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Solar Power Plant with Constant Power Generation using Incremental Conductance MPPT Method

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Abstract: In order to use solar energy as a possible power plant to be constructed, Indonesia, a tropical nation, has the advantage of receiving sunlight all year round. Power instability caused by the solar panels, which rely heavily on irradiance and have low energy conversion efficiency, is one of the issues with the solar power plant system. The Incremental Conductance approaches need the Maximum control of Power Point Tracking (MPPT) to tackle this issue. Solar PV is operated at the MPP point by this Incremental Conductance MPPT control, maximizing its output power.

In order to use solar energy as a possible power plant to be constructed, Indonesia, a tropical nation, has the advantage of receiving sunlight all year round. Power instability caused by the solar panels, which rely heavily on irradiance and have low energy conversion efficiency, is one of the issues with the solar power plant system. The Incremental Conductance approaches need the Maximum control of Power Point Tracking (MPPT) to tackle this issue. Solar PV is operated at the MPP point by this Incremental Conductance MPPT control, maximizing its output power. However, the CPG mode operates to limit the solar panel's output power when the solar PV output power is greater than or equal to the reference power. Based on the simulated outcomes of this MPPT CPG control, it is possible to maintain a constant load output voltage response of 48 V with less than 5% error, which has been confirmed using a variety of irradiances and reference powers.

Keywords: Solar PV, maximum power point tracking (MPPT), constant power generation (CPG), and Incremental Conductance

I. INTRODUCTION

According to information from the National Energy Council, Indonesia has a solar energy potential of 4.8 kilowatt-hours per square meter per day (kWh/mm2 / day), which is equal to 112,000 GWh when compared to Indonesia's prospective land. Given the diminishing supply of fossil fuels, this has a lot of potential to be used as a solar power plant to supply electrical energy needs. Solar panels are used in solar energy to transform the energy produced by the solar power plant system into electrical energy. Nevertheless, because solar PV is so dependent on irradiance, using it as a solar power plant has a drawback, which is the volatility of the power produced. Moreover, the efficiency of energy conversion is also quite low (around 30%) [3, 11].As a result, in order for solar PV to operate, the MPPT technique must be pushed to run at the MPP points [2], [5].The MPPT approach has recently been the subject of extensive investigation, utilizing both traditional and artificial intelligence techniques. One of the traditional techniques that is frequently utilized is Incremental Conductance. This is due to the fact that Incremental Conductance is simple to implement [3, [4,] [7], [13], inexpensive [13], has a quick rise time [6], and can generate high power efficiency. Because the voltage supplied to the load exceeds the load rating voltage itself when the MPPT Incremental Conductance method is used, it might result in severe voltage disturbances because the output voltage to the load is likewise maximized. Due to the MPPT Incremental Conductance condition, solar PV must operate at the MPP point. Irradiance fluctuations can result in overvoltage under these circumstances. Constant Power Generation (CPG) is added to the MPPT to prevent this [5].In order for the generated voltage to always be at the rated voltage, the MPPT Incremental Conductance -CPG works to limit the maximum power produced by the MPPT Incremental Conductance method [8].This MPPT Incremental Conductance -CPG modification requires a DC-DC converter in order to be used. The SEPIC converter is the DC-DC converter in use. The SEPIC converter's duty cycle is constantly altered in accordance with modified MPPT Incremental Conductance -CPG, which have two modes, namely MPPT and CPG modes. To optimize the power generated by the SEPIC converter, the MPPT mode operates when the PV output power (P_{pv}) is less than or equal to the reference power (Pref) [9]. The PV output power (P_{pv}) will be maintained constant when (P_{pv}) = (P_{ref}), in contrast to CPG mode, which operates when (P_{pv}) reaches Pref [9].In order to test the effectiveness of both MPPT Incremental Conductance operations and CPG operations in preventing overvoltage by restricting PV output power, solar modules with varying loads and irradiation conditions were used in a PSIM simulation.

