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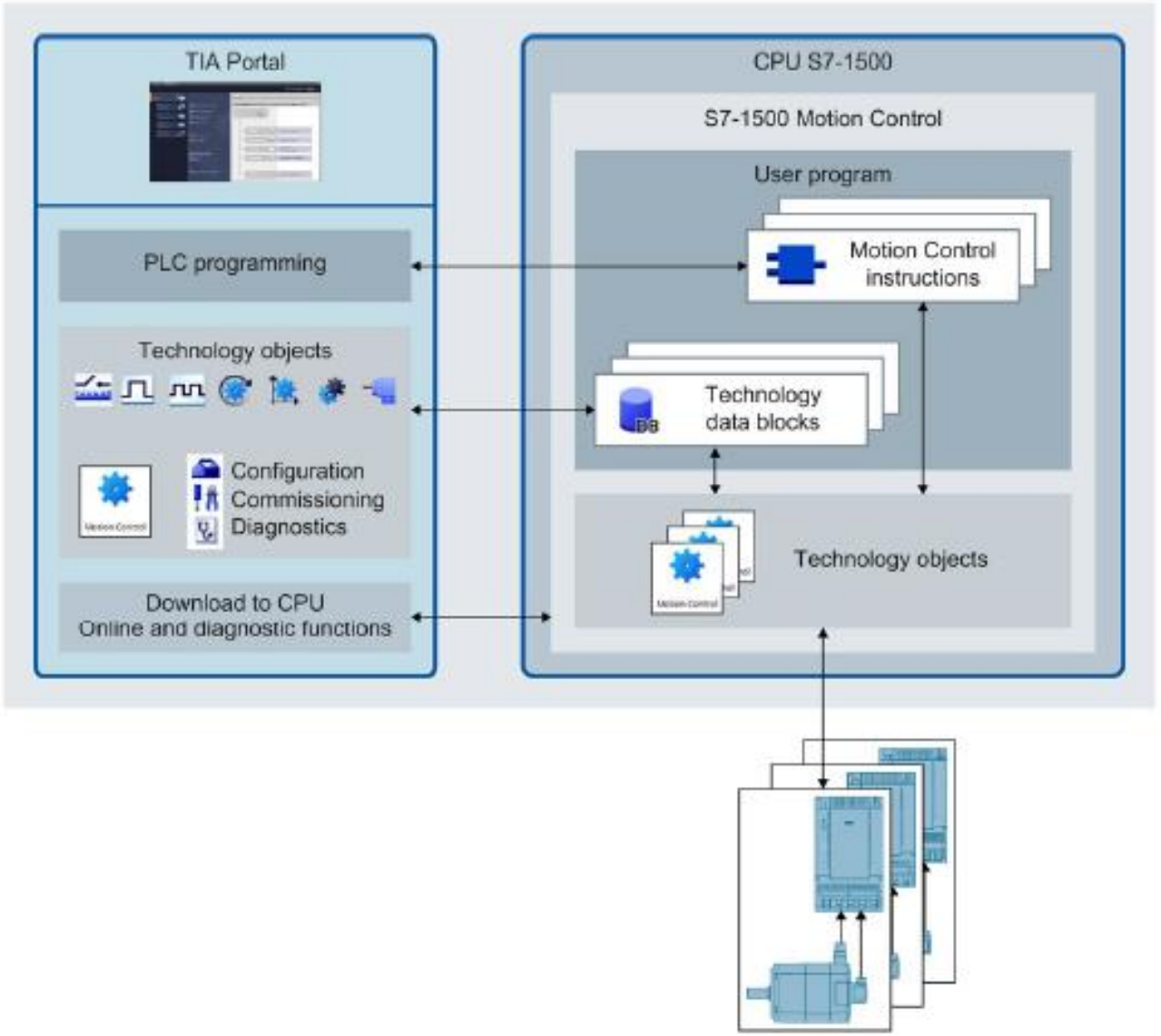
TO Basics

Vesa Kovalainen & Pyry-Pekka Lehto

Technology objects for Motion Control



- Motion control function in 1200/1500-CPU
- Easy to configure w/o deep knowledge of drives
- Can be configured as Real or Virtual [1] axis
- Visual user interface
- Each TO has it's own:
  - Configuration
  - Control panel [2]
  - Diagnostics [3]
  - Datablock
  - Simulation [2]

- PLC-open commands
- Similar programming apart which drive is used
- No additional installations nor licenses are needed

1) Not 1200
2) Not MeasuringInput, OutputCam, Camtrack, Cam
3) Not Cam

Technology objects for Motion Control

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Technology objects

Motion Control	V5.0
TO_SpeedAxis	V5.0
TO_PositioningAxis	V5.0
TO_SynchronousAxis	V5.0
TO_ExternalEncoder	V5.0
TO_OutputCam	V5.0
TO_CamTrack	V5.0
TO_MeasuringInput	V5.0
TO_Cam	V5.0
TO_Kinematics	V5.0
TO_LeadingAxisProxy	V5.0

