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Application Focus: Drives, Motors and Motion

Tips for Specifying Variable Frequency Drives

For nearly 40 years, variable frequency drives (VFD) have been controlling the speed of three-phase alternating-current (AC) induction motors. In addition to saving energy, there are many things to consider for maximum efficiency, control, operation and motor life when using VFDs.

A VFD's speed control is necessary for applications where variable torque and horsepower are needed such as centrifugal pumps, blowers, fans, mixers and agitators.

Benefits of using VFDs

Reducing motor speed saves energy in a variety of fan, blower and pump applications. Reduced inrush current when starting the motor along with controlled acceleration and deceleration are big benefits. Other key advantages include non-emergency motor start-stop control and motor overload protection. Features on the VFD, such as a keypad or potentiometer, allow manual adjustment of parameters, including speed and torque. Automatic or dynamic adjustment of these parameters is also possible using a PLC or other controller.

Size based on loads

When it comes to sizing the VFD, don't just match the horsepower of the motor. Review of the operating profile is also important. Changing loads, continuous running vs frequent starts and stops, changes in torque, and peak current demands can all affect the size of the VFD required for the application.

Peak current demands may create temporary overload conditions, yet the VFD must provide adequate current for proper motor performance. In an application such as a conveyor with a heavy load, high breakaway torque may demand power and torque, requiring an oversized VFD. The additional headroom provided by a larger drive is worth the small increase in price and extra panel space.

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Braking

When decelerating a motor, a VFD can provide approximately 20% of the available torque for braking (it's a matter of shedding the extra current that is generated during braking). For heavy, high-inertia loads and frequent start-stop applications, adding a braking resistor can significantly increase braking torque.

Interface to the VFD

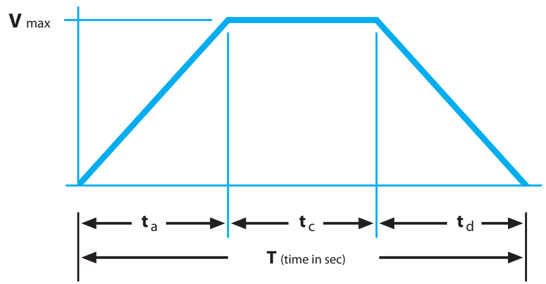
While simple pushbuttons are sometimes used, an automated approach might include the use of discrete and analog output signals from a PLC (or other controller) for the run, jog and speed control functions of the VFD. Often a combination of discrete, analog and preset control is used. For example, a controller may send an analog speed signal to a drive, and discrete signals to control run and jog functions, with acceleration and deceleration parameters preprogrammed.

Understanding digital communication options

To reduce or eliminate hardwiring, digital communication such as Modbus RS-232/RS-485, EtherNet/IP or other protocols can be used to control the drive and set parameters. This type of communication also enables monitoring of drive status, such as speed and current, and may also enable remote configuration capability.

Apply the right control mode

Some drive control modes require specific types of AC drives. Volts-per-Hertz (V/Hz) drives are most common and work well for pump and fan applications. As speed accuracy requirements increase, sensorless vector (SVC) drives, field oriented control (FOC) drives and closed-loop VFDs with encoder feedback provide accurate speed regulation for web handling, paper mills, printing presses and converting applications.



Define the motion profile

Before setting a drive's parameters, be sure to understand the motion profile required. What speed is needed; and can the motor accelerate slowly or must it start quickly, are just some of the questions to be answered. VFD parameters must also be understood for optimum drive setup and control.

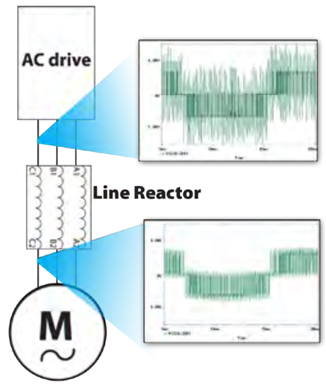
Outline installation requirements

VFDs create heat during operation that may need to be vented out of the control cabinet, particularly if there are frequent starts and stops. Running a motor at low speeds for extended periods also generates heat and can require an inverter-duty rated motor, which includes a built-in fan.

Some VFDs may have a NEMA 4X rating (wash down rated) and are mounted directly onto equipment. Ambient temperature is still a concern in this case.

Specify operation parameters

The AC drive manual covers many installation requirements. An important installation note is to not use a contactor or disconnect switch at the AC drive input for run-stop control, but only to remove power from the drive input under an emergency stop condition. Use discrete signals or digital communication for non-emergency start and stop functions during normal operation.



