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# Design and development of Marx Generator

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**ABSTRACT**

**A new structure of Marx generator (MG) based inverter is proposed to generate high-voltage pulses. In this structure, a single-phase inverter is employed to supply parallel diode–capacitor units by positive and negative values of the input dc source (±Vin). The main contribution of this paper is proposing a new switching strategy, by which a group of capacitors are charged properly. Finally, the charged capacitors are connected in series such that the output voltage is equal to summation of the capacitors' voltages. Considering specified value of the output voltage, the number of circuit elements in the proposed structure is reduced in comparison with other topologies of unipolar MG. Furthermore, voltage rating of switches and diodes in the proposed topology is lower than that of other unipolar MG structures. Design of the structure ensures that there is no need to connect the switches in series, when the number of stages is increased. To verify the performance of the proposed MG structure, simulation has been carried out in MATLAB/Simulink.**

**Keywords : MG(Marx generator), Inverter, Matlab, Capacitor.**

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## I. INTRODUCTION

Power systems equipment must tolerate not only the rated voltage which corresponds to the highest voltage of a particular system, but also over voltages. Accordingly, it is mandatory to test high voltage (HV) apparatus during its development stage. Protection of power system is an important aspect for the continued service of the electrical power system. Mostly the protection of electrical power depends on the performance of insulation systems under transient over voltage conditions arises due to lightening and switching applications. Transient over voltages along with the abrupt changes in the state of power systems, e.g. switching operations or faults are known as switching impulse voltages and that due to lightening are known as lightening impulse voltages. It has become generally identified that switching impulse voltages are usually the relevant factor affecting the design of insulation in HV power systems for rated voltages of about 300 kV and above. Hence attention is required for these two types of over voltages. The Marx Impulse generator is used to generate lightening impulse voltage. The magnitude and nature of test voltage varies with the rated voltage of particular equipment. The generated voltage from impulse generator must satisfy the standard values of voltage defined by the International Electro Techno Commission in order to qualify as a standard impulse voltage that can be used for testing purposes. The standard methods of measurement of high-voltage and the basic methods for application to all types of apparatus for alternating voltages, direct voltages, switching impulse voltages and lightning impulse voltages are laid down in the important national and international standards. Although the wave shapes of impulse voltages occurring in the system may vary extensively. The standard waveform of a lightening impulse wave is 1.2/50μ seconds. The entire impulse generator system has two parts. The first part

 

produces dc voltage through a rectifier circuit in particular a voltage multiplier circuit and the second part is the Marx circuit and using these two parts the lightening impulse voltage is obtained as an output from the Marx Topology.

## II. OBJECTIVE

- To develop Standard and Improved Marx Generator circuit using Multisim software to generate an impulse voltage
- The final goal is to compare the theoretical values of front time, tail time and peak voltage obtained in simulation with those recorded in practical circuit.
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## III. LITERATURE SURVEY

High voltage technology was introduced at the beginning of the last century for electrical power generation and transmission systems. Long before that efforts have been made to study the lightening characteristics inside laboratory to carry out the tests on power system equipment in order to protect them from hazardous of lightning strike. A number of theories on lightening formation and generation have been presented [5-8].

Since the exploration on lightening started, efforts have been made to realis the lightening phenomenon inside laboratory so that the characteristics of the lightening can be studied more accurately and tests on power system equipment can be carried out. Many authors have presented their work about the generation of lightening impulse inside laboratory [3-15].

Marx has been the important guiding principle in generating lightening impulse voltage [16-20]. Almost in every paper Marx theory has been used but some paper have modelled the same principle differently for different application. Modified Marx generator has also been studied extensively [20-21].

In almost all the papers discussed so far has employed capacitive loading for getting the impulse responses. Marx circuit has been widely used in the generation of high repetition voltage pulses, high power microwaves where rise time ranges in the ns region. For accurate measurement of high voltage pulses through measuring instruments, measurement techniques and procedures have also been proposed [4], [19].

