

Siemens Digital Industries Webinari

FA3: Redundantni kontroleri serije S7-1500R/H

Siemens Digital Industries Webinari 1/2



Datum	Tema	Predavač
14.04. / 19.05.	FA1: Motion Control	<i>Darko Živković, Jelena Đukić</i>
15.04. / 14.05.	FA2: Energy Management System	<i>Zoran Jovanović</i>
 22.04. / 21.05.	FA3: Redundantni kontroleri serije S7-1500R/H	<i>Mirko Milovanović</i>
05.05. / 26.05.	FA4: WinCC Unified	<i>Mirko Milovanović</i>
15.04. / 13.05.	MC1: DT konfigurator	<i>Nenad Bakal, Pavle Dragišić</i>
23.04. / 22.05.	MC2: Sizer, large drives	<i>Miloš Marković, Pavle Dragišić</i>
06.05. / 26.05.	MC3: Sizer, motion drives	<i>Miloš Marković, Pavle Dragišić</i>
21.04. / 21.05.	CI1: Industrial Networks	<i>Jelena Đukić</i>

Siemens Digital Industries Webinari 2/2



Datum	Tema	Predavač
16.04. / 15.05.	PI1: PI Academy world	Andrijana Popara, Miljan Miljanić, Marko Marić
24.04. / 22.05.	PI2: PI workshop for specialist	Andrijana Popara, Miljan Miljanić, Marko Marić
08.05. / 29.05.	PI3: #New@PI	Andrijana Popara, Miljan Miljanić, Marko Marić
30.04. / 29.05.	AE1: Digitalna rešenja u procesnoj industriji	Jelena Đukić, Marko Milenković
29.04.	CP1: Control Panel Online Symposium	Siemens worldwide webinar
22.04. / 27.05.	CP2: Clever engineering in the control panel	Tijana Džodžo
28.04. / 12.05.	CP3: New series of signaling devices 3SU	Tijana Džodžo
21.04. / 20.05.	CP4: SIRIUS 3RW Soft starters	Bojan Janković
07.05. / 28.05.	DE1: Siemens Digital Enterprise	Zoran Jovanović

Današnji predavač

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**Mirko
Milovanović**

Responsibility

PLC
HMI/SCADA/IPC

Contact

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🏭 RC-RS DI FA

🏠 Belgrade, Serbia

SIMATIC S7-1500R/H

Unrestricted @ Siemens 2020

[siemens.com/S7-1500](https://www.siemens.com/S7-1500)

V16

SIMATIC S7-1500 Redundant Systems



- Motivation and Product Strategy
- System Overview
- System Redundancy and Network Configuration
- Failure Scenarios
- Communication
- S7-1500R/H and Safety
- HMI Connection
- Installation Recommendations
- New Features with TIA Portal V16 
- Remaining Restrictions
- Ordering Information

SIMATIC S7-1500 Redundant Systems

Motivation



Preventing plant downtime

High availability during operation,
Avoidance of loss of production



Prevention of damages

Avoidance of unplanned production
stops where the product to be
processed would be permanently
damaged



Prevention of data losses

The data remain intact and long restart
times after a failure are eliminated.

Operation without persons locally

Maintenance trips can be better
planned

Save on maintenance

Application solutions are mostly
complicated and difficult to maintain



Redundant systems reduce costs

SIMATIC S7-1500 Redundant Systems

Product Strategy S7-1500R/H

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Based on Standard S7-1500 CPUs and PROFINET

- Basis Hardware Standard-CPU/Fail-safe CPUs



Transparent Programming

- Standard Engineering Tool TIA Portal
 - Redundancy functions fully integrated in TIA Portal
 - General handling like standard
 - No deep Redundancy Know-How needed



Extensive Scalability

- Scalability of switch-over time
- Scalability of the Redundancy Architecture
- Scalability of the CPU Performance (1513 → 1517)



Step by Step Product Launch Strategy

- First release with basic redundancy functions
- First release will not include all standard and redundancy functions
- Step by Step increasing of feature set in future versions



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SIMATIC S7-1500 Redundant Systems

System overview

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Consistent concept –
Identical synchronization
process

Scaling of the switching
performance over the **available
bandwidth** of the
sync connection

CPU type

Synchronization

Switchover time

I/O systems

Type of connection

Redundant – S7-1500R



CPU 1513R / CPU 1515R

via **PROFINET Ring (MRP)**

300 ms

High Available – S7-1500H



CPU 1517H

via **Sync-Module**

50 ms

ET 200SP and ET 200MP ¹⁾

Single connection (PN redundancy S2) and switched S1 ²⁾

SIMATIC S7-1500 Redundant Systems

PLC Hardware



	CPU 1513R-1 PN 6ES7513-1RL00-0AB0	CPU 1515R-2 PN 6ES7515-2RM00-0AB0	CPU 1517H-3 PN 6ES7517-3HP00-0AB0	Short Distance <= 10m	Long Distance <= 10km
Program / memory	350 kB code 1,5 MB data	500 kB code 3 MB data	2 MB code 8 MB data	Fiber Optic Cable	
Interfaces	X1  	X2 X1   	X2 X1 X3 X4     	Plastic	Glass fiber
Firmware	V2.8	V2.8	V2.8	Sync module SFP	
				6ES7960-1CB00-0AA5	6ES7960-1FB00-0AA5



X1: PROFINET IO Controller, Supports RT, MRP, Transport Protocol TCP/IP, Open User Communication
X2: PROFINET Basic Services, Transport Protocol TCP/IP, Open User Communication

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PROFINET System Redundancy Concept

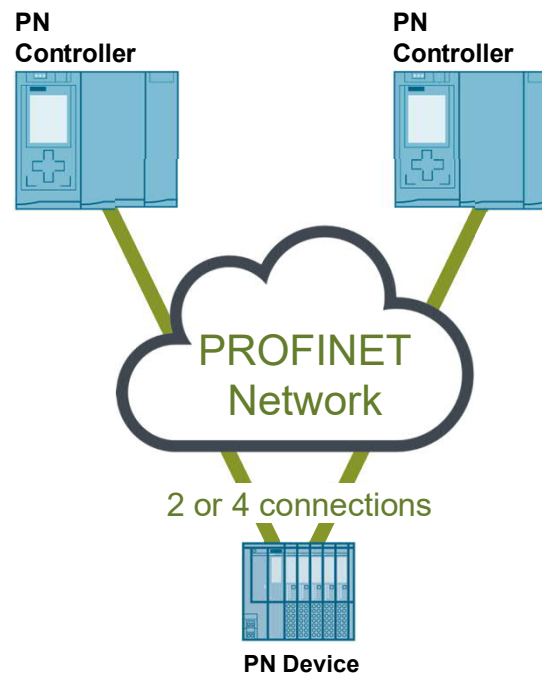
PROFINET SR

A System with redundant PN controllers and single or redundant PN devices.

Three levels:

1. PN Controller
2. PROFINET Network
3. PN Device

Redundancy at one level is independent of redundancy at each other level.



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PI
PROFIBUS • PROFINET

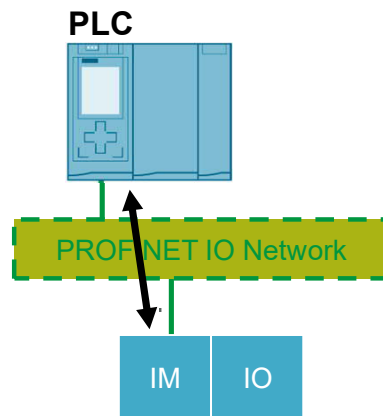
System Redundancy

*Common profile
for PROFINET*

*Version 1.11 – Date: February 2017
Order No.: 7.122*

PROFINET System Redundancy

S1 Mode

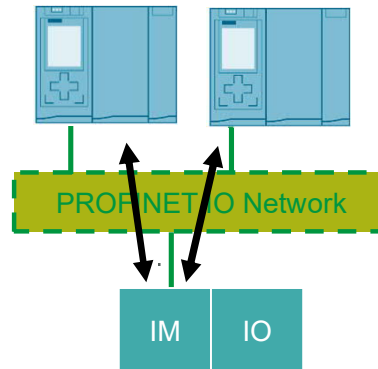


S1 Device

S → Single interface
1 → one connection to one PLC

Standard PLC + R/H

S2 Mode

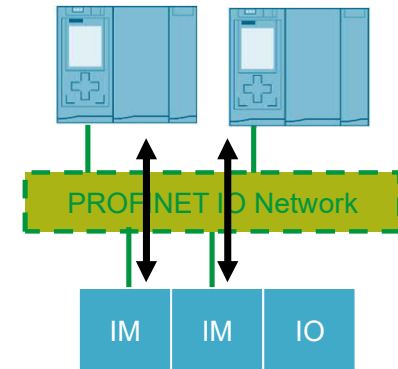


S2 Device

S → Single interface
2 → can switch between two connections

For R/H PLC

R1 Mode



R1 Device

R → Redundant interface
1 → each interface has one connection to one PLC

Future 1500H release

PROFINET System Redundancy

Siemens PN IO-Devices with PN S2 Support



I/O-Systems

ET 200SP - IM155-6PN HF (FW>=4.2)		6ES7155-6AU01-0CN0 6ES7155-6AU30-0CN0
ET 200MP - IM155-5PN HF (FW>=4.2)		6ES7155-5AA00-0AC0
PN/PN-Koppler		6ES7158-3AD10-0XA0
ET 200eco PN M12-L ¹⁾		6ES7 14*-6**00-0BB0

PROFINET System Redundancy

Siemens PN IO-Devices with PN S2 Support



Drives

S120, CU310-2PN (FW >=5.2) (with gsdml)		6SL3040-1LA01-0AA0
S120, CU320-2PN (FW >=5.2) (with gsdml)		6SL3040-1MA01-0AA0

Switches

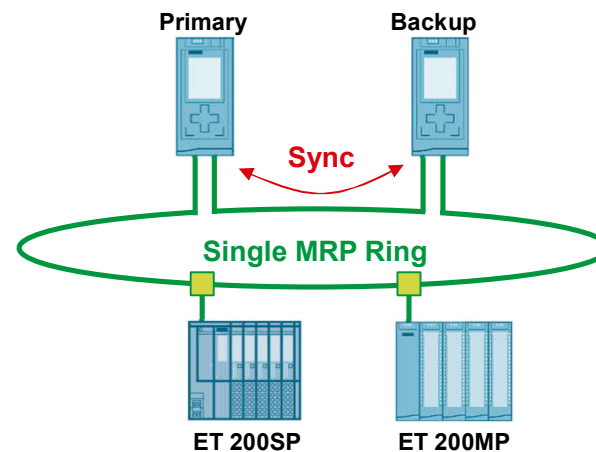
SCALANCE XC-200 Serie		6GK5 2 . . - . . . 00 - 2 . C2
SCALANCE XP-200 Serie		6GK5 2 . . - 0 . A00 - . . S6
SCALANCE XF204-2BA		6GK5 204-2AA00-2GF2

Network Configuration with S7-1500R/H Requirements

Requirements for the PROFINET network configuration

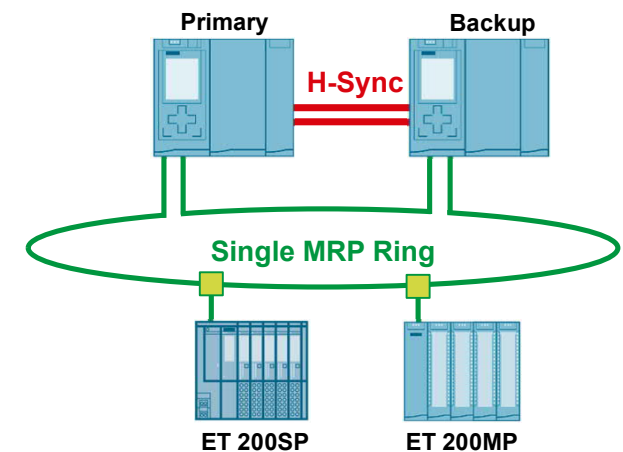
- MRP Ring (default setting in the configuration)
- PN IO only at X1 interface
- PLC's need to be part of the ring
- S7-1500R → no devices in the connection between the two PLC's
- PN Devices need to support PN System redundancy
NAP S2 (V1.11)

Redundant – S7-1500R



Max. 16 devices in ring*)

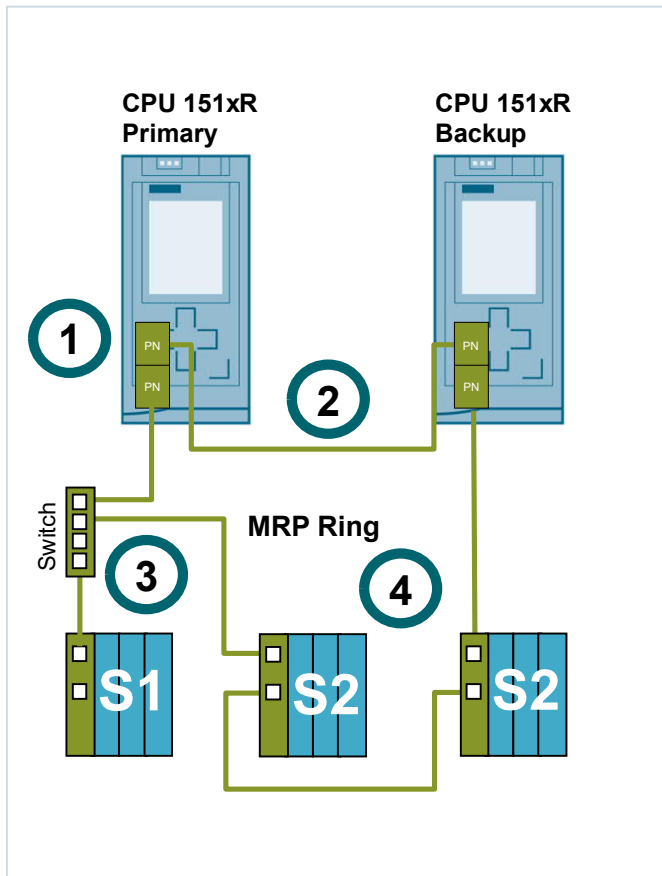
High Available – S7-1500H



Max. 50 devices in ring*)

Network Configuration with S7-1500R/H

Basic System Configuration



Structure

- 1 MRP-Ring must be connected to the X1 - Port
- 2 Synchronization over PN-Ring – no device in this segment
- 3 S1 Devices should be connected via a switch to the ring¹⁾
- 4 S2 Devices can be integrated into the ring or also separated with a switch

1) Reason: S1 devices do not forward H-sync telegrams during a MRP reconfiguration phase. This would lead to a high PLC cycle time in the case that segment 2 is interrupted.
See chapter „H-Sync Forwarding“ in the system manual of S7-1500R/H for details.

