SIEMENS

SIMATIC

S7-1500/ET 200MP, S7-1500R/H Product Information on documentation S7-1500/ET 200MP, S7-1500R/H

Product Information

01/2024

A5E31876033-BE

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠ WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠ CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠ WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Introduction

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1.1 Scope of validity

Scope of validity of the product information

This product information supplements the documentation for SIMATIC S7-1500/ET 200MP, S7-1500R/H and takes precedence over our system manuals, function manuals and equipment manuals.

You can find additional information on the S7-1500 fail-safe CPUs in the Product Information for F-CPUs on the Internet (https://support.industry.siemens.com/cs/us/en/view/109478599).

You can find additional information on SIMATIC S7-1500 Motion Control in the corresponding product information on the Internet (https://support.industry.siemens.com/cs/us/en/view/109794046).

Cybersecurity information

2

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

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For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Amendments to documentation S7-1500/ET 200MP

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System Manual S7-1500/ET 200MP, Edition 11/2023

"Protection, Local user management, Useful information on local user management and access control, Download to device" section

If you want to download changes to the user configuration in RUN mode, the hardware configuration in the CPU and in the STEP 7 project must be unchanged. Otherwise, a transition to STOP is required to download the user configuration together with the changed hardware configuration. Save your STEP 7 project and then configure only the desired changes in the user configuration. Load your project into the CPU.

Changes to the access rights for the "Anonymous" user can only be loaded in STOP mode.

A fail-safe S7-1500 CPU may only load a user to whom the runtime right "Full access including fail-safe" is assigned. Otherwise, STEP 7 displays an error message when loading the configuration.

Explanations of the options for the user management download (Load preview):

- If you select the option "Keep online user management data", the local user management is not downloaded to the CPU.
- If you select the option "Download all user management data (reset to project)", all passwords changed online via WebAPI are deleted. After the download, the configured local user data is valid.
- If you select the option "Update user management data, but keep online passwords" and have not changed existing user names, the passwords changed via WebAPI are retained. Only changes to function rights and/or roles take effect. Newly configured users are downloaded with their settings and deleted users are no longer available after the download to the CPU.
  If you have changed a user name in the project and assigned a password to this user in the project, this setting becomes valid after the download. The previously valid user name with the password changed online is deleted during the download.

"Display of the CPU" section and "Web server" section

Display of the lock icon

The icon is incorrectly displayed in the CPU display and the web server when the access control is configured as follows:
You have not configured access control and the "Anonymous" user does not have full access rights (e.g. read-only access) to the CPU.

Integrity protection

Equipment Manuals S7-1500 CPUs (Standard, Fail-safe, Compact, Technology):

Section Product overview, properties or

Section Product overview, firmware functions or

Section Product overview, hardware properties and firmware functions, firmware functions of the CPU section

Integrity protection

The CPUs feature an integrity protection function by default. This helps to detect any manipulation of the engineering data on the SIMATIC Memory Card or during data transfer between the TIA Portal and the CPU, and to check communication from a SIMATIC HMI system to the CPU for possible manipulation of engineering data. The user receives a corresponding message about manipulations of engineering data that are detected by the integrity protection.

Communication Function Manual, Edition 11/2023

OPC UA - Global Discovery Push (GDS Push) function: Update problem with downloaded certificates

Under certain conditions, the CPU does not register a downloaded certificate (e.g. a new OPC UA server certificate, or an updated web server certificate). A certificate error may be signaled during a connection attempt in this case.

The update problem occurs only when the CPU still manages certificates that were provided during runtime (GDS Push) and when certificates are then transferred by loading the hardware configuration to the CPU. The certificates loaded via the hardware configuration are not registered by the CPU under these conditions.

Examples:

- You have initially enabled the GDS Push function and selected the option "... use certificates provided during runtime" for the certificate settings and loaded this configuration. The required server certificate as well as the trust lists/CRLs are provided exclusively via GDS Push methods in this case.
- You then change the hardware configuration by adding new certificates or changing existing certificates (e.g. web server certificates or certificates for secure PG/HMI communication). During loading, you have **not** deleted existing certificates provided during runtime so that you can use them later.
  Result: The newly loaded server certificates (e.g. web server certificates or certificates for secure PG/HMI communication) are not registered by the CPU.
- The problem also occurs when you have disabled the GDS Push function and selected the option "... use configured and downloaded certificates" for the certificate settings and loaded this configuration. During loading, you have **not** deleted existing certificates provided during runtime so that you can use them later.
  Result: The newly loaded OPC UA server certificate is not registered by the CPU.

Solution: When the CPU still has certificates that were provided during runtime and you want to transfer new/changed certificates by loading the hardware configuration to the CPU, proceed as outlined below:

- After loading the configuration, perform a "Memory reset" or restart the CPU (POWER OFF > POWER ON). After performing these measures, the CPU reorganizes the loaded configuration and uses the current certificates.

OPC UA server: Change in behavior when using multi-dimensional arrays in a UDT

From firmware version V2.9.4 onwards, S7-1500 CPUs code multi-dimensional arrays within structures according to OPC UA specification V1.04. CPUs with older firmware versions code the corresponding structures in another form. If you have used multi-dimensional arrays in structures for CPUs with older firmware versions and are upgrading to the latest firmware version, then you must modify your client programs accordingly.

Certificate checks when establishing encrypted connections (e.g. OPC UA)

An S7-1500 CPU as of firmware version V3.1 has an extended certificate check compared with predecessor versions.

Consequently, additional warnings/errors may appear in the diagnostics buffer (BadSecurityChecksFailed), which did not occur in predecessor versions. However, these messages do not prevent the connection from being established.

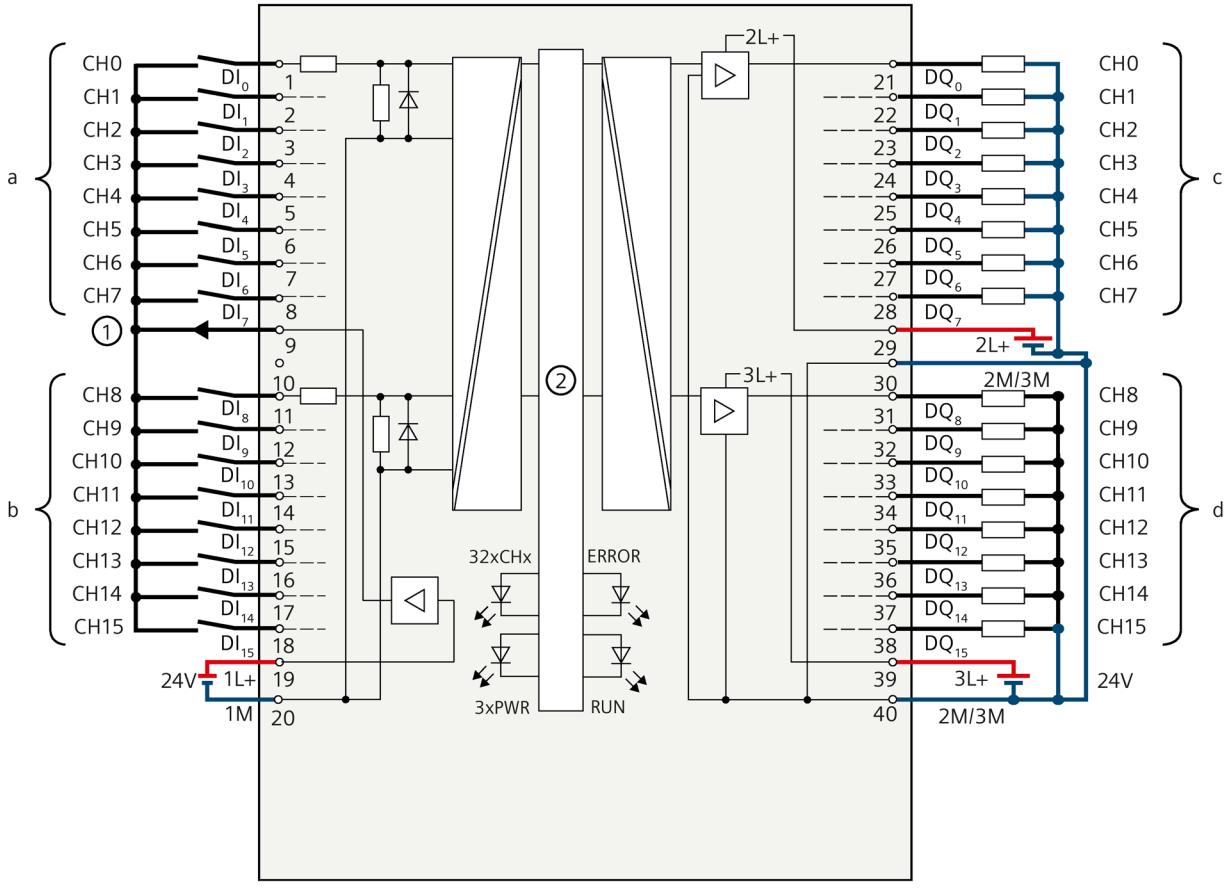
This refers to the following messages:

