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Engineering of the Configuration Control for IO Systems

ET 200SP, “ReconfigIOSystem”

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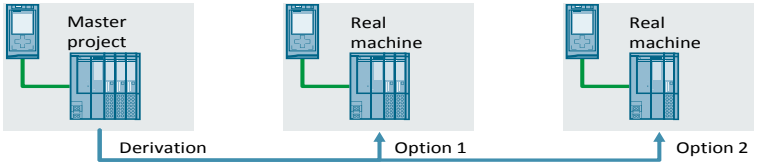
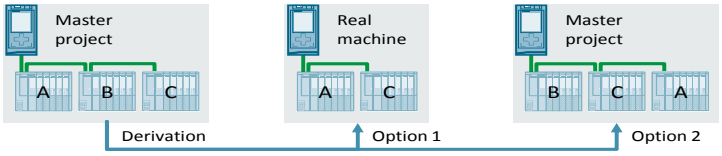
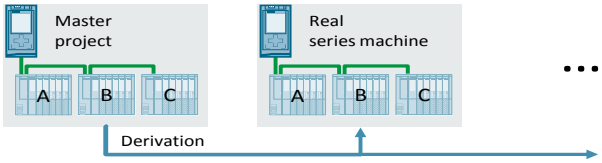
Introduction

The present engineering example is part of the documents dealing with the variants management with SIMATIC S7. This chapter gives you an overview of several applications.

Definition of the term “Variants Management”

“Variants Management” is a generic term for an innovative machine concept in the series production of modular machines that may be adapted to customer requirements as easy as possible. Yet this presupposes possibilities that are just as flexible. An addressing of all the plant and machine parts performed at a time must be adaptable without great effort and changes in the engineering project.

The table below shows the fields of application of the variants management:

Term	Explanation of the fields of application	In this DOC
Module-level Configuration Control	The module-level Configuration Control allows for flexible configuration levels of the distributed and centralised I/O systems within a project. Thus a single STEP 7 project (maximum configuration) may be used for multiple configuration levels of I/O stations. 	✗
Configuration Control for IO systems	The Configuration Control for IO systems allows for flexible configuration levels and interconnections of stations within an IO system. Thus a single STEP 7 project may be used for several concrete IO system versions as long as they can be derived from the maximum configuration. 	✓
Multiple Use IO systems	“Multiple Use IO systems” means that a single IO system is used for several machines. Thus a PROFINET IO system created in a STEP 7 project may be used for several machines since the IP addresses and the device names are fixed by the IO controller and not directly by the STEP 7 project. 	✗

1 Task and Solution

1.1 Task definition

Description

In the series machine production, one and the same machine must very often be used and supplied in different configuration levels. These configuration levels are obtained by different variants of the IO system. This variation, however, requires an increased engineering and commissioning effort.

Requirements

The following requirements have to be considered:

- Efficient engineering
- Shorter time span until commissioning
- Easy extension of the machine
- Different machine variants from one and the same project

1.2 Possible solution

Description

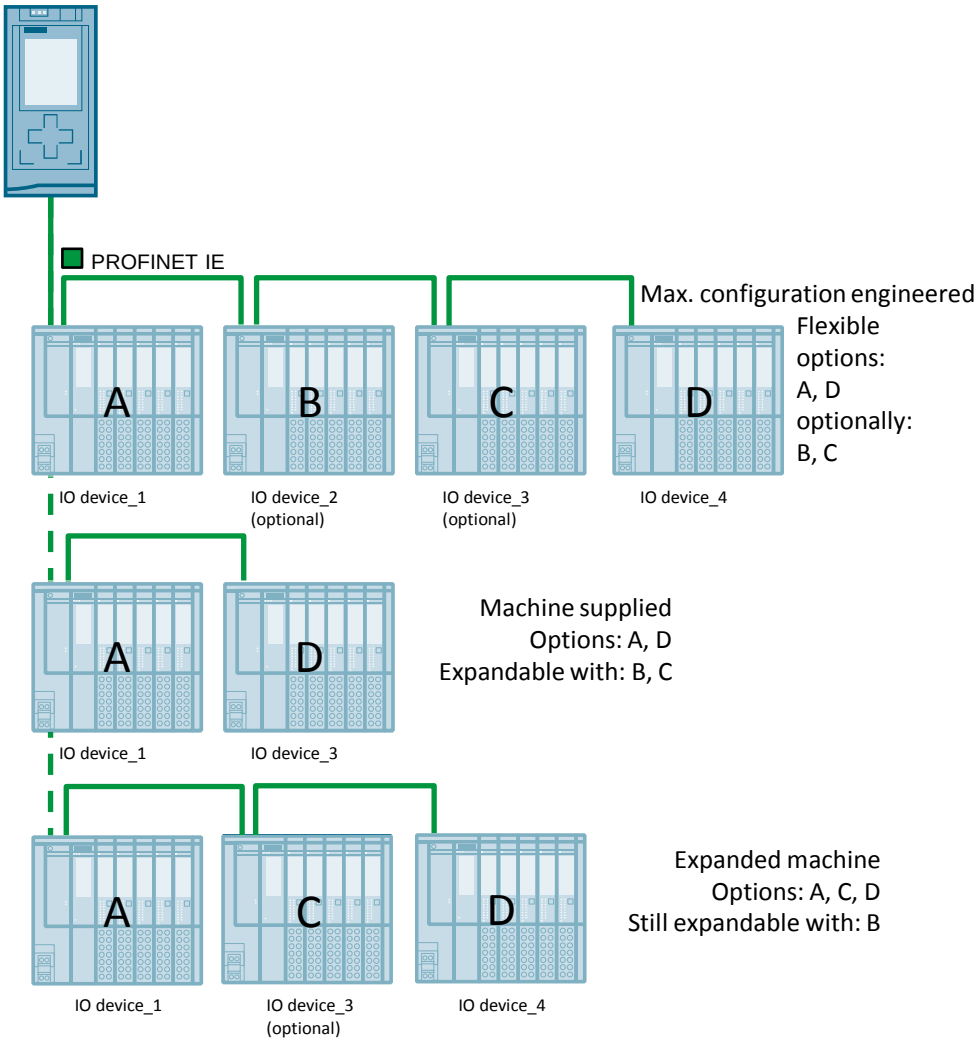
The variants management in the PROFINET IO system (Configuration Control for IO systems) enables you to create several concrete variants of a series machine from one and the same project.

The configuration of an IO system can thus flexibly vary for a determined application as long as the real configuration can be derived from the engineered one. Thus the engineered configuration represents the superset of all the real configurations to be derived.

The derivation is done using the instruction “ReconfigIOSystem“ by transferring the data record “CTRLREC“ to the IO controller.

Schematic diagram

Figure 1-1



The Configuration Control enables you to operate different configuration levels of a series machine with a single project engineered in the maximum configuration. You can select the configuration level via the application program.

Usable components

The components below support the Configuration Control:

- S7-1500 CPU as of Firmware version V1.7 or higher as IO controller
- STEP 7 as of V13 SP1 or higher
- Distributed I/O systems with PROFINET interface

2 Principles of the Configuration Control

2.1 Description of the Configuration Control for IO systems

Concept

For the flexible use of modules and components on the device level, the principle of the Configuration Control, known under the name of “Operation Handling”, has long been inherent part of the SIMATIC S7 features. Different configurations may be derived from a single engineering project for both the centralised and the distributed I/O systems.

