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Design and implementation of increasing efficiency of solar power by using MOSFET L-C dc-dc converter

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Abstract – *In this method, we are needed to improve the efficiency level of solar power using mosfet switching. Mostly using dc-dc converters, such as chopper, DC chopper is a fixed dc input voltage to variable dc output voltage. The regulator is used for increasing and decreasing of voltage given to battery parts. There are various types of dc-dc converters like boost and buck converters respectively. Solar power depends on the light intensity of day and night effect. We need to be a secure optimal charging given to battery for the running purpose It shows the matching of output voltages and currents. With increasing demand of power utilization and power sector, we need to save energy by using this technology. We are showing you by the simulation for the input side given to the dc sources and output side required a battery charging.*

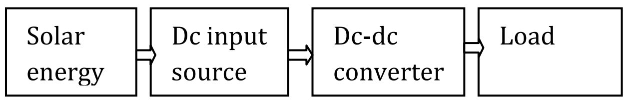
Key Words: *Solar power, dc-dc converter, proposed topology of MOSFET,pwm, MOSFET LC switching*

1. INTRODUCTION

DC Chopper is a fixed dc input voltage to variable dc output voltage. The switches are generally passive or Active type. Passive switches consists of a diode, where as the active switches are like MOSFET transistor. MOSFET transistors are an efficient and fast way to allow a pulse width modulation (PWM) signal to control the frequency and duty cycle of the ON and OFF time of the "switch". More power is transferred from input to Output when Duty cycle is high. One of the advantages of the PWM is that the signal remains digital from the source i.e. from the Microcontroller to the MOSFET's so that any analog-to-digital signals conversion is no more needed. There are many DC-to-DC converters so far studied .Some are like Buck, Boost, Buck-Boost, and Cuk. These regulators do not produce power. In fact some of the input power according to their efficiency is consumed by these Regulators. Therefore considering ideal case to maintain the same power level the adjusted voltage level affects the current level. Since current and voltage are both directly proportional to power therefore in buck mode the voltage is reduced as the current increases. While in boost mode the voltage is increased as the current decreases. The Solar Charge controller consists of various Components like Dc-Dc Converter, Microcontroller, LCD, Temperature sensors, Voltage sensors, Current sensors, Irradiance Sensors. The Dc- Dc Converter is one among the major component of the controller which receives the input voltage from the PV panel and converts the voltage without use of transformer and gives the desired output as that required for various charging stages of Battery. The power control scheme uses semiconductor devices such as MOSFET, IGBT, etc. with various switching techniques. The designers are forced to optimization of the performance of solar power DC motor drives. These drives have now dominated the area of variable speed because of their low cost reliability and simple control the various converter topologies are

a. Rectifier – Conversion of AC to DC
b. Cycloconverter – Providing variable AC, Conversion of AC to AC
c. Inverter – Conversion of DC to AC
d. Chopper – Conversion of DC to DC i.e. Providing variable DC.Application used to saving energy.

1.1 Block diagram



1.2 Comparison of DC-DC boost converters

Transformerless solutions:- In order to satisfy the stringent requirements with performance in renewable energy grid connected power applications, many researchers concentrate on how to realize high voltage gain step-up, low cost and high efficiency single-stage converters . The brief comparison of available single-stage transformer less converters will be presented below. They provide the voltage gain up to 20 using coupled inductors or switched capacitor technique. Usually the efficiencies of high voltage gain step-up converters are at the levels over 90% at sub kilowatt or single kilowatt powers. To increase the overall efficiency of converter soft switching technique as well as active clamped circuit introduction may be considered. Boost converter. The single phase single switch boost converter is a basic step-up topology (Fig. 1). The voltage gain theoretically is infinite when duty cycle reaches 1. But switch turn on period becomes long as the duty cycle (D) increases causing conduction losses to increase. The power rating of single switch boost converter is limited to switch rating. In order to obtain higher gain several boost converters can be cascaded at the expense of efficiency decrease. Interleaved parallel topology is the solution to increase the power and reduce input current ripple allowing lower power rated switches to be used.

