

Continuity and Low Resistance Testing

||||||| BY JEFF JOWETT



NO ELECTRICAL TEST IS SIMPLER... and few more commonly employed... than the continuity test. This simple test is a ubiquitous option on multi-meters (DMMs) and insulation testers. It is simple to perform; connect two leads across opposite ends of the test item (IUT), press the test button, and within seconds you have the resistance reading. Low is good, high is bad. It's so simple and easy that it is readily applied to testing situations that require a more rigorous performance from the test instrument. This article will examine the parameters that determine the separation between the types of instrumentation.

Voltage is not a critical consideration in testing low resistance. Both DMMs and low resistance ohmmeters operate with only a few volts. The critical determinants between the two types of tester are level of current and range and resolution of reading. The average DMM supplies about 5 mA of test current. A particularly good one may go to 200 mA. The most common test current for low resistance ohm-

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meters is 10 A. That's Amps, not milli-Amps. Similarly, a DMM will read down to a tenth, or possibly a hundredth, of an ohm. For a low resistance ohmmeter, this is edging toward the high end! The instrument isn't worth its salt if it can't read a micro-ohm (0.000001Ω), and a quality tester will measure ten times lower.

So what? The purpose of an electrical continuity test is to establish just that; the circuit is continuous. It is used by electricians to be certain that no wires have been crossed at a junction box and all connections are correct and tight. Hundreds of similar applications assure that electrical continuity has been established or maintained. Similarly, diodes and other components are readily tested. Often, an actual measurement isn't even needed; the IUT passes by a preset buzzer. The small, handheld electrician's DMM will never be superseded for operations such as these.

The low resistance ohmmeter comes into its own for measurements below 1Ω . At this level, mere continuity isn't enough but it must be assured that the circuit or joint can do its job without burning open or causing excessive heat. Such applications include grounding for lightning protection, fault clearance, mating of contact surfaces for maximum transfer of energy without heating, and maintenance of bolted connections and solder joints. For such demanding applications, a change in only a few microns of resistance can indicate an installation error or a developing problem that can be corrected before any damage.

Let's look at some sample readings.

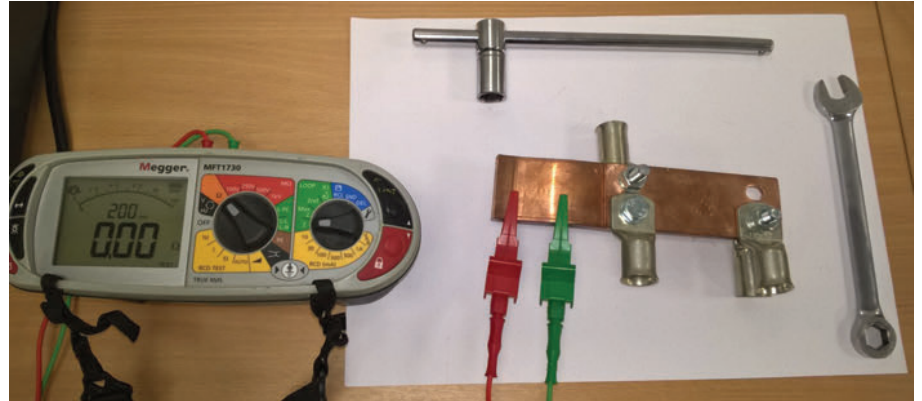
Even a good quality DMM connected across a short piece of copper would show only 0.00Ω at 200 mA.

Spread the leads wider on a bus bar with a bolted connection between and the reading may still be 0.00.

Connecting from a bus to a bolted termi-

nation might still show the same.

But a low resistance ohmmeter, even at just 1A, on the same sample shows $4 \mu\Omega$ across the short span of copper, increased to 10 across the longer span, and at 18 from the bolted termination. Furthermore, this goes to $1.131 \text{ m}\Omega$ when Continued on page 12





a skewed connection, caused by improper tightening of the bolt, is included. These examples illustrate that while basic continuity testing has a vital place in the electrical maintenance spectrum, there are many instances where a developing problem would show up only as a falsely reassuring “0” on a multimeter whereas a rigorous low resistance test would boldly expose it.

How does the low resistance ohmmeter accomplish such precise measurement? The critical role is filled by the application of a “Kelvin bridge” 4-wire technique. Where a DMM uses only two leads to connect across the IUT, this introduces both the resistance of the leads themselves plus the contact resistance with the surface of the IUT into the measurement. For a continuity measurement, these are minuscule amounts and can be disregarded. But they loom large when introduced into a measurement on the micro-ohm level. Quality DMMs often have a null function that further refines the measurement by neutralizing the lead resistance. But that still leaves the potential for considerable contact resistance. A Kelvin bridge eliminates all of this extraneous resistance. The instrument measures how much current it can inject into the circuit, thereby nulling out lead and contact resistance, and measures the voltage drop between the two points of contact. Hence, the measurement is of the resistance between the two potential leads and nothing else. By such precise measurement, the smallest of resistance problems can be recognized.

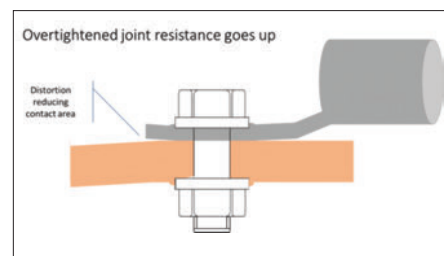
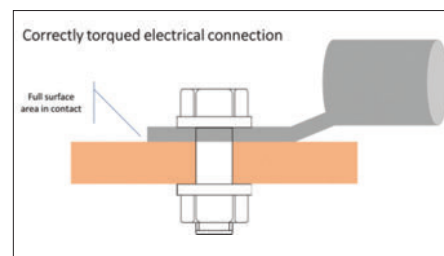
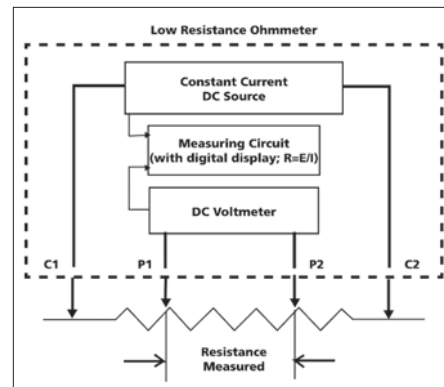
A practical application can be illustrated in the torquing of bolts. Common practice is the tighter, the better. But this is not so



where electrical current is involved. Overtightening can cause the connection to become skewed, with less surface contact and higher resistance.

The amounts can be small, but the added heat generated over time is a stress point that will eventually fail. A low resistance ohmmeter will reveal these as standing out from similar connections and facilitate preventive maintenance.

A final consideration is a nod in the di-



A fully developed low resistance ohmmeter includes the ability to store and document a full regime of preventive maintenance tests.

rection of modern technology...and litigation. To a large part, DMM applications are go/no go and move on. All the wiring can be quickly confirmed at a panel as having no open or crossed connections. But for conformance to regulations and insurance requirements, nothing beats a documented maintenance program. A fully developed low resistance ohmmeter includes the ability to store and document a full regime of preventive maintenance tests. □