Solar grid-tied inverter

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***Abstract*— This paper will give the basic idea of designing the solar Photovoltaic (PV) system with grid connections. With the increasing demand of electricity, it is necessary to increase the generation of it, so with an aim to reduce the usage of non-renewable energy sources and to reduce carbon emissions, solar PV system plays a vital role. With this view in mind this project was developed. The technology behind this is developing day-by-day, in order to ensure proper designing to fulfill the basic requirement this paper will prove to be useful. PV systems can be designed with various components which may include PV panels, batteries, battery charge controller, DC-DC (Direct current-Direct current) converter, DC-AC (Direct current-Alternating current) converter, and many more. All these components can be called as Balance of System (BoS). BoS are discussed in this paper in brief.**

***Index Terms*— solar grid inverter, solar inverter, grid connected, solar home system**

I. INTRODUCTION

Solar PV systems are generally designed to supply power to the load (AC or DC). As the source is solar (Sun), it is necessary to store this energy for night time requirement, so battery proves useful. But, to store this power in battery requires proper controlling to prevent the battery from damage, so proper charging mechanism has to be designed. Also, battery is useful as a constant source. A proper converter is required in between inverter and charge controller which is known as DC-DC converter, which either boosts or bucks the voltage from the battery. This is then feed into inverter to convert into ac or if the application requires a DC then no inverter is required directly the converter output can be applied to the load. The basic classification of Solar PV systems includes:

1. Stand-alone PV system,
2. Grid-tied or connected PV system,
3. Hybrid (auxiliary renewable power sources along with solar) PV system.

However, this paper defines only the second one i.e. Grid-tied PV systems.

II. SOLAR GRID-TIED PV SYSTEM

This system is designed in order to fulfill the energy requirement during day and night time. Unlike stand-alone and hybrid system this system is less costly. This system is economically also more viable, as Sun is available everywhere. There are various topologies available for this system which includes various stages for processing PV power and ultimately feed into grid. Some 2-stage system includes a MPPT (Maximum power point tracking) mechanism to trap maximum power from PV module which is then given to either boost converter or boost-buck converter and finally to the inverter to get high quality AC output. There are also multi-stage system which has addition of push-pull converter in between DC-DC converter and DC-AC inverter for galvanic isolation.

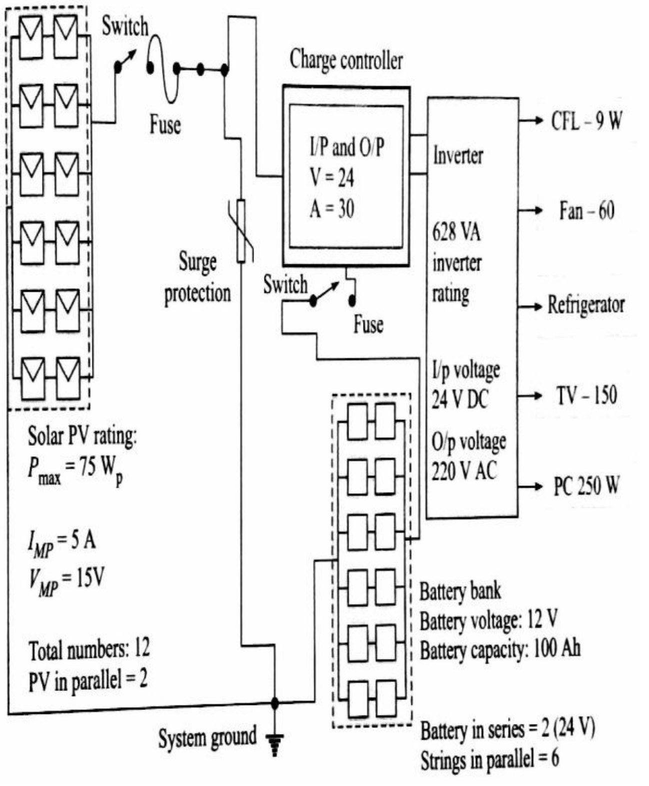

Fig. 1 Grid connected Solar System

A. Solar Module

Solar cell consists of p-type and n-type of Si (Silicon) semiconductor in wafer form. The solar consists of photons which when fall on this p-n junction results in the flow of electrons due to electron-hole pair formation, this is photovoltaic effect. Various solar cells in series-parallel form a solar PV module and module together in series-parallel form an array. The solar cells are fabricated in various shapes like circular, pseudo-square and square shape. Power from the cell depends largely upon its efficiency. Solar cells are available in smaller size ranging from 0.25W (Watt) to 3.37W depending on cell efficiency. Solar modules are available with power ranging from 3W to 300W. And arrays are used based on the type of application which may be several kilowatts to mega or even giga watts of power.

