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Solar Based Air Compressor for Tire Inflation

[1]Shrinivas N.T, [2]Mayur H.G.[3]Chetan C. B. [4]Shivaprasad B. A.[5]Deepak V. P.
[1]*Assistant Professor, Dept. of Mechanical Engineering, KLEIT, Hubballi, Karnataka, India*
[2]*Final year UG students, Dept. of Mechanical Engineering, KLEIT, Hubballi, Karnataka, India*

Abstract: *With the existing push in the direction of sustainable, clean sources of power, it is no surprise that solar power has become one of the most popular alternative energy sources. Free and available everywhere, the power of the sun can be employed to power everything like cell phones and motors. The sun's energy is usually harvested through solar panels that are made up of photovoltaic cells. These cells can convert the sun's power into electricity that can be used for a number of purposes. For private use, a handheld solar hybrid charger can be employed to recharge little device for instance a DC fan, a cell phone, or a camera. This project consists of Microcontroller based control unit that continuously monitors and controls the DC voltage of the battery. This live voltage value gets display on Alpha Numeric LCD display in real time. Regulated output of Solar cell is connected to rechargeable battery through a unidirectional current flow circuitry. This particular charged battery output given as input to the air compressor motor, this motor will controlled by the user manually using control button. In this project micro controller has the input modules like control buttons and output modules are LCD display and buzzer to give alarm in case of low voltage.*

Keywords: *Air compressor, Solar panel, Battery tank, Microcontroller circuit, Alpha Numeric LCD*

I. Introduction

The green energy also called the regeneration energy, has gained much attention nowadays. Green energy can be recycled, much like solar energy, water power, wind power, biomass energy, terrestrial heat, temperature difference of sea, sea waves, morning and evening tides, etc. [1, 2]. Among these, solar energy is the most powerful resource that can be used to generate power. So far the efficiency of generating power from solar energy is relatively low. Thus, increasing the efficiency of generating power of solar energy is very important. Solar energy is the most powerful resource that can be used to generate power. So far the efficiency of generating power from solar energy is low because solar cells have been hooked with fixed elevating angles. They do not track the sun and therefore, the efficiency of power generation is low. Since the fixed-type solar panel cannot obtain the optimal solar energy, the transformation efficiency of solar energy is limited. With rising energy costs and more awareness of the need to be environmentally friendly, companies and individuals are beginning to utilize the solar power air compressor. Solar Power Air Compressors are used By Oil and Gas Companies. "Air compressor" is one of those terms you hear all of the time, but couldn't tell one if it compressed you in the face.Simply, the compressor compress air. They work like power generators or battery cells in that they force energy to where it needs to go in order to make a device work. They are often used in more remote and inaccessible areas where you just can't plug your drill into a wall socket.
A solar power air compressor is not just a tank and portable generator looking device, but also needs solar power panels and wiring from the panels to your solar power air compressor.

II. Solar Cell

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic(PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic converts light into electric current using the photoelectric effect. A solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as *photovoltaic cells*. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Because a single solar panel can only produce a limited amount of power, many installations contain several panels. This is known as a photovoltaic array. A photovoltaic installation typically includes an array of solar panels, an inverter, batteries and interconnection wiring. Photovoltaic systems are used for either on- or off-grid applications, and on spacecraft

The solar cell is composed of the semiconductors of the P-N junctions. It can convert light into electric energy. Therefore we can assume that electricity produced using sunlight shining on the solar cell can be used like common electricity. The equivalent circuit of the solar cell is shown in Fig. 1. The current supply I_{ph}represents the electric current generated from the sun beaming on the solar cell. $R_j$is the non-linear impedance of the P-N junction. $D_j$is a P-N junction diode, R_{sh} and R_s represent the equivalent lineup with the interior of the

materials and connecting resistances in series. Usually in general analysis, R_{sh} is large, and the value of $R_s$is small. Therefore in order to simplify the process of analysis, one can ignore R_{sh} and R_s. The symbol $R_o$represents the external load. *I* and *V* represent the output current and the voltage of the solar cell, respectively.

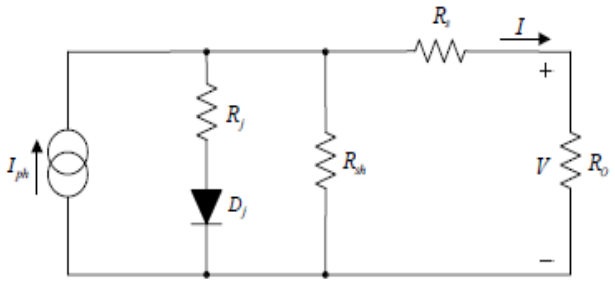

Fig. 1. Solar cell equivalent circuit.

