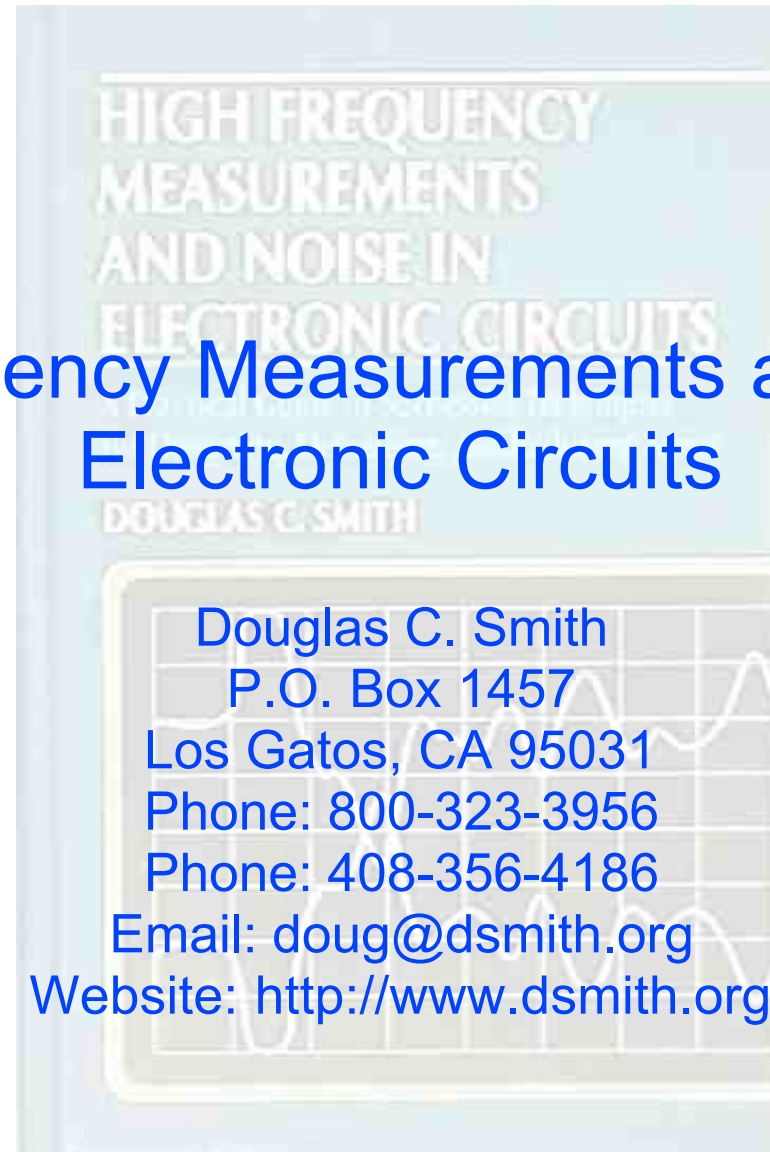


# High Frequency Measurements and Noise in Electronic Circuits



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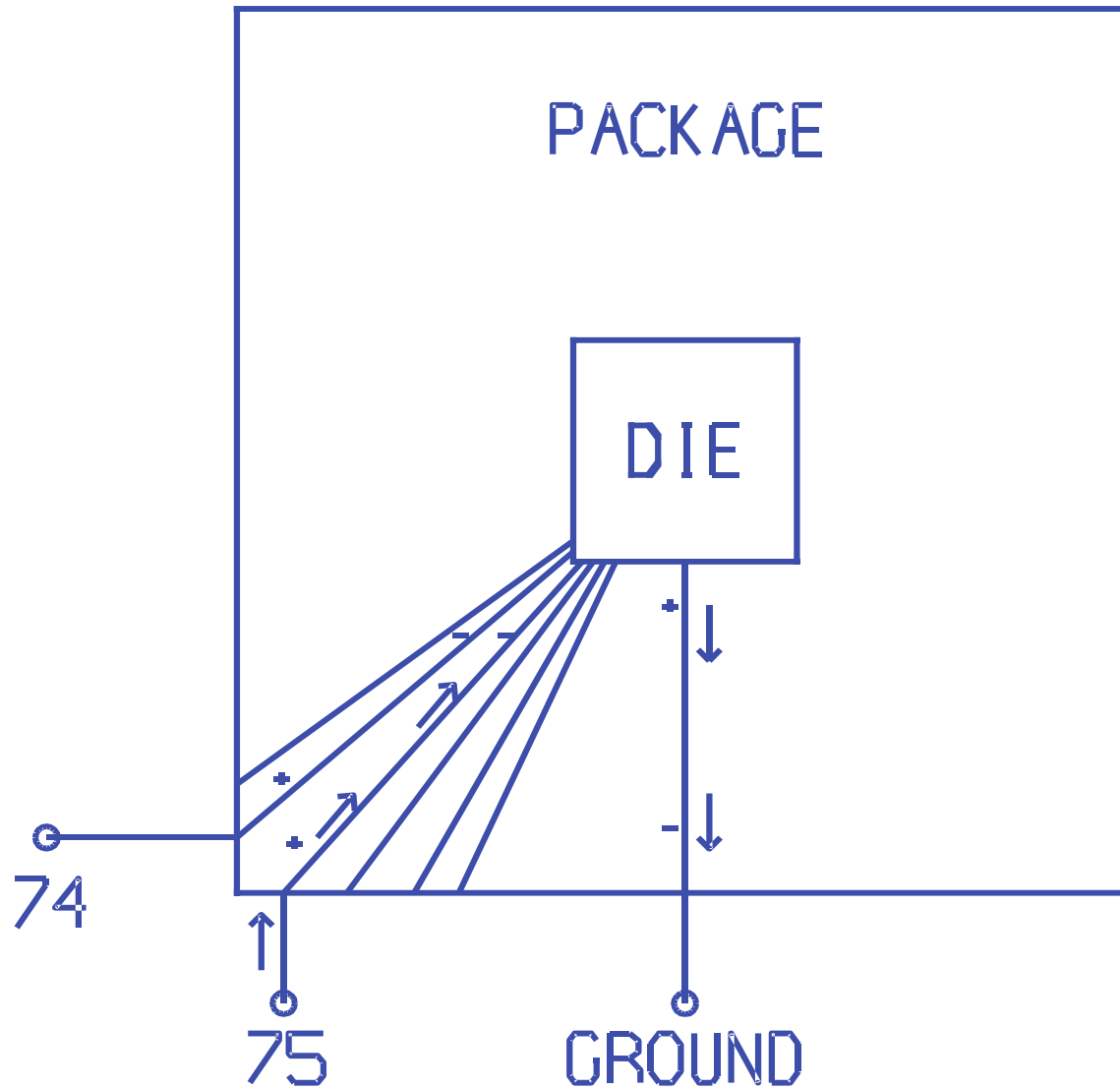
## IC NOISE MEASUREMENT

A square loop can be used to measure inductive drop in chip bonding wires within the IC package and even in the IC die itself.

