

Electronics Manufacturer Develops Cost-Effective Test Solution

by Juergen Dendorfer, Siemens Automotive, and Tesha Sengupta, Agilent Technologies

Testing modules
one at a time is
like painting
each piece of a
jigsaw puzzle
separately.
Multiple-up test
is the answer.

For Siemens Automotive, a worldwide leader in automotive electronics manufacturing, the rules governing business success are clear: gain the highest test coverage in the least time without compromising quality. The challenge is to find the most cost-effective solution for high-volume production that maintains a worldwide standard of excellence.

Headquartered in Regensburg, Germany, and with more than 25,000 employees worldwide, Siemens Automotive is on the cutting edge of automotive electronics manufacturing. The company's decision to adopt parallel testing of multiple units under test (UUTs) proved to be a cost-effective, faster solution for low pin-count Electronic Control Module (ECM) testing. The 400% test-speed increase not only resulted in higher throughput, but also greatly improved the return on the initial capital investment.

In creating a practical, high-quality manufacturing solution based on multiple-up testing, Siemens test engineers are helping to change the way their company thinks about test. Having addressed their throughput and cost concerns, engineers can focus their efforts on increasing test coverage and enhancing test plans to create quality products.

The Problem

A unique aspect of airbag ECM testing is the use of a mechanical shake table. Test engineers combine functional testing of specific electronic components with real-world crash simulations via the shake table to meet high safety and performance standards. Shaking the modules while monitoring the squib firing response for a given input allows test engineers to determine the health of the airbag system.

The traditional single-up series strategy made testing this low pin-count module expensive in terms of time and cost per pin when the high capital investment in the shake tables was considered. Decreasing the volume of airbag ECM production or relaxing the test standards to decrease test time were not options for creating a more cost-effective solution to this functional test problem.

Evolution of a Solution

Automatic testing includes the following elements:

- Loading the UUT.
- Powering the system and UUT.
- Setting up the measurement instrumentation.
- Switching instrument and load relays.
- Prompting the UUT into the test mode.
- Executing the desired measurement(s).
- Writing test data to the network.
- Unloading the UUT.

For testing a series of single-up UUTs, these elements are executed in succession per UUT (**Figure 1**).

