Anti-saturation Diodes for Audio Amplifier VAS Stages

www.hifisonix.com

Transistor saturation and excessive base charge storage

Excessive *base charge storage* arises when a transistor is in saturation (i.e. turned fully ON with Vce≈ 0 and the collector current has plateaued but current well in excess of that required to keep the transistor ON continues to be pumped into the base.

This accumulates as base charge on the device, and will cause it to continue conducting even after the base current is reduced to zero.

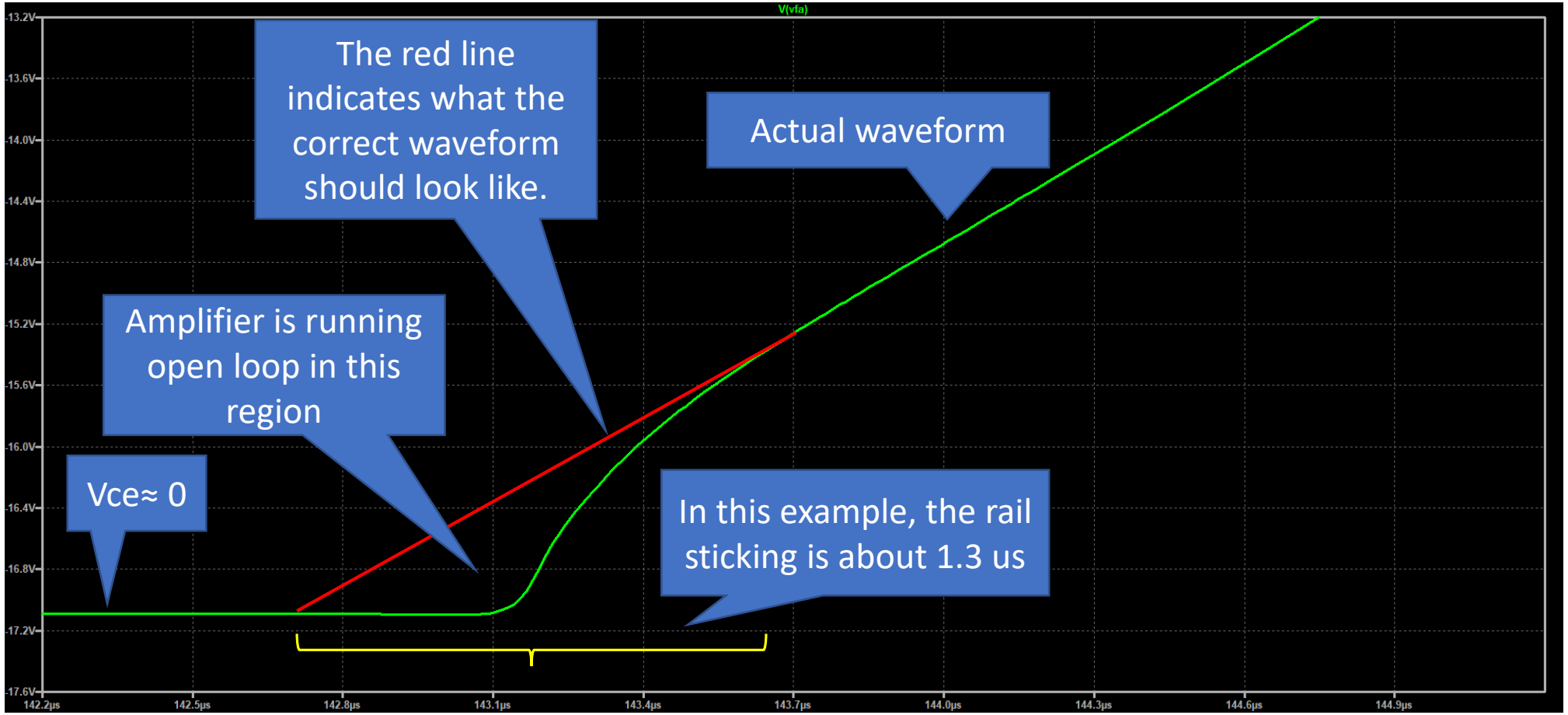
To speed-up transistor switching, base current *in excess* of that required to just ensure Vce≈ 0, has to be diverted away from the devices base – a circuit technique commonly referred to as a Baker clamp

