RESISTANCE MEASUREMENT BASICS

Bob Thiel

INTRODUCTION

Digital Multimeters, such as the Pickering Interfaces 41-200 family, allow the measurement of resistance in a variety of ways. The measurement method chosen can affect the measurement accuracy. This application note explains how the three different modes of measurement operate and their limitations.

TWO WIRE MEASUREMENTS

Most resistance measurements can be made using the simple 2-wire Ohms method.

To perform a measurement with the 41-200 simply connect V+ to one end of the resistor and V - to the other end and set the DMM to measure resistance. The DMM supplies a constant current source to the resistor and the meter measures the voltage across it, the voltage being proportional to the resistance.

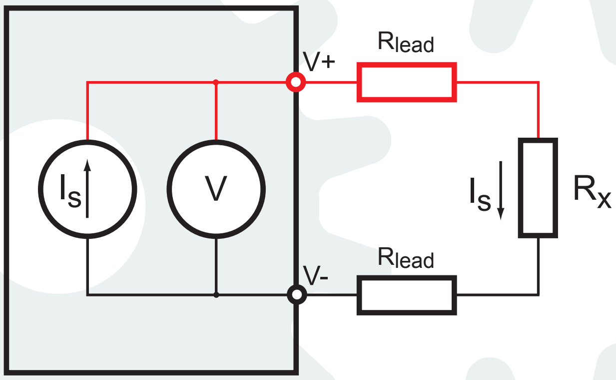

Figure 1 - Equivalent Circuit 2-Wire Ohms Measurement

As shown by the equivalent circuit diagram in Figure 1 the lead resistance can introduce a significant error since the measured voltage is across both the load and resistance of the leads. The error is most significant on low resistance measurements and usually needs to be considered only for resistances below 30 kohms.

The impact of the lead resistance on the measurement can be corrected by using the Relative function on the DMM. To make the correction you should null out any lead resistance errors by first by connecting the V, + and V, - test leads together and then performing a Relative function. The reading will be changed from that of the test leads to 0 ohms. Any resistor now placed between the ends of the test leads will now be measured relative to that the new test reference plane at the end of the two leads.

If the user is making measurements above 300 k ohms shielded or twisted leads may have to be used to avoid unstable readings due to signal pick up on the leads. The problem of noise pick up becomes worse as the resistance to be measured is increased.

FOUR WIRE MEASUREMENTS

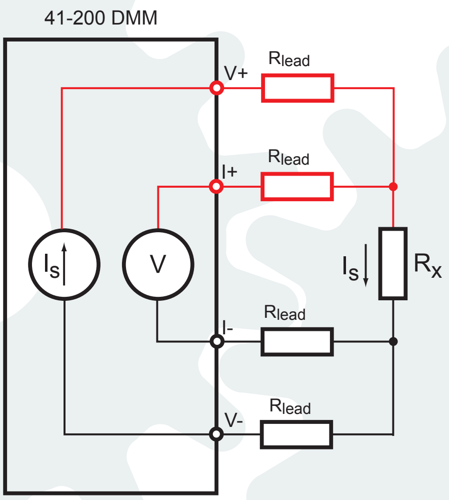

Figure 2 - Equivalent Circuit 4-Wire Ohms Measurement

Four Wire resistance measurements are ideal for making measurements of lower value resistance since the DMM is able to remove the effects of the leads without resorting to the use of the Relative Function. The correction is entirely automatic.

In Four Wire measurements the V+ and V- terminals still supply the current to the resistor via the test leads. The voltage drop across V+ and V- is determined by the sum of the lead resistance and the resistor being tested.

The sense lines are connected to the terminals of the resistors and measure the voltage across the resistor, it does not include the voltage across the test leads and the input impedance is sufficiently high that is does not divert any current. The reading is therefore dependent on just the resistor and is virtually independent of the test lead resistance.

Four wire measurements produce very accurate, repeatable and stable measurement of resistance and are particularly suited to the measurement of low values. The 41-200-044 four wire measurements permit measurements on resistors as low as 10 milliohms. It is less suited to the measurement of high value resistance since the input impedance and leakage current to the voltmeter may effect the reading. In general four wire measurements are not recommended above 330 Kohms despite the fact that the 41-200 series has very high input impedance and low input current.

