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Using Matrix Method for the Application of Graph Theory to Electrical Circuits

Poorva V. Adhyapak[1]
[1](*Department of Mathematics, KLS Gogte Institute of Technology, "Jnana Ganga", Udyambag, Belagavi, Karnataka, India)*

Abstract: *In this paper we present a circuit network in the concept of application of graph theory and circuit models of graph are represented in logical connection by using truth table. We formulate the matrix method of adjacency and incidence of matrix followed by application of truth table.*
Keywords: *Adjacent Matrix, Network Circuit, Electrical Circuit, Representations of Graph Models.*

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I. Introduction

The electrical circuits are the main building blocks of electrical appliances. Graph theory has great influence and impact in most of the fields. The properties of electrical 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 [1]. In this paper, we present graph as a worthy way of presenting circuit networks of electric circuit. In section II we recall some useful and basic definitions of graph theory and few definitions from circuit to make the circuit network presentable and sensible as well. Section III involves the method of representing circuit network as graph. Section IV contains the core concept of the paper which describes how to apply graph theory to model the circuit network. Section V illustrates the circuit network by working out the test example.

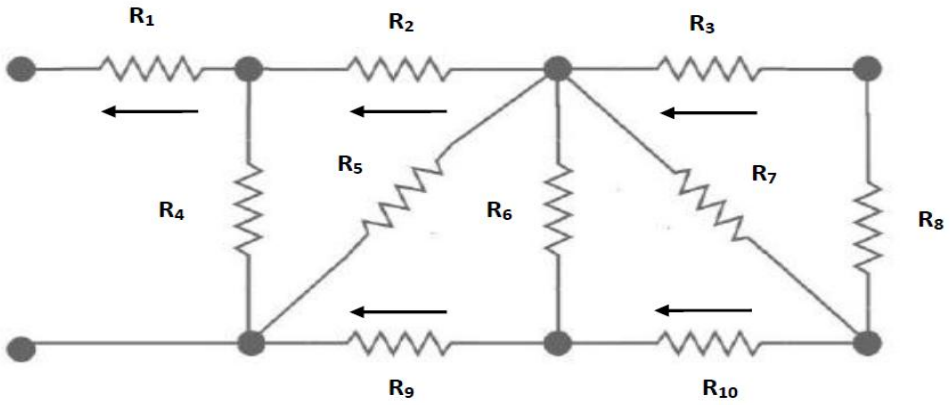
II. Definitions

1) Circuit: A closed network is called circuit i.e. it is the path whose end and beginning vertex are same.
2) Electric circuit: An electric circuit is a closed loop containing source wire, load, and switch. The electric circuit is said to be on when its switch is turned on and current flows from negative terminal of power source.
3) Types of electrical circuits: Series, parallel and series and parallel circuit are the types of electric circuits.
4) Euler graph: A graph is said to be Eulerian if it covers all the edges of the graph.
5) Euler circuit: Euler circuit in graph $V = (V, E)$ is a closed path containing every edge of $G = (V, E)$.
6) Euler path: Euler path in a graph $G = (V, E)$ is a path containing every edge of $G = (V, G)$.

III. Graph Representation of Circuit Network

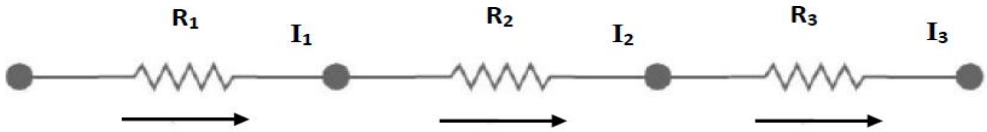
A graph can be obtained from a circuit. Here we identify the graph $G = (V, E)$, where V stands for vertices and E is the set of edges. Representing graph in circuit network is one of type of representation in which current flows in the circuit present the linking connection between resistors which are in series and parallel connections and are determined in the circuit [2].

