A project report on

IoT-ENHANCED FLUID POWER SYSTEM WITH SENSOR FEEDBACK

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in
Mechatronics Engineering

by

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ABSTRACT

This project presents the design and implementation of an IoT-Enhanced Fluid Power System with Sensor Feedback for industrial material handling applications. The system demonstrates how intelligent control, sensor integration, and IoT connectivity can enhance the performance and reliability of fluid power circuits typically found in pneumatic or hydraulic systems.

Due to limitations in hardware and physical fluid components, the project utilizes a digital twin prototype developed in *Schneider Electric Experior 7*, representing a conveyor-based load handling system. The model simulates actuator dynamics and sensor responses, allowing for functional demonstration of closed-loop feedback, real-time monitoring, and fault detection. Control logic is implemented using *CODESYS Control Win V3* in Ladder Logic, managing virtual sensors and actuators to replicate real-world automation.

For data acquisition and visualization, *Node-RED* is configured as an IoT dashboard, enabling real-time data publishing, threshold-based alerts, and historical data logging. The integrated setup validates the potential of combining PLCs, digital twin simulation, and IoT analytics to achieve smart, responsive, and sustainable automation systems.

The project highlights a scalable framework for Industry 4.0-ready fluid power systems, showcasing how virtual environments can bridge the gap between theoretical design and industrial implementation.

Keywords: *Digital Twin, IoT, CODESYS, Experior, Node-RED, Feedback Control, Industry 4.0, Smart Manufacturing, Sensor Integration, Automation Systems*

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1. Introduction

This report presents details for the IoT-Enhanced Fluid Power System project. The project demonstrates electronically controlled fluid circuits using a digital twin environment built in *Schneider Electric Experior 7*, with real-time control via *CODESYS Control Win V3* and IoT integration using *Node-RED*. The system is designed to simulate industrial handling operations with feedback control, IoT-enabled data acquisition, and cloud-based monitoring.

2. Problem Statement Analysis

The project aims to design and demonstrate an IoT-Enhanced Fluid Power System integrated with sensor feedback, used for industrial material handling applications. Traditional fluid circuits—hydraulic or pneumatic—rely heavily on manual control and are prone to inefficiencies due to lack of feedback-based automation.

The objective is to:

- Implement sensor-based control (pressure, flow, position) for improved accuracy.
- Integrate IoT-enabled PLCs for data acquisition and cloud-based diagnostics.
- Implement a feedback control loop for real-time performance tuning and fault detection.
- Demonstrate the system through a digital twin prototype using Experior connected to *CODESYS Control Win V3*.

Rationale for Digital Twin Implementation:

Since physical hydraulic/pneumatic circuit components are unavailable, a conveyor-based load handling system is modeled in Experior, acting as an analogous environment for demonstrating control logic, sensor feedback, and IoT integration.

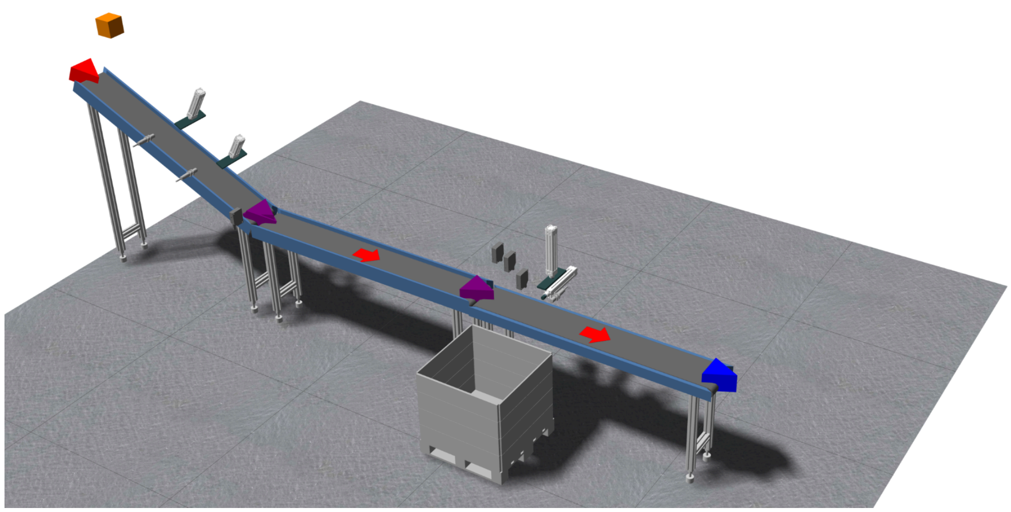
3. Design of Fluid Circuit System for Industrial Material Handling

The proposed digital twin model represents an automated material handling system, analogous to a pneumatic cylinder-actuated conveyor used in packaging or sorting systems. In a real-world setup:

- Pneumatic cylinders would drive linear motion.
- Solenoid valves would control air flow.
- Sensors would monitor pressure, position, and flow.

