A Theoretical Investigation on Multistage Impulse Voltage Generator

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Abstract:- *For the reliable supply of electrical power the power system protection is necessary the protection power system placed an important role for the protection power system from transient over voltages which occur during lightning and switching condition. The lightning gives rise to very high current which has to be limited to protect the system. During lightning the system insulation should with stand it for this insulation strength is checked before it is actual operation. For this high voltage is generated which is equivalent of lightning pulse the impulse generator is used to generate the high voltage in laboratory. In impulse generator we have multiple capacitors and resistors. The capacitors are charged in parallel using charging resistors by high DC voltage then this charged voltage is discharged with the switching operation of the circuit. The impulse wave generated is linked with the original impulse wave with front time 1.2μs and fall time 50μs. The simulation of the impulse generator is done in MATLAB / Simulink. In this paper, the whole circuit is simulated.*

Keywords:- component; Marx Generator; high voltage; Multi stage; Mat lab.

I. INTRODUCTION

The high voltages (A.C and D.C) are used in the field of electrical engineering and applied physics for different purposes. In electrical engineering the power system equipment components must bear not only the rated voltage but also overvoltage, during its development stage it is compulsory to test the apparatus of high voltage. High impulse voltages are used for testing purpose to stimulate the high voltage that occurs in the system due to lighting or switching surges. To generate high voltage impulse the impulse Marx generator is used such as lighting impulse or switching impulse. The size and nature of test voltage changes with rated voltage of particular power system utensils. The impulse voltage generated from the impulse generator must qualify as a standard impulse voltage that can be used for testing purpose. The original waveform of a lightening impulse wave is 1.2/50μ sec and withstands original switching impulse voltage of wave shape 250/2500 μs. The figure 1 shows the basic circuit diagram of Marx Generator. The original ways of measurement of high-voltage and the basic methods for application to all types of equipments for ac voltages, dc voltages, switching voltages and lightning voltages are present in the IEC values. Although the impulse voltages wave shapes taking place in the system can vary broadly [1].

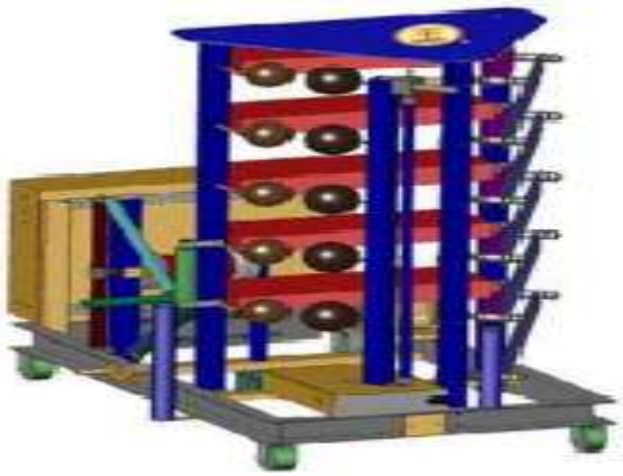

Figure 1 Basic Circuit of Multi Stage Marx Generator

Mihir A Bhatt [1] described Simulink on a multistage generator used to generate the impulse voltages of 1.2/50μs or 250/2500μs which can be used in the laboratories to test the impulse voltage withstanding capability of the insulation. The charging capacitor used is in the order between 10 to 100 kΩ. Each capacitor C is chosen such that the CRs is of between 10s to 1min. The wave shaping circuit comprises of wave front resistor (Rf or R1) and wave tail resistor (Rt or R2). It includes five stages of capacitors initially charged with a voltage of 10 kV, 15 kV, 20 kV and 25 kV respectively.

Schon k. [2] Described a multistage inverter used to generate the impulse voltages using a capacitor and a resistor connected in the π-model with a switch in the middle. Front time and tail time of the impulse wave are, T1 is 1.2 μs and T2 is 50 μs. When the value of the front resistor is increased, front voltage will decrease. The author also discussed a repetition of Marx Generator. Each capacitor stage rating of 5.2 nF, 40 kV. It included 13 different stages. The Marx generator was able to deliver 5.5 kA of peak current into a load of 63 Ω with 350 kV of peak output voltage. It was operated successfully with a repetitive frequency of 110 Hz.

