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Fabrication of a Cost effective Automatic Dual/Single Axis Active Solar Tracker with Built in Inverter Designed for Grid Connectivity and Standalone Systems

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Abstract*— In our Dual axis automatic solar tracker project, AT89S52 micro-controller has been used. Four photo-sensors (LDR VAC54) are used for sensing the sunlight to know sun's movement. Two gear motors (12V, 300 rpm) are there to rotate the solar panel (E-W and N-S) as the sun changes its direction. ADC chip 0808 is used to decode analog voltage to digital voltage. PROTEUS software coding has been used for designing and simulating the tracker. Photo sensors, battery charging level and solar panel voltage will be monitored by the micro-controller through ADC chip. Attempts have been made to make this pilot project cost-effective with successful completion for standalone systems and can be expanded further for grid connectivity.

Index Terms*— Dual/Single axis solar tracker, ADC, Crystal Oscillator, multi-vibrator, micro-controller, PCB, Gear motors, Inverter, Proteus software simulation.

I. INTRODUCTION

In an attempt to fight against the continual global warming and reduce its impact, the Gujarat government undertook the solar mission. A solar tracker traces and focuses the sunlight as the sun moves across the sky with its position varying during different seasons and different time of the day. The panel gives maximum efficiency when sun is directly overhead i.e. at 1:25 pm in experimental laboratory, Bardoli as per the solar insolation data available. The automatic solar tracker that tracks the solar energy accurately throughout the day will definitely help to increase the effectiveness of this technique. This paper aims to design and fabricate a cost effective and accurate automatic solar tracker using controller logic and coding in Proteus software.

II. MANUFACTURING

Manufacturing of this solar tracker require many components. The design and construction of it was divided into various stages as follows:

- PCB Design
- Sensor and Sensor Controller
- Interfacing through micro-controller
- Motor and Motor Controller
- Inverter Design

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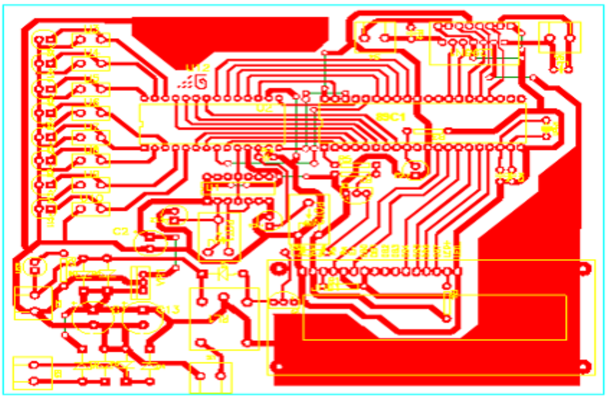

Fig 1: Original PCB layout

III. SYSTEM COMPONENTS

- ISIS Schematic Capture – a tool for entering designs.
- PROSPICE Mixed mode simulation- Standard SPICE3F5 simulator combined with digital simulator.
- ARES PCB Layout – PCB design system with automatic component placer, rip up and retry auto – router and interactive design rule checking.
- VSM - To simulate embedded software micro-controllers alongside hardware design.
- System Benefits- Common user interfacing and fully context sensitive help.

The designed system is made up of photo sensors, ADC 8 bit chip, multi-vibrator, micro-controller, gear motors, LCD display, logic switches, solar battery, solar PV module, MOSFET inverter. Photo sensors and logic switches are connected with the ADC chip. The sun travels 360 degrees in E-W direction on any given day [5].When sunlight will be available, the solar panel moves to the sunrise position in morning.

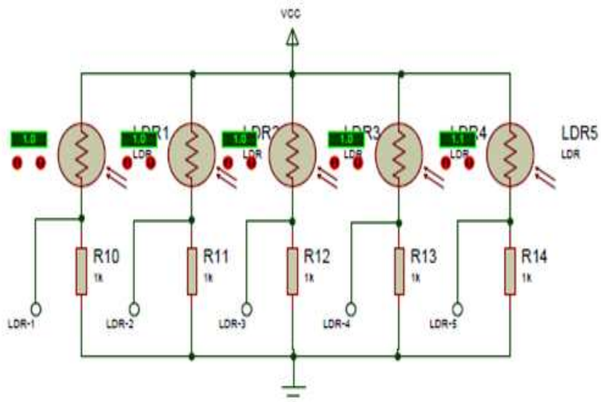

Fig 2: Connection diagram of LDRs along with resistors.

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As shown in the schematic diagram in figure 2, when sun light falls on the sensors, the value of potential divider circuit will be changed. This change will activate the dual axis movement routine which will result in either horizontal or vertical movement. According to the sun's movement, the sensors will collect the actual light and send the data to ADC chip. The ADC 0808 data acquisition component is a monolithic CMOS device with 8 bit analog to digital converter, 8-channel multiplexer and micro-controller compatible logic [4].

