FLUKE®

What it takes to design custom control panels

Application Note

Testing Functions
Case Study

Your finger is poised over the touch screen of a process control panel.

All around, watching in anticipation, are your customers—including a dozen inspectors and engineers. This is the test where six months of work you've just completed is about to culminate with a simple touch of the finger.

But in spite of the pressure, you're confident that the test will be successful. You and your team have already been there and tested this system a thousand ways.

Your finger presses Start, and inside the panel, a programmable logic controller (PLC) reads the signal and sends power to a variable speed drive. A hundred feet away, a 100-horsepower blower motor eases into action as a giant industrial dust collection system powers up. Its operation is key to environmental compliance and safety in this huge wood products plant. Motor starters trigger smaller blowers—you can see it all happening on the touch screen. No alarms are showing, so you know the interface with the fire control system is working.

You're on your way to passing the test.

Tools: Fluke 787 Process Meter™, Fluke 289 True-rms Industrial Logging Meter, Fluke ScopeMeter®, Fluke 1587 Insulation Multimeter

Operator: Zach Bryson, operations manager, Keithly Electric

Measurements: Continuity, control signal response, signal voltage

The hands-on advantage

For Zach Bryson and the controls team at Keithly Electric in Seattle, it's another job well done. Keithly is a full-service contractor focused on heavy industry: sand and gravel, asphalt and concrete, maritime, manufacturing, and food and beverage processing. Though it started in installation and service, Keithly saw new opportunities in designing and building the custom programmable controls that keep plant systems running right.

"If it's got wire we deal with it, whether it's medium voltage work, communications, general electrical wiring—we have residential, commercial, and industrial divisions, as well as programmers and panel builders," said Bryson, operations manager for Keithly.

When designing custom control panels, Keithly's end-to-end experience makes a difference and helps create new opportunities. Their design standard means every company electrician, from PLC programmers

to field electricians (many of whom are programmers too), knows how a Keithly panel goes together. Keithly panels are assembled with the service electrician in mind, with spares for future expansion built in and easy access for testing. Plastic "finger safe" shields guard against inadvertent contact with energized components.

That breadth of experience comes into play throughout the process of planning, construction, testing, and installing a new control panel. Such projects can start with a marker and a blank white board, Bryson said—and sometimes evolve into a complete redesign, automation, and optimization of the entire industrial process.

"Have you guys thought about this?"

"Sometimes it's just an idea out of a guy's head, other times it's a complete pre-designed package where you have a set of prints that show the panel layout and everything," Bryson said, "and even some of those we'll rework. We'll take their existing design and say, 'Have you guys thought about this?' This is good time to develop criteria for future expansion, maintenance, power availability..."

Automating a 550-acre sand and gravel plant in Auburn, Washington went way beyond replacing a mind-boggling and deteriorating array of gauges and control buttons with simple touch screens. Working with the customer to redesign the system, Keithly created a design that also eliminated 30 motorized conveyors and reduced motor load by hundreds of horsepower, saving thousands of kilowatt hours in energy consumption. Now a single operator runs the entire crushing, sorting, and washing facility.

"We've greatly reduced the chance of error," Bryson said. "In automatic mode the operator has become a monitor. Before, he was starting and stopping conveyors, adjusting feeders and doing all this manually to make this thing run as smoothly as possible."

Zack Bryson and Jerry Katona examine the operation of the low-voltage side of the dust collector control panel while Kim Kruckenberg sends test commands from his laptop.

"Using less horsepower, they're able to process more rock faster," Bryson added. "If they have a call for 100 tons of rock they're able to do it thirty percent cheaper, with less wear and tear on the equipment, less equipment to maintain, and less power use. It's better for the environment all around."

Today many such projects aim for energy savings. "Part of why we're doing these dust collectors, moving them over to variable speed drives and replacing all of the controls, is because there's an energy conservation program out there," Bryson said. "So rather than dampering those dust collector fans, they're now slowing them down using variable speed drives in order to conserve energy. The green effect has really grown a lot of this."

