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Programmable Controllers

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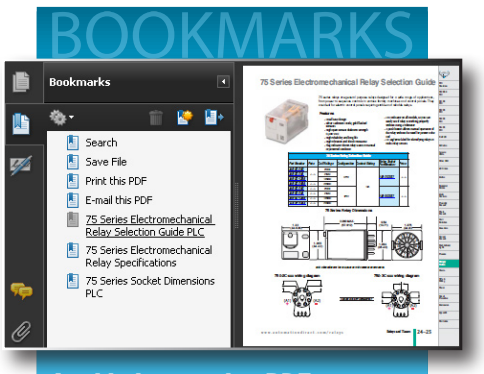

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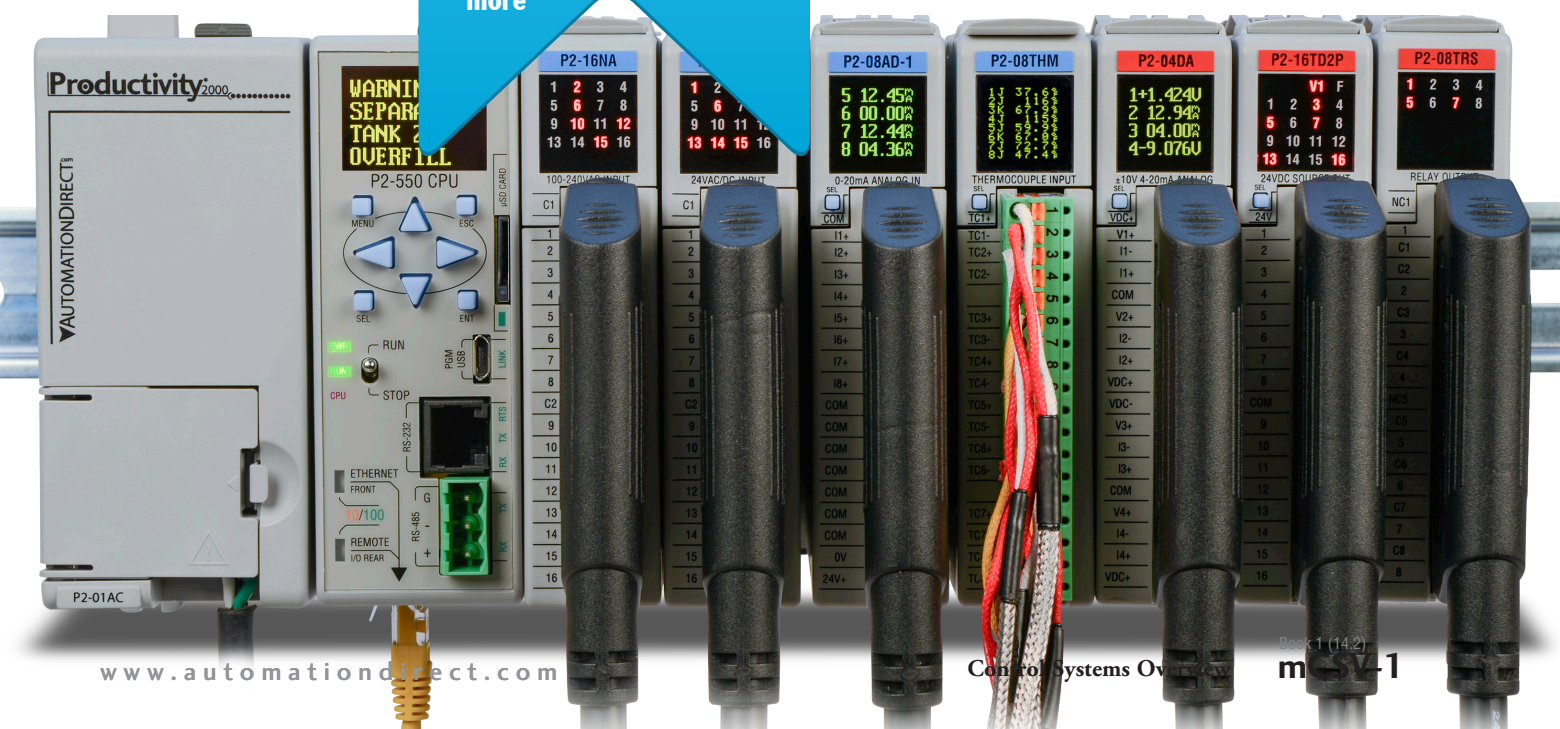


What is a Programmable Controller?

