

THE TEMEMETRY TEST STATION - AN INTRODUCTION

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ABSTRACT

The Telemetry Test Station has been developed at the Digital Systems Division, ISRO Satellite Centre, to test House Keeping Telemetry Packages which will be flown onboard satellites. The main feature of the Test Station is its configurability, since it is intended to be used with different types of (low bit rate) telemetry packages. Other features include automation of test procedure, and reduction in testing time/increase in repeatability due to minimisation of manual interaction.

Since the test station comprises GPIB controlled equipment, hardware and software, thf configurability should be built in at all levels and stages, from design to implementation. Thus since the specification is subject to change, the configuration for structure of the system is traosferred from the designer to the user. This results in a large part of the system being devoted to user interface design, since the computer which is an integral part of the setup must be 'invisible' to the user. Due to specialised requirements the user and the system are treated at peer level i.e, at any time during the entire test session, the user can override system process and verify/correct it and equally, the system must also verify/correct user input especially with regard to critical test procedures.

The test tession itself (after configuration) is divided into three equally important sections: preprocessing, test and analysis. All the data required during the test run should be made ready before the actual test. Since it has been found by experience that this is not always convenient, the preprocessing software is integrated in to the test session so that the user can perform this at any time. Similarly, the results of the test can also be analysed

immediately or even during the test to improve subsequent procedures.

This paper describes the prototype telemetry test station which has been built and tested over the past two years. This performance has been satisfactory. The system integration features and design problems and solution are high lighted.

KEY WORDS (1) Satellite Telemetry
 (2) Configurability
 (3) Automated testing

INTRODUCTION

A setup to test Satellite Telemetry Systems, the Telemetry Test Station, is described here. The aim of the test session is the exhaustive and efficient testing of all electrical specifications of the system under test. The test equipment has to provide all inputs to and measure all outputs of the system under test. The specification of the test session must also include all procedures, parameters, controls, signals and environments under which the system is to be tested. The test setup must be modified quickly and easily to suit the system under test and must provide especially robust and failsafe interfaces so that the satellite system is in no circumstance jeopardised or over stressed under faulty conditions.

The aim in designing the Telemetry Test Station is to be able to test any low bit rate telemetry system. The Telemetry (TM) systems designed by ISRO Satellite Centre fall into three broad categories, i.e., those designed for Experimental Satellites, Low earth, operational satellites, and Geostationary, operational satellites.

Moreover the TM systems designed for different satellites within each category may differ from one another. Thus configurability is the main feature of any test setup that is to be capable of test any or all TM systems.

After study of a number of telemetry systems in each category, the common features and differences can be listed

with reference to the testing aspect (not design criteria). Every system can be decomposed in to the following minimum set of building blocks, with any specific requirements, such as payload interface, being added on as another block. The variable features of each block and the method of test are also listed in Table 1.

Section-1 of the paper describes the interfaces of the test station which perform all the required tests outlines above. Next the configurability of the system is examined. Since the specification of the test session (its procedures, parameters and environments) is to be made changeable, the 'configuration' is to be achieved by the user (section-3). The design structure to achieve this is briefly touched on in section-4 with a example taken from an area with real time constraints.

TABLE-1

Building block and function	Features which vary from system to system	Method of Test at package level
1. Formatter to define the output format	Number, types and contents of PROMS which define the format	Examine PROM contents.
2. Multiplexer array to combine all the signals monitored onboard the satellite	Number, types and structure of the multiplexer array.	Supply inputs and check appropriate outputs
3. ADC to convert analog signals into digital	Resolution, accuracy type of ADC	Supply every analog input over the entire input range, monitor the output so as to prepare an accurate input Vs output graph

Building block and function	Features which vary from system to system	Method of Test at package level
4. Onboard timer generating the onboard clock reference	Number of bits allotted, clock speed and sampling rate	Monitor a clock signal over extended periods of time to measure the drift.
5. Command interface block to receive the telecommands and act on them	Number and type of command	Simulate all commands and combinations of and check the action by monitoring system status.
6. Control signal to generate specific interface pulses	Number and type of pulse, period and pulse width of the pulses.	Measurement of each wave form.
7. Modulator to convert the PCM stream to the required subcarrier modulated analog waveform	Type of modulation filter characteristics.	Measurement of each waveform.

