

Process automation

Human-machine interfaces (HMI)

BS UNI studies, Fall semester 2025/2026

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Outline

- Introduction to HMI and SCADA Systems
- Evolution and Applications of SCADA
- SCADA Components and Functions
- Data Visualization, Alarms, and Reporting
- SCADA Software and Tools

Introduction

- Individual processes are controlled by programmable logic controllers (PLCs)
 - They are programmed for manual and automatic control of the process
 - They are usually spatially distributed across production
 - Information is difficult for operators to access and understand
- Human-Machine Interface (HMI) systems have evolved as user-friendly displays of the control system's operation
 - Buttons and lights
 - Displays, consoles, panels
 - SCADA systems
- SCADA (Supervisory Control and Data Acquisition)
 - Collects information from controllers and displays it in a simple and clear way
 - Enables the operator to intervene in the process (in an easy way)
 - An important element is generating alarms, which draw the operator's attention and allow for quick reactions

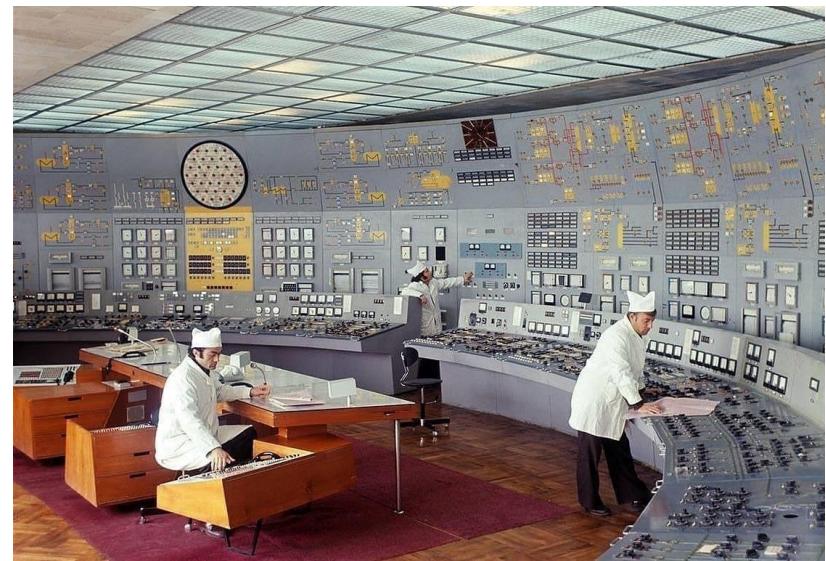
Basics

Two meanings:

- SCADA as a comprehensive control system
 - Monitoring station MTU (Master Terminal Unit) – limited to supervisory control
 - Peripheral input/output devices RTU (Remote Terminal Unit), PLC – automatic process control
 - Equipment for data acquisition and executing actions (sensors and actuators)
 - Communication network
- SCADA as a monitoring system (our interpretation)
 - Monitoring is the real-time assessment of the technological process's status
 - As part of monitoring, the operator must:
 - Observe the measured data in the process
 - Detect deviations from normal conditions
 - Make assumptions about the possible causes of irregularities
 - Take action in exceptional situations
 - Correctly assess the condition when there are irregularities or insufficient accurate data

