LOW RESISTANCE MEASUREMENT

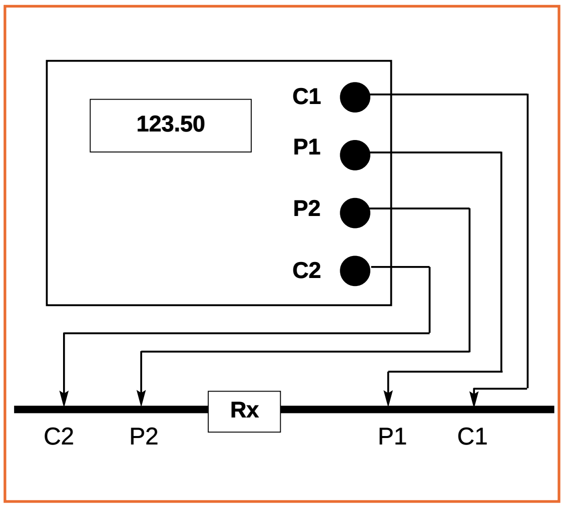
INTRODUCTION

CROPICO specialise in low resistance measurement and offer a variety of ohmmeters to cover the various applications and customer circumstances. Typical applications are listed on the next page which we hope will give you a guide to the suitability and versatility of our ohmmeters.

Some applications and testing standards require special leads jigs for connecting to the sample under test. We offer a wide range of connecting leads, and have a number of standard jigs available, and will always be happy to supply special jigs if required, all we need is the drawing, description of the application, or a sample of the item to be measured.

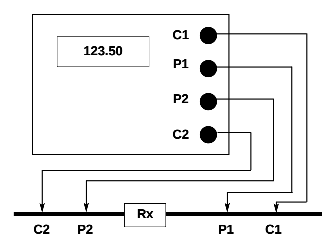
These application notes are intended to explain good measurement practice and highlight some of the more common sources of error.

FOUR TERMINAL MEASUREMENT

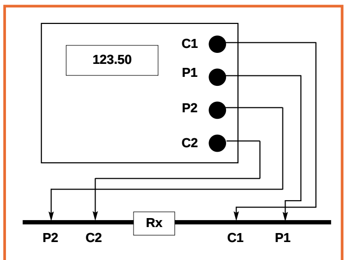


When measuring resistance below 100 ohms it is advisable to use a four wire measurement technique (fig. 1), this is often referred to as a Kelvin or Thomson configuration. By using this type of measurement configuration the connecting lead resistance is not included in the measurement, and the need for lead balancing and nulling is eliminated.

The measuring current is passed through the unknown resistance Rx using the C1 and C2 leads. The placing of these leads is not critical but should always be outside the P1 and P2 leads. The Volt drop across the Rx is measured across P1 and P2 and these should be placed at exactly the points to be measured. The measuring current is simultaneously passed through an internal reference standard in the ohmmeter and the volt drop across Rx is compared with the volt drop across this internal standard. From the ratio of these two volt drops the resistance value of Rx is calculated and displayed. Because the same current is passed through both the standard and the Rx and the ratio is calculated, the current does not need to be a precise value, all that is required is that the current is stable for the period during which each measurement is made typically 0.5 seconds.



Correct



Wrong

Most common cause of errors when making low resistance measurement are due to poor or inappropriate connection of the Rx. Connections should be clean, mechanically firm and free from oxides which can cause an insulating effect.

MEASURING CURRENT

It is a misconception by a lot of customers that they must have a high measuring current, the higher the better they believe. This was true of the older digital instruments and their predecessor, the Kelvin Bridge. High currents were needed to realise sufficient volts across the Rx for measurement. For example Rx = 0.001Ω

Measuring Current	Volt Drop	Voltage Measurement required for resolution of 1µΩ
1 Amp	1mV	1µv
10 Amp	10mV	10µv
100 Amp	100mV	100µv

With today's measuring components and techniques we are able to reliably and consistently measure these low voltages and prove reliable and accurate measurements at the low currents. The disadvantages of using high current are added cost, added weight to instrument, increased size of instrument, less measuring time when batteries are used. Test current heats up the Rx and changes its value, and possible introduction of thermal emf's which will effect the reading accuracy.

