Application Note AP205

Signature differences — device vendor differences, or a genuine fault?

Using Nodal Impedance techniques to locate faults on a net

With fault locators using techniques such as Nodal Impedance Analysis or In-Circuit Functional Test, you sometimes need to use some detective skills to get to the root cause of the problem, and a little background knowledge of typical IC inputs can help point you in the right direction. Here's an explanation of a real life fault which ultimately turned out to be an open circuit supply pin... follow the example below to find how we deduced the fault...

Consider the circuit below. Net1 connects the devices as shown.

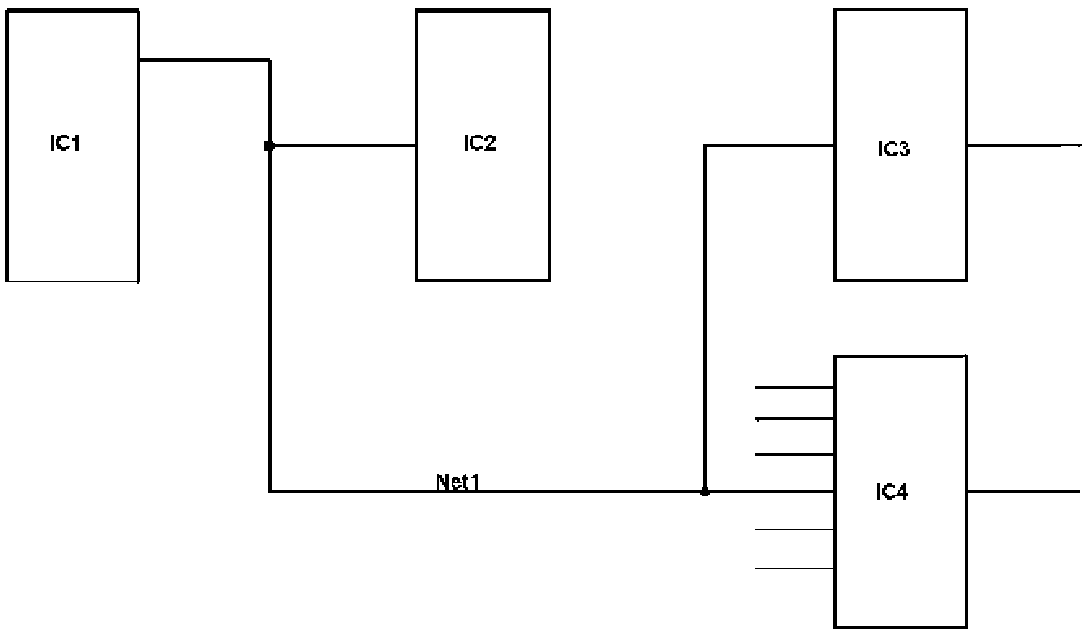
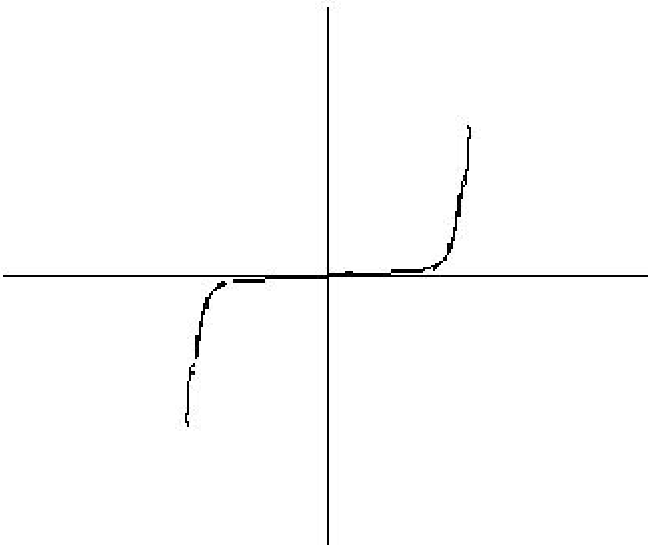


