MICROCONTROLLER BASED INTELLIGENT SOLAR POWERED CHARGEABLE UPS

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CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in this thesis titled “Microcontroller Based Intelligent Solar Powered Chargeable UPS”, carried out by Capt Haider Ali Abbasi, Capt Muhammad Rizwan Younis, Capt Ashar Habib and Capt Sikandar Khalid under the supervision of Lt Col Dr. Naveed Ahmed in partial fulfillment of the Bachelors of Telecommunication Engineering, is correct and approved.

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ABSTRACT

The concept of intelligent UPS is evolved to conserve the precious energy sources. Most of the developing countries are unable to provide electricity to its people either completely or partially. On the other hand, even the citizens of developing countries cannot afford high prices of electricity.

There is a huge potential for utilizing renewable energy sources, for example solar energy to provide a quality power supply in developing countries. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid.

The intelligent solar UPS will enable them to use maximum energy from solar and complete the extra load requirements from grid electric energy. Microcontroller is used to manage and share the load intelligently.

DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATED TO

Almighty Allah,

Faculty for their help

And our parents for their support

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We bow in gratitude to Allah Almighty for giving us strength and knowledge to accomplish this task as nothing happens without his will.

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AC	Alternating Current
DC	Direct Current
IMN	Impedance Matching Network
MHz	Megahertz
RF	Radio Frequency
PSU	Power Supply Unit
LED	Light Emitting Diode
FET	Field Effect Transistor
PCB	Printed Circuit Board

Chapter 1

INTRODUCTION

Currently Pakistan is facing worst energy crisis of its kind. The situation necessitates a low cost, reliable and out of box solution. Geographically, Pakistan is located at a place where sufficient sunlight is available throughout the year. Sunlight is a clean, renewable source of energy. It is a sustainable resource, meaning it doesn't run out so the supply can be maintained. Solar power generated through the small solar panels can provide a distributed and efficient solution to partially offset this crisis and lessen the pain of ordinary people. UPS available in the market provides un-interrupted power during the periods of load shedding and it does not need rewiring. However, efficient and intelligent integration of solar power with that of UPS is either non-existing or available at very high cost which is beyond the reach of ordinary people so there is a need to design a solar charged UPS which is affordable for the general public.

1.1 Motivation

The energy of the sun will never set. Human beings need to conserve the precious energy sources they have discovered so far, for the generations to come. The available energy sources are expensive and demands a continuous billing. Whereas the biggest energy source, i.e. sun, is available for free. In order to reduce economic burden an intelligent solar UPS is designed which will make use of maximum solar energy available and will share the energy from other sources to run the load.

Power generated from a renewable energy sources are more reliable, affordable and used more efficiently. This thesis focuses on the combination of solar and grid electric power and energy storing systems for sustainable power generation. The solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. Thus, a system with a battery bank (energy storage bank) can be integrated with the solar-system to ensure that the system performs under all conditions. The dynamic model, design and simulation of a Solar-Grid intelligent hybrid power generation system together with storage bank and with power flow controllers will be proposed here. In the proposed system, when there is enough energy from the sun, the load demands can be supplied from the PV-array system. If the available power from the solar panels cannot satisfy the load demand, the Grid power can meet the excess power demand.

1.2 Project Description

The Project aims to make an intelligent solar powered chargeable UPS, which would be able to run/share the load intelligently along with battery charging. Combining different energy sources like solar and grid is called a hybrid system. The project which is presented in this paper is to look for the best design layout; to size the system elements properly; simulate for the different power management strategies which are defined for the system, which consists of renewable energy source (PV-arrays), conventional energy source (grid energy) and energy storage bank (battery bank) to sustainably and efficiently satisfy the energy demand. It would use solar power as primary source of energy and grid power as secondary source of energy, along with automatic switchover to grid energy during night once solar power is not available.

1.3 Project Objectives

Objective of this paper is to design such a system which would get benefit from solar energy intelligently. It will not only provide a relief to common man in developing countries but also lessen the burden on government of these countries. An economic and efficient solution will be formulated to use the grid energy as less as possible. It will open the gates for new researchers to find a solution to provide extra solar energy to grid system, thus contributing towards the power requirements of the country.

1.4 Approach

To attain the objectives of the thesis, the following approach was adopted. To get a better insight about the solar energy and its advantages, an elaborated literature study was essential. The general introduction about the thesis on intelligent power sharing system is described in Chapter-1. The system includes sub-elements (solar arrays, inverts, transformers, charge controllers and energy storage) which are explained in detail in Chapter-2. The different possible connecting techniques of the different energy sources are discussed in Chapter-3. The circuitry and design selected for the system, and the microcontroller used to make the system intelligent is discussed in chapter 4. Analysis, advantage and conclusions are carried out in chapter 5. Recommendations for future work are also included in this project paper.

1.5 Outline

This thesis paper includes 5 chapters and 3 appendices. Chapter-1 includes general introduction. Chapter-2 discusses the theory of the system elements and thesis related issues. Chapter-3 discusses the researches made on the connecting topologies. Chapter-4 explains the design development and making the system intelligent. Chapter-5 starts with the power calculations, followed by cost and efficiency analysis. Proteus simulations, Programming code, Different data tables and graphs are presented in the appendices.

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Work

Uninterrupted power supply/source is the system which saves the power and provide that to a load when existing power fails or unable to run the electric/electronic gadgetry. Normally this backup power is provided by the battery bank to save the equipment or data. There are many techniques and categories of UPS but generally it is distributed into three main categories. That are online/double conversion , line-interactive and Offline/standby UPS.

2.2 Online - UPS

An on-line UPS uses a "double conversion" method of accepting AC input, converts it into DC for passing through the rechargeable battery, then inverting back to 120 V/220 V AC to power the protected equipment. The batteries are always connected to the inverter, so that no power transfer switches are necessary. When power loss occurs, the rectifier simply drops out of the circuit and the batteries keep the power steady and unchanged. When power is restored, the rectifier resumes carrying most of the load and begins charging the batteries, though the charging current may be limited to prevent the high-power rectifier from overheating the batteries and boiling off the electrolyte.

2.3 Line-interactive UPS

A line-interactive UPS maintains the inverter in line and redirects the battery's DC current path from the normal charging mode to supplying current when power is lost. Most UPS below 1 kVA are of the line-interactive or standby variety which are usually less expensive. The line-interactive UPS contains a multi-tap variable-voltage autotransformer. This is a special type of transformer that can add or subtract powered coils of wire, thereby increase or decrease the magnetic field and the output voltage of the transformer. It can tolerate continuous under voltage brownouts and overvoltage surges without consuming the limited reserve battery power.

2.4 Offline/Standby UPS

The offline/standby UPS offers only the most basic features, providing surge protection and battery backup. The protected equipment is normally connected directly to incoming utility power. When the incoming voltage falls below or rises above a predetermined level the standby UPS turns on its internal DC-AC inverter circuitry, which is powered from an internal storage battery. The UPS then mechanically switches the connected equipment on to its DC-AC inverter output. The switchover time can be as long as 25 milliseconds depending on the amount of time it takes the standby UPS to detect the lost utility voltage.

2.5 Solar energy

Solar radiation represents the largest energy flow entering the terrestrial ecosystem. After reflection and absorption in the atmosphere, some 100,000TW reach the surface of Earth and converted to all forms of energy used by humans, with the exception of nuclear, geothermal, and tidal energy. This resource is enormous and corresponds to almost 6,000 fold the current global consumption of primary energy (13.7TW). Thus, solar energy has the potential of becoming a major component of a sustainable energy portfolio with constrained greenhouse gas emissions.

2.5.1 Solar Panels

Solar energy has experienced an impressive technological shift. Older solar technologies constituted small-scale photovoltaic (PV) cells, while modern technologies are represented by solar concentrated power (CSP) and also by large-scale PV systems that feed into electricity grids. The costs of solar energy technologies have dropped substantially over the last 30 years. Theoretically, solar energy has resource potential that far exceeds the entire global energy demand. Despite this technical potential and the recent growth of the market, the contribution of solar energy to the global energy supply mix is still negligible. Solar energy refers to sources of energy that can be directly attributed to the light of the sun or the heat that sunlight generates. Solar energy technologies can be classified along the following continuum:

2.5.2 Passive And Active

Passive solar energy technology merely collects the energy without converting the heat or light into other forms. It includes, for example, maximizing the use of day light or heat through building design. In contrast, active solar energy technology refers to the harnessing of solar energy to store it or convert it for other applications.

2.5.3 Photovoltaic

Two types of PV technology are currently available in the market:

a. Crystalline silicon-based PV cells

b. Thin film technologies made out of a range of different semi-conductor materials

2.5.4 Thermal

Solar thermal technology can be divided into two categories:

a. Solar thermal non-electric

b. Solar thermal electric.