II. PHOTOVOLTAIC MODULE PROPERTIES

A. Model of the PV Equivalent Circuit

A group of solar cells that can transform solar energy into electrical energy make up the photovoltaic module [11]. An ideal current source, series resistance, and parallel resistances can be used to represent a PV module. The solar cell's exposure to light is comparable to the direct current produced by the perfect source of current sources. Resistance in series and parallel exhibit values for leakage current and drop voltage [4]. Fig. 1 depicts the photovoltaic cell's equivalent circuit.[3], [6], [7], [11], [12], and [13] are typical equations for the current and voltage of solar modules based on a single diode model.

$$I_{pv=I_{ph-I_s}}\left(\frac{V_{pn}+I_{pv}R_s}{e^{nNsVt}}-1\right)-\frac{V_{pv}+I_{pv}R_s}{R_{sh}} \quad \ldots\ldots\ldots (1)$$

Two solar panels, each with a 100 WP capacity, were employed in this study and were wired in series. The electrical parameters of the solar module utilized under ideal circumstances (the surrounding temperature is adjusted at 25 o C and radiation is at 1000 W/m2) are shown in Table I.

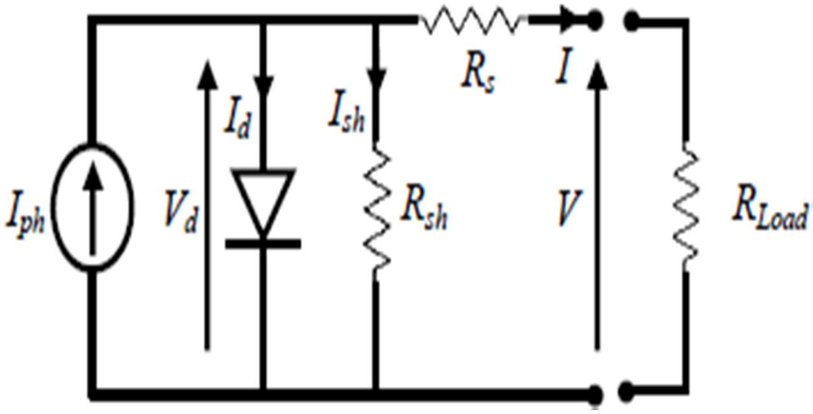

Fig. 1 Equivalent circuit of the photovoltaic cell

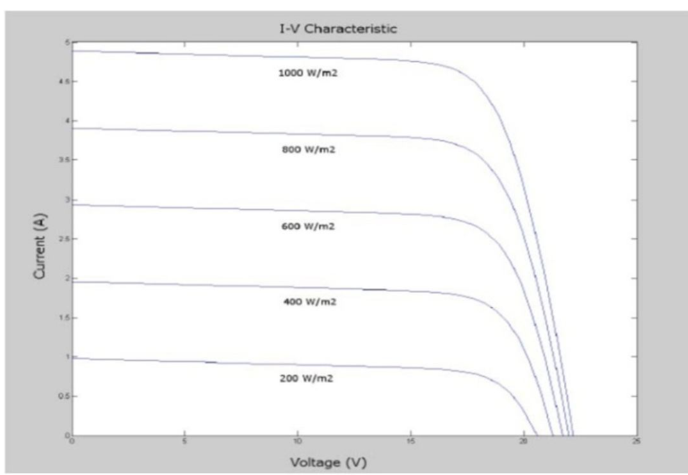

Fig. 2 Current-Voltage (I-V) characteristics with variable irradiation

TABLE -1 Photovoltaic Module Parameter AT 25°C AND 1000 W/M^2

Polycrystalline Photovoltaic Module	
Parameter	Value
Maximum Power (P_{mp})	200 W
Maximum Power Current (I_{mp})	5.62 A
Maximum Power Voltage (V_{mp})	35.6 V
Short Circuit Voltage (I_{sc})	6.4 A
Open Circuit Voltage (V_{oc})	43.8 V

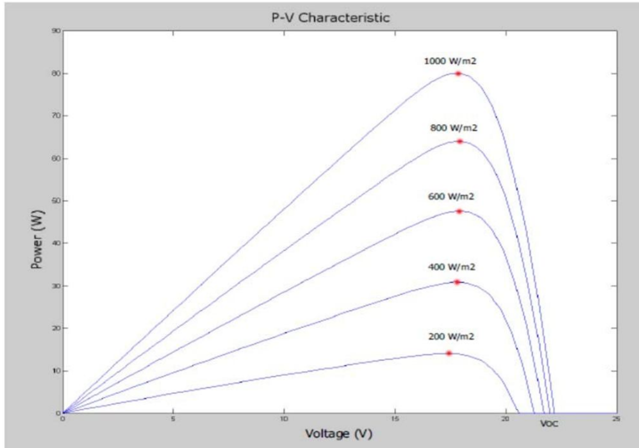

Fig. 3 Power-Voltage characteristics (P-V) with variable irradiation

The link between the current and the output voltage (IV curve) and the power and the output voltage in solar cells is depicted by a characteristic curve (P-V curve).The current photovoltaic voltage (I-V) and power voltage (P-V) characteristic curves with an irradiation value variation of 200–1000 W/m2 are shown in the accompanying Figures 2 and 3.

