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Test case generation for On Board Computer Software Major Components

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Abstract

PES Institute of Technology along with five other institutions is developing a student imaging satellite. In imaging satellite development, software implementation plays an important role. On Board Computer (OBC) is one which runs the satellite software. Satellite software has its sub components like telemetry, control modes, data processing, actuator, tele command and etc. Design, development and testing of these components are done successfully. Testing plays very important role to assure its software components functionality. In this paper, we present the testing methodology that we used along with main software components that we tested for on board computer. These test cases used to assure the functional correctness of control modes, actuator, tele command, telemetry and data processing of on board computer components.

Keywords

On Board Computer, Satellite Software components, Test case generation, imaging satellite, control modes;

1. Introduction

The primary objective of this student satellite program is to encourage the students in a satellite. Main intention to understand satellite components like on board computer, launch vehicle, payroll and etc. It is to provide a learning opportunity to students. It also empowers them with the skills to develop the satellite through different phases like defining, analysis, design, development, integration and testing. The main scope of this student satellite is to capture the pictures of earth and downlinks to the pesit ground station [1][2]. Its planned to launch in a polar sun synchronous orbit at an altitude of around 650 km and inclined at an angle of about 99º. The orbital period is around 90 minutes; eccentricity is about 0.001 and semi major axis of about 7000km. The hardware components used are magnetometer, magnetic actuators, sun sensors, power sensors, thermistors, transmitter, receiver, solar panels and camera. The processor used here is UT32UC3A0512. It is of 32 bits, 512Kb memory and speed of 1.49 DMIPS (Dhrystone MIPS)/MHz. Programming language used to develop on board computer software is Embedded C [3]. Figure 1 depicts the OBC software system functionalities. In this the function of Payload is to capture the image and stores it in telemetry .The power subsystem manages the power among various components, also does power consumption analysis, batter and panel power analysis . The attitude of spacecraft is controlled by ACS (Attitude control system). Telemetry transmits data from the spacecraft to ground station after forming a frame which includes both housekeeping and payload data. Tele command's function is to receive commands from the ground station and distribute to various subsystems of space craft [7]. All the processed information will be send to telemetry buffer [4] [5].

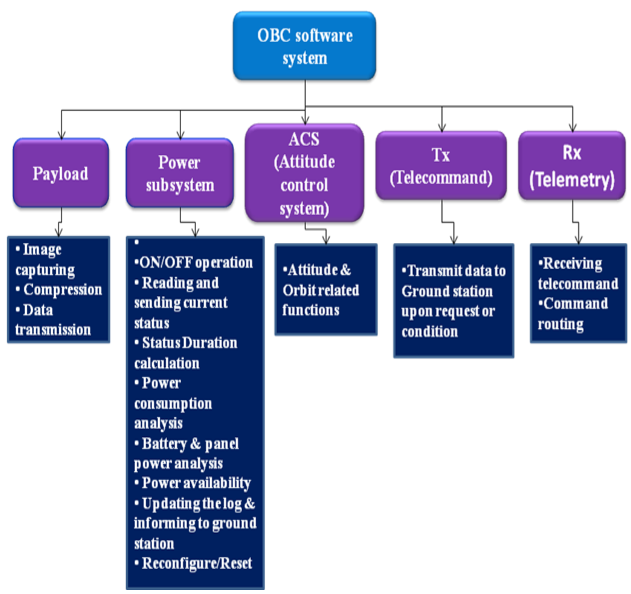

Figure 1: OBC software system

This paper is structured as follows – testing methodology discussed in section II. The design of the test cases for OBC components are described in section III. Section IV concludes the paper with future enhancements.