Network Configuration with S7-1500R

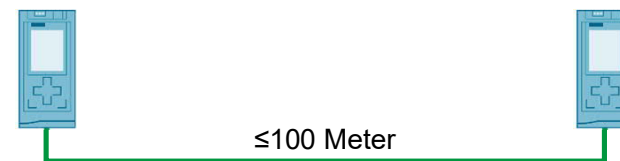
Length of the synchronization connection

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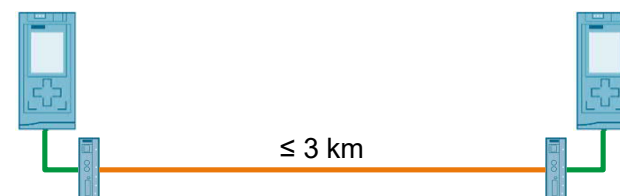


CPU 1513R
CPU 1515R

Direct link up to 100 m

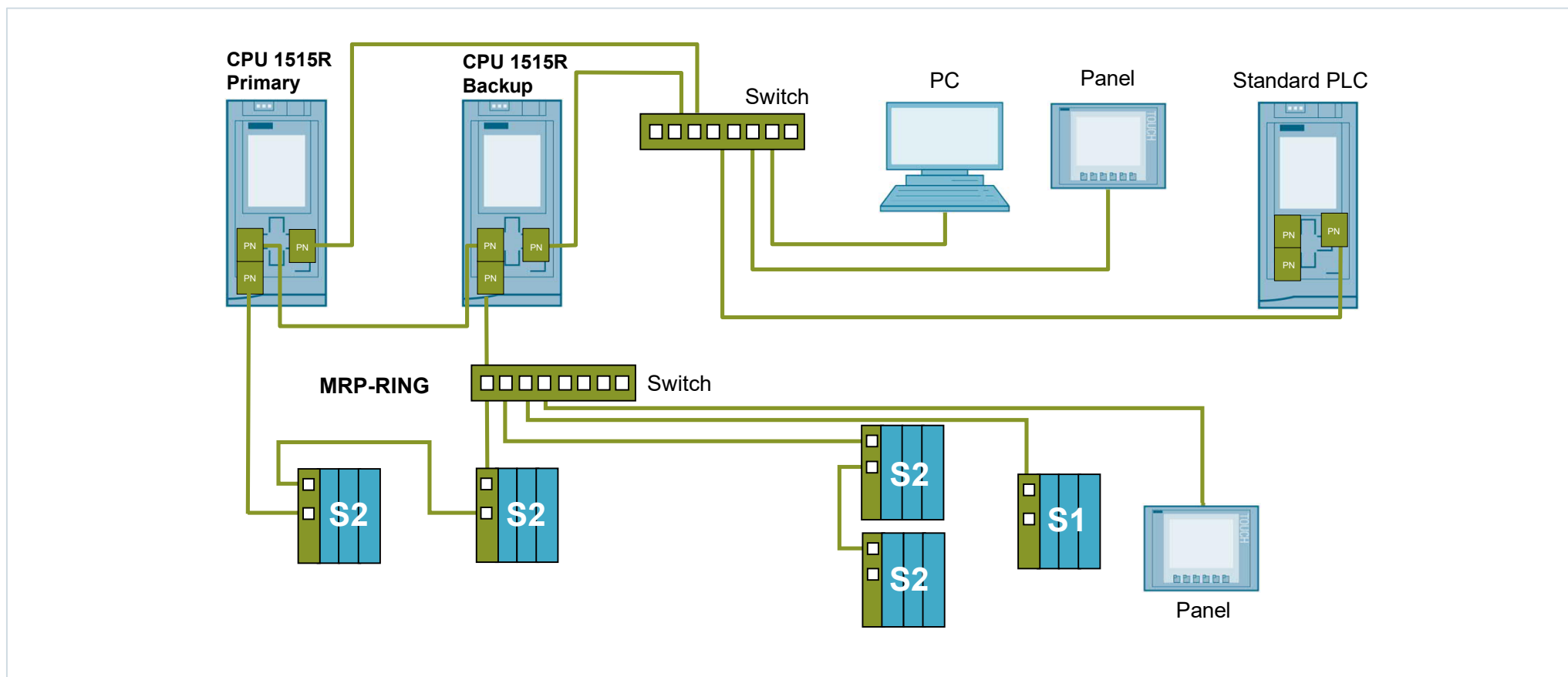


Fiber optic link
(media converter) up to 3 km



Configuration example CPU 1515R

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Network Configuration with S7-1500H

Length of the synchronization connection

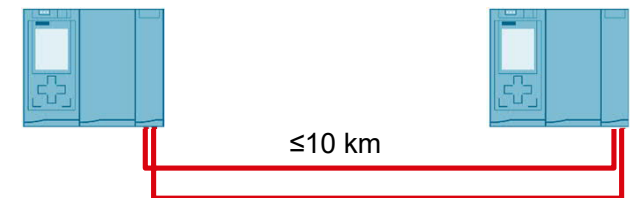
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CPU 1517H

Short distance Sync modules
up to 10 Meter (LED)

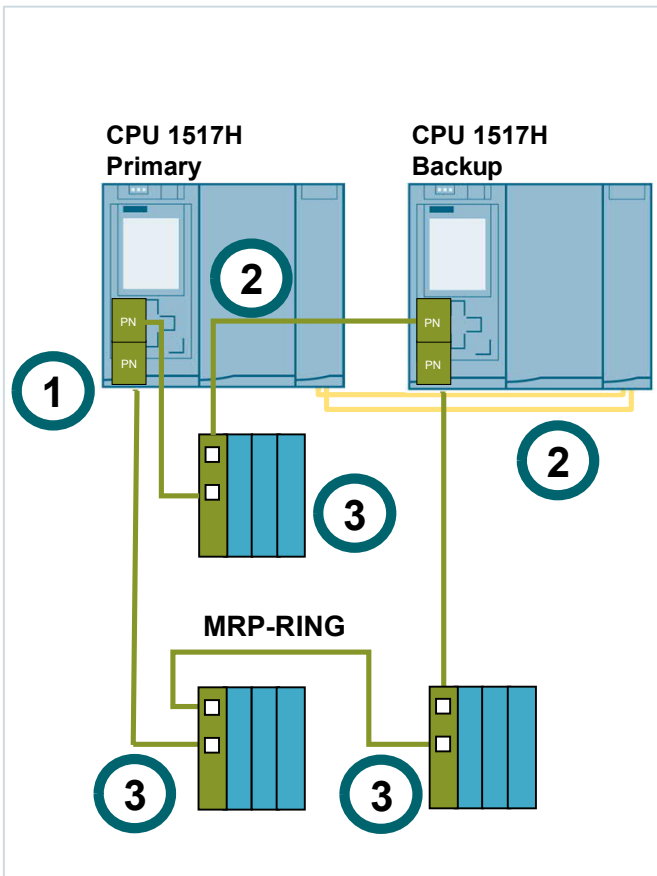
Long distance Sync modules
up to 10 km



The sync cables are redundant.
The loss of one fiber optic cable has no impact on the runtime behavior.

Network Configuration with S7-1500H

Basic System Configuration

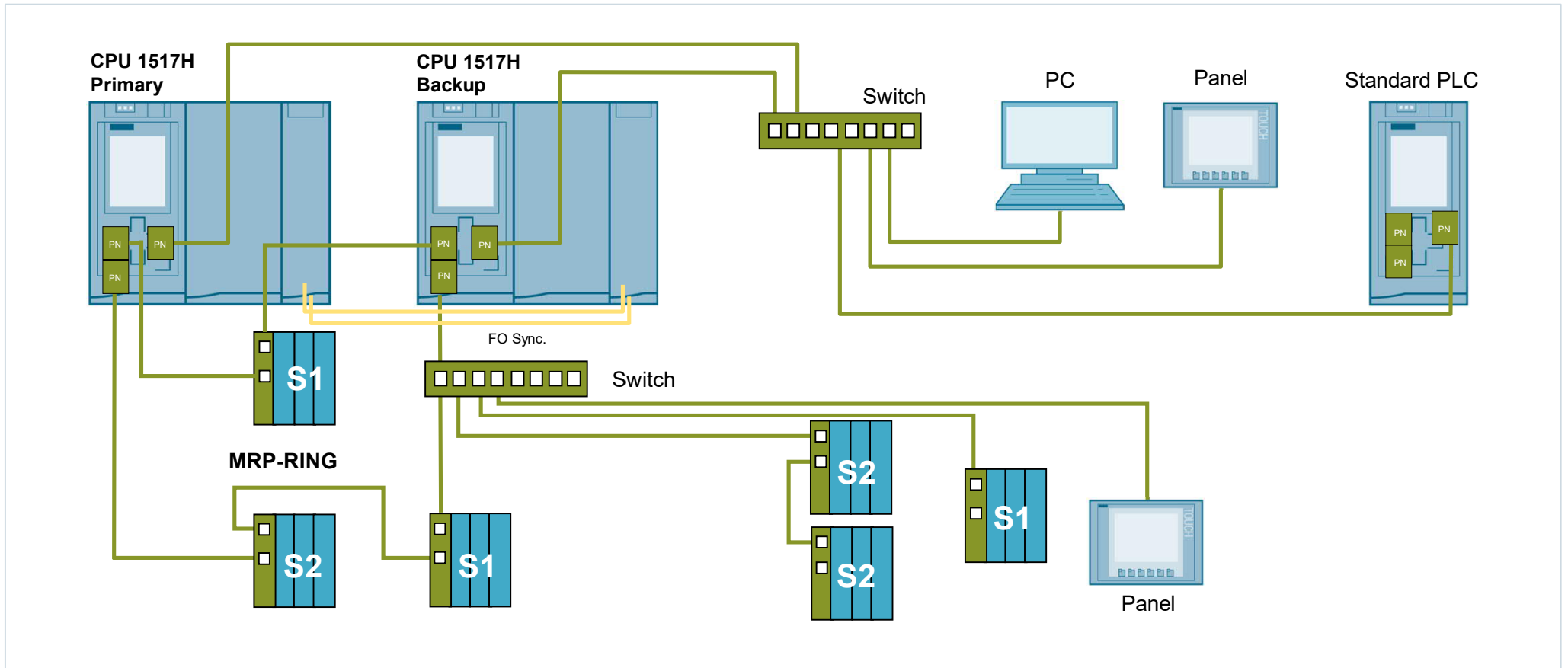


Structure

- 1 MRP-Ring must be connected to X1 - Port
- 2 Synchronization over Sync-Modules – Device connection possible
- 3 S1 and S2 devices can be integrated into the MRP ring

Configuration example SIMATIC S7-1500H CPU 1517H

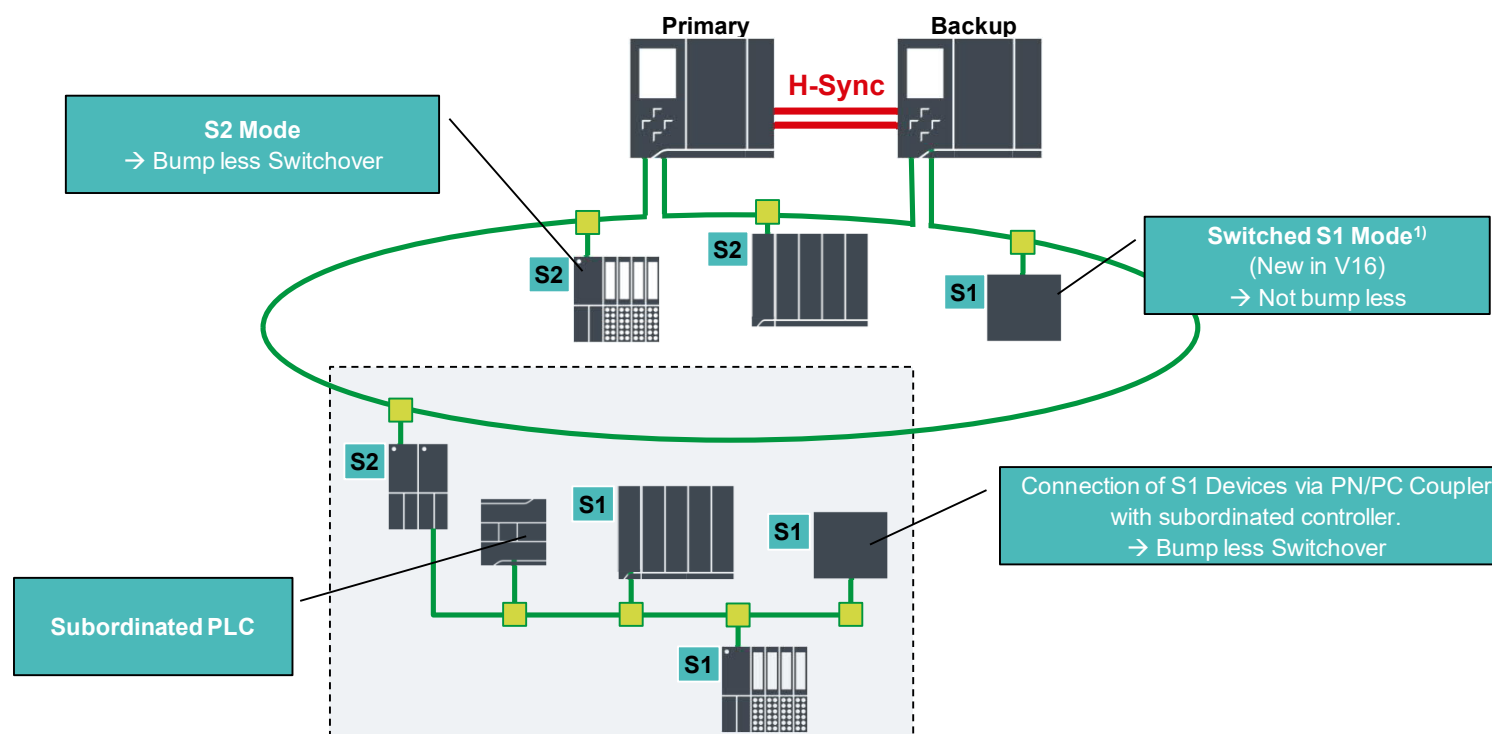
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Network Configuration with S7-1500R/H