TEST STATION INTERFACES

The structure of the test station is shown in fig.1. It is composed of a number of GPIB controlled equipment, a set of hardware modules to interface the system under test and software utilities in the controlling PC.

The test station provides the following interfaces to measure and/or monitor the signals output by the system under test:

1. Digital PCM Interface
2. Analog Interface
3. Control Pulses Interfaces

The Digital PCM interface to acquire the basic TM output through decommutation. This is used in all the tests described in Table 1 except 6 and 7. This is done by designing a plug in card to the PC and writing the decommutation software. The card can work to an absolute maximum 60 Kbps and decommutation features are fully programmable. These features are described in detail in the companion paper (Ref.3). The hardware is fully transparent to all (low bit rate) TM systems so that only the software needs to be configured during run time.

Analog waveform interface: This basically demodulates the subcarrier modulated output of the TM and provides the digital interface for decommutation. The appropriate demodulator and bit sync. equipment simply convert the analog signal into the digital data and clock stream. The digital data and clock are then used for decommutation. In the absence of GPIB controlled demodulator and bit synchronizer a change in subcarrier frequencies could entail the physical replacement of these equipment.

Control pulse interface: This is achieved by using a GPIB equipment like a frequency counter or oscilloscope which measures the waveform characteristics under software control. Some equipment may need different methods of configuration.

The following interfaces are provided to simulate all inputs to the system under test.

1. Analog and Digital Channel Interface
2. Telecommand Interface
3. Power Interface

Analog and Digital channel interface: Satellite health monitoring parameters are simulated here. The simulation is done by hardware demultiplexer arrays distributing the specified analog and digital value under software control. The number of channels handled can vary between 50 to 1500.

Telecommand interface: This is a set of digital lines (programmable through software) which simulate the pulses and data lines as defined by the user.

Power supply interface: The system under test may possess its own regulation unit within the package or receive regulated power. A GPIB controlled power supply generates the required voltage and automatically provides overcurrent, overvoltage and alarm/safe shutdown features.

WHAT TO CONFIGURE

Given a test setup and a new system to be tested, the system under test and the test session must be clearly specified. This is done in three stages: abstract, parameterwise and physical definitions and descriptions.

The abstract description is the writeup of the telemetry system i.e its input and output interfaces and its modes of operation. This may be defined especially with reference to table-1. The parameter wise description specifies the characteristics of each physical input/output wire that is to be simulated or monitored. The physical 'description' is to physically connect each input/output to the corresponding output/input of the test station and to make sure that the actual connection supports the parameter wise description.

The requirements of the test parameters and procedures, controls, environments etc must be specified to suit the system under test. The first effect of this specification may be to change the equipments which compose the test station. A simple example could be systems with 12 bit ADC may not be tested with the same voltage calibrator as that used for a system with 8 bit ADC (the accuracy and resolution of the output is obviously far higher in the first case). Similarly, systems with widely varying subcarrier frequencies will need different demodulator modules to be used.

Thus the configurable sections of the test station may be divided as follows:

1. The GPIB Controlled Equipments
2. The Hardware interface between the controller and the system under test
3. The controlling software routines and procedures

4. The data files and structures which define the inputs and outputs of the system under test

The major physical change in the test station is the actual hardware interface between the system under test and the test controller. i.e different types and numbers of hardware cards are needed to interface to the physical wiring. This consists of :

1. Sets of demultiplexers to generate the analog and digital channel inputs
2. Sets of multiplexers to route the control pulses to the measuring equipment one at a time
3. Sets of Telecommand Simulation lines
4. Sets of multiplexers to route the TM output lines for decommutation.