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2. Testing Methodology

This paper deals with functional testing and its test cases. Because using functional testing we can know the system behavior as it is expected and all components are functioning properly. Testing methodology is designed to carry out testing in a procedural manner and it divides the testing life cycle into phases [6]. The testing methodology we are using to test OBC software components is shown in figure 3. Before testing any software first need to generate test cases, which describes an input and an expected output to determine whether the software components are working correctly. Our testing methodology includes functional test cases; these test cases are written in a positive perception and also in a negative perception. So Test cases can be positive test cases or negative test cases. The testing operation performed using the valid data that is the actual input which gives the actual output , then this can be done through positive test case. The testing operation performed using the invalid data and the expected output should be an error, then this is done through negative test cases. Test cases of OBC software components consists of unique identifier number to reference each and every test cases, test case description gives the objective written in two or three lines, test data used to execute the action and it produces the actual output that is compared with the expected output, remarks indicates that the test is passed or failed. All these aspects are represented pictorially in figure 2.

Figure 2: Aspects considered in generating test case [8]

3. Test case generation for the OBC components

The OBC components are developed using the component based development cycle. This is advantageous because, we can start developing and testing each component independently. Figure 3 shows the student imaging satellite software components namely Power-On initialization, Control modes and actuators, Data acquisition, Data processing, Telecommand (TX) and Telemetry (RX). Below section presents the test cases of OBC software components.

1) **Control modes and actuators:** satellite behavior has been controlled and regulated when it is in different modes like Detumbling mode where after the separation of satellite from launch vehicle, body may be in tumbling mode and have high body rates. In Detumbling mode rates along transverse axis are brought down to low values so that the coning motion is within the specified limits. And the work of Actuator Processing is to check whether polarity reversal happened in any torque input; if yes make the input zero for three cycles else fire or actuate the torque.

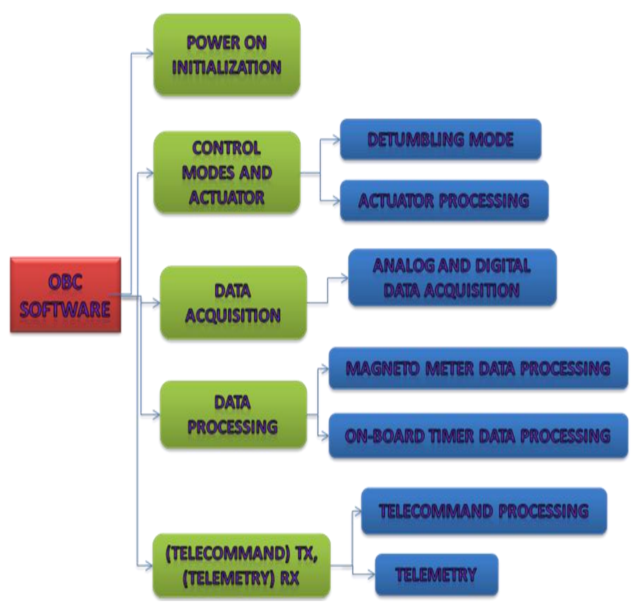

Figure 3: OBC Software Components

2) **Data processing:** In the data processing magnetometer data will be processed and OBT

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data will also be processed, where magnetometer is a digital compass solution designed for use in navigation and precision pointing applications. It has two-axis magnetic sensors providing X, Y, and Z axis magnetic sensing of the earth's field. The Magnetometer automatically begins streaming magnetometer output data at 8Hz and at 8 samples per second rate. Magnetometer communicates through ASCII characters with the * or # characters as start characters. The OBT (on board timer) data processing is a 32 bit hardware counter. The counter output is getting latched in every instant. To read the correct OBT data processor.

