Basic Electricity For Technology Programs

BASIC ELECTRICITY FOR TECHNOLOGY PROGRAMS

Ministry funded

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Saskatchewan Polytechnic

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CONTENTS

1.

FUNDAMENTALS OF ELECTRICITY

BASIC ELECTRICITY FOR TECHNOLOGY PROGRAMS

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2

LAB 1: MEASURING RESISTANCE

Objectives:

• Work safely on electrical equipment

• Observe concepts of *resistance, continuity, conductors,* and *insulators*

• Measure resistance with a multimeter.

Materials:

Multimeter with probes

Copper wire spools:

wet sponge

14 AWG 300 meters

wood

16 AWG 300 meters

20 AWG 300 meters

22 AWG 75 meters

22 AWG 1500 meters

Information:

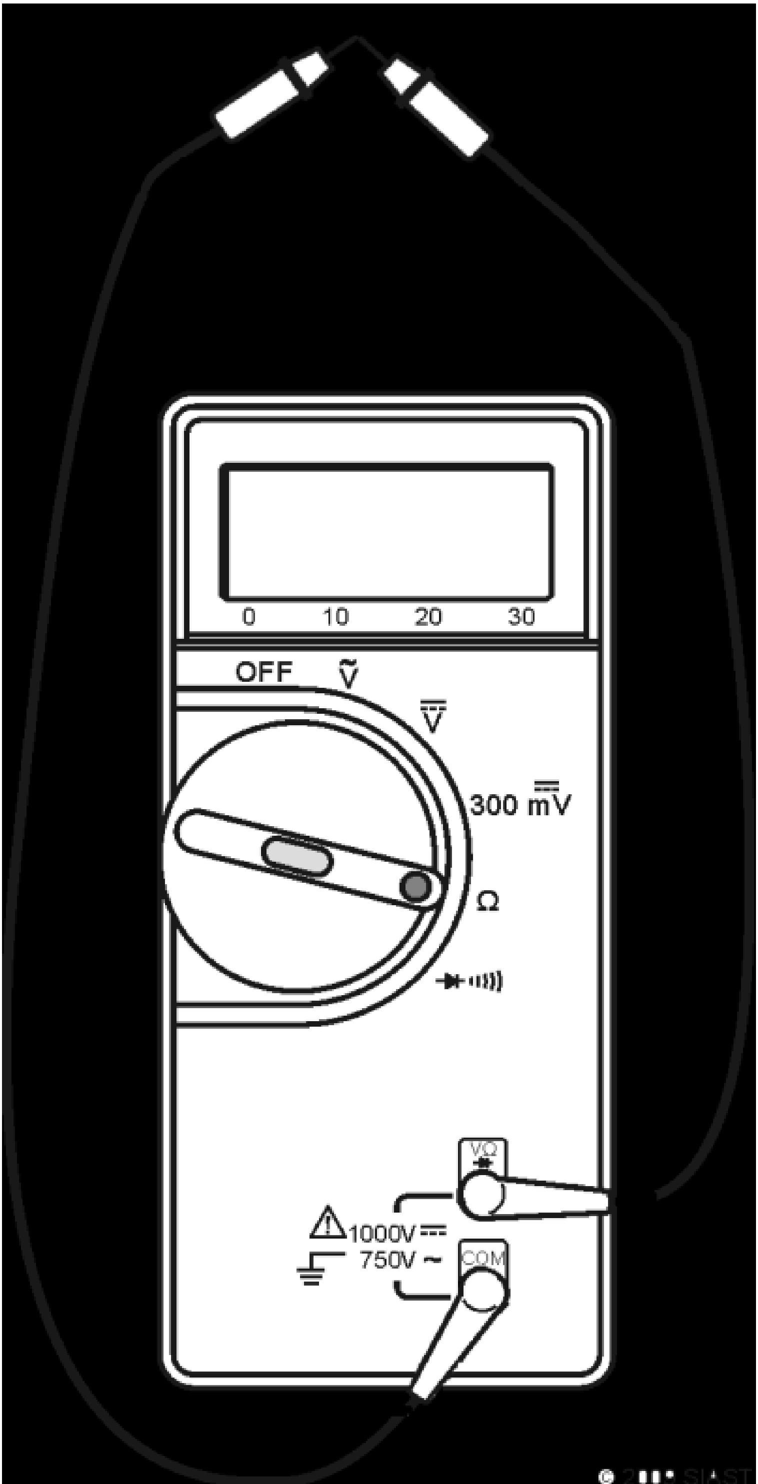
In this lab we will measure the resistance of common equipment using a hand-held multimeter.

When the resistance you are measuring is greater than 32MΩ (32,000,000 ohms), the Fluke 70 will display O.L (over limit).

You must ensure to apply the proper amount of pressure on the probe tips when you are making a resistance measurement. If the probes are just resting there will not be a good connection and the meter will not read the correct resistance.

If you push too hard you could damage the probe or slip and injure yourself.

3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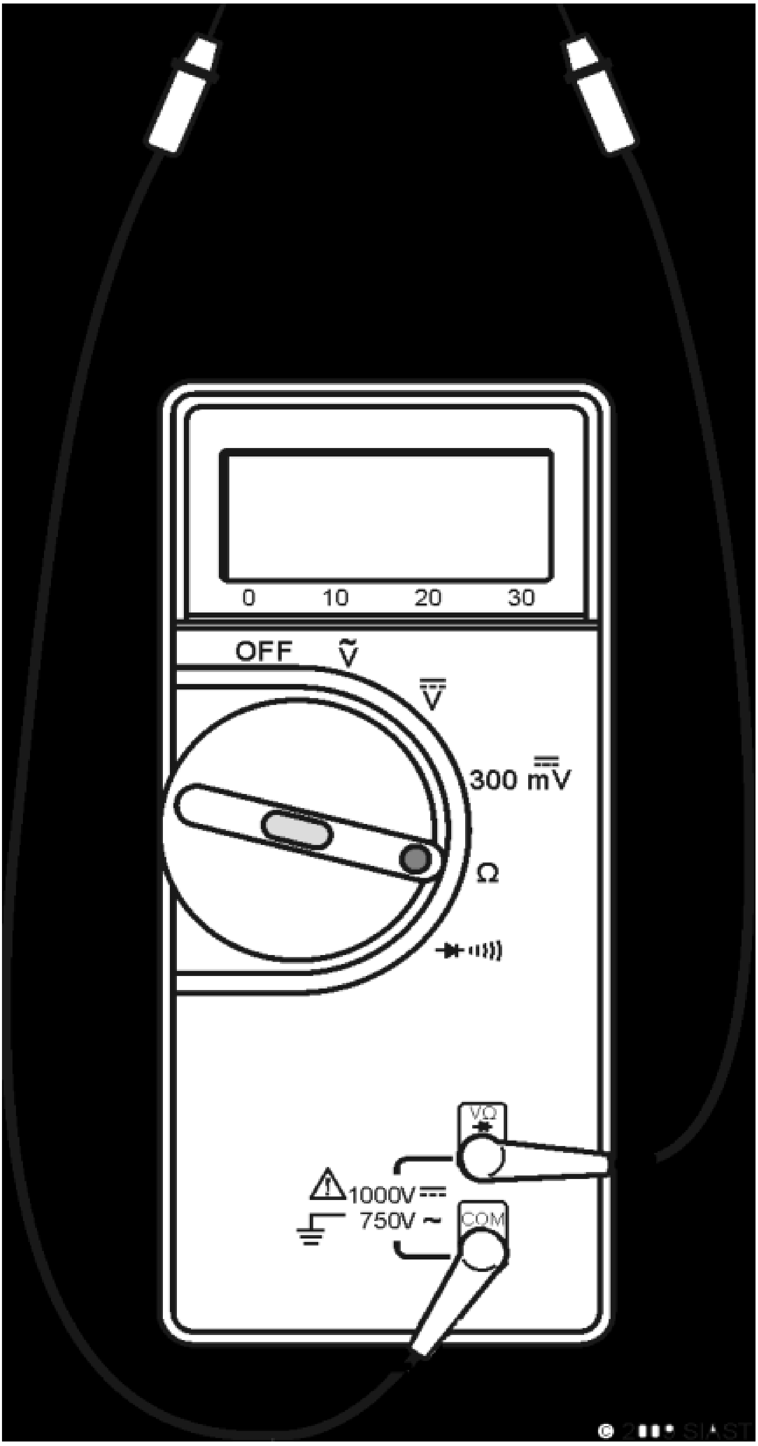
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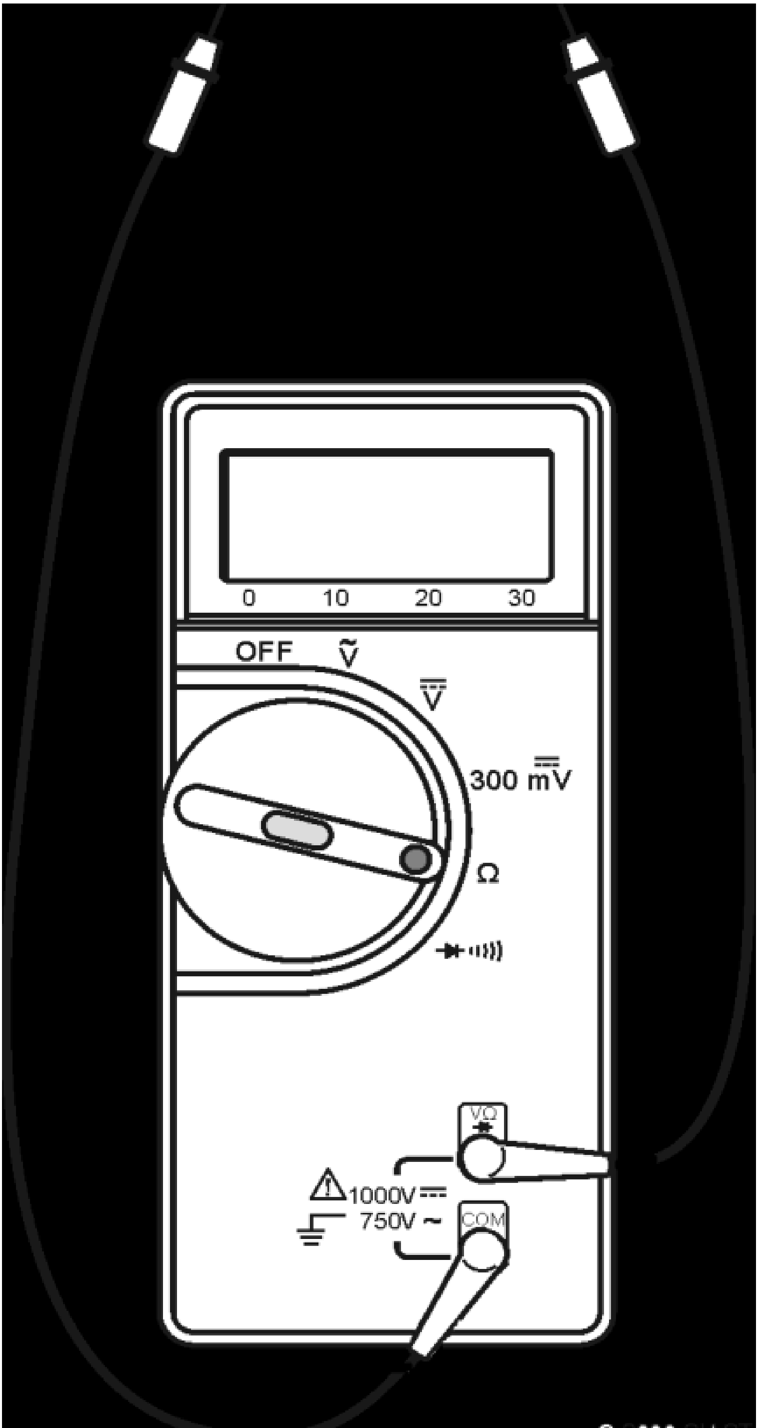
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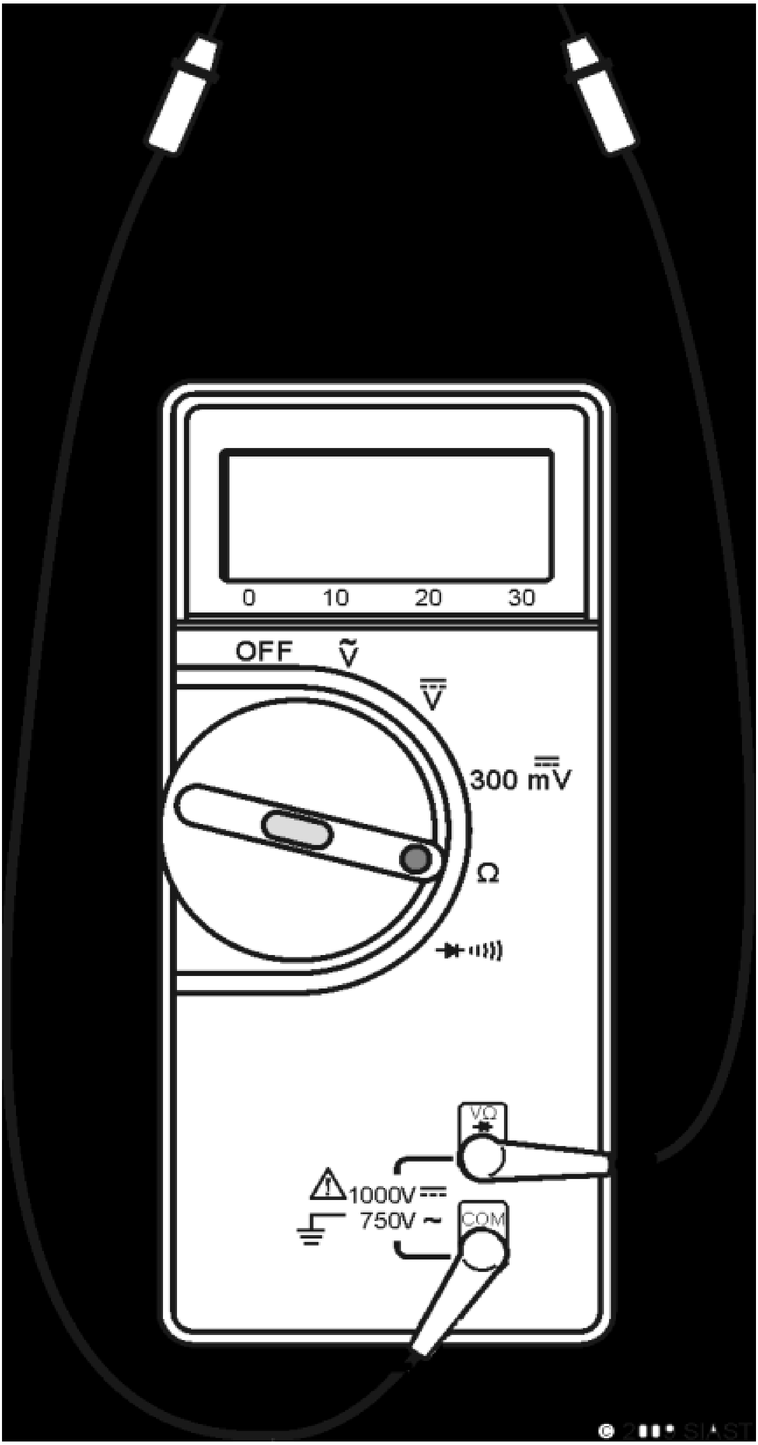
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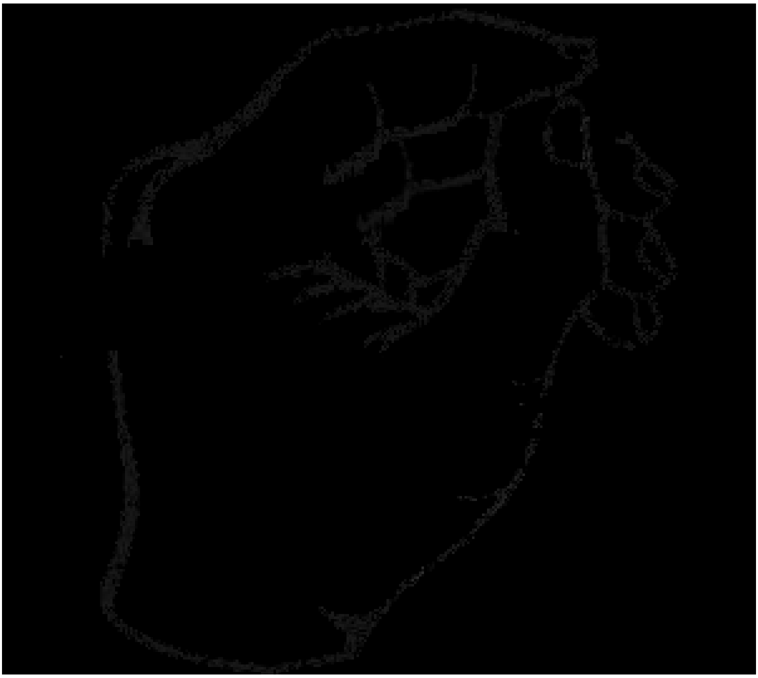
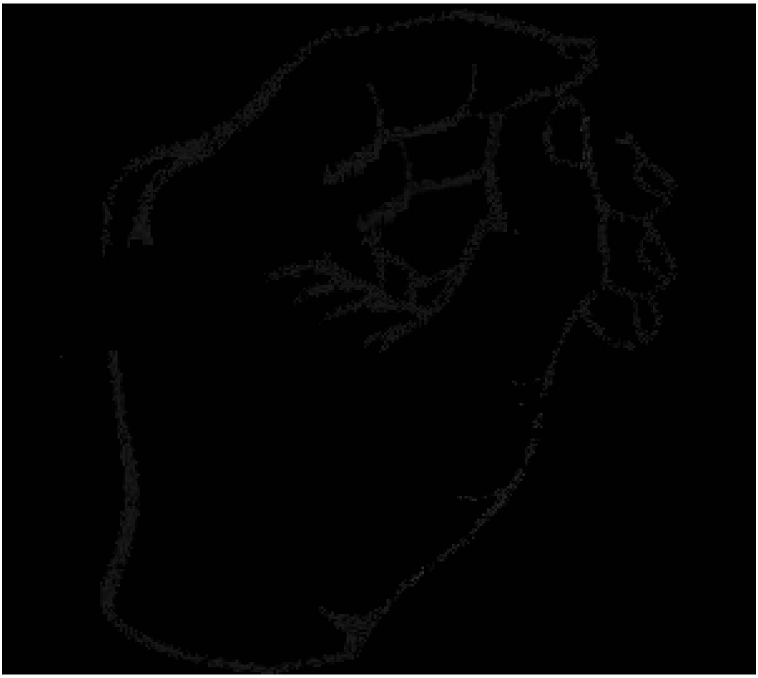