1) Application
2) Technology object
3) CPU
4) Programming

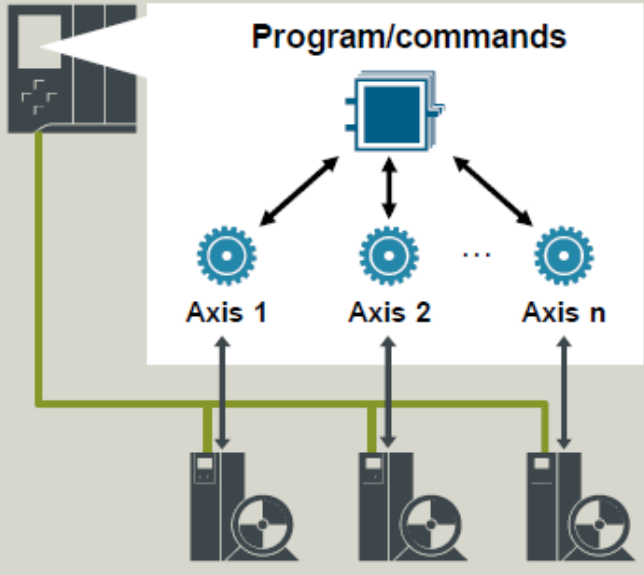
CPUs

- Controllers
  - SIMATIC S7-1200
  - SIMATIC S7-1500
    - CPU
      - CPU 1511-1 PN
      - CPU 1511C-1 PN
      - CPU 1512C-1 PN
      - CPU 1513-1 PN
      - CPU 1515-2 PN
      - CPU 1516-3 PN/DP
      - CPU 1517-3 PN/DP
      - CPU 1518-4 PN/DP
      - CPU 1518-4 PN/DP ODK
      - CPU 1518-4 PN/DP MFP
      - CPU 1511F-1 PN
      - CPU 1513F-1 PN
      - CPU 1515F-2 PN
      - CPU 1516F-3 PN/DP
      - CPU 1517F-3 PN/DP
      - CPU 1518F-4 PN/DP
      - CPU 1518F-4 PN/DP ODK
      - CPU 1518F-4 PN/DP MFP
      - CPU 1511T-1 PN
      - CPU 1515T-2 PN
      - CPU 1516T-3 PN/DP
      - CPU 1517T-3 PN/DP
      - CPU 1511TF-1 PN
      - CPU 1515TF-2 PN
      - CPU 1516TF-3 PN/DP
      - CPU 1517TF-3 PN/DP

PLCopen commands

Motion Control	
MC_Power	Enable, disable technol..
MC_Reset	Acknowledge alarms, r...
MC_Home	Home technology obje...
MC_Halt	Pause axis
MC_MoveAbsolute	Position axis absolutely
MC_MoveRelative	Position axis relatively
MC_MoveVelocity	Move axis with velocity...
MC_MoveJog	Move axis in jog mode
MC_MoveSuperimposed	Position axis overlapping
MC_SetSensor	Switch alternative enco..
MC_Stop	Stop axis and prevent n..
MC_SetAxisSTW	Control bits of control ...
MC_WriteParameter	Write parameter
Measuring input, output cam,...	
Synchronous motion	
Cam	
MotionIn	
Torque data	
Motion (kinematics)	
Zones	
Tools	
Coordinate systems	

Motion Control fully interated in STEP 7 Professional V14, no option package needed



Technology objects for Motion Control

Correct controller to each application

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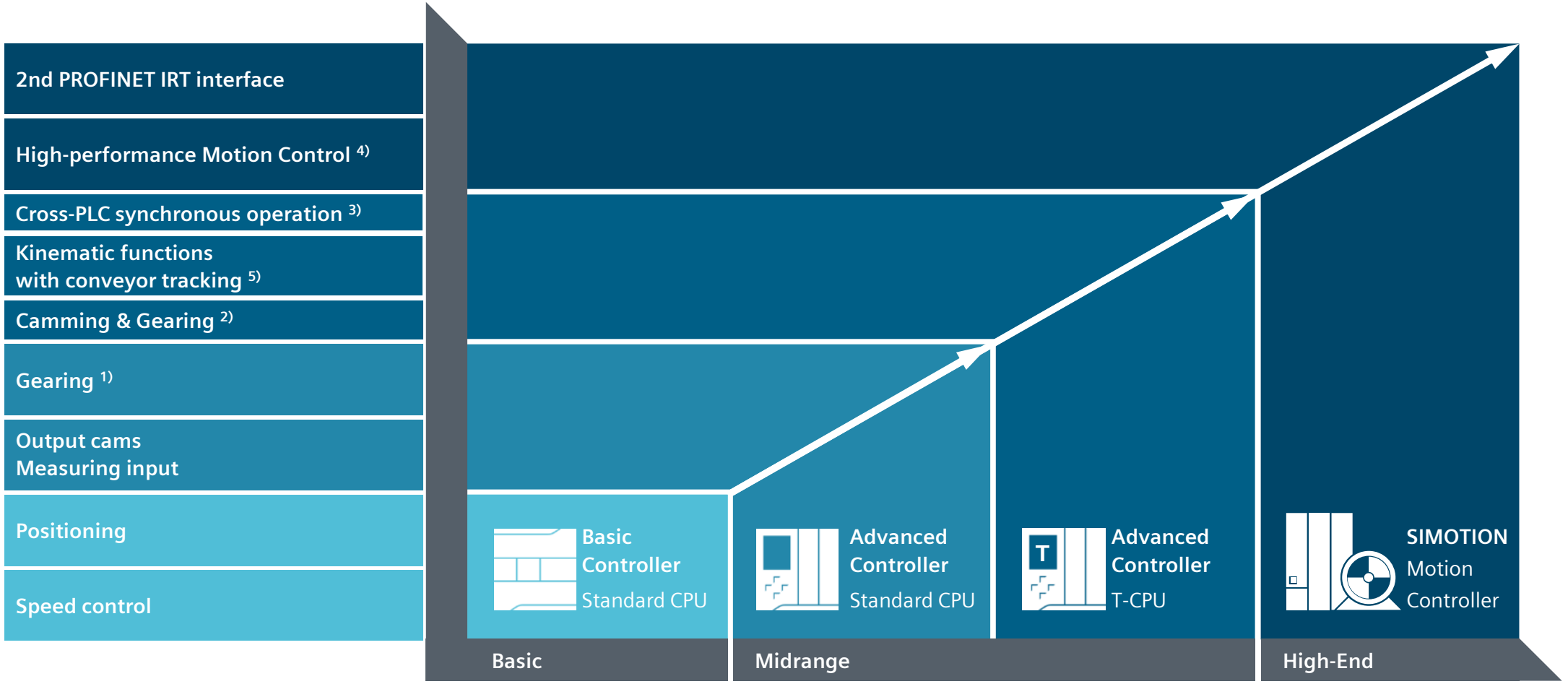

