

# The integrated HMI-PLC

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## The heart of a “lean automation” solution

Lean manufacturing is a proven, powerful tool that boosts efficiencies in production processes. Similar concepts and practices that eliminate “waste”—unnecessary equipment and process steps—can be applied to the design, construction, and support of the automation systems. Lean automation solutions enable increased productivity and reliability, and propel best-in-class solutions—yielding a real competitive advantage.

A combination HMI-PLC plays a pivotal role in the design of a truly lean automation solution, providing a host of benefits throughout the life cycle of machine automation. Combining visualization and control means:

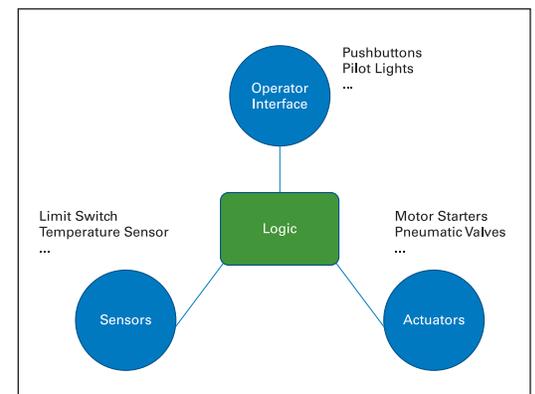
- Faster machine design by providing an integrated development environment
- Reduced machine construction costs by eliminating components and wiring
- Reduced machine support cost and improved operation by centralizing remote access and administration

More than at any other time, there is a range of trends in both control system architecture and manufacturing that are coming together to support an integrated HMI-PLC. For OEMs and control engineers alike, this means that it is easier to build smaller, smarter machines faster—freeing both OEMs and engineers from using controllers and equipment just because of a familiarity and in spite of a prohibitive cost to change.

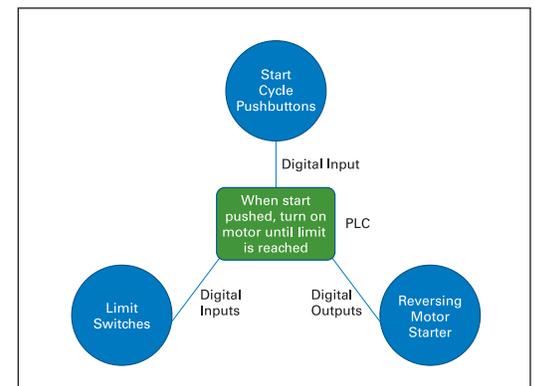
### Control system basics

To better understand the trends driving HMI and PLC technology, it is useful to first examine the basic architecture of a control system and how the control system itself is evolving. Fundamental changes in control system architecture are making HMI-PLC technology a compelling alternative—streamlining functionality, reducing equipment (and costs), and propelling the next generation of machine control.

The basic control system structure includes sensing, actuation, operator interface, and logic control devices. Sensors measure a physical quality, like temperature, and convert that information into an electrical signal; the actuation device acts upon that information; the operator (or user) interface is where the interplay between equipment and people occurs; and the logic device controls machine operation. The logic control device examines input from the operator and sensor, sending signals to the actuation device. This simple model of sensors, actuators, human interface, and logic applies to control systems in both the discrete and the process control space.



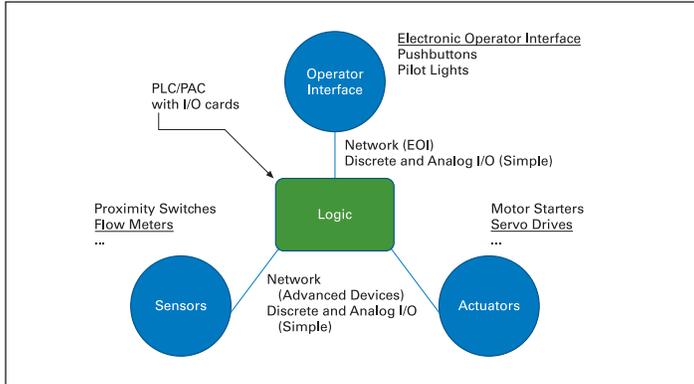
**Figure 1. The Basic Components of a Control System**



**Figure 2. A Simple Motor Control Example of the Basic Control System**



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**Figure 3. Common Control Architecture**

**Figure 3** recasts the basic control system model in terms of a common machine control architecture that would be encountered today.

