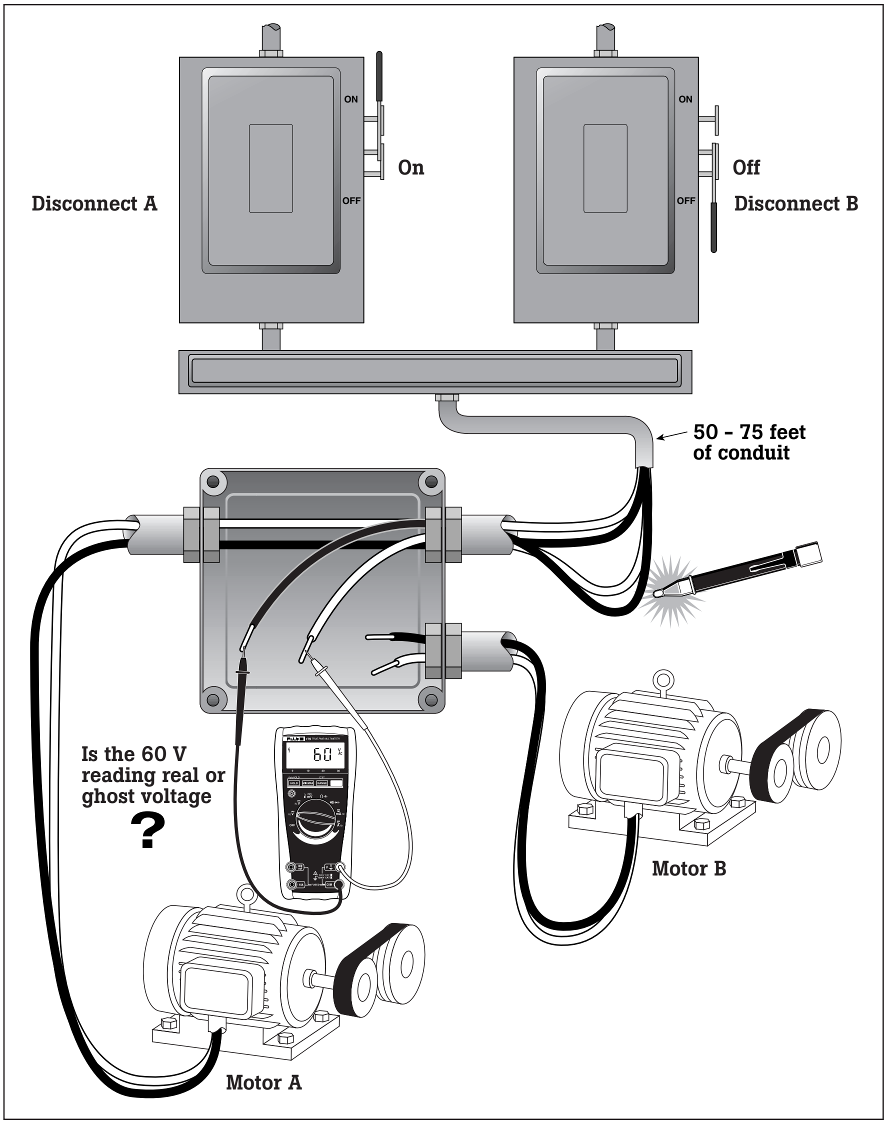
Ghost voltages – phantom readings can lead to the wrong diagnosis

Application Note

Introduction

Ever measured an ac signal on a branch circuit that you know to be dead or even disconnected completely? It can be a real head scratcher. How can a wire, with no connection at either end, have a voltage on it? What you're experiencing is a phenomenon aptly termed "ghost voltage." While its appearance may seem an indecipherable mystery, it usually can be solved without too much trouble.



The clues

Does the wire, somewhere along its length, share a run with many other wires? It's not uncommon practice for electrical contractors to think ahead for their customers and pull extra circuits for possible future expansion of the electrical system. Or you may have just pulled a new wire(s) in a run with other wires. If so, we know that our open wire is running alongside other circuits that are connected to the electrical system and are providing current to real loads such as lights, motors, computers and heaters.

Two metal plates (the conductors) separated by the conductor's insulation and air would appear to fit the definition of a capacitor. We know from basic electrical theory that ac signals run across a capacitor are coupled while dc voltages are blocked. The amount of ac signal passed through a capacitor is determined by its capacitance and that capacitance is based on three factors:

1. The surface area of the plates
2. The distance between the plates
3. The make up of the insulation separating the plates.

In our ghost voltage case, the surface area of the plates is determined by the size of the wire and the length of the two conductors that are laying side-by-side. The longer the run, the larger the surface area and therefore, the higher the capacitance. Increasing the number of wires in a conduit will cause the wires to be packed closer together, reducing the distance between conductors and increasing capacitance. The insulation around the conductors will stay pretty constant and won't change the capacitance. However, external factors will change the effective insulation between the conductors. For instance, while pulling the bundle of wires through a conduit, the insulation may be compressed, reducing distance between conductors. In addition, water may get into a conduit and effectively increase the capacitance as well. Another external factor may be carbon between conductors where an arc took place some time in the past. So in an electrical situation, the amount of ac signal coupled into the disconnected wire is based on a lot of factors.

But wait! This wire is open on both ends! Isn't Ohms Law still working in this situation? To see voltage, don't we need resistance and current flow? Of course you do! This is where we need to look at another part of the puzzle: The digital multimeter (DMM) making the voltage measurement.

When you place your DMM leads between the open circuit and the neutral conductor, you effectively complete the circuit through the input of the DMM. The capacitance between the connected and live hot conductor and the floating conductor forms a voltage divider in conjunction with the DMM input impedance. The DMM then measures and displays the resulting voltage value. With most DMMs, like the Fluke 170 and 180 Series, the input impedance is very high — on the order of 10 megohms. This results in a false reading on the DMM, which is actually measuring voltage coupled into the disconnected conductor.

In most cases the amount of ac coupling between conductors is very low, so the amount of current that can be pulled through this coupling is limited. However, these voltages, at times, can be significant enough to cause confusion when we are troubleshooting circuit problems.

The solution

To reduce the confusion, and save time troubleshooting an electrical system, use a DMM with a low input impedance. Fluke Models 7-600 and 12 (with VCheck) are designed to respond differently to "ghost voltages" than normal voltages. The DMM's input impedance varies depending on what the input circuitry senses. Initially, the input impedance is on the order of two kilohms. So, when the leads are placed on the open circuit that contains a ghost voltage, the low input impedance will cause the ghost voltage to dissipate and the meter will display "OL" with the Ω symbol indicating the meter is still in the resistance function with no voltage present. When the leads are placed on a live circuit however, the input senses the presence of a "hard" voltage and automatically adjusts the input impedance to a much higher value and then displays the actual voltage present. This variable impedance design effectively eliminates reading ghost voltages on open circuits while still making accurate measurements on live power circuits without having to change meter settings.

So remember to put voltage readings in perspective when troubleshooting. If you feel there shouldn't be any voltage present, but there is, check for the conditions listed in this article. The voltage is not an apparition, just a result of the physics of electricity.

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