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DEVELOPMENT OF A PORTABLE SOLAR POWERED GLUCOMETER

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ABSTRACT

This study implemented a novel design for affordable and portable solar-powered glucometer. The level of the charging current is controllable and any residue power is saveable to a rechargeable 9V battery. Two power sources are used, and two charging speeds are possible. The end product comes with a solar panel to capture and convert solar energy to electrical energy. The electrical energy is stored in a rechargeable battery (9V), with a charge controller to regulate the charging process. A battery charger indicator is in place to monitor the battery storage. A low-cost square wave inverter was built to generate the AC power supply required for the operation of this low power (1Watt) glucometer. A voltage regulator was constructed to step down the 9V DC voltage to a regulated 5V DC power supply for the charging of the glucometer. The final product carries a weight of about 150g that provides both simultaneously a portable 230V 50W AC power generator and a regulated 5V 1W DC power supply source in times of emergency. Hence, it is designed to be portable, optimize capturing of solar energy, storing it into a battery, and providing both standard household alternating current (AC) and most common direct current (DC) power for the glucometer. While this device is designed to optimize capturing solar energy and storing it into a battery, this device was designed to have its weight and size minimized (portable). The model was implemented first in MATLAB/Simulink, and the results have been compared with the data sheet values and characteristics of the PV panels in standard test conditions.

KEY WORDS: Development, Design, Photovoltaic, Solar -powered, Glucometer.

INTRODUCTION

1.1 Background of the study

Solar energy is an important source of renewable energy because it is readily available all year round (Daudu, 2002). Solar PV technology is one of the renewable technologies which have a potential to bring a clean, reliable, scalable and affordable electricity system for the powering of devices, (Tyag et al., 2013). The abundance and widespread availability of solar energy, however, make it the most attractive among other energies that can be feasibly extracted. It can be converted into electricity through low-power Photovoltaic (PV) energy systems, for portable applications, like in solar-powered devices, (Boico and Lehman, 2012). There are several medical and household instruments that requires electrical or thermal energy, (Whiffen et al., 2013).

Glucometer is a small, portable medical device widely used to measure the level of glucose concentration in blood or solution (Suarez and Casillas, 2009). There are several glucometers available in the market which uses non-rechargeable battery (Bularzik et al., 2006). Ordinary batteries are nowadays the main energy provider to portable devices. They are used because of their high power density and convenience. But their disadvantages, however, limit their applications, as there is no accuracy in it, because the energy density of the battery drops to as low as 200Wh/kg within a short period of time, and their technology is not improving as other technologies, (Ching and Connolly, 2007). Glucometers in the market lack access to this reliable, affordable and sustainable energy for improving the healthcare delivery especially in the local areas; as they use only battery as their source of power. This battery powered Glucometers are expensive to maintain, as one need to be changing the battery always.

This study considered using a photovoltaic system to develop a portable powered rechargeable Glucometer. It provided an alternative, affordable, and reliable power source for Glucometer from solar energy through a charging current via photovoltaic system..

MATERIALS AND METHOD

2.1 Materials

Solar PV system includes different components that was selected according to the glucometer system requirements and applications. In this research, the concept of a solar power generation system consists of batteries, low emissivity glass, the aluminum sheet plates, icrocontroller, LCD Display, Op-amp, Diode, Resistors, Variable resistors, and Switch.

2.1.1 PV module

It is made from semiconductor and convert sunlight to electricity. The PV converts sunlight into DC electricity. The PV modules is silicon based.

2.1.2 Battery

9V battery was used, and it stores energy for supplying to the glucometer when there is a demand. It serves as a battery bank, which is involved in the system to make the energy available at night or at day of autonomy (sometimes called no-sun-days or dark days), when the sun is not providing enough radiation. This 9V battery is designed to gradually discharge and recharge 80% of their capacity hundreds of times. We avoided the use of automotive battery in this research because it is shallow cycle battery, and should not be used in PV systems because they are designed to discharge only about 20% of their capacity.

2.1.3 Current to voltage converter

The EBGTS sense the glucose concentration present in the blood sample, then produces a current proportional with the glucose concentration. This amount of current is converted to analog voltage using current-voltage converter (Gayakward, 2007). The output voltage depends on the current from test strips. Mathematically, V1= -(input current* feedback resistance (RF1)). Here, V1 is negatively polarized. But microcontroller cannot sense negative voltage. So voltage is inverted with unity gain.

2.1.4 Inverting amplifier

Inverter converts DC output of PV panels into a clean AC current for AC appliances or fed back into grid line. It is one of the solar energy system's main elements, as the solar panels generate dc voltage. Inverters are different by the output wave format, output power and installation type. It is also called power conditioner because it changes the form of the electric power. The efficiency of the inverter used in this research reaches its nominal efficiency (around 90 percent) when the load demand is greater than about 50 percent of rated load.

Simple but reliable op-amp inverting amplifier is used in proposed design. The gain of this scheme depends on -Av = -RF1/R1.