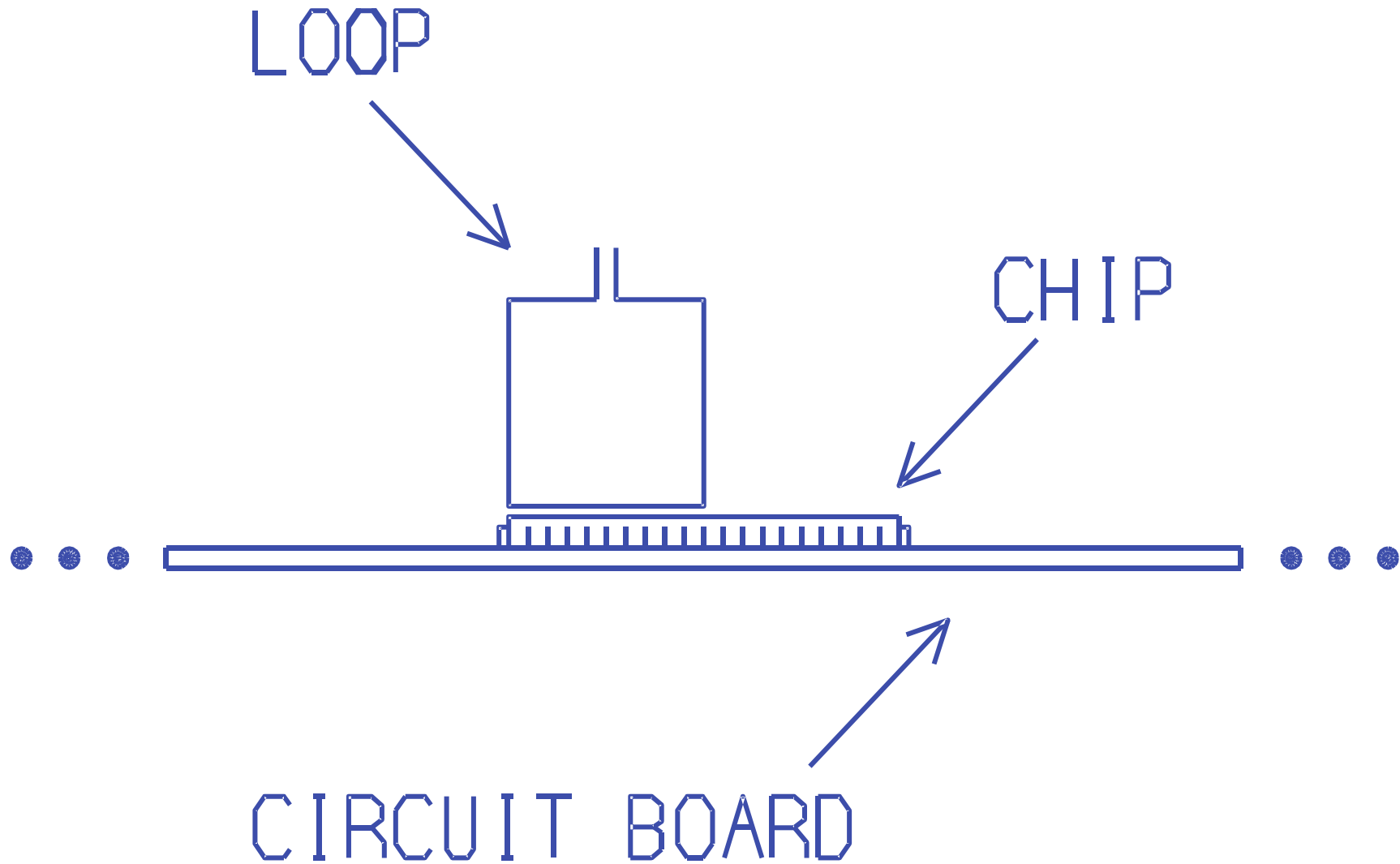
By triggering on the inductive pickup and using a second scope channel to look at each chip output one at a time, resultant glitches in the signals can be seen and measured.

Reference: *A Method for Troubleshooting Noise Internal to an IC*, Douglas C. Smith, Proceedings of the 1997 IEEE EMC Symposium, pp. 223-225.

