Drinking Water Management using Solar Power BLDC Motor

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***Abstract*— in this paper low cost automatic drinking water supply management is provided using a PMBLDC (Permanent Magnet Brushless DC Motor) drive coupled to a pump load. In this proposal PIC microcontroller is used to drive the BLDC motor and the solenoid operated valve which reduces the overall cost of the drive system. Solenoid operated valves is used to distribute the water to various lanes. When the output from the solar panel is reduced due to increase in cell temperature, or during low weather conditions the solar charge controller used here will maintain the required output power. The water level sensors attached to the tank indicates the water level to the controller and automates the pumping system.**

Keywords- PMBLDC; PIC Controller; solenoid valve; sensors

I. INTRODUCTION

Nowadays the major problem we met is the global energy crisis which is being experienced by all. In order to overcome this we need more energy efficient management systems. Solar energy, an inexhaustible energy which is having the features of being environmental friendly and acts as a substitute of shrinking energy resource, therefore it is considered as an ideal form of energy over other energy resources. Solar energy is available all over the world with varying intensity, Mono crystalline Silicon the main element used in the manufacturing of solar cells is the base material for silicon chips and is used as a light absorbing material in the solar panels .The problem of resource availability will be less. The main asset of ECM (Electronically Commutated Motors) or Brushless motors over the brushed motors are less maintenance requirements, reduced environmental effects and less electromagnetic radiation, reduced wear and tear problems. Within the last five decades, several improved magnetic materials are developed for high performance PM motors. The features of high operating efficiency, brushless construction, maintenance free operation and increasing awareness about energy conservation have given a scope to the demands of the motor in water pumping application operated by the PV array, particularly inn remote villages where electric supply is not available. Water Automation process plays a vital role when these systems are installed in rural unattended zones, village's areas where scarcity of water prevails in summer. The available water resources can be utilized effectively without wastage and which will increase the efficiency of the system. The Level sensors are used to determine the water level which is also of low cost. This system is designed to use the energy efficiently and economically. BLDC motor coupled pump is selected to increase the cycle efficiency of the system.

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II. ANALYSIS OF THE SYSTEM

A. OVERALL BLOCK DIAGRAM

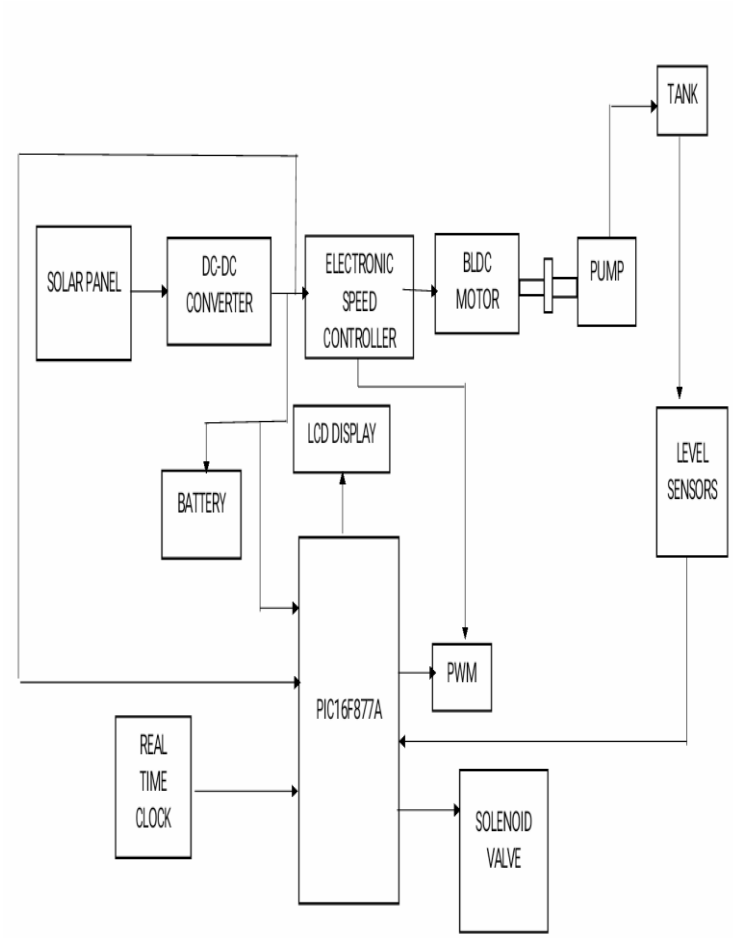

Fig 1: Overall Block diagram of drinking water management

B. PV MODULE

A Photovoltaic module is a packaged, connect assembly of typically 6*10 photovoltaic solar cells. Each module is rated by its Dc output power under standard test conditions (STC), and typically ranges from 100 to 365 watts. The efficiency of the module determines the area of a module given the same rated output –an 8% efficient 230 watt

module will have twice the area of a 16% efficient 230 watt module.

