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Design and Implementation of CanSat (A Pico–Satellite)

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Abstract**-** Students are also exposed to research technique that is a strong motivational factor to work towards a graduate degree. Satellites of 350 millilitres and the mass about 500 grams, called CanSats, are small and cheap enough that most universities are able to design and build them as fully functional satellites. Designing satellite systems in this new, small, and light-weight design presents a new challenge to satellite developers. This research describes the design of a flexible CanSat capable of acquiring information at Near space regions. The data received is presented and explained. Variation of pressure, temperature and relative humidity with altitude are shown in the investigational outcome. The CanSat in this work was designed and built in 13 weeks and was used to generate location information of its flight path and also used to measure parameters like temperature, relative humidity, atmospheric pressure variation of a location in real time with the aid of the on board sensors. The design and implementation of this project is geared towards achieving results which will answer the objectives set for this project.

Keywords*- CanSat, Soda Can, Onboard Sensors*

I. INTRODUCTION

A satellite is an artificial object which has been intentionally placed into orbit. Such objects are sometimes called artificial satellites to distinguish them from natural satellites such as Earth's Moon.

CanSat is a nano-scale satellite model, weighing 350 to 1050 g, which provides excellent training opportunities for those who wish to pursue careers that involve satellite design, fabrication and operation. All basic functions of a satellite, such as those of power and communications, are fitted into a soda can of 350 ml or a little more, and it could perform various experiments such as attitude control, image capture and downlink as well as differential GPS measurement. The need for telecommunications, micro-gravity experiments, multidisciplinary academic participation and the miniaturization of technology has made the dream closer to reality space for academic institutions (public and private) and business through technology integration designed reduction of size, resources, and costs of artificial satellites. This lead to development of CubeSat specifications with overall weights of less than 1kg in 1999 by California Polytechnic University (CalPoly) by Prof. Jordi Puig-Suari and Prof. Robert Twiggs of Stanford University proposed the concept of CanSat in 1998 and that of Cubesat in 1999 at University Space Systems Symposium (USSS) held in Hawaii (Yasuyuki Miyazaki and Masahiko Yamazaki, 2013). Picosatellite developments have gained popularity over the years which have led to the development of a large number of CubeSats by CubeSat-class platforms such as University of Surrey, Stanford University, Hawaii Space Flight Lab, Aerospace Corporation, Angstrom Aerospace in Sweden, etc (Bordetsky et al, 2010). There are now more than 20 organizations worldwide that are developing and launching of CubeSat picosatellite annually (Puig-Suari, 2011). Not only is the CubeSat project beneficial to the academia, but also in Picosatellite integration experiments, enabling finding enhanced tagging, tracking, and global data sharing solutions for emerging network **-** controlled Operations scenarios (Rodrigo, 2011). The idea behind the CanSat concept was to let students be able to deal with some of the same challenges in building a satellite, but at the same time it had to be done over a much shorter period of time and with small expenses. The students have to design and build instruments, place them inside a soda can and launch it with a rocket or balloon. The soda can then falls down to the ground in a parachute while doing different kind of experiments (Nylund, 2008). This experimental research is based on the CanSat concept. The onboard computer as well as all the sensors and GPS will be placed inside the Soft Drink Can and launch with a helium- filled weather balloon.

II. LITERATURE REVIEW

Satellites are semi-independent computer-controlled systems. Satellite subsystems attend many tasks, such as power generation, thermal control, telemetry, attitude control and orbit control (David Strumfels, 2015). Etymologically, it is derived from the Latin word "satellite" or "satelles" meaning an attendant, one who is constantly hovering around and attending to a master or big man (Etymology Dictionary). In the context of spaceflight, a satellite is an artificial object which has been intentionally placed into orbit. Such objects are sometimes called artificial satellites to distinguish them from natural satellites such as the Moon. Satellite orbits vary greatly, depending on the purpose of the satellite, and are classified in a number of ways. Well-known (overlapping) classes include low Earth orbit, polar orbit, and geostationary orbit. They are usually semi-independent computer-controlled systems. It subsystems attend many tasks, such as power generation, thermal control, telemetry, attitude control and orbit control.

