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Important User Information

This document is intended to provide a good understanding of the functionality offered by the CM CANopen Module for SIMATIC S7-1200.

The reader of this document is expected to be familiar with high level software design, and communication systems in general. The use of advanced CANopen-specific functionality may require in-depth knowledge in CANopen networking internals and/or information from the official CANopen specifications. In such cases, the people responsible for the implementation of this product should either obtain the CANopen specification to gain sufficient knowledge or limit their implementation in such a way that this is not necessary.

Liability

Every care has been taken in the preparation of this manual. Please inform HMS Industrial Networks AB of any inaccuracies or omissions. The data and illustrations found in this document are not binding. We, HMS Industrial Networks AB, reserve the right to modify our products in line with our policy of continuous product development. The information in this document is subject to change without notice and should not be considered as a commitment by HMS Industrial Networks AB. HMS Industrial Networks AB assumes no responsibility for any errors that may appear in this document.

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Warning:	This is a class A product. in a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.
ESD Note:	This product contains ESD (Electrostatic Discharge) sensitive parts that may be damaged if ESD control procedures are not followed. Static control precautions are required when handling the product. Failure to observe this may cause damage to the product.

Table of Contents

P. About This Document

P.1 How To Use This Document

This document contains a general introduction as well as a description of the technical features provided by the CM CANopen Module for SIMATIC S7-1200, including configuration of the device.

The reader of this document is expected to be familiar with PLC and software design, as well as with communication systems in general. The reader is also expected to be familiar with the Microsoft Windows operating system.

P.2 Related Documents

Document name	Author
CiA 301 rev. 4.2	CAN in Automation
CiA 302 Draft Standard Proposal 302 rev. 4.1	CAN in Automation
CiA 303-1 rev. 1.7	CAN in Automation
CiA 303-3 rev. 1.3	CAN in Automation
TIA Portal configuration tool user manual	

Please visit the support pages at the HMS Industrial Networks web site at www.hms-networks.com/can-for-S7-1200/ for more documents

P.3 Document History

Summary of Recent Changes (... 1.00)

Change	Page(s)

Revision List

Revision	Date	Author	Chapter	Description
1.00	2013-09-26	KeL	All	First revision

P.4 Conventions & Terminology

The following conventions are used throughout this document:

- Numbered lists provide sequential steps
- Bulleted lists provide information, not procedural steps
- The term 'user' refers to the person or persons responsible for installing the CM CANopen module in a network.
- Hexadecimal values are written in the format NNNNh, where NNNN is the hexadecimal value.
- Decimal values are represented as NNNN where NNNN is the decimal value
- A byte always consists of 8 bits

P.5 Glossary

Term	Meaning
Byte	8 bits
COP	CANopen
User	Person or persons responsible for installing the CM CANopen module
Higher Level Network	CANopen
Network	
Fieldbus	
RO	Read only. A register, parameter or object labeled RO can only be read, not written.
RW	Read/Write. A register, parameter or object labeled RW can both be read and written
EDS	Electronic Data Sheet. A file that describes the properties of a network device, in this case a CANopen device.

P.6 Support

For general contact information and where to find support, please refer to the contact and support pages at www.hms-networks.com.

1. Product Overview

1.1 Introduction

The CM CANopen Module for SIMATIC S7-1200 is a plug-in IP20 compliant communication module designed to be used as an accessory to a SIMATIC S7-1200 PLC. It provides the user with the possibility to connect a CANopen network to a SIMATIC S7-1200 PLC.

The figure below shows a CM CANopen module attached to a SIMATIC S7-1200 PLC to provide the connection from the PLC to CANopen. In this case the PLC is standalone, but it is possible to connect it to a PROFINET network.

CM CANopen module

CANopen

Slave devices on the CANopen network
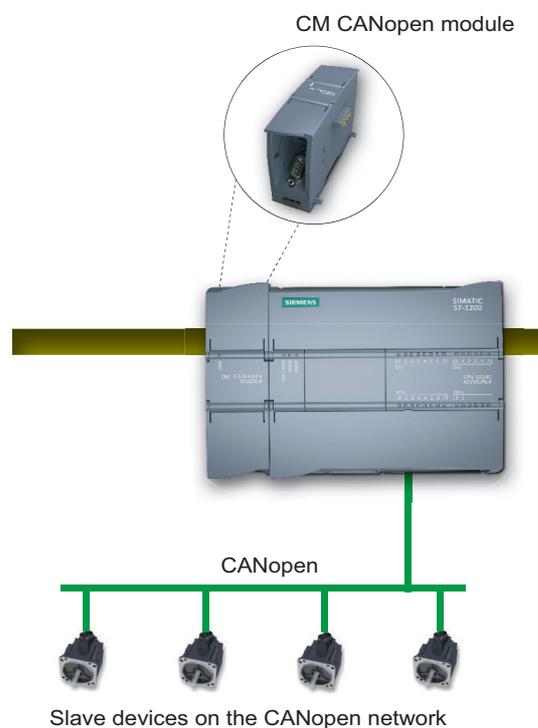
The CM CANopen Module for SIMATIC S7-1200 can be configured either as a CANopen manager or as a slave, depending on the application. The network and the module are configured using external configuration tools (TIA Portal and CM CANopen Configuration Studio). See "Configuration" on page 10.

1.2 Features

- Powerful CANopen module for SIMATIC S7-1200 PLC.
- 3 modules per CPU can be connected.
- Connects up to 16 CANopen slave nodes per module in manager mode.
- 256 byte input and 256 byte output per module.
- CANopen slave functionality supported.
- 3 LEDs provide diagnostic information on module, network and I/O status.
- The module can be integrated in the hardware catalogue of TIA Portal.
- CANopen configuration via CM CANopen Configuration Studio (external tool).
- Complies to the CANopen communication profile CiA 301 rev. 4.2 and the CiA 302 Draft Standard Proposal rev. 4.1.
- Transparent CAN supported.

