HYBRID SOLAR SYSTEM FOR HORTICULTURE

Naveen B M, Raghu S, Deepak Salian, Ganesh Shetty

***Abstract*— this paper aims at extracting maximum power from sunlight using PV modules and using this power for Horticulture purpose. Pumping water and LED lightning for effective plant growth are used as two applications, LED lighting systems have several unique advantages over existing horticultural lighting, including the ability to control spectral composition, the ability to produce very high light levels with low radiant heat output when cooled properly, and the ability to maintain useful light output for years without replacement. LEDs are the first light source to have the capability of true spectral composition control, allowing wavelengths to be matched to plant photoreceptors to provide more optimal production and to influence plant morphology and composition. Because they are solid-state devices, in this sense, the successful achievement of this demonstrator can be considered as a central paper objective. 8051 microcontroller is used to control the solar tracker. KEIL software is used to write the embedded C Program for tracking DC motors.**

***Index Terms*— Horticulture, KEIL, LED, microcontroller, PV modules.**

I. INTRODUCTION

Solar power is a renewable source of energy, which has become increasingly popular in modern times. Photovoltaic (PV) technology involves converting solar energy directly into electrical energy by means of a solar cell. It will absorb sunlight and produces electricity through a process called the photovoltaic effect. Solar photovoltaic generation systems have two inherent major problems. The first is low conversion efficiency (Typically around 10 to 16%). Second is presence of highly nonlinear I-V characteristics and have got optimum operating point, called the Maximum Power Point (MPP). In order to extract the maximum amount of energy, the PV systems must be capable of tracking the solar panel unique maximum power point that varies with irradiance and temperature. Therefore, the system needs a Maximum Power Point Tracker (MPPT) [1], [2], which sets the system working point to the optimum and increases the system's output power.

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This paper develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency. This is because the sunlight can generate a clean and free power. This paper helps for power generation by setting the equipment to get maximum sunlight automatically. When there is decrease in intensity of light, this system will automatically change it direction using a motor to get a maximum intensity of light. This system will use P89V51RD2 Microcontroller as a brain to operate this system and a L289 driver motor to change the inclination of solar panel.

LEDs allow production of bright and long-lasting grow lights that emit only the wavelengths of light corresponding to the absorption peaks of a plant's typical photochemical processes. For vegetative growth, blue LEDs are preferred, where the light has a wavelength in the mid-400 nm (nanometer) range. Not only are LEDs great for encouraging plant growth, they are very energy-efficient.

A solar powered water pumping system [3] is made up of two basic components. These are PV panels and pumps. The smallest element of a PV panel is the solar cell. Each solar cell has two or more specially prepared layers of semiconductor material that produce direct current (DC) electricity when exposed to light. This DC current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines, or stored in batteries for later use by the pump.

How Solar Cells Work: When a photon with sufficient energy impinges upon a semiconductor it can transfer enough energy to an electron to free it from the bonds of the semiconductor's valence band so that it is free to move and thus carry an electric current. The junction in a semiconductor diode provides the necessary electric field to cause the current to flow in an external circuit.

The typical output voltage of a PV cell is between 0.5 and 0.6 Volts and the energy conversion efficiency ranges from less than 10% to over 20%. An array of cells can therefore generate about 200 Watts of electrical power per square meter when illuminated by solar radiation of 1000 Watts per square meter. The corresponding current density will be about 400 Amps/m2. Because of climatic conditions the intensity of the insolation rarely reaches 1000 W/m2.

Solar Cell Operating Characteristics:

The graph below figure 1.1 shows that with constant irradiance the output voltage of a cell or an array of cells falls as it is called upon to deliver more current.

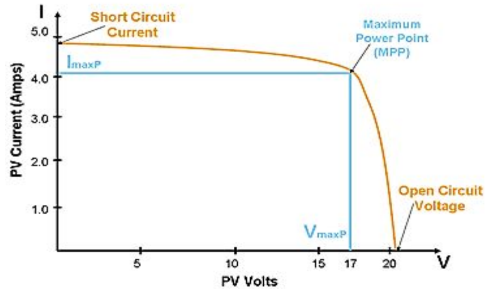

Figure 1.1: Photovoltaic Array voltage / Current Characteristic

Maximum power delivery occurs the voltage has dropped to about 80% of open circuit voltage. The Fill Factor (FF) is defined as the ratio between the power at the maximum power point and the product of the open circuit voltage and short circuit current. It is typically better than 75% for good quality solar cells.