Handle noise and harmonics

Noise and harmonics generated by a VFD can damage connected motors and nearby equipment. Passive harmonic filters such as AC line reactors and chokes are often installed to reduce these problems. Check the drive installation manual and use these filters to reduce harmonics and protect the VFDs from transient overvoltage. Active harmonic filters can also be used to reduce noise generated by the VFD.

Selecting Motors for Industrial Applications

Efficient use of motors is always important, but there are many other things to consider when specifying an electric motor. Mechanical and environmental considerations are on the list, as is the application and operation. All of these factors are important, but the application is where the selection process should start.

The application defines the motor load, speed, acceleration, deceleration and duty cycle of the motor. This all feeds into the horsepower and torque requirements. Specific shaft speed and position requirements help determine the type motor used, and defines whether the motor load is constant or variable horsepower/torque.

Load Types

Applications drive the type of motor load, and there are four main types in industrial automation:

Type 1 - Variable horsepower and constant torque

Gear pumps, cranes and conveyors are examples of variable horsepower and constant torque applications. Constant speed AC and DC motors work well in these applications where the horsepower requirements may vary, but the load remains constant.

Type 2 - Variable torque and constant horsepower

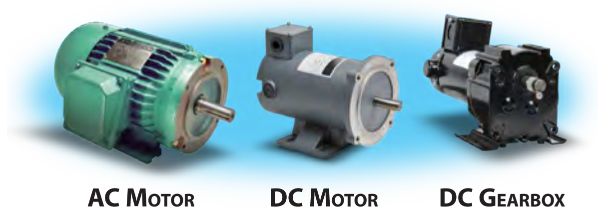
A web unwind or rewind machine is an example of a variable torque and constant horsepower application because the load increases with the diameter of the roll and vice versa. DC motors and servo motors work well here, and AC motors with closed loop drives are another option. Consider regenerative power in this case to increase efficiency.

Type 3 - Variable horsepower and variable torque

Centrifugal pumps, fans and mixers/agitators require variable horsepower and variable torque. When speed increases, so does the motor load. Variable frequency drives (VFDs) are often used in these situations.

Type 4 - Positional control or torque control

Motion control applications with linear motion slides and actuators often require accurate positional control, and some presses and tension control systems use torque control. Feedback is usually required, and servo and stepper motors are often a good choice.



You only need to choose between two classifications of motors, AC and DC, but there are over three dozen motor types used in industrial applications. Fortunately, looking through AutomationDirect's website, you'll find solutions for motor applications using servo systems, stepper systems, general purpose and inverter duty AC motors, or general purpose DC motors and gearmotors. The selection of motors and drives should cover most industrial automation motor applications.

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Three common motor speed/torque control applications include constant speed, variable speed and position (or torque) control.

Constant Speed

Many applications only require the motor to run at constant speed with no need for acceleration and deceleration ramps. Simple on-off control using branch circuit protection fusing, contactor and overloads are all that is needed to turn the motor on and off. Motor starters, manual motor control or soft starters are also often used. Common AC and DC motors are suitable in these applications. Both are simple and efficient designs and require minimal maintenance.


Contactor (w/overload)


Motor Starter


Soft Starter

Variable Speed

Precisely controlling the speed of fans, centrifugal pumps, mixers/agitators, conveyors and other loads can greatly increase energy efficiency. The ability to control acceleration and deceleration may also help handle product better, such as on a conveyor, and reduce mechanical issues by being gentler on the motor and drivetrain of the system. Coarse positioning of product can also be accomplished with variable speed control using slowdown and stop photoeyes.

DC and AC motors work well in most variable speed applications. DC drives have been around for over 100 years, and variable speed drives for AC motors have been in use for about 30 years.


DC Drive


AC Drive

DC motors are commonly used on conveyors and other fractional horsepower applications because they provide full torque at low speeds, with torque remaining constant throughout much of the speed range. Many DC motors use brushes which require maintenance, so keep that in mind or spend a little more money for brushless DC motors, or switch to AC motors and drives. An AC induction motor with a VFD is the popular choice today. If it is a fan or pump application, this is often the best option, especially if motor loads are over 1 HP.


Servo System


Stepper System

Position (or torque) Control

Beyond simple constant speed and variable speed applications is motion control. Executing precise position control, and implementing motion profiles with closed loop control, often requires a servo or stepper system. Dispensing applications and moving a linear slide or actuator are examples.

