FINAL YEAR PROJECT REPORT

IMPLEMENTATION OF ANTI-ISLANDING SCHEME FOR DISTRIBUTED GENERATION SYSTEM USING OVER/UNDER VOLTAGE AND FREQUENCY MONITORING TECHNIQUE

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IMPLEMENTATION OF ANTI-ISLANDING SCHEME FOR DISTRIBUTED GENERATION SYSTEM USING OVER/UNDER VOLTAGE AND FREQUENCY MONITORING TECHNIQUE

Project Report submitted to the

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In

Electrical Engineering

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Abstract

In this project we have integrated Photovoltaic system with power grid. By interconnecting separate utilities with the high voltage (DG) system, it is possible to pool both generation and demand, not only providing a number of economic and other benefits, including a more efficient bulk transfer of power from generation to demand centers. The interconnected DG system, by linking together all participants across the transmission system, makes it is possible to select the cheapest generation available. Transmission circuits tend to be far more reliable than individual generating units, and enhanced security of supply is achieved because the transmission system is better able to exploit the diversity between individual generation sources and demand. An interconnected DG system enables surplus generation capacity in one area to be used to cover shortfalls elsewhere on the system, resulting in lower requirements for additional installed generation capacity, to provide sufficient generation security for the whole system. Without DG interconnection, each separate system would need to carry its own frequency response to meet demand variations, but with interconnection the net response requirement only needs to match the highest of the individual system requirements to cover for the largest potential loss of power (generation) rather than the sum of them all.

Main idea is to work on Anti-Islanding Scheme in which we calculate voltage, frequency of both sides. If they lie in tolerable range then permission to close command is issued for respective circuit breaker.

High performancePIC18F458 RISC CPU is used for processing the inputs.
Sinusoidal signal from load end of system are converted to digital form and after full wave rectification these samples are used for calculation of voltage. To measure frequency input is given to the controller in the form of pulses and then pass it to ADC controller.

Measuring phase angle was quite an interesting task and caused a lot of effort. Time difference between starting of two waves is used to compute phase angle.

Dedication

This Research Paper is lovingly dedicated to our respective parents who have been our constant source of inspiration. They have given us the drive and discipline to tackle any task with enthusiasm and determination. Without their love and support this project would not have been made possible.

Acknowledgements

First of all we are very thankful to ALLAH who gave us strength and courage to complete this project.

We have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them.

We are highly indebted to Faculty ofUniversity of Management and Technology for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project.

We would like to express our gratitude towards our teachers for their kind co-operation and encouragement which help us in completion of this project.

We would like to express our special gratitude and thanks to Mr.Rauf Ali &Mr.AsifHussainforsupporting us with their precious time.

My thanks and appreciations also go to my friends in developing the project and people who have willingly helped us out with their abilities.

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CHAPTER I - INTRODUCTION

Recently, the penetration of Distributed Generation (DG) at medium and low voltages in utility networks is increasing in developed countries and takes special place for them worldwide. Renewable distributed generation involves the interconnection of small-scale, on-site distributed energy resources (DERs) with the main power utility at distribution voltage level. DERs mainly combined from renewable energy sources like solar PV, wind turbines, fuel cells, small-scale hydro, tidal and wave generators, micro-turbines, combined heat power (CHP) systems, etc.

Bulk of distributed generations in power system is from renewable energy. Depending on the distributed generations, their production can be AC or DC. But in all, most of these products are connected through electronic power converter to the network. Most of inverters of DGs that produce DC voltage usually operate with current control system in order to control the output power of DG. But DGs will have affects in the network. One of these effects has become an islanding phenomenon**.**

Islanding is a condition in which a portion of the utility system, which contains both Load and generation, is isolated from the remainder of the utility system and continues to operate. The isolation point is generally on the low voltage distribution line when an islanding condition exists, but islanding may also occur on the higher voltage distribution or transmission lines when large numbers of PV and other distributed generation are present.

1.1 PROBLEM STATEMENT

An essential requirement of the grid interconnected DG system is the capability of islanding detection.Islanding state happens when one or more DGs without connecting to the network are connected and supplied local loads. In most cases this phenomenon can occur unwanted. The islanding operation of DG may causepotential hazards to:

- Line-maintenance personnel.
- Equipment damage due to instability in user voltage and frequency
- Risk the DG in being damaged by out of phase reconnection to the grid

The majority of utilities require that DG should be disconnected from the grid as soon as the islanding occurs. Therefore, according to IEEE1547 standard, islanding state should be detected and disconnected in less than 2 seconds.

