



Development of a GUI interface for the cooling and thermal stabilization systems of the Time Projection Chamber “TPC” and Electromagnetic Calorimeter “ECAL” detectors of the Multi-Purpose Detector “MPD” in the Master-SCADA 4D framework

Full name

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Agenda

✦ System Architecture

- GUI built with TIA Portal + Master-SCADA
- Enables integrated control and monitoring

□ Control Capabilities

- Continuous instrumental & logical control
- Supports diagnostics and case analysis

□ Data Management

- Archiving of measured data
- Event messages (warnings & errors)

▣ Monitored Parameters

- Temperature
- Pressure
- Coolant flow rate
- Coolant level
- Vacuum in water vessels
- Other key indicators

□ GUI Development Status

- Presentation of the current design stage
- integration from TIA Portal Scada to Master Scada



Introduction

Cooling System – Time Projection Chamber (TPC)

- A graphical user interface (GUI) was developed for the **control, monitoring, and data logging** of the **cooling and thermal stabilization systems** of the **TPC and ECAL detectors** in the **MPD experiment**.
- The system is built using **Master-SCADA 4D** software and communicates via the **OPC protocol with TIA Portal Tool**.
- All cooling systems are designed as “**leakless**”, ensuring coolant pressure remains **below atmospheric pressure** to prevent water leakage inside the detector.

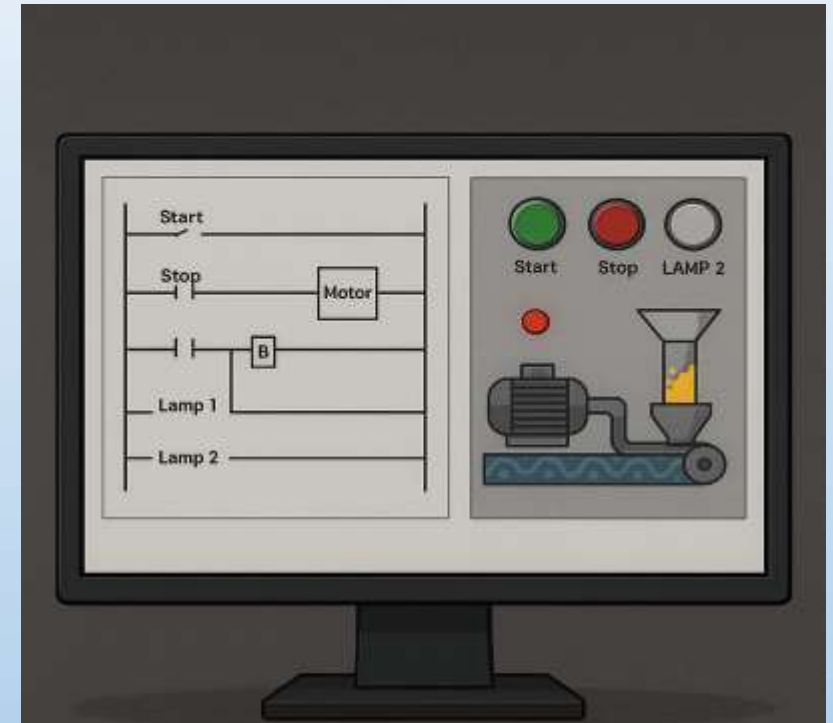


Platform concept for MPD detector cooling system



Cooling System – Time Projection Chamber (TPC)

- The system includes **~110 channels**, with **76 dedicated to thermal stabilization**.
- Each channel comprises:
 - A **water pressure reducer**
 - An **electric heater**
 - **Temperature and pressure sensors**
 - A **flow meter**
- A network of **250 temperature sensors** on the TPC enables **multi-zone PLC-based temperature control** across all channels.



