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Design of CUK Converter for Solar Panels Using PID Controller

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ABSTRACT:-Constant and required level of output voltages are important features of DC-DC converters. This paper describes CUK converter using PI controller for PV Application. Modelling of CUK converter operating in continuous conduction mode using state space averaging technique. There are so many methods for tuning the PID controller gain specification and to find the best tuning method is a difficult task. But a method is not generalized for other system it's just best for a given application. Hence for different application there may be different methods of tunings for better results. Interest in solar power as a cheap and clean source of electrical power is increasing these days. A lot of research is released in the field of extracting electrical power efficiently from solar power using photovoltaic (PV) solar cells.

The CUK converters that are designed based on their mathematic models. MATLAB /SIMULINK is used to model the power converters as open loop and closed loop control systems. The simulation results of proposed PV systems shows that these converters can provide the required output voltage.

Keywords – DC-DC Converters, CUK converters, PID controller, switched mode power supply, PV panel, Open loop and Closed loop systems, MATLAB/SIMULINK.

I. INTRODUCTION:

Now a days power electronic devices areplaying a very important role in electrical and control system. Considering the capability of the devices many industries are utilizing these devices to improve the efficiency of the system .In this updated technology we require circuit like lightweight, high storage capacity, reliable and efficient power supplies based on the voltages and current divider are in efficient.

The several practical and industrial applications of power electronics based CUK converters are used in hybrid electric vehicles, renewable energy system, electronic voltage regulators etc.,to provide required voltageregulation between the input DC and output DC for the better result of all these kind of practical applications, it seeks a quick and stable response from a CUK converter along with regulated DC output magnitude. By using the closed loop PID(proportional integral derivative) controller it can be controlled . By using the PID controller the efficiency of the overall converter depends on how well thePID controller has been tuned.

There are so many methods for tuning the PID Controller gain specification and to find the best tuning method is difficult task. Hence for different application there may be different methods of tuning for the better result.So basically this project is performed on MATLAB software where the PID controller can be tuned by several methods and compare all of them and taken out the best result for the CUK converter control application,with the help of time domain performance model and frequency domain stability model.

The CUK converter is redesigned to have low switching losses reducing size of the components that have been used with boosted overall efficiency reducing voltage and current stress on element to have constant supply from the solar panel .CUKconverter is also provided with feedback loop where the output can be adjusted automatically which helps the system stability against voltage fluctuation, voltage regulation.

The new three-phase inverter is convenient for PV applications where continuous input currents are required for maximum power point tracking operation.The CUK converters that are designed based on their Mathematic models.MATLAB/SIMULINK is used to model the power converters as open loop and closed loop control systems.

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The basic structure, control design and MATLAB/SIMULINK results are presented.

II. METHODOLOGY:

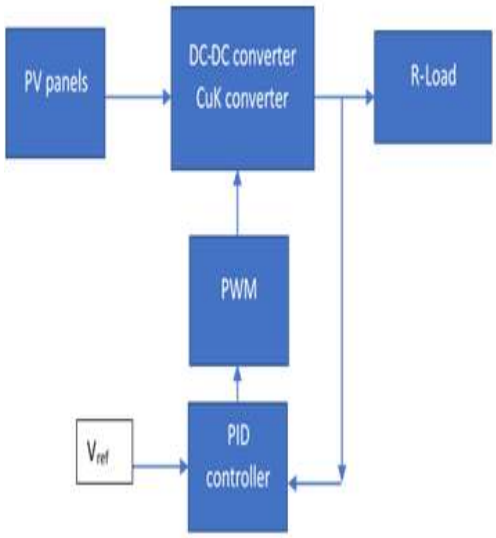

Fig.1:Block diagram of CUK converters for solar panels using PID controller

The PV panel can supply only a specific power. PV array should have 1000 irradiance, only then it will work. The setting here is 120W, that is 12V and 10A rating. So the reference voltage (V_{ref}) should be adjusted, which is to be maintained at the PV panel. The V_{ref} which is set will be measured from PV panel and the error voltage will be converted as a PWM signal. This signal is given to the CUK converter.