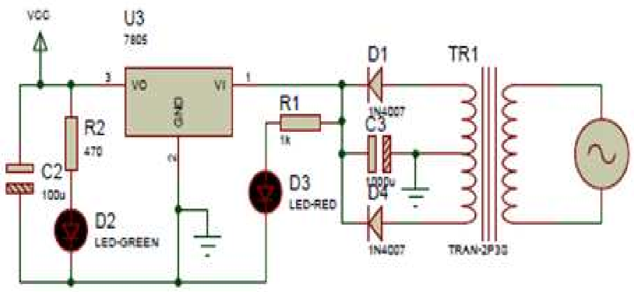

Fig 3: Crystal Oscillator circuit with logic switches.

The ADC chip will decode it and send to the microcontroller. The micro-controller will compare all sensors data and will give command to the two gear motors to go forward/reverse and to rotate the panel left/right. Two logic switches are placed to know the start and stop position of panel. Battery voltage and panel voltage will be scanned with the help of AT89S52 micro-controller through Analog to Digital converter IC (ADC0808).

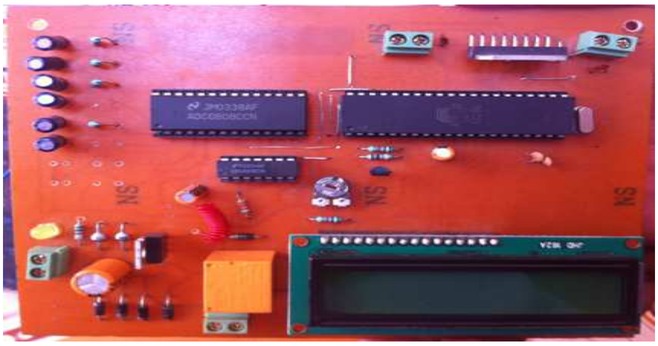

Fig 4: Final layout of PCB of Dual Axis Solar Tracking System

The micro-controller will measure and monitor all photo sensors data for continuous solar tracking. When battery will get fully charged, it will automatically cut off and LCD will show the notification. In the same way, when battery gets discharged below a certain level, the inverter will be switched off automatically.

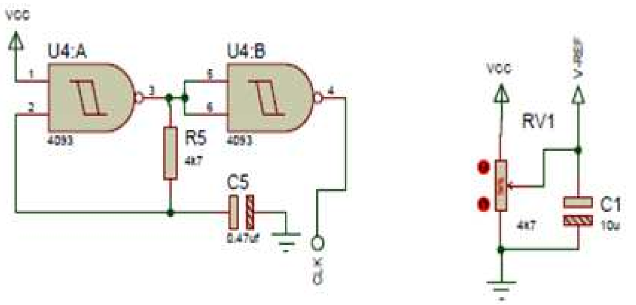

Fig 5: Magnetic relay circuit with Filter circuit.

DC gear motors are used to direct the tracker as per the command given by AT89S52 micro-controller in response to the LDR sensing higher intensity solar radiations.

Fig 6: Horizontal Motor Terminal with Side Shaft Gear

Gear motors are cheaper to buy and simple to drive but they need control circuitry (here Dual H-bridge motor driver circuit) to allow control of the speed. The gear motors will be driven by this bidirectional motor driver IC L298N. Driving commands will be fed by the micro-controller with two interrupts and two timers. Whatever procedure is going on will be displayed on LCD like forward move and reverse move etc. Fabrication of a MOSFET based inverter:

In inverter section, mosfet has been used which is more energy efficient, cost effective and reliable. In inverter section we have:

1. Oscillator
2. Driver
3. O/P

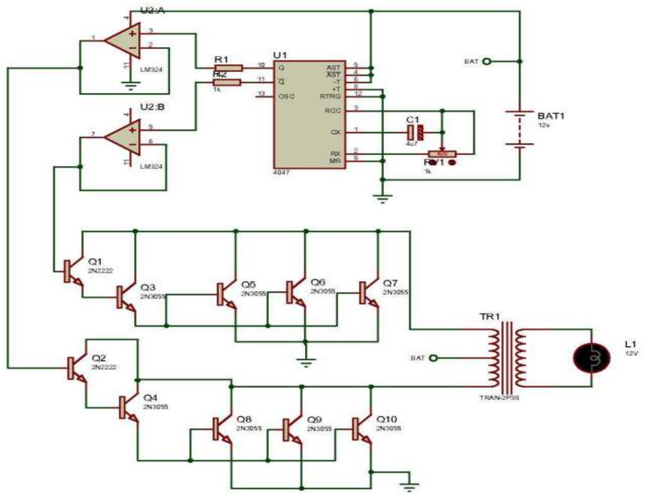

Fig 7: Inverter Design

In oscillator we are using CD4047, a stable multivibrator to generate 50HZ square wave. This frequency will be fixed to driver section for further amplification to drive o/p MOSFET. We can change o/p frequency with the help of one preset connected with a stable multivibrator.