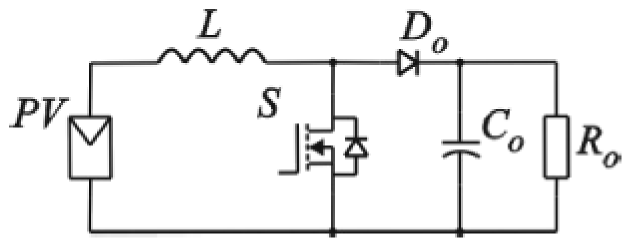


Fig.1 shows boost converter

1.3 Soft switching boost converters.

This high performance converter has slightly improved voltage gain in comparison to single switch boost converter. It operates in ZVS (Zero Voltage Switching) mode with MOSFET circuit (fig. 2) dramatically reducing switching losses thus achieving better efficiency. The driving sequence is bit more complex, but both switches operate at the same ground potential thus additional separation at driver side is needless. The disadvantage of that topology is the complexity of the circuit, because of 5 more components addition including a switch and an extra inductor.

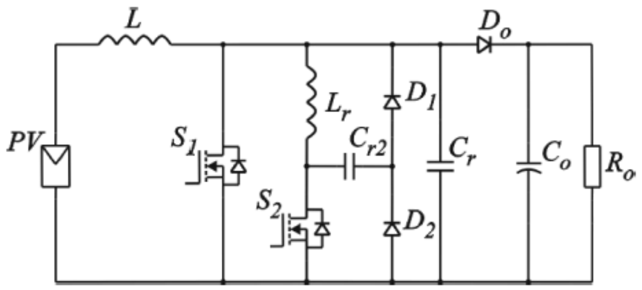


Fig.2 Soft switching MOSFET circuit

1.4 Coupled inductor topology.

Coupled inductor can serve as a transformer to enlarge the voltage gain in non isolated DC/DC converters in proportion to winding turns ratio (Fig. 3). These converters can easily achieve high voltage gain using low RDS–on switches working at relatively low level of voltage. The switch driving scheme is simple as the converter usually utilizes single switch. Common mode conducted EMI is reduced due to balanced switching. To reduce passive component size coupled inductors can be integrated into single magnetic core. However, the voltage gain can be easily achieved by turns-ratio of coupled inductors the leakage energy induces high voltage stress and switching losses. Thanks to the active clamp circuit used the leakage energy can be recycled. The other benefits of presented circuit are wide input voltage range, high voltage gain and low cost simultaneously.

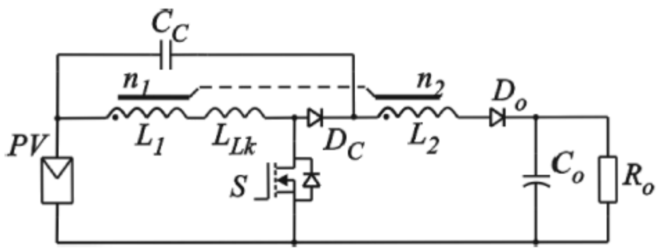


Fig.3 Inductor MOSFET circuit

2. Proposed topology

It satisfies high efficiency and high voltage gain in combination with isolation requirements (Fig. 4). In order to share large input current and conduction losses parallel circuit is adopted. Output inductors are connected in series to double an output voltage gain. The switching losses are reduced and efficiency improved by applying active clamp technique. ZVS soft switching mode is implemented leveraging the efficiency. Because of the inductor used in the other hand there is the limitation as to the maximum operating temperature above which the magnetic core losses its magnetic features.