The short circuit (SC) current is directly related to the number of photons absorbed by the semiconducting material and is thus proportional to light intensity. The conversion efficiency is therefore reasonably constant so that the power output is proportional to the irradiance down to fairly low levels as shown in figure 1.2; however the efficiency is reduced if the cell temperature is allowed to rise. The open circuit (OC) voltage varies only slightly with light intensity.

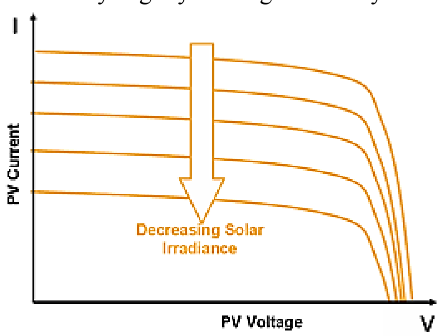

Figure 1.2: Photovoltaic array Irradiance Characteristic

As temperature increases, the band gap of the intrinsic semiconductor shrinks, and the open circuit voltage (Voc) decreases as shown in figure 1.3. At the same time, the lower band gap allows more incident energy to be absorbed because a greater percentage of the incident light has enough energy to raise charge carriers from the valence band to the conduction band. A larger photocurrent results. The increase in the current for a given temperature rise however is proportionately lower than the decrease in voltage. Hence the efficiency of the cell is reduced.

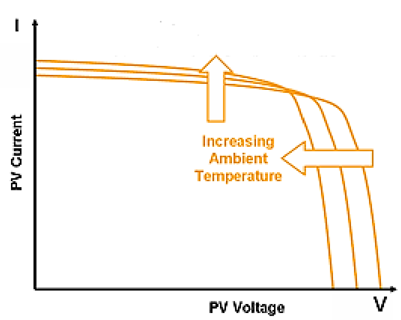

Figure 1.3: Photovoltaic array temperature characteristic

II. SYSTEM DESIGN

The overall block diagram of this paper is as shown in figure 1.4 Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT varies the electrical operating point of the modules so that the modules are able to deliver maximum available power.

Charging unit: The charging unit is a global block that includes the Maximum Power Point Tracking allied to a DC/DC converter with buck topology. Figure 1.5 below gives a general description of the charging unit block.

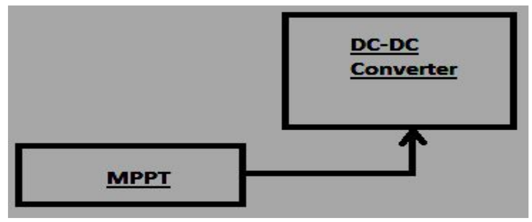

Figure 1.5: Block diagram of the charging unit

Light sensor: The sun tracker uses a photocell for light detection. A complementary resistor value of 10KΩ was used to construct the circuit. From this, the output voltage will increase as light intensity increases. The complementary resistor value should be chosen such as to achieve average light condition, and bright light conditions.

Charging Lead Acid Battery: Lead-acid battery chargers typically have two tasks to accomplish. The first is to restore capacity, often as quickly as practical. The second is to maintain capacity by

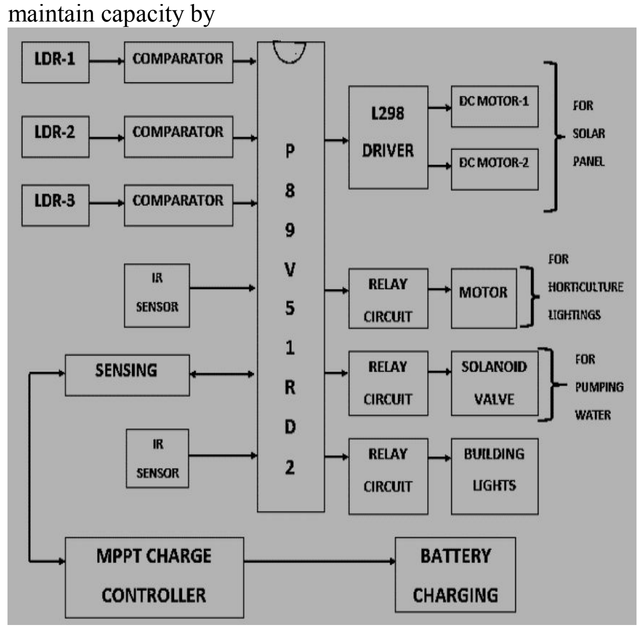

Figure 1.6: Overall block diagram

compensating for self-discharge. In both instances optimum operation requires accurate sensing of battery voltage and temperature. To maintain capacity on a fully charged battery, a constant voltage is applied. The voltage must be high enough to compensate for self-discharge, yet not too high as to cause excessive over-charging. While simply maintaining a fixed output voltage is a relatively simple function, the battery's temperature coefficient of -3.9mV/degree C per cell adds complication. If battery temperature is not compensated for, loss of capacity will occur below the nominal design temperature, and over-charging with degradation in life will occur at elevated temperature.

