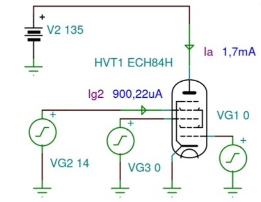
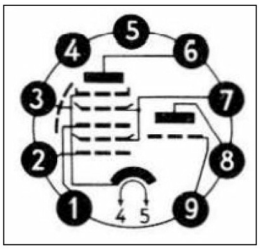
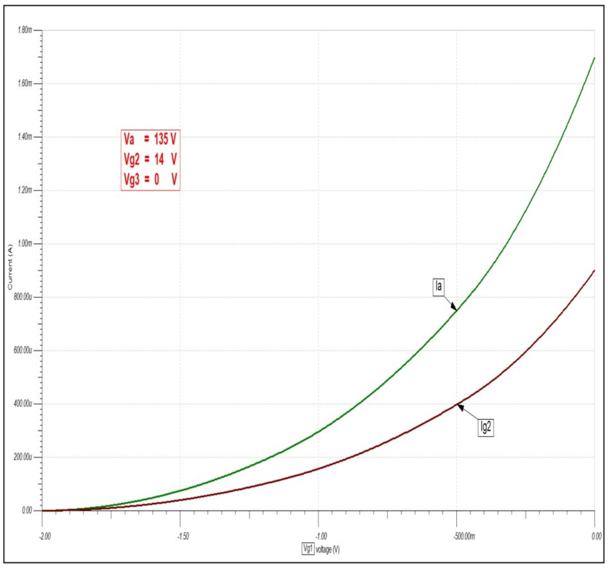
ECH84 Low Voltage Triode Heptode SPICE Macro Model

