

# Compact Modbus SL Logic Controller M221 Book

## System User Guide

09/2018



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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



## Important Information

### NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, service, 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.

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.

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**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.

### **WARNING**

#### 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 death, serious 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 M221 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 for the release of EcoStruxure™ Machine Expert - Basic V1.0.

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## Related Documents

Title of Documentation	Reference Number
PowerPact Multistandard, Catalogue	LVPED212023EN
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
LAD5C Instruction Sheet	HRB8873800
Preventa, Machine Safety Products	MKTED208051EN
The essential guide: Preventa machine safety	DIA4ED2041204EN
Magelis Small Panels HMI STO, User Manual	EIO00000000239
Magelis XBT G/XBT GT, Modbus TCP/IP driver	35007091
Harmony XB5R, Expert Instruction Sheet	EIO0000000812 (EN)
Control and signaling components	MKTED208031EN
Modicon M221 Logic Controller, Hardware Guide	EIO00000001384
Modicon M221 Logic Controller, Programming Guide	EIO00000001360
Modicon TM3, Expansion Modules Configuration, Programming Guide	EIO00000001402
Modicon TM3, Digital I/O Modules, Hardware Guide	EIO00000001408
Modicon TM3, Expert I/O Modules, Hardware Guide	EIO00000001420
Control and protection components	MKTED210011EN
TeSys U, Starter-controllers, Catalogue	DIA1ED2081003EN
The essential guide, TeSys for power control & protection	DIA1ED2040401EN
Altistart 01, Soft Starts for Single-Phase and Three-Phase Asynchronous Motors	45A01SS
Characteristics, Soft starters for asynchronous motors Altistart 01	60541-EN
Reduce mechanical stress on your machines	DIA2ED1121204EN
Instruction Sheet ATS01N1...FT	1624685
Altivar 12, Variable speed drives for asynchronous motors, User manual	BBV28581
Altivar 12 Variable speed drives for asynchronous motors, Modbus Communication Manual	BBV28590
RFID OsiSense XG, Compact Stations	9006CT1101
ConneXium Ethernet Switches, TCSESU0••F•N0, Quick Reference Guide	31007950

Title of Documentation	Reference Number
Osisense XG, Radio Frequency Identification System, Catalog	9006CT0902
Detection for automation solutions OsiSense	MKTED210041EN
The essential guide of Detection	DIA4ED2041203EN
Transparent Ready, User Guide	31006929
Modbus Serial Line, Planning and Installation Guide	33003925

You can download these technical publications and other technical information from our website at <https://www.schneider-electric.com/en/download>

### 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.**

This equipment has been designed to operate outside of any hazardous location. Only install this equipment 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.**

## **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.**

### **Terminology Derived From Standards**

The technical terms, terminology, symbols and the corresponding descriptions in this manual, or that appear in or on the products themselves, are generally derived from the terms or definitions of international standards.

In the area of functional safety systems, drives and general automation, this may include, but is not limited to, terms such as *safety*, *safety function*, *safe state*, *fault*, *fault reset*, *malfuction*, *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.

Standard	Description
EN 61496-1:2013	Safety of machinery: Electro-sensitive protective equipment. Part 1: General requirements and tests.
ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN 60204-1:2006	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 1088:2008 ISO 14119:2013	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
ISO 13850:2006	Safety of machinery - Emergency stop - Principles for design
EN/IEC 62061:2005	Safety of machinery - Functional safety of safety-related electrical, electronic, and electronic programmable control systems
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.
2006/42/EC	Machinery Directive
2014/30/EU	Electromagnetic Compatibility Directive
2014/35/EU	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 60034 series	Rotating electrical machines
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 *Machinery Directive (2006/42/EC)* and *ISO 12100:2010*.

**NOTE:** The aforementioned standards may or may not apply to the specific products cited in the present documentation. For more information concerning the individual standards applicable to the products described herein, see the characteristics tables for those product references.



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# Chapter 1

## General Information

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### What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Introduction	18
Deliverables	19

## Introduction

### Overview

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

TVDA 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, 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

### Project Template

The 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 EcoStruxure Machine Expert – Basic 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)

## General Information

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# Chapter 2

## System Architecture

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### What Is in This Chapter?

This chapter contains the following topics:

Topic	Page
Architecture Related Safety Information	22
System Architecture	24

## 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

Care must be taken and provisions made for use of this product as a control device to avoid inadvertent consequences of commanded machine operation, state changes, or alteration of data memory or machine operating parameters.

### **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, if so equipped, or, other external means within the application, so that local control over the starting or stopping of the device can be maintained regardless of the remote commands sent to it.

**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

Fieldbusses 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 M221 Logic Controller (book format)
- Magelis HMI STO touch panel
- Energy metering
- Modbus serial line communication
- Ethernet connectivity
- Application of machine functional safety
- Wireless and batteryless operator push-buttons
- 24 digital inputs
- 24 digital outputs
- 2 analog inputs
- 2 TM3XTYS4 expansion modules for connection with up to 8 TeSys motor starters

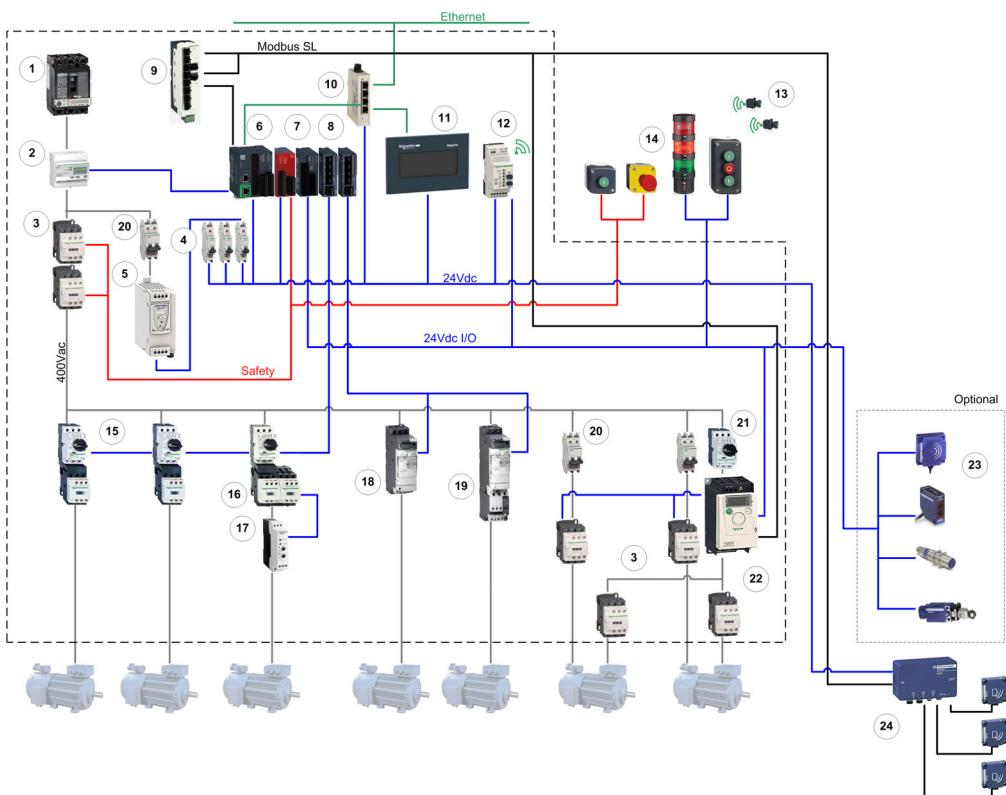
The following devices are linked to Modbus serial line and are controlled and monitored by the controller:

- Altivar 12 variable speed drive
- 3 RFID compact smart antennas

The architecture implements 5 motor starters which are linked to the TM3XTYS4 expansion modules on the controller. The control and monitoring of the motor starters is realized with the controller via hardwired signals.

- 2 TeSys D motor starter combinations
- 1 TeSys D motor starter combination and Altistart soft starter
- 2 TeSys U motor starter controller

## Layout



1	PowerPact H-Frame circuit breaker	13	Harmony wireless push-buttons
2	iEM3110 energy meter	14	Harmony signaling/control devices
3	TeSys D contactor	15	TeSys D motor starter + wiring adapter
4	Multi-9 C60 (UL 1077) circuit breaker	16	TeSys D rev. motor starter + wiring adapter
5	Phaseo power supply 24 Vdc	17	Altistart ATS01N1 soft starter
6	Modicon M221 Logic Controller (book format)	18	TeSys U motor starter
7	TM3 embedded safety module	19	TeSys U rev. motor starter
8	TM3 I/O expansion module	20	Multi-9 C60 (UL 489) circuit breaker
9	Modbus RS-485 hub	21	TeSys GV2P motor circuit breaker

10	Ethernet switch (unmanaged)	22	Altivar 12 variable speed drive
11	Magelis HMI STO touch panel	23	OsiSense sensors and switches
12	Harmony wireless receiver	24	OsiSense XG tap-off box + RFID compact smart antennas

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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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Risk Assessment	32
Functional Safety Standards	36
Standard EN ISO 13849-1 Machinery Safety - Safety-Related Parts of Control System	37
Standard EN/IEC 62061 Machinery Safety - Safety-Related Parts of Control System	45
Selecting the Applicable Standard	52
More Information Regarding Safety	53
Functional Safety Measures Implemented in this Architecture	56

## Safety Evolution Structure for the System User Guides

### Overview

1. Evolution of legal framework (*see page 29*)
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*)
6. Selecting the applicable standard (*see page 52*)
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/EC/96/82/EC
Sector of Activity	Machine Builder	End User System Integrator	End User System Integrator
<b>Safety Standards</b>			
Generic Standard EN/IEC 61508	Harmonized Standards EN ISO 13849-1 EN ISO 13849-1 EN/IEC 62061	EN ISO 13849-1 EN/IEC 62061 EN/IEC 61508	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:

<b>Type A standards</b> Basic safety standards giving basic concepts, principles for design, and general aspects that can be applied to all machinery.	
<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:	
<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>	
<b>Type C standards</b> Machine safety standards dealing with detailed safety requirements for a particular machine or group of machines.	

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.

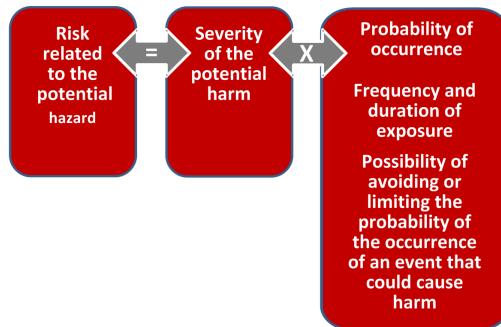
### Risk Assessment

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

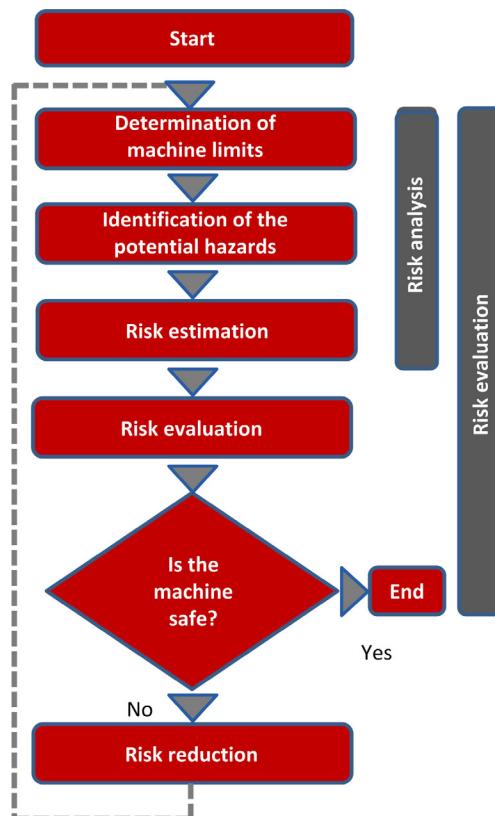
Risk assessment starts by determining the limits of the machine at all stages of its life cycle:

- 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.

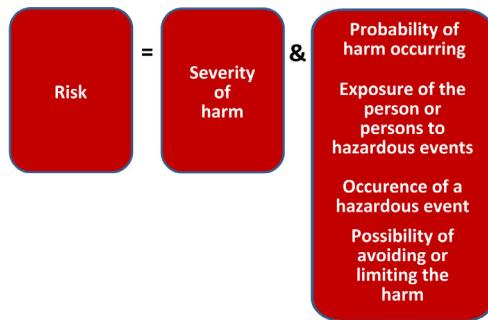
The risk is a function of the severity of the harm and the probability that this harm will occur. The severity of the harm takes into account:

- 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, carters, fix 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 relative 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.

## 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 (PL<sub>r</sub>).
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 (PL<sub>r</sub>).
6. Check that all requirements are satisfied.

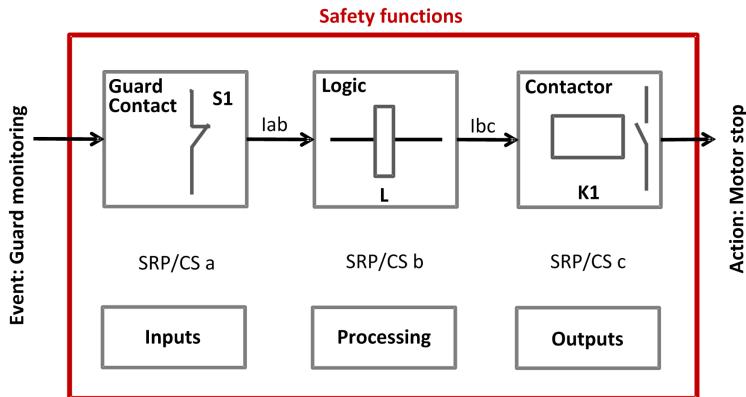
The above 6 stages will be illustrated taking as an example a safety function where a severe injury can be caused by a horizontal movement on a machine not stopping where an operator maybe exposed to this dangerous situation. The machine is sometimes accessed by production workers and monitored during 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/CS<sub>a</sub>)
- The control logic, limited in this example to opening or closing of a contactor coil (SRP/CS<sub>b</sub>)
- The power output that controls the motor (SRP/CS<sub>c</sub>)
- The connections (I<sub>ab</sub>, I<sub>bc</sub>)

### 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:

**S:** Severity of the injury

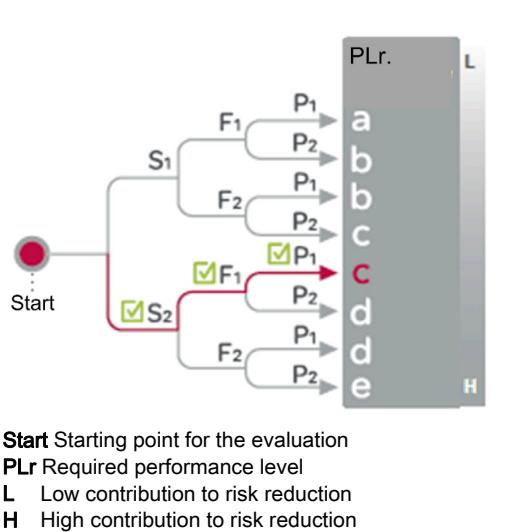
- **S1:** Slight injury, normally reversible
- **S2:** Serious, normally irreversible, including death

**F:** Frequency and/or duration of exposure to the hazardous phenomenon

- **F1:** Rare to fairly frequent and/or short duration of exposure
- **F2:** Frequent to permanent and/or long duration of exposure

**P:** Possibility of avoiding the hazardous phenomena or limiting the harm

- **P1:** Possible under certain circumstances
- **P2:** Virtually impossible



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.

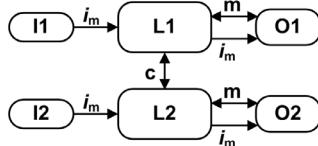
For a SRP/CS (or a combination of SRP/CS), PL could be estimated with the figure after estimation of several factors such as:

- Hardware and software system structure (categories)
- Mechanism of failures, diagnostic coverage (DC)
- Components reliability, mean time to dangerous failure ( $MTTF_d$ )
- 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.	

Category	System Behavior	Designated Architecture
4	When faults occur, the safety function is always ensured. Faults will be detected in time to prevent loss of the safety function.	 <pre> graph LR     I1((I1)) -- i_m --&gt; L1[L1]     I2((I2)) -- i_m --&gt; L2[L2]     L1 -- m --&gt; L1     L1 -- c --&gt; L2     L2 -- m --&gt; L2     L2 -- c --&gt; L1     L1 -- i_m --&gt; O1((O1))     L2 -- i_m --&gt; O2((O2))   </pre>

**I<sub>m</sub>** Interconnecting means

**C** Cross monitoring

**I, I<sub>1</sub>, I<sub>2</sub>** Input device, for example sensor

**L, L<sub>1</sub>, L<sub>2</sub>** Logic

**m** Monitoring

**O, O<sub>1</sub>, O<sub>2</sub>** Output device, for example main contactor

**TE** Test equipment

**OTE** Output of TE

### 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 ≤ MTTF <sub>d</sub> < 10 years
Medium	10 years ≤ MTTF <sub>d</sub> < 30 years
High	30 years ≤ 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)

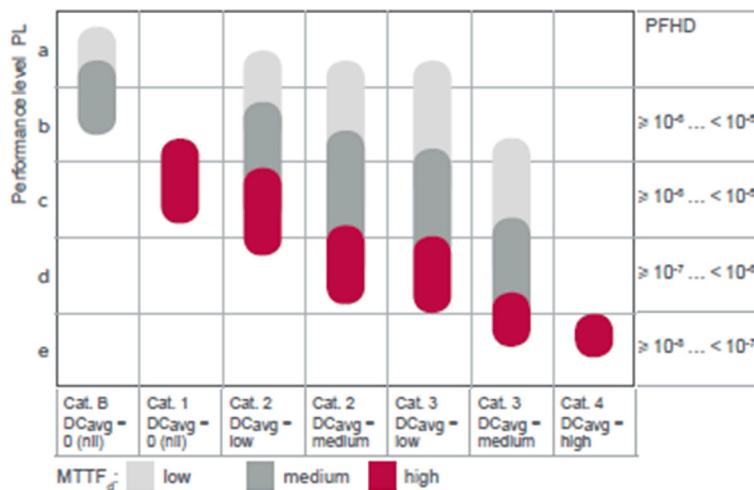
This term is expressed as a percentage and quantifies the ability to diagnose a dangerous failure.

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% ≤ DC < 90%
Medium	90% ≤ DC < 99%
High	99% ≤ DC

The relationship between categories, DC and MTTF<sub>d</sub> 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<sub>d</sub> values.

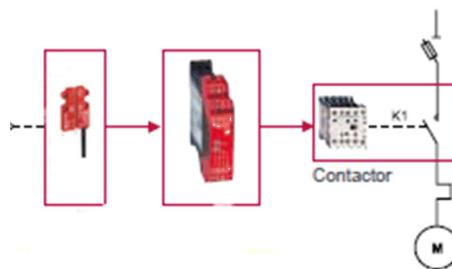
As the example requires PL=c the chart states as a minimum a category 1 architecture with a diagnostic coverage of 0 (Nil) and a MTTF<sub>d</sub> of high is required.

