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# Demand Side Management Using Load Shifting and Peak Clipping Technique for Microgrid System Using Intelligent Control Technique

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## Abstract

This initiative aims to reach the goal of energy usage and reshape the grid stability with the help of peak shaving, sharing the load, and an ANN-based forecasting method. The module comprises a solar photovoltaic (PV) array coupled to a LANDSMAN converter with the control via RBFNN MPPT controller. Although a unidirectional converter is preferred for active power, a bidirectional battery is installed and equipped with a LANDSMAN converter so that a three- phase inverter can be connected to the grid. Demand side management is made possible by introducing the ANN technique for predicting the maximum demand that will shift the appliances to off condition when the amount of demand becomes higher than the capacity of the grid. With the help of a PWM rectifier, the AC-DC conversion of the WECS with DFIG is done and a rectifier control is accomplished through a PI controller. Similarly, consumers might cut down their electricity bills by changing the time of electricity consumption and the amount of energy used, which allows them to save on some costs. The energy system is noticeably changing before the consumption of energy reduces from high to low hours peak improving global efficiency. Load sharing and demand regulation systems ensure logical energy utilization, and therefore, these elements maintain the stability of the grid. Furthermore, the demand-side system strengthens consumers' awareness and walks the talk by providing immediate data and tariffs for shifting the load. The project brings consumers into the management of energy on an active basis by creating an environment in which people highly consider energy conservation. Lastly, the project will be carried out and outcomes will be delivered in MATLAB 2021a /Simulink software.

## Keywords
Photovoltaic, WECS, DFIG, RBFNN MPPT, LANDSMAN converter.

## I. Introduction
In conventional electrical distribution power networks, there are power generation centers, and distribution generation substations that reciprocate each other and between them, they support all the loads needed, and they are upgraded in the future whenever there is a necessity to cover for further rising demands. It is true that MG, which operates side by side with the main network, helps to ensure the stability of the power and can damage the entire system when equalized (Benbouzid et al. 2021). But this linking of microgrids with the main system may cause a disturbance within the total system, especially Its basic parameters: voltage, and frequency. The power supply from the local microgrinnight fail for different reasons such as not enough supply to meet the highest possible load demand. Therefore, the system is not stable, and it might go under malfunction. For this, malfunctioning must be detected early to disconnect it directly. Furthermore, maintaining the DG Isolated ensures the safety of the workers and the equipment as sometimes the maintenance team may be exposed to electric hazards while fixing the fault line (Sarasúa

et al. 2022; Sundaram et al. 2020).

The recent advancement of renewable energy sources is the fast spread of resources for distributed energy, including PV, wind turbines, and other dynamic energy sources which have become an essential component of the main grid. Renewable DG (distributed generators) are connected to the grid through Inverters that are fed into the main grid at the common coupling point (PCC). The DGs are managed, protected, and monitored separately in their systems. With renewable energy (RE) stations constantly declining power, the flow of power between the grid, DG and load keeps continuously changing even when the local load remains constant. Consequently, when a power grid is shut down, the inverter must also be turned off to ensure that no dangerous situation will occur to system parameters stability. Lately, the dilemma of increasingly serious environmental pollution, with the scarcity of traditional energies has grown rapidly Accordingly, DERs are an effective solution to the problems mentioned. AS DERS is expected to take over and the microgrid (MES) concept comes up to organize between traditional grid and DERs and maximize the advantages of DERS (Armendia et al. 2021). Department of Energy, MGS are groups of loads and energy resources located within narrowly defined electrical border mat behave as a single block concerning the grid the group can connect and disconnect from the grid to work in either grid-connected mode or Islanded mode. Demand Response is a method whereby microgrid managers manipulate the consumer's energy usage when there is a sudden surge or sudden decrease in the energy demand (Khan  and Khalid 2021).

The Demand-Side Management principle has become a black spot in the global energy market systems since renewable energy sources naturally penetrate the system causing the decentralization of the power generation and all sorts of disruptions at the microgrids as well as other related services and, a balance is therefore needed. Dynamics of demand and supply is a very big challenge: the generated energy must be within acceptable limits and supply is in conjunction with the fossil fuel demand which is overlapping with the consumption habits. System operators can develop these programs that offer them payable lines services, which in effect make the electricity system costs higher (Figure 1).

