

# Compact Hardwired Logic Controller M221

## 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.

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

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

## START-UP AND TEST

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

### **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
Preventa, Machine Safety Products	MKTED208051EN
The essential guide: Preventa machine safety	DIA4ED2041204EN
Magelis HMI STU 655/855, User Manual	EIO0000000614
Control and signaling components	MKTED208031EN
Modicon M221 Logic Controller, Hardware Guide	EIO0000001384
Modicon M221 Logic Controller, Programming Guide	EIO0000001360
Modicon TM3, Digital I/O Modules, Hardware Guide	EIO0000001408
Modicon TM3, Expert I/O Modules, Hardware Guide	EIO0000001420
Modicon TM3 Safety Modules, Hardware Guide	EIO0000001831
Modicon TM3, (EcoStruxure Machine Expert - Basic) Expansion Modules Configuration, Programming Guide	EIO0000001396
EcoStruxure Machine Expert - Basic - Generic Functions, Library Guide	EIO0000003289 (ENG)
Control and protection components	MKTED210011EN
The essential guide, TeSys for power control & protection	DIA1ED2040401EN
Altivar 12, Variable speed drives for asynchronous motors, User manual	BBV28581
Altivar 312, Variable speed drives for asynchronous motors, Installation manual	BBV46391
Altivar 312, Variable speed drives for asynchronous motors, Programming manual	BBV46385
LXM28A and BCH2, Servo drive system, Product manual	0198441114054-EN
ConneXium Ethernet Switches, TCSESU0•F•N0, Quick Reference Guide	31007950
Detection for automation solutions OsiSense	MKTED210041EN
The essential guide of Detection	DIA4ED2041203EN
Transparent Ready, User Guide	31006929
EcoStruxure Machine Expert - Basic - Operating Guide	EIO0000003281 (ENG)

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Title of Documentation	Reference Number
Modicon TMH2GDB Remote Graphic Display, User Guide	EIO0000002063 (ENG)

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.**

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

### DANGER

#### POTENTIAL FOR EXPLOSION

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

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

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

## **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.**

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## Applicable Terminology

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.
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

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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*.

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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

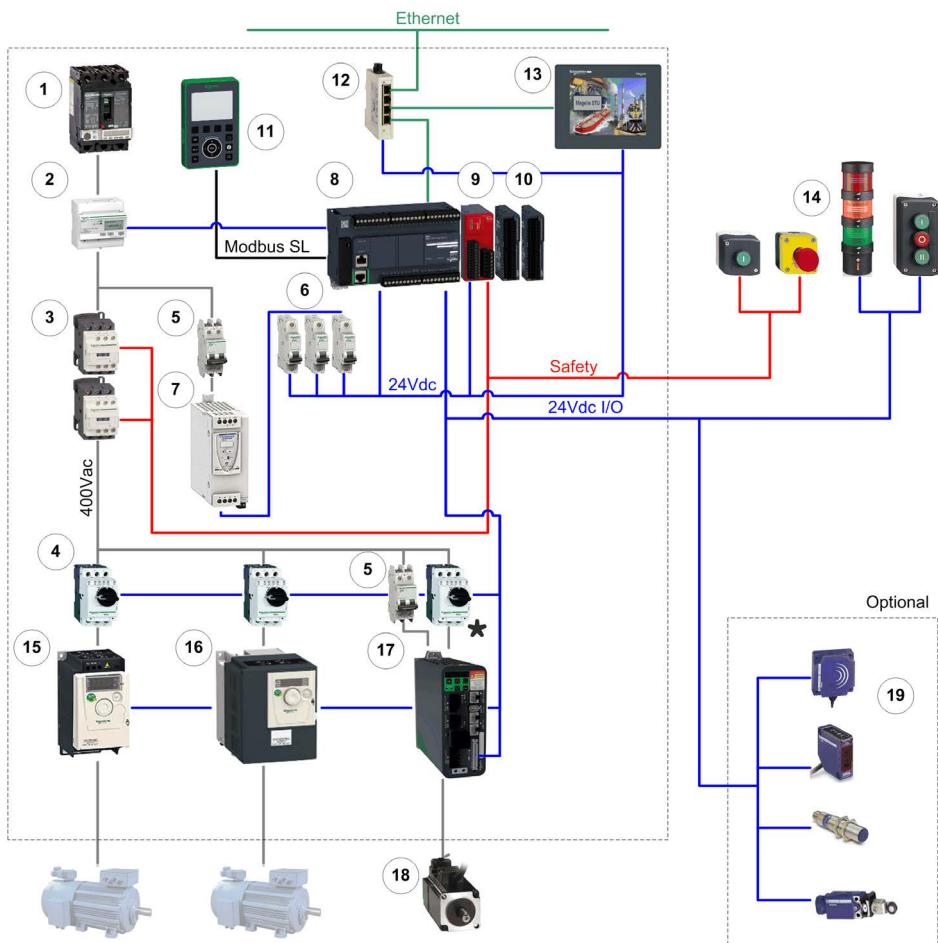
The architecture is arranged into the optimized performance class and is distinguished by the following characteristics:

- Modicon M221 Logic Controller
- Magelis HMI STU touch panel
- Modicon Remote Graphic Display TMH2GDB
- Energy metering
- Ethernet connectivity
- Application of machine functional safety devices
- 24 digital inputs
- 32 digital outputs
- 2 analog inputs
- 4 analog outputs

The architecture implements three coordinated drives which are linked to the local I/O of the controller. The control and monitoring of the drives are realized with the controller via hardwired signals.

- 1 Altivar 12
- 1 Altivar 312
- 1 Lexium 28

## Layout



1	PowerPact circuit breaker	11	Remote Graphic Display TMH2GDB
2	iEM3110 energy meter	12	Ethernet switch (unmanaged)
3	TeSys D contactor	13	Magelis HMI STU touch panel
4	TeSys GV2P (UL) motor circuit breaker	14	Harmony signaling/control devices

\* Conformance to UL standards requires that fuses as per UL248 or circuit breakers as per UL489 are used for the branch circuit protection in place of the motor circuit breakers depicted above in front of the Lexium servo drives. For more information, refer to the LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.

5	Multi 9 C60N (UL 489) circuit breaker	15	Altivar 12 variable speed drive
6	Multi 9 C60N (UL 1077) circuit breaker	16	Altivar 312 variable speed drive
7	Phaseo power supply 24 Vdc	17	Lexium 28 servo drive
8	Modicon M221C Logic Controller	18	Lexium BCH2 servo motor
9	TM3 Preventa safety module	19	OsiSense sensors and switches
10	TM3 expansion module	-	-

\* Conformance to UL standards requires that fuses as per UL248 or circuit breakers as per UL489 are used for the branch circuit protection in place of the motor circuit breakers depicted above in front of the Lexium servo drives. For more information, refer to the LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.

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# Chapter 3

## Safety & Safety Requirements

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### What Is in This Chapter?

This chapter contains the following topics:

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Evolution of Legal Framework	29
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/EC96/82/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/IEC 62061	EN ISO 13849-1 EN/IEC 62061 EN/IEC 61508	EN/IEC 61511

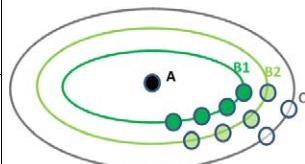
A list of such standards can be accessed at:

<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.

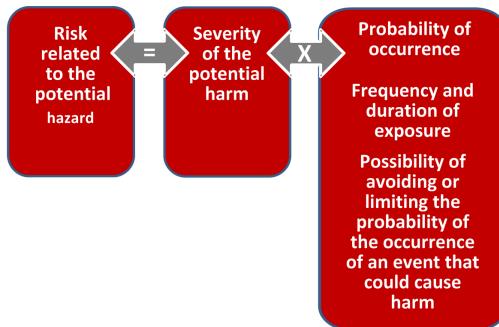
### Risk Assessment

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.

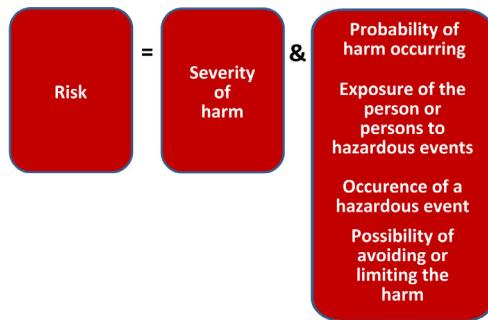
The risk is a function of the severity of the harm and the probability that this harm will occur. The severity of the harm takes into account:

- 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 (PLr).
3. Design and technical creation of safety functions: identify the parts that perform the safety function.
4. Evaluate the performance level PL for each safety-related part.
5. Check that the performance level PL achieved is greater than or equal to the required level (PLr).
6. Check that all requirements are satisfied.

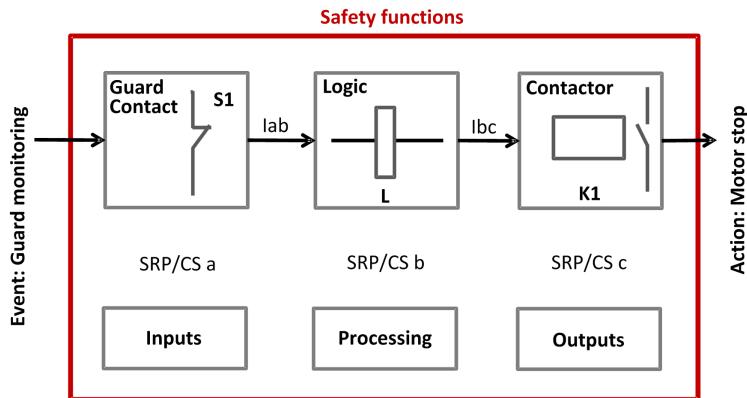
The above 6 stages will be illustrated taking as an example a safety function where a severe injury can be caused by a horizontal movement on a machine not stopping where an operator maybe exposed to this dangerous situation. The machine is sometimes accessed by production workers and monitored during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

### Stage 1 - Selection of Safety Functions

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

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

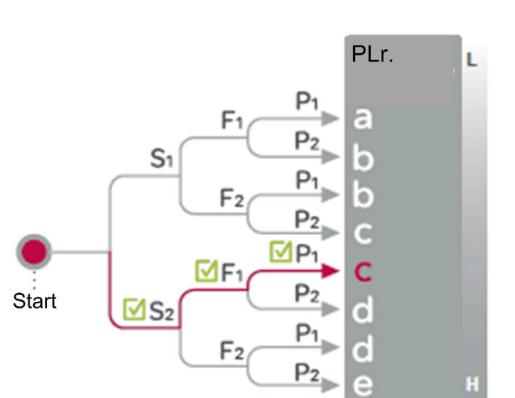
- **S1:** Slight injury, normally reversible
- **S2:** Serious, normally irreversible, including death

**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



Start Starting point for the evaluation

PLr Required performance level

L Low contribution to risk reduction

H High contribution to risk reduction

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

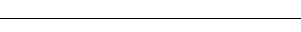
There is a need to describe the PL (performance level) calculation method.

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.	

Category	System Behavior	Designated Architecture
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.	<pre> graph LR     I1((I1)) -- i_m --&gt; L1[L1]     L1 -- m --&gt; O1((O1))     I2((I2)) -- i_m --&gt; L2[L2]     L2 -- m --&gt; O2((O2))     O1 -- c --&gt; L2     O2 -- i_m --&gt; L1   </pre>
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]     L1 -- m --&gt; O1((O1))     I2((I2)) -- i_m --&gt; L2[L2]     L2 -- m --&gt; O2((O2))     O1 -- c --&gt; L2     O2 -- i_m --&gt; L1   </pre>

Im Interconnecting means  
 C Cross monitoring  
 I, I1, I2 Input device, for example sensor  
 L, L1, L2 Logic  
 m Monitoring  
 O, O1, O2 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)

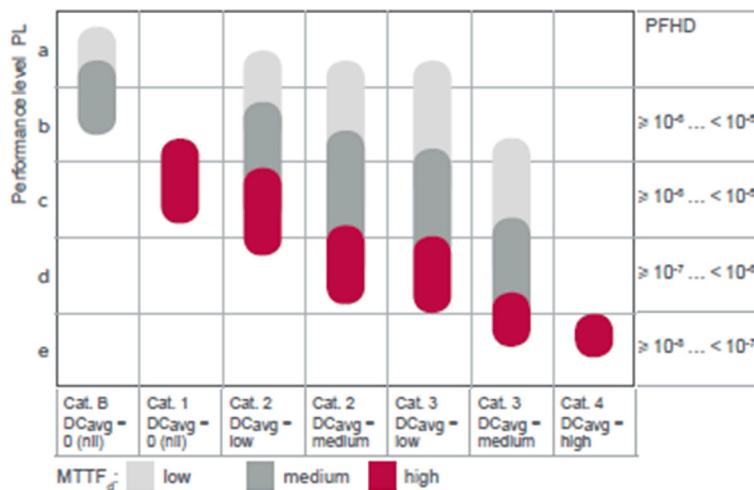
This term is expressed as a percentage and quantifies the ability to diagnose a dangerous failure.

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.

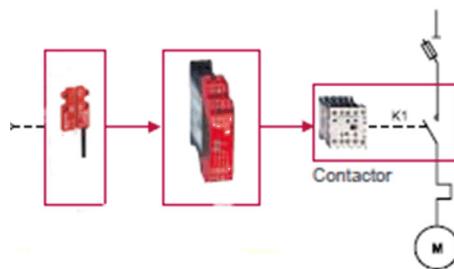
As the example requires PL=c the chart states as a minimum a category 1 architecture with a diagnostic coverage of 0 (Nil) and a MTTF<sub>d</sub> of high is required.

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 x 8 x (3600 / 90) = 70,400 operations/year
- MTTF<sub>d</sub> = B<sub>10d</sub> / (0.1 x 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) x 70,400 = 194 years The 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:

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

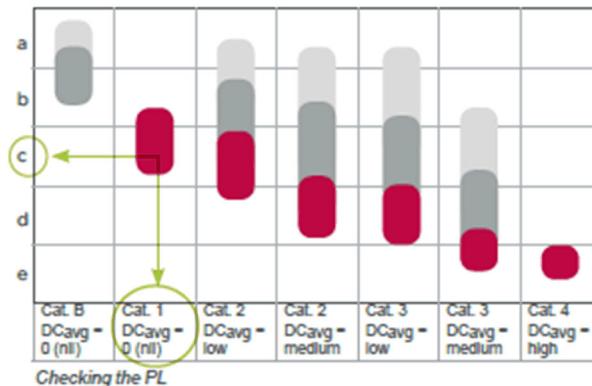
The DC in the example is < 60%, for example nil.