2. CANopen Fieldbus Functionality

The functionality of the CM CANopen Module for SIMATIC S7-1200 is defined by the CANopen CiA 301 rev. 4.2 specification and the CANopen CiA 302 Draft Standard Proposal rev. 4.1. The module can be configured either as a manager or as a slave on the CANopen network.

2.1 Supported Fieldbus Services

Communication and parameters in the CANopen protocol are built around objects. There are different services available to communicate with the objects and to perform other CANopen tasks like supervising the network. The following message types and objects are implemented in the CM CANopen Module for SIMATIC S7-1200:

- NMT (Network Management)[1] messages trigger the NMT state transitions for the slaves and/ or perform network and device monitoring, as well as handle errors. If the module is configured as a slave, startup is performed by the manager.

- The CMT (Configuration Manager)[1] configures the CANopen devices. This primarily involves PDO parameters and mapping of information. If the module is configured as a slave, the configuration is performed by the manager.

- PDOs (Process Data Objects) are used for I/O communication. There are 64 Receive PDOs and 64 Transmit PDOs implemented in the CM CANopen Module for SIMATIC S7-1200 that each can transfer up to 8 bytes. Supported PDO message types are event driven (COS or timing), Cyclic Synchronous and Acyclic Synchronous

- SDOs (Service Data Objects) are asynchronous data transmission, and are used to access objects without mapping them to an I/O (PDO) connection. Access is provided to all CANopen objects in the module and in the network nodes (manager mode). SDO messages are used to configure the modules and they can transfer more than 8 bytes, which is the upper limit for a PDO. (Expedited Upload/Download Protocol and Normal (Segmented) Upload/Download Protocol are supported)

- A SYNC (Synchronization Object) is used for synchronizing PDO communication. A manager can be either a producer or a consumer of the synchronization. A slave can only be a consumer.

- The Heartbeat Mechanism helps a device to monitor the status of another node. The module can act either as heartbeat producer or consumer or both at the same time.

- The Node Guarding Protocol provides active surveillance of a slave by the manager. Slaves can be configured to expect a node guarding request from the manager.

- An EMCY (Emergency Object) is used for error reporting when a fault has occurred in the module and for reporting when all faults in a module have been cleared.

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1. Only available when the module is configured as manager.

3. Transparent CAN Mode

The CM CANopen Module for SIMATIC S7-1200 integrates Transparent CAN 2.0A (11 bit identifiers). With this protocol, the module allows transmission of any CAN frame from the PLC regardless of the overlaying CAN protocol, and is capable of receiving a number of predefined CAN frames from the CAN network. No other functionality is available.

CAN 2.0A is the underlying protocol of CANopen, directly working on the bus. During configuration in TIA Portal, Transparent CAN can be selected in the Options menu. When this configuration is downloaded to the module, the CANopen functionality is not possible to use. If CANopen functionality is to be reactivated, a new configuration from TIA Portal will have to be downloaded. It is not possible to change between CAN and CANopen at runtime.

Each CAN frame is tagged with an identifier. Only received frames with an identifier specified by the function block CAN_CTRL will be forwarded to the PLC. The data in the frame is then available for the user to interpret. When sending a frame, the user specifies the data and adds a valid identifier before sending it to the module.

To facilitate the use of Transparent CAN, separate PLC function blocks are available[1]. They are described in "Transparent CAN Function Blocks" on page 47. The blocks give the designer of the PLC program the possibility to integrate Transparent CAN functionality (sending, receiving, configuration) into the PLC program, thereby making it possible to implement customer specific CAN protocols.

Note: The receive buffer can hold up to 256 unread received messages

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1. The function blocks can be downloaded from www.hms-networks.com/can-for-S7-1200.

4. Installation

The mounting and configuration of the CM CANopen Module for SIMATIC S7-1200 is done following these steps:

1. Mounting

2. Configuring the SIMATIC S7-1200 PLC to use the module (See "SIMATIC S7-1200 PLC Configuration" on page 10)

3. Setting the parameters of the module (See "SIMATIC S7-1200 PLC Configuration" on page 10)

4. If in a CANopen operation mode, configuring the CANopen network, including the module (See "CANopen Network Configuration" on page 12)

The following items are needed to perform the installation:

- TIA Portal V11, SP2 or later
- HSP (configuration file) for the module[1]
- CM CANopen Configuration Studio
- Function blocks (optional)[1]

4.1 Mounting

The CM CANopen Module for SIMATIC S7-1200 is designed to be connected directly to a SIMATIC S7-1200 PLC.

CANopen connection is provided via a DSUB contact.

No.	Name	Description
2	L	CAN_L, low level in CANopen communication
3, 6	GND	Ground, provides connections to the CANopen network ground
5	SHLD	Shield, provides connection to the CANopen network shield
7	H	CAN_H, high level in CANopen communication
1, 4, 8, 9	N.C.	Not connected[a]
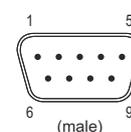
a. To ensure backwards compatibility, these contacts should not be connected.

A new module is configured from scratch, using TIA Portal and CM CANopen Configuration Studio.

See also:

- "CANopen Network Configuration" on page 12

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1. Can be downloaded from www.hms-networks.com/can-for-S7-1200

4.2 Status LEDs

Three status LEDs indicate the status of the module as shown in the table below. The DIAG LED is visible on the front of the module and the other two are found behind the lid at the top of the module. The behavior of the LEDs is described in "Status LED Timing Diagrams" on page 56

LED	Indication	Status
DIAG (red/green)	Green	Normal operation
	Blinking green	Hardware address not configured yet
	Blink red	CM bus error state. Note: This LED only report errors on the CM backplane bus. Diagnostic errors are indicated by the error LED on the PLC.
ERR - CANopen error (red)	Off	Normal operation
	Blinking	General configuration error
	Single flash	Warning limit reached in CAN controller, for example due to bad or no signal on the CANopen network.
	Double flash	A nodeguard event or a heartbeat event has occurred.
	Triple flash	Sync error. The sync message has not been received within the configured communication cycle time
	1 Hz	Fatal error, contact support.
	On	The CAN controller is bus off.
RUN - CANopen state (green)	Off	No power, not configured or no CANopen network
	Blinking	Pre-operational
	Single flash	Stopped
	Triple flash	Transparent CAN mode
	On	Operational

4.3 Maximum Cable Lengths

When designing the CANopen network, please take into account the maximum cable length for different baud rates.