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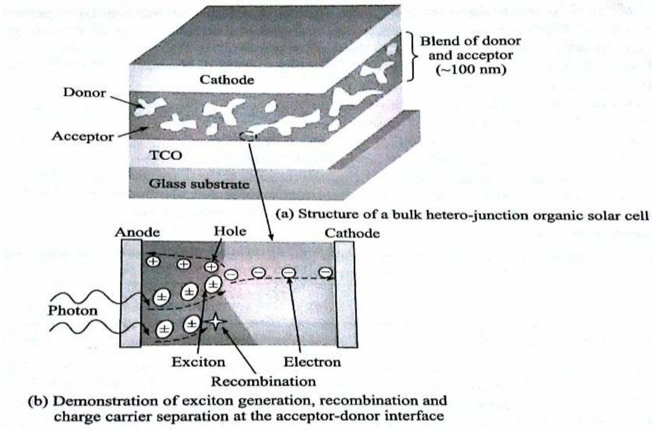


Fig. 2 Photovoltaic effect mechanism

B. Charge controller

Charge controller is necessary to regulate the charging and discharging of a battery in order to preserve the batteries life and performance. Based on the circuitry connections, there are three types of charge controller shunt-type, series-type and DC-DC converter type. The latter one is usually preferred as there are no conduction losses, regulation is superior and output PV voltage and battery voltage can be different (need not be same).

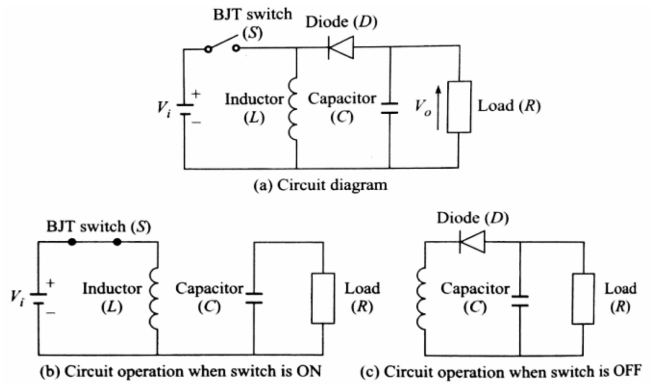


Fig. 3 Solar charge boost-buck type controller

C. Lead Acid Battery

It is an electrochemical device which can produce direct voltage by simply converting chemical energy contained in its active material into electrical energy by means of oxidation-reduction reaction. The lead-acid batteries are more economical and simple to manufacture, so we can use it. Also, these batteries have lowest self-discharge.

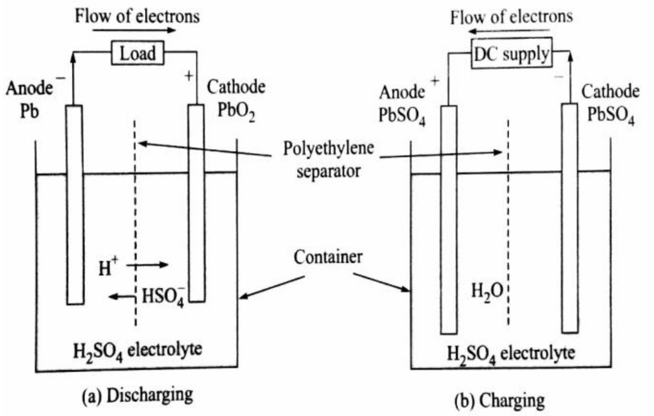


Fig. 4 Lead Acid Battery

III. Inverter

A DC to AC converter is called as Inverter. Basically there are two types of inverter: a) Voltage Source Inverter (VSI), b) Current Source Inverter (CSI).

A. Inverter Topology

Fig. 5 shows that actual circuit configuration of 2 stage inverter. Fig.5a shows Boost converter (DC to DC converter) which is then converted into high quality AC using inverter stage. Fig.5b shows Boost-buck converter at first stage followed by AC inverter at second stage. Fig. 5c shows Boost type converter at first stage followed by inverter.