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]     Action -- feedback --&gt; Input   </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<sub>d</sub>, 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, B10d values are provided by the supplier in some cases. When the B10d values are not available, the annex C from the 13849-1 standard can be used.

Example	B <sub>10d</sub> (Where 10% of the Population Fail to Dangerous Failure Mode)	MTTF <sub>d</sub>	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<sub>d</sub>, the DC, and the category from each component are known. The procedure to follow:

- Calculation of MTTF<sub>d</sub> and DC of the complete system
- Analysis of the category

For electromechanical products:

- The MTTF<sub>d</sub> is calculated based on the total number of operations that the product can perform, using B<sub>10d</sub> values.

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

- N = 220 × 8 × (3600 / 90) = 70,400 operations/year

- MTTF<sub>d</sub> = B<sub>10d</sub> / (0.1 × N)

For the magnetic switch:

- The MTTF<sub>d</sub>= 1578 years

For the contactors:

- The MTTF<sub>d</sub> = (1,369,863) / (0.1) × 70,400 = 194 yearsThe MTTF<sub>d</sub> for each channel will then be calculated using the formula:

$$\frac{1}{MTTF_d} = \frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}} \text{ that is, 284 years}$$

A similar formular is used to calculate the diagnostic capability:

$$DCavg = \frac{\frac{DCa}{MTTF_{da}} + \frac{DCb}{MTTF_{db}} + \frac{DCc}{MTTF_{dc}}}{\frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}}}$$

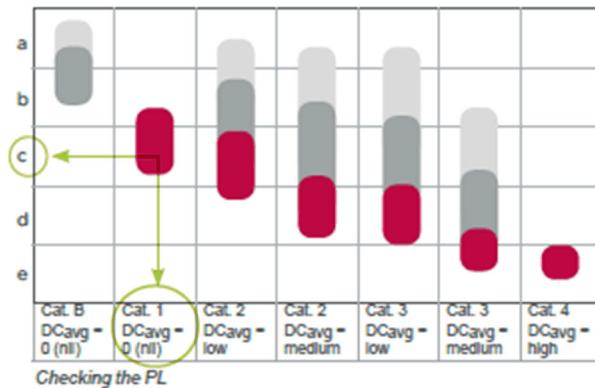
The DC in the example is < 60%, for example nil.

### 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<sub>d</sub> >> 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.

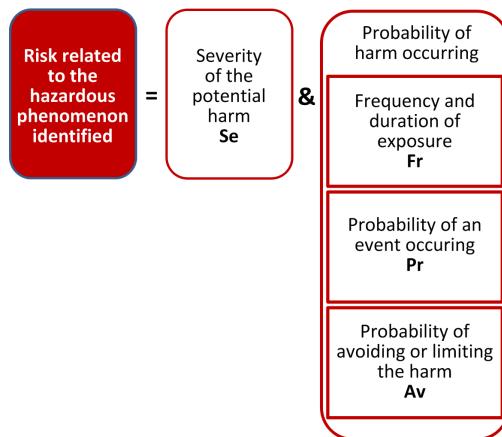
The method consists of assigning a SIL to each function, taking into account the following parameters:

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

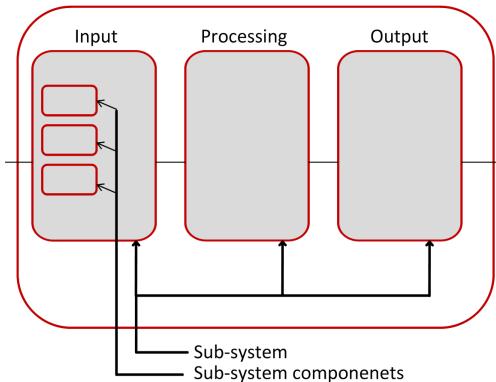
Designing a system is split into 5 stages after having drawn up the functional safety plan:

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
2 weeks ≤1 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  $\text{CI} = 5 + 2 + 3 = 10$

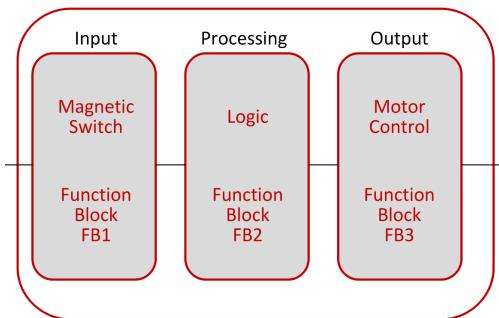
A level of SIL 2 must be achieved by the safety-related electrical control systems (SRECS) on the machine.

Se	Class CI				
	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.

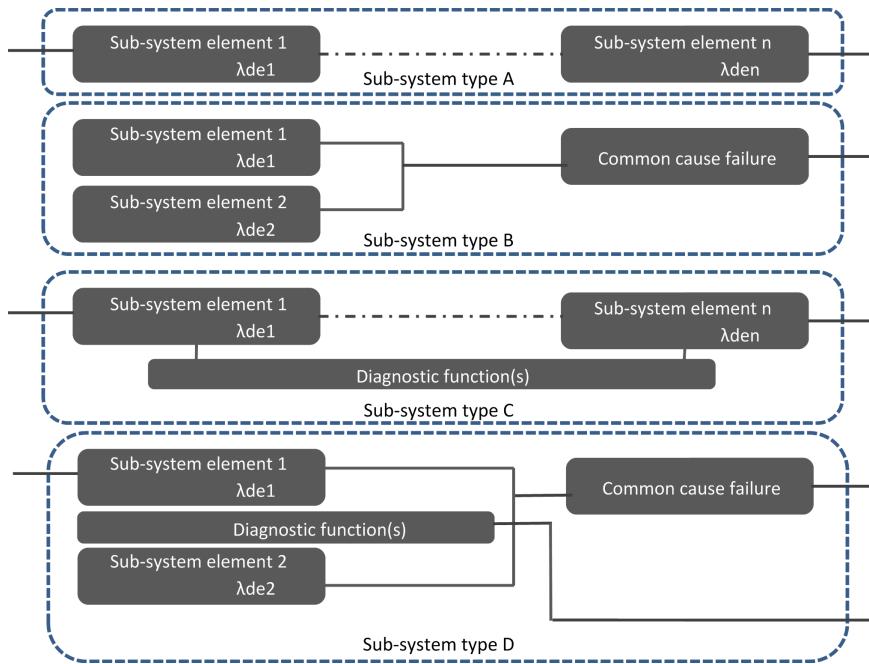
### Stage 3 - List the Safety Requirements for Each Function Block and Assign the Function Blocks to the Subsystems

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 ( $\text{PFH}_d$ ) 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  $\text{PFH}_d$  values

SIL	Probability of Dangerous Failures Per Hour ( $\text{PFH}_d$ )
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  $\text{PFH}_d$ . 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/bgia/en/prä/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 (PLr) 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.

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

<b>Step</b>	<b>Action</b>	<b>Comment</b>
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.
<p>* <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></p>		

## Functional Safety Measures Implemented in this Architecture

### Overview

Within the described architecture, the safety function emergency stop is applied what is described in this section.

**NOTE:** The safety function proposed in this architecture does not provide a preferred safety chain solution for your machine. This is a proposal 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 <b>TM3SAF5R</b>
Output	2 redundant contactors with feedback loop LC1D

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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	58
4.2	Safety Modules	69
4.3	HMI	74
4.4	Controller	81
4.5	Communication	95
4.6	Motor Control	97
4.7	Detection	119

## 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	59
Multi-9 C60 (UL 1077) Circuit Breaker - Hardware	61
Multi-9 C60 (UL 489) Circuit Breaker - Hardware	63
Phaseo Power Supply Universal - Hardware	64
iEM31xx Energy Meter Series - Hardware	66

## 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

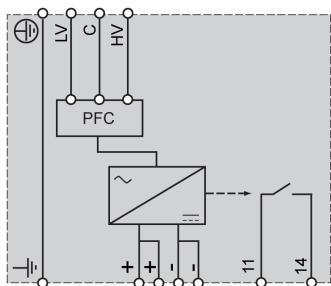
Dimensions	6 different types (W x H x D): 44...165 x 143 x 120...155 mm (1.73...6.5 x 5.63 x 4.72...6.1 in.)
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For more information, refer to :

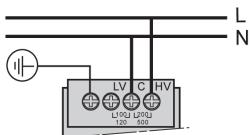
- The essential guide for power supplies and transformers, DIA3ED2070412EN
- Phaseo power supplies and transformers, Catalogue Pages, 14082-EN

## 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.

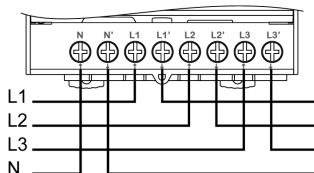
- Graphical display for easy viewing
- Self-powered meters
- Direct measurement up to 63 A
- Onboard Modbus, LON, M-Bus or BACnet communication
- Commissioning safely with ease
- Compact size

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.)

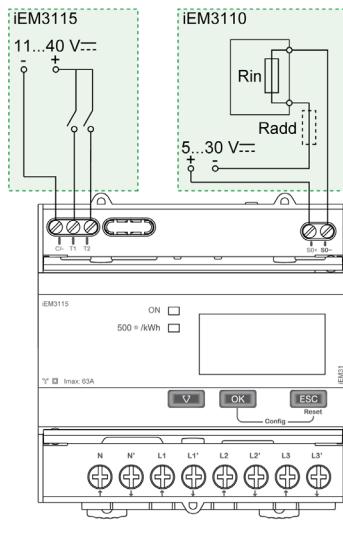
For more information, refer to [iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN](#).

## Wiring

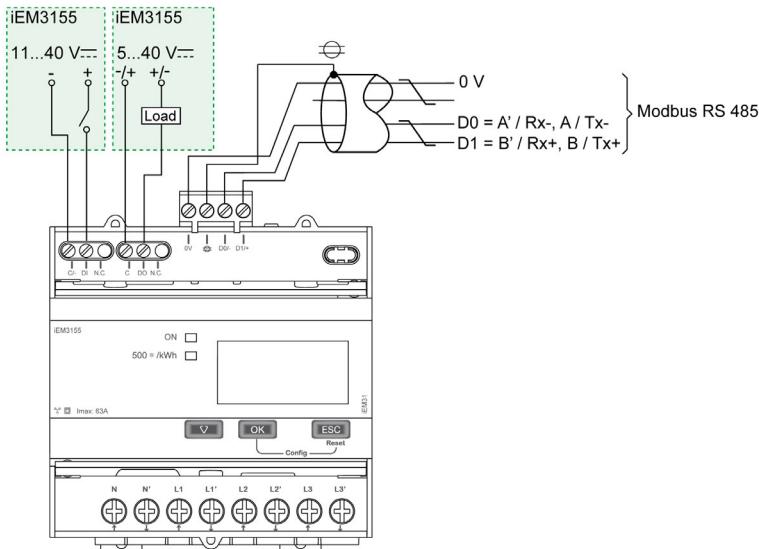
The graphic shows the wiring on three-phase systems for direct measurement of iEM31..



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	70
Preventa Detection and Dialog - Hardware	73

## 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.

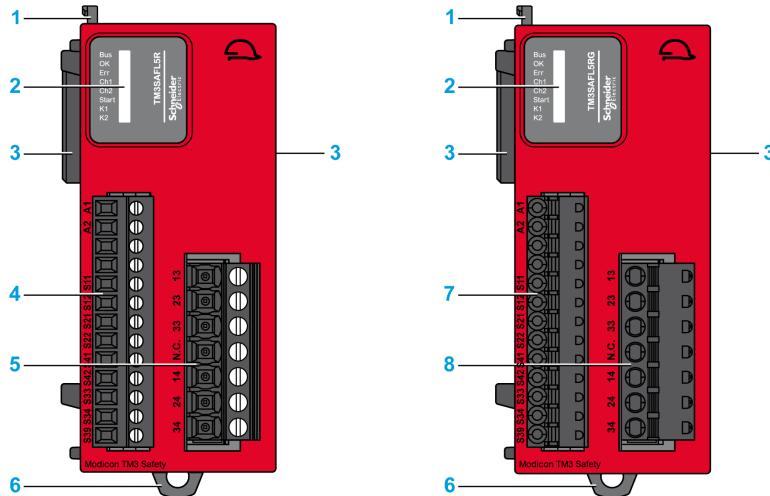
The module used in the described architecture is the TM3SAF5R. The main characteristics are described in the table below.

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

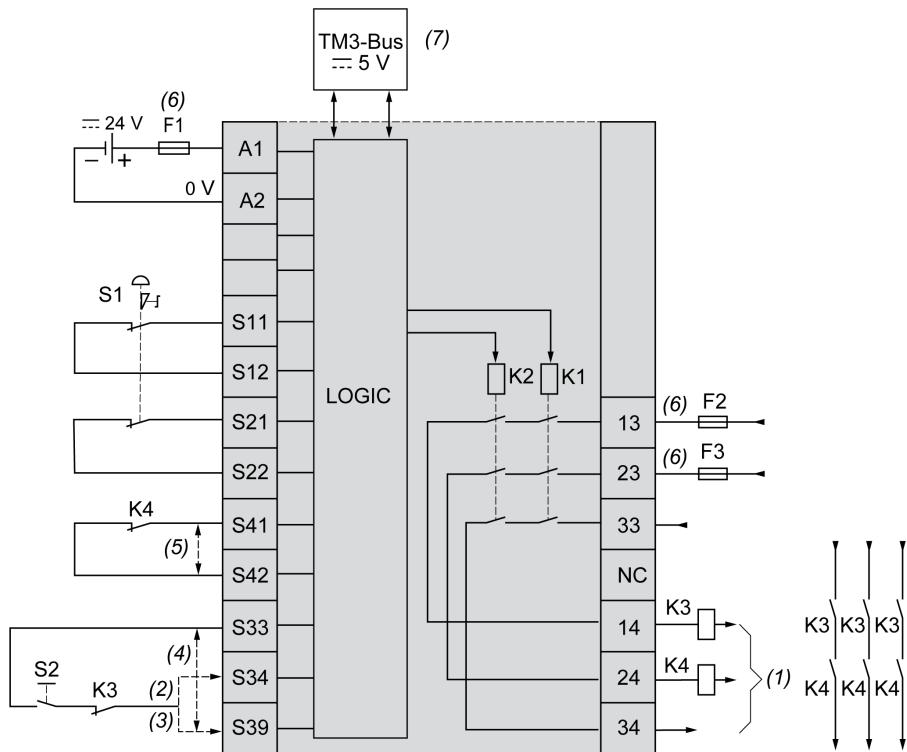


1	Locking device for attachment to the previous module
2	Status LEDs
3	Expansion connector for I/O bus (one on each side)
4	Power supply and input removable screw terminal block with a 3.81 mm (0.15 in) pitch
5	Relay output removable screw terminal block with a 5.08 mm (0.20 in) pitch
6	Clip-on lock 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, EIO0000001831.

## 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 [S33] and [S39] terminals
(5)	Second external device monitoring channel. Connect [S41] and [S42] 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

Schneider Electric is the provider of the safety chain covering the safety functionality and scalability for your machine. Preventa offers an extensive range of safety-related products, compliant with international standards, designed to provide protection for personnel and equipment.

For more information, refer to Preventa solutions for efficient machine safety - catalogue, MKTED2140201EN.

Complementary safety-related products like light curtains, emergency stop rope pull switches or switches are offered by Telemecanique Sensors; brand of Schneider Electric.

Telemecanique Sensors proposes a number of ranges of safety-related products:

- Discover this offer on the website: <http://www.tesensors.com/global>
- Access to the catalog by product at this URL:  
<http://www.tesensors.com/global/en/product/catalog/>

## Section 4.3

### HMI

---

#### What Is in This Section?

This section contains the following topics:

Topic	Page
Magelis HMI STO - Hardware	75
Harmony XB5R ZBRRCC Wireless Access Point - Hardware	78
Harmony Control and Signaling - Hardware	80

## Magelis HMI STO - Hardware

### Front View

Magelis HMI STO product range



### Description

Magelis HMI STO touch screen small panels offer you ease of use and efficiency, while boasting high-end features and capabilities in a small package. The HMI STO product has capabilities more typical of larger products, including data management, remote access, and multiplex connectivity to major controllers and control products, as well as other products.

