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A System to Design and Implement the Solar Sensors

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Abstract

The planet Earth's nearest star is Sun, like all the stars in Universe Sun can also emits strong radiations across all the spectral regions. The human and human eyes have evolved to the optical region through evolution and can only detect radiation in this small range from 390 nm to 700 nm. Moreover, the latest technology is in the Solar or Sun sensors, specifically for determining cubsat's altitude, which is one of the most significant metrics that actually decides the cubesat's life or death. The Sun emits radiation in all regions of the spectrum that brings us to the essential sensor question that will be taken care in this work. Because of the availability of 'n' number of sensors , which are used to detect radiation such as Infrared rays, Gamma rays, Microwaves etc., any sensor can be selected for the construction of proposed device or else specifically for the payload of cubesat. The current work involves selecting a particular sensor based on its response to all types of environments, as space is not an environment that is not welcoming or would be appropriate or fair to anyone.

Keywords: *Cubesat, LDR, Magnetorqurer, Pico satellite.*

1. Introduction

Today's world does not live fully in a space age as described by people of the Apollo era, but it definitely exists in a world that is gradually linked to space or the "outer dimension" by the means of science and technology that was once regarded as a myth. In the future days the technology fights will not be fought on the current systems that will be used in our homes or but with the vehicles that will be used or that will be used in the cars we drive but the, wars are waged for the technological supremacy in the "outer world" to the Planet, i.e. the outer space. In addition to various benefits, imagery and satellite collection data present compared to other ground observation springs such as air photography, field statements and Google maps. Hence earth observation satellites were designed and operated successfully for science, for commercial and academic purposes, which include data collection which performs imaging activities [1**].**

One of the fields where cutting edge technology will lie in the future or the entire future lies on the production of Pico Satellite. This part of name called as Pico-Satellite , which is just an old wine packed in a new bottle, the world's first Sputnik satellite sent into space, in today's nomenclature world, would actually qualify as a PicoSat. Satellite communications is commonly utilized in huge areas of present life, such as media distribution, mobile service applications, radar and visualization, and as well

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about climatic conditions [2]. In today's world the recent launch of pico-satellites has allowed their use in a limited portion of the area conventionally sponsored by larger satellites for earth monitoring and space-climate forecasts. Compared to their scale and production time, the costs compared with traditional satellites are greatly reduce [3]

The main purpose of carrying out this work is to develop awareness in emerging engineering fields. This work was further broken down into smaller units for strategic purpose and smoother project execution. The new development is composed of the system's smaller unit CubeSat. In 1999 CubeSats started as a joint project between Jordi Puig-Suari, a professor at California Polytechnic State University (Cal Poly), and Bob Twiggs, a professor at the University of Stanford's Space Systems Development Laboratory (SSDL). The CubeSat system designed to reduce the satellite development cycle to the time frame for the student's career and maximize the launch opportunities with a wide range of satellites [4].

2. Related work

According to BenDor et al.,[5] performed 60 GHz wideband propagation measurements by considering the Line of Sight and also Non-Line Of Sight (NLOS) propagation situations in an outside environment. They extracted the respective vast-scale models of peer-to-peer wireless connectivity loss pathways.

K.Woellert et.al [6] discussed Cubesats as price-effective and also illustrates how well it operates for evolving and developing countries Science and Technology platforms with a group dedicated to earth observation but this section was not exhaustive.

Violette et al.[7] once observed the features of Mille Meter Wave signals when beginning to spread through building materials and other structures typically found in a region based on works of measurement conducted in an urban area taking into account both Line Of Sight and Non Line Of Sight propagation. However, despite all of these studies, very few measuring tests are currently available on the effects of solar radio emissions from the 60 GHz band.

Daniel Selva and David Krejci[8] illustrated Strict mass and spatial specifications of the Cubesat which changes and reduces capacity for the mass, energy and data transferred per second provided to payloads compared to those of larger missions

3. Methodology and Objective

A solar sensor is a tool, as it is comparatively simpler to construct and in one form or another is an integral part of virtually every spacecraft. In any space mission, determining the relative location of the sun treated as an major criteria as it is essentially the largest source of energy for all the other celestial bodies present in our solar system. As a part of this, understanding the relative location of the sun is very important to a spacecraft. Since the satellite uses solar energy it will become essential for the solar panels to be correctly synchronized with the sun, other sections or elements will also have to be shielded from the sun within the spacecraft and in all these situations it becomes very important to know the relative location of the sun determined by the solar sensor.

The main focus of the work is to get on the designs for the Sun Sensors, which will serve as an ideal scenario for further system development, the value produced by this would be used to control the Magnetorqurer, which will produce basically the magnetic field that is necessary to control the device in space.

