Mini Project (19EE606)
Report on

DESIGN AND ANALYSIS OF 100W BOOST CONVERTER (12V-24V)

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Abstract

Nowadays, DC-DC Converters are widely used in Electric vehicles, trolley cars, marine hoists, Photovoltaic (PV) system, Uninterruptable power supplies (UPS) and fuel cell system. A DC –DC switching converter converts directly from fixed DC voltage to variable DC voltage. In this paper, the performance parameters of the dc-dc boost converter are analyzed. The converter is simulated using LT-spice software and also the converters are implemented in Hardware. The converter is tested with constant duty cycle and variable input voltage in Continuous Conduction Mode (CCM).The simulation and Hardware implementation results of the converters are compared with theoretical results.

Chapter 1

Introduction

Renewable energy sources are wonderful options compared to non-renewable energy sources because they are limitless and they do not pollute our air and water like way burning fossil fuels will do. To make any renewable energy system efficient, they need to have the suitable converter. An efficient dc to dc converter is needed as the interface between a low-voltage fuel cell source and a high-voltage bus for inverter operation. DC-DC converters are more important component in power electronic interfaces such as photovoltaic power systems and fuel cells

We have already mentioned in the beginning that boost converters are types of chopper circuits. In chopper circuits, we have discussed that it performs dc to dc conversion, i.e., a fixed dc voltage is changed into an adjustable dc voltage. boost converters are the ones that perform a reverse operation of the buck converter. Due to the type of operation performed by boost converters, these are referred to as step-up choppers. It is to be noted here that since the product of voltage and current results in power then with the increase in the output voltage, the output current through the circuit will automatically decrease. In chopper circuits, power MOSET, BJT, IGBT, etc. are used as switches while the thyristors are not used for such purposes and the reason for the same is that an external commutation circuit is needed in order to commutate the device. .
TYPES OF CONVERTERS

- AC-AC converter
- DC-DC converter

- AC-DC converter
- DC-AC converter

AC-AC CONVERTER:

An AC-AC converter converts an AC waveform such as the mains supply, to another AC waveform, where the output voltage and frequency can be set arbitrarily. It is also called as cycloconverter. The input to the cycloconverter is normally single phase or three phase Ac mains supply. It is fixed voltage and fixed frequency. The cycloconverter provide the output which has variable voltage and variable frequency. The output frequency is lower than the input frequency. The Cycloconverter are used mainly for AC traction drives.

DC-AC CONVERTER:

A DC-AC converter is also called as an INVERTER. An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted . AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. The inverter performs the opposite function of a rectifier. There are two main types of inverter.

- Modified sine wave.
- Pure sine wave.

The output of a modified sine wave inverter is similar to a square wave output except that the output goes to zero volts for a time before switching positive or negative. A pure sine wave inverter produces a nearly perfect sine wave output that is essentially the same as utility-supplied grid power.

AC-DC CONVERTER:

AC to DC Converters are one of the most important elements in power electronics. This is because there are a lot of real-life applications that are based on these conversions. The electrical circuits that transform alternating current (AC) input into direct current (DC) output are known as AC-DC converters. They are used in power electronic applications where the power input a 50 Hz or 60 Hz sine-wave AC voltage that requires power conversion for a DC output.The process of conversion of AC current to dc current is known as rectification. The rectifier converts the AC supply into the DC supply at the load end connection. Similarly, transformers are normally used to adjust the AC source to reduce the voltage level to have a better operation range for DC supply.

DC-AC CONVERTER:

DC-to-AC Converters are one of the most important elements in power electronics. This is because there are a lot of real-life applications that are based on these conversions. The electrical circuits that transform Direct current (DC) input into Alternating current (AC) output are known as DC-to-AC Converters or Inverters. They are used in power electronic applications where the power input pure 12V, 24V, 48V DC voltage that requires power conversion for an AC output with a certain frequency.

Chapter 2

PROJECT DESCRIPTION

A 100W BOOST CONVERTER with an input of 12v and output of 24v is designed.They are generally used for industrial purposes such as load matching for variable drives and also for the testing /trouble shooting of small scale electronics.so,in this project we are going to build a simple 12v to 24v dc to dc converter circuit using NE555 precision timer IC.the PWM signal required for the mosfets is provided by the triggering circuit.

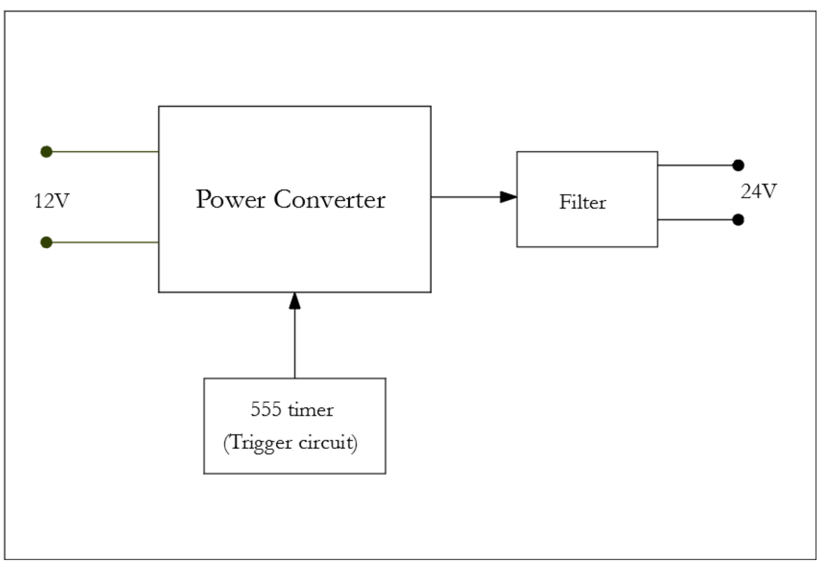
A NE555 timer IC serves as the core of this circuit. The IC possesses an oscillation frequency ranging 2kHz. Here, this NE555 timer acts as an astable multivibrator An astable multivibrator is a free-running oscillator that switches continuously between its two unstable states. With no external signal applied, the transistors alternately switch from cutoff to saturation state at a frequency that RC time constants of the coupling circuit determine. If these time constants are equal (R and C are equal) then a square wave will generate with a frequency of 1/1.4 RxC. Hence, an astable multivibrator is also a pulse generator or a square wave generator