III. Design Methodology and Simulation

In this section, the definition of requirements which include the software and the components of the payload as well as the experimental design is discussed. The devices used for the experiment to collect and record data as well as the software will be discussed as well. This will be followed by the experimental setup, design and launching of the CanSat.

A. *Circuit Analysis*

The system uses two circuits, circuit 1 (CANSAT) transfer information to the ground station (circuit 2). Figure 2, shows the circuit that measures the temperature.

B. *General Description of the Microcontroller Program*

The microcontroller is the brain of the CanSat. It samples signals from various sensors. It communicates with the ground station using a radio module.

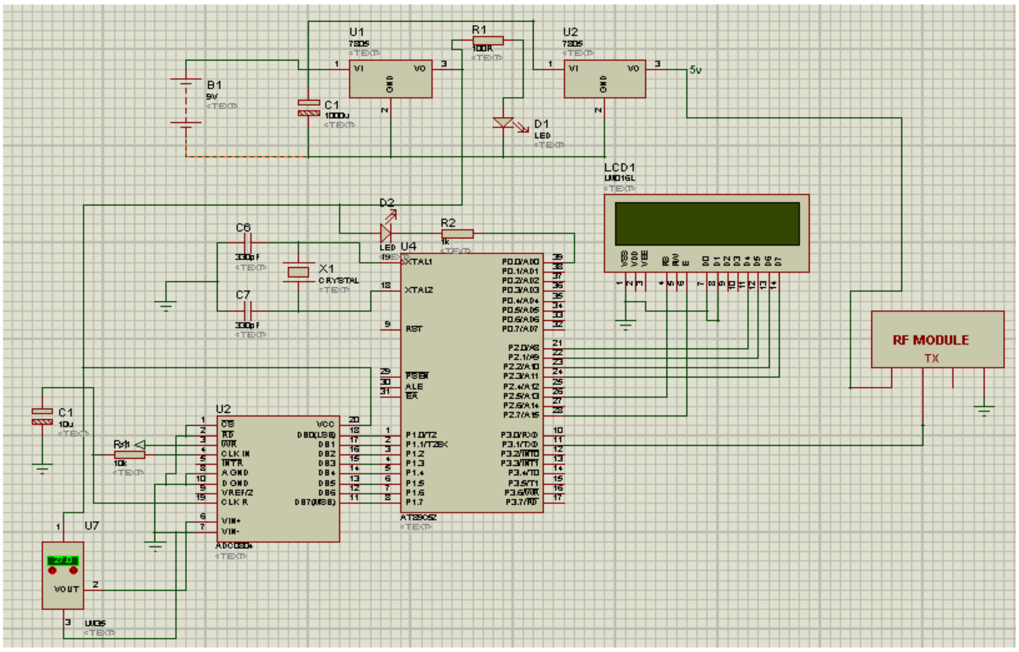

Figure 1. Circuit Diagram of the CANSAT transmitting circuit

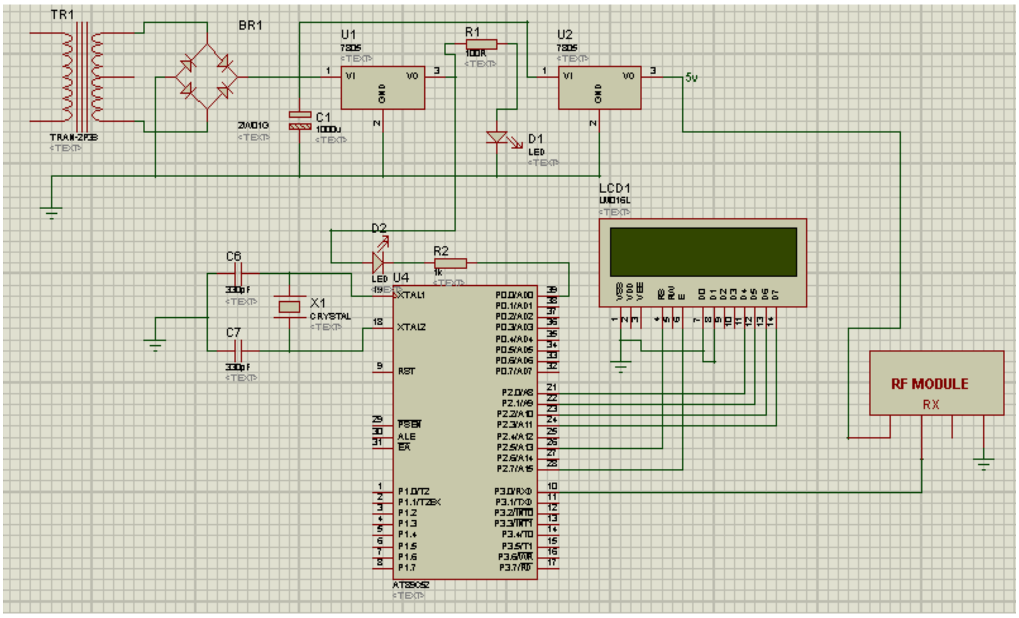

Figure 2. Circuit Diagram of CANSAT ground station

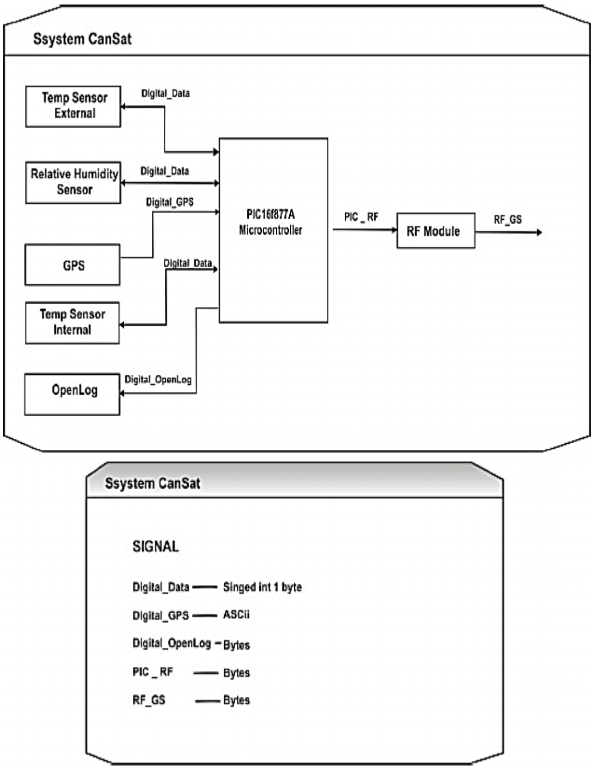

Figure 3. CanSat SDL diagram

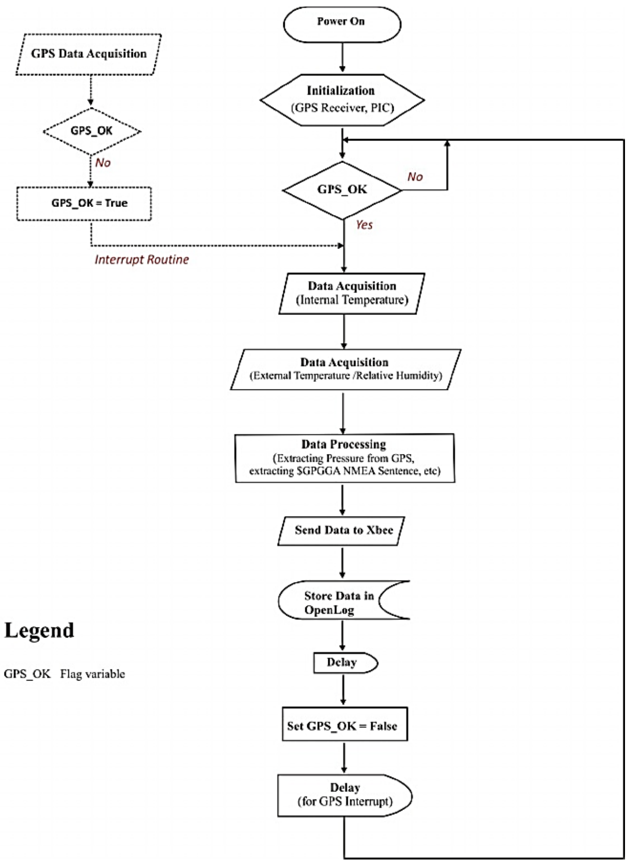

Figure 4. CanSat Flow Chat diagram

IV. TEST AND RESULT