Connection of PROFINET Devices

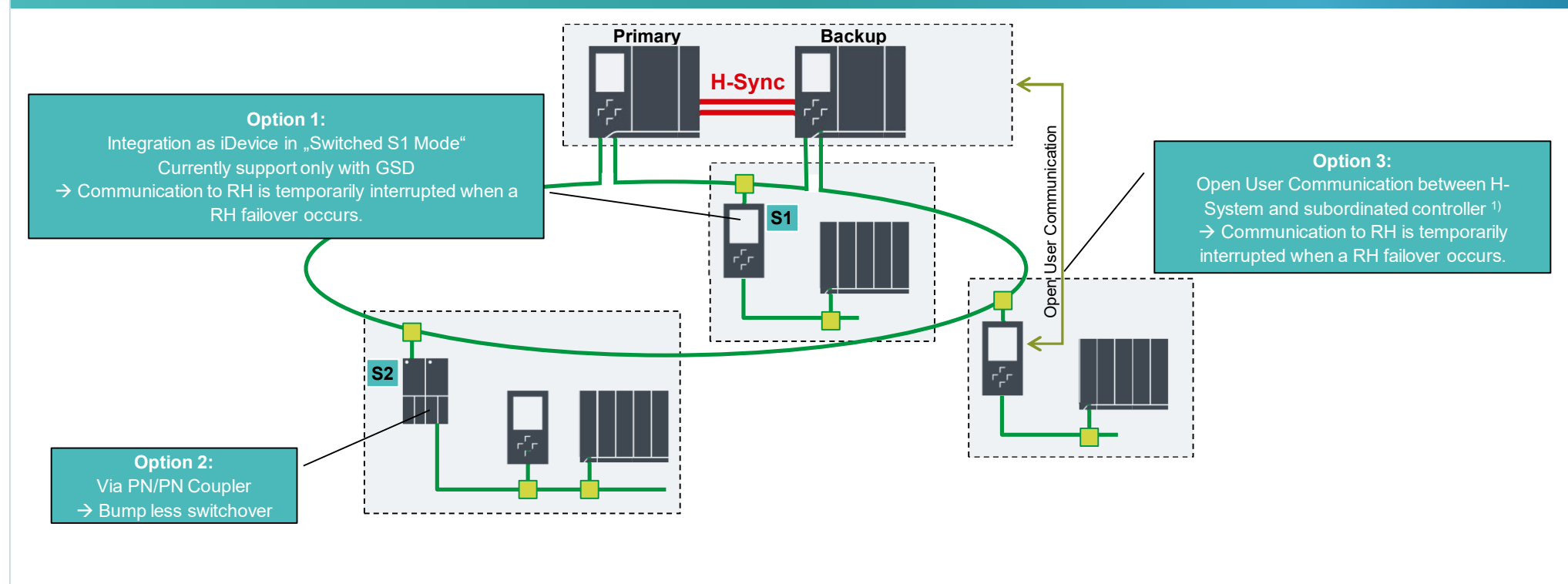
S2 and S1 Devices can be connected



Network Configuration with S7-1500R/H

Connection of Subordinated Controller

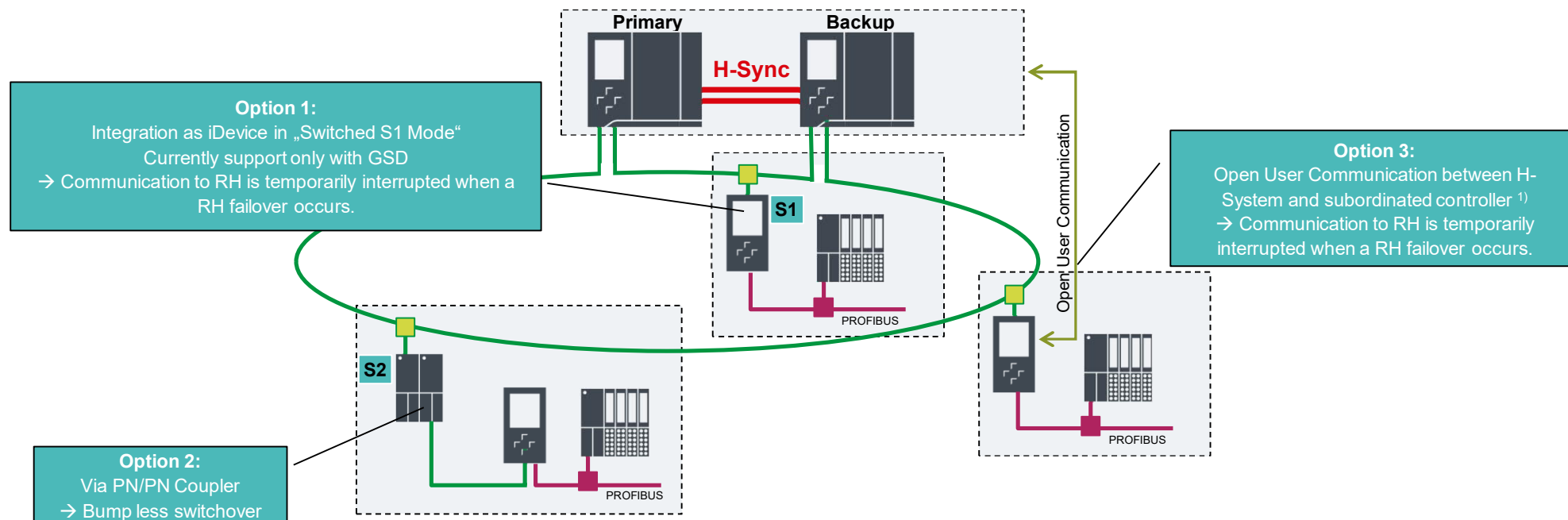
New in V16: Connection without PN/PN coupler is possible



Network Configuration with S7-1500R/H

Connection of PROFIBUS DP Slaves

New in V16: Connection without PN/PN coupler is possible

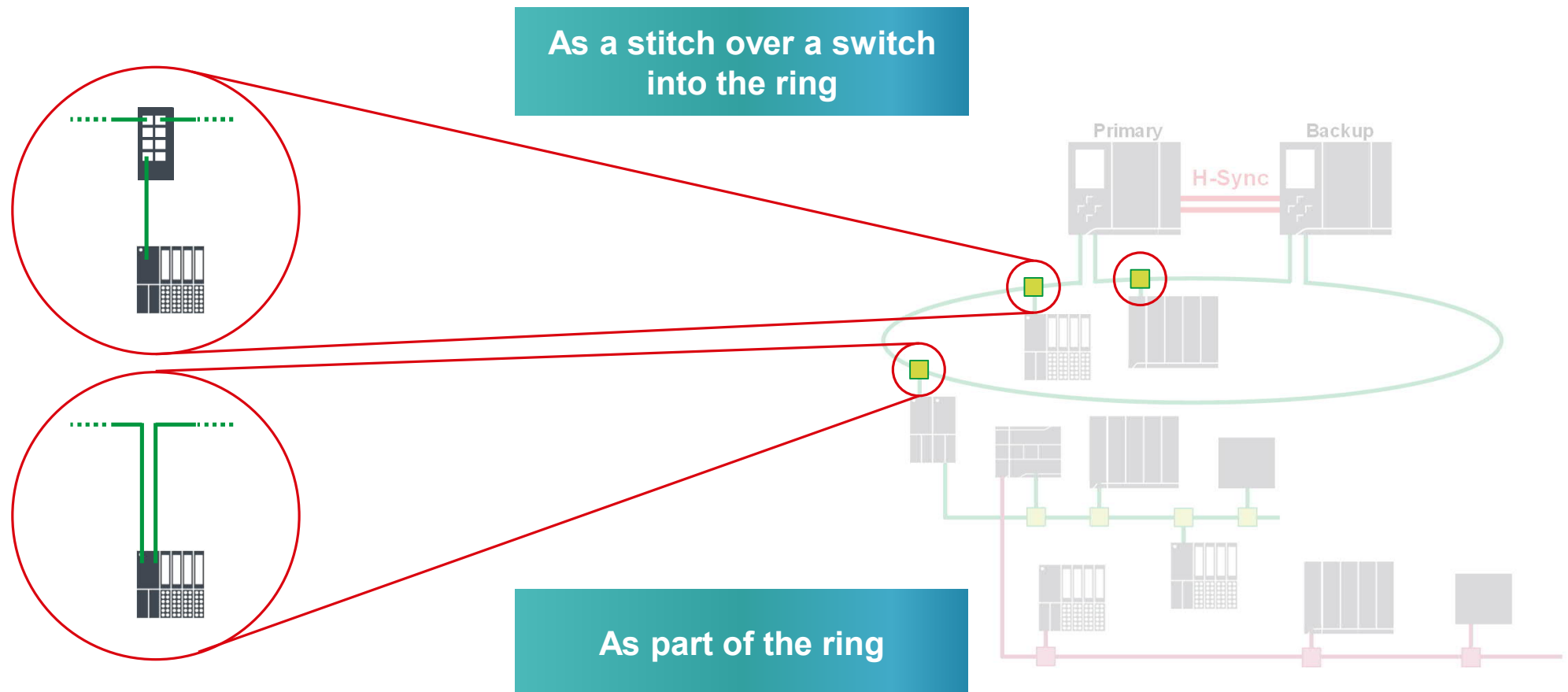


Please note: IE/PB Link and IE/PB LINK HA are currently not supported

Network Configuration with S7-1500R/H

Network connections

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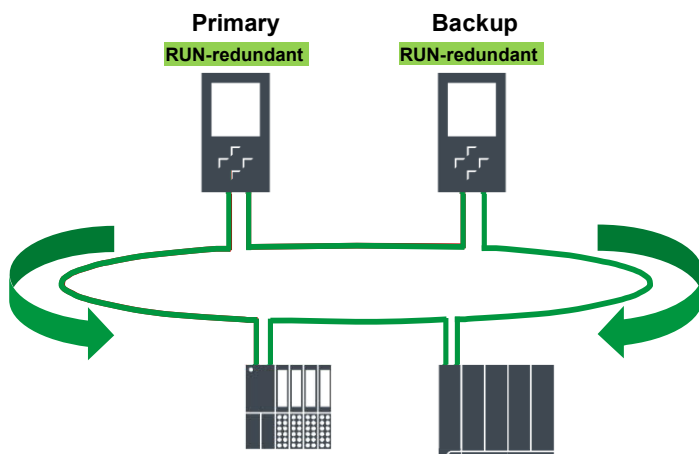
SIMATIC S7-1500 Redundant Systems



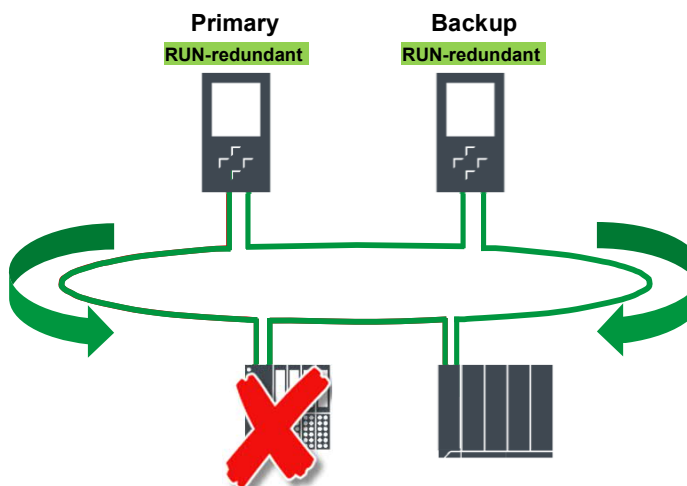
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Failure scenarios for S7-1500R/H

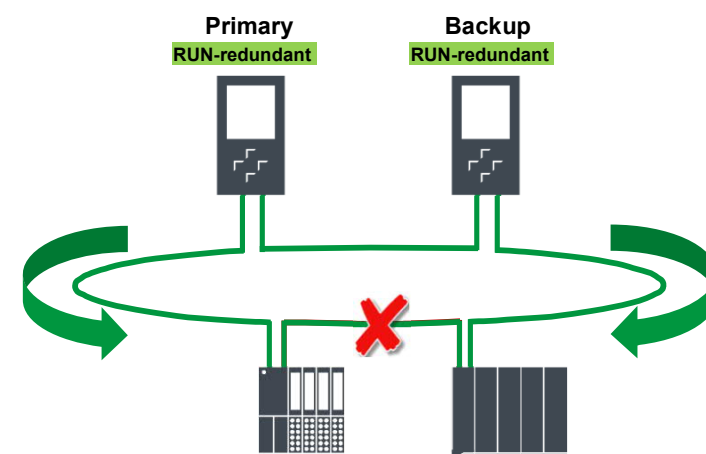
Primary or Backup CPU failure



Failure of an IO device in the PROFINET ring

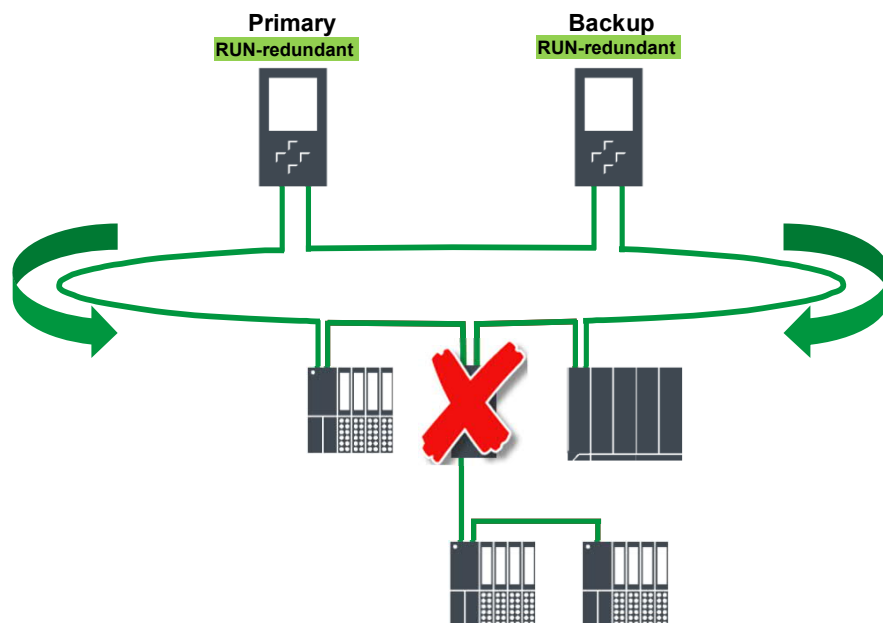


Failure of the PROFINET cable in the PROFINET ring

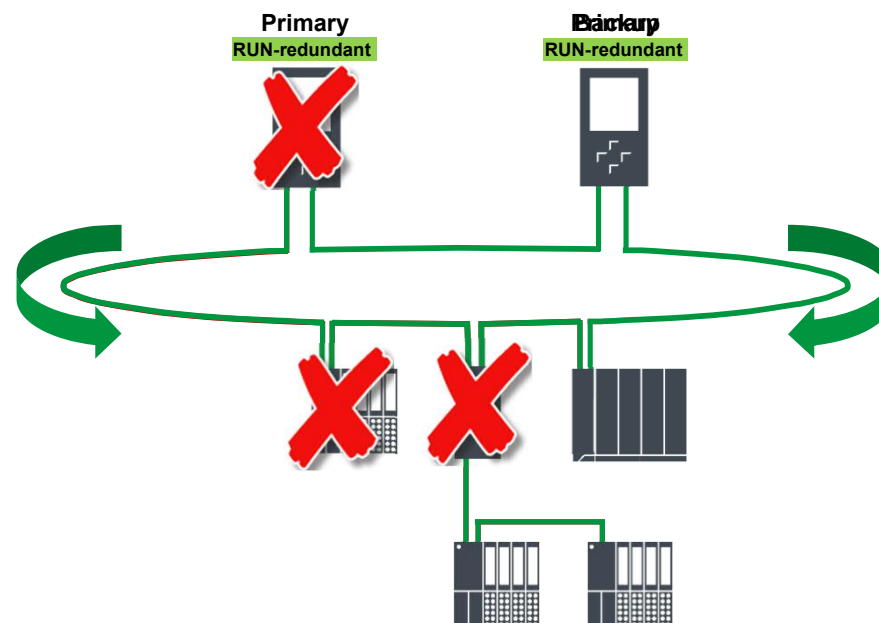


Failure scenarios for S7-1500R/H

Failure of a switch in the PROFINET ring (with line topology)



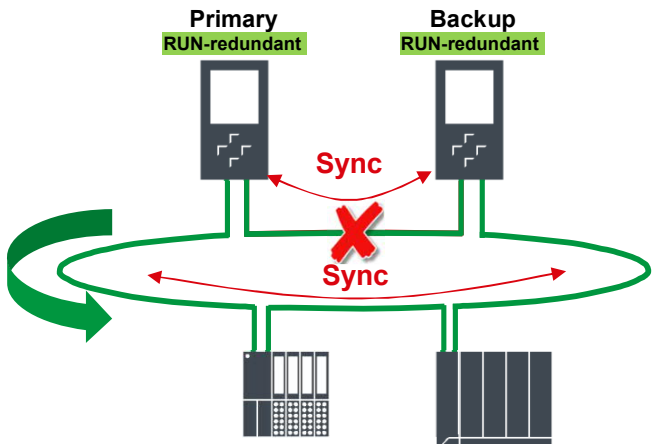
Failure of an IO device in the PROFINET ring AND of the Primary CPU



