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PLCs & PACs

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Where's the logic in the PLC?

PC-based control is still forging its way amidst a ladder-logic world

By Jeremy Pollard, CET

Way back when, I declared that PC-based control would take up over 40% of the market from the standard firmware-based PLC. Why?

Because of the cost and the availability of having the control, as well as the HMI, on the same machine. The operating systems were varied, from Windows to VxWorks real-time OS. Various OS kernels were developed to provide a more real-time response to occurrences in the field due to the interrupt-based systems, typically, the IBM PC platform. A problem arose, however, since basic hardware configurations were used. These included things such as a CD drive and more interrupt-driven resources that were placed on the system.

So the platform was redefined, and finally the control software had a good place to execute the algorithms and code needed to control the process.

We take so much for granted in a PLC environment because our interface to it is a slick programming environment—an integrated development environment (IDE)—which provides all the commands and instructions needed to create, download and monitor the process software.

With PC-based control it was no different. You would never really know the difference by looking at the screen where you would create and monitor your application software.

Windows CE was a common platform for embedded OS-based systems. The IBM PC board design and chipsets were copied into different form factors, such as PC104, VME bus and PCI. This allowed the control software to reside in an embedded system and allowed for better control methodologies.

One of the very first PC-based control systems was a product called FloPro which was developed by Ron Lavallee in the mid-1980s. It was based on flowcharts, which constitutes a decision-by-decision method of creating a process flow.

However his first go-round was a post processor that took flowchart symbols and converted them to ladder logic using code that was generated on an HP-85, which is another story.

In fact he demonstrated his development to Gould Modicon, which made overtures about buying the technology but moved away from it for some unknown reason.

FloPro moved over to the IBM platform, and, with the addition of a communication card to connect to Allen-Bradley remote IO system, FloPro made it into the development world at General Motors, and a new paradigm was born.

Sequential function chart (SFC) was alternative-state-based control software that was used in PLC firmware. It is now available in many hardware formats, and has replaced flowcharting as a control software state-based system.

Mike Klein started a flowcharting company called Steeplechase, which had early success in the world of computer-based control. It was Windows-based and provided a much better interface than FloPro by all accounts. Steeplechase formed alliances with various companies and in fact spawned additional flowcharting companies such as Think & Do.

Another company that was formed because of FloPro was FlexIS process control. It was a post processor that took SFC programming of the control algorithms and converted that to Allen-Bradley's PLC-5 subroutines in ladder logic. It was really slick and very well done, but there was some pushback from the industry regarding these graphical languages because the development minds really didn't think in the way that was needed. Their minds were geared for ladder-logic development, and most of the development occurred one rung at a time.

I actually ran into a system at the Nike distribution center in Toronto that was still running Steeplechase flowcharting software. If anything went wrong, they would have no resources to help, I would suspect. And therein lies the rub.

It is all well and good to have a novel idea and a new way of creating a controlled process program, but you have to have the resources to create, as well maintain, the end result. FloPro ran into a brick wall after a project in Windsor, Canada, as the integrator reportedly blasted the software for really bad visualization and the lack of tools for troubleshooting.

