DESIGN OF SYNCHRONOUS BUCK CONVERTER WITH DUAL OUTPUTS MATLAB/SIMULINK

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ABSTRACT *The Photo Voltaic (PV) energy system is a very new concept in use, which is gaining popularity due to increasing importance to research on alternative sources of energy over depletion of the conventional fossil fuels world-wide. The systems are being developed to extract energy from the sun in the most efficient manner and suit them to the available loads without affecting their performance.*

In this paper, synchronous buck converter based PV energy system for portable applications; especially low power device applications such as charging mobile phone batteries are considered. Here, the converter topology used uses soft switching technique to reduce the switching losses which is found prominently in the conventional buck converter, thus efficiency of the system is improved and the heating of MOSFETs due to switching losses reduce and the MOSFETs have a longer life. The DC power extracted from the PV array is synthesized and modulated by the converter to suit the load requirements. Further, the comparative study between the proposed synchronous buck converter and the conventional buck converter is analyzed in terms of efficiency improvement and switching loss reduction.The proposed system is simulated in the MATLAB-Simulink environment. Open-loop control of synchronous buck converter based PV energy system is realized and results were observed

Keywords: *P.V Energy,MOSFETS,Synchronous Buck Converter,Soft Switching,Open-loop control*

INTRODUCTION:

The demand for energy is increasingparticularly in developing countries like India and China. Unfortunately, the existing fossil reserves that fuel the conventional power is depleting at high rate. The unavailability of fossil fuel and increased demand for energy has pushed us towards finding alternative sources of energy. There are many alternative sources of energy such as solar, wind, ocean thermal, tidal, biomass, geo-thermal, nuclear energy etc.

The abundance of solar energy present everywhere makes it readily available than any other source of energy that can be feasibly extracted and utilized. This solar energy can be converted into electricity with the help of solar panel that are made up of silicon photovoltaic cells. This ready availability can be utilized opportunistically for portable applications. Rural India constitutes the major portion of the population which has very limited access to electricity. Since designing low cost high efficiency solution to generate power in rural areas is easier with PV systems than most of the other systems available, the project is aimed at developing low power energy systems for portable applications such as mobile charging solar lamps, etc. for use in rural areas.

India imports more than 80% of its oil; hence it has a huge dependency on external sources for development. With depleting fossil reserves worldwide, there has been a threat to India's future energy security. Hence, the government of India is investing huge capital on development of alternative sources of energy such as solar, small hydroelectric, biogas and wind energy systems apart from the conventional nuclear and large hydroelectric systems.

The distribution of power generation from various sources according to the Ministry of New and Renewable Energy, Government of India as on 31.01.2017 is shown in Table 1.1

Table 1.1 Current Distribution of Power Generation from various sources in India

Technology	Capacity Installed (MW)	Percentage Installed Capacity
Thermal	93,838	54.20
Hydro	37,367	21.69

Renewable	18,842	10.94
Gas	17,456	
Nuclear	4,780	

HARD SWITCHING CONVERTER:

Hard Switching converters comprise of those converters which obeys the conventional switching phenomenon. While the switch is turned ON, the voltage across the switch tends to decrease and the current across the switch tends to increase. This results in some switching losses There are several topologies of these conventional hard switching converters of which we discuss mainly 3 types of converters:

1.BuckConverter
2.BoostConverter
3.Buck – BoostConverter

(1). **BUCK CONVERTER** :

Buck Converter is also known as Step-down Converter. When the MOSFET switch is ON, the voltage across the load is Vs. The current flowing through the load is same as shown in the diagram. When the MOSFET switch is turned off, the current through the load is in the same direction as mentioned but the voltage across the load is zero. The power is flowing from source to load

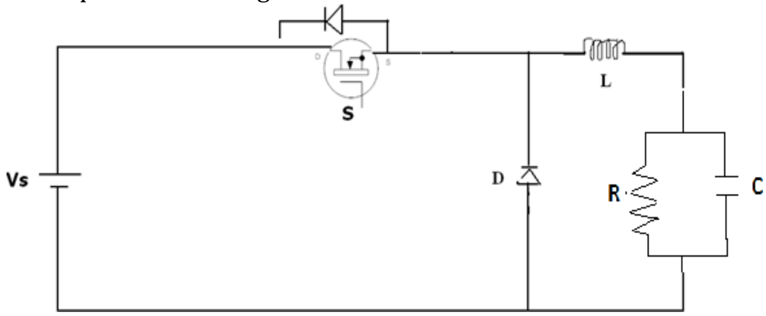

Figure:1 Buck converter topology

SOFT SWITCHING CONVERTERS:

Conventional PWM converters operate on hard switching phenomenon where voltage and currentpulses, during their transition from high to low values or low to high values interact with each other and cause power losses called switching losses and generate a substantial amount of electromagnetic interference[10]. Switching losses arise because of output capacitor of transistor, capacitance of diode, diode reverse recovery. It is observed that switching losses are proportional to switching frequency. So, higher switching losses lead to the limitation of switching frequency. Because of wide spectral range of harmonics present in PWM waveform, a high Electro Magnetic Interference (EMI) occurs. EMI also results from high current spikes caused by diode recovery. Switching losses and EMI can be reduced by using soft switching techniques at the expense of stress on the device. If the semiconductor device is made to turn off or turn on when current or voltage is zero, then the product of voltage and current during transition is zero which leads to zero power loss. Thus switching losses are eliminated and the device can be made to operate at high switching frequencies. Size and weight of the device also reduces because of non-requirement of heat sink.
The soft switching techniques are widely categorized into two types namely
Zero Voltage Switching (ZVS)
Zero Current Switching (ZCS)

Zero Voltage Switching (ZVS): The technique in which the MOSFET or any other semiconductor turns on at zero voltage is called ZVS.ZVS is used during turn on of the device. Initially the main MOSFET S is off and the auxiliary MOSFET S1 is on. So the current through main switch is zero whereas voltage is not zero. During turn on voltage is made zero across the switch and current is given some time delay such that current begins to rise after the voltage becomes zero. This is called ZVS.

ii. Zero Current Switching (ZCS): The technique in which MOSFET or any other semiconductor device turns off at zero current is called ZCS. ZCS is used during turn off of the device. Initially the device is conducting. So the current passing through the device is not zero and the voltage across the device is zero. In the ZCS condition,current is made zero and the voltage is made to rise only after the current becomes zero. Thus there is no power loss during turn off of the device.

