SIEMENS

SIMATIC

S7-300
SM331; AI 8x12 Bit Getting Started part 1: 4 -20mA

Getting Started

05/2008
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1.1 General

Purpose of the Getting Started

The Getting Started gives you a complete overview of the commissioning of the analog module SM331. It assists you in the installation and configuration of the hardware of a 4-20mA sensor and the configuration with SIMATIC S7 Manager.

The intended readership of Getting Started is a novice with only basic experience in configuration, commissioning and servicing of automation systems.

What to expect

The procedures, from mounting the module to storing analog values in the STEP7 user program, are explained step-by-step and in detail based on an example. In the following sections you will be introduced to:

- Problem analysis
- Mechanical setup of the example station
- Electrical connection of the example station
- Configure hardware with SIMATIC Manager
- Creating a small user program with STEP7 which stores the read analog values in a data block
- Triggering and interpreting diagnostic and hardware interrupts

Requirements 2

2.1 Basics

Basic Knowledge Required

No special knowledge of the field of automation technology is required in order to understand the Getting Started guide. As the configuration of the analog module is done with the software STEP7, proficiency in STEP7 would be advantageous.

Further information on STEP7 can be found in the electronic manuals that are supplied with STEP7.

You will also need to know how to use computers or PC-like equipment (such as programming devices) under Windows 95/98/2000/NT or XP.

Required hardware and software

The scope of delivery of the analog module consists of 2 parts:

- The module itself
- A front connector, which enables you to conveniently connect the power supply and the data cables.

Analog module components

Quantity	Article	Order number
1	SM 331, Electrically ISOLATED 8 AI, ALARM DIAGNOSTICS	6ES7331-7KF02-0AB0
1	20-pin FRONT CONNECTOR with spring contacts	6ES7392-1BJ00-0AA0

The general SIMATIC components required for the example are as follows:

SIMATIC components of the example station

Quantity	Article	Order number
1	PS 307 Power Supply AC 120/230V, DC 24V, 5A	6ES7307-1EA00-0AA0
1	CPU 315-2 DP	6ES7315-2AG10-0AB0
1	MICRO MEMORY CARD, NFLASH, 4 MB	6ES7953-8LM00-0AA0
1	SIMATIC S7-300, RAIL L=530MM	6ES7390-1AF30-0AA0
1	Programming device (PD) with MPI interface and MPI cable PC with corresponding interface card	depending on the configuration

Software STEP7

Quantity	Article	Order number
1	STEP7 Software version 5.2 or later, installed on the programming device.	6ES7810-4CC06-0YX0

The following current transducers can be used for the acquisition of analog signals:

Current transducers

Quantity	Article	Order number
1	2-Wire current transducer	depending on the manufacturer
1	4-Wire current transducer	depending on the manufacturer

Note

This "Getting Started" describes only the application of 4 – 20 mA current transducers in the 2-Wire or 4-Wire model. If you wish to use other transducers, you will need to wire and configure the SM331 differently.

General tools and materials:

Quantity	Article	Order number
various	M6-bolts and nuts (Length depending on the mounting position)	commonly available
1	Screwdriver with 3,5 mm blade	commonly available
1	Screwdriver with 4.5 mm blade	commonly available
1	Side cutters and wire stripping tools	commonly available
1	Tool for crimping wire-end ferrules	commonly available
X m	Cable for grounding the mounting rail with 10 mm^2 cross-section, ring terminal with 6.5 mm hole, length appropriate for local requirements.	commonly available
X m	Flexible wire with 1mm^2 diameter with fitting wire end sleeves, form A in 3 different colors – blue, red and green	commonly available
X m	3-wire power cord (AC 230/120V) with protective contact socket, length according to local conditions.	commonly available
1	Calibration device (measuring instrument for commissioning, that can measure and supply current)	depends on the manufacturer

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3.1 Example of an application

Overview

You want to connect three analog inputs to your station. One of them should have a 2-wire current transducer and the other two should share a 4-wire current transducer.

You need failure diagnostic capabilities and want two sensors to be able to trigger hardware interrupts.

You have the analog input module SM331, AI8x12 Bit
(order number 6ES7 331-7KF02-0AB0) available. The module is diagnostic and hardware interrupt capable and can process up to 8 analog inputs. The module is diagnostic and hardware interrupt capable and can process up to 8 analog inputs (e.g. 4- 20 mA; PT 100; thermocouple).

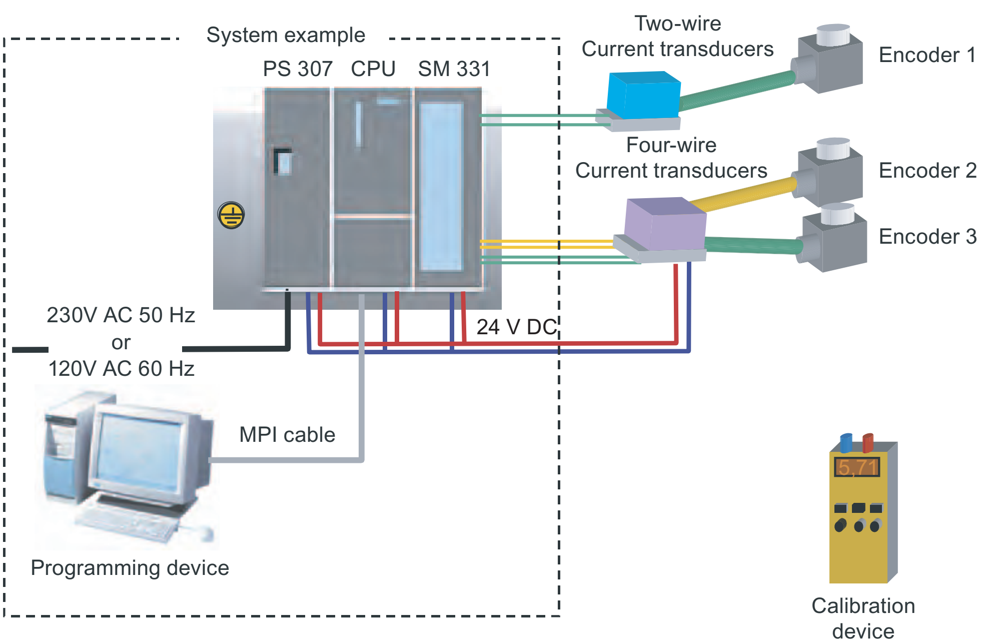


Figure 3-1 Sample station components

In the following sections you will be introduced to:

- Mechanical setup of the example station
  - General mounting instructions for S7-300 modules
  - Configuration of the SM331 for the two selected measurement transducer types
- Electrical connection of the example station
  - Wiring the power supply module and the CPU
  - Wiring of the analog module
  - Standard pin assignment of two measurement transducer types
  - Wiring of unused inputs
- Configuring the SIMATIC Manager
  - Using the project wizard
  - Completing the automatically generated hardware configuration
  - Integrating the supplied user program source
- User program testing
  - Interpreting the read values
  - Converting the measured values into readable analog values
- Utilizing the diagnostic capabilities of the SM331 module
  - Triggering a diagnostic interrupt
  - Evaluating the diagnostics:
- Application of hardware interrupts
  - Configuration of hardware interrupts
  - Configuration and analysis of hardware interrupts

Mechanical setup of the example station 4

4.1 Mounting the example station

Overview

The setup of the example station is divided into two steps. First, the setup of the power supply and the CPU is explained. After becoming acquainted with the analog module SM331, the mounting of it is described.

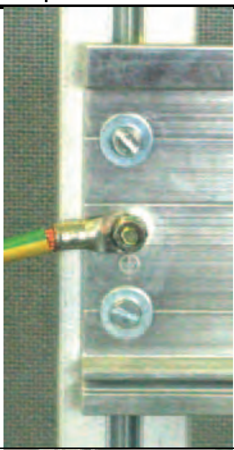
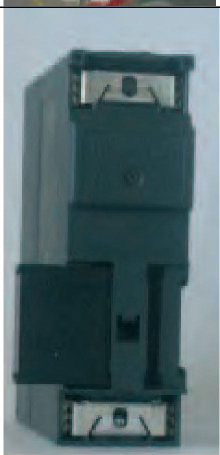
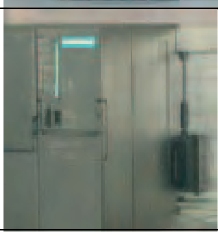
Requirements

Before you can use the analog input module SM331, you need a basic setup of general SIMATIC S7-300 components.

The order of the mounting takes place from left to right:

- Power supply PS307
- CPU 315-2DP
- SM331

Instructions (without SM331)

step	Graphic controller	Description
1		Screw on the mounting rail (screw size: M6) so that at least 40 mm space remains above and below the rail. When mounting it on a grounded steel panel or on a grounded device mounting panel made of steel sheet, make sure you have a low impedance connection between the mounting rail and the mounting surface.
2		Connect the mounting rail with the protective conductor. An M6 protective conductor screw is provided on the mounting rail for this purpose.
3	 	Mounting the power supply: • Hang the power supply on to the top end of the rail • Screw it tight to the rail underneath
4		Connect the bus connector (delivered with the SM331) to the **left** connector on the back of the CPU
5		Mounting the CPU: • Hang the CPU on to the top end of the rail • Push it all the way left to the power supply • Push it down • Screw it tight to the rail underneath

4.2 Mounting of analog module components

4.2.1 General

Overview

Before the actual mounting of the SM331 the module has to be completed with a front connector and the desired measurement mode of the inputs is set.

In this section, you will learn about:

- The components you need
- The properties of the analog input module
- What a measuring range module is and how it is configured
- Mounting a configured module

4.2.2 Components of the SM331

Overview

A functional analog module consists of the following components:

- Module SM331 (in our example 6ES7331-7KF02-0AB0)
- 20-pin front connector There are two different types of front connectors:
  - With spring contacts (order number 6ES7392-1BJ00-0AA0)
  - With screw contacts (order number 6ES7392-1AJ00-0AA0)

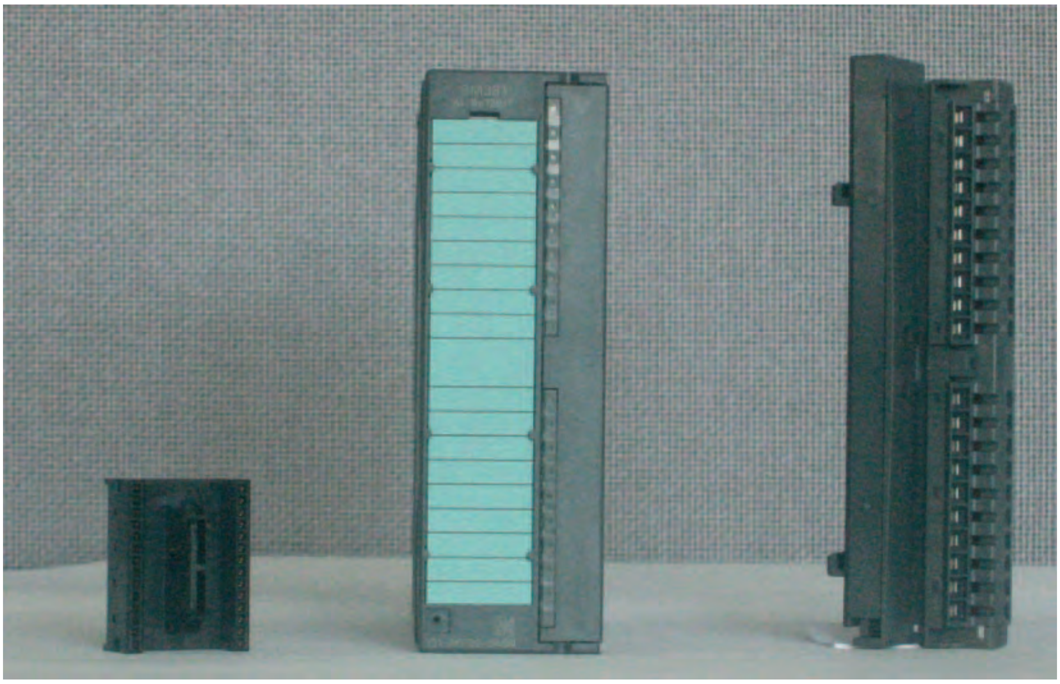


Figure 4-1 Components of the SM331

The scope of delivery of SM331

Components
Module
Labeling strips
Bus connectors
2 cable ties (not in the picture) to tie the external wiring

4.2.3 Features of the analog modules

Characteristics

- 8 inputs in 4 channel groups (each group with two inputs of same type)
- Measurement resolution adjustable for each channel group
- User defined measuring mode per channel group:
  - Voltage
  - Current
  - Resistance
  - Temperature
- Programmable diagnostic interrupt
- Two channels with limit alarms (only channel 0 and channel 2 are configurable)
- Electrically isolated against backplane bus
- Electrically isolated against load voltage (exception: at least one module is set to position D)

The module is a universal analog module designed for the most commonly used applications.

The desired measuring mode should be set up directly on the module with the measuring range modules.

4.2.4 Measuring range modules

Terminal

The module SM331 has 4 measuring range modules (one per channel group). The measuring range modules can be set to 4 different positions (A, B, C or D).

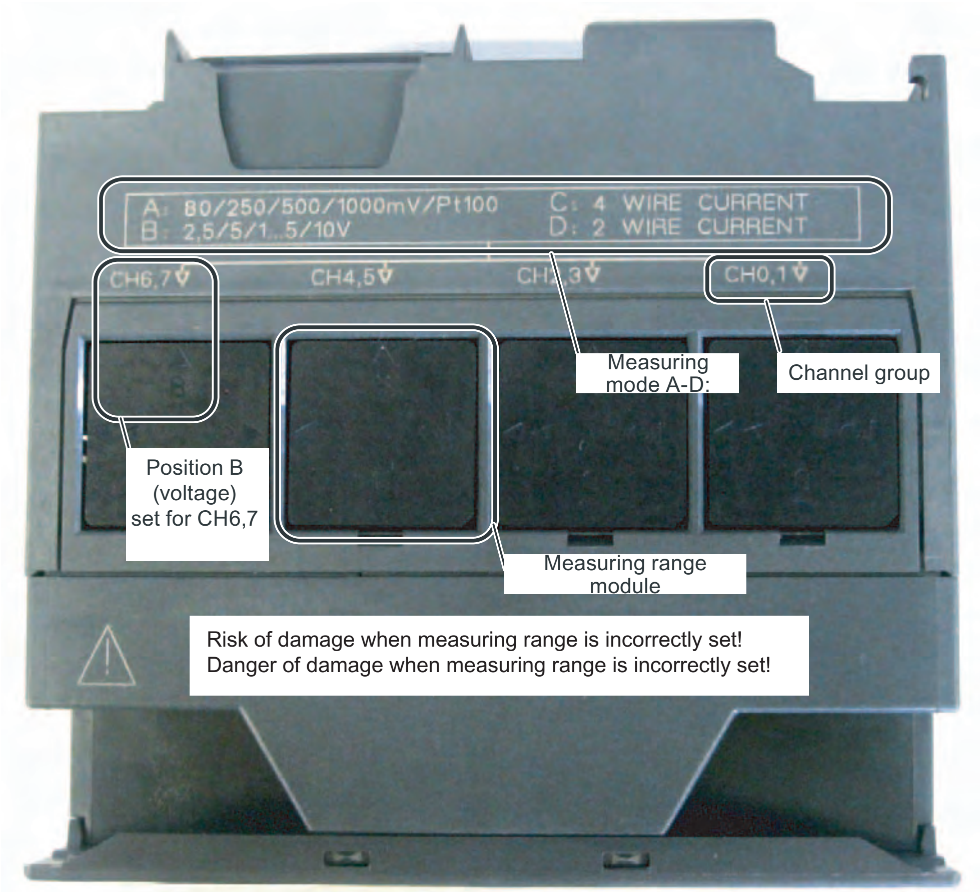


Figure 4-2 4 measuring range modules with default setting B (Voltage)

Positions of the measuring range modules

The position enables you to specify the transducer to be connected to the respective channel group.

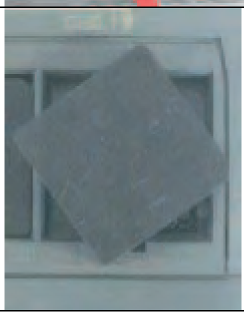
Position	Type of measurement
A	Thermocouple / resistance measurement
B	Voltage (factory setting)
C	Current (4-wire transducer)
D	Current (2-wire transducer)

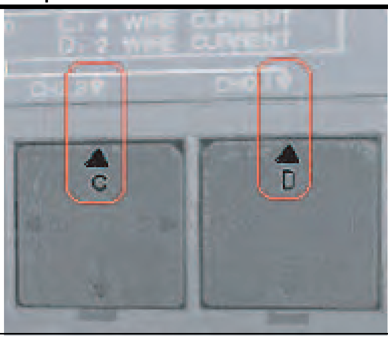
In our example, a sensor with a 4 to 20mA 2-wire transducer is connected to channel group 1 at input 0.