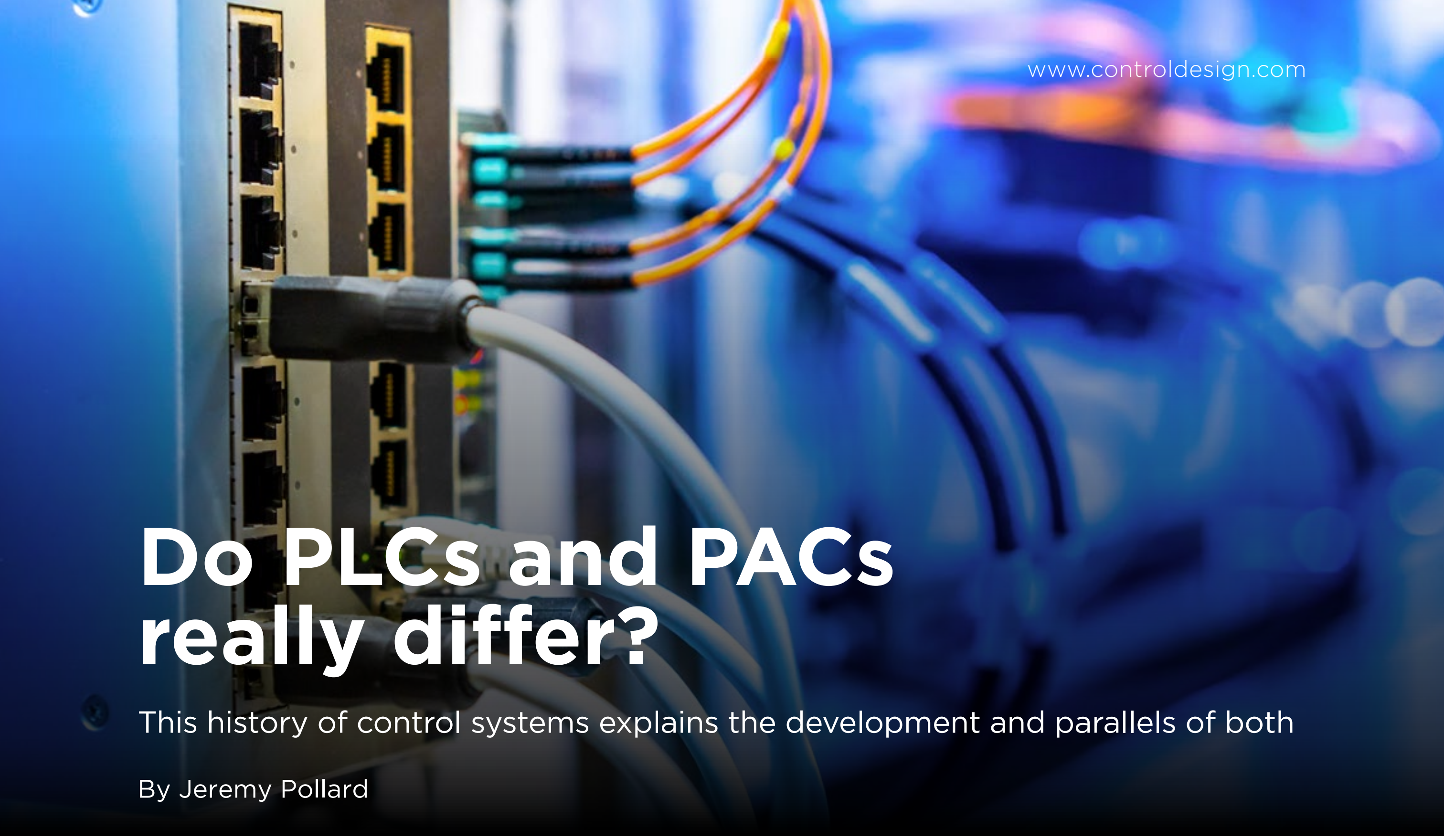
IEC 61131 has been around for almost 30 years and compliance with it is now becoming accepted as a control software platform. Beckhoff Automation uses a PC-based hardware platform and runs IEC-61131-compliant control software on the machine, which also includes the HMI. This emulates the original perceived benefit of the original reason for PC-based control.

Control software has morphed over the past 40 years, but interestingly enough most processes are still PLC-based and mainly created with ladder-logic implementations.

Almost every survey done in the past 10 years has ladder logic being the leader in how processes are controlled.

And, as luck would have it, the PLC is far from dead, but PC-based control is nowhere near the potential it could have risen to. It’s interesting that Rockwell Automation’s new ControlLogix platform has the opportunity to run Windows-based software.

A PC in a PLC—so, which is it?



Do PLCs and PACs really differ?

This history of control systems explains the development and parallels of both

By Jeremy Pollard

I don't want to belabor the difference between PLCs and PACs. OK, maybe I do.

Why did the industry feel it had to rename a functional device that has been around forever to a name that is supposed to change the functionality of the device in question? I have wondered about this, and it has kept me up at night—well, almost!

I am most familiar with Rockwell Automation platforms, so I will use them as examples. I used to work for Rockwell when it was Allen-Bradley and started in the PLC world at the genesis. Yep, I'm that old.

A PLC in the 1980s was a device that had a universal I/O system with remote I/O, as well as local I/O. The platforms, of which there were many, mainly consisted of the PLC-2/3/5, as well as the new SLC 500/MicroLogix lineup.

While it is true that the industry was moving toward a more open I/O structure using industrial Ethernet and various bus systems, it was also moving toward smaller CPU form factors with much more computational and control power.

However, they were still PLCs.

One of the largest debates that raged onward was the application of a PLC to a process system. PLCs had analog connectivity, as well as the ability to be accessed by HMI/SCADA systems using various communication methods. Distributed control systems, which were expensive and sometimes clumsy, were being upstaged by the PLC because they could have all the necessary capabilities to perform the actions needed.