Chapter 3

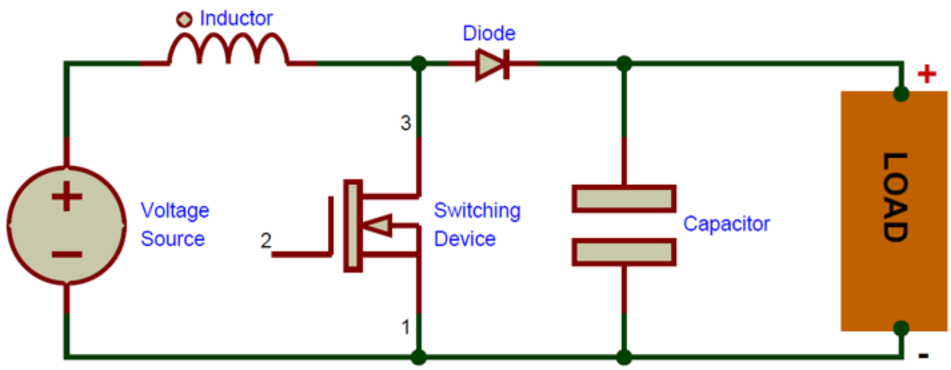
BOOST CONVERTER

A boost converter is one of the simplest types of switch mode converter. As the name suggests, it takes an input voltage and boosts or increases it. All it consists of is an inductor, a semiconductor switch (these days it's a MOSFET, The input and output voltage relationship is controlled by the switch duty cycle. An ideal boost converter is lossless in terms of energy, so the input and output power are equal.

BLOCK DIAGRAM



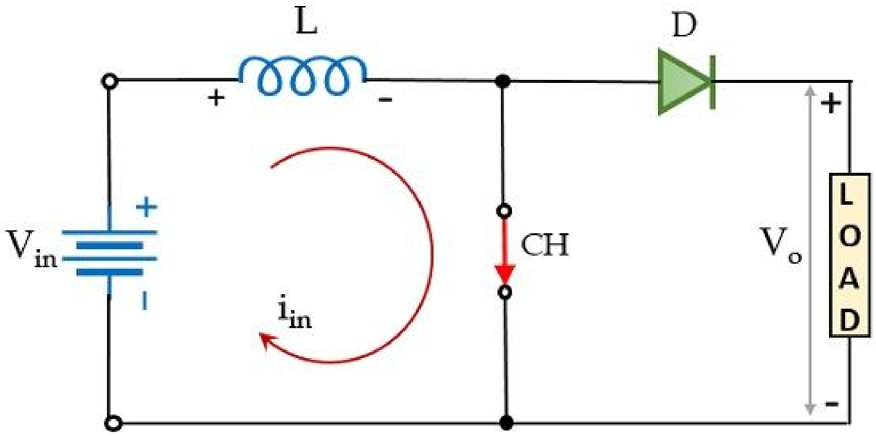
WORKING PRINCIPLE:
An ideal boost converter is lossless in terms of energy, so the input and



output power are equal. In practice, there will be losses in the switch and passive elements, but efficiencies better than 90parameters such as the switch frequency. The internal operations of a boost converter can be thought of as a charge storage and transfer mechanism. There are two states, on and off.

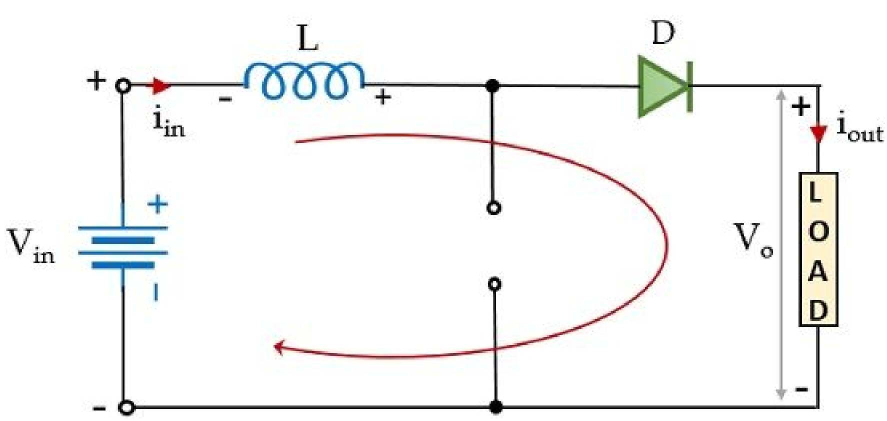
Switch is ON:

When the shown device (which could be any standard power BJT or a mosfet) is switched ON, current from the input supply enters the inductor and flows clockwise through the transistor to complete the cycle at the negative end of the input supply.During the above process the inductor experiences a sudden introduction of current across itself and tries to resist the influx, which results in the storing of some amount of the current in it through the generation of a magnetic field. Here, the polarity of the inductor will be according to the direction of the flow of current. In this particular case, the diode in the configuration is in reverse biased condition and so current will not be allowed to flow through that particular part of the circuit during on state of the chopper. Resultantly, the voltage across the chopper will appear across the load.



