Hysteresis Current & SPWM Controller based Power Sharing Mechanism for Photovoltaic Micro-Grid System

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Abstract

Microgrid is the small grid which consists of the large number of micro sources. These micro sources are the source of energy mainly the renewable energy sources. The main purpose of this project is to connect the microgrid with the main utility grid. In this paper the micro grid will work in synchronism with the utility grid. The power supplied to the loads is via main utility grid as well as by microgrid as per the demand of the loads. If the load increases than the extra power is supplied by the main grid. When the intentional islanding takes place or due to any other power quality issues than the microsources have to generate extra power to fulfill the demand of the local loads all these conditions are analyzed and shown with the help of MATLAB on simulink.
Keywords: Microgrid, Photovoltaic, SPWM, Hysteresis Current

I. INTRODUCTION

MGs, using renewable power resources, have various times used as an alternative to expansion of utility grids to supply electricity in remote areas of developing countries. Previously, these MGs have operated in isolation from the main grid, now it is changing as Main grids are extending their reach into rural areas, offering the opportunity to interconnect with MGs with national or regional energy infrastructure. For customers, the main grid offers an electricity supply constrained neither by the MG's generation capacity nor by renewable energy resources availability. This, in turn, can expand the customer base in step with growing village population and expanded use of electricity such as cooking, space, water heating, and industrial loads. For MG operators, grid interconnection may provide an opportunity to increase their revenue by selling surplus electricity to the utility grid.

II. PROPOSED WORK

A. MGD Model

The proposed Micro Grid Distribution system (MGD) is simulated in Matlab/Simulink environment as shown in the fig.1. Two identical PV based micro sources (solar-1 and solar-2) are connected to a common bus through 3 phase VSI and filter (R-L). The MGD is further connected to the main grid (which is modelled by the 3 phase ac source) through circuit breaker.
The performance of the proposed controller is verified through measuring the following parameters.

1) Grid voltage (Vgrid) and current (I grid)
2) Inverter1 output voltage (Vms1) and current (Ims1)
3) Inverter 2 output voltage(Vms2) and current(Ims2)
4) Voltage at load bus of MCS 1 (Vload1), Current at load bus of MCS 1 (Iload1)
5) Voltage at load bus of MCS 2 (Vload2), Current at the load bus of MCS 2 (Iload2)
6) Total load power (P_total).

Performance of the proposed system is tested under grid connected mode and off-grid mode with equal and unequal load distribution. The main power sources of the proposed system are considered as photovoltaic renewable sources. Different parameters of controller are tabulated in Table-1

Table – 1
Controller Parameters

Parameters	*Values*
Hysteresis Band	*0.1 mA*
Carrier Frequency of SPWM	*15000 Hz*
Proportional Gain	*0.001*
Integral Gain	*0.1*
Sampling frequency of controller (PI)	*0.3 ms*