At the low speed end of the precision scale, a stepper system, open or closed loop, is a good choice, especially since the stepper has full torque at zero speed. As speeds and accuracy requirements increase, a servo system is a good choice because it handles dynamic loads and complex motion profiles better than a stepper.

Gearing

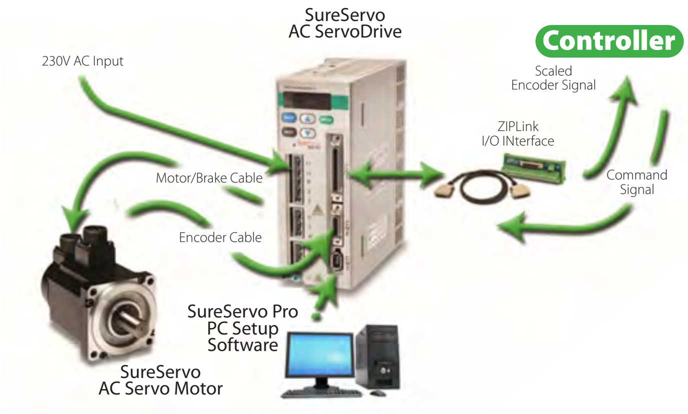
Depending on the speed required, a gearbox may be considered regardless of the motor type. Gearboxes increase the available torque while reducing the top speed available. A gearbox can allow the motor to run in a more efficient speed range, to operate in a range where more power is available, to run more coolly, or all of the above.

To help with motor, drive and gearbox sizing, AutomationDirect has online product selectors and configuration utilities for SureServo Complete Systems, AC Motors, SureGear Gearboxes and more. With application and environmental information in hand, it's possible to calculate load inertia, torque and speed, along with mass and size of the load.

There is a wide choice of AC, DC, stepper and servo motors available for your applications. Identify whether it is a constant speed, variable speed or position control application—and then size and select appropriately using online guidance from AutomationDirect.


Gearboxes

Have questions about Motion Control?
Chances are, you're not alone.

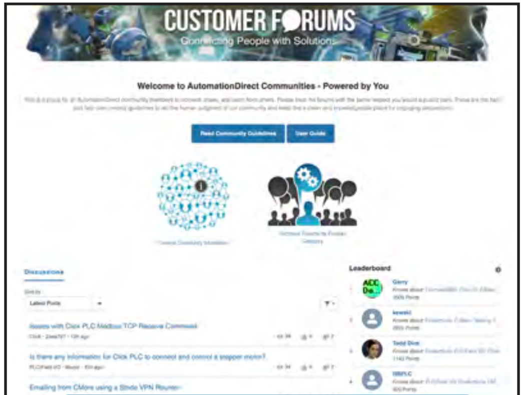


Motion control is generally understood to mean the use of servo and/or stepper systems as the "muscle" to move a given load. These motion control systems are capable of extremely precise speed, position, and torque control. Applications which require positioning of product, synchronization of separate elements, or rapid start/stop motion are all perfect candidates for the use of motion control. PLCs are very capable of providing the signals required to command these servo and stepper systems in a cost-effective and digital (noise-free) manner.

In a typical motion control system, there are three basic components: the controller, the drive (sometimes referred to as an amplifier), and the motor. The path planning or trajectory calculations are performed in the controller, which sends low-voltage command signals to the drive, which in turn applies the necessary voltage and current to the motor, resulting in the desired motion. Sometimes feedback devices on the motor or the load are used to notify the drive or the controller with specific details about the actual movement of the motor shaft or the load (thus "closing the loop"). This feedback data is used to increase the accuracy of the motion, and can be used to compensate for dynamic changes that may occur at the load, such as changes in mass, friction or other disturbances. Servo systems operate in a closed-loop fashion and vary output torque to move into/stay at the commanded position, while most stepper systems typically provide open-loop position control (a stepper will drive at full force to get to the commanded position or will fail trying).

The choice of open-loop versus closed-loop control depends on many factors and both are useful methods for controlling motion. PLC-based controllers can be used for either type of system. Applications that can be accomplished with a low-cost PLC and servo/stepper components include cut-to-length, indexing tables or conveyors, and x/y tables (plotter/cutter/router/placer).

