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[Vani* *et al.*, 6(9): September, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SOLAR PV-POWERED INTEGRATED MULTIPLE OUTPUT SYNCHRONOUS BUCK CONVERTER FOR ELECTRIC VEHICE POWER SUPPLY

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DOI: 10.5281/zenodo.995958

ABSTRACT

This paper proposes a solar PV powered Integrated multiple output synchronous buck converter for battery operated portable applications like Electric vehicles,Mp3 players,cellular phones,Digital cameras etc.,This project deals with the operational principle, performance characteristics of a simplified dual output buck converter and solar pv powered batteries for electric vehicle power supply.The proposed converter reduces the number of switching components when compared to the conventional buck converter by achieving multiple independently regulated outputs. It also achevies high efficiency,avoids cross regulation problem, reduces both conduction and switching losses and also reduces the cost. In addition to this its dynamic behaviour is similar to the conventional buck converter and thus the simple PWM based PI contoller is used. Finally the proposed converter with solar powered battery by using mppt technique is simulated in matlab and the results are obtained.

KEYWORDS: Integrated, Multiple Output, Synchronous Buck converter, PI controller, PWM method, Solar PV panel, Mppt (maximum power point tracking),Battery.

I. INTRODUCTION

Multiple dc-dc converters are usually required to satisfy different load conditions.Many system boards require multiple voltage rails to drive a variety of semiconductor Ics spread across the board.For example consider a modern set-up box,It includes devices ranging from a system on a chip to chips like logic,wifi,HDMI,Ethernet PHY and interfaces such as USB and SDIF.Electric vehicle is an another example where multiple loads like USB,Rain wiper,CD player,Dc motor etc.,requires multiple voltage rails as shown in fig1.Traditionally to generate these multiple voltages designers have been using multiple switching dc-dc converters to step-up/step down voltagesfrom the closest voltage bus.In addition to the cost and space, using multiple switching converters means more power consumption,increased losses and lower over all efficiency.Although employing N independent dc-dc converters is an effective candidate to generate N outputs,cost is high because it requires 2N switcheswhere as an integrated synchronous buck converter requires only N+1 switches to generate N outupts as shown in below fig.2. In addition to the reduced number of switches the inductors are also reduced. Therefore in comparsion with the conventional separate multiple output buck converter output voltages V_{01}, $V_{02,}$ $V_{03,}$..........V_{0N} are independently regulated with reduced number of switches in the proposed converter.Hence the overall cost is significantly reduced.Generally batteries are used to satisfy different load conditions such as electric vehicle chargers,power supplies etc.,.But these batteries are to be frequently charged by plugging into any main supply.so the solar power is the best alternative way to overcome this problem.Solar power and electric vehicle chargers are the key to significantly reduce our dependence on fossil fuels and is the natural evolution of our energy infrastructure.

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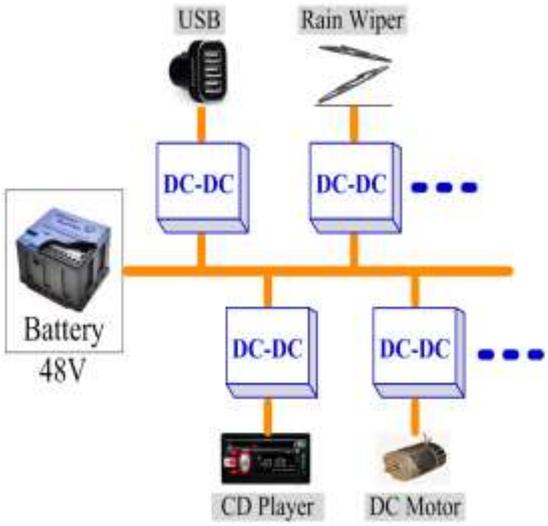

Fig.1 Power supply system of electric vehicles

Powering your plug in electric vehicle or plug in hybrid electric vehicle provides substantial savings over purchasing gas.The interest on technologies for Electric Vehicles (EVs) [1-4]and Plug-in Hybrid Electric Vehicles (PHEVs) has significantly increased in the last years. Besides the increasing interest on the subject, it is predictable that the number of EVs will immensely grow in the next decades.

