Usage of Mathematics Tools with Example in Electrical and Electronic Engineering

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Abstract

Usage of mathematics in different flow of electrical and electronic engineering is outstanding by everybody. In this paper, a good number of examples of applications of mathematics in electrical and electronic engineering have designed. The motivation behind this paper is to relate mathematics to electrical and electronic engineering subject. Numerous electrical and electronic engineering students think that it's hard to tackle electrical and electronic engineering problems which require mathematics a considerable measure. It is not possible to investigation of current, voltage, electric LR and RC circuit, electromagnetic fields, designing and analyzing circuits without utilization of scientific instruments of trigonometry, Calculus, Geometry and Differential Equation.

Keywords: Applications; Electrical; Electronic; Electric circuit.

1. Introduction

Electrical and Electronics Engineering is an occupation which based on enhancing systems to encourage humankind [1]. Smart phones, for example, have reformed the way we communicate, electrical systems in medical hardware enable us to screen all more viably the conduct of those in require, and the electronics in security systems enable us to feel more secure .

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Electrical and electronic engineering is the branch of engineering that creates utilization of electricity and concentrations on systems for producing and transmitting huge electrical currents and changing over them into different types of vitality, for example, mechanical motion [2].

Electronic Engineering concentrates on lower energy currents for processing and communicating data. Electrical and Electronic Engineering includes creativity with the generation, stockpiling and utilization electricity; the design and programming of smart systems, for example robots and cell phones; and the plan and utilization of integrated circuits, sensors, and actuators [3]. This train additionally includes the transmission and transformation of information utilizing computers and communication networks, and the plan of new electronic and computer products. Robotics, Advanced TV, unmanned elevated vehicles, medical imaging and e-commerce and space investigation have all been conceivable in substantial part on account of electrical engineering innovation. A program that prepares individuals to apply numerical and sensible guidelines to the outline, headway and operational evaluation of electrical and electronic structures and their parts, including electrical power age structures; and the examination of issues, for instance, superconductor, wave spread, imperatives accumulating and recuperation, and social affair and upgrade.

Mathematics is a tool which the only one way to solve the engineering problems. Fluid mechanics, electromagnetic theory, and Maxwell's wave and heat equations are not possible without mathematics. Additionally in deciding of different properties like area, volume, centroid, moment of inertia, radius of gyration, slimness proportion and so on of various segments like rectangle, triangle, circle and compound section mathematics had assumed essential part. There all can only be defined by application of mathematics by using Eulerian and Langrangian approach of particle analysis, curl of function, vector calculus, in fluid mechanics in the analysis of type of motion of fluid particle, type of flow, energy equation, continuity equation, velocity potential, stream function etc.

2. How mathematics uses in electrical and electronic engineering [4]

Engineering especially in Electrical engineering is nothing without math. The knowledge of Calculus is most important in Electrical engineering field. From circuit theory to control systems, from thermodynamics to microprocessors, digital signal processing, linear control system, high voltage engineering, robotics, micro controller with program and illumination, solar, energy structures, communication all are based on this pillar. In the field of voltage generator, computation of current, power, efficiency, RLC circuits and other useful quantities are relies heavily on the knowledge of trigonometric identities. Linear algebra is widely used in digital signal processing, communication systems, error control coding, circuit analysis, robotics circuits and power systems. Ordinary, linear, non-linear, partial all these differential equations are plays a very important role in electrical engineering, such as in basic electric machines, power systems, antennas, optics and it is also in image processing. Fourier Transforms come into play and help us with our signal processing, heat transfer, power systems and control system. In electromagnetism we use the knowledge of Vector Algebra. If we want to find the probability of signals and events in telecommunication systems and random events then we must have learned about Probability and Statistics. To understand the geometrical structures in complex form, electronics and quantum field theory, moreover in designing power systems of planning control and flight systems and in

robotics, we need to the help of Geometry.