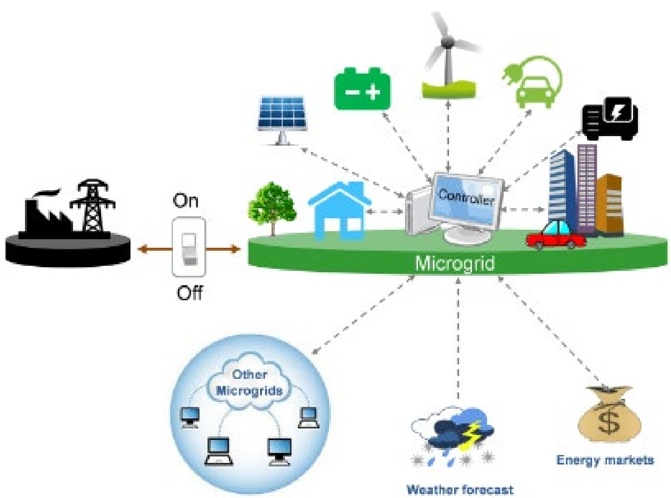


Figure 1. Demand response for microgrid system

## 2. Literature Review

The author (Benbouzid et al. 2021) implemented a solar-centered Dynamic Voltage Restorer (DVR) which is a state-of-the-art converter (TransZSI) as a power quality improver and on-grid PV systems. DVR is the power low-pass filter that uses electronics to inject the compensated voltage at the neighborhood of the location to which the voltage wave disturbance is occurring (PCC). This is the case with the MCBC controller which is the best controller to reduce the transient conditions that cause severe voltage drops that could be dangerous to equipment. The consecutive flashes after each impulse of the UVT-MCBC get abolished, consequently, it follows that the device gives the precise and correct techniques that can be called the most comprehensive one, as each of them has its limitations. The SBC way, on the other hand, can be problematic in case the amperage is not enough to push the output voltage higher than the stage before.

Sarasúa et al. (2022) has presented a contribution to increasing the islanding system which combines a diesel plant and a frequency control in an isolated system and few of the systems such as a pump-storage hydropower plant existed within the power system of El Hierro. Its FESS properties enable us to solve this dilemma about how to guarantee the required frequency quality efficiently. In addition, the cycling of the flywheel gives the vehicle a chance to move forward. using NLP GCS for the flywheel lifetimes of the manufacturers, only a small fraction of the long lifetimes would be found.

Sundaram et al. (2020) have developed that a new hybrid microgrid management technology is included in the residential power distribution system as an enhancement measure to reduce the conversion processes. The system of renewable energy is checked for the availability of power and then the demand is met. Moreover, the batteries are operated with a smart system that monitors the charge status. The interconnecting DC voltage variation is used to monitor and control energy systems. The battery bank voltage level is used by battery backup to operate.

Moreover, the author (Chakraborty et al. 2021) highlighted that the improving driving cycles in HEV operations in order to preserve the optimal function. An analytical study of different HEV control strategies thoroughly for four configurations: battery-UC, FC-battery, FC-UC, and FC- battery-UC. The paper provides a relative comparison of diverse control strategies for varied configurations according to goals, control elements, battery lifetime, fuel consumption, dynamic responsiveness, and operating situations.

Armendia et al. (2021), have written to explain the relevance of adopting production scheduling using multi-objective optimization. Both the plant's net profitability and the battery's value loss—which is determined by the number of cycles and the shift in market price—are optimized by the multi-objective cost function. On the other hand, as with MILP optimization, the objective function also needs to be linearized to solve the problem.

Nair et al. 2020, developed an MPC-based EMS system that was optimized for a synergetic PV with a hybrid energy storage system on an island microgrid. Significant reduction in the SOD (0.8) at the SOC high level by charging batteries at the peak generation. More stable set point variation using MPC in regenerative FC.

Roy et al. 2020, implemented a Wind-solar hybrid power system dispatching technique (WSHPS) over one hour for a whole day utilizing a configuration of battery and supercapacitor (HESS). A frequency managing setup is executed to increase the life span of the battery system using the high energy density property of the battery and the high- power density property of the supercapacitor in the (HESS) perspective.

Tang and Wang (2021), have presented a wavelet transform and fuzzy logic-based fuel cell/battery/ultra-capacitor hybrid power vessel management approach that takes into account the dynamic characteristics of each power source. Particularly, the energy output of the cruiser is not separated at the wavelet transform type and it is implemented to various energy sources that are needed according to their dynamic characteristics, For the ongoing steady operation and reliability of the hybrid power system, the fuzzy logic control method is considered in order to ensure the energy storage system operates safely.