There are two main types of problems that occur when an amplifier VAS (aka TIS) is driven into saturation

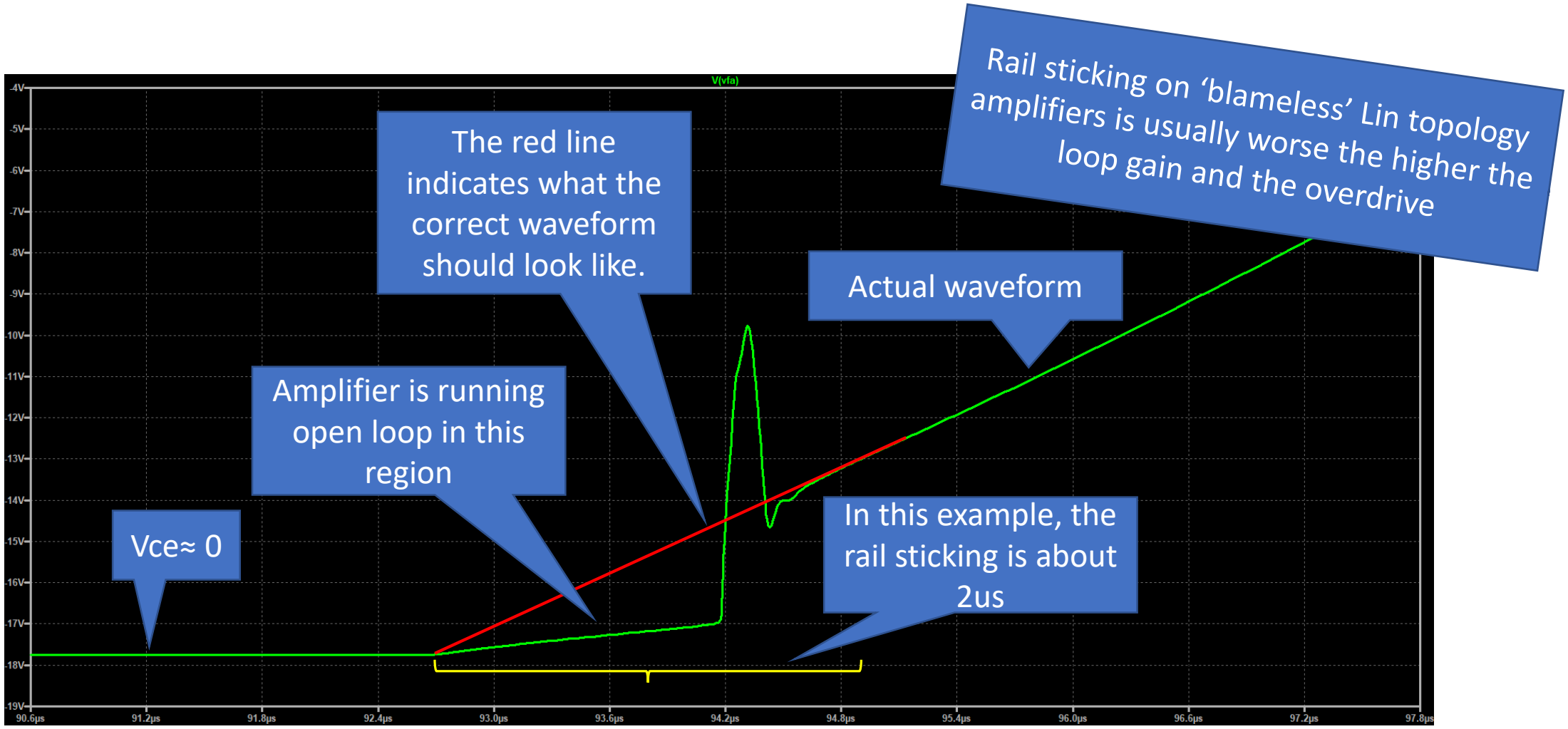
1. On single ended or ‘blameless’ amplifier types loaded with a current source, a phenomena called ‘rail sticking’ arises wherein the saturated amplifying device remains ‘stuck’ to either of the two supply rails, despite the input signal having progressed well away from its peak. This causes severe recovery problems and while the overhang is in progress, the amplifier is effectively operating open loop *– note this has nothing to do with SID/TIM – it’s a completely different mechanism*.
2. In balanced, symmetrical amplifier types overdrive also causes the VAS current to spike to very high levels. This is especially an issue in CFA topology amplifiers where the current on demand behaviour can cause the VAS current to exceed the standing current by up to 10x even with no load connected to the output – i.e. the OPS drive current is negligible
3. In all cases, the problem is exacerbated by high(er) loop gains and level of overdrive