3.1 Characterization of satellites

(i) Small Satellites: Spacecraft size and cost depend on the application; certain metrics you can keep in mind while others like Telescopes are as large as a school bus. Small satellites (SmallSats) [9] concentrate on satellites weighing less than 180 kg and around the size of a large kitchen refrigerator. There's a wide range of size and density that can be distinguished even with small spacecraft.

(ii) Cube Satellites: Cubesat's are Nano satellite groups use a predetermined scale and form variable. The standard size Cube sat uses a "one box" or "1U" of 10x10x10 cm and can be expanded to larger sizes; 1.5, 2, 3, 6 and even 12U, as shown in Figure 1. Originally founded to provide a platform for space exploration and education by California Polytechnic State University at San Luis Obispo (Cal Poly) and Stanford University in 1999. The development of Cubesat has advanced into its own market, collaborating with government, academia and industry with ever-increasing capacity. Cubesat's offers a cost-effective platform for science research, new technology demonstrations, and advanced constellation mission ideas, broad groups of disaggregated systems [10].

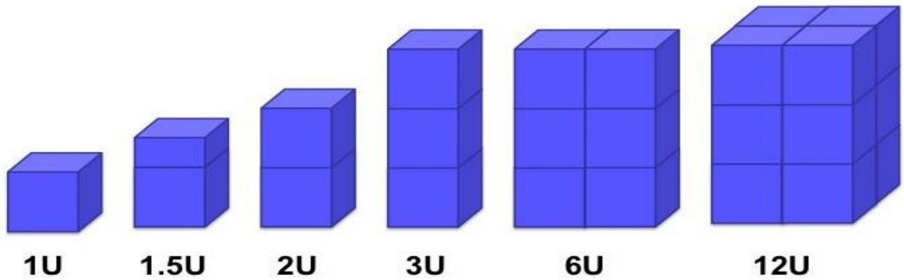

Figure 1: Cubestat characterization

3.2 Components

There are certain components that are needed to carry out the process of design and characterization of solar sensors that are illustrated in the below Figure 2

(i) **Source:** Sun is the closest and brightest star relative to the earth's surface, so sun would naturally be the main source for the sun's sensors. It is very necessary to power the satellite system efficiently and solar energy is the simplest and cheapest way to do it. The strength of the source light radiation should be taken care of when designing the sensor and must have a robust sensitivity based on the characteristics of its output.

(ii) **Sensing Element:** Many sensing elements of the sun sensor will be based on photocells, LDR, or photodiodes. The sensor provides data in analog values format. For the further operation, certain analog values are sent to the controller. The Light Dependent Resistor or LDR is currently the sensing device used in the project under consideration.

(iii) **Controller:** Controller is used to analyse the output of the sensor and perform the action which is required. Atmel 328P on the Arduino Uno Development Board is used by a microcontroller to achieve this operation, which belongs to the Atmel family.

(iv) **Arduino:** The Arduino Uno R3 is built on Microcontroller module ATmega328. It does have 14 digital input / output pins out of which 6 can be used as PWM outputs, 6 analog inputs, 16 MHz crystal oscillator, a

USB connector, a power socket, an ICSP header and a restart key. It includes all support provided by the microcontroller.

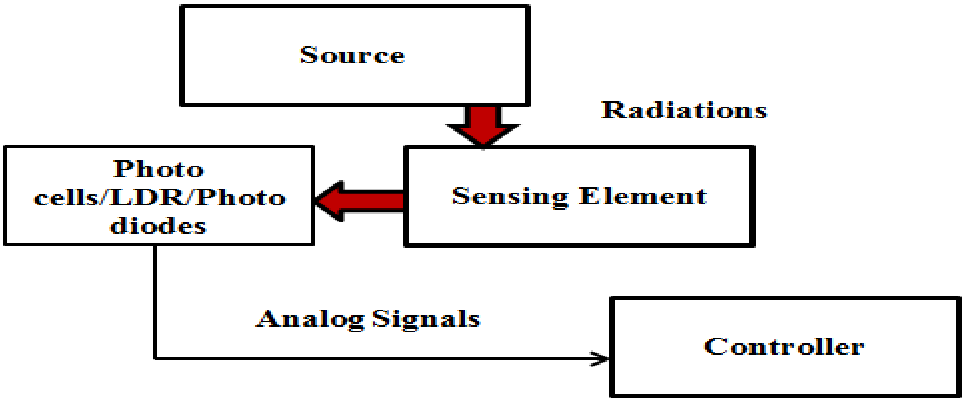

Figure 2: Components for design and characterization of solar sensors

3.3. Completely assembled 1U Satellite

The outline of the completely assembled Pico Satellite can be seen in Figure 3, which also indicates the existence of a 126 photodiode array at the entrance of each face, this is the array sensor which will eventually be used to finalize the conceptualized satellite implementation [11].

