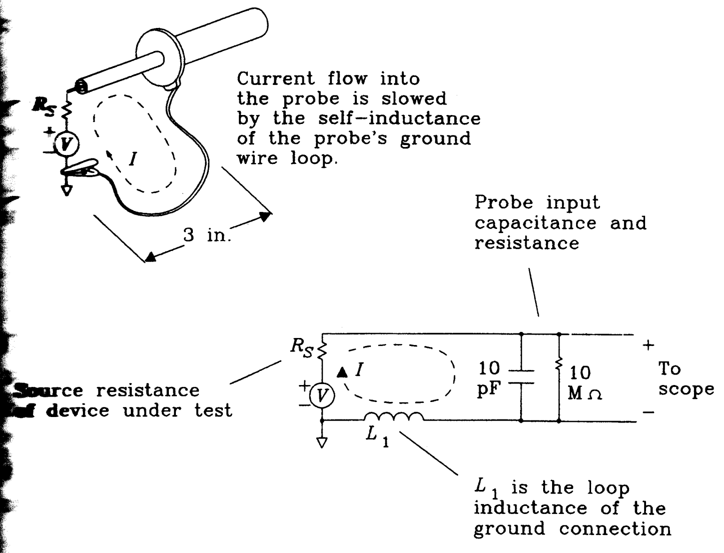

Figure 3.4 Electrical model of an oscilloscope probe.

to their source. The self-inductance of the ground loop, represented in series inductance L_1, impedes these currents.

the inductance L_1 affect our measurements? The reactance of L_1, work- impedance of the probe input, has a finite rise time. We will calculate find the 10–90% rise time, and then discuss its significance.

Ground Loop Inductance

of the ground loop in Figure 3.4 are 1 in. × 3 in. A typical ground wire of probe is American Wire Gauge (AWG) 24, having a diameter of the inductance formula from Appendix C for the case of a rectangular inductance is

$$L \approx 10.16\left[1 \ln\left(\frac{2\times 3}{0.02}\right) + 3 \ln\left(\frac{2\times 1}{0.02}\right)\right] \text{nH} \qquad [3.9]$$

$$\approx 200 \text{ nH}$$

the 10–90% Rise Time

stant for this circuit is

$$C = 10 \text{ pF}$$
$$L = 200 \text{ nH}$$
$$T_{LC} = (LC)^{1/2} = 1.4 \text{ ns} \qquad [3.10]$$

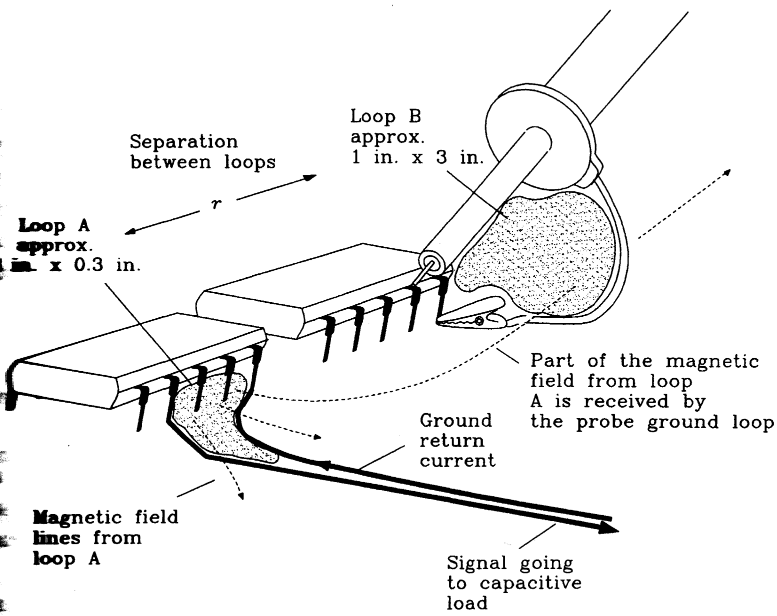

Figure 3.9 A probe ground loop picks up spurious noise voltages.

