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Grid Optimizing Grid Modernization Using MPPT (P&O) and LC Filters

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Abstract *– This paper investigates the power demand of a microgrid and the benefits of integrating a power electronics-enabled Energy Management System (EMS). A detailed analysis is conducted on the power demand of a single-family household, highlighting the limitations of peak power demand on the commercial electricity grid and the impact on connected installations. The field of power and energy management in the context of electric vehicles (EVs) is a relatively new area, spanning multiple disciplines. One of the key challenges in EVs with multiple energy storage systems is managing energy consumption efficiently. This involves determining optimal power distribution, managing energy expenditure, and developing effective methods for interfacing between various energy storage systems. These efforts ensure that both propulsion and auxiliary loads are met without compromising vehicle performance.*

Additionally, to manage complex control functions such as mode selection, generator scheduling, blackout prevention, and fault tolerance, a Power Control Module (PCON)-based distributed Power and Energy Management System (PEMS) is developed. The proposed control framework is validated in real-time using a Real-Time Digital Simulator (RTDS), demonstrating its effectiveness in addressing energy management challenges within these advanced systems.

Keywords: Microgrid, Energy Management System (EMS), Power demand analysis, Peak power demand, Power electronics, Electric vehicles (EV), Multiple energy storage systems, Power split optimization, Auxiliary load management, Power Control Module (PCON), Distributed Power and Energy Management System (PEMS)

I. Introduction

Decentralized energy resources (DERs) refer to small-scale energy generation and storage systems that are located close to where energy is consumed, rather than relying solely on large, centralized power plants. DERs include renewable energy technologies such as solar panels, wind turbines, small hydropower systems, battery storage, and even electric vehicles capable of feeding power back into the grid. These resources are often owned and operated by individuals, businesses, or communities, allowing them to generate, store, and manage their own energy.

DERs play an increasingly important role in the modern energy landscape by enhancing grid efficiency, resilience, and sustainability. One of the key benefits of DERs is their ability to reduce transmission and distribution losses, as electricity is generated closer to the point of use. This leads to improved energy efficiency and lower operational costs. Additionally, DERs contribute to grid resilience by providing backup power during outages and reducing reliance on large, centralized systems that can be vulnerable to failures or disruptions.

From an environmental perspective, DERs support the integration of renewable energy sources, significantly

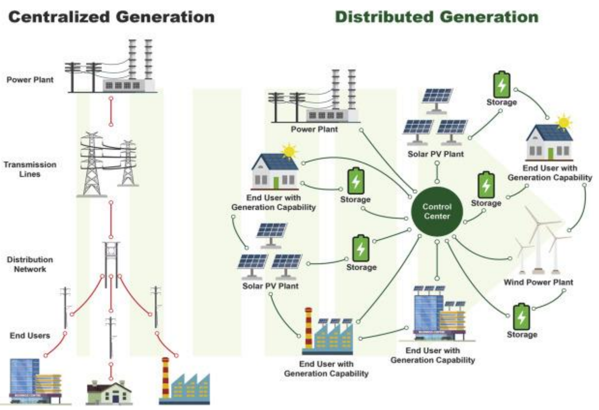

Figure 1 Show Decentralized Energy Resource

reducing greenhouse gas emissions by decreasing dependence on fossil fuels. Moreover, they empower consumers to have more control over their energy

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consumption, offering energy independence, especially in regions with unreliable or expensive grid infrastructure.As technology advances and the cost of renewable energy decreases, DERs are becoming more accessible, playing a vital role in the transition to a decentralized, cleaner, and more sustainable energy future.Decentralized energy resources (DERs) are gaining widespread adoption as their benefits become more apparent in addressing the challenges of modern energy demands. These resources include small-scale power generation technologies like rooftop solar panels, wind turbines, battery storage, and even electric vehicles that can feed energy back into the grid. DERs are often located near the point of consumption, meaning energy is produced closer to where it is used, which enhances overall system efficiency and reduces reliance on large, centralized power plants. The growing popularity of DERs stems from their ability to enhance grid reliability, increase energy resilience, improve energy efficiency, and contribute to the reduction of greenhouse gas emissions.

