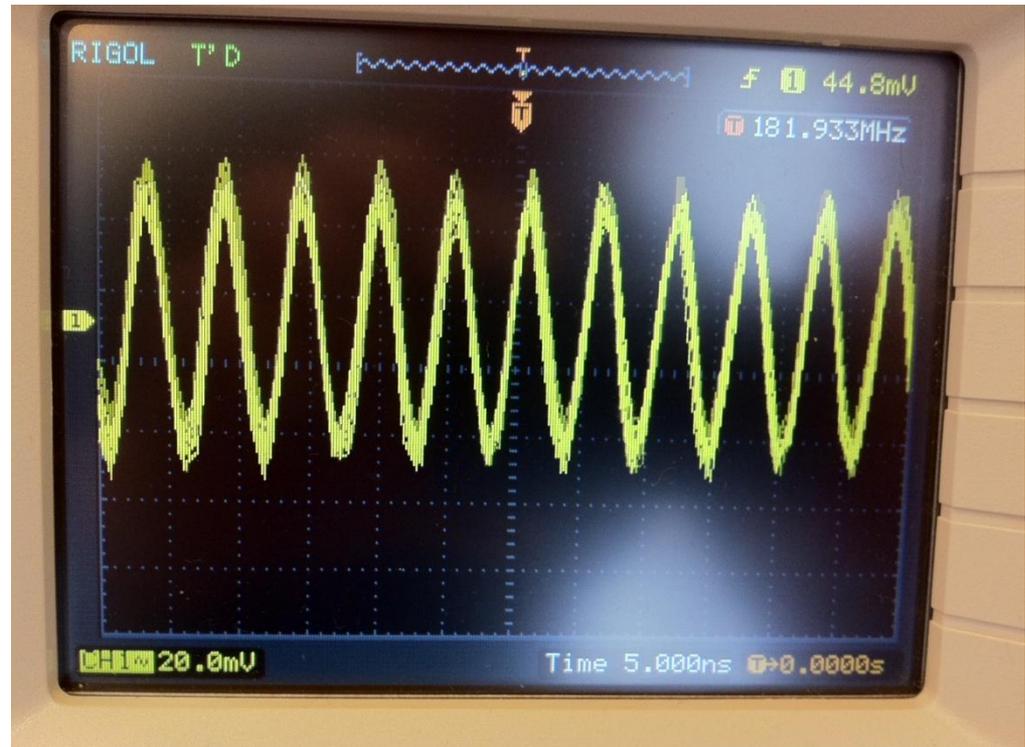


Cascode Oscillation in Audio Amplifiers

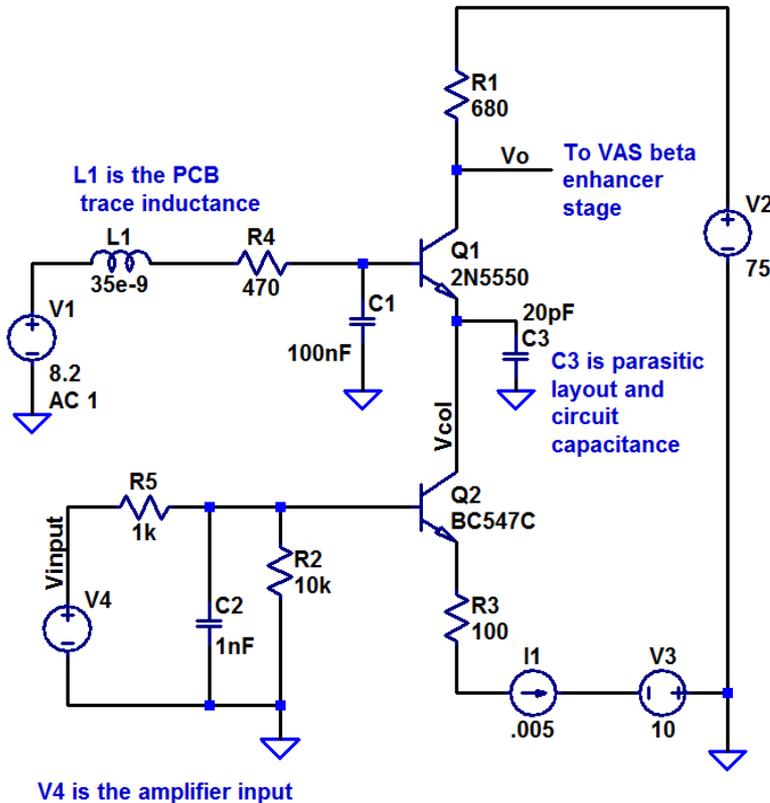
- About 80mV pk-pk oscillation at $\sim 182\text{MHz}$ was noted on the oscilloscope during routine debugging of a cascoded front end circuit for a high power balanced symmetrical amplifier
- This showed up as hash on an analog scope that was being used (Philips 200MHz) due to its inability to trigger reliably in the presence of a lot of phase noise. However, when using a digital scope (a Rigol 1GHz model), the oscillation and frequency readout were clearly discernable.
- In the PCB layout, the track between the cascode Zener reference diode (8.2V) and the cascode base is about 4cms long, which at c. 10nH/cm comes out at about 40nH.
- Capacitive loading on the cascode emitter causes a negative resistance to be reflected in the base circuit of the cascode transistor, and this is exacerbated by the presence of any inductance in the base circuit, forming a Colpitts oscillator structure.
- The cure is to insert a damper resistor into the base circuit of the cascode transistor, as physically close as possible to the device.
- However, simulation shows that if peaking (always an invitation for trouble in this type of circuit) is to be completely removed, then a capacitor from the cascode base to ground will provide a belt and braces cure