Sensors: LDR sensor and IR sensors are used based on the applications. Sensors are used to detect the variations between initial set values and newly entered values in order to reach the requirements of the applications.
IR Sensor: The circuit we are using for each sensor looks like figure 1.7.

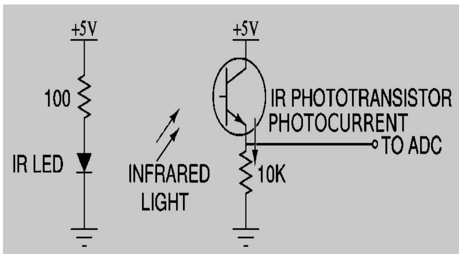

Figure 1.7: Circuit diagram of IR LED and IR Phototransistor

IR is an Infrared based transmitter/receiver module capable of detecting obstacles in proximity of 1cm to 10cm. The transmitter transmits Infrared pulses at a frequency of 38 kHz using the on-board LM358. The strength of the IR pulses can be adjusted using the on-board potentiometer.
LDR (Light dependent resistor): Light-dependent resistor alternatively called an LDR, photo resistor, photoconductor, or photocell, is a variable resistor whose value decreases with increasing incident light intensity. An LDR is made of a high-resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. The figure 1.8 below shows the LDR interfaced with LM358 controller used for paper purpose.

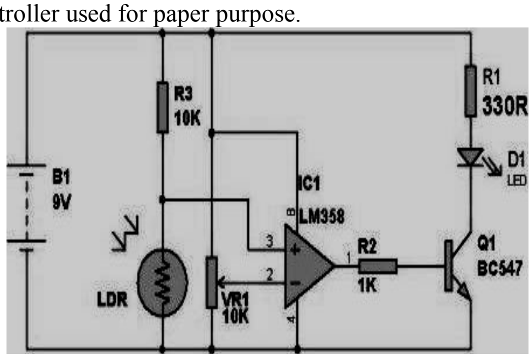

Figure 1.8: Interfacing with LM358

Relays: Relays are devices which allow low power circuits to switch a relatively high Current/Voltage ON/OFF. A relay circuit is typically a smaller switch or device which drives (opens/closes) an electric switch that is capable of carrying much larger current amounts. Interfaced with transistor BC547Input pin connected to microcontroller P89V51RD2 port 0.1 The figure 1.9 is the circuit board of 1 CH relay which used to pump a motor for pumping water in paper.

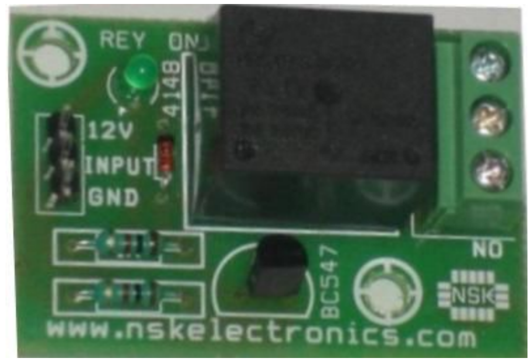

Figure 19: 1-CH Relay board

Motor: NR-DC-ECO is high quality low cost DC geared motor. It contains Brass gears and steel pinions to ensure longer life and better wear and tear properties. The gears are fixed on hardened steel spindles polished to a mirror finish. These spindles rotate between bronze plates which ensures silent running. The output shaft rotates in a sintered bushing. The whole assembly is covered with a plastic ring. All the bearings are permanently lubricated and therefore require no maintenance. The motor is screwed to the gear box from inside.

Figure 1.10: 12v 100 rpm DC Geared Motor [3].

Motor Driver: L298 Motor Driver board features ST Microelectronics' L298 Motor Driver. The driver board is ideal for controlling up to 2-DC Motors or 1 Bi-Polar Stepper Motor in Robotics and Automation based applications.
Liquid Crystal Display: LCD is connected to microcontroller as 4 pin for data and a single pin for register select and enable, LCD initialization is done by using microcontroller, before initialization the LCD have to wait for 30ms delay. The main application of LCD in this paper is to display the tilting angle of solar panel. For example if microcontroller is initializing sensor, display the exact angle of solar panel has tilted, so the usage of LCD to display the status.

