Design and Development of Single Axis Solar Tracking System using C8051F120 (CYGNAL) Microcontroller

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Abstract:

As the energy demand and the environmental problems increase, the natural energy sources have become very important as an alternative to the conventional energy sources. The renewable energy sector is fast gaining ground as a new growth area for numerous countries with the vast potential it presents environmentally and economically. Solar energy plays an important role as a primary source of renewable energy, especially for rural area. This project aims for the development of process to track the sun and attain maximum efficiency using C8051F20 Microcontroller for real time monitoring. The project is divided into two stages, which are hardware and software development. In hardware development, light dependent resistor (LDR) has been used for capturing maximum light source. Stepper motor has been used to move the solar panel at maximum light source location sensing by LDR. The performance of the system has been tested and compared with static solar panel. This project describes the design of a low cost, solar tracking system.

The main objective of this paper is to design and development of Single Axis Solar Tracking System that effectively used for Direction finding and also it can be used to improve the overall electricity generation &it provides the design for residential use. Solar tracker sense the direction of the sun and tilt the panels itself as needed for maximum exposure to the light.

Conclusion: In this paper, we have designed and developed a Single Axis Solar Tracking System .It plays an important role in finding the direction of the sun. In this project the sun falls on the LDRs unit determines the position of the solar panel towards the direction of the sun and follows across the sky. Then finally it effectively finds the direction of the sun.

Keywords: C8051F120 Microcontroller, LDRs, Serial Communication, Stepper Motor, Solar panel.

I. INTRODUCTION

The main impulsion is to design a high quality solar tracker. This paper is divided into two parts; hardware and software. It consists of three main constituents which are the inputs, controller and the output photo resistor or Light dependent resistor (LDR) or photocell which is a light-controlled variable resistor. LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 10,00000Ω, but when they are illuminated with light then its resistance drops dramatically. LDR's have low cost and simple structure. The Stepper motor can turn either clockwise or anticlockwise direction depending upon the sequence of the logic signals. The sequence of the logic signals depends on the difference of light intensity of the LDR sensors. The principle of the solar tracking system is done by Light Dependant Resistor (LDR). LDR's are connected to C8051F120 that acts as the input for the system. The built-in Analog-to-Digital Converter will convert the analog value of LDR into digital. The inputs are from analog value of LDR, as the controller and the Stepper motor will be the output. LDRs are

taken as pair .If one of the LDR gets more light intensity than the other, a difference will occur on node voltages sent to the respective channels to take necessary action. The Stepper motor will move the solar panel to the position of the high intensity LDR that was in the programming.
Many different methods have been proposed and used to track the position of the sun. Since we want to be able to track the sun we need some form of light detector. The simplest of all uses an LDR (light dependent resistor) to detect light intensity and monitor the position of the sun for these LDRs are arranged in a manner of parabolic shape and each LDR is separated with specific angle.

The Proposed Method:

Since last ten years, many of residentials around the world used electric solar system as a sub power stations at their houses. This is because solar energy is an unlimited energy resource, set to become increasingly important in the longer term, for providing electricity and heat energy to the stakeholders. Solar energy also has the potential to be the major energy supply in the future. Solar tracker is an automated solar panel that actually follows the Sun to increase the receiving power. The sun's position in the sky varies both with equipment over any fixed position and time. Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. The solar tracker can be used for several application such as solar cells, solar day-lighting system and solar thermal arrays. The solar tracker is very useful for device that needs more sunlight for higher efficiency such as solar cell. Many of the solar panels had been positioned on a fixed surface such as a roof. As sun is a moving object, this approach is not the best method. One of the solutions is to actively track the sun using a sun tracking device to move the solar panel to follow the Sun. With the Sun always facing the panel, the maximum energy can be absorbed, as the panel is operating at their greatest efficiency. The main reason for this project is to get the maximum efficiency for the solar cells.

II. GENERAL DESCRIPTION OF THE HARDWARE AND SOFTWARE

Block diagram

The overall setup is as shown in Figure 1 which consists of C8051F120 Microcontroller, Power supply, LDR Units, Serial communication, L293D (Motor Driver), Stepper Motor.

