Design and Implementation of SMR Based Bidirectional Laptop Adapter

Gowrinathan.M[1], DeviMaheswaran.V[2]

Abstract: **Rechargeable batteries are now widely used in many applications. The bidirectional adapter having the function of charging and discharging provides 230V/50Hz emergency output from the battery embedded in the laptop computer, and other possible appliances. The bidirectional adapter possesses the grid to battery and battery to emergency need capabilities. The two power stages are implemented using**
Intelligent Power Module. In discharging mode, a front end DC/DC converter is equipped to establish boosted DC-link voltage from battery. This DC is inverted in to emergency source for critical appliances using H-Bridge converter. The output AC sinusoidal voltage obtained with inverter circuit. Conversely in charging mode, a Switch Mode Rectifier (SMR) based charger is formed using Intelligent Power Module. This Intelligent Power Module consists of one converter module and inverter module.In the proposed power module, the design and implementation of switch mode rectifier (SMR) based bidirectional laptop adapter is being simulated and the result are being presented.

Keywords-DC/DC Buck-Boost Converter, Emergency Power, Inverter, Laptop computer, Intelligent Power Module, Battery, Power factor correction, Robust Control.

I INTRODUCTION

Electricity is most essential part required for the basic needs of the human and the growth of any nation. The new generation people are focusing on renewable energy particularly in solar power and wind power generation. The solar power and battery based converter circuit is formulated for the bidirectional adapter because of low cost high efficiency. Battery used as main source of energy for the various applications, such as PDA (personal digital assistance), UPS (uninterruptable power supply), EVS (electrical vehicles), and cellular phone. It is also commonly used for energy storage devices. Most of the renewable energy is produces a DC power which can be utilized for various applications. The DC power is stored in battery using solar panel.

1. Gowrinathan.M, Research scholar**,**

RajalakshmiEngineering College

2. DeviMaheswaran.V

RajalakshmiEngineering College

When the AC power is not available, during that period we can use the battery power. These three input sources are used to convert the DCDC Buck-Boost converter topology. Hence this paper is motivated to develop a bidirectional adapter for the charging mode and discharging mode for the emergency purpose. The DC-DC converter is used as the fixed DC voltage to variable DC voltage for our application needs and requirement. The variable DC voltage is given in the H-bridge inverter circuit; the DC power is inverted into the AC sinusoidal power for all application. This is the charging mode or forward direction of the of DC-DC converter. In discharging mode the H-bridge converter is used to convert the AC to DC power. The DC-DC converter is achieved by variable DC into fixed DC power. This stored DC power is used for the emergency purpose.

The bidirectional adapter is useful for today trend scenario, and also used for various applications. The power is demand for the various applications like an industrial and commercial purpose, due to power demand all are focusing on the inverter and renewable energy sources like a solar power and wind power. The battery power is used for critical power appliances, for large power application the two or more battery is connected to series and parallel combination.

II WORKING PRINCIPLE OF BATTERY AND SOLAR POWERED BUCK-BOOST CONVERTER

Charging a battery with solar power has becomes very popular. A solar cell typical voltage is 0.7V that is derived from the data sheet. The number of single solar cell is connected in series and parallel combination to achieve a required DC power. The growing market for the solar energy technology has resulted in a rapid growth in the power electronics. The most of renewable energy is produced a DC power and hence power electronics and control equipment are required to convert the DC in to AC power.

The solar power generation from sun is at the outer atmosphere is 1.373 kW/m^2.The incident of sunlight on the earth surface has peak density of 1kW/m^2 at noon in the tropics. The technology of PV system is conversion of sun ray's into usable electricity form. The solar power provides the consumer application like lighting and water pumping, refrigeration, telecommunication. Thesolar cell relay on the quantum-

mechanicalprocess known as the “photovoltaic effect” to produce DC power.

Battery is the energy storage devices used as emergency purpose. Battery means two or more cell which are electrically connected together and fitted with necessary for usage. Cell means a single electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals.The differences in chemistry among various battery types result in different chargerequirements. Li-Ion batteries are charged with a constant-voltage, constant-current. The charge current is usually expressed as C-rate. The C-rate describes the battery capacity in Ampere-Hours. It measures how much current is required to fully charge the battery within one hour, assuming no losses. For a 1600 mAh battery 1C charge current means charging the battery with 1.6A. Ideally, it will take one hour to fully charge the battery at 1C rate. But because batteries are not 100% efficient in converting charge current into stored charge, it takes longer than one hour to fully charge the battery at 1C rate For any energy system requires the battery to store the DC power to meet the power demand during the period of low solar irradiation and night time. As generally recognized importance of battery ha gradually increased in reducing carbon oxide emission and energy storage application. Battery is served as the main source of energy for various applications, such as electrical Vehicles, laptop computer and personal digital application.

