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AUTOMATIC MEASUREMENT SYSTEMS
APPLICATIONS SERIES

Automation in Production Testing

A Solution to a Measurement Problem for CANADIAN MARCONI CO., Montreal, P.Q., Canada



An IC test in progress on the Hewlett-Packard 9500 Automatic Test System.



Automation in Production Testing

Cramming more and more components into correspondingly less space definitely seems to be the trend in modern electronics packaging. The benefits of reliability, space savings, less maintenance, etc. make the application of large-scale component integration very attractive from the cost-effectiveness standpoint. But, how can such complex devices be tested? Should *many* people be hired and trained to manually test each individual device, or is it wiser to install an automatic test system and let *one* unskilled production worker do the testing?

This situation is quite prevalent in the electronics industry and, in particular, faced the Telecommunications Division of the Canadian Marconi Company in Montreal, P.Q., Canada two years ago. The division designs and manufactures military ground radio communications equipment and a line of digital microwave communications equipment. High operational reliability is an extremely important requirement and is given top priority at CMC — it is more than just another specification that has to be met. CMC regards reliability as a necessity, especially since the equipment is often subjected to harsh environmental and operating conditions in military use, or mounted atop a remote mountain where service help is hours away. The high level of reliability built into the equipment must be verified; that is, only after passing comprehensive testing sequences can the equipment be installed with confidence that it will perform in accordance with published specifications.

AUTOMATION: THE BEST SOLUTION

The Canadian Marconi Company conducted an extensive investigation aimed at solving its testing needs in the most efficient manner possible without sacrificing accuracy. *The essential criteria upon which all judgments were based consisted of the need to test a variety of integrated circuits (ICs) and a variety of finished printed circuit (PC) boards.*

Manual testing was early ruled out because it would be prohibitively costly on two counts. First, additional test technicians would have to be hired and, second, troubleshooting faulty PC boards would be difficult and very time consuming. Manually troubleshooting with a probe and meter may take ten minutes or more per card. On the other hand, an automatic test system could reduce troubleshooting time from minutes to a matter of seconds per board by localizing failure to the particular group of ICs involved. It is far less costly to discard and replace a few ICs than to manually search for the cause of a failure.

CMC wanted an automatic system that could be operated by a relatively low-skilled person, ideally a production line worker. Since all testing was of a digital nature, the system had to have digital test capability.

Thus, CMC had thoroughly determined that an automatic test system was the best solution to handle its IC and PC board testing needs. The fact that CMC's needs involve a number of different types of tests and relatively low volume, completely shatters the popular belief that automatic test systems are applicable for large-volume testing only.

CONFIGURING THE TEST SYSTEM

After comparing the capabilities of several different automatic test systems available at the time, CMC selected an HP 9500A Automatic Test System. The system configuration is shown in Figure 1. Looking to future needs, CMC placed considerable importance on the inherent expandability and flexibility of the HP system. Modular construction gives CMC a good deal of latitude for adding to its present testing capabilities. CMC can expand its system to include both analog and digital testing for very large testing needs encompassing many types of stimuli and measurements.

CMC's automatic test system is configured for digital testing with the HP 9401B Digital Test Unit (DTU). Stimuli, in the form of voltage levels, are interfaced to the unit under test by means of the front-mounted interface panel. Inputs to the system are through this same panel. The entire test system is under control of the HP 2116C Computer. The heavy-duty teleprinter is the operator interface with the system and also prints out test results. New programs are input to the system through the punched-tape input. The tape punch is used to obtain a permanent copy of test results that can subsequently be printed on the teleprinter in an off-line mode. (To some readers, the absence of measuring devices, such as digital voltmeters or counters, may seem puzzling. CMC's system performs "static functional testing", which does not require that discrete measurements be made and recorded. The inherent expandability of the system, as mentioned above, makes it easy for CMC to add these instruments if so desired.)