A 4-wire transducer is connected to channel group 2 at inputs 2 and 3.

Therefore, the first measuring range module should have position D and the second should have position C.

Positioning of the measuring range modules

step	Graphic controller	Description
1		With a screwdriver, pull out the two measuring range modules
2		Turn the measuring range module to the desired position:

step	Graphic controller	Description
3		Plug the measuring range module back into the module In our example, the module should have the following positions: CH0,1: D CH2,3: C

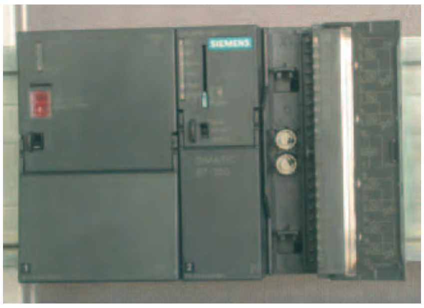
Note

When you use a 2-wire transducer, the electrical isolation against the load voltage is lost for all the channels in the module (at least one measuring range module is set to position D)

4.2.5 Mounting the SM331 module

Proceed as follows

After you have prepared the analog module accordingly, mount it to the rail as well.

step	Graphic controller	Description
1		Mounting the SM331: • Hang the SM311 to the top end of the rail • Push it all the way to the left up to the CPU • Push it down • Screw it tight to the rail underneath
2		Mounting the front connector: • Press the upper release button of the front terminal block • Insert the front connector into the module until it snaps in

The example station is now mechanically mounted.

Electrical connection 5

5.1 Overview

Overview

This chapter shows you how the various parts of the example station are electrically wired from the power supply to the analog module.

⚠ WARNING
You might get an electrical shock if the power supply PS307 is turned on or the power cord is connected to the line. Always switch off power before you start wiring the S7-300.

5.2 Wiring the power supply module and the CPU

Overview

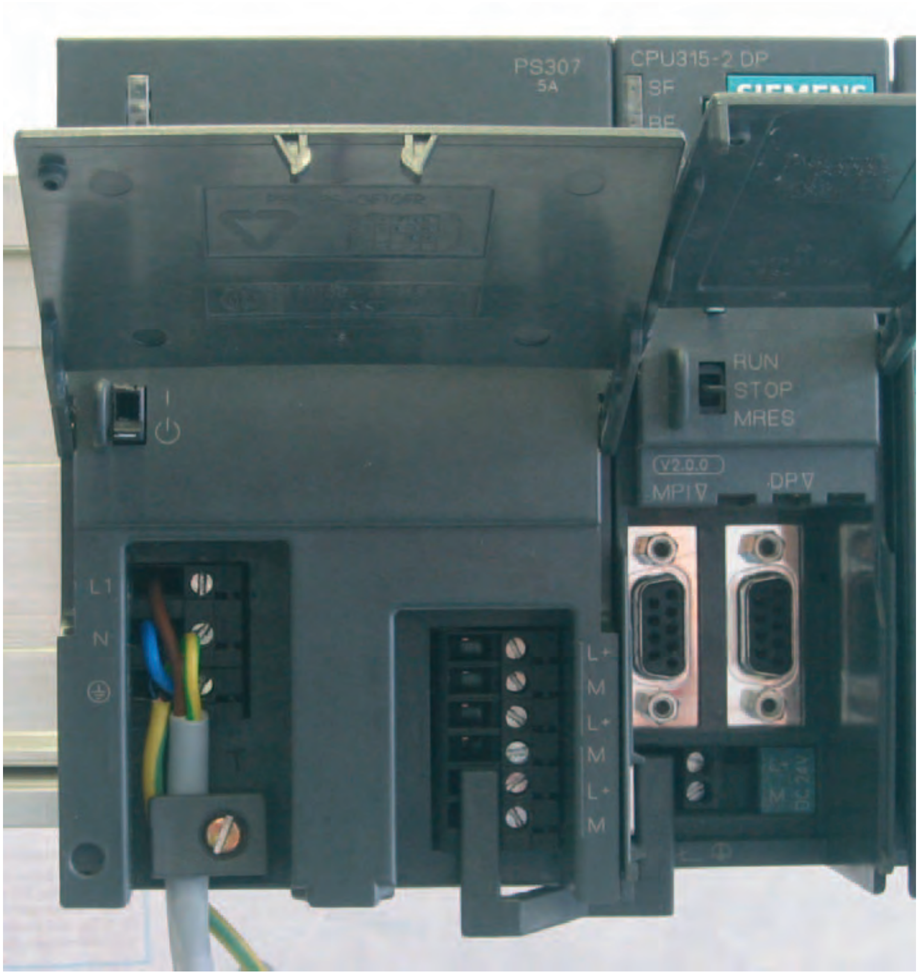
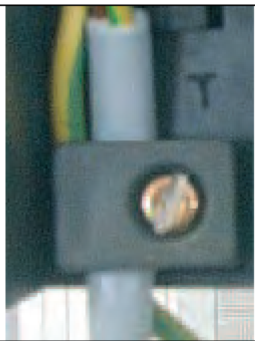
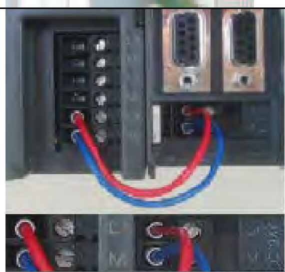
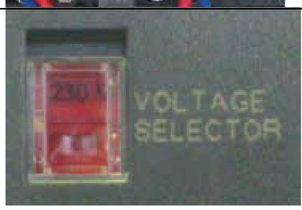


Figure 5-1 Wiring the power supply module and the CPU

The example station requires a power supply. The wiring is done as follows:

Step	Graphic controller	Description
1		Open the front panel covers of the power supply module and CPU.
2		Unscrew the cable grip on the power supply
3		Remove the insulation from the power cord, attach the cable end sleeves (for stranded conductors) and connect it to the power supply
4		Screw down the clamp of the cable grip.
5		Insert two connecting cables between the power supply and the CPU and tighten them
6		Verify that the setting of the selector switch matches your mains voltage. The default line voltage setting for the power supply module is 230 VAC. To change this setting, proceed as follows: Remove the protective cap with a screwdriver, set the selector switch to match your line voltage, then insert the protective cap again.

5.3 Wiring of the analog module

5.3.1 Requirement

General

The wiring of an analog measurement transducer is depends on its type and not on the SM331 module.

5.3.2 Current transducer wiring - principle

Options

Depending on the current transducer you use, you have to modify the wiring of the power supply. We differentiate between the wiring of a 2-wire current transducer and a 4-wire current transducer.

Wiring principles of a 2-wire current transducer

This transducer type is supplied with power from the analog input module.

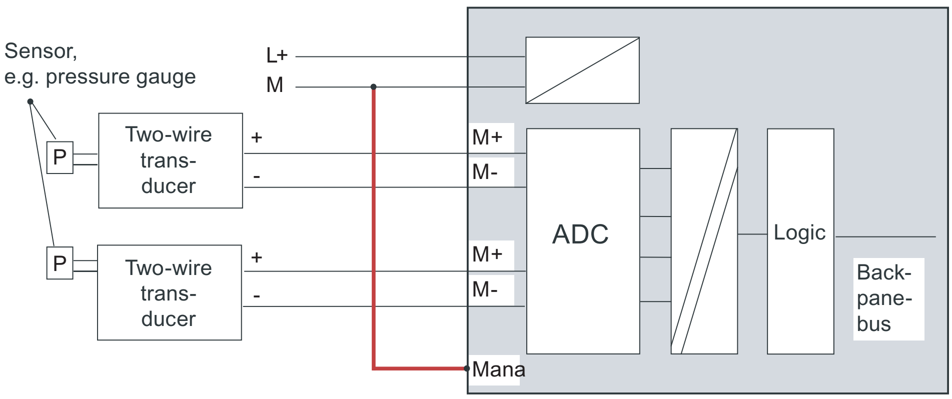


Figure 5-2 Wiring: 2-Wire current transducer

Wiring principles of a 4-wire current transducer

Unlike a 2-wire transducer, this transducer has its own power supply.

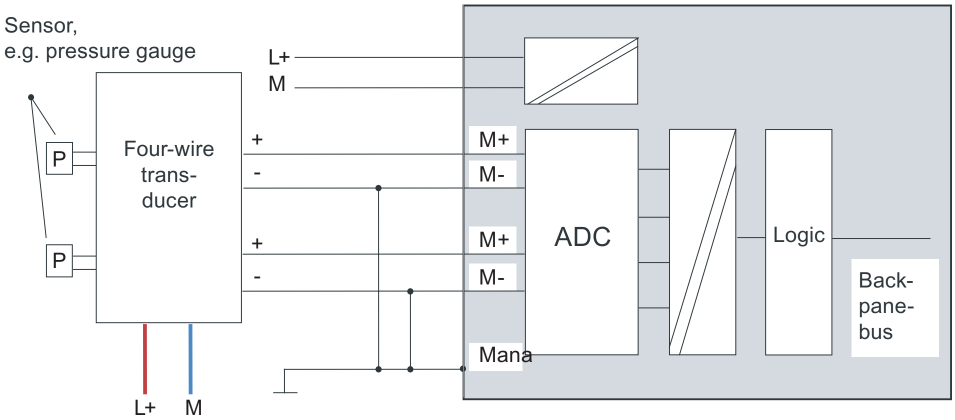


Figure 5-3 Wiring: 4-Wire current transducer

5.3.3 Wiring of the analog module

Tasks

The wiring of the analog module consists of the following tasks:

- Connecting the power supply (red cable)
- Connecting the 2-wire current transducer (green cables)
- Terminating unused channels with a resistor
- Connecting the 4-wire current transducer (green cables)
- Connecting the 4-wire current transducer (green cables)
- Connecting to ground and short-circuiting the other unused channels (blue wires)

SM331 Front connector wiring

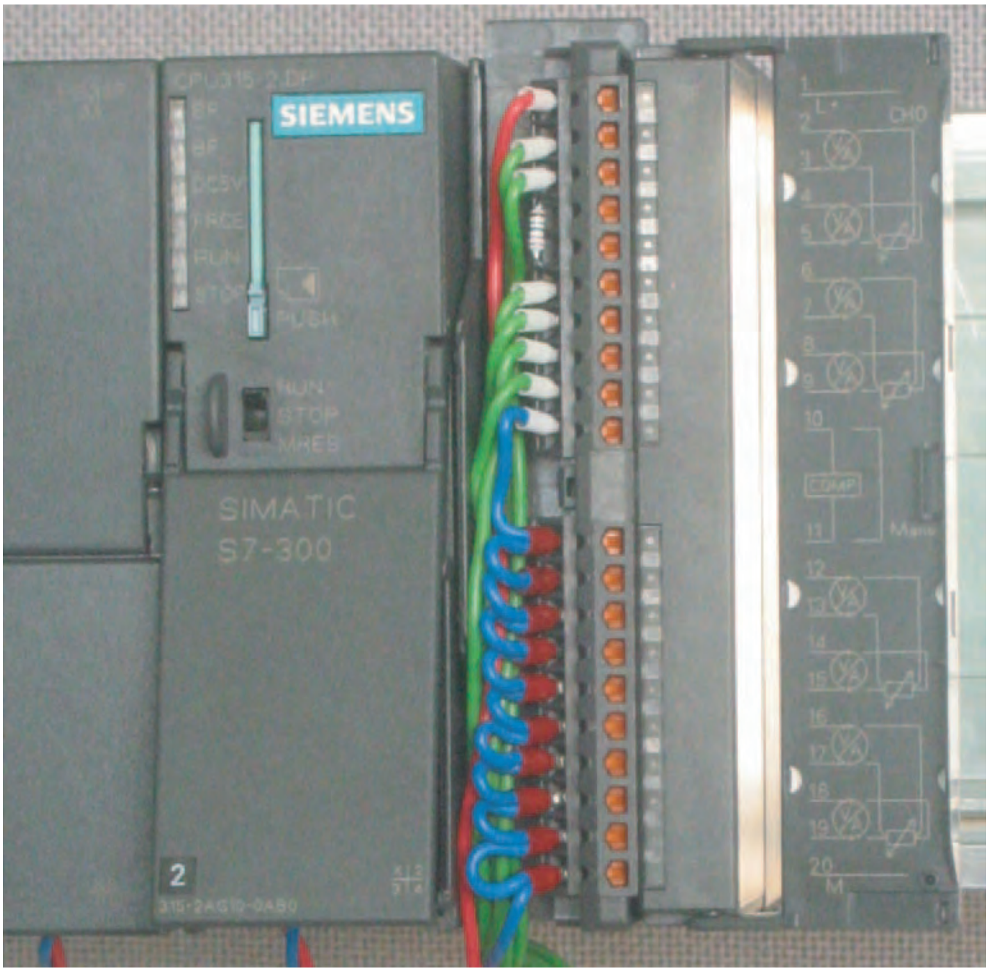
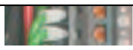
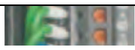
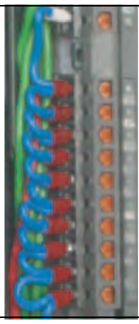


Figure 5-4 SM331 Front connector wiring

NOTICE
Possible destruction of the module! If you connect a defective 4-wire current transducer to an input, which is configured for a 2-wire transducer, the module may be destroyed.

The required wiring tasks are explained below step-by-step:

Proceed as follows

Step	Graphic controller	Connecting-up	Comment
1		Open the front door of the SM331	The connection diagram is printed on the front flap
2		Remove 6 mm of the insulation from the ends of the wires that go into the front connector. Attach cable end sleeves to these ends.	
3		Wire the front connector as follows: Terminal 1: L +	Power supply of the module
4		Terminal 2: M+ sensor 1 Terminal 3: M- sensor 1	Standard wiring for 2-wire current transducer
5		Connect terminal 4 and 5 with a 1.5 to 3.3 kΩ resistor	In order to maintain the diagnostic capability of channel group 0, the second unused input must be connected to a resistor.
6		Terminal 6: M+ sensor 2 Terminal 7: M- sensor 2	Standard wiring for 4-wire current transducer
7		Terminal 8: M+ sensor 3 Terminal 9: M- sensor 3	
8		terminal 10 (Comp) and connect terminal 11 (M_{ana}) to M Short-circuit terminals 12 to 19 and connect with M_{ana} Terminal 20: M	For measuring current comp is not used Mandatory for 2-wire current transducers Unused channel groups should be short-circuited with M_{ana} in order to achieve a maximum interference resistance

5.3.4 Test

Proceed as follows

If you want to test the wiring, you may now switch the power supply on.

Do not forget to set the CPU to STOP (see the red circle)

Figure 5-5 Successful wiring, CPU in position STOP

If a red LED is lit, then there is an error in the wiring. Verify your wiring.

6 Configuration of the SIMATIC Manager

6.1 Creating a new STEP7 project

6.1.1 Creating a new project

"New Project" wizard

Use STEP 7 V5.2 or later for configuring the new CPU 315-2DP.

Start SIMATIC Manager by clicking the "SIMATIC Manager" icon on your Windows Desktop and create a new project with the "New Project" wizard.

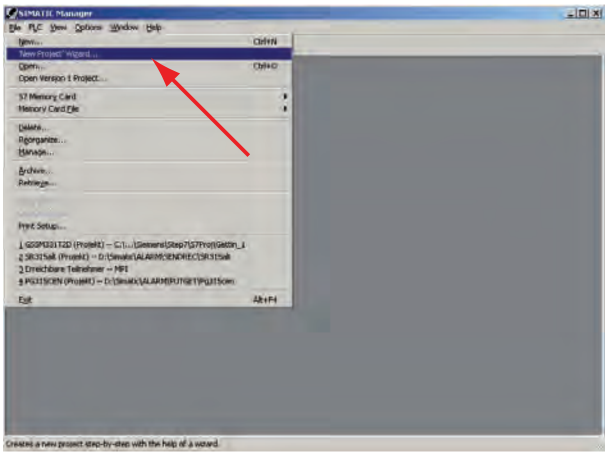


Figure 6-1 Starting the "New Project" wizard

A project wizard introduction window appears. The wizard guides you through the procedure for creating a new project.

