Welcome to Module 25, Electronic Operator Interfaces. Operator interfaces, often shortened to OI, are the technology that allows humans to control and monitor machines and plant operations.

Early forms of OI included the steam pressure gauges on old locomotives, and pushbuttons and chart recorders.

Starting in the 1980’s, electronic operator interface devices became available to provide a more compact, manageable, and flexible way for plant personnel to interact with plant processes. Electronic OIs typically feature some type of luminous display and often include a method for personnel to perform inputs.

Using software, electronic OI can be on-screen replacements for indicating lights, gauges, message displays, and other conventional hardwired devices.

The remainder of this workbook explores the design and function of electronic OI products.

Like the other modules in this series, this one presents small, manageable sections of new material followed by a series of questions about that material. Study the material carefully, then answer the questions without referring back to what you’ve just read. You are the best judge of how well you grasp the material. Review material as often as you think necessary. The most important thing is establishing a solid foundation to build on as you move from topic to topic and module to module.

A Note on Font Styles

Key points are in bold.

Glossary terms are underlined and italicized the first time they appear.

Viewing the Glossary

You may view definitions of glossary items by clicking on terms and words that are underlined and italicized in the text. You may also browse the Glossary by clicking on the Glossary bookmark in the left-hand margin.
WHAT YOU WILL LEARN

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In the cab of an 1800’s steam locomotive, the steam pressure gauges and water supply indicators were the crew’s “Operator Interface.” These OI devices linked the crew to the status of the boiler and enabled them to make decisions.

In the 20th century, dials, gauges, status lamps, and chart recorders became available to help plant personnel check status and make decisions in industrial manufacturing operations. Pushbuttons, switches, and analog controls let technicians supply inputs to modify and control events.

Eventually, as computer and Programmable Logic Controller (PLC) technology became available, great volumes of information could be observed and manipulated by operators. **Since unpredicted events can occur, humans continue to be an important part of plant floor control and monitoring.**

However, the volume of available information has sometimes led to unmanageable “forests” of hardwired display and entry devices on Operator Interface panels. (See Figure 2.)
The Role of Plant Floor “Operators”

Plant floor personnel interact with hard-wired devices on control panels as well as with electronic operator interface devices. Both need to support the same kinds of functions. Examples include:

- Control (start/stop discrete functions)
- Numeric entry
- Monitoring and status display
- Alarm annunciation
- Messaging
- Diagnostic and troubleshooting support
- More advanced information display, such as data trending

To be effective, OI devices must provide efficient and flexible methods to support these types of OI functions.
In the 1970’s and 1980’s, the Programmable Logic Controller became the dominant plant-floor electronic tool for control, sequencing, and data storage. Conventional hardwired, panel-mounted operator interface devices were connected as PLC inputs (pushbuttons, thumbwheels, etc.) and outputs (lamps, dials, numeric and text readouts). (See Figure 3.)

Figure 4 shows that, with a conventional control panel, every single panel device consumes input/output (I/O) capacity of the PLC. This becomes a three-part burden on the PLC, that of input, output, and processing:

- Every pushbutton requires a physical input terminal connection and PLC memory allocation.
- Every lamp on the panel occupies an output terminal connection and an output memory bit.
- The PLC must have programming to monitor and control the devices on the Operator Interface panel. Since these devices typically have no intelligence of their own, the PLC must assume all responsibility for numerical calculations, logical comparisons, alarm monitoring, etc.
The end result is that the devices on a conventional hardwired panel use up much of the PLC that could otherwise be used for the control and monitoring of real devices on a machine or in the plant.

There are further consequences to adding several dozen hardwired operator interface devices to a panel. They:

- Are expensive to install (counting panel design, wiring, PLC I/O modules, etc.)
- Take up a lot of space
- Lead to a confusing layout for the operator
- Can be difficult to modify or expand
As mentioned earlier, electronic operator interfaces typically feature some type of luminous display, and often include a method for operators to perform inputs and entries.

- Electronic OIs can be as small as a paperback book, with focused functionality, and can sell for under $500.