## Objectives

- The utilization of energy resources by the efficient management of the demand side of the electrical grid.
- This power grid network a solar PV array, a battery bank, and a grid-connected inverter to get them to work together toward efficient load sharing according to real-time demand, power grid conditions, or available energy sources.
- In order to indicate PV, Wind power, and battery system capabilities, in MATLAB Simulink design space, the characteristics of these systems are analyzed.
- The ANN model is trained to accurately predict the maximum demand in a load so that it becomes possible to manage and shed loads in peak periods.

## 3. Proposed System

### *A. Introduction*

Under abnormal situations of power systems, voltage collapse is the most threatening because accidents can quickly cause cascading instabilities, that resulted in a power grid failure. To avoid the blackout, separate enclosed self-healing entities of the power system could be created at entities with a condition of reconnection. Nevertheless, an islanding scheme to be effective has many barriers to be addressed at the same time. Coordinating islanding locations, the time of disconnection, and the closing point are specified when taking into consideration network operating topology or relays. The target is to coordinate the power of each island to achieve the balance of the maximum islanding power, considering the cohesiveness of the generator this thread of configuration assumes that in each entity, the number of islanding entities. is predetermined while the autonomous operation can be done accordingly. In a study power islanding execution algorithms and topology islanding were investigated. The process for figuring out when islanding occurs is carried out in real time, online and face-to-face. Z- The number of islands with Protection degree predetermined by tracking the amplitude of inter-area oscillations between the dominant groups (GSS), For MAS- the entities exchange information and coordinate control over the tightly linked network of cyber-communication.

While in the autonomous operation mode, every entity acts independently by generating, storing, and distributing energy for economic and ensuring self-efficient goals. By ideal, MGs shouldn't need any power flow or data exchange between them. When a fault takes place in an object, the neighbor entity supplies it with power until the mode of self-healing begins. Operation is Flexible in future Power Systems (Figure 2).

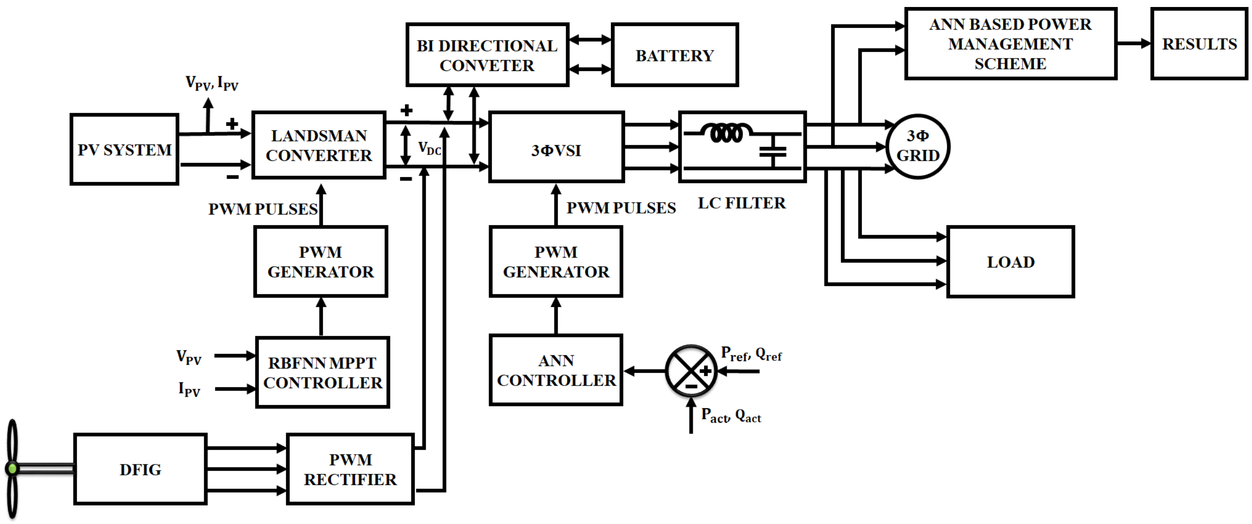


Figure 2. Block diagram

***B.* Landsman Converter**

This full-bridge converter called DC-DC Landsman filter operates in continuous conduction mode (CCM). And with switch S on in Mode 1, capacitor C_1 is connected across the output and supplies energy to the output through inductor L1. When diode D is conducted in Mode 2 with S turned off, thestored energy is delivered from inductor L2 to the output (Figure 3).