## IV. BLOCK DIAGRAM

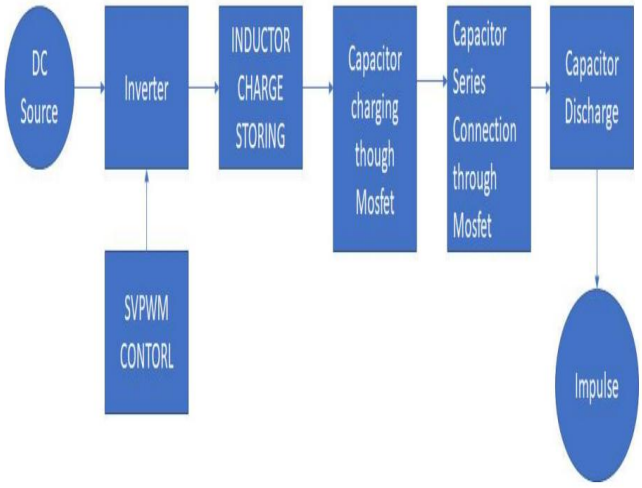


Fig 1. Block diagram of Modified Marx Generator

**Working:**

A. Switching Modes In the proposed structure, generation of each pulse is realized in five steps.

1) Direct charging of the inductor.
2) Energy transfer from the inductor to the capacitors C1 and C2. Thus, these capacitors are charged.
3) Inverse charging of the inductor.
4) Energy transfer from the inductor to the capacitors C3 and C4. Hence, these capacitors are charged.
5) Series connection of C1, C2, C3, and C4 and generation of the pulse. To realize the mentioned five steps, five switching modes are employed as follows .n The basic job is to find the resistor values for R1 and R2, as C2 and C1 are known in general. For larger generators the discharge capacitors are always provided and dimensioned for a good efficiency within a certain range of C2. This total load capacitance can be easily measured if it is not known in advance.

**Parameters and Values when input is 250V:**

| Parameter | Value |
|---|---|
| Input Voltage ($V_{in}$) | 250V |
| Output Voltage ($V_o$) | 900V |
| Load Resistance ($R_L$) | 500Ω |
| Pulse Repetition Frequency ($F_r$) | 50Hz |
| Voltage Rating of Switch ($V_{ces}$) | 7KV |
| Number Of Stages (n) | 1 |
| Capacitor (C) | 3.3μF |
| Inductor (L) | 6.6μH |
| Capacitor Charging Time ($T_c$) | 0.005sec |

Table 1. MATLAB Parameters

 

