Automated test system for test and evaluation of C-Band Receiver packages for GEOSAT Spacecrafts

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Abstract— This paper aims to develop an Automated Test System for the Test and Evaluation of C-Band Receiver Packages for GEOSAT Spacecrafts. Automated testing is the best way to increase the efficiency, coverage, quality and accuracy of the Test and Evaluation of Device under Test (DUT). Once automated tests are created they can easily be repeated and can be extended to perform tasks impossible with manual testing. Automated testing optimizes time and saves money. The importance of ATS has always been closely linked to the performance of the instrument interface architecture used in the system. GPIB (general purpose interface bus) is one such instrument interface standard that offers many benefits for establishing communicating between different measuring and analyzing instruments used in an ATS. This paper describes the details of hardware selection and software implementation for the realization of ATS for C-BAND RECEIVER.

Key words: ATS, C-BAND RECEIVER, DUT, GEOSAT

I. INTRODUCTION

Testing is the process in which a test is conducted on a complete integrated system to evaluate and analyze the system's results with its specified requirements. Thus any hardware before its end use application needs to undergo testing, to ensure that it meets all the specifications under different environmental conditions. This paper aims to develop an Automated Test System for the Test and Evaluation of C-Band Receiver Packages of GEOSAT Spacecrafts.

A. *C-Band Receiver*

The C-Band Receiver in a transponder [1] is responsible to receive and demodulate the command signal transmitted from ground stations. Also it demodulates the ranging tone information from the transmitted up link carrier and passes the same to the C-Band Transmitter. C-Band receiver operates at 6.4GHz uplink frequency. There are two types of modulating frequencies for C-Band receiver viz. command signals and ranging signals. The command signals are at 283Hz, 27.7777 kHz, 3.498 kHz and ranging tones are 3.125 kHz and 5.555 kHz.

The block diagram of C-Band receiver is shown in fig. 1, consists of low noise amplifier (LNA), IF mixers, Local oscillator, Video amplifier and FM discriminator A Satellite revolving in a geostationary orbit will be 36,000 kilometers above the earth. Any signal send from ground station will suffer an attenuation of approximately 200 dB, while making this 36,000 kilometer journey from the ground to the receiver sitting on the satellite. The ground station signals which finally arrive at satellite receiver are extremely weak. These weak signals are received and processed by sophisticated electronic components. Given the low signal strength, the signals need to be immediately amplified. However, it is very important that the amplification does not contribute any significant amount of noise which would otherwise spoil the weak signals received. This is done by a “Low Noise Amplifier” (LNA). The LNA consist of low noise amplifying stages that boost the signal to a reasonable level at which it can be further processed without disturbing the useful information.

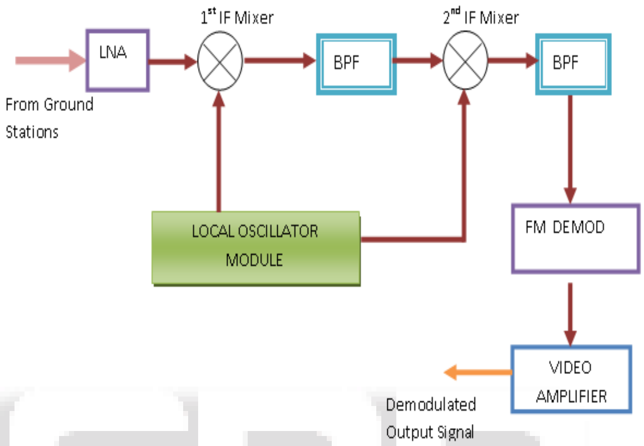

Fig. 1: Block diagram of C-Band Receiver

The mixer uses the heterodyne principle [1] for conversion of a block of C- Band frequencies to the IF or Intermediate Frequencies. In communications engineering, an intermediate frequency (IF) is a frequency to which a carrier frequency is shifted as an intermediate step in transmission or reception. The intermediate frequency is created by mixing the carrier signal with a local oscillator signal in a process called heterodyning, resulting in a signal at the difference or frequency.

