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DC To DC Boost Converter with High Voltage Gain

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Abstract: *the main objective of this work is to produce a very high DC output voltage from a small input voltage. The input voltage range is from 4 to 6 DC voltages and the output voltage is 810 V with no load. Depending upon the load connected, the output voltage and the output current will vary. Booster circuit has a wide range of applications but this work main application is to light electrical appliances which required high input voltage and driving up of electronic components which require high voltage from small input voltage. Variable output can be obtained by varying the switching frequency of the MOSFET which is controlled by 555 timer circuit output pulse. The highest output is obtained when the switching frequency of MOSFET is 57.15 Hz.*
Keywords: *Booster, 555 timer, step up transformer, astable mode, voltage doubler.*

I. Introduction

Amplifier is an electronic circuit which amplifies or increases the signal parameters such as voltage or current or power. It multiplies the input signal with its internal gain to give a high output. The more the gain the more the output it gives. Booster circuit is a type of DC voltage amplifier which has a wide range of application in the field of electronic circuit. Power obtained from solar cell and thermocouples are usually very low. To increase the output from such low energy source, booster circuit is often used [1], [2]. It even finds its application in power generation from wind energy and lighting of CLF bulbs. Fig.1 shows the basic classical schematic of boost converter. When the switch is initially closed, current flows through inductor towards the switch and nothing flows towards diode and capacitor as it is short circuited. During this period the inductor store energy in its magnetic field. When the switch is opened again, current starts to flow towards the diode as it is forward bias by the summation of input voltage and back emf across inductor. This will start charging the capacitor up to the sum of input voltage and back emf of the inductor minus the small diode voltage drop.

i.e. $V_c= (Vin + V_L) - V_D$ (1)

Where V_c is capacitor voltage, V_{in} is input voltage, V_L is inductor back emf voltage and V_D is diode voltage drop which is relatively small. Again when the switch is closed as the diode is reverse bias it is turn off and the output of the circuit is isolated from the input, however the load is continued to be supplied with Vin + VL from capacitor voltage. Although the capacitor voltage drain away towards the load, C is recharged again each time the switch is open again maintaining almost a constant voltage across the load. So the repeated on and off cycle of the switch is the key role of booster circuit which will gradually increase the output voltage from a small input voltage.

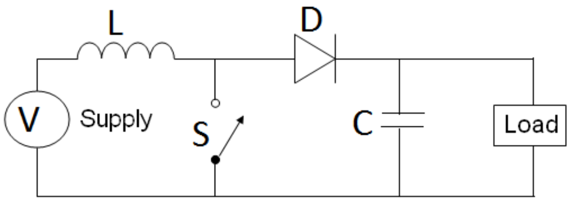


Fig. 1 Booster circuit

Many experts has already designed DC to DC boost converter for wide range of electronic circuit applications. A boost converter output which is 10 times the input voltage i.e 600V from 60V with output power of 900 watts for solar power application is already designed [1]. In order to boost the small output voltage of thermoelectric cooler, booster is used to boost the voltage of 0.2 to 0.8 voltages to 2.7 to 5.5 voltages. This can be used to power small electronic application such as sensor circuit [2]. A microcontroller based project to control the switching circuit to give maximum output voltage from input voltage between 3-12 volts is also reported by [3]. A high power of 100 W and 24 V constant output voltages from fluctuating solar panel is also design using microcontroller as heart of control system of the circuit exhibiting a good performance [4]. A DC to DC converter for photovoltaic module application to boost the input voltage of 15 V to 55.64 output voltage is designed and simulated with Matlab [5]. A new configuration of DC to DC boost converter to achieved high voltage gain using two inductors with same value of inductance which are charged in parallel during on period and are again discharge in series during off time is also presented [6]. An isolated buck boost DC to DC converter with high efficiency with input range 250-500 V, 360 V output, and 6KW rated prototype is also already fabricated and verified [7].

II. Circuit Implementation

The proposed DC to DC boost converter is shown in Fig.2. Here the MOSFET is used as switch to create an alternating voltage in the primary winding of the step up transformer. The more the rate of change of flux across L1, the more the voltage it will induced across L2 of the transformer according to Faraday's second law of electromagnetic induction.

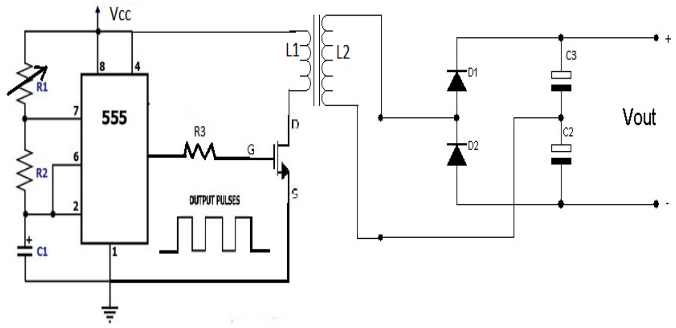


Fig.2 Proposed Circuit Diagram

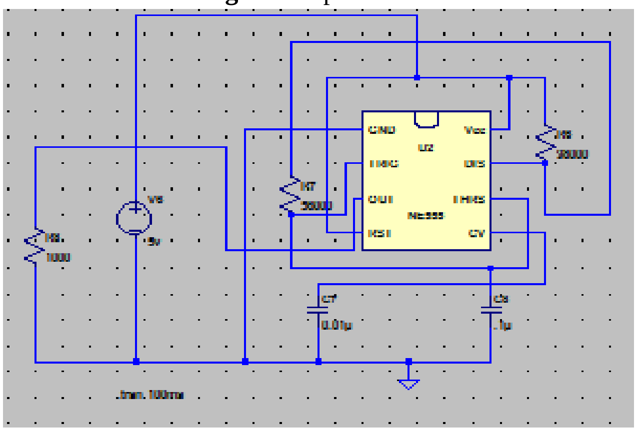
Flux changing rate of L1 is controlled by the output frequency of 555 times operating in astable mode which alternately switch the MOSFET in on and off condition. The output frequency of the 555 timer is express as