With the type S7-1500 CPUs as of Firmware version V1.7 or higher, this principle is also applicable to the IO system level. This possibility enables you to activate / deactivate stations (IO devices, I devices) or to vary the sequence of the stations of a PROFINET IO system in a concrete plant.

It is possible to combine the Configuration Control for devices with the Configuration Control for IO systems, as their functions are independent from each other.

From a single IO system in the maximum configuration, several variants derived from it can be operated. For a series machine project, you can for example, prepare a tool kit consisting of IO devices which you can flexibly vary to meet the different configuration levels using the Configuration Control.

You can choose between the following variants:

- Variation of the number of IO devices involved
  You include in your configuration optional IO devices for the Configuration Control by transferring a data record containing the desired configuration with the help of the application program.
- Variation of the sequence of IO devices involved
  You adapt the specified port interconnections of the IO device to the real existing topology by transferring a data record containing the desired topology with the help of the application program.
- Combined use of optional IO devices and flexible port interconnection.

2.2 Description of the “ReconfigIOSystem” instruction

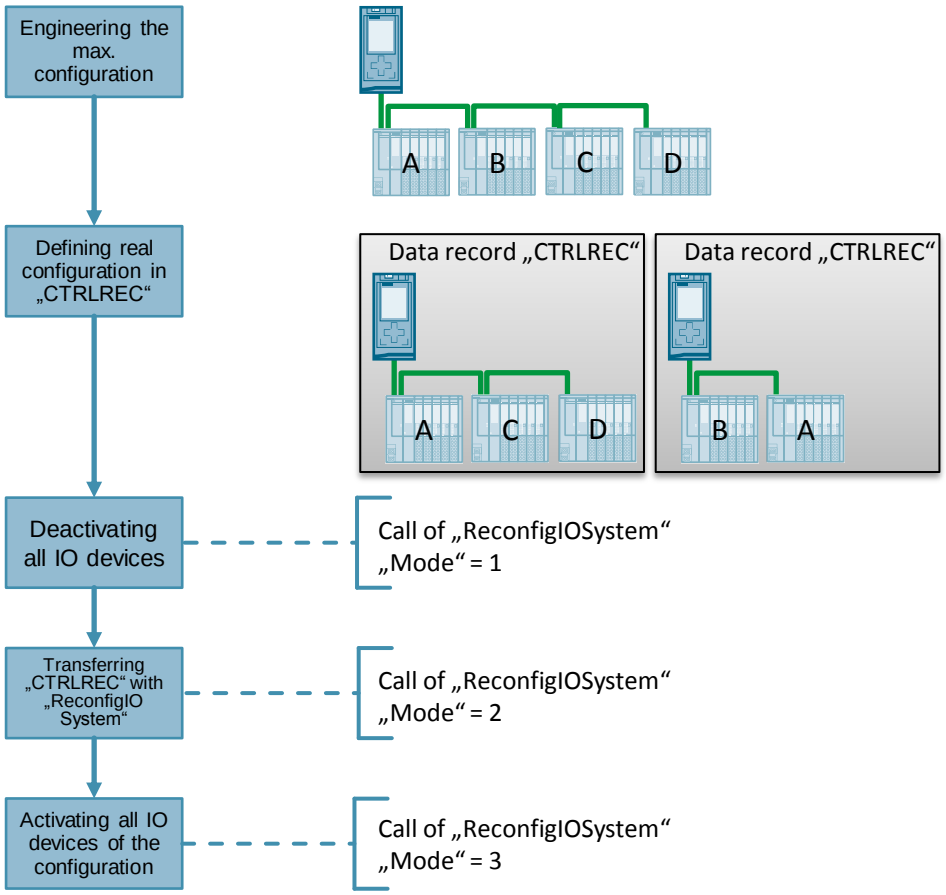
General

The “ReconfigIOSystem” instruction is used to transmit the “CTRLREC” data record to the PROFINET interface of the CPU.

This instruction allows you to adapt the topology of the IO system to the application requirements even at running system by using optional IO devices and specified port interconnections.

The Figure below shows the principle of the “ReconfigIOSystem“ instruction.

Figure 2-1



The table below shows the input parameters of the “ReconfigIOSystem“ block.

Table 2-1

Parameters	Data type	Description
REQ	Boolean	Edge-triggered control parameter
MODE	UInt	Controls the instruction. Detailed information can be found further down in this chapter.
LADDR	HW_Interface	HW flag of the IO controller’s PROFINET interface.
CTRLREC	Variant	Data record to control the actual configuration of the IO system.

The table below shows the output parameters of the “ReconfigIOSystem““ block.

Table 2-2

Parameters	Data type	Description
DONE	Boolean	TRUE as soon as the instruction is completed.
BUSY	Boolean	TRUE if the instruction is active.
ERROR	Boolean	TRUE if the instruction is completed with error.
STATUS	DWord	Status of the instruction.
ERR_INFO	Word	HW flag of the IO device last determined that has caused the error.

Mode of Operation

“ReconfigIOSystem“ is an instruction working in asynchronous mode. The complete processing of the job occurs by several calls in different modes (parameter “MODE”).

The task starts as soon as a positive edge is acquired at input “REQ”.

The output parameters “STATUS“, “BUSY“, “DONE“, and “ERROR“ display the status of the task.

Parameter “MODE”

The parameter “MODE” is used to control which operation the block “ReconfigIOSystem“ is performing.

The block “ReconfigIOSystem“ can be called up in the three following modes:

- Mode 1: Deactivation of all the IO devices in the IO system.
- Mode 2: Transferring the data record “CTRLREC” to the controller addressed by the input “LADDR”.
- Mode 3: Activation of all the IO devices in the IO system. The data record “CTRLREC” considers the change in configuration of the IO system.

Control data record “CTRLREC”

The control data record “CTRLREC” can be used for the configuration of two variants.

- Optional IO devices by means of default topology.
- Flexible array of the IO devices using specified port interconnections.

The table below shows the structure of the data record “CTRLREC“:

Table 2-3

Name	Data type	Description
Version_High, Version_Low	Word	Version of the control data record “High” byte: 01 “Low” byte 00
Variant with fix topology.		
Number_of_opt_ Devices_used	Word	Number of optional IO devices used in the real IO system. IO devices not mentioned remain deactivated. If no optional IO device is configured, type “0” here.
Activate_opt_Device_1	Word	First optional IO device present in the real configuration.

Name	Data type	Description
		Use the system constant of the IO device (data type “HW_Device”).
Activate_opt_Device_n	Word	N^{th} optional IO device present in the real configuration.
Variant with flexible array.		
Number_of_Port_ Interconnections_used	Word	Number of port interconnections. If no port interconnection is specified, type “0” here.
Port_Interconnection_ 1_Local	Word	First port interconnection: HW flag of the local port. Use the system constant of the interconnected port (data type “HW_Interface”).
Port_Interconnection_ 1_Remote	Word	First port interconnection: HW flag of the partner port. Use the system constant of the interconnected port (data type “HW_Interface”).
Port_Interconnection_ n_Local	Word	N^{th} port interconnection: HW flag of the local port.
Port_Interconnection_ n_Remote	Word	N^{th} port interconnection: HW flag of the partner port.

Note

An IO device cannot be an optional IO device and possess a specified port interconnection at a time.

Ports whose specified port interconnections are not defined in the application program are being declared as “Any partner”. The related IO devices are activated.

ATTENTION

Reconfiguring may take up a lot of time, depending on the number of optional IO devices / flexible port interconnections.