- They can also feature displays as large—or larger—than 15” diagonal, perform a multitude of functions, and sell for upwards of $10,000.

Figure 5 shows a typical modern Electronic OI. Notice there is no keyboard or mouse: operators touch the screen icons to input data.

Electronic OI not only solves some of the input, output, and processing problems of conventional wiring; it enhances the "usability" of the system, and extends the information across networks.
Let's contrast this diagram of electronic OI connectivity to the PLC (see Figure 6) with the conventional control panel described in the previous section.

Figure 6: Single-Wire Connection from Electronic OI to PLC
While the design details of the electronic OI and how it communicates to the PLC will be taken up later, the key advantages are:

1. In many cases, the electronic OI need not take up actual PLC I/O point capacity—most electronic OI devices are connected to a PLC communication port or PLC network via a single cable.

2. Since most electronic OI devices have at least some local intelligence (mathematical and logic comparison abilities), much less dedicated PLC programming is required to support the electronic OI.

3. The same electronic OI can often communicate with more than one PLC or other device, via communication networks.

4. The ability of electronic OI to group information on multiple screens or pages permits better organization of information, so operators can more easily understand and respond to the data. (See Figure 7.)

5. If the OI permits the use of color, blink, animation effects, or customized visual images, then faster, more effective human interface is possible.

6. Since the electronic OI is configured using a software package, it permits rapid and flexible changes to the content and layout of the OI screens.

Electronic OI devices have become extremely popular because of their flexibility and their power. Ultimately, they help plant personnel do a better job of making decisions and taking action, which keeps plant processes running as intended.

FIGURE 7: USING AN ELECTRONIC OI PANEL
1. As greater amounts of information began to accumulate, what problem developed with conventional operator interface panels?

2. In conventional hardwired systems, each panel device consumes input/output capacity of the PLC.

TRUE    FALSE

3. List three activities of plant-floor operator personnel.
   a) 
   b) 
   c) 

4. If electronic operator interfaces have some intelligence, how can they reduce the processing demand on PLCs?

5. List two visual cues that electronic OI can supply to make possible more effective human interface.
   a) 
   b) 

6. The effect of configuring electronic OI with software packages is that rapid and more flexible changes can be made to both the _____________ and _____________ of operator interface screens.
Now that you’ve traced the background leading up to electronic OI, let’s examine how it approaches different types of applications, and review examples of where electronic OI are used. There are industry-wide terms that you’ll need to become familiar with; and most important, how electronic OI actually benefits the operators in the field.

Electronic OI is effective in controlling and monitoring two styles of manufacturing, discrete and process.

Operator interfaces used for **discrete manufacturing** control address diagnostic, maintenance, and productivity challenges associated with transfer lines, assembly and other machines used in **volume manufacturing**. The operator interface screens typically contain *templates* that provide *machine control*, *diagnostic instruction*, *fault log*, *motion monitoring*, and *operator guidance*.

![FIGURE 8: A TYPICAL ELECTRONIC OI SYSTEM LAYOUT](image)

Operator interfaces used for **process manufacturing** control address diagnostics, maintenance, statistical process control, recipe management, and productivity challenges associated with **batch processes**. The operator interface screens typically contain templates that provide machine control, diagnostic messages, *temperature bar graphs*, *flow meters*, and *recipe editors*.

Where are electronic OI devices used?
- Wherever PLCs or industrial networks are in use
- Where operator controls (pushbuttons, switches, etc.) are needed
- Where message and graphical displays are used

Here are some real-life examples of applications where electronic OI have provided cost or process advantages.
An induction heating manufacturer runs an assembly line close to a 150 kW oscillator. That kind of equipment is large, and its manufacture creates an electrically harsh environment. Electronic OI reduced wiring and control boxes to free space and lower electrical demand. Flatscreen technology allowed full monitoring and control at the site without electromagnetic interference distorting the screen images.

An integrator and manufacturer of specialty assembly lines required significant flexibility. Conventional hard-wired devices would take too long to reconfigure.