The following pages show how the anti-saturation diodes can mitigate the problem

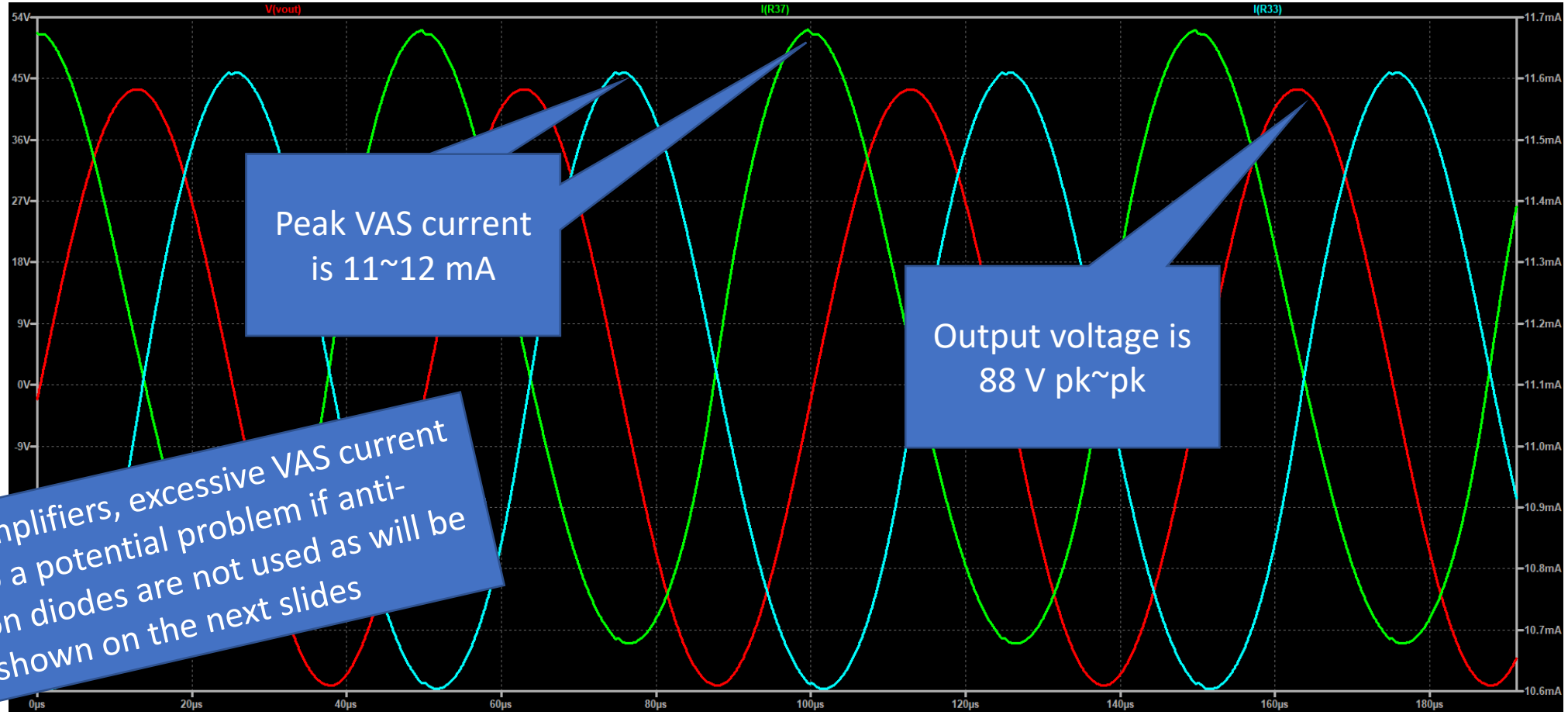
An example of a mild case of rail sticking – VAS collector voltage on an overdriven Lin topology amplifier



