

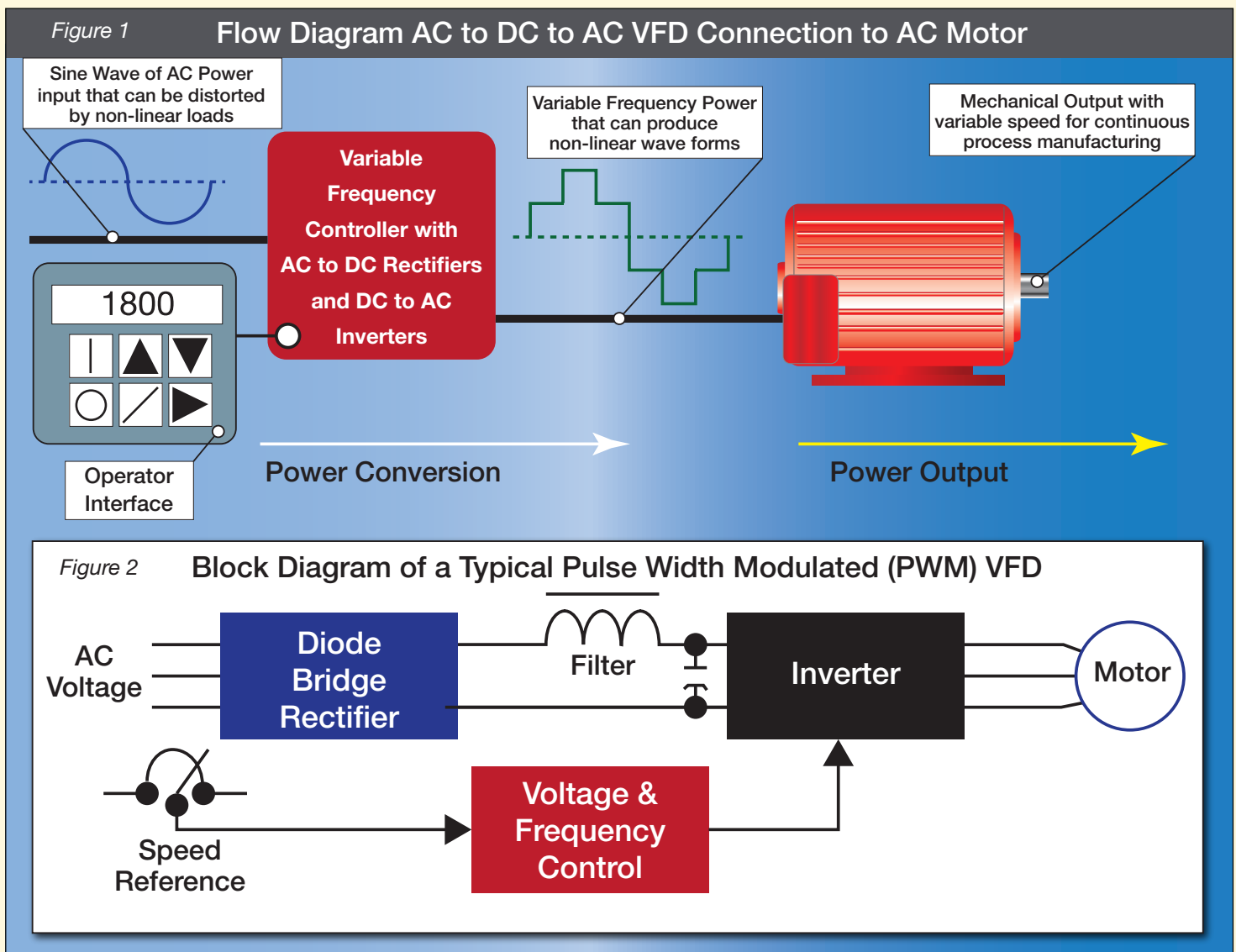


A significant market application for standby and prime power generator systems is the Industrial Sector. Many industrial processes use a Variable Frequency Drive (VFD). It refers to technology that provides fine control of motors with an electro-mechanical drive system. VFDs have two principal benefits: first, a more efficient way to start and ramp up an electric motor, and second, a method for finely controlling motor speed and/or movement across a wide range of systems, including but not limited to continuous manufacturing processes, industrial and commercial machinery, and water-treatment plants. This technology uses advancements in digital switching technology. A generator system designer must ensure the generator can handle the characteristics of a load with a high percentage of digital switching. This information sheet discusses the principles behind VFDs, the benefits of using VFD technology, and the load characteristics a generator system engineer must consider when specifying a suitable standby or prime power generator system.

1.0 EXPLANATION OF VFD TECHNOLOGY:

The primary purpose of a VFD is precise control of electric motor speed. With a VFD, a system designer can precisely control ramp-up and ramp-down speed to ensure all components in a process are coordinated and operate efficiently in sync. Without a VFD, an AC electrical-mechanical device, such as a constant-speed electric motor, runs up to constant speed as current is applied and, in the process, can consume up to 7 times the running amps required to overcome starting torque. Before VFDs, motors had to be connected to various mechanical components, such as gears.