3. Some of the mathematical tools that are used in electrical and electronic engineering [4]

- Calculus
- Co-ordinate Geometry
- Vector analysis
- Probability and Statistics
- Complex variable
- Linear algebra
- Differential Equation
- Fourier and Laplace transform
- Trigonometry

3.1. Calculus

Calculus is a branch of mathematics that concerning rates of change and accumulation. The majority electrical and electronic engineering programs need calculus. Calculus is a requirement for the majority Electrical and electronic engineering courses. It consist

- Derivatives and integrals of functions in one dimension. These groups additionally cover themes like speed.
- Calculus requires in an electrical and electronic engineering program contact with functions in two and three d measurements and takes in issue like surface and volume integrals, and partial derivatives.

Calculus is likewise really valuable. Some basic conditions are basically derivations of others with a touch of differentiation or integration tossed in [5]

For real example

Current i Amps am the rate of change of charge q Coulombs. That is Current, $I = dq/dt$.

Current i Amps flowing in a capacitor is the capacitance C farads times, the rate of change of voltage v Volts across the capacitor. That is: Current, $I = C \, dv/dt$.

Voltage v Volts across an inductor is the inductance L henrys times the rate of change of current i Amps flowing in the inductor; Voltage $v = Ldi/dt$ [6]

Utilizes of integration in electrical and electronic engineering to decide the correct length of intensity link expected to associate two substations that are miles separated. Since the link is swung from posts, it is always bending. Calculus enables an exact figure to be resolved.

3.2. Co-ordinate Geometry

Geometry plays an important role in electrical engineering. Geometry is   used in designing power systems, in planning control and flight systems. Computational geometry is used in design and manufacture electrical circuit. Also algebraic geometry is used to solve implicitization and inversion problems [7]

3.3. Vector analysis

In Vector analysis, there has a fundamental bit of electromagnetism. Students ought   to have the capacity to recognize areas in which the extents of the difference or twist will be substantial or little. To help calculated understanding, graphical elucidation, and verbal depiction it is useful to associate students of vector analytics with applications [8].

For example, electromagnetic fields, liquid mechanics and warmth exchange. In electromagnetism student find out about Stokes and Divergence theorems and how they are utilized as a part of depicting basics of electricity produced via friction [9]

3.4. Probability and statistics

The key mastery in designing is evaluating and researching peril and a decent number of electrical and electronics engineering programs require understudies take courses in probability and statistics to develop the aptitudes and figuring out how to gauge danger and prosperity in their plans. Courses in measurements cover focuses like frequency understanding of probability, probability theory, discrete probability and combinatory, distribution and density capacities, and sampling theory. These courses also start the utilization of probability and Statistical models to discover the execution of Success or disappointment of understudy system   .
Probability theory gives ground-breaking apparatuses to clarify, model, analyze, and design technology created by electrical and electronics engineering. From the field of correspondence building, advanced correspondence, Filter outline for clamor retraction, design acknowledgment if there should be an occurrence of Radar are for the most part display by Probability, stochastic process and insights [10].

For Example: We are giving an example [10]

Three switches associated in parallel work autonomously. Each switch stays shut with probability p. (a) Find the probability of getting an input signal at the yield. (b) Find the probability that switch S1 is open given that an input signal is gotten at the yield?

Solution: (a) Let A_i = "Switch S_i is blocked". Then P (Ai) = p, i = 1, 2, 3.

Since switches work freely, we have

$P(A_i A_j) = P(A_i)P(A_j)$; $P(A_1 A_2 A_3) = P(A_1)P(A_2)P(A_3)$.

Let R = "input signal is gotten at the yield". For the event R to happen either switch 1 or switch 2 or switch 3

must stay blocked, i.e. $R = A_1 \cup A_2 \cup A_3$.

$$P(R) = P(A_1 \cup A_2 \cup A_3) = 1 - (1-p)^3 = 3p - 3p^2 + p^3 \tag{1}$$

We can also determine this equation in an alternate way. Since any event and its compliment form a trivial partition, we can always write

$$P(R) = P(R/A_1) P(A_1) = P(R/\overline{A}_1) P(\overline{A}_1)$$

But $P(R \mid A_1) = 1$, and $P(\overline{A}_1) = P(A_2 \cup A_3) = 2p - p^2$ using these in the above equation we obtain

$$P(R) = p + (2p - p^2)(1 - p) = 3p - 3p^2 + p^3$$

Note that the events A_1, A_2, A_3 do not form a partition, since they are not mutually exclusive. Obviously any two or all three switches can be closed (or open) simultaneously.

