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# LEAN

## ELECTRICAL CONTROLS

### WHITE PAPER CASE STUDY

As industry shifts and economic realities affect resource availability and customer requirements grow more demanding, providers of electric control products across industry need to become more familiar with the growing, modular alternatives to in-house, hand-wired solutions.

This paper considers the experience of two manufacturers of electric control products that made the switch from managing the processes and responsibilities of hand-wiring solutions—including the inventory of raw materials such as terminal blocks, connectors, and wire spools, as well as end-product liability—to using pre-wired modules and reaping huge savings across several principal stages of product development. One company profiled experienced a 96% drop in assembly costs.

## EXECUTIVE SUMMARY

## An examination of the costs encountered in the use of electrical controls.

Deciding where to spend time wisely and efficiently to add value to the customer is critically important. The decision to make or buy components used in an end product is a perennial question for manufacturers of all types. As such, this paper considers the value and costs associated with the “make” decision, ranging from materials, engineering time, labor, and construction to customer delivery expectations and potential liabilities. It also details the options presented with the “buy” decision, including conformity to specifications, inventory impacts, and application of in-house resources.

By exploring the circumstances of two companies—Power Temp Systems and Severn Trent DeNora—in moving from the use of in-house, hand-wired electric components in their products to pre-wired modules from an outside vendor, this white paper offers insight helpful to companies facing the “make or buy” dilemma.

Specific issues covered in the paper include:

- >> Explanation of the “make or buy” proposition facing electric control manufacturers.
- >> A look at how Power Temp Systems, a manufacturer of portable power distribution systems, opted for a modular approach in the construction of its products to build panel boards with the exact number of circuits a customer requires. This switch allows the company to adapt to last-minute customer specification changes. Power Temp's president says the use of pre-wired modules has saved his company 20-30% in labor requirements and he expects the use of such modules to help grow the business by 10-15%.
- >> Severn Trent DeNora's switch from handwiring PLC I/O points to the use of pre-manufactured modules for all jobs exceeding 200 I/O points. Prior to making this switch, wiring a 1,000 I/O point PLC required more than 165 hours of labor and cost the company \$7,500 per control panel in labor alone. Using modules that consist of a cable with a pre-wired terminal block at both ends, the company can now produce a 1,000 I/O point panel using only five hours of labor at a cost of \$235.
- >> A focus on the costs encountered at the six principal stages associated with product development, manufacturing, and support, and how the use of modular solutions when designing products generates cost savings that resonate throughout these stages.

## Lean Electrical Controls

**As industry shifts and economic realities affect resource availability and customer requirements grow more demanding, users of electric control products need to leverage lean methodologies to reduce waste and bring products to market faster. These processes, which have proven so successful in high volume production manufacturing, need to be driven into the design, assembly, integration, test, purchasing, field support, and project management processes of machine design. To do this effectively, companies today must examine entire processes and remove steps that do not add value to the end customer. This paper focuses on the use of such processes that can significantly reduce electrical control costs.**

Achieving a cost-effective manufacturing operation requires not only the minimization of total costs over the life of a product or project, but the elimination of non-value-added time. When weighing approaches to achieve these end goals, you should realize that merely choosing the lowest purchase price could easily incur much higher costs down the road by forcing steps into the process that do not add value. Compromises on quality and reliability, down-time and repair costs, out-of-warranty service needs, maintenance, and a host of other “incidental” time and money costs can quickly eliminate any apparent advantages of opting for the lowest initial investment.

Suppose, for example, that you need to distribute electrical power efficiently to a collection of motors, switches, sensors, and other electrical products in the field. You have a power source on one side and a plethora of equipment on the other. Your objective is simply to divide and distribute the output of the power source efficiently and reliably, with a minimum of loss along the way.

Traditionally, you would bring power into the panel directly to a terminal block, then custom connect cables to carry portions of that power to the destinations that need it. But this approach often leads to wiring errors that can negatively affect assembly operations and, because there could be multiple different lengths and sizes of

wire and cable, a rat’s nest of wire that’s difficult to manage can be created in the process. The pain such wiring errors can create becomes especially apparent if any movement of the terminal block during installation, wiring, testing or shipping dislodges wires that then require painstaking signal tracing to identify which wire is actually loose so that it can be repaired. In fact, any kind of maintenance in such situations related to wire connections can become costly and difficult to find. Remember, your customer does not value custom wiring, they value the distribution of power to the proper electrical devices to make their system run. But what choice do you have to traditional wiring?

