A THEME BASED PROJECT REPORT
ON

SOLAR BATTERY CHARGER CIRCUIT(SIMULATION)

By

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TABLE OF CONTENT :

SOLAR BATTERY CHARGER CIRCUIT

ABOUT THE PROJECT:

As there is an ongoing renewable power deficiency problem, our projects aims to give solution by providing a reliable source and a method to charge a few daily must need devices of 12V DC rating . Which can then be used directly or boosted to operate other necessary systems(Higher Rating Or Lower Rating). Our main goal is to power a 12V DC operated power devices which we will demonstrated by charging a 12V battery. As solar is the most reliable renewable source, we are limiting our input range to a voltage range around 4V to 6V that which is obtained by general portable solar cells. We are aiming to make our project as a small scale version of solar energy harvest, so that it is portable and cost friendly.

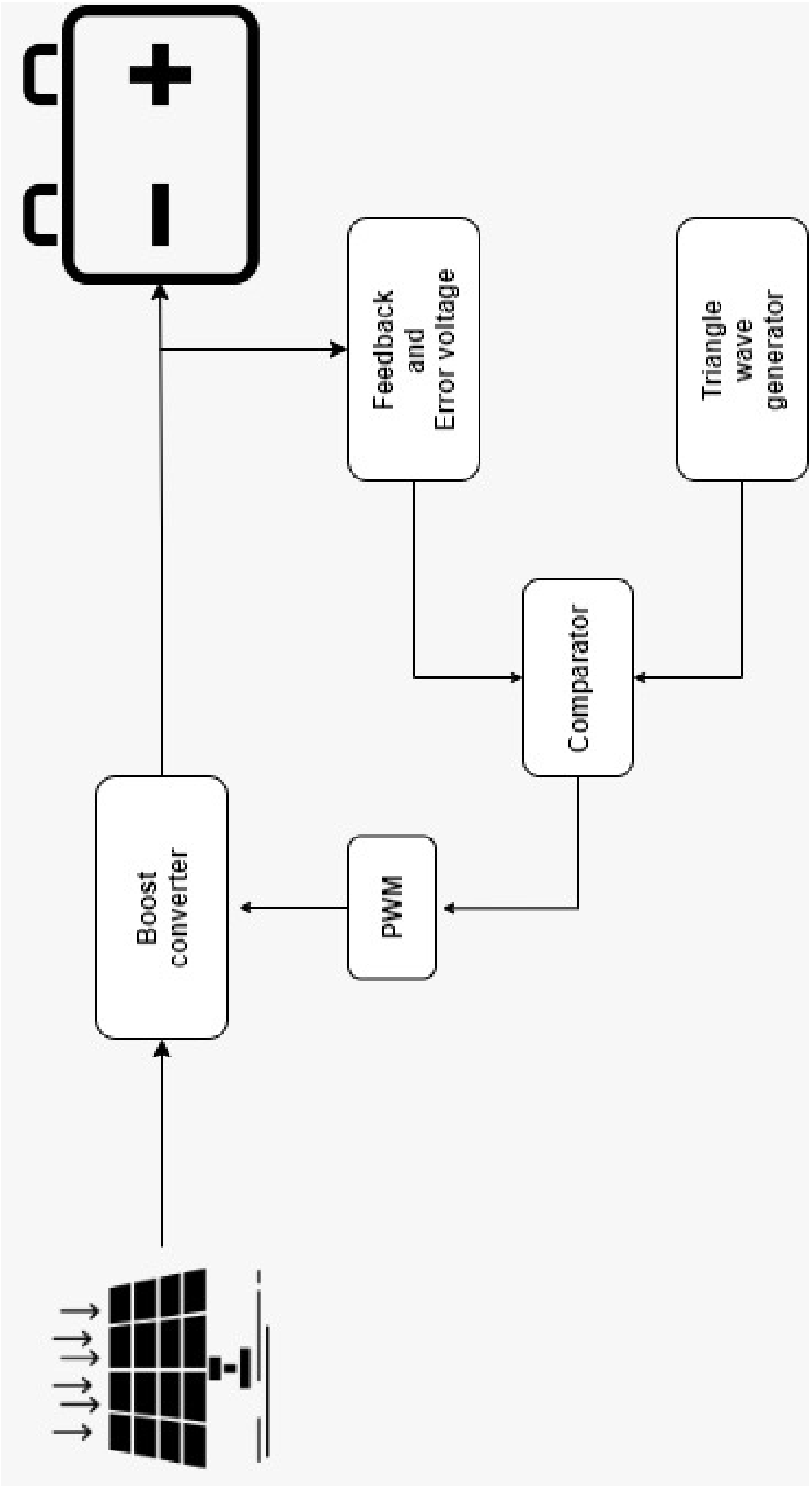
PLATFORM USED:

For this simulation project **NI MULTISIM** software is used.
Multisim™ software provides SPICE simulation, analysis, and printed circuit board (PCB) tools to help you quickly iterate through designs and improve prototype performance.
This platform is selected as it is free source and universally available and can be run on almost every computer.