The classic pulse and direction' signals that are widely used with PLCs provide an inexpensive, noise-free (digital) method for precision motion control. Extensions or function blocks within the PLC ladder logic are typically used for programming and are easy for factory personnel to understand and maintain. While typically limited to a few axes of control and where coordination between axes is limited, PLC controllers with pulse and direction capability are an excellent fit for many motion applications. Often, low-cost PLCs are already being used for logic control on the machinery and can also handle the motion tasks with the addition of a pulse output card and some additional programming. This can eliminate the need to integrate the logic controller with a separate motion controller. Machine builders can also save considerable time when implementing PLC-based systems, especially if they are already familiar with the PLC and its programming software.



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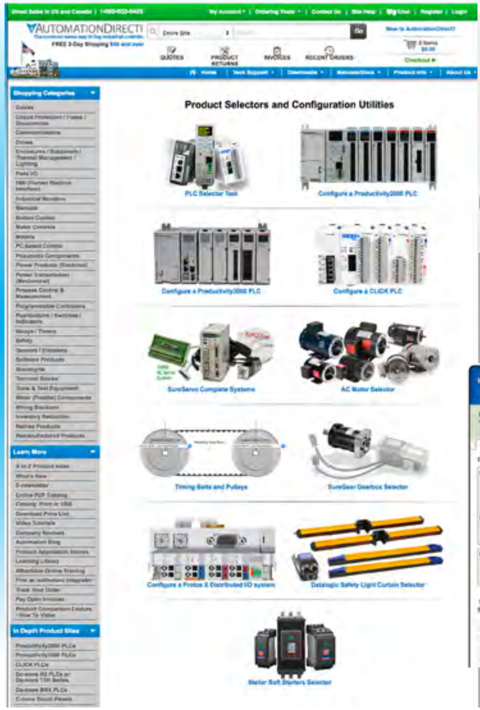

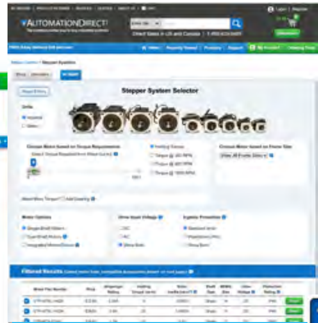

Stepper Selector

Gear Box Selector

Servo Selector

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Soft Starter Selector

Like our other selectors, this selector has a simple drop-down style menu. You can choose from a comprehensive list of over 40 soft starter applications that most closely match your requirements (or simply choose an application class), select your motor voltage and size, then answer a few simple questions such as "Anticipated starts per hour" (you can try a conservative number and a liberal number to see how it affects the product offering); "Ambient temperature"; "Altitude" etc., and the selector will provide suggestions for an appropriate soft starter.

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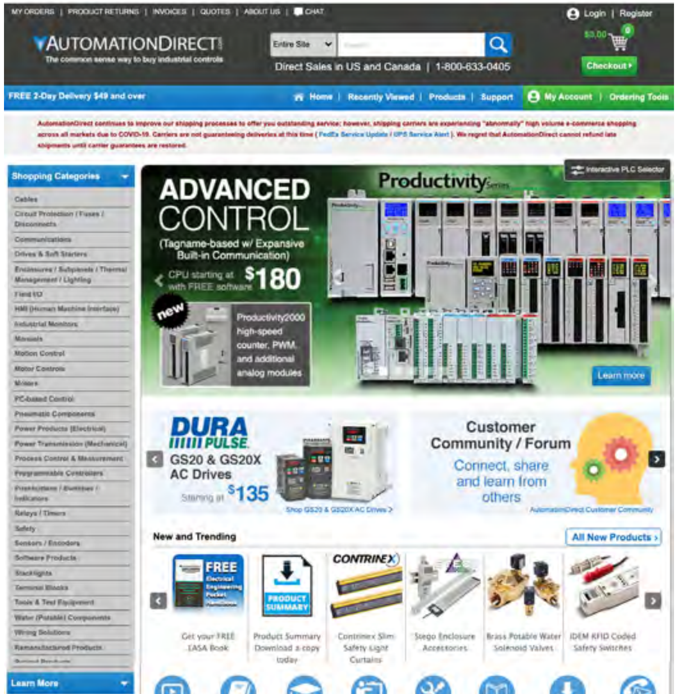

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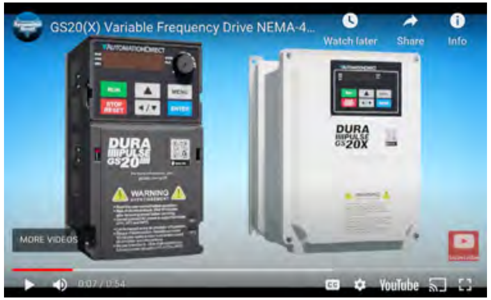