Fast forward to the 2000s. Enter the programmable automation controller (PAC). What does this new device bring to the table?

In my opinion, not all that much in its infancy. The ControlLogix platform, which was introduced in the late 1990s, created a brand-new approach to the control functions of any application. It wasn't cheap, nor was it easy to configure at first. But what it did was introduce the concept of electronic data sheets (EDS files) for integrating third-party devices into the system.

Trying to connect a Keyence color camera to an SLC 500 would be a chore. With the Control/CompactLogix [CCL] platform and EDS files the integration is very easy. Score one for the PAC.

The other main issue a PLC had was the inability to have multiple communication methods. The PLC-5 Ethernet versions supported Ethernet/IP and Data Hiway+ and serial communications. The PLC-3, the predecessor to the Control/CompactLogix platform, had a similar form factor as the CCL with the ability to have multiple processor and scanner cards, but the communications options were very limited. Due to the movement of technology, the development cycle for the PLC-3 stopped since the CCL platform was the platform of choice.

The CCL platform introduced the concept of a processor bus and an I/O bus. Multiple communication cards could be used, as well as having built-in communication systems. By this point it was really all Ethernet and all protocols that ran on Ethernet. DeviceNET and ControlNET took a back seat.

Most devices were Ethernet/IP-compliant, so third-party I/O systems, such as those from Murr, could be used. Third-party devices exploded due to the use of the EDS system. Autoconfiguration of external devices made the transitions easy. Score two for the PAC.

The Industrial Internet of Things (IIoT) with MQTT protocol is not available with a standard PLC as such. The PLC-5 cannot be used with that protocol unless there is a separate module created by a third-party to fit into the I/O system. That's not going to happen over the brick wall that comes up when you try and join legacy into modern day and are met with a you-have-to-upgrade-your-PLC moment.

When the PAC was first introduced the industry veterans needed a moniker to differentiate standard control from advanced control.

So, what are you going to upgrade to? Another PLC? The answer is yes. But it is also a PAC. When you replace a SLC-500 or PLC-5 with a CCL product, you are not redesigning the application, so you are replacing it with a PLC.

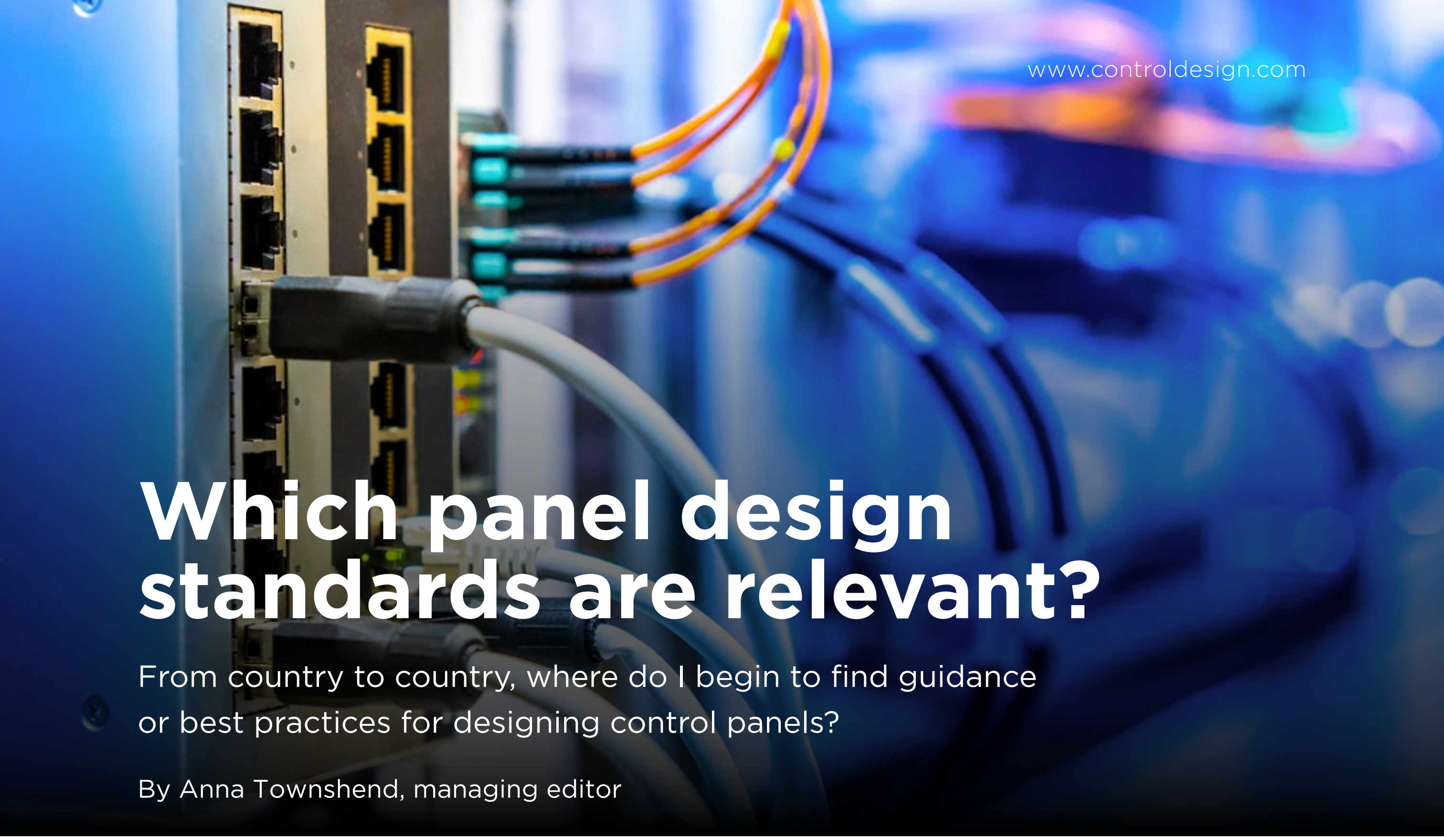
However, if you are adding new functionality and/or different I/O configuration and communications issues such as IIoT, then it migrates to a PAC.

