

The Study Of Kirchhoff Law And Inverse Matrix For Electrical Network Solutions

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Abstract - In this study the electricity network discussed was a very simple electricity network using Matlab. Matlab makes it easy for users to find assistance in connection with all the facilities provided by Matlab. For example, help on how to start Matlab for the first time, programming tricks, creating 2 and 3-dimensional graphics, using data acquisition tools, signal processing, solving partial differential equations. Power grid problems can be solved using elementary line operations and besides being solved by using elementary line operations, electricity networks can also be solved using inverse matrix

Keyword : *electrical network, matrix, Matlab*

1. BACKGROUND

Electricity is the most suitable and appropriate form of energy for modern human life as it is today, where electrical energy has a function that can provide a need or service of electrical power obtained by consumers. Electrical energy can be biased to consumers because through a network consisting of generating units and channeling units and installed equipment for operation. Energy that is channeled to the load is smaller than the energy generated, this is due to the energy losses from the electric power system. The electric power system is a process in which electrical energy is obtained from the power station and channeled through high or extra high voltage transmissions to the substations which are then distributed to consumers.

In the distribution of electrical energy from the power plant to the load center using high voltage transmission lines. The electrical power of the high-voltage transmission line is converted into medium voltage electric power, then channeled to the primary distribution system to connecting substations or directly to the distribution substation. At the electric power distribution substation, the voltage is used using a distribution transformer to be low voltage, and directly to consumers through a medium voltage network. From this distribution transformer, the electricity customers are served by pulling low voltage cables across the residential centers, both commercial and some existing industries. Electric power that is commonly used in everyday life to operate these equipment is electricity with a low voltage (380/220). While medium voltage

electricity (20 KV system) and high voltage (150 KV system) are only used as a distribution (transmission and transmission) system for long distances. This is aimed at system reliability because it can reduce power losses and voltage losses and has a high level of distribution reliability.

In this study the electricity network discussed was a very simple electricity network using two voltage sources and several electrical resistance.

2. Basic theory

2.1 Electricity Network

An electrical network is the connection of various passive electrical elements such as resistors, capacitors, inductors, transformers, voltage sources, current sources, and switches. The term electrical circuit is slightly distinguished from electricity networks, where the electricity network discusses the use of electrical circuits in a wider scope such as in the distribution network of power plants from generator to electricity customers in each home. Actually these two types of circuits use the same basic principles, only in the electricity network are discussed about the transmission line which is about the nature of cables at high frequencies. This electrical circuit is often discussed and analyzed in three types of response (response time): the response to DC current (current current or battery current), its response to AC current or voltage (Alternating Current, such as state electricity company's current, for example), and its response to transient time. Electric DC current is often also known as direct current electricity, and the AC current is interpreted as an alternating

current. Electricity can be connected through several types of circuits, because the shape of the circuit is very influential on the strength of the electric current.

Well, here are the types of electricity networks:

- **Series circuit** Is an electrical circuit where the input of a component comes from the output of another component. One of the advantages of using a series circuit is that it saves costs, because it only uses a small number of connecting cables. While the drawback or weakness of the series is that if one component is revoked or damaged, the other component will not function properly.

- **Parallel Circuit** Is an electrical circuit, in which all component inputs come from the same source. All components are arranged in parallel. The advantage of parallel arrangement is that if one component is revoked or damaged, the other component still functions properly. Whereas one of the disadvantages of using parallel circuits is that the required costs are more expensive because they require more connecting cables.

Mixed Circuits Mixed electrical circuits (series-parallel) are electrical circuits combined from series electrical circuits and parallel electrical circuits.

Whereas based on the configuration of electricity networks, the distribution network system can be grouped into 3 (three) types, namely the radial distribution network system, loops and spindles.

- **Radial Distribution Network System**

This form of network is the simplest, most used and inexpensive form. Named radially because this channel is drawn radially from a point which is the source of the network and branched to the load points served. The power supply comes from one source point and because of the branching, the load current flowing along the channel becomes not the same, so the cross-sectional area of the conductor on this radial network is not the same size because the largest current flows in the network closest to the substation parent. So that the channel closest to the substation is relatively large in size and the channels of the branches are increasingly up to date with smaller load currents having smaller conductor sizes.