Switch is OFF:

Furthermore, at the instant when CH is in the off state, then the part of the circuit through which the current was flowing earlier will not be active in this case. However, as the inductor stores, the energy in the form of a magnetic field and so the current through it will not die out instantly. Also, we know according to Lenz's law a reverse current will be induced that will oppose the cause which has produced it. And so, due to the induced current, the polarity of the inductor will get reversed. This reverse polarity of the inductor forward biases the diode present in the circuit. This provides the path for the current through the diode that flows through the load during the off state of the chopper i.e., Toff. However, we must note here that the current through the inductor is of decreasing nature and will die out after a point in time.



Chapter 4

TRIGGERING CIRCUIT

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.

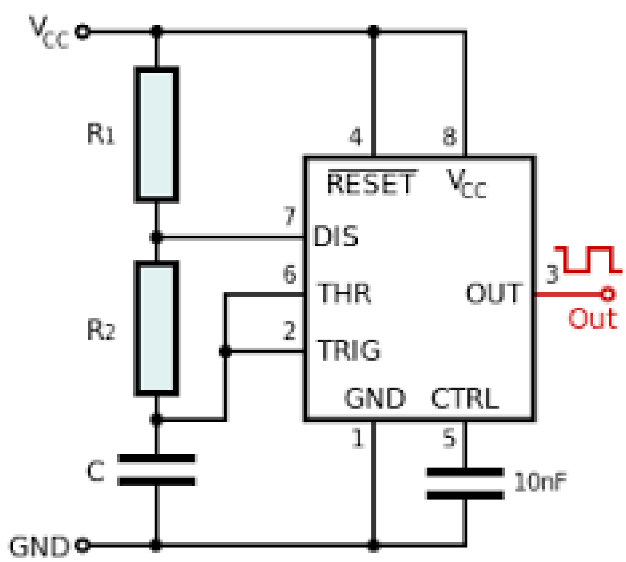


Figure 4.1: 555 TIMER

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.

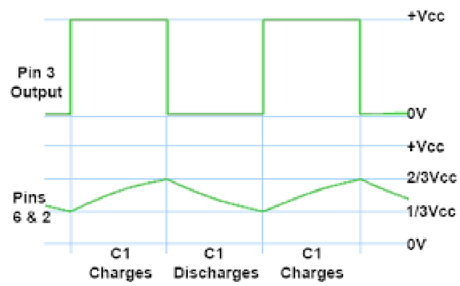


Figure 4.2: SQUARE WAVE

HOW DOES A 555 TIMER WORK? The pins responsible for making

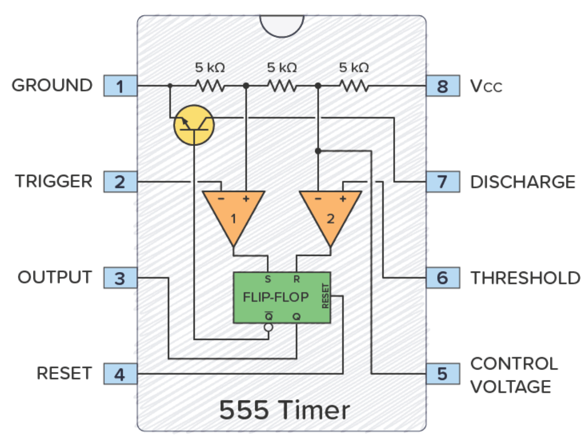


Figure 4.3: INTERNAL DIAGRAM

the Output (pin 3) go high or low are the Trigger (pin 2) and the Threshold (pin 6).The Trigger pin is responsible for setting the output high. When the voltage on the trigger pin goes lower than one-third of VCC, comparator 1 outputs high and sets the flip-flop high, which in turn sets the Output pin high.The trigger and threshold pin are connected together so, there is no need of external trigger pulse.

The comparator will output 1 while charging the trigger because the input voltage at trigger pin is still lower than 1/3 of supplied voltage. This time, the output of timer is high. Once the voltage across reaches 1/3 of the supplied voltage, the trigger comparator will output 0,keeping the situation unchanged as both R and S input of flip flop are 0.Once the voltage across the capacitor reaches 3/7 of applied voltage, the threshold comparator will output 1 to R input of the flip-flop. Now, the capacitor will start discharging through resistor R2 and discharging transistor. The output of 555 Timer is low at this point. Once the voltage across capacitor drops to 1/3 of the supplied voltage, the trigger comparator will output 1.The high time depend on resistors R1, R2 and capacitor. On the other hand, low time depends only on resistor R2 and capacitor.

ON TIME:
Ton= 0.693 x (R1 x R2) XC1

OFF Time:
Toff = 0.693 x (R2) X (C1)

Period for one cycle:
T = Ton+Toff x (R1+ 2R2) C1

Frequency:

f =1.44 / (R1 + R2) C1) Hz

It is also known as self-triggering mode, the Timer is used in this mode as clock pulse generator or oscillator. The Timer switches between two quasi stable states and without any external trigger input.

