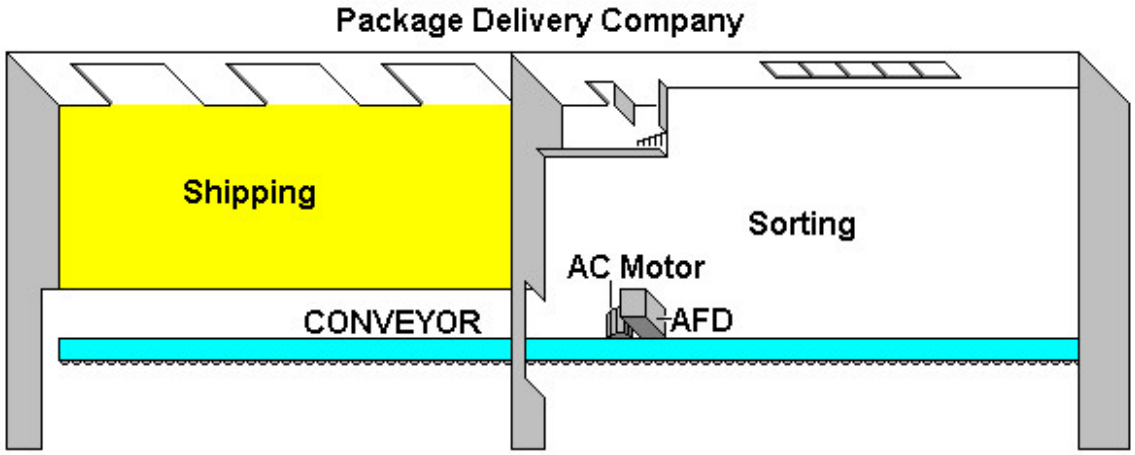
Drives 101

Lesson 1

Functions of an Adjustable Frequency Drive (AFD)

This lesson covers the basic functions of an Adjustable Frequency Drives (AFD).



Outline:

3-phase AC Motor

1. Bi-Directional Operation
2. Change Speed
3. Constant Speed
4. Limits
5. Ramping
6. Braking
7. Save Energy

Drives 101
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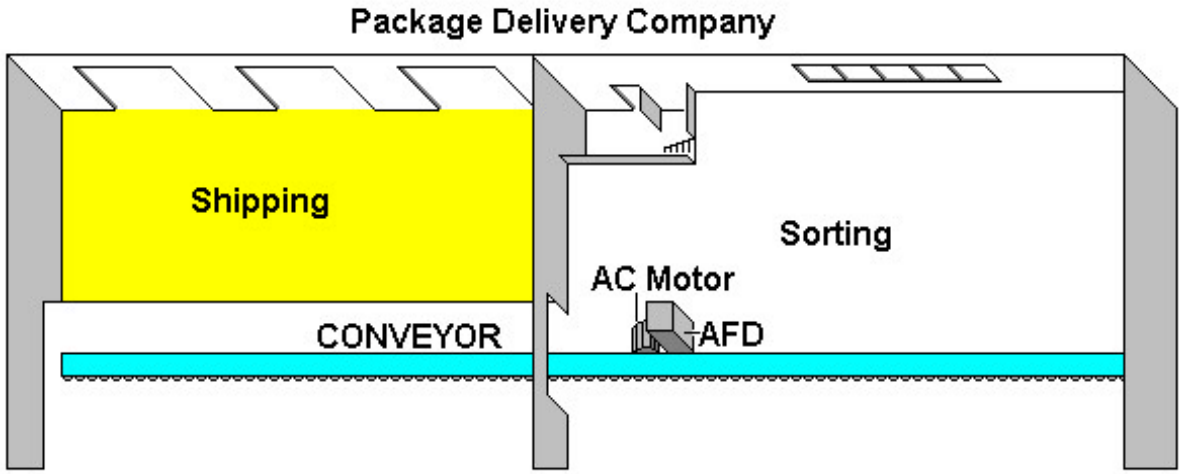
This lesson covers the basic functions of an Adjustable Frequency Drive (AFD) on a 3-phase AC (alternating current) motor. Pictured below is an AC motor.

The one pictured above is for industrial or commercial use, but in your home, AC Motors are used as well. A vacuum cleaner uses an AC motor to clean the carpet; a blender uses an AC motor to process food; and the clothes dryer uses an AC motor to dry clothes. In each of these examples, how is the AC motor controlled?