The solution lies in modularity—pre-wired modules that can be mixed and matched to meet a variety of functional requirements. Modules can plug into a power bus-bar system where the system supports hot-swapping and plug-and-play, which means that turning off or disconnecting one module has no effect on the others. The modular system will tremendously reduce wiring difficulties compared to the rat’s nest affect, and repair only requires identification of the bad module (not difficult, since you know which functions no longer work) and replacing just that module while the rest of the system operates undisturbed.

Modular solutions also offer enormous flexibility because the initial installation includes only the features that the customer requires. Expansion of the system's capabilities involves only the addition of the modules needed at the time, so the customer need not overbuy for fear of underbuying. The result is a cost-effective solution that can accommodate future needs.

### PORTABLE POWER DISTRIBUTION

Power Temp Systems of Houston, TX ([www.powertemp.com](http://www.powertemp.com)), a manufacturer of portable power distribution systems for applications as diverse as outdoor concerts, theatrical lighting and sound, chemical plants, nuclear power facilities, and military operations world-

wide, recently faced the challenge of lowering their costs of electric controls in order to stay competitive in its market. To meet specific production goals, the company compared its hand-wired in-house solution to a modular solution.

The decision surrounding this potential switch from a hand-wired to pre-assembled modular solution was particularly critical for Power Temp because common to all the situations in which their products are used is the need for reliability, dependability, ruggedness, durability, and fail-safe operation. Designing such portable systems is akin to the contrast between building desktop and notebook computers. A design that proves adequate for a stationary desktop computer will likely not suffice for a

notebook computer that must endure the indignities of being constantly transported.

Although Power Temp offers numerous standard products, the company deals primarily in custom products. According to Power Temp's President and CEO Cliff Frazier, customer specifications typically include performance criteria as well as strict size and weight constraints. As a result, constructing systems from traditional electrical and electronic components would severely limit the company's ability to meet either performance or form-factor requirements.

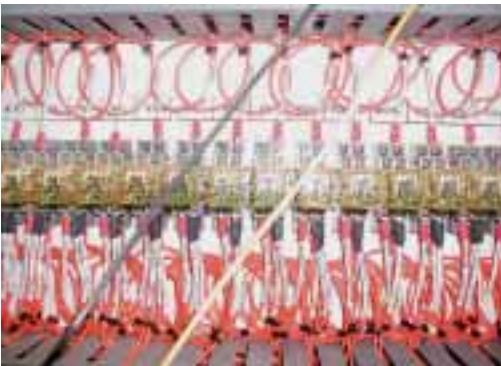
Instead, Power Temp has opted to provide a more modular approach for its customers. The modular solution Power Temp offers starts with a DIN rail, to which any number of 6- or 8-module socket units can be attached. This arrangement allows mounting main and auxiliary bus-bars, as well as external socket bases, if necessary. It also accommodates any type or

### MAKE OR BUY?

Consider the classic "make or buy" dilemma. When implementing lean methodologies, you must focus on lowering the costs by driving out the wasted time from your processes. Buying parts and making something yourself certainly costs less than buying a finished product directly from a vendor, but how much time is wasted in the process? In addition to materials, you have to include the costs of engineering time, labor, and construction. Following this path also means that you will likely have to sacrifice performance or delivery date, and the people involved may be unavailable to work on other projects. In the end, you must be able to affirmatively answer the question: Has your customer value been improved?

Another aspect to consider is that building something yourself introduces a host of uncertainties. Integrated systems purchased from vendors, however, generally conform to established specifications. Vendors know how to build their products most efficiently, just as you know your own. They capitalize on that experience to provide exactly what you need. They have already encountered and overcome the pitfalls inherent in an activity that would be unfamiliar to you. And because these systems—which to you represent infrastructure or incoming material—represent their livelihood, they have probably found better ways to produce the end product than you could.

When you look closely at all costs involved in the make-or-buy decision, you may find that the reality is vastly different from what you expected.