Fig. 2 illustrates that as irradiance rises at a constant temperature of 25°C, the output current follows suit. Fig. 3 demonstrates that as irradiance increases at a constant temperature of 25 °C, so does PV power.

III. SEPIC DC-DC CONVERTER

A variant of the BuckBoost converter is the SingleEnded Primary Inductance Converter (SEPIC).The output voltage of a SEPIC con verter can be either higher or lower than the input voltage without affecting its polarity [10].

A SEPIC converter has the following features

1) The current is generated more consistently thanks to the large values of both inductors.
2) The voltage is more steady and stable as a result of both capacitor values being very large.
3) Network in steady state, which denotes periodic voltage and current waveforms.
4) The ratio of the duty cycle D, the time between the switch closing and opening (1-D) T.
5) Diodes and switches in ideal circumstances

Fig. 4 depicts the power series of a SEPIC converter, which consists of a diode D output, a load resistor R Load, a SEPIC inductor (L1 and L2), filter capacitors (C1 and C2), and power switches K (a MOSFET transistor).Setting the duty cycle value as shown in equations 2 and 3 results in the SEPIC converter's big output value. A time comparison between the switch being on and the switching period is called duty cycle (D).

$$D = \frac{V_O}{V_O+V_S} \qquad \text{……….} (2)$$

$$v_o = V_s \frac{D}{(1-D)} \qquad \text{……….} (3)$$

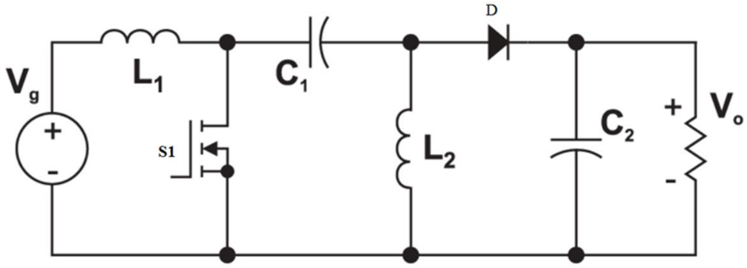

Fig. 4 The power series of SEPIC converter

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IV. PROPOSED METHOD

A. Simulation Of Proposed System

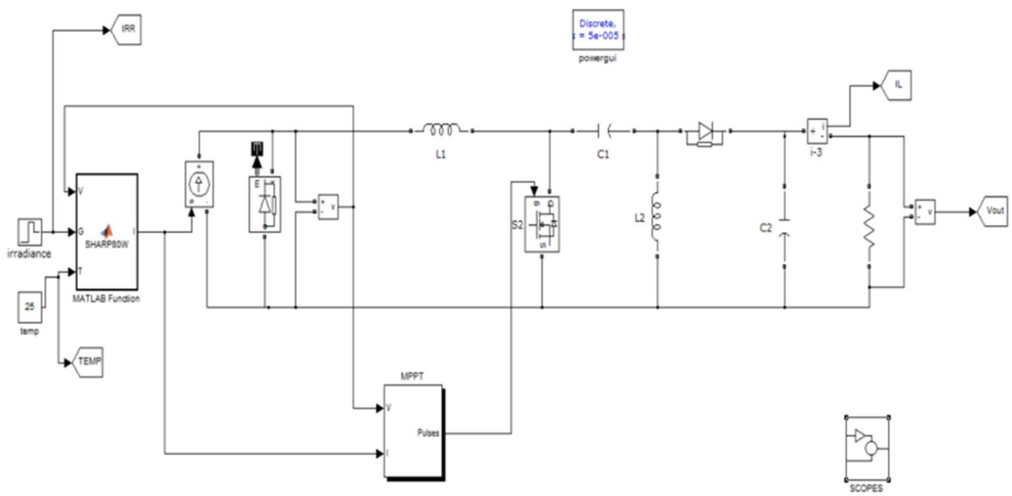

Fig. 5 Simulation diagram of MPPT INCREMENTAL-CPG method

The flowchart of the incremental conductance MPPT algorithm has been implemented in Matlab/Simulink. The Fig.6 illustrated the modeling diagram for the above algorithm. The simulation results of the output power of the PV module and the MPPT pulse width modulated output is shown in Fig. 5 The modeling diagram of Figure 6 represents the whole PV system with MPPT along with the boost converter has been implemented in the Matlab/Simulink.

