

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

Department of Electrical Engineering

INTRODUCTION

Experiment No. _____ Analog Field Plots

The electric field is an artifice to explain the phenomenon of “force at a distance;” that charges placed a distance apart in a vacuum exert attraction or repulsion. The electric field intensity, E , is simply the force per unit charge at that point, i.e.,

$$\frac{\vec{F}}{Q} \equiv \vec{E} \quad (\text{Newtons/Coulomb})$$

To move a charge in the electric field of other charges requires an amount of work,

$$W = \int \vec{F} \cdot d\vec{l} = \int (Q \times \vec{E}) \cdot d\vec{l}$$

The unit of electromotive force (emf) or voltage is the “volt,” which is defined as 1 watt/ampere or 1 joule/coulomb. It has dimensions of work per unit charge, or,

$$\frac{W}{Q} \equiv \text{emf} = \frac{(\int (Q \times \vec{E}) \cdot d\vec{l})}{Q} = \int \vec{E} \cdot d\vec{l} = V$$

If E is constant or we move a small distance, d , then,

$$V \cong |\vec{E}| \times d$$

The electric field magnitude would be,

$$|\vec{E}| \cong \frac{V}{d}$$

or,

$$|\vec{E}| \cong \frac{\Delta V}{\Delta d}$$

The distance must be measured in such a manner to produce the maximum change in voltage, or, perpendicular to the equipotential surfaces. Mathematically, this operation is known as the gradient, or,

$$\vec{E} = -\text{grad}V = -\nabla V$$

An equipotential surface or line is a surface or line on which the potential, or voltage, is everywhere the same. Since any two points on the surface or line have the same potential, there is zero potential difference and therefore zero electric field everywhere along (or tangential to) the surface or line. This means that the electric field must always be perpendicular to an equipotential surface or line.

In this experiment, electric fields will be produced using resistance paper for a variety of potential surfaces. The current density, J , is actually the quantity plotted but in a conductor of conductivity s (the resistance paper),

