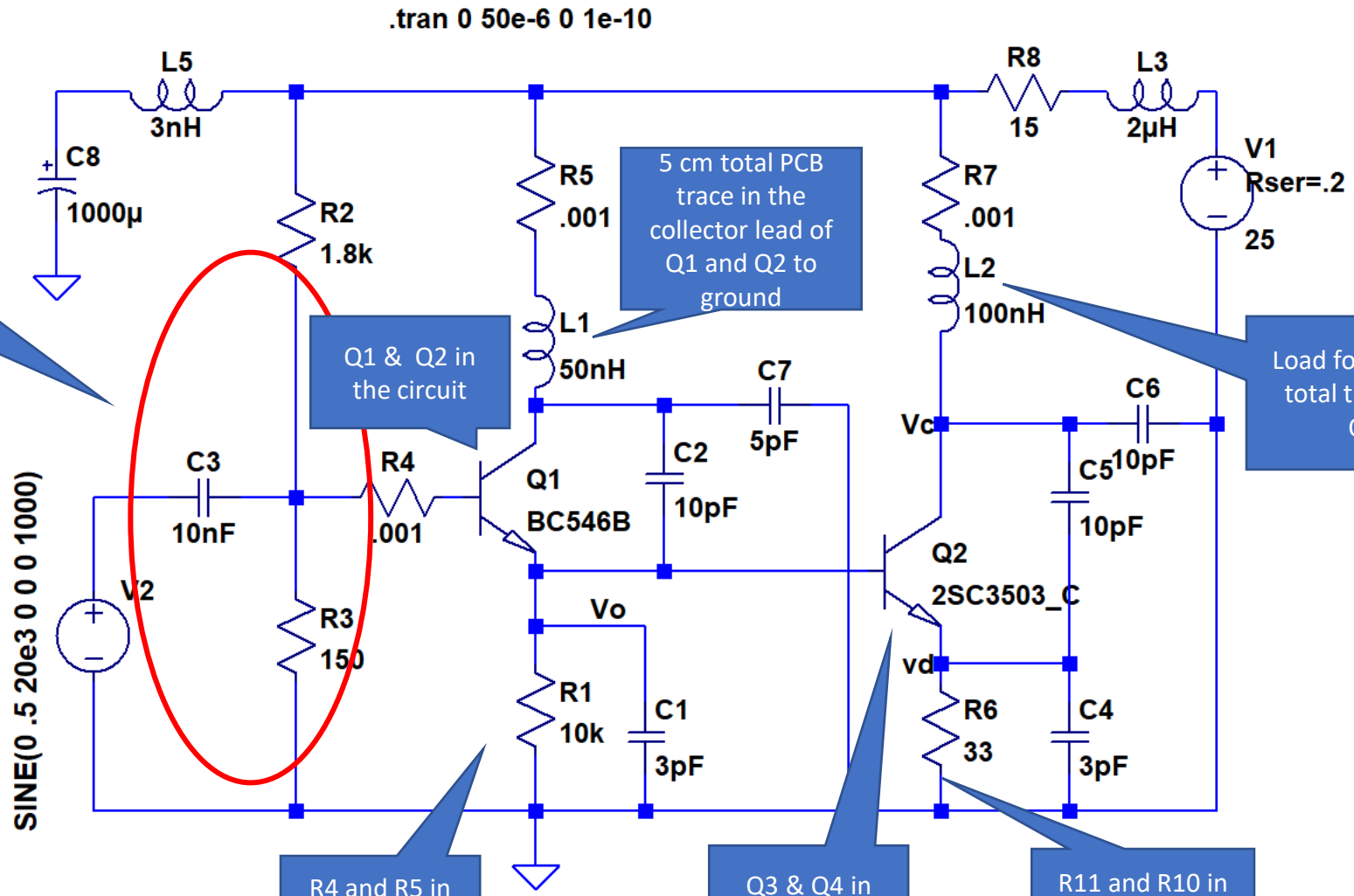
Kx-Amplifier Oscillation Problem

Problem with kx-Amplifier HF Oscillations

- More than 100 kx-Amplifier board sets have been sold (December 2020)
- A number of builders (5 thus far, but could be higher if constructors did not have access to an oscilloscope) noted oscillation at ~20 MHz, and one reported a ‘Shhh’ sound from the speakers – normally an indication of HF oscillation
- Constructors with the problem measured between 1.7mV pk-pk through to 80mV pk to pk at the output
- They reported touching on the bases and/or collectors of Q1 to Q4 stopped the oscillation or suppressed it
- Prior to homing in on the VAS/beta helper (these are transistors Q1 and Q2), the output stage was investigated with the option of increased the base stoppers to 10 Ohms and adding additional 1uF XR7 0805 decoupling capacitors across the 1000uF bulk decouplers.
- The current controller circuit comprising Q7 was investigated. Removing C5 made the situation worse for one of the builders.
- It was determined that the issue was not related to TPC loop compensation stability. By removing R42, the amplifier is converted to very conservative Miller compensation – builders reported the ~20 MHz oscillation did not stop. The ULGF on the kx-Amp with the TPC comp scheme is 800 kHz – i.e. very conservative.
- It should be noted that I was not able to reliably trigger oscillation on my kx-Amplifier build.

Model to Investigate kx-Amp Parasitic oscillation in VAS stage



R2, R3 set up to bias output stage at about ~20mA. C3 used to move the input around

5 cm total PCB trace in the collector lead of Q1 and Q2 to ground

Q1 & Q2 in the circuit

Load for simulation purposes and total trace inductance between Q4 and Q3 collector

