

# EFFICIENCY CONTROLLER

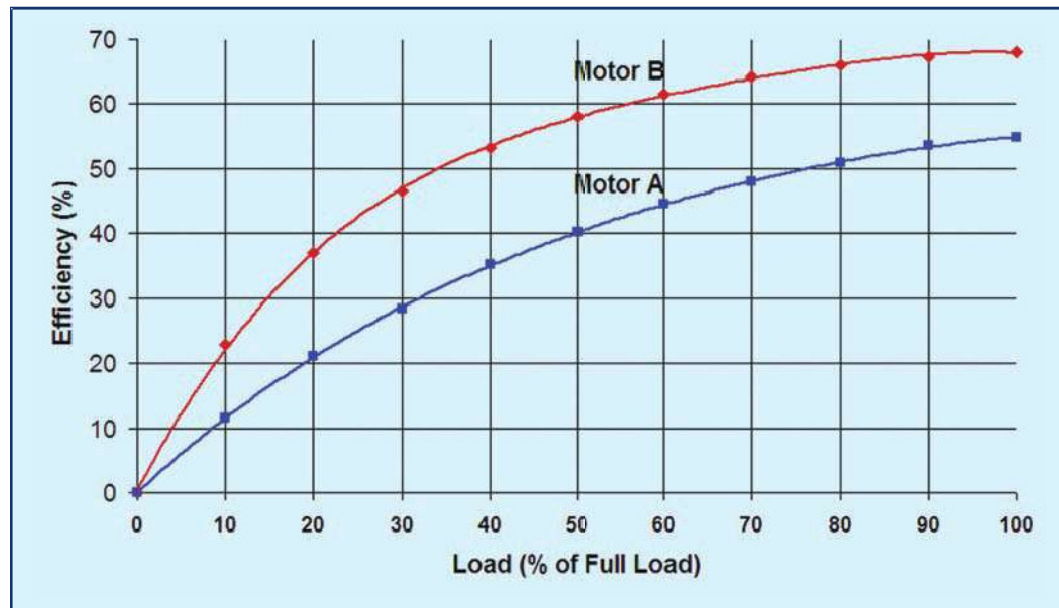


Fig. 2. Efficiency curves of motors tested.

*Device improves  
appliance efficiency.*

**M**any appliance motors operate inefficiently. Single-phase AC induction motors, particularly in the fractional horsepower range, are naturally inefficient. Furthermore, most manufacturing techniques used to improve natural motor efficiency (iron reduction, improved lubrication to reduce friction, etc.) are either not applicable or prohibitively expensive for these motors. For these reasons, most of the effort in improving appliance efficiency has centered on other areas of the system. For example, most refrigerators are able to achieve energy reduction (and thus the coveted Energy Star rating) by improving the seals, insulation, and airflow paths. Until very recently, little effort has been expended on improving the efficiency of the compressor motor itself. The same holds true for most appliances using an AC induction motor.

by **john hurst**

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Power Efficiency Corp. of Las Vegas, Nev., a manufacturer of three-phase, motor-efficiency controllers, has been developing and testing a single-phase version of its device

for use with motors in appliances and other residential and small commercial equipment. Recent tests on an early prototype show significant opportunities for saving energy on partially or variably loaded single-phase motors. For example, testing on a 1/3 HP Emerson split-phase motor (similar to the motors one might find in larger or commercial appliances) show that if the motor is run at full power for 40 percent of the time, and at 30 percent load for 60 percent of the time, Power Efficiency's single-phase motor controller can save as much as 25 percent of the power consumed by the motor. As expected, larger (and thus more efficient) motors afford less potential for savings. (See Fig. 1, Fig. 2, and Fig. 3). Fig. 2 shows the measured efficiency of the two motors whose nameplate data is in Fig. 1. The graphs in Fig. 3 represent the measured energy savings based on the percentage of full load and the duty cycle for the same two motors. Each of the curves represents a different load factor, and the x-axis indicates the percentage of time

<p><b>Motor A:</b>  <b>Ratings:</b> 1/3 HP, 120 V, 1,725 RPM  <b>Brand Name:</b> Emerson  <b>Type:</b> Split-Phase  <b>Model No.</b> SA55NXSFB-4866</p>	<p><b>Motor B:</b>  <b>Ratings:</b> 3/4 HP, 115/230 V,  <b>Brand name:</b> Baldor  <b>Type:</b> Capacitor-Run  <b>Spec. No.</b> 24G426Y094</p>
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Fig. 1. Nameplate information for motors tested.

that the motor spends at full load, with the assumption that the motor spends the balance of its running time at the load factor indicated by the curve.

### The technology

Power Efficiency's energy-saving technology reduces the amount of electricity used by lightly loaded motors while maintaining the motor at a constant operating speed. The technology works by sensing when a motor is lightly loaded and then reducing the voltage at the motor terminals. This in turn reduces the magnetizing current and the shaft torque without changing the shaft rotation speed, thus eliminating the need to

change any mechanical or electrical control features that expect the motor shaft to rotate at a particular speed. By dynamically monitoring the load requirements, and matching the power to the load, the technology effectively constantly sizes the motor to the load. As the load increases or decreases, the controller adjusts the voltage and current delivered to the motor to precisely match the load requirements.