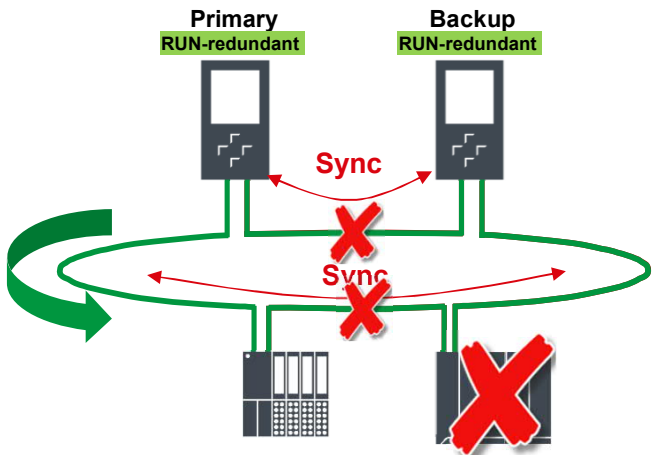
Specific failure scenarios for S7-1500R



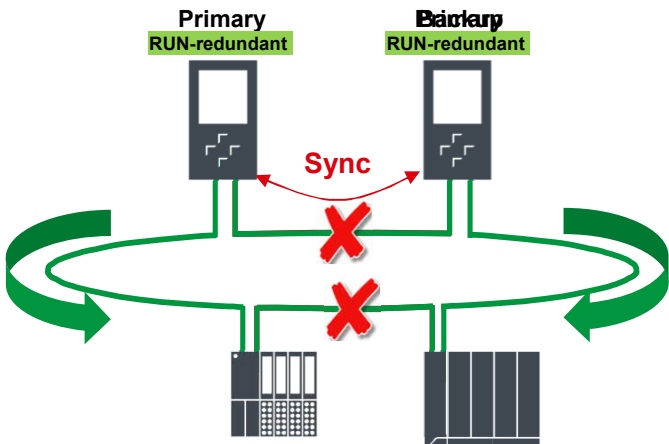
Failure of the direct redundancy connection



Failure of the two direct redundancy connections and PROFINET cable in the PROFINET ring



Time interval 2nd failure
> 1500ms

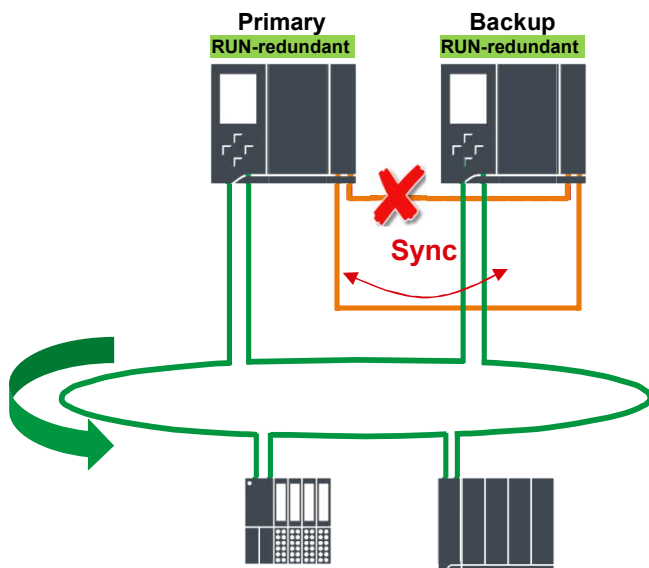


Time interval 2nd failure
< 100ms

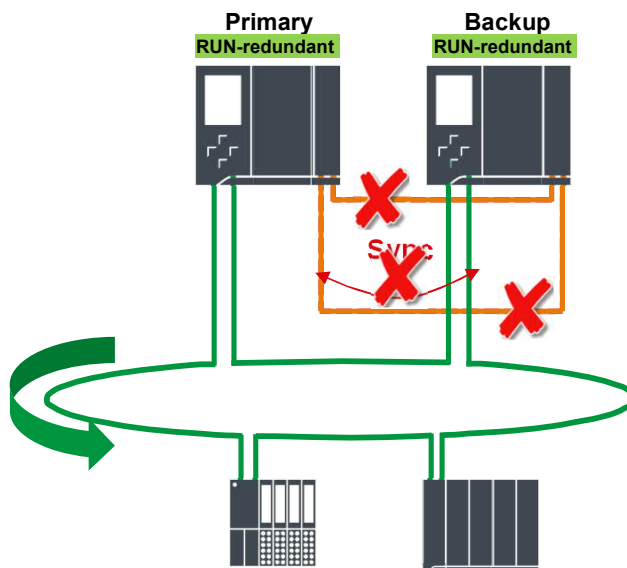
Undefined condition

Specific failure scenarios for S7-1500H

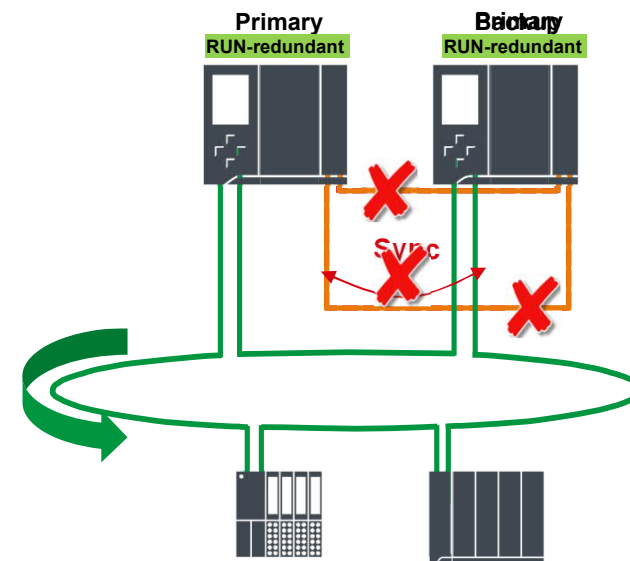
Failure of a direct redundancy connection



Failure of the two direct redundancy connections



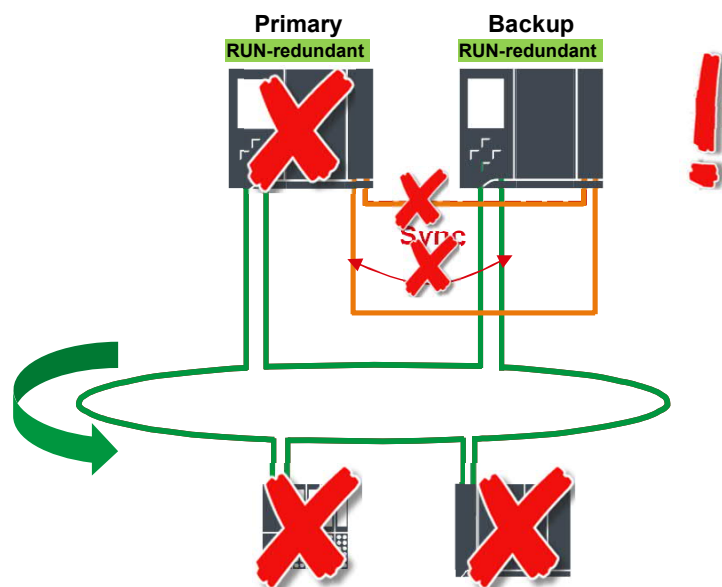
Time interval 2nd
failure
> 1500ms



Time interval 2nd
failure
< 100ms
**Undefined
condition**

Specific failure scenarios for S7-1500H

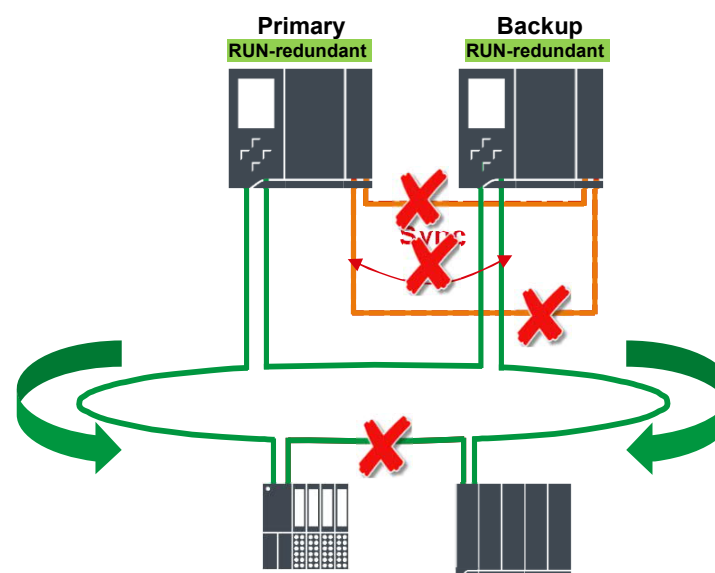
Failure of the direct redundancy connection and of the Primary CPU



Time interval 2nd
failure

> 1500ms

Failure of the two direct redundancy connections and PROFINET cable in the PROFINET ring