# A Typical IC



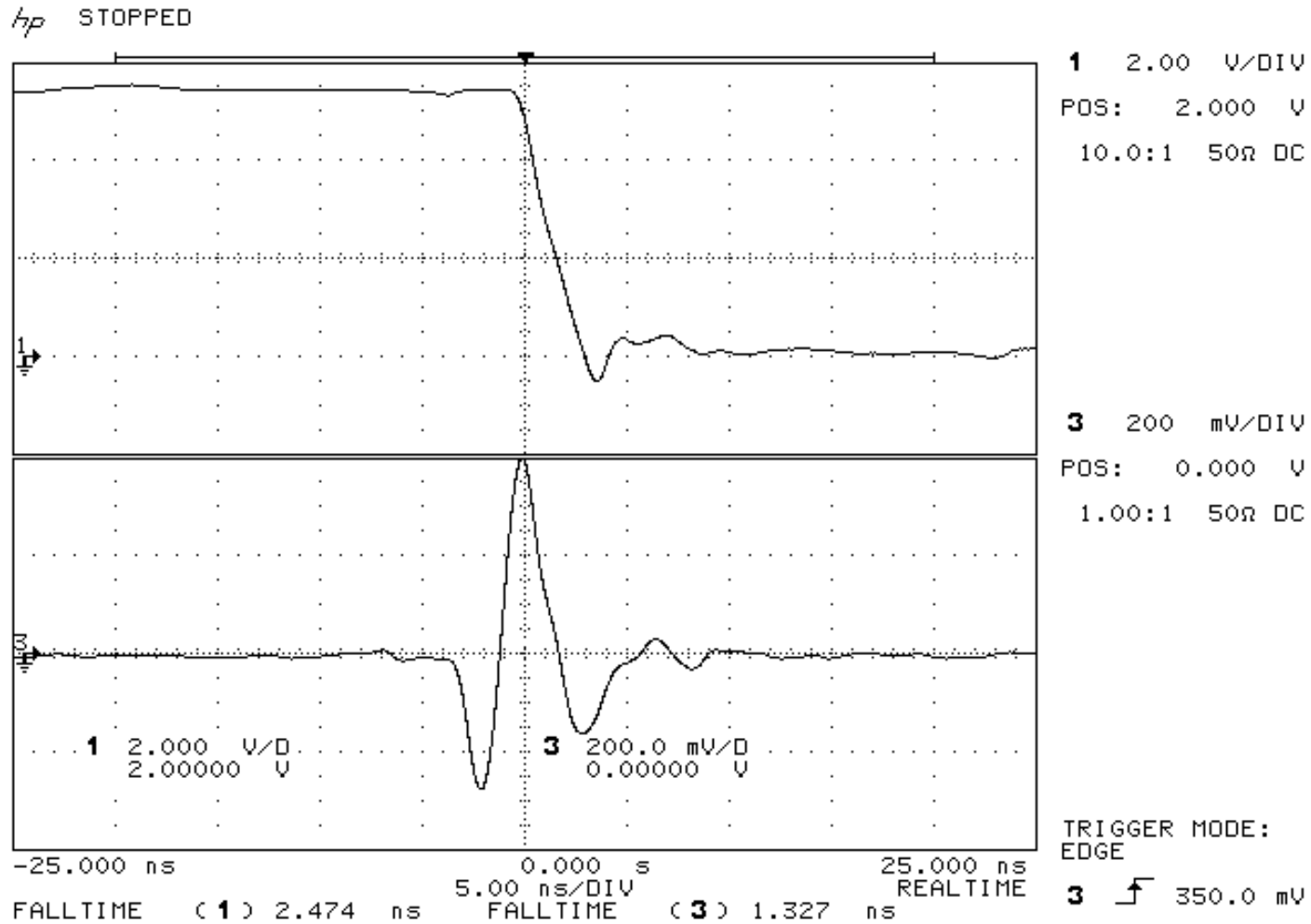
# IC Noise Measurement Setup



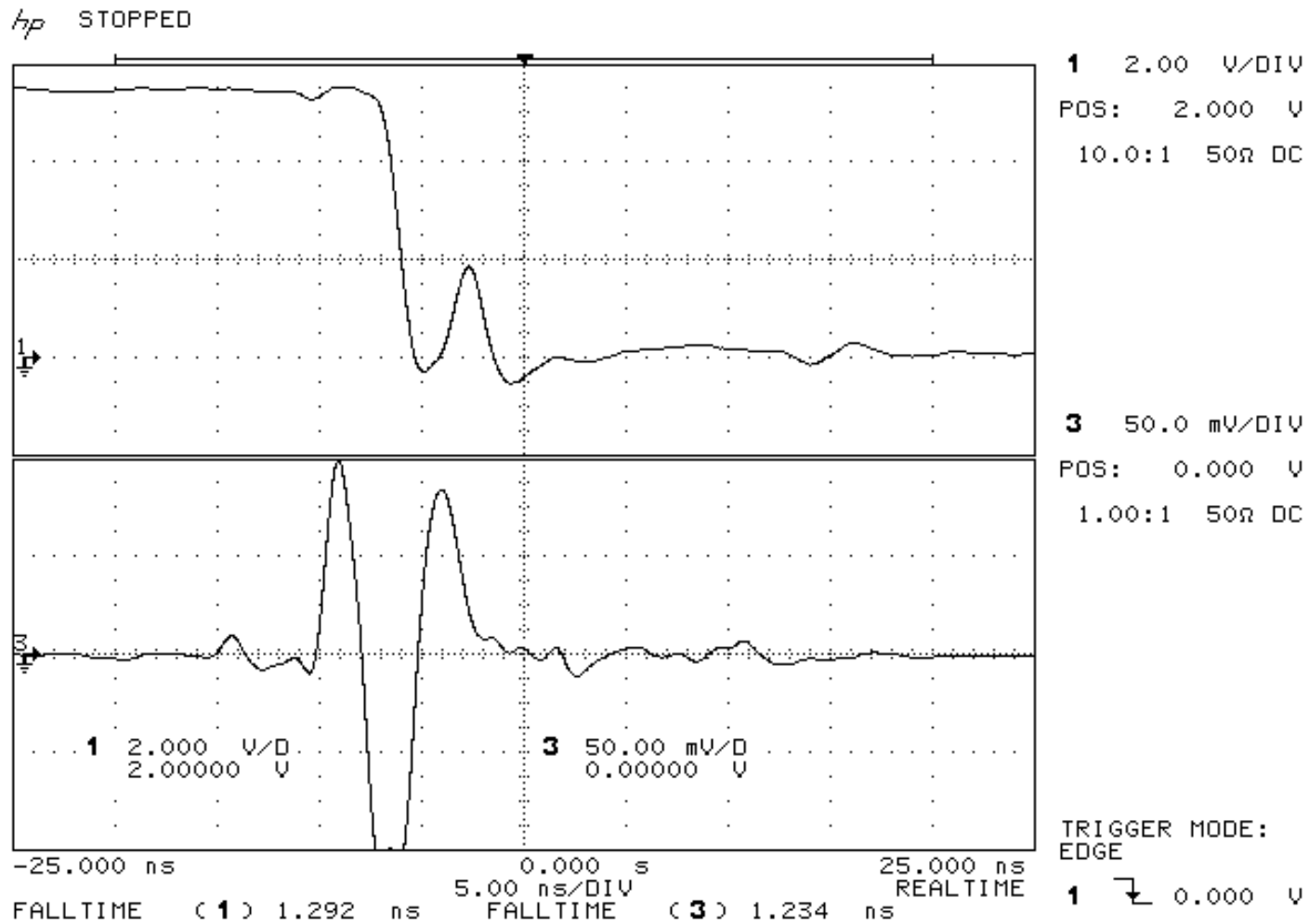
## IC Noise Measurement Method

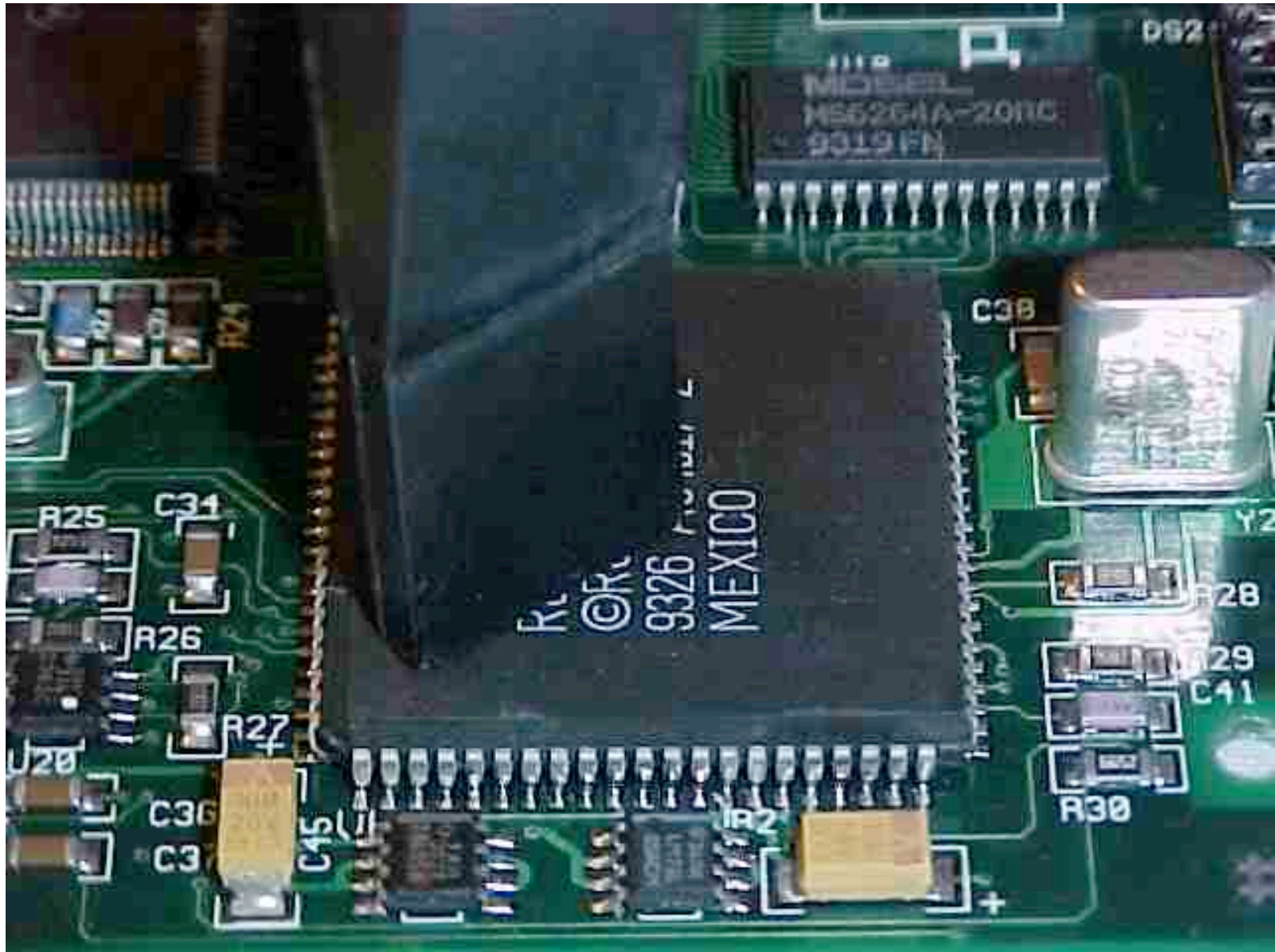
- 1) **Slowly** rotate the loop around the chip with one corner of the loop at the chip package center.
- 2) **Mark** positions of the loop where pickup noise is greater than 50 mV.
- 3) At each of the marked positions, **measure** all chip outputs with a scope probe on the second channel.