Today, the basic functionality of a control system remains largely intact, but the architecture that achieves that functionality is shifting. All the devices in each category are evolving—both in terms of their intelligence and how they interface to the logic device. Industrial networking technologies are driving changes in the latter—how devices interface. Simple device networking is replacing I/O points and wiring on the machine, while Ethernet-based system networking is connecting machines to the enterprise and enabling remote access—both of these trends are propelling rapid change in sensors, actuators, logic controllers, and operator interface devices. And the most dramatic changes are happening at the operator interface and controller levels, where functionality overlap makes a combined device a compelling alternative.

### Device-level networks drive HMI-PLC technology

While somewhat overshadowed by the advances in enterprise networking, device-level networks have also progressed, enabling more cost-effective connection of even simple devices through a network to the logic control within the system. These advances have taken place both within the control cabinet and outside of it—to sensors and actuators mounted on the machine. The impact of moving from traditional I/O cards and wiring to simple device-level networking in a control cabinet can be seen in **Figure 4** and **Figure 5**.

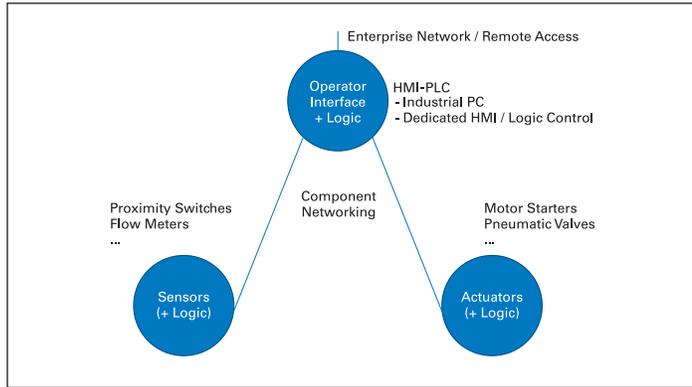


**Figure 4. Control Cabinet Before**



**Figure 5. Control Cabinet After a Device-Level Network like Eaton's SmartWire-DT® System Connects Devices, While Eliminating the Hassles of Traditional I/O Wiring.**

Traditionally (**Figure 4**), basic devices in the cabinet are connected through discrete I/O cards and point-to-point wiring to the logic controller. Today (**Figure 5**), this wiring is being replaced by a simple networking system that connects all the devices to a single communications port on the controller and also incorporates the device power connections. Device-level networks yield multiple advantages: reducing time to wire and commission the control panel, removing the I/O cards from the system, and improving operational diagnostic information for more reliable systems.



**Figure 6. Emerging Lean Automation Architecture**

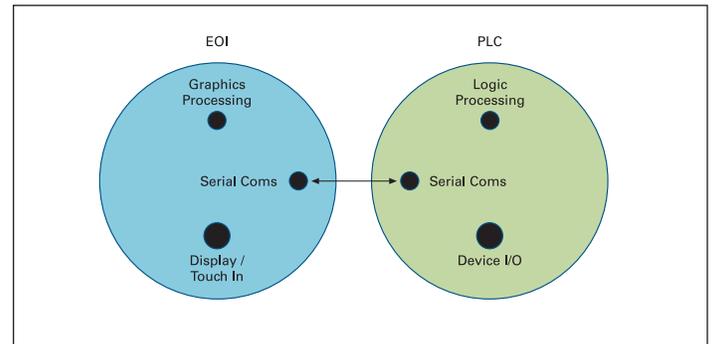
The move away from I/O to networking for connecting sensors, actuators, and human interface in machine control is a key enabler of moving to a combined HMI-PLC. Once the role of the I/O cards in a system is removed or significantly reduced, the value of having a separate PLC from the electronic operator interface (EOI) is greatly reduced. The processing power available in today’s microprocessors makes handling both the operator interface task and the programmable logic control task manageable from a single device. Further, as remote access is increasingly important, the case for a combined HMI-PLC is strengthened, changing the basic control system and enabling a leaner automation approach that combines logic and visualization.