Electronic OI include standard templates that provide visual replacements for traditional hardwired devices such as dials, gauges, status lamps and message displays.
When a machine builder expanded its operations, increased control requirements also significantly increased the need for messaging displays. To accomplish this in a conventional wiring system became cost-prohibitive. Electronic OI gave them all the messaging they needed, at lower costs, and carried on a single wire.

A number of expressions have been used to refer to monitoring and controlling machine activity.

**Man-Machine Interface (MMI):** This early abbreviation has more recently been replaced by the term Operator Interface, or OI.

**Supervisory Control and Data Acquisition (SCADA):** As computers began to connect with machine control operations, their ability to process and store information was summarized under this acronym.

**Human-Machine Interface (HMI):** This more recent, gender-neutral term is sometimes used to refer to electronic OI products providing higher capacity and more advanced features.
How Electronic OI Benefits The User

By helping plant-floor personnel make faster, better decisions and take action more effectively, electronic OI devices can generate benefits such as:

- Increased operator confidence and cooperation
- Reduced material losses by reducing scrap
- Reduced downtime by providing faster diagnostics
- Enhanced product quality through closer monitoring of product parameters

In addition, as electronic OI devices have gotten smarter, they have been able to offload operator interface-related tasks from PLCs and other control devices. They do this by performing calculations and logical comparisons, tracking alarms, generating printed summaries and completing additional tasks which might otherwise burden the PLC, network, or other control device.
The following scenario is typical of the benefits resulting from installing an electronic OI with a PLC-based control system.

Originally, this transfer machine operation featured PLC-generated diagnostics, shown by a text display. When a fault was detected, a simple “fault” message was generated. Then technicians had to:

1. Locate wiring and logic diagrams
2. Use a hand-held PLC programmer to confirm the I/O status
3. Troubleshoot the problem
4. Perform the repair

Plant personnel then installed an electronic OI whose display information included:

1. An overview screen that identified station faults by flashing a pictorial representation of the station
2. Specific fault messages
3. Instructions for operators to select additional displays, for more detailed views of the problem
4. Detailed views of each station that included customized shapes and colors, for easy recognition
5. Other screens that included summaries of tool cycle counts, cycle times and restart procedures

As a result of installing the electronic OI, operator-level personnel became able to detect and diagnose many more elementary faults themselves, without calling upon electronics technicians. They were then able to direct repair crews to the source of the problem more rapidly.
ELECTRONIC OPERATOR INTERFACES

Two basic categories of electronic OI devices today are:

1. The “proprietary” design, featuring both hardware and software that is unique to the particular brand of OI. Examples of this approach include the PanelMate Power Series product from Cutler-Hammer and the PanelView product from Allen-Bradley.

2. The “open platform” design, featuring software that is unique, but which typically runs on a Windows-based personal computer platform.

The variety of OI products found in the first category is immense. However, most of these products share the following design characteristics:

- Display Mechanism
- Electronics Section
- Operator Input Methodology
- Display Image Creation and Linkage Methodology
- Communication to PLCs, networks, or other plant automation

Let's examine each of these areas in detail.
The smallest, least expensive OI products often feature liquid-crystal display (LCD) screens which may only be able to display text or very simple graphics, in a monochrome fashion with no shading. These devices may be limited to screen resolutions of 320 x 240 dots (“pixels”) or less.

The next level of display options include grayscale or color monitors, or flatscreen displays. At the base level, these typically permit at least 8 colors or 8 gray shade variations. The screen resolutions of these devices are often the same as that found in today’s personal computer products: 640 x 480 pixels, or better.
In the past, monitor (cathode-ray tube, or CRT) technology was dominant, but the new flatscreen technologies are now becoming brighter, more affordable, and therefore more popular. Flatscreens take up much less space, generate less heat, and are unaffected by electromagnetic fields (unlike CRTs).

There are two types of color flatscreen technologies:

**Dual-scan LCD** color screens are currently more affordable, but have a somewhat limited viewing angle, and are less luminous.