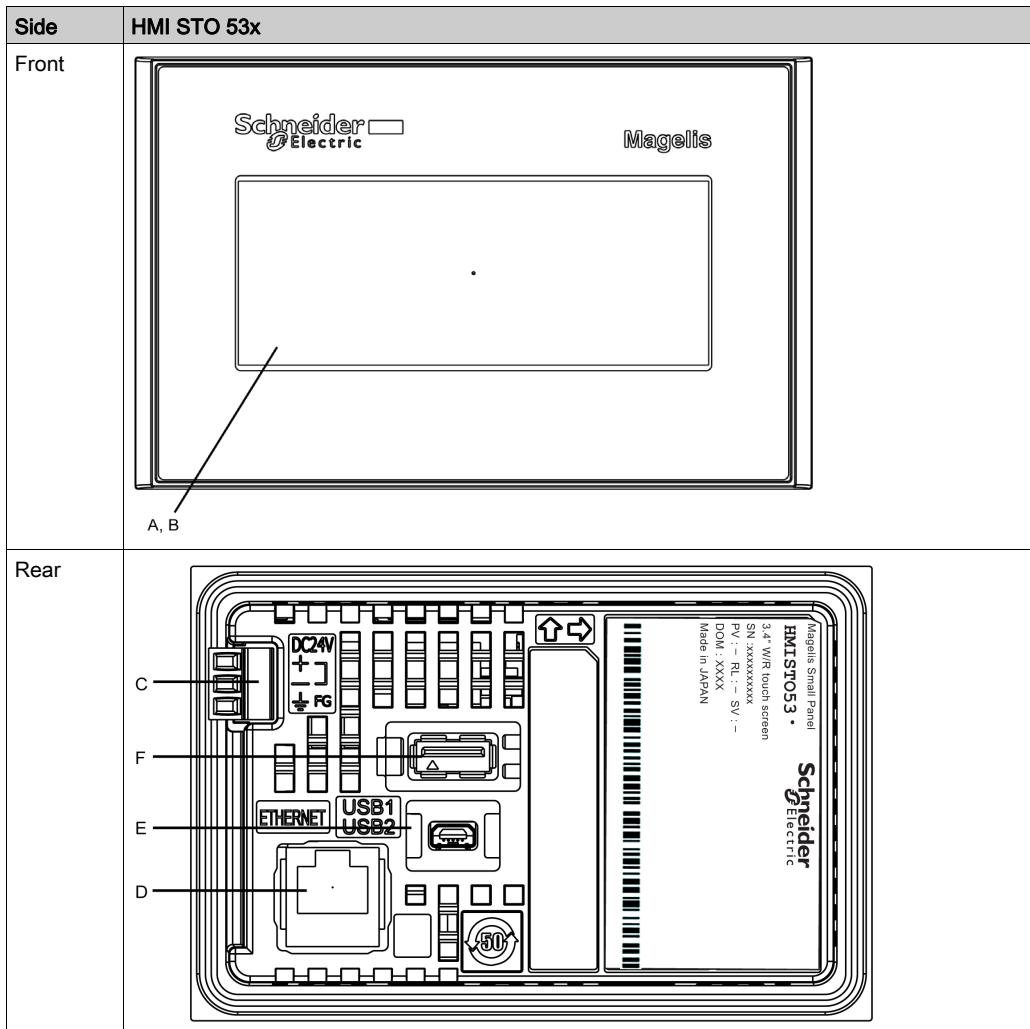
- 3.4" monochrome touch screen, available with 2 different types of backlighting:
  - Green, orange, red
  - White, pink, red
- Tool free mounting with Magelis spring clips
- Connectivity depending on the model:
  - Ethernet
  - Serial line
- 2 USB V2.0 ports for data transfer

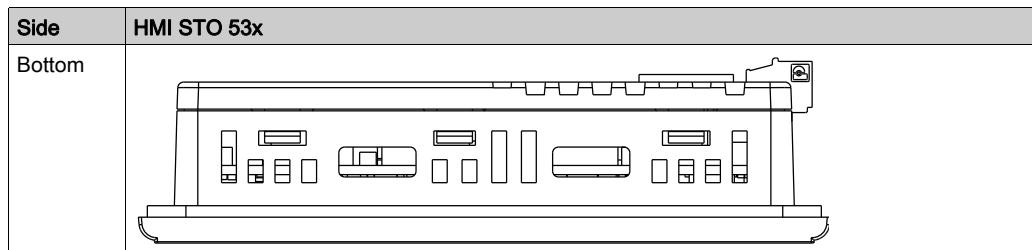
Standards and certifications	EN, IEC, UL 508, ISA 12.12.CSA, Marine Bridge & Deck, Gost
Power supply	24 Vdc with removable connector
Degree of protection	<ul style="list-style-type: none"> <li>● Front panel: IP 65</li> <li>● Rear panel: IP 20</li> </ul>
Interfaces	Type HMI STO 53-: <ul style="list-style-type: none"> <li>● Ethernet port: 1x RJ45</li> <li>● USB: 1x mini-B (2.0) + 1x Type-A (2.0)</li> </ul>
Display	3.4", 200 x 80 pixels, 2 versions 3 colors

Memory	<ul style="list-style-type: none"> <li>Application: 16 Mb</li> <li>Backup: 128 Kb</li> </ul>
Dimensions	W x H x D: 117 x 78 x 28 mm (4.6 x 3.1 x 1.1 in)

For more information, refer to Magelis Small Panels HMI STO, User Manual, EIO0000000239.

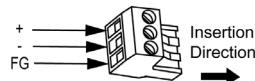
## Wiring





A	Display: displays user created screens and remote equipment variables.	D	Ethernet interface: connects an Ethernet cable (from the host/controller) to the unit.
B	Touch panel: performs screen change operations and sends data to the host (controller).	E	Mini-B USB port connector: connects the data transfer PC cable to the unit (USB2 port).
C	Power input terminal block: connects the power input and ground wires to the unit.	F	Standard A USB port connector: connects the data transfer cable or memory stick to the unit (USB1 port).

#### Power plug



- + 24 Vdc
  - 0 Vdc
- FG** Grounded terminal connected to the unit chassis

## Harmony XB5R ZBRRCC Wireless Access Point - Hardware

### Front View

Harmony ZBRRCC 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:

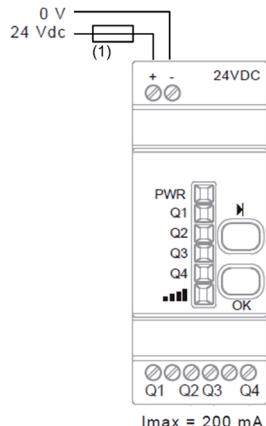
- packing lines
- automatic doors in logistic centers
- automobile industries
- bag filling in cement industries
- office lighting for efficient usage of the power

Standards and certifications	BT2006/95EC, CE: R:TTE1999/5/EC, EMC2004/108/EC, C-Tick, UL, CSA, CCC, Gost, RSS, ANATEL, SRRC, 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, EIO0000000812 (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

---

#### What Is in This Section?

This section contains the following topics:

Topic	Page
Modicon M221 Modular Logic Controller - Hardware	82
Modicon TM3 Modules - Hardware	87
TM3XTYS4 TeSys Module - Hardware	89

## Modicon M221 Modular Logic Controller - Hardware

### Front View

Modicon logic controller TM221M16TG



### Description

The Modicon M221 Logic Controller has various powerful features and can service a wide range of applications. Software configuration, programming, and commissioning are accomplished with the EcoStruxure Machine Expert - Basic software described in the EcoStruxure Machine Expert - Basic Operating Guide.

The EcoStruxure Machine Expert - Basic software supports the following IEC 61131-3 programming languages:

- IL: Instruction list
- LD: Ladder diagram
- Grafcel (List)

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

- Ethernet
- USB programming
- Serial line

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

- Regular inputs
- Fast inputs associated with counters
- Regular transistor outputs
- Fast transistor outputs (PWM/PLS/PTO/FREQGEN)
- Regular relay outputs
- Analog inputs

Standards and certifications	IEC/EN 61131-2, UL 508
Rated voltage	24 Vdc
Degree of protection	IP 20
Memory	<ul style="list-style-type: none"> <li>● RAM: 640 Kbytes, of which 256 Kbytes are available for the application</li> <li>● Flash: 2 Mbytes - of which 256 Kbytes are used to back up the user application</li> </ul>
Dimensions	W x H x D: 70 mm (3.35 in) x 102 mm (4.02 in) x 85 mm (3.35 in)
Options	<ul style="list-style-type: none"> <li>● SD card</li> <li>● TM2 I/O modules</li> <li>● TM3 I/O modules</li> </ul>

For more information, refer to :

- Modicon M221 Logic Controller, Hardware Guide, EIO0000001384
- Modicon M221 Logic Controller, Programming Guide, EIO0000001360

## M221 Modular Logic Controllers

Reference	Digital inputs	Digital outputs	Analog inputs	Communication ports
TM221M16R/ TM221M16RG <sup>1</sup>	4 regular inputs <sup>3</sup> 4 fast inputs (HSC) <sup>4</sup>	8 relay outputs	2 analog inputs 0...10 V	2 serial line ports 1 USB mini-B programming port
TM221M16T/ TM221M16TG <sup>1</sup>	4 regular inputs <sup>3</sup> 4 fast inputs (HSC) <sup>4</sup>	6 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>5</sup>	2 analog inputs 0...10 V	2 serial line ports 1 USB mini-B programming port
TM221ME16T/ TM221ME16TG <sup>1</sup>	4 regular inputs <sup>3</sup> 4 fast inputs (HSC) <sup>4</sup>	6 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>5</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221M32TK <sup>2</sup>	12 regular inputs <sup>3</sup> 4 fast inputs (HSC) <sup>4</sup>	14 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>5</sup>	2 analog inputs 0...10 V	2 serial line ports 1 USB mini-B programming port

**1** With removable spring terminal blocks.

**2** With HE10 (MIL 20) connectors.

**3** The regular inputs have a maximum frequency of 5 kHz.

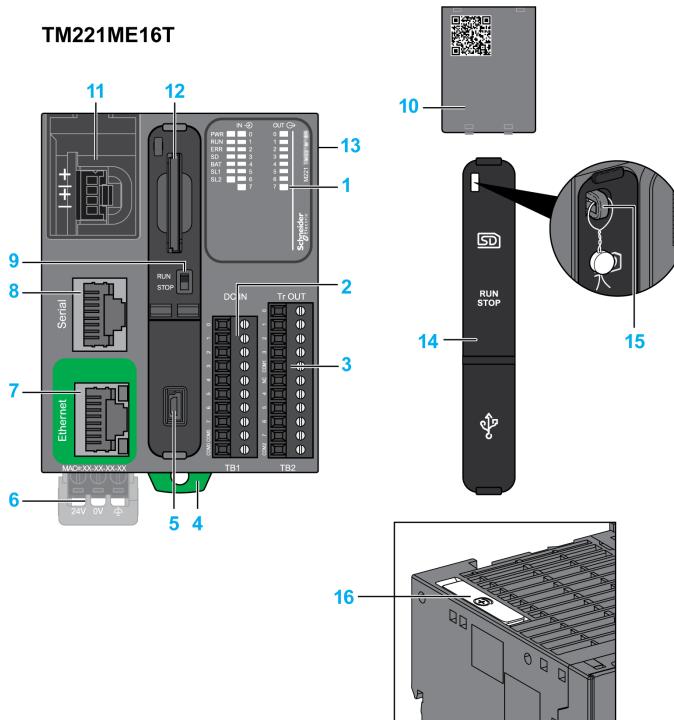
**4** The fast inputs (max. 100 kHz) can be used either as regular inputs or as fast inputs for counting or event functions.

**5** The fast transistor outputs (max. 100 kHz) can be used as regular transistor outputs, or for PWM, PLS or PTO functions, or reflex outputs for HSC.

Reference	Digital inputs	Digital outputs	Analog inputs	Communication ports
TM221ME32TK <sup>2</sup>	12 regular inputs <sup>3</sup> 4 fast inputs (HSC) <sup>4</sup>	14 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>5</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port

**1** With removable spring terminal blocks.  
**2** With HE10 (MIL 20) connectors.  
**3** The regular inputs have a maximum frequency of 5 kHz.  
**4** The fast inputs (max. 100 kHz) can be used either as regular inputs or as fast inputs for counting or event functions.  
**5** The fast transistor outputs (max. 100 kHz) can be used as regular transistor outputs, or for PWM, PLS or PTO functions, or reflex outputs for HSC.

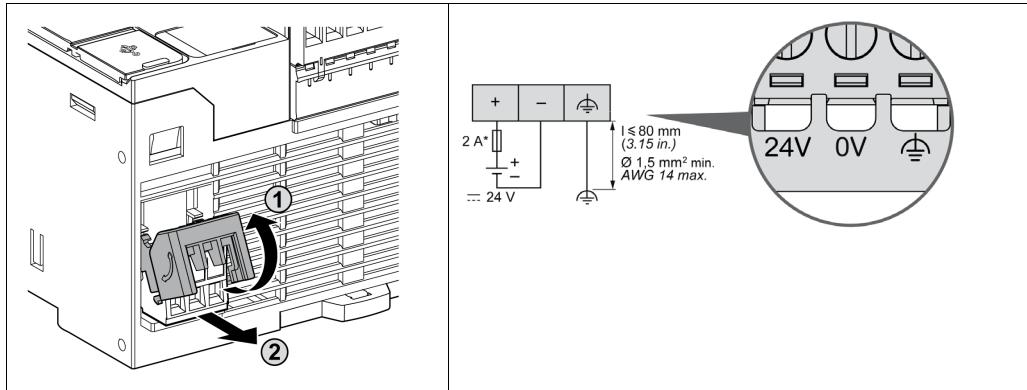
## Physical Description



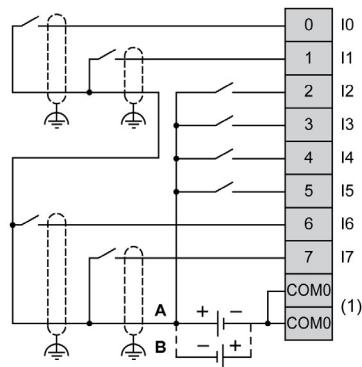
1	System LED	9	Run/Stop switch
2	Input removable terminal block	10	Removable analog inputs cover
3	Output removable terminal block	11	Analog input terminal block
4	Clip-on lock for 35 mm (1.38 in) DIN-rail	12	SD card port
5	USB mini-B programming port, for terminal connection to a programming PC (EcoStruxure Machine Expert - Basic)	13	TM3/TM2 bus connector
6	24 Vdc power supply	14	SD card, Run/Stop switch, and USB mini-B programming port protective cover.
7	Ethernet / RJ45	15	Locking hook
8	Serial line port / RJ45 (RS-232 or RS-485)	16	Battery holder

## Wiring Diagrams for TM221ME16T

Connection of the DC power supply of the controller



## Connection of the digital inputs to the sensors

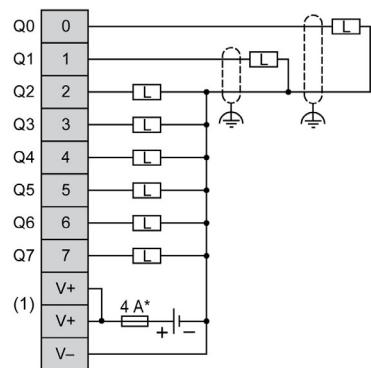


(1) The COM0 terminals are connected internally.

A Sink wiring (positive logic).

B Source wiring (negative logic).

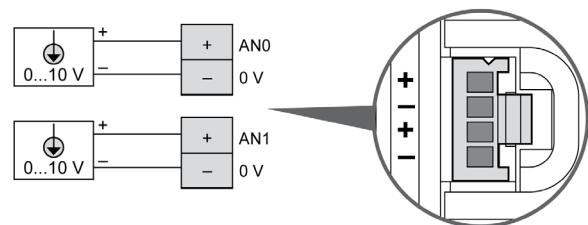
## Connection of the digital outputs to the actuators



\* Type T fuse

(1) The V+ terminals are connected internally.

## Connection of the analog inputs to the sensors



The (-) poles are connected internally.

## 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:

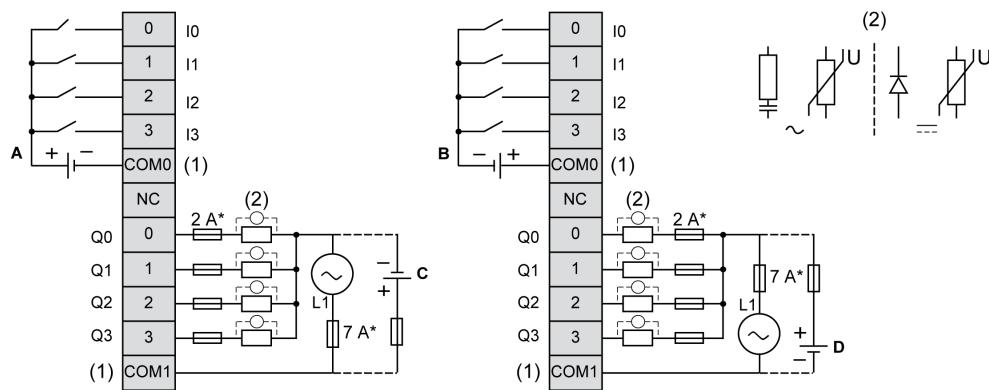
- Embedded diagnostics for local and distant supervision
- Wiring simplicity: spring terminals, removable terminal blocks

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)

## TM3XTYS4 TeSys Module - Hardware

### Front View



### Description

The TM3XTYS4 I/O expansion module connects the controller to the parallel wiring system of TeSys. This I/O expansion module provides the status and command information for each TeSys motor starter via an RJ45 connector. One TM3XTYS4 module can manage up to 4 TeSys motor starters, reverse or forward, whatever they are TeSys D or TeSys U or mix.

The TM3XTYS4 module is compatible with:

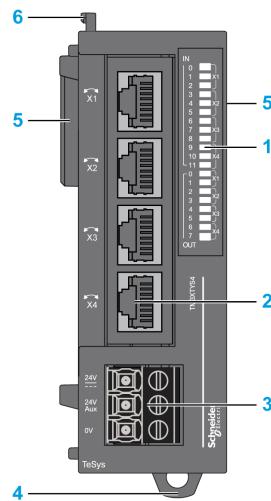
- TeSys U system equipped with the LUFC00 parallel wiring module
- GV and TeSys D system equipped with the LAD5C• wiring adapter

The TM3XTYS4 module provides:

- 4 channels each with an RJ45 connector
- Each channel provides:
  - 3 sink transistor inputs (24 Vdc type 1 (IEC/EN 61131-2))
  - 2 source transistor outputs (24 Vdc / 0.3 A)
- Removable 24 Vdc power supply terminal block

For more information, refer to Modicon TM3, Expert I/O Modules, Hardware Guide, EIO0000001420

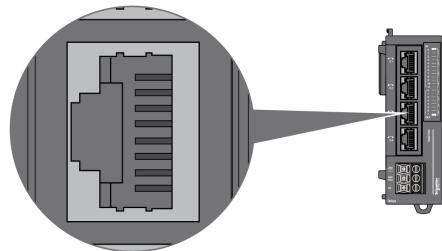
## Physical Overview



1	LEDs for displaying the state of the I/O channels
2	TeSys RJ45 connectors
3	Removable power supply screw terminal block
4	Clip-on lock for 35 m (1.38 in) top hat section rail (DIN-rail)
5	Expansion connector for I/O bus.
6	Locking device for attachment to the previous module

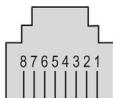
### I/O Channel RJ45 Connector

The TM3XTYS4 module is equipped with 4 channel RJ45 connectors.



## Pin Assignment

RJ45 connector



Pin	Type	Signal	Description
1	Output 1	Direction 1 control	Drives to direct (forward) command of the motor
2	Output 2	Direction 2 control	Drives to direct (backward) command of the motor
3	0 V	-	-
4	Input 1	Ready	Active if the selector of the TeSys is in the ON position
5	Input 2	Run	Input active if the power contacts of TeSys are closed.
6	N.C.	-	Reserved. Do not connect.
7	Input 3	Trip	Input active if the selector of TeSys is in the TRIP position (only for TeSys U).
8	24 Vdc input common	Common for sensors	Power supply for inputs 1, 2 and 3 (pins 4, 5 and 7).

## ⚠ 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.**

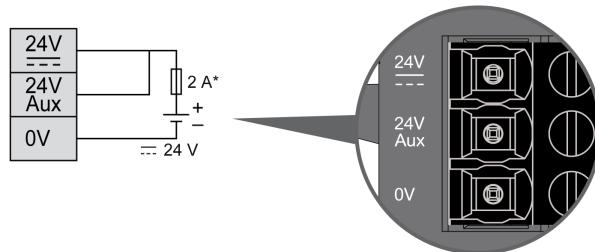
## ⚠ CAUTION

### INCOMPATIBLE EQUIPMENT

Use the RJ45 connector only for the link with devices which are compatible with the TeSys RJ45 connection system.

