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MATRIX REPRESENTATION OF GRAPHS IN ELECTRONIC CIRCUITS

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Abstract: The concept of logical connection between graph theory and analog circuit models of graph are presented in this paper. We formulate an analog electronic circuit network model based on truth table and its various components.

Keywords: Adjacent matrix, Incident matrix, Network Circuit, Electronic Circuit, Representation of Graph Models.

I. Introduction

Mathematical methods are integral to the study of electronics. Electronics has a major effect on the development of modern society. Electrons, a component of atoms and their use known as electronics play an important role in many pieces of household equipment. Basic electronics comprises the minimal "electronic components" that make up a part of everyday electronics equipment. Basic electronics also concerns the measurement of voltage, current (electron flow) and resistance in the assembled working "circuit".

Electronics is widely used in information processing, telecommunication, and signal processing. The properties of electronic circuits can be studied in the easier way with the help of graph theory nowadays it is a trend which is growing rapidly. Graph is a pair of two sets, vertex V and edge E so that $G = (V, E)$. Graphs are amenable for pictorial representation of a system using the two basic and main concepts vertex and edge. If the edges of graph direct one vertex to other, then it is called directed graph else it is undirected graph.

The association of this paper is as follows:

In this paper, we present a graph as a worthy of presenting analog circuit networks of electronic circuit. In section II we recall some useful and basic definitions of graph theory and few definitions from electronic circuit to make the analog circuit network presentable and sensible as well. Section III involves the method of representing analog circuit network as graph. Section IV contains the core concept of the paper which describes how to apply graph theory to model the analog circuit network. Section V illustrates the analog circuit network by working out the test example.

II. Definitions

1. **Circuit:** A closed network is called circuit i.e. it is the path whose end and beginning vertex are same.
2. **Electronic circuit:** An electronic circuit is a structure that directs and controls electric current to perform various functions including signal, amplification, computation, and data transfer. It is composed of individual electronic components, such as resistors, transistors, capacitors, inductors and diodes, connected by conductive wires or traces through which electric current can flow.
3. **Types of electronic circuit:** It can be categorized into three types.
   - Analog Circuit
   - Digital Circuit
   - Mixed signal circuit(a combination of analog and digital circuits)
4. **Analog Circuit:** Analog electronic circuits are those in which current or voltage may vary continuously with time to correspond to the information being represented. It is constructed from two fundamental building blocks: series and parallel circuits.
5. **Series Circuit:** In a series circuit, the same current passes through a series of components. A string of Christmas lights is a good example of a series circuit: if one goes out, they all do.
6. **Adjacent matrix:** Adjacency matrix is the $V \times V$ matrix $A(G) = [a_{ij}]$ in which a_{ij} is the number of edges joining $v_i \; and \; v_j$. Also it is defined as the square matrix whose entries are either 0 or 1 defined by $= \begin{cases} 1, & if \; v_i \; and \; v_j \; are \; adjacent \\ 0, & if \; v_i \; and \; v_j \; are \; not \; adjacent \end{cases}$
7. **Incidence matrix:** Any graph G there corresponds a $V \times E$ matrix called an incidence matrix of G. Let us denote the vertices of G by $v_1, v_2, \dots, v_n$ and the edges by $e_1, e_2, \dots, e_n$. Then the incidence matrix of G is the matrix $M(G) = [m_{ij}]$ where m_{ij} is the number of times that $v_i \; and \; e_i$ are incident.

III. Graph Representation of Analog Circuit Network

A graph can be obtained from a analog series circuit. Here we identify the graph $G = (V, E)$, where V stands for vertices and E is the set of edges. Representing graph in analog circuit network is one of type of

representation in which the current flows in the circuit present the linking connection between resistors which are in series connections and are determined in the analog circuit.

