“CURRENT AND VOLTAGE CONTROL OF SINGLE-STAGE VOLTAGE SOURCE INVERTER FOR PHOTOVOLTIC SYSTEM”

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A thesis submitted for the award of

Degree of

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in

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CERTIFICATE OF GUIDE

This is to certify that the thesis entitled "**Current and Voltage Control of Single-stage Voltage Source Inverter for Photovoltaic System**" submitted by Bhavik Arvindbhai Brahmbhatt in fulfillment of the degree of DOCTOR OF PHILOSOPHY in Electrical Engineering Department, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, Vadodara is a bonafide record of investigations carried out by her under my guidance and supervision. In my opinion the standard fulfilling the requirements of the Ph.D. Degree as prescribed in the regulations of the University has been attained.

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DECLARATION

I, Bhavik Arvindbhai Brahmbhatt declares that the thesis entitled "**Current and Voltage control of Single-stage voltage source inverter for photovoltaic system**" submitted by me for the degree of Doctor of Philosophy is the record of research work carried out by me during the period from 2014 to 2022 under the supervision of my guide Dr. Hina B. Chandwani. This work has not formed the basis for the award of any degree, diploma, associateship, and fellowship, titles in this or any other University or other institution of higher learning.

I further declare that the material obtained from other sources have been duly acknowledged in the thesis. I shall be solely responsible for any plagiarism or other irregularities, if noticed in the thesis.

Name of Research Scholar: Bhavik Arvindbhai Brahmbhatt

Date: ……

Place: ……

DEDICATED TO MY FAMILY

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ABSTRACT

The main aim of the thesis is to investigate the current and voltage control of Single-stage grid-tied voltage source inverter for photovoltaic system. To make low-voltage power generation flow bidirectional, Photovoltaic (PV) systems may be simply incorporated into residential infrastructures. This thesis emphases on a real and reactive power flow management in a single-stage photovoltaic system (PV) by performing various mode of operation such as active power injection, voltage regulation at point of common coupling(PCC),and power factor correction(PFC) at grid side. Grid-tied system needs the phase-locked loop (PLL) to synchronize converter operation with grid voltage, which has an impact on converter stability and performance. Synchronous Reference Frame-PLL (SRF-PLL) is a common grid synchronization technology since it is simple and reliable. To avoid fundamental frequency and phase oscillations, the SRF-PLL must include a DC offset suppression feature. The bandwidth of an irregular grid should be decreased to enable sufficient disturbance rejection without losing detection speed. The pre/in-loop filter was added to modern PLLs in order to improve phase-angle estimation speed and accuracy. It is critical that PLLs have the ability to increase dynamic responsiveness and shorten settlement time without sacrificing system stability or the ability to remove disturbances. The widely accepted phase-locked loop (PLL) algorithm has a complex architecture and requires a tedious tuning process to obtain a good stability margin. The SOGI-FLL (second-order generalized integrator-based frequency locked loop) was the most effective of the several control approaches tested. Even in the presence of harmonics, voltage changes, frequency fluctuations, and the like, it accurately monitors the grid voltage frequency. Dual-second order generalized integrator-based frequency-locked loop (DSOGI-FLL) is proven to have the most promising performance by eliminating both the negative and harmonic distorted components under non-ideal grid voltage conditions. Moreover, even in the absence of any PI controller, when the grid voltage has characteristics such as dips, swells, harmonics, unbalance, and frequency changes, it can accurately track the frequency of the grid voltage Low-frequency oscillations are included into the frequency calculation in the case of a DC offset. Grid voltage anomalies of various kinds are addressed in this thesis, including DC offsets, using a modified dual second-order generalized integrator frequency-locked loop (MDSOGI-FLL). MDSOGI-FLL is employed using one of the approaches from this two different methods described in this thesis. The first approach is to eliminate DC offset by inserting an IIR-based DC blocker in each

sensed signal from ADCs prior to the DSOGI-FLL/DDSRF-PLL. The second method is to modify the structure of DSOGI-FLL by adding a third integrator. The MSOGI-FLL is implemented by utilizing waijung block-set of Simulink/MATLAB and tested its performance in the presence of grid voltage anomalies. Experimental results validated that MDSOGI-FLL performs better during grid voltage anomalies. The term "multipurpose PV system" refers to an inverter that is capable of more than just producing electricity. For the reactive power compensation, this thesis presents an innovative control approach in multipurpose single-stage PV system for the PV inverter. There are three different modes of operation that may be achieved in multipurpose single-stage PV system control: Fully active power injection (PV mode), active power injection with reactive power support mode (Partial PV and Partial STATCOM); and fully reactive power support mode (Full STATCOM) depending on system requirements. In a daytime, the modified control approach in multi-purpose PV system can be utilized as Distributed generating station and partial STATCOM by providing active power injection and maintain unity power factor at grid side respectively. In a night time and also at critical day time, it can be operated as fully STATCOM. To maintain DC-bus voltage in a single-stage PV system, the voltage controller has to track the reference voltage provided by the MPPT algorithm using feedback linearization approach is presented. In this paper, Modified dual-Second order generalized integrator (MDSOGI) technique is used for grid synchronization to estimate precise phase-angle of grid during non-ideal grid conditions while DC-current sensor less MPPT algorithm is used for MPP tracking in control of single -stage grid tied PV inverter. One new number for MPPT for single-stage grid connected PV system without a DC current sensor is presented in this thesis. The PV current quantity(which is sensed by DC current sensor) is replaced with a new quantity, which is the d-axis current component of inner current control loop. This modified MPPT has presented a theoretical proof and implementation. The dynamic performance of presented control approach is evaluated based on simulation results obtained using a simulink/MATLAB environment and experimental results obtained from laboratory setup to confirm desired performance of presented control algorithm for single stage grid tied PV inverter during a different mode of operation.