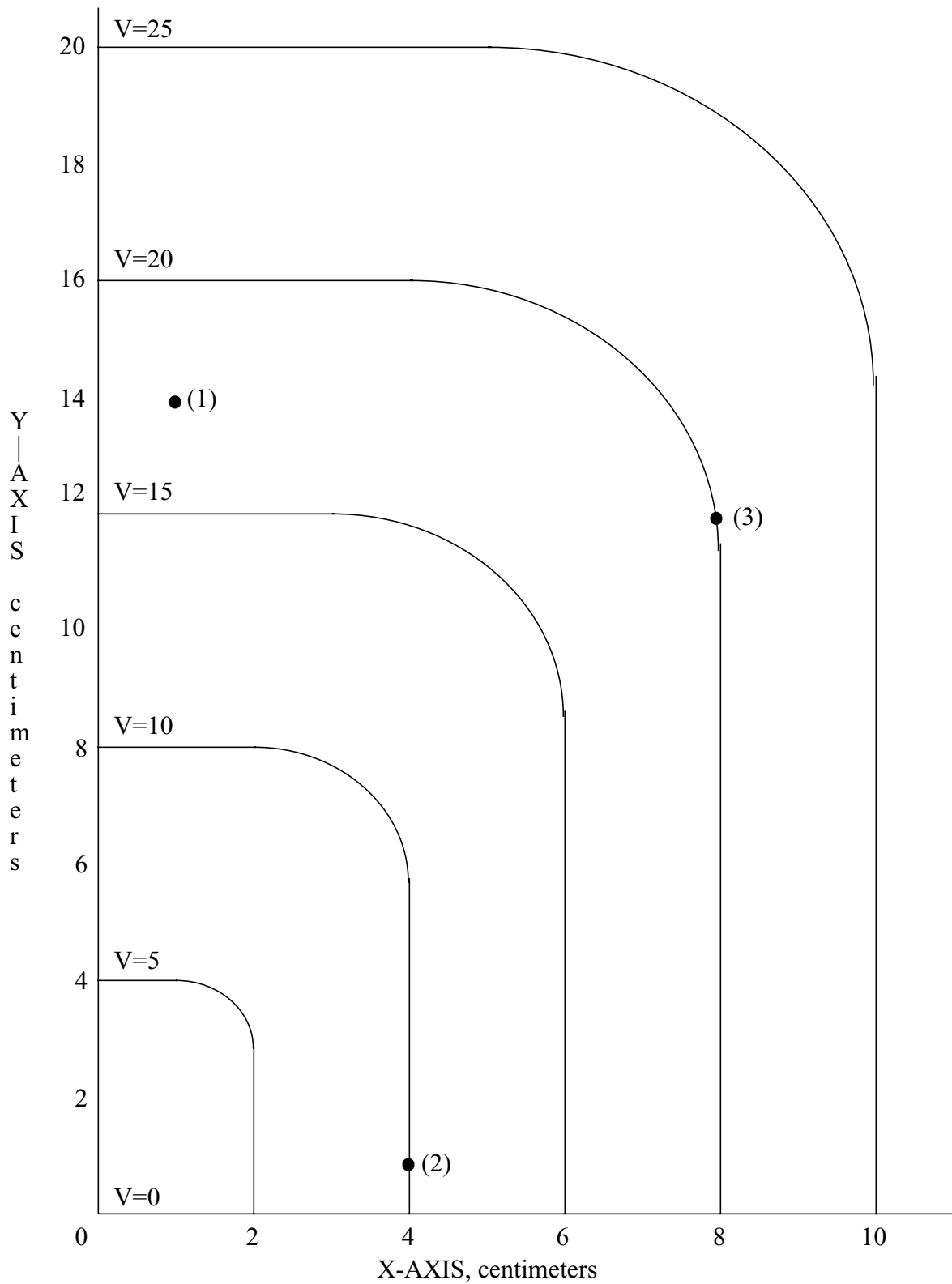
$$\bar{J} = \sigma \times \bar{E}$$

so current density is directly proportional to electric field intensity.

The purpose of this experiment is to familiarize the students with analog field plots and graphical field computations.

PRELIMINARY

- P-1. On the following field plot, draw in the electric field intensity lines that would pass through the points (1), (2), and (3). Determine the electric field intensity at these points expressing each in vector notation.



INSTRUCTOR'S SIGNATURE _____ DATE _____

PROCEDURE

- F-1. Connect one of the resistor boards as shown in Figure 1. Record the coordinates, in centimeters, of the conductors.
- F-2. Record the coordinates, in centimeters, for the equipotential lines of 5, 10, 15, 20, and 25 volts. Remember to take more points in areas where the equipotential line changes direction rapidly.
- F-3. Repeat Procedures F-1 and F-2 above for three additional resistor boards.

REPORT

- R-1. Plots the points obtained in the Procedures above on centimeter graph paper, scaling if necessary (i.e., one centimeter on the graph paper could equal to two centimeters on the resistor board). Carefully draw in the equipotential lines using a French curve if necessary to obtain a smooth plot. Label the equipotential lines as to their voltage values.
- R-2. Carefully draw in at least five electric field intensity lines. Include at least one in the areas of minimum and maximum electric intensity. Graphically determine the electric intensity at the maximum and minimum points on the graph. Express the results in vector notation.
- R-3. Discuss the results of the experiment.

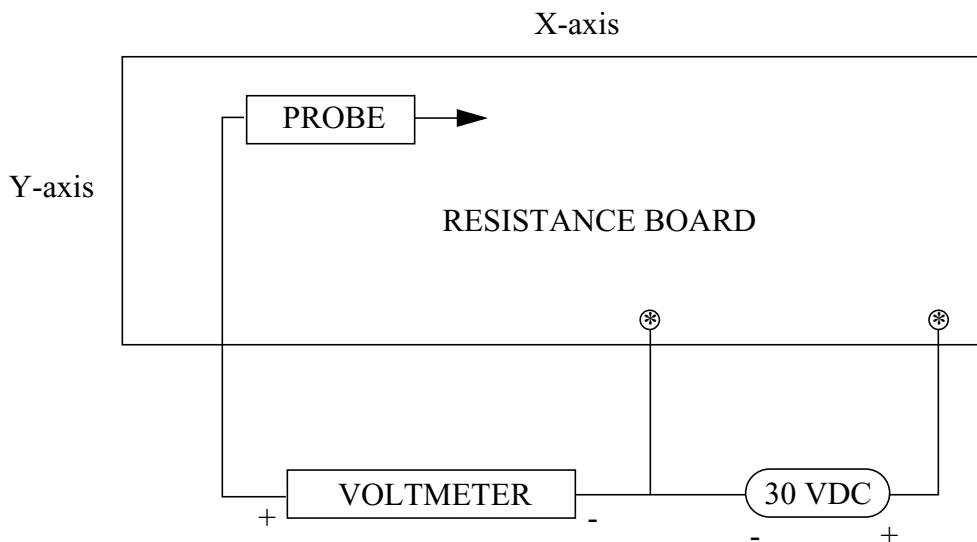


Figure 1.