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IMPACT OF ROUND TRIP TIME ON THE TRANSIENT ANALYSIS OF LUMPED PARAMETER R-L CIRCUIT USING ONE DIMENSIONAL TRANSMISSION LINE MODELING (TLM) METHOD

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Abstract: Here, the effect of the round trip time on the transient analysis of lumped parameter R-L circuit was observed using one dimensional TLM method. Firstly, the sample circuits were modeled to derive the required algebraic iterative equation using stub model of the TLM method. The classical method using differential equations was considered as the reference method. Finally, the analytical results using TLM method for different values of the round trip time were compared with classical method for conclusion.
Keywords: Classical method, lumped, stub model, Transient analysis.

INTRODUCTION

The method of transmission line modeling (TLM) is first mentioned by [1] and then further developed by [2-7]. They described that it is a space and time discretizing method for time domain modeling of electromagnetic structures. The TLM method is not only the powerful method for the analysis of the numerical and creative electromagnetic problems, but also provides a strong technique for analytical solution of lumped parameter electric circuit. In [8] the distributed circuits were solved by TLM method. Lumped means concentrated instead of being distributed. And the classical method is the method of circuit solving using differential equations. It is the established method for circuit solution. That's why the classical method was used as the reference method for comparison purpose.

The main feature of this method is the simplicity of formulation and programming for a wide range of applications [3, 6]. To the best of author's knowledge, there is no published work concerning the solution of the problem for lumped parameter RL circuit considering different values of round trip time, Δt for analyzing the validity of the TLM method for circuit solution.

Motivated by all the authors above, here, the TLM method is used to make the transient analysis of lumped parameter RL circuit for different values of Δt. For this reason, we

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considered two steps [9]. Firstly TLM equivalent network is drawn by replacing the concerned lumped network for the derivation of the simple algebraic equations. And secondly the network is solved by using one type of iterative methods.

The remainder of this paper is organized as follows. Section 2 describes the methodology. The Transient analysis is depicted in section 3. Numerical results are shown in Section 4 and section 5 provides the concluding remarks.

2. METHODOLOGY

For 'Stub' model of inductor let us consider the following Fig.1 at time k from [6],

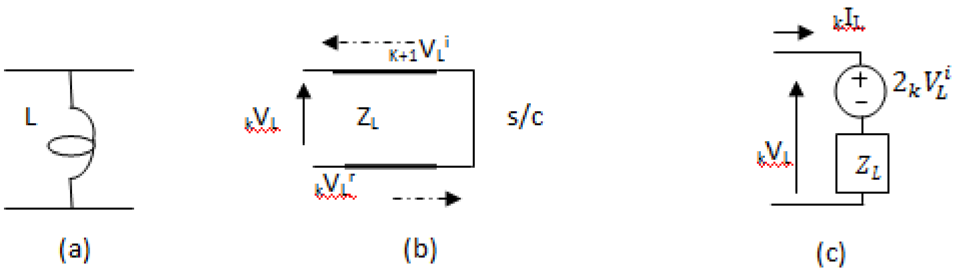

Fig. 1. (a) An inductor (b) its stub model (c) Thevnin's equivalent of the stub model.

Similarly the characteristics impedance,

$$Z_L = \sqrt{\frac{L_d}{C_d}} = \frac{2L}{\Delta t} \quad (1)$$

From Fig. 2. (c) => we can write for k+1 step,

$$_{k+1}V_L^i = -\, _kV_L^r \quad (2)$$

It is reasonable choice because reflection coefficient of load for short circuit termination is -1.

3 TRANSIENT ANALYSIS

The following circuit is considered to find out the parameter of V_L(t) and I(t) for analysis.