SIX WIRE MEASUREMENTS

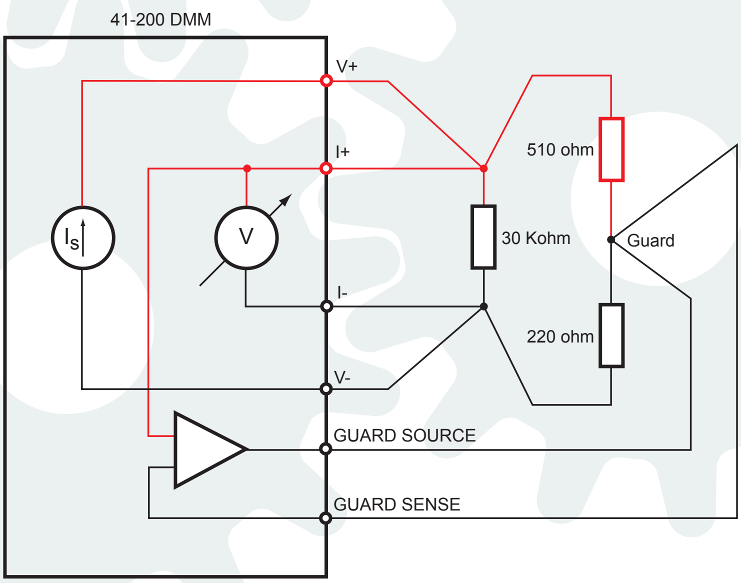

Figure 2 - Equivalent Circuit 6-Wire Ohms Measurement

The 41-200-044 also provides a guarded 6-wire resistance measurement method.

Six wire measurements are used where the resistor to be measured is shunted by other resistors, a common problem in ATE systems where the resistor is to be measured in situ on a PCB.

The technique isolates the resistor under test by maintaining a guard voltage at a user-defined node, the guard voltage being driven by a voltage buffer from the V+ terminal. The guard voltage ensures the constant current source from the DMM does not have current diverted into the alternate path

The following is an example of how it works:

Assume a 30 kohm resistor is in parallel with two series resistors (510 ohms and 220 ohms (as in Figure 3). In a normal resistance measurement, the 510 ohms and 220 ohms would shunt most of the DMM Ohms source current, causing a very inaccurate reading. By sensing the voltage at the top of the 30 kohm resistor, and then applying this same voltage to the junction of the 510 ohms and 220 ohms, there is no current flow through the shunt path. The guard has forced the junction to be the same as the voltage at V+ and current required through the 220 ohm resistor is supplied by the Guard Source. The 41-200-044 accurately measures the 30 kohm resistor since the current I_s flows through the 30 kohm resistor.

The current capability of the Guard Force terminal is limited to a maximum of 20 mA and is short circuit protected, so there are limitations on the amount of driving that can be achieved,

The resistor connected between the low of the 4-wire terminals and the guard point is the burden resistor, or R_b. Due to the limited guard source current, this resistor can not be lower than Rbmin where:

R_{bmin} = Io * R_x / 0.02,

where Io is the ohms source current for the selected range

R_x is the resistance being measured.

For example, selecting the 330 ohm range and measuring a 300 ohm resistor imposes a limit on R_b of at least 15 ohm or greater.

Since the top burden resistor, R_a, does not have this limit imposed on it, choosing the measurement polarity can help since R_a can become R_b and vice versa. It is best to set the measurement polarity such that Ra is the higher of the two burden resistors.

The 6 wire method is specified for measurement of resistors to 330 kohms, for resistors above this range the 6 wire configuration can be maintained but the DMM should be set to two wire measurement mode (with its lower source current).

SUMMARY

Two wire ohms measurement are commonly used when the resistance of the test leads is much less than the resistance being measured. The results are generally good enough for most functional test measurements. To eliminate errors associated with test lead resistance in two wire ohms measurements a “Relative” operation is available or alternatively the test system can provide the function.

Four wire measurements substantially eliminate the test lead resistance from the system, and are very useful when measuring lower value resistors. The four wire system is particularly useful when the lead resistor varies because, for example, the DMM is switched through a multiplexer or matrix that does not have the same lead resistance for each path. The 4 wire method should be avoided for measuring high resistor values.

Six wire measurements can allow resistors to be measured in situ where they may be shunted by other components. It requires the switching system that connects the DMM to the device under test to provide 6 connections, so can add complexity to the switching system.

Contact Information

Pickering Interfaces Inc.
2900 Northwest Vine Street
Grants Pass
Oregon 97526
USA

Tel: 541 471 0700
Fax: 541 471 8828
E-Mail: ussales@pickeringtest.com

Pickering Interfaces Ltd.
Stephenson Road
Clacton-on-Sea
CO15 4NL
United Kingdom

Tel: +44 (0)1255-428141
Fax: +44 (0)1255-425349
E-Mail: sales@pickeringtest.com

Pickering Interfaces AB
Karl Nordströmsväg 31
432 53
Varberg
Sweden

Tel: +46 340-69 06 69
Fax: +46 340-69 06 68
E-Mail: ndsales@pickeringtest.com

Pickering Interfaces GmbH
Buchenstrasse 15
D-77880
Sasbach
Germany

Tel: +49 7841 66 49 10
Fax: +49 7841 66 49 12
E-Mail: desales@pickeringtest.com