It might be necessary to increase the cycle time of the controller!

Version of the data record „CTRLREC“

The table below shows the versioning of the data record “CTRLREC“:

Table 2-4

TIA Portal version	V13 SP1	V14	
Version of CTRLREC	1.0	1.0	1.1
Array of	Word	Word	UINT
symbolic operation	Yes	---	Yes
numeric operation	Yes	Yes	Yes

3 Engineering and Programming

3.1 Infrastructure information

Software package

Install STEP 7 Professional V14 on your PC/PG.

Required devices/components:

You need the components below for the present engineering project:

- One S7-1500 CPU Firmware >= V1.7
  (a CPU 1516-3 PN/DP is used in the example project).
- One SIMATIC MEMORY CARD
- Four IM 155-6 PN ST interface modules for the ET 200SP with arbitrary input and output modules.
- One DIN rail for the S7-1500.
- One PC/PG with the engineering tool “STEP 7 Professional V14” installed.
- The necessary network cables, TP cables (twisted pair) according to the IE FC RJ45 standard for Industrial Ethernet.

Note The configuration described below explicitly refers only to the components listed in the section "Required devices/components".

Setting up the infrastructure

Interconnect all the components involved in this solution via the integrated PROFINET interface.

3.2 Implementing and configuring the devices

Preparation

Open the TIA Portal configuration software and create a new project.

Implementing the devices

Add an S7-1500 CPU (as of firmware version 1.7 or higher) using the project navigation.

In the overview “Devices & networks”, add the PROFINET interface modules and equip the different interface modules with the desired modules and a server module each.

Configuring the devices

To set up the Configuration Control, the individual hardware components must be configured, parametrized and connected to each other. For this purpose, access the “Devices & networks” overview.

Proceed as follows:

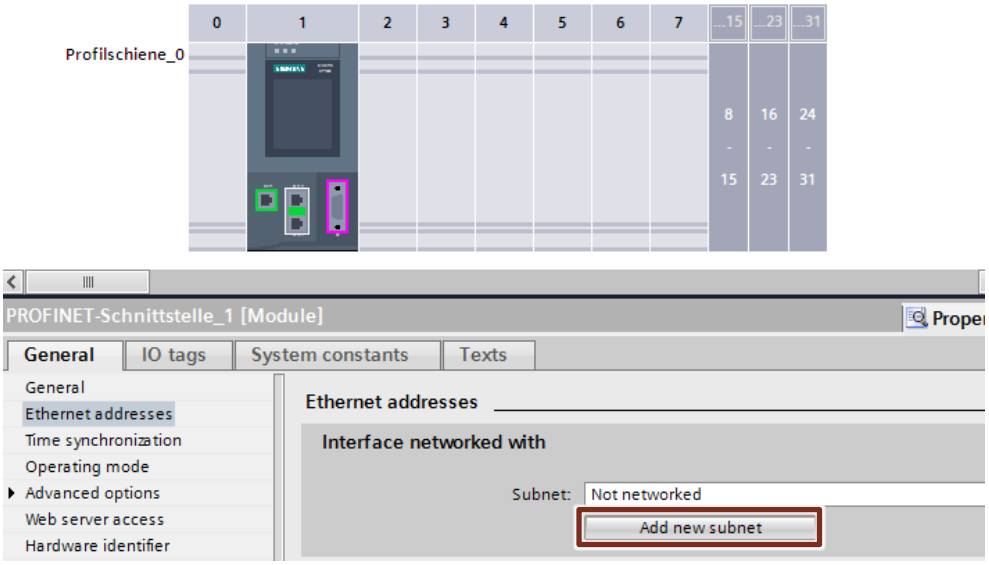
1. Select the S7-1500 CPU (IO controller) in the project tree and open its folder.

2. Open the device view of the component by double clicking “Device configuration”.

3. In the graphical view, select the component interface to be networked.
   The properties of the selected interface are displayed in the inspector window.

4. Select the parameter group “Ethernet addresses” and, under “Interface networked with”, click “Add new subnet”.

   Figure 3-1



Result
The interface is now connected to a new subnet of the suitable subnet type. The address parameters of the interface are thus automatically set in a consistent manner.

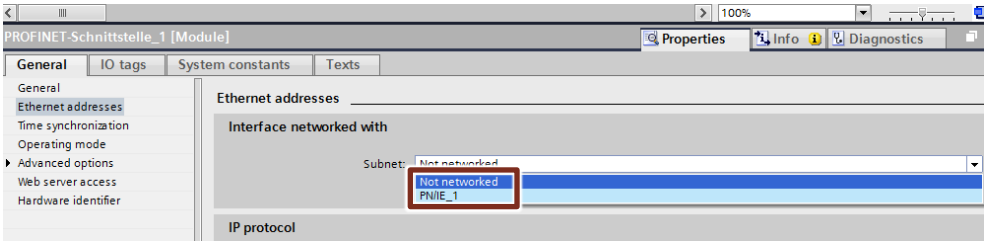
Finally, add the interface modules to the new network. For this purpose, access the “Devices & Networks” overview.

Proceed as follows for any of the IO stations used:

1. In the graphical view, select the interface of the interface module to be networked.
   The properties of the selected interface are displayed in the inspector window.

2. Select the parameter group “Ethernet addresses” and, under “Interface networked with”, select the subnet to be connected from the “Subnet” drop-down list.

   Figure 3-2



Result
The interface and the selected subnet are connected now. The address parameters of the interface are thus automatically set in a consistent manner.

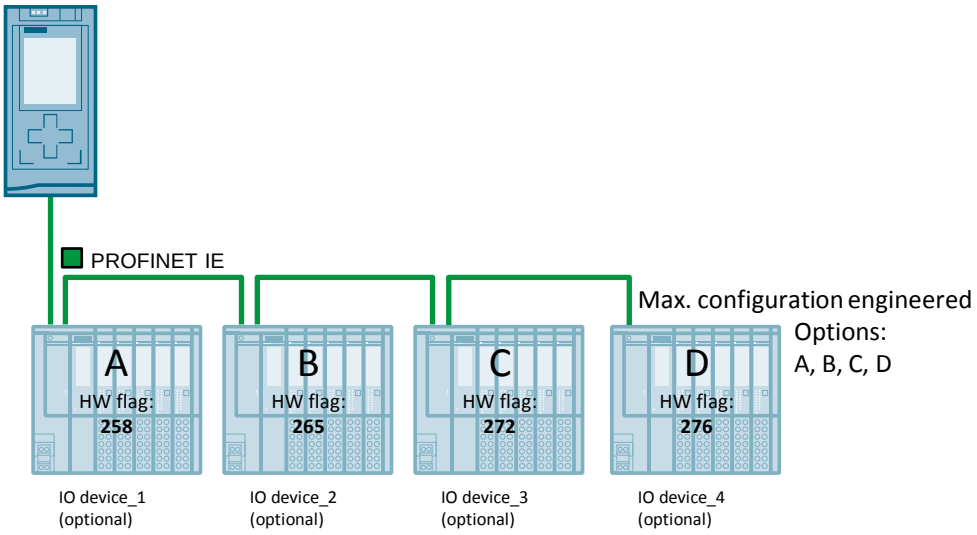
3.3 Configuring with optional IO devices

3.3.1 Set-up and topology

Set-up

The Figure below shows an example of the engineered maximum configuration of optional IO devices.

