Journal of Energy Engineering and Thermodynamics
ISSN: 2815-0945
Vol: 02, No. 06, Oct-Nov 2022
http://journal.hmjournals.com/index.php/JEET
DOI: https://doi.org/10.55529/jeet.26.18.28

An Improvement of Power Control Method in Microgrid Based PV-Wind Integration of Renewable Energy Sources

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Received: 10 August 2022 **Accepted:** 26 October 2022 **Published:** 28 November 2022

Abstract:** Microgrids are quickly becoming a great success for the future of electricity. The notion of the microgrid combines several microsources without interfering with the functioning of the larger utility grid. The DC and AC networks of this hybrid Microgrid are powered by photovoltaic and wind generators. Both AC and DC Microgrids may couple with energy storage devices. A microgrid powered by a combination of renewable energy sources, such as wind and solar, is shown and controlled in this project. The wind energy conversion machine is a doubly fed induction generator (DFIG), and it is coupled to a battery bank through a DC bus. Solar power is efficiently converted utilising a DC-DC boost converter from a solar photovoltaic (PV) array and then evacuated at the common DC bus of DFIG. With the line side converter's droop characteristics implemented, voltage and frequency may be regulated using an indirect vector control. A battery's energy level is monitored, and the frequency set point is adjusted accordingly to prevent excessive charging or discharging. When wind power is not available, the system can still function. Maximum power point tracking (MPPT) is a feature of the control algorithm used by both wind and solar energy blocks. All conceivable operational scenarios have been accounted for in the system's design, making it fully autonomous. An external power supply is included into the system and may be used to charge the batteries whenever needed. The feasibility of wind and solar energy, imbalanced and nonlinear loads, and a depleted battery are only some of the scenarios simulated in this paper, along with the corresponding simulation findings.

***Keywords:** Microgrid, Power Control, Hybrid System, BESS, PV System, Wind Energy.*

1. INTRODUCTION

In the previous several years, electrical energy consumption is steadily expanding day-to-day over the globe. To keep up with the rising need for electricity, many power plants have been constructed. However, the typical centralised power plant has numerous limitations like

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lower power, large transmission failures with a lack of fossil energy, carbonic emissions, greater cost, high formwork time, lower dependability, etc. Thus, with new issues in the electricity sectors across the world, the ideas behind centralised power generation are evolving (like generation, transmission, and distribution). As a result of the negative impacts on the environment and the scarcity of fossil fuels, conventional power generation is increasingly turning to environmentally friendly energy resources through decentralised small units. Renewable energy sources (RESs) that are close to the points of consumption are ideal for use as distributed generation (DG) units in a decentralised system. Different types of renewable energy sources, such as solar PV, wind, micro-hydro, fuel-cell, micro-turbine, etc., may see the emergence of trends in DG units that are both cost-effective and environmentally friendly. You may also hear these resources referred to as dispersed energy sources (DERs). As governments place more and more pressure on business to address environmental concerns, renewable or green alternatives to supply the grid are being increasingly common. Large-scale energy storage on a grid scale is a viable green energy option. The versatility of energy storage makes it an exciting technology. Power from renewable sources like the sun or the wind can't be stored for later use since their output is unpredictable. Because the energy produced by these random processes is not always immediately usable, energy storage technologies must be integrated in order to make the greatest use of the power produced by these sources. There are a number of ways in which energy storage might be put to use in the realm of upkeep. The current system of infrastructure is obviously outdated and in need of updating. The necessity for continuous grid energization, especially when working with sensitive loads, is one of the main obstacles to maintaining and modernising the grid. Grid repair that does not necessitate de-energizing a specific section of the grid may be performed quickly and cheaply with the help of local energy storage devices.

Microgrid architectural design includes of many elements with evolving ideas such as DERs, linked optimum and essential charges with or without transmission medium. As can be seen in Fig 1, the current MG design serves as a connection to the primary grid. Each DERs unit is coupled with a power conditioning interface to accomplish regulated operation, metering, and security along with the applicability of a plug'n'play facility, notwithstanding MG control schemes like islanded and grid-connected. The goals of taking these into account are to minimise project costs and ensure a sustainable future by increasing dependability, efficiency, robustness, reducing system losses, optimising energy usage, and mitigating greenhouse gas emissions.

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Fig.1: Microgrid architecture.

