

Photovoltaic Based Dc-Dc Multiport Converter with Distributed Generation

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Abstract: The main objective of the paper is The growing concern for energy saving has increased the usage of LED-based Street Lights, Electronic Chokes, Compact Fluorescent Lamps, And Inverter-Fed Drives. Hence, the load profile seen by the electrical grid is undergoing a notable change as these devices have to operate from a dc source. Photovoltaic (PV) being a major energy source, the loads can be connected directly to the dc bus. A grid-connected PV system involves a power source (PV array), a power sink (load), and two power sources/sink (solar and ac grid), and hence, a power flow sharing system is required to balance the power flow among these sources. This method is reduce the burden of input voltage because whenever the solar output reduces then the input voltage share to AC grid so the distribution AC grid and solar panel is takes place

Index Terms: Renewable Energy System, Solar, grid, SEPIC converter.

I. INTRODUCTION

Electrical energy plays a vital role in all our activities. The available conventional energy resources will be depleted in another few decades. The renewable energy resources that will not harm the environment have been steadily growing. AC Grid, which is considered as backbone of power grid is not able to meet the ever increasing load demand and therefore Such a system is referred to as a hybrid power system Much interest has arisen in utilizing renewable energy to curb greenhouse gas emissions and resist climate changes.

Compared with traditional fossil fuels, the renewable energy is more environments friendly and sustainable. However, renewable energy sources such as photovoltaic (PV) solar energy and wind energy rely heavily on the climate and weather Conditions. So, multiple energy sources that are mutually complementary could be combined to maintain continuous power delivery to the load. Photovoltaic conversion of solar energy involves a wide range of knowledge, energy problems, and properties of solar radiation reaching the earth's surface, photovoltaic effect in the p-n junction properties semiconductors which are important in photovoltaic conversion, technology of solar cells, construction of photovoltaic panels modules and arrays, control systems of photovoltaic power station as well as ecological and economic problems of photovoltaic installations. Photovoltaic links together many branches of science and technology. The main scientific goal of photovoltaic is produce solar cells and solar systems with high stability, efficiency and which are economically acceptable.

Photovoltaic systems are designed to perform the following functions they are

- Convert solar energy to direct current electrical energy
- Regulate the electrical energy output
- Feed the electrical energy into an external load circuit to perform work.
- Store the electrical energy in a battery subsystem for later use

BLOCK DIAGRAM

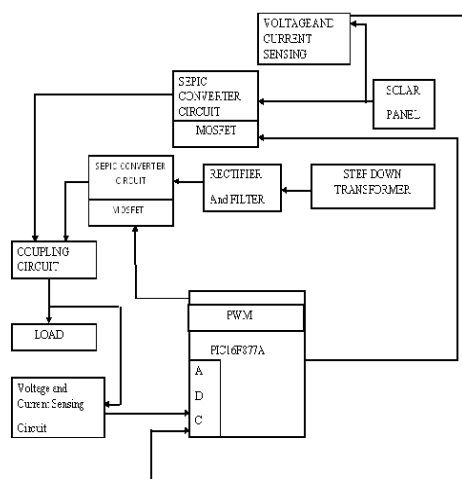


Fig1.1 Block diagram of pv based dc-dc multiport converter with distributed generation

Fig (1.1) shows the block diagram of the proposed system. The input Dc source is 6 V and another input of 6 V from AC grid is fed to the sepic converter circuit the both input voltage getting from AC grid and solar panel is adjustable. The converter circuit produces the output of DC and is fed into the load through coupling circuit.

Then the output is used for various applications such as street light, water heater solar radiation reaching the earth's surface, photovoltaic effect in the p-n junction properties of semiconductors which are important in photovoltaic conversion, technology of solar cells, construction of photovoltaic panels modules and arrays, control systems of photovoltaic power station as well as ecological and economic problems of photovoltaic installations. Photovoltaic links together many branches of science and technology. The main scientific goal of photovoltaic is produce solar cells and solar systems with high stability, efficiency and which are economically acceptable Photovoltaic systems are designed to perform the following functions they are Convert solar energy to direct current electrical energy. Regulate the electrical energy output. Feed the electrical energy into an external load circuit to perform work. Store the electrical energy in a battery subsystem for later use.

II. SEPIC TOPOLOGY

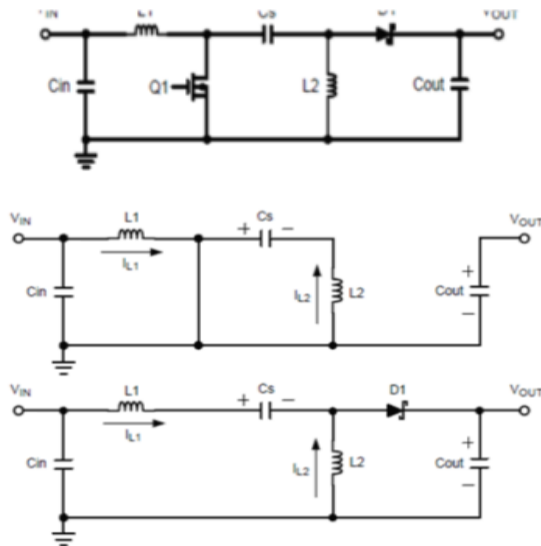


Fig 2 shows sepic topology

Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of cycle of the control transistor

A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit output), and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.

