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Analysis of Inductance Front Controlled Impulse Voltage Generator Circuit By MATLAB Simulink

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Abstract: **According to national and international standard electrical equipment should be tested by a standard 1.2/50 µs impulse voltage. In the testing this standard impulse wave can be easily generated for the capacitance object. Difficulties arise in getting the standard tail time of 40 to 60 µs in case of inductive object. In case of object having high inductance does not create much problem but when the inductance is medium (4 to 15mH) or low (0.4 to 4mH) there are particular range of values of parameters for which the standard wave tail can be achieved. In this case a longer front time is obtained which cannot be control by front resistance easily. Hence an inductance is connected across the front resistance and then the various parameters of circuit are analysed by MATLAB Simulink. It was found that with the help of this inductance front controlled circuit, the front time can be obtained within the range more easily.**

Keywords: **Analysis of Inductance, MATLAB Simulink, Voltage Generator Circuit.**

I. INTRODUCTION

National and international standards specifies a lightning impulse voltage of 1.2/50 µs when impulse voltage testing of electrical equipments is carried out. For ultra-high-voltage transformers it is found that their inductance is never in any case lower than 15mH, so that the standard time to half-value can always be obtained when testing the high voltage windings of these transformers merely by using the ordinary testing circuit. Small inductive loads which are often experienced in practice when testing low-voltage windings of generator transformers, or distribution transformers results in a time less than 40µs with the conventional Marx impulse voltage generator circuit.

According to K. Feser the inductance of these equipment lies in the range of 1mH to 12.4mH which appear in low voltage winding of generator transformers and distribution transformers. He proposed a modified impulse voltage generator circuit. This circuit has a lower limit of approximately 5mH for impulse capacitance of 1.1 µF and a time to half-value of 40µs, He says that the lower limit for production of an acceptable wave shape with this impulse generator circuit is reached with a series resistance of 65 ohms and the appropriate parallel resistance value and a longer time to half-value can be obtained with the modified circuits. In this paper he tested impulse voltage generator practically with medium inductive load of 5mH. With the considered value of the circuit a standard time to half value can be obtained but in that circuit wave shape is obtained with a longer front time. Hence modifications of the conventional circuit thus become essential for a better wave shape.

(A) Simulation of Impulse Generator For medium Inductive Loading (5mH)

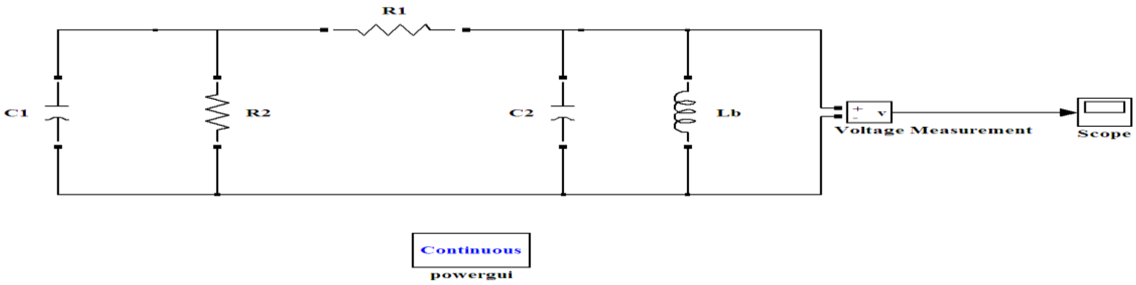

Fig.1 Simulation Circuit (A)

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The values [1] considered for this circuit are **C_1**=1.1µF, **C_2**=10nF, **R_1**=65Ω, **R_2**= 2900Ω & **L_b** =5mH. With the help of simulation maximum output voltage obtained is 959.08kV with front and tail time of 3.1668 µs & 42.044 µs respectively. This also shows that T_1 is not in range. So for finding out the standard impulse wave its parameters are varied one by one.