Figure 3-3



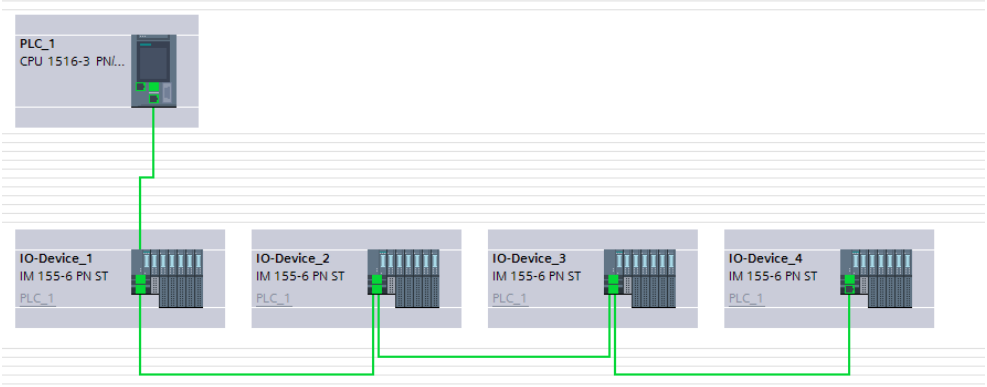
In this example, you are free to choose the options and use them in the machine supplied.

This means that the machine supplied may be extended with the different options.

Topology

The Figure below shows the topology to be engineered for the present example.

Figure 3-4



All the IO devices are configured as optional IO devices; hence all the ports have to be firmly connected following the topology.

3.3.2 Configuring the IO controller

Prerequisites

The following requirements must be met:

- The S7-1500 CPU used has firmware >=V1.7.
- The IO controller is assigned to a subnet.

Configuring the IO controller

To configure the Configuration Control with optional IO devices, no parametrization is required at the IO controller.

The IO controller must be correctly connected to the IO devices following the project topology (see Chapter 3.3.1 under “Topology“).

3.3.3 Configuring the IO devices as optional IO devices

Requirements

The following requirements must be met:

- The interface modules used are equipped with a PROFINET interface.
- The distributed I/O stations are assigned to the same subnet as the IO controller.
- The IO devices have a fixed topology.

Configuring the interface modules

To configure optional IO devices, you have to parametrize those IO devices (A, B, C, D) which shall be optional ones.

Proceed as follows:

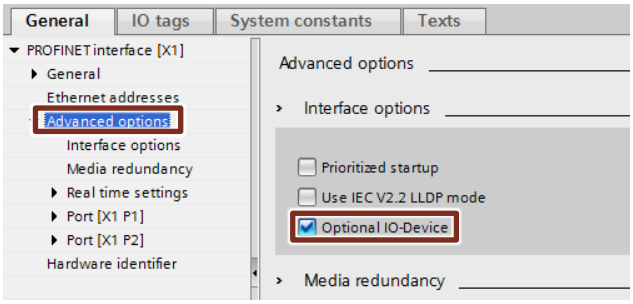
1. Access the “Devices & Networks” overview.

2. Double click the symbol of the corresponding IO device to open the related device view.

3. Click the PROFINET interface of the IO device. Access the “Advanced options”.

4. Under “Interface options” in the inspector window, check the “Optional IO Device” check box.

   Figure 3-5



Note Repeat steps 1 thru 4 for any station to be used as an optional “IO Device”.

Result

The data record “CTRLREC“ is used to determine which of the IO devices shall be activated for which variant.
The function block “ReconfigIOSystem“ sends this control data record to the IO controllers of the PROFINET IO system which activate the IO devices following the information contained in the data record.

3.3.4 Adapting the “CTRLREC” data record

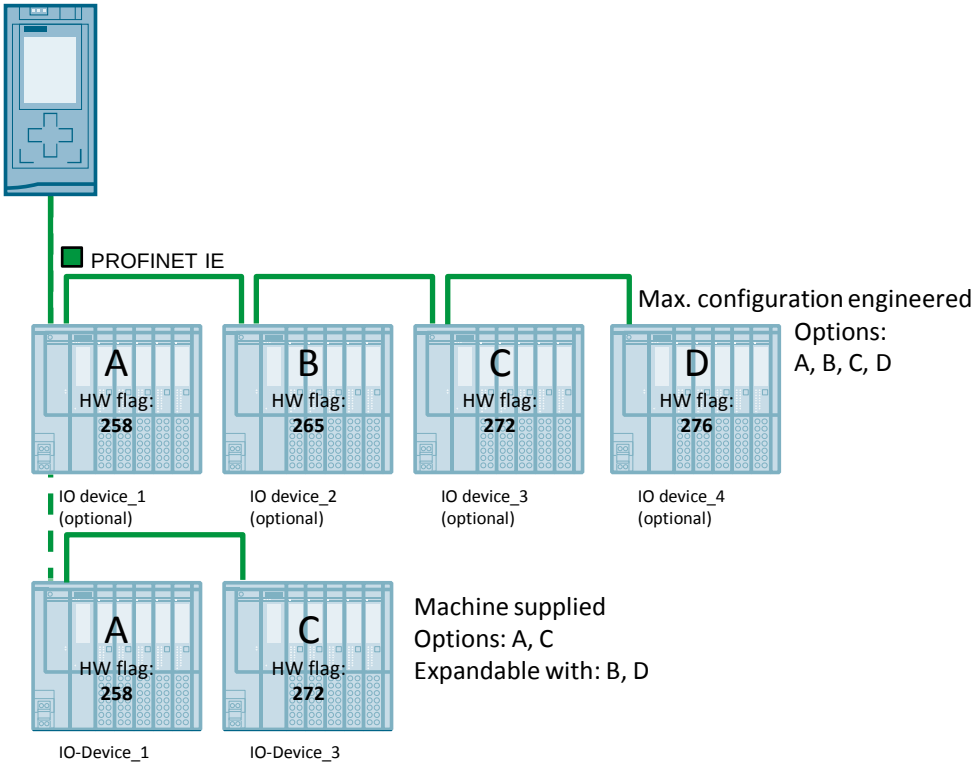
An IO device declared as an optional IO device and used in the real configuration must be activated by the instruction “ReconfigIOSystem”. For this purpose you must set the optional IO device in the “CTRLREC” data record by entering the IO device’s HW flag into the data record.

Use the CPU system tags (in this case data type “HW_Device”) for the interconnection in the “CTRLREC” data record.

“PLC tags“ > “Show all tags“ > “System constants“

The Figure below shows how the example from Chapter 3.3.1 may be used.

Figure 3-6



This means that the machine supplied may be extended with the different options. In the present example, options A and C are activated. At a later moment, the machine can also be extended with options B and D.

The table below shows how the data record “CTRLREC” is written for our example in order to activate options A and C. The parameter „Number_of_Port_Interconnections_used“ must be “0” here as the optional IO devices are firmly connected following the topology.

Table 3-1

Parameters	Data type	Value
Version	Word	16#0100
Number_of_opt_Devices_used	Word	2
Activate_opt_Device_1	Word	258
Activate_opt_Device_2	Word	272
Number_of_Port_Interconnections_used	Word	0

Note The IO devices declared as optional IO devices must be firmly stored to the project topology.