1) Insert the red and black meter leads into the meter and keep the tips separated.
2) Set meter dial to Ω.

3)Recordthereadingon themeterinfigure1A.

4)**Whatdoesthismeter readingmean?**

5)Touchthetipsofthe meterleadstogether andrecordthereading onthefaceofthe meterinfigure1B.

Figure1A

Figure1B

6)Holdthemetaltipsof themeterleadstightly inyourdryfingers.

7)Recordtheaverage valueinFigure2A.

8)Wetyourhandsonawet sponge,pleasedonot lickyourfingers.

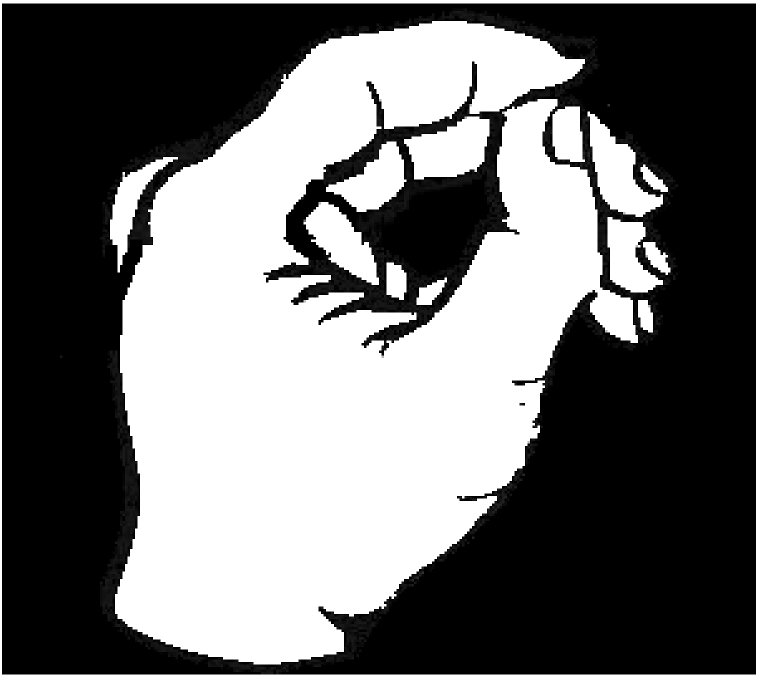
9)Holdthemetaltipsof themeterleadstightly whileyourfingersare wet.

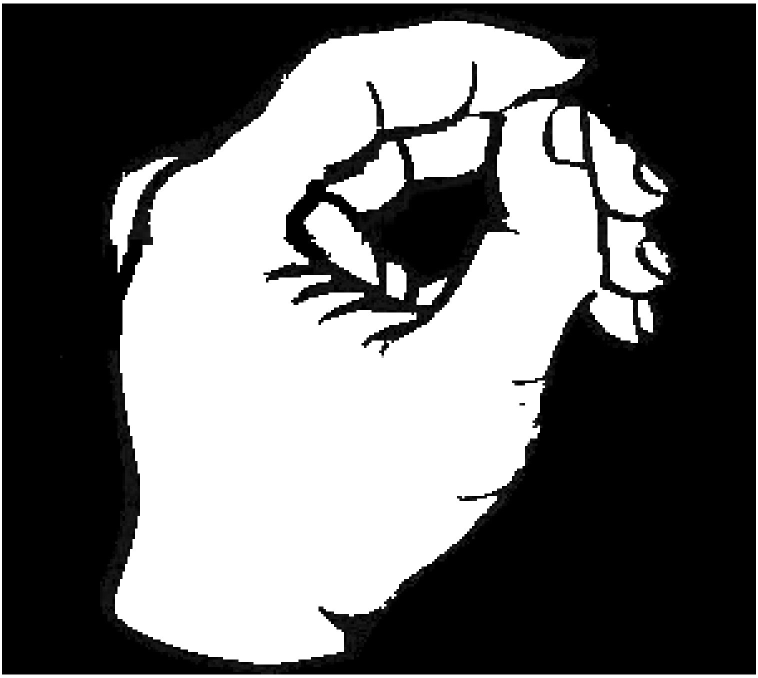
10)Recordtheaverage valueinfigure2B.

