Troubleshooting on Assembled Printed Circuit Boards using Analogue Signature Analysis (ASA)

INFO-BOX

Task:

Fault-finding on assembled printed circuit boards, where either:
- powering up the board is either undesirable, dangerous or impossible, or
- access to board documentation is limited, or
- labour and time savings are required, or
- testing of prototype development boards is difficult and time-consuming

Solution:

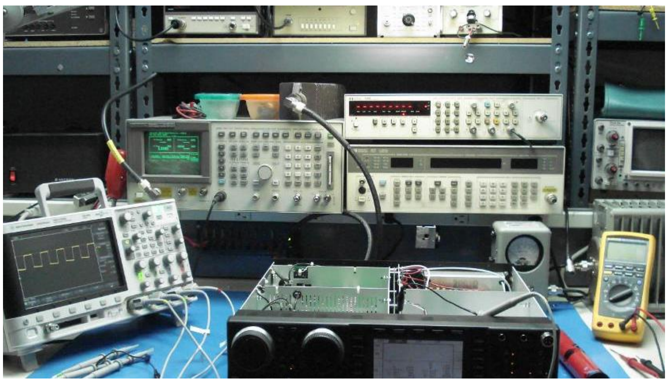
Power OFF fault diagnosis by using V/I characteristics.

Strategies for Troubleshooting

The context in which board errors occur determines the strategy of the fault detection method. For example, in the manufacturing environment, the focus is on process fault detection. Proven techniques include optical / X-ray inspection, in-circuit test, boundary scan and function test. However, in the areas of diagnosing faulty boards (in production or field returns) and for testing prototype development boards, diagnostic tools are invariably more effective. Traditional tools such as digital multimeters and oscilloscopes require expensive and time-consuming technical knowledge. However, Analog Signature Analysis (ASA) can be used to greatly de-skill, automate and speed-up fault diagnostics.

The Functional Test Approach

Very often, functional testing alone is used to find board faults. To do so, power needs to be applied to the board then the operational and test procedures are executed. Complex devices may have their own test modes to support testing.

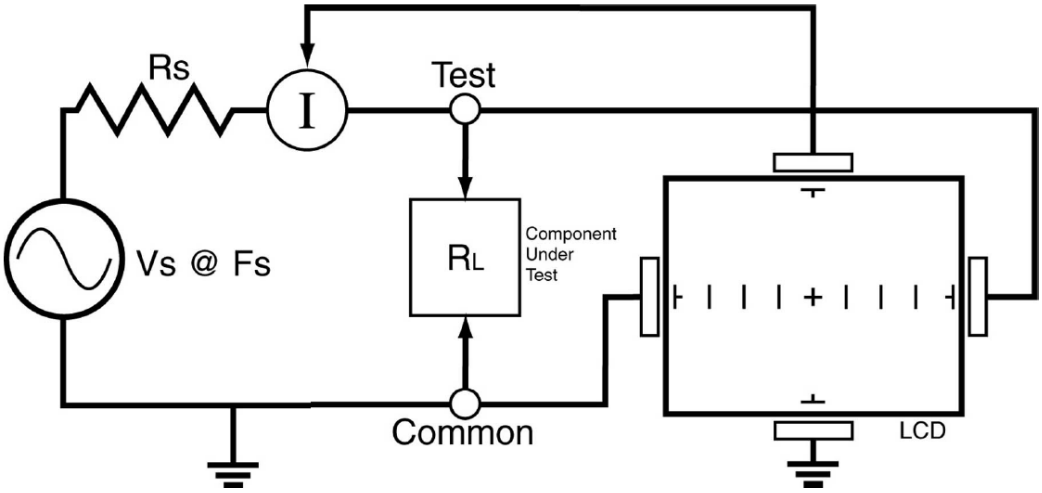


Using simple measurements (such as voltage with a DMM) at strategic points, technicians can verify certain functions at the point of measurement. It is often helpful to change the operating mode of the DUT during a measurement in order to obtain further information. The error zone is determined when the measured signal does not correspond to the expected operating principle. Using the simple example of a defective laboratory voltage source, the first measurements are made at the various internal supply voltages. If the supply is operational, then the technician follows the logical signal course, starting with the D/A converter → the preamplifier → the power output stage.