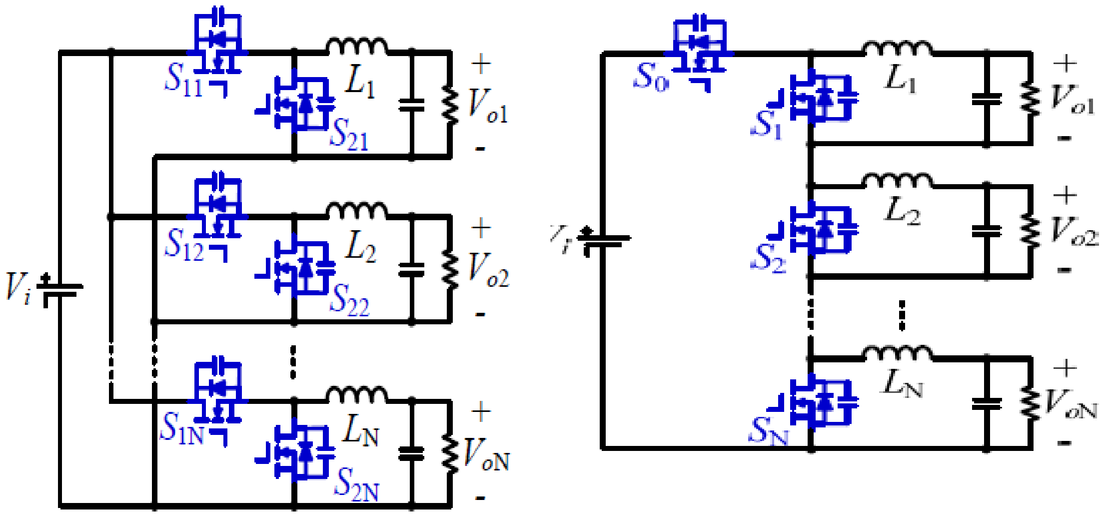

Fig.2 comparison of conventional and proposed converters circuit diagrams for N outputs

Generally, the PV-fed EV has a similar structure to the hybrid electrical vehicle, whose internal combustion engine (ICE) is replaced by the PV panel. The PV-fed EV system is illustrated in Fig.3. Its key components include an off-board charging station, a PV, batteries and power converters.

Many methods like single inductor multiple output (SIMO) [5-8] converters, multiport DC-DC converters with simulatneous buck and boost outputs, multiple output converters with shared switches are available to achieve multiple regulated outputs. SIMO suffers from severe cross regulation problem in continuous conducion mode.

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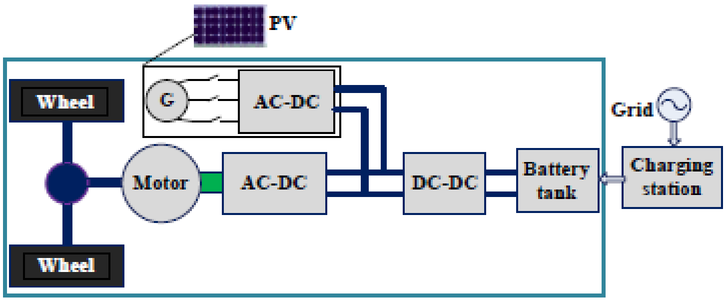

Fig.3 Pv fed electric vehicle system

So to overcome this problem Time multiplexing control technique in discontinuous conduction mode (DCM) is used. But in this method peak inductor current is very lrge which degrades the converter performance. So, in order to reduce the peak inductor current free wheel switching technique is used to operate the converter in Pseudo continuos conduction mode. But this needs an additional freewheeling switch which results in increased cost and conducion losses.

In order to overcome all these problems integrated converter is proposed which independently regulates two output voltages with two duty cycles. In addition only three switches are enough while four switches are needed in aconventional dual output DC-DC converter.

II. PROPOSED INTEGRATED DUAL OUTPUT SYNCHRONOUS BUCK CONVERTER

In this section, the simplified dual output synchronous buck converter in Fig.4 is thoroughly analysed as an example.It is composed of only three switches S_0, S_1, S_2 and two passive filters L_1-C_{01} and L_2-C_{02}, two independent duty cycles D_1, D_2 which are respectively employed to control output voltages V_{01} and V_{02}.