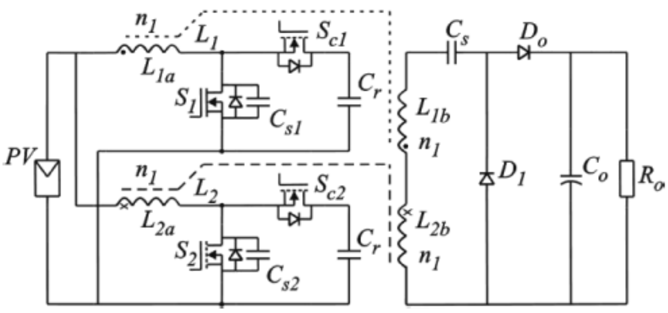


Fig.4 proposed topology of MOSFET dc-dc converter

Topologies such as fly back, forward or push-pull, and their variants have been described in detail in the literature. The voltage step-up obtained in these systems is high, unfortunately, does not go hand in hand with efficiency. Only by applying ZVS, ZCS soft switching techniques, these systems can achieve a satisfactory efficiency. Although the efficiency of the system seems to be the most important parameter distinguishing the converter in many cases, the designers also strive to simplify the control system. Thanks to the resonance of leakage inductance of the transformer and capacitors paralleled with the rectifier diodes the reverse-recovery loss of these diodes can be eliminated which, combined with an active-clamp circuit for soft switching of the MOSFET transistors ensures high system efficiency.

3. SOLAR CHARGE CONTROLLER.

Solar Charge Controllers are the controllers which regulate the power output or the Dc output voltage of the solar panels to the batteries. Thus we can say these controllers take the Dc output voltage as the input voltage converts it into same Dc voltage but as that required for Battery charging. These are mostly used in off grid scenario and uses MPP i.e. Maximum Power Point Tracking scheme which maximizes the output efficiency of the Solar Panel. In Battery charging the output voltage Regulation plays an important factor as batteries require specific charging method with various voltage and current levels for specific stage. These charging processes enhance battery performance and battery life. Standard Charge controllers are used where the solar panel voltage used as input are higher than the output voltage. Thus keeping the current constant the voltage will be reduced by the controller. This results in loss of power. MPPT based solar charge controllers use smart technologies such as microcontrollers to compute highest possible power output at any given time i.e. voltage will be monitored and regulated without power loss. The Controller will lower the voltage simultaneously increase the current, thereby increasing the power transfer efficiency.

4. SWITCHING CONVERTER TOPOLOGY.

Switching regulators are preferred over linear regulators for their high efficiency and providing step up, step down or inverter output unlike linear regulator which does only step down operation. In practice, the conversion efficiency of linear regulators is limited to only 30% and they find application in analog circuits to ensure nearly constant supply voltage providing high power supply rejection ratio (PSRR). In switching regulator circuits, semiconductor switches control the dynamic transfer of power from input to output with very short transition times. Because of this switching action there is ripple added to output voltage. The output requirement is a dc voltage with a minimum superimposition of ac ripple. Pulse width modulation (PWM) is the most widely used method for controlling the output voltage. It maintains a constant switching frequency and varies the duty cycle. Duty cycle is defined as the ratio of switch on time to reciprocal of the switching frequency (fsw). Since the switching frequency is fixed, this modulation scheme has a relatively narrow noise spectrum allowing a simple low pass filter to sharply reduce peak-to-peak ripple at output voltage. This requirement is achieved by arranging an inductor and capacitor in the converter in such a manner as to form a low pass filter network. This requires the frequency of low pass filter to be much less than switching frequency (fsw).The following section discusses various converter topologies and their operation. Idealized circuits are considered for ease of understanding and explanation. The key difference between each is the arrangement of the switch and output filter inductor and capacitor.