When the PAC was first introduced the industry veterans needed a moniker to differentiate standard control from advanced control. Motion for instance is a breeze with the CCL. Programming is IEC-61131 based, which the global market was screaming for because it includes function block for DCS applications.

Score three for the PAC.

So what's in a name? Seems that it really doesn't matter what we call something; it is about what is does. Whether you call it a PLC or a PAC is immaterial. They both mean control at the highest level with programming software that would make the engineers from the 1970s and 1980s froth at the mouth.

Today's functionality buries that of the availability of functionality from devices of yesteryear. It deserves a different name. Kudos to the veterans.



Which panel design standards are relevant?

From country to country, where do I begin to find guidance or best practices for designing control panels?

By Anna Townshend, managing editor

A Control Design reader writes: Having spent many years writing PLC programs, I am familiar with electrical and pneumatic schematics and am creating these design documents. However, lately, I'm drawing these schematics and panel layouts myself, and I am constantly thinking about what are the best practices in control panel design. I'm in need of a mentor.

I'm creating many designs for industrial control systems small to large, most with small to midsize PLCs that control machines and equipment. Can you point me to national and international standards that I should be using and other resources to get the design right. I want to ensure I get the wiring, panel layouts and integration done in an industry standard way.

ANSWERS

HMI INDUSTRY STANDARDS

The interactive impact of the human-machine interface (HMI) is much more significant than its basic functionality. An HMI system is the principal point of contact between the user and a machine or process. A good HMI system makes this interaction seem intuitive. A poor HMI system can alienate users or potential customers, encourage users to circumnavigate the system or result in poor or unsafe system performance. As the direct link to the user, the HMI directly represents the core system's quality and value. A sophisticated mix of design and layout considerations, such as contemporary style, color and tactile response, coupled with ergonomic and intuitive operation, create an optimal user experience that determines a customer's satisfaction with the core product.

A highly reliable HMI system that delivers safe, cost-effective, consistent and intuitive performance relies on the application of engineering best practices throughout design and panel layout, production, testing and quality assurance processes. Just as critical, in-depth knowledge of and compliance with all relevant ergonomic, safety and industry standards must inform each step of the design and manufacturing cycle. Clear definitions of the functional requirements, the operator's level of expertise and any communications/interactions with other systems provide the starting point in the knowledge-intensive design process.

The tools needed for effective operator control of the equipment, as well as the requirements of the overall application, determine the selection of interface functions. There are many factors to consider in the initial design phase that are critical to both the HMI and the core system to which it is interfaced. Besides industry and functional requirements, selection priorities also depend upon the experience level of the operator and environment, among many other factors. The driving priority might tilt toward ergonomics, for example, as is the case for applications subject to ADA (Americans With Disabilities Act) guidelines. On the other hand, production floor applications are typically robust and strictly functional, driven by the need to withstand a harsh environment. In the transportation industry, for example, consistency with a previous design—to provide a consistent operator environment—is very often the ruling priority.

