



# YASKAWA

## Application Report Commercial Laundry

- Variable Frequency Drives provide a performance and cost competitive alternative to traditional control schemes.*
- They offer virtually unlimited speed variation for wash and spin cycles.
  - They have built-in capability for unbalanced load detection.
  - They improve power factor, reduce inrush & eliminate most of the existing electro-mechanical control devices.

Recent developments in the drive industry have made a compact, cost effective Variable Frequency Drive (VFD) available for commercial laundry applications.

Manufacturers have already introduced VFD drive coin and on-premise laundry washers with capacities to 150 pounds.

Additional benefits of using the VFD in laundry applications is that control components are greatly reduced. The VFD eliminates contactors and capacitors, and provides electronic overload protection.

The VFD is capable of converting single-phase input to three-phase output. This feature allows the use of standard, off-the-shelf three-phase motors, including energy efficient designs, rather than more expensive single-phase multi-speed motors, which are often difficult to obtain. The laundry equipment can be operated on either single or three-phase power, which will reduce inventory needs and the associated costs for both manufacturing and operation.

Variable speed ac drives have a well-founded reputation for versatility and dependability, with many features and benefits that are not available from other drive technologies. They are now used in applications ranging from simple fan control to complex operations including process loops, positioning, indexing, and industrial laundry applications.

An ac variable frequency drive simultaneously controls both output frequency and voltage to efficiently control the speed and torque producing capabilities of a three-phase induction motor.

Common induction motors are typically offered in 2-pole (3600 rpm), 4-pole (1800 rpm), and 6-pole (1200 rpm) designs. Applying 60 Hz to a 4-pole motor will produce a motor speed of 1800 rpm at no load. Actual speed at any applied frequency is influenced by motor load requirements. If frequency is cut in half (30 Hz), then motor speed is cut in half.

Voltage is applied in proportion to frequency to achieve rated motor torque throughout the speed range (Figure 1). If the motor is running at half speed (30 Hz), the voltage applied is also cut in half. Failure to reduce applied voltage with reduced speed will result in excessive current draw and motor overheating. Above 60 Hz, a VFD changes from a constant torque device to a constant horsepower device. This occurs because voltage is held constant above 60 Hz. (You cannot get more voltage out of the VFD than you put in.) This results in a reduction of available torque, a fact that must be considered when sizing motor/drive packages.