FLEXIBLE TEST PROGRAMMING

An outstanding feature of CMC's automatic test system is that it does not require a full-time programmer to conduct tests — to a large extent due to the use of Hewlett-Packard's automatic test system (ATS) BASIC language programming. *Now at CMC, all IC and PC board testing is handled by one person, usually a production worker.*

The automatic test system was supplied with a complete software operating system. *Thus, CMC had only to write individual test programs before placing the system in operation.* CMC developed a master test program (referred to as a program writing program) to make it as easy as possible to prepare test programs. The master test program is written in a general form using ATS BASIC. Initially, a new test program is generated by entering certain parameters associated with specific IC types. This new program will then be punched out on the tape punch and entered into the system whenever that particular IC type is to be tested. Presently, CMC has available over 250 such test tapes. Figure 2 shows a partial teleprinter printout of program development for an IC, showing questions asked by the master test program and the typed-in answers given by the operator. (The device type number refers to a truth table previously entered in a library in computer memory.)

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TYPE 1 FOR THE AVIONICS JIG.. 2 FOR THE TELECOMS JIGS?2
WHAT IS THE DEVICE TYPE.....?3 (Truth table)
WHAT IS THE GROUP IDENTIFIER.....?1
WHAT IS THE DEVICE NUMBER.....?7400
HOW MANY INPUT PINS.....?8
WHAT IS THE FIRST INPUT PIN NUMBER.....?1
    NEXT INPUT PIN...?2
    NEXT INPUT PIN...?4
    NEXT INPUT PIN...?5
    NEXT INPUT PIN...?9
    NEXT INPUT PIN...?10
    NEXT INPUT PIN...?12
    NEXT INPUT PIN...?13
HOW MANY OUTPUT PINS.....?4
WHAT IS THE FIRST OUTPUT PIN.....?3
    NEXT OUTPUT PIN..?6
    NEXT OUTPUT PIN..?8
    NEXT OUTPUT PIN .?11
TYPE 0 IF USING EXTERNAL DTU REF VOLTAGES ELSE TYPE 1?1
TEAR OFF THE TAPE AND TYPE CTRL C WHEN READY
PAUSE
TYPE DEL AND LOAD THE SCRATCH TAPE
WHEN THE TAPE IS LOADED AND ANY TITLES ADDED TYPE SAVE
.....THE NEW TAPE IS THE I.C. TEST TAPE .....
READY
    
