DESIGN AND CONTROL OF GRID TIED BI-DIRECTIONAL AC-DC CONVERTER

BY

SHAFQAT IMRAN

01-244132-044

SUPERVISED BY

JEHANZEB AHMAD

Spring 2016

A Report submitted to the Department of Electrical Engineering

Bahria University, Islamabad.

In partial fulfilment of the requirement for the degree of MS(EE)

CERTIFICATE

We accept the work contained in this report as a confirmation to the required standard for the partial fulfilment of the degree of MS (EE).

_____	_____
Head of Department	Supervisor
_____	_____
Internal Examiner	External Examiner

DEDICATION

Dedicated to my loving parents and family

Shafqat Imran

DECLARATION OF AUTHORSHIP

I hereby declare that content of this thesis is my own work and that it is the result of work done during the period of registration. To the best of my knowledge, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

Shafqat Imran

ACKNOWLEDGEMENTS

I would like to thanks my Supervisor; Jehanzeb Ahmad – Associate Professor, BUIC Islamabad for his time, constant support throughout, motivation and guidance; which went a long way in the completion of this thesis. I truly appreciate and value his esteemed guidance and encouragement from the beginning to the end of this thesis.

I would further like to express my appreciation to my friends Mr. Mudassar Hassan, Mr. Muhammad Arif, Mr. M Mohsin Naveed and Mr. Junaid Saeed for their support and contribution in mathematical computational work during the course of my thesis; without whose help this research would not have been possible. My special thanks to all my other friends who helped me in manufacturing the practical prototype in the Electronics Lab. And I would like to thanks all whose direct and indirect support helped me completing my thesis.

In the end, I wish to express my gratitude to my parents, family and friends whose love and encouragement have supported me throughout my education and the progression of this research.

Shafqat Imran

Abstract

Distributed hybrid power systems consist of AC and DC sub-systems connected to various load types, where the distributed generation (DG) resources can be either AC or DC. These resources are normally interfaced to the grid through power electronic converters. A single phase grid tied bi-directional AC-DC converter is presented in this research work. The bi-directional AC-DC converter works as the interface between the DC link and the AC grid. It meets the requirements of bidirectional power flow and to ensure high power factor and low THD as well as regulate the DC link voltage. It operates in two modes: the rectifier mode and the inverter mode. This research work is mainly focused on improvement and optimization of the converter in rectifier mode where it converts the AC line voltage into constant DC voltage which is used for energy storage systems and other DC loads.

The goals of the research work are to design and control a bi-directional AC-DC converter which has improved total harmonic distortion (THD) of the current and nearly unity power factor. The previously used AC-DC converters designed with diodes and/or thyristors have a great influence over the grid in terms of current harmonics and power factor degradation. The existing designs of bi-directional AC-DC converter use larger passive components like line inductor and output filter capacitor. The PI control and current hysteresis control (CHC) methods are used for the control of such converters. The CHC method has a great impact on converter performance in terms of switching losses and load dependency. The conventional PI control scheme has poor current tracking and non-zero steady state errors at line frequency.

A novel proportional-resonant (PR) control scheme is presented in the research work. A comparison of the conventional diode bridge AC-DC converter and the proposed bi-directional converter is made. Also, comparison is made between PI control and novel PR control for their effects on the converter in steady state and load changing conditions. The PR controller tracks reference currents with a very small steady state error and fast response to changes of grid voltage, load value and frequency which contributes to energy conversion and bidirectional flow of electricity.

The converter design and proposed control system is validated and verified in MATLAB/SIMULINK and practical prototype. The simulation and practical results proved the converter design and proportional resonant control structure for their capabilities of very low THD and power factor.

List of Figures

List of Tables

Table of Contents