Error code (hexadecimal values)	Name of the error	Explanation
2852_0000	Key Usage Certificate Sign invalid for non CA	In a CA-derived certificate, the keyCertSign bit has been set in the KeyUsage field despite not being permitted.
2859_0000	Basic constraints not critical	The BasicContraints field of the CA of a certificate is not set as "critical", even though this should always be the case in CA certificates.
285C_0000	CA no Key Usage	The KeyUsage field of the CA of a certificate is not present, even though it should always be present in CA certificates.
2017_0000	CA-Signed Application Instance CA Certificate	In a CA-derived certificate, the CA bit has been set despite not being permitted.
2018_0000	Self-Signed Application Instance CA Certificate	In a self-signed certificate, the CA bit has been set despite not being permitted.

S7-1500 CPU 1511C-1 PN and CPU 1512C-1 PN

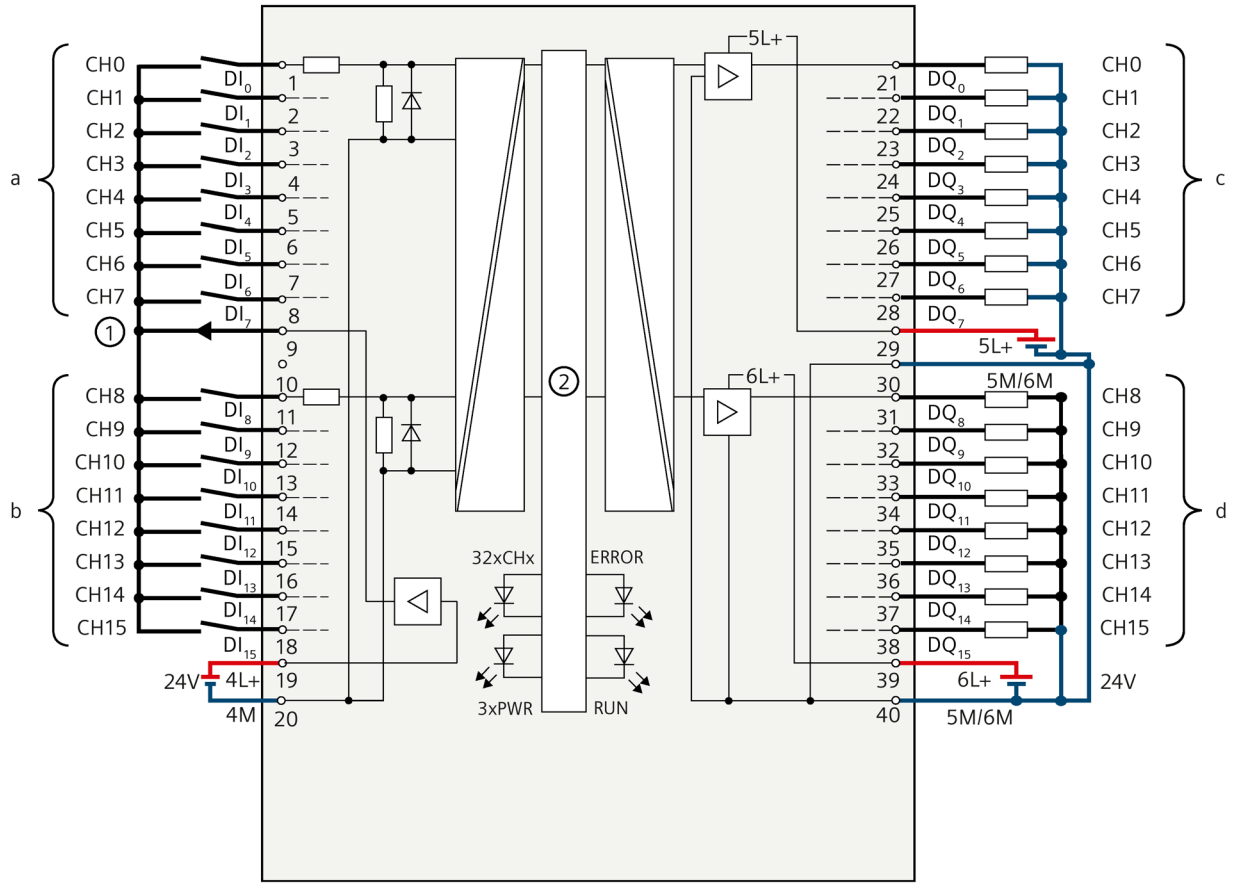
Equipment Manuals CPU 1511C-1 PN and CPU 1512C-1 PN, Edition 05/2021

The loads of the digital onboard I/O X11 and X12 connected at the outputs have a connection to ground 2M/3M and 5M/6M.



①	Encoder supply for the digital inputs
②	CPU interface module
xL+	Connection for 24 V DC supply voltage
xM	Connection for ground
CHx	Channel or channel status LED (green)
RUN	Status display LED (green)
ERROR	Error display LED (red)
PWR	POWER supply voltage LED (green)

Figure 3-1 Block diagram and pin assignment X11 of CPU 1511C-1 PN and CPU 1512C-1 PN



①	Encoder supply for the digital inputs
②	CPU interface module
xL+	Connection for 24 V DC supply voltage
xM	Connection for ground
CHx	Channel or channel status LED (green)
RUN	Status display LED (green)
ERROR	Error display LED (red)
PWR	POWER supply voltage LED (green)

Figure 3-2 Block diagram and pin assignment X12 of CPU 1512C-1 PN

ET 200MP with IM 155-5 MF HF - BusAdapter for IRT operating mode

IM 155-5 MF HF interface module Equipment Manual, edition 11/2023

Contrary to what is stated in the Equipment Manual, only the following BusAdapters support the IRT operating mode:

- BusAdapter BA 2×RJ45
- BusAdapter BA 2×LC
- BusAdapter BA 2xSCRJ
- BusAdapter BA 2×FC
- BusAdapter BA 2xM12

ET 200MP with IM 155-5 PN ST - Channel diagnostics, MSI/MSO

Equipment Manual IM 155-5 PN ST interface module, Edition 11/2017

Channel diagnostics

In contrast to the order specified in the manual, the User Structure Identifiers (USI) are structured as follows:

- USI data block
- Reserved bytes
- Manufacturer-specific diagnostics

ET 200MP with IM 155-5 DP ST – Operation on a WIN AC RTX

When operating the ET 200MP (PROFIBUS) on a WIN AC RTX, configuration is only possible via GSD file (selection in the hardware catalog under "Additional field devices"). Configuration on the basis of a support package is not supported in the TIA Portal for this device arrangement.

ET 200MP with IM 155-5 DP ST - operation on Y-Link, interrupts, technical specifications

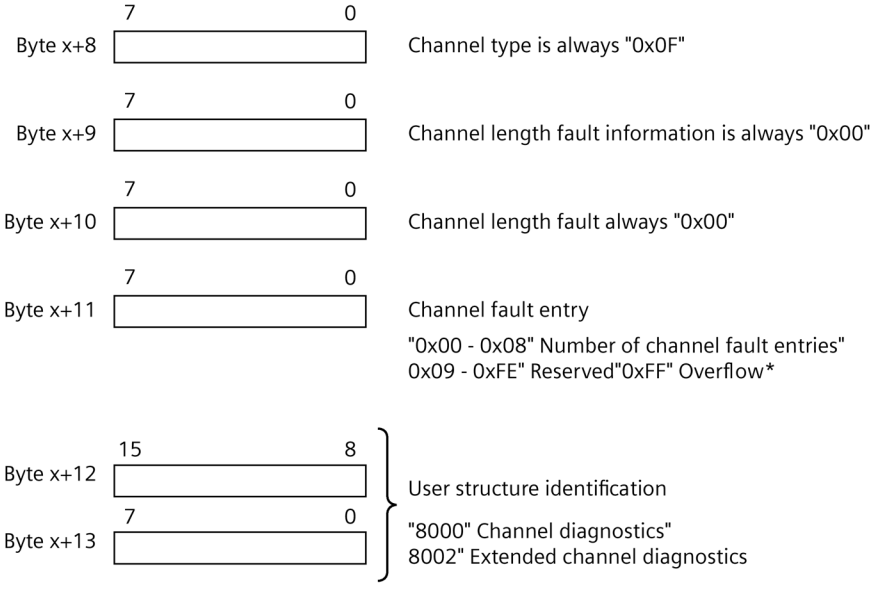
Equipment Manual IM 155-5 DP ST interface module, Edition 08/2013

Operation on Y-Link

As of firmware version V2.0.0, the IM 155-5 DP ST interface module can be operated as DP slave after the Y-Link.