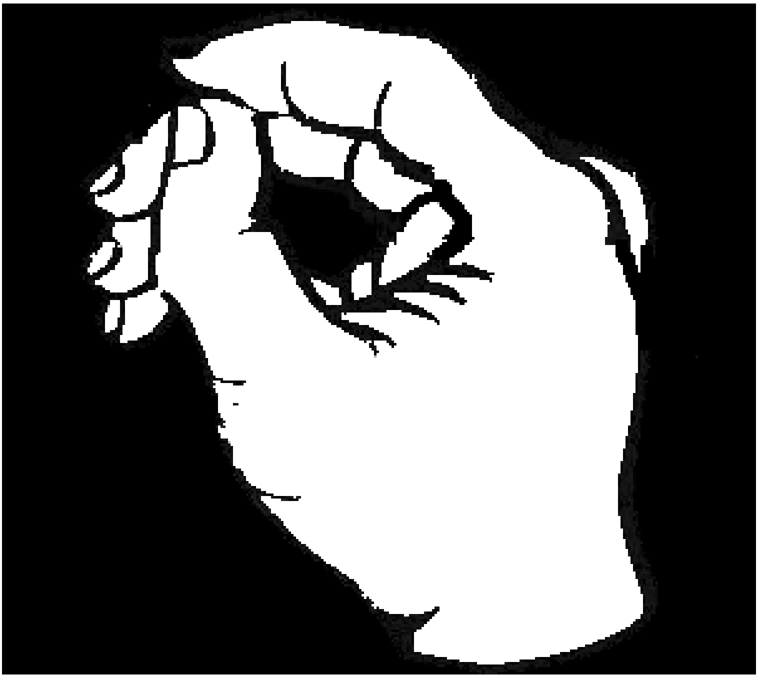
Figure2A

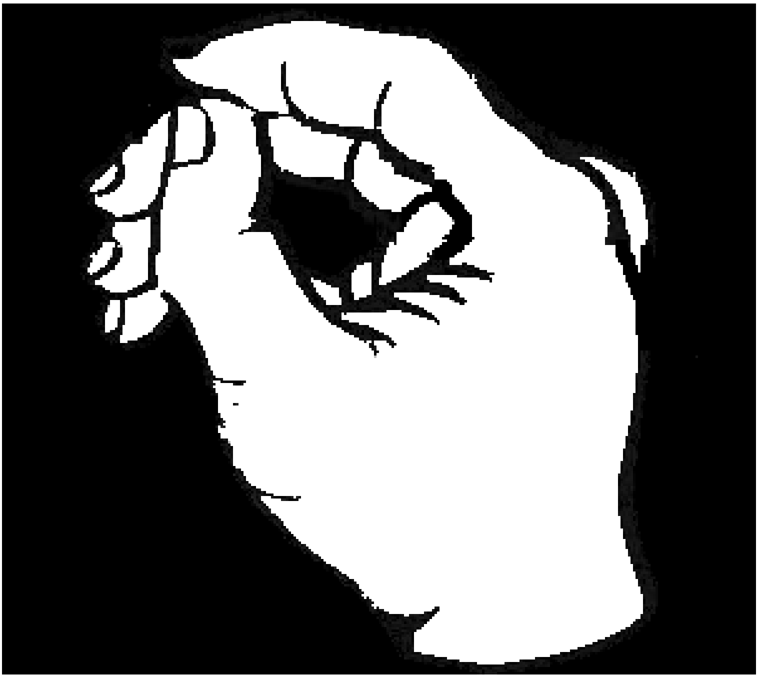
Figure2B

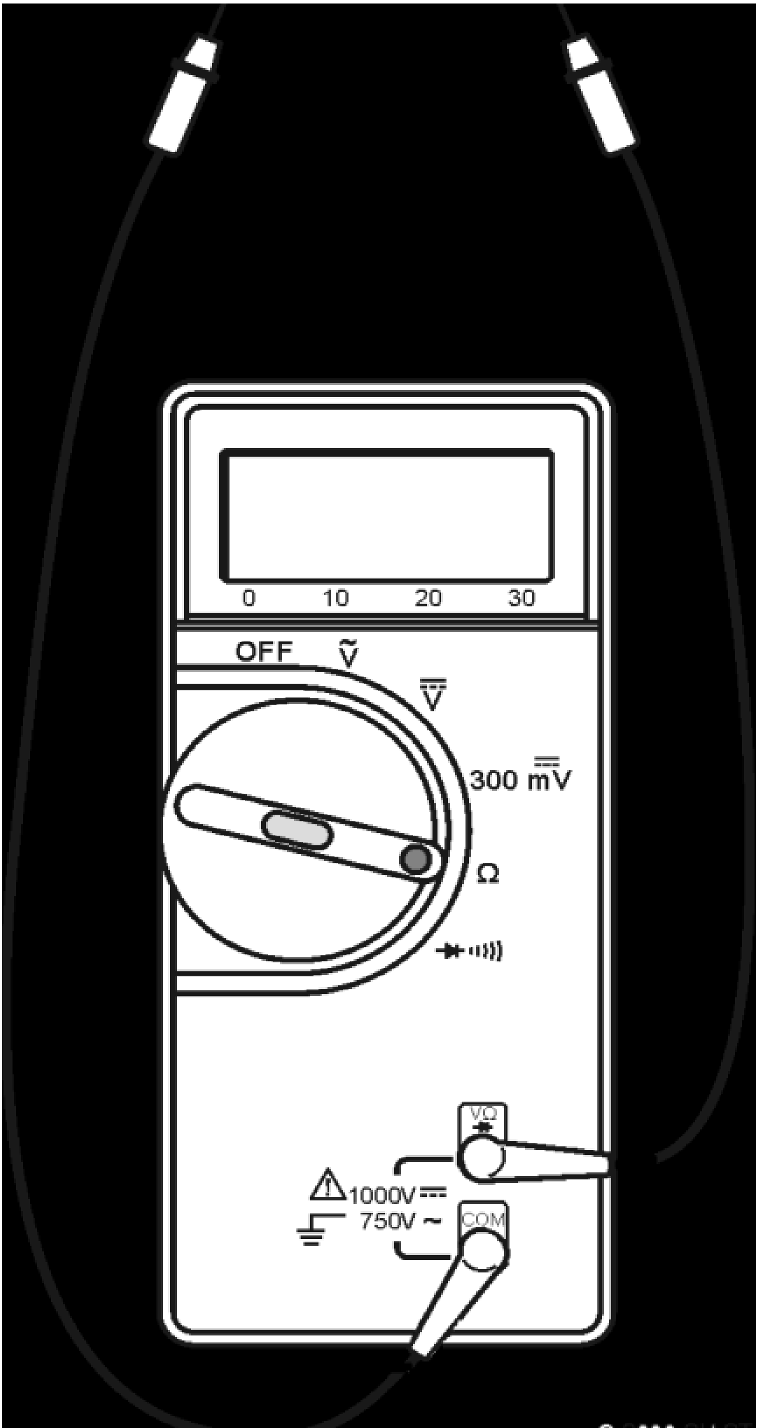
4







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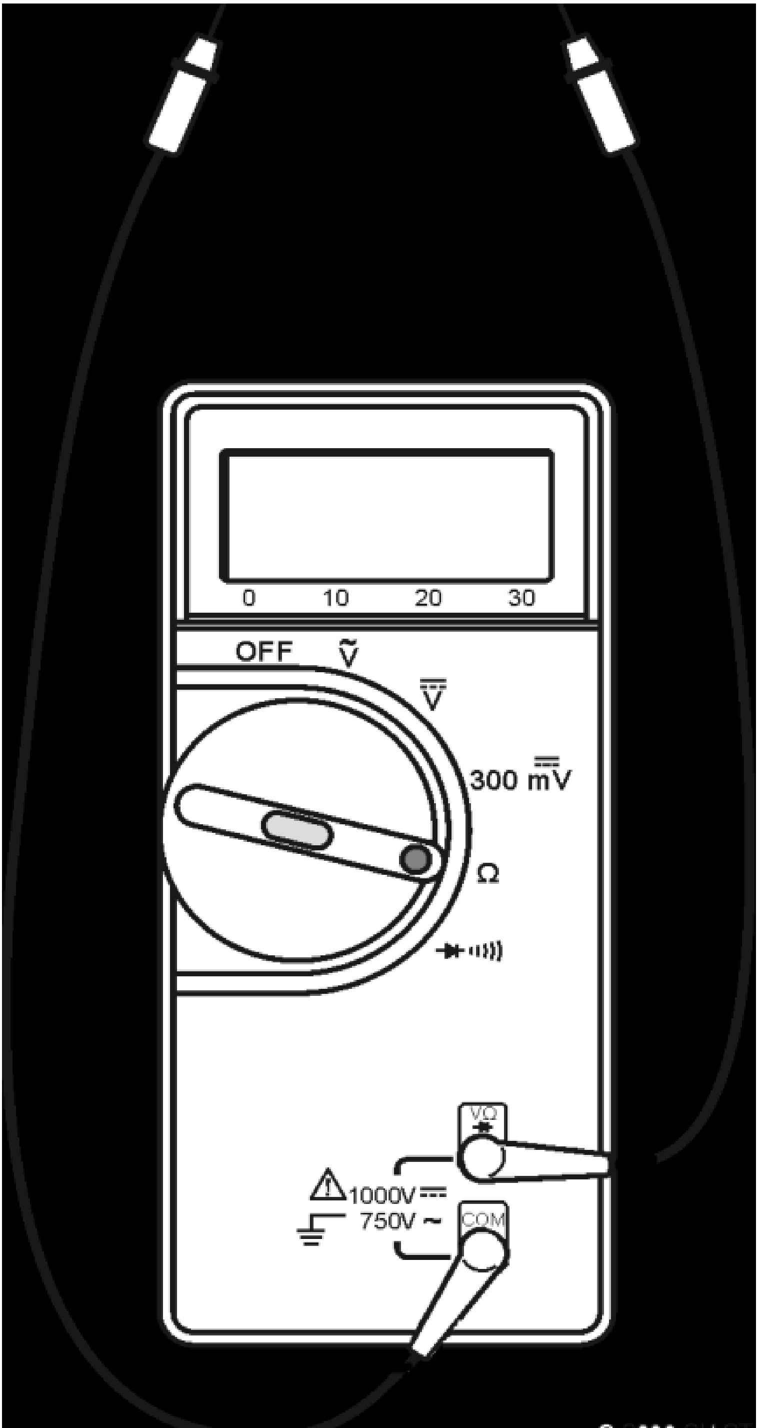
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11) Without touching the metal probe tips, measure the resistance of wood. Write the reading in Figure 3A.

12) Now, touch the metal tips of your meter leads with your fingers while you measure the resistance of the wood. Record the reading in figure 3B.

13) **How is the reading affected when you touch the meter leads?**

Figure 3A

Figure 3B

14) Measure and record the resistance of the three spools of wire provided.

300m

300m

300m

14AWG

16AWG

20AWG

____

____

____

15) Does thinner wire have more or less resistance than thicker wire?

More

Less

5

16) Measure the resistance of the two 22AWG spools of wire provided. Record the resistance below.

75m 22AWG

1500m 22AWG

____

____

17)Doeslongerwirehavemoreorlessresistancethanshorterwire?

More

Less

18)Measuretheresistanceofoneofthecoilsofwireandthentouchthewirewhileyouaremeasuringtheresistance.Doesthevalueofresistancechangewhenyouaretouchingthewire?

Nochangeor

bigdifference

verylittlechange

(morethan10%

(0to10%change)

change)

6

19)Measureresistancebetweenspeedwiresofthemulti–speedPSCmotor.Recordallofthepossiblecombinationsofresistanceinthefollowingchart:Black

Blue

Red

Yellow

Green

Motor

Frame

Black

Blue

Red

Usethethermostatforthefollowingstep. Recordyourmeterreadingsinthetablebelow.Thermostatoperationprovideseitheraclosedswitch(On)oropenswitch(Off)

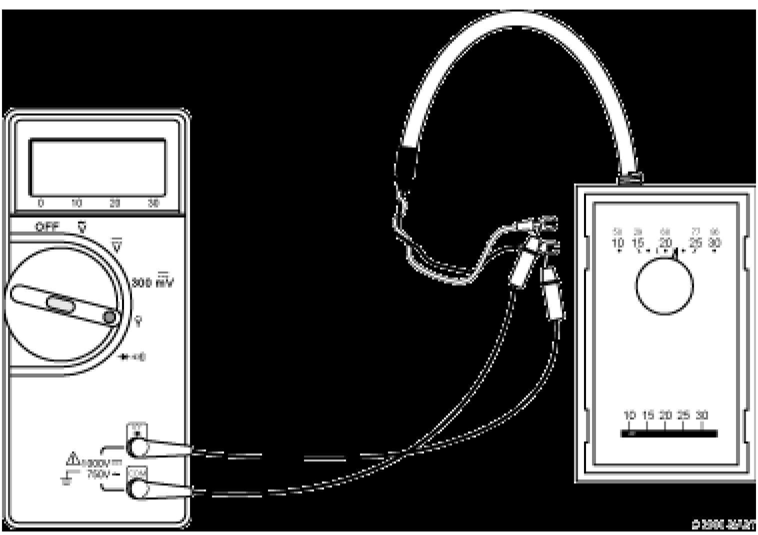
20)Adjustthermostat:

i)soitiscallingforheat(>30degrees).

ii)soitisnotcallingforheat(<10degrees)21)Measuretheresistancebetweentheredandwhitewires.

22)Recordtheresistancebetweentheredandwhitewires.

7



Thermostat Resistance calling for heat

Thermostat Resistance not calling for heat

8

23)Removeafusefromthestandingpilotfurnacetrainer.

Measureandrecordtheresistanceofthefuse.

Fuseresistance=____________

24)Replacethefuse.

Questions(circlethebestanswer):

1)Theresistanceofagoodfuseis?

Lessthan100Ω

Largerthanthemetercanmeasure2)Theresistanceofanopenswitchis?

Lessthan100Ω

Largerthanthemetercanmeasure3)Whatistheresistanceofagoodconductor?

lessthan100Ω

100Ω–10kΩ

10kΩ–10MΩ

4)Howdoeslengthaffecttheresistanceofawire?

Shorterwireshave

Noeffect

Longerwireshave

moreresistance.

moreresistance.

5)Howdoesgaugeaffecttheresistanceofawire?

Thinnerwireshave

Noeffect

Thickerwireshave

moreresistance.

moreresistance.

9

6)Whenwillyourbodyresistanceaffectaresistancemeasurement?

Whentheresistancetobe

Whentheresistanceto

measuredismuchlowerthan

bemeasuredismuch

yourbodyresistance.

higherthanyourbody

resistance.

7)Whataffectdoesmoisturehaveontheresistanceofyourskin?

Moisturelowers

Moistureincreases

resistance

resistance

8)WhenyoutestamultiplespeedPSCmotorwhatlevelofresistancedoyouexpecttomeasurebetweenthedifferentmotorspeedwires?

lessthan100Ω

greaterthan100Ω

9)Whenyoutestamultiplespeedmotor,wh

atlevelofresistancedoyouexpecttomeasure betweenthemotorspeedwiresandthemotorf rame?

lessthan100Ω

greaterthan100Ω

10

LAB 2 – RESISTANCE MEASUREMENT

Objectives:

1.

Practice reading the resistance colour code.

2.

Measure resistance using a digital multimeter.

3.

Study the operation of a variable resistor.

Information:

Band 1

Band 2

Band 3

Band 4 (Tolerance)

(Multiplier)

Table 2-1: Resistor Colour Chart

Resistors

Significant Figures

Colour

Multiplier

Tolerance, ± %

1 or 100

–

0

Black

10 or 101

–

1

Brown

100 or 102

–

2

Red

1,000 or 103

–

3

Orange

10,000 or 104

–

4

Yellow

100,000 or 105

–

5

Green

106

–

6

Blue

107

–

7

Violet

108

–

8

Gray

109

–

9

White

0.10 or 10-1

5

–

Gold

0.01 or 10-2

10

–

Silver

–

20

–

No Color

11

Materials:

1 – Digital Multimeter

6 – Assorted Resistors (All different values)

1 – 1.0 kΩ or 5.0 kΩ Potentiometer

Breadboard and connecting leads

References:

• Class Notes

Procedure:

A.

FIXED RESISTOR

1.

Place resistors neatly on your breadboard.

2.

Determine the rated value of each resistor from the colour code and record the information in the following table.

Resistor Colour and Value

Measured

Resistor No.

Value

1st Colour

2nd Colour

3rd Colour

4th Colour

Rated Value

Tolerance

1

2

3

4

5

6

3.

Measure the resistance of each individual resistor and record in the table.

NOTE: Be sure you are not touching the metal parts of the probe when you are taking your resistance readings as this may give you a false indication.

12

B.

VARIABLE RESISTORS

1.

Obtain a potentiometer.

a. Place the variable resistor on the breadboard so that the three prongs leading from it are in the same position as indicated in Figure 2-2.

A

C

B

Figure 2-2: Variable Resistor

2.

Turn the shaft of the variable resistor completely counter-clockwise. Place the probes of the multimeter on points A and C.

R = ________ ohms

3.

Now rotate the shaft, leaving the probes on the points A and C. Do you get a change in reading?

4.

Now place the probes on points A and B. Rotate the shaft to approximately halfway between CCW (Counter-clockwise) and CW

(Clockwise).

R = ________ ohms

5.

Now with probes on points A and B, rotate shaft completely clockwise.

R = ________ ohms

6.

Explain the reason for the readings in steps 2 through 5.

13

Questions:

1.

List the colour code for the following resistors (assume 5% tolerance): A) 27 ohms

____

B) 2200 ohms

____

C) 39 ohms

____

D) 560 ohms

____

E) 33 000 ohms

____

14

LAB 3 – BATTERIES AND D.C. VOLTAGE MEASUREMENT

Objectives:

1.