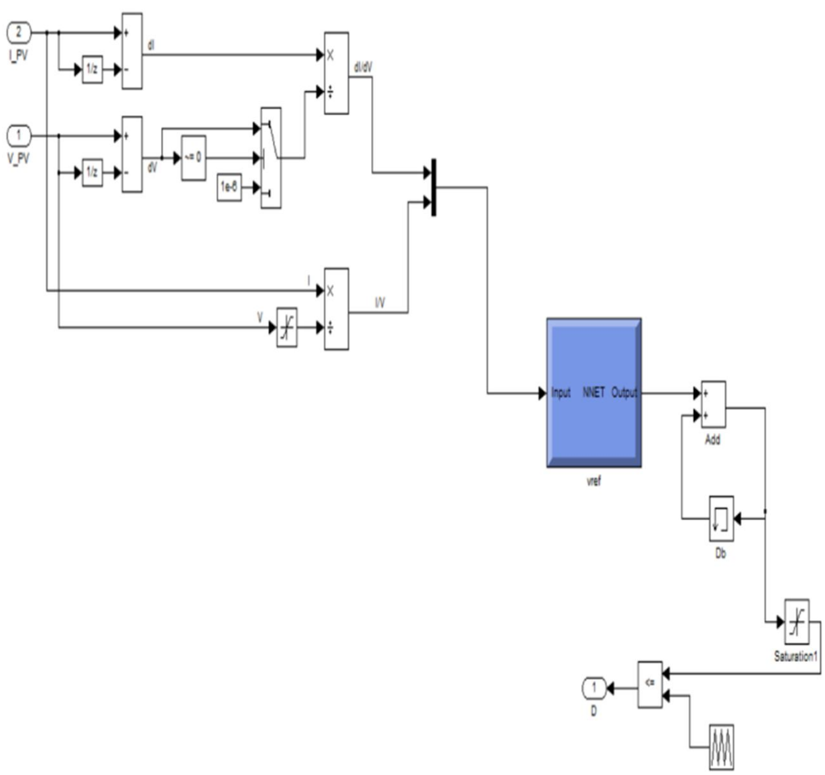

Fig. 6 Simulation diagram of sub system of MPPT INCREMENTAL-CPG method

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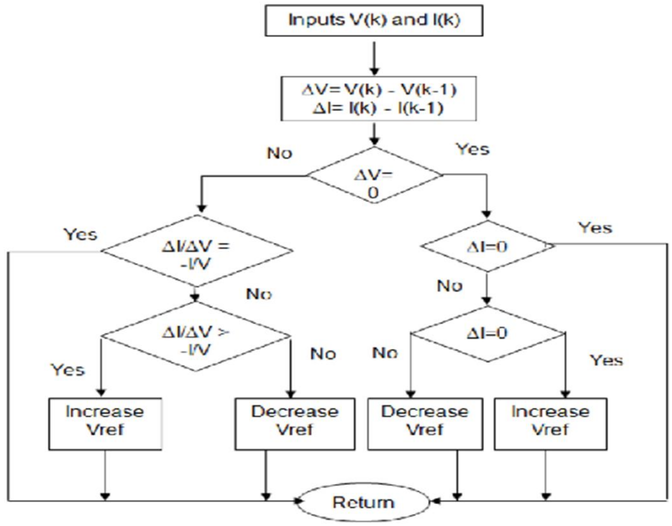

Fig. 7 Flowchart of MPPT INCREMENTL-CPG method

V. SIMULATION RESULTS

Simulated testing is done to determine the effectiveness of the proposed MPPT INCREMENTAL-CPG method, utilizing three different reference power (Pref) values (75W, 150W, and 200W) and three different irradiance values (300 W/m2, 650W/m2, and 1000W/m2), all at the same temperature of 25°C.The outcomes of the response MPPT INCREMENTAL -CPG technique and the response MPPT INCREMENTAL method are then contrasted.

The load resistor was calculated in Table III for the reference power (Pref) that was previously tabulated. Using a 2x100 WP solar panel with an irradiation fluctuation of 300W/m 2,650W/m2, and1000W/m2 and a load of 75W, the simulated results of the MPPT Incremental Conductance method and the MPPT Incremental Conductance-CPG method are shown in Figures.

