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Date: September 2, 2019
Professor Steven Gillette

Abstract
Using a breadboard, transformer, 10kΩ resistor, and a 12V lamp, I constructed the circuit below to demonstrate effects of currents across the lamp and as measured with a digital multimeter. I calculated current values in different voltage scenarios and answered questions regarding the effects of current through the human body. I observed that when there is no difference in electrical potential, the lamp does not light up and when there is an electrical potential difference across the power source, the lamp does light up. Additionally, I learned that even small currents can hurt the human body and it is best to be mindful of safety procedures when working with electricity.

Introduction
Learning Objectives

- Build a simple electrical circuit to demonstrate shock current paths
- Test the electrical circuit to identify potential shock current paths
- Calculate shock currents encountered in typical industrial facilities

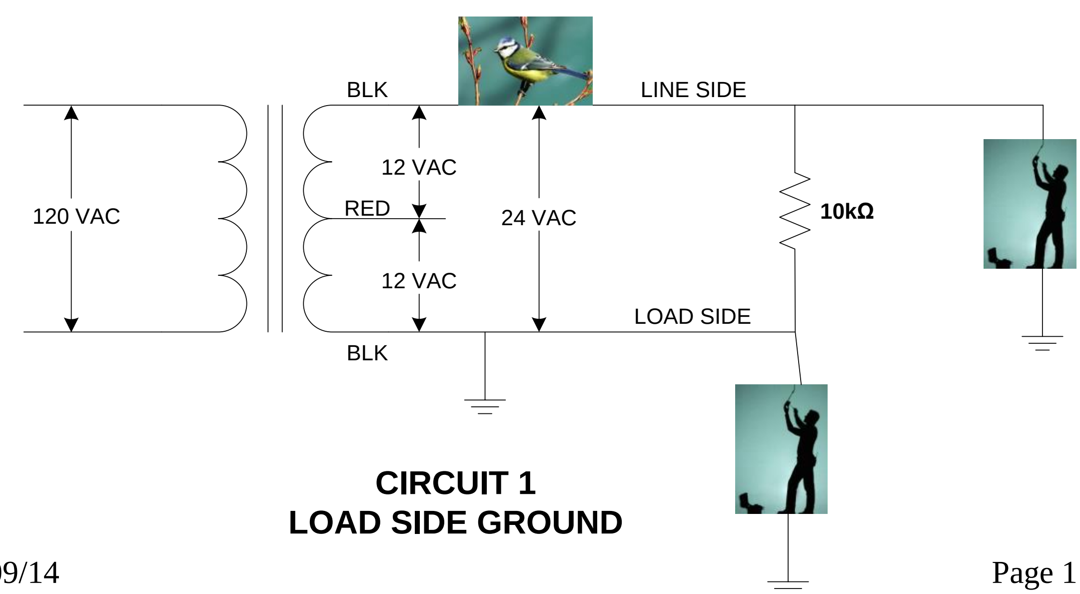
Materials

We substituted a 12V lamp where a 24V lamp was called for in this experiment.

Quantity	Description
1	120 / 12-24 VAC Center Tap Transformer
1	12-volt lamp
1	10kΩ resistor
1	Digital multimeter

Setup – General

1. Connected a 10K Ω resistor between the two secondary sides of the transformer, as shown in Circuit 1 below.



CIRCUIT 1
LOAD SIDE GROUND

Setup – Circuit 1

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2. ***Grounded one side of the circuit*** [1] as shown in Circuit 1 above. (Ran a wire from one power buss and secured it beneath a sheet metal screw on the transformer casing.)
3. ***See signature in Appendix A – Lab Notes and Signoff***
4. Energized the transformer primary windings by plugging it into a 120 VAC circuit and closed the transformer power switch.
5. Verified with the multimeter 24 VAC ± 3V between the two outermost transformer taps. Verified with the multimeter 12 VAC ± 2V between the outer taps and the center tap.

[1] Note; the grounded side of the circuit that is always considered as the load side of the circuit.

Activities – Circuit #1

1. Used a 12-volt lamp to simulate the bird in contact with a single point of electrical potential (both feet on one wire). Answer the following questions.

a. Does the bird's contact with the line side result in a shock current path?	No. Both legs are at the same potential and there is no alternate circuit path. Thus, electricity won't flow through the bird.

