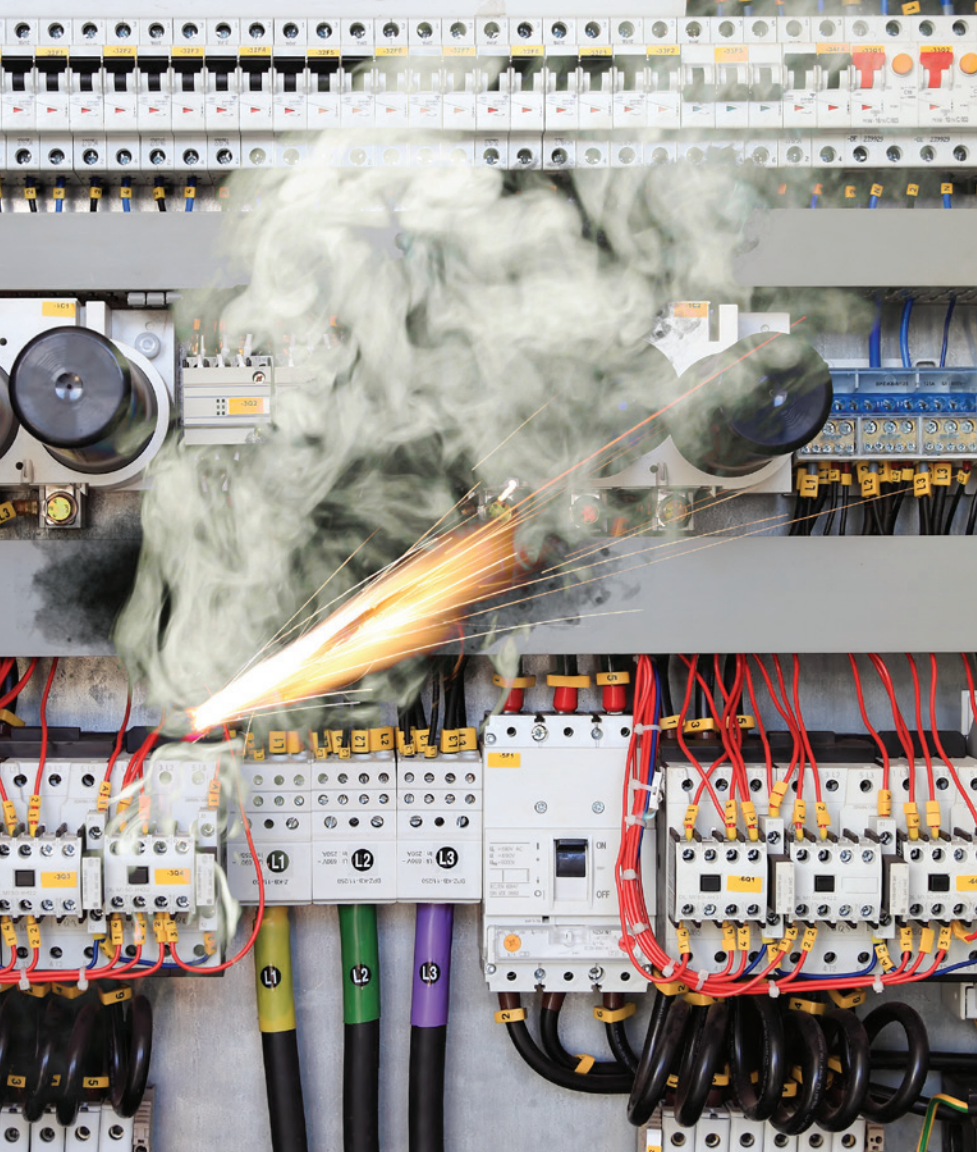


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Product Focus: Circuit Protection



What is Circuit Protection?

Circuit protection is a crucial element of industrial machine and electrical system designs, providing the utmost safety for both personnel and equipment. A circuit can become overloaded when its current exceeds the load it was designed to handle. There are many reasons why an electrical circuit may become overloaded and potentially cause damage to equipment, as well as fires and injury to personnel. In the U.S., all construction and equipment design and installation must adhere to rules and regulations developed by agencies such as the National Fire Protection Association (NFPA), who publishes NFPA70, the National Electrical Code (NEC). There may also be local requirements that must be followed as well. For every code and regulation, there are easily obtained devices that have been specifically designed to make meeting these requirements and ensuring the safety of systems and personnel as easy as possible.

