OPTIMAL DESIGN OF COST EFFECTIVE SOLAR BASED POWER PACK INSTRUMENTATION FOR CIRCUIT LABORATORY APPLICATIONS

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ABSTRACT:

Energy has become an important and one of the basic infrastructures for economic development of a country. Energy demand in the world is steadily increasing and new types of energy sources must be found in order to cover the future demand, since the conventional sources are about to be emptied. Conventional energy is the major energy sources that is being used in the world to meet there requirement for power. Today to generate most of electrical power from conventional sources like coal, gas, nuclear power generators are used. The known reserves of fossil fuel have depleted to large extent due to its continuous uses. Instead of conventional energy, non-conventional energy sources are widely used. Among them solar photovoltaic system is more significant. Objective of this paper is to provide an alternative source of power supply via solar PV system and can be added during power cut and supply power to small laboratory applications.

KEYWORDS: Electric power; solar PV model; inverter; charge controller;

INTRODUCTION:

In the World population is expected to double by the middle of the 21st century (Global Energy, 1998). This will consequently result in a 3-5 fold increase in world economic output by the year 2050, and a 10-15 fold increase by the year 2100.

Energy has an established positive correlation with economic growth. Providing adequate, affordable and clean energy is a prerequisite for eradicating poverty and improving productivity. The inevitable increase in the use of fossil fuels alongside a country's economic growth presents associated side effects of threat to the nation's energy security, as well as environmental degradation through climate change. A feasible alternative to the indiscriminate burning of fossil fuels lies in the accelerated use of renewable energy. In tropical countries, which have sunshine almost throughout the year in most parts, solar energy is one of the most viable options.

Energy from the sun has been used to provide electricity for many years. This form of renewable energy occupies less space compared to the space occupied by hydropower papers. Developing countries can cover all their demands for energy by solar systems with 0.1% of the land area.

With the improvement in technology over the years, consumption of power to support the standard of living has also increased tremendously. This led to the fact that we need to find a way to harvest energy from alternative methods since traditional methods like burning will deplete natural resources in time and also causes pollution. Solar power is a source of 'clean energy' or 'green energy' and together with its abundance, there is sufficient reason for us to continue to explore solar energy not just as an alternative energy sources but as a potential foundation of energy creation.

Conventional energy is the major energy source that is being used in the world to meet there requirement for power. The known reserves of fossil fuel have depleted to large extent due to its continues uses. Instead of conventional energy, non-conventional energy source are widely used. Among them photovoltaic panel is more significant. In this paper work, it has been selected that renewable energy likes solar as the alternative energy source to overcome power cut problem for the small load laboratory applications [3]

PRINCIPLE OF SOLAR OPERATION:

Solar energy is available in abundance in most parts of the world. The amount of solar energy incident on the earth's surface is Approximately 1.5 x 1018 kWh/year which is about 10,000 times the current annual energy consumption of the entire world. The density of power radiated from the sun (referred to as solar energy constant) is 1.373 kW/m^2

Solar panel or also known as solar photovoltaic module is a most effective thing of way to produce the electricity. Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell. A photovoltaic cell is usually made of semiconductor material that is able to conduct sunlight and generates it into DC voltage using photovoltaic effect. Sunlight is made of photons, a small particle of energy. These photons are then absorbed by the solar cell. The movement along the path will generates electricity. Nowadays, solar panels are widely used in many application of alternative energy as it is commonly known as harmless to the environment.

A solar cell is a basically a p-n junction device with no direct voltage applied. The fundamental idea of a solar cell is to convert light energy to electrical energy. Light energy, which comes mainly from the sun, is transmitted by photons, small packets or quantum of light. Photons of sufficient energy creates mobile electron–hole pairs in a semiconductor as shown in Fig.1 Therefore, a solar cell converts light energy which is a flow of photons, to electrical energy which is a flow of electrons. This is known as the photoelectric effect. The photo-generated minority carriers will be collected at the p-n junction where the excited electrons will get swept to then-region while the holes will get swept to the p-region to become majority carriers [6]

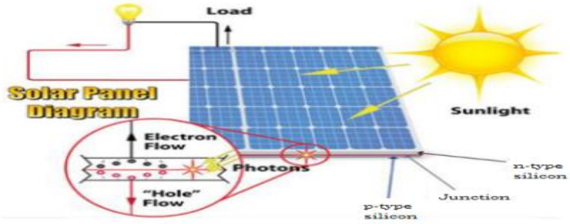

Fig.1: Conversion of light energy to electrical energy [1]

