VICTORIA UNIVERSITY OF WELLINGTON TE HERENGA WAKA NEW ZEALAND

XMUT204 Electronic Design

Laboratory 1: Instrumentation – Basic Instrumentation and Measurement

1. The Electronics Work Station and Equipment

In XMUT204 course and other related courses in VUW-XMUT programme, your workstation in the lab will contain the following instruments:

a. A GW Instek GOS-6021 analogue oscilloscope

b. A Rigol DG1022 waveform generator

c. A GW Instek GPD-3303 dual power supply

d. A Victor vc9801A+ digital multimeter

e. A As2294D AC dual channel millivolt meter

All these instruments require a basic knowledge of their operation if we want to effectively use them in our laboratories and we gradually get familiar with the operation of each. In this lab, we will concentrate on the use of the DC power supply and multimeter in measuring DC voltage and current as well as resistance measurements.

2. Digital Multimeters

A **Digital Multimeter (DMM)** can be used to measure voltage, current and resistance and in the case of higher end meters may also be able to measure frequency or perform other measurement. It is based around an analogue to digital converter that converts the analogue input voltage a digital signal which is then displayed. It is also contains a range of internal resistances that enables it to be connected as either a voltmeter or as an ammeter. It uses an internal current source to enable the measurement of resistance. We may have to move the move the leads to different connection points depending on whether we are measuring current, voltage or resistance and we should also ensure that we have the correct AC vs DC setting for our measurement.

Ideal measuring instruments should not affect the parameter being measured. This means that voltmeters and ammeters connected into a circuit should not change the voltages and currents within the circuit (i.e. they should not *load* the circuit). This is achieved by ensuring that:

a. voltmeters have internal resistances that are much higher than the circuit values they are connected across; and

b. ammeters have small internal resistances relative to the circuit components.

c. In the case of measuring resistance, the DMM uses an internal constant current source to drive a known current through the test resistor, then measures the voltage drop over the current source and use a calculation of Ohms Law to calculate the resistance.

It is a good idea to spend some time handling each of these instruments and have a look at their user manuals so that you become familiar with their operation.

3. DC Power Supply

Each work station is supplied with a dual channel power supply, consisting of two variable (0 -20 V) supplies that have individual controls for varying the voltages and setting upper current limits. The supplies may be used independently or as a combined bipolar supply (+, earth or ground, -).
Note that power for this unit is derived from the ac mains so there will always be some ac 'rip ple' or noise present (if you look hard enough). In many applications this noise is minimised by ensuring that one terminal of the supply is earthed but care should be taken when making measurements with earthed instruments (e.g. the oscilloscope).

4. Breadboard for Prototyping

We will be using breadboards such as the one in the photo below for prototyping our circuit. This allows us to quickly construct a circuit without any soldering. We can then experiment with the circuit the circuit on breadboard and before we solder it on stripboard or fabricate a printed circuit board (PCB).