III. DESIGN OF SEPIC CONVERTER CIRCUIT

Here,

V_o = output voltage = 12v

V_s = Supply voltage = 6v

A = duty cycle

F = pavn frequency = 1 kHz

I_{in} = Input current

I_o = output current = 1A

V_d = diode voltage drop = 0.3v

I_{cin} = input capacitor current.

Duty cycle calculation:

$$a = ((V_o + V_d) / (V_s + V_o + v_d))$$

$$a = ((12 + 0.3) / (6 + 12 + 0.3))$$

$$a = 12.3 / 18.3 = 67\%$$

Inductor selection (L_1 , L_2 and L):

A good rule for determining the inductance is to allow the peak-to-peak ripple current to be approximately 40% of the maximum input current at the minimum input voltage. The Ripple current flowing in equal value inductors L_1 and L_2 is given by:

$$I_L = I_{in} * 40\% = ((I_o * V_o * 40\%) / (V_s)) = ((1 * 12 * 0.4) / (6)) = 0.8 \text{ A}$$

$$L_1 = L = ((v_s * a) / (I_L * F)) = ((12 * 0.67) / ((0.8 * 1 * 1000)))$$

$$L_1 = L = ((8.04) / (800)) = 10 \text{ milli henry}$$

Capacitor selection (C_1, C_4):

$$I_{cin} = I_L / \text{root}(12) = 0.8 / 3.46 = 0.23 \text{ A}$$

The input capacitor should be capable of handling the RMS current. Although the input capacitor is not so critical in a SEPIC application, a 10 μF or higher value, good quality capacitor would prevent impedance interactions with the input supply.

$$C_4 = C = 10 \text{ Mf}$$

Capacitor selection (C_2):

$$C_2 = ((I_o * a) / (V_{\text{ripple}} * 0.5 * f))$$

$$C_2 = ((1 * 0.67) / (1 * 0.5 * 1 * 1000))$$

$$C_2 = 1340 \text{ uf}$$

SEPIC coupling capacitor selection (C_1, C_5):

The RMS current of the C_1 is:

$$I_{c1} \rightarrow \text{RMS Current of the capacitor } C_5$$

$$I_{c1} = I_o * \text{root}((v_o + v_d) / \text{and the ripple voltage is, } V_{cs} \square \text{ ripple voltage}$$

$$V_{cs} = ((I_o * a) / (c_1 * f))$$

$C_1 = C_5 = 10 \mu\text{F}$ capacitor is selected.

Diode selection (D_1):

To reduce losses, Scotty diodes should be used. The forward current rating needed is equal to the maximum output current.

$$I_F = I_{OUT}(\text{max})$$

I_F = average forward current of the rectifier diode

$I_{OUT}(\text{max})$ = maximum output current necessary in the application diode

V_F = forward voltage of the rectifier diode

Diode Snubbers:

Snubbers are needed in diode circuits to minimize over voltages. Over voltages Usually occur during turn-off process.

RC SNUBBER CIRCUITS:

RC snubber circuits are normally connected across a switching device to limit the dv/dt . An RC snubber circuit can be polarized or un polarized. Due to the switching characteristics of the MOSFET, a snubber circuit has to be considered to suppress the ringing of the MOSFET during turn ON and turn OFF. This design concentrates on using a RC snubber Let the minimum switching time constant is $T = 1/20 \text{ KHz} = 0.05 \text{ mill seconds}$ Hence the RC should satisfy this time constant i.e $RC=0.05\text{msec}$. Let $C1 = 0.05\mu\text{F}$, then $R1 = 1 \text{ Kilo ohm}$.

DIODE SNUBBERS:

When the current flowing is DC, a simple rectifier diode is often employed as another form of snubber. The snubber diode is wired in parallel with an inductive load (such as a relay coil or electric motor). The diode is installed so that it does not conduct under normal conditions. When current to the inductive load is rapidly interrupted, a large voltage spike would be produced in the reverse direction (as the inductor attempts to keep current flowing in the circuit). This spike is known as an "inductive kick". Placing the snubber diode in inverse parallel with the inductive load allows the current from the inductor to flow through the diode rather than through the switching element, dissipating the energy stored in the inductive load over the series resistance of the inductor and the (usually much smaller) resistance of the diode (over-voltage protection). One disadvantage of using a simple rectifier diode as a snubber is that the diode allows current to continue flowing, which may cause the relay to remain actuated for slightly longer; some circuit designs must account for this delay in the dropping-out of the relay. This delay often leads to greatly decreased life of the relay contacts due to arcing.