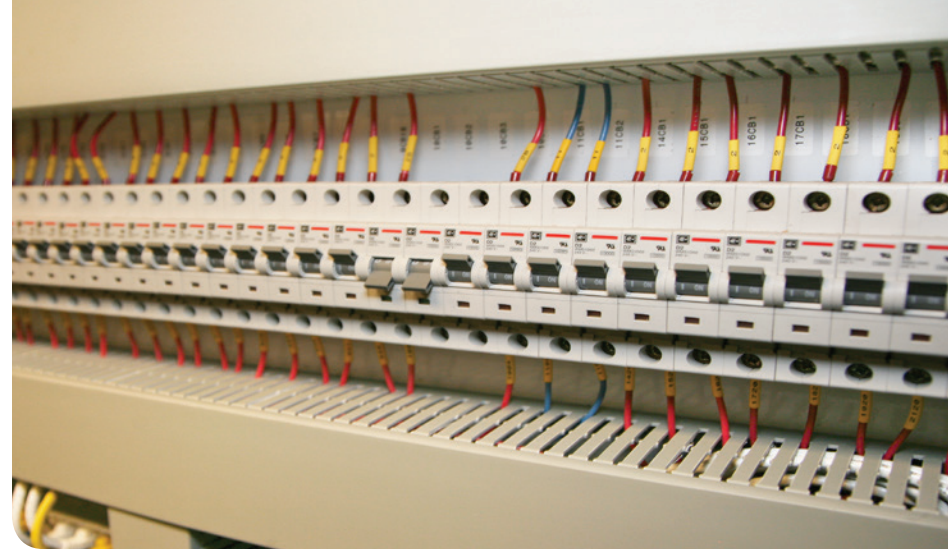
Common Causes of Electrical Problems

When designing, updating, or modifying a system or industrial machine, it is extremely important to understand the overall electrical system. You may want to add equipment and assume that all you need is to have the electrical power source available and simply add wiring to connect to this addition. However, it is critical to know if adding this load will overtax the system and create problems. Knowing the voltage, amperage and any other requirements ensures that your new design or modification can handle the load and operate efficiently.

Many common issues in electrical systems can be addressed with practical measures:

- **Power Surge:** Power surges cost U.S. companies more than \$80B yearly in equipment losses, downtime, and other damages. There is a tendency to associate a power surge with lightning strikes; however, about 80% of surges are generated within a power system. This can be solved by installing industrial surge protection devices, which will protect branch and/or individual equipment.
- **Overloading:** When adding new equipment or devices, it is important to ensure that the power source can handle the additional load required. A higher amperage breaker or fuse may be adequate, but sometimes a new circuit may be required to ensure safe and reliable operation.

- **Exposed Wiring:** Exposed wiring is a serious potential hazard for various reasons. A careless or temporary installation may leave wires exposed, or a damaged wire jacket might go unnoticed. Exposed wires could cause a short resulting in equipment damage, fire, and even serious injury to personnel. Correct exposed wiring, add wire ducts or conduit, or replace wire with a wire/cable that meets the specifications for the installation.
- **Incorrect Wire/Cable:** All cable and wire are designed to meet specific voltage, amperage, and even environmental conditions. The wire gauge size, material, sleeve material and jacket material all have an application purpose. It is important to select the wire that meets all requirements for your installation.
- **Improperly Sized Circuit Breakers or Fuses:** Circuit breakers and fuses are available in many sizes, shapes, ratings and configurations. A circuit breaker or fuse whose capacity has been undersized will cause service interruption and failure, while an oversized capacity circuit breaker or fuse will not protect the downstream system, causing system failure, equipment damage and even fire. Make sure all circuit breakers or fuses are properly sized for their loads.
- **Inadequate Control or Disconnect Switches and Devices:** Improperly sized control switches, disconnects, and power devices can cause failure or damage to components. Make sure all such devices support the specifications of the equipment they are controlling.
- **Improper Grounding:** Inadequate grounding can lead to serious system damage due to voltage fluctuations from power supplies, lightning, or accidental contact with a high voltage line. In addition, electronic devices within the system, lightning, or even the switching of heavy electrical loads like motors, may cause Electromagnetic Interference (EMI), which in turn can cause erratic operation or failure of any electronic circuit. Grounding provides a low impedance path that limits these voltages and stabilizes interference.



