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Study about Electrical Current Solutions Using the MATLAB Matrix Inverse Method and MATLAB Gauss-Jordan Method

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Abstract: This study investigates the solutions of electrical current in linear circuit systems using two numerical methods implemented in MATLAB: the Matrix Inverse Method and the Gauss-Jordan Elimination Method. The objective is to analyze the effectiveness, accuracy, and computational efficiency of both techniques in solving systems of linear equations derived from Kirchhoff's laws. Several circuit models with varying levels of complexity are tested to compare results obtained from each method. The findings indicate that both methods yield consistent solutions, although differences in computational steps and processing time are observed. This research highlights the practicality of MATLAB as a powerful tool for electrical circuit analysis and provides insights into the selection of appropriate numerical methods for solving engineering problems.

Keywords: Gauss-Jordan Elimination Method; linear circuit systems; Matrix Inverse Method

1. Introduction

In electrical circuit analysis [1], determining the current in a circuit [2] system is a fundamental aspect that is crucial in the context of design, testing, and optimization of electrical [3] system performance. One approach frequently used to solve the system of linear equations arising from basic circuit [4] laws such as Ohm's Law, Kirchhoff's Current Law (KCL), and Kirchhoff's Voltage Law (KVL) is through numerical methods. These equations, which often form linear systems with many variables, can be solved using various linear algebra methods, two of which are the matrix inverse method and the Gauss-Jordan method. Each method has its advantages and disadvantages in terms of efficiency, accuracy, and numerical stability. With the advancement of computational technology, software such as MATLAB has become a powerful tool to solve these systems of equations quickly and accurately. The use of MATLAB in this context is highly relevant, as it provides a comprehensive set of matrix functions and is capable of handling numerical computations efficiently. Therefore, it is important to study and compare the application of these two methods , the matrix inverse method and the Gauss-Jordan method, in the context of current analysis in electrical circuits[5], using MATLAB as the primary tool. This research aims to study the effectiveness and accuracy of both methods in solving current problems in simple to complex circuit systems. It is expected that the results of this study will provide insights for students, researchers, and electrical engineering practitioners in choosing the most appropriate method for their analytical needs.

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2. Preliminaries or Related Work or Literature Review

In this session, two fundamental concepts that are closely related in the fields of engineering and physics will be discussed, namely systems of linear equations and electric current[6]. Understanding these two topics is essential, as many physical phenomena and engineering systems can be modeled and analyzed using a mathematical approach through linear equations systems, especially that contains about electrical circuits.

First, the discussion will focus on systems of linear equations, which are sets of mathematical equations used to determine the values of several interrelated variables. These systems are frequently employed in modeling various engineering problems, including the calculation of current in electrical circuits[7]. This concept forms the foundation for several numerical and symbolic solution approaches, look as Row Reduction, RREF Method, and the matrix inversion method.

The discussion will then continue with the theory of electric current[8]. Electricity [9] in motion is called electric current that occurs due to a difference of potential between two points in a conductor. In network analysis[10], a magnitude of the current [11] flowing through a circuit[12] element can be determined using fundamental electrical [13] formulas look as Law of Ohm and Laws of Kirchhoff, which essentially result in systems of linear equations as their mathematical models.

By combining an understanding of systems of linear equations and electric current[14] theory, participants are expected to be able to analyze and solve various problems in electrical [15] systems in a more systematic and structured manner.

2.1. Definition of a System of Linear Equations

A system of linear equations is a collection of mathematical equations, each of which is linear, meaning that each equation involves variables raised only to the first power and does not include any multiplication between variables. A system of linear equations can be represented in matrix form as:

AX=B

where:

1.A is the coefficient matrix of size m×nm \times nm×n,

2.X is the column vector of variables,

3.B is the column vector of constants.

This representation simplifies the process of solving the system by enabling the use of various linear algebra methods such as Gaussian elimination, Gauss-Jordan elimination, matrix inversion, and others.

2.2 Definition of Electric Current

Electric current [16] is the flow of electric charge that moves through a conductor, such as a copper wire, due to a difference in electric potential (voltage) between two points. This current [17] arises because free electrons in the conductor are pushed from a region of lower potential to a region of higher potential. In technical convention, the direction of electric current [18] is taken from the positive terminal to the negative terminal, even though, physically, electrons flow in the opposite direction. Mathematically, electric current is expressed by the formula: I=Q/t where:

1.I is the electric current (in amperes, A),

2.Q is the electric charge (in coulombs, C),
3.t is the time (in seconds, s).