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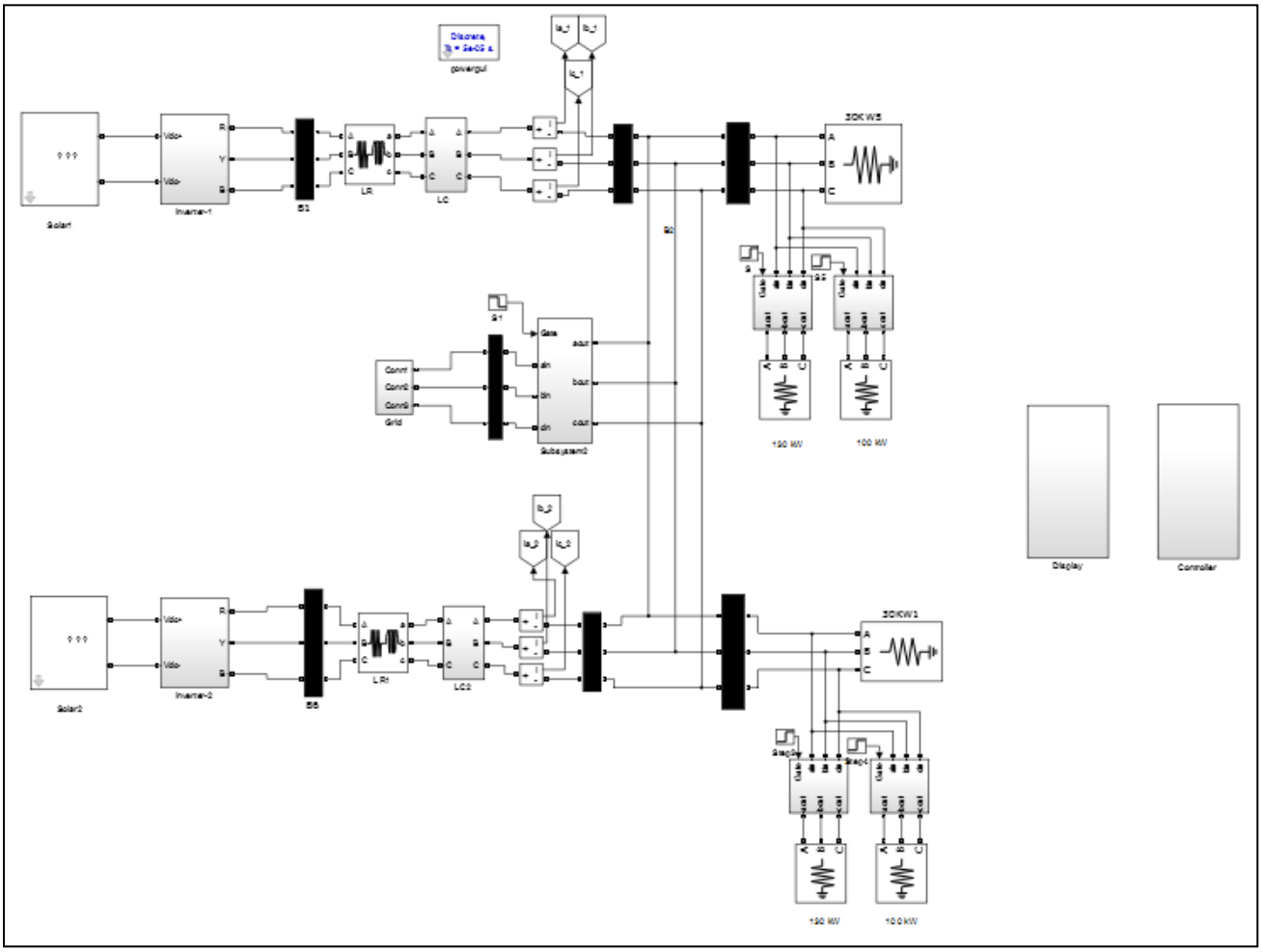
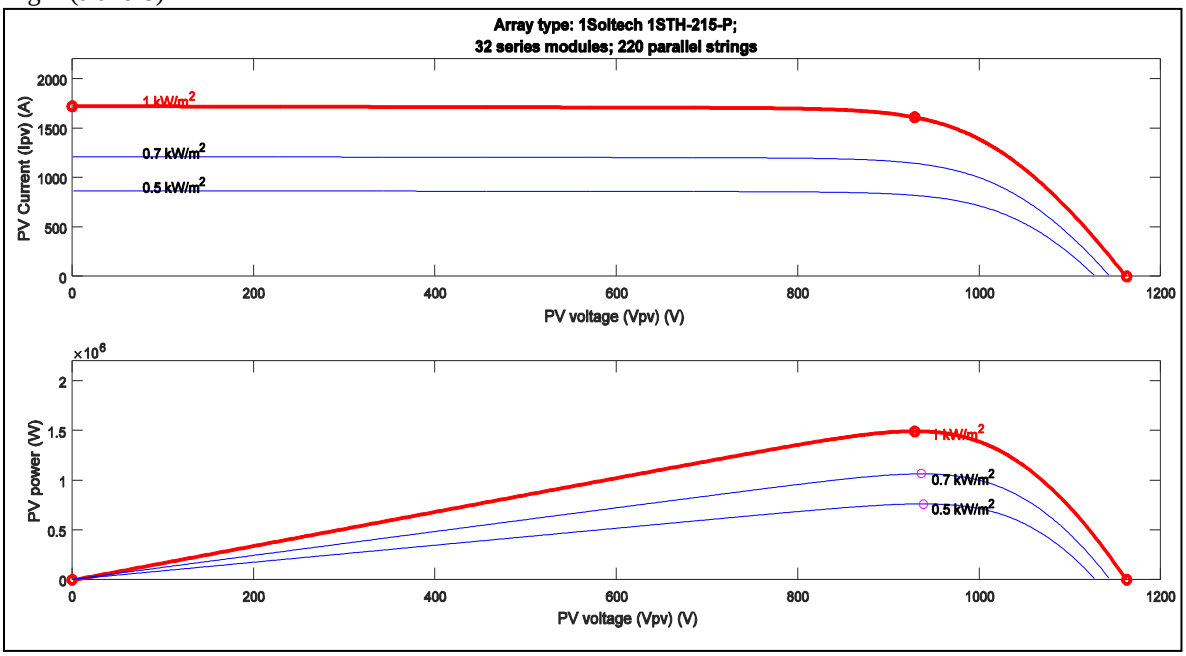