Baud rate (kilobaud)	Maximum cable length (m)
20	2500
50	1000
125	500
250	250
500	100
800	50
1000	25

4.4 Line Termination

To minimize the signal's reflections from the end of the cable, a line termination is needed close to each end of the bus. If the cable you are using is not terminated, connect a line termination between contacts 2 and 7 (CAN_L and CAN_H) beneath the slot, where the module is mounted. The impedance of the termination should be 120 Ω (5%, 1/4 W max.).

5. Configuration

5.1 General

Configuration of the SIMATIC S7-1200 PLC to provide connectivity to a CAN/CANopen network, using the CM CANopen Module for SIMATIC S7-1200, can be done in different ways, depending on the application.

The CANopen network, and the behavior of the module on this network, have to be configured using an external CANopen configuration tool on the PC and the configuration is downloaded to the CM CANopen module through the module USB connection.
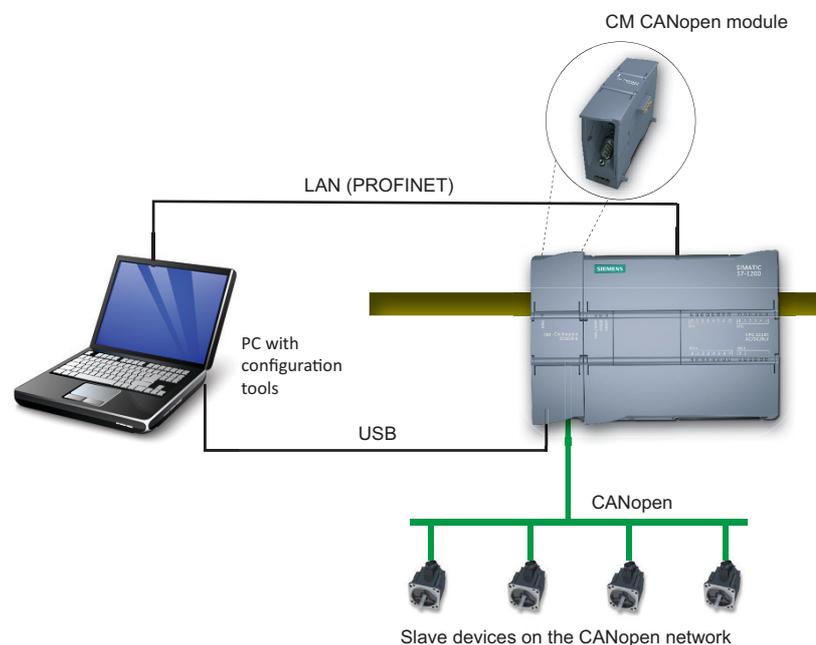
The module can be configured either as a manager or as a slave, depending on the application.

5.2 SIMATIC S7-1200 PLC Configuration[1]

Siemens TIA Portal is used to configure the SIMATIC S7-1200 PLC and the CM CANopen Module for SIMATIC S7-1200. The module can be imported into the tool.

The CM CANopen module offers the SIMATIC S7-1200 PLC access to a CAN/CANopen network, where the CM CANopen module either acts as a Transparent CAN module or acts as a slave or a manager on a CANopen network, depending on the settings in the parameter list. The SIMATIC S7-1200 may act as a PROFINET slave, with another PLC on the PROFINET network as master. If so, the SIMATIC S7-1200 together with the CM CANopen module can act as a gateway between PROFINET and CANopen.

A example on how to configure the system is given on page 12.

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1. The configuration procedure in TIA Portal is the same for CANopen and CAN networks.

Double-clicking on the CM CANopen Module for SIMATIC S7-1200 in the list of modules in TIA Portal will open a window, where the user can set the values of the module parameters.

The following parameters, that have to be defined, can be found in the CANopen Interface tab:

Parameter	Description	Values	Default value
Node number	Node-ID on the CANopen network. Allowed values are 1 - 127	1-127	1
Operating mode	The operating mode of the module can be changed at any time using this parameter.	Transparent CAN CANopen Manager CANopen Slave	CANopen Manager
Baudrate	This parameter defines the baud rate on the CAN network.	20 kbit/s 50 kbit/s 125 kbit/s 250 kbit/s 500 kbit/s 800 kbit/s 1000 kbit/s	500 kbit/s
CANopen input data size[a]	This parameter defines the CANopen input data size. The direction is defined from the CANopen network point of view, that is input is input to the module from the CANopen network. Possible values are 1 - 256 bytes.	1 - 256	32
CANopen output data size[a]	This parameter defines the CANopen output data size. The direction is defined from the CANopen network point of view, that is output is output to the CANopen network from the module. Possible values are 1 - 256 bytes.	1 - 256	32
CANopen Manager auto configuration[b]	Auto configuration scans the network for devices at startup and tries to start them. Default PDO mapping is used. Auto configuration is enabled by checking a box in the configurator.	Disabled Enabled	Disabled

a. Only valid in CANopen mode
b. Only valid in CANopen manager mode

The parameterization is downloaded to the PLC with the HW configuration, using an Ethernet connection.

5.3 CANopen Network Configuration

An external CANopen configuration tool[1] is used to configure the nodes on the CANopen network. The resulting Concise DCF files are downloaded to the CANopen manager using a USB connection between the PC and the CM CANopen module. At the next startup the CANopen manager will configure the network, if this function was set in the configuration tool during initial configuration.

The CM CANopen Module for SIMATIC S7-1200 can be configured either as a manager or as a slave on the CANopen network. The configuration is decided by the PLC (by the Parameterization values).