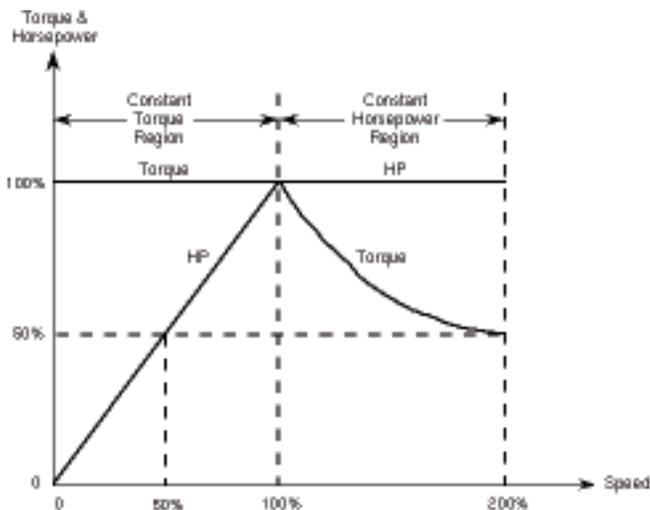


Figure 1-Relationship of Torque & Horsepower to Speed

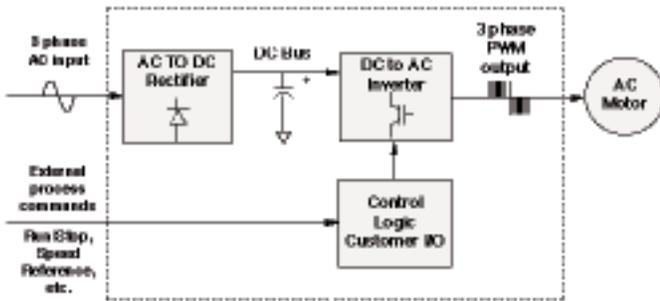


Figure 2-VFD Major Elements

Pulse Width Modulation (PWM) control is the present state-of-the-art method used to control frequency and voltage. An ac power source is connected to the drive rectifier, converted to dc, and then “inverted” in a logic controlled output of dc pulses of varying width (voltage) and polarity (frequency). A motor is an inductive device constructed of coils of wire embedded in iron. The motor's inductance resists the rapid voltage changes, averaging (smoothing) the pulses and making them appear to the motor as a three-phase sine wave. There are three major elements in a PWM VFD:

- Rectifier - Converts ac power source to dc
- DC Bus- Pulsating dc is averaged by large capacitors. A measurement at the output of this section indicates a dc voltage equal to the ac peak value of approximately 1.4 times the ac input.
- Inverter- Receives instructions from control logic, converting dc to variable frequency, variable voltage three-phase PWM output.

Modern VFDs utilize Insulated Gate Bipolar Transistors (IGBT), which are state-of-the-art power devices. Most PWM drives originally used bipolar transistors with low frequency switching rates (Carrier Frequency), which offered limited torque producing capability, produced unacceptable levels

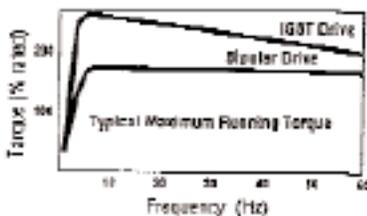


Figure 3 - % Rated Torque vs Frequency

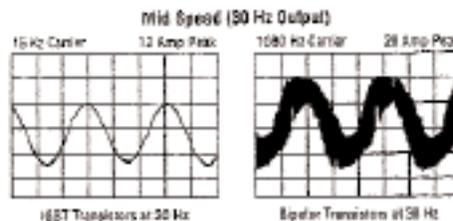


Figure 4 - Motor Current Waveforms

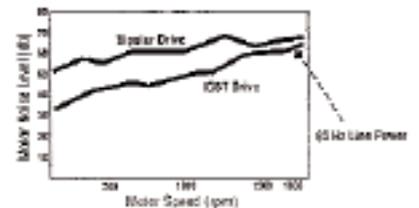


Figure 5 - Audible Motor Noise Comparison

of audible motor noise, and caused excessive motor heating. IGBT devices significantly improve the motor torque characteristics. The current waveform is nearly sinusoidal, reducing peak currents. Starting torque of 100% is available at 0.5 Hz. 150% is available at 1.5 Hz.

Motor noise is virtually eliminated within the audible frequency range. Motors run cooler because of the clean current waveform, extending insulation and motor life and lowering overall operating costs.

### Recent Developments

Cost-effective Variable Frequency Drives are now available for commercial laundry machines. They offer the latest in IGBT technology, the Application Specific Intelligent Power Module (ASIPM). This module eliminates control components normally associated with transistor firing schemes. All components are imbedded in the ASIPM module. The resulting fewer parts greatly reduces the cost of the VFD, making it competitive with present conventional control methods using contactors and multi-speed motors. Figure 6 shows the major components of this drive. It can be used with both single and three-phase input power, and voltages from 190 to 480 v.

Control logic is stored in one application specific IC and is user addressable to allow programming for special requirements. Wash formulas, unbalance detection and cycle times can all be programmed directly into the VFD software, eliminating the need for timers, microprocessors, etc.