2. Used the 12-volt lamp to simulate the Mechatronics technician in contact with the line side (hands contacting the line side and feet contacting ground)

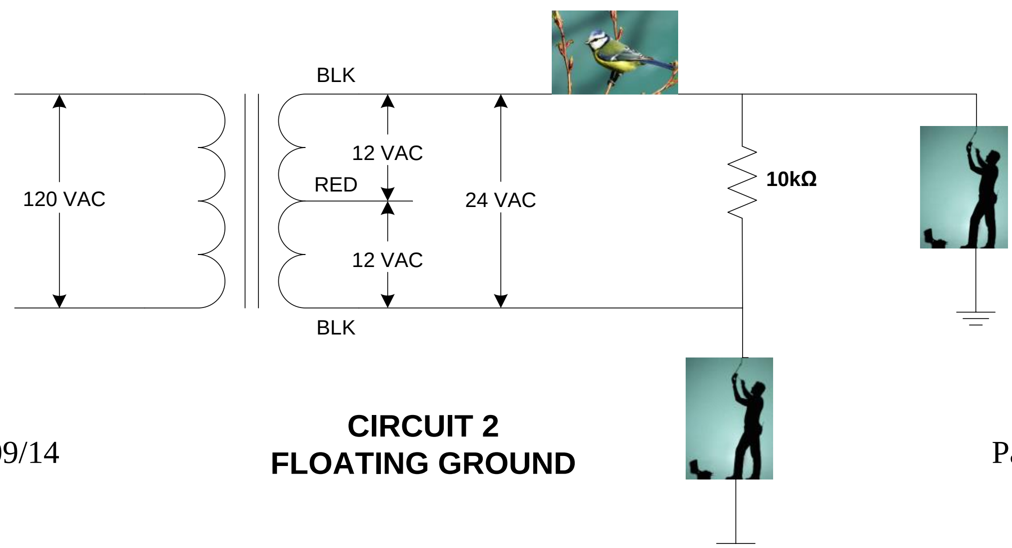
a. Does the technicians contact with the ***line side*** result in a shock current path?	Yes. The hands and legs of the Mechatronics technician are at different potentials providing a current path across the circuit at body resistance which is less resistance than the 10KΩ resistor.

3. Used the 12-volt lamp to simulate the Mechatronics technician in contact with the load side (hands contacting the load side and feet contacting ground.)

a. Does the technicians contact with the ***load side*** result in a shock current path?	No. Both legs are at the same potential and there is no alternate circuit path. Thus, electricity won't flow through the bird.
b. Calculate shock current using these electrical values. i. 120 VAC source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $I = \frac{120V}{2250\Omega}$ $I = .053A$ $\boxed{I = 53mA}$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes. Table 1 describes the effects being an extremely painful shock, breathing stoppage, muscle contractions, holding on, and death is possible.

Setup – Circuit 2

1. De-energized the circuit.
2. Removed the ground on the load side of the circuit as shown in Circuit 2 below. This circuit configuration is a ***floating ground*** system.



CIRCUIT 2
FLOATING GROUND

Activities – Circuit #2

1. Energized the circuit and used the 12-volt lamp to simulate the Mechatronics technician in contact with one side of the circuit and ground (touch one lamp lead to the transformer case.)

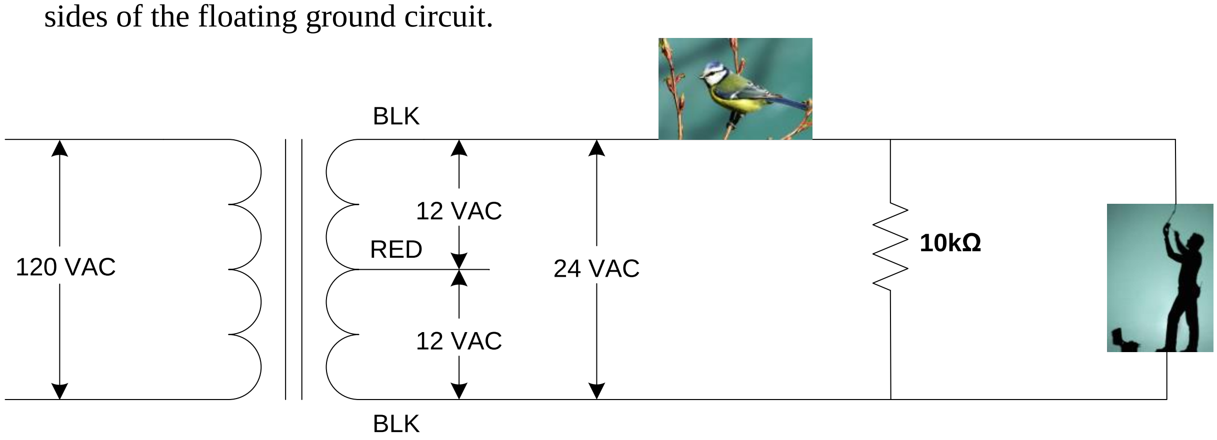
a. Does the technicians contact with one side of the circuit and ground result in a shock current path?	No. Both arms and legs are at the same potential and there is no alternate circuit path. Thus, electricity won't flow through the technician.