3. Proposed Method

In this study, two computational methods are proposed to solve systems of linear equations: the matrix inverse method using MATLAB software and the Gauss-Jordan elimination method, also with the assistance of MATLAB. The matrix inverse method utilizes fundamental concepts of linear algebra, where the solution is obtained by multiplying the inverse of the coefficient matrix by the constant vector. Meanwhile, the Gauss-Jordan method is an elimination technique aimed at reducing the augmented matrix to its reduced row echelon form, allowing the solution to be obtained directly through substitution. Both methods are implemented in the MATLAB environment due to its advantages in numerical processing and its capability to efficiently handle matrix computations. By comparing these two approaches, the study aims to evaluate the effectiveness and efficiency of each method in the context of solving linear equations systems.

3.1. Method of Matrix Inversion Based on Matlab

In this study, the proposed methods are the matrix inverse method in MATLAB and the Gauss-Jordan method of MATLAB. The matrix inverse method is a commonly used mathematical approach to answer the problem of linear equations systems, especially the problem of the electrical circuit analysis. For a mathematical model, a network of electrical consisting of several elements such as resistors and voltage sources can be formulated as a linear equations system:

$A \cdot I = V$ where:

1.A is the coefficient matrix containing the resistance or impedance values of each branch in the circuit,
2.I is the current vector, which represents the variables to be solved,
3.V is the voltage vector from the power sources in the circuit.

The solution to this system can be obtained by using the inverse of matrix A, provided that the matrix is non-singular (i.e., its determinant is not zero). Thus, the current in each branch can be determined using the formula:

$I = A^{-1} \cdot V$

This approach is particularly useful in deterministic linear circuit systems that have a unique solution. However, the use of the inverse method requires attention to the condition of matrix A, because if the matrix is non-invertible, then the solution cannot be obtained using this method.

MATLAB is a highly reliable software for performing numerical computations, including solving systems of linear equations using the matrix inverse approach. The implementation of this method in MATLAB involves several steps:

1.Constructing the Coefficient Matrix A:

The way of first is to form the matrix of coefficient from the equations derived based on Kirchhoff's Voltage Law (KVL). The resistance values of each branch in the circuit are arranged into a matrix according to the interconnection between nodes or loops.

2.Constructing the Voltage Vector V:

Next, the voltage vector is constructed based on the voltage values of the sources provided in each loop or branch of the circuit. This vector represents the magnitude of the voltages that serve as the input to the system.

3.Using MATLAB Functions:

MATLAB provides the inv() function to calculate the inverse of a matrix and perform matrix multiplication.

3.2. Method of Gauss-Jordan using Matlab

The Gauss-Jordan [19] method is one of the most commonly used elimination techniques in linear algebra for solving systems of linear equations in a systematic and efficient manner. This method works by reducing the augmented matrix which is a combination of the coefficient matrix and the constant vector into reduced row echelon form (RREF). Compared to the standard Gaussian elimination method, the Gauss-Jordan [20] technique includes additional steps to eliminate all elements both above and below each pivot element, resulting in a reduced matrix that forms an identity diagonal. This allows each variable in the system to be obtained directly, without the need for back-substitution, which is often a potential source of error in manual calculations.

In the context of software-based implementation, MATLAB is an ideal tool for applying the Gauss-Jordan [21] method due to its powerful capabilities in numerical computation and matrix manipulation. MATLAB provides a variety of built-in functions that facilitate the execution of the elementary row operations required for the elimination process. By using functions such as rref(), users can quickly and accurately obtain the reduced row echelon form of an augmented matrix without having to manually perform complex calculations.

The general steps for applying the Gauss-Jordan [22] method using MATLAB can be outlined as follows:

1.Forming the Augmented Matrix

The first step is to combine the coefficient matrix of the system of linear equations with the constant vector on the right-hand side into a single augmented matrix. This matrix serves as the foundation for the subsequent reduction process.