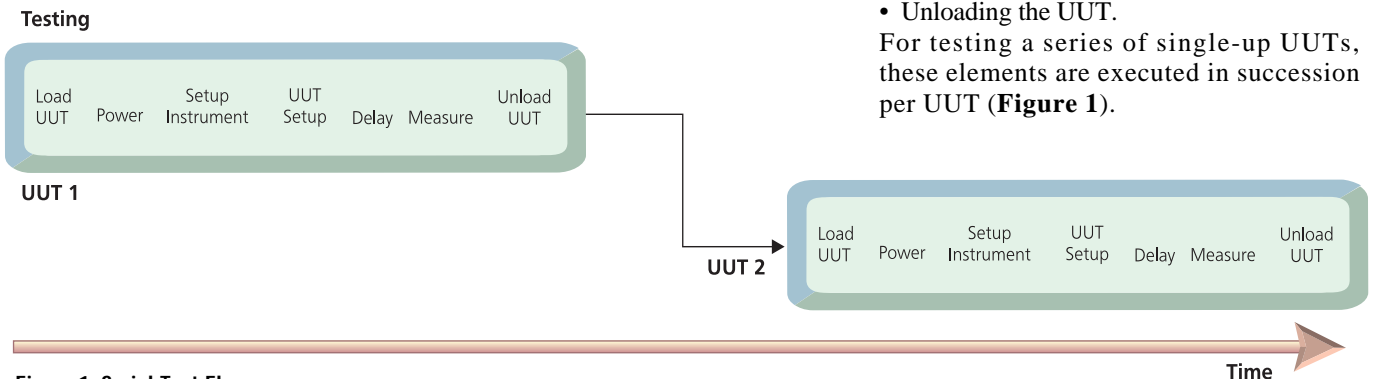


Figure 1. Serial Test Flow

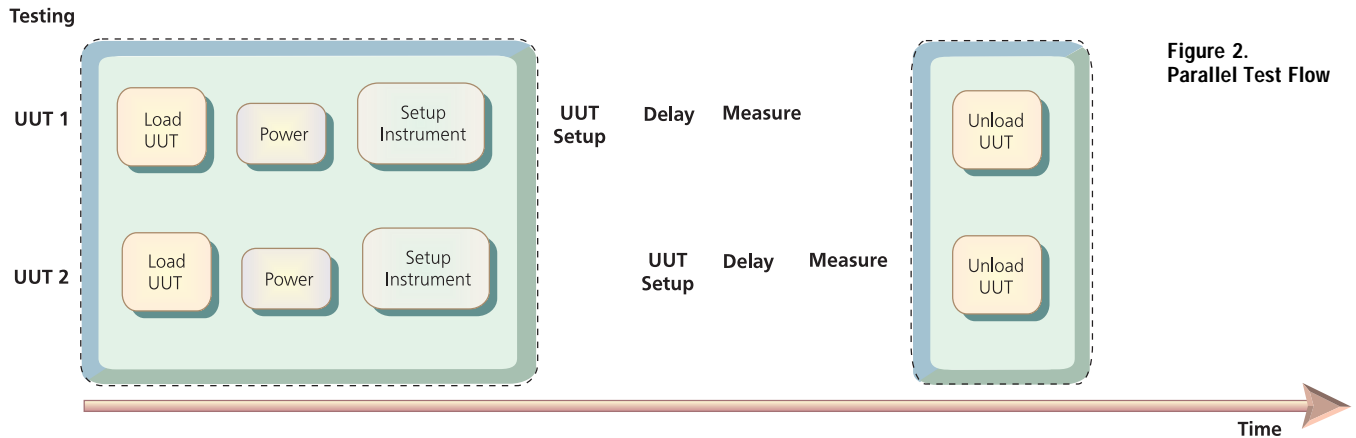


Figure 2. Parallel Test Flow

A parallel test strategy overlaps the time associated with common tasks. For this application, the time for UUT loading, application of system and UUT power, instrument setup, and UUT unloading could be consolidated and applied to multiple modules (Figure 2). The measurement of all signals and UUT communications also can be leveraged using this strategy.

From Theory to Practice

A practical multiple-up strategy has several requirements:

- Logging test results per UUT—multiple-up UUT testing is ineffective if failures cannot be captured for each module so they may be tagged for repair.
- Stopping test processes on any failed UUT—the time-saving benefit to multiple-up UUT testing is negated if testing cannot be stopped on a failed module without bumping the remaining units out of their test loops.
- Developing test plans for multiple modules that accommodate increased switching—with an increased number of relay closures to incorporate, multiple-up test-plan development must account for greater time delays.
- Testing a variable number of UUTs in

parallel—in production, sometimes it is necessary to avoid testing an empty position or desirable to test only one module.

The Solution

To meet these requirements, Siemens Automotive partnered with Agilent Technologies to develop a multiple-up test-executive capability. Siemens engineers established the boundary conditions of faster test times and lower cost while emphasizing the test requirements, and Agilent Technologies engineers developed and tested the software.

This collaborative effort led to the development of the test-executive feature now known as the Throughput Multiplier (TM). The TM is an option available on all Agilent Technologies' Electronics Functional Test Platforms and HP 3070 In-Circuit Testers.

When using the TM, the test plan for a single module, including debugging, is developed first. Then it is modified to accommodate multiple modules using built-in leveraging capabilities. The time required for this phase will vary depending on the complexity of the application.

The standard Operator/User Interface (OPUI) offered with the TM is

customized according to operating language and which test results are required for display. Test results for each module are displayed independently while the program maintains separate report streams for each UUT. Each module gets its own datalog file tagged by its serial number. Serial-numbered repair tickets are printed for the respective modules.

Starting from the test plans for a single module's position, the TM determines the relay paths required to execute the test plan on additional module positions. Test plans with universal tests and sequenced group tests for all modules are included in this capability. Operator interface radio buttons accommodate a variable number of UUTs.

The test strategy now is used in smaller-body electronics modules and navigation units. For airbags, the plan is to use the strategy on all new stations testing two to 24 modules in parallel, depending on the complexity of the module and the production-line concept.

