TOC Teaser:
Today's hybrid temperature controllers can replace a basic temperature controller, a mini-PLC and an operator interface terminal in many applications. This cuts costs, saves space and simplifies systems by using one device to perform multiple functions.

Fast Forward Bullet Points:
- Automation system manufacturers have created hybrid temperature controllers that combine some of the functions of basic temperature controllers, PLCs and HMIs.
- User demands drive these developments as machine builders, integrators and end users seek simpler and less expensive installations.
- For appropriate applications, hybrid temperature controllers can perform many key functions at a much lower cost than separate components.

Resource Box
1. Good Temperature Control,
http://www.isa.org/InTechTemplate.cfm?Section=Communities2&template=/TaggedPage/DetailDisplay.cfm&ContentID=75380

2. Selecting Temperature Measurements and Control Systems,
http://www.isa.org/InTechTemplate.cfm?Section=Control_Fundamentals1&template=/ContentManagement/ContentDisplay.cfm&ContentID=92620

3. Hybrid Control Identity Crisis,
http://www.isa.org/InTechTemplate.cfm?Section=Article_Index1&template=/ContentManagement/ContentDisplay.cfm&ContentID=63834

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Hybrid Temperature Controllers Offer More Versatility

If you haven't looked at today's technologies, you might not recognize temperature controllers, as they've taken on PLC and HMI capabilities.

Many process plant units have temperature loops that must be monitored and controlled. If these units are self-contained to some degree, as with a process skid or a remote unit, they often have just a few discrete and analog I/O points that must be monitored and controlled in addition to temperature. These units also often have a need for some limited operator interface.

In the past, these remote units were often controlled by basic temperature controllers, a PLC and an HMI operator interface terminal. But now, a single hybrid temperature controller can perform all of these functions by controlling and monitoring multiple temperature loops, by acting as a mini-PLC, and by providing limited but often sufficient operator interface functionality.

These hybrid temperature controllers excel at loop control, often employing self-tuning and basic artificial intelligence algorithms, in addition to other advanced functions such as ramp-soak. This makes them suitable for the most demanding temperature control applications, as their performance often exceeds that of a separate PLC.

Two forces that continue to drive the development of hybrid temperature controllers are the consolidation of instrumentation, and the migration from discrete controls to PLCs. User demands typically guide changes in products as they try to force as much capability as possible into a controller in an effort to squeeze every dollar out of costs (Table 1).

Table 1: Comparative Functionality of Various Controllers

Feature	*Traditional Temperature Controller*	*Hybrid Temperature Controller*	*Mini-PLC*	*Traditional Large-Scale PLC*
I/O Count	<10	<20	<40	100+
Programming Complexity	Low	Medium	High	Very High
Program Execution Speed	100+ ms	50-200 ms	20-100 ms	10-50 ms
Connectivity Options	Serial	Serial, Ethernet	Serial, Ethernet	Serial, Ethernet
Internal HMI capability	Minimal	Medium	Medium	Minimal
Loop processing capability	1	1 to 3	1 to 5	10+

In many applications, temperature control, logic control and operator interface are all required at the process unit. In cases where a lot of computation or loops are required, a full-blown PLC-based system with a sophisticated separate HMI system makes sense. But in situations with just a few control loops and 10 to 20 other I/O points, this type of solution is cost prohibitive.

In the past, many users would turn to one or more temperature controllers, a mini-PLC and an operator interface panel to get the needed functionality, but there's a better alternative.

How Much Can One Device Do?

To help bring costs down, some instrument manufacturers have moved to combine temperature control, PLC logic control and operator interface functionality into a single hybrid temperature controller package (Figure 1). This approach makes sense for a couple of reasons.

First, powerful semi-conductors allow for complex operations to be performed at higher speeds than traditional controllers. Second, the existing operator interface on the temperature controller can also be used to provide an interface to the logic control, and to provide additional operator interface as required.

There are many benefits resulting from combining these functions into a single instrument. Besides the reduced cost of the unit itself, there are other costs savings that emerge in the larger implementation.

- The size of the enclosure can be reduced as less space is needed for housing one control device versus three.
- The amount of wiring and the wiring time can be minimized as wiring does not need to be split between two controllers and the operator interface terminal in the panel.
- Many wired connections that are typically required among the temperature controller, the PLC and the operator interface terminal are no longer needed.
- Programming time and interface complexity among the temperature controller, the PLC and the operator interface terminal can be reduced or eliminated.
- Only one PC-based programming software package needs to be learned and maintained, as opposed to three.

Many of these functions are intuitively tied together inside the controller such as timers, counters, and relay latches. This simplifies programming and speeds implementation. Similarly, interface to the internal operator interface functions are tightly integrated, providing further simplification.