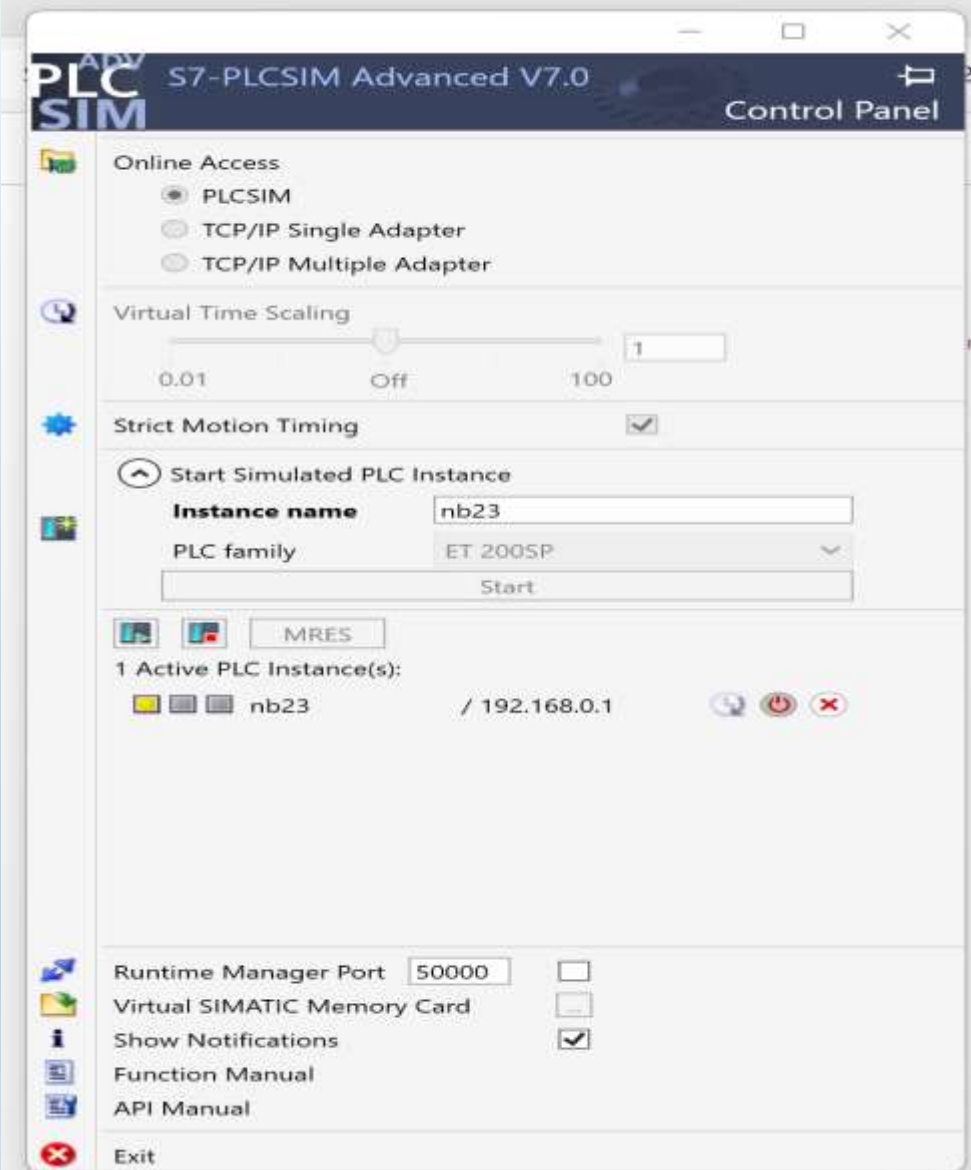
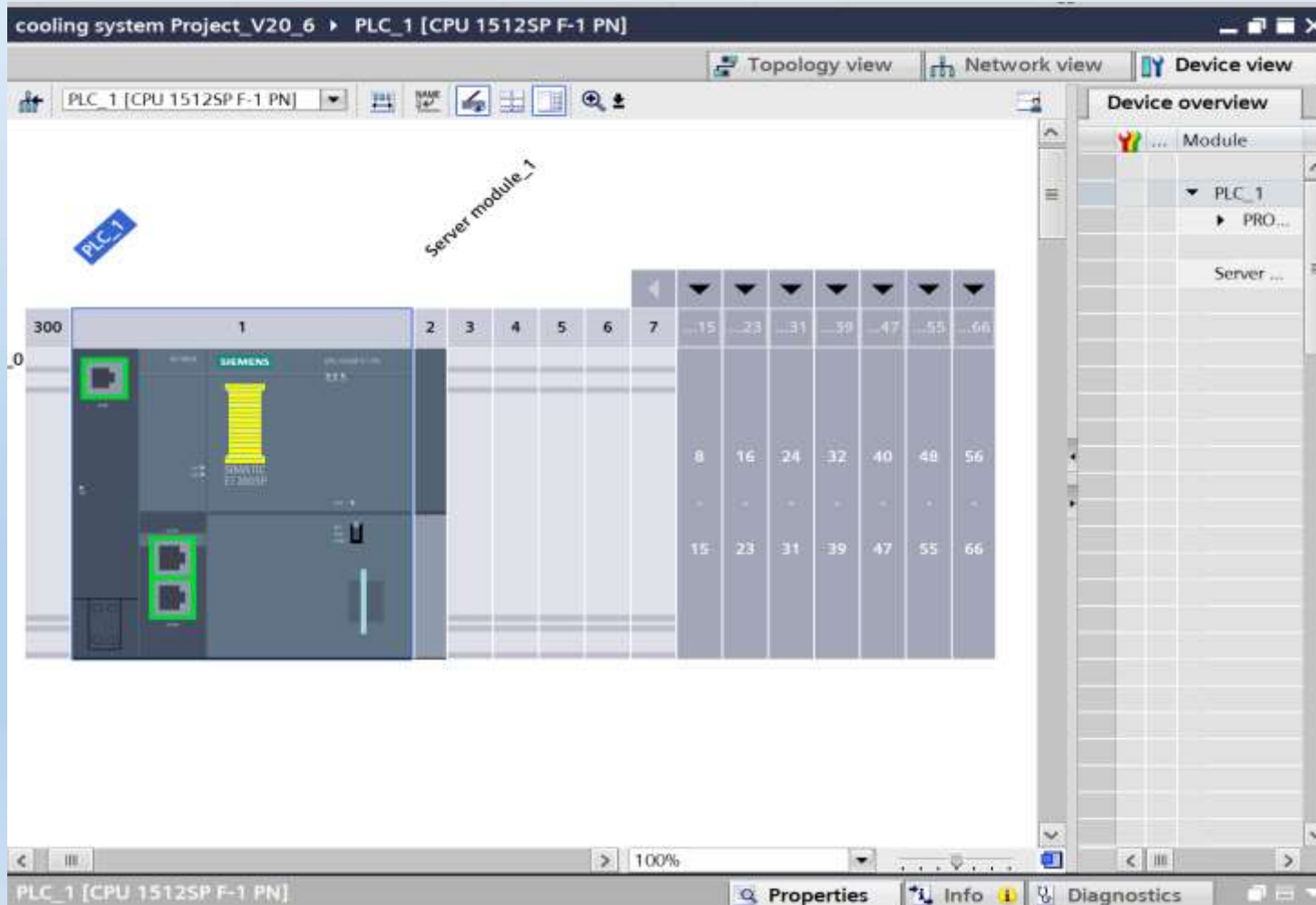
PLC Sim

