Motors: Power Factor Controllers

Why Should I Care?

If your facility employs alternating-current (AC) induction motors that require constant speed but operate for considerable periods at very low load —which means at less than peak efficiency—you may be able to cut your energy costs by installing a device known as a power factor controller.

The term power factor controller is somewhat misleading. Although the devices sense power factor as a control variable, what they actually control is voltage, to provide just the amount needed to maintain rated speed and torque for a particular load. The effect is what's important: reducing the voltage applied to motors operating at less than full load can sometimes reduce their losses (see **Figure 1**).

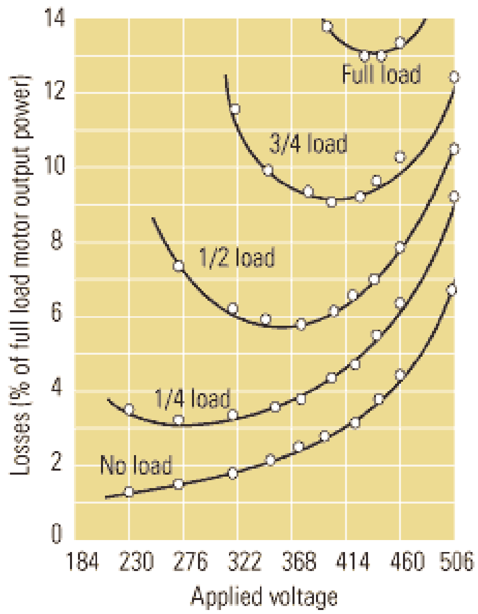
These controllers are most likely to be cost-effective in situations where single-phase motors operate at constant speed but spend a lot of time at very low loads. Key applications include escalators and elevators, conveyors, crushers, injection molding and vacuum forming machines, lumber saws, sewing and weaving machines, machine tool spindle drives, and washing machines.

What Are the Options?

Soft-start. Most power factor controllers come with a feature known as a soft-start capability. By gradually ramping up the voltage to a motor, soft-starting cuts the abrupt inrush current to less than half of the current that accompanies full-voltage starting. Benefits include reduced heat in the motor windings and lower mechanical stresses on belts, couplings, and transmissions. In addition, soft-starting can limit the interference with other, voltage-sensitive equipment in a plant. Some products offer an adjustable soft-start capability that can adapt to the operator's needs—from an instantaneous start to a ramp-up of 20 seconds or more.

Figure 1: Effect of voltage on motor loss

At low loads, motor losses decrease as voltage decreases.



Source: Westinghouse Electric Corp.

Contrary to some claims, soft-starting does not reduce peak demand charge. Soft-starters do not reduce the amount of energy necessary to start a motor; rather, they spread it over a period of seconds rather than fractions of a second. Because utility demand charges are typically calculated based on peak demand within a window of at least 15 minutes, it isn't likely that soft-starting will reduce demand charges.

Motor protection. Some models include circuits that protect motors from overcurrent and phase imbalance.

Motor monitoring. Some power factor controllers provide a digital readout of current, voltage, power factor, and power and energy consumption. The data can be downloaded to a PC for analysis of energy use and to assist with predictive maintenance.

Learning capability. A learning capability in some power factor controllers enables them to adapt to the characteristics of the particular motor they're connected to.

Anticipator circuits. Some controllers have circuits that react quickly enough to load changes to prevent stalling, even with sharp increases in required torque.

How to Make the Best Choice

Estimate cost-effectiveness. Beware of the misleading marketing claims made by some manufacturers of power factor controllers. At low load, these controllers can reduce losses by an impressive percentage, but saving even a large percentage of the small amount of energy used at low loads may or may not result in a cost-effective application. Pay attention to power and kilowatt-hour savings rather than the percentage by which losses are reduced. For a given application, determine the load profile and estimate the power savings using **Figure 2**, next page or **Figure 3**, next page. For example, a single-phase motor that spends 20 percent of its operating time at full load and 80 percent at one-quarter load might reduce energy use by about 25 percent.