**Active-matrix thin-film transistor**, or TFT color screens are more expensive than either LCD or CRT technology, but TFT screens are quite bright, easily viewable and pleasing to the eye.
### Electronics Section

The electronics section houses the "brains" of the operator interface. It stores configuration information, processes operator inputs, and communicates with the PLC(s) and field network.

The electronics module is essentially a computer, containing a processor, RAM, non-volatile storage, and input/output capability both to the operator and the controller. Electronics modules may be either proprietary or "open" in design.

- Proprietary units typically have the advantage of lower pricing, since they are designed for dedicated use only as an operator interface.

- Open designs are typically based on an Intel architecture PC, allowing for use of off-the-shelf hardware and software to extend the capabilities of the operator interface. Today’s open systems are typically a bit more expensive than proprietary designs; although that is changing quickly.

### Operator Input Methodology

Operator Input Methodology gives operators the ability to do entries through technology that is suited to their environment, as well as to the type and complexity of information they have to enter. Some examples of techniques that allow data to be entered in the system include:

- **Touchscreens** - Operators make selections on a display screen by touching the screen with a finger. Touchscreens most often detect finger touches by sensing pressure, or changes in electrical capacitance. Information kiosks are common examples of touchscreens. Below are listed various forms of touchscreens.

  - **Resistive Touchscreens** are the most popular technology in use in industrial environments, due to their ability to respond to activation by a bare finger, stylus, glove, or credit card edge.

  - **Capacitive Touchscreens** are not well suited for the industrial environment, since they cannot be simultaneously calibrated to work with a bare finger, glove, or other object.

  - **Infrared Touchscreens** react differently when touched with a fingernail or finger, and they can react before users actually touch the screen.

  - **Digital Touchscreens** have discrete switch locations etched into the polyester film with a pre-defined number of switches.

- **Keypads** are input devices that, upon activation, register a single input.

- **Membrane keys** are covered by a transparent, plastic shell. The keys have very little movement, but are sensitive to pressure applied to them. Membrane keys are sealed to protect the circuit components from dirt patches.

- **Mousepads** are pointing devices with two internal X,Y tracking sensors that translate the mouse position to the screen via a cursor.
Graphics And How They Are Linked To Data

Most electronic OI products today provide Windows-based software packages with which users can create screen images, then link the images to data available in a PLC or over a network. The images are often built from tools such as icons, templates, or symbols.

Frequently, some type of spreadsheet or dialog box permits developers to link the onscreen images or objects to the data.
• In some software packages, PLC or network addresses may be referenced directly.
In other packages, developers have the ability to create *tag names*, which can be used as a reference to an actual PLC address or data point. In Figure 18, the icon links to a tag name, which is associated in the software with a specific processing point.

How do all the addresses, data points, and tag names communicate with each other and with the central program? Typically, the developer creates the desired images and linkages using the software in a Windows-based PC environment. The information is condensed by the software into a transportable file that is downloaded into the OI hardware platform, most commonly using a *cable with a serial file transfer*.

The software typically supports other necessary “housekeeping” tasks. These include downloading new “executive” software (containing the basic feature and function set) to the OI, and downloading new communications software (to support linkage to different PLCs or networks).
An interface provides a medium for the transfer of data. The majority of all interfaces to PLCs, networks, or other plant automation employ serial transfer of data. Serial transfer of data involves one sender and at least one or more listeners. Once the connection is made then the data is transferred as a string of bits (1s and 0s).

Early PLCs incorporated the Bell System of serial data transfer by incorporating the RS232 interface into their hardware platform. As the need for the transfer of serial data continued to grow new interfaces were developed to enable communication over greater distances (20 MA, RS422) and finally to allow multiple senders and listeners to occupy the same physical wire (RS485, Proprietary). In the late 80s, high speed proprietary busses were developed to permit the transfer of serial data at greater speeds and to enable the connection of many devices on the same physical wire.