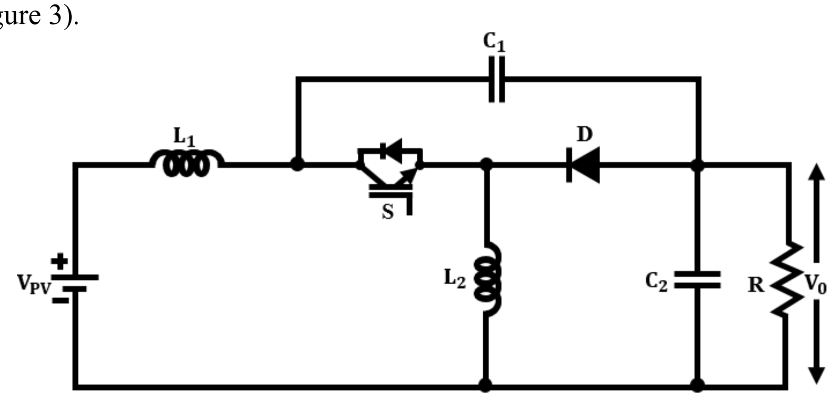


Figure 3. LANDSMAN Converter

***C. RBFNN MPPT***

RBFNN has made it possible to develop an MPPT algorithm for the optimization of photovoltaic systems by tracking and extracting maximum power from the solar panels. The architecture includes 3 layers: input, hidden, and output, but not regression, using radial basis functions to build interconnections by training and adjusting the weights and centers of the neural network by developing such an algorithm (Figure 4).

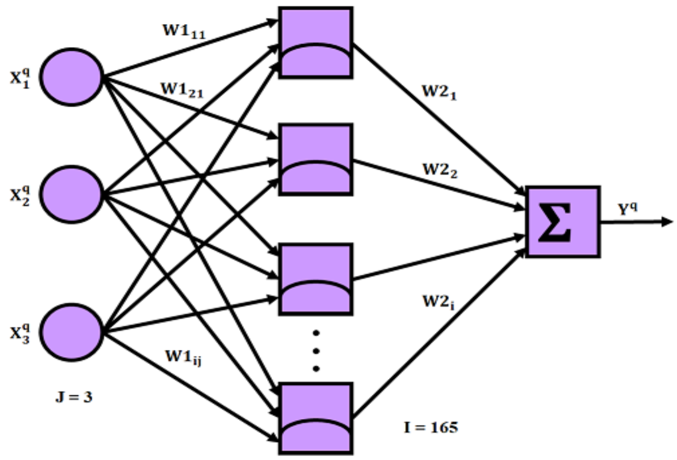


Figure 4. RBFN MPPT

***D.*** **Modeling of Three Phase VSI And Grid**

The rectifier with a two-stage inverter is a power electronic system that is used. On the other hand, the coming of inverter- side power management will determine the cycle of the duty. Voltage regulation of inverters involves keeping voltage within the inverter constant by sending electric power to the inverter as well as receiving it back. Different approaches are used for example, storable reactors, magnetic amplifiers, and phase-controlled rectifiers (Figure 5). The consistent switching effects of the solid state can be incorporated into a switching time ratio control using those switching devices (Khan and Khalid 2021, Alturki et al. 2020, Tawfiq et al. 2021, Fu and Gao 2020)

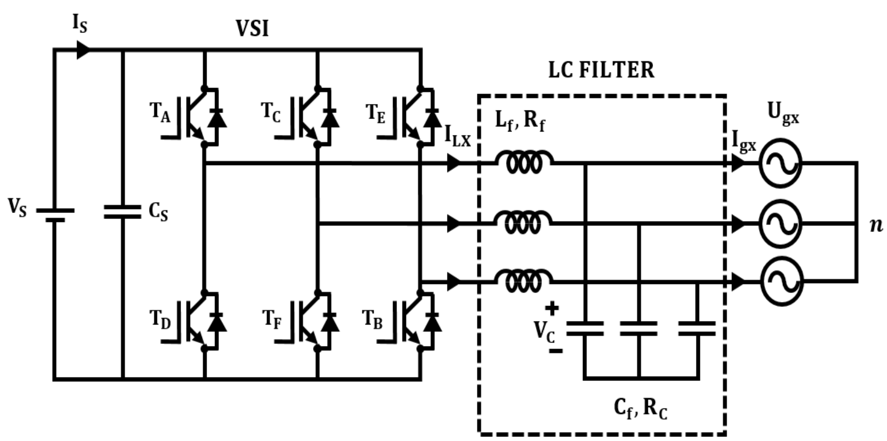


Figure 5. Grid synchronized 36 VSI with LC filter

The switching state (S_X) of variables is given b.