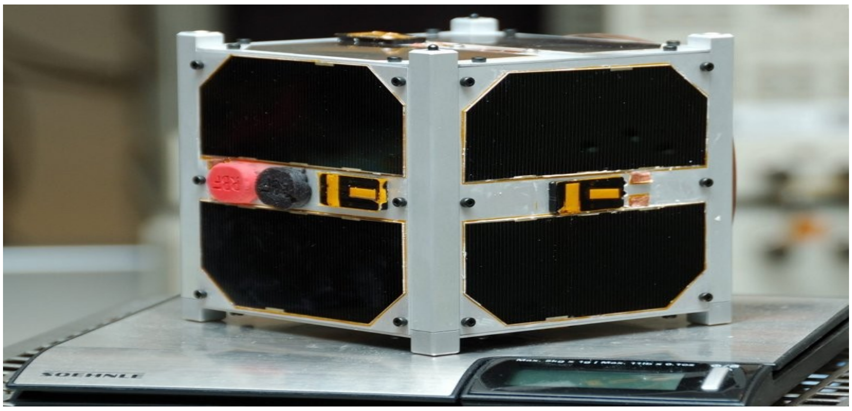

Figure 3: By Erik Kulu, ESTCube-1 team

3.4 System Architecture

The working of proposed work have been explained in the below Figure 4 . The working initiated with providing input from the solar source, in which we are taking the input from the sun, which is naturally be the main source for the sun's sensors. The data or radiations got from the solar source made to fall on light dependent sensors; in our work we have placed 6 LDR (Light Dependent Resistors) [12]. By considering the highest value obtained from LDR sensors output by keeping the raw data which is not processed as it is in database , one can check for artifacts or disturbances with the output obtained from the sensors. If in case the output obtained from LDR sensor is having any sorts of disturbances the procedure restarts from making the light to fall on LDR again. If it is not having any sorts of disturbances then it will be given for further pre-processing through the processor present locally.