CONCEPT OF THE PROJECT:

The main concept of this project is controlling a Boost converter with the help of feedback signal so as to regulate the output with respect to the variations in input and output.
The idea behind using a boost converter is because, it is a switched voltage regulator so has relatively high efficiency and as we only need to boost small voltages (i.e., less than 10) to higher voltages (other converter like buck and buck boost are not suited for this specific operation).
The energy from solar is captured by photovoltaic cells and provides us in the form of voltage. This voltage is then power processed into getting desired voltage and stored in to battery.

blockdiagram



COMPONENTS:

S. No.	Name of Component	Quantity
1	LM741	4
2	IRL540	1
3	TL431ACD	1
4	BAT54	1
5	Inductor	1
6	Resistors	11
7	Capacitors	2
8	Potentiometer	2

COMPONENTS DESCRIPTION:

LM741:

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.
The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.
The LM741C is identical to the LM741 and LM741A except that the LM741C has their performance ensured over a 0°C to +70°C temperature range, instead of −55°C to +125°C.

IRL540 :

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness. The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

TL431ACD:

The TL431 and TL432 devices are three-terminal adjustable shunt regulators, with specified thermal stability over applicable automotive, commercial, and military temperatureranges. The output voltage can be set to any value between Vref(approximately 2.5 V) and 36 V, with two external resistors.

BAT54:

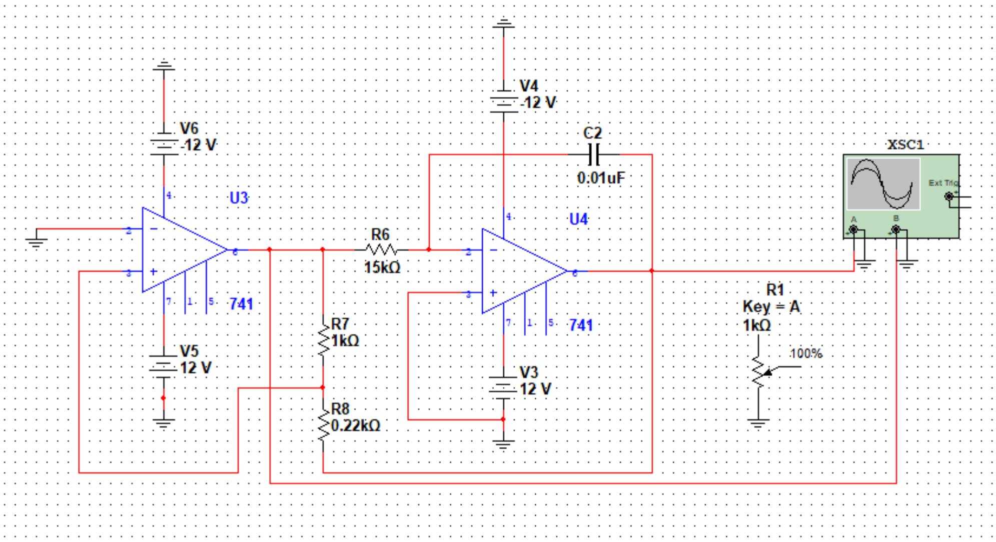
The BAT54 is a Schottky diode with a low forward voltage drop and high switching speed. It is commonly used in high frequency applications like Inverters, DC-DC converters etc.

PARTS OF PROJECT :

The circuit is divided into four major parts based on their operation.
They are:

- *Triangle wave generator*
- *Comparator*
- *Error voltage generator*
- *Boost converter*

TRIANGLE WAVE GENERATOR:



This is a wave shaping circuit generated by op amps. This circuit is a combination of a square wave generator and integrator coupled together in order to generate a triangle wave at the output.
The magnitude of triangle wave can be adjusted to a suitable value with the potential divider at the output.
And the frequency of output is adjusted by the capacitor value.