2.Performing Elementary Row Operations

Using operations such as row swapping, multiplying a row by a non-zero constant, and adding or subtracting one row from another, the matrix is gradually reduced to RREF. This process is carried out systematically so that each column has a leading one (pivot), and all other entries in that column are zero.

3.Interpreting the Reduced Result

Once the elimination process is complete and the matrix reaches its RREF, the solutions to the system of equations can be read directly from the result. Each row in the resulting matrix represents the explicit value of the corresponding variable.

Thus, the Gauss-Jordan method implemented in MATLAB not only simplifies the process of solving systems of linear equations but also enhances the accuracy and efficiency of the computation. This approach is particularly useful in engineering, science, and other fields that require large-scale numerical data processing.

4. Results and Discussion

This study provides an in-depth explanation of the issues and applications of two primary numerical methods: the matrix inversion method using MATLAB and the Gauss-Jordan elimination method, also implemented with the aid of MATLAB software. Both are computational approaches choosed to get the solution linear equations systems, which frequently arise in electrical circuit analysis, particularly when determining the magnitude of electric current across various circuit elements. This problem is especially significant in electrical engineering due to the large number of interconnected components in a circuit, such as resistors, capacitors, current sources, and voltage sources, which form complex and interdependent systems. In such cases, manually solving the system of equations is not only inefficient but also prone to logical and computational errors that may compromise the accuracy of the results. The central issue addressed in this research relates to the need for methods capable of delivering fast, precise, and structured solutions to large-scale linear systems.

These systems are typically formulated based on fundamental electrical laws such as Ohm's Law, Kirchhoff's Current Law (KCL), and Kirchhoff's Voltage Law (KVL), which are then converted into coefficient matrices to be solved numerically. The use of MATLAB as a computational tool is highly relevant in this context due to its powerful capabilities in handling matrix operations and numerical computation. MATLAB also offers flexibility in scripting, simulation, and result visualization. It not only accelerates the computation process but also helps reduce the likelihood of human error in the formulation and solution of these systems. This research goes beyond merely implementing the matrix inversion and Gauss-Jordan methods; it also evaluates their performance based on several parameters, including result accuracy, computation time, algorithmic efficiency, and resilience to non-ideal systems, such as those with nearly singular coefficient matrices or systems that are overdetermined or underdetermined. In this regard, the matrix inversion method tends to perform better for small to medium-sized systems with stable and unchanged structures but becomes inefficient when applied to large systems. On the other hand, the Gauss-Jordan method is more adaptable to various system forms and provides a more general solution due to its process, which does not rely on the determinant of the matrix.

This evaluation is expected to offer recommendations for users in selecting the most appropriate method based on the characteristics of the system being analyzed. More broadly, this study is expected to make a meaningful contribution to the development of computation-based engineering education, particularly in courses such as circuit analysis, linear systems, or numerical methods. By presenting a practical implementation through MATLAB programming, both students and engineering practitioners can gain a deeper understanding of not only the theoretical concepts behind solving systems of equations but also their practical applications in real-world industrial scenarios. Furthermore, the findings of this research have potential applications in the development of control systems, modeling of electrical systems, and the design of engineering software based on numerical simulation. Thus, the integration of numerical methods with software technologies like MATLAB can be seen as a strategic solution that is adaptive to the evolving needs of both industry and education in the current era of digital transformation.

4.1. Matrix Inversion Method Based on Matlab

At this stage, the approach used to analyze the electrical circuit is the matrix inversion method, computationally implemented using MATLAB software. This method was chosen due to its efficiency in solving complex systems of linear equations and its ability to provide a clear and systematic structure for problem-solving. In electrical engineering, systems of linear equations are commonly used as mathematical models to describe the relationships between current and voltage across various elements in an electric circuit. Therefore, solving such systems accurately is essential for understanding circuit behavior and ensuring operational reliability.

The analysis at this stage focuses on three fundamental components commonly found in electrical circuits: resistors, voltage sources, and electric currents. Resistors act as current-limiting elements that cause voltage drops at specific points in the circuit. Voltage sources serve as the driving force behind current flow, while the electric currents themselves are the primary unknown variables to be determined based on the configuration and characteristics of the other components. The relationships among these components are quantitatively described the application of Law of Ohm plus the two of Laws of Kirchhoff : Kirchhoff's Current Law (KCL), which states that the total current entering a node equals the total current leaving it, and Kirchhoff's Voltage Law (KVL), which states that the algebraic sum of voltages in a closed loop must equal zero.

