Design of DC - AC Inverter Using Microcontroller PIC Control

By

QAIS HAMID JEFLAWI

(1432221159)

A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science (Electrical Power Engineering)

School of Electrical Systems Engineering

UNIVERSITI MALAYSIA PERLIS

2015

DEDICATION

To My Father and Beloved My Mother

To Dears My Uncle (Dr. Amer Dahham) and My Aunt (Ali's Mother)

To Dear My Wife and My Sons (Mohammed- Fatima)

To All My Brothers and Sisters

& All My Friends.

ACKNOWLEDGMENT

(In The Name Of Allah, the Most Gracious, the Most Merciful)

I would like grateful to Allah for providing me with his generosity and blessing to finish this research.

I would like to express my sincere thanks and appreciation to (**Dr. *Abadal-Salam T. Hussain***) not only for his valuable advice, guidance and supervision, but also for theoretical and practical knowledge that I gained from his design for inverter system.

I would also like to thank for Dean School of Electrical Power Engineering and Postgraduate Chairman School of Electrical Power Engineering, University Malaysia Perlis (UniMAP), to help and support me in overcoming the difficulties that we face to complete the project perfectly.

I would like to extend my thanks to all my lecturers in School of Electrical Power Engineering, University Malaysia Perlis (UniMAP), for shearing me all knowledge that some of it has been very beneficial to achieve this work.

Last but not least, I would like to extend deepest gratitude to all my family members for their support and endless moral inspiration and encouragement to overcome all the obstacles to completing this research. And I would like to thank in particular to ***my wife and my sons (Mohammed- Fatima),*** who has provided moral support and stand by my side to complete the project.

And especially I would like to extend deepest gratitude to my dear uncle (**Dr. *Amer Dahham***), who has provided moral support and stand by my side to complete the project.

And I would like to thank in particular to my brothers (***Ali Amer Dahham, Omer Hamid, Bahaa Hamed, Zaidon Hamid and All my sisters.)***

And I would like to thank for all my friends.

To my beloved mother and father

"1 would not achieve this without both of you"

THANK YOU

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATION

PIC	Peripheral Interface Controller
AC	Alternating Current
ADC	Analog Digital Converter
BJT	Bipolar Junction Transistor
CSI	Current Source Inverter
DAC	Digital to Anulog Converter
DC	Direct Current
DMC	Dynamic Matrix Control
EDLC	Electric Double-Layer Capacitor
EMI	Electro Magnetic Interference
EPROM	Erasable Programmable Read Only Memory
FPGA	Field Programmable Gate Array
GSPS	Giga samples per second
GTO	Gate Turn off Thyristor
HCC4069	Extended Temperature Range
HCF4069	Intermediate Temperature Range
HF	High Frequency
IGBT	Insulated Gate Bipolar Transistor
MBC	Multilevel Boost Converter
MCT	Mos Controlled Thyristor
MIPs	Million Instructions per Second
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MSPWM	Modified Sinusoidal Pulse Width Modulation

PCB	Printed Circuit Board
PWM	Pulse Width Modulation
RAM	Random Access Memory
RC	Resistor Capacitor
RCD	Resistor Capacitor Diode
RMS	Root Mean Square
SHEPWM	Selective Harmonic Elimination Pulse Width Modulation
SIT	Static Induction Transistor
SoC	System-on-a-Chip
SPWM	Sinusoidal Pulse Width Modulation
SVPWM	Space Vector Pulse Width Modulation
THD	Total Harmonic Distortion
UART	Universal Asynchronous Receiver Transmitter
UPS	Uninterruptible Power Supply
VSI	Voltage Source Inverter

Reka bentuk DC - AC Inverter menggunakan pengawal mikro PIC kawalan

ABSTRAK

Projek ini bertujuan untuk mereka bentuk satu fasa gelombang sinus DC-AC kuasa penyongsang bersepadu dengan pengawal mikro (PIC16F877A), simulasi dengan menggunakan perisian Proteus dan pelaksanaan litar penyongsang dan membincangkan hasil kepada output AC kualiti kuasa input DC bekalan kuasa. Ia melibatkan penjanaan isyarat unipolar menggunakan pengaturcaraan untuk Interface Programmable Komputer (PIC) dan hex penyongsang. Kawalan ke atas output dengan untuk menggunakannya untuk memodulasi yang 12 V DC ke AC 230 V dan kekerapan yang stabil (50 Hz). Tumpuan diberikan kepada mereka bentuk sistem inverter adalah murah, lebih stabil, sistem yang cekap tinggi dan licin penyongsang gelombang sinus. Penyelidikan ini membantu perkhidmatan elektrik syarikat kuasa yang berbeza-beza kerana pelbagai faktor termasuk reka bentuk grid kuasa, ciri-ciri pelindung, sistem kuasa amalan penyelenggaraan dan cuaca yang teruk dan ketersediaan sumber tenaga boleh diperbaharui. Keputusan simulasi adalah hasil kejayaan penyongsangan.