The local oscillator excites a frequency for mixing with the incoming signal to get the intermediate frequency. The IF is produced by mixing a local oscillator signal with the incoming signal. The local oscillator is, therefore, essential to efficient operation and must be both tunable and very [1] stable. The output frequency is directly related to the local oscillator frequency. Hence it is very important to have an extremely stable (fixed) local oscillator frequency.

As shown in the Block diagram, Band pass Filters are introduced after the mixers. The filters after the mixer suppress or filter out all frequencies except the required frequency which is the difference between the microwave broadcast and the local oscillator frequency. FM demodulator is used to demodulate command and ranging signals from ground station for further necessary processing. The function of a video amplifier is to amplify a signal containing high-frequency components without introducing distortion. The video amplifies the demodulated baseband signals from the demodulator and amplifies these signals, and passes on these signals for further processing

II. MANUAL TESTING SYSTEM

Manual testing is the oldest type of testing. In this method testers plays an important role and run tests manually. Analyze the test results by comparing [2] the actual outcomes with the expected output, verify all features of the DUT and ensures they meet the requirements.. Manual Tests take more effort, cost and time resulting less reliable as it is more prone to human errors. Manual testing can be iterative based on requirement, hence boring. As a result, many testers have a hard time staying engaged in this process and errors are more likely to occur. Lack of training is a common problem in manual testing. There are certain disadvantages of manual testing such as

(1) Manual tests can be very time consuming
(2) During every condition and phases of Testing, the same set of tests to be repeated, this can be tiresome.
(3) Less accurate and prone to errors.
(4) Manual testing is less reliable as manual interventions leads to manual errors.
(5) Test's have to be carried out for different environment conditions, thus for each temperature sets of instruments to be calibrated which is very time consuming.
(6) Huge investment in human resources: As test cases need to be executed manually so more testers are required in manual testing
(7) Regression Test cases are time consuming if it is manual testing.
(8) Manual Testing is non-repeatable.
(9) After every test the failure or success has to be checked by a user.
(10) If Test Cases have to be run a small number of times it's more likely to perform manual testing

To overcome all the problems and limitations using manual testing system, we can adapt an automated testing system which has many advantages over manual testing system.

III. PROPOSED AUTOMATED TEST SYSTEM

The Automated Testing System [2] (ATS) is a system for automating the execution of tests on Device under test (DUT). Automatic test system is an apparatus that is designed to perform tests on specific DUT. It runs these tests, either in serial or in parallel and creates a log file (or files) describing the results of running the tests and analyze the same**.** Automated testing is the best way to increase the effectiveness, efficiency, coverage and quality of testing. Once automated tests are created they can easily be repeated and reusable the code written for a certain application can be reused with required changes in input or some features can also be added to the application by adding code to those features and they can be extended to perform tasks.
There are many advantages of ATS when compared to Manual testing system .

- SPEED-Automated test runs with minimal human interventions and the inter instruments communications are held through different communication buses. Hence the test time as compared to manual testing is very less results in saving more time.
- REPEATABLE**-** The same tests [2] can be re-executed in exactly the same manner eliminating the risk of human errors such as testers forgetting their exact actions, intentionally omitting steps from the test scripts, missing out steps from the test script, all of which can result in either defects not being identified or the reporting of invalid bugs (which can again, be time consuming for both developers and testers to reproduce.
- ACCURATE-Even the most conscientious tester will make mistakes during monotonous manual testing. Automated tests perform the same steps precisely every time they are executed and never forget to record detailed results.
- REUSABLE-As the instruments are fixed in a single system, tests can be re-used in different test conditions.
- RELIABLE- Tests perform precisely the same operation each time they are run thereby eliminating human errors
- PROGRAMMABLE-Testers can perform additional tests with less effort.
- EFFICIENCY-Automation will improve efficiency in production minimizing the errors delay anticipated in manual testing.
- FLEXIBLE- It provided flexibility in upgrading the test requirements based on end-user demand.