From the equivalent circuit, and based on the characteristics of the P-N junction, (1) presents the connection between the output current *I* and the output voltage *V*:

$$I = n_p I_{ph} - n_p I_{sat}\left[\exp\left(\frac{q}{kTA}\frac{V}{n_s}\right) - 1\right],$$

……Eqn (1)

Where '*np'* represents the parallel integer of the solar cell; '*ns'* represents the series connected integer of the solar cell; '*q'*represents the contained electricity in an electro (1.6×10−19 Columbic); '*k'*is the Boltzmann constant (1.38×10−23 *J* / °*K)*; '*T'*is the temperature of the solar cell (absolute temperature °*K)*; and '*A'*is the ideal factor of the solar cell (A= 1 ~ 5). The current I_{sat}in (1) represents the reversion saturation current of the solar power. Further, I_{sat}can be determined by using the following formula:

$$I_{sat} = I_{rr}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{qE_{Gap}}{kA}\left(\frac{1}{T_r} - \frac{1}{T}\right)\right],$$

……..Eqn(2)

Where $T_r$represents the reference temperature of the solar cell; $I_{rr}$is the reversion saturation current at the time when the solar cell reaches its temperature T_r and E_{Gap} is the energy needed for crossing the energy band gap for the semiconductor materials. (The crystalline $E_{Gap}\cong 1.1$eV).

From the study we are able to know that when the temperature is fixed, the stronger the sunlight is, and the higher the open-circuit voltage and short-circuit current are. Here we can see the obvious effects of illumination on the short-circuit current, rather than the open-circuit current. Therefore the solar cell can provide higher output rate as the sunlight becomes stronger, i.e. solar cell facing the sun.

Solar panels range in size from 1 watt to 300+ watts. Most solar panels up to 135 watts are 12 volt. Many solar panels over 135 watts are 21 to 40 volts - designed mainly for grid tie applications (Evergreen is one exception).Higher voltage solar panels can be used on battery charging systems when using MPPT controllers such as the Outback Power FM60 & FM80, Xantrex XW-SCC, and the Morningstar MPPT solar charge controls. Solar World panels are Enphase Micro inverter compatible. All solar panels are rated in **Watts**. The watt rating is how much power (amps times volts) the panel will produce in full sunlight at 25 ^{0}C (77F). This is the industry standard (STC) for all PV panel ratings. However, that is a "best case" scenario; in actual real life on a year around average you can expect 10-15% less for all panels.

This provides a simple system that provides 12V DC output of 183 Amps. Adding additional batteries will increase the runtime in direct proportion to what is added. Insure that you do not overload your system.

Battery Draw	Output Wattage	Max Runtime
12V @ 1A	12 Watts	183 Hours
2V @ 4A	48 Watts	45 Hours
12V @ 16A	192 Watts	11 Hours
12V @ 32A	384 Watts	5 Hours
12V @ 183A	2196 Watts	1 Hour

Table No. 1: Types of solar cells with various input-output parameters

III. Lead Acid Battery

Fig 2: Lead Acid Battery of 12V, 1.2AH

Lead-acid batteries are the most common in PV systems because their initial cost is lower and because they are readily available nearly everywhere in the world. There are many different sizes and designs of lead-acid batteries, but the most important designation is that they are deep cycle batteries. Lead-acid batteries are available in both wet-cell (requires maintenance) and sealed no-maintenance versions. AGM and Gel-cell deep-cycle batteries are also popular because they are maintenance free and they last a lot longer. Lead acid batteries are reliable and cost effective with an exceptionally long life. The Lead acid batteries have high reliability because of their ability to withstand overcharge, over discharge vibration and shock. The use of special sealing techniques ensures that our batteries are leak proof and non-spillable. Other critical features include the ability to with stand relatively deeper discharge, faster recovery and more chances of survival if subjected to overcharge. The batteries have exceptional charge acceptance, large electrolyte volume and low self-discharge, which make them ideal as zero-maintenance batteries.

IV. Air Compressor

Fig 3: Air Compressor used for small tire inflations.