3) **Tele-command processing (TX) and Telemetry processing (RX):** Tele-Command processing is a part of OBC. Commands are to be executed as soon as it is received by spacecraft are called Real Time Command. Telemetry is the process of measuring the characteristics of an object. It is the communication for transmission and response of measured quantities for the purpose of remotely monitoring spacecraft environmental conditions or equipment parameters. The measured data will be transmitted to another station to store, display or to maintain record of an object. The OBC processor logic stores the acquired telemetry data in telemetry RAM. Each telemetry word is of 32 bit. All the parameters are assigned with telemetry address, and sent for telemetry downlink. The realization of Normal telemetry involves following operations

- Mapping between Raw Data Buffer to Telemetry RAM
- Formatting TM Mainframe
- TM Frame data dump

Table 1: Positive test cases for control modes and actuators

Test case ID#	**Test case description**	**Test data**	**Expected output**	**Actual output**	**Remarks**
CA1	In detumbling mode rates are brought down to low values so that the coning motion of satellite is within the specified limits.	Detumbling mode rates are bring down to low values	Coning motion of satellite should be within the specified limits.	Coning motion of satellite should be within the specified limits.	Success
CA2	If input to torquer is of reverse polarity, then input should be made zero for the next 3 cycles and torquer is not actuated.	Giving reverse polarity input to torquer	Torquer actuated	Torquer actuated	Success
CA3	If input to torquer is of not reverse polarity, then input shouldn't be made zero for the next 3 cycles and torquer actuated.	Giving non reverse polarity input to torquer	Torquer not actuated	Torquer not actuated	Success

Table 2: Positive test cases for magnetometer processing

Test case ID#	**Test case description**	**Test data**	**Expected output**	**Actual output**	**Remarks**
DP1	Sending query to magnetometer to read the magnetometer data	Query	Read the character from the magnetometer via USART till carriage return is encountered.	Read the character from the magnetometer via USART till carriage return is encountered	Success
DP2	Once the data has been read from magnetometer it is in ASCII format should be converted into decimal format	ASCII data	Conversion from ASCII data to decimal data and stored in RAM memory.	Conversion from ASCII data to decimal data and stored in RAM memory.	Success

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DP3	Store the converted data from ASCII to decimal is stored in RAM	Converted data	Converted data from ASCII to decimal is stored into RAM.	Converted data from ASCII to decimal is stored into RAM.	Success
DP4	Use RTC get the current value of on-board timer	RTC address	OBT current value has stored in Value register of RTC.	OBT current value has stored in Value register of RTC.	Success

Table 3: Positive test cases for telecommand and telemetry processing

Test case ID	Test case description	Test data	Expected output	Actual output	Remarks
TE1	First execute the commands received by spacecraft then put the executed commands to telemetry	Receive data from telecommand	Spacecraft executed the commands and updated the telemetry buffer	Spacecraft executed the commands and updated the telemetry buffer	Success
TE2	Storing remote programmable data to desired RAM address. Both RAM address and data are to be issued from ground	Data and RAM address	Stored remote programmable data to desired RAM address	Stored remote programmable data to desired RAM address	Success
TE3	Mapping up of data between raw data buffer to telemetry RAM then formatting telemetry frame telemetry frame	Raw data buffer and telemetry RAM	Formatted telemetry frame	Formatted telemetry frame	Success
TE4	After formatting telemetry frame data is dumped to telemetry frame.	Telemetry frame	Data dumped to telemetry frame	Data dumped to telemetry frame	Success
TE5	Reading of Telemetry Frame from telemetry buffer RAM	Telemetry buffer RAM	Read the telemetry frame from telemetry buffer	Read the telemetry frame from telemetry buffer	Success
TE6	Dumping the read data from telemetry RAM to telemetry port and make each word frame of size 32 bit and store it in TM Frame.	Read data from telemetry buffer	Dumped Telemetry frame into telemetry port and made the telemetry frame size of 32 bit and stored it into TM Frame.	Dumped Telemetry frame into telemetry port and made the telemetry frame size of 32 bit and stored it into TM Frame.	Success

4. Conclusion and Future Work

This paper presents the testing methodology that we used along with main software components test cases of on board computer. These test cases used to assure the functional correctness of control modes, actuator, tele command, telemetry and data processing of on board computer components. The future work will be on automation of testing process based on these test cases. Automation testing can be helpful for regression testing.

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