4.1 Boost Converter.

The boost converter is capable of producing a dc output voltage greater in magnitude than the dc input voltage. The circuit topology for a boost converter is as shown in (fig. 6)

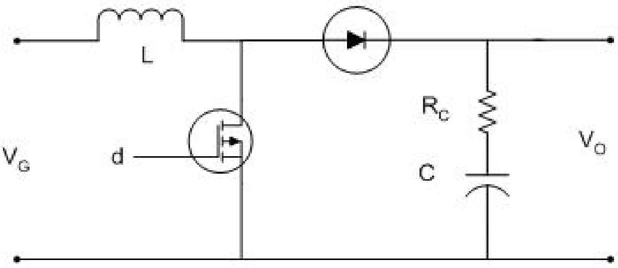


Fig.6 Boost converter

When the transistor Q1 is on the current in inductor L, rises linearly and at this time capacitor C, supplies the load current, and it is partially discharged. During the second interval when transistor Q1 is off, the diode D1 is on and the inductor L supplies the load and, additionally, recharges the capacitor C. The steady state inductor current and voltage waveform is shown in (fig. 7)

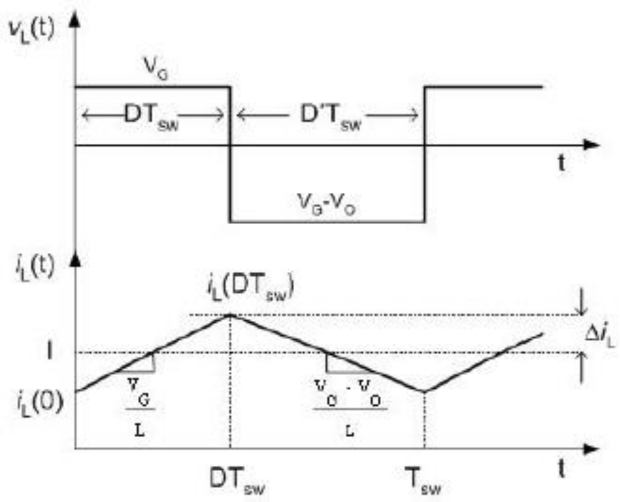


Fig.7 waveform of load current and load voltage

Using the inductor volt balance principle to get the steady state output voltage equation yields, since the converter output voltage is greater than the input voltage, the input current which is also the inductor current is greater than output current. In practice the inductor current flowing through, semiconductors Q1 and D1, the inductor winding resistance becomes very large and with the result being that component non-idealities may lead to large power loss. As the duty cycle approaches one, the inductor current becomes very large and these component non idealities lead to large power losses. Consequently, the efficiency of the boost converter decreases rapidly at high duty cycles.

$$V_G.T_{ON} + (V_G - V_O).T_{OFF} = 0$$

$$\frac{V_O}{V_G} = \frac{T_{SW}}{T_{OFF}} = \frac{1}{1-D}$$

5. POWER MOSFET SELECTION

Mosfets are used as power switches for their near zero DC gate current and fast switching times. Its turn-on delay time is proportional to Cgs which is illustrated as Ciss minus Crss in datasheets. The delay time is equal to product of Cgs and impedance of source driving it ignoring any miller effect. It is a requirement to have delay time much less than switching period. Mosfets power dissipation impacts converter efficiency. This includes Rdson conduction losses, leakage losses, turn on-off switching and gate transition losses. Rdson of the power mosfet determines the current it can handle without excessive power dissipation. Rds on directly affects the converter efficiency. To minimize Rdson, the applied gate signal should be large enough to maintain operation in the linear, triode or ohmic region. Mosfets positive temperature coefficients means conduction loss increases with temperature. A second important consideration when designing gate drive circuitry is due to Cgd illustrated as Crss in data sheets. During turn-on and turn-off, the large swing in Vgd requires extra current sourcing and sinking capabilities for the gate drive as a direct result of miller effect

6. BUCK-BOOST CONVERTER.

Buck-Boost Converter is a Dc Converter in which the output voltage can be increased or decreased than the input voltage. One of the striking features of this regulator is that it provides output voltage polarity reversal without the use of transformer. It is also called an Inverting Regulator. It has high efficiency and the output short circuit protection can be easily implemented. However it shows discontinues input current and high peak current flows through the switch. Buck Boost Converter consists of a switch which may be Mosfet or a Transistor, Inductor, Diode, Capacitor and Load may be resistive or any other.