A software tool for simulating and testing programmable logic controller (PLC) programs



PLC Simulator & TIA Portal Integration

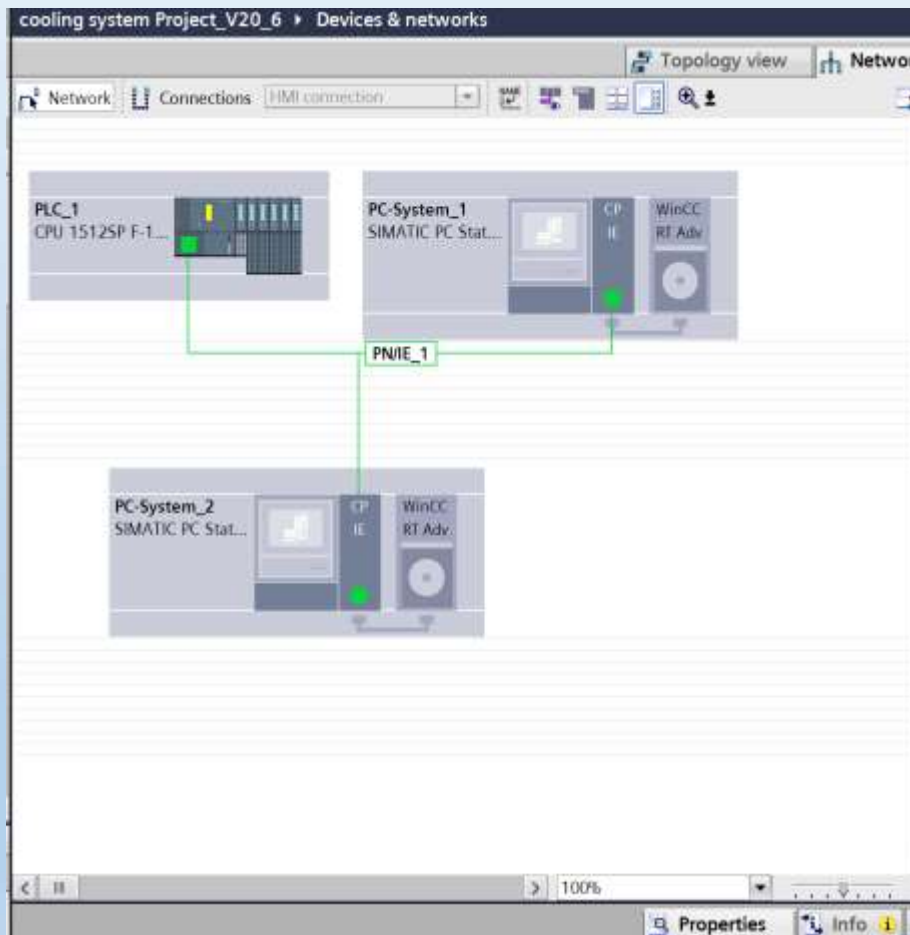
PLC-SIM allows virtual testing of PLC programs in TIA Portal, enabling real-time logic simulation, HMI interaction, and system verification—**without physical hardware**.