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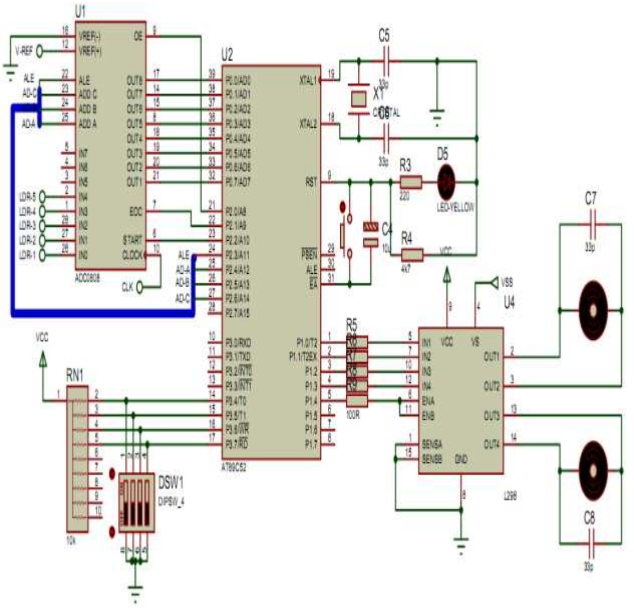

Fig 8 : Simulated Overall Circuit Design

IV. INTERFACING OF ADC0808 USING CLOCK FROM AT89S52 MICRO-CONTROLLER

ADC0808 is a parallel ADC chip with 8-bit resolution. ADC0808 has 8 input channels (eight analog signals). Three select pins A, B and C (pin 23, 24 and 25) are used to select any one of the eight input channels. Vref (+) (pin12) and Vref (-) (pin16) are used to set the reference voltage. ADC0808 has 8 input pins IN0-IN7 (pins 1 to5 and 26 to 28). ALE (Address latch enable, pin22) is given a low to high pulse to latch in the address. SC (Start conversion, pin6) instructs the ADC to start the process of conversion. When an active high pulse is given to this pin ADC starts converting the data. EOC (end of conversion, pin7) is an output pin and goes low when the conversion is completed and OE (output enable, pin9) is given a high pulse to bring the converted data from the internal register of ADC to the output port. Pin no.11 is Vcc (source) and pin no.13 is GND. Here, we are using external clock for clock input (pin 10).

