



## CHECKSUM TECHNOLOGY BACKGROUNDER

February 2005

Contact:

Charla Gabert

Castle Hill Communications, Inc.

925.256.6723 (CA)

[charlagabert@yahoo.com](mailto:charlagabert@yahoo.com)

### THE WORLD OF TEST HAS CHANGED—AGAIN!

In the last five years, a lot has changed in the world of circuit-board test. With the severe industry downturn, capital budgets for test and inspection and in-house tester resources have been squeezed as never before. Time to ramp to production has been cut as well. Meanwhile, device, board, and process technologies have continued their rapid evolution. Devices are faster, circuits denser, and digital complexity is greater. Overall device and board quality are up, as are manufacturing yields. Assembly beat rates continue to rise, as does the pressure to reduce manufacturing costs.

#### Fault Spectrum Has Shifted

Most significantly, the fault spectrum has shifted dramatically. As overall defect rates have decreased, assembly yields have increased, and the typical distribution of defect types for a given board or manufacturing process has shifted over the past five years:

- Solder defect rate has increased as SMT opens predominate over through hole shorts.
- Solder defects now relate mainly to quality (e.g., cold solder joints), which are well addressed by automated imaging techniques such as X-Ray or optical.
- The SMT process defect rate is lower than the through-hole rate is. There are fewer missing or mis-oriented parts, although the small size of SMT components has created new defect categories such as skewed devices and tombstoning.
- Overall parts defect rate has decreased dramatically, especially for digital ICs.

The "classical" fault spectrum based on through-hole technology consisted mainly of shorts, analog component problems (missing, out-of-tolerance), and failed digital devices. The new fault spectrum based on SMT processes consists mostly of solder defects like opens, mis-oriented analog components, and almost no digital defects. As manufacturing shifts to lead-free soldering processes, the fault spectrum will continue to change.

#### Impact on In-circuit Test

So, why does the shifted fault spectrum matter? First, it matters because the tools and capabilities of traditional in-circuit testers have become less useful. Smaller, more densely packed boards and higher device speeds common in handheld products like PDAs and mobile phone handsets effectively eliminate test pads required for the bed-of-nails fixture. Loss of electrical access means less ICT fault coverage. New chip package types such as

BGAs impair ICT test access as well. Increasingly complex digital and mixed-signal chips such as SOC make digital vector tests impractical or extremely expensive and time-consuming to develop.

Second, the shifted fault spectrum means that the fault classes that traditional ICT is adept at finding occur much less frequently. Out-of-tolerance analog components rarely happen. SMT processes produce opens and other solder quality problems such as cold solder that ICT has trouble finding. Digital backdrive is best at finding defects on “jelly bean” logic—but these devices are appearing much less frequently in circuit designs and almost never fail, so there’s not much reason to test them in the first place.

The upshot is that new component technology and circuit designs have eliminated the requirement for almost all the tests traditional “big iron” ICT was designed to do well. What’s left are simple in-circuit test programs focused on shorts, analog component measurements, and a few power-on tests, which leave all that traditional, expensive ICT capability either underused or unused.

### **The Economic Consequences of Sticking with the “Tried & True”**

But even when their excess capability is left unused by simpler ICT test jobs, “big iron” testers result in high ongoing costs resulting from “technology overhead.” The inherent complexity of fixtures, programs, and maintenance for these sophisticated systems drives up costs—even when the tester itself is “free,” i.e., no capital costs or depreciation.

Unfortunately for the electronics industry, however, many test and manufacturing engineers believe that traditional ICT is required for all projects and all boards. The excess “big iron” ICT capacity sitting on most manufacturing floors today makes it convenient to transform this belief into daily practice. Immediate tester availability means no thought is given to the economic consequences.

Checksum estimates that each year the North American electronics manufacturing industry spends \$250 million more than it needs to by implementing test jobs on “big iron” ICT instead of lower-cost ICT alternatives. This number is calculated by estimating the fixture, programming, and support costs of using traditional ICT when testing could be done on a lower-cost test platform such as CheckSum. CheckSum fixtures, programming, and support costs are typically half of that of traditional ICT, and the purchase price is a fraction of traditional ICT.

This is money spent needlessly when excess tester capability is not matched to the reality of higher yields and the shifted fault spectrum. Since test budgets are rarely increasing anywhere, this adds up to a significant opportunity cost in foregone purchases of new inspection technologies such as automated imaging.

### **Time for a Change in Test Strategy**

Simple economics calls for a new test and inspection strategy that faces up to the changes in the fault spectrum. The reality is that many boards today require only a fraction of the available tester resources found on traditional ICT.

While ICT remains the most economical means to identify process faults, new technologies such as X-Ray and AOI are being integrated into assembly lines to deal with the new defect classes that ICT can no longer—or simply never could—identify. For in-circuit test, the strategy should be to move to low-cost ICT that has eliminated unneeded technologies such as backdrive, and their associated costs. This means less expensive testers, fixtures, programs, and support.