VFDs control an AC motor's speed by varying the frequency supplied to the motor. The drive also regulates the output voltage in proportion to the output frequency to maintain a relatively constant voltage-to-frequency (V/Hz) ratio, as required by the AC motor's characteristics to produce adequate torque. A VFD uses three components (see Figure 1).



The installation information provided in this information sheet is informational in nature only, and should not be considered the advice of a properly licensed and qualified electrician or used in place of a detailed review of the applicable National Electric Codes and local codes. Specific questions about how this information may affect any particular situation should be addressed to a licensed and qualified electrician.

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2.1 AC MOTOR:

The AC electric motor used in a VFD system is usually a three-phase induction motor. Some single-phase motors or synchronous motors can be advantageous in certain situations, but three-phase induction motors are generally preferred because they are the most economical. Elevated-voltage stresses imposed on induction motors that are supplied by VFDs require that such motors be designed for definite-purpose inverter-fed duty in accordance with such requirements as Part 31 of NEMA Standard MG-1.

2.2 VFD CONTROLLER:

VFD electronics operate on direct current (DC), while most applications connected to the utility use alternating current (AC). The first step is to convert the AC supply voltage to DC using a rectifier. DC power contains voltage ripples which are smoothed using filter capacitors. Once converted to DC, this part of the VFD is called the DC link.

The resultant DC voltage is then converted back to AC voltage using an inverter. The inverter output AC voltage is turned on and off at a high frequency, with the duration of on-time, or width of the pulse, controlled to approximate a sinusoidal waveform. Finely ramping up and ramping down the AC input frequency and voltage enables precise control of the AC motor's speed.

The entire process (see block diagram, Figure 2) is controlled by a microprocessor which monitors:

- Incoming voltage supply
- Speed set-point
- DC link voltage
- Output voltage and current to ensure operation of the motor within established parameters

2.3 OPERATOR/PLC INTERFACE:

A manual interface can control the inverter output voltage to the AC motor to start and stop the motor and adjust operating speed; however, in most automated industrial and commercial applications using VFD technology, a Programmable Logic Controller (PLC) is used through Modbus or a similar interface.

3.0 VFD REMOTE SPEED CONTROL:

There are two main ways to control a VFD's speed: networked or hard-wired. Networked control transmits the intended speed over a communication protocol such as Modbus, Modbus/TCP, Ethernet/IP, or via a keypad using a Display Serial Interface. In contrast, hard-wired control uses a purely electrical means of communication.

4.0 INDUSTRIAL GENERATOR APPLICATIONS STANDBY/PRIME USING VFD:

Because a VFD enables precise control of an AC motor's speed as it varies and/or ramps up the input voltage, operators and system designers have a tool to control motor starting and speed precisely. Applications for VFDs are numerous and include:

4.1 CONTINUOUS PROCESS INDUSTRIES:

Steel plate and paper production are manufacturing processes where raw material enters the process slowly and exits much faster. Electric motors driving the stages of these manufacturing processes can be accurately synced and controlled by VFD technology.

4.2 MORE EFFICIENT MOTOR STARTING:

By applying VFD starting to electric motors, an operator/user can significantly reduce current draw compared with direct motor starting, with lower power consumption and a more efficient start-up process.

4.3 WATER TREATMENT PLANTS:

Water treatment plants incorporate many electric motor-powered pumps to move wastewater from one segment and level to another. The whole plant requires fine control of the pumped water to ensure all treatment processes are coordinated. Using a VFD connects all the various pumps and level switches and controls the flow rate.

5.0 WHAT ISSUES CAN VFDs HAVE WHEN CALCULATING AND SPECIFYING GENERATOR OUTPUT:

The primary concern when specifying a generator system for powering VFD loads is the characteristics of digital switching. VFDs use Silicon Controlled Rectifiers (SCRs). SCR loads are defined as non-linear loads. (See information sheet: The Effect of Nonlinear Loads on Generator Systems). The key generator specification items to consider in sizing a generator are:

5.1 REQUIRED STARTING KVA:

By applying VFD starting to electric motors, an operator/user can significantly reduce the motor's current draw, which reduces the generator size required to start the motor. A generator must be rated to a certain kVA to overcome the inrush current on start; in simple terms, the inertia. VFD lowers in-rush current or starting kVA. If there is one motor, you cannot stagger start as you can with several motors.

5.2 REQUIRED STARTING KVA:

The other issue is voltage regulation. When a high percentage of the load is SCR, it can create voltage spikes and non-linear loads that overwhelm the generator's internal voltage regulation. The primary solution is to fit a PMG regulator to provide independent excitation and to increase the kVA capacity of the generator

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