulse / B Direction**
- **General** →A output location: **Q0 (LXM28\_1) / Q2 (LXM28\_2)**
- **General** →B output location: **Q1 (LXM28\_1) / Q3 (LXM28\_2)**

For the other parameters, the default settings have been used for the present template.

For more information about the PTO configuration, refer to Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG).

## Counters

In this architecture, a **High Speed Counter (HSC)** function is used to process the pulse and direction signals of an incremental encoder. In addition, the **Preset-** and the **Capture** function using fast inputs have been enabled for the **High Speed Counter (HSC)**.

The HSC settings are performed in the device editor of the counter. To open the device editor, double-click the **Counter** node in the **Devices tree**.

The settings for this architecture are:

- **Counting function: HSC Main Dual Phase**
- **General** →Instance Name: **IncEnc**
- **General** →Counting Mode: **Free-large**
- **General** →Input Mode: **A=Pulse, B=Direction**
- **Range** →Preset: **0**

- **Control inputs** →**SYNC input** →**Location: I2**
- **Capture** →**CAP input** →**Location: I3**
- **Capture** →**Mode: CAP Rising**

For the other parameters, the default settings have been used for the present template.

For more information about the counter configuration, refer to Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG).

## HMI

### Overview

The HMI in this architecture is a Magelis panel of type HMIS5T.

The mandatory settings for the HMI device are described below.

The parameter values depicted in this document relate to the template project and the test equipment used during development.

### Ethernet

The Ethernet network in this architecture is used for the communication between the HMI and the controller.

In addition, the network provides the possibility for a remote connection with the controller and the HMI.

In Vijeo-Designer, select **Network** in the target property editor and click the button ... to open the **Network Configuration** dialog box. Enter the Ethernet configuration as listed below, and click **OK** to apply your settings.

- IP address: 172.20.10.181
- Subnet mask: 255.255.0.0

For the other parameters, the default settings have been used for the present template. The Ethernet configuration becomes effective after a download of the application to the HMI.

### I/O Manager

The communication between HMI and controller is performed via SoMachine network protocol based on Ethernet.

The SoMachine network driver on the panel accesses variables in the controller by a named reference. Therefore, the node name (equipment address) of the connected controller must be set in the SoMachine network configuration dialog in Vijeo-Designer ([see page 153](#)).

The node name of the controller is per default a combination of controller type and MAC address, but you can change it to a user-defined name like *machine 1*.

In this application, the default node name of the controller has been set within the Vijeo-Designer configuration.

For more information about the SoMachine network driver, refer to the document Magelis XBT GC/XBT GK/XBTGT, SoMachine - Combo and Network Drivers, EIO0000000219 (ENG).

## Devices

### Overview

In this chapter, the devices configured within the SoMachine project are described.

### TM3 Safety Modules

The TM3 safety modules are configured as I/O expansion modules and must be connected to the TM3 bus of the controller. Diagnostic and administrative control functions are provided over the TM3 bus, while the safety function is managed in the module. The diagnostic and control signals are treated as I/O in the controller configuration, and can be processed in the application program as such.

To add a TM3 module to the configuration, select the command **Add Device** from the context menu of the **IO\_Bus** node in the **Devices tree**. In the **Add Device** dialog box, double-click the desired device.

In this architecture, the following modules were added to the IO\_Bus.

Module Name	Module Type	Comment
Module_1	TM3SAF5R	Safety module emergency stop Cat. 4.
Module_2	TM3SAF5R	Safety module emergency stop Cat. 4.

For more information, refer to Modicon TM3 Safety Modules, Hardware Guide, EIO0000001831.

### TM3 I/O Expansion Modules

The controller provides the possibility to expand the embedded I/Os by adding TM3 expansion modules to the controller.

To add a TM3 module to the configuration, select the command **Add Device** from the context menu of the **IO\_Bus** node in the **Devices tree**. In the **Add Device** dialog box, double-click the desired device.

Each expansion module provides an individual configuration. Double-clicking the module in the **Devices tree** opens the associated device editor. In the device editor, you can modify the module-specific parameter in accordance with your application.

In this architecture, the following modules were added to the IO\_Bus.

Module Name	Module Type	Comment	Configuration
Module_3	TM3DI16	16 channel, 24 Vdc digital input expansion module, with one common line	default
Module_4	TM3DM24R	16-channel sink/source inputs with one common line, 8-channel 2 A relay outputs with two common lines, 24 Vdc digital expansion module	default

Module Name	Module Type	Comment	Configuration
Module_5	TM3DQ16T	16-channel, 0.5 A source transistor outputs expansion module with one common line	default
Module_6	TM3AM6	Expansion module with four analog inputs and two analog outputs, 12 bits	For each output channel: Type: 0 - 10 V Minimum: 0 Maximum: 1000 For the other parameters the default values have been used for the present template.
Module_7	TM3TI4	Expansion module with four analog inputs, 16 bits	For each input channel: Type: PT100 Scope: 0.1° C (32.18° F) For the other parameters the default values have been used for the present template.

For more information about the TM3 configuration, refer to the documents:

- Modicon M241 Logic Controller, Programming Guide, EIO0000001432 (ENG)
- Modicon TM3, Expansion Modules Configuration, Programming Guide, EIO0000001402

### Energy Meter iEM3150

The architecture implements one energy meter of type iEM3150 for energy measurement. The energy data are read from the device via Modbus serial line.

The device itself is not configured in the application. The Modbus communication is performed by system functions as part of the function block `FB_PowerMeter` out of the **ModbusEnergyEfficiencyToolbox** library.

The program code to read and to process the data of the power meter was created in the application by adding the Device Module `MED_iEM3150_ModbusSL` which is represented as a function template within the **TVDA Device Module Library** (see page 176).

The only configuration is the assignment of the slave address and the network ID to the associated variables (CONSTANTS) within the **Add Function From Template** dialog box.



## Altivar 32

The architecture implements two variable speed drives of type Altivar 32 which are controlled via hardwired signals.

The devices themselves are not configured in the application. Only the variables to control, and to monitor each drive, are assigned to physical I/Os of the configuration.

The program code in relation with the needed variables to control and to monitor one drive, was created in the application through adding the Device Module VSD\_HW\_1Motor\_2DVS which is represented as a function template within the **TVDA Device Module Library** (see page 176).

The name of each added application object corresponds with the name which was assigned within the **Add Function From Template** dialog box.

In the table, the variables are listed which were assigned to physical I/Os of the configuration within the **Add Function From Template** dialog box for each Device Module.

Variable Name	Assigned To	Comment
GVL_ATV32_*.xMcbRdy	Digital input	Signal associated with the motor circuit breaker contact indicating that the device is under power.
GVL_ATV32_*.xDriveNoFlt	Digital input	Signal associated with the drive contact indicating that the drive is operational (no error detected).
GVL_ATV32_*.xDriveRun	Digital input	Signal associated with the drive contact indicating that the drive is running.
GVL_ATV32_*.xDriveCmdMotFwd	Digital input	Operates the drive in a forward direction. Associated to a connected input on the drive.
GVL_ATV32_*.xDriveCmdMotRev	Digital input	Operates the drive in a reverse direction. Associated to a connected input on the drive.
GVL_ATV32_*.xDriveRst	Digital input	Resets the drive in case an error is detected. Associated to a connected input on the drive.
GVL_ATV32_*.iDriveSpeedRef	Analog output	Speed reference associated with the drive via analog output. Connected to an analog input on the drive.
* stands for the sequential number (1 or 2) of each drive.		

## Lexium 28

This architecture implements 2 servo drives of type Lexium 28. The servo drives are controlled via pulse train signals. The signals are generated with the PTO (pulse train output) functions, which are configured in the M241 Logic Controller. The PTO functions control the fast outputs of the M241 Logic Controller. For the configuration of the PTO functions, refer to Pulse Generators (see page 140).

The Lexium servo drives are not configured in the application. Only the variables to control, and to monitor each servo drive, are assigned to physical I/Os of the configuration.

For every drive a program and a GVL (Global Variable List) was created. In the GVL, the necessary variables are declared and the program contains the code for the controlling and monitoring functions of the drive.