A.1 Variation in R_1

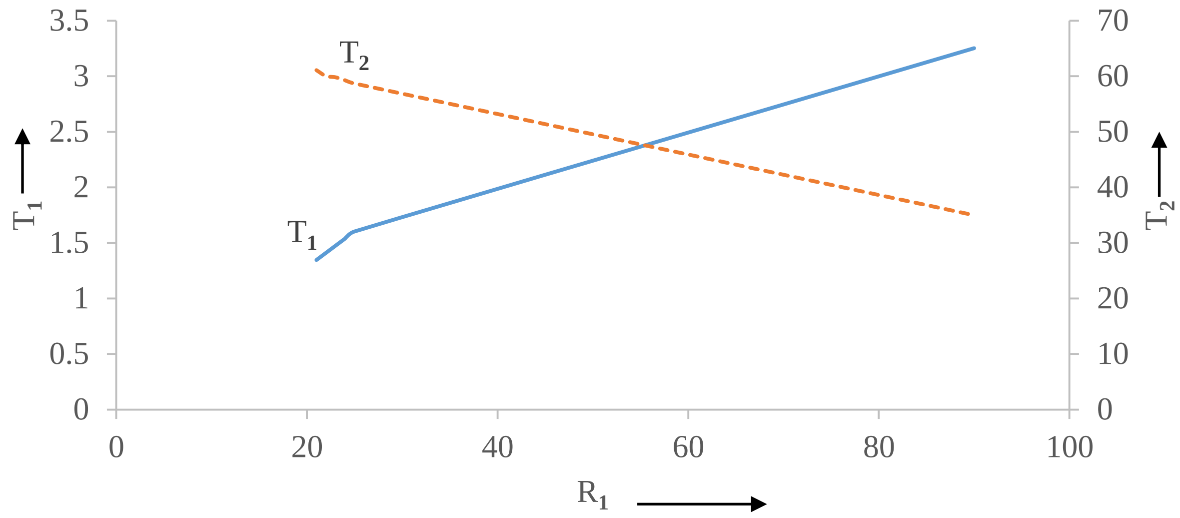

Fig.2. Variation in R_1

From the above graph of variation in R_1 it can be seen that the range of R_1 is only from 22Ω to 24Ω , to get the standard front time which is very difficult to achieve practically.

A.2 Variation in R_2

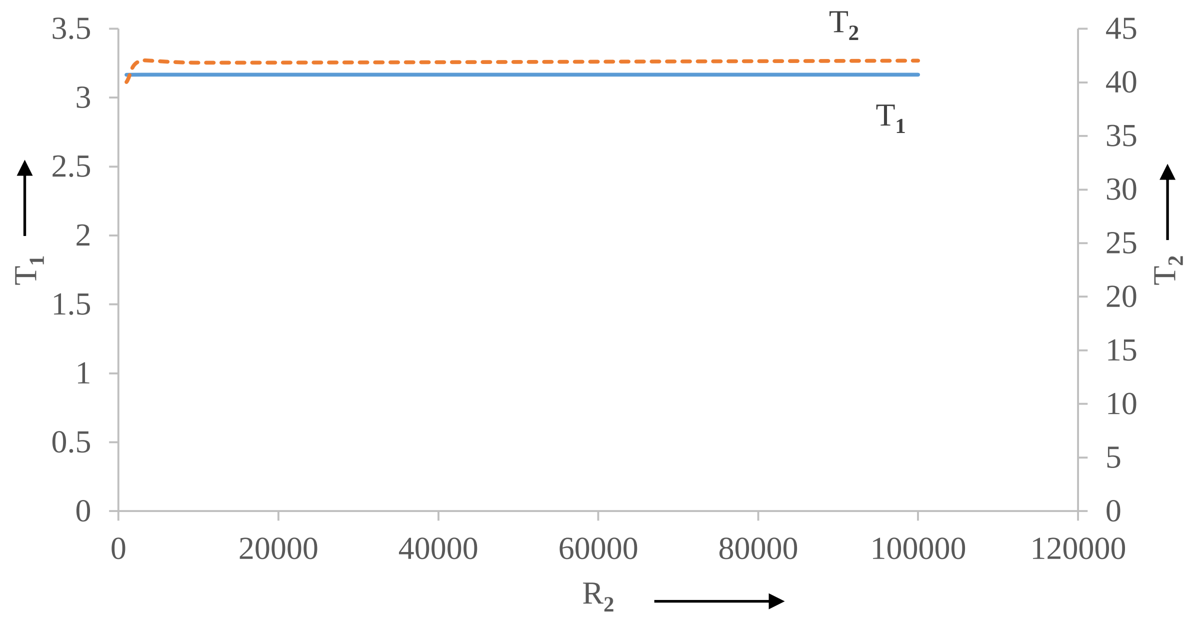

Fig.3. Variation in R_2

R_2 is ineffective on the wave tail time T_2 as well as T_1 in the case of medium inductive load.