Where RF1= feedback resistance and R1= input resistance. Since, unity gain configuration is selected, so the input will be the just invert in output.

2.1.5 Microcontroller unit

Solar charge controller regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life. Atmega8A as microcontroller unit is introduced. The Atmel AVR ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC Architecture. It has internal ADC & oscillator. So cost is reduced. ATmega8 can operate in both 8 MHz & 16 MHz clock signal. Earlier mentioned that, the small current produced by the test strip rapidly changes. So the use of 16 MHz clock signal provides much accurate result. The coding of designed meter is developed in C. Data type float is used. It requires four bytes of memory to store each result. Atmega8A has 512 bytes of EEPROM. Though the results are displayed in both units, but stored only the result of mg/dL for future access. So 128 result of glucose testing can be stored.

Component Selection for Controller Design:

In light of the foregoing appraisal of design styles, the following components formed an integral part of the design and hence, their importance and working principles are discussed.

(i) Diodes

These are simply blocking diodes which ensure that the current flows only in one way, so that the battery doesn't discharge when the output from the solar panel is low.

(ii) Zener Diodes

This part of the circuit ensures that once the charging cut off voltage is reached by the battery, the charging stops. The zener diode is rated at 6.8V as breakdown voltage.

(iii) MOSFET

The metal-oxide-semiconductor field effect transistor was used for amplification or switching electronic signals. It ensures cut off of the load in low battery or overload conditions.

(iv) Transistor

It was used to bypass the solar energy to a dummy load while the battery gets fully charged. Once the battery is fully charged, it draws all the current thus protecting the battery.

2.2 Methodology

The design of an effective BGM device must incorporate a wide range of functions such as sensing of the blood sample, computation to determine the glucose level in the blood, user interface to display results and control and store in memory.

2.2.1. The power consumption demands was determined

The first step in designing a solar PV system is to find out the total power and energy consumption of the Device needed to be supplied by the solar PV system as follows:

1a The total Watt-hours needed by the Glucometer was calculated.

1b The total Watt-hours per day needed from the PV modules was also calculated. The total Glucometer Watt-hours per day times 0.20 (the energy lost in the system) is multiplied to get the total Watt-hours per day which must be provided by the panel.

Method: 1. Total Glucometer use = (2.5 W x 24 hours) = 60 Wh/day

Total PV panels energy needed = 60 x 0.20, where 0.20 is the energy lost in the system

= 12 Wh/day.

2.2.2. Sizing the PV modules

Different size of PV modules will produce different amount of power. In sizing of the PV module, the total peak watt produced was needed. The peak watt (Wp) produced depends on size of the PV module and climate of site location. We considered panel generation factor, which is different in each site location. For Nigeria, the panel generation factor is 3.6, (Jessica et al., 2019). The sizing of PV modules is calculated as follows:

2a The total Watt-peak rating needed for PV modules is calculated. The total Watt-hours per day needed from the PV modules (from item 1a) was divided by 3.6 to get the total Watt-peak rating needed for the PV panels needed to operate the Glucometer.

2b The number of PV panels for the system was calculated. The answer obtained in item 2a was divided by the rated output

Watt-peak of the PV modules that is available. Fractional part of result was increased to the next highest full number and that is the number of PV modules used in this study.

Result of the calculation is the minimum number of PV panels. If higher PV modules is installed, the out power will be unnecessarily higher for this Glucometer . If lower PV modules is used, the Glucometer may not be accurate, or work at all during cloudy periods and battery life will be shortened.

Method: 2a Total Wp of PV panel capacity needed = 12/ 3.6 = 3.33 Wp

2b Number of PV panels needed = 3.33/ 3, where 3W is the rated output Watt-peak of the PV modules = 1.11 modules

Actual requirement = 1 modules

So the Glucometer is powered by 1 modules of 3 Wp PV module.

2.2.3. Inverter sizing

An inverter was used in the system where AC power output is needed. The input rating of the inverter is not lower than the total watt (1W) of the Glucometer. This is the same nominal voltage as the battery.

But for stand-alone systems, the inverter must be large enough to handle the total amount of Watts that will be in use at one time. The inverter size should be 25-30% bigger than total Watts of appliances. In case of appliance type is motor or compressor then inverter size should be minimum 3 times the capacity of those appliances and must be added to the inverter capacity to handle surge current during starting.

For grid tie systems or grid connected systems, the input rating of the inverter should be same as PV array rating to allow for safe and efficient operation.

Method: Inverter sizing

Total Watt of all Glucometer = 1W

For safety, the inverter should be considered 25-30% bigger size.

The inverter size should be about 1.25 - 1.30 W or greater.

