

## EE283 Lab 2 Digital Multimeter (DMM) And Volt Ohmmeter (VOM) Input Impedances

### Maximum Power Transfer

Objective: The object of this exercise is to

- Determine the effect of the input impedance of a DMM and VOM on voltage measurements.
- Determine the value of load resistor that results in the maximum power dissipation in that resistor.

Equipment Operation:

- Digital Multimeter (DMM)
- Volt Ohmmeter (VOM)
- Resistor Decade Box
- Resistor Color Codes (see attachment A)
- Power Supply (see attachment B)
- Breadboard (see attachment C)

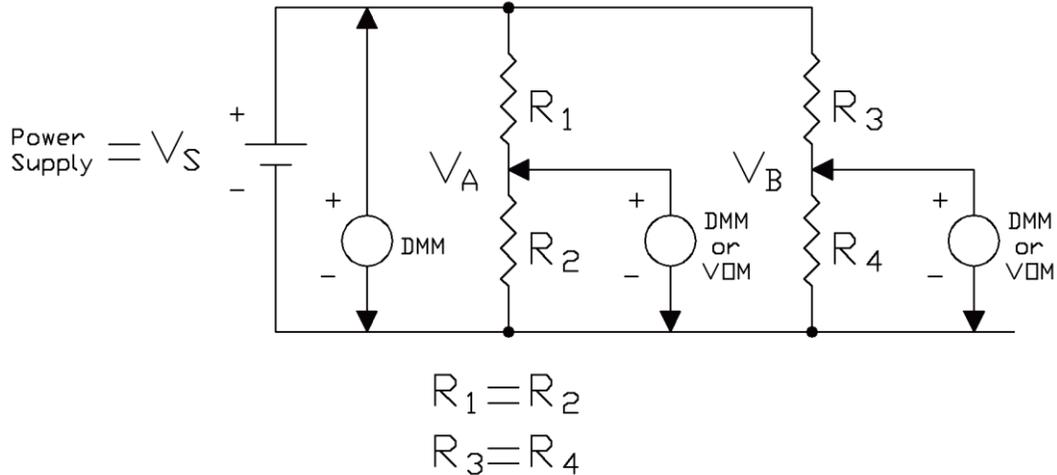
Procedure:

- Determine the effect of the input impedance of a DMM and VOM on voltage measurements. The input impedance,  $R_M$ , is the impedance of the meter connected across the meter leads.
1. Pick four resistors from those supplied. Two of the resistors must be the same value and be greater than 1Meg. The other two resistors must be the same value and be less than 1K. Determine each resistor value using the color code shown in appendix A. Assign each resistor a reference designation ( $R_1$  and  $R_2$  for the high value resistors and  $R_3$  and  $R_4$  for the low value resistors) and write the resistance and tolerance values in the table below. The nominal resistance value and tolerance is determined from the resistor color code and the actual resistance is determined by the DMM.

Reference Designation	Nominal Resistance value – Ohms	Actual Resistance Value – Ohms	Resistor Tolerance %
$R_1$			
$R_2$			
$R_3$			
$R_4$			

Record these values in your report.

2. Set up the power supply and resistors (installed on the breadboard) as shown below. Make  $R_1$  and  $R_2$  the high value resistors and  $R_3$  and  $R_4$  the low value resistors.



3. Set the power supply voltage to  $V_S = 10V_{DC}$ . Set DMM to measure DC voltage and measure  $V_S$  and record it in the table below. Using the measured value for  $V_S$  and the actual resistor values calculate the ideal voltage at  $V_A$  and  $V_B$ . Record these values in the table. Measure the voltages  $V_A$  and  $V_B$  with both the DMM and VOM. Record these voltages in the table.

$V_S$ DMM	$V_A$ Ideal	$V_A$ DMM	$V_A$ VOM	$V_B$ Ideal	$V_B$ DMM	$V_B$ VOM
$V_{DC}$	$V_{DC}$	$V_{DC}$	$V_{DC}$	$V_{DC}$	$V_{DC}$	$V_{DC}$

4. Using the  $V_S$  DMM value, the actual values for  $R_1$  and  $R_2$  and the  $V_A$  DMM value calculate the DMM internal meter resistance  $R_M$  according to the equation

$$R_M = \frac{R_1 R_2}{R_2 \left( \frac{V_S}{V_{A \text{ DMM}}} - 1 \right) - R_1}$$