Time interval 2nd
failure

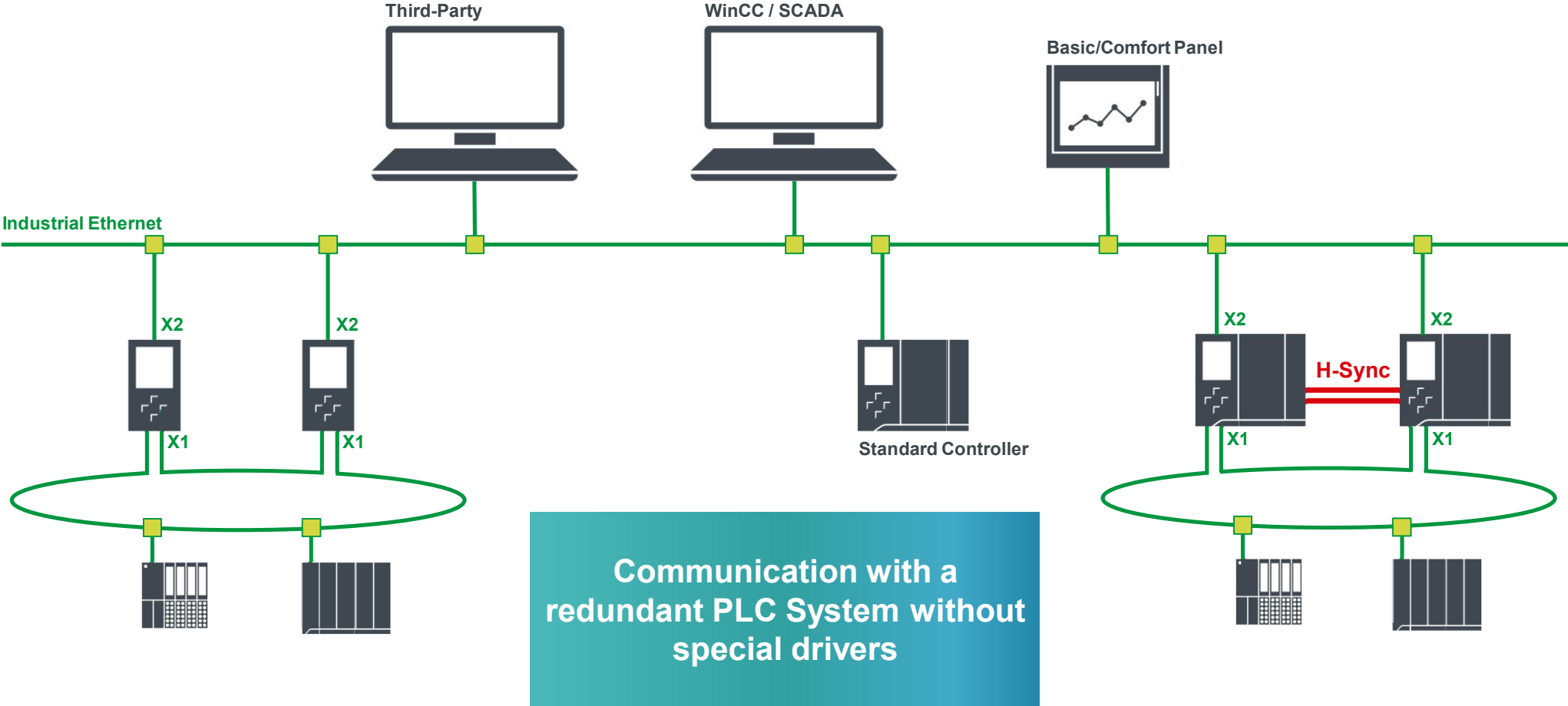
> 1500ms

SIMATIC S7-1500 Redundant Systems

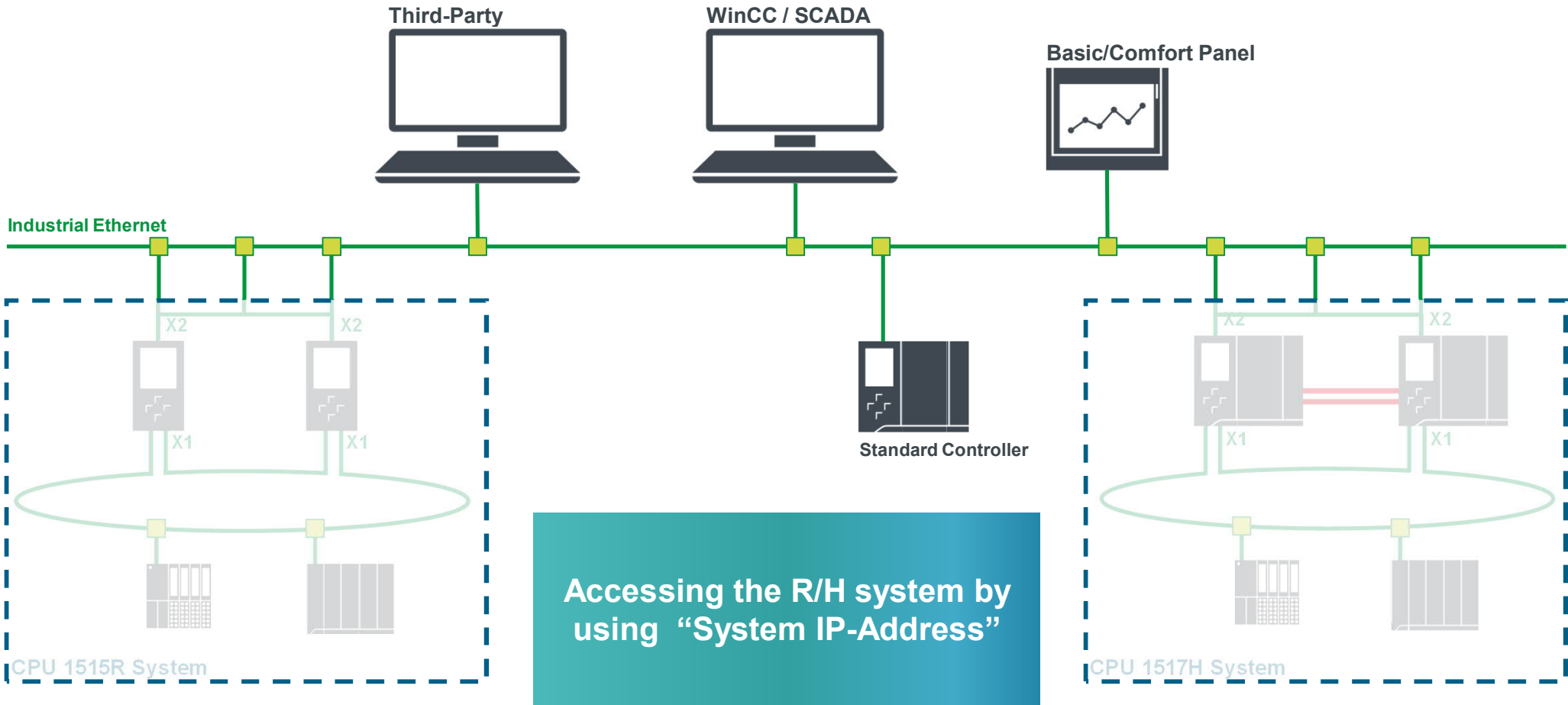


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Communication



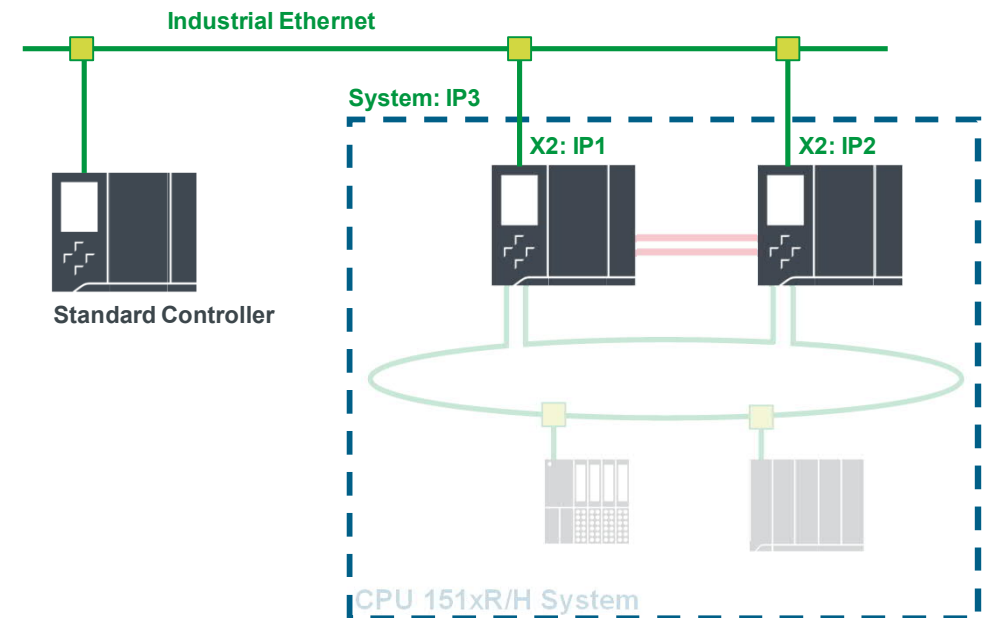
Communication System IP-Address



Communication System IP-Address

Using System IP instead of PLC interface IP

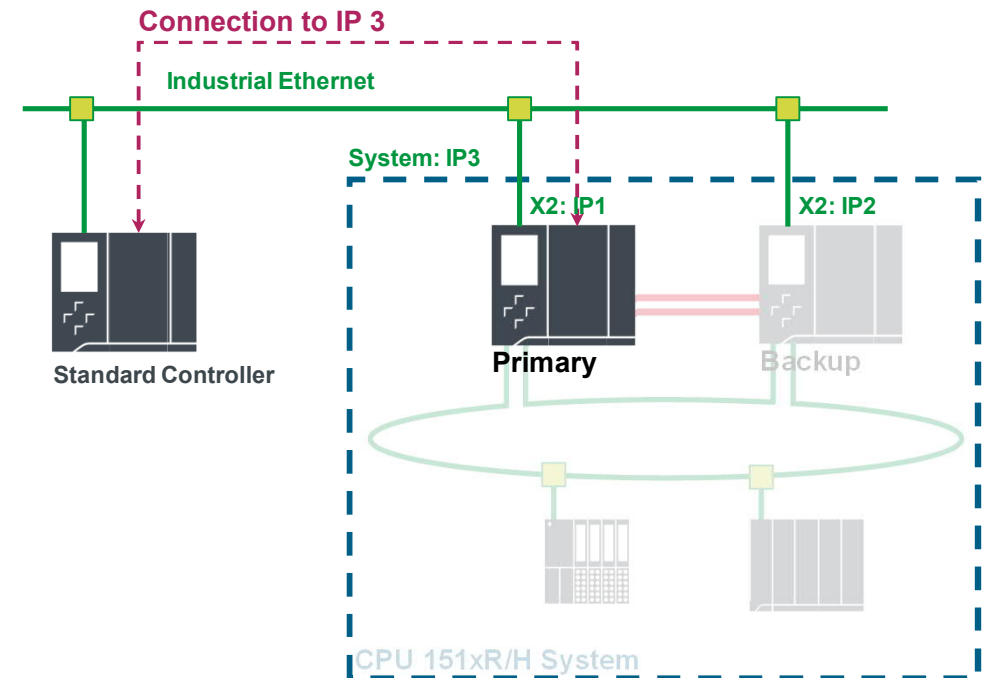
- Transparent communication between standard PLC and R/H-System
- The standard communication partner is automatically connected to the primary PLC



Communication System IP-Address

Using System IP instead of PLC interface IP

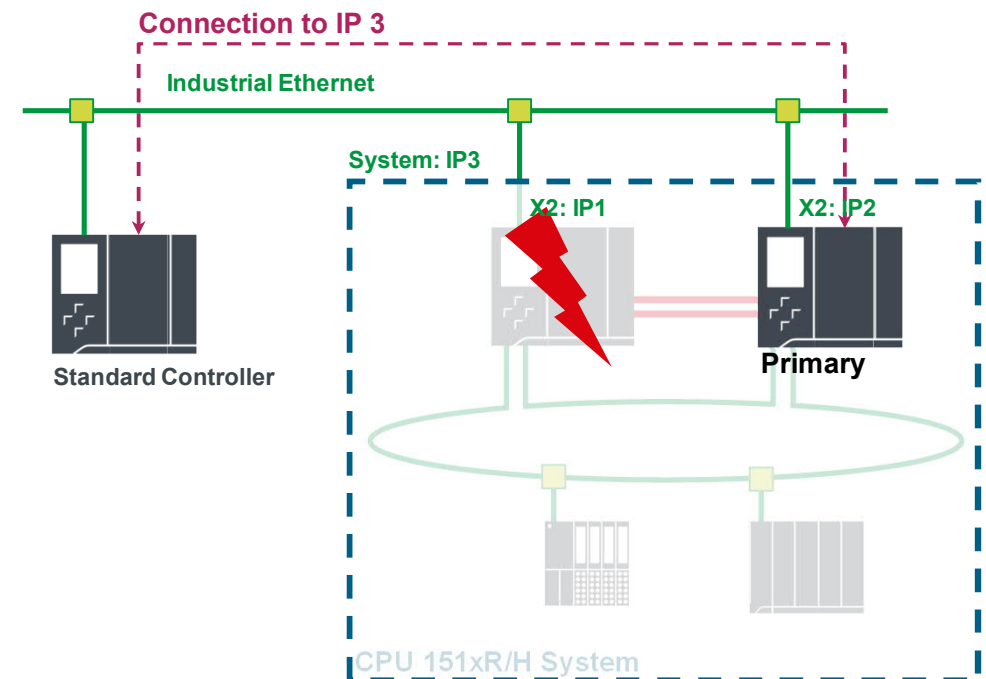
- Transparent communication between standard PLC and R/H-System
- The standard communication partner is automatically connected to the primary PLC



Communication System IP-Address – Switching Primary

Using System IP instead of PLC interface IP

- Transparent communication between standard PLC and R/H-System
- The standard communication partner is automatically connected to the primary PLC



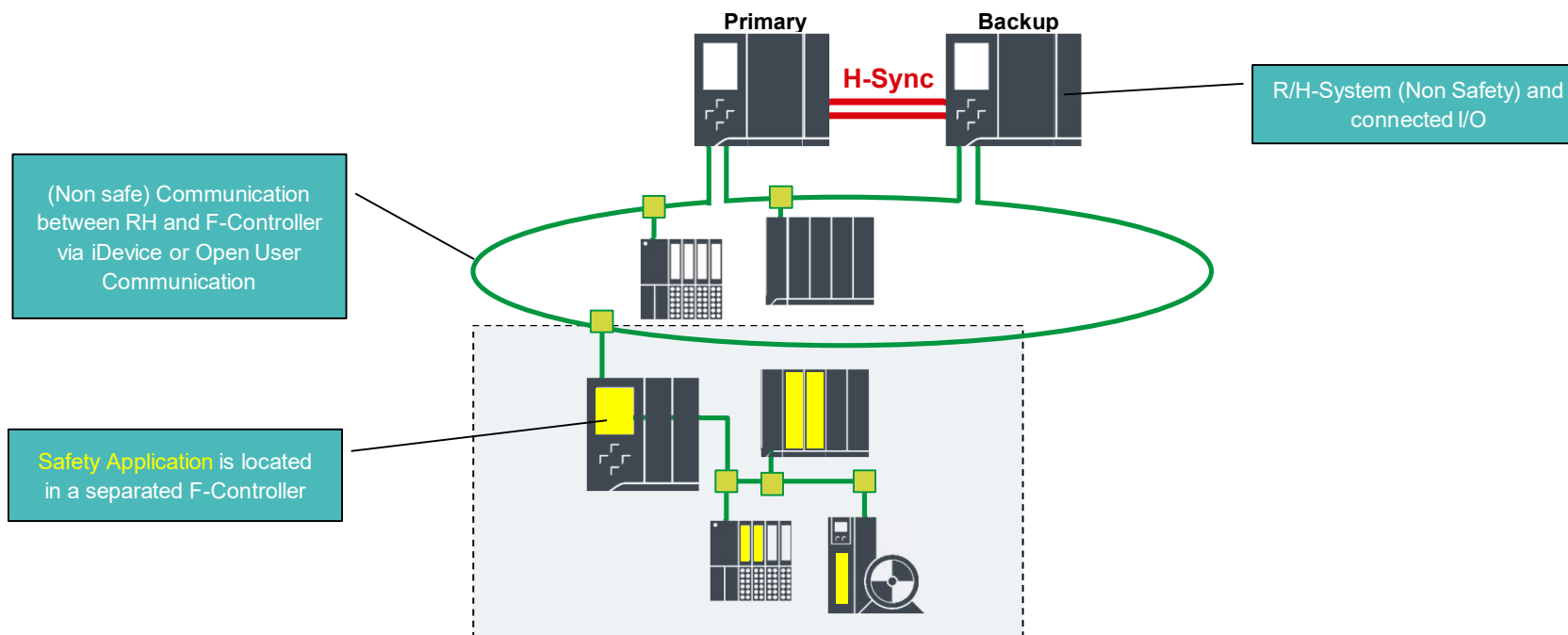
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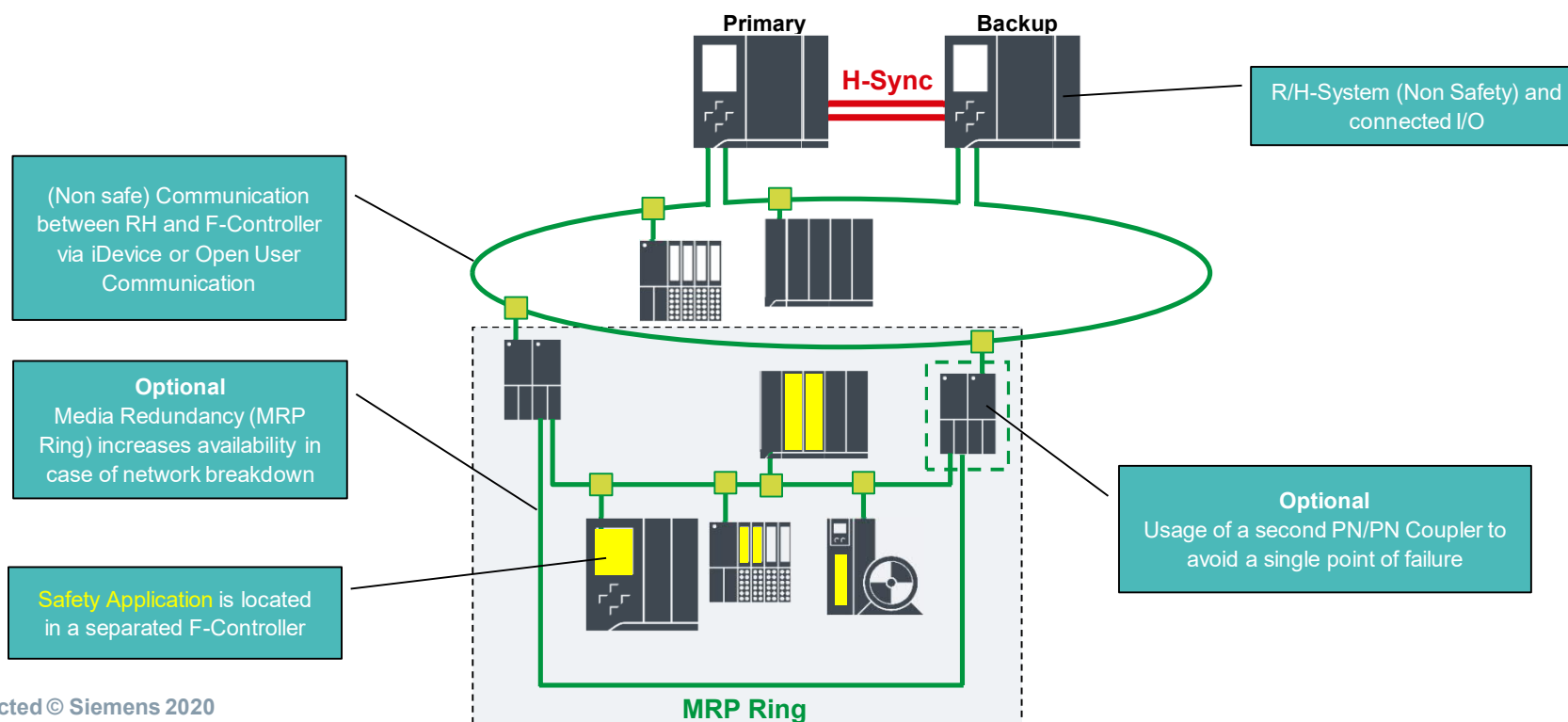
Network Configuration with S7-1500R/H Safety Devices

