

Hybrid Combination of PV, FC and Battery System with different modes

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Abstract— This paper presents a new hybrid system, consisting of PV, FC and battery system, proposed by authors. This paper presents a novel technique, multi-input DC-DC boost converter which combines three DC input sources. This introduces five different duty ratios for the proposed boost converter. Supplying the load with PV/FC/Battery, and also battery charging and discharging are possible. By using these duty ratios all power operation modes of the converter are possible. In the previous control strategy, the duty ratios have restrictions that the summations should be 1 which introduces low values of duty ratios therefore not it restricts to achieve high power output. In this paper, this restriction is being removed.

Index Terms— Photo-Voltaic Cell, Fuel Cell, Hybrid Combination

I. INTRODUCTION

As non-renewable energy sources are decreasing day by day, we need to think of some alternative sources of energy. Amongst all the energy sources, photo-voltaic cell is the most common renewable energy source because it requires less maintenance, simple operation and noise free operation. Though photo-voltaic cell is the most common source but it has some disadvantage like dependency on sun irradiation level which makes the system unreliable power source. Therefore the pv based power system is being clubbed by other energy source that is fuel cell system. Nowadays, fuel cells are becoming popular because of its advantages like high efficiency, cleanness and high reliability. Now as the demand power changes regularly, pv and fc system alone cannot supply the power, so batteries are used with pv and fc system to improve the response. So combining all these energy sources, we get hybrid distributed generation scheme.

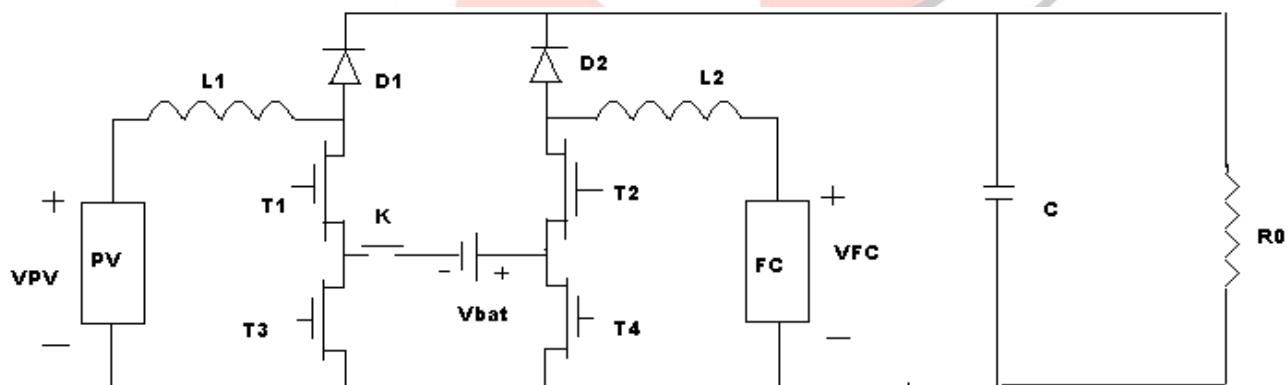


Fig.1: Circuit Diagram of Hybrid system.

This paper presents a new hybrid system, consisting of PV, FC and battery system, proposed by authors. This paper presents a novel technique, multi-input DC-DC boost converter which combines three DC input sources. This introduces five different duty ratios for the proposed boost converter. Supplying the load with PV/FC/Battery, and also battery charging and discharging are possible. By Using this duty ratios all power operation modes of the converter are possible. In the previous control strategy, the duty ratios have restrictions that the summations should be 1 which introduces low values of duty ratios therefore not it restricts to achieve high power output. In this paper, this restriction is being removed.

II. HYBRID SYSTEM

Fig. 1 shows the circuit diagram of the hybrid system. Now this paper introduces three-input DC-DC boost converter. As given in previous paper that summation of all duty ratios should be equal to 1 which results in low value of dc voltage. Now to solve this problem this paper introduces some new schemes as follows:

There are total seven modes of operation in this paper.

In First mode, when demand power is less than or equal to FC power than only FC will supply the power to load. In this case Duty Ratio D2 and D4 will operate.

In Second mode, when demand power is more than FC but less than PV power than only PV will supply the power to load. In this case Duty Ratio D1 and D3 will operate.

In Third mode, when demand power is more than both PV and FC but less than PV+FC than both PV and FC will supply the power to load. In this case Duty Ratio D1, D2, D3 and D4 will operate.

In Fourth mode, when demand power is more than both PV and FC power than the extra power is supplied by Battery. Therefore in this, battery discharging is needed. In this case, duty ratio D1, D2, D3, D4 and D5 will operate.

In Fifth mode, when demand power is more than PV and FC but less than PV+FC than in that case extra power is supplied to Battery. Therefore in this, Battery charging is needed. In this case, duty ratio D1, D2, D3, D4 and D5 will operate.

In Sixth mode, when demand power is more than PV power than in that case battery discharging is needed. In this case, duty ratio D1, D3 and D5 will operate.

In Seventh mode, when demand power is less than FC power than in that case battery charging is needed. In this case, duty ratio D2, D4 and D5 will operate.

Now depending on different demand power, PV power, FC power, and battery charging/discharging necessity, proper operation mode is determined. Table I shows possible power operation modes of the system.

Table I: Various Power operation modes of the system.

Duty Ratio	Operating Mode
D2, D4	Only FC
D1, D3	Only PV
D1, D2 D3, D4	PV and FC
D1, D2 D3, D4 D5	PV,FC and Battery Discharging
D1, D2 D3, D4 D5	PV,FC and Battery Charging
D1,D3,D5	PV And Battery Discharging
D2,D4,D5	FC And Battery Charging

III. SIMULATION RESULTS

In order to verify the performance of the proposed converter, it has been simulated by MATLAB. In the simulation, the maximum deliverable power of the PV, the FC and the battery are $PPV_{max}=2.5kW$, $PFC_{max}=1.5kW$, and $P_{Battmax}=1.0kW$, respectively. Moreover, MPPT of the PV source is made by the Perturb and Observe MPPT algorithm [8]. During the simulation, the DC-link voltage is regulated at $VDC=550V$.

First simulation stage

In this stage, when load power is 1500, than power can be supplied by FC system. In this case, duty ratio D2 and D4 are chosen as 62.