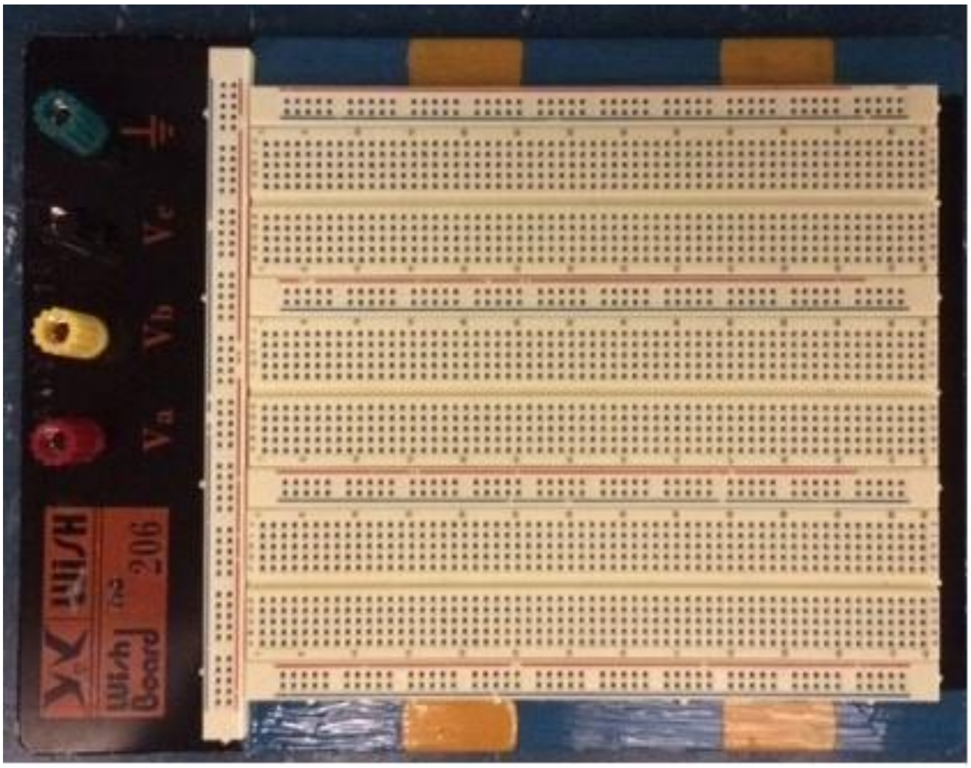

Figure 1: Breadboard for prototyping

5. Resistors and other Components

The components that are needed for each lab will normally be available in a small bin at the work station. In addition, have containers of additional components at the back and side of the class.

Resistors are colour coded with bands to indicate both the resistor value as well as the precision of the value that can be expected.

Resistors are (in theory!) purely dissipative electrical element (cannot store any electrical energy) that provides a specific resistance to the flow of electrical current. Resistors come in all shapes and sizes, but the following points should be kept in mind when using them:

- The value of the resistor is normally provided by a four or five band colour scheme on the body of the resistor. Shown below is a resistor with a four band colour scheme, where the first two bands indicate the first two digits in the resistance value and the third band indicate the multiplier. See in the sketch below how the colour of the band indicate the numeric value.

