

Optimization Method of Impulse Current Generation Using MATLAB/SIMULINK

Raghavendra. F. C¹, Dr.Kiran V²

^{1,2}Department of Electronics and Communication Engineering,
 R V College of Engineering, Mysore Road, Bangalore – 560 059

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ABSTRACT—The impulse current generator is broadly utilized in the electrical force framework, and the plan technique for the impulse current generator is principally founded on the old style hypothesis. Considering this, this paper proposes new strategy for ideal plan for the impulse current generator dependent on the MATLAB/SIMULINK reproduction innovation and the PSO knowledge improvement calculation. This strategy can rapidly and precisely decide the impulse current generator capacitance C , the resistance R , inductance L and the underlying DC voltage U_0 as indicated by the front time T_f , wave tail time T_t , top current I_m and the hour of current arrives at greatest time. PSO-Simulink advancement plan strategy is fit to the plan of the straight and the nonlinear impulse current generator, notwithstanding, the arrangement of the conventional insightful technique is muddled and doesn't have any significant bearing to constraint of nonlinear obstruction. The examination aftereffects of this paper have the specific reference an incentive for the plan and activity of the impulse current generator.

Keywords-Impulsecurrent generator ; PSO-Simulink ;

I.INTRODUCTION

The impulse current generator is generally utilized in the field of force framework. By reenacting the waveform of motivation flow under the lightning, activity and different conditions, the flow shock opposition capacity of the force hardware is checked, for instance, the lightning obstruction level confirmation in the sort trial of force arrester[1]. Simultaneously, it is likewise revealed that being developed of airplane lightning insurance innovation, impulse current generator which can produce explicit current waveform is additionally expected to recreate lightning current to check the lightning security level of airplane [2]. In the enormous current test and the examination of the lightning drive qualities of establishing gadget, it is additionally important to configuration relating huge impulse current generator[3]. Thusly, it has significant field application worth to plan the impulse current generator which can meet prerequisites of uncommon waveform in various use conditions. In the customary plan of drive current generator, the age of the motivation current waveform is acknowledged through the conventional old style RLC circuit, as displayed in Figure 1.

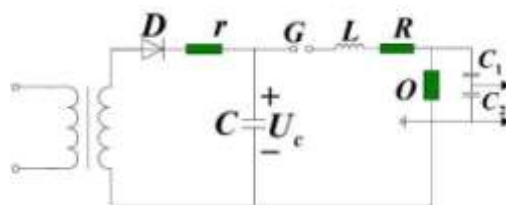


Fig 1 Topology structure of typical impulse current generator

In Figure 1, C is the absolute capacitance worth of many shunt capacitors, L and R are the inductance and obstruction esteems including the capacitors, circuit wiring, shunt, ball hole and starts on test object, and once in a while extra inductance and opposition esteems for the wave change. G is

the start ball hole, D is the silicon heap, R is the insurance opposition, t is the charging transformer, O is the test object, s is the shunt, C_1 and C_2 are voltage divider, CRO is the oscilloscope. The voltage divider is utilized to quantify voltage on the test object. The shunt is really non inductive little

opposition, which is utilized to quantify the current moving through the test object. During activity, the rectifier will charge the capacitor bank to the necessary voltage, send a trigger heartbeat to the three ball hole G to make hole breakdown, and afterward the capacitor bank C will release through L, R and the test object. As indicated by the charging voltage and the circuit boundaries, beat current of the various sizes can be created. Truth be told, the drive current generator is RLC release circuit.

