Specifying An AC Induction Motor Drive Platform

By Darrow Hanesian

Industrial processes and applications consume nearly half of the electrical energy produced in developed countries today. Electrical drive systems used for energy conversion are responsible for a majority portion (approximately 63 percent) of the total amount of consumed energy. Even modest increases in the efficiency of drives used for electronic speed control of AC induction motors can yield substantial returns in energy savings and productivity over the product life-cycle. For these reasons it is imperative to make informed choices when specifying motor and motor control equipment.

AC drives are among the most important devices deployed in machinery and facility automation applications. Gone are the days when an inverter drive was a complex and expensive investment. Water resistant, dust protected inverter drives are as easy to install and as simple to use as basic mechanical speed control devices, such as belts, clutches, two speed gearboxes and low reduction gearboxes.

AC Drive Advantages

An AC inverter drive can be installed virtually anywhere, without the need for a protective cabinet, it is not susceptible to oil mist, atmospheric moisture or low pressure water jets, it is also a very clean alternative as it does not produce oil leaks, oil mist, dust or debris like gearboxes, belts and chains. In many cases using an IP65 ingress protected drive is a lot less expensive than the purely mechanical alternatives; this is particularly true of conventional heavy gearbox types providing limited speed variation but adding significantly to the cost and the weight of a machine or an installation.

Addressing one of the most pressing issues in the competitive industrial marketplace, the use of an AC drive can substantially improve efficiency and reduce energy usage by a huge margin, particularly compared to clutches that absorb energy for speed control and worm gearboxes that can be as little as 60 percent efficient. There are also huge benefits to replacing soft start equipment that does not provide intelligent speed control or the level of energy saving that a drive can deliver.

Also referred to as variable frequency drives or VFDs, the latest developments in AC drive technology have brought to market standard and custom products that blend affordability, compact size, and simplicity. When controlling the speed of an AC motor, there are three main VFD platforms from which to choose, including: Volts/Hertz (V/Hz), Open Loop Vector and Closed Loop Vector.

While each platform offers distinct advanced technological features and benefits, it can be confusing when trying to specify which level of AC drive technology is appropriate for a particular application. Following is an overview of the main benefits of each VFD platform.

V/Hz platform

V/Hz technology is the most economical and easiest platform to apply. The drive controls applied voltage and frequency to an AC induction motor, with the rotor of an induction motor magnetically coupled to its stator through an induced magnetic field.The speed at which the magnetic field rotates is known as synchronous speed and can be determined by the following equation:

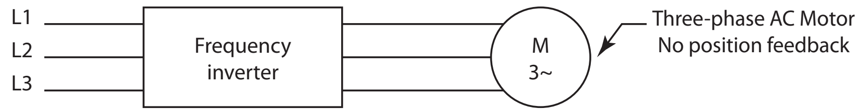
$$n = 120 * f / N$$

Where n = *synchronous speed*
120 is an electrical constant
f = *applied frequency*
N = *number of motor poles*

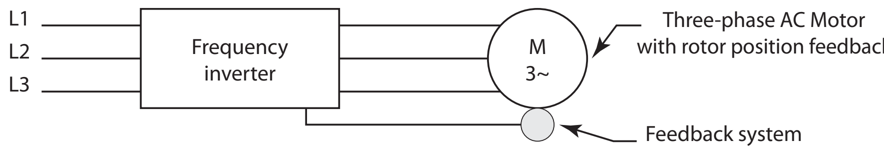
Reducing applied frequency to an induction motor causes the magnetic field to rotate at a slower speed.

Open Loop Vector Platform

The design architecture of open loop vector drives is similar to V/Hz drives. However from a hardware standpoint, the main difference is the addition of current sensors, with the biggest overall difference in firmware. Open loop vector (OLV) drives use sophisticated motor control algorithms that independently control magnetizing current and torque producing current. The benefits of OLV drives are higher starting torque, more accelerating torque, better speed regulation, improved torque production at low operating speeds, as well as control in both speed and torque modes.