### 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.

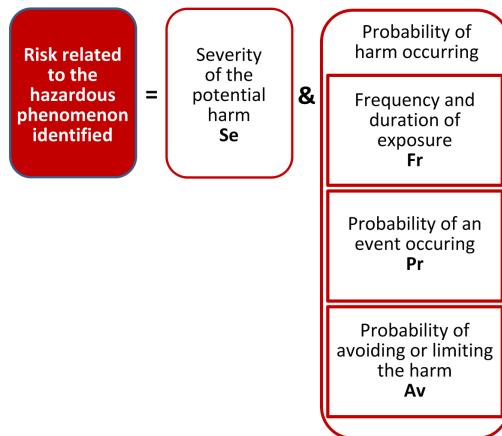
The method consists of assigning a SIL to each function, taking into account the following parameters:

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

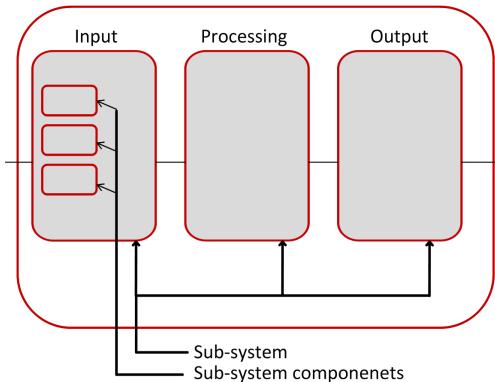
Designing a system is split into 5 stages after having drawn up the functional safety plan:

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

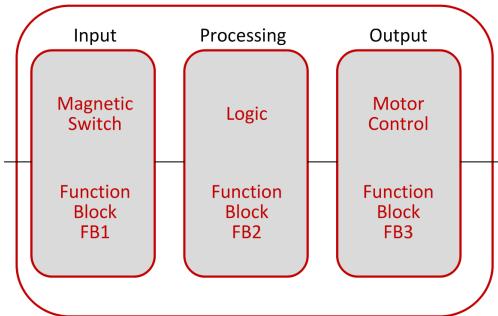
A level of SIL 2 must be achieved by the safety-related electrical control systems (SRECS) on the machine.

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.

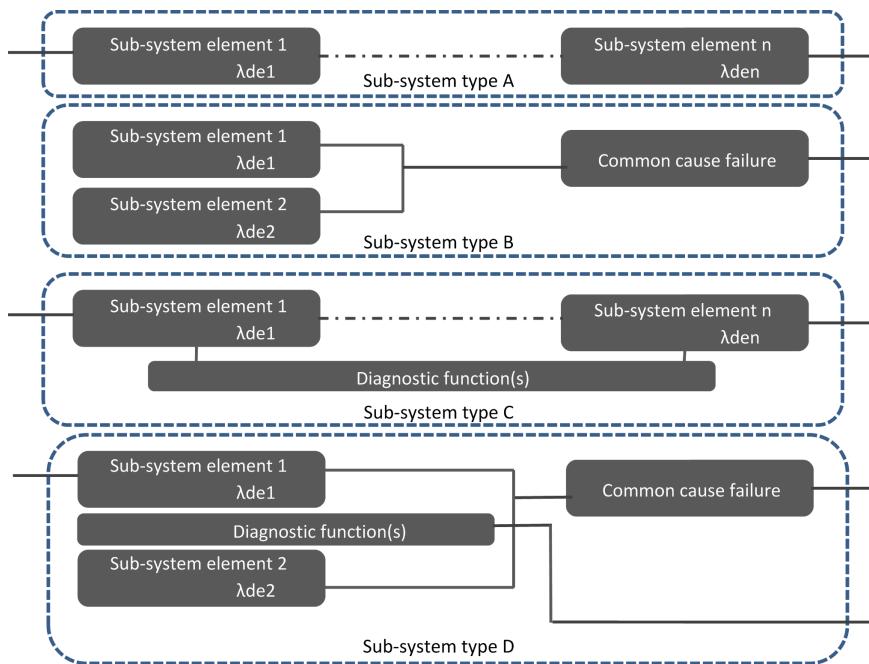
### Stage 3 - List the Safety Requirements for Each Function Block and Assign the Function Blocks to the Subsystems

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:

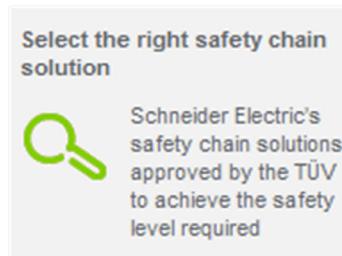
[http://www2.schneider-electric.com/documents/original-equipment-manufacturers/SCHNEIDER-ELECTRIC-SAFETY-EN\\_2012\\_09.zip](http://www2.schneider-electric.com/documents/original-equipment-manufacturers/SCHNEIDER-ELECTRIC-SAFETY-EN_2012_09.zip)

## 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	70
4.3	HMI	75
4.4	Controller	84
4.5	Communication	94
4.6	Motor Control	96
4.7	Detection	116

## 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

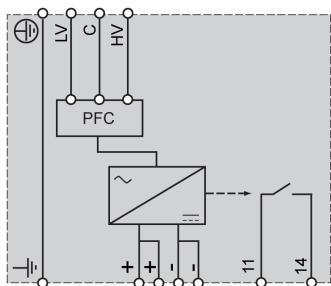
Dimensions	6 different types (W x H x D): 44...165 x 143 x 120...155 mm (1.73...6.5 x 5.63 x 4.72...6.1 in.)
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For more information, refer to :

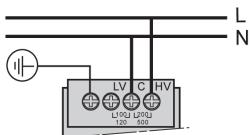
- The essential guide for power supplies and transformers, DIA3ED2070412EN
- Phaseo power supplies and transformers, Catalogue Pages, 14082-EN

## 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

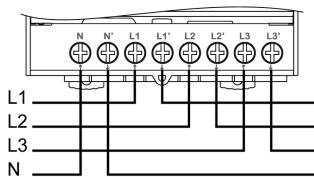
Standards and certifications	IEC 61557-12, IEC 61036, IEC 61010, IEC 62053-21/22 class 1 and 0.5S, IEC 62053-23, EN50470-3
Current (max)	63 A
Models	iEM3100, iEM3110, iEM3115, iEM3135, iEM3150, iEM3155, iEM3165, iEM3175

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.)

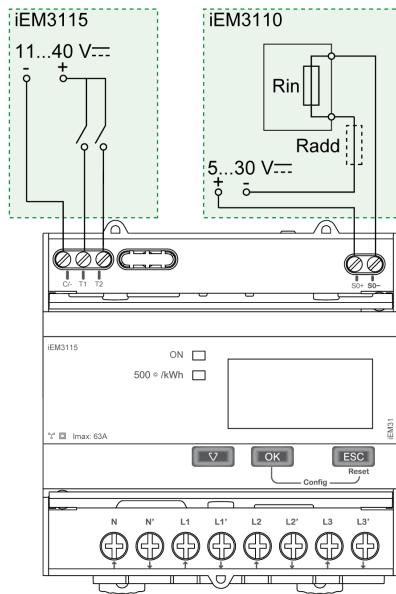
For more information, refer to iEM3100 series / iEM3200 series, Energy Meters, User Manual, DOCA0005EN.

## Wiring

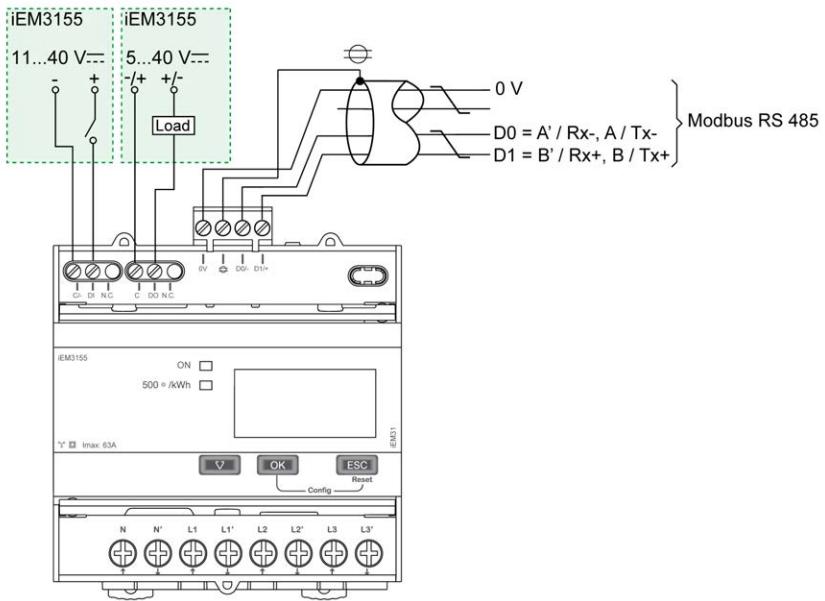
The graphic shows the wiring on three-phase systems for direct measurement of iEM31..



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	71
Preventa Detection and Dialog - Hardware	74

## 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.

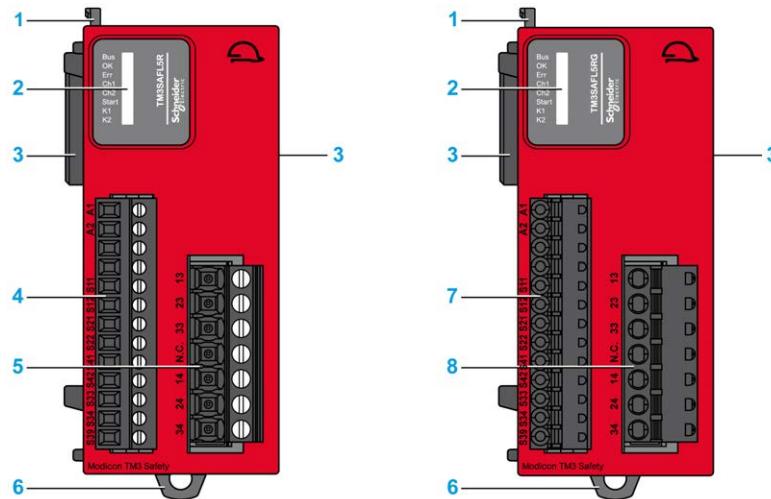
The module used in the described architecture is the TM3SAF5R. The main characteristics are described in the table below.

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

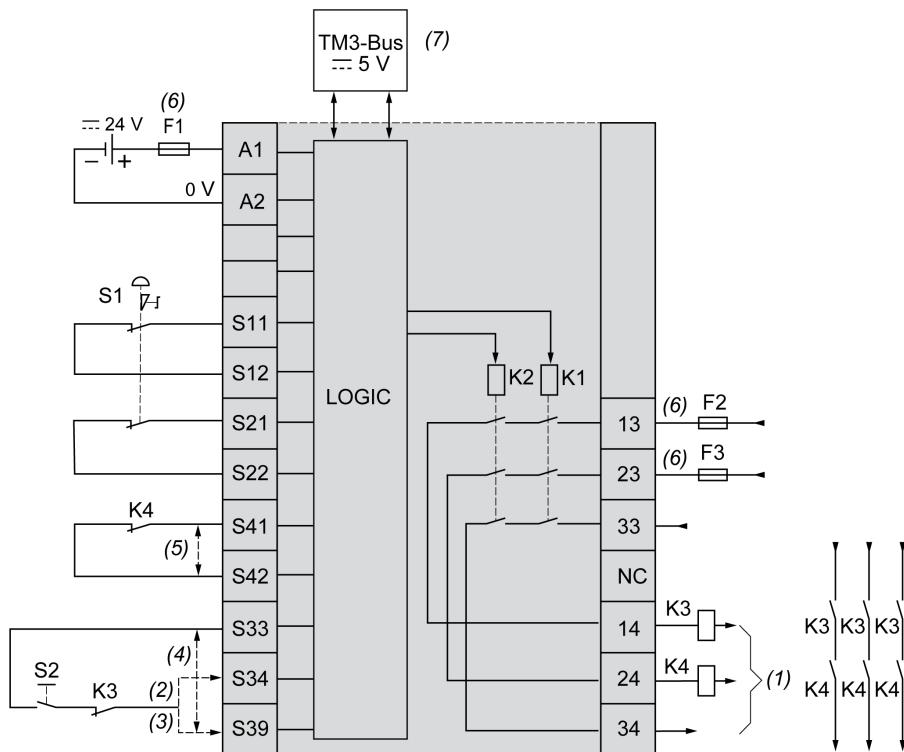


1	Locking device for attachment to the previous module
2	Status LEDs
3	Expansion connector for I/O bus (one on each side)
4	Power supply and input removable screw terminal block with a 3.81 mm (0.15 in) pitch
5	Relay output removable screw terminal block with a 5.08 mm (0.20 in) pitch
6	Clip-on lock 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 STU	76
Modicon Remote Graphic Display TMH2GDB - Hardware	79
Harmony Control and Signaling - Hardware	83

## Magelis HMI STU

### Front View

The graphic shows the front of the Magelis HMI STU:



### Description

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

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

Magelis STU provides the following features:

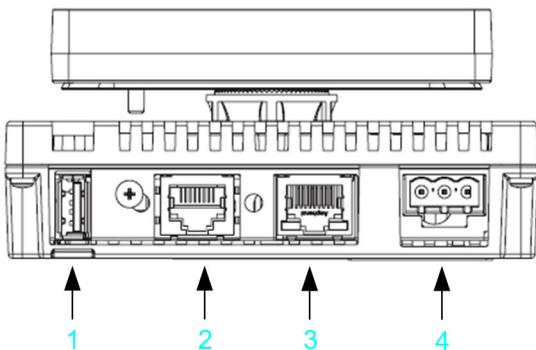
- High definition color screen TFT QVGA with LED backlight
- 2 screen sizes: 3.5" (HMI STU655) and 5.7" (HMI STU855)
- Tool free mounting with the Schneider Electric 22 mm (0.86 in.) push-button system
- Connectivity via Ethernet (Modbus TCP, Ethernet IP, and PROFINET protocols)
- Interfaces to allow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