*"Before" — STDN used to rely on hand-wired assemblies. Building such assemblies proved expensive and time-consuming, and the assemblies experienced quality and reliability problems.*



*"After" — Adopting modular solutions for control panels requiring more than 200 I/O points gave the systems a more aesthetic appearance, provided a faster, more reliable assembly, and eliminated most wiring labor costs.*

location of power supply block, along with an adjacent surge suppressor to guard against over-voltage. With adapters, any modular device of the same mounting height can mechanically and electrically connect to the bus-bar system. Socket bases allow inserting bus-bars individually as required, which is an appealing option because bus-bar covers completely touch-proof the system.

Employing this modular approach allows Power Temp to build panel boards with the exact number of circuits a customer requires without including unneeded features and without making the panel larger than necessary. The ease of assembly allows fast, simple configuration changes—a useful feature when the push to complete a product or project may demand last-minute changes to specifications. This is of critical importance to Power Temp's customers because, in most performance-critical situations, its customers cannot afford to shut down the entire system. Modularity permits hot-swapping system components, and turning off individual devices for repair or replacement while the rest of the harness remains active.

### **COST CONSIDERATIONS**

When considering the cost of a electronic control solution, there are two basic categories to examine: 1) meeting the customer requirements with a reduction in waste; and 2) comparable cost of components with more features, better performance, quality, reliability, or flexibility.

Using its new, modular approach, Frazier says his company now experiences both types of

cost effectiveness. He says Power Temp's modular solutions are reducing waste by saving 20 to 30% of the labor required to manufacture a system—with significantly improved reliability. In addition, the modular approach opens up new applications for his products. As a result, Frazier predicts that moving from hand-wired to modular designs alone will add 10 to 15% growth to his business.

It's important to realize, when considering Frazier's economic analysis, that Power Temp's primary competition is its customers—which introduces the classic make-or-buy decision for the customer. Frazier estimates that buying his modular solutions can save customers 20 to 30% over the cost of making it themselves. Recognizing such savings, however, requires that customers understand and account for all of the associated costs (see "Make or Buy" sidebar on pg. 4).

Yet another advantage of the modular approach is that it permits certification by UL and other national and international bodies. Considering OSHA oversight and other aspects of today's safety-conscious environment for all power-distribution applications, such assurance relieves customers of a considerable, additional concern. For Power Temp, supplying modular power-distribution systems allows their customers to concentrate efforts, resources, and expertise on their own products.

### **STATIONARY ADVANTAGES**

Severn Trent DeNora (STDN), Sugarland, TX ([www.severntrendenora.com](http://www.severntrendenora.com)), is a provider of

water disinfection systems using onsite-generated sodium hypochlorite produced from seawater. The company builds electrolytic cells—rectifiers that convert ac to dc power to run those cells—and the ancillary equipment necessary to run the disinfection plant, including PLC control panels. Large-plant PLCs, of the type that STDN typically builds, often contain more than 300 I/O points. The largest PLC that STDN ever built in-house had more than 1,000 points. For such a control panel, using the conventional technique of wiring each point to a terminal block proved extremely time-consuming and expensive.

According to Vince Wedelich, electrical engineering supervisor at STDN, wiring each PLC I/O point requires a technician to make two custom wire marker tags, cut and strip each end of the wire, route the cable through a wire way, torque each end of the termination, and perform a final test on each point to ensure that wires are neither loose nor connected to the wrong point. The task takes approximately 10 minutes per PLC point. Wiring the 1,000-point PLC in this way required 166.67 hours of labor. An hourly labor rate of \$45.00 translates to a total cost of \$7,500 per control panel in labor alone

to wire the PLC to the terminal block.

The manual approach also limited STDN to PLC I/O cards with no more than 16 points, because a technician cannot accurately assemble cards with a higher density of points. As a result, if a third of the 1,000-point PLC requires discrete inputs, those 333 I/O points would require 21 cards—21 slots in the PLC, along with a comparable number of PLC racks and power supplies, as well as a large enclosure. Making the problem even more complex is the fact that the build specification for control applications generally calls for #14 AWG wire, which is too large for PLC input cards. Such large wires make wiring each point more difficult, and panel covers may not close properly as a result.

