PHOTOVOLTAIC SYSTEM ANALYSIS USING PARTIAL SHADING CONDITION WITH KY CONVERTER

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Abstract— This paper investigated the effect of partial shading in Photovoltaic (PV) system characteristics under various environmental condition including non-shading and shading condition. This technique had been developed based on experimental study and effect of partial shading on photovoltaic modules investigated. The impact of various partially shading condition is different irradiance level can be simulated. The simulation model is employed to quantify the effect of partial shade on parameter of I-V curve maximum power point tracking (MPPT) and the Boost Converter. The Boost Converter is a new KY Boost Converter. The KY boost converter is increases the voltage value in the ratio of 1:3 with low ripple and simulated the result with P&O MPPT algorithm in Simulink of Mat lab.

Keywords- Solar energy, Maximum power point tracking (MPPT), photovoltaic (PV) modules, non-shade, partial shading, KY boost converter.

I. INTRODUCTION

Main objective of this paper, besides analysing the effect of partial shading on PV module performance, the main factors of shading impacts of atmospheric elements like passing clouds, along with shadows from surrounding structures. Such as buildings and trees. It will blocks the solar radiation across PV modules. The partial shading condition is the one of the major sources of reduction in energy of the PV system [2]. Under this condition, the series connection of shaded and non-shaded cells can be reduce the maximum power. The shaded cells through bypass diodes provides to saving the system from damages due to hot-spot formation [4]. By using the bypass diodes into system may result in multiple peaks of output power. In this case; the MPPT difficult to identify the global maximum power [4].

This paper focuses on developing a simulation model of PV system in non-shade and partial shade condition.

II. SOLAR ENERGY SYSTEM

Solar energy is one of the world's fastest growing power generation technologies. It's one of the most important of non-conventional sources energy because it's non-polluting it's characterized as either passive or active solar, it's depending on the way of capture, convert and distribute the solar energy

Active solar is include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the sun selecting material with thermal mass or light dispersing properties and naturally circulating air.

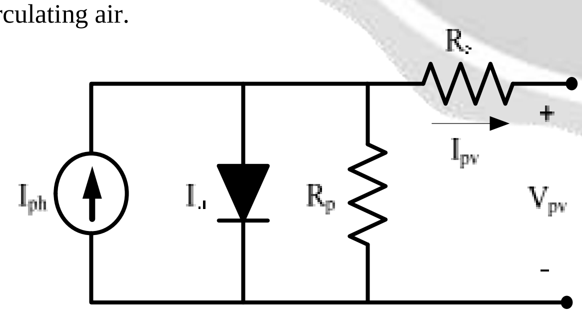

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Fig.1.Equivalent circuit of a photovoltaic array

The photovoltaic system to generate the electricity in commercial and residential applications. A single solar module can produce only a limited amount of power; therefore most of the installations contain multiple modules each module is rated by dc output power under standard test condition (STC) its range from100 to 320 watts. The Fig.1 shows the single–diode equivalent circuit model of PV cell.

A photovoltaic system typically includes a panel or an array of solar modules, a dc-dc converter, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic

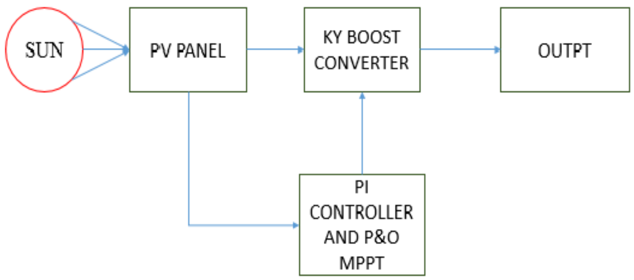

Fig.2.Block Diagram of Proposed Photo Voltaic System

The block diagram of the photovoltaic system is shown in the fig.2 in the block diagram shows the photovoltaic system with MPPT, controller and boost converter. The solar radiation from sun falls on the photovoltaic system and the photovoltaic system has been generate the electric power in dc output power. It will flows the MPPT, controller and boost converter. MPPT tracked the maximum power point and it will connected to the boost converter.

Electrical connections are made in series or parallel to achieve a desired output voltage or current respectively. The conducting wires modules may contain silver, copper or other non-magnetic conductive transition metals that take the current off. The cells must be connected electrically to other cells and to the rest of the system. PV System in Partial Shading Condition

III. PV SYSTEM UNDER PARTIAL SHADING CONDITION

Partial shading on a solar panel occurs when only a part of the panel's surface is shaded and the remaining's are fully illuminated.

