n recent years, there has been a trend toward using variable speed to operate motors for equipment and systems that provide heating, ventilation, and air conditioning for buildings. Variable speed has been shown to improve the operating efficiency of equipment such as fans, chillers, and pumps, the capacity of which must be modulated for proper system operation. Furthermore, designers now understand that motors powering devices traditionally operated at constant speed, such as fan coils and fan-powered terminal units, can benefit enormously in terms of both performance and efficiency from the application of variable speed. It is becoming clear that virtually every motor involved in a building HVAC system today has the capacity to improve the efficiency and effectiveness of the system when operated with variable speed.

An obstacle on the road to variable speed has been the cost associated with variable-frequency drives, which are the most popular and efficient method of applying variable speed to AC motors. In recent years, however, that cost has fallen dramatically. For the most popular sizes of motors for HVAC fan and pump applications, variable-frequency-drive cost is approaching $50 per horsepower. When all costs are considered, variable speed is now much less costly than two-speed-control alternatives. In addition, the soft start from variable speed adds enormous life to belts and other drive components.

One of the largely untapped cost-saving features of variable-speed drives is built-in intelligence. The internal control logic of variable-speed drives is microprocessor-driven. Most drives have capacity to contribute to building control systems with networking services and processing capabilities. It is possible to envision a system in which much of the control sequencing takes place in intelligent end devices connected to the system, such as variable-speed drives, rather than in dedicated control panels of the building control system, where it takes place now.

Unfortunately, control-sequence capabilities from separate components are not easily integrated into building control systems. This is one area where networked control can prove valuable. Instead of having to program each separate control component to operate on its own and then hope all components work together to achieve the desired result, the networked control solution allows all components to be programmed to work together as a part of a single system.

By THOMAS HARTMAN, PE
The Hartman Co.
Marysville, Wash.

FIGURE 1. Preferred direct network connection of variable-speed drives.
control systems because each building control system employs proprietary programming functions that are not compatible beyond the product. The use of coordinated, distributed processing without some level of programming compatibility complicates the operation of such a configuration. However, one area in which standards have greatly progressed and now permit a certain level of integration and resulting economy is the incorporation of variable-speed drives directly into the control network, rather than through discrete point connections, as has been the norm.

HISTORICAL IMPEDIMENTS TO DIRECT NETWORK CONNECTION
While the direct network connection of variable-speed drives and other equipment no longer is rare, the reliance on the network for control, as well as monitoring function, still appears to be. The reason for this is that design engineers continue to be somewhat hesitant to rely on the control network to execute direct control actions. This hesitation goes back to the early days of direct digital control (DDC), when, from reliability and time-of-response standpoints, it was recommended that all input and output points of control for each system be implemented in a single panel. That is why control designs still are made with remote static-pressure sensors wired all the way back to the panel in which the fan or pump they are controlling is connected.

Although this approach had value when it was developed a decade or more ago, network speed and reliability have improved substantially since that time. Also, the industry has realized that the most effective control of any variable-speed device almost always requires the use of multiple factors in making control decisions. Furthermore, it is now understood that very frequent speed adjustments to large fans or pumps can waste energy. For these reasons, relying on building control networks to operate HVAC equipment is not just acceptable, it is absolutely necessary if the highest possible levels of system performance and efficiency are desired.

DIRECT-NETWORK-CONNECTION CONFIGURATION CONSIDERATIONS
Once the decision to consider the use of direct network connections for variable-speed drives is made, the operator needs to determine the nature of the integration of the drives into the building control system. Leading the list of considerations is the type of connection to be made. Presently, the most popular means of connecting variable-speed drives to building control networks are BACnet, LonWorks, and Modbus interfaces. The benefit of a BACnet or Lonworks connection is that many systems employ one of these communication protocols as their network backbone. Thus, it may be possible to connect

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variable-speed drives directly to a building control network with relative ease. Such a connection is shown in Figure 1. Figure 1 illustrates the direct connection of variable-speed drives to a building network as nodes, just as the building DDC panels are connected. The DDC panels connect to equipment and devices associated with the chillers, towers, and air handlers. The variable-speed drives are connected directly to the high-speed building network. The chillers may be connected via either direct network connection or the DDC panel, as shown. The chillers’ variable-speed drives usually are part of that overall chiller interface.