In this Experior-based simulation, equivalent elements include:

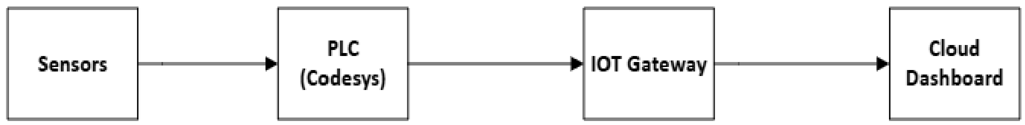
- Conveyor belt pneumatic pistons → represent fluid-powered actuators.
- Sensors (Photoelectric, Position Sensors) → emulate pressure/flow/limit sensors.
- Solenoid logic blocks → implemented via CODESYS I/O control.



Functional Objectives

1. Automatically detect presence of load on conveyor.
2. Initiate actuator control logic based on sensor feedback.
3. Publish real-time operational data via IoT dashboard.
4. Implement threshold-based decision-making for efficiency and safety.
5. Enable data logging for diagnostics and fault prediction.

Block Diagram



4. Identification of Sensors, Solenoids and Actuators

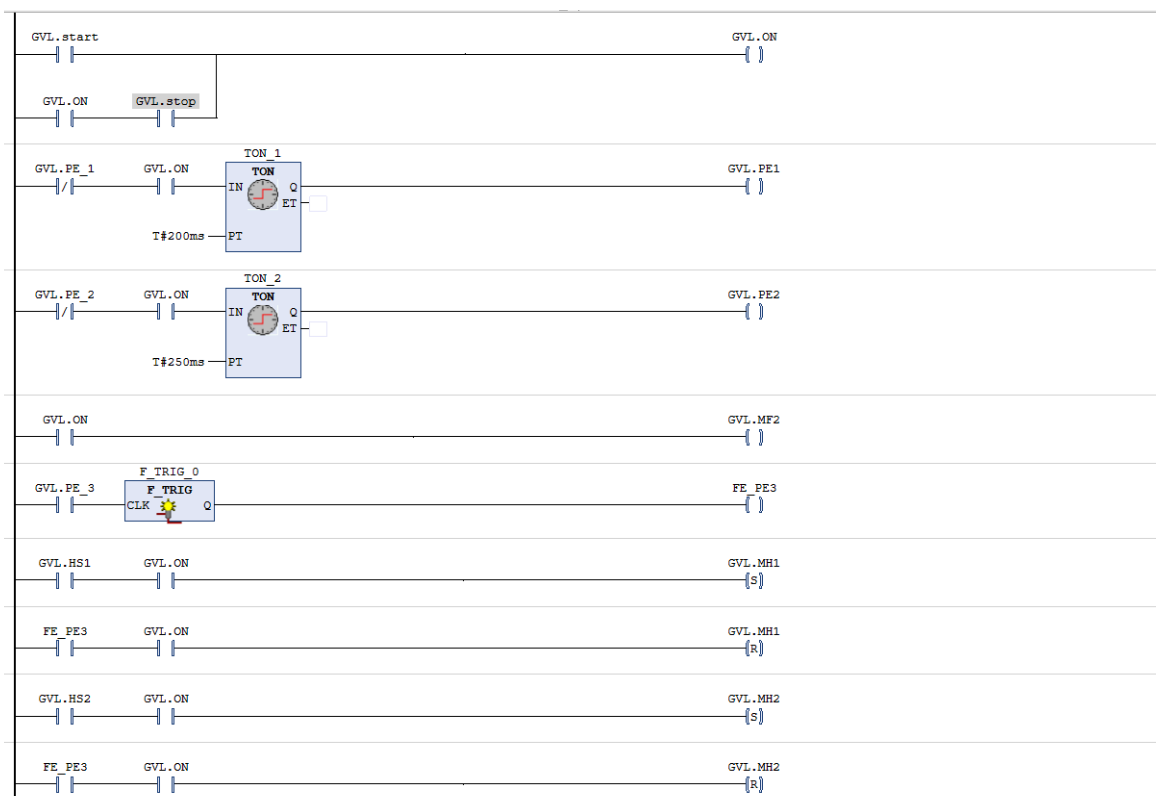
Component Type	Representation	Function	Simulation Equivalent (Experior)
1. Flow Sensor	- Analog Input	- Measure fluid flow	- Conveyor speed sensor
2. Position Sensor	- Digital Input	- Detect actuator position	- Photoelectric / Proximity Sensor
3. Solenoid Valve	- Digital Output	- Control actuator flow	- Output coil in PLC
4. Pneumatic Piston Actuator	- Output Device	- Perform motion	- Conveyor motor / piston simulation

