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 Keysight 34461A see appendix C)
- Volt Ohmmeter (VOM)
- Resistor Decade Box
- Resistor Color Codes (see appendix A)
- Power Supply (see appendix B)
- Breadboard (see appendix D)

Procedure:

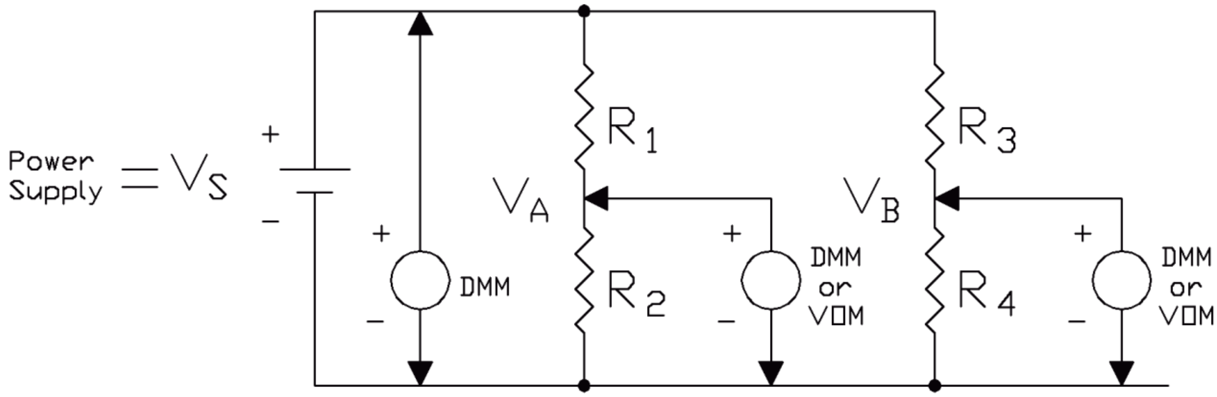
- Determine the effect of the input impedance of a DMM and VOM on voltage measurements. The input impedance, R_M, is the impedance of the meter connected across the meter leads.

1. Using the color chart in appendix A determine which resistor corresponds to the reference designation shown in the table below. Determine the resistor tolerance from the color code and record it in the table below. Measure the actual resistance using the DMM and record it in the table below. Be sure to keep your fingers off the resistor when making the resistance measurement.

Reference Designation	Nominal Resistance value – Ohms	Actual Resistance Value – Ohms	Resistor Tolerance %
R_1	1.0 Meg		
R_2	300K		
R_3	1.0K		
R_4	300 Ohms		

Record these values in your report.

2. Set up the power supply and resistors (installed on the breadboard shown in appendix D) as shown below.



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. This table must appear in your report.

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

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

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.

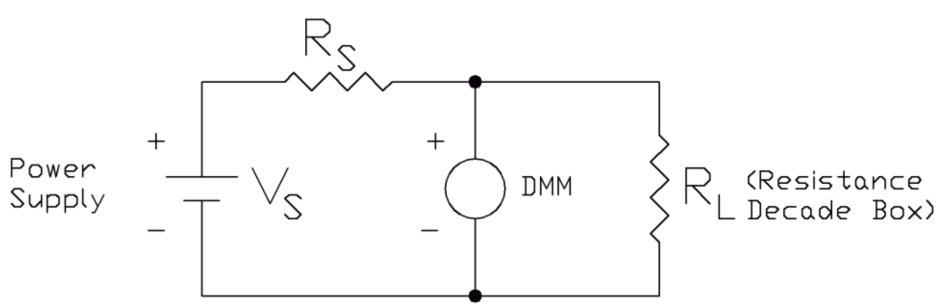
$R_{M\ DMM}$ At V_A	$R_{M\ VOM}$ At V_A	$R_{M\ DMM}$ At V_B	$R_{M\ VOM}$ At V_B

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		

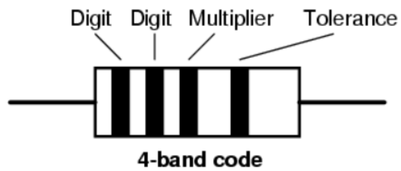
2. Set the decade box to zero ohms (all knobs set at 0) and record the decade box resistance and the DMM voltage. Increase the decade box resistance to 2000 ohms in steps of 100 ohms. For each decade resistance value record this value (as read from the decade resistance box dials) and the DMM reading. 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!