Once the faulty section or module has been detected, the problematic component can sometimes be determined by further measurements. Stimulation with an external signal source also helps to find errors on adjacent components, but often the entire module is replaced when component level diagnosis is not possible or not economic due to time restraints or technical resources.

The Analogue Signature Analysis (ASA) Approach

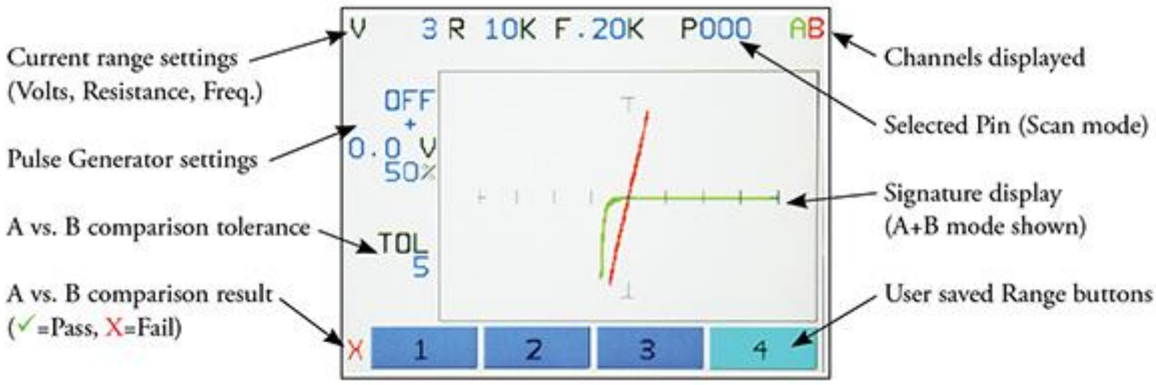
The ASA principle generates a sinusoidal signal on the test probe at the measuring point and simultaneously detects the current via the shunt resistor, and the voltage drop. Similar to the X-Y mode of an oscilloscope, a signature is registered.



Picture 1: Block diagram of the ASA

According to Ohm's law, the measuring principle can be understood as a "graphic impedance measuring device". R_S = internal source resistance = impedance, V_S = source voltage, F_S = source frequency, R_L = load resistance = test object. R_S, V_S and F_S are adjustable parameters of the measurement.

For discrete components, the signature corresponds to known characteristics, e.g. a line through the origin for resistors, a hysteresis for coils or the diode characteristic. In a real network, the signal response on most nets is a superposition of multiple characteristics.



Picture 2: **ASA Signature Display:** The picture of the defective test (red), in comparison to the "golden" reference (green).

The troubleshooting strategy with ASA does not follow the functional path. Instead, the board under test remains unpowered (Power OFF Test), so that the response to the injected test signal is defined only by the passive electronic characteristics of the network/component under test. The measurement is carried out by using one probe, whilst a second probe is normally connected to ground. It may also be appropriate to change the reference ground point to the supply voltage, or to measure differentially across components. The generated complex characteristic, or signature, of the network point is automatically compared with the saved reference signature from a good board. If an acceptable match is not found, then a fault is indicated, both on the screen and also audibly if required. By comparing the shapes of the good and bad signatures, the specific failing component on that network can be determined.