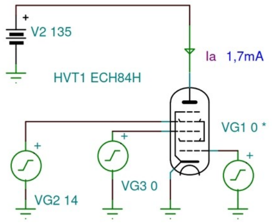
Transfer Characteristics

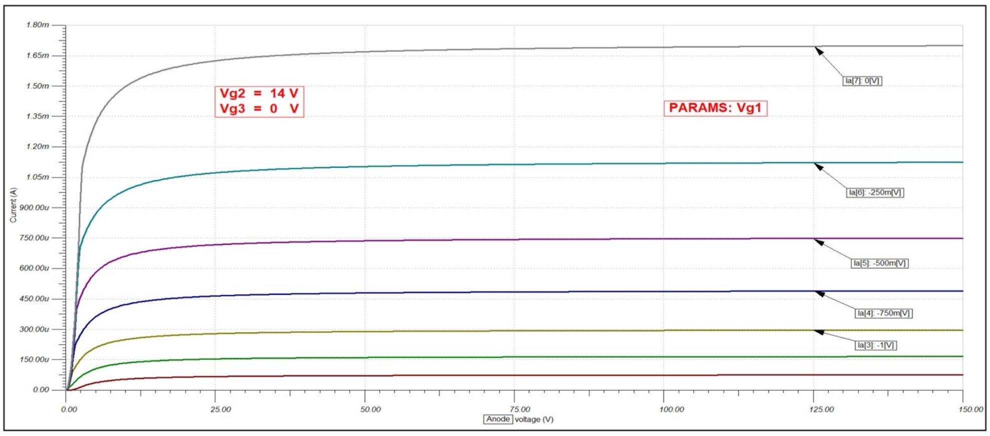




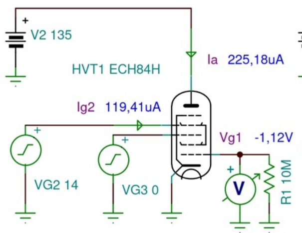


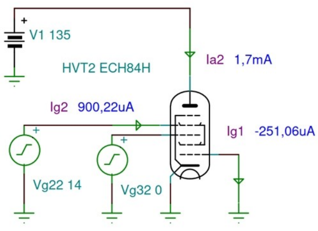
Output Characteristics



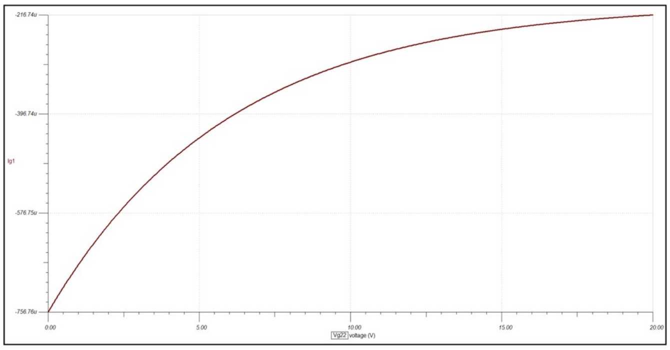


Grid Diode Splash Current



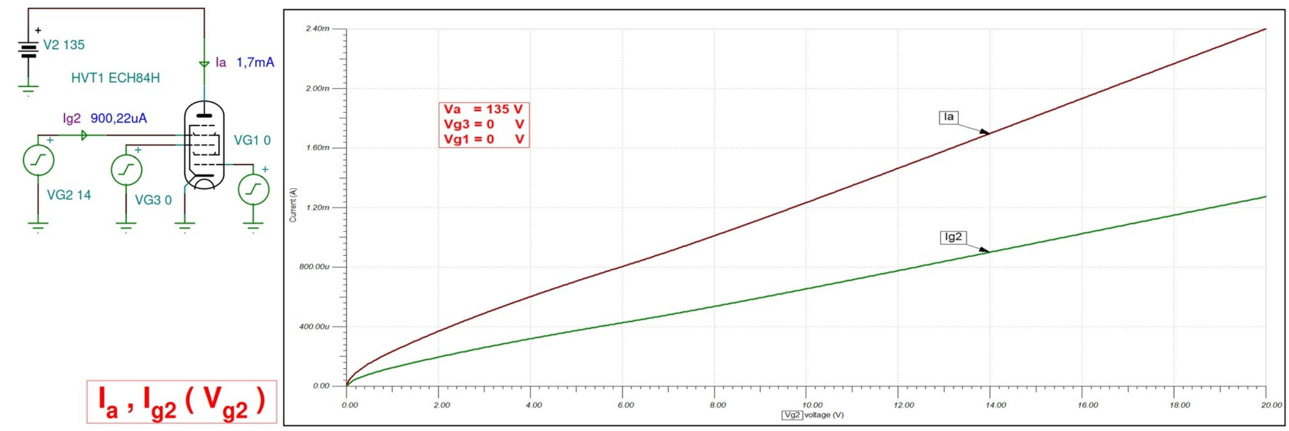


I_{g1} (V_{g2})

