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

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ABSTRACT

In this paper comparison of the resistance front controlled (R.F.C.) circuit with capacitive (C) load and resistance front controlled circuit with capacitive inductive (C -L) load has been done and both circuits are analysed to obtain the impulse voltage wave shape within the tolerance limit (1.2µs±30%/50µs±20%)by using Simulink/ MALTAB. It is found that in the R.F.C. circuit with capacitive load impulse voltage wave shape can be obtained easily by using fixed ratio C_1/C_2but for capacitive inductive load it is difficult to obtain impulse voltage wave shape within the tolerance limit by using same ratio C_1/C_2. It is also observed that wave tail time can be obtained within the range but wave front time cannot be obtained within the range.

Keywords:—*Model of impulse voltage generator, capacitive load, Inductive load, Simulink/MATLAB version R2010a.*

I. INTRODUCTION

National and international standards specifies a lightning impulse voltage of 1.2/50 µs when impulse voltage testing of electrical equipment is carried out. In the testing this standard impulse wave can be easily generated for the capacitive object. Difficulties arise in getting the standard tail time of 40 to 60 µs in case of inductive object. 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. 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.

II. GENERAL ANALYSES OF THE CIRCUITS

(A) Analysis of basic impulse voltage circuit having purely capacitive LOAD C_1/ C_2=66.66µF

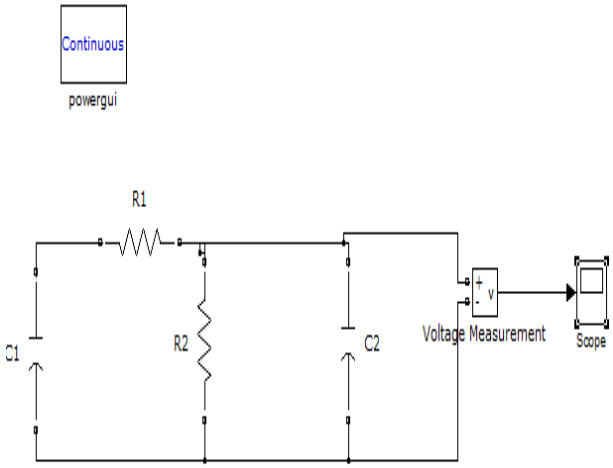


Figure 1: Simulation Circuit (A)

By using basic impulse voltage circuit having purely capacitive load a standard impulse wave form can easily be obtained within the range.

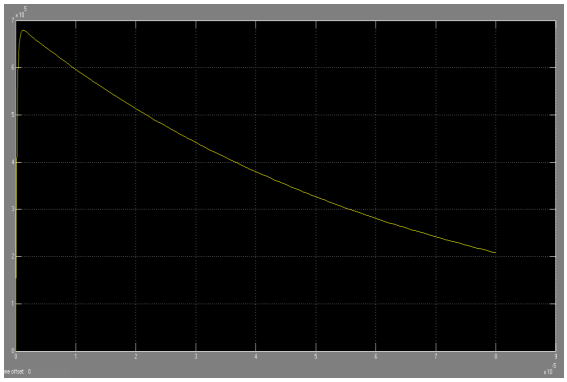
Standard wave shape: - A standard wave shape is specified by (1.2µs±30%/50µs±20%)

1.Effect of variation in $R_1$and R_2 for the fixed ratio C_1/C_2=66.66µF

The wave shape of the considered circuit can be controlled by the generator capacitance (C_1), load capacitance (C_2).The effect of impulse voltage waveform can be controlled by wave front and wave tail resistancesR_1 is varied from 75 to 160Ω and R_2 is varied from 2600 to 3000Ω by keeping other parameters constant.

Consider Table:(1) Simulation Result can be obtain by using table :-(1)

SL. No.	Resis-tance R_1(Ω)	Resis-tance R_2(Ω)	Maximum Output Voltage (KV)	Front time T_1 (µs)	Front time T_2 (µs)
1	75	2600	898.58	0.84	50.26
2	90	2700	896.27	1.22	50.26
3	110	2900	890.14	1.46	51.30
4	160	3000	887.18	1.55	59.58



Wave tail time (T_2)

Figure 1(a) Simulation withC_1/C_2=66.66µF

Y-axis represents voltage V (t)& X- axis represents Time period T (t)

(B) Analysis of Impulse Generator Circuit for Medium Inductive Loading.

(6500µH to 13500 µH)

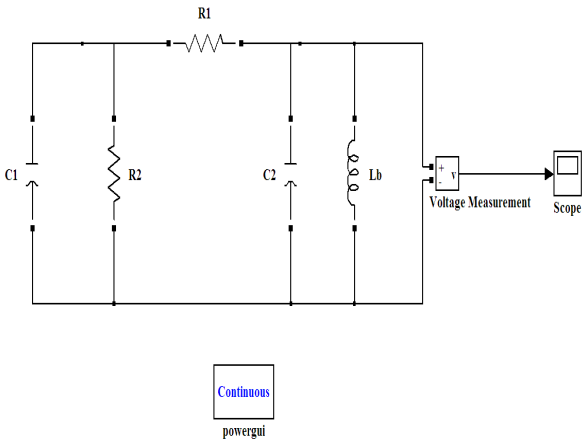


Figure 2:Simulation Circuit (B)

Effect of variation of $R_1$and R_2 in the fixed ratio C_1/C_2=66.66µF

The variation of R_1 and R_2 is to control the wave-front time and wave-tail time respectively by keepingC_1/C_2 ratio fixed to observe the effect on wave front time and wave tail time of the impulse wave shape having different loading condition.