These points summarize the general techniques for connecting an OI device to other equipment:

- **Serial communication** (RS232, RS422, RS485) to one other device, typically a PLC. These forms of communication are slower, but widely available; most individual devices can connect to each other through serial ports.
Communication to PLCs, Networks, Or Other Plant Automation (continued)

- **High-speed proprietary communication** to proprietary PLC networks (e.g., DH+, Genius I/O, Modbus). Communication protocols that offer high-speed transmission, but demand that all connected devices read and transmit its software. Mission-critical systems might require this amount of transmission speed, and might prefer the security that proprietary systems offer.

![High-Speed Proprietary Communication](image1)

**FIGURE 21: HIGH-SPEED PROPRIETARY COMMUNICATION**

- **Communication to other networks** (DeviceNet, Profibus) including multi-layer industrial networks such as Ethernet-Controlnet-DeviceNet or Ethernet-Profibus, DeviceBus, Fieldbus, Ethernet. These are higher volume communication networks that link through a series of gateways, or standardized forms of information exchange. This allows some quasi-proprietary networks to export data to a wide-field network. Building control systems would use these types of networks.

![Communication to Other Networks](image2)

**FIGURE 22: COMMUNICATION TO OTHER NETWORKS**
ELECTRONIC OPERATOR INTERFACES

Answer the following questions without referring to the material just presented. Begin the next section when you are confident that you understand what you’ve already read.

1. What is the difference between the hardware used for "open platform" systems and proprietary systems?

2. Which of the following is NOT a benefit of using electronic OI?
   A. Reduced involvement and control by operator
   B. Improved product quality through closer monitor of processes
   C. Reduced downtime through faster diagnostics
   D. Reduced scrap

3. Just by looking at the image below, why would you suspect that it is not from a simple OI product, with a monochrome screen?
   Reason: ________________________________________________________

4. One worker touches a screen while wearing a glove. Another worker approaches the same screen and touches it with the eraser end of a pencil. A third worker uses his finger to make a change. Is the touchscreen resistive or capacitive?

5. Match the communication type name with the phrase summarizing that method's advantage.

   1. Network  
      A. Standard, widely available communication protocol. Often uses RS232.

   2. Serial  
      B. Bridge multiple layers of information via gateways. Can export data.

   3. High-Speed Proprietary  
      C. Fastest level of control response combined with higher levels of data security.
Earlier, we discussed how operators physically input information. Now, we will talk about the kinds of information operators enter, and the tools that electronic OI has available to make data entry easier and inform the operator better.

Icons and symbols visually simulate the equipment and devices in the field, helping operators to immediately identify the source of data. The same tasks are completed, only they are done in software, rather than a set of mechanical devices wired together. One can initiate control action by pressing the on-screen control button.

Templates are onscreen icons that replicate a group of specific tasks that used to take several conventional devices to accomplish.

**FIGURE 23: AN OPERATOR CHOOSING ICONS AND TEMPLATES VIA A TOUCHSCREEN**

**FIGURE 24:**
THIS INDICATOR TEMPLATE DISPLAYS DEVICE STATUS, SUCH AS ON, OFF, AND FAULT. IT REPLACES UP TO FIVE CONVENTIONAL INDICATING LIGHTS.

**FIGURE 25:**
THIS READOUT TEMPLATE DISPLAYS, IN DECIMAL FORM, A PRIMARY VALUE AND OPTIONAL SETPOINTS OR SECOND VALUES FROM THE PLC. IT REPLACES CONVENTIONAL NUMERIC AND DIGITAL READOUTS.
ELECTRONIC OPERATOR INTERFACES

Color, Blink, Animation Effects
The use of color and animation allows the software to replicate on-screen the dynamic process of the actual task. After creating images (or importing them from CAD packages or other third party software), the software can highlight the motion, speed, and direction of the process. Once you have the images, you can re-use and copy them for a number of purposes. Special effects, such as blink, can differentiate between severity levels of fault conditions.

Advanced Features
Electronic OI can gather, sort and display complicated patterns of data. Trending is one example, in which the software logs the rate of change in the process, and builds predictive actions based on the likely activity about to occur.

