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Application Focus: Drives, Motors, and Motor Controls

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 available, 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 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

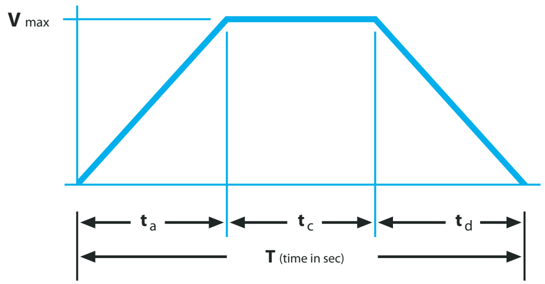
While simple pushbuttons are sometimes used, an automated approach might include discrete and analog output signals from a PLC (or other controller) for the run, jog, and speed control functions of the VFD. Often, a combination of discrete, analog, and preset control is used. For example, a controller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

Understanding digital communication options

To reduce or eliminate hardwiring, digital communication such as Modbus RS-232/RS-485, EtherNet/IP, EtherCAT, or other protocols can be used to control the drive and set parameters. This type of communication also enables monitoring drive statuses, 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 the 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. What speed is required? Should the motor be accelerated slowly or quickly? These are just some of the questions that need to be answered. The VFD parameters must also be understood to ensure optimum drive setup and control.

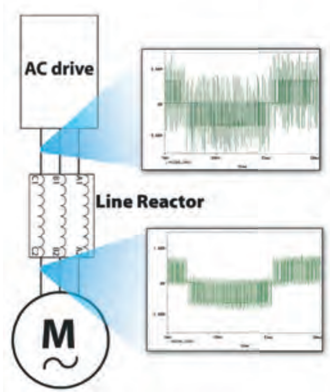
Outline installation requirements

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 (washdown) rating and can be mounted externally. 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 of motor used, and define whether the motor load is constant or variable horsepower/torque.

Load Types

There are four main load types commonly used 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.

AC Motor **DC Motor** **DC Gearbox**

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 a constant speed with no need for acceleration and deceleration ramps. Simple on/off control using branch circuit protection fusing, contactors, and overloads are all that is needed to turn the motor on and off. Motor starters, manual motor controllers, or soft starters are also often used. Common AC and DC motors are suitable in these applications. Both types have 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 torque while reducing the top speed. 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 Sure-Servo 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 the 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

Introduction to Motor Controls

Most factory automation involves moving machinery driven by electric motors. These automated systems frequently use general-purpose motors with simple on/off (across-the-line) control. Although these applications seem deceptively simple, NEC article 430 provides lengthy guidelines for motor controllers, installations, and wiring. It covers the requirements and specifications for motor control components, such as:

- Disconnecting means
- Branch circuit protection
- Motor controllers
- Overload protection

Disconnecting Means

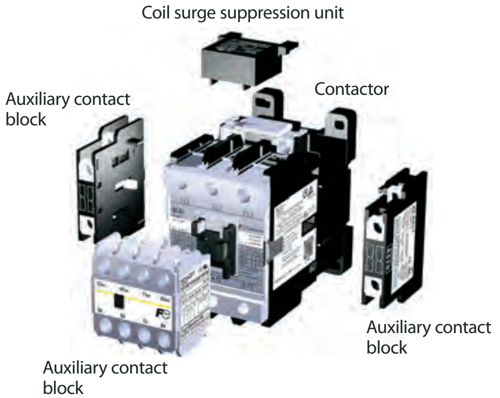
A disconnecting means must be able to open all ungrounded supply conductors and is usually required to be within sight of the controller, the motor, and the driven machinery.

Branch Circuit Protection

Branch circuit protection devices provide short-circuit and ground fault protection. They must also be able to handle the motor starting current, which can be several times the full load amp rating (FLA) of the motor.

Motor Controllers

Motor controllers must have suitable ratings to stop and start the motor, and be able to interrupt the locked-rotor current of the motor. If they don't also function as disconnects, they are only required to open as many conductors as necessary to stop the motor.



Overload Protection

Overload protection against heating due to motor overloads and failure to start. It does not protect against short circuits or ground faults, but the prolonged excessive current that can cause damage due to overheating.

Across-the-line Motor Starting

Across-the-line motor starting is used when the application can run at the motor's maximum speed, where speed and voltage sags/spikes don't pose a problem. These motor starting components are commonly used when neither the electrical and mechanical softening effects of a soft starter nor the speed control of a variable speed drive are required.

Typical devices used for across-the-line starting:

- Motor starters operate induction motors and protect them against running or stalled overcurrents
- Manual motor protectors provide an all-in-one motor control/protection solution, integrating control, disconnecting means, and circuit protection
- Magnetic contactors provide compact, electrically operated load control for diverse load switching needs
- Overload relays provide reliable and accurate electronic or thermal protection from device or component overload or phase loss

IEC Magnetic Contactors

IEC magnetic contactors in capacities up to 400A are well-suited for switching and controlling motors and other heavy loads for industrial applications. Contactors are available with AC or DC coils and a wide selection of voltage ratings.

IEC Safety Contactors

IEC safety contactors provide a safe and reliable way to control electrical power in industrial and commercial applications.

IEC Magnetic Motor Starters

IEC motor starters are a combination of devices used to start, run, and stop induction motors based on commands from an operator or a controller. The motor starter must have at least two components to operate: a contactor to open or close the flow of energy to the motor, and an overload relay to protect the motor against thermal overload.

