RESEARCH ON RENEWABLE GENERATION SYSTEMS USING MULTI-PORT CONVERTERS BASED ON FULL BRIDGE AND BI-DIRECTIONAL DC-DC TOPOLOGIES

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Abstract: *Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, Tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts. A PV array consists of a number of PV modules, mounted in the same plane and electrically connected to give the required electrical output for the application. Output results for renewable energy resources due to wind and solar are mentioned.*

Keywords: *Solar Energy, Wind Energy, PV array, PV cell Modelling*

INTRODUCTION:

The photovoltaic effect was first reported by Edmund Becquerel in 1839 when he observed that the action of light on a silver coated platinum electrode immersed in electrolyte produced an electric current. Forty years later the first solid state photovoltaic devices were constructed by workers investigating the recently discovered photoconductivity of selenium. In 1876 William Adams and Richard Day found that a photocurrent could be produced in a sample of selenium when contacted by two heated platinum contacts. The photovoltaic action of the selenium differed from its photoconductive action in that a current was produced spontaneously by the action of light. During the 1990s, interest in photovoltaic’s expanded, along with growing awareness of the need to secure sources of electricity alternative to fossil fuels. The trend coincides with the widespread deregulation of the electricity markets and growing recognition of the viability of decentralized power. During this period, the economics of photovoltaic’s improved primarily through economies of scale. In the late 1990s the photovoltaic production expanded at a rate of 15{25% per annum, driving a reduction in cost. Photovoltaic first became competitive in contexts where conventional electricity supply is most expensive, for instance, for remote low power applications such as navigation, telecommunications, and rural electrification and for enhancement of supply in grid-connected loads at peak use [Anderson,2001]. As prices fall, new markets are opened up. An important example is building integrated photovoltaic applications, where the cost of the photovoltaic system is offset by the savings in building materials. There are several types of solar cells. However, more than 90 % of the solar cells currently made worldwide consist of wafer-based silicon cells. They are either cut from a single crystal rod or from a block composed of many crystals and are correspondingly called mono-crystalline or multi-crystalline silicon solar cells. Wafer-based silicon solar cells are approximately 200 µm thick. Another important family of solar cells is based on thin-films, which are approximately 1-2 µm thick and therefore require significantly less active, semiconducting material. Thin-film solar cells can be manufactured at lower cost in large production quantities; hence their market share will likely increase in the future.

The electrical output of a single cell is dependent on the design of the device and the Semi-conductor material(s) chosen, but is usually insufficient for most applications. In order to provide the appropriate quantity of electrical power, a number of cells must be electrically connected. There are two basic connection methods: series connection, in which the top contact of each cell is connected to the back contact of the next cell in the sequence, and parallel connection, in which all the top contacts are connected together, as are all the bottom contacts. In both cases, this results in just two electrical connection points for the group of cells.

SERIES CONNECTION:

Figure 2 shows the series connection of three individual cells as an example and the resultant group of connected cells is commonly referred to as a series string. The current output of the string is equivalent to the current of a single cell, but the voltage output is increased, being an addition of the voltages from all the cells in the string (i.e. in this case, the voltage output is equal to 3Vcell).

It is important to have well matched cells in the series string, particularly with respect to current. If one cell produces a significantly lower current than the other cells (under the same illumination conditions), then the string will operate at that lower current level and the remaining cells will not be operating at their maximum power points.

PARALLEL CONNECTION:

Figure 3 shows the parallel connection of three individual cells as an example. In this case, the current from the cell group is equivalent to the addition of the current from each cell (in this case, 3 I cell), but the voltage remains equivalent to that of a single cell. As before, it is important to have the cells well matched in order to gain maximum output, but this time the voltage is the important parameter since all cells must be at the same operating voltage. If the voltage at the maximum power point is substantially different for one of the cells, then this will force all the cells to operate off their maximum power point, with the poorer cell being pushed towards its open-circuit voltage value and the better cells to voltages below the maximum power point voltage. In all cases, the power level will be reduced below the optimum.