A Timer Counter Access Module (TCAM) program allows a user to "look" into the process and change the program (e.g., select addresses) without having to call a programmer.

Pushbutton, Alphanumeric and Numeric Entry
While operators can "push buttons" on the screen to re-create in software what used to take hardwired pushbuttons to accomplish, they may also need to enter text or numeric data. They can do this from either a keyboard, a numeric keypad, or directly on the screen. In the image below, the user's finger is selecting templates and entering setpoints using the "offscreen" membrane keys.

![FIGURE 26: AN OPERATOR USING "OFFSCREEN" PUSHBUTTONS AND KEYPAD](image)

Mathematical Calculations And Subroutines
One of the advantages of a modern electronic operator interface is its inherent computing capabilities. Most OI applications allow the user to configure automatic mathematical operations based on conditions being monitored. A typical application is for scaling or conversion of data, e.g., Celsius to Fahrenheit, etc. More complex operations such as multiplication, division, Boolean operations, and most other mathematical functions, can be automatically applied to incoming data or operator inputs.

This computing capability of electronic OI effectively off-loads these chores from the PLC, meaning less PLC processing and memory are required for a given application. PLC memory is notoriously expensive, which means that electronic OI can save the user money.
Tag Name Referencing

Tags are names that represent specific input/output data mapped to particular devices on the system. An example of a tag name might be "Solenoid Retract," whereas its data information might read "Output_21_2".

The tag name can be used in programming (rather than the piece of data itself). This makes for easier programs to create, read, and troubleshoot. Below is an image of software applying tag names to a data point.

![FIGURE 27: TAG NAME APPLIED TO A DEVICE USING SOFTWARE](image)

Upload and Download Of Applications

Applications designed to run on an operator interface are typically configured on a standard desktop or laptop PC. Once the application is configured, some mechanism is required to download it into the operator interface.

The **most common method for transferring an application to or from the OI is via standard serial ports on the PC and OI**. The transfer is initiated much like a typical modem connection.

Other optional methods of application transfer include communications over proprietary high speed networks (e.g., AB Data Highway Plus, Modicon Modbus Plus, etc.) or over standard PC networks (Ethernet) to open platform OI units.

Boolean Logic And Its Applications

**Boolean logic** is a method of testing for desired outcomes, or “states,” by combining data, using mathematical operators such as AND, OR, and NOT. Boolean logic is frequently used in PLCs to compare input data in order to generate outputs.
Designing OI software to work on PC hardware provides **significant gains in standardization and availability**, as well as **lowered-costs from worldwide mass development**. Here are some other, not so obvious, benefits:

- As automation assumes ever-higher levels of control, the need for multi-tasking and real-time response grows as well. PC microprocessors and operating systems have rapidly evolved to handle multi-tasking projects.

- Programming models develop advanced capabilities on the PC platform, such as data logging and retrieval, trending, and process simulation.

- PC programs are able to analyze and exchange data with other software “processes” running in the PC environment. This is possible through adherence to standardized programming libraries and codes, such as Dynamic Link Library (DLL) and Dynamic Data Exchange (DDE) and Networked DDE (NetDDE).

There is a tremendous range of price and performance available today in the electronic operator interface market.

- At the low end, very simple text-only message displays may be purchased for $100 or less.

- More capable message displays may be had for a few hundred dollars.

- Full-blown text-only OI starts at around $400, up to $1,000.

- Text/graphic capable OI starts around $500 up to about $1,200.

- Extensive mathematical capabilities start at around $1,000 up to $1,500

- Full VGA graphics (gray-scale) models start at about $1,500.

- Full Color, dual-scan or active-matrix (TFT) VGA and SVGA models, with display sizes ranging from 10.4” through 17”, run the gamut from $2500 to over $10,000 for the very largest LCD displays.

- Open platform operator interface models (with software) at $6,000 and up, depending again on display size, as well as the variety of PC options and capacity required for the application.
Answer the following questions without referring to the material just presented.