2.5.5 Concentrating

Concentrating systems are those systems which use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Four types of Concentrating Solar Power technologies are currently available in the market:

a. Parabolic Trough

b. Fresnel Mirror

c. Power Tower

d. Solar Dish Collector

2.5.6 Working of solar panel

PV devices allow the direct production of electricity from absorption of ultraviolet rays. The active material in a PV system is a semiconductor capable of absorbing photons with energies equal to or greater than its band gap. Upon photon absorption, an electron of the valence band is promoted to the conduction band and is free to move through the bulk of the semiconductor. In order for this free charge to be captured for current generation, decay to the lower energy state, i.e. recombination with the hole in the valence band, has to be prevented through charge separation.

2.5.6.1 Photon Absorption And Carrier Generation

One of the major requirements for a single junction cell is that the band gap energy must be optimized to transfer maximum energy from the incident light to the photogene rated electron-hole pairs. An optimal value of band gap energy is 1.1-1.4Ev. The band gap energy of silicon (1.12Ev) is nearly ideal and allows absorption of photons in the near-infrared (NIR), visible, and ultraviolet spectrum.

2.5.6.2 Charge Transfer And Separation

Photo excitations in organic semiconductors result in the formation of excitations, or electron-hole pairs that are bound together by Coulomb attraction and must be dissociated. Dissociation can happen in the presence of high electric fields, at a defect site in the material. Usually the excitation dissociation is very effective, resulting in the transfer of electrons from the donor to the acceptor material and holes from the acceptor to the donor material with efficiencies approaching 100% on sum picoseconds

2.5.6.3 Charge Transport

c-Si cells need a relatively large thickness (~300μm) because of mechanical constraints (Si is brittle) and the long light absorption length associated with the indirect bandgap of Si. Consequently, good material with high chemical purity and structural perfection is required to fight recombination. Surfaces must be effectively passivated to reduce recombination. Additionally, impurities and imperfections in the bulk must be avoided as they can absorb the extra energy of the conduction-band electrons and convert it into heat. Various deposition and growing technologies, surface treatments and contact designs allowed the incremental enhancement of the electronic properties of Si wafers.

2.6 Battery

The back bone of the Inverter system is the battery. A high current tubular battery is used to give a maintenance free performance. The charge in the battery is used to convert DC to AC by the inverter. Measure of charge is Coulomb and each electron carries a charge of 1.602 e- 19 coulomb. As a rule, when 1 amps current passes through a conductor in 1 second, it uses 1 coulomb charge

charge Q = I x t (time)

If 1 amps current flows through the conductor in 1 hour, 3600 coulomb charge will be utilized. The amount of charge in the battery is represented in Amps hour (Ah). That is Amps times Hour. It is the amount of charge present in the battery. But Amps hours cannot be used to measure the charge level, since the voltage changes during discharge. So the measure of charge is Watts Hours. Watt hour can be calculated by multiplying the nominal voltage with the battery capacity in Amps hours.

E = C x Vg. Where C is the capacity of the battery in Ah and Vg is the discharge rate.

2.6.1 Charge Requirement Of The Load

The following equation tells us, how much battery charge is required for load. First find out the capacity of the battery. If ‘X amps’ current is drawn by the load in ‘t hours’, then the capacity of the battery.

C = X x t

Suppose the load is drawing 120 Ma current in 24 hours, then the capacity of the battery should be **C = 0.12A x 24 = 2.88 Ah**

It is not a good practice to discharge the battery completely till the load shut off. So it is better to stop running the load, if the battery charge reduces to 30%.

2.6.2 Battery Capacity

If the load takes 120 Ma current in 1 hour, maximum capacity of the battery should be 0.12A x 24 = 2.88 Ah. Best method to keep the charge/discharge cycles perfect is to stop discharging the battery till it maintains 30% charge. Hence to retain 20% charge, the capacity of the battery should be **C / 0.7**

If the battery requires 2.88 Ah in one hour, then to keep 30% charge in it, the capacity of the battery should be **2.88Ah / 0.7 = 4.11Ah.**

2.6.3 Discharge Rate

Lead acid batteries have few Amps hour if the discharge rate is fast. Generally, the lead acid battery is rated for 20 hours discharge rate provided the discharge rate is slow. At high discharge rate, the capacity of the battery drops steeply. Suppose the battery is 10 Ah and its discharge rate is 1C. One hour discharge of the battery at the rate of 1C (10

Amps in 1 hour), the capacity reduces to 5 Ah in one hour. To keep a steady discharge rate of the battery, if we want to run a load at 20 Amps for 1hour, then the capacity of the battery should be

C = It = 20A x 1 Hour = 20Ah.

As we keep discharge rate to maximum 70%. Then the battery capacity should be

20Ah / 0.7 = 28.57 Ah

So a 28.57 Ah battery can give 20 Amps current for 1 hour to run the load.But it is better to drain the battery to 50% only then, **25 Ah / 0.5 = 50 Ah.**

Hence as a rule of thumb, it is better to use a 50Ah battery to run the load at 20 Amps per Hour to keep 50% charge in the battery.

Suppose the load is not drawing 20 Amps continuously in 1 hour. During the first second, it draws 20 Amps and then 100 Ma during the remaining period. So the average current drawn by the load is

20A x 1/ 3600 + 0.1 / 3600 = 0.1044 A

(3600 is the total seconds in 1 hour.)

In short, if the load is not drawing the charge in a steady manner, the capacity of the battery will be increased.

2.6.4 How To Calculate The Charge

It is difficult to measure the current drawing by the load at different times. The easy way is to consider the power rating (Watts) of the load. Suppose the power rating of the load is 250 watts and is drawing current from the inverter system for 5 hours.

Then, its Watts hour is Watts x Hour = 250 x 5 = **1250 Watts hour.**

Consider the efficiency of the inverter as 85 % (as no inverter is 100% efficient).

So 1250 / 0.85 = **1470 watts hour**

2.6.5 How To Calculate Battery Capacity

As, Watt is Amps x Volt

So if the Watt hour is divided by Voltage of the battery, we will get the Amps hour

Watt hour / Volt = Amps hour

1470 / 12 = 122.5 Ah

Thus to run 1470 watts load, minimum capacity of the battery should be 125Ah to run the load for 5 hours. As already stated, it is better to use a 150 Ah battery to keep discharge cycle 50%.

2.6.6 How To Select An Inverter

Let Total load to be connected **= 500 watts**

Power factor = **0.8** (all inverters have a power factor between 0.6 to 0.8)

Inverter VA = 500 / 0.8 **= 625 VA**

So select 800 VA inverter to run 500 Watts load

2.6.7 HOW TO SELECT THE BATTERY

Backup time = Watt / Battery voltage x Hours

500 / 12 x 3Hr = 125 Ah

A 12 volt tubular battery has a terminal voltage of 14.8 volts in fully charged condition. Usually the inverter has cutoff facility to protect battery from deep discharge. Most of the inverters are set for 80 % (Retaining charge) cutoff voltage. That is after 20% discharge, inverter will shut off.

Inverter cutoff voltage = 14.8 x 0.8 = **11.84 volts**

Watt hour = watt x hour = 500 watts x 3 hours = **1500 watt hours**

Ah of battery = watt hour / volt = 1500 / 11 = **126 Ah.**

In short, an 800 VA inverter with 126 Ah battery can power 500 watts load for 3 hours.

Load calculation chart

Appliance	Watts (VA) W x 1.5 for AC	Hours of Backup	Total Average watts

Calculation

Wattage of the appliance = Volt x Ampere = ……………. Watts

Inverter loss = Watts x 1.5 = …………….. AC Watts

Total AC load in watts = ………………

Total watts / day (watts x hour) = ………………

Battery selection chart

Inverter Rating VA	Battery voltage	Battery Ah	Backup time	Appliances
150-200	12	150	3Hr	1 Fan+1 Tube
250	12	150	3Hr	1 Fan+2 Tubes / TV
300-350	12	150	3Hr	2 Fans+2 Tubes/TV
400-450	24	150	3Hr	2Fans+4tubes or 2 Fans+2Tubes+TV
800	24	150	3Hr	4 Fans+4Tubes or 2 Fans+4Tubes+TV

2.7 Step Down Transformer

Step down transformers are designed to reduce electrical voltage. Their primary voltage is greater than their secondary voltage. Step down transformers convert electrical voltage from one level or phase configuration usually down to a lower level. They can include features for electrical isolation, power distribution, and control and instrumentation applications. Step down transformers typically rely on the principle of magnetic induction between coils to convert voltage and/or current levels.