DIRECT AND DIFFUSE SOLAR RADIATION:

Sunlight coming from the sun is reduced by about 30% before it reaches the earth due to

- Scattering by atmospheric particles
- Scattering by aerosol, dust particles etc
- Absorption by atmospheric gases

It is common to consider separately the 'direct' (or beam) radiation coming from solar disk and the 'diffuse' radiation from elsewhere in the sky with their sum known as 'global' radiation. The component of the radiation coming from all direction in the sky is diffused. When the sun is directly overhead, it has diffuse component of about 10% when skies are clear. Percentage increases with increased Air Mass.

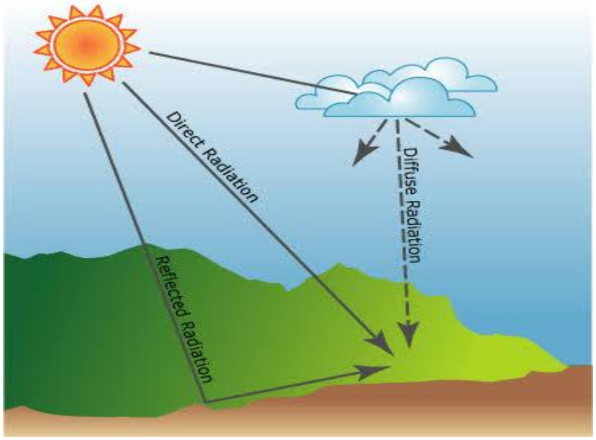

Fig.2: Direct and diffuse solar radiation [5]

SOLAR CHARGE CONTROLLER HAS THREE BASIC FUNCTIONS:

- To limit the voltage from the solar panel and regulate the same so as not to overcharge the battery.
- Do not allow the battery to get into deep discharge mode while dc loads are used.
- To allow different dc loads to be used and supply appropriate voltage.

SOLAR PV PANEL:

Fig.3: Solar PV panel [5]

The PV cell is the basic building block of a PV system. In this paper work it has been considering 12W 500mA panel. Individual cells can vary in size from about 0.5 inches to about 4 inches across. However, one cell only produces 1 or 2 Watts, which is only enough electricity for small uses.

PV cells are electrically connected together in a packaged, weather-tight PV module or panel. PV modules vary in size and vary in the amount of electricity they can produce. PV module electricity generation capacity increases with the number of cells in the module or in the surface area of the module. PV modules can be connected in groups to form a PV array. A PV array can be composed of two or several thousand PV modules. The number of PV modules connected together in a PV array determines the total amount of electricity that the array can generate. Photovoltaic cells generate direct current (DC) electricity. This DC electricity can be used to charge batteries that, in turn, power devices that use direct current electricity.

Nearly all electricity is supplied as alternating current in electricity transmission and distribution systems. Devices called inverters are used on PV modules or in arrays to convert the DC electricity to alternating current (AC) electricity. PV cells and modules will produce the largest amount of electricity when they are directly facing the sun. Tracking systems can be used to move PV modules to constantly face the sun, but these systems are expensive. Most PV systems have modules in fixed positions with the modules facing directly south and at an angle that optimizes the physical and economic performance of the system at the location where it is installed [6]

MICROCONTROLLER:

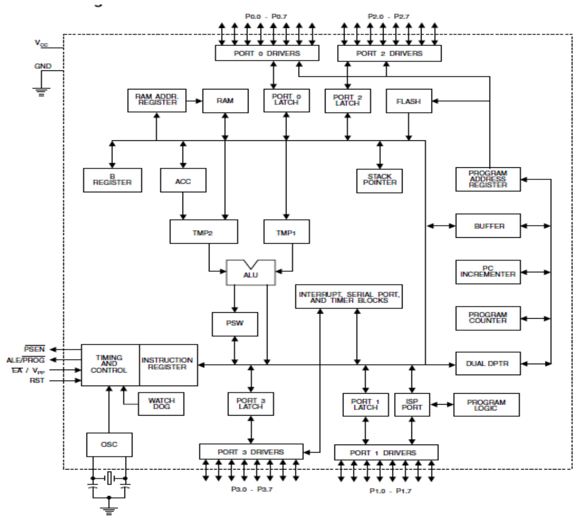

Fig.4: Pin diagram showing process of microcontroller [8]