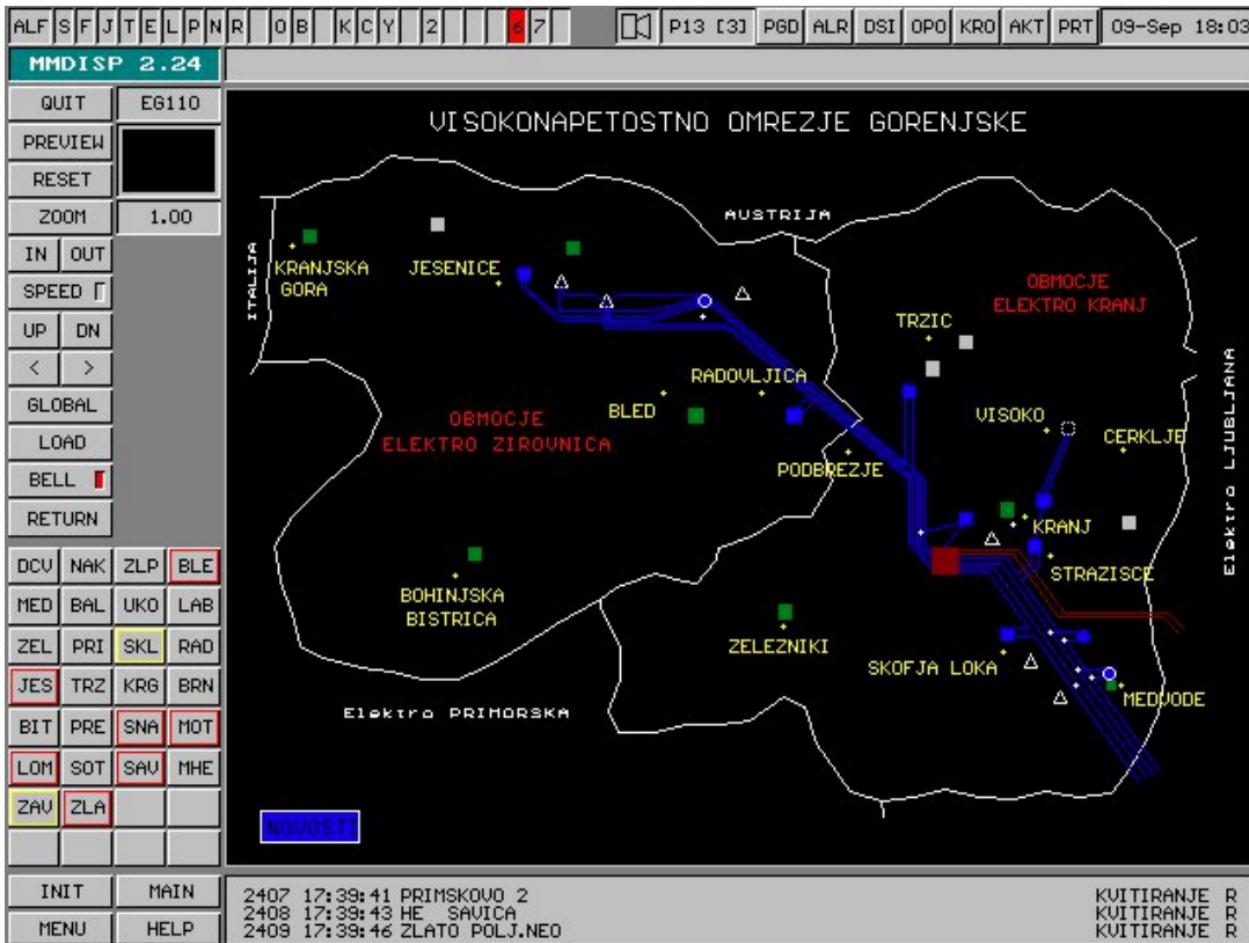
Development

- **Beginnings: 1960s**
 - Data acquisition and transmission over long distances
 - Early systems were more centralized:
 - Power plants, dispatch centers
 - More frequent operator interventions
 - Relatively expensive
- **1973: the term SCADA**
- **Today:**
 - With the falling cost of computing equipment, SCADA systems have become increasingly accessible, even for smaller applications.
 - More autonomous lower levels, distributed systems
 - Less operator intervention



