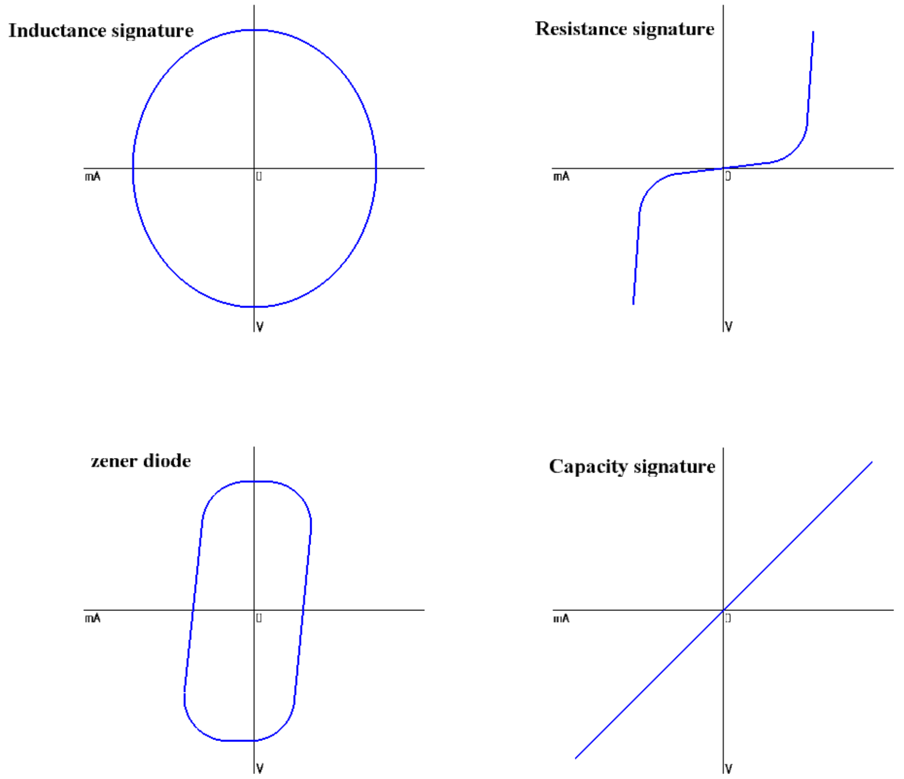
What is an analog signature analyzer and how does it work?

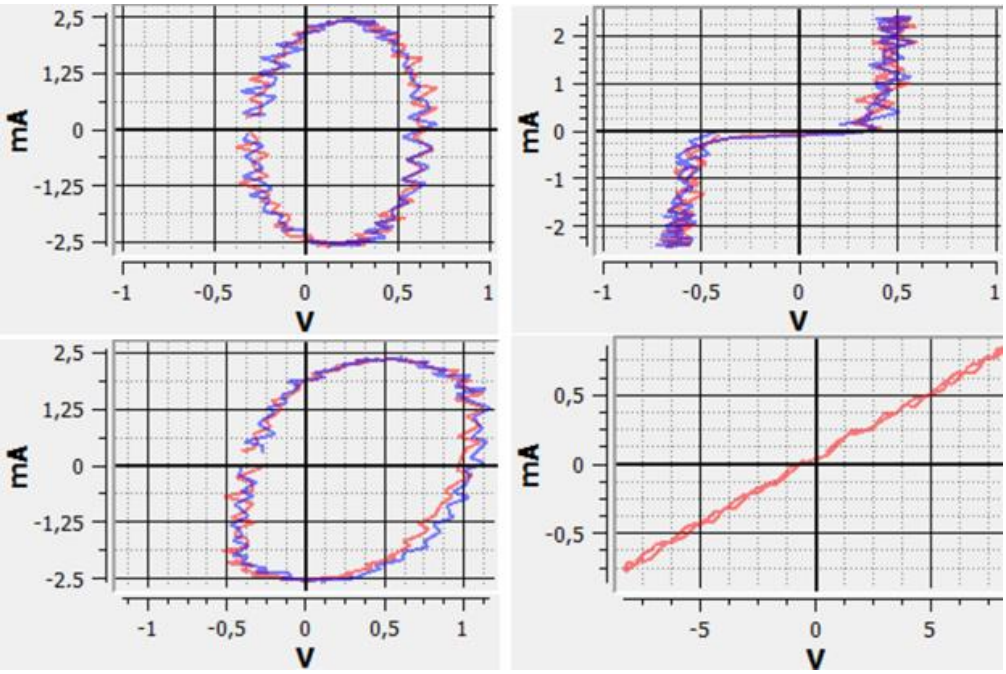
Simultaneously with the first complex electronic circuits, the task of creating effective means of diagnosing and repairing them appeared. In previous decades, specialized programmable stands were used for diagnostics of serial electronic products, as well as various testers and probes for troubleshooting during their operation. But the dramatic increase in production in parallel with the very rapid modification of electronic products made programmable stands economically ineffective even in mass production. The use of traditional laboratory equipment (oscilloscopes, multimeters, etc.) requires power supply to the defective modules, which is often impossible and unsafe, since it can lead to failure of the working modules of the module. In addition, the use of this equipment requires documentation and highly qualified personnel. More automated and sophisticated signature analysis systems came to the rescue in solving this problem. A feature of these devices is that they allow you to test digital and analog assemblies without dismantling.