It is the capacity of MG, under the impact of the controller, to keep the voltages at a constant value under both typical and abnormal operating situations. Unbalanced real/reactive power, varying loads (especially inductive load), significant load shedding during periods of low voltage, etc., are all examples of such situations. You can see the whole tree structure of the MG's many stability problems in Fig 2. Several problems with the MG system's stability are depicted in Fig 2.

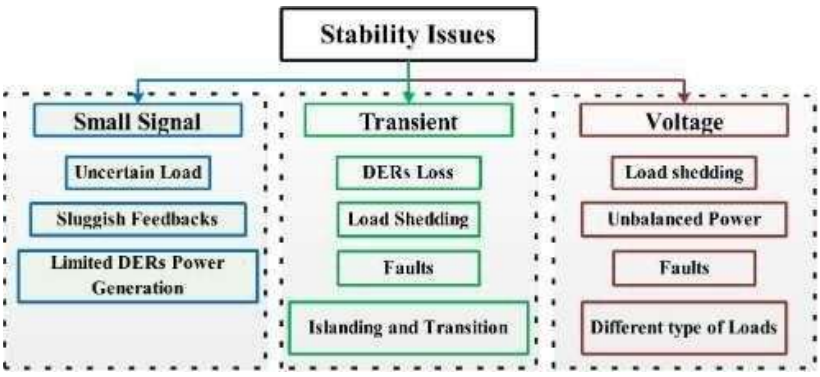

Fig.2: Stability issues of microgrid.

The present technique incorporates the characteristic drop into the DFIG load side converter (LSC) control. Batteries may be charged more slowly and overloaded less frequently thanks to this function. In the suggested setup, the DFIG additionally makes use of two VSC converters. DFIG also contains a rotor-side VSC, or RSC, connected to the rotor side. The MPPT (W-MPPT) wind is a unique aspect of RSC. Adding photovoltaic (PV) sun cells to a system boosts the DC bus voltage. With this system, solar electricity may be evacuated at a low cost. The solar maximum power point tracking (S-MPPT) control method is also included in this converter to extract maximum power from the sun. In case of a power outage caused by a lack of wind, the backup power source, the storage battery, may be charged via

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the regular electricity system. Variable amounts of wind and solar electricity are used to maintain the LSC's real frequency and voltage at the consumer ends. Inaccessibility of renewable energy sources like solar or wind, Load or breakdown of the distribution infrastructure, Uneven or erratic billing, etc.

System Modeling

Fig.3 is a system diagram of a micro grid-fed REGS device. The system's 15 kW and 5 kW average power demands are tailored to meet the needs of the most power-hungry environments. Blocks of wind and solar energy with ratings of up to 15 kW can be used by REGS. Providing the hamlet with one day's worth of electricity use from each of the two source blocks with a 20% power use factor is feasible. In the case that the wind energy source has insufficient power, the circuit breaker is isolated from the rest of the system, as shown in the plan. Battery storage is connected to the high voltage (HV) side of the solar system, which in turn is connected to the DC side, where the RSC is located. RSC allows the wind power technology to continuously operate at the optimum rotational speed as determined by the W-MPPT algorithm. The system voltage together with frequency are controlled by the LSC. The kinetic energy of the wind is captured by the turbine and used to provide a driving torque for DFIG.

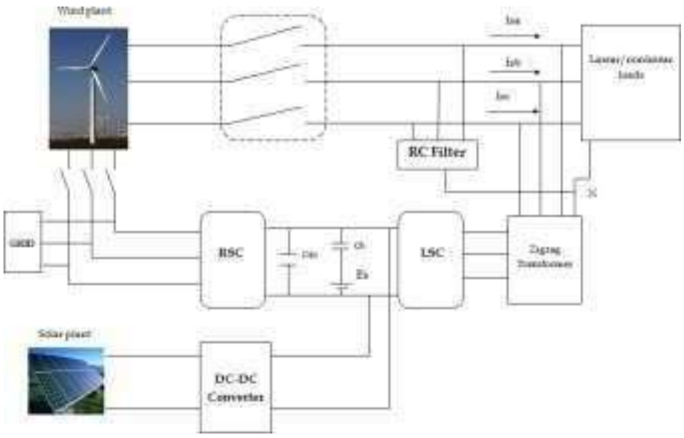

Fig.3: System modeling of hybrid microgrid.