- **Equipment/Device Failure:** It is possible for equipment to fail and cause an overload or power surge, resulting in damage to other devices. Make sure that all equipment connected to the same circuit is also individually protected from power surges or spikes.
- **Enclosures and Wiring:** Even something as simple as selecting the correct enclosure, fittings, cable glands, terminals and more can cause issues if not done correctly. All these components are designed to meet certain specifications to ensure that all personnel and equipment is protected. An enclosure exposed to water splash or hazardous conditions will leak and cause shorts if the correct NEMA rating is not selected. Make sure all meet your requirements.
- **Electrical Noise or Electromagnetic Interference:** Certain industrial equipment and devices may cause a disturbance in an electrical system. This disturbance is created by electromagnetic induction or radiation, which can generate a frequency that will cause other devices to operate erratically. To prevent this, the addition of power line filters will reduce or eliminate the effects of any EMI or RF frequencies carried by cables/wiring in a system. Shielded cables can also help reduce or eliminate this problem. Use both to ensure the most trouble-free operation.

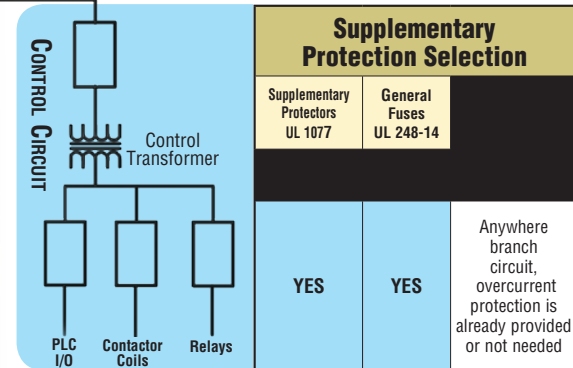
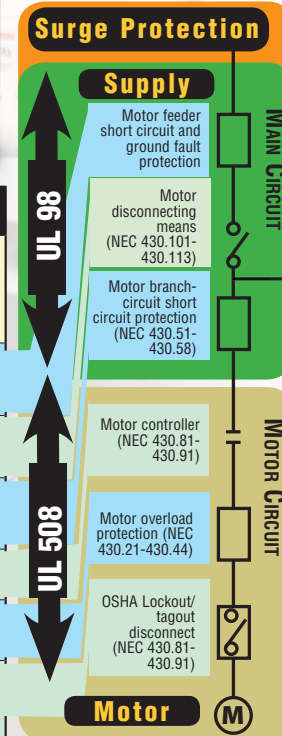


What Type of Protection to Use?

With so many products available, it has become increasingly difficult to choose appropriate devices for specific requirements.

This chart provides general guidance on what devices are suitable for various aspects of circuit protection within an electrical system.

Circuit Protection Selection							
	Molded Case and DIN rail mounted UL489 Circuit Breakers	Current Limiting Fuses UL 248	Disconnect Switches UL 98	Manual Motor Starters (MMS) UL 508	Load Switches UL 508	Supplementary Protectors UL 1077	General Fuses UL 248
Short circuit for feeder and branch circuits	YES	YES	YES	NO	NO	NO	NO
Motor disconnecting means (NEC 430.101-430.113)	YES	YES	YES	NO	NO	NO	NO
Motor branch-circuit short circuit protection (NEC 430.51-430.58)	YES	YES	YES	NO	NO	NO	NO
Motor controller (NEC 430.81-430.91)	YES	YES	YES	NO	NO	NO	NO
Motor overload protection (NEC 430.21-430.44)	YES	YES	YES	YES	NO	NO	NO
OSHA Lockout/tagout disconnect (NEC 430.81-430.91)	YES	YES	YES	YES	YES	NO	NO



Supplementary Protection Selection		
Supplementary Protectors UL 1077	General Fuses UL 248-14	
YES	YES	Anywhere branch circuit, overcurrent protection is already provided or not needed