Glucometer components:

1.One (1) Microcontroller
2. One (1) LCD Display
3. Two (2) Op-amp
4. Six (6) Resistors
5. One (1) Variable resistors
6. Two (2) Switch
7. One (1) Mother-board

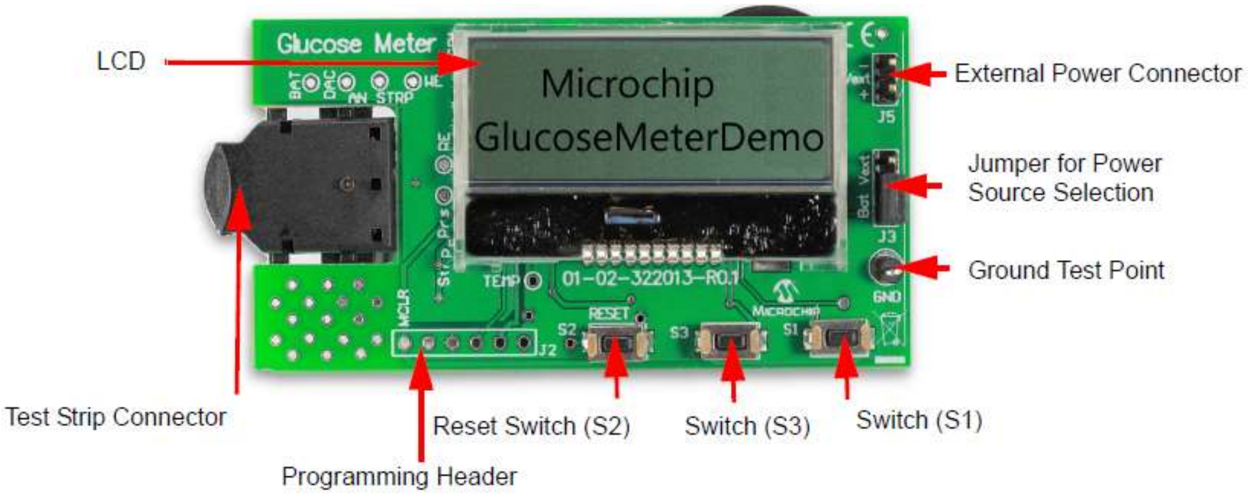

Figure 2.1: Glucometer mother-board

EEPROM

Glucose readings are stored in the internal EEPROM. During Sleep mode if the switch S1 is pressed, the PIC16LF178X device enters Memory mode and the stored glucose reading is displayed on the LCD. To view the previous glucose readings, the switch S2 has to be pressed. Press the switch S1 again to exit Memory mode.

2.2.4. LCD Interface

A 16 x 2 character LCD "NHD_C0216CZ-FSW-FBWLCD" from NHD is used for displaying the glucose reading and text messages. Power to the LCD is cut off during Sleep mode by controlling the VSS of LCD through the port pin of the microcontroller.

2.2.5. Model of solar cell

Any photovoltaic model is based on diode behavior, which gives photovoltaic cell its exponential characteristic. A modeling system using SimElectronics advanced component library, which contains a block called Solar Cell was used. The solar cell from MATLAB 8.5.0. (R2015a) is a solar current source, which includes solar induced current and temperature dependence.

2.2.6. Photovoltaic models

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs proportional to the incident irradiation. Under the influence of the internal electric fields of the p-n junction, these carriers are swept apart and create a photocurrent which is directly proportional to solar insolation. PV system naturally exhibits a non-linear I-V and P-V characteristics which vary with the radiant intensity and cell temperature.

A. Solar Cell Model

A general mathematical description of I-V output characteristics for a PV cell has been studied. Such an equivalent circuit-based model is mainly used for the MPPT technologies. The equivalent circuit of the general model which consists of a photo current, a diode, a parallel resistor expressing a leakage current, and a series resistor describing an internal resistance to the current flow is used. The voltage-current characteristic equation of a solar cell is given as

$I = IPH - IS \exp q(V + IRS) / kTCA - 1 - (V + IRS) / RSH$ (1)

where IPH is a light-generated current or photocurrent, IS is the cell saturation of dark current, q (= 1.6×10^{-19}C) is an electron charge, k (= 1.38×10^{-23}J/K) is a Boltzmann's constant, TC is the cell's working temperature, A is an ideal factor, RSH is a shunt resistance, and RS is a series resistance. The photocurrent mainly depends on the solar insolation and cell's working temperature,

which is described as $I\,PH = [ISC + KI\,(TC - TRef)]\lambda$

(2)

where ISC is the cell's short-circuit current at a 25°C and 1kW/m2, KI is the cell's short-circuit current temperature

coefficient, TRef is the cell's reference temperature, and λis the solar insolation in kW/m2. On the other hand, the cell's saturation current varies with the cell temperature, which is described as $I\,I\,(T/T)\exp[qEG\,(1/TRef\ 1/TC)/kA]$

(3)

$S = RS\,C\,Ref - (3)$

where IRS is the cell's reverse saturation current at a reference temperature and a solar radiation, EG is the bang-gap energy of the semiconductor used in the cell.