Since the user of the test station would like to configure the test procedure to suit the system under test, the number and type of test procedures must be under user control at run time. This affects preprocessing, test and analysis stages. Different data files will be offered to the test station for use during the test run, different operations (tests) performed using this data and finally different kinds of analyses performed on the results. This kind of configuration may be required even if the system under test does not change i.e at different stages of qualification of a single TM system.

WHEN AND HOW TO CONFIGURE

The configurable features of the test station are:
Equipments and hardware cards/modules and their corresponding software modules.

The physical change of a component equipment must be reflected 'automatically' in the test station software. This 'automation' means that (1) user input for defining the change is minimised as far as possible and this is required only during the 'configuration' stage as distinct from the test session stages. (2) The equipment features are monitored and taken care of throughout the test session. All types of alarms, failsafe conditions, protection features

etc of the equipments will be transparent to user, i.e provided whatever the equipment chosen.

This can be done in two ways: Any software related to the automated control of equipment can be divided into (a) Initialisation (b) Normal working and © Error/Exception handling procedures. Given a limited set of equipment types to choose from each software stage can process each equipment by a series of itf 'equip 1' then 'proc 1', if 'equip 2' then 'proc 2' etc. Any change (addition, modification or deletion of equipment) would be reflected in each division. This is not recommended generally for modulating systems built with object oriented methods, but is easy to implement as far less overhead when the equipment types are few.

The other way is to link in a set of modules corresponding to the configured equipments. The advantage here is that only those modules needed for the session are used thus saving, code time and space. However, the 'configuration' phase is now distinct from the 'test session' phase with an intermediate linking to be performed so that configuration during the run itself is difficult. If this is simple and short, eg. chaining in the required modules into the work area, it is transparent to the user and results in well structured extensible code. Also, if the operation of equip-1, is widely different from that of equip-2 this method is far neater to implement.

The change in the hardware modules composing the test station is easy to implement since configuration constraints are builtin to the hardware design itself. The 'configuration' therefore consists in specifying the number and types of each specifying the number and type of each module/card described above. The software then checks for the actual presence of the module and its performance as far as possible and prepares a list of input addresses and values. This is used during the test session. The 'changeable' feature is therefore a data set. This can be dynamically shared between modules during run time (RAM areas) or created as files if configuration is not done often. Dynamic sharing saves time but increases code space. File structures need overhead intime of access but are

simple and easy to use. Both types are used in the test station.

Apart from designing reliable hardware and software modules, two features to help ensure safe sessions are built in. At every stage, the system checks the user input semantically and logically. Help features such as overall and specific status monitoring are available for the user at any time, to assess the correct working. Thus the user and the test system are treated at peer level, each verifying the other. However, the user is always given priority in commanding the system.

EXAMPLE: THE ADC CHECK ROUTINE

As described above the test station session consists of three phases, preprocessing, testing and analysis. Each of these stages perform certain operations on certain data. Errors in data entry should be removed as far as possible before its activation and is therefore checked mainly during preprocessing. The integration of a configurable system is to put all the operations together and ascertain that all modes of operation will operate reliably and automatically independent to the data content.

The routine to check the characteristics of the ADC in a TM system is one of the most complex and involves most parts of the test station. The function is to obtain a graph of the input (Analog) vs output (Digital) of the ADC which will completely describe its characteristics. Note that the test is performed at package level where neither the input nor the output of the ADC is directly accessible.

The input to the ADC will be routed as any one (chosen by user) of the analog monitoring channels. The output of ADC will be monitored through the formatted TM output. To scrutinise the behaviour of the ADC closely, at large number of samples must be examined to verify the analog to digital conversion characteristic over the range of interest. To save time, the TM system can be commanded to repeatedly sample only the selected channels to maximise the information content of the frame. Thus the program must input the analog value monitor the output calculate the next

required analog value based on the output pattern and stop when the stopping criterion is reached.