The equations of CUK converter are as follows:

Duty cycle of CUK converter:

$-V_o/V_s=D/1-D$ (1)

Where,

V_o- Output Voltage

V_s- Source Voltage

D- Duty Ratio

$L_1=V_s*D/\Delta iL_1*f$ (2)

$L_2=V_s*D/\Delta iL_2*f$ (3)

$C_1=V_0*D/R*\Delta Vc_1*f$ (4)

$C_2=1-D/8L_2(\Delta V_0/V_0)f_2$(5)

Calculations:

V_s-Source voltage=29 V

Vo-Output voltage=48V

F=20KHz.

I_0-Output current= 1A

Power $=V_0*I_0=$ 48V

$(-V_s/V_0)=D/1-D$

$D=1/(V_0/V_s)+1$

$D= -V_s/V_0+(-V_s)$

D=29V/29V+48V=0.62.

III. CIRCUIT DIAGRAM:

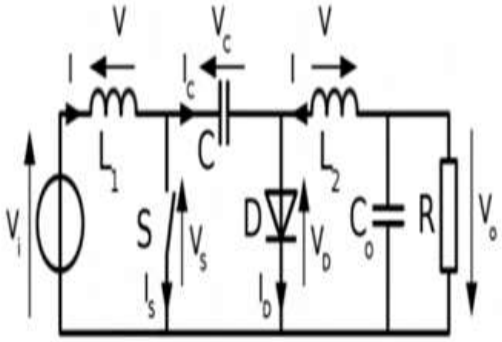

Fig.2: Basic circuit diagram of CUK converter

The circuit consists of DC input voltage source V_S, input inductor L_1, controllableswitch S, energy transfer capacitor C1, diode D, filter inductor L2, filter capacitor C,and load resistance R.

The basic CUK converter circuit consists of two modes (Mode 1 and 2).

Mode 1: When the switch is open:

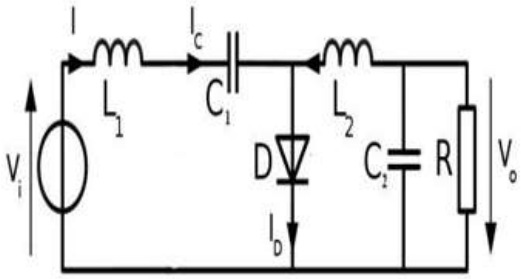

Fig 2.1: Circuit diagram when the switch is open

When the switch S is open, the inductor currents I_{L1} and I_{L2} flows through the diode. Capacitor C_1 is charged through the diode by energy from both the input and L_1. Current I_{L1} decreases, because V_{C1} is lesser than V_d. Energy stored in L_2 feeds the output. Therefore, I_{L2} also decreases.

Mode 2: When the switch is closed:

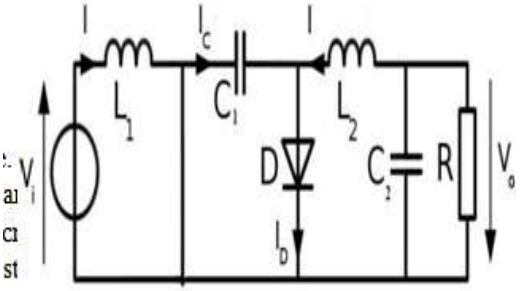

Fig 2.2: Circuit diagram when the switch is open

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When the switch S is closed, V_{C1} reverse biases the diode. The inductor currents I_{L1} and I_{L2} flows through the switch. Since $V_{C1} > V_O$, C_1 discharges through the switch and transfers energy to the output and L_2. Therefore, I_{L2} increases. The input feeds energy to L_1 causing I_{L1} to increase.