PLC Simulator & TIA Portal Integration

“Device & Networks”



Project tree cooling system Project_V20_6 ▶ PLC_1 [CPU 1512SP F-1 PN] ▶ Program blocks ▶ Data_block_1 [DB4]

Devices Plant objects

cut

Keep actual values Snapshot Copy snapshots to start values

Data_block_1

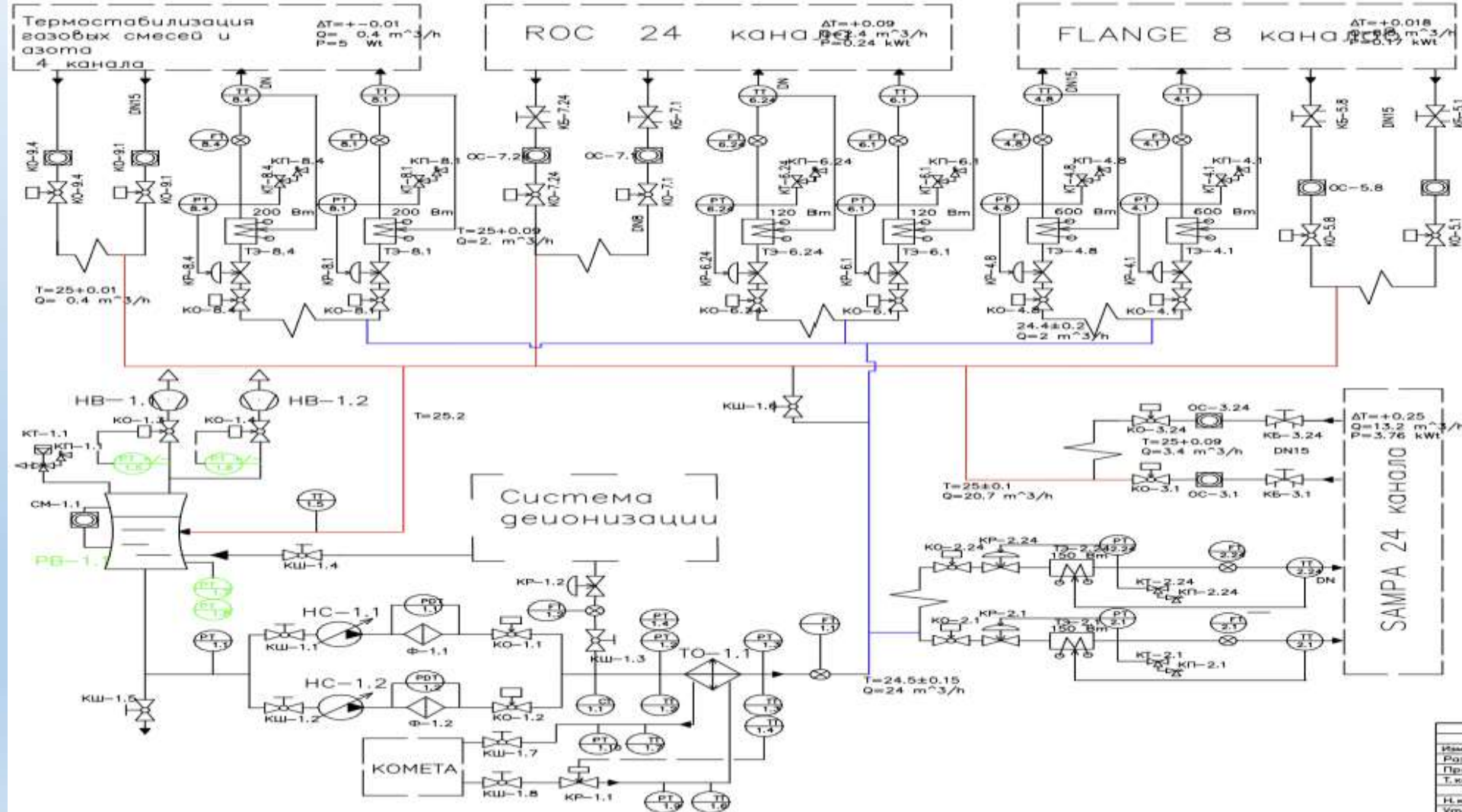
Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	Static		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	pressure		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	pressure[0]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	pressure[1]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	pressure[2]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
6	pressure[3]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
7	pressure[4]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
8	pressure[5]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
9	pressure[6]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
10	pressure[7]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
11	pressure[8]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
12	pressure[9]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
13	pressure[10]		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
14	temperature		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
15	temperature[0]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
16	temperature[1]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
17	temperature[2]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
18	temperature[3]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
19	temperature[4]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
20	temperature[5]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
21	temperature[6]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
22	temperature[7]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
23	temperature[8]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
24	temperature[9]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
25	temperature[10]		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Details view Data Technology objects

pressure[0] Properties Info Diagnostics



Copper Thermal Stabilization Scheme



Имя	Дата	Лист	Фон	Плат
Разработ			Новиков	
Проверил			Семинин	
Т. контр.				
И. контр.				
Утв. проект			Леонов	



GUI Interface screen using TIA Portal

Siemens - C:\Users\youmn\Downloads\cooling system Project_V20_6\cooling system Project_V20_6\cooling system Project_V20_6

Project Edit View Insert Online Options Tools Window Help

Save project Go online Go offline <Search in project>

Project tree ... Project_V20_6 > PC-System_2 [SIMATIC PC station] > HMI_RT_2 [WinCC RT Advanced] > Screens > Screen_3