The various options and the features of error checking by the system and the user are summarised in Table 2.

Table 2.

What to Config.	When to Config.	Software check	User check
1. Database file containing information about all monitoring channels. This is needed so that user can select any analog channel at run time and the appropriate input simulated output monitored automatically.	At preprocessing stage the structure and content of the database must be clearly specified to minimise channel access time during actual testing.	The pre-processing software checks the entire file for validity of structure and content. The file needed by the run time software is created automatically from the data base.	User can check the configuration of the data base and can modify data which has been signalled erroneous by the pre-processing software
Overall parameters such as ADC Specs.GPIB specs.(address) log file names	Before actual run, parameters stored as a file	-	User has complete control
2. Command information regarding input and output switches and modes of operation of the Telemetry system. The run time software uses the command output file to perform the command simulation.	At preprocessing stage the command no. an type to perform each action must be specified and stored as a file.	User entry is only checked for typing errors	Specification of the format etc is completely under user control.

What to Config.	When to Config.	Software check	User check
3. The selected analog channel which can be used for checking the ADC characteristics.	At run time the user can simply identify a channel by number from the given list	The channel is verified from the data base file and its contents used for runtime.	Channel address an format allocation can be checked by user.
4. Selection of type test run i.e how closely to characterise the ADC	At run time the file is created to describe the analog values and their step sizes.	Software checks whether all analog values lie within the safe ADC range and also enables the GPIB communication for instrumentation errors	User can check whether the analog value is correctly transmitted from the equipment to the system input
5. Stopping criteria	Before or at run time, user can specify whether stop on anyone <ol style="list-style-type: none"> 1. No. of values acquired 2. Particular file size is reached 3. ADC maximum is reached 4. Time of run is reached 	S/W checks if spec. criteria is safe (within ADC specs).	User can read back the translation in term of final value step sizes etc.
6. Analysis of output	Analysis of output can be specified after the run to give the user short form or detailed results in text or graphic mode.	Normal software checks like type checking, dimensioning graphics positioning display modes etc.	User can check file names etc at operating system level

CONCLUSION

The test station comprises at number of GPIB equipments, hardware modules and software utilities. The test session consists of preprocessing, testing and analysis phases. To