The lower control level refers to the control systems associated to the system components, while the higher level relates to the management of the energy flows, using a mixed criteria that takes into consideration both energy cost and battery lifespan. Lower level implementation for wind energy system guarantees ideal regimes for wind farm (in terms of resource criteria), i.e. guarantees maximum power transfer in light load and power constraint in full load determines. The sun's rays are harnessed and transformed into electricity in this system. Using photovoltaic (PV) cells, solar energy may be transformed into electricity in a direct process. Enhanced output power is seen in PV energy systems at ideal loads. To reach the necessary voltage level when hooked up to the utility grid, numerous converter topologies such as boost, buck-boost converter, SEPIC, and fly back are discussed in this section. The kinetic energy of wind is converted into mechanical energy, and then into electricity by a wind turbine generator. Turbine blades are paired with a generator via a gear box in this system to harvest energy in a flexible and adaptable fashion.

The amount of electricity generated by the wind, is represented as Pwe, $P_{we} = \eta_g P_{wm} = \eta_g \cdot 0.5\pi\rho R^2 C_p(\lambda) v^3$

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Where, Pwm represents the mechanical power, ηg represents the electric generator efficiency, ρ represents the air density, R represents the length of the turbine blades, v represents the wind speed, and Cp represents the wind turbine coefficient, which is dependent on the tip speed ratio. The analogous circuit of a typical PV model includes the photocurrent, diode, parallel resistor (expressing leakage current), and series resistor (expressing internal resistance to current flow). A solar cell's voltage current typical equation is as follows:

$$I_{pv} = I_{PH} - I_S[\exp\left(q(V_{pv} + I_{pv}R_S)/kT_C A\right) - 1] - (V_{pv} + I_{pv}R_S)/R_P$$

Traditional methods of control used to maintain stability in MG. The Proportional (P), Integral (PI), Derivative (PID), and Resonant (PR) controllers all fall under this category. The considerable benefits of a PI/PID controller in improving the reliability of a power converter MG provide a significant challenge in the form of imprecise, unpredictable, and unexpected system disruptions. Because of this, the fuzzy inference approach may be used to tune PID while simultaneously adjusting to system perturbations. The integration's main benefit is the PID controller's improved tuning capabilities, which are complemented by fuzzy logic's rapid and accurate decision making.

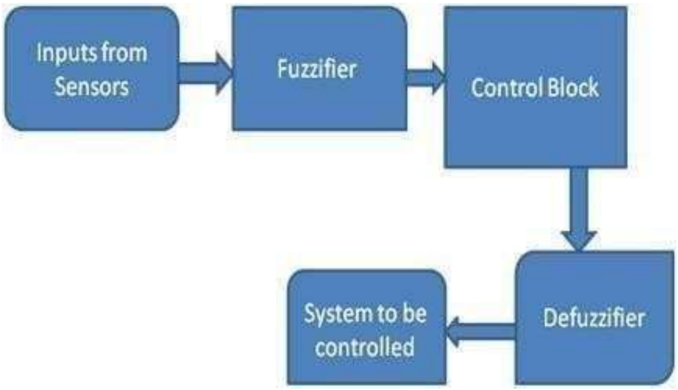

Fig.4: Control system of Fuzzy logic.

A Fuzzy Logic Controller that allocates outputs using language data. It accomplishes the control logic by means of approximation reasoning based on the human manner of interpretation. The inference engine and knowledge base make up the controller. The membership functions and fuzzy rules that result from understanding how the system works in a given setting make up the knowledge base.

Table 1: fuzzy set rules

$\dot{T}$ \ T	LOW	MEDIUM	HIGH
LOW	FAST	MEDIUM	MEDIUM
MEDIUM	FAST	SLOW	SLOW
HIGH	MEDIUM	SLOW	SLOW

2. SIMULATION RESULTS

Matlab/Simulink is used to model a hybrid microgrid. This action is being taken in preparation for grid-connected functioning. The efficiency of the hybrid microgrid is

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evaluated, as is that of the induction generator and PV system that fed it simultaneously. Hybrid microgrid research also factors in the amount of available solar irradiation and the average wind speed in the area. Simulation results found in MATLAB are used for the performance evaluation.