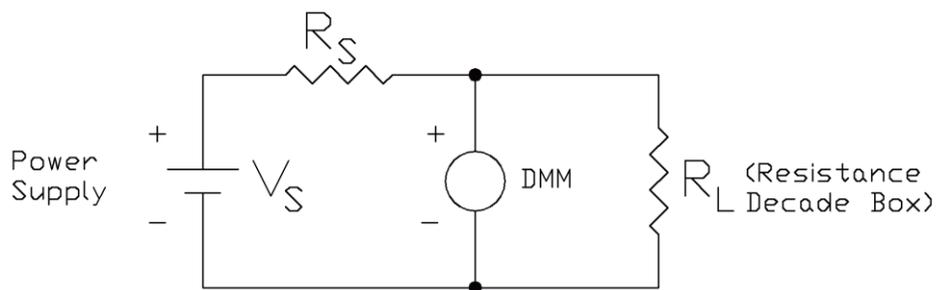
Repeat this procedure using  $V_A$  VOM to calculate the VOM internal meter resistance. Record these values in the table below. Show all of your calculations in the report.

Repeat the above procedure using  $R_3$  and  $R_4$  and the voltages  $V_B$  DMM and  $V_B$  VOM to again calculate the internal meter resistance of the DMM and VOM. Record these values in the table below. Show all of your calculations in the report.

$R_{M \text{ DMM}}$	$R_{M \text{ VOM}}$	$R_{M \text{ DMM}}$	$R_{M \text{ VOM}}$
At $V_A$	At $V_A$	At $V_B$	At $V_B$

Extra Credit: Derive the equation used to calculate the meter resistance,  $R_M$ .

5. Conclusion: Describe why the voltages measured at  $V_A$  are so different when measured with the two meters compared to the voltages measured at  $V_B$  using these same two meters.
- Determine the value of load resistor that results in the maximum power dissipation in that resistor. Every voltage or signal source has an output impedance associated with it. This resistance has the reference designation,  $R_S$ , as shown in the following figure. Determine the value of the load resistor,  $R_L$ , that will give the maximum power dissipation in  $R_L$ .
1. Connect the power supply and resistors as shown below. One end of the resistor,  $R_S$ , can be connected directly to the terminal of the power supply. Use the resistor decade box for the resistance,  $R_L$ .



Set the power supply voltage,  $V_S$ , to 10  $V_{DC}$ . Use a 1K resistor for  $R_S$ . Measure this resistance value and record its value and tolerance here.

Reference Designation	Nominal Resistance value – Ohms	Actual Resistance Value – Ohms	Resistor Tolerance %
$R_S$	1K		

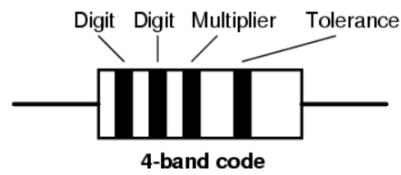
2. Set the decade box to zero ohms (all knobs set at 0) and record the decade box resistance and the DMM voltage. Increase the decade box resistance to 2000 ohms in steps of 100 ohms. For each decade resistance value record this value (as read from the decade resistance box dials) and the DMM reading. Enter your data in an Excel spreadsheet and use Excel to calculate the power dissipation in the decade box according to the equation

$$P_{R_L} = \frac{(V_{DMM})^2}{R_L}$$

Use Excel to make a graph showing the power dissipation in  $R_L$  (Y axis) versus the resistance,  $R_L$  (X axis). Be sure that the graph is properly annotated!! At what value of  $R_L$  is the power dissipation in this resistor a maximum. Record this value and your graph (with data) in your report.