The main objective of our project is to integrate photovoltaic system with power grid and detection of islanding phenomena and checking the parameters range (voltage & frequency) during Anti-Islanding. Applications of our work include:

- Integrating PV system with Power Grid

- Checking Islanding State
- Measuring Parameters (Voltage & Frequency)
- Cease the PV system (if parameters are not in acceptable range)
- Re-connection of PV System with Power Grid

1.2 SCOPE OF WORK

Upon completion of project we will be able to present a technique that will measure voltages andfrequencyprovides an output to enable the closing of circuit breaker when all of the values fall within the set limits and remain there for the duration selected in the setting. It will test:

- Voltage difference
- Frequency

1.3 PROJECT METHODOLOGY

Anti-Islanding is basically a protection scheme. In this project we first Integrated PV Array with Power Grid using Inverter. Pulses are provided to Inverter using 12 to 220 volts Transformer and also by the Microcontroller when the power is off by Transformer. The output form Inverter is step-up from 12 V to 220 V and the load is driven.

There is one Microcontroller which is used for the purpose of Analogue to Digital Conversion for the measurement of Voltage and Frequency and then it will be displayed on the LCD. There is also a function in Microcontroller which consequently detects the abrupt change in frequency and voltage and the signal is passed by Microcontroller using Relay and the system will be ceased in case when Islanding is occur.

1.4 SOFTWARE USED

1.4.1 MPLAB IDE Compiler for Microchip PIC®

MPLAB provides a complete, integrated tool suite for developing and debugging embedded applications running on Microchip PIC® MCUs and ds PIC® DSCs. This suite includes an IDE for project management, a context sensitive Assembly aware editor, build tools and real time debugger...helping developers create, analyze, debug and document project code.

The MPLAB IDE allows developers to manage every aspect of their embedded software development, from code creation through device programming. External programs can be invoked from the IDE, simplifying integration with other programmers and debuggers.

The heart of this development tool suite is the MPLAB intelligent code optimizing Assembly compiler, which frees developers to concentrate on design functionality instead of having to become an MCU architecture expert. Maximize code reuse by easily porting from one MCU to another.

1.4.2 PROTEUS

1.4.2.1 The VSM Advantage

The Proteus Design Suite is wholly unique in offering the ability to co-simulate both high and low-level micro-controller code in the context of a mixed-mode SPICE circuit simulation. With this Virtual System Modeling facility, you can transform your product design cycle, reaping huge rewards in terms of reduced time to market and lower costs of development.

If one person designs both the hardware and the software then that person benefits as the hardware design may be changed just as easily as the software design. In larger organizations where the two roles are separated, the software designers can begin work as soon as the schematic is completed; there is no need for them to wait until a physical prototype exists.

In short, Proteus VSM improves efficiency, quality and flexibility throughout the design process.