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

### DC Power Supply Wiring Diagram



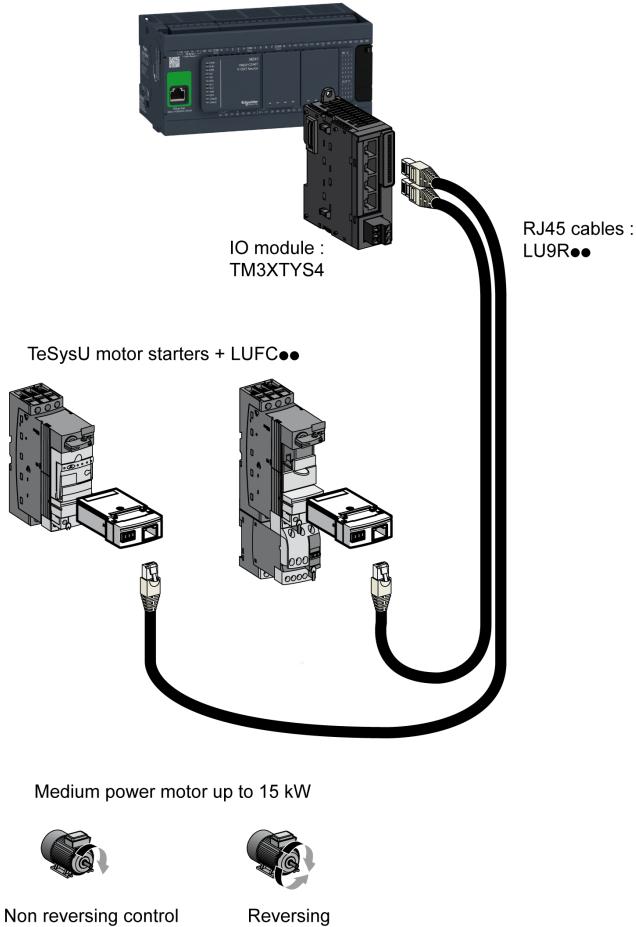
\* Type T fuse

**24 Vdc** Is dedicated to outputs power supply

**24 Vdc Aux** Is dedicated to inputs power supply

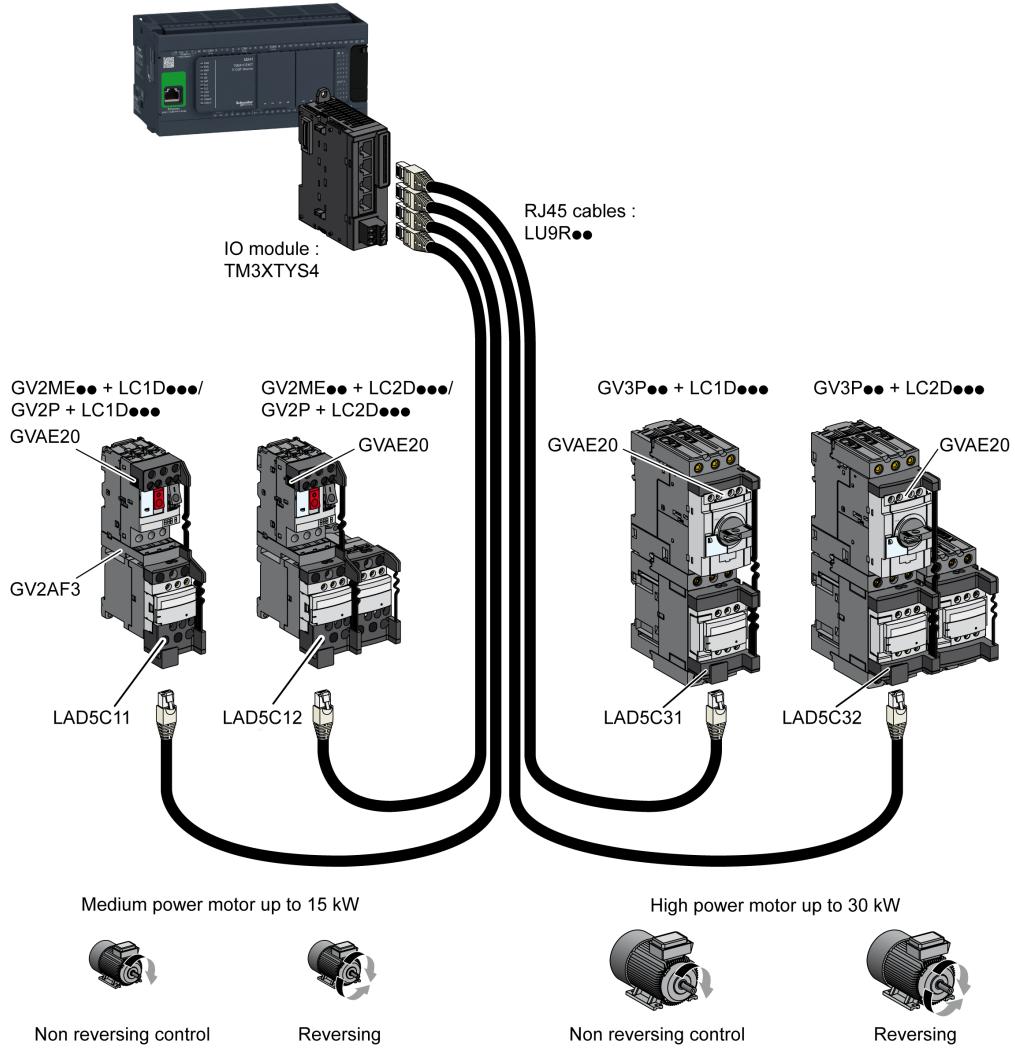
## Application Example with TeSys U

Logic controller:  
Modicon M221, M241, M251



## Application Example with TeSys D

Logic controller:  
Modicon M221, M241, M251



## 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.

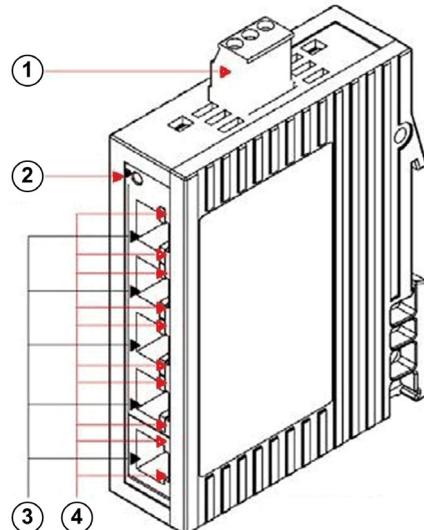
- Multi-address capability
- Storage and rerouting of received data
- Data packets with VLAN tags are transmitted unchanged (IEEE 802.1 Q)
- Automatic negotiation of 10/100 Mbit/s and duplex mode
- Automatic change of polarity
- Low-cost wiring solution

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

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### What Is in This Section?

This section contains the following topics:

Topic	Page
TeSys D Contactor - Hardware	98
TeSys GV2 Motor Circuit Breakers - Hardware	100
TeSys U LU2B Motor Starter- Hardware	102
TeSys GV2DP - Hardware	107
TeSys LAD5Cxx Wiring Adapter - Hardware	109
Altistart 01 Soft Starter - Hardware	111
Altivar 12 Variable Speed Drive - Hardware	115

## 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.

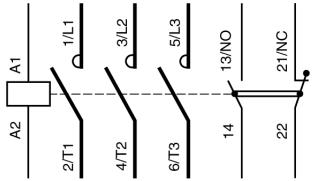
- AC, DC, and low-consumption DC control circuit
- All types of starter: reversing or non-reversing, star/delta, by auto-transformer, and so on.
- Various connectors: spring terminal, EverLink terminal block, screw clamp, ring-type connection, faston connector
- Easy and simple direct mounting between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

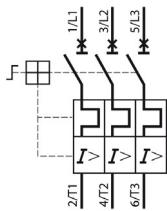
- Motor and personnel protection
- Live parts are protected from direct finger contact
- Compact size
- Easy to install: screw mounting or clip-on mounting
- Control by rotary knob
- Connection by screw clamps

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

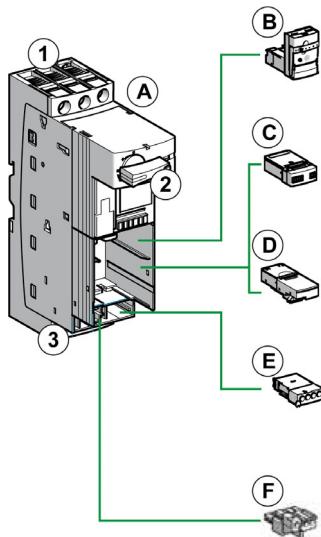
Standards and certifications	IEC/EN 60947-6-2, CSA C22-2 N°14, Type E, UL508 type E: with phase barrier LU9SP0, UL, CSA, CCC, Gost, ASEFA, ABS, BV, DNV, GL, LROS, ATEX
Power range	0...15 kW at 400 V
Rated insulation voltage	<ul style="list-style-type: none"><li>● Conforming to IEC/EN 60947-1, overvoltage 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 signalling 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>

For more information, refer to :

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

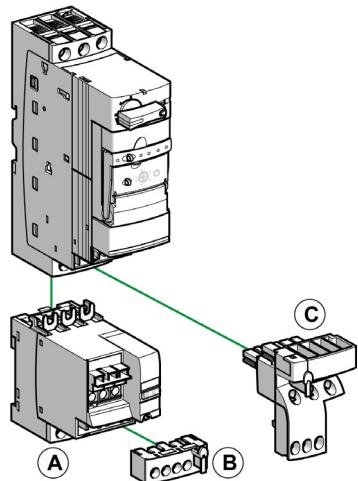
## Components

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

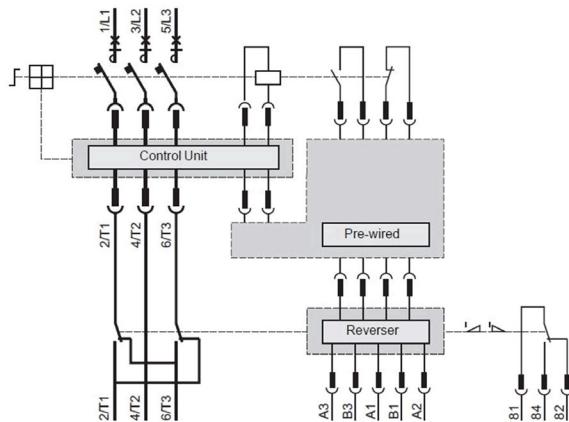


- A Reverser block
- B Plug-in terminal blocks
- C Control circuit pre-wiring system

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

### Wiring

#### TeSys U - reversing



## TeSys GV2DP - Hardware

### Front View

TeSys GV2DP



### Description

The Schneider Electric TeSys product range offers a wide range of pre-assembled automatic motor starter combinations with a power rate of up to 15 kW at 400/415 Vac. Motor starter combinations with higher power ratings are available for customer assembly.

The product range of the TeSys GV2D..... motor starter combinations offers you a quick and simple selection and product compatibility. The TeSys D contactor, when combined with the TeSys GV2 motor circuit-breaker, provides a compact motor starter solution.

#### Range description

- Direct On Line (D.O.L.) or reversing starters, 45 mm (1.77 in), and 90 mm (3.54 in) wide respectively
- Motor circuit-breaker with control via push-buttons (GV2ME) or selector switch (GV2P)
- Circuit-breaker with built-in overload protection
- Type 1 or type 2 coordination
- Breaking capacity up to 130 kA
- Enclosure for thermal-magnetic circuit breakers TeSys GV2ME

Each pre-assembled combination comprises:

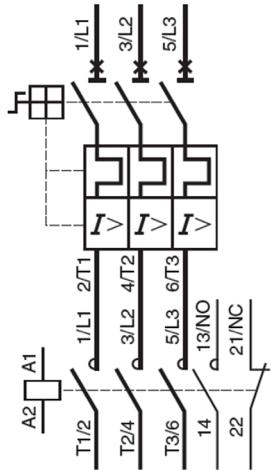
- 1 motor circuit breaker GV2ME or GV2P
- 1 3-pole contactor LC1D or LC2D
- 1 combination block GV2AF3

For more information, refer to :

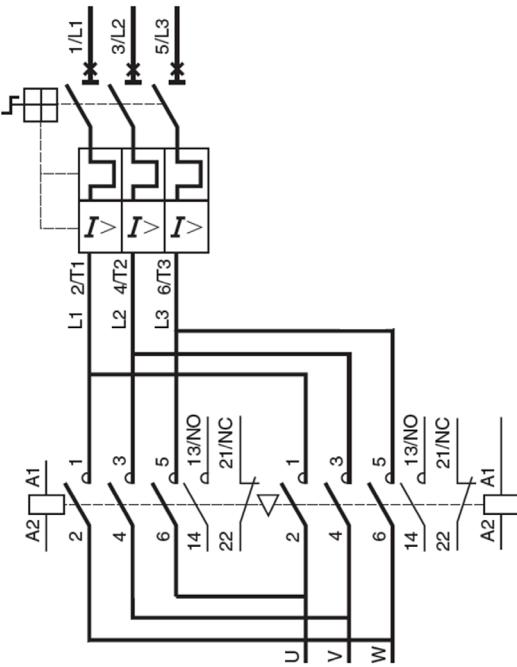
- The essential guide, TeSys for power control & protection, DIA1ED2040401EN
- Control and protection components, MKTED210011EN

**Wiring**

GV2DP1....

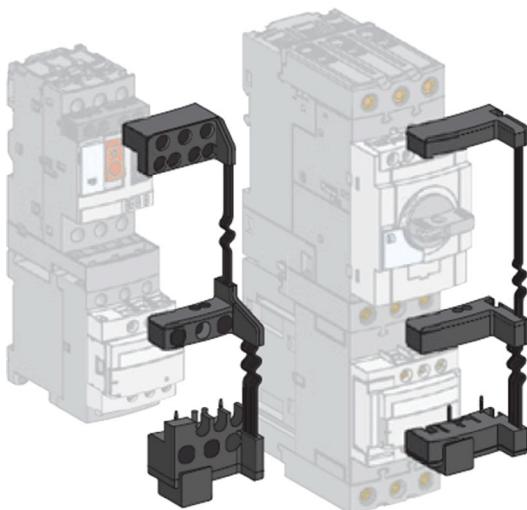


GV2DP2....



## TeSys LAD5Cxx Wiring Adapter - Hardware

### Front View



### Description

The TeSys LAD5C• wiring adapter makes the TeSys motor starter combinations with screw-clamp terminals compatible to the RJ45 connection system.

The RJ45 connection system offers a quick and easy connection to the TM3 I/O expansion module TM3XTYS4.

All the control and command terminals of the motor starter combination are individually connected to the adapter with pre-shaped pins. The upstream liaison with the TM3XYS4 module is carried out with a simple RJ45 preformed cable.

4 types of the wiring adapter are available:

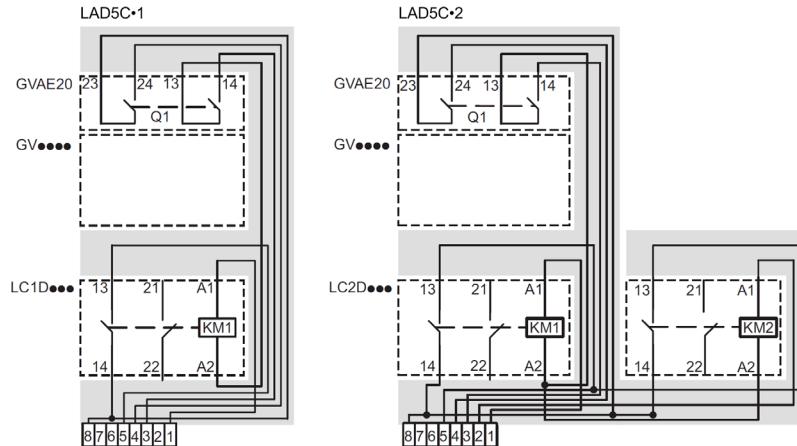
Reference	Motor control	Motor starter combination
LAD5C11	Non-reversing	GV2ME/GV2P with LC1D09BL to LC1D32BL
LAD5C12	Reversing	GV2ME/GV2P with LC2D09BL to LC2D32BL
LAD5C31	Non-reversing	GV3P with LC1D40ABD to LC1D65ABD
LAD5C32	Reversing	GV3P with LC2D40ABD to LC2D65ABD

## Notes:

- GV2AF3 combination block is required for GV2 circuit breaker/contactor assembling.
- GVAE20 auxiliary contact block must be assembled on GV2 and GV3 circuit breaker before LAD5C•
- Depth of the motor starter assemblies is increased by 15 mm (0.59 in), height is increased by 22 mm (0.87 in).

For more information, refer to [LAD5C Instruction Sheet, HRB8873800](#)

## Electrical Schematics



## Altistart 01 Soft Starter - Hardware

### Front View

Altistart 01



### Description

The Altistart 01 soft starter enhances starting performance by providing a smooth and controlled start for asynchronous motors, while providing torque surge suppression during both the starting and stopping operation. This highly functional mini soft starter can help to decrease your maintenance work and production downtime by helping to prevent the mechanical shocks that create wear and tear on your motor and machinery.