Design of DC - AC Inverter Using Microcontroller PIC Control

ABSTRACT

This project aims to design single-phase sine wave DC-AC power inverter integrated with a microcontroller (PIC16F877A), simulated by using proteus software and implementation inverter circuit and discuss the result to output AC power quality an input DC power supply. It involves generating of unipolar signals using programming to Programmable Interface Computer (PIC) and hex inverter. Control on output to use them to modulate a 12 V DC to 230 V AC with stable frequency (50 Hz). The focus is on designing inverter system is an inexpensive, more stable, high efficient system and smooth sine wave inverter because of the reliability of power company electricity service varies greatly due to many factors including the design of the power grid, protective features, power system maintenance practices and severe weather and availability of renewable energy sources . The results of simulation were successful results of inversion.

CHAPTER 1

INTRODUCTION

1.1 Background of the Project

Today, inverters are widely used in many application. low voltage DC sources; batteries, PV panels are usually integrated into inverters to provide AC power for running appliances and devices. For example, electrical power from a cars battery can be converted to turn on a laptop computer, TV and cell phone (Lima, 2010). Therefore, DC-AC inverter circuit design is proposed in this project. The target is converts the DC voltage source to AC voltage source with higher efficiently.

There are many different type of DC- AC inverters in a markets. However, they are principally different types of AC outputs generated; the first is called a modified sine wave and the second is called a pure sine wave type. The modified sine wave type normally produces a square wave rather than sine wave form. This type of inverters passes a fixed DC voltage for certain period of time, so that the average voltage and rms voltages will be similar to sine wave form. These inverters are known to be of low-cost, while pure sine wave inverters are more expensive. Thus, these inverters are considered as good alternate. (Narendiran, 2013)

The pure sine wave inverter type produces a sine wave output that is similar to the incoming power. Therefore, pure sine wave inverters are recommended to be used with sensitive devices. However, a modified sine wave used in laser printers, desktop or laptop

computers, digital clocks, power tools, and medical equipment that may cause damage. (Abatan, 2010)

The manner in which the DC voltage power is inverted to AC voltage by using inverter circuit using microcontroller PIC16F877A to control and generate a stable sine wave at a constant frequency. Can be used in electrical application to reduce the bad effects of a change in frequency for the electrical hardware. This form of AC power including fluorescent lights and running inductive loads also reduces an audio noise in devices such as devices such as AC type of motors are faster and more softly because of the lower harmonic deformation. That is an intelligent inverters are available in the markets now a days. Microcontroller (PIC) Technologies offers a exhaustive list for the tasks of an smart inverter, as shown in Table 1.1

Table 1.1: Intelligent Power Functions (Abatan, 2010)

Digital On/Off control for low standby power
Power supply sequencing and hot-swap control
Programmable soft-start profile
Power supply history logging and fault management
Output voltage margining
Current fold back control
Load sharing and balancing
Regulation reference adjustment
Compensation network control and adjustment
Full digital control of power control loop
Communications for status monitoring and control
AC RMS voltage measurement
Power factor correction

Microcontroller based circuits are designed for both ON/OFF applications. These circuits were operating with uninterruptable power supplies (UPS). The main purpose is to supply an AC power to loads. They work as generators or a wall outlets to supply a constant energy when the major source of AC power goes offline. (Online, 2010)

Many technologies are performed to meet the work above. Computers and microcontrollers are used to control those applications . Inverters of square wave, modified sine wave and pure sine wave are used to acomplish the power supply task with certain reliability. Microcontroller circuitry exploit timer and op-amps to measure voltage and current in these systems depending on the requirements for loading. Similarly, they are applied to the battery charging circuitry. (Online, 2006 & 2010)

1.2 Problem Statement

In markets today, there are many types of power inverter circuits. Starts from a very expensive to very cheap devices with different quality, efficiency, and ability for power output. However, devices with high quality and efficiency are highly competitive in the market despite its high cost. High and pure sine wave inverters with high power capability digital ingredients are very expensive. The modified sine wave units can be considered so effective because there are not many processes perform in the output waveform. Nevertheless, the output result are waveform with many harmonic affecting responsive equipment such as medical monitors. Much kinds of inverters are considered as low-priced devices with a square waveform output.

