EELE 354 Lab Assignment 5: Fuse and Ground Fault Current Interrupter (GFCI) Operation

Lab Overview:

In electrical circuits, it is often necessary (either through code or just good safety practice) to have protection devices in place to reduce the risk of electric shock to a human and electric shorts which can damage equipment. In this lab you will learn about the operation of two types of electrical protection devices, the fuse and the ground fault current interruptor (GFCI). The fuse is essentially a low-valued resistor which melts (fuses) when too much current is drawn through it. Thus, the fuse is a "one-off" device that must be replaced once it has "blown," or melted.

The GFCI is a device which detects when current is flowing from a circuit into an unintended path to ground. This device operates by comparing the current supplied to a circuit through the phase (hot) wire to the current returning from the circuit through the neutral wire. If an imbalance is detected, i.e. the two currents are not the same, then the GFCI disconnects the circuit.

In this lab, you will study and observe the operation of both the fuse and a GFCI. In the case of the fuse, you will use pieces of soldering wire which melt under over current conditions to simulate the operation of a fuse. In the case of the GFCI, you will use a potentiometer to vary the "leakage" current flowing out of the GFCI protected circuit. In both cases, you will observe the relationship between the current conditions (short or leakage) and the operation of the protection devices.

Objectives:

The objectives of this laboratory assignment are:

- Observe the basic operation of two circuit protection devices: the fuse and the GFCI.
- Observe and study the relationship between time, current magnitude and fuse operation.
- Observe and study the relationship between leakage current and GFCI operation.
- Learn the safety benefits of the two circuit protection devices.

Pre-lab Assignment:

Read through the entire lab assignment. Draw the schematic diagram of the circuit required for completing item 3 of the lab experiment on the next page.

Draw schematic here:

Lab Experiment Part I: The Fuse

1. At the terminals of the 120 Vac supply at your workbench, measure the voltage between the following terminals:

   Black and white, V_{bw} = __________ V

   Black and green, V_{bg} = __________ V

   White and green, V_{wg} = __________ V

2. From the above readings determine which terminal is connected to the phase (hot) wire, which terminal is connected to the grounded conductor wire, and which terminal is connected to the equipment grounding conductor (EGC) wire? Explain.

3. Connect a piece of soldering wire in series with the 100 Ω resistor on your workbench to the 120 Vac supply. Additionally, connect a power analyzer in the circuit to read the line current and source voltage. **Have your lab instructor check your circuit prior to energization.**

4. Energize the circuit.

5. Once your circuit is approved, turn on the single-phase 120 Vac power supply. For each of the resistance values in the table below, measure the current flow through the wire and the time it takes for the wire to melt (measure from the moment the circuit is energized). Additionally, for each resistor value, calculate the parameter,

   $$A = t_{fuse} I_{meas}^2$$

   Once all measurements have been taken, calculate an average value for A. **Note: You will have to combine resistors in parallel to achieve some of the values.**

R_{load}	I_{meas}	t_{fuse}	A
100			
50			
33.3			
25			
20			
14.3			

A_{avg} ____________

6. **Disengage the circuit and disassemble your circuit.**

7. Draw a graph of t_{fuse} versus I_{meas} (with current on the x-axis) on the graph papers supplied by your instructor. Note, one of these papers allows for a log-log plot. On this log-log plot, extrapolate the curves on both sides of the time-axis from 0.1 sec to 100 sec. Draw conclusions.

8. The magnitude of the current and fusing time are approximately related by the expression $A = t_{meas} I_{fuse}^2$ where A is a constant. Is this what you find in the results of your experiment? What are the units of A. Is A_{avg} a good estimate to use? Explain answers.

Lab Experiment Part II: The GFCI

For the second part of the lab, you will test the characteristic of an outlet equipped with a GFCI. There are four terminals coming out of the outlet: the black (hot), white (neutral), green (ground), and the red terminal.

9. Measure the resistance between the black and red terminals.

$$R_{br} \underline{\hspace{3cm}} \Omega$$

10. Measure the maximum resistance of the potentiometer available at your workbench.

$$R_{max} \underline{\hspace{3cm}} \Omega$$

11. Connect the potentiometer between the red and green terminals. Measure the resistance between the black and green terminals.

$$R_{bg} \underline{\hspace{3cm}} \Omega$$

12. Connect the bulb available at your workbench between the black and white terminals.

13. Draw the schematic diagram for the outlet-bulb combination. Assume a 120 Vac supply is connected between the black and white terminals. **Have your instructor inspect your schematic.**

14. Calculate the leakage current that you expect to flow between the hot and ground terminals.

I_{leak} ___________A

15. Now connect the outlet to the 120 Vac supply. **Have your instructor check your circuit and then energize when approved.** If the GFCI doesn't trip, slowly decrease the resistance of the potentiometer until the GFCI trips.

16. Measure the resistance of the potentiometer and estimate the leakage current required to cause the GFCI to trip.

R_{pot} ___________Ω, I_{trip} ___________A.

Lab Questions:

1. Based on your experience with the first part of the experiment, what is the difference between a slow-blow and a fast-blow fuse that have the same current rating?

2. Based on your experience in the second part of the experiment, explain what I_{trip} is

3. Which wire(s) of the power lines are required to be protected against overloads and short circuits, i.e. hot wire, neutral wire, ground wire, or a combination of them all?

4. According to the National Electric Code (NEC), receptacles in which areas of dwellings are required to be protected by a GFCI? Speculate as to why that is.

Name and initial of lab partners:

Lab Partner 1: ________________________________

Lab Partner 2: ________________________________

Lab Partner 3: ________________________________