

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

FINAL YEAR PROJECT REPORT

Intelligent Solar Panel Tracking System with Sinewave Inverter



Project Advisor

Khan Muhammad Nazir

Project Co-Advisor

Jawad Ullah

Submitted by

Nabeel Rashid-----091420-113

Waqas Ahmed-----091420-128

Muhammad Mustaqeem--091420-300

Department of Electrical Engineering
School of Engineering
University of Management and Technology, Lahore

DEDICATION

To our respected parents whose utmost love, care and struggle against all odds brought us to this height of knowledge with the blessings and help of the
ALLAH ALMIGHTY.

STATEMENT OF SUBMISSION

A report submitted to the

Department of Electrical Engineering

In partial fulfillment of the requirements for the Degree

Bachelor of Science in

Electrical Engineering

By

Nabeel Rashid

Waqas Ahmed

Muhammad Mustaqeem

University of Management and Technology, Lahore

September 12, 2013

Project Advisor

Project Co-Advisor

Acknowledgements

We are grateful to ALMIGHTY ALLAH who gave us the strength to achieve our goals. Without HIS divine help, we could not do anything. We would like to express our gratitude to Khan M Nazir, Asstt. Prof. EE, UMT for guidance and support throughout this project work. He has been a constant source of inspiration to us throughout the period of this work. We consider ourselves extremely fortunate for having the opportunity to learn and work under his supervision over the entire period.

We would also take this opportunity to express my gratitude and sincere thanks to Mr.Javadullah, lecturer, EE, UMT for his valuable support.

Abstract

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. Our project includes the design and construction of a microcontroller-based solar panel tracking system and Pure Sinusoidal Inverter. The tracking system computes the position of the sun from available data input by user i.e. (date, month, year and time) and controls the movement of a solar panel so that radiation of the sun comes normally to the surface of the solar panel. The main advantage of the system is that it is programmed, so that it could rotate solar panel at a pre-determined angle and at predetermined periods by using short pulses without using sensors. The developed-tracking system tracks the sun both in the azimuth as well as in the elevation plane. The operation of the experimental model of the device is based on a DC motor intelligently controlled by a dedicated drive unit that moves a PV panel according to the yearly calendar stored in microcontroller.

This report also focuses on DC to AC power inverter, which aim to efficiently transform a DC source to a high voltage AC source. An inverter circuit by using sinusoidal Pulse Width Modulation (SPWM) switching schemes is developed to run AC utilities. DC is one type of energy that is found in solar panels and can be stored in batteries for usage in future. Semiconductor device, Metal Oxide Field Effect Transistor (MOSFET) is used as switch in full bridge (H-Bridge) inverter configuration using Unipolar voltage switching. Driver circuit for MOSFET is also very important as it is used to interface between control circuits (Low voltage part) and inverter (High voltage part). PIC microcontroller chip is used to generate modulating signals. At the end of this project, the SPWM output signal is developed from the Microcontroller and applied to the MOSFET driver and the inverter. The method to complete the desires outcome would be to first convert the low voltage DC to AC by using pulse width modulation, and then use a transformer to boost the voltage to 220 volts to drive the AC load.

Table of Contents

CHAPTER 1

INTRODUCTION.....	1
1.1 Motivation.....	1
1.2 Aim of Project	2

CHAPTER 2

SOLAR RADIATION AND PHOTOVOLTAIC.....	2
2.1 Concept on Solar radiation.....	2
2.2 Declination Angle.....	2
2.3 Hour Angle.....	3
2.4 Solar Altitude (θ_z).....	3
2.5 Solar Azimuth (θ_A).....	4
2.6 Insolation.....	4
2.7 Projection Effect.....	4
2.8 Working of Photovoltaic.....	5

CHAPTER 3

SOLAR TRACKER.....	5
3.1 What is solar tracker ?.....	6
3.2 Motivation.....	6
3.3 Types of solar trackers.....	6
3.3.1 Horizontal Axis Solar tracker.....	7
3.3.2 Vertical Axis Solar tracker.....	7
3.3.3 Altitude azimuth Solar tracker.....	7
3.3.4 Two Axis mount Solar tracker	8
Intelligent Solar Panel Tracking System with sinewave Inverter	

3.3.5 Multi mirror Reflective unit	8
3.3.6 Active Solar trackers.....	8
3.3.7 Passive Solar trackers.....	8
3.3.8 Chronological Solar trackers.....	9