The problem statement is to fill niches in the power inverter markets. Therefore, a quite efficient, cheap inverter with a pure stable sine wave output using microcontroller (PIC16F877A) and analog ingredients is proposed. The expected output will be a soft sine wave with low cost that comes with an analog approach.

1.3 Objectives of the Project

The Objectives of this project is to design an inverter that can be derived by 12 V battery and can be used to operate AC loads while minimizing the conventional inverter cost and complexity using microcontroller PIC 16F877A. The system's main properties are:

- To design a circuit based on microcontroller PIC for DC-AC inverter and simulate using proteus software

- To produce a pure sine wave, smooth sine wave, stable frequency wave (50 Hz) with THD less than 4.3% depending on the IEEE 519- 1992 requirements standard to used on many application as connect with distribution panel and used for AC sensitive machines and household appliances at the absence of main AC power supply.

- To implementation 12 V DC- 230 V AC inverter circuit using microcontroller PIC16F877A and get on smooth sine wave.

1.4 Scope of the Project

To complete the design for this project, a single inverter using microcontroller (PIC 16F877A) is proposed. The scope is an experimental based simulation and produced hardware. The project scope determines the power inverter characteristic involved, and a microcontroller source code will be developed. Then, the source code will be implemented todigita pulse the switch of power inverter digitally. Finally, the inverter at fundamental frequency to a 50 Hz is maintained.

1.5 Significance of the Project

The conversion of the voltage source from a DC voltage to AC voltage in an efficient manner is proposed in this project. It mainly focuses on the power inverter of DC-AC. Many applications of inverter input source panels are being converted to run AC devices or appliances such as batteries, fuel cells.

1.6 Project Organization

This project report is divided into five chapters.

Chapter 1 presents the background, objectives, problem statement, the scope of the study and the significance of the sudy.

Chapter 2 goes on to deal with the types of inverters and relevant literature review. Previous studies related to the present studies are clearly summarized and critically reviewed.

Chapter 3 describes the research methodology. It gives a full description of the whole process on how the current project is conducted in sequence. Therefore, all progresses regarding simulation, inverter design with microcontroller PIC, programming PIC and hardware development are presented in this chapter. Regarding circuit and sequencing control is also described in this chapter.

Chapter 4 reports the results. Discussed of inverter circuit design and the results of this study is also discussed and compared with those of previous studies in this chapter. The circuit was successful to generate a pure sine wave, smooth sine wave, stable frequency wave (50 Hz) with THD less than 4.3% depending on the IEEE 519- 1992 requirements standard.

Chapter 5 ends with the project summary. Suggestions, commercialization potential in possible future studies are also presented in this section.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter describes type of inverters and baesic for inverters and many of the past studies on inverter circuits and a number of cases which discussed it and the problems which they have studied and their solutions them and the results for those cases. And discussed the use of microcontroller circuit (PIC family) in inverter circuits. Among these the following studies:-

2.2 Inverter

An inverter is a device that converts the DC sources to AC sources. The purpose of a DC-AC power inverter is typically to take DC power supplied by batteries system or renewable energy, such as a 12 V car battery, and transform it into a 230 or 240 V AC power source operating at 50 Hz, simulating the power available at an ordinary household electrical outlet. Inverters are used in applications such as adjustable-speed ac motor drivers, Uninterruptible Power Supplies (UPS) and AC appliances run from an automobile battery. Inverter system used in remote areas when the cost of transmission line is very high and the renewable energy in that area is available such as sped of wind, sunlight,provides waste, fuel cells and etc. And it is used as an energy source in the state of interruption of electrical energy suddenly or in the types.

2.3 Classification of Inverters

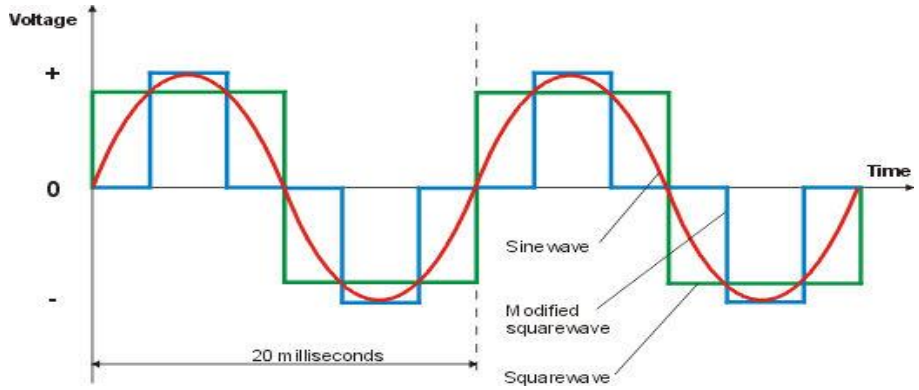
On the market today there are two different types of inverters:

- Modified Square Wave (Modified Sine Wave)
- Pure Sine Wave (True Sine Wave)

These inverters differ in their outputs, providing varying levels of efficiency and distortion that can affect electronic devices in different ways.

2.3.1 Modified Sine Wave

A modified sine wave is similar to a square wave but instead has a "stepping" look to it that relates more in shape to a sine wave. This can be seen in Figure 1, which displays how a modified sine wave tries to emulate the sine wave itself. The waveform is easy to produce because it is just the product of switching between three values at set frequencies, thereby leaving out the more complicated circuitry needed for a pure sine wave hence provides a cheap and easy solution to powering devices that need AC power. However it does have some drawbacks as not all devices work properly on a modified sine wave, products such as computers and medical equipment are not resistant to the distortion of the signal and must be run off of a pure sine wave power source modified sine wave inverters approximate a sine wave and have low enough harmonics that do not cause problem with household equipment's. The main disadvantage of the modified sine wave inverter is that peak voltage varies with the battery voltage**.** The output waveform as shown in Figuer 2.1



Figuer 2.1: Output waveform for modified sine wave

2.3.2 Pure Sine Wave

Pure sine wave inverter represents the latest inverter technology. The waveform produced by these inverters is same as or better than the power delivered by the utility. Usually sine wave inverters are more expensive than the modified sine wave inverters due to their added circuitry.

There are two methods in which the low voltage DC power is inverted to AC power;

1. The low voltage DC power is first boosted to high voltage power source using a DC-DC booster then converted to AC power using pulse width modulation.
2. The low voltage DC power is first converted to AC power using pulse width modulation then boosted to high AC voltage using a boost transformer.

The second method is used in modern inverters extensively because of its ability to produce a constant output voltage compared to the first method that require additional circuit to boost the voltage.

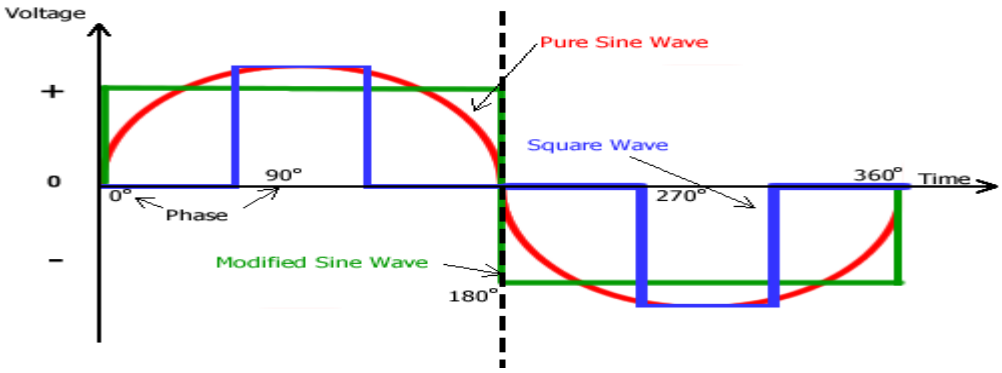


Figure 2.2: Output waveform for pure sine wave.

2.3.3 Pulse width modulation

Pulse width modulation (PWM) is a powerful technique for controlling analogue with a processor's digital outputs. . It is also known as pulse duration modulation (PDM). The leading edge of the carrier pulse remains fixed and the occurrence of the trailing of the pulses varies. PWM signals find a wide application in modern electronics. Some of these reasons are:

1. Reduced Power Loss – switched circuits tend to have lower power consumption because the switching devices are almost always off (low current means low power) or hard-on (low voltage drop means low power). Common circuits that utilize this feature include switched-mode power supplies, class D audio power amplifiers, power inverters and motor drivers. Frequently, these circuits use semi-analogue techniques (ramps and comparators) rather than digital techniques, but the advantages still hold.

2. Easy to Generate – PWM signals are quite easy to generate. Many modern microcontrollers include PWM hardware within the chip; using this hardware