MAXIMUM POWER POINT TRACKING (MPPT):
The below block diagram shows the proposed maximum power point tracking (MPPT) charger. The whole system can be divided into three major parts: microcontroller-based MPPT controller, power stage and output stage.

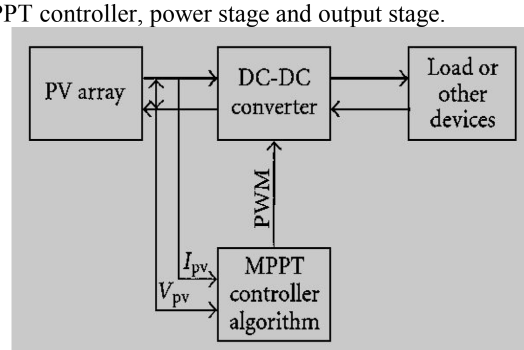

Figure 1.11: Block diagram of the MPPT battery charger

The whole system can be divided into three major parts: microcontroller-based MPPT controller, power stage and output stage. The MPPT controller is used to perform the MPPT algorithm, and provides the gating signals of the power stage. The fly back-type DC/DC converter connects the PV panel to the batteries. The output stage consists of a battery bank, which issued to absorb the energy generated by PV panel.

The figure 1.12 shows the performance of a17 Volt, 4.4 Amp, 75 Watt PV array used to top up a 12 Volt battery. If the actual battery voltage is 12 Volts, the resulting current will only be about 2.5 Amps and the power delivered by the array will be just over 50 Watts rather than the specified 75 Watts: an efficiency loss of over 30%. Maximum Power Point Tracking is designed to overcome this problem [5].

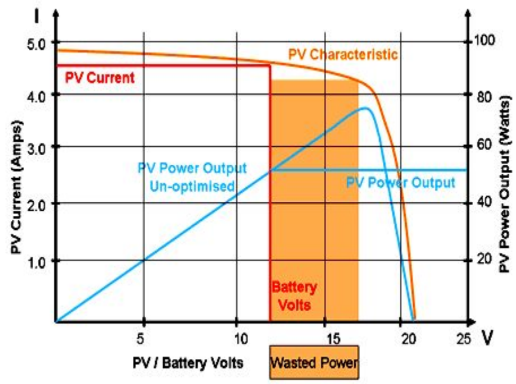

Figure 1.12: Photovoltaic array battery charging power transfer

MICROCONTROLLER:
The NXP (founded by Philips) P89V51RD2 DIP is a 40MHz, 5 Volt 8051-based Microcontroller with 32 I/O lines is an extremely popular 8051 family of microcontroller available in standard 40-pin DIP package. The microcontroller comes with an on-chip boot loader which makes it easy to program using the serial port. The microcontroller is compatible with our EASY 8051, 8051 KICK and GENESIS development Boards.

III. SOFTWARE DESCRIPTION

To implement this design software is written using 'Embedded C' written using KEIL software which runs under 8051 microcontroller. Microcontroller is integrated fully for communication with hardware such as RS-232, L298 driver, relay circuits and MPPT charge controller.
KEIL: This software is used to write the microcontroller code and to simulate it on the computer itself. It is also used to generate the hex code for the code written in C.
Software Details: The program code acts as the decision-maker embedded in the microcontroller i.e. it decides what will be the outputs for particular set of input combination. Programs for the 8051 microcontroller is written in C.

Flash Magic: The Flash Magic utility connects the PC's COM port to the serial port of the microcontroller and provides In-System Flash Programming (ISP) support for Intel HEX files.