CHAPTER 4

DESIGN OF SOLAR TRACKER.....	9
4.1 Tracker Design.....	9
4.2 Our Mechanism.....	10
4.3 Architecture of overall system.....	11
4.3.1 Features.....	11
4.3.1a Keypad.....	11
4.3.1b Real-time Clock.....	11
4.3.1c Microcontroller.....	11
4.3.1d Movement Adjustable Circuit	12
4.4 Circuit Description.....	12

CHAPTER 5

INTRODUCTION	12
5.1 Dc Motor.....	12
5.2 Driver Circuit.....	12
5.2.1 Motor Control Circuit.....	13
5.2.2 Bipolar Junction Transistor (BJT).....	14
5.2.3 Simulation on Proteus of Motor Driver Circuit.....	15
5.2.4 Motor Driver Hardware Circuit.....	16

..

Intelligent Solar Panel Tracking System with sinewave Inverter

CHAPTER 6

MATHEMATICAL MODELING.....	16
6.1 Solar Time & Local Standard Time.....	17
6.1.1 Equation of Time.....	17
6.1.2 Solar Time.....	18
6.1.3 Solar Hour angle(h).....	18
6.2 Solar Declination angle(δ).....	18
6.2.1 Altitude Angle (θ).....	18
6.3 Kinematics.....	19
6.4 Dynamics.....	19

CHAPTER 7

GEAR SYSTEM.....	20
7.1 Spur Gear.....	21
7.2 Diametral Pitch (PD).....	21
7.3 Pitch Diameter.....	21
7.4 Pitch Circle.....	21
7.5 Center-to-Center Distance.....	22
7.6 Addendum(A).....	22
7.7 Dedendum (D).....	22
7.8 Clearance(C).....	22
7.9 Whole Depth(WD).....	22
7.10 Pressure Angle (PA).....	22
7.11 Rotation.....	23
7.12 Backlash.....	23

7.13	Gear Ratios.....	24
7.14	Velocity.....	24
7.15	Torque in Gear Drives.....	24
7.16	Proposed Gear System.....	25
7.16.1	Gear Calculation.....	25
7.16.1a	Gear Ratio.....	26
7.16.1b	Velocity of Driven Gear.....	26
7.17	Angle Calculation.....	26
7.17.1	Horizontal Movement.....	26
7.17.2	Vertical Movement.....	26

CHAPTER 8

	ARCHITECTURE OF THE MODEL.....	27
8.1	Model Overview.....	27
8.1.1	Specification of the Model.....	27
8.2	Working Mechanism.....	29
8.3	Assembling the Model.....	30

CHAPTER 9

	ELECTRONIC COMPONENTS.....	31
9.1	C-5200 transistor.....	32
9.2	TIP-122 transistor.....	32
9.3	8-pin Relay.....	33
9.3.1	Features.....	33
9.4	DC Power Motor.....	33

9.4.1 Features.....	34
9.5 Real Time Clock.....	34
9.5.1 OPERATION.....	35
9.5.2 Pin Description.....	35
9.5.3 Key Features.....	36

CHAPTER 10

INVERTER.....	36
10.1 What is Inverter?.....	37
10.2 Inverter AC Outputs	38
10.3 Objective.....	38
10.4 Methodology.....	38
10.4.1 Why Use Second Method.....	39
10.4.2 Our Approach.....	40
10.5 Pure Sine Wave Inverter.....	40
10.5.1 Sinusoidal Pulse Width Modulation.....	40
10.5.2 Bipolar Switching.....	41
10.5.3 Unipolar Switching.....	42
10.5.4 Modified Unipolar Switching	44
10.5.5 Why Use Unipolar Switching.....	44
10.6 MOSFET Driver.....	45

Intelligent Solar Panel Tracking System with sinewave Inverter

10.7 Implementing the Design.....	45
10.7.1 Software design.....	45
10.7.2 H-Bridge with Opto-coupler Isolator.....	47
10.7.3 Schematic of H-Bridge with Opto-coupler.....	48
10.8 TRANSFORMER.....	48
10.8.1 Introduction.....	48
10.8.2 Our Transformer.....	49
10.8.3 Filter.....	50
10.9 Efficiency.....	51
10.10 Microcontroller.....	51
10.10.1 Microcontroller Setup for PWM Operation.....	51
 CHAPTER 11	
EXPERIMENTAL RESULTS.....	52
11.1 Proteus schematic.....	52
11.1.2 Proteus Outputs.....	53
11.2 Inverter Output Results.....	54
11.3 Inverter Circuit Overview.....	55
11.3.1 Sine wave inverter.....	55
11.3.2 Sine wave inverter With Load.....	55
11.4 Electronic Components.....	56
11.4.1 Other Components.....	57
Intelligent Solar Panel Tracking System with sinewave Inverter	

