Power Quality Improvement through Grid Integration of Renewable Energy Sources: A Review

Bhooshan Lal Sahu[1], Dr. Yogesh Tiwari[2]

[1] M.tech scholar, Department of Electrical Engineering, Shri Shankaracharya Technical Campus Junwani, Bhilai
[2]Associate Professor, Department of Electrical Engineering, Shri Shankaracharya Technical Campus Junwani, Bhilai

---***---

Abstract - These traditional energy systems are built to use huge reliable energy plants and have limited flexibility to quickly scale output or trim capacity below a certain level. Maintaining utilization efficiency is critical in order to save more resources for future ages. The rise in consumption unpredictability brought on by intermittent power Photovoltaic (PV) energy sources boost the system's adaptability. The purpose of this study is to examine, evaluate and emphasize the relevance of a PV system that is connected to the grid due to the availability of renewable energy sources, and as a result, the description of PV systems in relation to the grid regulation is analysed. In this analysis the review of more than 10 papers is carried out in order to critically examine and make an analysis for any probable issues and solutions to the issues.

***Key Words*:** Photovoltaic energy (PV), Hybrid Micro grid, Total Harmonics Distortion (THD).

1.INTRODUCTION

Micro-sources near the load have the effect of reducing power loss and preventing communication delays. Additionally, the likelihood of later part connected to a low voltage (LV) distribution network experiencing a voltage level interruption is decreased since consecutive micro-sources, controlled loads, and energy storage devices can function in islanded mode in the case of a severe malfunction. This is now referred to as a micro grid. Renewable radiation, sustainable energy, and essential load in variety of systems, voltages, power, and resource management are all part of the hybrid micro grid architecture. A bidirectional AC-DC inverter is used to link the AC and DC sides by managing the active and reactive power flow between regions. Out from consumer's viewpoint, micro grids meet both electrical and heat energy requirements, increasing local effectiveness, reducing emissions, improving grid stability through proper regulation, reducing voltage dips, and perhaps lowering electricity generation prices.

The increased operating performance and reduced emission rate, the growth of distributed generation systems is increasing rapidly than in recent times. Distributed generators, including Photo voltaic panels, batteries, micro turbines and fuel cells, utilize many micro-sources for their action. When the energy costs are increasing, DGs support peak production during peak load hours and stand by generation during device shutdowns. In a certain local area, Micro grid is constructed by integrating a group of modules and parallel distributed generation systems. Micro grids have broad power capability and greater versatility of control that meets both the system's stability and the power efficiency requirements.[1]

Micro grid design offers the ability to both decrease pollutants and fight global warming. It's due to the increased availability and advancement of technologies focused on alternate fuels and smaller assets , that emit fewer pollutants than dispersed sources of energy.

End-users, infrastructural facilities, and communities gain from micro-grids in a variety of ways, including improved energy efficiency, lower overall energy consumption, reduction of greenhouse emissions and contaminants emissions, enhanced performance and consistency of services, and expense energy connectivity replacement. The management and regulation of micro grids are fraught with technological challenges.

2. AC/DC HYBRID MICROGRID FRAMEWORK

The different kinds of hybrid micro grid architectures are AC-coupled, DC-coupled, and AC-DC-coupled micro grids. Distributed generators (DGs), storage elements (SEs), and loads are linked through an AC bus / sub-grid in AC-coupled micro grids.

To identify the capacity of generating power, a technological approach, i.e. a micro grid is utilized, that identifies generation and related loads as a subsystem. This technique necessitates targeted distributed generation control, reducing the requirement for centralize installation. During disturbances caused by islanding generation and loads ,the micro grid local stability can be stronger than the entire power system.

The micro grid enables the machine's efficiency to double the requirement sources, planned islanding permissions and the usage of useable heat energy from power producing systems as a great advantage.[2,3].

2.1 AC-COUPLED HYBRID MICROGRID

Micro grid is an intriguing solution from a grid standpoint, since it recognizes that the electricity grid is thorough, antiquated, and can only develop slowly. This approach enables for widespread adoption of utility grid without requiring a complete overhaul of the distribution network.[4,5,6].