The simple reciprocating air compressor has a piston which reciprocates inside the cylinder wall and cylinder head. The piston is attached to the crankshaft with the help of a connecting rod and thus the rotation of the crankshaft causes the piston to move up and down inside the cylinder. The crankshaft is mounted on the crank case. The cylinder head contains valve pockets where the suction and delivery valve are fixed. These suction and delivery valves are of simple pressure differential types. They open and close, due to the pressure difference on either side of the valve plates.1. When the compressor stops or idles for some time, it is always assumed that there is some residual compressed air left in the cylinder space. This residual air expands when the piston moves down.

The pressure drops in the cylinder space at a particular point as the piston moves down, where the pressure inside the cylinder becomes lesser than the atmospheric pressure. Thus this difference in pressure makes the suction or inlet valve open.2. This opening of inlet valve allows fresh air to be drawn inside the cylinder space as the piston still continues to move in the downward direction. The inlet valve will remain open till there is pressure difference between the atmosphere and inside of the cylinder space. As the pressure difference starts to reduce, the inlet valve starts slowly closing. The inlet valve closes completely when there is no pressure difference and then the piston reaches bottom dead center (BDC), and it starts to travel in an upward direction. At this position, both the inlet and delivery valve remains closed. Thus as the piston moves up, the pressure starts to build inside the cylinder space.3. The delivery valve starts to open when there is a pressure difference between the cylinder space and air receiver. Let us assume the air receiver is at a pressure of 7bar. The delivery valve will not open until the pressure inside the cylinder space is slightly above 7 bar. As the pistonmoves in upward direction, the pressure increases and at some point the pressure grows beyond 7 bar making the delivery valve open. Thus the compressed air is delivered into the air receiver.4. As the piston

reaches top, the pressure starts to fall and the delivery valve starts to close. The residual compressed air remaining in the space again starts to expand as the piston moves down continuing the next cycle.

V. 16*2 LCD

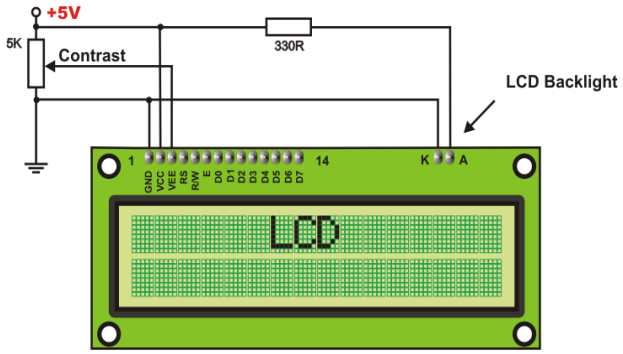

Fig 4: LCD Screen to display output (16*2).

16 X 2 LCD is used to display the operating instructions and status of the output. HD44780U is used in the project. The HD44780U dot-matrix liquid crystal display controller and driver LSI displays alphanumeric, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8-bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver. A single HD44780U can display up to one 8-character line or two 8-character lines. The HD44780U has pin function compatibility with the HD44780S which allows the user to easily replace an LCD-II with an HD44780U. The HD44780U character generator ROM is extended to generate 208 5X8 dot character fonts and 32 5X10 dot character fonts for a total of 240 different character fonts.