11.5 P75N75.....	57
11.5.1 Features.....	57
11.6 Opto-coupler Isolator.....	57
11.6 .1 Features.....	58
11.7 LM7805.....	58
11.7.1bPin Layout.....	59
11.8 Crystal oscillator.....	59
11.9 Capacitor.....	59
11.10 Battery.....	60
11.11 Wire.....	60
11.8 LED.....	61
CHAPTER 12	
MICROCONTROLLER.....	62
12.1 Introduction.....	62
12.2 What is Microcontroller?.....	62
12.3 Significance of Microcontroller... ..	62
12.3.1 Application of Microcontrollers.....	63
12.4 Pic Microcontroller 16f877a/18f452.....	63
12.4.1 Features.....	63
12.4.2 Parameters.....	65
CHAPTER 13	
OVERALL HARDWARE AND SOFTWARE CIRCUIT OVERVIEW.....	65
Intelligent Solar Panel Tracking System with sinewave Inverter	

CHAPTER 14

SOFT TOOL.....	67
14.1 Introduction.....	67
14.1.1 Mikroc PRO for PIC.....	68
14.1.1a Features.....	68
14.1.2 Untitled – Isis Professional.....	69
14.1.2a General Features.....	70
14.1.3 CCS.....	71
14.1.3a Key Features.....	71

Chapter 15

CONCLUSION.....	73
-----------------	----

APPENDICES

APPENDICES (A).....	74
APPENDICES (B).....	143
REFERENCES.....	147

List of Figures

2.1 Declination angle.....	3
2.2 Solar Altitude & Azimuths Typical Path on Sun line.....	3
2.3 Projection Effect.....	5
2.4 Photovoltaic Panel	5
3.1 Active tracking system.....	8
3.2 Passive tracking system.....	9
4.1 Proposed tracking design.....	10

Intelligent Solar Panel Tracking System with sinewave Inverter

4.2	Processing Mechanism.....	10
4.3	Overall system working.....	11
4.4	Algorithm of Tracking System.....	12
5.1	working of DC motor.....	13
5.2	Motor Control Circuit Operation	13
5.3	BJT Application	14
5.4	Proteus simulation of Driver Circuit	15
5.5	Motor Driver Circuit	16
6.1	Typical Behavior of Sun.....	17
6.2	Configuration of angle.....	20
7.1	Overview of Gear System	20
7.2	Diametral Pitch.....	21
7.3	Pitch Circle.....	21
7.4	Center-to-Center.....	22
7.5	Rotation of Gear.....	23
7.6	Backlash and Pressure angle.....	23
7.7	Low gearing to increase Torque.....	24
7.8	High gearing to increase velocity.....	25
8.1	Architecture Prototype.....	28
8.2	Base of Actual Architecture.....	28
8.3	Frame of Actual Architecture.....	29
8.4	Front view of Actual Architecture.....	29
8.5	Back view of Actual Architecture.....	29
8.6	Movement of Panel.....	30

8.7	Movement of Base.....	31
8.8	Base Architecture.....	31
8.9	Frame Architecture.....	31
9.1	C-5200 power Transistor	32
9.2	TIP-122 power Transistor.....	32
9.3	12V, 8-pin Relay	33
9.4	12V, 8-pin Relay specification	33
9.5	12V, DC power motor	33
9.6	DC power motor specification.....	34
9.7	DS-1302.....	34
9.8	Operating Circuit of DS-1302.....	35
9.9	Pin Description of DS-1302.....	35
9.10	Pin Configuration of DS-1302.....	36
10.1	Basic Diagram of Inverter	37
10.2	Overview Of inverter Output.....	38
10.3	Process of Inverter.....	39
10.4	Process of Inverter.....	39
10.5	Block Diagram of Pure Sine Wave Inverter.....	40
10.6	A full bridge inverter.....	41
10.7	Bipolar PWM generator.....	41
10.8	SPWM with Bipolar voltage switching.....	42
10.9	Unipolar PWM scheme and output voltage.....	43
10.10	Unipolar PWM generator.....	43
10.11	Modified Unipolar PWM scheme and output voltage.....	44