- Reduce mechanical stress on drive-train components
- Ensure smooth acceleration of conveyors
- Suppress water hammer on pumping applications
- Eliminate belt slippage on fan loads
- Minimize voltage sags on the distribution system

Standards and certifications	UL, CSA, C-Tick, CCC, B44.1-96/ASME A14.5 for starter wired to the motor delta terminal
Power range	<ul style="list-style-type: none"> <li>● ATS 01N1::: 0,37...11 kW</li> <li>● ATS 01N2::: 0,75...75 kW</li> </ul>
Voltage range	<ul style="list-style-type: none"> <li>● ATS 01N1::: 110...480 V</li> <li>● ATS 01N2::: 230, 400, 480 V and 690 V</li> </ul>
Functions	<ul style="list-style-type: none"> <li>● 2-wire control</li> <li>● Adjustable starting time</li> <li>● Signaling completion of starting</li> </ul>
Degree of protection	IP 20

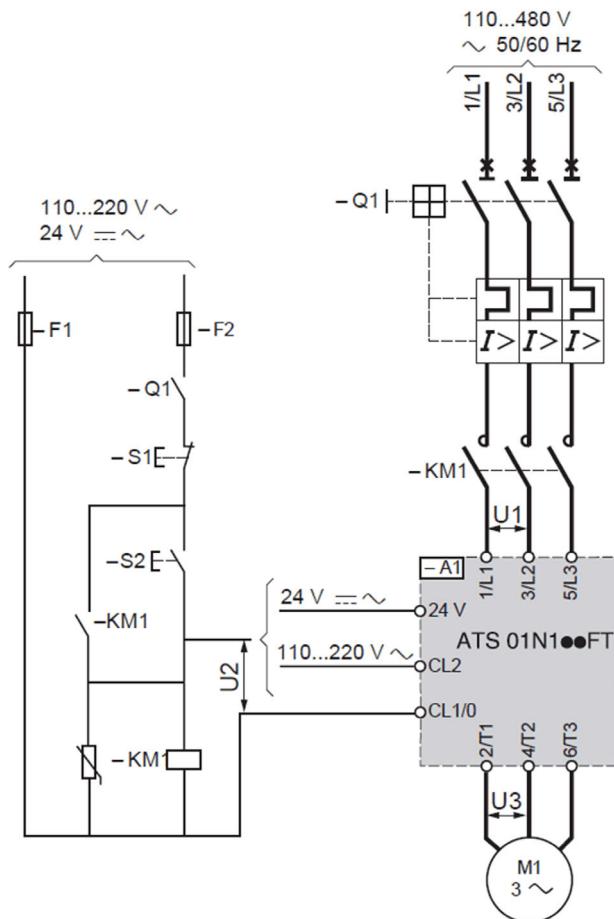
Dimensions	W x H x D (depends on the model): 22.5...180 x 100...242 x 100.4...126 mm (0.89...7.1 x 3.94...9.5 x 3.95...4.96 in)
------------	--

For more information, refer to :

- Characteristics, Soft starters for asynchronous motors Altistart 01, 60541-EN
- Reduce mechanical stress on your machines, DIA2ED1121204EN
- Instruction Sheet ATS01N1...FT, 1624685

## Wiring

Wiring example power supply and motor



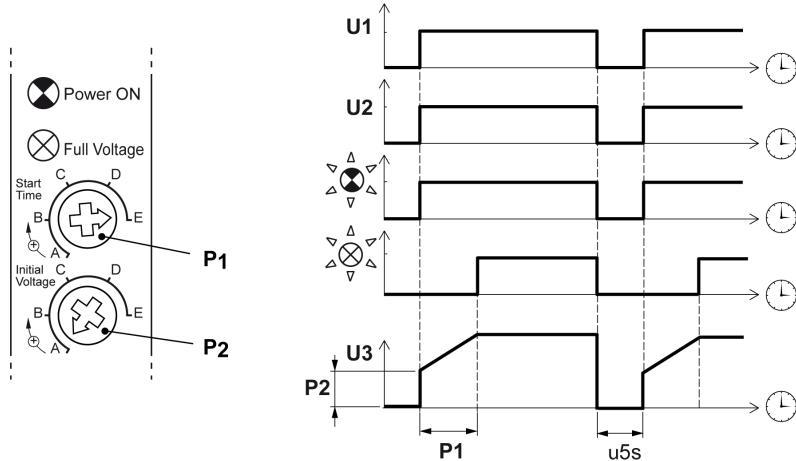
Directly applying line voltage to the Altistart soft starter will result in passing one of the three phases to the motor, even in the case where there is no control power to the soft starter.

## ! DANGER

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

Always use a contactor (-KM1) to remove all power from the motor when using the soft starter of type ATS01N1\*\*\*.

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



## Altivar 12 Variable Speed Drive - Hardware

### Front View

Altivar 12 variable speed drive



### Description

The Altivar 12 drive is a frequency inverter for 200...240 V three-phase asynchronous motors rated from 0.18 kW to 4 kW.

The Altivar 12 drive is robust, compact, and easy to install. Its integrated functions are suitable for the requirements of applications involving simple industrial machines for example, packaging machines, pumps, compressors, fans.

- Small: easily integrated in any machine
- Easy communication with all other machine components via integrated universal Modbus serial link.
- Low noise level
- Product factory set for most applications
- Numerous application-specific functions

Standards and certifications	IEC 61800-5-1; IEC 61800-3 (environments 1 and 2, categories C1 to C3, cat. C1 with option for ATV 212); UL, CSA, C-Tick, NOM, GOST
Power range	0.18...4 kW
Voltage range	<ul style="list-style-type: none"> <li>● Single-phase 100...120 V (0.18 to 0.75 kW)</li> <li>● Single-phase 200...240 V (0.18 to 2.2 kW)</li> <li>● Three-phase 200...240 V (0.18 to 4 kW)</li> </ul>
Output frequency	0.1...400 Hz
Transient overtorque	150...170 % of the nominal motor torque
Communication	Integrated: Modbus
Functions	<ul style="list-style-type: none"> <li>● Switching between local control and control via the terminals</li> <li>● Motor control profiles: standard, performance, and pump/fan</li> <li>● Frequency skips</li> <li>● Preset speeds</li> <li>● PID regulator</li> <li>● S ramp, U ramp, ramp switching</li> <li>● Freewheel stop, fast stop</li> <li>● Jog operation</li> <li>● Configuring the logic and analog I/O</li> <li>● Underload and overload detection</li> <li>● Viewing the state of the logic inputs on the drive display</li> <li>● Configuring how the parameters are displayed</li> <li>● Error log</li> </ul>
I/Os	<ul style="list-style-type: none"> <li>● 1 analog input</li> <li>● 4 logic inputs</li> <li>● 1 analog output</li> <li>● 1 logic output</li> <li>● 1 relay output</li> </ul>
Degree of protection	IP 20
EMC filter	<ul style="list-style-type: none"> <li>● Integrated: ATV12...M2 and ATV312H...N4</li> <li>● Optional: ATV12...F1; ATV12...M3</li> </ul>
Dimensions	ATV12H018M2 (W x H x D): 72 x 142 x 102.2 mm (2.84 x 5.6 x 4.02 in)
Options	<ul style="list-style-type: none"> <li>● SoMove and SoMove Mobile setup software</li> <li>● Simple-loader and multi-loader configuration tool</li> <li>● Remote display terminals</li> <li>● EMC plate</li> </ul>

For more information, refer to Altivar 12, Variable speed drives for asynchronous motors, User manual, BBV28581.

## Wiring

### Altivar 12 connector overview

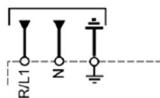


- 1** Power terminals
- 2** Control terminals
- 3** RJ45 communication port

## Wiring examples: power supply and motor

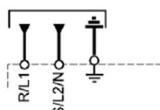
ATV12\*\*\*\*F1

Single-phase supply 100...120 V



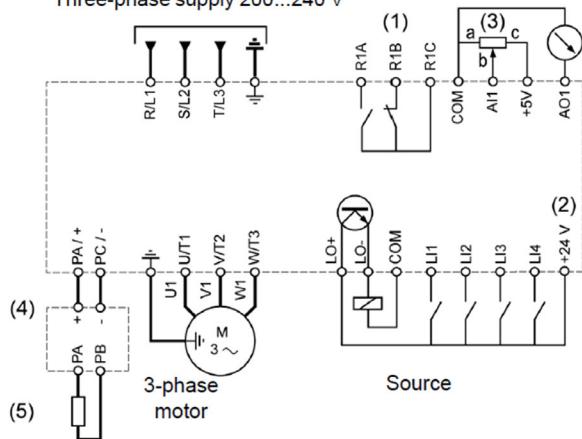
ATV12\*\*\*\*M2

Single-phase supply 200...240 V



ATV12\*\*\*\*M3

Three-phase supply 200...240 V



Item	Description
1	R1 relay contacts, for remote indication of the drive status.
2	Internal +24 Vdc. If an external source is used (+30 Vdc maximum), connect the 0 V of the source to the COM terminal, and do not use the +24 Vdc terminal on the drive.
3	Reference potentiometer SZ1RV1202 (2.2 kΩ) or similar (10 kΩ maximum).
4	Optional braking module VW3A7005.
5	Optional braking resistor VW3A7*** or other acceptable resistor. See the possible resistor values in the catalog.

**NOTE:**

- Use transient voltage surge suppressors for all inductive circuits near the drive or coupled to the same circuit (relays, contactors, solenoid valves, and so on).
- The ground terminal (green screw) is located on the opposite side in comparison with its position on the ATV 12 (see wiring trap label).

# Section 4.7

## Detection

---

### What Is in This Section?

This section contains the following topics:

Topic	Page
OsiSense XG Tap-off box - Hardware	120
OsiSense XGCSx90 RFID - Hardware	121
OsiSense Industrial Sensors - Hardware	125

## OsiSense XG Tap-off box - Hardware

### Front View

OsiSense XG tap-off box



### Description

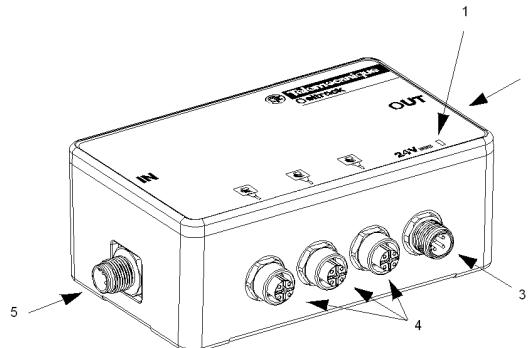
The OsiSense TCSAMT31FP tap-off box enables XGCS smart antennas to be connected to Modbus SL communication bus.

The TCSAMT31FP box is fitted with M12 connectors. It is used to connect the power supply, the communication bus (Modbus SL) and 1 to 3 XGCS smart antennas (up to 15 smart antennas, by daisy-chaining). It consists of a sealed metal enclosure.

For more information, refer to :

- Osisense XG, Radio Frequency Identification System, Catalog, 9006CT0902
- RFID OsiSense XG, Compact Stations, W916556690111

### Components



- 1 Green LED indicating the voltage present
- 2 Subbase to another splitter box (OUT network) - 1x M12 5pin female A-coded connector
- 3 24 V power supply subbase - 1x M12 4-pin male A-coded connector
- 4 3 OsiSense XG compact station subbases - 3x M12 5-pin female A-coded connectors
- 5 Subbase to an API or another tap-off box (IN network) - 1x M12 5-pin male A-coded connector

## OsiSense XGCSx90 RFID - Hardware

### Front View

OsiSense XGCS•90



### Description

The OsiSense XG smart antennas with RS-485 serial port combine a compact design and remarkable features to provide elevated performances in read/write operations on 13.56 MHz RFID tags.

OsiSense XG compact smart antennas integrate functions which simplify communication between tags, smart antennas, and controllers (automation platform, PC, and so on).

Embedded functions are activated by standard requests to read/write words, sent by the PLC:

- Reset: The RFID part of the smart antenna is reinitialized and assumes its factory default configuration.
- Init: The smart antenna is reinitialized and operates as it would after being switched back on (address unchanged, RFID parameters deleted).
- Sleep mode: Transmission of the electromagnetic field of the smart antenna is only activated upon receipt of a read or write instruction. This mode reduces the power consumption of the smart antenna and helps to prevent interference when the smart antennas are in close proximity to each other.
- Auto read/write: This mode enables the smart antenna to execute up to 10 read or write instructions on a tag automatically (without PLC command) as soon as the RFID tag enters the dialogue zone.

Standards and certifications	UL, FCC part 15, CE, ETS 300330-1/2, EN 301489-1/3
Power supply	24 Vdc PELV
Power consumption	< 60 mA

Nominal sensing distance	<ul style="list-style-type: none"> <li>• XGCS4901201: 10...70 mm (0.39...2.76 in) depending on associated tag</li> <li>• XGCS8901201: 20...100 mm (0.78...3.94 in) depending on associated tag</li> </ul>
Type of associated tag	Standardized ISO 15693 and ISO 14443 tags, automatic detection of the tag type
RFID frequency	13.56 MHz
Communication	<ul style="list-style-type: none"> <li>• Interface: RS-485, Modbus RTU and Uni-Telway</li> <li>• Connection: A single male 5-pin shielded M12 connector for connection to the communication network and power supply</li> </ul>
Temperature	Operation: -25...+70 °C (-13...+158 °F) Storage: -40...+85 °C (-13...+158 °F)
Degree of protection	IP 65 according to IEC 60529
Dimensions	W x H x D: <ul style="list-style-type: none"> <li>• XGCS4901201: 40 x 40 x 15 mm (1.56 x 1.56 x 0.59 in)</li> <li>• XGCS8901201: 80 x 80 x 26 mm (3.15 x 3.15 x 1.01 in)</li> </ul>
Options	<ul style="list-style-type: none"> <li>• Network connection box</li> <li>• RFID hand held terminal</li> <li>• Field expander</li> <li>• Connection and mounting accessories</li> </ul>

For more information, refer to :

- Osisense XG, Radio Frequency Identification System, Catalog, 9006CT0902
- RFID OsiSense XG, Ethernet Smart Antenna, User Manual, EIO0000001601

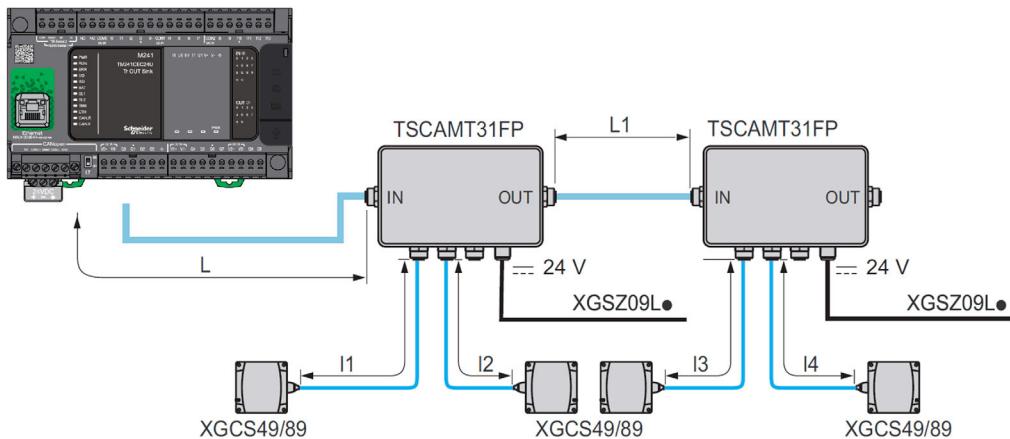
## Components



- 1 TAG: Tag LED  
 2 COM: Communication LED

## Wiring

### Example of a Modbus network



#### Maximum length of bus:

The maximum length of the bus (**[L]** + **[I1]** + **[I4]**) depends on the speed of the network:

- 9600 bauds: 1000 m (3281 ft)
- 19,200 bauds: 500 m (1640.4 ft)

#### Maximum length of tap-offs:

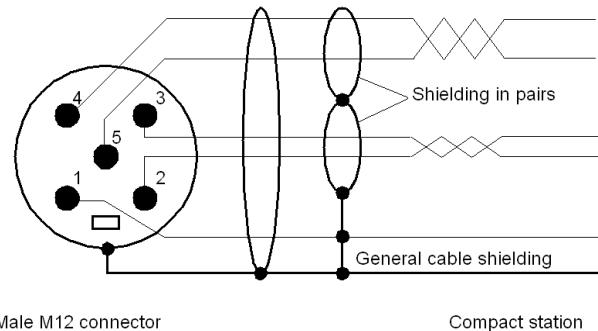
**[I1]**, **[I2]** and **[I3]**: 10 m (32.8 ft)

## Connector Wiring

The stations are equipped with a single male M12 A-coded connector for the power supply and communication bus.

The communication bus wires are shielded separately from the power supply cables to avoid disturbances carried by the power supply causing interference on the communication wires.

## Station M12 connector pinout



Pin	Signal	Description
1	(SHLD) drain	Cable shielding
2	24 Vdc	Station power supply
3	0 V/GND	0 V
4	D0	D0 (-/A) RS-485 2-wire
5	D1	D1 (+/B) RS-485 2-wire
Connector casing	Shielding	Cable shielding

For the connection between the station and the TSCAM31FP tap-off box, use the preformed cordset TCSMCN1M1F•.

The TCSMCN1M1F-00 cordset is a shielded cable, with 5-way male/female A-coding M12 connectors for Modbus RS-485 connection between one TCSAMT31FP tap-off box and an XGCS-90 station (or to another tap-off box).

## 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

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### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
5.1	Introduction to System Communication	128
5.2	Ethernet Network	129
5.3	Modbus Serial Line Network	136

## Section 5.1

### Introduction to System Communication

---

#### Introduction

##### Overview

The TVDA (Tested Validated Documented Architecture) includes 2 different communication networks.

- Ethernet

The Ethernet network is used for the communication between the Modicon M221 Logic Controller and the Magelis panel HMI STO. Both devices are connected via an Ethernet switch. The communication is based on the Modbus TCP protocol.

In addition, a PC can be connected to the Ethernet network 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 M221 Logic controller (master), the Altivar 12 (slave), and the OsiSense RFID antennas (slave).

## Section 5.2

### Ethernet Network

---

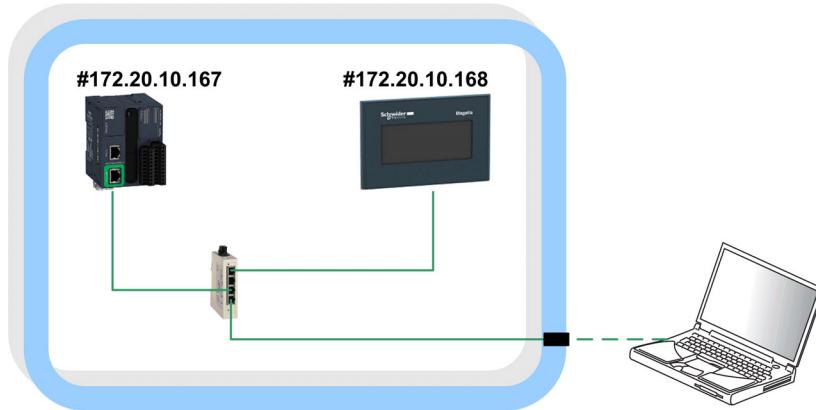
#### What Is in This Section?

This section contains the following topics:

Topic	Page
Ethernet Network Topology	130
Ethernet Wiring	131
Modicon M221 Modular Logic Controller - Wiring	133
Magelis HMI STO - Ethernet Wiring	135

## Ethernet Network Topology

### Ethernet Topology



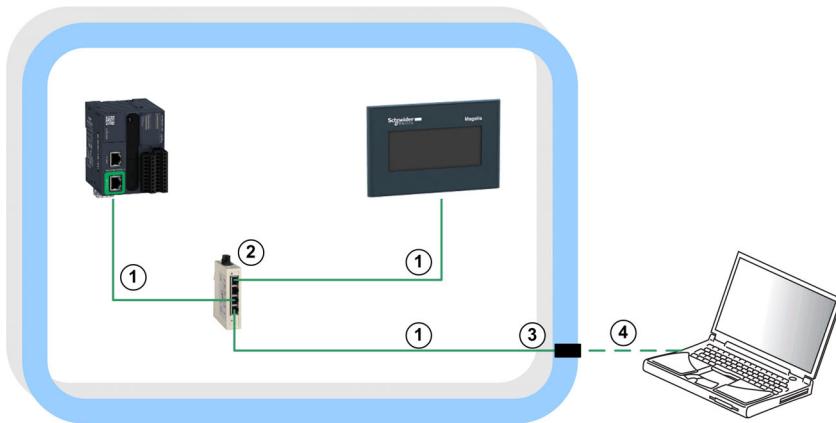
#... IP address

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

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

### Switch

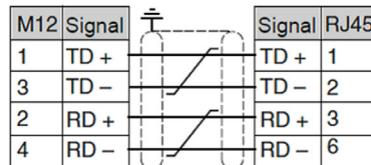
Reference	Designation	Description	Position
TCSESU053FN0	Ethernet TCP/IP unmanaged switch	10BASE-T/100BASE-TX - 5x RJ45 ports copper cable	2

**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	
	-	-	No connection	4	
	-	-	No connection	5	
	-	-	No connection	7	
	-	-	No connection	8	

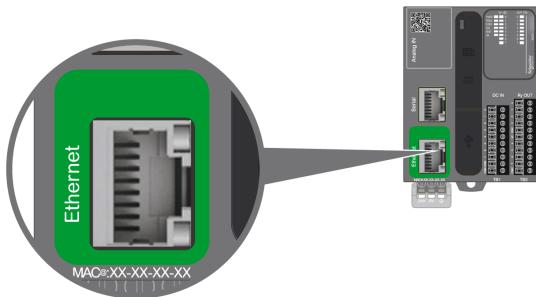
**ConneXium Ethernet Cable**

## Modicon M221 Modular Logic Controller - Wiring

### Ethernet Port

The TM221-E<sup>\*\*\*</sup> controllers are equipped with an Ethernet communication port.