What are programmable controllers and how do they work?

Programmable controllers are often defined as miniature industrial computers that contain hardware and software used to perform control functions. A controller consists of two basic sections: the central processing unit (CPU) and the input/output interface system. The CPU, which controls all system activity, can further be broken down into the processor and memory system. The input/output system is physically connected to field devices (e.g., switches, sensors, etc.) and provides the interface between the CPU and the information providers (inputs) and controllable devices (outputs).

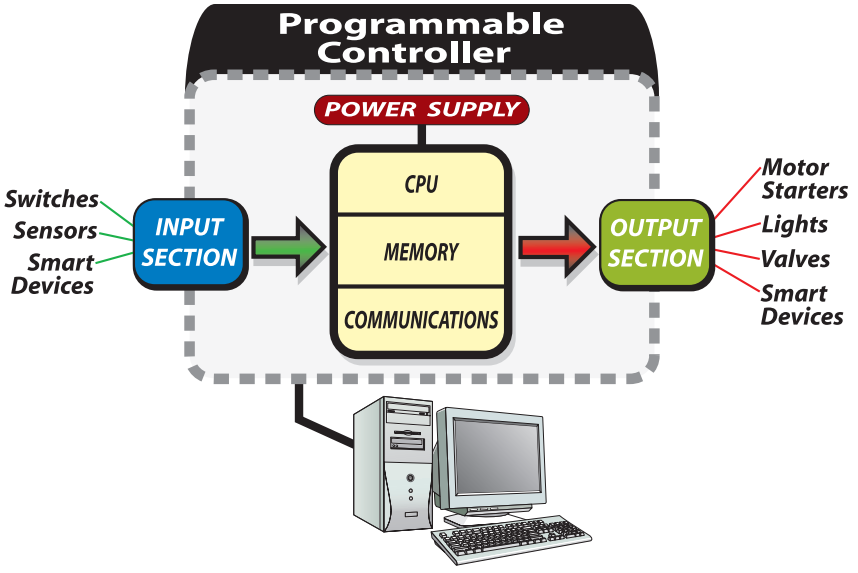
To operate, the CPU "reads" input data from connected field devices through the use of its input interfaces, and then "executes" or performs the control program that has been stored in its memory system. Programs are typically created in ladder logic, a language that closely resembles a relay-based wiring schematic, and are entered into the CPU's memory prior to operation. Finally, based on the program, the PLC "writes" or updates output devices via the output interfaces. This process, also known as scanning, typically continues in the same sequence without interruption, and changes only when a change is made to the control program.

Discrete applications

Programmable controllers are often used to control machines or processes that are sequential in nature, using "discrete" inputs and outputs that have defined states. For example, if a limit switch detects the presence of an object, it provides an "ON" signal to the PLC; if no object is detected, it provides an "OFF" signal. The machine or device typically performs actions based on time or events in a pre-defined order. The expected sequence is typically interrupted only when an abnormal condition occurs.

Process control applications

Programmable controllers can also control continuous processes that use analog I/O. For example, a temperature sensor may provide a variable signal, such as 0-10 volts, based on the measurement of an actual temperature. The controller program monitors the sensed values continuously and operates devices that may also be analog in nature. This could include setting the position of a valve between 0-100% open, or controlling the speed of a motor. Continuous applications are so called because they typically have no defined start or end once they are initiated; they maintain a process in a "steady" operating state.



