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T. LAKSHMI GAYATRI M

Abstract

Electrical practices for the entire power system industry are tremendously changing and these progressions will mark an evolution of new concepts and strategies in the future, particularly concerning planning and operation of the power systems. The renewable energy based distributed generation is definitely taking a lead in the present and future power generation. Therefore, the emphasis has increased on distributed generation (DG) networks with the integration of renewable energy sources (RESs) into the grid. A distributed generation like solar (photovoltaic and solar thermal), wind, biomass, and mini-hydro along with the use of fuel cells and microturbines will contribute heavily to the electricity generation.

A microgrid (MG) is a small-scale power network designed for a low voltage distribution system to provide supply for a small community/island. The major elements of MG would be DG units, storage devices, different loads, and power converters for the operation and control of the microgrid. The power generated in the MG is mainly based on the RESs. Two RESs, PV and Wind are considered and modeled to form the MG and supply of quality power to the local load is studied. The RES based power generation is not a constant source of the supply as the power generated directly relies on the environmental conditions. The challenges observed are maintaining output voltage and frequency constant. The present-day these MG based distribution systems are facing a number of power quality problems, especially due to the use of sensitive power electronic equipment. Some of PQ issues are voltage swells and sags, and low power factor, requiring reactive power compensation. On the other hand, nonlinear loads with solid state converters in the MG also draw reactive power component from the MG supply and create harmonics in the voltages and currents. Hence, the power quality (PQ) issues occurring during load and generation balance in MG are to be thoroughly investigated. A compensating device to deal with all these PQ issues is to be established in the MG. The custom power devices (CPDs) can operate in this direction and ensure to maintain the PQ norms.

With this motivation, the two custom power devices: Dynamic Voltage Restorer (DVR), Distributed Static Compensator (DSTATCOM) are considered in mitigating the problem of voltages and currents occurring in MG.

Initially, the DVR provides compensation for voltage issues in terms of magnitude. Further, it is enriched by filtering feature to provide harmonic compensation as a series active filter. PI and SRF theory based control techniques are considered to provide compensation for sag/swell conditions during supply and load changes. However, in case of nonlinear loads, a novel control technique based on IVTG approach is proposed to improve its performance in providing harmonic compensation and compared with control techniques like PI, SRF theory. The performance of the device is also analyzed for fault ride through by limiting the fault current to a safe value under different symmetrical and unsymmetrical conditions in the MG.

In three-phase systems of the MG, unbalanced currents and excessive neutral currents are caused due to different loads. To mitigate these current quality problems in MG, DSTATCOM that contains a self-supported DC link is considered. DSTATCOM is further enhanced as a shunt active power filter (shunt APF) to compensate harmonic currents. To provide RPC, different control techniques such as IVTG and 3-phase p-q theory for shunt APF are applied and compared. Further, a modified 3-phase (or) 1-phase p-q theory based control technique is proposed to improve its performance in providing current harmonic compensation.

Subsequently, a single device that has the features of both series and shunt APFs to deal with voltage and current quality problems simultaneously is recommended. The CPD, Unified power quality conditioner (UPQC) constituting the combination of enhanced DVR and enhanced DSTATCOM acting as the series and shunt APFs is proposed in this direction. The enhanced DVR of UPQC deals with all voltage related issues whereas enhanced DSTATCOM takes care of current related issues for critical and sensitive loads. An exhaustive analysis and design of UPQC are presented in detail. In addition to the above, to validate the performance of the device experimentally in MG, a small scale PV-Wind emulator is considered as MG into which the designed UPQC is implemented. The performance of the device to mitigate voltage sag condition is investigated. The UPQC has given satisfactory results.

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Abbreviations

AC	**A**lternating **C**urrent
APF	**A**ctive **P**ower **F**ilter
ASD	**A**djustable **S**peed **D**rives
BESS	**B**attery **E**nergy **S**torage **S**ystem
BPF	**B**and **P**ass **F**ilter
CPD	**C**ustom **P**ower **D**evice
CSC	**C**urrent **S**ource **C**onverter
CSI	**C**urrent **S**ource **I**nverter
DC	**D**irect **C**urrent
DG	**D**istributed **G**eneration
DQ	**D**irecct- **Q**udrature axes
DER	**D**istributed **E**nergy **R**esource
DBR	**D**iode **B**ridge **R**ectifier
DSTATCOM	**D**istribution **Stat**ic **Com**pensator
DUPQC	**D**istribution **U**nified **P**ower **Q**uality **C**onditioner
DVR	**D**ynamic **V**oltage **R**estorer
EMC	**E**lectro **M**agnetic **C**ompatability
FACTS	**F**lexible **AC** **T**ransmission **S**ystems
FFT	**F**ast **F**ourier **T**ransform
GTO	**G**ate **T**urn **O**ff
HPF	**H**igh **P**ass **F**ilter
IEC	**I**nternational **E**lectrotechnical **C**omisssion
IEEE	**I**nstitute of **E**lectrical and **E**lectronics **E**ngineers
IGBT	**I**nsulated **G**ate **B**ipolar **T**ransistor
IVTG	**I**dentity **V**ector **T**emplate **G**eneration

LPF	**L**ow **P**ass **F**ilter
MG	**M**icro **G**rid
MOSFET	**M**etal **O**xide **S**emiconductor **F**ield **E**ffect **T**ransistor
PCC	**P**oint of **C**ommon **C**oupling
PI	**P**roportional **I**ntegral
PLL	**P**hase **L**ocked **L**oop
PQ	**P**ower **Q**uality
PV	**P**hoto **V**oltaic
PWM	**P**ulse **W**idth **M**odulation
RES	**R**enewable **E**nergy **S**ource
RPC	**R**eactive **P**ower **C**ompensation
SCO	**S**hort **C**ircuit **O**peration
SMES	**S**uperconducting **M**agnetic **E**nergy **S**torage
SMPS	**S**witch **M**ode **P**ower **S**upply
SSSC	**S**tatic **S**ynchronous **S**eries **C**ompensator
SPWM	**S**inusoidal **P**ulse **W**idth **M**odulation
SRF	**S**ynchronous **R**eference **F**rame
STATCOM	**S**tatic **C**ompensator
THD	**T**otal **H**armonic **D**istortion
TSC	**T**hyristor **S**witched **C**apacitor
TSR	**T**hyristor **S**witched **R**eactor
VAR	**V**olt **A**mpere **R**eactive
VSC	**V**oltage **S**ource **C**onverter
VSI	**V**oltage **S**ource **I**nverter
UPF	**U**nity **P**ower **F**actor
UPQC	**U**nified **P**ower **Q**uality **C**onditioner
WECS	**W**ind **E**nergy **C**onversion **S**ystem
ZVR	**Z**ero **V**oltage **R**egulation
3P3W	**T**hree **P**hase **T**hree **W**ire
3P4W	**T**hree **P**hase **F**our **W**ire

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