Partial shading on solar panels are reduces the efficiency, the partial shading is leads to an inefficient to the same string experience in different irradiance. In each cell's has been produce different power.

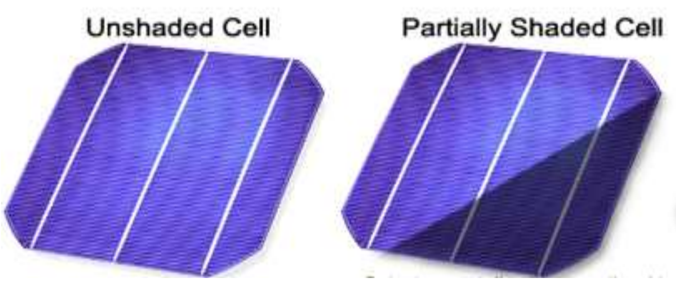

Fig.3.PV System in Different Condition

In Fig .3 shows the PV system in under non-shading and shading condition it will generate the different power range.

- Effect of Partial Shading

A shadow falling on a group of cells will reduce the total output by reducing the energy input to the cell, and by increasing energy losses in the shaded cells. This Problems are more serious when shaded cells get reverse biased. In Fig.4.is group of cells under full illumination is connected in series with another group of cells under shaded illumination. Unshaded cells are considered fully illuminated at 1000W/m2. Irradiance on shaded cells is considered uniformly and varies from 0 to 1000W/m2 with a step of 100W/m 2.

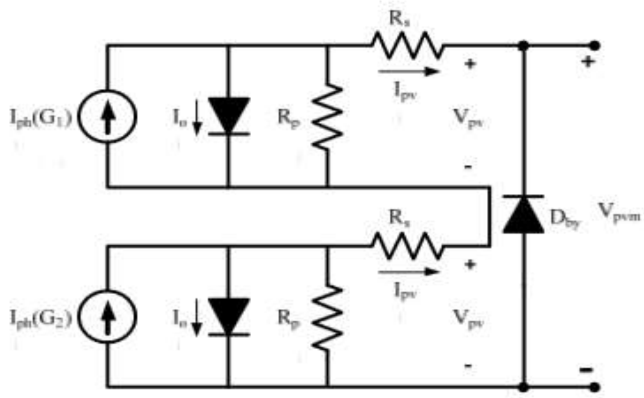

Fig.4. Circuit Diagram of Partial Shaded Array

Fig.6.depicts number of PV modules are connected with series connection and their bypass diodes connected in parallel to the array. It is important to note that the characteristics of an array with bypass diodes differ from the one without these diodes. The bypass diodes provide an alternate current path.

The power-voltage curve develops multiple maxima, shown in Fig.5 this figure shows how the extractable maximum power point differs in PV array with and without bypass diodes. MPPT algorithms may not distinguish between the local and global maxima. [12]

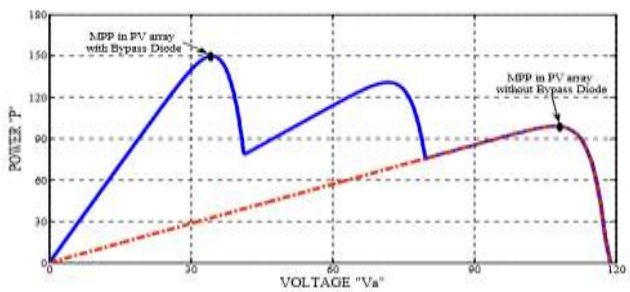

Fig.5. Power-Voltage Curve of a PV Array under Partial Shading Condition.

The solar PV modules are used to generate a higher level of electrical output power. A partially shaded module can be modelled by two groups of PV cells connected in series inside a module. Each group receives different level of irradiance. Let's assume no bypass diode for the cells inside a module, so Fig.6 shows the circuit model for a partially shaded module. The module is composed of series connected cells in which s shaded cells receive irradiance G1 and shaded cells receiving irradiance G2. The PV parameters can be represented as:

$$I_{pva} = I_{pvm(i)} I_{pva} \geq I_{ph(i+1)} \quad (11)$$

$$V_{pva} = \sum V_{pvm(i)}$$

Shading Problems in Solar Array

- It wouldn't be practical to fit bypass diodes to every cell - manufacturers fit at most two or three per panel. So even if a single cell is shaded, you will still lose at least a third of the panel output. [11]
- Quite a lot of the power that the good cells are producing will be used up in forcing the current through the bypass diodes.[11]
- Converters are designed to specific size of PV system in the given input voltage. But that time you have lost the voltage from the shaded cells, and then reduced the remaining voltage is further amount needed to force the current through the bypass diodes, the remaining voltage will be produced lot of less.[11]

IV. KY CONVERTTER

A boost converter is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductors and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors are normally added to the output of the converter to reduce output voltage ripple.