Conformity to standards	EN, IEC, UL 508, ISA 12, CSA, Marine Bridge & Deck, GOST
Power supply	24 Vdc with removable connector
Degree of protection	IP 65
Interfaces	<ul style="list-style-type: none"> <li>● Ethernet port: 1x RJ45</li> <li>● Serial line: 1x RJ45 (COM1: RS 232C / RS-485)</li> <li>● USB: 1x mini-B (2.0) + 1x Type-A (2.0)</li> </ul>
Protocols	<ul style="list-style-type: none"> <li>● Modbus TCP</li> <li>● Ethernet IP</li> <li>● Modbus SL</li> <li>● Uni-Telway</li> </ul>
Display	320 x 240 pixels, 65,536-color TFT
Memory	<ul style="list-style-type: none"> <li>● Application/Backup: 32 Mb/64 Kb</li> <li>● Extension: via USB stick only</li> </ul>
Functions	<ul style="list-style-type: none"> <li>● Real time clock: Access to controller real-time clock</li> <li>● Variables: max. 8000</li> </ul>
Dimensions (W x H x D)	<ul style="list-style-type: none"> <li>● Front 3.5": 98 x 81 x 6 mm (3.858 x 3.188 x 0.629 in.)</li> <li>● Front 5.7": 163 x 129.5 x 17.5 mm (6.42 x 5.09 x 0.69 in.)</li> <li>● Rear module: 118 x 98 x 30 mm (4.64 x 3.85 x 1.18 in.)</li> <li>● Cut-out (diameter: 22 mm / 0.86 in.)</li> </ul>

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

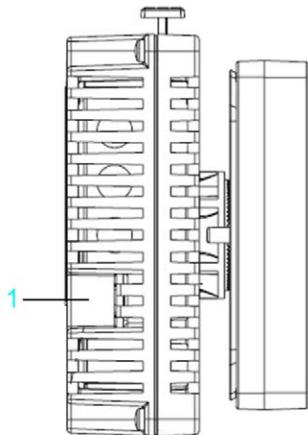
## Wiring

Bottom view of the connector:



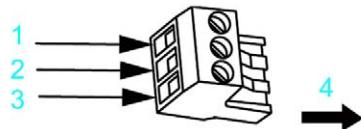
- 1 Standard A USB port connector
- 2 Serial I/F (host I/F 8-pin RJ45)
- 3 Ethernet interface (LAN)
- 4 Power input terminal block

Side view of the connector:



1 Mini-B USB port connector

The graphic shows the power plug:



1 + / 24 Vdc

2 - / 0 Vdc

3 FG / grounded terminal connected to the unit chassis

4 Insertion direction

## Modicon Remote Graphic Display TMH2GDB - Hardware

### Front View

Remote Graphic Display TMH2GDB



### Description

The Remote Graphic Display is a local control unit. It is used in conjunction with the Modicon M221 Logic Controller for monitoring, commissioning, operating, and maintenance activities. The operator interface (customized pages) is a component of the controller application and is downloaded from the controller as soon as the Remote Graphic Display is connected to it. Therefore, one Remote Graphic Display can be used for different controllers, respectively applications.

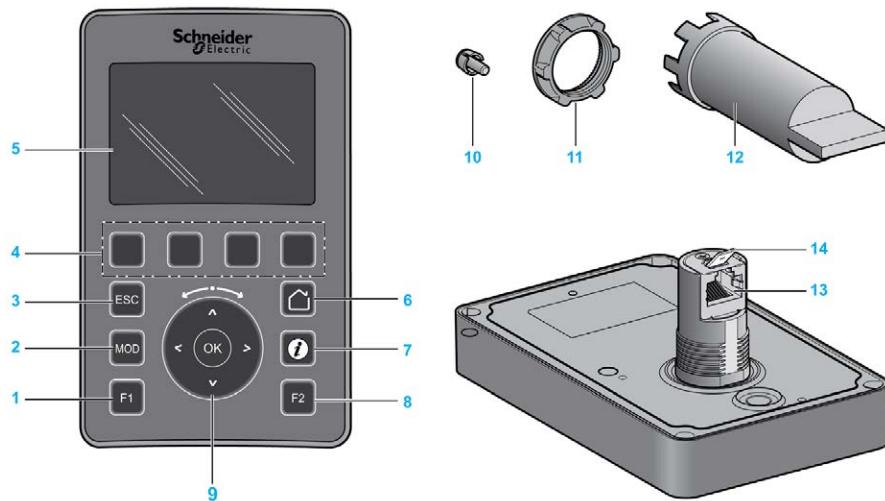
- Easy connectivity via Modbus Serial Line using RS-485 link
- Power supply via serial line link from the Modicon M221 Logic Controller
- Access to controller data and application control
- Access protection via password
- Ten command buttons, two of which can be customized

Standards and Certifications	IEC/EN 61010-2-201, UL508 CE, cULus Listing Mark
Power supply	5 Vdc, via serial link from the controller
Degree of protection	IP65 (excluding the RJ45 connector)
Interface	Serial line port: 1x RJ45
Dimensions (W x H x D)	80 x 126 x 19.2 mm (3.15 x 4.961 x 0.756 in.)

For more information, refer to Modicon TMH2GDB Remote Graphic Display, User Guide, EIO0000002063 (ENG).

## Physical Description

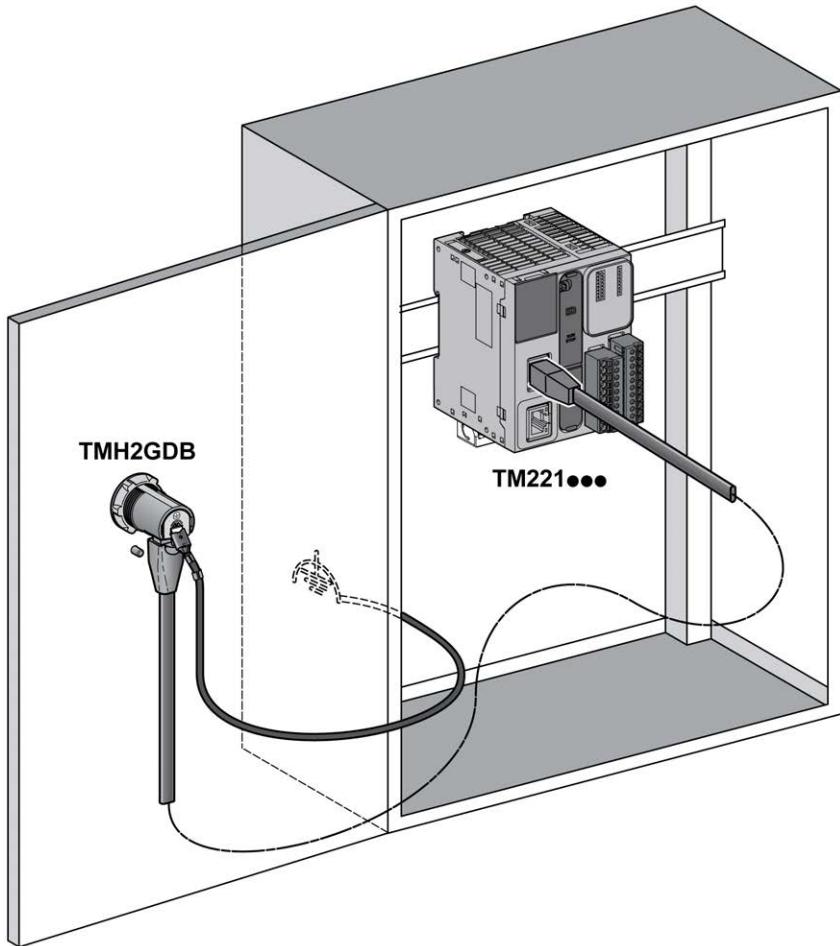
The illustration presents the Remote Graphic Display



- 1 F1 key
- 2 MOD key
- 3 ESC key
- 4 R1 to R4 keys
- 5 Graphic screen
- 6 Home key
- 7 Information key
- 8 F2 key
- 9 Touch wheel/OK/arrows
- 10 Anti-rotation tee
- 11 Installation nut
- 12 Socket wrench (ZB5AZ905)
- 13 RJ45 serial line (RS-485)
- 14 Connector for functional ground (earth)

## Wiring

The Remote Graphic Display must be connected only to the **Serial** or **Serial 1** port of the logic controller. These serial ports of the logic controllers provide the 5 Vdc power supply of the Remote Graphic Display. The connection between the Remote Graphic Display and the logic controller is RS-485 (Modbus protocol).



## Grounding

The grounding lug of the Remote Graphic Display must be connected to the ground terminal screw of the cabinet.

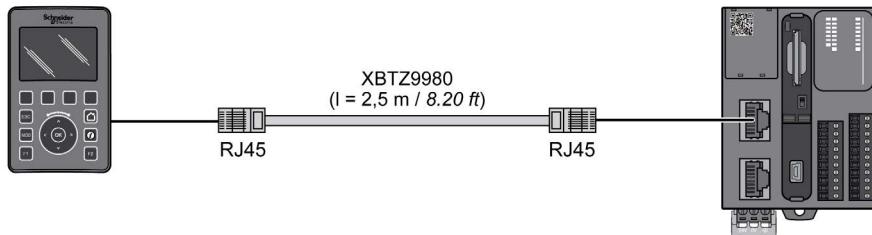
This table presents the characteristics of the grounding connection:

Characteristic	Description
Minimum wire gauge	2.5 mm <sup>2</sup> (AWG 14)
Lug size	6.35 x 0.81 mm (0.25 x 0.032 in)
Connection	Female spade terminal (AMP 6392-1 or similar)

## Connecting Cables

You can use the following cable for connecting the Remote Graphic Display to the logic controller:

Reference	Description	Length
XBTZ9980	Modbus serial link cable (2 RJ45 male connectors)	2.5 m (8.20 ft)



## 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 M221C Logic Controller - Hardware	85
Modicon TM3 Modules - Hardware	92

## Modicon M221C Logic Controller - Hardware

### Front View

Modicon logic controller TM221CE40T



### Description

The Modicon M221 Logic Controller provides various features to serve 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 (*see 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
- Grafcet (List)

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

- 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)
- Regular relay outputs
- Analog inputs

Standards and certifications	IEC/EN 61131-2, UL 508
Rated voltage	<ul style="list-style-type: none"> <li>• 24 Vdc</li> <li>• 100...240 Vac</li> </ul>
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	<p>W x H x D</p> <ul style="list-style-type: none"> <li>• 95 mm (3.74 in) x 103.6 mm (4.08 in) x 75.9 mm (2.99 in)</li> <li>• 110 mm (4.33 in) x 103.6 mm (4.08 in) x 75.9 mm (2.99 in)</li> <li>• 163 mm (6.42 in) x 103.6 mm (4.08 in) x 75.9 mm (2.99 in)</li> </ul>
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

## Modicon M221C Logic Controllers

Reference	Digital inputs	Digital outputs	Analog inputs	Communication ports
TM221C16R	5 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	7 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port
TM221C16T	5 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	5 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port
TM221C24R	10 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	10 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port
TM221C24T	10 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	8 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port

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

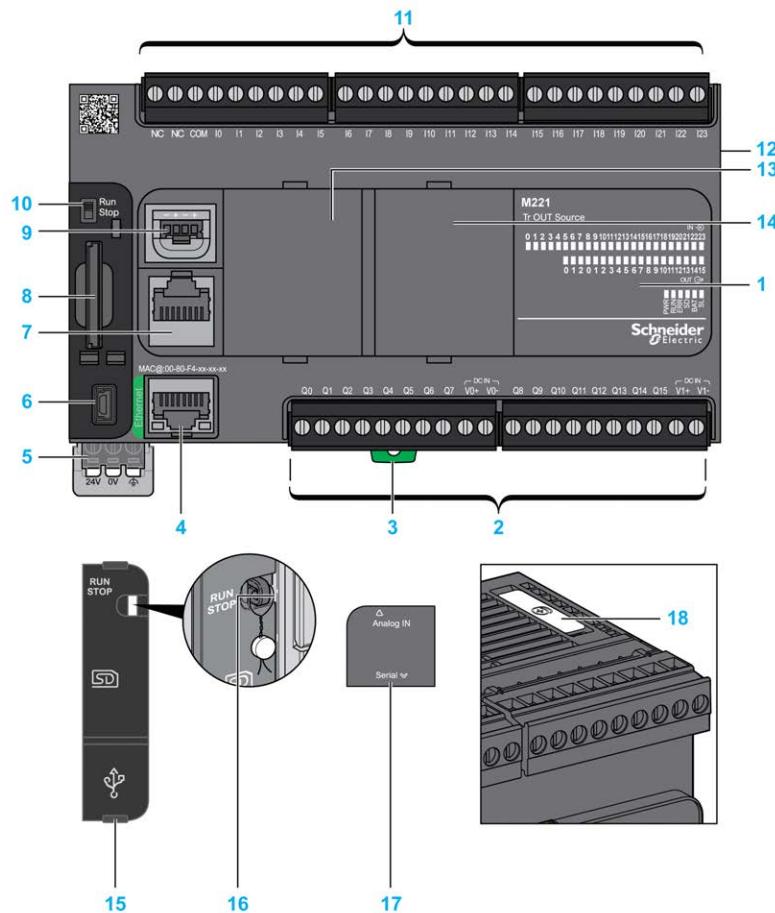
**2** The fast inputs (max. 100 kHz) can be used either as regular inputs or as fast inputs for counting or event functions.

