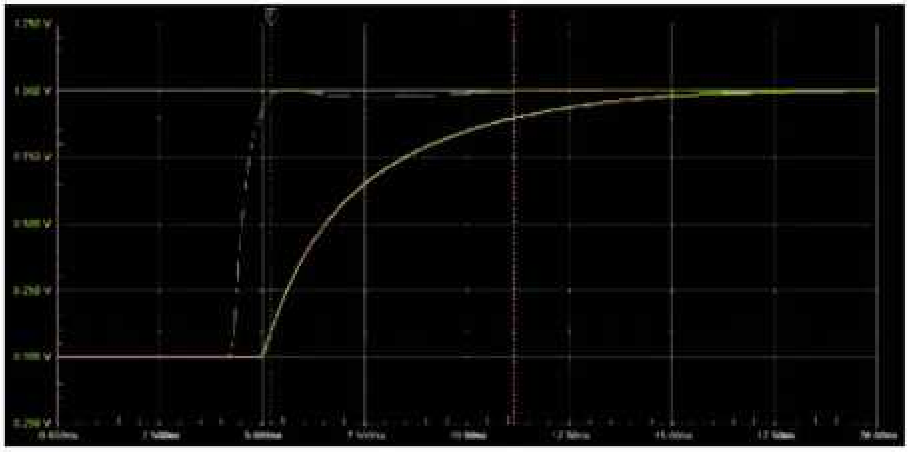

Fig.11: time-domain responses of 60MHz and 600MHz probes.

compensation trim (R_{COMP} in Fig.10) appears to play a significant role. It appears to terminate the lossy transmission line.

For example, if this resistor is shorted, the –3dB bandwidth is reduced to 180MHz and the optimum transmission line resistance is 110Ω/m instead of 115Ω/m. If R_{COMP} is increased above 68Ω to (say) 150Ω, the frequency response shows several dB of peaking at 200MHz.

Interestingly, it makes little difference whether the compensation trimmer and its 68Ω resistor are positioned at the scope end or probe end of the transmission line.

This indicates that the choice of trimmer location is probably a manufacturing decision rather than performance issue.

Rise-time and propagation delay

It is useful to compare the delay (propagation) times of different bandwidth probes. Fig.11 shows the response to a 10V pulse of the 60MHz probe of Fig.9, and the 250MHz probe (with 600MHz bandwidth!) of Fig.10.

The "600MHz" probe (green) has a propagation delay of around 4.2ns while the 60MHz probe (yellow) has around 5.1ns delay.

The propagation delay is the time between the input pulse edge and the start of the pulse edge at the scope end of the cable.

A difference of less than a nanosecond might not seem much, until you're chasing race conditions in logic circuits with mismatched probes.

The rise-time of the scope end waveform is the time taken for the voltage to go from 10% to 90% of the final value. The simulated 60MHz probe shows 5.9ns rise-time; the "600MHz" probe shows 0.7ns rise time.

The effects of faster or slower rise times are in proportion to the nature of the signals you're observing. Nanosecond differences in rise time are irrelevant if you're observing the squarewave response of audio op amps with microsecond rise time but they become vital if you're chasing problems in high-speed digital circuits.

Probe impedance

Does your x10 probe actually have a 10MΩ input impedance? Yes – but only at low frequencies.

Fig.12 shows the input impedance in "dB re 1Ω" of the 60MHz probe of Fig.9. The impedance is 140dB (10MΩ) below 1kHz but the capacitance of the compensation cap determines the impedance at higher frequencies.

It is worth noting that when probing audio circuits at 20kHz, the probe impedance is less than 1MΩ.

At frequencies above the probe's 60MHz bandwidth, the impedance is no longer dominated by the 15pF input capacitance.

It flattens out at 100Ω, dictated by the 50Ω probe tip resistor plus the 50Ω coax impedance.

Probe grounding and ground clips

How "grounded" is the ground clip on your probe?

A typical probe ground wire with alligator clip is around 150mm long. Typical wire inductance is around 1nH/mm, so the ground lead exhibits 150nH of inductance. The probe tip's separation from its ground-lead attachment will add another 50nH or so. This ground inductance was added to the high-bandwidth probe circuit, shown in Fig.13.

The frequency response of this circuit can be compared to the "natural" response of the probe. So our nice, flat 600MHz probe's response has been peaked at 100MHz, with premature rolloff above this.

The transient response isn't pretty either, as seen in Fig.14.

It is worth noting that since most x10 probes have similar input capacitance (10pF to 25pF) and most ground clip leads have a similar length, they will all exhibit peaking around 100MHz, irrespective of probe bandwidth.

For this reason, high-bandwidth probes are generally supplied with a kit of attachments which allow the probe ground to be connected to the circuit via coaxial or other low-inductance paths.

If you're measuring circuit operation above tens of MHz or rise times faster than 50ns, use these fittings!

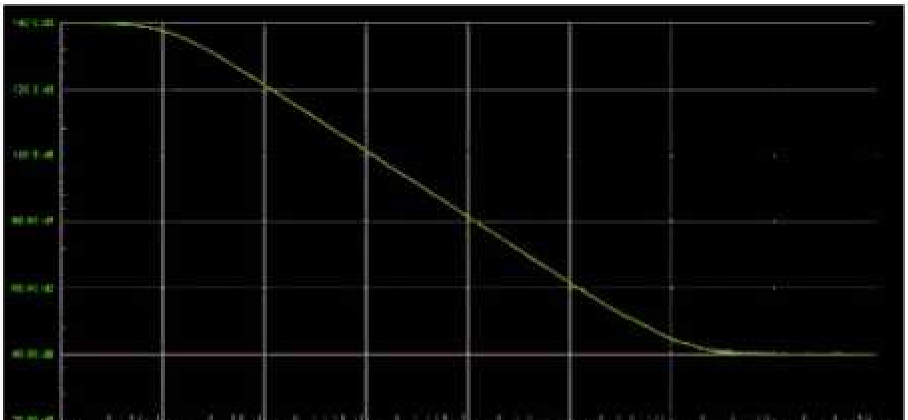

Fig.12: Probe input impedance magnitude.