5.4 Configuration Files

The Electronic Data Sheet (EDS) file for the CM CANopen Module for SIMATIC S7-1200 will be automatically installed with the CANopen configuration tool. This file is necessary to perform the configuration of the module on the CANopen network. Updated versions will be available at www.hms-networks.com/can-for-S7-1200.

The necessary information for configuring the module with the SIMATIC S7-1200 PLC can be included in TIA portal by installing the HSP file[2].

5.5 Configuration Example

This section gives an example of a TIA Portal configuration of the CM CANopen module from HMS Industrial Networks in combination with the S7-1200 PLC from Siemens. In this example a CPU of type 1214C is used, but the example can be applied to all other PLC types as well. To run this example, the HSP file, that can be downloaded from www.hms-networks.com/can-for-S7-1200, must have been installed.

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1. Please visit www.hms-networks.com/can-for-S7-1200 or contact HMS support for further information, see "Support" on page 2.
2. Available for download at www.hms-networks.com/can-for-S7-1200.

1. Open the TIA Portal program and start a new project by clicking "Create new project" on the left side of the screen.
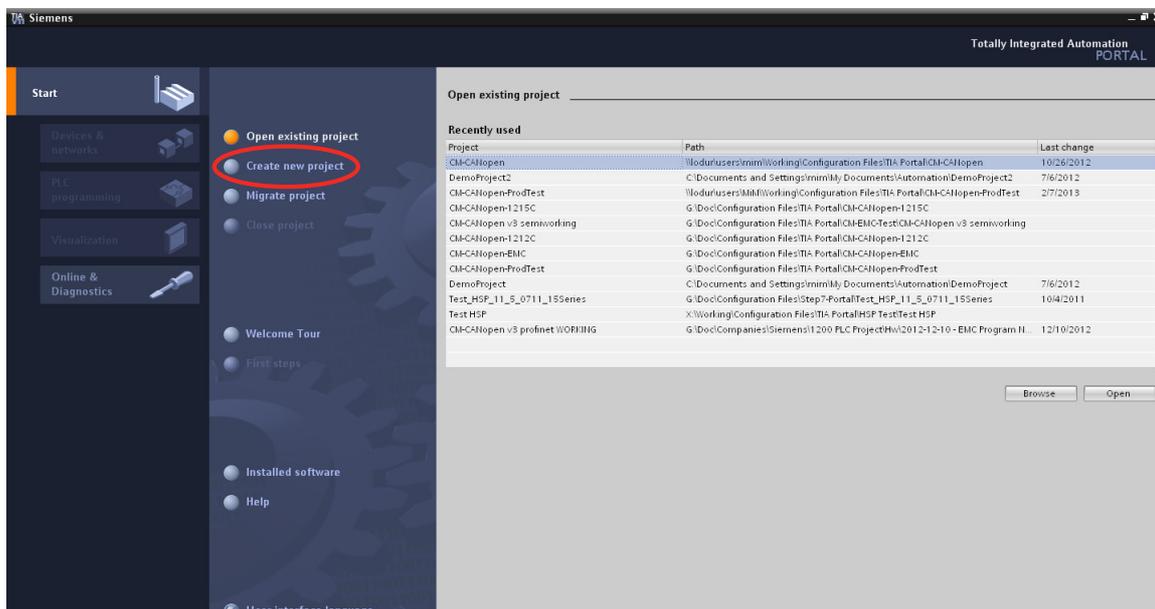
2. Enter a name for the project and the path to where the project should be stored, optionally with information like author and descriptive comments. Press "Create".
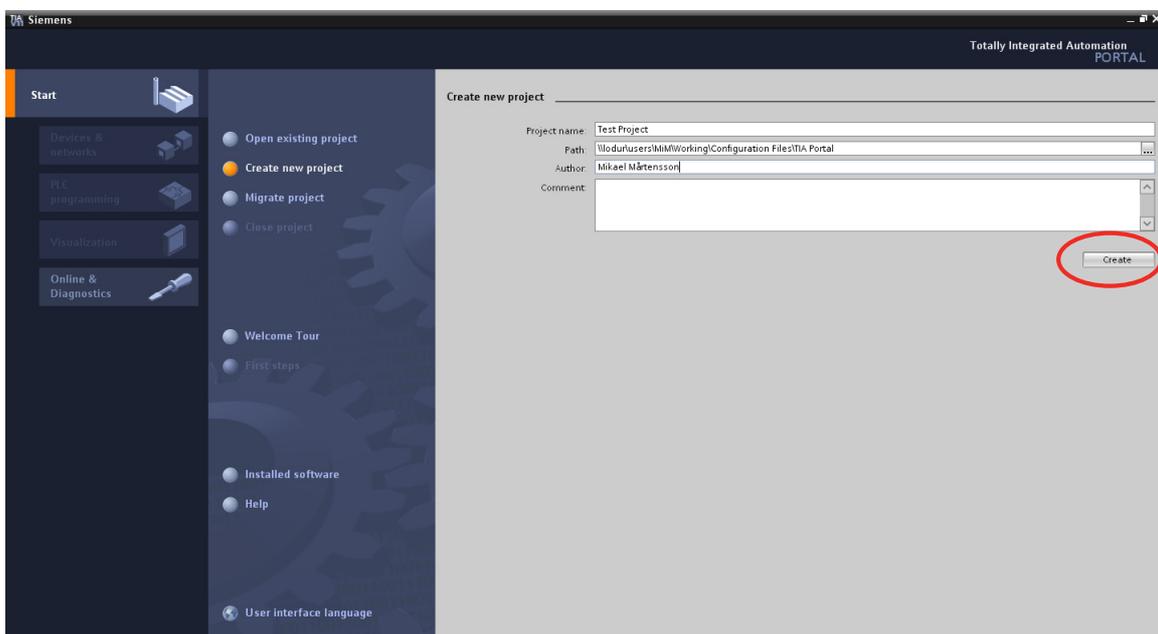
3. Select "Devices & networks" to the left and then press "Add new device".
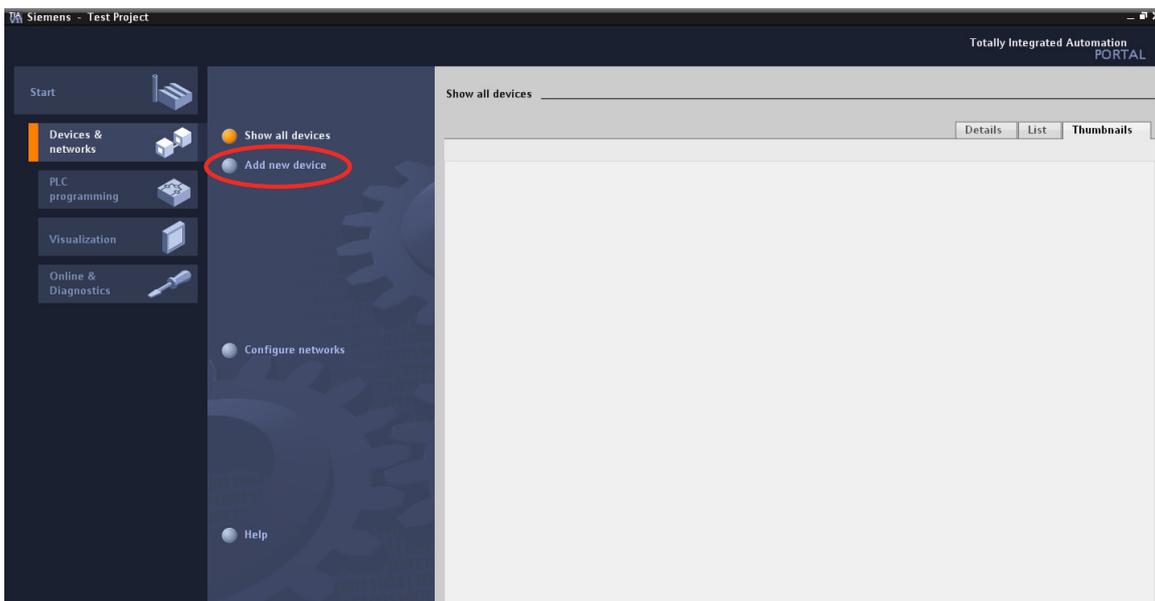
4. Select the PLC type used in the configuration. Select correct software version and optionally enter a name for the PLC (default PLC_1). Press "Add".
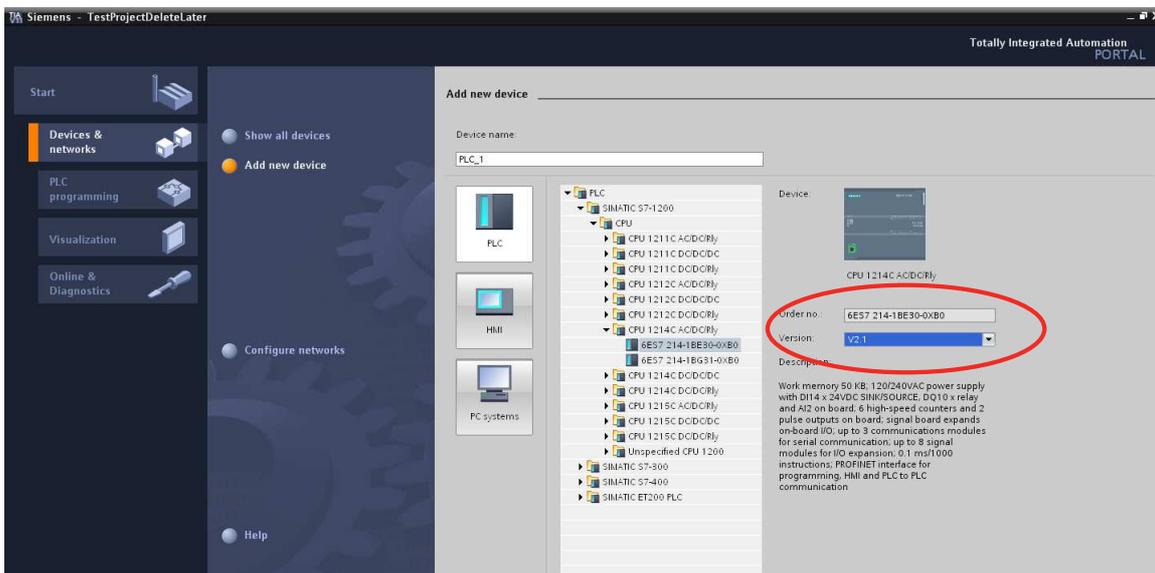
5. Select the CM CANopen module in the list as shown in the picture. Drag and drop an instance of the module to the left side of the PLC module.