A thorough knowledge of technical ergonomic, design and manufacturing standards is fundamental to proper and effective HMI system design whether working independently or with a sanctioned design partner. These include engineering standards, such as MIL-STD-1472F, which establishes human engineering design criteria for military systems, subsystems, equipment and facilities; federal standards set by the Americans With Disabilities Act; and industry guidelines such as those from SEMI S2-93, the global semiconductor industry association, covering HMI for semiconductor manufacturing equipment. Additional HMI specifications are defined by the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), the International Organization for Standardization (ISO) and others.

The EU provides specifications in its EU Machinery Directive for any equipment for domestic, commercial or industrial applications that have parts actuated by a power source other than manual effort. Meeting this directive earns the equipment a CE mark. There are also standards for public access HMI systems, including security and cryptography standards for systems that handle payment cards; specific flammability standards and test procedures for transportation systems; and medical device and equipment standards.

Depending on the ultimate product application, observing appropriate standards ensures that a product will meet industry criteria. This includes the placement of components, legend size and color, emergency stop switch configuration and guards and other ergonomic factors that improve usability, efficiency and safety.

U.S. AND INDUSTRY STANDARDS BY APPLICATION

Manufacturing and Process Industries (shop floor applications) International standards

- EU Current Machinery Directive, from Dec. 2009
- MIL-STD-1472F, addresses human engineering design criteria for military systems, subsystems, equipment, and facilities
- IP (International Ingress Protection) codes
- ISO 9001 and ISO 14001
- CE Mark—meets European Union (EU) requirements and guidelines for safety, health, or environmental requirements
- CSA International—Canadian Standards Association provides product testing and certification
- UL, C-UL—Underwriters Laboratories, U.S./Canadian rating organization
- VDE—Electrical, Electronic & Information Technologies, a German testing organization
- DIN EN ISO 13850: 2008 (Safety of machinery—emergency stop—principles of design) The first edition of ISO 13850 (published in 1996) replaced the EN 418 "Emergency Stop" directive in March 2008. Significant changes in this second draft mandate the manual resetting of E-Stops; require E-Stops to use mechanical latching; and state that the revision will remain unchanged until 2010.

U.S. FEDERAL

- ADA Standards for Accessible Design, 28 CFR Part 36
- NEMA (National Electrical Manufacturers Association) similar to the international IP standard, e.g., the NEMA 4 standard is similar to IP 65
- ANSI

INDUSTRY STANDARDS

- IEC Safety Integrity level (SIL)

Transportation Industry

- ISO: 9000, specifically for railway
- EN 5155 develops standards for electronics on railway passenger vehicles
- The Federal Railroad Administration (FRA, under the U.S. Department of Transportation) is responsible for defining standards

covering safety issues
- ASTM (under ANSI) specifies testing procedures in transportation; A range of ASTM standards provide methodology and performance specifications for testing FRA regulations flammability testing
- 49 CFR Appendix B to Part 238 – Test Methods and Performance Criteria for the Flammability and Smoke Emission Characteristics of Materials Used in Passenger Cars and Locomotive Cabs
- ADA
- ANSI
- IEEE
- IRIS (International Railway Industry Standard) Rev. 02; ensures products meet globally recognized quality levels

Semiconductor Industry
- Semiconductor Equipment and Materials International
- Safety Guidelines for Semiconductor Manufacturing Equipment SEMI S2-93
- Safety Guidelines for Ergonomics/Human Factors Engineering of Semiconductor Manufacturing Equipment SEMI S8-95

Medical Industry
- ISO Standards for medical devices—ICS 11.1100.20 and ICS 11.040.01 [5], [6]
- Quality and risk management—ISO 13485 and ISO 14971
- IEC 60601-1 and IEC 62304 for medical software
- U.S. FDA 21 CFR Subchapter H—medical Devices [7]
- Food, Drug, and Cosmetic Act—Section 510(k) —for pre-market notifications

JOHN PANNONE

VP Sales, HMI systems, key customer management, North America / EAO / www.eao.com

ART AND COMMON SENSE IN DESIGN

If you are designing control panels for the North American market, one of the best standards to be familiar with is UL508A. UL508A is a standard for the construction of electrical control panels. Additionally, the National Fire Protection Agency (NFPA) 79A (Electrical Standard for Industrial Machinery) and the National Electrical Code (NFPA 70) are great resources.