Interrupts

The bytes x+8 to x+19 of the diagnostic interrupt are assigned as follows:



* The number of existing channel faults is greater than 8.

Figure 3-3 Structure starting at byte x+8

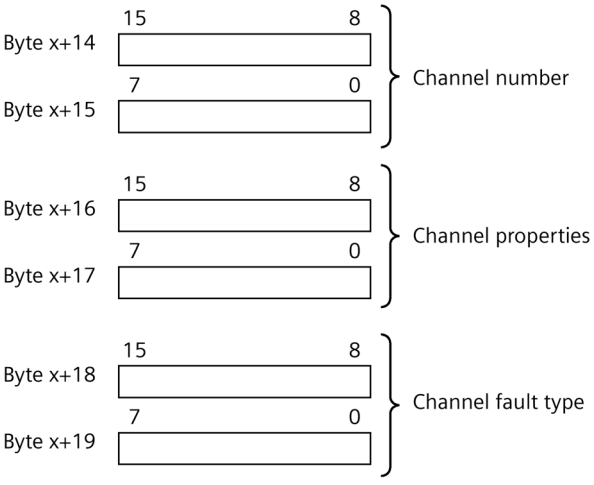


Figure 3-4 Structure starting at byte x+14

Technical specifications

For the IM 155-5 DP ST, the address space of each module can be assigned a maximum of 64 bytes of inputs and a maximum of 64 bytes of outputs.

S7-1500/ET 200MP - Substitute value behavior in shared device mode

Observe the following special characteristics for substitute value behavior in shared device mode with the modules/configurations in the following table:

Note

Substitute value behavior in shared device mode

If the system is in shared device mode and one of the IO controllers involved goes into STOP or fails due to a communication breakdown, for example, all submodules of the output module perform the configured substitute value reaction (e.g. shutdown).

This means that even when only one IO controller fails, that the other IO controllers associated with the shared device no longer control the assigned submodule of the output module.

Module/module name	Configuration	Article no.:
DQ 32x24VDC/0.5A BA	4 x 8-channel without value status	6ES7522-1BL10-0AA0
DQ 16x24VDC/0.5A BA	2 x 8-channel without value status	6ES7522-1BH10-0AA0

S7-1500/ET 200MP - Modules with isochronous mode

The following configurations rule out isochronous mode of the module:

- Module-internal shared input (MSI)
- Module-internal shared output (MSO)
- Submodules for shared device

S7-1500/ET 200MP - Calibration of analog modules

Requirements: The module is integrated in the hardware catalog of STEP 7 (TIA Portal) (no GSD file).

The "Calibration" function (calibration in RUN) is only possible with the following configurations.

Module/module name	Configuration	Article no.:
AI 8xU/I/RTD/TC ST QI	1 x 8-channel with value status	6ES7531-7KF00-0AB0
AI 8xU/I/RTD/TC ST	1 x 8-channel without value status	
AI 8xU/I HS QI	1 x 8-channel with value status	6ES7531-7NF10-0AB0
AI 8xU/I HS	1 x 8-channel without value status	
AQ 8xU/I HS QI	1 x 8-channel with value status	6ES7532-5HF00-0AB0
AQ 8xU/I HS	1 x 8-channel without value status	
AQ 4xU/I ST QI	1 x 4-channel with value status	6ES7532-5HD00-0AB0
AQ 4xU/I ST	1 x 4-channel without value status	
AQ 4xU/I HF QI	1 x 4-channel with value status	6ES7532-5ND00-0AB0
AQ 4xU/I HF	1 x 4-channel without value status	
AI 4xU/I/RTD/TC/ AQ 2xU/I ST QI	1 x 6-channel with value status	6ES7534-7QE00-0AB0
AI 4xU/I/RTD/TC/ AQ 2xU/I ST	1 x 6-channel without value status	
AI 4xU/I/RTD/TC ST QI	1 x 4-channel with value status	6ES7531-7QD00-0AB0
AI 4xU/I/RTD/TC ST	1 x 4-channel without value status	
AQ 2xU/I ST QI	1 x 2-channel with value status	6ES7532-5NB00-0AB0
AQ 2xU/I ST	1 x 2-channel without value status	

S7-1500/ET 200MP - Technical specifications

Equipment Manual AI 8xU/I HS (6ES7531-7NF10-0AB0), Edition 12/2016

Equipment Manual AI 4xU/I/RTD/TC ST (6ES7531-7QD00-0AB0), Edition 09/2016

Equipment Manual AI 4xU/I/RTD/TC / AQ 2xU/I ST (6ES7534-7QE00-0AB0), Edition 09/2016

Contrary to the information given in the manuals, the following statements apply:

24 V encoder supply	
Short-circuit protection	Yes
Output current, max.	20 mA; max. 47 mA per channel for a duration < 10 s

The "encoder supply" depends on the module and is described in the technical specifications of the respective device manual. You can find the data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td). Enter the article number or the short designation of the desired module on the website.

S7-1500/ET 200MP - Analog Output Module AQ 8xU/I HS

Equipment Manual AQ 8xU/I HS (6ES7532-5HF00-0AB0), Edition 09/2016, Technical specifications section

Derating depending on mounting position, ambient temperature and output type (per module):

Deviating from the information in the equipment manual, the following statement applies:

The trends illustrated in the equipment manual show the number of channels (CHx) that can be **simultaneously activated** in horizontal and vertical installation of the S7-1500 automation system / ET 200MP distributed I/O system depending on the ambient temperature.

Shared device

Shared device is not possible with the HSP0318 in the combination of active backplane bus and S7-300/400 CPUs as IO controller.

This combination is possible with GSD file (in STEP 7 as of V5.5 and in STEP 7 (TIA Portal)).

Shared device with active backplane bus and S7-1500 CPUs as IO controller is possible with the HSP0318 and with GSD file.

S7-1500/ET 200MP - Digital Input Module DI 16xNAMUR HF

Equipment Manual DI 16xNAMUR HF (6ES7521-7TH00-0AB0), Edition 07/2021, Technical specifications section

Tolerances of the programmable input delay

Deviating from the tolerance range for input delay 0.05 ms specified in the Equipment Manual, the following values apply:

Input delay	Tolerance range
0.05 ms	14 µs to 22 µs

This modified tolerance range applies to all operating modes of the module.

The difference in tolerance range from that of other S7-1500 digital input modules is due to the extended counting frequency of the module of up to 20 kHz.

Integrated counting functions

You can optionally parameterize up to 4 inputs as counters with 2 x 20 kHz and 2 x 10 kHz or 4 x 10 kHz.