# IC Noise Measurement #1

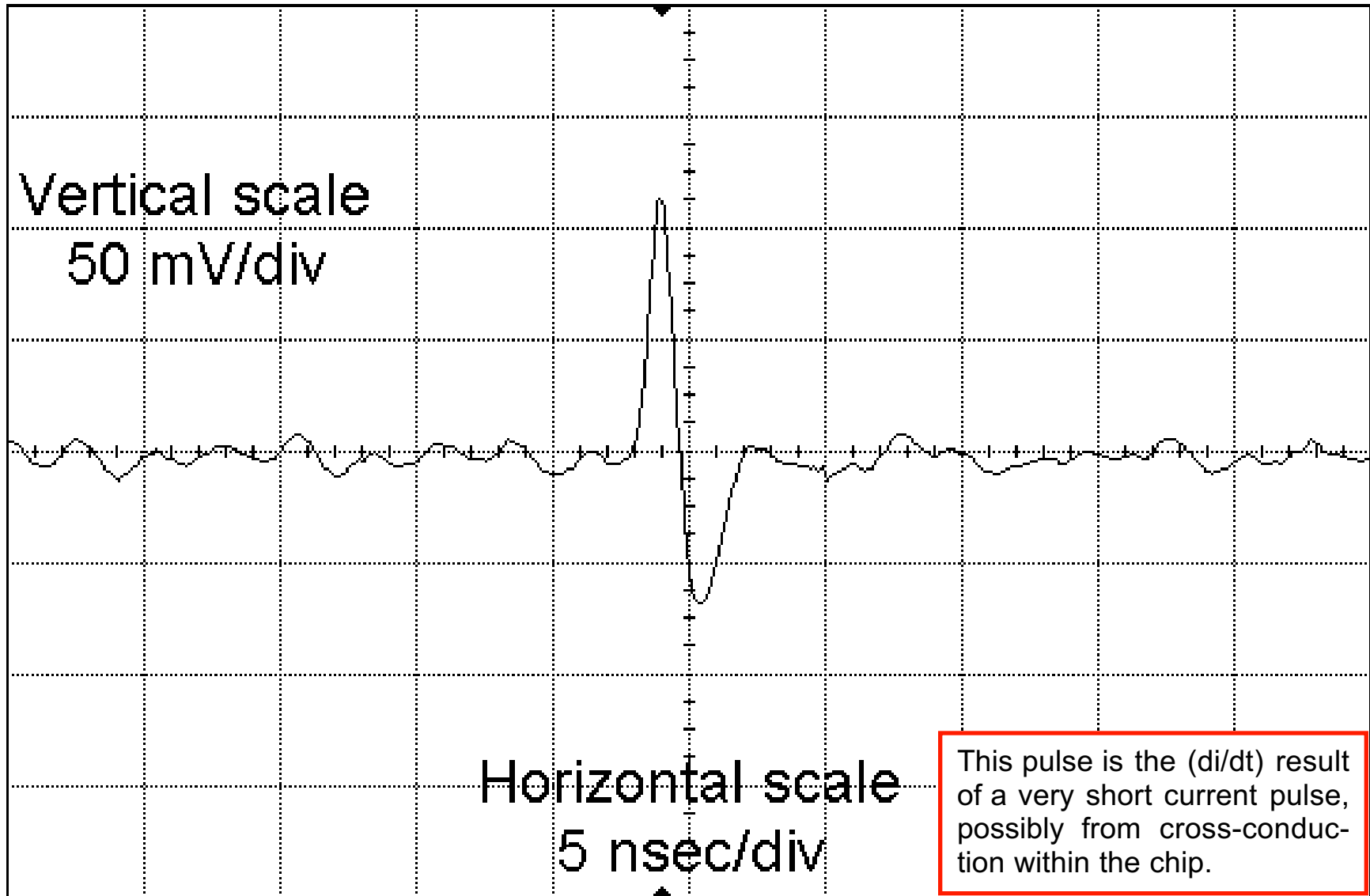


# IC Noise Measurement #2





## Position of Loop for Measurement

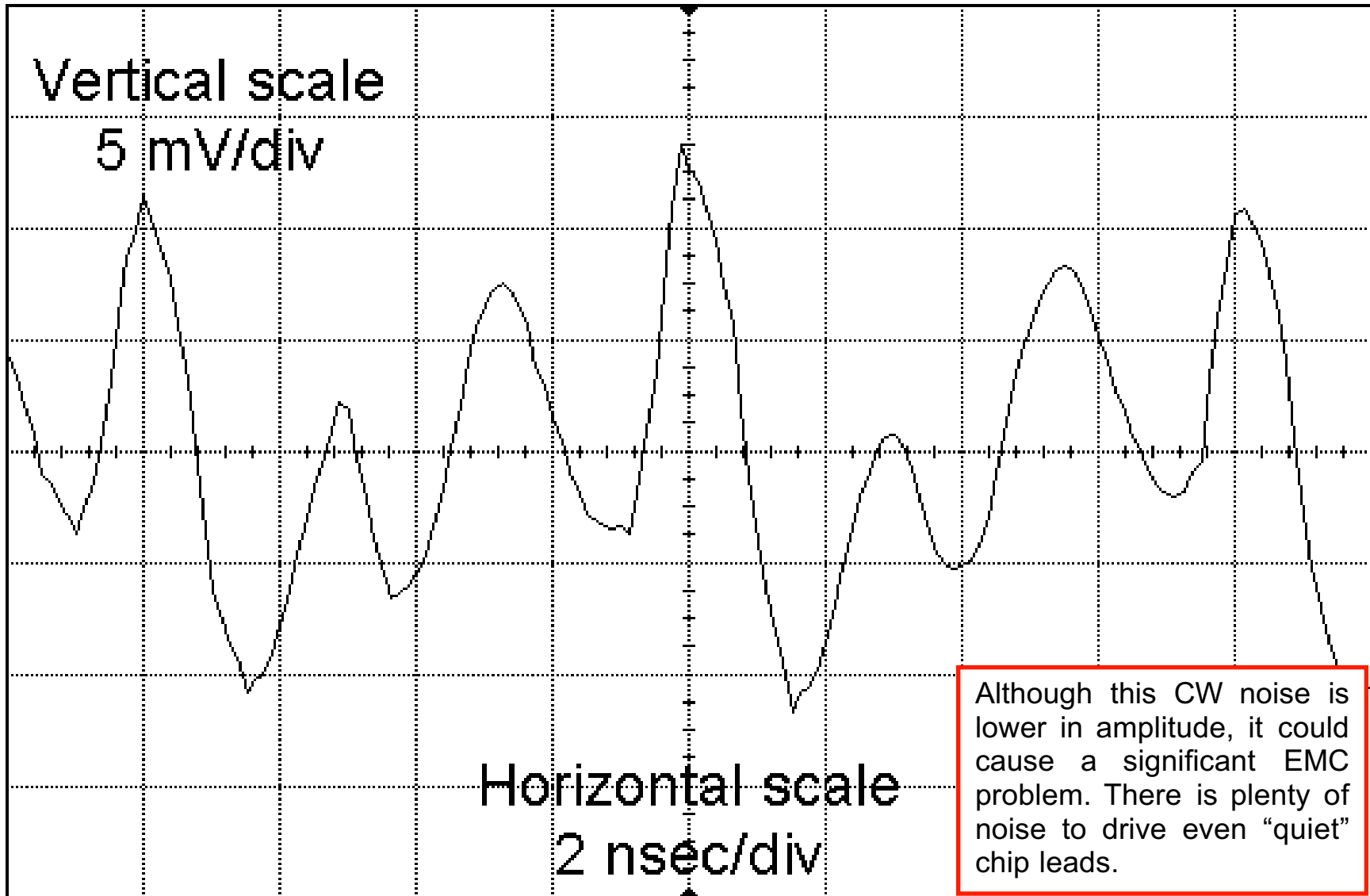


## Example of Pulsed Noise

## Characteristics of Possible SI Problems

- Usually isolated pulses
- High peak values ( $> 50$  mV)
- Cross conduction is potential problem.  
(spike followed immediately by spike of opposite polarity as in the last figure)
- Spike amplitude is often bit pattern sensitive.

Note: Remember, the loop only reads 1/4 or less of the actual voltage drop across the package leads.



## Example of CW Noise

## Characteristics of Possible EMC Problems

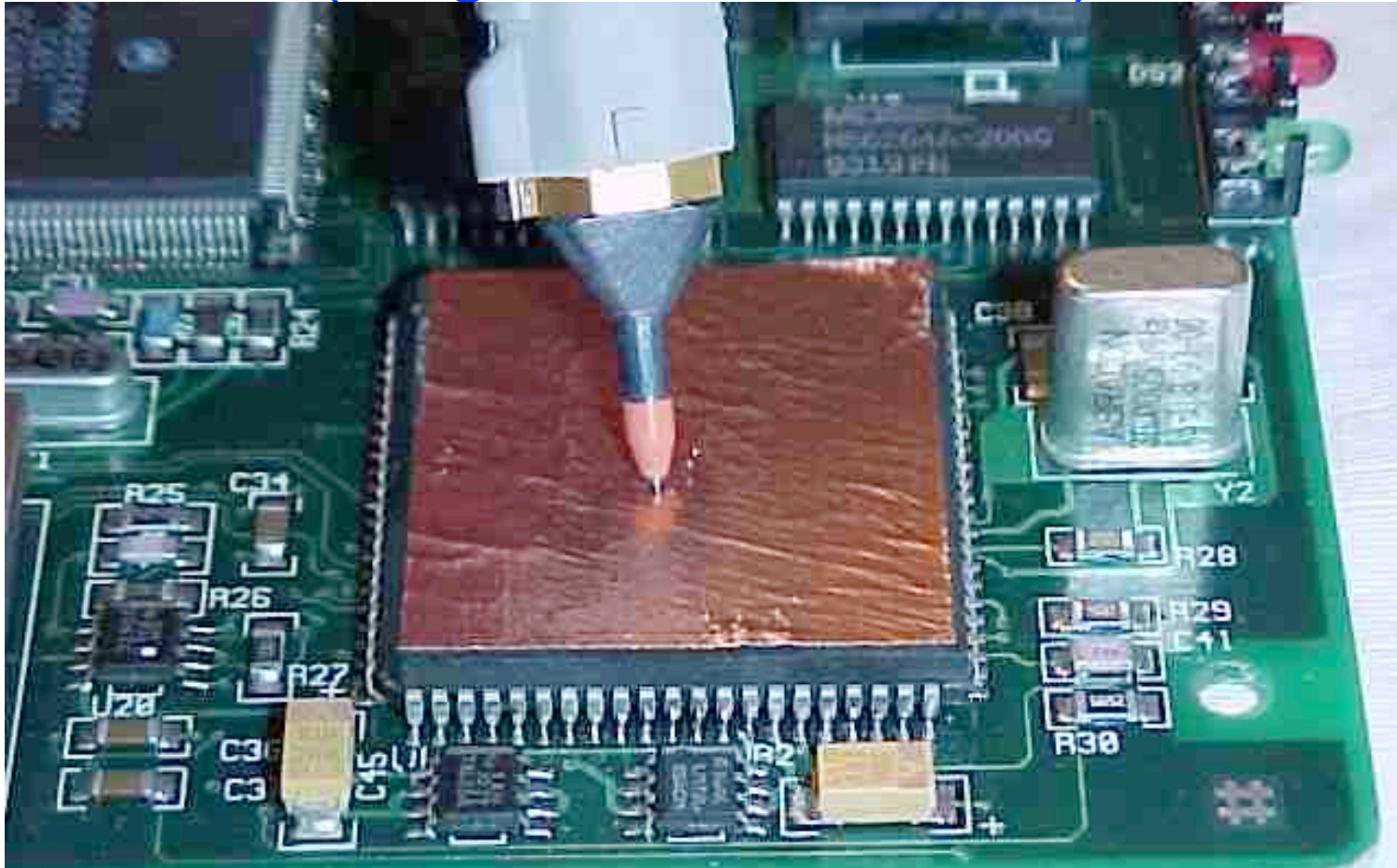
- Usually continuous signals
- Can have low peak values ( $\sim 10$  mV)
- Clocks and other regular signals are possible causes.
- Spike amplitude is not usually bit pattern sensitive.