K. I. Hwu, and Y. T. Yau, designed KY Boost converter, which is the KY converter combined with the traditional boost converter in Fig.8. Such a converter has continuous input and output inductor currents, different from the traditional boost converter. Converters needed to supply one boosted voltage or more under a given low voltage, especially for portable communications system. Converter has the voltage ratio limited up to one plus D, where D is the duty cycle.[8]

This converter always operates in CCM, the turn-on type of two switches is defined to be (1-D, D), and where 1-D and D are for S1 and S2 respectively and D is the duty cycle of the gate driving signal for S2.

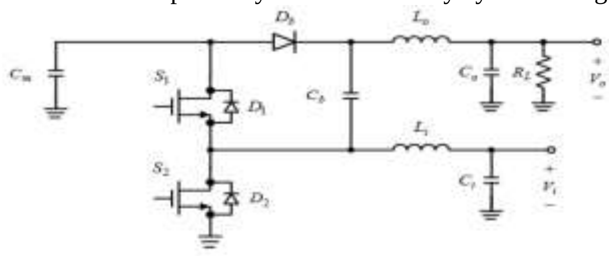

Fig.6.KY Boost Converter

Voltage VC_m across Cm is equal to the voltage VC_b across C_b and can be expressed as

$$V_{cm} = V_{cb} = \frac{1}{1-D} vi$$

Since this converter always operates in CCM, there are only two operating modes in this converter.

- Mode I
- Mode II

In mode I operation S1 is turned off and S2 is turned on. During this mode, Cm is discharged whereas Cb is charged. Therefore the voltage across Lo is vo subtracted from vCm, Also, the current flowing through Co is equal to iLo minus the current flowing through RL. [8]

In mode II operation S1 is turned on and S2 is turned off. During this mode, Cm is charged whereas Cb is discharged. Therefore, the voltage across Li is VCm subtracted from vi, whereas the voltage across Lo is Vo subtracted from sum of VCm and VCb, Also, the current flowing through Co is equal to iLo minus the current flowing through RL. [9]

$$\frac{V_o}{V_i} = \frac{2-D}{1-D}$$

V. MAXIMUM POWER POINT TRACKING ALGORITHM

In the source side we are using a boost convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like motor load. By changing the duty cycle of the boost converter through MPPT and automatically find the voltage (VMPP) or current (IMPP) at which a PV array should operate to obtain the maximum power output (PMPP) under a given temperature and irradiance, MPPT is applied Partial shading conditions is possible to have multiple local maxima, but overall there is still only one true MPP. [7]

Perturb & Observe MPPT

The Perturb and Observe (P&O) method is one of the most commonly used methods in practice. The P&O algorithms operate by periodically perturbing, i.e. incrementing or decrementing, the array terminal voltage and comparing the PV output power with that of the previous perturbation cycle. If the PV array operating voltage changes and power increases, the control system moves the PV array operating point in that direction. Otherwise the operating point is moved in the opposite direction.

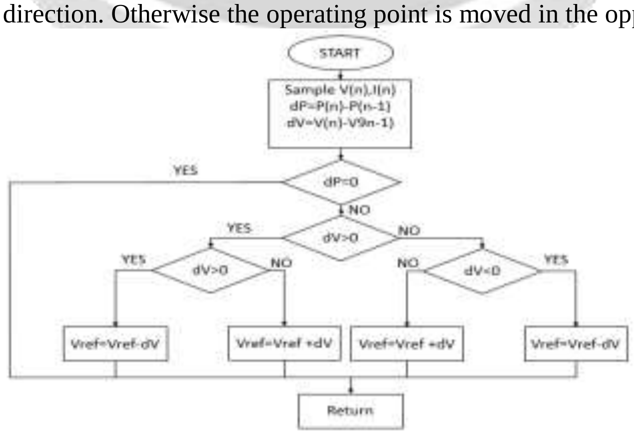

Fig.7.P&O Method Flow chart

The table 2 shows the perturb &observe MPPT methods. From the table, '1' refers positive and '0' refers negative.