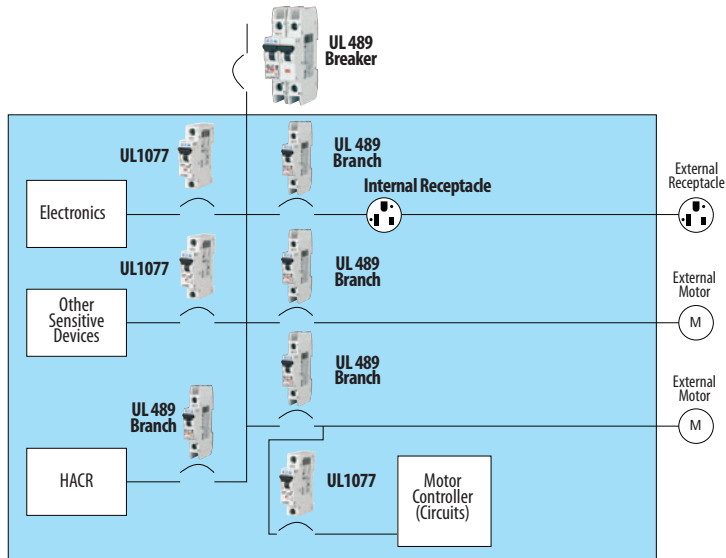
Branch or Supplementary Circuit Protection?

• Branch Circuit Protection

Branch circuit protection typically refers to overcurrent protection for conductors and devices following a previous protective device. UL 489-rated circuit breakers are often used for branch circuit protection of feeder circuits downstream from a main disconnect, internal/external receptacles, external motors or HACR equipment (heating, air conditioning and refrigeration).

• Supplementary Protection

UL1077-rated supplementary protectors are used for overcurrent protection within appliances or electrical equipment, or where branch circuit protection is already provided or not required. Supplementary devices are often used for lower-load equipment, internal loads, or as a simple additional disconnecting means.



Example of UL 489 and UL 1077 Application

UL489 Branch Protection

- UL489 Listed or Recognized
- CSA C22.2 No. 5
- International ratings available depending on breaker type

Function

- Opens automatically on Overload and Short Circuit when properly applied within its ratings
- Protects wire and cable against Overload and Short Circuit

Applications

- Branch circuit protection in control panels, panelboards, switchboards and motor control centers
- Motor overload and motor short circuit protection (UL489 Recognized motor circuit protectors) for control panels and motor control centers

Features

- Bolted down or DIN-rail mounted
- External handle mechanisms available
- Field mounted accessories
- Stand alone branch circuit protection
- Various levels of protection (curve type)
- High voltage and interruption levels (up to 100 kAIC @ 480V)

kAIC = thousands of Amps interrupt capacity

Summary

A Supplementary Protector can't be used for Branch Circuit Protection.

Understanding the difference between Branch Circuit Protection and Supplementary Protection helps to ensure their proper use.

UL1077 Supplementary Protection

- UL Recognized under UL1077
- CSA 22.2 No. 285
- IEC 60947-2 or IEC 898

- Opens automatically on Overload and Short Circuit
- Provides additional equipment protection where branch circuit protection is already provided or not required
- Not suitable for the protection of branch circuit conductors

- Used within appliances or other electrical equipment such as control circuits, control power transformers, relays, PLC I/O points and lighting circuits
- Ideal replacement for fuses that are applied as supplementary protection

- DIN-Rail mounted
- Field mounted accessories
- Various levels of protection (curve type)
- 10 kAIC @ 240 VAC
- 10 kAIC @ 277 VAC and 5 kAIC @ 480VAC
- 10 kAIC @ 48VDC



Fuses: Why and Where

Fuses can serve the same purpose as circuit breakers and are usually a more cost-effective method of overcurrent protection. They work well in applications where high fault current exists, and are commonly used to protect transformers, power supplies, and motors.

Fuses' main advantage is that they don't wear out as there are no moving parts, and contamination by dust or oil is unlikely. The biggest disadvantage is the need for replacement after operation, unlike a circuit breaker, which can typically be reset.

Also, fuses inherently increase the chance of single phasing. Thus, while a fuse protects the system from a fault, equipment can be damaged by a single-phase condition, so key devices should be equipped with blown-fuse detection phase monitoring devices.

Common terms for fuse selection

Ampere Rating: The continuous current carrying capability of a fuse under defined laboratory conditions. The ampere rating is marked on each fuse.

Fast-Acting Fuse: This is a fuse with no intentional time-delay designed into the overload range. It is sometimes referred to as a "single-element fuse" or "non-delay fuse."

Fault Current: Short-circuit current that flows partially or entirely outside the intended normal load current path of a circuit component. Values may be from hundreds to many thousands of amperes.

Available Fault Current: The maximum short-circuit current that can flow in an unprotected circuit.

Interrupting Rating: The maximum level of fault current that the fuse has been tested to safely interrupt.