The power converterhas been classified into two control systems:

a) Open loop control systems
b) Closed loop control systems

(a) Open loop CUK converter:

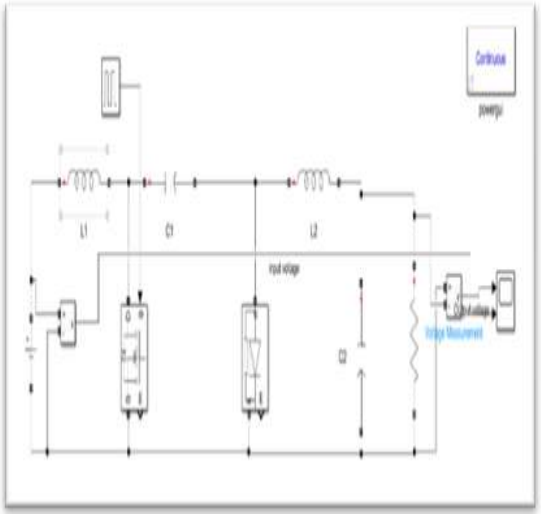
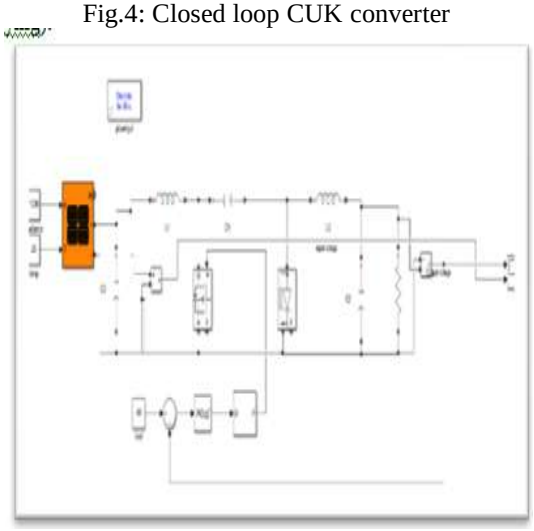


Fig.3: Open loop CUK converter

(b) Closed loop CUK converter:

Fig.4: Closed loop CUK converter



The figures (a) and (b) shows the open loop and closed loop CUK converter.

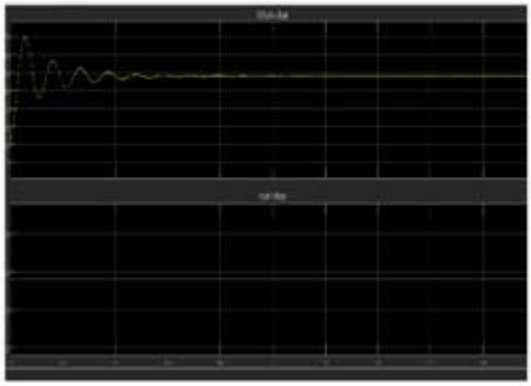
The equations which are given above are substituted with the values and the obtained parameters are,

Input/source voltage=29V(for open loop it is constant and for closed loop it is varying).

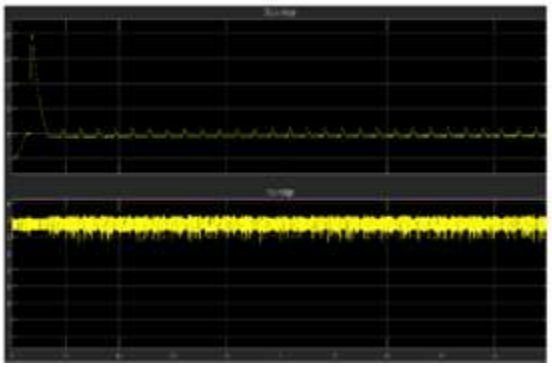
Output voltage= - 48V
Duty cycle= 0.37
L1 and L2=0.05 H and 0.05 H
C1 and C2=0.77 F and $3.937*10^{-7}$ F

IV. RESULTS:

(a) SIMULATION OUTCOME OF OPEN LOOP CUK CONVERTER



(b) SIMULATION OUTCOME OF CLOSED LOOP CUK CONVERTER



V. CONCLUSION:

Simulations were carried out in MATLAB environment and results were verified for the set voltage. The gains of the PID controller are turned for the power converters to achieve the desired output. The open loop CUK converter simulation results having transients in the voltage and current. PID controller has been used to reduce transients. Using Manual method the PID controller has been designed. Replacing battery by PV panel the closed loop characteristics have been obtained.

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