For body electronics modules, the strategy will be used for all smaller modules and certain high-complexity modules depending on the pin-count. The latest project is a programming station for navigation units, which provides multiple-up testing of 32 modules in parallel.

The Benefits

Parallel testing not only consolidates tasks common to multiple modules, such as instrument setup or signal and load routing, but it also overlaps inherent latencies in the UUT or test system. Benefits are particularly sig-

Strategy	Test Execution	Capital Cost
Single-Up (IEEE test station, HP Basic SW)	28 s for 4 modules, 7 s/module	~\$124k (shake table) + ~\$44k (test station) = \$168k
Multiple-Up (HP TS-5400 Series I, HP TestExec SL Throughput Multiplier)	14 s for 8 modules, 1.75 s/module	~\$124k (shake table) + ~\$38k (test station) = \$162k

Table 1. Example Results of Airbag Testing

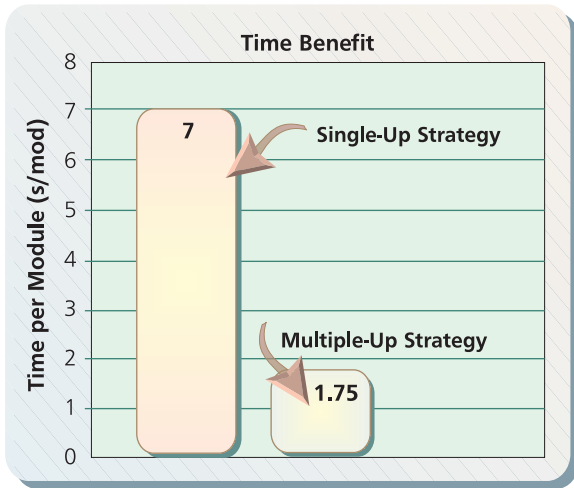


Figure 3. 400% Faster Test Execution With Multiple-Up Strategy

nificant for low pin-count modules and slower modules or applications where expensive peripheral equipment can be used more efficiently.

Multiple-up testing decreases test time for n modules (where $n > 1$), improves productivity from capital investment, and increases both production volumes and floor-space productivity. In general, test costs and floor-space requirements are reduced by a factor of approximately $1/n$. See **Table 1** and **Figure 3**.

In some applications, Siemens has seen even better results. In fact, where the challenge previously was to provide the floor space to accommodate the growing number of testers for high-volume productions, the problem now

is transporting a sufficient number of modules in parallel to the systems to maintain the high-volume output.

Siemens currently is installing an airbag ECM production line in its plant in Johnson City, TN, where all stations will use multiple-up UUT testing of two to 24 modules. As they continue to develop plans for manufacturing other safety and

convenience modules, the strategy will be adopted wherever possible.

For airbag and other small ECMs, the development time for extending the single-unit test plan averaged an additional 20% of the original programming time. For a more complex application such as the programming station for navigation units, the overall programming time increased by 50%. Developing a specifically tailored OPUI required less than six months.

In both single-up and multiple-up testing, the tester was used nearly 100% of the time, three shifts per day. However, faster test execution in this high-volume manufacturing environment implied greater productivity for

the same cost of capital. With one tester now performing the tasks previously requiring two, Siemens has seen a 50% decrease in floor space.

About the Authors

Juergen Dendorfer received degrees in electrical engineering in 1990 and business economics in 1998 while working part-time at Siemens in Germany. After graduation, he spent three years in the company's test department and three years in the production planning department and currently is the worldwide group leader of the electronic control unit test group. Siemens Automotive, Postfach 100943, 8400 Regensburg 1, Siemensstrasse 12, Regensburg, Germany, e-mail: JuergenDendorfer@at.siemens.de.

Tesha Sengupta joined Agilent Technologies in 1999 after graduating from the University of Illinois with a B.S. in electrical engineering and a minor in Japanese studies. She has worked as a marketing programs engineer for the HP TS-5400 Series II Automotive Electronics Functional Test Platform. Agilent Technologies, 815 14th St. S.W., Loveland, CO 80537, (970) 679-2634, e-mail: tesha_sengupta@agilent.com.

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