

**CLASS TEST 1 EL10A, CIRCUIT ANALYSIS
OCTOBER 22 2004**



ANSWERS

Instructions:

- 1 Answer the two (2) questions in PART ONE in the one hour provided.**
- 2 Hand in the answers to the remaining two (2) questions in PART TWO to the office by 5:00pm Monday, 25th October, 2004.**
- 3 Ensure your name is written at the top of each page.**
- 4 Answers to be written in ink. Workings may be in pencil.**

Marks

Question 1	/30
Question 2	/20
Question 3	/25
Question 4	/25
<u>Total Class Test # 1</u>	<u>/100</u>

PART ONE

Question 1: Charge, Voltage, Current, Power, Energy Sources and Laws.

Complete the following sentences:

- a. Charge is bipolar, meaning that electrical effects are described in terms of **positive** and **negative** charges. (2)
- b. Electric charges exist in discrete quantities that are integral multiples of the electronic charge, **1.6×10^{-19} C**. (1)
- c. Whenever **positive** and **negative** charges are separated, energy is expended. (3)
- d. Voltage is the **energy** per unit **charge** created by the separation. (2)
- e. The rate of **charge** flow is known as the current. (1)
- f. The passive sign convention determines the reference direction of current flow in a circuit element to be **negative** when it occurs in the direction of voltage rise. (1)
- g. The power associated with any circuit element is the **product** of the voltage across it and the current flowing through it. (1)
- h. Positive power means that power is being **delivered** to the circuit inside the box while negative power means that power is being **extracted** from the circuit inside the box. (2)
- i. An electrical source is a device that is capable of converting **chemical/mechanical** energy to electrical energy and **vice versa**. (3)
- j. There are two types of electrical sources considered in this course. They are **independent** and **dependent** current and voltage sources. (2)
- k. An **active** element is one that models a device capable of generating electrical energy. A **passive** element is one that models devices that cannot generate electrical energy. (2)
- l. State Kirchoff's two laws. Draw diagrams to illustrate. Ensure that your diagrams follow the passive sign convention (6)
- m. State Ohm's Law. Draw diagrams to illustrate. Ensure that your diagrams follow the passive sign convention. (4)

See Book for l. and m.

Question 2: Resistors in series and Parallel, Voltage and Current Dividers, Source Transformations and Superposition

2.1 Determine using the superposition principle the voltage V in Figure 2.1. Show your diagrams and your working. (7)

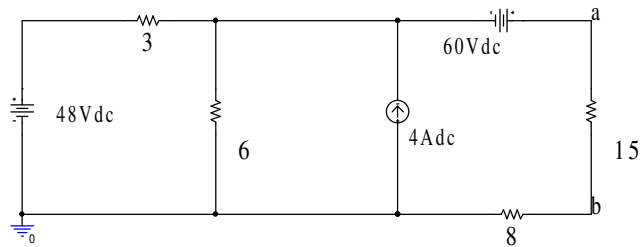
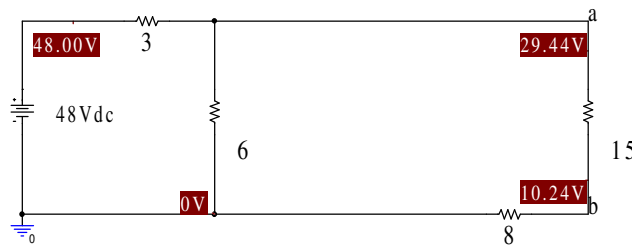


Figure 2.1

There are three circuits to solve, each corresponding to one independent source with the other two replaced by their corresponding internal resistances, short for voltage source, open for current source. The three voltages resulting are then added together.

