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Power Quality Improvement of Microgrid by Using STATCOM

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ABSTRACT:

Increased energy demand due to rapid industrialization, environmental concerns with fossil fuel-based generation, decreasing fossil energy resources, overloading of the transmission grids and deteriorating technical performance are the motivations for the integration of small decentralized renewable generation units (DG) and the conversion of existing energy. Optimizing the technical advantages of a DG placement is a well-known challenge for Distribution System Operators (DNOs) for DGs based on fossil and renewable energy resources, but renewable DG systems have several challenges in the network quality characteristic of renewable DG systems, as electricity loads react more sensitively to PQ disturbances and the penetration of renewable energies as well as non-linear loads, it spreads in the power distribution in grids.) Technologies are becoming inevitable due to the ongoing reform in traditional distribution networks through the integration of renewable energies. This article contains a comprehensive analysis of the challenges of network quality in the network integration of renewable DG systems and the current state of research on corresponding mitigation techniques, theoretically emphasizes all the decisive challenges in network quality associated with the network integration of renewable energies, and, secondly, creates a MATLAB model of distribution line with STATCOM. Observing various fault and adding rectifier load on line with and without STATCOM we can conclude the benefit of STATCOM. The high penetration of renewable energies and techniques for reducing power quality are also demonstrated by the simulation of a grid-integrated PV-based DG system in MATLAB / Simulink. This article is believed to be very useful for academics and industry professionals to understand existing PQ challenges, PQI techniques, and future research guidelines for renewable energy technologies.

Keyword: Solar photovoltaic, Wind energy, Hybrid PV-Wind system, STATCOM, Voltage stability.

Introduction:

The interest in renewable energy sources (RESs) has boosted significantly in previous years owing to rising energy demand and awareness towards environmental protection. It goes without saying that RES is pollution- free, harmless, amenable, and sustainable means of power generation and their penetration is proliferating by leaps and bounds all over the world.1,2 The growing penetration of renewable energy can be evidenced and comprehended from Figure 1A that shows the relative boost in renewable energy consumption from the years 2004 to 2016 in European Union (EU) member states, Iceland and Sweden.3 It can be clearly understood from Figure

1A that 11 member states have already met their 2020 targets in 2016 only by extraordinarily performing in the field of renewable energy during the considered tenure of 12 years. While states like the Netherlands and France are most far from their planned targets, with 72.6% of its energy obtained from RESs, Iceland had the crowning share in 2016 and followed by Norway and Sweden from the EU group, respectively. RESs considered in this assessment were solar thermal, PV, hydro, wind, geothermal, and biomass. However, the above-mentioned benefits of utilizing energy from RESs come along with certain power quality challenges. Power quality is an aspect, which is critically responsible for reliability in smart distribution grids and hence paying attention to that is unavoidable. Utilizing the energy of RESs requires generating units to be integrated with the distribution network grids. The stable operation of grid integrated renewable DG systems is a challenging task due to associated PQ challenges arose by environmental intermittency and generation technological differences from fossil fuel- based DG systems those are constant source of energy.4-8 Only the smooth integration and stable operation of such integrated DG systems can turn the idea of future smart grids into a reality. During last few years, the widespread integration of power electronic inverters, employed for integrating DG units with the grid, has created major trials and tribulations for distribution power networks, especially harmonics distortion and complications in attaining frequency stability because of the decrease in the overall inertia.9-11 The power electronic (PE)–based generation technologies rather than the traditional synchronous generators one and the intermittent nature of RESs are primarily liable for PQ issues with renewable DG systems. The foremost PQ concern is fluctuations in voltage and frequency, which originate due to noncontrollable inconsistency in renewable energy. The inconsistent behavior of renewable energy because of frequently varying weather characteristics results in voltage and frequency fluctuations at the grid of integration.12-14 In Albarracín et al15 and Khatri et al16 a model used for the assessment of voltage fluctuations under sunny as well as cloudy weather situations with photovoltaic (PV) DG system is studied. The study showed that intermittent solar irradiation resulting from cloud motion causes voltage, frequency, and power fluctuations. In Gardner MA PV project report,17 four areas were researched: the impact of slows cloud transients on PQ performance; the impact of fast transients; harmonics impact on DG system; and the overall performance of distribution network with intend to assess the overall system performance under high PV penetration. The report concluded that penetration level up to 37% led to no significant issue. Automation in industrial plants is generally prone to voltage sags because some of their equipment's control devices function superfluously at the time of voltage sags.18-20 Voltage sag score limits of 4% are recommended as the threshold at each bus in European standard EN 50160.21 It has been proved that distribution power systems are more susceptible to the power fluctuations in the medium frequency range varying from 0.01 to 0.1 Hz, in which the most of wind power fluctuations do exist.22 Frequency regulation ratio (FRR) limits of 1% are taken as the threshold at each bus in standard IEC61000.23 Second major PQ concern is the harmonics. Harmonics associated with the DG systems can be classified into two categories, and collectively, they can result in excessive PQ worsening at the point of common coupling (PCC). The harmonics of the first category is produced by power electronics inverter interfacing employed for integrating RES and injecting active power into the grid.24,25 Such inverters operate at the very high switching frequency and inject these high-frequency harmonics (also called supraharmonics) current components into the grid along with intended active power component of the current.26-28 The harmonics of the second category is caused by locally connected nonlinear loads at PCC. Harmonics distortion causes several issues like resonance, overheating of lines, cables, and transformers, and spurious tripping of protection equipment.29,30 Total voltage harmonics distortion (TVHD) limits of 5% are taken as the thresholds at PCC as per IEEE standard 519.31 Fekete et al32 examined the influences of harmonics resulting from both a 10-kW residential PV system integrated with low voltage distribution power network and grid in two periods: winter and summer. The PV DG system's contribution to utility grid harmonic distortions are extensively addressed in literature.33-36 It is also inevitable that a high penetration level of renewable energy in the future will exacerbate the existing power quality performance up to the next level if no PQI techniques are adopted. Although the additional power quality issues emerged by renewable DGs lies in the same and general class of PQ issues existing also in the traditional power system but their characteristics fall slightly apart from them.37,38 It can be foretold that not only the PQ issues caused by the grid and load bus side disturbances will make the seamless integration of renewable DGs a herculean task but also their interaction with disturbances of DGs will worsen the PQ performance. A number of PQI researches are reported in literature targeting the minimization of the negative impacts caused by renewable DG systems; however, each one is having certain drawbacks, so the research is expected to be continued on this topic in future. The objective of this paper is to present a comprehensive analysis of power quality challenges with the integration of renewable DG systems and a systematic literature.

