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Design and simulation of DC voltage multiplier using 555 timer

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ABSTRACT

This paper contains simulation and design of DC voltage multiplier using the principle of charging, discharging and storing properties of a capacitor with the help of different stages of boosting with each stage containing capacitor and diode set, contributing to the particular boosting multiplier. In this project we have used 4 stages of the cascaded multiplier, each stage adding 12 volts, stepping up 12V DC input to 48V DC output. Since charging and discharging of capacitor requires pulsating DC voltage, so a constant DC voltage is first converted into pulsating DC voltage with the help of a 555 timer.

Keywords— *555 Timer, Voltage multiplier, PSIM, Capacitors, Stages*

1. INTRODUCTION

1.1 General

As the world is moving more towards DC because of various advantages of DC over AC, demands of DC converters have increased considerably in recent years. Earlier AC was preferred over DC for various purposes as a conversion of DC was not possible back then but with the advent of DC Converters and high voltage diodes, stepping up and stepping down of DC become possible. There are many instances where stepping up of DC voltage is required, as DC is constant in nature so changing DC voltage with the help of flux is impossible, as flux will be constant because of constant voltage, due to which alternating flux will not be produced and hence stepping up or stepping down of DC voltage is not possible. So we require an alternate method to convert voltage level effectively. One of the most effective methods has been explained in this paper with simulation and design. Here we have used charging, discharging and storing properties of the capacitor to boost the voltage level of DC. A special arrangement of capacitor and diode along with a 555 timer prohibits discharging of voltage from certain capacitors by blocking due to effective reverse biasing of a diode. Hence charge gets the store and in next cycle gets added with previous voltage and effectively boosting up the voltage. By cascading stages, further voltages can be multiplied. Isolated converter structures with cascaded configuration enable to achieve high voltage gain. [1] However, these are used up to several kW applications [2, 3].

1.2 Application of DC Voltage multiplier

This principle of stepping up of DC voltage can be used in various medical purposes such as in X-ray, laser etc. Stepping up DC is required in physics research such as in plasma research and particle accelerator. Now a day's concept of DC voltage boosting is being used in DC microgrid. HVDC transmission, DC boosting is preferred in many cases over the transformer as the transformer is limited by flux losses and also in transformer turn ratio is limited. Nowadays DC voltage boosting is being used for space technology. Apart from that DC Voltage booster is used in various fields such as Power amplifier applications, automotive applications, consumer electronics, adaptive control applications, and communication applications. In many industrial applications, it is required to convert a fixed-voltage dc source into a variable-voltage dc source. A dc-dc converter converts directly from dc to dc and is simply known as a dc converter. [4] DC Converters are used in DC voltage regulators; and also are used, with an inductor in conjunction, to generate a DC current source, specifically for the current source inverter. [5] DC-DC converters can be used in regenerative braking of dc motors to return energy back into the supply, then this feature results in energy savings for transportation systems with frequent stops. [6]

2. DESIGN DETAILS AND SPECIFICATIONS

2.1. 555 Timer

The 555 timer is an integrated circuit which is used for various purposes, for example in timer, pulse generation, and oscillation. A 555 timer is a device that has zero, one or two stable output states. Depending on the number of stable output states there are three basic types of multivibrator circuits namely Bistable multivibrator having two stable states, Monostable multivibrator having one stable state and Astable multivibrator having zero stable states.[7]

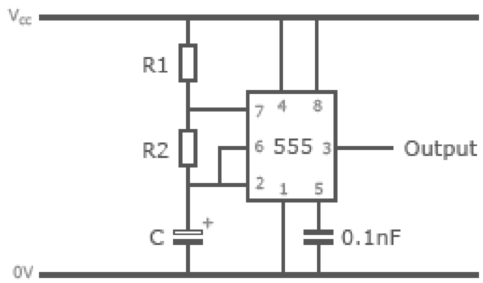

Fig. 1: 555 Timer Circuit

A Monostable Circuit produces a single pulse of a set length. The output of the circuit remains in the low state until the input is triggered. The 555 timers can be used in an astable mode where the 555 timer has no stable states, so it cannot stay in any state and hence start oscillating.