Europe has its own standards, mainly IEC (International Electrotechnical Commission). I would start with a study of the various IEC standards. For example, IEC 60204-1 is a basic safety standard, "Electrical equipment of machinery—Part 1: General requirements for the electrical equipment of machines." There are many IEC standards, and individual countries have their own versions of the IEC standards.

There are two things to keep in mind:
1. Always follow the codes for the country/region that the control panel is going to.
2. Use good, common sense.

Simply following codes is only part of the art of designing control panels. A neat, nicely laid-out control panel is very important.

The Internet has a plethora of resources for you; definitely research articles and look at other designs.

In my opinion, providing a great panel design is a mixture of engineering, art and common sense.

JIM DAVIS

automation engineer / Motion Industries / www.motion-industries.com

COMPONENT CONSIDERATIONS AND CODES

Control panel design requires knowledge in several interrelated areas.

Codes

- Hazardous area considerations: This may define the type of protection required of the enclosure and/or the components.
- If the panel must be UL approved, the pertinent UL standards must be followed. This may dictate the components that may be allowed.

Electrical considerations

- Follow the applicable codes (the National Fire Protection Agency (NFPA) handbook), and UL standard when required
- Wire size, type and color or insulation
- Fuses, circuit breaker

Thermal considerations

- Consider the temperature rating of the items in the enclosure, the heat output of those items and the ambient conditions where the assembly will be installed.
- Various methods for controlling the internal temperature can be utilized if necessary: selection of the exterior color, insulation, air purging, insulation, heater/thermostat, compressed air cooler, air conditioning.

Familiarity of various components: This comes with experience and involves knowing which types of components are acceptable for the sector you are selling to. Having knowledgeable vendors and distributors can be a big help.

- Enclosure
- Wire ducts or guides
- Wire markers
- Terminal blocks
- Fuses, circuit breakers

Client's requirements

- Where will it be located?
- How will the client access it?
- Does it need a convenience outlet or internal lighting?
- From which direction(s) will the client run his cabling or conduit?

Practical sense (if not defined elsewhere)

- Space needed between components
- Space between component wiring terminals and wire ducts
- Size of wire duct
- Space to allow between cable entry and ducts or components
- Space around the edge of the panel

- Location of some components relative to others for ease of access, considerations for inter-wiring or other factors.

MICHAEL CORWIN
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PLC definitions and requirements
IEC 61131 is an IEC standard for programmable logic controllers (PLCs). The purposes of this standard are:

- to establish the definitions and identify the principal characteristics relevant to the selection and application of PLCs and their associated peripherals
- to specify the minimum requirements for functional, electrical, mechanical, environmental and construction characteristics, service conditions, safety, EMC, user programming and tests applicable to PLCs and the associated peripherals.

IEC 61499 proposes applications hosted and running in several devices.

IEC 61499 proposes applications hosted and running in several devices. Function blocks running in different devices, within a distributed application, have to be strongly coupled, so it is required to have more sophisticated synchronization methods than IEC 61131-3 defines. For example, in contrast with the Send/Receive functions or Networked Variables, the IEC 61499 offers publisher/subscriber and client/server services.

NEMA GFCI P1-2019 covers products intended primarily to protect human beings from the harmful effects of electric shock by sensing ground fault(s) and/or leakage current(s) on grounded and/or ungrounded systems rated 1,000 Vac or Vdc and below.

NEMA IA 2.2-2005 Programmable Controllers (PLC), Part 2 Equipment Requirements and Test specifies requirements and related tests for PLC and their associated peripherals, such as programming and debugging tools and human-machine interfaces, which are intended to be used for the control and command of machines and industrial processes.

NEMA IA 2.3-2005 Programmable Controllers (PLC), Part 3 Programming Languages specifies syntax and semantics of programming languages for PLC as defined in Part 1 of IEC 61131.

NEMA IA 2.5-2005 Programmable Controllers (PLC), Part 5 communications specifies communication aspects of a PLC. This standard is a NEMA Adoptive Standard based on Part 5 of IEC 61131.

The control panel needs to be UL Standard 60947-4-1 or NEC compliant. Article 409 [Industrial Control Panels] of the National Electrical Code (NEC) has been a part of the code since the 2005 edition. Industrial control panels are defined in

Article 100. Basically, these panels can be any assembly of relays, pushbuttons and motor controllers.

DANIEL WEISS

senior product manager / Newark / www.newark.com

UL508A CERTIFIED

My answer is relatively simple: get certified for UL508a. There are as many wrong ways to design as there are control panels, and one correct way—designing it to UL508a standards and building it out to those standards, so it can pass certification.

