VFD Serial Communications: Which Points Should I Use And Why?

The available LEED credits and most obvious energy-saving possibilities are one thing. The potential for a ripple effect of system-wide savings by deploying VFDs as part of better overall monitoring are another.

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Variable frequency drives (VFDs) have become omnipresent in the building automation world. This proliferation of VFD’s is due to two main factors. First, when properly applied to centrifugal fans and pumps, VFDs conserve a tremendous amount of energy. The Affinity Laws, sometimes referred to as the “fan laws,” state that the horsepower required to drive a centrifugal fan or pump drops as the cube of the speed of said fan or pump. Second, VFD usage is all but required in ASHRAE standard 90.1.

Serial communications with modern VFDs have been available since 1994. The advent of the BACnet communications protocol standard has only helped to increase the availability of direct digital communications.
with devices such as VFDs. Modern VFDs and electronic bypasses have over 100 points of information available from the VFD and bypass. This article will discuss some of the main advantages and usage of the information now available.

Basic operation of a typical supply fan requires approximately five points for proper control. The BAS must start and stop the application based on a time schedule, occupancy, or IAQ considerations. A speed signal must be sent to the VFD to control the speed of the driven application. Safeties are also required so that the supply fan will shut down if smoke exists in the supply fan ductwork, for example. Any safeties are wired into the VFD system to allow a controlled shut down of the VFD if the safety opens. Finally, the status of the application is required in most situations. The VFD run-stop and fault status is usually monitored by the BAS.

Therefore, proper control of typical supply fan application requires a minimum of five inputs and outputs (I/O). Before the advent of serial communications, this meant that five sets, or approximately 10 wires, at minimum were required to be run between the BAS and the VFD being controlled. With the advent of serial communications, all of this and much more information is available simply by running one twisted shielded pair of wires to the VFD being controlled.

**ENHANCED OPERATION**

With serial communications, the user can now easily monitor status of the application, such as the position of the Hand/Auto selection from the VFD. The user can also monitor the status of the safety inputs and run permissive proofs (damper end-switch contacts) to the VFDs. In addition to the VFD displaying which safety has opened, the BAS system also has access to and can display this information which greatly aids in getting the system back up and running. Fault monitoring and remote fault reset capability allows the user or building manager to get systems back on line remotely.

**AVAILABLE LEED CREDITS**

All modern VFDs monitor the kilowatt-hour usage and operating hour data. Once serial communication is established, one can easily monitor the power being required by a given fan or pump. The LEED system allows for credits for monitoring energy usage in buildings. VFD communications allow “free” LEED credits for monitoring and verification of energy usage. Depending on how many VFDs are installed and how much power the VFDs are delivering in relation to the power on the entire building, one or two LEED credits are available for monitoring and verification.

Before this capability was available, users would often purchase kilowatt-hour meters and operating hour meters and manually monitor the energy usage of their large fan and pump systems. In addition to the approximate $800 cost of purchasing and installing these meters, someone was typically required to walk to the application, document the running hours and kilowatt hours, and manually press the reset button on both meters. With the advent of serial communications, this data can automatically be mined from the VFD on a monthly basis and the counters reset over the serial communications system. While the $800 first cost of the meters is not trivial, the saved labor cost is significant. Some VFDs can even calculate the amount of CO2 production avoided by not burning coal to make electricity in addition to the energy conserved using the VFD and transmit this information back to the energy management system.
ENHANCED ENERGY SAVINGS STRATEGIES

Using the real time information gathered from the VFD operation allows for enhanced energy savings strategies. For example, a high-rise building in Dallas deploys 84 VFDs on supply and return fans. During the retrofit investigation, the VFD vendor provided a computerized estimated energy savings analysis for the proposed retrofit of 84 VFDs. This analysis used the Dallas cost per kWh, the building occupancy times and dates, and an assumed VAV duty cycle. The computer estimated savings calculation yielded a 2.5-yr payback on the 84 VFDs.