$$S_X = \begin{cases} 0 \; when \; T_n = on \\ 0 \; when \; T_n = off \end{cases} \qquad (1)$$

The 36 VSI modeling is undertaken by dq theory which operates on direct (d) as well as quadrature (q) components and the resulting output is.

$$Z_S = \begin{bmatrix} Z_d & Z_{qd} \\ Z_{dq} & Z_q \end{bmatrix} \qquad (2)$$

The output impedance is, Zqd and Zdq are neglected in the stability analysis simplification. After applying the Nyquist stability criterion, the stability is analyzed and performed from the transfer functions,

$$G_d(S) = \frac{1}{1+Z_L(S)/Z_d(S)} \quad (3)$$

$$G_q(S) = \frac{1}{1+Z_L(S)/Z_q(S)} \quad (4)$$

Applying Kirchhoff's law along with d-q theory, the equations for VSI are obtained as,

$$V_C = L_g \frac{dI_{gX}}{dt} I_{gX} + V_{gX} \quad (5)$$

$$I_{LX} = C_S \frac{dV_S}{dt} + I_{gX} \quad (6)$$

$$I_S = C_S \frac{dV_S}{dt} + \sum_{X=a,b,c} I_{gX}\, S_X \quad (7)$$

LC filter: $C_f$=650µF, $R_c$ = 0.030Ω, $L_f$ = 0.70mH, $R_f$ = 0.012Ω. Eliminates the high-frequency switching components from the reference frame while preserving dq measurements.

## 4. Results and Discussions

MATLAB/Simulink is a powerful tool for technical computing, offering computation, visualization, and programming in a familiar mathematical environment. It's extensively used for signal analysis and system modeling. Simulink's graphical representation simplifies the simulation of mathematical models, making it ideal for engineers and scientists in various disciplines.

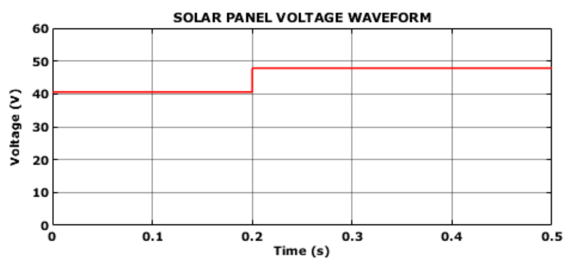


Figure 6. Solar panel voltage

Figure 6 demonstrates the waveform of the solar panel voltage which reached 48V under the step input of 0.2s at 35⁰ Temperature, 1000 $w^2$/sq. irradiance.

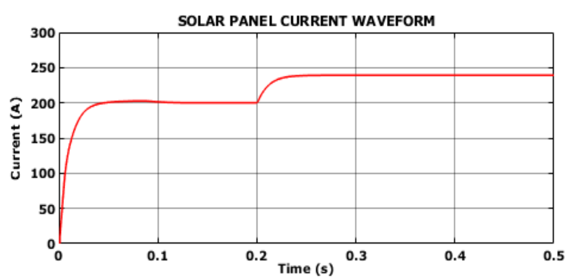


Figure 7. Solar panel current

solar current waveform representation in Figure 7 which produced a voltage 248A, having a step input of 0.2s and a temperature of 35⁰ and 1000 $w^2$/sq. irradiance.

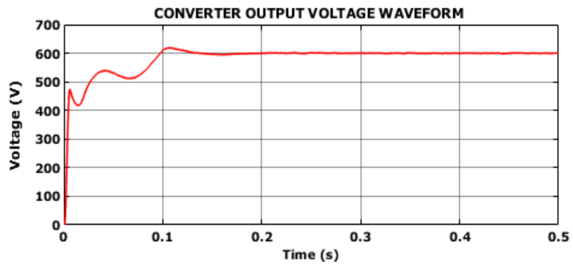


Figure 8. Converter output voltage waveform

Figure 8 is comprised of the converter output voltage waveform that obtained 600V due to the existence of the proposed converter.