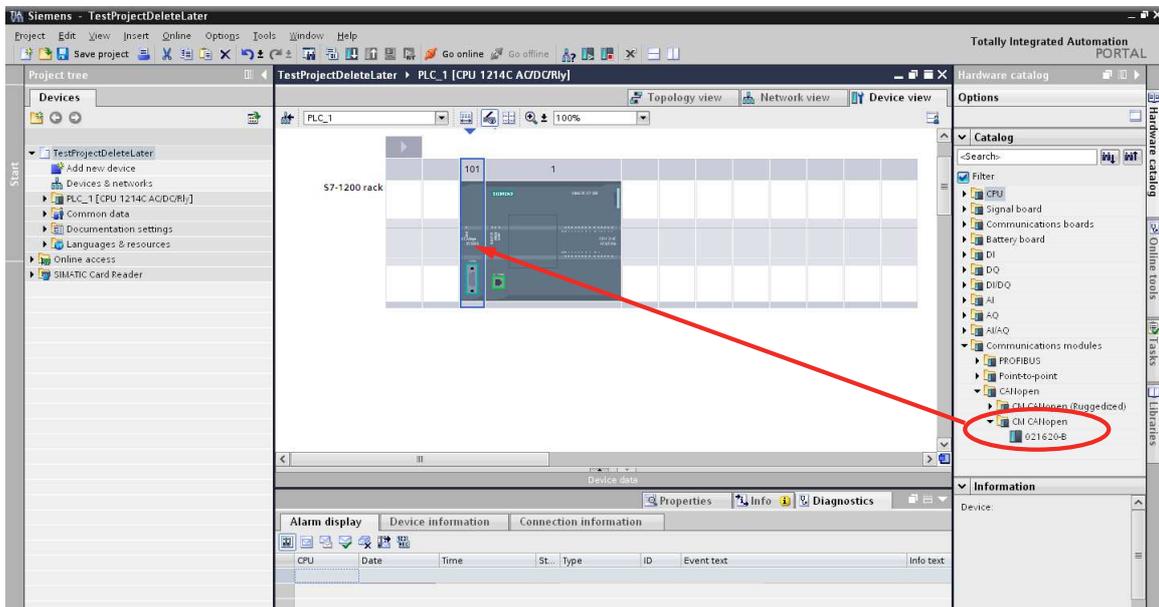
6. Double click on the Ethernet connector on the PLC and enter a proper IP address for the PLC.
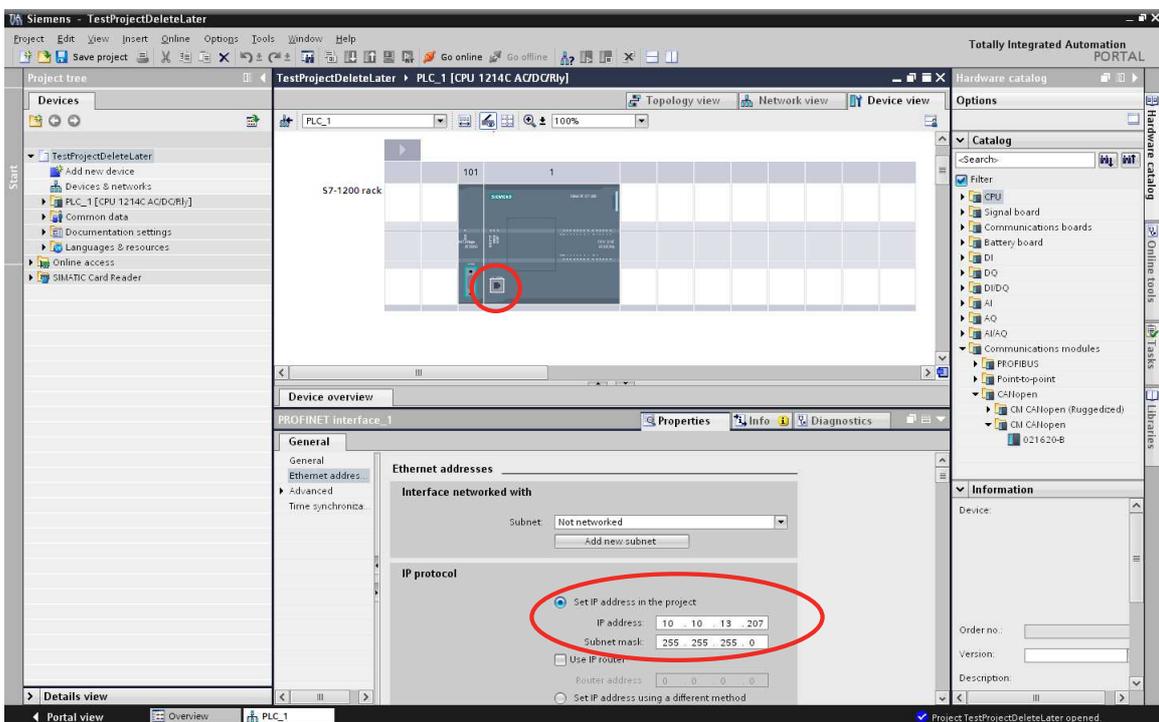
7. Double click on the connector of the CM CANopen module and choose the module parameter tab. Enter the values in the parameter list. Please note that these parameters are valid for the module on the CANopen network.
In this example, the CM CANopen module for S7-1200 is configured as a CANopen manager. The node number on the CANopen network is 1. The CANopen baud rate is set to 500 kbit/s and both the input data size and the output data size are set to 32 bytes.
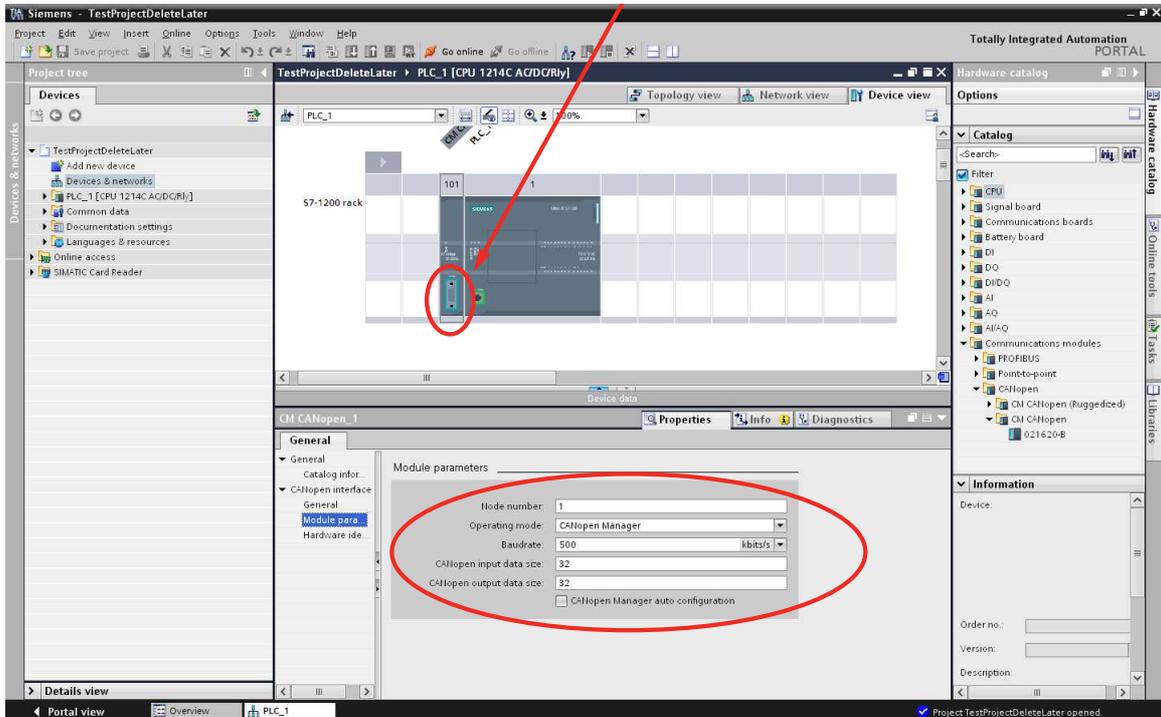
8. The configuration is now finalized and can be downloaded to the S7-1200 device. To download the software configuration select the PLC_1 on the right and choose "Online" > "Download to device". To download the hardware configuration, right-click on the device in the tree and choose "Download to device" > "all".