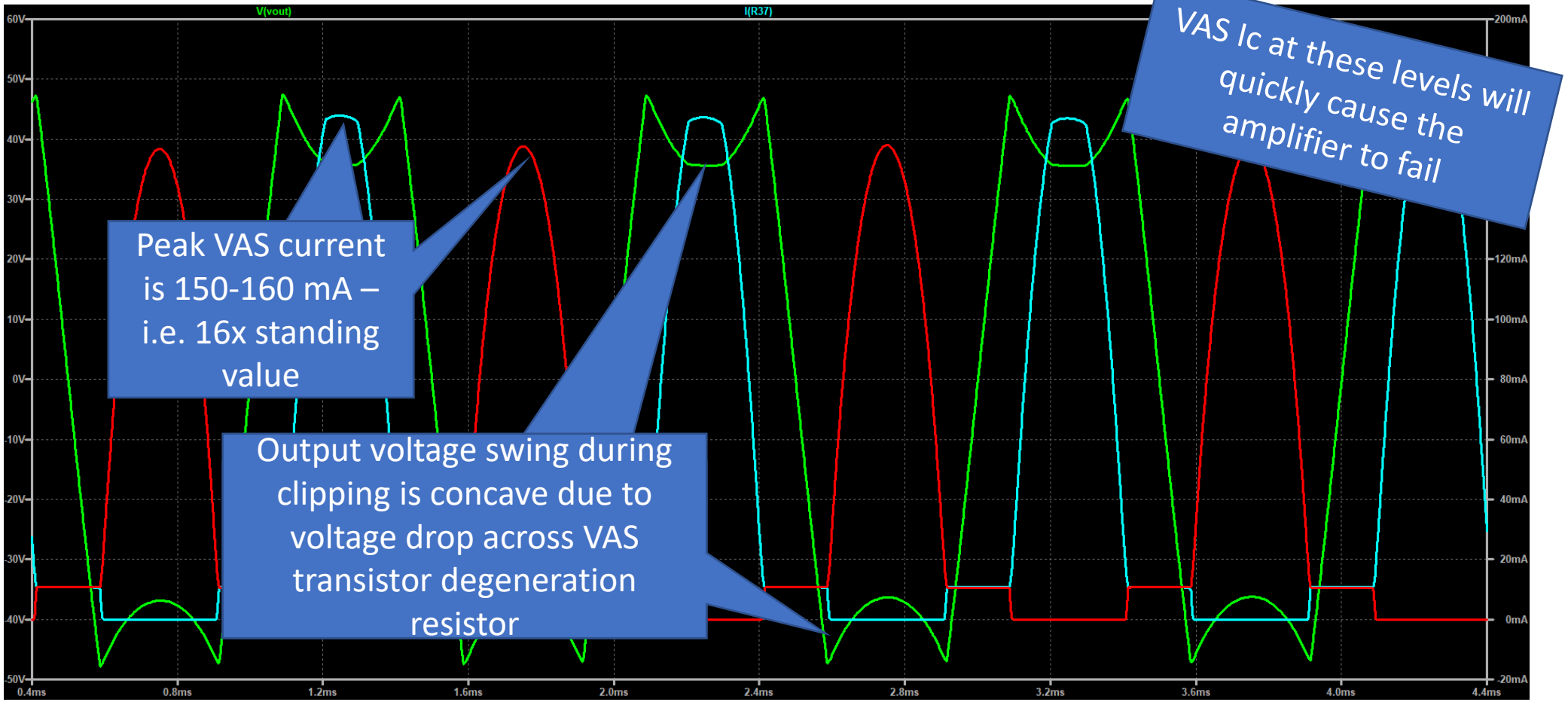
An example of a severe case of rail sticking – VAS collector voltage on an overdriven Lin topology amplifier



