POWER QUALITY IMPROVEMENT OF MULTI-FUNCTIONAL GRID CONNECTED INVERTER WITH RENEWABLE SYSTEM

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ABSTRACT

To improve performance of voltage profile and current profile of power quality issues in renewable sources. This paper propose a multi-functional grid connected inverter and MFGCI is improve both voltage-based and current-based power quality issues. Using a shunt-series MFGCI (SSS-MFGCI). The SSS-MFGCI is connected in series or parallel to grid which gives the compensation of the grid voltage. The propose system is implemented and validated the Simulation result. The proposed system more effective for multi-function grid connected.

Key words: Distributed Energy Resources (DERs); Multi-Functional Grid-Connected Inverters (MFGCIs); Static Compensator (STATCOM); Active Power Filter (APF).

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1. INTRODUCTION

Dynamic loads and different kinds of distributed energy resources (DERs) are penetrating more in distributed generation system and micro grid application, power quality issue becomes significant to supply stable and clean power. To utilize DERs effectively, multi-functional grid-connected inverters (MFGCIs) have proposed as the interface between the grid and DERs. While it has the capabilities of converting DC power produced by DER into AC power and it can also be used to improve the power quality of the grid as an auxiliary function.

Variety of topologies and control methods of MFGCIs are there. MFGCIs can be operated to achieve unity power factor and active power filtering. Power conversion applications include solar power, wind power, energy storage systems, and various generators in
distributed generation and micro grid applications. Focus on the use of MFGCI to mitigate current-based power quality problems and MFGCI functions as a static compensator (STATCOM) and an active power filter (APF).

MFGCIs are connected in parallel to the grid. MFGCIs as shunt compensator can inject current into the system to mitigate current-based power quality problems such as poor power factor, unbalanced current, increased neutral current, and harmonic current in the nonlinear load. Conventional GCIs can also improve the voltage-based power quality issues such as voltage sag, swell, unbalance, and flicker. However, conventional GCIs when used as shunt compensators have a limitation when mitigating voltage based power quality problem. Compensating voltage sag swell, and unbalance by injecting current may require more active and reactive power than compensating by injecting voltage. Because injecting the reactive current is an indirect way of reducing these issues. Injecting current that flows into the grid makes the larger voltage decrease or increase across the grid inductance for compensation. Shunt-connected GCI requires large current to mitigate deep sag or swell. Also, the capability of compensating power quality problem using shunt-connected GCI is highly dependent on grid inductance and the location of the compensator.

The required reactive power of series-connected GCI to mitigate voltage sag is typically less than shunt-connected GCI. For example, for 208 Vrms of grid voltage and 5kW of the load with 0.8 of power factor, shunt-connected GCI needs 34.5 kVAR of reactive power when 20% of the voltage sag occurs as shown in Table I. On the other hand, series connected GCI only needs 3.75 kVAR of reactive power. Both angles of injected current and voltage are optimized to achieve zero active power for the shunt- and series-connected is, respectively.

2. METHODOLOGY

The proposed MFGCI can be connected in series or parallel to the system using bidirectional switches. There are different operation modes: conventional GCI mode, a shunt-connected mode for improving current-based and shallow voltage-based power quality, and a series-connected mode for mitigating severe voltage-based power quality problems. Improving both power quality issues, whether it is current-based or voltage-based, is achievable using only one inverter without over-rating the design. Compensation strategy of zero average active power injection method is applied, and control schemes for different operating modes are presented. The controller is designed using positive and negative sequence component to effectively deal with unbalanced fault condition of the grid. The algorithm to make a transition into other modes according to different voltage-based power quality problems is proposed with the consideration of the analysis on the available capacity of the proposed MGCI.

![Figure 1 Block Diagram of Proposed System](https://ssrn.com/abstract=3536774)
Major difference of the proposed SSS-MFGCI compared to the Conventional MFGCI is that SSS-MFGCI can be connected in parallel or series to compensate different power quality problems of the grid. Bidirectional switches enable SSS-MFGCI to have different operating modes according to different switching operation and grid disturbances. Here the $v_g$ and $i_g$ are grid voltage and current, respectively. $R_g$ is grid resistance, and $L_g$ is grid inductance.

Grid condition is stiff in this project. $v_{pcc}$ is the point of common coupling (PCC) voltage. $v_c$ and $i_c$ are compensating voltage and current for voltage regulation, respectively. $vL$ and $iL$ are load voltage and current, respectively. $L_f$, $C_f$, and $R_d$ are filter inductor, capacitor, and damping resistor.

Four different operating modes of SSSMFGCIs are there. In Mode A, SSS-MFGCI functions as the conventional GCI that converts DC power produced from DERs to AC power for the grid.

Mode B Current-based power quality problems or minor voltage based power quality problems can be mitigated during mode B. In this mode, switches SWi and SWT are closed and switch SWv is opened. The SSS-MFGCI is still connected in parallel and compensating current is injected into the system. The SSS-MFGCI in Mode B can function as an active power filter to solve current-based power quality problems and a static synchronous compensator to mitigate minor voltage-based power quality problems.

Mode C is when SSS-MFGCI is in series connection to the grid. The SSS-MFGCI injects the required compensating voltage to mitigate voltage based power quality problems. Switches SWT and SWi are opened, and SWv is closed.

Mode D SSS-MFGCI also has the capability of functioning as an uninterruptible power supply (UPS) in Mode D. SSS-MFGCI provides the required power of load when the main grid is disconnected and switch CBg is opened. Proposed SSS-MFGCI can be applied to mitigate voltage harmonics, unbalance, and balanced voltage sag and swell issues. In this project, the unbalanced voltage sag on grid voltage is compensated as an example to assess the performance of the proposed SSS-MFGCI in different modes.
3. SIMULATION RESULTS

Figure 3 Compensated Output Voltage

Figure 4 Compensated Output Current

Figure 5 Grid Voltage
4. CONCLUSIONS
This paper proposes a power quality improvement of multifunctional grid-connected inverter with renewable system. The proposed shunt-series switched MFGCI can be connected in series or parallel to the grid and load using bidirectional switches and operate different operation modes according to different grid disturbances. Attainable operating modes are conventional GCI mode, a shunt-connected mode for improving current-based power quality and minor voltage based power quality, and a series-connected mode for mitigating the voltage-based power quality problems that SSS-MFGCI in a shunt-connected mode cannot mitigate. Improving both voltage and current based power quality issues are achievable using only one inverter without overrating design. This paper also presents the compensation strategies and control scheme for different operation modes and shows simulated results to prove the concept of proposed SSS-MFGCI.

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