Fig. 1: Simulink implementation of proposed system

The power (Ppv) vs voltage (Vpv) and current (Ipv) vs voltage (Vpv) of Pv sources at different environmental conditions is shown in Fig-2 (a and b)



(a)

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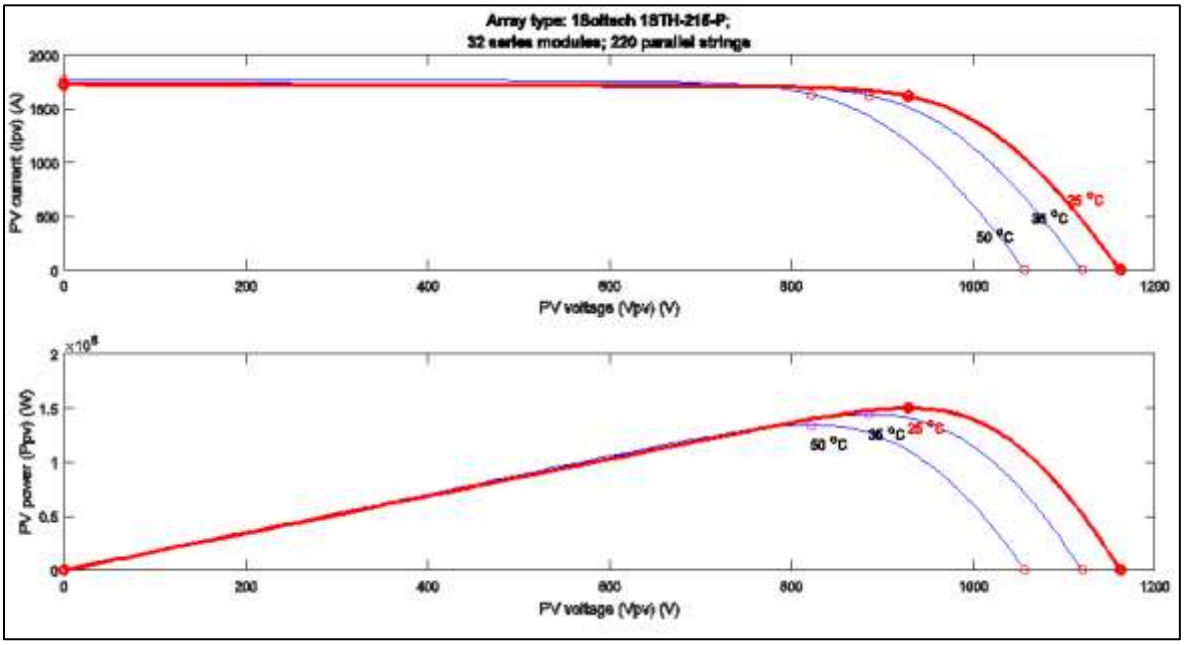

(b)

Fig. 2: PV characteristics (a) at fixed temperature (25°C) and different radiations (b) at different temperatures and fixed radiation (1 kW/m^2)

III. MGD OPERATION DURING EQUAL LOADS

First of all, the system starts in the grid connected mode. The load of 30kw is placed on the both micro sources. The frequency of grid is 50Hz. At time setting of 0.15s, load is increased by 130kw. At 0.25 sec, the main grid is isolated from the system by circuit breaker. Now the power has to be provided by the two MCS. Here the role of solar module comes into play. The solar module with the help of inverter is providing the power demands of the loads. Again at the time setting of 0.35 sec, additional load of 100 kw is added to MCS1 and 100kw is added to the MCS2. The power demand is still provided by the MCS as shown in the fig.3. It is also observed that injected inverter current is with same phase of grid voltage hence unity power factor operation is achieved in grid connected mode.