Today's controllers

Initially, devices that exhibited the attributes discussed here were known as Programmable Logic Controllers (PLCs). This tended to emphasize that the main functionality of these systems was LOGIC operations. As technology has advanced, so have programming languages and communications capabilities, along with many other important features. These developments seemed to demand the definition of a new class of controller, the Programmable Automation Controller (PAC), which combines features of traditional PLCs with those of personal computers.

In the past, size was typically used to categorize controllers, and was often an indication of the features and types of applications it would accommodate. Small, non-modular PLCs (also known as fixed I/O PLCs) generally have less memory and accommodate a small number of inputs and outputs in fixed configurations. Modular PLCs have bases or racks that allow installation of multiple I/O modules, and will accommodate more complex applications. With the emergence of PACs, functionality is the determining factor in categorizing controllers.

Which programmable controller is right for you?

Choosing the most effective controller for your application depends on a number of factors. To begin the selection process, a drawing of the machine or process is a good start. This can help identify field devices and physical requirements for hardware locations. From the drawing, you can determine how many analog and/or discrete devices you will have.

Once the field device requirements and hardware locations are defined, you can review controllers that will meet your requirements. See the Controller Selection Worksheet in this section that will help you work through the considerations for determining the type of controller you will need, regardless of which manufacturers you are evaluating.

Considerations for Choosing a Controller

Use the worksheet on the following pages as a checklist of the things to consider when determining programmable controller requirements. It lists the most important areas to consider when choosing a system, and provides space for recording determinations of your system needs.

Consideration	Information to Record		Why this is important
1. Proposed System	____ New system	_____ Existing system	Determine whether your system is new or existing: Will your system be installed from scratch or are there existing products already installed? The rest of your system will need to be compatible with new components. ***Why this is important:*** Certain controller products may not be compatible with others. Making sure your existing products are compatible with any new products you are researching will save you time and money. Check appropriate entry.
2. Environmental Issues	____ Codes/environmental issues to consider	____ No codes or environmental issues to consider	Consider any environmental issues that will affect your application (temperature, dust, vibration, codes specific to your facility, etc.). ***Why this is important:*** Certain environments may affect the operation of a controller. For example, typical controllers have an operating temperature of 0-55 degrees Celsius (32-130 degrees F). If your application will include any extreme environmental conditions, or you have specific codes at your facility that must be met, you will need to either research products that meet those specifications or design the installation to meet requirements. Check appropriate entry.
3. Discrete Devices	_____ Total inputs: _____ AC _____ DC	_____ Total outputs: _____ AC _____ DC	Determine how many discrete devices your system will have. Which types (AC, DC, etc.) are needed? ***Why this is important:*** The number and type of devices your system will include is directly linked to the amount of I/O that will be necessary for your system. You will need to choose a controller that supports your I/O count requirements and has modules that support your signal types. Enter quantities and type based on corresponding field devices.
4. Analog Devices	_____ Total inputs: ____ Voltage ____ Current ____ Thermo ____ RTD	_____ Total outputs: ____ Voltage ____ Current	Determine how many analog devices your system will have. Which types (voltage, current, temperature, etc.) are needed? ***Why this is important:*** The number and type of devices your system will include is directly linked to the amount of I/O that will be necessary for your system. You will need to choose a controller that supports your I/O count requirements and has modules that support your signal types. Enter quantities and type based on corresponding field devices.
5. Specialty Modules or Features (application-specific)	_____ High speed counter _____ Positioning _____ Servo/stepper _____ BASIC programming _____ Real-time clock _____ Others (list)		Determine whether your system will require any specialty features: Will your application require high-speed counting or positioning? What about a real-time clock or other specialty feature? ***Why this is important:*** Specialty functions are not necessarily available in a controller CPU or in standard I/O modules. Understanding the special functions your system may perform will help you determine whether or not you will need to purchase additional specialty modules. Check all features required.