Devices Plant objects

- Scheduled tasks
- Cycles
- Reports
- Text and graphic lists
- User administration
- Local modules
- PC-System_2 [SIMATIC PC station]
- HMI_RT_2 [WinCC RT Advanced]
- Screens
- Screen management
- HMI tags
- Connections
- HMI alarms
- Recipes

Visualization

Thermal Stabilization of Gas Mixtures

Switch OFF

Switch OFF

100%

Screen_3 [Screen] Properties Info Diagnostics

Properties Animations Events Texts

Property list

General

Pattern Tooltip

Options

- Basic objects
- Elements
- Controls
- My Controls
- Graphics

WinCC graphics folder

Mv graphics folder

Toolbox

Animations

Layout

Instructions

Tasks

Libraries



GUI Interface screen using TIA Portal

The screenshot displays the Siemens TIA Portal software interface for creating a GUI. The main workspace shows a WinCC HMI screen titled "ROC 24 CHANNELS" with a detailed piping diagram. The diagram includes two vertical tanks on the left, two horizontal tanks at the top, and two pumps in the center. Various valves, switches, and sensors (labeled TS 6.24 and PS 6.1) are connected to the piping. A red pipe leads from the bottom left, and a blue pipe leads from the bottom right. The interface includes a project tree on the left, a toolbar at the top, and a toolbox on the right. The bottom panel shows the Properties window for the selected screen.

Project Tree (Left):

- PC-System_2 [SIMATIC PC station]
- HMI_RT_2 [WinCC RT Advanced]
- Screens
 - Screen_1
 - Screen_2
 - Screen_3
 - Screen_4
 - Screen_5

Toolbox (Right):

- Basic objects
- Elements
- Controls
- My Controls
- Graphics

Properties Window (Bottom):

- Screen_2 [Screen]
- Properties | Animations | Events | Texts
- General
- Pattern
- Tooltip