Testing is one of the important stages in the development of any new product or repair of existing ones. Because it is very difficult to trace a fault in a finished work, especially when the work to be tested is too complex. For the purpose of this project, two stages of testing are involved

i. Pre-implementation testing
ii. Post-implementation testing.

A. Pre-Implementation Testing

It is carried out on the components before they are soldered to the Vero board. This is to ensure that each component is in good working condition before they are finally soldered to the board. The components used in this design are grouped into two.

- Discrete components e.g. resistors, light emitting diodes, capacitors, transistors. Etc.

- Integrated circuit components.

The discrete components are tested with a millimeter by switching the meter to the required value and range corresponding to each discrete component to check for continuity.

B. Post-Implementation Testing

After implementing the circuit on a project board, the different sections of the complete system were tested to ensure that they were in good operating condition. The continuity test carried out is to ensure that the circuit or components are properly linked together. This test was carried out before power was supplied to the circuit. Finally, after troubleshooting has been done on the whole circuit, power was supplied to the circuit at the voltage shown in table 1. Visual troubleshooting was also carried out at this stage to ensure that the components do not burn out. After all the test and observations as explained above, the project was now certified ready for packaging

TABLE I. MEASUREMENT AND RESULTS

Power output	Expected values	Measured values
7805 regulator 7805 regulator	+ 5V + 5V	+ 5.02V + 5.02V
RF receiver and transmitter	180mA	150.0mA
HMNB Current Voltage	+5V 20mA +5V	+5.01 19.82mA +4.99V
Input Voltage PHCN	220Vac	208.14Vac

TABLE II. LM35 PIN DESCRIPTION AND FUNCTION

Pin No	Function	Name
1	Supply voltage; 5V (+35V to -2V)	Vcc
2	Output voltage (+6V to -1V)	Output
3	Ground (0V)	Ground

V. RESULT ANALYSIS

The construction of the work started by drawing the circuit and analyzing the principle of operation needed for the construction. The circuit was then simulated on an integrated environment called Proteus. It was test run and it worked perfectly.