1) Synchronization without specification of the synchronous position
2) Synchronization with specification of the synchronous position
3) In one project
4) Cross-project synchronization; cams with dynamic size; 2 servo for axis groups
5) planned for FW-Update V2.8.x (V16)

Technology objects for Motion Control

Motion Control resources

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Technology object	Required Motion Control Ressources
Speed axis	40
Positioning axis	80
Synchronous axis	160
External Encoder	80
Measuring input	40
Output Cam	20
Cam track	160

Technology object	Required Extended Motion Control Ressources
Cam	2
Kinematics	30

- Motion resources correspond to the memory that can be flexibly assigned with technology objects
- Every CPU has a specific number of available motion resources (e.g. S7-1515T has 2400)
- Identical quantity structure for S7-1500 and S7-1500 T-CPU

Selection guide:
SIZER und TIA Selection Tool

As the number of technology objects increases, the CPU requires more computation time to process the technology objects →motion control cycle becomes longer.

Technology objects for Motion Control

Amount of axes and performance

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+ **Identical basic motion control functions in each CPU**

+ **Scalable according to amount of axes and performance**

1511T/TF 

1515T/TF

1516T/TF

1517T/TF

Max. 5-10 Axes [1)]

7-30 Axes [1)]

40-80 Axes [1)]

30-60 Axes [1)]

64-128 Axes [1)]

1510SP
1512SP

1511

1513

1515

1516

1515SP PC
ET 200SP
Open Controller

1507S*
S7-1500
Software Controller

1517

1518

[1)] Positioning axes
[*)] IPC4x7D, IPC6x7D ja IPC8x7D

System Portfolio – SIMATIC S7-1500 Motion Control

Amount of axes and features

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Performance (TIA Portal V16)			SIMATIC S7-1500 Controller							Distributed Controller	Drive Controller	
			CPU 1511	CPU 1513	CPU 1515	CPU 1516	CPU 1516T	CPU 1517	CPU 1518	CPU 1515SP PC2	1504D TF	1507D TF
Number Positioning axes	Typical [3]		5		7		55	70	128	30	10	55
	Maximum		10		30		80	128	128	30	30	160
Motion Control functionality	Cross-PLC synchronous operation	Technology									New	
	Kinematics functions	Technology										
	Camming	Technology										
	Gearing[1] (with synchronous position)	Technology										
	Gearing[2] (without synchronous position)	Standard										
	Output cam / Measuring input	Standard										
	Positioning	Standard										
	Open-loop speed control	Standard										

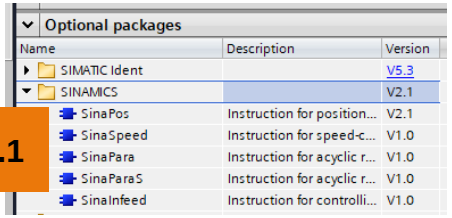
[1] Synchronization with specification of the synchronous position
[2] Synchronization without specification of the synchronous position
[3] In 4 ms at 35% CPU load

Technology objects for Motion Control

When to use Technology objects

-"If motion control is something else than speed control -> TO"

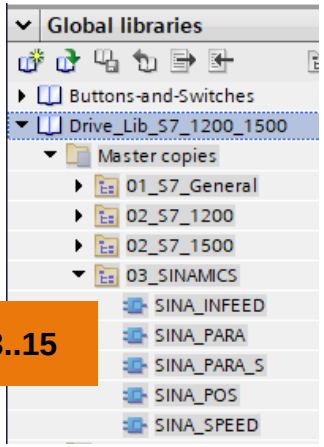
-Readymade FBs w/o TO for speed controlled axis:
SINA_SPEED, SINA_SPEED_20, SINA_SPEED_352 (G120_PZD352)