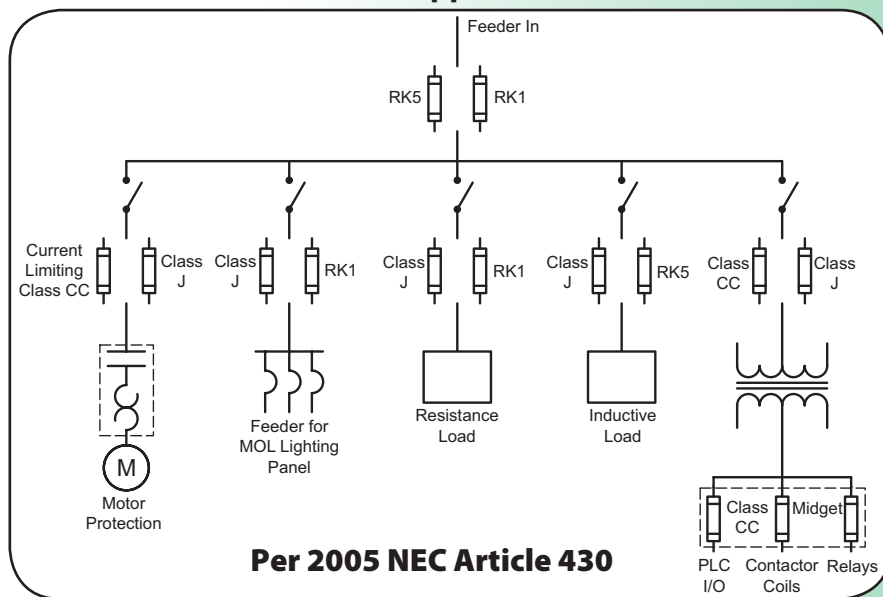
Current-limiting Fuse: A fuse that meets the following three conditions:

1. Interrupts all available overcurrents within its interrupt rating.
2. Within its current limiting range, limits the clearing time at rated voltage to an interval equal to, or less than, the first major or symmetrical current loop duration.
3. Limits peak let-through current to a value less than the available peak current.

Element: A calibrated conductor inside a fuse that melts when subjected to excessive current. The element is enclosed by the fuse body and may be surrounded by an arc-quenching medium such as silica sand. The element is sometimes referred to as a link.

Ferrule: The cylindrical brass, bronze or copper mounting terminals of fuses with amp ratings up to 60 amperes. The cylindrical terminals at each end of a fuse fit into fuse clips.

Fuse Classes and Application Guidelines



Other Commonly Used Circuit Protection Devices

Another important circuit protection device that is often overlooked are disconnects, typically used for industrial control systems to ensure the electrical feed circuit to a machine or system is completely de-energized to protect maintenance and operations personnel from electrical shock. Regulations require all power to the equipment MUST be shut OFF, locked out, and tagged out before servicing. Disconnects provide this functionality.

A partial list of products available from AutomationDirect include the following, shown with their suitable applications:

Surge Protection Devices

- Surge Protection for Feeder and Branch Circuits
- Designed with industry leading Mersen TPMOV Technology
- NEMA 4X enclosure for outdoor or indoor use

Molded Case Circuit Breakers (MCCB) / Current Limiting Fuses (UL 248) / Disconnect Switches (UL 98)

- Short Circuit and Ground Fault Protection for Feeder and Branch Circuits
- Motor Disconnecting Means (NEC 430.101 – 430.113)
- Motor Branch-Circuit Short Circuit Protection (NEC 430.51 – 430.58)
- Motor Controller (NEC 430.81 – 430.91)
- Motor Overload Protection (NEC 430.21 – 430.44)
- OSHA Lockout/Tagout Disconnect (NEC 430.81 – 430.91)

Manual Motor Starters (UL 508)

- Motor Overload Protection (NEC 430.21 – 430.44)
- OSHA Lockout/Tagout Disconnect (NEC 430.81 – 430.91)
- Suitable to reliably perform both motor control and disconnect
- Used to switch loads ON or OFF with manual operator controls