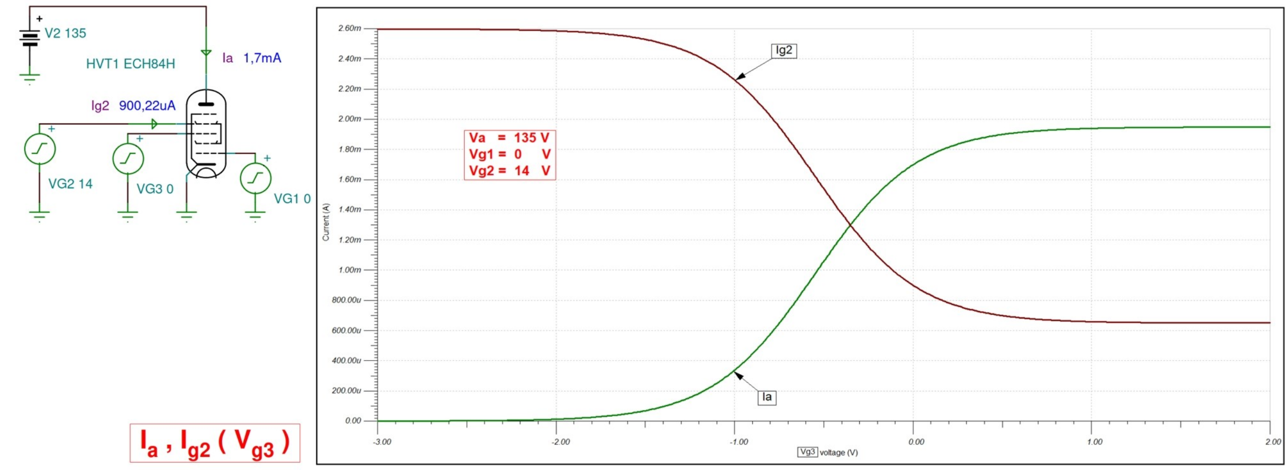


The grid current is not zero when the grid voltage is zero. A small grid current flows due to the energy distribution of the electrons emitted from the cathode. The splash-current phenomenon can be observed on every grid of the heptode, but it is most pronounced on the first (control) grid. This is simply because it is the closest electrode to the cathode. Its magnitude is always influenced by the voltage applied to the following grid; therefore, increasing the G2/G4 voltage will reduce the splash current flowing into G1.

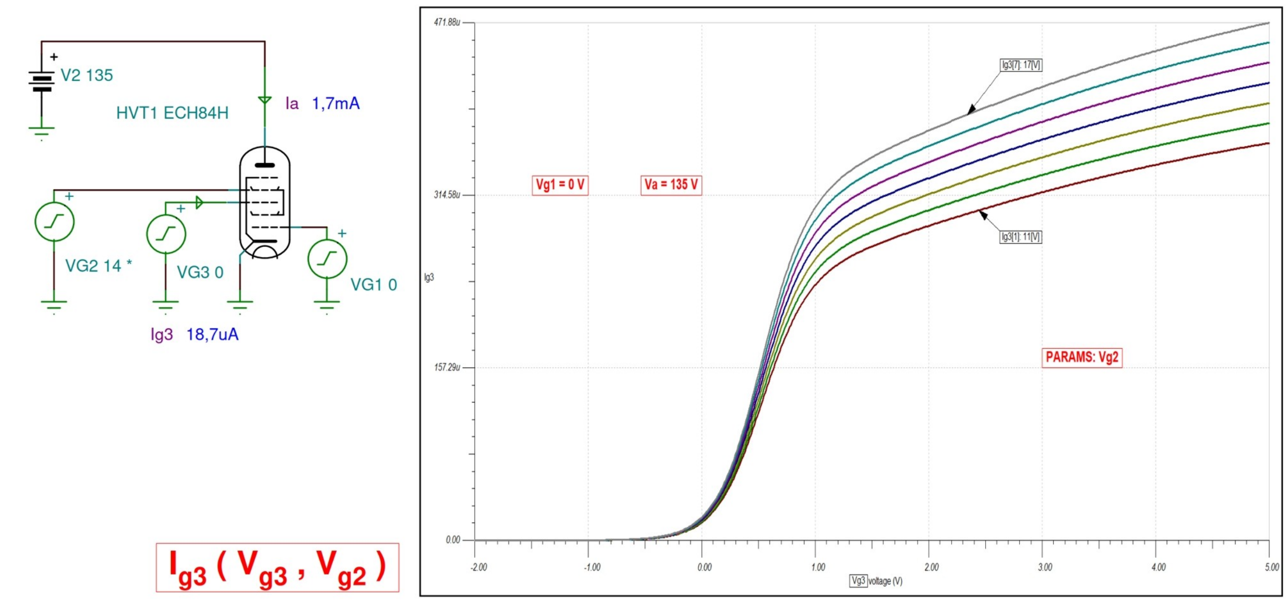
Anode and Screen-Grid Currents as a Function of G2 Voltage



