

Chapter 5

Electric Motors

PART 5 Alternating Current Motor Drives

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AC drives connect to standard AC induction motors, and have similar capabilities of **adjustable speed, torque, and horsepower control** as DC drives.



- AC induction motor speed depends upon the number of motor poles and the frequency of the applied power.
- The number of poles on the stator of the motor could be increased or decreased but this has limited usefulness.
- Although the AC frequency of the power source has been standardized at 60 Hertz, advances in power electronics make it practical to vary the frequency and resulting speed of an induction motor.

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VARIABLE FREQUENCY DRIVE

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A *Variable Frequency Drive (VFD)* system generally consists of an AC motor, a controller and an operator interface.

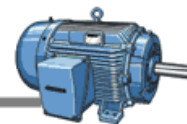
➤ Three-phase motors are usually preferred but some types of single-phase motors can be used.

➤ Motors that are designed for fixed-speed mains voltage operation are often used, but certain **enhancements** to the standard motor designs offer higher reliability and better VFD performance.

Controller

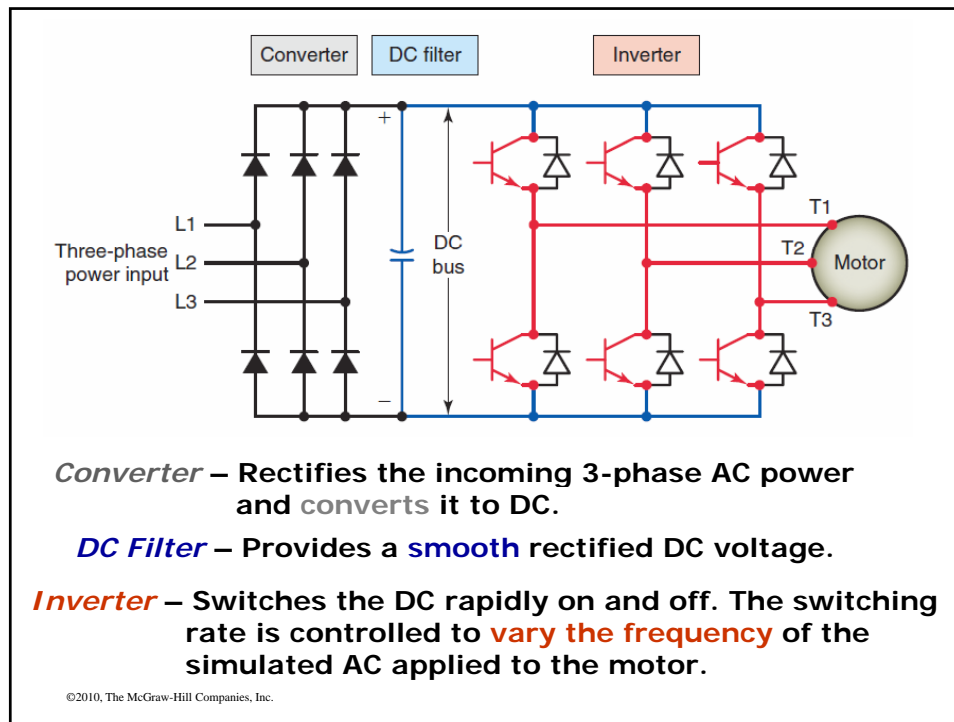


Operator Interface

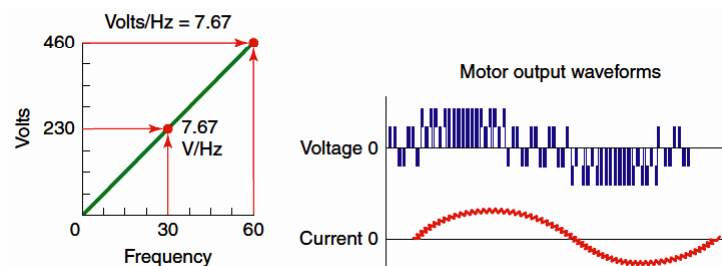


AC Motor

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AC motor characteristics require the applied voltage to be proportionally adjusted by the drive whenever the frequency is changed.

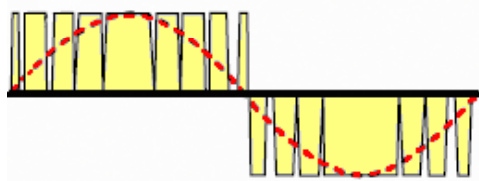


➤ If a motor is designed to operate at 460 volts at 60 Hz, the applied voltage must be reduced to 230 volts when the frequency is reduced to 30 Hz

➤ Thus the ratio of volts per hertz must be regulated to a constant value ($460/60 = 7.67$ in this case).

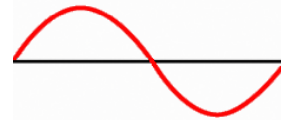
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The most common method used for adjusting the motor voltage is called *Pulse Width Modulation (PWM)*.



