In many applications, a smart inverter is a better solution than combining a traditional inverter with an external controller and operator interface.

Traditional inverters simply control motor speed, and must be paired with some type of an additional logic controller in all but the most basic applications. This additional logic controller is generally a local PLC or industrial PC, or a remote plant-wide automation system. In many applications, a local external operator interface is also required, further increasing cost and complexity.

A better solution in many cases is to include the logic controller, I/O and related operator interface functionality in the inverter itself. This creates what will be referred to as a smart inverter, and provides a number of benefits.

This white paper will first discuss the general concept of adding a logic controller, I/O and related operator interface functionality to an inverter. It will then look at the advantages of such an approach, and finally show typical applications where it's particularly advantageous to use a smart inverter.

Adding Intelligence to an Inverter

Before the advent of smart inverters, motor speed was typically controlled by an inverter without much in the way of added intelligence. These basic inverters typically required an external logic controller, and often an external operator interface, in all but the simplest applications.

Smart inverters have added a new option for controlling motor speed by including a logic controller, I/O and operator interface functionality in one compact housing (Figure 1).

Figure 1 – Smart inverters with a built-in logic controller and operator panel are a better solution than traditional inverters in many applications.

Smart inverters typically include PC-based programming software that allows users to program the smart inverter's built-in logic controller. This programming software usually offers users the ability to program in a number of different languages.

For example, one popular family of inverters is offered in a size range from ¼ to 600 hp. A logic controller is built into the drive, with PC-based programming via a proprietary structured text language, similar to C++ and Visual Basic.

Once the program is written, it's compiled and downloaded to the smart inverter via its communications port. The compiled program is then executed in the smart inverter's CPU, with the CPU also being used to perform normal inverter functions. With many smart inverters, the compiled program resident in the inverter can be password protected from unauthorized field adjustments. Combining inverter and logic controller functionality into one CPU keeps costs down, and can often increase execution speed.

The logic controller interfaces with I/O built into the inverter, typically a combination of discrete and analog inputs and outputs. Most smart inverters also offer the ability to expand upon the built-in I/O with expansion I/O connected to the inverter via a communications port, and this added I/O can expand the range of potential applications.

An operator interface panel is included with most smart inverters, allowing users to interact with the device as required. Information provided on the operator interface display can include operating status, alarm indications and other pertinent data. Pushbuttons or other user input devices allow users to adjust setpoints, enter settings, acknowledge alarms and perform other functions. Some smart inverters also allow users to make changes to the logic controller program from the operator interface.

Different suppliers implement smart inverter logic controller and operator interface functionality via varying methods, but in all cases the result is the same: a compact smart inverter that combines inverter, logic controller, I/O and operator interface in one integrated housing—providing a number of benefits.

Advantages of Using a Smart Inverter

The primary advantages of a modern smart inverter are lower cost and ease of installation. As described in Table 1, there is no need to purchase an external logic controller and operator interface, and no need to integrate these components into the motor control system.

This also eliminates the need to wire, cable, install, debug and commission multiple components; and it results in a much smaller footprint—that is, the physical space required for the control equipment. Eliminating wiring and cabling among components also eliminates communication errors and problems that can occur when electrical noise hinders data transfers. Reducing the overall system footprint cuts cost by reducing panel size.

Most smart inverters come with built-in PC-based programming software, which often is supplied free with the drive. With a traditional motor control system, the user often has to purchase programming software for the logic controller and the operator interface. Once purchased, the software often requires users to pay annual licensing fees, further adding to costs. Users must become familiar with each software package, whereas the single software package in a smart inverter eliminates these extra learning curves.

Execution speed is often faster with a smart inverter, because the motor control system doesn’t have to wait for an external logic controller to process I/O, and then send control instructions back over a communications link. In some cases, an external logic controller may be dealing with multiple motors, and its processing and communications time are divided among several systems, thus further slowing its reaction time. With a smart inverter, the control logic is devoted exclusively to one system and executes internally, so it responds much faster.

For safety-related conditions, this can be extremely important. A smart inverter can shut down its motor immediately based on an E-stop pushbutton, a process variable exceeding some value, or any external switch indicating an emergency—as it doesn’t have to wait for an external logic controller to process the information.

With fewer components, less software, less wiring and a much simpler installation—maintenance and troubleshooting time are vastly reduced.