Table continued on the following page

Considerations for Choosing a Controller

Consideration	Information to Record	Why this is important
6. CPU Required	**Hardware requirements:** _____ K program memory required (estimated) _____ K data memory required (estimated) _____ Fast scan time required? _____ Battery backup required? **Software/special function requirements:** ____ PID ____ Floating Point Math Others (see Programming section below)	Determine the type of CPU you will need: How much memory will your system require? How many devices will your system have (determines data memory)? How large is your program, and what types of instructions will your program include (determines program memory)? How fast a scan time do you need? ***Why this is important:*** Data memory refers to the amount of memory needed for dynamic data manipulation and storage in the system. For example, counter and timer instructions typically use data memory to store setpoints, current values, and other internal flags. If the application requires historical data retention, such as measured device values over a long period of time, the size of the data tables required may determine the CPU model you choose. Program memory is the amount of memory needed to store the sequence of program instructions that have been selected to perform the application. Each type of instruction requires a specific amount of program memory, typically defined in a programming manual. Applications that are basically sequential in nature can rely on the I/O device rule of thumb to estimate program memory (five words of memory for each I/O device); complex applications will be more difficult to judge. If scan time is important in your application, consider the CPU processor speed as well as instruction execution speed. Some CPUs are faster at boolean logic but slower with data handling instructions. If special functions such as PID are required, the CPU you select may make those functions easier to perform. For program memory required, follow this rule of thumb: 5 words of program memory for each discrete device and 25 words for each analog device. Check or calculate all requirements that apply.
7. I/O Locations	_____ Local … only _____ Remote Locations Specific remote I/O protocol required? Which one? _____	Determine where your I/O will be located: Will your system require only local I/O, or both local and remote I/O locations? ***Why this is important:*** If subsystems will be needed at long distances from the CPU, you will need a controller that supports remote I/O. You will also have to determine if the remote distances and speeds supported will be adequate for your application. Serial and Ethernet-based I/O hardware are two typical choices available for most systems. This I/O may also be referred to as distributed I/O, and may require a particular protocol, such as Modbus. Enter number of physical locations needed, and if/what specific protocol may be required.
8. Communications	_____ Ethernet _____ PLC to PLC _____ Modbus RTU _____ ASCII (interface to serial devices) _____ Other	Determine your communication requirements: Will your system be communicating to other networks, systems or field devices? ***Why this is important:*** Communication ports (other than the programming port) are not always included with a controller. Knowing your system communication requirements will help you choose a CPU that supports your communication requirements, or additional communication modules if necessary. Check any/all communications functions required.
9. Programming	_____ Floating point math _____ Drum sequencer _____ PID loops _____ number of loops needed _____ Subroutines _____ Direct interrupts _____ Others (list)	Determine your programming requirements: Does your application require only traditional programming instructions, or are special instructions necessary? ***Why this is important:*** Certain controllers may not support every type of instruction. You will need to choose a model that supports all instructions that you may need for a specific application. For example, built-in PID functions are much easier to use than writing your own code to perform closed-loop process control. Typical instructions such as timers, counters, etc. are available in most controllers; note any other special instructions required here. Check any/all programming functions required.

Programmable Controller Summary

Those making the buying decisions for Programmable Controller applications can have very different needs. We offer a selection of controller families that can fit a variety of applications. Regardless if you are a newcomer to programmable controllers or if you are a seasoned veteran; whether you need simple discrete control or if you need to calculate complex algorithms lightning fast, we have a controller family that is perfect for you.

Easy for new user
Basic machine control
Lowest cost
Simple analog
FREE Software

CLICK: Our best value PLC

The CLICK PLC is becoming one of the industry's favorite control systems in the 142 I/O or less category.