IV. SYSTEM ANALYSIS

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it. The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation it is quiet impossible to proceed further. It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complimentary to each other. However computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

A static converter is an electrical circuit which can control the transfer of energy between a generator and a receiver. The efficiency of a converter should be excellent. The components constituting a converter are:

- Capacitors, inductors and transformers with minimum losses,
- Power semiconductors operating as switches. The design of power converter consumes time with a significant cost. Performance is generally determined after testing converters at nominal operating points. Thus, simulation can substantially reduce development cost. The development of specific software dedicated to simulation of power electronic systems (PSIM, SABER, PSCAD, "Sam Power Systems" toolbox of Simulink) allows simulating fast and accurately the converter behavior. Unfortunately, the designers of converters don't always have such available software. In many cases, they have to simulate power electronics devices for occasional need. So they don't want to buy the Sim Power Systems toolbox in addition to Mat lab and Simulink. The purpose of this chapter is to present the ability to simulate power converters using only Simulink.

A. THE ROLE OF SIMULATION IN DESIGN:

Electrical power systems are combinations of electrical circuits and electro mechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation.

Land-based power generation from hydroelectric, steam, or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance objectives.

Sim Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Sim Power Systems uses the Simulink environment, allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and Sim Mechanics share a special Physical Modeling block and connection line interface

B. LINEAR LOAD MODELING IN SIMULINK:

This paragraph deals with the modeling of linear elements commonly encountered in the electrical energy conversion. Elementary linear dipoles are described by a system of linear differential equations. There are several different ways to describe linear differential equations.

The state-space representation (SSR) is the most easy to use with Matlab.

C.INTRODUCTION TO MATLAB:

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses includes

1. Math and computation
2. Algorithm development
3. Data acquisition
4. Modeling, simulation, and prototyping
5. Data analysis, exploration, and visualization
6. Scientific and engineering graphics
7. Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation.

MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems.

Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

D. SIMULATION DIAGRAM OF PV PANEL:

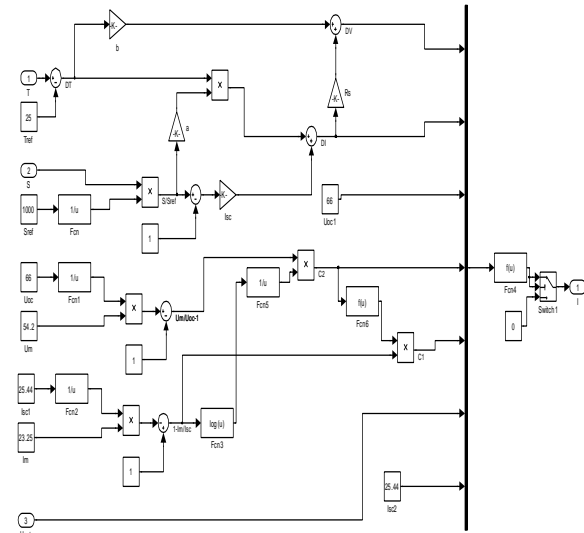


Fig 4.1 simulation circuit of PV Panel

Figure 4.1 shows the design calculation of solar panel. The pv panel function is to generate voltage for that purpose need the brightness and temperature. so in order to change the temperature and brightness the output of the panel also changes.

These design calculations and circuit diagrams are show above.

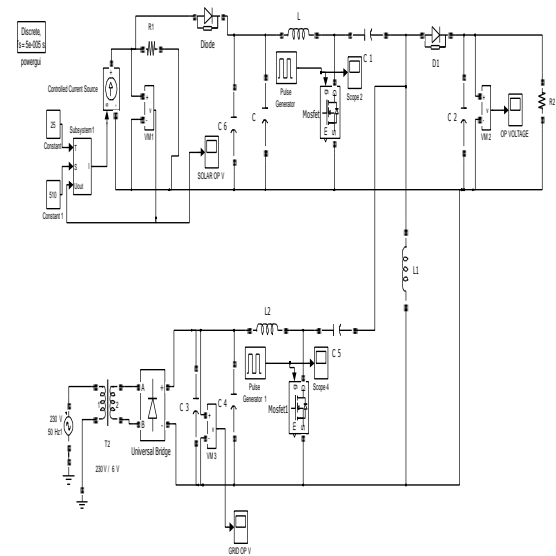


Fig 4.2 Simulation circuit of p v based dc-dc multiport-converter with distributed generations-Open Loop Control

Fig 4.2 shows the diagram of simulation of PV based dc-dc multi-port converter with distributed generation. The input of the system is PV panel then the output of the 6volt is fed into the converter. Then the PWM output also fed to the device. Similarly the output of ac grid also connected through the coupling device. If any voltage variations then the output is shared and distributed to solar and ac grid device. Then then the final output is available in 12v.