2.8 Bridge Rectifier

When four/ more diodes are arranged in a way that it provides continuous single polarity output irrespective of the input polarity. It is mostly used to covert AC voltage into DC voltage; it is named as bridge rectifier. Bridge rectifier rectify the whole input AC wave from a two wire input thus providing more efficiency, less cost and weight in caparison to 3-wire input rectifier. The most important characteristic of any bridge rectifier is that output polarity is independent of input polarity. It is sometimes also called as "Graetz circuit" named after its German inventor Leo Graetz.

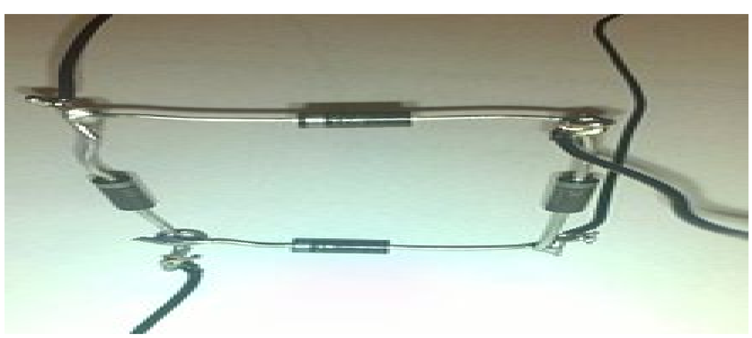

Figure 2.1: Bridge Rectifier

2.9 DPDT Relay

DPDT stands for "Double Pole Double Throw". It is an electromagnetic device used to separate two circuits electrically and connect them magnetically. They are often used to interface an electronic circuit, which works at a low voltage to an electrical circuit which works at a high voltage. Relays are available in different configuration of operating voltages like 6V, 9V, 12V, 24V etc.

There are two sections input and output. The input section consists of a coil with two pins which are connected to the ground and the input signal. The output section consists of contactors which connect or disconnect mechanically. The output section consists of six contactors with two sets. Each set has three changeover contacts, namely, normally open (NO), normally closed (NC) and common (COM). When no supply is given the COM is connected to NC. When the operating voltage is applied the relay coil gets energized and the COM changes contact to NO.

DPDT relay can be used to power with one device/appliance or another. While SPDT relay can only switch the output circuit between on and off states; a DPDT relay can also be used to change the polarity at the terminals of a device connected at output.

2.10 Solar Charge Controller

The solar charge controller is used with battery backup systems. The charge controller is an electronic voltage regulator that is used to limit the rate at which electric current is drawn in or out of the batteries. It fully charges the battery without permitting overcharge while preventing from reverse current flow. The overcharge or overvoltage may reduce the battery performance or lifespan and may pose a safety risk.

Figure 2.2: Solar Charge Controller

Figure 2.3: Power Supply Unit

2.11 Power Supply Unit

Power supply unit (PSU) gives low voltage regulated DC output power while rectifying AC voltage in order to power up DC devices. A switched mode supply is being used in personal computers all over the world. For few supplies user has to manually select the input power however there are also auto input power selector power supplies.

By regulated power supply we mean controlled output voltage/ current; irrespective of variations in load current or voltage supplied the controlled values are held almost constant. Power supply gets enough energy from its source which meets the power requirement of its own and the load as well. Power supply design dictates to get its energy from

a. Main power source example is normal AC to DC converter

b. Devices that store energy like batteries.

Power supply can be used as separate device or as imbedded device.

2.12 Voltage Regulator

An electronic device which maintains steady voltage level automatically at the output. There are two designs one with forward feedback which is also a simple one, second design includes a controlled negative feedback as well. It can be electromechanical or electronic based component. According to its design, it can be implemented to regulate single or multiple AC/ DC voltages.

Voltage regulator ICs are present in all types of power supplies that are used to give power to the voltage sensitive devices.

LM78XX series is a three terminal voltage regulators with positive output. TO-220 package is also available which gives us several fixed voltage outputs which makes them useful to be used in a large number of applications. Internal current limiting, safe operating area protection and thermal shut down are the qualities which make it indestructible. With provision of enough heat sinking can give above 1A of output current. Primarily they are designed as fixed voltage regulators but can be used with other electronic components to get adjustable voltages/ currents. LM 7805 is on such type of voltage regulator which can give 5v output for the purpose of mobile phone charging. Data sheet attached as Annexure A.

CHAPTER 3

INTELLIGENCE

3.1 PIC Microcontroller

PIC microcontrollers are electronic circuits that are used to perform various controlling tasks. Various programming techniques including C language, assembly language are used to program a controller. They are used in many electronic devices such as alarm systems, computer control system, security systems, devices which include timers etc. Many types of PIC controllers exist and vary in the range of memory. These are programmed and simulated by Circuit Wizard software. Memory units, I/O interfaces and processor are all exist on a single piece of chip. It can be used to read and write data on electronic devices. In our project we have used PIC16F877a, The PIC16F877a, is a low-power, high-performance microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using PIC's high-density non-volatile memory technology and is compatible with the industry-standard and its silent features are as follow.

a. Operating frequency of 20MHz (200 ns instruction cycle)

b. 8K Flash Program Memory

c. 368 Bytes of Data Memory

d. 256 bytes of EEPROM Data Memory

e. 33 Input and Output Ports (Ports A,B,C,D,E)

3.2 Microcontroller Architecture

a. Peripheral interface controllers are a family of microcontrollers by Microchip technology.

b. To programmed a PIC controller is much easier with many attractive features and are suitable for many applications.

c. Use of separated program and data memories.

d. Separate busses for data and address allow increased data flow to and from the CPU.

e. Width of data and address busses vary from each other.

f. Harvard architecture is used in PIC16F877 which makes it much efficient then von-Neumann architecture.

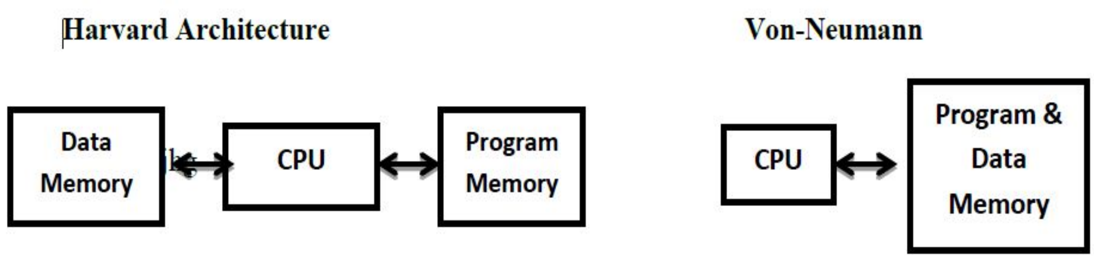

Figure 3.1: Comparisons between Architecture

Figure 3.2: PIC 16F Microcontroller

3.2.1 Schematic and Pin Assignment

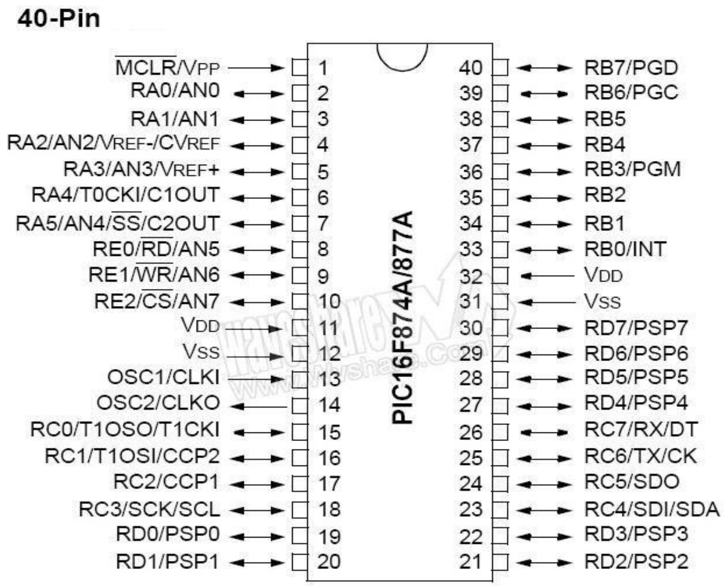

Figure 3.3: Schematic and Pin Assignment

Feature and characteristics are given in Annexure B

3.3 Current Sensor

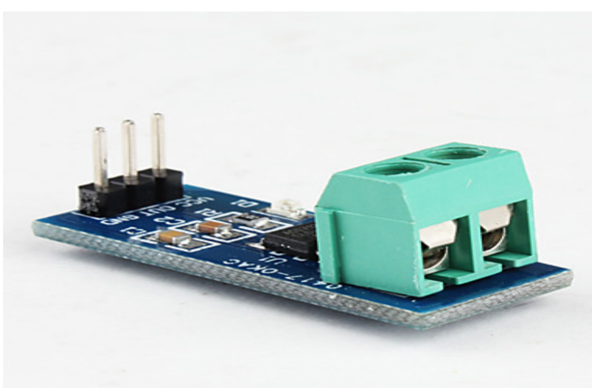

Figure 3.4: Current Sensor (ACS 712)

Current sensor **IC ACS712** provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. It consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.