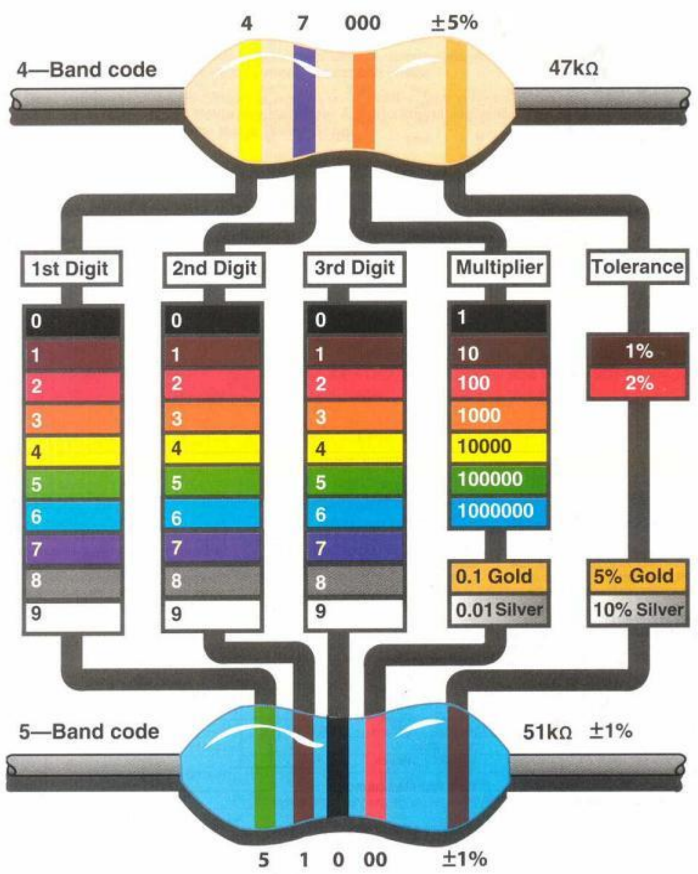

Figure 2: Resistor values as based on colour codes

- Every decade of resistor values (0.1 to 1 Ω, 1 to 10 Ω, 10 to 100 Ω……) should contain 12 resistor values. For example the decade from 1 kΩ to 10 kΩ should contain the following resistor values: 1) 1.0 kΩ 2) 1.2 kΩ 3) 1.5 kΩ 4) 1.8 kΩ 5) 2.2 kΩ 6) 2.7 kΩ 7) 3.3 kΩ 8) 3.9 kΩ 9) 4.7 kΩ 10) 5.6 kΩ 11) 6.8 kΩ 12 8.2 kΩ follows by 10 kΩ which will be the first resistor in the next decade.
- The last band (4^{th} or 5^{th}) will indicate the tolerance in the resistor value that can be expected. A silver band will then indicate that the real value of the resistor should be within ±10% of the marked value.
- Every resistor (as is true for every electronic component!) will also have a maximum power rating, indicating the maximum power that is should be able to dissipate before starting to overheat. The size of a resistor is a good indication of the amount of power it can dissipate, with larger resistors being able to handle larger powers. The lab

resistors we use are normally ¼ W resistors, meaning we should stay below 0.25 W unless we want to run into problems.

6. Resistance Measurement with a DMM

The figure below illustrates how a DMM operates when it makes a resistance measurement. An internal current source applies a constant current to the resistor under test, and the voltage drop is measured internally, with the resistance calculated from these current and voltage readings.

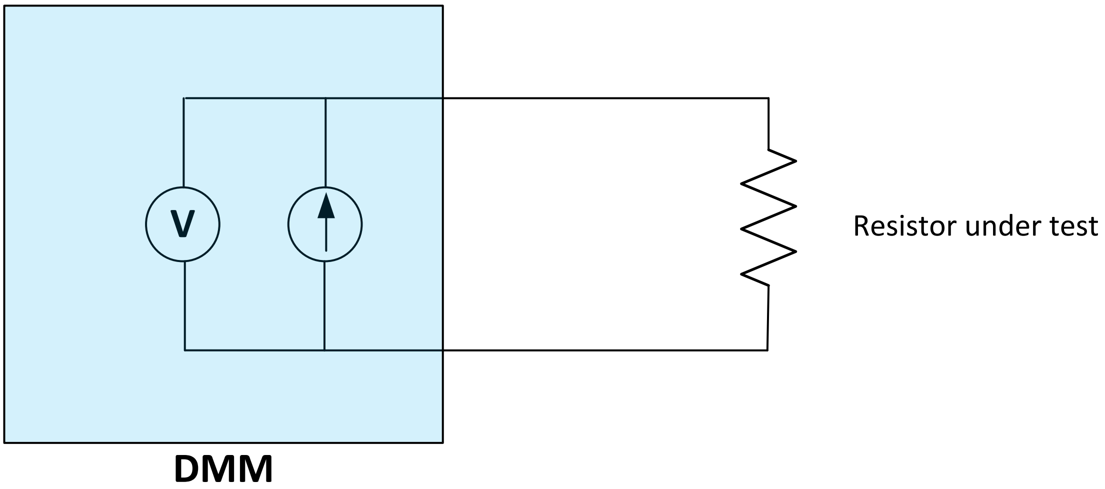

Figure 3: A normal two-wire resistance measurement

However, this picture is a simplification, because we will always have at least two other potential sources of resistance present in the circuit:

- The leads of the ohmmeter will have a small but non-negligible resistance, typically in the order of ~ 1Ω depending on the quality of the leads.
- The contact between the probes and the resistor leads will lead to a contact resistance.

The more accurate model of this measurement will thus look as below:

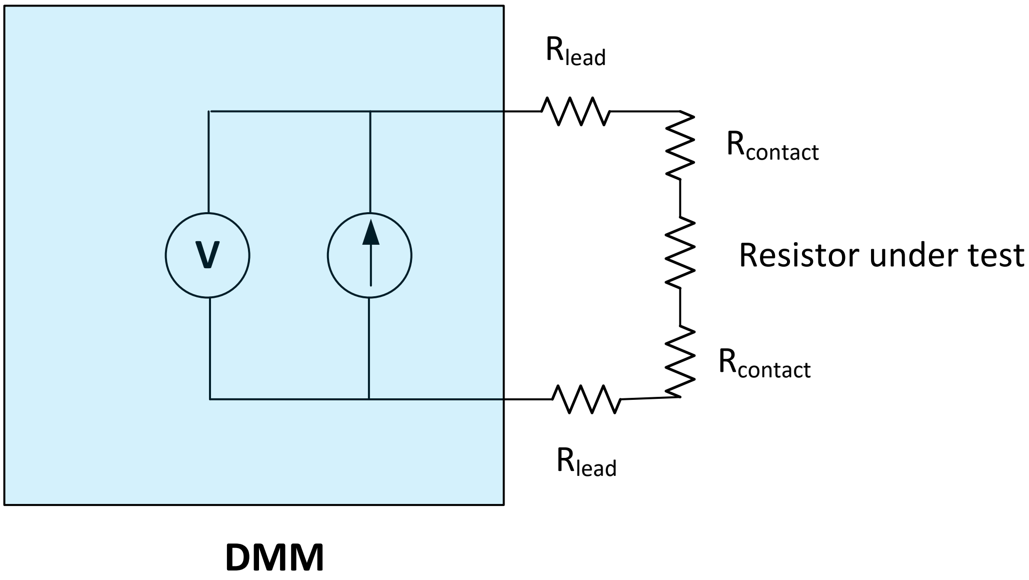

Figure 4: More accurate model of resistances during a two-wire resistance measurement

These additional resistances are not of great influence if the resistor under test is significantly greater than the parasitic resistances, but in the case where we need to measure a small resistance (< 1 Ω), the value obtained will be strongly influenced by the parasitic contributions.

To solve this problem, most high-end (benchtop) multimeter will have the capability to perform a so-called four-wire resistance measurement. This allows a second set of leads and probes to be used, separating the current leads from the voltage measurement leads as shown in

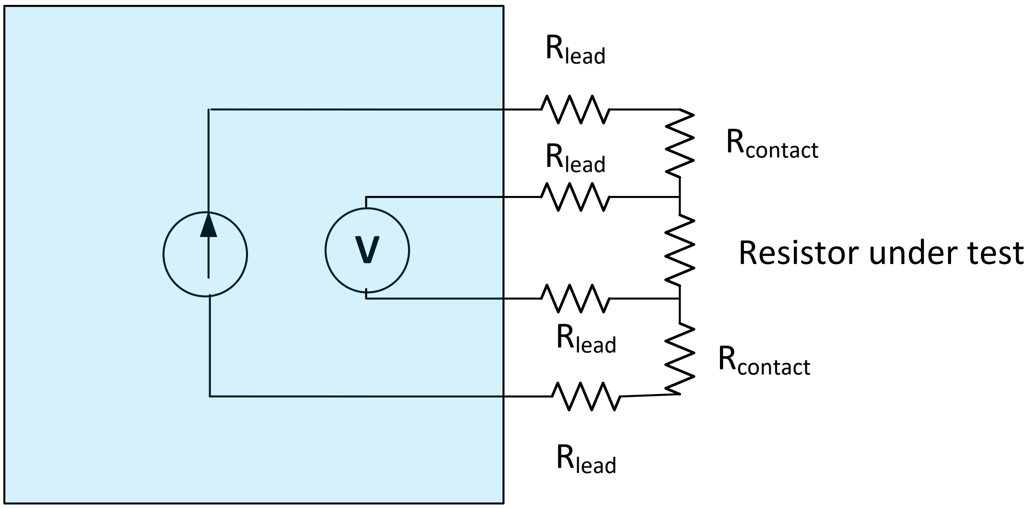

Figure 5: A four-wire resistance measurement

At first glance, it looks like we have simply introduced more leads with more lead resistances into the measurement. However, keep in mind that the voltmeter has a very high resistance so that very little (~no!) current will flow in these voltmeter leads and the only voltage drop that will be measured will be across the resistor under test.

Using this method, we can make very accurate resistance measurements, particularly at low resistance. Unfortunately our hand held DMMs are not equipped with this function and a high-end benchtop DMM with this function will be illustrated in the lab.

7. Other Equipment

The other equipment (oscilloscope, waveform generator) will be described in more detail in a following laboratory.