IEC Manual Motor Protectors

IEC manual motor protectors integrate a local ON/OFF control, motor overload protection, disconnecting means, instant short-circuit trip, and phase-loss protection into one device. Models are available in capacities up to 100A, from brands such as WEG, Fuji, IronHorse, and AutomationDirect.

IEC Overload Relays

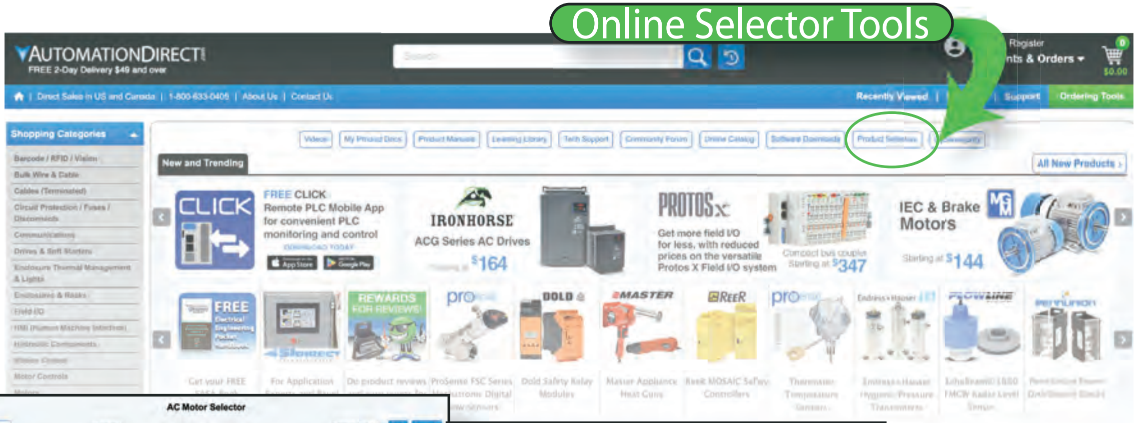
IEC overload relays provide reliable electronic or thermal protection from device or component overload or phase loss relays are available in various amperage capacities with models offering configurable parameters, self-powered operation, and communications capabilities.

Motor Disconnects & Controllers

Manual motor controllers and disconnects safely control and disconnect power from motors and provide an OSHA required lockout means.

Need help choosing the correct part for your next project?

Our online product selectors for motors and motor control make it easy



AC Motors Selector

Soft Starter Selector

Gear Box Selector

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Focus: 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.

You'll also find technical data and definitions to help you gain more soft starter application knowledge, increasing your confidence as you make your selection. Once you've decided on the criteria that best matches your application needs, you can simply choose from the list of models offered and add one to your shopping cart. The end result is the purchase of a correctly sized (and economically priced) soft starter that will meet your needs and requirements: quickly, easily and confidently.

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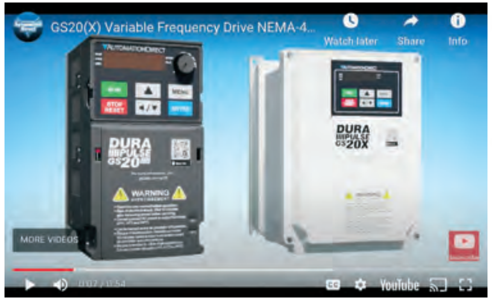

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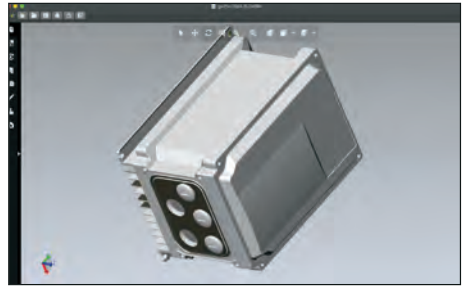

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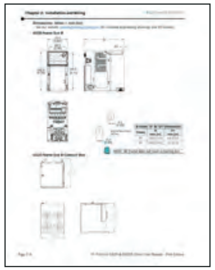

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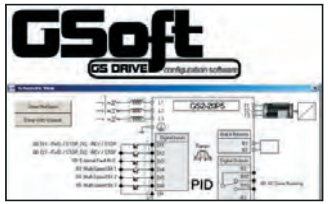

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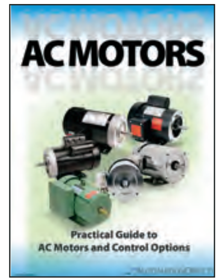

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- IronHorse variable frequency drives up to 30hp featuring ACN and ACG series
- WEG CFW100, CFW300 and CFW500 AC drives up to 150hp, depending on series
- WEG CFW500 drives up to 20hp, IronHorse® AC drives up to 30hp and DURAPulse GS20X drives up to 10hp available in a NEMA 4X enclosure
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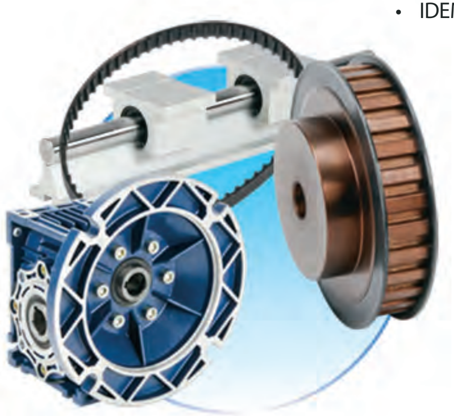

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- Eaton and Gladiator UL1077 supplementary protectors
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- Motor and VFD supply cables
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Minimum lengths of 10ft unless otherwise indicated

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