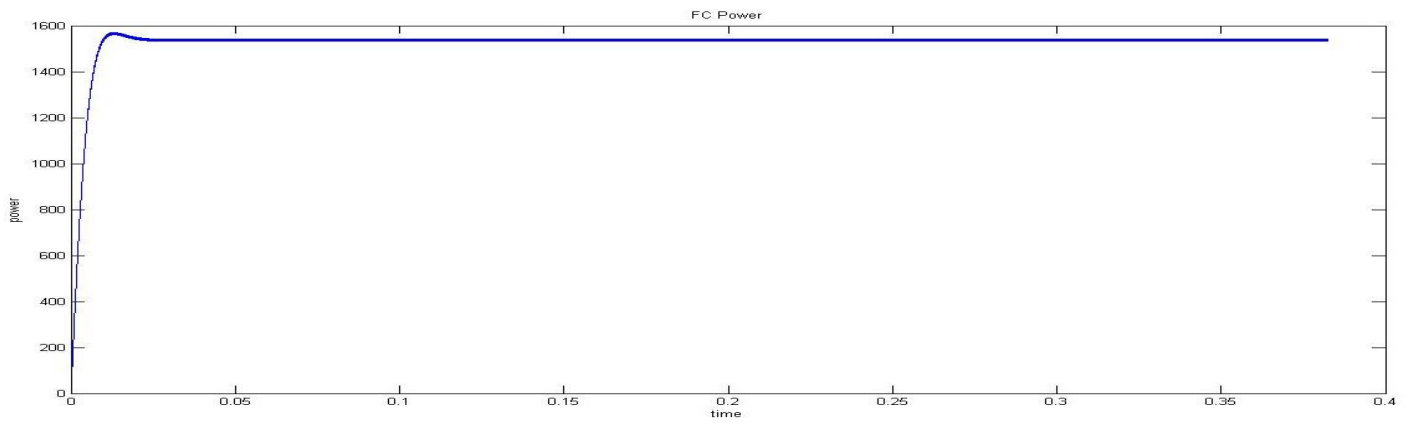


Fig.2. FC Power

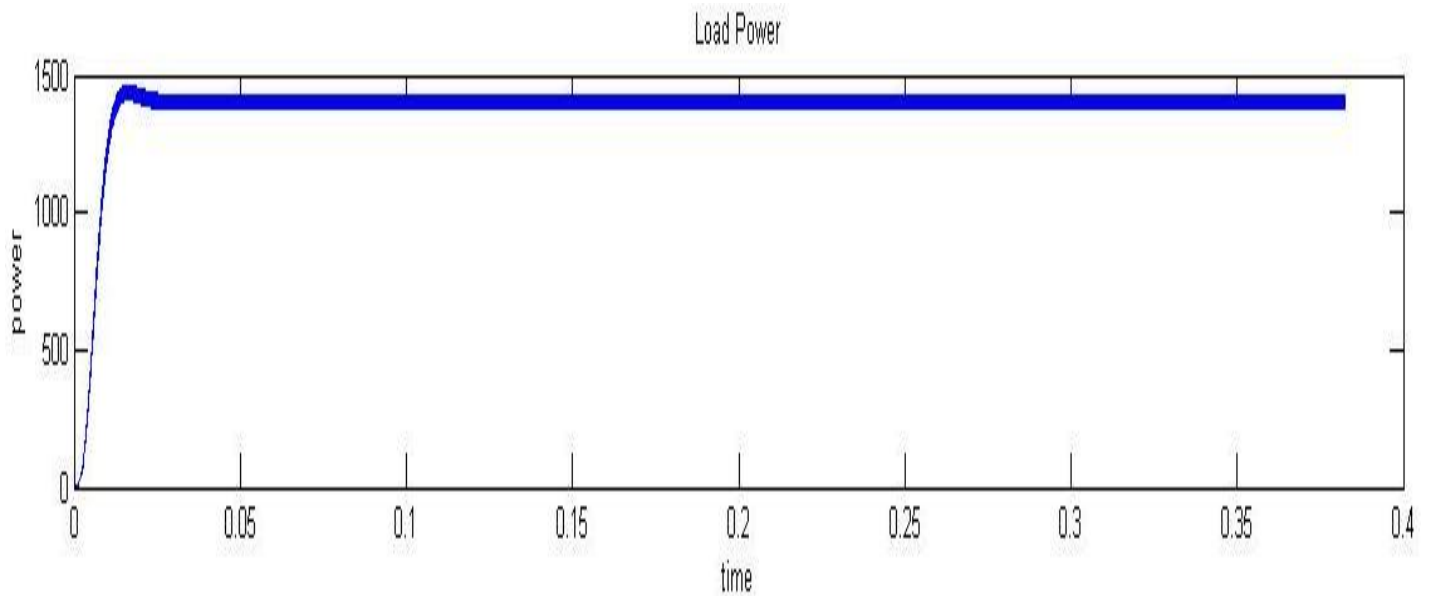


Fig.3. Load Power

Second simulation stage

In this stage, when load power is 2500 and $S=1000W/m^2$, than power can be supplied by PV system. In this case, duty ratio D1 and D3 are chosen as 68.