Ethernet port on the controller

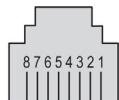


Characteristic	Description
Standard	Modbus TCP/IP
Connector type	RJ45
Driver	<ul style="list-style-type: none"><li>• 10 M half duplex (auto negotiation)</li><li>• 100 M full duplex (auto negotiation)</li></ul>
Cable type	Shielded
Automatic cross-over	Yes

For more information, refer to Modicon M221 Logic Controller, Hardware Guide, EIO0000001384.

## Pin Assignment

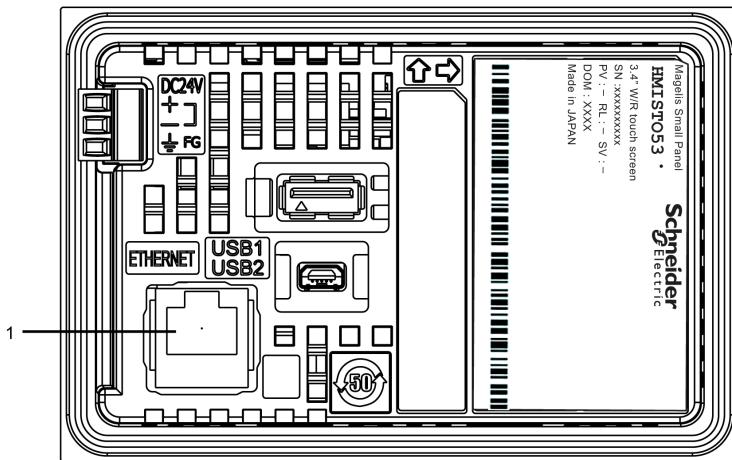
RJ45 Ethernet connector



Pin	Signal
1	TD+
2	TD-
3	RD+
4	N.C.
5	N.C.
6	RD-
7	N.C.
8	N.C.

## Magelis HMI STO - Ethernet Wiring

### Ethernet Port



The HMI STO 53• comes equipped with an IEEE802.3 compliant Ethernet interface (1). This Ethernet port 10BASE-T/100BASE-TX is used either for application download or Ethernet communication.

For more information, refer to [Magelis Small Panels HMI STO, User Manual, EIO0000000239](#).

## Section 5.3

### Modbus Serial Line Network

---

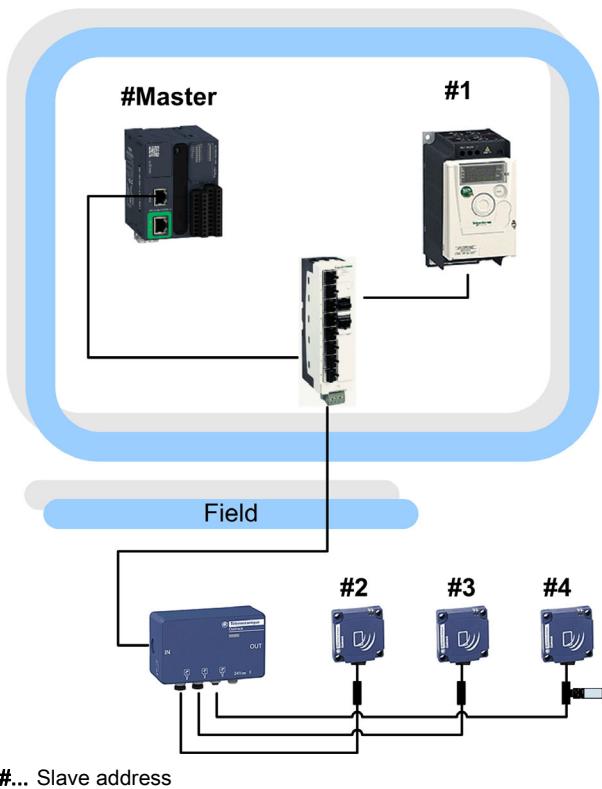
#### What Is in This Section?

This section contains the following topics:

Topic	Page
Modbus SL Network Topology	137
Modbus SL Wiring	138
Modicon M221 Modular Logic Controller - Wiring	140

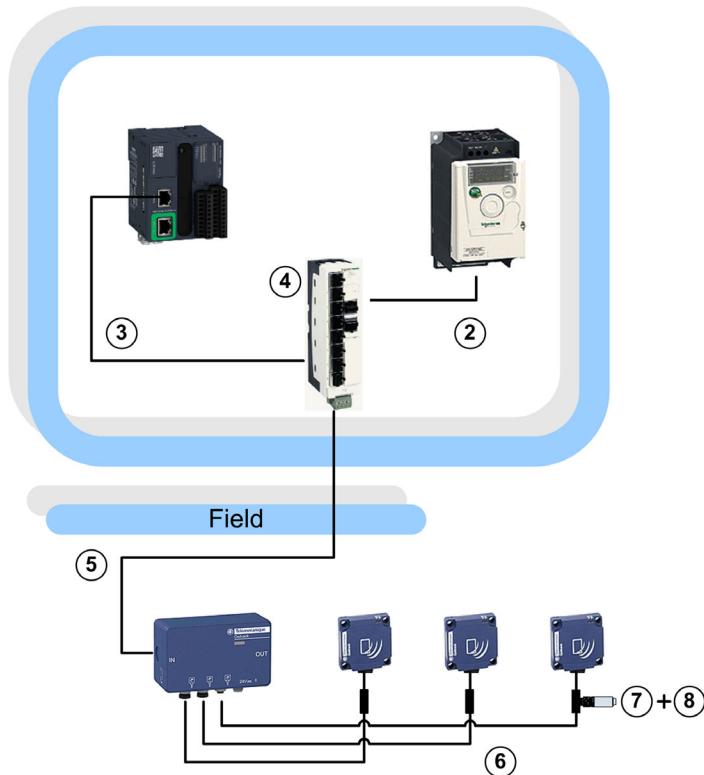
## Modbus SL Network Topology

### Modbus SL Topology



## Modbus SL Wiring

### Modbus SL Overview



For more information, refer to [Modbus Serial Line, Planning and Installation Guide, 33003925](#).

## Cable

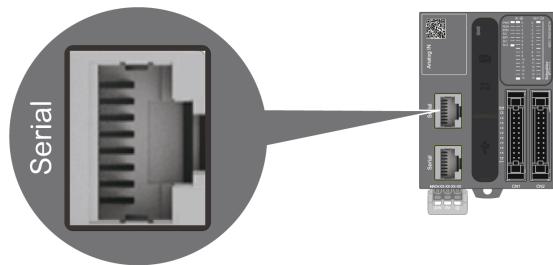
Reference	Designation	Description	Position	Cable length
VW3A8306R10	Modbus SL drop cable	2 RJ45 connectors	2	1.0 m (3.28 ft)
VW3A8306R30			3	3.0 m (9.8 ft)
LU9GC3	RS-485 hub	Modbus SL hub with 10 RJ45 connectors and 1 terminal block	4	-
TCSMCN1F2	Modbus SL cable	Shielded cable, 5-way female A-coding M12 / flying leads, for Modbus RS-485 connection between one TCSAMT31FP tap-off box and a LU9GC3 box.	5	2.0 m (6.56 ft)
TCSMCN1F5				5.0 m (16.4 ft)
TCSMCN1F10				10.0 m (32.8 ft)
TCSMCN1M1F1	Preformed cordset for Modbus SL communication and 24 Vdc power supply	Shielded cable, 5-way male /female A-coding M12, for Modbus RS-485 connection between one TCSAMT31FP tap-off box and an XGCS station (or to another tap-off box)	6	1.0 m (3.28 ft)
TCSMCN1M1F2				2.0 m (6.56 ft)
TCSMCN1M1F5				5.0 m (16.4 ft)
TCSMCN1M1F10				10.0 m (32.8 ft)
TCSCTN011M11F	M12 tee	5-pin female A-coding M12/5-pin male A-coding M12 + 5-pin A-coding female M12, used to connect the line terminator	7	-
FTXCNTL12	Line terminator	120 Ω line terminator, 5-pin male A-coding M12	8	-

## Connection of Line Terminators in Modbus

The use of long network cables may produce signal deformations. The installation of a line terminator corrects these deformations. Depending on the cable quality and the EMC environment, a line terminator near the RFID XGCS station (M12 tee) may be necessary.

## Modicon M221 Modular Logic Controller - Wiring

### Modbus SL Port



The serial line:

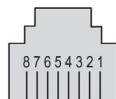
- Is used to communicate with devices supporting the Modbus protocol as either master or slave, ASCII protocol (printer, modem...), and EcoStruxure Machine Expert - Basic protocol (HMI,...)
- Provides a 5 Vdc power distribution

For more information, refer to [Modicon M221 Logic Controller, Hardware Guide, EIO0000001384](#).

### Pin Assignment

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	-	RTS	RS-232: Request to send
4	D1	-	Modbus SL: D1 (+B) RS-485 2-wire
5	D0	-	Modbus SL: D0 (-A) RS-485 2-wire
6	-	CTS	Clear to send
7	5 Vdc	-	5 Vdc supplier
8	Common	Common	Modbus SL signal ground

---

# Chapter 6

## Implementation

---

### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
6.1	Software Requirements	142
6.2	Access the EcoStruxure Machine Expert – Basic Project Template	143
6.3	Project	144

## Section 6.1

### Software Requirements

---

#### Software Requirements

##### EcoStruxure Machine Expert - Basic

The project template of the described architecture is part of EcoStruxure Machine Expert - Basic V1.0 or later.

The EcoStruxure Machine Expert - Basic project includes the application for the M221 controller.

The Vijeo-Designer application for the Magelis HMI panel is provided as a separate file of type \*.vdz (Vijeo-Designer export file) and is also part of the EcoStruxure Machine Expert - Basic V1.0 software.

For using the project template the following software must be installed on your PC:

- EcoStruxure Machine Expert - Basic V1.0 or later
- Vijeo-Designer V6.2 SP4.1 or later

## Section 6.2

### Access the EcoStruxure Machine Expert – Basic Project Template

#### Access the EcoStruxure Machine Expert - Basic Project Template

##### Overview

The EcoStruxure Machine Expert - Basic project related to the described architecture is available in terms of a project template.

It is tested and validated and comprises the EcoStruxure Machine Expert - Basic application with all program code and device configurations for the M221 controller.

The Vijeo-Designer project for the defined Magelis panel in this architecture is available in terms of a Vijeo-Designer export file (\*.vdz) and can be opened with the appropriate Vijeo-Designer version.

##### Procedure

You can access the project template as described below.

Step	Action	Comment
1	Launch EcoStruxure Machine Expert - Basic.	-
2	Click <b>Templates</b> .	The browser with the example projects is displayed. From here, you also have access to other project-related files as for example the System User Guide (SUG) or the Vijeo-Designer project, if available. Whether additional files are available is indicated by the symbol + in front of the name of the example project.
3	Select a template from the list.	The description is displayed.
4	Click <b>Open Template</b> .	A new project based on the selected template is opened in EcoStruxure Machine Expert - Basic.
5	Now you can adapt your new project according to your requirements.	-

For opening a project-related file, select the example project in the template browser and click **Open Folder**. Then the folder which contains the example projects opens in the Windows Explorer. From here, you can open the desired file by double-click.

## Section 6.3 Project

---

### What Is in This Section?

This section contains the following topics:

Topic	Page
Controller	145
HMI	147
Devices	151
Application	155
Vijeo-Designer	159

## Controller

### Overview

The controller in this architecture is the TM221ME16T, which is assigned to the category of optimized logic controllers of Schneider Electric.

The mandatory settings for the controller are described below.

All 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 M221 controller. The data exchange is realized via Modbus TCP with the HMI as client (master) and the M221 controller as server (slave).

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

Perform the Ethernet configuration of the controller in the **Configuration** window of the EcoStruxure Machine Expert - Basic application. When selecting the node **ETH1** in the **Hardware tree**, the associated configuration editor opens.

The Ethernet settings for the controller are:

- Fixed IP address
  - IP address: 172.20.10.167
  - Subnet mask: 255.255.0.0
- Security settings
  - Enable the check box labeled **Modbus server enabled**

Additional settings for the Modbus TCP communication can be performed in the Modbus TCP configuration editor. When selecting the **Modbus TCP** node in the **Hardware tree**, the associated configuration editor opens.

To help to prevent unauthorized access to the application data, the IP address of the Modbus master can be set. Therefore, the parameter **IP Master Address** is set with the IP address of the HMI device in this application.

For all other parameters, the default settings have been kept.

For more information about the Ethernet settings, refer to the document Modicon M221 Logic Controller, Programming Guide, EIO0000001360.

## Serial Line

The serial line in this architecture is used for the communication between the controller, the RFID smart antennas, and the Altivar 12.

The serial line configuration for the M221 controllers Modbus SL interface are as follows:

- Physical settings:
  - Device: No Device
  - Baud rate: 19200
  - Parity: even
  - Data bits: 8
  - Stop bits: 1
  - Physical medium: Modbus SL RS-485 2-wire
- Protocol settings
  - Protocol: Modbus RTU
  - Addressing: Master
  - Response time (x100 ms): 10
  - Time between frames (ms): 10

For more information about the serial line configuration, refer to the document Modicon M221 Logic Controller, Programming Guide, EIO0000001360.

## HMI

### Overview

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

The mandatory settings for the HMI device are described below.

All 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 M221 controller. The data exchange is realized via Modbus TCP with the HMI as client (master) and the M221 controller as server (slave).

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

Perform the Ethernet configuration of the HMI device in the Vijeo-Designer application as described in the table:

Step	Action	Comment
1	In Vijeo-Designer, select the <b>Target</b> node in the <b>Navigators Project</b> tab.	The target property editor opens.
2	Select <b>Network</b> in the target property editor.	The network property editor opens.
3	Click the ... button for network configuration.	The <b>Network Configuration</b> dialog box opens.
4	Perform the Ethernet configuration in the <b>Network Configuration</b> dialog box.	<p>The Ethernet settings are:</p> <ul style="list-style-type: none"> <li>● <b>Fixed IP Address</b></li> <li>● <b>IP address:</b> 172.20.10.168</li> <li>● <b>Subnet Mask:</b> 255.255.0.0</li> </ul> <p>For all other parameters, the default settings have been kept.</p>
5	Click <b>OK</b> to apply the settings.	The Ethernet configuration becomes effective after a download of the application to the HMI.

## I/O Manager

Vijeo-Designer uses driver to enable communications with equipment without you having to write complex communication programs.

To establish a Modbus TCP communication, the Modbus TCP/IP driver and the M221 controller (Modbus equipment) must be configured in the Vijeo-Designer application as described in the table:

Step	Action	Comment
1	Select the <b>New Driver...</b> command from the context menu of the <b>IO Manager</b> node in the <b>Navigators Project</b> tab.	The <b>New Driver</b> dialog box opens.
2	Select the manufacturer: <b>Schneider Electric Industries SAS</b> .	The list of the available drivers is updated.
3	Select the driver <b>Modbus TCP/IP</b> and the equipment <b>Modbus Equipment</b> and click the <b>OK</b> button.	The driver and the equipment are added to the <b>Navigator</b> and the <b>Equipment Configuration</b> dialog box opens.
4	Configure the <b>Modbus Equipment</b> in the <b>Equipment Configuration</b> dialog box.	The <b>Modbus Equipment</b> represents the M221 controller as Modbus TCP slave and the settings are: <ul style="list-style-type: none"> <li>● <b>IP address:</b> 172.20.10.167</li> <li>● Activate the check box labeled <b>IEC61131 Syntax</b></li> <li>● <b>Double Word word order:</b> Low word first</li> </ul> For all other parameters, the default settings have been kept.
5	Click the <b>OK</b> button.	–
6	Select the <b>Rename</b> command from the context menu of the <b>Modbus Equipment</b> in the <b>Navigators Project</b> tab in Vijeo-Designer.	The name of the <b>Modbus Equipment</b> becomes editable.
7	Enter a meaningful name for the <b>Modbus Equipment</b> and press <b>Enter</b> .	In this application, the name is set to <b>M221_Controller</b> .

For more information, refer to **Magelis XBT G/XBT GT, Modbus TCP/IP driver description** in the Vijeo-Designer online help.

## Variable Editor

Upon configuring the communication between the HMI and the M221 controller, the variables for the data exchange need to be configured in the **Variable Editor** of Vijeo-Designer.

An example on how to configure such a variable is described in the following table.

The variable which shall be exchanged between the HMI and the M221 controller is of type BOOL and has the address `%M1` in the EcoStruxure Machine Expert - Basic application:

Step	Action	Comment
1	In Vijeo-Designer, select the <b>Variables</b> node in the <b>Navigators Project</b> tab.	The <b>Variable Editor</b> opens.
2	Click the <b>New Variable</b> button in the <b>Variable Editor</b> .	The <b>New Variable</b> dialog box opens.
3	Set the <b>Variable Name</b> .	Select a meaningful name, for example <code>xStartMotor01</code> .
4	Select the <b>Data Type</b> from the menu.	In this example, the data type is BOOL.
5	Select the <b>Data Source</b> .	In this example, the variable is exchanged with the M221 controller. Therefore, <b>Data Source → External</b> is selected.
6	Select the <b>ScanGroup</b> from the menu.	The equipment added under the <b>IO Manager</b> is available in the menu. In this example, the equipment <b>M221_Controller</b> is selected.
7	Click the ... button to open the assistant to select the <b>Device Address</b> .	In this example, the variable has the address <code>%M1</code> on the M221 controller. The settings in the open <b>Modbus TCP/IP</b> dialog box are: <ul style="list-style-type: none"><li>● <b>Address:</b> <code>%Mi</code></li><li>● <b>Offset(l):</b> 1</li></ul>
8	Click the <b>OK</b> button in the <b>Modbus TCP/IP</b> dialog box.	The address field is filled with <code>%M1</code> .
9	Click the <b>OK</b> button in the <b>New Variable</b> dialog box.	The variable is created. During runtime, the variable is linked to the memory address <code>%M1</code> of the M221 controller assuming an Ethernet connection is established.