LOAD HAVIND $L_{b.}$ =6500µH

Variation of R_1

SL. No.	Lb.	Resis-tance $R_1(\Omega)$	Resis-tance $R_2(\Omega)$	Front time T_1 (µs)	Tail time T_2(µs)	Maximum Output Voltage (KV)
1	6500	60	2600	2.0	58	976
2	6500	80	2600	2.7	54	969
3	6500	100	2600	3.4	51	962
4	6500	120	2600	3.1	47	955
5	6500	135	2600	3.5	45	951

Variation of R_2

SL. No.	Lb.	Resis-tance $R_1(\Omega)$	Re-sistance R_2 (Ω)	Front time T_1 (µs)	Tail time T_2 (µs)	Maximum Output Voltage(KV)
1	6500	60	2600	2.0	58	974
2	6500	60	3000	2.0	58	975
3	6500	60	6000	2.0	60	975
4	6500	60	8000	2.0	60	975
5	6500	60	10000	2.0	60	975

LOAD HAVIND $L_{b.}$ = 13500µH

Variation of R_1

SL. No.	Lb.	Resis-tance $R_1(\Omega)$	Resis-tance $R_2(\Omega)$	Front time T_1(µs)	Tail time T_2 (µs)	Maximum Output Voltage (KV)
1	13500	60	2600	2.0	58	976
2	13500	80	2600	2.7	54	969
3	13500	100	2600	3.4	51	962
4	13500	120	2600	3.1	47	955
5	13500	135	2600	3.5	45	951

Variation of R_2

SL. No.	Lb.	Resis-tance $R_1(\Omega)$	Resis-tance $R_2(\Omega)$	Front time T_1(µs)	Tail time T_2 (µs)	Maxi-mum Output Voltage (KV)
1	13500	60	2600	2.0	58	974
2	13500	60	3000	2.0	58	975
3	13500	60	6000	2.0	60	975
4	13500	60	8000	2.0	60	975
5	13500	60	10000	2.0	60	975

Considered Fig (1&2)for the fixed ratioC_1/C_2, C1=0.40µF, C_2=0.006µF,

Simulation Result can be obtain by using table :-(2)

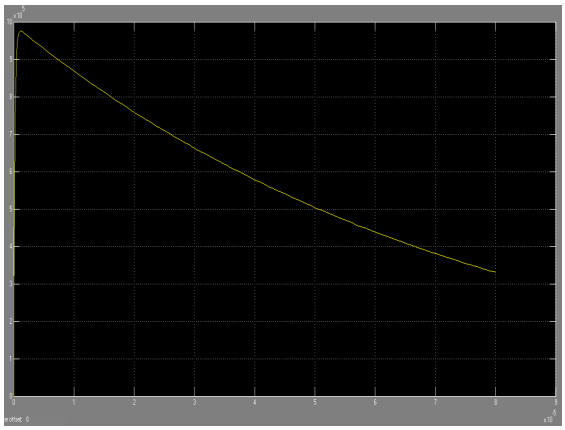


Figure 2 (b): Simulation with C_1/C_2=66.66µF

Y-axis represents voltage V (t) & X- axis represents Time period T (t)

Simulation of Impulse Generator For medium inductive Loading **(L_b=6500**µH to**13500** µH)

Variation in **L_b=6500** µH to **13500** µH has been done according to standard circuit and it is found that the standard front time cannot be obtained for the existing values of parameters: L_b=6500µH, R_1=60Ω, R_2=10,000 Ωt_1 =2.07µs, t_2 =60µsand by keeping other parameter constant. It is found that Standard wave shape can be obtained easily by varying R_1 and R_2 for a capacitive load having ratio C_1/ C_2 = 66.66µF.Butfor the variation of inductive load.$L_{b.}$ =**6500 µH to 13500µH**. the front wave

time and tail wave time of 2.07μs & 60μs respectively with the help of simulation. This shows that T_1 is not obtained within the tolerance limit. ButT_2 is obtained within the tolerance limit. So for finding out the standard impulse wave. Difficulties arise when testing low-voltage winding of large generator transformer, high-voltage windings of distribution transformers and inductance is less than 15μH.

III. CONCLUSION

Analysis of both impulse voltage generator circuit for different loading conditions. It is found that Standard wave shape can be obtained easily by varying R_1 and R_2 for a capacitive load having ratio C_1/C_2 = 66.66μF. But inductive load it is difficult to obtained standard wave shape for the fixed ratio C_1/C_2. The simulation analysis of Resistance Front Controlled circuit with capacitance- inductance (C-L) load shows that the wave front time is obtained asT_1=2.07μF, (which is beyond tolerance limit: 1.2μs±30% / 50μs±20%).The desired range of wave tail time (T_2= 40μs to 60μs) can be easily obtained by keeping L_b in the range **6500μH to 13500μH,** having fixed ratio **C_1/C_2=66.66μF.**

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