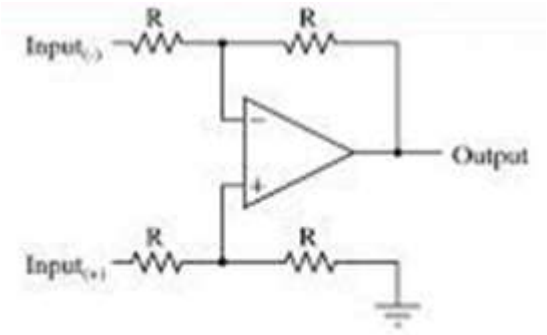

Fig 1

The schematic diagram of electronic analog circuit network

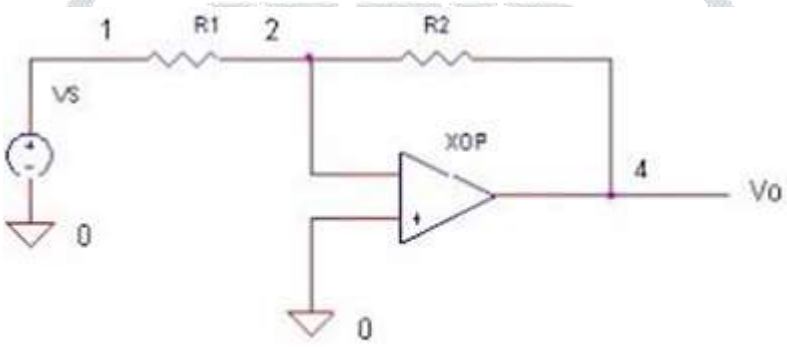

Fig 2

IV. From Analog Circuit to Graph

A graph can be obtained from the analog circuit. We identify the graph $G = (V, E)$, where V is the set of vertices and E is the set of edges. This graph model is used to represent analog circuit network by tracing the vertices of the analog circuit and edges of the given analog circuit.

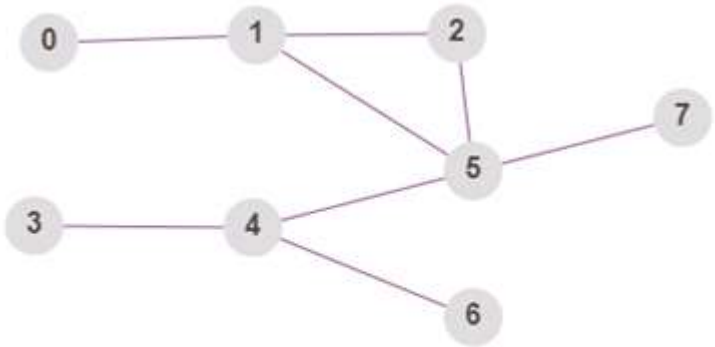

Fig 3

An undirected model representation of the analog circuit network with its edges is weight corresponding to the resistor value of each branch.

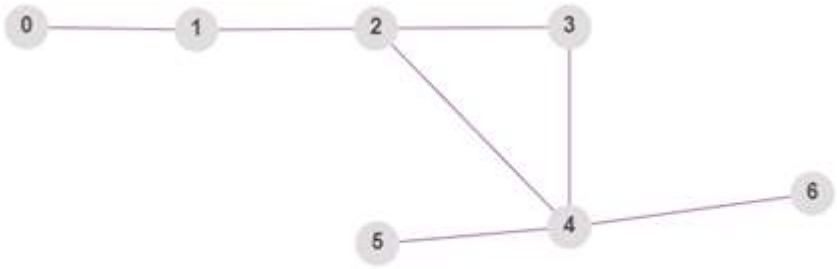

Fig 4

V. Graph Representation of Matrices

A graph can be represented using matrix method, the main and widely used matrices to represent graph are Adjacency matrix and Incident matrix.

Consider figure 1, it has seven vertices $V = \{v_0, v_1, v_2, v_3, v_4, v_5, v_6, v_7\}$ this means that the square matrix must be 8×8. Let each row and column is represented by each of eight vertices in V.

Adjacency matrix generated by 8×8 square matrix and represented by

$$G = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Incident matrix generated by 8×8 square matrix and represented by

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Also in figure 2, it has 7×7 vertices $V = \{v_0, v_1, v_2, v_3, v_4, v_5, v_6\}$ this means that the square matrix must be 7×7. Let each row and column is represented by each of seven vertices in V.

Adjacency matrix generated by 7×7 square matrix and represented by

$$G = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

Incident matrix generated by 7×7 square matrix and represented by

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

VI. Conclusion

In this research paper, the methodology of graph theory matrix approach and its applications have been reviewed. The potentiality of graph theory of matrix approach is proved in the field of analog electronic circuits. Graph theory is very interesting concept in Mathematics due to its numerous applications in the fields of science and engineering course especially in electronic and electrical, computer engineering and in communication industry.

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