TIA15.1

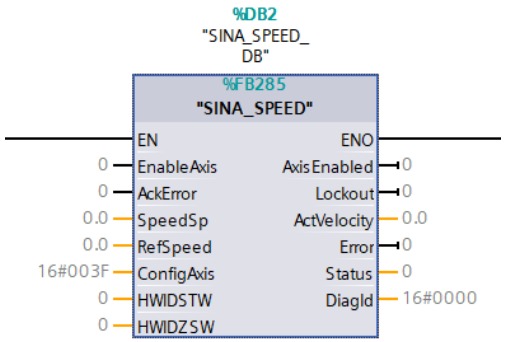
https://support.industry.siemens.com/cs/document/109747655/sinamics-s-g-v%3A-simple-cyclic-funktions-blocks-for-controlling-a-sinamics-in-tia-portal-?dti=0&lc=en-US

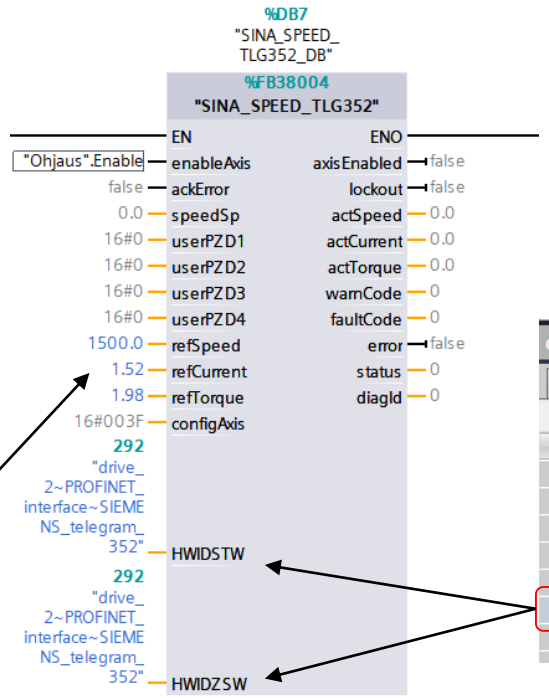
https://support.industry.siemens.com/cs/document/109738702/libraries-in-the-tia-portal?dti=0&lc=en-WW

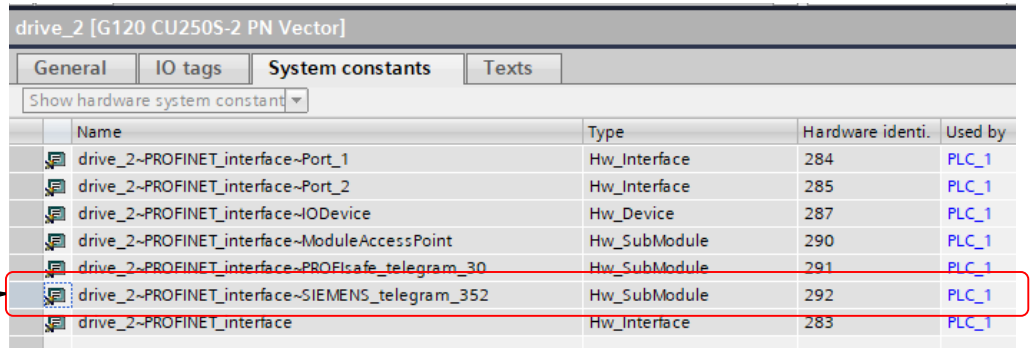


TIA13..15

.







Reference variables: Drive param. p2000→

LdrvSafe: SIMATIC-safety library for SINAMICS G/S

Readymade FBs for PROFIsafe-control

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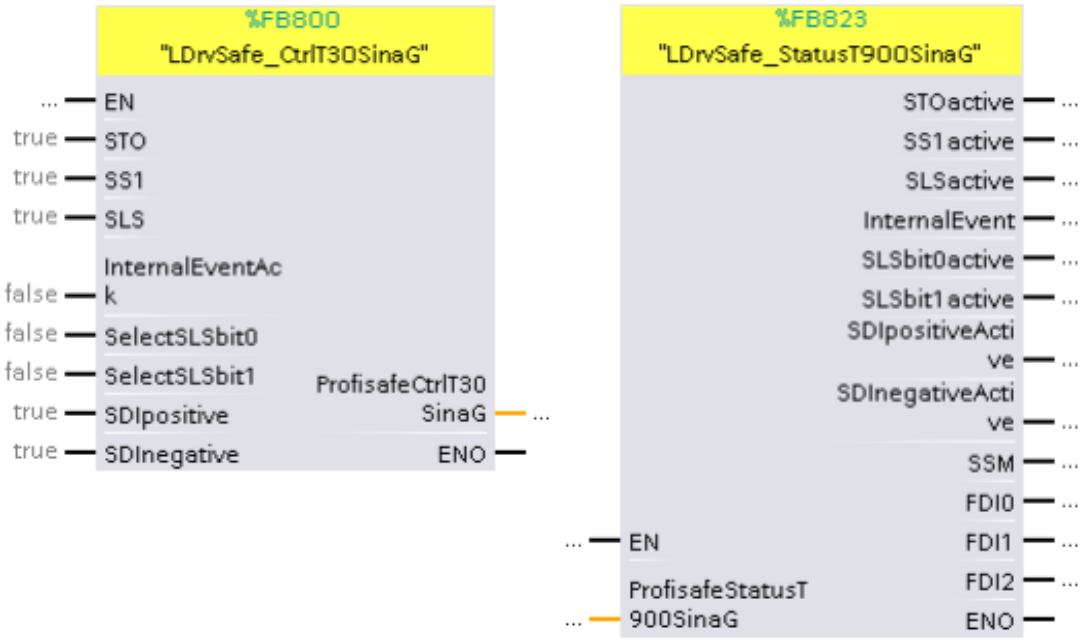
SIMATIC - Failsafe library LDrvSafe to control the Safety Integrated functions of the SINAMICS drive family