Like its distributed control cousins in the process control world—where for years control functions have been moved to the field—a smart inverter is perfectly capable of carrying out its local control function even if networks fail or the main plant control system goes down.

Typically, smart inverters will be networked to a main control system through a digital network, but internal intelligence will allow a smart inverter to continue to provide local control and operator interface, or an orderly shutdown, in the event of a failure of either the network or the main control system.

While a smart inverter is perfect for many small, self-contained and easily-defined applications—it is generally not suitable to control more complex systems on its own, especially those involving coordinated action among multiple drives. Such a system generally requires an external logic controller and operator interface, and can use smart or traditional inverters.

As referenced above, it often makes sense to pair smart inverters with an external logic controller and operator interface in a hybrid system, as this will improve performance. These hybrid systems will also provide an extra margin of safety in the event of main control system or network failure.

Table 1: Advantages of Using Smart Inverters

1. No need to purchase external logic controller
2. No need to purchase external operator interface
3. No need to integrate external logic controller, operator interface and inverter
4. Only one programming language to learn and support
5. No need to purchase software if its included with inverter
6. Can provide faster execution speeds
7. Lower wiring costs
8. Smaller footprint and reduced control panel size lower costs
9. Simpler maintenance and faster troubleshooting
10. Inverter can act autonomously in the event of network or main control system failure

The advantages of smart inverters make more sense in some applications than others, particularly those that have relatively simple functionality outside the basic task of controlling motor speed.

Smart Inverter Applications

Many of the applications most suited to smart inverters are those that have been accomplished by other complex, expensive methods for years—such as pump control. Table 2 lists some of the most common applications for smart inverters.

Table 2: Smart Inverter Applications

1. Pump control
2. Control valve replacement
3. Conveying system
4. Cranes and hoists
5. Energy management
6. Low-precision CNC
7. Material Handling and Packaging
8. Ramp & Soak

Pump control—One of the best applications for a smart inverter is pump control. This is usually a relatively simple application that can easily be handled by a smart inverter, as all that's normally needed is control of pump speed along with Hand-Off-Auto and other basic functionality.

Pump Control – Water/wastewater system pump controls is typically a relatively simple application that can easily be handled by a smart inverter.

A typical pump control application is found in wastewater pump stations, which are often located in far-flung locales. These remote pump stations are typically maintained by roving personnel who are responsible for a range of maintenance and repair duties, as opposed to dedicated automation system specialists.

These personnel in particular appreciate the simplicity that a smart inverter offers as compared to more complex alternatives, both in terms of troubleshooting and maintenance. For example, a maintenance technician would only have to stock one smart inverter in case replacement was required, as opposed to multiple components. His or her PC would only require one software program for smart inverter troubleshooting, instead of multiple programs. Instead of multiple communication cables, only one cable would be required to connect the PC to the smart inverter. Most modern smart inverters include a Modbus RTU port, the preferred communication protocol in the water/wastewater industry.

Control valve replacement—Hundreds of thousands of control valves have been installed worldwide over the past few decades, with many more installed every day. These control valves are typically used to control fluid flow rates in various industrial applications, with a valve installed downstream of a constant speed pump (Reference 2).

Control Valves – many simple applications that currently utilize control valves can benefit from the integration of a smart inverter.

A better solution in most cases is to eliminate the control valve, and to instead control fluid flow by regulating the pump speed with a smart inverter. This saves energy as it is no longer necessary to generate relatively high fluid pressure that must immediately be throttled down by a control valve, and also results in a simpler system requiring much less maintenance.

Control valves have problems with hysteresis, stickiness, speed of response, fugitive emissions at the valve packing, and so on. Valves and actuators have to be monitored constantly with diagnostic programs for problems, and taken out of service periodically for maintenance. As valves degrade in service, auto tuning or other complex methods have to be incorporated to account for stickiness and other problems in order to maintain the fluid flow rate close to setpoint.

Fluid flow rates can generally be controlled closer to setpoint with a smart inverter, increasing quality and reducing waste. Pumps with smart inverters provide a faster speed of response to a setpoint change than mechanical valves, which have to physically move a valve plug or butterfly to achieve the new setpoint.

In the past, varying pump speed to control fluid flow rates wasn't a viable option to control valves because inverters were too expensive. Inverter prices declined, but replacement still often entailed installation of an external logic controller and operator interface. The smart inverter has changed this equation, making replacement of a control valve with a smart inverter the preferred option in many instances.

