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A Multiuser Test System

By D. L. Cogan

Published September 1980

Final Report

MASTER

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**Kansas City
Division**

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Final Report
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SUMMARY

A multiuser test system, the DT1048, was designed and developed to avoid the cost of additional computerized testers for product development. The DT1048 contains adequate general instrumentation to provide test capability for many development products and eliminates the need for a unique tester for every new product.

Over the past 3 years, equipment has been purchased, instrumentation interfaces have been designed and built, and software has been developed. As a result of these efforts, a multiterminal, real-time laboratory test system is in operation at Bendix Kansas City with more than \$200,000 in cost avoidances realized in support of two projects.

DISCUSSION

SCOPE AND PURPOSE

Each development project requiring computerized testing usually has funding for its own unique tester requiring design, development, and prove-in. In an effort to reduce this cost, the DT1048 was designed to test a broad range of digital electronic products. Not only would the cost of testing be greatly reduced, but also the time required to design, order, fabricate, program, and checkout the tester would be reduced significantly.

ACTIVITY

In January 1978, work was begun to build the laboratory system. The basic hardware work, including a special purpose interface chassis (patch panel) to provide access to every tester instrument and an RT-11 based single-user version of the tester, was completed in October 1978.

Work then was begun to complete the original idea of a multiuser operating system that would provide multiple terminals to be used in parallel software development without interfering with concurrent product development testing.

Hardware

Although some items of hardware had been interfaced to support earlier part testing, the majority have been built since January 1978. Major items of hardware work included instrumentation interfacing, patch panel design, and fabrication.

Instrumentation

A variety of instruments provides the DT1048 (Figure 1) with the capability to test a broad range of products. Among the programmable instruments available are: 18 power supplies, a pulse generator, an arbitrary waveform generator, a versatile digital multimeter, a multiplexed analog-to-digital converter, a digital counter, two programmable clocks, and 80 general purpose relays. Details on the individual instruments are included in the Appendix.

Patch Panel

The patch panel chassis houses the general purpose relays that are available for product testing. A complete definition of each connector on the patch panel is provided in the USER'S GUIDE section of the system documentation.

Figure 1. DT1048 Test System

Instrument/Processor Interface

Two interface techniques are standards on the DT1048. The original method makes use of the Bendix Kansas City-designed, digital tri-state bus interface chassis. This tri-state bus provides 40 sixteen-bit parallel input-output registers to interface directly to the processor bus. In addition, the tri-state bus provides a marked improvement in the parallel I/O communication power over the standard PDP-11 interface cards. All of the first generation instruments are controlled by binary or binary counting decimal (BCD) interfaces using the tri-state bus.

The second generation of instruments added to the DT1048 uses the IEEE 488 general purpose interface bus (GPIB) technique. The GPIB interface card was acquired in order to interface the Wave-tek waveform generator; since then, several additional instruments have been added using this technique. Although the option costs more and requires longer time delays to send information (versus the binary technique), the tradeoff in programming ease and simplicity (only a FORTRAN control routine is required) is often worthwhile.

Currently, instruments using the GPIB are the HP clock-calendar, the Wavetek generator, the HP probe and counter, two HP 0-to-600-V power supplies, an HP 0-to-40-V power supply, and an HP multimeter.

Software

In programming the hardware, software was generated to control the Fluke power supplies and ADAC converters. These routines were easily adapted to the DT1048 concept.

Single User System

The RT-11 operating system is a single-user system. The inherent limitation of the single-user RT-11 system--monopolizing all computer resources thereby creating inefficient processor use--was the motivating force to implement the next phase of the original plan for a multiuser system.

Multiuser System

The RSX-11M operating system is a multitasking, real-time, software executive. On the DT1048, it can provide access to the processor for up to 10 terminals in order to take full advantage of the PDP-11/34 CPU and memory. These terminals normally would each be serviced in a timesharing manner, with each terminal being allowed approximately 5 ms of processing time, one terminal at a time, in a cyclical manner. Programs may be assigned a

running priority; if this priority is set above the timesharing range of priorities, it will continue to execute until it is blocked from execution (possibly because of its request for an I/O operation).

Normally, because of the inherent complexity of the RSX system, I/O processing can be much slower than the RT-11 system. This device driver standard technique was bypassed for the device common region concept for controlling the instrumentation. The common region method is easier to debug and has none of the normal I/O queueing (QIO) delay. The disadvantage is that one 4K mapping register must be used to map this common region, thereby reducing the maximum task size to 28K, just as in RT-11.

Because the device common region was chosen, modifying the RT-11 device control routines to function under the RSX system became a fairly straightforward task. The major differences in the two systems were their system directives. For instance, the PRINT directive in RT-11 must be changed to a QIO\$ directive for RSX. All normal MACRO-11 assembly language as well as all device addresses remained the same.

A major hurdle to overcome was the interrupt handling technique. RSX-11M version 3.1 provided a directive to allow the individual task to contain the interrupt service routine rather than a special device driver. Once understood, this technique was implemented on the interruptable devices, including the programmable clocks, the power supply overload indicators, and the patch panel input port.

Documentation

In order to conveniently provide documentation on the tester, a user manual was generated on the tester. In this manner, the manual could be modified or updated easily. The manual provides information on instrumentation capabilities, patch panel connector pinouts, and software calling techniques. In essence, the manual provides the user with a complete guide to writing a program for the DT1048. In addition, a complete set of prints documenting the tester hardware were generated.