The application of these fundamental laws leads to the formation of a system of linear equations, which is then explained in the standard matrix formulas $Ax = b$, that declare:

1. A is the matrix of coefficient, constructed from resistor values and the topology of the circuit,
2. x is the vector of unknown currents,
3. b is the result vector, consisting of known values derived from the voltage sources.

` To solve this system, a numerical approach is applied using matrix inversion, where a solution vector x is obtained by multiplying the inverse of matrix A with vector b, represented mathematically as $x = A^{-1}b$.

In its implementation, MATLAB plays a crucial role as a computational tool. MATLAB offers robust capabilities for matrix operations, which are central to this method. Built-in functions such as inv(A) for computing the inverse of matrix A, and the * operator for matrix-vector multiplication, allow users to efficiently and accurately solve linear systems without the need for manual, error-prone calculations. Furthermore, MATLAB provides powerful visualization tools, enabling users to display results in graphical or tabular formats that simplify the verification and analysis of the final output.

One of the primary advantages of the matrix inversion method is its simplicity and effectiveness when applied to systems with constant coefficients, such as circuits with fixed configurations. In such cases, the inverse of matrix A only needs to be computed once and can then be reused to solve multiple scenarios with different b vectors, making it particularly efficient for repetitive simulations or parameter sensitivity analyses.

However, the matrix inversion method also has certain limitations that must be considered. A key issue is numerical stability, especially when matrix A is close to singular (i.e., non-invertible) or has a very small determinant. Under such conditions, the inversion process may become unstable and produce significant round-off errors, which can compromise the accuracy of the final solution. Therefore, it is essential to evaluate the numerical properties of matrix A beforehand to determine the suitability of this method for a given system.

In conclusion, the application of the matrix inversion method using MATLAB for circuit analysis offers significant advantages in terms of speed, accuracy, and computational efficiency. This approach not only aids in solving complex electrical engineering problems but also enhances the understanding of linear algebra concepts that underpin many engineering applications. The integration of numerical methods and computational technologies such as MATLAB demonstrates how modern tools can offer practical, reliable solutions for electrical system analysis in today's digital era, making this approach highly relevant in academic, research, and industrial contexts.

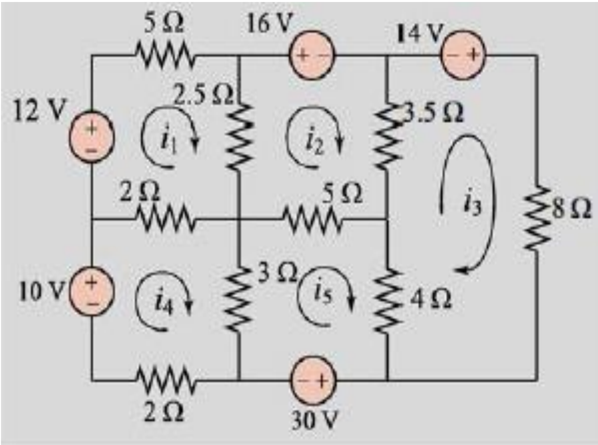

Figure 1. Electrical Circuit

At this stage, an analysis is conducted on a complex electrical circuit consisting of five closed loops, each of which yields one equation based on fundamental electrical principles. The objective of this analysis is to determine the current values flowing through each branch of the circuit, taking into account the interactions between elements such as resistors and voltage sources. The application of basic laws, such as Ohm's Law and Kirchhoff's Laws (both KCL and KVL), forms the primary foundation in formulating the system of linear equations.

Below are the equations derived from each loop in the circuit:

1.equation's first : $9.5i1-2.5i2-2i4=12$

2. equation's second : $-2.5i1+11i2-3.5i3-5i5=-16$

3. equation's Third :$-3.5i2+15.5i3-4i5=14$

4. equation's Fourth:$-2i1+7i4-3i5=10$

5. equation's Fifth:$-5i2-4i3-3i4+12i5=-30$

These five equations form a system of linear equations with five current variables: i1,i2,i3,i4, and i5. This system is then represented in matrix form as Ax=b, where:

1.A is the coefficient matrix that reflects the relationship between components and the topological structure of the circuit.