**Enterprise networking and remote access propels HMI-PLC technology**

The manufacturing community stands to make significant productivity gains with the emergence of industrial Ethernet applied to the factory floor. The expanding web of Internet networking and smart devices that can interface over it are driving improved diagnostics, faster troubleshooting, and overall improvements in machine reliability. With the information that Ethernet connectivity is enabling, there are increasing opportunities to reduce the time and costs involved in diagnosing and fixing issues—heading off problems at the pass, before they cause downtime or delay commissioning. These changes also impact the automation systems on machines, demanding a fresh look at the automation architecture and the role of the PLC and the HMI in that system.

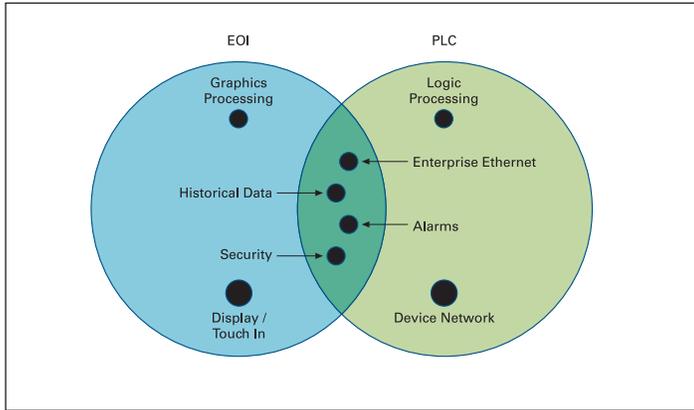
To better understand the convergence of HMI-PLC functionality and equipment options, a historical perspective of the PLC and OI technology and development is useful. Traditionally, the PLC was developed to provide control, sequencing, and safety functionality for manufacturing processes, replacing systems that involved numerous devices—multiple control relays, timers and drum sequencers, and closed loop controllers. Largely, the I/O cards used to interface to the sensors, actuators, and simple operator interface devices, such as pushbuttons and pilot lights, made up the controller.

The electronic operator interface was introduced as a complement to this simple PLC. By connecting to the PLC through a simple serial network connection, the EOI added the ability to present much richer information to the machine operator, replacing some of the simple pushbuttons and pilot lights in the process. This historical relationship between the EOI and PLC is shown in **Figure 7**.



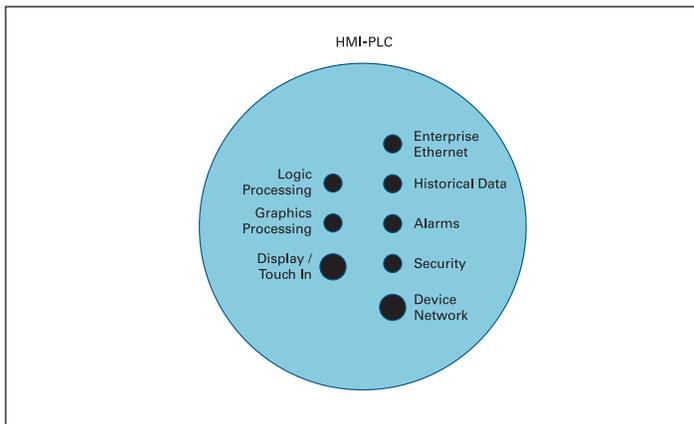
**Figure 7. Historical Complementary EOI / PLC Relationship**

With industrial Ethernet, the advent of remote access in the automation space means increased automation functionality, including historical data capture and exchange, alarm notification and management, and security administration. These features have been introduced into both the PLC and the EOI and tend to overlap today, as vendors of both PLC and EOI equipment have vied to address new requirements for historical information, alarming, and security (see **Figure 8**).