**3** 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
TM221C40R	20 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	16 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port
TM221C40T	20 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	14 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port
TM221CE16R	5 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	7 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221CE16T	5 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	5 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221CE24R	10 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	10 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221CE24T	10 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	10 regular transistor outputs 4 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221CE40R	20 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	16 relay outputs	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
TM221CE40T	20 regular inputs <sup>1</sup> 4 fast inputs (HSC) <sup>2</sup>	14 regular transistor outputs 2 fast transistor outputs (PWM/PLS/PTO) <sup>3</sup>	2 analog inputs 0...10 V	1 serial line port 1 USB mini-B programming port 1 Ethernet port
<p><b>1</b> The regular inputs have a maximum frequency of 5 kHz.</p> <p><b>2</b> The fast inputs (max. 100 kHz) can be used either as regular inputs or as fast inputs for counting or event functions.</p> <p><b>3</b> 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.</p>				

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

## Physical Description TM221CE40T

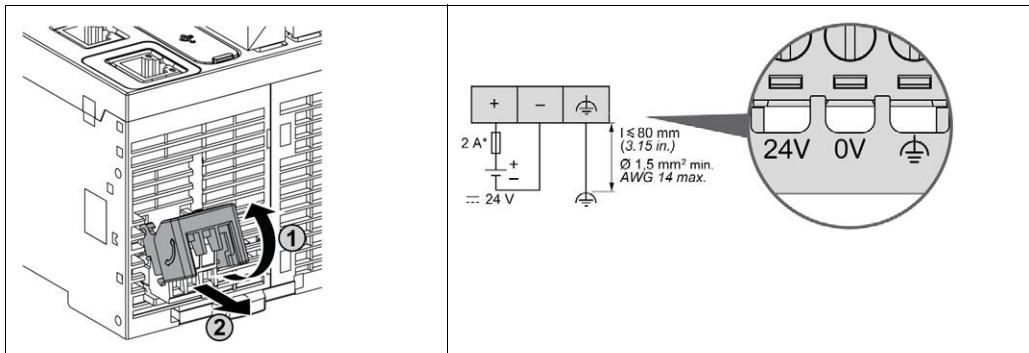


N°	Description	Refer to
1	Status LEDs	–
2	Output removable terminal block	Rules for Removable Screw Terminal Block ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
3	Clip-on lock for 35 mm (1.38 in.) top hat section rail (DIN-rail)	DIN Rail ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
4	Ethernet port / RJ45 connector	Ethernet port ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )

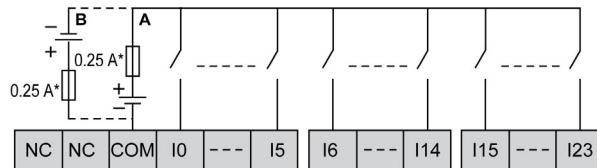
N°	Description	Refer to
5	24 Vdc power supply	Power supply ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
6	USB mini-B programming port / For terminal connection to a programming PC (EcoStruxure Machine Expert - Basic)	USB mini-B programming port ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
7	Serial line port 1 / RJ45 connector (RS-232 or RS-485)	Serial line 1 ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
8	SD Card slot	SD Card Slot ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
9	2 analog inputs	Analog Inputs ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
10	Run/Stop switch	Run/Stop switch ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
11	Input removable terminal block	Rules for Removable Screw Terminal Block ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )
12	I/O expansion connector	–
13	Cartridge slot 1	–
14	Cartridge slot 2	–
15	Protective cover (SD Card slot, Run/Stop switch and USB mini-B programming port)	–
16	Locking hook	–
17	Removable analog inputs cover	–
18	Battery holder	Installing and Replacing the Battery ( <i>see Modicon M221 Logic Controller, Hardware Guide</i> )

## Wiring Diagrams for TM221CE40T

Connection of the DC power supply of the controller



The following figure presents the connection of the inputs to the sensors for TM221C40T and TM221CE40T:

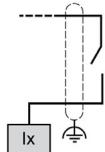


\* Type T fuse

A Sink wiring (positive logic).

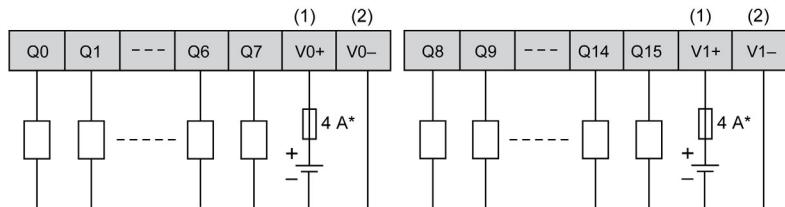
B Source wiring (negative logic).

The following figure presents the connection of the fast inputs:



Ix I0, I1, I6, I7

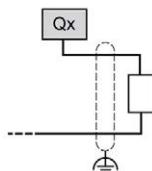
The following figure presents the connection of the outputs to the load for the TM221C40T / TM221CE40T:



\* Type T fuse

- (1) The V0+ and V1+ terminals are **not** connected internally.
- (2) The V0- and V1- terminals are **not** connected internally.

The following figure presents the connection of the fast outputs:



**Qx** Q0, Q1

## Modicon TM3 Modules - Hardware

### Front View

Modicon TM3 Modules



### Description

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

Flexible and scalable I/O configuration:

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

Simplified maintenance installation:

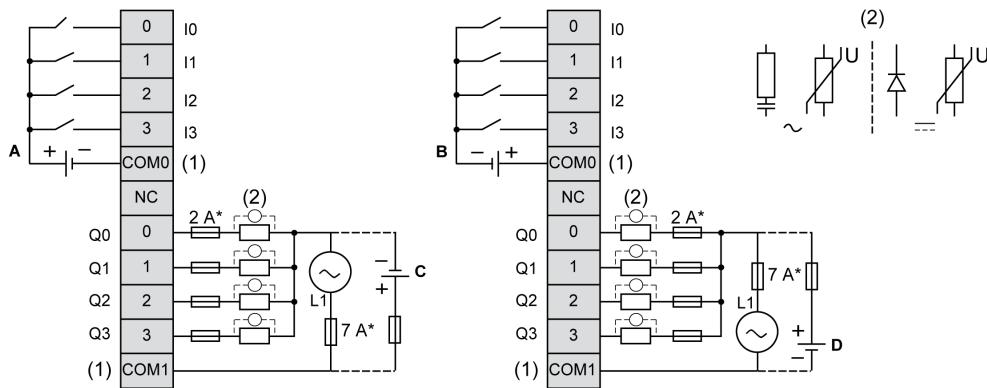
- Embedded diagnostics for local and distant supervision
- Wiring simplicity: spring terminals, removable terminal blocks

Standards and certifications	IEC/EN 61131-2 ed. 3 2007, UL 508, CSA 22.2 No. 142, CE
Power supply	24 Vdc or 120 Vac* * only TM3DI8A
Degree of protection	IP 20
Dimensions	One assembled integral module (W x H x D): 21.4...42.9 x 94.5...95 x 81.3...88.1 mm (0.84...1.69 x 3.72...3.74 x 3.2...3.47 in.)

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

## Wiring

Wiring example TM3DM8R



\* Type T fuse

- (1) The COM0 and COM1 terminals are **not** connected internally.
- (2) To improve the life time of the contacts, and to protect from potential inductive load damage, you must connect a free wheeling diode in parallel to each inductive DC load or an RC snubber in parallel of each inductive AC load.

- A Sink wiring (positive logic)
- B Source wiring (negative logic)
- C Source wiring (positive logic)
- D Sink wiring (negative logic)

## Section 4.5

### Communication

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#### ConneXium Ethernet Switch (Unmanaged) - Hardware

##### Front View

5-port TCSESU053FN0 Ethernet switch (unmanaged)



##### Description

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

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

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

All switches are mounted on a standard DIN rail.

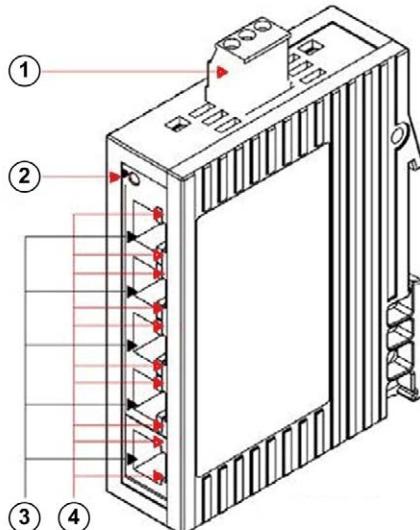
- Multi-address capability
- Storage and rerouting of received data
- Data packets with VLAN tags are transmitted unchanged (IEEE 802.1 Q)
- Automatic negotiation of 10/100 Mbit/s and duplex mode
- Automatic change of polarity
- Low-cost wiring solution

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

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

## Wiring

TCSESU053FN0 connector overview



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

## Section 4.6

### Motor Control

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#### What Is in This Section?

This section contains the following topics:

Topic	Page
TeSys D Contactor - Hardware	97
TeSys GV2 Motor Circuit Breakers - Hardware	99
Altivar 12 Variable Speed Drive - Hardware	101
Altivar 312 Variable Speed Drive - Hardware	105
Lexium 28 Servo Drive - Hardware	108

## 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.

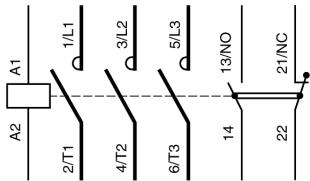
- AC, DC, and low-consumption DC control circuit
- All types of starter: reversing or non-reversing, star/delta, by auto-transformer, and so on.
- Various connectors: spring terminal, EverLink terminal block, screw clamp, ring-type connection, faston connector
- Easy and simple direct mounting between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

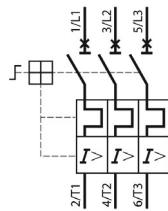
- Motor and personnel protection
- Live parts are protected from direct finger contact
- Compact size
- Easy to install: screw mounting or clip-on mounting
- Control by rotary knob
- Connection by screw clamps

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>● Padlockable 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



## 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

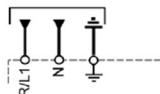


- 1 Power terminals
- 2 Control terminals
- 3 RJ45 communication port

## Wiring examples: power supply and motor

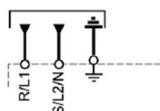
ATV12••••F1

Single-phase supply 100...120 V



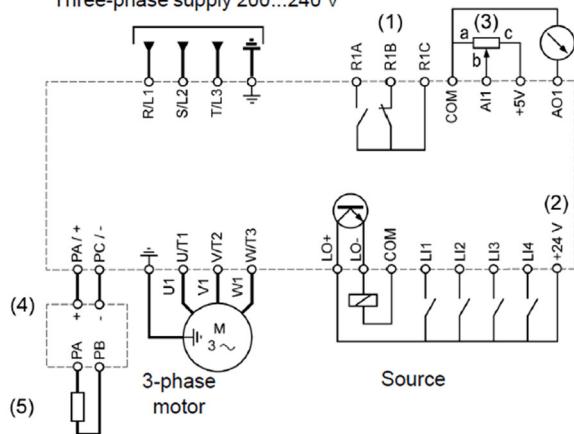
ATV12••••M2

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).

## Altivar 312 Variable Speed Drive - Hardware

### Front View

Altivar 312 variable speed drive



### Description

The Altivar 312 drive is a frequency inverter for 200...600 V three-phase asynchronous motors rated from 0.18 kW to 15 kW. The Altivar 312 drive is robust, compact, and easy to install.

With its various communication cards that are available as options, the Altivar 312 drive integrates in the main control system architectures.

Its integrated functions are suitable for the requirements of applications involving simple industrial machines (for example packaging machines, pumps, compressors, fans, and so on).

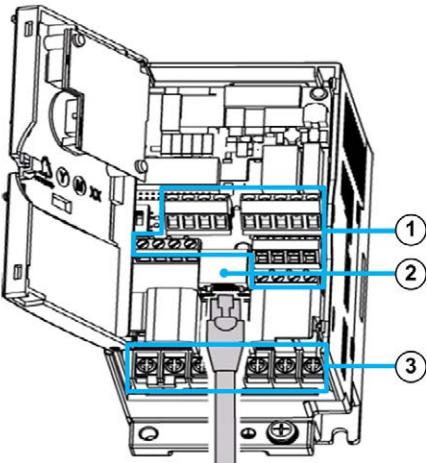
- Motor and drive protection
- Open: communication cards available as options
- Auto-tuning for optimum performance
- Multi-loader for storing configurations and loading them quickly
- Numerous application-specific functions
- Replaces the Altivar 31 range: Total compatibility, increased productivity

Standards and certifications	IEC 61800-5-1, IEC 61800-2, IEC 61800-3 (environments 1 and 2, category C2), ISO/EN13849-1/-2 (category 3, PL d), CE, UL, CSA, NOM, Gost, C-Tick, RoHS
Power range	0.18...15 kW
Voltage range	<ul style="list-style-type: none"> <li>● single-phase 200...240 V (0.18 to 2.2 kW)</li> <li>● three-phase 200...600 V (0.18 to 15 kW)</li> </ul>
Output frequency	0...500 Hz
Transient overtorque	170...200 % of the nominal motor torque
Communication	<ul style="list-style-type: none"> <li>● integrated: Modbus SL RS-485 2-wire and CANopen</li> <li>● optional: CANopen daisy chain, DeviceNet, PROFIBUS DP</li> </ul>
Functions	<ul style="list-style-type: none"> <li>● Application-specific functions</li> <li>● Saving the configuration in the drive</li> <li>● Error detection configuration and stop type configuration</li> <li>● PI regulator and references</li> <li>● 16 preset speeds</li> <li>● Local control of the speed references using the navigation buttons</li> <li>● Linear, S, U, or customized acceleration and deceleration ramps</li> </ul>
Protections	<ul style="list-style-type: none"> <li>● Thermal protection against overheating</li> <li>● Input phase loss protection</li> <li>● Short-circuit protection between motor phases</li> <li>● Protection against motor phase breaks</li> <li>● Overcurrent protection between motor output phases and ground</li> </ul>
I/Os	<ul style="list-style-type: none"> <li>● 3 analog inputs</li> <li>● 6 logic inputs</li> <li>● 2 analog outputs</li> <li>● 1 relay logic output - 1 NC and 1 NO contact</li> <li>● 1 relay logic output - 1 NC contact open on error detection</li> </ul>
Degree of protection	IP 31 and IP 41 on upper part and IP 21 on connection terminals
EMC filter	<ul style="list-style-type: none"> <li>● integrated: ATV312...M2 and ATV312H...N4</li> <li>● optional: ATV312H...M2, ATV312H...M3 and ATV312...N4</li> <li>● Without EMC: ATV312H...M3 and ATV312H...S6</li> </ul>
Dimensions	<p>3 types (W x H x D)</p> <ul style="list-style-type: none"> <li>● 72 x 145 x 122...142 mm (2.83 x 5.7 x 4.8...5.6 in.)</li> </ul>
Options	<ul style="list-style-type: none"> <li>● SoMove setup software</li> <li>● simple and multi-loader configuration tool</li> <li>● remote display terminals</li> <li>● communication cards</li> <li>● EMC plate</li> <li>● EMC filter</li> </ul>

For more information, refer to Altivar 312, Variable speed drives for asynchronous motors, Installation manual, BBV46391.