2.x is the current vector, which represents the unknown variables to be solved.

3.b is the constant vector containing the total voltage in each loop.

To solve this system of linear equations, the matrix inversion method is used—a numerical approach that is highly effective when the number of equations matches the number of variables being solved. This method works by inverting the coefficient matrix and then multiplying it by the constant vector, thereby producing a direct solution for each variable in the system. This approach is particularly useful in the analysis of complex electrical circuits involving multiple loops and elements, as it enables quick and accurate solutions without the need for manual elimination steps.

In its implementation, MATLAB is chosen as the primary computational tool due to its superiority in handling numerical calculations, especially matrix operations, which are central to this method. MATLAB offers a wide range of built-in functions that simplify the computation process and also support data analysis and interactive result visualization. MATLAB's speed and precision are extremely helpful in solving complex engineering problems in significantly less time compared to manual calculations.

In MATLAB, the solving process is performed using functions such as:

1.inv(A) to calculate the inverse of the coefficient matrix AAA, which represents the relationships between components in the electrical circuit.

2.The * operator to perform multiplication between the inverse matrix and the voltage vector bbb, resulting in the current vector xxx which is the solution to the system.

Below is the current solution in the circuit obtained from the MATLAB computation:

X =
 2.1290
-3.0072
-0.7895
0.3535
-3.9278

This result shows the current values flowing through each loop or branch of the circuit:

1.i1= 2.1290 A and i4= 0.3535 A represents a small current, most likely due to a high total resistance in that loop, which limits current flow.

2.i2= -3.0072 A and i5= -3.9278 A have negative signs, indicating that the actual current direction is opposite to the initially assumed direction during the formulation of the loop equations. This is common in circuit analysis, where current directions are first assumed arbitrarily, and the calculations reveal the correct directions.

3.Currents i3= -0.7895 A, which are also negative, further illustrate the dynamics of current flow within the system, influenced by the complex interactions between resistances and voltage sources in each path.

Overall, this result not only provides the magnitude of the current in each part of the circuit but also offers valuable insights into current direction and how component configuration affects current distribution. By using MATLAB, this analysis becomes significantly more practical, accurate, and efficient than conventional methods, making it a highly relevant tool in the modern field of electrical engineering.

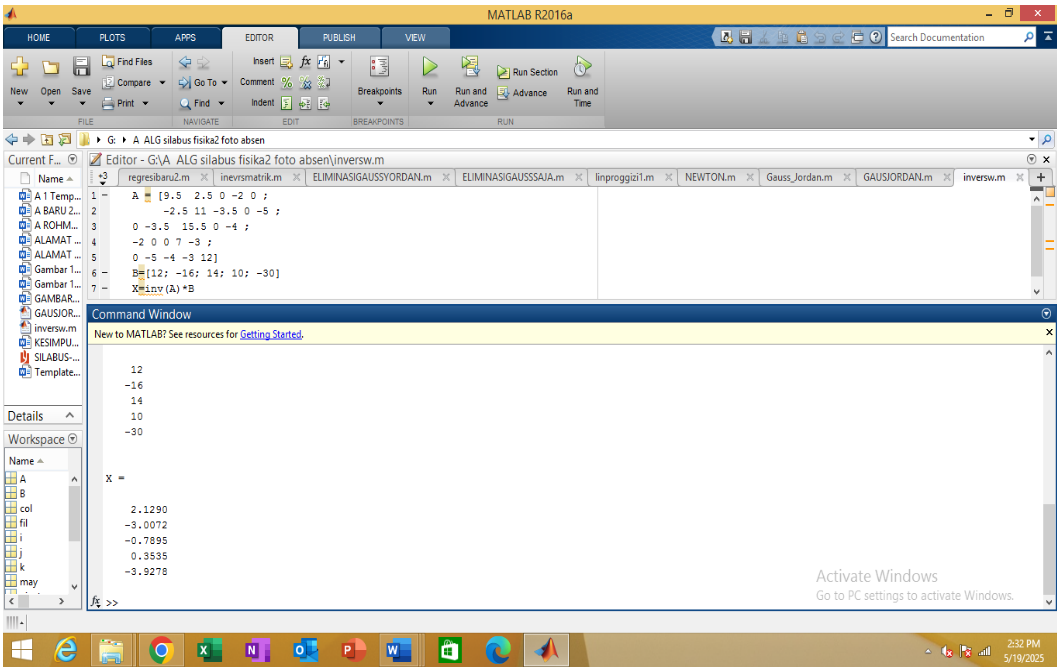

Figure 2. MATLAB Output Display for Circuit Current Calculation

This figure shows the MATLAB interface displaying the results of current calculations using the matrix inversion method. The display illustrates that MATLAB not only produces numerical solutions but also has the capability to visualize data in the form of graphs, tables, or interactive plots, depending on the user's commands.