B. Solar Module and Array Model

Since a typical PV cell produces less than 2W at 0.5V approximately, the cells must be connected in series-parallel configuration on a module to produce enough high power. A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage. The equivalent circuit for the solar module arranged in NP parallel and NS series. The terminal equation for the current and voltage of the array becomes as follows.

$I = NP\,IPH - NP\,IS[\exp(q(V / NS + IRS / NP) / kTCA) - 1]$

$- (NPV / NS + IRS)/RSH$

(4)

In fact, the PV efficiency is sensitive to small change in RS but insensitive to variation in RSH . For a PV module or array, the series resistance becomes apparently important and the shunt down resistance approaches infinity which is assumed to be open. In most commercial PV products, PV cells are generally connected in series configuration to form a PV module in order to obtain adequate working voltage. PV modules are then arranged in series-parallel structure to achieve desired power output. An appropriate equivalent circuit for all PV cell, module, and array is generalized. It can be shown that NS = NP = 1 for a PV cell, NP =1 and NS : series number of cells for a PV module, and NS

and NP: series-parallel number for a PV array. The mathematical equation of generalized model can
be described as:

$I = NP\ IPH - NP\ IS[\exp(q(V / NS + IRS / NP) / kTCA) - 1]$ (5)

C. Determination of Model Parameters

All of the model parameters can be determined by examining the manufacturer's specifications of PV products. The most important parameters widely used for describing the cell electrical performance is the open-circuit voltage VOC and the short-circuit current ISC . The aforementioned equations are implicit and nonlinear; therefore, it is difficult to arrive at an analytical solution for a set of model parameters at a specific temperature and irradiance. Since normally IPH > IS, and ignoring the small diode and ground-leakage currents under zero-terminal voltage, the short-circuit current ISC is approximately equal to the photocurrent IPH , i.e., I PH = ISC. On the other hand, the VOC parameter is obtained by assuming the output current is zero.

2.2.7. Digital implementation of Glucose Meter using the Pic16lf178x Device:

This section details the hardware design and the software development of the glucose meter using the Amperometric method. Figure 2.1 illustrates the block diagram of a typical glucose meter. The glucose meter was implemented using the PIC16LF178X device.