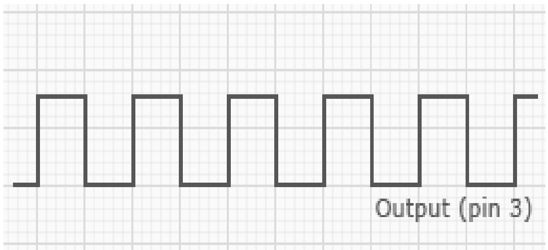

Fig. 2: Output of 555 Timer during astable mode

2.2. 555 Timer Specifications

Resistor, R1=1kΩ, and R2=1kΩ

Capacitance, C=10nF

High Time, T1=0.693(R1+R2)*C =1.386x10^{-5}second

Low Time, T2=0.693(R2)*C =6.93x10^{-6}second

Time Period, T=T1+T2 =1.386x10^{-5}+6.93x10^{-6} =2.079x10^{-5}second

Frequency, f=1/T =1/ (T1+T2)
=1.44/ ((R1+2*R2)*C)
= 48.10 kHz

%Duty Cycle= [T1/(T1+T2)]*100
= [(R1+R2)/ (R1+2*R2)]
=66.66%

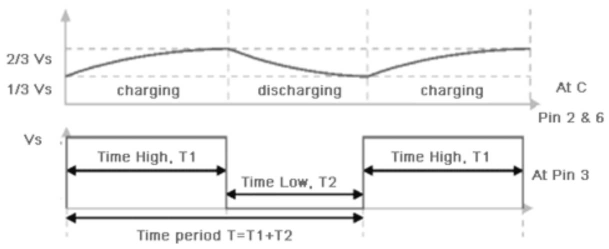

Fig. 3: High Time and Low Time of 555 Timer

3. CIRCUIT DIAGRAM AND WORKING

Considering stage one of the circuit with Capacitor C3 and C4 in action, since 555 timers are operating in astable mode, a square wave pulse generated at the output of 555 timers with high mode and low mode. During high mode diode, D1 will effectively be forward biased and D2 will effectively be reverse biased C3 will be charged through D1 and due to reverse biasing of D2, it will block flowing of current through C4, so 12V will be stored in C3. During low mode diode D1 will effectively be reverse biased and diode D2 will effectively be forward biased so stored 12V from capacitor C3 along with input voltage in series will charge Capacitor C4 through D2 and due to effective reverse biasing of diode D2 there will not be any path for capacitor to discharge and hence 24V (12V from capacitor C3 and 12V from input voltage) will be stored in capacitor C4, effectively voltage will be doubled to input voltage. If assuming a combination of diode and capacitor as stage then each stage will be able to add voltage up to input voltage, so each stage will act as a voltage multiplier. The advantage of this circuit is that it converts high voltage from low power source without the need of a transformer. Voltage can be stepped up as much as required by just adding stages. By reversing the direction of diodes and capacitors in this circuit we can change the polarity of the output voltage. By cascading stages, a very high voltage can be produced so minimum reverse breakdown voltage of capacitor and diodes should be at least twice the peak voltage across them. With the addition of each stage, rating of capacitors increases. Due to voltage drops across diodes, practically output voltage will be slightly lower than expected.

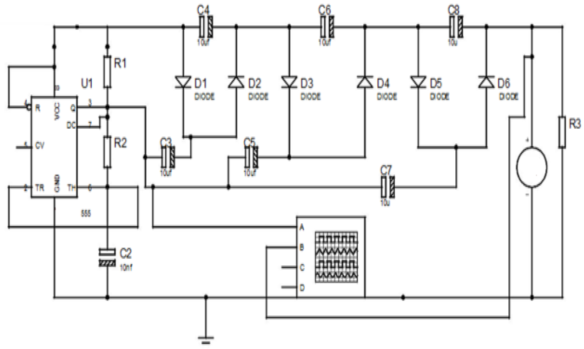

Fig. 4: Circuit Diagram of four stages model

4. RESULTS AND SIMULATION

The Simulation was done on PSIM with four stages and waveform of voltage variation across capacitors and 555 timers was recorded and observed. Output voltage comes out to be four times of input voltage because of four stages.

4.1. Simulink Circuit on PSIM

An input voltage of 12V DC is applied which is required to be stepped up. Output at 555 timers will be pulsating DC which is desirable as charging and discharging of the capacitor will require pulsation DC voltage. 555 timer under astable mode gives pulsating DC. Here four stages of multiplication have been used so output voltage will be multiplied to four times and ideally output should be 48V during Simulation but practically due to drops across diodes, the output will be slightly less than 48V. The voltage of 12V DC is given for the purpose of stepping up, this 12V DC is first converted into pulsating DC in order to charge and discharge the capacitor. During this mode output at 555 timers oscillate between high and low mode to give pulsating DC. Capacitors C3, C5, and C7 get discharge while charging capacitors C4, C6 and C8. Their variations in the form of the waveform are given in simulation results. These capacitors get charged and due to effective reverse biasing of diode they don't get the path to discharge and hence start storing voltage.

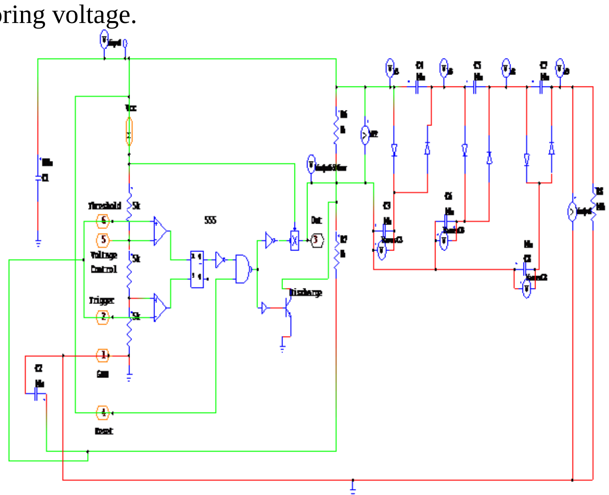

Fig. 5: Simulink model on PSIM

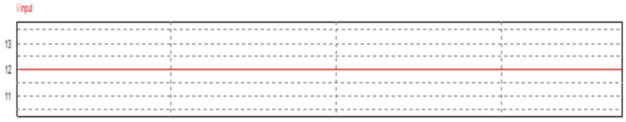

Fig. 6: Input voltage (12V)