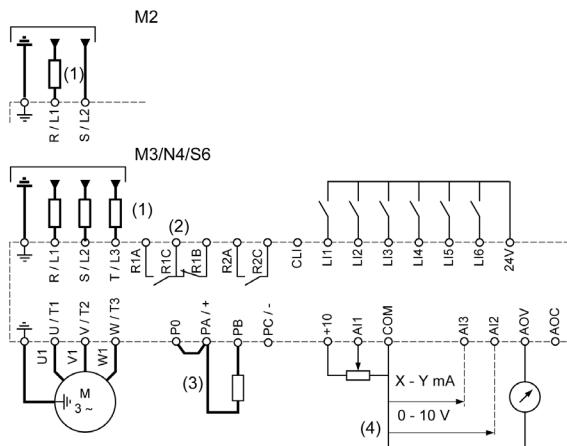
## Wiring

### Altivar 312 connector overview



- 1 Control terminals
- 2 RJ45 connector (Modbus/CANopen)
- 3 Power terminals

### Wiring example



- 1 Line choke, if used (single phase or 3 phase)
  - 2 Error detection relay contacts, for remote indication of the drive status
  - 3 Braking resistor (if needed)
  - 4 Reference potentiometer
- M2** ATV312.....M2, single-phase supply  
**M3/N4/S6** ATV312.....M3/N4/S6, 3-phase supply

## Lexium 28 Servo Drive - Hardware

### Front View

Lexium 28 servo drive



### Description

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

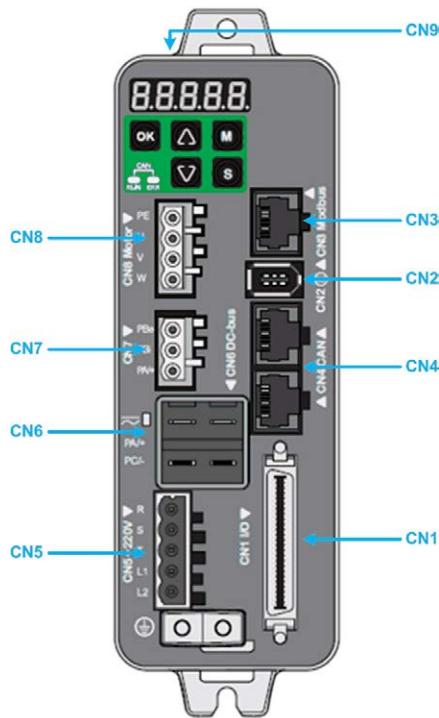
- Integrated CANopen / CANmotion communication
- Integrated safety function STO (Safe Torque Off)
- I/O interface with numerous digital and analog I/Os
- Numerous servo drive functions supported such as positioning, speed, and torque control
- Compact size
- Easy to configure and set up with SoMove configuration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

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

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

## Physical Description

Front view of the Lexium 28

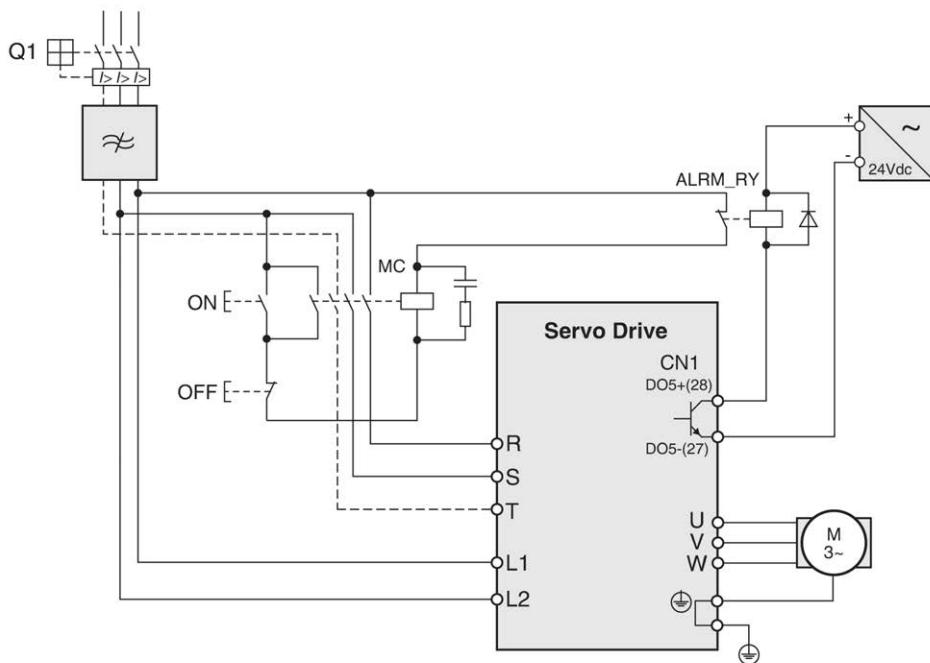


Connector	Description
CN1	I/O interface connector
CN2	Motor encoder connector
CN3	RJ45 connector – Modbus (commissioning interface)
CN4	RJ45 dual port connector (in/out) - CAN interface
CN5	<ul style="list-style-type: none"> <li>• R/S/T: Power stage supply</li> <li>• L1/L2: Controller power supply</li>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

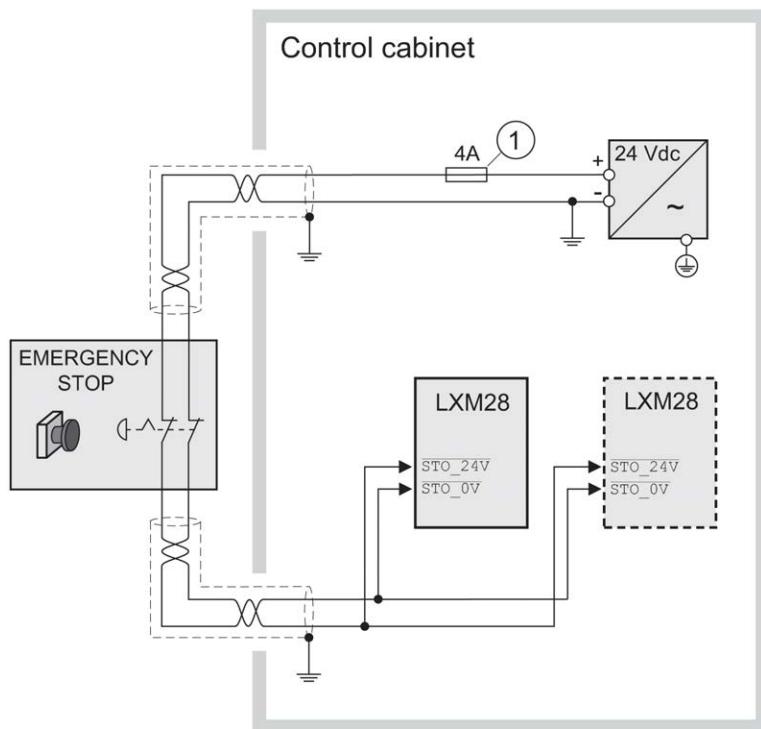
## Wiring

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

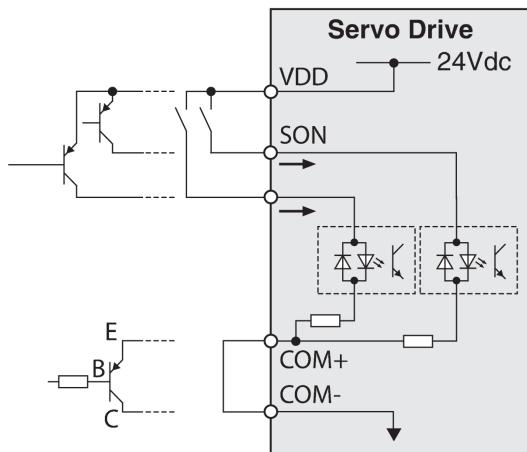
Wiring example power stage and controller power supply



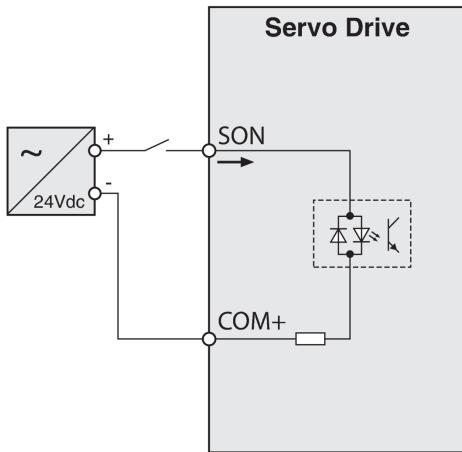
## Wiring example STO with category 0 stop (IEC 60204-1)



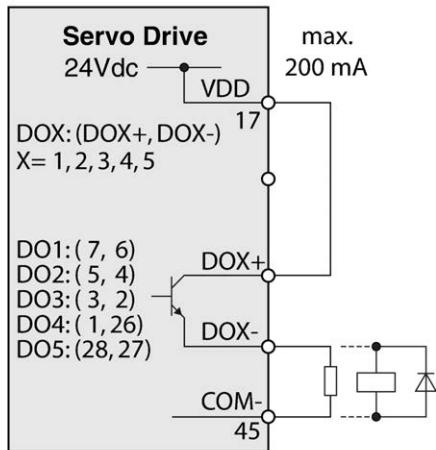
Wiring example digital input (logic type 1) with internal power supply



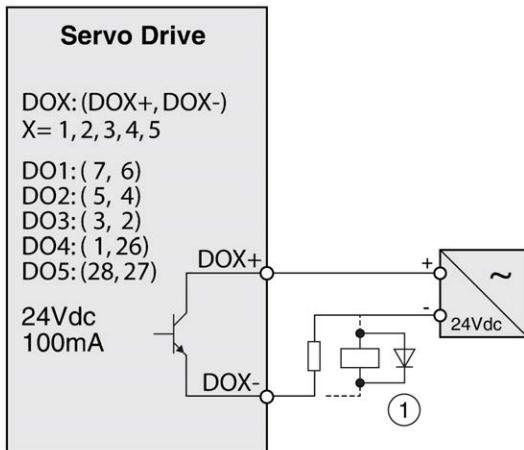
Wiring example digital input (logic type 1) with external power supply



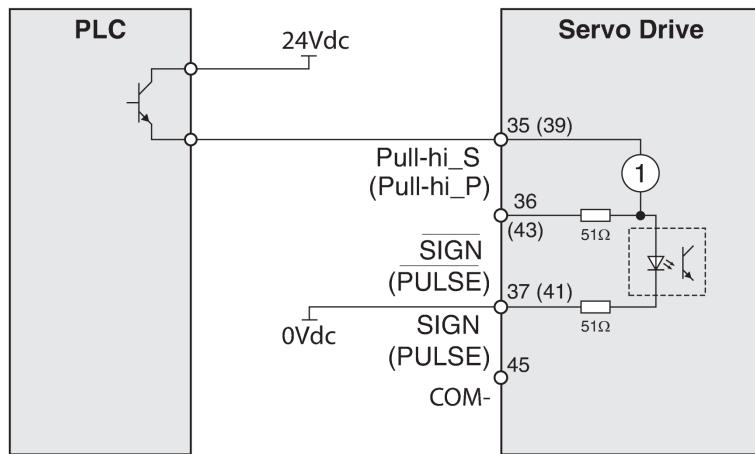
Wiring example digital output (logic type 1) with internal power supply



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



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



## Section 4.7

### Detection

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#### 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	118
5.2	Ethernet Network	119
5.3	Modbus Serial Line Network	126

## Section 5.1

### Introduction to System Communication

---

#### Introduction

##### Overview

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

- Ethernet

The Ethernet network is used for the communication between the Modicon M221 Logic Controller and the Magelis panel HMI STU. 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 (slave) and the Modicon Remote Graphic Display TMH2GDB (master).

## Section 5.2

### Ethernet Network

---

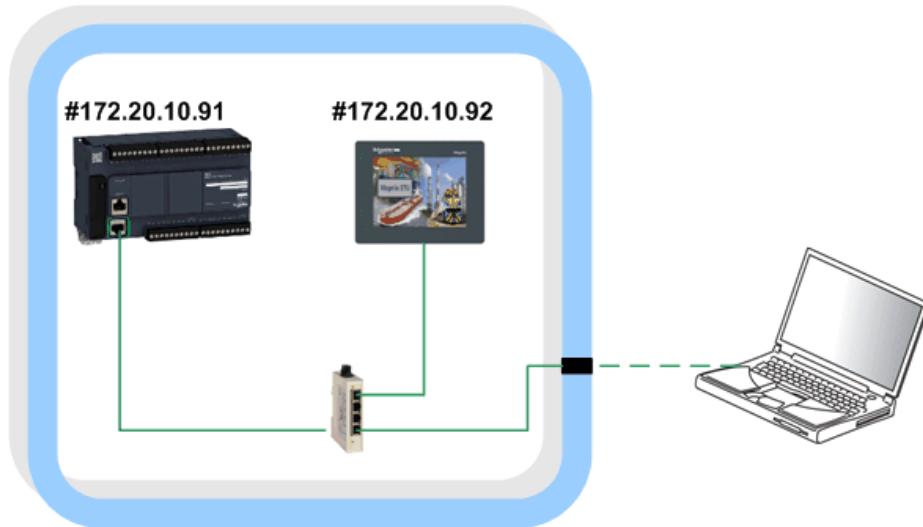
#### What Is in This Section?

