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Choosing Between Soft Starters and Drives

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Soft starters are cheaper, but VFDs often provide better value

Regardless of whether they are used in processing plants or in discrete manufacturing, commercial, municipal, or institutional facilities—motors that are started across the line require large amounts of energy when accelerating quickly to full speed. Standard EPAct motors started across the line typically require 5-6 times the locked-rotor or full load amp (FLA) starting current to reach operating speed, and NEMA premium motors can require 8-10 times FLA at start up.

In applications such as fans, pumps, compressors, mixers, and conveyors—reduced voltage soft starters (RVSS) or variable frequency drives (VFD) can be used instead of traditional contactors or motor starters to reduce inrush current. Both RVSSs and VFDs reduce the AC RMS voltage applied to the motor during startup. Both can also reduce inrush currents, and consequently starting torque, by as much as 30% to 70% compared to across-the-line starting.

In equipment that experiences frequent starts and stops, reducing the inrush current significantly reduces motor heating because it lowers I2R, resulting in longer motor life. Reduced start up motor torque can also significantly extend the life of belt-driven and mechanically-geared equipment. In fact, some equipment such as large fans and pumps requires extended ramp times at start up to prevent mechanical system damage.

RVSSs and VFDs share energy, motor, and equipment saving attributes—but they have significant differences. The choice between VFDs and RVSSs depends on the application, control and performance requirements, initial cost and system life cycle costs, and operational complexity.

RVSS Operations

RVSSs offer lower initial cost, limited digital and analog diagnostic signals, simple RUN/STOP control schemes, and the ability to reduce peak current draws and mechanical shock to equipment (see Comparison Table). Potential applications for RVSSs include very large (200-500 hp) pumps, fans, mixer, and centrifuges that generally require very few starts and stops; have little or no integration into plant control networks; and are required to run at full rated speed during operation.

Figure 1. The obvious advantage that VFDs offer over soft starters is the ability to control motor speed. Depending on the application, lowering motor speed by 20% could reduce energy use by as much as 50%.

An RVSS adjusts the voltage applied to the motor to control its current and torque characteristics during startup. Silicon-controlled rectifier arrays are configured back-to-back so that the control circuit can gate them on both positive and negative excursions of the AC waveform. The control circuit, or gate-firing control processor, controls the slope of the acceleration and deceleration ramps. The amount of the AC line voltage waveform allowed to pass through to the motor is directly proportional to the gate-firing ramp. This allows the RVSS to regulate the voltage applied to the motor from zero up to line voltage.

Most RVSSs incorporate current transformers (CTs) on two of the three phase outputs to provide current measuring feedback to the control processor. Current feedback allows the soft starter to adjust to programmed torque limits during acceleration. Monitoring current feedback over time also allows an RVSS to be used as an external motor overload device.

Acceleration times vary depending on the load on the motor when started. When bypass relays are used, they allow the RVSS to be taken out of the circuit when the motor reaches operating speed.

The efficiency of an RVSS is typically around 99.5%. Some soft starters have the ability to limit the output voltage to the motor. Applications that don't require the motor to be fully loaded also don't require full magnetizing current. Reducing the voltage to the motor also reduces the current, which increases its efficiency without sacrificing speed.

VFD Operation

Although VFDs offer many application benefits such as energy efficiency, reduced stress on motors and equipment, diagnostic capabilities, and process control integration—the primary reason to use a VFD is to control motor speed. The bonus is that lowering motor speed usually increases energy efficiency.

For example, using VFDs to lower speed or flow by just 20% can potentially reduce energy use by 50%. Although a VFD is typically about 95% to 97% efficient—its ability to directly vary motor speed instead of using dampers, flow controls and blocking valves usually results in an overall increase in system efficiency along with lower maintenance costs.

A VFD rectifies the AC line voltage into DC voltage, which is applied to a DC bus. The DC bus voltage is "inverted" into pulsed DC, the RMS value of which simulates a sine-coded AC voltage. The result is a pulse-width-modulated DC output gated through insulated-gate bipolar transistors.

The output frequency of a VFD typically varies from 0 to the AC input line frequency. However, on some applications, the frequency can exceed the line frequency to beneficial effect. Like RVSSs, VFDs use CTs to measure motor current. Sensing current allows VFDs to implement motor overload monitoring, stall prevention, and torque and current limiting.

RVSS-VFD Comparison

The major advantage of a VFD over an RVSS is speed control. VFDs can vary output frequency from zero to above base motor frequency. If a process requires very tight speed regulation, the frequency applied to the motor must be changed in relation to the load in order to accurately control the speed.