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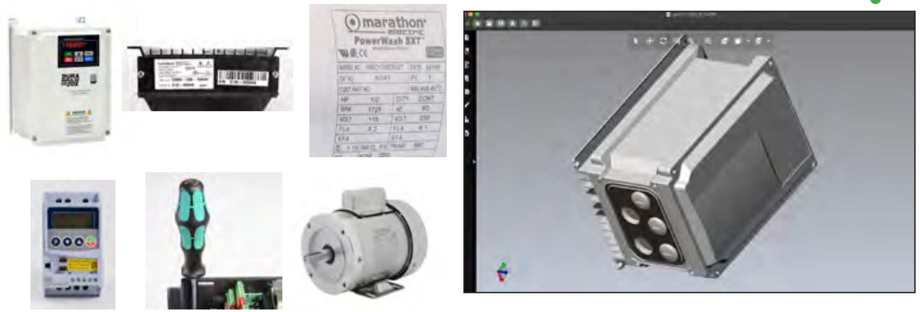

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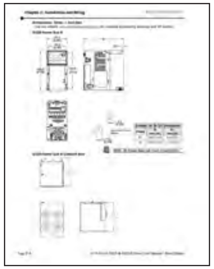
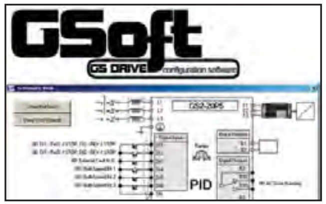


Manuals



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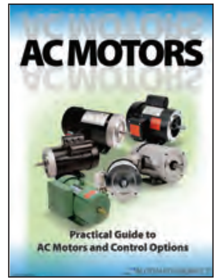

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Programmable Controllers

PLC CPU and I/O Comparison	AutomationDirect Productivity2000	VS. Allen-Bradley CompactLogix
Base (if required)	$81.00 P2-04B	N/A N/A
Power Supply	$79.00 P2-01AC	$531.00 1769-PA4
CPU	$273.00 P2-550	$3,186.02 1769-L33ER
16 AC Inputs	$113.00 P2-16NA	$325.00 1769-IA16
16 24VDC Inputs	$74.00 P2-16NE3	$283.00 1769-IQ16
8 Relay Outputs	$54.00 P2-08TRS	$327.00 1769-OW8I
8 Analog Input Channels (mA)	$222.00 P2-08AD-1	$913.00 1769-IF8
ASCII Comm Module	$0.00 Built in to CPU	$824.00 1769-ASCII
Modbus RTU Comm Module	$0.00 Built in to CPU	$910.00 1769-SM2
Total System Price with USB, Ethernet and Serial	$896.00	$7,299.02

All prices are U.S. published prices. AutomationDirect prices as of 4/17/2020.
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- Level sensors and controllers
- Flow sensors and transmitters
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- Pipeline valves
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Safety

- Reer MOSAIC safety controllers
- IDEM® and Dold® safety relays
- Speed/Standstill safety relay modules
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- Magnetic coded safety switches
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- Light curtains
- Safety relays
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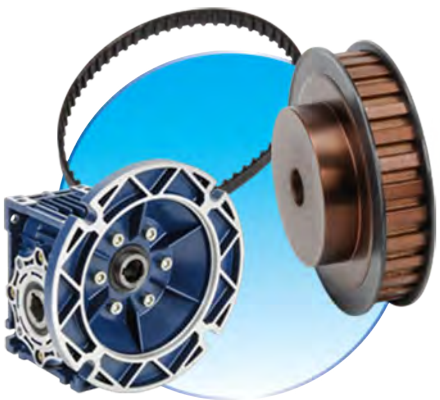
- Safety mats and edges
- Safety bumpers



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Digital Servo Drive	**$483.00** SVA-2040		**$1,410.00** 2098-DSD-005
100W Servo Motor with connectorized Leads	**$322.00** SVL-201		**$660.00** 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		**$99.10** 2090-CFBM6DF-CBAA03
10' Motor Power Cable	**$33.50** SVC-PFL-010		**$112.00** 2090-CPBM6DF-16AA03
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Complete 1-axis 100W System	**$978.50**		**$2,682.17**

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

All prices are U.S. list prices, AutomationDirect prices as of 4/17/2020.
The Allen-Bradley 100W system consists of part numbers shown in table above with prices from www.wernerelectric.com, www.todaycomponents.com 4/17/2020.