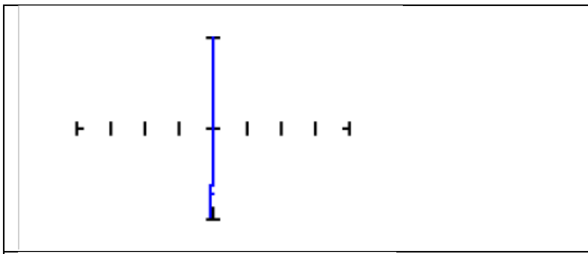
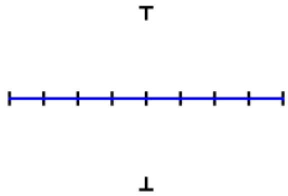
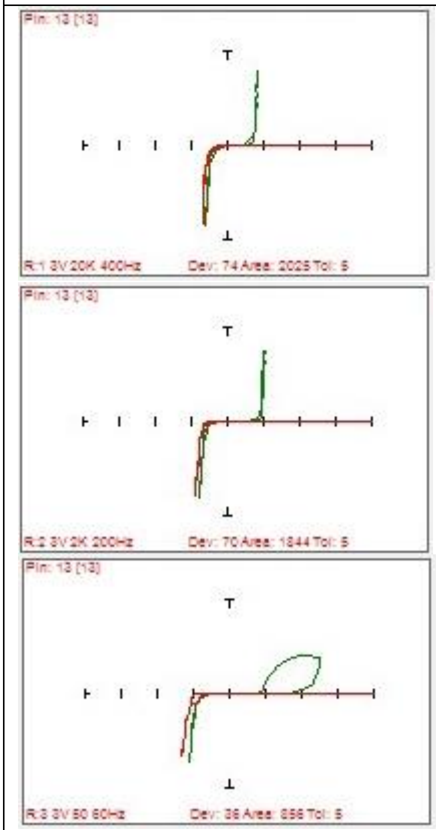
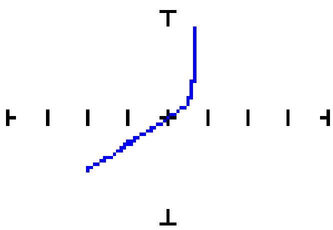
To gain high confidence of a successful repair, multiple networks are normally measured. It is recommended to scan all pins of a specific component. This makes it possible, in the event of a component-specific accumulation of defective pins, to reliably and precisely indicate the defect. It is more time saving to work through the network sequentially at neighboring points. This avoids duplicate measurements if the same network is connected to different pins.