1. Templates are onscreen icons that replicate a group of specific tasks that used to take several conventional devices to accomplish. Identify a template on the screen below and describe what hardwired devices it might replace.

   TEMPLATE: _________________________________
   ________________________________________
   REPLACES: _______________________________
   ________________________________________

2. A form of logic that reduces or compares results through operations such as AND, OR, and NOT commands is known as ______________ logic.

3. Put into sequential order characteristics of OI that would increase its price:
   • Extensive mathematical capabilities
   • Active-matrix displays with touchscreens
   • Text message displays
   • Full color dual-scan displays

4. What is the driving force behind lowered prices and enhanced capabilities of OI software running on PC hardware?
**ELECTRONIC OPERATOR INTERFACES**

**GLOSSARY**

**Boolean Logic**
A method of testing for desired outcomes or “states” by combining data, using operators such as AND, OR and NOT. Boolean logic is frequently used in PLCs to compare input data in order to generate outputs.

**CRT**
Abbreviation for Cathode Ray Tube, or monitor. This has been the dominant luminous display technology until the late 1990’s, when flatpanel technology is starting to replace CRTs in popularity.

**Cursor**
A visual indicator on display devices to call the operator’s attention to a particular location on the screen. Cursors may take many forms, from text underlines, to background shading, to enclosure boxes.

**DDE/NetDDE**
Dynamic Data Exchange (Networked DDE). This is a software protocol, much like a PLC protocol, designed to transfer individual bytes of data between different programs either in the same computer (DDE), or through a network (NetDDE).

**Dual-scan**
A type of color, liquid crystal, flatpanel display. Dual-scan displays are quite affordable, but they have somewhat limited luminosity and viewing angle.

**Ethernet**
Ethernet is a local area network protocol that uses a bus physical connection and supports data transfers at 10 Mbps. The physical media consists of different types of copper cable dependant on the network distance required. Ethernet uses the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) method to handle simultaneous demands. It is one of the most widely implemented local area network standards.

**Flatscreen, Flatpanel**
A generic name for several kinds of display technologies which are flat and shallow in depth.

**HMI**
Abbreviation for Human Machine Interface. This is an abbreviation for an indistinctly defined category of electronic operator interfaces that normally provide high capacity and advanced features.
### ELECTRONIC OPERATOR INTERFACES