**Figure 8. Emerging Overlap of EOI and PLC Features.**

More is not always better, and redundancy in EOI and PLC feature sets has several downsides: the needless duplication of hardware (that is, Ethernet is required on both devices), unnecessary complexity of programming (redundant alarm systems), and increased risks of security holes. Instead of two devices with overlapping functionality, a single device with a feature set that covers requirements without duplication means less equipment to buy, program, and configure (see **Figure 9**).



**Figure 9. Convergence of HMI and PLC**

**Logic programming standardization**

A robust development environment underpins efficient automation design, and can crucially provide standardization. Standardization promotes interoperability, saves engineers’ time when they work with products from multiple vendors, and drives “lean” efficiencies by enabling reuse (of code) and reducing the retraining effort.

In December 1993, the development of IEC 61131-3 was a groundbreaking effort—bringing standardization to logic programming. It provided a core-programming model with a variety of benefits:

- Structured software based on Program Organization Units (POUs)
- Strong and consistent data typing
- Task-based execution control

Beyond the standardization of program structure, IEC 61131-3 defined a standard set of programming languages: ladder logic, function block, structured text, instruction list, and sequential function chart.

Globally, suppliers and end-users of automation products adopted IEC 61131-3. By providing a common programming model and language set, the standard allowed control engineers to work effectively with controllers from different suppliers, enabling engineers to more easily understand programs generated for various logic controllers. Additionally, the task of porting a program from one supplier’s programming software to that of another became faster and easier.

Despite the many benefits to an IEC 61131-3 program model and language, control engineers have still found themselves “locked in” to a single supplier’s equipment. The IEC language was the first step in the right direction; while the program model and base language may be the same, there are still some large differences:

- Supplier-specific language extensions that prevent interchange-ability between different makers
- The look and feel of the programming environment, making it difficult to program on one controller versus another
- Program file storage formats that create compatibility issues with different memory organization, even with the same manufacturer

Consequently, changing between suppliers of IEC 61131-3 controllers has still resulted in significant staff retraining and manual program re-entry. It is the advent of CoDeSys (Controller Development System) software technology that has elevated the IEC 61131-3 standard to the next level by providing a flexible platform that is easier to use.

CoDeSys is a comprehensive open software tool for industrial automation, and consists of two parts:

- The programming system CoDeSys, a common IEC 61131-3 programming tool
- The runtime system CoDeSys Control, which turns any intelligent automation device into an IEC 61131-3 controller programmable with CoDeSys

The CoDeSys system was designed to easily adapt from one vendor “target” device to another. So, a control engineer can incorporate multiple targets into a single programming environment or move from the programming environment of one CoDeSys controller to another, with no re-training required. Additionally, program file formats are common, and programs can be imported without manual intervention.

The commonality of the CoDeSys Control runtime environment across targets means that a program operates similarly on the new target. The ability to reuse proven control code provides a high level of quality assurance in the critical runtime environment.

The CoDeSys Control runtime system has been deployed on a host of various devices, like PLCs, operator interfaces, and drives. It is ideally suited to support the trend toward distributed control to end devices (like operator interfaces and drives), while still allowing best-of-class selection of those devices.

As more than 100 companies in the automation industry have adopted the CoDeSys system for their control solutions, control engineers are no longer hamstrung to accommodate a PLC across applications. The cost of change is prohibitive—even if there are better suited controllers available for a given application. Today, there are real choices between controllers and the portability fostered by the CoDeSys environment makes that possible. Further, more than 250 device manufacturers from the industrial sector are programming with CoDeSys today.

Ultimately, users who adopt CoDeSys are able to achieve the standardization benefits of the IEC 61131-3 development environment, with a rich set of programming tools in an open package. As it is widely adopted, CoDeSys is the de facto standard for open logic control. Additionally, users can realize significant savings on development costs associated with software, training, and support—across a wide selection of logic platforms. And further, they can virtually eliminate the cost to migrate between hardware from different vendors, allowing them to select optimum devices to run their logic.