Although the means of connection shown in Figure 1 is preferred because of its simplicity, many manufacturers of variable-speed drives continue to employ older communications and have developed gateways so that their drives can be connected to the more-advanced building control networks. So while these drives may advertise BACnet or LonWorks compatibility, they actually employ a gateway to provide that compatibility.

Virtually every motor involved in a building HVAC system today has the capacity to improve the efficiency and effectiveness of the system when operated with variable speed.

and it may not be economically attractive to buy a gateway for each drive. This results in many direct-connect networks that need to be configured as shown in Figure 2. In Figure 2, the connections are functionally the same as in Figure 1, but the variable-speed drives are connected to their own network(s) and then connected to the high-speed building network with special gateways.

While the configuration shown in Figure 2 does result in connection of the variable-speed drives to the high-speed building network, it is more complicated. Also, because the variable-speed-drive network may employ older communications that are slow by today’s standards, it can result in some communication bottlenecks, which can lead to data-exchange delays (the issue of timing will be discussed later). In short, while the configuration in Figure 2 is acceptable and widely employed, the configuration in Figure 1 is preferred.

Another connection option is shown in Figure 3. This configuration permits the variable-speed drives to be integrated with the building control system, but without a direct connection to the building network. This configuration usually is employed when the high-speed building network is proprietary and the interface, therefore, must be provided by the supplier.
of the DDC system. For such connections, gateways often are provided as an integral component of the control panels, as shown in Figure 3. The most common interface technique is to connect the variable-speed drives on their own network and integrate them into the control system via one or more DDC panels that have gateway features. In some systems, it is preferred that each variable-speed drive be connected to the panel in which the related systems are connected. This type of connection is shown in Figure 3. The reason for this is that many of the proprietary building networks in use today are legacy networks that do not employ the most modern network-management technologies and, therefore, can be subject to certain network-traffic limitations.

DIRECT-NETWORK-CONNECTION OPERATING CONSIDERATIONS

There has been a great deal of discus-

Response Time and VFDs

Some designers avoid the direct network connection of variable-speed drives (VSDs) because they are concerned about the time it takes a VSD to receive and execute a command after a signal is issued from DDC logic. Although modern network capabilities are lightning fast, at this early point in building-system networking, many equipment manufacturers employ crude network interfaces that result in signal-transfer delays, which can add up to several seconds in certain applications. While response time for direct network connection eventually will take care of itself, the question is whether such delays are detrimental to proper system operation.

The answer comes in part from looking closely at the system that each variable-frequency-drive (VFD) operates. For the most part, each system involves motors, pumps or fans, and fluid circuits, all of which contain substantial inertia. Adjusting the speed of these systems at short intervals not only is ineffectual, it also usually is detrimental to the energy performance of the system. It is like driving a car by constantly pressing down and letting up on the accelerator. Most of us were taught in driver’s education that this is an inefficient method of operating a car, and for similar reasons, it also is true for fans and pumps. I recommend that control for VFD-operated motors be developed so that a speed adjustment is required at intervals no shorter than 30 seconds under normal operating conditions. This constraint can be implemented easily, and when done properly, it almost always leads to more stable and more efficient operation of the system. Furthermore, with this larger interval, response-time issues associated with the direct network connection of VFDs disappear.
The idea that effective and efficient control can be achieved in modern buildings without the use of the network simply is out of date.
of the central plant.

REFERENCES


Additional information on technologies discussed in this article is available at www.hartmanco.com.


PHOTO A. All-variable-speed chiller plant configured with direct network connections for the variable-speed drives (silver and black enclosures).