Function blocks used to control the PTO function of the M241 Logic Controller:

Function Block	Library	Vendor
MC_Power_PTO	M241 PTO PWM	Schneider Electric
MC_Stop_PTO		
MC_Halt_PTO		
MC_ReadAxisError_PTO		
MC_Reset_PTO		
MC_MoveVelocity_PTO		
MC_MoveAbsolute_PTO		
MC_MoveRelative_PTO		
MC_Home_PTO		
MC_ReadActualPosition_PTO		
MC_ReadActualVelocity_PTO		

Variables assigned to physical I/Os of the configuration:

Variable Name	Assigned To	Comment
GVL_LXM28_*.xMcbRdy	Digital input	Signal associated with the motor circuit breaker contact indicating that the device is under power.
GVL_LXM28_*.xDriveNoFlt	Digital input	Signal associated with the drive output indicating that the drive is operational (no error detected).
GVL_LXM28_*.xDriveRdy	Digital input	Signal associated with the drive output indicating that the drive is ready for operation.
GVL_LXM28_*.xDriveCmdRst	Digital output	Resets the drive in case an error is detected. Associated to a connected input on the drive.
GVL_LXM28_*.xDriveCmdEn	Digital output	Enables the drive for operation. Associated to a connected input on the drive.
* stands for the sequential number (1 or 2) of each servo drive		

## TeSys U

The architecture implements a motor starter controller of type TeSys U which is controlled via hardwired signals.

The device itself is not configured in the application only the variables to control and to monitor the motor starter, are assigned to physical I/Os of the configuration.

The program code in relation with the needed variables to control and to monitor one motor starter, was created in the application through adding the Device Module TeSysU\_HW\_2D which is represented as a function template within the **TVDA Device Module Library** (see page 176).

The name of each added application object corresponds with the name which was assigned within the **Add Function From Template** dialog box.

In the table, the variables are listed which were assigned to physical I/Os of the configuration within the **Add Function From Template** dialog box for each Device Module.

Variable Name	Assigned To	Comment
GVL_TeSysU_*.xTeSysU_Rdy	Digital input	Signal associated with the TeSys U contact indicating that the device is under power
GVL_TeSysU_*.xTeSysU_Trip	Digital input	Signal associated with the TeSys U contact indicating that the device is tripped (error detected)
GVL_TeSysU_*.xTeSysU_Actv	Digital input	Signal associated with the TeSys U contact indicating that the contactor is activated
GVL_TeSysU_*.TeSysU_MotFwd	Digital input	Activates the contactor in a forward direction
GVL_TeSysU_*.xTeSysU_MotRev	Digital output	Activates the contactor in a reverse direction
*stands for the sequential number (1 or 2) of each motor starter		

## Incremental Encoder

The architecture implements an incremental encoder. The signals of the encoder are processed with an HSC (high speed counter), which is configured in the M241 Logic Controller. The HSC function uses the fast inputs of the M241 Logic Controller. For the configuration of the HSC, refer to Counters (see page 140).

For the encoder respectively the HSC a program and a GVL (Global Variable List) were created. In the GVL, the necessary variables are declared and the program contains the code for the control and monitoring functions of the HSC.

Function blocks used to control the HSC function of the M241 Logic Controller:

Function Block	Library	Vendor
HSCMain_M241	<b>M241 HSC</b>	Schneider Electric
EXPERTGetDiag		
EXPERTSetParam		
EXPERTGetCapturedValue		

## Application

### Library Manager

The library manager is a standard object of the application.

Within the library manager, you can add or remove libraries.

In this example application, the following libraries were added manually:

- Toolbox (from Schneider Electric)
- SysTimeRtc

The other libraries were loaded automatically on adding devices or Device Modules.

### Symbol Configuration

The symbol configuration functionality allows to create symbol descriptions, by that project variables can be accessed from external, for example, when exchanging variables with HMI via Vijeo-Designer or via OPC server.

The variables for control and monitor functions on the Magelis HMI were published within the symbol configuration editor. By publishing the variables in SoMachine, they will automatically be available for use in the Vijeo-Designer HMI application as SoMachine variables. For the manual export of the variables, use the command **Export Variables to Vijeo-Designer** from the context menu of the **Symbol Configuration** in the **Tools tree**.

For more information, refer to the following chapters of the SoMachine Programming Guide:

- Symbol Configuration Editor (*see SoMachine, Programming Guide*)
- SoMachine Controller - HMI Data Exchange (*see SoMachine, Programming Guide*)

### Task Configuration

The **Task Configuration** defines one or several tasks for controlling the processing of an application program.

Thus it is a basic resource object for an application and is automatically added to the application node.

In this example application 1 task is configured:

Task	Type	Comment
MAST	Cyclic: 5 ms	This task includes the program calls related to the motor control devices, Modbus communication and general application code.

For more information, refer to Task Configuration Editor (*see SoMachine, Programming Guide*).

---

## Program Code

The program code is divided into several POUs (Program Organization Units) of type program and GVLs (Global Variable Lists).

Each POU is called separately within the associated task.

The POUs and GVLs which are related to the devices or functional units were created on adding the Device Modules. Hence, they are placed in folders (with the corresponding names) under the **Application** node.

The following folders including the respective POUs and GVLs are available:

- ATV32\_1
- ATV32\_2
- iEM3150\_MdbSL

Further POUs and related GVLs for equipment control, which are not available as Device Module, are listed in the following:

- LXM28\_1
- LXM28\_2
- IncEnc

For the general programming part, additional POUs are available. In these POUs, the processing of HMI commands, a summary of information about devices, the communication state, and state of the safety functions is performed in relation to the different functional units of the application.

The following POUs are available:

- **Preprocessing**  
Processing of command signals for the devices (for example, operator push buttons, HMI commands, and so on).
- **MAIN**
  - Processing of summary information about device and communication state.
  - Date and time handling of the RTC of the controller.
- **AlarmManager**  
Processing of alarm management of the architecture.
- **Output Mapping**  
Processing of output signals for tower light, operator push-button lighting, and analog outputs.

## Vijeo-Designer

### Overview

The HMI application is created with the configuration software Vijeo-Designer, which is integrated in SoMachine.

This architecture implements a Magelis HMI panel of type HMI STU.

The application is executed on this panel and provides extensive monitoring and control functions of the architecture.

### Start Page

The start page provides general information about the state of the architecture:

- Device state
- Communication state
- Safety state

### Alarm Page

The alarm page provides detailed alarm messages sorted by time of occurrence.

### Date and Time Page

The date and time page provides the value of the RTC (Real Time Clock) of the controller. In addition, it allows you to set the RTC of the controller and the HMI.

### Energy Pages

The energy pages provide information about the energy data of the architecture.

### Device Pages

The device pages provide monitor and control functions for each device grouped by products:

- Altivar
- TeSys U
- Lexium
- Encoder
- I/Os

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# Chapter 7

## System Setup

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### Overview

This chapter describes the steps necessary to set the architecture in operational mode. It is not intended to replace any specific product documentations or manuals.

The setup procedure depicted in this document is relevant only for the proposed architecture.

Before using any device in this application, perform the following steps:

- Thoroughly read this manual and the respective related documents before running this application.
- Install the drives according to their usage and configure the connected motors.
- Thoroughly verify your installation.
- Set up the communication parameters of the devices.

### WARNING

#### LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical control functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are emergency stop and overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.
- Observe all accident prevention regulations and local safety guidelines.<sup>1</sup>
- Each implementation of this equipment must be individually and thoroughly tested for proper operation before being placed into service.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

<sup>1</sup> For additional information, refer to NEMA ICS 1.1 (latest edition), "Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control" and to NEMA ICS 7.1 (latest edition), "Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems" or their equivalent governing your particular location.

## What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
7.1	Setup Controller and HMI	153
7.2	Setup Other Devices	156



# Section 7.1

## Setup Controller and HMI

### Setup Controller and HMI

#### Overview

Download the applications from the PC to the controller and to the HMI to run the applications.