Formule:

$$v_{01} = \pm v_{sat}(square\ wave)$$

$$v_{02} = \frac{-1}{R_1 C_f}\int_0^1 v_{01}\, dt$$

$$\frac{v_{02} - v_A}{R_3} = \frac{v_A - v_{01}}{R_2}$$

$$Let\ v_{01} = +v_{sat}\ ;\ v_A = 0$$

$$\frac{V_{02}}{R_3} = \frac{-v_a}{R_2}$$

$$v_{02} = -\frac{R_3}{R_2} * (v_{sat})$$

$$if\ v_{01} = -v_{sat}\ ; v_A = 0$$

$$\boldsymbol{v_{02} = \frac{R_3}{R_2} * (v_{sat})}$$

$$v_{02(p-p)} = \frac{2R_3}{R_2} \times (v_{sat})$$

$$v_{02} = \frac{-1}{R_1 C_f}\int_0^{t/2} v_{sat}\, dt \approx \frac{-v_{Sat}}{2R_1 c} \times T$$

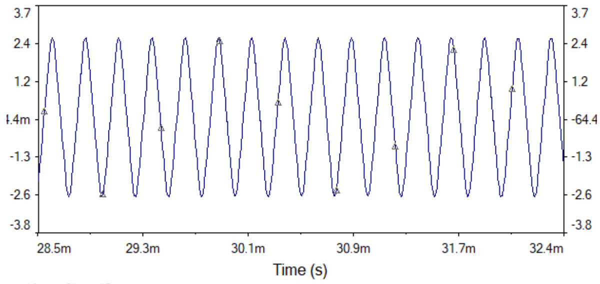
$$eq_1 = eq_2$$

$$2\,\frac{R_3}{R_2} \times (v_{sat}) = \frac{v_{Sat}}{2R_1 c} \times T$$

$$T = \frac{4R_1 R_3 c}{R_2}$$

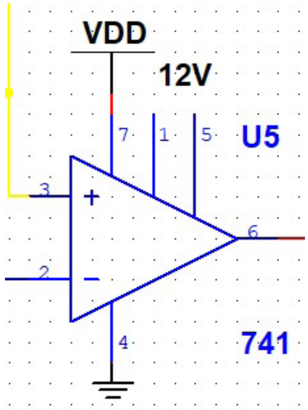
$$\boldsymbol{f = \frac{R_2}{4R_1 R_2 c}}$$

Output :



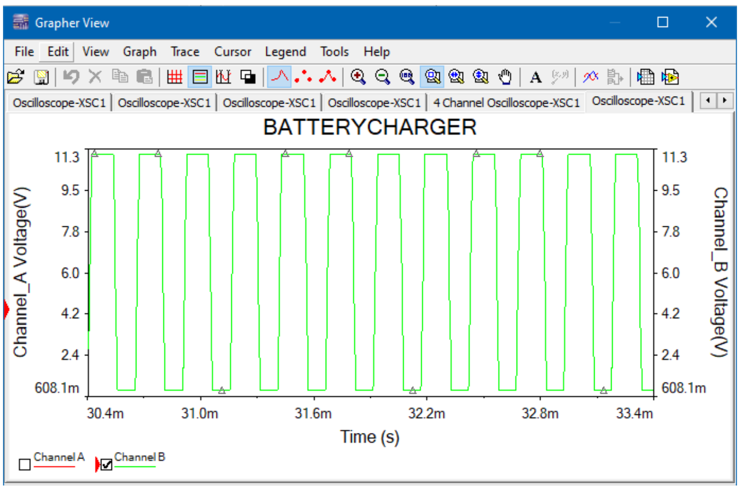
Triangle wave
Output

COMPARATOR:

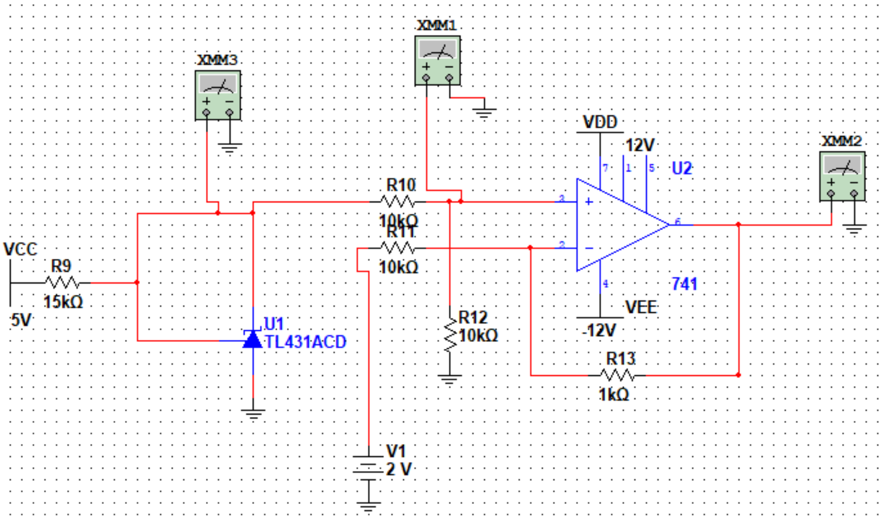


This op amp acts as a comparator and compares the error voltage at positive terminal with the triangular wave voltage at negative voltage. When the error voltage is greater than triangular wave voltage the output gives high value 10-12V and when its lower than triangular wave voltage it gives low value of voltage 0v.
This forms the rectangular wave of voltage having values 12v and 0v; Which is then used as the duty cycle for operating power MOSFET.
The duty cycle is controlled by error voltage.

Output :



ERROR VOLTAGE GENERATOR :

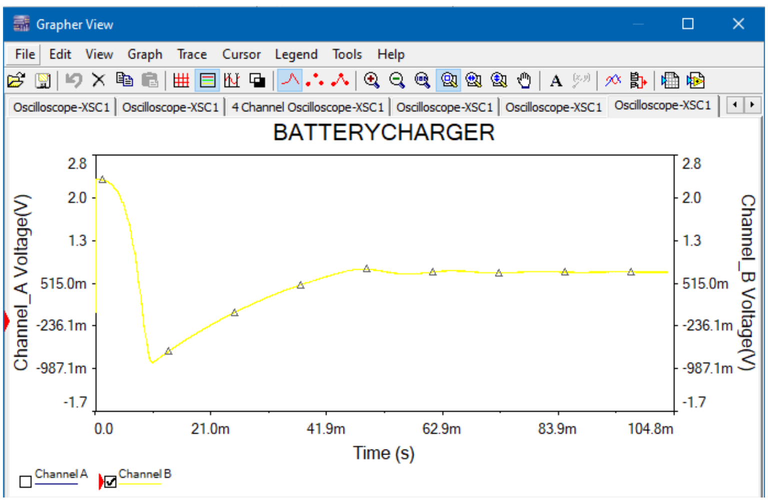


This circuit is used to generate an error voltage. The voltage from the feedback component at output is compared with the reference voltage of 2.5v. The differential amplifier then gives difference of both the signals as error voltage. As the reference voltage is fixed the error voltage is dependent on the feedback component only.

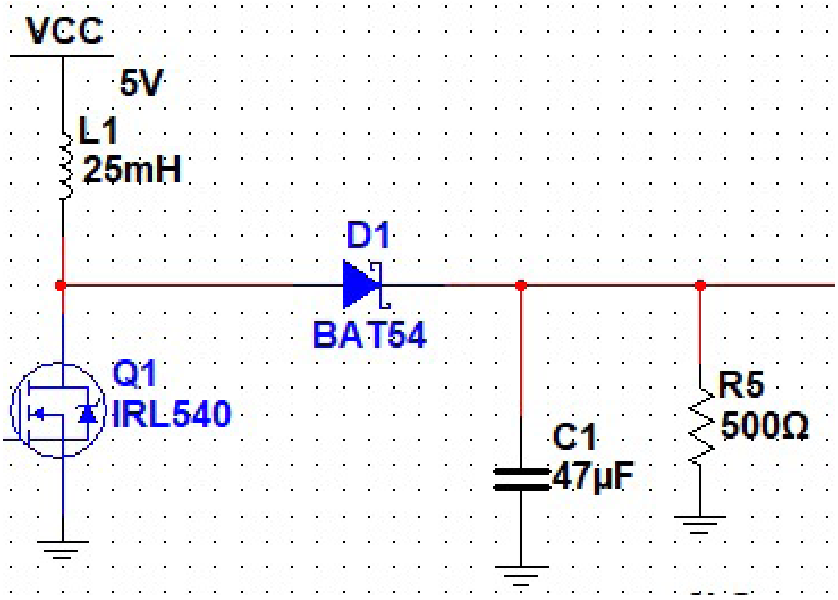
Formula:

V error = V ref - V feedback.