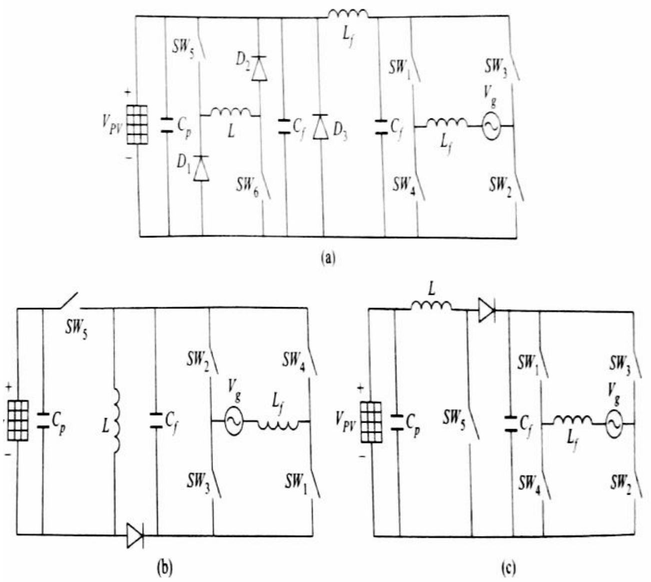


Fig. 5 Two-stage inverter

B. Inverter single stage circuit diagram

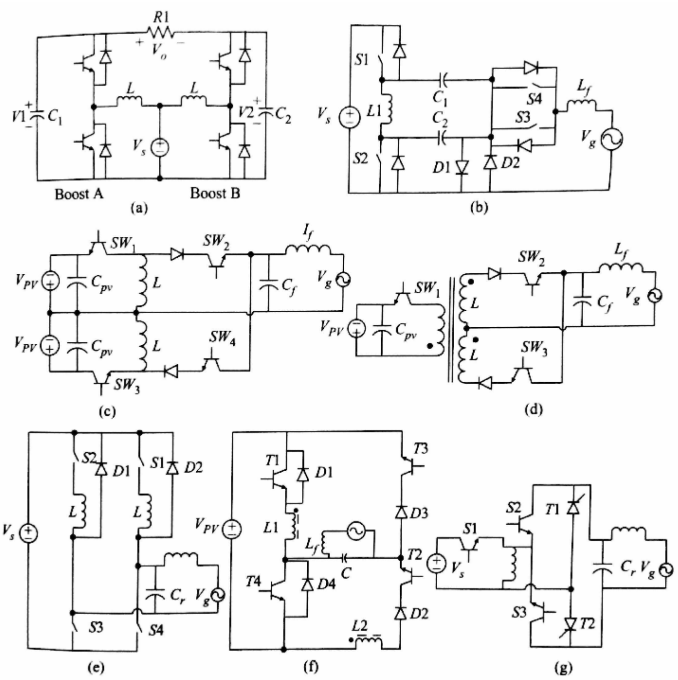
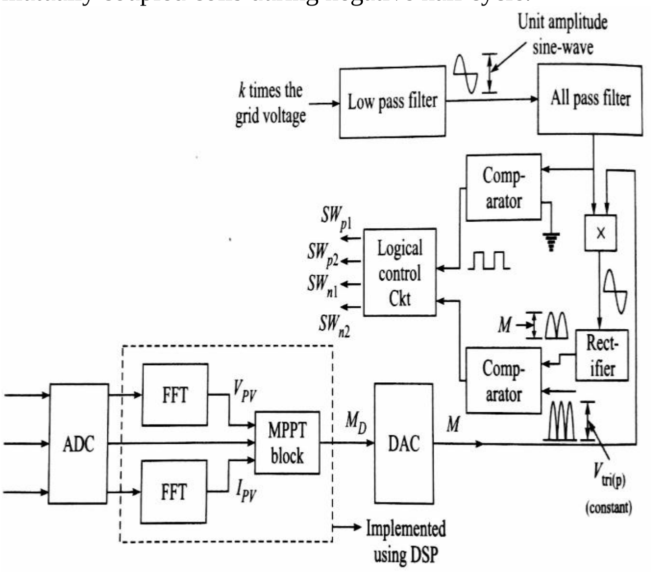


Fig. 6 Single stage DC-AC inverter circuit diagrams

Fig. 6 shows the single stage inverter topologies. Fig. 6a shows the single stage Boost plus inverter topology with two Boost converters. In Fig. 6b switch S1 is at high frequency while S2 and S4 are kept ON. Power transfer takes place based on Boost-buck principle. Fig. 6c shows half bridge Boost-buck inverter configuration. Fig.6d shows half bridge Boost-buck topology with an isolated, flyback configuration. In Fig.6e S4 operates at high frequency while S1 is ON. It is a single-stage full bridge configuration that is based on Boost-buck principle. Fig.6f uses flyback principle with mutually coupled coils during negative half cycle.



IV. APPENDIX

A. Mathematical equations

Total Harmonic Distortion $= \frac{\sqrt{C_2^2 + C_3^2 + \cdots C_n^2}}{C_1}$ (1)

C_2, C_3…are RMS values of different harmonics waveforms.

For Buck type: $R_{in} = R_L \times (1/D)^2$ (2)
For Boost type: $R_{in} = R_L \times (1\text{-}D)^2$ (3)
For Buck-Boost type: $R_{in} = R_L \times ((1\text{-}D)/D)^2$ (4)

B. Units

R_{in} = input resistor value of converter in ohm
R_L = load resistor value in ohm
D = Duty cycle for time on and time off

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