By contrast, an RVSS applies only the line frequency, and the motor operating speed is therefore fixed. But for applications that don't need to vary the load's speed, a soft starter can be a very cost-effective solution.

VFDs fit well in applications that require consistent acceleration times. Acceleration time for an RVSS depends more on the load than the selected ramp time, so unlike a VFD precise acceleration time can't be controlled.

But if consistent acceleration time isn't an issue, and controlling the torque or current is all that's needed, an RVSS may be the more cost-effective solution. If current limiting is the main

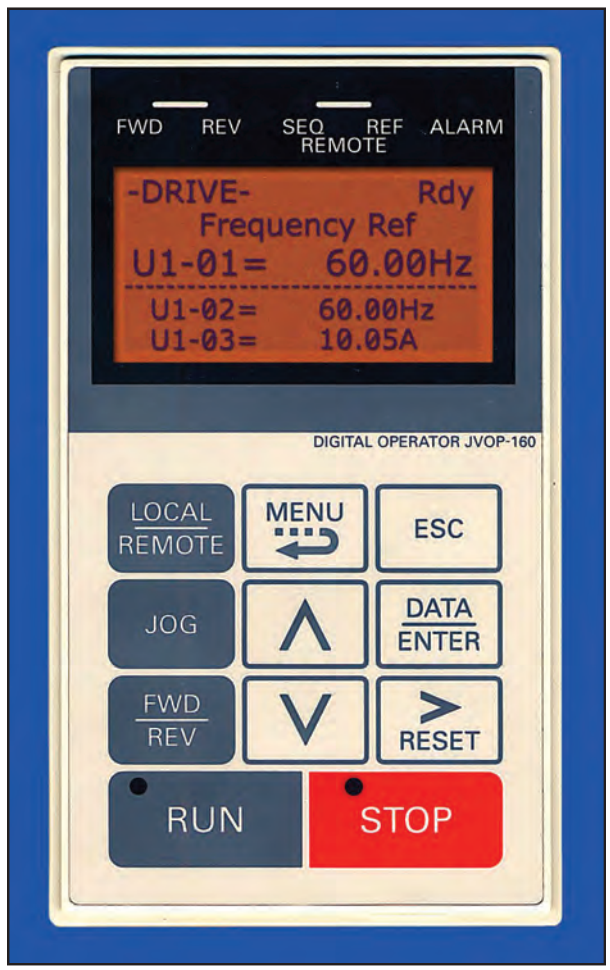

Figure 2. VFDs vary motor speed by supplying frequencies that can vary from 0 to above line frequency. VFDs also offer network connectivity, programmable tuning and flexible user interfaces.

reason for not starting at full voltage, an RVSS may be an appropriate choice. The difference in cost between an RVSS and a VFD at the Amp rating where current limiting becomes a factor may be the deciding factor.

VFDs can be two to three times the initial cost of an RVSS, and generally require a slightly higher expertise to integrate into a process. However, they offer much greater control over the processes and applications in which they are used. There are applications in which the additional cost of a VFD is justified, such as when the motor can't provide sufficient torque to start the load because of the current limitations imposed by the distribution system.

Unlike an RVSS, a VFD can accelerate a motor to full sped at full-load torque with line current that does not exceed the motor's FLA. If starting torque is a concern, consider that VFDs have a much higher torque per amp ratio.

Besides motor control advantages, VFDs provide functionality benefits over RVSSs. VFDs provide more analog and digital diagnostic information, and have programmable performance parameters that can interface with plant automation and control networks. They can often be customized to function within process requirements, eliminating the need for higher-level external controllers.

Using VFDs in variable torque applications such as centrifugal pumps and fans can provide very fast payback in energy saving because processes are maintained at reduced speeds, which offsets initial investment costs. Some applications can even pay back the entire cost of a typical VFD within months, especially if the local utility offers a VFD rebate program.

Both RVSSs and VFDs provide reduced voltage motor starting, reduced energy consumption, and reduced stress on motors and mechanical equipment. But when looking for value, users may need to look beyond initial cost and determine if the added performance and functionality of a VFD justifies the added cost.

Characteristics	RVSS	VFD
Initial cost	Lower	Higher
Reduces motor starting voltage	Yes	Yes
Reduces motor starting current	Yes	Yes
Reduces energy use	Some	More
Extends motor, equipment life	Yes	Yes
Varies motor speed	No	Yes
Efficiency	~ 99.5%	~ 95% to 97%
Operational complexity	Lower	Higher
Current feedback via CTs	Yes	Yes
Torque per amp ratio	Moderate	Very high
Performance parameters	Few	Many
Tuning functions	Few	Many

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