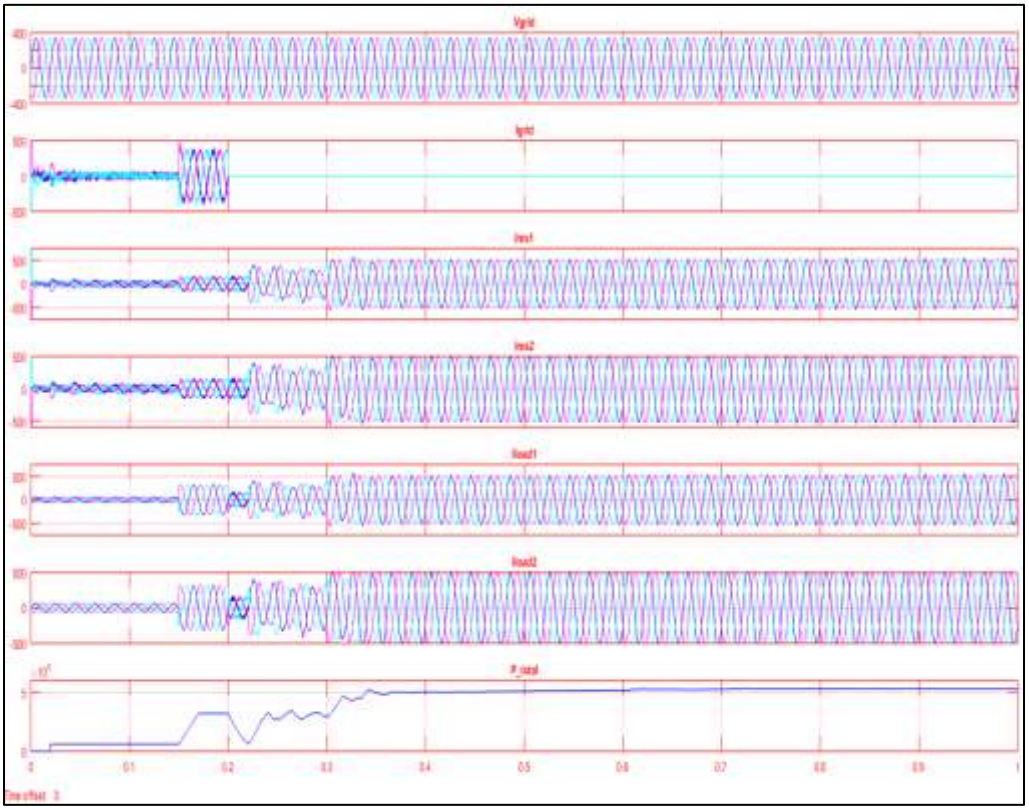

Fig. 3: Operation of MGD during equal Loads

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Furthermore inverter1 output voltage (Vms1), inverter2 output voltage (Vms2), voltage at load bus of MCS 1(Vload1), voltage at load bus of MCS 2 (Vload2) during the grid connected and islanded condition under equal load conditions are shown in fig.4. It is observed that at islanding mode load voltage maintain at around 239 V RMS (L-N). It proves that PI controller with SPWM working perfectly.

