Strategies for Lowering the Cost of Manufacturing Test

Introduction

Today's electronics manufacturers face unprecedented cost and time-to-market pressures. As the complexity of electronics systems has rapidly increased and component costs and margins have continued to shrink, testing has become a larger contributor to the final cost of manufactured goods. To remain competitive, contract manufacturers and OEMs are looking for ways to lower the cost of test by increasing test throughput, increasing their development productivity, and reducing maintenance and support costs.

A typical electronics manufacturing line is shown in Figure 1. Raw materials enter on the left-hand side of the diagram and complete, tested products are placed in inventory or shipped on the right-hand side. Testing, once confined exclusively to the end of the line, now occurs at several points along the line to provide greater failure isolation and feedback to the manufacturing process. Process tests, such as in-circuit test (ICT), automated X-ray inspection (AXI), and automated optical inspection (AOI) sit at various points along the line to immediately catch process flaws. Functional test, which tests the operation of the system of components, typically will reside at one or more points along the line and at the end of the line as the final test of the fully assembled product.

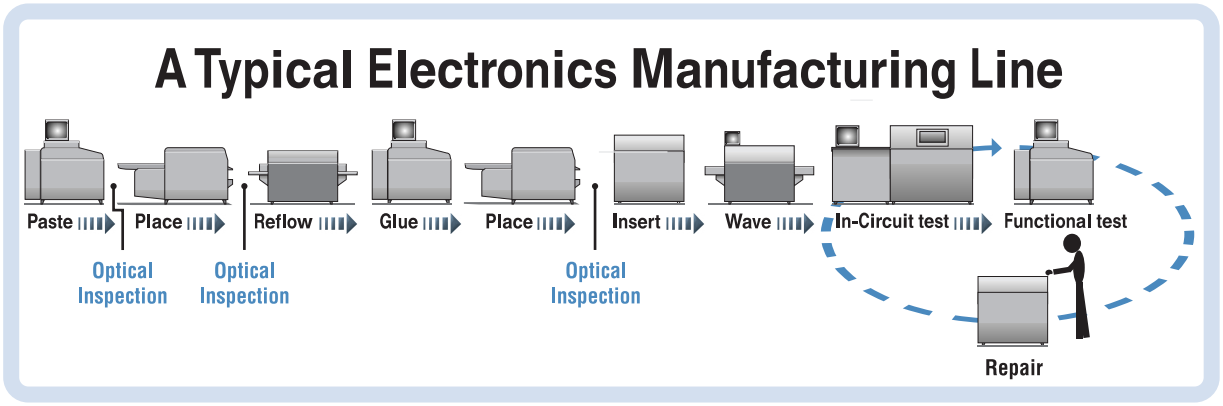


Figure 1. A Typical Manufacturing Line

With decreasing component size and correspondingly increasing circuit board density and complexity, many products no longer have access points for the bed-of-nails fixtures used for in-circuit testing. Although AOI and AXI continue to become more common and more comprehensive, functional test is used more extensively to find and even isolate faults. With the need for higher throughput and more efficient production and testing, electronics contract manufacturers and OEMs are demanding sophisticated test platforms for functional testers that are built on open industry standards.

The NI Platform for Manufacturing Test

As a leader in functional test hardware and software, National Instruments has been at the forefront of the evolution of electronics manufacturing and test. Based on many years of working with electronics manufacturers, NI has built a complete modular hardware and software platform for functional test. This platform offers high test throughput, increased productivity, and a lower cost of ownership than traditional disjoint systems or turnkey solutions based on proprietary architectures. This platform for functional test is represented in Figure 2.