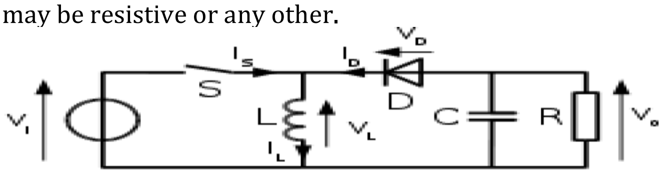


Fig. 8 buck-boost converter

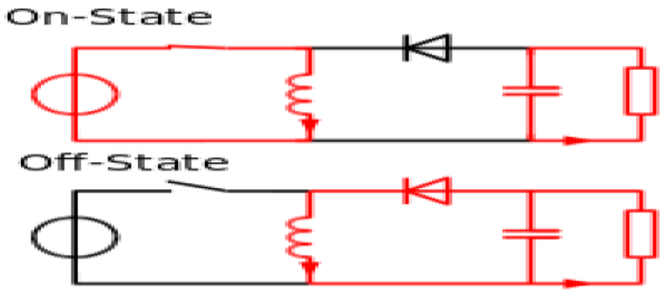
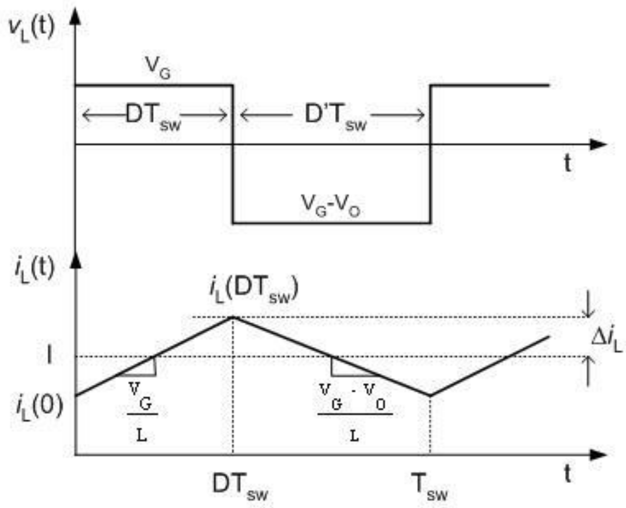


Fig. 9 circuit diagram of on/off switch

The principle of operation of the buck–boost converter is a) While in the On-state, the input voltage source is directly connected to the inductor (L) resulting in accumulating of energy in L. In this stage the output load is supplied with energy from the Capacitor. b) While in the Off-state, the output load and capacitor are connected with the Inductor, so energy is transferred from L to C and R via Diode D. The characteristics of the buck–boost converter comparing to Buck and Boost are mainly:1) The output voltage polarity is opposite of the input voltage polarity.2) In case of an Ideal Converter the output voltage can vary continuously from 0 to 0. The ranges for a buck and a boost converter are respectively 0 to and to 0.



$$V_G.T_{ON} + (V_G - V_O).T_{OFF} = 0$$

$$\frac{V_O}{V_G} = \frac{T_{SW}}{T_{OFF}} = \frac{1}{1-D}$$

Fig.10 waveform of current and voltage

7. DC/DC BOOST CONVERTERS WITH TRANSFORMER ISOLATION.

Transformers have significant influence on efficiency of whole energy conditioning system and hence on the quality of energy supplied to the network. The absence of transformer in the system may result in injecting DC currents into AC current, which may disturb the operation of electric grid distribution transformers due to saturation of magnetic cores. Moreover the absence of active elimination of unwanted DC currents injected to the grid can lead to distribution transformers damage and whole electric grid failure. According to the electrical regulations and standards which is in place in some countries the galvanic isolation of the PV system may be necessary or not. It is performed by the transformers of high or low frequency. Galvanic isolation can be accomplished by either line frequency transformer or a high frequency one. Both are shown in Fig. 12. The grid frequency transformer (50/60 Hz) is not often used because of high price, and low power efficiency.