As automated test system overcomes all the disadvantages of Manual testing system, we develop an automated test system for C-band receiver using LABVIEW software and GPIB communication interface as shown in Fig 2.

IV. DESCRIPTION OF ATS FOR C- BAND RECEIVER

An ATS for C-Band Receiver is developed to test C-Band Receiver and compare the outcomes with its specified requirements.

A. Hardware requirement

The block diagram of automated test system is as shown in figure 2 it consists of equipments such as power supply, DMM, oscilloscope, signal generator etc. In the block diagram, the device under test (DUT) is C-Band Receiver package. A power supply is used for powering the DUT and a DMM is used in ammeter mode for measuring the current drawn by the DUT. Signal generator and Audio analyzer is used for simulating the input stimuli to the DUT. Audio Analyzer and oscilloscope are used to analyze the response from the DUT. Other measurements such as Thermister reading, continuity checks and ON/OFF Status monitoring of DUT are done by the other DMM.

B. Communication Interface

The importance of ATS has always [6] been closely linked to the performance of the instrument interface architecture used in the system. GPIB (general purpose interface bus) is one such instrument interface standard used in the realized ATS. All instruments in the ATS of C-Band receiver are communicated through IEEE488.2 interface bus (GPIB). The GPIB or IEEE 488 bus is a very flexible system, allowing data to flow between any of the instruments on the bus, at a speed suitable for the slowest active instrument. Up to fifteen instruments may be connected together with a maximum bus length not exceeding 20 m. There must also be no more than 2 m between two adjacent instruments on the bus. As GPIB cards are relatively cheap, this makes the inclusion of a GPIB card into the system a very cost effect method of installing it. Devices have a unique address on the bus. Instruments are allocated addresses in the range 0 to 30, and no two instruments on the same bus should have the same address. it has a data rate of up to 1MB/s. GPIB has 24 pins 8 for data lines, 8 for ground, 3 for handshaking lines and 5 for interface management lines.

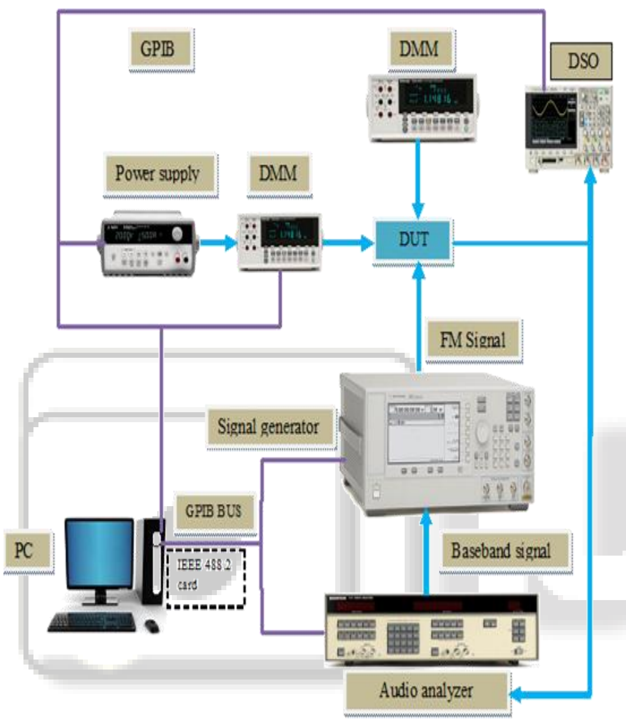

Fig. 2: Block diagram of ATS of C-BAND RECEIVER

C. Software requirements

The software implementation [3] plays an important role in any ATS. So choosing a software platform also matters in designing any ATS. The software used is LABVIEW which is a graphical programming language with build in functions for various applications. LABVIEW uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LABVIEW uses dataflow programming, where the flow of data determines execution order. LABVIEW programs are called virtual instruments (VIs).