There are several possibilities to perform the application download:

- Via an USB cable (linked to the integrated mini USB port on the devices).
- With an USB key (linked to the integrated USB port on the HMI).
- Via an SD card (plugged into the SD card slot on the front of the controller).
- Via an Ethernet connection (linked to the Ethernet network).

By using a USB connection or an Ethernet connection between controller and PC, additional features like monitoring of the application in online mode are available.

**NOTE:** SoMachine V4.1 and the associated Vijeo-Designer configuration software are required on the PC.

#### Communication Settings

To set up the communication between controller and HMI, it is mandatory to configure the communication settings in both applications (controller and HMI) using SoMachine and Vijeo-Designer.

To set up an Ethernet communication between controller and HMI, following configurations are mandatory:

- Ethernet configuration of the controller
- Ethernet configuration of the HMI
- Controller equipment address (node name) in the HMI application

To configure these settings, proceed as follows:

Step	Action	Comment
1	In the <b>Devices tree</b> of the SoMachine Logic Builder, double-click the <b>Ethernet</b> node of the controller.	The <b>Ethernet</b> device editor opens.
2	Configure the Ethernet settings of the controller.	The Ethernet configuration is required to set up a connection between controller and HMI. The two devices have to be in the same sub network.
3	Select <b>Vijeo-Designer</b> from the <b>Quick Toolswitch</b> list of the SoMachine Central overlay bar (refer to SoMachine Central, User Guide ( <i>see SoMachine Central, User Guide</i> )).	The Vijeo-Designer opens in a new window.

Step	Action	Comment
4	In Vijeo-Designer, select the target node in the <b>Navigators Project</b> tab.	The target property editor opens.
5	Select <b>Network</b> in the target property editor.	The network property editor opens.
6	Click the ... button for network configuration.	The <b>Network Configuration</b> dialog box opens.
7	Perform the Ethernet configuration in the <b>Network Configuration</b> dialog box.	The <b>Network Configuration</b> dialog box allows the Ethernet configuration for the HMI. The Ethernet configuration is required to set up a connection between controller and HMI. The two devices have to be in the same sub network.
8	Click <b>OK</b> to apply the settings.	The Ethernet configuration becomes effective after a download of the application to the HMI.
9	In Vijeo-Designer, double-click <b>SoM_MyController</b> under the <b>I/O Manager</b> → <b>SoMachineNetwork01</b> node in the <b>Navigators Project</b> tab.	The <b>SoMachine - Network Equipment Configuration</b> dialog box opens.
10	Set the address of the associated controller in the field <b>Equipment Address or Node Name</b> .	The required information is provided in the <b>Controller selection</b> tab of the device editor of the controller in SoMachine Logic Builder if the PC is connected to the controller.

## Download Procedure

For the download procedure described in this section, an USB connection between PC and controller is used.

To set up a communication between a controller and a PC via USB, use one of the following cables:

- TCSXCNAMUM3P
- BMXXCAUSBH045

If HMI and controller are successfully connected via the Ethernet network, the HMI application can be transferred to the HMI using the USB connection between PC and controller.

The controller is routing between the mini USB and the Ethernet interface.

Using the established USB connection between PC and controller and the Ethernet connection between controller and HMI, proceed as follows to download the SoMachine Logic Builder and HMI application.

Precondition for this workflow is a working Ethernet connection between controller and HMI.

Step	Action	Comment
1	Double-click the controller node in the <b>Devices tree</b> .	The controller device editor opens.
2	Select the <b>Controller selection</b> tab.	The compatible controllers detected by the gateway on the PC are listed.

Step	Action	Comment
3	Double-click a list entry to select a controller.	The selected controller is displayed in bold and the address is displayed at the bottom of the device editor.
4	Double-click the HMI device node in the <b>Devices tree</b> .	The HMI device editor opens.
5	Select the <b>Controller selection</b> tab.	The compatible HMIs detected by the gateway on the PC are listed.
6	Double-click a list entry to select an HMI.	The selected HMI is displayed in bold and the address is displayed at the bottom of the device editor.
7	Click <b>Online</b> → <b>Multiple Download...</b> to download the applications.	The <b>Multiple Download</b> dialog box opens. You can choose which application should be downloaded. Using the <b>Additional operations</b> a start of all applications after download can be performed.

**NOTE:** The firmware version of the controller must correspond with the firmware version of the controller in the SoMachine project. If the versions of the devices mismatch, upgrade the version of the controller. The procedure to update the firmware of the controller is described in the SoMachine online help and in the appropriate product guide of your controller. For the initial download, the HMI requires the latest version of the runtime kernel. This is accomplished by using Vijeo-Designer for the initial download. Alternatively, use the **Runtime Installer** to download the runtime on the HMI. The **Runtime Installer** is accessible via the tool access bar (see *SoMachine Central, User Guide*) in SoMachine Central (**Tool Access Bar** → **Maintenance** → **Download Firmware HMI**).

## Section 7.2

### Setup Other Devices

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#### What Is in This Section?

This section contains the following topics:

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Altivar 32 - Hardwired Setup	159
Lexium 28 - Pulse Train Control Mode Setup	162
iEM3150 Energy Meter - Modbus SL Setup	166
Harmony ZBRRC Wireless Receiver - Setup	168

## Network and Device Parameter Settings

### Overview

This section describes the steps required to initialize and configure the different devices required to attain the described system function.

The following devices are configured by using the local control panel on the device itself:

- Lexium 28
- Altivar 32
- Energy Meter iEM3150

**NOTE:** If a device has already been configured for some other use, re-establish the factory settings. Instructions on how to do this can be found in the respective documentation.

**NOTE:** Be sure that the controller is in a STOP state before parameterizing the drives.

### **WARNING**

#### **UNINTENDED EQUIPMENT OPERATION**

- Never assume that your controller is in a certain controller state before commanding a change of state, configuring your controller options, uploading a program, or modifying the physical configuration of the controller and its connected equipment.
- Before performing any of these operations, consider the effect on all connected equipment.
- Before acting on a controller, always positively confirm the controller state by viewing its LEDs, confirming the condition of the Run/Stop input (if so configured) and/or the Run/Stop switch (if so equipped), verifying the presence of output forcing, and reviewing the controller status information via SoMachine <sup>(1)</sup>.

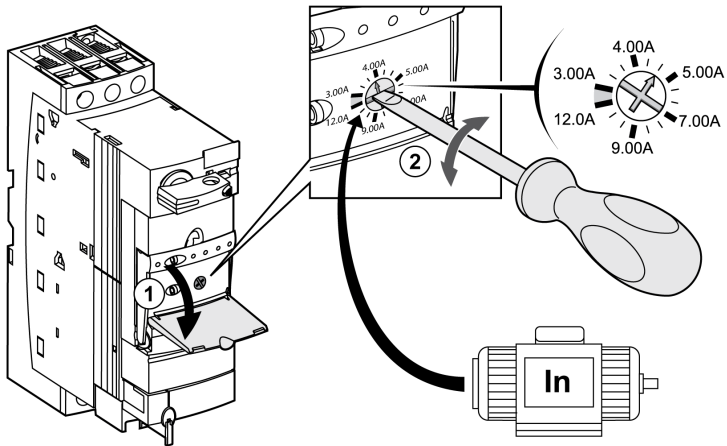
**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

<sup>(1)</sup> The controller states can be read in the `PLC_R.i_wStatus` system variable of the M241 PLCSystem library (see *Modicon M241 Logic Controller, System Functions and Variables, PLCSystem Library Guide*).

## TeSys U Motor Starter - Setup

### Overview

The thermal protection of the motor is set by the rotary switch on the front of the control unit LUCA05BL. The set value has to be appropriate for the connected motor.



## Altivar 32 - Hardwired Setup

### Overview


To operate the Altivar 32 via hardwired signals as it is defined in this example, the I/O configuration has to be set for the drive. In addition to this, it is mandatory to set the parameter of the connected motor in the drive. Further configuration settings are dependent on your application and on the installation.