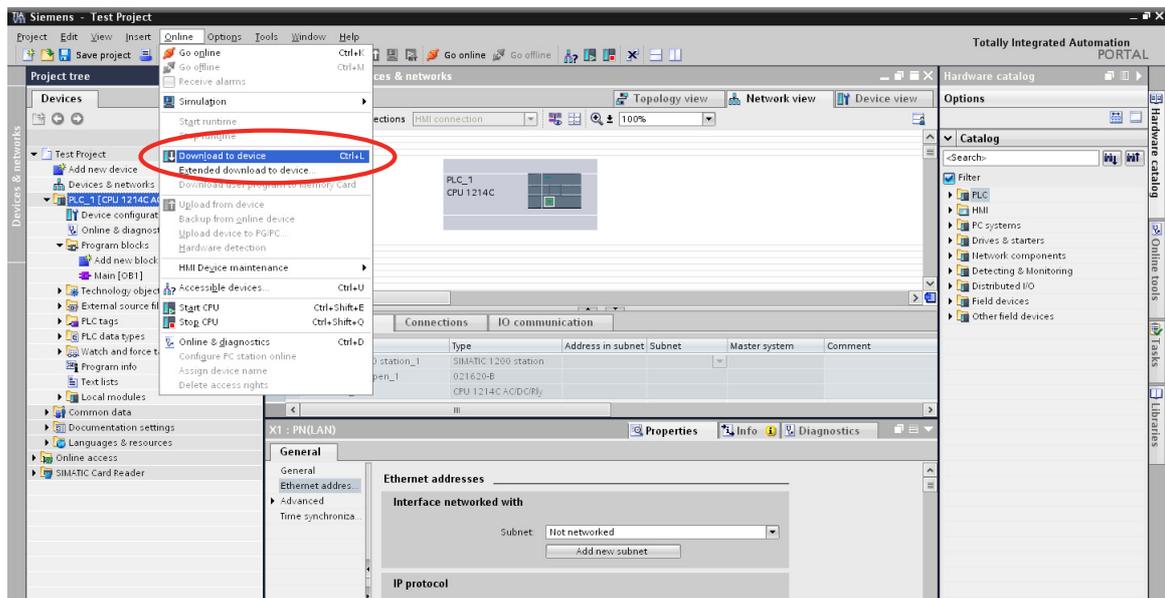
9. Select the PG/PC interface you are using (in this example PN/IE) and the Ethernet interface on your PC (in this example Intel 82577...). If the IP address, entered earlier, is found on the network press "Load" to download to your device. If not, select the correct device from the list available in the "Accessible devices in target subnet" window. If the device is on another subnet, and not available in this window, the check box "Show all accessible devices" will have to be checked.
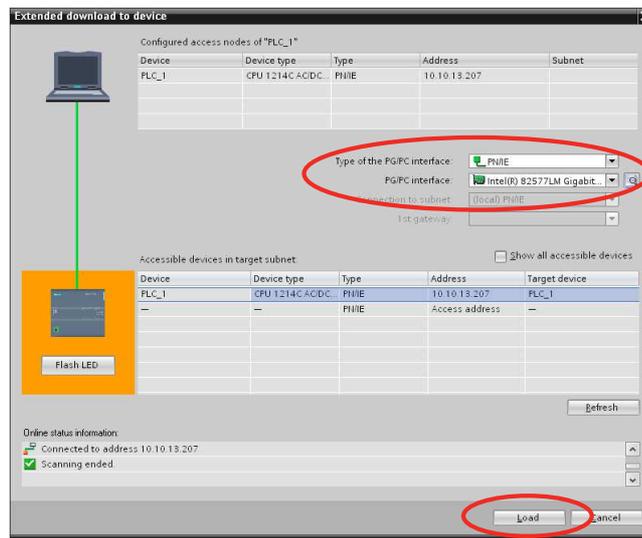
10. If the download was successful the following screen will appear asking if the PLC should start. Press Finish and the PLC will start running the empty program that was downloaded.
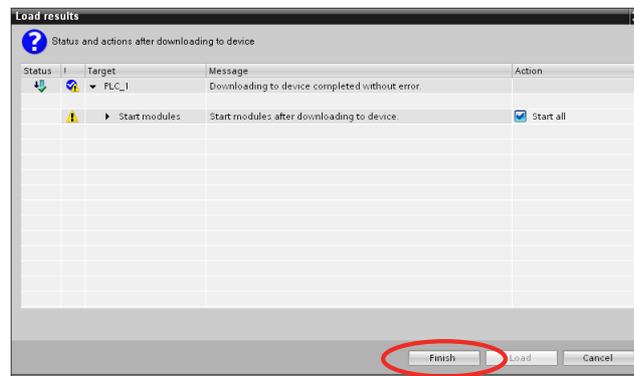
11. The configuration of the module is now finished and the PLC programming can start.