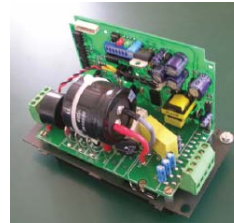
Pulse Width Modulated Waveform

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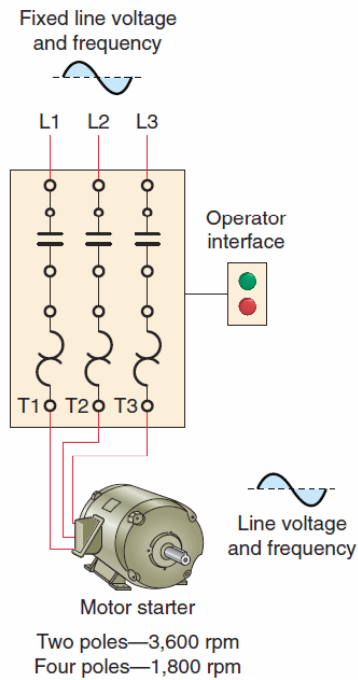
Equivalent Sine Wave

Electronic **inverter switching** is used to divide the DC waveform into a series of narrow voltage pulses and modulate the width of the pulses.



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With a standard *AC across-the-line motor starter*, line voltage and frequency is applied to the motor and the speed is solely dependent on the number of motor stator **poles**.



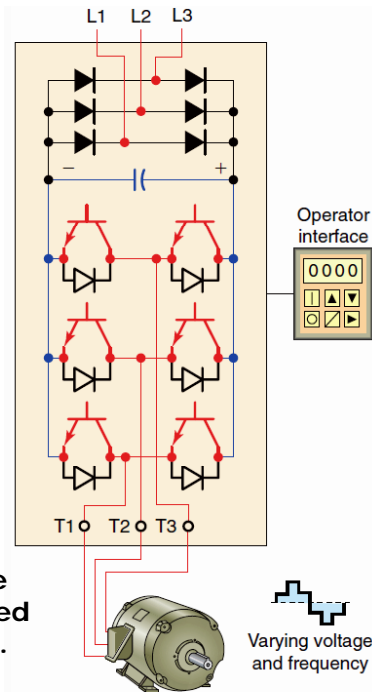
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AC motor drives deliver a varying voltage and frequency to the motor, which determines its speed.



- The higher the frequency supplied to the motor the faster it will run.
- Speed can be lowered below the nameplate base speed or increased to synchronous speed and higher.

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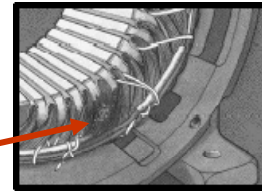
INVERTER DUTY MOTOR

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***Inverter Duty* and *Vector Duty* describe a class of AC induction motors that are specifically designed for use with variable frequency drives**



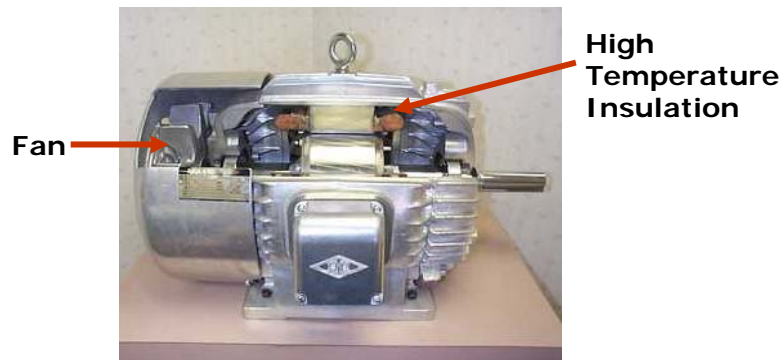
➤ The high switching frequencies and fast voltage rise times of AC motor drives can produce high voltage peaks in the windings of standard AC motors which exceed their **insulation breakdown** voltage.



➤ Operating motors for an extended time at low motor RPM reduces the flow of cooling air, which results in an increase in temperature.

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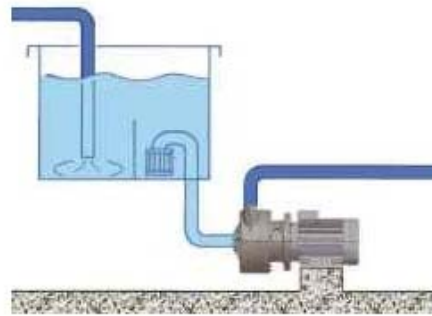
***NEMA rated inverter or vector duty* motors use high temperature insulating materials that can withstand higher voltage spikes and operating temperatures. This reduces the stress on the insulation system.**



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AC motors frequently drive **variable loads** such as pumps, hydraulic systems and fans. In these applications, motor **efficiency** is often poor due to operation at low loads and can be improved by using a VFD in place of speed controllers such as belts and pulleys, throttle valves, fan dampers and magnetic clutches.

A pump, controlled by a variable speed drive, running at **half-speed** consumes only **one-eighth** of the energy compared to one running at full speed.



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