There are several options to configure the drive:

- By the local HMI on the front of the drive
- By a graphic display terminal\*
- By a remote display terminal\*
- By the configuration software SoMove installed on a PC\*
- By the FDT/DTM integrated in SoMachine installed on a PC\*
- By the software SoMove Mobile installed on a mobile phone linked via Bluetooth

(\* linked to the integrated communication port on the front of the drive)

**NOTE:** If a device has already been in use, re-establish the factory settings. Instructions on how to do this can be found in the respective documentation.

 <b style="font-size: 1.2em;">WARNING</b>
<p><b>UNINTENDED EQUIPMENT OPERATION</b></p> <ul style="list-style-type: none"> <li>● Verify that both wiring and mounting are correct before you start to configure the drive.</li> <li>● Verify that an unintentional start of the connected motor will not endanger personnel or equipment in any way.</li> </ul> <p><b>Failure to follow these instructions can result in death, serious injury, or equipment damage.</b></p>

If necessary, disconnect the motor from the drive to prevent an unintentional motor start.

### I/O Assignment

The table lists the signals to control the Altivar 32:

Signal	Control terminal ATV32	Description
Run forward	LI1	Command to start the drive in forward direction.
Run reverse	LI2	Command to start the drive in reverse direction.
Fault reset	LI3	Command to reset the drive in case an error state.
Drive no fault	R1A (relay output)	R1 is active if the drive has no error detected.

Signal	Control terminal ATV32	Description
Brake control	R2A (relay output)	R2 is activated by the brake control logic of the Altivar 32 and is used to control the external brake contactor.
Drive run	LO-	Indicates if the drive is in RUN state.
Speed reference	AI1	Speed reference signal, 0...10 V.

## Configuration

The submenus and parameters listed in the table are accessible via **[CONFIGURATION]** (CO<sub>n</sub>F) → **[FULL]** (FULL) menu.

Step	Action	Comment
1	Switch on the power supply.	Do not give a RUN command to the drive.
2	Configure the motor parameters under the menu <b>[Motor Control]</b> (drc-): <ul style="list-style-type: none"> <li>● <b>[Standard mot. freq]</b> (bFr)</li> <li>● <b>[Max frequency]</b> (tFr)</li> <li>● <b>[Motor control type]</b> (Ctt)</li> </ul>	Refer to the motor rating plate. Values have to be adjusted if the factory settings differ with your application. If the drive shall apply the brake control logic, the parameter <b>[Motor control type]</b> (Ctt) has to be set either to <b>[SVC V]</b> (UUC) or <b>[Energy sav.]</b> (nLd).
3	Configure the motor parameters under the menu <b>[Async. Motor]</b> (ASY-): <ul style="list-style-type: none"> <li>● <b>[Rated motor power]</b> (nPr)</li> <li>● <b>[Motor 1 Cosinus Phi]</b> (COS)</li> <li>● <b>[Rated motor volt.]</b> (UnS)</li> <li>● <b>[Rated motor current]</b> (nCr)</li> <li>● <b>[Rated motor freq.]</b> (FrS)</li> <li>● <b>[Rated motor speed]</b> (nSP)</li> </ul>	Refer to the motor rating plate. Values have to be adjusted if the factory settings differ with your application.
4	Configure the parameters under the menu <b>[Settings]</b> (Set-): <ul style="list-style-type: none"> <li>● <b>[Acceleration]</b> (ACC)</li> <li>● <b>[Deceleration]</b> (dEC)</li> <li>● <b>[Low Speed]</b> (LSP)</li> <li>● <b>[High Speed]</b> (HSP)</li> <li>● <b>[Mot. Therm. current]</b> (ItH)</li> </ul>	In most cases, the factory settings can be maintained for a quick start. But nevertheless, you have to verify the values.
5	Configure the command channel under the menu <b>[COMMAND]</b> (Ct1-): <ul style="list-style-type: none"> <li>● <b>[Ref. 1 channel]</b> (Fr1)</li> </ul>	In this example, the analog input AI1 is set for the parameter. Fr1= AI1



Step	Action	Comment
6	Configure the I/O assignment under the menu <b>[Inputs/Outputs CFG]</b> (I_O-) <ul style="list-style-type: none"> <li>● <b>[2/3 wire control]</b> (tCC)</li> <li>● <b>[2 wire type]</b> tCt</li> <li>● <b>[Forward]</b> (Frd)</li> <li>● <b>[Reverse]</b> (rrS)</li> <li>● <b>[R1 Configuration]</b> (r1-) → (r1)</li> <li>● <b>[LO1 Assignment]</b> (LO1-) → (LO1)</li> </ul>	In this example, the following values are set for the parameters: <ul style="list-style-type: none"> <li>● tCC = 2C (2 wire control)</li> <li>● tCt = trn (transition)</li> <li>● Frd = LI1 (logical input LI1)</li> <li>● rrS = LI2 (logical input LI2)</li> <li>● R1 = FLt (drive error detection status)</li> <li>● LO1 = rUn (drive running)</li> </ul>
7	Configure the [Fault reset assignment] under the menu <b>[Fault management]</b> (FLt-) <ul style="list-style-type: none"> <li>● <b>[Fault reset]</b> (rSt-) → (rSF)</li> </ul>	In this example, the logic input LI3 is used for the reset of a drive error. rSF= LI3 (logical input LI3)
8	Set the access level to enable further application functions under the menu <b>[Access Level]</b> (LAC) .	To enable the settings for the brake control logic, the parameter <b>[Access level]</b> (LAC) has to be set to <b>[Expert]</b> (EPr) .
9	Configure the parameter for the brake control under the menu <b>[Brake logic control]</b> (bLC-) <ul style="list-style-type: none"> <li>● <b>[Brake assignment]</b> (bLC)</li> </ul>	In this example, the relay output R2 is set for the parameter. bLC=r2 The relay output R2 controls the release of the electro-magnetic brake on the motor. Further parameter can be set dependent to your application.
10	Power cycle the drive.	After the configuration has been finished, power cycle the drive because some parameters only become effective after a power cycle.

For more information, refer to Altivar 32, Variable speed drives for synchronous and asynchronous motors, Programming manual, S1A28692 (ENG).

## WARNING

### UNINTENDED EQUIPMENT OPERATION

Power cycle the drive after any configuration changes or adjustments (power removal followed by power reapplied).

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## Lexium 28 - Pulse Train Control Mode Setup

### Overview

In this architecture, the Lexium 28 is operated in Pulse Train (PT) operation mode. During the PT operation mode, movements are carried out according to externally supplied reference value signals. A position reference value is calculated based on these external reference values plus an adjustable gear ratio.

The configuration of the Lexium servo drive for PT operation mode is described in this section.

There are several options to configure the drive:

- By the local HMI on the front of the drive
- By the configuration software SoMove installed on a PC\*
- By the FDT/DTM as part of the SoMachine software installed on a PC\*

(\*linked to the serial communication connector CN3 on the front of the drive)

**NOTE:** If a device has already been configured for some other use, re-establish the factory settings. Instructions on how to do this can be found in the respective documentation.

### ⚠ WARNING

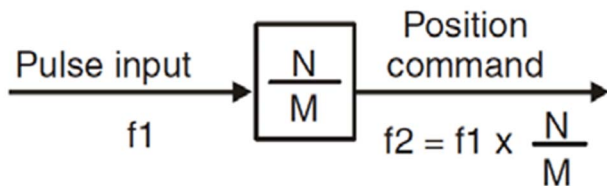
#### UNINTENDED EQUIPMENT OPERATION

- Verify that both wiring and mounting are correct before you start to configure the drive.
- Verify that an unintentional start of the connected motor will not endanger personnel or equipment in any way.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

### Electronic Gear Ratio

During PT operating mode, the position command is calculated on basis of the external pulses and the electronic gear ratio. The resolution of the motor (position command) is determined with 1.280.000 ppr.



**N** Numerator (parameter P1-44)

**M** Denominator (parameter P1-45)

In this architecture, an electronic gear ratio of 640 ( $N/M = 640/1$ ) is used.

The resulting position command for the motor is described below.

- **Continuous motion:**

If the frequency of the external pulses is 100.000 Hz, the motor is rotating with a speed of 3000 rpm.