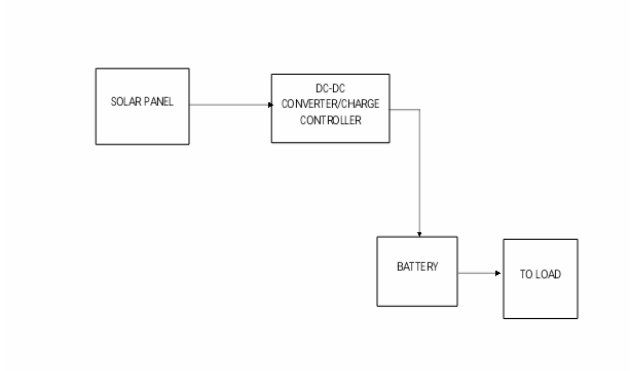

Fig 2: Connection of solar panel

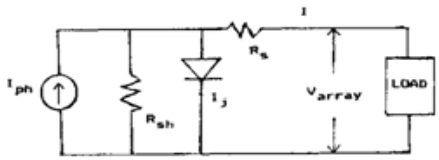

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Fig 3: Equivalent Circuit of PV array

The *I-V* equations of a solar cell is given by

$$V = -IR_s + (1/D) \ln (1 + (I_{ph} - I)/I_o) \quad \ldots\ldots\ldots \quad (1)$$

where I_{ph} is the photon current proportional to the insolation, R_s the series resistance of the cell, I_o the cell reverse saturation current, D the *q/AK T*, *q* the electric charge of an electron, K the Boltzmann constant, T the absolute temperature, and A the compilation factor[1] .

C. Abbreviations and acronyms

BLDC- Brushless DC Motor
PIC - Peripheral Integral Controller

E.Battery

In various pumping systems the need for a battery is obviated with the addition of a water reservoir, which in many cases is preferable for its simplicity, cost effectiveness, maintainability and lifespan. In this case supply for up to 5 days is considered good and water storage tanks should be designed to have a low impact on static head of the pumping system [2]. It is further argued that to reduce overall costs, several pumps feeding individual storage systems should be considered over a single larger pumping system with piped distribution.

The use of a battery carries with it a level of environmental consideration, due to disposal of the battery at the end of its operating life, usually in the form of lead or 16 acid waste. This is especially true for rural areas using an off-grid pumping system as it becomes increasingly difficult to dispose of an obsolete battery efficiently.

F.Automation

Level sensors are used to indicate the water level. When the lowest level is reached the PWM signals are given to the BLDC driver which starts the BLDC motor thereby initiating the pumping process. When the medium level is reached the duty cycle is reduced to run the drive at a relatively low speed. When the highest level is reached i.e. when the tank is full the controller provides the brake signal to the BLDC motor thereby stopping the pumping operation.

G.PIC controller

PIC microcontroller has the reduced instruction set computer with only 35 instructions. Usually PIC microcontrollers are fabricated using CMOS (complementary metal oxide semiconductor) technology that uses separate bus for instruction and data. The main benefit of RISC and CMOS combination is low power consumption that results in a very small chip size with a small pin count. The main advantage of CMOS is that it has high input impedance and immunity to noise than other fabrication techniques.

The pic controller used here is PIC16F877A.The features of PIC16F877A includes

- Only 35 single bot mode instructions to learn.
- Power on reset.
- Brown out detection circuitry for brown out reset.
- Self-programmable under software control
- Power-saving sleep mode.
- Watch dog timer with on-chip oscillator.

III. BLDC MOTOR

In recent trends brushless dc motors is used to make the operation more reliable, more efficient and less noisy. They are lighter compared to brushed motor with the same power output. The efficiency of a BLDC motor is typically around 70-85%% whereas the conventional motors are only 60-70%.