- **Loop Distribution Network System**

This network is a closed form, also called the ring network. The arrangement of the channel

circuit forms a ring, which allows underserved load points of two-way channels, so that continuity of service is guaranteed and the power quality is better, because the voltage drop and power loss in the channel become smaller.

- **Spindle Distribution Network System**

Spindle distribution network is a medium voltage ground cable channel whose application is very suitable in big cities. The specialized distribution network system is suitable for meeting needs such as increasing reliability or continuity of system services, and reducing or reducing losses due to interference.

2.2 Matlab

Matlab makes it easy for users to find assistance in connection with all the facilities provided by Matlab. For example, help on how to start Matlab for the first time, programming tricks, creating 2 and 3-dimensional graphics, using data acquisition tools, signal processing, solving partial differential equations. To get this help, we can choose MATLAB Menu from the Help menu. For help with Matlab itself, it is divided into several parts including:

- **Development Environment**, this section will provide complete information about the desktop from Matlab
- **Mathematics**, the section that explains how to use the features that Matlab has for processing mathematical and statistical data. The contents in this assistance are included, among others: Matrxs and linear algebra, polynomials and interpolations, data and statistical analysis, function functions, sparse matrix.
- **Programming and data type**, this section explains how to create scripts and functions using Matlab. M-File programming, array, multidimensional array, optimal Matlab performance, Matlab programming tip.
- **Graphics**, this section explains how to create or plot graphics from the data we have. Included in this section, among others, the basics of plotting, graphic format, making special graphics such as charts in the form of bars, histograms, contour and others
- **3-D Visualization**, this section explains thoroughly how to display the data that we have in 3-dimensional graphics, including creating 3D graphics, determining the appearance of objects, transparency of objects, lighting and others.

- Creating Graphical User Interfaces, this section explains how we can create Matlab-based GUI (Graphical User Interface). In addition to the parts mentioned above, here are also some additional sections that complement the explanation documentation about

Broadly speaking, MATLAB's work environment consists of several elements, namely:

- Command window (control screen)
- Workspace (data rack)
- Command history (reminder screen)
- M-files (editors) will be discussed in a special section.

2.3 Elementary Line Operations (ELO)

To determine the solution of linear equation system (LES) is done by forming an expanded / enlarged matrix of the LES and performing Elementary Line Operations on the enlarged matrix. This ELO is obtained at a stage by applying the following three types of operations to eliminate unknown numbers systematically.

1. Multiply the equation by a constant that is not equal to zero.
2. Exchange the two equations.
3. Add multiples of one equation for the other.

Since the line (horizontal line) in the enlarged matrix corresponds to the equation in the system associated with the row, these three operations correspond to the following operations in the enlarged matrix row.

1. Multiply a line with an equivalent constant with zero.
2. Exchange the two lines.
3. Add multiplication of one row to the other row.

These operations are called Elementary Line Operations.

Properties of rows of echelon rows (row-echelon form) and reduced row echelon forms:

1. If the line does not consist entirely of zeros, then the first taknol number in the row is 1. (we call this the main 1).
2. If there is a row consisting entirely of zeros, then all such rows are grouped together under the matrix.
3. In any two consecutive rows that do not consist entirely of zeros, 1 main in the lower row there is a further right than the main 1 in the higher row.

4. Each column containing 1 main has zero elsewhere.

3. RESEARCH METHODOLOGY

In this study, the method used is the literature study method and experimental methods. The literature study method is used as a comparison method with existing research. While the experimental method is located as another method, which is used to find out whether this method produces the same output when applied to the same problem. Thus the experimental method is a form of another method, which is used to test the literature study method of the same problem. The following is a research diagram of this study.

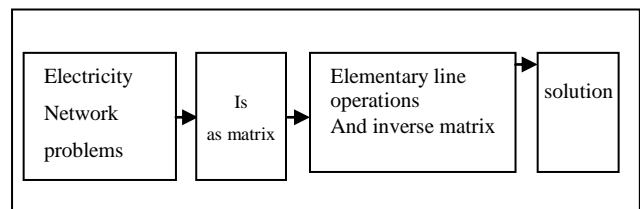


Figure 1. Research diagram

Initially electricity problems were discovered. Furthermore, from the problem of electricity networks a matrix is formed. To solve the matrix problem, the elementary and inverse matrix operations are used. Both of these methods are used, as a tool to produce final results and as a solution.