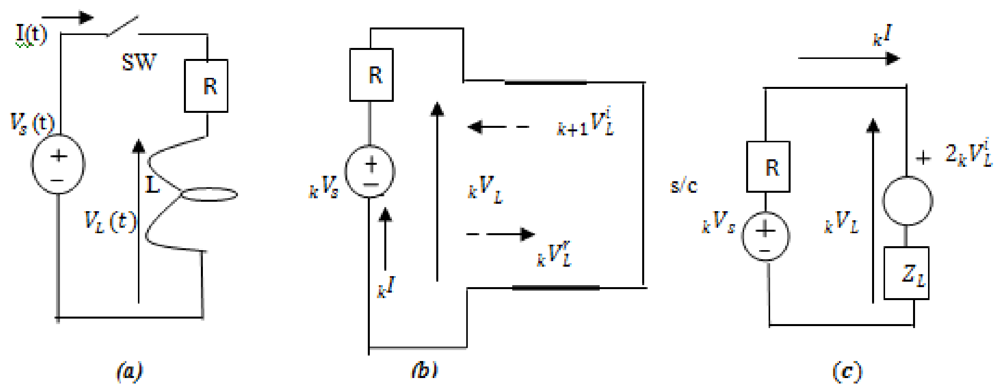

Fig. 2- ***(a) A series R-L circuit, (b) its TLM models, and (c) its Thevenin's equivalent***

From **Fig. 2-(c)**, the current at time kΔt is,

$$ {}_{k}I = \frac{{}_{k}V_{s} - 2{}_{k}V_{L}^{i}}{R+Z_{L}} \tag{3} $$

The voltage across the inductor is,

$$ {}_{k}V_{L} = 2{}_{k}V_{L}^{i} + {}_{k}IZ_{L} \tag{4} $$

And the reflected voltage may be obtained from

$$ {}_{k}V_{L}^{r} = {}_{k}V_{L} - {}_{k}V_{L}^{i} \tag{5} $$

The new incident voltage is the voltage pulse for short circuit termination,

$$ {}_{k+1}V_{L}^{i} = -{}_{k}V_{L}^{r} = {}_{k}V_{L}^{i} - {}_{k}V_{L} \tag{6} $$

4. NUMERICAL RESULTS

For the **circuit of Fig. 2,** we taken Δt=0.1 s, R=1 Ω and L=1 H, time constant= L/R=1/1=1 s, and $V_s(t)$ =10V. For different values of round trip time $\boldsymbol{\Delta t}$ **,** the analytical results are shown below:

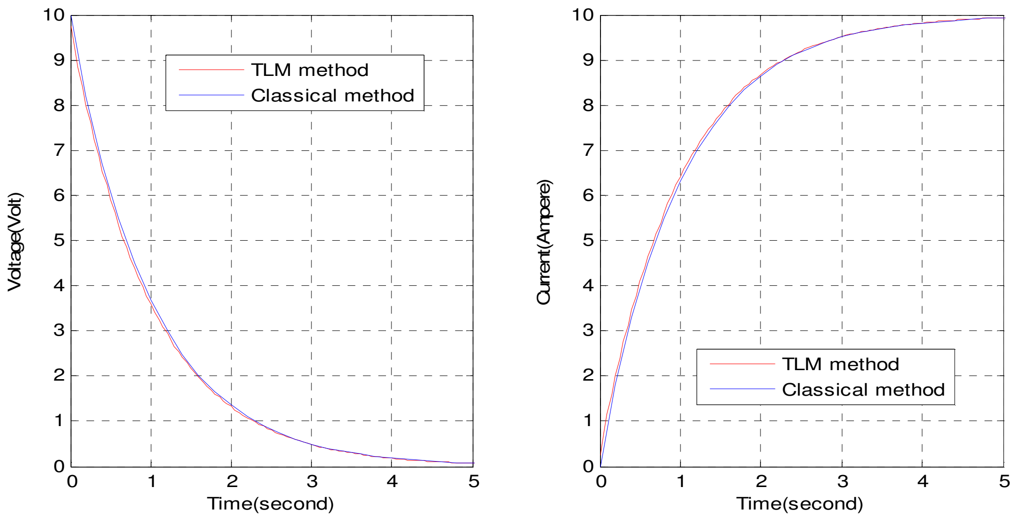

Fig. 3. Analytical results of Fig. 2 using the both classical and TLM method for round trip time, Δt=0.05 s.