III TRADITIONAL CIRCUIT

The fig (1) traditional circuit of the bidirectional adapter is one input source, using in front side of bidirectional. The DC input source to the converter circuit is not compensate for the all-time, when the power is not present it has disadvantage of this adapter. The buck-boost converter circuit is used to convert fixed DC power in to variable DC power. The forward mode of operation it is acting as boost mode, and reverse direction acts as the buck mode to store the DC power to the battery. This is achieved by DC-DC converter topology techniques. The stored DC power is using for emer

gency purpose.

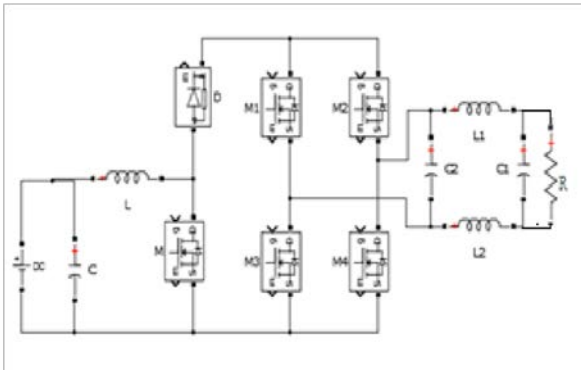

Fig.1.Traditional circuit

IV SIMPLIFIED CIRCUIT DIAGRAM OF PROPOSED CIRCUIT MODEL

The proposed circuit with bidirectional adapter has the solar power and buck-boost converter circuit and energy storage devices act as battery which is using in emergency purposes.High regulation requirement for low-power high-frequency integrated DC-DC switching mode rectifier (SMR) converter systems becomes more and more demanding in industry.

V WORKING PRINCIPLE

The fig (2) SMR based bidirectional laptop computer adapter is used to utilize the power in both directions. The two or three input source is using based upon the SMR (switch mode rectifier) based converter. First input is AC source we can use directly. The sun shines at noon time peak energy production

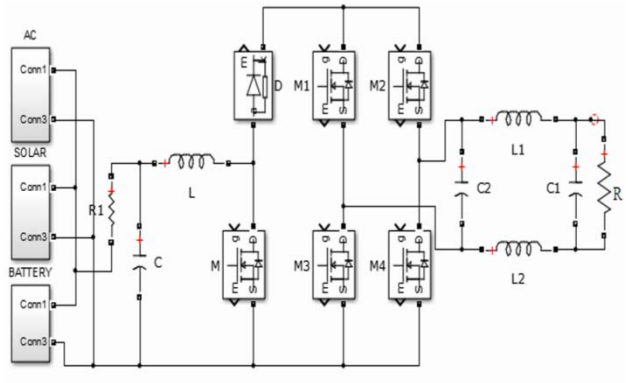

Fig.2.Circuit Diagram

The third input is battery source when power is not present we can utilize the power from battery using inverter circuit. The input source is used to convert the (Buck-Boost

converter) fixed DC to variable DC for giving required gate pulse to the pulse generator. That variable DC power is again inverted in to AC power using H-bridge inverter circuit that is used for application. The inverted power not pure sine wave power some ripple and harmonics will be presented. This ripple and harmonics will be filtered out using filter circuit. The consumer appliance used to provide the services such as lighting water pumping refrigeration, telecommunication.

VI DESIGN SPECIFICATION:

K should be greater than 0.5

Let as assume k=0.75 and F=500KHZ.