FEATURES:

- 8K Bytes of In-System Programmable (ISP) Flash Memory – Endurance: 10,000 Write/Erase Cycles
- 4.0V to 5.5V Operating Range
- Fully Static Operation: 0 Hz to 33 MH
- Three-level Program Memory Lock
- 256 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Eight Interrupt Sources
- Full Duplex UART Serial Channel
- Low-power Idle and Power-down Modes

DESCRIPTION:

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the

AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset [8]

OBJECTIVES:

The Main objective of this paper work is,

1. To provide an alternative source of power supply via solar PV system
2. To add power during main power-cut
3. To supply power to the smaller loads in laboratories

METHODOLOGY:

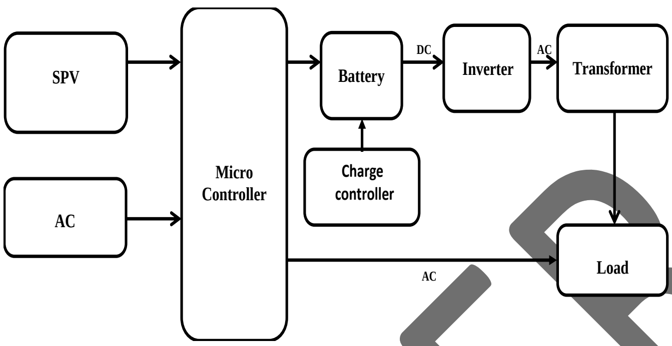

Fig.5: Block diagram [2]

A Solar cell or photovoltaic cell is a device that converts light directly into electricity by the photovoltaic effect. Photovoltaic cells combined together to make solar panels, solar modules, or photovoltaic arrays. The solar panel used here is meant to charge a 12V battery and the wattage can range from 12W. Solar cells are usually made from silicon, the same material that is used for making transistors and integrated circuits. In order to generate electric current the silicon is doped or treated so that when light strikes it electrons are released. Crystalline solar cells are wired in series to produce solar panels. To charge a 12V battery 36 cells are required to produce an open circuit voltage of about 20Volts as each cell produces a voltage of between 0.5V-0.6V.

A charge controller or regulator is a small box consisting of solid state circuits PCB which is placed between a solar panel and a battery. The main function is to regulate the amount of charge coming from the panel that flows into the battery bank in order to avoid the batteries being overcharged. Solar charge controller has three basic functions [3]

- To limit the voltage from the solar panel and regulate the same so as not to overcharge the battery.
- Do not allow the battery to get into deep discharge mode while dc loads are used.
- To allow different dc loads to be used and supply appropriate voltage.

The proposed solar charging application requires a deep cycle battery. Deep cycle batteries have larger plates and different chemistry to avoid the corrosive effect of frequently using the full capacity. The solar energy is converted into electrical energy and stored in a lead-acid battery. The ampere-hour is the rated capacity of the battery. If lead acid batteries are maintained properly, they will function at 80-90% efficiency. To extend the life of the battery and maintain efficiency it is important to maintain a full charge under most condition. Hence the use of a charge controller with solar panels to charge, so they don't over charge the battery or apply the wrong voltage .The battery output is given to inverter and it converts to 12V DC signal into 12V AC signal and step up to 230V.

An 8-bit microcontroller (AT89S52), it has been programmed and implemented to determine the specific load to be powered by the photovoltaic system or by the AC mains [2]

BASIC BATTERY OPERATION:

Fig.6: Battery strcture [4]

Two electrodes (positive and negative, made of two chemically different materials) are separated by an electrolyte - a solution that easily conducts ions (charged particles) An Electrical Load is applied to the cell, causing the cell to discharge [7]

- Electrons are pulled from the positive terminal of the battery through a chemical reaction between the positive terminal and the electrolyte

- Electrons flow through the electrical load
- Electrons return to the negative terminal
- Electrons are put back into the negative side of the battery through a chemical reaction between the negative terminal and the electrolyte

LM555/NE555/SA555:

DISCRIPTION:

The LM555/NE555/SA555 is a highly stable controller capable of producing accurate timing pulses. With mono stable operation, the time delay is controlled by one external resistors and one capacitor With astable operation, the frequency and duty cycle are accurately controlled with two external resistors and one capacitor [8]

