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ANALYSIS OF PV FED MODIFIED CUK CONVERTER WITH INCREMENTAL CONDUCTANCE MPPT CONTROL

N.LAKSHMIPRIYA , K.ARULPRABHA

***Abstract*—** The most reliable and efficient renewable source of electrical power generation is the solar energy. The solar photovoltaic panels can give the effective electrical power output. Solar photo array has variable power production based on irradiance and temperature of the solar cell. To control the output, the modified Cuk converter with the incremental conductance maximum power point tracking is used. In the existing system, the Cuk converter is used. It cannot offer the steep step up and step down of the line voltage. In the proposed system, modified Cuk converter with the incremental conductance maximum power point tracking is used. The modified Cuk converter is used to enhance the voltage level of the DC output from solar photovoltaic panel. The maximum power point tracking is an algorithm to obtain the maximum power from the solar panel effectively. The appropriate performance of the proposed system is verified and simulated by using MATLAB.

***Keywords* --** Solar energy, modified CUK converter, incremental conductance maximum power point tracking, generated voltage.

I. INTRODUCTION

Energy consumption is tending to grow continuously. Now a day's conventional energy sources are depleting rapidly and renewable energy sources are becoming more popular. Renewable energy comes from the natural resources such as solar, wind, ocean and geothermal. The surface of the earth receives about 10^{14} kW from sun in the form of solar energy which is approximately five orders of magnitude greater than that currently being consumed from all resources.Energy consumption is tending to grow continuously. Now a day's conventional energy sources are depleting rapidly and renewable energy sources are becoming more popular. Renewable energy comes from the natural resources such as solar, wind, ocean and geothermal. Power electronics plays a significant role in solar power production. It consists of switches, converters and controllers. DC-DC converters are used to boost the voltage level. So that maximum energy can be extracted from source to load. Cuk converters are the combination of buck and boost converters. Cuk converters can be used for power factor correction. In this analysis, Modified Cuk converters are used to enhance and step up the voltage extracted from the solar panel. It is necessary to use controllers for the stability and improved performance of the converter.Maximum power point tracking is the control used here to track the maximum power extracted from the solar panel. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

N.Lakshmipriya , Assistant Professor, Department of EEE, Jay Shri Ram Group of Institutions.

K.Arulprabha , PG Scholars, Department of EEE, Jay Shri Ram Group of Institutions.

II. OBJECTIVE

As the solar power is abundant than any other renewable resources, it is important to make use of the solar power effectively. The suitable converter should be used to enhance the DC voltage output of the solar panel. As the atmospheric conditions changes day to day, we are in need to get high accuracy even under the rapidly varying atmospheric conditions. So it is important to monitor both the current and voltage response. The tracking method should also be simple, reliable and effective.

III. PRINCIPLE AND WORKING OF MODIFIED CUK CONVERTER

Among all the existing topologies, Cuk, sepic and buck boost converters offer the chance to have either higher or lower output voltage, compared with input voltage. Buck-boost configuration is cheaper than Cuk, but some limitations such as discontinuous input current, pulsated output current, high peak currents in power components and poor transient response make it less efficient. As like buck boost converters, sepic converter is also having a pulsating output current. It requires higher current handling capability capacitor at the output side. Alternatively, Cuk converter does not have this disadvantage. But it has low switching losses and maximum competence among non-isolated DC-DC converters. It can also offer a better output current trait because of the inductor on the output stage. Hence, Cuk configuration is an appropriate converter to be employed in designing the MPPT. Cuk converter is actually the cascade combination of a boost and a buck converter. Cuk converter has the following advantages such as continuous input current, continuous output current and output voltage can be either higher or lower than the input voltage But, Cuk cannot offer a steep step-up and step-down of the line voltage, as needed by several sophisticated applications. To offer a high voltage conversion ratio, the fundamental converters would have to operate with a higher value of the duty cycle that is higher than 0.9 in voltage-step-up converters, smaller than 0.1 in voltage-step-down converters. An extreme duty cycle impairs the competence and enforces obstacles for the transient response. Moreover, in order to create such an extreme duty cycle, the control circuit must include a fast and expensive comparator. Hybrid converters can be constructed by inserting either the step-down switching blocks Dn1, Dn2, or step-up switching structures UP2, UP3, in a classical Cuk converter. Simple switching dual structures, formed by either two capacitors and 2–3 diodes, or two inductors and 2–3 diodes are defined.

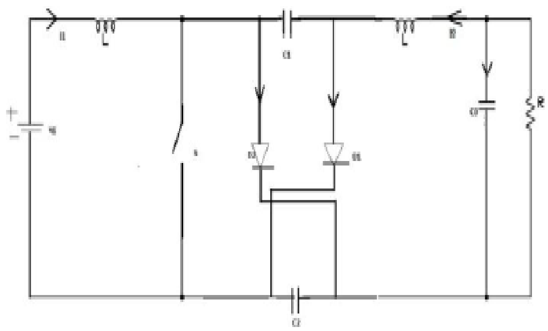

Figure 1 Circuit Diagram of Modified Cuk Converter

The working of modified Cuk converter involves two modes of operations. Modified Cuk converter can be constructed by inserting either the step down switching blocks Dn_1, Dn_2 or step up switching structures UP2, UP3, in a conventional Cuk converter. Simple switching dual structures formed by either two capacitors and two diodes, or two inductors and two diodes as shown in above figure.