Output :



BOOST CONVERTER :



Circuit here is a basic construction of boost converter. It is designed to give a voltage of 15V when supplied with 5V.

Charging Phase :

A boost configuration is depicted in above figure . Assuming that the switch has been open for a long time and that the voltage drop across the diode is negative, the voltage across the capacitor is equal to the input voltage. When the switch closes, the input voltage, +VIN, is impressed across the inductor and the diode prevents the capacitor from discharging +VOUT to ground. Because the input voltage is DC, current through the inductor rises linearly with time at a rate proportional to the input voltage divided by the inductance.

Discharging Phase :

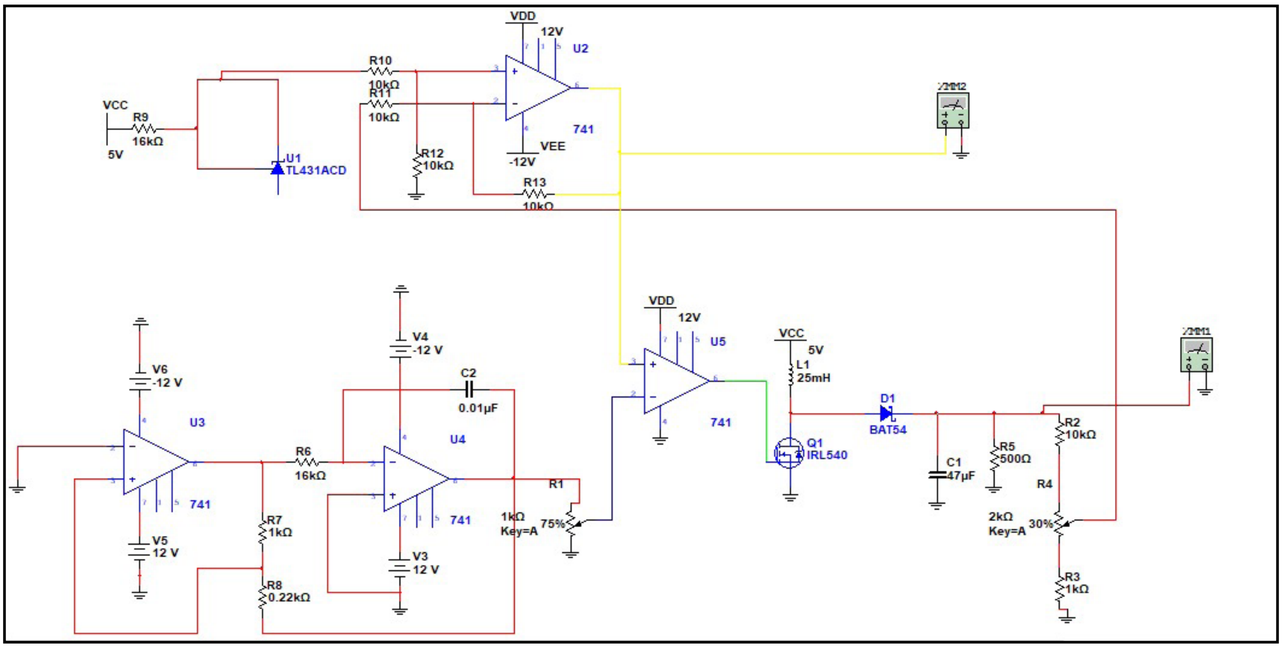
When the switch opens again, the inductor current continues to flow into the rectification diode to charge the output. As the output voltage rises, the slope of the current, di/dt, though the inductor reverses. The output voltage rises until equilibrium is reached or:
$VL = L \times di/dt$
In other words, the higher the inductor voltage, the faster the inductor current drops.

Input and Output Relations :

In a steady-state operating condition, the average voltage across the inductor over the entire switching cycle is zero. This implies that the average current through the inductor is also in steady state. This is an important rule governing all inductor-based switching topologies. Taking this one step further, we can establish that for a given charge time, t_{ON}, and a given input voltage and with the circuit in equilibrium, there is a specific discharge time, t_{OFF}, for an output voltage. Because the average inductor voltage in steady state must equal zero, we can calculate for the boost circuit:

$V_{IN} \times t_{ON} = t_{OFF} \times V_L$
And because:
$V_{OUT} = V_{IN} + V_L$
We can then establish the relationship:
$V_{OUT} = V_{IN} \times (1 + t_{ON}/t_{OFF})$
Using the relationship for duty cycle (D):
$t_{ON}/(t_{ON} + t_{OFF}) = D$
Then for the boost circuit:
$V_{OUT} = V_{IN}/(1-D)$
Similar derivations can be made for the buck circuit:
$V_{OUT} = V_{IN} \times D$
And for the inverter circuit (flyback):
$V_{OUT} = V_{IN} \times D/(1-D)$.