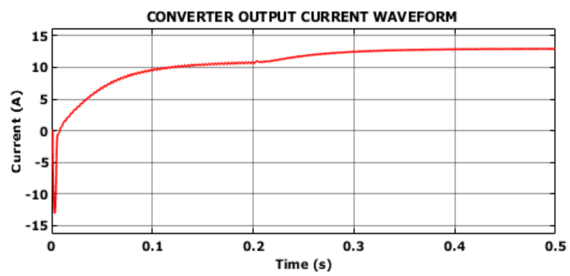


Figure 9. Converter output current waveform

As shown in Graph 9, the present output current waveform attained 13A because of converter is included.

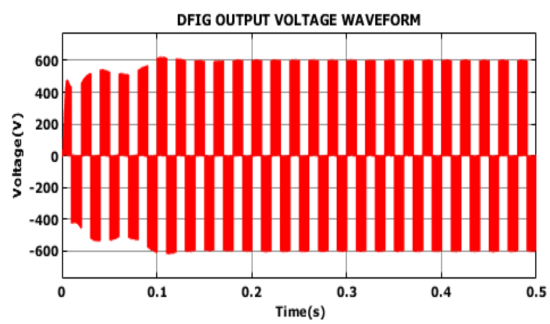


Figure 10. DFIG output voltage waveform

Figure 10 demonstrates the DFIG-based output voltage of the WECS system; the voltage took a value of 600V.

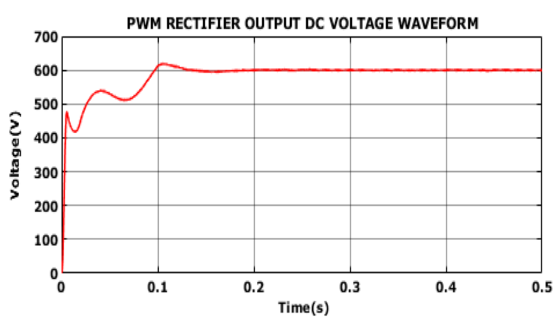


Figure 11. PWM Rectifier output DC voltage waveform

Figure 11 depicts the PWM rectifier's output voltage is around 600V.

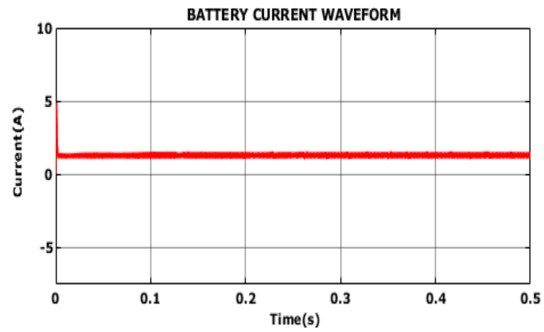


Figure 12.Battery current waveform

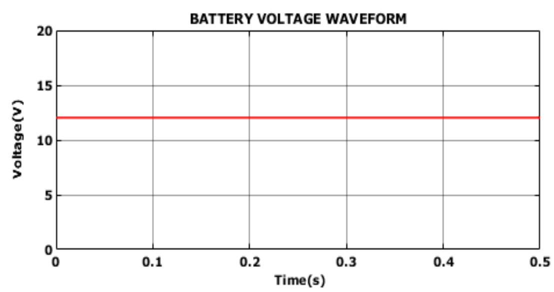


Figure 13. Battery voltage waveform

Figures 12 and 13 represent both the current and voltage levels for the battery. As for the battery, the value of the current and voltage is 2.3A and 12V, respectively. The PV excess power is saved in the battery. The secondary power source or the battery steps in to maintain the process of power transfer to the load when there is a lapse in the primary power source.

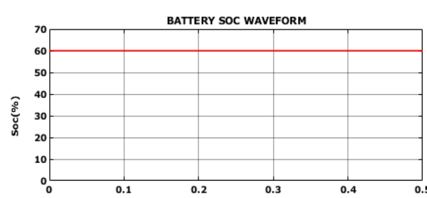


Figure 14. Battery state of charge (SOC)

In Figure 14 SOC of the battery is 60% the SOC of the battery is well-monitored.