SaffetAyasun [3] discussed three type of induction motor tests namely dc, no-load, and blocked-rotor tests performed to identify equivalent circuit parameters. In order to enhance the electrical machinery education, these simulation tools are necessary. The steady state operating characteristics of three phase induction motor by connecting a variable load at the end. DC test is performed to compute the stator winding resistance. The No-load test on an induction motor is conducted to measure the rotational losses of the motor and to determine various operating circuit parameters. Blocked-rotor test is performed to determine some of the equivalent circuit parameters of the motor.

In [4] High voltage test techniques, this method is intended to provide uniform techniques for high voltage testing of equipment. With the increase of more number of high voltage and extra high voltage transmission system being constructed in the country, the need for such testing methods has been very vital. As per this, the impulses with the front duration of up to 20 μs are considered as lightning impulses and those with longer fronts are defined as switching impulses.

Different tests with DC voltage or AC voltage, Lightning impulse voltage, switching impulse voltage and with impulse current are given under these techniques. Different pollution test procedures are also given. Calibration of a Non-Approved Rod/Rod Gap Measurement Device is also discussed generation of high voltage is mainly required in the areas of pure and applied physics. Rectifiers are used for the conversion of ac voltage to dc voltage using special type of rectifier valve for high voltages. The value of high voltage capacitor is chosen such that the time constant CR_L is 10 times that the period of ac supply. Cascaded voltage multiplier circuits for higher voltages require too many isolating transformers. But by using a single transformer and by extending a simple voltage double circuit the conversion can be made more easily and are known as Marx circuits.

II. OBJECTIVE

The over voltages occurring on the power system lines are very harmful for the equipment, reliability of power and protection of human life. Hence tremendous amount of exploration is going on in the field of study of impulse waves. Its generation and features .The transmission lines are directly exposed to troposphere, hence lighting phenomena is common. The main barrier in the field of hve is the structure of proper high voltage insulation with minimum dimension at small price .The finest approach to defend the power system component is to test the equipment insulation before its actual operation.

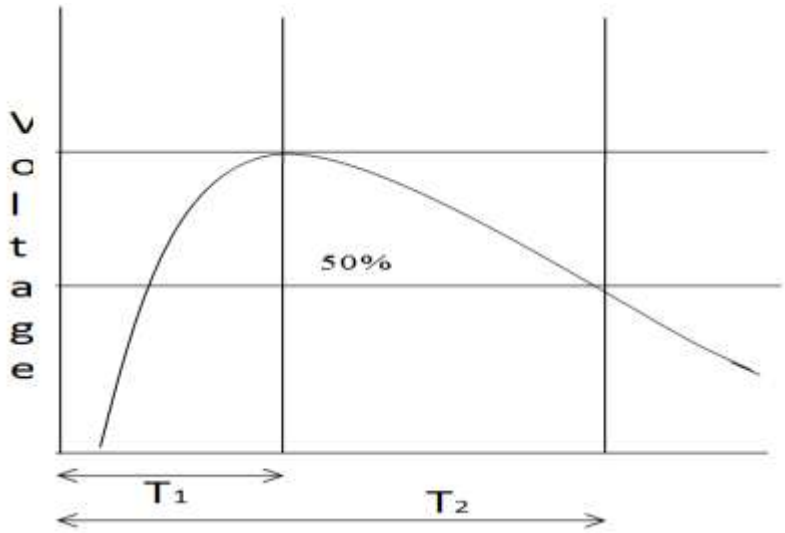

Figure 2 Standard Impulse Wave

This felts the requirement for theoretical high voltage generation using Marx generator. Marxgenerator is used to generate high impulse voltage for examining the stability of equipment insulation for lighting impulse had switching impulse. The figure 2 shows the standard pulse of impulse generator between voltage and time.

The key points of this paper is

- To establish standard Marx generator in MATLAB.
- To generate standard impulse voltage.