Position command:  $100.000 \text{ Hz} * 640 = 64.000.000 \text{ pps (Hz)}$

Rotation speed:  $64.000.000 \text{ pps} / 1.280.000 \text{ ppr} * 60 \text{ s} = 3000 \text{ rpm}$

- **Discrete motion:**

If the number of the external pulses is 2000, the motor moves 1 revolution.

Position command:  $2000 \text{ pulses} * 640 = 1.280.000 \text{ pulses}$

Revolutions:  $1.280.000 \text{ pulses} / 1.280.000 \text{ ppr} = 1 \text{ revolution}$

#### Abbreviations

Abbreviation	Long Form	Description
Hz	Hertz	Unit for frequency, $\text{s}^{-1}$
rpm	revolutions per minute	Unit for rotation speed
pps	points (pulses) per second	Unit for the frequency of the position command, same meaning as Hz
ppr	points (pulses) per revolution	Unit for the resolution of an encoder

### I/O Assignment

The table lists the signals to control the Lexium 28:

Signal	Control terminal Lexium 28	Description
Servo on	DI1	Command to enable the drive.
Alarm reset	DI5	Command to acknowledge an alarm on the drive.
Negative inhibit limit switch	DI6	If FALSE drive is stopped immediately with alert AL014.
Positive inhibit limit switch	DI7	If FALSE drive is stopped immediately with alert AL015.
Operation stop	DI8	If FALSE drive is stopped immediately with alert AL013.
Servo on	DO1	Indicates if the servo drive is ready for operation (power stage enabled).
Zero speed detected	DO2	Indicates if the velocity is less than the zero speed velocity.
Positioning completed	DO4	Indicates if the positioning process is completed. The position deviation is within the set tolerance.

Signal	Control terminal Lexium 28	Description
Alarm detected	DO5	Indicates the alarm detection status of the drive.
Pulse signal (24 Vdc)	PULL_HI_P	The number and frequency of the pulses determine the movement of the motor.
Direction signal (24 Vdc)	PULL_HI_S	Determines the direction for the motor (1 = positive).

## Configuration

To adjust the parameters, use the following path and values

Step	Action	Comment
1	Configure the control mode and the output direction with parameter [P1-01].	In this example, the parameter [P1-01] is set to 1100 hex. The meaning of the digits from right to the left is: 00: Pulse Train (PT) control mode via external pulses 1: Output direction (motor), positive = clockwise 1: Digital I/O settings ([P2-10] ... [P2-22]) are changed to their default values after a power cycle.
2	Power cycle the drive.	In order to restore the default values for the I/O settings if selected in step 1 (P1-01).
3	Configure the external pulse input type [P1-00].	In this example, the parameter [P1-00] is set to 0022 hex. The meaning of the digits from right to the left is: 2: input pulse type = pulse + direction 2: input pulse filter = 100 kHz 0: input polarity = positive logic 0: source of pulse command = low-speed pulse
4	Configure the electronic gear ratio [P1-44] (nominator) and [P1-45] (denominator).	In this example, the electronic gear ratio is set to 640. This means for the two parameters: [P1-44] = 640 [P1-45] = 1
5	Configure the digital input functions [P2-10] to [P2-17].	In this example, the configuration of the digital inputs is: [P2-10] (DI1) = 0101 hex: Servo on, normally open [P2-11] (DI2) = 0100 hex: Not used [P2-12] (DI3) = 0100 hex: Not used [P2-13] (DI4) = 0100 hex: Not used [P2-14] (DI5) = 0102 hex: Alarm reset, normally open [P2-15] (DI6) = 0022 hex: Negative inhibit limit switch, normally closed [P2-16] (DI7) = 0023 hex: Positive inhibit limit switch, normally closed [P2-17] (DI8) = 0021 hex: Operational stop, normally closed

Step	Action	Comment
6	Configure the digital output functions [P2-18] to [P2-22].	In this example, the configuration of the digital outputs is: [P2-18] (DO1) = 0102 hex: Servo drive is on, power stage enabled [P2-19] (DO2) = 0103 hex: Zero speed detected [P2-20] (DO3) = 0100 hex: Not used [P2-21] (DO4) = 0105 hex: Positioning completed [P2-22] (DO5) = 0007 hex: No alarm is detected
7	Power cycle the drive.	After the configuration has been finished, power cycle the drive because some parameters only become effective after a power cycle.

## WARNING

### UNINTENDED EQUIPMENT OPERATION

Power cycle the drive after any configuration changes or adjustments (power removal followed by power reapplied).

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

After the configuration, an additional commissioning procedure needs to be performed. For example, a tuning of the drive system and the scaling of the axis.

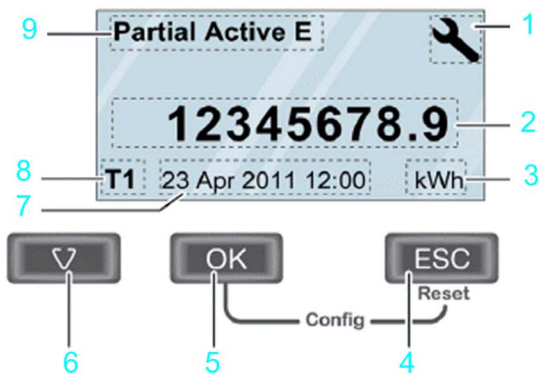
For more information, refer to LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.

## iEM3150 Energy Meter - Modbus SL Setup

### Overview

The energy meter features a sophisticated and intuitive human machine interface (HMI) with signaling LEDs, a graphic display, and contextual menu buttons for accessing the information required to operate the energy meter and modify parameter settings. The navigation menu allows displaying, configuring, and resetting parameters.

The graphic shows the general display:



- 1 configuration mode
- 2 values / parameters
- 3 unit
- 4 cancellation
- 5 confirmation
- 6 selection
- 7 date and time (except for iEM3100 / iEM3200 )
- 8 Active tariff (iEM3115 / iEM3155 / iEM3215 / iEM3255)
- 9 functions / measurements

In addition to this system user guide the product manual for the iEM3150 energy meter has to be read carefully.

For more information, refer to iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN.

## Configuration

Before starting the configuration of the energy meter, verify and ensure that your equipment is properly installed and the application functions correctly:

Step	Action	Comment
1	Set date and time.	When the power is interrupted, the iEM3150 automatically resets the date and time. The start screen after power-on prompts you to set the date and time.
2	Enter the configuration mode. Press and hold <b>ESC + OK</b> for at least 2 seconds.	The display switches to configuration mode.
3	Select the submenu <b>Wiring</b> and set the parameter for it.	The default wiring parameter is set to 3PH4W.
4	Select the submenu <b>Frequency</b> and set the parameter for it.	The default frequency parameter is set to 50 Hz.
5	Select the submenu <b>Communication</b> and set the slave address, baud rate, and parity for it.	The default values of the parameters are set to: <ul style="list-style-type: none"> <li>● slave address = 1</li> <li>● baud rate = 19200</li> <li>● parity = even</li> </ul>
6	Leave the setup menu by pressing <b>ESC</b> .	–

**NOTE:** Further configuration can be done depending on your application needs. For more information, refer to iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN.