Note: Remember, only a few mV can drive a half-wave dipole to an emissions failure.

# Capacitively Coupled Chip Measurements

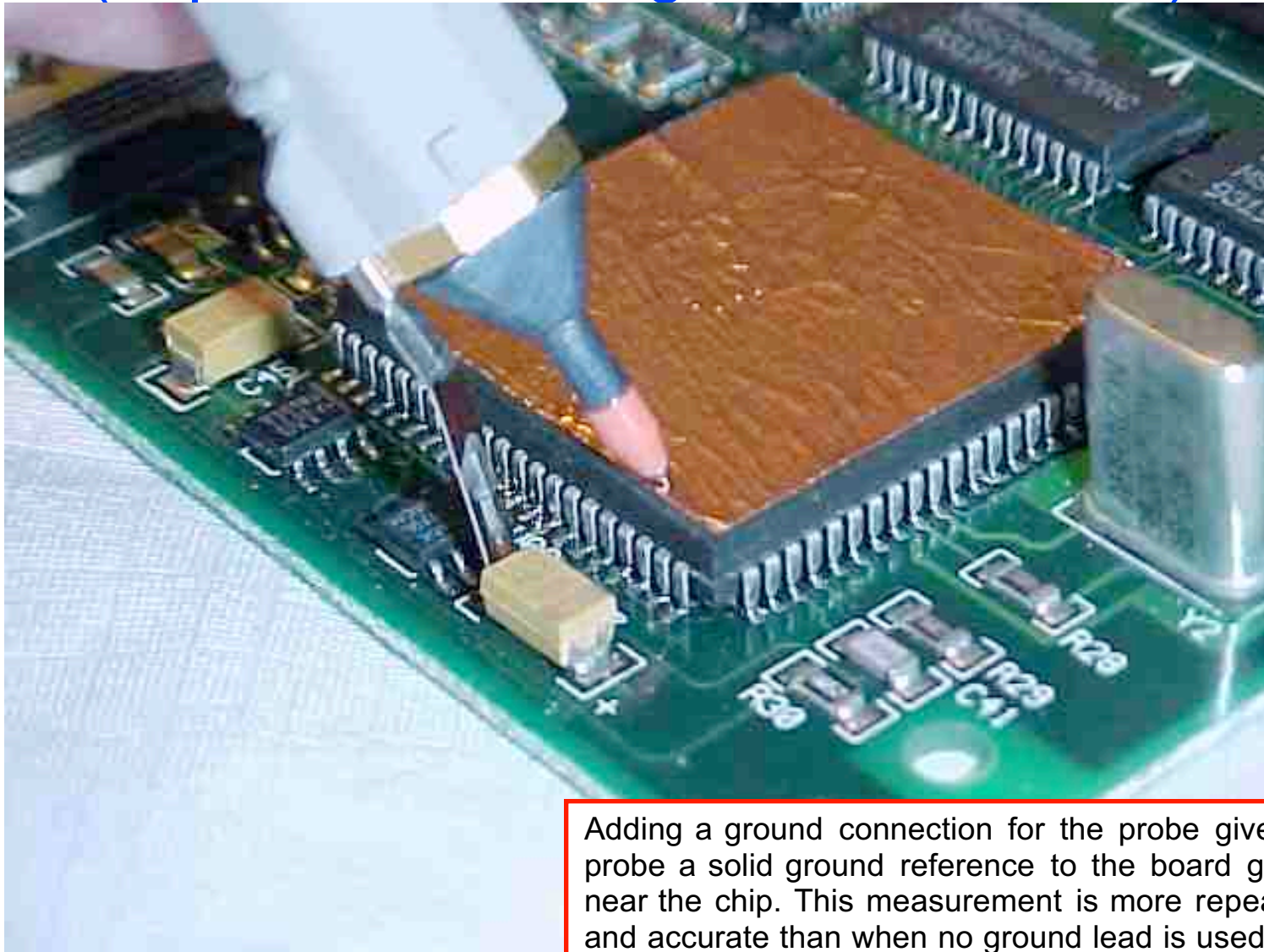
- Measure internal signal risetimes
- Develop chip “signature” for troubleshooting
- Gives insight into chip-heatsink coupling

## Using Low Capacitance Probe (no ground connection)



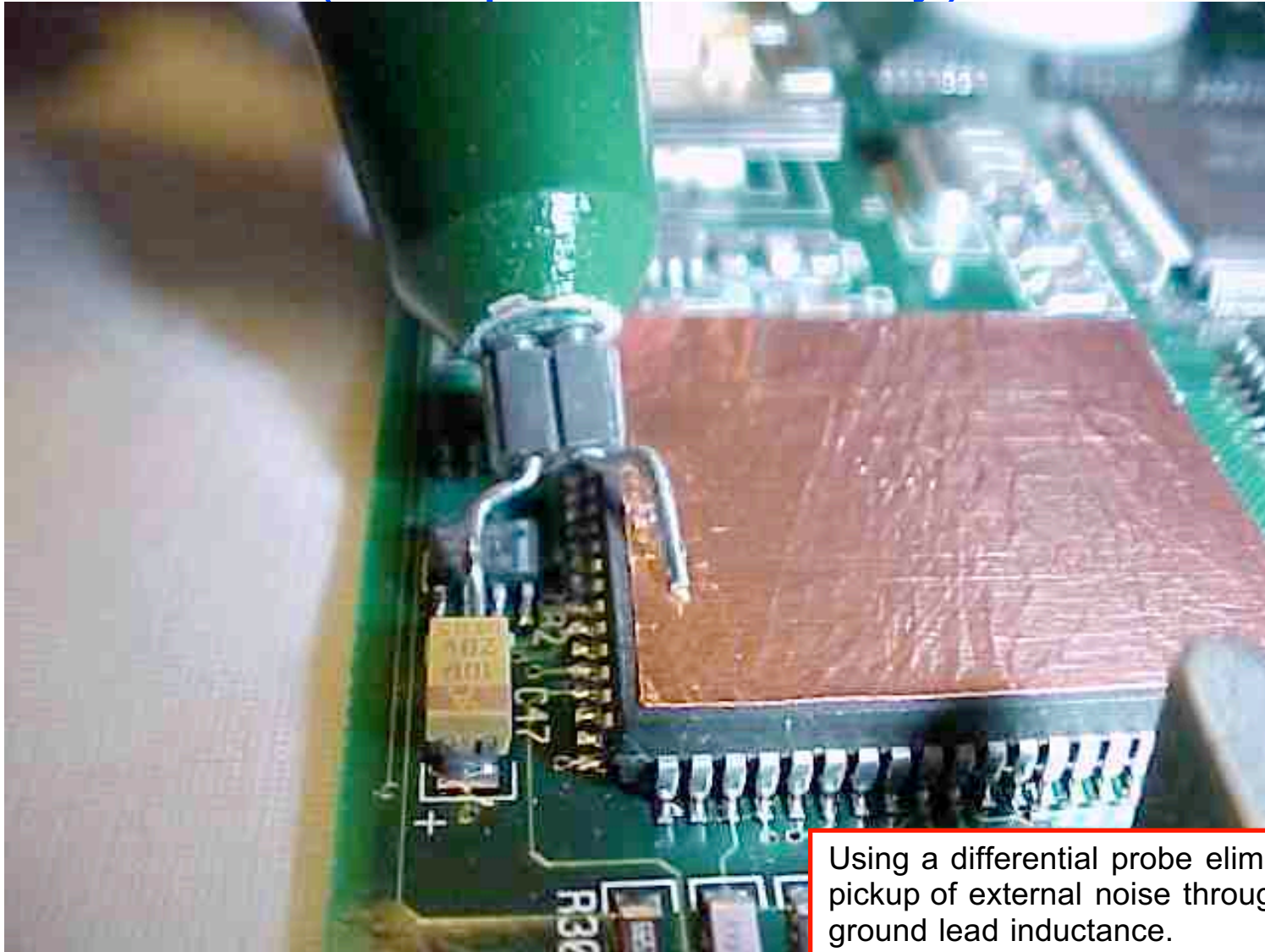
The probe is connected to the chip die and bonding wires through a capacitive divider (chip to copper tape and probe input capacitance). The probe ground reference is completed through probe and body capacitance to the average of the board ground. As regions of the chip change state, the probe will read voltage variations that represent the fraction of the die that changes state.