Advantages of using MATLAB in this context include:

1.Time efficiency, as computations are completed in seconds, even with many variables and equations.

2.Minimal human error, since all calculations are performed by the software using precise numerical algorithms.

3.Ease of documentation and re-analysis, as results can be saved, exported, or reused for further analysis.

Analyzing electrical circuits using the matrix inversion method in MATLAB has proven to be an exceptionally effective solution for managing complex systems that involve multiple variables and interdependent components. This approach not only ensures high accuracy in determining electrical parameters such as current and voltage across various elements but also dramatically reduces the time required for analysis when compared to traditional manual methods. In systems where the number of loops and branches increases, the computational burden grows significantly, something that manual calculations struggle to handle efficiently. MATLAB, with its optimized numerical algorithms and robust matrix manipulation capabilities, enables engineers and researchers to perform these calculations seamlessly, ensuring both speed and precision. This efficiency is especially critical in the field of electrical engineering, where timely decision-making can directly impact design outcomes, system stability, and overall project success. Whether used in academic settings for teaching circuit theory and problem-solving skills, or in professional environments for simulation and optimization of industrial-scale electrical systems, the integration of MATLAB into the workflow empowers users to explore complex scenarios, conduct iterative testing, and refine designs with minimal risk of error. Moreover, the use of MATLAB encourages a more interactive and visual approach to circuit analysis. Engineers can go beyond numerical results to generate plots, graphs, and system models that offer deeper insights into circuit behavior under various conditions. This capability supports not only better understanding but also more effective communication of technical results to both technical and non-technical stakeholders. In conclusion, the integration of numerical methods like the matrix inversion approach with technical computing tools such as MATLAB represents a strategic and forward-looking solution for addressing the increasingly complex challenges faced in modern engineering. In the digital era—where speed, accuracy, and adaptability are vital—such tools are indispensable for ensuring that electrical systems are analyzed, designed, and implemented with the highest standards of efficiency and reliability.

4.2. Gauss-Jordan Method using Matlab

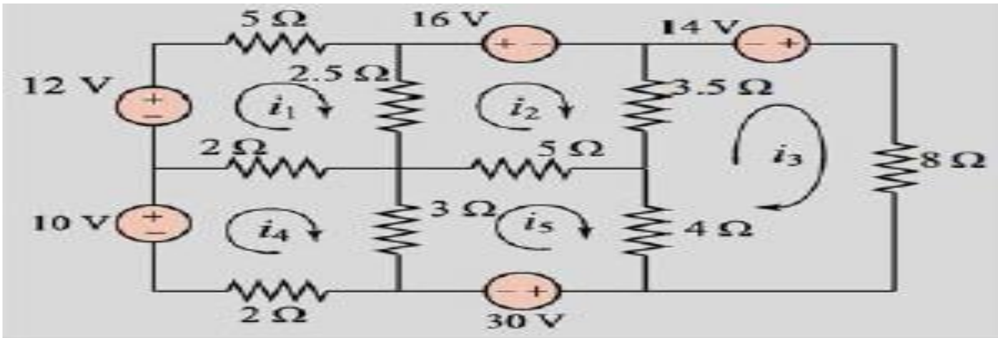

Figure 3. The solution of electrical circuit using the method of based on MATLAB.

A method is chosen due to its advantages in solving systems of linear equations efficiently, quickly, and accurately, particularly in the context of analyzing complex electrical circuits with multiple loops. This approach is highly relevant both in academic and industrial settings, as it provides precise and consistent numerical results.