Vijeo-Designer provides further opportunities to create variables. To these belongs the **Export/Import Variables** feature, which is an efficient way to create variables.

For more information, refer to the Vijeo-Designer online help.

## Startup Options

Due to the use of the **Alarm Summary** object in the HMI application, the **Time Management** option is required and has been enabled automatically. The used HMI panel does not provide an internal battery to back up the RTC of the panel, thereby on startup the **Date and Time** configuration is displayed. To avoid this, the **Auto Start** option has been enabled. This setting became applicable because in this application, the RTC of the HMI is synchronized on each startup with the RTC of the M221 controller. In addition, the HMI application provides a page for the date and time adjustment.

The table describes how to configure the **Startup Options**:

Step	Action	Comment
1	In Vijeo-Designer, select the <b>Target</b> node in the <b>Navigators Project</b> tab.	The target property editor opens.
2	Select <b>Options</b> in the target property editor.	The network property editor opens.
3	Activate the check box <b>Auto Start (seconds)</b> .	The activation of this option suppresses the prompting for the date and time configuration on startup.

## Devices

### Overview

In this chapter, all devices configured within the EcoStruxure Machine Expert - Basic project are described.

### TM3 Embedded Safety Modules

The TM3 embedded safety modules are handled as I/O expansion modules and must be linked to the TM3 bus of the controller. The safety function is managed in the module itself and via the TM3 bus the diagnostic and the administrative control functions are provided. The diagnostic and control signals are provided as inputs and outputs in the controller configuration and can be processed in the application program which is running on the controller.

In this architecture, the following module was added to the TM3 bus (IO\_Bus).

Module name	Module type	Comment
Module_1	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.

The expansion modules must be configured within the EcoStruxure Machine Expert - Basic project.

In this architecture, the following modules were added to the TM3 bus (IO\_Bus).

Module name	Module type	Comment	Configuration
Module_2	TM3DI16	16-channel, 24 Vdc digital input expansion module with 1 common line, sink/source, and removable terminal block	Default
Module_3	TM3DQ16T	16-channel, 0.5 A source transistor outputs expansion module with 1 common line and removable terminal block	Default
Module_4	TM3XTYS4	TeSys expansion module, connection of up to 4 TeSys motor starters via RJ45 connection system	Default
Module_5	TM3XTYS4	TeSys expansion module, connection of up to 4 TeSys motor starters via RJ45 connection system	Default

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 iEM3110

The architecture implements 1 energy meter of type iEM3110 for energy measurement. The energy meter provides a pulse output which indicates the energy consumption. The output of the energy meter is connected to an input of the M221 controller.

The program code for counting the energy consumption based on the number of pulses is part of the POU `Energy` and is called in the **Master Task**.

## GV2DP Motor Starters

The architecture implements 3 motor starters of type GV2DP which are controlled via hardwired signals.

The devices themselves are not configured in the application. Only the variables to control, and to monitor each motor starter, are assigned to physical inputs and outputs of the configuration.

The inputs and outputs for each TeSys GV2DP device are provided via an RJ45 connector on a TM3XTSYS4 expansion module.

- Module\_4 X1 is connected to the TeSys GV2DP1 non-reversing (motor 1)
- Module\_4 X2 is connected to the TeSys GV2DP1 non-reversing (motor 2)
- Module\_4 X3 is connected to the TeSys GV2DP2 reversing (motor 3)

For the control and monitoring of each TeSys GV2DP device, three separate POUs are created in the application.

All POUs are called in the **Master Task**.

The POUs are:

- Motor 1 - TeSysD 1D - controls the TeSys GV2DP1 non-reversing (motor 1)
- Motor 2 - TeSysD 1D - controls the TeSys GV2DP1 non-reversing (motor 2)
- Motor 3 - TeSysD 2D - controls the TeSys GV2DP2 reversing (motor 3)

These motor control functions have a standardized interface via configured memory objects in the application and can be clearly identified by their symbol names. These memory objects are assigned to inputs and outputs and/or are processed from the HMI via Modbus TCP.

## TeSys U

The architecture implements 2 motor starter controllers of type TeSys U which are controlled via hardwired signals.

The devices themselves are not configured in the application only the variables to control, and to monitor each motor starter, are assigned to physical inputs and outputs of the configuration.

The inputs and outputs for each TeSys U device are provided via an RJ45 connector on a TM3XTSYS4 expansion module.

- Module\_4 X4 is connected to the TeSys U non-reversing (motor 4)
- Module\_5 X1 is connected to the TeSys U reversing (motor 5)

For the control and monitoring of each TeSys U device, two separate POUs are created in the application.

Both POUs are called in the **Master Task**.

The POUs are:

- Motor 4 – TeSysU 1D - controls the TeSys U non-reversing (motor 4)
- Motor 5 – TeSysU 2D - controls the TeSys U reversing (motor 5)

These motor control functions have a standardized interface via configured memory objects in the application and can be clearly identified by their symbol names. These memory objects are assigned to inputs and outputs and/or are processed from the HMI via Modbus TCP.

## Altivar with 2 Motors

The architecture implements a motor control function comprising of two motors and one variable speed drive of type Altivar 12.

It must be preselected which motor shall be operated via the Altivar drive. The other motor cannot be operated during this time. The switching between the motors is realized via hardwired signals and the control of the Altivar drive is realized via Modbus SL communication.

The program code for this motor control function is created in the POU `Motor 6&7 – ATV MBSL`.

The POU is called in the **Master Task**.

This motor control function has a standardized interface via configured memory objects in the application and can be clearly identified by their symbol names. These memory objects are assigned to inputs and outputs, are exchanged via Modbus SL using the communication functions, and/or are processed from the HMI via Modbus TCP.

## OsiSense RFID Smart Antennas

The architecture implements three OsiSense RFID smart antennas of type XGCS-90.

The antennas are linked to the controller via Modbus SL.

The space in front of the antenna is monitored periodically for a tag. If a tag is in front of an antenna, the reading or the writing of data is executed.

For the control and monitoring of each RFID antenna, three separate POU<sup>s</sup> are created in the application.

The POU<sup>s</sup> are:

- RFID Station 1
- RFID Station 2
- RFID Station 3

The POU<sup>s</sup> are called in the **Master Task**.

These RFID control functions have a standardized interface via configured memory objects in the application and can be clearly identified by their symbol names. These memory objects are assigned to inputs and outputs, are exchanged via Modbus SL using the communication functions, and/or are processed from the HMI via Modbus TCP.

## Application

### Task Configuration

The M221 modular logic controller supports the following task types:

- **Master Task**
- **Periodic Task**
- **Event Task**

The **Master Task** represents the main task of the application program. It is obligatory and is created by default. In this application, all POU's are associated to the **Master Task**.

The configuration of the **Master Task** in this application is:

- **Scan mode:** Periodic
- **Period:** 10 ms

When a logic controller is in periodic scan mode, the logic controller waits until the configured scan time has elapsed before starting a new scan. Every scan is therefore the same duration.

### Free POU's

In EcoStruxure Machine Expert - Basic you can configure **Free POU's** which can be assigned to the **Periodic Task** or which can be called as a subroutine in the program code.

In this application, three **Free POU's** are created which are called under certain conditions with a subroutine call (**SRi**) in the POU's under the **Master Task**. To these belong:

- **Get DateAndTime**

This program reads and converts the Real Time Clock (RTC) of the controller for display on the HMI.

- **Set DateAndTime**

This program sets the RTC of the controller from the HMI.

- **Initialization**

This program is called after a cold-restart of the controller. The program code initializes the application with the default values.

### Timers

The M221 controller supports up to 255 software objects of type **Timer**. Each timer needs to be configured in the application. In the **Programming** workspace in the **Tools** tab of the programming tree, select the node **Timers** under **Software Objects**. The window **Timer properties** is displayed that allows you to view and to configure all available timers.

In this application, the following timers have been configured covering different tasks.

Address	Symbol	Configuration	Description
%TM0	T_ESTOP_DELAY	<b>Type:</b> TON <b>Time base:</b> 100 ms Preset value: 20	Timer for delaying (2 s) the EStop okay signal.
%TM1	T_FEEDBACK_Motor1		Timers for feedback monitoring (2 ) of the respective motor.
%TM2	T_FEEDBACK_Motor2		
%TM3	T_FEEDBACK_Motor3		
%TM5	T_FEEDBACK_Motor4		
%TM6	T_FEEDBACK_Motor5		
%TM8	T_DLY_MCB_RDY_ATV	<b>Type:</b> TOF <b>Time base:</b> 100 ms Preset value: 20	Timer for delaying (2 s) the MCB ready signal for ATV. The delay is used to suppress the communication with the ATV as long as the boot process is not completed.
%TM4	T_DLY_REVERSE_MOTOR3		Timers for interlocking the reversing of the direction of rotation (2 s) of the respective motor.
%TM7	T_DLY_REVERSE_MOTOR5		
%TM9	T_DLY_RFID_START_COM	<b>Type:</b> TOF <b>Time base:</b> 100 ms Preset value: 60	Timer for delaying (6 s) the start of the communication with the RFID stations to prevent communication errors during boot-up phase.

## Communication Objects

The M221 controller supports different communication objects to manage the Modbus communication with Modbus slaves which are linked to the SL or the Ethernet interface of the controller. Each communication object needs to be configured in the application. In the **Programming** workspace in the **Tools** tab of the programming tree, select the node for the respective type under **Communication Objects**. Depending on the selected node, the associated property window is displayed that allows you to view and to configure the available communication function blocks.

The table lists the communication function blocks used in this application

Address	Symbol	Configuration	Description
%READ_VAR0	COM_READ_STATUS_RFID1		
%READ_VAR2	COM_READ_STATUS_RFID2		
%READ_VAR4	COM_READ_STATUS_RFID3	<b>Link:</b> SL1 <b>Id:</b> 2/3/4 <b>Timeout:</b> 2 (200 ms) <b>ObjType:</b> %MW <b>FirstObj:</b> 32768 (8000h) <b>Quantity:</b> 1 <b>IndexData:</b> 300/400/500 (%MW)	Read the status word of the respective RFID station.
%READ_VAR1	COM_READ_DATA_RFID1		
%READ_VAR3	COM_READ_DATA_RFID2		
%READ_VAR5	COM_READ_DATA_RFID3	<b>Link:</b> SL1 <b>Id:</b> 2/3/4 <b>Timeout:</b> 10 (200 ms) <b>ObjType:</b> %MW <b>FirstObj:</b> 0 <b>Quantity:</b> 50 <b>IndexData:</b> 302/402/502 (%MW)	Read the data from the tag in front of the respective RFID station.
%WRITE_VAR0	COM_WRITE_DATA_RFID1		
%WRITE_VAR2	COM_WRITE_DATA_RFID2		
%WRITE_VAR4	COM_WRITE_DATA_RFID3	<b>Link:</b> SL1 <b>Id:</b> 2/3/4 <b>Timeout:</b> 10 (200 ms) <b>ObjType:</b> %MW <b>FirstObj:</b> 0 <b>Quantity:</b> 50 <b>IndexData:</b> 302/402/502 (%MW)	Write data on the tag in front of the respective RFID station..
%WRITE_VAR1	COM_WRITE_CMD_RFID1		
%WRITE_VAR3	COM_WRITE_CMD_RFID2		
%WRITE_VAR5	COM_WRITE_CMD_RFID3	<b>Link:</b> SL1 <b>Id:</b> 2/3/4 <b>Timeout:</b> 2 (200 ms) <b>ObjType:</b> %MW <b>FirstObj:</b> 32795 (801Bh) <b>Quantity:</b> 1 <b>IndexData:</b> 301/401/501 (%MW)	Write the command word of the respective RFID station. The function is used to activate the <b>Sleep mode</b> of the RFID station.
%WRITE_READ_VAR0	COM_ATV	<b>Link:</b> SL1 <b>Id:</b> 1 <b>Timeout:</b> 2 (200 ms) <b>ObjType:</b> %MW <b>FirstWriteObj:</b> 8501 (2135h) <b>WriteQuantity:</b> 2 <b>IndexDataOut:</b> 200 (%MW) <b>FirstReadObj:</b> 3201 (C81h) <b>ReadQuantity:</b> 2 <b>IndexDataIn:</b> 202 (%MW)	Write the command word and the frequency setpoint to the Altivar. Read the status word and the output frequency of the Altivar.

For more information about the **Communication Objects**, refer to the document EcoStruxure Machine Expert - Basic - Generic Functions, Library Guide, EIO0000003289 (ENG).

## Program Code

The program code is divided into several POU (Program Organization Units). Each POU is called separately within the associated task.

For each device in this architecture, a separate POU is created which contains the program code with control and monitoring functions for the respective device. Which POU is related to which device can be easily detected by the name of the POU.

The following POU are created in this application:

- Motor 1 - TeSysD 1D
- Motor 2 - TeSysD 1D
- Motor 3 - TeSysD 2D
- Motor 4 - TeSysU 1D
- Motor 5 - TeSysU 2D
- Motor 6&7 - ATV MBSL
- RFID Station 1
- RFID Station 2
- RFID Station 3
- Energy

In addition to the POU for the devices, further POU are created for general functions of the application. These are:

- **Preprocessing**
  - Initialization of the application.
  - Pulse generator for the blink function of indicators.
- **System**
  - Processing of summary information about the devices.
  - Date and time handling of the RTC of the controller.

## Vijeo-Designer

### Overview

The HMI application is created with the configuration software Vijeo-Designer.

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

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.

- State of the safety function
- Device state
- Modbus communication state
- General operator mode
- General alarm reset

### Alarm Page

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

### Energy Page

The energy page provides information about the energy consumption of the architecture. In addition, the energy counter can be reset and the elapsed time since the last reset is displayed.

### Date and Time Page

The date and time page provides the value of the real time clock on the controller. In addition, it allows you to set the real time clock of the controller and the HMI.

### Device Pages

The device pages provide monitor and control functions for each device:

- Motor 1
- Motor 2
- Motor 3
- Motor 4
- Motor 5
- Motor 6/7
- RFID 1
- RFID 2
- RFID 3
- Wireless Push Buttons



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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:

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7.2	Setup Other Devices	166

# Section 7.1

## Setup Controller and HMI

### Setup Controller and HMI

#### Overview

You must download the applications from the PC to the controller and to the HMI to run the applications.

There are several options to perform the application download:

- Via an USB cable (linked to the integrated mini USB port on the devices)
- Via an SD card (plugged into the SD card slot on the front of the M221 controller)
- With an USB key (linked to the integrated USB port on the HMI)
- 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:** EcoStruxure Machine Expert - Basic and the associated Vijeo-Designer configuration software are required on the PC.

#### Download the EcoStruxure Machine Expert - Basic Application

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

Using the established USB connection between PC and M221 controller, proceed as follows to download the EcoStruxure Machine Expert - Basic application.

Step	Action	Comment
1	Click the <b>Commissioning</b> tab in EcoStruxure Machine Expert - Basic	The <b>Commissioning</b> tree opens
2	Select <b>Connect</b> in the <b>Commissioning</b> tree.	The <b>Connect</b> window is displayed on the right.
3	Select the USB device in the <b>Local Devices</b> field.	The field <b>Local Devices</b> displays all logic controllers directly connected to the PC with the physical COM ports of the PC (COM1, for example), with USB cables, or through virtualized COM ports (by USB-to-serial converters or Bluetooth dongles).

Step	Action	Comment
4	Click the <b>Login</b> button	When the connection is successfully established, details about the logic controller appear in the <b>Selected Controller</b> area of the window and the button to download the application is available.
5	Click the <b>PC to Controller (download)</b> button.	The download of the application starts.
6	To run the application you have downloaded, click <b>Start Controller</b> and click <b>OK</b> to confirm the action.	If the message <b>Unable to start controller (RUN mode)</b> appears, click <b>Close</b> and verify whether the RUN/STOP switch on the logic controller is in the STOP position. Refer to the <i>Hardware Guide</i> ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> ) of the logic controller for details.

For more information, refer to the EcoStruxure Machine Expert - Basic operating guide (*see EcoStruxure Machine Expert - Basic, Operating Guide*).

**NOTE:** The firmware version of the controller has to correspond with the firmware version of the controller in the EcoStruxure Machine Expert - Basic project. If the versions of the devices mismatch, you have to upgrade the version of the controller. The procedure to update the firmware of the controller is described in the EcoStruxure Machine Expert - Basic operating guide (*see EcoStruxure Machine Expert - Basic, Operating Guide*) and in the M221 logic controller programming guide (*see Modicon M221, Logic Controller, Programming Guide*).

### Download the Vijeo-Designer Application

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

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

- TCSXCNUMAM3P
- BMXXCAUSBH045

Using the established USB connection between PC and HMI, proceed as follows to download the Vijeo-Designer application.

Step	Action	Comment
1	Open the project in Vijeo-Designer.	-
2	Select the <b>Target</b> node in the project tab of the navigator window.	The property window of the target opens.
3	Select the <b>General</b> node in the properties window.	The editor for the general settings of the target opens.
4	Select <b>USB</b> in the <b>Download</b> field.	-
5	Right-click the <b>Target</b> node in the project tab of the navigator window and select <b>Download to (USB)</b> .	Downloading erases the files on your target. You can preserve them by using the <b>Preserve Run-Time Data</b> feature.

For more information, refer to the Vijeo-Designer online help.

**NOTE:** The Vijeo-Designer project and Vijeo-Designer runtime must be compatible. In most cases, you will not have to install Vijeo-Designer runtime separately from downloading the Vijeo-Designer project. When you download the project from Vijeo-Designer, Vijeo-Designer automatically downloads and updates the Vijeo-Designer runtime on the target machine. In some cases, you may want to install Vijeo-Designer runtime separately. Therefore the Vijeo-Designer runtime installer tool is used to download, install, and upgrade the target's Vijeo-Designer runtime.

## 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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OsiSense XGS - Setup	174
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## 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:

- Altivar 12
- iEM3110 energy meter

**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**

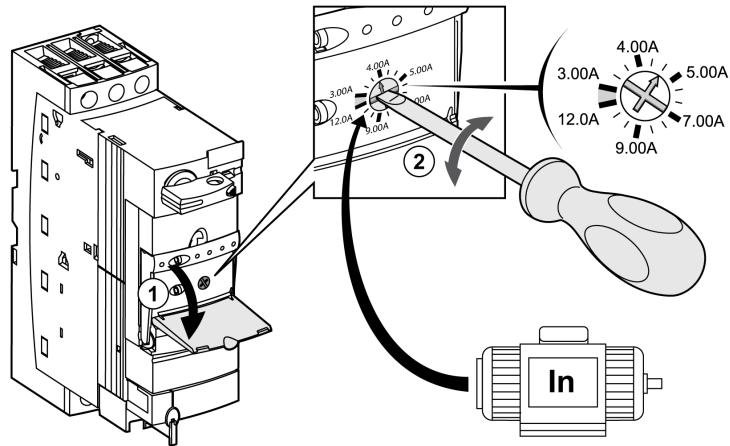
- Never assume that your controller is in a certain controller state before commanding a change of state, configuring your controller options, uploading a program, or modifying the physical configuration of the controller and its connected equipment.
- Before performing any of these operations, consider 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 EcoStruxure Machine Expert - Basic.

