A COMPARISON OF PLCs AND LADDER LOGIC WITH OPTO 22 HARDWARE AND SOFTWARE

A Little History

Industrial automation was originally implemented with discrete relays and timers, which were connected with copper wire. Banks of relays appeared in semi-automated factories, notably automobile plants. Although a great improvement over manual control, this type of automation structure had a major disadvantage: to change the function (or logic) of the control system, the system had to be literally re-wired.

The PLC (programmable logic controller) was developed to replace physical relays and timers with a purpose-built small computing unit designed for industrial environments. A PLC's CPU (central processing unit) is essentially a scanning device that runs a loop through every I/O point. The loop scans all the PLC's input points, solves the user logic program, and then sets all its outputs, over and over. Because a PLC works in this way, the speed of its *scan time* is a measure of its capability.

In contrast, Opto 22 controllers are **logic-driven** devices. An Opto 22 groov EPIC® (edge programmable industrial controller), a SNAP PAC (programmable automation controller), or even a legacy mistic controller (dating from the early 1990s) does not have to look at I/O or variables until the logic in the controller requires it. When logic requires I/O or variable values, an Opto 22 controller immediately gets only the values needed. The values are fresh, and the controller doesn't have to waste processing power continually scanning I/O.

An Opto 22 control system also works differently from a PLC system because it utilizes a **distributed architecture**. The controller runs the control program, but an intelligent I/O processor in each I/O rack handles many functions independently. These functions include counting, latching, pulsing, frequency and period measurement, watchdogs, totalizing, minimum and maximum values, scaling, clamping, ramping, and more. An I/O unit can also run multiple PID (proportional integral derivative) control loops independently. All of this distributed intelligence reduces the load on the controller.

Most PLCs are part of proprietary systems built by one manufacturer and designed to be used with their own products. Opto 22 systems, however, are built on **open standards**—not only automation standards such as OPC UA and Modbus, but also internet and IT (information technology) standards such as Ethernet, HTTPS, and MQTT.

Comparing PLCs and Opto 22 Control Systems

The combination of logic-driven control, a distributed architecture, and open standards gives Opto 22 control systems some distinct advantages, including efficiency, scalability, and the computing capacity for abilities far beyond control.

Efficiency: Apples, Oranges, and PLCs

Because PLCs and Opto 22 systems are so different, it is easy to be misled by comparisons. For example, a critical specification for a PLC is speed in checking I/O points, often expressed in terms of the time required to complete one process scan. Many PLCs have very fast scan times, but fast is not necessarily efficient.

With Opto 22's logic-driven control and distributed intelligence, scan speed isn't a valid performance metric. The reaction time for Opto 22's intelligent I/O processors depends on the processor and the application and can reach low millisecond timeframes. Counting speeds vary by I/O module and range up to 200 kHz; pulse measurement has 100 microsecond resolution. These and other time-critical operations are standard functions for Opto 22's distributed, intelligent I/O. The result of this distributed approach is that Opto 22 controllers can perform other required tasks in the control system much more efficiently.

For some discrete applications, such as bottling lines, PLCs are efficient and scan time essential. For larger, more complex applications, especially involving analog processing, data acquisition, or industrial internet of things (IIoT) data communications, the architecture of Opto 22 systems is more adaptable and efficient.

Scalability: Change and Expand at Will

Distributed intelligence, logic-driven control, and open standards also make it easier to change and expand control systems. I/O units can be added where needed without disturbing the system as a whole or putting too much strain on the central controller. Distributed intelligence also builds fault tolerance into the system, because an I/O unit can continue to solve its logic locally even if the connection to the main controller is severed. Systems can be scaled more easily to meet these kinds of needs:

- Updating a process with additional equipment
- Controlling pumps and pressures at multiple remote sites
- Adding a production line in your factory
- Monitoring access to a remote installation
- Getting data that is trapped in legacy PLCs

Although a PLC may be very fast, as the number of I/O points or PID loops increases, the system's ability to scan the I/O and resolve the logic diminishes. Because Opto 22 products are distributed and modular, it is much more difficult to overload an Opto 22 system. But if that happens, Opto 22's product philosophy means that options are usually available. That product philosophy includes:

- Designing new products for the long term
- Providing upgrade paths, so existing systems will work with new ones

- Continuing to build older products as long as required components are available
- Supporting all products (for free) as long as customers have them

Capacity: Capabilities Beyond Control

In 2018, Opto 22 introduced the *groov EPIC® system*. Based on the company's 40+ years of experience in automation, *groov* EPIC was designed from the ground up to meet the new requirements that control engineers are seeing today—and will see tomorrow. In addition to real-time industrial control, these requirements include security, data communications with legacy as well as newer equipment, and easy ways to interact with IT systems.

- Security features in *groov* EPIC include user authentication, data encryption, a configurable device firewall, security certificate management, and VPN client. (For more information on security, see the *groov EPIC Security Design and Best Practices Technical Note*.)
- In addition to control programming software, tools include Ignition Edge® from Inductive Automation® (providing OPC UA drivers for Allen-Bradley®, Siemens® PLCs, and Modbus® hardware and software), Node-RED for creating simple data flows with prebuilt functions, and efficient MQTT publish-subscribe communication. These tools help you communicate with a variety of automation devices, software, and services, both on premises and cloud based.
- With its Linux® operating system, dual independent Gigabit Ethernet network interfaces, HDMI and USB ports, and features such as LDAP (lightweight directory access protocol) *groov* EPIC provides flexible standards-based networking.

Practical Examples

Two practical examples of the differences between centralized PLC architecture and Opto 22's distributed architecture are how analog signals and PID control loops are handled.