Design and build

As the scope of the project is nailed down, Keithly creates a functional specification that lays out which devices—motors, sensors, alarms, and more—will interface with the control panel and how they will interact with each other. A sensor that detects light inside a sawdust duct, for instance, may trigger a water spray to quench a hot spark. But too many spark signals could indicate a fire, so after a threshold is passed, the system shuts down the entire plant and sounds a fire alarm.

The next step is to develop a list of all the components that must be incorporated into the control panel. The PLC will be there, together with terminal blocks for communications (Ethernet, ControlNet, or other protocols) and control circuits, motor starters, motor drives, power cables, fuses and disconnects. The team then enters this components list into a computer-assisted design program, and lays out the panel.

Downstairs, the panel shop is busy attaching and wiring components. Controllers and terminal blocks snap onto aluminum DIN rail; plastic wire ducts keep wiring tidy.

Here too, Keithly adds a touch of experience. Knowing systems may grow, the panel designers leave room for additional devices and connections. Electricians appreciate convenient access to components, so they place connections in easy reach. Every wire is labeled at both ends to make connections obvious and speed troubleshooting. And knowing the importance of safety, Keithly color codes wiring to indicate voltage, and places high- and low-voltage wires in separate conduits.

Meanwhile, Keithly programmer Kim Kruckenberg is busy on his computer, creating the step-by-step chain of logic that will be programmed into the PLC. For instance, if a sensor signals that a dust bin is full, a warning lights up on the control panel. If the "over-full" sensor signals, the blower feeding the bin shuts down. And so on, step by step, circuit by circuit, and device after device.

Test... and test again

The Keithly approach includes a multi-step testing regimen that starts when the panel is complete and ends only when the panel is installed and the customer is happy. The initial tests are the easiest: tug tests to ensure that every terminal screw on every wire has been securely tightened. Continuity tests follow, using a Fluke digital multimeter to verify that those nice, tight wires connect where the address table says that they should.

Functional testing of the electronics comes next. Senior technician Jerry Katona uses the Fluke 787 ProcessMeter™ to generate low-voltage dc control signals and verify that panel-mounted devices are responding as they should.

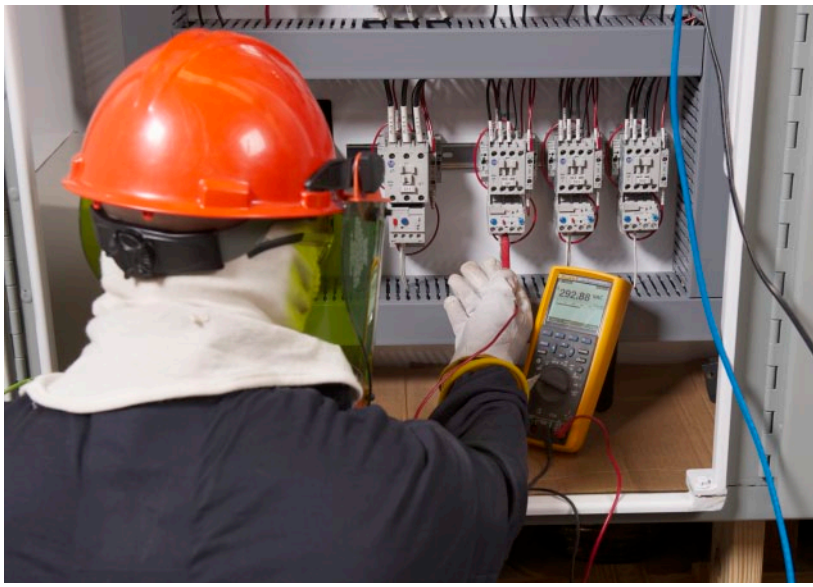
Then the PLC system is bench tested to determine that the programmed commands and responses are working correctly with the devices on the panel. As Katona triggers commands, Bryson reads signal voltages on his Fluke 289 True-rms Industrial Logging Multimeter with TrendCapture. Another push on the touch screen triggers the panel's variable speed drive (VSD), and a test motor on the floor, standing in for the main blower motor, whirrs to life. A Fluke ScopeMeter® Test Tool displays the waveforms produced by the VSD.