$f = 1.44/C*(R1+2R2)$ (II)

So changing the value of R1 using potentiometer by keeping C and R2 constant, the switching frequency of the MOSFET is varied by the 555 timer output. Properly adjusting the potentiometer, maximum alternating output voltage is obtained across L2 which is again fed as input to the voltage doubler circuit to obtain a dc output voltage which is twice the input voltage across C2 and C3. The list of component for the circuit implementation is shown in Fig.3

Sl No.	components	values
1	Timer	555
2	Transformer	6-230V
3	MOSFET	BD135 transistor
4	R1	Variable Resistor (0-100k Ohm)
5	R2	56 k ohm
6	R3	1 K ohm
7	C1 ceramic	0.1 micro F capacitor
8	C2 ceramic	400V
9	C3 ceramic	400V
10	D1	IN4937
11	D2	IN4937

Fig.3. Component list



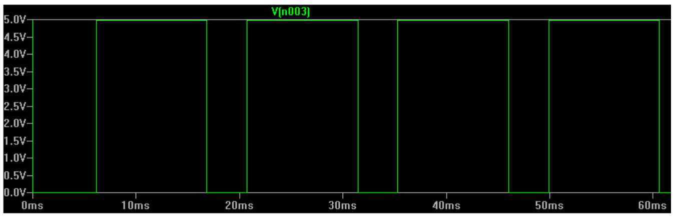


Fig.4 Pulse Generation Circuit And Simulation Result

The simulation result of the 555 timer output pulse to control the switching frequency of the MOSFET is shown in Fig.4. The simulation is carried out for duty cycle 61.1% and pulse frequency of 51.15 Hz with pulse amplitude of 5 V. Variable output Vout is obtained by varying the pulse frequency of the 555 timer. The snapshot of the complete hardware implementation of the designed circuit showing the final DC output with no load and load of 1 Watt is also shown in Fig. 5 and Fig. 6 respectively.

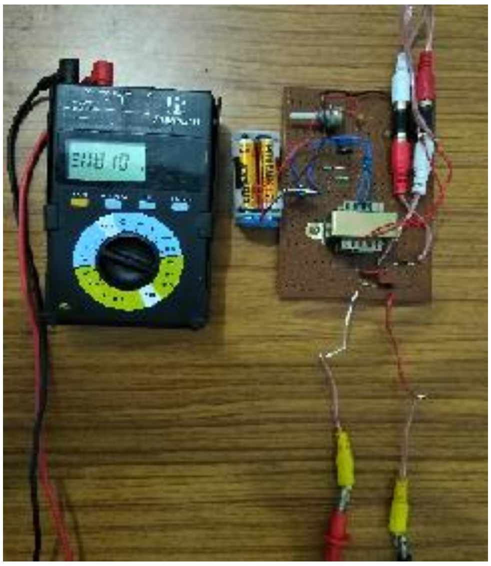


Fig. 5 open circuit voltage drop

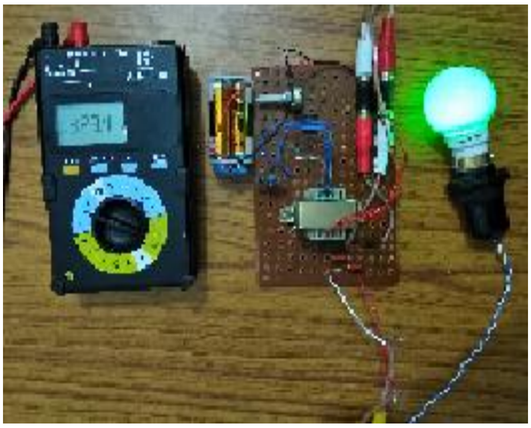


Fig.6 voltage drop across 1 watt bulb

The various electrical parameters of the designed circuit is shown in observation table Fig. 7. The AC voltage obtained from the output of transformer across L2 is as high as 200 V and the final DC output from the voltage doubler circuit is 810 V with no load which is the highest when the switching frequency of the MOSFT is 51.15 Hz. When a bulb of 1 Watt is connected as load the voltage drop is 323 V.

Fig.7 Observation Table

Particulars	**Readings**
Input Voltage (Vin)	5 V
R(variable)	98 k Ohm
R1	56 k Ohm
AC Voltage Output (Vac)	200 V
DC Voltage Output (Vdc)	810 V
Duty Cycle	61.10%
Frequency	57.15 Hz
At DC output terminal, Voltage drop across 1W LED Bulb	323 V

III. Conclusion

This designed circuit is robust and efficient with a very high gain. It work satisfactorily for input range between 4 to 6 V. The switching of the Mosfet is controlled by 555 timer output in astable mode. The output voltage can be adjusted by varying the duty cycle of the timer circuit with a potentiometer R1. It gives the highest output when the switching frequency of the Mosfet is 57.15 Hz. The advantage of this circuit is it can operate in both AC and DC mode. From the output of the step up transformer it gives AC voltage of 200 V. This AC voltage is again pass through voltage doubler circuit to give a very high DC voltage of 810 V. The simulation result of 555 timer for controlling the switching activity of the Mosfet and the hardware implementation of the booster circuit is shown in Fig.4 and Fig.5 respectively. The tool use for simulation is LT spice.

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