### **REDUCE, REDUCE, REDUCE**

Because the hand-wired method is not practical for such large assemblies, Wedelich has reduced waste by turning to pre-manufactured wire modules for all jobs that exceed 200 I/O points. The modules consist of a cable with a pre-wired terminal block at both ends. Installing a 32-point PLC card involves merely plugging the card into the PLC rack, connecting the PLC end of the pre-manufactured multiconductor cable, and

### **MODULAR SAVINGS AT EVERY STAGE**

Minimizing overall costs in electric control products requires paying attention to costs at six of the principal stages associated with product development, manufacturing, and support. Utilizing modular solutions when designing products generates cost savings that resonate throughout these stages:

#### **DESIGN**

Designing a non-modular system with hundreds of I/O points and power components such as circuit breakers, disconnect switches, contactors and motor starters requires specifying exactly where each of those devices will be wired and how they will contribute to your product's performance. A pre-wired I/O module or pre-configured plug-in bus architecture that requires some or all of the items

mentioned above provides a convenient short cut. Vendors have already made the necessary design decisions, freeing your design people to address issues that make your product truly unique. In that way, achieving your design goals consumes as few engineering resources as possible.

#### **ASSEMBLY**

Here, a modular solution provides an enormous and quantifiable cost advantage. The Severn Trent DeNora example in this article provides a classic case example—hand-wiring a large control panel would have taken the company more than 150 hours and incurred an unreasonable and unmanageable labor cost of \$7,500 per panel. The modular solution permitted accomplishing the same task in a mere 5 hours at a labor cost of only \$235, a reduction of more than 96%.

snapping the pre-manufactured I/O module onto the DIN rail. This entire step takes only as long as wiring one PLC point in the conventional way. The already-tested, pre-manufactured modules require no further troubleshooting.

The 1,000 I/O point panel that required more than 165 hours of labor would take only five hours at a labor cost of \$235 using the modular approach.

In addition, because modules can be denser than the hand-wired variety, each system requires fewer modules and less space, permitting quicker installation. The resulting system looks cleaner and neater (see Before and After photos, pg. 5). Because all PLC points are pre-wired, spares are already connected, making field changes a snap. The large #14 AWG wire specification does not apply to pre-manufactured modules, so that problem disappears as well.

Wedelich notes that when designing this type of panel, the PLC manufacturer is of no consequence. The field interfaces with the I/O modules, reducing the pain of cut sheets and designing custom PLC panels. The company supplying the pre-manufactured card performs interfacing to the PLC module. Designers who plan to adopt

the modular approach, however, should realize that some module manufacturers do not connect to all available PLCs.

### **FINAL ANALYSIS**

At first glance, hand-wiring your own assemblies often appears to be the most cost-effective way to distribute power and control signals through a complex system. After all, that's how the process has historically been handled. The quality and reliability drawbacks to hand-wiring, however, coupled with the difficulties the process can bring to your ability to meet delivery dates and customer specifications, often translates into a number of intangible costs that can hurt your business. In addition, liability and responsibility for supporting these hand-wired systems can consume scarce human resources. Buying such assemblies from a vendor whose livelihood depends on them can alleviate these problems and allow you to focus your resources on your primary products and services. Taking that approach to the next level by finding a vendor who provides modular harnesses and assemblies will further reduce your direct costs by a substantial margin and provide you with more product options to present to your clientele.

### **INTEGRATION AND TESTING**

A hand-wired solution requires testing and verification throughout the assembly process to ensure that it works and to minimize the time required to identify any failures. Modules come in tested and guaranteed, completely eliminating this burden.

### **PURCHASING**

Buying pre-wired modules is in stark contrast to hand wiring your own, which requires you to acquire all the necessary raw materials—terminal blocks, connectors, wire markers, and huge spools of wire you must cut to the proper length. This translates into fewer items to store and track, making the process of managing inventory against production levels far less complicated. Although quantifying these costs may prove difficult, streamlining the production process by itself adds considerable value.

### **FIELD SUPPORT**

Pre-wired modular assemblies fail much less often than more fragile, hand-wired varieties. When a failure does occur, swapping out a bad module and replacing it minimizes your customer's downtime as well as your service and support costs. Customers can even perform the swap themselves, reducing your costs further, and the vendor can supply the appropriate level of support.

### **PROJECT MANAGEMENT**

Modular I/O solutions simplify the logistics of managing a product throughout its life, from inception to the field to its retirement. In addition to quantifiable savings in time and money, your customer gets a higher quality, more reliable system—and you get a more satisfied customer.