X100994

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Department of Electrical Engineering

Experiment No._____ Terminal Equations of Linear and Non-Linear Passive Elements and Graphical Solutions

INTRODUCTION

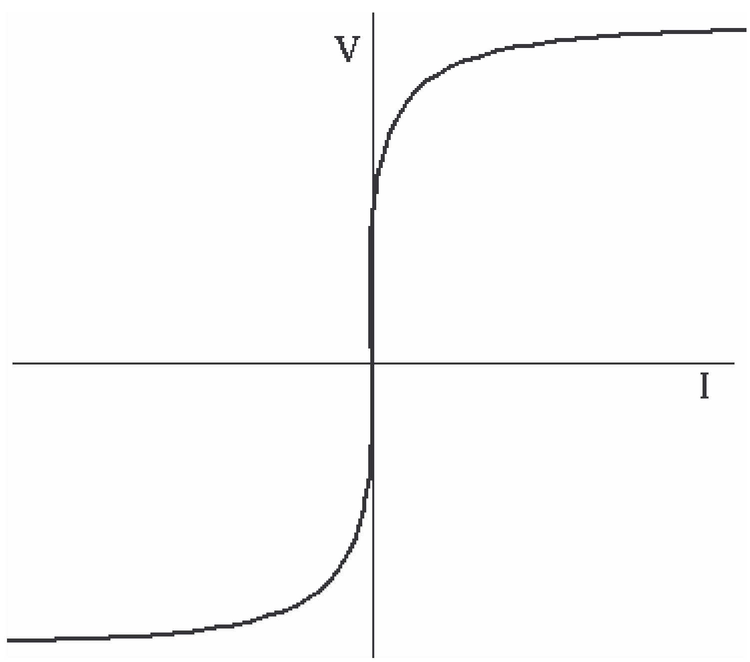
One of the primary objectives of experimental work in engineering is the determination of the terminal relation (often called the characteristics) of an element or of a component consisting of many elements. In electrical engineering, this terminal relation is usually the so-called “volt-ampere” relation. This relationship or characteristic may be obtained in the laboratory by applying a series of different values of similar voltages and recording the resulting current. The plotted result of these measurements or observations is called the volt-ampere characteristic of the element or component. The terminal equations describing the behavior of the element are evolved from these graphs. For example, if the plot of i(t) versus v(t) is linear, the element is called an R-element or a resistor. The mathematical model for this element is $v(t) = R\, i(t)$, where R is a constant and equal to the inverse slope of the graph. If the slope of the graph is not constant, then the resistor is non-linear and its model is taken as its graphical characteristic. In either case, the resistor is represented in a system graph by an oriented line segment, where the arrow indicates the direction of the current and the tail of the arrow (opposite the point) designates the positive reference of the voltage. However, if the element is non-linear, the mathematical model is generally replaced by the graphical model.

Networks involving any combination of linear or non-linear elements or components must satisfy both Kirchhoff's Voltage Equation (KVE) and Kirchhoff's Current Equation (KCE) upon interconnection. When the elements or components are all linear, it is possible to determine the variables by analytical methods. When non-linear elements are included, it is often easier to employ a graphical solution. Non-linear elements are sometimes approximated by a power series or by straight-line approximations over given regions, and analytical solutions are found. Graphical solutions are usually limited to series-parallel networks.

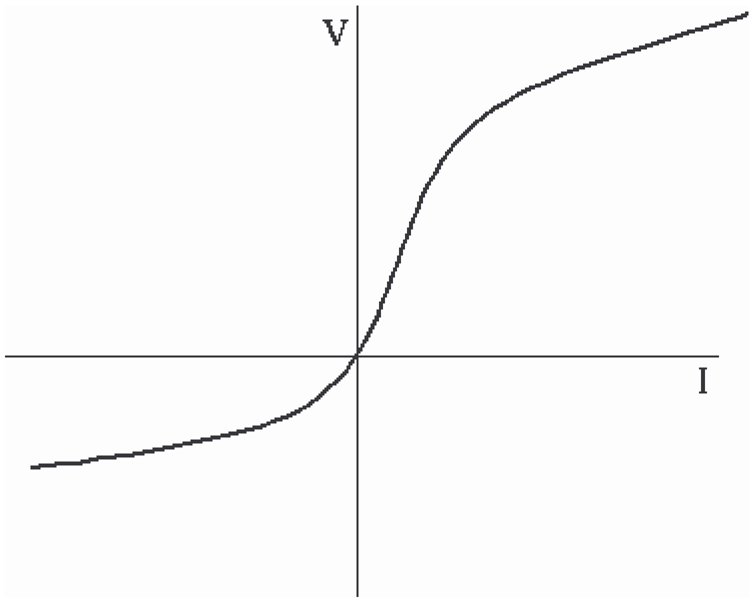
The object of this experiment is to obtain the terminal characteristics of several elements, to determine their terminal equations, and to analyze some simple networks consisting of these elements by using their characteristic graphs or mathematical models.