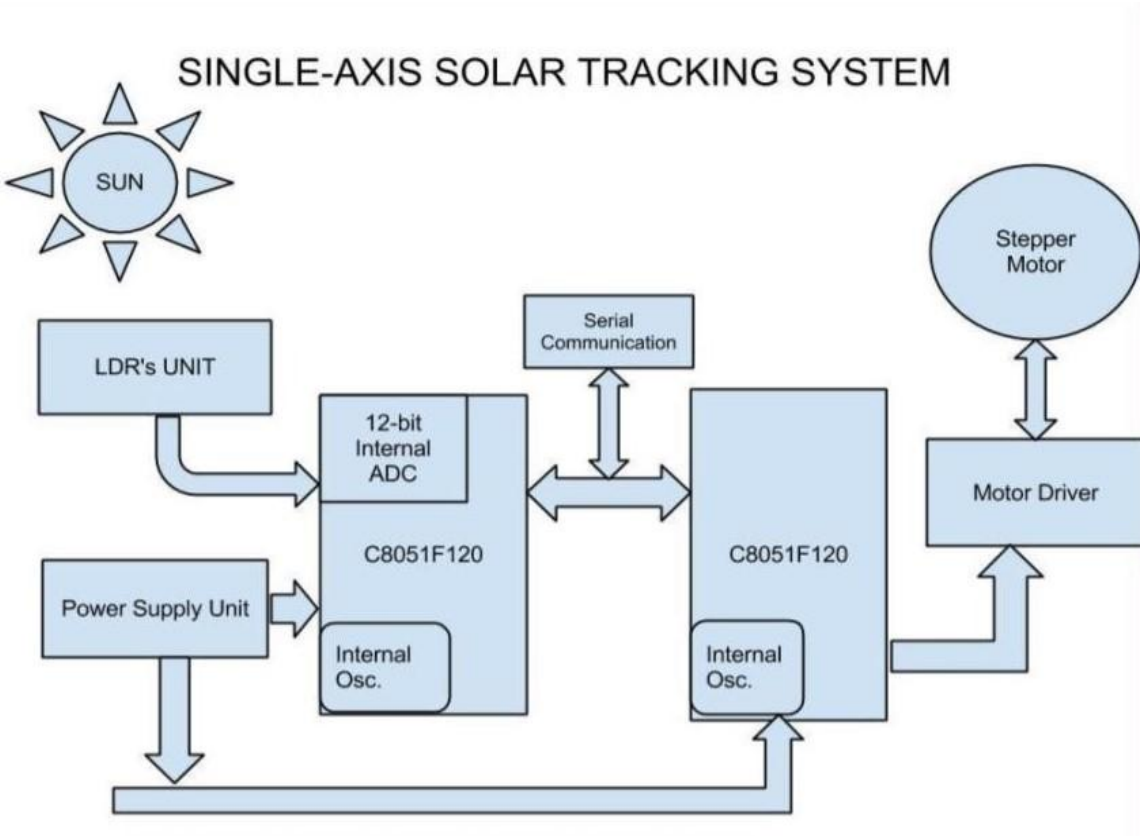

Figure 1

A. Hard ware Description

Here LDRs receives sunlight and it gives the voltage as the output by the voltage divider circuit and this output is fed to the input of C8051F120 Microcontroller. ADC converts analog value into digital form and selects only one LDR signal depending on the selection lines of multiplexer which is presented internal ADC of C8051F120.One controller sends the information that how much angle a stepper motor is to rotate depending on LDR values. Another Microcontroller receives that angle information and it rotates the stepper motor to that angle. Serial communication is used between two microcontrollers

A.1.CYGNAL (C8051F120) MICROCONTROLLER:

The C8051F12x and C8051F13x device families are fully integrated mixed-signal System-on-a-Chip MCUs with 64 digital I/O pins (100-pin TQFP) or 32 digital I/O pins (64-pin TQFP) With on-chip VDD monitor, Watchdog Timer, and clock oscillator, the C8051F12x and C8051F13x devices are truly stand-alone System-on-a-Chip solutions. All analog and digital peripherals are enabled/disabled and configured by user firmware. The Flash memory can be reprogrammed even in-circuit, providing non-volatile data storage, and also allowing field upgrades of the 8051 firmware. On-board JTAG debug circuitry allows non-intrusive (uses no on-chip resources), full speed, in-circuit debugging using the production MCU installed in the final application. This debug system supports inspection and modification of memory and registers, setting breakpoints, watch points, single stepping, run and halt commands. All analog and digital peripherals are fully functional while debugging using JTAG.

A.2. LDR

Light dependent resistor or photo resistor is a resistor whose resistance value decreases with respect to increase in light intensity. Normally the resistance of an LDR is up to 1Mega ohm,

but when exposed to light the resistance value automatically decreases and voltage across it increases. Voltage can be measured by voltage divider rule.