In mode I, the switch S is in ON state. The current through the input inductor rises and the input capacitor reverse biases the diodes and makes it open circuit. The input capacitor discharges its stored energy to the circuit formed by the input capacitor, the output capacitor, load and the output inductor.

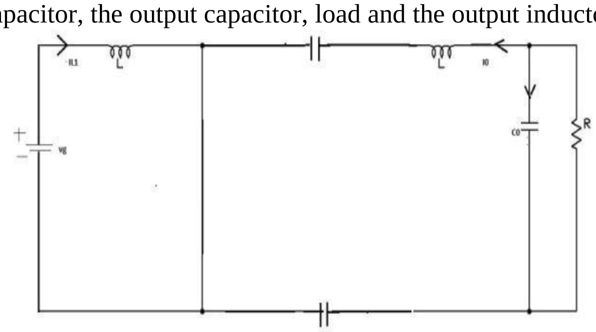

Figure 2 Mode I operation

The voltage across the inductor L_1 is,

$V_{L1}=V_g$

The voltage across the inductor L_2 is,

$V_{L2}=V_0-2V_c$

The current through the capacitor C_1 is,

$I_{C1} = I_{C2} = I_0$

In mode II operation, the switch is in OFF state. The switch becomes open circuited. The current through the two diodes are equal.

The current through the diode, $I_{D1} = I_{D2}$

$$I_{D1} = \frac{I_1 + I_o}{2}$$

Current through capacitor C_1,

$$I_{C1} = \frac{I_1 + I_o}{2}$$

Voltage across inductor L_1,

$$V_{L1} = V_g - V_c$$

Voltage across inductor L_2,

$$V_{L2} = V_0 - V_c$$

Inductor volt sec balance equation

$$V_{L1} = V_g D + (V_0 - V_c)(1 - D) = 0$$

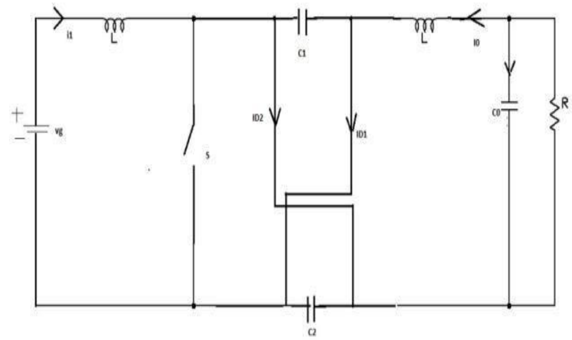

Figure 3 Mode II Operations

$$V_{L2} = (V_0 - 2V_c)D + (V_0 - V_c)(1 - D) = 0$$

From the above equation

$$V_c = \frac{V_g}{(1-D)};$$

$$V_0 = V_c(1 + D)$$

$$V_0 = \frac{V_g(1 + D)}{(1 - D)}$$

IV. ROLE OF INCREMENTAL CONDUCTANCE MPPT

In the incremental conductance method, the controller measures incremental changes in PV array current and voltage to predict the effect of a voltage change. This method requires more computation in the controller, but can track changing conditions more rapidly than the perturb and observe method (P&O). Like the P&O algorithm, it can produce oscillations in power output. This method utilizes the incremental conductance (dI/dV) of the photovoltaic array to compute the sign of the change in power with respect to voltage (dP/dV).

The incremental conductance method computes the maximum power point by comparison of the incremental conductance (I_Δ / V_Δ) to the array conductance (I / V). When these two are the same ($I / V = I_\Delta / V_\Delta$), the output voltage is the MPP voltage. The controller maintains this voltage until the irradiation changes and the process is repeated.

The incremental conductance method is based on the observation that at the maximum power point dP/dV = 0, and that P = IV. The current from the array can be expressed is a function of the voltage: P = I(V)V. Therefore, dP/dV = VdI/dV + I(V). Setting this equal to zero yields: dI/dV = -

I(V)/V. Therefore, the maximum power point is achieved when the incremental conductance is equal to the negative of the instantaneous conductance.

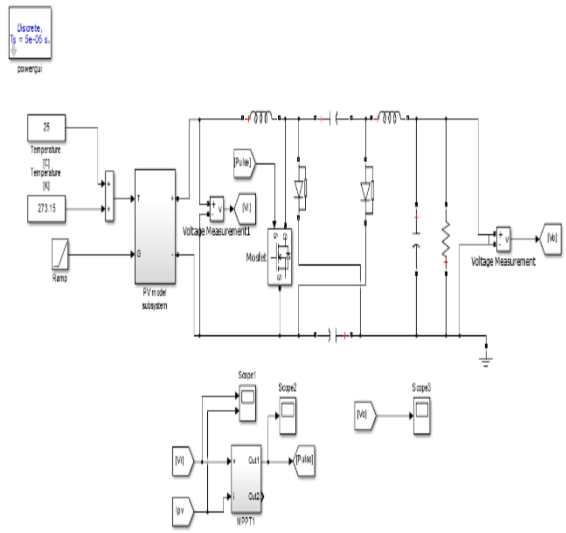

Figure 4 Incremental conductance algorithms.