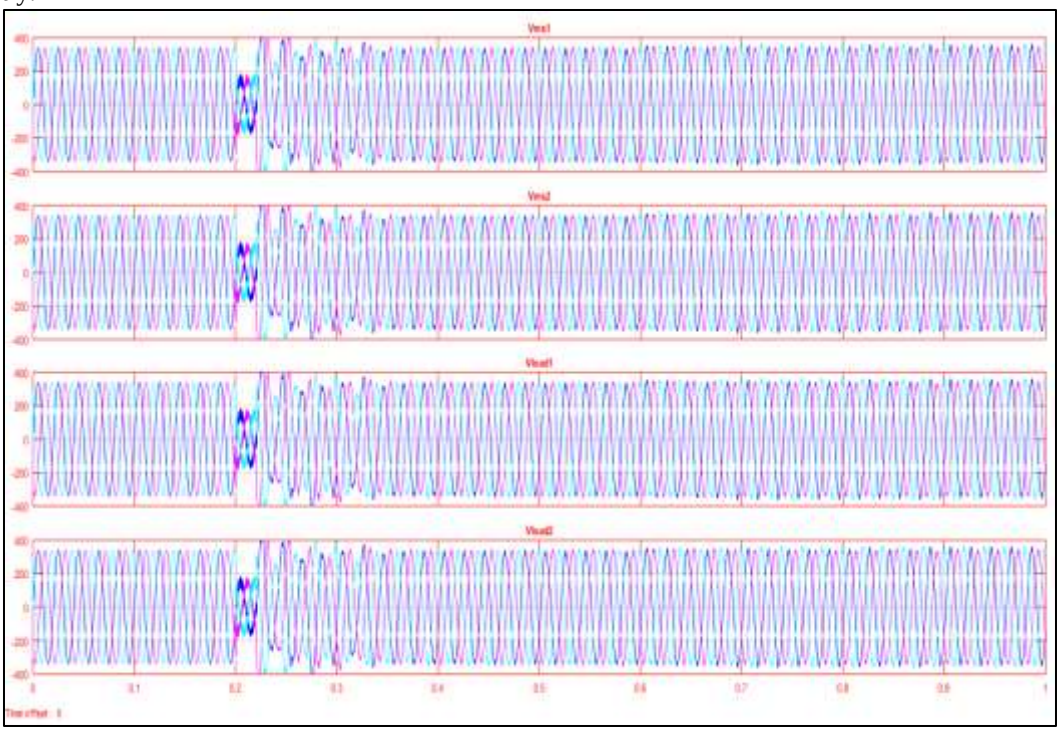

Fig. 4: Voltage waveforms during Equal Loads(Vms1, Vms2, Vload1, Vload2)

IV. MGD OPERATION DURING UNEQUAL LOADS

During Unequal loads, the system also starts in the grid connected mode. The load of 30kw is placed on the both micro sources. The frequency of the grid voltage is also 50Hz which is provided by the grid. At time setting of 0.15, load is increased by 130kw. At 0.25 sec, the main grid is isolated from the system. Now the power has to be provided by the MCS. Here the role of solar module comes into play. The solar module with the help of inverter is providing the power demands of the loads. Again at the time setting of 0.35 sec, additional load of 100 kW is added to MCS1 and 50 kw is added to the MCS2. The power demand is still provided by the MCS as shown in the fig.5

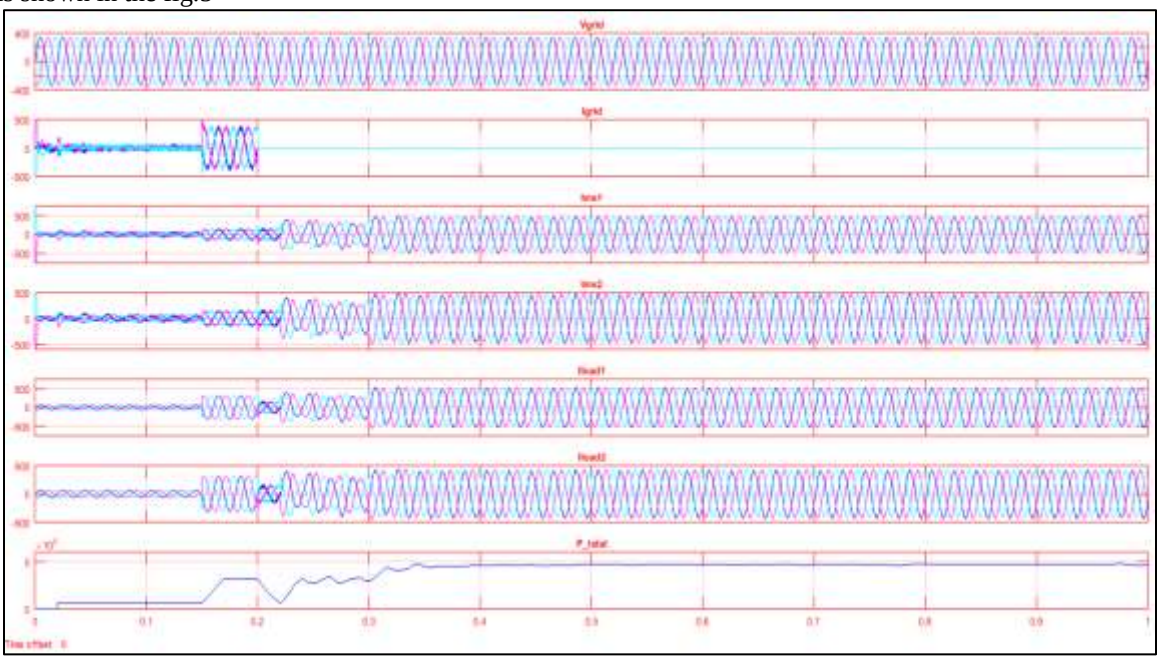

Fig. 5: Operation of MGD during Unequal Loads

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Moreover, inverter1 output voltage (Vms1), inverter2 output voltage (Vms2), voltage at load bus of MCS 1 (Vload1), voltage at load bus of MCS 2 (Vload2) during the grid connected and islanded condition under unequal load conditions are shown in fig.6.

