JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design and Fabrication of Atmospheric Sensing CubeSat by using Acrylic sheet

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Abstract: The article is regarding the analysis which has been done on the Design and Fabrication of Atmospheric Sensing CubeSat. The cause of aiming the project is easy to construct and cost-efficient to fabricate make clear for students at the graduation level for doing capstone projects. By investigating this paper one will incur construct the CubeSat and understand the factors that should be scrutinized while designing or studying CubeSat. The study will present from the structure design constrain to payload constrain. With the ESP board connecting with these sensors followed by DHT 11, GPS sensors (NEO-6m), Gyroscope (L3G4200D), and Ultrasonic (HC- SR04) were used with the intention of extrapolating the database. Introducing efficient design with preferable structural analysis. The Acrylic sheet is used to have superior strength to the CubeSat and the properties of the material are also mentioned in table no.1. Monoacrylate Solar Cells are used to charge the battery naturally. Sensors are connected to get data from satellite-like temperature, humidity, the position of the satellite, movements of satellite, and obstacle distance. 2 cells of 7.4V 30C having 360 mah battery are used. The Brushless fan is used for air intake.

Keywords: CubeSat, acrylic sheet, ESP 32, DHT, Ultrasonic Sensor, GPS, Gyroscope, Atmosphere.

1. INTRODUCTION

Therefore, the CubeSat platform was launched in 2003 but it was introduced in 1999 after launching the CubeSat will get affordable access to space for new players. The bulk of CubeSats distributes educational purposes and research projects for universities. As presently the private companies also make the amount of CubeSat deploy per Anum rapidly increase. Now present work focus on the design and fabrication of CubeSat for sensing atmospheric changes in temperature and humiditydesign and fabrication of CubeSat for sensing atmospheric changes in temperature and humidity.

The humans had successfully cracked and had continued operation of spacecraft since 1957. In little more than 30 years there are many instances of disturbed explorer spacecrafts flying over all the vital forms of the solar system. Plethora of nations had the ability of putting satellite with regards into path; satellites have now set up a rigid space as a segment of the base of the community. For each belief could have much more to suggest in the time ahead. The Cube-Satellites plan main task is to get allow to foothold for tiny payloads. The satellites are cube- form also called Pico-satellites having nominal distance of 10cm each face, weighing not more than 1kg. Center of mass being 2cm inside geometric center. Also, CubeSat is manufactured in such a way that it can bear highest loading and progressive loading of experiment and put into space.

First Nano Satellite will establish the satellite medium and new extremely accurate solar cells from the manufacturing. The present work of CubeSat is single-configuration (10x10x10 cm^3) characteristics employ photovoltaic cell. This model upgrades the execution of CubeSats in several ways. This thesis work will contribute the improvement plan, the satellite model has been designed in a system engineering tool (v)-Sys. The motive of the system has been to keep track of the product architecture and entire system parameters like mass, energy utilization, bulk memory size, and so on. Although, the engineering instruments of the model has been utilized to proportion various design limitations like solar array size, battery size, link budgets, and data budgets. The forecasting of the characteristics must play key role to identify most of the designs or task requirements in an early stage of the design improvement. Sensors and material used in the current project described below.

1.1. Material

crylic is a glassy fiber-plastic material with excellent power, rigidity, and crystal clear. Acrylic sheet is simple to fabricate, consists of combining well with adhesives and solvents, and is simple to thermoform. It has high sustainable atmosphere properties considered as with other glassy fibers.

Acrylic sheet shows glass-like qualities—precision, brightness, and crystal clear— having a less weight & having more impact resistance of fiber. The properties of acrylic sheet are introduced on table no.**1**. From long lasting indication and casement to impressive dealer store installation, shows and rack, acrylic plastics provide excellent adaptable, resistive, and attractive qualities.

