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Monthly Informative Application Guidelines, with respect to *Motors & Drives* to keep you better INFORMED.

APPLICATION GUIDELINE #21

(Variable Frequency Drives – Basics)

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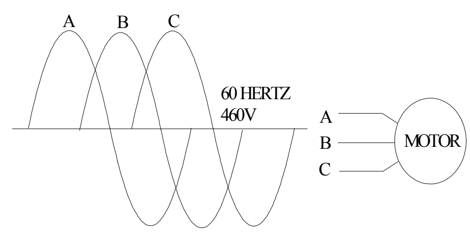
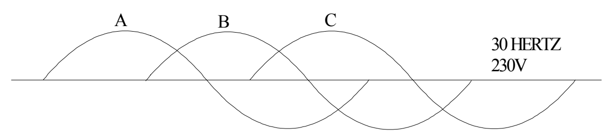
Many names in industry are used to describe the device that controls the speed of a motor: AC drives, inverters, adjustable speed drive (ASD), and variable frequency drive (VFD) are the most common. To simulate a sine wave electronically is actually very difficult. Before microprocessors, the electronic circuitry was complex and gave marginal performance. Power devices had limitations thus increasing the technical challenges. To fully understand the motor performance, some basics are required.

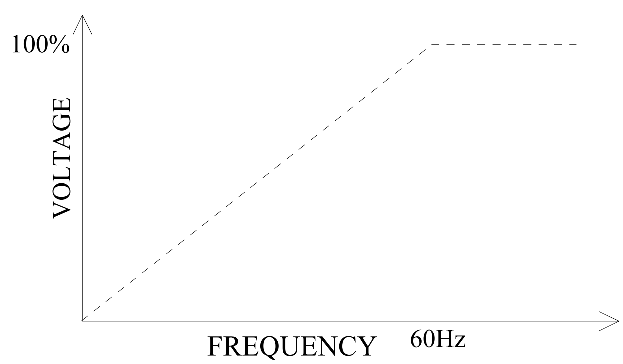




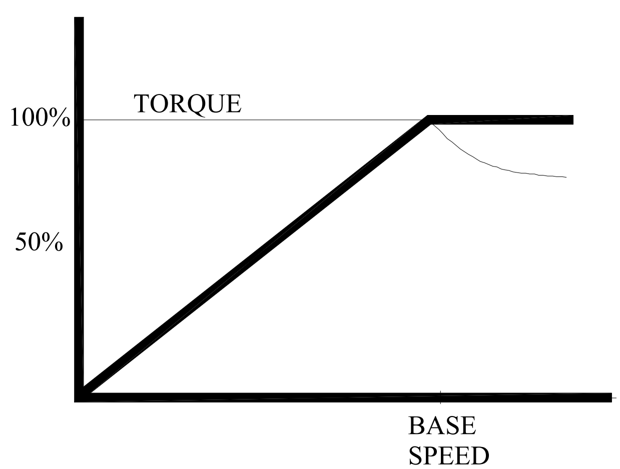
An AC motor controller must vary the voltage and frequency at the stator to get variable speed.

At full speed (usually 50 or 60 cycles) the motor needs full voltage. Half speed would require half frequency and half voltage.

A utility company normally supplies this voltage which is generated using a rotating generator. A very sophisticated controller is needed to perform all the functions required to assure normal motor operation while varying motor speed.



When using a drive, the across the line starting torque curve is no longer valid. The rotor is turning at the proper speed with respect to the applied frequency (high slip situations never occur). Inrush current is gone and torque is proportional to amps delivered to the motor. Each frequency has a new torque curve.