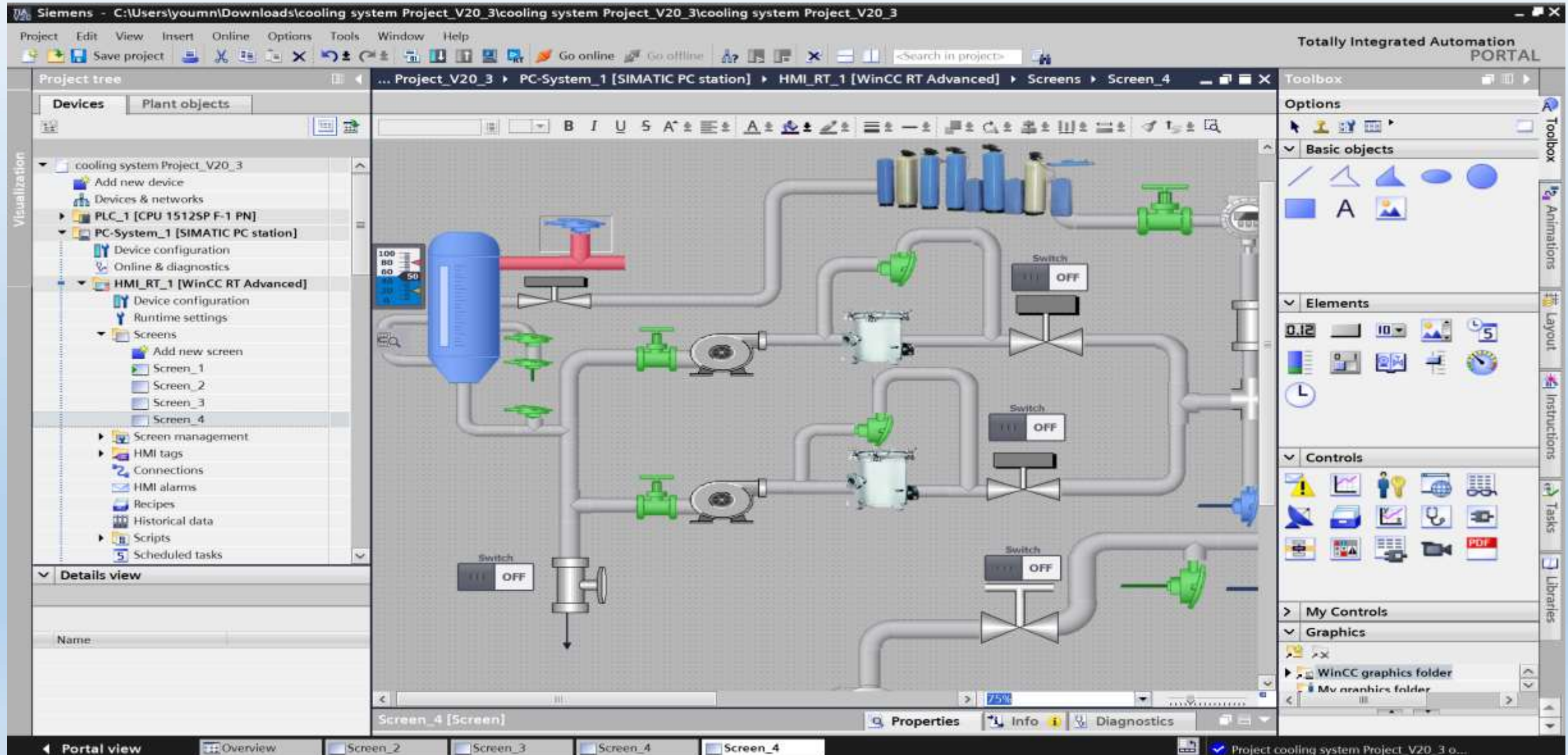


GUI Interface screen using TIA Portal

The screenshot displays the Siemens TIA Portal software interface for configuring an HMI screen. The main workspace shows a detailed piping diagram titled "Flange 8 Channels". The diagram consists of two parallel processing channels. Each channel starts with a pressure sensor (PS 4.3) and a temperature sensor (TS 4.3) at the top. Below these are pumps, valves, and heaters. The diagram is annotated with "Switch DFI" and numerical values such as "+00i" and "0000i".

The software interface includes a project tree on the left side, showing the hierarchy of the project: "Project_V20_6" > "PC-System_2 [SIMATIC PC station]" > "HMI_RT_2 [WinCC RT Advanced]" > "Screens" > "Screen_4". The top toolbar contains various icons for file operations and navigation. The bottom panel shows the "Properties" window for the selected screen, with tabs for "General", "Animations", "Events", and "Texts".

GUI Interface screen using TIA Portal



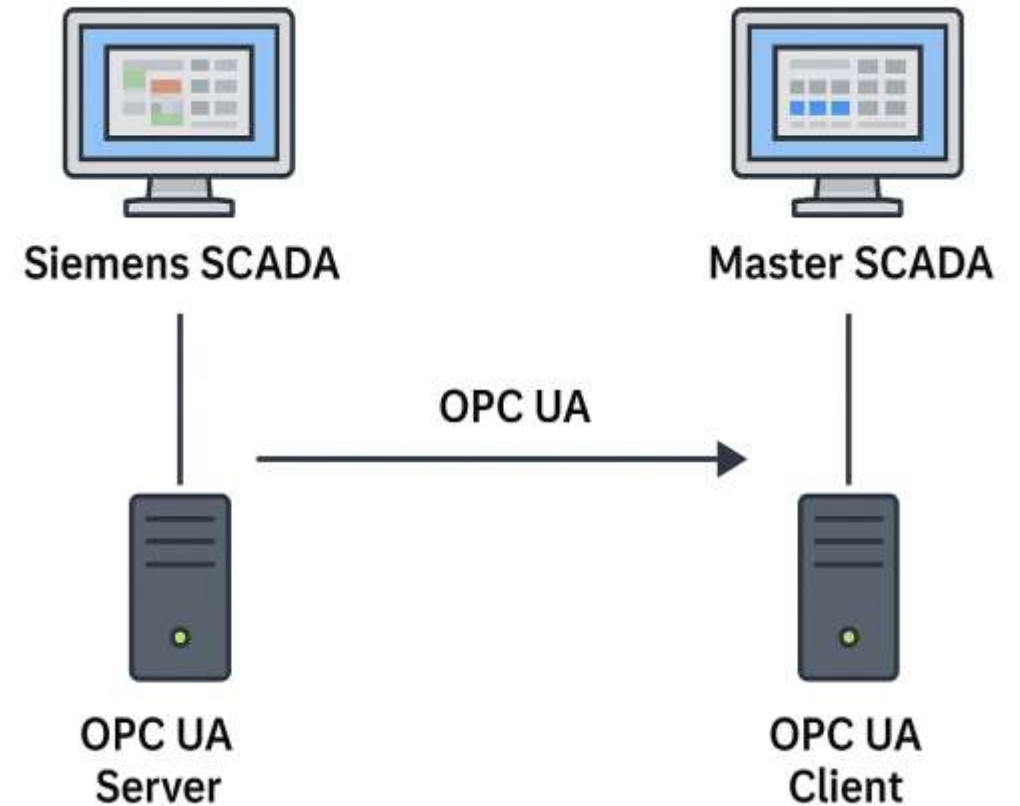
The screenshot displays the Siemens TIA Portal software interface for a cooling system project. The main workspace shows a 3D schematic of the system, including a large blue cylindrical tank, several pumps, pipes, valves, and control switches. The interface is divided into several panels:

- Project tree (left):** Shows the project structure, including the cooling system Project_V20_3, PLC_1 [CPU 1512SP F-1 PN], PC-System_1 [SIMATIC PC station], and HMI_RT_1 [WinCC RT Advanced]. The HMI_RT_1 section includes options for device configuration, runtime settings, and screens (Screen_1, Screen_2, Screen_3, Screen_4).
- Toolbox (right):** Contains various graphical elements and controls, categorized into Basic objects, Elements, and Controls. The Basic objects section includes shapes and text. The Elements section includes numerical displays and indicators. The Controls section includes warning symbols, keys, and other control elements.
- Properties panel (bottom right):** Shows the properties of the selected object, including Name, Properties, Info, and Diagnostics.
- Navigation bar (bottom):** Shows the current screen (Screen_4 [Screen]) and other screens (Screen_2, Screen_3, Screen_4).



