

Hybrid Power System Using Current Fed Inverter

¹Dr.C.Nagarajan, ²D.Kalidass, ³C.Manivannan

¹Professor, Department of EEE, Muthayammal College of Engineering, Rasipuram, Tamilnadu, India

²Assistant Professor, Department of EEE, Muthayammal College of Engineering, Rasipuram, Tamilnadu, India

³PG Scholar, Department of EEE, Muthayammal College of Engineering, Rasipuram, Tamilnadu, India

ABSTRACT: Renewable energy systems, such as photovoltaic (PV) and wind power generation (WPG), are playing a more and more important role in energy production. However, the output power of PV and WPG are usually strongly fluctuant due to the randomness and intermittence of solar and wind energy, which requires a large capacity of energy storage to satisfy the load demand when the system works in stand-alone mode, and results in a strong impact on the utility grid when the system works in grid-connected mode. Here we are going to utilize that two combined generation very wisely using mppt concept; and there by using mppt technique we are charging and discharging the battery based on power generation & typical load conditions respectively. Due to which battery life is increased. Here wind power generation is considered as primary source as it exists day fully comparing with solar generation. As we know current fed topology is able to provide constant current even at load variations; we utilized that topology for grid loads.

I. INTRODUCTION

Hybrid power systems combine two or more energy conversion mechanisms, or two or more fuels for the same mechanism, that when integrated, overcome limitations inherent in either. Hybrid systems provide a high level of energy security and reliability through the integrated mix of complementary generation methods, and often will incorporate a storage system (battery, fuel cell) or fossil-fueled power generation to ensure consistent supply. Current commercial, utility-scale hybrid energy systems include geothermal + solar PV, biomass + solar CSP, solar PV + fuel cells, wind + solar PV, biodiesel + wind, gas + solar CSP, and coal + solar CSP

Traditional renewable energy sources like biomass and large hydropower installations, and the “new renewable energy sources” like solar energy, wind energy, geothermal energy, etc. Development of renewable energy sources (especially from wind, water and sun) is important because of a couple of reasons:

- Renewable energy sources have major role in decreasing emissions of the carbon dioxide (CO₂) into atmosphere.
- Increased proportion of renewable energy sources enhances energetic viability of the energy system.

It also helps to enhance energy delivery security by decreasing dependency on importing energetic raw materials and electrical energy

II. ENERGY MANAGEMENT AND OPTIMIZATION PRINCIPLES

According to the connection bus, the network architecture of WSB can be classified into three types: dc-bus, ac-bus, and hybrid-bus, among which, the dc-bus architecture has been widely used in small-scale DPGS for its convenient control and interface of renewable energy to the system. The PV panel and wind turbine are connected to the dc bus by the dc/dc and ac/dc converters, respectively, which can realize the maximum power point tracking (MPPT) function. The battery cells are connected to the dc bus dc/dc converter in a concentrated location, which are used to control the dc bus voltage. Please note that the storage system is composed of many battery modules connected in series or parallel. The balance circuits among different modules are usually included in the system. The dc voltage is converted to ac voltage through an inverter. The power generated by WSB provides the demanded power for the local load and can be transferred into the utility grid through a step-up transformer.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

Mathematical Model of the Components in WSB

Photovoltaic Generation Model:

Assuming that the PV array is equipped with a MPPT controller, thus, the output power of PV array can be expressed as

$$P_{pv} = f_{pv} P_{pv,r} \frac{G}{G_{STC}} [1 + \alpha_T (T - T_{STC})]$$

Where is the rated output power of PV array, is the de rating factor considering shading, wiring losses and snow cover, etc. and are the solar radiation and temperature on PV cell under standard test conditions, respectively. And are the solar radiation and temperature in current time, respectively, and is the temperature coefficient of power. It should be noted that the PV panel title angle, rotating capability, etc. can also affect the output power of PV array beside and . In this study, these factors are taken into account when calculating the solar radiation on PV panel.

Wind Power Generation Model

The output power curve of the wind turbine (WT), which can be described as

$$P_{wt} = \begin{cases} 0 & v_w < V_{ci} \text{ or } v_w > V_{co} \\ P_{wt,r} \frac{v_w - V_{ci}}{v_r - V_{ci}} & V_{ci} \leq v_w \leq V_r \\ P_{wt,r} & V_r \leq v_w \leq V_{co} \end{cases}$$

Where is the wind speed, is the rated wind speed, and are the cut-in and cut-out wind speeds, respectively.