The AC-voltage regulation of an AC-coupled micro grid is indeed easier than other hybrid-micro grid arrangements wherein DC sub grids are interconnected with AC sub grids.

In this architecture, the high voltage AC bus can be employed. SEs requires bi-fractional conversion to offer bidirectional power capabilities.

In an AC-coupled technology, the controlling approach and power management approach are primarily focused on energy / utilization synchronization and AC bus voltage / frequency regulation, especially in discrete operation mode.[7]. Fig 1 shows the AC-coupled hybrid micro grid.

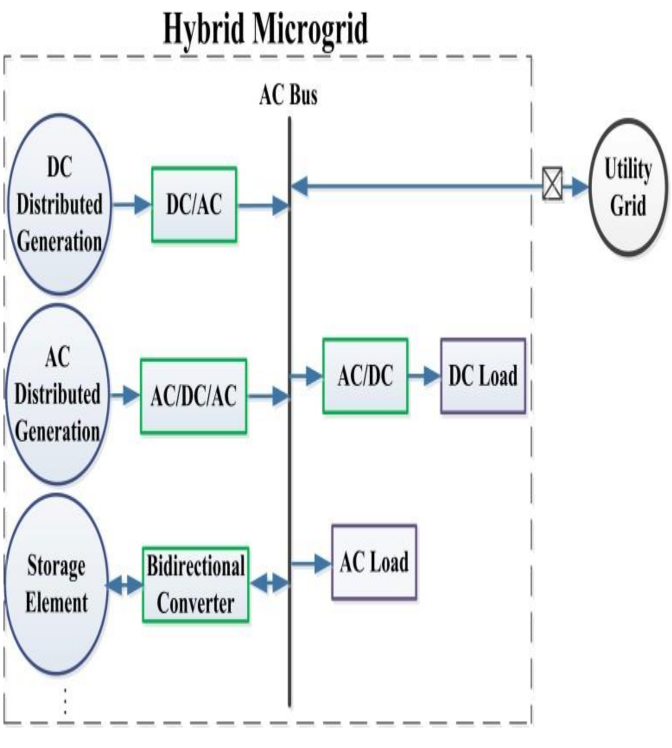

Fig. -1 : AC-coupled hybrid micro grid.

2.2 DC-COUPLED HYBRID MICROGRID

Within the DC-coupled architecture, DGs, SEs, and loads are connected to the normal DC bus / sub-grid, and the AC-DC bus / sub grids are connected via the annexing converters. When several DGs are interconnected, the DC-coupled micro-grid is adaptable and requires no synchronization.

When the micro grid's energy producing technologies are DC sources of electricity, this configuration is employed.

Note that under this structure, the DGs and SEs may all be linked to the DC bus. Figure 2 depicts the operation of a hybrid network using DC-couples.