A.3. Stepper Motor

Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a precise number of degrees each time a pulse of electricity is sent to the motor. Since the shaft of the motor moves a few number of degrees that it was designed for when each pulse is delivered, you can control the pulses that are sent and control the positioning and speed. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current sent to the stator and the number of turns in the windings. The stepper motor uses the theory of operation for magnets to make the motor shaft turn a precise distance

A.4. ULN2003

The ULN2002A, ULN2003A and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector common emitter pairs. Each pair is rated at 500mA. Suppression diodes are included for inductive load driving, the inputs and outputs are pinned in opposition to simplify board layout.

A.5.Serial Communication:

A popular way to transfer commands and data between a personal computer and a microcontroller is the use of standard interface, like the one described by protocols RS232 (older) or USB (newer). This chapter is devoted to communication conforming to RS232 protocol, the hardware for such interface is provided on board. An example will be presented showing the processing of commands received through RS232 interface, and sending of a string of numbers using the same interface. The protocol RS232 defines the signals used in communication, and the hardware to transfer signals between devices.

B. Software Description:

The C programming language is a general purpose programming language. Cis not designed for any one particular area of application. Its generality combined with its absence of restrictions makes C a convenient and effective programming solution for a wide variety of software tasks. Many applications can be solved more easily and efficiently with C than with other more specialized languages.

The source code written in source file is the human readable source for your program. It needs to be "compiled" into machine language so that your CPU can actually execute the program as per the instructions given. The compiler compiles the source codes into final executable programs. The most frequently used and free available compiler is the GNU C/C++ compiler, otherwise you can have compilers either from HP or Solaris if you have the respective operating systems. The following section explains how to install GNU C/C++ compiler on various OS. We keep mentioning C/C++ together because GNU gcc compiler works for both C and C++ programming languages.

Keil Software provides a software development tools for the 8051 and 251 family of microprocessors. With thistools, we can generate embedded applications for the multitude of 8051 and 251 derivatives.

B.1.Algorithm

Algorithm is representation of working process of a particular task in terms if theoretical as shown in figure.

The following sequence of operation has been followed for tracking the sun.

Step 1: Initialization of all ADC, UARTS & SFRs of C8051F120.
Step 2: Monitoring and reading the inputs from LDR units.
Step 3: Finding the MAX value of LDR
Step 4: Transmitting the max value to host controller.
Step 5: The motor will rotate.

B.2.Flow chart
The flow chart of Single Axis Solar Tracking System & software is as shown in Figure 2

