

PendoTECH Sensors and Industry 4.0: Integrating a PendoTECH Single Use Sensor System with a Digital Highway

Introduction

Biopharmaceutical manufacturing is currently evolving with the progression of Industry 4.0. The integration of business and manufacturing systems in an intelligent, digital-based, bidirectional communication solution is enabling companies to further improve and refine their manufacturing capabilities. In this Technical Note, PendoTECH explores how its products can be easily integrated with an industrial platform and the opportunities that this creates. At the heart of the platform that enables PendoTECH sensors and instrumentation to be conveniently adapted to a digital highway is an *intelligent automation platform* (IAP) with analog inputs, digital inputs/outputs, and industrial communication capabilities. The example IAP reviewed in this document presents a single solution that retrieves important bioprocessing parameters from PendoTECH devices reading its single use sensors (pressure, conductivity, temperature, UV absorbance, turbidity, flow, air in tube detection and pH as shown in Figure 1 below) as well as 3rd party devices. It can be conveniently installed on a DIN rail to ease the interface of the other devices to it. When the IAP receives commands from the external highway, it can send commands to the devices for actions such as taring devices, controlling a pump, switching a valve, or sending data from all devices connected to the platform. It is compatible with many forms of digital communication (MODBUS, OPC UA, etc.).



Figure 1: PendoTECH's Single Use Sensor Portfolio

Background

Industry 4.0 refers to the ongoing Fourth Industrial Revolution, which is currently transforming modern manufacturing and production practices through the use of smart technology and artificial intelligence. At a high level, Industry 4.0 has paved the way for the integration of manufacturing execution systems (MES) with enterprise resource plan (ERP) systems and supervisory control and data acquisition (SCADA) systems. By connecting these systems together, and optimizing the process with the help of machine learning, companies are able to greatly improve their manufacturing proficiency. This is especially appealing to the biopharmaceutical industry, where production can be a long, meticulous, complex process. Optimizing manufacturing procedures is crucial for completing drug production runs in a timely matter and avoiding costly mistakes or batch failures.

To accomplish this, all unit operation devices (sensors, transmitters, monitors, etc.), either as standalone instruments or when grouped together (often referred to as skids), must be connected to a common IAP. These devices can communicate to the IAP via different methods, such as analog or digital signals. The IAP establishes a central communication gateway via Ethernet, WiFi, RS485, etc. and can communicate in the required language (MODBUS, PROFIBUS, OPC UA, etc.). Figure 2 below shows a traditional system map, which depicts how these systems connect and communicate, starting with the physical instruments and scaling all the way up to the MES/ERP system.

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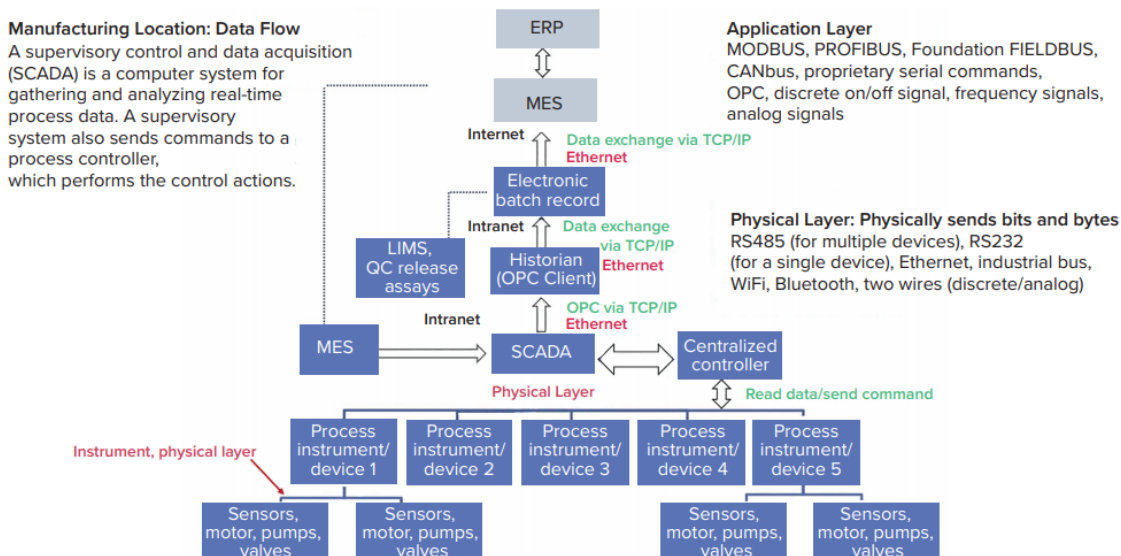