The figure 1.13 shows the overall working logic of the program written in C language

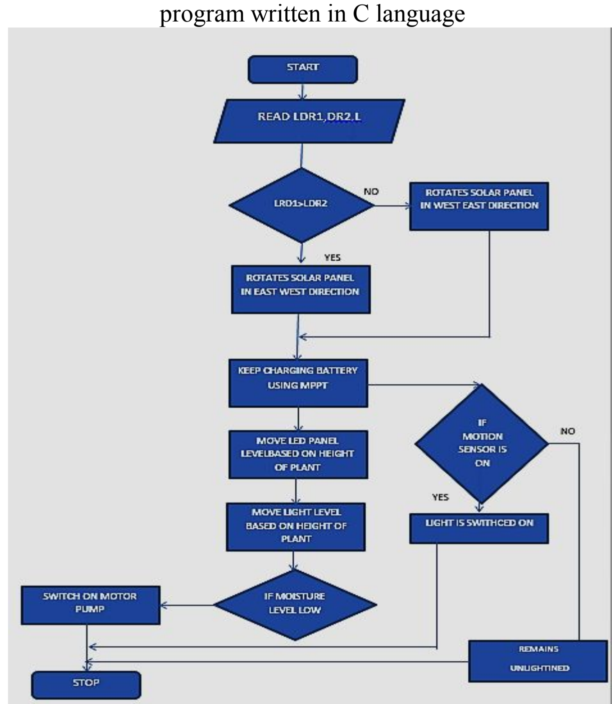

Figure 1.13: Overall flowchart

IV. RESULT AND DISCUSSION

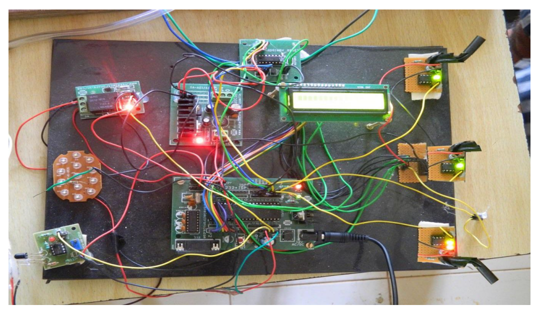

Figure 1.14: Overall circuit Board

To complete this paper in an efficient manner a thorough understanding of solar technology and important aspects of it is essential. A variety of different applications were researched and determined whether or not they are even feasible at the current state of solar technology. The most feasible application for solar power is for remote locations requiring small quantities of power to run lighting, pumping water, horticulture, and other low power application.

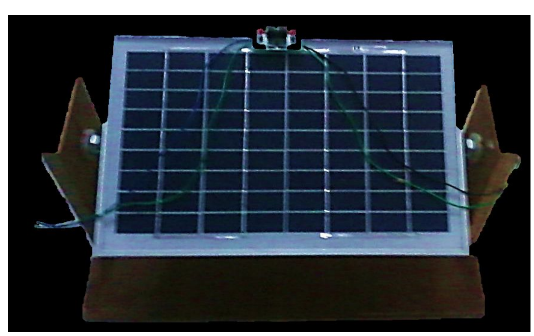

Figure 1.15: Solar Panel

Figure 1.15 demonstrates a working software solution for maximizing solar cell output by positioning a solar module at the point of maximum light intensity. This paper presents a method of tracking the sun and resetting itself for a new day.

Figure 1.16: Water being pumped

The use of a tracker similarly reduces the required array size to pump the daily water requirements since the tracker has extended operating hours at peak sun conditions.

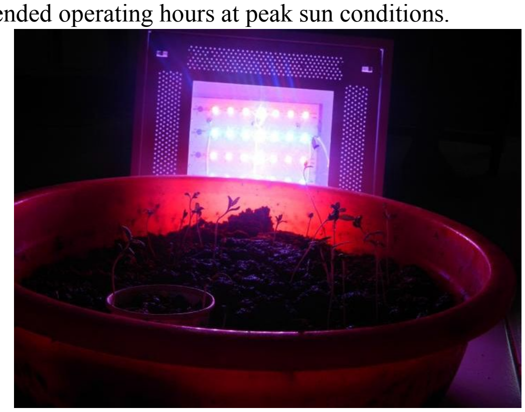

Figure 1.17: LED lighting for plant growth LED lighting results to rapid growth of plants. The Figure

1.18 shows yield through LED light is much faster.

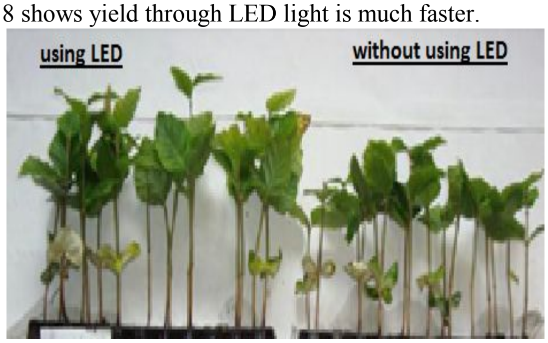

Figure 1.18 Plant growth under LED and without LED

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