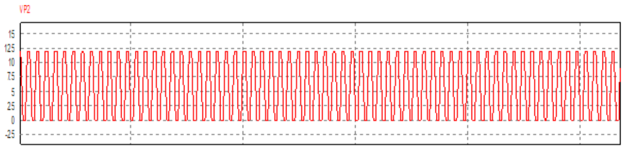

Fig. 7: Variations of the voltage across 555 Timer as pulsating DC

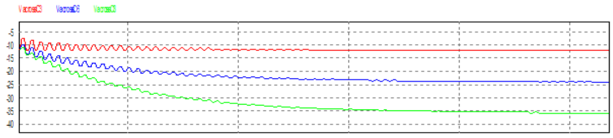

Fig. 8: Voltage across discharging capacitors C3, C5, and C7

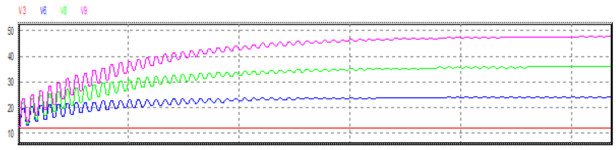

Fig. 9: Voltage across charging capacitors C4, C6 and C8

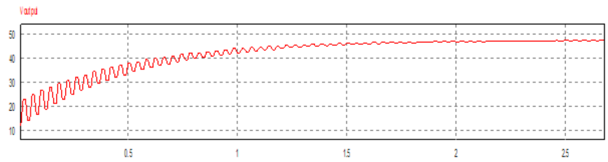

Fig. 10: Output voltage (48V DC)

5. HARDWARE IMPLEMENTATION

Hardware implementation was done for three stages with an input voltage of 12V, the result was recorded on screen and voltage was measured with the help of multimeter. Ideally, the 36V output voltage was expected according to simulation but due to diode drops output voltage was observed to be 32.5V. With three stages cascading efficiency was around ninety percent.

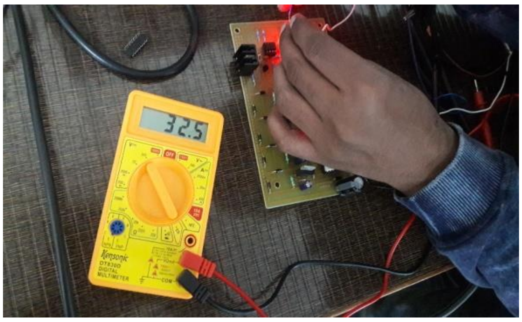

Fig. 11: Practical output voltage with three stages (32.5 V DC)

6. CONCLUSION

In this paper, we have designed a prototype which is capable of boosting DC voltage level as much as we want by adding stages to the circuit, more the numbers of stages; more the voltage can be multiplied. Voltage can be boosted up to thousands of volts from the very low input. As we are moving more towards DC due to various advantages of DC over AC, we will require voltage boosting in many instances. This method of boosting DC voltage can become quite effective in the future.

7. REFERENCES

[1] B. Huang, A. Shahin, J. P. Martin, S. Pierfederici, and B. Davat, “High voltage ratio non-isolated DC-DC converter for fuel cell power source applications,” in Proceedings of the 39th IEEE Annual Power Electronics Specialists Conference (PESC ’08), pp. 1277–1283, June 2008.

[2] A. M. Tuckey and J. N. Krase, “A low-cost inverter for domestic fuel cell applications,” in Proceedings of the IEEE 33rd Annual Power Electronics Specialists Conference (PESC ’02), pp. 339–346, June 2002.

[3] C. Smith, M. Gilliom, D. Urciuoli, A. Mclandrich, E. Pepa, and J. S. Lai, “Low-cost solid oxide fuel cell power conditioning with bi-directional charging,” in Proceedings of the Fuel Cell Seminar, pp. 8–15, Miami Beach, Fla, USA, November 2003.

[4] Robert W. Erickson and Dragon Maksimoni, “Fundamentals of Power Electronics”. SECOND EDITION, Springer International Edition.

[5] K. I. Hwu, C. F. Chuang, and W. C. Tu, “High Voltage-Boosting Converters Based on Bootstrap Capacitors and Boost Inductors” IEEE Trans. On Industrial Elec., Vol., 60 No 6, June 2013.

[6] R. Tymerski and V. Vorperian, “Generation, Classification and Analysis of Switched-mode DC to DC Converters by the use of Converter Cells”. Proc. INTELEC’86, pp. 181-195, Oct. 1986.

[7] Anil K. Maini, Varsha Agarwal, Electronic Devices and Circuits (New Delhi: Wiley India Pvt. Ltd. 2009), 457-458 and 527-539.