Basic PLCs:
- 8 DC In / 6 DC Out (sinking)
- 8 DC In / 6 DC Out (sourcing)
- 8 DC In / 6 Relay Out
- 8 AC In / 6 Relay Out

Standard PLCs:
- 8 DC In / 6 DC Out (sinking)
- 8 DC In / 6 DC Out (sourcing)
- 8 DC In / 6 Relay Out
- 8 AC In / 6 Relay Out

Analog PLCs:
- 4 DC In / 4 DC Out (sinking), 2 Analog In, 2 Analog Out (current/voltage selectable)
- 4 DC In / 4 DC Out (sourcing), 2 Analog In, 2 Analog Out (current/voltage selectable)
- 4 DC In / 4 Relay Out, 2 Analog In, 2 Analog Out (current/voltage selectable)

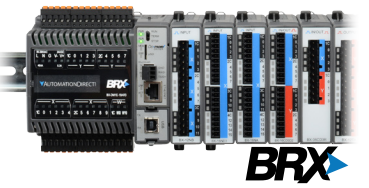
- Built-in communication ports (two in Basic PLC units, three in Standard and Analog PLC units)
- Optional battery backup (Standard and Analog PLCs units only)
- Real time clock/calendar (Standard and Analog PLCs units only)
- Removable terminal blocks for easy wiring
- Stackable discrete and analog I/O option modules (DIN-rail or panel mountable)
- Program AND documentation stored in PLC unit
- Decimal memory addressing
- 21 easy-to-use instructions
- 8,000 steps of program memory

Fast CPU
CPU w/ built-in Ethernet
H2 works with most DL205 I/O modules. T1H works with most Terminator I/O.
Advanced discrete
Process control
Expandability
FREE Software

Do-more Series PLCs: Spend Less, Do More!

The Do-more PLC family is a robust, versatile controller family that boast many high-performance features at a fraction of the cost of comparable controllers.

- Cost effective hardware
- Documentation can be stored on board
- Built-in communications include USB programming, serial, and (optional) Ethernet
- Practical counting/pulse
- Data-logging included
- High-performance processors
- FREE programming software (with built-in simulator)
- Hot-swappable communications ports (BRX series only)
- Powerful control over program execution
- Enhanced troubleshooting tools
- FREE online training with coupon
- Starter kits available



Advanced discrete and process
Data collection
Extensive communication
Built-in data displays
Web Server
FREE Software

Productivity Series: Premium features at a value price

The Productivity controllers shatter the price per feature paradigm in every category, with prices that can't be beat and a two-year warranty on all modules.

- Auto discovery of hardware, including remote I/O bases (P3000 only) and GS drives when connected to the Ethernet remote I/O network
- Tag name database programming
- Task management
- Advanced "fill-in-the-blank" instructions
- Seamless corporate database connectivity
- Run-time editing and project transfer
- Project file, tag database and ladder documentation stored in the CPU
- FREE Productivity Suite software

Advanced discrete
Basic process control
Expandability
Ethernet
FREE Software*

*100-word program limitation, $395 for unlimited program sizes

DirectLOGIC: Long-running PLCs

*Direct*LOGIC PLCs (nano fixed I/O to modular units) are industry workhorses, time-tested in some of the toughest industrial settings.

All platforms use the same *Direct*SOFT programming software, so your investment is protected.

Six PLC platforms to choose from in the *Direct*LOGIC family:
- DL05 stand-alone brick with one option slot (30 I/O max)
- DL06 stand-alone brick with 4 option slots (100 I/O max)
- DL105 stand-alone brick with high amp relays (18 I/O max)
- DL205 powerful modular PLC with the most available option modules (up to 16,384 I/O max)
- DL305 time tested, legacy control platform (up to 368 I/O max)
- DL405 time tested, legacy control platform (up to 16,384 I/O max)

Application Briefs

DL06 PLC puts heaters to the test

Pyromatics Automation Systems of Crystal Lake, Il. was contracted by a customer to develop a Life Cycle Test Station for its electric heating elements.

This test station needed a user-friendly graphical interface to give operators the ability to select multiple ramp/soak parameters, output voltages, temperature sensor types, amperage ratings and total cycle counts on tests for the cast-in electric heater platens. The system also needed to record temperature, volts, and current draw throughout the test for use in quality reports. Also, a failure of the heater required a safe shutdown of the test while alerting the quality department of the alarm condition.