Real world cascode oscillation

- This screen shot shows clearly around 80-90mV of oscillation at 182MHz – the scope probe was switched to 10x, so the amplitude was considerably higher than this at around 800-900mV
- Triggering difficulties on the 200MHz analog scope on which this problem was originally discovered caused it to show up as hash which was mistaken for noise



LT Spice modeling was used to investigate the cascode oscillation and develop a fix



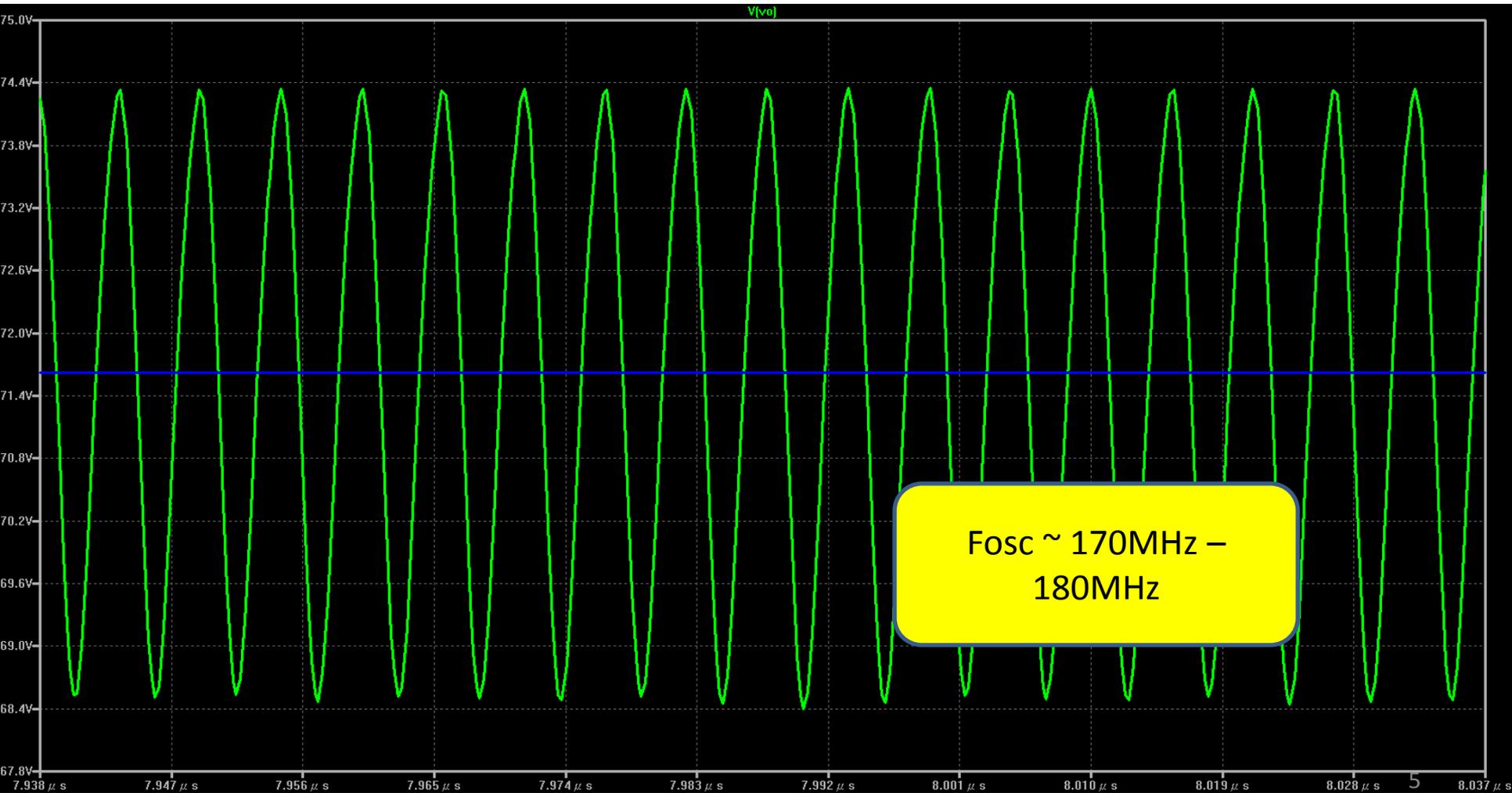
Cascode Oscillation

This model was used to investigate the 182MHz oscillation discovered on the R1 collector load in the e-Amp. On the Ovation amp, the casode was base (Q1) was decoupled in close proximity with a 10uF capacitor. On the e-Amp proto, this was omitted and the result was oscillation of 800-900mVpk-pk at 182MHz. further, the trace from the base of Q1 to V1 (8.2V zener) was about 5cm long which translates to around 50nH of inductance. C3 models the parasitic capacitance to ground. R4 is the damper resistor. Without, oscillation is assured, with it there is no oscillation.