INTERNAL BLOCK DIAGRAM:

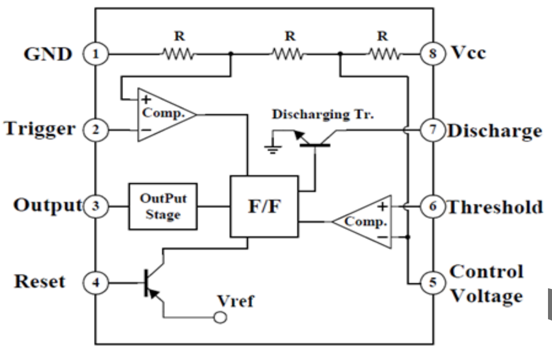

Fig.7: Interanal block diagram [7]

FEATURES:

- High Current Drive Capability (200mA)
- Adjustable Duty Cycle
- Temperature Stability of 0.005%^{0}c
- Timing from μs to hours
- Turn off time less Than $2\mu s$

APPLICATIONS:

- Precision timing
- Pulse generation
- Time delay generation
- Sequential timing

INVERTER:

Here is a simple PWM dc to ac voltage inverter circuit based on IC SG 3524. The SG3524 IC chips is a fixed frequency PWM (Pulse Width Modulation) voltage regulator control circuit, with indifferent outputs for single ended or push pull applications. The SG3524 IC integrated circuit has all the functions necessary for the production of a regulating power supply, electrical inverter or switching regulator on a single chip. Moreover it can be used as the control element for high power output purposes. We know pulse width modulation PWM theory, i.e. a method of adjusting the width of the pulses in a pulse train relative to a control signal. If greater the control voltage, wider is the resultant pulses. Using a sinusoidal frequency as the control voltage for pulse width modulator circuits, it is likely to generate a high power waveform whose average voltage varies with the sine wave, which is suitable for driving ac loads [7]

WORKING OF PWM INVERTER CIRCUIT:

- The IC SG3524 operates at a fixed frequency; the oscillation frequency is determined by one timing resistor RT and one timing capacitor CT.
- RT set up a constant charging current for CT. So there exists a linear ramp voltage at CT, which is connected to the comparator.
- Comparator provides a linear control of the output pulse width (duration) by the error amplifier.
- The SG3524 contains an inbuilt 5V regulator that supplies as a reference voltage, also providing the SG3524 internal regulator control circuitry.
- The inside reference voltage is divided on the outside by a resistor network to give a reference to inbuilt error amplifier. (External reference can also be used).
- The output is sensed by a subsequent resistor divider network and the error signal is amplified. This voltage is then compared with the linear voltage ramp at timing capacitor CT, thus producing a pulse width modulation (PWM) pulse.
- The resultant PWM pulse from the comparator is passed to the corresponding output pass transistor (Q1, Q2 refer block diagram) using the pulse steering flip flop, which is synchronously toggled by the oscillator output.

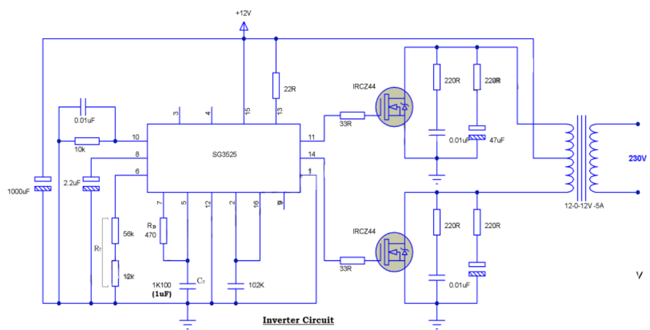

Fig.8: Circuit diagram of PWM inverter [7]

DESIGN VERIFICATION: TESTING AND ANALYSIS:

Buck converter testing was carried out in a similar manner to the testing of the boost converter. The same power supply was utilized as well as the CFL load; the same output power limitation of 75W was present. The input voltage was varied between 19V and 23V, while varying the load as well. The output voltage was held at 12V and associated input/output voltage levels and power measurements were taken[5]

Table.1: different voltage conversion's [3]

SI. No	Circuit	Input Voltage	Output Voltage
1	Boost converter	12V (DC)	22.4V (DC)
2	Buck converter	22.4 (DC)	12V (DC)
3	Half bridge inverter	12V (DC)	12V (AC)
4	Transformer	12V (AC)	230V (AC)