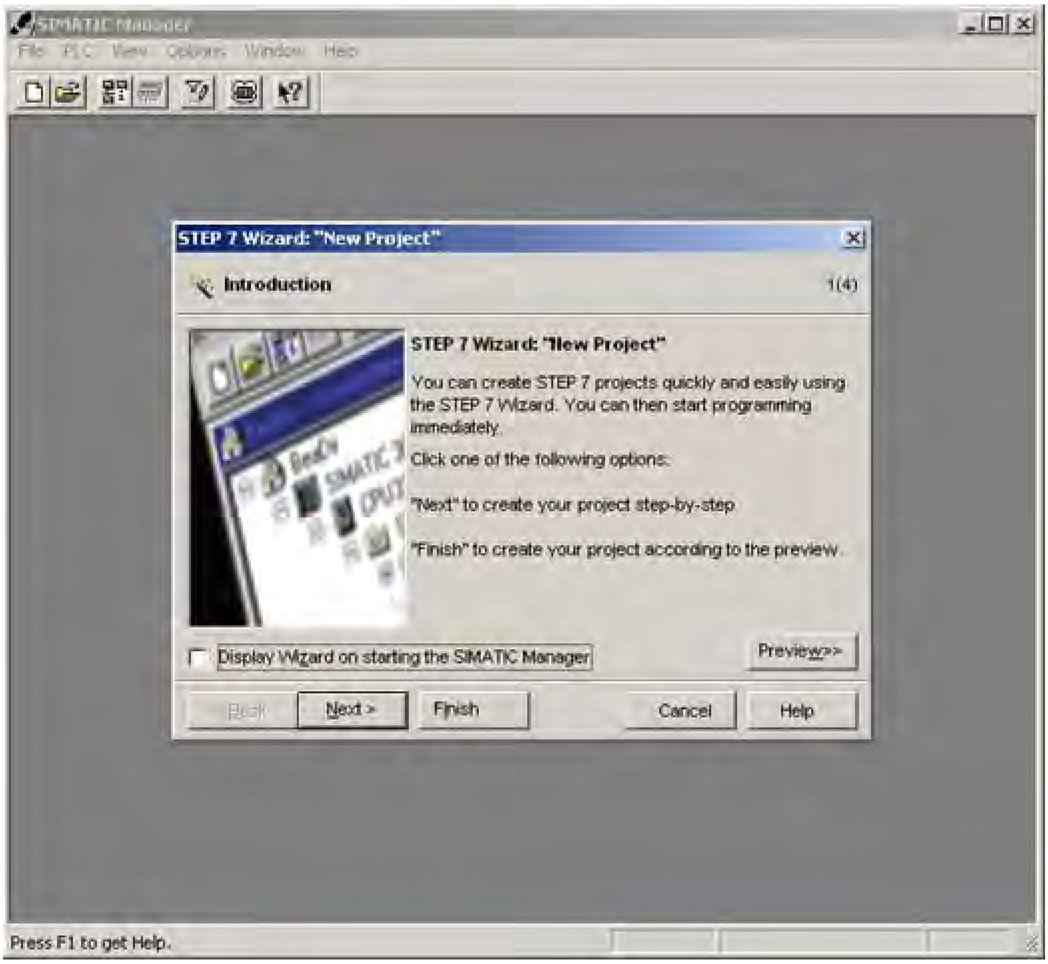


Figure 6-2 "New Project" wizard start

The following must be specified during the creation procedure:

- The CPU type
- The basic user program
- The organization blocks
- Project name

Click "Next".

6.1.2 CPU selection

Proceed as follows

Choose the CPU 315-2DP for the example project. (You can also use our example for a different CPU. Select the appropriate CPU in this case.)

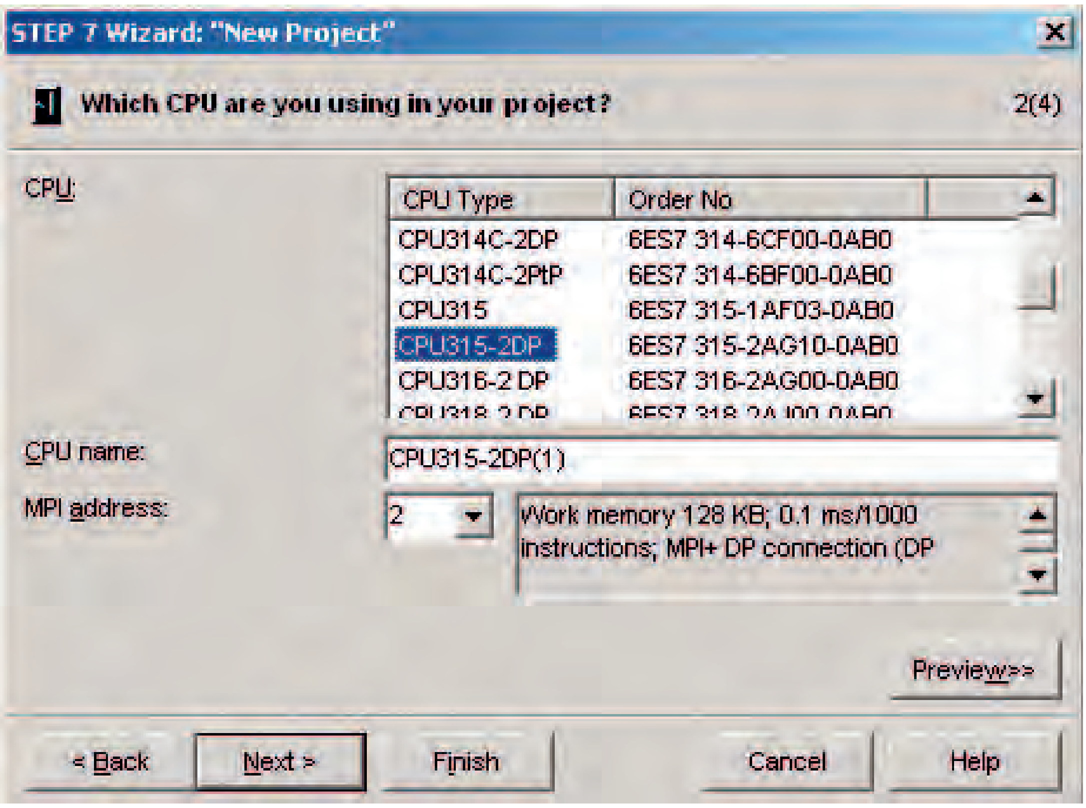


Figure 6-3 "New Project" wizard: selecting a CPU

Click "Next."

6.1.3 Defining the basic user program

Proceed as follows

Choose the SIMATIC language STL and select the following organization blocks (OBs):

- OB1 cyclically executed block
- OB40 hardware interrupt
- OB82 diagnostic interrupt

OB1 is required in every project and is called cyclically.

OB40 is called when a hardware interrupt occurs.

OB 82 is called when a diagnostic interrupt occurs.

If you use a module with diagnostic capabilities and OB82 is not inserted, the CPU changes to STOP mode when a diagnostic alarm occurs.

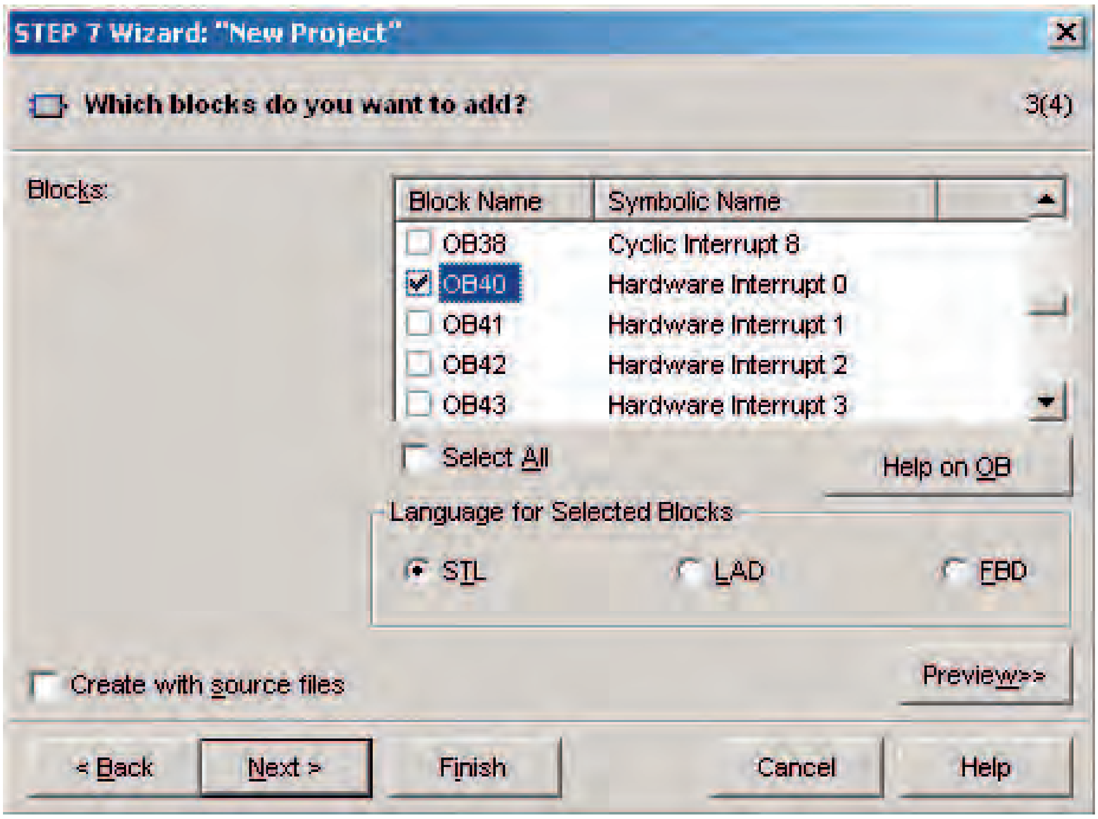


Figure 6-4 "New Project" wizard: Inserting organization blocks

Click "Next."

6.1.4 Assigning the project name

Proceed as follows

Select the “Project name” text box and overwrite the name in it with “Getting Started S7 SM331”.

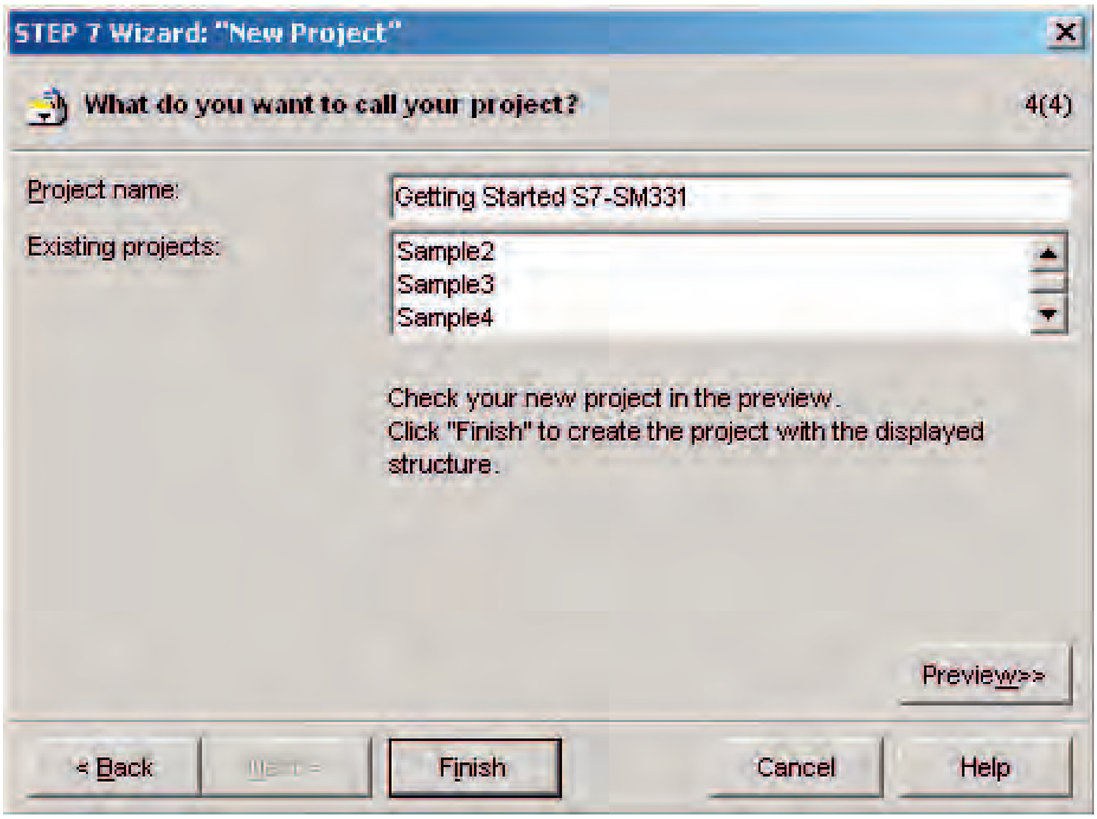


Figure 6-5 "New Project" wizard: Assigning the project name

Click "Finish". The basic STEP7 project is created automatically.

6.1.5 Result S7 project is created

Result

The wizard has created the project “Getting Started S7-SM331”. You can see the inserted organization blocks in the right window.

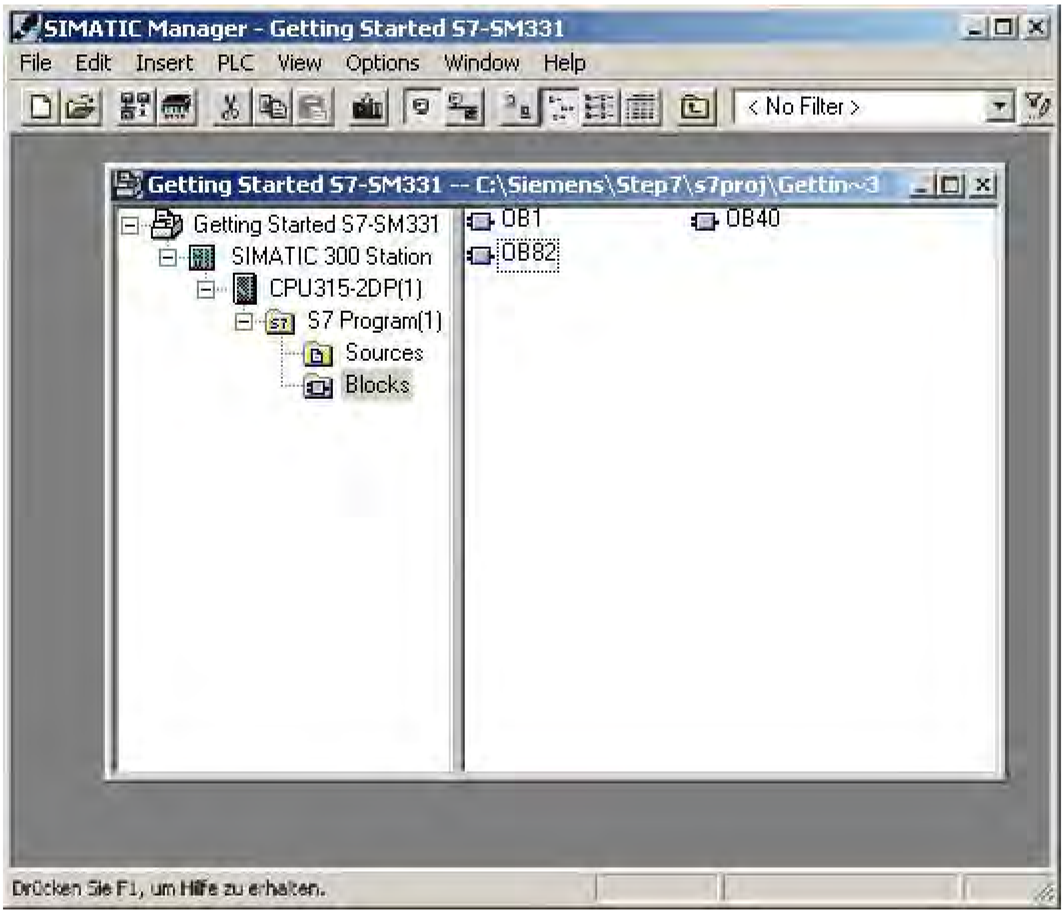


Figure 6-6 "New Project" wizard results

6.2 Hardware configuration

6.2.1 Creating the hardware configuration

Requirements

The STEP7 wizard has created a basic S7 project. You also need a complete hardware configuration in order to create the system data for the CPU.