When controlling motors in the home we control them by applying AC power, and removing it usually through a switch. Obviously when power, 120 or 220 VAC, is applied to the motor it runs. With no power, the motor stops.

With the use of an Adjustable Frequency Drive not only can the AC motor be started and stopped as in the home but more sophisticated controls are accomplished. An AFD can send a modulating signal to the motor, which allows a variety of speeds to be delivered not just an ON/OFF signal. This variety can be used to match a motor speed to a particular process. There are a number of functions that the AFD accomplishes with commercial 3-phase AC motors, which are covered in the pages that follow.

To understand the functions of an AFD better, an example of a conveyor at a Package Delivery Company is used.



A Package Delivery Service uses a conveyor to deliver packages from the shipping area to the sorting area. Once sorted, the conveyor is used to return the boxes back to shipping.

Looking at the example above, see if you can identify some of the functions that must be performed by the AFD and AC motor? In other words, what must the conveyor do? Take a couple of minutes to jot down the functions of the conveyor.

The conveyor must …

_____ _____

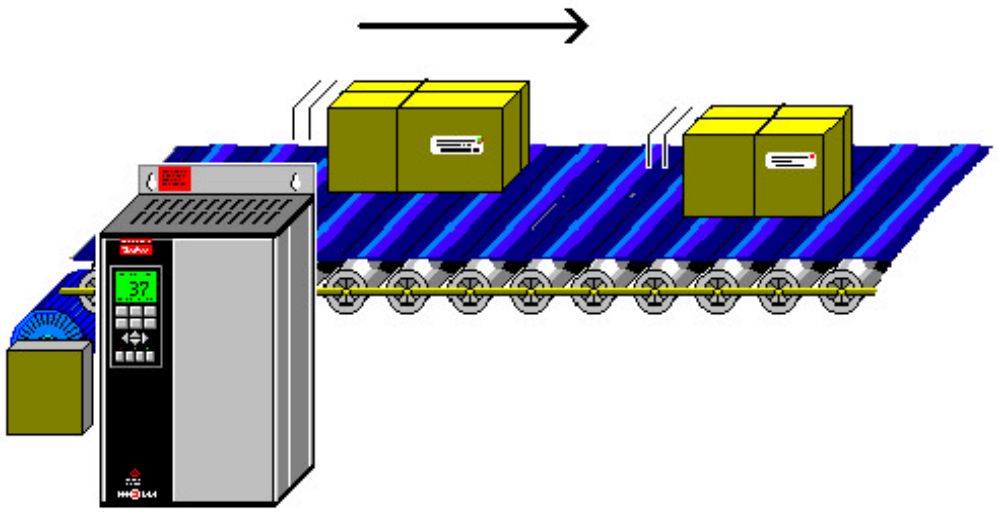
_____ _____

A few of the basic functions of an AFD in controlling the AC motor and conveyor are covered here.

1. Bi-Directional Operation

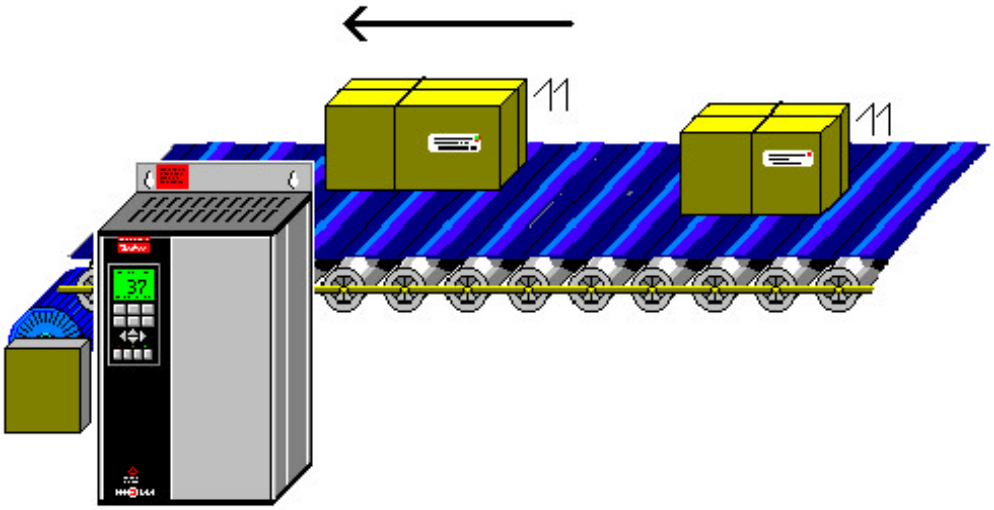
FORWARD

One function of the AFD is to operate the motor in a forward direction, to move the packages from the shipping area to the sorting area.