Use a multimeter to measure DC voltage.

2.

Measure batteries in series and parallel configurations.

Information:

A.

MEASURING DC VOLTAGE

Measurement of DC voltage is basic in electrical or electronic work. In this experiment, you will use the voltage function of a DMM to measure various dry cell arrangements. Interpretation of your measurements will assist you in determining characteristics of the dry cell arrangements.

Voltage is defined as electrical pressure. It is the difference in electrical pressure between two points. The voltage across two points is measured with a voltmeter.

Therefore you must select the DC voltage function on the DMM.

Generally, the following steps apply for meter setup:

1.

The DMM must be turned on.

2.

The meter test leads should be plugged into the proper inputs. Insert the black lead in the input labelled common and the red lead in the input labelled voltage (V-Ω).

3.

The function switch should be set to DC Voltage.

4.

The test leads are then connected to the circuit under test.

5.

Step the scale or range down until the most accurate voltage value is displayed.

15

B.

DRY BATTERIES

Dry batteries consist of arrangements of primary cells, called "dry cells". The familiar flashlight "battery" is a dry cell. Individual dry cells produce a low voltage.

By connecting dry cells in a series aiding arrangement, we produce a battery whose voltage is the sum of the dry cell voltages. By connecting two or more dry cells in parallel, we produce a battery whose voltage is the same as that of an individual dry cell. Parallel arrangements increases the amount of available current. Dry batteries usually consist of a series / parallel arrangement of cells. These arrangements support batteries with higher voltage and higher capacity.

Materials:

- 4 – D Cells (1.5 volts per cell)
- 1 – Multimeter and Probes
- 1 – Tray of Connecting Wires

References:

- Class Notes

16

Procedure:

A.

BATTERIES IN SERIES

NOTE: If you notice wire getting warm, please disconnect immediately and recheck your circuit.

1.

Measure and record in Table 3-1 the VOLTAGE of each of the individual dry cells supplied.

Table 3-1

Dry Cell #

1

2

3

4

Voltage

2.

Connect cells 1 and 2 in Series as shown in Figure 3-1 or Figure 3-2a.

Measure and record the total voltage in Table 3-2.

NO DATA

DC V

+

+

Figure 3-1

3.

Connect cells 1, 2 and 3 in series as per Figure 3-2b. Measure and record the total voltage in Table 3-2.

17

A

A

A

cell

cell

1

1

cell

cell

cell

2

1

2

cell

cell

cell

3

2

3

cell

B

4

B

B

3-2a

3-2b

3-2c

Figure 3-2: Series Configurations

4.

Now connect the four cells in series as per Figure 3-2c. Measure and record the total voltage in Table 3-2.

Table 3-2

Step No.

2

3

4

Voltage (Volts)

18

B.

BATTERIES IN PARALLEL

1.

Connect two cells in parallel, as shown in Figure 3-3a. Measure and record the voltage in Table 3-3.

A

A

A

cel 1

cel 2

cel 3

cel 1

cel 2

cel 3

cel 4

cel 1

cel 2

B

B

B

3-3a

3-3b

3-3c

Figure 3-3: Parallel Configurations

2.

Connect three cells in parallel as per Figure 3-3b or Figure 3-4. Measure and record voltage in Table 3-3.

NO DATA

DC V

+

+

+

Figure 3-4

19

3.

Connect four cells in parallel as per Figure 3-3c or Figure 3-5. Measure and record voltage in Table 3-3.

NO DATA

DC V

+

+

+

Figure 3-5

+

Table 3-3

Step No.

1

2

3

2 D-Cells

3 D-Cells

4 D-Cells

Voltage (Volts)

20

C.

SERIES PARALLEL CONNECTION

1.

Connect four cells as indicated in Figure 3-6. Measure the voltage from points A to B and record in space provided.

+

+

A

EA-B = ________ volts

B

+

+

Figure 3-6

2.

Now connect cells as per Figure 3-7 and measure the voltage from points A to B. Record voltage reading in space provided.

A

+

+

EA-B = ________ volts

+

+

B

Figure 3-7

21

D.

BATTERIES IN SERIES OPPOSING

1.

Connect two cells in series opposing as per Figure 3-8. Measure and record the voltage reading obtained from points A to B in space provided.

EA-B = _________ volts

+

A

+

B

Figure 3-8

2.

Connect three cells as per Figure 3-9. Measure and record the voltage obtained from points A to B in space provided. Also, indicate relative polarities in spaces below.

EA-B = ________ volts

+

A

A's polarity is _________

B's polarity is _________

+

B

+

Figure 3-9

22

3.

Connect four cells as per Figure 3-10. Measure and record the voltage obtained from points A to B in space provided. Also indicate relative polarities in spaces provided

+

EA-B = ________ volts

A

A's polarity is ________

+

B's polarity is ________

+

+

B

Figure 3-10

NOTE: Please turn off the meter and return equipment before leaving the lab.

23

Questions:

1.

Name some precautions which must be observed in measuring voltages.

2.

What arrangement of six dry cells would give the maximum life, regardless of voltage?

3.

What arrangement of six dry cells would give the maximum voltage?

4.

Draw the best arrangement of ten 1.5 volt dry cells to give an overall voltage of 7.5 volts.

24

LAB 4: CURRENT

Name ______________________

Objectives:

- Understand the flow of electrical current
- Measure current with in-line and clamp-on ammeters

Materials:

1 – Fluke 70 multimeter

1 – Fluke 8010 bench meter

1 – DC power supply

4 – 12 V lamps

1 – toggle switch (SPST)

2 – banana plug leads (1 red and 1 black)

2 – alligator clips for banana plug leads

Instructor will setup a station for measuring AC current with a clamp-on meter: 1 – Fluke 30 clamp meter

1 – electric kettle

1 – extension cord with outer jacket removed

Evaluation:

The questions at the end of this lab will be graded and you will get a mark out of 16 possible for this lab.

Background:

Current flows through a circuit. A few simple rules apply:

• Current takes the "easiest" path.

• The amount of current flowing in a circuit will increase if the amount of resistance in that circuit decreases.

• The amount of current flowing into a junction equals the amount of current flowing out of the same junction.

• Conventional current flows from the source's positive terminal through the circuit and back to the source's negative terminal.

25

Reference:

How to Measure Current using an In-line Ammeter:

Current is measured in units of amps and the symbol for amps is A.

1. Insert the leads into the bench meter, red lead into the red ‘mA’ terminal and black lead into the black ‘common’ terminal.
2. Select AC or DC as appropriate.
3. Select current.
4. Select the 2000 mA range.
5. Turn off power to the circuit.
6. Remove a wire from the circuit and replace it with the ammeter and leads.
7. Restore power to the circuit.
8. Select the lowest range which will display the current to get a reading with the best precision.

26

Procedure:

2.

FUNDAMENTALS OF ELECTRICITY

Part 1

Current Takes Easiest Path

1.

The circuit in figure 4-1 will show that current takes the "easiest path". Build this circuit. Get an instructor to check your wiring and initial: ______________

L2

+

12V

L1

L3

Figure 4.1

2.

Turn on the DC supply and set it at 12 V.

You should see that L1 is brighter than L2 or L3. This is because more current flows through L1 than L2 or L3. Since the *path through L1 is "easier" than the path through both L2 and L3 more current flows through L1.*

27

3.

FUNDAMENTALS OF ELECTRICITY

Part 2

Lower Resistance Equates To Higher Current

1.

The circuit in figure 4-2 will show that if a path becomes "easier" more current will flow through it. Build this circuit.

L1

+

12V

L2

L3

Figure 4.2

2.

Turn on the DC supply and set it at 12 V. Note how bright the lamps are.

Remove L2 and L3 and reconnect the circuit as in figure 4-3.

+

12V

L1

Figure 4.3

3.

Turn on the DC supply and note how bright L1 is now. *L1 should be much brighter now since the path has been streamlined by removing L2 and L3.*

28

4.

FUNDAMENTALS OF ELECTRICITY

Part 3

Current In Equals Current Out

1.

The circuit in figure 4.4 will show that the current that flows into a junction equals the current that flows out of the junction. Connect the following circuit and get an instructor to check your wiring and initial here: ______________

L1

+

L2

L3

12V

L4

Figure 4.4

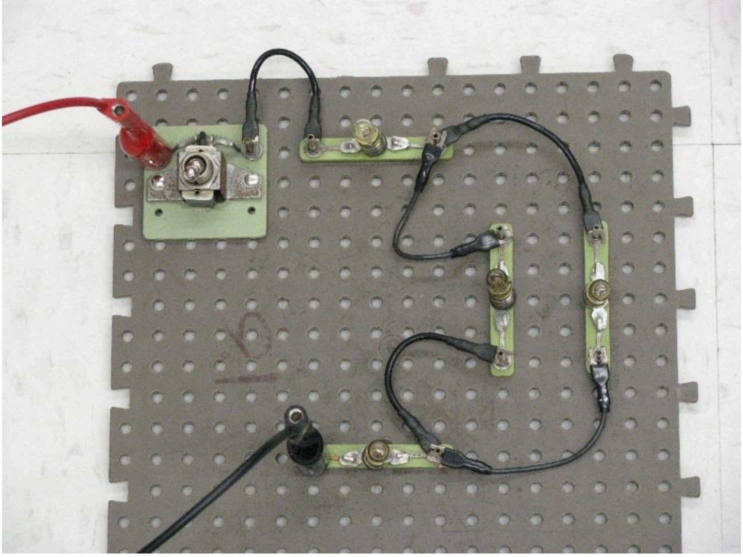
2.

Turn on the DC supply and set it at 12 V.

In this circuit all of the current flows through the switch and L1. L1 shines brightly because the current is high. The current is split between L2 and L3

and they are dimmer because each lamp has roughly half of the current. The currents combine then flow through L4 and it shines brightly because the current is high. In the next section we'll measure these currents.

29



Part 4 – Using an In-line Ammeter

1.

Before we use the in-line ammeter we'll study its characteristics. We'll use a bench meter as our ammeter, set the bench meter to measure DC current on the 200 mA range.

Plug a red banana lead into the red 'mA' terminal and a black banana lead into the black 'common' terminal.

2.

Use another multimeter to measure the resistance of the ammeter and leads and record here: _____________. *(You should find that the in-line ammeter has very low resistance – it is a conductor.* ***We must be careful when we***

connect an in-line ammeter to a circuit, as we would with any

conductor! *)*

3.

It will be easiest to connect the ammeter if the circuit is connected exactly as shown below, change your circuit so it matches this photo.

Figure 4.5

4.

Now we'll measure the current through each of the lights. To measure the current in a light we connect the ammeter in series with the light. Turn the power off to the circuit and remove the wire in series with L1 as shown in Figure 4.6.

30

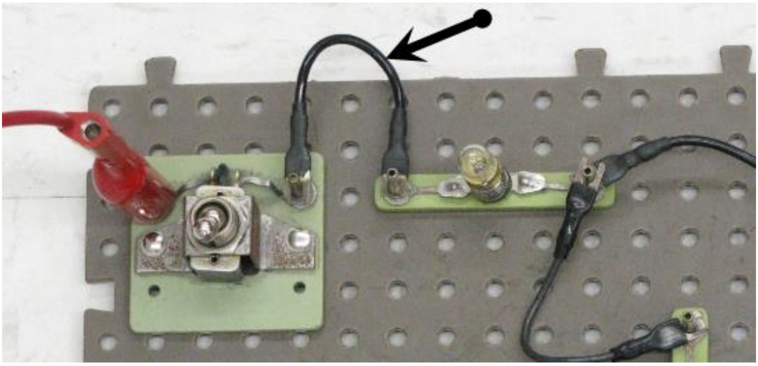


Figure 4.6

5.

Replace this wire with the ammeter and leads (recall that the ammeter is a conductor).

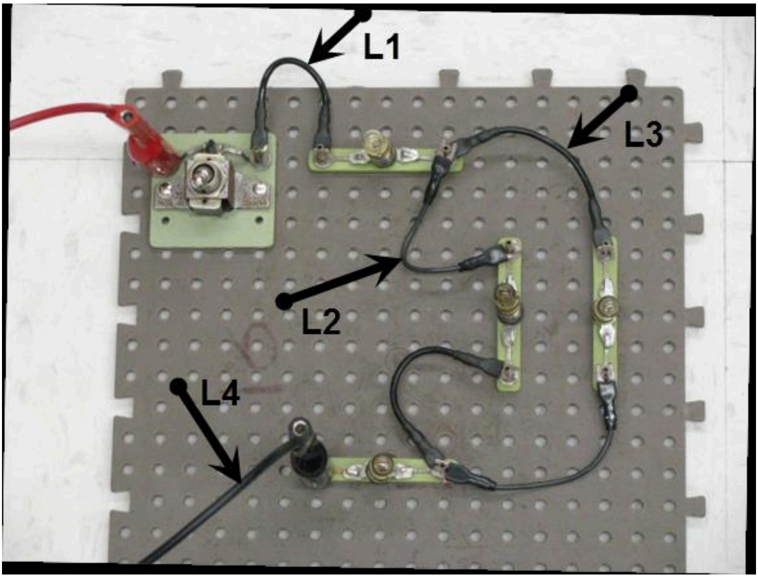
6.

Turn on the power and record the current in Table 4.1. A positive reading indicates that the current flows from the ammeter's red terminal to the black terminal, a negative reading indicates a flow in the opposite direction.

7.

Remove the ammeter and replace the wire.

31



8.

Follow a similar method to measure the current in the other lights. The figure below shows which wire to remove and replace with the ammeter.

Figure 4.7

Table 4-1

Light

Current

L1

(mA

)

L2

L3

L4

9.