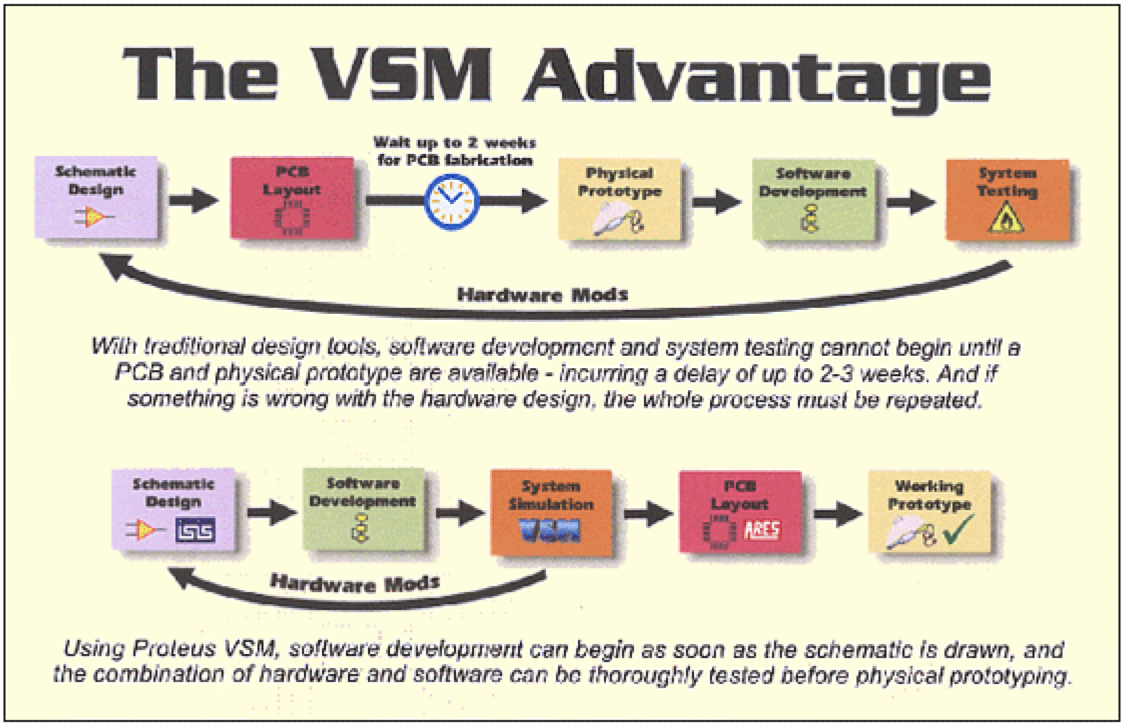


Figure 1.1

1.4.2.2 What is Proteus VSM?

Proteus Virtual System Modeling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. For the first time ever, it is possible to develop and test such designs before a physical prototype is constructed.

This is possible because you can interact with the design using on screen indicators such as LED and LCD displays and actuators such as switches and buttons. The simulation takes place in real time (or near enough to it): a 1GMHz Pentium III can simulate a basic 8051 system clocking at over 12MHz. Proteus VSM also provides extensive debugging facilities including breakpoints, single stepping and variable display for both assembly code and high level language source.

1.4.2.3 Schematic Entry

Proteus VSM uses our proven Schematic Capture software to provide the environment for design entry and development. ISIS is a long established product and combines ease of use with powerful editing tools. It is capable of supporting schematic capture for both simulation and PCB design. Designs entered in to Proteus VSM for testing can be net listed for PCB layout either with our own PCB Design products or with third party PCB layout tools. ISIS also provides a very high degree of control over the drawing appearance, in terms of line widths, fill styles, fonts, etc. These capabilities are used to the full in providing the graphics necessary for circuit animation.

1.4.2.4 Circuit Simulation

At the heart of Proteus VSM is ProSPICE. This is an established product that combines uses a SPICE3f5 analogue simulator kernel with a fast event-driven digital simulator to provide seamless mixed-mode simulation. The use of a SPICE kernel lets you utilize any of the numerous manufacturer-supplied SPICE models now available and around 6000 of these are included with the package.

Proteus VSM includes a number of virtual instruments including an Oscilloscope, Logic Analyzer, Function Generator, Pattern Generator, Counter Timer and Virtual Terminal as well as simple voltmeters and ammeters. In addition, we provide dedicated Master/Slave/Monitor mode protocol analyzers for SPI and I2C - simply wire them onto the serial lines and monitor or interact with the data live during simulation. A truly invaluable (and inexpensive!) way to get your communication software right prior to hardware prototyping.

Should you wish to take detailed measurements on graphs, or perform other analysis types such as frequency, distortion, noise or sweep analyses of analogue circuits, you can purchase the

Advanced Simulation Option. This option also includes Conformance Analysis - a unique and powerful tool for Software Quality Assurance.