This section contains the following topics:

Topic	Page
Ethernet Network Topology	120
Ethernet Wiring	121
Modicon M221C Logic Controller - Ethernet Wiring	123
Magelis HMI STU 655/855 - Ethernet Wiring	125

## Ethernet Network Topology

### Ethernet Topology



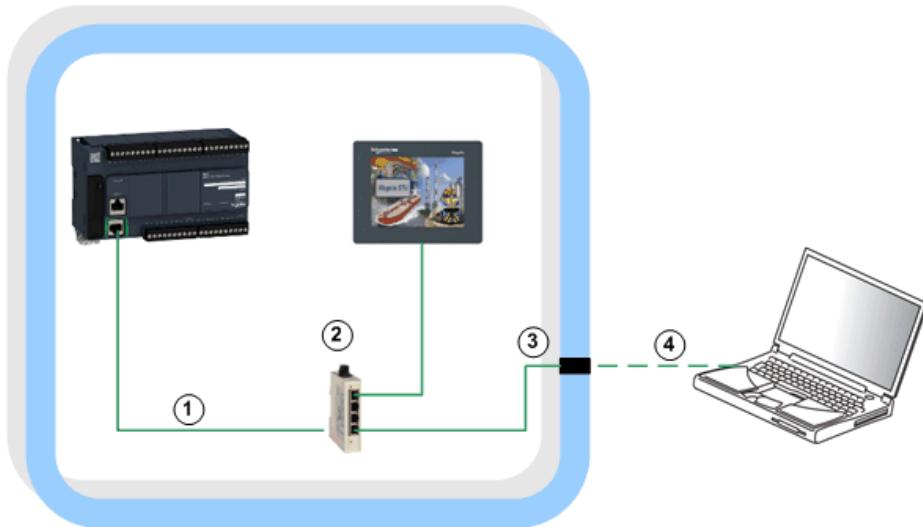
#... IP address

The subnet mask is: 255.255.0.0.

Optionally a PC can be linked to the Ethernet network.

## Ethernet Wiring

### Overview Ethernet



For more information, refer to [Transparent Ready, User Guide, 31006929](#).

### Wiring Accessories

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

### Switch

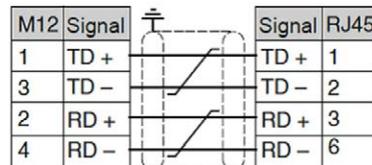
N°	Reference	Designation	Description
2	TCSESU053FN0	Ethernet TCP/IP unmanaged switch	10BASE-T/100BASE-TX - 5x RJ45 ports copper cable

**ConneXium Ethernet Adapter**

TCSECL1M3M3S2

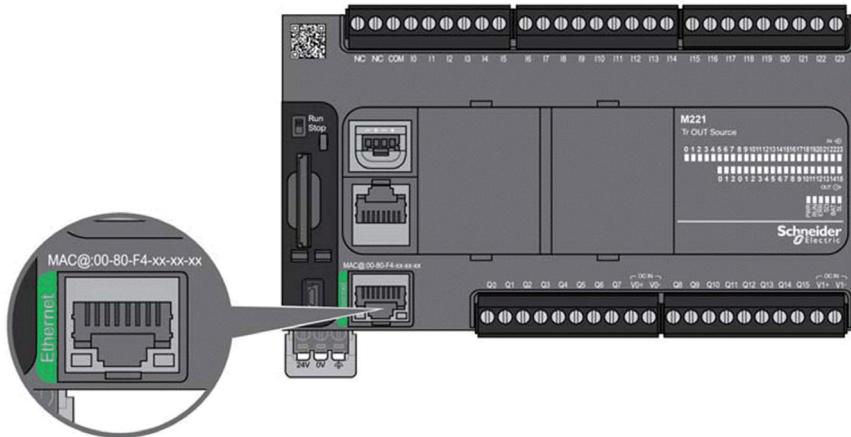


M12 connector (D-Coded)	M12 pin	Signal	Description	RJ45 pin	RJ45 connector
	1	TD+	Transmit data +	1	
	2	RD+	Received data +	3	
	3	TD-	transmit data -	2	
	4	RD-	Received data -	6	
	-	-	No connection	4	
	-	-	No connection	5	
	-	-	No connection	7	
	-	-	No connection	8	

**ConneXium Ethernet Cable**

## Modicon M221C Logic Controller - Ethernet Wiring

### Ethernet Port

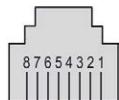


Characteristic	Description
Standard	Ethernet
Connector type	RJ45
Baud rate	Supports Ethernet 10BaseT and 100BaseTX with auto negotiation.
Cable type	Shielded
Automatic cross-over	MDI / MDIX
Services supported	<ul style="list-style-type: none"> <li>● Modbus TCP client / server</li> <li>● Modbus TCP slave</li> </ul>
IP address	<ul style="list-style-type: none"> <li>● DHCP</li> <li>● BOOTP</li> <li>● Fixed IP</li> </ul>
Power over Ethernet (PoE)	No

For more information, refer to Modicon M221 Logic Controller, Hardware Guide, EIO00000001384.

## Pin Assignment

RJ45 Ethernet connector



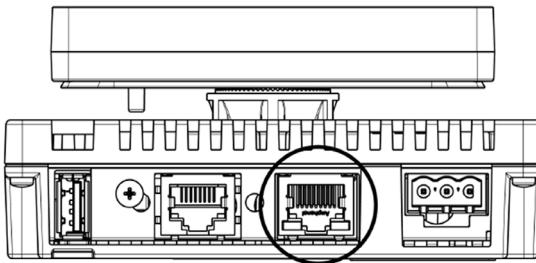
Pin	Signal
1	TD+
2	TD-
3	RD+
4	N.C.
5	N.C.
6	RD-
7	N.C.
8	N.C.

## Magelis HMI STU 655/855 - Ethernet Wiring

### Ethernet Port

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

The graphic shows the Ethernet port of Magelis HMI STU:



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

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

For more information, refer to [Magelis HMI STU 655/855, User Manual, EIO0000000614](#).

## Section 5.3

### Modbus Serial Line Network

---

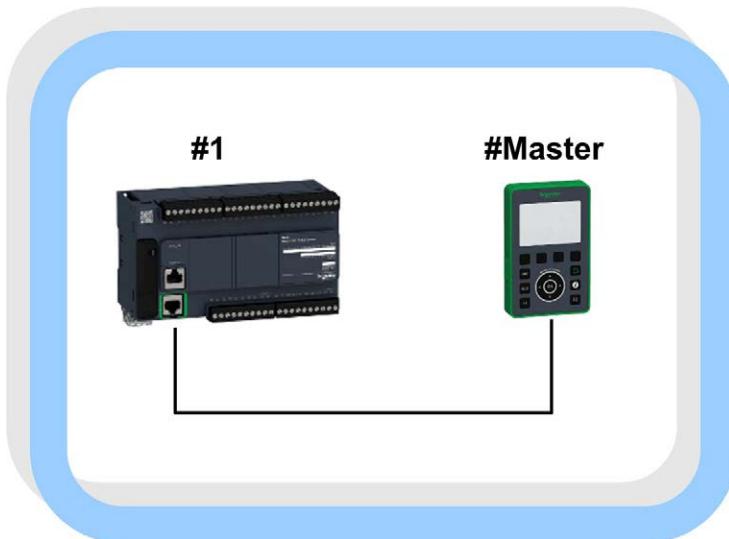
#### What Is in This Section?

This section contains the following topics:

Topic	Page
Modbus SL Network Topology	127
Modicon M221C Logic Controller - Modbus SL Wiring	129
Remote Graphic Display TMH2GDB - Modbus SL Wiring	131

## Modbus SL Network Topology

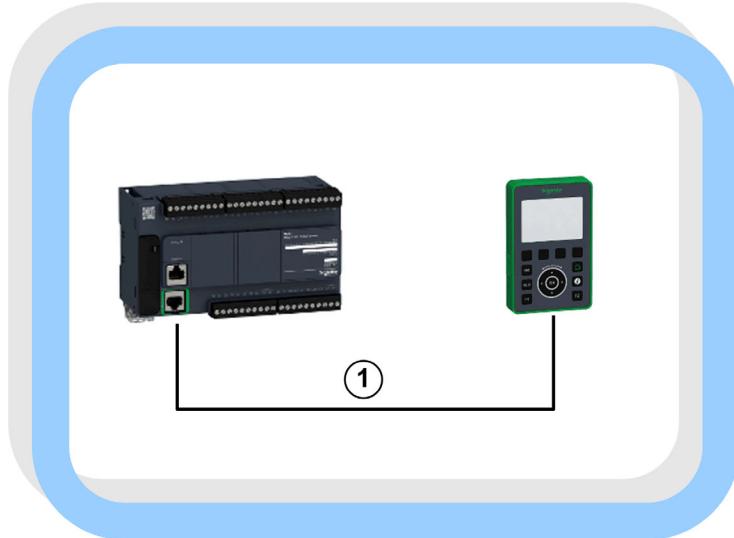
### Modbus SL Topology



#... Slave address

## Modbus SL Wiring

### Modbus SL Overview

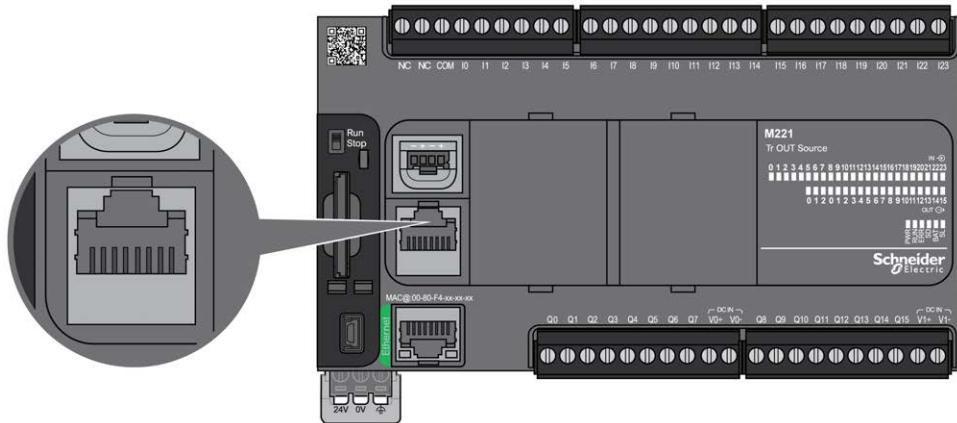


## Cable

N°	Reference	Designation	Description	Cable length
1	XBTZ9980	RS-485 Modbus serial link cable, supporting the 5 Vdc power supply for the Remote Graphic Display	Two RJ45 connectors	2.5 m (8.2 ft)
	XBTZ9982			10 m (32.8 ft)

## Modicon M221C Logic Controller - Modbus SL Wiring

### Modbus SL Port



The serial line:

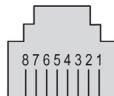
- is used to communicate with devices supporting the Modbus protocol as either master or slave, ASCII protocol (printer, modem...), and EcoStruxure Machine Expert - Basic protocol (HMI,...), and
- provides a 5 Vdc power distribution.

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

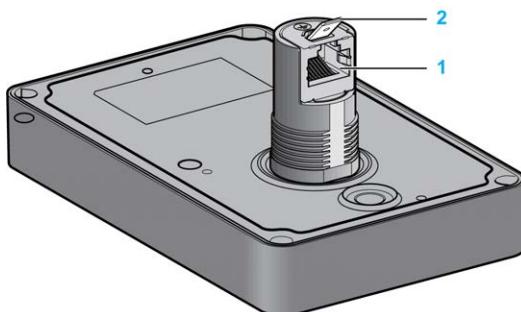


Pin	Signal RS-485	Signal RS-232	Description
1	-	RxD	RS-232: Receive data line
2	-	TxD	RS-232: Transmit data line
3	-	RTS	RS-232: Request to send
4	D1	-	Modbus SL: D1 (+/B) RS-485 2-wire
5	D0	-	Modbus SL: D0 (-/A) RS-485 2-wire
6	-	CTS	Clear to send
7	5 Vdc	-	5 Vdc supplier
8	Common	Common	Modbus SL signal ground

## Remote Graphic Display TMH2GDB - Modbus SL Wiring

### Modbus SL Port

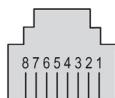
The serial line connection is used for the communication between the Modicon M221 Logic Controller and the Remote Graphic Display. The Remote Graphic Display must be connected only to the **Serial** or **Serial 1** port of the controller. The serial port of the logic controller provides the 5 Vdc power supply of the Remote Graphic Display. The connection between the Remote Graphic Display and the controller is an RS-485 link.



- 1 RJ45 serial line connector
- 2 Connector for functional ground (earth)

### Pin Assignment

The illustration represents the pin assignment of the RJ45 connector for the RS-485 protocol:



Pin	Signal	Description
1	N.C.	No connection
2	N.C.	No connection
3	N.C.	No connection
4	D1	Modbus SL: D1 (+/B) RS-485 2-wire
5	D0	Modbus SL: D0 (-/A) RS-485 2-wire
6	N.C.	No connection
7	5 Vdc	Power delivered by the logic controller
8	0 Vdc	-

 **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.**

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# Chapter 6

## Implementation

---

### What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
6.1	Software Requirements	134
6.2	Access the EcoStruxure Machine Expert – Basic Project Template	135
6.3	Project	136

## 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 Logic 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 SP2 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	137
HMI	139
Devices	143
Application	146
Vijeo-Designer	151

## Controller

### Overview

The controller in this architecture is the TM221CE40T, which is assigned to the category of optimized logic controllers of Schneider Electric.

The mandatory settings for the controller are described below.

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

### Ethernet

The Ethernet network in this architecture is used for the communication between the HMI and the M221 Logic Controller. The data exchange is performed via Modbus TCP with the HMI as master and the M221 Logic Controller as 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: 172.20.10.91
  - 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 the other parameters, the default settings have been used for the present template.

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 and the Remote Graphic Display.