Density	1.18 - 1.19 g/cc	0.0426 - 0.0430 lb/in³	Averagevalue: 1.19 g/cc Grade Count: 29
Water Absorption	0.130 - 0.800 %	0.130 - 0.800 %	Averagevalue: 0.257 % Grade Count: 25
Water Absorption at Saturation	0.650 - 2.60 %	0.650 - 2.60 %	Average value: 1.40 % Grade Count: 16
Moisture Expansion	0.500 %	0.500 %	Average value: 0.500 % Grade Count: 3
Moisture Vapor Transmission	55.0 cc-mm/m²-24hr-atm	140 cc-mil/100 in²-24hr-atm	Average value: 55.0 cc-mm/m²-24hr-atm Grade Count: 3

TABLE.1. Properties of Acrylic sheet

1.2. Temperature sensor

DHT11 is a sensor that detects Humidity & Temperature in the atmosphere and provides calibrated digital output. DHT11 will computed with microcontrollers like Arduino, Raspberry Pi, ESP, etc., and provides instant results. It is economically friendly humidity & temperature sensor to gives high dependability and more strength over a time.
The Humidity and Temperature Sensor contains 3 major parts. A protected type humidity sensor, having NTC (negative temperature coefficient) thermistor (to measure the temperature), and an 8-bit microcontroller, changes the analog signals from the sensors and send out a single digital signal.

1.3. GPS Module

GPS sensors (NEO-6m) are receiving data from antennas that use a real-time satellite-based navigation system providing parameters like position, velocity and time.
Also, to surpass the distance parameter problem a pseudocode is generated with both satellite and GPS receiver. The satellite transmits the pseudocode; which is received by the GPS receiver. Using Trilateration method the varying from the signals to travel time. Knowing These two signals are different and the varying from the signals to the travel time. Knowing the distance 3 or more satellites and their locations helps us achieve this.

1.4. Gyroscope sensor

For 3D motion capturing and inertial measurement a gyroscope paired with accelerometer helps sense motions in different axes.
This sensor is an is three-axis angular rate sensor, with a digital I2C/SPI serial compute standard output, which can be set to ±250, ±500, or ±2000 degree/sec scale for a high range of responsiveness. In construct large and less pass sensing let data processing easier, this chip supports both 12C and SPI that can be connected with any microcontroller.

1.5. Ultrasonic sensor

Ultrasonic (HC-SR04) is the sensor that control the distance. This low-cost sensor gives 2cm to 400cm of hertzian measurement available with a ranging accuracy which will help to reach up to 3mm. Every HC-SR04 module involve an ultrasonic transmitter, a receiver, and a control circuit.

This sensor consists of pins that VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground). It is very simple to set up and can be used for many projects.

This sensor had extra control circuitry which can stop at odds with "spongy" data hang on on the application.

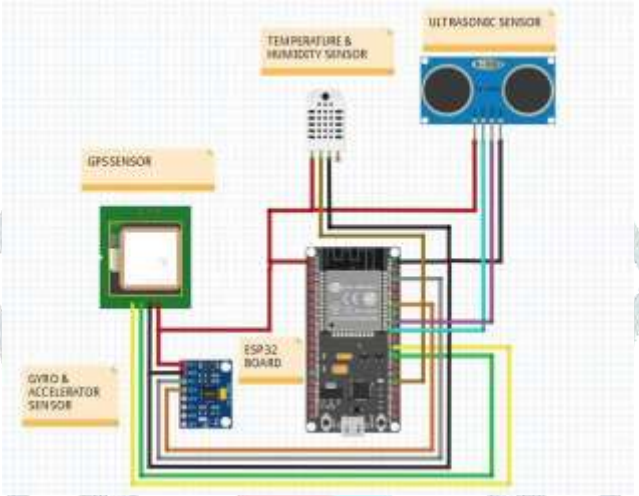

FIGURE 1. Design of Circuit using Fritzing

1.6. Brushless fan

Brushless fan is used for suction the air through the satellite inside (passing through sensors) for getting efficient data from the sensors.

1.7. Battery

2 cells lipo battery of 7.4V 30C having 360 mah battery are used. It is easily chargeable and also store the power from solar panel.

