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Hybrid Micro Grids and their Harmonics Analysis using DSTATCOM- A Review

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Abstract - *The energy crisis has resulted from the rapid depletion of fossil resources and the rising awareness of the need of environmental conservation. As a result, researchers are working to find new ways to harvest renewable energy sources. The micro grid idea reduces the number of reversal transformations in a single AC or DC grid and makes it easier to link variable renewable AC and DC sources and loads to energy systems. Energy storage systems (ESS) are one method for improving the quality of power source and ensuring stable operation. If the AC micro grid is unable to meet the reactive power demand, the distributed static synchronous compensator (D-STATCOM) is employed to compensate. This study intends to bring the idea of Energy Storage Systems (ESS) and the state of the art of DSTATCOM with approaches for micro-grids and renewable energy integration to light.*

Key Words: Micro-grids, DSTATCOM, Energy Storage Systems, PV system

1. INTRODUCTION

Micro-grids integrate various energy sources in the most efficient way feasible to meet local demands, and they can function either linked or detached from the utility grid. They may be thought of as a controlled subsystem that generates energy from Distributed Energy Resources (DER), which are mainly renewable.

Excessive concentration has a number of disadvantages, including restrictions on the use of non-renewable energies, network growth, congestion reduction on current lines, and risks from hostile groups.[9-11]

Because of their stochastic character, certain sources' power is sporadic or not of the desired power quality. As a result, a comprehensive transition from fossil fuel to renewable energy will necessitate a non-single mix of these alternative energies.

Alternative energy sources such as hydro, geothermal, biomass, wind, solar, hydrogen, nuclear, and fossil fuels must be made to function as a single unit in various combinations to fulfil a shared requirement region. The word Hybrid Renewable Energy Sysytem(HRES) refers to a system that combines many DGs to meet a customer's need.

As illustrated in Fig. 1, HRES can be a combination of traditional resources such as diesel generators and/or renewable energy sources such as photovoltaics (PV) and wind turbines (WT) used in various configurations with storage devices.

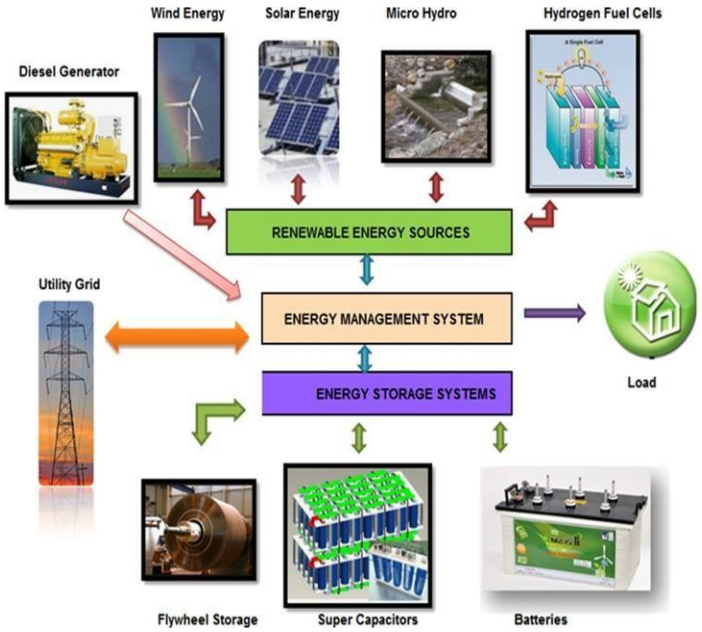

Fig -1:Hybrid renewable energy systems

Solar energy is the energy emitted by the sun that is captured by converting light photons into electrons. Solar energy is now widely produced, with numerous energy investment firms pushing it.

The PV unit composed of a photovoltaic array that transforms light photons into electrons when they strike it. This produces a DC current that may be amplified with DC–DC converters and then reversed to provide AC power to the loads.

Semiconductor polycrystalline substances are used in the majority of PV cells. PV cells come in a variety of shapes and sizes, including mono-crystalline, poly-crystalline, and thin-film PV cells.[12]

New advances in cellular manufacturing techniques have led to the emergence of titanium-oxide clad PV cells, which enhance output efficiency significantly.

PV cells are combined into modules, which are then electrically linked in series and/or parallel to produce big units with scaled voltages and higher power outputs. To

improve the efficiency of the conversion system, an MPPT system is essential for efficient solar energy reception.