The output of the device has a positive slope ($>V_{IOUT(Q)}$) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sensing. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the sensor IC leads (pins 5 through 8). This allows the ACS712 current sensor IC to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques. Data Sheet is attached as Annexure C.

3.3.1 Features And Benefits

a. Low-noise analog signal path

b. Device bandwidth is set via the new FILTER pin

c. 5 μs output rise time in response to step input current

d. 80 kHz bandwidth

e. Total output error 1.5% at TA = 25°C

f. Small footprint, low-profile SOIC8 package

g. 1.2 mΩ internal conductor resistance

h. 2.1 kVRMS minimum isolation voltage from pins 1-4 to pins 5-8

i. 5.0 V, single supply operation

j. 66 to 185 mV/A output sensitivity

k. Output voltage proportional to AC or DC currents

l. Factory-trimmed for accuracy

m. Extremely stable output offset voltage

n. Nearly zero magnetic hysteresis

o. Ratio metric output from supply voltage

3.4 Connection Topologies

When two or more energy sources are combined it is called a hybrid system. In order to combine the energy of these sources certain techniques are used, known as connection topologies. Two energy sources cannot be combined until matched. So these topologies help us in better understanding of combining energy sources. Solar and WAPDA energy is combined in this system and energy storage bank i.e. battery is also incorporated in this project.

WAPDA provides AC and Solar panels provide DC power directly. These energy sources need to be connected at some point and somewhere before the loads are supplied. In this section different connection topologies are discussed for easy understanding of intelligent hybrid system.

3.5 AC/DC-Coupled Hybrid Power Systems

For the hybrid power system, generally there are three accepted categories of hybrid system technological configurations. According to the voltage they are coupled with each other and the load. These are:

a. AC-coupled hybrid power systems

b. DC-coupled hybrid power systems

c. Mixed-coupled hybrid power systems

3.5.1 AC-Coupled Hybrid Power Systems

With this type of configuration, the different HPSs are connected at the AC-bus with the load. The AC coupled HPSs are further divided into two sub-topologies.

a. Centralized AC-coupled HPSs

b. Distributed AC-coupled HPSs

These two sub-topologies are explained below in order to understand the insight of the overall system.

3.5.1.1 Centralized AC-coupled Hybrid Power Systems

An AC-coupled HPS is said to be centralized when all the energy conversion systems constituting it are connected to a main AC-bus before being connected to the load.

The WAPDA provides AC powers, thus they can be directly connected to the main AC-bus . The PV-array produces DC power and an inverter must be used before it is coupled onto the main AC-bus. The charging or discharging of the battery bank with a DC current seeks for a bidirectional inverter must be used.

3.5.1.2 Distributed AC-coupled Hybrid Power Systems

In this topology, the power sources need not to be connected to one common bus. These sources may not also be installed close to each other i.e. the sources are distributed in different geographical locations and each source is connected to the load separately. The DC powers obtained from the PV-system and the battery need to be converted to AC before feeding the AC load, thus appropriate inverters are required.

3.5.2 DC-coupled Hybrid Power Systems

In DC-coupled HPSs configuration, all the Energy conversion systems are connected to a DC main bus before being connected to the load. Connection with the AC loads is done through a main inverter. This configuration is also termed as centralized DC-bus topology.

3.5.3 Mixed-coupled Hybrid Power Systems

It is also possible to combine AC-coupled and DC-coupled HPSs and form mixed HPSs. With this type of configuration, some of the energy sources are connected with the battery bank at the DC-bus and some are connected at the AC-bus.

A comparison of mixed, AC- and DC-coupled systems show that AC-coupled systems have numerous advantages such as standardized coupling of different components, off-the-shelf grid components can be used, simplified design and operation of island grids, compatibility with existing grids, reduction of system costs, increased reliability of electrical power supply as well as expandability. DC integration in many cases involves high costs for engineering, hardware, repair and maintenance; and more importantly power system expandability for covering needs of growing energy and power demand is also difficult with DC integration.

3.6 Series-Parallel Hybrid Power Systems

Based on how the load is supplied from the energy sources, two broad classes of configurations are explained. These are

a. series hybrid systems

b. parallel hybrid systems

From this point of view, the AC/DC coupled or mixed HPS schemes, which are explained earlier, can be included within these classes.

3.6.1 Series Hybrid Power Systems

In the series HPSs scheme, all the DC power is fed into the battery. Thus, the power of WAPDA and solar PV-array are used to charge a battery bank before supplied to the load. Therefore, each component has to be equipped with an individual charge controller and in the case of WAPDA with a rectifier.

Then, the inverter will convert the DC power stored in the battery bank to AC at standard level of voltage and frequency and then supplies to the AC load. The charge regulators used can prevent overcharging of the battery bank from the PV generators when the renewable power exceeds the load demand and the batteries are fully charged. In a similar fashion, they will protect the battery bank from deep discharge when demand exceeds the supply, if it happens.

This type of configuration is also termed as Centralized DC-bus topology in the sense that all the energy generators and the battery are connected at the DC-bus and the AC load is supplied via a single point. Here, it has to be noted that the AC power from the WAPDA must be converted into DC by utilizing AC/DC converters or rectifiers before power is delivered to the DC bus where the battery bank is connected. This configuration type results in relatively simple implementation. A major drawback with this configuration is that most of the energy passes through the battery, it results in increased cycling of the battery bank and reduces system efficiency.

3.6.2 Parallel Hybrid Power Systems

In parallel hybrid system configuration WAPDA and Solar power supply a portion of the load demand directly. There are two types of sub-configurations of this hybrid system. These are the DC-coupled and AC-coupled configurations.

The DC-coupling configuration system utilizes a bi-directional inverter, which is operated in parallel with the WAPDA and can act as inverter and rectifier/battery charger. It is a DC-coupled configuration hybrid system in a sense that the energy sources are connected together at the DC bus to the battery and supply the AC load via the bi-directional inverter. Here, the AC power from the WAPDA must be converted into DC by utilizing AC/DC converters or rectifiers before power is delivered to the DC-bus.

The parallel hybrid power system with DC-coupling configuration can further be improved by connecting all of the energy sources to the AC-bus to perform an AC-coupling configuration. The load can be supplied from the Solar energy supplies in parallel with the WAPDA. A bidirectional inverter is utilized here such that the battery can either supply the load or be charged depending upon the load requirement and the status of other energy sources. Over and above, the DC power obtained from the PV-array system and battery must be converted to AC before it is fed into the AC-bus. This type of configuration is also referred to as centralized AC-bus topology in a sense that all the energy sources are connected at the AC-bus and the load is supplied at a single point.

CHAPTER 4

DESIGN AND DEVELOPMENT

4.1 Description

The project is designed to maximize the use of solar energy and lower the unit cost of electricity by getting maximum power for the connected load from solar and minimize the WAPDA source usage. The man theme of project is that in presence of Solar power all the load will be powered from solar panel and battery connected will be charged from solar panel, if solar power gets down or absent than connected load will be powered from battery, battery until there is charge of 30 % available, if charge of battery becomes less than 30 than load will be disconnected from battery and will be shifted to WAPDA supply. Again when the charge becomes up to 70% load will be shifted to battery. If both solar power and battery is down than load will automatically shifted to WAPDA supply. Solar panel is installed for limited load, if the load exceeds from its limit than the excess load will be shifted to WAPDA

4.2 Load Sharing Panel

This panel is composed of three parts: (Proteus file is attached as per Annexure D)

a. Current Sensor

b. Microcontroller

c. Relay Switches

4.2.1 Current Sensor

It will sense the available current from solar panels and will forward its value to microcontroller.

4.2.2 Microcontroller (PIC 16F)

Microcontroller is the brain of this system. It reads the value from current sensor and gives the decision as to how much load has to be supported through solar power and would shift remaining load on Grid power. Decision will be implemented using relays.

4.2.3 DPDT Relays

Load is distributed through relay switches which are connected to solar and grid, and controlled via distribution panel. They will work in following formats with respect to the loads attached to them.

a. When we have peak current value from solar panels sufficient to drive the complete load , load will be driven on solar power.
b. When solar current is less than required load attached, Solar plus Grid power.
c. When solar current is less than the threshold value, complete load will be driven through Grid power. (as a normal UPS – bypass circuit)
d. In the absence of solar and Grid power load will be driven on battery.

4.3 Methodology

4.3.1 Solar Panel Monitoring

Voltage and current of solar panel are monitored through microcontroller and displayed upon LCD. Current censor IC ACS712 is used to monitor the current from solar panels. If the input current from solar panel is greater than or equal to the required current of load, than only solar panel will be used to run the load. If the input current is less than the desired output current than the rest of the current will be drained from WAPDA or grid current.

