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CUK Converter in Optimal Power Management of Smart Grid using PV System

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Abstract- **In this project Photo Voltaic (PV) cell which is a direct method of generating electricity using solar energy is used. This project is concerned with the optimal management of power in residential areas by using the energy generated by the PVC when it is in full swing operation. By doing so the energy which is consumed under normal conditions that is electricity from the grid, a nonrenewable source of energy (FOSSIL FUELS) can be saved. The main idea of this project revolves around the fact of saving electricity from the grid which is nonrenewable source of energy to the maximum by generating electricity using PVC that generates electricity using solar energy. But even by using PVC to generate electricity there is a small issue regarding the spillage or leakage that occurs. This spillage by using a CUK converter in the circuit which boosts the voltage generated by PVC to the required level of the voltage.This project is proposed to design a CUK converter for photovoltaic (PV) system using microcontroller.**

Keywords:PVC (Photo voltaic cell) , PIC (Peripheral Interface Controller), MOSFET (Metal Oxide Semiconductor Field Effect Transistor)

1. INTRODUCTION& OVERVIEW

1.1 Overview

In the recent years, the development of renewable energies is increasing rapidly. Solar PVC has become alternate for both the industrial and residential power production. Now a days country's major power production is based on the availability of the coal. Most of the plants are operating at 70 % capacity only. To improve the capacity utilization without building the new plants means solar PVC's is the only way to cascade with the thermal power plants. Now country coal production rose from 2 million tons to 562 .8 million in the year 2013. So from the above data, consumption of coal become increasing day by day .Statistics shows that coal may be depleted in 30 years . By focusing on renewable energy sources solar PV is the best methodology to implement at thermal power stations to improve the efficiency of the power plant.

Solar power plants are pollution free and energy is last up to billions of years. It will be used in the remote areas where it is too expensive to extend the electricity power grid. By controlling the Grid connected non –renewable energy by using solar energy to reducing consumption of coal every day.

The CUK converter is designed to step up solar panel voltage to a stable 12V output. It is controlled by a microcontroller unit using voltage-feedback technique. The output of the CUK converter is measured continuously and the values are sent to the microcontroller unit to produce pulse-width-modulation (PWM) signal.

The PWM signal is used to control the duty cycle of the cuk converter. Typical application of this cuk converter is to provide DC power supply for inverter either for grid-connected or stand -alone system. The amount of boosting required as well as the automatic switching of the relays between the two sources of power is achieved with help of PIC16F877A microcontroller interfaced with Matlab software.

1.2 Block Diagram

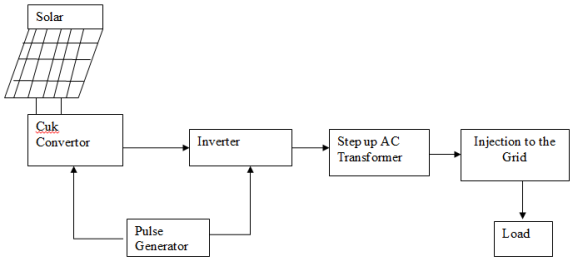

Fig 1 . Block diagram

II.MODELING OF CUK CONVERTER

Figure 1 shows the PV powered cuk converter connected to the load. The PV array output is adjusted by the Cuk converter. The current equation for the solar cell is given by

$$i = i_p - i_d \left(e^{qv/Kt} - 1\right)$$

$i = i_p - i_d$

Where

i_p = The photo current

i_o= The reverse saturation current

q = The electron charge

K = The Boltzmann constant

i_d = The diode current

T = The solar cell operating temperature

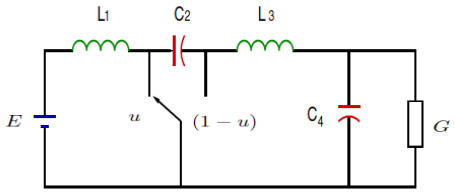

Fig 2 . CUK converter circuit

CUK converter is most familiar converter in Regulating DC power supplies .It is used to invert the polarity of the input voltage and to step up or step down input voltage. It has very Low ripples due to inductor loops in input and output side of the circuit diagram.