The nature of inductive motors is that they are most efficient at approximately 90 percent of full load. As the load decreases, the magnetizing current required to keep the rotor turning decreases at a much slower rate. The magnitude of the magnetizing current

is dependent on a number of factors, most noticeably the construction of the rotor and stator, and the amount of iron in the core. As the size of these motors increase, these factors become less of an issue, and the efficiency tends to increase — and remain higher for a larger percentage of the Efficiency vs. Load curve. (See Fig. 4.)

Since most single-phase motors, particularly those used in appliances, tend to be small, fractional-horsepower motors, they have a naturally low efficiency. With very few exceptions, the smaller the motor, the less efficient it will be. This is reflected in Fig. 4, in which the efficiency of the 1 HP motor begins to decline at a higher percentage of

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# MOTORS

full load than the 100 HP motor.

Although the magnetizing current does no actual work, it does have to pass through the wiring, both in the power cabling and in the windings of the motor itself. This produces heat losses that are in direct proportion to the current squared. Thus, doubling the current effectively quadruples the loss in the wiring. Conversely, halving the current reduces the I<sup>2</sup>R losses by one-fourth. Thus, a motor that is running more efficiently, and with less magnetizing current, will also run much cooler, extending the motor life in the process.

## Other options

Other technologies exist or are being developed for reducing energy on partially loaded motors. Variable-frequency drives (VFDs) for single-phase appliance motors have recently received a lot of attention, in part because they are a well-established technology for reducing energy consumption for larger, three-phase motors. However, implementing a VFD in an appliance is relatively expensive compared to the expected cost of Power Efficiency's single-phase motor controller. VFDs need to rectify the AC current coming into the motor and invert the DC back into AC, which requires significant filtering and other components that Power Efficiency's technology does not. Also, VFDs generally require inverter-rated motors. Equally important, VFDs save energy by changing the speed of the motors, which will generally require adding additional sensors and changing an appliance's control systems to work effectively. Power Efficiency's technology keeps the motor running at a constant (full) speed, and therefore generally will not require changes to the appliance-control system.

Another option is the use of two-speed motors, and this has been applied to some pump applications. However, this essentially requires either two sets of windings or tapped windings, which can make for a much more expensive motor. As with VFDs, to be effective in most appliances, two-speed motors also require additional control circuits and sensors.

These other technologies all have something in common — they cannot be simply added to an existing motor and control system without (sometimes extensive) modifi-

cations. That is where the Power Efficiency single-phase motor controller provides an advantage. Since it is a self-contained device and it keeps the motor running at full operating speed, the Power Efficiency single-phase motor controller can be added to the existing motor and control system.

## Applications

With its single-phase controller (as with its three-phase controller) Power Efficiency is targeting applications in which the motor operates for a significant percentage of time at reduced load, or in which the load changes over time. As can be seen from the graphs, even small reductions in load can yield sig-

nificant savings. Many appliances fall into this category, such as refrigeration (including refrigerators and air conditioners), clothes washers and dryers, heat pumps, and shop tools.

As an example application, consider a typical clothes dryer. The motor that turns the drum is normally sized to accommodate a completely full load of soaking wet clothes. There are two factors that may cause this motor to be lightly loaded and operating inefficiently:

1. Most loads of laundry are not as large as the dryer motor is designed to handle, so the motor is oversized for the "average" load of laundry.
2. As the clothes dry out, they become