Integration of TIA Portal SCADA into Master SCADA

- Utilize **OPC UA** or **Modbus TCP** for seamless communication.
- Configure **WinCC (TIA Portal)** as an OPC UA Server.
- Master SCADA connects as an OPC UA Client to read/write data.
- Share and map **key process tags** (e.g., alarms, setpoints, status).
- Implement **security settings**: authentication, access control, encryption.
- Perform real-time **testing and validation** to ensure proper integration.



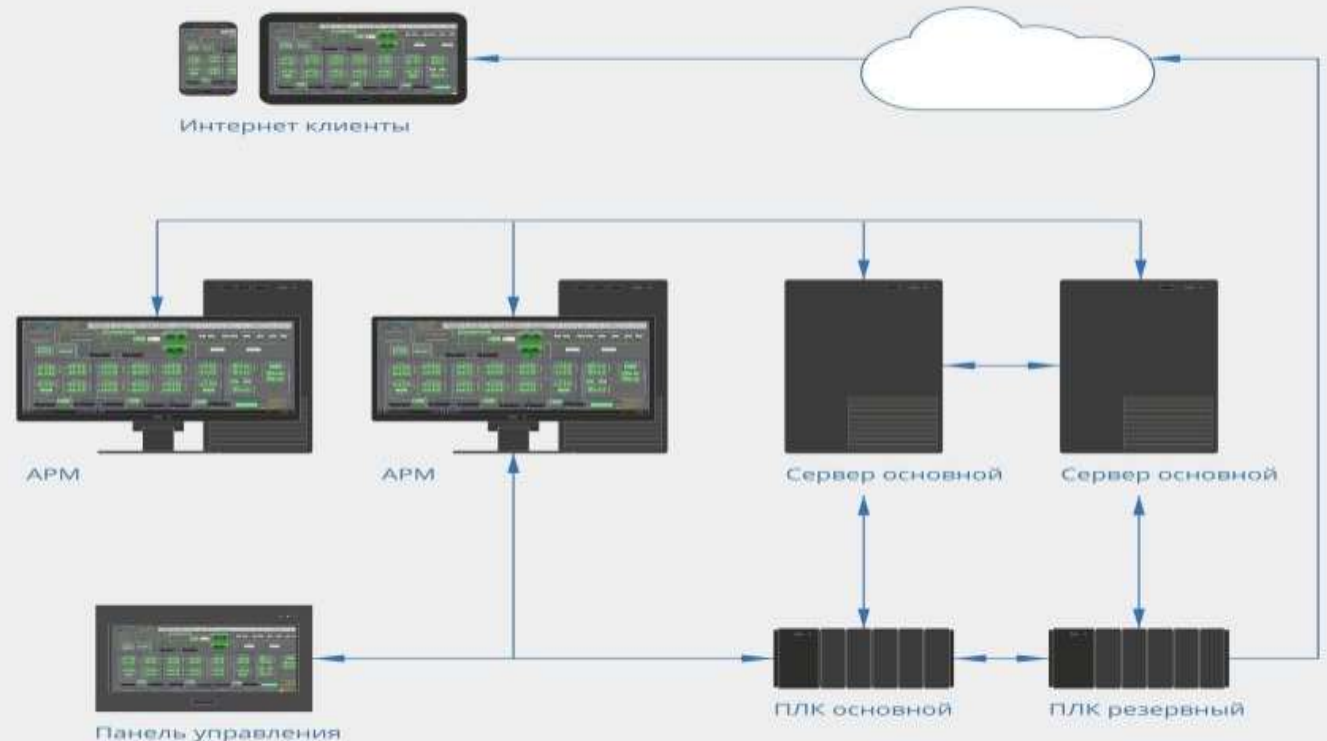


Master SCADA 4D – New Generation of SCADA

- **Next-gen SCADA** system by MPS Software with enhanced support for **IoT and large distributed systems**.

- Enables full integration across all management levels:

- **PLC controllers**
- **Local HMI panels**
- **Operator workstations**
- **Servers**
- **Cloud services**





Integration Strategy Overview

Goal: Connect Siemens SCADA (WinCC/PCS 7) to a Master SCADA system

Key Protocols:

- OPC UA / DA: Standard for SCADA integration
- Modbus TCP: Lightweight and widely used
- MQTT / REST: For IoT or cloud-based systems

Use Siemens SCADA as a Data Server

Use MasterSCADA as the OPC UA Client

- In MasterSCADA, add Siemens as OPC UA data source
- Connect to Siemens OPC UA server (IP, Port 50000)
- Browse and import tags
- Assign tags to screens, trends, alarms, etc.