Safety Devices can be integrated via subordinated F-Controller



Network Configuration with S7-1500R/H Safety Devices

Safety Devices can be integrated via subordinated F-Controller and PN/PN Coupler

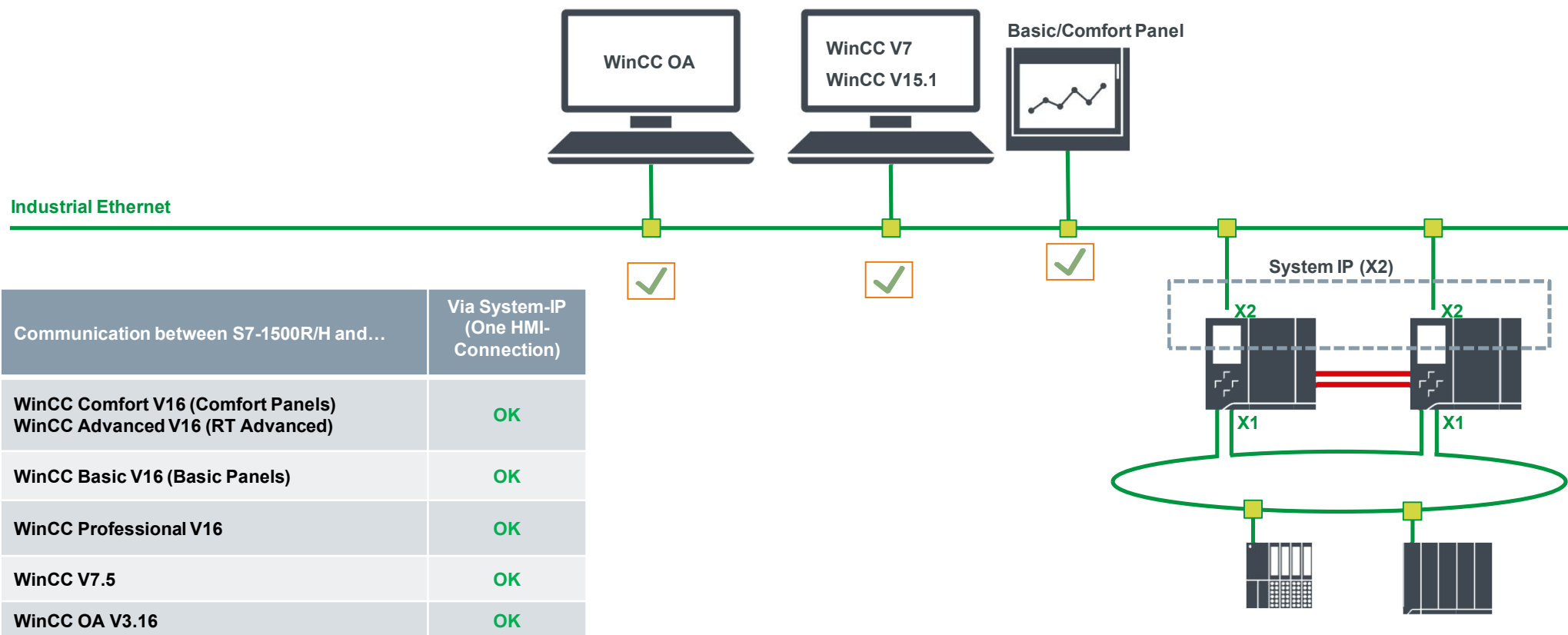


SIMATIC S7-1500 Redundant Systems

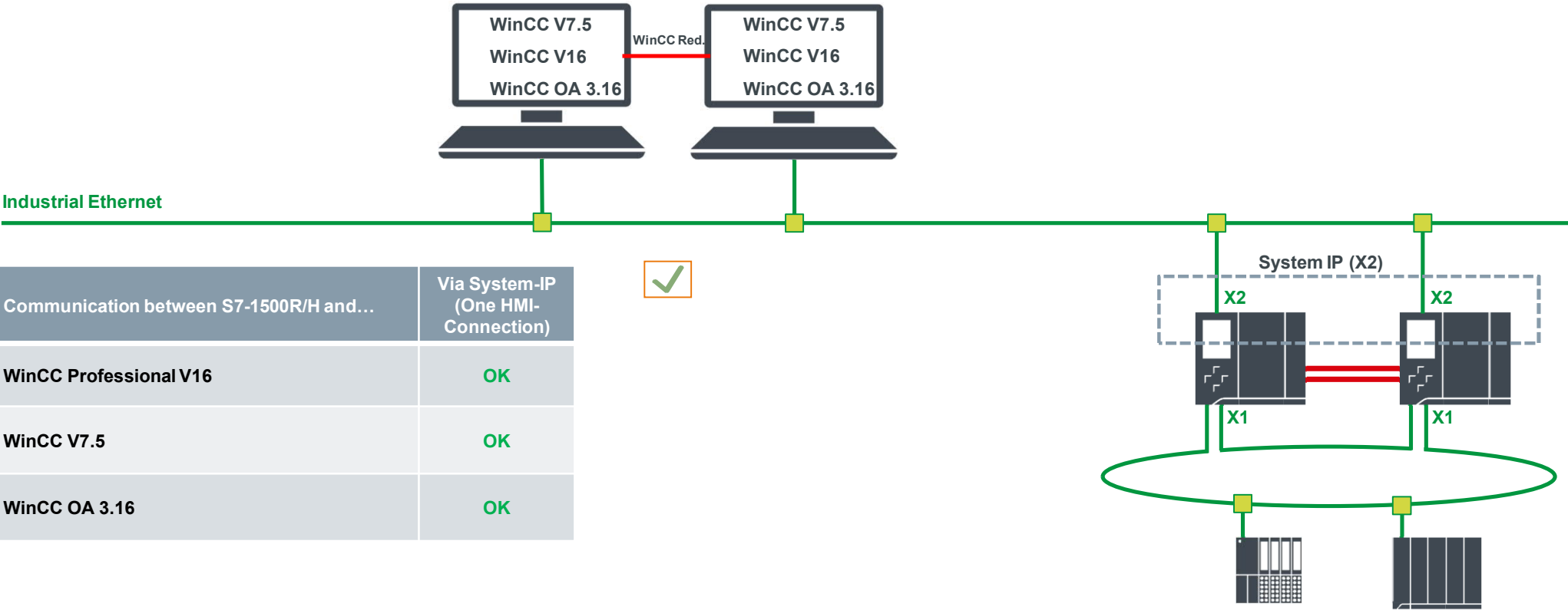


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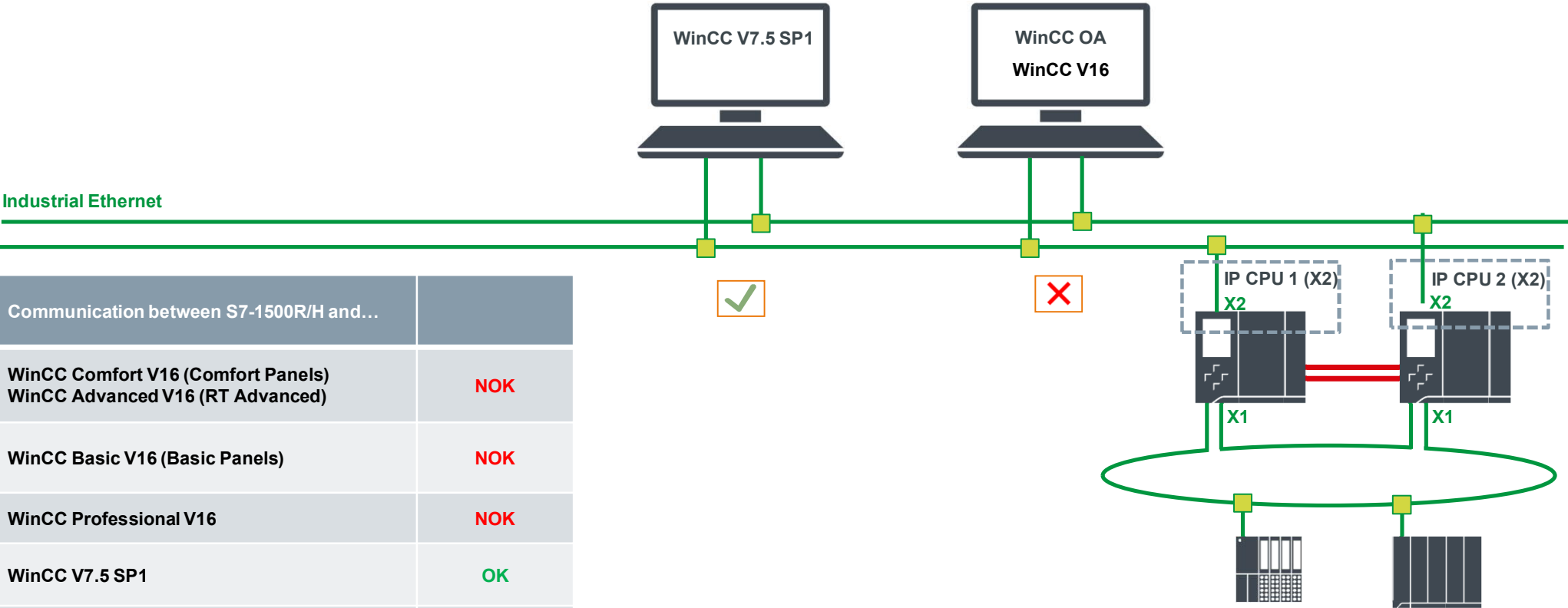
HMI Connection via 1 Network (Ring or Line)



HMI Connection via 1 Network (Ring or Line)

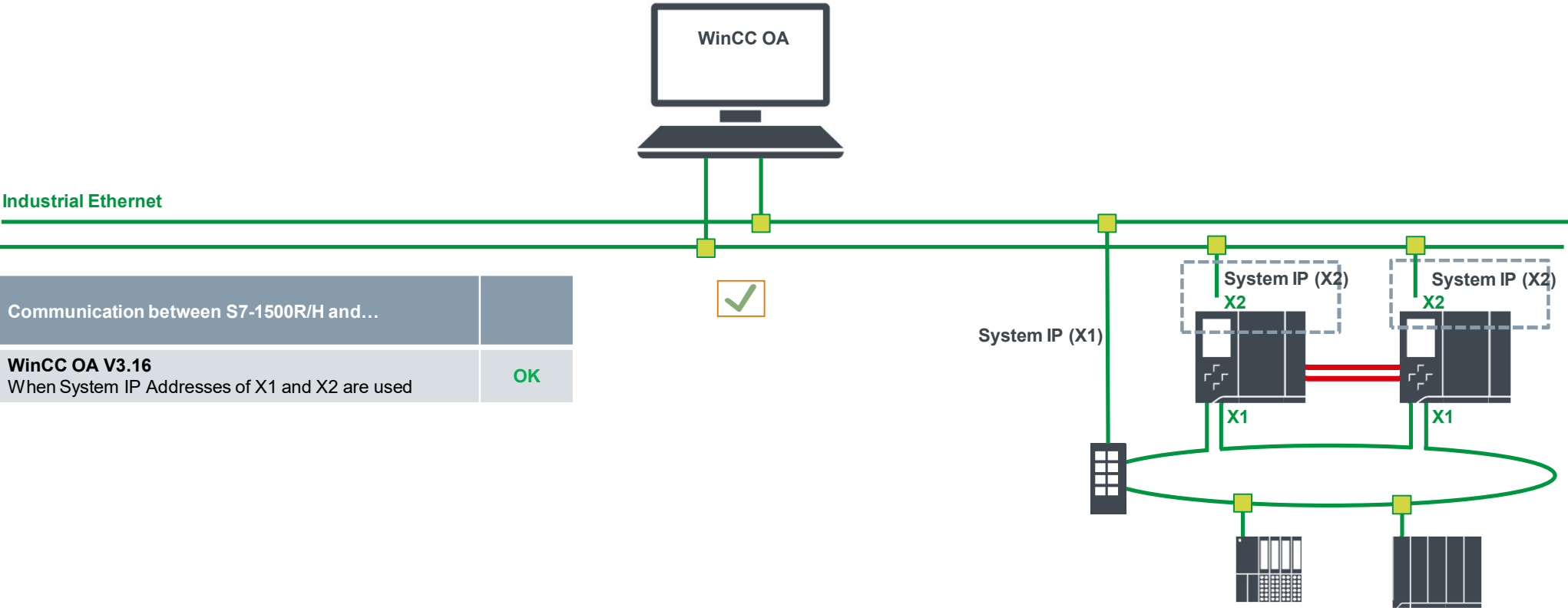


HMI Connection via redundant Network



Communication between S7-1500R/H and...	
WinCC Comfort V16 (Comfort Panels) WinCC Advanced V16 (RT Advanced)	NOK
WinCC Basic V16 (Basic Panels)	NOK
WinCC Professional V16	NOK
WinCC V7.5 SP1	OK
WinCC OA V3.16	NOK

HMI Connection via redundant Network



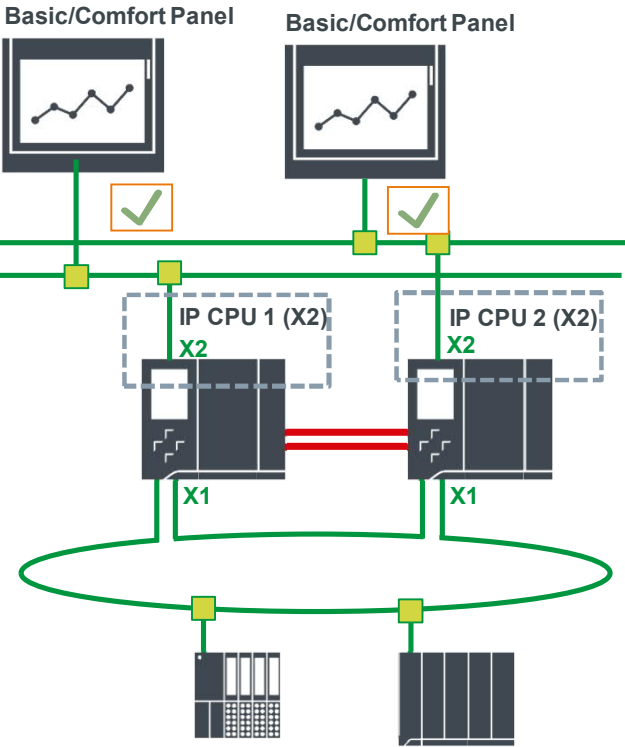
Communication between S7-1500R/H and...	
WinCC OA V3.16 When System IP Addresses of X1 and X2 are used	OK

Single sided HMI Connection via redundant Network



Industrial Ethernet

Communication between S7-1500R/H and...	Single sided connection
WinCC Comfort V16 (Comfort Panels) WinCC Advanced V16 (RT Advanced)	OK
WinCC Basic V16 (Basic Panels)	OK