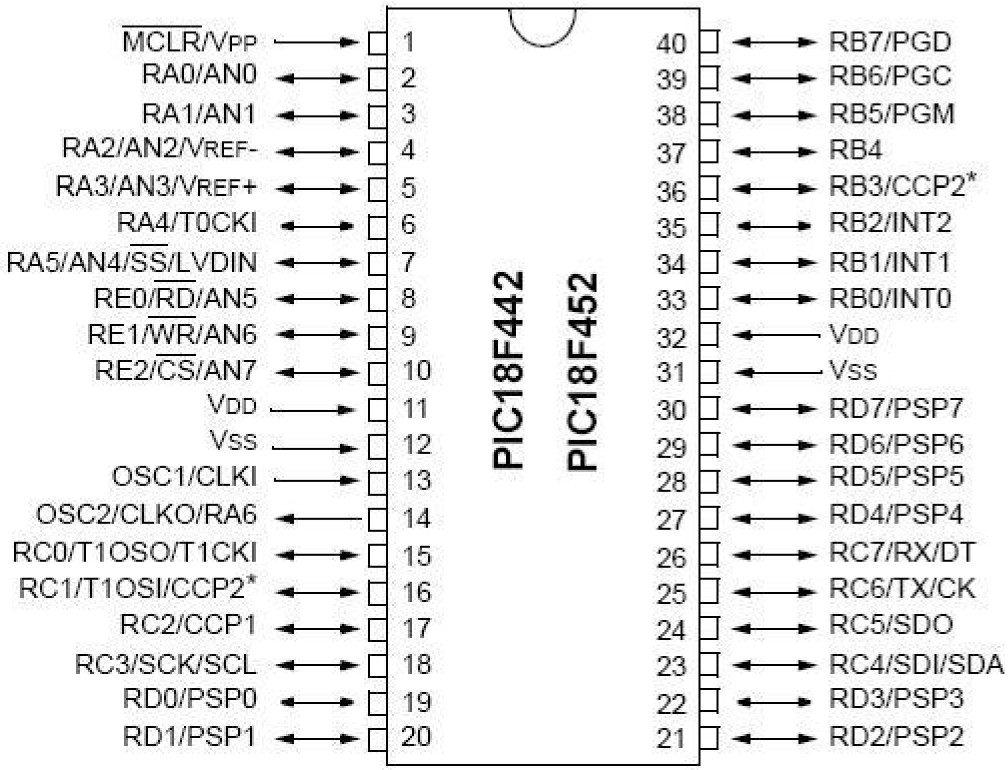
1.4.2.5 Source Level Debugging

Whilst Proteus VSM is already unique in its capability to run near real time simulations of complete micro-controller systems, its real power comes from its ability to perform these simulations in single step mode. This works just like your favorite software debugger, except that as you single step the code, you can observe the effect on the entire design - including all the electronics external to the microcontroller

1.5 MAJOR COMPONENTS

1.5.1 PIC18F452 MICROCONTROLLER

PIC18F452 with high performance RISC CPU is used for processing the input.This powerful 10 MIPS (100 nanosecond instruction execution) yet easy-to-program (only 77 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX, PIC16CXX and PIC17CXX devices and thus providing a seamless migration path of software code to higher levels of hardware integration. The PIC18F452 features a 'C' compiler friendly development environment, 256 bytes of EEPROM, Self-programming, an ICD, 2 capture/compare/PWM functions, 8 channels of 10-bit Analog-to-Digital (A/D) converter, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus and Addressable Universal Asynchronous Receiver Transmitter (AUSART). All of these features make it ideal instrumentation and monitoring, data acquisition, power conditioning, environmental monitoring, telecomandconsumeraudio/videoapplications.


