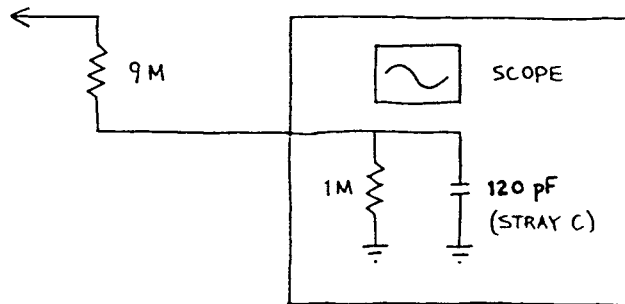


補充資料 <五> ——— X10 probe 的結構
 Scope Probe

That mishap leads nicely into the problem of how to design a scope probe.

Until now, we have fed the scope with BNC cables. They work, but at middling to high frequencies they don't work well. Their heavy capacitance (about 30 pF/foot) burdens the circuits you look at, and may make those circuits misbehave in strange ways—oscillating, for example. So, we nearly always use “10×” probes with a scope: that's a probe that makes the scope's input impedance 10× that of the bare scope. (The bare scope looks like 1MΩ parallel about 120pF—cable and scope.)

Here is a defective design for a 10× probe:



不好的探針

Figure N3.3: Crummy 10× probe

Do you see what's wrong? It works fine at DC. But try redrawing it as a Thevenin model driving a cap to ground, as in the example we did at the start of these notes. The flaw should appear. What is f_{3dB} ?

Remedy

We need to make sure our probe does *not* have this low-pass effect: scope and probe should treat alike all frequencies of interest (the upper limit is set by the scope's maximum frequency: for most in our lab that is up to 50 or 60 MHz; a few are good to 100 MHz).

The trick is just to build two voltage dividers in parallel: one resistive, the other capacitive. At the two frequency extremes one or the other dominates (that is, passes most of the current); in between, they share. But if each delivers $V_{in}/10$, nothing complicated happens in this “in-between” range.

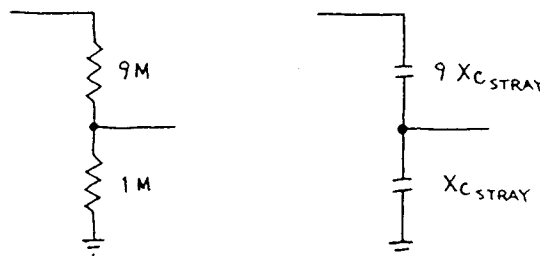


Figure N3.4: Two dividers to deliver $V_{in}/10$ to the scope

What happens if we simply *join* the outputs of the two dividers? Do we have to analyze the resulting composite circuit as one, fairly messy thing? No. No current flows along the line that joins the two dividers, so things remain utterly simple.

So, a good probe is just these two dividers joined:

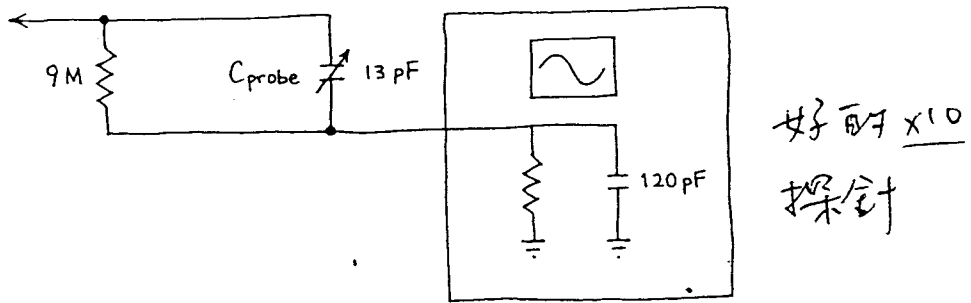


Figure N3.5: A good $\times 10$ probe: one capacitor is trimmable, to allow use with scopes that differ in C_{in}

Practical probes make the probe's added C adjustable. This adjustment raises a question: how do you know if the probe is properly adjusted, so that it treats all frequencies alike?

Probe "compensation": Fourier again

One way to check the frequency response of probe and scope, together, would be to sweep frequencies from DC to the top of the scope's range, and watch the amplitude the scope showed. But that requires a good function generator, and would be a nuisance to set up each time you wanted to check a probe.

The easier way to do the same task is just to feed scope and probe a *square* wave, and then look to see whether it looks square on the scope screen. If it does, good: all frequencies are treated alike. If it does not look square, just adjust the trimmable C in the probe until the waveform *does* look square.

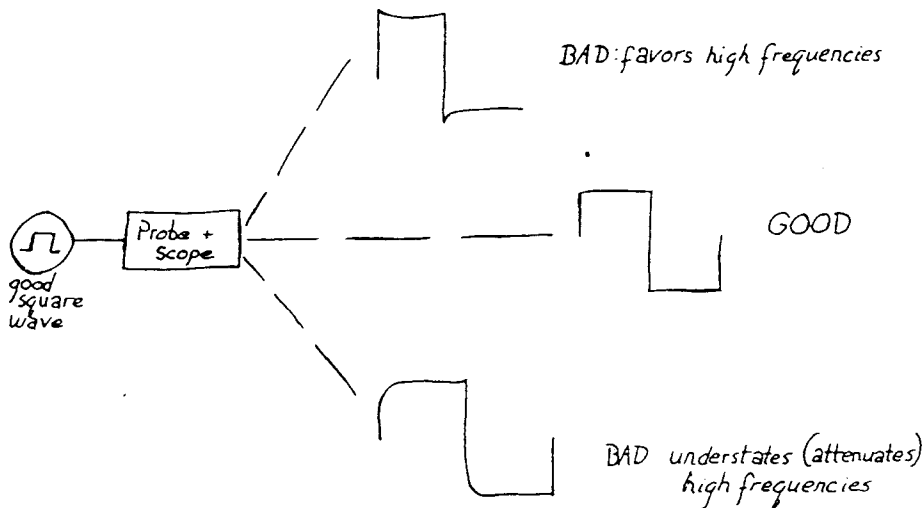


Figure N3.6: Using square wave to check frequency response of probe and scope

Neat? This is so clearly the efficient way to check probe *compensation* (as the adjustment of the probe's C is called) that every respectable scope offers a square wave on its front panel. It's labeled something like *probe comp* or *probe adjust*. It's a small square wave at around 1kHz.