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AN IMPROVED MPPT BASED INTERLEAVED BOOST CONVERTER FOR PV PANEL

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Abstract: Traditional energy sources are becoming more scarce as the need for electricity rises sharply. To get over this issue, a photovoltaic solar cell based system is preferable to traditional fossil fuel power production due to its low cost, abundance, and lack of environmental impact. The converters are the most delicate component of an Incremental Conductance (INC-MPPT) based PV system. Therefore, it is important to assess the Interleaved Boost Converter's (IBC) dependability so that reliable power can be supplied without interruption. The failure rates and dependability of the interleaved boost converter are calculated with the use of simulation studies performed in MATLAB/Simulink, which include measuring the power losses of the converter's many individual components. There hasn't been much research done on the dependability of IBC. In contrast to the more straightforward Reliability Block Diagram, the Markov methodology has been used in just a small number of publications to build reliability expression (RBD). This research thus presents a simple RBD approach for modelling and evaluating the dependability of an Interleaved boost converter in an INC-MPPT-based photovoltaic system.

Maximum Power Point Tracking (MPPT), Interleaved Boost Converter (IBC), Reliability Block Diagram (RBD), and Incremental Conductance (INC-MPPT)

I.INTRODUCTION

Many of the machines and tools we use run on direct current, or DC, on the inside (DC). Alternating current (AC) outlets power these gadgets. There is a loss of efficiency and some energy waste during the conversion from alternating current (AC) to direct current (DC) that is required for these devices to function properly. Traditional energy sources are rapidly being depleted while the demand for electricity continues to rise at an alarming rate. As a result, renewable energy sources are now necessary to address this issue. Most recently built structures are using DC-powered solar energy systems. Since the load is DC, these converters are required to provide a stable output voltage.

The use of PV energy-based power systems for off-grid power generating has become more common. Although the cost to operate a PV system is little, the initial investment is very significant. Due to the system's reliance on solar irradiance, connecting loads directly to the solar panels is not an option. The system's ability to generate electricity varies from one setting to the next. Maximum Power Point Tracking (MPPT) is utilized to reduce this impact and maximize energy production from PV panels. Multiple MPPT techniques have been developed and deployed. Boost Converters serve as the central processing unit and Maximum Power point tracker in a typical photovoltaic system. The converters, especially the Boost converter, play a

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significant role in the PV system's reliability. If the converter system is hacked in any way, it might result in the breakdown of the whole system. Because of this, testing the converters' dependability is essential. Few authors have employed a complicated technique for evaluating the dependability of these converters, and studies of their reliability are quite uncommon. The standard function of a boost converter is to increase the DC voltage by a certain amount. The maximum power point tracking in response to the state of the Photovoltaic panels introduces the duty cycle that is essential to the converter's operation. It also helps reduce ripple currents in the input and output circuits, which is a nice bonus. Splitting the output current in two ways also reduces the ac loss of the inductor. In this research, we conduct an in-depth analysis of the MPPT-based, IBC-integrated dependability of a photovoltaic system. MATLAB/Simulink is used for comprehensive modelling of the proposed converter and reliability testing. The development of a reliability block diagram

II. PROPOSED SYSTEM

Block schematic for PV system with IBC converter is shown in fig 1. The proposed system is shown in figure 1 and comprises of the PV system, the IBC Converter, and the load.

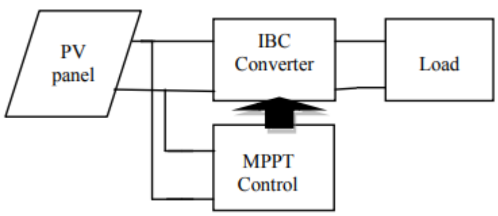

Fig1Block diagram for PV system with IBC converter

PV PANEL

Semiconductor solar cells have the unique ability to transform solar energy directly into usable electricity [4]. These modules may be linked in a series connection or a parallel connection, or both. Parallel connections are used to acquire high output current, whereas series connections are used to generate high output voltage. The voltage-current relationship is given by the following equation [5].

$$I = I_{pv} - I_s\left(exp\frac{q(V+R_s)}{N_s kTa} - 1\right) - \frac{(V+R_s I)}{R_p} \quad 1$$

Here:

T: Temperature (K)

Ipv : Photovoltaic Current (A)

Rs : series resistance of cell (Ohm)

K : Boltzmann constant (1.38 J/K)

Ns : Number of cells connected in series

Is : Saturation current

Q : Electron charge (1.6 C)

Rp : Resistance connected in parallel (Ohm)

a: Diode ideality constant

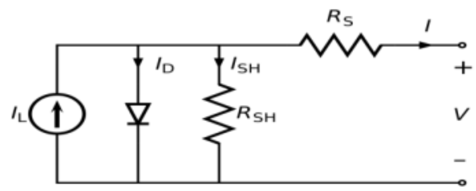

Fig 2 Equivalent circuit of PV cell

To get an understanding of how a single-diode Photovoltaic cell's comparable circuit works, see Fig. 2. Even though a diode coupled in parallel to a separate current source may theoretically create the perfect PV cell, in practice, no cell comes close to this ideal. An ideal PV cell, seen in Fig. 2, has a shunt coupled to a series resistance. Solar irradiation and temperature are the primary determinants of PV panel output power.