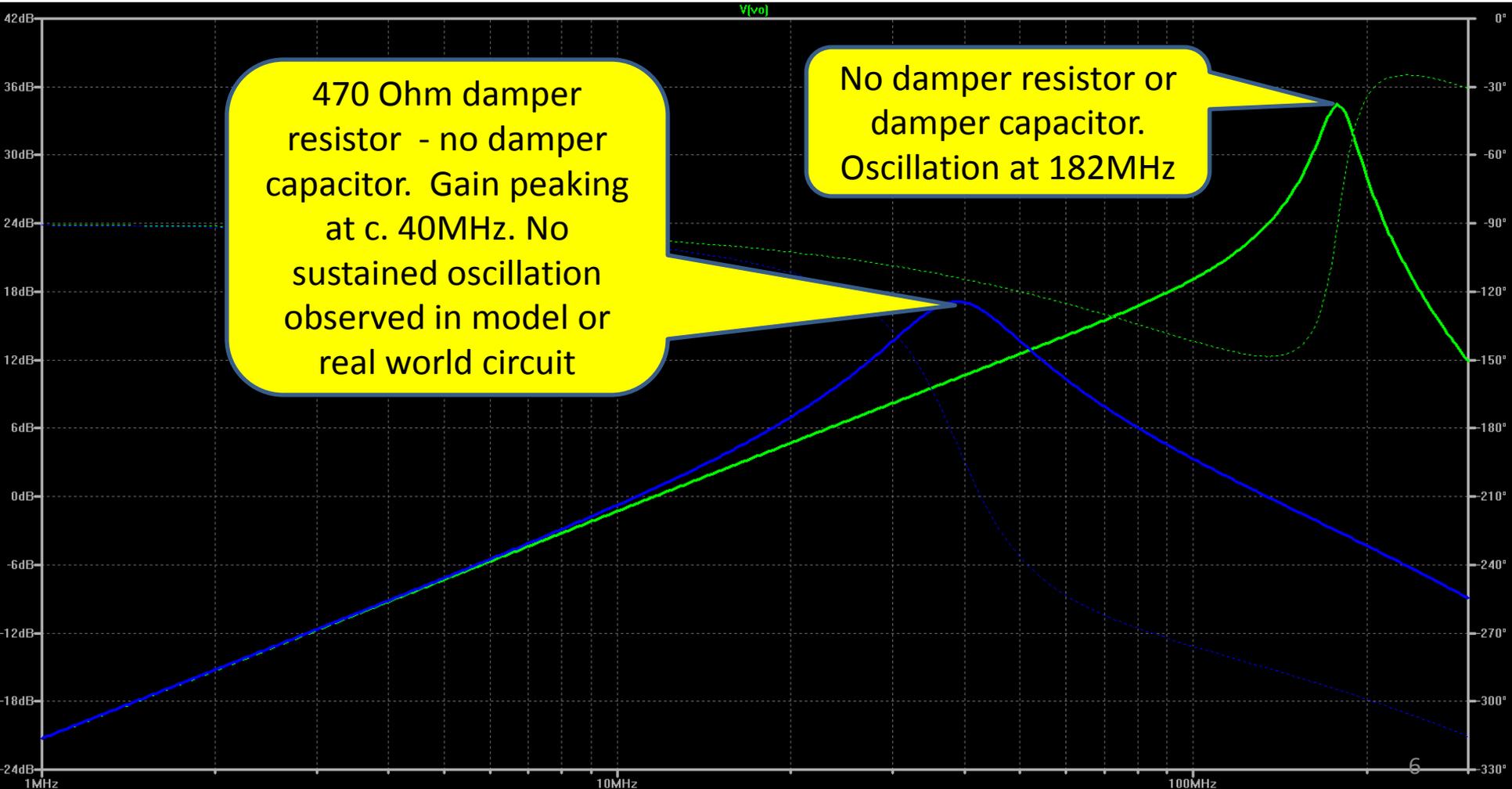
Adding a small capacitor (c. 100nF) directly at the base of Q1 instead of Rdamper also completely quells any oscillation, while the two together offer a belt and braces option. note that Rdamper and/or C1 must be placed as close as possible to the base of Q1. C1 connection to ground must ensure minimal loop inductance between C3 ground and C1 ground connection.

```
.ac dec 100 1e6 300e6
;tran 0 20e-6 0 1e-9
.step param Rdamper 1 2 1
.step param Cdamper 10nF 100nF 90nF
```