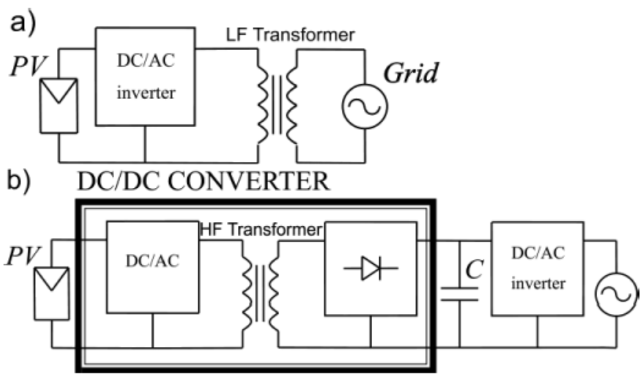
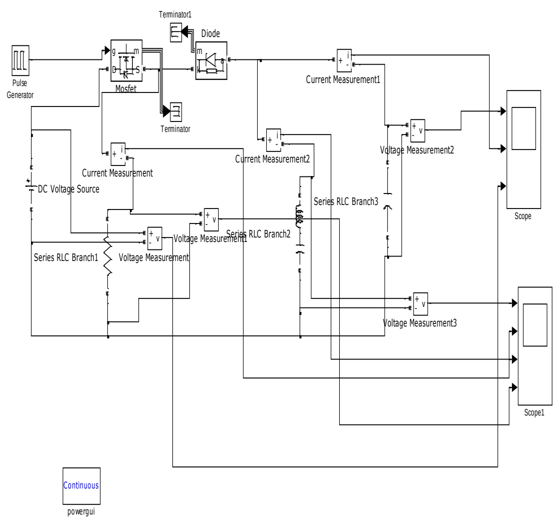
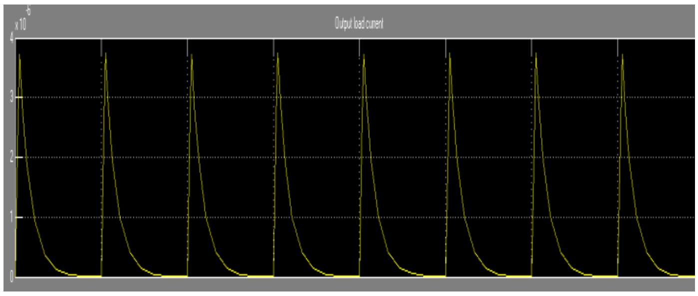


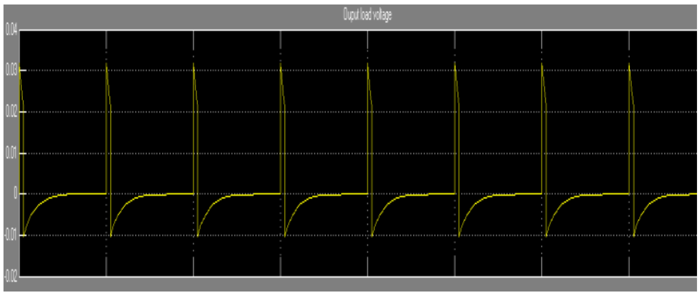
Fig.11 dc-dc converter with isolation transformer

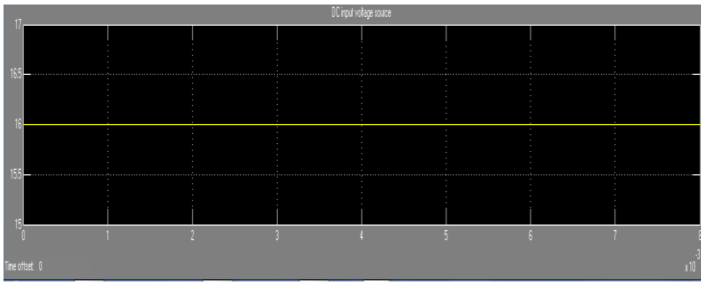
8. SIMULATION RESULT.