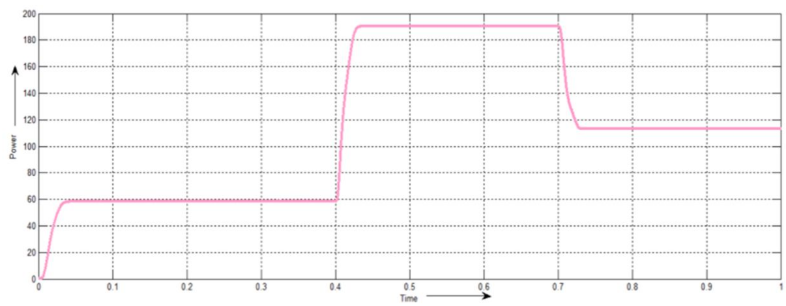

Fig. 8 P_{out} (w), response with 75W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method

The output power is 110W at the irradiance point of 650W/m2 and the output reference power is190W at the irradiance point of 1000W/m2.The MPPT mode with a preference of 75W when the irradiance point of 300 W/m2 is not attained.

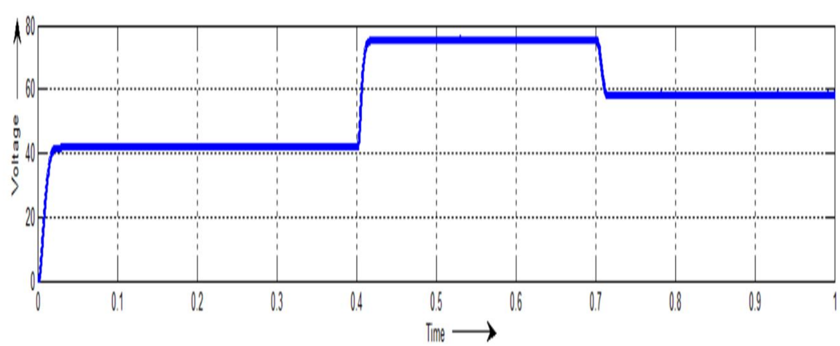

Fig. 9 V_{out} (V) response with 75W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method

The Output voltage is 75.48V at the irradiance point of 1000W/m2 and when the output voltage is 59V at the irradiance point of 650W/m2. The MPPT INCREMENTAL method demonstrated an overvoltage when the converter output voltage reached 75.48V and 64.32V at the irradiance points of 650W/m2 and 1000W/m2, respectively. This overvoltage occurred when the converter's output voltage exceeded the rating load voltage of 48 V.

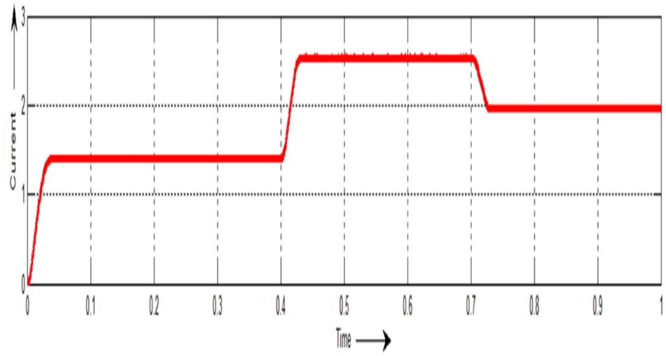

Fig. 10 I_{out} (A) response with 75W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The load is stated to be over voltage when tension is greater than 5% of the load voltage rating, and the output voltage will fluctuate by the control fault limit of 5% of 48V(the load voltage rating).when irradiance changes cause the reverse overshoot or when MPPT mode converts to CPG mode.

Using a 2x100 WP solar panel with an irradiation fluctuation of 300 W/m2, 650W/m2, and1000W/m2 and a load of150W, the simulated results of the MPPT INCREMENTAL method and the MPPT INCREMENTAL -CPG method are shown in Fig.