Proceed as follows

You can create the hardware configuration of the example station with SIMATIC Manager.

To do this, select the folder "SIMATIC 300 Station" in the left window. Start the hardware configuration by double clicking the folder "Hardware" in the right window.

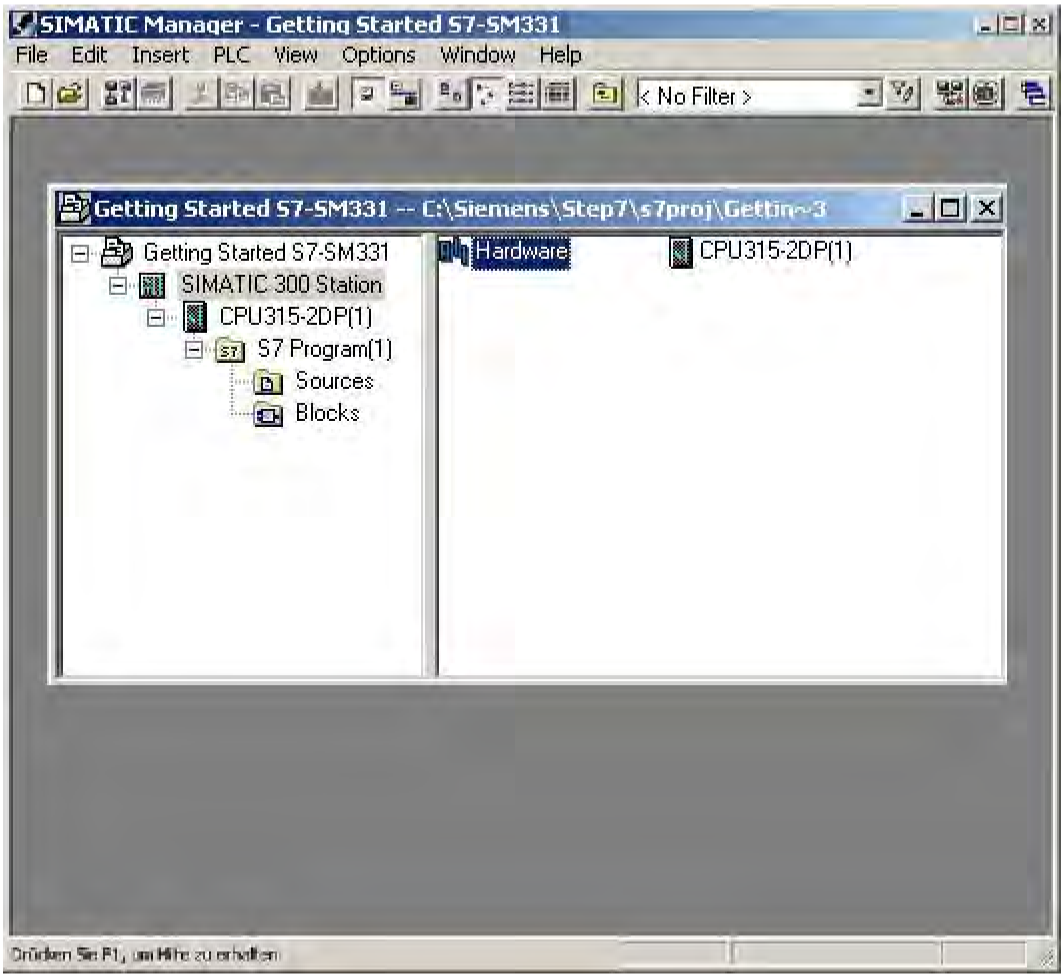


Figure 6-7 Opening the hardware configuration

6.2.2 Adding SIMATIC components

Proceed as follows

First select a power supply module from the hardware catalog.

If the hardware catalog is not visible, open it with the shortcut key Ctrl+K or by clicking the catalog icon (blue arrow).

In the hardware catalog you can browse through the folder SIMATIC 300 to the folder PS-300.

Select the PS307 5A and drag it into slot 1 (see red arrow).

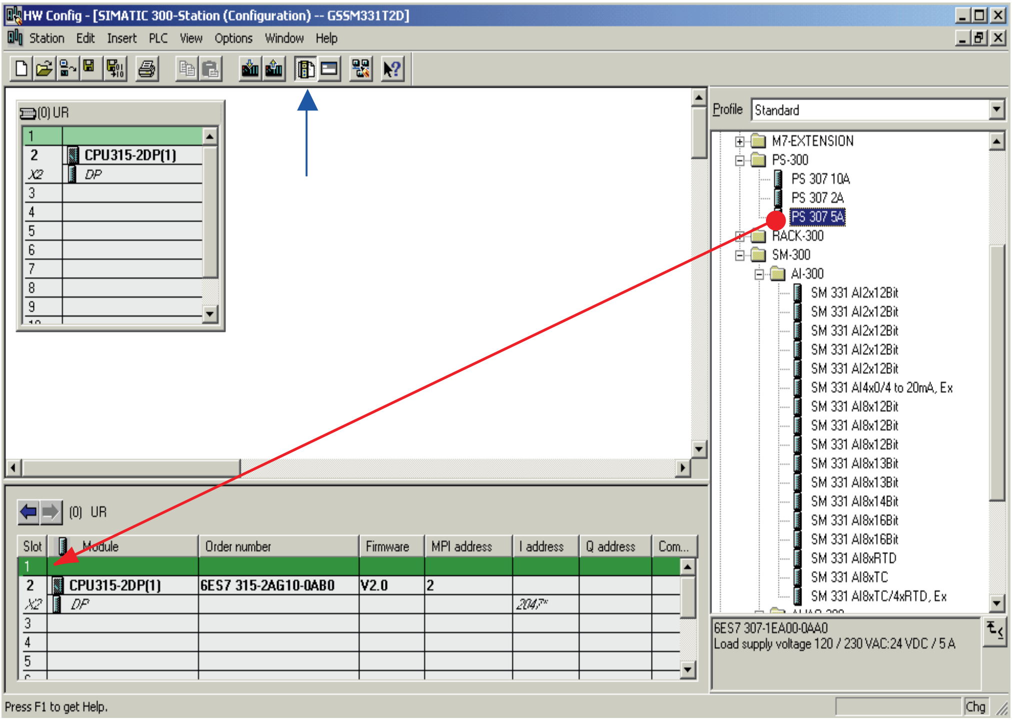


Figure 6-8 Hardware configuration: Basic configuration

Result: PS 307 5A appears in the configuration of your rack.

Inserting an analog module

There are many SM331 analog modules. For this project we use an SM331, AI8x12 bit with the order number 6ES7 331-7KF02-0AB0.

The order number is displayed at the bottom of the hardware catalog (see blue arrow).

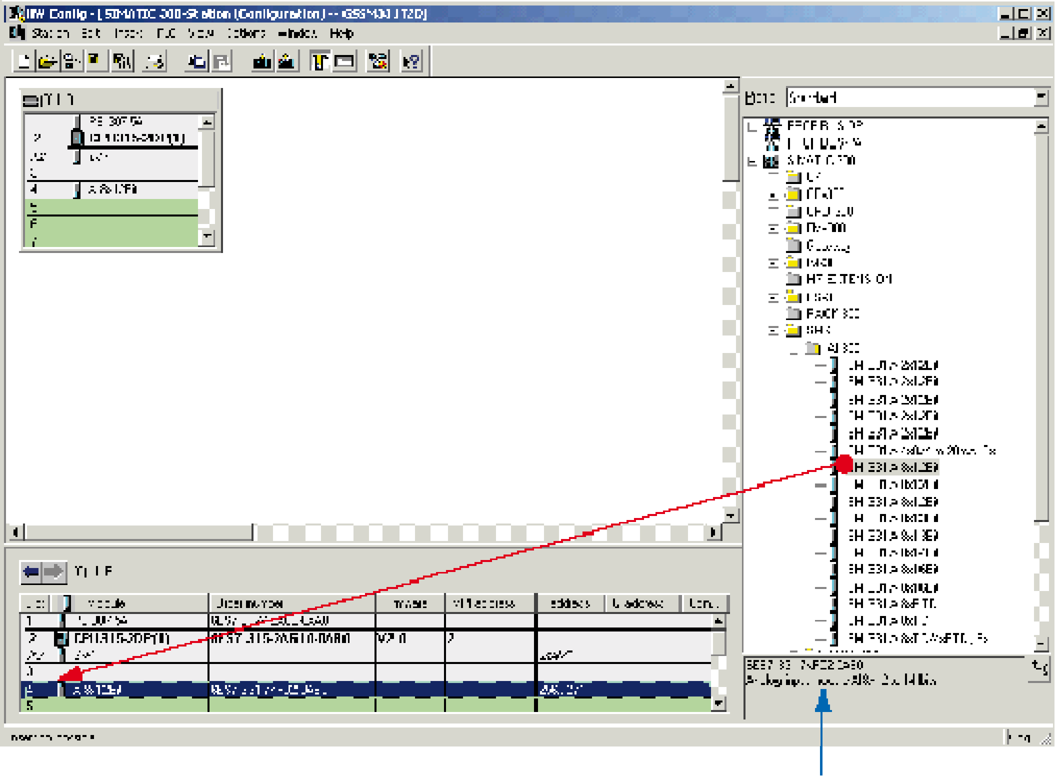


Figure 6-9 Hardware configuration: SM331 insert

Drag the module into the first available field at slot 4 of your rack (see red arrow).

You have inserted all the modules into the hardware configuration. In the next step, you configure the modules.

6.2.3 Configuring the analog module

Overview

SIMATIC Manager inserts the analog module with its default settings. You can modify the parameters to change the sensor types, diagnostics and interrupt capabilities.

Mounting the example station

The table shows, which parameters have to be set for our example station.

SM331 functions of the example station

Functions	Description
Process reactions	• Diagnostics – enabled • Hardware interrupt when limit exceeded - enabled
Encoder 1	• 2-Wire current transducer • Group diagnostics • Check for wire break • Measuring range 6 mA and 18 mA
Encoder 2 & 3	• 4-Wire current transducer • Group diagnostics • Wire break monitoring • Limit values 6 mA and 18 mA

Opening the configuration

Double-click on slot 4 that has the SM331 in it.

Select the "Inputs" tab.

Configure the following functions:

- Diagnostic interrupt enabled
- Hardware interrupt enabled
- Input 0-1:
  - Type of measurement: 2DMU
  - Group diagnostics enabled
  - Wire break enabled
- Input 2-3:
  - Type of measurement: 4DMU
  - Group diagnostics enabled
  - Wire break enabled

- Input 4-5 and 6-7
  - Type of measurement: Disabled (- - -)
- Interference frequency
  - Select your power frequency (50 Hz or 60 Hz)
- Hardware interrupt trigger
  - Upper limit value 18 mA
  - Lower limit value 6 mA

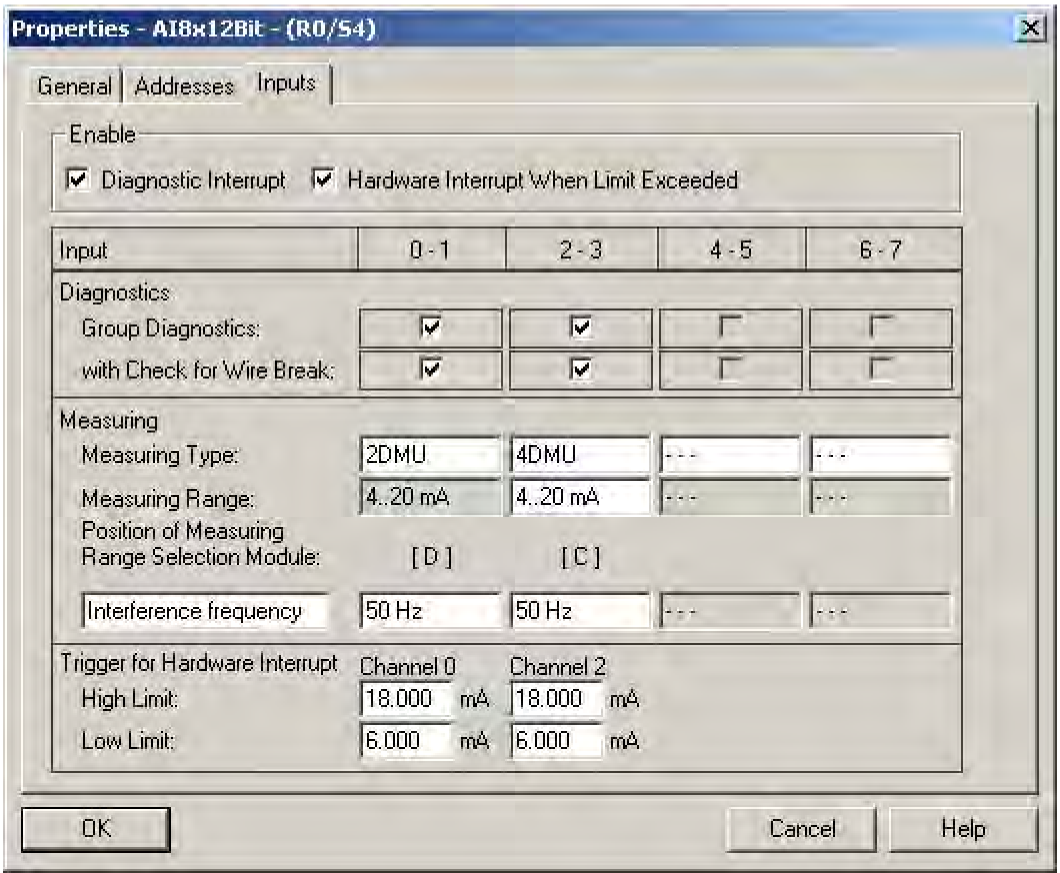


Figure 6-10 SM331: Configuration

Explanation of the individual settings

Measuring type:

2DMU and 4DMU stand for 2-wire and 4-wire current transducers

- - - means that the channels are deactivated. If you deactivate channels, the remaining channels are processed faster.

Measuring range modules

The required setting of the measuring range module is displayed.

Interference frequency (Interference frequency suppression)

The frequency of your AC power system can interfere with the measured value, particularly when measuring in low voltage ranges and using thermocouple elements. With this parameter you specify the frequency of your power supply on site.

This parameter also influences the granularity, integration time and the basic execution period of the channel group.

- Resolution (accuracy)

  The analog value is stored in a 16-bit word.

- Integration time

  The module requires a certain amount of time to measure the analog signal. This time is called integration time. The higher the required accuracy is, the longer the module needs for measuring the voltage.

- Basic processing time

  Besides the integration time, the module also needs a certain amount of time to provide the binary value.

  Relationship between accuracy, interference frequency and integration period

Resolution	Interference frequency	Integration time	Basic processing time
9 bits	400 Hz	2.5 ms	24 ms
12 bits	60 Hz	16.6 ms	136 ms
12 bits	20 Hz	20 ms	176 ms
14 bits	10 Hz	100 ms	816 ms

Hardware interrupt:

Only the channels 0 and 2 have hardware interrupt capabilities. You can use hardware interrupts to trigger an alarm when the analog signal exceeds its high or low limit.

Finish the hardware configuration:

Close the window with the configuration.

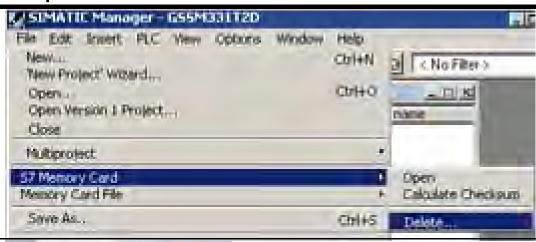
Compile and save the project with the command Station > Save and Compile (Ctrl+S)

This completes your hardware configuration for the project.

6.2.4 Test

Proceed as follows

For testing, do a power up test and download the system data.

Step	Graphic controller	Description
1		Erase your Micro Memory Card with a Power PG or a PC with external programming device: In SIMATIC Manager click "File -> S7 Memory Card > Delete …". The MCC will be deleted.
2		Switch off the power supply to the CPU. Insert the MMC into the CPU. Switch on the power supply.
3		If the CPU is in RUN mode, set it to STOP mode.
4		Switch the power supply on again. If the STOP LED blinks, the CPU requests a reset. Acknowledge this by turning the mode switch to MRES for a moment.
5		Connect the CPU to the PG with an MPI cable. To do this, connect the MPI cable with the CPU's MPI port. Connect the other end to the PG interface of your programming device.

Downloading hardware configuration

Download the hardware configuration into the CPU with HW Config.