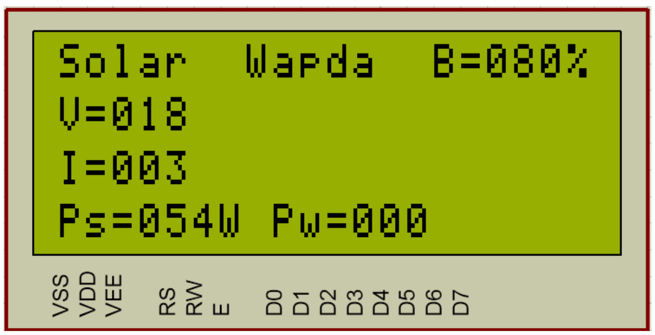

Figure 4.1: Solar Panel Monitoring

4.3.2 Output Current Monitoring

The output current is monitored through ACS 712 and microcontroller will compare both the currents i.e input and output current. If output current requirement is more than input current from solar than only excess current will be drawn from WAPDA. Otherwise the complete load will be managed by solar current.

4.3.3 Battery Monitoring

Battery voltages are measured by microcontroller, if terminal voltage of battery is 11.8V = 0% means battery is fully discharged and when terminal voltages is 13.8V = 100% charged. In programming there is check upon battery terminal voltages when it becomes less than 12.4 = 30% the batter will stop supplying power to load, again when voltages rises to 13.2 = 70% battery will continue supplying power to load connected. Also there is over charging protection for battery. Moreover battery is used as last priority i.e when there is no solar and WAPDA than battery will completely take over the load.

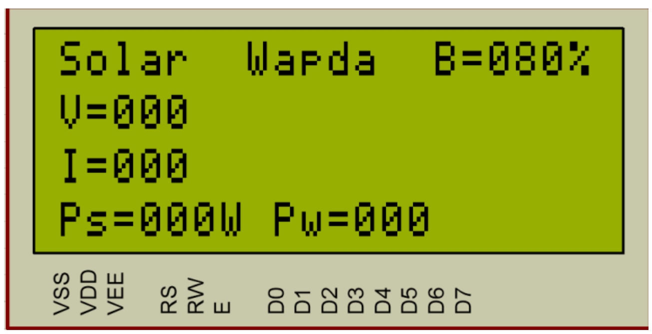

Figure 4.2: Battery Monitoring

4.3.4 Microcontroller Management

Microcontroller is managing the complete circuit. It will monitor input current from solar and desired output current. If solar panel is providing the current greater than the load requirement than microcontroller will switch on first and third DPDT relay. If solar panel is unable to run the load completely than microcontroller will switch on DPDT relay two as well in order to share the excess load requirements from WAPDA. At night hours when there is no solar available than forth DPDT relay will be switched on i.e bypass relay, inorder to improve the efficiency of system. When there is no solar and no WAPDA available than third DPDT relay will be on i.e. battery backup relay.

4.3.5 Solar And WAPDA Mixing

4.3.5.1 Solar Supply Parallel To WAPDA Supply

As there is phase angle (Power factor) (when converted into AC) difference between solar supply and WAPDA supply, to overcome this issue WAPDA supply is converted into DC by using step down transformer and rectifier.

4.3.5.2 Making Solar Supply At High Potential

To power the load maximum from solar energy solar source must be at high potential for which we have made solar source voltage greater than 18V and WAPDA source less than 18V. Solar source will become prominent and take the load. Through microcontroller only excess load will be shared from WAPDA.

4.3.6 Sharing Of Sources (Supplies)

For sharing of sources Double Pole Double Throw (DPDT) relays are used. It is an electromagnetic device used to separate two circuits electrically and connect them magnetically. They are often used to interface an electronic circuit, which works at a low voltage to an electrical circuit which works at a high voltage. Relays are available in different configuration of operating voltages like 6V, 9V, 12V, 24V etc.

Four DPDT relays are used. First DPDT relay is on when the load is completely run by solar panel. Second DPDT relay is of WAPDA and it will be on along with first relay if load is shared by solar energy and WAPDA. And only excess load requirements are provided by second relay. Third relay is of battery, when there is no solar and WAPDA than the load will run by battery backup energy. Battery is also used with solar so overcome the spikes generated by solar panels and provide a steady current to the load. The forth relay is the bypass relay for WAPDA. When there is no solar energy at night and no WAPDA energy due to load shedding or any other reason than the bypass relay will be on. The purpose of this relay is to improve efficiency of UPS, because when we convert WAPDA into DC through transformer and rectifier, and again convert it into AC through inverter than there is a decrease in efficiency. So in bypass mode WAPDA current will be directly provided to load without converting and reconverting.

CHAPTER 5

5.1 Analysis

The paper shows the complete working and concept of "Microcontroller Based Solar Powered Intelligent UPS". In this it is discussed that why Pakistan need such a system. Previous concepts are discussed which provide basis for this new system. A load sharing panel was developed to monitor the the current from different sources and than share them intelligently by using maximum the source which is low cost. This system is very helpful for developing countries as it puts less burden on people and provides a relief to government as well. Further developments in this system, as discussed next, will provide a revolutionary change in power management system for Pakistan.

5.2 Advantages

- Cost effective
- Reliable
- Auto sharing of loads
- Charging of battery from two different sources
- Over charge protection for battery
- Enhance battery life and efficiency

5.3 Recommendations For Future Work

Though a lot of work has been done in recent years but there is always a room for improvement. Solar energy must be utilized in a more efficient way, by introducing a grid-tied system. In which the extra energy from solar will be transported back to the main system by reverse metering and the customers will be paid for the energy they energy they have supplied to the system.

Data logging can be introduced through wifi or GSM, which would enable the user of intelligent UPS to manage its load from anywhere. If solar is providing less energy than the user can switch off extra load, or any other facility can be provided to user.

In order to increase efficiency the energy sources can be shared at AC level instead of DC level by matching the phase, frequency and amplitude of these sources.

5.4 Conclusion

Energy crises in developing countries and especially in Pakistan became the motivational factor in the development of Microcontroller based intelligent solar powered chargeable ups. In addition to that the economic condition of people of these countries is so that they cannot afford high billing. So an out of box solution is presented in the form of intelligent UPS. The intelligent mixing of energy sources is a critical task which was accomplished through microcontroller. Input from solar panels and output requirement is monitored through current sensor and then the decision is taken by microcontroller and it is implemented through DPDT relays. In this way WAPDA is just used to share excess load requirements. This solution will provide a great relief not only to the government of developing countries but also to the people of these countries. By further adding the features recommended in future work this solution will be cheaper and more users interactive.