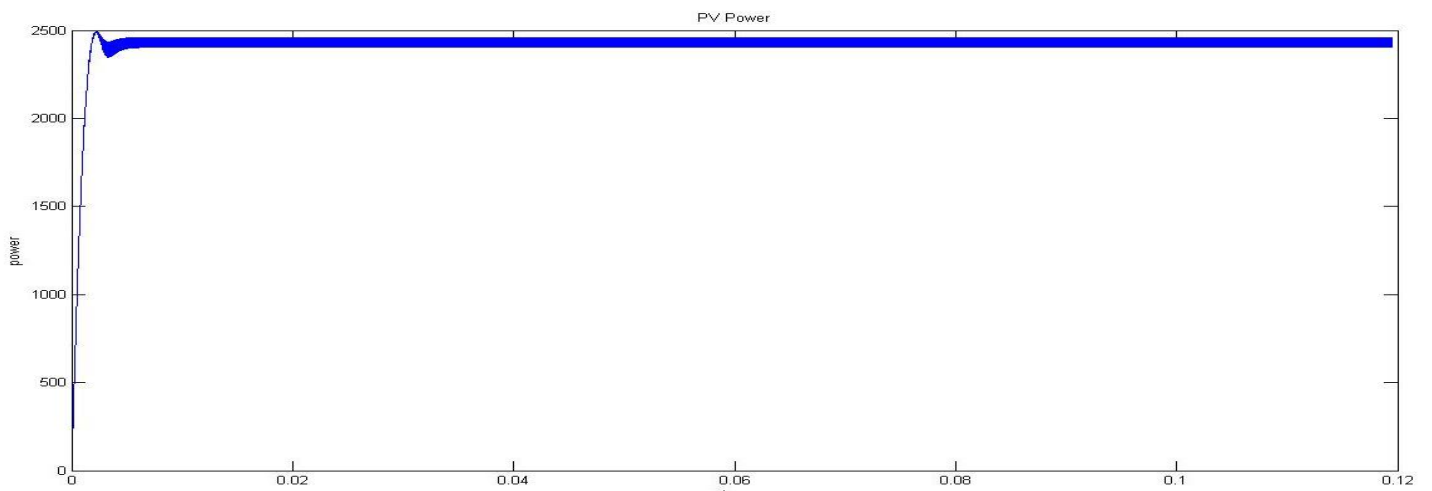


Fig.4. PV Power

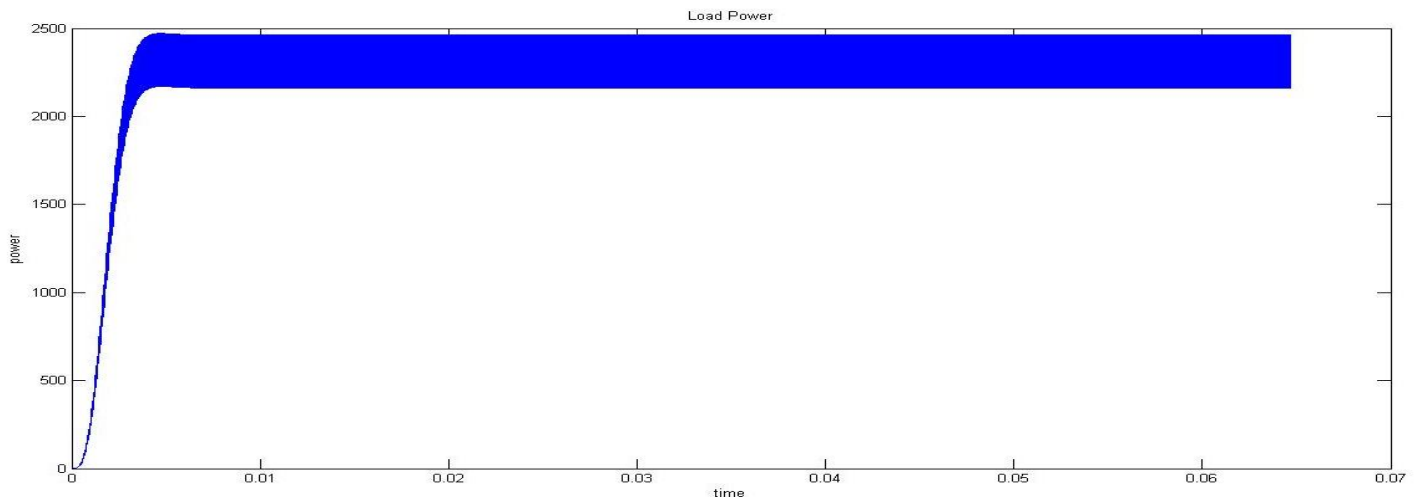


Fig.5. Load Power

Third simulation stage

In this stage, when load power is 4000 and $S=1000W/m^2$, than power can be supplied by both PV and FC system. In this case, duty ratio D1 and D3 are chosen as 68 and D2 and D4 are chosen as 62.