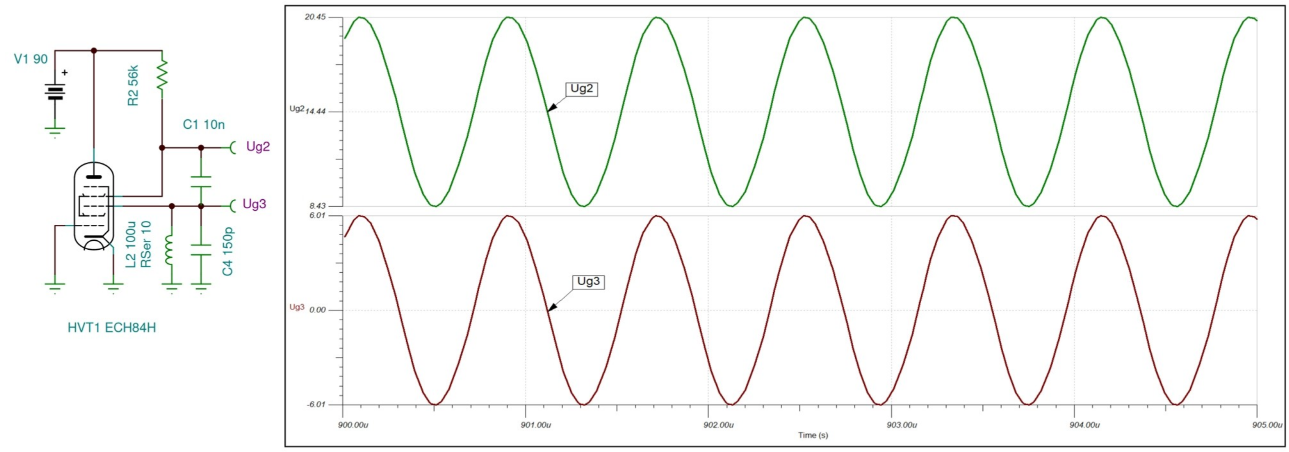
Anode and Screen-Grid Currents as a Function of G3 Voltage

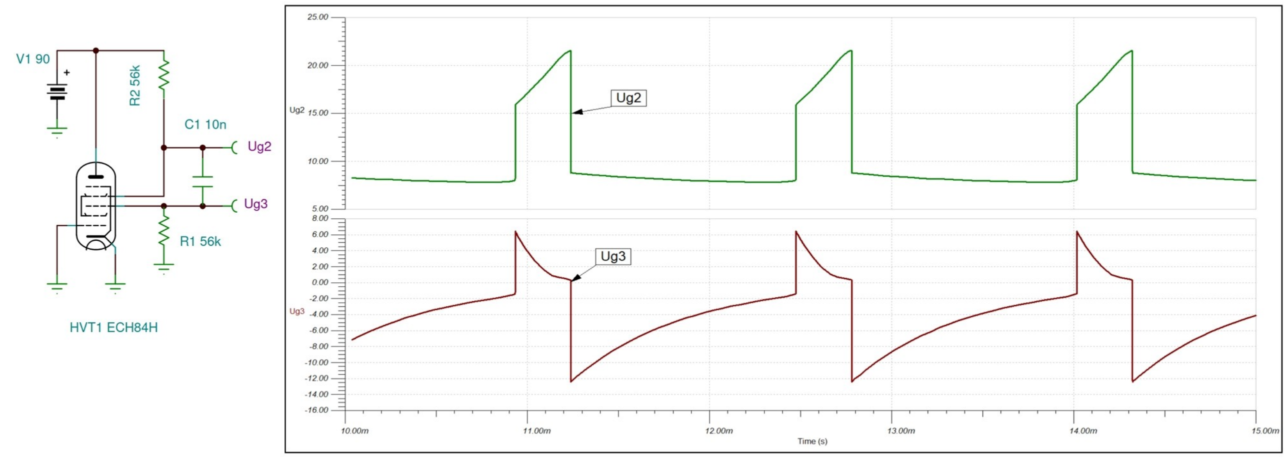


Ig3 vs. Vg3 Characteristics (Parameter: Vg2)