PRELIMINARY

P-1. If two non-linear elements are placed in series, outline a procedure to GRAPHICALLY find the resultant volt-ampere characteristics. Use a sketch to illustrate the method.



P-2. If two non-linear elements are placed in parallel, outline a procedure to GRAPHICALLY find the resultant volt-ampere characteristics. Use a sketch to illustrate the method.



P-3. Define STATIC and DYNAMIC resistance and explain how they are obtained from the volt-ampere characteristics.

Static resistance R = V/I
Dynamic(differential) resistance r = dV/dI

(INSTRUCTOR'S SIGNTURE ______________________ DATE ________)

PROCEDURE

L-1. Using the circuit in Figure 1, obtain the volt-ampere characteristics (CURRENT vs. VOLTAGE) of each of the following element connections, plotting them on the indicated graph.

DO NOT EXCEED THE RATINGS OF THE ELEMENTS!!
THINK AHEAD!!

Graph I

Connection #1: a No. 1829, 28-volt lamp
Connection #2: a 2-watt, 500-ohm resistor

Graph II

Connection #3: a No. 1488, 14-volt lamp
Connection #4: a No. 1813, 14-volt lamp
Connection #5: the above two elements connected in SERIES

Graph III

Connection #6: a No. 313, 28-volt lamp
Connection #7: a No. 1829, 28-volt lamp
Connection #8: the above two elements connected in parallel

Graph IV

Connection #9: a 2-watt, 200-ohm resistor
Connection #10: a 2-watt, 300-ohm resistor
Connection #11: the above two elements connected in series

Graph V

Connection #12: a 2-watt, 300-ohm resistor
Connection #13: a 2-watt, 500-ohm resistor
Connection #14: the above two elements connected in parallel

Graph VI

Connection #15: a No. 313, 28-volt lamp
Connection #16: a No. 1829, 28-volt lamp
Connection #17: a No. 1488, 14-volt lamp
Connection #18: a No. 1813, 14-volt lamp
Connection #19: the connection shown in Figure 2

Graph VII

Connection #20: a 2-watt, 200-ohm resistor
Connection #21: a 2-watt, 300-ohm resistor
Connection #22: a 2-watt, 500-ohm resistor
Connection #23: the connection shown in Figure 3

REPORT (should include at least the following)

R-1. Of the elements investigated, which can be considered Relements?

R-2. Of the remaining elements not considered R-elements, specify the range of voltage over which each may be considered Relements and determine the DYNAMIC resistance over that range (see Preliminary P-3).

R-3. Determine the DYNAMIC resistance of each lamp where the current is near zero.

R-4. Determine the DYNAMIC resistance of each lamp where the voltage is near maximum.

R-5. Determine the resistance of each of the R-elements from the slope of the graphs of connections #2, #9, and #10 and calculate the percent deviation of each from the manufacturer's specification. Also state whether each of them are within the manufacturer's specified tolerance.

R-6. Using the methods outline in the Preliminary report, verify GRAPHICALLY at least one point on the volt-ampere characteristics of the connections #5, #8, #11, #14, #19, and #23. THIS IS TO BE DONE ON THE RESPECTIVE GRAPHS!

R-7. Determine the total resistance of the connections #11, #14,and #23 from the slope of their respective graphs and compare the results with values determined analytically.