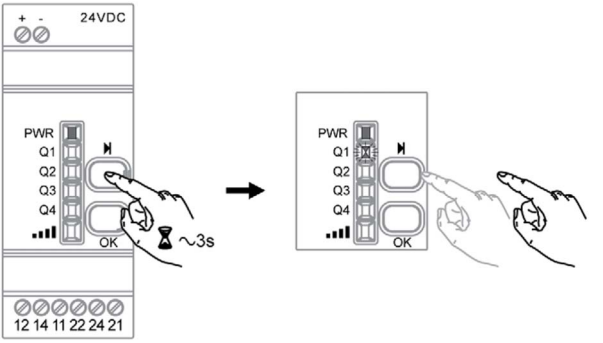
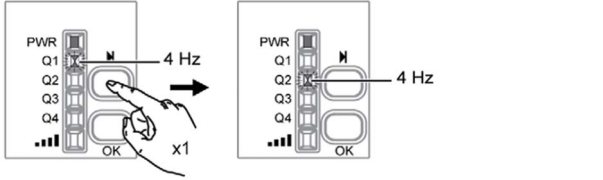
## Harmony ZBRRC Wireless Receiver - Setup

### Overview

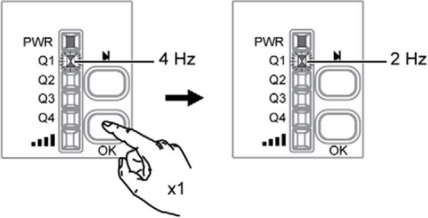
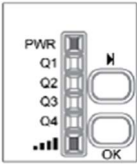
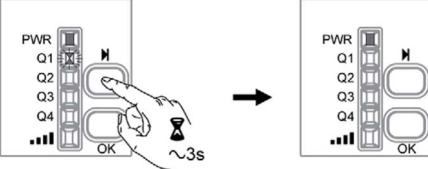
Use the integrated push-buttons on the receiver module to configure the Harmony ZBRRC wireless receiver.

### Settings

Before you work with the devices, the receiver module has to be connected to the power supply and the wireless push button has to be in reach of the receiver module.

Step	Action	Graphic/Comment
1	Enter the teach/unteach mode for push-buttons: <ul style="list-style-type: none"> <li>● Press the arrow key for approximately 3 seconds.</li> </ul>	 <p>Release the key when only the <b>Q1</b> indicator lamp on the device starts flashing green.</p>
2	Select the output for teaching or unteaching: <ul style="list-style-type: none"> <li>● Press the arrow key to switch between output 1, 2, 3, or 4.</li> </ul>	 <p>During selection between the outputs, the corresponding LED is flashing with 4 Hz.</p>



Step	Action	Graphic/Comment
3	Activate the output for teaching or unteaching: <ul style="list-style-type: none"> <li>● Press the <b>OK</b> button to activate the desired output.</li> </ul>	 <p>When the output is selected, the corresponding LED is flashing with 2 Hz. The teach procedure has to be performed within 1:30 minutes.</p>
4	Teach-in the push button: <ul style="list-style-type: none"> <li>● Push the wireless button 3 times within 3 seconds.</li> </ul>	
5	Unteach the push button: <ul style="list-style-type: none"> <li>● Push the wireless button 6 times within 6 seconds.</li> </ul>	<p>Transmission indicator LED at the bottom illuminates when teaching is completed.</p>
6	Exit the teach/unteach mode for push buttons: <ul style="list-style-type: none"> <li>● Press the arrow key for approximately 3 seconds.</li> </ul>	

For more information, refer to Harmony XB5R, Expert Instruction Sheet, EIO000000812 (EN).



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# Chapter 8

## Adapt TVDA Template

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### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
8.1	Adapt SoMachine Project Template	172
8.2	Adapt HMI Application	179

# Section 8.1

## Adapt SoMachine Project Template

---

### What Is in This Section?

This section contains the following topics:

Topic	Page
Introduction	173
Device Modules in General	174
Device Modules Used in This Project Template	175
Add Device Modules	176
Remove Device Module	178

## Introduction

### Overview

The structure of a TVDA project template has a modular design which is based on Device Module (*see page 174*).

This allows you to create your customized project in an easy and flexible way by adapting the TVDA project template.

## Device Modules in General

### Overview

The Device Modules out of the **TVDA Device Module Library** are represented by Function Templates (see *SoMachine, Programming Guide*) within SoMachine. They are especially created for the TVDA project template.

Device Modules are available for all functional units implemented in the different TVD architectures.

By definition functional units in the extent of Device Modules are all sorts of field devices controlled (connected) in various ways by the controller.

All required SoMachine application content, beginning with integrating the device to the hardware configuration up to integration of all needed program code is provided.

Each Device Module comes with its own global variable definition and helps to ensure consistency within the application.

During the device module insertion process, the software prompts you to assign the required configuration such as addresses, names, variable assignment to I/Os, and parameter assignment. (Refer to Add Device Module (see *Compact CANopen Logic Controller M241, System User Guide*.)

Each Device Module provides a ready to use interface within the application program to control the device and to monitor its status.

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## Device Modules Used in This Project Template

### Used Device Modules

The following Device Modules of the **TVDA Device Module Library** are used in this project template.

Device Module
VSD_HW_1Motor_2DVS
TeSysU_HW_2D
MED_iEM3150_ModbusSL

Refer to TVDA Device Module Library (see *TVDA Device Module Library, Function Template Library Guide*).

## Add Device Modules

### Procedure

To add a Device Module, proceed as follows:

Step	Action
1	Right-click the <b>Application</b> node in the <b>Tools tree</b> and select <b>Add Function From Template</b> from the context menu. The <b>Add Function From Template</b> dialog box is displayed.
2	Enter a <b>Function Name</b> that is used for the new folder of the Device Module and for the naming of the elements it contains (GVL, POU, POU call, and so on).
3	Click the ... button and select a Device Module (Function Template) from the <b>TVDA Device Module Library</b> . Confirm with <b>OK</b> .
4	Now you can edit the different properties. Which properties can be edited depends on the selected Device Module.
5	The <b>I/O Mapping</b> field is an optional feature and not mandatory. For some Device Modules, it is possible to map variables directly to I/Os of current I/O configuration. In <b>Mapping</b> column of the <b>I/O Mapping</b> field, click the ... button to open the <b>Select I/O Mapping</b> dialog box and map the variable to a <b>Channel</b> of your I/O configuration. Confirm with <b>OK</b> .
6	In <b>New Value</b> column of the <b>Parameters</b> field, you can enter an initial value for the displayed variables (for example constants). If you do not enter a value, the <b>Default</b> value is used in your project.

### Objects Added

If you add a Device Module, all associated objects are added to the project at the appropriate position. Information on what was done during adding the Device Module, is displayed in the **Messages** window.

Potential objects and actions are listed in the table.

Object	Description
root folder	A new folder is added under the <b>Application</b> node in the <b>Tools tree</b> that is named as defined in the <b>Function Name</b> text box in the <b>Add Function From Template</b> dialog box.
GVL (global variable list)	The global variable list that is included in the Device Module is added below the root folder using the <b>Function Name</b> . For example <code>GVL_VSD_HW_1Motor_2DVS</code> .
POU (program organization unit)	The POU that is included in the Device Module is added below the root folder using the <b>Function Name</b> . For example <code>Prg_VSD_HW_1Motor_2DVS (PRG)</code> .



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Object	Description
POU call	The call of the POU that is included in the Device Module is added below <b>Task Configuration</b> → <b>MAST</b> using the <b>Function Name</b> . For example <code>Prg_VSD_HW_1Motor_2DVS</code> .
I/O mapping	Variables mapped in the <b>Add Function From Template</b> dialog box ( <b>I/O Mapping</b> field), appear in the device editor of the respective device.
libraries	Libraries referenced by the Device Module are automatically added to the <b>Library Manager</b> of your project.

## Remove Device Module

### Procedure

By adding (see *Compact CANopen Logic Controller M241, System User Guide*) a Device Module, various objects are added to your project.

To remove a functional unit (based on a Device Module) from your project, you have to remove the following objects manually from your project.

### Objects to be Removed

Object	Description
root folder	Remove the folder of the Device Module under the <b>Application</b> node in the <b>Tools tree</b> .
GVL (global variable list)	As the GVL is part of the root folder, it is removed with the root folder.
variables	Remove the variables coming from your Device Module and being used in the project. For example in the <b>Symbol configuration</b> or in the I/O mapping.
POU (program organization unit)	As the POU is part of the root folder, it is removed with the root folder.
POU call	Remove the POU call of the Device Module from <b>Task Configuration</b> .
libraries	Remove the libraries referenced by the Device Module from the <b>Library Manager</b> of your project (if not referenced by other objects in your project).

# Section 8.2

## Adapt HMI Application

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### Introduction

#### Overview

The provided HMI application is a general solution.