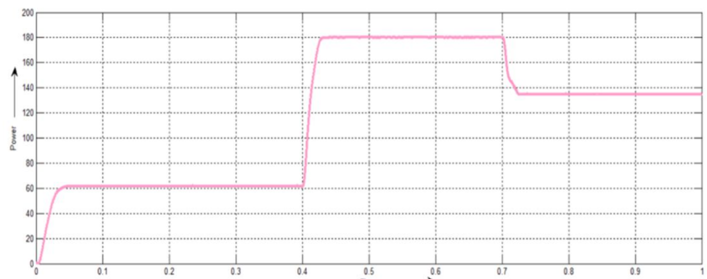

Fig. 11 P_{out} (w), response with 150W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The output power is 180W at the irradiance point of 1000W/m2. When the irradiance point drops to 650 W/m2, the MPPT mode is re-activated. When MPPT mode switches to CPG mode or instead of overshoot occurs due to irradiance fluctuations.

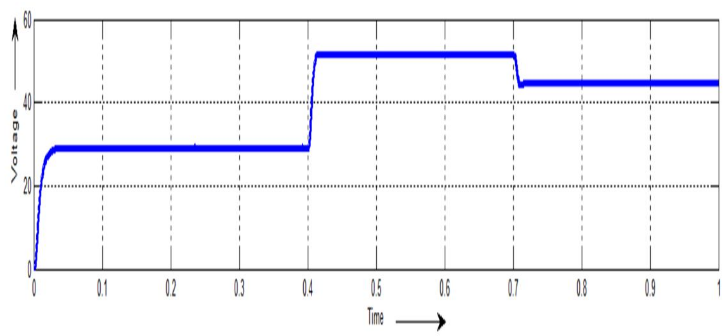

Fig. 12 V_{out} (V) response with 150W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The V_{Out}(V) of the MPPT INCREMENTAL method revealed an overvoltage only when the irradiance point reached 1000 W/m2 and the converter's output voltage reached 53.76V, which was when the converter's output voltage exceeded the rating load voltage of 48 V at the irradiance points of the 650 W/m2.

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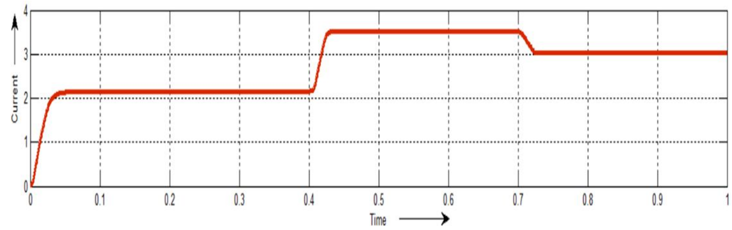

Fig. 13 I_{out} (A) response with 150W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The output current is 2.2A at the irradiance points of 300 W/m2 and whenever the irradiance points of 1000 W/m2 for reaches the output current 3.5A. When reaches the output current 650 W/m2 irradiance points of 3.1A the MPPT INCREMENTAL method.

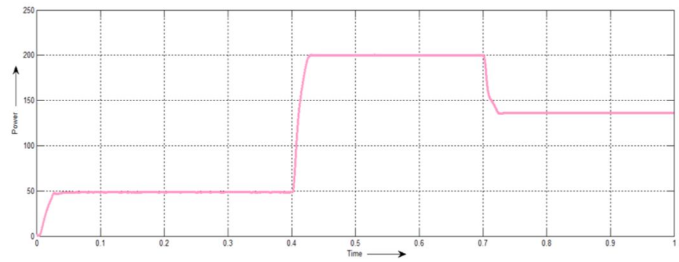

Fig. 14 P_{out} (w) response with 200W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The maximum output power is only attained at 200W when the irradiance point is1000W/m2.when the CPG mode is never engaged under these circumstances.

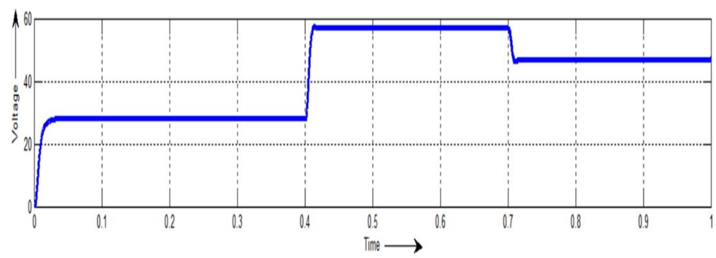

Fig. 15 V_{out} (V) response with 200W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The maximum output voltage are only attained at 47V when the irradiance point is1000W/m2. The results are The MPPT INCREMENTAL approach in this instance does not result in overvoltage in any of the three irradiance variations.