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- Temperature sensors, switches, transmitters and thermometers
- Liquid level sensors
- Flow sensors
- Ultrasonic sensors
- Fork sensors
- Linear position sensors

Pushbuttons, Switches and Lights

- 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
- Hazardous location control stations
- Captron capacitive pushbutton switches
- WERMA audible devices and visual signals
- WERMA and Patlite stacklights
- IP69K-rated Patlite stacklights
- Patlite signal towers and LED lighting
- Foot switches
- Enclosure and work area LED lighting

Communications

- Industrial managed and unmanaged Ethernet switches
- StrideLinx VPN routers and cloud services for secure remote access
- Pocket Portal IIoT remote I/O
- MQTT gateways
- Modbus gateways
- Network adapters/ converters
- Ethernet cables
- Power over Ethernet (PoE) switches

Power Products

- Acme Electric®, Hammond and Jefferson Electric® transformers
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- 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

Pneumatics

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- Solenoid valves
- Rodless air cylinders
- Modular solenoid valves (Ethernet or hardwired)
- Air preparation and air relief valves
- Pushbutton valves
- Total Air Prep (TAP) all-in-one units
- Rotary actuators and grippers
- Pressure switches, transmitters, and transducers
- Pneumatic pushbuttons and limit switches

Water (Potable) Components

- Regulators
- Solenoid valves in lead-free brass, 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
- Socomec Manual Transfer Switches

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
- Multi-wire connectors
- Sensor cables
- DYMO XTL label makers and labels
- General, latching, UV resistant, releasable, mounting head, identification, and metal-detectable cable ties

All of our cable is now available cut to your specified length so you can eliminate waste and purchase only what you need - **plus it's cut and shipped FAST!!**

Types of cable we offer:

- Flexible portable cord
- Bulk data cable (RS232/ RS422/ RS485)
- Flexible control cable
- Variable frequency drive (VFD) Cable
- Instrumentation cable
- Continuous flexing control cable
- Continuous flexing motor supply cable
- Continuous flexing industrial Ethernet cable
- Control and signaling cable
- DLO, RHH, RHW-2 Heavy Duty Flexible Power Cable
- Power Machine Tray Cable
- VFD / Servo Cable with single pair
- Tray rated continuous flexing control cable
- Continuous flexing profinet cable
- Profibus cable
- Sensor / actuator cable
- Cat5e Industrial Ethernet Cable
- VNTC Tray Cable
- Thermocouple Extension Cable

Minimum lengths of 10ft unless otherwise indicated

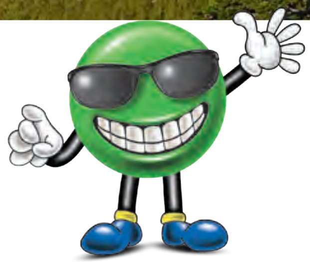
Enclosures	AutomationDirect Hubbell/Wiegmann Price/Part Number	VS. Hoffman Price/Part Number
NEMA 1 wall mount 24 x 24 x 08"	$222.00 N1C242408LP	$367.22 A-24N24BLP
NEMA 12 wall mount 20 x 16 x 08"	$290.00 N12201608	$500.20 A-201608LP
NEMA 12 free-standing mount 60 x 60 x12"	$1,966.00 N12606012	$2,934.66 A-606012LP
NEMA 4 wall mount 20 x 20 x 06"	$396.00 N4202006	$646.60 A-20H20ALP
NEMA 4X wall mount 20 x 20 x 06"	$780.00 SSN4202006	$1,563.50 A-20H2006SSLP
NEMA 4/12 wall mount 36 x 24 x 08"	$345.00 N412362408C	$634.40 C-SD36248

*All prices are U.S. published prices. AutomationDirect prices as of 6/30/2020. Hoffman prices are taken from www.alliedelec.com 4/17/2020. Prices may vary by dealer. Many other part numbers are available from all vendors.

Enclosures

- Over 4,500 NEMA rated enclosures to choose from
- Stainless steel, carbon steel and aluminum enclosures
- Polycarbonate enclosures and PVC enclosures
- Thermoplastic ABS enclosures
- NEMA rated fiberglass, polycarbonate enclosures
- Heating, cooling and climate control
- Lighting
- Over 2,000 enclosure accessories

- Honest up-front pricing (no gimmicks)
- Quick delivery - order today, it ships fast!
- FREE tech support - independently rated tops in service for 15 years
- FREE shipping on orders over $49



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