V. SIMULATION DESIGN AND RESULT

The performance analysis of the proposed system is simulated in MATLAB/SIMULINK environment using SIM power system toolbox. The below figure shows the simulation model of the proposed system.

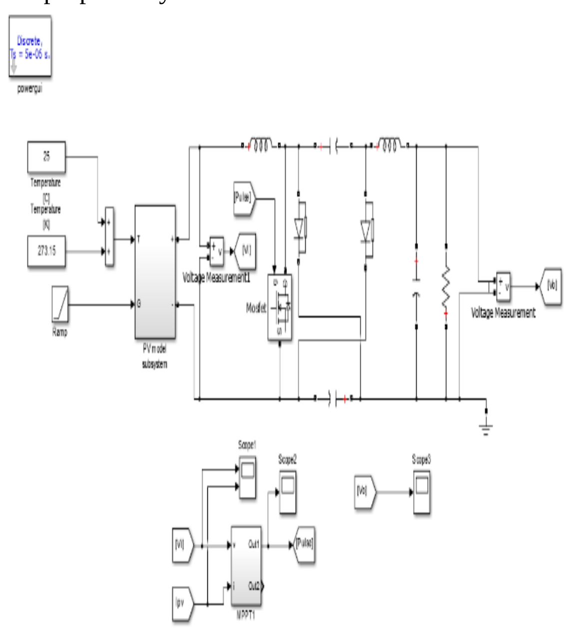

Figure 5 Simulink model

1) Input Voltage

The input voltage to the modified Cuk converter from the PV panel is shown in the below figure. Here, X – axis is taken as time in seconds and Y – axis is taken as the voltage in volts.

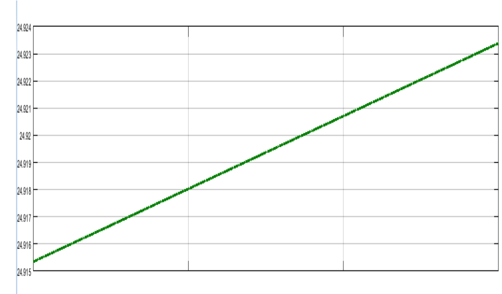

Figure 6 Input Voltage Waveform

2) Input Current

The input current fed to the modified Cuk converter from the PV panel is shown in the below figure. The X – axis represents the time in seconds and Y – axis represents the current in amps.

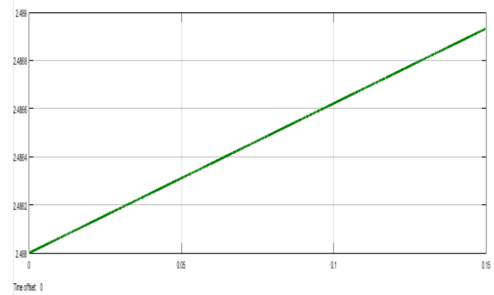

Figure 7 Input current

3) TRIGGERING INPUT

The below figure shows the trigger pulse for the converter circuit generated by the maximum power point control. Here, the X – axis represents time in seconds and the Y – axis represents voltage in volts.

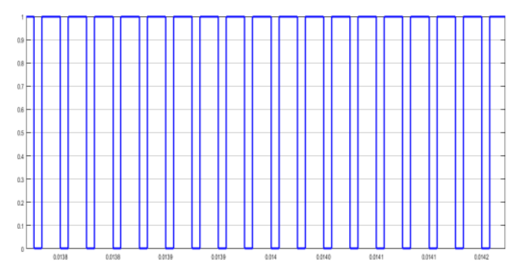

Figure 8 Triggering pulse

4) OUTPUT VOLTAGE

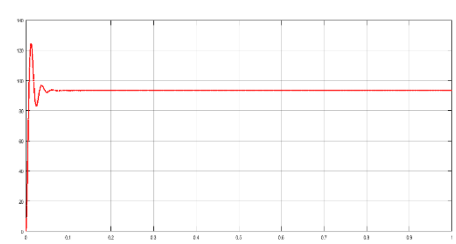

Figure 9

The wave form for output voltage from the modified Cuk converter is shown in the figure. Here the X – axis represents the time in seconds and the Y – axis represents the voltage in volts.

VI. CONCLUSION

In this project, the PV fed modified Cuk converter with incremental conductance maximum power point tracking control was discussed. It is analyzed by providing varying input to the converter with the help of the solar photovoltaic panel. The drawbacks of the existing system were overcame and the simulation results were shown. The steep step up voltage was obtained by implementing the modified Cuk converter. The maximum power point was traced for the varying input of the PV panel. The enhanced output voltage of the modified Cuk converter can be used for the applications such as battery charging, agricultural pumping etc.

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