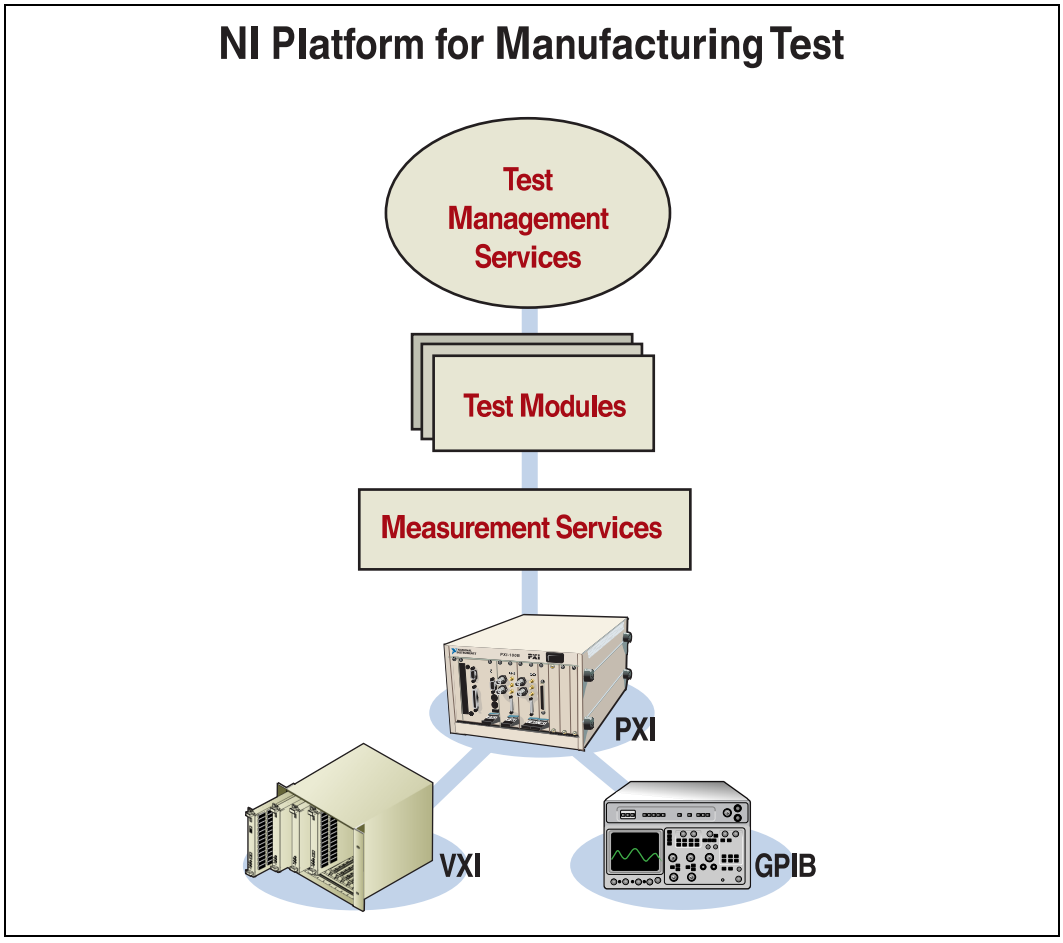


Figure 2. The NI Functional Test Platform

The platform starts with the Measurement layer. PXI, an industry-standard modular hardware architecture, sits at the center of the Measurement layer. Other hardware platforms, such as VXI and GPIB, may be used in combination with PXI for control of legacy devices or to add certain application-specific measurement functionality.

The first level of the software architecture is Measurement Services, which consists of software modules that present the measurement functionality of the hardware to the test development environment in a user-friendly way. Measurement Services includes instrument and measurement device drivers, but also configuration, calibration, and asset-management tools.

The Test Modules layer consists of tools, such as LabVIEW and Measurement Studio, for creating individual test modules by automating measurement devices and analyzing measurement results. The test module is where the test engineer or integrator adds the most value by creating customized test routines for the specific device being tested.

The Test Management layer, commonly referred to as a test executive, acts as a framework for the entire test system. It provides sequencing, looping, and decision-making capabilities to the test program, generates reports, and provides an interface between the test system and various enterprise systems, such as databases, manufacturing execution systems, and quality systems.

Lowering the Cost of Test

The economic impact of a test system is typically measured in the cost as amortized over all of the products tested. A functional test system for a mobile phone, for example, might add $2 to the cost of producing each phone. The cost of test is an important metric because it measures capital expenditure with respect to the test throughput and productivity that a system achieves. Therefore lowering the cost of test, an important goal of manufacturers, can provide a significant competitive advantage.

The National Instruments functional test platform lowers the cost of test in three key ways:

1. Increasing test system throughput
2. Increasing engineering productivity
3. Lowering overall cost of ownership

Strategy 1 – Increasing Test System Throughput

Increasing throughput is a goal of every high-volume manufacturer. In many manufacturing lines, functional test cannot keep up with the beat rate of devices coming out of production. Because it is usually highly undesirable to slow down the production process to accommodate test, the most common solution is to have multiple functional testers at the end of each line to keep up with the production throughput. This condition is commonly called test fan-out. Because this proliferation of test equipment can be avoided by reduced test times, lower capital equipment expenditures can be achieved.

The PXI platform provides tremendous performance advantages over other hardware platforms. Built on the industry-standard PCI bus, PXI offers data throughput of up to 132 Mbytes/s – more than 100 times faster than the throughput of a GPIB device. This high data throughput means you can quickly transfer measurement data from the measurement device to the computer where you can make a decision or log the data, and thus significantly reduce the test time for the device.

To further increase throughput, PXI provides star-triggering capability. With the star trigger, several PXI devices can be tightly synchronized on common trigger or clock signals. In many applications, the use of the star trigger has resulted in throughput gains of 10X or more.

To lower test execution duration, LabVIEW and Measurement Studio deliver optimized performance and multithreading capabilities. These environments combine rapid program development with rapid program execution. LabVIEW, for example, contains a graphical compiler that intelligently groups sections of the test code together to run in parallel and compiles the entire test module into machine code to run at speeds comparable to compiled code in C or other languages.