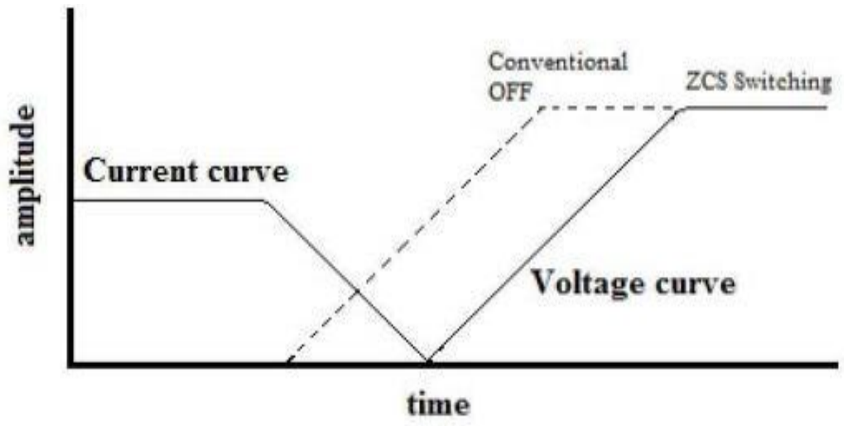

Figure:2 Graph showing the current and voltage variations during soft switching

SYNCHRONOUS BUCKCONVERTER

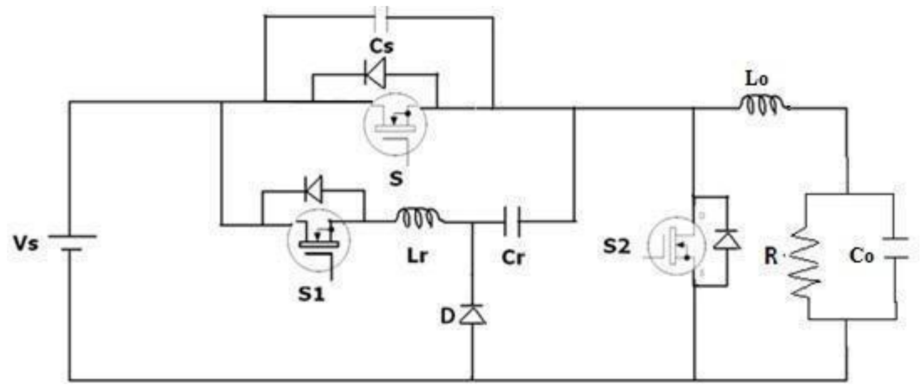

Figure:3 Synchronous Buck converter topology

OPERATING MODES AND ANALYSIS:
The operation of the Synchronous DC - DC Buck converter is explained in 8 modes
Mode 1: At t0, the switch S1 is turned on. S1 realizes zero-current turn-on as it is in series with the resonant inductor Lr.
Mode 2*:*At this mode, iLr reaches its peak value iLrmax. Since iLr is more than load current I0, the capacitor Cs will be charged and discharge through body diode of main switch S.
Mode 3 : This mode ends when iLrfalls to zero and S1 can be turned-off withZCS.
Mode4: At this moment the body diode of S1 is turned off and the mode ends.
Mode5:. This mode continues till the time ton of the synchronous buck converter is required.
Mode6: In this mode current is delivered to the load through source Vs. So in this process, Cs gets charged to Vs
Mode7: At starting of this mode, the main switch S is turned off withZVS.
Mode8*:*During this mode, the converter operates like a conventional PWM buck converter until the switch S1 is turned on in the next switchingcycle.

CONTROL TOPOLOGY:
The drive signals for the switches in both topologies are generated by comparing reference values at which the output of synchronous buck converter need to be maintained with the saw tooth waveform and the switching
sequence forS0.

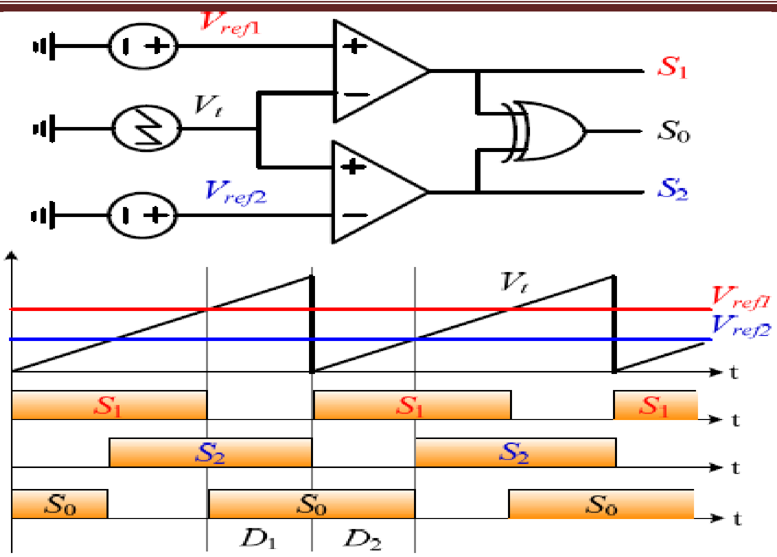

Figure:4 Control Topology and Switching sequence for proposed converter

SIMULINK DIAGRAM OF PROPOSED SYSTEM

Synchronous buck converter is designed in Simulink. The fig shows the model of designed circuit in this topology for each level of output voltage we use separate switches for each level i.e no switches in common for two levels and RLOAD1=2ohm;RLOAD2=1ohm and this will represent equivalent resistance load and shown in figure:**5**