### **What is Low-Cost ICT Anyway?**

A common misperception in the test engineering community is that a significant capability gap exists between low-cost ICT such as CheckSum testers and traditional ICT from ATE companies such as Agilent and Teradyne.

One issue is the term “MDA” (manufacturing defects analyzer). Though manufacturing faults represent the vast majority of today's faults, the term "MDA" is viewed as representing a low-capability machine. The logic goes: "It only costs a fraction of the cost of ICT, so it must not do the same thing." Although CheckSum products started out as fitting into the MDA category, the company has worked hard to expand the capabilities of test systems beyond basic MDA capabilities. Today CheckSum offers powered-up functional test, TestJet vectorless test technology, ISP programming (faster and less expensive than on traditional ICT), and boundary scan.

### **Digital Backdrive and Analog Accuracy.**

There are two main differences in capabilities between low-cost ICT and traditional ICT: *digital capabilities* and *analog accuracy*.

Many companies using traditional ICT do not use the backdrive capabilities of these machines but they are paying for those capabilities, both directly in higher purchase price and indirectly in higher operating costs. CheckSum does not offer backdrive capability for vector testing of digital ICs. Most electronics manufacturers find that that backdrive is of little value for common ICs and newer devices, for different reasons. Common ICs (jellybean parts) have low PPM failure rates, so vectors are looking for faults that don't exist. New high-speed ICs are too complex to be tested with backdrive; test vectors of adequate fault coverage are too time-consuming and costly to write.

The analog accuracy specification of traditional ICT is typically +/- 0.4%, while the spec for a CheckSum system is +/- 2%. So, if a customer has very tight analog requirements and will fail components at +/-3%, then they need the analog accuracy of traditional ICT. However, there are very few actual projects where this level of accuracy is required. CheckSum specs exceed typical analog accuracy and resolution requirements by at least a factor of two. Fewer defective analog parts mean that the reliable sold-state switching found in CheckSum testers can replace the space-consuming, failure-prone reed relays found in traditional ICT—with virtually no impact on test coverage.

The key thing to understand about in-circuit test technology is that the additional capabilities of traditional ICT are what make it so expensive, when compared to low-cost ICT. Not only

is the acquisition price of a new CheckSum low-cost ICT system a fraction of traditional ICT, the ongoing operating costs (fixtures, programs, and support) are typically 50% less. Just the difference in operating costs is sufficient for many CheckSum customers to switch, even if they already own traditional ICT. In fact, one automotive OEM reduced ICT cost-per-board by 60% in just three years by replacing traditional ICT with CheckSum Analyst testers.

### **Managing a Tester “Portfolio”: The Key to Test Cost Reduction**

Shifting as many test jobs as possible to low-cost ICT reduces test job implementation time, saves money, and speeds production.

However, this approach flies in the face of the beliefs of many test engineers who wish to “standardize” on a single brand or model of ICT. Intuitively, standardization makes sense: only one vendor to deal with, common fixturing, a single programming environment, and simplified support. In fact, standardizing on a high-end in-circuit tester that has all the reserve horsepower—high accuracy analog, sophisticated digital backdrive, functional test facilities, etc.—that the test engineer might ever need has become industry practice.

But the standard is burdened with the high operating cost of fixturing, programming and support that a traditional ICT entails. The savings promised by standardization rarely materialize. A high-capability tester is absolutely right for a high-complexity board. But putting a simpler board on a "big iron" ICT is akin to planting a rosebush with a backhoe: The job gets done, but it's a lot more complicated and expensive compared to putting the less complex board on a tester with lower application and support costs.

CheckSum advocates using a strategy called “tester portfolio management.” Just as an investor maximizes portfolio return via a variety of financial products rather than “standardizing” on a single stock or bond, the test manager evaluates the test job and determines which of two tester alternatives to employ based on criteria such as board complexity and expected failure modes. Low-cost ICT is used for boards that do not demand digital backdrive or high-accuracy power-off analog. More expensive traditional ICT is chosen when backdrive and accuracy requirements demand it.

Manufacturers employing the portfolio strategy find that the large majority of test jobs—80% in most cases—achieve the same fault coverage on the low-cost ICT as they would have on the “big iron” ICT. This adds up to optimizing test cost rather than maximizing test capability resulting in a reduction of total test cost by avoiding unneeded tester overhead.

Tester portfolio management is straightforward. Electronics manufacturers should seek the lowest-cost test solution for each new board that enters the test department, even if it means investing in "non-standard"—but much lower-cost—test system. They should use the traditional high-cost tester only when its resources are clearly required. And the decision should be made on a project by project basis. Today, "big iron" and low-cost ICT coexist on an increasing number of test floors, delivering much lower total test cost than relying on a single high-end standard. By matching test capabilities to a board’s test requirements, manufacturers can reduce their total ICT test costs dramatically and free up budget money to invest in vital new test and inspection technologies such as AXI and AOI.