GENERATION OF HVDC BY USING MARX GENERATOR PRINCIPLE

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Abstract :

This project is designed to generate high voltage DC using Marx generator principle by using MOSFET and capacitor stacks. The Marx Principle was developed by Erwin Otto Marx. Its principle is to generate a high voltage pulse using a number of capacitors in parallel to charge up during the on time and then connected in series to develop higher voltage during the off period. This principle is used to generate voltages in the range of KV's in real-time for testing the insulation of the electronic appliances like transformers and the insulation of the power carrying lines.

This project consists of 4 stages and each stage is made of one MOSFET, two diodes, and one capacitor. MOSFET is used as a switch; diodes are used to charge the capacitor at each stage without power loss. A 555 timer generates pulses for the capacitors to charge in parallel during ON time. During OFF tine of the pulses the capacitors are brought in series with the help of MOSFET switches. Finally, number of capacitors used in series (4 in our project) adds up the voltage to approximately 3 (4 capacitors-1 capacitor) times the supply voltage. This system structure gives compactness and easiness to implement the total system from a DC supply of 12V to get approximately (30V-36V). This concept in future can be extended to Generate High voltages (KV) using more number of capacitors. This technique is adopted for insulation testing of the electronic components, wires, gadgets etc.

***IndexTerms* – MOSFET, IGBT, Marx Generator, 555 Timer, Opto-isolator**

I. INTRODUCTION

Rapid discharge of stored energy in short interval as electrical pulses into a load produces big quantity of instant power. The traits of pulse as rise time, fall time, pulse width, repetition charge, a voltage and strength tier varies with unique applications. High voltage pulsed electricity have extensive variety of programs in exclusive fields like industrial, scientific, agricultural, environmental etc. Marx Generator is an excessive voltage pulse generator. The essential precept of Marx Generator is that the capacitors are charged in parallel as much as its input DC voltage stage. Those capacitors are then related in series the use of switches to produce an excessive voltage pulse throughout the burden technology. With the improvement of solid state electronics, solid-state devices have become more and more appropriate for pulsed power application. They might offer the pulsed energy systems with compactness, reliability, excessive repetition fee, and lengthy existence time. The rising of pulsed electricity generators the usage of solid-state gadgets gets rid of barriers of traditional additives, and promises pulsed strength era to be extensively utilized in business packages.

However, strong-state switching devices inclusive of MOSFET to be had now are best rated up to 3 kilo volts. Maximum of pulsed power systems demand of much higher voltage rating. Switching devices are vital additives in pulsed power systems. Conventional Marx Generator use spark gas switches. These switches possess barriers like short lifestyles time in terms of number of operation cycles, low switching frequency, huge length, extra maintenance and many others. In current years the strong country switches like MOSFET or IGBT is utilized in place of spark gaps. The benefits of solid country switches are compact, reliable, bendy, more efficient, long lifestyles time, low charges and reduced losses.

The output pulse width and amplitude each may be varied by controlling the gate control pulses to the switches. Both MOSFET and IGBT give variable pulse width and can generate a fast pulse rise time within a few ns across the load. The switching time of MOSFET is much lesser than IGBT (typically:- 20 ns for a MOSFET, 200 ns for an IGBT). IGBT are available at higher voltage ratings (up to 6500 V), where as the MOSFETs are limited to 1200 V.

Solid state Marx Generator has replaced the charging resistors in conventional Marx with high voltage diodes. Many new topologies with solid state Marx Generators are proposed in literature. Yifan Wu has proposed repetitive and high voltage Marx Generator using solid-state devices with inductive based charging. Inductor here acts as a current limiter at the time of pulse generation. Drawback of this topology is that it limits the pulse frequency due to long charging time constant. Also it provides no isolation from input supply source during discharging mode.

A novel solid-state pulsed power modulator driving by magnetic ring transformers is introduced by Jian Qiu. The charging power supply here is a full bridge resonant inverter. There is provision of isolation between charging and discharging loops implemented by magnetic rings. But the limitation is that due to the use of magnetic rings, the stray parameters distort the output voltage waveforms. Ju Won Baek proposed a novel repetitive impulse voltage generator of uni polar configuration by using aboost converter array. The circuit can easily obtain a high voltage pulse without pulse transformer.

The proposed circuit allows operation at kilohertz frequency with high efficiency. The drawback is that if the number of boost stacks increases the line inductance increases and hence the rise time of the output pulse increases. L.M. Redondo have proposed a topology of solid state Marx Generator with energy recovery reset circuit using transformer connected at the output. This scheme provides galvanic isolation to the load. But a limitation is that leakage inductance of transformer limits the rise time of output pulse. The efficiency of the system decreases due to losses and size of transformer

II. BLOCK DIAGRAM

The Marx precept changed into advanced by way of Erwin Otto Marx. Its precept is to generate an excessive voltage pulse. The use of some of capacitors in parallel to charge up during the on time after which connected in collection to increase higher voltage during the off length. This precept is used to generate voltages inside the range of KV's in actual-time for testing the insulation of the digital home equipment like transformers and the insulation of the power carrying lines.

