Implementation of Closed loop Boost Converter for a Solar Panel

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Abstract: Due to the decline in power of photovoltaic module as a result of changes in irradiation which affect the photovoltaic module performance, the design and implementation of closed loop DC-DC boost converter operating in continuous conduction mode using a 555 timer circuit to generate Pulse Width Modulation (PWM) signal to established a constant output voltage was proposed. This paper presents the design and implementation of high performance closed loop Boost converter for solar powered for lighting load. The proposed system consists of solar photovoltaic module, a closed loop boost converter and LED lighting module. The closed loop boost converter is used to convert a low level dc input voltage from solar PV module to a high level dc voltage required for the load. To regulate the output of the converter, closed loop voltage feedback technique is used. The feedback voltage is compared with a reference voltage and a control signal is generated and amplified. The amplified signal is fed to 555 Timer which in turn generates a PWM signal which controls the switching of MOSFET. Thus by switching of MOSFET it would try to keep output as constant. Initially the boost converter, timer circuit, amplifier circuit and LED light circuits are designed, simulated and finally implemented in printed circuit board. The simulation studies are carried out in MULTISIM. The experimental results for solar PV and boost converter obtained in both software and hardware are presented here.

Index terms-solar panel simulator, dc-dc boost converter, 555 Timer, 741 op amp Lighting loads.

I. INTRODUCTION

Renewable energy sources play an important role in electricity generation. People are finding the benefits of having their own renewable energy system more attractive than they ever had before. Specially, energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. The merits of solar PV system are cleanliness, relative lack of noise or movement, as well as their ease of installation and integration when compared to others. On average the sunshine hour in India is about 6hrs annually also the sun shine shines in India for about 9 months in a year. Electricity from the sun can be generated through the solar photovoltaic modules (SPV). The SPV comes in various power output to meet the load. However, the output power of a PV panel is largely determined by the solar irradiation and the temperature of the panel. At a certain weather condition, the output power of a PV panel depends on the terminal voltage of the system. To maximize the power output of the PV system, a high efficiency, low-cost DC/DC converter with a voltage feedback signal is commonly employed to control the terminal voltage of the PV system at optimal values in this paper presents the design and the proposed system consists of solar photovoltaic module, a closed loop boost converter and lighting module. The closed loop boost converter is used to convert a low level dc input voltage from solar PV module to a high level dc voltage required for the load. To regulate the output of the converter, closed loop voltage feedback technique is used. The feedback voltage is compared with a reference voltage and a control signal is generated and amplified. The amplified signal is fed to 555 Timer which in turn generates a PWM signal which controls the switching of MOSFET. Thus by switching of MOSFET it would try to keep output as constant. Initially the boost converter, timer circuit, amplifier circuit and LED light circuits are designed, simulated and finally implemented in printed circuit board.

II. OVER VIEW OF PHOTO VOLTAIC ARRAY

Photovoltaic cell also known as solar cell is used to convert energy from the sun directly into electrical energy without any form of rotational parts. Photovoltaic cells represent the basic fundamental power conversion unit of photovoltaic system. These cells are made from semiconductors and like any other solid-state electronic devices e.g diode, transistors and integrated circuit, they have similar behavior. Photovoltaic cells are usually arranged into modules and array when applied practically [6]. There are different types of photovoltaic cells available on the market and yet different other types of cells are under development e.g. dye- sensitized N and-crystalline cells. The reason for different types of photovoltaic cell, materials and structure is to extract maximum power from the cell and to maintain cost to a minimum. According to [6] efficiency above 30% have been achieved in laboratory and efficiency of practical application is usually less than half of this value. Crystalline silicon technology is well established and its cell is more expensive but still controls a major part of the photovoltaic market with efficiency approaching 18%. Other types of
photovoltaic cells like amorphous thin films are less expensive but with disadvantage of poor efficiency. There are several factors that affect the electrical Performance of a photovoltaic module from operating at optimal operating point. These factors are (1) Sunlight intensity/irradiation (2) Cell temperature (3) Load resistance and (4) Shading and the use of photovoltaic array and maximum power point tracker (MPPT) to curb these challenges are developing rapidly.

III. OVERVIEW OF DC-DC CONVERTER

DC-DC conversion technology is a major subject area in the field of power electronic, power engineering and drives. The conversion methods have application in industries such as telecommunications, automotive, renewable energy, research etc and have gone under series of developmental stages for more than sixty (60 years). This conversion technique is widely adopted in industrial application and computer hardware circuits. The ideas of DC-DC conversion technique and development have been on for over 80 years. The simplest DC-DC conversion technology is a voltage divider, potentiometer and so on. But the effect of these simple conversion techniques resulted in poor efficiency due to fact that transfer output voltage is lower than the input voltage. According to [7], there have been more than 500 prototypes of DC.

A. BOOST CONVERTER ANALYSIS

The designed DC-DC boost converter is connected between the photovoltaic module and the load so as to enable the module operates at maximum power at all time. Boost converter is made of up four elements as shown below in figure 1, they include the inductance, diode, capacitor and M0SFET. As the name of the converter implies, it steps up the input voltage which makes the output voltage greater than the input voltage. The converter is control through the MOSFET which act as a switch. The ON and OFF of the switch (MOSFET) controls the output voltage by changing the voltage of the inductance so as to enable the photovoltaic module power the load at maximum voltage. The operation of the converter is analyzed in different operating condition. The operation of the converter is analysis in continuous conduction mode.
IV. DESIGN APPROACH LOAD REQUIREMENT

A DC/DC closed loop boost converter with LED lighting load is designed in NI-Multisim (Version -11) and simulation characteristics are verified. The input is taken from solar panel which is equivalently represented as DC power supply in the diagram. The output of the solar panel can vary from 10 to 18 volts. So in order to regulate the output voltage for the variation in input a closed loop voltage feedback technique is used. In which a reference voltage is generated using a potential divider at the output of the converter. The 10 percent of total output of the boost converter is generated by using a voltage divider and is compared to a reference voltage. A voltage divider consists of two resistors; one resistor is 10% of another one. So the voltage generated at this resistor is 90% of the total load voltage. This voltage is compared with a reference voltage whose value should be 9% of 24 i.e. 2.18 volts (by equation X) and this difference was amplified with gain of 100 and this amplified output will drive 555 timer, thereby generating a PWM wave of 50 percent duty cycle.

555 timer is fed to the gate terminal of the power MOSFET. This pulse in turn will control the switching of the MOSFET based on its switching frequency; here it is designed for a switching frequency of 219 kHz. Thus when pulse is at high level the MOSFET would be in saturation mode thereby making switch ON condition.
REFERENCES