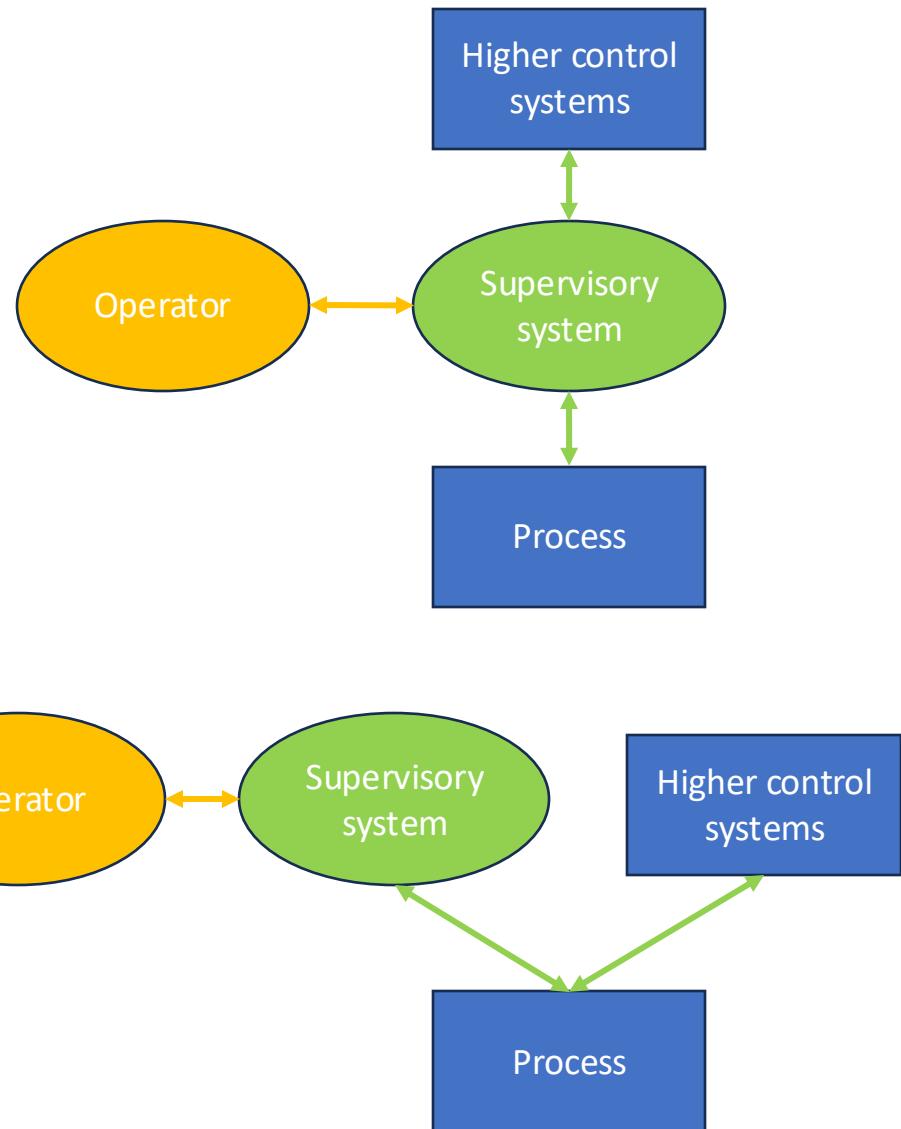
Areas of Application

- Distribution systems
 - Electric power, gas, water
- Transport
 - Railways, highways
- Power plants
- Telecommunications
- Laboratories, experimental systems
- Manufacturing systems
 - Automotive industry, chemical, refineries, dairy industry, etc.



Integration

- SCADA is an addition to the control system
- Linking element:
 - between the process and the operator, as well as between process control and higher-level control systems.
 - Newer paradigms (Industry 4.0) suggest a different model where the supervisory system is parallel to the higher-level control systems, which have direct access to process controllers.
- Control systems provide support to the operator.
- Lower levels must function independently in case of supervisory system failure.