**CASE 1**
**DURING NORMAL CONDITION**

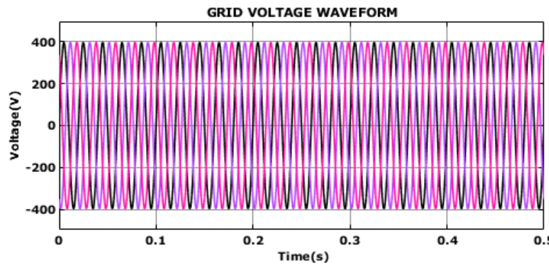


Figure-15 a. Waveform of grid voltage

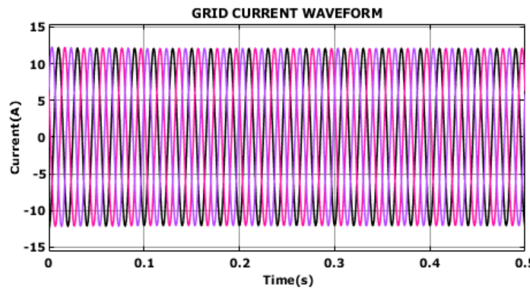


Figure-15 b. Waveform of grid current

Figures 15(a) & 15(b) display the grid voltage and grid current in the load phase. Load sharing is done in the on-demand side management system.

**CASE 2**
**DURING PEAK CLIPPING CONDITION**

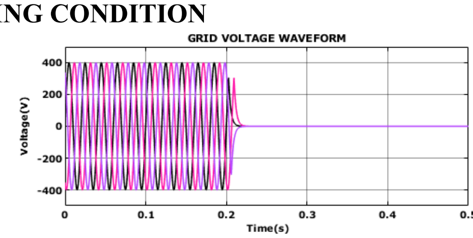


Figure-16 a. Waveform of grid voltage

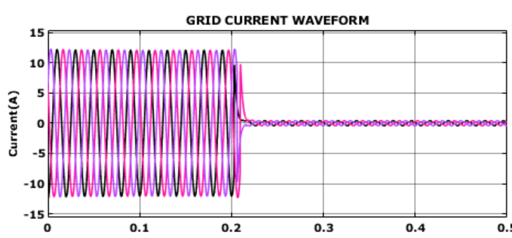


Figure16 b. Waveform of grid current

The grid output voltage is 415V, which is illustrated in Figure 16(a) & (b) and remains constant up to 0.2s. The peak clipping condition is the next phase, hence the constant output voltage corresponds to the stability of grid output current, which is illustrated by 12.3A.

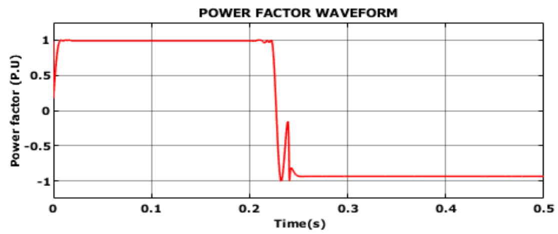


Figure 17. Power Factor Waveform

The curve in Figure 17 becomes a power factor waveform which is almost unity and after reaching 0.2s the condition in the peak clipping control happens in the demand-side management.

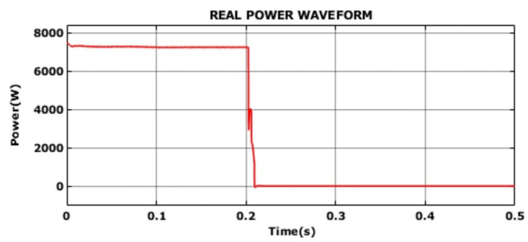


Figure 18. Real Power waveform

In Figure 18 the real power waveform after 0.2s. The peak clipping phenomenon takes place in the demand side management is shown.

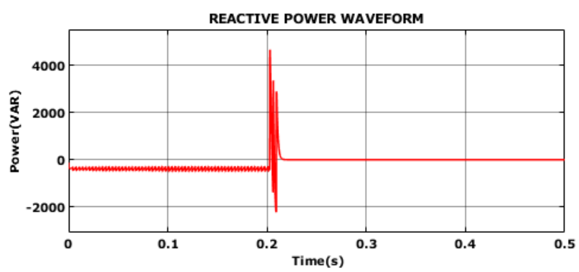


Figure 19. Reactive power Wave form

The curves in Figures 18 and 19 show the magnitude of real and reactive powers of the three-phase grid, the value of real power is higher is 7500W, and reactive power in contrast is low magnitude and 150VAR approximately 150VAR.