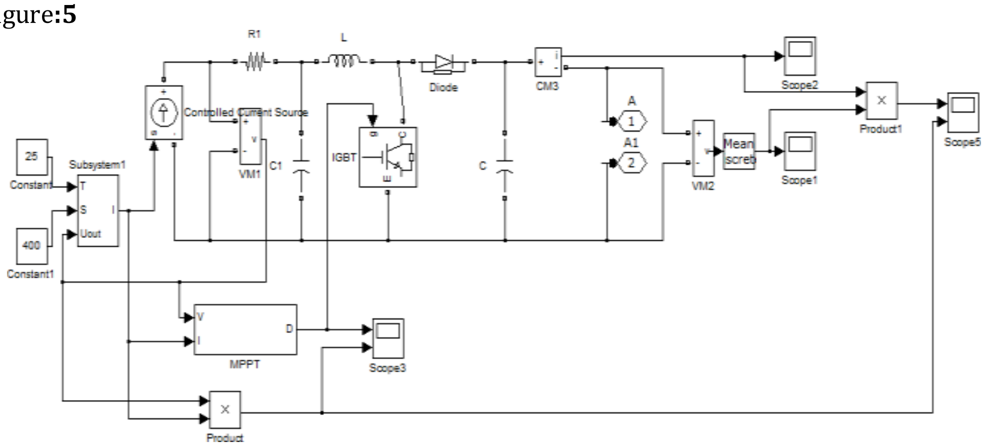

Figure:5 Simulink Diagram Of Proposed System

SIMULINK RESULTS:

The Simulink results of the voltage and current waveforms across the each switch is observed with control topology and soft switching and voltage across resonant converter and current across the inductor is observed by using scopes connected.The below figure 6 shows the waveforms of voltage oeacross the three switches in convereter and figure 7 show the voltage across capacitor.

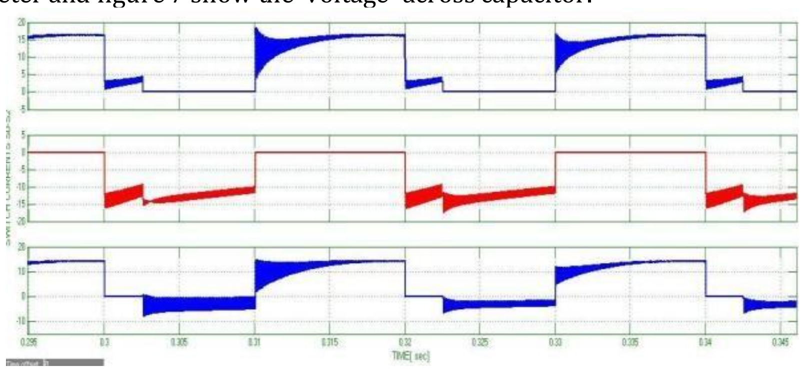

Figure:6 Voltage across switches with new control technique

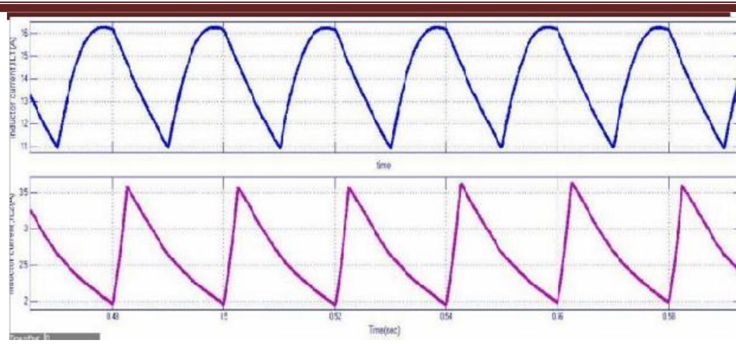

Figure:7 Voltage across capacitor

CONCLUSION:

The PV energy systems that are available in the market are known and the feasibility of portable charging systems is analyzed. The PV array model is simulated and check with the practical model to check its characteristics. The high efficiency synchronous buck converter is studied and is simulated in MATLAB-Simulink environment with PV array to know the characteristics of the converter. Further, the conventional buck converter is also designed in MATLAB-Simulink environment with PV array to know the characteristics of the converter. Moreover, the comparative study is made between conventional Buck converter and the proposed synchronous Buck Converter in terms of efficiency improvement; as a result, the overall system is highly portable and cost effective and also the switching losses are also less in proposed system and also one switch was reduced for dual output. If there are n-multiple outputs there will nswitches will be reduced.

FUTURE SCOPE:

The converter designed in this project operates at 200 KHz. However, for faster response at higher frequencies with easily customizable control, FPGA implementation can be made and can be integrated with micro controller control for more stability in output at various conditions. Such low cost systems with less error due to digital operation can be used to operate low power high current devices and also the isolated house power can be managed with these microcontroller based systems which has an added advantage of flexibility and ability to interact with other devices. Thus the freedom to get electricity anywhere and the adaptability of micro controllers to suit many conditions easily can be exploited to make such portable systems in an effective and user-friendly manner.

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