GALILEO BATTERY TESTING

AND THE IMPACT OF TEST AUTOMATION

Walter T. Pertuch and C. Thomas Dils
Honeywell Power Sources Center

ABSTRACT

Test complexity, changes of test specifications, and the demand for tight control of tests led to the development of automated testing used for Galileo and other projects at Honeywell. The use of standardized interfacing, i.e., IEEE-488, with desktop computers and test instruments, resulted in greater reliability, repeatability, and accuracy of both control and data reporting. Increased flexibility of test programming has reduced costs by permitting a wide spectrum of test requirements at one station rather than many stations.

INTRODUCTION

Throughout the 1960's and early 1970's, battery testing was frequently done with some rather basic equipment, such as the VTVM (Vacuum Tube Voltmeter), source current driven recorders, carbon and wire-wound resistors, and bulky constant current power supplies. Precision and accuracy were somewhat limited and often cost prohibitive.

The more complex test parameters and high accuracy requirements were usually met with the design and build of dedicated test stations. These custom stations would include the use of hybrid circuits composed of vacuum tube, transistor, early generation integrated circuit, and mechanical designs, such as cams, relays, and stepping switches. Profile discharge testing required the use of multiple load elements--constant current supplies, resistors, etc. The resulting test station yielded more accurate data and improved test repeatability.

The disadvantages to such systems were as follows:

- Could be cost prohibitive except in certain production applications
- Major test specification changes frequently required major hardware changes (timing control, load profile sequencing, or the addition/deletion of loads)
- Reuse of test station subassemblies is limited

Rapid advances in electronics technology have created the need to have more exacting test techniques. Military, space, commercial, and bio-medical electronics continue to demand self-contained power sources, i.e., batteries. Consequently, the testing of these batteries must closely approximate the application for which they are designed. One such application is that of the battery designed for powering the instrumentation contained in the Jupiter probe of the Galileo Project. Developing a suitable testing method became an immediate challenge.

THE MODULAR TEST STATION

THE LOAD SIMULATOR

A load simulator is an electronic instrument which is designed to simulate electrical loads to test power supplies, batteries, and other similar power sources. Many commercially available units can synthesize the load parameters of both constant current and fixed resistance which may be varied over a wide range determined by the specification limits of each design. The power is dissipated by a bank of parallel connected power transistors. For constant current, regulation is achieved by feedback circuits which sample current. In the case of fixed resistance, feedback circuits sample current and load voltage.

REMOTE PROGRAMMING

In practice, load simulators can be programmed to change loads by means of an external input from a variable precision voltage source. For example, a programming input of 0-10 Vdc could correspond to 0-50 Adc or 5 amps/volt as a programming sensitivity. The load simulator can thus be used to replace multiple loads if programming voltages and timing are properly sequenced.

EARLY GALILEO PROFILE TESTING

A multi-segment (8 independent output levels) function generator was calibrated to drive the load simulator at current levels similar to those shown in Table I. With the aid of a clock, the test operator manually sequenced profile changes. A second simulator and voltage source was used to load the pyro bus (the pyrotechnic load tap on the Galileo battery).

Advantages were as follows:

- Equipment usually required no extensive modification if load or timing specifications changed.
- Equipment could be used on a larger variety of tests (multi-device).
- The need for custom control circuits was reduced.

Disadvantages were as follows:

- Most load changes were done manually. The prototype module discharge tests required 17 manual load switching operations and 42 manual logging functions.

- The function generator was complicated--instructions were a translation to English from another language.
- The risk of error from set-up and control was high.
- Instrumentation drift approached tolerance limits.

ASSESSING THE TEST SITUATION

The use of manual control and the load simulator/function generator test set-up presented problems in conducting many discharge tests over a period of many months. These problems were identified as operator-related and set-up or equipment failures.

THE DESKTOP COMPUTER AND THE IEEE-488 INTERFACE

SEARCHING FOR A BETTER METHOD

After much consideration, Honeywell decided to purchase a desktop computer system and instrumentation that could be controlled by the IEEE-488 interface bus or GPIB (General Purpose Interface Bus). This standard has been accepted internationally and many test instrument manufacturers offer this capability as an option.