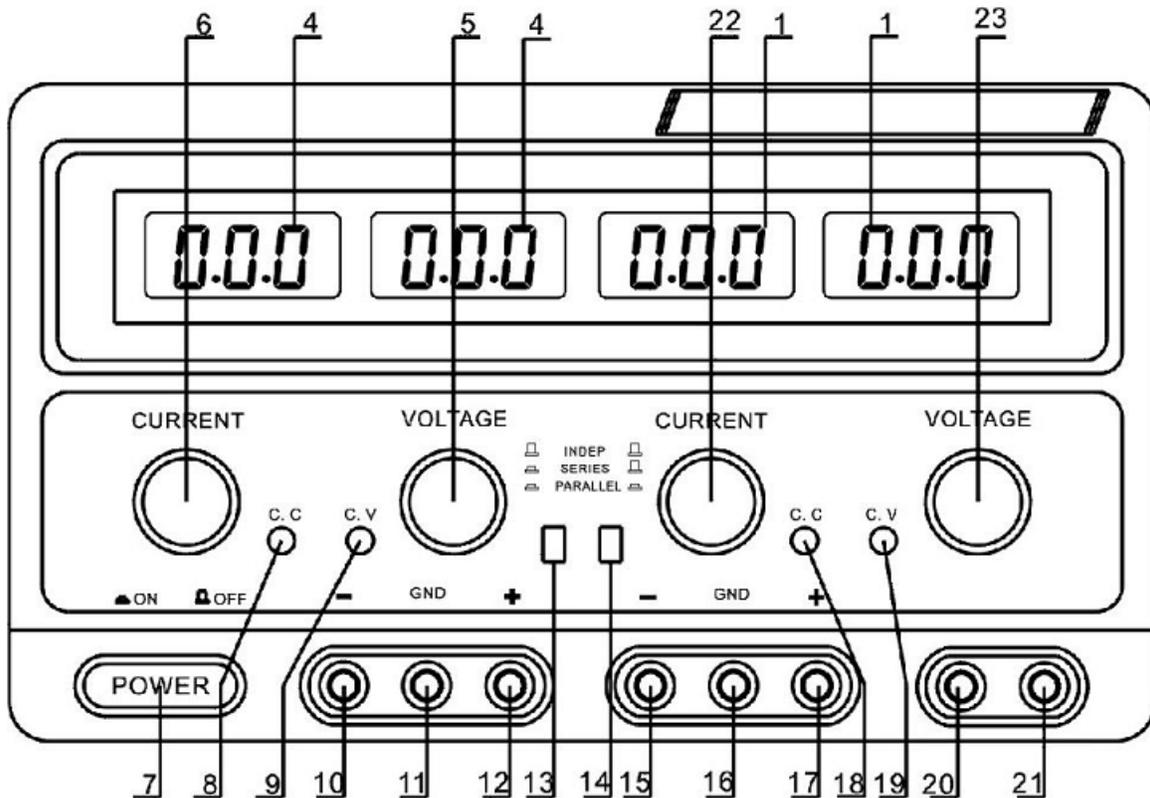
Remember that your report must be legible. If I can't read it you won't get credit for it!

Appendix A



Color	Digit	Multiplier	Tolerance (%)
Black	0	$10^0$ (1)	
Brown	1	$10^1$	1
Red	2	$10^2$	2
Orange	3	$10^3$	
Yellow	4	$10^4$	
Green	5	$10^5$	0.5
Blue	6	$10^6$	0.25
Violet	7	$10^7$	0.1
Grey	8	$10^8$	
White	9	$10^9$	
Gold		$10^{-1}$	5
Silver		$10^{-2}$	10
(none)			20

## Appendix B

**TekPower TP3005D-3 Power Supply**

To turn this power supply on push in the power switch 7. This unit has three independent and isolated power supplies.

The first supply has an adjustable voltage range of 0 to 30 volts and can supply up to 5 amperes of current. The controls and terminals for this supply are located on the left side of the unit. Knob 5 controls the voltage, knob 6 sets the maximum current limit and the output voltage is obtained from terminals 12(+) and 10(-). Terminal 11 is connected to the chassis (we won't use this terminal). The digital readout directly above the current limit knob displays the power supply current and the digital readout directly above the voltage adjustment knob displays the power supply output voltage. If the power supply is in voltage control mode the indicator light 9 will be illuminated. If the power supply is in current limiting mode the indicator light 8 will be illuminated. We will always operate the power supply in voltage control mode.

The second power supply is identical to the first power supply except that all of the controls and terminals are located on the right hand side of the unit.

The third power supply has a fixed voltage of 5 V<sub>DC</sub> which is obtained from terminals 21(+) and 20(-). We will use this voltage for our digital lab exercises.

Appendix C

# Breadboard Connections

These holes are all connected together but they are not connected to anything else.

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Integrated circuit 14 pin dip package is inserted here so the package pins are inserted into the column E and F holes. Connection to the package pins is then made by connecting wires to the A,B,C and D holes or the G, H, I and J holes