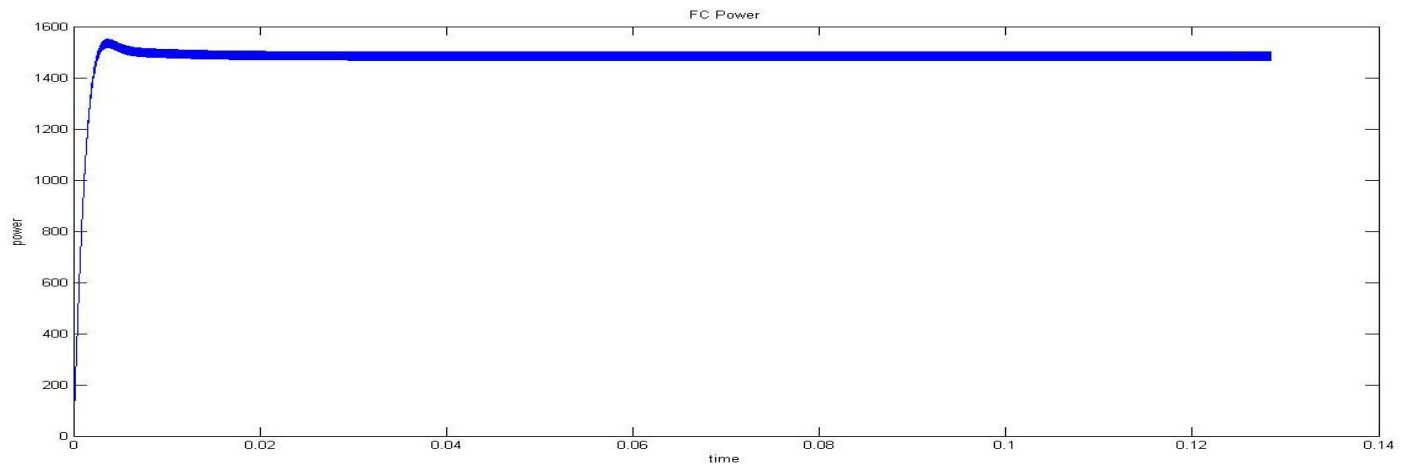


Fig.6. FC Power

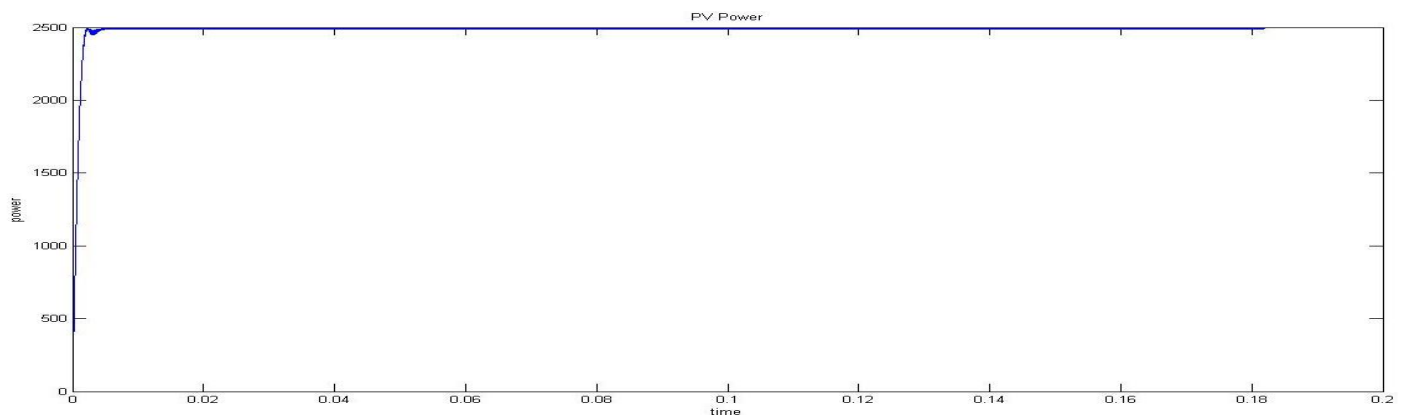


Fig.7. PV Power

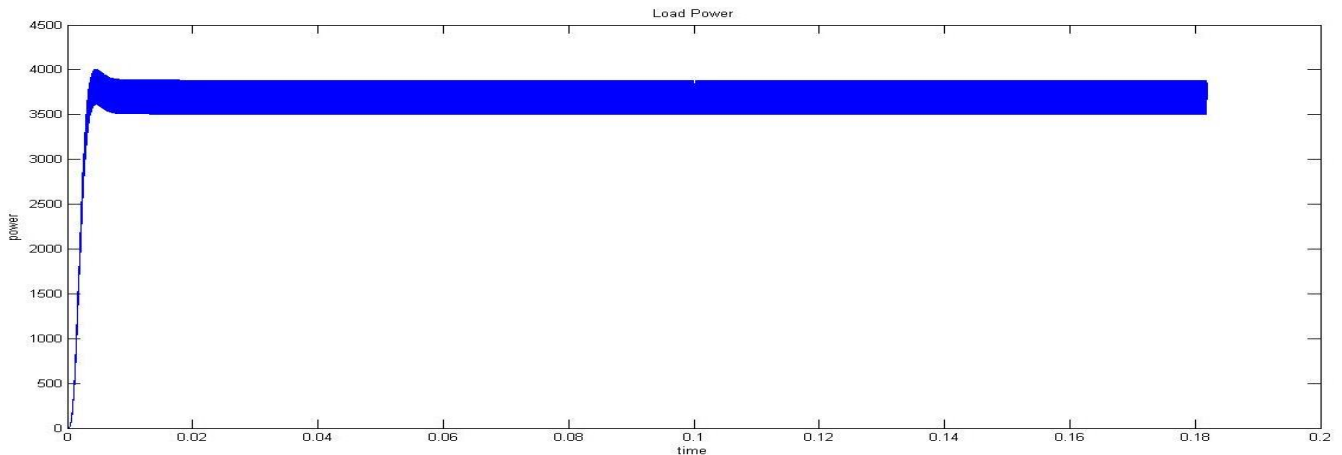


Fig.8. Load Power

Fourth simulation stage

In this stage, when load power is 3500 and $S=700W/m^2$, than power cannot be supplied by PV and FC system only. Here Battery discharging is needed. In this case, duty ratio D1 and D3 are chosen as 68 and D2 and D4 are chosen as 62 and D5 is 32.

