AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ELECTRONICS AND COMMUNICATION ENGINEERING DEPT.

DESIGN AND PERFORMANCE ANALYSIS FOR PHOTOVOLTAIC SYSTEMS AT REMOTE EGYPTIAN SITES

By

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B.Sc. in Electrical Engineering

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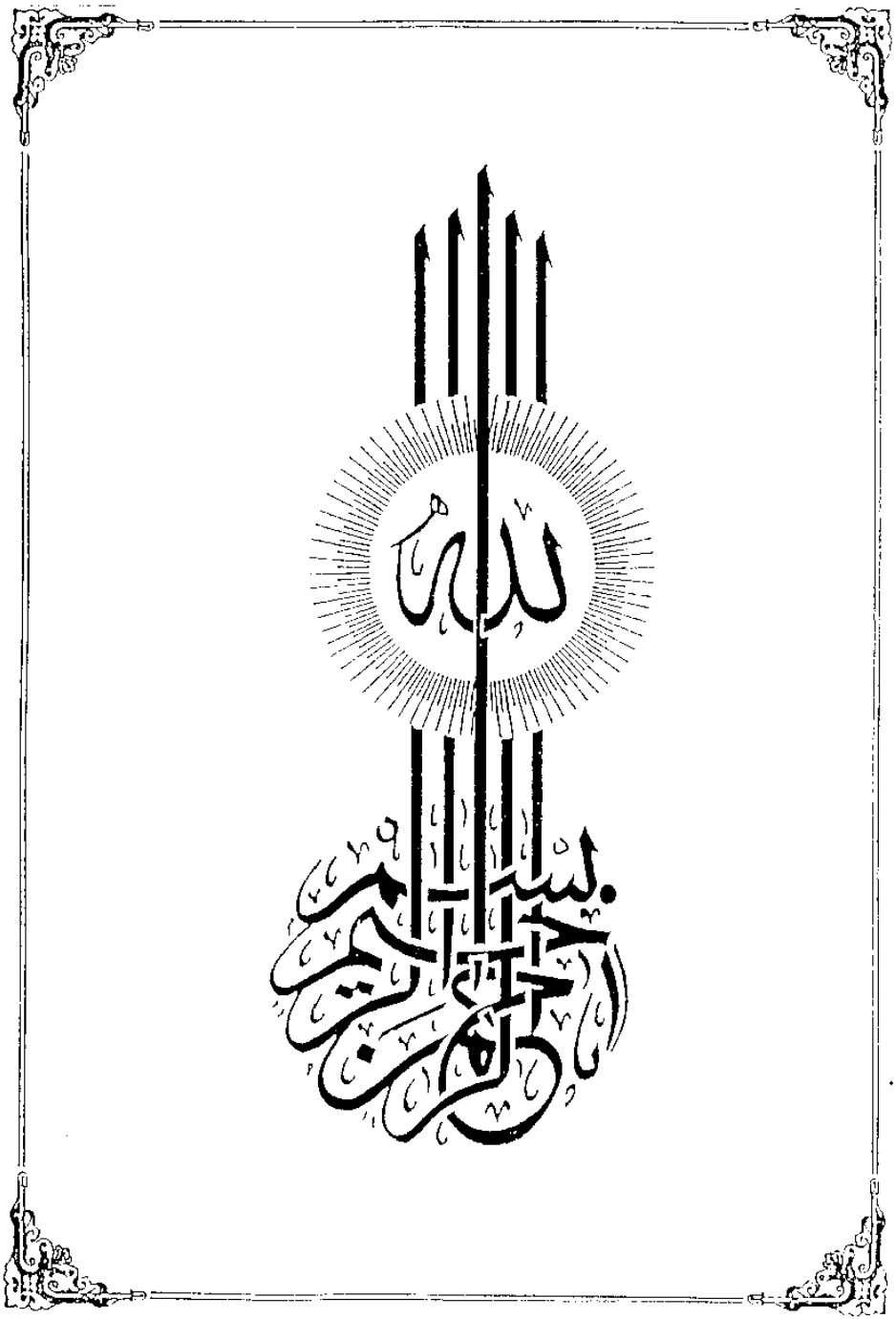

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering.