Table.1.P&O Method perturbation

Perturbation	Change in Power	Next Perturbation
1	1	1
1	0	0
0	1	0
0	0	1

VI. SIMULATION DIAGRAM OF PROPOSED SYSTEM

Simulation diagram of proposed system is shown in the Fig.10 it will have the three sub systems, the PV System contains Solar cells, Modules, and arrays. Converter has the KY Boost Converter. And the MPPT has contains P&O and PI Controller. And the output is connected to the CRO.

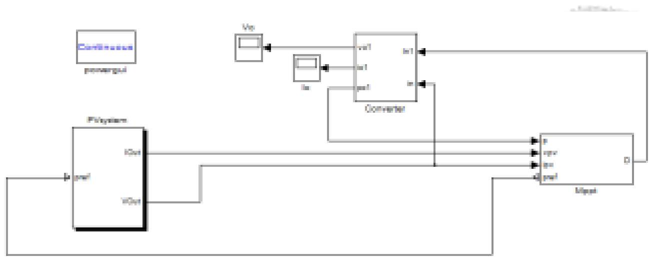

Fig.8.Simulation Diagram of Proposed System

VII. SIMULATION RESULT OF PVS ON SHADING CONDITION

Simulation is the imitation of the operation of a real-world process or system. It can be simulated the electrical and electronics diagram. The proposed system is modelled in MATLAB software and its results are evaluated by comparing with standards. The simulation results of the PV system are given below with different irradiance levels.

Normal Condition (Irradiance is 1000 W/m^2)

The result of the solar string is shown in Fig.11 & 12 result in an unshaded condition and it operates and generated normal power.

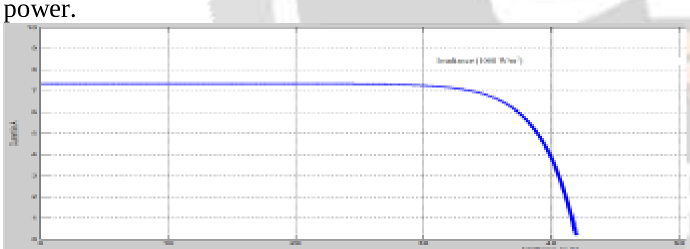

Fig.11.V-I Curve Normal condition of PV system

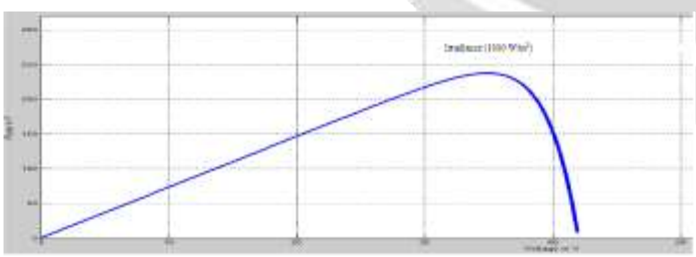

Fig.12.P-V Curve Normal condition of PV system

Under normal condition the solar system shadings will not be presented and generated power will be normal. The generated peak voltage, current & power values are 42 V, 7.34 A & 237.7 W respectively, The Maximum Power Point of 237.7 W is obtained at the point of voltage & current is 35 V & 6.79 A respectively.

Under Shading Conditions

The PV system can be operated low irradiance level the generated power can be reduced. In the different irradiance condition is shown in below,

- Irradiance is 900 W/ m^2:- Fig.13 shows the I-V and P-V characteristics of solar panel at the irradiance level is 900 W/ m^2.