PIC18F442
PIC18F452
MCLR/VPP
RA0/AN0
RA1/AN1
RA2/AN2/VREF-
RA3/AN3/VREF+
RA4/T0CKI
RA5/AN4/SS/LVDIN
RE0/RD/AN5
RE1/WR/AN6
RE2/CS/AN7
VDD
VSS
OSC1/CLKI
OSC2/CLKO/RA6
RC0/T1OSO/T1CKI
RC1/T1OSI/CCP2*
RC2/CCP1
RC3/SCK/SCL
RD0/PSP0
RD1/PSP1
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26
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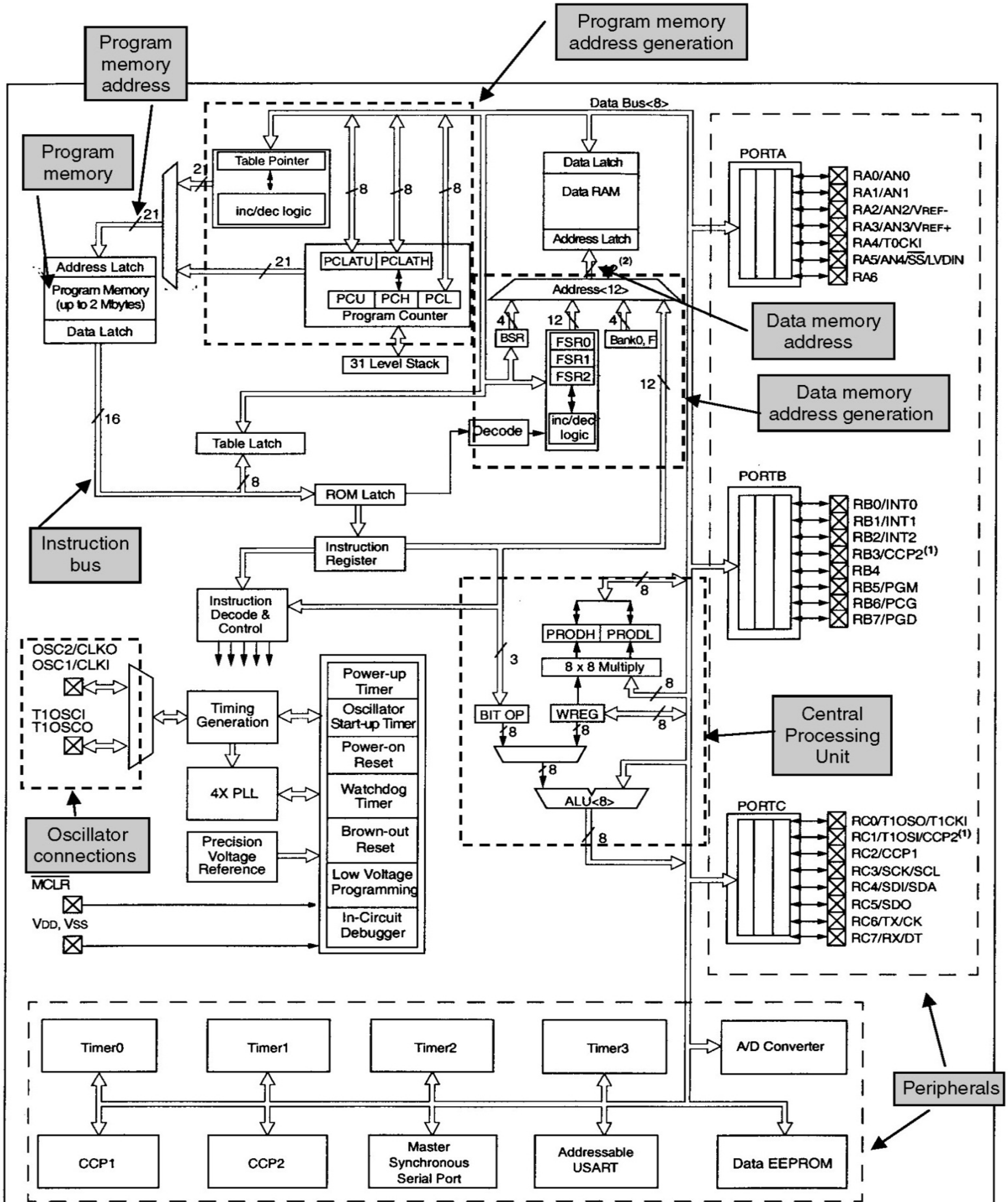
24
23
22
21
RB7/PGD
RB6/PGC
RB5/PGM
RB4
RB3/CCP2*
RB2/INT2
RB1/INT1
RB0/INT0
VDD
VSS
RD7/PSP7
RD6/PSP6
RD5/PSP5
RD4/PSP4
RC7/RX/DT
RC6/TX/CK
RC5/SDO
RC4/SDI/SDA
RD3/PSP3
RD2/PSP2

Figure 1.2



Note 1: Optional multiplexing of CCP2 input/output with RB3 is enabled by selection of configuration bit.

2: The high order bits of the Direct Address for the RAM are from the BSR register (except for the `MOVFF` instruction).

3: Many of the general purpose I/O pins are multiplexed with one or more peripheral module functions. The multiplexing combinations are device dependent.

Figure 1.3

1.5.2 PIC16F877A MICROCONTROLLER

PIC16F877A with high performance RISC CPU is used for processing the input.This powerful 10 MIPS (100 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40 package and is upwards compatible with the PIC16C5X, PIC12CXXX, PIC16CXX and PIC17CXX devices and thus providing a seamless migration path of software code to higher levels of hardware integration. The PIC16F877A features a 'C' compiler friendly development environment, 256 bytes of EEPROM, Self-programming, an ICD, 2 capture/compare/PWM functions, 8 channels of 10-bit Analog-to-Digital (A/D) converter, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and Addressable Universal Asynchronous Receiver Transmitter (AUSART). All of these features make it ideal instrumentation and monitoring, data acquisition, power conditioning, environmental monitoring, telecomandconsumeraudio/videoapplications.