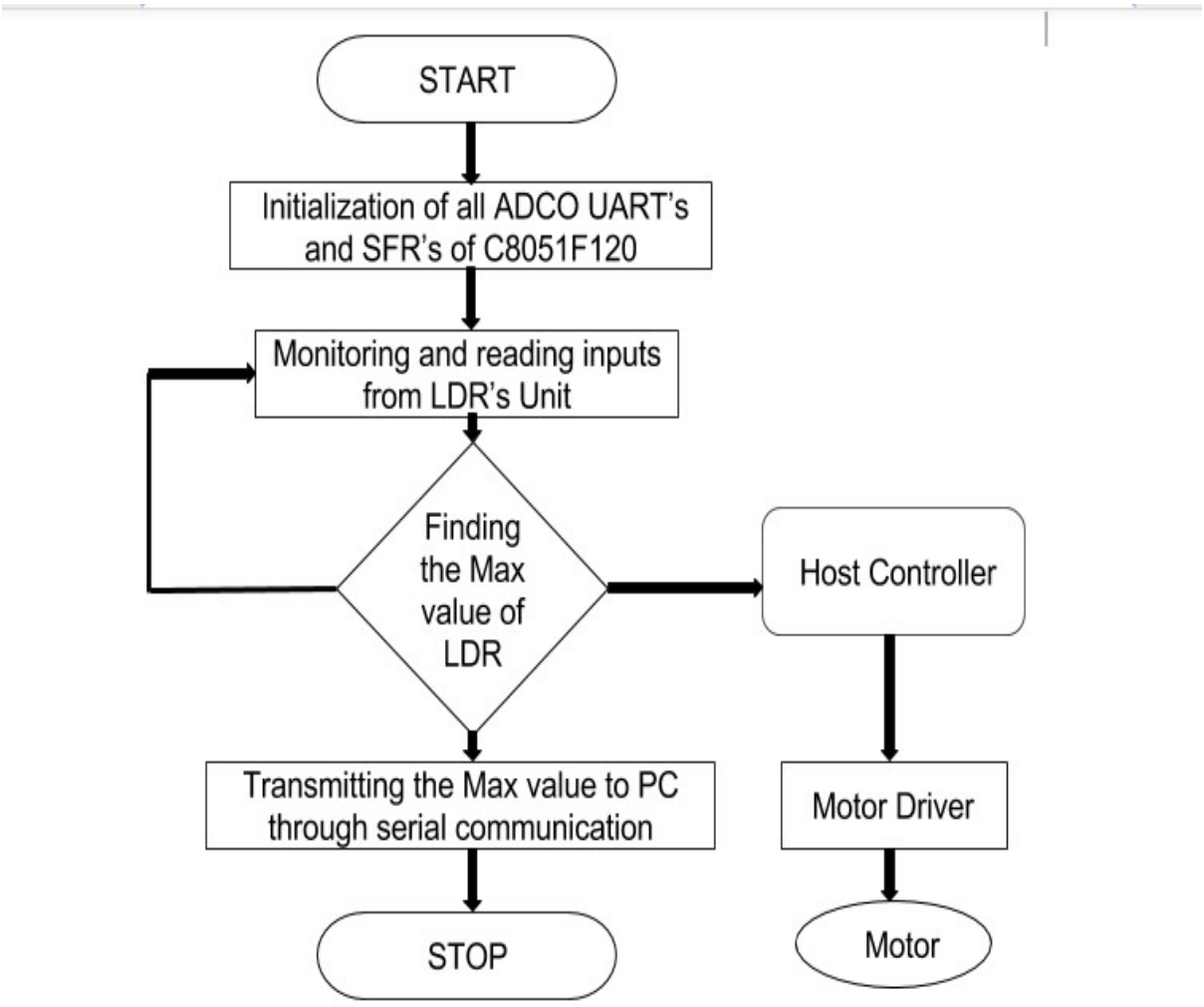

Figure 2

III EXPERIENTAL SETUP

Here LDR receives sunlight and it gives the voltage as the output by the voltage divider circuit and this output is fed to the input of C8051F120 Microcontroller. ADC converts analog value into digital form and selects only one LDR signal depending on the selection lines of multiplexer which is presented internal ADC of C8051F120.One controller sends the information that how much angle a stepper motor is to rotate depending on LDR values. Another Microcontroller receives that angle information and it rotates the stepper motor to that angle. Serial communication is used between two microcontrollers

The result of the experimental setup is shown in Figures3, 4 & 5.