## Using a Ground Lead (to provide a solid ground reference)

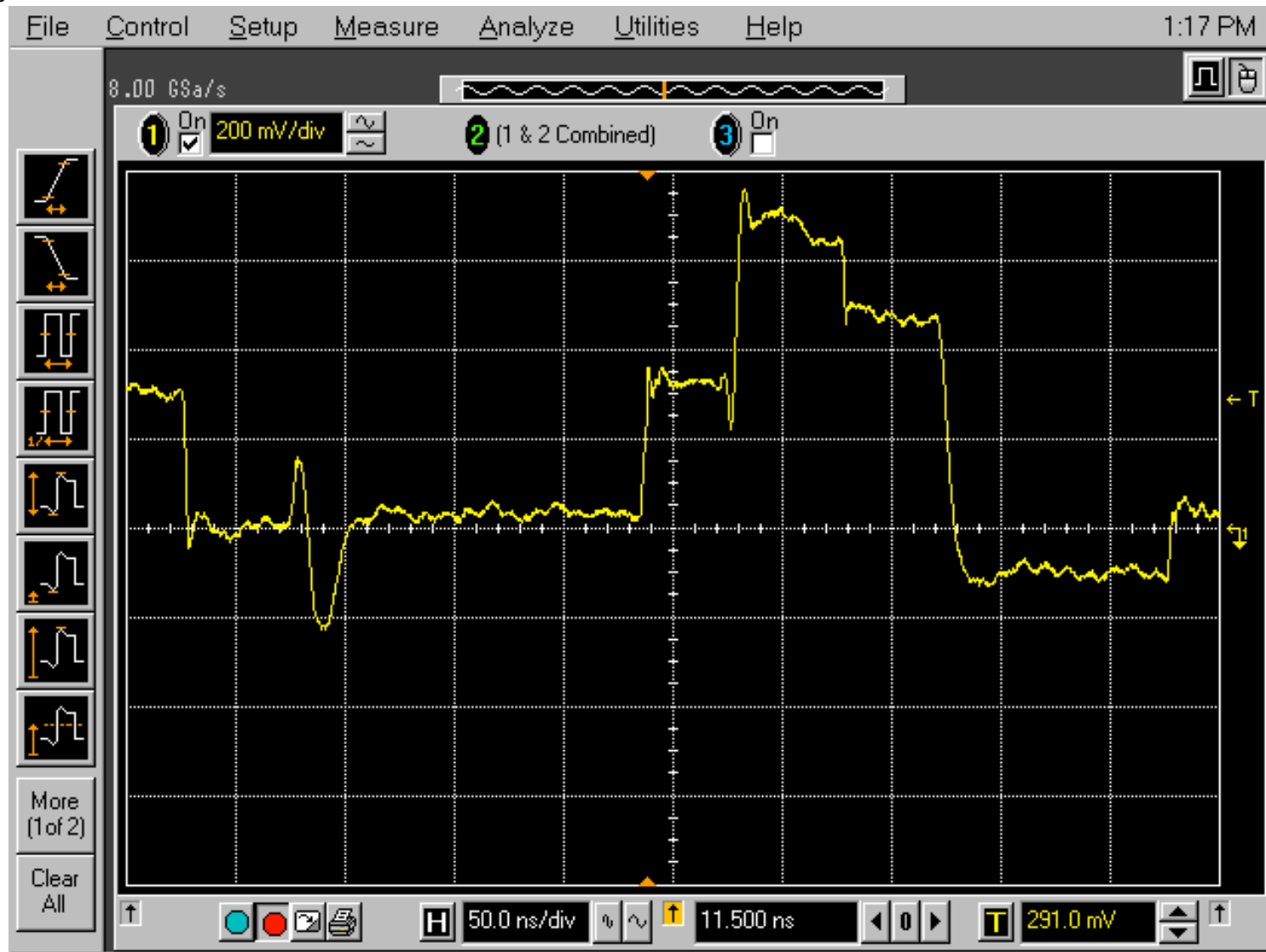


Adding a ground connection for the probe gives the probe a solid ground reference to the board ground near the chip. This measurement is more repeatable and accurate than when no ground lead is used.

## Using a Differential Probe (to improve accuracy)

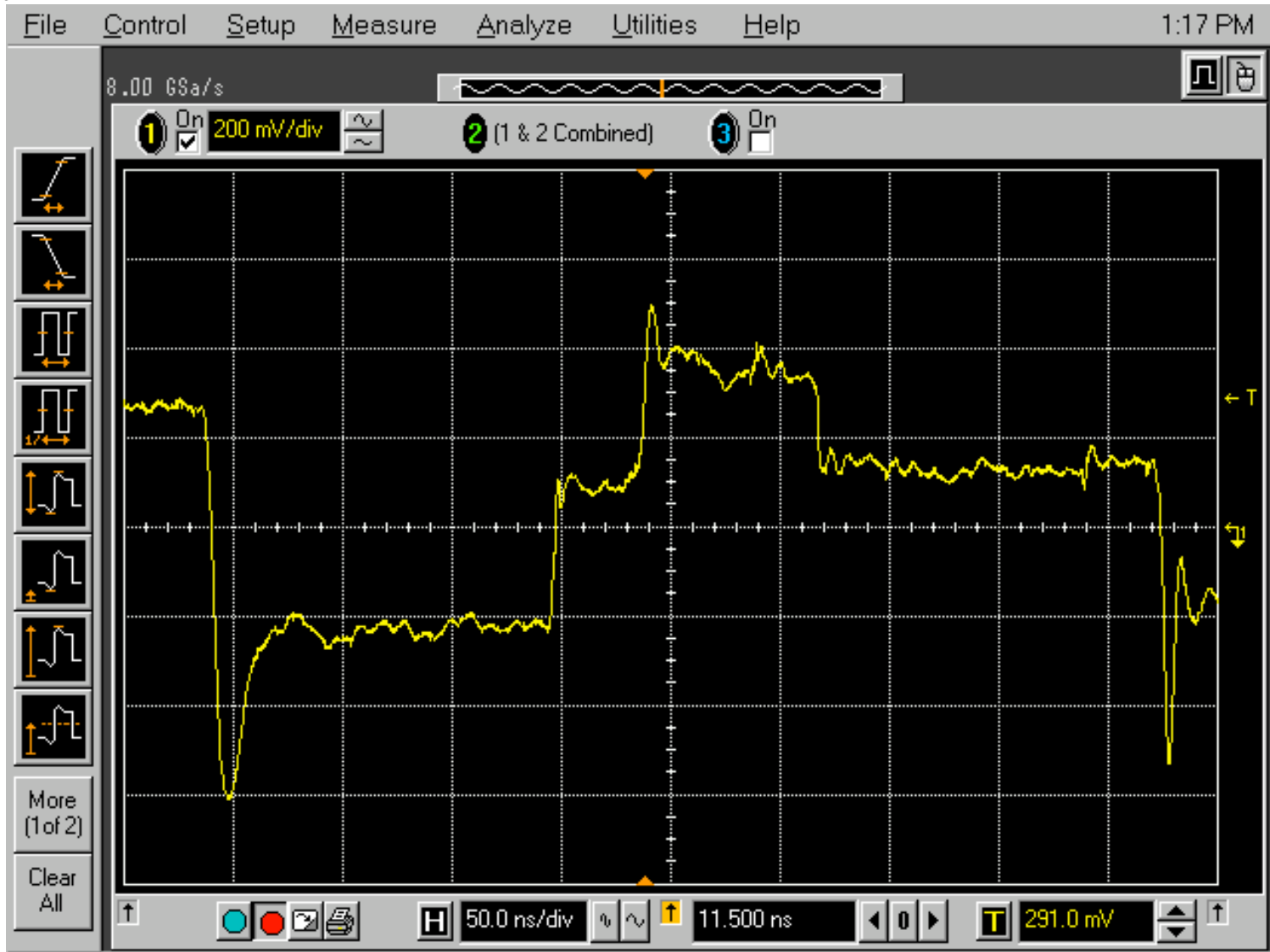


Using a differential probe eliminates pickup of external noise through the ground lead inductance.

