Asian Journal of Applied Science and Technology (AJAST)
Volume 6, Issue 1, Pages 122-126, January-March 2022

LR Electrical Circuit Analysis by Using Some Mathematical Methods

Shilpa kulkarni[1] & Pralahad Mahagaonkar[2]

[1]*Department of Physics, SSA Govt. First Grade College, Ballari, Karnataka. Email: shilpa20112011@gmail.com*
[2]*Department of Mathematics, Ballari Institute of Technology & Management, Ballari, Karnataka. Email: pralahadm74@gmail.com*

DOI: http://doi.org/10.38177/ajast.2022.6114

Article Received: 15 December 2021 *Article Accepted: 04 March 2022* *Article Published: 22 March 2022*

ABSTRACT

In this paper we have been discussed the analysis of solving inductance L and resistance R circuit by using first order linear differential equation and also solved numerical methods. Here we have choosen a L-R circuit and assigned the constant values of voltage, inductance and resistance and by assigning the different values for time, the results of current have been studied by the differential equation. Introducing the higher values in the above circuit of first order differential equation, the obtained results were compared with numerical method, RK Method and Taylor's Series method, the obtained results were in the divergent values.

Keywords: *Linear differential equations, Numerical method, L-R circuit, RK (Runge-Kutta method), Taylor's series method.*

1. Introduction

A differential equation gives an idea of involving the differential coefficient. If any differential equation has a single independent variable as a derivative then that is said to be ordinary differential equation. Electricity can be understood as substance which flows through conductors such as wires. The flow of charges through the closed circuit is called the electric current. It can also be defined as measure of rate of flow of charges through the conductor. Generally the electric circuit is involved with components like resistance (R), inductance (L) and capacitance (C) etc., and also the involvement of active element sources.

2. Results and Discussion

Here, we have studied the ordinary differential equation and obtained the solutions by classical method, RK Method and Taylor's Series method.

Consider the circuit with resistance R, inductance L and electromotive force E.

The circuit was solved by the Differential equation,

$$L\frac{di}{dt}+Ri=E$$

Here, the values of L and R are Constants and initially the current i =0.

By using the linear equation i.e. $\frac{dy}{dx}+Py=Q$

Here, the solution of LR circuit is $y(I.F)=\int(I.F)dx+c$ Where IF= $e^{\int Pdx}$.

$$\frac{di}{dt}+\frac{R}{L}i=\frac{E}{L} \qquad (1)$$

Let IF (Integral Factor) = $\int e^{\frac{R}{L}dt}$.

Then the solution is,

$$i\,e^{\frac{Rt}{L}} = \frac{E}{L}\int e^{\frac{Rt}{L}}dt + C$$

$$i\,e^{\frac{Rt}{L}} = \frac{E}{L}\frac{e^{\frac{Rt}{L}}}{(R/L)} + C$$

$$i\,e^{\frac{Rt}{L}} = \frac{E}{R}e^{\frac{Rt}{L}} + C$$

Therefore $i = \frac{E}{R} + Ce^{\frac{-Rt}{L}}$ (2)

In this case, we consider initially consider the current i=0, and t=0, then $C = \frac{-E}{R}$

Thus, equation (2) gives us

Then, $i = \frac{E}{R}\left(1 - e^{-\left(\frac{Rt}{L}\right)}\right)$ (3)

In this paper, we consider the value of L=2 Henry, R=10 Ohms, E=200 Volts.

Then Equation (3) becomes,

$i = 20\left(1 - e^{-5t}\right)$ (4)

2.1. Ruge Kutta Method for 1st Order Differential Equation

Consider the differential equation $\frac{dy}{dx} = f(x, y),\ \ y(x_0) = y_0$ then calculate the following,

$$k_1 = hf\ \ x_0, y_0$$

$$k_2 = hf(x_0 + h/2, y_0 + k_1/2)$$

$$k_3 = hf(x_0 + h/2, y_0 + k_2/2)$$

$$k_4 = hf(x_0 + h, y_0 + k_3)$$

$$y(x_0 + h) = y_0 + 1/6(k_1 + 2k_2 + 2k_3 + k_4).$$

Which gives the required approximate value of $y_1 = y(x_0 + h)$.