Manufacturers

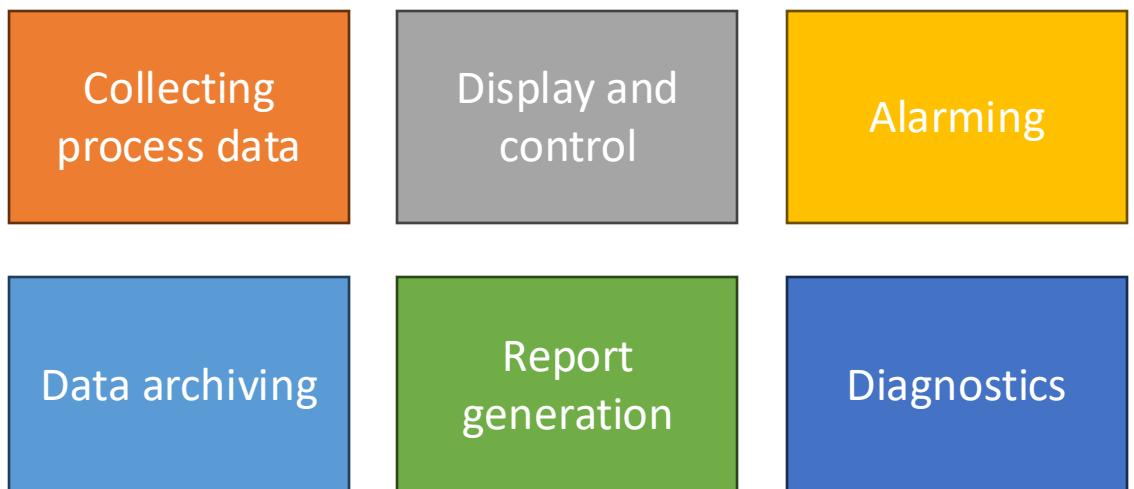
Various manufacturers

- Process equipment manufacturers
 - RSView (Rockwell)
 - LabView (National Instruments)
 - WinCC (Siemens)
 - TwinCAT HMI (Beckhoff)
- Independent manufacturers
 - FactoryLink (USData - UGS)
 - InTouch (Wonderware)
 - iFIX (Intellution – GE Fanuc)
- Open-source projects
 - OpenSCADA (<http://oscada.org>)
 - OpenAPC (<https://www.openapc.com>)
 - ScadaBR (<https://github.com/ScadaBR>)
 - IndigoSCADA (<http://www.enscada.com/a7khg9/IndigoSCADA.html>)

Overview

Functions provided by software tools:

- Collecting process data
- Display and control
- Alarming
- Data archiving
- Report generation
- Diagnostics