VI. The Working Model

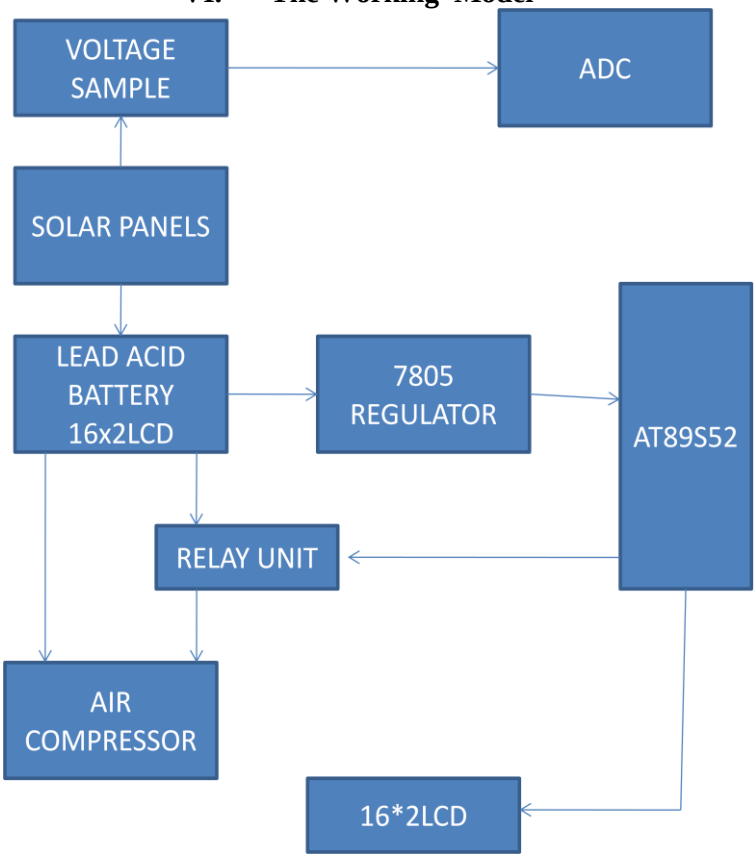

Fig 5: Flow Chart Showing Sequential steps of Microcontroller to send commands to LCD

AT89S52 MCU: AT89S52 is 8-bit microcontroller from Atmel Semiconductors. This comes into 8051 family microcontroller. This is the heart of the project. The complete control logic program is stored in this microcontroller. It sends and receives control and data signals to LCD, Stepper motor and to the other Devices based on the program logic.

Solar Panel: This is a photo voltaic cell. This converts light energy into electrical energy. The output voltage of the solar panel depends on the amount of light falling on the panel.

Voltage Sampling Circuit: The output voltage of the solar panel is given to voltage sampling circuit. This is a voltage divide network. The sample voltage is given to Analog to Digital converter circuit. Contrast Control: It is a simple variable resistor (preset) with linear characteristics. This is used to adjust the contrast of the display.

ADC0804 (Analog to digital converter): The ADC chip that is used in this project is ADC0804. The ADC0804 IC is an 8-bit parallel ADC in the family of the ADC0800 series from National Semiconductor. It works with +5 volts and has a resolution of 8 bits. In the ADC0804, the conversion time varies depending on the clocking signals applied to the CLK IN pin, but it cannot be faster than 110μs.

Reset: Reset control circuit is used to reset the microcontroller at any stage of work. This section also comprises of auto power on reset. If the reset switch is pressed, the microcontroller restarts and the function will start from the beginning. This circuit is connected to 9^{th} pin of microcontroller.

Crystal: A crystal is used to supply clock frequency to the microcontroller. The clock frequency is 11.0592MHz. 11.0592 MHz crystals are often used because it can be divided to give you exact clock rates for most of the common baud rates for the UART, especially for the higher speeds (9600, 19200). Despite the "oddball" value, these crystals are readily available and commonly used.

A few real time picture taken during the research:

Fig 6: Disassembled piston-cylinder type air compressor during research.

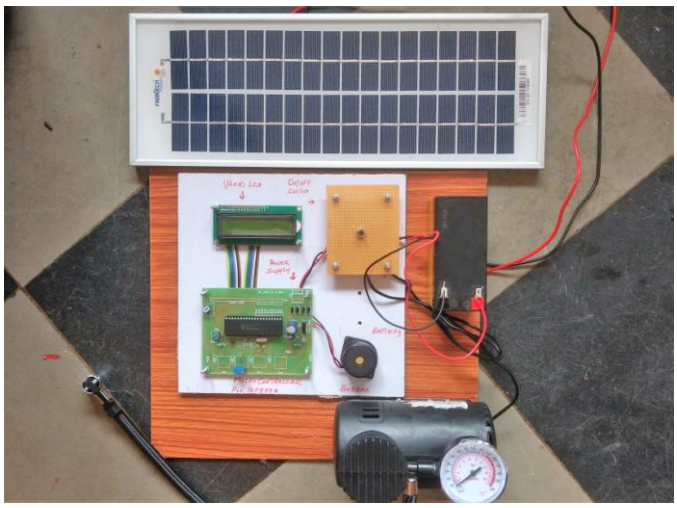

Fig 7: Final Assembled Solar Based Air Compressor Working Model.

VII. Conclusion

Thus we have seen the actual operation of an Air compressor it can be operated by using solar panel voltage stored in a rechargeable battery which is used to drive the air compressor effectively without any external supply which eliminates the usage of using conventional source of energy. In this project we are able to interface the air compressor with the help of microcontroller through relay section and programmatically we are calculating voltages which can be displayed on 16X2 LCD. Where this product is reliable and has an advantage of Easy maintenance, Compact Size, Easy to carry to remote place,Quick Inflation and it has got the application in Oil Industries, Gas Industries, House hold applications,Paint Spraying, Lubrication and in Automobile Industries.

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