Pyromatics selected the cost-effective DirectLOGIC® DL06 PLC as the heart of the system because of its ability to control up to eight PID loops and the multiple expansion slots available for thermocouple cards and analog input modules. It also controls two heaters, two chillers and an array of panel indicators, buttons, switches and relays.

A C-more 10-inch TFT touch-screen operator interface was used to provide operators with the necessary interface to operate and monitor the tests.

The completed system allows users to quickly connect the heater to be tested, enter test parameters, and run the test. Trend charts on the C-more panel track test parameters and quickly identify potential issues such as sudden drops in current or temperature.

Alarm reporting and history are also automatically recorded, allowing the operator to determine causes of failure. Data from the test can be easily uploaded to a USB thumb drive from the C-more panel. The data can then be imported into the user's choice of word processor or spreadsheet.

Semi cab sheeting production improved

ITS, a design build firm in Columbus, Ohio specializes in industrial automation. The company was contacted by a division of International Harvester responsible for the manufacturing of semi cabs. International Harvester uses automated machines to place aluminum rivets on sheeting that is attached to the frame of the semi cabs. The original CNC machines were becoming antiquated and needed to be upgraded.

ITS chose a DL205 PLC as the new controller for the machines, along with discrete I/O and an H2-CTRIO high-speed counter module that drives a dual axis servo. An H2-ECOM Ethernet Communications card links the machines back to an office for data acquisition. ITS also added a 15-inch touch screen for diagnostics.

In the new system, an operator stamps sheets of aluminum to welded framework with a handful of hand rivets and then places the product onto a dual axis servo table. After the operator selects one of five different parts programs, the machine will navigate the panel under the head assembly, which is responsible for the drilling and riveting, with a tolerance of 1/10 of a millimeter. The panel is drilled and a rivet is installed and squeezed to approximately 1200 PSI, producing a rivet consistency within .003 in. After completion of the panel (between 64 and 138 rivet locations), the machine will return to its home position and await the next product.

The solution increased productivity by approximately 30% and provides an easy way to run and maintain the machines.

Cost-effective I/O simplifies hydroelectric plant controls upgrade

Lockhart Power Company owns and operates a hydroelectric plant located on the Broad River in upstate South Carolina.

The plant includes an 8-gate dam feeding a canal that channels the water flow to the powerhouse. The powerhouse contains five turbine generators with a combined power capacity of over 17 MW. The dam and turbine control system receives data from power, flow, and level sensing devices to perform monitoring and control of the dam, generators, and associated equipment.

Lockhart Power contracted North Fork Electric in Crumpler, NC, to lend their expertise to a renovation of the conrtol system.

The system consists of seven DirectLOGIC DL205 micro-modular PLCs with built in PID functionality. Each of the five systems for generator control includes discrete and analog I/O, and an Ethernet communications module. The remaining two PLCs are configured in a master/slave arrangement and control the dam gates, located upriver from the powerhouse, via radio modems. Operator interfaces include two 6-inch color touch screen panels and a Windows NT-based PC running the LookoutDirect SCADA/HMI software package.

In the automatic mode, the PLC can start, stop, and operate the generator, and control startup and synchronization of the turbine. Changing the generator gate position varies the flow of water to the turbine.

The dam control system controls the eight canal gates located at the dam, which regulate the flow of water downstream to the turbines.

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- **Advanced PLC training course (three days) covering advanced programming and debugging, with remote I/O, networking, modems and more**
- **PID training course (two days) covering PID loop setup, tuning and troubleshooting, as well as shortcuts and tools the experts use**

Go online to:
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Training sets

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Want to learn how to program our PLCs in the comfort of your own office? Doug Bell has created two hands-on training kits, one based on his world-famous basic PLC training class, the other focusing on PLC analog principles. The basic PLC training kit includes two videotapes or one DVD, a pre-wired trainer containing a DL05 PLC, and the DL05 User Manual.