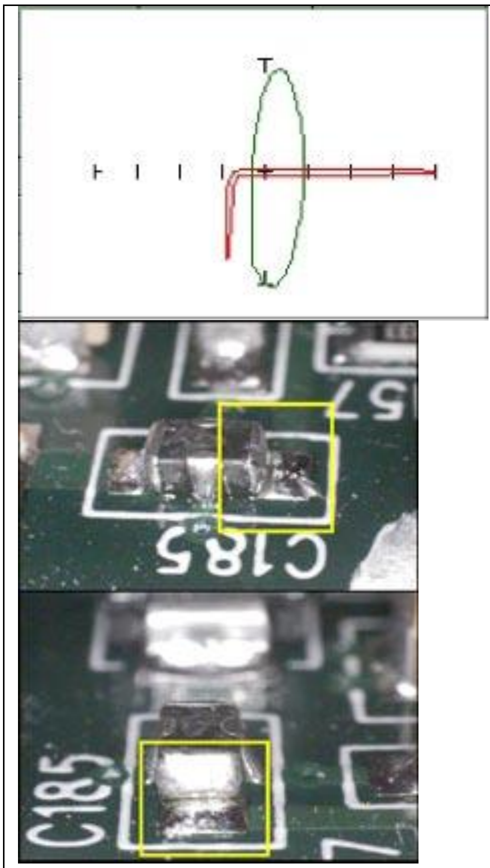
INFO-BOX

Advantages and disadvantages of Power-OFF testing

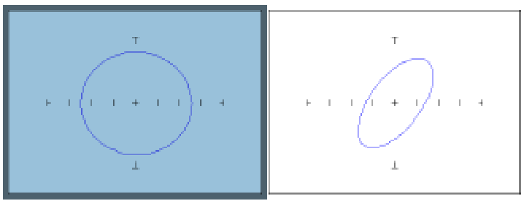
+ Troubleshooting is possible when the device under test cannot be activated in operation or test mode. This happens when the documentation is missing, or an affected circuit board cannot be operated without the surrounding product infrastructure (e.g. power or control).
+ Troubleshooting is possible when the board under test cannot, or must not, be powered up. This is particularly the case when a repair after replacement of a component is feared error propagation in the circuit.
+ A prototype can securely be "switched on": ASA enables valuable prototypes in development to be cleared of risky errors before the supply voltages are connected.
+ The measurement setup gets simplified. When functional testing, in order to gain access to the measuring points, a break-out is often required. For this, the board to be measured is taken out of the system and connected with cables or extender cards to restore the function. With ASA, none of this is necessary since functioning the board is not required.
+ Fault finding requires no functional or operational knowledge of the product thereby greatly de-skilling the task.
+ It is possible to diagnose faults with little or even no circuit board documentation.
+ The speed of fault finding can be greatly reduced.
+ ASA can detect certain problem components which functional test may miss e.g. leaky capacitors.
– There is no functional analysis of the IC components. Analogue signature analysis typically checks portions of the input circuitry and output drivers of the IC pins. However, subcomponents, e.g. internal registers or logic, cannot be checked with this measuring principle as compared with power-on test techniques.

Analysis of typical errors, and use of the measurement parameters

	**Graph 1: Short circuit to ground** Vertical line. Set the impedance of the meter low to distinguish between a small resistor on the DUT from a short circuit.
	**Graph 2: Open contact** Horizontal line. Set the impedance high to detect between a high resistance and an open circuit.
	**Graph 3: Short circuit between adjacent pins on an IC** Show the same signatures, although they should be different.
	**Graph 4: Diode with leakage current** Increase voltage to detect the breakdown of the diode characteristic. A current flow in the blocking area indicates a leakage current. If the voltage is applied below the breakdown, the diode virtually disappears from the circuit. This allows us to consider the behavior of the other devices on the network. If the voltage of Z-diodes is increased, the Zener voltage becomes visible.



Graph 5: Missing capacitor
Frequency must be set low and impedance high to detect the circular shape. The smaller the capacity, the lower the frequency. In this example, the circular signature of a capacitor is missing. Here an open solder joint of the adjacent capacitor has caused the error.



Graph 6: Capacitor with leakage current
The degree of tilt on the circle in the right-hand image is proportional to the leakage.

Analogue Signature Analysis Instrumentation

Picture 3: **Huntron Tracker 3200S** as a stand-alone desktop unit. Easy to use with a user-friendly touch screen, and a 128-way scanner.

A "current over voltage" characteristic can be recorded with an oscilloscope and a sine wave generator. However, a product specifically design for the application makes troubleshooting far more flexible, more efficient and more accurate.

Built-in power protection monitors limit the stimulus input to the device under test. This prevents semiconductor components from being damaged by the test. Easily adjustable parameters such as voltage, frequency and impedance help with error analysis.