UL 508-rated Disconnects

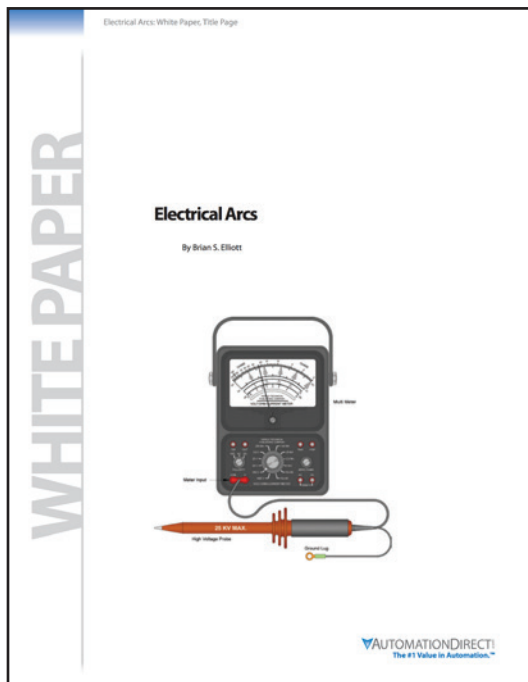
- Provide safe control and disconnect for motors
- Suitable to reliably perform both motor control and disconnect
- Used to switch loads ON or OFF with manual operator controls

General Fuses (UL 248-14) / Supplementary Protection (UL 1077)

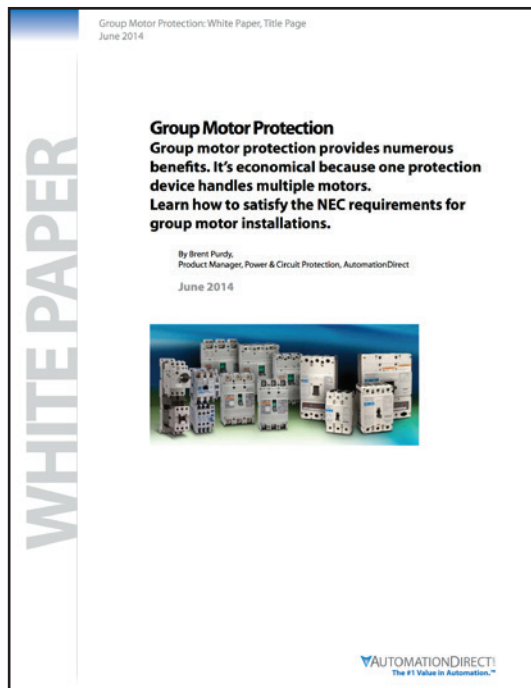
- Anywhere branch circuit or overcurrent protection is already provided or not needed

Check out these white papers on electrical systems and circuit protection

An entire wealth of knowledge is available in our library. In addition to the two white papers highlighted here, we have a bunch more on a variety of topics.



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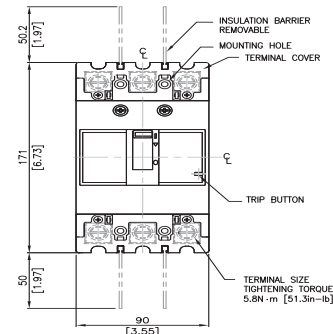


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CAD drawings

Many **FREE** resources are available 24/7



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Manuals



Software -
full-featured
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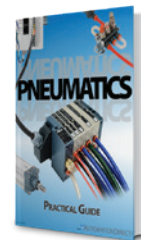
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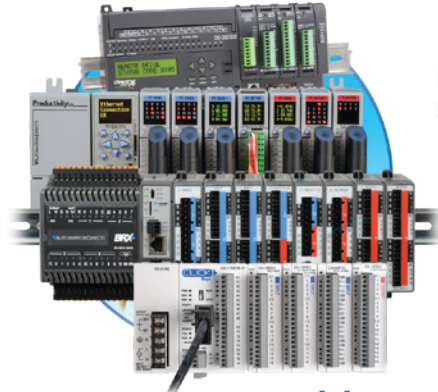


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YouTube



Universal Field I/O

Distributed I/O with
Modbus® TCP, EtherNet/IP,
Modbus RTU, DeviceNET
and Profibus® support