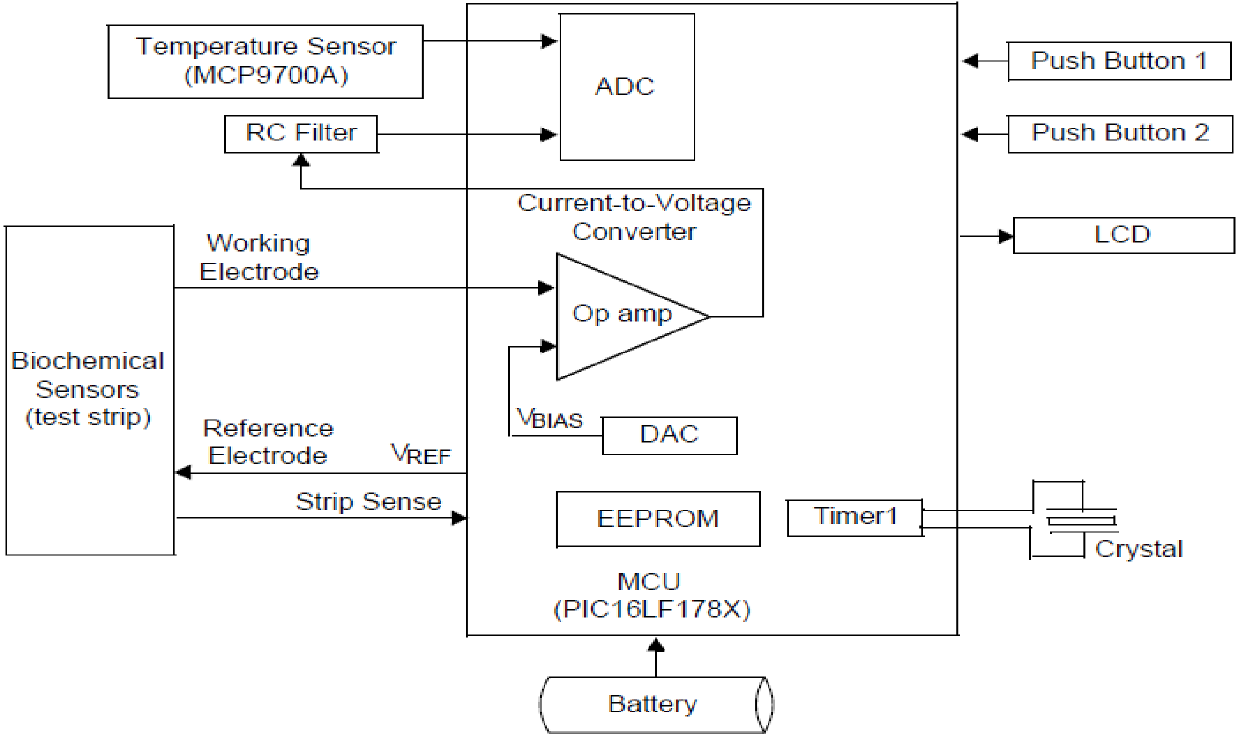

Figure 2.2: Non-Solar And Dc Rechargeable Glucose Meter Block Diagram

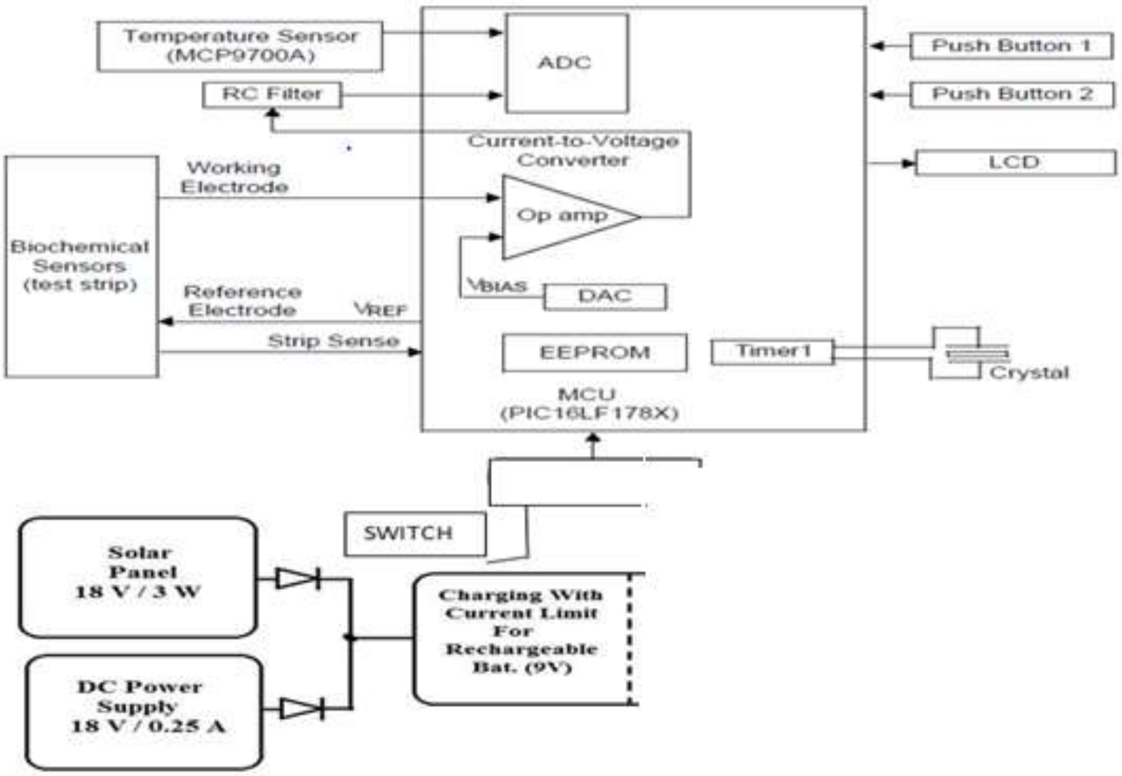

Figure 2.2: Solar And Dc Rechargeable Glucose Meter Block Diagram

RESULTS

3.1. Implementing the Design

The design is a PV-based (230V 50W AC supply, and 5V DC 1W power output) solar powered glucometer. It contains a PV array, a circuit design model, an oscilloscope, and a 9V DC battery for charging (see plate). After full charging, the battery starts converting energy through the 9V DC battery (which is used when the solar source dries up, or at night). Control of the battery charging involves maintaining the current level at the high-speed charging limit equaling 34mA.

Different levels of charging current are possible (the normal charging level is 100mA).

3.2. Implementing a Solar Power System

In this research, the concept of a solar power generation system consists of batteries, low emissivity glass and silicon module plates. When light from the sun is collected by the flat solar collector, it is directed on the focus point where the thermoelectric generators are mounted. The working principle simply is that as one side of the thermoelectric generator is heated; the other side's temperature is lower (cool side) then a temperature difference is generated within thermoelectric module. This event lead to the generation of electricity. The solar and dc power sources join through two decoupling diodes. The meeting point provides the dc supply voltage to the main part of the design.

3.3. Generalized PV model building and simulation

A. Built Generalized PV Model

A model of PV module with moderate complexity which includes the temperature independence of the photocurrent source, the saturation current of the diode, and a series resistance is considered based on the Shockley diode equation. It is important that the generalized model suitable for all of the PV cell is built, module, and array, which is used to design and analyze a maximum power point tracker. On illumination with radiation of sunlight, PV cell converts part of the photovoltaic potential directly into electricity with both I-V and P-V output characteristics. This generalized PV model is built using Matlab/Simulink to illustrate and verify the nonlinear I-V and P-V output characteristics of PV module.

