FLUKE®

Foolproof circuit troubleshooting and validation

Application Note

Testing Functions
Case Study

Tool: Fluke 1653 Installation Tester

Profile: Sunbelt Construction, (residential) master electrician

Measurements: Voltage drop/ loop impedance, line-to-neutral, line-to-ground, insulation resistance, installation validation

Using an instrument designed principally for European electricians, one Texas electrician saves time by performing loop impedance and insulation resistance testing on old and new electrical circuits.

Dean Belcher, master electrician at Sunbelt Construction, downloading installation verification data from the Fluke 1653 tester.

Dean Belcher is the master electrician for Sunbelt Construction, a small, family-owned remodeling and construction company headquartered in El Paso, Texas. He explains that his father owns the company, which employs 15 to 20 people. The work they do is primarily on residential structures from California to Mississippi and as far north as Colorado. What Belcher wants to share with his fellow electricians is how he uses a Fluke 1653 Multifunction Installation Tester to troubleshoot and validate circuits.

Acquiring the instrument

Belcher had seen information about using Fluke 1650 Series installation testers to perform loop impedance tests on circuits. (See the box, "Fluke 1650 Series capabilities.") While these instruments are made principally for European electricians and designed to perform tests mandated by European regulations, Belcher immediately saw how his own work would benefit from loop impedance testing, which is another way of looking at what American electricians typically call *voltage drop*.

Electrician in Europe using the Fluke 1653 to test a receptacle.

Looking to take a 1650 Series instrument for a "test drive," Belcher acquired a 1653 model, the instrument in the series with the most features, including data storage for 500 measurements and the capability to download that data into a computer. Since acquiring the instrument, the master electrician has been reaping many benefits from its use on the job. He does caution, however, that there is a "learning curve" associated with using a 1650 Series instrument successfully.

Using the instrument – troubleshooting

Belcher explains that when his company begins a remodeling project—typically in an older home—he begins by determining the status of the existing electrical system. "I've got a Fluke 43B Power Quality Analyzer," he reveals, "and I use that in conjunction with the 1653. I check the amps to see if we have amps and volts rising at the same level or have the amps rising and the voltage decreasing, indicating a problem. If there is an apparent problem, then I use the 1653."

He uses the 1653's loop impedance test function to determine what the problem is. To do that, he simply plugs the instrument into a receptacle and uses either the line-to-neutral or line-to-ground test mode. The line-to-neutral mode checks impedance. During a test, the circuit is powered and the instrument actually loads the circuit, measures the resulting voltage drop and calculates the resistance. Belcher calls this a "stress test". Then, given the voltage and resistance of the loop to the panel and back, the instrument calculates possible amperage based on Ohm's Law.

"When there is a problem with a circuit, the amount of time the tester saves is dramatic," Belcher says. "I can't say specifically that it saves me 80 or 100 minutes a day, but it saves a lot of time when someone is having a problem. I go to each receptacle in a room and see where I have the amperage drop. If I have 700 amps everywhere, and it immediately drops to 200 amps, then I can say that the problem is between these two receptacles."

Belcher says that the greatest benefit he achieves with the installation tester is in diagnosing grounding problems. For example, with receptacles a line-to-ground test can reveal how long it will take a fault-to-ground to trip the breaker. "I want to know if the ground is sufficient," Belcher says. "Is it going to take 30 milliseconds for the breaker to trip when it should take one millisecond?"

"When a computer is plugged into a receptacle, for example, you want to be sure that you have a good ground back to the panel. And if someone gets shocked in a bathroom, you don't want it to take a long time for that breaker to trip. You want it to happen instantaneously," Belcher emphasizes.

Insulation resistance testing – a bonus

All the meters in the Fluke 1650 Series provide insulation resistance testing in which a higher-than-usual-working-level dc voltage is introduced into a de-energized circuit. Such testing is used on motor windings, motor cables, transformers, switchgear and residential and commercial buildings. The goal is to test the integrity of the insulation surrounding the conductors for potential leakage and arcing. Insulation resistance tests on new installations protect against incorrect wiring methods and flawed equipment, while protecting property from fires and people from electric shocks. As a preventive maintenance procedure, insulation testing can serve to spot deterioration of insulation before it leads to system failures or endangers people or property.

The dc voltages available for insulation testing using 1650 Series instruments are limited, with the 1653 having the broadest range and largest number of available voltages,

but there are more versatile instruments available for these kinds of tests. Nevertheless, having this capability on an instrument geared to electricians rather than maintenance technicians means that electricians gain new access to a test that can further ensure the integrity of their installations and retrofits. That was precisely the case with Dean Belcher.

"I had never done insulation resistance until I got this meter," Belcher admits. "Now, I check motors. I check wires. For my business, it's great to have the convenience of an insulation and loop impedance and voltage check all in one meter."

In providing an example of the usefulness of insulation resistance testing, Belcher begins by admitting to having attempted to save money on a job by pulling three used wires about 150 feet through a conduit. Then, he hooked them up to a breaker at one end and a panel at the other end. The wires looked fine, but when Belcher turned on the power, the breaker tripped. Using the insulation resistance testing capabilities of his multifunction tester, he checked the insulation on the wires. What the tester displayed was less than 80 volts. If the insulation had been sound, the tester might have displayed in excess of 1,000 volts. Briefly stated, these figures showed that the insulation on the wire was breaking down and leakage was occurring. Belcher pulled new wires.