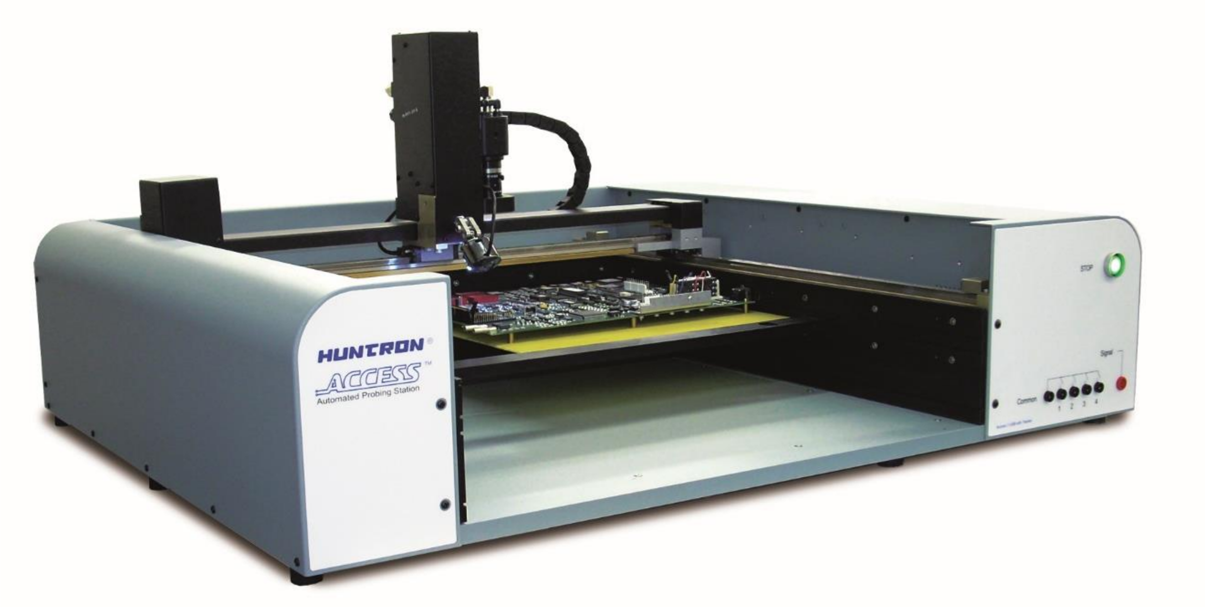
It is possible to run alternating measurements on two boards at the same time, comparing the test board with the reference board. This shows at a glance the differences of the signatures. Built-in algorithms recognise the different lines and provide the "plain text" fail / pass information.

A built-in multiplexer (scanner) can automatically scan many test points in succession. The scanner can be connected to edge connectors, sockets etc., greatly speeding up the testing by reducing the amount of manual probing required. Clips connected to the scanner can also be used to make multiple contacts with multi-pin devices.

Additional synchronous pulse generators can be connected to the controlling input of a component. This allows the testing of active power components, such as relays, triacs or transistors.

Automation

By using a robotic prober, test points can be probed automatically at up to 10 times the speed of manual probing and with substantial labour savings. This can allow for higher throughput or you can probe an increased number of measured networks and/or a higher number of measurement parameters, thereby increasing fault coverage. Automation also allows for accurate probing on small geometry boards and virtually eliminates human error.