At the Irradiance level of 900 W/ m^2, peak voltage, current & power values are 42 V, 6.6 A & 212.2 W respectively,

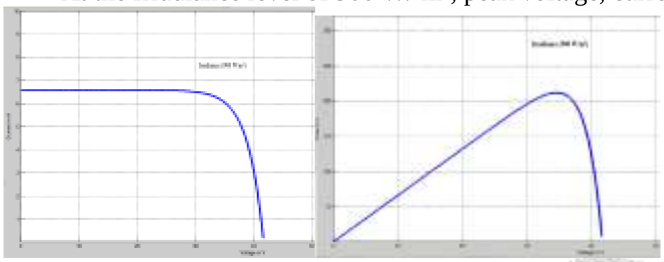

Fig.13.IV & PV Curve of Irradiance 900W/ m^2

The Maximum Power Point of 212.2 W is obtained at the point of voltage & current is 34.6 V & 6.133 A respectively.
Irradiance is 800 W/m^2
At the Irradiance level of 800 W/m^2. In this condition peak voltage, current & power values are 42 V, 5.87 A & 186.9 W respectively,

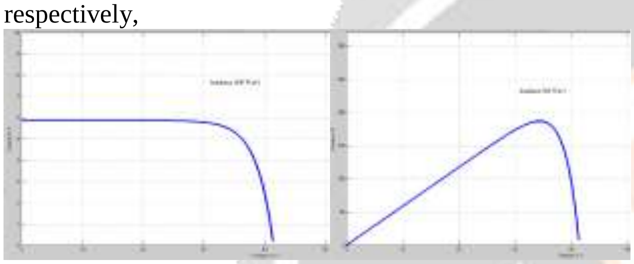

Fig.14.IV & PV Curve at Irradiance of 800 W/ m^2

The Maximum Power Point of 186.9 W is obtained at the point of voltage & current is 34.34 V & 5.443 A respectively.

VIII. SIMULATION OUTPUT OF PV SYSTEM WITH PARTIAL SHADING

The simulation results of the PV systems are given in below if the result is different partial shading.

- Partial Shading on 14 cells:-

In Fig.15 a & b shown the simulated result of panel with the 14 cells are shaded and remaining cell are operate in normal condition.

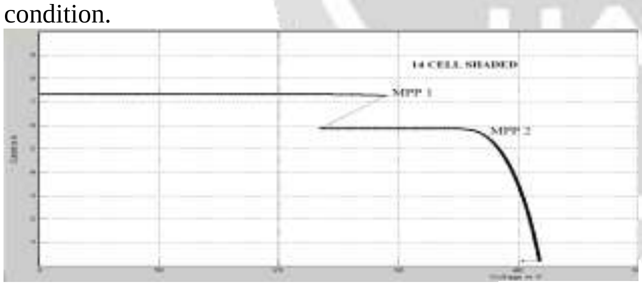

Fig.15.a. IV Curve for 14 Cells Shaded

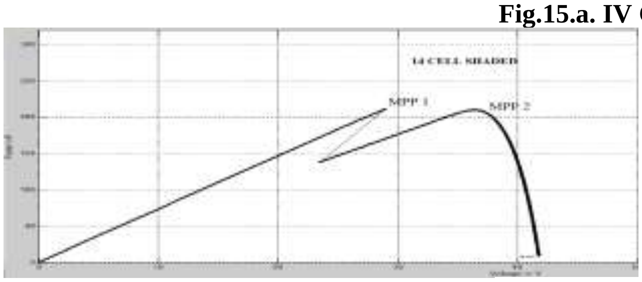

Fig.15.b. PV Curve for 14 Cells Shaded

In 14 cells are shaded condition in PV System, the peak voltage current & power values are 42 V, 7.34 A& 211.12 W respectively. It produce the two Maximum Power Point is MPP 1 & MPP 2.

The MPP 1 power is 211.12 W is obtained of the point of voltage &Current is 29 V & 7.28 A respectively.

The MPP 2 power is 210 W is obtained of the point of voltage &Current is 36.4 V & 5.77 A respectively.

- Partial Shading on 28 cell:-

In Fig.16 shown the simulated result of panel with the 28 cells are shaded and remaining cell are operate in normal condition. In 28 cells are shaded condition in PV System, the peak voltage current & power values are 42 V, 7.34 A& 211.12 W respectively. It produce the two Maximum Power Point is MPP 1 & MPP 2.

The MPP 1 power is 211.12 W is obtained of the point of voltage &Current is 29 V & 7.28 A respectively.