Step1:



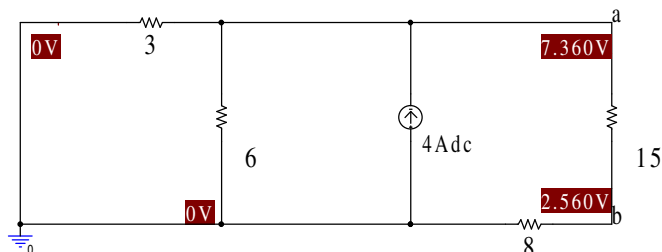
$$V_{ab}' = 29.44 - 10.24 = 19.2 \text{ Volts from PSPICE}$$

To calculate the value, you can view V_{ab}' to be the result of two voltage dividers as shown below. You could also calculate currents and apply ohm's law.

$$V_{ab}' = \frac{6 // (15 + 8)}{3 + 6 // (15 + 8)} \times \frac{15}{15 + 8} \times 48 = \frac{6 // 23}{3 + 6 // 23} \times \frac{15}{23} \times 48 = \frac{6 \times 23}{6 + 23} \times \frac{15}{23} \times 48$$

$$V_{ab}' = \frac{6 \times 15}{29 \times 3 + 6 \times 23} \times 48 = \frac{2 \times 15}{29 + 2 \times 23} \times 48 = \frac{2 \times 15 \times 48}{75} = \frac{96}{5} = 19.2 \text{ Volts}$$

Step2:



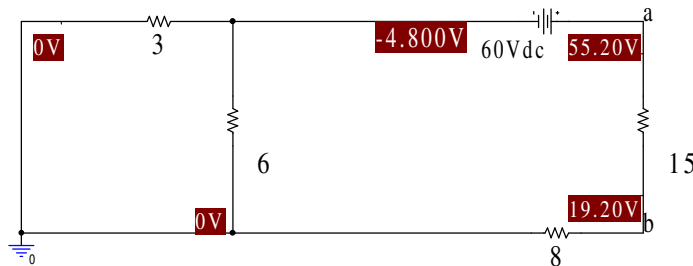
$$V_{ab}'' = 7.36 - 2.56 = 4.8 \text{ Volts from PSPICE}$$

To calculate V_{ab}'' , you can use the current divider principle and realize that the 4A will divide between 6//3 branch and the 15+8 branch according to the formula. Once

the current is calculated in the 15+8 branch, then the voltage in the 15 ohm resistor is known.

$$V'_{ab} = \frac{6/3}{6/3 + (15 + 8)} \times 4 \times 15 = \frac{2}{25} \times 4 \times 15 = \frac{120}{25} = 4.8 \text{ Volts}$$

Step3:



$$V_{ab}'' = 55.2 - 19.2 = 36 \text{ Volts from PSPICE}$$

To calculate V_{ab}'' , you can calculate the total current flowing in the circuit through the 15 ohm resistor and use ohm's law to get the voltage.

$$\text{Total resistance} = 2 + 8 + 15 = 25 \text{ ohms}$$

$$\text{Current} = \frac{60}{25} = 2.4 \text{ Amps}$$

$$V'_{ab} = 2.4 \times 15 = 36 \text{ volts}$$

$V_{ab} = \text{the sum of the 3 voltages} = 36 + 4.8 + 19.2 = 60 \text{ Volts}$

- 2.2 **Explain** in terms of the superposition principle what would happen to your result if the three sources were all doubled simultaneously, i.e. 48V became 96V, 4A became 8A and 60V became 120V. (3)

If the doubling occurred, it would be necessary to do the superposition once more resulting in a doubling of the voltage to 120 Volts.

- 2.3 **Confirm** your value for the voltage V in Figure 2.1 using source transformations. **Show** your diagrams and your working. (5)

Convert the 48Volt and the 3 ohm resistance in series into a current source of 16A in parallel with the 3 ohms.

Next, realize the 16A current source is in parallel with the 4A current source and they are equivalent to a 20A current source. Also realize that the 3 ohm resistor is now in parallel with the 6 ohm resistance and together they give 2 ohms.

Convert the 20A current source in parallel with the 2 ohm resistance to a 40Volt voltage source in series with the 2 ohms. The result is a 40Volt source in series with the 60Volt source, ie 100Volts in series with 2 ohms, 15ohms and 8 ohms.

Finally, apply the voltage divider rule to the 15 ohm resistance and get a value of $100 \times 15 / 25 = 60$ Volts.

- 2.4 **Determine** the resistance “seen” looking back into the circuit at terminals a-b with the various sources replaced by their open and short circuits as required. Draw the resulting circuit. (3)

The resulting resistance is $15 // 10 = 6$ ohms.

- 2.5 **Draw** the Thevenin equivalent of the above circuit from your results. (2)

A 60 volt source in series with 6 ohms.