



# **LOW-COST GENERIC TEST USING VXI TECHNOLOGIES**

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## ABSTRACT

The evolution to VXI-based final test is accelerating at a rapid pace. Indeed, VXI manufacturers have designed an impressive portfolio of VXI-based products to address the eclectic needs of the marketplace. Mezzanine module (a.k.a., M-module) technology has recently been developed that can provide the right mix of system resources for particular custom final test system applications.

The final test system definition for high-volume test applications is a relatively straight-forward exercise in engineering judgment. However, there is a world-wide evolution to generic test based on the inescapable evolution to high-mix manufacturing. Customers are demanding more choices and those that fail to respond to this competitive reality in a cost-effective manner will cease to exist. A generic final test paradigm based on VXI technology offers a cost-effective approach to achieving time-to-market and budgetary criteria.

Although technology choices have a significant impact on the total cost of test, they are necessary but insufficient for attaining competitive advantage in cost, delivery, and responsiveness. An understanding of the ingredients and dynamics of supply chain related issues is a cost effective imperative for winning in today's competitive global marketplace. This paper will highlight some of the important issues relevant to attaining a competitive advantage in the total cost-of-test by examining VXI-based generic test technology choices and the impact that manufacturing planning and control system decisions have on the generic test technology lifecycle.

## GENERIC TEST

Generic test is a test platform strategy capable of testing a relatively broad mix of products over a given bandwidth and test point count. From a total cost-of-test standpoint, Dfx issues are central to the efficient interfacing of the device-under-test to the test electronics. The use of PCB drop-in fixtures to a standard interface panel will facilitate ease in reconfiguring the generic test system for the mix of products to be produced. In the same manner that VXI has standardized the P1 and P2 interface connectors, device-under-test products should use Dfx

principles for designing standard (although proprietary) interface connectors as well. Although connector pins may have different functional characteristics, the geometry is what is critical from a test system reconfiguration standpoint.

The type of generic test system(s) to be employed in a particular manufacturing environment should be based on bandwidth considerations. High frequency generic test applications (e.g., frequency > 500MHz) typically require expensive test resources (e.g., spectrum analyzer, network analyzer, etc.). Lower frequency test applications require less expensive test resources (e.g., DMM, waveform generator, etc.). A generic test strategy designed to test products over an inordinate bandwidth (e.g., DC to 5GHz) may damage the competitiveness of a manufacturer from a return-on-assets standpoint based on the adverse cost of high frequency test technology resources. Based on mix and volume considerations, we do not want fast cycle time products waiting for longer cycle time products. This conclusion is based on fundamental queuing theory and can be analogized to why traffic jams occur on two-or-more lane highways. The result of a bifurcated generic test strategy based on bandwidth considerations and test technology resource cost is a lower cost-of-test. A cost-effective generic test strategy based on bandwidth, test technology resource cost, and mix and volume flexibility considerations can provide a high-mix electronic manufacturer a competitive advantage in cost, delivery, and responsiveness over a less adept competitor.

From a VXI instrumentation standpoint, several common resources (e.g., relays, DACs, etc.) on a VXI card often result in the situation where many of these resources are not used for a particular defined generic test application. This problem can be alleviated given the advent of M-module mezzanine technology. A M-module is a self-contained increment of functionality that offers the flexibility to improve the mix of functionality required to support a particular defined generic test platform definition. M-modules are installed in piggy-back fashion on a C-size motherboard. Up to five M-modules can be interfaced to a C-size M-module carrier. M-module technologies currently available include:

- . 16 channel form-A switch
- . 4x4 matrix switch



- . Dual 8-to-1 relay multiplexer
- . 8 channel form-C switch
- . 4 channel form-C power relay
- . 16 bit digital I/O
- . Quad RS-232 interface

In order to ensure ease-of-use criteria, all of these M-modules have SCPI and VXIplug&play drivers available. Now that the world has access to the low-cost multifunctional advantages of M-module technology, the cost-of-test will decrease as a direct result of improved return-on-assets. The mix of functionality is improved. For less than \$3400 you can achieve five different types of functionality while preserving four C-size slots for other functional resources.

For lower frequency (i.e., <500MHz) generic test applications, high accuracy and flexibility in test electronics switching are often required. Unfortunately, increased flexibility requires increased configurable serial switches that result in a consequent reduction in accuracy. Although self-test can be used to characterize test system error as means for fudging device-under-test measurements for improved accuracy, high accuracy capability should also be obtained through the use of test system external access ports. The external access ports will substantially reduce or eliminate serial relay(s) altogether. A flying lead or other alternative external interfacing strategy can be used to connect the high accuracy external port(s) to the device-under-test.