2. Used the 12-volt lamp to simulate the Mechatronics technician in contact with the other side of the circuit and ground (touch one lead to the transformer case.)

a. Does the technicians contact with the other side of the circuit and ground result in a shock current path?	No. Both arms and legs are at the same potential and there is no alternate circuit path. Thus, electricity won't flow through the technician.
b. Calculate shock current using these electrical values. i. 480 VAC source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $I = \frac{480V}{2250\Omega}$ $I = .213A$ $\boxed{I = 213mA}$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes. Table 1 describes the effects at least being an extremely painful shock, breathing stoppage, muscle contractions, holding on, and death is possible to more severe symptoms. 213mA is higher than the 50-150mA description, but significantly more than the 1000-4300mA description.

Activities – Circuit #3

3. Use the 24-volt lamp to simulate the Mechatronics technician in contact between the two sides of the floating ground circuit.



CIRCUIT 3
FLOATING GROUND

a. Does the technicians contact between the two sides of the circuit result in a shock current path?	Yes. The hands and legs of the Mechatronics technician are at different potentials providing a current path across the circuit at body resistance which is less resistance than the 10KΩ resistor.

b. Calculate shock current using these electrical values. i. 12,000 -volt source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $I = \frac{12000V}{2250\Omega}$ $\boxed{I = 5.3A}$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes. Table 1 describes ventricular fibrillation, muscle contraction, nerve damage and death are likely.

Problems Encountered

No problems occurred during this lab.

Conclusions

This lab effectively demonstrated why birds on power lines are safe from electrical shock and similarly why Mechatronics technicians should be careful to not create a pathway for electricity to pass through them or risk injury or death from electrocution. It is therefore extremely important to follow safety procedures when working with electricity.

Appendix A – Lab Notes and Signoff

SIERRA COLLEGE	MECH 10 – Lab 02 Shock Current Path	Mechatronics Real Skills Real Jobs
Name Cayce Beames		

Learning Objectives

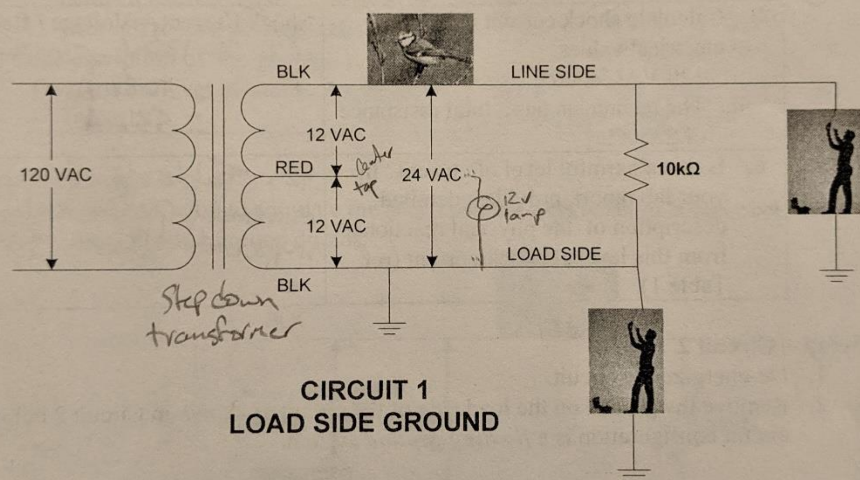
- Build a simple electrical circuit to demonstrate shock current paths
- Test the electrical circuit to identify potential shock current paths
- Calculate shock currents encountered in typical industrial facilities