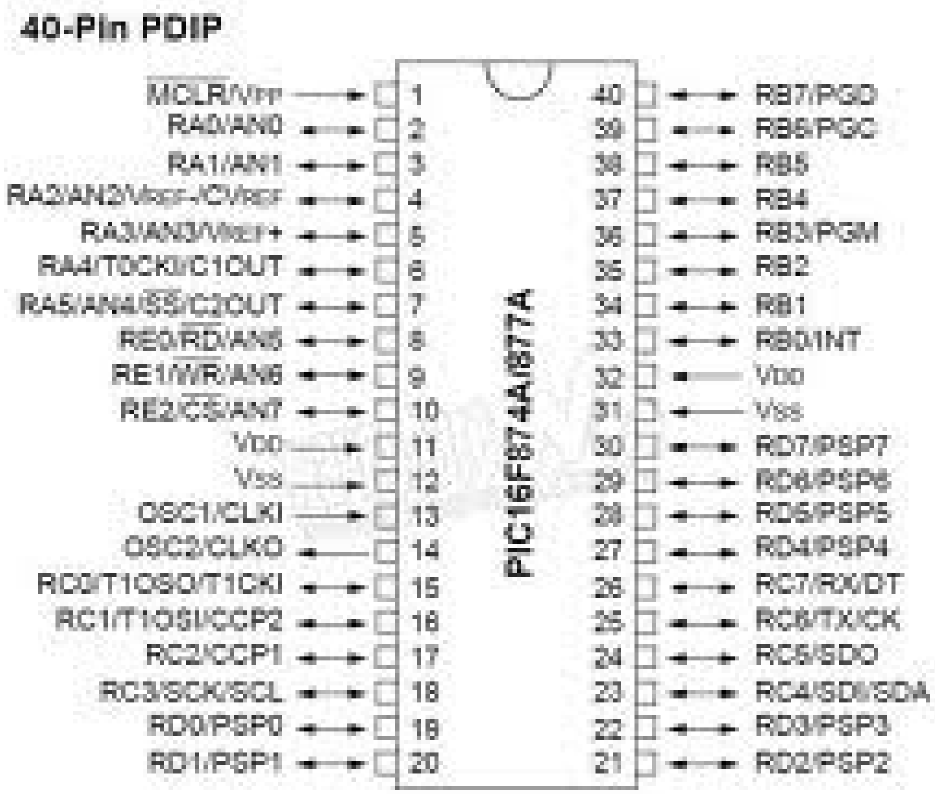


FIGURE 1.4

1.5.3 POWER INVERTER

A **power inverter**, or **inverter**, is an electrical power converter that changes direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. The square wave output has a high harmonic content, not suitable for certain AC loads such as motors or transformers. Square wave units were the pioneers of inverter development. The capacity of a power inverter would determine the type and number of devices it can be used to power. Models differ in wattage capacity and you need to be sure you a get an inverter that suits your needs. To calculate what the capacity you require you need to measure the wattage that your devices would draw and add another 50% to cover for spikes or peaks in the power draw. For example if you intend to power two devices each requiring 100 watts that would amount to 200 watts plus 50%. The recommended inverter you require should be a minimum of 300 watts.

1.5.4 POWER TRANSFORMER

A **transformer** is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the *primary* winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic flux through the *secondary* winding. This varying magnetic flux induces a varying electromotive force (emf) or voltage in the secondary winding.

Transformers range in size from thumbnail-sized used in microphones to units weighing hundreds of tons interconnecting the power grid. A wide range of transformer designs are used in electronic and electric power applications. Transformers are essential for the transmission, distribution, and utilization of electrical energy.

1.5.5 RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Figure 1.5

1.5.6 LCD

LCD controller is one of the most common dot matrixliquid crystal display (LCD) display controllers available. Hitachi developed the microcontroller specifically to drive alphanumericLCD display with a simple interface that could be connected to a general purpose microcontroller or microprocessor. Many manufacturers of displays integrated the controller with their product making it the informal standard for this type of displays. The device can display ASCII characters, Japanese Kana characters, and some symbols in two 28 character lines.

These LCD screens are limited to monochrome text and are often used in copiers, fax machines, laser printers, industrial test equipment, networking equipment such as routers and storage devices.

The screens come in a small number of standard configurations. Common sizes are 8x1 (one row of eight characters), 16×2, 20×2 and 20×4. Larger custom sizes are made with 32, 40 and 80 characters and with 1, 2, 4 or 8 lines. The most commonly manufactured larger configuration is 40×4 characters, which requires two individually addressable HD44780 controllers with expansion chips as a single HD44780 chip can only address up to 80 characters. A common smaller size is 16×2, and this size is readily available as surplus stock for hobbyist and prototyping work.

Character LCDs can come with or without backlights, which may be LED, fluorescent, or electroluminescent.

