Options Beyond Three-Phase For Serving Remote Motor Loads

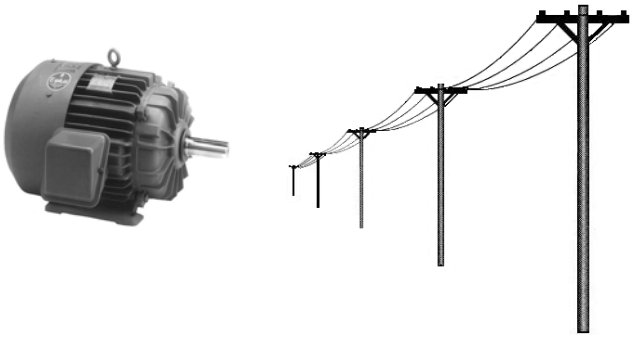
Greg Stark, P.E.
RERC Program Associate

Richard Hiatt, P.E.
President/Exec. Manager

Rural Electricity Resource Council ~ www.rerc.org

Getting power to large motor loads located in remote areas has always been an economic challenge for rural customers and their utilities. Two key factors define the challenge: (**1**) higher costs for constructing three-phase service to remote sites, along with (**2**) the low operating hours (and revenue to the utility) of seasonal loads like grain drying, irrigation pumping, and dozens of other motor applications. Simply put, it's difficult to justify the high cost to build three-phase lines to remote sites that have seasonal or low kilowatt-hour usage.

In the past, serving a remote motor load was limited to using single-phase service (lower construction costs) coupled with a conventional phase converter. There are now three additional choices, but it's important to know the advantages and disadvantages of each.



The reason that electric utilities cannot serve larger motors from single-phase lines comes from the high start-up current required by motors. For anything larger that 10 Hp on most lines, this initial starting current and the accompanying voltage drop causes blinking problems (voltage sags) for other customers on the line. Because building three-phase to remote sites is often cost prohibitive, the only alternatives have been diesel engines, or conventional phase converters, which work for some applications but not all. Below is a review of the key considerations for conventional phase converters, and three relatively new electric alternatives.

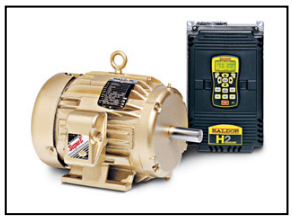
The Old and the New

Phase converters have been around for decades. They mechanically "create" three-phase power from a single-phase input. Three separate sources (phases) are delivered, but the phase converter must be carefully matched to the needs of the equipment being served. One common style is a rotary phase converter, which spins like a motor to create three-phase power. A static phase converter is simpler, but can only be used with certain loads. Phase converters have their limitations, such as slightly higher operating costs and reduced motor life. This factor must be considered, particularly if the load has a high number of run hours during the year.

With advances in technology, new alternatives have emerged in recent years to compete with phase converters. These include **Adjustable Speed Drives** (ASD), **Written-Pole Motors** and a specially designed electronic package called **Phase Perfect**. Each employs solid-state electronics in one form or another, but a full explanation is beyond the scope of this article. However, we offer a concise review of the key features of each, and decision factors to consider for any application.

A Quick Description of the New Technologies

Adjustable-speed drives (ASDs) are electronic devices used to vary the operating speed of standard motors. When sized correctly, they can also convert single-phase to three-phase, and serve motors up to 125 Hp.



The *Written-Pole Motor* does not convert power like the other technologies. It is actually a specially designed single-phase motor that can be substituted for a three-phase motor to drive the given load. Available in sizes up to 100 Hp, this highly efficient motor can start and run without exceeding the limits of most distribution lines.

Phase Perfect is the newest product. Labeled as a "digital phase converter", it is similar to an ASD, but specifically built to supply three-phase motors from single-phase lines. Phase Perfect is a brand name, so check around for other suppliers. Limited to motor sizes up to 30 Hp, this may be a preferred choice for some installations, particularly where there are several smaller three-phase devices in a single building.

Helping Customers Evaluate The Options

To help rural businesses and farmers understand the advantages and disadvantages of each, consider the criteria below. Use the **summary table** (below) as well to make your comparisons.

☑ **The size of the motor** being served may limit your choice. The Phase Perfect in particular can only handle motors up to 30 Hp; for anything larger go to the other products. The Written-Pole motor now comes in a 100 Hp size. The upper limit for an ASD is a 125 Hp motor. This can be a determining factor for higher Hp installations like irrigation or other motor loads larger than 30 Hp.