IVI, the Interchangeable Virtual Instrument standard for instrument drivers, provides a state-caching driver model to eliminate redundant calls to instrumentation and significantly increase performance. IVI instrument drivers can deliver performance gains of 10X or more over traditional drivers without state-caching technology.

To deal with fan-out at functional test, many manufacturers place several independent, identical testers in parallel. However, this method uses capital equipment very inefficiently, because even under-used instruments are duplicated for each tester. A far more efficient method is to test several devices in parallel on a single, parallel tester with multiple test sockets. A parallel test strategy offers the most efficient use of equipment because more expensive, under-used instruments can be shared among sockets while more common instrumentation can be duplicated per socket for maximum throughput. TestStand, the test management environment from National Instruments, delivers a comprehensive set of features for creating and managing parallel test systems.

Strategy 2 – Increasing Engineering Productivity

Decreasing time to market continues to pressure today's manufacturers. In consumer electronics and communications sectors, product life cycles have shrunk from 18 months to six months or less. Getting a product into volume production and on the market as soon as possible can make the difference between a successful product and a failure. In highly competitive industries, for example, a 6-month delay in the shipment of a product can result in more than a 30% decrease in cumulative profits over the entire life cycle of the product. For such applications, developing a manufacturing test system rapidly is essential, as is quickly adapting a tester after product revisions.

Technologies based on widely available commercial technologies have inherent productivity advantages. PXI, for example, takes advantage of standard Intel and Microsoft platforms to deliver plug-and-play device installation and easy, consistent device configuration. PXI measurement devices also offer increased flexibility over proprietary platforms, because the PXI device makes only the raw measurement and uses software for analysis and decision making. Thus, when new products are brought to production, systems using PXI can be quickly changed to add new measurement routines in software, often without requiring hardware changes.

To maximize productivity in test development, development environments designed specifically for test applications include the correct tools for measurement and analysis. For test applications, LabVIEW and Measurement Studio are capable of delivering productivity advantages several times greater than general-purpose programming languages. Because LabVIEW and Measurement Studio are two of the leading test development environments in the industry, third-party hardware support is widespread, and programmers trained in these environments are readily available when personnel shortages or other pressures require outsourcing.

Another way to maximize productivity is to use commercially available software whenever possible instead of creating custom software packages in house. Many organizations, for example, write their own test executives instead of using an off-the-shelf product. Spending valuable engineering time recreating software that already exists reduces overall productivity and ties up even more resources over time for maintenance of the software. Today's successful manufacturing organizations concentrate on core competencies such as the design of products and test strategies to achieve the most efficient use of available resources.

Strategy 3 – Lowering Overall Cost of Ownership

The cost of the test system is measured in two quantities:

- Initial cost of the equipment, plus development and/or integration services
- Cost over time for maintenance and support of the test system

The NI test platform can substantially lower both of these costs.

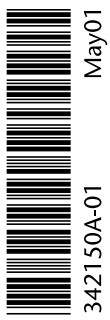
PXI measurement devices use commercially available technologies such as standard integrated circuits for analog-to-digital conversion and PCI bus interfacing. Because these devices are widely used in other high-volume technologies, such as telecommunications and consumer electronics products, their unit cost is substantially lower than highly customized components. This feature results in measurement functionality at cost much lower than devices in proprietary platforms. In addition, the PXI platform uses components already present in your computer – the processor, memory, and monitor – to perform the measurement analysis and display instead of duplicating this functionality in a customized box instrument.

PXI also lowers costs by delivering a platform capable of diverse measurement and control capability. In many systems, the platform for analog measurements is completely separate from functionality such as optical inspection, motion control, or continuous data acquisition. PXI, however, integrates this diverse set of measurements into a single hardware platform to lower your overall equipment costs and to permit a greater degree of integration between these systems.

Much of the total cost of a test system comes after the initial capital expenditure, because software training and maintenance costs can add significantly to the cost of test. Commercial software significantly reduces your maintenance and support costs. Widely used commercial software has standard training, technical support, and a large user base. The more commercial technologies you can use in your test system, the better you can take advantage of these cost savings. Maintenance is often a hidden cost in software development. All software requires some amount of maintenance over time. Keeping up with the latest operating systems, for example, is a requirement for compatibility with hardware and other systems in the enterprise. Porting customized software to a new operating system can use up valuable resources and time. Some companies have spent several million dollars, for example, to port in-house test software from DOS to Windows NT. Using commercial software tools offloads much of the maintenance burden to the software vendor and lowers your overall cost.

Results

Building a functional test system on widely used hardware and software platforms built on commercial technologies and open industry standards will dramatically lower your cost of test. This platform will increase your test throughput with fast measurement hardware and software capable of managing multiple test routines in parallel. Engineering productivity will increase, because engineers can fully take advantage of powerful software programs to develop tests rapidly. The time required to redesign test systems for new products will decrease with the use of flexible, modular software and hardware platforms. Finally, the cost of the test system, both in initial capital expenditure, and in overall cost of ownership, will be drastically lower thanks to the leverage of commercial technologies and widely used standards.



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