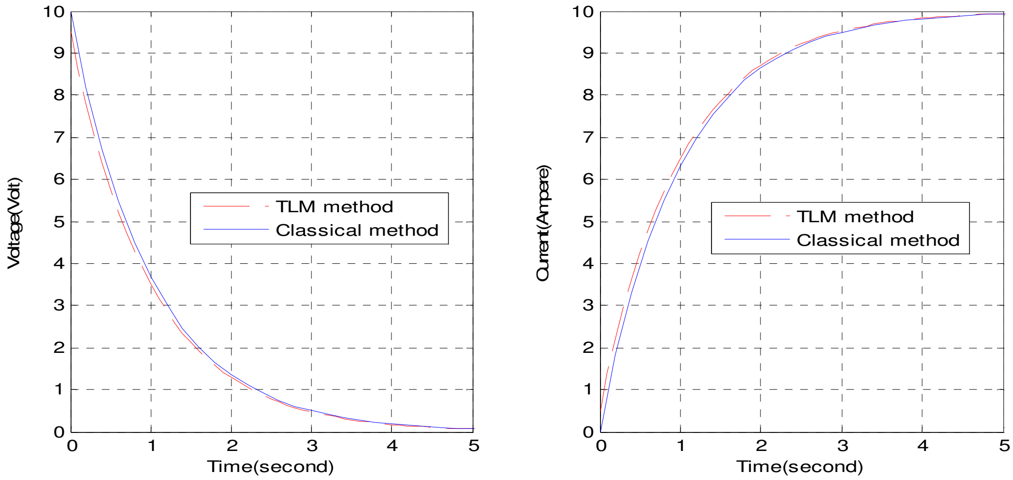

Fig. 4. Analytical results of Fig. 2 using the both classical and TLM method for round trip time, Δt=0.1 s.

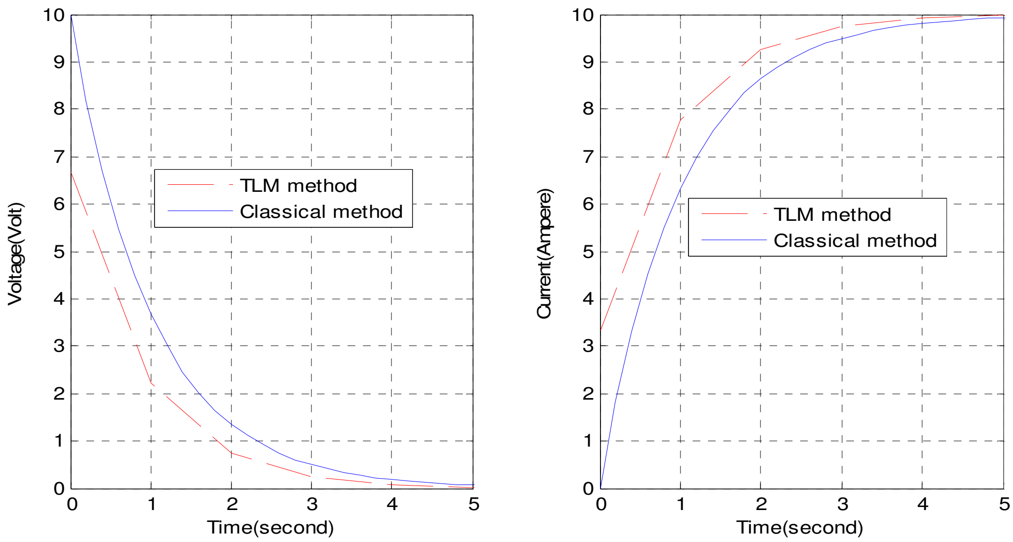

Fig. 5. Analytical results of Fig. 2 using the both classical and TLM method for round trip time, Δt=1 s.

5. Conclusion

The circuit solving validity of TLM method was observed by comparing the analytical results of these lumped element circuits with classical one. The output figure using both methods were about same in shape up to the value of Δt is 0.1 second . When the round trip time is increased beyond it, the analytical result using TLM method decreased the current and increased the voltage significantly. We observed that, the TLM method gives an accurate result (exactly the same result as classical method), if when we took Δt<= (time constant of R-L circuit/10. Finally, we conclude that TLM method is the powerful tools for solving not only for the microwave transmission line but also for the lumped parameter electric circuits.

The impact of the round trip time for TLM method on the analytical results for other types of electric circuits can be studied next.

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