Customer:  
A major Asian manufacturer of semiconductor packages, employing some 1,000 people.

Introduction:  
The density of the integrated circuit (IC), or semiconductor chip, has been increasing rapidly in the past few years. For example, the Motorola 68000 chip, introduced in the early 1980's, contained some 68,000 transistors. A modern Pentium chip has more than 1 million transistors in about the same size. On average, the density of the IC doubles every year. In addition, the number of I/O pins has also increased – 1024-pin chips are now common.

Situation:  
High-density IC packages, ranging from 256 to 1024 pins, are becoming more and more popular. Because of extreme competitive pressure and increasingly short life cycles, the marketing window for these ICs is very narrow – time-to-market is critical. However, each IC package must be thoroughly tested.

The manufacturer get its silicon semiconductor wafers from an upstream supplier and places each individual wafer with I/O pins into the package. Following that, it tests all packages before shipping, thus ensuring proper function, physical integrity, and reliability. One critical
test (described below) ensures that there is no short or open-wire bonding between the I/O pins and the die.

**Problem:**
In the past, PC plug-in card test systems were used to test the chips. Individual modules contained an analog-to-digital (A/D) converter to measure IC pins’ short or open, digital I/O to control the automatic handler, and a solid state multiplexer. However, the company’s PC-based systems had the problem of shutting down periodically due to bad hardware quality or the incompatibility of multi-vendor software. Consequently, productivity suffered.

**Implications:**
Each IC must be individually tested – without exception. If this were not done, defective ICs would be shipped, malfunctions would occur in customers’ products, and serious problems would arise with warranty and customer relations.

**Solution:**
To replace the PC-based test systems, HP VXI equipment was chosen as the exclusive solution. The hardware included an HP E8401A VXI C-size mainframe, an HP E1411B 5.5-digit multimeter, an HP E1328A 4-channel D/A converter, an HP E1330B digital I/O, two HP E8460A 256-channel reed relay multiplexers, and an HP E8491A PC-to-C-size VXI interface (IEEE 1394). Hewlett-Packard engineers completely integrated the hardware with HP VEE, HP’s graphical programming language, along with a third-party testing fixture. In integrated form, the package is known as the HP Z8400T tester.

HP VEE was used because of its friendly user interface, and C++ was used in certain routines because of its speed.

**Description of Test:**
The open/short test is the first and key step for the IC package.

The HP Z8400T tester is used to test each IC chip. The HP E1328A 4-channel D/A converter supplies positive or negative current to the protection diode; the sign of the current indicates the diode direction of the IC. Besides acting as a source, the HP E1328A can also act as a sink for the IC. An HP E1411B multimeter is used to measure voltage. If the voltage is between 0.2 to 1 and -0.2 to -1 volt, the pin is normal. If the voltage is + or - 20 volts, the pin is open (+/- 20 volts is the HP E1328A’s clamping voltage). If the voltage is 0, the pin is short.

The first HP E8460A multiplexer connects to 256-pin ICs from pin 1 to pin 256. A second HP E8460A also connects to the same pins. Every pin is connected to both the HP E1328A 4-channel D/A converter and the HP E1411B multimeter. The HP E1328A is used as the current source and the HP E1411B is used to measure signal.

For example, to test the first pin of the IC package, the first HP E8460A multiplexer is open, except that the first channel is closed. The second HP E8460A is closed, except that the first channel is open. Since pins 2 to 256 are all connected to the LO of the HP E1411B multimeter (as a voltmeter), the HP E8460A becomes the ‘0’ potential (the HP E8460A is configured as a one-wire switch).

The HP E1328A 4-channel D/A converter is a source for 100 microamps. The HP E1411B measures the voltage at pin 1. If the pin 1 shorts to an adjacent pin, the voltage will be 0. If the pin is open, the voltage will be 20 volts, which means that the bonding wire is broken and the chip defective. If the voltage is between 0.2 to 1 volt, the pin is normal. Again, the HP E1328A will sink 100 microamps and the sign change if the diode is reversed.
Each pin is tested this way. Once all the tests are done, results are logged to a file, and the file can be printed out or stored to a disk.

**Results:**
As a result of the new HP VXI test system, throughput for the IC tests was dramatically increased and downtime reduced by 30%. Space was saved on the production floor, and the system is scaleable for future expansion.

Most importantly, this test system can be used to test ICs from 256-pin to 1024-pin units using only one VXI C-size mainframe. Prior to this, it took four or five PC-based testers to test 1024-pin ICs.

### Configuration:

<table>
<thead>
<tr>
<th>Computer</th>
<th>HP Vectra (330 MHz)</th>
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<tbody>
<tr>
<td>VXI</td>
<td>HP E8401A C-size, 13-slot mainframe</td>
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<tr>
<td></td>
<td>HP E1411B 5.5-digit multimeter</td>
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<td></td>
<td>HP E1328A 4-channel D/A converter</td>
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<td>HP E1330B 4-channel digital I/O</td>
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<td>HP E8460A 256-ch reed relay multiplexer (2)</td>
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<td></td>
<td>HP E8491A PC-to-C-size VXI interface (IEEE 1394)</td>
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<td>Software</td>
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