Using the instrument — validation

In addition to using the instrument when someone has a problem, Belcher uses it for checking everything at the end of a project, a process known as installation testing or validation. That was the case in a home in Pascagoula, Miss., that had been subject to the ravages of Hurricane Katrina. Belcher validated his work before walking off the site, and that move paid big dividends.

The entire downstairs of the home had been flooded with four feet of salt water during the storm. Everything had been under water. Electrical receptacles, wires and every electrical device including the circuit breaker panel and the main meter panel had been saturated with salt water.

"I came in late on the project," Belcher acknowledges. "The panels were already put back into service and the power was restored throughout the home, but the panels had not been replaced."

Belcher set about to replace every receptacle in the house and all of the wires that were problems, but he had safety concerns. Using the 1653 tester, he determined that there was a problem with the grounding system. "If somebody were to get shocked or there was a fault-to-ground from a wire touching something or from a toaster burning up or whatever," Belcher says, "it would have taken a long time before any breaker tripped because the grounding system in the home had such high impedance. What we were about to do was load up the breakers and have them get hotter and hotter and have the wires get hotter and hotter, but the breakers were not going to trip."

Tipped off to this problem by his 1653 tester, Belcher worked all the way back to the main panel and the meter and found two bad connections: one where the grounding electrode conductor attaches to the ground rod, and one in the housing for the electric company's meter. When these connections were repaired, Belcher retested the circuits. This time the readings were nominal.

"We had two problems," the master electrician reiterates. "Without the meter, I would not have known that. I would have replaced the receptacles and wire and walked off the job. The 1653 told me that we had problems."

Data storage

Asked whether he uses the data storage capacity of the 1653 Multifunction Installation Tester, Dean Belcher answers in the affirmative. He says that he "saves a whole house" in the instrument, describing a process by which each room and its receptacles are individually identified. When he gets back to his office, he downloads the data into his computer and using software available from Fluke called FlukeView® Forms, he gets a readout of volts, amps and impedance for each point on each circuit where he took a reading. "If we have problems at that site again, the data will help," Belcher says. "I have an earlier report, and I can see what has changed since the time we did the earlier work."

"The meter and the backup data are safety nets," Belcher explains. "I did the home in Mississippi, and I walked away with confidence that every panel and receptacle was up to its optimum condition. Now, I'm 1,500 miles away and have that peace of mind that everything was taken care of correctly. No callbacks represent a major advantage of using that meter."

Another use — pre-sale home inspections

In the El Paso area, Belcher has used the Fluke 1653 to inspect the electrical systems of homes before they were sold. In fact, he recommends that home inspectors consider acquiring and using the meter, although he does note that these inspec-

tors will require time to learn how to use it effectively. His point is that the 1653 is a vast improvement over the simple test lights most home inspectors use to test receptacles, and that it does an outstanding job of analysis on entire electrical systems.

One example Belcher uses to prove his point is the case of the failing toaster. A woman purchased a house following a typical home inspection. When she plugged her toaster into a kitchen receptacle and turned it on, the toaster glowed briefly and then shut off. A test light had shown and continued to show that the receptacle had been wired correctly. Belcher applied his 1653 to the task.

The problem turned out to be a loose and incorrectly wired connection on the neutral. The neutral was actually connected to the ground wire, but it was a poor connection. So, there was enough "bleeding" to allow a low impedance test light to show a positive test and the toaster to briefly glow when turned on. Of course, the faulty wiring job could not support the full load of the toaster. The 1653 revealed specifically what the problem was, and even identified it by an error code that can be referenced on an error code sheet that accompanies the meter.

Dean Belcher, master electrician, says that he would recommend the meter to any journeyman or electrical contractor. "I work on the premise that I must be my own inspector," he says. "I don't want to rely on somebody else to tell me that my electrical work is good. Until recently, the only way I could do that was to take extra care in making my electrical connections. Now, the Fluke 1653 puts uncertainty to rest."

Of course, these multifunction installation testers do not eliminate all human errors. Bad connections and faulty wiring schemes will always be with us, but these meters will pinpoint them in new construction and uncover developing problems in older installations.

Fluke 1650 Series capabilities

Of the three models of Fluke 1650 Series Multifunction Installation Testers, the 1653 has the most features, but all three perform continuity, loop impedance and insulation resistance testing. All three also perform RCD (Residual Current Device) tripping tests. An RCD is a circuit breaker similar to the American and Canadian GFI that detects current imbalance but does not provide overcurrent protection. Of special interest to electricians in the U.S. and Canada are these meters' capabilities to perform loop impedance and insulation resistance testing. Also of use to North American electricians are the 1653's built-in memory and interface capabilities.

Loop impedance testing or branch circuit loop testing checks circuits for high impedance by placing an electrical load on an already powered circuit. The test is especially useful for pinpointing problems in the middle of a circuit by checking where in the loop impedance goes from high to low.

Insulation resistance testing consists of the application of a relatively high but controlled dc voltage but limited current to a de-energized circuit. This combination reveals any areas in a conductor's insulation where leakage or arcing might occur without further damaging deteriorating insulation or exposing the operator to potentially dangerous current levels.

The built-in memory and interface capabilities of the Model 1653 Installation Tester help electricians and electrical contractors meet reporting and documentation requirements. The meter stores as many as 500 readings, which can be downloaded into a computer. There, with the help of FlukeView Forms software, a contractor can document, store and analyze individual readings or a series of measurements and, if required, convert them into polished reports.

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