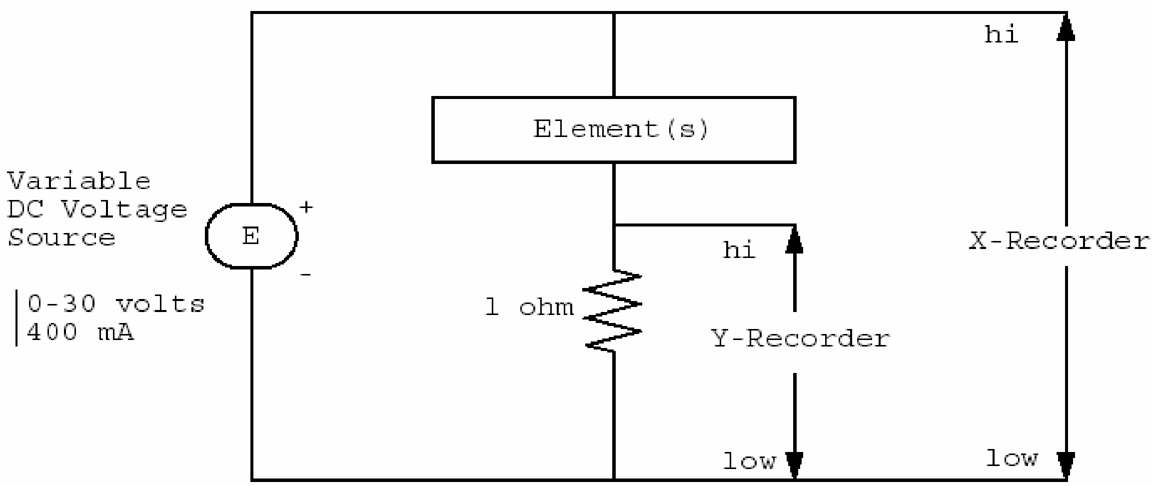


Figure 1.

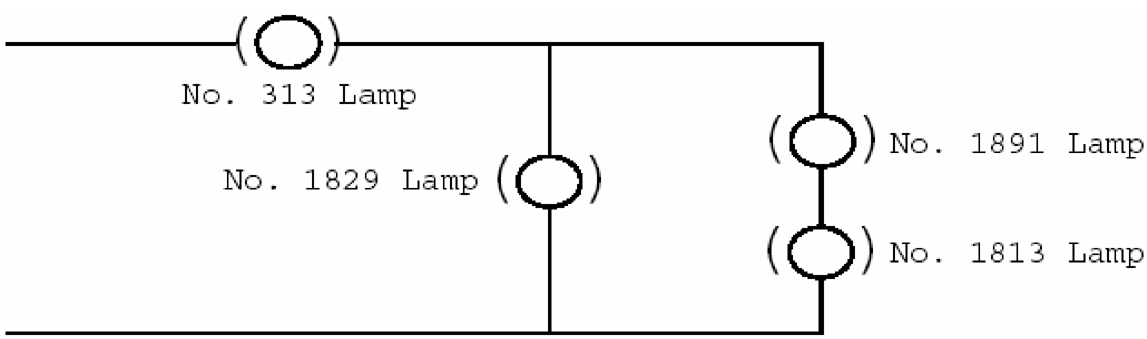


Figure 2.

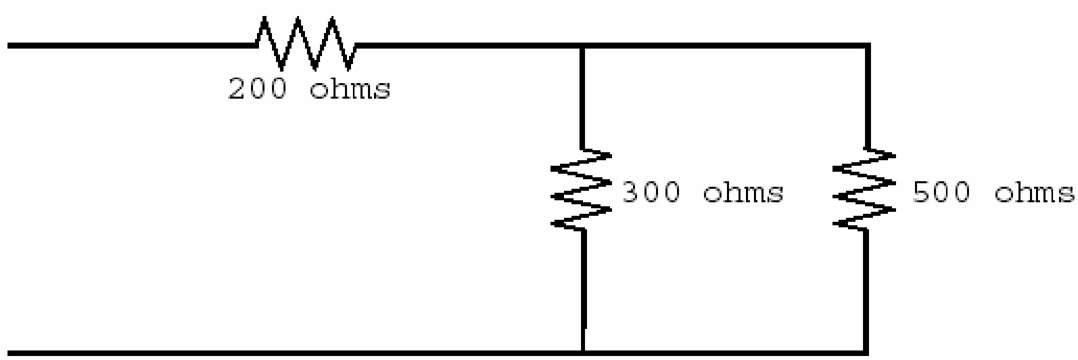


Figure 3.