II. ENERGY DECENTRALIZATION

Energy decentralization is a transformative approach to energy production and consumption, where energy is generated closer to the point of use, as opposed to relying solely on large, centralized power plants. This shift not only empowers local communities and individuals to take control of their energy needs but also fosters a more sustainable and resilient energy system. Decentralized energy resources (DERs), such as solar panels, wind turbines, and battery storage systems, enable small-scale, localized generation of electricity, often from renewable sources. This reduces the reliance on fossil fuels, leading to a significant decrease in carbon emissions and air pollution, thus contributing to global decarbonization efforts.

The decentralization of energy also promotes energy efficiency and reduces transmission losses. Traditional, centralized energy systems require electricity to be transmitted over long distances, often resulting in energy loss during the process. By generating energy closer to where it is consumed, decentralization minimizes these losses and optimizes energy use. This approach is particularly beneficial in remote or rural areas where access to reliable grid infrastructure may be limited or costly. With decentralized systems, such areas can achieve energy independence and reduce their vulnerability to power outages or fluctuations in electricity prices.

Additionally, energy decentralization encourages the adoption of advanced technologies like smart grids and energy storage systems, which are essential for balancing supply and demand in real-time. Decentralized systems can integrate distributed generation sources, allowing energy to be stored and used when needed, further enhancing the flexibility and reliability of the grid. These systems also create opportunities for consumers to become "prosumers," where they not only consume energy but also generate and sell excess power back to the grid.

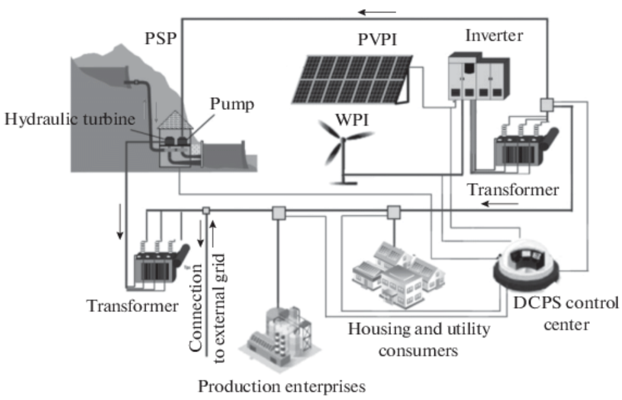

Figure 2 Shows decentralized Energy

In the broader context of the energy transition, decentralization is key to creating a cleaner, more equitable energy system. It aligns with the global shift towards renewable energy and the goal of reducing carbon emissions to mitigate climate change. By decentralizing energy generation, communities can take ownership of their energy future, reduce their environmental impact, and contribute to the creation of a resilient and sustainable energy infrastructure.

III. METHOD

Artificial nonlinear controller with a current-limiting property is planned to ensure correct dc output voltage regulation and unity power issue operation for three-phase pulse-width modulating rectifiers while not the requirement of a phase-locked-loop (PLL). to possess harmonic current alleviation of the provision voltage and also the grid current harmonics, a compensation technique utilizing expedited management of 2 parallel interfacing converters is planned during this section. To boost the ability quality and system performance and reduces the overall harmonic distortion mistreatment the 3 section pulse breadth modulating rectifier and MPPT ways.