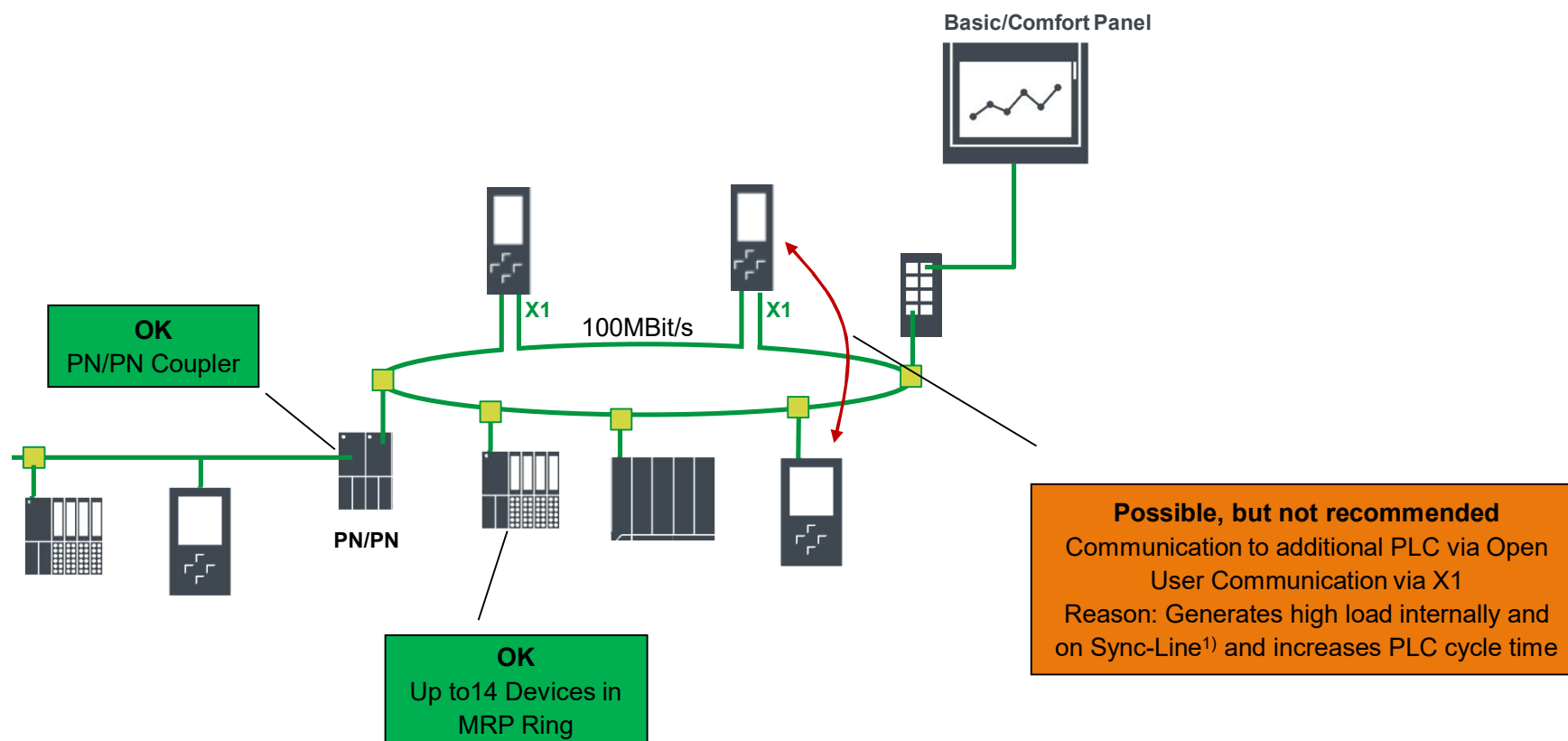


SIMATIC S7-1500 Redundant Systems

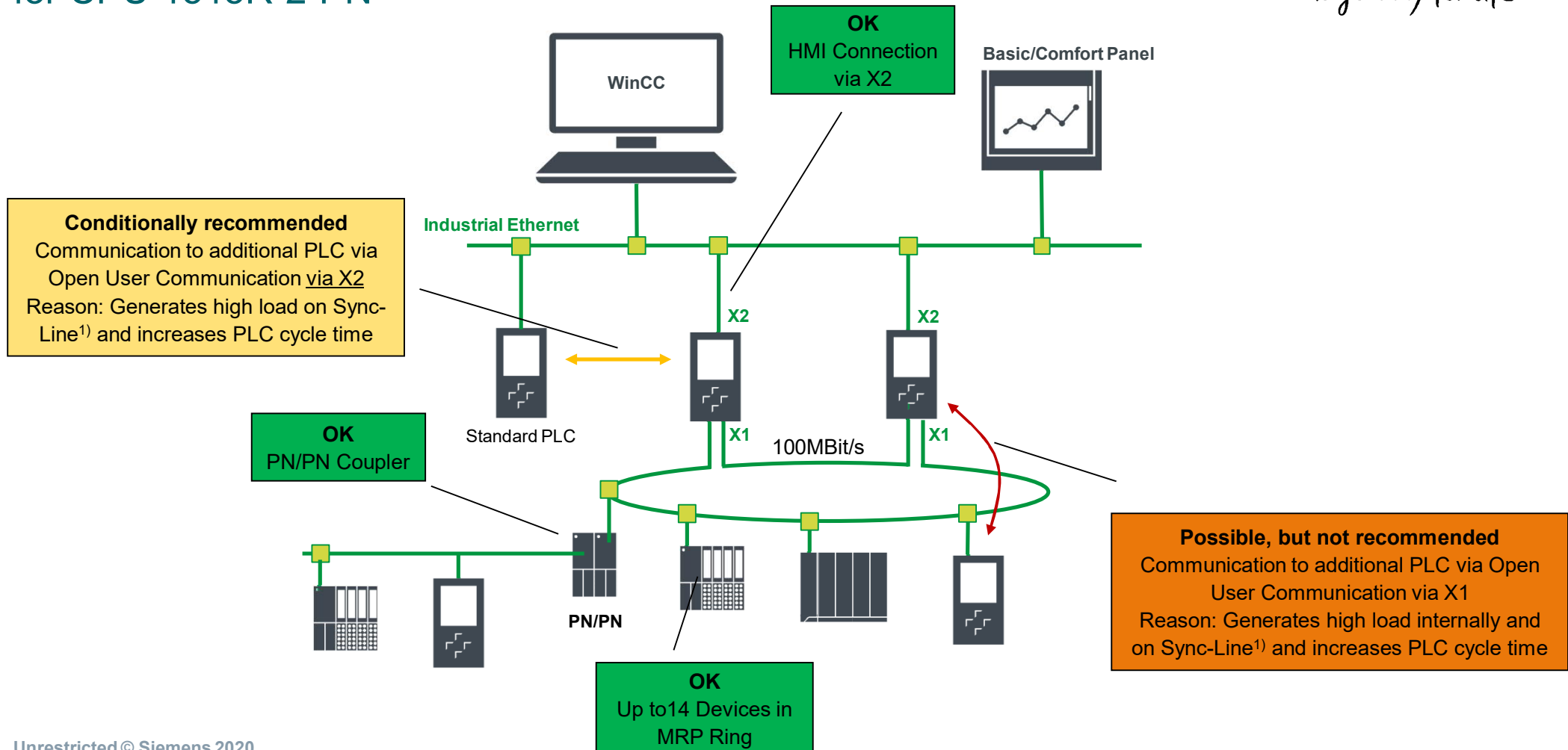


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- **Installation Recommendations**
- New Features with TIA Portal V16
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Installation Recommendations for CPU 1513R-1 PN

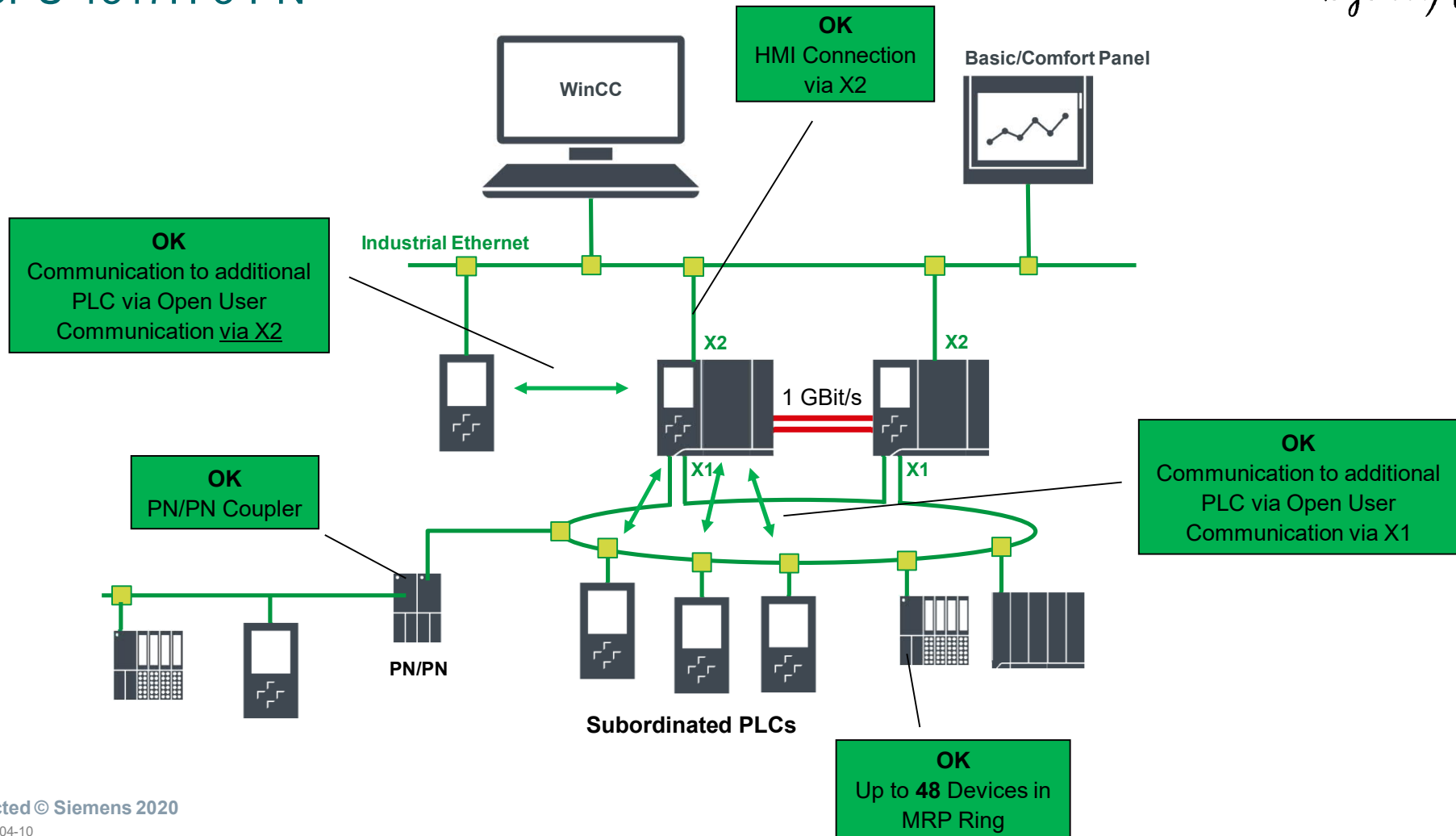


Installation Recommendations for CPU 1515R-2 PN



Installation Recommendations for CPU 1517H-3 PN

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SIMATIC S7-1500 Redundant Systems



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SIMATIC S7-1500 R/H

New Features with V16 and Firmware Version 2.8



New Features and improvements

- Connection of standard (non redundant) PN devices: Switched S1**
- Program Download in Run-Redundant Mode**
- IP Forwarding**
- Significantly reduced communication breakdown time during Sync-Up**

Reduction of functional gaps compared with S7-1500

- Support of Alarm SFC's and Diagnosis SFC's**
- Support of ProDiag und S7-Graph**
- Support of PNIO SFB's**
- Support of Loop Control Blocks (PID)**
- S7-Routing**

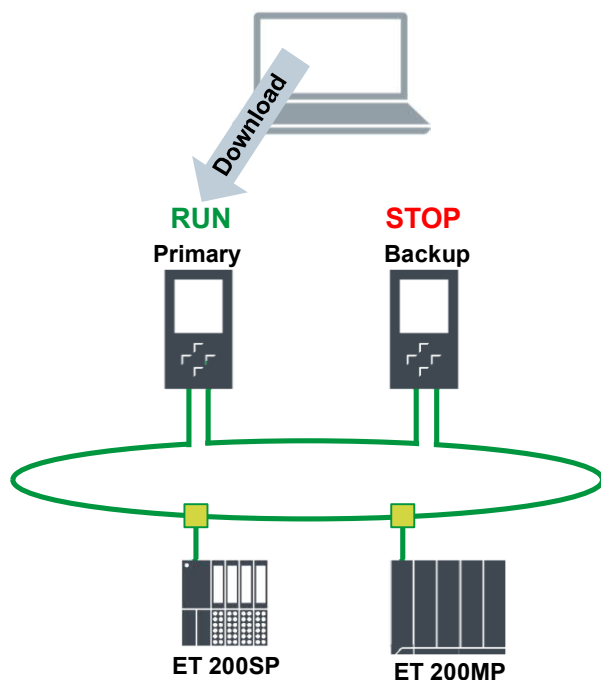
New in V16: Program Download in RUN-Redundant Mode

The Backup-PLC can remain in RUN redundant during program download

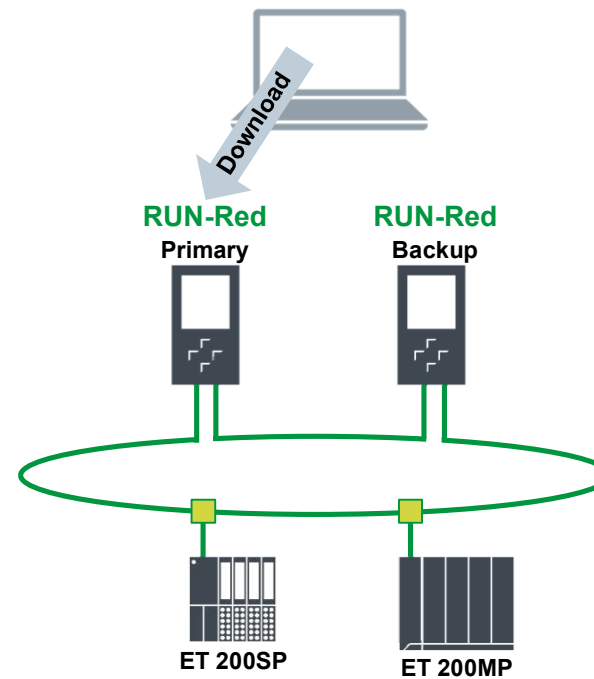
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V15.1



V16



Benefits:

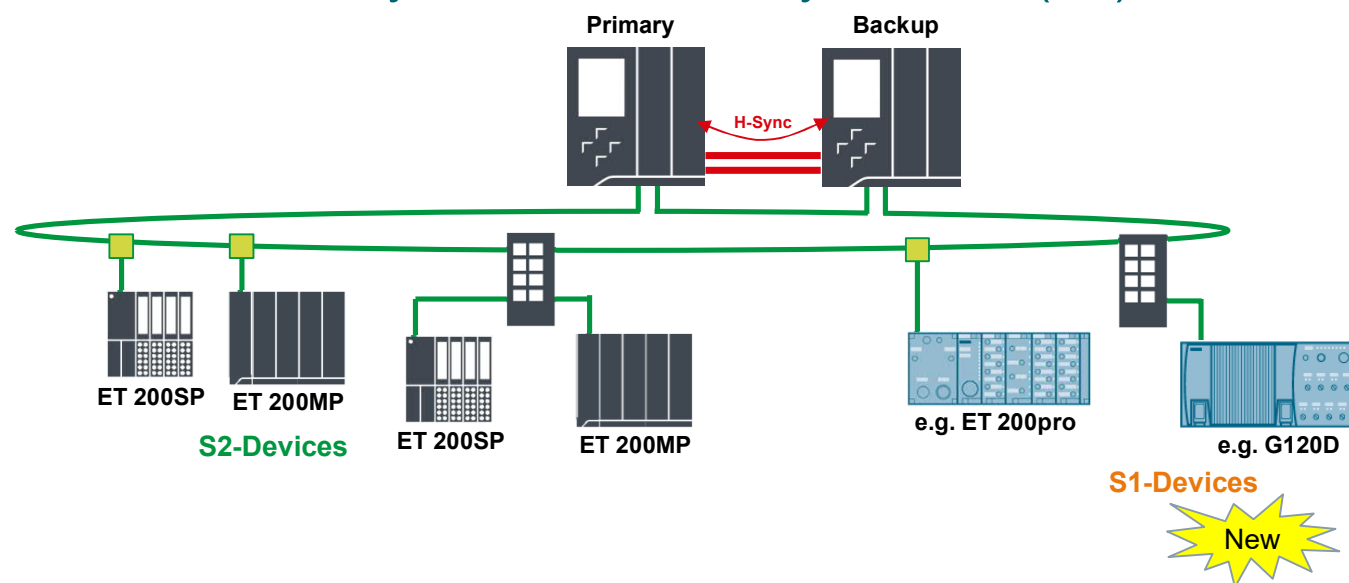
- No RUN/STOP handling of Backup PLC required
- No SyncUp Phase (with temporary loss of communication)
- User Program is synchronized automatically