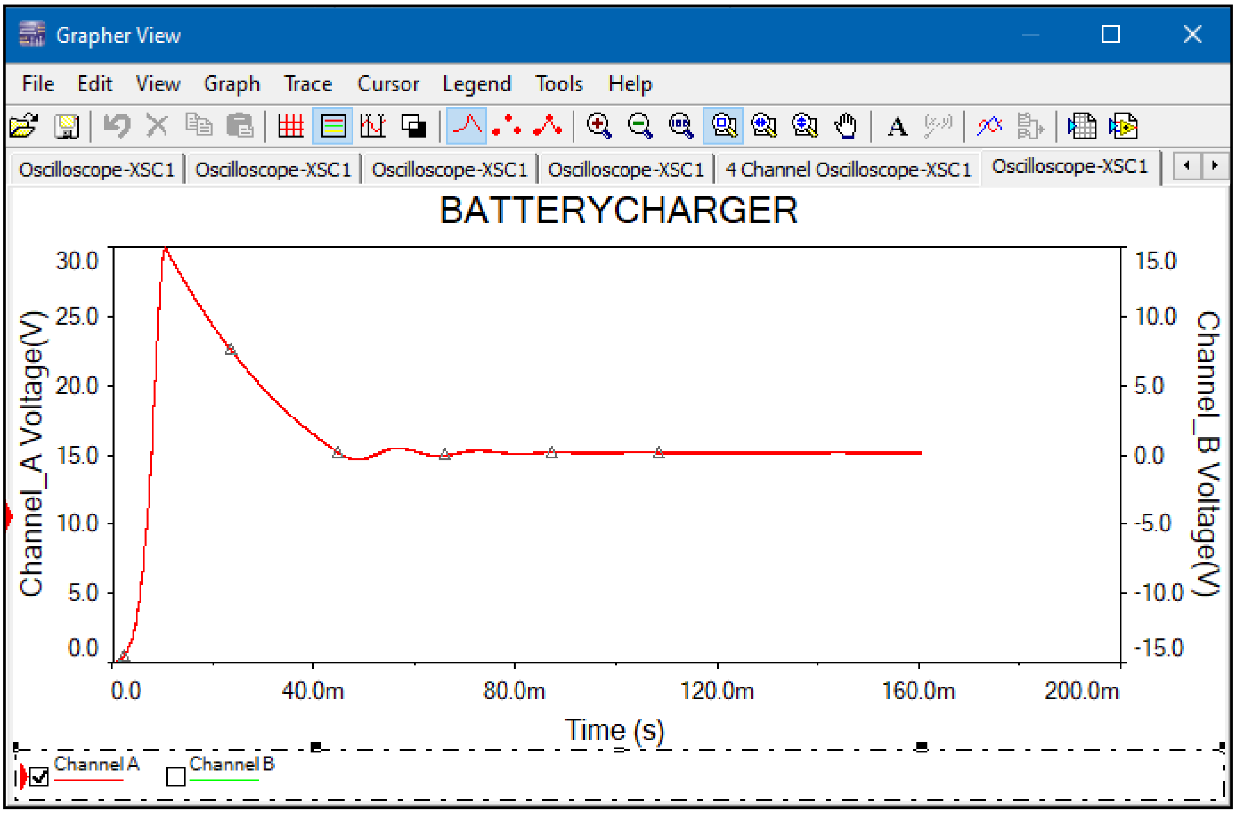
COMPLETE CIRCUIT :



Working principle:

- Initially, If there is a input voltage above 5V and initial feedback is 0V. Error voltage would be 2.5V and when it is compared with the triangle wave generated by wave shaping circuit, the comparator develops a duty cycle with almost 1. Hence the input voltage is boosted. While in the process when output voltage is increased the feedback fed is also increased which in turn reduces the error voltage. Because of this Duty cycle is reduced and output increases slowly. At certain point of time error voltage will be zero and duty cycle remains constant for constant input giving constant boosted output.
- Now if this state is disturbed by either variation in input or variation in output, the duty cycle will be adjusting itself to bring output back to stable point.
- For example, let's consider output is stable at 15V at error voltage as 0V. If output is increased, feedback increases, error voltage will become slightly negative and duty cycle is reduced below 50% which controls output by boosting less.
- In case for some reason output is reduced, feedback reduces, error voltage is increased, increasing the duty cycle which in return boosts input more to get more output.