Figure 2: Sample system map depicting dataflow in a manufacturing process

In an Industry 4.0 system, each process instrument device would have an IAP that could be connected anywhere in the facility and link up to a centralized controller. It gives flexibility to the facility to enable the correct equipment to be used when and where it is needed.

PendoTECH's Industrial Single Use System

In order to demonstrate the potential of integrating a bioprocessing system with an IAP, PendoTECH assembled a sample system that measures and controls important parameters at the process instrument level. This setup is able to monitor pressure, conductivity, flow, temperature, UV absorbance/turbidity, pH, air in tube detection, weight via a scale, while also controlling pumps and valves. This is achieved in a compact DIN rail mountable solution. Table 1 below describes all of the PendoTECH equipment built into this system.

Bioprocess Parameter	PendoTECH Part Number	Description	Signals
Pressure	PT-60	DIN rail mountable Pressure Transmitter	4-20mA Analog output Tare via Digital input
Conductivity	CT-2	DIN rail mountable Conductivity Transmitter	4-20mA Analog output
Flow Rate	FM-LF-CONVERT	DIN rail mountable ultrasonic flow meter transmitter	4-20mA Analog Output* Tare via Digital input
Temperature	TT1	DIN rail mountable loop powered temperature transmitter	4-20mA Analog output
UV Absorbance/ Turbidity	SPEC-P-280-PHOTO	Photometer with 280nm light source with DIN rail mount option	4-20mA Analog output Tare via Digital input
pH	TX100	Panel Mount 2 Wire pH Transmitter	4-20mA Analog output
Air detection	AD-16	Ultrasonic air in tube detector	5V Digital output
Flow Control	PUMP-MFD-LS-TW	Masterflex L/S peristaltic pump	Start/Stop: Digital input
Weight	SCALE-MT-35000-0	Mettler Toledo industrial scale with 35000g capacity	RS232 communication
Flow Control Valve	PDKT-PVE2-TFF-M	Electric diafiltration pinch valve pair	Digital output to relay module

*Flow as frequency output is possible with a digital counter or high frequency digital I/O card

Table 1: Summary of all PendoTECH equipment used in sample setup

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A centralized controller is required to utilize this PendoTECH equipment in an “intelligent” process. In order to read data from the IAP in each process instrument device there must be a physical layer and a communication protocol established. The centralized controller is also responsible for sending commands from the SCADA back to the devices, for example to start or stop a pump. Figure 3 below provides an overview for how the devices interface with each other.