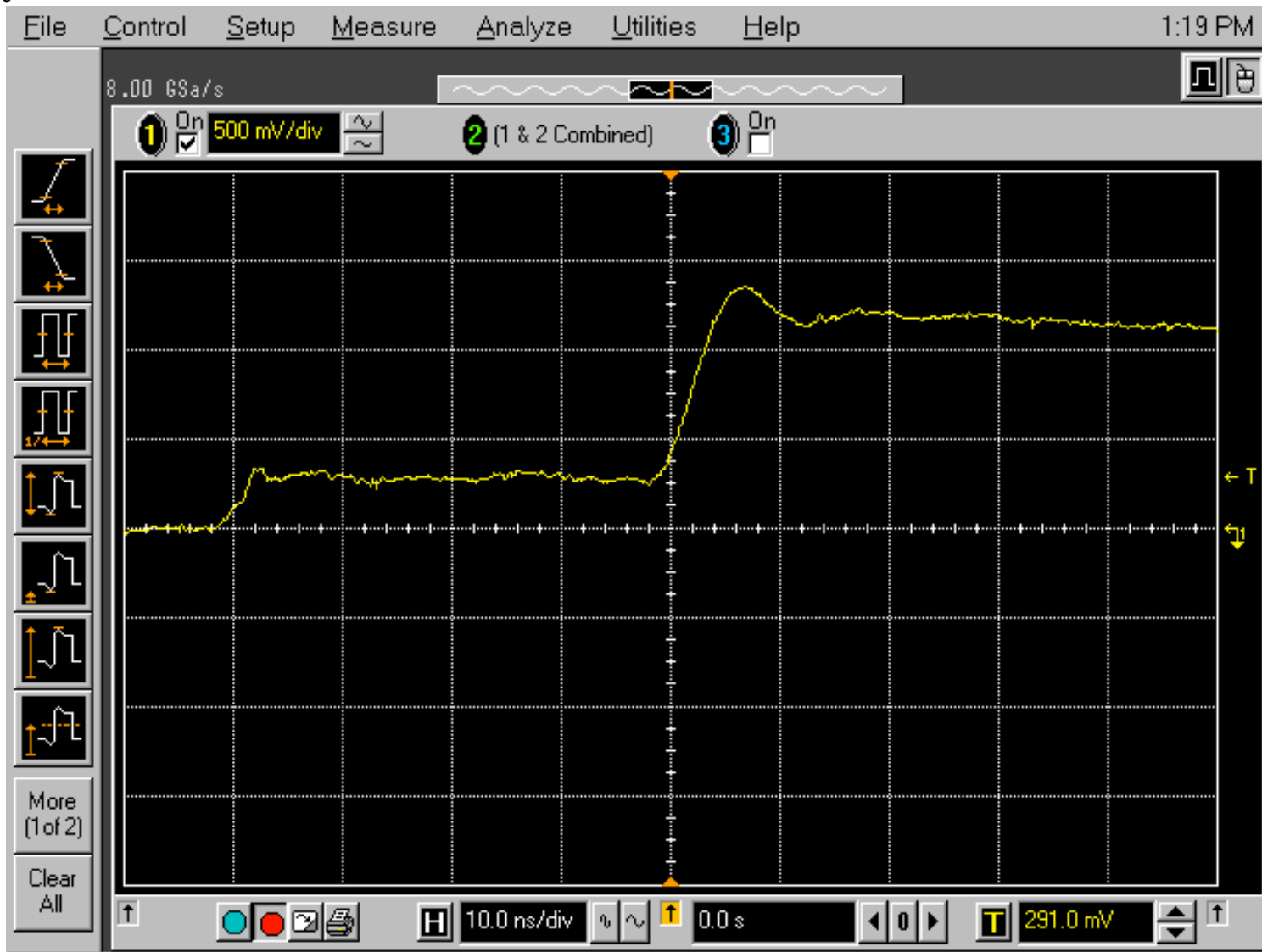


## Typical Waveform

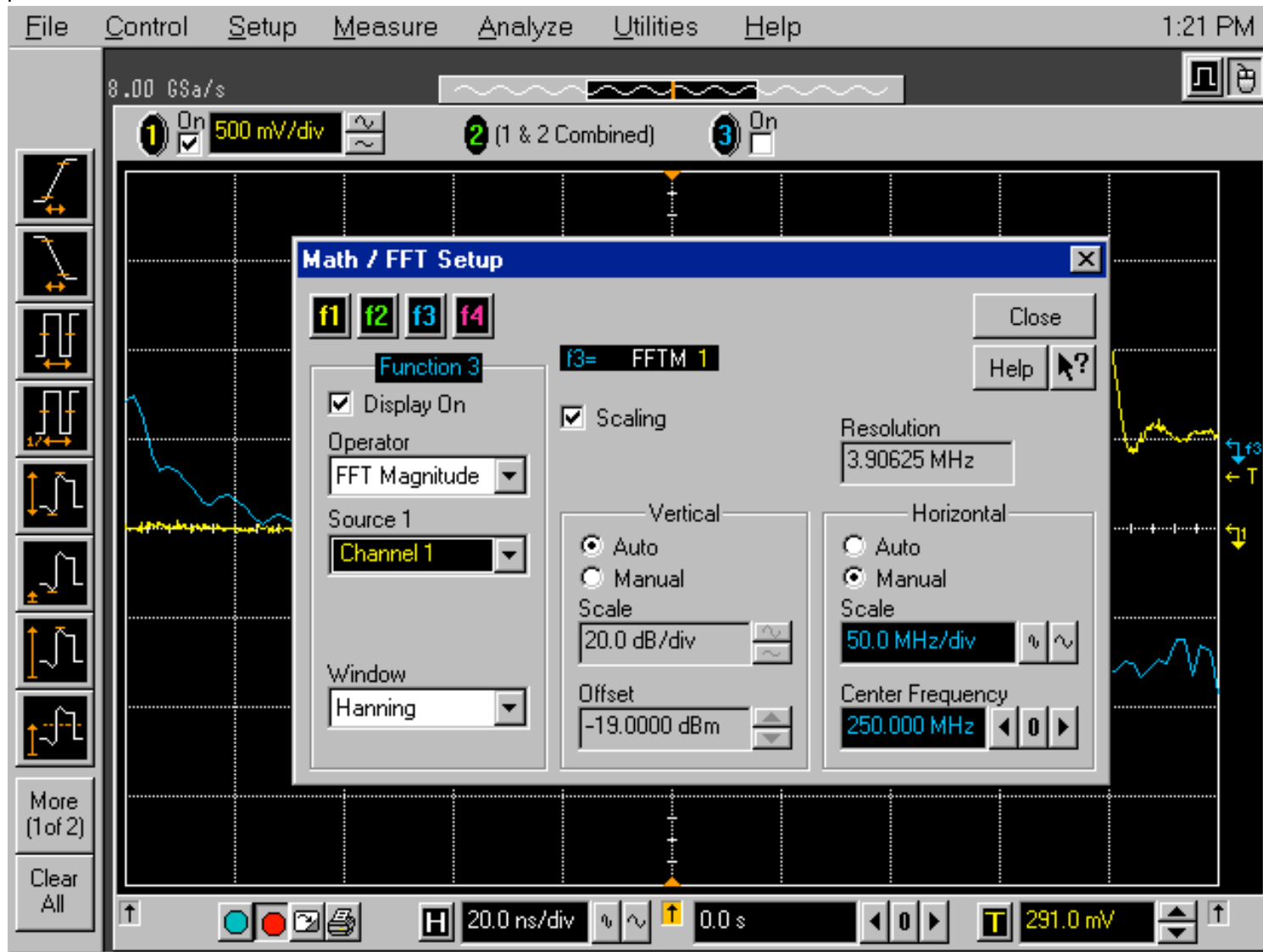
Risetimes and clock rates can be seen in the wave-form above. The amplitudes also give an estimate of the fraction of the chip that has changed state (ground bounce modifies this estimate).