REVERSE

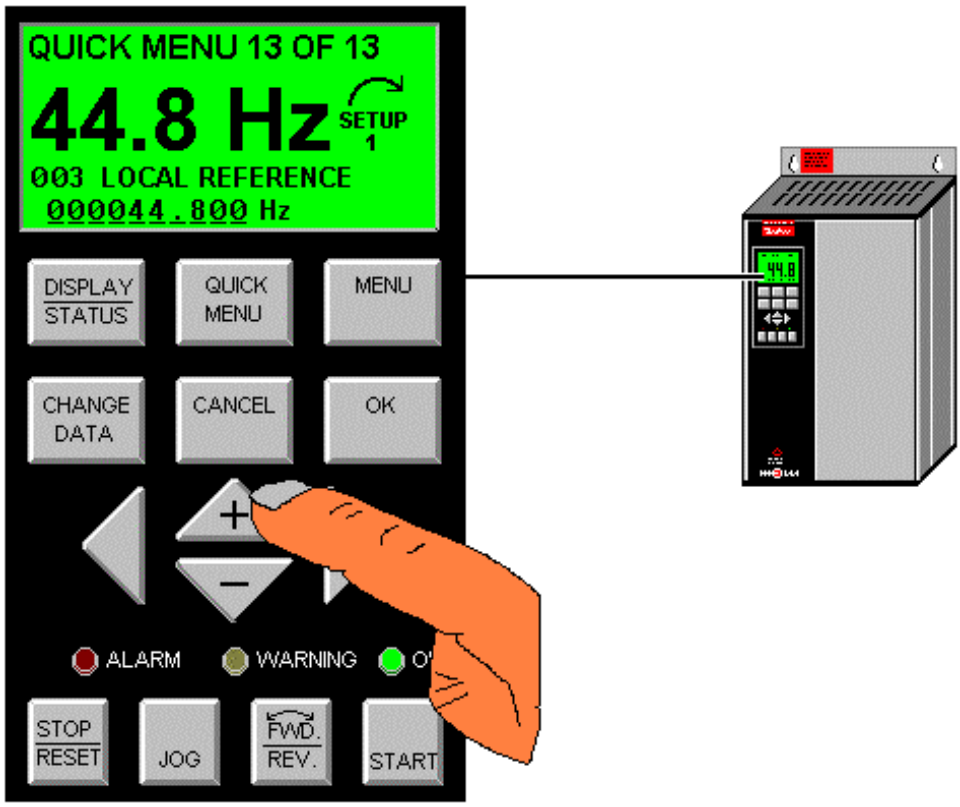
Power going to the motor must be changed to move the packages backward (Reverse) from the sorting area back to the shipping area. If there were no AFD, 2 of the 3 leads of the 3-phase motor would be switched in order for the motor to change its direction and go backwards.



2. Change Speed

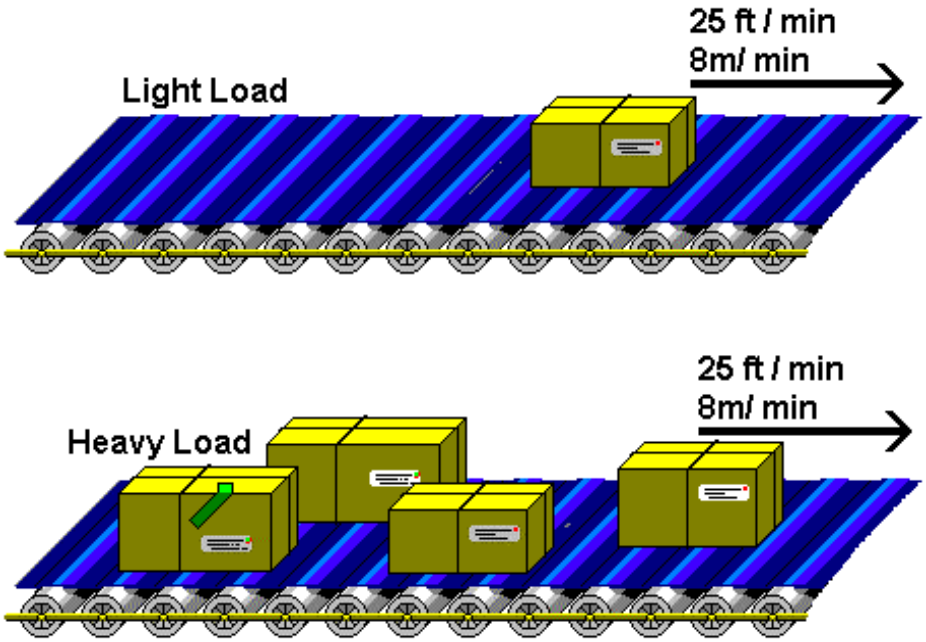
The speed of the conveyor must be adjustable to allow for a slower speed when fewer packages and employees are present and a faster speed for large volumes. This allows the operator to match the speed of the conveyor to a particular process. The setting of this speed is known as the Reference. Commonly reference refers to speed in Hertz (Hz), maximum reference of 60Hz, and minimum reference of 0Hz. It could also be used in regards to a pressure setting, maximum reference of 100psi, minimum reference of 40psi, if a transmitter were attached to the AFD.