2.2. Taylor's Series Method

Consider the initial value problem: $\frac{dy}{dx} = f(x, y)$ *and* $y(x_0) = y_0$.

The Solution of y(x) is approximated to the power of $(x-x_0)$ using Taylor's series.

The Taylor's series expansion for y(x) about the point x_0 in the form:

$$y(x) = y(x_0) + (x - x_0)y'(x_0) + \frac{(x - x_0)^2}{2!} y''(x_0) + \frac{(x - x_0)^3}{3!} y'''(x_0) + ...$$

2.3. Comparison of the Solutions of RK method and Taylor's method

In this section the classical method, RK method and Taylor's method results have been compared. The obtained values were listed in the table 1.

In order to verify these techniques of two methods and classical methods have been selected for our results. For both the methods selected step size was h=1/32 and table 1 gives a data with respect to different solutions and table 2 represents the error occurred in RK method and Taylor's method with classical method.

Table 1. Results of classical, RK and Taylor's methods

t=l/32	Current (i) Classical method	RK method	Taylor's method
1/32	2.893122	2.907621	2.919812
3/32	7.484323	7.477125	7.539521
5/32	10.84345	9.603331	10.87245
7/32	13.30084	15.63992	13.15671
9/32	15.09885	17.29037	14.43972
11/32	16.39265	18.36030	14.58122
13/32	17.37652	19.04246	15.25512
15/32	18.08066	19.47135	17.45821
17/32	18.59578	19.74241	18.12584
19/32	18.97265	19.92462	18.92145
21/32	19.24837	20.07378	19.25811
23/32	19.45009	20.24355	19.24158
25/32	19.59761	20.50813	19.52481
27/32	19.70565	20.98966	19.92851
31/32	19.87245	23.65944	20.12532

Asian Journal of Applied Science and Technology (AJAST)
Volume 6, Issue 1, Pages 122-126, January-March 2022

Table 2. Errors from RK method and Taylor's method

x=l/32	RK Method	Taylor's Method
1/32	0.016401	0.02669
3/32	-0.007198	0.055198
5/32	-1.240119	0.029000
7/32	2.33908	-0.14413
9/32	2.19152	-0.65913
11/32	1.96765	-1.81143
13/32	1.66594	-2.1214
15/32	1.39069	-0.62245
17/32	1.14663	-0.46994
19/32	0.95197	-0.0512
21/32	0.99518	0.00974
23/32	0.79346	-0.20851
25/32	0.91052	-0.07351
27/32	1.28401	0.22286
31/32	3.78699	0.25287

3. Conclusion

In a Series circuit when we use higher values in the first order differential equation the result of exact solution by using the method of integrating factor and numerical method (RK Method and Taylor's Series method), the solutions are divergent.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

Volume 6, Issue 1, Pages 122-126, January-March 2022

References

[1] Pant, G. D & Shrestha, G. S. Integral Calculus and differential equation. Kathmandu: Sunila Prakashan.

[2] Sharma, D., Poudel, & Adhakari, Engineering Mathematics II. Kathmandu: Sukanda Pustak Bhawan.

[3] Text book of Calculus and linear algebra: Dr. K.S.C, Sudha Publications (2018-19).

[4] Shrestha, K.K, Regmi, R. P., Poudel, M. P. & Pandey, H. R.(2015). Fundamental of Engineering Mathematics Volume II. Pokhara: Ozone Books and Stationery.

[5] Soni, K.M. (2013). Circuits and System. Delhi: S.K. Kataria and Sons.

[6] Tiwari, S.N. & Saroor, A.S. (1992). A first course in Electrical Engineering.Allahabad: Wheeler Publication. SICAL method, Rajendra Prasad Regmi.

[7] Application of differential equation in L-R and C-R circuit analysis by classical method. Rajendra Prasad Regmi, Janapriya Journal of Interdsciplinary Studies, 5, December 2016.

[8] B. P. Lathi, Principles of Linear Systems and Signals, Second Edition, Oxford, 2009.

[9] John Alan Stuller, An Introduction to Signals and Systems, Thomson, 2007.

[10] www.nepjol.info (Accessed: 12 December 2021).

[11] www.scribd.com (Accessed: 05 December 2021).

[12] www.coursehero.com (Accessed: 14 December 2021).