Chapter 5

555 TIMER CIRCUIT DESIGN

Specifications

Duty Cycle = 60

Switching Frequency (Fs) = 2k HZ

Vcc = 12V

For 555 Timer Ith = 0.25uA

Itrig = 0.5uA

T= 1/PRF = 500u sec

Ton = 0.6*500u = 300u sec

Toff = 500u – 300u = 200u sec

Select I1(min) = 1mA

R1+R2 = Vcc/3*I1(min) = 4k ohm

Select C1 = Ton/(0.693(R1+R2) = 0.1uF

R2=Toff/0.693*C1 = 2.7k+1k ohm (std)

R1 =(R1 +R2)-R2 = 1.2k+220 ohm (std)

Assume ,C2 = 10nF

5.1 SIMULATION MODEL OF TRIGGERING CIRCUIT USING LT-SPICE

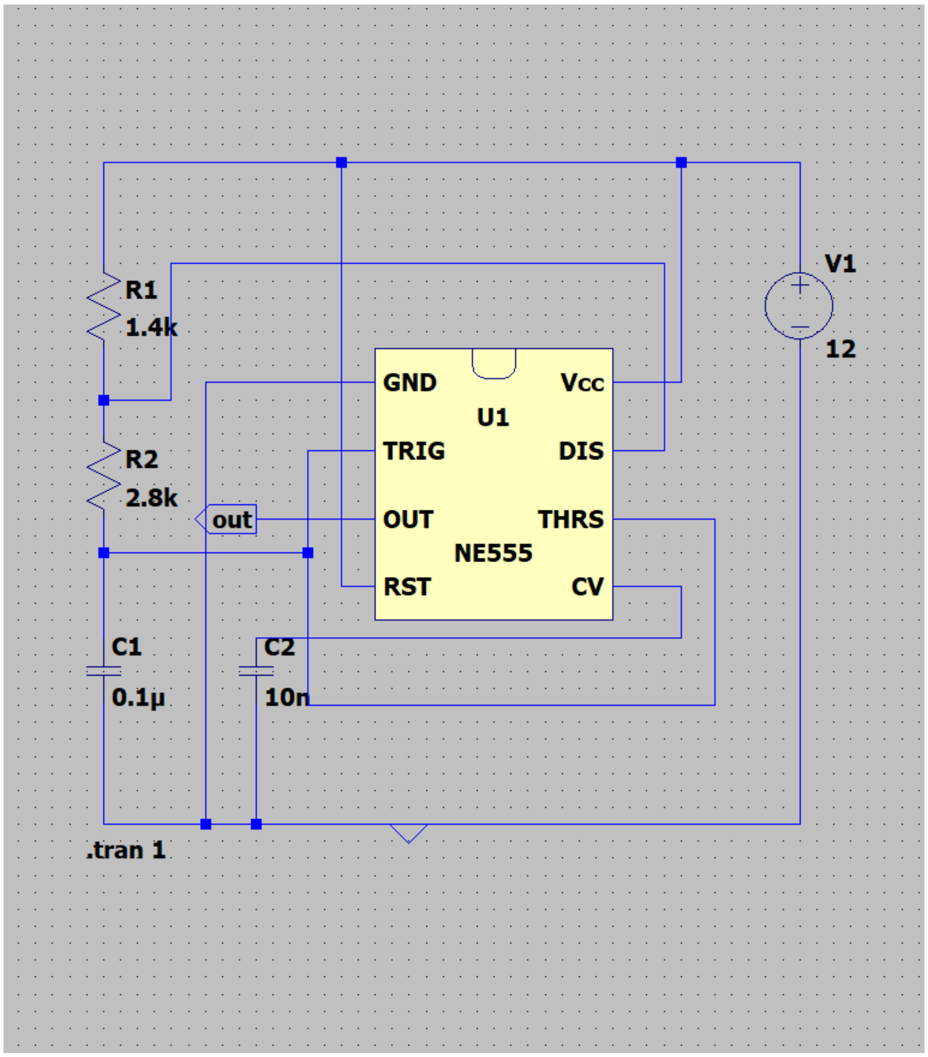
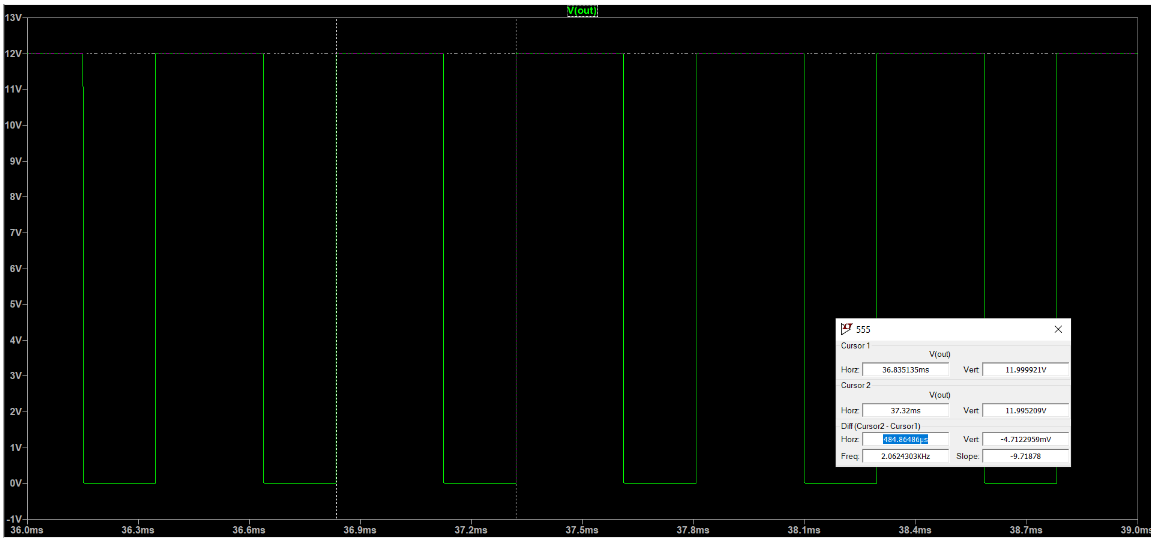


Figure 5.1: NE555 TIMER

5.2 SIMULATION



Above is the schematic simulate in LTSpice. The input signal is a 12V.The signal is fed as an input to the timer 555(NE555 in LTSPice).