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APPENDIX A

PROGRAMMING CODE

```
#include <pic.h> //header define pic family  PIC16F877A


//    Configuration
//=================================================================
=============================================
__CONFIG ( 0x3F32 );                            // Set the
configuration bits for the microcontroller.


//    Define
//=================================================================
=============================================
#define    rs                    RB7                    // RS pin
of the LCD.
#define    e                     RB6                    // E pin
of the LCD.
#define    d7                    RC3                    // DB7 pin
of the LCD.
#define    d6                    RC4                    // DB6 pin
of the LCD.
#define    d5                    RC5                    // DB5 pin
of the LCD.
#define    d4                    RB1                    // DB4 pin
of the LCD.
#define    d3                    RB2                    // DB3 pin
of the LCD.
#define    d2                    RB3                    // DB2 pin
of the LCD.
#define    d1                    RB4                    // DB1 pin
of the LCD.
#define    d0                    RB5                    // DB0 pin
of the LCD.

#define LED                      RB0                    // RUN
switch.
#define LED1            RD2              //
#define LED2            RD3

//    Global Variables
//=================================================================
=============================================
unsigned char V = 0;
unsigned int Vg = 0;
unsigned char I = 0;
unsigned int Ig = 0;
unsigned int Pg = 0;
```

```
unsigned char BM = 0;


//    Function Prototypes
//=================================================================
============================================


unsigned char ai_read(unsigned char an_sel);
void delay(unsigned long data);
void e_pulse(void);
void lcd_clr(void);
void lcd_goto(unsigned char data);
void send_char(unsigned char data);
void send_config(unsigned char data);
void send_string(const char *s);
void send_dec(unsigned long data,unsigned char num_dig);


//    Main Function
//=================================================================
============================================
void main(void)
{
     unsigned long rec_data=0;
float P=0.00;


     // Set the I/O direction.
     TRISB = 0b00000000;                         // Configure
PORTB I/O direction.  /// 0 for output and 1 for input selection
     TRISC = 0b00000000;                         // Configure
PORTC I/O direction.
     TRISA = 0b11111111;                         // Configure
PORTA I/O direction.
    TRISD = 0b00000000;

     // Initialize the ports.
     PORTB = 0;
     PORTC = 0;
    PORTD=0;

     // Setup ADC.
     ADCON1 = 0b01000000;                   // Set ADx pin
digital I/O.
     ADCON0 = 0b00000001;                   // A/D converter
module powered up.

     //Configure the LCD
     send_config(0b00000001);               // Clear the LCD.
```

```
      send_config(0b00000010);              // Return cursor to
home.
      send_config(0b00000110);              // Entry mode -
cursor increase 1.
      send_config(0b00001100);              // Display on, cursor
off and cursor blink off.
      send_config(0b00111000);              // Function set.

lcd_goto(0);                                // Put cursor on
position 0.
      send_string("CAPTAIN RIZWAN");    //  I use only one column
and count 80 coulmns only and discard rows
    lcd_goto(20);
    send_string("CAPTAIN ASHAR");
    lcd_goto(40);
    send_string("CAPT HAIDER");
    lcd_goto(60);

    send_string("CAPT SIKANDAR");
delay(500000);
      lcd_clr();                                 // Clear the
LCD.
      lcd_goto(0);                               // Put cursor on
position 0.
      send_string("Solar");
lcd_goto(7);                                // Put cursor on
position 0.
      send_string("Grid");
      lcd_goto(20);                              // Put cursor on
position 11.
      send_string("V=");                         // Send string
"V=".
      lcd_goto(28);
send_string("V=");                          // Send string "V=".
      lcd_goto(40);                              // Put cursor on
position 20.
      send_string("I=");                         // Send string
"I=".
lcd_goto(48);                               // Put cursor on
position 20.
      send_string("I=");
lcd_goto(68);                               // Put cursor on
position 20.
      send_string("Pg=");
      lcd_goto(14);                              // Put cursor on
position 26.
      send_string("B=");                         // Send string
"B=".
      lcd_goto(19);                              // Put cursor on
position 26.
      send_string("%");
```

```
        lcd_goto(60);
      send_string("Ps=");                                // Send string
"B=".
      lcd_goto(66);                                      // Put cursor on
position 26.
      send_string("W");

      while(1)
      {
      //    rec_data = (unsigned long)ai_read(0) * 3600 / 255;
      //    lcd_goto(6);

      //    send_dec(rec_data, 4);


            V = ai_read(2);    // solar voltage is connected to
channel 2
            lcd_goto(22);

            send_dec(V, 3);
delay(10);
      Vg = ai_read(4);  // channel 4
Vg=(Vg*220)/255;
            lcd_goto(31);

            send_dec(Vg, 3);
delay(10);



            I = ai_read(0);  // solar current
I=(I*20)/255;
            lcd_goto(42);

            send_dec(I, 3);
delay(10);
                  Ig = ai_read(1);
Ig=(Ig*20)/255;
            lcd_goto(51);

            send_dec(Ig, 3);
delay(10);
Pg=Vg*Ig;
  lcd_goto(71);
            send_dec(Pg, 3);

            BM = ai_read(3);

            lcd_goto(16);

            send_dec(BM, 3);
```

```
delay(10);
P=V*I;
lcd_goto(63);
           send_dec(P, 3);
     if(BM<30)
{
motor_1=1;

LED=1;
LED1=0;
delay(5000);
}
if(BM>70)
{
motor_2=1;
LED=0;
LED1=1;
LED2=0;
delay(5000);
}
if(P<30)  // solar power less than 30 shut down solar and shifted
towards mains
{
LED2=1;
LED1=0;
delay(5000);
}
if(P>30)
{
LED2=0;
//LED1=0;
delay(5000);
}




           }
}


// Read the ADC.
unsigned char ai_read(unsigned char an_sel)
{
     if(an_sel == 0)            ADCON0 = 0b00000001;  // AN0 is
selected, set ADCON0.
     else if(an_sel == 1)  ADCON0 = 0b00001001;  // AN1 is
selected, set ADCON0.
     else if(an_sel == 2)  ADCON0 = 0b00010001;  // AN2 is
selected, set ADCON0.
```

```
	else if(an_sel == 3)  ADCON0 = 0b00011001;  // AN3 is
selected, set ADCON0.
	else if(an_sel == 4)  ADCON0 = 0b00100001;  // AN4 is
selected, set ADCON0.

	delay(100);


	ADGO=1;

	while(ADGO==1);

	if(an_sel == 0 ) return ADRESH;
else if(an_sel==1)    return ADRESH;
else if(an_sel==2)
{
return ADRESH * 20 / 255;
}
	else if(an_sel==3)
{
 return ADRESH * 100 / 255;
}
else if(an_sel==4)  return ADRESH;

//else return ADRESH * 100 / 255;
}

// Delay function. The delay time depends on the given value.
void delay(unsigned long data)
{
	for( ; data > 0; data -= 1);
}


// Send a pulse to the E pin of the LCD.
void e_pulse(void)
{
	e = 1;
	delay(50);
	e = 0;
	delay(50);
}




// Send the configuration the the LCD.
void send_config(unsigned char data)
{
	unsigned char test;
	unsigned char i;
```

```
    rs = 0;
                // Clear RS pin for config mode.
    for(i = 0; i < 8; i++)
          // Loop for 8 times.
    {
          test = (data >> i) & 0b00000001;
    // Shift data to right.
          switch(i)
          // Detect a byte of data one bit by one bit.
          {
                case 0:
                      if(test == 1)    d0 = 1;
                      else             d0 = 0;
                case 1:
                      if(test == 1)    d1 = 1;
                      else             d1 = 0;
                case 2:
                      if(test == 1)    d2 = 1;
                      else             d2 = 0;
                case 3:
                      if(test == 1)    d3 = 1;
                      else             d3 = 0;
                case 4:
                      if(test == 1)    d4 = 1;
                      else             d4 = 0;
                case 5:
                      if(test == 1)    d5 = 1;
                      else             d5 = 0;
                case 6:
                      if(test == 1)    d6 = 1;
                      else             d6 = 0;
                case 7:
                      if(test == 1)    d7 = 1;
                      else             d7 = 0;
          }
    }
    delay(50);
    e_pulse();
}


// Clear the LCD.
void lcd_clr(void)
{
    send_config(0x01);
    delay(600);
}
```

```
void lcd_goto(unsigned char data)
{
	if(data < 20)
	{
		send_config(0x80 + data);
	}
else if(data>19&&data<40)
	{
		data = data - 20;
		send_config(0xc0 + data);
	}
else if(data>39 && data<60)
	{
		data = data -40;
		send_config(0x94 + data);
	}
else if(data>59 && data<80)
{
data=data-60;
send_config(0xd4 + data);
}
	delay(200);
}


// Send a character to the LCD.
void send_char(unsigned char data)
{
	unsigned char test;
	unsigned char i;
	rs = 1;
			// Set rs for data mode.
	for(i = 0; i < 8; i++)
		// Loop for 8 times.
	{
		test = (data >> i) & 0b00000001;
	// Shift data to right.
		switch(i)
		// Detect data one bit by one bit.
		{
			case 0:
				if(test == 1)	d0 = 1;
				else		d0 = 0;
			case 1:
				if(test == 1)	d1 = 1;
				else		d1 = 0;
			case 2:
				if(test == 1)	d2 = 1;
				else		d2 = 0;
			case 3:
```

```
                    if(test == 1)    d3 = 1;
                    else             d3 = 0;
               case 4:
                    if(test == 1)    d4 = 1;
                    else             d4 = 0;


               case 5:
                    if(test == 1)    d5 = 1;
                    else             d5 = 0;
               case 6:
                    if(test == 1)    d6 = 1;
                    else             d6 = 0;
               case 7:
                    if(test == 1)    d7 = 1;
                    else             d7 = 0;
          }
     }
     delay(50);
     e_pulse();
}


// Send a string to the LCD.
void send_string(const char *s)
{
     unsigned char i = 0;
     while (s && *s) send_char (*s++);
     delay(300);
}


// Send a decimal number to the LCD.
void send_dec(unsigned long data, unsigned char num_dig)
{
     if(num_dig >= 10)
     {
          data = data % 10000000000;
          send_char(data / 1000000000 + 0x30);
     }
     if(num_dig >= 9)
     {
          data = data % 1000000000;
          send_char(data / 100000000 + 0x30);
     }
     if(num_dig >= 8)
     {
          data = data % 100000000;
          send_char(data / 10000000 + 0x30);
     }
     if(num_dig >= 7)
```

```
        {
              data = data % 10000000;
              send_char(data / 1000000 + 0x30);
        }
        if(num_dig >= 6)
        {
              data = data % 1000000;
              send_char(data / 100000 + 0x30);
        }



        if(num_dig >= 5)
        {
              data = data % 100000;
              send_char(data / 10000 + 0x30);
        }
        if(num_dig >= 4)
        {
              data = data % 10000;
              send_char(data / 1000 + 0x30);
        }
        if(num_dig >= 3)
        {
              data = data % 1000;
              send_char(data / 100 + 0x30);
        }
        if(num_dig >= 2)
        {
              data=data % 100;
              send_char(data / 10 + 0x30);
        }
        if(num_dig >= 1)
        {
              data = data % 10;
              send_char(data + 0x30);
        }
  }
```