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

- Physical settings:
  - Device: TMH2GDB
- Protocol settings
  - Address [1...247]: 1
  - 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.

## Pulse Generator

The M221 Logic Controller includes two pulse generators. One of these is used for the control of the Lexium 28 servo drive via pulse/direction signals.

Configure the pulse generator in the configuration window of the EcoStruxure Machine Expert - Basic application. When selecting the node **Pulse Generators** in the **Hardware tree**, the associated configuration editor opens.

The configuration for the **Pulse Generator 0** in this architecture is as follows:

- General
  - Type of pulse generator: PTO
  - Output Mode: A=pulse / B=direction
- Software Position Limits
  - Deactivate the check box labeled **Enable the software position limits**

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

For more information about the PTO (Pulse Train Output) settings, refer to the document Modicon M221 Logic Controller, Advanced Functions Library Guide, EIO0000002007 (ENG).

## HMI

### Overview

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

The mandatory settings for the HMI device are described below.

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

### Ethernet

The Ethernet network in this architecture is used for the communication between the HMI and the M221 Logic Controller. The data exchange is performed via Modbus TCP with the HMI as master and the M221 Logic Controller as 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> 172.20.10.92</li> <li>● <b>Subnet Mask:</b> 255.255.0.0</li> </ul> <p>For the other parameters, the default settings have been used for the present template.</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 Logic 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.	<p>The <b>Modbus Equipment</b> represents the M221 Logic Controller as Modbus TCP slave and the settings are:</p> <ul style="list-style-type: none"> <li>● <b>IP address:</b> 172.20.10.91</li> <li>● Activate the check box labeled <b>IEC61131 Syntax</b></li> <li>● <b>Double Word word order:</b> Low word first</li> </ul> <p>For the other parameters, the default settings have been used for the present template.</p>
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 Logic 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 Logic 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 <b>xStartMotor01</b> .
4	Select the <b>Data Type</b> from the menu.	In this example, the data type is <b>BOOL</b> .
5	Select the <b>Data Source</b> .	In this example, the variable is exchanged with the M221 Logic 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 <b>%M1</b> on the M221 Logic Controller. The settings in the open <b>Modbus TCP/IP</b> dialog box are: <ul style="list-style-type: none"><li>● <b>Address:</b> <b>%Mi</b></li><li>● <b>Offset(l):</b> <b>1</b></li></ul>
8	Click the <b>OK</b> button in the <b>Modbus TCP/IP</b> dialog box.	The address field is filled with <b>%M1</b> .
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 <b>%M1</b> of the M221 Logic 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 Logic 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, the devices configured within the EcoStruxure Machine Expert - Basic project are described.

#### Remote Graphic Display TMH2GDB

The use of the Remote Graphic Display TMH2GDB is configured under the serial line settings of the controller. After the Remote Graphic Display has been configured, the workspace for the **Display** tab becomes editable.

The **Display** tab enables you to:

- configure the general properties of the Remote Graphic Display.
- assign actions to function keys F1 and F2.
- configure the alarm view.
- create customized pages for the operator interface.

For more information about the configuration of the Remote Graphic Display, refer to the Modicon TMH2GDB Remote Graphic Display, User Guide, EIO0000002063 (ENG).

#### TM3 Safety Modules

The TM3 safety modules are configured 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 the diagnostic and the administrative control functions are provided via the TM3 bus. The diagnostic and control signals are provided as I/Os in the controller configuration and can be processed in the application program which is running on the controller.

In the right area of the configuration window of EcoStruxure Machine Expert - Basic, a hardware catalog with the supported controllers and expansion modules is provided. To add a module to the hardware configuration, drag and drop it onto the configuration in the configuration window.

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

## 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 the right area of the configuration window of EcoStruxure Machine Expert - Basic, a hardware catalog with the supported controllers and expansion modules is provided. To add a module to the hardware configuration, drag and drop it onto the configuration in the configuration window.

When selecting the desired component in the **Hardware tree** of the configuration window, a specific configuration editor is displayed.

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

Module name	Module type	Comment	Configuration
Module_2	TM3DQ16T	16-channel, 0.5 A source transistor outputs expansion module with 1 common line and removable terminal block	Default
Module_3	TM3AQ4	Expansion module with 4 analog outputs ( $\pm 10$ V, 0...10 V, 0...20 mA, 4...20 mA), 12 bits, removable terminal blocks	For each channel <b>Type:</b> 0–10 V <b>Min/Max:</b> 0/1000 <b>Fallback:</b> 0

## Energy Meter EM3110

The architecture implements 1 energy meter of type EM3110 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 Logic 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**.

## Altivar 12/312

The architecture implements two motor control functions. Each controls a motor which is driven by a variable speed drive of type Altivar 12 respectively Altivar 312. Each Altivar is controlled and monitored via hardwired signals which are linked to inputs and outputs of the controller. The speed reference signals are provided by two analog signals (0...10 V) from the controller.

The program code for these motor control functions is created in the POUs **Altivar12** and **Altivar312**. Both POUs are called in the **Master Task**.

Both motor control functions 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.

## Lexium 28

The architecture implements one servo motor control function. The servo motor is driven by a servo drive of type Lexium 28. The Lexium servo drive is controlled and monitored via hardwired signals which are linked to inputs and outputs of the controller. The speed and positioning control is performed using the system function Pulse Train Output (PTO) of the M221 Logic Controller. For the configuration of the PTO function, refer to *Pulse Generators* ([see page 138](#)).

The program code of the servo motor control function is created in the POU `Lexium28` and is called in the **Master Task**.

The servo motor control function interfaces via configured memory objects in the application and can be clearly identified by its symbol name. These memory objects are assigned to inputs and outputs and/or are processed from the HMI via Modbus TCP.

## Application

### Task Configuration

The M221 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, the POUs 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

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 POUs 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 or can be triggered by a command from the HMI. The program code initializes the application with the default values.

## Timers

The M221 Logic 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 available timers.

In this application, three 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 to delay (2 s) the EStop okay signal.
%TM1	T_FEEDBACK_ATV12		Timer for feedback monitoring (2 s) of the Altivar 12.
%TM2	T_FEEDBACK_ATV312		Timer for feedback monitoring (2 s) of the Altivar 312.

## Pulse Train Output (PTO) Objects

The M221 Logic Controller provides a number of function blocks to realize the PTO function. The PTO function is used to control the positioning or speed of one or two independent linear single-axis stepper or servo drives in open loop control mode. Each instance of such a function block (PTO object) needs to be configured in the application. In the **Programming** workspace in the **Tools** tab of the programming tree, select the node of the desired function block under **PTO Objects**. The properties window is displayed that allows you to view and to configure the available instances of the selected PTO object.

The table lists the PTO objects used in this application

Address	Configuration	Description
%MC_POWER_PTO0	<b>Axis:</b> %PTO0 Further parameters such as <b>Acceleration</b> , <b>Deceleration</b> , <b>Velocity</b> are not pre-configured because their values are variable and they are changed during runtime from the application program.	Enables power to the axis, switching the axis state from <b>Disabled</b> to <b>Standstill</b> . While the %MC_Power_PTO0.Status bit is FALSE, no motion function block can be executed for that axis
%MC_MOVVEL_PTO0		Causes the specified axis to move at the specified speed, and transfers the axis to the state <b>Continuous</b> .
%MC_MOVREL_PTO0		Moves the specified axis an incremental distance at the specified speed, and transfers the axis to the state <b>Discrete</b> .
%MC_MOVABS_PTO0		Causes the specified axis to move towards a given position at the specified speed, and transfers the axis to the state <b>Discrete</b> .
%MC_HOME_PTO0		Commands the axis to perform the sequence defining the absolute reference position, and transfers the axis to the state <b>Homing</b> .
%MC_STOP_PTO0		Commands a controlled motion stop and transfers the axis to the state <b>Stopping</b> .
%MC_HALT_PTO0		Commands a controlled motion stop until the velocity is zero, and transfers the axis to the state <b>Discrete</b> .
%MC_READACTVEL_PTO0		Returns the value of the velocity of the axis.
%MC_READACTPOS_PTO0		Returns the value of the position of the axis.
%MC_READSTS_PTO0		Returns the state of the axis.
%MC_READAXISERROR_PTO0		Returns a detected axis control error, if any.
%MC_RESET_PTO0		Resets the detected axis-related errors, conditions permitting to allow a transition from the states <b>ErrorStop</b> to <b>Standstill</b> .

For more information about the PTO function blocks, refer to the document Modicon M221 Logic Controller, Advanced Functions Library Guide, EIO0000002007 (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 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:

- **Altivar 12**
- **Altivar 312**
- **Lexium 28**
- **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 flash function of indicators.
- **System**
  - Processing of summary information about the devices.
  - Date and time handling of the RTC of the controller.
- **HMI I/O State**
  - Processing of information about the I/O states for display on the HMI.

## Modicon Remote Graphic Display Configuration

In addition to the Magelis HMI, this architecture implements the Modicon Remote Graphic Display TMH2GDB. The Remote Graphic Display is a local control unit. It is provided to the Modicon M221 Logic Controller for monitoring, commissioning, operating, and maintenance operations.

The Remote Graphic Display application is divided into two main menus, the **Setup Menu** and the **Operator Interface**.

The **Setup Menu** provides pages with access to the controller information and settings. Furthermore, the **Setup Menu** provides an **Alarm Menu** with a list of the triggered alarms (**View**) and an alarm history (**History**). The alarm messages displayed in the alarm **View**, respectively the alarm **History**, needs to be configured in the application.

The **Operator Interface** provides customized pages which are created individually for the associated application. The pages created in this application are described in the following.

- **Operator Interface Home Page**

This page is based on the **Menu template** and lists the pages created under the operator interface. From here, you can navigate to the customized pages under the **Operator Interface**.

- **Energy Page**

This page is based on the **Monitor template** and provides information about the energy consumption of the architecture.

- **Device Pages for Altivar 12, Altivar 312, and Lexium 28**

For each drive, two pages have been created. One page is based on the **Monitor template** and provides information about the respective drive. The second page is based on the **Control table template** and provides the possibility to start and stop the respective drive for maintenance operations during manual mode.

## Vijeo-Designer

### Overview

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

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

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

### Start Page

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

- State of the safety function
- Device state
- General operator mode

### 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 RTC (Real Time Clock) of the controller. In addition, it allows you to set the RTC of the controller and the HMI.

### Device Pages

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

- Altivar 12
- Altivar 312
- Lexium 28
- I/Os: Display the status of the I/Os.



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# Chapter 7

## System Setup

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### Overview

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

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

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

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

### **WARNING**

#### **LOSS OF CONTROL**

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

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

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

## What Is in This Chapter?

This chapter contains the following sections:

Section	Topic	Page
7.1	Setup Controller and HMI	155
7.2	Setup Other Devices	158

## Section 7.1

### Setup Controller and HMI

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#### 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).
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> (see <i>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:

- TCSXCNAMUM3P
- 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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Altivar 12 - Hardwired Setup	160
Altivar 312 - Hardwired Setup	163
Lexium 28 - Pulse Train Control Mode Setup	166
iEM3110 Energy Meter - Setup	170

## 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
- Altivar 312
- Lexium 28
- 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.**

## Altivar 12 - Hardwired Setup

### Overview

To operate the Altivar 12 via hardwired signals as it is defined in this example, the I/O configuration has to be set for the drive. In addition to this, it is mandatory to set the parameter of the connected motor in the drive. Further configuration settings are dependent on your application and on the installation.

There are several options to configure the drive:

- By the local HMI on the front of the drive
- By a remote display terminal\*
- By the software SoMove installed on a PC\*
- By the FDT/DTM integrated in EcoStruxure Machine Expert 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.

### I/O Assignment

The signals to control the Altivar 12 are defined in the table below.

Signal	Control terminal Altivar 12	Description
Run forward	LI1	Command to start the drive in forward direction.
Run reverse	LI2	Command to start the drive in reverse direction.
Fault reset	LI3	Command to reset the drive in case of error state.
Drive no fault	R1A (relay output)	R1 is active if no error state has been detected for the drive.
Drive run	LO-	Indicates that the drive is in run state.
Speed reference	AI1	Speed reference signal, 0...10 V

## Configuration

The following steps to set up the drive are based on the configuration by the local HMI on the front of the drive. All submenus and parameters listed in the table are accessible via [CONFIGURATION] (COnF), [FULL] (FULL) menu.

Step	Action	Comment
1	Switch on the power supply.	Do not give a run command to the drive.
2	Configure the I/O parameters under the menu (FULL) -> (I_O-): <ul style="list-style-type: none"> <li>● <b>[Type of control]</b> (tCC)</li> <li>● <b>[2 wire type control]</b> (tCt)</li> <li>● <b>[Logic inputs type]</b> (nPL)</li> <li>● <b>[R1 assignment]</b> (r1)</li> </ul>	In this example, the drive is controlled in two wire control with transient detection. The inputs are of type positive logic. The output R1 indicates that the drive has no error detected. <ul style="list-style-type: none"> <li>● tCC = 2C (2 wire)</li> <li>● tCt = trn (transient detection)</li> <li>● nPL = POS (positive logic)</li> <li>● r1 = FLt (inactive when error state detected)</li> </ul>
3	Configure the logical output LO1 under the menu (FULL) -> (I_O-) -> (LO1-): <ul style="list-style-type: none"> <li>● <b>[LO1 assignment]</b> (LO1)</li> <li>● <b>[LO1 output active level]</b> (LO1S)</li> </ul>	In this example, the logic output indicates that the drive is running. <ul style="list-style-type: none"> <li>● LO1 = rUn (active in RUN state)</li> <li>● LO1S = POS (active high)</li> </ul>
4	Configure the motor parameters under the menu (FULL) -> (drc-): <ul style="list-style-type: none"> <li>● <b>[Standard mot. freq.]</b> (bfr)</li> <li>● <b>[Rated mot. power]</b> (nPr)</li> <li>● <b>[Rated mot. volt.]</b> (UnS)</li> <li>● <b>[Rated mot. current]</b> (nCr)</li> <li>● <b>[Rated mot. freq.]</b> (FrS)</li> <li>● <b>[Rated motor speed]</b> (nSP)</li> </ul>	Refer to the motor rating plate. Values have to be adjusted if the factory settings differ from your application.
5	Configure the parameter <b>[Reference Channel 1]</b> under the menu (FULL) -> (Ctl-) -> (Fr1).	In this example, the analog input AI1 is set for the parameter. Fr1 = AI1
6	Configure the ramp parameters (FULL) -> (Fun-) -> (rPt-): <ul style="list-style-type: none"> <li>● <b>[Acceleration]</b> (ACC)</li> <li>● <b>[Deceleration]</b> (dEC)</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 parameter <b>[Reverse direction]</b> under the menu (FULL) -> (Fun-) -> (rrs)	The reverse direction is disabled per default and is activated by the assignment of a logic input. rrs = L2H (L12 - start reverse)
8	Configure the <b>[Fault reset assignment]</b> under the menu (FULL) -> (Flt-) -> (rSF).	In this example, the logic input LI3 is used for the reset of a drive error. rSF = L3H (LI3 - reset fault)
9	Configure the parameter <b>[Motor thermal current]</b> 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.