Proposed methodology:

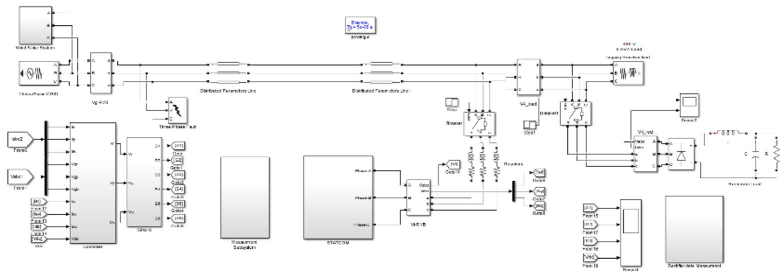

Figure 1 Distributed line with STATCOM

In this work the final model is created taking into account two cases, in the first case the distributed line is created with STATCOM. In this model, the AC load is connected on the receiving side, and a rectifier load is added for the addition of harmonics.It occurs for a reasonable time and also the disturbances with the help of three-phase faults that push the system to 0. 8 sec. to 1.2 sec.

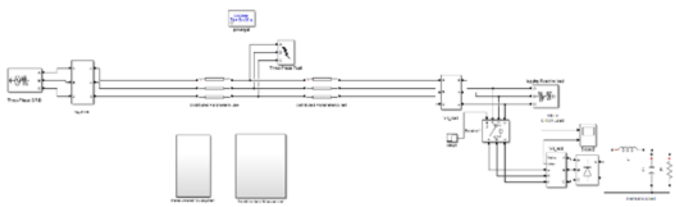

Figure 2 above describes the Statcom model

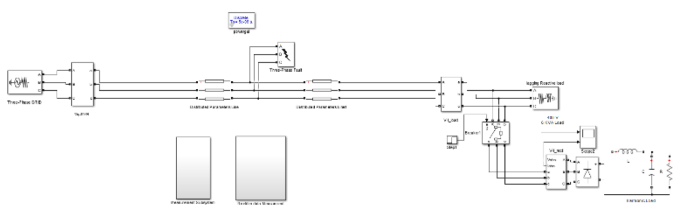

Figure 3 Distribution line without STATCOM

Figure 3 shows the distribution line without STATCOM, in this model only the AC load is connected on the receiving side and the rectifier load is connected in order to generate harmonics in the line. Here I also considered case 2, case 1 is B. when grinding the load is applied online to generate harmonics for more than 0.5 seconds and in case 2 multiple errors are applied online for a period of 0.8 seconds to 1.2 second.