S7-1500/ET 200MP - Digital output module DQ 8x230VAC/2A ST Triac

Equipment Manual DQ 8x230VAC/2A ST Triac (6ES7522-5FF00-0AB0), Edition 12/2021,
Address space section

Table 3- 1 Configuration options

Configuration	Short designation / module name in the GSD file	Configuration software, e.g., STEP 7 (TIA Portal)	
		Integrated in hardware catalog STEP 7 (TIA Portal)	GSD file in STEP 7 (TIA Portal) V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 8-channel without value status	DQ 8x230VAC/2A ST	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x230VAC/2A ST MSO	V13 Update 3 or higher (PROFINET IO only)	X (PROFINET IO only)
1 x 8-channel with value status	DQ 8x230VAC/2A ST QI		

S7-1500/ET 200MP - Digital output module DQ 16x230VAC/1A ST Triac

Equipment Manual DQ 16x230VAC/1A ST Triac (6ES7522-5FH00-0AB0), Edition 12/2021,
Address space section

Table 3- 2 Configuration options

Configuration	Short designation / module name in the GSD file	Configuration software, e.g., STEP 7	
		Integrated in hardware catalog STEP 7 V13, SP1 or higher with HSP 0119	GSD file in STEP 7 V12 or higher or STEP 7 V5.5 SP3 or higher
1 x 16-channel without value status	DQ 16x230VAC/1A ST	X	X
2 x 8-channel without value status	DQ 16x230VAC/1A ST S	X (PROFINET IO only)	X (PROFINET IO only)
1 x 16-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 16x230VAC/1A ST MSO		
1 x 16-channel with value status	DQ 16x230VAC/1A ST QI		
2 x 8-channel with value status	DQ 16x230VAC/1A ST S QI		

S7-1500/ET 200MP - Digital output module DQ 8x24VDC/2A HF

Equipment Manual DQ 8x24VDC/2A HF (6ES7522-1BF00-0AB0), Edition 06/2018

Minimum pulse duration

The minimum pulse duration of 300 µs applies for a duty cycle > 0.

The following table shows the duty cycles and the values actually output for a duty cycle of 2 ms:

Duty cycle as a %	Pulse duration
0	0 µs
0.1	300 µs
10.0	300 µs
15.0	300 µs
15.1	302 µs
20.0	400 µs

Example for energy saving by reducing the holding current

The variable `PWM_Out` applies for the outputs QB x+2/3 for Channel 0 or QB x+4/5 for Channel 4.

The following special points apply for the duty cycle and the minimum pulse duration:

- At a duty cycle of 0 no PWM output is active
- At an on-load factor < 300 µs no signal is output

Address space operating mode pulse width modulation

If you have set "Pulse width modulation" mode for Channel 0 and Channel 4 in the operating mode parameter, Bit 0 and Bit 4 are not evaluated. Actuation of the PWM channels is effected via the duty cycle (QB x+2/3 and/or QB x+4/5).

Assignment in the process image output (PIQ)

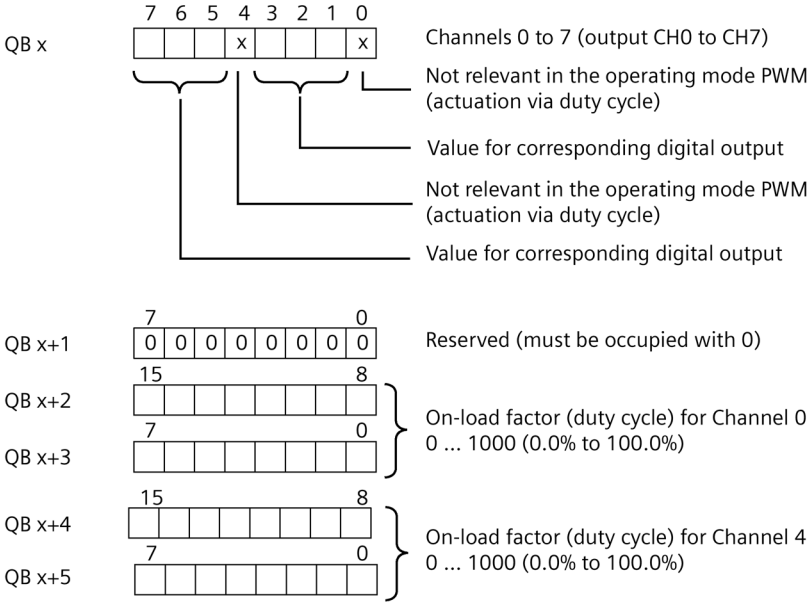


Figure 3-5 Allocation in the process image output

Amendments to SIMATIC S7-1500R/H documentation

4

Device IP addresses

S7-1500R/H System Manual, Edition 01/2024

Section System overview, Communication, System and device IP addresses

Note

If you communicate with the redundant system via the device IP addresses, you should preferably use the device IP address of the primary CPU. The transfer rate is better and the communication load is lower via the device IP address of the primary CPU.

Display of the source address in multicast packages

Communication Function Manual, Edition 11/2023

If an S7-1500 R/H CPU sends UDP multicast messages via the system IP address, the device IP address of the CPU is entered as the source address in the multicast packages instead of the system IP address. Take this behavior into consideration for filters and firewalls.

In case of a reply to the multicast sender, use the system IP address.

Configure FTP or Secure FTP in the S7-1500R/H redundant system

Communication Function Manual, Edition 11/2023

The S7-1500R/H redundant system supports the use of CP 1543-1 communications processors as of FW version V3.1. If you use the CP 1543-1 communications processors on the S7-1500R/H redundant system, you can also set up communication via FTP or secure FTP.

You configure the FTP server functionality in the properties of the respective CP. In the FTP configuration of each CP, always assign the R/H CPU to mounting rail_0. Only this R/H CPU can be selected in the selection list. The same applies to CPs that are plugged onto mounting rail_1.

Configuring VPN on the S7-1500R/H redundant system

Communication Function Manual, Edition 11/2023

If you are using the CP 1543-1 communications processors on the S7-1500R/H redundant system, you can also set up communication over a VPN. You can configure a VPN in one of the following ways:

- Both CPs in the same slot of the primary and backup CPU are in the same VPN
- Each CP in the same slot of the primary and backup CPU is located in a specific VPN

Communication over a VPN is only possible via the physical interfaces of the CPs. The virtual interface W1 of the CPUs does not support communication over a VPN.

Using the firewall of the CPs

You also configure the access to the CPUs via the device and system IP address of the virtual interfaces W1 in the firewall settings of the CPs.

4.1 Using an OPC UA server in an S7-1500R/H system

4.1.1 Information worth knowing on the OPC UA server in the S7-1500R/H system

As of firmware version V3.1, S7-1500R/H CPUs support OPC UA server functions. An OPC UA client is not supported.

The extensions for the OPC UA server of S7-1500R/H systems comply with the OPC 10000-4 specification: Services (Rel. 1.04), taking into account the restrictions described below.

The OPC UA server is accessible via all the integrated interfaces of the CPUs as well as via a CP 1543-1. To this end, the CP must be connected via the virtual interface W1 of the CPU (area "Access to PLC via communication module" in the CPU properties).

An OPC UA server facilitates open and standardized access to the CPU. In the R/H system, an OPC UA server runs on each of the two CPUs. The OPC UA servers of the primary and backup CPUs synchronize via redundancy mechanisms. In redundant operation, from the perspective of an OPC UA client, it is **a** server application.

Compared to standard CPUs, S7-1500R/H CPUs offer an advanced information model. With this advanced information model, it is possible for clients to take into account the specific features of the redundant system.

From the perspective of an OPC UA client, the same mechanisms are used to access the S7-1500R/H system (e.g. Discovery Service) as when accessing standard S7-1500 CPUs.

Restrictions for the OPC UA servers

When the OPC UA server is used in the S7-1500R/H system, there are restrictions as compared to the scope of capabilities of standard-S7-1500 CPUs:

- Data access only via server interfaces. The standard SIMATIC server interface is not supported. Therefore, a nodeset export (OPC UA XML file of the standard SIMATIC server interface) is also not supported.
- No support of GDS (certification management in runtime).
- No support of Alarms & Conditions.
- No access to the address space of a CPU's own OPC UA server via the OPC_UA_ReadList and OPC_UA_WriteList instructions.

  That is, the functions described in the following sections of the TIA Portal information system are not possible:

  - Diagnosing the OPC UA server with OPC_UA_ReadList
  - Set OPC UA-DataValue with OPC_UA_WriteList
- The resolution of the time stamps provided by the server is 1 ms (standard CPU: 1 ns).

An overview of the general restrictions of the S7-1500R/H redundant system compared to the S7-1500 automation system can be found in the section "Application planning > Restrictions" in the "S7-1500R/H redundant system" system manual.

You can find a description of how to configure an OPC UA server (e.g. creating server interfaces) in the Communication Function Manual or in the information system of the TIA Portal.

Influence on cycle and response times

If you enable the OPC UA server of an S7-1500R/H system, this will affect the cycle and response times.

You must consider the following effects:

- The cycle time for an S7-1500R/H system in the RUN-Redundant system state is extended by activating the OPC UA server.
- The accuracy with which higher-priority alarms interrupt a cycle OB, for example, decreases. Example: The "Jitter" for a cyclic interrupt increases.
- Otherwise, the basic rules from the following document apply: Function Manual "Cycle and Response Times" (https://support.industry.siemens.com/cs/us/en/view/59193558).