You should find that the currents through L1 and L4 are equal. This is because they are in series. Add the currents through L2 and L3 and record here: ___________. You should find that this combined current is equal to the current through L1 and L4.

10.

The in-line ammeter isn't used much as a troubleshooting tool because it is so inconvenient to use. The voltmeter is the primary troubleshooting tool and the ohmmeter is the secondary troubleshooting tool.

32

Part 5 – Modified Circuit

1.

Turn off the power and add a wire in parallel with L2 and L3 as shown in figure 4.8.

L1

+

L2

L3

12V

L4

Figure 4.8

2.

Turn on the power. Current now flows easily through the low resistance wire instead of L2 or L3. As a result very little current flows through L2 or L3, not enough to light them.

Because this new path permits current to more easily flow from L1 to L4 the current through the circuit increases and L1 and L4 are brighter.

33

5.

FUNDAMENTALS OF ELECTRICITY

Part 6 – Clamp-on Ammeter

1.

A clamp-on ammeter is very convenient to use and it is often used to check the load on motors.

2.

Set the dial on the current clamp meter to the 200 A position. At this setting the meter can measure currents up to 200 A.

3.

Plug the kettle into the receptacle and measure the individual currents in the hot, neutral and ground wires and record in Table 4-2.

4.

Measure the current in both the hot and neutral wires and record in Table 4-2.

Unplug the kettle after taking these readings.

Table 4-2

Wire

Current (A)

Hot

(Black)

Neutral

(White)

Ground

(Green)

Hot & Neutral (Black & White)

5.

Replace all the components used in this lab and complete the following questions.

6.

Get an instructor to check your results _______________ .

34

Questions

Mark:____________/16

*Assume all switches are closed.

1.

Consider the following circuits:

Original Circuit:

L1

+

12V

L2

L3

Modified Circuit:

L1

+

12V

L2

L3

Will the lamps will be brighter, the same, or dimmer when the circuit is modified (circle the correct answers).

L1:

brighter

same

dimmer

L2:

brighter

same

dimmer

L3:

brighter

same

dimmer

35

2.

Consider the following circuits:

Original Circuit:

L1

+

L2

L3

12V

L4

Modified Circuit:

L1

+

L2

L3

12V

L4

Will the lamps will be brighter, the same, or dimmer when the circuit is modified (circle the correct answers).

L1:

brighter

same

dimmer

L2:

brighter

same

dimmer

L3:

brighter

same

dimmer

L4:

brighter

same

dimmer

36

3.

Consider the following circuits:

Original Circuit:

L1

+

L2

L3

12V

L4

Modified Circuit:

L1

+

L2

L3

12V

L4

Will the lamps will be brighter, the same, or dimmer when the circuit is modified (circle the correct answers).

L1:

brighter

same

dimmer

L2:

brighter

same

dimmer

L3:

brighter

same

dimmer

L4:

brighter

same

dimmer

37

4.

In the following circuit, if the current through L2 is 1A and the current through L3 is 1A, what is the current:

a. through L1? ___________

b. through L4? ___________

c. supplied by the DC source? ___________

L1

+

L2

L3

12V

L4

5.

What value of current do you expect to read if you place a clamp meter around: a. both the hot and neutral conductors of a power cord? ___________

b. the ground cable? ___________

38

LAB 5 – OHM'S LAW

Objective:

- Study the relationship between VOLTAGE, RESISTANCE and CURRENT in an electrical circuit.

Information:

Ohm's Law may be generalized as follows:

I = E / R

I = E/R states that current in a resistor is directly proportional to the voltage across the resistor and inversely proportional to the resistance R, where I is expressed in amperes, E in volts, and R in ohms.

Measurement Accuracy

Measurement errors are unavoidable. Multimeters have measurement error specifications and components have tolerance specifications.

Please measure the values of the resistors you will use in this lab procedure and then use the measured value of resistance for the calculations in this lab.

We will not track errors during this procedure as we are focused on ohm's law and not measurement inaccuracies. Expect a 10% tolerance between measured values and calculated values.

Materials:

Multimeters, bench and hand-held

1 – 1 kΩ resistor

1 – 1.5 kΩ resistor

1 – 3.3 kΩ resistor

1 – 6.8 kΩ resistor

1 – SPST switch (Two terminals)

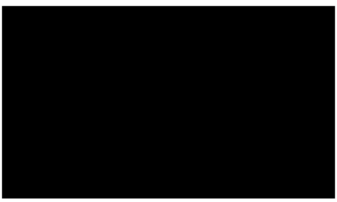
Alligator Clips

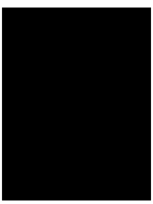
Breadboards and Connecting Wires

Reference:

- Lecture Notes, Class Webpage

39





Procedure:

1.

Measure and record below the value (including units) for these four resistors: R1 (1 kΩ) =

____

R2 (1.5 kΩ) =

____

R3 (3.3 kΩ) =

____

Fluke8010A

–

+

–

A

+

0.000

R4 (6.8 kΩ) =

____

Measured values may vary within component tolerance.

2.

Connect the circuit as shown in the schematic Figure 5-1

Figure 5-1

3.

Apply power and with switch closed adjust voltage control until 6 Volts is measured across the resistor with a hand held voltmeter.

4.

Record the current (I) measured by the ammeter in table 5-1.

Table 5-1

R

1000 Ohms

E

6 V

8 V

10 V

12 V

14 V

I (mA)

E / I (Ohms)

5.

Measure and record in turn, the current (I) at each of the voltages setting shown in table 5-1 for R = 1000 ohms.

6.

Calculate the ratio E/I for each corresponding value of E and I and record in table 5-1. When calculating current values use measured resistance values.

7.

Using the OHM'S LAW formula, calculate the current you would expect in the circuit when R = 1000 Ω and E = 9 Volts; E = 18 Volts. Ensure that you use actual measured voltage and resistance for your calculations. Record the 40

computed values in table 5-2. Measure and record currents for the two voltage values.

Table 5-2

Formula Test

E

9 V

18 V

I (mA)Calculated

I (mA)Measured

8.

Turn off the power supply then replace the 1 kΩ resistor with 1.5 kΩ resistor.

9.

Follow the same experimental procedure in steps 4 and 5 for each value of voltage in table 5-3. R = 1.5 kΩ.

41

Table 5-3

R = 1,500 Ohms

E

8 V

12 V

16 V

18 V

20 V

I (mA)

E / I (Ohms)

10.

Replace 1.5 kΩ resistor with 3.3 kΩ resistor and again repeat experimental procedure for each value of voltages shown in table 5-4.

Table 5-4

R = 3,300 Ohms

E

12 V

16 V

20 V

24 V

I (mA)

E / I

(Ohms)

11.

Repeat the experimental procedure for the 6.8 k resistor using Table 5-5.

Table 5-5

R = 6,800 Ohms

E

16 V

20 V

24 V

28 V

I (mA)

E / I (Ohms)

12.

Using ohm's law, calculate the current you would expect in the circuit when R = 6,800 Ω and E = 18 Volts; E = 26 Volts.

Record the computed values in table 5-6.

Table 5-6

42

Formula Test

E

18 V

26 V

I Computed (mA)

I Measured (mA)

13.

Measure currents for the two voltage values and record in table 5-6.

43

Questions:

1.

For a constant value of R, what is the effect on I if E is doubled?

2.

For a constant value of E, what is the effect on I if:

A)

R doubled?

____

B)

R halved?

____

3.

An instrumentation sensor provides a signal that varies between 4mA and 20mA.

A) If the sensor is connected to a 250Ω resistor, what voltage would you expect to measure across the resistor when the sensor is supplying 14.4mA?

B) What would be the minimum voltage you would measure across the 250 Ω resistor?

C) What would be the maximum voltage you could measure across the 250 Ω resistor?

4.

What is the resistance of an electric heating element on a stove that draws 5A from a 110V source?

44

LAB 6 – SERIES & PARALLEL CIRCUITS

Objectives:

1.

Investigate and compare the features of series and parallel circuits.

Materials:

1 – Bench Meter

1 – DC Power Supply

1 – Hand held multimeter

1 – 330 Ω, 2W, 10% Resistor

1 – 470 Ω, 2W, 10% Resistor

1 – 1.2 kΩ, 2W, 10% Resistor

1 – 2.2 kΩ, 2W, 10% Resistor

1 – 3.3 kΩ, 2W, 10% Resistor

1 – 4.7 kΩ, 2W, 10% Resistor

1 – 5.6 kΩ, 2W, 10% Resistor

1 – 10 kΩ, 2W, 10% Resistor

1 – 1 Amp Fuse with Holder

1 – SPST Switch (two terminals)

Breadboards and Connecting Wires

Information:

Record all the digits that are reported by your instruments to maintain the highest precision during this experiment.

Reference:

- Class notes

45

Procedure:

A.

DETERMINING RT FOR SERIES CONNECTED RESISTORS. (METER)

1.

Use your hand held multimeter to measure the values of resistors. Record results in Table 6-1.

Table 6-1

Rated Value,

330

470

1.2k

2.2k

3.3k

4.7k

5.6k

10k

Ohms

Measured Value,

Ohms

2.

Connect the 330Ω and the1.2 kΩ resistor in series combination 1.

3.

Using the hand held multimeter, measure the total resistance of combination 1. Record in Table 6-2.

Table 6-2

Combination

Rated Value (Ohms)

RT (Ohms)

Computed Value

Measured Value

R1 + R2 + ...+ RN

1

330

1.2k

X

X

X

2

330

470

1.2k

2.2k

X

3

330

470

1.2k

2.2k

3.3k

General Formula: RT =

4.

Repeat the procedure in steps 2 and 3 for the remaining resistor combinations in Table 6-2.

5.

Calculate the sum of the measured values of each combination and record in Table 6-2 computed value column.

46

B.

DETERMINING RT FOR SERIES CONNECTED RESISTORS (CIRCUIT)

1.

Ensure the power supply is set to 0V.

2.

Connect the 330Ω and 1.2 kΩ resistors in series combination 1 as per Figure 6-1.

1A

+ mA

330 R

+

D.C. Variable

V

Power Supply

1.2 K

Figure 6-1

3.

Close switch and adjust power supply for 10 volts.

4.

Measure total current IT. Record in Table 6-3.

Table 6-3

Combination

Source(E) V

Current(IT) mA

RT = E/I Ω

Computed Value R1 + R2 + ...+ RN

1

2

3

General Formula: RT =

5.

Repeat steps 1, 2 and 3 for each of the remaining resistors combinations.

6.

Compute and record the RT for each series combination in Table 6-3.

47

C.

SERIES VOLTAGE DROP RELATIONSHIP

1.

Connect four resistors in series as shown in Figure 6-2.

1A

+

mA

330 R

+

D.C. Variable

Power Supply

470 R

2.2 K

1.2 K

Figure 6-2

2.

Apply power and with hand held multimeter adjust power supply for 10

volts.

3.

Close switch and read the current that is flowing in the circuit and record below:

IT = ___________ mA

VERIFY YOUR ANSWER USING OHM'S LAW.

I = E/RT

Calculated IT = ____

48

4.

Using the measured resistance values of each resistor, and the measured current value, calculate the VOLTAGE DROP of each resistor around the circuit.

*The voltage drop across a resistor is equal to I x R (V = IR).

V1 = ____________ V2 = ____________

V3 = ____________ V4 = ____________

5.

Now add the four voltage drops computed (Eapplied = V1 + V2 + V3 + V4).

Total Voltage Drops = ____________

6.

Using the hand held multimeter measure the voltage drop across each of the four resistors.

V1 = ___________ V2 = ____________

V3 = ___________ V4 = ____________

7.

Add the four voltage drops measured (Eapplied = V1 + V2 + V3 + V4).

Total Voltage Drops = ___________

8.

Now using the actual applied voltage and the current measured in step 3, compute the total resistance of the circuit (RT = E/I).

RT (computed) = ___________

9.

DISCONNECT POWER SUPPLY from the circuit. Using hand held multimeter measure and record the total resistance of the circuit.

RT (measured) = ___________

49

D.

PARALLEL CIRCUIT

1.

Connect the parallel circuit combination as per Figure 6-3.

2.

Ensure the Power Supply is set to 0 volts.

1A

+

mA

+

3.3 K

D.C. Variable

2.2 K

10 K

Power Supply

Figure 6-3

3.

Close switch and adjust power supply for 10 volts. Maintain this voltage level under load until you have completed measurements.

4.

Measure and record the total current (IT) in Table 6-4.

NOTE: When calculating current values, use MEASURED resistance values.

50

Table 6-4

Rated Value

Measured Values

Computed Values

Combination

Step

s

Ohms

Volts

mA

mA

Ohms

R1

R2

R3

E

IT

I1

I2

I3

Total Current

Total

IT = I1 + I2 + I3

Resistanc

e

RT = E/IT

4

2,200

3,300

10,000

1

to

—

3,300

10,000

X

12

—

—

10,000

X

X

13

3,300

4,700

5,600

2

to

—

4,700

5,600

X

14

—

—

5,600

X

X

15

4,700

5,600

10,000

3

to

—

5,600

10,000

X

16

—

—

10,000

X

X

5. Measure and record the individual branch currents I1, I2 and I3 as per Figure 6-3.

(Remember that a current meter is connected in SERIES with the resistive load).

You will need to alter circuit connections to facilitate these current measurements.