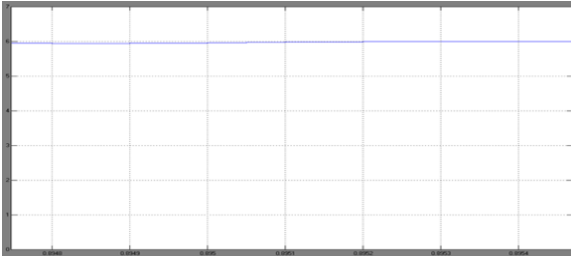


Figure 4.3 shows the output of solar panel output voltage. Figure 4.3 shows the output of solar panel output voltage. Take y-axis in voltage and x axis in time.

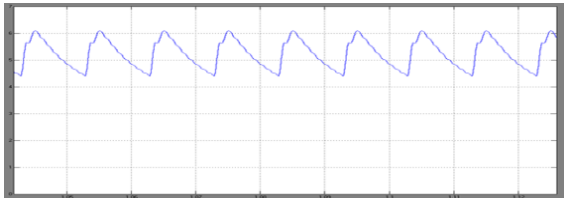


Fig 4.4 simulation output of Ac grid

Figure 4.4 shows the output of AC grid system. Take x-axis in time y axis in voltage

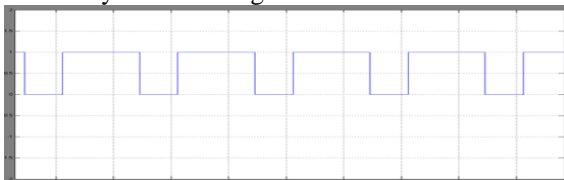


Fig 4.5 Simulation output of PWM

Figure 5.5 shows the output of simulation diagram of pulse width modulation. Take x-axis is represented as time and y-axis is voltage

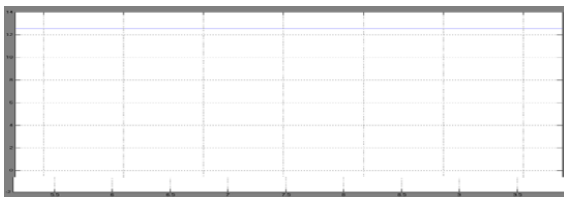


Fig 4.6 Output voltage of proposed system connected to Ac grid and solar panel

Fig 4.6 shows diagram of output voltage of a PV based dc-dc multiport generated distribution System. The simulation shows the final output voltage of sharing of ac grid and photovoltaic system.

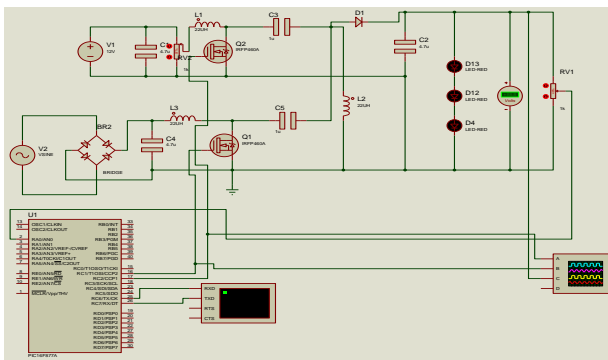


Fig 4.7 shows the diagram for proposed system in proteus software

Figure 4.7 shows the proteus software diagram of pv based multiport DC – DC converter with distributed generated systems. It is used to shows the output in animation. Here the input voltage is 12 volt and it produces the voltage of 24 volt. ADVANTAGES:

It is applicable to all renewable energy sources.

- Switching losses are low.
- Small size.
- Low cost.
- High efficiency.
- It has a storage system.
- Speed of operation is high

APPLICATIONS;

- Home appliances.
- Automobile industry(Vehicle lamp)
- Industries
- Street light
- AC grid

V. CONCLUSION

This project has presented the procedures for a the growing concern for energy saving has increased the usage of LED-based street lights, electronic chokes, compact fluorescent lamps, and inverter-fed drives. Hence, the load profile seen by the electrical grid is undergoing a notable change as these devices have to operate from a dc source. Photovoltaic (PV) being a major energy source, the aforementioned loads can be connected directly to the dc bus. A grid-connected PV system involves a power source (PV array), a power sink (load), and two power sources/sink (solar and ac grid), and hence, a power flow sharing system is required to balance the power flow among these sources. The Basic circuit and modified circuit elements are designed using relevant equations. The simulation circuits are developed using elements of Simulink library. The Simulation is successfully done and open loop simulation results are presented.

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