B. Simulation Results of PV Cell and Module

For a PV cell with an ideal I-V characteristic, its open circuit voltage and short-circuit current are given as $V_{OC} = 0.596V$ and $I_{SC} = 2.0A$, respectively. The nonlinear nature of PV cell is apparent, i.e., the output current and power of PV cell depend on the cell's terminal operating voltage and temperature, and solar insolation as well. In as much as the increase in the output current is much less than the decrease in the voltage, the net power decreases at high temperatures.

C. Statistical Simulation

For easy simulation, the solar radiation intensity for a sample day is assumed to be a function of Gaussian function
which is defined as [2 2]
$\lambda (t) = \lambda max \exp - (t - tC) / 2\sigma$ (12)
where λmax is the maximal radiation intensity at a given time, tC is the center time, and σ is the standard deviation of Gaussian function. The peak of sunlight intensity occurs at noon. The cell temperature for a sample day is assumed to be at a fixed temperature of NOCT by ignoring the effect of the solar irradiation. Given sunlight irradiance for a sample day, the output current is governed by its output voltage which is determined by the ensuing load. Without taking cell temperature variations into consideration, the maximum power is determined by both radiation intensity and output voltage.

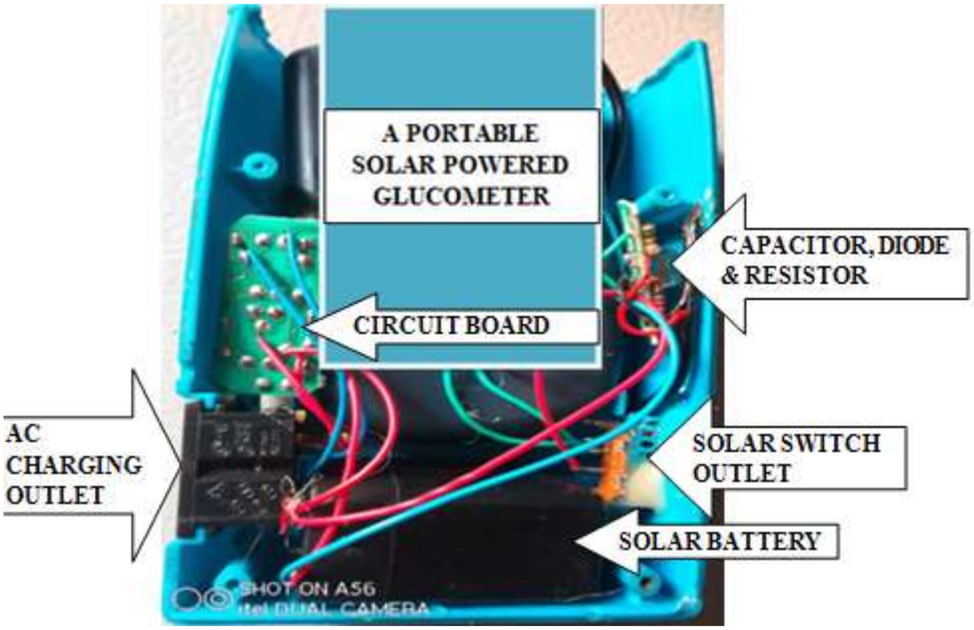

Plate 3.1: Interior of the Solar Powered Glucometer System

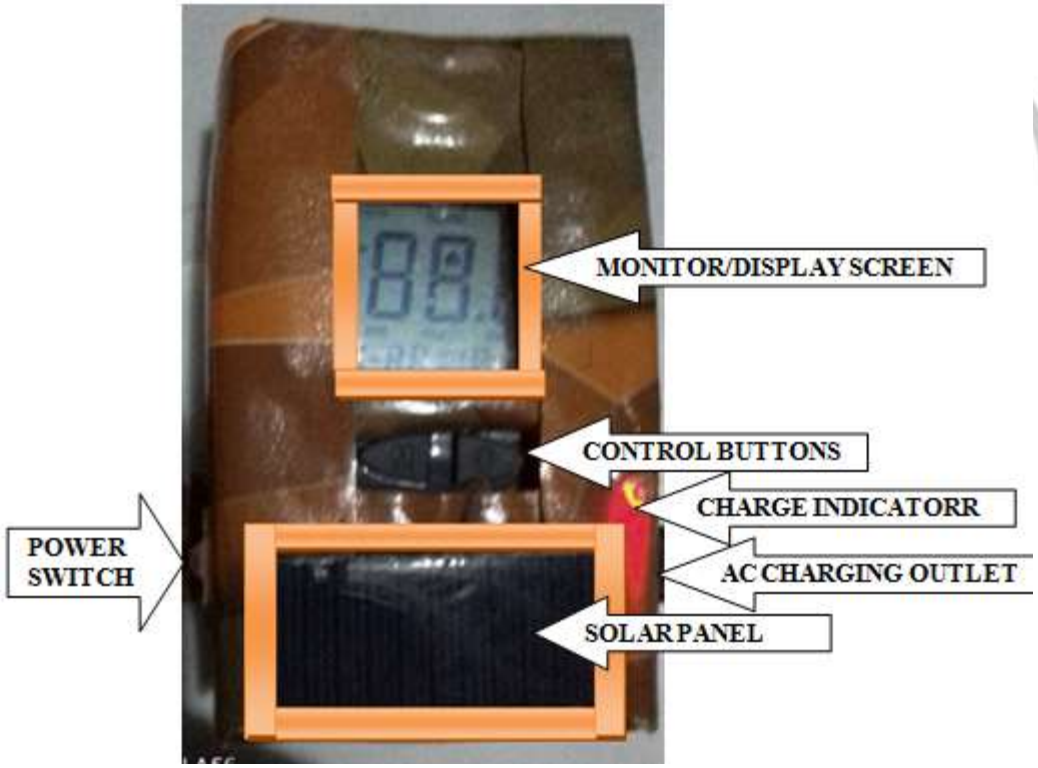

Plate 3.2: Final product of the Solar Powered Glucometer System

3.4. Simulation process and Results

The main simulation time-step is one hour, and it starts with half-charged battery. SOC and grid interaction for row N is being derived from excess energy at row N and SOC at row N-1 according to figure 2.

Firstly, the excess of energy is computed, if it is positive and the battery is not full, then the excess of energy will be stored in the battery. Otherwise, in the case that the battery gets fully charged, the rest is not locally utilised and it leads to grid injection or PV power limitation. If the excess power is negative, firstly the battery is used for the rest of energy needed to supply the loads. If the battery is empty (e.q. there is SOC limitation) the energy needed is covered from the grid. In the end the sum of energy taken from the grid, injected to the grid and used from PV is used to calculate the annual statistics.

Simulation Results:

The dc power supply delivered the required load currents to the photovoltaic device. The battery was charged and the results fully correspond with the simulation results. Two panes of glass with small thickness was interchanged on the SPB to determine the temperature, voltage, power output and heat transferred. Two panes of glass shield with small thickness shows that the temperature in the trapped thermal environment was at the highest for 30 mins. The downward thermal trend for both glass shields is because of the reduced solar irradiance.

3.5. Test procedure