Typical V/Hz and open loop vector connection diagram



Typical closed loop vector connection diagram

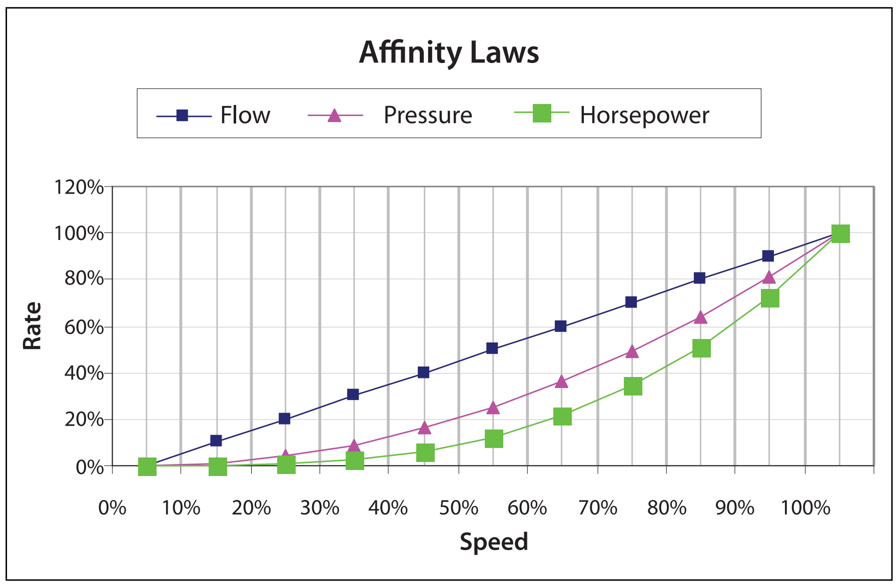


Figure 1

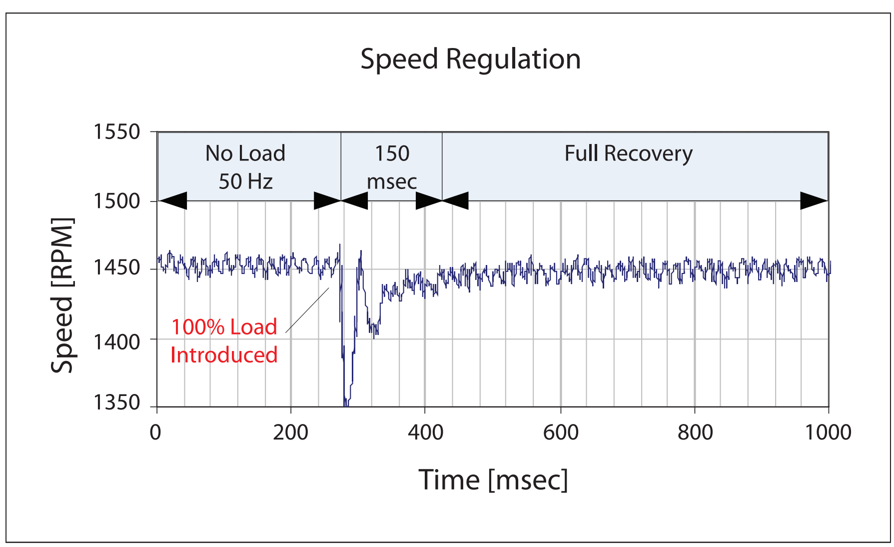


Figure 2

Closed Loop Vector Platform

In a closed loop or CL vector drive, there is typically a more sophisticated processor used for motor control as well as a feedback device located at the motor. The feedback device is usually an encoder that monitors speed and position. By reporting this information back to the drive it is able to make adjustments to ensure accurate control of speed, torque and position. So as a result, the main benefits are better speed regulation, full torque production at 0 speed, basic positioning and electronic gearing.

Common Applications

In many applications, low price and simple speed control are required. With these requirements, the V/Hz drive is the best bet. It is the simplest to install and has the lowest price of the three technologies. In fact, V/Hz drives are frequently replacing older forms of motor control. Technologies such as mechanical variable speed drives, solid state starters and conventional motor starters are all susceptible to the price, performance and simplicity of V/Hz drives. Common applications for this type of technology include centrifugal pumps and fans, conveyors and mixers.

With centrifugal loads, there is an added benefit of energy savings when using a variable frequency drive for control. To illustrate, there are a set of physical properties known as the affinity laws that govern centrifugal loads:

Q is proportional to n
P is proportional to n^2
Hp is proportional to n^3

Where: Q is flow
n is speed
Hp is Horsepower

Figure 1 illustrates the benefit of using V/Hz drives to control flow instead of dampers, inlet vanes or throttling valves. A small drop in flow results in a large drop in power consumption. For example, a fan operating at 80 percent flow consumes only 51 percent of the energy required to operate the same fan at 100 percent flow.

Certain applications require a little more capability than simple speed control. In applications requiring tighter speed regulation and high starting/accelerating torque, an open loop vector drive is appropriate. Figure 2 shows how an OLV drive dynamically responds to a 100 percent step change in load, with

Comparison of Technology			
Feature	V/Hz	O.L. Vector	C.L. Vector
Typical Speed Range	20 : 01	60 : 1	1000 : 1
Typical Speed Regulation	1% to 3%	1%	0.01%
Typical Holding Torque	N/A	N/A	200%
Typical Starting Torque	150%	200%	200%
Multiple Motor Control	Yes	No	No
Feedback Required	No	No	Yes

the motor operating at 50 Hz with no load applied.

OLV drives today have achieved a level of performance and simplicity that frequently allow users to replace older DC drives without affecting performance. Common applications benefiting from OLV technology are extruders, filling machines, forming machines and presses.

So when is it appropriate to select a CL vector drive over an OL vector drive? Closed loop vector drives are capable of controlling the motor speed down 0 Hz while producing “holding torque.”

Additionally, CLV drives need feedback to close the speed and position loops. Therefore a feedback device (typically an encoder) is required on the motor. This feedback allows the drive to continuously monitor speed and position, making corrections as needed. And performance comes at a cost. More advanced microprocessors and feedback devices for CLV applications are expensive; however, CLV systems are migrating into areas once reserved for high end servo technology and the system price compared to servos is dramatically less, due to the better cost structure of asynchronous induction motors versus synchronous servo motors. Common applications for CLV drives are lifts, hoists, incline/decline conveyors and extruders of fragile material.

Conclusion

Simplicity is another factor in selecting the right technology for a specific application. It is difficult to justify using a closed loop vector drive in a simple speed control application. While the CLV drive is perfectly capable, it would be cost prohibitive and require an unnecessary level of expertise to implement. Conversely, to apply a V/Hz drive in an application requiring torque control would certainly yield unsatisfactory results compared with an OLV drive. Each of these technologies has its place in the industry today. The key is to weigh cost, performance and simplicity to determine the correct drive for your requirements.

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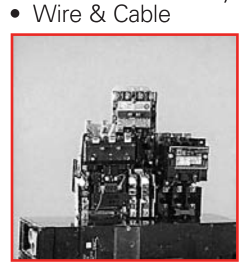

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