TABLE III. SAMPLE CANSAT DATA

TOF (S)	UTC Time	Latitude (N)	Longitude (E)	Fix Quality	Num Of Sat	HDOP	WGS84	Altitude (M)	Pressure (KPa)	RH (%)	Int Temp (*C)	Ext Temp (*C)
7	167423	498.23	746.22	1	4	1.7	18.2	56.34	100.456	72.12	28.54	29.11
14	167131	498.24	746.23	1	6	1.4	18.2	76.32	100.453	72.21	28.68	29.11
21	167432	498.25	746.25	1	6	2.1	18.2	79.34	100.435	71.22	28.67	29.12
28	167751	498.26	746.21	1	5	2.1	18.2	67.21	100.342	72.25	28.66	29.13
35	165432	498.25	746.22	1	8	1.3	18.2	68.34	100.213	72.24	28.69	29.11
42	164321	498.27	746.23	1	5	1.4	18.2	80.12	100.213	72.21	28.56	29.12
49	165538	498.29	746.22	1	6	1.4	18.2	58.21	100.213	72.12	28.69	29.12
56	164531	498.28	746.22	1	7	1.4	18.2	76.23	100.243	72.12	28.67	29.12
63	163452	498.28	746.22	1	7	1.4	18.2	76.22	100.342	72.22	28.68	29.12
70	165321	498.28	746.21	1	8	1.4	18.2	67.23	100.213	71.22	28.69	29.12
77	164321	498.29	746.22	1	5	2.1	18.2	65.12	100.231	72.33	28.65	29.13
84	167432	498.26	746.23	1	4	2.4	18.2	39.21	100.241	72.34	28.68	29.13
91	165432	498.27	746.23	1	6	0.9	18.2	45.32	100.213	72.31	28.69	29.12
98	167843	498.28	746.24	1	7	1.1	18.2	78.34	100.211	72.22	28.65	29.12
105	167543	498.27	746.24	1	6	2.3	18.2	68.32	100.231	72.22	28.69	29.21
112	165432	498.26	746.21	1	7	1.6	18.2	85.21	100.213	71.22	28.66	29.12
119	167543	498.26	746.22	1	4	1.6	18.2	67.34	100.211	72.23	28.66	29.12
126	167321	498.26	746.21	1	5	1.5	18.2	65.56	100.213	72.32	28.69	29.13
133	165432	498.26	746.33	1	6	1.4	18.2	87.22	100.219	72.32	28.69	29.12
147	167541	498.28	746.32	1	7	2.2	18.2	66.86	100.215	72.21	28.69	29.21
154	167322	498.27	746.22	1	8	1.6	18.2	65.77	100.227	72.23	28.69	29.13
161	167554	498.28	746.22	1	4	2.1	18.2	65.74	100.214	72.21	28.69	29.21
168	167543	498.27	746.23	1	5	2.2	18.2	65.99	100.231	72.53	28.67	29.12
175	167453	498.26	746.26	1	4	1.9	18.2	76.21	100.241	71.32	28.66	29.12
182	167231	498.27	746.30	1	6	1.5	18.2	72.43	100.217	72.32	28.67	29.13
189	168765	498.28	746.24	1	7	1.7	18.2	69.97	100.231	72.22	28.67	29.12
196	167321	498.27	746.24	1	8	2.3	18.2	70.12	100.221	72.22	28.67	29.21
203	167543	498.28	746.27	1	5	1.2	18.2	71.22	100.212	72.22	28.66	29.12
210	167543	498.28	746.29	1	9	1.1	18.2	71.21	100.232	72.22	28.66	29.12
217	167543	498.28	746.25	1	6	1.6	18.2	69.56	100.111	72.22	28.67	29.13

The graphs plotted from the above table are shown below.

a) The graph below shows the variation of pressure with time during the time of flight.

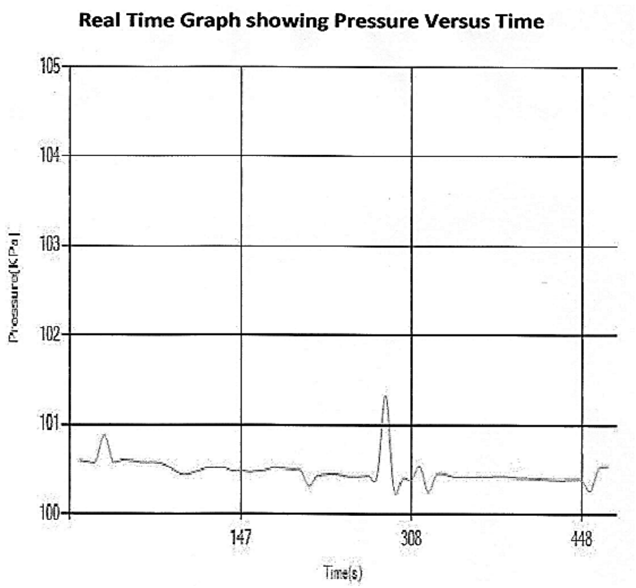

Figure 5. Pressure vs Time Graph

b) The figure below shows the variation of relative humidity with time during flight.