OUTPUT :


Grapher View
File Edit View Graph Trace Cursor Legend Tools Help
Oscilloscope-XSC1
Oscilloscope-XSC1
Oscilloscope-XSC1
Oscilloscope-XSC1
4 Channel Oscilloscope-XSC1
Oscilloscope-XSC1
BATTERYCHARGER
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Channel_A Voltage(V)
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
Channel_B Voltage(V)
0.0
40.0m
80.0m
120.0m
160.0m
200.0m
Time (s)
Channel A
Channel B

ALTERNATE CIRCUIT:

For the voltages higher then 20v there is another circuit with same working principle but with better performance as the feedback component and PWM generator are integrated in to one IC i.e., UC3842.
The boost converter for both the circuits is similar in terms of construction except the parameters may change depending on input and output values.
The main requirement here though is that it requires a minimum of 10V to operate. If requirement is met then this circuit has the advantage over other circuit.

COMPONENTS:

S. No.	Name of Component	Quantity
1	UC3842	1
2	IRF540	1
3	1N5820	1
4	Resistor	6
5	Inductor	1
6	capacitor	4

COMPONENTS DESCRIPTION:

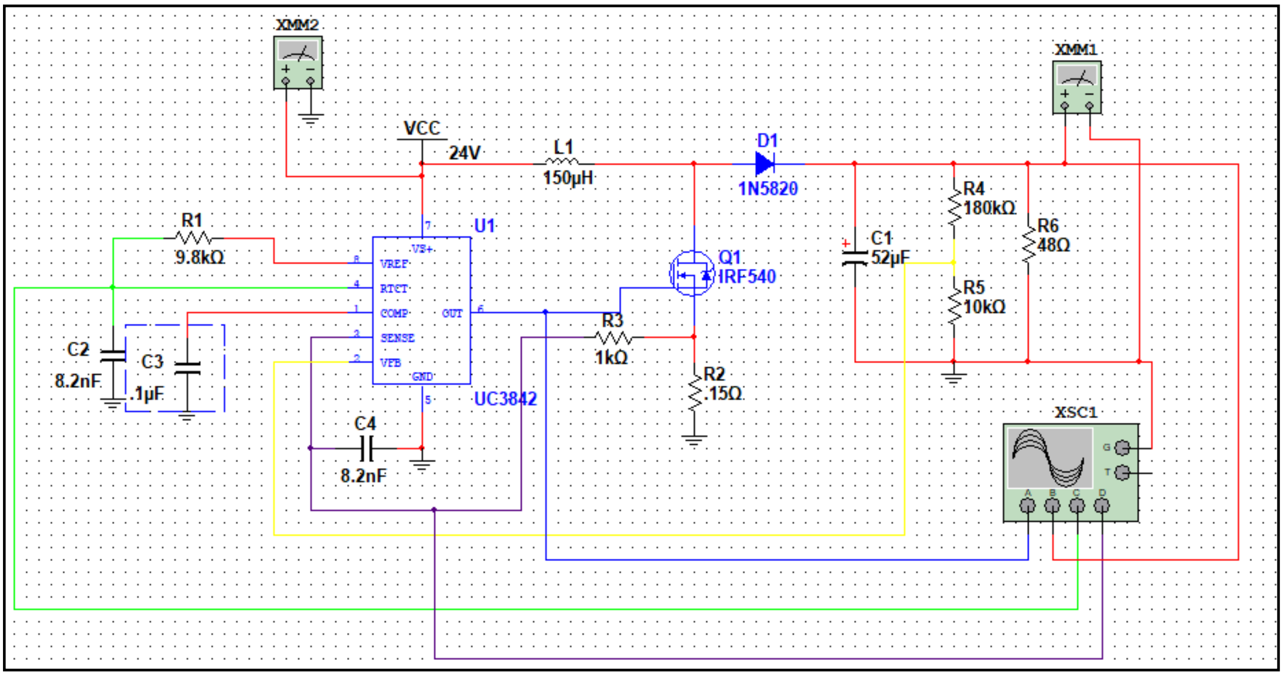
UC3842 :

The UC3842/UC3843/UC3844/UC3845 are fixed frequencycurrent-mode PWM controller. They are specially designed for Off-Line and DC to DC converter applications with minimum external components. These integrated circuits feature a trimmed oscillator for precise duty cycle control, a temperature compensated reference, high gain error amplifier, current sensing comparator and a high current totempole output for driving a Power MOSFET.