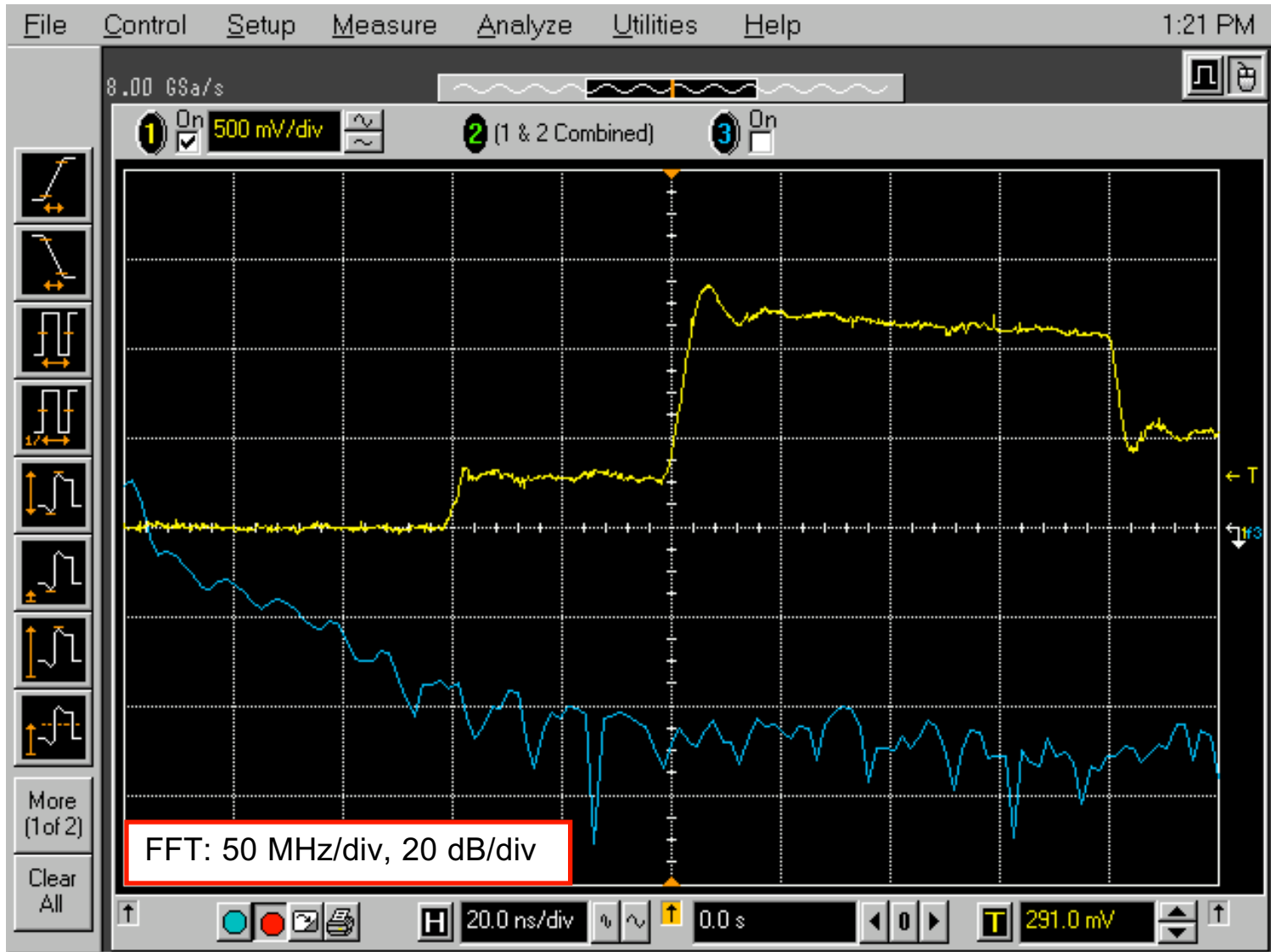
## Another Example



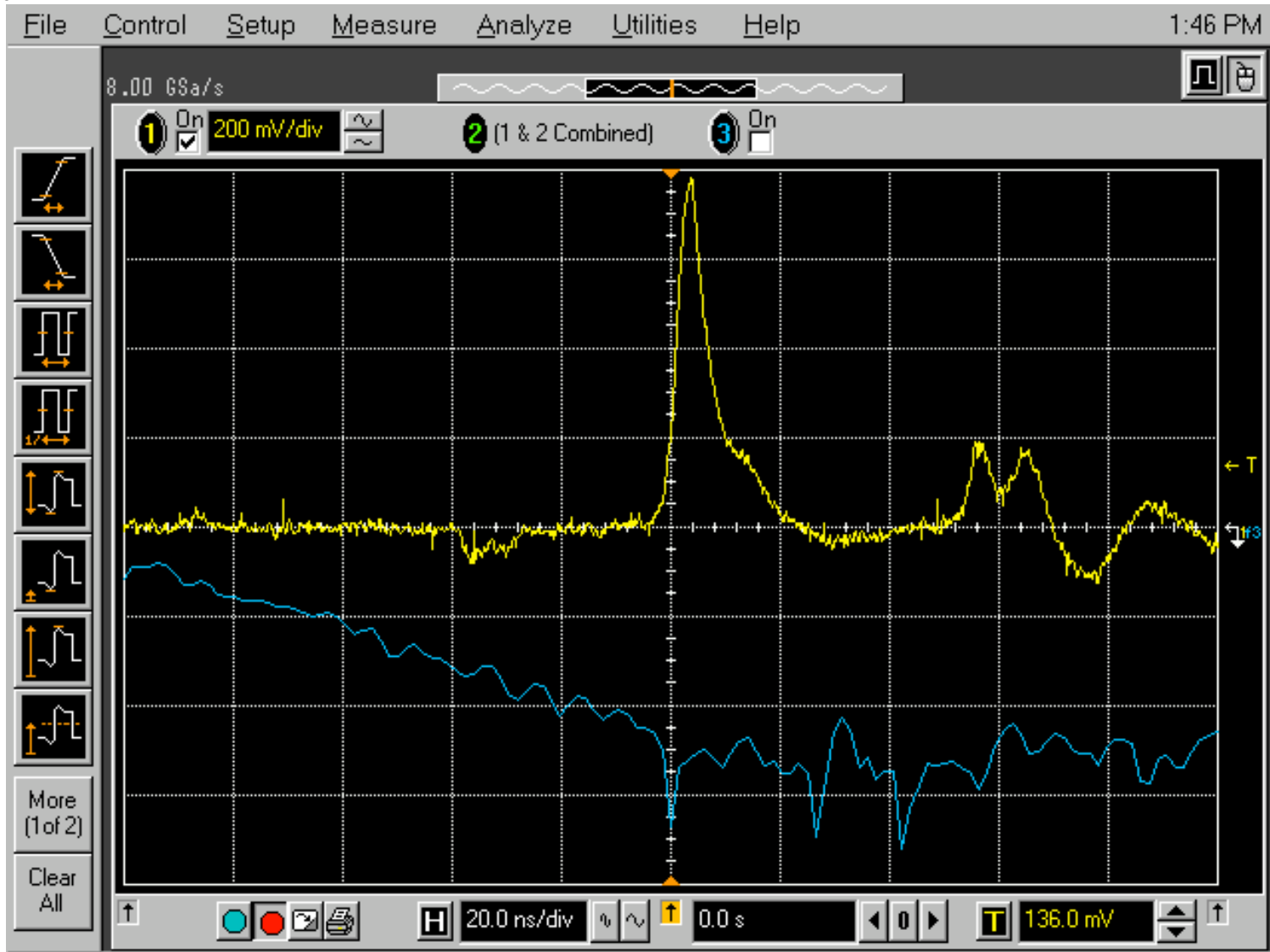
## Edge Rates of Chip Signals Can Be Seen



## FFT Parameters of Measurement



## FFT Example



## Measurement with Passive Differential Probe

Resistive input impedance of the passive differential probe reduces low frequency response.

## Chip Noise Summary

- Chip noise as a result of package parasitics (inductance and crosstalk) can result in strange problems.
- New chips and old chips, implemented in a new technology, should be evaluated to make sure the package can support the chip speed.
- A good scope, voltage probe, home-made magnetic probe, and copper tape can be very useful for evaluating packages.