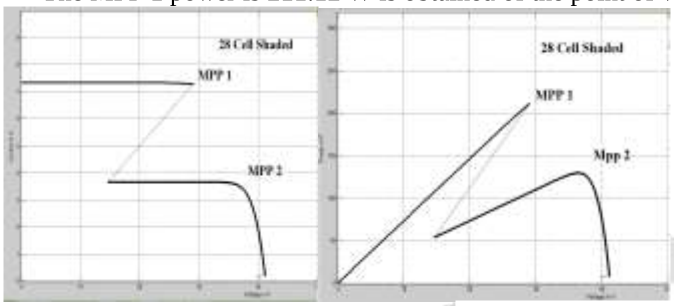

Fig.16. IV & PV Curve under 28 Cells Shaded

The MPP 02 power is 130 W is obtained of the point of voltage &Current is 36.5 V & 3.56 A respectively.

- Partial Shading on Multiple Shading:-

In Fig 17a & b shown the simulated result of panel with the multiple cells are shaded and remaining cell are operate in normal condition

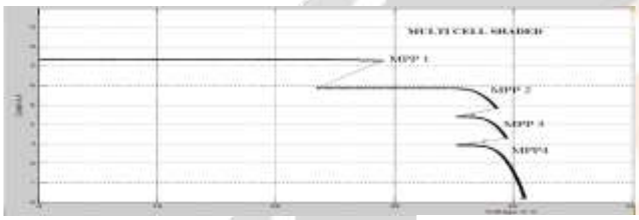

Fig.17.a. IV Curve under multiple Shaded conditions

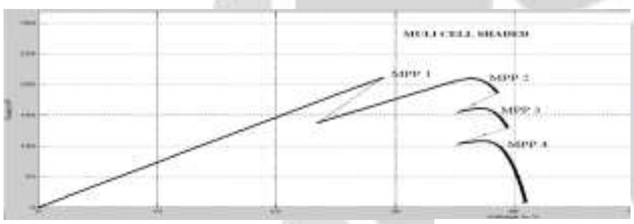

Fig.17.b. Curve under multiple Shaded conditions

In multiple cells are shaded condition in PV System at different time, the peak voltage current & power values are 42 V, 7.34 A& 211.12 W respectively. It produce the four Maximum Power Point is MPP 1, MPP 2, MPP 3 and MPP 4.

IX. SIMULATION RESULT OF PV WITH CONVERTER

The simulation result of PV System and KY Boost converter output is shown in the Fig.18 closed looped by P&O algorithm and PI controller and the corresponding gate pulse is shown in Fig 19.

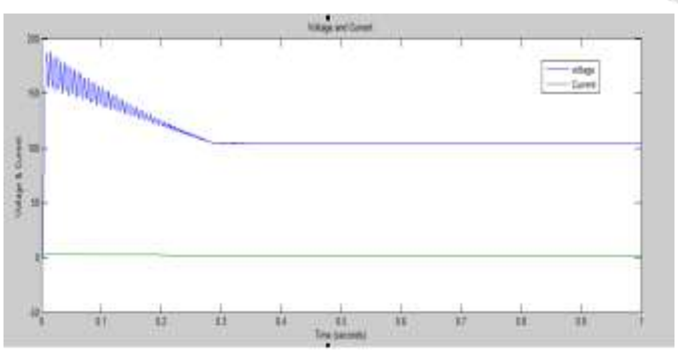

Fig.18.Output Voltage & Current of Solar with Converter

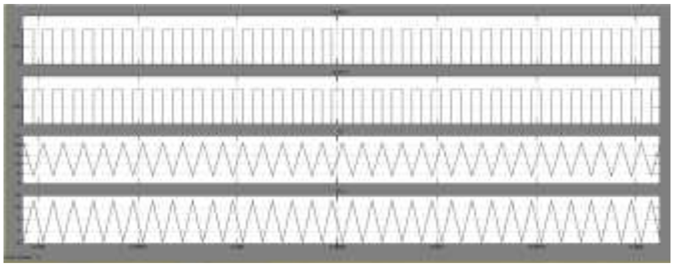

Fig.19.Gate pulse & Inductor: (1) M1; (2) M2; (3)i_{Lo}; (4) i_{Li}

X. CONCLUSION

The partial shading effect has been simulated under various irradiance level and different shaded condition in different cell. The performance of partial shading on PV module is analyzed in order to provide a simple and easily applicable methodology for the calculation of shadow effects on the main electrical characteristics of a PV module. Implemented simplified equations to estimate the multiple MPPs using information from datasheet, dispensing with the need to resort to laborious modelling and time consuming simulations. The accuracy of the simplified equations is proved to be quite satisfactory, permitting quick and reliable estimation of partial shading effects on a PV string.

XI. REFERENCE

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