Case-1: wind changes

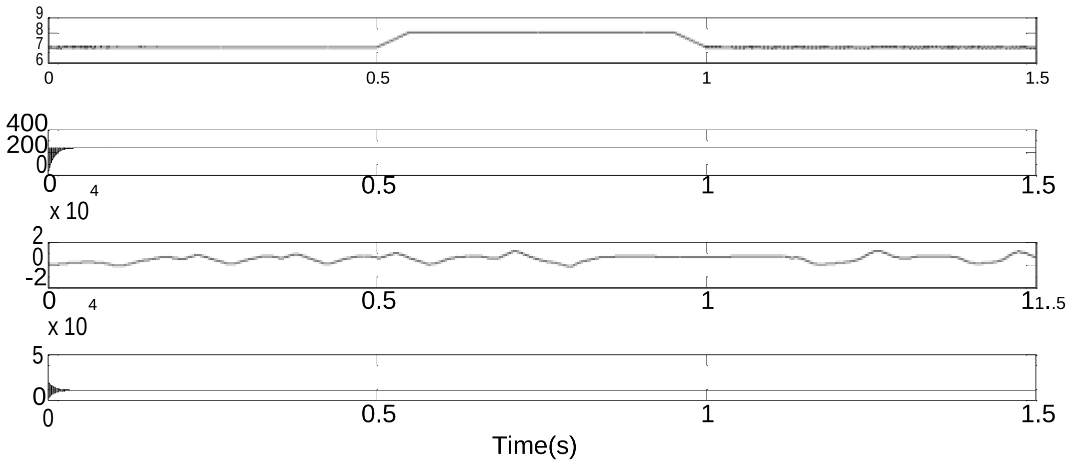

Fig.5: Existing system.

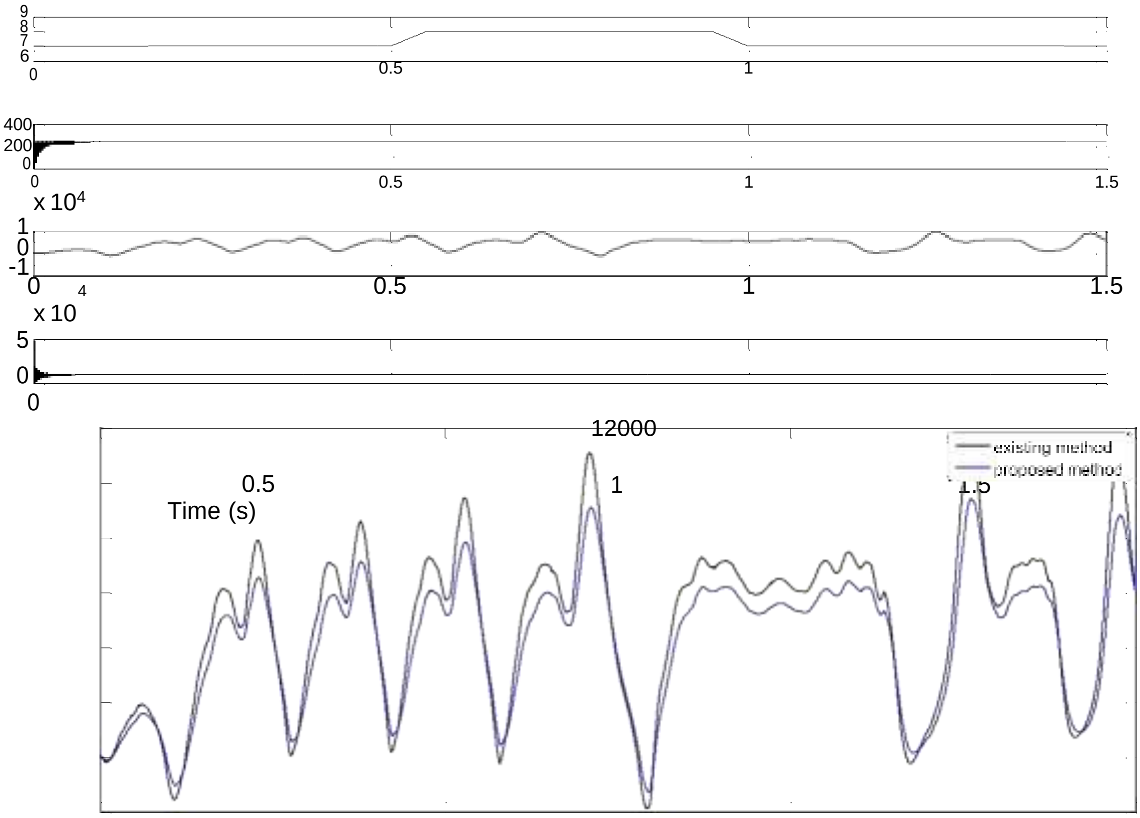

Fig.6: Proposed system.

