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Title of Thesis: Development of an Enhanced Power Quality Inverter for Stand-alone & Grid connected PV system

ABSTRACT

Due to various serious concerns associated with conventional energy sources like fossil fuels etc., the attention of world's has been shifted for power generation sources which act as the most clean and environment friendly and overcome the concerns raised by conventional energy sources. In view of global warming and environmental aspects, the renewable energy sources (RESs) have been considered to be the most appropriate sources globally. Among the various RESs, solar photovoltaic (SPV) has emerged as one of the most prominent source of future power and has become the most appropriate solution in the form of green & clean energy. India has reached upto 36 GW solar PV installations and now GoI has planned to accomplish a 100 GW PV installed capacity by the end of year 2022. At present the SPV power has a share of 9.7% (As on October 2020) share in the India's total installed capacity but in accordance to the future demand of electricity, there is an urgent need to strive for advancements in PV system technology. It has been already planned by GoI that, the only solar PV power will share around 35% of total installed capacity by the year 2030.

Generally, two means of harnessing SPV power are available; the first alternative is to feed the solar PV power to the stand-alone systems or off-grid system, in which the power has to be supplied to the distant areas where the power lines are unavailable or not economical from installation point of view like hilly areas, remote villages etc., and the configuration has been termed as Stand-alone PV system (SAPV). Another possible alternative is to feed the SPV power directly into the utility grid, which is also known as grid connected PV system (GCPV). For GCPV system, power conditioning system has the vital role during the integration of PV panels to the AC grid. For converting dc into ac power, inverters which provide high quality ac supply, are needed for the proper operation of both SAPV and GCPV system. Nowadays, multilevel inverters (MLI) have gained more popularity for this purpose.

The extensive use of various power electronic devices affects the quality of waveforms and degraded from sinusoidal standards. Apart from this, the connection of various non-linear loads such as electric furnace, SMPS, TVs, vapor lamp etc., results in the deterioration of the power quality at the point of common coupling, which has to be taken care of. Therefore, to maintain the proper power quality at PCC, suitable control strategies have to be developed. This research work mainly focuses on the operation of GCPV system with the connection of various non-linear loads and then developing a control strategy for maintaining the power quality at PCC.

To analyze the complete behavior of a solar PV, the modeling of solar PV has been carried out starting from a PV cell. For selecting an appropriate model, the various models have been presented and finally single-diode model has selected as a suitable one due to its simplicity and accurate enough and hence simulated in this work at various operating conditions at Matlab/Simulink platform. It has been observed that solar insolation affects short circuit current more as compared to open circuit voltage.

Once the SPV analyzed, an improved power quality inverter is required for dc to ac conversion. In this thesis, A MLI's configuration feeding from SPV power has been presented, which produces single phase ac supply with reduced harmonic contents. This configuration has been analyzed for a stand-alone system having the isolated load with variation of the load power factor. The results achieved for harmonic as well as circuit efficiency analysis have been discussed graphically. The harmonic elements appeared are found to be little bit higher which further reduced to below the IEEE standard range by inserting a shunt passive filter across the load.

Then the focus of research has been shifted to analyze the behavior of a GCPV system accomplishing a MLI and a various types of connected loads at PCC. This has been clearly stated that for the rectifier type non-linear load connected at PCC, the quality of PCC voltage and grid current worsened more if compared with the results obtained from the case when linear R-L load connected at PCC. The performance of complete network mainly emphasizing on THD and circuit efficiency, has been analyzed for both types of load by varying the load power factor. In the similar manner as earlier, the harmonics contents can brought within the permissible limit by inserting a passive filter. It is also concluded that the power transfer (active and passive) to/from the utility grid is proportional to the phase difference between inverter output voltage and the grid voltage, and hence a thorough power transfer analysis has also been discussed with the variation of grid phase angle and then the results have been compared with that of analytically computed one.

Finally, various power quality issues and their mitigation strategies, in view of a grid integrated distribution system, have been illustrated emphasizing on the active shunt compensation techniques. The behavior of a three phase grid integrated distribution system has been analyzed by supplying compensation through VSC based DSTATCOM for the purpose of load balancing, harmonics mitigation and reactive power compensation. Various control algorithms discussed for providing switching pulses for DSTATCOM, and then least mean square (LMS) based adaptive control algorithm has been finalized due its accurate and fast response. Initially, the behavior was observed for linear R-L load at PCC, later for a rectifier type non-linear load and then hybrid type of load i.e. the combination of these two, with a load disconnection of very short duration of time. The various results for THD, active & reactive power transfer to load and grid have been tabulated and explained graphically by showing the variations with a load disconnection for a certain amount of period. At last, it has concluded from the analysis that the DSTATCOM in the distribution system improves the power quality significantly and serves better to regulate the PCC voltage, eliminate harmonic contents and provide reactive power compensation as shown from the simulation results.