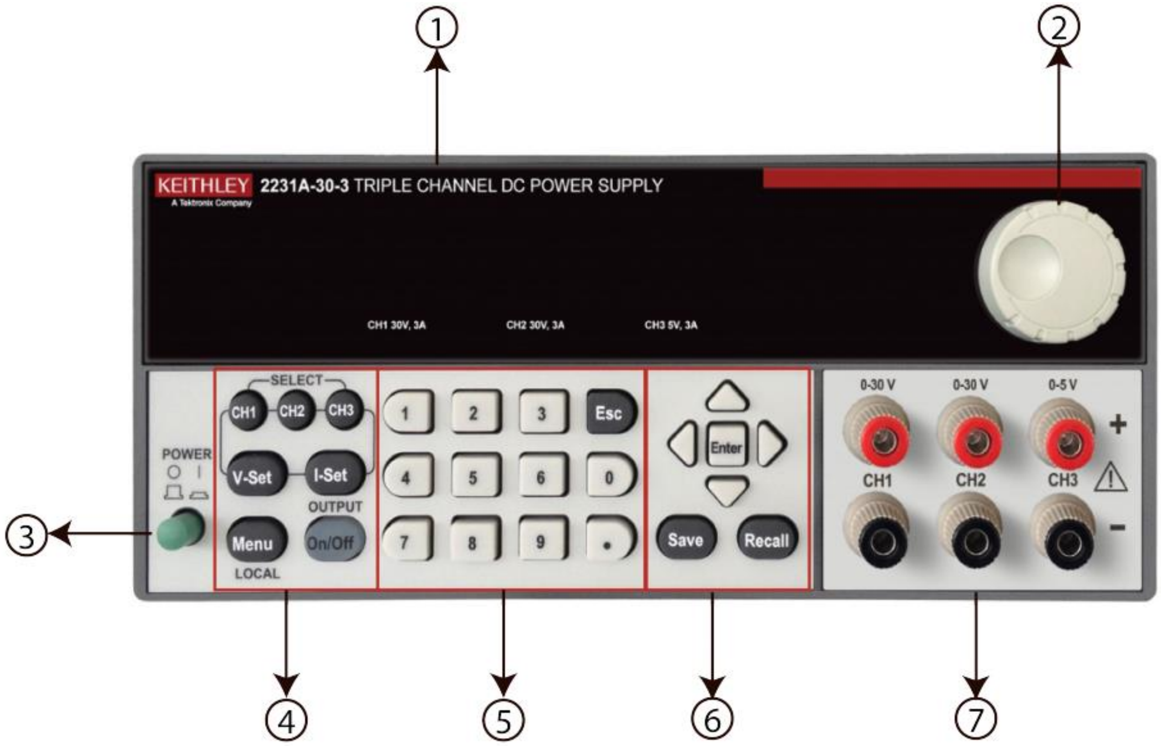
Appendix A



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

Keithley 2231A-30-3 Power Supply



Item	Description
1	Vacuum fluorescent display (VFD)
2	Rotary knob
3	POWER button
4	Function buttons: Channel select buttons, V-Set (voltage setting), I-Set (current setting), Menu and Output On/OFF
5	Numeric buttons and ESC button
6	Up/Down/Left/Right arrow buttons, Enter button and Save/Recall function buttons
7	Output terminals

This unit has three independent and isolated power supplies CH1, CH2 and CH3. The output voltages for each supply are obtained at the terminals in item 7. The red terminal is positive with respect to the black terminal.

The CH1 and CH2 output voltages each has an adjustable voltage range of 0 to 30 volts and can supply up to 3 amperes of current. The CH3 output voltage has an adjustable voltage range of 0 to 5 volts and can supply up to 3 amperes of current. Each power supply channel can operate in either a constant voltage or constant current mode. For all of the lab exercises we will operate the power supplies in constant voltage mode and with the current limit set to $0.5A_{DC}$.