II. THEORETICAL FORMULA DERIVATION OF IMPULSE CURRENT GENERATOR

As indicated by the IEC and the Chinese public principles, the standard motivation current waveform can be separated into two classes, the first is dramatic wave, the second is square wave. As far as TF/TT, there are 4 sorts: $1\mu\text{s}/20\mu\text{s}$, $4\mu\text{s}/10\mu\text{s}$, $8\mu\text{s}/20\mu\text{s}$, $30\mu\text{s}/80\mu\text{s}$. The pinnacle length TD of square wave is $500\mu\text{s}$, $1000\mu\text{s}$, $2000\mu\text{s}$ and $2000\mu\text{s}\sim 3200\mu\text{s}$ [4]. Permissible deviation of pinnacle esteem, the front time TF and half rush hour TT of dramatic shock flow wave is inside $\pm 10\%$. Little overshoot or wavering is permitted close to the pinnacle worth of the dramatic shock wave, yet the overshoot and swaying of a solitary pinnacle worth ought not surpass 5% of pinnacle esteem. At the point when the current drops to nothing, the plentifulness of the opposite extremity wavering ought not surpass 20% of the pinnacle esteem. For the pinnacle worth of the square wave drive current and the all out span TF, permissible deviation is pinnacle esteem, the complete length of square wave will not surpass 1.5 occasions of pinnacle span. As indicated by geography of the motivation current generator[5], as per the diverse damping states of the circuit, the release can be partitioned into three circumstances:

(1) The over damping i.e $R > 2\sqrt{L/C}$, $\alpha > \omega_0$, and $\alpha = R/(2L)$, $\omega_0 = 1/\sqrt{LC}$, $\alpha d = \sqrt{\alpha^2 - \omega_0^2}$, In this case, the characteristic root of the second-order circuit is

$$P1 = -\alpha + \alpha d, P2 = -\alpha - \alpha d \quad (1)$$

(2) Under damped condition, i.e $R < 2\sqrt{L/C}$ or $\alpha < \omega_0$ in this case, the second order circuit has the pair of the conjugate complex roots,

$$P1 = -\alpha + j\omega d, P2 = -\alpha - j\omega d \quad (2)$$

(3) Critical damping case, i.e $R = 2\sqrt{L/C}$ or $\alpha = \omega_0$: $i = (U_c/L)t \exp(-\alpha t)$

The maximum value of current is $I_m = 0.736U_c/R$ (3)

The aim of the impulse current generator is to charge the capacitor through the rectifier circuit, and afterward through the flash hole release to make test pass the motivation current. The customary impulse current generator mostly builds up circuit model as per the geography of the motivation current generator schematic, infers second request consistent coefficient homogeneous differential condition of RLC release circuit relating to the circuit model through the circuit model. The above is the old style plan strategy for motivation current generator. Be that as it may, in the genuine plan of impulse current generator, there are uncommon necessities for current sufficiency I_m , head time TF, tail time TT, and so forth even in the plan of impulse current generator, the long span motivation current, long tail drive current, the square wave drive current generator, and so on. There are numerous improvement plan boundaries of the drive current generator. The customary plan technique dependent on circuit examination is hard to meet the plan prerequisites, so it is important to advance the somewhat new improvement plan strategy for the drive current generator.

III. SIMULINK REALIZATION OF IMPULSE CURRENT GENERATOR

In light of the MATLAB/Simulink programming stage, it can successfully reenact the capacitance, inductance, obstruction and different parts, and through the current extraction gadget, it can viably acquire the current and voltage esteem coursing through test object. The reenactment strategy for impulse current generator on MATLAB programming stage is as per the following.

1) As shown in Figure 2 set beginning values of capacitance esteem C, obstruction esteem R and the inductance esteem L, and afterward give the underlying voltage U_0 with certain capacitance esteem.

(2) For the arrangement boundaries on the MATLAB/Simulink, the reenactment start time is t_0 , the recreation end time is T_1 , and the solver is the ode45 solver, $t_0=0$, $T_1=100\mu\text{s}$ in the resulting reproduction estimation. 50000 estimation focuses are for the most part chosen to guarantee that acquired voltage and current waveform have adequate information focuses, in order to meet perfection of bend.