Each VI contains three main parts:

- Front Panel – How the user interacts with the VI
- Block Diagram – The code that controls the program
- Icon/Connector – Means of connecting a VI to other VI's

In LABVIEW, you build a user interface by using a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart. Users interact with the Front Panel when the program is running. Users can control the program, change inputs, and see data updated in real time. Controls are used for inputs such as, adjusting a slide control to set an alarm value, turning a switch on or off, or to stop a program. Indicators are used as outputs. Thermometers, lights, and other indicators display output values from the program. These may include data, program states, and other information. Every front panel control or indicator has a corresponding terminal on the block diagram. When a VI is run, values from controls flow through the block diagram, where they are used in the functions on the diagram, and the results are passed into other functions or indicators through wires.

V. RESULTS

ATS for C-Band Receiver is developed using LABVIEW and various parameters such as voltage consumed , SNR, Power consumption etc are tested and compared with the specified requirements. The front panel of C-Band Receiver is as shown below

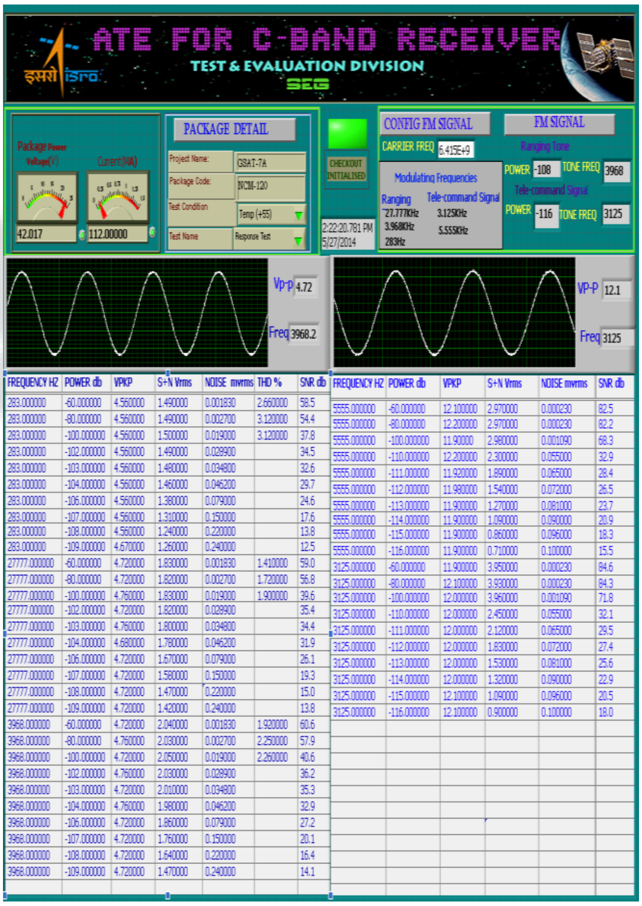

Fig. 3 Front Panel of Ats For C-Band Receiver

The result analysis after testing using automated test system is is as shown below in table 1

Parameters	Specified values	Test results
Supply voltage	25V to 42.5V	42.01V
Power consumption	5 watts (max)	4.7 watts
Command	2vp-p to 12vp-p	11.9vp-p

channel output		
Ranging channel output	5vp-p ±10%	4.72vp-p
Command threshold	-108dbm (max)	-116 for 3.125khz -115 for 5.555khz
Ranging threshold	-103dbm (max)	-108 for 283Hz -109 for 27.777khz -109 for 3.968khz
Minimum ranging SNR	+13db	13.8 for 283Hz 13.8 for 27.777khz 14.1 for 3.968khz
Minimum command SNR	+18.75db	18.0 for 3.125khz 18.3 for 5.555khz
Modulation scheme	PCM/FSK/FM (+400 KHZ deviation)	FM modulation with 400khz deviation

Table 1: Result Analysis

VI. Conclusion

This paper describes an Automated Test System for the Test and Evaluation of C-Band Receiver Packages for GEOSAT Spacecrafts. Automated testing is the best way to increase the efficiency, coverage, quality and accuracy of the Device under Test (DUT). This paper also describes the details of hardware selection and software implementation for the realization of ATS of C-BAND RECEIVER packages used for GEOSAT spacecrafts.

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