6. Calculate Total Current by adding I1, I2 and I3 and record in Table 6-4.

7. Compute Total Resistance by substituting the measured values of E and IT into RT = E/IT and record in Table 6-4.

8. Remove R1 from the circuit. Measure IT, I2 and I3 and record in Table 6-4.

9. Compute and record RT and IT as in steps 7 and 8.

10. Remove R2 from circuit (R1 is also out). Measure IT and I3 and record Table 6-4.

11. Compute and record RT and IT as in steps 7 and 8.

12. Power off, replace resistors in Combination 1 with those of Combination 2. Then repeat step 4 through 12.

13. Power off, replace resistors in Combination 2 with those of Combination 3

14. Repeat step 4 through 12.

51

15. Referring to Figure 6-4, use the hand held multimeter as an ohmmeter and measure the individual resistances of R1, R2, R3. Be sure that no power supply is connected to the circuit.

16. Connect the circuit as per Figure 6-4 using values of Combination 1 (2.2KΩ, 3.3KΩ

and 10KΩ resistors). Measure the total resistance RT and record in Table 6-3.

2.2 K

3.3 K

10 K

Figure 6-4

Table 6-3

Measured Value, Ohms

Computed Value of RT Ohms

Combination

Steps

R1

R2

R3

RT

Total Resistance

Total Resistance

RT = E/IT

1/RT = 1/R1 + 1/R2 + 1/R3

18-20

1

—

21

22

2

—

23

24

3

—

25

19.

Calculate the Total Resistance by substituting the measured values of R1, R2 and R3 into the following equation:

1 = 1 + 1 + 1

RT R1 R2 R3

20.

Connect a power supply to the circuit and apply 10V to the circuit and measure total current (IT).

21.

Remove R1 and repeat steps 18 to 20.

52

22.

Replace resistors in Combination 1 with those of Combination 2 (3.3KΩ, 4.7KΩ and 5.6KΩ resistors).

23.

Using Combination 2, repeat steps 18 to 21 inclusive.

24.

Replace resistors in Combination 2 with those of Combination 3 (4.7KΩ, 5.6KΩ and 10KΩ resistors).

25.

Using Combination 3, repeat steps 18 to 21 inclusive.

53

Questions:

5.

How do you determine the total resistance of series connected resistors?

6.

How do you determine the total resistance in a parallel resistor network?

7.

In series resistance circuits, the sum of the voltage drops around a closed circuit is equal to:

8.

In a series circuit, what is the relationship between voltage drops across a resistor and the relative size of the resistances?

54

9.

Will three lamps connected in parallel use more or less electric power than two lamps in parallel? Prove with an example using a lamp with R = 10Ω and a supply of 10V.

10.

Will three lamps in series will use more or less power than two lamps in series? Prove with an example using a lamp with R = 10Ω and a supply of 10V.

55

LAB 7 – ELECTRICAL POWER

Objectives:

1.

Study the power relationships in an electrical circuit.

2.

Study internal resistance characteristics for a lamp.

Materials:

1 – DC Power Supply

1 – Bench multimeter

1 – Hand held multimeter

2 – 12 Volt Lamps and Sockets

1 – SPST Switch (Two Terminals)

1 – 1 Amp Fuse with Holder

Breadboard and Connecting Wires

Reference:

- Electric Circuits and Machines, Chapter 4.

Procedure:

1.

Using the DC power supply, connect circuit as shown in Figure 7-1.

1A

+

mA

DVM

+

D.C. Variable

+

V

Power Supply

Figure 7-1

2.

Apply power and set the variable DC power supply for 0 volts on your voltmeter.

3.

Complete Table 7-1 for each setting of applied voltage. Remember Units.

Table 7-1

56

ONE BULB ONLY

Applied

Current(I)

Calculated Total

Calculated Total

Voltage(E)

Resistance (R = E/I)

Power (P = EI)

2 v

4 v

6 v

8 v

10 v

12 v

NOTE: As the current in the lamp is increased, the temperature of the tungsten filament rises. This rise in temperature causes an increase in the resistance of the lamp. Most metals behave this way, changing resistance with changing temperature.

4.

Place two 12 volt bulbs in Series as per Figure 7-2.

1A

+

mA

Lamp #1

D.C. Variable

+

Power Supply

Lamp #2

Figure 7-2

5.

Complete Table 7-2 on the next page use a maximum supply voltage of 24 volts DC.

57

Table 7-2 (Both Bulbs)

Applied

Current(I)

Total Calculated

Total Calculated

Voltage (E)

Resistance (R = E/I)

Power (P = EI)

4 v

8 v

12 v

16 v

20 v

24 v

6.

Continue to use Figure 7-2 and complete Table 7-3. For each applied voltage, MEASURE AND RECORD the Voltage Drop (V1) across Bulb #1, the Voltage Drop (V2) across Bulb #2, and the current flowing through the bulbs.

58

Table 7-3

Applied

Voltage Drop

Calculate

Calculate

Current(I)

Voltage(E)

Across Each Bulb

Resistance (R = E/I)

Power (P = EI)

For Each Bulb

For Each Bulb

4 v

V1

B1

V2

B2

8 v

V1

B1

V2

B2

12 v

V1

B1

V2

B2

24 v

V1

B1

V2

B2

7.

Add the first two power figures from Table 7-3 (4 volts applied level).

Total = ____________ watts.

8.

Now compare the total power in Table 7-2 to the power figures in Step 7

(4 volt applied level).

59

Questions:

1.

Name two appliances in your home that operate by converting electricity to heat.

2.

Explain why the resistance of a bulb increased when its power increases?

3.

Write the three formulas for determining power in an electrical circuit.

4.

At the cost of 13¢ per kWH, how much does it cost to burn a 100 Watt lamp for 24

hours?

5.

Compute the power consumed:

A) I = 50 ma, E = 100 v

P = __________ W

B) I = 2 amps, R = 100 Ω

P = __________ W

C) E = 100 v, R = 100 Ω

P = __________ W

D) E = 50 v, R = 100 Ω

P = __________ W

E) I = 6 amps, E = 220 v

P = __________ W

F) I = 6 amps, R = 20 Ω

P = __________ W

60

LAB 8 – AC RESISTANCE CIRCUITS

Objective:

1.

Confirm that the same rules apply for AC and DC Resistive Circuits.

Materials:

2 – Multimeters

1 – Variable A.C. Power Source (Variac)

1 – 560Ω, 2W, 10% Resistor

2 – 1000Ω, 2W, 10% Resistor

1 – 1.2KΩ, 2W, 10% Resistor

2 – 2.2KΩ, 2W, 10% Resistor

1 – 3.3KΩ, 2W, 10% Resistor

1 – SPST Switch

Breadboards and Connecting Wires

Reference:

- Lecture notes

61

Procedure:

A.

AC SERIES RESISTANCES

1.

Using a multimeter to measure and record in Table 8-1, the individual resistances of the circuit (Figure 8-1).

Table 8-1: Component Data

Measured

Calculated

Resistance Values

Resistance Values

RT

R1

R2

R3

R4

2.

Connect the series circuit given in Figure 8-1. Before connecting the ammeter and supply, measure the total Resistance (RT) of the circuit and record in table 8-1.

R1

S1

560R

mA

F1

1A

R2

1k

65 Volts RMS

R4

R3

3.3K

2.2K

Figure 8-1: Series Circuit

3.

Now apply power and adjust the Variac for 65 Volts RMS. Read and record the total current in the circuit.

IT = ___________

62

4.

Using OHM's LAW, verify your current reading in step 2. Show your work.

Calculated IT = __________

Table 8-2: Series Circuit Data

Calculated

Measured

Voltages

Voltages

EAPPLIED

V1

V2

V3

V4

5.

Measure the applied voltage and the voltage drops across each of the four resistors. Record in Table 8-2.

6.

Using the measured current and voltage values, calculate the total resistance and the individual resistance of the four resistors. Record in Table 8-1.

7.

Using the measured values of each resistor, calculate the applied voltage and the voltage drops around the circuit. Record in Table 8-2.

63

B.

AC PARALLEL RESISTANCES

1.

Connect three resistors in parallel across the variable A.C. power source.

Insert a current meter in series with the parallel network as shown in Figure 8-2.

S1

mA

I1

I2

I3

F1

1A

30 Volts RMS

R1

R2

R3

1K

2.2K

3.3K

Figure 8-2:Parallel Circuit

2.

Now apply power and adjust power source to 30 Volts RMS. Read the total current IT. Record in Table 8-3.

Table 8-3: Parallel Circuit Data

Measured Currents

Calculated Currents

IT

I1

I2

I3

3.

Place the current meter in series with R1 as shown in Figure 8-2 (R2 and R3 still connected). Read the current through R1. Record in Table 8-3.

4.

Place the current meter in series with R2 as shown in Figure 8-2 (R1 and R3 still connected). Read the current through R2. Record in Table 8-3.

5.

Place the current meter in series with R3 as shown in Figure 8-2 (R1 and R2 still connected). Read the current through R3. Record in Table 8-3.

6.

Calculate the total line current IT and the individual branch currents for Figure 8-2. Remember to use measured voltage and resistance values.

Record in Table 8-3.

64

C.

AC SERIES-PARALLEL RESISTANCES

1.

Connect the series-parallel circuit combination to a variable AC power supply as per Figure 8-3.

R1

2.2 k

S1

mA

R2

1.2 k

R3

F1

1k

1A

R4

R5

R6

60 Volts RMS

560R 1k

2.2 k

R7

3.3 k

Figure 8-3: SERIES / PARALLEL CIRCUIT

2.

Using the step by step procedure for determining series/

parallel resistances, calculate the total resistance and total current for the circuit in Figure 8-3. Remember to use measured voltage and resistance values.

RT = ___________

IT = ___________

3.

Using the total current determined in step 2, calculate the voltage drops across each resistor in Figure 8-3 and enter their values in Table 8-4.

(Use measured resistance values).

Table 8-4: SERIES/PARALLEL CIRCUIT DATA

V1

V2

V3

V4

V5

V6

V7

Calculated Voltage Drops

Measured Voltage Drops

4.

Close switch and adjust AC power supply for 60 volts rms.

65

5.

Measure the voltage drops across each of the resistors. Record in Table 8-4.

6.

Measure the total and individual branch currents of the series-parallel circuit. Record in Table 8-5.

Table 8-5: SERIES/PARALLEL CIRCUIT DATA

Measured

IT

I1

I2

I3

I4

I5

I6

I7

Currents

66

Questions:

1.

State the formulas for finding current, voltage and total resistance in a series circuit.

2.

State the formulas for finding current, voltage and equivalent resistance in a parallel circuit.

3.

State any appreciable differences between AC resistance circuits and DC resistance circuits.

67

LAB 09 – INDUCTIVE CIRCUITS

Objective:

1.

Determine the effect that inductance has in electrical circuits.

Information:

LENZ's LAW: A changing value of current in a coil induces a Counter EMF or back EMF, which opposes the change of current.

In DC circuits, the effects of inductance occurs only when there is a change in current value, such as turning the circuit "on" or "off". In AC circuits, the current is constantly changing its value and a counter emf is continuously present which opposes the applied source voltage and thus the current flow. Inductance may be defined as that "property of a circuit which resists a change in current flow".

The inductors used in this lab are rated for 7H at full current. We use less current then that maximum during this lab. The calculations performed in this lab will indicate an inductor of a larger value. A large error when determining the value of the inductor is expected.

Materials:

1 – Handheld multimeter

1 – Bench top multimeter

1 – Variable DC Power Supply

1 – 7 Henry Coil (Choke)

1 – 500Ω Variable Resistor or 1kΩ Variable Resistor

1 – switched power cord with fuse

1 – SPST Switch

1 – SPDT Switch

1 – Variable AC Power Source (Variac)

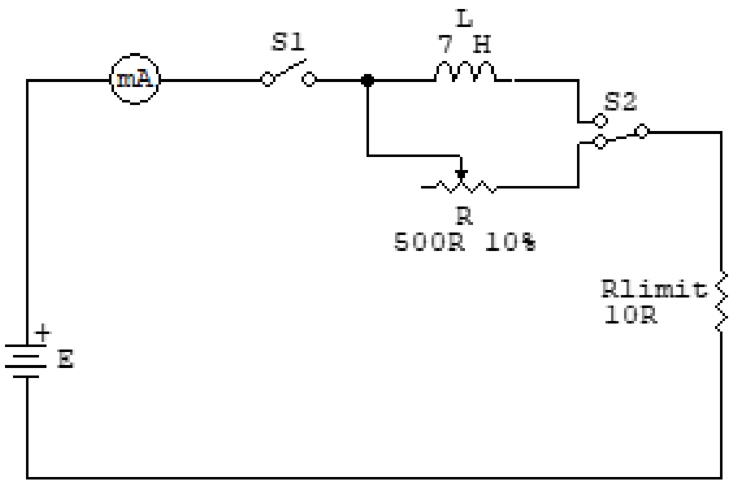
1 – Breadboard and Connecting Wires

1 – 10 Ohm Resistor

Reference:

- Lecture notes

68



Procedure:

A.

EFFECT OF A COIL (CHOKE) IN A DC CIRCUIT

1.

Measure and record the resistance of the 7 Henry Coil (choke).

Rcoil = ____________ ohms

2.

Adjust the 500 OHM POT (variable resistor) to have the SAME resistance as the 7 Henry Choke.

Rvariable = ___________ ohms

3.

Connect the circuit according to the schematic in Figure 09-1.

Figure 09-1

HAVE INSTRUCTOR CHECK BEFORE PROCEEDING.

4.

Adjust switch S2 so the variable resistor R is in the circuit.

5.

Close the S1 switch. Turn power on and adjust the DC Power Supply for 10 volts DC.

6.

Read and record the current through the variable resistor.

DO NOT VARY SUPPLY VOLTAGE.

Iresistor = ________________________

7.

Adjust switch S2 so that the coil is in the circuit. The voltage across the coil should be the same as was across the resistor. Record the voltage E.