Moreover, $P(A_1) + P(A_2) + P(A_3) \neq 1$

(b) We require, $$P(\overline{A}_1 / R) = \frac{P(R/\overline{A}_1) P(\overline{A}_1)}{P(R)} = \frac{(2p - p^2)(1 - p)}{3p - 3p^2 + p^3} = \frac{p^3 - 3p^2 + 2p}{3p - 3p^2 + p^3}$$

Because of the equilibrium of the switches, we also have

$$P(\overline{A}_1 / R) = P(\overline{A}_2 / R) = P(\overline{A}_3 / R) \cdot$$

3.5. Complex analysis and Fourier Transform

Complex analysis is used in electrical and electronics engineering in 2 major areas, one is in signal processing and another in control theory. In signal processing, complex analysis is utilized as a part of examination of signs, in communication systems: broadband, wifi, satellite communication, picture-video-audio compression, signal filtering/reconstruction [11] describe RCL practices with the point of phasors so on some of complex logical capacity techniques are utilized as a part of the multiband issue [7] etc.

Complex Numbers were acquainted with enable complex conditions to be unraveled with numbers that are the square underlying foundations of negative numbers, √-1. In electrical designing this sort of number is called a "imaginary number" and to recognize a imaginary number from a real number the letter "j " referred to regularly in electrical engineering as the j-operator, is utilized. In this manner the letter "j" is set before a real number to mean its imaginary number task. Examples of imaginary numbers are: j5, j10, j99 etc. At that point a complex number comprises of two particular yet especially related parts, a "Real Number" in addition to an "Imaginary Number" [14]. In Electrical Engineering there are distinctive approaches to speak to complex number either graphically or mathematically. Here is one way that applies the cosine and sine control is known as the

Cartesian or Rectangular Form. For mathematically example: $Z = 6 + j\,4$ and $\theta = tan^{-1}\dfrac{2}{3}$
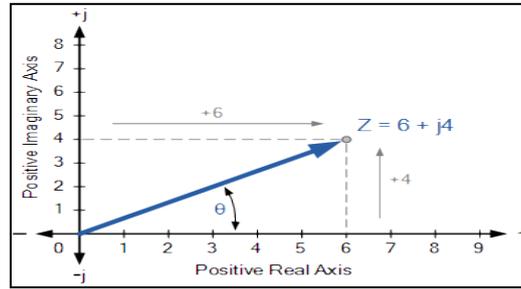

Figure 1: Complex number

The mathematics utilized as a part of Electrical Engineering to include resistances, currents or DC voltages utilize what are called "real numbers" utilized as either whole numbers or as divisions.

Complex Number Forms: $Z = x + jy = A < \theta = A(\cos\theta + j\sin\theta)$

For Example: We will give an example of Complex Analysis [14]

(RCL practices with the point of phasors so on some of complex logical)

A coil has a resistance of 20Ω and an inductance of 0.4H.If the current flowing through the coil is 4 amps. What will be the value of the supply voltage if its frequency is 60Hz?
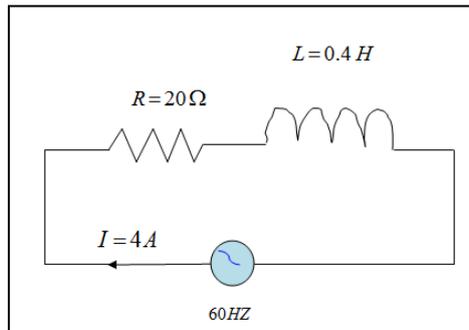

Figure 2: Impedance of the circuit

The impedance of the circuit will be above and we get from above circuit:

$X_L = 2\pi f L = 2\pi \times 60 \times 0.4 = 151\Omega$

$Z = \sqrt{R^2 + X_L^2}$

$Z = \sqrt{20^2 + 151^2}$

$= 152.32\Omega$

Then the voltage drops across each part is calculated as:

$$V_s = I.Z = 4 \times 152.32 = 610V$$
$$V_R = I.R = 4 \times 20 = 80V$$
$$V_L = I.X_L = 4 \times 151 = 604V$$