Frequency=2.062kHz

T=484.846us

Ton=281.45us

Duty Cycle=0.6

Chapter 6

BOOST CONVERTER CIRCUIT DESIGN

Assumptions

Efficiency = 0.8

Current ripple = 0.3 of Iout

Voltage Ripple = 0.1 of Vout

DESIGN CALCULATIONS

Power input (Pin)= Pout/Efficiency = 125W

Duty Cycle (D)= 1-(V(in) Efficiency)/Vout = 0.6

Input Current (Iin)= Pin/Vin = 10.41A

Output current (Iout) = Pout/Vout = 4.17A

Inductor (L)=(Vin*Vout)- Vin/(Fs*current ripple*Vout) = 2.87mH

Output Capacitance = (Iout*D)/(Fs*voltage ripple) = 5.212mF

LOAD (R)=(Vout)2/Pin = 5.76 ohm

MOSFET SPECIFICATION

IRF540

Id =37A

PD=130W

VD=100V

6.1 SIMULATION MODEL OF BOOST CONVERTER USING LT-SPICE

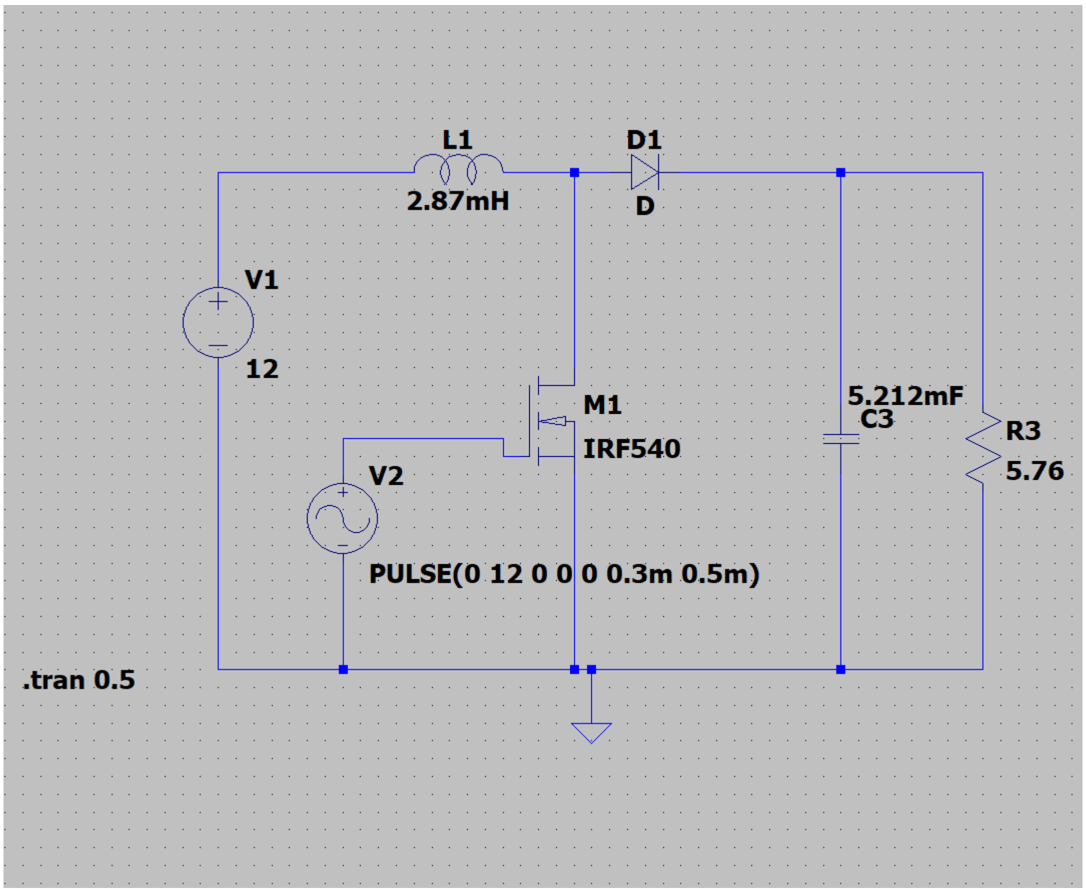
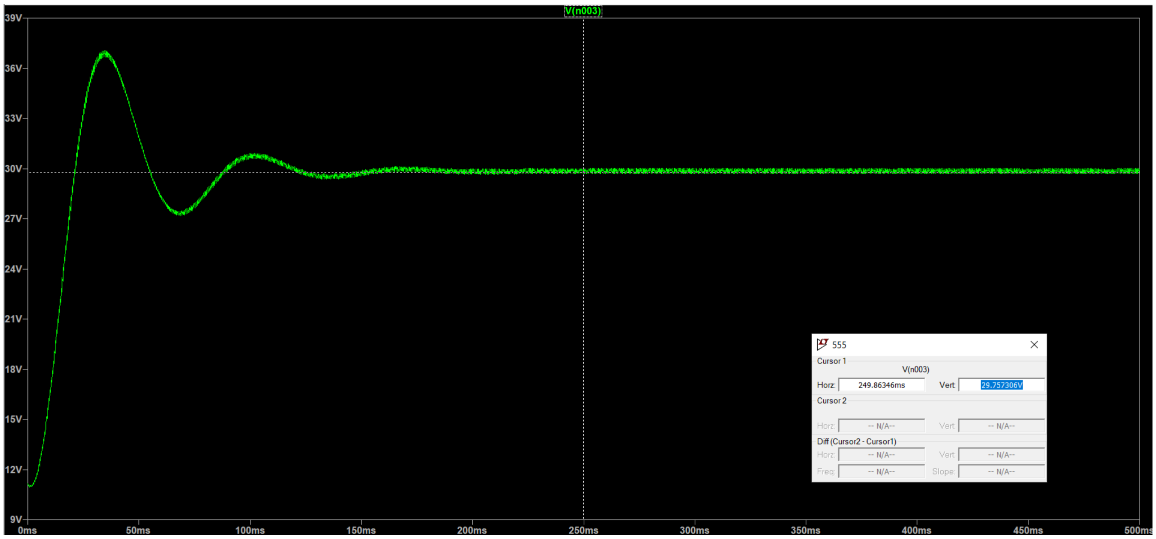