CAUTION

Thorough testing of the maximum cycle time during the commissioning phase

During the commissioning phase, check whether the S7-1500R/H system works reliably with the set maximum cycle time even under worst-case conditions (alarms, communication load from maximum number of clients including connection/disconnection).

Requirements

- TIA Portal V19 with installed Hardware Support Package (HSP) "HSP_V19_0445_001_S71500_RH_3.1".

  The S7-1500R/H CPUs are installed with this HSP.

Redundancy at OPC UA

The redundant system consisting of two or more servers is called a "Redundant Server Set" in OPC UA. Server redundancy in accordance with the OPC UA specification recognizes the following operating modes (Modes of Redundancy):

- Transparent Mode (transparent Redundancy)

  In transparent operating mode, the server is solely responsible for failover in the event of an error (Failover). The OPC UA client does not require any redundancy knowledge to continue the data exchange. To work in the Transparent Mode, the client must connect to the system IP address of the CPU interface. If you are using a CP 1543-1, use the virtual interface W1 of the CPU with the configured system IP address.

- Non-transparent Mode (non-transparent Redundancy)

  In non-transparent mode, the client is responsible for switching from one server to the other in the event of an error (Failover). The client must initiate the required actions in order to benefit from the redundant system. To work in non-transparent Mode, the client must connect to the corresponding device IP addresses of the R/H CPUs. If you are using a CP 1543-1, use the virtual interfaces W1 of the CPUs with configured device IP addresses.

An S7-1500R/H system supports both operating modes.

The Redundant Server Set provides access to information on availability via the "ServiceLevel" variable; a byte that numerically reflects the "Health status" of a server.

The ServiceLevel allows conclusions to be drawn about the redundancy status, e.g. whether the CPU is the primary or backup CPU or whether the system is in the RUN-Redundant system state. You can find information on the ServiceLevel in the section on non-transparent mode.

More information

You can find additional and up-to-date information on using the OPC UA server with S7-1500R/H systems in the following entry: FAQ How do you use the OPC UA server in an S7-1500 R/H system? (https://support.industry.siemens.com/cs/ww/en/view/109822965)

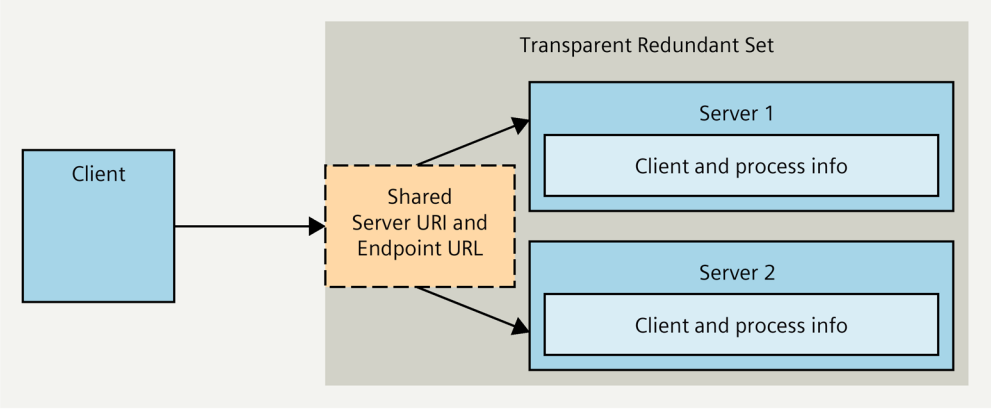
4.1.2 Transparent Mode (transparent Redundancy)

Details on transparent redundancy are explained below - an operating mode that allows a client to deal with the redundant system as with a single system or with an OPC UA server of a standard CPU.

Primary CPU always accessible via system IP address

For an S7-1500R/H station, use the system IP address for transparent redundancy. With the system IP address, a client accesses the primary CPU, i.e. the CPU that is currently hosting this IP address.

The following figure shows an example of the use of transparent redundancy in accordance with OPC UA 10000-4.



Response upon loss of primary CPU (RUN-Redundant > RUN-Solo)

In the event of an error (failover), communication between the client and server is briefly interrupted. All established sessions and subscriptions are retained and can be resumed - with the new primary CPU. In this case, the behavior from the client's point of view corresponds to the behavior in the event of temporary communication errors in which the session is also resumed.

As soon as the new primary CPU can be accessed after the failover via the system IP address, the client can resume communication (reactivate session).

Behavior when restoring redundancy (SYNCUP > RUN-Redundant)

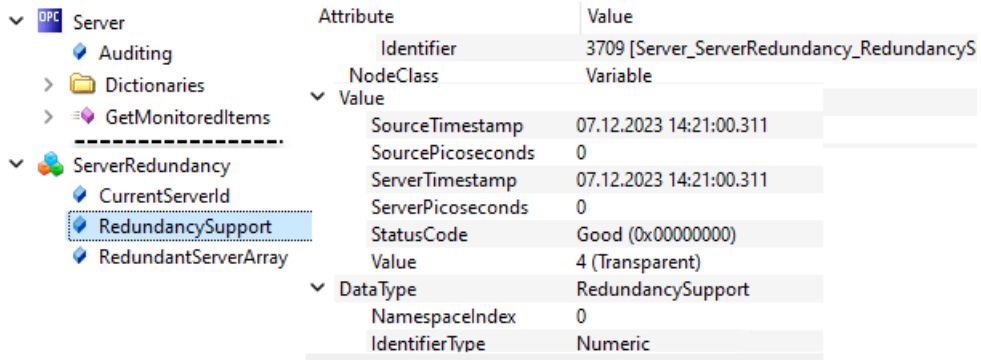
If the initial state of the redundant system is restored after a failover, e.g. after replacing the faulty CPU, the system performs a SYNCUP.

During SYNCUP, the OPC UA servers are restarted in both CPUs. All existing sessions and subscriptions are deleted.

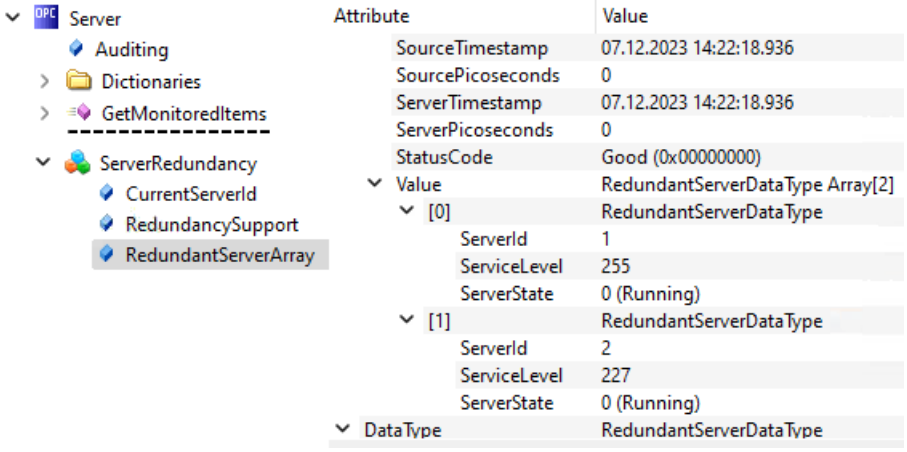
As soon as the server of the primary CPU is accessible again, the client must recreate the sessions and subscriptions.

Relevant nodes in the information model for transparent redundancy

Information in the information model on transparent mode of the R/H station can be found under the "ServerRedundancy" object (namespace index "0" or namespace "http://opcfoundation.org/UA/").



You can determine the ServerState and ServiceLevel of the redundant servers using the RedundantServerArray:



You can find more information on the ServiceLevel in the next section.