Most of these control valves are installed in process plants, and these plants have a long history of using distributed control solutions where intelligence is pushed down to the field component level. These smart field devices are then connected to a central control system via a digital network. A smart inverter fits perfectly into this type of a control system architecture, as well as providing a number of other advantages as outlined above.

Conveying system—Many conveying systems must vary the speed of separate conveyors in order to control product flow. These are relatively simple applications in many cases, and often require frequent local operator attention and interface. For instance, a secondary conveyor section may need local speed adjustments to coordinate with a main conveyor section.

These characteristics make many conveying systems a perfect candidate for smart inverters, which usually include sufficient functionality to control the conveyor section, along with adequate operator interface to make local adjustments as needed.

Conveying system – A smart inverter can provide local control of a conveying line, allowing an operator to make speed adjustments as required.

The alternative approach of combining a traditional inverter with a local logic controller and operator interface device is too costly. Tying each traditional inverter back to the central control system and operator interface is another approach, but that doesn't provide autonomous operation in the event of central controller or network failure, often needed for safe shutdown. It also doesn't provide for a local operator interface, also often needed.

Using a smart inverter addresses all of these issues, providing the degree of required local control and operator interface required, and doing so in a more cost effective fashion than a traditional inverter paired with an external logic controller and operator interface.

Cranes and hoists—Many industrial plants use overhead cranes and hoists to move materials. These cranes and hoists must often move at varying speeds, for instance faster for moving a load from one side of a facility to another, but slower as the load approaches its destination and is set in place.

For cranes and hoists, perhaps the most important feature of a smart inverter is the ability to perform a local controlled shutdown in the event of an external E-stop or other emergency condition. Heavy loads are typically being conveyed, with inherent dangers. Relying on an external logic controller to make decisions in an emergency situation is ill advised.

Cranes and hoists are mobile, so connections from a traditional inverter to an externally-mounted logic controller and operator interface would be very problematic. Using a smart inverter eliminates these connections, providing a further advantage.

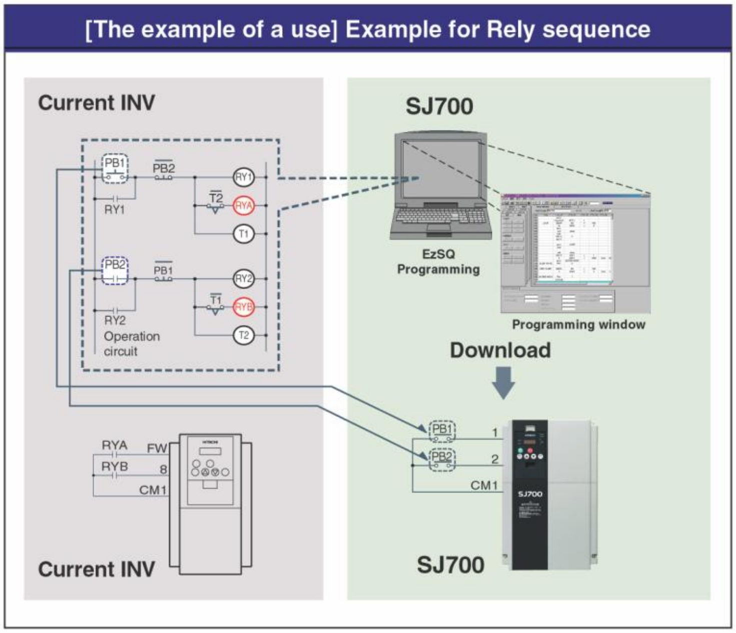
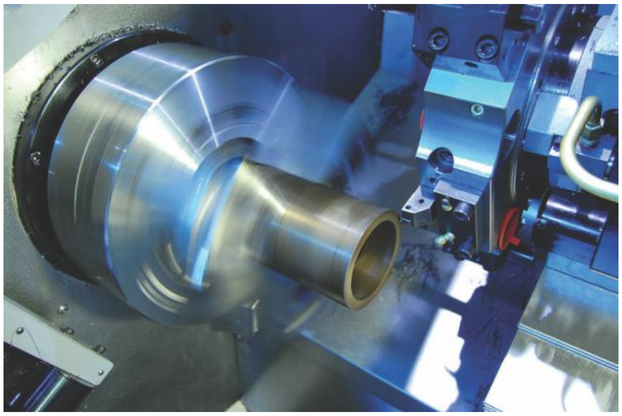


Figure 2 – A smart inverter can automatically reduce motor speed during periods of peak electrical demand, resulting in significant energy savings.