E = ___________ Volts

8.

Measure and record the current flowing through the coil.

Icoil = ______________________

69

B.

EFFECT OF A COIL IN AN AC CIRCUIT

1.

Connect the schematic circuit in Figure 09-2. Use an isolation transformer and a variac for the AC source, AC line cord with an inline fuse for F1 and ensure the DMM is set for AC current measurement.

L

S1

7 H

mA

S2

F1

1A

R

500R 10%

Rlimit

10R

10 Volts RMS

Figure 09-2

NOTE: HAVE INSTRUCTOR CHECK BEFORE PROCEEDING.

2.

Apply power and adjust the source for 10 volts AC. Record the current through the variable resistor R. DO NOT VARY SUPPLY VOLTAGE.

Iresistor = ____________ mA = ___________ A

3.

Switch the coil in the circuit, ensure the source is 10 volts AC. Record the current flowing through the coil L.

Icoil = ___________ mA = __________ A

4.

Leave the coil switched in the circuit. Adjust the source voltage to establish each of the currents shown in Table 09-1. Record the applied voltage at each current level. Make sure you do not switch in the resistor when the voltage is not 10V AC.

Table 09-1

5 mA

10 mA

15 mA

20 mA

VSOURCE (Volts)

XL = V/I (Ohms)

NOTE: Knowing the voltage across the COIL and the current through the COIL, one can calculate the COIL'S AC opposition known as inductive reactance (XL).

70

5.

CALCULATE the reactance for each current level in Table 09-1.

(XL = VSOURCE / I).

6.

Calculate the average value of XL. Using this average value, calculate the inductance of the coil in Henries. ($XL = \omega L = 2\pi f L\ \Omega$)

Questions:

1.

Drawing from the data collected during this lab, explain any difference between the amount of direct current and the amount of alternating current flowing through the coil when the supply voltage was 10V?

2.

State in your own words the property of electrical inductance.

3.

Describe an application for an inductor in either DC or AC operation.

71

LAB 10 – CAPACITORS

Objective:

1.

Determine the effect capacitance has in electrical circuits.

Information:

A capacitor consists of two parallel metallic plates separated by an insulating material called a dielectric. The dielectric may be air, waxed paper, mica, ceramic or other materials. A capacitor blocks the flow of DC, but only partially impedes the flow of AC. There are hundreds of different types and values of capacitors designed for specific applications.

Capacitance is a measure of the amount of charge which a circuit or device can store in the dielectric between two conductors when a given voltage is applied.

Capacitance is measured in Farads.

Many large capacitors retain their charge after the power has been turned off.

These capacitors should be discharged by shorting their terminals together with an insulated screwdriver or other conductor. If this is not done, these voltages may destroy test equipment and might give a shock to anyone working on the equipment.

Materials:

- 1 – Variable DC Power Supply
- 1 – Variable AC Power Supply (Variac)
- 1 – UEI DL389 Multimeter
- 1 – Benchtop Digital Multi Meter (DMM)
- 1 – 1.0μF Capacitor, 600 Volts
- 1 – 20μF Capacitor, 450 Volts (Electrolytic)
- 1 – 40μF Capacitor, 450 Volts (Electrolytic)
- 1 – Miniature Lamp and Socket
- 1 – SPST Switch
- Breadboard and Connecting Wires

Don't use fuses in the circuit for this lab. The DC supply is protected with a current limit and the Variac has the fuse built in.

Reference:

- Lecture notes.

72

Procedure:

It takes a couple of seconds for the multimeter to settle on a measured value.

You should use alligator clips to secure the terminals to capacitor. When using hand-held probes, intermittent connection may yield inconsistent results.

1.

Measure the value of the capacitors using the capacitor test feature of the UEI DL389. Capacitance is displayed as the lower value of the display in µF.

Rated Capacitor Value

Measured Capacitance

1.0 µF

20 µF

40 µF

2.

Connect the 20µF electrolytic capacitor in series with a miniature lamp across a DC power source as per Figure 10-1. (Observe the correct POLARITY when using electrolytic capacitor).

(**Do not connect shorting wire yet**).

S1

mA

L1

F1

1A

C1

+ V1

20uF

Shorting Wire

Figure 10-1

73

3.

Apply power and adjust the voltage for 10 volts. Does the lamp light?

__________. Explain.

4.

With the power still on, short out capacitor with a connecting wire. What effect does this have on the lamp?

5.

Connect the circuit shown in Figure 10-2. (Set the ammeter to AC) S1

mA

F1

L1

1A

12 Volts RMS

C1

20uF

Figure 10-2

6.

Apply AC power and observe effects on the lamp. Does the lamp light?

__________ Explain.

7.

Replace the 20µF capacitor with a 40µF capacitor. Does the lamp light?

__________ Does it glow brighter or dimmer than before?

74

8.

Connect the 20µF capacitor to power supply as per Figure 10-3.

Do not connect the shorting wire yet.

S1

mA

+ V1

C1

Shorting Wire

20uF

Figure 10-3

9.

Turn on the switch, and adjust the power supply from 0 to 15 volts DC.

10.

Measure the DC voltage across the capacitor.

11.

Keep the meter connected while you turn off the switch.

12.

Describe what happens to the voltage reading of the voltmeter when the switch is turned off.

13.

SHORT OUT the capacitor terminals with connecting wire and describe what happens to the DC voltage across the cap.

75

14.

Connect the circuit given in Figure 10-4. Set V1 at 0V.

S1

mA

+ V1

C1

20uF

Figure 10-4

15.

Adjust milliammeter to read DC.

16.

Turn down the power supply voltage to zero.

17.

Observe the current meter as you slowly increase the voltage to 15 Volts.

Does current continue to flow in the circuit? ___________

For this section, speed of change of the DC voltage is more important than the final voltage value. 25 V should be close to the maximum the DC supplies will produce. Also, the 5 V level is just a coarse target. If you are more concerned with arriving at 5 V that you are about getting there quickly you may not see the effect we are focusing on in this section.

18.

QUICKLY increase the voltage to 25 Volts and observe the direction of current flow.

State direction of flow. ___________________________________

19.

Now QUICKLY decrease the supply voltage to 5 volts and observe the direction of current flow – then continue to slowly decrease to 0 volts and observe current flow.

State direction of flow. ___________________________________

20.

Explain why in step 17 and 18 current flowed only when the voltages was Increased and Decreased:

76

Questions:

1.

What are the units that capacitors are rated in?

2.

What effect does a capacitor have on DC current?

3.

What could happen if an electrolytic capacitor were connected with opposite polarity?

4.

Which capacitor allows greater flow of AC current (smaller or larger capacitor)?

Please explain why.

77

LAB 11: TRANSFORMERS

Objective:

- Determine the relationship between the Primary side and Secondary side of a transformer by considering Resistance, Voltage and Current.
- Observe the operation of a transformer under load.
- Make proper voltage measurements in a transformer circuit.

Materials

- 1 – Hand Held Multimeter (Fluke 70 or equivalent)
- 1 – Bench Top Multimeter (Fluke 8000A)
- 1 – Transformer, Hammond 167L12
- 1 – 25Ω 75W tapped power resistor
- 1 – Switched line cord with fuse
- 2 – 12 Volt Lamp
- 1 – SPST switch
- 4 – Alligator clips for banana leads
- Misc. Connecting wires as required.

6.

FUNDAMENTALS OF ELECTRICITY

Introduction

There is a limited supply of 25Ω resistors. It is recommended that you do this lab with a partner.

Transformers are used in distribution systems to bring power from the generating stations into the customer's location. Transformers are also used in control circuits, like those found in gas appliances.

Transformers are constructed from two sets of windings called the primary and the secondary windings. These windings are wrapped around an iron core to improve efficiency.

Step-down transformers bring the voltage down to an easily managed level like 24V

AC. 24V AC controls are smaller, less expensive, and most importantly safer to work with.

If you have difficulty distinguishing between the primary and secondary windings of the transformer in this lab, please ask the instructor for assistance.

Procedures

1. Use a multimeter to measure the resistance of the primary and secondary windings of the transformer. Enter the results of your tests in the table below.

Resistance of the primary

Ω

Resistance of the

Ω

secondary

Table 1 – Transformer resistance

2. You should notice that the resistance of the primary windings is larger than the resistance of the secondary windings.

79

Primary 115 VAC 60 Hz.

Part No.	VA	Secondary (R.M.S.)		Hz
		VAC	Amps	
167L12	25	12.6 C.T.	2.0	60

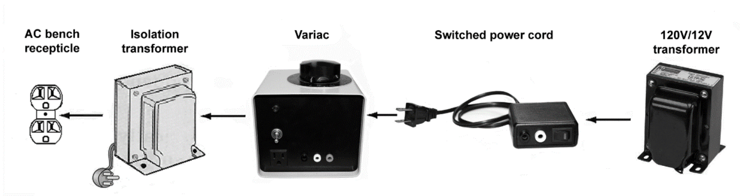
The wire used for the primary winding is longer than the secondary winding. The wire used for the primary winding is also thinner than the secondary wire.

120V

Primary

Secondary

80



3. The secondary voltage is dependent on the primary voltage and the turns-ratio.

Now we will determine the turns-ratio of the transformer.

- Connect the switched power cord to the primary side of the 120/12V transformer. Use alligator clips on the end of banana leads for this connection.
- Plug the switched power cord into the adjustable Variac transformer.
- Plug the Variac transformer into the large black isolation transformer.
- Plug the large black isolation transformer into the 120-volt receptacles located on the bench.

4. Turn the variac dial fully counter – clockwise to zero and turn on the Variac power switch.

5. Turn the Variac knob to adjust the voltage on the primary side of the transformer to the values in table 2 and record the corresponding secondary voltages.

Note: You must measure the transformer primary voltage with a multimeter while you adjust the dial, the Variac dial does not indicate output voltage.

Primary

Secondary Voltage

Turns-ratio

Voltage

60 Volts

VAC

90 Volts

VAC

120 Volts

VAC

Table 2 – Unloaded voltage measurements

6. Calculate the turns ratio for each of the rows in table 2 using the turns ratio equation below. Vp is the primary voltage, and Vs is the secondary voltage.

VP

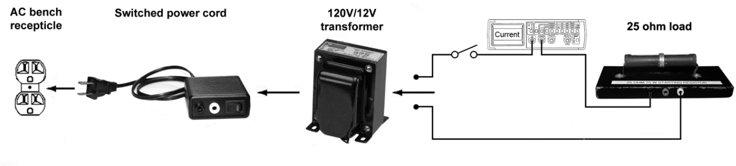
Turns R

atio =

VS

7. Turn off the power. Disconnect the Variac and place it aside.

81


AC bench
recepticle
Switched power cord
120V/12V
transformer
Current
25 ohm load

7.

FUNDAMENTALS OF ELECTRICITY

Part 2: Transformer operation under load

Transformers have small internal resistances due to transformer windings. This resistance will cause the transformer secondary to slightly decrease as the load current increases. Part two will demonstrate this fact.

1.

Connect the following circuit using the 25Ω resistor as shown in the diagram.

2.

Apply power to the circuit and open the switch (turn off). Measure the secondary voltage and current and record in table 3.

3.

Close the switch and measure the secondary voltage and current with the 25Ω

load connected and record in table 3.

4.

Reconfigure the load resistor to 12.5Ω by moving one resistor wire to the center banana jack. Measure the secondary voltage and current and record in table 3.

5.

Does the secondary voltage increase, decrease or stay the same as the load increases? Circle one choice below:

Increase

Decrease

Stay the same

Load

Secondary Voltage

Secondary Current

No-Load

0 mA

25Ω

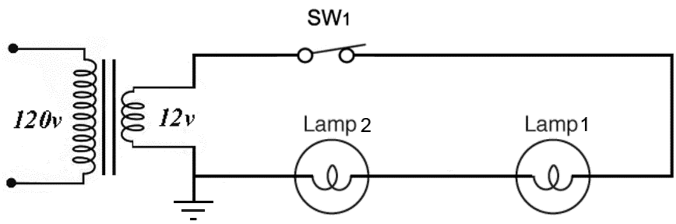
12.5Ω

Table 3: Transformer under load

6.

Table 3 will show an increase in secondary current and a small decrease in secondary voltage as the load increases.

82



Part 3: Measurements taken with and without a grounded secondary.

Do not use the isolation transformer. *Have your circuit inspected before applying power.*

Procedure

1.

Connect the following circuit, plug it into a **regular wall outlet** and turn on the

lamps. Ensure that the secondary circuit is connected to a good ground.

2.

Complete the following table of voltage measurements. When taking the measurements you must choose a proper ground reference for the multimeter.

You may use the metal conduit located on the back wall of your bench.

Measurement

Voltage

Measurement

Voltage (Volts)

(Volts)

Across primary

Across secondary

One side of

One side of

primary to

secondary to ground

ground

Other side of

Other side of

primary to

secondary to ground

ground

Bulbs to ground

Bulbs to ground with

switch on

switch off

83

3. Remove the ground from the secondary circuit and repeat the measurements.

Measurement

Voltage

Measurement

Voltage (Volts)

(Volts)

Across primary

Across secondary

One side of

One side of

primary to

secondary to ground

ground

Other side of

Other side of

primary to

secondary to ground

ground

Bulbs to ground

Bulbs to ground with

switch on

switch off

84

Questions

1.

In part 3, did the lamps light up when the ground was removed?

2.

What effect did varying the primary voltage have on the Vp / Vs ratio?

3.

What circuit requirement must be present before you are able to make accurate measurements from a transformer secondary circuit to ground?

4.

The transformer has a primary winding with 680 turns.