CUK converter has the combined advantages of the buck, boost and buck-boost converters. CUK converter act as a current –voltage –current converters. The switching loss is comparatively very low than the other converters, because it has a less number of switches. It is the very simple converter with high reliability and it is easy design. Especially CUK converter gives more efficiency in solar power conversion. The design procedure of this converter will be discussed in following sections

2.1 Features of Cuk Converter

1. Continuous input Current

2. Continuous output Current

3. Input Voltage can be either greater or less than output voltage

The averaged model of the DC–to–DC Cuk converter ´shown in Fig is given by the equations

$$L_1 \frac{d}{dt} i_1 = -(1-u)\, v_2 + E$$

$$C_2 \frac{d}{dt} v_2 = (1-u) i_1 + u i_3$$

$$L_3 \frac{dy}{dx} i_3 = -u v_2 - v_4$$

$$C_4 \frac{d}{dt} v_4 = i_3 - G v_4$$

Where

i_1 – current through the inductor L_1

i_3– current through the inductor L_3

v_2 – voltage across the capacitor C_2

v_4 – voltage across the capacitor C_4

G – load admittance

E – source voltage

U – slew rate of the PWM

2.2 Advantages of cuk converter over Buck-boost converter

1. Cuk converter uses L-C filter, so peak –peak ripple current of inductors are very less as compared to the Buck-Boost converter.

2. In CUK converter, when switch is closed, source from the capacitor is supplied to the load and the inductive filter. But in the buck-boost converter, source is disconnected from the load.

III. SYSTEM DESCRIPTION

3.1 MOSFET

The component that is used as the switch in the inverter unit is the MOSFET which is a voltage controlled device. They are the power semiconductor devices that have a fast switching property with a simple drive requirement.

V_{dss}= 500 V

Rds (on) = 0.27 ohm

Id= 20 A

Mosfet is a device with a best combination of higher switching speeds, low cost and on state resistance. This package is preferred for commercial and industrial applications where higher power levels are to be handled.

3.2 ADVANTAGES OF MOSFETs OVER BJT

Being the majority the power MOSFET does not have the built of excess carrier concentration that controller of the dynamic behavior of the BJT. The fast switching times of the MOSFET is very little with temperature as opposed to that of BJT.

The higher switching speed of the MOSFET also gives lower switching losses. Unlike the BJT which is current controlled, the MOSFET is a voltage controlled and its high input impedance results in low driver requirements. Also the secondary break down phenomena is absent in MOSFET due to their positive temperature coefficient of resistance

3.3 CURRENT RATING OF MOSFETs AND DIODES

Let the rms value of the line current of the load be I_L Therefore

I_L =square root of (2/3)*I

I_{rms}MOSFET= I_{rms}diode = 0.707 I_L

3.4 VOLTAGE RATING OF MOSFET'S

It is easily seen that the peak forward blocking as well as the peak reverse voltage on the MOSFET is equal to the maximum capacitor voltage. Hence the voltage rating of the thyristor is equal to V_{co}.

IV. CONTROLLER DESCRIPTION

4.1 PIC16F877MICROCONTROLLER

High-Performance, Enhanced PIC Flash Microcontroller in 40-pin. In this project, PIC16F877 microcontroller is used as a main controller. The output of the CUK converter is fed to the microcontroller .the micro controller generates the pulses for the CUK converter and the voltage source inverter .voltage feedback technique is used in the circuit for the further process.

4.2 ADVANTAGES

The 16F877A is one of the most popular PIC microcontrollers and it's easy to see why - it comes in a 40 pin DIP pin out and it has many internal peripherals. The 40 pins make it easier to use the peripherals as the functions are spread out over the pins. This makes it easier to decide what external devices to attach without worrying too much if there pins to do the job One of the main advantages is that each pin is only shared between two or three functions so its easier to decide what the pin function (other devices have up to 5 functions for a pin).

V. TABLE DESCRIPTION

5.1 Table 1

Design values of CUK converter

S.No	Parameters	Design Values
1	V_{in}/v_{out}	12/65 V
2	R_L	1Ω-10Ω
3	f_s	100 KHZ
4	L_1	5mH
5	L_2	5mH
6	C_1	47 µF
7	C_2	10 µF
8	Output ripple	3-5 %

The following equations are used to design the Cuk converter:

$$\Delta I_1 = \frac{Vdc\ D}{L1\ f}$$

$$\Delta I_2 = \frac{Vdc\ D}{L2f}$$

$$\Delta V_{c2} = \frac{Is(1-D)}{C1f}$$

$$\Delta V_{c1} = \frac{\Delta I2}{8C2f}$$

f is the switching frequency of the MOSFET Switch.