CPU and I/O Comparison	AutomationDirect CLICK	AutomationDirect Do-more! (BRX)	AutomationDirect Productivity2000	Allen-Bradley CompactLogix
Base (if required)	N/A N/A	N/A N/A	\$81.00 P2-04B	N/A N/A
Power Supply	\$41.50 CD-01AC	N/A N/A	\$79.00 P2-01AC	\$508.00 1789-P4A
CPU	\$145.00 CD-10ARE-D (Ethernet built in)	\$489.00 BK-DM1E-36ER3 (Ethernet built in)	\$273.00 P2-550 (Ethernet built in)	\$7,600.00 1788-L4S (Serial port only)
16 AC Inputs	\$42.00 CD-08NA (8-point AC input)*	\$60.00 BK-16NA	\$113.00 P2-16NA	\$325.00 1789-IA16
16 24VDC Inputs	\$47.00 CD-16ND3	\$0.00 Included with CPU	\$74.00 P2-16N3	\$277.00 1789-IQ16
8 Relay Outputs	\$42.50 CD-08TR	\$0.00 Included with CPU	\$54.00 P2-08TR5	\$327.00 1789-QW8I
8 Analog Input Channels (mA)	\$95.00 x 2 (2) CD-04AD-1	\$188.00 BK-08AD-1	\$222.00 P2-08AD-1	\$895.00 1789-IF8
Total System Price	\$447.00	\$556.00	\$896.00	\$9,932.00

*CD-08NA used in conjunction with right AC inputs on CPU gives the 16 points needed
All prices are suggested retail prices and may vary. All prices are in US dollars. For more information, visit www.automationdirect.com



HMI/Operator Interface

- C-more® operator interface HMI touch panels in various sizes up to 15 inches with wide screen options available
- C-more headless HMI - same functionality as C-more touch panels without display size restrictions
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- ViewMarq® LED message displays
- ATLAS® industrial monitors



AC and DC Drives

- DURA^{PULSE} variable frequency AC drives up to 300hp
- WEG CFW300 AC drives up to 5hp
- IronHorse[®] DC drives up to 3hp
- Cost-effective GS2 series VFDs up to 10hp
- Drive accessories
- Soft starters up to 480A



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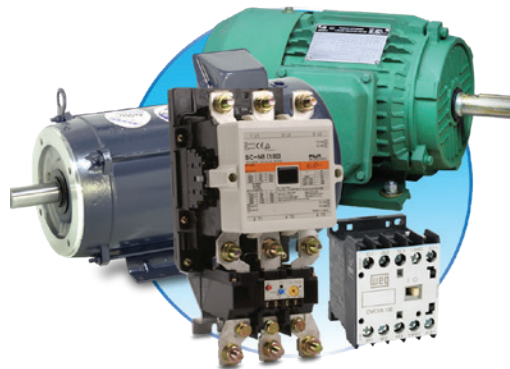


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- System configuration
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- Signal conditioners
- Pipeline valves
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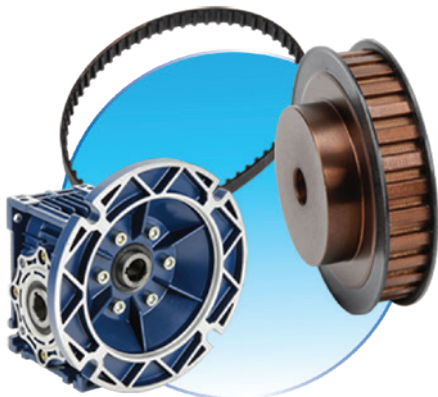
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- Precision gearboxes
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- Couplings and bushings
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- igus polymer bearings

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"I have been purchasing electronic parts for over 10 years and the products and service I have received from Automation Direct have never disappointed me. I will continue to purchase from here, keep up the good work ! I wish other vendors I have were as good as you."

Leonard in SUWANEE, GA wrote :

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Mark in MURFREESBORO, TN wrote:

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- Cable tie tools
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- RUKO grinders and burrs
- SapiSelco® wire ties
- AutomationDirect interchangeable die crimping tool, self-adjusting crimper and rotatable die crimpers

Servo Systems

	AutomationDirect Price/Part Number	VS.	Allen-Bradley Price/Part Number
Digital Servo Drive	\$483.00 SVA-2040 		\$1,418.00 2098-DSD-005 
100W Servo Motor with connectorized Leads	\$322.00 SVL-201 		\$643.65 TLY-A130T-HK62AA 
Breakout Board Kit for CN1 Control Interface	\$84.00 ZL-SVC-CBL50 + ZL-RTB50 		\$316.05 2090-U3BK-D4401 
10' Motor Feedback Cable	\$56.00 SVC-EFL-010 		\$96.68 2090-CFBM6DF-CBAA03 
10' Motor Power Cable	\$33.50 SVC-PFL-010 		\$109.00 2090-CPBM6DF-16AA03 
Configuration Software	FREE SV-PRO* 		\$85.02 2098-UWCPRG 

*SureServo Pro software is FREE when downloaded and is also available for \$9.00 on a CD

Complete 1-axis 100W System \$978.50 \$2,668.40

All prices are U.S. list prices. AutomationDirect prices as of 11/4/2019.
The Allen-Bradley 100W system consists of part numbers shown in table above with prices from
www.wernerelectric.com, www.todaycomponents.com 4/25/2019.