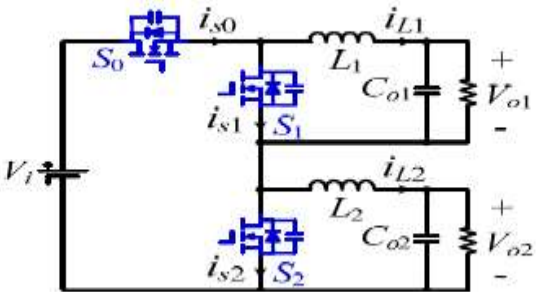

Fig.4 Proposed dual output synchronous Buck conveter

1. Operational Principle

In order to simplify the analysis several assumptions are made:switches are ideal,dead time between switches is neglected,inductor current i_{l1} greater than i_{l2},on resistance of all switches are assumed to be constant.The proposed converter operates in three modes .It consists of different operating intervals and corresponding euivalent circuits are illustrated in below figures.a,b,c.

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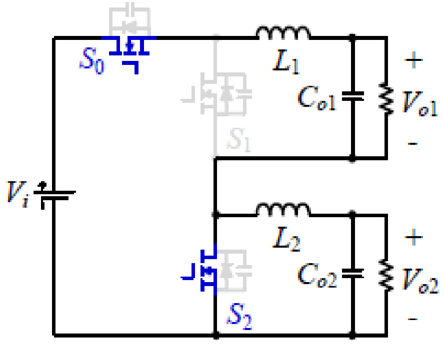
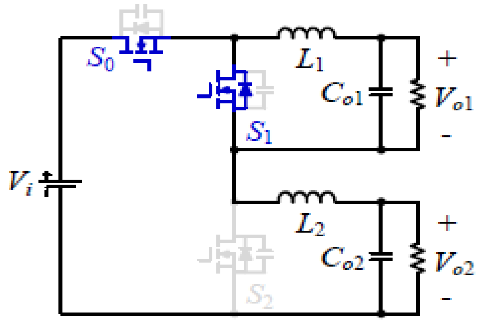
Mode1 (t0-t1)



(a)

Prior to *t*0, both *S*1 and *S*2 are on. At *t*0, *S*1 isturned off and *S*0 is turned on. Then the inductor current *iL*1commutes from *S*1 to *S*0 and the drain-to-source current in *S*2changes from -*iL*2 to *iL*1-*iL*2. In thisstage, the inductor *L*1 ischarged and the inductor *L*2 is discharged.

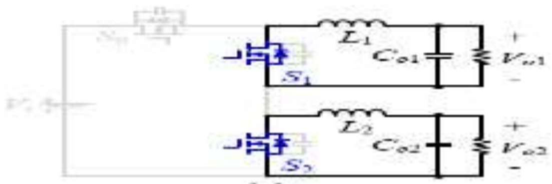
Mode2:(t1-t2)



(b)

At *t*1, *S*2 is turned off and *S*1 is turned on. Thedrain-to-source current of *S*0 changes from *iL*1 to *iL*2 and the differential current -*iL*1+*iL*2 flows through *S*1. In this stage, the inductor *L*1 is discharged while the inductor *L*2 is charged.

Mode3: (t2-t3)



(c)

At *t*2, *S*0 is turned off and *S*2 is turned on. The drain-to-source current in *S*1 changes from -*iL*1+*iL*2 to -*iL*1 and the inductor current *iL*2 flows through the parallel body diode of *S*2. In this stage, both inductors *L*1 and *L*2 are discharged.

2. Drive signal generation

The generation of drive signals s0, s1, s2 is simple that drive signals of s1,s2 are directly derived from the comparison between reference vref1,vref2 and saw tooth waveform and drive signal of s0 is the logic xor result of s1 and s2 as shown in fig.5