The variation in parallel resistance shows that there is no change in the front time and very little change in the tail time with a wide variation of shunt resistance R_2.

A.3 Variation in ratio C_1/C_2

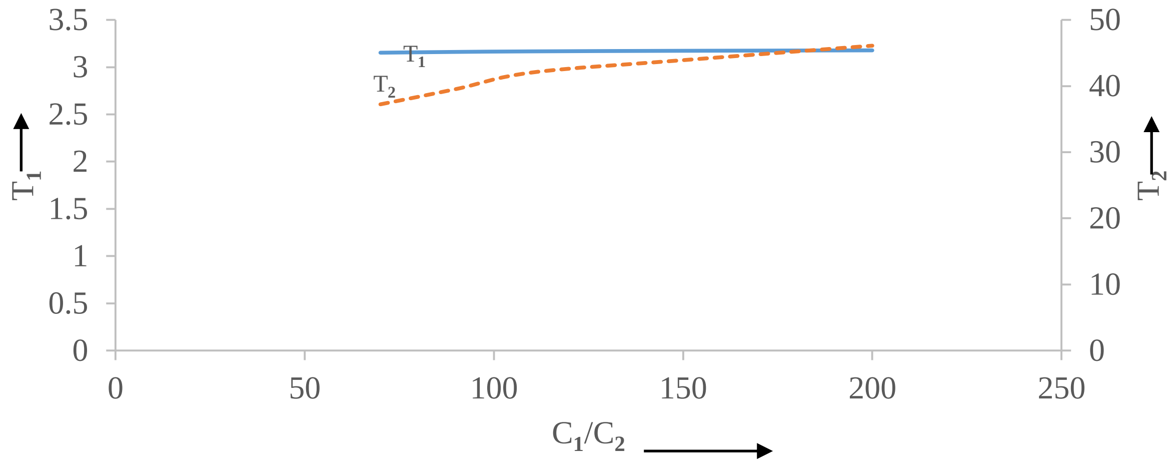

Fig.4. Variation in C_1/C_2

The variation in C_1 is showing the effect on the tail time as it happens in the conventional equivalent circuit of the impulse voltage generator. By increasing the ratio C_1/C_2 (from 110 to 200), it is ineffective on the front time (T_1 does not decreases) while tail time T_2 increases slightly (from 42 to 46µsec.). On the other hand decrease in C_1/C_2 ratio beyond 90 is ineffective on the front time T_1 (varies from 3.1668 to 3.103µsec.) but the T_2 will decrease (from 42 to 39.544µsec.).

This analysis shows that variation in all the parameter does not give the standard wave shape at the given loading condition.

(B) Simulation of modified impulse generator with inductive load

Now to get standard front time within the range (0.84 to 1.56µsec.), a modification requires in previous circuit (Fig.1). Although in this circuit the tail time has been achieved but the front time does not come in the standard range. Hence to get the front time in the standard range an inductance L_d is connected in parallel with the series resistance R_1 and the circuit is analysed by simulation by keeping other parameters constant.

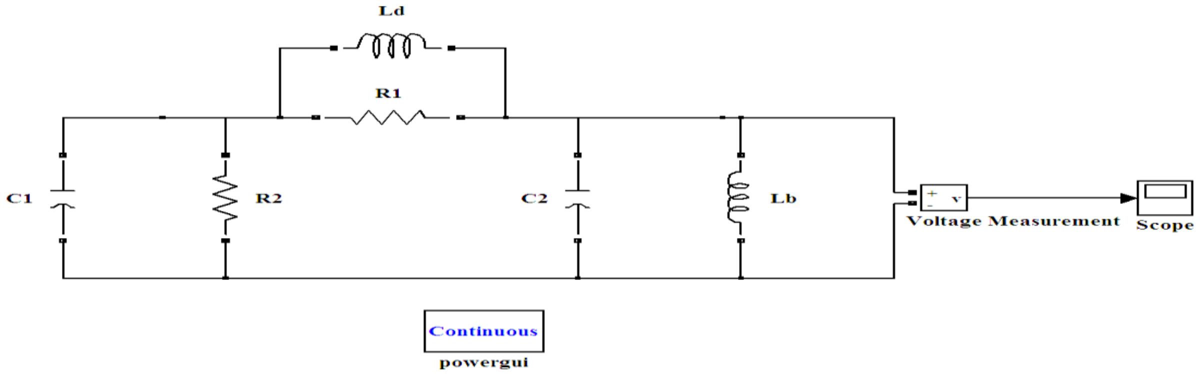

Fig.5 Simulation Circuit (B)