APPENDIX B

TIME LINE

SERIAL	WORK DONE	TIME
1	Research on Solar Panels and available Hybrid UPS	4 weeks
2	Construction/Designing of Control circuit board	8 weeks
3	Integration Of Inverter with Control Card	2 Weeks
4	Integration Of Other Modules with Control Card	2 weeks
5	Programming of microcontroller	2 week
6	Testing and Evaluation	2 week
7	Preparation of Evaluation reports and other documentation	2 weeks

COST ON PROJECT

SERIAL	WORK DONE	COST
1	Construction/Designing of Control circuit board	Rs 21000
2	Transformer	Rs 2000
3	DC/AC Inerter	Rs 5000
4	Preparation of Evaluation reports and other documentation	Rs 7000
5	**Total Cost**	**RS 35000**

APPENDIX C

Extended Title: Design and development a microcontroller based, low cost, efficient and intelligent solar powered chargeable UPS

Brief Description of The Project / Thesis with Salient Specs:
 	
➢ Being intelligent means: it should sense/compare the load and the battery charging rate and make a deliberate decision to switchover the excess solar power to run the load along with battery charging.
➢ It provides much needed flexibility and improves the efficiency.
➢ We took two sources solar and WAPDA and attached their input firstly to a sensing circuit which sense amount of current available from each source. Their values are displayed on LED.
➢ Then current sensor attached with a microcontroller which detects that how much each source is providing the current and how much is the requirement of load.
➢ DPDT relays are then operated by microcontroller to derive the load with following priorities of sources to run the attached load
    ➢ Solar
    ➢ Solar + Grid
    ➢ Grid
    ➢ Batteries

Scope of Work : To develop a low cost, integrated UPS which should use solar power as primary source of energy during day time, share the solar power with WAPDA when solar power is low and should automatically switch over to WAPDA power during night.
Academic Objectives : ➢ To learn about the hybrid renewable energy resources. ➢ To know the potentials of this system in energy starved countries. ➢ Potentials of such systems in Pakistan.

Application / End Goal Objectives : This integrated UPS would help in partially offsetting the current energy crisis by incorporating the solar power generated through small panels installed at homes in distributed configuration.
Previous Work Done on The Subject : NO
Material Resources Required : ➢ Solar Panel of 150W ➢ DC/AC Inverter ➢ Transformer ➢ PIC Controller (16F877a) ➢ LCD Display ➢ Proteus software for Simulations
No of Students Required : 4
Special Skills Required : NO

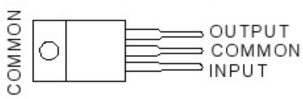
DATA SHEET OF VOLTAGE REGULATOR LM7800

μA7800 SERIES
POSITIVE-VOLTAGE REGULATORS

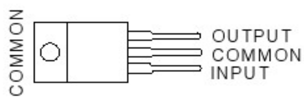
SLVS056J – MAY 1976 – REVISED MAY 2003

- 3-Terminal Regulators
- Output Current up to 1.5 A
- Internal Thermal-Overload Protection
- High Power-Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation

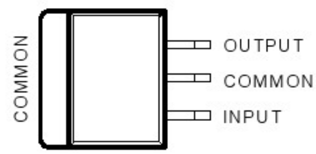
KC (TO-220) PACKAGE
(TOP VIEW)



KCS (TO-220) PACKAGE
(TOP VIEW)



KTE PACKAGE
(TOP VIEW)



description/ordering information

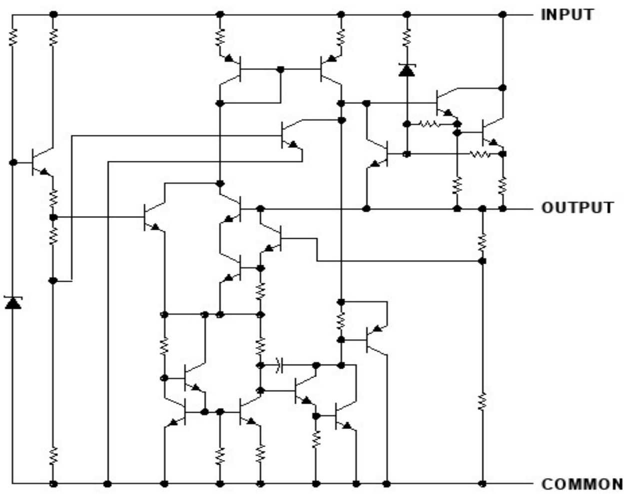
This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

ORDERING INFORMATION

T_J	$V_{O(NOM)}$ (V)	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	5	POWER-FLEX (KTE)	Reel of 2000	μA7805CKTER	μA7805C
		TO-220 (KC)	Tube of 50	μA7805CKC	μA7805C
		TO-220, short shoulder (KCS)	Tube of 20	μA7805CKCS	
	8	POWER-FLEX (KTE)	Reel of 2000	μA7808CKTER	μA7808C
		TO-220 (KC)	Tube of 50	μA7808CKC	μA7808C
		TO-220, short shoulder (KCS)	Tube of 20	μA7808CKCS	
	10	POWER-FLEX (KTE)	Reel of 2000	μA7810CKTER	μA7810C
		TO-220 (KC)	Tube of 50	μA7810CKC	μA7810C
	12	POWER-FLEX (KTE)	Reel of 2000	μA7812CKTER	μA7812C
		TO-220 (KC)	Tube of 50	μA7812CKC	μA7812C
		TO-220, short shoulder (KCS)	Tube of 20	μA7812CKCS	
	15	POWER-FLEX (KTE)	Reel of 2000	μA7815CKTER	μA7815C
		TO-220 (KC)	Tube of 50	μA7815CKC	μA7815C
		TO-220, short shoulder (KCS)	Tube of 20	μA7815CKCS	
	24	POWER-FLEX (KTE)	Reel of 2000	μA7824CKTER	μA7824C
		TO-220 (KC)	Tube of 50	μA7824CKC	μA7824C

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

schematic



absolute maximum ratings over virtual junction temperature range (unless otherwise noted)†

Input voltage, V_I: µA7824C . . . . 40 V
All others . . . . 35 V
Operating virtual junction temperature, T_J . . . . 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . 260°C
Storage temperature range, T_{stg} . . . . –65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

package thermal data (see Note 1)

PACKAGE	BOARD	θ_{JC}	θ_{JA}
POWER-FLEX (KTE)	High K, JESD 51-5	3°C/W	23°C/W
TO-220 (KC/KCS)	High K, JESD 51-5	3°C/W	19°C/W

NOTE 1: Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

recommended operating conditions

			MIN	MAX	UNIT
V_I	Input voltage	μA7805C	7	25	V
		μA7808C	10.5	25	
		μA7810C	12.5	28	
		μA7812C	14.5	30	
		μA7815C	17.5	30	
		μA7824C	27	38	
I_O	Output current			1.5	A
T_J	Operating virtual junction temperature	μA7800C series	0	125	°C

electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	μA7805C MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, V_I = 7 V to 20 V, $P_D \leq$ 15 W	25°C	4.8	5	5.2	V
		0°C to 125°C	4.75		5.25	
Input voltage regulation	V_I = 7 V to 25 V	25°C		3	100	mV
	V_I = 8 V to 12 V			1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	62	78		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Output resistance	f = 1 kHz	0°C to 125°C		0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		–1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40		μV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.2	8	mA
Bias current change	V_I = 7 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

† Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-μF capacitor across the input and a 0.1-μF capacitor across the output.

ANNEXURE B

Features And characteristics of Microcontroller PIC16F

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

SPECIAL FEATURES OF THE CPU

All PIC16F87XA devices have a host of features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving operating modes and offer code protection. These are:

- Oscillator Selection
- Reset
  - Power-on Reset (POR)
  - Power-up Timer (PWRT)
  - Oscillator Start-up Timer (OST)
  - Brown-out Reset (BOR)
- Interrupts
- Watchdog Timer (WDT)
- Sleep
- Code Protection
- ID Locations
- In-Circuit Serial Programming
- Low-Voltage In-Circuit Serial Programming
- In-Circuit Debugger

PIC16F87XA devices have a Watchdog Timer which can be shut-off only through configuration bits. It runs off its own RC oscillator for added reliability.