VI.SIMULATION & OUTPUT WAVEFORMS

6.1 SIMULATION RESULTS

In this chapter , overall circuit diagram was simulated using MATLAB and simulated results are shown below,

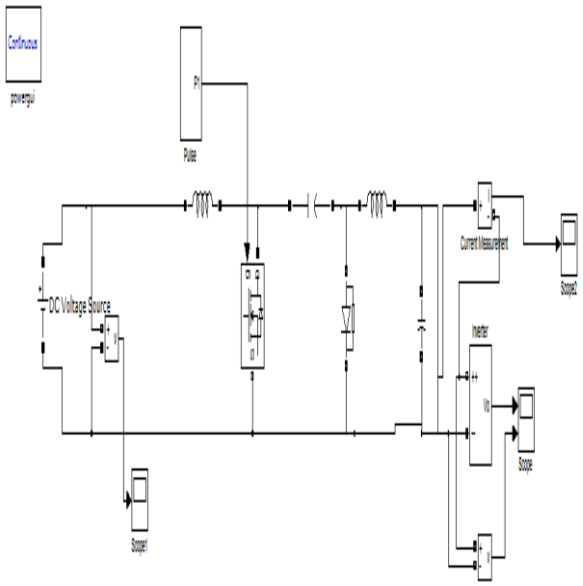

Fig 3.Simulation of cuk converter and VSI

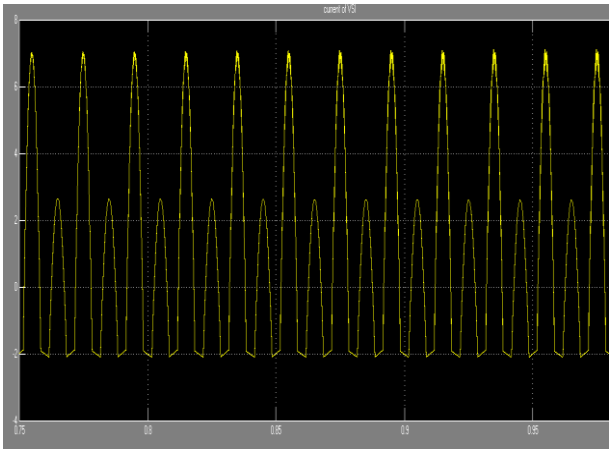

Fig 4 .Output of CUK converter

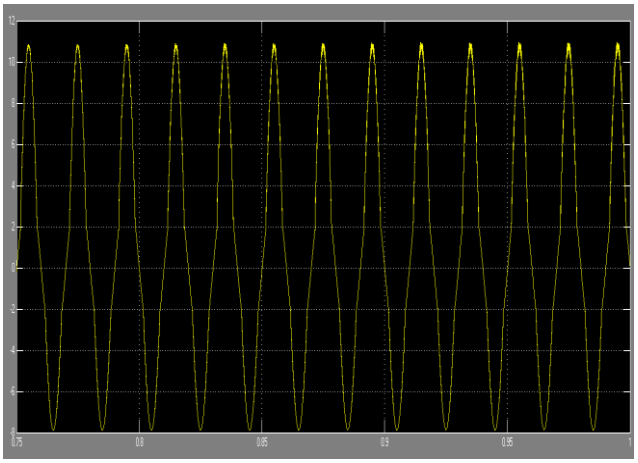

Fig 5 AC output of the inverter which is boosted depending upon the input of the solar panel

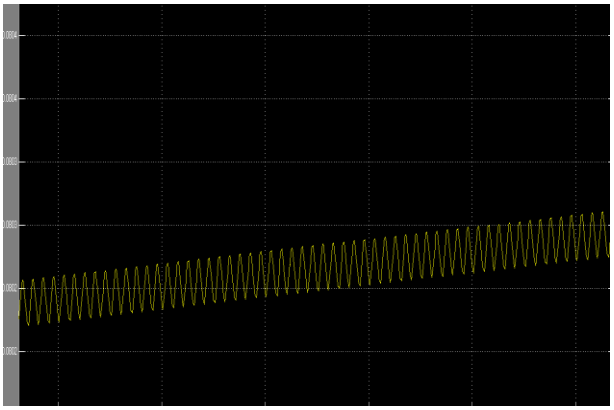

Fig 6 This image shows the charging of the capacitor present in the CUK converter which is gradually increasing

