ASSET INTERTECH

White Paper:

Non-Intrusive Board Bring-Up:
Software tools ensure fast prototype bring-up

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Executive Summary

Bringing up prototype circuit boards is a tipping point in the product development cycle. Unfortunately, it too often becomes a tripping point. Boards that won't come up can derail the project entirely, delaying the launch of the product into the market and generating staggering opportunity costs. Board bring-up must verify the functionality of the hardware so that application software can be loaded and debugged. Without a known-good-board, diagnosing software bugs would be futile.

The legacy technologies that have been employed during board bring-up have their limitations. Some, like manufacturing defect analysis (MDA) and in-circuit test (ICT) systems, involve fixtures that are very expensive and time-consuming to design and assemble. And any design change on the board will necessitate another set of expensive fixtures and long delays while they are fabricated. Other types of test equipment, like oscilloscopes and logic analyzers, may not require a fixture, but they are expensive and finding physical access for the probes they rely on

for high-speed I/O testing is like finding a needle in a haystack. Test pads are disappearing from boards and device pins are hidden underneath silicon.

Now many engineers are turning to software-based non-intrusive embedded instruments to perform tests, to gather validation data and to diagnose any hardware faults that may be present on a circuit board. And these tools can be employed before operating firmware or software have been loaded onto the board. Without fixtures and without probes, non-intrusive validation, test and debug techniques can accelerate the board bring-up process, reduce the costs associated with board bring-up and help deliver new systems to the marketplace on time.

First Things First

One of the most critical points in the new product development process is circuit board bring-up. The first batch of prototypes of a newly designed board has just been manufactured and engineers must verify that the hardware on the boards functions as expected and that the boards achieve their targeted performance levels. When prototypes can't be brought up quickly, the entire product launch process can be derailed, delaying a new product's introduction and jeopardizing the product's success in the marketplace.

Of course, the typical impulse of engineers or technicians when the first small batch of prototypes arrives is not the right one to follow. That first thought is usually that the quickest way to bring up a prototype board is to hook up the power and see if it comes up. If it doesn't, then the engineer is faced with a board bring-up project. Unfortunately, this could be the worst possible way to bring up a newly assembled circuit board. The development process could be set back by weeks if there were a major hardware fault on the board and it caused severe damage when power is applied. Moreover, once the damage is done, determining its cause is very difficult, if not impossible. So, the first phase in board bring-up should be based on common sense.

- ***Take a good look***

Rather than powering up a prototype board before anything else is done to it, a thorough visual inspection might reveal a fault that could be rectified before power is applied. Loose or partly soldered parts, bent pins, small metal fragments and other faults are visually obvious and can be fixed quickly.

- ***Check the power***

After the visually obvious problems have been addressed, the basic power sub-system should be validated. Once power is applied to the board, the outputs of the various voltage regulators or monitors on the board can be verified to determine whether the correct voltage rails are being distributed where they should be. A digital multi-meter can be used for this.

Having the correct voltage rails on the board is the base level functionality needed from the power system. In addition to this the system must be powered up in the correct order or sequence for it to boot properly. A low-end oscilloscope can be employed to compare the board's actual

power sequence against the sequencing defined in the specification. If the scope detects a deviation from the correct power sequence, the firmware in the board's power controller may be at fault and require debugging.

At this point, the clocks to the board's main processors and chipsets should also be checked. Without correct timing throughout the board, it may not be able to boot up or function at all.

With or Without Software

Once all of the preliminary checkpoints mentioned above have been verified, the board is ready for a boot attempt if the boot loader or BIOS (basic input/output software) is available. In many cases all of the system firmware may not be available at this point in the process. If this is the case, the engineers charged with bringing up the board are faced with a dilemma. They can wait for the firmware/software to be available and possibly put the project's timeline at risk or they can continue verifying the hardware and thereby eliminate any hardware faults that haven't been found yet. If the presence of hardware faults can be eliminated or reduced to a minimum, then any problems with booting the board once the firmware is available will likely be limited to software bugs. The bring-up team could then focus on software issues and not have to diagnose both hardware and software issues to determine the possible causes of a boot failure.

Take the Next Non-Intrusive Step

Several innovative non-intrusive board test (NBT) technologies can be effectively integrated into a board bring-up framework which will have significant long term benefits for an organization over and above the benefit of shorter board bring-up cycles. For example, many of the non-intrusive software-driven test procedures and processes used during board bring-up can migrate seamlessly into a manufacturing test environment, eliminating from the new product introduction process the time devoted to developing hardware tests for the assembly line.