4.1.3 Non-transparent Mode (non-transparent Redundancy)

In the following, details on non-transparent redundancy are explained. In this operating mode, OPC UA provides the following information for a client:

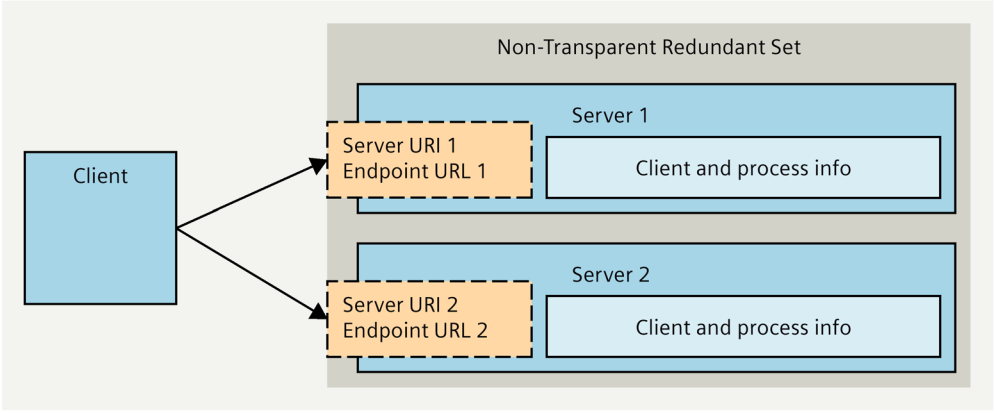
- Which servers are available in the Redundant Server Set
- Which types of failover between the available servers are supported

This information allows the client to determine what it needs to do to achieve switchover. The client must not only be able to interpret the ServerRedundancy attribute, but also know the extended information model of the redundant server.

Address parameters of the redundant OPC UA server in an R/H system

In contrast to transparent redundancy, the servers in the R/H system are addressed via their unique IP address (device IP address or virtual IP address in the case of a configured CP 1543-1).

The following figure shows an example of the use of non-transparent redundancy in accordance with OPC UA 10000-4.



Response upon loss of primary CPU: Failover modes

According to OPC 1000-4: Services, servers can support different failover modes: Cold, Warm, Hot and HotAndMirrored.

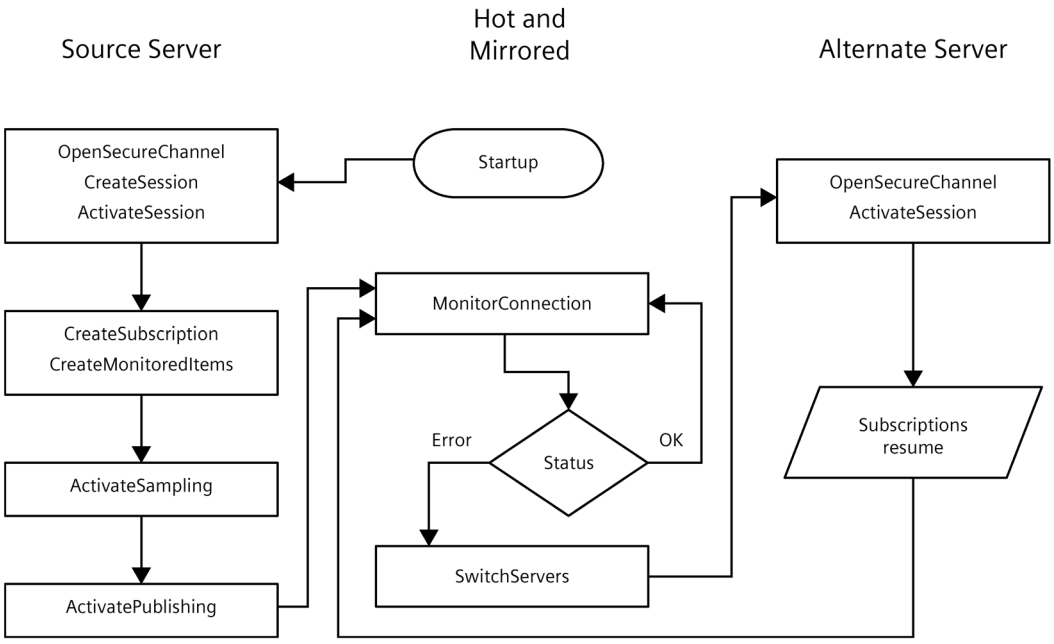
The OPC UA server of an S7-1500R/H CPU supports "HotAndMirrored" failover mode.

The client must know that the OPC UA server is a redundant server and must perform the failover process in a certain way due to the supported Failover modes.

The way in which the failover process should take place is described in the OPC 10000-4 specification: Services, section "Client failover behavior - HotAndMirrored". The client is responsible for tracking the status of the server, i.e. periodically querying the ServiceLevel and switching to the alternative server (in the case of an S7-1500R/H system, this means the backup CPU) in the event of an error. This type of redundancy control offers the following advantages:

- The client has full control in the selection of the alternative server.
- The client can access the OPC UA server via separate networks.

The following figure from the specification OPC 10000-4: Services shows the steps that the client goes through when it receives the signal to switch to the "Alternate server" due to a low ServiceLevel value for the "Source server".



ServiceLevel

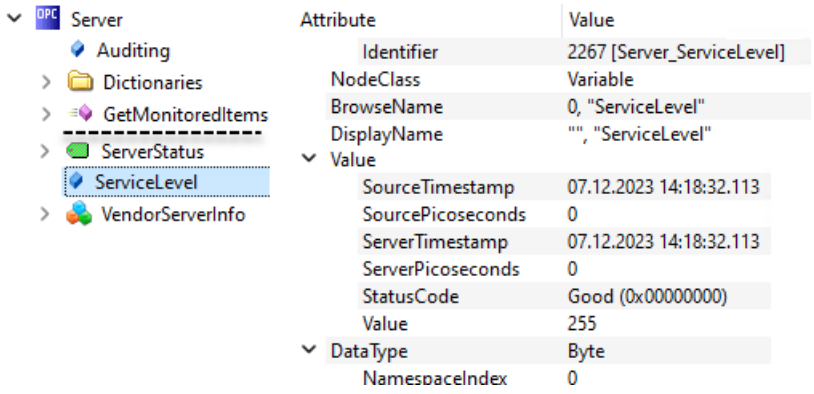
ServiceLevel is a variable that is modeled as a property of the ServerType object in the address space of the server. You use the ServiceLevel to find out whether the addressed server is still supplying data, for example. The ServiceLevel is a numerical value for the "Health status" of the server and thus provides the client with a trigger for switching the server.

The structure of the ServerType object is described in the OPC 10000-5: Information Model specification, section "ServerType".

For S7-1500R/H, the following ServiceLevel values apply to the respective OPC UA server:

- **RUN-Redundant**: ServiceLevel primary CPU = 255 (CPU in RUN), service level backup CPU = 227 (CPU in RUN).
- **CPU in STOP**: ServiceLevel of the failed CPU (RUN STOP transition) = 1 (NoData). This is the trigger for the client for the failover.

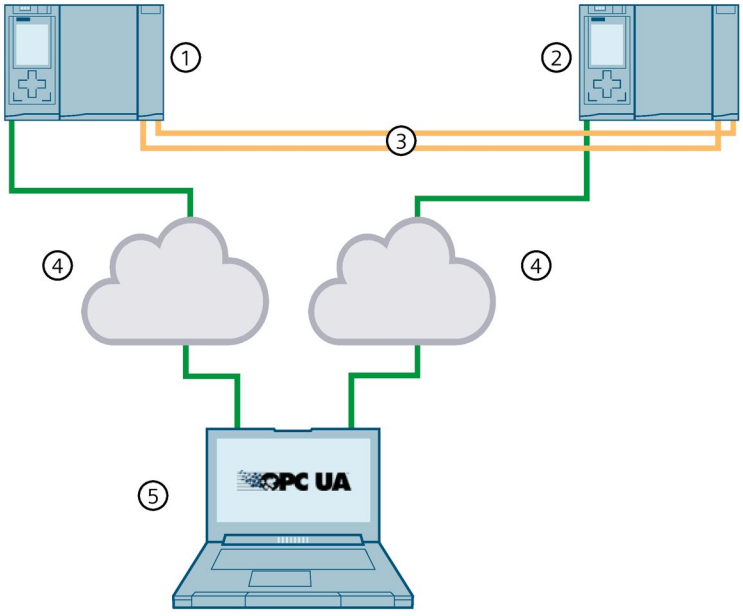
Example for a primary CPU in RUN:



Application of non-transparent redundancy

If a client accesses the OPC UA server via different, i.e. independent subnets, transparent redundancy using the system IP address is not possible.

The following figure shows a configuration with an H system that is connected to a client via two subnets.