The values considered for this circuit and the result is as following

Table 1: Circuit Parameters and Result of Circuit (B)

Circuit Parameters						Results		
C_1	C_2	R_1	R_2	L_d	L_b	Maximum Output Voltage (kv)	T_1 (µs)	T_2 (µs)
1.1µF	10nF	65Ω	2900Ω	0.4mH	5mH	103.6	3.3508	72.914
1.1µF	10nF	65Ω	110Ω	0.4mH	5mH	101.84	2.5002	45.161

Result With this value of R_2 (2900) the tail time has increased up to 72.83µsec and front times also increases up to 3.3508µsec.Hence decrease in the R_2 up to the value of 110 ohm gives the standard tail time. But front time is still more than the standard value.

B.1 Variation in R_1

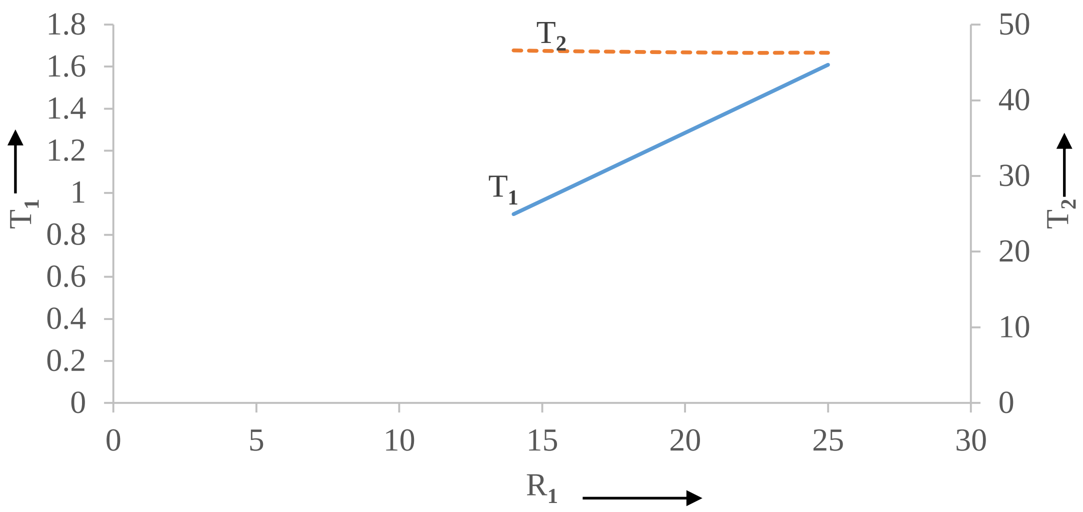

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Fig.6. Variation in R_1

When L_d was not connected in the impulse voltage generator circuit with inductive load of 5mH, standard wave front time T_1 (from 1.41µsec. to 1.53µsec.) was obtained for the values of R_1 (from 22 to 24ohm only) i.e. there was no increment in the wave front time T_1 with increase in the value of R_1. Secondly the wave tail time is also on the border value (59 to 60µsec.)

When L_d is connected in the impulse voltage generator circuit with inductive load of 5mH, variation in front time T_1 from 0.89 to 1.54 µsec. has been obtained with variation in R_1 from 15 to 24 ohms. Hence it can be said that R_1 is much more effective to get the standard front time in this circuit.