Hardware Experimental setup

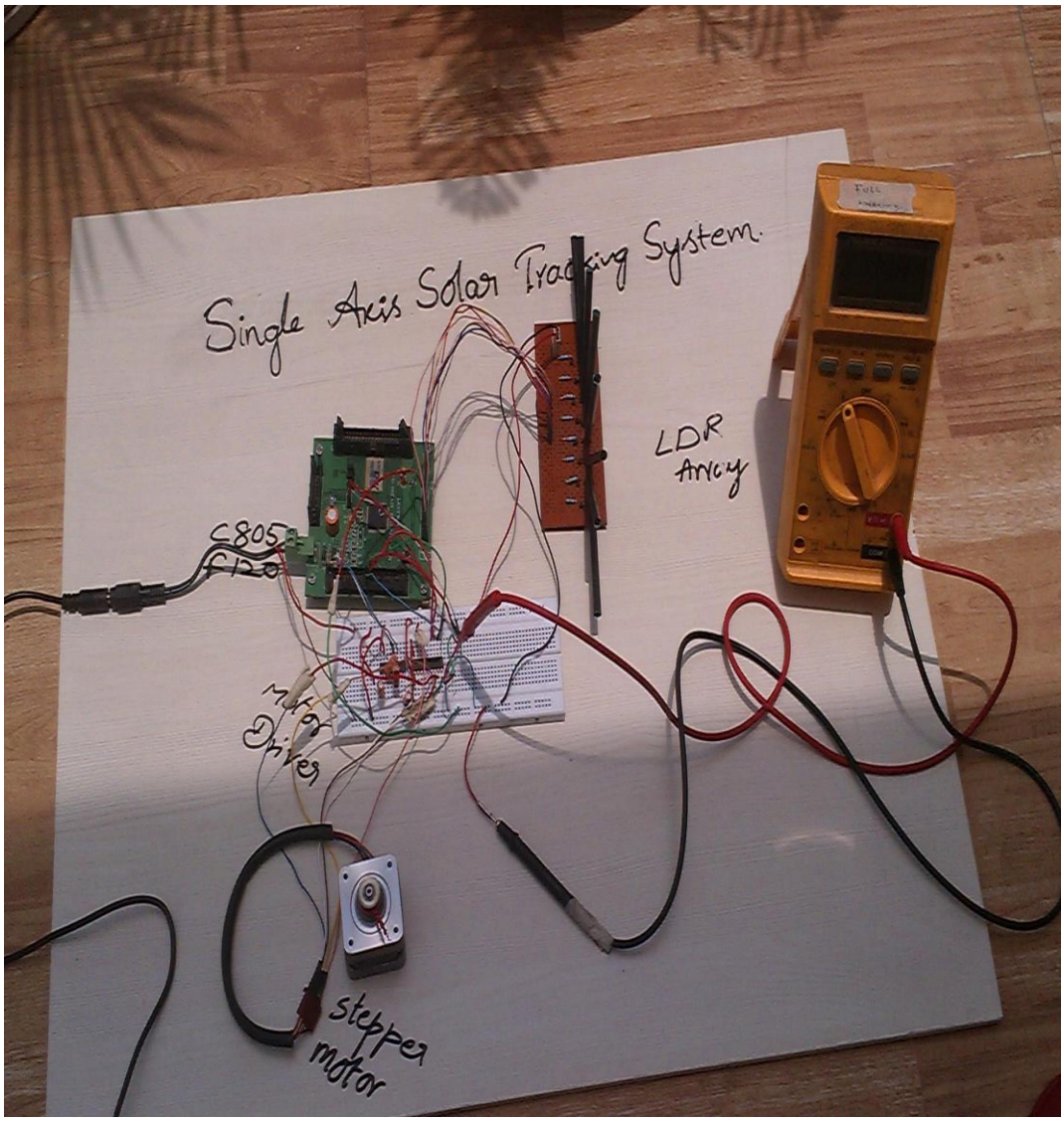

Figure 3

Hardware setup using USB Debugger

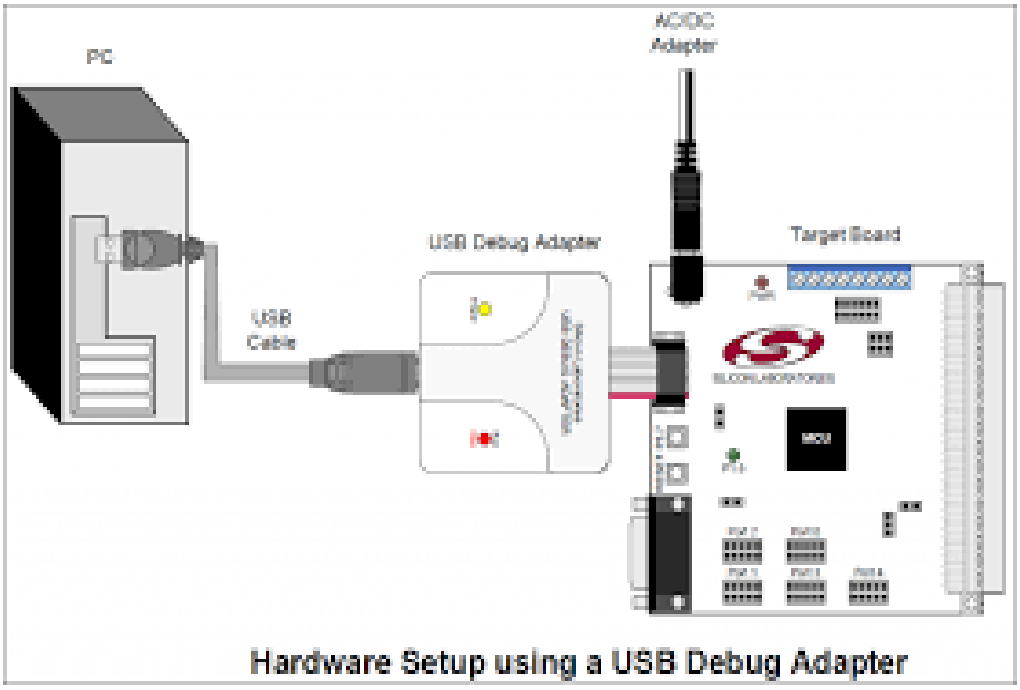

Figure 4

C8051F120 Target Board

Figure 5

IV CONCLUSION

Solar trackers generate more electricity than their stationary counterparts due to an increased direct exposure to solar rays.There are many different kinds of solar tracker, such as single-axis and dual-axis trackers, which can help us to find the perfect fit for our unique jobsite.

Installation size, local weather, degree of latitude, and electrical requirements are all important considerations that can influence the type of solar tracker that is best for us.Solar trackers generate more electricity in roughly the same amount of space needed for fixed tilt systems, making them ideal optimizing land usage. Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation. Some ongoing maintenance is generally required, though the quality of the solar tracker can play a vital role in how much and how often this maintenance is needed.

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