After development of the Portable Solar Powered Glucometer, it was tested as a single unit to make sure that everything works properly when connected together. The first type of testing was performed indoors. Firstly, the solar tracking capabilities was tested by shining a moving flashlight. The first part of the portable solar power supply that was tested is the 9 volt, 35Ah battery. In the biotechnology design laboratory, a positive and negative terminal from a three output power supply was attached to match the positive and negative terminals of the battery. Then after a period of time, the terminals of the three output power supply was removed from the battery. Then a multimeter's positive and negative terminal was connected to match the positive and negative terminals of the 9 volt 35Ah battery. The multimeter's display was checked to see if there is a voltage and current reading from the battery. The process described above was repeated once a voltage and current reading from the multimeter is not obtained. If the test procedure for the battery above has to be repeated more than three times, then there is high probability that the battery is defective.

Next, the solar panel was placed in the sunlight or in an area with bright lighting, and the positive and negative output terminals was connected to match the positive and negative terminals of a multimeter. Then, the multimeter's display was checked for a voltage and current reading. This process was repeated several times when the voltage and current reading was not obtained. When this process was repeated several times, it means that the solar panel is defective, but the reverse was the case as it was not repeated several times.

After the battery and the solar panel were confirmed to be working properly, the charge controller was connected to the microcontroller. Also, the LCD display was attached to the microcontroller. Then a simulated solar panel input voltage from the positive and negative terminals of three output power supply was applied to match the positive and negative input terminals of the charge controller. Then, the positive and negative output terminals of the charge controller waas attached to match the positive and negative terminals of a multimeter. Both the multimeter and the LCD display was observed for a voltage and current reading. When there are voltage and current readings on both the LCD display and the multimeter, the readings on both displays was checked for consistency. The readings on both displays were consistent, which confirms that the microcontroller and the charge controller work properly. Also, it confirms that the LCD display is configured properly and works properly. The components were each tested and proved to be working before they were connected.

The charge controller's positive and negative input voltage terminals were attached to the solar panel's output's positive and negative voltage terminals. Also, the output positive and negative voltage terminals of the charge controller was attached to match the battery's positive and negative terminals. Also, a multimeter's positive and negative terminals was attached to match the positive and negative terminals of the battery. Then, the display of the multimeter was observed for a voltage and current reading. The reading shown indicated that the battery, the charge controller, the microcontroller, and the solar panel are all working properly when they are all connected.