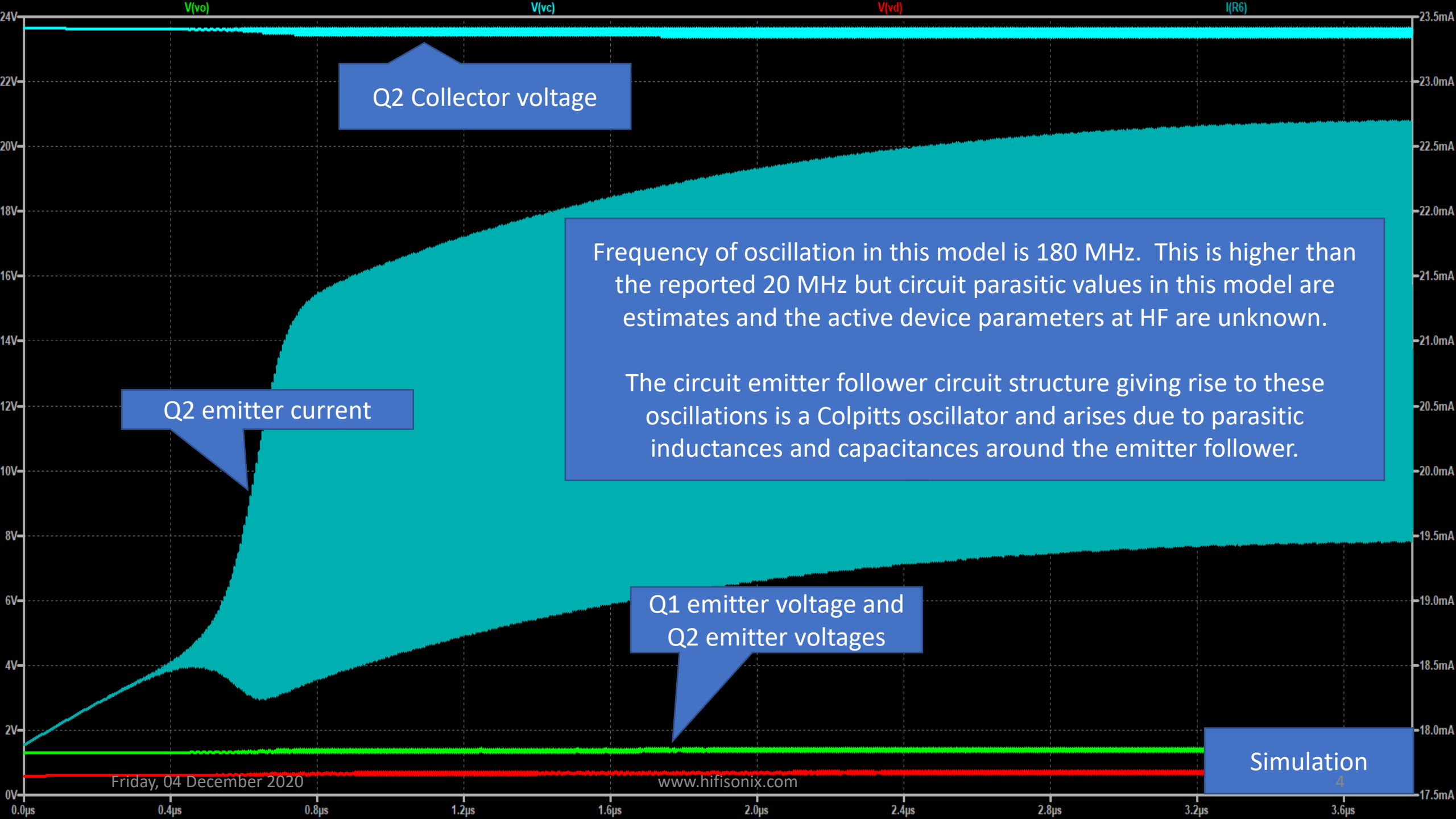
Assume 10nH/cm trace inductance

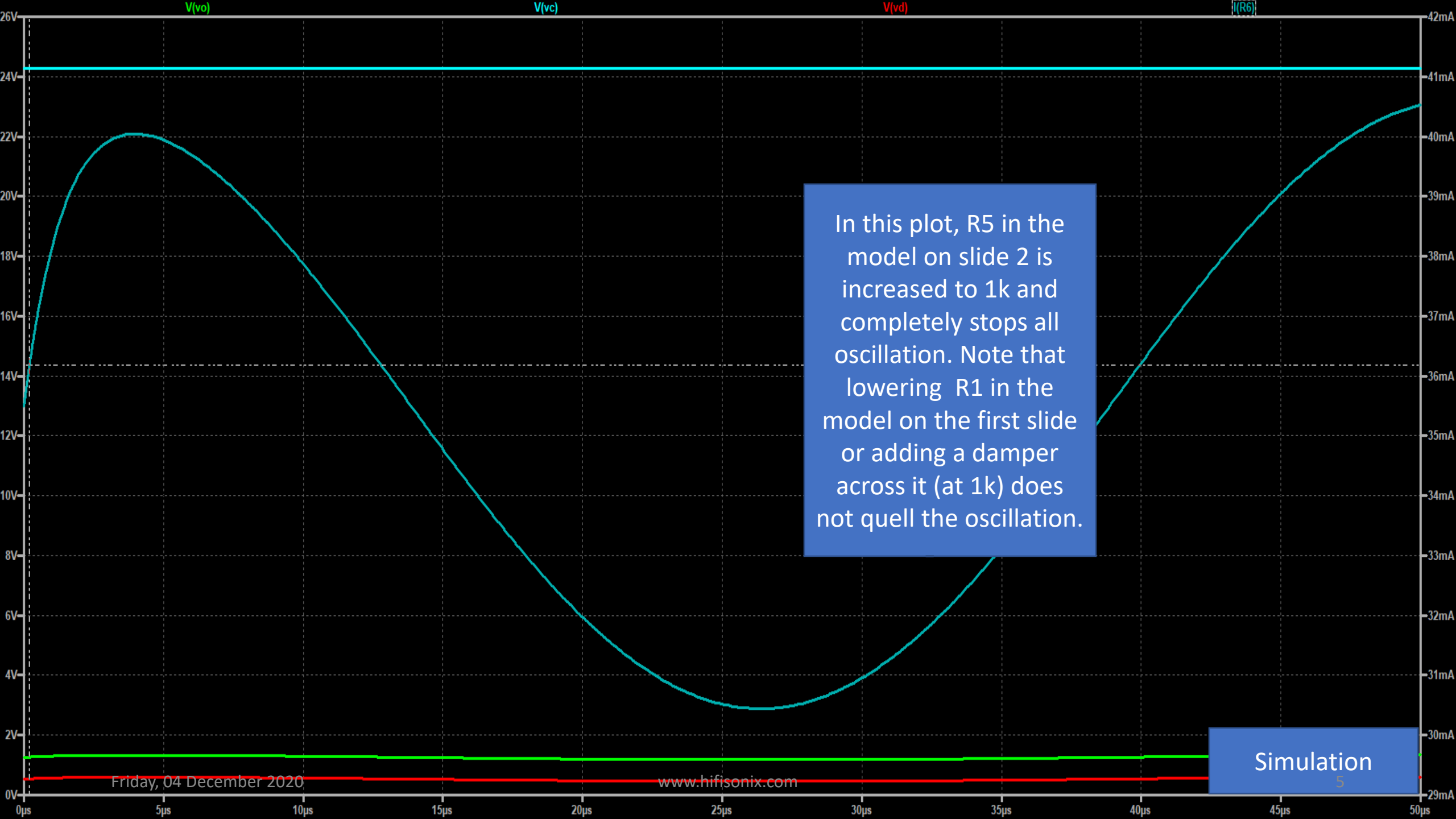
R4 and R5 in circuit

Q3 & Q4 in the circuit

R11 and R10 in circuit

Attention: C1, C3-C6 are ***estimated*** circuit capacitances


V(vo)
V(vc)
V(vd)
I(R6)
24V
22V
20V
18V
16V
14V
12V
10V
8V
6V
4V
2V
0V
23.5mA
23.0mA
22.5mA
22.0mA
21.5mA
21.0mA
20.5mA
20.0mA
19.5mA
19.0mA
18.5mA
18.0mA
17.5mA
0.0µs
0.4µs
0.8µs
1.2µs
1.6µs
2.0µs
2.4µs
2.8µs
3.2µs
3.6µs
Q2 Collector voltage
Q2 emitter current
Frequency of oscillation in this model is 180 MHz. This is higher than the reported 20 MHz but circuit parasitic values in this model are estimates and the active device parameters at HF are unknown.
The circuit emitter follower circuit structure giving rise to these oscillations is a Colpitts oscillator and arises due to parasitic inductances and capacitances around the emitter follower.
Q1 emitter voltage and Q2 emitter voltages
Simulation