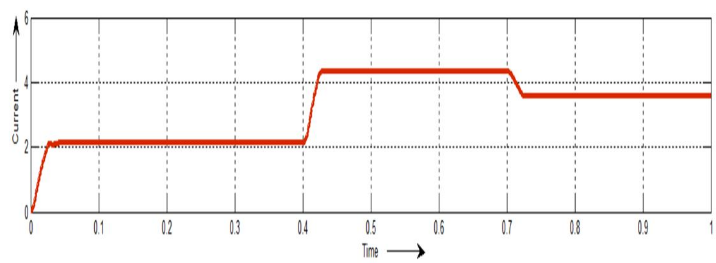

Fig. 16 I_{out} (A) response with 200W load when using MPPT INCREMENTAL and MPPT INCREMENTAL-CPG method.

The output current reaches at the irradiance points of 650W/m2 for value 3.7A and when the output current 2.1A reaches the 300W/m2 and the irradiance points of reaches output current 4.3A for 1000W/m2. Moreover, both techniques yield the same POUT, VOUT, and IOUT responses since the MPPT INCREMENTAL -CPG method's active MPPT mode operates on all three irradiance variations.

VI. CONCLUSION

In this Paper, the MPPT Incremental Conductance-CPG technique to be able to control solar panels that operate under two conditions, namely, MPPT operations and CPG operations, to prevent overvoltage on the load. Through the use of a PSIM simulation, this MPPT Incremental Conductance-CPG technique has been assessed. According to the outcomes of the simulations, the MPPT mode is activated when the load requirements are greater than or equal to those of the solar power panel (PPV = Pref) and the voltage on the output side of the 48V.

When CPG mode is indicated, the solar panel's power requirements exceed the load's power (PPV > Pref) and the voltage more than 48V output. With a control error limit of 5% of the rating voltage on the load, the MPPT Incremental Conductance-CPG approach has demonstrated its ability to prevent excess voltage, but it is still overshot during mode switching due to irradiance changes.

REFERENCES

[1] M. Hassani, S. Mekhilef, A. Patrick Hu, and N. R. Watson, "A novel MPPT algorithm for load protection based on output sensing control," IEEE Ninth International Conference on Power Electronics and Drive Systems (PEDS), pp. 1120-1124, 2011.

[2] T. Esram, and P. L. Chapman, "Comparison of photovoltaic array maximum power point tracking techniques," IEEE Transactions on Energy Conversion, vol. 22, no. 2, pp. 439-449, June 2007.

[3] D. Beriber, and A. Talha, "MPPT techniques for PV systems," 4th International Conference on Power Engineering, Energy and Electrical Drives, pp. 1437-1442, 2013.

[4] N. Moubayed, A. El-Ali, and R. Outbib, "Comparison of two MPPT techniques for PV system," WSEAS Trans Environ Dev, 2009.

[5] E. Prasetyono, D. O. Anggriawan, A. Z. Firmansyah, and N. A. Windarko, "A modified MPPT algorithm using incremental conductance for constant power generation of photovoltaic systems," Engineering Technology and Applications (IES-ETA) International Electronics Symposium on, pp. 1-6, 2017.

[6] A. Gaga, F. Errahimi, and N. Es-Sbai, "Design and implementation of MPPT solar system based on the enhanced P&O algorithm using labview," International Renewable and Sustainable Energy Conference (IRSEC), pp. 203-208, 2014.

[7] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, "Optimization of perturb and observe maximum power point tracking method," IEEE Transactions on Power Electronics, vol. 20, no. 4, pp. 963-973, July 2005.

[8] Y. Yang, F. Blaabjerg, and H. Wang, "Constant power generation of photovoltaic systems considering the distributed grid capacity," IEEE Applied Power Electronics Conference and Exposition (APEC), pp. 379-385, 2014.

[9] A. Sangwongwanich, Y. Yang, and F. Blaabjerg, "High-performance constant power generation in grid-connected PV systems," IEEE Transactions On Power Electronics, vol. 31, no. 3, pp 1822- 1825, March 2016.

[10] T. Bhavin, B. Patel, J. Desai, and K. Sonwane, "Analysis of SEPIC converter," International Journal of Engineering Development and Research (IJEDR), vol. 6, issue 2, 2018.

[11] H. Suryoatmojo, R. M. Hakim, D. C. Riawan, R. Mardiyanto, S. Anam, E. Setijadi, and M. Ashari, "MPPT Based on Modified Incremental Conductance Algorithm for Solar Powered UAV," International Seminar on Intelligent Technology and Its Applications (ISITIA), pp. 108-113, 2019.