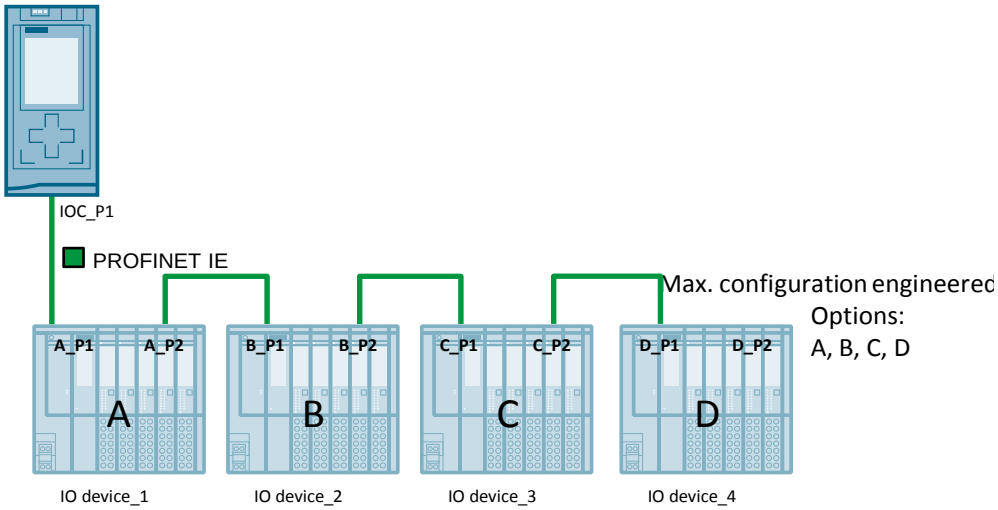
3.4 Configuring with specified port interconnections

3.4.1 Set-up and topology

Set-up

The Figure below shows an example for the engineered maximum configuration of specified port interconnections.

Figure 3-7



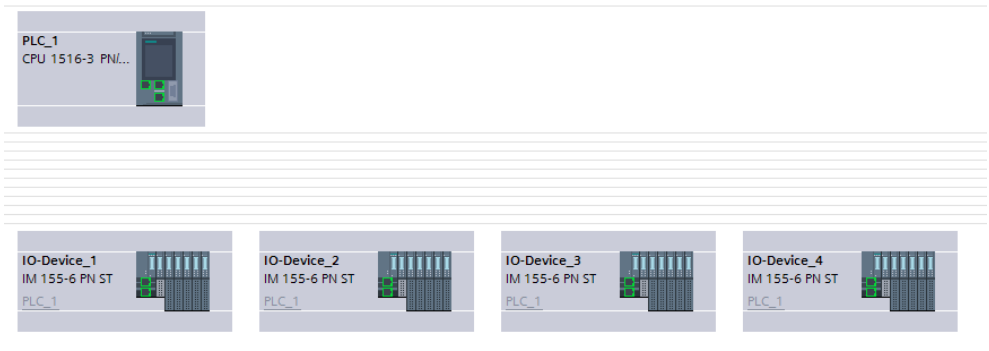
In this example, you are free to change the sequence of the IO devices A, B, C, and D.

This means that the machine supplied can be set up flexibly, for example in order to reduce the amount of wiring.

Topology

The Figure below shows the topology to be engineered for the present example.

Figure 3-8



3.4.2 Configuring the IO controller

Prerequisites

The following requirements must be met:

- The S7-1500 CPU used has firmware >=V1.7.
- The IO controller is assigned to a subnet.

Configuring the IO controller

Further settings are necessary at the IO controller to configure the Configuration Control:

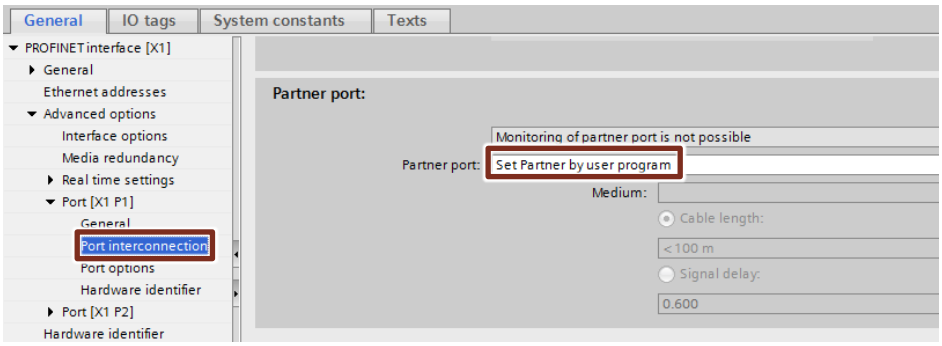
Note The steps below are necessary only if you wish that the partner port of the IO controller shall be flexible. You can skip these steps if the partner port shall be firmly connected to an IO device.

1. Open the device view of the IO controller by double clicking “Device configuration”.

2. Click the PROFINET interface of the IO device to be connected. Access the “Advanced options”.

3. In the submenu, select the port connected to the IO system (“IOC_P1” in this case). In the submenu “Port interconnection”, set the “Partner port”.
   Select the option “Set Partner by application program“ from the drop-down list.

   Figure 3-9



Result

The partner port of the local IO controller port is now defined by the data record “CTRLREC“. The function block “ReconfigIOSystem“ sends this data record to the IO controller of the PROFINET IO system thus transferring to that IO controller the interconnection of the PROFINET interfaces of the IO devices.

3.4.3 Configuring the IO devices using specified port interconnections

Requirements

The following requirements must be met:

- The interface modules used are equipped with a PROFINET interface.
- The distributed I/O stations are assigned to the same subnet as the IO controller.
- The port interconnection of the flexibly used ports of the IO devices is not defined by topology.
- The flexibly used ports are not located at an optional IO device.

Configuring the interface modules

To obtain a flexible array of IO devices, the settings below are necessary at the IO devices (A, B, C, D):

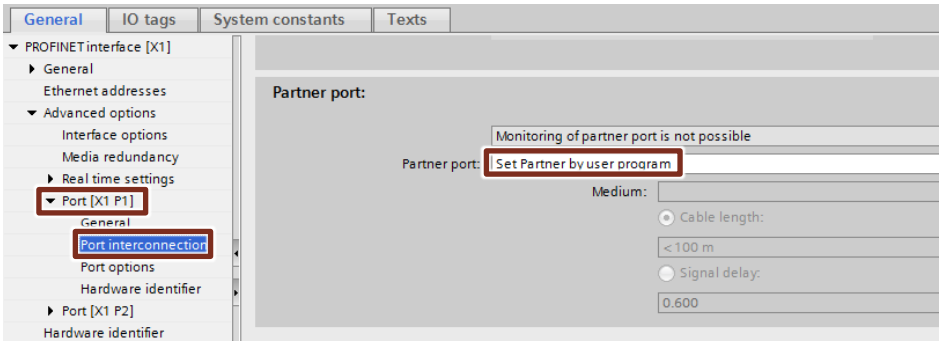
1. Access the “Devices & networks” overview.