There are two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in Reset until the crystal oscillator is stable. The other is the Power-up Timer (PWRT), which provides a fixed delay of 72 ms (nominal) on power-up only. It is designed to keep the part in Reset while the power supply stabilizes. With these two timers on-chip, most applications need no external Reset circuitry.

Sleep mode is designed to offer a very low current power-down mode. The user can wake-up from Sleep through external Reset, Watchdog Timer wake-up or through an interrupt.

Several oscillator options are also made available to allow the part to fit the application. The RC oscillator option saves system cost while the LP crystal option saves power. A set of configuration bits is used to select various options.

Additional information on special features is available in the PICmicro® Mid-Range MCU Family Reference Manual (DS33023).

Configuration Bits

The configuration bits can be programmed (read as '0'), or left unprogrammed (read as '1') to select various device configurations. The erased or unprogrammed value of the Configuration Word register is 3FFFh. These bits are mapped in program memory location 2007h.

It is important to note that address 2007h is beyond the user program memory space which can be accessed only during programming.

17.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Ambient temperature under bias .... -55 to +125°C

Storage temperature .... -65°C to +150°C

Voltage on any pin with respect to VSS (except VDD, $\overline{MCLR}$. and RA4) .... -0.3V to (VDD + 0.3V)

Voltage on VDD with respect to VSS .... -0.3 to +7.5V

Voltage on $\overline{MCLR}$ with respect to VSS **(Note 2)** .... 0 to +14V

Voltage on RA4 with respect to Vss .... 0 to +8.5V

Total power dissipation **(Note 1)** 1.0W

Maximum current out of VSS pin .... 300 mA

Maximum current into VDD pin .... 250 mA

Input clamp current, IIK (VI < 0 or VI > VDD) .... ± 20 mA

Output clamp current, IOK (VO < 0 or VO > VDD) .... ± 20 mA

Maximum output current sunk by any I/O pin .... 25 mA

Maximum output current sourced by any I/O pin .... 25 mA

Maximum current sunk by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sunk by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Note 1: Power dissipation is calculated as follows: Pdis = VDD x {IDD - ∑ IOH} + ∑ {(VDD - VOH) x IOH} + ∑(VOl x IOL)

2: Voltage spikes below VSS at the $\overline{MCLR}$ pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$ pin rather than pulling this pin directly to VSS.

3: PORTD and PORTE are not implemented on PIC16F873A/876A devices.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

ANNEXURE C

ACS712

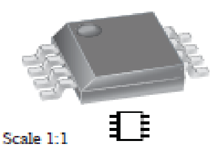
Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 2.1 kVRMS Isolation and a Low-Resistance Current Conductor

Features and Benefits

- Low-noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5 µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at T_A = 25°C
- Small footprint, low-profile SOIC8 package
- 1.2 mΩ internal conductor resistance
- 2.1 kVRMS minimum isolation voltage from pins 1-4 to pins 5-8
- 5.0 V, single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Nearly zero magnetic hysteresis
- Ratiometric output from supply voltage

TÜV America
Certificate Number:
U8V 06 05 54214 010

Package: 8 Lead SOIC (suffix LC)



Approximate Scale 1:1

Description

The Allegro™ ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch-mode power supplies, and overcurrent fault protection. The device is not intended for automotive applications.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.

The output of the device has a positive slope (>$V_{IOUT(Q)}$) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of

Continued on the next page…

COMMON OPERATING CHARACTERISTICS[1] over full range of T_A, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

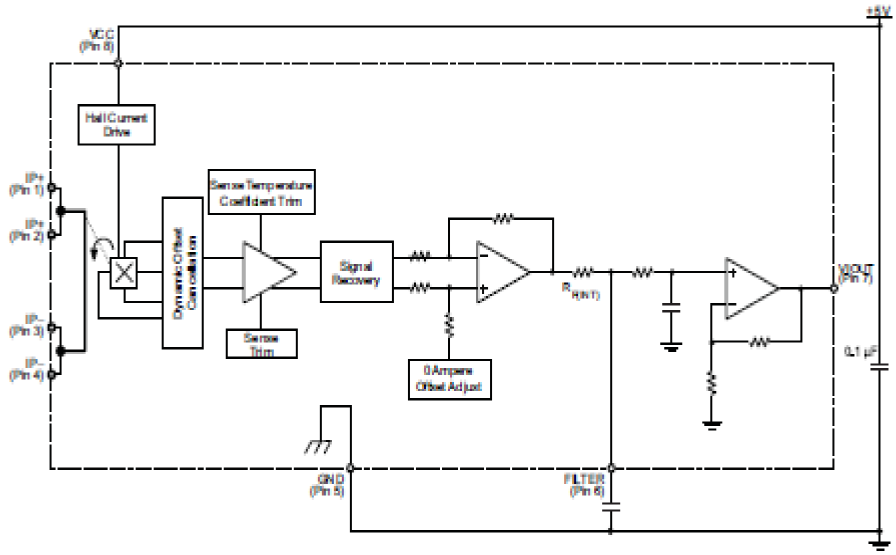
Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	3.5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J=25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling[2]			–	12	–	G/A
Internal Filter Resistance[3]	$R_{F(INT)}$			1.7		kΩ

[1]Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

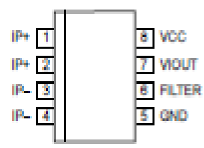
[2]1G = 0.1 mT.

[3]$R_{F(INT)}$ forms an RC circuit via the FILTER pin.

Functional Block Diagram



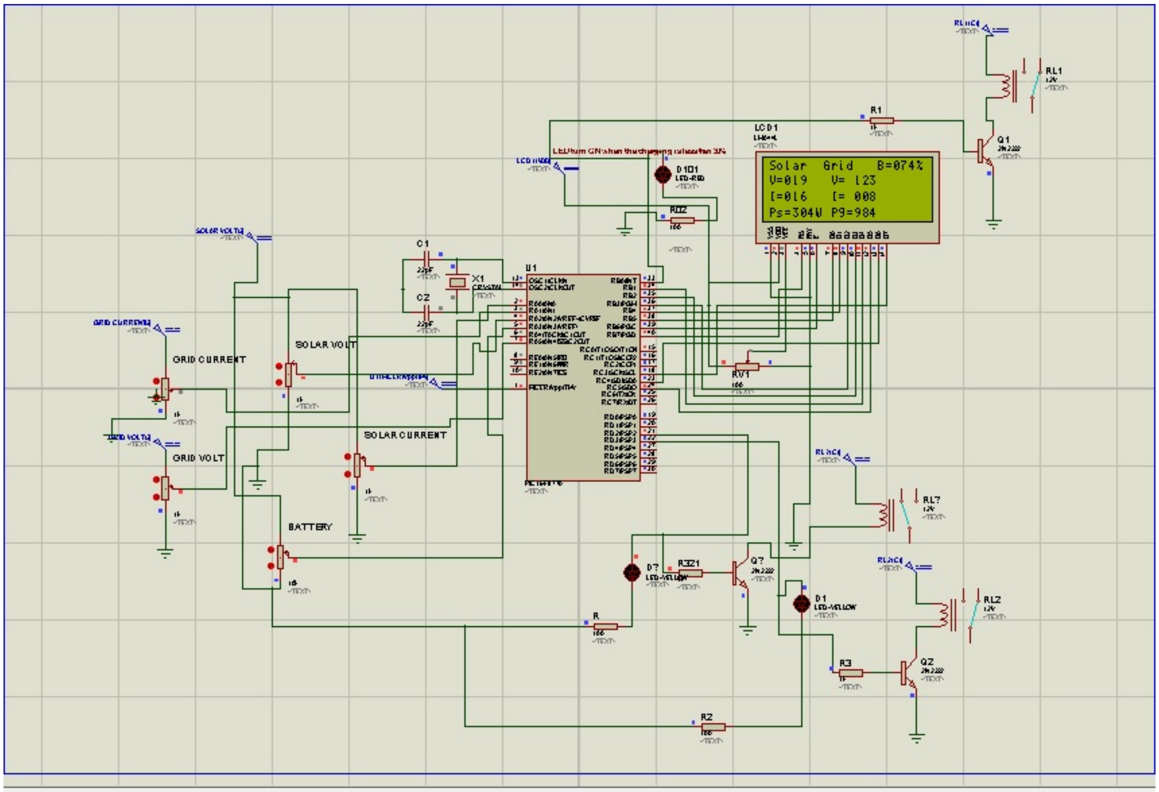
Pin-out Diagram



Terminal List Table

Number	Name	Description
1 and 2	IP+	Terminals for current being sampled; fused internally
3 and 4	IP–	Terminals for current being sampled; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

ANNEXURE D



Solar Grid B=074%
V=019 V= 123
I=016 I= 008
Ps=304W Pg=984
GRID CURRENT
SOLAR VOLT
SOLAR CURRENT
GRID VOLT
BATTERY