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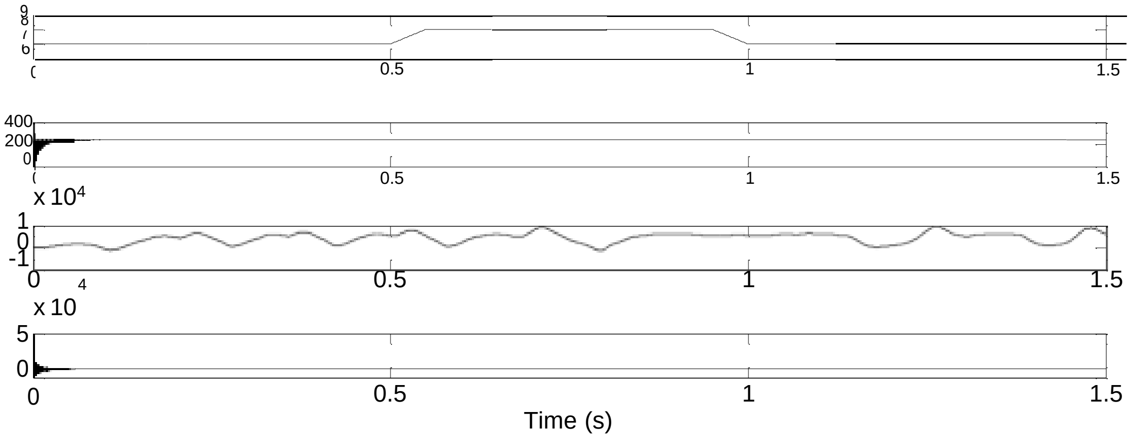

Fig.6: Proposed system.

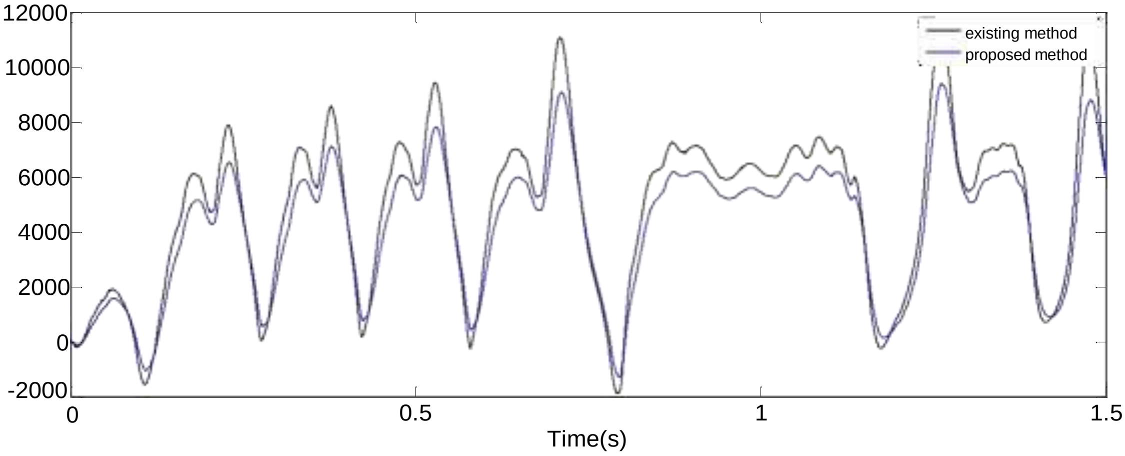

Fig.7: Comparison waveforms.

Fig 5 & 6 depicts the same scenario with no wind or solar sources of energy, starting with a 10 kW and 6 kVAR demand. At t = 0.05 s, when the wind speed is 7 m/s, the wind generator kicks on. The voltage of the gadget will temporarily fluctuate as a result of this. The wind speed at the turbine rises from 7 m/s to 8 m/s at t = 0.5 s, and then decreases to 5 m/s at t = 1.0 s. The optimum rotor speed is maintained via the rotor control method in line with the W-MPPT technique. And comparison waveform for existing and proposed system is representing in fig 7.