2. Double click the symbol of the corresponding IO device to open the related device view.

3. Click the PROFINET interface of the IO device. Access the “Advanced options”.

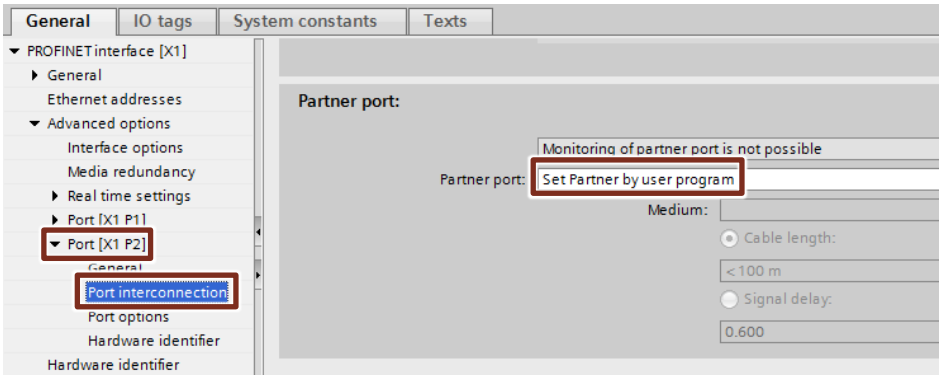
4. In the submenu, select the port connected to the component **before** (“A_P1” in this case). In “Port interconnection”, set the “Partner port”.
   Select the option “Set Partner by application program“ from the drop-down list.

   Figure 3-10



5. In the submenu, select the port connected to component **after** (“A_P2” in this case). In “Port interconnection”, set the “Partner port”.
   Select the option “Set Partner by application program“ from the drop-down list.

   Figure 3-11



Note Repeat steps 1 thru 5 for any station to be arranged in flexible array by the application program.

Result

The partner ports of the IO devices A, B, C, and D are now defined by the data record “CTRLREC“. The function block “ReconfigIOSystem“ sends this data record to the IO controller of the PROFINET IO system thus transferring to that IO controller the interconnection of the PROFINET interfaces of the IO devices.

3.4.4 Adapting the “CTRLREC” data record

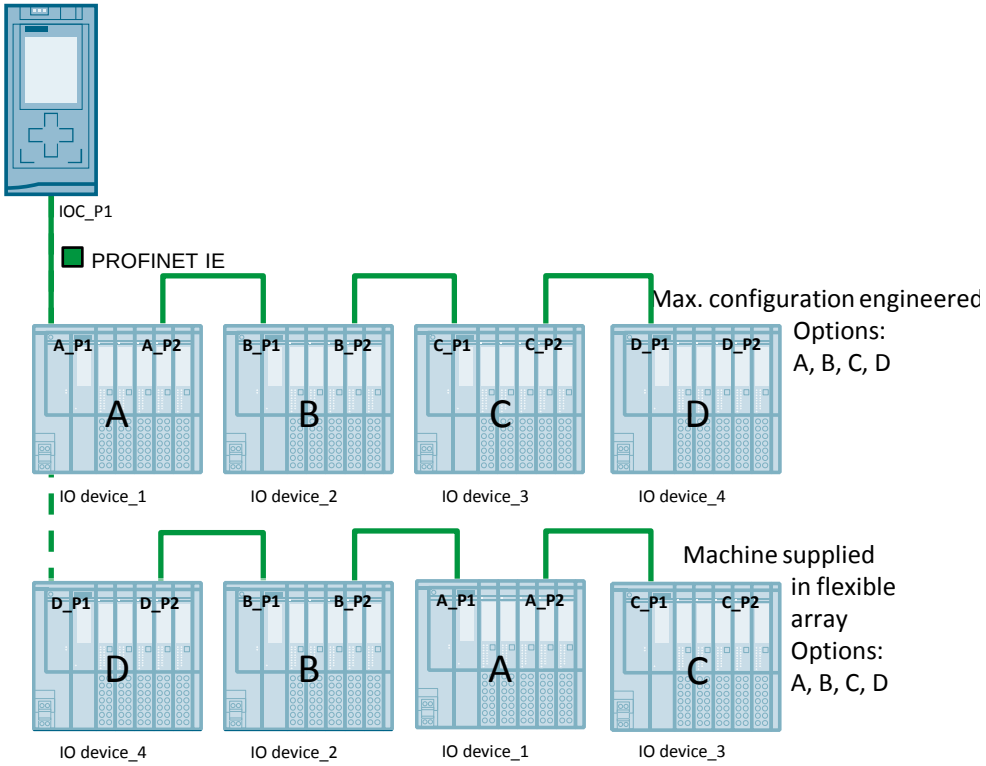
If you wish to arrange an IO device flexibly and without fixed topology, you must activate it with the instruction “ReconfigIOSystem”. For this purpose, the port interconnections must be defined in the data record “CTRLREC”. Both the local and the partner port of the connection are indicated.

Use the CPU system tags (in this case data type “HW_Interface”) for the interconnection in the “CTRLREC” data record:

“PLC tags“ > “Show all tags“ > “System constants“

The Figure below shows how the example from Chapter 3.4.1 may be used.

Figure 3-12



This means that the machine supplied can be set up in flexible array, for example in order to reduce the amount of wiring. In our example, the sequence (A, B, C, D) of the maximum configuration is changed to D, B, A, C.

The table below shows how the data record “CTRLREC” is written for our example in order to activate options in the sequence D, B, A, C.

Table 3-2

Parameters	Data type	Value
Version	Word	16#0100
Number_of_opt_Devices_used	Word	0
Number_of_Port_Interconnections_used	Word	4
Port_Interconnection_1_Local	Word	IOC_P1
Port_Interconnection_1_Remote	Word	D_P1
Port_Interconnection_2_Local	Word	D_P2
Port_Interconnection_2_Remote	Word	B_P1
Port_Interconnection_3_Local	Word	B_P2
Port_Interconnection_3_Remote	Word	A_P1
Port_Interconnection_4_Local	Word	A_P2
Port_Interconnection_4_Remote	Word	C_P1

Note

The ports of the IO devices whose port interconnections are defined in the application program must not be defined in the project topology or declared as an optional IO device.

Ports which are not defined in the application program are being declared as “Any partner”. The related IO devices are activated.

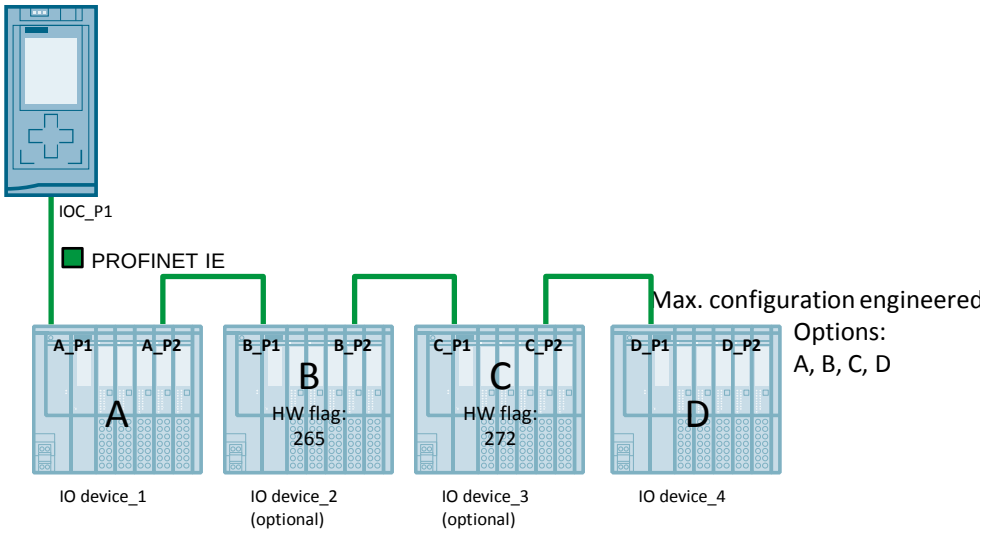
3.5 Configuring with optional IO devices and specified port interconnections

3.5.1 Set-up and topology

Set-up

The Figure below shows an example of the engineered maximum configuration combined with optional IO devices and specified port interconnections.