Optimal Sizing Principles of WSB

For a given load demand, fully utilizing the complementary characteristics of wind and solar can achieve a smaller fluctuation of output power, which results in a reduction of the required battery capacity. It is obvious that there exists power exchange between the WSB and utility grid in grid connected mode. A strongly fluctuant power injected into the grid may lead to the voltage or frequency at key nodes exceeding their limitation and large losses. Thus, how to smooth the fluctuation of power injected into the grid must be taken into account when optimizing the capacity of PV/WPG/battery. In addition, the lifetime of WSB is usually restricted by the lifetime of the battery, which is mainly affected by the batteries DOD, the charge/discharge current, and the charge/discharge rate and the charge/discharge cycles. Thus, these factors must be considered.

According to the analysis above, the proposed optimal sizing method is based on the following principles:

- Achieving high power supply reliability
- Making full use of the complementary characteristics of wind and solar
- Ensuring a small fluctuation of power injected into the grid
- Optimizing the battery's charge and discharge state
- Minimizing the total cost of WSB

III. HYBRID RENEWABLE ENERGY SYSTEM

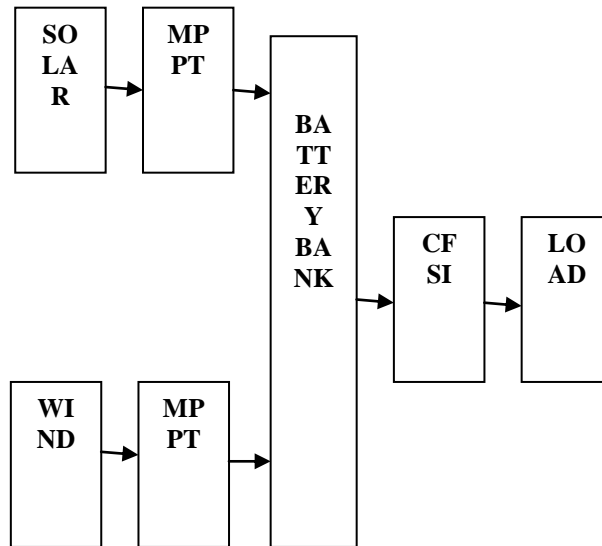
A combination of different but complementary energy generation systems based on renewable energies or mixed is known as a hybrid power system. Hybrid systems capture the best features of each energy resource. Hybrid systems can provide a steady community level electricity service, such as marine, village or lighthouse electrification, offering also the possibility to be upgraded through grid connection in the future. Furthermore, due to their high levels of efficiency, reliability and long term performance these systems can also be used as an effective backup solution to the public grid in case of blackouts or weak grids, and for professional energy solutions such as telecommunication stations or emergency rooms in hospitals.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

BLOCK DIAGRAM:



DC-DC CONVERTERS

The main purpose of a DC-DC converter is to supply a regulated DC output voltage to a variable-load resistance from an unstable DC input voltage. DC-DC converters are commonly used in applications requiring regulated DC power, such as computers, medical instrumentation and communication devices. DC-DC converters are also used to provide a stable variable DC voltage for DC motor speed control applications.

Switched capacitor converters implement switches and capacitors to perform voltage conversion. Since they do not use magnetic components like inductors the amount of EMI (Electro Magnetic Interference) is low which makes these converters suitable for applications which are sensitive to this phenomenon. Switched converters operate by passing energy in discrete packets over a switch.

Hence, the output voltage can be higher, lower or inverted compared to the input voltage. They offer higher power efficiency than their linear and switched capacitor counterparts. However, switched converters generate significant amounts of electrical noise caused by the switching activity. Presence of this phenomenon known as voltage ripple is their main drawback, fortunately this problem can be solved as it will be shown later in this section.

The output voltage in switched DC-DC converters is generally controlled using a switching technique, as illustrated by the basic switched DC-DC converter shown in figure 3.1.

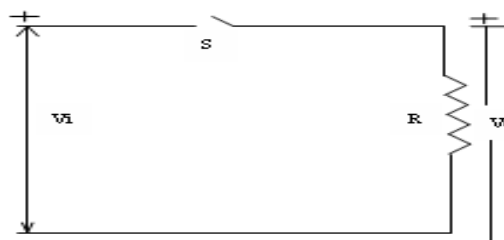


Figure 3.1: Basic switched DC-DC converter.

There are three main topologies of switched DC-DC converters used today:

1. Buck or step-down converters are used to produce an output voltage between ground and the input voltage.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

2. Boost or step-up converters operate in the opposite manner compared to the step-down converters generating higher voltage at the output than at the input.
3. Buck-Boost converters are used in applications where the output voltage is required to have levels both higher and lower than the input voltage.