1.8. Monoacrylate Solar Cells

The Photo- Voltaic cells are used as a source of energy they are mounted in a frame for installations. A group of modules make up a PV Panel, and a group of panels form an array. These PV arrays helps changes Solar energy to electrical energy used to power the equipment. The basic utilize of this is collection of solar energy for solar power.
Every module is estimated by the DC output power under particular test conditions. Power commonly varying from 100 to 365 Watts (W). The effective of a module results the field of a module gives the same rated output – an 8% efficient 230 W part had double the area of a 16% accuracy 230 W module. Some low-cost available solar modules exceed 24% efficiency.

1.9. Literature Review

The atmospheric sensing system concept is not latest. somewhere, a position-based exact observing system with using the internet is rare **[1],[2]**. All before works had showed a difficult hardware system and various models were made for the examination of various weather parameters**[3],[4],[5]**. Satellite-based systems in main times did not economically friendly. Hardly one or two works have been done using embedded applications. Previous work showed some of the standard-based, design data which will address the unique needs of standardized dimensional data for 1U CubeSats**[6],[7]**.
The introduced model of the cube satellite is cost-efficient, reliable, and the simplest design ever**[8],[9],[10],[11]**. the work shows a simple ground receiving station and the basic design of the F-1 nanosatellite and gives an insight into the design, manufacturing, components, and working of a Small Satellite and its ground control station**[12],[13]**. The design and fabrication of the working model were made properly**[14]**. The data was obtained from the device for different altitudes and at different methods conducted through the testing of the device provides about 90% accuracy**[15],[16]**.

1.10. System Overview

This present work system is easy to plan. Therefore, four various sensors are utilized in this project for a various usage which are temperature & humidity sensor (DHT11), GPS (NEO-6m), Ultrasonic (HC-SR04), and Gyroscope (GY-50 L3G4200D).
The details clearing unit is an ESP 32 Dev which is a economically friendly embedded platform. The data can be collected and examined on a personal system or on a simple android app known as Blynk app for mobile phone.To transfer the data, the CubeSat to the observing system, a transmitter, and a receiver module is utilized. An RF module of 240 MHz is utilized for data transmission. A drone has been used to hover & carry as payload of the CubeSat.

2. Conceptual Design

The main mission objective of CubeSat is to use them for educational purposes, learn how to build and control satellites, enhance student engineering skills, and carry out scientific data gathering. The 2D design of the CubeSat is shown in figure no. 2.

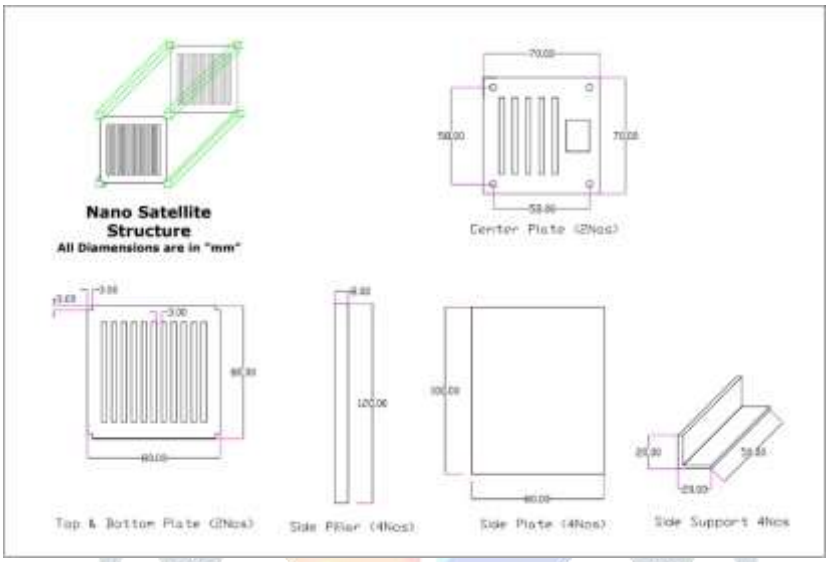

FIGURE 2. 2D Design of Atmosperic Sensing CubeSat

The geometrical model is the intersection of the satellite mission to the design. It gives the initial design values to decide on the model planning. It also sets the preliminary parameters to initiate the satellite design irrespective of the commercially available component datasheets. To start with the design procedure for a satellite, the required subsystems are to know, for example, the electrical power system, communication system, attitude control system, etc. Even though the above terms come out of the design books, each system needs dimensioning to decide on the satellite application requirement. The 3D Design of Atmospheric Sensing CubeSat Outer Structure is shown in figure no.3. The 3D Design of Atmospheric Sensing CubeSat internal Structure is shown in figure no.4.