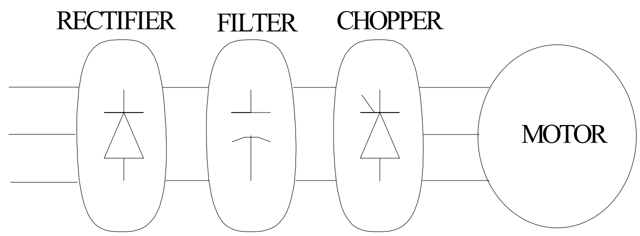
With a variable speed controller using solid state devices, the torque is also limited by the current ratings of the devices. A new torque speed curve applies as shown here on the left. The dark line shows horsepower available. At half speed, although delivering constant torque, the motor only develops one-half horsepower.

For short periods of time a motor can deliver more than 100% torque. The amount and time depend on the motor and usually is limited by heating.

The motor controller can also limit the amount of torque. To protect the power components, current is usually limited to 150%, which would mean torque is limited to 150%.

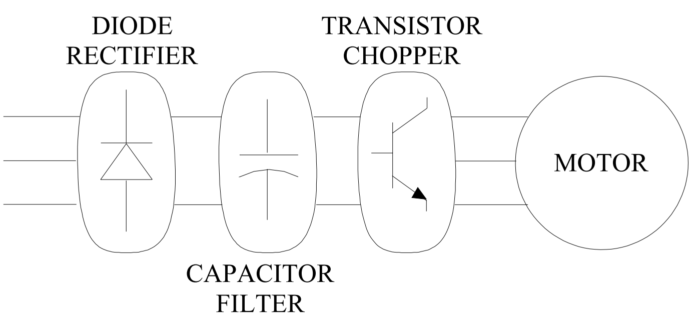
Torque starts to reduce linearly after base speed because the VFD cannot continue increasing voltage and therefore the proper volts per hertz ratio cannot be maintained. This is called constant horsepower operation. At some point depending on motor design, constant HP operation is not possible and torque decreases dramatically at high speeds.

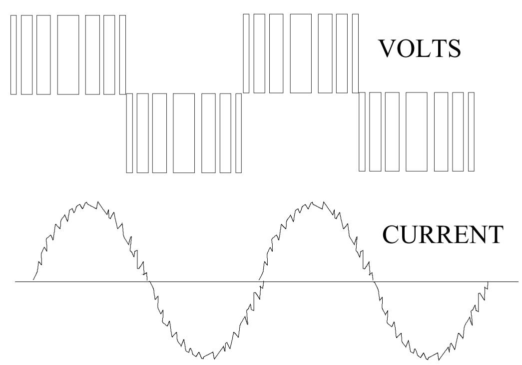
The block diagram to the right shows how most drives change the AC input to DC. Some type of filter smoothes the DC, which is then chopped into the motor leads to simulate AC.



PWM-Pulse Width Modulated Variable Frequency Drives

Past technologies using SCR or Thyristor power devices prevented the ASD from obtaining the optimum performance from an AC motor. The first introduction of PWM VFD's using newly developed high power transistors from Toshiba gave industry a hint that the VFD had promise to operate an AC motor with the same performance as DC. The PWM drive removed the complexity of the input thyristor rectifier. It used diodes to change AC to a fixed DC bus. Capacitors were used to filter the D.C. bus, and the bus voltage was then chopped at high frequencies into the motor leads. The pulse width is varied to vary the voltage to the motor. Wide pulses give high voltage and narrow pulses give low voltage. Toshiba's microprocessor controlled regulator encodes the PWM waveform to give a near sinusoidal motor current.
Transistors with high voltage and fast switching capability were introduced to the market in 1980.





Commutation problems were gone and reliability increased dramatically. Small AC motors could produce wide speed ranges with smooth torque. Some characteristics of the available transistors still limited the performance especially in the larger ratings above 100 horsepower. The transistor devices were difficult to parallel to get higher current ratings and a new power device was necessary to move to larger ratings.

Toshiba introduced the first IGBT ASD, which incorporated IGBT transistor technology in 1988. <u>This advance in the drive market allowed our PWM output to switch the transistors more efficiently and it was possible to parallel the devices for larger capacities</u>. The faster switching speed device allowed for an improved current control and made the ASD more application insensitive.