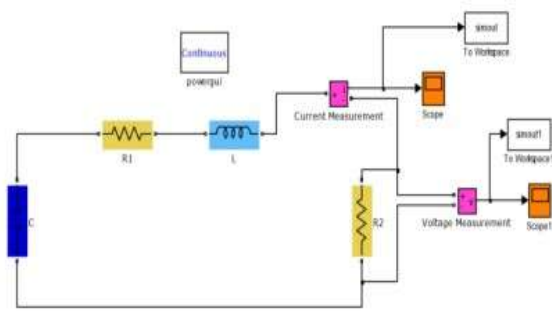


Fig 2 The SIMULINK model of typical impulse current generator

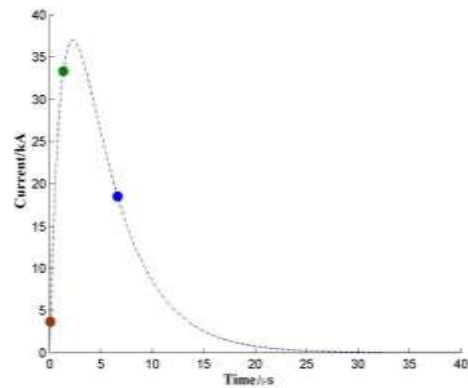


Fig 3 The typical impulse current waveform(non-oscillation)

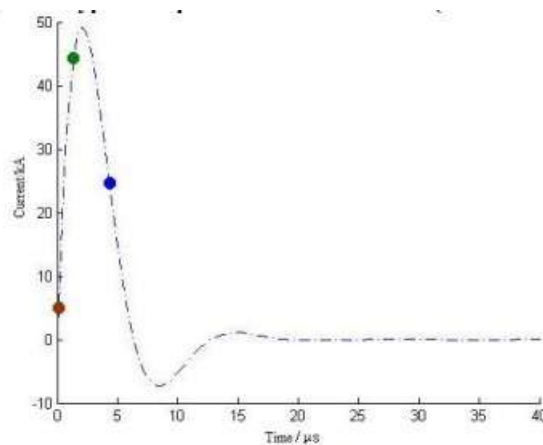


Fig 4 The typical impulse current waveform(oscillation)

(3)After the reenactment, the voltage and the current qualities on example are acquired by current and voltage estimation module, and waveform is shown instinctively by oscilloscope. Simultaneously, the voltage and current information are yield to the MATLAB work area by the information yield module for information postprocessing.

(4)After handling the current waveform information, the objective of the post-preparing is to get the wave front time TF, wave tail time TT, greatest motivation current IM, DC voltage U0,

source impedance RP and different boundaries of the current waveform through discrete information focuses. The meaning of wave front time TF is $TF=(T_b-T_a)*10/8$, and the meaning of wave tail time TT is $TT=T_c-(9*T_a-T_b)/8$. TA, TB and TC are characterized as the time esteem when the drive current scopes 10% IM, half IM and 90% IM. Ordinary non oscillatory drive current waveform is displayed in Figure 3. Three of them relate to the time esteem when the current spans 10% IM, half IM and 90% IM separately, $C=5e6F$, $L=1.13e-6H$, $R=1.1ohm$.