It is very important to understand that there is a big difference between building a control panel using UL508a-certified components and designing and building a UL508a-certified control panel. Just because the pieces are UL508a, that does not mean the final solution is.

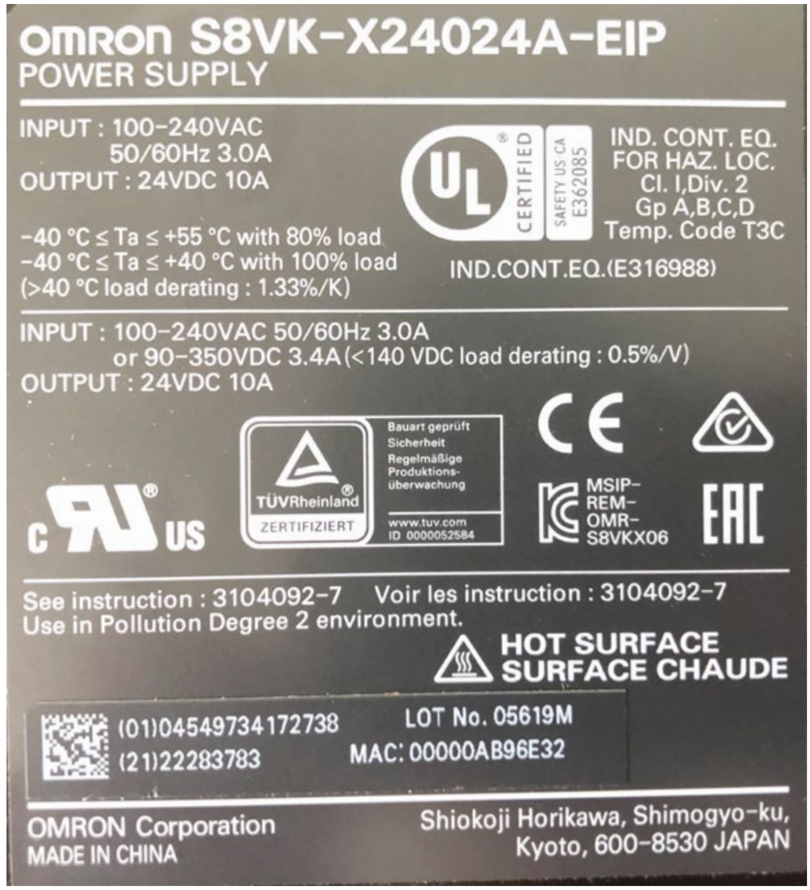
For UL training, visit www.controldesign.com/ultraining. You can find Intertek training for UL 508a certification and panel builder program at www.controldesign.com/intertektraining.

Take the classes, get certified, design and build your control panels.

It's not hard, but it's not simple.

TED WODOSLAWSKY

director of commercial marketing / c3controls / www.c3controls.com



GLOBAL STANDARDS

Figure 1: Selecting components that have been tested and that comply with global standards significantly reduces engineering time and cost by unifying the panel design for different markets.

COMPONENTS THAT MEET GLOBAL STANDARDS

Figuring out which standards are required for industrial control panel design in different areas around the world can be a daunting task, since the standards change constantly in relation to technological innovation and new safety requirements.

Although there is a movement to harmonize some of these standards, there are still many differences that must be addressed. It is possible to cover most requirements by following a few standards like UL508A, NFPA79 and CSA C22.2 No. 286-17 in North America, and the EU Directive in Europe, as well as the international IEC standards such as IEC 60204-1.

When designing a control panel to meet industry standards, it's a good idea to choose a component supplier that has both a global presence and a large product portfolio. Suppliers with a presence around the world have more knowledge about standards compliance across all markets, while those with large product portfolios are more likely to offer products that are suitable for a wide range of industrial control systems.

The first step in engineering a panel that meets industry standards is to select components that have been tested and that comply with global standards. This significantly reduces engineering time and cost by unifying the panel design for different markets (Figure 1).

Companies are also developing new component technologies to help panel builders more easily comply with control panel standards while improving design efficiency. Components that feature a slim profile, consistent heights and a means of making wiring more simple and secure provide advantages that help meet spacing requirements, optimize heat dissipation and simplify the panel layout. It's also important to follow manufacturing instructions when installing components, including those related to mounting, wiring and device protection, to ensure that the panel is built to comply with industry standards.