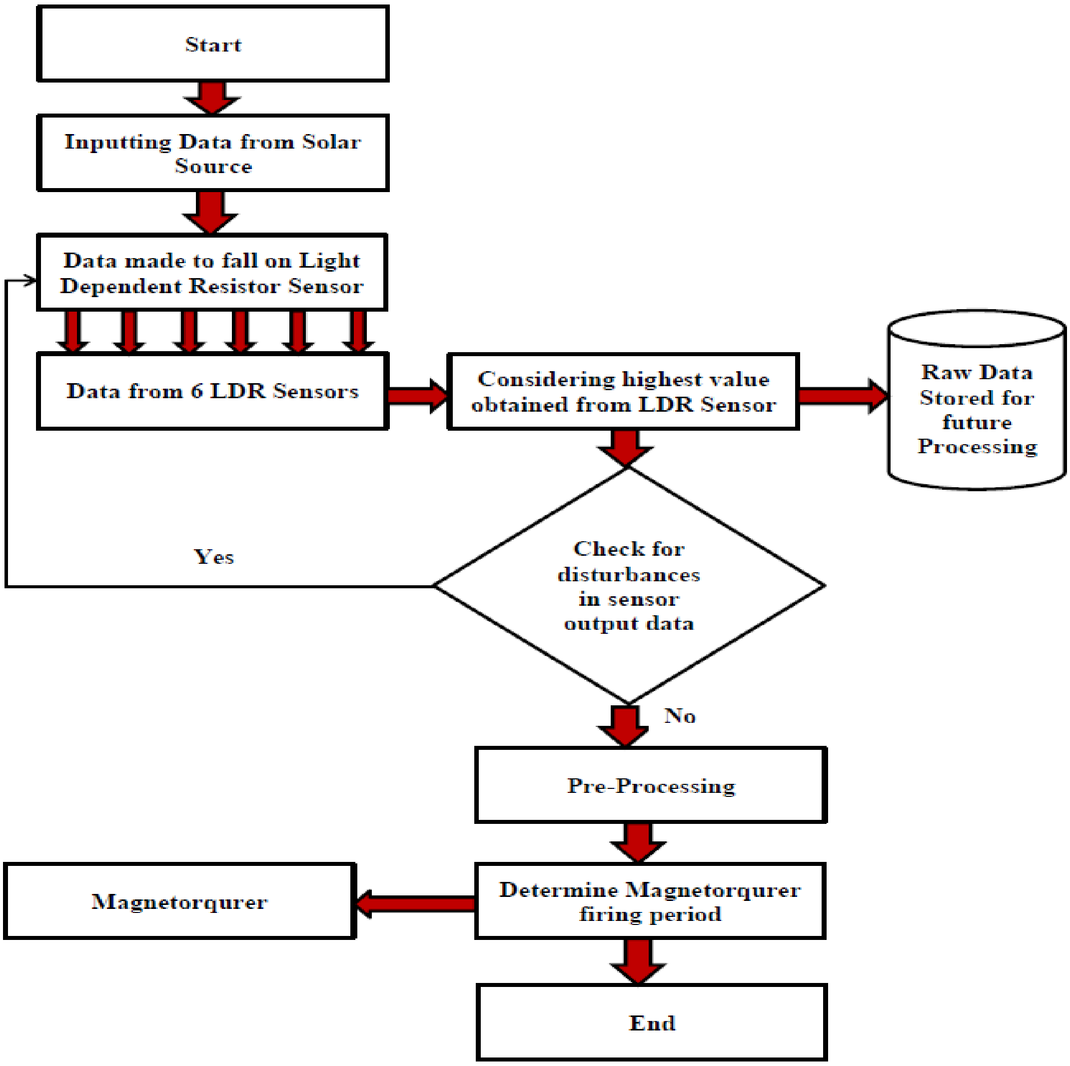

Figure 4: General Flowchart for Design and Characterization of Solar Sensors

After pre-processing, determining of magnetic torque firing period, which is a satellite device constructed from electromagnetic coils to regulate and stabilize the attitude. It also creates a magnetic dipole that interacts with an ambient magnetic field, usually Earth's, so that useful torque is given by the counter forces generated which stops the procedure.

3.5 Implementation

3.5.1 Arduino IDE: Arduino is in reality open source computer hardware and software for enterprise, project, and user community, which creates and manufactures single-board microcontrollers and microcontroller kits to create digital devices and collaborative objects that can detect and track objects in the digital and physical environment. Atmel in our work which gives a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers: AVR Studio and Atmel Studio.

3.5.2 Python: Python is a programming language of high quality used for general purpose programming. Python provides adaptive customization of the system and powerful memory management. It combines numerous programming paradigms, including object-oriented, imperative, functional, and procedural paradigms, and has a standard library that is wide and comprehensive. Below Figure 5 illustrates LDR output obtained through serial monitoring and Figure 6 describes the code used to determine the values on the LDR.

```
import  serial
import matplotlib . pyplot as plt from drawnow import *
import at exit values = [ ]
plt.ion() cnt=0

serial Arduino  =   serial.Serial('COM7' ,9600 )

def plot Values ( ) :
plt.title('Serial value from Arduino') plt.grid( True )
plt.ylabel('Values')
plt.plot(values ,' rx - ' , l a b e l =' values ') plt.legend(loc ='upper right ')

def do AtExit( ):
serial Ardui no . close() print (" Close serial ")
pri nt (" serial Arduino.isOpen () = " +str(serial Arduino.isOpen( )))

at exit.register(doAtExit)
print ("serial Ardui no.isOpen ()= " + str(serial Arduino.isOpen( )))#pre-load dummy data
for i in range(0,26):values.append(0)

while True :
while (serial Arduino.in Waiting()==0):pass
print ("readline( )" )
valueRead = serial Arduino.readline( 1000 )

#check  if valid value can be casted try :
value In Int= int( valueRead )
print(value In Int )
if value In Int<=1024:
if value In Int>=0:
values.append(value In Int)values.pop(0)
drawnow(plot Values)except Value Error :
print (" Invalid !cannot cast ")
```

Figure 5: Python Program for plotting LDR output through the serial monitor

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```
#include<stdio.h>
int LDR0 = 0 ;
int LDR1 = 0 ;
int LDR2 = 0 ;
int LDR3 = 0 ;
int LDR4 = 0 ;
int LDR5 = 0 ;

int LDRValue0 = A0 ;
int LDRValue1 = A1 ;
int LDRValue2 = A2 ;
int LDRValue3 = A3 ;
int LDRValue4 = A4 ;
int LDRValue5 = A5 ;
//int LDRValue6 = 8 ;
//int light sensitivity = 500 ; */
//file = G:/x.txt void setup()
{
Serial.begin( 9 6 0 0 ) ; //pinMode(13,OUTPUT);
}

void loop ()
{
LDRValue0 = analogRead(A0);
LDRValue1 = analogRead(A1);
LDRValue2 = analogRead(A2);
LDRValue3 = analogRead(A3);
LDRValue4 = analogRead(A4);
LDRValue5 = analogRead(A5);