5. Sensor Mapping for Fluid System

Sensor	Signal Type	I/O Address	Function
1. Photoelectric Sensor	Digital Input	GVL.PE	Detects object presence
2. Position Feedback Sensor	Digital Input	GVL.HS	Confirms actuator position
3. Inductive sensor	Digital Input	GVL.MB	Metal load detection

6. Embedded Code for Data Capture

Developed in Ladder Logic (LD) in CODESYS, this logic reads sensor data, processes conditions, activates actuators, and publishes key metrics.



7. Real-Time Publishing Setup

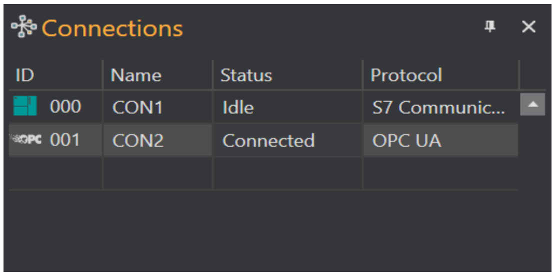
Approach:

- Use OPC UA from CODESYS v3.5 to publish sensor/actuator data.
- Connect to a cloud platform such as Node-RED Dashboard.

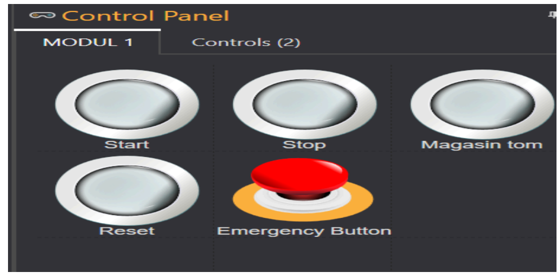
Data Published:

- Load Detection Status
- Actuator State
- System Performance Metrics

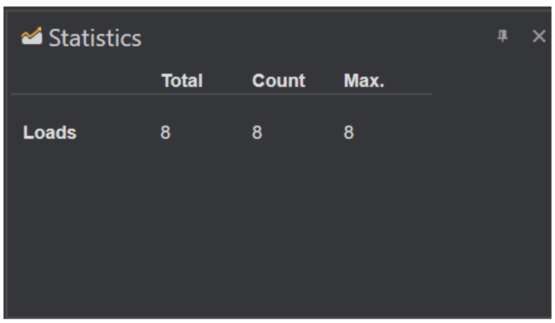
8. Results & Discussion



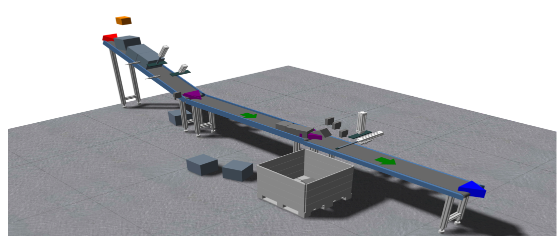
- Connection with OPC UA protocol to SoftPLC in Codesys 3.5



- Control panel for model the model operation



- Real time analytics of the load handling



- Load handling emulation

9. Limitations

• Physical fluid circuits not explicitly simulated.

• Pressure/flow dynamics replaced by discrete event modeling in Experior.

• Cloud integration limited by trial license connectivity.

10. Future Scope

• Integrate MATLAB/Simulink co-simulation for fluid dynamics.

• Add a digital twin of the hydraulic cylinder for realistic modeling.

• Deploy edge computing for real-time fault prediction.

11. Conclusion

This project demonstrates a cyber-physical prototype of an IoT-enhanced fluid power system through a digital twin load handling setup. It bridges the gap between industrial automation and IIoT analytics, embodying Industry 4.0 principles. Despite hardware constraints, the Experior 7 + CODESYS architecture effectively captures the essence of closed-loop control, data-driven monitoring, and cloud-based diagnostics.

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