Today, CoDeSys is helping to propel the IEC 61131-3 standard into the future and increasing adoption, making it simpler to use devices from multiple vendors. It enables end-users to select the devices best suited to their needs—reducing time and costs associated with migrating from devices manufactured by different vendors. And, CoDeSys provides a single software package for control and visualization—supporting a combined HMI-PLC and allowing OEMs to leverage programming environments across a range of systems. It helps OEMs lower costs, program their equipment faster, and simplify integration. Even device-level networks can be configured with CoDeSys. Therefore, the visualization, logic, and end devices are all conveniently programmed with a single software package.

### Key attributes of a combined HMI-PLC

There are a variety of HMI-PLC options for OEMs to select from. The two major kinds of HMI-PLC devices are open/industrial PC (IPC) based and closed-platform solutions.

Both types of HMI-PLCs have their place. The open, IPC-based approach provides the additional flexibility to combine additional programs on the control platform, whereas the closed approach enables a more optimized solution that is easy to administer. Both open and closed devices have similar key features and functionality (see **Figure 9**).

### Logic and graphics processing

The heart of the combined HMI-PLC is the logic and graphic processing capabilities. Specifically, a robust and repeatable performance over the range of intended application, powerful logic programming, and extensive graphics programming capabilities are critical. In addition to the runtime capabilities, an intuitive and integrated development environment that combines both logic and graphics programming is crucial for the automation engineer—making programming and deployment faster. Further, a development environment with well developed tools for simulation, debugging, and program updates saves time upfront and at the back end—speeding up development and maintenance.

### Display and touchscreen

Combined HMI-PLC devices provide display characteristics similar to standard HMIs:

- A broad range of screen sizes, providing flexibility
- Resolution and brightness of the display
- Touchscreen technology options, including rugged environment considerations

### Enterprise Ethernet and remote access

This goes beyond the presence of a physical Ethernet port and includes the services that are provided through that port, including:

- Remote access for screen viewing
- Remote access from various devices, including smartphones and tablet computers
- Remote program administration
- Remote database access options
- Additional data protocols supports (for example, OPC)

## Security

Cyber security continues to be an area of concern in manufacturing environments, and the enterprise Ethernet connection can be a point of weakness. Important areas to examine include:

- Is each of the remote access methods described above adequately secured?
- Are all open-enterprise Ethernet ports documented, and can they be shut off if not used?
- Is a method in place to secure the Logic/Visualization program?

## Device networking

As direct I/O wiring is replaced by device-level networking, the integration of the HMI-PLC with device-level network and the information and data points that it is able to provide is key—saving time during commissioning, expanding diagnostics capabilities, and providing ongoing information that enables smarter, faster machines.

- Does the device provide the network options you need?
- Can you combine multiple network options when needed?
- Is the cost reasonable for the network option you can foresee?

## Historical and alarm data management

Today's machine automation is more than machine control. Machine automation today includes the ability to obtain and evaluate critical performance data, and be quickly alerted of any operational issues. Considerations include:

- Do the historical data features offered by the system meet your needs?
- Is the method of historical data access and format of data sufficient for your applications?
- Is the alarm system adequate for your needs?
- Do the alarm notification system capabilities meet your needs?

A thorough review of these points will allow you to identify a combination HMI-PLC that meets your application needs.

## HMI-PLC enables lean automation

Today, a host of trends are coalescing to support an integrated HMI-PLC. The control system architecture is shifting, and networking technology—both at the device and at the enterprise level—is advancing, while there is an established and portable programming environment for both HMI and PLC devices. Ultimately, the HMI-PLC not only eliminates entire device levels, but also enables remote intelligence, reduces training costs, and empowers OEMs to take advantage of a variety of suppliers—driving best-in-class solutions.

Further, the integrated HMI-PLC is enabling lean automation—boosting efficiencies and reducing waste—both in terms of equipment and time. In a highly competitive business environment, providing best-in-class solutions that are also intelligent, intuitive, and elegant means a real business advantage: yielding control systems that are faster to design, commission, and maintain.





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