In the picture below, the display of an AFD, a Danfoss VLT 5000, is shown. Speed in Hz is the reference. The plus (+) key is used to increase the reference making the conveyor go faster and the minus (-) is used to decrease the reference point.



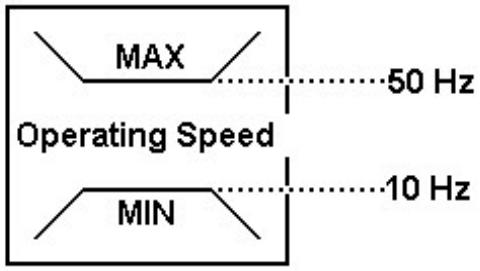
3. Constant Speed

Another function of the AFD is to maintain the speed of the conveyor regardless of the number of packages. The AFD automatically compensates the current and torque to accommodate changes in the load, from hundreds of boxes to a few.



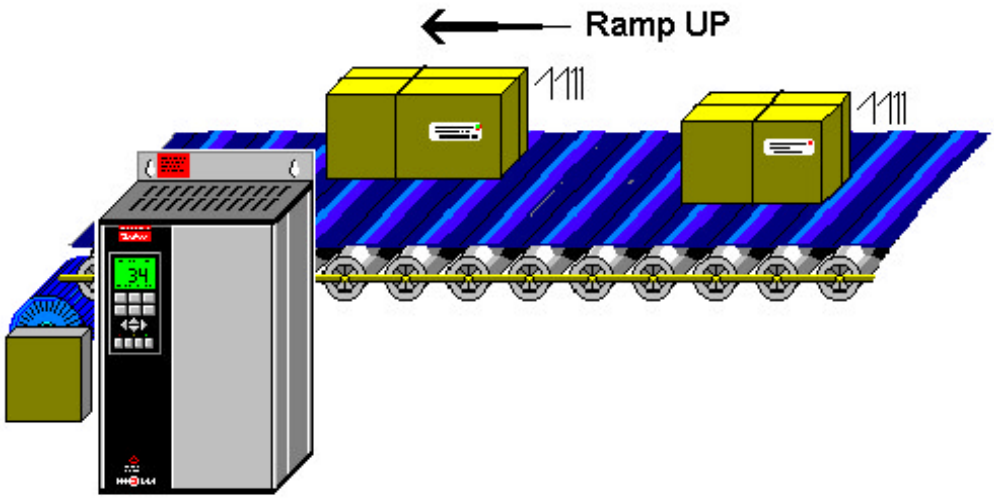
4. Limits

It is important that limits be placed on an AFD. Speed limits can be placed in the program of the AFD so an operator can not go beyond a maximum speed or less than a minimum speed. If a package gets stuck, there are torque limits that the AFD monitors stopping the motor if they are exceeded. Current limits are also important for protection of the drive and motor. In the picture below the maximum reference is set to 50 Hz. Notice that in the diagram there is a minimum speed or reference of 10Hz.