Testing and Troubleshooting

Fig 9 : Dual axis Solar Tracker

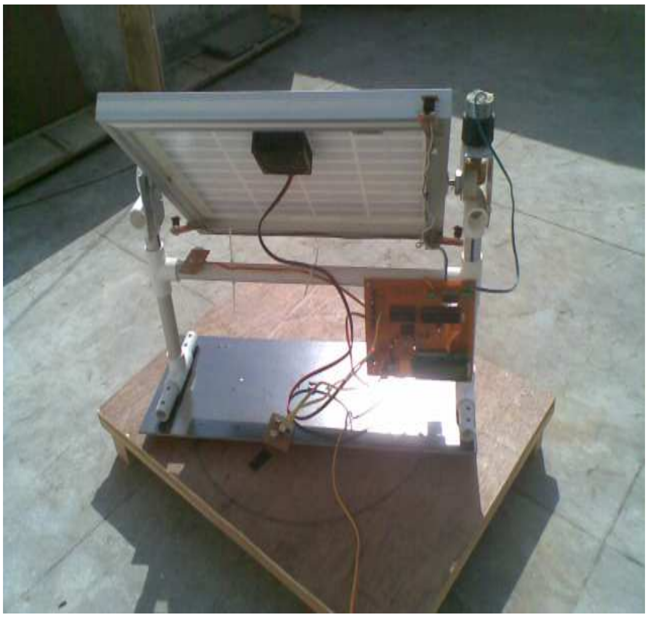

Fig 10: PCB connection with solar panel

V. RESULTS

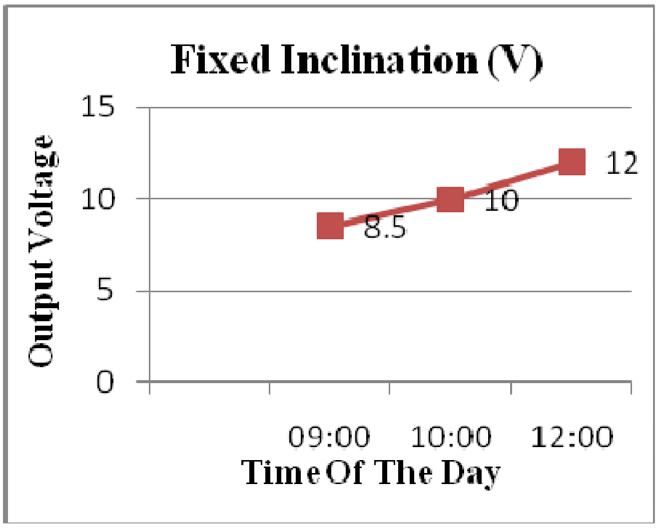

Fig 11: Fixed Solar Tracking System

The above graph represents the output voltage of our solar tracker with respect to time in fixed mode.

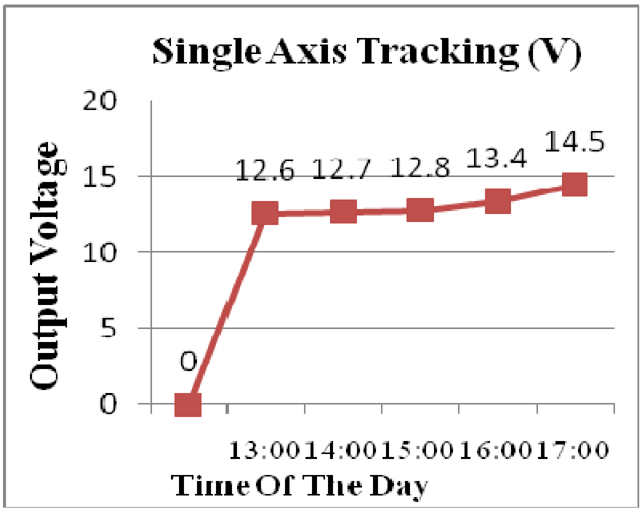

Fig 12: Single axis solar tracking system

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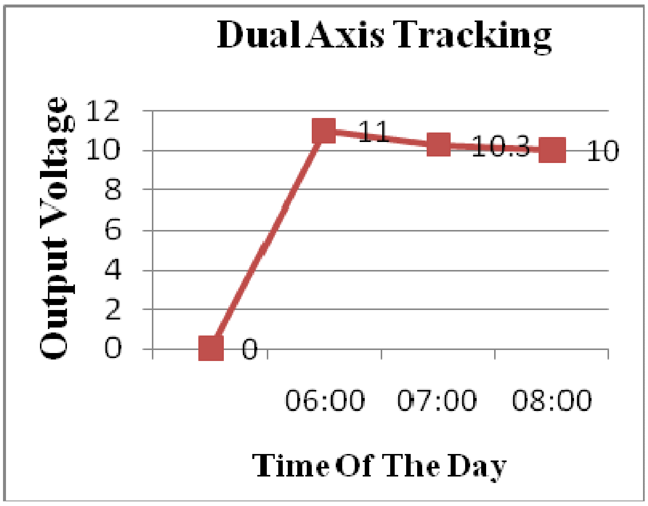

Fig 13: Dual axis solar tracking system

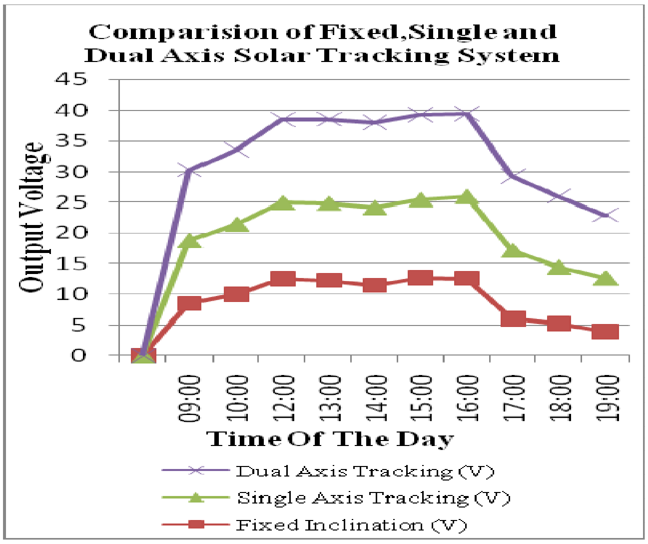

Fig 14: Comparison of fixed, single and dual axis solar tracking system

VI. CONCLUSION

From Various results, it is observed that significant power is available even in early mornings and late afternoons.Dual axis solar trackers track in both the directions with the help of horizontal and vertical axle to follow the Sun's movement and therefore results in higher efficiency as can be inferred from the above graph.

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