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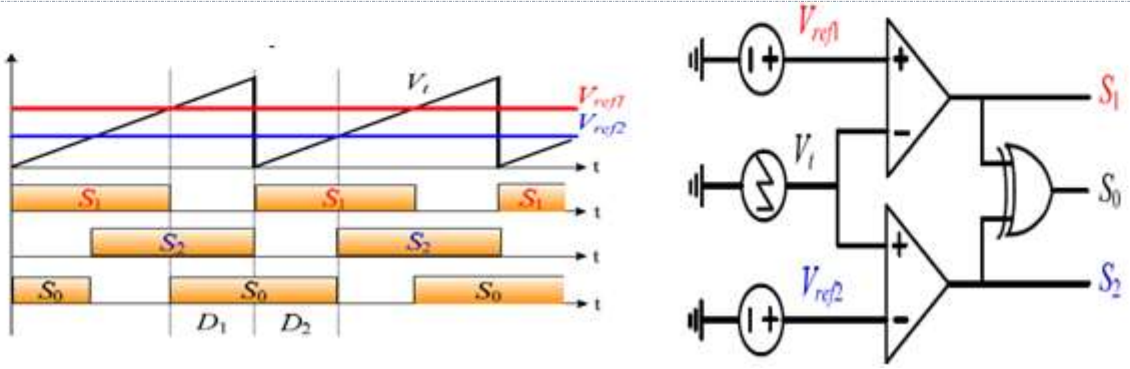

Fig.5Drive signal generator

3. PI Controller

Integrated synchronous Buck converter dynamic behaviour is similar to the conventional converter and thus the simple pwm based pi compensators can be employed in the closed loop system as shown in below fig.6.

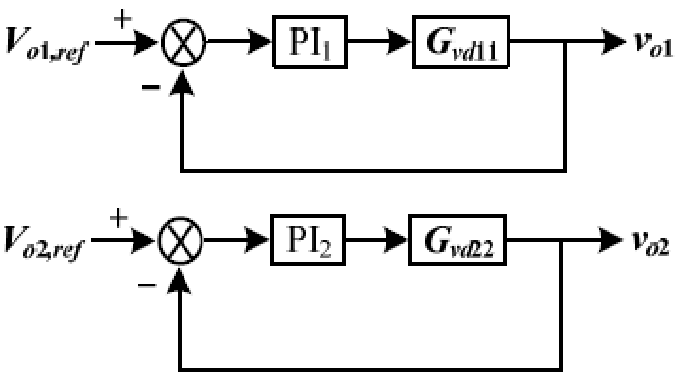

Fig.6 closed loop control system of PI controller

The PI parameters for the two control loops are shown in the below equations 6.1,6.2

PI_1= (0.005+1/0.0005) ………(6.1)

PI_2= (0.01+1/0.001)…………(6.2)

Comparison of both Conventional and Proposed methods

Table.1Comparison of current stresses in both the conventional and proposed converters

	Conventional	Proposed
[t0 ,t1]	is11 = iL1, is12 = 0 is21 = 0 is22 = - iL2	is0 = iL1 is1 = 0 is2 = iL1 – iL2
[t1,t2]	is11 = 0 , is12 = iL2 is21 = -iL1 is22 = 0	is0 = iL2 is1 = iL2 -iL1 is2 = 0
[t2 ,t3]	is11= 0 , is12 =0 is21 = -iL1 is22 = -iL2	is0 = 0 is1 = -iL1 is2 = -iL2

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III. SOLAR PV POWERED BATTERY USING MPPT TECHNIQUE:

Solar power is an important source of renewablwe energy.Solar power is the conversion of energy from sunlight to electricity either directly using pv,indirectly using concentrated solar power or a combinaton.concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam.photo voltaic cells convert light into anElectric current using the photo voltaic effect.In order to extend the Electric vehicles the use of pv panels on the vehicle helps decrease the reliance on vehicle batteries.

Implementation of MPPT technique:

Maximum Power Point Tracking, frequently referred to as MPPT, operates Solar PV modules in a manner that allows the modules to produce all the power they are capable of generating. MPPT is not a mechanical tracking system but it work on a particular tracking algorithm[9-10] and it based on a control system. MPPT can be used in conjuction with a mechanical tracking system, but the two systems are completely different. MPPT algorithms are used to obtain the maximum power from the Solar array based on the variation in the irradiation and temperature. The voltage at which PV module[11] can produce maximum power is called 'maximum power point' (or peak power voltage). Maxium power varies with Solar radiation, ambient temperature and solar cell temperature.

IV. SIMULATION MODEL AND RESULTS

The circuit of solar pv powered Integrated synchronous Buck converter is simulated using the matlab software and multiple output voltages,output currents are obtained in the simulation results as shown in figs.9,10.Circuit parameters chosen are shown in the below table.2.The input Dc voltage (48v)is given through two 12v pv panels by MPPT techique using boost converter.