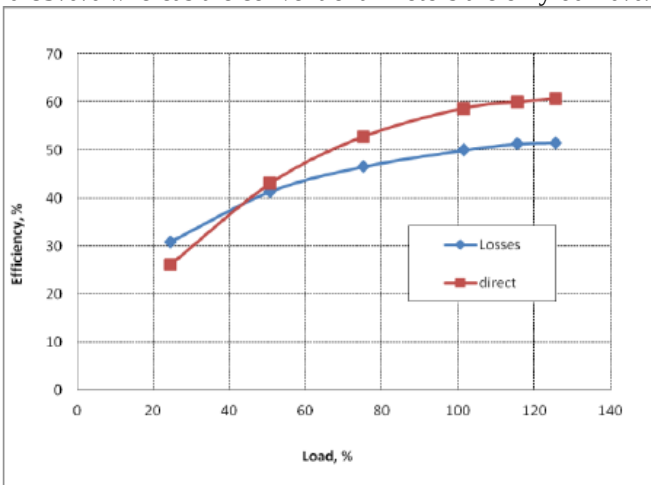

Fig 4: BLDC Motor efficiency

A.Back EMF method

Considering the interval while phases A and C are conducting and phase B is open as indicated by the shaded region, Phase A is connected to the positive terminal of the dc supply, whereas phase C is connected to the negative terminal of the dc supply and phase B is open. Therefore, $I_A = -Ic$ and $Ib = 0$. It is evident from the Figure. 5 (shaded region) that the back EMF in phases A and C are equal and opposite. The differences in line voltages waveform is an inverted representation of the back EMF waveform. It is again evident from that during this interval (shaded portion) the back EMF *Ebb is* transited from one polarity to another zero crossing. Therefore, the operation $V_{ab} - V_{bc}$ (V_{abbc}) enables detection of the zero crossing of the phase B EMF. Therefore, the zero-crossing instants of the back EMF waveforms may be estimated indirectly from the measurements of only three terminal voltages of the motor [2].

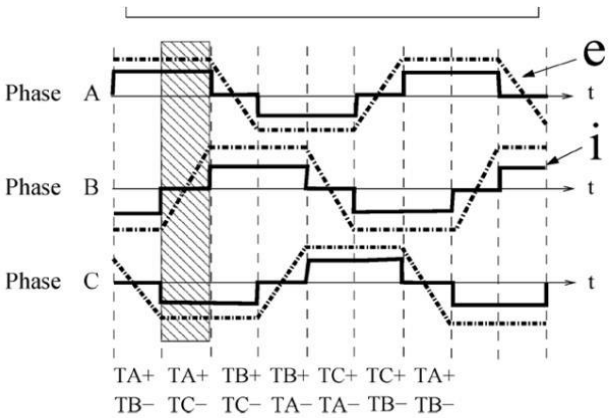

Fig 5: Line voltage and trapezoidal back emf of BLDC Motor.

B.Electronic Speed Controller

An electronic Speed Controller is an electronic circuit with the purpose of varying an electric motors speed. ESC's are most often used for brushless motors essentially providing an electronically generated three phase electric power with low voltage source of energy.

Brushless ESC's basically create a triphase Ac power of limited voltage from the onboard dc power input to run the brushless motors by sending AC signals which is generated from the ESC'S circuitry, employing a very low impedance for rotation.

Features

- Extremely low internal resistance.
- Super smooth and accurate linearity.
- Auto shut down in case of signal lose situation.
- Power arming protection.
- Supports high RPM motors.
- Runs motor in forward or reverse.
- Soft start ramp up.
- Pump coupling

C. ESC Connections

BLDC ESC has three Blue wires coming from one end which is to be connected to the BLDC motor. On the other end, it has red and black wires that will be connected to the battery. It is also having a 3 pin servo connector which is used for receiving the throttle command and for giving out regulated 5V, 3Amp supply for the remote receiver and the servo motors.

TABLE 1: ESC connection with BLDC

Connection type	**Color and functions**		
	Wire color	***Function***	
power	***Red***	***7.4 to 14.8 V***	
	Black	Ground	
BLDC connections	Three blue wires	BLDC ESC connections	
Servo Connector	White	Throttle Input	
	Red	5V,2 Amp Out	
	Black	Ground	