Materials

Quantity	Description
1	120 / 12-24 VAC Center Tap Xfmr
1	24-volt lamp
1	10k resistor
1	Digital multimeter

Setup – General

1. Connect a 10K Ω resistor between the two secondary sides of the transformer, as shown in Circuit 1 below.



CIRCUIT 1
LOAD SIDE GROUND

Setup – Circuit 1

2. ***Ground one side of the circuit***[1] as shown in Circuit 1 above. (Run a wire from one power buss and secure it beneath a sheet metal screw on the transformer casing.)
3. ***SAFETY INSPECTION REQUIRED! Have the instructor or lab technician verify the circuit before energizing. Signature required.*** SDS
4. Energize the transformer primary windings by plugging it into a 120 VAC circuit and closing the transformer switch.
5. Verify 24 VAC ± 3V between the two outermost transformer taps. Verify 12 VAC ± 2V between the outer taps and the center tap.

[1] Note; the grounded side of the circuit that is always considered as the load side of the circuit.

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Activities – Circuit #1

1. Use a ~~24~~ 12-volt lamp to simulate the bird in contact with a single point of electrical potential (both feet on one wire). Answer the following questions.

a. Does the bird's contact with the line side result in a shock current path? ***Explain why in your lab submittal.***	no. both legs at same potential

2. Use the ~~24~~ 12-volt lamp to simulate the Mechatronics technician in contact with the line side (hands contacting the line side and feet contacting ground)

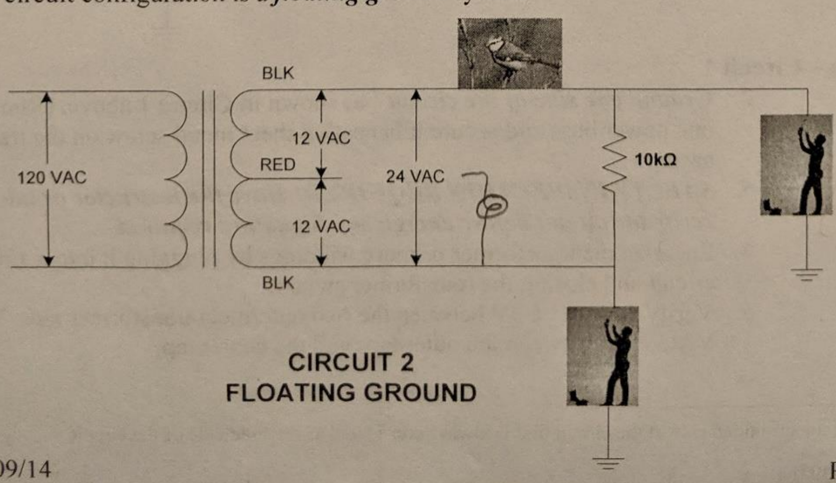
a. Does the technicians contact with the ***line side*** result in a shock current path? ***Explain why in your lab submittal.***	yes. legs are at different potential, across the circuit

3. Use the ~~24~~ 12-volt lamp to simulate the Mechatronics technician in contact with the load side (hands contacting the load side and feet contacting ground.)

a. Does the technicians contact with the ***load side*** result in a shock current path? ***Explain why in your lab submittal.***	no. Both legs are at the same potential at ground
b. Calculate shock current using these electrical values. i. 120 VAC source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $I = 120V / 2250\Omega$ $= .053\ A$ $= 53\ mA$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes, Table describes extremely painful shock, breathing stops, etc. Death is possible

Setup – Circuit 2

1. De-energize the circuit.
2. Remove the ground on the load side of the circuit as shown in Circuit 2 below. This circuit configuration is a ***floating ground*** system.



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Activities – Circuit #2

1. Energize the circuit and use the ~~24~~ 12-volt lamp to simulate the Mechatronics technician in contact with one side of the circuit and ground (touch one lamp lead to the transformer case.)