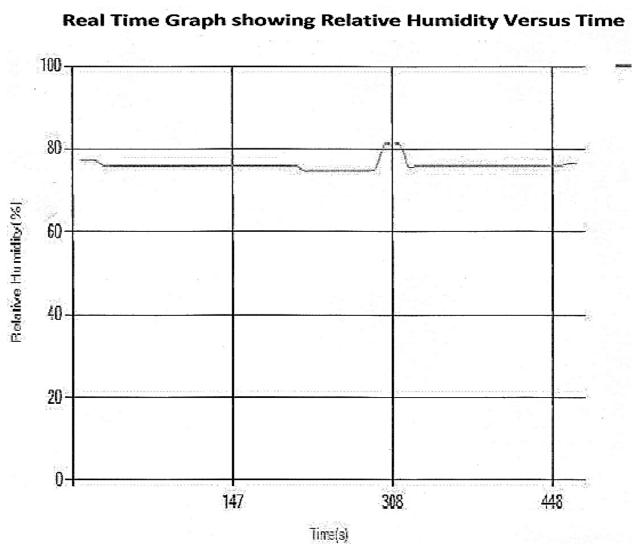

Figure 6. Relative Humidity Vs Time Graph

c) The figure below shows the variation of the temperature with the time during the CanSat flight. This helps us to know the temperature of the environment throughout the flight time.

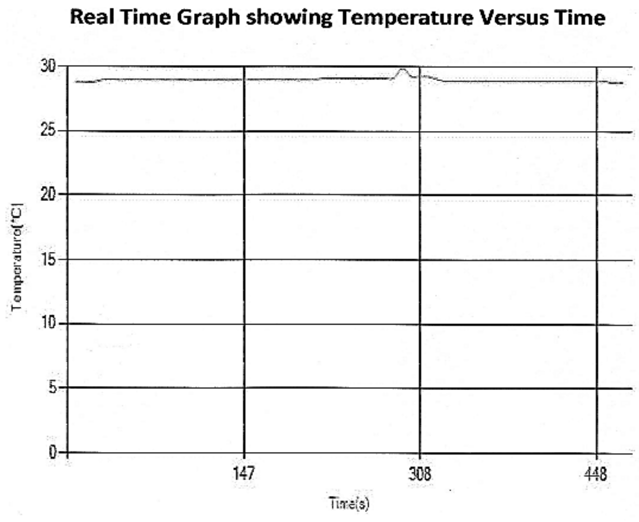

Figure 7. Temperature Vs Time Graph

VI. CONCLUSION AND RECOMMENDATION

This research focuses on the design and simulation of CanSat. Going through the whole process of a satellite development and design, it is the most practical experience in which I have been exposed to. Though there have been challenges and limitations in the development of this project in which this chapter will emphasize the achievement so far is encouraging.

A. Recommendations

- Microcontroller used for projects of this magnitude-using multiple UART devices should be of PIC18 or PIC32 families which have multiple UART I/O ports to reduce the need of creating virtual UART ports which have performance impact on the system.
- The power supply needs to be properly filtered and decoupling capacitors should be soldered as closely as possible to the PIC's Vdd/Vss pins for transient response.
- A project of this magnitude should be given a period of a least 6 months.
- It is a necessity to properly equip our laboratories as project of this caliber cannot be carried out effectively without a standard laboratory as compare to how it is being done in the developed countries.

B. Future Work

1) Additional Sensors

- The CanSat may fly to altitude where the ozone concentration is significantly higher than on ground level. A measurement of ozone concentration as a function of position would be of scientific interest.

- Pressure sensor, humidity sensors and accelerometer can be incorporated into the payload to measure the pressure, humidy and acceleration of the CanSat respectively.
- Magnetometer can be added to the payload to measure the strength and the direction of the magnetic field at a point in space.

2) The CanSat Improvement

The CanSat can be improved in a number of ways.

- The voltage over the battery can be measured. This would allow for monitoring and fault detection.
- Mobile tracking devices can be added to the payload and the ground station and this could be integrated with Google Earth.
- Camera module can also be added to take aerial photographs as the payload rises.

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