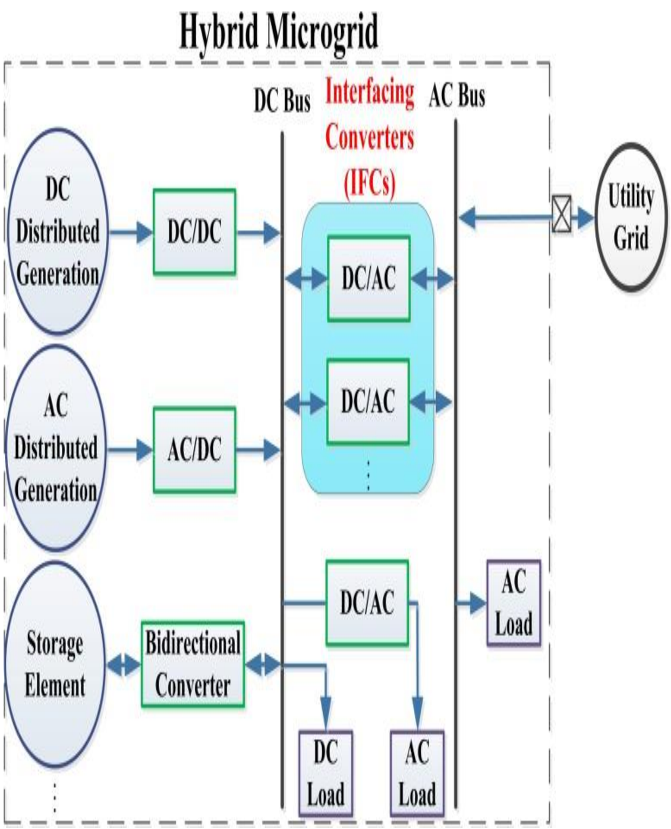

Fig. -2 : DC-coupled hybrid micro grid.

The notion that micro grids may be used to add large amounts of micro production without disturbing the energy grid's operation, the grids end or distributing system can create less problem for the energy network than traditional micro production provided that there is adequate and informed coordination of micro generating units without any disturbance in operation.[8,9].

2.3 AC-DC COUPLED HYBRID MICROGRID

AC-DC-coupled systems have DGs and SEs in both AC and DC lines / power networks, making them the most particular use micro grid architecture. Figure 3 depicts the setup of an AC-DC-coupled micro grid.

Both DC and AC buses contain DGs and SEs, as illustrated in the diagram and interconnecting converter linking them.

The AC-DC paired combination micro grid, unlike in DC-coupled system, features DGs and SEs on the AC bus, requires an additional synchronization among DC and AC subsystems for voltage and power regulation.

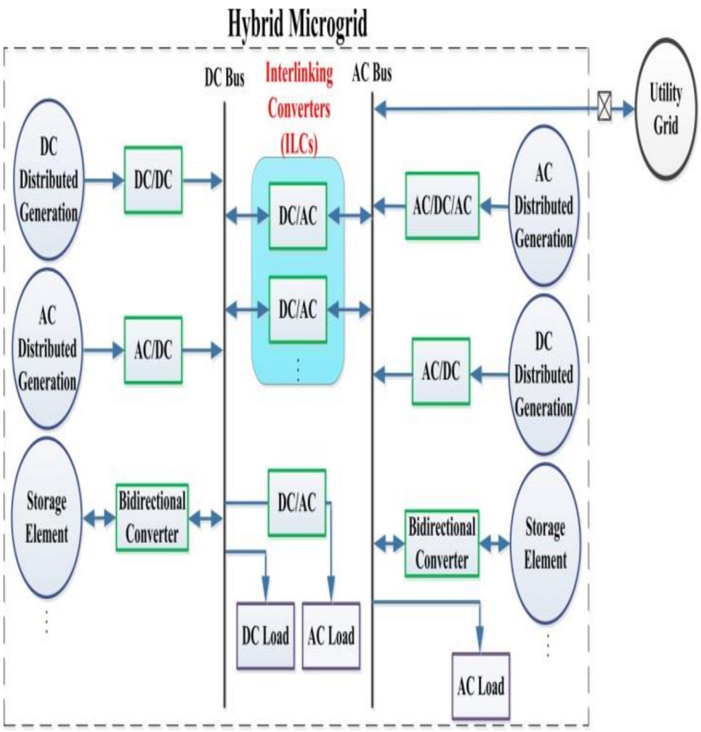

Fig.-3 : AC-DC-coupled hybrid micro grid

An AC/DC converter is used to deliver DC loads in a power grid. In drive systems, AC/DC adapters are frequently performed to analyze motor speed. High-voltage transmission across great distances is no longer required since power would be provided by local power generators.

In a DC system, AC outlets must be converted to DC and AC feeds connected to the DC micro grid using DC/AC inverters.[11,12].

3. CONTROL ALGORITHM

3.1 SYNCHRONOUS REFERENCE FRAME THEORY

Figure 4 shows a schematic diagram of a synchronous reference frame. A moment wave navigation system with a desired line sensor that is an upgraded a-b-c comparison model based on the d-q principle to solve the problem of diverting efficient power amplifiers (SAPF) in non-ideal circumstances is utilized [10].