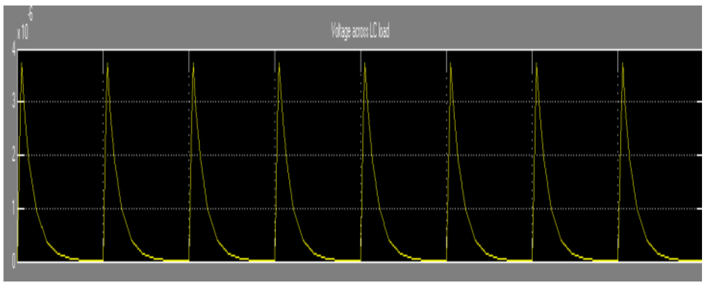


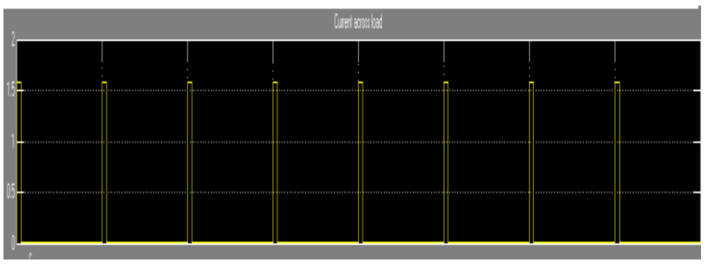
9. SIMULATION WAVEFORM.

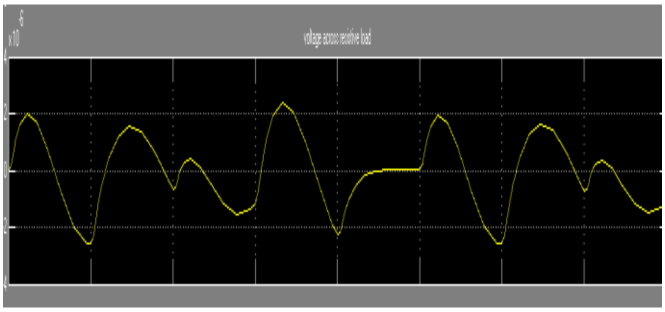


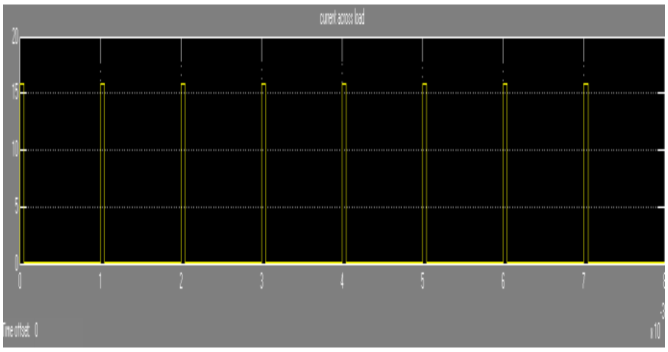












10. SIMULATION PARAMETER.

Input dc source	16v
Output power	12v,1.2 amp
Duty cycle	0.48
Source current	1,3amp
Resistor	10ohm
Inductor	200uh
Capacitor	350uf
Time frequency	0.1*10e-3s
Maximum voltage	12-18v
Mosfet	1e-3,0.1ohm
Duty cycle(alpha)	0.5
Maximum power	15-20watt

$V_o = -V_{S*} D/1-D$

11. CONCLUSION.

In this method we are using for saving electrical energy. The dc-dc mosfet design has been simulated in MATLAB SIMULINK environment. From the simulation results the output of the Dc-Dc Converter is checked which can be used as an input to the Battery. The most important feature of this Design is that it is very simple and easy to implement as it requires very less number of components. By this technique of dc-dc topology converter proposed, to maintain the increased and decreased the power level and voltage level at optimal value. The aspect of future scope to saving the utilization of energy and industrial purpose by minimizing and increasing the improvement of efficiency of solar voltage level.

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BIOGRAPHIES

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