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

## 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 12 Variable Speed Drive - Setup

### Overview

To operate the Altivar 12 via Modbus serial line, the communication parameters have 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 remote display terminal\*
- By the software SoMove lite installed on a PC\*

(\* linked to the integrated communication port 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.**

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

For more information, refer to :

- Altivar 12, Variable speed drives for asynchronous motors, User manual BBV28581.
- Altivar 12 Variable speed drives for asynchronous motors, Modbus Communication Manual, BBV28590.

## Settings

The following steps to set up the drive are based on the configuration by the local HMI on the front of the drive.

Step	Action	Comment
1	Engage the power supply.	Do not give a run command to the drive.
2	Configure the parameter [R1 assignment] under the menu: (FULL) -> (I_O-) -> (r1).	In this example, the output R1 is used to control the brake contactors. Therefore the assignment of R1 is set to (RUN) what is signaling the drive is running.
3	Configure the motor parameters under the menu: (FULL) -> (drc-): <ul style="list-style-type: none"> <li>● [Standard mot. freq.] (bfr)</li> <li>● [Rated mot. power] (nPr)</li> <li>● [Rated mot. volt.] (UnS)</li> <li>● [Rated mot. current] (nCr)</li> <li>● [Rated mot. freq.] (FrS)</li> <li>● [Rated motor speed] (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 parameter [Reference Channel 1] under the menu: (FULL) -> (Ctl-) -> (Fr1).	The drive is operated via Modbus. The parameter [Reference Channel 1] is set to Modbus (Mdb).
5	Configure the ramp parameters under the menu: (FULL) -> (FUn-) -> (rPt-): <ul style="list-style-type: none"> <li>● [Acceleration] (ACC)</li> <li>● [Deceleration] (dEC)</li> </ul>	In most cases, the factory settings can be maintained for a quick start. But nevertheless, you have to verify the values.
6	Configure the speed limit parameters under the menu: (FULL) -> (FUn-) -> (SPL-): <ul style="list-style-type: none"> <li>● [Low Speed] (LSP)</li> <li>● [High Speed] (HSP)</li> </ul>	In most cases, the factory settings can be maintained for a quick start. But nevertheless, you have to verify the values.
7	Configure the [Motor thermal current] under the menu: (FULL) -> (Flt-) -> (tHt-) -> (ith).	Refer to the motor rating plate. Values have to be adjusted if the factory settings differ from your application.
8	Configure the communication parameters under the menu: (FULL) -> (COM-): <ul style="list-style-type: none"> <li>● [Modbus Address] (Add)</li> <li>● [Modbus baud rate] (tbr)</li> <li>● [Modbus format] (tFO)</li> <li>● [Modbus time out] (tto)</li> </ul>	The communication parameters in this example are set as follows: <ul style="list-style-type: none"> <li>● [Modbus Address] = 1</li> <li>● [Modbus baud rate] = 19.2</li> <li>● [Modbus format] = 8E1</li> <li>● [Modbus time out] = 2 seconds</li> </ul>

## **WARNING**

### **UNINTENDED EQUIPMENT OPERATION**

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

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

## Altistart 01 Soft Starter - Setup

### Soft Start Functions

#### Starting time

The ATS01N1 soft starter controls the starting time of the motor by ramping up the voltage applied to one phase of the motor.

The starting voltage ramp time can be adjusted 1...5 seconds with the potentiometer on the front of the soft starter. Since the actual motor starting time is dependent on the level of the applied load, the scale on the front of the soft starter is calibrated from A to E rather than 1...5 seconds, with A being the shortest time and E being the longest time.

The starting voltage ramp begins at the AC line voltage level set by the initial voltage adjustment. See the diagram below for more detail.

The ATS01 soft starter is internally bypassed at the end of the time set by the start time adjustment. If the motor is not up to speed by that time (due to a heavy load), the internal contactor can be damaged, requiring replacement of the soft starter.

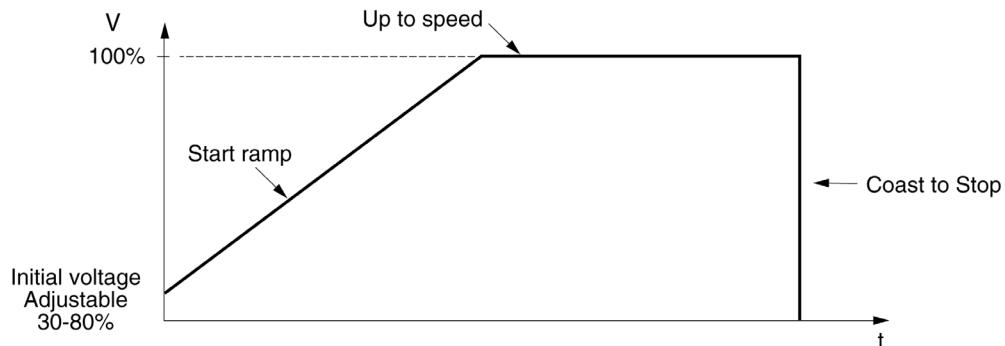
#### ⚠ CAUTION

##### INOPERABLE EQUIPMENT

Set the start time to a level that can be reached even if the motor is operating with maximum load conditions.

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

Voltage start ramp, initial voltage, and up to speed



### Initial voltage

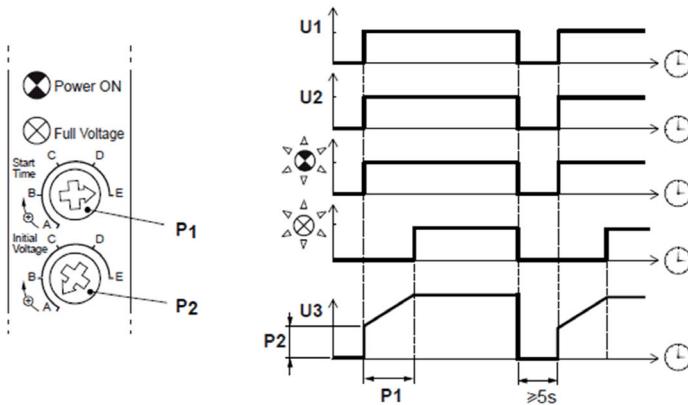
The initial voltage applied to the motor (the level at which the voltage ramp begins) can be adjusted by a potentiometer on the front of the ATS01N1 soft starter.

The initial voltage level can be adjusted from approximately 30 to 80% of the AC line voltage level. See the diagram above for more details.

Since the resultant motor torque varies in proportion to the square of the applied voltage, the scale on the front of the soft start is calibrated from A to E rather than from 30 to 80%, with A being the lowest level and E being the highest level. A lower setting reduces motor torque during starting.

Set this level to the minimum required that will result in motor rotation immediately after a start command.

### Settings



**U1** Level of input voltage

**U2** Level of voltage on control terminals

**U3** Level of output voltage (motor)

**P1** Potentiometer for starting voltage ramp time adjustment, A (min.) to E (max.)

**P2** Potentiometer for initial voltage adjustment, A (min.) to E (max.)

For more information, refer to Altistart 01, Soft Starts for Single-Phase and Three-Phase Asynchronous Motors, 45A01SS.

## OsiSense XGS - Setup

### Overview

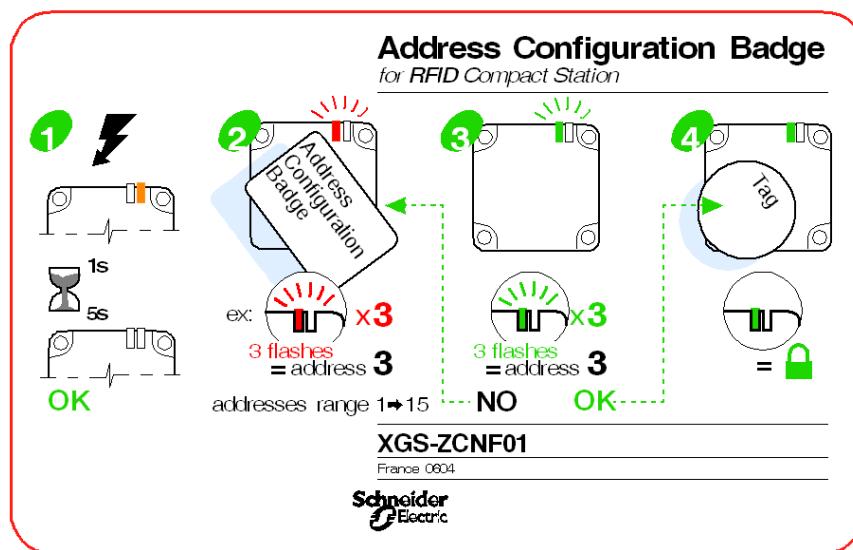
Each time the station is powered up, it automatically detects the format and network speed. The stations are supplied configured at network address 1. Before use, it is essential to configure the network address of each station.

Stations can be addressed in 2 ways:

- Using the XGS ZCNF01 configuration badge (supplied with the station)
- Via the network (Modbus or Uni-Telway write command)

### Configuration Badge

The addressing procedure is described on the back of the configuration badge:



Configuring the station network address:

Step	Action	Comment
1	Power up the station. Wait for 5 seconds.	Station self-test
2	Place the configuration badge in front of the station. Count the number of flashes.	The TAG LED flashes red. Each red flash emitted corresponds to one increment of the network address.
3	Remove the configuration badge when the required network address is reached.	The TAG LED flashes green. The number (if green) corresponds to the network address that has been configured.
4	Place a 'normal' (XGHB) tag in front of the station.	The configured network address is confirmed and saved in the station.

**NOTE:** The network address ranges from 1...15.

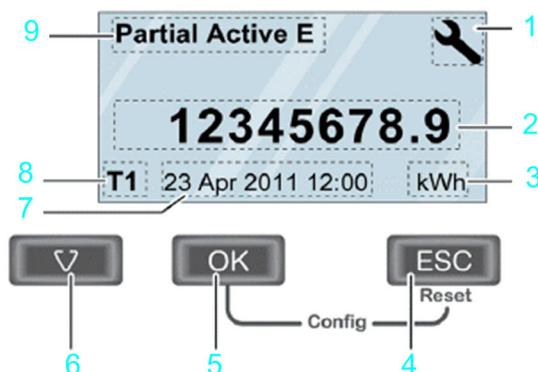
For more information, refer to [RFID OsiSense XG, Compact Stations, W916556690111](#).

## iEM3110 Energy Meter - 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 Cancelation
- 5 Confirmation
- 6 Selection
- 7 Date and time (except for iEM3100 / iEM3200 )
- 8 Tariff used (iEM3115 / iEM3155 / iEM3215 / iEM3255)
- 9 Functions / measurements

In addition to this system user guide the product manual for the iEM3110 energy meter has to be read carefully.

For more information, refer to [iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN](#).

## Basic Configuration

Before starting the configuration of the energy meter, verify that the installation is correct.

Step	Action	Comment
1	Set date and time.	When the power is interrupted, the iEM3110 automatically resets the date and time. By default the required password is 0010.
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>Pulse Output</b> and set the parameter for it.	The default pulse output is set to 100 imp/kWh. In this architecture, you have to set the value to 1000 imp/kWh
6	Leave the setup menu by pressing <b>ESC</b> .	-

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

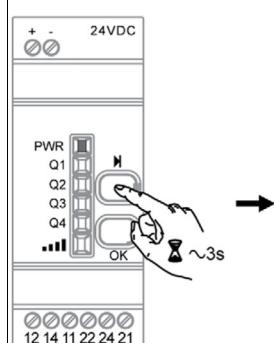
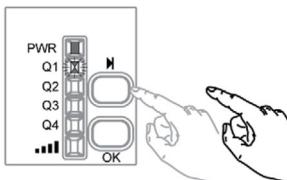
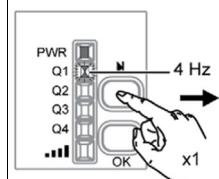
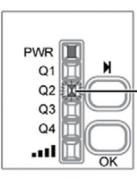
## Harmony ZBRRC Wireless Receiver - Setup

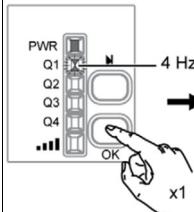
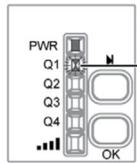
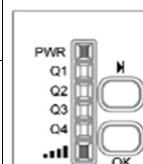
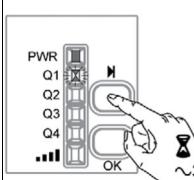
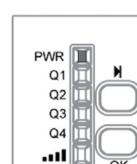
### Overview

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	<p>Enter the teach/unteach mode for push-buttons:</p> <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	<p>Select the output for teaching or unteaching:</p> <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, EIO0000000812 (EN).



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# Chapter 8

## 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 SCGRs. 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/offering/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 iEM3110, direct measurement up to 63 A, pulse output	A9MEM3110	x	x

## Emergency Stop

Quantity	Description	Reference
1	TM3 embedded safety module	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
1	Legend holder and blank label (white or yellow) 18x27 mm	ZBY6102

## 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
6	Legend holder and blank label (white or yellow) 18x27 mm	ZBY6102
1	Mounting plate for use on vertical support of tower light	XVBC12
1	Mounting 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 M221 Logic Controller 24 Vdc, 8x DI, 8x DOs, 2x AI, 1x SL, 1x Ethernet	TM221ME16T
1	TM3 expansion module 16 DI	TM3DI16
1	TM3 expansion module 16 DO	TM3DQ16T
2	TM3 expansion module TeSys, 4x RJ45 connector for TeSys motor starter	TM3XTYS4

**Magelis HMI**

Quantity	Description	Reference
1	Magelis HMI small panel with touch screen 3.4" (monochrome), Ethernet	HMI ST0532

**Control Voltage Power Supply and Distribution**

Quantity	Description	Reference	IEC	UL
1	Circuit breaker Multi9 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 Multi9 UL1077 1P, C, 1 A (24 Vdc)	24425	x	x
9	Circuit breaker Multi9 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>TeSys D</b>				
2	TeSys D motor starter combination, 24 Vdc, 3~400 V/ 0.18 kW	GV2DP104BD	x	x
1	TeSys D motor starter combination reversing, 24 Vdc, 3~400 V/ 0.18 kW	GV2DP204BD	x	x
2	SoLink wiring kit TeSys D motor starter combination	LAD5C11	x	x
1	SoLink wiring kit TeSys D motor starter combination reversing	LAD5C12	x	x
3	TeSys connection cable (SoLink), 2x RJ45, 1 m (3.28 ft)	LU9R10	x	x
2	Auxiliary contact block TeSys D contactor, 1 NO + 1 NC	LADN11	x	x
3	Auxiliary contact for circuit breaker, 2 NO	GVAE20	x	x
3	Auxiliary contact for circuit breaker, 1 NO, 1 NC	GVAN11	x	x
1	Set of 3-pole 63 A busbar 5 tap-offs, 54 mm (2.13 in)	GV2G554	x	x
1	Terminal block for supply busbar sets	GV1G09	x	x
1	Cover for unused busbar connection points	GV1G10	x	x
1	Altistart softstarter 3~400 V/ 1.1 kW (3 A)	ATS01N103FT	x	x
<b>TeSys U</b>				

Quantity	Description	Reference	IEC	UL
1	TeSys U base module, 12 A (without terminals)	LUB120	x	x
1	TeSys U base module reversing, 12 A (without terminals)	LU2BA0BL	x	x
2	TeSys U control unit, standard 0.15...0.6 A	LUCAX6BL	x	x
1	TeSys U wiring kit coil	LU9BN11C	x	x
1	TeSys U wiring kit coil (reversible)	LU9MRC	x	x
2	TeSys U function module parallel wiring	LUFC00	x	x
1	Set of 3-pole 63 A busbar 2 tap-offs, 54 mm (2.13 in)	GV2G254	x	x
2	TeSys connection cable (SoLink), 2x RJ45, 1 m (3.28 ft)	LU9R10	x	x
<b>Altivar 12 - 2 motors</b>				
1	Altivar 12 variable speed drive, 0.37 kW	ATV12H037M2	x	x
1	Magnetic circuit breaker, 6.3 A (1~230 V)	GV2L10	x	-
1	Auxiliary contact for circuit breaker, 1 NO, 1 NC	GVAE11	x	-
1	Thermal-magnetic circuit breaker, 4.0...6.3 A (1~240 V)	GV2P10	-	x
1	Insulating barrier for motor circuit breaker	GV2GH7	-	x
1	Auxiliary contact for circuit breaker, 1 NO, 1 NC	GVAN11	-	x
4	TeSys D contactor, AC-3 400 V / 4 kW	LC1D09BD	x	x
2	Auxiliary contact block TeSys D contactor, 1 NO, 1 NC	LADN11	x	x
2	Auxiliary contact for Multi9 circuit breaker	60137	x	x
2	Circuit breaker Multi9 UL489 2P, C, 2 A (~230 V)	26925	x	x

## Sensors

Quantity	Description	Reference
1	OsiSense tap-off box for 3 stations XGCS, Modbus SL, 24 Vdc	TCSAMT31FP
1	Power cable tap-off box with M12 connector at one end and flying leads at the other end, 2.0 m (6.56 ft)	XGSZ09L2
3	Compact station flat form 40(1) M12 male connector on flying lead	XGCS4901201
3	Modbus shielded connecting cable, IP 67 M12 connectors, male/female, A coding, 1 m (3.28 ft)	TCSMCN1M1F1

## 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 splitter block - 10 RJ45 and 1 screw terminal block	LU9GC3
1	Modbus shielded pre-wired M12 connector, IP 67, female/bare wires, A coding, 5 m (16.4 ft)	TCSMCN1F5
1	Modbus SL drop cable, RJ45 connector at each end, 1.0 m (3.28 ft)	VW3A8306R10
1	Modbus SL drop cable, RJ45 connector at each end, 3.0 m (9.8 ft)	VW3A8306R30
1	M12 tee 5-pin female A-coding M12/5-pin male A-coding M12 + 5-pin female A-coding M12, used to connect the line terminator.	TCSCTN011M11F
1	Line terminator 120 Ω, 5-pin male A-coding M12	FTXCNTL12

## Software Tools

Quantity	Description	Reference
1	EcoStruxure Machine Expert - Basic V1.0 on CD or for download	SOMBASAP13
1	Vijeo-Designer V6.2, HMI configuration software single license	VJDSNDTGSV62M
1	Programming cable (USB)	TCSXCNAMUM3P
1	Ethernet cable M12 - RJ45	TCSECL1M3M3S2
1	SD card, 2 GB	TMASD1

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# Glossary

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## C

**CANopen**

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

**CSA**

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

**CW/CCW**

ClockWise / Counter ClockWise

## E

**Ethernet**

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

**expansion bus**

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

## 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.

## 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

### RJ45

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).

## 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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