As feedback control, the DSTATCOM senses the load currents (i_{La}, i_{Lb}, i_{Lc}), PCC voltage (Vsa, Vsb, Vsc), and bus voltage ((V_{dc}). The Park's conversion is used to translate the current in the three phases into the dq0 frame and is given as follows:

$$\begin{pmatrix} i_{Ld} \\ i_{Lq} \\ i_{L0} \end{pmatrix} = \frac{2}{3} \begin{pmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos(\theta - \frac{2\pi}{3}) & -\sin(\theta - \frac{2\pi}{3}) & \frac{1}{2} \\ \cos(\theta + \frac{2\pi}{3}) & \sin(\theta + \frac{2\pi}{3}) & \frac{1}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix}$$

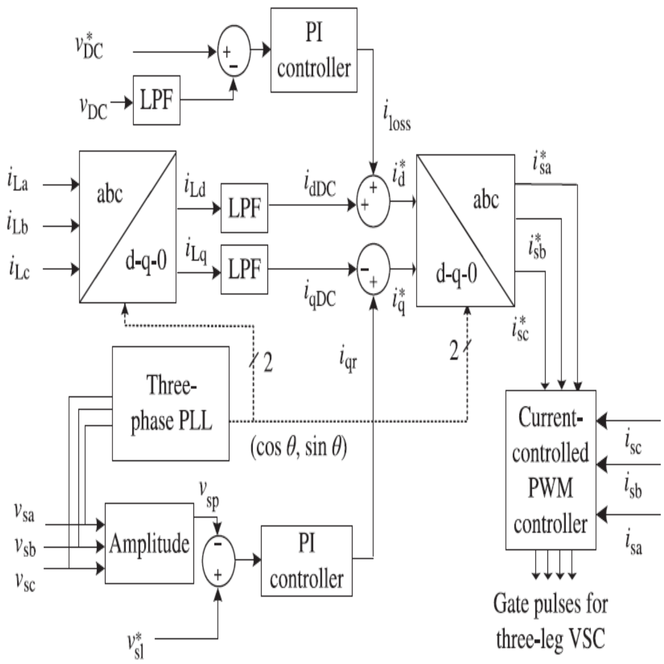

Fig.-4 : Block diagram of SRF based control algorithm

A LPF pulls DC values from an SRF controller, separating the non-DC variables from the modulating signal.

3.2 INSTANTANEOUS REACTIVE POWER THEORY

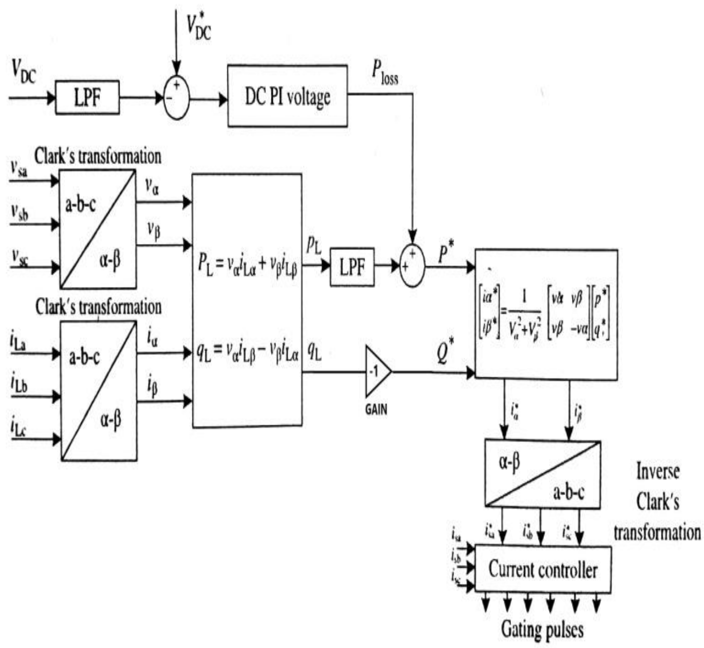

Fig. -5: Instantaneous Reactive Power Theory

Fig 5 shows the instantaneous reactive power theory block diagram. The instantaneous reactive power theory (IRPT) is recognized for traditional active filters [13] may be used to convert three-phase voltage a-b-c into α-β-0 transverse dimensions.