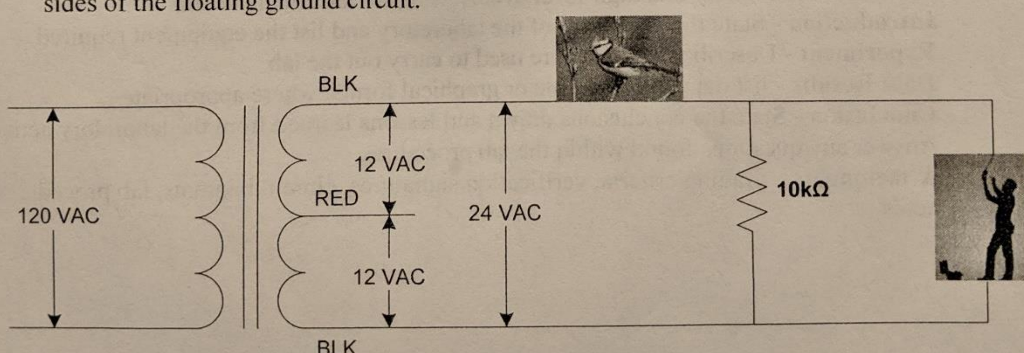
a. Does the technicians contact with one side of the circuit and ground result in a shock current path? ***Explain why in your lab submittal.***	No, both legs at same potential

2. Use the ~~24~~ 12-volt lamp to simulate the Mechatronics technician in contact with the other side of the circuit and ground (touch one lead to the transformer case.)

a. Does the technicians contact with the other side of the circuit and ground result in a shock current path? ***Explain why in your lab submittal.***	No. both legs at same potential
b. Calculate shock current using these electrical values. i. 480 VAC source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $=480V/2250\Omega$ $=.213A$ $=213mA$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes, Table describes extremely painful, breathing stops, etc. death likely. at most Fribilation & death

Activities – Circuit #3 ~~24~~ 12

3. Use the ~~24~~ 12-volt lamp to simulate the Mechatronics technician in contact between the two sides of the floating ground circuit.



CIRCUIT 3
FLOATING GROUND

a. Does the technicians contact between the two sides of the circuit result in a shock current path? ***Explain why in your lab submittal.***	Yes. legs at different potential across the circuit

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b. Calculate shock current using these electrical values. i. 12,000 -volt source ii. The technician has a total resistance of 2250Ω.	Shock Current = Voltage / Resistance. $I = \frac{12{,}000V}{2250\Omega}$ $I = 5.3A$
c. Is this a harmful level of current? In your lab report, provide a detailed description of the physical reaction from this level of shock current (ref Table 1).	Yes. Ventricular fribrillation death likely

Grading Criteria

		Points Possible	Points Earned
Documentation	Abstract, introduction, experiment, data results, conclusions neatness, clarity, spelling, grammar, completeness	**10**	
Inspection	Safety inspection completed	**5**	
Circuit Analysis	Shock currents paths identified and explained, currents calculated, documented and accurate	**10**	
Physical Reactions	Detailed description of physical reaction to shock current levels	**10**	
Conclusions	State conclusions drawn and lessons learned from the lab	**10**	
On-time submittal	Lab report is submitted in accordance with the assignment due date as posted on Canvas	**5**	
	Total	**50**	

Abstract - a summary and high-level overview of the lab and its results
Introduction - State the objectives of the laboratory and list the equipment required
Experiment - Describe the procedure used to carry out the lab
Data Results - list data taken in table or graphical format where appropriate
Conclusion - State the conclusions drawn and lessons learned from the laboratory activities. Answer any questions found within the lab procedure.
Attachments – grading criteria, verification signatures, circuit diagrams, lab procedures & notes

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Current Level	**Physical Reaction**
1 milliamp	Faint tingle.
5 milliamps	Slight shock felt. Disturbing, but not painful. Most people can "let go." However, strong involuntary movements can cause injuries.
6-25 milliamps (women) 9-30 milliamps (men)	Painful shock. Muscular control is lost. This is the range where "freezing currents" start. It may not be possible to "let go."
50-150 milliamps	Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible.
1,000-4,300 milliamps (1-4.3 amps)	Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles contract; nerve damage occurs. Death is likely.
10,000 milliamps (10 amps)	Cardiac arrest and severe burns occur. Death is probable.
15,000 milliamps (15 amps)	Lowest over current at which a typical fuse or circuit breaker opens a circuit!

Table 1