RESULTS AND DISCUSSION:

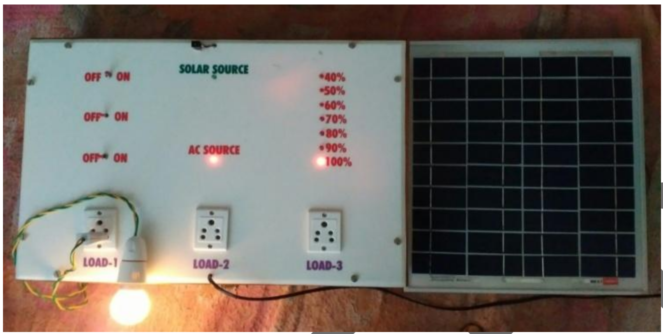

Fig.9: Practical observation while load is connecting to AC source

In the fig.9 it is seen that practical observation of the paper work. If the AC source is available the microcontroller senses the signal and it is automatically connecting the load to AC source.

In this paper work is to provide an alternative source of power supply via solar PV system and solar PV system can be added during power cut and supply power to smaller loads.

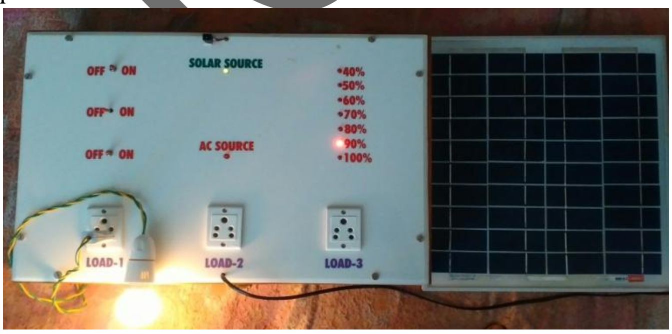

Fig.10: Practical observation while load is connecting to solar source

Similarly fig.10 also shows that practical observation of the paper work while the load is connecting to solar source whenever the AC source is not available.

CONCLUSION:

Solar (PV) power system has a great potential in future as one of renewable energy technologies for off-grid power generation. A creative concept of Solar Based Power Pack Instrumentation will be powered by the natural source like solar has been used in this paper work. The solar photovoltaic cell is used to utilize the solar energy to generate electricity. The electricity generated will be stored in battery. If there is no supply from the grid the stored energy can be used as an alternative source of energy. Since electricity produced will be DC, it must be converted to AC before it can be used for small voltage laboratory applications and can also be used for lighting. It needs only initial investment.

The future scope of this paper work can be implemented by using maximum power point tracker system to increase the efficiency of the solar PV system.

REFERENCES:

i. Wallies Thounaojam[1], V Ebenezer[2], Avinash Balekundri[3], *"Design and Development of Microcontroller Based Solar Charge Controller"* (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 5, May 2014)

ii. P.H.Patil, Poonam Undre[1], Shriti Wavhal[2], Pooja Patil[3], *"Solar Based Inverter and Charger"* International Journal of Scientific & Engineering Research, Volume 4, Issue 7, July-2013 ISSN 2229-5518

iii. M. Hashmi, S. Hanninen and K. Maki, "*Survey of smart grid concepts, architectures, and technological demonstrations worldwide"*, 2011 IEEE PES Conference on Innovative Smart Grid Technologies (ISGT Latin America), **(2011)**, pp. 1-7.

iv. M. I. Ridwan, M. H. Zarmani, R. M. Lajim and A. Musa, "*TNB IEC 61850 System Verification and Simulation (SVS) laboratory: Enabler to a successful smart grid implementation*", 2012 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia), (2012), pp. 1-6.

v. Maruti Pammar[1], Santosh Chavan[2] 1 *"design and Development Of Advanced Microcontroller Based Solar Battery Charger And Solar Tracking System"* eISSN: 2319-1163 | pISSN: 2321-7308

vi. *All hardwear equipments requiments*,www. electrical components.com

vii. Hurny-Liahng Jou*, "Voltage-Mode Grid-Connected Solar Inverter with High Frequency Isolated Transformer*" IEEE International Symposium on Industrial Electronics (ISlE 2009) ,July 5-8, 2009,

viii. www.LM555 IC.com

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