This control approach calculates the fixed parameters to estimate harmonic components. This control strategy enhances harmonic adaptation by using an active filter in conjunction with a passive filter, as well as the load power component. [14].

$$\begin{pmatrix} v_{s0} \\ v_{s\alpha} \\ v_{s\beta} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_{sa} \\ v_{sb} \\ v_{sc} \end{pmatrix}$$

Similarly, may be used to convert three phase currents (i_{sa}, i_{sb}, i_{sc}) into $(i_{s0}, i_{s\alpha}, i_{s\beta})$ perpendicular dimensions.

$$\begin{pmatrix} i_{s0} \\ i_{s\alpha} \\ i_{s\beta} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_{sa} \\ i_{sb} \\ i_{sc} \end{pmatrix}$$

3.3 MAXIMUM POWER POINT TRACKING

The photovoltaic (PV) module functions as electronics maximum power point tracking (MPPT) mechanism, allowing the Solar panels to create all of the electricity that they are capable of.

This isn't a mechanized sun-monitoring system that mechanically moves the elements to react more precisely to the sun, because the MPPT is an entirely electronic component, it changes the device's operation mode so that the elements can supply the maximum available power.

The output voltage will not be exactly produced since the PV component ports rely on warmth, irradiance, and the MPPT load characteristics. MPPT must be included in the Photovoltaic system in order to maximize the PV array output voltage[15].

The power versus voltage curve of a Photovoltaic panel has a specified power restriction. In other words, a maximum power corresponding to a specific voltage or current arises. The efficiency of around 13% of solar PV systems is substandard.

Because the component's functionality is restricted, it's better to run it at maximum power to ensure that the system gets all of the energy required below a broad range of temperatures and illumination conditions.

This energy-efficient architecture aids in the functioning of solar panels. A maximum power point tracker (MPPT) extracts the utmost power from the PV panel and sends it to the demand.

3.3.1 PREREQUISITE OF MAXIMUM POWER POINT TRACKING

As interface equipment, the DC/DC converter transfers the maximum power from the solar photovoltaic system to the demand.

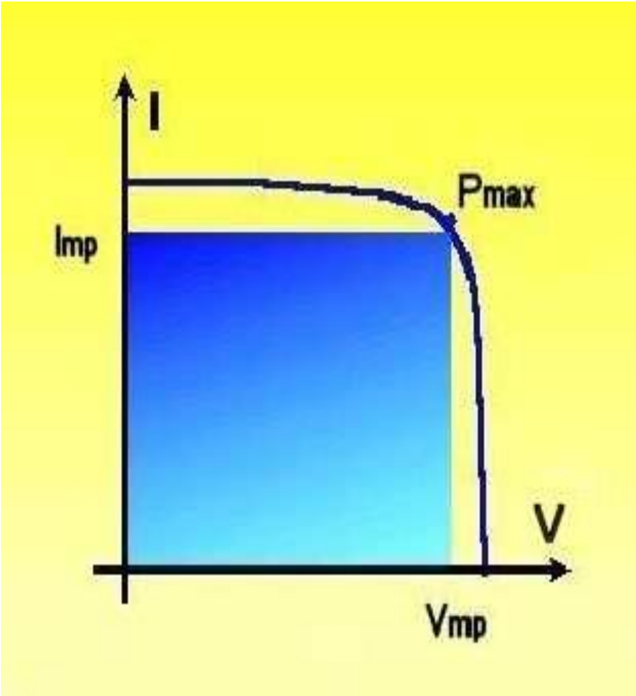

Fig.-6 : MPP Characteristics

By altering the duty ratio, the demand impedance fluctuates and is oriented with the source at the optimum output extent to pass the most energy. Fig 6 shows the characteristic of maximum point power tracking.

