HVAC Control System with PID, Damper & Alarm Handling

Studio 5000 Emulator + FactoryTalk View SE HMI Project

1. Project Objective

This project demonstrates an HVAC control system with fans, dampers, and PID-based temperature control implemented in Rockwell Studio 5000 and FactoryTalk View SE. It highlights Auto/Manual control, AOI/UDT usage, fault monitoring, alarm handling, and full HMI integration. Designed as a portfolio project to showcase industrial automation skills.

2. Scope of Work

- Build logic to control supply and return fans using AOIs
- Implement Auto and Manual control modes
- Integrate damper actuator with PID-based temperature regulation
- Provide manual override for damper position via HMI
- Perform analog scaling for temperature and feedback inputs (4–20 mA equivalent)
- Output damper command as analog value (0–100%)
- Implement alarm system for damper deviation and fan faults
- Design modular routines: IO_MAP, MODE_HANDLING, FAN_CONTROL, DAMPER_CONTROL, TEMP_PID, FAULT_MONITOR, ALARM_HANDLER
- Full system simulation on Studio 5000 Emulator with HMI integration

3. Modes of Operation

Manual Mode:

- Operator manually starts/stops fans
- Operator manually sets damper position (HMI_Damper_Setpoint)
- CMD_Damper_Position follows manual input

Auto Mode:

- Operator sets temperature setpoint (TEMP_SP)
- PID regulates damper position to maintain setpoint
- CMD_Damper_Position = PID_Clamped output
- Fans interlocked with Auto/Manual system mode

4. Hardware & Software Setup

Slot	Module	Description
Slot 0	CPU Emulator	Studio 5000 Emulator
Slot 1	1756-IB16D	Digital Inputs
Slot 2	1756-OB16D	Digital Outputs
Slot 3	1756-IF8	Analog Inputs
Slot 4	1756-OF8	Analog Outputs

Software:

- Studio 5000 Logix Designer
- Studio 5000 Emulator
- RSLinx Classic
- FactoryTalk View SE

5. Analog Signal Scaling

Signal	Raw Range	Scaled Range
Temperature Sensor	Raw 0–32767	0–100 °C
Damper Feedback	Raw 0–32767	0–100 %
Damper Command	Raw 0–32767	0–100 %

6. Control Logic Overview

- **IO_MAP** – maps physical/virtual IO
- **MODE_HANDLING** – selects Sys_Auto or Sys_Manual
- **FAN_CONTROL** – AOI_FanControl for supply & return fans
- **TEMP_PID** – PID instruction regulating temperature
- **DAMPER_CONTROL** – mode select, command vs feedback, fault
- **FAULT_MONITOR** – gathers fan, damper, EStop faults
- **ALARM_HANDLER** – drives HMI alarms

7. User-Defined Data Types (UDTs) & AOIs

UDTs:

- Fan_UDT: CMD, Status, Fault
- Damper_UDT: Command, Feedback, Fault
- Alarm_UDT: Active, Ack, Reset

AOI_FanControl:

- Inputs: CMD_Start, Feedback
- Outputs: Running, Fault
- Handles feedback monitoring, auto stop, fault trip

8. Routine Documentation

- IO_MAP – MOV instructions mapping Local IO to internal tags
- MODE_HANDLING – ladder controlling Sys_Auto, Sys_Manual
- FAN_CONTROL – AOI calls for SupplyFan and ReturnFan
- TEMP_PID – scaling, PID block, clamp
- DAMPER_CONTROL – selects between PID_Clamped and HMI setpoint, deviation logic
- FAULT_MONITOR – latches fan/damper/EStop faults
- ALARM_HANDLER – maps faults to HMI alarms

9. Tag List

Digital Inputs:
DI_AutoMode, DI_ManualMode, DI_SupplyFan_FB, DI_ReturnFan_FB, DI_Estop

Digital Outputs:
DO_SupplyFan, DO_ReturnFan, DO_AlarmHorn

Analog Inputs:
AI_TempSensor_EU, AI_Damper_FB

Analog Outputs:
AO_Damper_Position

Control Tags:
Sys_Auto, Sys_Manual, HMI_Damper_Setpoint, CMD_Damper_Position

PID Block:
TEMP_PID (SP, PV=TempSensor_EU, CV=PID_Output, CV_Lim=PID_Clamped)

10. HMI Design Documentation

Screens:

- Home/Overview – navigation
- Fan Screen – start/stop, mode, status
- Damper Screen – position command vs feedback
- PID Tuning – SP, PV, Output, PID params
- Alarms – banner + ack

Navigation:
GoTo buttons for Home, Fan, Damper, PID, Alarms

Object-Tag Mapping:

- Fan Start button → CMD_SupplyFan
- Fan Status lamp → SupplyFan.Running
- Damper setpoint → HMI_Damper_Setpoint
- PID PV display → TempSensor_EU

11. Alarm & Notification System

- Fan Fault – feedback missing after CMD
- Damper Fault – deviation >10% for 5s
- Emergency Stop – system fault
- All alarms mapped to HMI, with Ack/Close

12. Simulation & Testing Procedure

1. Set Sys_Auto=1 → fans start automatically when required
2. Adjust TEMP_SP to 22°C → PID drives damper
3. Switch to Sys_Manual=1 → HMI setpoint drives damper
4. Force missing feedback → Fan Fault alarm
5. Force deviation >10% → Damper Fault alarm
6. Trigger EStop → all faults latched

13. Results & Observations

- PID produced smooth output (0–100%)
- Manual setpoint worked as expected
- Damper fault triggered correctly after 5s
- Alarm system functional
- HMI navigation tested successfully

14. Conclusion & Portfolio Highlights

This project demonstrates:

- Industrial control design using Studio 5000
- Reusable AOIs and UDTs
- PID tuning and damper modulation
- Alarm handling and HMI integration
- End-to-end simulated system ready for portfolio presentation