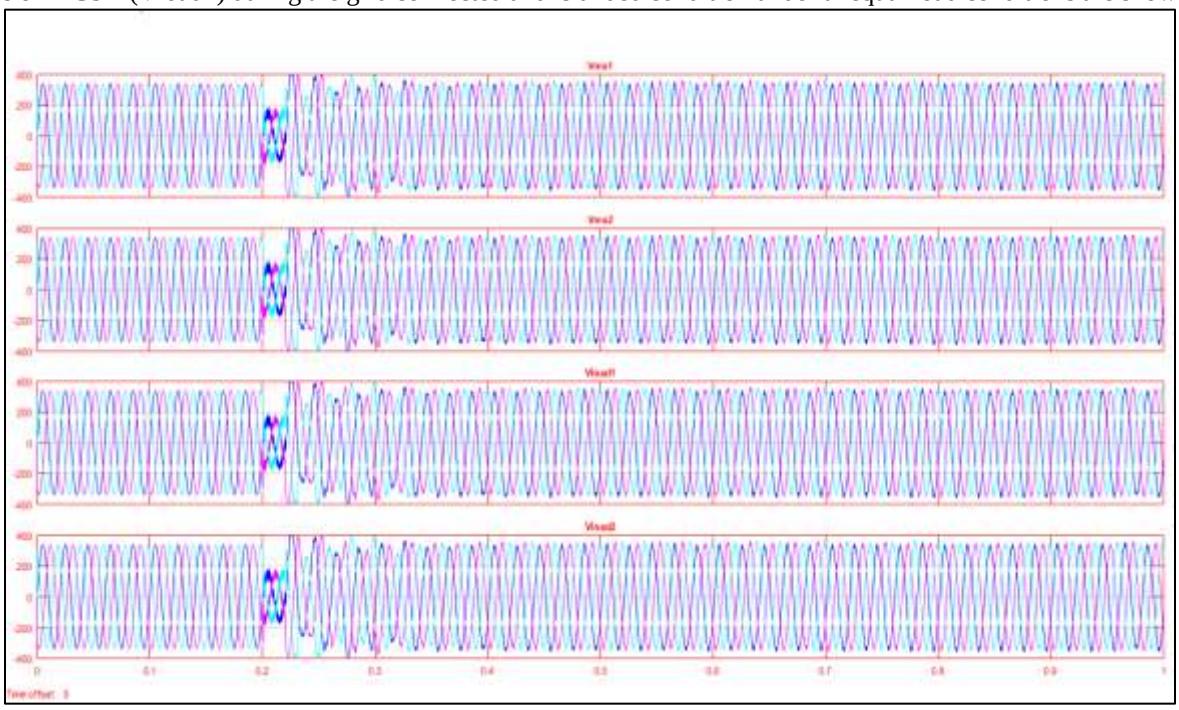

Fig. 6: Voltage waveforms during unequal loads(Vms1, Vms2, Vload1, Vload2)

V. COMPARISON

It is observed from the base paper that two micro sources are not shared the equal amount of power. The MS-2 shared more current than MS-1. But, through our proposed controller, both the micro sources shared the equal amount of current as shown in Fig.7.