III. IMPULSE VOLTAGE GENERATORS

The impulse voltage generators basically are of two type's i.e. single stage impulse voltage generators and multi stage impulse voltage generator. Basically in this paper the author discuss only about the multi stage impulse voltage generator.

A Marx generator is a simple high impulse voltage generator which has various technical uses, ranging from insulation and lightning safety testing to fusion research. It is based on slow, parallel charging Stack level of capacitors, which are then quickly discharged in series, usually by means of spark-gaps.

Due to extraordinary power handling capabilities of spark gaps, Marx generators are able of providing pulses of peak powers along with multi mega volt voltages. The essential modules of impulse voltage generators are essentially;

- capacitor impulse
- capacitor load
- wave front shaping resistor
- wave tail shaping resistor

In adding the other modules transformer rectifier charging, resistor charging, spark gaps and the other ancillary. In other schemes, it contains of numerous smaller resistors connected in series with the capacitors in all stage in order to damp out any oscillations arising due to stage inductance.

In the principle, the generation of tremendously high voltages is up to 6000 kV or 6 MV needs a very large number of stages of capacitors, each evaluated for about 200 kV, to be charged in parallel from the low voltage, and discharged in series.

i. Multi Stage Impulse Voltage Generators

This voltage generator is also known as the multi stage Marx impulse voltage generator.Functioning Principle of the generator is: Capacitor will charging in parallel and it will discharging in series into the load circuit. multi stage impulse [5]. The figure 3 shows the circuit diagram of multi stage impulse voltage generator.

Table 1Parameter of the Circuit

Parameter	Value
Charging Resistor	270 KΩ
Generator capacitor (C1 to C2)	0.7 μs
Load capacitor (Test sample)	3000 pF
Wave Front Resistor	32Ω
Wave Tail Resistor	720Ω

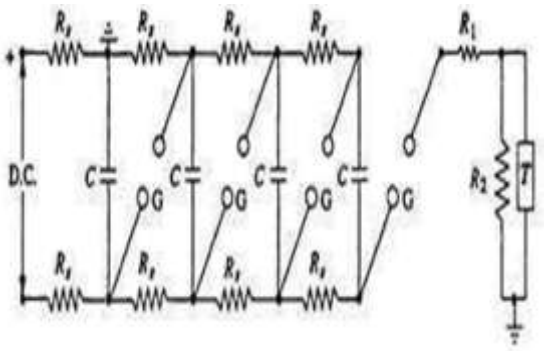

Figure 3 Multistage impulse voltage generator

There is time continual of the circuit with three times the time constant of the circuit and is give by:

$$a^{1/n}T_f = 3 \times R_f \times \frac{C1 \times C2}{C1 + C2} \qquad (1)$$

The time full for discharging (fall time/tail time) is given by the time full to achieve 50% of peak value during discharging that arises finished the parallel combination of the generator capacitance, load capacitance and the series grouping of R1 and R2.

$$T_t = 0.7 \times (R_f + R_t) \times (C_1 + C_2) \qquad (2)$$

Normal impulse testing technique needs the application of a stated wave- shape. IEC60060-1 and -2 are an international standard that agrees the high voltage measuring equipment and method for impulse testing. As per the international standard, a full lightning impulse wave-shape is definite as taking a wave front time (T_f) of 1.2μs ± 30% and a wave tail time (T_t) of 50μs ± 20% [5].

IV. EXPERIMENTAL RESULTS

The The simulink model shows thatof marx impulse voltage generator. This circuit istriggering all five switches at the same instant(G1 to G2). The impulse voltage of standard time is got by triggering all five switches at the same direct. All of them five stage capacitors are initiallay charged with a voltage of 10KV, 15KV, 20KV,and 25KV respectively in steps,as we used the same actuall voltage generator for giving the voltage supply.The figure 4 represents the Simulink model of multi stage Marx generator and Table 1 shows the parameter of the circuit. The wave front resistor permits the wave to reach peak magnitude in the desired time and wave tail resistor