RESULT

A) Result for with STATCOM model

Case 1: only rectifier load for harmonics generation

In case 1 model is run with AC Load containing harmonics above 1.2 sec, this harmonic is negligible by using statcom. also, at after 0.8 sec fault is occur on line the effect of fault on line is less as compare to without STATCOM model.

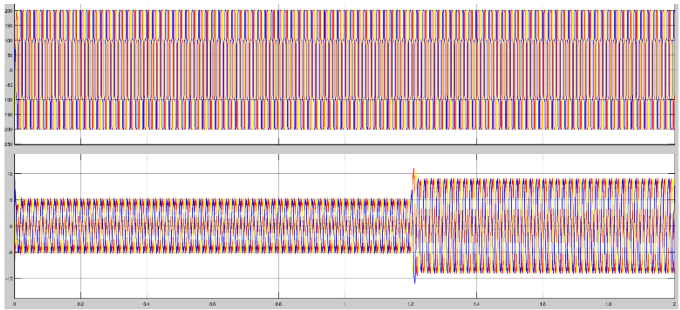

fig: 4 model with harmonics at source

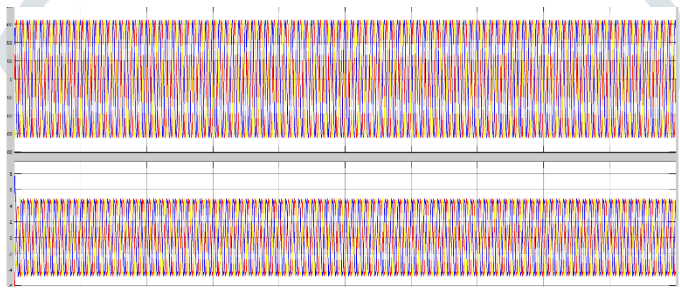

fig:5 model with harmonics at load

case 2 : fault at load side with STATCOM

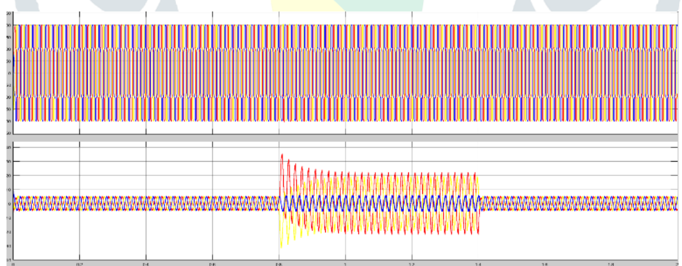

Fig.6 LLG fault on load side

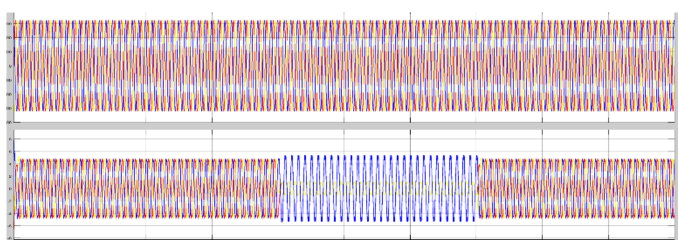

fig.7 LG fault on load side

B) Result for with STATCOM model

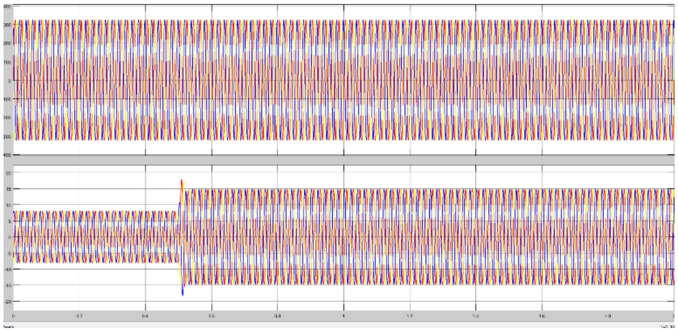

Fig 8 model with harmonics at source

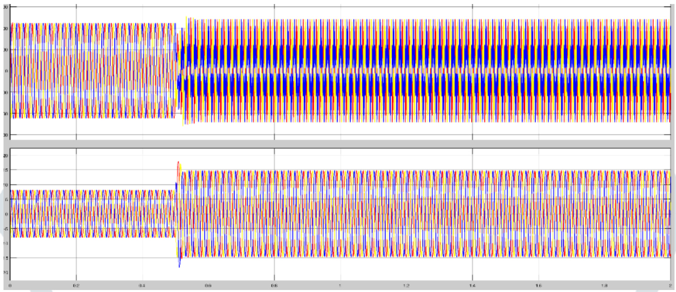

fig:9 model with harmonics at load

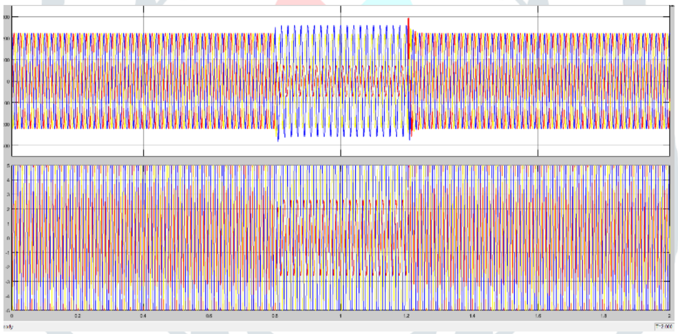

Fig.10 model with LG fault on source

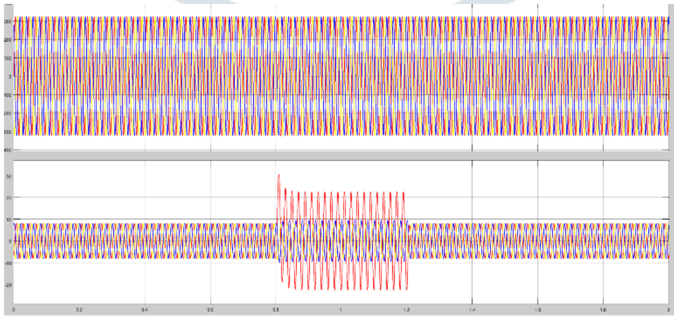

fig.11 model with LG fault on load

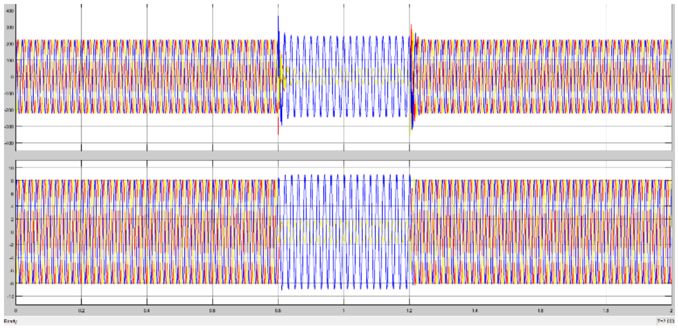

Fig.12 model with LLG fault on source

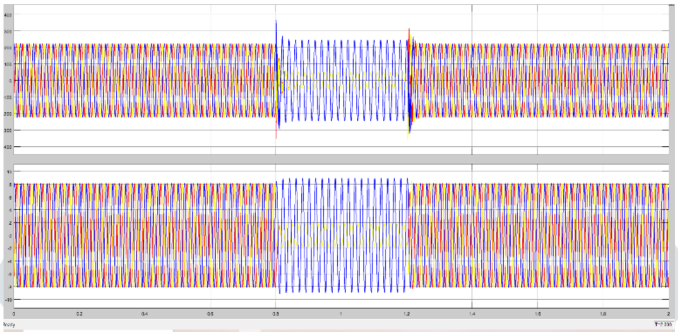

fig.13 model with LLG fault on load

By considering and studying above fault and harmonics, in this by using STATCOM the effect of fault and harmonics on load can be neglected or reduced.

CONCLUSION

In this article, the potential influence of STATCOM in associated grid-connected hybrid-star-solar-PV system environments was examined under different load conditions. 3 completely different eventualities were developed to evaluate the effectiveness of STATCOM in strengthening voltage regulation. The measurement must first be carried out for the transitional responses received in each case. The results obtained showed that the voltage profile is successfully maintained in the presence of STATCOM, which effectively counteracts a greater flow of reactive energy on the road and suppresses its undesirable effects. the performance of the system Hence a unit of conclusion generally drawn from the simulation result, it was found that the STATCOM has the ability to stabilize the voltage on the connection bus by compensating for the reactive power and could give a shocking answer to the energy suppliers to the event of the performance and responsibility of this This work thought of purely linear clusters, either strictly resistive or inductive for easy simulation. However, these clusters are rarely found in energy systems. Common sense, for the most part, encompasses heaps of inductive and nonlinear motors, all of which add system disturbances in terms of current imbalance and harmonic injections. In the future, this work could even be expanded by implementing these intelligent stacks in networked hybrid RES environments to review their effects on system dynamics and to examine the diverse potential of different FACTS controllers to perform different functions.

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