There are however, some applications where Test Specifications demand higher measuring currents and there is an argument that says a higher test current also tests the mechanical integrity of joints i.e. if only a strand of wire is making the connection a high test current would burn away this strand, but we believe there are better and more reliable ways of testing a joints mechanical integrity.

CROPICO - Measurement & innovation at its best

POSSIBLE MEASUREMENT ERRORS

POOR CONNECTION:

Most causes of measurement error can be traced back to poor or inconsistent connection to the object under test. In many cases it is desirable if not essential to make a jig to suit the particular component, this ensures that the P1 P2 connections are always made at the same point on the sample. We offer a variety of jigs and test leads which are listed at the end of the ohmmeter's section.

THERMAL EMF:

Another source of error can be thermal emf. When two dissimilar metals are joined together an emf can be generated (thermocouple effect). Most ohmmeters use a dc measuring system to ensure true resistance and not impedance, is measured. If the Rx is also generating an emf it is obvious that this will add or subtract to the emf measured at the P1 P2 connections. This is overcome by making two measurements and reversing the current C1 C2 connections on the second measurement. The two readings are averaged to give the correct answer.

RX = (R1+R2)/2

Most of the CROPICO ohmmeters have the ability to select forward or reverse measurement current and to automatically average the two readings thus displaying the correct value.

Simple precautions should also be taken when making connections. The material used should be carefully selected, for example Nickel Plated Brass connecting clips can cause very large thermal emfs to be generated when connected to copper wires. For best results unplated copper or brass leads and fittings should be used.

APPLICATIONS

There are many reasons why resistance of material are measured, and here are a few.

Manufacturers of components such as resistors, inductors and chokes all have to verify that their product meets the specified resistance tolerance, end of production line and quality control testing.

Manufacturers of switches, relays, connectors all need to verify that the contact resistance is below pre specified limits, end of production line testing and quality control.

Cable manufacturers must measure the resistance of the copper wires they produce, resistance to high means that the current carrying capability of the cable is reduced, resistance to low means that the manufacturer is being too generous on the cable diameter using more copper than he needs to, this can be very expensive.

Installation and maintenance of power cables, switchgear and Voltage tap changers require the cable joints and switch contacts to be of the lowest possible resistance thus avoiding the joint or contact from becoming excessively hot, a poor cable joint or switch contact will soon fail due to this heating effect. Routine preventative maintenance with regular resistance checks ensures the best possible life performances.

Electric Motor and Generator manufacturers need to determine the maximum temperature reached under full load. To determine this temperature, the temperature coefficient of the copper winding is used. The resistance is first measured with the motor/generator cold i.e. at ambient temperature, the unit is then run at full load for a specified period and then the resistance measured again from the change in resistance value, the internal motor/generator temperature can be determined. Our ohmmeters are also used to measure the individual coils of a motor winding to ensure there are no short or open circuit turns and that each coil is balanced.

Automotive Industry needs to measure the resistance of Robot Welding Cables to ensure that the weld quality does not deteriorate. Battery lead crimp connectors, Air bag detonator resistance, resistance of wiring harness. Quality of crimp connectors on components.

Fuse manufacturers for quality control.

Resistance bonding measurements on Aircraft and military vehicles. It is necessary to ensure that all equipment installed in aircraft is electrically connected to the air Frame, this includes galley equipment. Tanks and other military vehicles have the same requirements. Producers and users of large electrical currents all need to measure distribution joint resistance, bus bars, connectors to electrodes for electroplating.

Railway utilities including trams and underground railways (Metro) For the measurement of power distribution cable joints. The resistance of rail track joints, the rails are often used for signalling information.