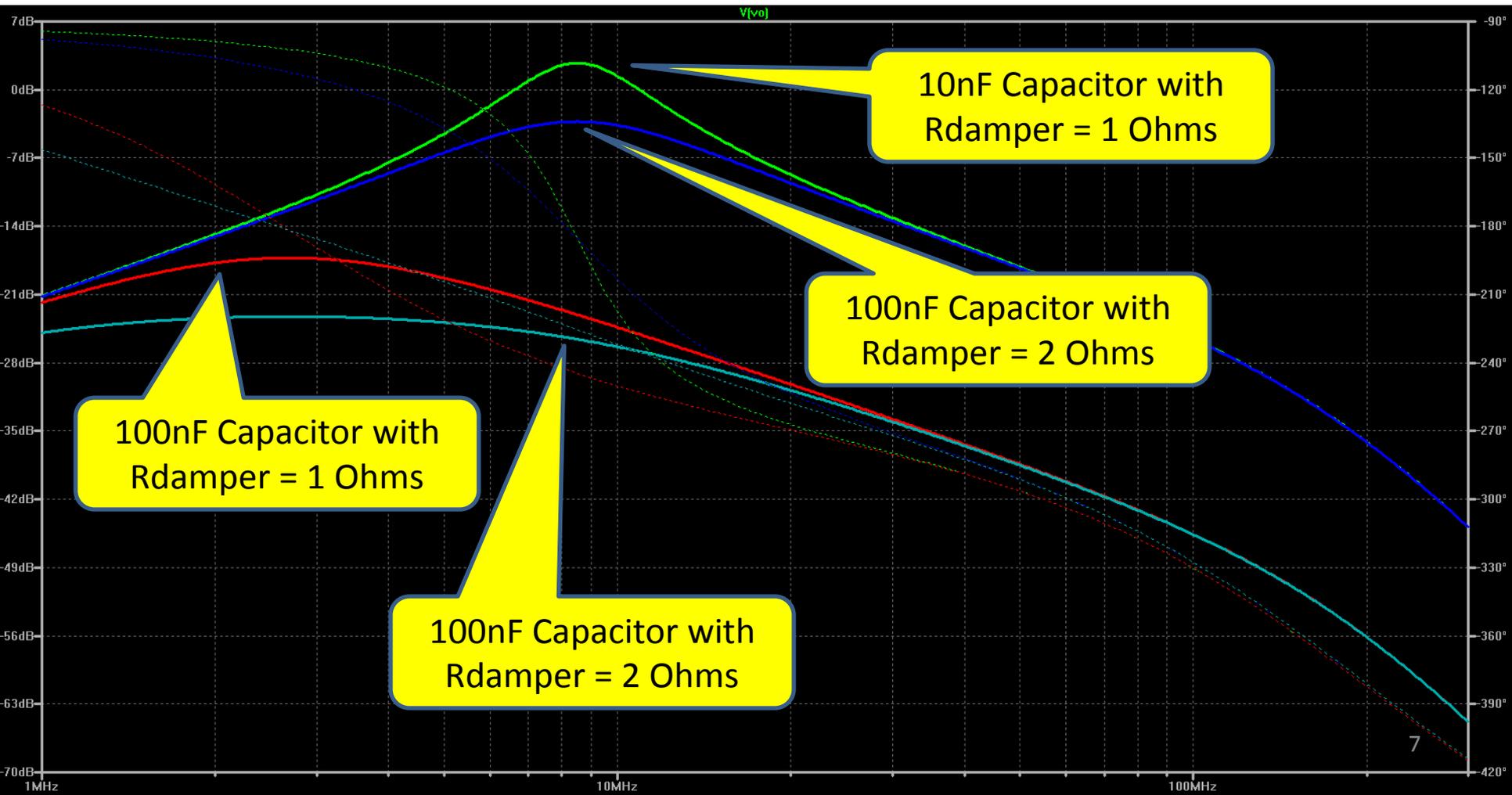
Transient simulation result with no resistive or capacitive damper. Cascode base L and emitter C were varied over wide ranges, with oscillation persisting, albeit at different frequencies