This task includes 4 stages and each stage is manufactured from one MOSFET, two diodes, and one capacitor. MOSFET is used as a switch; diodes are used to charge the capacitor at every stage without. A 555 timer generates pulses for the capacitors to charge in parallel during ON time. During OFF time of the pulses the capacitors are brought in series with the assist of MOSFET switches. Subsequently, wide variety of capacitors utilized in series (four in our challenge) adds up the voltage to approximately 2 (4 capacitors-1 capacitor) instances the supply voltage. This device shape gives compactness and easiness to make entire system.

Primary energy supply is taken as a step down AC supply. Its means step down to suitable voltage and rectified to get consistent DC supply for charging of capacitors. Capacitors are charge storage tool. The charging of capacitor takes place as they are parallel linked to the rectifier. When capacitor is having suitable charge saved in it, switches are used to attach all capacitor in series and discharge of capacitor take region and we get n times of rectifier voltage across the burden. Because of numerous sensible constraints, the output voltage is incredibly much less than n/2×V (in which n is number of stages).

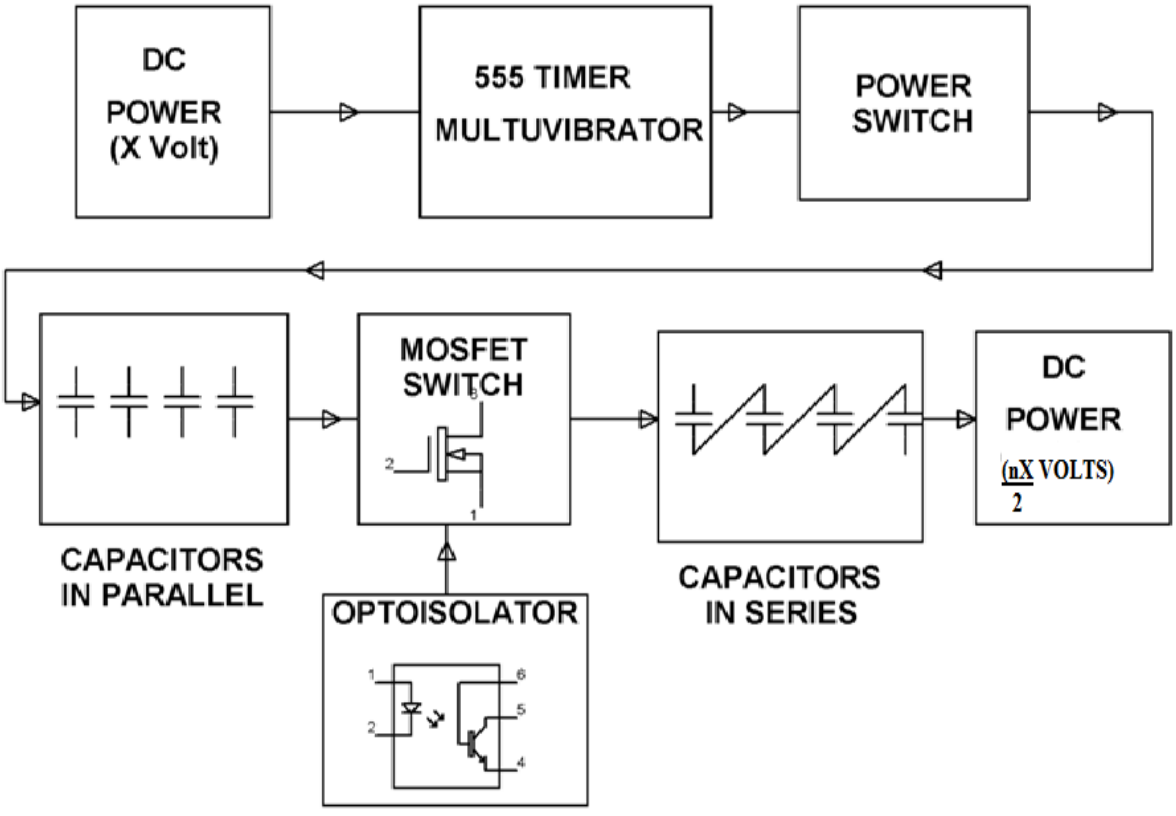

Fig1: Block diagram

III. SCHEMATIC DIAGRAM

3.1 Connections:

A 555 timer is used astable mode, i.e., pin 2 and 6 are shorted and output is connected to base of BC547 Q6. Collector of Q6 is connected to base of Q5. Pin 3 of timer is also connected to base of Q12 which drives Q11. Collector of Q11 is connected to base of Q7, Q8, Q9 and Q10. Collectors of Q7, Q8, Q9 and Q10 are connected to pin 2 of U4, U3, U2, U1 opto-isolator IC resp. pin 1 of U4, U3, U2 and U1 is connected to Vcc. Emitters of Q7, Q8, Q9 and Q10 are grounded.