Energy management—In many applications, a simple way to cut energy costs at times of high electrical demand in a plant is to simply slow down the motors. This can easily be accomplished with some simple programming in most smart inverters (Figure 2). In this particular example, the smart inverter's programming language was used to define the times when motor speed would be reduced.

Such energy-saving measures can certainly be accomplished by a plant-wide energy management system (EMS). But employing these measures means the EMS has to be programmed to control each motor, with all the attendant costs—such as programming, wiring, sensors, and development of HMI screens. The EMS itself requires a control system, an HMI, I/O, networks, and an expensive systems integrator or EMS vendor to design, install and configure it.

A smart inverter, on the other hand, requires none of this extra cost. In fact, depending on the application, using smart inverters programmed to save energy at peak times could completely eliminate the need for an expensive EMS in the first place—while delivering a large percentage of the potential plant-wide savings.



Lathe – Low precision CNC machines like this lathe can often be completely controlled by a smart inverter, providing a low cost solution with all required features and functionality.

Low-precision CNC—Smart inverters can be used on some kinds of basic CNC machines, such as a variable speed lathe. For precise positioning, a stepper or servo motor is best, but inverters can be used on many lathes, cutting machines, welding machines, coating machines, die handlers and hammer mills.

Some common smart inverter functionality useful in these types of applications includes the ability to count events, such as encoder pulses, and intelligence to take appropriate action accordingly via conditional branching. Encoder pulses can also be converter to angular or linear displacement, hence positioning.

A smart inverter can't replace a CNC or the main operator HMI on a large, complex machine tool, but it can offload many of the motor control tasks. All the CNC has to do is send a motor speed setpoint to the smart inverter.

In simpler machine tools, as well as simpler machines of other types, a smart inverter can often be used to control the entire machine. This can eliminate the need for an external logic controller, I/O and operator interface—drastically cutting costs and the automation system footprint, as well as greatly simplifying the system.

OEMs that make machines that perform relatively simple and repetitive tasks are under tremendous cost pressure, as these types of machines typically don't feature proprietary technology that would eliminate competition. These OEMs must therefore compete primarily on cost, making it a necessity to reduce automation system costs to the bare minimum, while still providing reliable operation that meets performance requirements. A smart inverter can be the ideal answer to meet these goals.

Material Handling and Packaging—Like some machine tools, many material handling and packaging devices are simple and straightforward. Conveyors, bottling machines, palletizers and many other systems typically run at a fixed range of speeds. Automation is only required for stopping, starting, changing speed, and responding to emergency conditions. Yet many of these systems are equipped with a traditional inverter, a logic controller, and an operator interface.

A smart inverter, with its built-in logic controller and operator interface, is perfectly capable of dealing with many of the conditions that occur in material handling and packaging equipment, thus eliminating the expense of a traditional automation system.

WJ200 - Smart inverters are also capable of simple speed control, therefore offering further value through their innate versatility.

Ramp & Soak—Industrial equipment such as mixers, centrifuges, and commercial/industrial washers and dryers often require what is commonly referred to as ramp & soak functionality. For example, a mixer might be required to accelerate to speed 1 in five seconds, run at speed 1 for ten minutes, ramp to speed 2 in ten seconds, run at speed 2 for five minutes, ramp to a stop, and wait for two minutes.

A smart inverter can be programmed to incorporate this functionality, providing substantial savings over a solution required a separate logic controller and operator interface.

In many cases, the item of equipment is built by an OEM and tested at their facility prior to shipment to a customer. Controlling the entire equipment functionality with a smart inverter allows complete testing in the OEM's facility, assuring proper operation when the equipment is installed at the site.

Conclusion

In most of the applications listed above, and in many others, a central control system will be used to provide overall control and monitoring of the entire facility. Using controllers such as smart inverters is an ideal fit in many of these applications, as it suits the distributed control architecture favored by many facilities. Not only do smart inverters fit well into a distributed control architecture, they also confer a number of benefits as described and detailed above.

As the cost of smart inverters decreases, more applications will lend themselves to this technology. Another factor that will favor more widespread use of smart inverters is their inherent simplicity as compared to more traditional solutions, important as end users continue to cut back on operating personnel.

When correctly applied, smart inverters are often the optimal solution, significantly cutting costs and simplifying the automation system, particularly as compared to traditional solutions.