Fig. 7: Current through micro-sources

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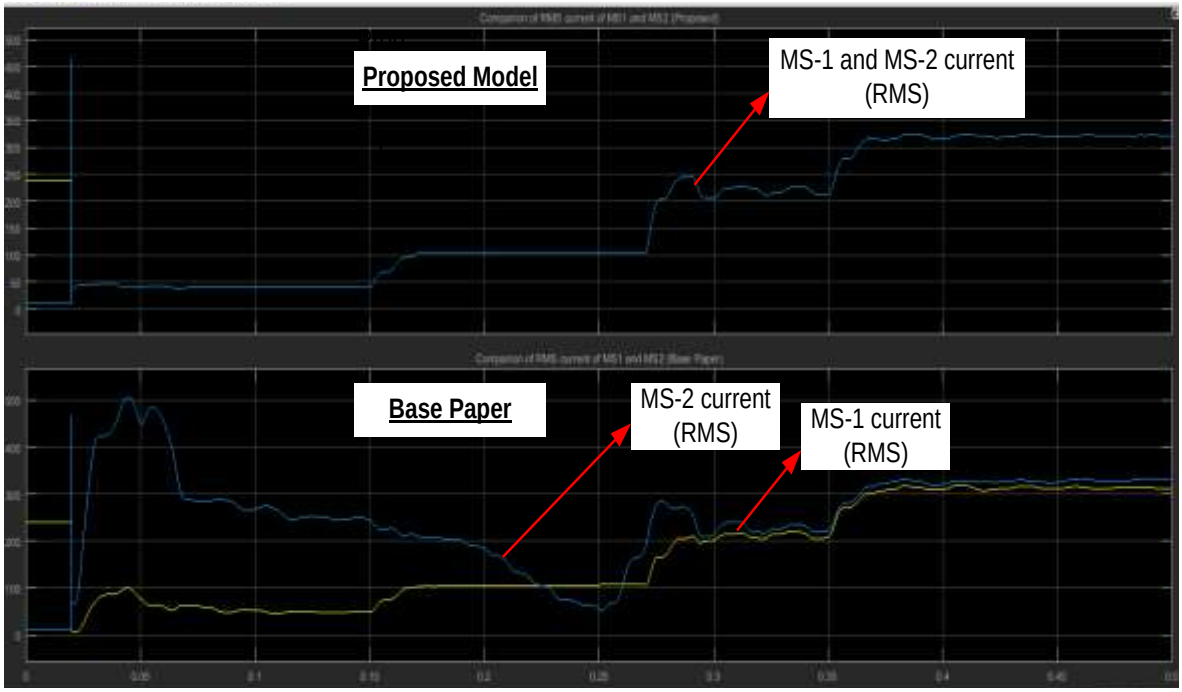

Fig. 8: Comparison of power sharing by micro sources (MS-1 and MS-2) between proposed model and base paper