10.12 Internal Schematic	45
10.13 Basic Implementation of PIC Microcontroller.....	46
10.14 Flow chart of SPWM.....	46
10.15 Full H-Bridge Inverter.....	47
10.16 Complete Schematic Diagram of Full Bridge Inverter.....	48
10.17 Actual Transformer.....	49
10.18 Basic Low Pass Filter.....	50
10.19 Our Low Pass Filter.....	50
10.20 Pic 16F877A.....	51
11.1 half Bridge Inverter.....	52
11.2 Proteus Result	53
11.3 Sine wave Proteus Result	53
11.4 Before Transformer Sine Wave Actual Result	54
11.5 Sine Wave Actual Result on Load after Filter	54
11.6 Top View of Inverter Circuit	55
11.7 Front View of Inverter Circuit	55
11.8 Working condition of inverter circuit.....	56
11.9 P75n75	57
11.10 Pin Configuration	57
11.11 PC 817-pin Configuration	58
11.12 PC 817-pin Configuration.....	58
11.13 7805 pin Configuration.....	58
11.14 Crystal oscillator.....	59

11.15	Capacitor.....	60
11.16	Battery.....	60
11.17	Wire.....	61
11.18	LED.....	61
12.1	16F877a Pin Configuration.....	64
12.2	Block diagram.....	64
13.1	Top View of overall Project Circuit	65
13.2	Top view of overall circuit.....	66
13.2	Complete Circuit.....	66
13.4	Proteus schematic of Motor Driver Circuit.....	67
14.1	Mikro C Interface.....	69
14.2	Proteus Interface.....	70
14.3	CCS Interface.....	72

CHAPTER 1

INTRODUCTION

With the alarming rate of depletion of the major energy resources worldwide, it has become an urgent necessity to seek for renewable energy resources that will power the future. According to the worldwide market economy, the increasing demand for energy had forced to put a huge price tag on natural combustible sources of energies. In fact, it has been predicted that in the near future the demand of energy will grow in such a rate that it will be completely impossible to find out or meet the demand with the resources that we had been using for so long, such as – oil, gas, coal, etc. This issue throws a positive challenge to the scientific community as more and more funds are being allocated for the research and development of new alternatives.

In this context, we have concentrated our focus on the research of renewable energy. Among these renewable energy resources, solar energy is one of a kind. In today's world, there is a growing demand to find greener ways to power the world and minimize greenhouse gas emission. The sun is a natural power source that will keep on shining for an estimated 4 billion years. Solar power (photovoltaic) systems are a sustainable way to convert the energy of the sun into electricity. The expected lifetime of a system is 25-30 years the energy potential of the sun is immense, and it is one of the emerging energy sources, which is subsidized in order to secure the distribution of the technology worldwide. By tracking the sun, the efficiency can be increased by 30-40%. The photovoltaic technology allows the conversion of sunlight directly to electricity with a conversion ratio of about 15-20%.

1.1 Motivation

With all the above information, the rapid depletion of the natural resources of the world, we would soon meet a great demand for alternative source of energy. In the very near future, experts are predicting that we will be bound to move to renewable sources of energy, solar being one of them. As long as our earth exists, the sun is there to give us unlimited solar energy. It is completely up to us how we are going to utilize this abandoned energy.

Not only the world but also our country is in a severe crisis of electricity. There are many rural areas, which are still deprived from the wonder of electricity. Due to the geographical location of our country, we get sun almost 300 days a year. Compared to many other countries like Canada and Norway, we are in a much better location for utilizing solar energy. It can be used in areas where there is no grid connection also. Considering all the above things, the environmental friendliness, economically sound, and the ease of implementation, we thought of working on it, as we believe that in the near future, our country along with the whole world will be benefited from this source of renewable energy.

1.2 Aim of Project

The aim of the project is to keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient. The dual axis solar photovoltaic panel takes astronomical data as reference and the tracking system has the capability to always point the solar array toward the sun and can be installed in various regions with minor modifications. The vertical and horizontal motion of the panel is obtained by taking altitude angle and azimuth angle as reference. The microcontroller has been used to control the position of DC motors. The mathematical simulation control of dual axis solar tracking system ensures the point-to-point motion of the DC motors while tracking the sun.