On the utility's side of the meter, there limits to the amount of load that can be added to the single-phase line. Of the four options, the conventional phase converter will draw the highest load per Hp served, while the Written-Pole Motor will have the lowest requirements.

☑ **The instantaneous starting current** drawn by any of these options is an added concern. Similar to the above issue, this is not the total motor size, but rather the specific inrush current drawn during the first seconds of start-up. Particularly for existing lines that are already heavily loaded, the starting of a large motor (and associated voltage drop) affects other customers. ASDs and the Written-Pole motor each reduce the starting current to the lowest levels, and provide a "soft start" that reduces voltage flicker at start-up. The standard phase converter and the Phase Perfect result in roughly the same level of starting current that a normal three-phase motor would draw.

☑ **Operating efficiency** will be an issue if loads are run for a large number of hours each year. Phase converters are 82 to 86% efficient while the other technologies are about 92 to 96% efficient. Both the ASD and Phase Perfect devices are installed ahead of a standard three-phase motor, so consider the *combined* efficiency. If a Written-Pole motor adapts to the application, it offers the highest efficiency, making it a good choice for loads with long run hours.

☑ **Available voltage** at the location is a consideration for larger motor loads. Written-Pole motors above 40 Hp require 480-volt single-phase service, as do some of the larger ASD installations. Although not a major issue for new services, for existing services going from 240 to 480 volts requires changing the transformer. This is not difficult, but it is an added cost to consider.

☑ **Power quality** is an issue in two ways. First, poor incoming power can adversely affect the device. Second, any outgoing disturbances from the device can disrupt sensitive customer equipment. ASD's in particular are sensitive to a variety of disturbances. They also create harmonic distortion that can affect motor life and impact sensitive electronics for other customers in the vicinity.

The Written-Pole motor can ride through most power disturbances without incident. Since a conventional phase converter does not supply perfectly balanced three-phase voltage to the motor, if the imbalance is large enough it will reduce the motor's life. The Phase Perfect is capable of supplying balanced voltage to the motor, and eliminates major transients. Therefore, consider how big an issue power quality is for the equipment operation and longevity.

☑ **Multi-motor control means that** a single device can be used to supply more than one three-phase motor at a time. This can be a savings when supplying multi-motor equipment like the drive motors on a center-pivot irrigation system, or multiple machine shop tools for a business. ASD's and standard phase converters allow multi-motor control, however; the system may not operate at its maximum efficiency when only one motor is operating and the device was selected to handle several at once.

☑ **Speed control** offers the ability to vary the speed of the motor and load as needed. Adjusting the speed of some pumping operations to control flow rather than opening and closing valves can save energy and lower operating costs. The ASD is the only option that provides this capability.

☑ **The need for a pump panel** is associated only with pumping applications, but it is a factor. These separate and required control boxes will be an added cost unless the phase-converting device has the controls built in. Both ASD's and the Phase Perfect have the required control capability built in, which could result in significant cost savings as compared to the other options.

With so many factors to consider, selecting an optimum solution requires an organized approach. Start by comparing the unique aspects of the specific application to each technology's capabilities and limitations. The on-site requirements of most importance will begin to whittle-down the choices to those that meet the customer's needs. In each case, the solution will be a compromise between all the factors. Once the options are narrowed-down, price becomes the final consideration in the ultimate decision.

We hope this review assists you and the rural customers you work with. If any member of the *Rural Electricity Resource Council* would like further help, we offer our assistance. #

Product	Starting Current	Motor Life Concerns	Efficiency	Speed Control	Multi-Motor Control	Eliminates Pump Panel
1. **Conventional Phase Converter** (Supplied by several manufacturers)	Normal Current	**YES**	85%	**NO**	**YES**	**NO**
2. **Adjustable-Speed Drive** (ASD) (Supplied by several manufacturers)	Soft Start	**YES**	92 to 96%	**YES**	**YES**	**YES**
3. **Written-Pole Motor** www.precisepwr.com	Soft Start	**NO**	96%	**NO**	**NO**	**NO**
4. **Phase Perfect Converter** www.PhasePerfect.com	Normal Current	**NO**	95%	**NO**	**YES**	**YES**