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Case-2: solar changes

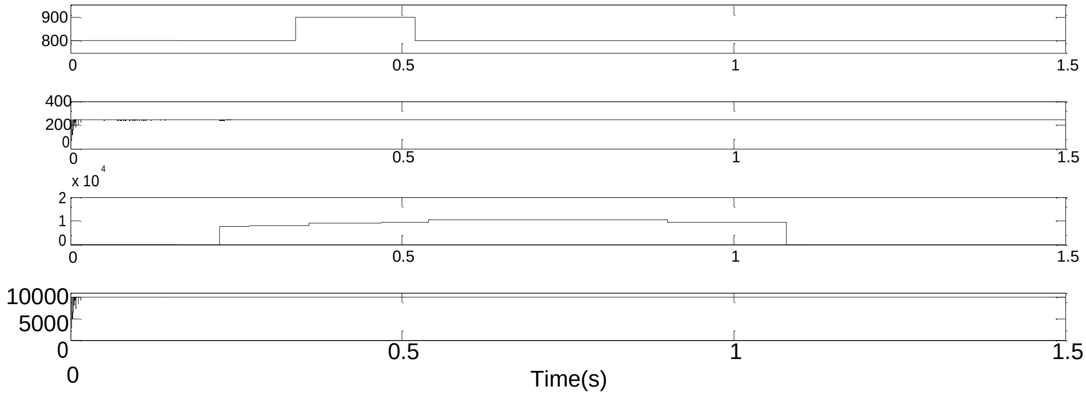
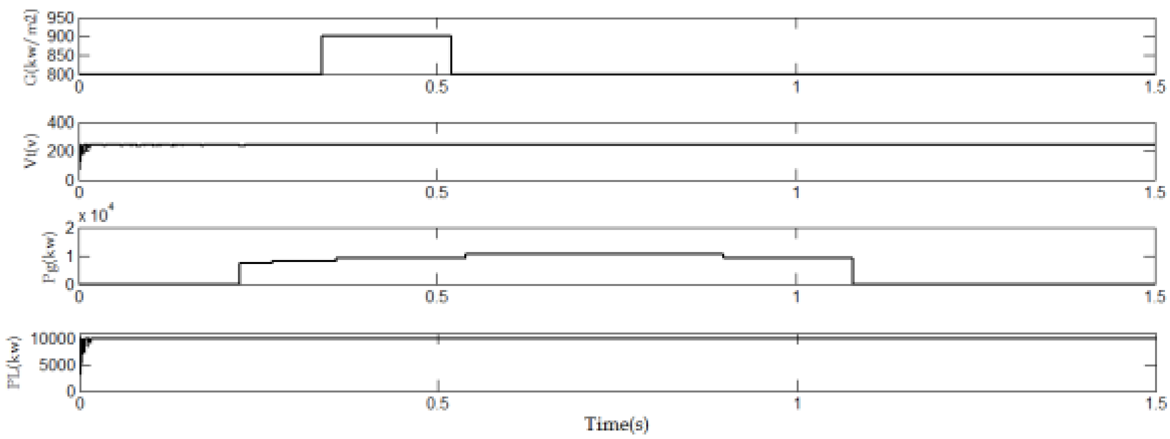


Fig.8: Existing system.



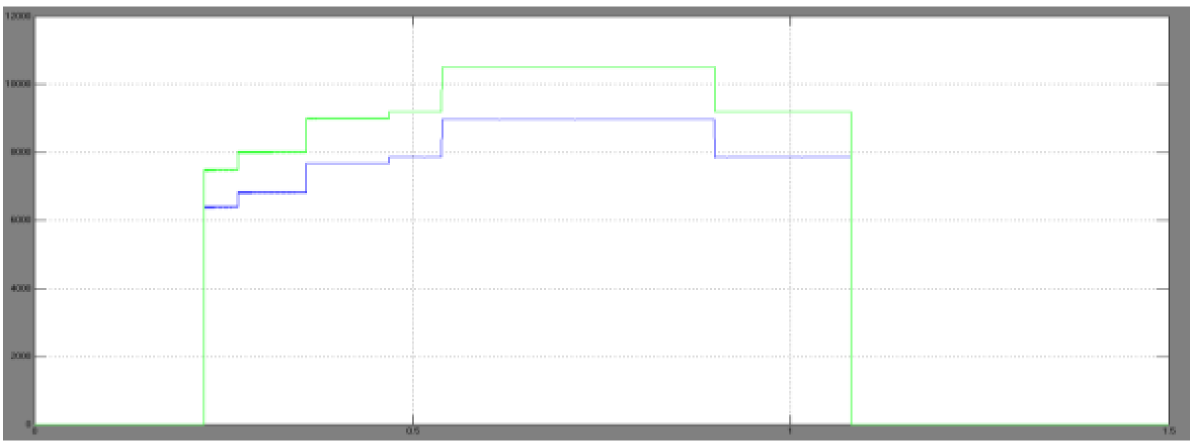


Fig.10: Comparison waveforms.