- ***Finding hardware defects***

Once all of the non-powered checks and inspections have been exhausted, the board bring-up team can apply power to the board with some level of confidence that it will not be damaged. If this is the case, team members will probably share a collective sigh of relief, but they may find that a correctly assembled board still may not boot its firmware or it may fail intermittently. At this point, boundary-scan tests based on the IEEE 1149.1 JTAG standard can be employed for net and pin-level diagnostics. Boundary scan test results are comparable to the results that might be provided by in-circuit test (ICT) systems or manufacturing defect analysis (MDA) testers, but boundary scan does not require a fixture as ICT and MDA do. As mentioned previously, designing and producing a test fixture at this point in the board bring-up process will add procurement costs and time that could otherwise be avoided. An organization that has adopted boundary-scan test as a component of its standard test strategy will be able to quickly implement boundary-scan tests to verify the structural integrity of the prototype boards. Boundary scan is a digital test technology which can thoroughly test a board for shorts and opens but, like all test technologies, its coverage is not 100 percent comprehensive.

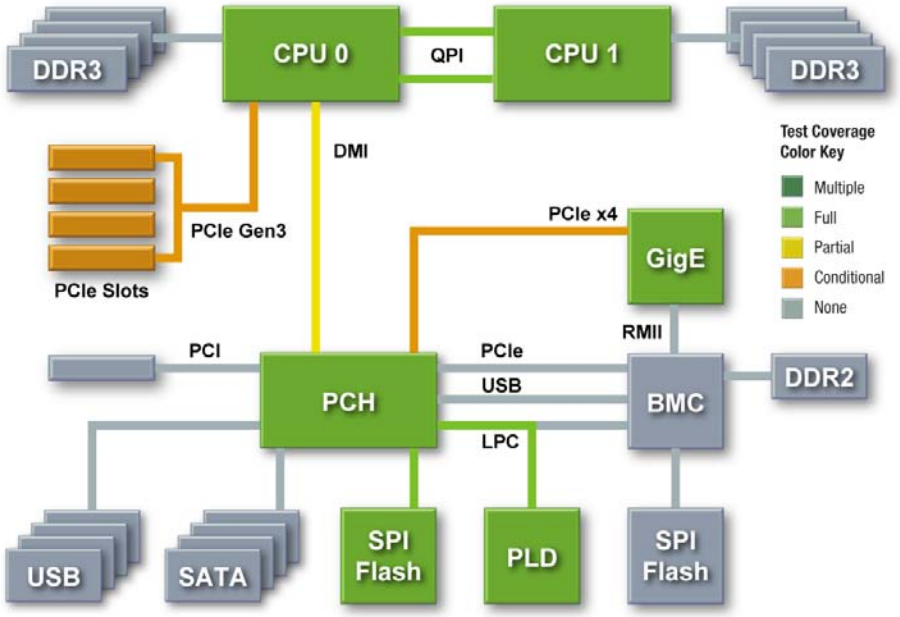

Figure 1: Coverage from boundary-scan test only

Another non-intrusive pre-boot test technology that works well as a component of the board bring-up process is processor-controlled test (PCT). PCT is similar to boundary-scan test in that it does not require that the circuit board boot up, but it differs from boundary-scan test because it is an at-speed functional test technology that provides both functional and structural test coverage. PCT executes out of the board's processor to test the structural and functional integrity of the devices and buses on the board.