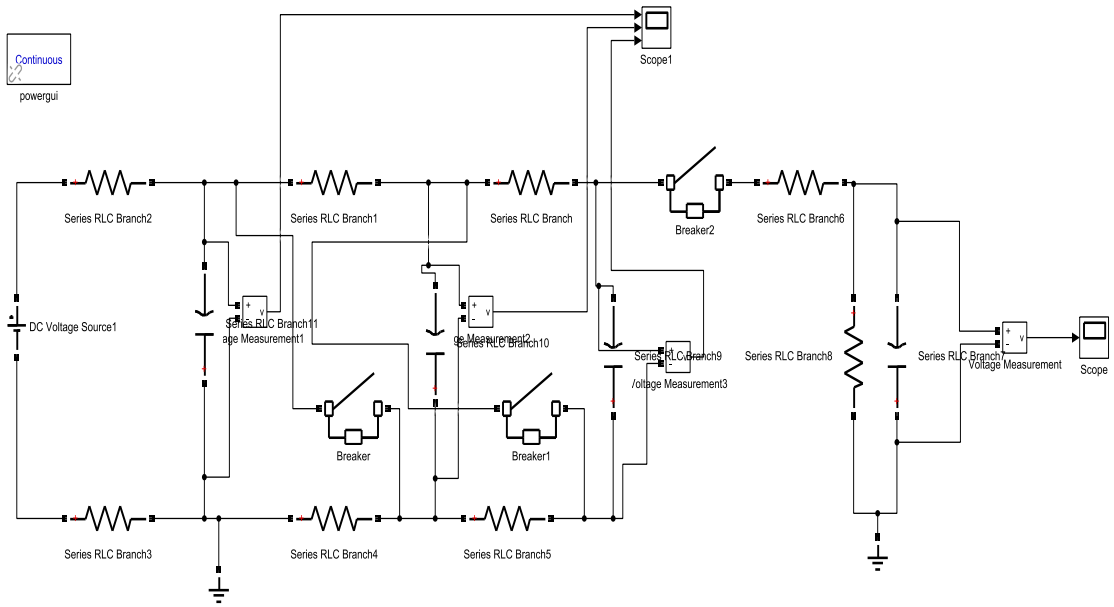

Figure 4 Multistage (Marx) Impulse voltage Generator

- OUTPUT WAVE FORM

The resulting output for simulation circuit of the peak output voltage of Marx impulse generator. To obtain the peak magnitude the output voltage wave takes the long time and also reduces towards zero with slow rate. Also, by increasing the resistor values, the output voltage is also reduced. That is shown below Figure 5.

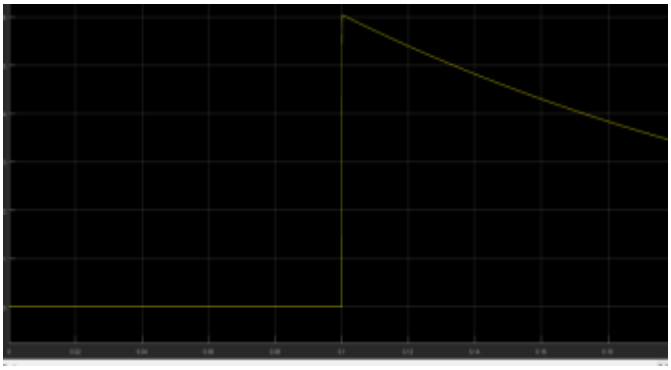

Figure 5 output wave form

V. CONCLUSION

In this paper, the MATLAB/Simulink model of Marx impulse voltage generator used to generate transient overvoltage of long and short duration used for testing the insulation strength of high voltage apparatus. Simulink model is simplified in definite way and its result is related with the equivalent hardware setup. The study shows that MATLAB combined with Simulink/PSB is a good simulation tool to investigate characteristic of impulse voltage. Forgetting thorough understanding of impulse voltage generator. A Comprehensible extension of the software laboratory would be to support the education related to impulse voltage generation by including Simulink/PSB model based experiment such as parametrical analysis of impulse generator, impulse testing of transformers and insulators.

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