Fig 1 Typical bus based circuit

Comparing bus signatures

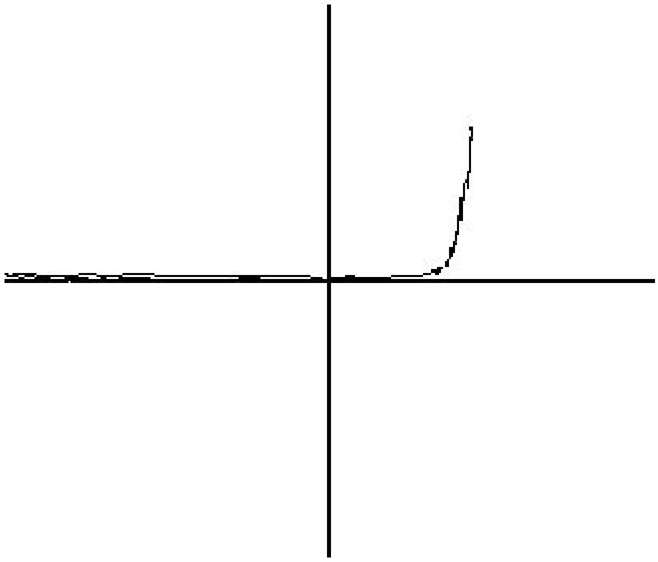
Suppose the signature on Net1 appears different from its reference signature. You would probably start by looking at the signatures on the other lines of the devices in the circuit for comparison purposes. The signatures on all the lines of a data bus should look similar and will be a composite of all the internal protection circuitry of all the devices.

In this example other net signatures look correct (see Fig 2), but the signature on Net1 and the signatures all the other pins on IC4 appear as in Fig 3.



The signatures on the good nets are typical of many data bus signatures and portray the behaviour of the device input protection diode circuitry.

Fig 2 Typical bus signature



On this board, the signature on the faulty Net1 shows significant differences from the reference signature. All the pins on this device (IC4) display similarly faulty signatures.

Fig 3 Faulty signature on Net1

So why the difference between the signatures? Look at the way signatures are created.

Polar's nodal impedance testers apply a sinusoidal waveform across a net under test and COM (usually ground) and display a graph of applied voltage versus resultant current (the net's signature). In digital circuits, you're actually applying the test voltage to the diode protection circuits of the digital IC.

Consider IC4 below (Fig 4). The diagram shows a typical (simplified) protection circuit comprising diodes D1 and D2, designed to protect the IC against voltage swings below ground and above Vcc (only one line is shown but all lines would have similar protection).

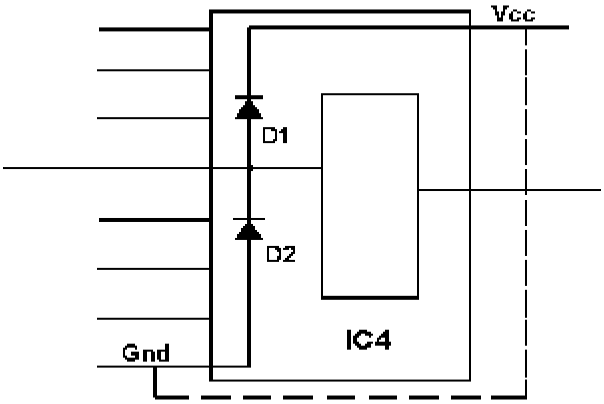


Fig 4 IC4 input protection circuitry

Device protection circuits
Looking inside IC4 — note the typical two-diode protection circuit, designed to guard against signal voltage swings outside the Vcc-Gnd range.

When testing boards with digital ICs it's common practice to connect the COM line to a convenient ground point on the board under test and also to the Vcc line, effectively shorting Vcc and ground. This can help improve the stability of signatures by removing the effects of charging/discharging the device decoupling capacitors . (See App Note 103.)

With Vcc and Gnd shorted, the applied sine wave will forward bias diode D1 and cause current to flow through D1 on the positive half cycle and do the same for D2 on the negative half cycle (the voltage applied by the tester will be sufficient on most ranges to cause both diodes to conduct). The result is the characteristic bus line signature (Fig 2).

All pins on a digital IC will include similar protection circuitry so all should exhibit similar signatures. In this case the faulty signature (Fig 3) appeared on *all* of IC4's lines, so the faulty signature revealed that each protection circuit's D2 was not conducting.

This could be caused by a faulty or wrong device or it may indicate differences in diode protection configuration between device vendors. While checking the signatures of this device with other devices from the same vendor (i.e. the same device on other boards), IC4 on other boards displayed the correct signature (Fig 2), ruling out device vendor differences.

The faulty signatures showed that no return path existed for current in any of the D2s. The line common to all D2s is the ground line. Checking the ground line showed up an unsoldered pin (open circuit ground).

As you can see, the fault would be difficult to detect using conventional methods, and probing the pin itself would have temporarily rectified the fault. By using net impedance the fault could be approached and detected using logical detective techniques.

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