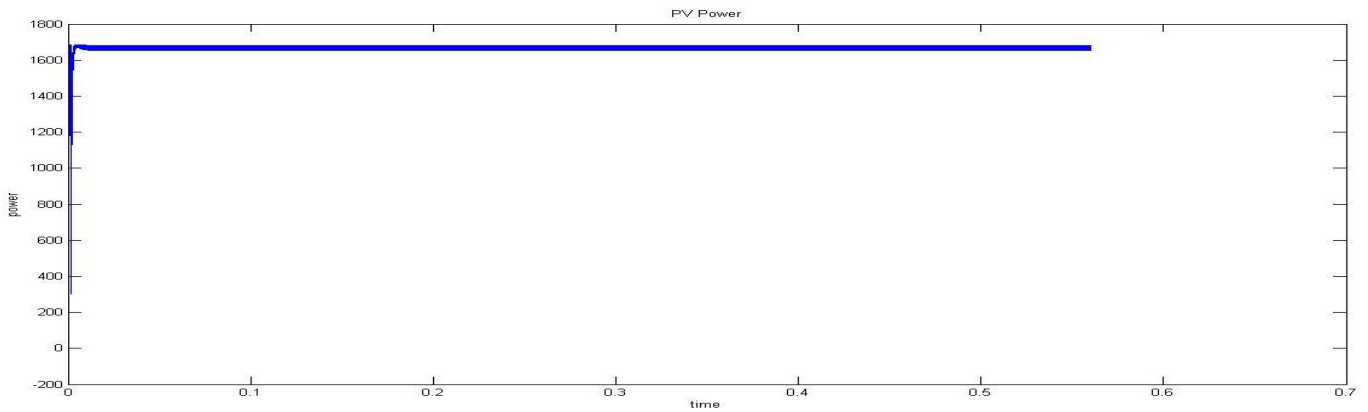


Fig.9. PV Power

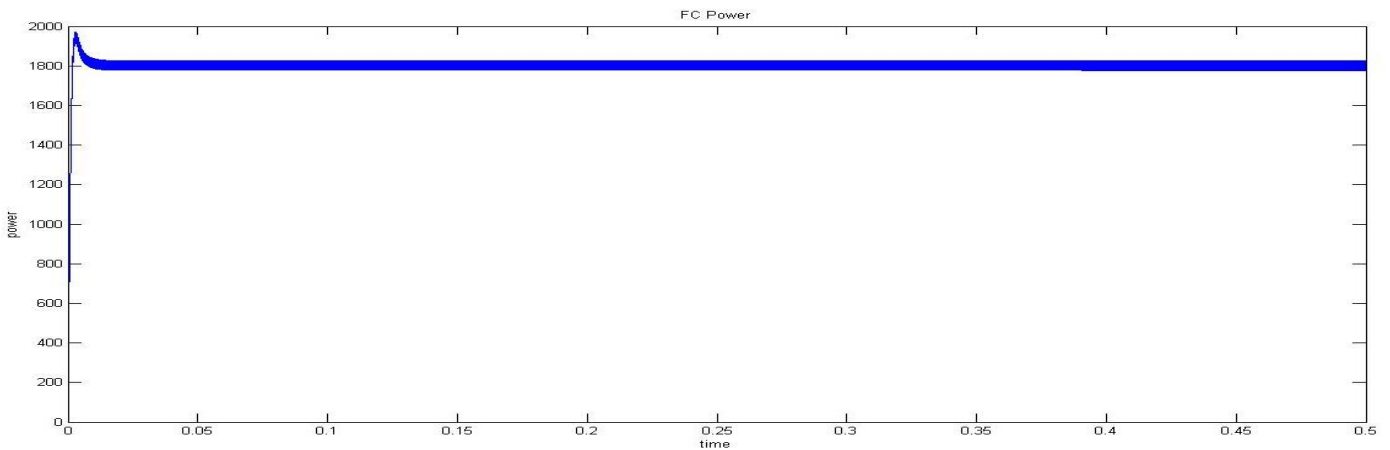


Fig.10. FC Power

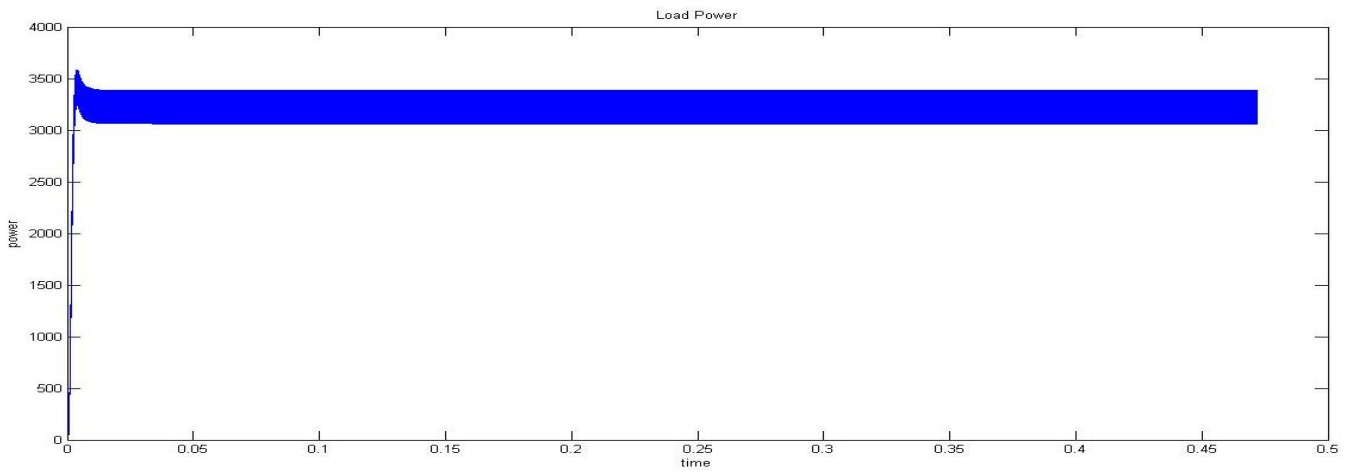


Fig.11. Load Power

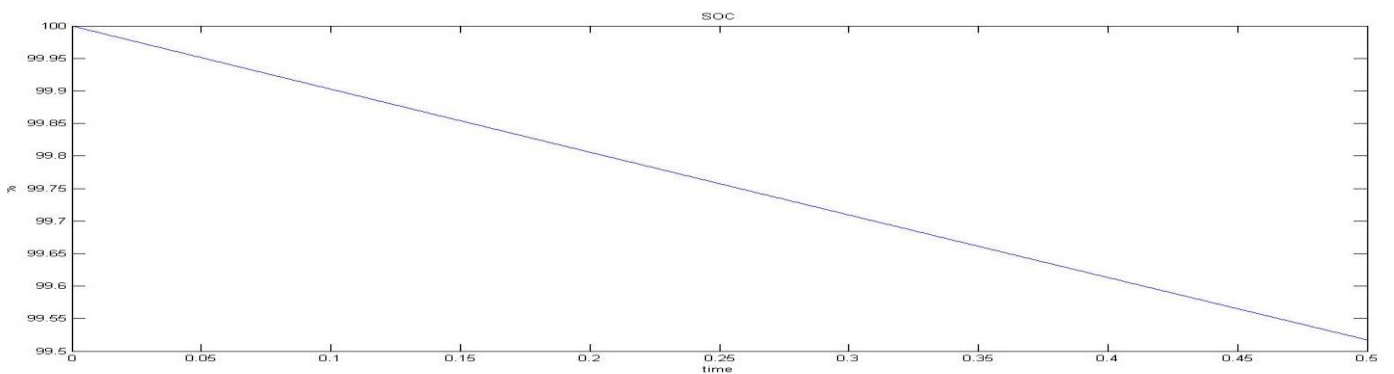


Fig.12. Battery Discharging

Fifth simulation stage

In this stage, when load power is 3000 and $S=1000W/m^2$, than power can be supplied by PV and FC system together and also here battery charging is possible. In this case, duty ratio D1 and D3 are chosen as 68 and D2 and D4 are chosen as 62 and D5 is 32.