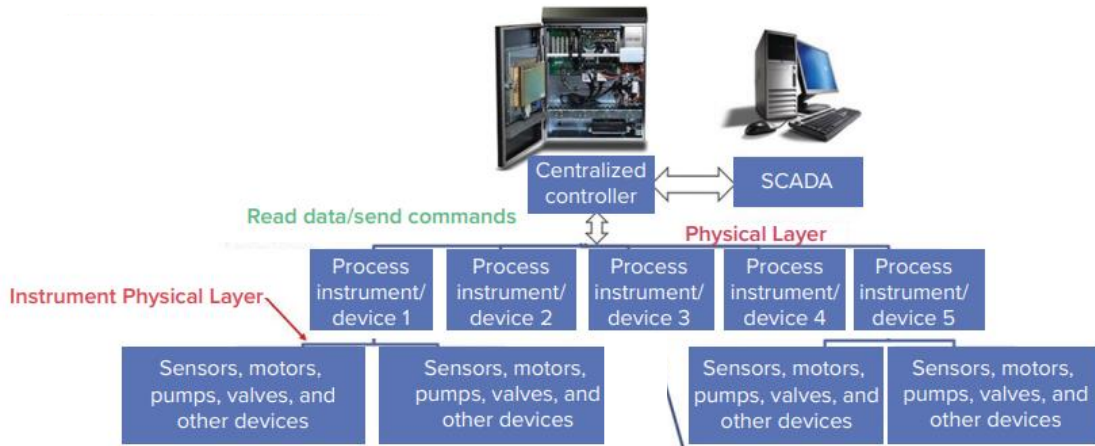


Figure 3: Breakdown of connections between IAP, centralized controller, and SCADA

Through research and customer interactions, PendoTECH selected the FlexEdge™ Intelligent Edge Automation Platform from Red Lion (a Spectris PLC Company) as the candidate of choice. The FlexEdge has onboard WiFi, RS232, Ethernet, and RS485 connections, which can be configured to communicate in MODBUS, with OPC UA, and other popular languages. The PendoTECH equipment communicates directly with the IAP through analog and digital signals.



Figure 4: Annotated picture of physical setup of PendoTECH’s Industrial Single Use System

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Figure 4 above displays the FlexEdge IAP along with 3 I/O modules: 2x Analog Input modules for reading the 4-20mA analog outputs of the transmitters and 1x Digital I/O module for reading the air detector and sending commands (e.g. taring) to the applicable devices (wiring is intentionally excluded for clarity). The system is very versatile, as everything connects seamlessly in a compact, DIN rail mountable setup. The diagram below in Figure 5 shows the information flow between the different components.