3.2 Working:

Capacitors C1 to C6 used supply the driving power to the MOSFETs while C1, C2, C4, C6 are used also for storing the charge in parallel mode while Q5 delivers positive pulses through diodes D1 to D4, D5 to D8 and D10-D13. A 555 timer is used in astable multi-vibrator mode near 50% duty cycle whose ON period delivers the power at point 'A' by 2 switching transistors Q5 & Q6. The ON period also switches to other switching transistors Q10 & Q11 which ultimately switch ON Q7 to Q10 which are used for driving the LEDs of the opto-isolators (MCT2E) U1 to U4. The output of the opto-isolators are connected to gate and source of respective MOSFETs which are thus kept switched OFF as their gate and source are at ground potential. During the OFF time period of the timer all the switching transistor Q5, Q6, Q11, Q12,& Q7 to Q10 remain OFF . This causes the capacitors C2, C3, C4 and C6 to start supplying the driving power to the MOSFETs which result in bringing C1, C2, C4 and C6 in series through the diodes D5 to D8. Therefore the capacitors which are kept in series develop 4 times the astable supply voltage. This is further rectified & stored in a capacitor C8 to develop a DC voltage approximately four times the supply DC negative voltage.

Four stages have been used in the circuit however it can be extended to any number of stages for getting desired high voltage.