Figure 6.1: BOOST CONVERTER

6.2 SIMULATION



Here output voltage first shoots up, and after some time settles to 29 volts output.

Chapter 7

Switching pulse Circuit and Boost DC-DC Converter for Hardware Implementation

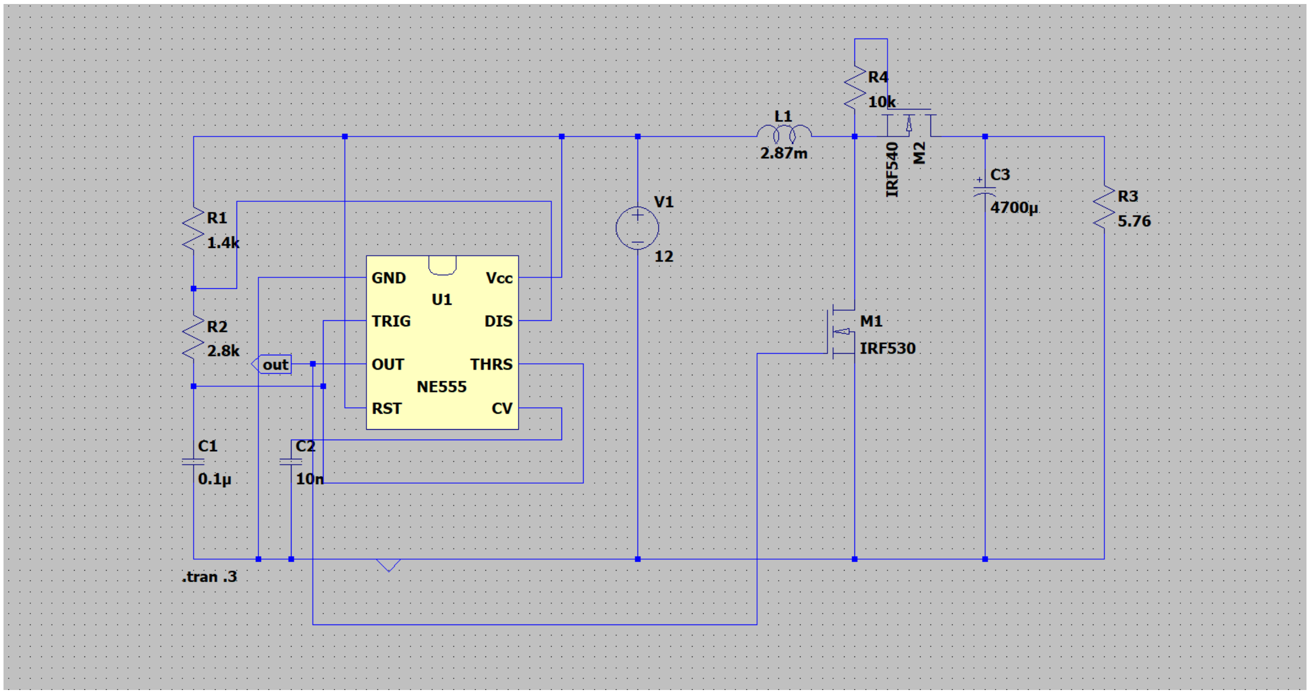
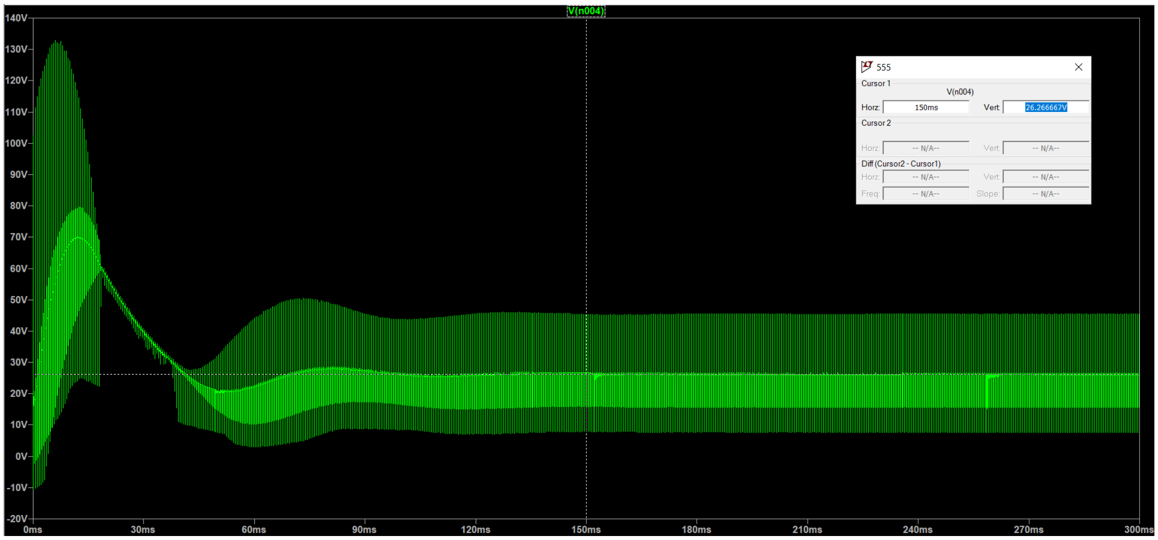