Figure 3 shows a simple electrical circuit, similar in structure to Figures 1 and 2. The circuit consists of several passive components, particularly resistors, as well as one or more DC voltage sources. Such circuits are commonly used in electrical engineering education, especially to introduce the concepts of current and voltage distribution, and the application of fundamental electrical laws. The purpose of this analysis is to determine the current flowing through each branch of the circuit using a mathematical approach based on linear algebra—specifically, the Gauss-Jordan method implemented digitally using MATLAB software.

The Gauss-Jordan method is a matrix elimination technique in linear algebra choosed to get the answer of linear equations systems (SLE). For an electrical circuit analysis, SLEs are derived by applying two fundamental principles:

1.Kirchhoff's Current Law (KCL): States that the total current entering a junction (node) must equal the total current leaving the junction. This law ensures the conservation of electric charge at every node.

2.The Law of Kirchhoff's Voltage (KVL): Expains a algebraic sum from all voltages circles any closed loop in a network is null. For this law underlies adistribution from the energy of electrical in closed circuits.

By applying KVL to each closed loop in the circuit, a system of linear equations is obtained that describes the relationship between currents in various branches. The equations are as follows:

1.Loop Equation 1: $9.5i_1 - 2.5i_2 - 2i_4 = 12$ (1)

2.Loop Equation 2: $-2.5i_1 + 11i_2 - 3.5i_3 - 5i_5 = -16$ (2)

3.Loop Equation 3: $-3.5i_2 + 15.5i_3 - 4i_5 = 14$ (3)

4.Loop Equation 4: $-2i_1 + 7i_4 - 3i_5 = 10$ (4)

5.Loop Equation 5: $-5i_2 - 4i_3 - 3i_4 + 12i_5 = -30$ (5)

From these five equations, there are five current variables to be determined: i_1, i_2, i_3, i_4, and i_5. To solve this system, the equations are written in augmented matrix form, consisting of a coefficient matrix and a constant vector. For this matrix is then answered using the algorithm of Gauss-Jordan in MATLAB. A method transforms a matrix into an identity matrix using elementary row operations, allowing the values of each variable to be directly and accurately obtained.

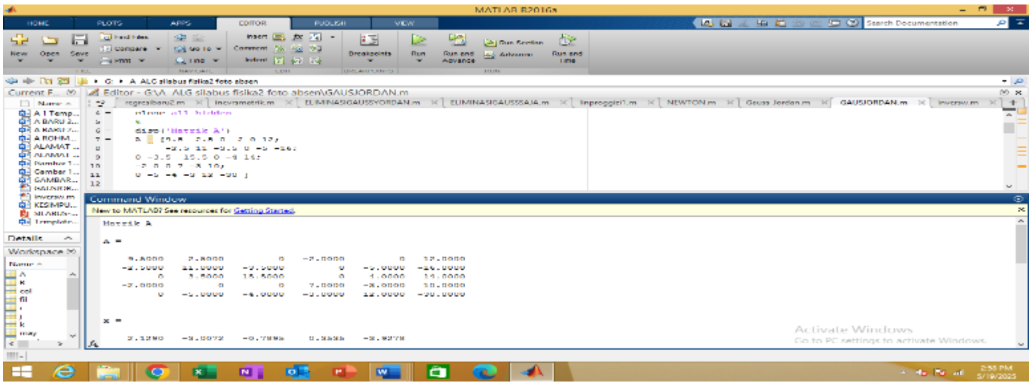

Figure 4. Results of Electrical Current Calculations Using the MATLAB-Based Gauss-Jordan Method

The output from MATLAB shows the values of the currents: i_1, i_2, i_3, i_4, and i_5 in each branch of the circuit. These values can be compared with experimental results obtained in the laboratory or with other numerical methods, such as Mesh Analysis or Nodal Analysis, to verify the accuracy of the calculations. The simulation demonstrates that the method of Gauss-Jordan has ability to answer linear equation system more quickly, without the need for manual algebraic manipulation, which can lead to errors.

In addition to speed and accuracy, another advantage of this method is its flexibility and scalability. MATLAB allows users to easily modify circuit parameters or configurations and instantly obtain new results without having to reconstruct the entire system. This makes the Gauss-Jordan method highly suitable for use in integrated electrical simulation systems, such as PCB design software or computer-based educational tools.