Figure 1



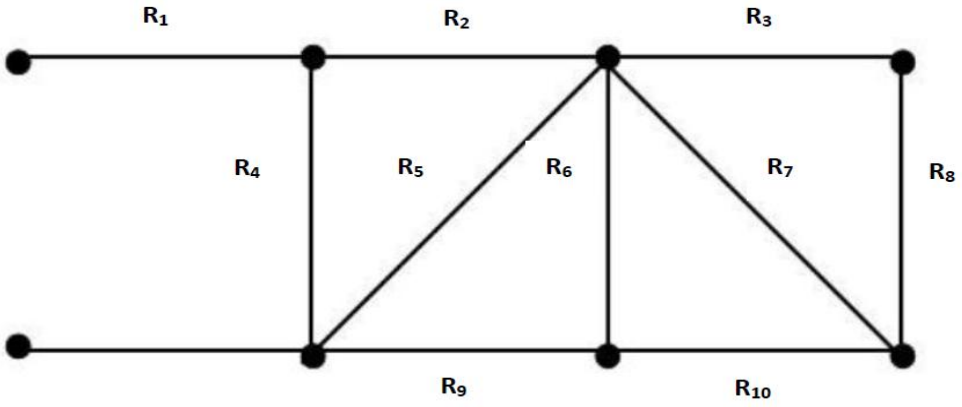
The schematic diagram of electric circuit network

Figure 2

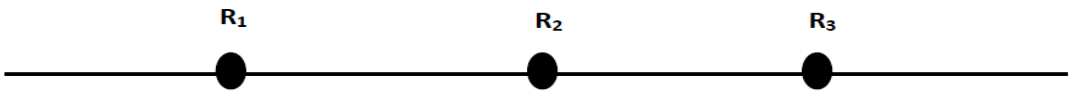


IV. From Circuit to Graph

A graph can be obtained from the 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 circuit network by tracing the vertices of the circuit and edges of the given circuit.



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



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.

Let V_i and V_j be any two vertices of graph G . Adjacency matrix of the graph G denoted by $A(G)$ is defined as the square matrix whose entries are either 0 or 1 defined by

$$a_{ij} = \begin{cases} 1, \ if \ V_i \ \& \mathrm{V_j} \ are \, adjecent \\ 0, \ if \ V_i \ \& \mathrm{V_j} \ are \, not \, adjecent \end{cases}$$

Consider figure 1, it has ten vertices. $V = \{R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{10}\}$ this means that the square matrix must be 10×10.Let each row and column is represented by each of ten vertices in V .

Logical Truth table

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	0	1	0	1	0	0	0	0	0	0
R_2	1	0	1	1	1	1	1	0	0	0
R_3	0	1	0	0	1	1	1	1	0	0
R_4	1	1	0	0	1	0	0	0	1	0
R_5	0	1	1	1	0	1	1	0	1	0
R_6	0	1	1	0	1	0	1	0	1	1
R_7	0	1	1	0	1	1	0	1	0	1
R_8	0	0	1	0	0	0	1	0	0	1
R_9	0	0	0	1	1	1	0	0	0	1
R_{10}	0	0	0	0	0	1	1	1	1	0

Adjacent matrix generated by 10×10 square matrix and represented by

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

Also in figure 2,it has three vertices $V = \{R_1, R_2, R_3\}$ this means that the square matrix must be 3×3. Let each row and column is represented by 10 vertices in V [3].

Logic Truth table

	R_1	R_2	R_3
R_1	0	1	0
R_2	1	0	1
R_3	0	1	0
R_4	1	1	0

R_5	0	1	1
R_6	0	1	1
R_7	0	1	1
R_8	0	0	1
R_9	0	0	0
R_{10}	0	0	0

The adjacent matrix generated by 3×3 square matrix and is represented as

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

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 electrical circuits. Graph theory is very interesting concept in Mathematics due to its numerous applications in the fields of manufacturing, management, product design, cost analyses, education sectors, maintenance, hydraulic systems, software engineering, operational research and various fields of science and engineering course especially in electrical, computer engineering and in communication industry.

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