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I/O</strong></td>
<td>Abbreviation for the concepts of input and output, as in the categories of devices managed by PLCs and other types of control equipment.</td>
</tr>
<tr>
<td><strong>LCD</strong></td>
<td>Abbreviation for liquid crystal display, a type of backlit display technology. LCD displays are available in color, monochrome and grayscale, but all varieties have limitations in luminosity and viewing angle.</td>
</tr>
<tr>
<td><strong>MMI</strong></td>
<td>Abbreviation for man-machine interface. This early abbreviation for any technology which provides a control and monitoring link between humans and machines or plant operations has more recently been replaced by the term Operator Interface, or OI.</td>
</tr>
<tr>
<td><strong>NEMA Rating</strong></td>
<td>Abbreviation for National Equipment Manufacturer’s Association. The NEMA rating is a numeric assignment for machinery or equipment, corresponding to a well-defined set of abilities to withstand environmental conditions.</td>
</tr>
<tr>
<td><strong>OI</strong></td>
<td>Abbreviation for operator interface. This is a more modern abbreviation for technology providing a control and monitoring link between humans and machines or plant operations. Often, the term OI is applied to interface devices at the simpler end of the spectrum of interface devices.</td>
</tr>
<tr>
<td><strong>Object</strong></td>
<td>A visual element in a graphic display which is stored and manipulated independently of other graphical objects. In comparison to bitmapped images, objects:</td>
</tr>
<tr>
<td></td>
<td>• require a relatively small amount of memory for storage</td>
</tr>
<tr>
<td></td>
<td>• can easily be edited</td>
</tr>
<tr>
<td></td>
<td>• can be visually layered on top of each other to produce more complex and useful images</td>
</tr>
<tr>
<td><strong>Pixel</strong></td>
<td>Abbreviation for picture element. A pixel is the smallest controllable, addressable element that can be used to build visual images on a display screen.</td>
</tr>
<tr>
<td><strong>ELECTRONIC OPERATOR INTERFACES</strong></td>
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<tr>
<td><strong>PLC</strong></td>
<td>Abbreviation for programmable logic controller. The PLC is the dominant tool for plant-floor control, monitoring, and sequencing of events involving input devices and output devices.</td>
</tr>
<tr>
<td><strong>SVGA</strong></td>
<td>Super Video Graphics Adapter, a display system designed to offer greater resolution than standard VGA. There are several varieties of SVGA: 800 pixels by 600 pixels; 1024 by 728; 1280 by 1024, and 1600 by 1200. All SVGA standards support 16 million colors, but the number of colors displayed simultaneously is limited by the memory in the computer system.</td>
</tr>
<tr>
<td><strong>Tag Name</strong></td>
<td>Refers to any name used to represent a data point in control or operator interface software. This permits the assignment of meaningful “labels” for data.</td>
</tr>
<tr>
<td><strong>TFT/Active Matrix</strong></td>
<td>Abbreviation for Thin Film Transistor—a type of flatpanel color display technology, which, although still somewhat costly, has good luminosity and viewability.</td>
</tr>
<tr>
<td><strong>Template</strong></td>
<td>A standardized onscreen visual tool used in some OI devices to perform the same function as a type of hardwired control panel device. For example, a “readout” template on an OI screen can display numeric information in the same way as a gauge or dedicated numeric readout device.</td>
</tr>
<tr>
<td><strong>Touchscreen</strong></td>
<td>Refers to technology which permits an operator to make a selection on a display screen by touching the screen with a finger. Touchscreens most often detect finger touches by sensing pressure or changes in electrical capacitance.</td>
</tr>
<tr>
<td><strong>VGA</strong></td>
<td>Video Graphics Array, a graphics display system developed by IBM for personal computers. VGA has become one of the de facto standards for PC displays, providing a resolution of 720 pixels by 400 pixels. In graphics mode, the resolution is either 640 by 480 at 16 colors or 320 by 200 at 256 colors.</td>
</tr>
<tr>
<td><strong>XGA</strong></td>
<td>Extended Video Graphics Array. XGA display systems provide a resolution ranging from 640 pixels by 480 pixels to 1024 by 768, all at 65,000 simultaneous colors.</td>
</tr>
</tbody>
</table>
1. Answer should basically say: “Unmanageable forests of hardwired display and entry devices congregated on Operator Interface panels.”

2. True

3. Any three of the following:
   - control (start/stop)
   - numeric entry
   - monitoring and status display
   - responding to alarms
   - responding to messaging
   - providing diagnostic and troubleshooting support
   - interpreting more advanced information display

4. Answer should basically say: “It reduces the amount of dedicated PLC programming because Electronic OI assumes some of the responsibility for numerical calculations, logical comparisons, alarm monitoring, etc.”

5. Any two of the following:
   - templates
   - icons
   - symbols

6. Content, layout

1. Answer should basically say: “The “proprietary” design features both hardware and software that is unique to the particular brand of OI. The “open platform” design features software that is unique, but which typically runs on a Windows-based personal computer platform.”

2. A

3. Answer should basically say: “If it was a monochrome screen it would only contain text or very simple graphics; in other words, the sophisticated form of display suggests that this is a color screen.”

4. Resistive

5. 1B, 2A, 3C
1. Template: Circle around ‘ON,’ ‘OFF,’ or ‘5.’
   Replaces: The on and off replace indicating lights; the 5 replaces digital readouts

2. Boolean

3. Text message displays
   - Extensive mathematical capabilities
   - Full color dual-scan displays
   - Active matrix displays with touchscreens

4. Answer should basically say: “Significant gains in standardization and availability, as well as lowered-costs from worldwide mass development.”