D. Simulation

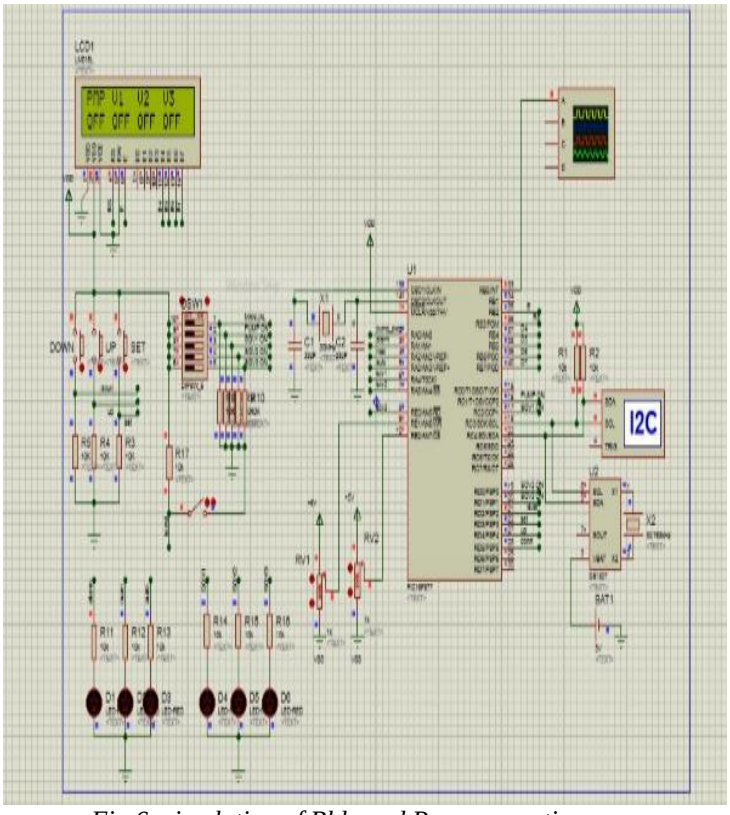

Fig 6: simulation of Bldc and Pump operation

IV. DESIGN DETAILS

A.PV panel sizing

PV panel sizing depends on the total system load, which means determination of total wattage of the load.
PV Array size = 300/ (0.9*0.9) = 370 W

Total power consumption demand
= (60*1hour) + (5.5*24) + (5*24)
=185.5*1.3=241.15 watt.
Considering the Panel generation factor=3.43
Total WP of PV panel
= 241.15/3.4
= 70.92 WP
Number of panels needed
=Total WP of the PV panel/Peak watt power of PV panel
=70.92/27.91
=2.7 modules
Therefore the system should be provided with 2 or 3 modules of 27.91WP PV module.

B. Rating of BLDC Motor

TABLE 2 BLDC SPECIFICATIONS

Specifications	Ratings
No. of Cells:	2 - 3 Li-Poly 5 - 7 NiCd/NiMH
KV:	2200 RPM/V
Max Efficiency:	75%
Max Efficiency Current:	14 - 22A (>72%)
No Load Current:	1.4A @10V
Resistance:	0.045 ohms
Max Current:	28A for 60S
Max Watts:	220W
Weight:	51.5 g / 1.82 OZ
Size:	27.8 mm x 31 mm
Shaft Diameter:	3.2 mm
Poles:	14
Model Weight:	300 - 1000g / 10.5 - 35 OZ

V Circuit Diagram of the Project

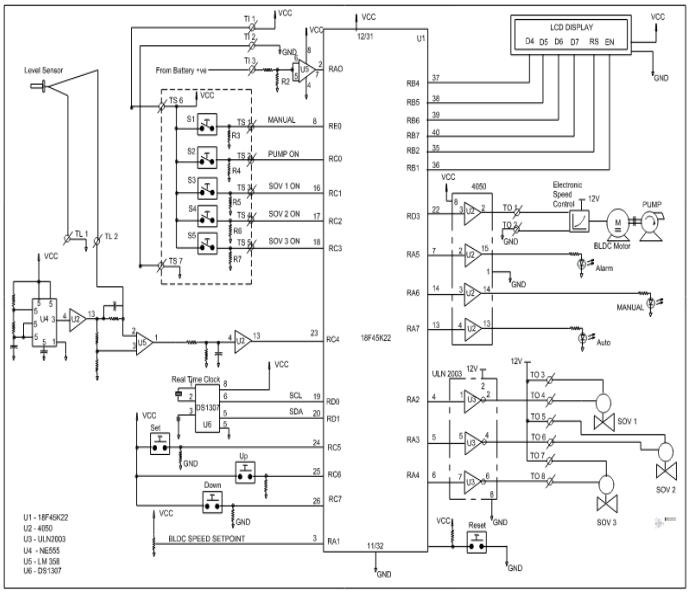

Fig 7: Detailed design connections

CONCLUSION

The proposed project will be useful in remote village areas where there is a scarcity of electricity. This project can be used in either automatic operation or manual operation in case of low weather conditions. Use of brushless motor provides low maintenance cost, less wear and tear etc.., the operation will be displayed in the LCD module which will reduces user intervention. BLDC coupled centrifugal pump runs at the rated speed and pump the water into the overhead tank fastly.

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