In addition to the VFD retrofit, the user installed IAQ sensors and a thermal storage system wherein they made ice during nights and weekends and turned the chillers off during the daytime peak electrical energy charged hours. This facility utilizes six 1,200-ton chillers to build ice.

Using serial communications, the VFDs are monitored for percent power and other real-time data. Room occupancy sensors and IAQ sensors were also installed and are monitored by the BAS. An energy savings strategy has been implemented wherein if any of the VFDs operate above 60% power the indoor air quality sensors are polled. If the IAQ is acceptable, the energy management system modulates a three-way valve to pump more water across the ice that was made the night before and less water through the bypass loop.

This valve adjustment lowers the chilled water supply temperature. By lowering the chilled water temperature and providing colder chilled water to the coils, the individual office spaces are satisfied faster, the VAV boxes close down, and the VFDs back off further in speed. The owner was previously overcooling the building, especially in the unoccupied spaces. While the energy savings from the supply and return fan motors is substantial, the largest savings come from an unexpected source.

What no one imagined, including this writer, was that by moving less air across the coils during a hot Dallas day, the chilled water loop picks up much less heat and therefore uses less ice. Because the chilled water system gains less heat, the chillers run fewer hours at night to rebuild the ice. The 1,200 ton chillers went from an average of over 11 hrs/night to build the ice for the next day’s usage down to less than five hrs/night. The payback on the installation of the 84 VFDs was accomplished in four and one half months.

Information from the VFD’s may also be used for peak energy avoidance. In a high-rise building in the northeastern United States, approximately 60 VFDs are installed on the AHUs. The owner unexpectedly received a new peak demand charge billing from his local utility. The bill was approximately $50,000 due to the ratchet clause in the utility’s billing structure and the fact that the new demand set the charged demand rate for the past six months. The building owner called in his BAS supplier and asked what could be done to make sure that he never received another $50,000 surprise bill in the mail.

The BAS company proposed several solutions, including installing expensive kilowatt-hour monitoring on the primary service entrance to the building. The cost for installing the complete building power monitoring system was substantial. The owner asked if there were any other possibilities. The BAS representative brought in the VFD manufacturer’s representative and together they devised a simple plan. A chart graph recorder was rented for one month and placed on the 480-volt main building power entry point. At the same time, the percent power usage from all 60 VFDs in the building were trended and stored in the BAS.

At the end of the one-month period, all the charts and graphs gathered from the previous month were spread out...
on a large table and analyzed. A large penthouse air handler VFD percent power tracked very closely with the entire buildings kilowatt usage. For example, at 2:00 a.m., the penthouse VFD was very lightly loaded, as was the entire building; at 2:00 p.m., the penthouse VFD percent power was at 90%, corresponding to the building’s peak load. A strategy was implemented wherein if the AHU in the penthouse reaches 85% power, a static pressure set point reset is accomplished. Instead of the air handlers controlling to 1.5 in of static pressure, the set point is reduced to 1.25 in.

This reduction in pressure set point Photo courtesy of Environmental Controls. the VFDs to back off in speed and shed load from the building. By the process of trial and error, the length of time of the set point fold back was optimized. The owner started at a three-hour set point reduction. At some point during setback, some tenants in the building would call the building manager and complain that their office spaces were getting warm. The time was gradually reduced to one hour and 45 minutes. At that configuration, no tenants in the building even knew that any changes had occurred. But for that one hour and 45 minutes, the load on the entire building was drastically reduced and the peak demand was cut substantially. This facility has not equaled the peak demand since this strategy was implemented and is once again billed at the former (lower) demand rate.

Finally, the real-time information available from the VFDs on your fans and pumps can be used to implement other load-shedding strategies to avoid or curtail load at peak periods of time. All of these enhanced energy savings opportunities are available simply by mining the data from serial communication with the installed VFDs and developing and implementing advanced energy savings strategies.