The stage point between the current and supply voltage is computed as: $\tan^{-1}\phi = \dfrac{X_L}{R} = \dfrac{151}{20} = 82.5^0$
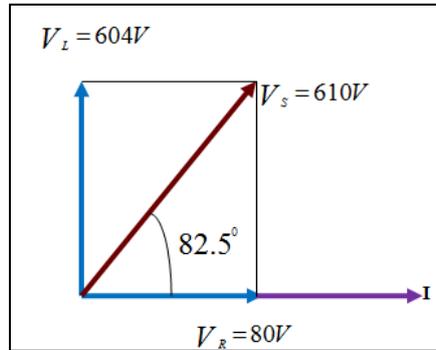

Figure 3: phasor

Fourier Transform

When dealing with signals **Fourier Transform** is very useful to convert time-based signals to their frequency based equivalents.

So it is anything but difficult to describe a signal based on its frequency behavior and range and configuration channels or transmission mediums to expand the proficiency of correspondence channels. This is the place Fourier Transforms become possibly the most important factor and help in flag examination. The second application territory is control theory, particularly in the investigation of strength of systems and controller plan.

3.6. Linear Algebra

The majority electrical and electronic engineering programs need courses in linear algebra.

These courses are basics for upper-division Electrical and electronic engineering courses.

Linear algebra, or matrix algebra, includes the investigation of solutions to systems of equations, determinants and vector spaces, including function spaces, linear transformations and eigen value and eigen vectors and quadratic forms.

For example

One of the most vital usages of linear algebra to electronics is to survey electronic circuits .

The objective of the Loop Current Analysis of Electric Circuits is to calculate the current flow in every part of the circuit [12]

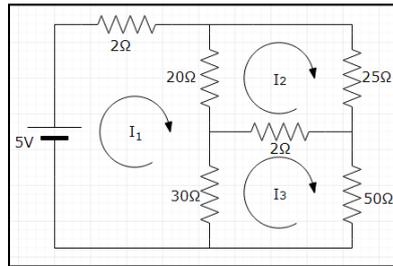Example 1: Find the current flowing in each branch of this circuit.

. **Figure 4:** Electronic Circuit

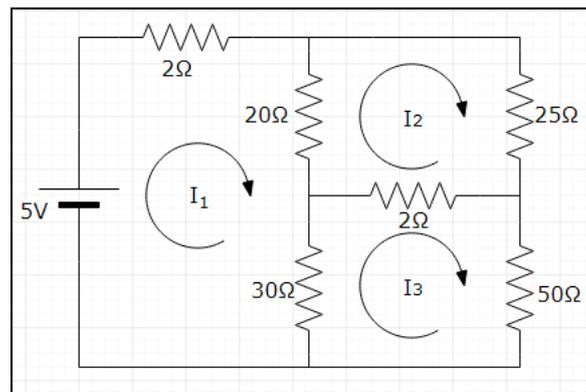**Solution:** The quantity of loop currents required is 3.

Figure 5: Electronic loop Circuit

We will prefer the loop currents exposed to the right. In fact these loop currents are net currents.

From Kirchoff"s Voltage Law for every loop. The result is the following system of equations:

$$2i_1 + 20(i_1 - i_2) + 30(i_1 - i_3) = 5$$
$$20(i_2 - i_1) + 25i_2 + 2(i_2 - i_3) = 0$$
$$30(i_3 - i_1) + 2(i_3 - i_2) + 50i_3 = 0$$

By Using Gaussian elimination solving the above system of equations, we get:

$$52i_1 - 20i_2 - 30i_3 = 5$$
$$-20i_1 + 47i_2 - 2i_3 = 0$$
$$-30i_1 - 2i_2 + 82i_3 = 0$$

Provides the following currents, all determined in amperes: $i_1 = 0.157, i_2 = 0.069, i_3 = .059$
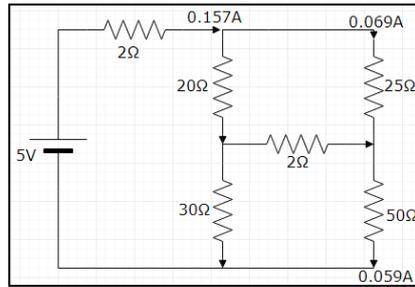
185

Figure 6: Electronic current Circuit

3.7. Differential Equations

Differential equations are a developed mathematics course required by some electrical and electronic engineering programs.