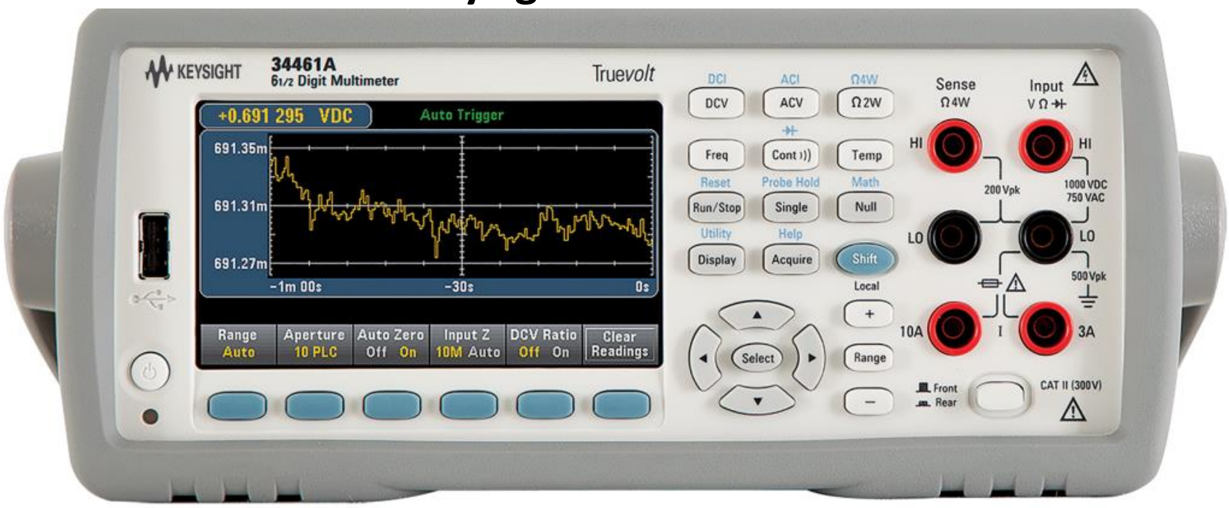
To set the CH1 output voltage:

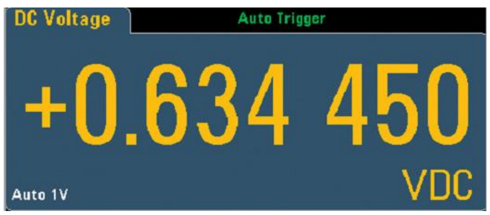
- Turn this power supply on by pushing in the power switch at item 3.
- Set the maximum output current to 0.5 A_{DC} by pushing the CH1 button at item 4. Then push the I-Set button at item 4 and enter 0.5 on the numeric keypad at item 5. Then push the Enter button at item 6.
- Push the CH1 button at item 4 then push the V-Set button at item 4 and enter the desired output voltage on the numeric keypad at item 5. Then push the Enter button at item 6.
- Pushing the Output ON/OFF button at item 4 outputs the desired voltage at the CH1 output terminals at item 7. At this point the CH 1 display shows the desired output voltage and the actual supply current (not the current limit). It should also display CV which means the power supply is operating in the constant voltage mode. If the display reads CC it means the power supply is supplying 0.5A_{DC} which means there is probably a short circuit someplace. Pushing the Output ON/OFF button a second time will turn off the voltage at the output terminals.

The CH2 and CH3 power supplies operate in the same manner as the CH1 power supply.

Appendix C

Keysight 34461A DMM

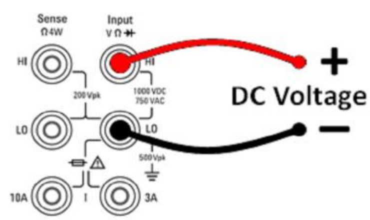




When measuring voltages the screen will look like this.

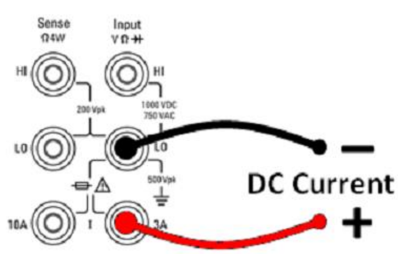
To measure DC voltages:

- Turn the DMM on by pushing the white power button in the lower left hand corner.
- Push the DCV button.
- Connect the test leads as shown below



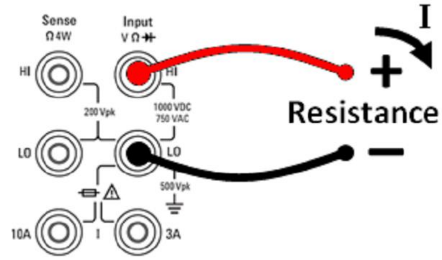
To measure DC currents:

- Turn the DMM on by pushing the white power button in the lower left hand corner.
- Push the blue Shift button and then the DCV button (this gets you DCI).
- Connect the test leads as shown below



To measure resistance:

- Turn the DMM on by pushing the white power button in the lower left hand corner.
- Push the Ω2W button.
- Connect the test leads as shown below



- To measure the value of a resistor it must be removed from the circuit. If the resistor is not removed from the circuit other circuit components will cause an error in the reading.

Appendix D

Breadboard Connections