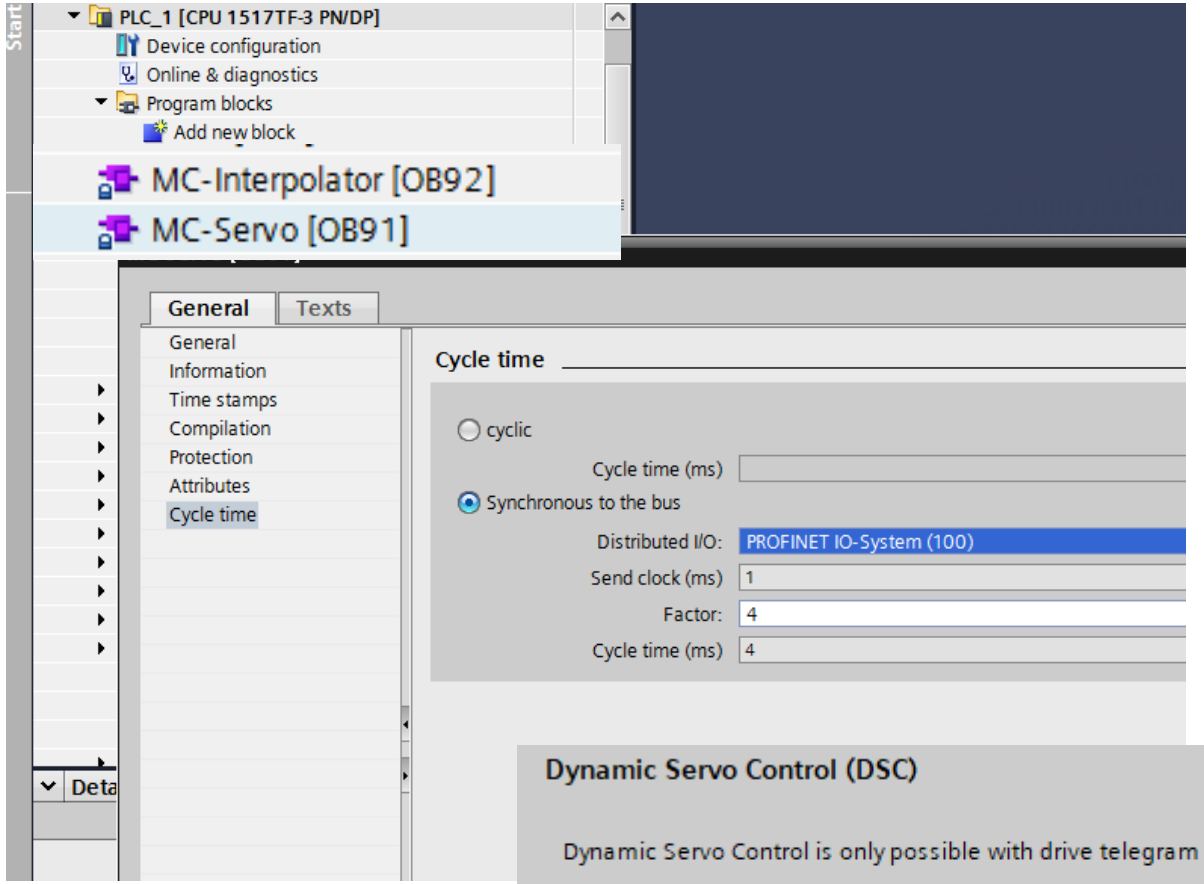
https://support.industry.siemens.com/cs/ww/en/view/109485794