Step	Action	Comment
10	Power cycle the drive.	If the configuration is finished, do a power cycle of the drive. Some parameters only become effective after a power cycle.

 **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.**

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

## Altivar 312 - Hardwired Setup

### Overview

To operate the Altivar 312 via hardwired signals as it is defined in this example, the I/O configuration has to be set for the drive. In addition to this, it is mandatory to set the parameter of the connected motor in the drive. Further configuration settings are dependent on your application and on the installation.

There are several options to configure the drive:

- By the local HMI on the front of the drive
- By a graphic display terminal\*
- By a remote display terminal\*
- By the configuration software SoMove installed on a PC\*
- By the FDT/DTM integrated in EcoStruxure Machine Expert 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.

### I/O Assignment

The signals to control the Altivar 312 are defined in the table below.

Signal	Control terminal Altivar 312	Description
Run forward	LI1	Command to start the drive in forward direction.
Run reverse	LI2	Command to start the drive in reverse direction.
Fault reset	LI3	Command to reset the drive in case of error state.
Drive no fault	R1A (relay output)	R1 is active if no error state has been detected for the drive.
Brake control	R2A (relay output)	R2 is activated by the brake control logic of the ATV 312 and is used to control the external brake contactor.
Speed reference	AI1	Speed reference signal, 0...10 V

## Configuration

The following steps to set up the drive are based on the configuration by the local HMI on the front of the drive. All submenus and parameters listed in the table are accessible via [CONFIGURATION] (COnF), [FULL] (FULL) menu.

Step	Action	Comment
1	Switch on the power supply.	Do not give a run command to the drive.
2	Configure the parameters under the menu <b>[Settings]</b> (Set-): <ul style="list-style-type: none"> <li>• <b>[Acceleration]</b> (ACC)</li> <li>• <b>[Deceleration]</b> (dEC)</li> <li>• <b>[Low Speed]</b> (LSP)</li> <li>• <b>[High Speed]</b> (HSP)</li> <li>• <b>[Mot. Therm. current]</b> (ITH)</li> </ul>	In most cases, the factory settings can be maintained for a quick start. But nevertheless, you have to verify the values.
3	Configure the motor parameters under the menu <b>[Motor Control]</b> (drc-): <ul style="list-style-type: none"> <li>• <b>[Standard mot. freq.]</b> (bFr)</li> <li>• <b>[Rated motor volt.]</b> (UnS)</li> <li>• <b>[Rated motor freq.]</b> (FrS)</li> <li>• <b>[Rated motor current]</b> (nCr)</li> <li>• <b>[Rated motor speed]</b> (nSP)</li> <li>• <b>[Motor 1 Cosinus Phi]</b> (COS)</li> </ul>	Refer to the motor rating plate. Values have to be adjusted if the factory settings differ from your application.
4	Configure the I/O modules under the menu <b>[Inputs/Outputs CFG]</b> (I_O-): <ul style="list-style-type: none"> <li>• <b>[2/3 wire control]</b> (tCC)</li> <li>• <b>[2 wire type]</b> (tCt)</li> <li>• <b>[Reverse]</b> (rrS)</li> <li>• <b>[R1 Configuration]</b> (r1-) -&gt; (r1)</li> </ul>	In this example, the following values are set for the parameters: <ul style="list-style-type: none"> <li>• tCC = 2C (2 wire)</li> <li>• tCt = trn (transition)</li> <li>• rrS = LI2 (logical input LI2)</li> <li>• R1 = FLt (drive error detection status)</li> </ul>
5	Configure the access level under the menu <b>[Command]</b> (Ctl-): <ul style="list-style-type: none"> <li>• <b>[Access level]</b> (LAC)</li> </ul>	In this example, Level 2 is set for the parameter. LAC = L2 Access level 2 enables the access to advanced functions under the menu <b>[Application Funct.]</b> (Fun-), for example brake control.
6	Configure the reference channel under the menu <b>[Command]</b> (Ctl-): <ul style="list-style-type: none"> <li>• <b>[Ref. 1 channel]</b> (Fr1)</li> </ul>	In this example, the analog input AI1 is set for the parameter. Fr1 = AI1
7	Configure the parameter for the brake control under the menu <b>[Application Functions]</b> (Fun-): <ul style="list-style-type: none"> <li>• <b>[Brake logic control]</b> (bLC-) -&gt; (bLC)</li> </ul>	In this example, the relay output R2 is set for the parameter. bLC = r2 The relay output R2 controls the release of the electro-magnetic brake on the motor. Further parameter can be set depending on your application.

Step	Action	Comment
8	Configure the <b>[Fault reset assignment]</b> under the menu <b>[Fault management]</b> (FLt-): • <b>[Fault reset]</b> (rSF)	In this example, the logic input LI3 is used for the reset of a drive error. rSF = LI3 (logical input LI3)
9	Power cycle the drive.	If the configuration is finished, do a power cycle of the drive. Some parameters only become effective after a power cycle.

## **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.**

For more information, refer to Altivar 312, Variable speed drives for asynchronous motors, Programming manual, BBV46385.

## Lexium 28 - Pulse Train Control Mode Setup

### Overview

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

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

There are several options to configure the drive:

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

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

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

### **WARNING**

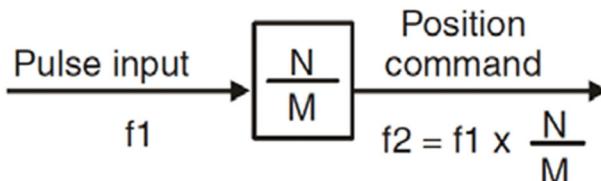
#### **UNINTENDED EQUIPMENT OPERATION**

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

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

## Electronic Gear Ratio

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



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

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

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

The resulting position command for the motor is described below.

- **Continuous motion:**

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

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

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

- **Discrete motion:**

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

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

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

### Abbreviations

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

## I/O Assignment

The table lists the signals to control the Lexium 28:

Signal	Control terminal Lexium 28	Description
Servo on	DI1	Command to enable the drive.
Alarm reset	DI5	Command to acknowledge an alarm on the drive.

Signal	Control terminal Lexium 28	Description
Negative inhibit limit switch	DI6	If FALSE drive is stopped immediately with alert AL014.
Positive inhibit limit switch	DI7	If FALSE drive is stopped immediately with alert AL015.
Operation stop	DI8	If FALSE drive is stopped immediately with alert AL013.
Servo on	DO1	Indicates if the servo drive is ready for operation (power stage enabled).
Zero speed detected	DO2	Indicates if the velocity is less than the zero speed velocity.
Positioning completed	DO4	Indicates if the positioning process is completed. The position deviation is within the set tolerance.
Alarm detected	DO5	Indicates the alarm detection status of the drive.
Pulse signal (24 Vdc)	PULL_HI_P	The number and frequency of the pulses determine the movement of the motor.
Direction signal (24 Vdc)	PULL_HI_S	Determines the direction for the motor (1 = positive).

## Configuration

To adjust the parameters, use the following path and values

Step	Action	Comment
1	Configure the control mode and the output direction with parameter [P1-01].	In this example, the parameter [P1-01] is set to 1100 hex. The meaning of the digits from right to the left is: 00: Pulse Train (PT) control mode via external pulses 1: Output direction (motor), positive = clockwise 1: Digital I/O settings ([P2-10] ... [P2-22]) are changed to their default values after a power cycle.
2	Power cycle the drive.	In order to restore the default values for the I/O settings if selected in step 1 (P1-01).
3	Configure the external pulse input type [P1-00].	In this example, the parameter [P1-00] is set to 0022 hex. The meaning of the digits from right to the left is: 2: input pulse type = pulse + direction 2: input pulse filter = 100 kHz 0: input polarity = positive logic 0: source of pulse command = low-speed pulse

Step	Action	Comment
4	Configure the electronic gear ratio [P1-44] (nominator) and [P1-45] (denominator).	In this example, the electronic gear ratio is set to 640. This means for the two parameters: [P1-44] = 640 [P1-45] = 1
5	Configure the digital input functions [P2-10] to [P2-17].	In this example, the configuration of the digital inputs is: [P2-10] (DI1) = 0101 hex: Servo on, normally open [P2-11] (DI2) = 0100 hex: Not used [P2-12] (DI3) = 0100 hex: Not used [P2-13] (DI4) = 0100 hex: Not used [P2-14] (DI5) = 0102 hex: Alarm reset, normally open [P2-15] (DI6) = 0022 hex: Negative inhibit limit switch, normally closed [P2-16] (DI7) = 0023 hex: Positive inhibit limit switch, normally closed [P2-17] (DI8) = 0021 hex: Operational stop, normally closed
6	Configure the digital output functions [P2-18] to [P2-22].	In this example, the configuration of the digital outputs is: [P2-18] (DO1) = 0102 hex: Servo drive is on, power stage enabled [P2-19] (DO2) = 0103 hex: Zero speed detected [P2-20] (DO3) = 0100 hex: Not used [P2-21] (DO4) = 0105 hex: Positioning completed [P2-22] (DO5) = 0007 hex: No alarm is detected
7	Power cycle the drive.	After the configuration has been finished, power cycle the drive because some parameters only become effective after a power cycle.

## WARNING

### UNINTENDED EQUIPMENT OPERATION

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.**

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

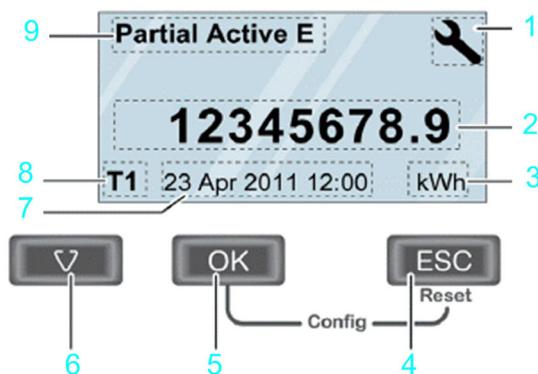
For more information, refer to LXM28A and BCH2, Servo drive system, Product manual, 0198441114054-EN.

## 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.



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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 your 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 information 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 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) 18 x 27 mm	ZBY6102

## Display and Indicators

Quantity	Description	Reference
1	Pilot light with integral LED 24 Vac/dc, white, complete unit	XB5AVB1
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
4	Legend holder and blank label (white or yellow) 18 x 27 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, 24x DI, 16x DOs, 2x AI, 1x SL, 1x Ethernet	TM221CE40T
1	TM3 expansion module 16 digital transistor outputs	TM3DQ16T
1	TM3 expansion module 4 analog outputs, ±10 V / 0...20 mA	TM3AQ4
1	Modicon Remote Graphic Display	TMH2GDB

## Magelis HMI

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

## Control Voltage Power Supply and Distribution

Quantity	Description	Reference	IEC	UL
1	Circuit breaker Multi9 UL1077 2P, C, 3 A (~230 V)	24444	x	x
1	Power supply 230 Vac / 24 Vdc, 10 A	ABL8RPS24100	x	x
3	Circuit breaker Multi9 UL1077 1P, C, 1 A (24 Vdc)	24425	x	x
8	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>Altivar 12</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
<b>Altivar 312</b>				
1	Altivar 312 variable speed drive, 0.37 kW	ATV312H037M2	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	-
2	TeSys DFCC fuse holders and class CC fuses 10 A (fuses to be ordered separately, no Schneider Electric product)	DFCC2	-	x
<b>Lexium 28</b>				
1	Lexium 28 servo drive, 1~230 Vac / 0.1 kW	LXM28AU01M3X	x	x
1	I/O terminal block module	VW3M1C13	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	Circuit breaker Multi9 UL489 2P, D, 6 A (~230 V)	60158	x	x
1	Circuit breaker Multi9 UL1077 2P, C, 2 A (~230 V)	24443	x	x
2	Auxiliary contact for Multi9 circuit breaker, 1 CO	26925	x	x
* In compliance with the standard IEC 60947-2, a magnetic motor circuit-breaker can be alternatively used instead of the Multi9 UL489 circuit breaker.				

Quantity	Description	Reference	IEC	UL
1	Servo motor 230 Vac three-phases	BCH2MB0131CA5C	x	x
1	Power cordset (motor cable), 5 m (16.4 ft)	VW3M5D1AR50	x	x
1	Encoder cordset (encoder cable), 5 m (16.4 ft)	VW3M8D1AR50	x	x
1	Adapter cable for STO connector CN9, 3 m (8.84 ft)	VW3M1C20R30	x	x

\* In compliance with the standard IEC 60947-2, a magnetic motor circuit-breaker can be alternatively used instead of the Multi9 UL489 circuit breaker.

## 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	490NTW00002
1	ConneXium M12 to RJ45 Ethernet adapter	TCSEAAF11F13F00

## Modbus SL Wiring

Quantity	Description	Reference
1	Modbus serial link cable	XBTZ9980

## 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)	TCSXCNAMEUM3P
1	Ethernet cable M12 - RJ45	TCSECL1M3M3S2
1	SD card, 2 GB	TMASD1

**NOTE:** The EcoStruxure Machine Expert add-ons can be downloaded from the Schneider Electric webpage or via the Schneider Electric Software Update (SESU) tool.



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# Glossary

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## C

**CANmotion**

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

**CANopen**

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

**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.

## I

*(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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