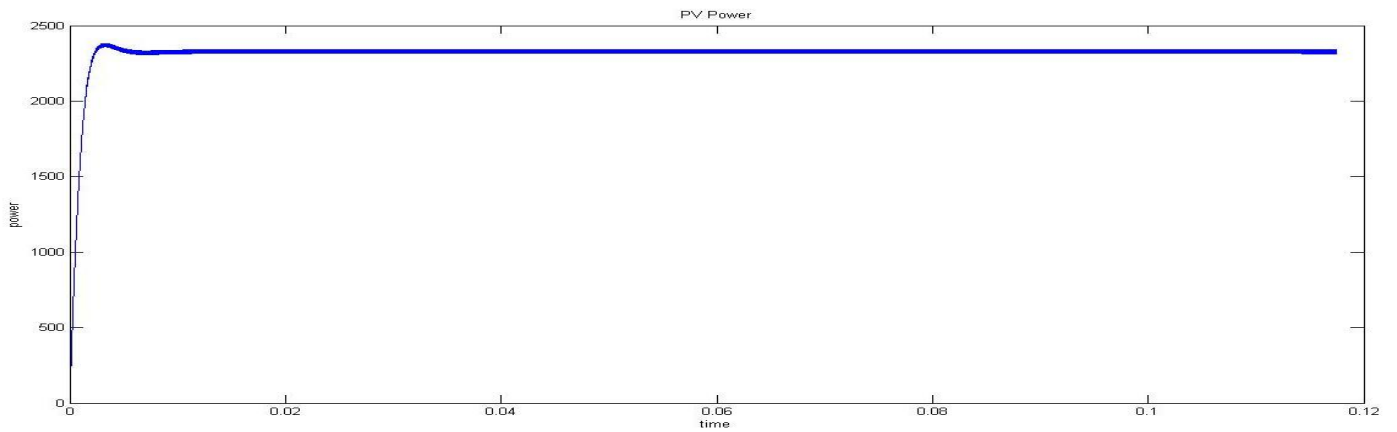


Fig.13. PV Power

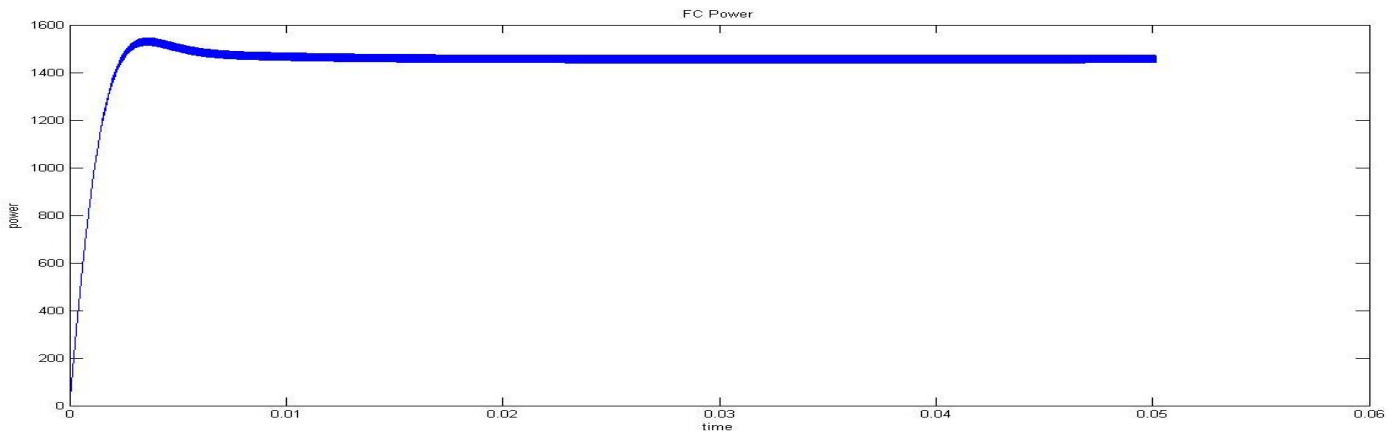


Fig.14. FC Power

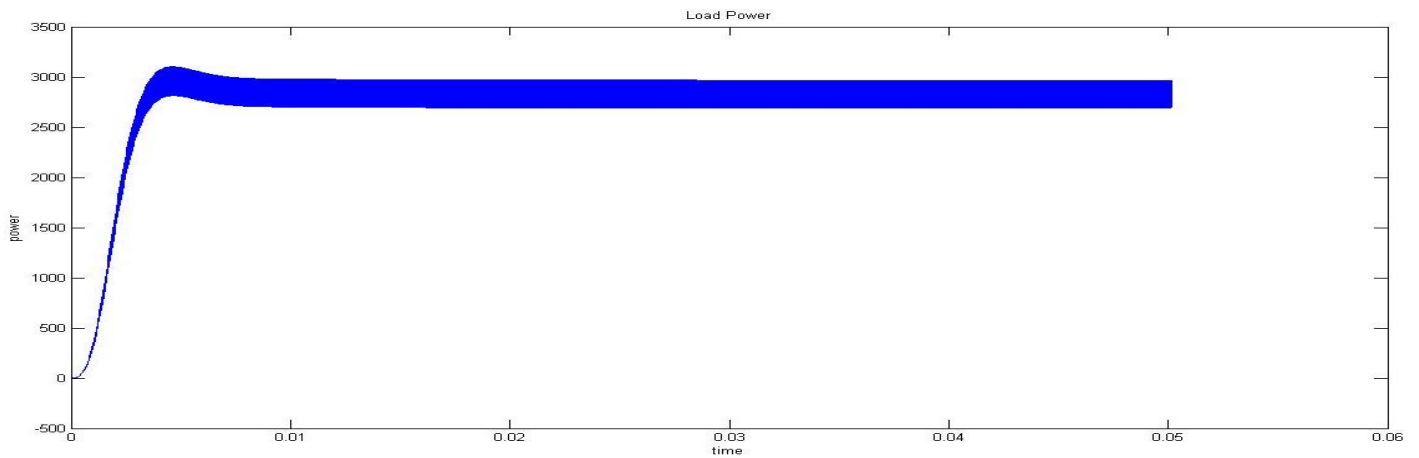


Fig.15. LOAD Power

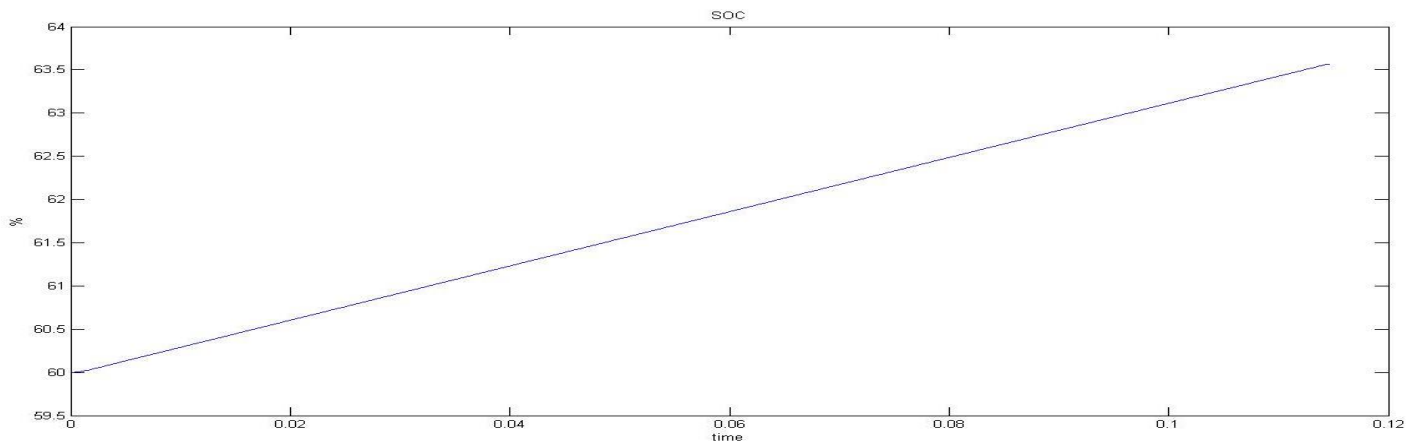


Fig.16. Battery Charging

Sixth simulation stage

In this stage, when load power is only 1200W, than power can be supplied by only FC system and also here battery charging is possible. In this case, duty ratio D2 and D4 are chosen as 62 and D5 is 38.

