



**FIGURE 1 — EXAMPLE OF A SIGNATURE ANALYSIS TESTING SETUP WITH THE NFF DEVICE UNDER TEST ON THE RIGHT-HAND SIDE.**

## Solving No Failure Found Situations using the Right Mixture of Tools and Know-how

**In the electronics industry, when a product fails to meet the expectations of an end-customer with regard to operational function, too often the electronics that are returned from the field will exhibit no failure during normal factory testing. This results in what has come to be known in the industry as an NFF (No Failure Found). When this happens, it always makes a bad situation even worse and more expensive. Low-cost approaches to dealing with this situation are therefore often of crucial importance. Dedicated specialists are able to provide customized solutions thanks to the right concepts, tools and specific know-how.**

“No Failure Found”, or NFFs for short, occur in the fields of industrial electronics, such as transportation systems, power plants or substations, for many reasons. For example, after experiencing a breakdown a customer may have exchanged various units until the system worked again without knowing anymore which unit(s) from a collection is actually defective. In this case, the customer might simply pack

up all of the suspected units and ship them to the test shop, and probably realizes in advance that at least some of the units could pass all of the testing. If the failure was weather dependent, for example, and rainwater or moisture inadvertently entered the electronics or connector enclosure, it could be that all the returned units will pass after drying out. More frustrating, however, is when a specific unit is

known to have failed in the field and yet the failure cannot be reproduced at the service center. Typical reasons for such NFF situations are, among others, intermittent failure, operating environment-dependent failure, human error, hidden software bugs, and/or insufficient test coverage.

Over the years, Enics, as a specialist in electronics manufacturing services along the entire product life cycle, has developed a reasonable process for how to deal with this situation: reasonable in the best meaning of fast, efficient and cost effective. This includes several different strategies, some more uncommon than others, but none that are cost-prohibitive. These strategies are focused on failure detection and not on determining root cause (FMEA), the latter of which often involves very specialized/expensive analytical equipment such as a scanning electron microscope (SEM) or extremely high-magnification microscopes and is often destructive in nature. Such capabilities are usually found only in scientific laboratories and are not part of the resident equipment of a typical EMS. If the original cause of the failure has disappeared, for example a short circuit created by a dendrite or other conductive path that in the meantime has fused away (burned through), then of course Enics' applied methods will not detect the failure either.

#### ABBREVIATIONS

- EMS Electronics Manufacturing Services
- FMEA Failure Mode and Effects Analysis
- NFF No Failure Found
- PCBA Printed Circuit Board Assembly

#### SUCCESS FACTOR: SKILLFUL COMMUNICATION

Expecting a trouble-shooter to find a failure that doesn't manifest itself is like sailing a ship across the Atlantic without a compass or any other directional aids and hoping that it lands in a specific port, i.e., success is highly improbable. Clear and prompt communication is therefore of great importance. Approaching the customer (and perhaps also the designer) with a request for a more detailed description of the failure situation is usually the first and easiest step. This is not to be underestimated since it can save enormous amounts of time in trying to troubleshoot a problem that could be anywhere in the circuit. Very good communication skills by every person in the failure reporting chain are essential, and by requesting further information, an obscure failure description can often be turned into a very helpful one.

#### SUCCESS FACTOR: SOPHISTICATED TESTING

Often an NFF arises because the testing house cannot properly duplicate the exact conditions under which the failure occurred. In an effort to simulate real loads and conditions that may occur in the field, stress testing of the product under temperature/vibrational cycling is a technique often used. Applying thermal or vibrational loading may be enough to cause the failure to appear, providing that the failure is at all detectable under the given fault coverage.

A more unconventional, but nonetheless often successful approach to the NFF problem, is signature analysis (Figure 1). With this method, which is like taking an electronic fingerprint, characteristic V-I curves at selected cir-

circuit nodes are compared to known good patterns to establish whether a particular part of the circuit is behaving normally. Although this technique has been around for several decades, modern equipment is capable of automatically testing the product, in addition to being able to semi automate the process of making a test program.