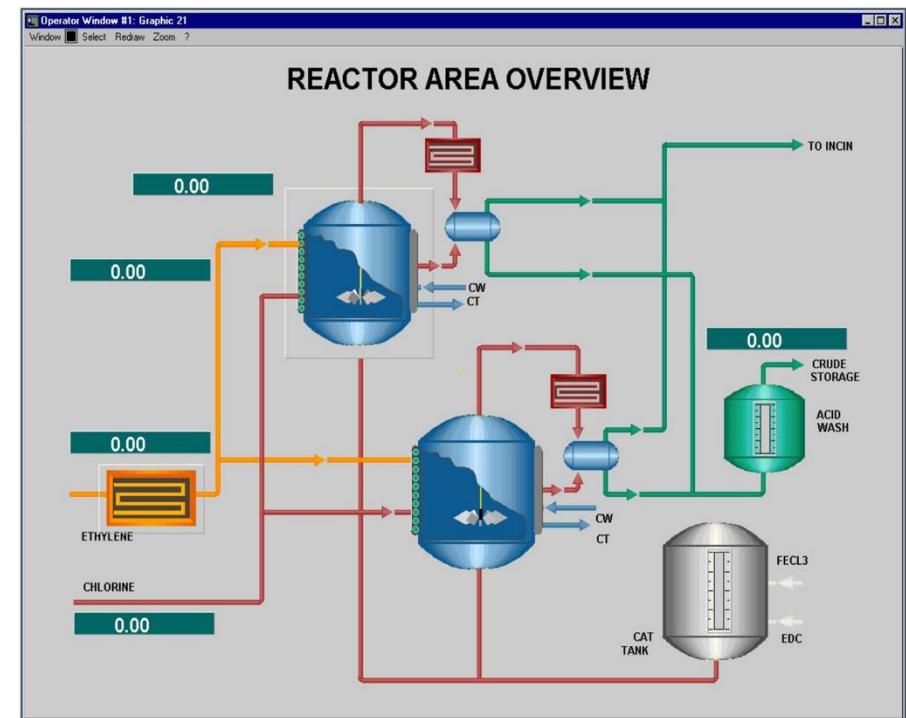


Collecting Process Data

- Based on a certain event or at a pre-determined time.
- The speed of handling process data depends on the process.
- We need interfaces and drivers to access process data:
 - Controllers, regulators, etc.
 - Standard ones are already available in software packages, specific ones need to be acquired from manufacturers.
- Elements of the data structure are called tags:
 - A tag represents a single input or output value in the system.
 - There can be from a few hundred to several thousand tags (ranging from a few 100 to around 10,000 points).

Displays and Control

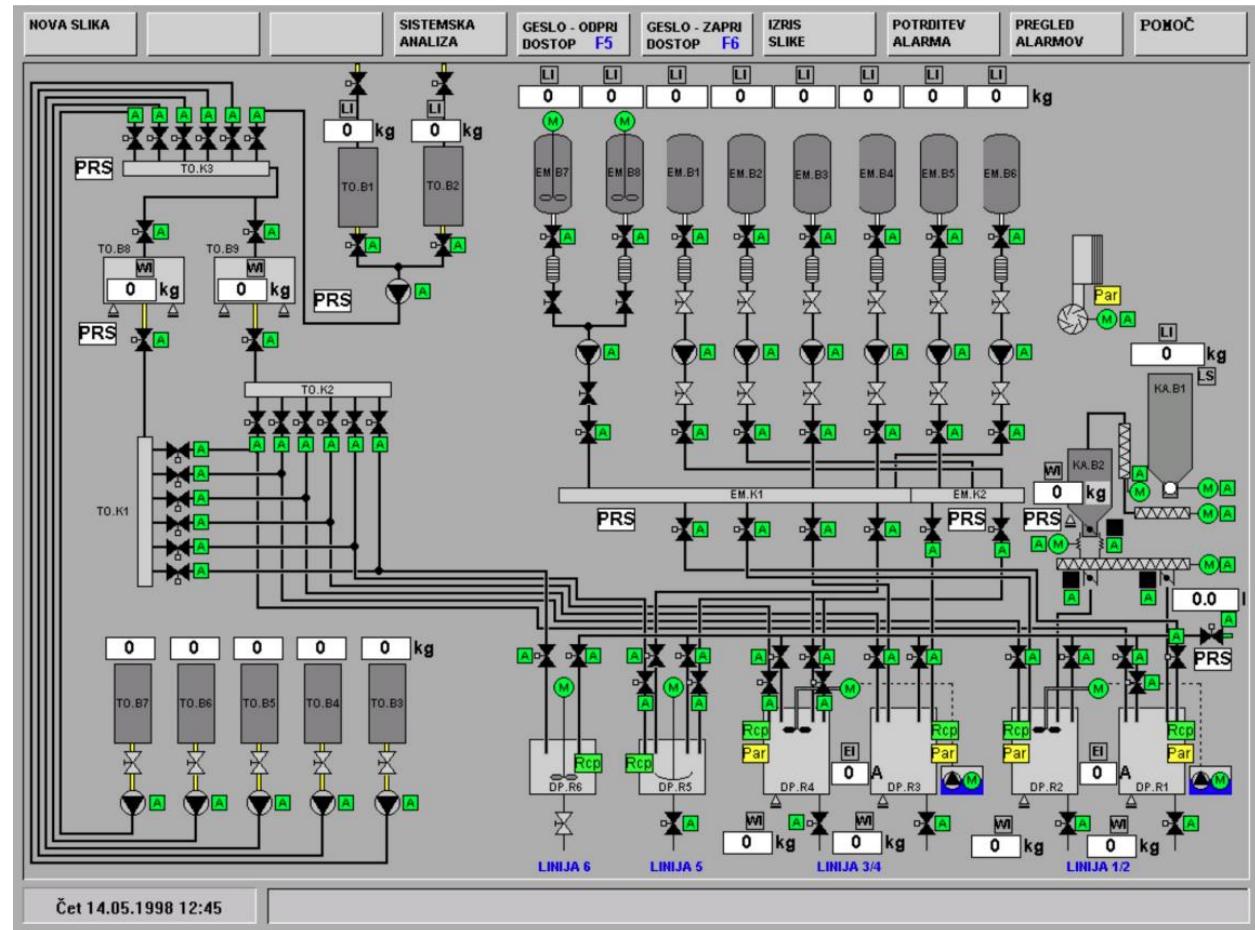
- The operator has the ability to view and intervene in the process operation.
- Interaction must be simple and understandable:
 - Typically, a process diagram is prepared for the system we are controlling.
 - Simple graphical elements: shapes, diagrams, photos, etc.
 - Less is more.
- Data can be displayed in various ways:
 - Textual displays
 - Graphical displays:
 - Simple displays: traffic lights (valve open/closed)
 - Complex: animations, colors (e.g., position of an elevator in a skyscraper)
- Access limitations and possibilities for intervention in the process (user accounts, permissions)
- Recipes