In conclusion, the use of the MATLAB-based Gauss-Jordan method in electrical circuit analysis is not only computationally efficient, but also systematic, accurate, and highly applicable in various contexts—both academic and practical. This approach greatly aids in accelerating the process of circuit design, simulation, and validation prior to physical implementation.

5. Comparison

The following presents the comparison between the inverse matrix method and the Gauss-Jordan method using MATLAB:

Table 1. Comparison between inverse matrix method & gauss-jordan method in matlab

Aspect	Description
Main Purpose	Both methods are used to solve systems of equations of linear (SLE) that has formula Ax = b, where A is the matrix of coefficient, x is the vector of variable, and b is the vector of constant.
Based on Linear Algebra	Both rely on fundamental principles of linear algebra and matrix theory.
Deterministic	Both provide exact solutions if the system has a unique solution.
Implemented in MATLAB	MATLAB offers built-in functions or scripting capabilities to execute both methods.
Requires Non-Singular Square Matrix (for unique solution)	Both methods require matrix A to be non-singular (non-zero determinant) in order to yield a unique solution.
Used in Circuit Analysis	Both methods can be applied in electrical circuit analysis, optimization, simulation, and other engineering fields.

6. Conclusions

This study comprehensively demonstrates that the matrix inversion method and the Gauss-Jordan elimination method, implemented through MATLAB software, are highly effective and efficient approaches t0 solves linear equations systems, especially in the content of electric current analysis in electrical circuits. In the field of electrical engineering, the ability to solve linear equation systems accurately forms the fundamental basis for understanding circuit behavior, whether in simple or complex networks. Complex electrical circuits typically involve various components such as resistors, voltage sources, and current sources, which are interconnected and result in numerous simultaneous linear equations. Accuracy in determining the magnitude of current in each branch of the circuit is crucial, as even minor errors in calculation can lead to circuit malfunction, reduced efficiency, or even permanent component damage. Therefore, the use of reliable numerical methods such as matrix inversion and Gauss-Jordan elimination is critical to ensure the accuracy of analysis results. Both methods have proven effective in solving systems derived from basic electrical laws, including The law of Ohm, The law of Kirchhoff's Current (KCL), and The law of Kirchhoff's Voltage (KVL), and has an accuration and numerically stable results.The implementation of these methods in the MATLAB environment adds a new dimension of efficiency and practicality to the computational process. MATLAB, as a numerical computing software, offers various advantages such as ease of scripting, comprehensive numerical and linear algebra functions, and dynamic result visualization capabilities. MATLAB's ability to handle data in matrix form aligns perfectly with the nature of problems involving systems of linear equations, allowing computations to be carried out quickly and with minimal errors. This advantage makes MATLAB an effective tool both in academic settings, as a medium for teaching and research—and in industrial contexts to support technical analysis and data-driven decision-making. Moreover, MATLAB enables faster iteration of solutions and allows users to perform simulations with various parameter scenarios, which would be difficult to achieve through manual methods. In terms of methodological characteristics, each approach has its own distinct strengths. The matrix inversion method is generally more practical when dealing with static systems, where the coefficient matrix remains unchanged. Its advantage lies in the straightforward implementation process and direct final solution. However, this method becomes less ideal when the coefficient matrix is near singular or when dealing with very large systems, as inversion calculations may become unstable or computationally expensive. On the other hand, the Gauss-Jordan elimination method offers greater flexibility in solving various types of systems, whether they have a unique solution, infinitely many solutions, or no solution at all. This method relies on the row-reduction process to reduced row echelon form, allowing solutions to be obtained by transforming the system into a simpler form without explicitly computing the inverse matrix. This makes it more reliable for handling complex or variable systems. Considering the effectiveness, efficiency, and flexibility of each method, and supported by MATLAB's computational capabilities, this study emphasizes the importance of integrating numerical methods with digital technologies in solving modern electrical engineering problems. This combination not only accelerates the technical analysis process but also enhances the accuracy and reliability of results on a larger scale. In educational contexts, this approach encourages students to gain a deeper understanding of theoretical concepts through practical, software-based implementation. In industrial applications, it aids engineers in designing, optimizing, and maintaining electrical systems with high precision. Therefore, the integration of MATLAB with the matrix inversion and Gauss-Jordan elimination methods can be regarded as an adaptive, accurate, and relevant model for system analysis aligned with current technological developments and digital-era demands.

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