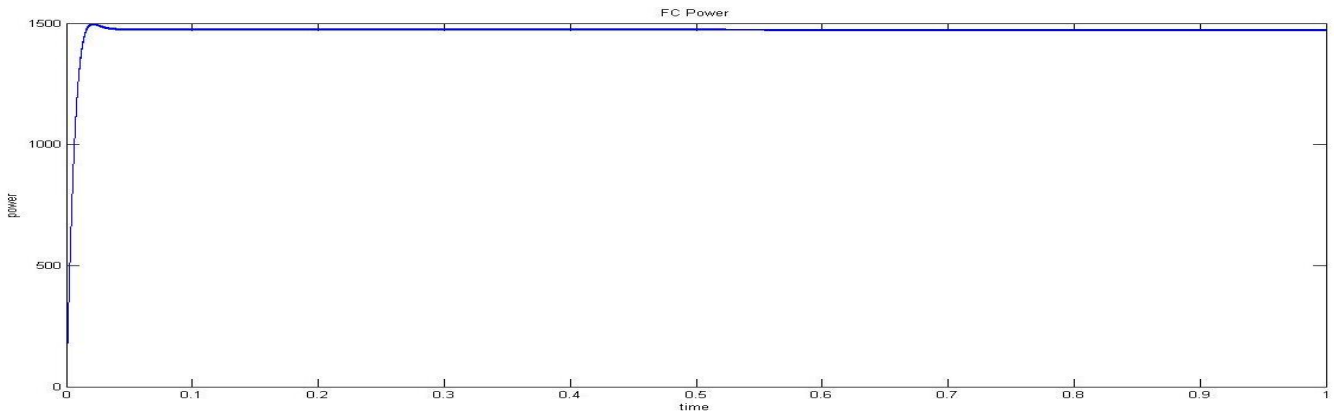


Fig.17. FC Power

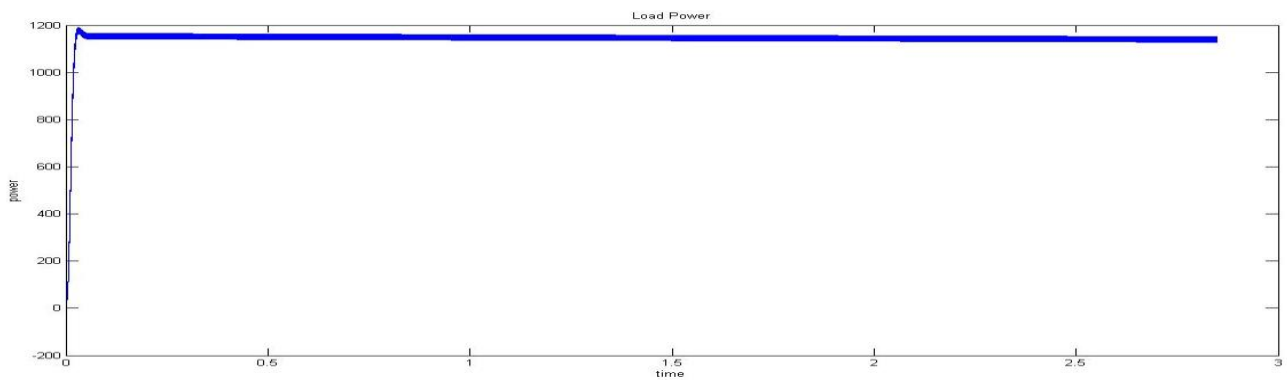


Fig.18. LOAD Power

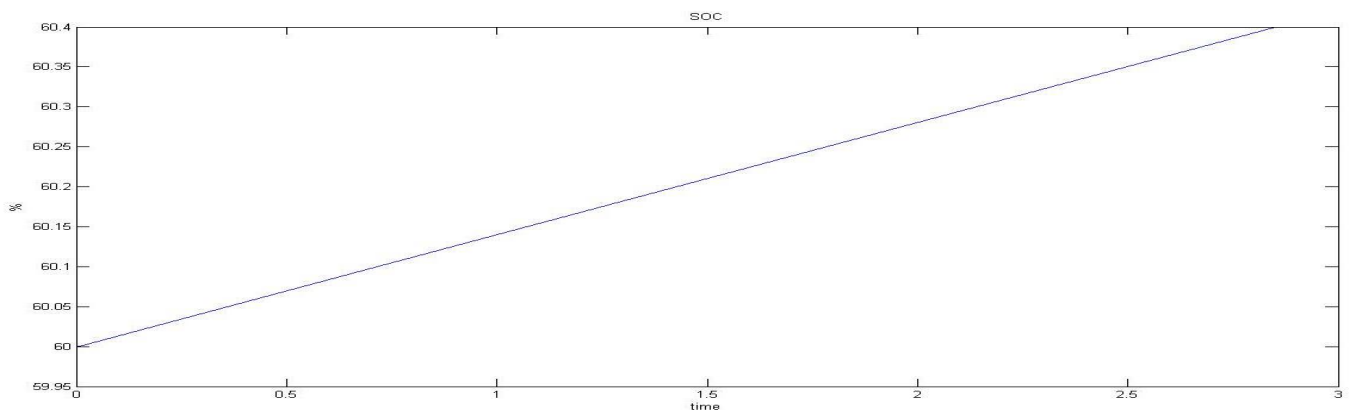


Fig.19. Battery Charging

Seventh simulation stage

In this stage, when load power is only 2500W and $S=700W/m^2$, than power cannot be supplied by PV system. Here we need battery discharging. In this case, duty ratio D1 and D3 are chosen as 50 and 62 respectively and D5 is 38.