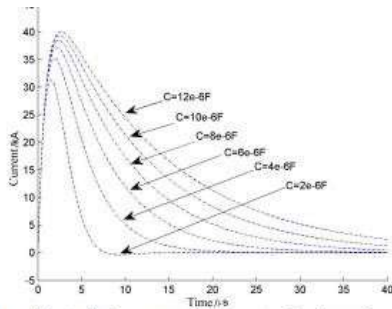


Fig 5 The effect of the capacitance to the impulse waveform

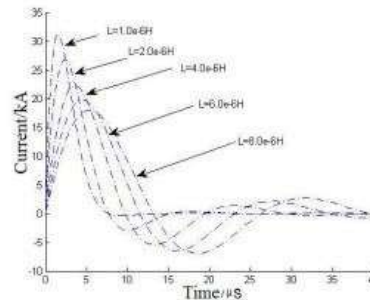


Fig 6 The effect of the inductance to the impulse waveform

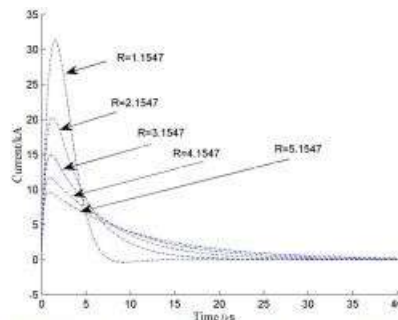


Fig 7 The effect of the resistance to the impulse waveform

Figure 5,6 shows the influence of capacitance and inductance value on impulse current waveform. It can be seen from the figure that with the increase of inductance value, the amplitude of impulse current presents downward trend, and wave front time T_F and wave tail time T_T of current waveform have backward trend, where $R=1.1547\text{ohms}$, $C=2\text{e-}6\text{F}$. Figure 7 shows influence of resistance value on impulse current waveform. It can be seen from the Figure that with the increase of resistance value, the amplitude of impulse current decreases gradually, and the front time T_F decreases gradually, and the tail time T_T increases gradually, in which $L=1.0\text{e-}6\text{H}$, $C=2\text{e-}6\text{F}$. The changes of T_F , T_T and I_m with the values of resistance, inductance and capacitance are listed in Table 1-3 respectively, which shows component parameters in the current impact generator have the complex impact on the impulse current waveform, which makes design of the impulse current generator more difficult. At present, design of impulse current generator is carried out by the complex mathematical operation in Formula(5), (4). This paper attempts to apply Intelligent Particle Swarm Optimization (PSO) algorithm to the optimal design of impulse current generator.

IV. PSO ALGORITHM DESIGN OF IMPULSE CURRENT GENERATOR.

The basic principle of particle swarm optimization algorithm has been introduced in relevant literature. Furthermore, the speed and

position of particles in search space are determined according to the following formula [8]:

$$V_{t+1} = \omega v_t + c_1 r_1 (P_t - x_t) + c_2 r_2 (G_t - x_t + 1) \quad (4)$$

$$X_{t+1} = x_t + v_{t+1} \quad (5)$$

Where, X represents particle's position; v represents the particle's speed. The C_1 and C_2 are the acceleration constant. R_1 and R_2 are the random numbers in the $[0,1]$ interval. P_t is the optimal position searched so far by particle. G_t is the optimal position searched so far by the whole particle swarm. The flow of PSO optimized the impulse current generator is as follows:

(1)Initialize the particle swarm, including the opposition R , capacitance C , inductance L and introductory DC voltage esteem U_0 on the capacitance, arbitrarily create the position and speed, all things considered, and decide the P_t and G_t of particles. (2)For every particle, its wellness esteem is contrasted and wellness worth of the ideal position P_t that the particle goes through. In case it is better, it is taken as current P_t . (3)For every particle, its wellness esteem is contrasted and the wellness worth of the ideal position G_t that the entire particle swarm goes through. In case it is better, it will be taken as the current G_t . (4)Press (10) and (11) to refresh the particle's speed and position. (5)If the end condition isn't fulfilled, the progression (2) is returned. Something else, the leave calculation gets the ideal arrangement. For instance, a impulse current generator is to be planned, in which T_F , T_T , I_m and T_M are needed

to be the 8s, 20s, 136kA and 10.26s separately. The outcomes acquired by joining SIMULINK and

PSO calculation are as per the following:

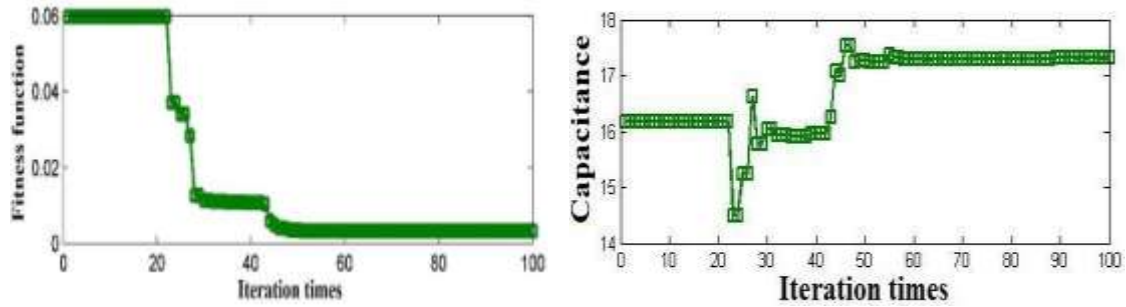
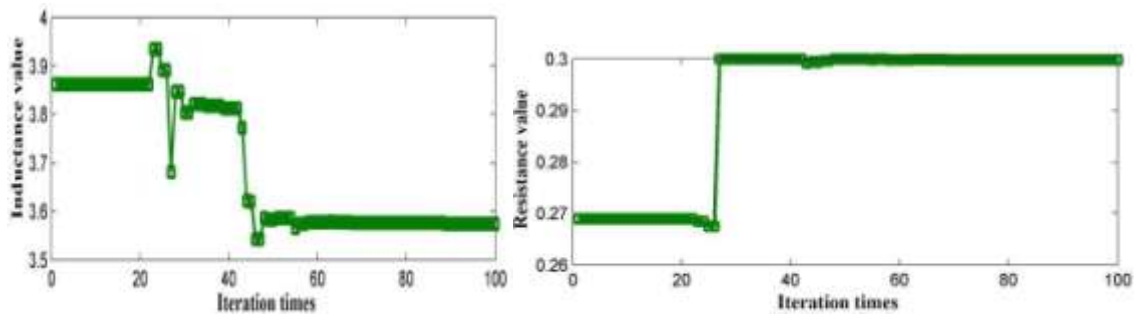
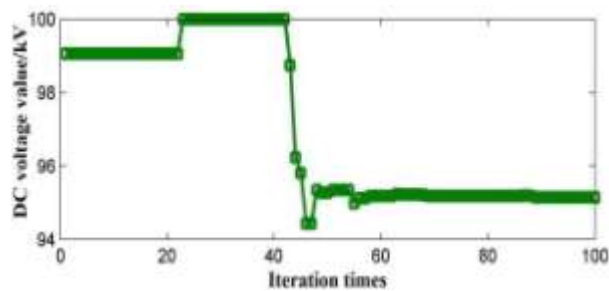


Figure 8(a) Fitness changes with the number of iterations
 (b) Capacitance changes with the number of iterations



(c) Inductance changes with the number of iterations
 (d) The resistance changes with the number of iterations



(e) The relationship between target parameters and interactive number

Figure 8 (a),(b),(c),(d),(e) shows that through the PSO algorithm for the optimal design of the impulse current generator, the fitness function value is 0.06 of first iteration, and after 100 iterations, the fitness function value approaches to zero. It can be seen that the joint PSO algorithm and the Simulink technology can better optimize the topology of the impulse current generator. After the PSO algorithm optimization, the original design parameters of the impulse current generator are $C=1.7309e-5F$, $L=3.5744e-6H$, $R=0.2998 \Omega$, $U_0=95.141kV$, and the impulse current waveform is as shown in Figure 9.

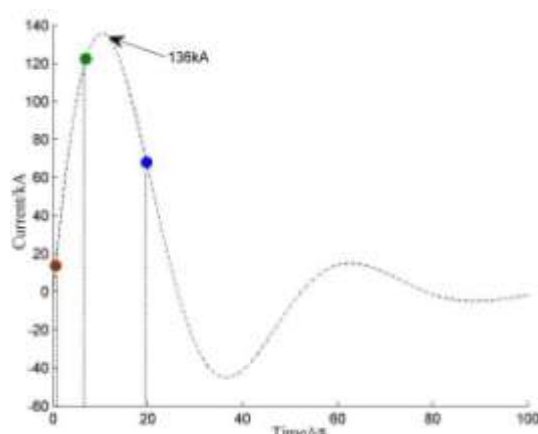


Fig 9 The optimized impulse current waveform using the PSO-Simulink

V. CONCLUSION

Based on the MATLAB/Simulink technology, this paper establishes topology structure of the impulse current generator, analyzes influence of capacitance, resistance and inductance parameters on the impulse current waveform, and realizes the optimal design of the impulse current generator based on PSO Simulink joint algorithm

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