The most widely used method for controlling the output voltage through the switch is pulse-width modulation (PWM). The pulse-width modulation control technique maintains a constant switching frequency and varies the ratio of the charge cycle (time when the switch is on) and the discharge cycle (time when the switch is off) as the load varies. This technique affords high power efficiency. In addition, because the switching frequency is fixed, the noise spectrum is relatively narrow, allowing simple low-pass filter techniques to greatly reduce the peak-to-peak voltage ripple at the output. This is a reason why, PWM is popular in telecommunication applications where noise interference is of concern.

TYPE OF DC-DC CONVERTERS

There are three types of dc to dc converter. They are

- 1) Buck
- 2) Boost
- 3) Buck – boost

2.4.1 BUCK CONVERTERS

As mentioned earlier, step-down converters are used to convert an input voltage to a lower level at the output. Basic principle of a buck topology is shown in figure 3.2. When the switch is in position one, the output voltage is equal to the input voltage and when the switch is in position two, the output voltage is equal to zero. The resulting average voltage level at the output is a function of the time when the switch is in position one and two respectively. This function is called duty ratio and it is defined by the expression $D = V_o/V_{in}$, where V_o denotes the average output voltage and V_{in} is the DC voltage generated by the power source.

The main problem of this basic circuit is the voltage ripple of the output signal of the converter. For this reason a LC-filter is used to decrease the voltage ripple. This modified circuit is shown in figure 3.3.

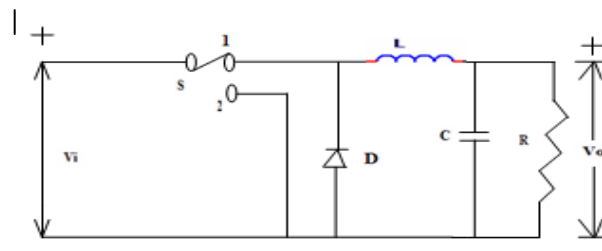


Figure 3.3 Buck converter

Since the average current through the load resistor R is approximately the same as the average current of the inductor, the voltage V_o across the load resistor contains less ripple. A diode is used when the switch is in position two. This allows the capacitor to be charged in both switching positions. When the switch is in position one the energy is transferred from the power source to the capacitor and when the switch is in position two the capacitor is charged with the energy stored in the inductor. This type of operation results in high power efficiency for buck converters.

2.4.2 BOOST CONVERTERS

A boost converter topology is obtained by rearranging the components of a buck converter according to figure 3.4.

During the time the switch is closed energy is transferred to the inductor while the diode is preventing the capacitor to discharge through the switch. When the switch opens current through the inductor continues to flow in the same direction as during the previous cycle. This forward-biases the diode and both the input voltage source and the inductor are transferring energy to the load. Hence, a voltage boost occurs across the load, which causes the output voltage to be higher than the input voltage. The capacitor must be large enough to keep the output voltage

approximately constant

IV. BUCK-BOOST CONVERTERS

Certain applications require voltage levels to be both higher and lower than the source voltage. A solution to this is a buck-boost converter. A simple buck-boost converter is shown in figure 3.5.

The basic operation of a buck-boost converter is the following. When the switch is closed energy from the source is transferred to the inductor and the diode is reversed-biased, thus, it is off. At the same time the capacitor is discharged into the output load RL and the output voltage is falling.

Next, the switch is open and the inductor maintains the current direction. This forward-biases the diode. During this period the inductor is transferring energy to the capacitor. In other words, the capacitor is being charged as the inductor is being discharged, and the output voltage is rising. Previous discussion implies, that by adjusting the on time of the switch compared to the time of one switching period, the output voltage V_o can be set to either lower or higher levels than the input voltage V_s .

MPPT is DC to DC converter which operates by taking DC input from PV module, changing it to AC and converting it back to a different DC voltage and current to exactly match the PV module to the battery.

Examples of DC to DC converter are

- **Boost converter** is power converter which DC input voltage is less than DC output voltage. That means PV input voltage is less than the battery voltage in system.
- **Buck converter** is power converter which DC input voltage is greater than DC output voltage. That means PV input voltage is greater than the battery voltage in system.

MPPT algorithm can be applied to both of them depending on system design. Normally, for battery system voltage is equal or less than 48 V, buck converter is useful. On the other hand, if battery system voltage is greater than 48 V, boost converter should be chosen. The above Topology is studied and simulated and output results are obtained using MATLAB.