[12] Soedibyo, S. Anam, I. Hafidz, G. R. Zulkarnain, and M. Ashari, "MPPTdesign on solar farm using perturb and observe technique considering tilt angle and partial shading in giligenting island," International Seminar on Intelligent Technology and Its Applications (ISITIA), pp. 222-226, 2017.

[13] Q. A. Sias and I. Robandi, "Recurrence Perturb and Observe algorithm for MPPT optimization under shaded condition," International Seminar on Intelligent Technology and Its Applications (ISITIA), pp. 533-538, 2016.

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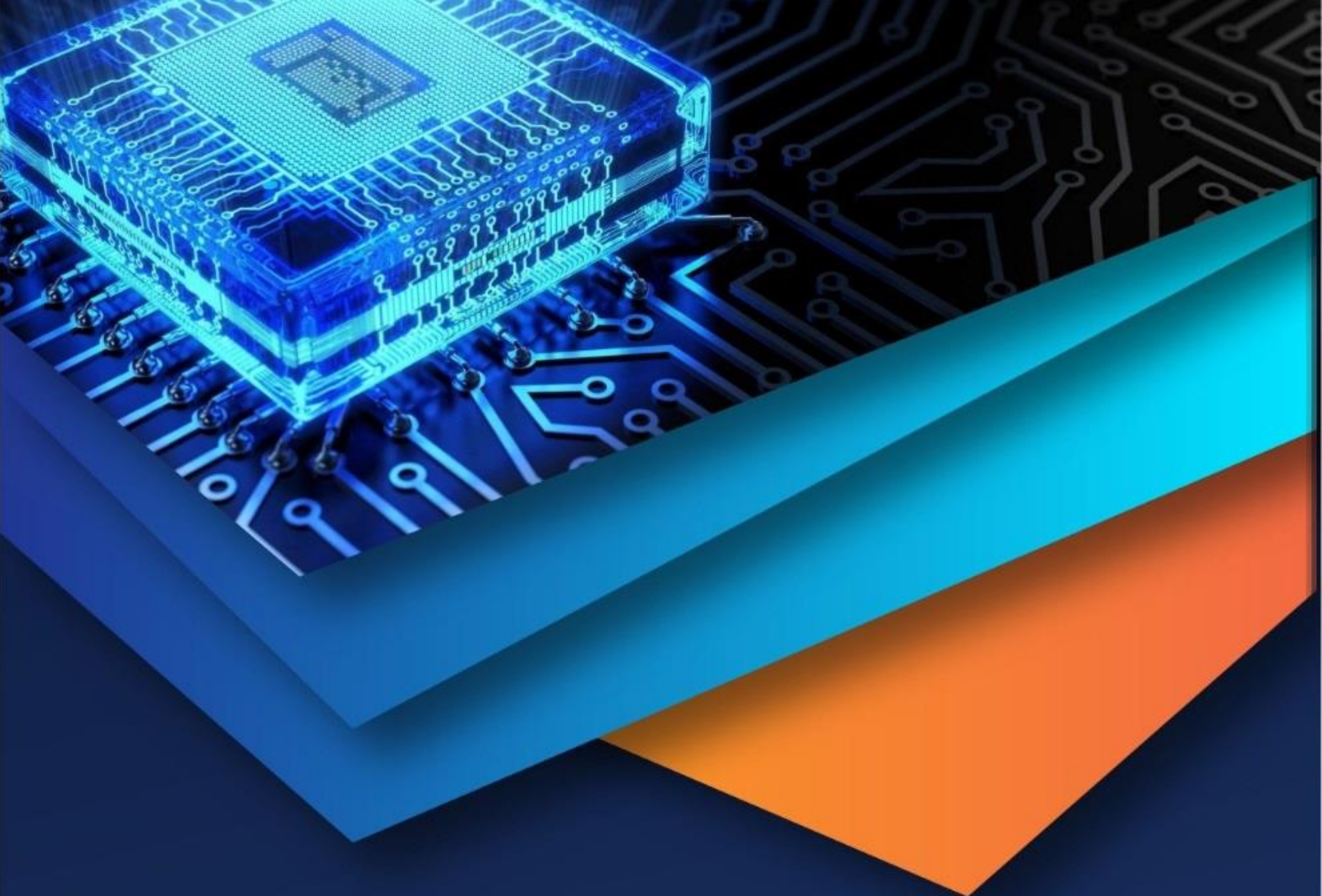

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