Joseph in FAIRLAND, IN wrote:

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- Area sensors
- Encoders
- Current and voltage sensors
- Pressure sensors and gauges
- Temperature sensors, switches, transmitters and thermometers
- Liquid level sensors
- Flow sensors
- Ultrasonic sensors
- Fork sensors



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- KILLARK® hazardous location control stations
- IDEM emergency stops
- Fuji®, Schmersal and Eaton metal/plastic 22 and 30mm pilot devices
- IP69K-rated selector switches, pilot devices and pushbuttons from Schmersal
- WERMA audible devices and visual signals
- WERMA and Patlite stacklights
- IP69K-rated Patlite stacklights
- Patlite signal towers and LED lighting
- Foot switches



Communications

- Industrial managed and unmanaged Ethernet switches
- StrideLinx Secure Remote Access
- Pocket Portal IoT Bridge
- MQTT Gateways
- Modbus gateways
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- Power over Ethernet (PoE) switches



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- Modular solenoid valves (Ethernet or hardwired)
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- Pneumatic pushbuttons and limit switches



Power Products

- Acme Electric®, Hammond and Jefferson Electric® transformers
- Rhino® DC power supplies and converters
- Mersen surge protectors
- Roxburgh and Eaton line filters and surge protectors
- Roxburgh power outlets
- ACME Electric encapsulated transformers
- Edison® power distribution blocks
- Bryant® electrical plugs, connectors and receptacles, and other wiring devices
- AcuAMP® AC current transformers
- Socomec multifunction power meters
- Trumeter graphical panel meters



Water (Potable) Components

- Regulators
- Solenoid valves in nylon or stainless steel bodies
- Hand valves
- Check valves
- Push-to-connect water fittings
- Lead-free brass fittings
- Tubing
- Hose
- Hose clamps



Circuit Protection

- Eaton UL 489 miniature circuit breakers
- Fuji UL 489 molded case circuit breakers
- Eaton UL1077 supplementary protectors
- Edison fuses, fuse holders and fuse blocks
- Socomec, Gladiator® and Bryant® disconnect switches
- Bryant UL 508 manual motor controllers



Terminal Blocks and Wiring

- Electrical hook-up wire / building wire
- Konnect-It® and DINnectors® terminal block systems
- Edison power distribution blocks
- Bryant power wiring devices
- Wire duct and tubing
- Wire end connectors cable glands, connectors and fittings
- ZIPport® connectors
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- Continuous flexing industrial Ethernet cable
- Control and signaling cable
- Bulk sensor/actuator cable
- DLO, R , RHW-2 Heavy Duty Flexible Power Cable
- Power Machine Tray Cable

Enclosures

	AutomationDirect Hubbell/Wiegmann Price/Part Number	VS.	Hoffman Price/Part Number
NEMA 1 wall mount 24 x 24 x 08"	\$222.00 N1C242408LP		\$343.81 A-24N24BLP
NEMA 12 wall mount 20 x 16 x 08"	\$290.00 N12201608		\$477.51 A-201608LP
NEMA 12 free-standing mount 60 x 60 x 12"	\$1,966.00 N12606012		\$2,813.35 A-606012LP
NEMA 4 wall mount 20 x 20 x 06"	\$396.00 N4202006		\$614.50 A-20H20ALP
NEMA 4X wall mount 20 x 20 x 06"	\$780.00 SSN4202006		\$1,447.97 A-20H2006SSLP
NEMA 4/12 wall mount 36 x 24 x 08"	\$377.00 N412362408C		\$602.87 C-SD36248

*All prices are U.S. published prices. AutomationDirect prices as of 11/4/2019. Hoffman prices are taken from www.alliedelec.com 4/30/2019. Prices may vary by dealer. Many other part numbers are available from all vendors.



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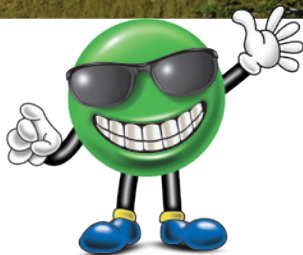
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