Figure 3-13

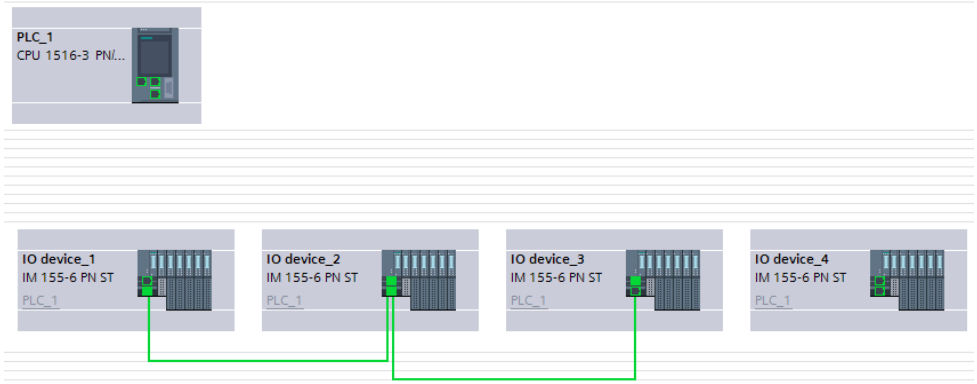


In our example, the options A and D are flexibly interchangeable. However, options B and C can only be used together with A and D as, following the topology, they are firmly connected to the interfaces “A_P2“ and “D_P1“.

Topology

The Figure below shows the topology to be engineered for the present example.

Figure 3-14



3.5.2 Configuring the IO controller

Prerequisites

The following requirements must be met:

- The S7-1500 CPU used has firmware >=V1.7.
- The IO controller is assigned to a subnet.

Configuring the IO controller

Further settings are necessary at the IO controller to configure the Configuration Control:

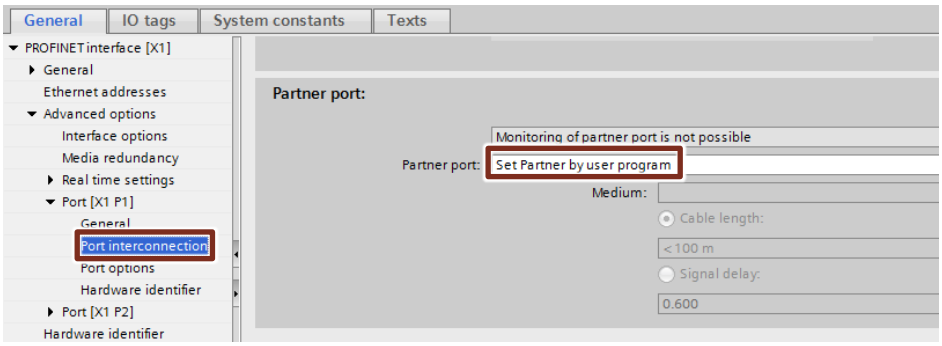
Note The steps below are necessary only if you wish that the partner port of the IO controller shall be flexible. You can skip these steps if the partner port shall be firmly connected to an IO device.

1. Open the device view of the IO controller by double clicking “Device configuration”.

2. Click the PROFINET interface of the IO device to be connected. Access the “Advanced options”.

3. In the submenu, select the port connected to the IO system (“IOC_P1” in this case). In the submenu “Port interconnection”, set the “Partner port”.
   Select the option “Set Partner by application program“ from the drop-down list.

   Figure 3-15



Result

The partner port of the local IO controller port is now defined by the data record “CTRLREC“.

3.5.3 Configuring the IO devices

Requirements

The following requirements must be met:

- The interface modules used are equipped with a PROFINET interface.
- The distributed I/O stations are assigned to the same subnet as the IO controller.
- The port interconnection of the flexibly used ports of the IO devices is not defined by topology.
- The flexibly used ports are not located at an optional IO device.

Configuring the interface modules of the optional IO devices

To configure optional IO devices, you have to parametrise those IO devices which shall be optional ones: In our example, the IO devices B and C are concerned.

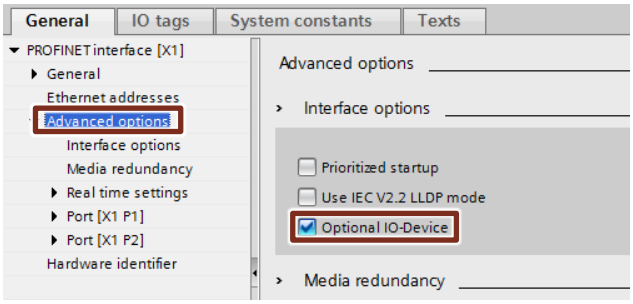
1. Access the “Devices & Networks” overview.

2. Double click the symbol of the corresponding IO device to open the related device view.

3. Click the PROFINET interface of the IO device. Access the “Advanced options”.

4. Under “Interface options” in the inspector window, check the “Optional IO Device” check box.

Figure 3-16



Result

The data record “CTRLREC” determines now the IO Devices which shall be activated for a given variant.

Configuring the flexibly interconnected ports of the IO devices

To obtain a flexible array of IO devices, the settings below are necessary at the IO devices: In our example, the IO devices A and D are concerned.

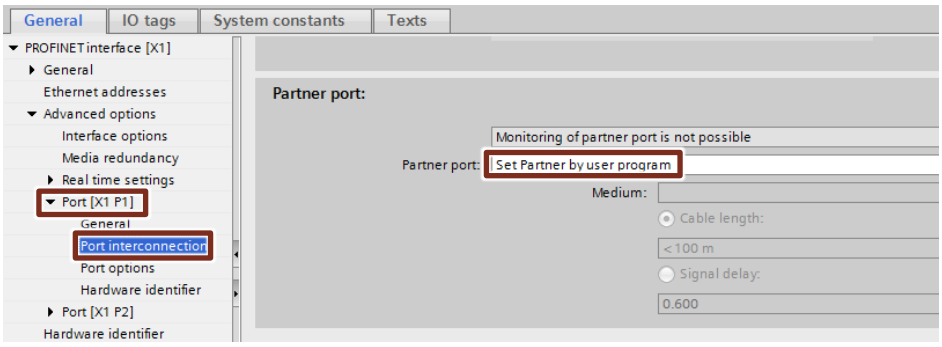
1. Access the “Devices & Networks” overview.

2. Double click the symbol of the corresponding IO device to open the related device view.

3. Click the PROFINET interface of the IO device which shall flexibly be interconnected in the application program later (“A_P1“ and „D_P2“). Access the “Advanced options”.

4. In the submenu, select the port connected to the component before (“A_P1” and “D_P2” in this case). In “Port interconnection”, set the “Partner port”. Select the option “Set Partner by application program“ from the drop-down list.

Figure 3-17



Result

The partner ports of the IO devices A and D are now defined by the data record “CTRLREC“. The function block “ReconfigIOSystem“ sends this data record to the IO controller of the PROFINET IO system thus transferring to that IO controller the interconnection of the PROFINET interfaces of the IO devices as well as the optional IO devices to be activated.