You can use that information to get a rough estimate of a simple payback period for the device (**Table 1**, page 4). The table shows a calculation based on energy savings alone.

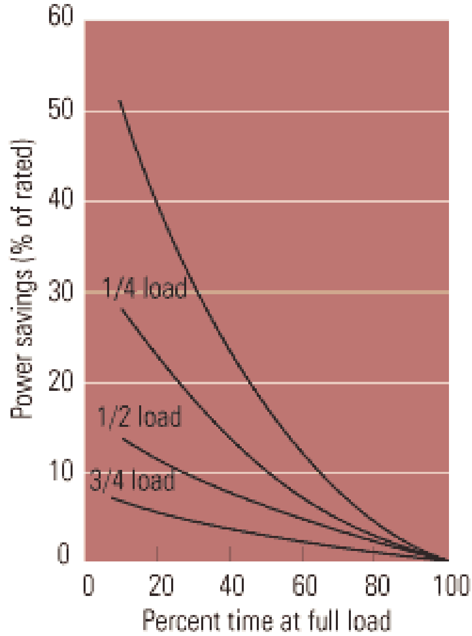
Retail prices for power factor controllers depend on the features of the unit and the voltage rating. They range from about $65 to $200 per horsepower (hp) for small motors to about $30 to $60/hp for 10-hp motors to about $22/hp for motors at 200 hp.

Pick a controller that matches the motor. Power factor controllers are available for single-phase and three-phase motors in the full range of NEMA enclosures, with voltage ratings up to 600 volts and in sizes up to 1,000 hp.

Look for devices that produce low total harmonic distortion (THD). The generation of harmonics within an AC induction motor circuit can cause a temperature increase and lead to interference with other electrical equipment. Some power factor controllers increase the harmonic content of the motor they are controlling more than others.

Figure 2: Single-phase power factor motor controller savings

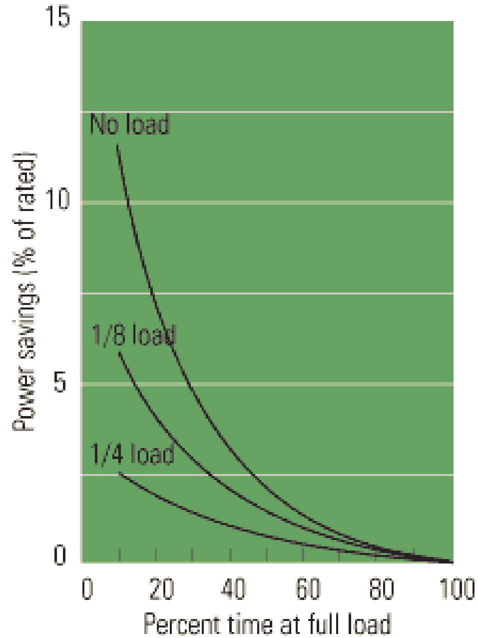
Power savings from the power factor controller increase with increasing time spent at low power levels



Source: E SOURCE

Figure 3: Three-phase power factor motor controller savings

Power savings from the power factor controller increase with increasing time spent at low power levels. Savings are less with three-phase motors than with single-phase motors because of the different loss mechanisms involved.



Source: E SOURCE

Table 1: Sample cost savings comparison

This table illustrates a payback calculation for a power factor motor controller after the savings percentage achievable for a given load profile has been estimated. The calculations are based on a 3-kilowatt (kW) motor operating 1,165 hours per year at full load and 4,659 hours per year at part load. In this example, the power factor controller will take more than three years to pay for itself.

Parameter	Motor without power factor controller	Motor with power factor controller
Total energy use (kilowatt-hours per year)	7,008	5,256
Energy cost ($/year)	561	420
Energy savings ($/year)	NA	141
Installed cost of power factor controller ($)	NA	500
Payback period (years)	NA	3.5

Assumptions: Motor operates 16 hours a day, seven days a week 20% of the time at full load and 80% of the time at 1/4 load; energy cost is $0.08/kWh.

Source: E SOURCE

NA = Not applicable