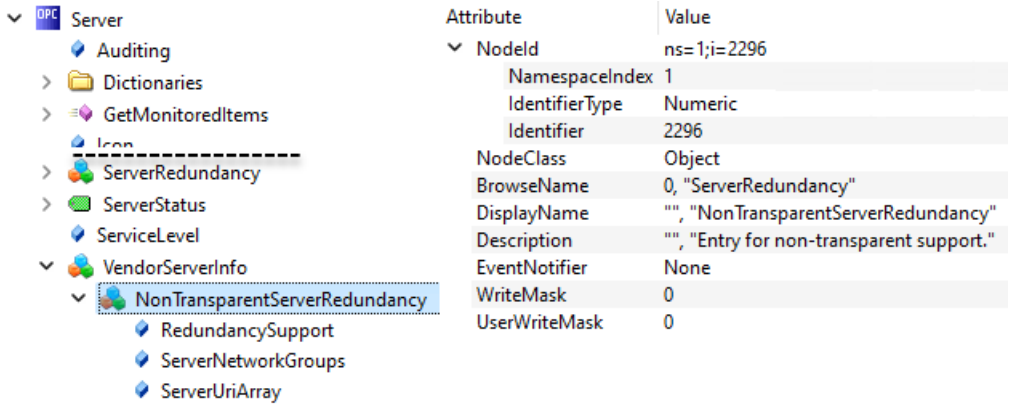
① Primary CPU (H CPU)
② Backup CPU (H CPU)
③ Fiber-optic sync cable
④ Network topology
⑤ OPC UA client (prepared for communication with a redundant server)

The client can connect to the H system via the two independent networks. The two H CPUs are not connected via one of the networks. In this way, the failure of a network can be tolerated.

Independent subnets are not a requirement for non-transparent mode. You can also use non-transparent mode for configurations with a subnet.

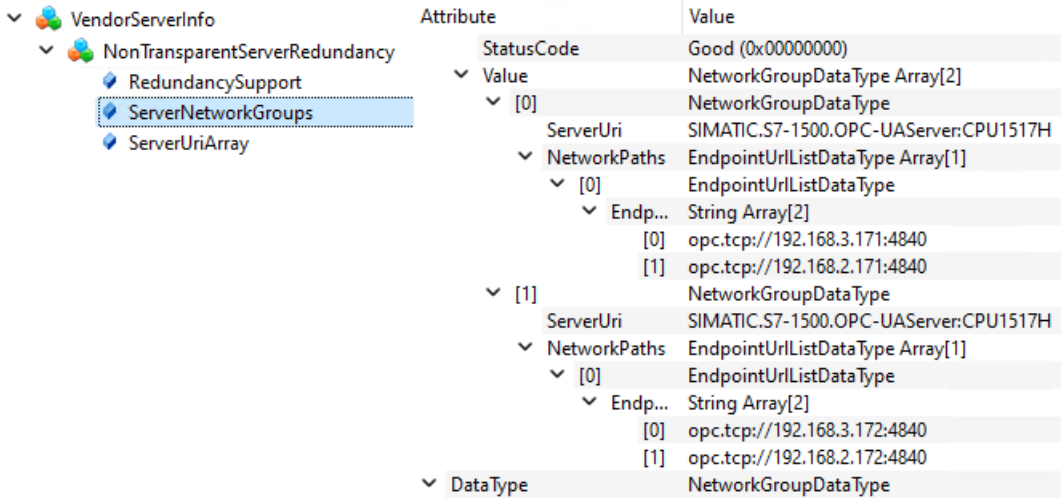
Relevant nodes in the information model for non-transparent redundancy

The information in the information model of the R/H station that is relevant for non-transparent mode is located under the "VendorServerInfo" object, a placeholder object for vendor-specific information about the OPC UA server. This vendor-specific node and the nodes below it are located in the namespace for the local server (e.g. urn: SIMATIC.S7-1500.OPC-UA.Application:PLC_1 with namespace index 1.



In the ServerRedundancy object below, a client can find all the required information to connect to the R/H system.

The ServerUriArray-Property allows a client to select a suitable server. The information on which network paths can be used to access the servers can be found via the object type NonTranparentNetworkRedundancyType - a subtype of NonTransparentRedundancyType. The object type NonTranparentNetworkRedundancyType references the ServerNetworkGroups variable, which contains an array of servers (EndpointUrlList) together with information on which redundant network paths exist for each server (NetworkPaths).



You can find a detailed description of the relevant nodes with their references below the VendorServerInfo node in the OPC UA specification (OPC 10000-5: Information Model).

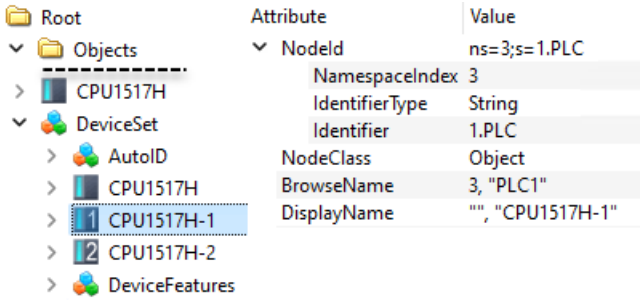
For an S7-1500R/H system, the EndpointUrlList contains an entry for each device IP address or virtual device IP address (if configured together with a CP 1543-1) via which the servers of the S7-1500R/H system can be accessed. In the event of a failure, the client can decide whether to connect to the same server via a different path or whether to choose the redundant server.

4.1.4 Information model in detail

The following sections show the structure of the information model of an S7-1500R/H system in detail. The information model is suitable for both clients that access the R/H system like a standard CPU and clients that want to have full control over the R/H system.

Advanced information model for redundant systems

The following figure shows by way of example how the R/H system is modeled in the DeviceSet node as a separate object next to the individual R/H CPUs.



R/H system as a separate node in the information model

Under the DeviceSet node, in addition to the nodes for each R/H CPU, there is also a node as a representative for the R/H system.

The OPC UA server is temporarily not available in the SYNCUP system state (RUN-Syncup mode for primary CPU). The server restarts in this state.

The nodes represent the following information:

Node **<config-ured name>**	**Contents**	**Accessible data in the RUN-Redundant system state**	**Accessible data in the RUN-Solo system state**
<R/H sys-tem>	Information regarding the R/H system	Server interface data (identical for both CPUs) CPU-specific information of the primary CPU	Client is connected with: • Primary CPU: Data of the server inter-face of the primary CPU. • Backup CPU: Server interface data (if ServiceLevel = NoData: server interface data is invalid or not available).
<PLC 1>	Information via R/H CPU with redundancy ID 1	Server interface data (identical for both CPUs) CPU-specific information of the CPU with redundancy ID 1	Client is connected with: • PLC 1 (= primary CPU): Data of the server interface of the primary CPU. • PLC 1 (= backup CPU): Server interface data (ServiceLevel = NoData signifies the data is invalid or not available). • PLC 2 (= backup CPU): No data (access error BadInvalidState / (BadRe-sourceUnavailable))
<PLC 2>	Information via R/H CPU with redundancy ID 2	Server interface data (identical for both CPUs) CPU-specific information of the CPU with redundancy ID 2	Client is connected with: • PLC 2 (= primary CPU): Data of the server interface of the primary CPU. • PLC 2 (= backup CPU): Server interface data (ServiceLevel = NoData signifies the data is invalid or not available). • PLC 1 (= backup CPU): No data (access error BadInvalidState / (BadRe-sourceUnavailable))

Nodes below the device nodes

Device nodes are the nodes below the DeviceSet node (R/H system, PLC 1, PLC 2).

The "OperatingMode" and "RedundancyMode" attributes are of particular interest.

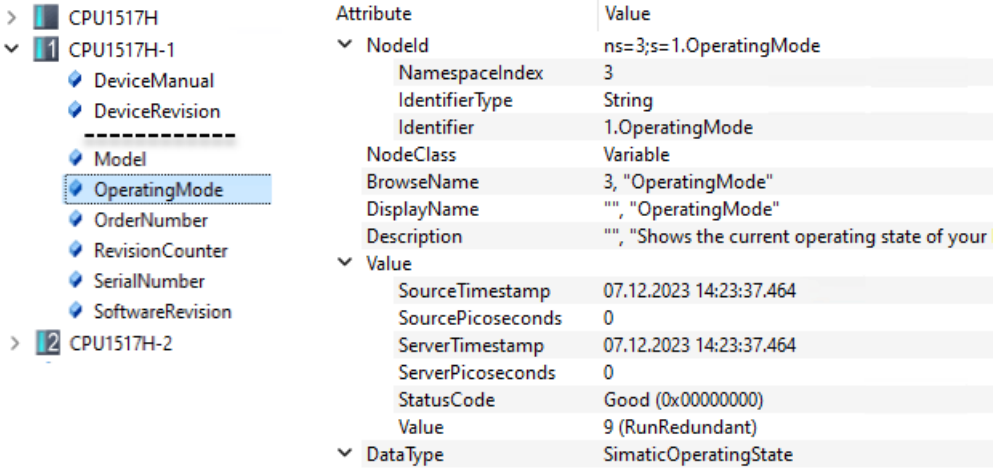
Operating mode

The OperatingMode-Property below the R/H system node shows the operating mode of the primary CPU for the R/H system node.