Input voltage of the converter is the output of solar panel.

$$V_{out} = \frac{V_s k}{(1-K)} \quad (1)$$

$$= \frac{(0.66*24)}{(1-0.66)} \quad (2)$$

V_{out}=47.58. (3)

$$L = \frac{V_s k}{(\Delta I * F)} \quad (4)$$

ΔI is the ripple current that is 20% to 30% of output current.

$$\Delta I = 0.2*\left(\frac{48}{50}\right). \quad (5)$$

ΔI =0.96. (6)

$$L = \frac{(24*.75)}{(0.96*500000)} \quad (7)$$

L=0.18mH. (8) Required

capacitance value (C) $= I_o * K$ (9)

$\Delta v * F$ Δv is the ripple current that is 20% to 30% of output voltage.

$$\Delta V = 0.2*\left(\frac{48}{50}\right). \quad (10)$$

ΔV=0.96. (11)

$$C = \frac{(0.96*.75)}{(0.2*500000)} \quad (12)$$

C=5000μF. (13)

$$\text{Efficiency} = \frac{\text{(output power)}}{\text{(input power)}} \quad (14)$$

$$\text{Efficiency} = \frac{(V_O * I_O)}{(V_I * I_I)} \quad (15)$$

$$= \left(\frac{47*0.42}{24*0.01}\right) \quad (16)$$

Efficiency=82%. (17)

TABLE I

VII COMPONENT SPECIFICATION

PARAMETER	VALUES
MAXIMUM POWER	18W.
AC INPUT VOLTAGE(Vs)	230V.
BATTERY INPUT VOLTAGE(Vs)	24V.
SOLAR INPUT VOLTAGE(Vs)	24V.
OUTPUT CURRENT(Io)	0.42Ah.
OUTPUT VOLTAGE(Vo)	47V.
INDUCTOR(L)	0.18mH.
CAPACITOR(C)	5000μF.
RESISTOR(R)	50Ω.

VIII SUMULATION CIRCUIT RESULT

A**. Forward direction:**

The switch is on condition by giving the proper gate pulse to the switch. In this mode the energy is stored in inductor by using input voltage of 24volts.The switch is off condition by

removing the gate pulse to the switch, the stored energy is transferred from inductor to the capacitor. This is forward mode or boost mode of operation. This boosted variable DC is given to the H-bridge inverter circuit. The H-bridge inverter circuit is used to convert the DC voltage to AC voltage. This Ac source is not pure one this will be given to the LC filter. This LC is used to filter the harmonics and ripple content in the AC source, and gives pure sinusoidal wave form. This sinusoidal AC source is using in application such mobile charging, and commercial purpose. Fig(3)

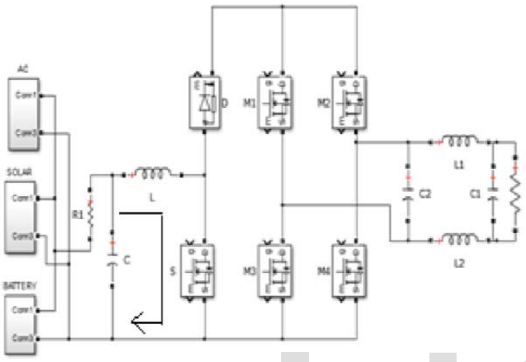

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Fig.3.Forward direction

B. Reverse direction:

The fig (4) input source is AC sinusoidal voltage source. This 48volts of AC source is given to the Hbridge inverter circuit and inverter circuit is used to convert the AC source into DC variable source. This DC variable source is not required to store the battery. It will be convert the variable DC source into fixed DC voltage by using Buck converter. Here the switch is on condition by giving proper gate pulse to the switch. This is turn on the switch and battery is charged from capacitor. The switch is off condition by removing the gate pulse to switch, at the time the diode is on condition and freewheeling action can take place, and energy is transferred from inductor to the battery. The battery stores the DC power and when the power is not present we can utilize the power from the battery and also used in emergency purpose.

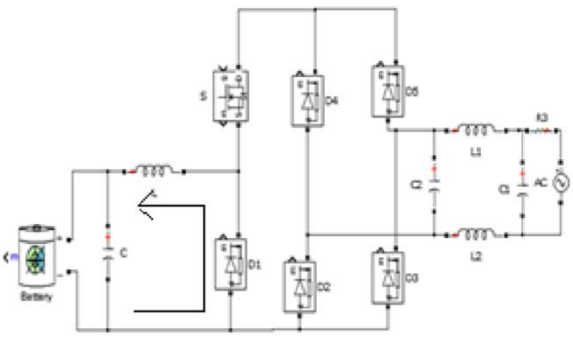

Fig.4.Reverse direction

IX SIMULATION WAVE FORM FOR FORWARD MODE:

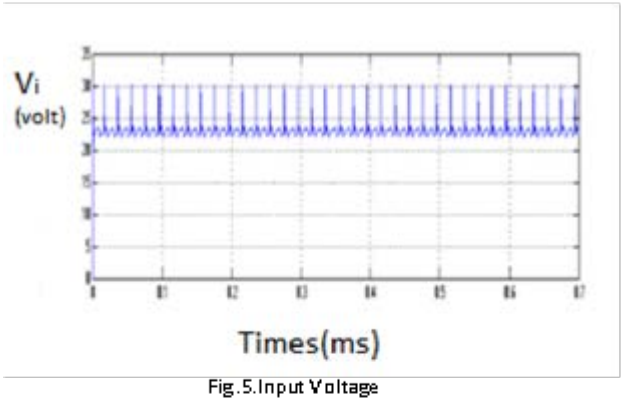

Fig.5.Input Voltage

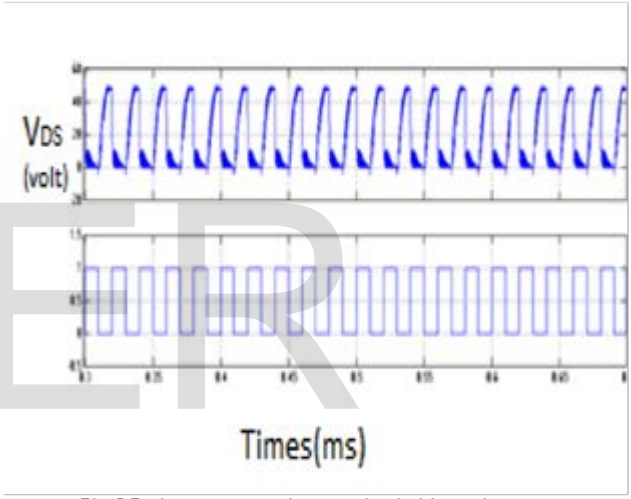

Fig.6.Drain to source voltage and switching pulse

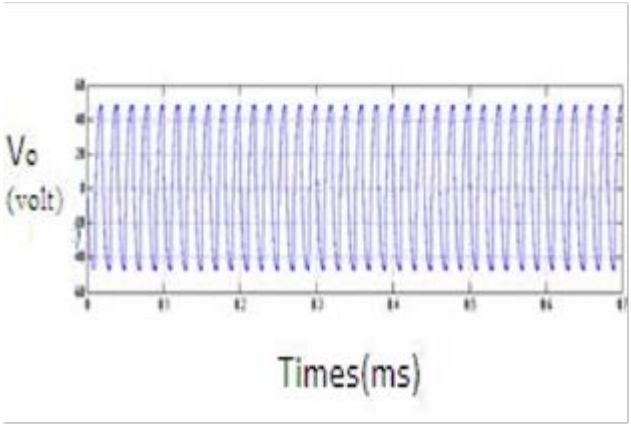

Fig.7.Output Voltage

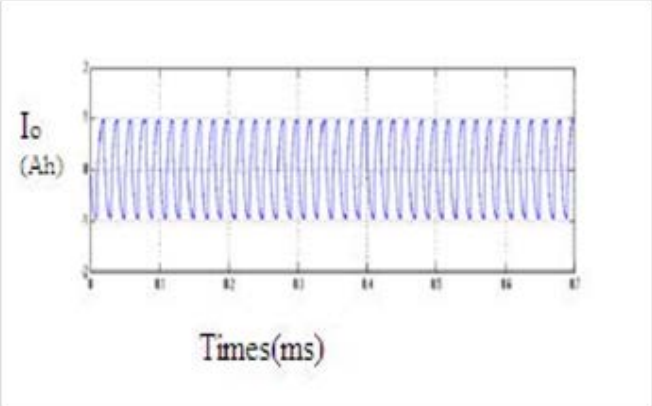

Fig.8.Outputs Current

X SIMULATION WAVE FORM FOR REVERSE DIRECTION :