The final and most important tests come after the panel has been installed and connected to power and control circuits. "Typically we would mount your panel and run the power feeds into your panel," Bryson said. "Once the power feeds are run we would meg them out to test the wire insulation values using a Fluke 1587 Insulation Multimeter before we apply power to them. This ensures that the wire's in good shape and there's no shorts and so forth. That all gets documented.

"Once that's been done we start to pull in and land all of our control wiring. Then we go through a point by point I/O checkout where we verify that wire number one goes to terminal one, and so on. It's a continuity check with a meter, before we power up. Once we've done our continuity checks, we apply power. It becomes the field electrician's issue to get it all up and running. Kim will work with the field electricians checking inputs and outputs, checking field devices, checking motors, and making sure it all comes together."

"One of the most common things is you'll have a typo: 'Hopper unload' versus 'Hopper load,'" Bryson added. "It just happens. But you catch it at that point, before you turn it over. That's always the goal: a system that works flawlessly and 100 percent before we leave the site."

All done? Not yet. Adjustments and customizing continue even after turning the system over to the customer. "We fine-tune the system based on their input," Bryson said. "A lot of times they're present during startup and we do some of that right there. You try to make the customer's life easy. When we're finished they're documented, they have backup, they have copies, they have AutoCAD drawings, they have absolutely everything they need, and we'll come out and service it any time of the day or night they want us to."



Zach Bryson of Keithly Electric tests for continuity and voltage at the load side of a motor starter overload module using the Fluke 289 True-rms Logging Multimeter.

More communication, more data... and more fun

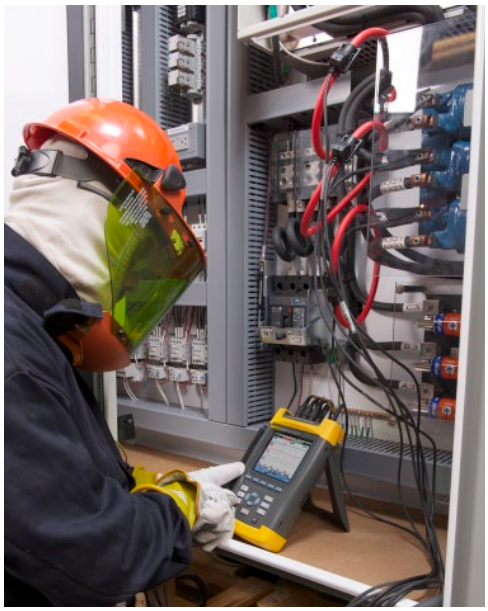
The arrival of graphical touch-screen human-machine interface (HMI) devices may be the most visible change in industrial controls, but there's more behind the scenes. Bryson said the increasing use of Ethernet communication networks makes it easier to collect data and use it to enhance system performance. At a paper mill electrical cogeneration plant in Tacoma, Washington, communication with new variable speed drives was all done by Ethernet. "It went into the PLC and out to the drives by Ethernet. They were able to harness all the information about a drive—what it was doing, how long it had been running, what temperature it was running, how many amps it was drawing, and what frequency it was running. Via trending you can actually take that to the next step and see what your actual speed was per motor. Any time you have information, you can make that information useful."

The spirit of entrepreneurship that got Keithly into control panels in the first place has helped build the business—and build satisfaction on the job. "Customers call upon us to assist with plants and machinery that aren't working as well as they could," Bryson said. "Now it does what it wouldn't do before, with less effort on their part. It makes their life easy and makes their job better. If you can do that for people every day, work is fun."

Key results of effective control system design and manufacture

From the front office to the shop floor, the Keithly approach to control system design and manufacture delivers results:

- Plant managers boost uptime, cut maintenance costs, and save big on power usage.
- System operators who once memorized the functions of hundreds of control buttons and gauges—a process that could take months—now use simple human-machine interface (HMI) touch screens that show the plant layout mapped on an illuminated display. Functions and alarms are automated, reducing human error.
- Plant maintenance technicians quickly see that Keithly controls designers have been there, done that—and used their experience as field electricians to make controls installation and maintenance easy and quick.



Using the Fluke 435 Three-Phase Power Quality Analyzer, Bryson examines wave forms and harmonics levels on the input side of a motor variable speed drive.

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