ual Inductance of Loops *A* and *B*

for loops A and B appear in Figure 3.9, and so we need only apply the formu- pendix C for the mutual inductance of two loops.

$$L_M = 5.08 \frac{A_1 A_2}{r^3} \quad [3.18]$$

$$= 5.08 \frac{(0.3 \times 0.3)(1 \times 3)}{2^3} \quad [3.19]$$

$$= 0.17 \text{ nH} \quad [3.20]$$

where A_1 = area of loop 1, in.^{2}

A_2 = area of loop 2, in.^{2}

r = separation of loops, in.

L_M = mutual inductance between loops 1 and 2, H

y the Definition of Mutual Inductance

voltage induced in loop B is the product of the rate of change in current in loop mutual inductance of loops A and B:

$$V_{\text{noise}} = L_M \frac{dI}{dt} = (0.17 \text{ nH})(7.0 \times 10^7 \text{ V/s}) = 12 \text{ mV} \quad [3.21]$$

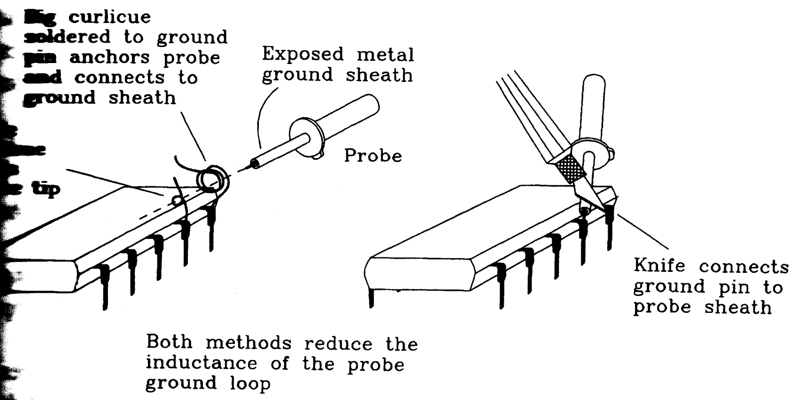

Figure 3.8 Methods for grounding a probe tip near a signal under test.

the knife blade method? Table 3.1 lists the 10–90% rise time in nanoseconds function of the ground loop inductance for both TTL (30-Ω) and ECL (10-Ω) ...ts.

TABLE 3.1 EFFECT OF GROUND LOOP INDUCTANCE ON 10- AND 2-pF PROBE PERFORMANCE

Ground loop inductance (nH)	10-pF probe			2-pF probe		
	$T_{10\text{–}90}$	Q_{TTL}	Q_{ECL}	$T_{10\text{–}90}$	Q_{TTL}	Q_{ECL}
200	2.8	4.7	14.1	1.3	10.5	32.0
100	2.0	3.3	9.9	0.89	7.4	22.0
30	1.1	1.8	5.4	0.49	4.1	12.0
10	0.6	1.1	3.2	0.28	2.4	7.1
3	0.3	0.6	1.7	0.15	1.3	3.9
1	0.2	0.3	1.0	0.09	0.7	2.2

10-pF probe, we would have to get the loop inductance down below 10 nH to ... overshoot performance on TTL rise times of 1 ns. For ECL circuits, we ... even lower inductance.

... reduced loop inductance, let's try replacing the ground wire in Figure 3.4 ... wire. If the original wire was AWG 24, we can try AWG 18, which has ...meter. Reworking Equation 3.9 for this new ground lead,

$$L \approx 10.16\,[1\ \ln(3/0.02) + 3\ \ln(1/0.02)]\ \text{nH} \qquad [3.16]$$

$$\approx 170\ \text{nH} \qquad [3.17]$$

... slowly inductance changes as a function of wire diameter? Doubling the ... in this case makes only a 15% change in inductance. The slow variation in