VACON
DRIVEN BY DRIVES

What is a variable speed AC drive and how does it work?

An AC drive is a device that is used to control the speed of an electrical motor, either an induction motor or a synchronous motor. AC drives are also known by various other names such as **adjustable speed drives** (ASD) or **adjustable frequency drives** (AFD) or **variable frequency drives** (VFD) or **variable speed drives** (VSD) or **frequency converters** (FC).

The first electrical AC motor was designed in 1899. Electrical motors convert electric energy into mechanical energy by electromagnetic induction. These motors are characterized by:

- fixed speed, determined by the frequency of the power supply
- fixed torque

Obviously, a fixed speed is not suitable for all processes in all circumstances; thus, the need for adjusting the speed according to need.

Industrial machinery is often driven by electrical motors that have provisions for speed adjustment. Such motors are simply larger, more powerful versions of those driving familiar appliances such as food blenders or electric drills. These motors normally operate at a fixed speed.

If speed control is required, that controller is called a (variable speed) AC drive. AC drives are used in a wide variety of industrial applications. To give an easy example, AC drives are often used with fans to provide adjustable airflow in large heating and air conditioning systems. The flow of water and chemicals in industrial processes is often controlled by adjusting the speed of pumps.

However, variable speed AC drives are commonly used in more complex and difficult environments such as water and wastewater processing, paper mills, tunnel boring, oil drilling platforms or mining.

The technology

The speed is controlled by changing the frequency of the electrical supply to the motor. The 3-phase voltage in the national electrical grid connected to a motor creates a rotating magnetic field in it. The rotor of the electrical motor will follow this rotating magnetic field. An AC drive converts the frequency of the network to anything between 0 to 300 Hz or even higher, and thus controls the speed of motor proportionally to the frequency.

1. Rectifier unit

The AC drive is supplied by the electrical network via a rectifier. The rectifier unit can be uni- or bidirectional. When unidirectional, the AC drive can accelerate and run the motor by taking energy from the network. If bidirectional, the AC drive can also take the mechanical rotation energy from the motor and process and feed it back to the electrical network.

2. DC circuit

The DC circuit will store the electrical energy from the rectifier for the inverter to use. In most cases, the energy is stored in high-power capacitors.

3. Inverter unit

The inverter unit takes the electrical energy from the DC circuit and supplies it to the motor. The inverter uses modulation techniques to create the needed 3-phase AC voltage output for the motor. The frequency can be adjusted to match the need of the process. The higher the frequency of the output voltage is, the higher the speed of the motor, and thus, the output of the process.

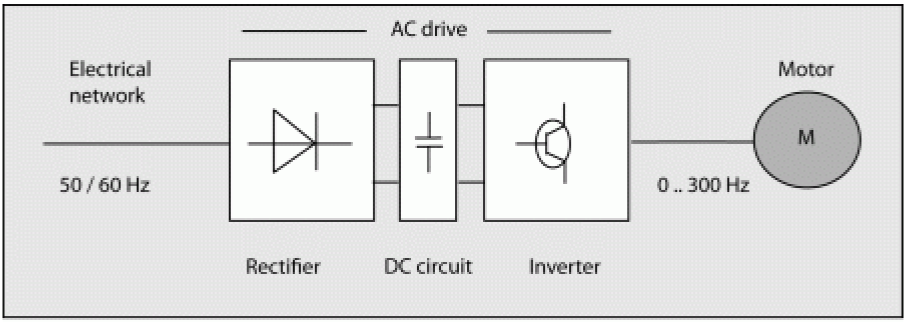


Figure 1: The main components of an AC drive: rectifier, DC circuit and inverter

The benefits

The types of motors that AC drives control are normally operating at constant speed. Enabling the user to control the speed of motor potentially gives him various benefits in terms of process control, system stress and energy savings.

Adjusting speed as a means of controlling a process

- Smoother operation
- Acceleration control
- Different operating speed for each process
- Compensate for changing process variables
- Allow slow operation for setup purposes
- Adjust the rate of production
- Allow accurate positioning
- Control torque or tension

System stress

- Reducing the start-up current, which allows use of smaller fuses and supply connections and reduces peak loads on the electrical network
- Reducing the mechanical shock in start and stop situations

Saving energy by using AC drives

An AC drive often uses less energy than an alternative fixed speed mode of operation. Fans and pumps are the most common energy saving applications. In these applications, energy savings are typically 20-50%.

When a fan is driven by a fixed speed motor, the airflow may sometimes be higher than it needs to be. Airflow can be regulated by using a damper to restrict the flow, but it is more efficient to regulate the airflow by regulating the speed of the motor.

See also: Calculate how much energy Vacon AC drives can save in pump and fan applications

Case study: AC drives in HVAC applications

40% of all energy in Europe and North America is consumed in buildings. The biggest share of this energy is consumed in heating, ventilation and air conditioning (HVAC) applications.

With the rising energy cost and concerns about the CO2 levels and global warming, it is crucial to use all means available to reduce the energy consumption in HVAC applications. **The savings potential is big**.

The key thing is to start looking more at lifetime costs of HVAC system, where energy cost plays a big role, rather than the initial investment in HVAC system. **To give an example, 90% of the lifetime costs of the pump or fan is energy.**

The majority of HVAC applications where AC drives are used are

- fans

- pumps
- compressors.