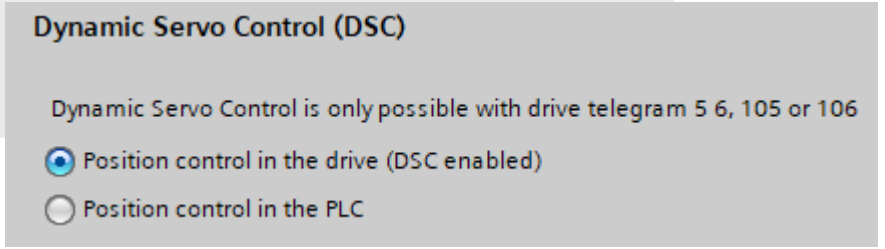
Block	Symbol	S7-300F / S7-400F	S7-1200F / S7-1500F (from TIA Portal V14)
FB800	LDrvSafe_CtrlT30SinaG	✗	✓
FB801	LDrvSafe_CtrlT30SinaS	✗	✓
FB802	LDrvSafe_CtrlT31SinaS	✗	✓
FB803	LDrvSafe_CtrlT900SinaG	✗	✓
FB804	LDrvSafe_CtrlT901SinaS	✗	✓
FB805	LDrvSafe_CtrlT902SinaS	✗	✓
FB810	LDrvSafe_Smooth	✓	✓
FB811	LDrvSafe_WinderRadius	✓	✗ ✓
FB820	LDrvSafe_StatusT30SinaG	✗	✓
FB821	LDrvSafe_StatusT30SinaS	✗	✓
FB822	LDrvSafe_StatusT31SinaS	✗	✓
FB823	LDrvSafe_StatusT900SinaG	✗	✓
FB824	LDrvSafe_StatusT901SinaS	✗	✓
FB825	LDrvSafe_StatusT902SinaS	✗	✓

✓ Available
✗ Not available



Technology objects for Motion Control
Organization blocks

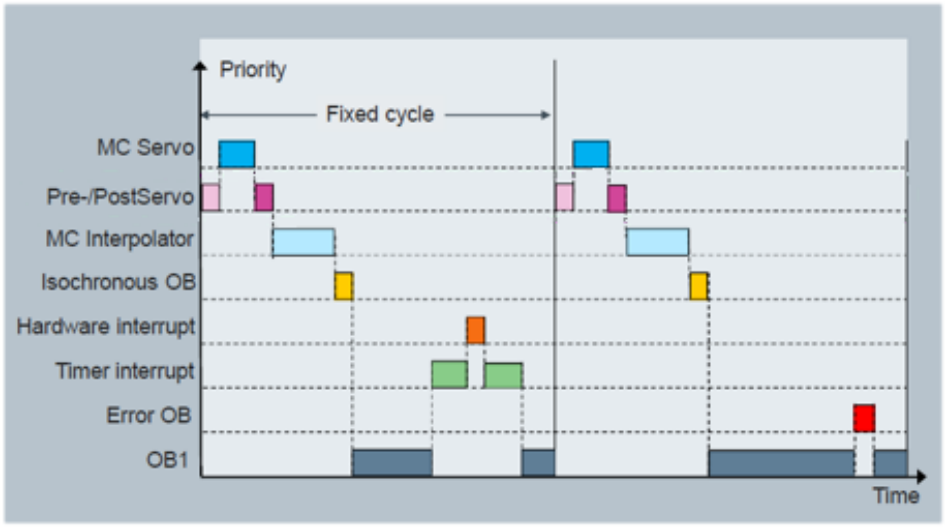




RT = Real time
IRT= Isochronous real time
DSC = Dynamic servo control

- When TO is created, simultaneously OB91 and OB92 are created where motion control tasks are executed
  - Highest priority (1500: 26, 1200: 25)
  - Shall not to be interrupted

- OB91 Cycle time
  - Shorter cycle loads CPU
  - Cyclic: RT, cyclic but not synchronous: G120
  - Synchronous to the bus: IRT, synchronous execution tied to CPU's send clock. HW support required: V90/S210/S120
  - With IRT and DSC: longer Cycle time do not affect positioning accuracy because position control at Servo CU.



Teknologiaobjektit liikkeenohjaukseen
Control loop

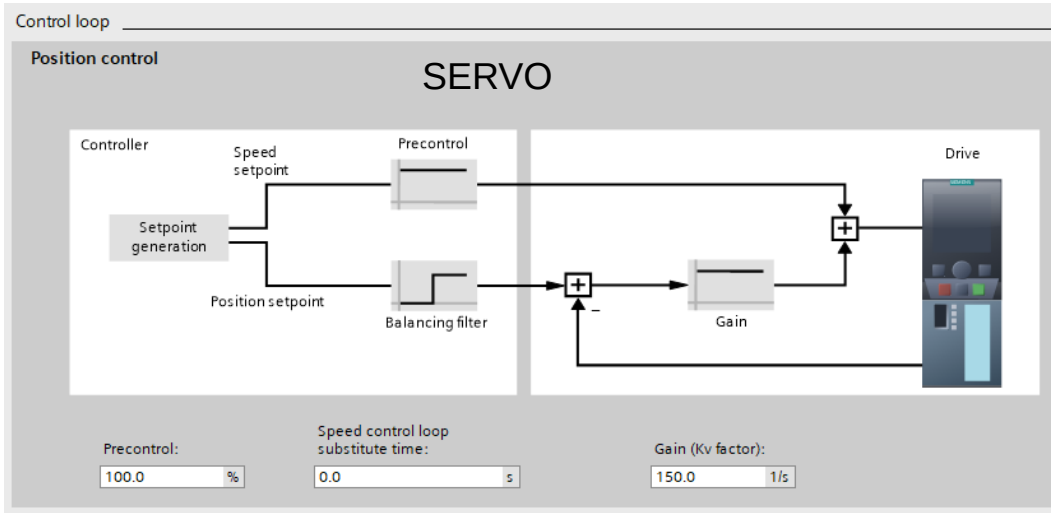
-Drive speed controller must be tuned before tuning TO position controller