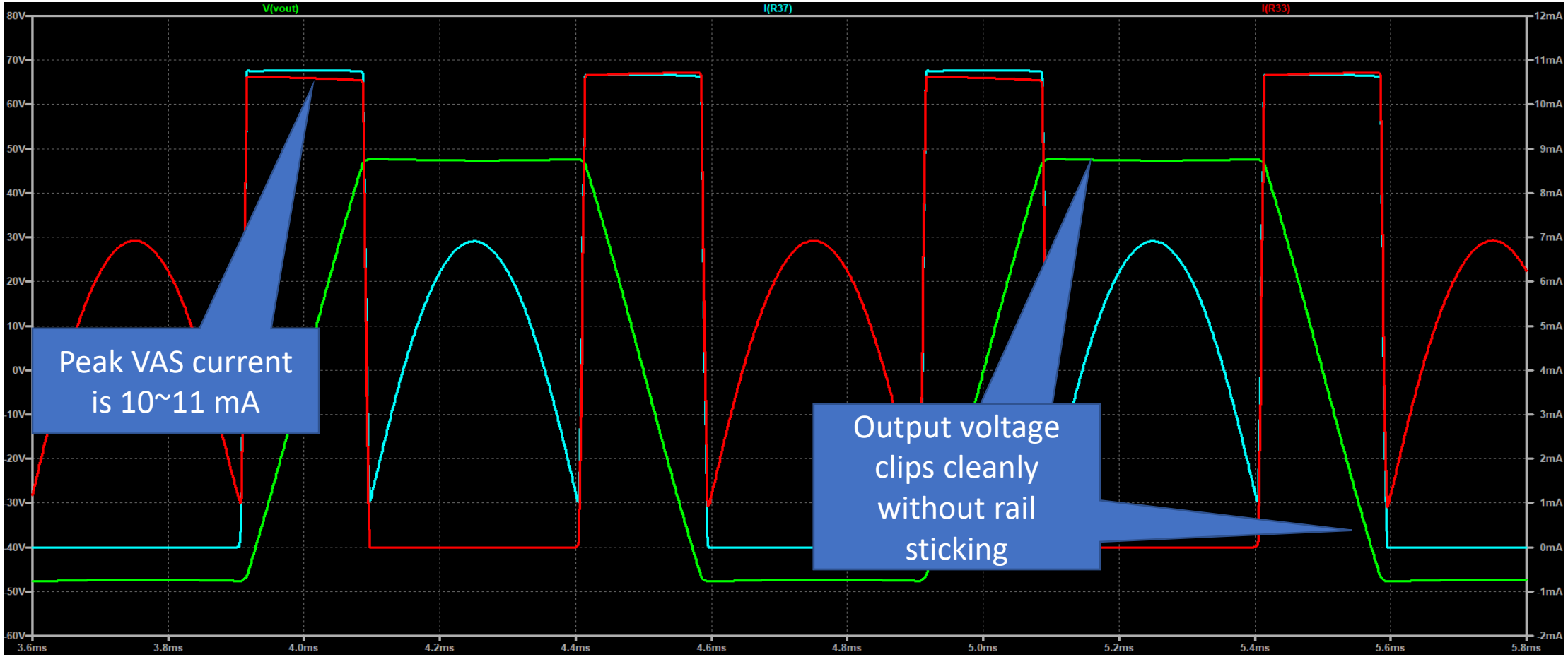
Balanced symmetrical CFA amplifier at onset of output clipping at 120 W RMS into 8 Ohms