```

Figure 2.

Partial printout of IC program development generated by CMC's master test program based on ATS BASIC language.

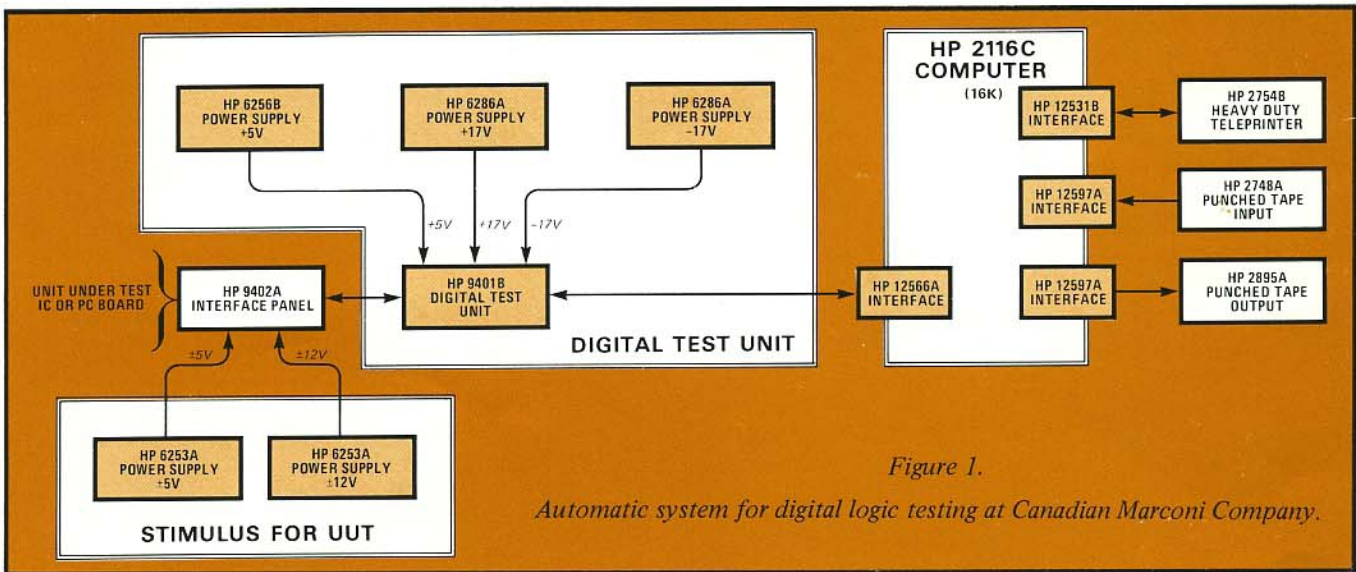


Figure 1.

Automatic system for digital logic testing at Canadian Marconi Company.

TWO-LEVEL TESTING

Quite conveniently, CMC divides the tests into two levels: IC testing and PC board testing. At the first level, all incoming ICs are tested for logic level defects. (CMC considers 100% incoming inspection essential because experience has shown that 3 - 5% of all ICs are dead on arrival.) At the second level, PC boards are given complete logic level tests.

As mentioned earlier, CMC's automatic test system performs static functional testing. This is sometimes called truth-table testing, which verifies the logic of the unit under test. Patterns of logical 1s and 0s, of appropriate voltage levels, are supplied to the IC input pins; its output patterns are then compared with the expected patterns. Two comparisons are made in the DTU, one to check that the IC responds with the appropriate voltage levels, and the second to check that the pattern of 1s and 0s is correct.

RUNNING THE TESTS

Every aspect of test system operation is designed to accommodate the non-skilled test operator. The automated system itself is located in a small room opening directly into the production area.

The cover photo shows IC testing in progress. (The tray of ICs, normally sitting at the operator's left, has been removed to more clearly show the IC testing procedure.) The operator follows a specified sequence to set up a test. A program test tape, for a particular IC family, is selected from the tape library and loaded into the system through the punched tape input (reader). A three-digit display notifies the operator which adapter card to insert into the interface panel. The adapter card routes signals to and from the computer system and IC under test. The computer then checks to make sure the correct adapter card has been inserted. If not, an indicator light will turn on. If all preliminary sequences are correct, a "ready" signal will be printed on the teleprinter to signify the system is ready to begin testing. The "start test" button will turn on. The operator inserts the IC into the test socket and the functional logic tests are made.

Testing ICs is done in either of two modes: (1) production testing, or (2) diagnostic testing. Production type testing is most commonly done. This involves testing until the first failure occurs and stops the test. A passed-failed indicator will turn on as required. This is strictly a go/no-go test and does not list the cause of failure. Diagnostic testing, on the other hand, does provide this information. On command,

the teleprinter will print out a diagnostic listing of input and output pins showing exactly where in the truth table the failure occurred. This information is particularly valuable as a guide for design engineers in specifying integrated circuits. All measured information can also be output on the tape punch to provide a total history of the testing. After each batch test, the teleprinter prints out the total number of ICs tested, total passed, total failed, and batch yield as a percentage of the total tested. Presently, CMC can test approximately 5,000 - 7,000 ICs in a single shift.

Testing PC boards is done under control of a master program, similar to the IC master test program. Current production PC boards, part of a digital multiplexer used in a telephone system, average about 30 ICs per board. Test points on the PC boards are located such that the circuitry is divided into functional blocks, i.e., groups of IC packs. By this technique, failures can be isolated to a particular group, usually 3 - 5 ICs. Repairs are made by replacing the entire group of ICs. CMC has chosen this approach because the cost to replace three ICs is about one dollar; the cost to find a specific failed IC may be as high as five dollars.

When a failure occurs, the teleprinter prints a message to replace the components within the failed functional block, listing them by their schematic reference symbols. A copy of the printout is sent, along with the failed PC board, to the production assembly area for repair. Another copy is sent to the failure analysis group where failure trends are observed and reported to IC suppliers as necessary. Over 700 boards can be tested in a single shift.

BENEFITS OF AUTOMATIC TESTING

For over two years now, CMC has been reaping the benefits of its automated production test facility. Indeed, only through automation could the wide variety of ICs and PC boards be satisfactorily tested both economically and technically. Compared with the alternative of manual testing, the automated system effectively reduces PC board troubleshooting time from minutes to seconds, at one-fifth the cost. Test accuracy and consistent repeatability have greatly increased the level of confidence in the equipment reliability. Thus, CMC benefits by helping to retain its reputation as a supplier of reliable communications equipment, and the end-user benefits from less equipment downtime in service. The system's modular expandability is playing an important role in CMC's plans for future production testing needs.



For more information, call your local HP Sales Office or East (201) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.