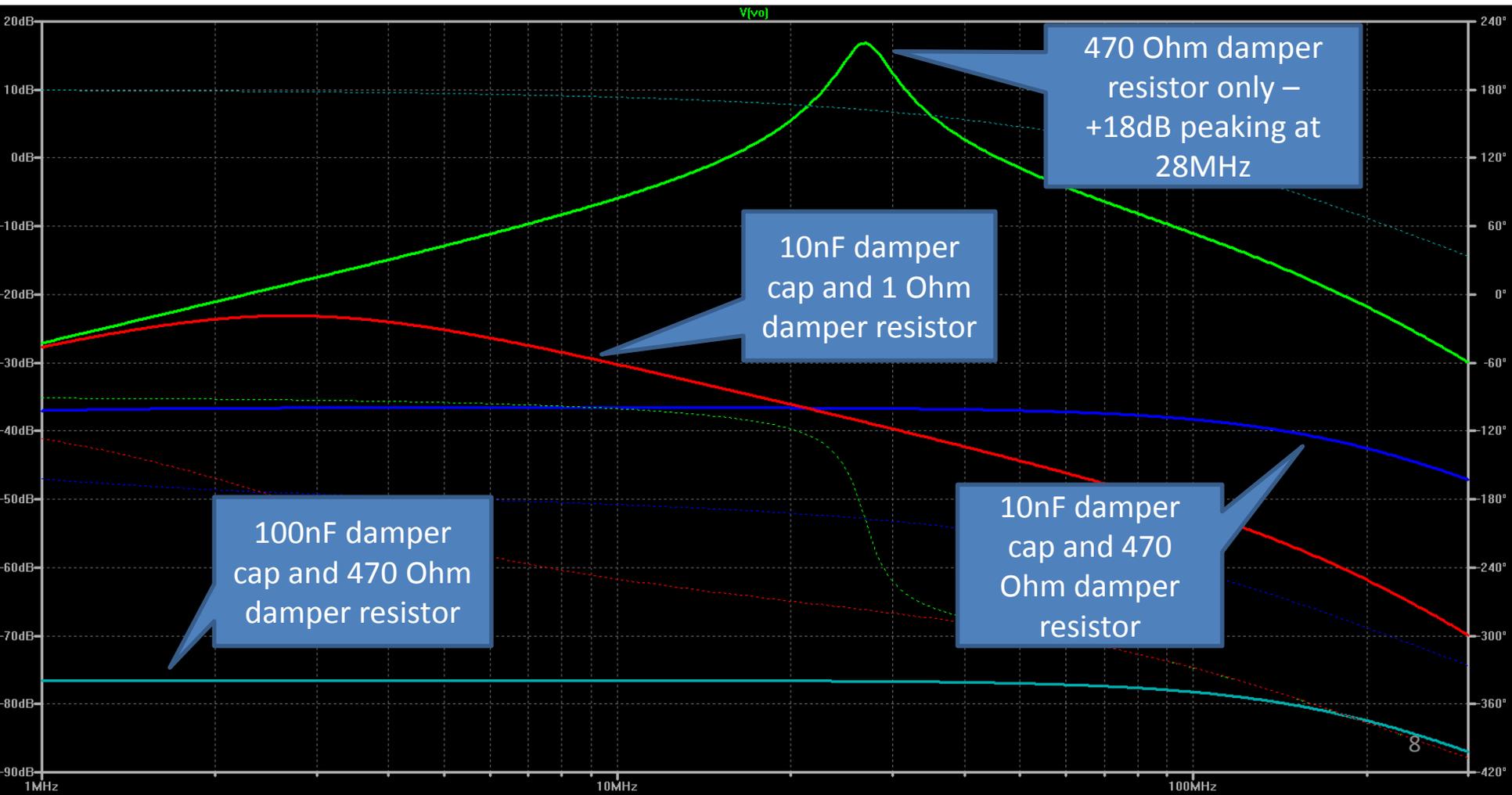
Using a only a damper resistor does not completely solve the problem. AC small signal analysis sweep excitation was via V1 in the model



Using only a damper capacitor improves the situation but there is still peaking. AC sweep excitation was via V1 in the model

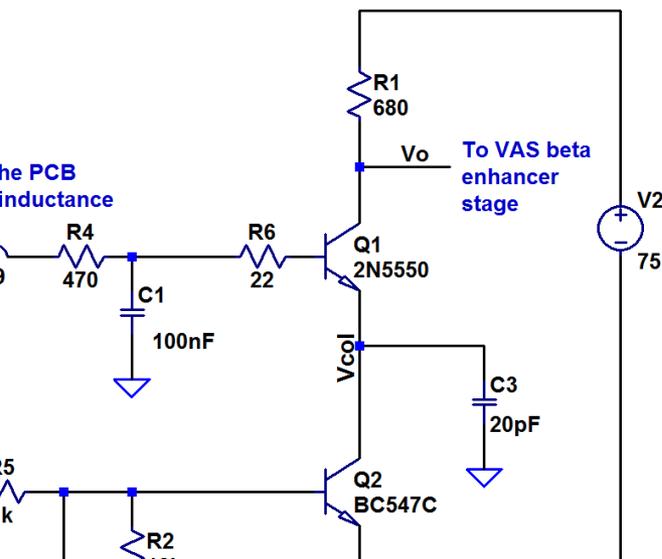


Combination R and C damper in the cascode base gives best 'belt and braces' result



Further Notes

- Some proposals for curing cascode parasitic oscillation problems advise to NOT locate a capacitor directly on the base of the cascode transistor as doing this does not fully solve the r_b' negative resistance in the base circuit that causes the oscillation in the first place.
- However, some inductance is also necessary in the cascode base to sustain oscillation, so it is layout that is also critical. The internal base inductance of a small signal bipolar transistor is in the region of about 0.1 to 0.5nH
- Experiments on the e-Amp LTP cascode showed that the addition of a 100nF 50V foil capacitor directly on the cascode base, along with a 470 Ohms series resistor completely cured the problem.
- The figure below shows an alternative approach which inserts a low value 220hm resistor between the R4/C1 network and the cascode base.



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