Configuration of the CANopen network

The configuration of the CANopen network, including the CM CANopen Module for SIMATIC S7-1200, is done separately with CM CANopen Configuration Studio.

Important: Before downloading the configuration to the CANopen network, make sure that the PLC is set to STOP!

1. Open CANopen configuration tool.
2. Add nodes to CANopen network.
3. Configure each node with the necessary parameters.
4. Check that there is no conflict between the parameters downloaded from the CANopen configuration tool and the parameters set up with TIA Portal, regarding operation mode and process data size.
5. Download the configuration to the CANopen manager as Concise DCF-files. The configuration is automatically stored locally in nonvolatile memory.

Please consult the user manual for the configuration tool for details and/or contact HMS support, see "Support" on page 2.

6. CANopen Module Specification

6.1 NMT State Machine

The function of the CM CANopen Module for SIMATIC S7-1200 can be described as a state machine with four states.

State	Description
Initialization	When the power is switched on, the module starts initializing. This is done in three steps: basic initialization, reset application and reset communication. The parameters are set to the so called power-on values, which are the default values or the latest stored values. If parameter values are stored from a previous configuration, these are used. If not, or if a restore_default command is issued, the parameters are reset to the default values according to the communication and device profile specifications.
Pre-operational	Once initialized, the module enters the pre-operational state. SDO (Service Data Object) communication is allowed. A configuration application or configuration from CM CANopen Module for SIMATIC S7-1200 can configure PDOs (Process Data Objects), device parameters and allocate application objects (PDO mapping).
Operational	In the operational state all communication objects are active. Data is communicated according to the configurations made. Not all SDO:s can be changed, as some information e.g. an object may contain the application program that needs to stay fixed throughout operation.
Stopped	All communication is stopped, except node guarding and heartbeat, if active. From this state any transition to another state is possible, depending on if a restart, reconfiguration or reset of the module is wanted.

The module changes states upon reception of a request from the CANopen network, a hardware reset or following a change in the PLC RUN/STOP state.

If the CM CANopen Module for SIMATIC S7-1200 is configured as a CANopen manager, the transitions are initiated from the PLC. The module will either enter PRE-OPERATIONAL state or OPERATIONAL state directly, depending on the configuration downloaded from TIA Portal to the PLC.

The module can not enter the state STOPPED when transitions are initiated from the PLC.

If the module is configured as a slave its behavior is controlled by a CANopen manager on the network by the use of NMT telegrams. If the connection to the manager is lost, though, the module sends an emergency code (FFA0h) and enters PRE-OPERATIONAL state.

Transition no.	Description
1	The initialization state is entered automatically at power on.
2	Initialization finished. The pre-operational state is entered automatically.
3	Reset node or reset communication. New parameters have been received and a new initialization is required.
4	If configured to do so, the controlling manager changes to "Run" mode. If the node is a CANopen manager, this transition is controlled by the PLC. If it is a slave, the transition is controlled by the CANopen manager using the command 'Start remote node'.
5	Return to pre-operational state. If the controlling manager is a PLC, this transition is initiated from the PLC.
6	Stop
7	Return to pre-operational state.
8	Start
9	Stop
10	Reset node or reset communication
11	Reset node or reset communication. New parameters have been received and a new initialization is required

Note: At a STOP from the PLC, the data last received is stored in the CM CANopen module. When the PLC issues a RUN the stored data is sent on the CANopen bus. The behavior of the module is the same if the connection is lost with the PLC on PROFINET.

6.2 Data Exchange

Process data is read and written using function blocks, see "Get Process Data In" on page 43 and "Set Process Data Out" on page 44.

6.2.1 PDO Functionality

Real-time data transfer is performed by means of PDOs (Process Data Objects). The PDOs are linked to entries in the Device Object Dictionary and provide the interface to the application objects. Number and length of PDOs in a device are node specific and have to be configured by the CANopen configuration tool.

PDOs are used both for data transmission and reception, using so called Transmit-PDOs (TPDOs) and Receive-PDOs (RPDOs). Each PDO corresponds to two entries in the Device Object Dictionary. The PDO parameter object holds information on the COB-ID, the transmission type etc. On recognition of the COB-ID the corresponding PDO mapping object can be identified, to make it possible to transmit/receive data to/from the correct object in the device. The default settings for the mapping can be changed during configuration.

Default PDO Mapping Scheme for Slave Mode[1]

The module features a simple default mapping scheme with 4 TPDOs and 4 RPDOs.

- **RPDO**

RPDO no.	Default COB-IDs	Mapped to...	Relating to...	Default State
1	200h + Node-ID	Object index A4C0h, subindex 1... 8	Output data buffer, bytes 0... 7	Enabled
2	300h + Node-ID	Object index A4C0h, subindex 9... 16	Output data buffer, bytes 8...15	
3	400h + Node-ID	Object index A4C0h, subindex 17... 24	Output data buffer, bytes 16... 23	
4	500h + Node-ID	Object index A4C0h, subindex 25... 32	Output data buffer, bytes 24... 31	
5	80000000h	Object index A4C0h, subindex 33... 40	Output data buffer, bytes 32... 39	Disabled
...		...	...	
16		Object index A4C0h, subindex 121... 128	Output data buffer, bytes 120... 127	
...		...	...	
31		Object index A4C0h, subindex 241... 248	Output data buffer, bytes 240... 247	
32		Object index A4C0h, subindex 241... 248 Object index A4C1h, subindex 1... 2	Output data buffer, bytes 248... 255	
33		No default mapping	-	
...		...	...	
64		No default mapping	-	

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1. There is no default mapping for master mode.