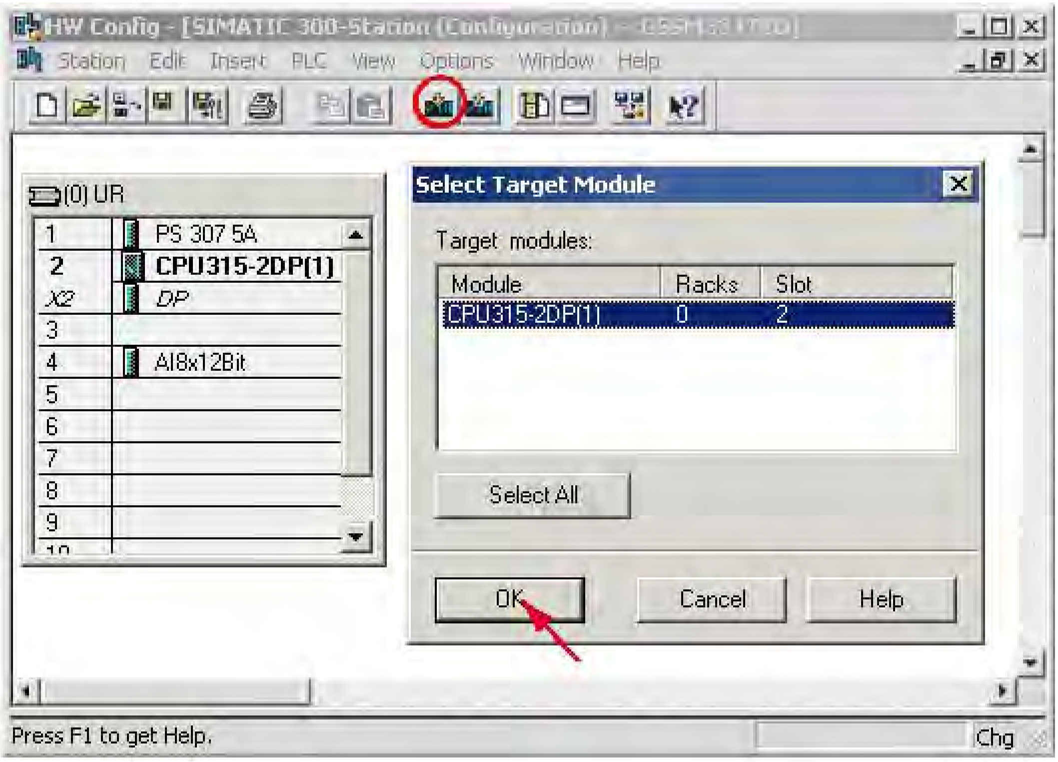


Figure 6-11 Download CPU hardware configuration (1)

Click the "Load to module" icon (shown in the red circle).

When the dialog window "Select target module" appears, click OK.

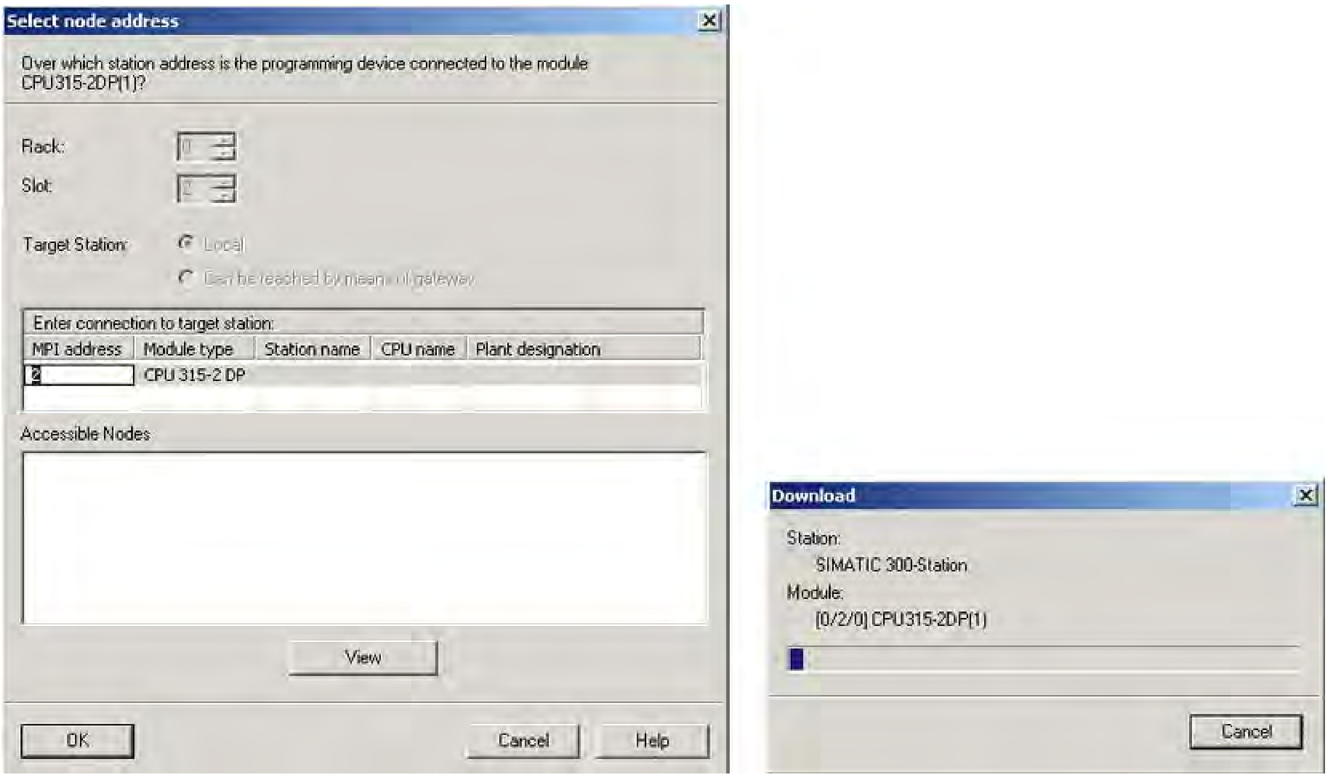


Figure 6-12 Download CPU hardware configuration (2)

The dialog window "Select target address" is shown. Click "OK." The system data will now be transferred to the CPU.

Starting the CPU

Switch the CPU to RUN.

If the hardware configuration was undertaken correctly, two red LEDs (RUN and DC5V) should be lit on the CPU.

Figure 6-13 CPU in error free state

6.3 STEP 7 user program

6.3.1 Tasks of the user program

Overview

In our example, the sensor values are stored in a data block. Also, the hardware interrupt status should be stored in a marker word. It should be possible to acknowledge the status information by means of a bit.

Furthermore, the channel values (values of the input words) should be stored in another data block.

The following tasks have to be performed in the user program:

- Cyclical storage of the analog input values in a data block (DB1)
- Cyclical conversion of the analog input values in floating point values (FC1) and storage in a data block (DB2)
- Acknowledgement of the hardware interrupt status when the acknowledge marker (M200.0) is TRUE.
- Save the status in a marker word (MW100) when a hardware interrupt occurs.

The structure of the user program is depicted in the following table:

Call type	Responsible organization block	Task to be programmed	Used block or marker
Cyclic execution	OB1	Save analog input values	DB1
		Convert and store the sensor values	FC1, DB2
		Acknowledge hardware interrupt	M200.0
Hardware interrupt triggered call	OB40	Save status	MW100
Diagnostic interrupt triggered call	OB82	Has to be implemented because a module with diagnostic capabilities is used	---

About OB82

OB82 is used for modules with diagnostic capabilities. If the diagnostic alarm is enabled for such modules, OB82 requests for diagnoses when a failure is detected (incoming and outgoing events). The operating system then calls OB 82.

In our example, we use OB82 to prevent the CPU from changing to STOP mode. You can program reactions to diagnostic interrupts in OB82.

6.3.2 Creating a user program

Proceed as follows

There are two ways to create a user program.

- If you know how to program STEP7 SCL, then you can create and program the necessary blocks and the function blocks in the Blocks folder of STEP7.
- You can insert the user program from an SCL source into the project. In this “Getting started” we describe this method.

Creating a user program in STEP7 requires three steps:

1. Downloading the source file directly from the HTML page
2. Importing a source file
3. Compiling the source

Downloading the source file

You can download the source file directly from the HTML page from which you loaded this “Getting Started”.

The German version of the source file has the name "GSSM331T1DE.AWL".

Save the source file to your hard drive.

Importing a source file

You can import the source file into SIMATIC Manager as follows:

Right click the folder "Sources".

Select "Insert new Object > External Source...".

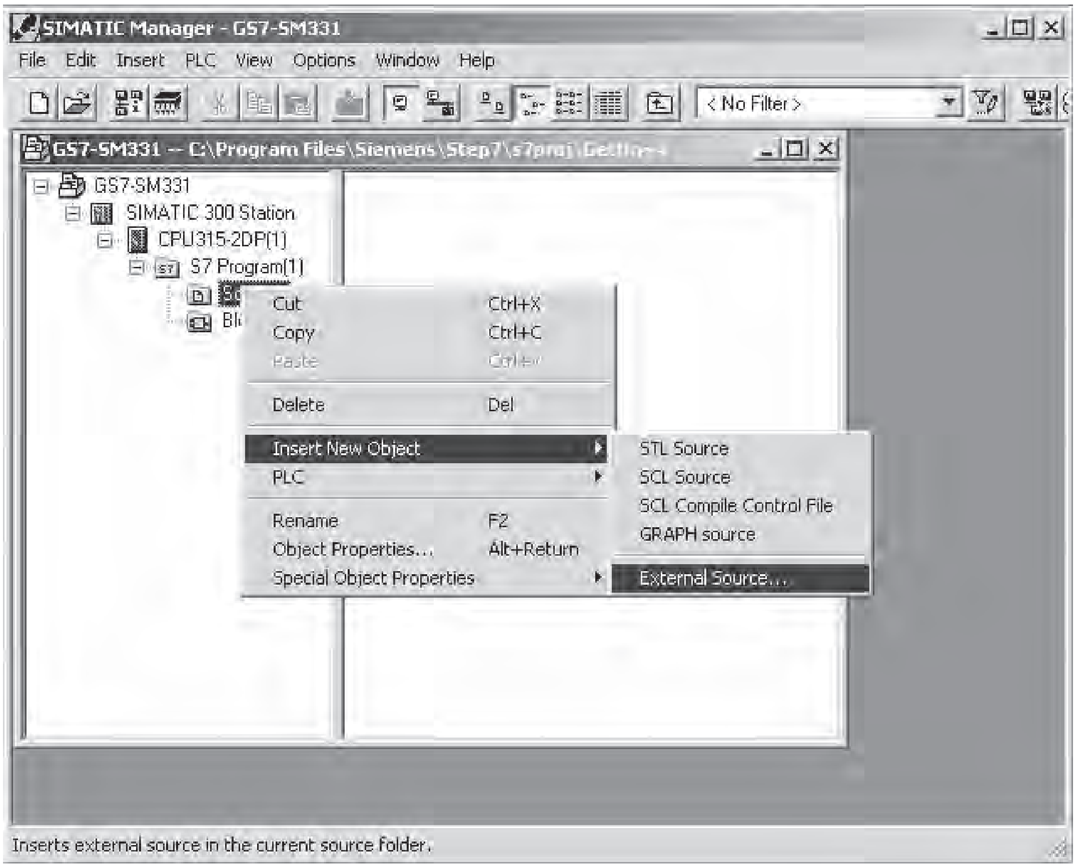


Figure 6-14 Importing an external source

In the "Insert external source" dialog browse for the source file GSSM331T1DE.AWL, which you have already downloaded and saved on your hard disk.

Select the source file GSSM331T1DE.AWL (red arrow).

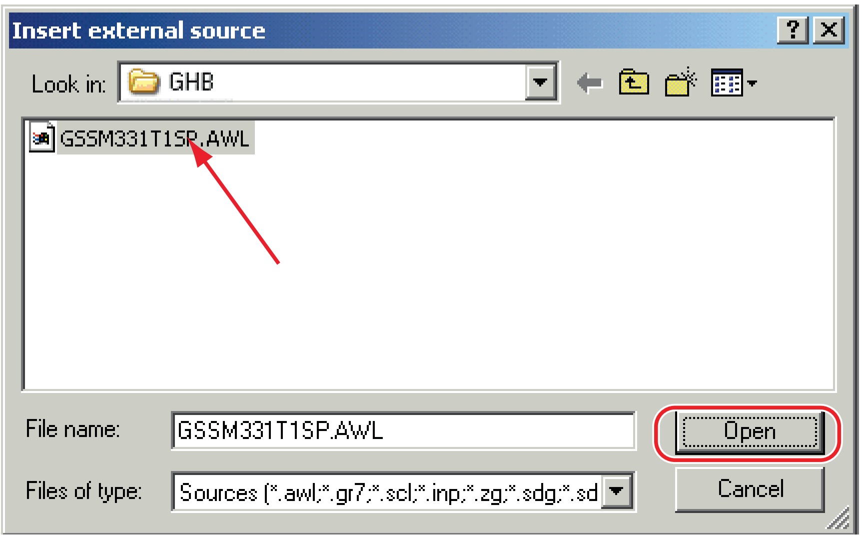


Figure 6-15 Importing an external source

Click "Open".

SIMATIC Manager has opened the source file. In the right window you can see the source file inserted.

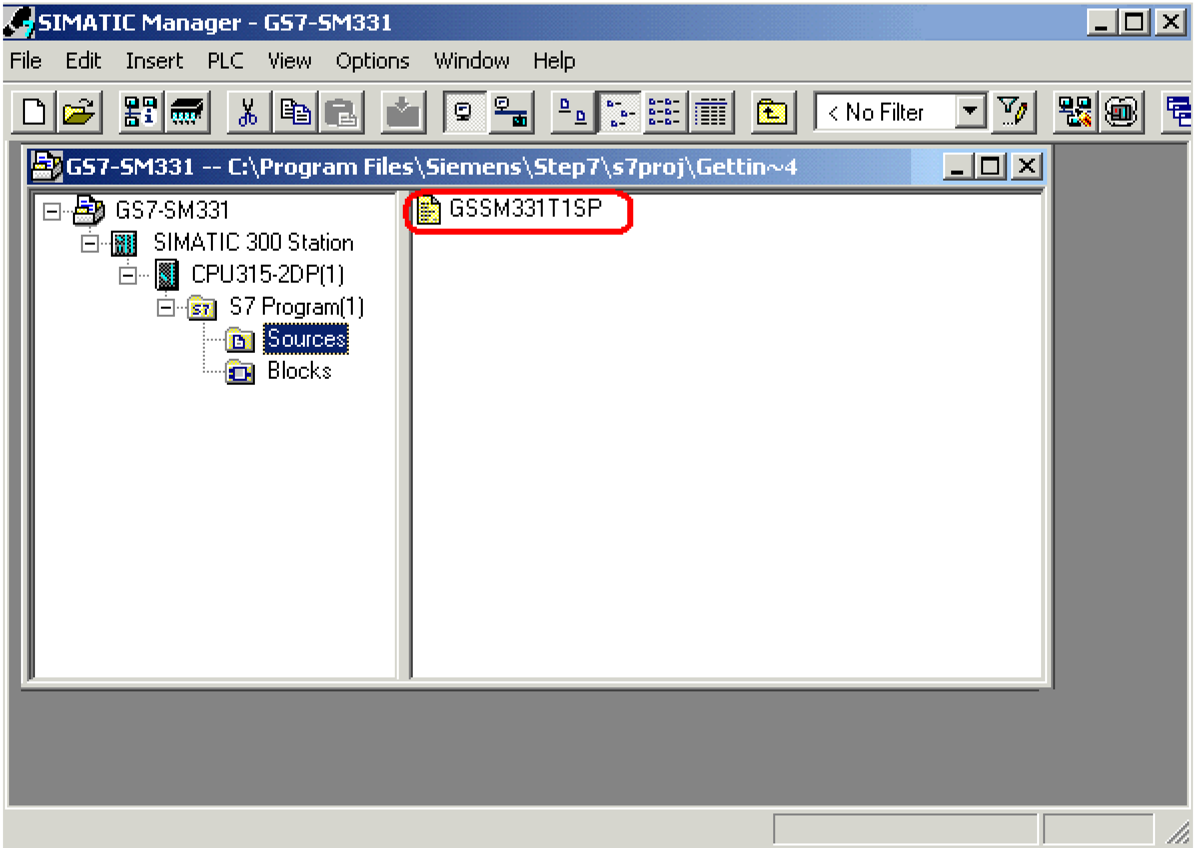


Figure 6-16 Compiling the source code

Compiling the source code

In order to create an executable STEP7 program, the STL source has to be compiled.

