**DESIGN OF HIGH VOLTAGE MARX GENERATOR**

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 ***Abstract***

**An  Marx generator  is an electrical apparatus which produces very short high-voltage or high-current surges. Such devices can be classified into two types: impulse voltage generators and impulse current generators. High impulse voltages are used to test the strength of electric power equipment against lightning and switching surges. Also, steep-front impulse voltages are sometimes used in nuclear physics experiments. High impulse currents are needed not only for tests on equipment such as lightning arresters and fuses but also for many other technical applications such as lasers, thermonuclear fusion, and plasma devices.In this project by using Cockcroft Walton multiplier and Marx generator we will produced impulse wave at the output. The impulse means the steep rise in magnitude and comparatively slower decay, according to IS the rise time and tail time is 1.2/50 µsec. Marx generators are used to provide high-voltage pulses for the testing of insulation of electrical apparatus such as large power**[**transformers**](http://en.wikipedia.org/wiki/Transformer)**, or insulators used for supporting power transmission lines. Voltages applied may exceed 2 million volts for high-voltage apparatus.The advantages of this project is that because of using Cockcroft Walton circuit in place of transformer is as follows**

1. **Cost is reduced**
2. **Space required is reduced**
3. **Easily portable**

 **Keywords:** Cockcroft Walton Voltage Multiplier Circuit, Marx Generator

1. **INTRODUCTION**

As we know that our electric power equipment are not design to sustain the high voltage like lightning and switching surges, so we have to protect the power system equipment from such overvoltage therefore we required the special circuit like Marx generator which produces the impulse wave so we can test the strength of that equipment and provide the protection according to their sustain capacity, that's why we design the impulse generator.

A Marx generator is an [electrical circuit](http://en.wikipedia.org/wiki/Electrical_circuit) first described by [Erwin Otto Marx](http://en.wikipedia.org/wiki/Erwin_Otto_Marx) in 1924. Its purpose is to generate a high-[voltage](http://en.wikipedia.org/wiki/Voltage) pulse. Marx generators are used in high energy physics experiments, as well as to simulate the effects of lightning on [power line gear](http://en.wikipedia.org/wiki/Electric_power_transmission) and aviation equipment. A bank of 36 Marx generators is used by [Sandia National Laboratories](http://en.wikipedia.org/wiki/Sandia_National_Laboratories) to generate [X-rays](http://en.wikipedia.org/wiki/X-rays) in their [Z Machine](http://en.wikipedia.org/wiki/Z_Machine).

The Marx generator is the simplest and most widely used high voltage pulse generation device. The basic principle involved is to charge a set of capacitors in parallel and then discharge them in series . A typical Marx generator consists of an *N* number of modules.

Each module consists of two resistors R, a capacitor C and a switch in the form of a spark gap(SG). All the modules are stacked together such that as long as the SGs are non-conducting, all the capacitors are charged in parallel up to a voltage *V* through the charging resistors R’s by a DC charging power supply. Once all the C’s get fully charged, switching is induced by triggering the first SG. This action not only brings the first and the second capacitors in series, it also makes the remaining SGs overvoltage, causing their self-breakdown. All the capacitors, each at V potential, are now in series; the impulse voltage, which can have a maximum value of NV (where N is the number of stages), ultimately decays through the load *RL* and Marx resistor R’s.

1. **IMPULSE WAVE**

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 **Fig. Marx Circuit**

An impulse voltage is a unidirectional voltage which, without appreciable oscillations, rises rapidly to a maximum value and falls more or less rapidly to zero [I]. The maximum value is called the peak value of the impulse and the impulse voltage is specified by this value. Small oscillations are tolerated, provided that their amplitude is less than 5% of the peak value of the impulse voltage. In case of oscillations in the wave shape, a mean curve should be considered.If an impulse voltage develops without causing flash over or puncture, it is called a full impulsevoltage; if flash over or puncture occur, thus causing a sudden collapse of the impulse voltage,it is called a chopped impulse voltage. A full impulse voltage is characterised by its peak value and its two time intervals, the wave front and wave tail time intervals defined below:

The wave front time of an impulse wave is the time taken by the wave to reach to its maximum

value starting from zero value. Usually it is difficult to identify the start and peak points of the wave and, therefore, the wave front time is specified as 1.25 times (*t*2 – *t*1), where *t*2 is the time for the wave to reach to its 90% of the peak value and *t*1 is the time to reach 10% of the peak value. Since (*t*2 – *t*1) represents about 80% of the wave front time, it is multiplied by 1.25 to give total wave front time. The point where the line *CB* intersects the time axis is referred to be the nominal starting point of the wave. The nominal wave tail time is measured between the nominal starting point *t*0 and the point on the wave tail where the voltage is 50% of the peak value *i.e.* wave fail time is expressed as (*t*3 – *t*0). The nominal steepness of the wave front is the average rate of rise of voltage between the points on the wave front where the voltage is 10% and 90% of the peak value respectively.