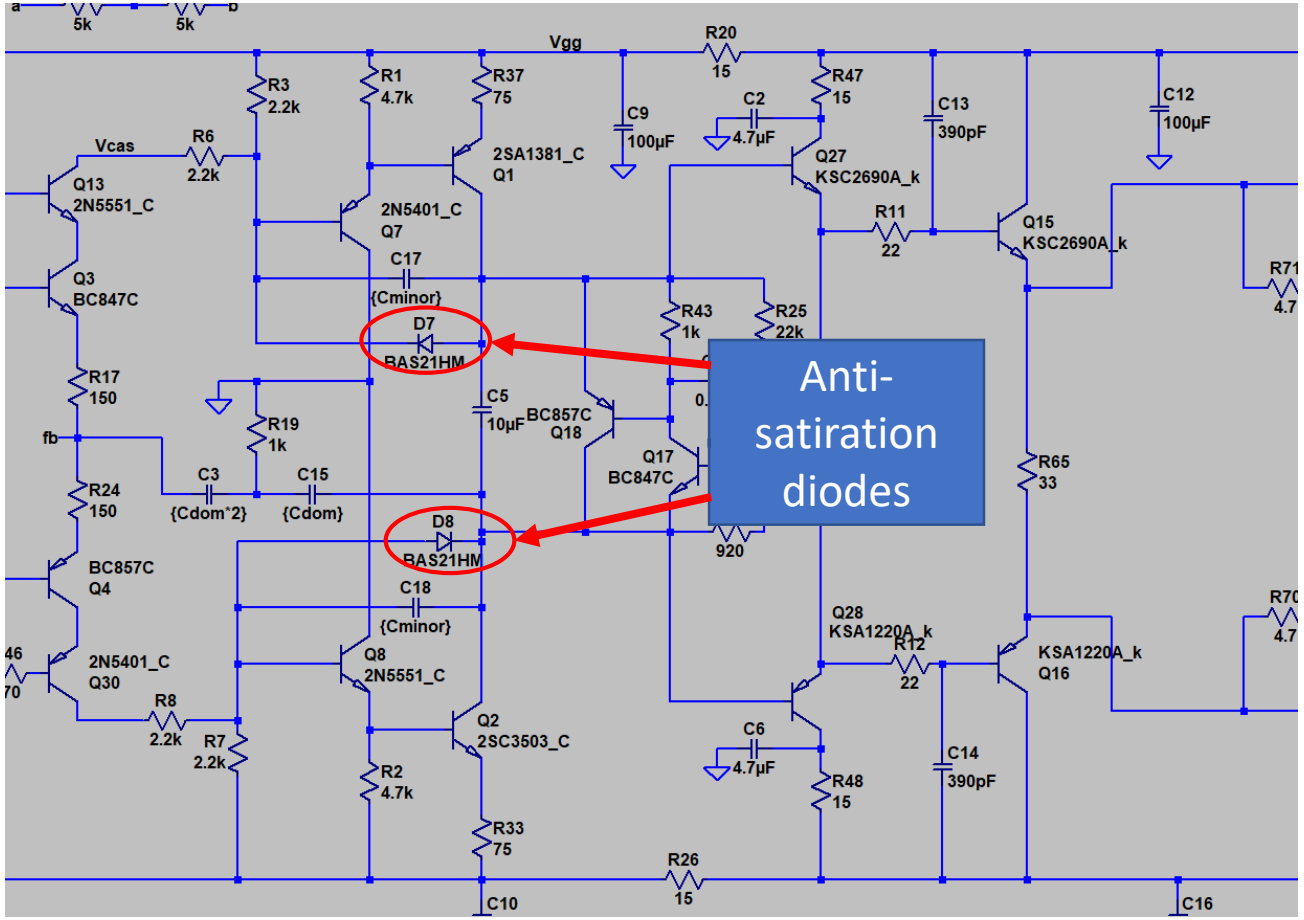
Balanced symmetrical amplifier driven into heavy clipping without VAS anti-saturation diodes



Balanced symmetrical amplifier driven into clipping with VAS anti-saturation diodes



Anti-Saturation circuit detail on 110 Watt CFA amplifier



Recommended anti-saturation diodes for audio amplifier VAS stages

- BAS21J – SMD SOD323F (SC90) – very fast, very low reverse capacitance (c. 0.3 pF typical) SMD diode Vrrm = 300 Volts peak

- BAV21 – Leaded SOD27 (D-05) – very fast, low reverse capacitance (C. 1.1 pF) through hole diode Vrrm = 250 Volts peak

Note: the Nexperia and Vishay types offer the best performance specifications