4. CONCLUSIONS

This paper presents a review of the existing advancements in Grid Connected Photovoltaic Systems and also the various hybrid micro grid connections along with the ongoing prospective requirements for addressing the technological issues associated with the expanding diversity of micro grids are examined. Maximum power point tracking (MPPT) will also result in significant electrical phenomena, photovoltaic system efficacy improvements while ensuring minimal grid disturbance.

The DSTATCOM and the comparative control scheme for the framework are also assessed, as converter that sustain prescriptive easement assistance such as reactive power administration, utility grid, and storage technology region unit, which are essential for minimizing the obstacles engendered by the increasing prevalence of micro - grid.

REFERENCES

[1] S. Bose, Y. Liu, K. Bahei-Eldin, J.de Bedout, and M. Adamiak, "Tie line Controls in Microgrid Applications," in iREP Symposium Bulk Power System Dynamics and Control VII, Revitalizing Operational Reliability, pp. 1-9, Aug. 2007.

[2] R. H. Lasseter and P. Paigi, "Microgrid: A conceptual solution," in Proc. IEEE- PESC'04, pp. 4285-4290, 2004.

[3] R. H. Lasseter, "MicroGrids," in Proc. IEEE-PES'02, pp. 305-308, 2002.

[4] F. Katiraei and M. R. Iravani, "Power Management Strategies for a Microgrid with Multiple Distributed Generation Units," IEEE trans. Power System, vol. 21, no. 4, Nov. 2006.

[5] P. Piagi and R. H. Lasseter, "Autonomous control of microgrids," in Proc. IEEE-PES'06, 2006, IEEE, 2006.

[6] M. Barnes, J. Kondoh, H. Asano, and J. Oyarzabal, "Real-World MicroGrids- an Overview," in IEEE Int. Conf. Systems of Systems Engineering, pp.1-8, 2007.

[7] Chi Jin, Poh Chiang Loh, Peng Wang, Yang Mi, and Frede Blaabjerg, "Autonomous Operation of Hybrid AC-DC Microgrids," in IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-7, 2010.

[8] Y. Zoka, H. Sasaki, N.Yomo, K. Kawahara, C. C. Liu, "An Interaction Problem of Distributed Generators Installed in a MicroGrid," in Proc. IEEE Elect. Utility Deregulation, Restructuring and Power Technologies, pp. 795-799, Apr. 2004.

[9] H. Nikkhajoei, R. H. Lasseter, "Microgrid Protection," in IEEE Power Engineering Society General Meeting, pp. 1-6, 2007.

[10] Zhenhua Jiang, and Xunwei Yu, "Hybrid DC- and AC-Linked Microgrids: Towards Integration of Distributed Energy Resources," in IEEE Energy2030 Conf., pp.1-8, 2008.

[11] Bo Dong, Yongdong Li, ZhixueZheng, Lie Xu "Control Strategies of Microgrid with Hybrid DC and AC Buses," in Power Electronics and Applications, EPE'11, 14thEuropean Conf., pp. 1-8, 2011.

[12] Poh Chiang Loh, Ding Li, and FredeBlaabjerg, "Autonomous Control of Interlinking Converters in Hybrid AC-DC Microgrid with Energy Storages," in IEEE Energy Conversion Congress and Exposition (ECCE), pp. 652-658, 2011.

[13] S. Rahmani, K. Al-Haddad, H. Y. Kanaan ,"A comparative study of shunt hybrid and shunt active power filters for single-phase applications: Simulation and experimental validation," Mathematics and Computers in Simulation, Volume 71, Issues 4–6, June 2006, Pages 345–359

[14] P. Salmerón and S. P. Litrán, " Improvement of the Electric Power Quality Using Series Active and Shunt Passive Filters" , IEEE Transactions On Power Delivery, Vol. 25, No. 2, April 2010.

[15] Mesut E. Baran, and Nikhil R. Mahajan, "DC Distribution for Industrial Systems: Opportunities and Challenges," IEEE Trans. Industry Applications, vol. 39, no. 6, pp. 1596-1601, Nov/Dec. 2003.