WHAT ARE ANALOG SIGNATURES?

All analog signatures are a combination of one or more signatures of the basic components, which are: resistance, capacitance, inductance, and semiconductor. The ability to recognize these basic signatures on the instrument display is one of the key conditions for a successful ASA troubleshooting. When components form a chain, the signature of each node in that chain matches the signature of the base elements in that chain (Figure below). For example, a circuit consisting of resistance and capacitance will have a signature that matches the signatures of the resistor and capacitance. The resistor signature is always represented by a straight line at an angle from 0 ° to 90 °. The signature of a capacitor (capacitance) is always represented as a circle or ellipse. The inductance signature is always represented as a circle or ellipsoid, with the possible presence of an internal resistance signature. Finally, the signature of a semiconductor diode always consists of two or more line segments, usually approximately at a right angle. The semiconductor signature can show the characteristics of the forward and reverse conductivity, i.e. type of characteristics of the zener diode.



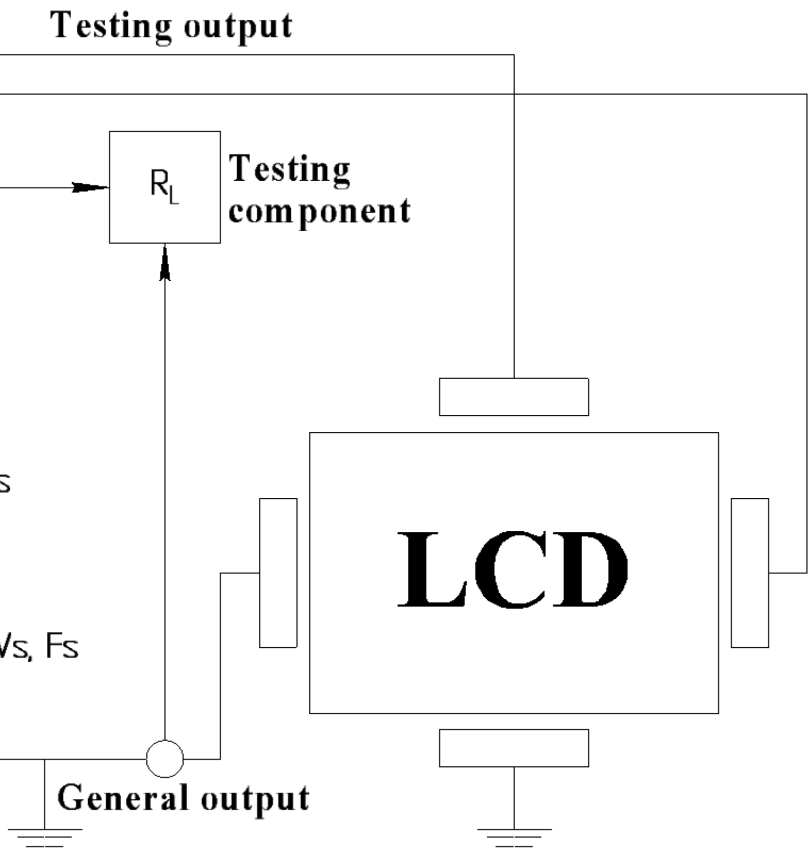
The signatures below were obtained by using the ASA EyePoint p10, EPC MSU. Some signatures were taken from actual tests of reference boards and non-working boards.