Table.2 circuit parameters of synchronous buck converter for simulation model

Parameter	Symbol	Value	Unit
Input voltage	Vi	48	V
Output voltage1	Vo1	12	V
Output voltage2	Vo2	5	V
Output current1	Io1	6	A
Output current2	Io2	4.8	A
Switching period	Ts	10	μs

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(a) Simulation model

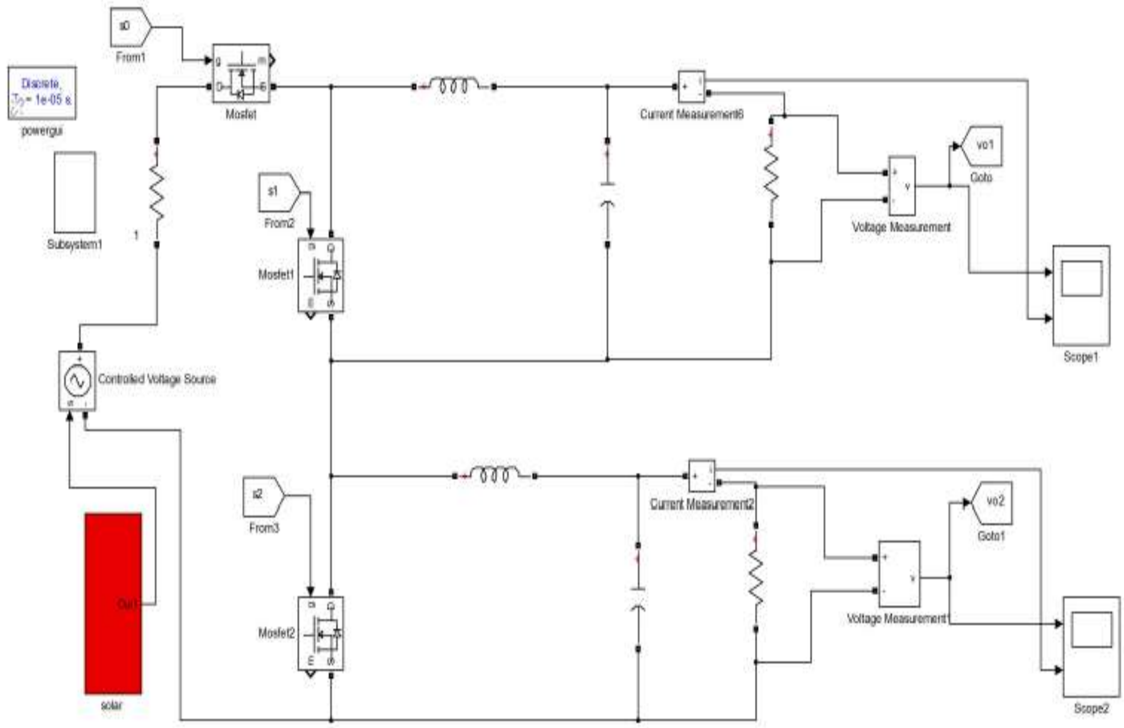

Fig.7 simulation circuit diagram of solar pv powered integrated synchronous buck converter

(b) **Simulation results:**

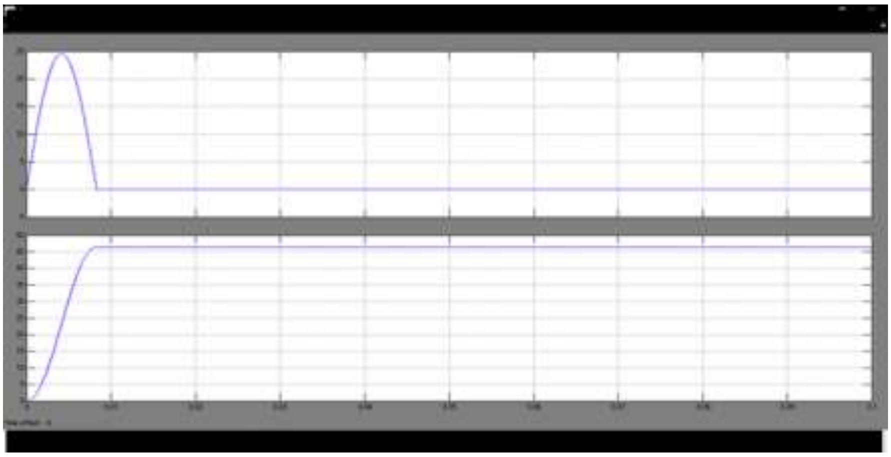

Fig.8 simulation results of solar pv powered output current and voltage fed to the battery