B.2 Variation in R_2

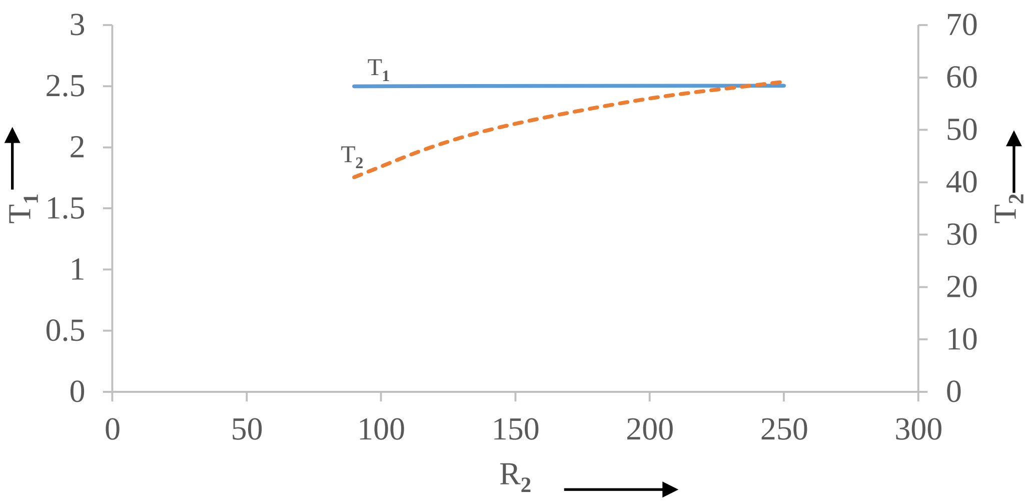

Fig.7. Variation in R_2

When L_d was not connected in the impulse voltage generator circuit with inductive load of 5mH, standard wave tail time T_2 (from 40µsec. to 42µsec.) for the values of R_2 (from 1000 ohm to infinity ohm) i.e. there was no increment in the wave tail time T_2 with increase in the value of R_2.

On the other hand when L_d is connected in the impulse voltage generator circuit with inductive load of 5mH, variation in tail time T_2 from 40 to 60μ sec. has been obtained with variation in R_2 from 90 to 260ohm. So R_2 is much more effective in this circuit.

B.3 Variation in ratio C_1/C_2

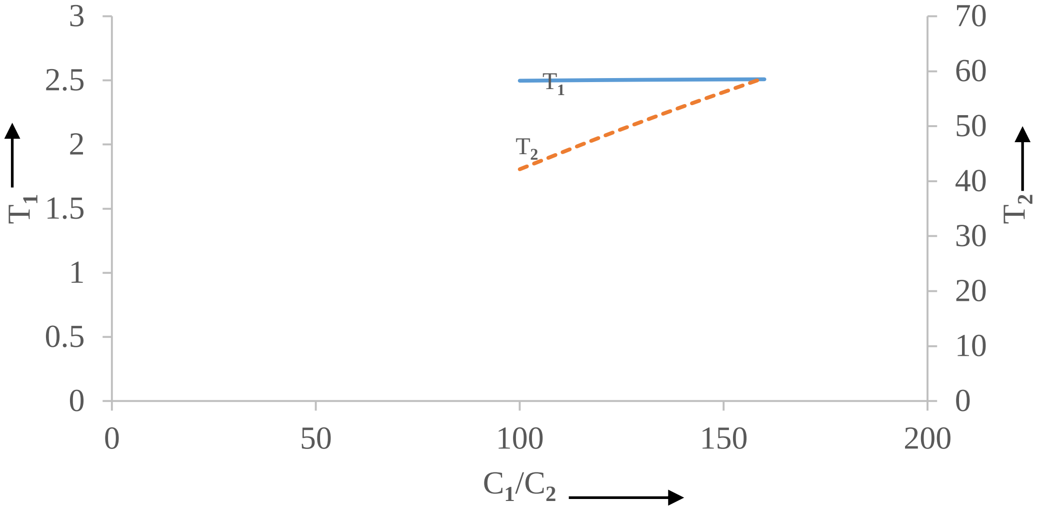

Fig.8. Variation in C_1/C_2

When L_d was not connected in the impulse voltage generator circuit with inductive load of 5mH, standard wave tail time T_2 (from 42μsec to 46μsec. only) for the values of C_1/C_2 (from 110 to 200) i.e. ratio C_1/C_2 is not much effective to get standard wave tail time T_2.

When L_d is connected in the impulse voltage generator circuit with inductive load of 5mH, variation in tail time T_2 from 42.169 to 58.788μsec. has been obtained with variation in C_1/C_2 from 100 to 160. Hence it can be said that ratio C_1/C_2 is much more effective

II. CONCLUSION

The simulation analysis of both circuits show that modified generator circuits as per Fig.5 can deliver a lightning impulse within the permissible tolerances even under medium inductive load conditions. When L_d is connected in parallel with series resistance R_1, the standard front time can be easily obtained by the variation of R_1. Similarly R_2 is much more effective in the modified circuit to get the standard tail time. The ratio C_1/C_2 obtained for this loading varies from 100 to 160 i.e. this ratio is more effective in modified circuit.

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