Since every machine needs its own specific interface, the provided HMI application will in all likelihood not match exactly your requirements. Therefore, you will need to modify the provided HMI application using the Vijeo-Designer configuration software.

Vijeo-Designer is an efficient and flexible tool. It provides numerous functions to facilitate the creation or adaptation of the HMI application.

Especially for an easy adaptation, the following features are highlighted:

- Objects can be saved as templates in tool chest.
- Placeholder in variable expressions can be used.
- Resources for object design can be used.
- Export/import function is available.
- Master panels can be used.

If desired, the provided HMI application can be used as pattern for your solution.



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# Chapter 9

## Bill of Material (BOM)

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### Bill of Material (BOM)

#### Overview

In this chapter, a Bill of Materials (BOM) for the main components of the architecture is provided.

Components and component combinations of the protection system of this architecture are marked with additional information about the conformity to standards IEC and UL. Those which are marked as UL can be considered as a multistandard solution. Nonetheless, you must consider and respect the local standards and codes, as well as the electrical and environmental conditions, where the system is installed and operated. For more information on this topic, refer to the associated product manuals and on the Schneider Electric webpage.

Regardless of the industrial application of a control panel, its protection systems and devices must comply with applicable international standards:

- IEC 60-204 safety of machinery
- UL 508A industrial control panel

Components and component combinations that meet multiple standards are equally important to design and size for ensuring that control panels meet legal requirements across international markets.

### WARNING

#### REGULATORY INCOMPATIBILITY

Ensure that all equipment applied and systems designed comply with all applicable local, regional, and national regulations and standards.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

Schneider Electric offers UL 508A support on the website at [www.Schneider-Electric.us](http://www.Schneider-Electric.us). A number of educational and product search tools are available on the website, including overview information, a UL 508A SCCR (Short Circuit Current Rating) determination flow chart, and information on Schneider Electric individual or product combination SCCRs. Underwriters Laboratories also publish SCCR tested combination ratings on its website. Updated tested combination ratings of Schneider Electric can be found on both websites and are free to download.

The UL 508A support website of Schneider Electric is located at:

<http://www.schneider-electric.us/sites/us/en/support/product-support-resources/ul-508a-support/ul-508a-support.page>

The UL 508A combination motor controller website of UL is located at:

<http://www.ul.com/global/eng/pages/offerings/industries/powerandcontrols/industrialcontrol-equipment>

### Main Switch

Quantity	Description	Reference	IEC	UL
1	PowerPact H-Frame multistandard circuit breaker, main switch, 3pin, 35 kA	NHGF36015TW	x	x
1	Lug kit 15...150 A	AL150HDS	x	x
1	Short lug shield	S37446	x	x
1	Extended rotary handle	LV429502	x	x
1	Red rotary handle on yellow bezel	LV429340	x	x

### Energy meter

Quantity	Description	Reference	IEC	UL
1	Energy meter iEM3150, direct measurement up to 63 A, Modbus communication	A9MEM3150	x	x

### Emergency Stop

Quantity	Description	Reference
1	TM3 safety module, emergency stop cat. 4	TM3SAF5R
1	Emergency stop push-button, 2 NC, 22 mm, complete unit	XB5AS8444
1	Emergency stop push-button, complete plastic control station, yellow/ red, 2 NC	XALK178F
1	Illuminated push-button, blue, 1 NO + 1 NC, integral LED, complete unit	XB5AW36B5
1	Circular yellow legend for emergency stop push button "emergency stop"	ZBY8330
2	TeSys D contactor, AC-3 400 V / 7.5 kW	LC1D18BD

### Door Guard

Quantity	Description	Reference
1	TM3 safety module, emergency stop cat. 4	TM3SAF5R
1	Door guard switch	XCSPA792
1	Actuator for door guard switch	XCSZ12
1	Illuminated push-button, blue, 1 NO + 1 NC, integral LED, complete unit	XB5AW36B5
1	Plastic control station, empty, 1 cut-out, IP 66	XALD01

## Display and Indicators

Quantity	Description	Reference
1	Pilot light with integral LED 24Vac/dc, white, complete unit	XB5AVB1
1	Harmony Wireless access point	ZBRRC
1	Plastic control station, empty, 2 cut-outs, IP 66	XALD02
1	Wireless push-button green	ZB5RTA3
1	Wireless push-button red	ZB5RTA4
1	Empty plastic box for mobile transmitter, 1 cut-out	ZBRM01
1	Wireless push-button blue	ZB5RTA6
1	Plastic control station, empty, 3 cut-outs, IP 66	XALD03
2	Push-button, green, 1 NO, complete unit	XB5AA31
1	Push-button, red, 1 NC, complete unit	XB5AA42
5	Legend holder and blank label (white or yellow) 18x27 mm	ZBY6102
1	Fixing plate for use on vertical support of tower light	XVBC12
1	Fixing base with support tube 80 mm, black	XVBZ02
1	Base unit for tower light	XVBC21
1	Set of 6 colored markers for the position	XVBC22
1	Signal element for tower light, green	XVBC2B3
1	Signal element for tower light, red	XVBC2B4
1	Signal element for tower light, blue	XVBC2B6
1	Signal element for tower light, clear	XVBC2B7

## Automation Components

Quantity	Description	Reference
1	Modicon M241 Logic Controller 24 Vdc, 24I/Os, 2xSL, CANopen, Ethernet	TM241CEC24T
1	TM3 expansion module 16 DI	TM3DI16
1	TM3 expansion module 16DI / 8DO	TM3DM24R
1	TM3 expansion module 16DO	TM3DQ16T
1	TM3 expansion module 4AI / 2AO	TM3AM6
1	TM3 expansion module 4TI	TM3TI4

**Magelis HMI**

Quantity	Description	Reference
1	Magelis HMI small panel with touch screen 5.7"	HMI STU855

**Control Voltage Power Supply and Distribution**

Quantity	Description	Reference	IEC	UL
1	Circuit breaker Mult i9 UL1077 2P, C, 3 A (~230 V)	24444	x	x
1	Power supply 230 Vac / 24 Vdc, 10 A	ABL8RPS24100	x	x
2	Circuit breaker Multi 9 UL1077 1P, C, 1 A (24 Vdc)	24425	x	x
6	Circuit breaker Multi 9 UL1077 1P, C, 2 A (24 Vdc)	24426	x	x
1	Ground disconnect terminal 9760 U/8 TKE 48	57.110.1655.0 (Wieland)	x	x

**Drives and Power**

Quantity	Description	Reference	IEC	UL
<b>Altivar 32</b>				
2	Altivar 32 variable speed drive, 0.37 kW	ATV32H037N4	x	x
2	Magnetic circuit breaker, 2.5 A (3~400 V)	GV2L07	x	-
2	Auxiliary contacts for circuit breaker, 1 NO, 1 NC	GVAE11	x	-
2	Thermal-magnetic circuit breaker, 1.6...2.5 A (3~480 V)	GV2P07	-	x
2	Insulating barrier for motor circuit breaker	GV2GH7	-	x
2	Auxiliary contacts for circuit breaker, 1 NO, 1 NC	GVAN11	-	x
2	CANopen communication card for daisy chain	VW3A3608	x	x
1	Circuit breaker Multi 9 UL489 2P, C, 2 A (~230 V)	60137	x	x
1	Auxiliary contact for Multi 9 circuit breaker, 1 C/O	26925	x	x
1	TeSys D contactor, AC-3 400 V / 4 kW (brake)	LC1D09BD	x	x
<b>Lexium 28</b>				
2	Lexium 28 servo drive 1~230 V/0.1 kW	LXM28AU01M3X	x	x
2	I/O terminal block module with 0.5 m (1.64 ft) cable for I/O connector CN1	VW3M1C13	x	x
2*	Magnetic circuit breaker, 6.3 A (1~230 V)	GV2L10	x	-
2*	Auxiliary contacts for circuit breaker, 1 NO, 1 NC	GVAE11	x	-
* In compliance with the standard IEC 60947-2, a magnetic motor circuit-breaker can be alternatively used instead of the Multi 9 UL489 circuit breaker.				