Double-click the source file GSSM331T1DE in the Sources folder. The source code editor opens.

In the window of the source code editor you can view the source code.

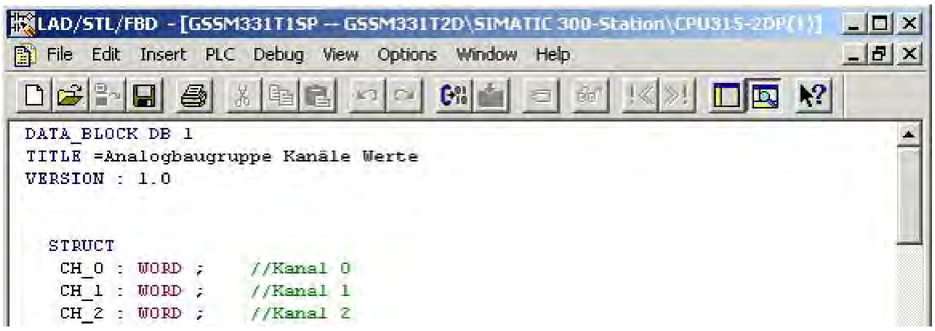


Figure 6-17 Source code editor

After the source code is loaded, start the compilation.

Press the shortcut key Ctrl+B or select File > Compile. The compilation starts immediately.

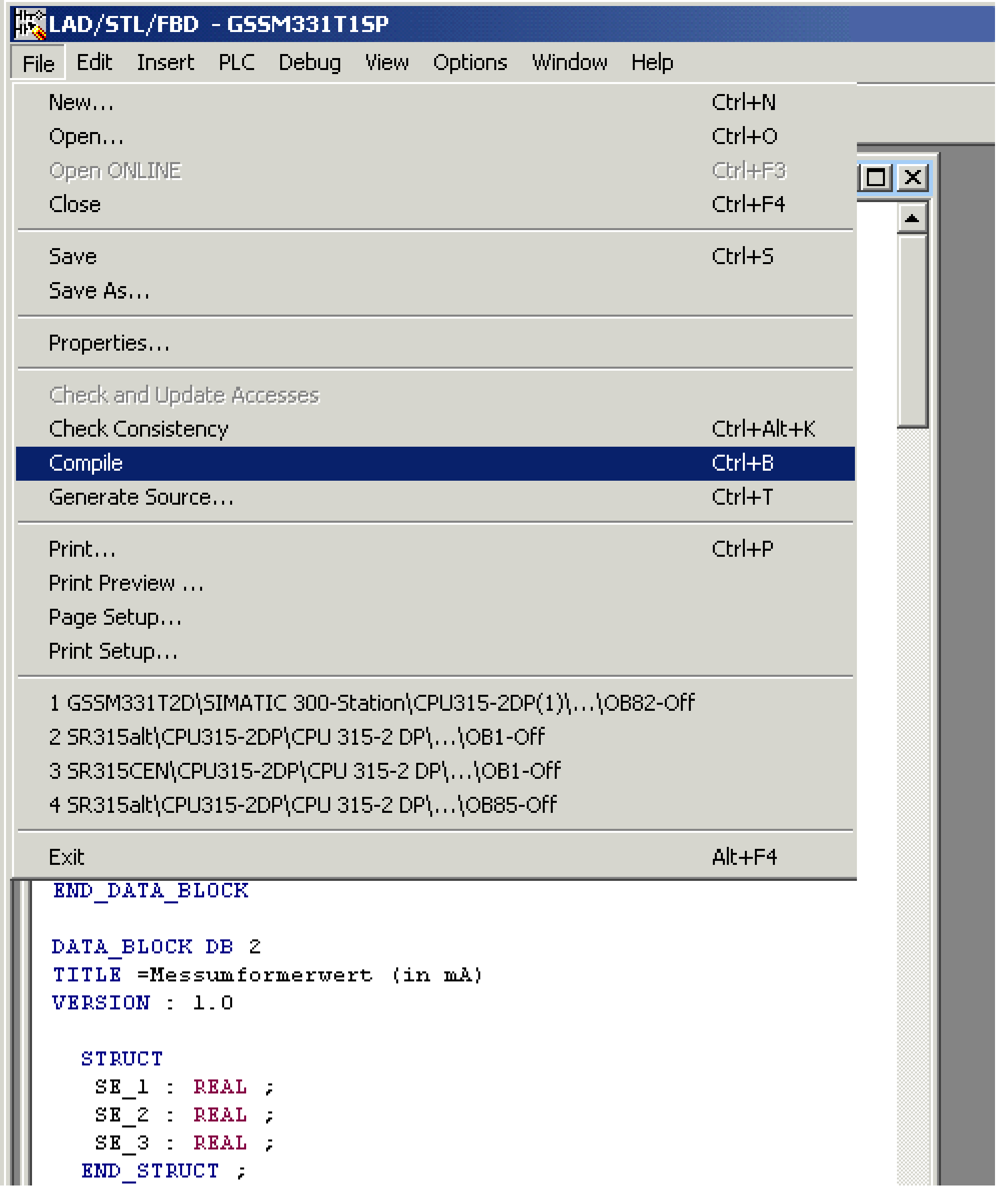


Figure 6-18 Compiling STL source

In case of warning or error messages, check the source code.

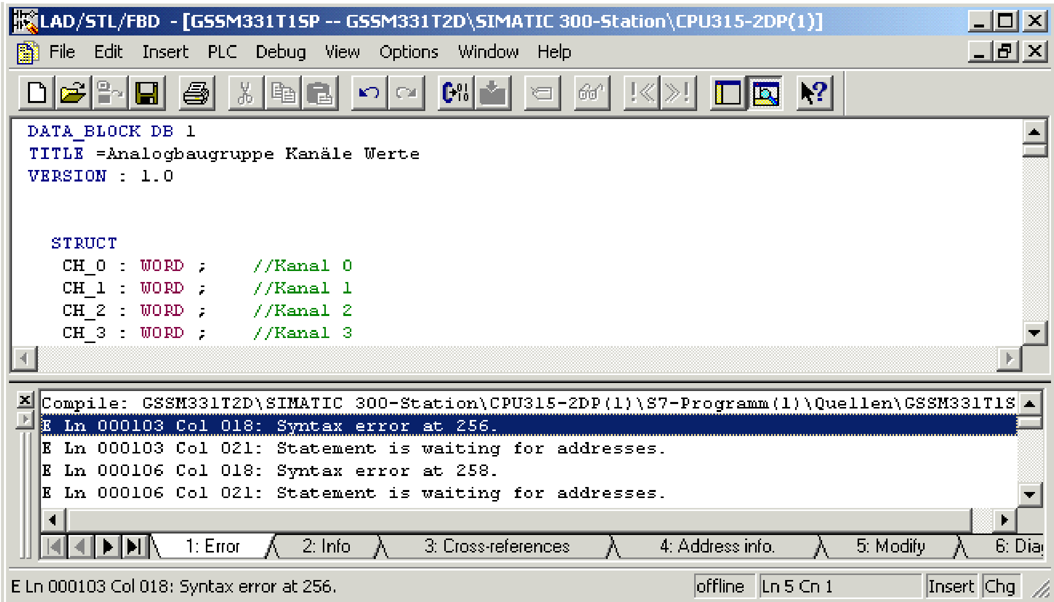


Figure 6-19 Source code editor, messages after compilation

Close the source code editor.

After compiling the STL source without errors the following blocks should appear in the Blocks folder:

OB1, OB40, OB82, FC1, DB1 and DB2

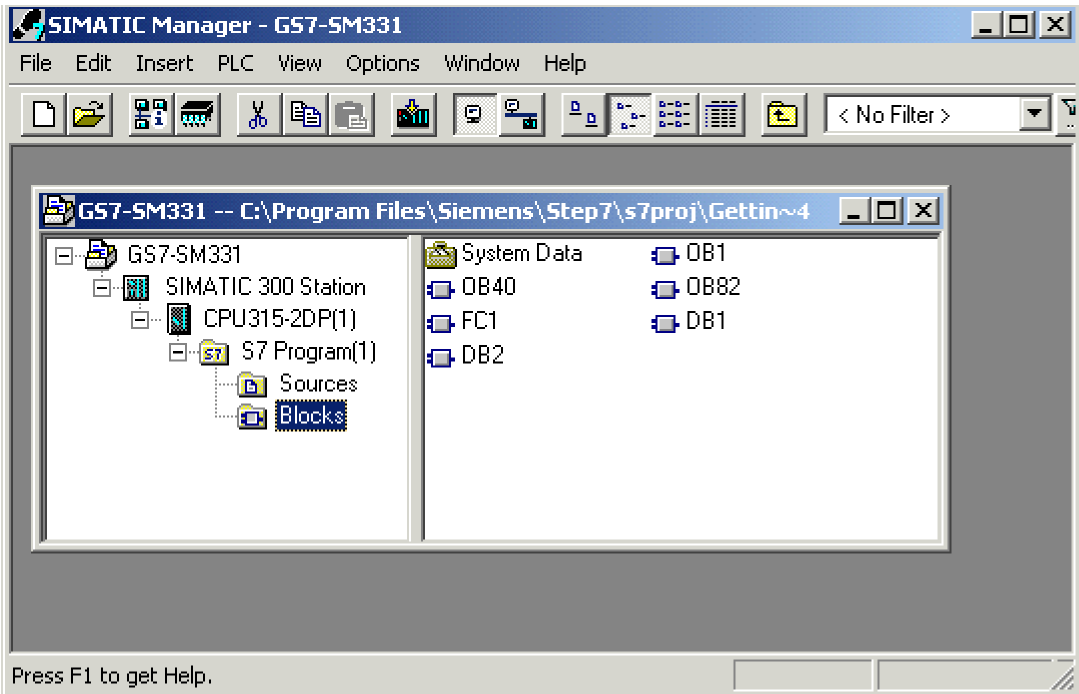


Figure 6-20 Generated blocks

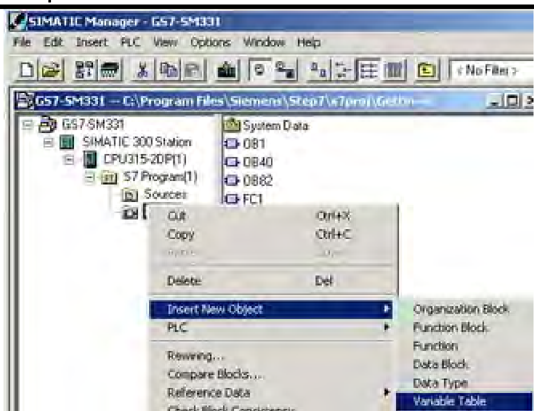
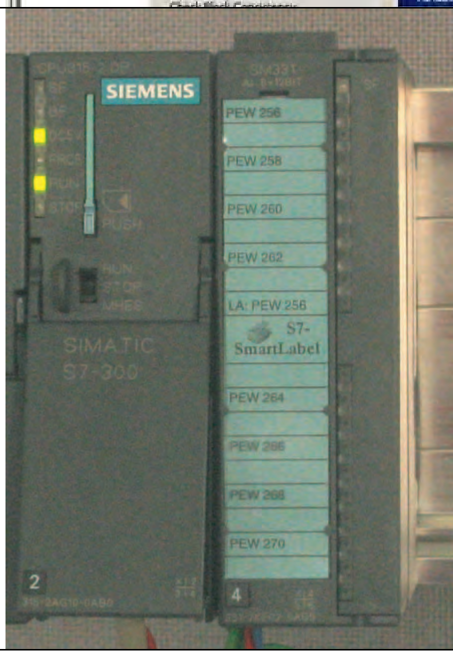
7 Testing the user program

7.1 Downloading system data and user program

Proceed as follows

The hardware and software are now ready. The next step is to download the system data and the user program into the automation system. To do this, proceed as follows:

Downloading the system data and user program

Step	Graphic controller	Description
1		Using the SIMATIC Manager, download the user program and the system data (containing the hardware configuration) into the CPU.
2		Follow the instructions displayed on the screen. If all sensors are properly connected, the CPU and the SM331 do not display an error light. The status of the CPU is displayed by the green "RUN" light.

Smart Label

The labeling strips for the modules were created with Siemens S7 Smart Label (order no: 2XV9 450-1SL01-0YX0).

A labeling strip in its actual size:

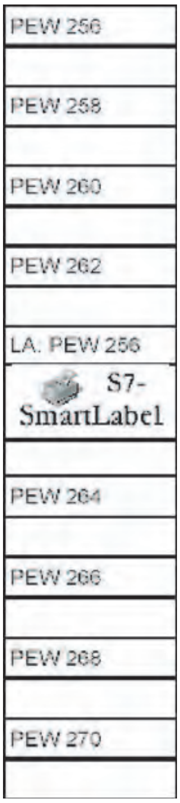


Figure 7-1 S7-SmartLabel labeling strip for the example

7.2 Visualization of the sensor values

Proceed as follows

In order to visualize the sensor values, insert a variable table as follows into the project. To do this, select from the context menu of the Blocks folder:

Insert new object > Variable Table

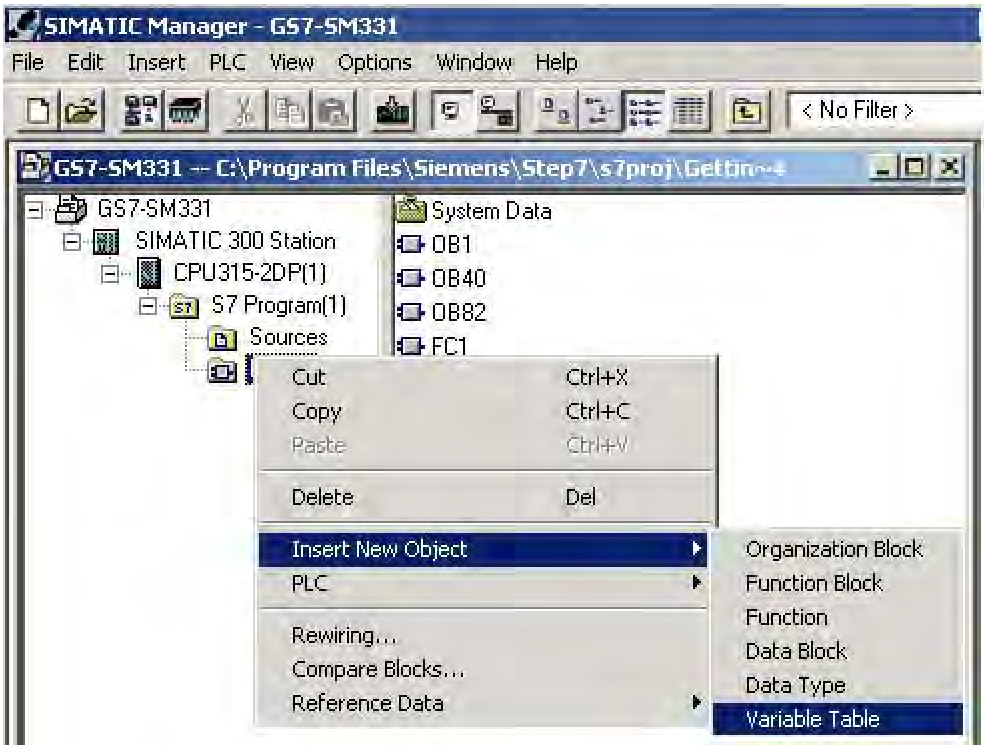
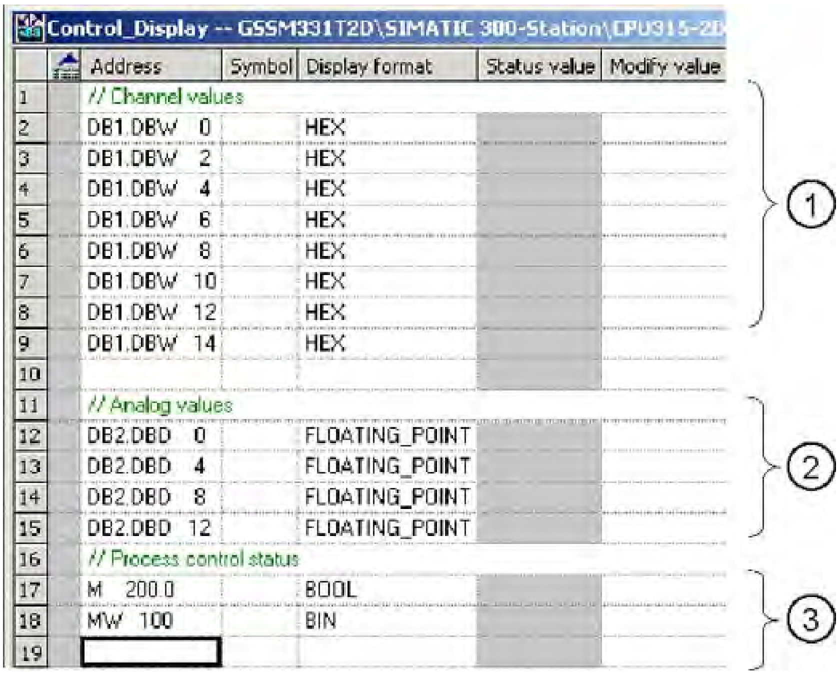