1. **Circuit And Operation**

 MARX CIRCUIT

COCKROFT WALTON CIRCUIT

TEST OBJECT

SUPPLY VOLTAGE

In this above sec [III] 230 v input voltage is given to the Cockcroft - Walton multiplier circuit, The Cockcroft–Walton(CW) generator, or multiplier, is an [electric circuit](http://en.wikipedia.org/wiki/Electric_circuit) which generates a high [DC](http://en.wikipedia.org/wiki/Direct_current) [voltage](http://en.wikipedia.org/wiki/Voltage) froma low voltage [AC](http://en.wikipedia.org/wiki/Alternating_current) or pulsing DC input. The CW is a [voltage multiplier](http://en.wikipedia.org/wiki/Voltage_multiplier) that converts AC or pulsing DC electrical power from a low [voltage](http://en.wikipedia.org/wiki/Voltage) level to a higher DC voltage level. It is made up of a voltage multiplier ladder network of [capacitors](http://en.wikipedia.org/wiki/Capacitor) and [diodes](http://en.wikipedia.org/wiki/Diode) to generate high voltages. Unlike [transformers](http://en.wikipedia.org/wiki/Transformer), this method eliminates the requirement for the heavy core and the bulk of insulation/potting required.

Using only [capacitors](http://en.wikipedia.org/wiki/Capacitor) and [diodes](http://en.wikipedia.org/wiki/Diode), these [voltage multipliers](http://en.wikipedia.org/wiki/Voltage_multiplier) can step up relatively low voltages to extremely high values, while at the same time being far lighter and cheaper than [transformers](http://en.wikipedia.org/wiki/Transformer).

The biggest advantage of such circuits is that the [voltage](http://en.wikipedia.org/wiki/Voltage) across each stage of the cascade is equal to only twice the peak input voltage in a half wave rectifier. In a full wave rectifier it is three times the input voltage. It has the advantage of requiring relatively low cost components and being easy to insulate. One can also tap the output from any stage, like a multitapped transformer.

From each stage of Cockcroft -Walton multiplier circuit we get twice of the input voltage and the output we get a voltage from given formulae,

Output voltage formula: Vout = 2 x Vin(as RMS) x 1.414 x n (n is no. of stages) .

At the output of this circuit we get approximate 16 kv, then the output voltage of Cockcroft-Walton multiplier circuit is given to the Marx circuit. A Marx generator is an [electrical circuit](http://en.wikipedia.org/wiki/Electrical_circuit) first described by [Erwin Otto Marx](http://en.wikipedia.org/wiki/Erwin_Otto_Marx) in 1924. Its purpose is to generate a high-[voltage](http://en.wikipedia.org/wiki/Voltage) pulse. Marx generators are used in high energy physics experiments, as well as to simulate the effects of lightning on [power line gear](http://en.wikipedia.org/wiki/Electric_power_transmission) and aviation equipment. A bank of 36 Marx generators is used by [Sandia National Laboratories](http://en.wikipedia.org/wiki/Sandia_National_Laboratories) to generate [X-rays](http://en.wikipedia.org/wiki/X-rays) in their [Z Machine](http://en.wikipedia.org/wiki/Z_Machine).

The Marx circuit works on the principle that the number of capacitor charge in parallel and then suddenly they discharge in series through spark gaps, when capacitor is charging the spark gaps act as a open switch and when it get discharge it act like closed switch.

The Marx circuit is used to test the strength of electric power equipment against lightning and switching surge, as we know our power equipment are not design to sustain such high voltage so to protect them from such high voltage, we have to test their insulation for that we require the Marx circuit.

**IV. CONCLUSION**

Circuit of multistage generator which is also called as Marx generator could be designed by using many types of software. Although the circuit design is not the same, but the output waveform of the surge should be fulfill the standard impulse waveform.As a conclusion, Marx generator is one of the best methods to design an impulse generator. The unique idea from Marx generator is charging capacitor in parallel then discharging it in series would get the desired output waveform which fulfill the standard waveform of 1.2/50 μs according to IEC61000-4-5 surge standard. From the resulted output waveform, the characteristics of the circuit could be identified and also could be a reference for further study.

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