The analog training kit includes two videotapes or one DVD, a pre-wired trainer with potentiometers and meters, a DL05 analog input/output module, I/O cable and 24 VDC power supply. Each kit can be ordered directly from ICA.

(*Direct*SOFT programming software must be purchased separately.)

Online training

If you can't travel and can't justify a training kit, how about inexpensive online training? Check out Doug's online training videos for PLCs and HMI.

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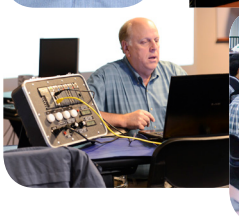
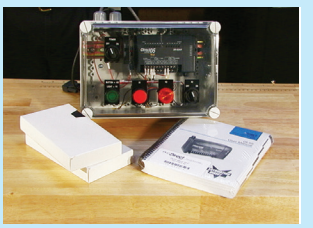


"Introduction to PLC Logic and Principles" video or DVD and training kit

Get the most important lessons from the three-day basic PLC seminar in a step-by-step two-video or DVD set.



"PLC analog I/O" training video or DVD and hardware

Learn the ins and outs of using analog I/O with PLCs in this step-by-step training set.

Check the Appendix for complete descriptions of the training kits and course contents.

Online training at www.interconnectingautomation.com

View the complete list of videos in each "library" as well as watch sample videos; when ready to purchase, register and pay for your selected libraries on a monthly basis. Get unlimited access anytime during the 30 days; videos can be viewed as many times as needed. Most libraries range from $29.95 - $39.95 per month. Typical libraries include:

- **Introduction to PLC Principles** (for the novice non-user with limited controls knowledge)
- **Do-More series PLC Training** (includes Introduction to PLCs library)
- **Productivity2000 series PLC Training** (includes Introduction to PLCs library)
- **CLICK series PLC Training** (includes Introduction to PLCs library)
- **Productivity3000 series Controller Training**

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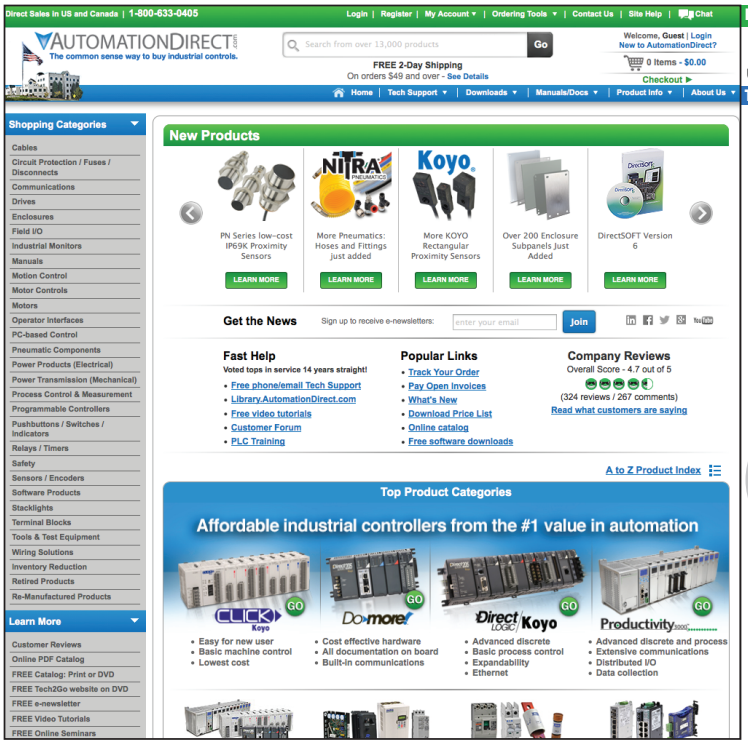

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- Search - use the Search box to find parts or information you need; use List or Picture organization. Parametric search results can help you find product by specifications required.
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