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AVTECH TECHNICAL BRIEF 16 (TB16)

THE IMPORTANCE OF

MINIMIZING PARASITIC INDUCTANCE

IN FORWARD RECOVERY

MEASUREMENT SYSTEMS

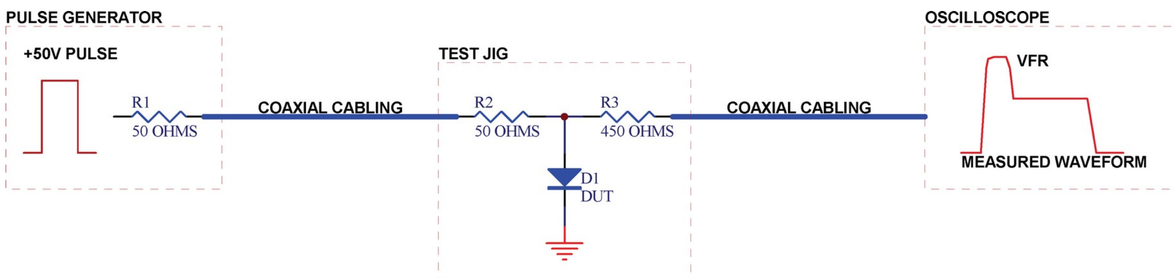
Manual Reference: /fileserver1/officefiles/instructword/appnotes/tb16/tb16.odt.
Last modified March 13, 2007.

INTRODUCTION

A manufacturer of semiconductor devices had constructed a system to measure the forward recovery voltage and time of their diodes (as per MILD-STD-750C Method 4026.2). However, the accuracy of the system was in question and the manufacturer contacted Avtech for suggestions.

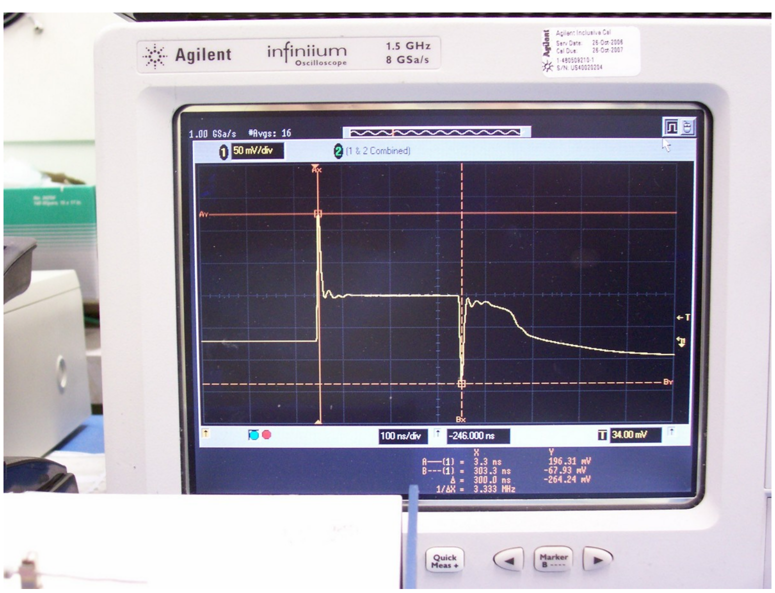
THE ORIGINAL TEST APPROACH

The basic test approach is shown below:

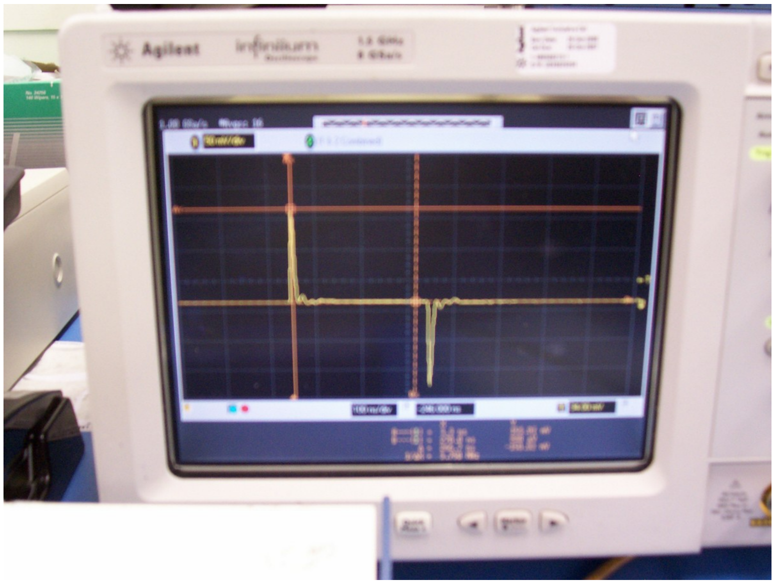


The pulse generator (an AV-1010-B, in Avtech's tests) generates +50V pulses with < 10 ns rise and fall times. The output impedance of the pulser is set to 50 Ohms, and a 50 Ohm resistance is in series with the DUT, so the pulsed current is (50V / 100 Ohms) = 500 mA. The 450 Ohms in the output branch is terminated by an oscilloscope with 50 Ohm input impedance, so that the oscilloscope displays V_{DUT} / 10.

The device manufacture was obtaining output waveforms like those shown below:



The user was concerned about the large spikes on the rise and falling edges. To determine if these were caused by the device action itself, or by parasitic inductance, the user replaced the DUT with a short circuit (a small piece of wire). The resulting waveform showed the same spikes:

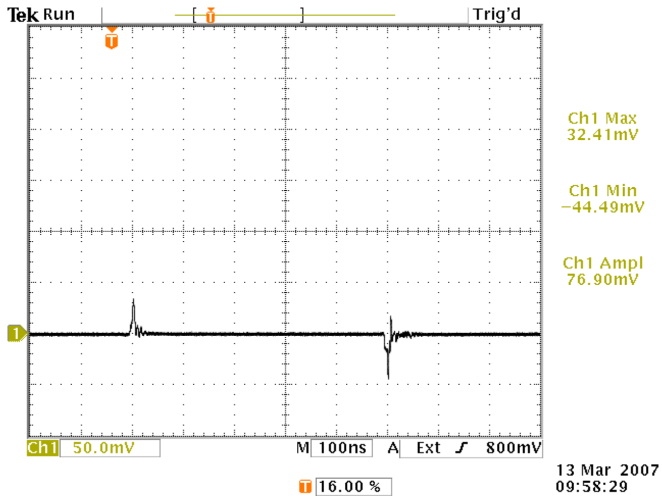


This clearly shows that the spikes are inductive in nature. The rising-edge spike is equal and opposite to the falling-edge spike, as one would expect for an inductor. The parasitic inductance can be estimated from the amplitude of the spikes ($V \approx 1.4V$), the current ($dI \approx 500$ mA), and the rise time ($dt \approx 10$ ns): $V = L \times dI / dt$, so $L \approx 28$ nH.

The inductance of #24 wire is roughly 10 nH / inch, and a typical DO-41-type axial package may have ~ 5 nH internally, so the user's circuit has an equivalent of 2.3 inches of inductive wiring. This can clearly be improved.

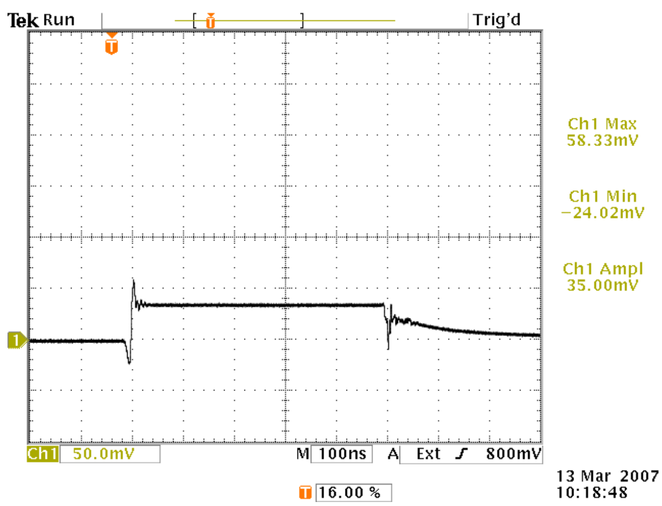
AVTECH'S IMPROVED TEST JIG

Avtech constructed a test jig using proper transmission line design concepts and high-speed pin sockets, to accommodate DO-41, TO-220, and similar thru-hole packages. With a shorting wire installed in the sockets, the following waveform was obtained:



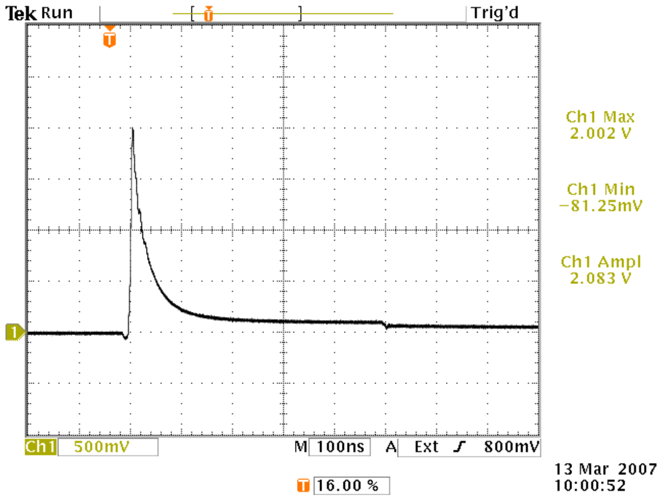
This waveform is scaled at 50 mV/div and 100 ns/div, the same as the user's waveform on the previous page. The inductive spike is approximately 35 mV × 10 = 350 mV, about one-quarter of that observed before. This corresponds to ~ 7 nH of inductance, most of which comes from the shorting wire itself.

The following waveform is obtained when a high-speed low-voltage Schottky diode (the 1N5819) is installed:



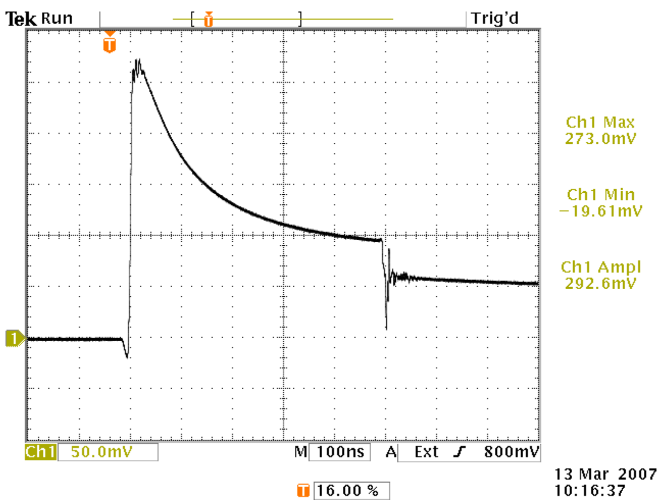
A small inductive spike is observed on both edges of the waveform. Most of this spike is due to the internal device inductance, and is thus “real” and needs to be included in V_{FR} measurements.

Schottky diodes are known for very fast forward transients. Non-Schottky diodes can be much slower and less conductive initially. Consider for instance the 1N4937 fast recovery rectifier:



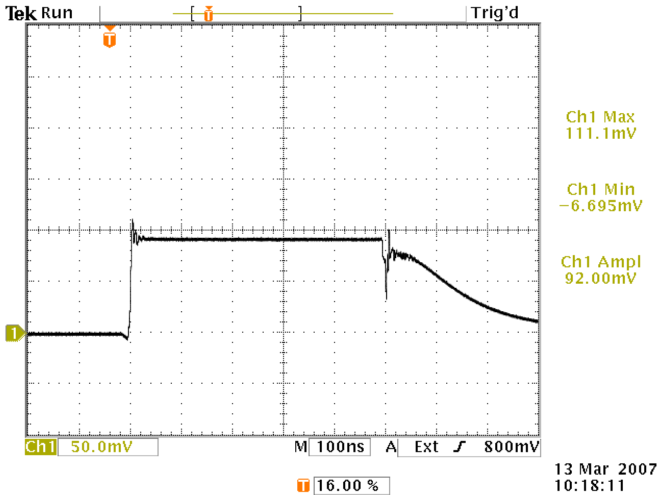
In this test, V_{FR} reaches 20V (2.002V × 10), compared to 0.58V for the 1N5819! In this case, the inductance of the original test jig would not have been noticed, because the inductive voltage was far smaller than the voltage generated by the PN junction itself.

The MUR8100E is a less extreme example; its V_{FR} reaches 2.73V:



The MUR8100E is very slow to turn on – the turn-on transient has not actually finished in the above waveform before the input pulse ends.

A high-voltage Schottky diode, the CSD10120, shows the same fast turn-on as the 1N5819 but it settles to a higher stead-state forward voltage drop (0.92V, versus 0.35V for the CSD10120):



SUMMARY

To measure a realistic value for V_{FR} in modern Schottky diodes and other rectifiers, it is important to minimize the test jig parasitic inductance.

Avtech can provide suitable customized test jigs for use with a variety of packages. Contact Avtech at info@avtechpulse.com with your requirement!