New in V16: Mode „Switched S1 Device“

Also devices without System Redundancy Feature (S1) can be connected

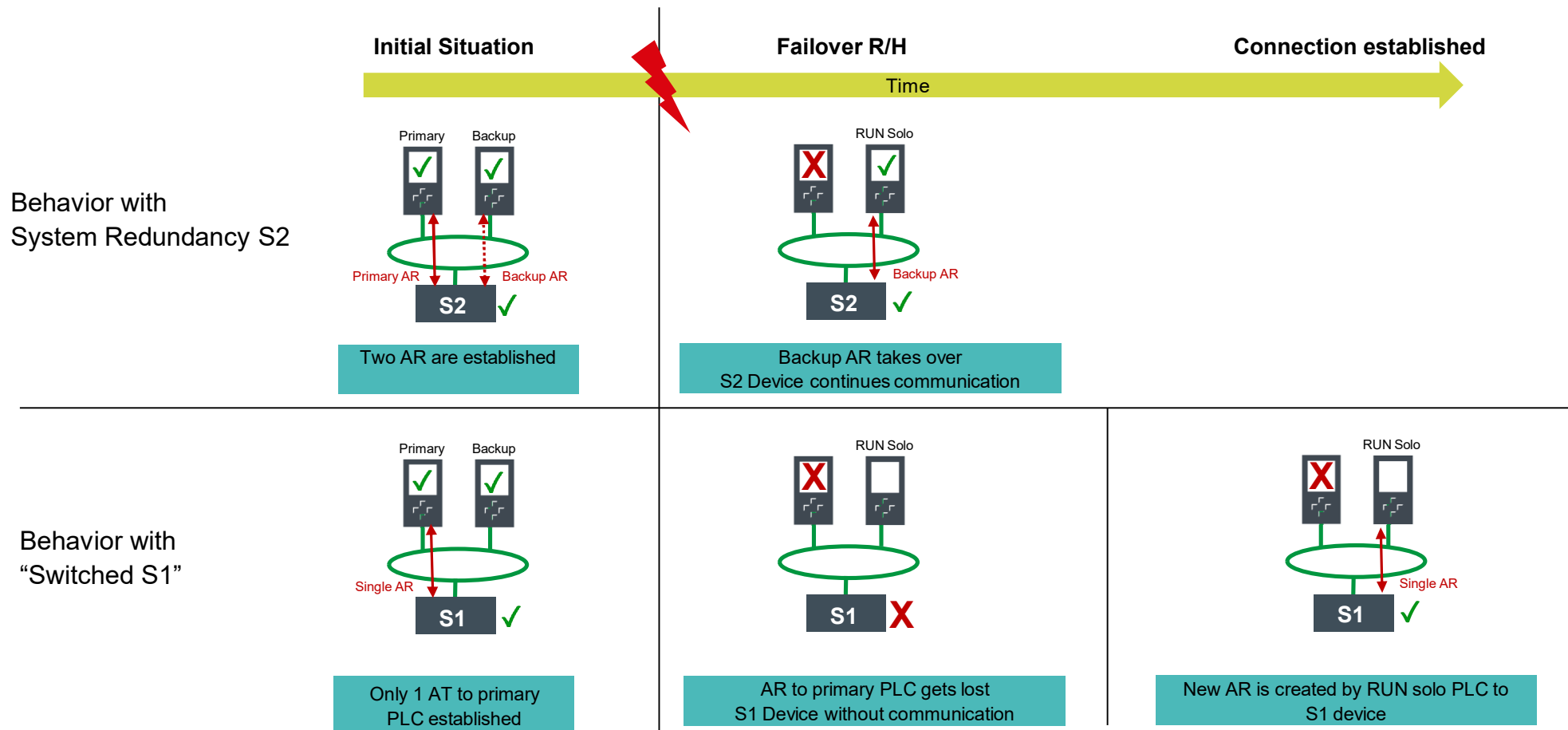
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System Behavior when Primary-Backup switch occurs	S2-Devices (with System Redundancy)	S1-Devices (without System Redundancy)
Activation time of device	Very short (50ms +) because backup communication relation is already established	Some seconds (depended on the device itself) since device is restarted
Behavior of Outputs	Keeps last valid value during failover	If the device supports the function "Hold last value" → no difference to S2 Otherwise: Outputs switches to "0" during activation time.

New in V16: Mode „Switched S1 Device“ Comparison with System Redundancy S2



New in V16: Mode „Switched S1 Device“ Visualization of redundancy modes in TIA Portal

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The screenshot displays the 'RH-DemoV151_V16' project in the 'Devices & networks' window. The 'Network view' is active, showing a network topology with a redundant PLC system (R-System_1) and two I/O modules (et200mp-01 and ET200S-01). The 'I/O communication' table on the right provides detailed information about the connections.

Partner 1	Partner 2	Interfa...	Mode	Optional...
1	▼ R-PLC_1			
2	▼ PROFINET-S...			
3	X1	↔ ET200SP-02	PROFIN... IO device(S2)	
4	X1	↔ et200mp-01	PROFIN... IO device(S2)	
5	X1	↔ ET200S-01	PROFIN... IO device(S1)	
6	▼ R-PLC_2			
7	▼ PROFINET-S...			
8	X1	↔ ET200SP-02	PROFIN... IO device(S2)	
9	X1	↔ et200mp-01	PROFIN... IO device(S2)	
10	X1	↔ ET200S-01	PROFIN... IO device(S1)	
11				

In the network view S1 and S2 devices are marked as „Multi-assigned“

Differences are shown in the column „Mode“ of the I/O communication table. Here: ET 200MP is connected as S2 device

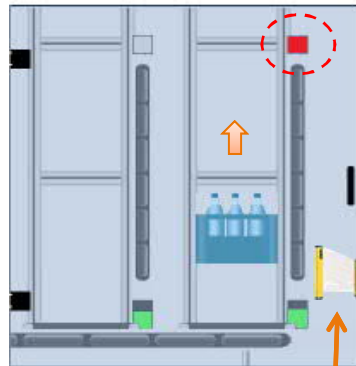
New in V16: Process Diagnosis and User Alarms

Program_Alarm“ and ProDiag

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Function

- Supervising the machine or plant and intervening in case of fault.
- The supervision alarms give specific information on supervision type, on the location and cause of fault.

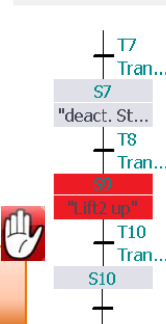


Root cause

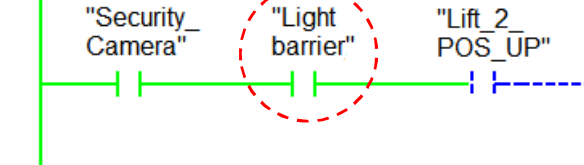
Time	Text
11:15:00 PM	Error : GRAPH-Supervision : Lift2 upper position not reached : PLC_1 : LiftSeq : Lift2 up : S9

Why ?

PLC_1 | InstLiftSeq | LiftSeq [FB12] | Network 1



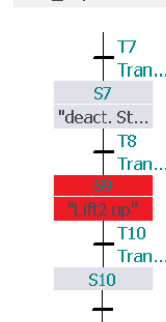
T10: Trans10



Current state



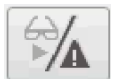
PLC_1 | InstLiftSeq | LiftSeq [FB12] | Network 1



T10: Trans10



Snap shot in case of an error



Programming and Handling of user created alarms and process diagnostic alarms are identical within Standard- and S7-1500R/H Controllers

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New in V16: Support of STEP 7 Graph

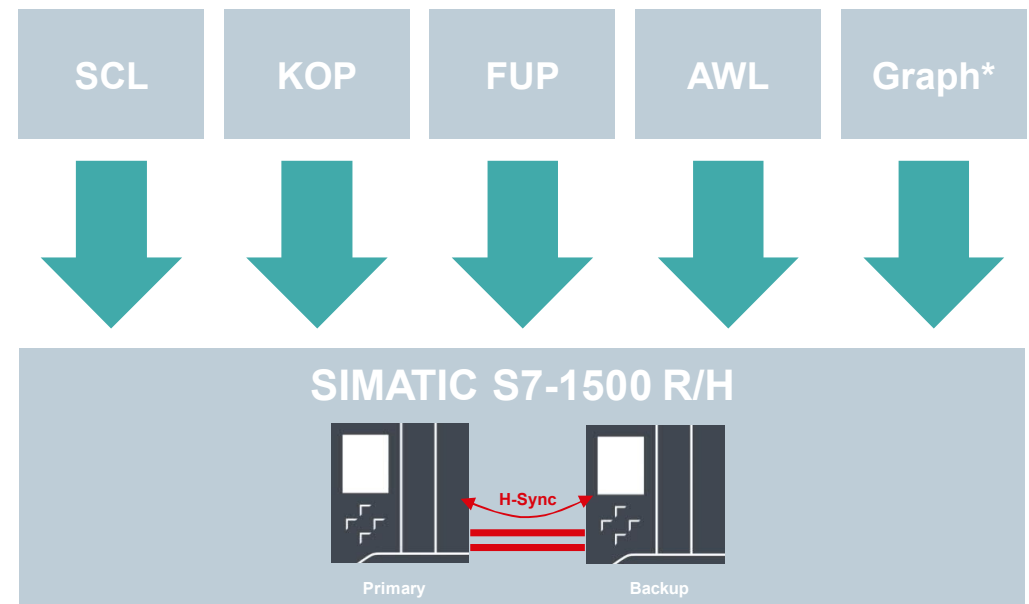


Function

- The graphical engineering language STEP 7 GRAPH is available for the S7-1500 R/ H Controller

Benefit of the function

- Graphical programming language for creating of sequence controls and processes on S7-1500 R/H CPUs
- Identical behavior regarding used language and editor for S7-1500 R/H CPUs and „standard“ CPUs
- Depending on the application the user is free to choose the appropriate programming language within the engineering of S7-1500 R/H CPUs



Identical engineering languages for Standard- and S7-1500R/H controllers

New in V16: Support of additional blocks



Program Block	
Program_Alarm	Generate program alarm with associated values
Get_AlarmState	Output alarm state
Gen_UsrMsg	Generate user diagnostic messages
Get_Alarm	Read pending alarm
Ack_Alarms	Acknowledge alarms
Technology	
PID_Compact	Universal PID controller with integrated optimization
PID_3Step	PID controller with integrated optimization for valves
PID_Temp	PID controller for temperature
Advances Instructions	
GETIO / GETIO_PART	Read process image
SETIO / SETIO_PART	Transfer process image
GetStationInfo	Read information of an IO device
DeviceStates	Read module state information in an IO system
GEN_DIAG	Generate diagnostics information

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Restrictions for S7-1500R/H



Restrictions of the configuration for S7-1500R/H

	S7-1500R/H	S7-1500	S7-400H
Single PLC projectable (H/R CPUs as redundant System only)	no	N/A	yes
Central periphery or central CPs / CMs projectable	no	yes	yes
Configure System-PS	no	yes	yes
Only MRP-Ring PN-Networks are supported (no „open Ring“ like in 400H)	yes	no	no
Operation as Shared Device or I-Device	no	yes	no

Restrictions for S7-1500R/H



Functional restrictions for S7-1500R/H

	S7-1500R/H	S7-1500	S7-400H
S7-Com, E-Mail, FDL, ISO, (OUC with dynamic connections is supported)	no ¹⁾	yes	yes
OPC UA	no	yes	no
System-supported H-communication (but the System IP-Address)	no	no	yes
Webserver	no	yes	no
System-supported redundant I/Os	no ²⁾	no	yes
PROFIsafe	no	F-CPU	yes
Technology Objects	some ³⁾	yes	no
Support for MRPD, clock synchrony and IRT	no	yes	no
CiR and firmware update in run is supported	no	no	yes
Direct migration through hardware replacement (Import of user programs via Copy/Paste)	no	n.a.	no
PLCsim and PLCsim advanced are supported	no	yes	yes

1) S7-Communication as server is supported

2) Can be realized on application layer: See SIOS article [109767576](#)

3) TO Count, Measuring, PID are supported

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Ordering Information



CPU S7-1500R

- CPU 1513R-1 PN 6ES7 513-1RL00-0AB0
- CPU 1515R-2 PN 6ES7 515-2RM00-0AB0

CPU S7-1500H

- CPU 1517H-3 PN 6ES7 517-3HP00-0AB0

Distance up to 10m between the S7-1500H PLCs

Use of the Synchronization Modules for FO cables up to 10 m

- MLFB Module: 6ES7960-1CB00-0AA5
- MLFB LWL-Cable 1m: 6ES7960-1BB00-5AA5
- MLFB LWL-Cable 2m: 6ES7960-1BC00-5AA5
- MLFB LWL-Cable 10m: 6ES7960-1CB00-5AA5

Distance up to 10km between the PLCs

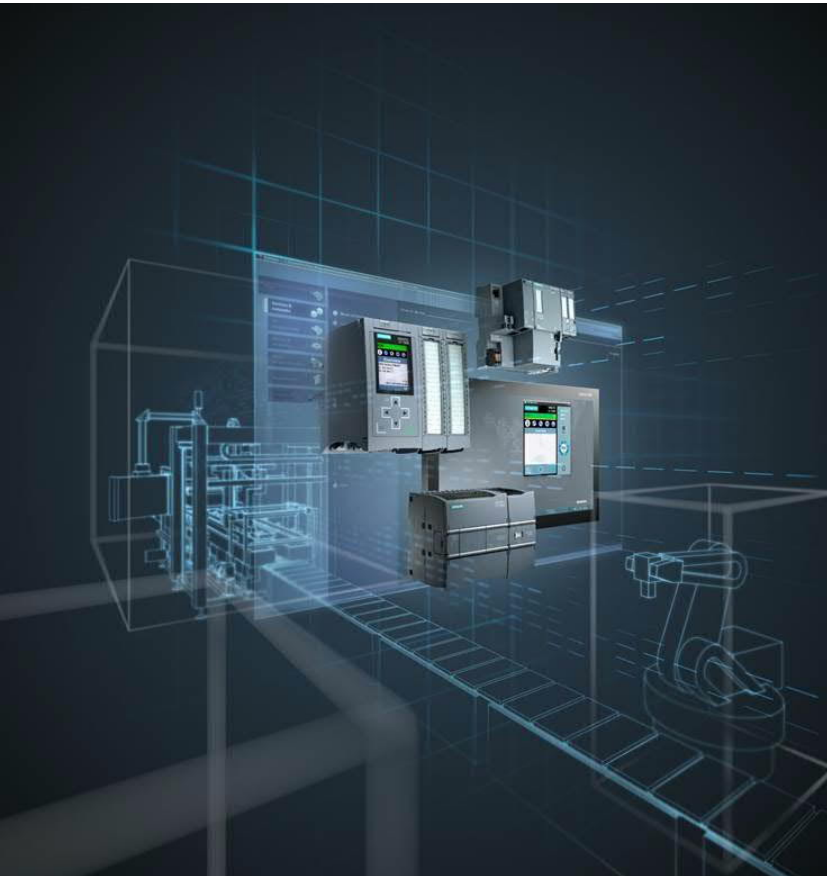
- MLFB Module: 6ES7960-1FB00-0AA5
- Monomode LWL-Cable LC/LC Duplex Crossed 9/125μ

S7-1500H Bundle (Consisting of 2 CPU 1517-3 PN, 4 Sync-Modules 10m and 2 Sync-Cables 1m)

- 6ES7500-0HP00-0AB0

SIMATIC S7-1500R/H

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