4. RESULTS AND DISCUSSION

In an electrical network it is possible to determine the amount of current in each branch expressed in resistance and voltage. An example of a problem in an electricity network is given in the figure below.

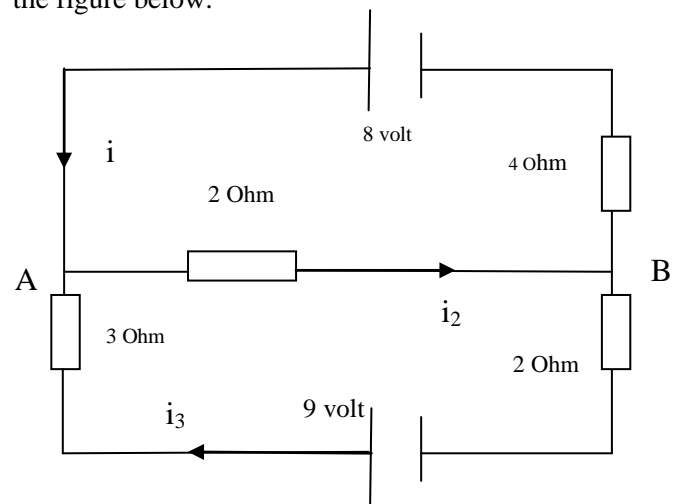


Figure 2. Power grid

The symbols in the picture above have the following meanings:

1. the electrically drained wire marked with a picture of an arrow
2. The electricity source is marked by volts
3. resistors or obstacles are marked with ohms

The power source is usually a battery that is measured in volts, which drives the charge and produces a current. This current will flow out of the battery terminal which is described by a longer vertical line. Resistance is measured in ohms. The letter code states the node (node) and i states the current between the nodes. The currents are measured in amperes. The arrow indicates the direction of the current. But if one current, for example i_2 , turns out to be negative, this means that the current along the branch is in the opposite direction with the arrow.

To determine current strength, Kirchhoff's laws are used:

1. At each node the sum of the current strength is equal to the sum of the current strengths who came out.
2. Around each loop, the amount of algebra from the voltage must be equal to the amount of algebra decreases in voltage.

The voltage drop E for each resistance is given by Ohm's law:

$$E = i R$$

Where :

i = states current in amperes

R = resistance in Ohm

Let's look for currents in the electrical network from the picture above. From Kirchhoff's first law, it was obtained:

$$i_1 - i_2 + i_3 = 0 \text{ (node A)}$$

$$-i_1 + i_2 - i_3 = 0 \text{ (node B)}$$

Based on Kirchhoff's second law, it was obtained:

$$4i_1 + 2i_2 = 8 \text{ (top node)}$$

$$2i_2 + 5i_3 = 9 \text{ (bottom node)}$$

Of the four equations above can be expressed by an enlarged matrix:

$$\begin{bmatrix} 1 & -1 & 1 \\ -1 & 1 & -1 \\ 4 & 2 & 0 \\ 0 & 2 & 5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 8 \\ 9 \end{bmatrix}$$

This matrix can be solved by using elementary line operations so that it results the form of matrix is as follow :

$$\begin{bmatrix} 1 & -1 & 1 & 0 \\ -1 & 1 & -\frac{24}{33} \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 9 \end{bmatrix}$$

Thus the completion of this matrix is $i_1 = 1$, $i_2 = 2$, and $i_3 = 1$.

Besides using Kirchhoff's law, you can also use formula the inverse matrix $X = A^{-1} * B$.

Where matrix X is a representation of i_1 , i_2 , and i_3 . Whereas matrix A represents the simulation results from Kirchhoff's first and second law. For matrix B is a representation of the right segment. To solve a matrix problem by using the inverse matrix formula $X = A^{-1} * B$, the matlab software is used with the formula: $X = \text{inverse}(A) * B$, so that the same result is obtained $i_1 = 1$, $i_2 = 2$, and $i_3 = 1$.

5. CONCLUSION

1. Power grid problems can be solved using elementary line operations
2. Besides being solved by using elementary line operations, electricity networks can also be solved using inverse matrix.

6. Suggestion

Elementary line operations are also recommended to be used to solve problems other than electricity grid problems, so it is expected to be applied in other fields of research.

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