The following values are defined for the individual CPUs of the R/H system and for the R/H system:

OperatingMode	R/H system	R/H CPU
1 (STOP - FW update)	x	x
3 (STOP - Initialization)	x	x
4 (STOP)	x	x
6 (Startup)	x	x
8 (RUN)	x	x
9 (Run Redundant)	x	x
10 (HOLD)	x	x
13 (Defective)	x	x
14 (Troubleshooting)	x	x
15 (No power)	x	x
17 (STOP - no de-energized/substitute value switch for outputs)	x	x
18 (RUN - de-energized/substitute value switch for outputs)	x	x
19 (Program test)	x	x
20 (Run program test)	8 (RUN)	x (primary; backup in test mode)
21 (RUN Syncup)	8 (RUN)	x
22 (Syncup)	8 (RUN)	x
31 (Remote unknown)	x	-

Example with node attributes for OperatingMode:

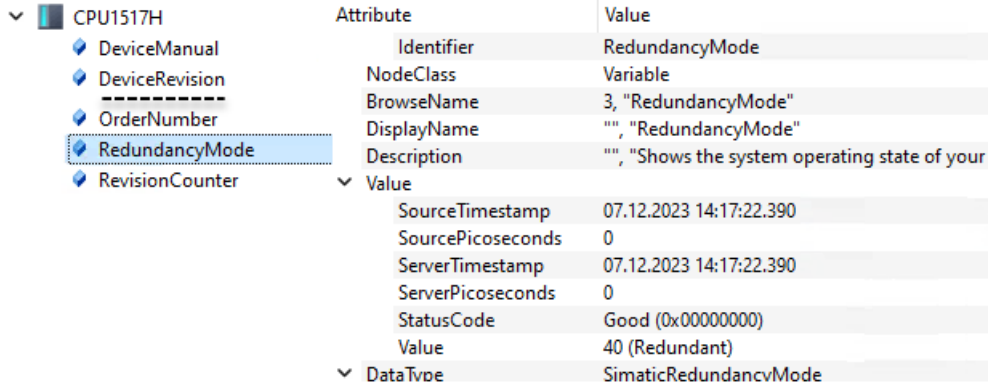


RedundancyMode

The RedundancyMode-Property property shows the system status of the R/H system and is only available in the R/H system node.

RedundancyMode	R/H system	R/H CPU
32 (No power)	x	-
33 (STOP)	x	-
34 (HOLD)	x	-
35 (Startup)	x	-
37 (Run solo)	x	-
38 (Syncup)	x	-
39 (Program test)	x	-
40 (Redundant)	x	-

Example with node attributes for RedundancyMode:



4.1.5 Updated instructions for server methods

To implement server methods in an S7-1500 CPU, use the "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" instructions. You can find details on the instructions in the TIA Portal information system under "OPC UA > Server instructions > Methods". The description relates to version V1.0 of these instructions.

Details of the new version V1.1 of these two instructions are explained below.

- For S7-1500R/H CPUs as of FW version V3.1, version V1.1 of the server instructions is mandatory - the use of version V1.0 is not permitted.
- The recommendation applies to S7-1500 standard CPUs: For new projects starting from TIA Portal V19 and CPU firmware version V3.1, always use the new server instruction version V1.1 or higher.
- Within a project, you can use both the instructions with version V1.0 and the instructions with version V1.1. You can only use one version within a CPU user program.

To implement server methods in the user program, use the example program published here and not the example from the help system of the TIA Portal.

Compatibility between version V1.0 and V1.1 of the instructions for server methods

There are the following differences between version V1.0 and V1.1 with regard to the server instructions:

- Resetting the output parameter "UAMethod_Called" of the server instruction "OPC_UA_ServerMethodPre":
  - V1.0: "UAMethod_Called" is automatically reset if both "DONE" of the "OPC_UA_ServerMethodPre" instruction and "DONE" of the "OPC_UA_ServerMethodPost" instruction are reset. "UAMethod_Called" is therefore only reset when "OPC_UA_ServerMethodPost" is completed.
  - V1.1: "UAMethod_Called" is automatically reset when output parameter "DONE" of the "OPC_UA_ServerMethodPre" instruction is reset. "UAMethod_Called" is therefore only available for one cycle.
- Release of the instances of "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost":
  - V1.0: No cyclic call of the server instructions required.
  - V1.1: Mandatory cyclical call of the server instructions required.
- The "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" instructions in version V1.1 behave in accordance with the description for asynchronous instructions. For information on this, see TIA Portal information system "Asynchronous working instructions".

Note

When switching to the OPC UA server methods from version V1.0 to version V1.1, check whether your user program takes into account the described change in functionality. Adjust your program if necessary.

Example program

```
FUNCTION_BLOCK "mySERVER_METHOD"
{ S7_Optimized_Access := 'TRUE' }
VERSION : 0.1
   VAR DB_SPECIFIC
      UAMethod_InParameters : Struct
         IN_BOOL : Bool;
         IN_INT : Int;
      END_STRUCT;
      UAMethod_OutParameters : Struct
         OUT_BOOL : Bool;
         OUT_INT : Int;
      END_STRUCT;
   END_VAR
   VAR
      OPC_UA_ServerMethodPre_Instance {InstructionName :=
'OPC_UA_ServerMethodPre'; LibVersion := '1.1'} :
OPC_UA_ServerMethodPre;
      DONE_PRE { S7_SetPoint := 'True'} : Bool;
      BUSY_PRE : Bool;
      ERROR_PRE : Bool;
```

```
      STATUS_PRE : DWord;
      UAMethod_Called : Bool;
      OPC_UA_ServerMethodPost_Instance {InstructionName :=
'OPC_UA_ServerMethodPost'; LibVersion := '1.1'} :
OPC_UA_ServerMethodPost;
      UAMethod_Result { S7_SetPoint := 'True'} : DWord;
      UAMethod_Finished : Bool;
      DONE_POST { S7_SetPoint := 'True'} : Bool;
      BUSY_POST : Bool;
      ERROR_POST : Bool;
      STATUS_POST : DWord;
   END_VAR


BEGIN
    #OPC_UA_ServerMethodPre_Instance(Done => #DONE_PRE,
                                     Busy => #BUSY_PRE,
                                     Error => #ERROR_PRE,
                                     Status => #STATUS_PRE,
                                     UAMethod_Called =>
#UAMethod_Called,
                                     UAMethod_InParameters :=
#UAMethod_InParameters);

    //Method is called
    IF #UAMethod_Called AND NOT #ERROR_PRE THEN

        //Functionality:  InParameters are valid and copied to
OutParameters

        #UAMethod_OutParameters.OUT_BOOL :=
#UAMethod_InParameters.IN_BOOL;

        #UAMethod_OutParameters.OUT_INT :=
#UAMethod_InParameters.IN_INT;


        //If Method is finished without errors prepare output
parameters of OPC_UA_ServerMethodPost accordingly

        #UAMethod_Result := 0;
        #UAMethod_Finished := TRUE;
    END_IF;



    #OPC_UA_ServerMethodPost_Instance(UAMethod_Result :=
#UAMethod_Result,
                                      UAMethod_Finished :=
#UAMethod_Finished,
                                      Done => #DONE_POST,
                                      Busy => #BUSY_POST,
                                      Error => #ERROR_POST,
                                      Status => #STATUS_POST,
                                      UAMethod_OutParameters :=
```

```
#UAMethod_OutParameters);

//Reset Input Parameters after OPC_UA_ServerMethodPost is done

    IF #DONE_POST OR #ERROR_POST THEN

         #UAMethod_Finished := FALSE;
         #UAMethod_Result := 0;


    END_IF;


END_FUNCTION_BLOCK
```