Character LCDs use a standard 16 contact interface, commonly using pins or card edge connections on 0.1 inch / 2.54mm centers. Those without backlights may have only 14 pins, omitting the final two pins powering the light. The pins are follows:

1. Ground
2. VCC (+3.3 to +5V)
3. Contrast adjustment (VO)
4. Register Select (RS). RS=0: Command, RS=1: Data
5. Read/Write (R/W). R/W=0: Write, R/W=1: Read
6. Clock (Enable). Falling edge triggered
7. Bit 0 (Not used in 4-bit operation)
8. Bit 1 (Not used in 4-bit operation)
9. Bit 2 (Not used in 4-bit operation)
10. Bit 3 (Not used in 4-bit operation)
11. Bit 4
12. Bit 5
13. Bit 6
14. Bit 7
15. Backlight Anode (+)
16. Backlight Cathode (-)

The nominal operating voltage for LED backlights is 5V at full brightness, with dimming at lower voltages dependent on the details such as LED color. Non-LED backlights often require higher voltages.

The HD44780 interface allows for two modes of operation, 8-bit and 4-bit. Using the 4 bit mode is more complex, but reduces the number of active connections needed. The chip starts in 8 bit mode, with the instruction set designed to allow switching without requiring the lower four data pins. Once in 4 bit mode, character and control data is transferred as pairs of 4 bit "nibbles" on the upper data pins, D4-D7.

Instruction	Code										Description	Execution time (max) (when f_{cp} = 270 kHz)
	RS	R/W	B7	B6	B5	B4	B3	B2	B1	B0		
Clear display	0	0	0	0	0	0	0	0	0	1	Clears display and returns cursor to the home position (address 0).	1.52 ms
Cursor home	0	0	0	0	0	0	0	0	1	*	Returns cursor to home position. Also returns display being shifted to the original position. DDRAM content remains unchanged.	1.52 ms

1.5.7 PHOTOVLTAIC TECHNOLOGY

Unlike other forms of renewable energy such as wind and water, solar energy is more prevalent around the world and as a result is being used more frequently as a source of energy. Photovoltaic technology provides a mechanism in which solar modules are used to capture and convert solar energy from the sun into electric energy. In a PV energy system, PV modules can be linked to form arrays or solar panels. These modules contain semiconducting material which absorbs photons of sunlight, which in turn energize electrons in the material, freeing them from their atoms and consequently creating DC current. Unfortunately, the efficiency of converting solar to electrical energy in PV modules is very low (roughly 19%); consequently, it is crucial that the DC-to-AC power converter be highly efficient (greater than 95%) in order to maximize the use of the harvested solar energy and minimize the footprint of the solar modules and the volume of the entire system. It is this challenge that motivates the need for the new technologies provided by Microsemi.

Fig:

PV Energy Systems

PV systems come in two distinct configurations, based on their application. In one case, a system operates independently of the electric utility grid, referred to as an off-grid or a standalone system. Conversely, a system can be integrated with the utility grid so that energy can be shared between the PV system and the grid (surplus power can be sold back to the utility). Naturally, this later configuration introduces additional complexity.

The components for a particular PV system vary depending on the functional and operational requirements of the system . The most common components are as follows:

•**PV modules:** These can be combined to create PV arrays and are used to convert sunlight into DC power. Because of this modularity, a PV system can be sized for different applications, ranging from powering a single machine to powering a commercial building.

Cooling system: Required when temperatures rise during operation; for example, in the case of heat generated due to the diodes in the junction boxes of the PV modules.

•**Energy storage/battery bank:** A battery is typically needed in the case of a standalone PV system. When the PV system is producing more power than the load's demand, this excess power can be stored in a battery for later use (for example, at night).

•**Load:** The load connected to the PV inverter can be of any size and AC, DC, or a combination of both.

•**Utility grid interface:** For grid-connected PV applications, a bidirectional interface between the PV system and the utility grid is included to allow the power produced by the PV system to back feed the grid when the PV system output is greater than the load demand. The balance of power required must be monitored in the case when the load demand is greater than the PV system output or when the utility grid is down and power cannot be fed back. Such control mechanisms are implemented as part of the PV system controller (which is part of the inverter system).

•**PV inverter system:** The PV inverter is the heart of the PV system, performing DC-to-AC conversion, power protection, monitoring, and control. The design of the various components of this system depends on the functional requirements of the end system. Moreover, power system interconnection regulations and international standards, such as IEEE 1547 and EN50160, impose constraints—including the necessity for galvanic isolation, the maximum harmonic distortion of the current injected at the point of common coupling (PCC), the maximum permitted DC current injection—all of which must be considered during the design of PV inverters.