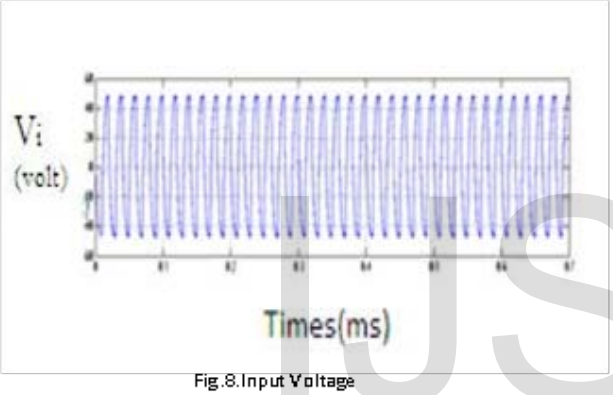

Fig.8.Input Voltage

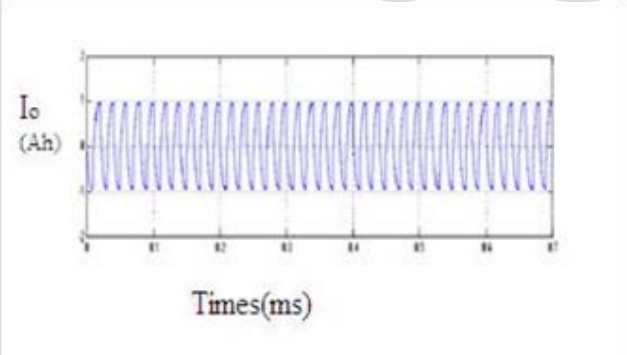

Fig.9.input current

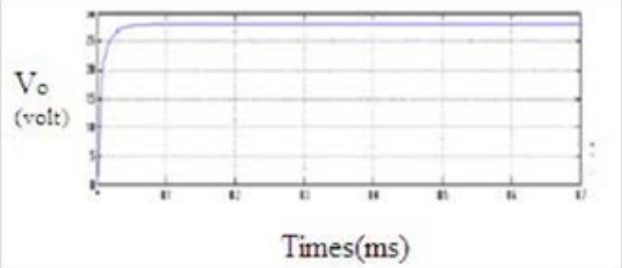

Fig.10.Output Voltage

XI SIMULATION RESULTS

INPUT VOLTAGE	230V
OUTPUT VOLTAGE	47V
OUTPUT CURRENT	0.42mA
OUTPUT POWER	19.47W
INPUT POWER	24W
EFFICIENCY	82%
INPUT RIPPLE VOLTAGE	0.2V
OUTPUT RIPPLE VOLTAGE	0.96V
INPUT CURRENT	0.01mA

XII CONCLUSION

Hence the simulation circuit of bidirectional adapter for, solar panel and battery with Buck Boost converter circuit is simulated. The circuit wave form for the converter circuit of both buck and boost mode of the operation was simulated. The bidirectional adapter with forward mode of operation, AC power will be utilizing and for the reverse mode of operation DC power can be stored in battery. When power is not available the DC power can be used in emergency purpose. The power circuit is analyzed; designed and implemented the simple robust control scheme is also developed. The SMR operation based characteristics of the entire converter and inverter circuit is performed. The miniaturization, efficiency improvement, and commercialization for the developed bidirectional adapter can easily be accomplished by the industries.

REFERENCES:

[1] Kai-Wei Hu and Chang-Ming Liaw.“On a Bidirectional Adapter with G2B Charging and B2X Emergency Discharging Functions”.

.

[2] KhagendraThapa, “Lithium Ion battery charging using bipolar transistors”Systems Engineer, Zetex Semiconductors.

[3] Jiann-Jong Chen, Fong-Cheng Yang, Chien-Chih Lai.“A High-Efficiency Multimode Li–Ion Battery Charger with Variable Current Source and Controlling Previous-Stage Supply Voltage”.

[4] Bruno Do Valle, Christian T. Wentz, and Rahul Sarpeshkar,”An Area and Power-Efficient Analog LiIon Battery Charger Circuit”.

[5] Lithium Ion Rechargeable Batteries Technical Handbook.

[6] Introduction to 12V battery charging from a solar panel.

[7] J.F. Reynaud1,C. E. Carrejo1, O. Gantet1, P. Aloïsi1, B. Estibals1, C. Alonsol."Active balancing circuit for advanced lithium-ion batteries used in photovoltaic application".

[8] NehaKondeka, Amit K Gupta, Prof. NavakantBhat Centre for Nano science and Engineering. "Project Report on Solar Charger Circuit using IC LM317 ".

[9] Huang-Jen Chi'u, Yu-Kang Lo, Chun-Jen Yao, and Shih-Jen Cheng "Design and Implementation of a Photovoltaic High-Intensity-Discharge Street Lighting System".

[10] Faisal Khan, Mohammed Khorshed Alma, "Optimization of Sub cell Interconnection for
Multifunction Solar Cells Using Switching Power Converters".

[11] S. Abinaya, A. Sivaranjani and S. Suja."Methods of Battery Charging with Buck Converter Using Soft-Switching Techniques".

[12] DC-DC converter for power electronics by Bimbra.