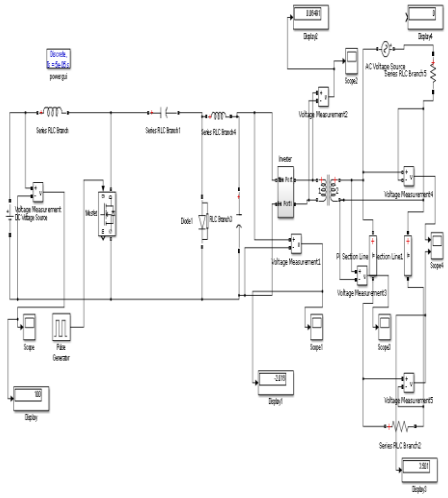

Fig 7 Simulation of the entire system

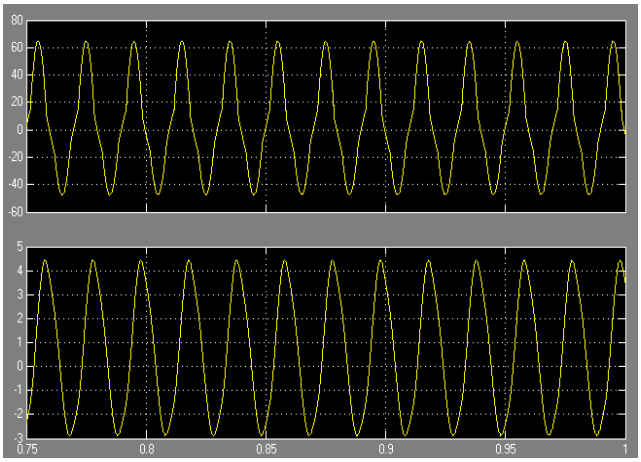

Fig 8 Final output of the system using the step up transformer

CHAPTER 7

7.1 Conclusion

The cuk converter boosts up the voltage there by providing an output voltage depending on the input solar energy and the action of giving the triggering pulse to the MOSFET switches used is done controlled using the PIC 16F877A microcontroller. The input solar energy is boosted using a CUK converter to a level depending on the input solar energy. This boosted voltage is then given to the injection grid. These activities are analyzed and executed through simulation using the matlab software. The main advantage of this is that by doing so we are able to reduce the burden of thermal power plant in the way of intimating the power plant as to how much coal has to be used based on the input solar energy. We all know that coal is non- renewable source of energy because there is a lot of probability in the near future for such source of energy to get depleted. Therefore by using this method we will able to conserve as much coal as possible to the maximum extent because saving even little amount of coal now can make a major difference in the future.

REFERENCES

(1) YuanxiongGuo,MiaoPanandYuguang Fang, "Optimal Power Management of Residential Customers in the Smart Grid, *"Proceedings of the IEEE*, 2012.
(2) A. Bellini, S. Bifaretti and V. Iacovone, 2008. "Resonant DC-DC converters for photovoltaic energy generation systems," in *Proc. Power Electronics, Electrical Drives, Automation and Motion*,pp. 815-820.
(3) E. Koutroulis, K. Kalaitzakis, and Nicholas C. Voulgaris, 2001. "Development of a microcontroller based, photovoltaic maximum power point tracking control system," *IEEE Trans. Power Electronics*, vol. 16, no. 1, pp. 46-54.
(4) V. Vittal, "The impact of renewable resources on the performance and reliability of the electricity grid," U.S. National Academy of Engineering, 2010. Available: http://www.nae.edu/Publications/Bridge/TheElectricityGrid/18587.aspx
(5) P. Ribeiro, B. Johnson, M. Crow, A. Arsoy, and Y. Liu, "Energy storage systems for advanced power applications," *Proceedings of the IEEE*, vol. 89, no. 12, pp. 1744 –1756, December 2001.
(6) B. Roberts and C. Sandberg, "The role of energy storage in development of smart grids," *Proceedings of the IEEE*, vol. 99, no. 6, pp.1139 –1144, June 2011.
(7) R. Anderson, A. Boulanger, W. Powell, and W. Scott, "Adaptive Stochastic control for the smart grid," *Proceedings of the IEEE*,vol. 99, no. 6, pp. 1098 –1115, June 2011.
(8) T. F. Wu, and Y. K. Chen, 1998."Modeling PWM DC/DC converter out of basic converter units,"*IEEE Trans. Power Electronics*, vol. 13, no. 5, pp. 870-881.
(9) Athimulam, K. and S.D. Subharensu, 2010. Simulation of closed loop controlled boost converter for solar installation. Serbian J. Electr. Eng., 7(1): 121-130.
(10) Tse, K.K., M.T. Ho, H.S.H. Chung and S.Y. Hui, 2002. A novel maximum power point tracker for PV panels using switching frequency modulation. IEEE T. Power Electron, 17(6): 980-989.