## 5. Conclusion

This project promotes the concept of demand side management and the combination of three different components, namely solar PV, bi-directional battery, and Pi-based grid section, provides a great deal of benefits. Consumers can save on their power expenses in multiple ways beginning with optimized adjustments in the timing and amount of usage, in addition, energy supply by electricity is emerging more efficiently making electricity consumption optimized. Although. Operation of each device requires the use of a PI controller: the integration of solar PV commended with a bidirectional battery results in improved system efficiency and reliability. The demand (D) section which is based on the PI grid element is the main factor in demand side management.

The Pi will forecast the total demand and in case of significant load to standby mode help to promote the balance between energy demand and energy supply. This leads to Improved energy management and optimized utilization of electricity resources.

## References

Alturki, F. A. H. O. Omotoso, A. A. Al-Shamma'a, H. M. H. Farh and K. Alsharabi, "Novel Manta Rays Foraging Optimization Algorithm Based Optimal Control for Grid-Connected PV Energy System," in IEEE Access, vol. 8, pp. 187276-187290,2020.

Armendia, J. Martinez-Rico, I. R. de Argandoña, U. Fernandez-Gamiz and E. Zulueta, "Multi-objective Optimization of Production Scheduling Using Particle Swarm Optimization Algorithm for Hybrid Renewable Power Plants with Battery Energy Storage System," in Journal of Modern Power Systems and Clean Energy, vol. 9, no. 2, pp. 285-294,2021.

Benbouzid, M.Mitolo, V. K. Ramachandaramurthy, A. Moghassemi and S. Padmanaban, "A Novel Solar Photovoltaic Fed TransZSI-DVR for Power Quality Improvement of Grid-Connected PV Systems," in IEEE Access, vol. 9, pp. 7263-7279,2021.

Chakraborty, H. H. Alhelou, S. Islam, N. Manoj Kumar and A.K. Podder, "Control Strategies of Different Hybrid Energy Storage Systems for Electric Vehicles Applications," in IEEE Access, vol. 9, pp. 51865-51895,2021.

Fu L. and X.Gao, "SOC Optimization Based Energy Management Strategy for Hybrid Energy Storage System in Vessel Integrated Power System," in IEEE Access, vol. 8, pp. 54611-54619,2020.

Khan K. A. and M. Khalid, "Improving the Transient Response of Hybrid Energy Storage System for Voltage Stability in DC Microgrids Using an Autonomous Control Strategy," in IEEE Access, vol. 9, pp. 10460-10472,2021.

Nair, N. H, and R. Costa-Castelló, "A Model Predictive Control-Based Energy Management Scheme for Hybrid Storage System in Islanded Microgrids," in IEEE Access, vol. 8, pp. 97809-97822,2020.

Roy, P. , J. He and Y. Liao, "Cost Minimization of Battery-Supercapacitor Hybrid Energy Storage for Hourly Dispatching Wind-Solar Hybrid Power System," in IEEE Access, vol. 8, pp. 210099-210115.,2020.

Sarasúa, J. I. Pérez-Diaz, H. García-Pereira, G. Martínez-Lucas, and M. Blanco, "Comparison and Influence of Flywheels Energy Storage System Control Schemes in the Frequency Regulation of Isolated Power Systems," in IEEE Access, vol. 10, pp. 37892-37911,2022.

Sundaram, E. Hossain, M. Rengasamy, R. M. Elavarasan, N. Das, and S. Gangatharan, "A Novel Battery Supported Energy Management System for the Effective Handling of Feeble Power in Hybrid Microgrid Environment," in IEEE Access, vol. 8, pp. 217391-217415,2020.

Tang D. and H. Wang, "Energy Management Strategies for Hybrid Power Systems Considering Dynamic Characteristics of Power Sources," in IEEE Access, vol. 9, pp. 158796-158807,2021.

Tawfiq, A.A. E. M. O. A. El-Raouf, M. I. Mosaad, A. F. A. Gawad and M. A. E. Farahat, "Optimal Reliability Study of Grid-Connected PV Systems Using Evolutionary Computing Techniques," in IEEE Access, vol. 9, pp. 42125-42139,2021

## Biographies

**Sathugari Karthik** is a passionate engineer with a strong in innovation and technology.Karthik completed his undergradute studies in Electrical and Electronics Engineering at B V raju Institute of Technology, in 2024. His Research interest include smat grids, microgrids, power systems.

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