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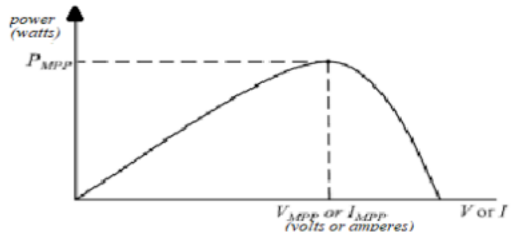

Fig 3 Power and voltage characteristic of PV cell

The link between PV panel power output and voltage is seen in Figure 3. Because of this trait, it is evident that MPPT is required to extract the most power from the panel and to introduce an approximative duty cycle for firing the switches in the suggested converter. In the present study, a solar array with 10 parallel strings and 748 cells in series is presented. Using [6,7], we can calculate the voltage at the plug.

$$V_{array} = 54.7 log_e \left(\frac{I_{ph} - I_{array} + 0.005}{0.005}\right) - 3.74 I_{array} \qquad 2$$

Here, we indicate photocurrent by, and its value changes linearly with the amount of sunlight reaching its receiver. (Assuming a solar insolation of 100% and a power output of 1 kW/m2).

Multiplying the previous equation by gives you the power you need to do,

$$P_{array} = 54.7 I_{array} log_e \left(\frac{I_{ph} - I_{array} + 0.005}{0.005}\right) - 3.74 I_{array}^2 \qquad 3$$

For maximum power,

$$\frac{dp_{array}}{dI_{array}} = 0,$$

After solving those relations, maximum power is evaluated for various insolation levels.

IBC MODELLING

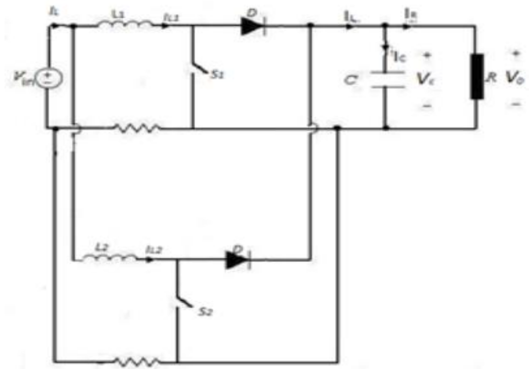

Fig 4 Circuit diagram of IBC

With identical inductors L1 and L2, the simplified circuit model for an interleaved boost converter is seen in fig. 4. Input voltage Vin, diode C, capacitor C, resistive load R, and output voltage Vc all stand for various electrical components. The inductor currents in the two parallel converters are the same since they are similar.

Thereby, IL1 = IL2

In order to activate the switch

$$I_{L1} = \int V_{in}\, u dt \qquad 4$$

$$I_{L2} = \frac{1}{L2} \int V_{in}\, u dt \qquad 5$$

Also, $I_{L1}+I_{L2}=I_L$ and $I_c = I_L - I_R$

$$C\frac{dV_c}{dt} = -\frac{V_0}{R} \qquad 6$$

For switch off condition,

$$L_1\frac{dI_{L1}}{dt} = V_{in} - V_0 \qquad 7$$

$$L_2\frac{dI_{L2}}{dt} = V_{in} - V_0 \qquad 8$$

Based on the boost converter's output and input voltage levels, we can calculate the duty cycle using the following formula (9).

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$$V_{output} = \frac{V_{input}}{1-\alpha} \quad 9$$

Where, α is the duty cycle.

II. PROPOSED INCREMENTAL CONDUCTANCE METHOD:

One way to get the maximum power point is to follow the slope of the current's derivative with respect to the voltage [2]. What benefit MPPT really provides depends on the array, the weather, and the seasonal load pattern. Only when the Vpp is more than around 1V greater than the battery voltage does it provide a useful current increase. This may not be the case in hot conditions, especially if the batteries are depleted. However, the Vpp may reach 18V in really frigid conditions. If ther energy demand is highest in the winter (as it is in most houses) and if the climate has cold winters, then may obtain a significant energy boost when they need it the most. An application of MPPT on a frosty winter day is shown below.

The current ambient temperature is 20 degrees Fahrenheit (-7 degrees Celsius). A little breeze is present, limiting the increase in PV cell temperature to just above freezing. Vpp = 18V The battery voltage is 12.0 since the loads are on and the batteries are getting low.

Vpp is 18/12, which is 1.5:1, compared to the voltage of the battery.