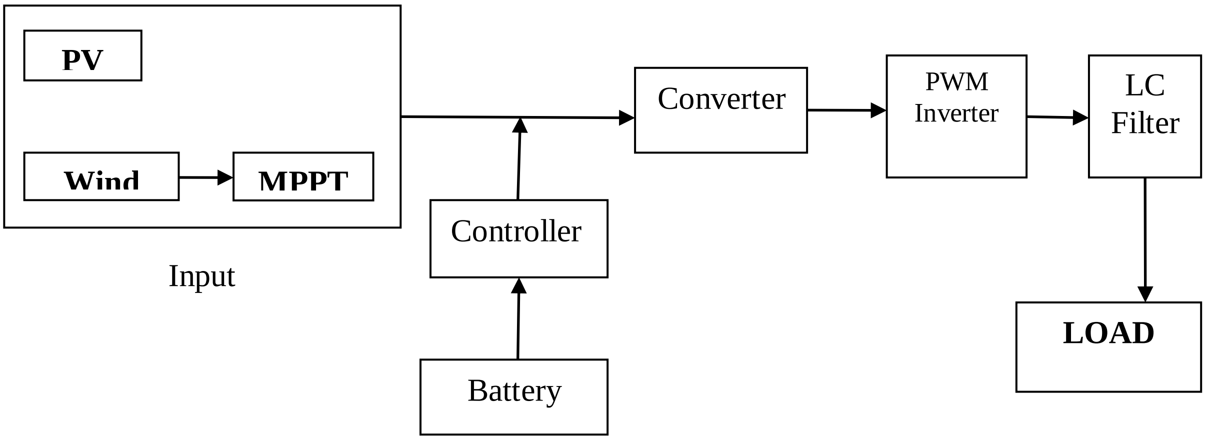

Figure .3 Block Diagram of Proposed System

A. Phase controlled rectifiers

The electric energy conversion created by semi conductive converters is getting used additional and additional. This had diode to the expansion of negative development that appeared negligible, once solely a couple of converters square measure used. But the event of semiconductor structures has enabled higher power to be transmitted and has additionally diode to wide unfold of converters. During this method, converters have a negative impact on the provision network. The regressive effects of overloads with harmonics and reactive power consumption have become major disadvantages of section controlled (mostly thyristor) rectifiers. These facet effects have to be compelled to be remunerated by extra filtering circuits with capacitors or inductances. However, such circuits raise the prices and additionally increase material and house necessities for the device.

Phase management and commutation of semi conductive devices impact the part displacement between 1st|the primary} harmonics of the consumed current and also the first harmonics of the provision voltage. This displacement ends up in power issue degradation and to reactive power consumption. The consumed current harmonics because non-sinusoidal voltage drops on provide the availability the provision} network impedances and cause supply voltage deformation. This could cause malfunctions of alternative devices that area unit wise to the curving form of the provision voltage (e.g. mensuration apparatuses, communication and management systems). The reactive power raises with longer management angle delays that the rectifier acts as time variable ohmic resistance that's nonlinear and causes ill-shapen current consumption.

B. Three Phase PWM Rectifier

The three-phase PWM rectifier/inverter consists of a three-phase bridge (implemented victimization six high speed electronic switches like IGBTs), a three-phase filter, line inductors, current and voltage sensors, and a current management loop (the current management loop allows the three-phase PWM electrical converter to control as a grid-tied rectifier or a grid tied inverter). The road inductors are necessary so as to limit the speed of modification of the present IAC flowing through the ac facet of the three-phase PWM rectifier/inverter, therefore rising the steadiness of the present management loop. Note that three-phase filters, though conditionally necessary to the operation of 3 part PWM rectifiers/inverters, are usually additional to the circuit to eliminate the distortion within the voltage wave shape created at the ac facet of the three-phase PWM rectifier/inverter. Figure 4.2 shows the diagram of a three-phase PWM rectifier/inverter connected to a dc power supply associate degreed an ac power supply.

Just as for single-phase grid-tied inverters, it's necessary for the dc power supply to provide a dc voltage EDC high enough to permit the three-phase PWM rectifier/inverter to impose a particular three-phase ac current IAC.

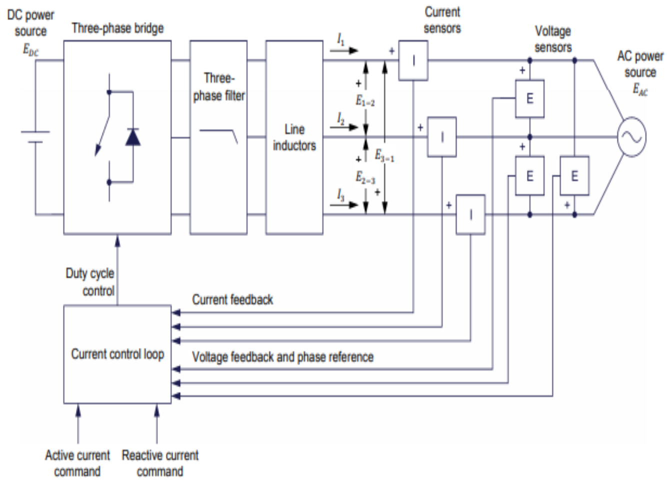

Figure.4 Block diagram of a three-phase PWM rectifier/inverter connected to a dc power source and an ac power source

The higher the worth of the three-phase ac voltage EAC across the ac aspect of the three-phase PWM rectifier/inverter, the upper the voltage EDC that the dc power supply should manufacture. identical suggests that accustomed eliminate or scale back this limitation in single-phase grid-tied inverters are employed in three-phase PWM rectifiers/inverters (e.g., connecting batteries asynchronous to extend the dc power supply voltage, adding a three-phase transformer to decrease the voltage at the ac aspect of the rectifier/inverter).