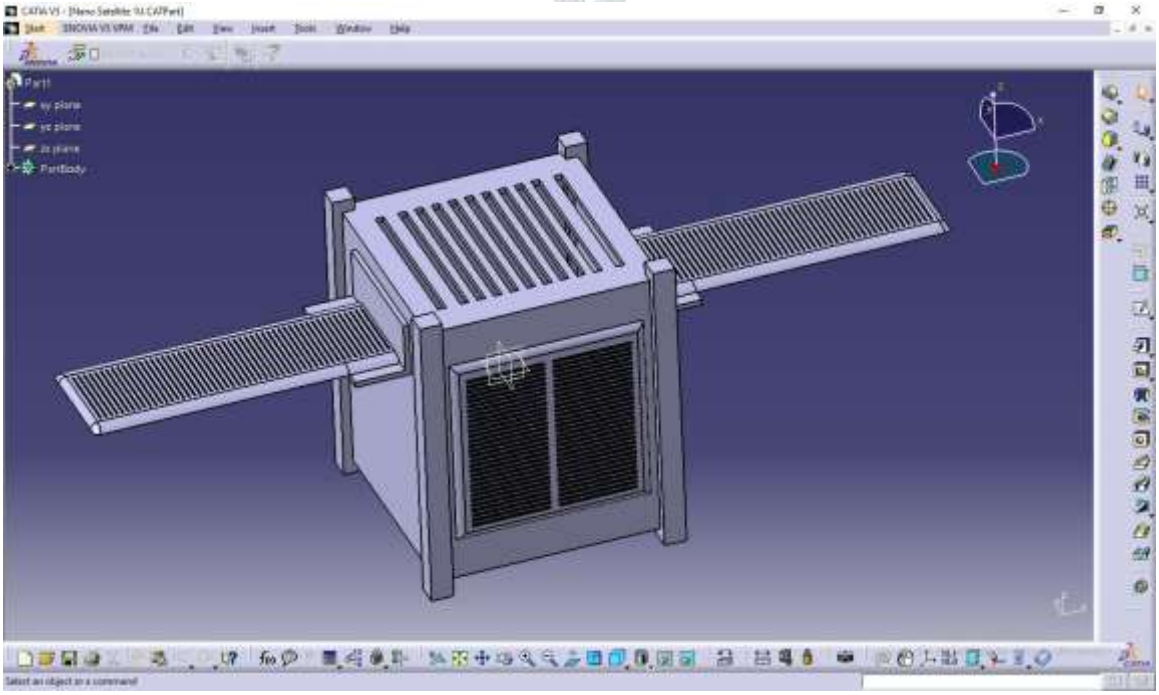

FIGURE 3. 3D Design of Atmospheric Sensing CubeSat Outer Structure

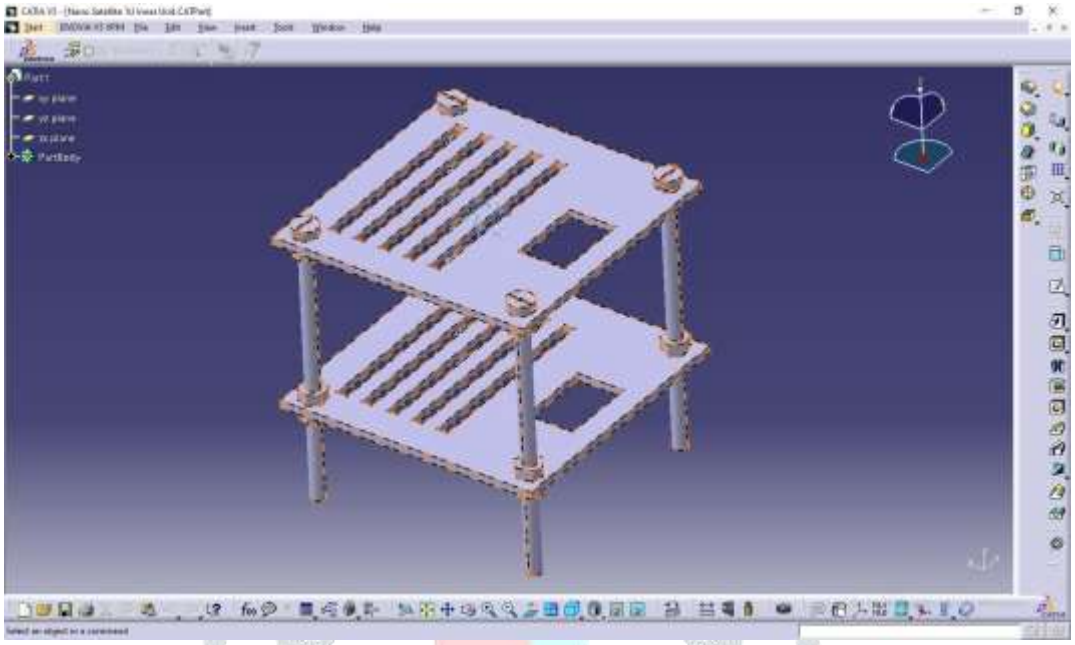

FIGURE 4. Structural Design of Internal Structure CubeSat

2.1. Design Calculations

In (v)-Sys, every component which makes a part of the product architecture has the property called mass. Since as explained earlier the (v)-Sys works in a hierarchical order. The mass parameter also sums up to get the total mass of the system in the same order.

$$M_s = \sum_{n=i} M_n$$

If a body is not seen as a dimensionless point, forces that act upon this body may not necessarily attack in the center of gravity. It is rather producing a torque with the lever arm the gap from the CG to the purpose. In this aper, the term CG is equally used with the term CM. This assumption is only true if gravity can be treated as a constant force across the rigid body. Therefore, it is important to know the location of the CG of the whole system. But since every component has its own center of gravity as well as its own coordinate system there are transformations to be made. The information about the position of the center of gravity of a component has to be transferred into the GPS. This requires rotation and vector addition. A aim addition finally gives the location of the local center of gravity in the GPS:

$$\begin{aligned} X_{cog,global} &= X_{cog,local,rot} + \Delta_x \\ Y_{cog,global} &= Y_{cog,local,rot} + \Delta_y \\ Z_{cog,global} &= Z_{coglocal,rot} + \Delta_z \end{aligned}$$

whereas $\Delta\vec{s} = (\Delta x, \Delta y, \Delta z)$ is the offset of the LCS in the GPS. With these transformations, each component's center of gravity can be shifted into the global reference frame. For the sake of get the unified CG of the whole system one should to calculate.

$$X = \frac{\sum_{i=0}^{n}(mi.Xi)}{\sum_{i=0}^{n} mi}$$

$$Y = \frac{\sum_{i=0}^{n}(mi.Yi)}{\sum_{i=0}^{n} mi}$$

$$Z = \frac{\sum_{i=0}^{n}(miZi)}{\sum_{i=0}^{n} mi}$$

While n is the quantity of parts of the model x, y and z are the parts of the vector giving the location of the total CG in the GPS.