The work included in this thesis was carried out by the author in the Armed Forces from Dec. 14, 1987 to.....

No part of this thesis has been submitted for a degree or a qualification at any other University of Institute.

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Abstract of M.Sc. Thesis in ELectrical Engineering

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Title of thesis:

Design and Performance Analysis for Photovoltaic Systems at Remote Egyptian Sites.

Supervisors:

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ABSTRACT

This work presents an improvement to the methods previously developed for sizing optimal stand alone photovoltaic (PV) systems. The design approach utilizes the loss of load probability concept to quantify and analyse the overall behaviour of the PV system. The described algorithm enables the designer to determine the components of the system that correspond to minimum life cycle costs at certain prescribed power availability. The developed method is applied for sizing a stand alone PV system that supplies electrical power in a typical remote site chosen on the North Western Egyptian coast. The obtained results are discussed and compared with those obtained on applying the existing methods.

A Comprehensive economic study for the designed system is presented. The study includes the utilization of locally manufactured lead acid batteries which, throughout the presented work, are tested and modelled to be used in PV applications. The cost of energy produced in remote sites by alternative sources (diesel or electrical grid extension) are estimated and compared.

CONTENTS

INTRODUCTION

INTRODUCTION

The significance of renewable energy sources has grown steadily since the last few years during the discussion of our future energy supplies. Public awareness has been awaken to the dangers of global climatic changes caused by burning fossil fuels as well as the limited nature of energy resources present in our environment. On the other hand, searching for a clean form of energy is becoming an essential demand facing the problem of pollution on the earth's crust. Therefore, great hopes have been attached to the increased use of renewable energy sources.

Photovoltaics (the technology of converting sunlight directly into electrical energy) represents one of the most versatile utilization methods and still possesses a high potential for further technical development.

Stand alone PV systems installed at remote sites have proved itself to be not only more convenient, but also the more economical solution. Their applications include vaccine refrigeration, telecommunication, water pumping and lighting.

As a renewable energy source, the PV system offer the following advantages:

- inexhaustible and free energy supplies.
- long system lifetime.
- no noise or other pollution.
- modular construction.

However, a number of important issues including cost, land area requirements, utility grid comparability, solar resource intermittency and storage will influence the rate and degree of PV market penetration.

Our work is concerned with the design and analysis of a small stand alone PV system supplies power to a typical remote Egyptian site. We address the problem of matching the load requirements with the mostly stochastic characteristics of incident solar radiation that is a fundamental problem facing system designers, and results in oversized and costly systems.

The principle of PV energy conversion is outlined in chapter one. Solar cell parameters, solar arrays and fabrication technology of solar cells and their encapsulation into modules and the associated cost are presented.

In the second chapter, the individual system components are described. A locally manufactured lead acid battery type

is experimentally tested. Its performance is measured in the cases of charging and discharging for a long period of time. A mathematical model that describes battery charging and discharging modes is developed and analysed.

Chapter three presents two developed techniques for the design of stand alone PV system, one of them depends on the use of computer programs and the other depends on a set of curves that match the nature of Egyptian climates.

The different factors that must be taken into consideration in sizing the PV system are presented. The load demand is specified to correspond to an actual load supplied by PV energy at a remote site near Mersa Matruh on the Egyptian Western desert. The sizing methodology is explained so as to obtain the system size that cover the load requirements while ensuring a certain degree of reliability with the minimum life cycle cost. The results of the developed algorithms together with the results of other sizing methods are compared and discussed.

In the fourth chapter, an economic analysis is conducted to calculate the cost of energy produced from the PV system that has been designed considering the incorporation of the examined local batteries and comparing the results with the installed systems using imported solar

batteries. The chapter also includes an economic study that identifies the best energy choice (PV-diesel-grid) to be used to feed different load demands at remote sites.

In the end, the conclusion and recommendations for future work are presented.

CHAPTER "1"