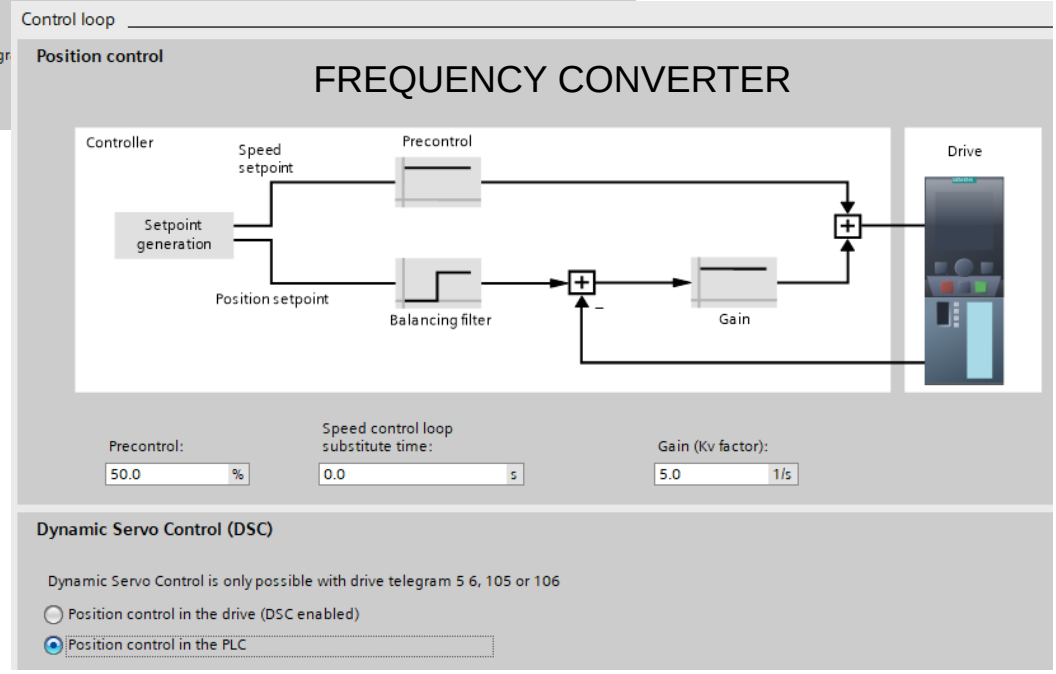
-DSC *“positiong controller at servo CU; TO gives only setpoint”*

-PreControl ja Gain improves motion dynamics and reduce following error

- Too large gains cause position overshoot especially with frequency converters

-Substitute time delays setpoint to position controller in relation to PreControl. Can be used to compensate position overshoot with large gains. In typical cases no need to adjust from 0.





Technology objects for Motion Control
Manuals

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Motion control manual for TIA Portal - 1200
https://support.industry.siemens.com/cs/document/109754206/simatic-step-7-s7-1200-motion-control-v6-0-in-tia-portal-v15?lc=en-US

Motion control manual for TIA Portal - 1500
https://support.industry.siemens.com/cs/document/109749262/simatic-s7-1500-s7%E2%80%911500-motion-control-v4-0-in-tia-portal-v15?lc=en-US

Motion control manual for TIA Portal – 1500T
https://support.industry.siemens.com/cs/document/109749263/simatic-s7-1500-s7-1500t-motion-control-v4-0-in-tia-portal-v15?lc=en-US

Motion control manual for TIA Portal - Kinematics
https://support.industry.siemens.com/cs/document/109749264/simatic-s7-1500-s7-1500t-kinematics-functions-v4-0-in-tia-portal-v15?lc=en-US

Application examples for motion control
https://www.automation.siemens.com/mc-app/sinamics-application-examples/Home/Index?language=en

Technology objects for Motion Control

Tips

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1) Frequency converters OFF1-ramps has to set 0s! All addional ramps at frequency converter cause additional delay to position controller and worsen the quality of positioning.
2) The datatype of Technology object is not automatically recognized (i.g TO_PositioningAxis). They have to manually typed completly.
3) Enable: level 0-1-0, Execute: rising edge
4) Motion tasks can be intrerrupted with another task
5) For same axis (TO) can have multiple similar or different motion tasks
6) Commands' ”Done” stays True as long as ”Execute” stays True. If only pulse (1 cycle) given to ”Execute”; Done stays True only one program cycle.
7) Motion task commands are ”normally” called in OB1. If faster reaction due to very rapid sequencies is needed, commands can be called in other OBs as well, i.g in Pre/PostServo-OB:ssa. Command is effective when OB-servo is executed next time .
8) MC_MoveVelocity and MC_MoveJog are positioning controlled as default. Set ”PositionControlled”-input False if this not preferable.