1N5820:

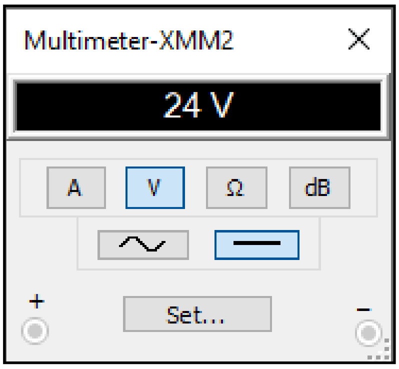
The 1N5820 is a Schottky diode with a low forward voltage drop and high switching speed. It is commonly used in high frequency applications like Inverters, DC-DC converters etc.

Circuit diagram :

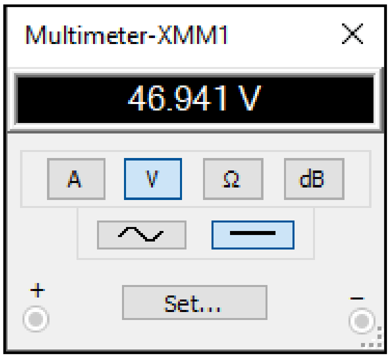


An alternate boost converter circuit with PWM signal generated by IC UC3842.

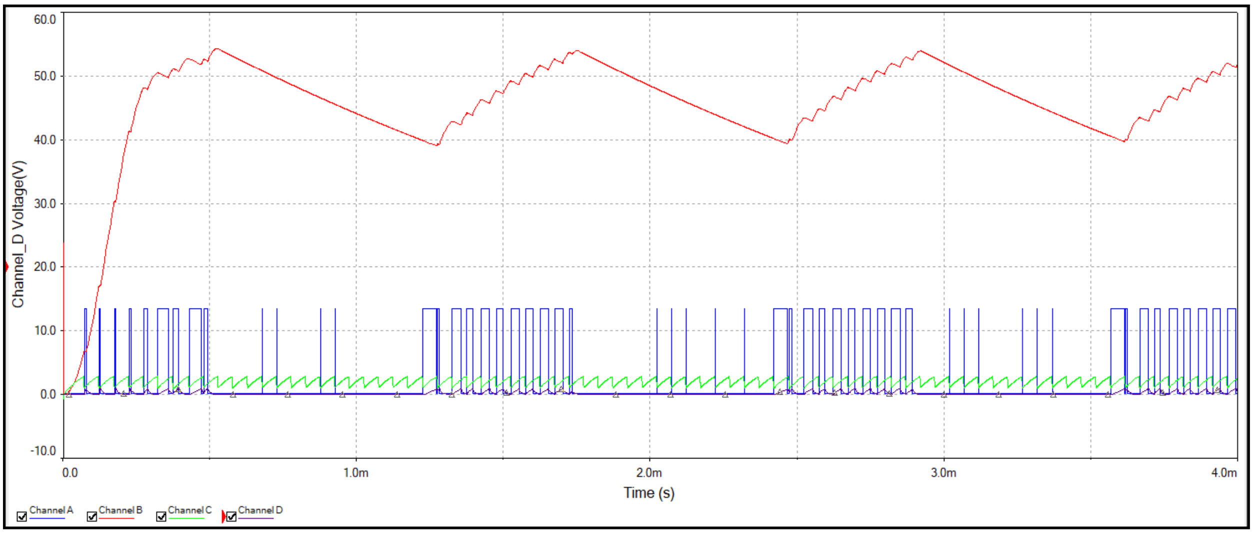
RESULTS :



Input
voltage



Output
voltage



Output

ADVANTAGES :

- Easy to construct

As these circuits are designed with basic components they can be constructed in short time and with ease.

- Cost efficient

Most of the components used here are general purpose components and hence these components or there alternatives will be available in low cost.

- Compact

As this circuit can be built on a perf board it takes less space. If we want to decrease size further then some components can be replaced by ICs but the cost overall may increase.

- Portable

This circuit is developed for general purpose solar cells hence as long as the input voltage is within the range of 4 to 6v this circuit can be used. This feature makes it a good choice for travelling as long as there are solar cells and a battery are available.

REFERENCES:

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