The secondary winding has 40 turns. The input voltage is 120 volts AC. Assuming an ideal transformer, what is the output voltage?

85

5.

Just before the electricity reaches a consumer it passes through a power transformer that reduces the voltage from 4kv to 240v. Which of the following must be true for this transformer?

a) The current is changed from direct current to alternating current b) The current is changed from alternating current to direct current c) There are more windings on the secondary coil than on the primary coil d) There are more windings on the primary coil than on the secondary coil 6.

A three-story building will use a hydronic heating system. This heating system is constructed of a number of zones. The main floor has 5 zones, the second floor has 3 zones and the third floor has 2 zones. Each zone requires a 24VAC valve and each valve draws 0.4A when it is open. Choose the appropriate transformer for each floor from the following list. Show your work!

5VA

40VA

10VA

50VA

15VA

65VA

20VA

85VA

25VA

100VA

30VA

125VA

a) main floor transformer ____________

b) second floor transformer ___________

c) third floor transformer _____________

d) If these transformers have a winding ratio of 8.7:1, what is the rated primary voltage?

86

Lab 12: Relays

Objectives:

- Work safely on electrical equipment
- Identify the terminals of a relay
- Verify operation of a Relay
- Use a relay to control a Fan and a Bulb

Materials:

- Multimeter with probes
- Control transformer; White Rogers

90-T40M1 40VA 24V

- Level 3 trainer
- Test leads as required
- Relay
- Fan Motor

Information:

Arelayisanelectricallycontrolledswitch. Theswitch(orContact)moveswhentheCoiloftherelayisenergizedorde–energized.Toenergize,theratedvoltageoftheCoilistobesuppliedtotheCoiloftherelay.

Relay Identification and Testing

1)IdentifythetworelaysontheLevel3trainer(pictureofoneoftherelayswithterminalslabelledisonthenextpage).

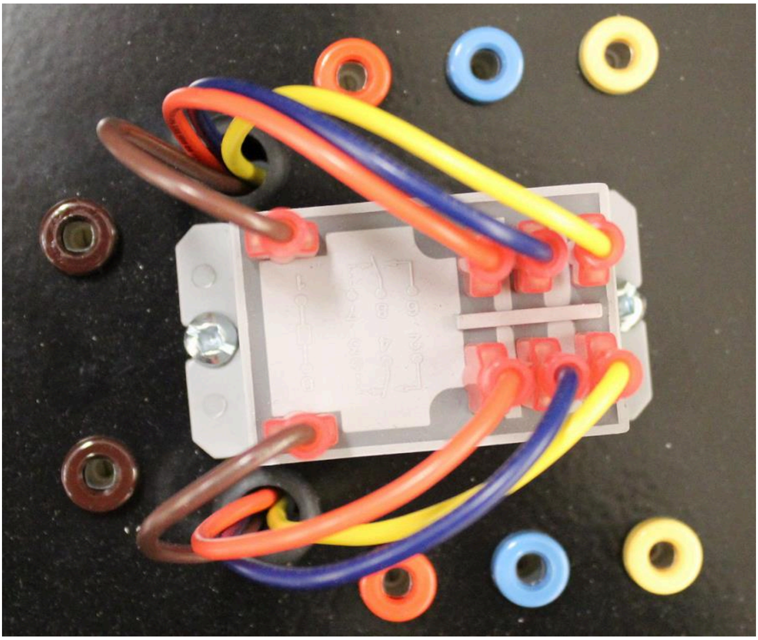
2)Examineandstudyoneoftherelays.

3)WhatisthetypeofswitchthattheCoiloftherelaycontrols(thecoilcontrols2switchesofthesametype)?

4)WhatistheCoilVoltageRatingoftheRelay?

5)WhatistheresistanceoftheCoiloftherelay(thecoilisconnectedbetweenthebrownterminals1&0)?

87



7

6

8

1

4

0

3

2

6) The Coil is not energized. In this state, what do you expect the resistance to be between terminals 7 & 8 (study the diagram on the relay)?

7) Measure the resistance between terminals 7 & 8.

8) The Coil is not energized. In this state, what do you expect the resistance to be between terminals 6 & 8?

9) Measure the resistance between terminals 6 & 8.

88

10) Identify terminals 6, 7 & 8. Which of these three terminals is Common, which is Normally Closed and which is Normally Open?

11) What would the resistance between terminals 6 & 8 be if the coil of the relay was energized?

Power supply check

12) Turn off the power switch on the left side of the trainer.

13) Remove any wires that may have been left between any connecting terminals of the trainer.

14) Plug a power cord between the trainer and a 120V wall receptacle.

15) Turn on the power switch on the side of the trainer. You should see a green indicator light turn on at the top left corner of the trainer.

If you do not see the green power indicator turn on, ask for assistance.

16) Turn off the power switch of the trainer.

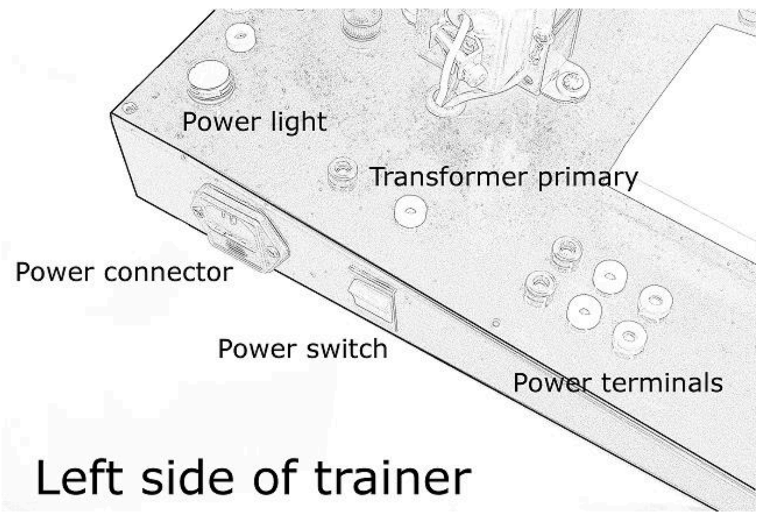
Setting up the Transformer

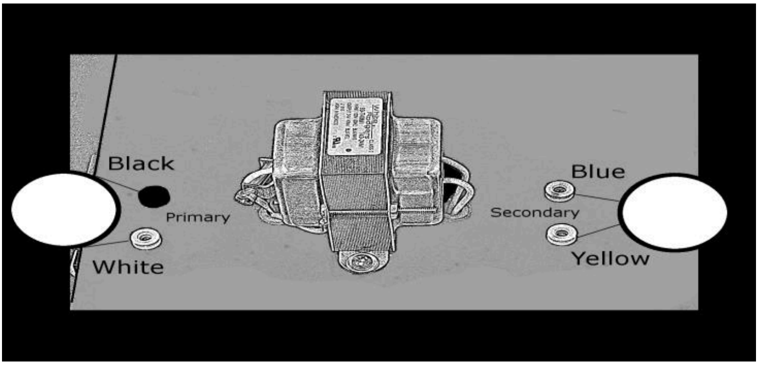
It is unsafe to touch live electrical connections, be careful when making voltage measurements.

The black and white wires of the transformer are connected to the primary coil. These wires will be connected to 120V power.

The yellow and blue wires of the transformer are connected to the secondary coil. These wires will supply 24V to the coil of the relay through the Thermostat.

89





17)Connectashortblackwirebetweenone oftheblackpowerterminalsandtheblackterminalofthetransformerprimary.

18)Connectashortwhitewirebetweenone ofthewhitepowerterminalsandthewhiteterminalofthetransformerprimary.

19)Turnonthepowerswitchontheleftside ofthetrainer.

20)Measurethevoltagebetweenthetransformerprimaryterminalsandrecordonthediagrambelow.

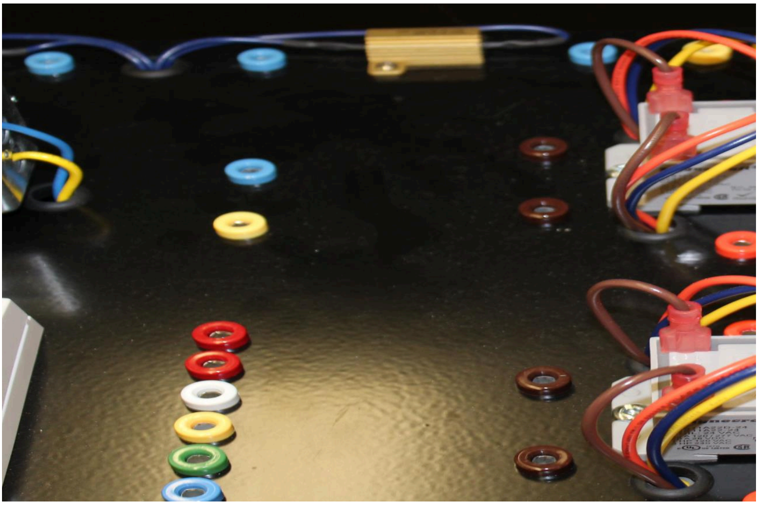
21)Measurethevoltagebetweenthetransformersecondaryterminalsandrecordinthediagrambelow.

22)**Turnoffthepowerswitch.**

23)Leavethetransformerprimaryterminalsconnectedto120V

powerterminals.

90



Energize the Coil

Ste

p 4

Ste

p 2

St

ep

3

24)Provide24VtotheCoiloftherelaythro ughthethermostat.

Thethermostatwillactasaswitchtoenergi zeandde–energizetheCoil:

25)EnsurethattheFan**Switchis'Off'ors etto'Auto'**.

26)ConnecttheYellowterminalofthesecondaryoftheTransformertothelowerRedter minaloftheThermostat(Rc)asshowninthepictureonthispage.

27)ConnecttheGreenFanterminal(G)oftheThermostattothelowerBrownterminal'0'oftherelay(Brownterminalssupplyvoltagetothe Coiloftherelay).

28)ConnecttheBlueterminalofthesecondaryoftheTransformertotheupperBrownterminal'1'oftherelay.

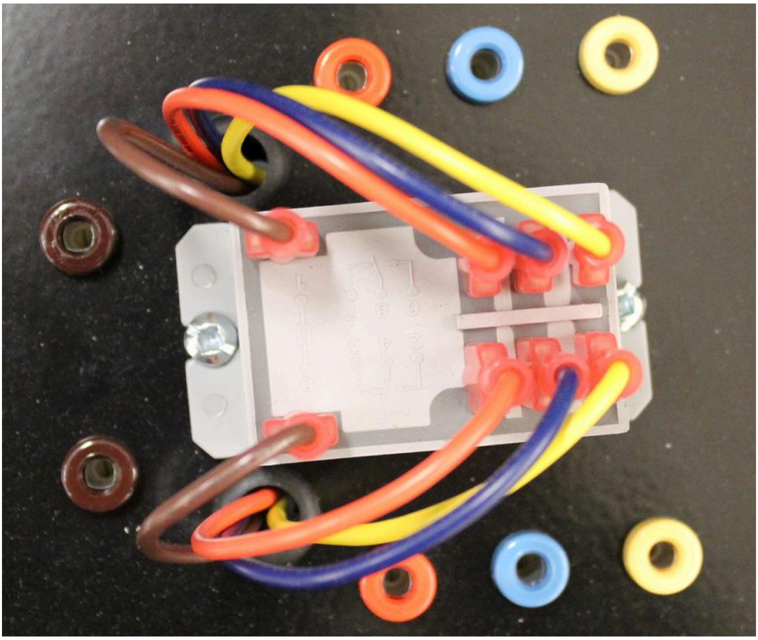
29)Turnonthe120Vpower.

30)TurntheFanSwitchto'On'.

31)TheCoiloftherelayshouldnowbeenergized.Measuretheresistancebetweenterminals6&8oftheContactoftherelay.

Doesitmatchyouanswertoquestion#11onpage#3?

91



32) Turn off the Fan switch or to 'Auto'.

33) **Turn off the 120V power switch.**

Connect the Fan

To Red Fan Wire (Step 11)

To Black Fan Wire (Step 12)

7

8

6

Terminal 8 to Black Power Terminal (Step 10)

92

ToYellowFanWire

ToGreenFanWire(Step14)

(Step13)

34)ConnectaBlackTerminal(Live)ofthePowerTerminaltotheBlueTerminal#8oftheRelay.

35)ConnecttheRedTerminal#7(NormallyClosed)oftheRelaytotheRedLowSpeedwireofthefan.

36)ConnecttheYellowTerminal#6(NormallyOpen)oftheRelaytotheBlackHighSpeedwireofthefan.

37)ConnecttheWhiteterminal(Neutral)ofthePowerTerminaltotheYellowNeutralwireofthefan.

38)Connectthe**Green,ground,terminalfromthepowerterminals**totheGreen,ground,wireofthefan.

39)Turnonthe120VPowerSwitch.

40)IstheFanrunningonlowspeed?

41) Turn the Fan Switch to 'On'.

42) Is the Fan now running on High Speed?

43) **Turn off the 120V Power Switch.**

44) Turn the Fan Switch off or to 'Auto'.

45) Disconnect all the wires.

46) Return equipment, answer the following questions.

93

Questions

1. What is the resistance between the C and NC contacts when the coil of a relay is not energized?

2. What is the resistance between the C and NC contacts when the coil of a relay is energized?

3. What value of voltage should be supplied to the coil of a relay to energize it?

a. 120V.

b. Whatever the contact rating is.

c. Whatever the coil voltage rating is.

d. 12V.

4. If a 12V AC relay coil is connected to 12V DC would you expect the coil to draw more or less current than if it was connected to an AC supply?

5. Record the coil and list of contact ratings for the relays used in this lab.

94