It incorporates subjects like first-order differential equations, undetermined coefficients and systems of linear differential equations, with an emphasis on applications to science and engineering. In circuit hypothesis, there will face circuits involving capacities and inductive loads. Here utilize learning of linear algebra and ODEs to solve these   circuits.

3.7.1. For example of series RL and RC circuit: [13]

3.7.1.1 (a) Series RL Circuit

The RL circuit exposed below has a resistor and an inductor connected in series.

The voltage drop across the inductor is given by L (di/dt); the voltage drop across the resistor is   given by i R; Kirchhoff's voltage law says that sum of voltage drop across the inductor L (di/dt).And the resistors iR are equal to the voltage E. This results in the following differential equation:
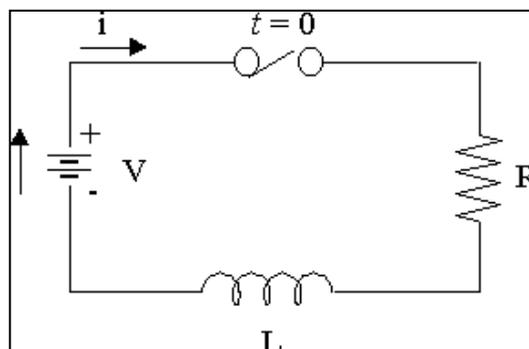
$$L\frac{di}{dt}+iR=E(t)$$

Figure 7: RL circuit diagram

3.7.1.2 (b) Series RC Circuit

The most RC circuit is a capacitor and a resistor in similar. At the point when a circuit comprises of just a charged capacitor and a resistor, the capacitor will release its put away vitality through the resistor. The voltage over the capacitor, which is time subordinate, can be found by utilizing Kirchhoff's current law, where the current charging the capacitor must equivalent the current through the resistor. These outcomes in the linear differential condition: $c\dfrac{dv}{dt}+\dfrac{v}{R}=0$
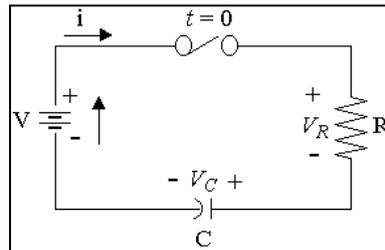

Figure 8: An RC series circuit

3.8. Trigonometry

Electrical Engineering covers a wide assortment of research, outline and item improvement exercises. Starting plans and ideas are quite often finished with PC displaying (or on paper) utilizing a scientific portrayal of the issue. It is extremely normal for trigonometry to be included. Specific PC programming's can stream-line the outline procedure yet there is no getting away from the need to completely comprehend the math ideas. **For example**, fundamental circuit components are demonstrated geometrically utilizing x and y arranges. Resistive and responsive qualities are plotted as right triangles. All standard trigonometric capacities (and their inverses) are exceptionally helpful in outlining and breaking down circuits. A wide range of electro-mechanical gadgets like engines, generators and automated instruments are demonstrated utilizing trigonometry. Turn is normally depicted by sine and cosine capacities and stage points. Correspondence signals like AM and FM broadcasting, advanced TV, mobile phone transmissions, and WiFi are planned and broke down utilizing trigonometric capacities. These sign rehash in time so they are displayed as sine and cosine capacities.

4. Conclusion

In this paper, various type of applications of mathematics in Electrical and electronic engineering fields have been shown. The various types of applications of mathematics problems have taken from real life. There don't require advanced mathematics to solve in any problems. Electrical and electronic engineering students with solid circumstance in calculus, Differential equations, Fourier analysis can explain them with no trouble. It is normal that these above problems shown in this paper will be rouse electrical and electronic engineering students to understand mathematics well. There ought to be agreeable of Mathematics as it has helped electrical and electronic engineering advanced.

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