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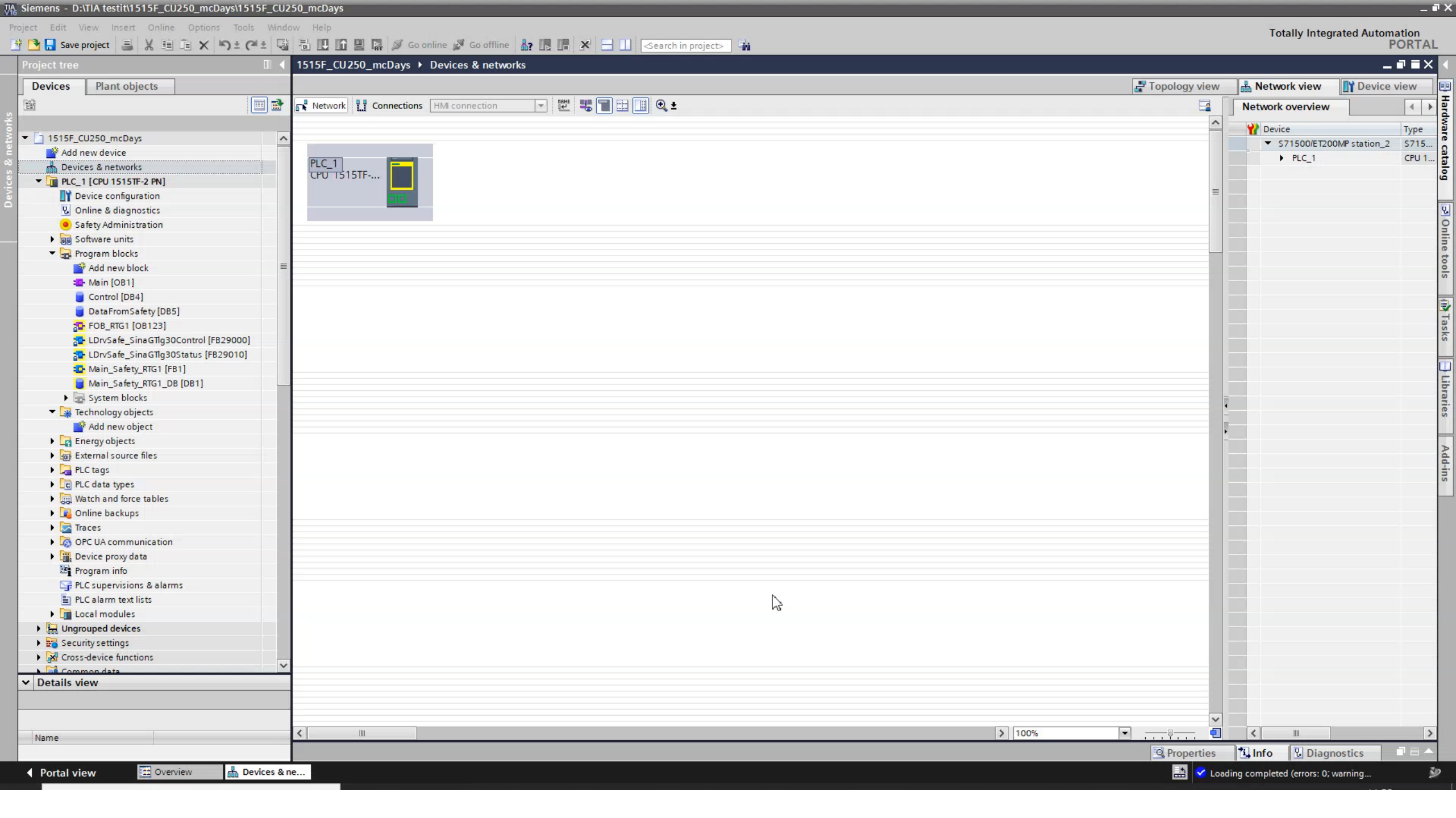
Live Demo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Project Edit View Insert Online Options Tools Window Help
Save project
Go online
Go offline
<Search in project>
Totally Integrated Automation
PORTAL
Project tree
Devices
Plant objects
1515F_CU250_mcDays
Add new device
Devices & networks
PLC_1 [CPU 1515TF-2 PN]
Device configuration
Online & diagnostics
Safety Administration
Software units
Program blocks
Add new block
Main [OB1]
Control [DB4]
DataFromSafety [DB5]
FOB_RTG1 [OB123]
LDrvSafe_SinaGTlg30Control [FB29000]
LDrvSafe_SinaGTlg30Status [FB29010]
Main_Safety_RTG1 [FB1]
Main_Safety_RTG1_DB [DB1]
System blocks
Technology objects
Add new object
Energy objects
External source files
PLC tags
PLC data types
Watch and force tables
Online backups
Traces
OPC UA communication
Device proxy data
Program info
PLC supervisions & alarms
PLC alarm text lists
Local modules
Ungrouped devices
Security settings
Cross-device functions
Details view
Name
1515F_CU250_mcDays ▸ Devices & networks
Topology view
Network view
Device view
Network
Connections
HMI connection
PLC_1
CPU 1515TF-...
Network overview
Device
Type
S71500/ET200MP station_2
S715...
PLC_1
CPU 1...
100%
Properties
Info
Diagnostics
Hardware catalog
Online tools
Tasks
Libraries
Add-ins
Devices & networks
Portal view
Overview
Devices & ne...
Loading completed (errors: 0; warning...

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Advanced Technology Objects for efficient motion control
Friday 3.4.2020 at 14:00-14:45

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