In the case of the ASA EyePoint, the analysis is based on comparison. This means comparing the signature of the reference (known to be working) printed circuit with the signature of the verified printed circuit (with suspicion of a malfunction). The difference in the received signatures may indicate that the tested schema is the source of a potential problem and may not meet the stated requirements.

WHAT DO THESE AXES MEAN?

The figure below shows a simplified diagram of a signature analyzer. The sine wave generator is a test signal source, connected to a voltage divider consisting of R_S and R_L resistances. Load impedance R_L is the impedance of the component under test. R_L is connected in series with the R_S internal resistance or source resistance. Since the resistance R_S is constant, the magnitude of the voltage drop across the investigated component and the magnitude of the current through the component depend only on the value of R_L.



Rs - source resistance, Vs - source voltage, R_L - load resistance, Fs - signal frequency.

Vertical axis on the signature plot - the deviation of the graph curve along the vertical axis on the instrument display is determined by the voltage drop across the internal impedance R_S of the instrument signal source. Since R_S is in series with R_L, this voltage will be proportional to the current flowing through R_L. The amount of current flowing through the component under investigation ultimately determines the vertical part of the signature. If we make R_L equal to zero (0 Ohm) by connecting the output and common connectors of the device, then the voltage drop across the R_L will also be zero. This will result in the horizontal part of the signature not being displayed, and the vertical part of the signature as a line to be displayed over the entire height of the instrument display.

Horizontal axis – the magnitude of the voltage drop across the component under study determines the deviation of the graph curve along the horizontal axis on the device display. If the component under test itself is removed from the test circuit, thus forming an open circuit (i.e., $R_L = \infty$), the voltage at the output connectors of the device will reach a maximum, which will result in a horizontal line being displayed across the entire width of the display.

CHOOSING RESISTANCE!

Signature analyzers usually provide operation with different resistance ranges, ranging from 10 Ohm to 100 kOhm (based on a comparative analysis of ASA market). The most suitable way to get started is to select some average resistance value (i.e. 100 ohms or 1 k ohms). If the signature on the display of the device is close in character to an open circuit (horizontal line), then in order to obtain a more visual image of the signature, it is necessary to set the next increasing resistance value. If the signature on the display of the device is close in character to a short circuit (vertical line), then in order to obtain a more visual image of the signature, it is necessary to set the next value in decreasing order of resistance.

WHY DO WE NEED A CHOICE OF FREQUENCY?

The test signal frequency can vary from 20 Hz to 5000 Hz, but in the case of the EyePoint range of instruments, the signal frequency range is from 1 Hz to 100 kHz. Typically, the frequency changes when testing reactive components such as capacitors and inductors. Changing the frequency changes the elliptical shape of the displayed signatures. One of the features of ***ASA EyePoint*** is the ability to actually see the signature picture as it is in reactive components, this can only be seen at a ***frequency of 100 kHz***.

YOU CAN ALSO CHOOSE THE VOLTAGE!

The test voltage is selected in the range of 200 mV to 20 V. These values refer to the peak values of the sinusoid applied to the component under test.

LET'S SUMMARIZE...

Incoming inspection of components is an integral part of product quality assurance in electronics manufacturing. As the level of complexity of manufactured products increases, the level of component responsibility in the product increases. It is especially important that when assembling critical components of control systems, incoming control of all electronic components is ensured. Failure of any one part can lead to failure of other parts, assemblies, and possibly the entire complex. Input control is necessary for all types of components, from resistors to integrated circuits (ICs).

As a rule, for the control of integrated circuits, equipment is required that performs a functional verification of the parameters against the truth table. With a large nomenclature of tested ICs, such testers are expensive, in addition, the process of writing test programs is quite laborious.

Usually, electronics manufacturers at the incoming inspection are limited to visual inspection and instrumental control of the geometry of microcircuits. However, in the absence of external damage to the case and in accordance with the drawings, there may be defects in the IC, detected only by testing the component.

Statistical data indicate that in practice, up to 80% of IC defects detected at the input control are damage to the input / output stages of integrated circuits, caused by "breakdown" of protective diodes or lack of communication between the crystal and the IC output. Therefore, for rejection of microcircuits at the incoming control, the most affordable solution is signature analysis systems.