***groov* EPIC system**

Analog Signals

The differences between PLCs and Opto 22 systems appear very quickly when dealing with analog signals. Many PLCs have to execute logic and instructions in the CPU to handle the conversion and scaling of analog values from the raw counts received from the physical I/O into meaningful scaled values (for example, rate of change, gallons per minute, degrees Fahrenheit, or PSI).

With an Opto 22 system, much of the overhead in handling analog signals is done by the intelligent I/O processor on the I/O unit. These processors scale and linearize analog signals into meaningful engineering units, so that when the values are read, no further conversion processing is required. Because these functions reside in the I/O unit, there is no degradation in performance as system size increases.

PID Loop Control

PID handling also illustrates the differences between the Opto 22 architecture and PLCs. Many PLCs handle PID loops, but almost all perform their PID calculations in the CPU of the PLC. The calculations needed for multiple PID loops can quickly bog down the PLC, and a separate loop controller may be required.

In an Opto 22 system, PID loops normally are not processed by the controller. Instead, they are handled by the distributed I/O processor on the I/O unit (up to 96 loops per unit). For more PID loops, more I/O units can be added. As the number of PID control loops in an Opto 22 system increases, there is no decline in performance.

Programming

When PLCs were developed to replace wired relays, they were programmed using a method called ladder logic. Ladder logic (or ladder diagram) is a software representation of the wiring diagrams used in the old days of discrete relays and timers, so it was easily understood by existing technicians at that time. Applications that closely resemble the discrete relay model are well suited for control with a PLC programmed in ladder logic.

When an application deviates from the relay model, however, programming in ladder logic becomes increasingly more difficult. Fundamentally, any statement in computer logic can be represented by a combination of on and off switches, or ones and zeros. But computer programmers don't work in machine language (ones and zeros) unless they absolutely have to. Instead, they use higher-level languages that make programming and maintenance faster and easier.

Over the years PLC manufacturers have improved the situation by offering alternative languages based on concepts like flowcharts. The IEC 61131-3 standard recognizes several languages, including:

- Function Block Diagram (FBD)
- Structured Text (ST)

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- Sequential Function Charts (SFC)
- Ladder Diagram (LD)

However, these languages generally compile into ladder logic, so even though the program may be easier to write, there are still functional limitations because the hardware platform was designed to run ladder logic.

To add features like communications or complex math functions to ladder logic, different hardware and programming environments often have to be implemented and integrated to support functions the ladder logic cannot perform. Linking the two environments causes additional overhead that can degrade the overall system performance. Programming becomes much more complex and therefore harder to understand. A system that is hard to program, understand, or document costs extra time and money in development and maintenance.

In contrast, Opto 22's *groov* EPIC is at heart a multi-threading computer with a quad core CPU. *groov* EPIC offers a choice of methods for control programming:

- PAC Control, a field-proven, flowchart-based, multi-chart control language (also used for SNAP PAC controllers)
- Any IEC 61131-3 compliant language with the CODESYS Development System and CODESYS runtime
- C, C++, Java, Python, or other custom applications, built for the *groov* EPIC's Linux RTOS using secure shell access (SSH)

Programs developed in Opto 22's PAC Control are especially easy to understand, because control logic is developed and represented in flowcharts that provide a visual illustration of the process. PAC Control's integrated real-time debugger makes it easy to follow the flow of control logic, understand what is happening, and maintain or troubleshoot the system after the project is in production. The entire system configuration is graphically presented in PAC Control's Strategy Tree, a representation of the distributed control system: controllers, I/O points, variables, and even the logic itself.

Thanks to its capable CPU, *groov* EPIC offers software tools in addition to control programming that can be used simultaneously:

- Node-RED, a visual, flow-based editor and runtime with free pre-built functions for sharing data with databases, web services, and other software
- *groov* View for building and viewing mobile HMIs
- Ignition Edge® or full Ignition from Inductive Automation®, providing OPC UA drivers, efficient MQTT data communications, and much more (additional license required)

The Bottom Line

Another important consideration when comparing PLCs with Opto 22 control systems is cost. While the cost of a particular piece of hardware may be more or less, it is important to consider the overall cost of a system—the life cycle cost.

Life cycle cost is the total cost to purchase, install, program, maintain, upgrade, and operate a control system over its life in the enterprise. In life cycle costs, Opto 22 systems are nearly always less expensive than PLCs.

- Opto 22 systems perform all the functionality mentioned with the standard hardware.
- Included software supports all these functions without additional fees (except as noted above) and without needing to add co-processors or special-function hardware.
- Most I/O is guaranteed for life.
- Pre-sales engineering assistance is free.
- Online product training is free.
- Product support is free and provided by experienced engineers in Opto 22's Temecula, California headquarters and factory.

For complex, flexible, reliable systems that can not only provide real-time industrial control but also meet newer requirements for modern connectivity and data communications, it pays to take a look at Opto 22 systems.

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

Famous worldwide for its reliable industrial I/O, the company in 2018 introduced *groov* EPIC® (edge programmable industrial controller). EPIC has an open-source Linux® OS and provides connectivity to PLCs, software, and online services, plus data handling and visualization, in addition to real-time control.

The company's latest product line, *groov* RIO®, provides compact, autonomous edge I/O that is ideal for communicating field data in IIoT applications.

All Opto 22 products are manufactured and supported in the U.S.A. Most solid-state SSRs and I/O modules are guaranteed for life. The company is especially trusted for its continuing policy of providing free product support and free pre-sales engineering assistance.

For more information, visit opto22.com or contact Opto 22 **Pre-Sales Engineering** using the **Contact Us form** on our website.

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