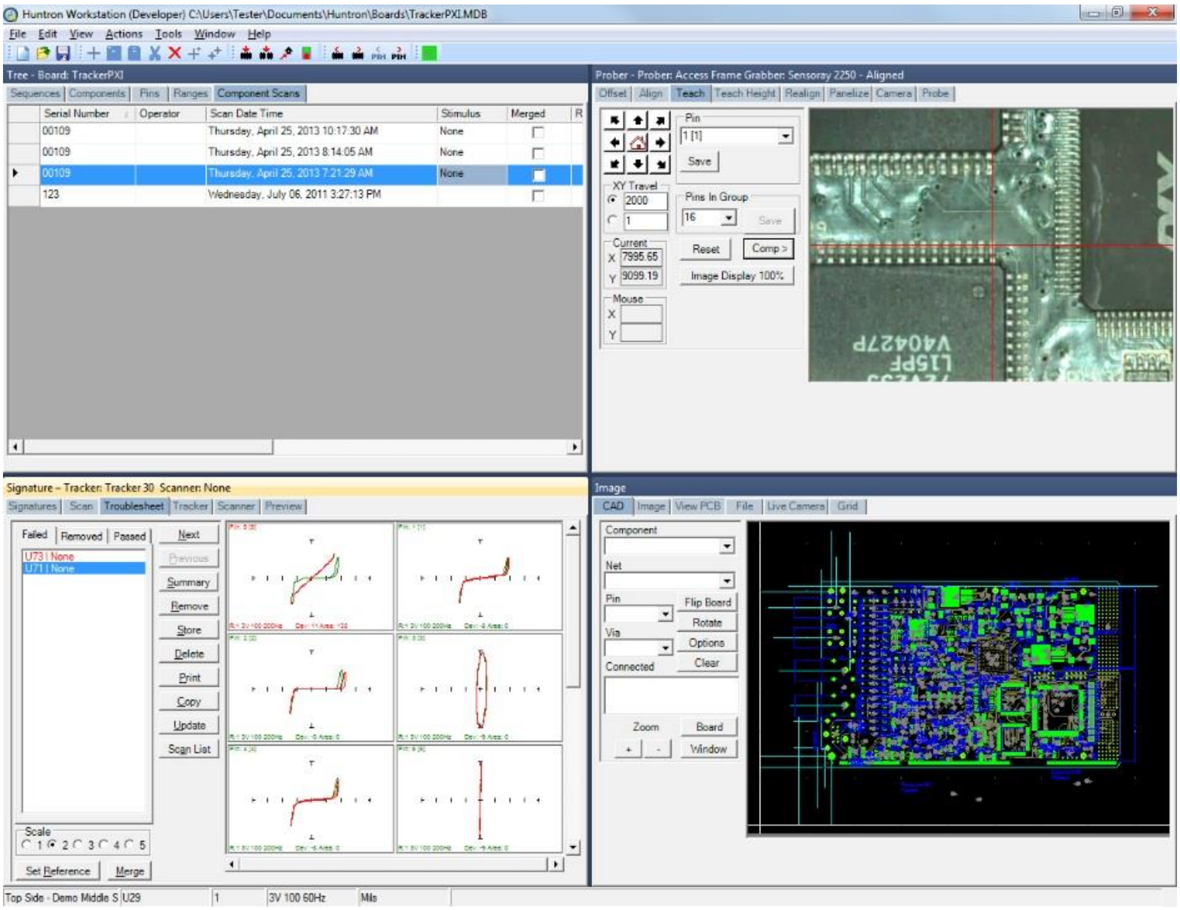
Picture 4: **The Huntron Access USB Prober** can be used with a Huntron Tracker 3200S to quickly and reliably probe boards with a precision of +/- 20 microns.

Synergy through Software

The software stores the analogue signatures in the internal database. This allows multiple acceptable signatures to be read for each test point. The combination of these signatures compensates for production-related variations or different types and manufacturers of components thereby avoiding false errors. Valuable reference 'golden' boards are therefore only required once to generate the signatures which are then stored for all future tests.

Illustrated operator instructions in the test sequence accelerate the test duration and at the same time reduce the caused error rate, e.g. due to incorrect placement of the probe. A clear user interface facilitates ease of operation. Programming interfaces make the core function of the software usable in own applications. Settings, such as measurement points, parameters and the corresponding results can be recorded immediately in test reports or log files. Where available, CAD data can also be imported to simplify the initial configuration of the test plan and the error analysis process.

Users quickly gain expertise in the proper selection of test points and configured test parameters. Setting up and saving a test plan makes it possible to reproduce all the test in the same repeatable quality. It also allows the transfer of know-how between operators.



Picture 5: Huntron Workstation Software clearly presents the test instructions on the board, the test sequence, and component/pin level test results. It also allows user guidance with integrated illustrated work instructions.

About the featured products

Further information can be found at http://stantronic.com/Circuit-Board-Debugging. Please contact Stantronic Instruments for further details or to discuss your application. Product demonstrations or trials of the Huntron solutions can also be arranged.

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Steve Evans is a graduate engineer with 30 years' experience in the Electronic Test & Measurement and Automatic Test Equipment (ATE) industries.