## MANUFACTURING PLANNING AND CONTROL

The cost-of-test for a generic test strategy is not only based on test system design and technology choices. How the generic test system(s) are used has a dramatic effect on cost, delivery, and responsiveness. Setup time, lot size, sequencing, and capacity utilization are the driving forces for obtaining a competitive advantage in cost, delivery, and responsiveness. Flexibility is a cost effective imperative when attempting to attain a competitive advantage in the aforementioned value propositions. For high-mix manufacturing environments a generic test strategy improves flexibility substantially. Flexibility increases or decreases disproportionately. For example: The total number of possible sequences for  $n$  products that can be tested on  $m$  parallel test systems is  $n!m$ . A decrease in the mix of products ( $n-x$ ) that can be produced on a particular test system ( $m-y$ ) will decrease mix flexibility disproportionately  $[(n-x)!m-y]$ . Increased mix flexibility results in a consequent reduction in test system volume fluctuations that in turn increases volume flexibility. Decreased mix and volume flexibility will increase cost. For instance,

if one test system is experiencing an overload, the excess capacity that may exist on another dissimilar test system cannot be used. This often results in a situation where production operations management will request a cloning of the test system experiencing an overload. This will not solve the underloading problem on the other test system. We now have a situation where increased capital investment, increased floor space, and decreased return-on-assets reduce our competitiveness in the marketplace. For high-mix manufacturing environments, a VXI-based generic test strategy is therefore a cost effective imperative for attaining competitive advantage in cost, delivery, and responsiveness.

Sequencing decisions should be based on shortest processing time criteria. Products should be sequenced in order of non-decreasing processing time (a.k.a., SPT, shortest processing time). Products should also be as equally distributed as possible across all generic test systems. SPT is optimal for mean flow time, mean inventory, and is distinctly superior for reducing the proportion of late deliveries. All of these considerations will have a direct impact on cost. The proper sequencing of products through identical parallel test systems can be accomplished by using the following heuristic: Successively schedule each product with the longest processing time (a.k.a., LPT) at the test system where it will be completed the earliest. This process is performed up to the available capacity level for each machine. SPT sequencing is subsequently performed for all products associated with each test system. This heuristic will yield schedule sequences that are almost always nearly optimal. Reduced cost, reduced inventory, reduced mean flow time, and improved delivery and responsiveness performance are the benefits that can be realized as a result of implementing this heuristic.

It is important to understand that high-mix manufacturing problems are intractable (a.k.a., nondeterministic polynomial complete). No direct solution has been offered to directly solve the parallel machine allocation problem. The simplest parallel machine allocation problem is just as difficult as the most difficult parallel machine allocation problems one can encounter (a.k.a. nondeterministic polynomial hard). It is disconcerting that many manufacturing planning and control software solution providers claim their solution is optimal. Tradeoffs are the name of the game even under the condition of a bifurcated generic test strategy based on bandwidth and test technology cost considerations that reduce flexibility. Solutions based on such tradeoffs are characterized as goal "satisficing" rather than optimizing



behavior. From basic economic theory, the minimum of the total cost function for test technology cost and return on assets (vis-à-vis flexibility) is referred to as the Pareto optimum.

The master plan establishes which products are to be produced over a given time horizon. In order to reduce aggregate lead times and effectively respond to change, master plans should provide daily visibility rather than time horizons based on time buckets of a week or more. If processing times for each product in the mix of products to be tested are unknown or incomplete, external demand volatility will be the driving force for setting master plans. Setup time, processing time, lot size, available capacity, and sequencing are the driving forces for obtaining competitive advantage in cost, delivery, and responsiveness. Although test systems have real time clocks, it is disturbing that test engineering departments do not make the effort to track and report return-on-asset or capacity utilization metrics and use them as a mechanism for achieving improved levels of performance. A planning department that does not cost-effectively utilize existing test capacity through proper capacity planning and sequencing techniques will damage the competitive position for any manufacturer. Engineering efforts that reduce setup time and improve test time can be rendered inconsequential by the adverse effects of poor master planning methods.

## CONCLUSION

Generic test is integral to attaining competitive advantage in cost, delivery, and responsiveness given the world-wide evolution toward high-mix manufacturing. VXi technologies are integral to the design of a cost-effective generic test technology platform. VXi mainframe cost is decreasing while performance is improving and the cost of incremental functionality is being reduced given the advent of M-module mezzanine technology. The startling truth is that manufacturing planning and control decisions significantly outweigh technology choices in terms of the ability of a manufacturer to attain competitive advantage in cost, delivery, and responsiveness. Therefore it is critical for test engineering managers to lead the effort to implement real-time measurement of return-on-assets and capacity utilization for their existing test system resources and use this data as a means for driving improved manufacturing planning and control decision-making. It is becoming more and more important for organizations to educate their people in the fundamentals of manufacturing planning and control. In fact, education may be the only real lasting source for attaining competitive advantage in today's competitive global marketplace. Those that fail to respond to this competitive reality may put their very existence at risk.