APPLICATION DEVELOPMENT

The desktop computer system and instrumentation was initially used for data acquisition. The new system capabilities expanded to not only acquire data, but also to control events, and by adding a power supply programmer (a precision GPIB controlled voltage source) and other instrumentation, we could eliminate the function generator and manual control.

MOST RECENT IMPROVEMENTS TO TEST CAPABILITIES

EQUIPMENT

The Test Group has recently added interface capability to a previously purchased datalogger and increased the number of available load simulators giving a wide range of current and power handling ability. Our most recent capital item was a GPIB compatible digital storage scope for recording high speed, high resolution transient data, and used on the most recent Lot 4 module descent test in July 1984.

OTHER APPLICATIONS

Similar equipment is being used internally for low frequency analysis in cell storage studies and dynamic impedance measurements on the same tests. Virtually all groups within our organization are using desktop systems and special instruments or peripheral equipment to improve work efficiency and to help maximize the repeatability of certain critical operations.

IMPACT ON THE GALILEO PROGRAM

The benefits to the Galileo Program are as follows:

- Testing personnel was reduced from 4 to 2 to conduct descent tests; one to observe and one to adjust a chamber to follow a specified temperature profile which is not yet automated.
- Manual load operations were reduced from 17 to 2; main bus connect and pyro bus connect.
- There is flexibility to changing specifications.
- Test reliability is high with no significant deviations in eight major tests; test duration is 150 days from background loading to the descent profile.
- Methods and equipment contribute to tight control of test parameters.
- In the Galileo cell storage program, we are using some of the same test equipment to log voltage and AC impedance on over 1000 cells each month.
- The test equipment and techniques are understood by Honeywell Power Sources Center and the customer.

SUMMARY AND CLOSING STATEMENTS

Facing the challenge of the Galileo program allowed us the opportunity to develop a better method which grew out of the concept of modular testing systems. We maintain full coverage of environmental chambers through an alarm system and communication by way of a terminal and modem whereby we can determine the nature of the alarm and take corrective action. We now use uninterruptible power supplies to provide backup to computers in the event of power outages.

Table I. DESCENT SEQUENCE–BATTERY LOAD PROFILE

Start Time	Duration	MOD #1	MOD #2	MOD #3	Pyro Tap
-10.115 sec	15 msec*	← (1)	75Ω	→	N/A
-10.100 sec	100 msec*	600Ω	600Ω	600Ω	N/A
-10.000 sec	10 sec	9.66Ω	9.66Ω	9.66Ω	N/A
0 sec	10 sec	←	1.44A**	→ (2)	N/A
+10 sec	5.527 hrs	←	0.35A**	→	N/A
+ 5.53 hrs	0.72 hr	←	1.52A**	→	N/A
+ 6.24 hrs	35 msec	←	1.52A	→	6.3A
+ 6.25 hrs	0.875 hr	←	9.6A **	→	N/A
+ 6.32 hrs	35 msec	←	9.6A	→	6.3A
+ 6.40 hrs	35 msec	←	9.6A	→	6.3A
+ 6.48 hrs	35 msec	←	9.6A	→	6.3A
+ 6.56 hrs	35 msec	←	9.6A	→	2.5A
+ 6.64 hrs	35 msec	←	9.6A	→	2.5A
+ 6.72 hrs	35 msec	←	9.6A	→	2.5A
+ 6.80 hrs	35 msec	←	9.6A	→	2.5A
+ 6.88 hrs	35 msec	←	9.6A	→	2.5A
+ 6.96 hrs	35 msec	←	9.6A	→	4.5A
+ 7.04 hrs	35 msec	←	9.6A	→	2.5A
+ 7.06 hrs	N/A		Specified End of Mission		N/A

* Pulse duration tolerances
15 msec   15 to 35 msec
100 msec   90 to 110 msec
Pulses to be overlapped to prevent "load gap"

** ←—— n ——→
Indicates load n applied across battery through isolation diodes (Constant Current).

(1) Place 75Ω across battery, add 600Ω to each module, add 9.8Ω in parallel to 600Ω. Remove resistance, then initiate 1.44 Amps.

(2) Maximum of 1 sec OCV between 9.66Ω and 1.44 Amps.

NOTE: Specification taken from Descent Test Procedure, GAL-H-0014.