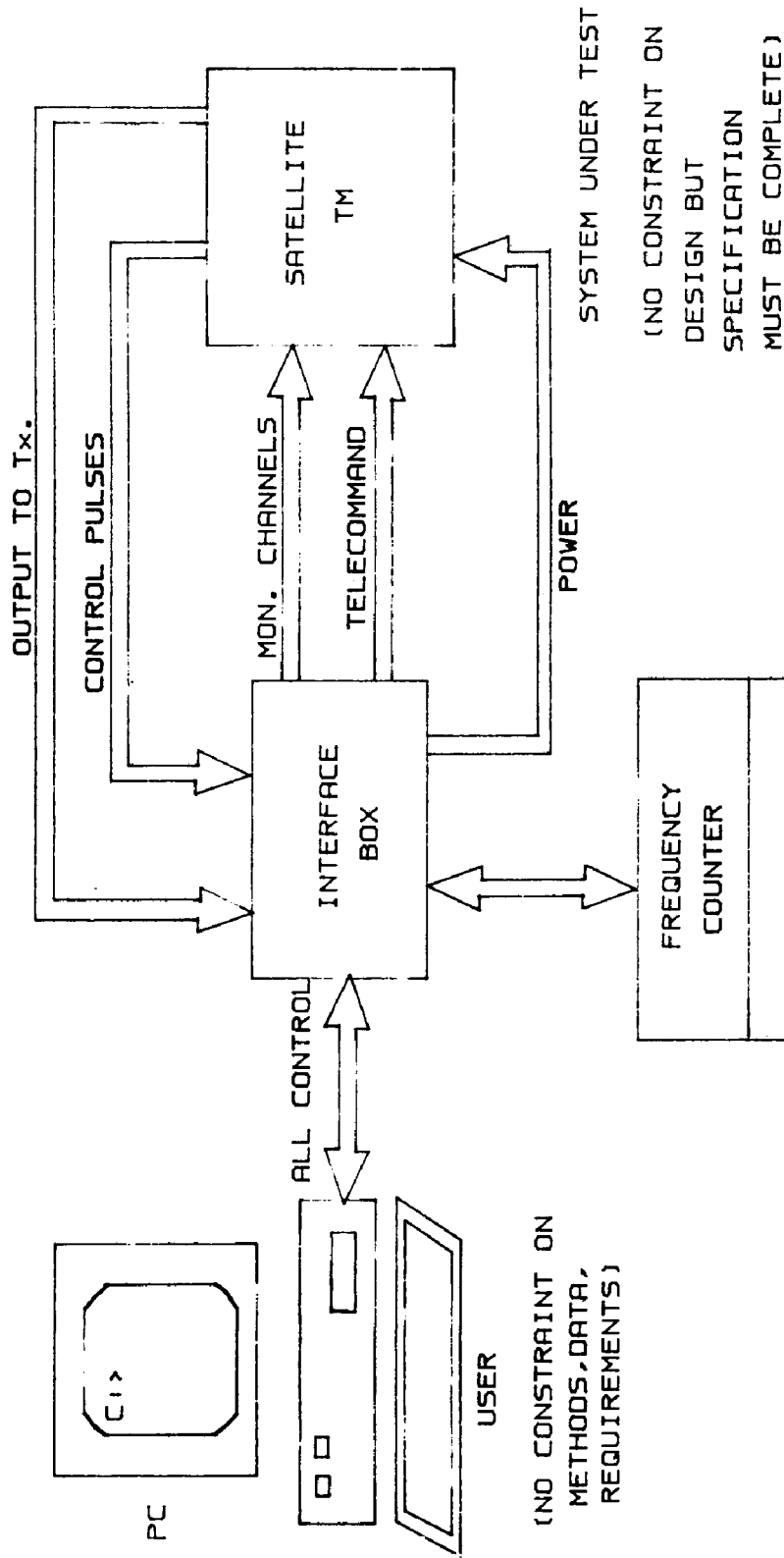
make this set up configurable, all features (equipment hardware modules and software for preprocessing, testing and analysis) must be changeable i.e can be added, deleted or specified in different ways by the user. The physical change of a component (equipment or hardware module) is immediately reflected in procedure especially of the test utilities is changeable. The data structures and values on which each software procedure works at any phase is also changeable.

A practical system with all these features has been briefly outlined. The system has been working for over two years and has performed satisfactorily with 4 types of TM packages. Its adaptability to suit future TM systems with unknown features and limitations remains to be seen.

REFERENCES

1. Martin, Kamalini, "User's Guide to the Telemetry Test Station, Doc.No.ISAC-11-89-09-03-17, ISRO Satellite Centre, Bangalore, September 1989.
2. Vijaya C, "Data Preprocessing Software for the Telemetry Test Station", M.Tech Report, University of Mysore, Hassan, March 1991.
3. Martin, Kamalini, et al "A simple Decommuation Scheme for the Telemetry Test Station". ITC/USA, Las Vegas, Nevada, Nov 4-9, 1991.
4. Vadiraj H.S., "Analog Channel Simulation for the Telemetry Test Station", M.Tech Report, University of Mysore, Hassan, June 1990.
5. IBM PC/XT Technical Reference Manual, Personal Computer Hardware Reference Library.

Fig 1. TELEMETRY TEST STATION



TITLE	TELEMETRY TEST STATION	
DRAWN BY	G. A. LAKSHMI.	Fig. No. 1
DATE	13/5	ISRO SATELLITE CENTRE
CODE	GPIB	DIGITAL SYSTEMS DIVISION BANGALORE-560017