SYSTEM DESIGN

There are two main system configurations – stand-alone and grid-connected. As its name implies, the stand-alone PV system operates independently of any other power supply and it usually supplies electricity to a dedicated load or loads. It may include a storage facility (e.g. battery bank) to allow electricity to be provided during the night or at times of poor sunlight levels. Stand-alone systems are also often referred to as autonomous systems since their operation is independent of other power sources. By contrast, the grid-connected PV system operates in parallel with the conventional electricity distribution system.

It can be used to feed electricity into the grid distribution system or to power loads which can also be fed from the grid.Hybrid systems can be used in both stand-alone and grid-connected applications but are more common in the former because, provided the power supplies have been chosen to be complementary, they allow reduction of the storage requirement without increased loss of load probability. Figures below illustrate the schematic diagrams of the three main system types.

A PV array consists of several photovoltaic cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. Typically a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current.

In this model we consider a current source (I) along with a diode and series resistance (Rs). The Shunt resistance (RSH) in parallel is very high, has a negligible effect and can be neglected. The output current from the photovoltaic array is

$I=ISC \ \_ \ Id$

$Id = Io\ (eqvd/kT\_\ 1)$

Where Io is the reverse saturation current of the diode, q is the electron charge, Vdis the voltage across the diode, k is Boltzmann constant (1.38 * 10-19J/K) and T is the junction temperature in Kelvin (K)

$I=ISC – I0(eqVd/KT -1)$

Using suitable approximations,

$I=ISC-I0(eq((V+IRS)/nnkT) -1)$

Where, I is the photovoltaic cell current, V is the PV cell voltage, T is the temperature (in Kelvin) and n is the diode ideality factor In order to model the solar panel accurately we can use two diode model but in our project our scope of study is limited to the single diode model. Also, the shunt resistance is very high and can be neglected during the course of our study.

The I-V characteristics of a typical solar cell areas shown in the Figure 1.13. When the voltage and the current characteristics are multiplied we get the P-V characteristics as shown in Figure 1.14. The point indicated as MPP is the point at which the panel power output is maximum.

Fig. 9 P-V characteristics curve of photovoltaic cell

Maximum Power Point Tracking Algorithm:

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevinin impedance of the circuit (source impedance) matches with the load impedance. Hence our problem of tracking the maximum power point reduces to an impedance matching problem. In the source side we are using a boost convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like motor load. By changing the duty cycle of the boost converter appropriately we can match the source impedance with that of the load impedance.

Different MPPT Techniques:

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

- Perturb and observe (hill climbing method)
- Incremental Conductance method
- Fractional short circuit current
- Fractional open circuit voltage
- Neural networks
- Fuzzy logic

Fig. 10 Steady-state waveforms with Ub= 72 V, UPV1 = 39 V,

UPV2 =42 V, PPV1 = 150 W, PPV2 = 300 W, and Po = 270 W. (a) Driving voltages of S1 and S3 and currents of inductors L1 and L2. (b) Driving voltage

Of S1, current of Lo, current of transformer primary winding, and voltage between the switching legs.

CONCLUSION AND FUTURE SCOPE:

A systematic method for synthesizing MPCs from FBC and BDCs has been proposed. The switching legs parasitized in the BDCs have been found and shared with the FBC to derive families of FB-BDC-MPCs. The proposed FBBDC-MPCs are capable of interfacing multiple bidirectional sources and isolated output load simultaneously. Single-stage power conversion between any two ports and ZVS of all the active switches have been achieved in the proposed MPCs. All the port voltages are controlled simultaneously by employing PWM and phase angle-shift control scheme. These topologies are good candidates for renewable power systems as interface converters due to their advantages of simple configuration, reduced devices, and easy control. A typical four-port converter developed by the proposed method, named as BB-FPC, is analyzed and implemented as an example, with detailed operation principles, design considerations, modulation, and power management strategies presented. In extension of the project by using the fuzzy controller the multi-port converter

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