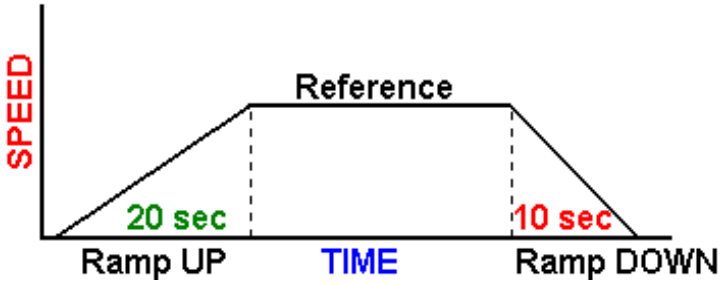


5. Ramping

The AFD also ramps the conveyor up and ramps it down. When the conveyor starts, acceleration, it is important that there is no sudden lurch to the reference speed, or packages can go rolling backward. In the example below, a ramp-up slowly increases the speed from stopped or 0 Hz up to the reference, 34 Hz, over a certain amount of seconds perhaps 10 seconds. If this ramp is too short, the drive can trip on an over current alarm or torque limit.



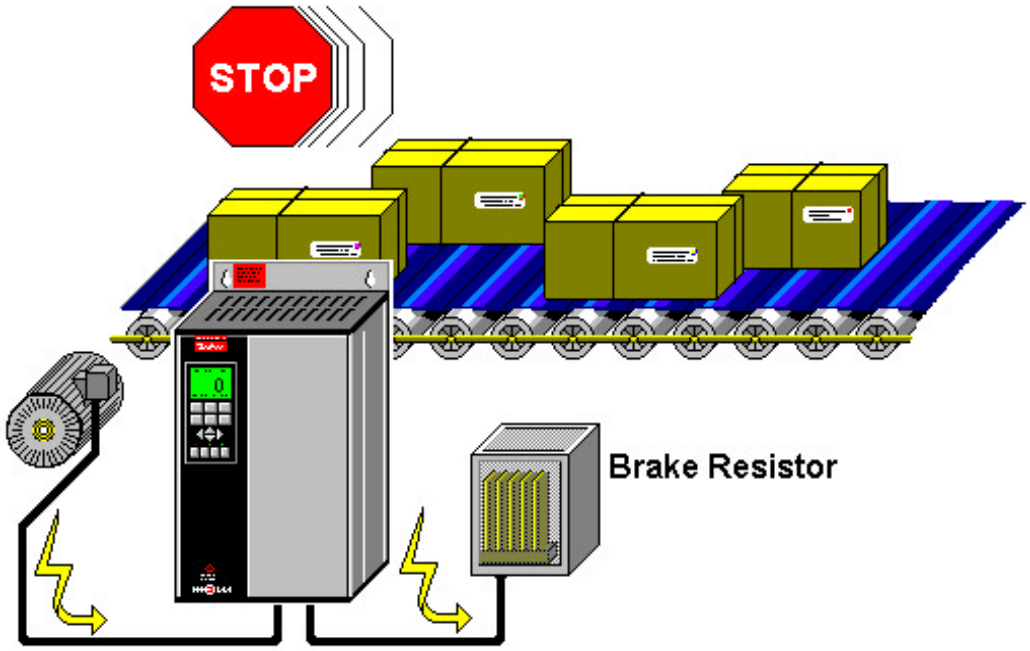
A ramp is also present on the stop side. This is referred to as a ramp down or deceleration. It is important that packages are not jerked to a halt. A ramp-down of 10 seconds might be entered into the program for this application. If the ramp is too short, the drive can trip on over voltage.



6. Braking

There are special challenges when the conveyor is stopping. With many packages on the conveyor there is a great deal of momentum, inertia, so that the motor continues to spin when it is trying to stop. The continued spinning causes the motor to generate energy instead of using it. This extra energy must be handled in the drive or it will trip. If the drive trips, the drive releases control of the motor and the conveyor would then coast to a stop, which might take some time. A special drive is used which has external brake resistors added to dissipate this extra energy as heat as pictured below.

Other ways of braking can also be used. DC Braking is an example that places a DC signal onto the AC motor, which can produce a certain amount of braking. DC braking works best at very slow speeds. Other arrangements have been engineered to handle this extra power, such as DC Load sharing, but will be discussed later. Only certain applications require special arrangements for braking.



7. Saving Energy

The major function of the AFD is to save energy and equipment. In the example below a drive is used on a screw compressor. Before drives, shown on the left, the motor was cycled On at full power 60Hz until the pressure setting (80psi) was reached. When 80psi was reached the motor was turned OFF coming back ON when the pressure dropped to perhaps 60psi. This arrangement used a great deal of energy and the frequent cycling caused a great deal of wear on equipment.

A drive is placed on the screw compressor, shown on the right, which slows the screw compressor down to perhaps 45Hz to constantly maintain the required pressure. The motor speeds up or slows down following load changes. This saves approximately 35% in energy costs and greatly reduces the wear on equipment.