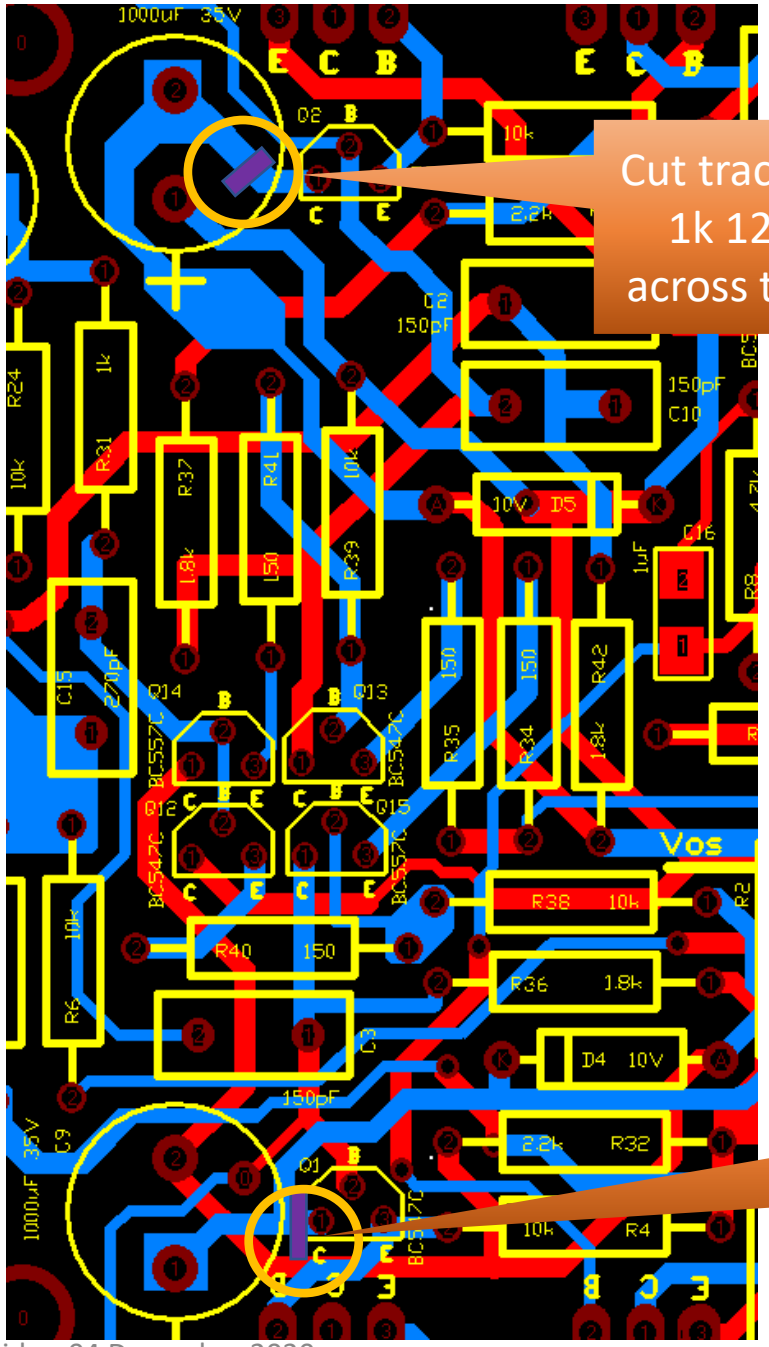

V(vo)
V(vc)
V(vd)
I(R6)
26V
24V
22V
20V
18V
16V
14V
12V
10V
8V
6V
4V
2V
0V
42mA
41mA
40mA
39mA
38mA
37mA
36mA
35mA
34mA
33mA
32mA
31mA
30mA
29mA
0µs
5µs
10µs
15µs
20µs
25µs
30µs
35µs
40µs
45µs
50µs
In this plot, R5 in the model on slide 2 is increased to 1k and completely stops all oscillation. Note that lowering R1 in the model on the first slide or adding a damper across it (at 1k) does not quell the oscillation.
Simulation

Notes and Observations from the Modelling (all component references are to the model on slide 1)

1. In the model, the various capacitances and inductances can be set to a wide range of values and the circuit will oscillate - for example even with L1 set to 1nH – so the propensity for oscillation is robust and not helped by the fact that both Q1 and Q2 are high fT devices.
2. Setting R4 to >50 Ohms also stops oscillation, but since this is in the loop and on the input to the VAS, it may lead to problems and would need a more thorough investigation
3. Changing R1 to 1k and adding a damper (330pF and 68 Ohms) does not help in the simulation. The circuit is less prone to instability with 10k (but see later comments on this point).
4. Setting R5 to 1k OR setting R7 to 100 Ohms stops oscillation. Since setting R7 to 100 Ohms is problematic, this is not recommended. However, adding base stoppers in the drivers could help, but again this specific solution will require additional work (and suitable models difficult to build) and to be avoided as this would require additional board mods
5. The single most effective solution is to set R5 (in slide 2) to 1k Ohms. This kills all oscillation, and is consistent with one of the methods used to prevent oscillation in emitter followers (the other being a base stopper per point (2) above

Recommendation for the kx-Amp (here we refer to the circuit diagram references)

- On the underside of the board, cut the trace that goes from the collectors of Q1 and Q2 on the PCB as close to the transistors as practicable – see slide 8
- Solder across the cut track a 1k 1206 resistor
- Power-up
- Recheck the amplifier output with a scope – it should no longer be oscillating.
- diyAudio member Rallyfinnen has suggested the amp works better with R4 and R5 set to 1k. With the 1k in the collectors of Q1 and Q2, R4 and R5 can safely be changed to 1k should constructors wish to do that.



Here is how to mod the kx-Amp board in order to solve the problem.

The tracks to be cut are on the underside of the board.

Recommendations for all designs using a beta helper transistor like the kx-Amp

- If connecting the 1st buffer transistor (‘beta helper’) collector directly to ground, or to some other low impedance point, always insert a resistor in the collector lead of 1k or greater.
- This will dampen any propensity to oscillate.
- Check that when doing so, the transistor cannot saturate under worst case drive conditions – for example when clipping