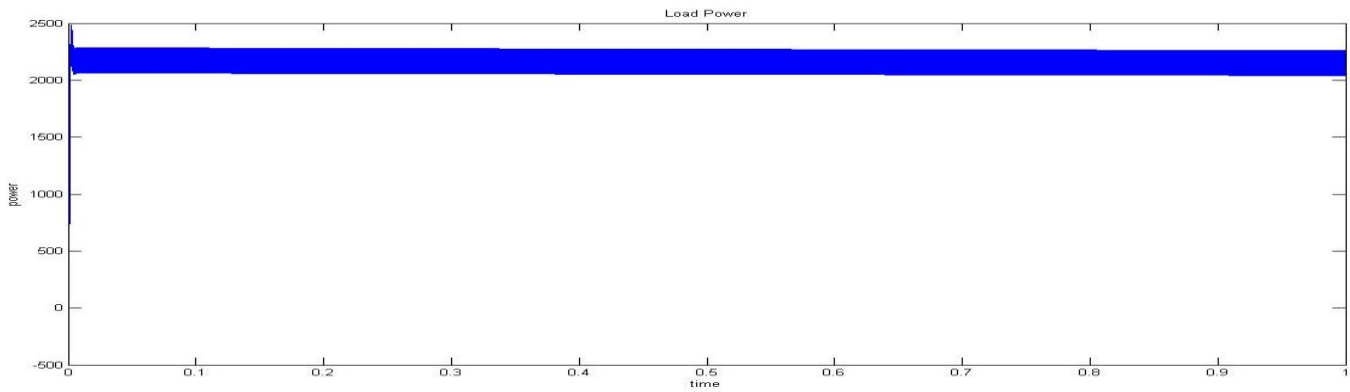


Fig.21. Load Power

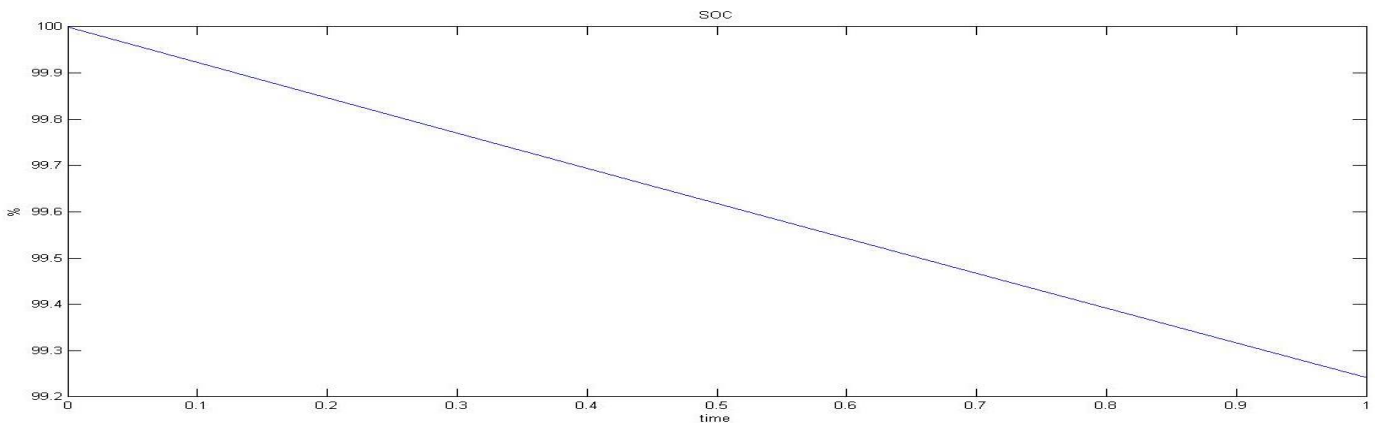


Fig.22. Battery Discharging

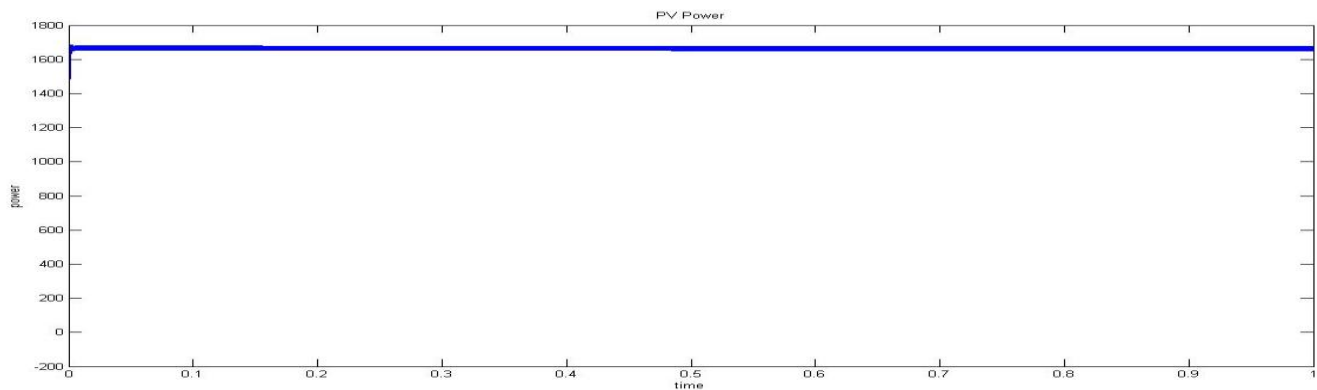


Fig.20. PV Power

IV. REFERENCES

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