## V. TESTING RESULT

**For Input 500V Results obtained are:**

Fig 3. 500V Input of modified Marx generator

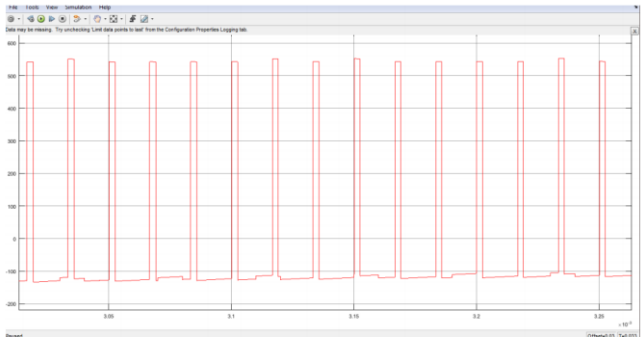

Fig 4. Inductor waveform modified Marx generator at 500V

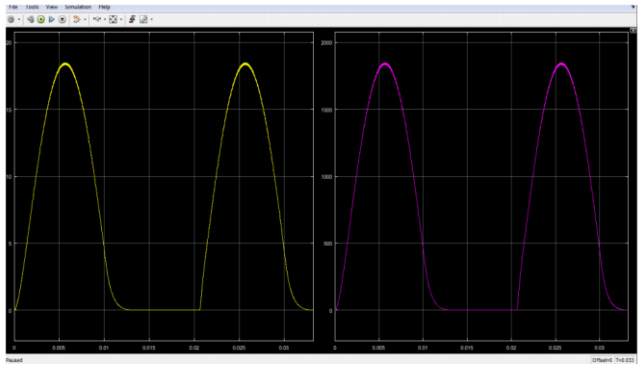

Fig 5. Output waveform modified Marx generator at 500V

**For Input 1000V Results obtained are :**

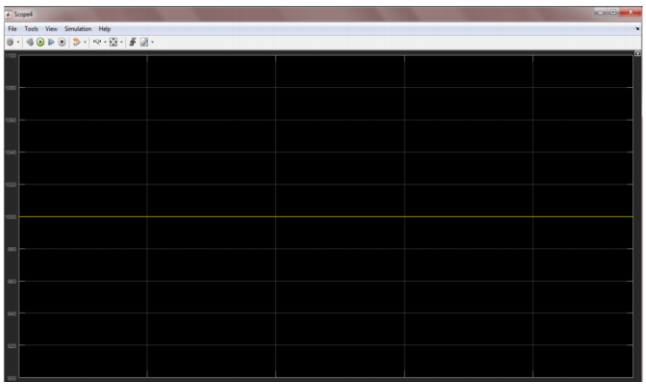

Fig 6. 1000V Input of modified Marx generator

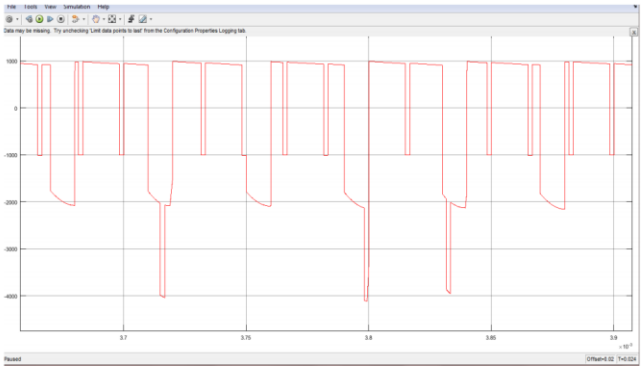

Fig 7 Inductor waveform modified Marx generator 1000V

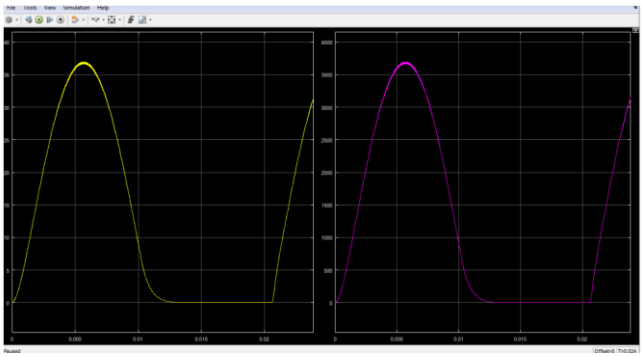

Fig 8. Output waveform modified Marx generator 1000V

## VI. CONCLUSION

A small scale of generation of high impulse voltage is implemented in the simulation with the MATLAB software environment. It is found that the overall simulated result is close to standard impulse generator 1.2 / 50 μs wave shape for all the stages of Marx generator. The ratio of C1/C2 is taken as 20 in each stage and the impulse waveform was governed by the values of front resistor and tail resistor. The energy and efficiency at each step was calculated and was tabulated. For simulation the sphere gap is replaced with a simple switch in Multisim Software. The values from practical and simulated waveforms in the fields of rise time, tail time, peak voltage and error in rise time and tail time have a considerable amount of difference. As explained in Chapter 5, the difference is caused by a number of factors. The prime reason is the difference in the charging resistors and capacitors used in the simulation and practical circuit. The tolerances level of resistors used in practical circuit are different from those used in Multisim and the maximum charging voltages in both practical and simulation aren't the same. Moreover the connection of resistors and capacitors in parallel and series gives an approximate value of what is exactly used in simulation also adds to the errors. Due to these parameters differences have resulted in the two circuits. In practice all the capacitors are not charged to the same value due to the presence of series resistance in the circuit as the series resistance between

 

the source and distant capacitor limits the voltage obtainable. In this work, the entire circuit is modelled, simulated and practically designed in two different parts one from source to rectifier consists of the first part and the impulse Marx circuit forms the second part.

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