[Block diagram showing the functional elements of a temperature controller, from I/O to HMI.]

Figure 1: This function-block diagram is typical of current offerings among hybrid temperature controllers.

Reduced Need for Complex HMIs
A large cost saving is gained because a separate HMI may no longer be required on some applications, or a smaller, cheaper one may be employed. Some controller features that merge well with internal ladder logic functions can work with programmable function keys, customizable displays with scrolling messages, and data entry capability.

Function keys on the front of the controller can replace panel push buttons. These can be used as digital inputs to a ladder program, allowing operator interaction without the need for external hardware (Figure 2).

[Photo of the front of a typical hybrid temperature controller so the programming buttons and on-board display are featured.]

Figure 2: With all the display and programming options built into a hybrid controller, there is little need for a separate operator interface panel, saving space and cost.

A process alarm or a door switch can trigger the display to scroll a text message such as “Low Flow Rate” or “Door Open.” This tight coupling of PID control and ladder logic program provides more benefit at a lower cost than using a separate temperature controller with a PLC, especially where an HMI is needed.

The displays on temperature controllers typically provide custom parameters. These parameters are two-fold: data display and data entry, similar to a traditional HMI. Program variables can be entered for use by the ladder program such as values for timers or ratio factors.

Custom calculated values from the ladder program such as BTU or flow totals can be displayed for use by the operator. This type of information typically is entered via a costly HMI, but these controller hybrids can do an adequate job of replacing touch panels in cases where costs are an issue.

The capabilities of hybrid temperature controllers can open up other applications, such as replacing remote DCS or PLC I/O.

Avoiding Costly Remote I/O
A hybrid temperature controller can often be used as remote I/O for a larger PLC or DCS that may be managing the entire process. A smaller, task-specific controller can be placed in proximity to the part of the process that it’s controlling, providing local operator interface while being monitored and directed from the host. Significant saving can be achieved by avoiding the need to buy I/O hardware manufactured by the PLC/DCS provider, which is typically quite expensive.

In addition, the local hybrid temperature controller can offload processing tasks from the host control system, and can provide an additional level of safety by allowing remote process units to shut down safely in the event of host failure.

This approach is extremely reliable for collecting process information and controlling remote I/O. Many PLC-based communication protocols are available in these hybrid controllers for just this type of situation. Modbus TCP/IP, EtherNet/IP, CC-Link, Profinet, and many other protocols are available, so there is a great deal of flexibility.

The selection of a protocol for your particular situation will based on many factors including the hardware you have selected, the types of data and diagnostics you require, and the technical expertise available to you to engineer and implement a communications system.

There are Limits
Hybrid temperature controllers have certainly added significant functionality over the past few years, but there are limitations to their use.

- I/O count: Hybrid temperature controllers are typically limited to about 20 discrete points and a handful of analog points. This is fine for small process units where a micro- or mini-PLC is needed, but replacing a large scale PLC is impractical.
- Execution speed of the ladder program: Logic execution in hybrid temperature controllers is going to be limited to the scan rate of the controller which is typically 50 - 200 ms, so high speed switching or sequence-of-events applications are out of the question.
- Programming capacity: All functions will need to work within about a 1,000 ladder step limit. This is usually plenty of space given the types of programs that work with small I/O counts, but

applications that require crunching a lot of numbers or performing floating point math will chew through ladder steps pretty quickly, so caution is in order.

That said, building a group of totalizers or calculating temperature/pressure compensation for process variables doesn't required much in the way of ladder programming, particularly as hybrid temperature controllers are optimized for these types of functions.

This leaves a wide range of applications open to hybrid temperature controllers, including the one described below.

Typical Application
A good application example for a hybrid temperature controller would be a batch furnace where the operation calls for a guaranteed soak time for a load, but where the complexity of a profile controller is not desirable.

The controller would employ a short ladder program that compares the process temperature to the setpoint. When the temperature reaches its setpoint, a timer with a user-defined time variable would start. When the time expires, the controller mode would be changed to stop, and a digital output would close to signal that the process was finished.

If a flame detector is needed for a gas-fired furnace, it could be brought into one of the I/O points. When a flame out is detected, the controller would go to manual mode and turn the output off. Another input would cause the output to go to 100% for a purge.

Temperature controller capabilities have increased substantially over the past few years. Some of the products that users have become accustomed to have been morphed by market forces into some truly interesting variants, such as hybrid temperature controllers.

These controllers are carving out a niche that provides significant benefits for applications needing good temperature control capability, modest I/O logic control, decent computational capability and limited operator interface. These benefits include cost savings, ease of use, and space saving.