IV. Result

The intuitive condition improves the displaying procedure, taking out the need to detail differential and distinction conditions in a dialect or program. Simulink is a chunk outline environment for multi territory renovation. It generally bolsters confirmation of inserted frameworks, reproduction, and programmed code age. Constant test and Simulink gives a graphical editorial manager, adaptable square libraries, and solvers for demonstrating and mimicking dynamic frameworks.

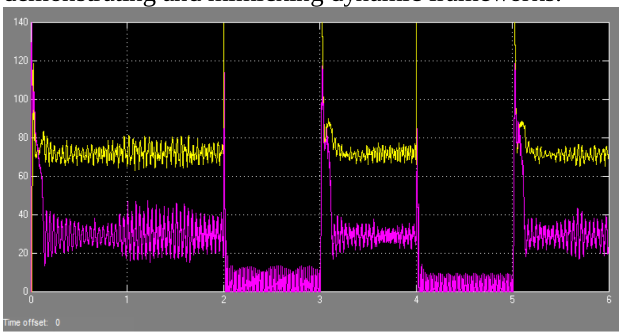

Figure.5. Output Voltage levels of load and PV Cell

Above Figure 5 shows the PV cell and load voltage output in which labels shows power and applied voltage level diagram. In this three color wave form blue color shows battery power, pink color shows wind power, and yellow color show PV power. The MPPT section describes the maximum power point tracking algorithm used to extract the maximum power available to wind hybrid – battery system for load requirement and charging the battery.

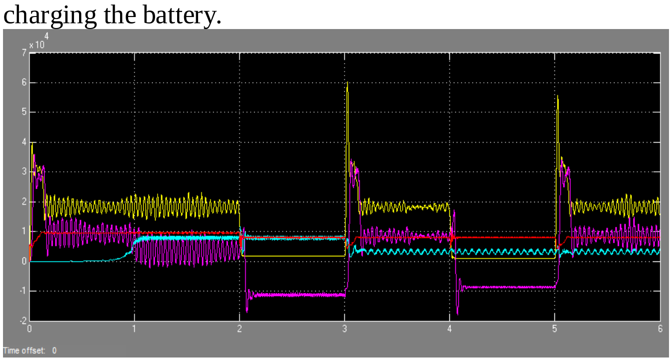

Figure 6 Simulation result of the power management when PV and Wind supplies load

In Figure 6, the power produced by PV and wind is high; the load demand is also high. In this case the PV alone is sufficient to run the load; the excess power from the wind is used to charge the battery through. In this four color wave form cyan color shows battery power, pink color shows wind power, yellow color show PV power, and red color shows load power.

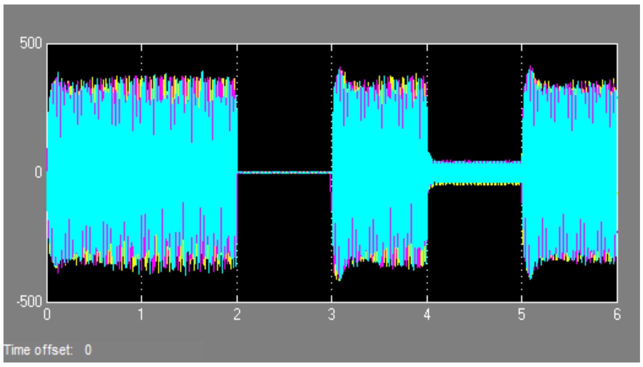

Figure 7 Simulation result of the FLC power management when battery alone supplies load

In Figure 7 the power produced by the PV is very high, approximately to its maximum power of, the power produced by wind is very low, less than load demand is high. In this case the FLC activates the PV selector switch, the wind selector switch and battery charging switches. Fuzzy rule which satisfies. In this three color wave form blue color shows battery power, pink color shows wind power, and yellow color show PV power.