Serial.println(LDRValue0);delay(500);
Serial.println(LDRValue1);delay(500);
Serial.println(LDRValue2);//delay(500);
Serial.println(LDRValue3);//delay(500);
Serial.println(LDRValue4);//delay(500);
Serial.println(LDRValue5);//delay(500);
//file.write(LDRValue);if(LDRValue0>500)
{
Serial.println("luminous at phase 0 ");
}
if(LDRValue1 > 500)
{
Serial.println("luminous at phase 1 ");
}
```

```
if(LDRValue2 > 500)
{
Serial.println("luminous at phase 2 " ) ;
}
if(LDRValue3 > 500)
{
Serial.println("luminous at phase 3");
}
if(LDRValue4 > 500)
{
Serial.println(" luminous at phase 4") ;
}
if(LDRValue5 > 500)
{
Serial.println("luminous at phase 5") ;
}
if(LDRValue0 < 500 && LDRValue1 < 500 && LDRValue2 <500 && LDRValue3 <500 & LDRValue4 <500 & LDRValue5 <500)
{
Serial.println(" no Luminous " ) ;
}
}
```

Figure 6: Arduino Code for determining the values on the LDR

4. Results

(i) The resulting module of the Sun sensor was tested under ambient conditions which led to the following results as shown in the Figure 7 mentioned below.

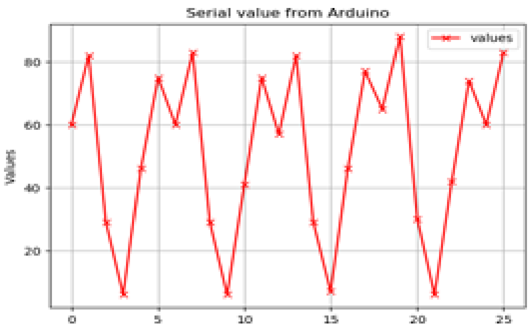

Figure 7: Characteristics plot of a stationary CubeSat.

The Figure 7 shown above consists of the plot of the Intensity value vs the time, when the light intensity is not concentrated, i.e., when the Cubesat is stable.

(ii) The Figure 8 shown below consists of the plot of the Intensity value vs the time, when the light intensity is varying considerably, i.e when the Cubesat is not stable.

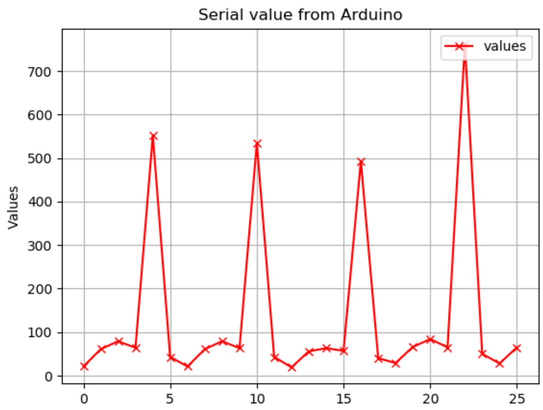

Figure 8: Characteristic plot of a non - stationary CubeSat

(iii) Intensity of light vs the time vs phases of the CubeSat can be seen in the plot below shown in Figure 9, this plot is 3-D plot, generated through the Python Matplotlib, this plot can be further used to determine the position of the Sun, which is indeed the main aim of the whole work.

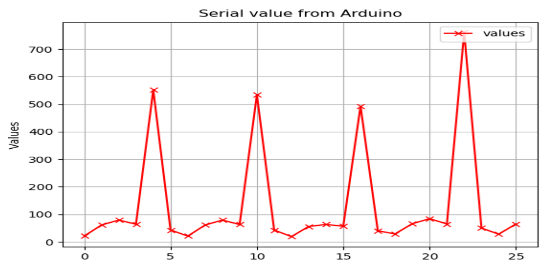

Figure 9: Plotting of Intensity vs time vs phases of CubeSat.

5. Conclusion

A type of solar sensor based on Arduino has been described in this paper. This study has proposed the work to determine the relative location of the sun which plays an important role for all the other celestial bodies. The process of design and determining the Nano-Satellites by using active light array sensors to improve and perform the cost optimization of sun sensors have been explained. The resulting module of the Sun sensor have undergone testing under ambient conditions by keeping cubestat stationary and also tested for non-stationary and obtained the graphs to checkout with the position of the Sun, which is indeed the main aim of the whole work.

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