Today's VFD units are compact and DIN rail mountable, which means additional time and cost savings in design and manufacturing

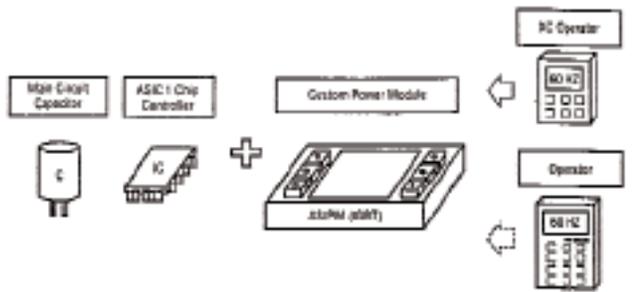


Figure 6 - Major Components of an ASIPM VFD

### Commercial Laundry Applications

Most existing commercial laundry washers use special multi-speed motors, normally 2-18 pole (3600 - 340 rpm), which require a reversing multi-speed starter, overload relay, starting capacitors and a solid state switch (Figure 7). The primary supplier of this special motor design is located in Europe, which can cause availability problems, especially for “Just-In-Time” manufacturing operations. Drum speed is limited to sheave sizes, with any variation requiring a sheave change. Also, voltage variations require different motor designs, adding additional inventory and the related costs.

The ASIPM based Variable Frequency Drive is already providing a performance and cost competitive alternative to the traditional control scheme. It offers virtually unlimited speed variation for wash and spin cycles, adds the built-in capability for unbalanced load detection, eliminates most of the existing electro-mechanical control devices, improves power factor and reduces inrush. Figure 8 shows a typical control scheme, utilizing a standard off-the-shelf three-phase ac induction motor design. These motors are lower in cost and much easier to obtain than their single-phase counterparts. Capacitors and solid state switches are no longer required.

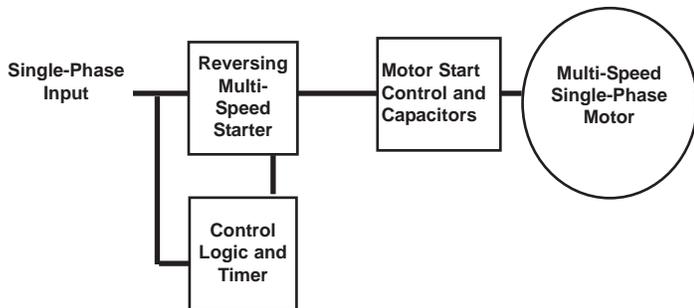


Figure 7 - Typical Existing Laundry Drive Circuit

The market for commercial laundry washers today is demanding increased “G” forces for water extraction, which requires higher spin speeds. However, to provide an adequate wash, wash speeds cannot vary. The multi-speed motor would have to be redesigned to a 2-20 pole to provide acceptable performance.

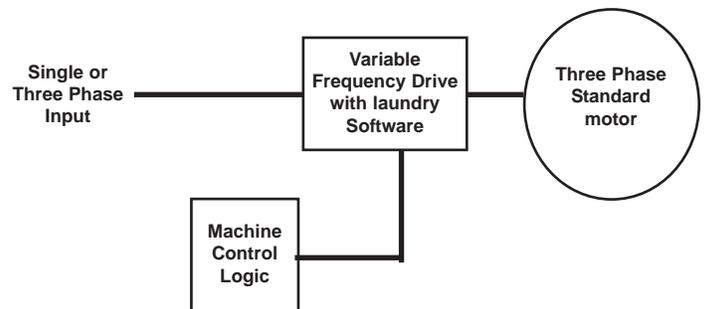


Figure 8 - Typical VFD Laundry Drive Circuit

A 120 v VFD design is already available, opening the door to residential washer applications in the future.

### Summary

The variable frequency drive for commercial laundry applications provides not only cost and time saving advantages in design and manufacturing, but also offers lower operating costs and a wide range of wash and spin speeds that can be changed at will. Optimum performance can be achieved for a load of heavy cotton towels by using wash and spin speeds specifically for that material. The next load might be more delicate materials, requiring different speeds for thorough cleaning and fabric protection. The change in operation is easily and quickly done via a contact closure in the variable frequency drive.