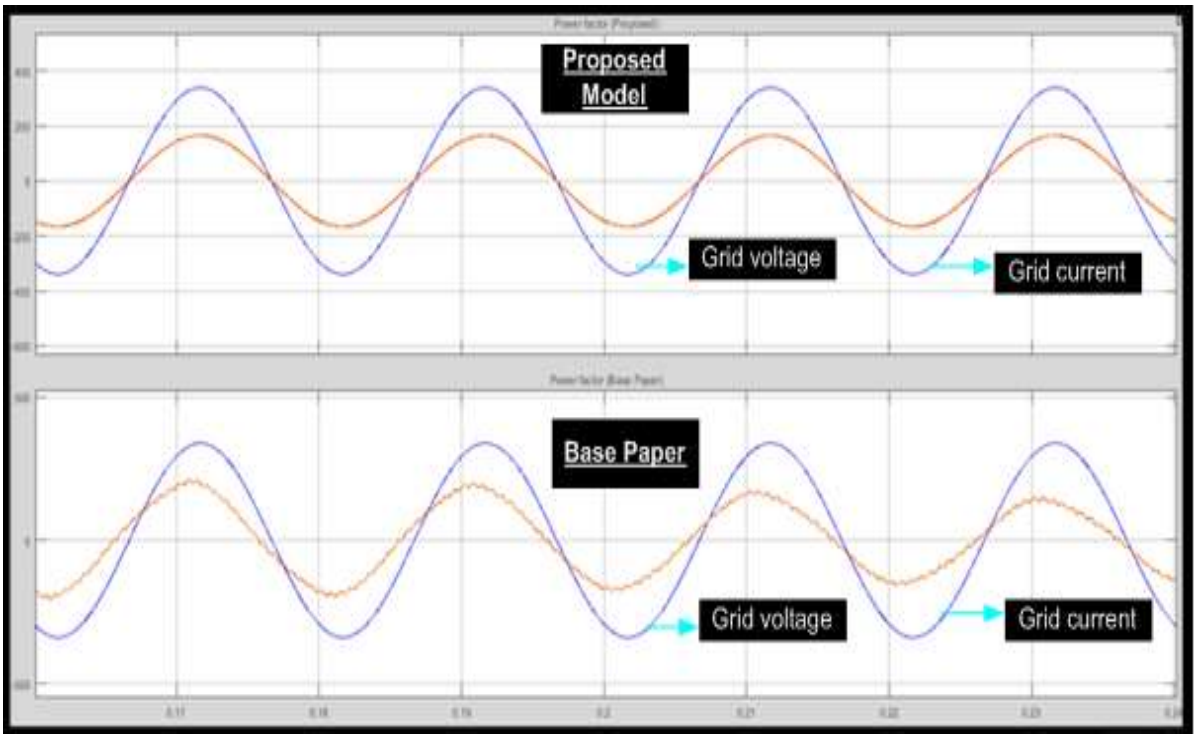

Fig. 9: Grid Voltage and Grid Current Comparison

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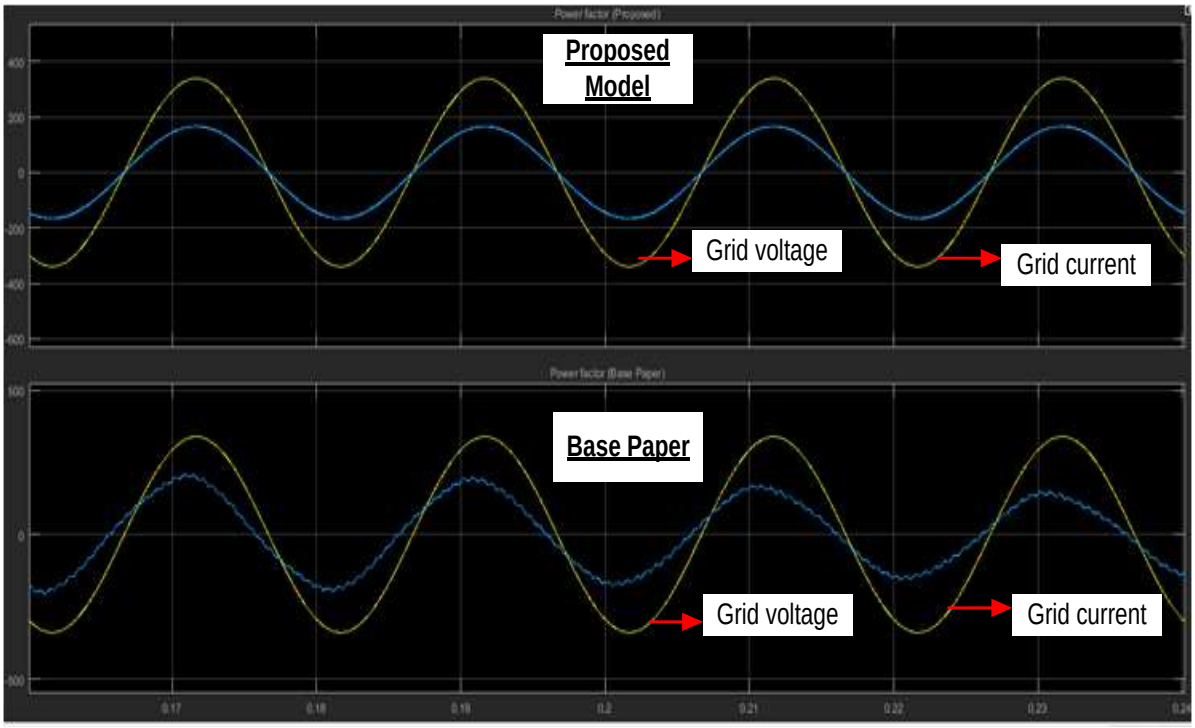

Fig. 10: Comparison of grid power factor between proposed model and base paper

It is observed from the base paper that during grid connection mode the grid power factor is not unity. But through our proposed controller, the grid power factor is improved to unity which is shown in Fig.10

VI. FUTURE SCOPE & CONCLUSION

Although smart grid enable power grid to be empowered with intelligent and advanced capabilities, it also opens up many new challenges and risks. Hence Hysteresis current controller and SPWM controller have been employed and performance can be visualized with the simulation results. Still there are risks and shortcomings in both topics, and there is need of possible solution to overcome it. One important control task in power systems is to maintain balance between power production and consumption which means keeping the power system's frequency at an appropriate level. This process is becoming more and more challenging due to an increase in the penetration level of intermittent power production. Hence, future work can be carried out to balance between power production and consumption so distribute equal loads.

The Performance of this model has been studied in grid connection mode and under islanded mode. The effectiveness of proposed control strategies is studied in simulation for different grid connection mode and different loading condition.

The proposed model not only improves the grid power factor but also improve the power sharing capability of two micro sources (MS-1 and MS-2).

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