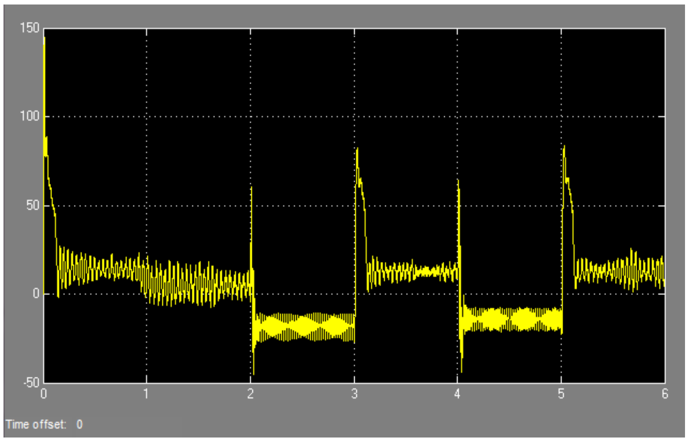

Figure 8 Rotor speed with respect to Time

Figure 8 shows the variation of the speed of rotor. It is seen that according to the wind speed variation, the generator speed varies and that its power to rotating speed of rotor is produced corresponding to the wind speed variation.

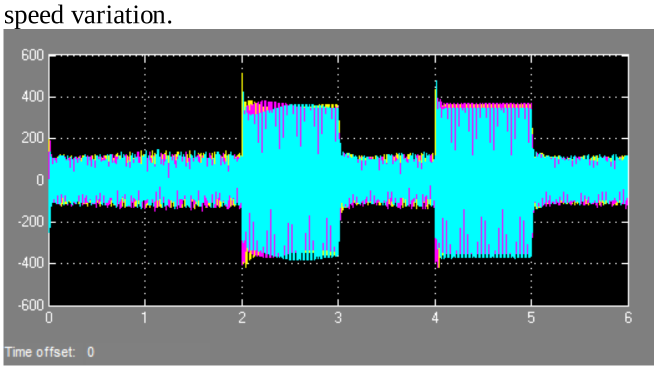

Figure 9 PV output power

Figure 9 shows the dynamic response of the PV output power at constant isolation level of and at constant temperature. In Figure 6.6, the power produced by PV and wind are very low, the load demand is medium and the battery state of charge is high enough to run the load. In this three color wave form blue color shows battery power, pink color shows wind power, and yellow color show PV power.

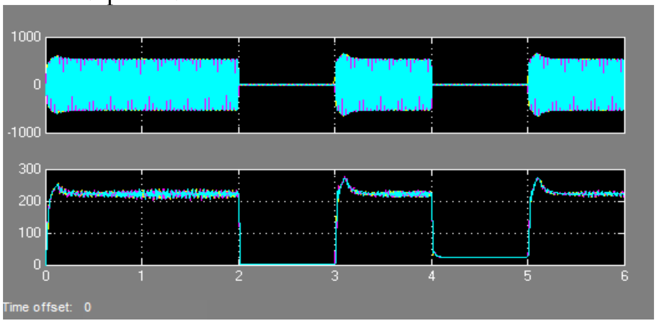

Figure 10 Output Voltage levels of load and PV Cell

Above figure 10 shows the load voltage & PV cell and output in which labels shows power and applied voltage level diagram. In this three color wave form blue color shows battery power, pink color shows wind power, and yellow color show PV power.

V. CONCLUSION

This paper work reduces the total harmonic distortion and the system power quality is improved using maximum power point tracking, wind power, PV cell and three phase pulse width modulated. In the meantime, the harmonic current brought on by the nonlinear load and the principal converter is repaid by the second converter. Consequently, the nature of the network current and the supply voltage are both essentially progressed. To lessen the computational heap of DG interfacing converter, the organized voltage and current control without utilizing load current/supply voltage harmonic extractions or stage bolt loops is produced to acknowledge composing control of parallel converters. At the point when a single multi-useful interfacing converter is received to compensating generation the harmonic current from nearby nonlinear burdens, the nature of supply voltage to neighborhood load can barely be enhanced in the meantime, specific once the basic network voltage is blended.

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