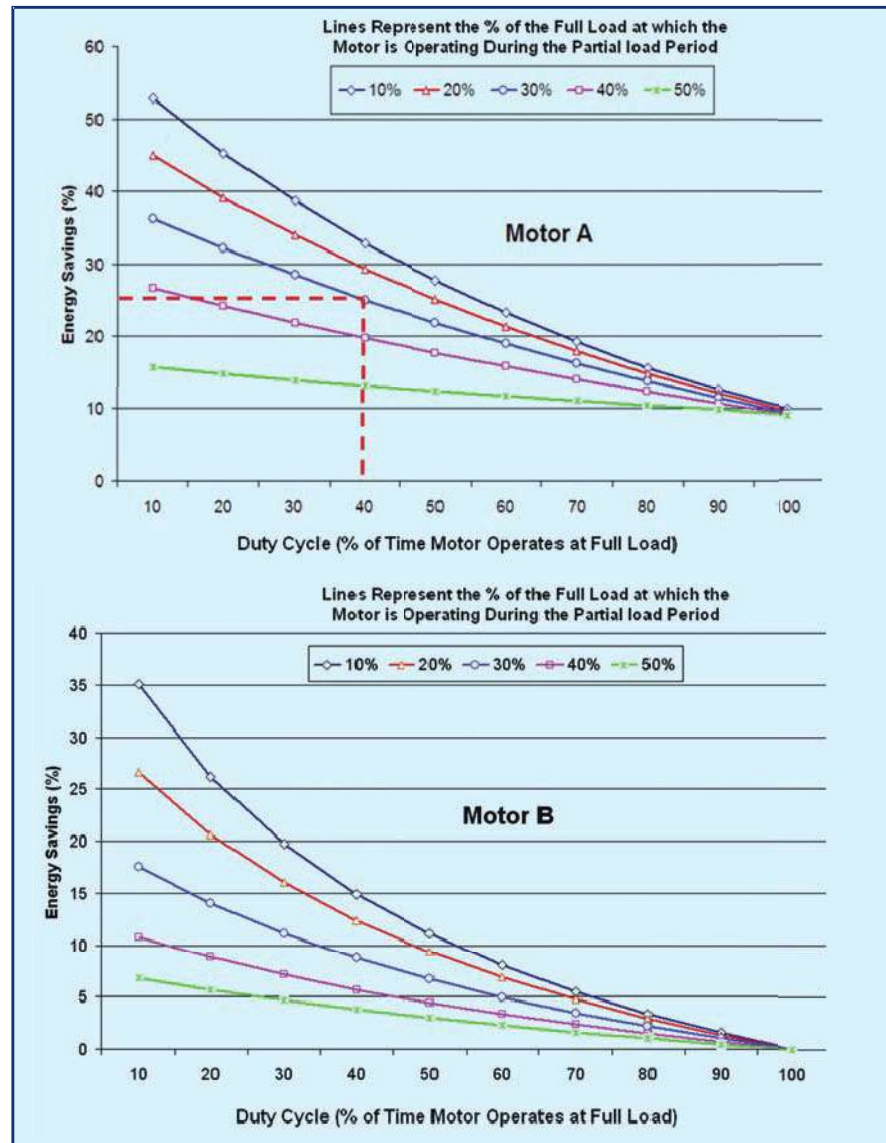


Fig. 3. Estimated energy savings at different partial-loads and duty cycles. For example, the dotted red line in the graph for Motor A represents the results for a motor run at full load 40% of the time it is operating and at 30% of full load for the remaining 60% of the time it is operating. The result, shown on the y-axis, is 25% overall energy savings.

lighter and lighter, making a progressively lighter load on the dryer motor.

Two-speed motors and VFDs are poor energy savers for this application, given that slowing the dryer drum is not practical. The single-phase motor controller keeps the motor operating at the same speed, but simply reduces the voltage and current at the motor terminals when the load on the motor decreases. It senses this low-load condition and responds by matching the power to the motor in real time. Unlike with VFDs, no external sensors are required, and no changes to the motor are required.

## Implementation

While the Power Efficiency single-phase motor controller is

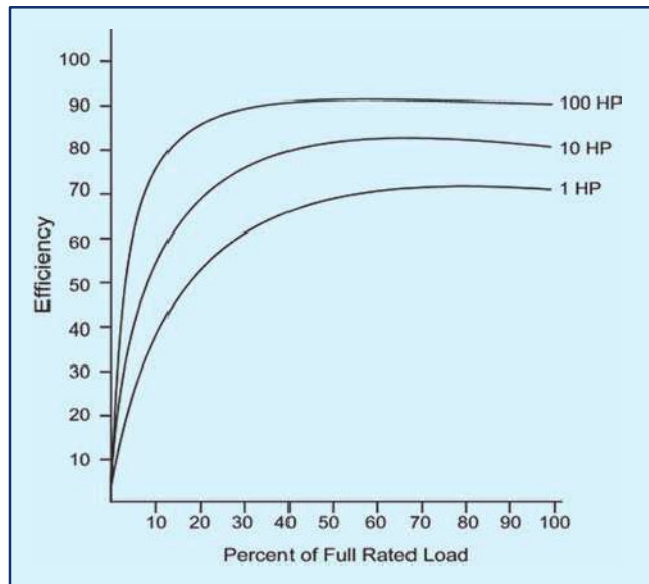


Fig. 4. Efficiency vs. load.

a standalone application, in that it doesn't require additional sensors or changes to existing control systems or components, it is

most effective when tailored to the specifications of an application's motor and load. In addition, since it must be installed


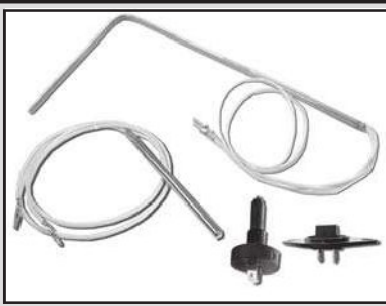
just before the motor on the power circuit, it is not feasible to sell as a retrofit device through retail channels.

Power Efficiency, therefore, anticipates working with motor and appliance manufacturers to incorporate the technology into appliances at the factory level. This will also ensure that the algorithm, software, and hardware are tailored for the specific appliance model or series, which will optimize efficiency. It may also help certain appliances qualify for the Energy Star certification that do not presently qualify, greatly increasing the potential sales price of the new appliance. ■

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