2. Power quality and cost control

Harmonics are a power quality issue that primarily affects the supply system. Harmonics are defined as "a sinusoidal constituent of a wave form or quantity with a rate that is an integral multiple of the fundamental frequency," according to the IEEE dictionary. [1].

Harmonics can be caused by power system issues such as transmission interference, solid-state device failure, and heating.

When non-sinusoidal current interacts with the distribution system, voltage impedance variation develops, which has a significant impact on the distribution network. [2].

Power conditioning equipment such as DSTATCOM and quality management techniques in distribution networks enhance power quality [3,4,5]. It is critical to position them in the best possible location and execute them properly in order to save money and boost efficiency [6].

2.1 DSTATCOM

When voltage quality difficulties arise, such as load imbalance, low power factor, bad voltage regulation, abnormal neutral current, and so on, the D-STATCOM technology is utilized to provide reactive power compensation.[8]

The emergence of rapid, self-commuting solid devices is one of the primary reasons D-STATCOM is utilized so commonly nowadays.

STATCOM or distribution STATCOM is a FACTS device that controls voltage fluctuations and flickers caused by distribution line disturbances by infusing reactive power into the line to balance for the reactive power.

D STATCOM may be controlled in two ways: voltage mode control and current mode control.

Whether the load side or source side current, the dc bus voltage is created sinusoidal in voltage mode control. The input current must be balanced sinusoids in current mode control. [7]

D STATCOM's operation is based on the SVPWM (Space Vector Pulse Width Modulation) technology, which may be used for both sinusoids and non sinusoids, balanced or unbalanced three-phase power systems with or without zero sequence elements.

2.1.1 PRINCIPLE OF OPERATION OF DSTATCOM

Sine triangle modulation was employed in the spatial domain, and space vector propagation was applied in the q-d stationary reference frame. Sine-triangle and space vector modulation are equivalent in every way.

The triangle shape and sine wave harmonics are examples of features of the sine-triangle scheme that are related to aspects of the space vector structure.

For the regulation of the APF's three-phase three-leg VSC, the synchronous reference frame concept is used. Figure 2 depicts a block schematic of the control scheme.

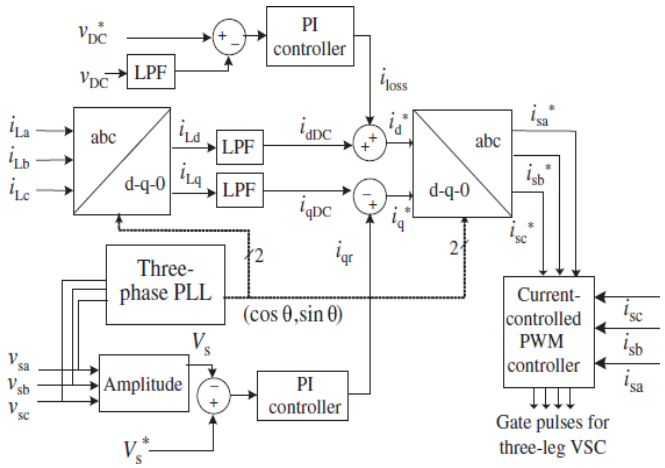

Fig -2: Synchronous Reference Frame theory based control algorithm

Low-pass filters (LPFs) are used to separate the DC components of iLd and iLq from these d–q current elements.

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

2.1.2 Space Vector Pulse Width Modulation Principle

$$\begin{pmatrix} v_d \\ v_q \end{pmatrix} = \frac{2}{3} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_{an} \\ v_{bn} \\ v_{cn} \end{pmatrix}$$

- The sinusoidal voltage is seen as a continuous

amplitude variability rotating at a constant frequency.

- This PWM method calculates the reference voltage V ref by varying the eight switching phases V 0 to V 7. (From the abc frame of reference to the consistent d-q frame)
- Coordinates Transformation: In the stationary d-q frame of reference, a three-phase voltage matrix is transformed into a matrix that defines the three-

phase voltage's coordinate sum of vectors.

3. CONCLUSIONS

This review paper discusses Hybrid Renewable Energy Systems (HRES) and the system metrics that are used to establish optimization goals. It is important to note that different storage systems provide different benefits, thus selecting a suitable system must be done carefully based on the needs. In distribution networks, power conditioning technology such as DSTATCOM and quality assurance approaches may be utilised to improve power quality and meet load demand. Active and reactive power can be balanced by using a FACTS control device such as DSTATCOM. Further study will aid in increasing the power quality from HRES and overcoming the existing scenario's shortcomings.

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