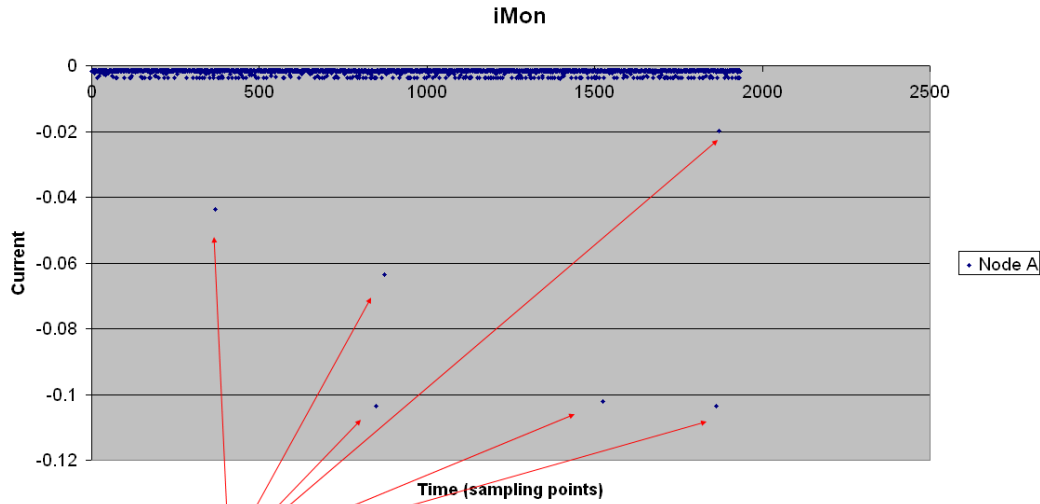
**SUCCESS FACTOR: INNOVATIVE THINKING**

Sometimes a failure is only intermittent but may have been severe enough to cause a shutdown of an entire plant. In the case of a sporadic failure, the causes of which can be many, special monitoring techniques are required. Here, innovative thinking and resourcefulness can be the most important attributes of the troubleshooter. Constant monitoring techniques and appropriate sensors may be necessary to have any chance of detecting the failure. If the failure is one that causes a component to malfunction, even if just for a short time, it will usually cause a deviation in the normal current draw of the circuit.

Enics' test equipment for monitoring uses a platform that's readily available in the marketplace. We run our own data collection, post-processing, and filtering procedures to obtain a time-based graphical representation of the test run (Figure 2). The tests can be run continuously for minutes, hours or even days as de-

sired. If an abnormality in the operating current as a function of time is large enough, it will cause a deviation from the typical sampling band. Such an abnormal sampling point is called an outlier and can be seen immediately by simply looking at the graph. Knowing how frequently the failure typically occurs under a given set of circumstances, and approximately where in the circuit it occurs, allows the troubleshooter to develop a detailed strategy for how to go about pinpointing the failure. Other possibilities for constant monitoring include strip-chart recording and digital signal capture. Constant monitoring has its limitations, however. Signals on the borderline of their threshold levels, for example, will be extremely difficult, if not impossible, to detect.

If a component on a PCBA has become defective, or its current draw has changed, its temperature characteristics have very probably changed also. This makes it possible to detect the location of a defective circuit by comparing infrared images of circuit boards from field returns against known good units by using thermography. If the product's PCBA has the same circuitry pattern repeated (several channels), a



**FIGURE 2 -- EXAMPLE OF A CONSTANT MONITORING APPROACH THAT MEASURES CURRENT. THE OUTLIERS ARE HIGHLIGHTED WITH ARROWS.**

known good unit may not even be necessary, as with the example shown in Figure 3.

### LAST RESORT: ON-SITE INVESTIGATION

If the testing lab is unsuccessful in detecting a failure, there may be no choice but to conduct an on-site investigation. The term “last resort” is used for good reason. It’s usually the most expensive alternative, requiring travel costs and more time since the service technician cannot work as efficiently as in his/her usual workplace. A hard failure can then be observed in its operating environment. Intermittent failures may not reoccur, however, since many are due to oxidized/corroded contacts or other effects that exist only temporarily. Through the process of disconnecting and reconnecting, both in the laboratory and back in the field,

adequate contact gets re-established and the unit once again works normally, so an on-site investigation also has its drawbacks and associated risks of success. Other effects, such as alpha flux, that may have caused the original (soft) failure may also be impossible to reproduce.

### RIGHT MIX BRINGS GREATEST RATE OF SUCCESS

Cleverly combining these troubleshooting techniques together can yield very powerful tools. For example, temperature/vibrational cycling combined with continuous monitoring can simulate operational stresses while at the same time continuously checking a collection of signals with an extremely short sampling interval. If an intermittent failure occurs under load, such a configuration may be enough to capture even the most elusive failure event.

In spite of all efforts and best available expertise - let’s face it: NFFs may not always be resolvable. Nevertheless, the prerequisites for successful resolution of many NFF mysteries are the right tools and concepts. Combining these with the specific know-how and experience of the troubleshooter, which may involve the actual operation of the customer’s system as well as review of its design, the customer often receives the required answers – quickly, efficiently, and with low cost impact.

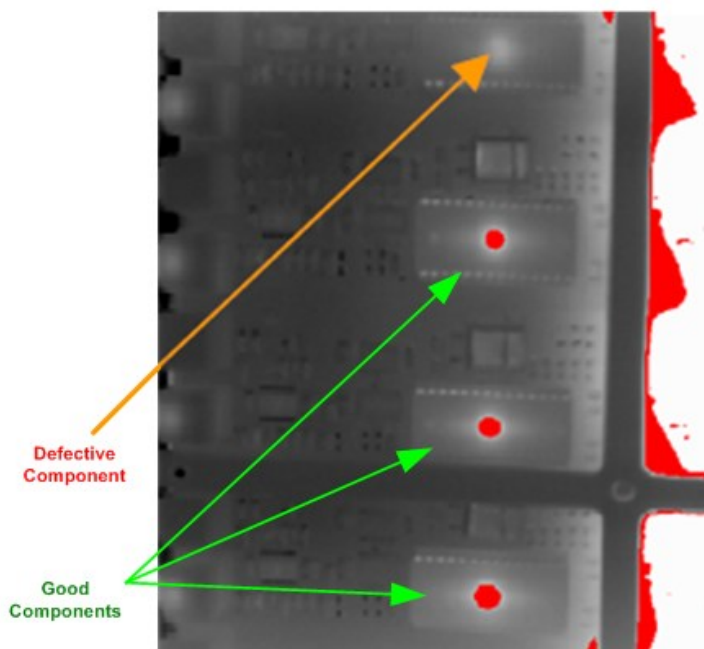


FIGURE 3 -- THERMOGRAPH OF A MULTI-CHANNEL I/O INTERFACE CIRCUIT BOARD.