DAVE LUNDQUIST

automation engineer / Omron Automation Americas / automation.omron.com

CUSTOMER-DRIVEN DESIGN

Control panel design is driven by your customer. What are the expectations? Where is the machine located? Europe? Canada? United States? What are the safety requirements?

You must understand the environment where the equipment will be located. NFPA 79 guidelines will ensure worker safety and the machine will perform without any electrical hazards.

The UL 508 and UL 508a standard covers control panel devices used for most industrial machines.

Special consideration is necessary for machinery that will be located in an explosive environment or need to be intrinsically safe. If the machinery will be shipped to Europe, CE mark is necessary. If the machinery is going to Canada, it must be inspected by CSA inspector for electrical safety.

You can always contact a certified control panel builder to work with you to guarantee conformance. Sometimes working with the experts pays in the long run.

WERNER LAMBERGER

technical support engineer / Automation24 / www.automation24.com

5 BEST PRACTICES FOR WIRING

In terms of laying out industrial control panels, wiring plays an absolutely critical role in effective design and construction. Here are five best practices I'd suggest in that area.

1. Separate power and control wiring
To reduce the possibility of electrical noise affecting the control signals, it is best to separate the power and control wiring. Lay out the panel so that the power and control are in separate sections. Group all power fuses, motor starters and variable frequency drives on the same side of the panel as the incoming power (typically the right side, when facing the front of the panel). Then locate all low-voltage control components on the opposite side. Contactors and variable frequency drives will require some control wiring. Consider how you can route the control wires over to the power side while trying to keep them separated.

2. Separate field wiring from internal wiring
Think about how field wiring going to the machine will route into the panel. Will you use conduit, cables or wireway? Will the wiring enter from the bottom, the top or the side? Referring back to our first best practice, consider how best to keep the power and control wiring separated. Lay out terminal strips so that there are separate wire ducts for the internal and field wiring. This simplifies the field wiring and also helps if you have to disconnect the wiring when shipping the machine.

3. Determine the right size wiring duct
Wire duct can consume a lot of space in a panel, especially if you run extra ducts to separate power and control. The proper size duct for each section is one that's neither under-filled nor over-filled and one that has space for easy access when wiring. It is sometimes helpful to draw a cross-section of the duct profile in CAD and then fill it with circles that represent the wire sizes and quantities. This quick visual can help evaluate the loading for different size ducts. This is especially useful when working with large-diameter wire and cables.

4. Provide adequate space for wire routing
When designing panel layouts in CAD, it's tempting to reduce the working space around components in order to shrink the overall size of the panel. However, you also need to provide adequate room to get your hands and tools into spaces. After building a panel, go evaluate the space you put around different devices and take some notes. This will help you improve future design. When working with larger wire, be sure to allow enough room to route and bend those wires.

5. Properly ground the panel and devices
Include a row of ground terminals in the panel and connect all ground wires here, including grounds from components, doors and the subplate. Consider mounting a ground terminal adjacent to the disconnect and running a large ground wire between it and the ground terminals. This makes it obvious where to terminate the ground for the incoming power.

Three useful national and international standards:

- NFPA79: Electrical Standard for Industrial Machinery—The official standard description is: "NFPA 79 provides safeguards for industrial machinery to protect operators, equipment, facilities, and work-in-progress from fire and electrical hazards," but it contains a wealth of helpful information and is an essential tool for anyone designing industrial controls and equipment.
- UL508A: the UL standard for the construction of Industrial Control Panels
- CE specifications for Europe – The CE specifications contain a mix of directives and standards, including 2006/42/EC Machinery Directive, 2014/35/EU Low Voltage Directive, 2014/30/EU Electromagnetic Compatibility Directive and a long list of other standards for machine safety systems, risk assessments, guarding, ergonomics.

There are also separate standards for specific types of equipment. The best way to get started is to consult with a notified body. A notified body is an organization authorized by the EU to assess the conformity of products. They can help you determine which directives and standards are applicable to your equipment and also discuss methods for certifying your equipment.

Some of the Machinery Directive elements should be incorporated into your standard designs. They're good practice and will help you create a more universal design. For example, use green/yellow wire for grounds and use touch-safe components throughout the panel.

And finally, for panel design and build resources, we have a section of Allied's Expert Advice content dedicated to industrial control panels, and we've partnered with both Schneider Electric and Eaton on industrial panel builder digital resource hubs.

JIM DAVIS
director of advanced solutions and technical support / Allied Electronics & Automation / www.alliedelec.com