Quantity	Description	Reference	IEC	UL
2	Circuit breaker Multi 9 UL489 2P, D, 6 A (~230 V)	60158	x	x
2	Circuit breaker Multi 9 UL1077 2P, C, 2 A (~230 V)	24443	x	x
2	Auxiliary contact for Multi 9 circuit breaker, 1 C/O	26925	x	x
2	Servo motor 230 Vac 3-phases	BCH2MB0131CA5C	x	x
2	Power cordset (motor cable), 5 m (16.4 ft)	VW3M5D1AR50	x	x
2	Encoder cordset (encoder cable), 5 m (16.4 ft)	VW3M8D1AR50	x	x
2	Adapter cable for STO connector CN9, 3 m (9.8 ft)	VW3M1C20R30	x	x
<b>TeSys U</b>				
1	TeSys U base unit reversible 24 Vdc	LU2B12BL	x	x
1	TeSys U control unit, standard 0.15...0.6 A	LUCAX6BL	x	x
1	TeSys U auxiliary contact module, 1 NO + 1 NC	LUFN11	x	x
1	TeSys U auxiliary contacts module 2x NO	LUA1C20	x	x
1	Insulating barrier for TeSys U	LU9SPO	-	x
* In compliance with the standard IEC 60947-2, a magnetic motor circuit-breaker can be alternatively used instead of the Multi 9 UL489 circuit breaker.				

## Encoder

The encoders are designed for compatibility with the UL standard, but they are not certified.

Quantity	Description	Reference
1	Incremental encoder, 1024 points, push-pull, 24 Vdc	XCC1510PS11Y
1	Cable for incremental encoder, 5 m	XCCPM23121L5
1	Encoder mounting bracket	XCCRE5SN

## Ethernet Wiring

Quantity	Description	Reference
1	Ethernet TCP/IP unmanaged switch, 10BASET/100BASE-TX, 5x RJ45 ports copper cable	TCSESU053FN0
3	Ethernet ConneXium cable, shielded twisted-pair straight cord, RJ45 connector at each end	2.0 m (6.56 ft) 490NTW00002
1	ConneXium M12 to RJ45 Ethernet adapter	TCSEAAF11F13F00

### Modbus SL Wiring

Quantity	Description	Reference
1	Modbus SL drop cable, 1 RJ45 connector and 1 end stripped	3.0 m (9.8 ft) VW3A8306D30

### Software Tools

Quantity	Description	Reference
1	SoMachine (includes Vijeo-Designer) on DVD	SOMNACS41*
1	Single user license for SoMachine	SOMNACCZXSPA41
1	Programming cable (USB)	TCSXCNAMUM3P
1	Ethernet cable M12 - RJ45	TCSECL1M3M3S2
1	SD card, 2GB	TMASD1
* The latest LXM28 add-on must be installed in addition to the SoMachine DVD separately.		



## C

### **CANmotion**

A CANopen-based motion bus with an additional mechanism that provides synchronization between the motion controller and the drives.

### **CANopen**

An open industry-standard communication protocol and device profile specification (EN 50325-4).

### **CFC**

*(continuous function chart)* A graphical programming language (an extension of the IEC 61131-3 standard) based on the function block diagram language that works like a flowchart. However, no networks are used and free positioning of graphic elements is possible, which allows feedback loops. For each block, the inputs are on the left and the outputs on the right. You can link the block outputs to the inputs of other blocks to create complex expressions.

### **CSA**

*(Canadian standards association)* The Canadian standard for industrial electronic equipment in hazardous environments.

## D

### **DTM**

*(device type manager)* Classified into 2 categories:

- Device DTMs connect to the field device configuration components.
- CommDTMs connect to the software communication components.

The DTM provides a unified structure for accessing device parameters and configuring, operating, and diagnosing the devices. DTMs can range from a simple graphical user interface for setting device parameters to a highly sophisticated application capable of performing complex real-time calculations for diagnosis and maintenance purposes.

## E

### **encoder**

A device for length or angular measurement (linear or rotary encoders).

### **Ethernet**

A physical and data link layer technology for LANs, also known as IEEE 802.3.

**EtherNet/IP**

*(Ethernet industrial protocol)* An open communications protocol for manufacturing automation solutions in industrial systems. EtherNet/IP is in a family of networks that implement the common industrial protocol at its upper layers. The supporting organization (ODVA) specifies EtherNet/IP to accomplish global adaptability and media independence.

**expansion bus**

An electronic communication bus between expansion I/O modules and a controller.

**F**

**FBD**

*(function block diagram)* One of 5 languages for logic or control supported by the standard IEC 61131-3 for control systems. Function block diagram is a graphically oriented programming language. It works with a list of networks, where each network contains a graphical structure of boxes and connection lines, which represents either a logical or arithmetic expression, the call of a function block, a jump, or a return instruction.

**FDT**

*(field device tool)* The specification describing the standardized data exchange between the devices and control system or engineering or asset management tools.

**H**

**HMI**

*(human machine interface)* An operator interface (usually graphical) for human control over industrial equipment.

**I**

**I/O**

*(input/output)*

**IEEE 802.3**

A collection of IEEE standards defining the physical layer, and the media access control sublayer of the data link layer, of wired Ethernet.

**IL**

*(instruction list)* A program written in the language that is composed of a series of text-based instructions executed sequentially by the controller. Each instruction includes a line number, an instruction code, and an operand (refer to IEC 61131-3).

**IP 20**

*(ingress protection)* The protection classification according to IEC 60529 offered by an enclosure, shown by the letter IP and 2 digits. The first digit indicates 2 factors: helping protect persons and for equipment. The second digit indicates helping protect against water. IP 20 devices help protect against electric contact of objects larger than 12.5 mm, but not against water.

**IP 67**

*(ingress protection)* The protection classification according to IEC 60529. IP 67 modules are protected against ingress of dust, contact, and water up to an immersion depth of 1 m.

**L****LD**

*(ladder diagram)* A graphical representation of the instructions of a controller program with symbols for contacts, coils, and blocks in a series of rungs executed sequentially by a controller (refer to IEC 61131-3).

**M****Magelis**

The commercial name for Schneider Electric's range of HMI terminals.

**Modbus**

The protocol that allows communications between many devices connected to the same network.

**Modbus SL**

*(Modbus serial line)* The implementation of the protocol over a RS-232 or RS-485 serial connection.

**P****Profibus DP**

*(Profibus decentralized peripheral)* An open bus system uses an electrical network based on a shielded 2-wire line or an optical network based on a fiber-optic cable. DP transmission allows for high-speed, cyclic exchange of data between the controller CPU and the distributed I/O devices.

**R****RJ-45**

A standard type of 8-pin connector for network cables defined for Ethernet.

**RS-232**

A standard type of serial communication bus, based on 3 wires (also known as EIA RS-232C or V.24).

**RS-485**

A standard type of serial communication bus, based on 2 wires (also known as EIA RS-485).

**S**

**SFC**

(*sequential function chart*) A language that is composed of steps with associated actions, transitions with associated logic condition, and directed links between steps and transitions. (The SFC standard is defined in IEC 848. It is IEC 61131-3 compliant.)

**SL**

(*serial line*)

**SoMachine**

A comprehensive controller development system software tool for configuring and programming the Modicon logic controller and devices compliant with IEC 61131-3.

**ST**

(*structured text*) A language that includes complex statements and nested instructions (such as iteration loops, conditional executions, or functions). ST is compliant with IEC 61131-3.

**T**

**TCP**

(*transmission control protocol*) A connection-based transport layer protocol that provides a simultaneous bi-directional transmission of data. TCP is part of the TCP/IP protocol suite.

**terminal block**

(*terminal block*) The component that mounts in an electronic module and provides electrical connections between the controller and the field devices.

**TVDA**

(*tested validated documented architectures*) Control system proposals based on Schneider Electric components. TVDAs cover a wide range of machine types and consider machine performance requirements, installation constraints, and target costs. To optimize the implementation effort, each TVDA comes with a detailed component list, wiring diagrams, and commissioning guide, as well as controller and HMI applications to control components of the system.



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