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For a 10 kW and 6 kVAR load, the device is deployed without the aid of wind or solar power. At t = 0.05 s, the same solar system as depicted in Fig. 8 & 9 must be employed, which emits radiation at a rate of 800 W/m2. At t = 0.34 s, solar radiation is raised to 900 W/m2, and then it is lowered to 800 W/m2 at t = 0.52 s. The S-MPPT is regulated by the solar converter, which regulates the voltage from solar panels. And comparison waveform for existing and proposed system is representing in fig 10.

Case-3: Load changes

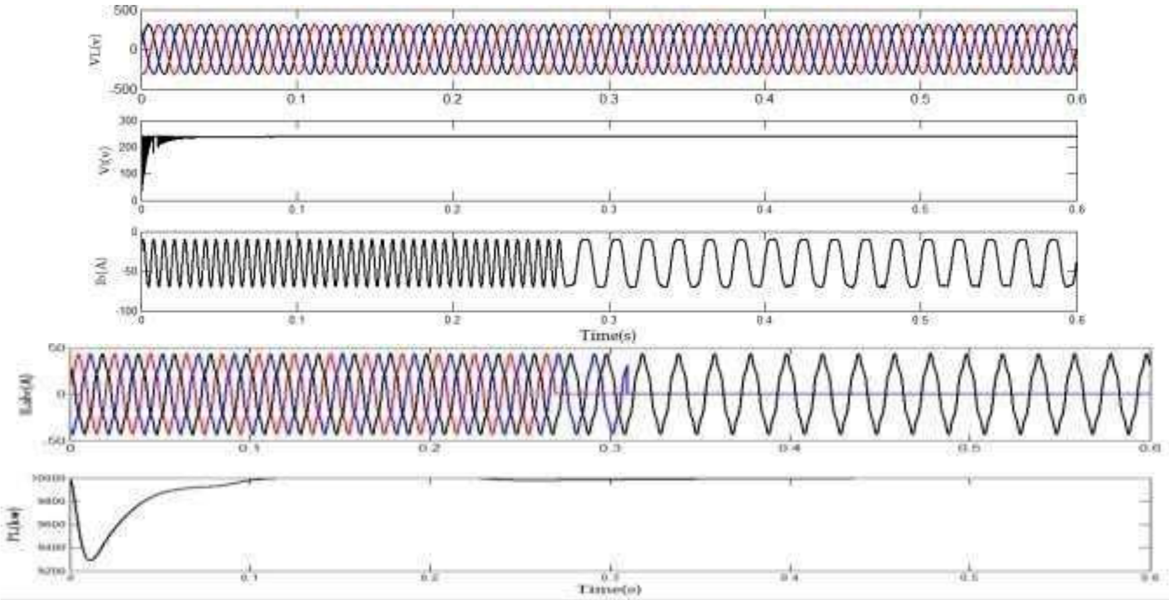
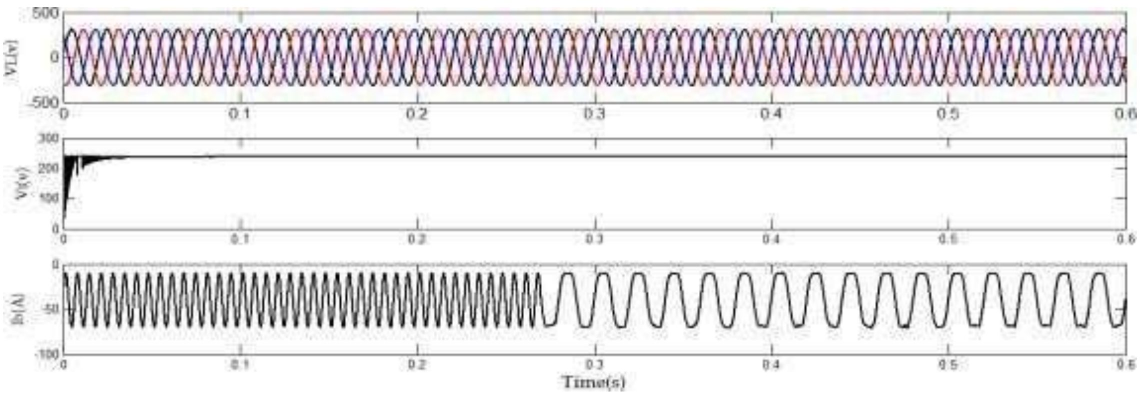