Figure 7-2 Insert Variable Table

Fill the new variable table as follows:



Control_Display -- GSSM331T2D\SIMATIC 300-Station\CPU315-2D

	Address	Symbol	Display format	Status value	Modify value
1	// Channel values				
2	DB1.DBW 0		HEX		
3	DB1.DBW 2		HEX		
4	DB1.DBW 4		HEX		
5	DB1.DBW 6		HEX		
6	DB1.DBW 8		HEX		
7	DB1.DBW 10		HEX		
8	DB1.DBW 12		HEX		
9	DB1.DBW 14		HEX		
10					
11	// Analog values				
12	DB2.DBD 0		FLOATING_POINT		
13	DB2.DBD 4		FLOATING_POINT		
14	DB2.DBD 8		FLOATING_POINT		
15	DB2.DBD 12		FLOATING_POINT		
16	// Process control status				
17	M 200.0		BOOL		
18	MW 100		BIN		
19					

(1) In this area you can monitor the channel values

(2) In this area you can see the analog values

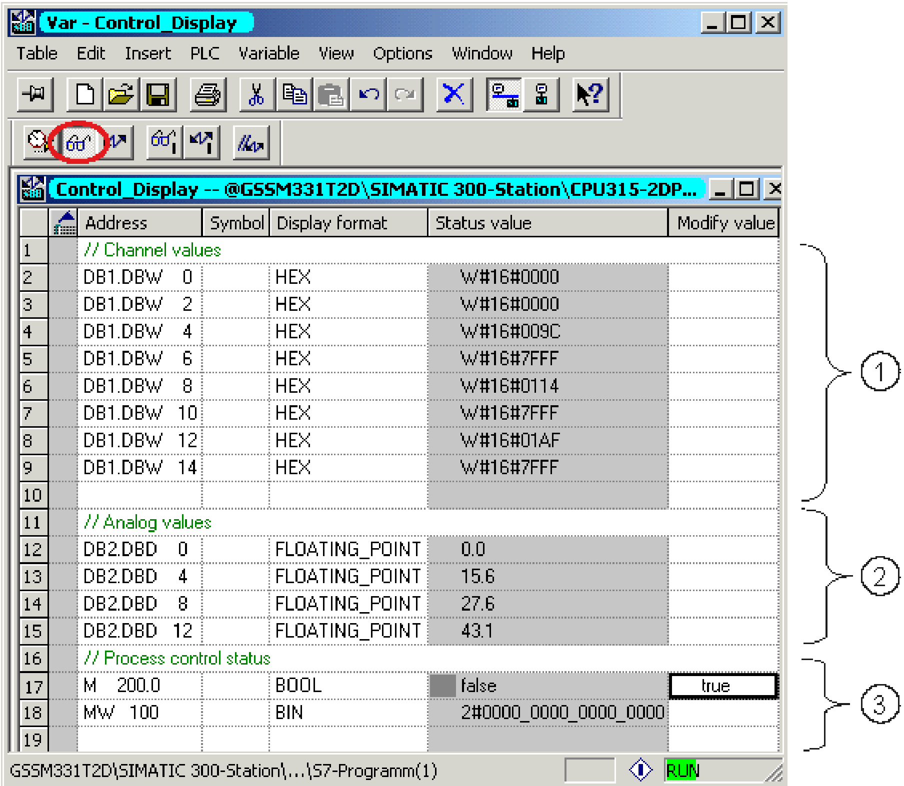
(3) In this area you can monitor and control the status signals

Variable description

Variables	Description
DB1.DBW 0	Channel 0 Display of analog value
DB1.DBW 2	Channel 1 Display of analog value
DB1.DBW 4	Channel 2 Display of analog value
DB1.DBW 6	Channel 3 Display of analog value
DB1.DBW 8	Channel 4 Display of analog value
DB1.DBW 10	Channel 5 Display of analog value
DB1.DBW 12	Channel 6 Display of analog value
DB1.DBW 14	Channel 7 Display of analog value
DB2.DBD 0	Transducer1 current (mA)
DB2.DBD 4	Transducer2 current (mA)
DB2.DBD 8	Transducer3 current (mA)
MW 100	Status hardware interrupt
MW 200.0	Acknowledge hardware interrupt
M101.0	Channel 0 exceeded low limit
M101.1	Channel 0 exceeded high limit
M101.2	Channel 2 exceeded low limit
M101.3	Channel 0 exceeded high limit

Monitoring values

In order to monitor values, open the online view of the controller by clicking the eye glasses symbol. Now you can monitor the values in the data blocks and markers.



(1) Channel values in hex format

(2) Converted analog value

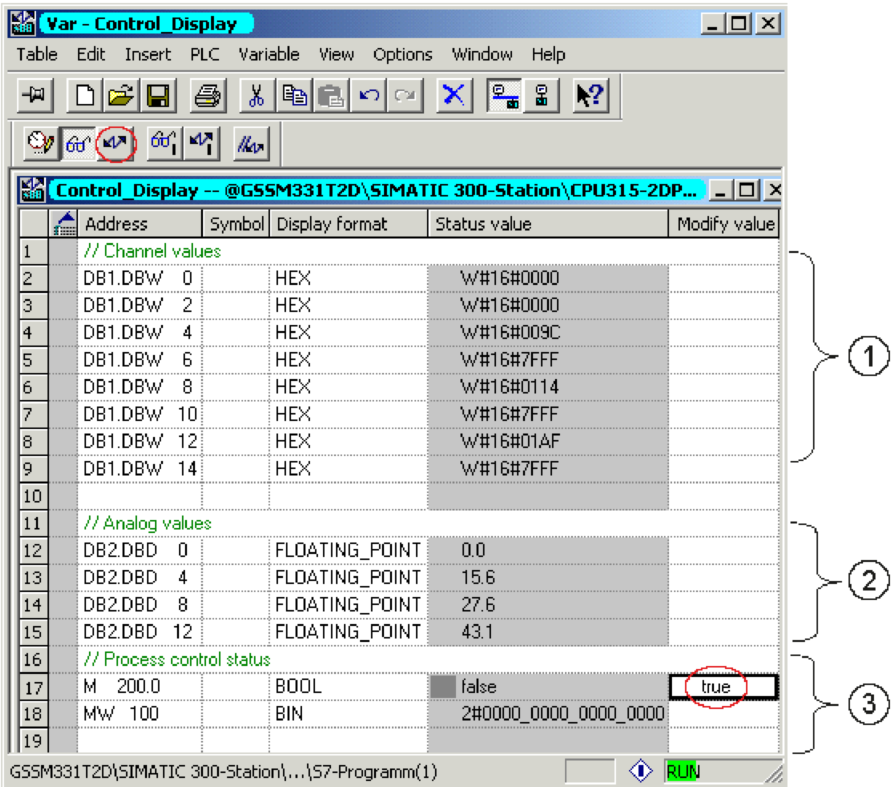
(3) Status information

Figure 7-3 Online view of the variable table

Controlling values

To control the process acknowledgement, enter the desired value (TRUE or FALSE, depending on whether you want to activate or deactivate acknowledgement) into the column "Control Value" and click the icon with the two arrows.

Controlling variables



(1) Channel value

(2) Analog value

(3) Status

Peculiarity in monitoring the values

While monitoring the values you will surely notice that the channel values are different from the analog values. The reason for this is that the analog module only supports the binary format “Word” (16 bits). Therefore, the values of the analog module have to be converted.

7.3 Analog value representation

Proceed as follows

The analog values are only processed by the CPU in binary form. Analog input modules convert the analog process signal into a digital format (16 bit word).

Five ranges have to be taken into account when converting from digital to analog values:

Representation of analog values in current measuring ranges 4 to 20 mA

Hex value	Current range	Comment	Meaning
7FFF	22.96 mA	Overflow	From hex value 16#F700 on, the sensor value is above the configured measurement value range and is no more valid.
7F00			
7EFF	22.81 mA	Overload range	This range corresponds to a tolerance band before the overflow range is reached. Within this range the resolution is not optimal though.
6C01			
6C00	20 mA	Rated range	The nominal range is the normal range for recording measurement values. This range guarantees optimal resolution.
5100	15 mA		
1	4 mA + 578.7 nA		
0	4 mA		
FFFF		Underload range	Range corresponding to the overload range but for low values.
ED00	1.185 mA		
ECFF		Underflow	From hex value 16#ECFF on, the sensor value is below the configured measurement value range and is no more valid.
8000			

It is necessary to convert the binary format of the values in order to display analog process values. In our example, mA are displayed. This is done by converting the display of analog values in mA in a programmed function (FC1).

Note

In our example, we look at the values from the output of the transducer.

Using a amperemeter, you can now compare the values on the meter with the values of the analog values display. The values will be identical.

Diagnostic interrupt 8

8.1 Reading diagnostic information from a PG

Overview

Diagnostic interrupts enable the user program to react to hardware errors.

Modules must have diagnostic capabilities in order to generate diagnostic interrupts.

In OB82 you program the reaction to diagnostic interrupts.

Display

The analog input module SM331 AI8x12 has diagnostic capabilities.

Diagnostic interrupts that occur are signaled by the red "SF" LED on the SM331 and on the CPU.

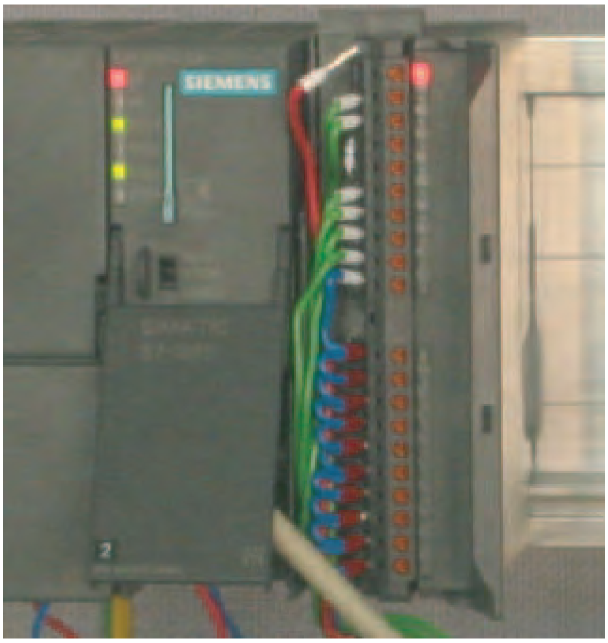


Figure 8-1 Hardware error

The cause of the error can be determined "online" by requesting the hardware status.

In order to determine the state of module "online", proceed as follows:

Select the SM331 in the hardware configuration. Click the menu command CPU -> Module Information... in order to perform a hardware diagnostics.

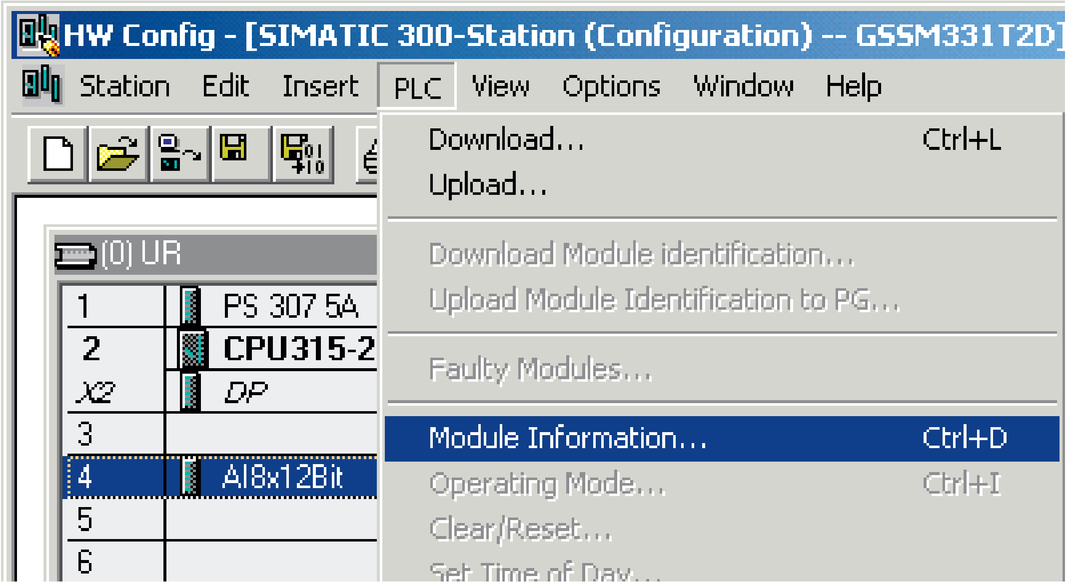


Figure 8-2 Module status

8.2 General diagnostics

Diagnostic interrupt tab

On the Diagnostic Interrupt tab you will find information for the reported error.

The interrupts are not channel dependent and apply to the entire module.

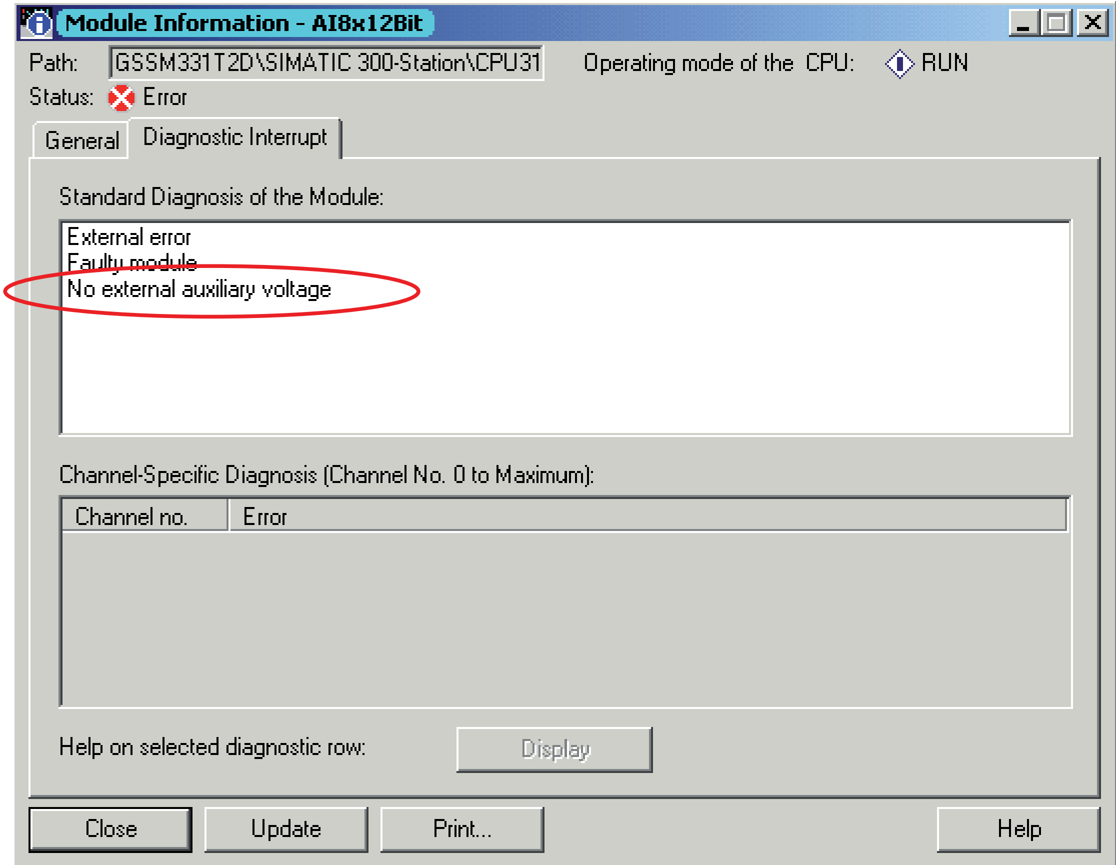


Figure 8-3 Diagnostics for SM331

8.3 Channel dependent diagnostic interrupts

8.3.1 There are five channel dependent diagnostic interrupts

There are five channel dependent diagnostic interrupts:

- Configuration / programming error
- Common mode error
- Wire break
- Underflow
- Overflow

Note

Here we show you only the channel specific diagnostics for the measuring modes 2 or 4-wire current transducers. Other measuring modes are similar but not described here.