Displays and Control

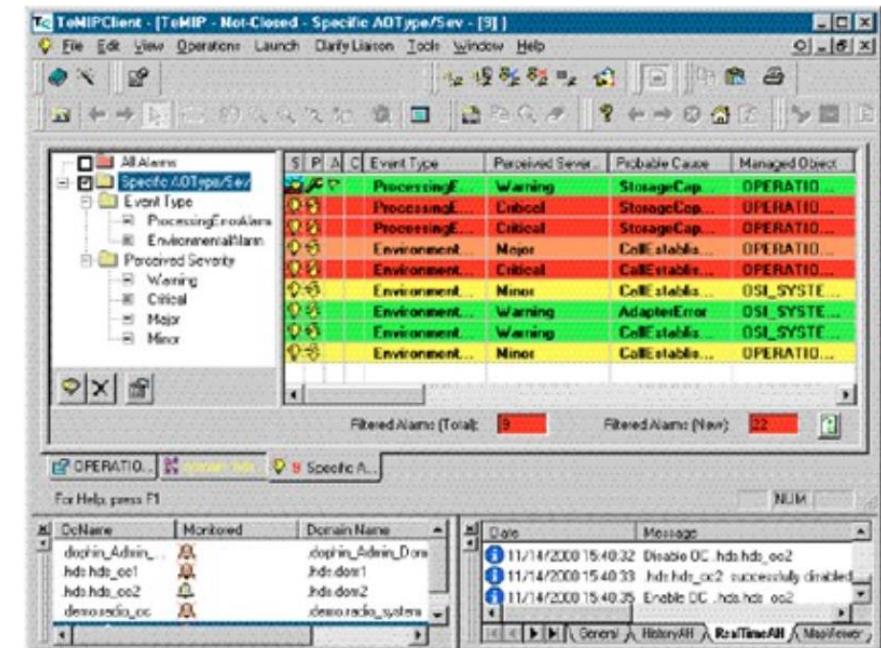
Example: Pump

- Display of flow (analog or digital)
- Display of any errors (color signals)
- The operator can turn off the pump via the keyboard/mouse – immediately visible on the screen as the flow decreases.