Fig.11: Existing system



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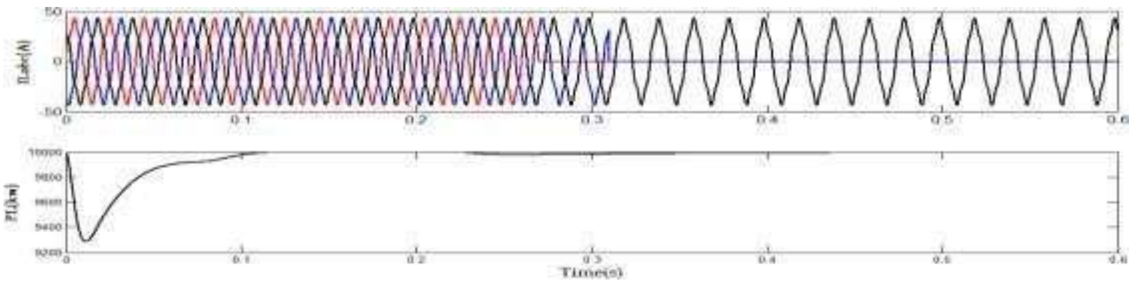

Fig.12: Proposed system

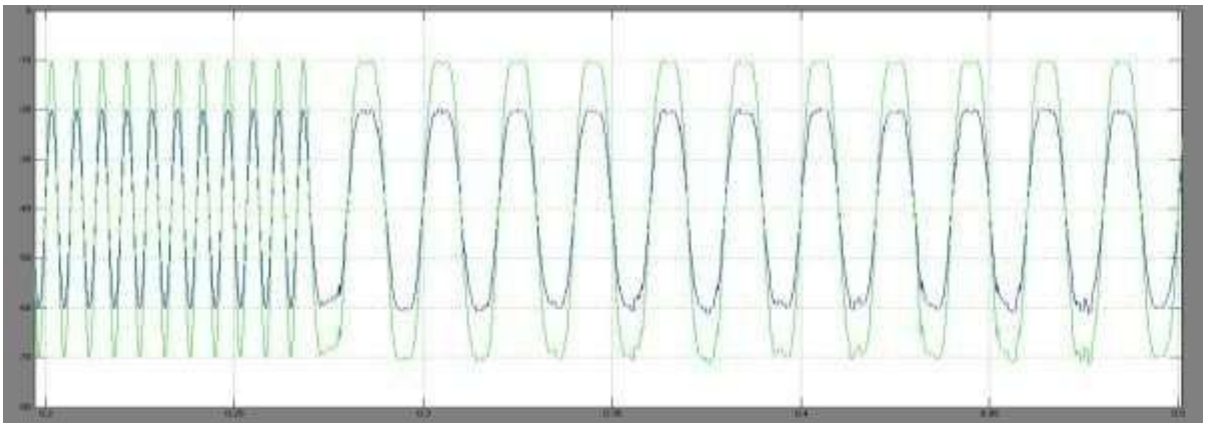

Fig.13: Comparison waveforms

Fig. 11 & 12 displays the inefficiency of an unbalanced nonlinear device. The micro-grid should be adequate to provide the nonlinear, unbalanced load. Taking the worst-case scenario into account if no other options exist. Load has a linear capacity of 2 kW and a non-linear energy of 8 kW. The a-phase load is disconnected from the network at time t = 0.28 s, followed by the b-phase load at time t = 0.31 s. The outcomes demonstrate that even under nonlinear and unequal loads, the device still delivers reliable power. And comparison waveform for existing and proposed system is representing in fig 13.

3. CONCLUSION

In a MATLAB/SIMULINK scenario, we construct a hybrid microgrid to simulate its power-system setup. The focus of the current study is on the hybrid grid's grid-tied mode of operation. All of the converters' models are built, and the stability of the system under different loads and resource situations is evaluated, along with the mechanisms of control. The maximum power point tracking (MPPT) technique is employed get the most out of Dc supplies and to regulate the flow of energy between the DC and AC grids. It has been determined that a rural area with modest residential load requirements can be serviced by the planned REGS micro grid system. REGS incorporates wind and solar resource blocks that are meant to harvest maximum electricity from wind sources and provide consumer grade electricity in parallel. It is envisioned that the gadget will be fully automated. This study also

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provides information on the size of the primary components. The results of the system were shown under varying input circumstances of various load profiles. The power quality at the load connected never deviates outside of a tolerable range.

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