DISCUSSION AND CONCLUSION

4.1 Discussion

The PIC16LF178X MCU is equipped with op amp, 12- bit ADC, DAC and EEPROM, which makes a great combination for this type of battery operated application needing precision measurement and lower current consumption. As this application note demonstrates, the Microchip PIC16LF178X MCU can be used to implement a flexible and low-cost glucose meter design. The current consumption of the glucose meter in Active mode is approximately 1.1 mA, and it consumes 3 μA during Sleep mode. The glucose meter will be in Sleep mode most of the time. We can consider Sleep mode time to be approximately 99.5%. The design showed tremendous heat energy entrapment during solar irradiance peak as the temperature on the solar panel was about three times the temperature absorbed. This is in agreement with the work by Dravid et al. 2012 where tremendous amount of heat energy was applied in photovoltaic system to power Autoclave sterilizing medical device. It was specifically noted that the convection of the heat transfer that is triggered by the module determines the functionality of the photovoltaic system. This is a clear indication that though the power output may be low to charge the batteries, the prospects of making the solar energy last long is very possible. This is because based on a study performed by Song et al. 2016, the density of produce power was dependent on the thickness and tone of skin. It was concluded that brighter and thinner skin led to higher generated power density. However, there were challenges to guide future construction. This includes scarce thermoelectric modules in the markets of developing countries; modes of optimizing the efficiency; and the false ratings of the normal specification.

A portable solar power supply was successfully built to the specification. The product is able to support simultaneous operation of low-power rated electrical appliances and charging of mobile phones. The product makes use of a 18V solar panel to capture the sunlight and convert it to electrical energy. A charge controller is in place to regulate the charging process of the 9V rechargeable battery. A low cost square wave inverter was built to generate a 230V AC power supply from the 9V battery. To support the charging of the glucometer, a voltage regulator was implemented to step down the 9V battery voltage level to a regulated 5V. The final product features a 3-pin power socket to provide a 230V 50W AC supply, and a USB port to provide regulated 5V DC 1W power supply.

4.2 Conclusion

People suffering from diabetes are solely dependent on exact blood glucose concentration information. Glucometer is a device which helps to detect blood sugar levels in human body. In developed countries people widely use this medical device. But in developing countries the usages of this helpful devices is limited to a very few people; due to illiteracy, affordability, and reliable power. In this project work, a real time solar powered glucose meter is developed which is very low in cost, targeting the poor people in developing and underdeveloped countries.

A portable solar power supply was successfully designed and implemented to the required specification. The product is able to support simultaneous operation of low-power rated glucometer. The product makes use of a 9V solar panel to capture the sunlight and convert it to electrical energy. A charge controller is in place to regulate the charging process of the 9V rechargeable battery. A low cost square wave inverter was built to generate a 230V AC power supply from the 9V battery. To support the powering of Glucometer, a voltage regulator was implemented to step down the 9V battery voltage level to a regulated 5V. The final product features a 3-pin power socket to provide a 230V 50W AC supply, and 5V DC 1W power supply. Its current limiter circuit extends battery life and it is safe even after full charging.

The proposed design is novel. It is simple and cheap but high performance with power economy. It also functions on two sources. Its simulation and experiment results show:

1. Above 95% charging efficiency (proving solar energy's feasibility in supplying energy to mobile phones).
2. Its current limiter circuit extending battery life and it is safe even after full charging.

Although conventional solar cells based on silicon are produced from abundant raw materials, the high-temperature fabrication routes to single-crystal and polycrystalline silicon are very energy intensive and expensive. The search for alternative solar cells has therefore focused on thin films composed of amorphous silicon and on compound semiconductor heterojunction cells based on semiconductors (e.g., cadmium telluride and copper indium diselenide) that can be prepared by less energy-intensive and expensive routes. A key problem in optimizing the cost/efficiency ratio of such devices is that relatively pure materials are needed to ensure that the photo-excited carriers are efficiently collected in conventional planar solar cell device designs.

The use of nanostructures offers an opportunity to circumvent this key limitation and therefore introduce a paradigm shift in the fabrication and design of solar energy conversion devices to produce either electricity or fuels. Result shows that the developed solar powered glucometer gives around 93% accuracy. Total cost of the proposed glucometer is very affordable so that poor people can have an easy access to this meter.

Challenges Encountered:

Some of the materials needed to design and implement this portable solar powered and direct current rechargeable based glucometer are not manufactured locally. Consequently, one need to import it or buy it from the importers.

4.3 Recommendation

Possible future studies in increasing the solar panel efficiency, and reducing the system size should be carried out. It was specifically noted that the convection of the heat transfer that is triggered by the surface determines the functionality of the thermo-electric module. Therefore, more emphasis on this convection of the heat transfer should be laid. This is a clear indication that though the power output may be low to charge the batteries, the prospects of the solar module to operate in convective-rural communities (in tropic region) is very high. Possible future work in increasing the solar panel efficacy and reducing the system side effect should be adopted. Organic photovoltaic (OPV) devices are in a comparatively early stage of development. Since the early proof of principle work on organic photovoltaics in the mid-1980s, total solar to electrical energy conversion efficiencies have been pushed to ca. 5%. A vigorous period of research and development is needed to refine structures, processing, and cell fabrication techniques to increase the efficiency of OPVs five- to ten-fold with respect to current values.

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