8.3.2 Configuration / programming error

Meaning

The position of the measuring range modules does not match the measuring mode set in the hardware configuration.

8.3.3 Common mode error

Meaning

The voltage difference U_{cm} between the inputs (M-) and the common voltage potential of the measuring circuit (M_{ana}) is too high.

In our example, this error cannot occur because M_{ana} is connected to M for a 2-wire transducer (fixed potential).

8.3.4 Wire break

Meaning

If wire break detection is enabled for 2-wire transducers, there will be no direct check for a wire break. The diagnostics instead reacts on the shortfall of the low limit current value.

With 4 to 20 mA current transducer, the diagnostic message “Analog input wire break“ is shown in the module diagnostics when the current goes below 3.6 mA.

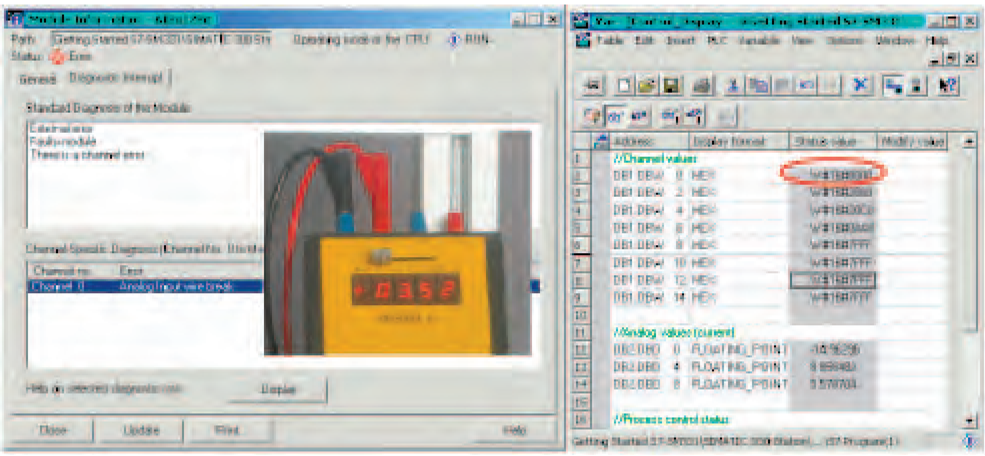


Figure 8-4 Left: Diagnostic message with wire break / Right: Variable table

The display of the analog values shows an underflow (Hex 8000) immediately even if the current measured is clearly above 1.1185 mA.

Underloading 3.6 mA is only possible if wire break detection has been disabled.

8.3.5 Underflow

Meaning

The display of the analog values shows an underflow immediately even if the current measured is clearly above 1.1185 mA.

8.3.6 Overflow

Meaning

If the current exceeds 22.81 mA, an overflow message stating "Analog in-put measuring range / High limit exceeded" is displayed.

The display of the analog value (HEX 7FFF) is in the overflow range.

Figure 8-5 Left: Diagnostic message with overflow / Right: Variable table

---

Note

Disabled channels also have 7FFF hex as the analog display value.

---

9 Hardware interrupt

9.1 Hardware interrupt

Overview

A special feature of the SM331 AI8x12bit is its capability to trigger hardware interrupts. Two channels (0 and 2) can be correspondingly configured.

Hardware interrupts generally trigger alarm organization blocks in the CPU. In our example, OB40 is called.

The limit values for hardware interrupts have to be specified in mA.

Example:

You have connected a pressure sensor with a 4-20mA transducer to channel 0. Here the limit values should be specified in mA and not in Pascal (Pa).

limit values

In order to trigger a hardware interrupt, the limit values have to be within the nominal values of the measuring mode.

Example:

If wire break detection (3.6 mA) is enabled, and you choose 3.5 mA for the low limit value, this setting is accepted by the system. A hardware interrupt will not be triggered because the diagnostic alarm is always triggered first.

In our example, 2 channels (sensor 1 and 2) are configured with the following limits:

- Lower limit value 6 mA
- Upper limit value 18 mA

Determining functions

If a hardware interrupt occurs, OB40 is called. In the user program of OB40 you can program the reaction of the automation system to hardware interrupts.

In the example user program, OB40 reads the cause of the hardware interrupt. This can be found in the temporary variable structure OB40_POINT_ADDR (local words 8 to 11).

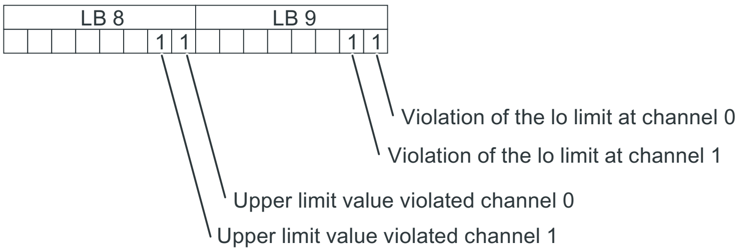


Figure 9-1 OB40 start information: In the example, and triggered a hardware interrupt

In the example, OB40 only transfers LD8 and LD9 into a marker word (MW100). The marker word is monitored in the existing variable table. You can acknowledge the marker word in OB1 by setting marker bit M200.0 or by setting it to TRUE in the variable table.

If you supply 5.71 mA with a calibration device to channel 0, you will get the value 0001 hex for MW100 in the variable table. This means that OB40 was called and channel 0 exceeded its low limit value (6 mA).

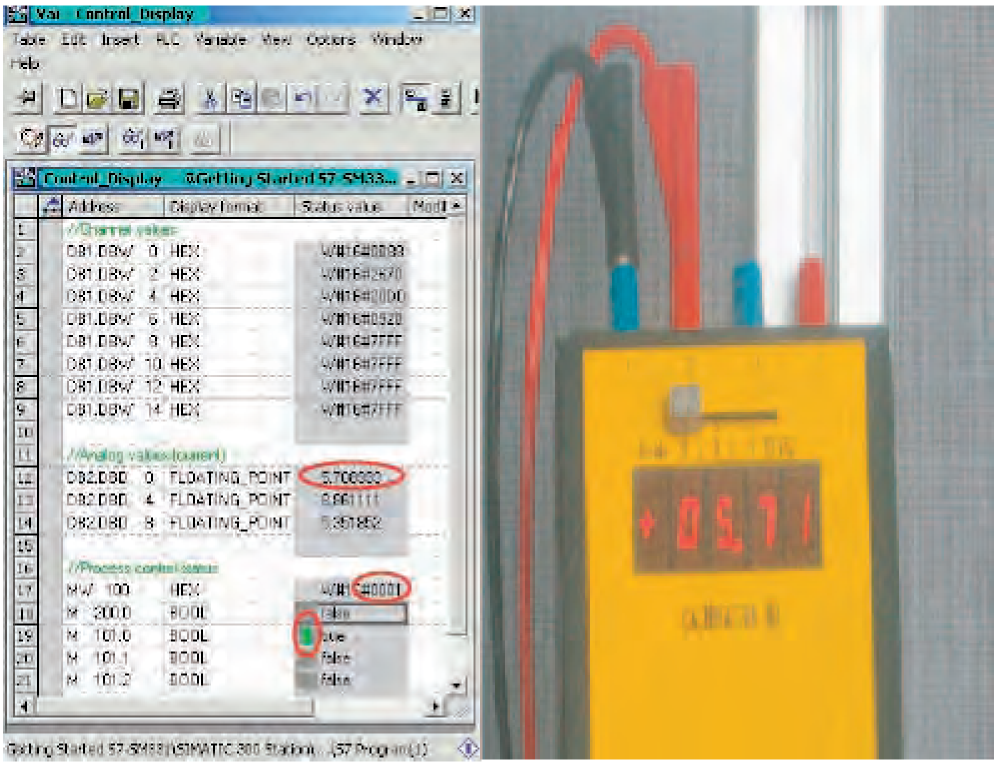


Figure 9-2 Hardware interrupt: Channel 0 exceeded low limit value

Appendix A

A.1 Source of the user program

STL source code

In this section you find the source code of the user program from the example.

You can download the source file directly from the HTML page from which you loaded this "Getting Started".

```
DATA_BLOCK DB 1
TITLE =Analog module channel values
VERSION : 1.0
   STRUCT
       CH_0 : WORD ; //Channel 0
       CH_1 : WORD ; //Channel 1
       CH_2 : WORD ; //Channel 2
       CH_3 : WORD ; //Channel 3
       CH_4 : WORD ; //Channel 4
       CH_5 : WORD ; //Channel 5
       CH_6 : WORD ; //Channel 6
       CH_7 : WORD ; //Channel 7
   END_STRUCT ;
BEGIN
       CH_0 := W#16#0;
       CH_1 := W#16#0;
       CH_2 := W#16#0;
       CH_3 := W#16#0;
       CH_4 := W#16#0;
       CH_5 := W#16#0;
       CH_6 := W#16#0;
       CH_7 := W#16#0;
END_DATA_BLOCK

DATA_BLOCK DB 2
TITLE =Current transducer (in mA)
VERSION : 1.0

   STRUCT
       SE_1 : REAL ;          //Sensor 1 current value (mA)
       SE_2 : REAL ;          //Sensor 2 current value (mA)
       SE_3 : REAL ;          //Sensor 3 current value (mA)
   END_STRUCT ;
```

```
BEGIN
       .SE_1 := 0.000000e+000;
       SE_2 := 0.000000e+000;
       SE_3 := 0.000000e+000;
END_DATA_BLOCK

FUNCTION FC 1 : VOID
TITLE =Conversion of a channel's raw values in mA
VERSION : 1.0

VAR_INPUT
   Raw : WORD ;              // Analog value display
END_VAR
VAR_OUTPUT
       Current : REAL ;      // Current in mA
END_VAR
VAR_TEMP
   TDoubleInt : DINT ;
   TInt : INT;
END_VAR
BEGIN
NETWORK
TITLE = Conversion of raw values in mA

          L   #Raw;
          T   #TInt;
// Only long integers can be converted into REAL format
          L    #TInt;
          ITD  ;
          T    #TDoubleInt;
          L    #TDoubleInt;       //               HEX value
          DTR  ;                  // Current =     ---------------
          T    #Current;          //               1728
          L    1.728000e+003;     //               !        /
          /R   ;                  //               !        /
          T    #Current;          //               !        /
                                  // -------       +-----   /------    +----
                                  //                        4          20
          L    4.000000e+000;     // Offset correction
          +R   ;
          T    #Current;

END_FUNCTION
ORGANIZATION_BLOCK OB 1
TITLE = "Main Program Sweep (Cycle)"
VERSION : 1.0
```

```
VAR_TEMP
  OB1_EV_CLASS : BYTE ;             //Bits 0-3 = 1 (Coming event),
                                    Bits 4-7 = 1 (Event class 1)
   OB1_SCAN_1 : BYTE ;              //1 (Cold restart scan 1 of OB 1),
                                    3 (Scan 2-n of OB 1)
   OB1_PRIORITY : BYTE ;            //Priority of OB Execution
   OB1_OB_NUMBR : BYTE ;            //1 (Organization block 1, OB1)
   OB1_RESERVED_1 : BYTE ;          //Reserved for system
   OB1_RESERVED_2 : BYTE ;          //Reserved for system
   OB1_PREV_CYCLE : INT;            //Cycle time of previous OB1 scan (milliseconds)
   OB1_MIN_CYCLE : INT;             //Minimum cycle time of OB1 (milliseconds)
   OB1_MAX_CYCLE : INT;             //Minimum cycle time of OB1 (milliseconds)
   OB1_DATE_TIME : DATE_AND_TIME ;  //Date and time OB1 started
END_VAR
BEGIN
NETWORK
TITLE =Read channels
// Channel values 0 to 7 are loaded and stored in DB1 (channel values)

          L     PEW 256;              //Channel 0
          T     DB1.DBW      0;

          L     PEW 258;              //Channel 1
          T     DB1.DBW      2;

          L     PEW 260;              //Channel 2
          T     DB1.DBW      4;

          L     PEW 262;              //Channel 3
          T     DB1.DBW      6;

          L     PEW 264;              //Channel 4
          T     DB1.DBW      8;

          L     PEW 266;              //Channel 5
          T     DB1.DBW      10;

          L     PEW 268;              //Channel 6
          T     DB1.DBW      12;

          L     PEW 270;              //Channel 7
          T     DB1.DBW      14;
```

```
NETWORK
TITLE = Conversion
// Conversion of the channel's raw data into current values (mA)
          CALL  FC         1 (
                Raw                                        := DB1.DBW 0,
                Current                                    := DB2.DBD 0);
          CALL  FC         1 (
                Raw                                        := DB1.DBW 4,
                Current                                    := DB2.DBD 4);
          CALL  FC         1 (
                Raw                                        := DB1.DBW 6,
                Current                                    := DB2.DBD 8);

NETWORK
TITLE = Reset hardware interrupt
// Even though the hardware interrupt was reset by the hardware upon terminating OB40
// the value of the hardware interrupt must be reset manually
             U             M         200.0;
             SPBN          lbl0;
             L             MW        100;
             SSI           4;
             T             MW        100;
             lbl0: NOP     0;
NETWORK
TITLE =The End

             BE;

END_ORGANIZATION_BLOCK

ORGANIZATION_BLOCK OB 40
TITLE = "Hardware Interrupt"
// Processing OB40_POINT_ADDR (L8 to L11)
//
//L8 High limit value exceeded
//L9 Low limit value exceeded
VERSION : 1.0

VAR_TEMP
   OB40_EV_CLASS : BYTE ;          //Bits 0-3 = 1 (Coming event),
                                   Bits 4-7 = 1 (Event class 1)
   OB40_STRT_INF : BYTE ;          //16#41 (OB 40 has started)
   OB40_PRIORITY : BYTE ;          //Priority of OB Execution
   OB40_OB_NUMBR : BYTE ;          //40 (Organization block 40, OB40)
   OB40_RESERVED_1 : BYTE ;        //Reserved for system
   OB40_IO_FLAG : BYTE ;           //16#54 (input module), 16#55 (output module)
   OB40_MDL_ADDR : WORD ;          //Base address of module initiating interrupt
   OB40_POINT_ADDR : DWORD ;       //Interrupt status of the module
   OB40_DATE_TIME : DATE_AND_TIME  //Date and time OB40 started
   ;
```

```
END_VAR
BEGIN
NETWORK
TITLE =Sensor 1 (Channel 0): Lower limit value

                U       L          9.0;      // Channel 0 low limit value
                SPBNB   L001;
                L       W#16#1;
                L       MW         100;
                OW      ;
                T       MW         100;
L001;           NOP     0;
NETWORK
TITLE =Sensor 1 (Channel 0): Upper limit value

                U       L          8.0;      // Channel 0 upper limit value
                SPBNB   L002;
                L       W#16#2;
                L       MW         100;
                OW      ;
                T       MW         100;
L002:           NOP     0;

NETWORK
TITLE =Sensor 2 (Channel 2): Lower limit value

                U       L          9.2;      // Channel 2 low limit value
                SPBNB   L003;
                L       W#16#4;
                L       MW         100;
                OW      ;
                T       MW         100;
L003:           NOP     0;

NETWORK
TITLE =Sensor 2 (Channel 2): Upper limit value

                U       L          8.2;      // Channel 2 upper limit value
                SPBNB   L004;
                L       W#16#8;
                L       MW         100;
                OW      ;
                T       MW         100;
L004:           NOP     0;
```

```
NETWORK
TITLE =Sensor 3 (Channel 3): Lower limit value
// Only for demonstration purposes. Channel 3 has now hardware interrupt capabilities
                U       L            9.3;    // Channel 3 low limit value
                SPBNB   L005;
                L       W#16#10;
                L       MW           100;
                OW      ;
                T       MW           100;
L005:           NOP     0;

NETWORK
TITLE =Sensor 3 (Channel 3): Upper limit value
// Only for demonstration purposes. Channel 3 has now hardware interrupt capabilities
                U       L            8.3;    // Channel 3 upper limit value
                SPBNB   L006;
                L       W#16#20;
                L       MW           100;
                OW      ;
                T       MW           100;
L006:           NOP     0;

END_ORGANIZATION_BLOCK
```

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