ACCOMPLISHMENTS

A computerized laboratory test system with multiterminal access for testing digital products in their developmental phases has been developed. This effort consisted of interfacing a computer to a broad range of programmable test instruments using a patch panel for access. Next, from an RT-11 single-user test system prototype an RSX-11M multiterminal system was developed. Finally, a documentation manual was prepared to explain use of the tester.

The cost avoidance potential of the DT1048 test system was proven by actual use on two ongoing projects. A cost reduction analysis compiled for the two projects, involving three assemblies, points to approximately \$216,000 in cost avoidance. DT1048 utilization is gaining acceptance by product engineers and significant cost savings should be realized for three new projects.

FUTURE WORK

Future work on the DT1048 must continue to maintain and upgrade certain services and to provide the support and assistance, in both hardware and software, necessary for efficient use of the tester. The work could take the following form:

- Evaluate the functions of the tester with several products being tested and with concurrent software development under way;
- Perform additional fine tuning of the system;
- Acquire additional equipment to support the projected workload; and
- Examine BASIC for possible implementation with the TLIB software.

Appendix

DT1048 INSTRUMENTATION DESCRIPTION

FACILITY

COMPUTER SECTION

The basic computer configuration is composed of the following items.

CPU	PDP-11/34
Dynamic Memory	224 KB or 112K words
Mass Storage	2 RK05 at 2.4 MB each 3 RL01 at 5.1 MB each
Terminals	1 Decwriter II LA-36 1 Decscope VT-52
Printer	LA-180
Operating System	RSX-11M

TESTER SECTION

All instruments in the tester are under program control and are available through connections on the patch panel.

Power Supplies	4 Fluke 4265A 2 Sorensen DCR60-30B 6 Burr-Brown 4800 6 ADAC D/A 600-N 1 Hewlett-Packard 6267B 2 Hewlett-Packard 6448B
Pulse Generator	1 Hewlett-Packard 8015A 1 Wavetek 175
A/D Converter	1 ADAC (32 mux diff channels)
Relays	40 SPDT reed 20 SPDT mercury-wetted contact 20 DPDT mercury-wetted contact
DVM	1 Dana 4800
DMM	1 Hewlett-Packard 3490A

INSTRUMENTATION DESCRIPTION

INSTRUMENTATION

Fluke	-65.532 to +65.532 V voltage range 16.383 V in 1 mV steps 16 to 65.532 V in 4 mV steps 0 to 100 mA in 10 mA steps and 0.1 to 1.1 A in 0.1 A steps Settles to 0.01 percent of the programmed change in 100 μ s Sense lines are brought to patch panel connector
Sorensen	0 to +60 V voltage range 14.65 mV steps 30 A, not programmable Sense lines are brought to patch panel connector
Burr-Brown	-65 to +65 V voltage range 10.0 V in 2.44 mV steps 10 to 60 V in 14.65 mV steps 1 to 200 mA Negative lines on the six Burr-Browns tied together
ADAC D/A	-10 to +10 V voltage range 4.88 mV steps 5 mA maximum current 100 V/ μ s slew rate
Hewlett-Packard Pulse Generator	-16 to +16 V pulse amplitude range 25 ns to 100 ms period 10 ns to 1000 ms width 6 ns to 600 ms transition time 45 ns to 1000 ms delay 0 to 9999 number of pulses in burst mode 50 Ω or 500 Ω output impedance Two outputs separate or combined.
Wavetek	-10 to +10 V pulse amplitude range into 50 Ω load 19.5 kHz to 3.90 μ Hz output frequency (block rate) Sine, square, triangle, ramp, arbitrary waveforms

Up to 1 MHz can be program manipulated
Four 256 by 255 point ram matrices for
arbitrary waveforms
Continuous, monitor, and preset trigger
Hold control and ramp-to-zero modes

ADAC A/D 32 mux diff channels
-10.24 V to +10.24 V maximum input for
proper operation
-15 V to +15 V maximum input no damage
100 M Ω input impedance
0.035 percent of FSR relative accuracy

Relays (1 to 40) SPDT
8 VA at 0.25 A maximum, resistive load
100 Vdc maximum voltage
600 μ s average operating time

Relays (41 to 60) SPDT

(60 to 80) DPDT
100 VA at 2 A maximum switching resistive
load
5 A maximum carry only
500 Vdc maximum voltage

Dana Millivolt Range 10 mV
DC Voltage Range 0.1, 1, 10, 100, and 1000 V
AC Voltage Range 0.1, 1, 10, 100, and 1000 V
Ohms Range 1, 10, 100 Ω
Ohms Range 1, 10, 100, and 1000 k Ω
Ohms Range 10 M Ω
290 μ s execution time
 $\pm$ 0.1 percent of full scale $\pm$ 1
digit accuracy
10000 M Ω input impedance on mV range
10000 M Ω input impedance on 0.1, 1, and
10 dc ranges
10 M Ω input impedance on 100 and 1000 dc ranges
1 M Ω input impedance on all ac ranges

Hewlett-Packard Multimeter makes dc voltage, ac voltage,
DMM and resistance measurements with 5-digit
resolution.
DC voltage range 0.1, 1, 10, 100, and
1000 V
AC voltage range 1, 10, 100, and 1000 V
Ohms range 0.1, 1, 10, 100, 1000, and
10000 k Ω

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ELECTRICAL: Test System

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