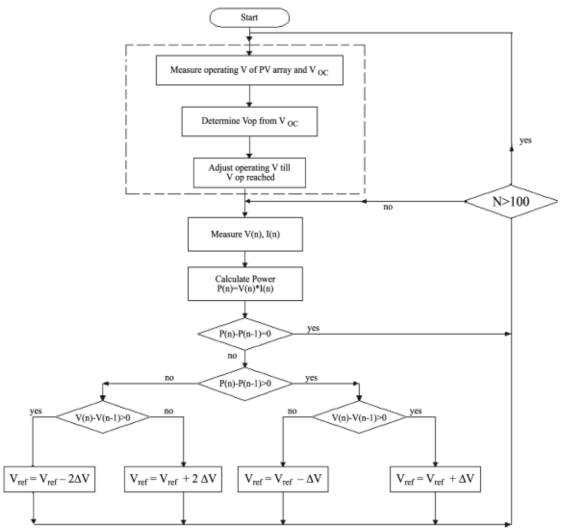

Fig 5 :Incremental Conductance Method Algorithm

In this scenario, the charge current might be increased by 50% with a perfectly functioning MPPT (assuming no voltage drop in the array circuit). As with a car's gearbox, there are inevitable losses throughout the transformation. According to field reports, rises of 20-30% are common.

Constant fine-tuning of the wind turbine and the solar array is required to ensure that both are producing at their optimum possible levels. Maximum power point tracking (MPPT) techniques have been developed and are commonly utilized for such systems. Two examples are the perturbation observation approach and the incremental conductance method. In this research, the wind turbine and the solar array use the perturbation observation technique due to its ease of implementation and high degree of precision. The method begins with the selection of a starting reference rotor speed for the wind turbine and a starting reference voltage for the PV array. The two systems' output powers are compared to one another. If this strength does not match their maximum strength, their starting reference values will be adjusted upwards or downwards accordingly. If this change improves their output powers, the following tweak will be done in the other way. The above procedures are continued until the rated outputs of the wind generator and solar array are achieved.

III. SIMULATION RESULTS

EXISTING RESULTS

By using MATLAB/SIMULINK the simulation for IBC is designed. Characteristics of various parameters are depicted below

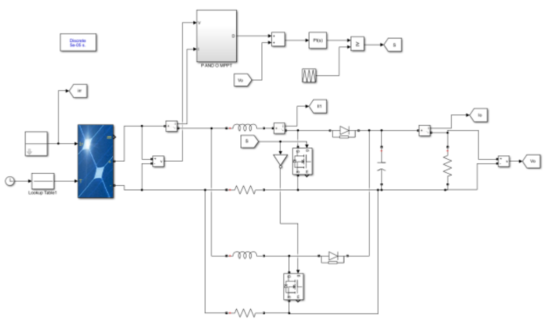

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Fig:6 MATLAB/SIMULINK circuit diagram of the proposed system

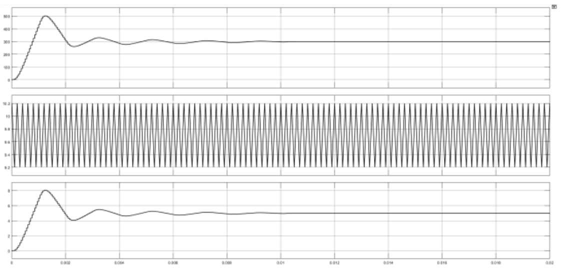

Figure.7 (a) output voltage characteristic, (b) inductor current characteristic and (c) output current characteristic respectively of IBC

EXTENSION RESULTS

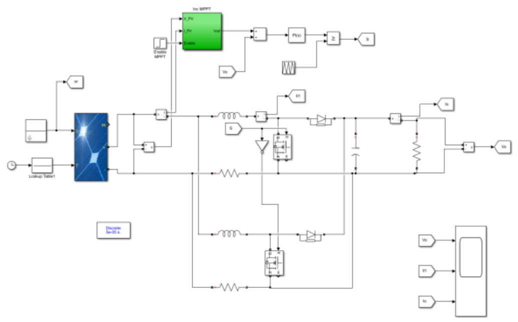

Fig:8 MATLAB/SIMULINK circuit diagram of the system with INC MPPT

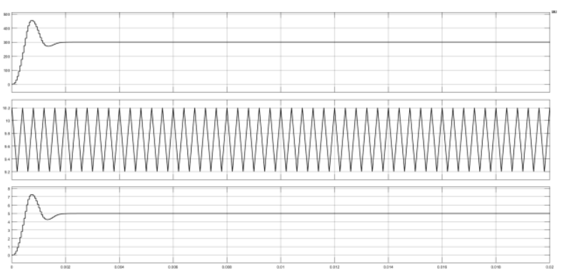

Figure.9 (a) output voltage characteristic, (b) inductor current characteristic and (c) output current characteristic respectively of IBC

CONCLUSION

Interleaved boost converter modeling and simulation findings using MATLAB/SIMULINK are shown and analyzed in detail. IBC failure rates are calculated for both individual parts and the whole system. The RBD model is created for the series system of a typical boost converter and IBC, and the parallel system of an IBC. This RBD is used to evaluate the overall dependability of the IBC in a grid-connected PV system and to calculate the MTTF. The interleaved boost converter is very dependable, thus it may perform the dual roles of power converter and Incremental Conductance (INC-MPPT) tracker. Other topologies of these converters used in other power production systems may also undergo reliability assessment.

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