Standards Impacting Solar Inverters

As with any industry, the solar industry has to contend with a number of regulations and standards, dealing with the design of the systems, how they interconnect to the grid, and the proper sizing and charging of lead-acid batteries.

IEEE 1547

The Standard for Interconnecting Distributed Resources with Electric Power Systems is a collection of multiple standards that cover the performance, operation, testing, maintenance and safety of the interconnection to the grid.

IEEE 1361

Guide for Selection, Charging, Test and Evaluation of Lead-Acid Batteries Used in Stand-Alone Photovoltaic Systems covers lead-acid battery charging requirements in PV systems as well as guidance in selecting batteries.

IEEE 1526

Recommended Practice for Testing the Performance of Stand Alone Photovoltaic Systems provides test methods and procedures for evaluating PV system performance.

IEEE 1561

Guide for Optimizing the Performance and Life of Lead-Acid Batteries in Remote Hybrid Power Systems provides methods regarding the use of lead-acid batteries.

CIRCUIT DIAGRAM

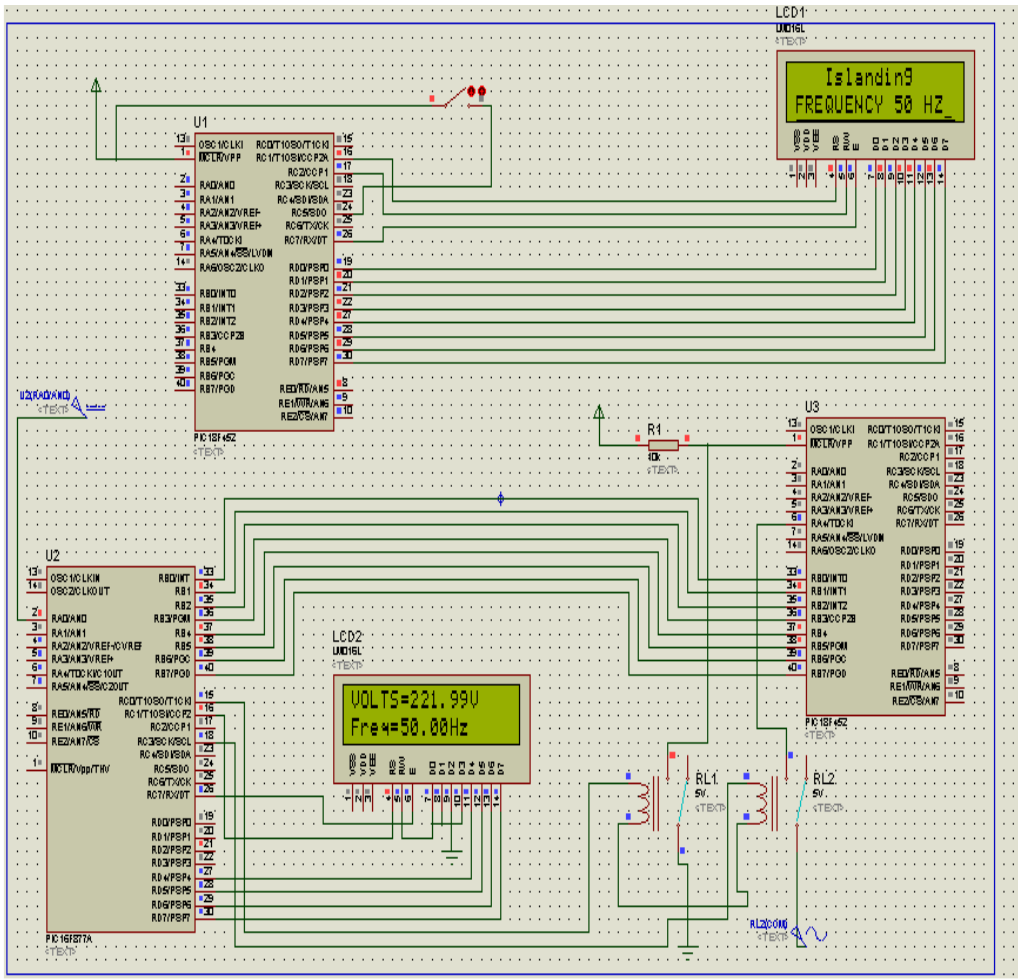


Figure 1.6