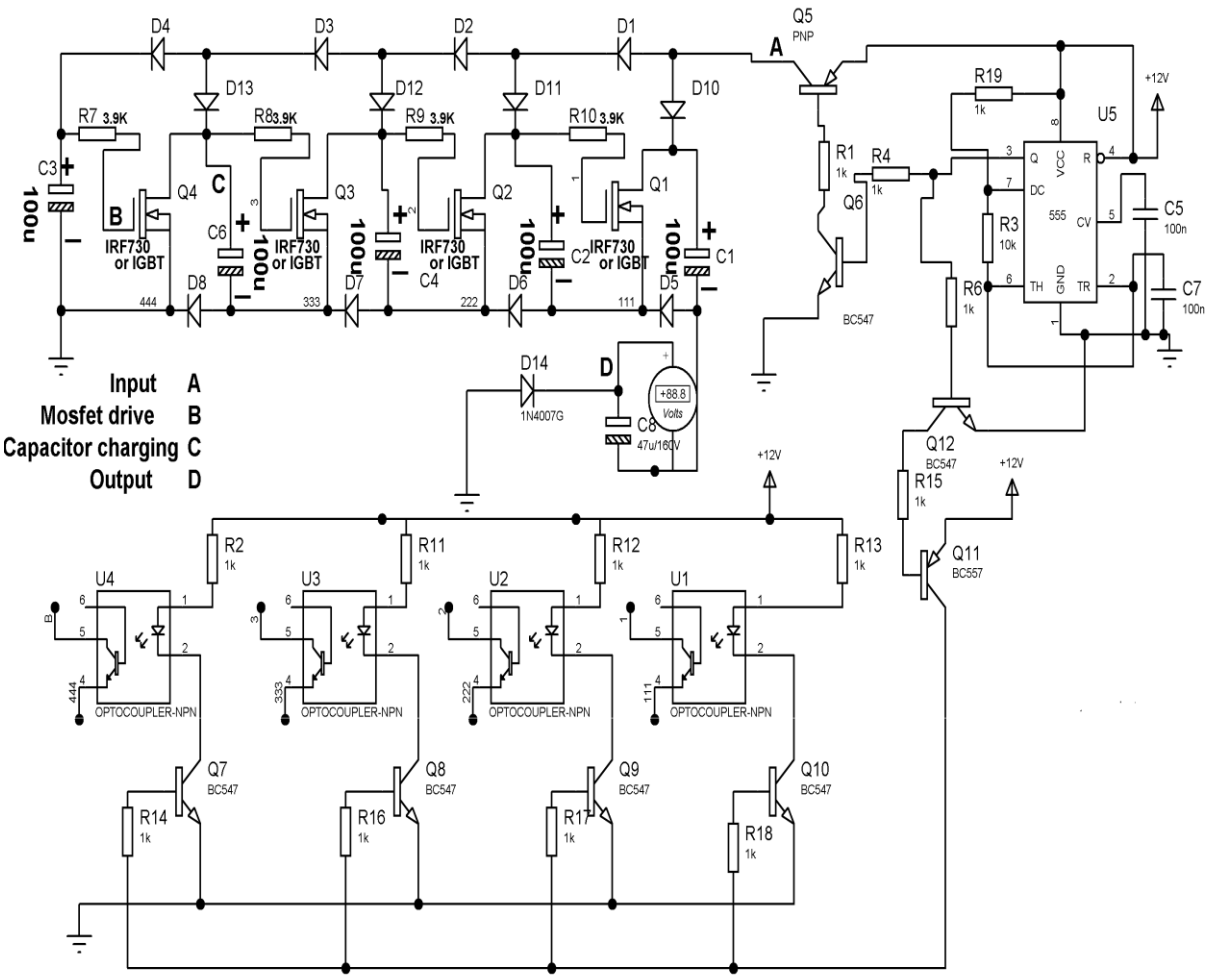

Fig:2 Schematic Diagram

Design Specifications:

C =(t* Vo)/((20% of Vo)*R)
Where,
Vo=Output voltage, t =maximum pulse width
R=Resistance connected at load side.
Assuming 10-21% drop in output voltage.
C=(20msec*48)/((48*21%)*3900) =24.42μF
Ceq=n*C=4*(24.42μF)=97.6800μF~=100μF.
Resistors - 1k,10k,3.9k
[range(10-100k);max voltage(50-100kV)]
MOSFET - IRFZ44
Diode - 1N4007
Opto-coupler - MCT2E

IV. RESULT & DISCUSSION

4.1 Working model

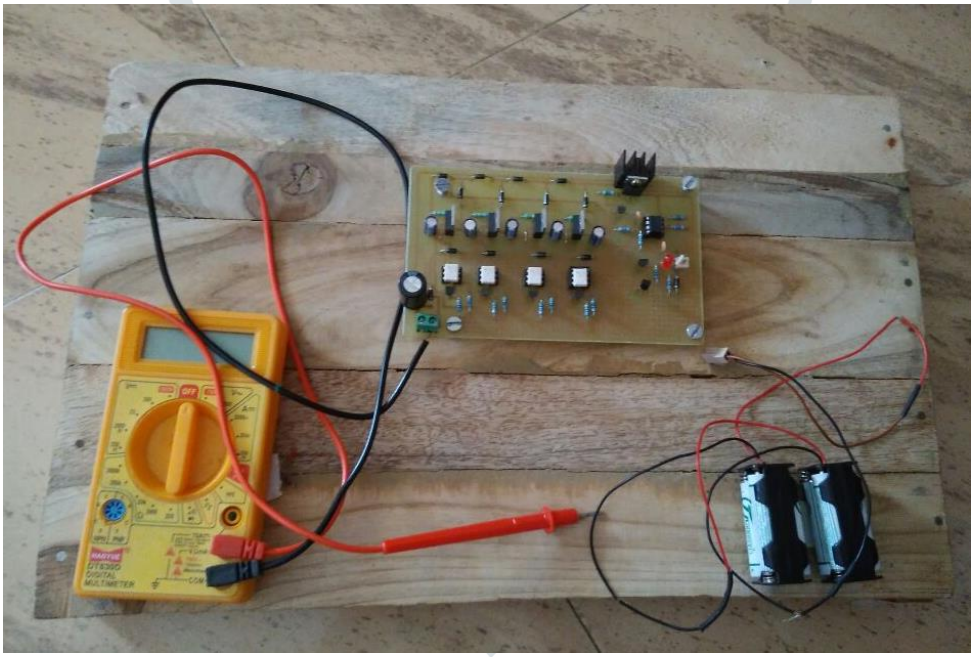

Fig:3 Working model

We give the input voltage 12V and at the output stage we get the output 24 V. The output voltage is depends on the no. of stages which are used in circuit. If we increase the no. of stages then the output voltage will change. Here we are using four stages hence the output voltage will be multiplied by two times. If we put hundred stages then output voltage will be multiplied by fifty times.

4.2 Conclusion

The hardware gives the idea of HVDC generation i.e., 2kV using sphere gaps. In this study, solid-state devices such as POWER MOSFET and diodes are used in Marx generator to replace of gap switches and resistors. Furthermore, it is reasonable that POWER MOSFET drivers utilize method of self-supplied power. The Marx generator is used to multiply voltage by using POWER MOSFETS. The number of POWER MOSFETS used decides the number of times the voltage should be multiplied. In this study we have used four stages in hardware and the circuit multiplies the input voltage two times successfully.

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