3.5.4 Adapting the “CTRLREC” data record

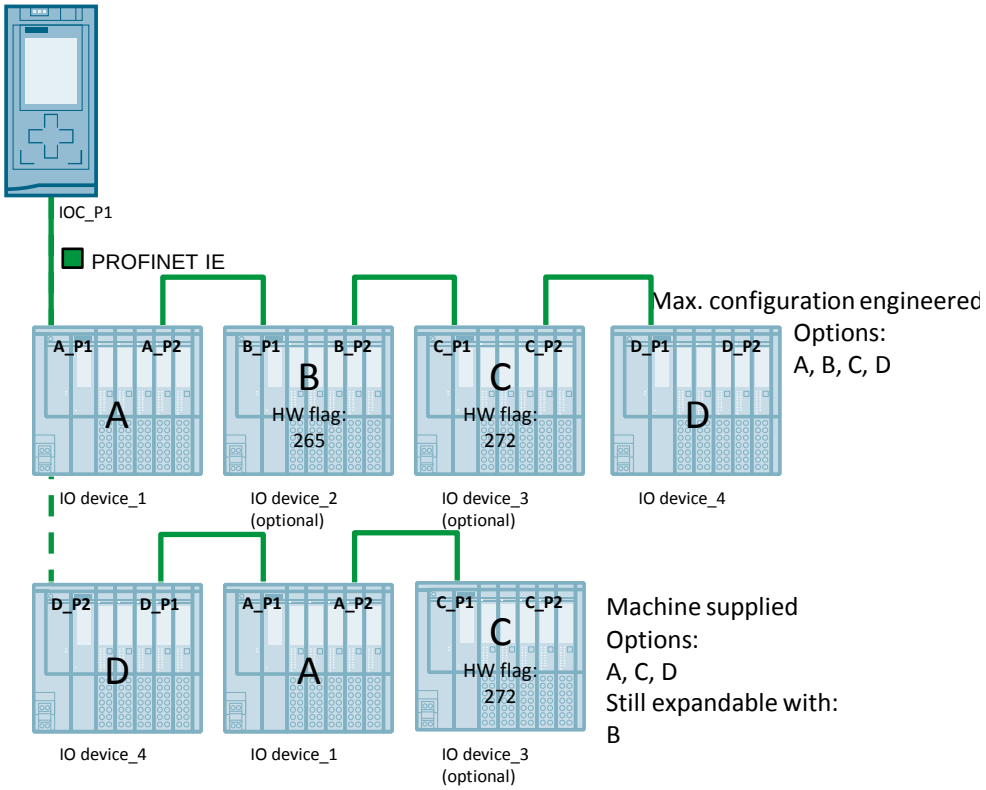
If you wish to combine the possibilities of optional IO devices with a flexible array of the IO devices, you must consider the rules of the individual features.

- An optional IO device must be firmly stored into the project topology.
- When the port interconnection is specified in the application program, the port cannot be part of an optional IO device.

This means that an optional IO device must always be connected to a port with an IO device connected through the specified port interconnection, to an IO controller, or to a standard IO device.

The Figure below shows how the example from Chapter 3.5.1 may be used.

Figure 3-18



In the machine supplied, the IO device D is connected to the IO controller with port “D_P2”. The IO device A is connected to D with the optional IO device C. The machine may still be extended with B.

The table below shows how the data record “CTRLREC” is written for the example in which D is connected to the IO controller and A is coupled to D together with option C.

Table 3-3

Parameters	Data type	Value
Version	Word	16#0100
Number_of_opt_Devices_used	Word	1
Activate_opt_Device_1	Word	272
Number_of_Port_Interconnections_used	Word	1
Port_Interconnection_1_Local	Word	IOC_P1
Port_Interconnection_1_Remote	Word	D_P2

3.6 Application program

Requirements

The following requirements must be met for the application program to yield the desired results:

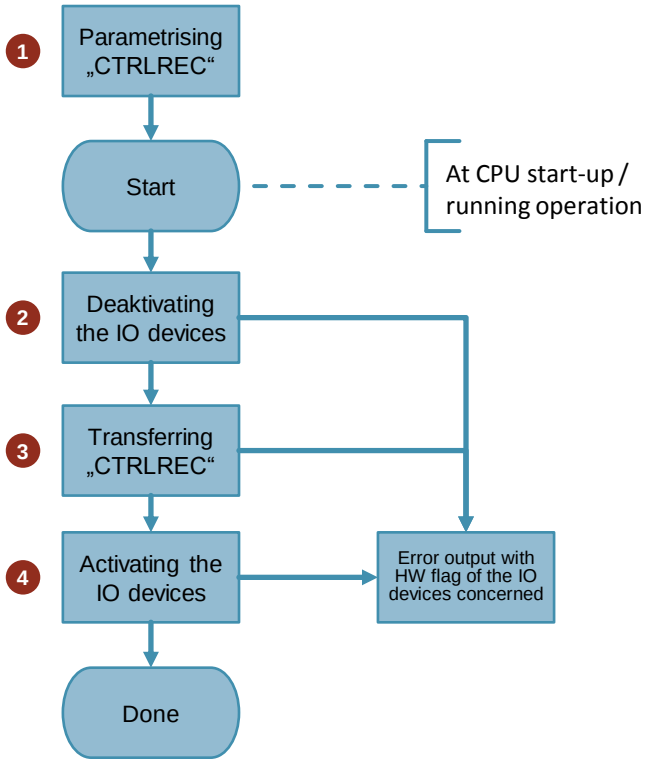
- The IO devices must be parametrised as described in chapters 3.3.2, 3.4.2, or 3.5.2, respectively.
- The data record “CTRLREC” must be correctly parametrised in order to activate the IO devices in their real configuration.

Program

The application program is identical for all the variants of the Configuration Control.

The Figure below shows the principle on how the “ReconfigIOSystem“ instruction is used.

Figure 3-19



To activate optional IO devices using the application program like in the real configuration, proceed as follows:

1. Create a data record “CTRLREC” for the instruction “ReconfigIOSystem" in a DB. For further information on the structure of the data record, please refer to Chapter 2.2.
2. Call up the instruction “ReconfigIOSystem" in “OB 1“ and select MODE 1 to deactivate all the IO devices.

Note If you take the CPU to the “STOP” or “POWER OFF” condition to modify the plant (e.g. to add an optional IO device), it is not explicitly necessary to deactivate the devices with “ReconfigIOSystem” in MODE 1. In this case, all the IO devices are automatically deactivated.

3. As soon as all the IO devices are deactivated, call the instruction “ReconfigIOSystem” again. Select MODE 2 to transfer the data record “CTRLREC”.
4. Once the data record transferred repeat calling the instruction “ReconfigIOSystem". Select MODE 3 now to activate all the IO devices included in the current configuration.

Result
The CPU activates the following IO devices:

- All the IO devices not parametrised as optional IO devices.
- All the optional IO devices included in the data record (CTRLREC).

The IO devices below remain deactivated:

- Docking Units (IO devices alternating in operation).
- All the optional IO devices not included in the data record.

Note Call up the instruction “ReconfigIOSystem“ for all the values of the “MODE“ parameter with the same “CTRLREC“ control data record.

4 Links & Literature

Table 4-1

	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Download page of the entry https://support.industry.siemens.com/cs/ww/en/view/29430270

5 History

Table 5-1

Version	Date	Revision
V1.0	06/2016	First version
V2.0	03/2017	Upgrade to STEP 7 V14