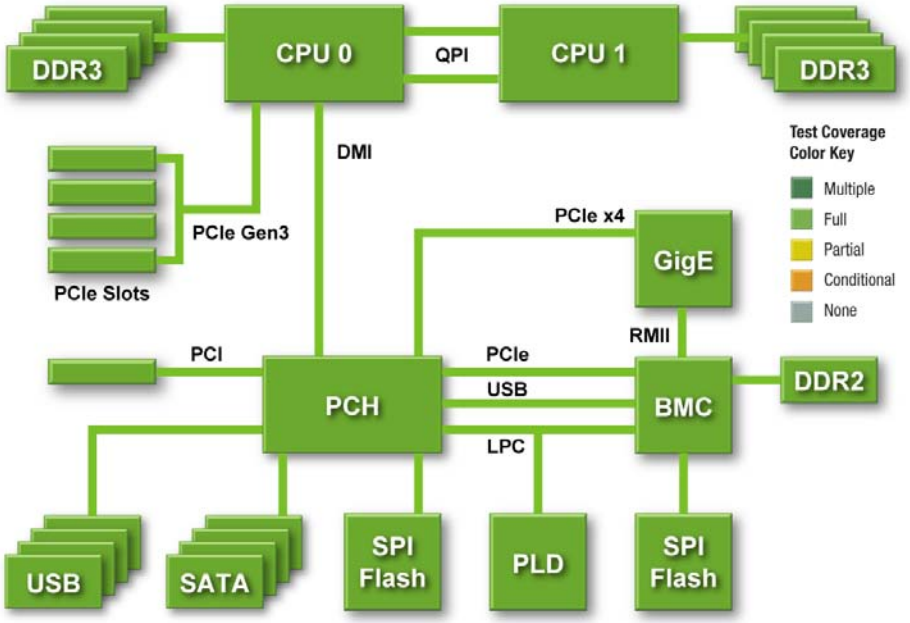

Figure 2: Cumulative coverage from boundary-scan and processor-controlled test

The cumulative coverage of boundary-scan test and PCT will go a long way toward eliminating any gross structural defects, but there still may be firmware issues or functionality anomalies on prototype boards. The final step before commencing software debug should be to validate the high-speed I/O (HSIO) buses on the board. Several non-intrusive built-in self test (BIST) technologies can be applied at this point in board bring-up. Intel®, for example, has developed its own embedded instrumentation technology, Interconnect Built-In Self Test (IBIST), and has placed it in next-generation processors and chipsets. IBIST tools can be utilized to validate the signal integrity on HSIO buses as well as their performance levels. Other chip vendors, such as PLX Technology, are turning to an emerging industry standard for embedded instruments, the IEEE P1687 Internal JTAG (IJTAG) standard. This specification describes the interface to instruments embedded in chips and thereby facilitates their portability from chip to chip while ensuring standardized methods for automating, controlling and managing embedded instruments. These embedded instruments can comprise another layer of non-intrusive test coverage for the board bring-up team. For example, Intel's IBIST technology for HSIOs will detect manufacturing and process variances like solder voids, micro-cracks, head-in-pillow defects and other such issues.

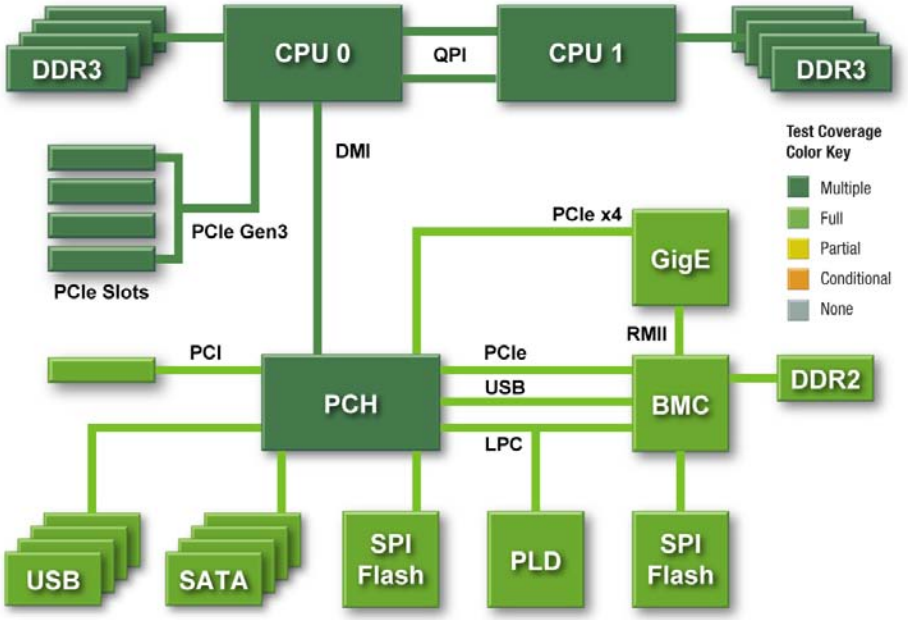

Figure 3: Total coverage from boundary-scan, processor-controlled and high-speed I/O test

Conclusions

The prototype board bring-up process need not be arduous or harrowing. And, more importantly, it need not jeopardize the successful new product introduction with unnecessary costs and schedule delays. A methodical, software-driven test, diagnostic and debug strategy for board bring-up can deliver the test coverage previously possible with legacy test technologies, but which now is eroding because of new more complex, high-speed chip and board innovations. The intrusive probe-based test and validation technologies of the past are giving way to a new

generation of non-intrusive tools based on instrumentation embedded in semiconductors – embedded instruments. Embodied in established techniques like boundary-scan test and new advancements such as processor-controlled test and HSIO BIST methods, non-intrusive board test (NBT) is able to accelerate prototype board bring-up, reduce the costs associated with it and ensure that new products are delivered to maximize their marketplace opportunities.

For more information on how the ASSET® ScanWorks® platform for embedded instruments can be used effectively in board bring-up applications, please visit www.asset-intertech.com.

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