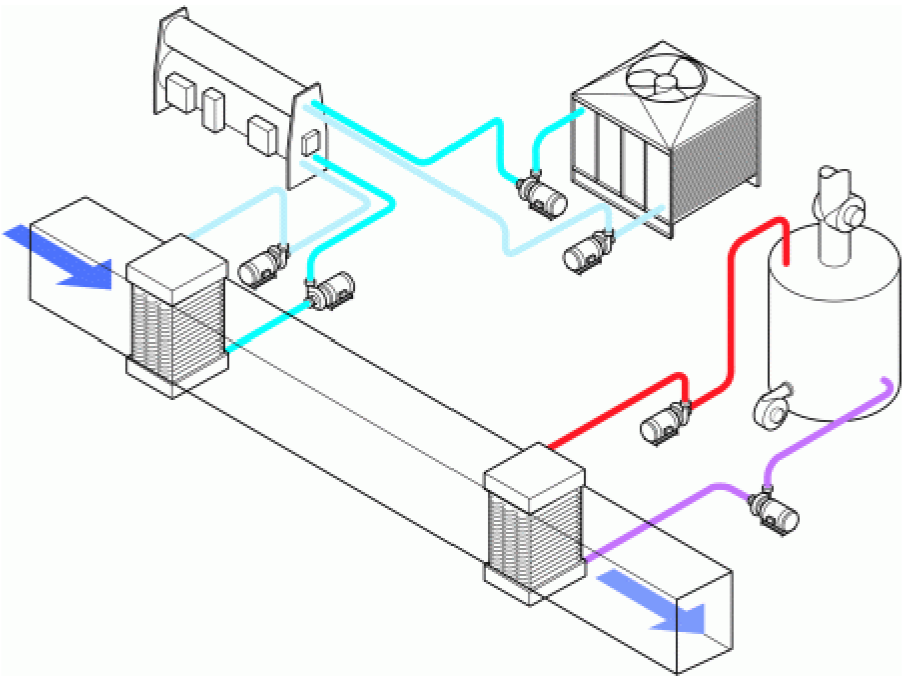
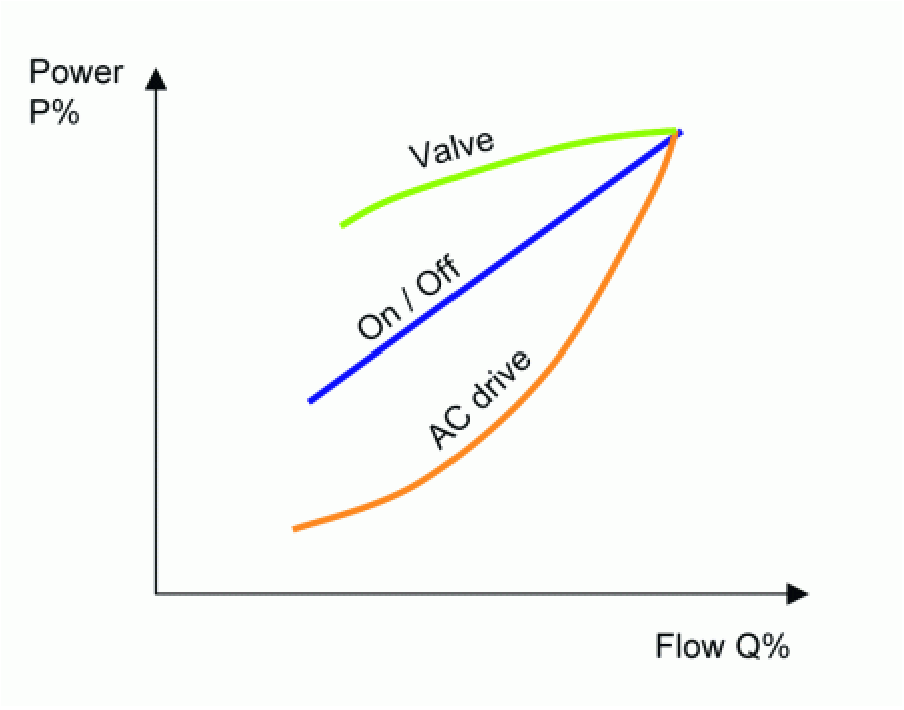


Figure 2: The main components of an HVAC system: air circulation, water cooling circuits and water heating circuits.

1. Fans and pumps

Using an AC drive to control the fan or pump output rather than using dampers, vanes, valves or on/off control brings substantial energy savings, if the required output is less than nominal most of the time.

The AC drive controls the speed of the pump and fan by changing the electrical energy supplied rather than damping the air- or water flow. It is like reducing the speed of a car by pressing less on the accelerator instead of using the brake to slow down the speed. **The payback time of an AC drive is typically one year or less.**



Graph 1: Electrical power consumed by pump at partial loads is significantly less with an AC drive than with valve or on/off control.

Other benefits of using AC drive to control the speed of fan or pump are:

- Smooth ramp up and ramp down causes less stress to the mechanics of fans and pumps and to air ducts and water piping
- Slowing down the speed rather than damping the output will result in lower noise levels
- Tuning the HVAC system during and after the commissioning is easier when the flexibility of an AC drive is used

2. Compressors

Compressors in HVAC are often used in chillers for cooling water, which again is used **for cooling air**. Utilising AC drives in compressor applications will potentially bring energy savings compared to on/off control.

Energy savings are achieved by optimising the system setup of compressor, chilled water circulation and condenser water circulation. The optimum set point for chilled water temperature and condenser water temperature is based on outdoor and indoor temperature and humidity.

The energy savings are most effectively achieved by tuning the system rather than optimizing individual functions. The AC drive gives the flexibility of tuning the setup of the system to operate in the most energy efficient operational point.

Other benefits

- Reduced number of starts and stops reduces the wear of the compressor
- The piping and mechanics are stressed less in ramp up or –down situations
- Reduced noise level in low load situations
- Possibility to use high speed compressors