CONTINUOUS IMPROVEMENT

Information from the VFD’s and the data shared with the energy management system can also be used in a proactive method. For example, once a benchmark is established, VFD power levels can be used to determine when it is time to change the filters in an air handler. A threshold can be set in the energy management system, wherein if the VFDs are running 40 Hz, for example, the drives should use a certain amount of power. Once the power exceeds the threshold, the user can print out a work order to have maintenance personnel change the dirty filters in that AHU and thus reduce the load on the VFD and motor. Not only does this strategy allow for proactive filter replacement, but it also eliminates the need for the differential pressure transmitter across the filters and the associated hardware, wiring, and energy management system points cost.

Similarly, by monitoring VFD temperature, one can ascertain when it is time to change the filters in the VFD enclosure. If the VFD temperature rises above a certain threshold, the work order can be generated to the maintenance staff to change the VFD air filters.

Some modern VFDs and bypasses allow for monitoring the status of the drive/bypass and the hand-off-auto keypad selection. If someone places the unit in hand for example, an alarm can be generated from the building management system to allow the maintenance staff to take the proper actions to get the unit back in to automatic energy savings mode. Similarly, if someone places the VFD system in the bypass mode, the fan is now operating at full 60 Hz power and no energy is being saved. An alarm can be generated at the BAS system to allow for putting the VFD back into service and back to saving energy. If your VFDs do not have the capability of monitoring drive or bypass selected, one can still monitor amps to determine if someone has placed the unit in the hand mode and run the unit up to full speed.
TROUBLESHOOTING AND REMOTE MONITORING

Modern VFDs have several fault diagnostic indications and capabilities. For example, if the VFD status goes from OK to Fault, someone can be dispatched to get the unit back into service. Alternately, if the VFD also transmits the fault information and the reason for the fault was understood, the VFD may be reset remotely and brought back into service without dispatching any service personnel.

For example, the writer is aware of a system where two VFDs in a hospital tripped during the middle of the night. After being paged, the director of facilities was able to go online from his home, drill down to the affected VFDs, and determine that on both units the fault experienced was an over-voltage fault. The director of facilities simply reset the fault from his computer at his kitchen table, then watched the units’ ramp back up to speed and stabilize. He could see static pressure again being maintained at the hospital and therefore simply went back to bed. In the days before serial communications, someone would have needed to be dispatched to the hospital, walk up to the affected VFDs and press the reset buttons, and then return back home.

In addition, it is often useful to time- and date-stamp any VFD faults for later troubleshooting. If a fault happens at the same time every day, it often allows for advanced troubleshooting, determining the cause of the fault.

Finally, one can use continuous monitoring to date- and time-stamp events. For example, if upon returning from overnight operations, the director of facilities notices that one of the VFDs is always in hand mode, he could automatically monitor the status of the hand-off auto selector on the VFD. In one case, it was determined that someone on the night shift was circulating through the building and putting all the VFDs in either hand or bypass mode. This misuse of the system was causing this hospital to use much more energy than was required if the VFDs were left in automatic mode. By date- and time-stamping the events when this occurred, the misbehaving employee was discovered and the problem was corrected.

CONCLUSION

We have looked here at some of the basics of VFD control over serial communications, such as start-and-stop and fault reset capabilities. In addition, we have seen that mining the data transmitted between the VFD and the BAS can allow for enhanced energy savings opportunities and enhanced energy management strategies to be developed and deployed. Finally, remote fault reset and remote M&V monitoring and report generation can also be extremely important. ES

FOOTNOTES

¹ ASHRAE standard 90.1 stipulates that all fans or pumps above a certain horsepower shall have efficient part load control. The only practical way to obtain efficient part load control is by applying a variable frequency drive to an AC Motor. Other methods of variable speed control are available, such as variable belts and sheaves or hydraulic clutches, but these methods of control often have high maintenance and other negative implications (hydraulic fluid that could leak for example).
² In many instances more information is required than the five points listed. Outputs such as drive power, amps, and speed are often required to the BAS. In the past, this was accomplished via the analog outputs from the VFD’s to the BAS system. Finally, the author recommends hard wiring any safeties to the VFDs instead of accomplishing safeties over the serial communications system.

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