FIGURE 5. Working Prototype

3. Connections

The detail commanding & gathering portion is an embedded coding program. An ESP32 Dev board is utilized as mother board. Which has charged by a 7.4 V battery & programmed for specific app using Arduino open- source software. The temperature & humidity sensor DHT 11 is joined to ESP 32 Dev. Pin no. 1, 2, and 3 of DHT11 are joined with Pin no. GND (ground), P25, and 5 V (supply) respectively. DHT11 gathered humidity and temperature data and supply to the ESP board for digital processing and analysis of data. The ultrasonic sensor HC-SR04 detect the object which are around the satellite. The connection of Ultrasonic to the ESP Board is done as follows: Vcc to 5 V, Trig to P18, Echo to P19, and GND to GND. A gyroscope is used. The connection of the Gyroscope GY-50 L3G4200D to the ESP Board is done as follows; Vcc to 5 V, SDA to P21, SCL to P22, GND to GND. GPS was also used. The joined of the GPS to the ESP Board is done; Vcc to 3 V, Rx to Tx, Tx to Rx (Tx-P17, Rx-P16), GND to GND. All parts are arranged into a cube shaped form of compact measurements. A transmitter & receiver parts is joined to the model. An EIRP transmitter-receiver part of 240 MHz is utilized for WIFI detail communication. The Cube-Satellite should be positioned where ever we want. The Circuit diagram of the complete model drawn in electrical software exhibit in Fig. 1. The working print of the atmospheric sensing CubeSat is exhibit in Fig. 5.

4. Testing and Results

Distance from the obstacle, location, Yaw, Pitch, Roll (Moments of Satellite) Pressure, and Relative humidity temperature against differentiation of Height in Kapurthala, law gate, Lovely professional University by Building dropping method have been collected in the month of April 2022. Table 2 illustrate the differentiation of temperature, humidity, and other values with respect to the differentiation in height.

Relative Humidity	Temperature	Roll	Yaw	Pitch	Distance
30.2	25.1	358.38	237.53	358.97	357
30.2	25.1	358.50	229.95	358.74	250
30.1	25.1	358.25	232.77	358.67	170
30	25.1	358.28	226.42	358.36	120
30	25.1	358.20	231.65	358.17	80

TABLE.2. Differentiation of Relative Humidity and Temperature Details with respect to the differentiation of Height.

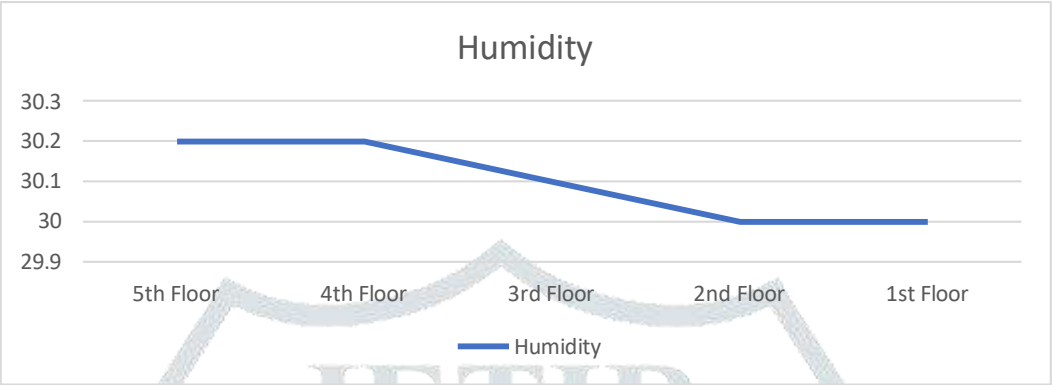

FIGURE. 6. Graphical Analysis for Humidity versus Different Height Details from Table 2.

From all of above six specifications, temperature variation has determined will provide a good effect on farming and manufacture, etc. Details for the variation of Relative Humidity for different heights have been collected in the month of April 2022 in Punjab.

5. Conclusion

Focus of the project which Design and Fabrication Atmospheric Sensing CubeSat Satellite. The recorded data of different parameters (temperature and humidity) from using building dropping method with the different height and era have been illustrate. Device utilizing internet system, details transfer has a economically efficient which expressing issue bulk implementation. It will provide a good effect on farming and manufacture. Although few restrictions that the system will not transfer data from far-distance, with the use of powerful transceivers will get data from far distance, and the collected data at higher altitudes with the support of a building testing method should be give few flaws. Device will destroy or endless utilization.

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