Figure 7.1: BOOST CONVERTER WITH TRIGGERING CIRCUIT

7.1 SIMULATION



Here output voltage first shoots up, and after some time settles to 26 volts output.The Switching pulses (PWM pulses) are generated by IC 555 timer in astable mode of operation. Duty cycles are varied by varying the resistance pot R2. The duty cycle and switching frequency are determined by R2 and C1. Depending upon the switching frequency and duty cycle, the output voltage of the converter is varied.

Chapter 8

HARDWARE IMPLEMENTATION

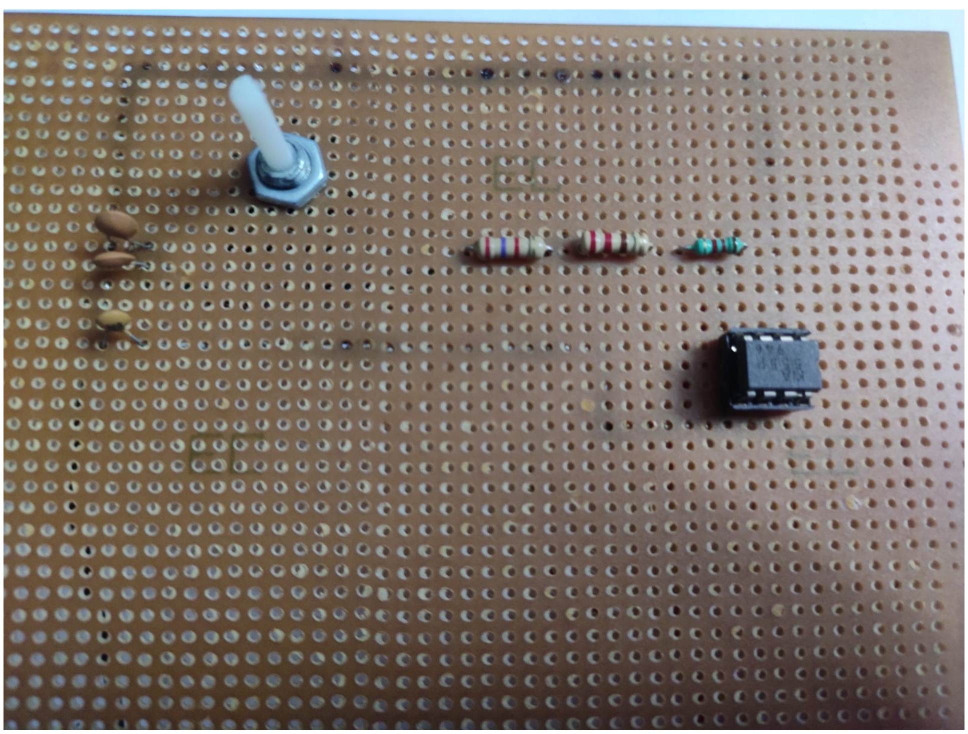


Figure 8.1: TRIGGERING CIRCUIT

8.1 SIMULATION

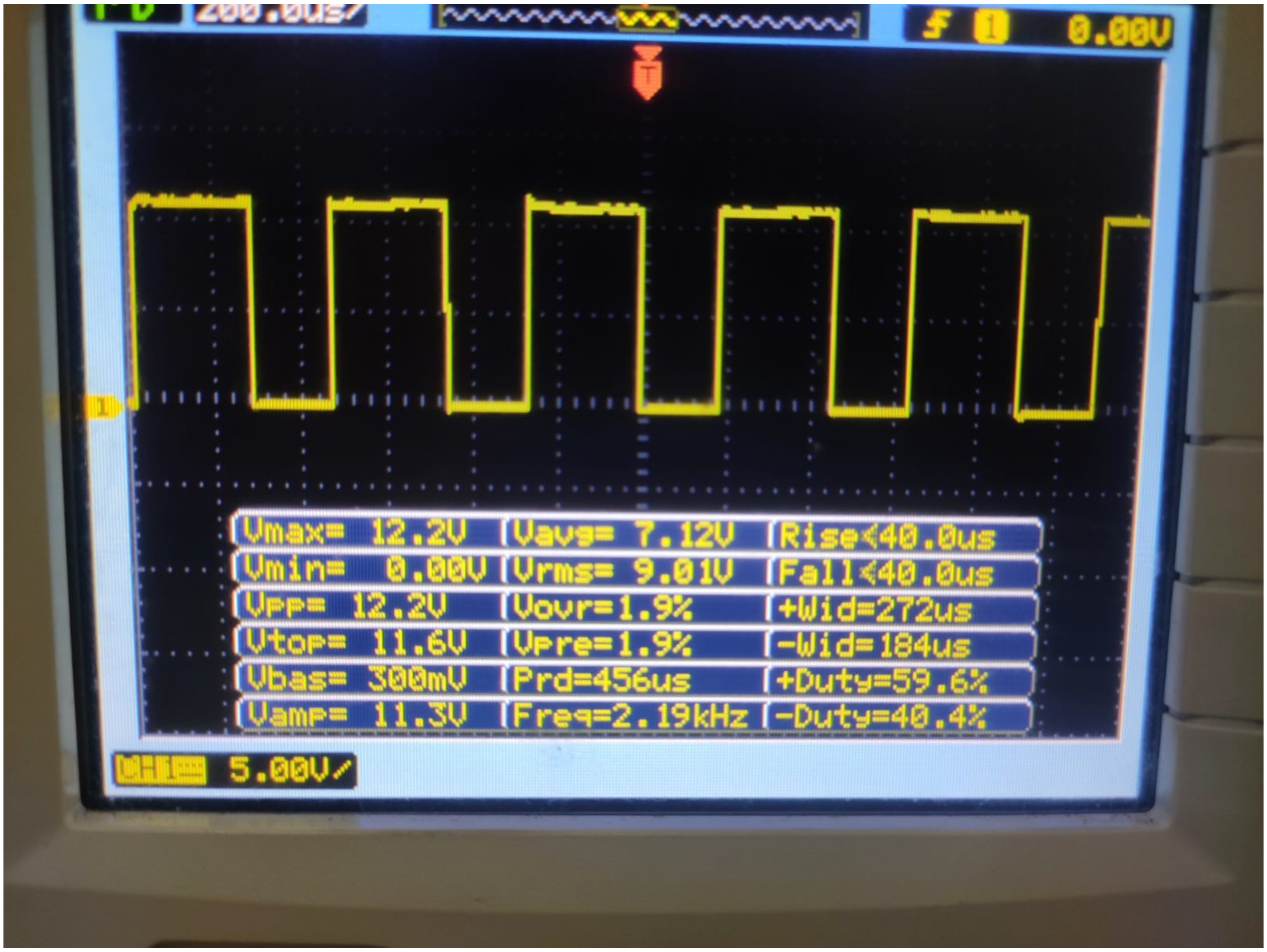


Figure 8.2: PWM SIGNAL

8.2 Overall view of Implementation of DC-DC Boost Converter

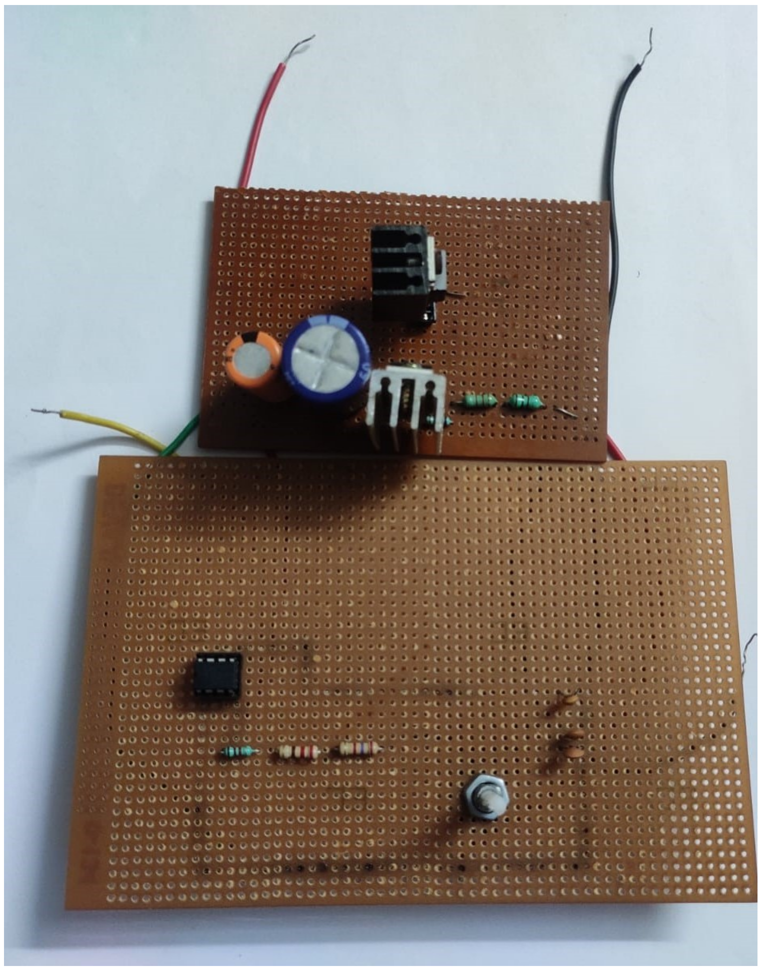


Figure 8.3: BOOST CONVERTER WITH 555 TIMER

Fig 7.3 shows the overall hardware setup of proposed converter for the measurement and acquisition of Input and Output Waveforms.

Chapter 9

RESULT

The Switching pulses (PWM pulses) are generated by IC 555 timer in astable mode of operation. switching frequency are determined by R2 and C1. Depending upon the switching frequency and duty cycle, the output voltage of the converter is varied.

CONCLUSION

The performance parameters of the boost dc-dc converter are analysed with various modes of operation in steady state analysis. The boost dc-dc converter is simulated using LT-spice and also implemented in Hardware. The converter is tested from input voltage 12 Volts and constant duty cycle of 60Simulation and Hardware implemented results almost agree with theoretical results. By using this converter we can step up the input voltage. The converters can be used with battery, photovoltaic system, fuel cell system for automotive applications like hybrid electric vehicle.

9.1 REFERENCES

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