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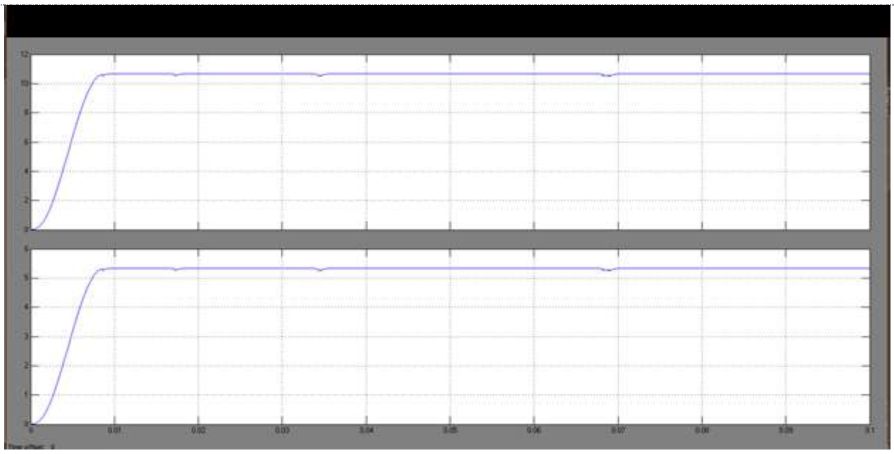

Fig.9 simulation results of output voltage(v01) and output current(Io1)

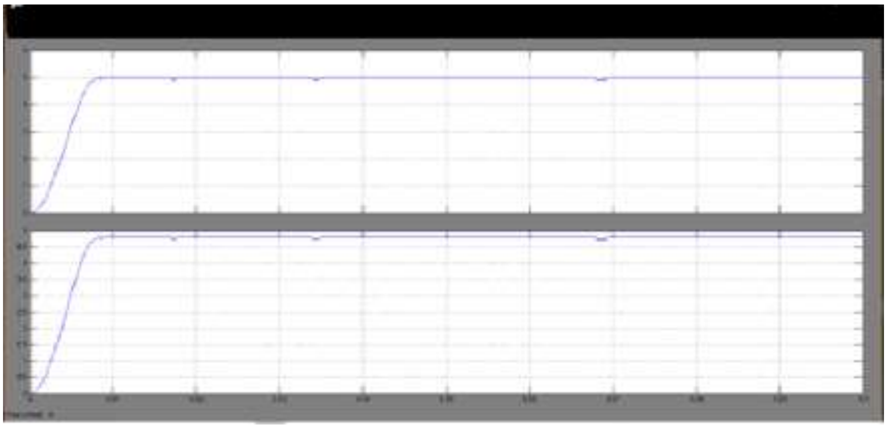

Fig.10 simulation results of output voltage(vo2) and output current(Io2)

V. CONCLUSION

The solar PV powered Integrated synchronous buck converter is simulated by using Matlab and results are obtained. To overcome the demerits of conventional converter, Integrated synchronous buck converter is poposed by reducing the number of switches. This achieves reduced cost, high efficiency, good dynamic behaviour, simple control startegy. Hence the proposed Integrated synchronous buck converter is suitable for applications like electric vehicles, digital cameras, cellular phones etc.,In order to extend the Electric vehicles the use of pv panels on the vehicle helps decrease the reliance on vehicle batteries. In this paper incremental conductance method is used in MPPT schme to get the maximum power from the panel and it improves the panel efficiency

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Vani, G., & Krishna, M. M. (2017). SOLAR PV-POWERED INTEGRATED MULTIPLE OUTPUT SYNCHRONOUS BUCK CONVERTER FOR ELECTRIC VEHICE POWER SUPPLY. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *6*(9), 465-473.