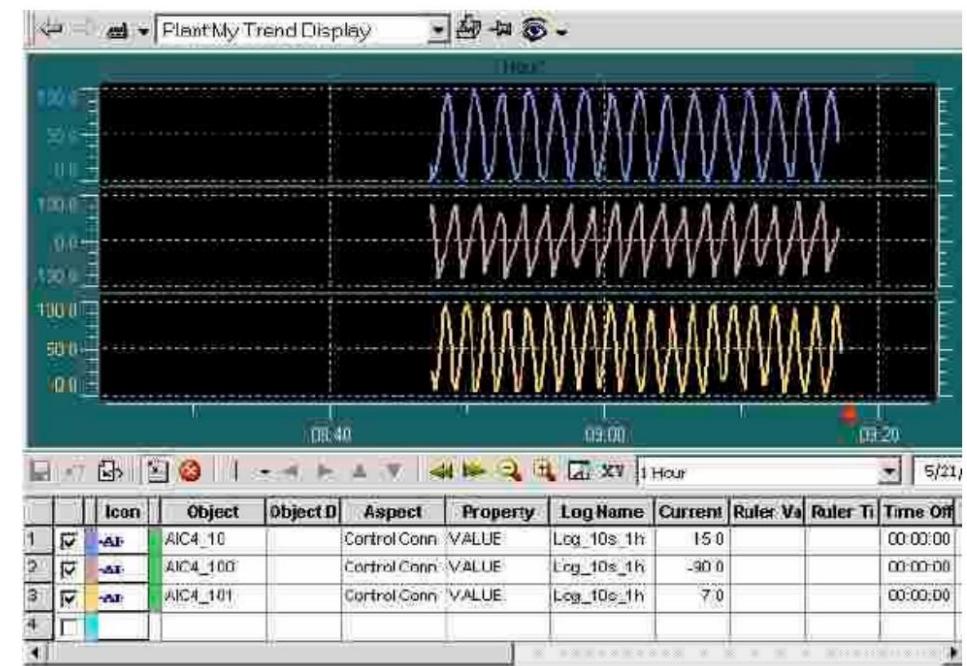
Alarms

- An important function of supervisory systems is to notify in case of deviations from the allowed value range.
- Alarms attract the operator's attention – requiring quick action.
- Managing Alarms
 - Defining a list of alarms
 - And conditions for their triggering.
 - Confirming alarms: Individually or all at once?
- Alarms can be grouped together, given priorities, and color-coded when displayed.
- Notifications
 - Display notification, siren, SMS, email, etc.



Archiving and Report Generation

- Data Archiving
 - Data is stored in files or databases (SQL, MS Access, etc.).
 - SCADA systems typically use distributed databases.
- Report Generation
 - Creation of various prints and reports based on current and archived process data.
- Additional
 - Increasing analysis of data, statistics, and special analyses stemming from technology.



Tools

- Development and Execution Environment
 - Modularity in larger systems
 - Integration and connectivity
- Development Environment
 - Object-oriented approach
 - Setting properties for objects, connecting to tags (points)
 - Support for security (authorizations)
 - Scripts
 - Multilingual support

TwinCAT HMI

- **Technology**

- Modern ecosystem for the web (HTML5, CSS3, JavaScript, TypeScript)
- Platform independence, responsive design

- **Architecture**

- TwinCAT Runtime (XAR) communicates via ADS, OPC UA with TwinCAT HMI Server
- TwinCAT HMI Server communicates via HTTP, WS (WebSocket) with TwinCAT HMI Client



- **Functionalities (official demo)**

- Basic elements (buttons, input fields, tables, graphs, icons, etc.)
- Alarms, events, diagnostics
- Recipes
- Past events, trends
- User account monitoring
- Multilingual support

[Video tutorials](#)

[Beckhoff Infosys](#)

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