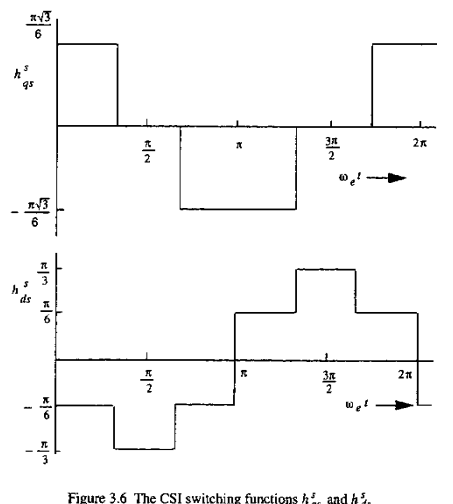


Figure 3.6 The CSI switching functions h_{gs}^s and h_{ds}^s

SOFTWARE DESCRIPTION:

MATLAB is an interactive system for numerical computation. Numerical Analyst Cleve Moler wrote the initial Fortuna version of MATLAB in the late 1970s as a teaching aid. It became popular for both teaching and research and evolved into a commercial software package written in C. For many years now, MATLAB has been widely used in universities and industries. MATLAB has several advantages over more traditional means of numerical computing.

Furthermore, MATLAB is a modern programming language and problem

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

Solving environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object oriented programming. These factors make MATLAB an excellent language for teaching and a powerful tool for research problem solving. Being interpreted, MATLAB inevitably suffers some loss of efficiency compared with compiled languages, but built-in performance acceleration techniques reduce the inefficiencies and users have the possibility of linking to compiled FORTRAN or C code using MEX files.

V. CONCLUSION

This paper has proposed a high-boost inverter structure based on the current-fed dc/dc converter topology. The proposed converter (CFSI) can work in both buck mode and boost mode and exhibits improved EMI noise immunity. The high gain of the converter is obtained due to insertion of shoot-through interval. In this paper, the development of the CFSI circuit has been described in detail along with its steady-state characteristics. The PWM switching scheme and the restriction on modulation index have also been described. The proposed inverter has been compared with traditional boost-VSI topology, SBI, and ZSI to present the advantages and disadvantages of CFSI. This paper has also presented a DSP-based closed-loop control scheme meant to regulate the ac and dc bus voltages. The proposed converter is tested on a laboratory prototype and verified.

REFERENCES

- M. C. Chandorkar, D. M. Divan, and R. Adapa, "Control of parallel connected inverters in standalone ac supply systems," *IEEE Trans. Ind. Appl.*, vol. 29, pt. 1, no. 1, pp. 136–143, Jan./Feb. 1993.
- F. Blaabjerg, Z. Chen, and S. B. Kjaer, "Power electronics as efficient interface in dispersed power generation systems," *IEEE Trans. Power Electron.*, vol. 19, no. 5, pp. 1184–1194, Sep. 2004.
- [1] F. Z. Peng, "Z-source inverter," *IEEE Trans. Ind. Appl.*, vol. 39, no. 2, C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis' - Springer, Electrical Engineering, Vol.93, March 2011.
- [2] C.Nagarajan and M.Madheswaran, Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques", Taylor & Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, 2011.
- [3] C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of ELECTRICAL ENGINEERING, Vol.63 (6), pp.365-372, Dec.2012.
- [4] C.Nagarajan and M.Madheswaran - 'Analysis and Implementation of LLC-T Series Parallel Resonant Converter with Fuzzy controller' - International Journal of Engineering Science and Technology (IJEST), Applied Power Electronics and Intelligent Motion Control. Vol.2 (10), pp 35-43, December 2010
- [5] C.Nagarajan and M.Madheswaran - 'Performance Estimation of LCL-T Resonant Converter with Fuzzy / PID Controller' - International Journal of Computer and Electronic Engineering (IJCEE), Vol.2 (3), pp.534-542, June 2010
- [6] C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model' - Acta Electrotechnica et Informatica Journal , Vol.13 (2), pp.18-31, April-June.2013
- [7] C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter' - Springer, Frontiers of Electrical and Electronic Engineering, Vol. 7(4), pp. 438-446, Dec.12.
- [8] C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis' - Iranian Journal of Electrical & Electronic Engineering, Vol.8 (3), pp.259-267, September 2012.
- [9] T. Kerekes, M. Liserre, R. Teodorescu, C. Klumpner, and M. Sumner, "Evaluation of three-phase transformerless photovoltaic inverter topologies," *IEEE Trans. Power Electron.*, vol. 24, no. 9, pp. 2202–2211, Sep. 2009.
- [10] J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galvan, R. C. P. Guisado, M. A. M. Prats, J. I. Leon, and N. Moreno-Alfonso, "Power electronic systems for the grid integration of renewable energy sources: A survey," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1002–1016, Jun. 2006.