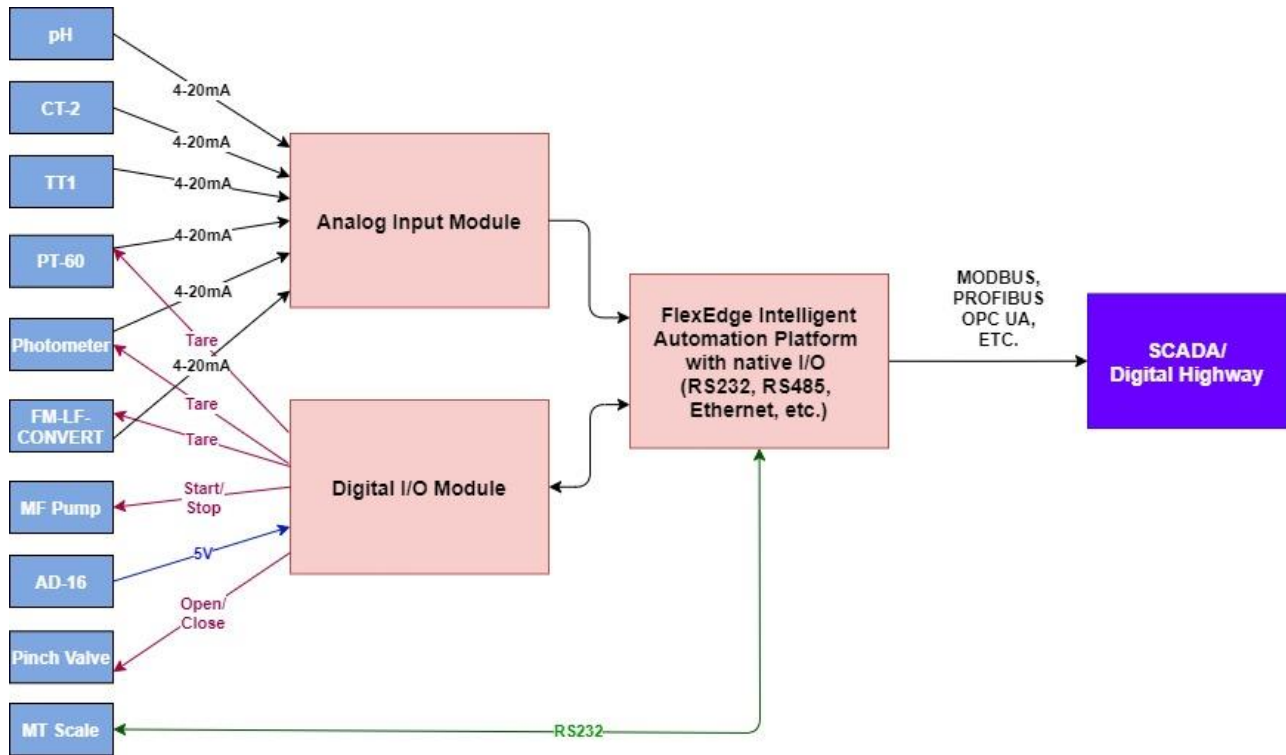


Diagram only shows one of each device. Duplicate devices were intentionally omitted for clarity.

Figure 5: Block diagram of signals from transmitters to controller/modules

User Configuration and Interface

The IAP interface receives the analog and digital signals from the sensors and map them to an internal “Tag”, which is a variable name that represents an input or output value. For example, if the system includes three pressure transmitters, each pressure value would be assigned a unique tag (e.g. Pressure1, Pressure2, and Pressure3). These tags can then be mapped to other interfaces, such as an HMI, or sent to other clients via MODBUS, OPC, or other protocols. Essentially, this integrates the process parameters to a digital highway, making them easily accessible. Furthermore, new tags can be calculated from other values or tags, i.e. generating a Transmembrane Pressure (TMP) tag using the values of Pressure1, Pressure2, and Pressure3.

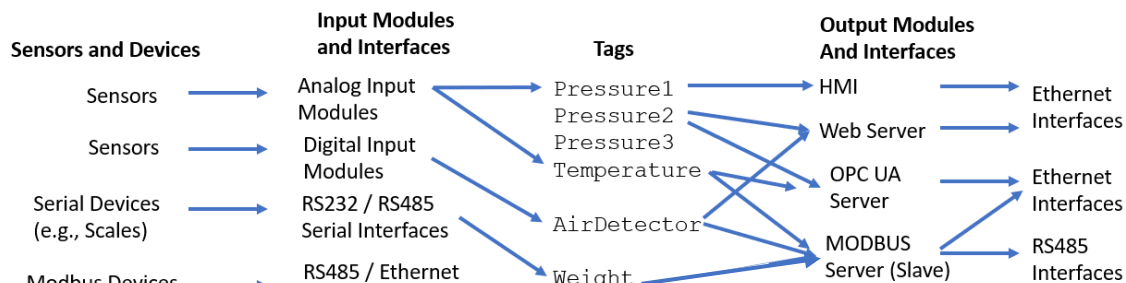


Figure 6: Conceptual diagram of dataflow in and out of an intelligent automation platform

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Their Crimson Software is available to configure the IAP and setup tags for the incoming data. This is how the scaling for each unique device is set, and functions, such as taring, are implemented. An added benefit of this software is its ability to setup a local user interface, which can be setup on its own web server or other similar platforms. Figure 7 displays the user interface used to monitor and control this example setup, which includes live readings/indicators and buttons for user interactions, such as taring.



Figure 7: User Interface created for operating PendoTECH's sample industrial system

Conclusion

Industry 4.0 is creating new opportunities for automation and optimization that will continue to transform biopharmaceutical manufacturing. The example industrial system designed with PendoTECH's single use sensor technology reviewed in this technical note only scratches the surface of the potential of Industry 4.0 for biopharmaceutical applications. For example, there are other modules compatible with the FlexEdge platform such as an Analog Output module and PID control module. These add-ons would enable further functionality, such as precise TMP control, alarm monitoring, and pump speed control. Not only can these industrial solutions reshape biopharmaceutical manufacturing, but they are easier to implement than ever before. The example industrial system above is just one of many ways to adapt PendoTECH products to a digital highway. For more details and information on the challenges, benefits, and implementation of Industry 4.0 on the biopharmaceutical industry, review the *Bioprocess International* article linked below.

Bioprocess International Industry 4.0 Article:

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