The two SCADA systems need a way to **communicate in real-time**. Choose a supported protocol:

Protocol	Use Case	Support
OPC UA / OPC DA	Most common & robust for SCADA-to-SCADA	Siemens WinCC, PCS 7 support OPC
Modbus TCP/RTU	Simple, for basic data sharing	Often used in industrial systems
MQTT	For modern IoT-oriented SCADA	May need gateway in Siemens
REST APIs	If master SCADA is cloud or web-based	Siemens usually needs middleware
Database exchange	For historical/logged data	Via SQL, CSV, etc.



GUI-Level Integration Methods

- Remote Desktop / VNC: Directly launch Siemens SCADA interface
- Hyperlink Launcher: Button in MasterSCADA opens Siemens HMI
- Thin Client: Host Siemens SCADA on terminal server for browser access
- Embedded HMI Web Page: Use iframe if web-enabled HMI is available

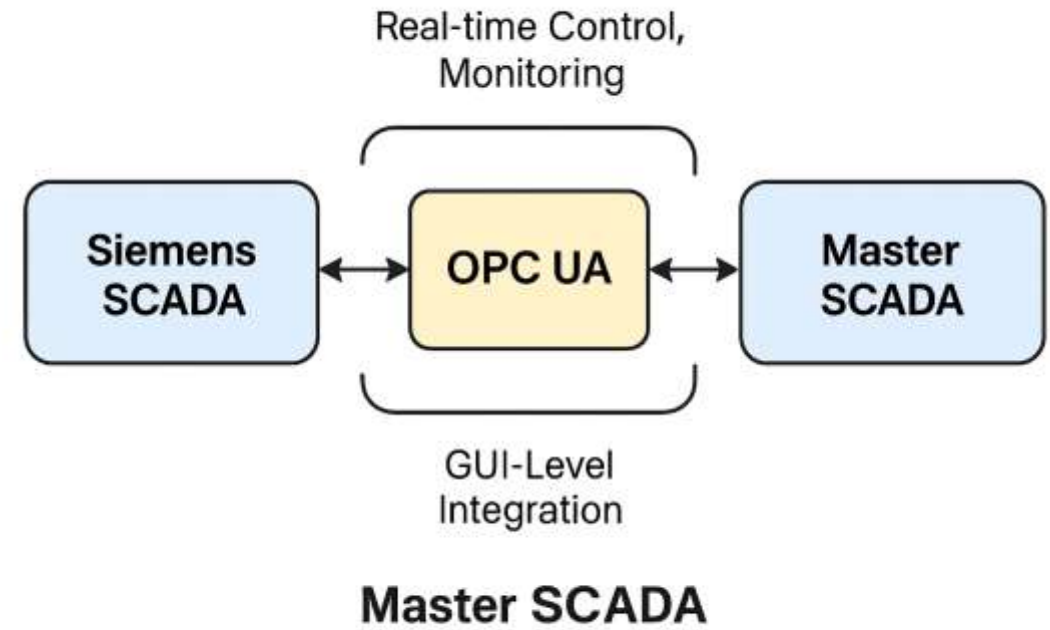
Recommendation Based on Use Case

Use Case	Recommended Setup
Real-time control + monitoring	OPC UA (Read/Write)
Monitoring only	OPC UA (Read-only) or Modbus TCP
GUI access only	RDP / VNC / Thin Client
Unified control center	Use a Master SCADA that supports OPC aggregation



Integration Layers Overview

1. Real-Time Control: OPC UA Read/Write
2. Monitoring: OPC UA Read-only / Modbus TCP
3. GUI Integration: RDP, VNC, Thin Clients



Method	Description
Remote Desktop Protocol (RDP)	Open Siemens HMI remotely from master
Thin Client / VNC	Access WinCC runtime as a web or VNC session
Hyperlink Button	Use a GUI button in master SCADA to open Siemens SCADA viewer
Embedded HMI Web Page	If Siemens HMI is web-enabled, embed in iframe in master SCADA



Conclusion

- A **GUI interface** was developed using **Master-SCADA 4D** and **TIA Portal**, enabling full control, monitoring, and data logging for the **cooling and thermal stabilization systems** of the MPD experiment.
 - The system manages **110 leakless cooling channels**, with **76 dedicated to thermal stabilization**, ensuring safe operation below atmospheric pressure.
 - Real-time monitoring of key parameters (temperature, pressure, flow, conductivity, vacuum, etc.) is integrated via **multi-zone PLCs** and **OPC communication**.
 - The interface supports **continuous control, diagnostics, and data archiving**, ensuring reliability and efficient system analysis.
 - Current status: **GUI design completed**, with performance and diagnostic tools in place.
-
- ✓ - Configure Siemens SCADA OPC UA server
 - ✓ - Setup Master-SCADA OPC UA client
 - ✓ - Secure and validate all communication
 - ✓ - Optionally enable GUI-level integration
 - ✓ - Test and document the full integration

Stay Tuned!
More Details Coming Soon...



Thanks for your Attention

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