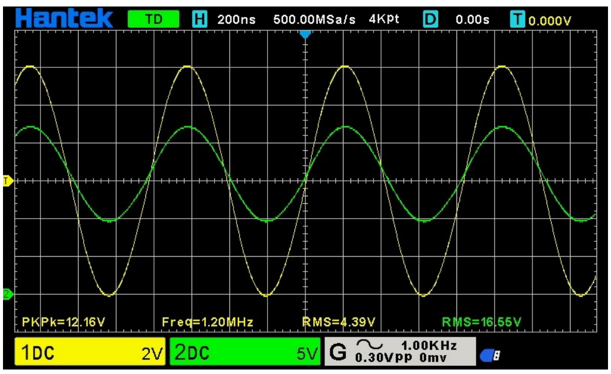


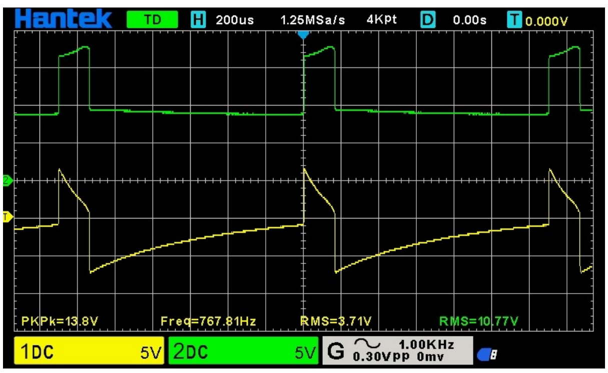
Heptode Transitron Oscillator





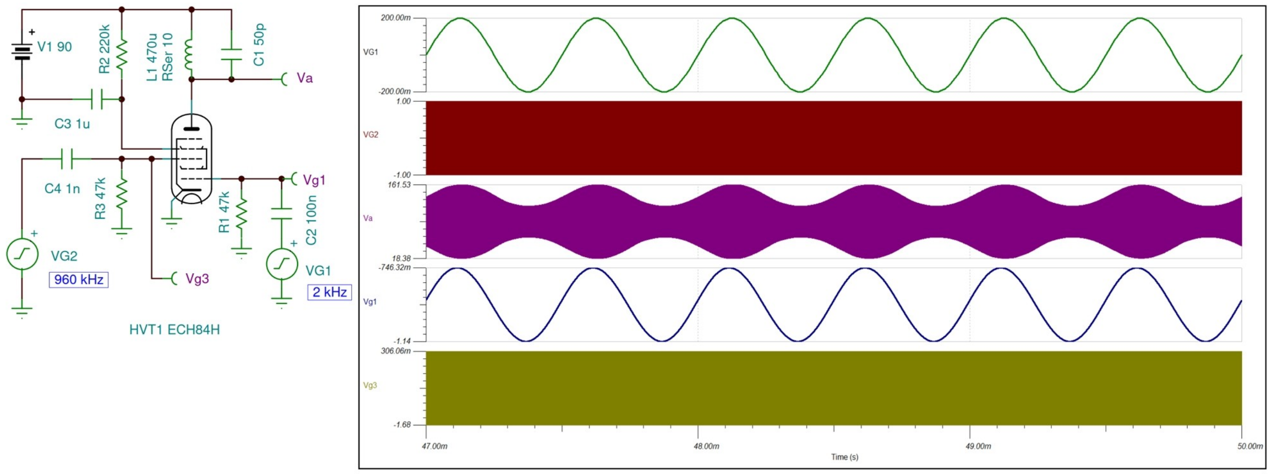
The screen grid (g2) has negative differential resistance with respect to the cathode and can be used to create oscillations. A major advantage is that it only requires a two-connection LC tank circuit (no tapped coil needed). By substituting the LC circuit with a resistor, the circuit becomes a current-controlled relaxation oscillator, producing lower-frequency, non-sinusoidal waveforms. The two operating modes are compared side by side in the oscilloscope recordings below. The upper circuit uses an LC tank to produce a nearly sinusoidal oscillation, while the lower circuit replaces the resonant network with a resistor, resulting in a current-controlled relaxation oscillator with strongly non-sinusoidal waveforms.





The measured waveforms closely match the simulated results, confirming that the negative-resistance model captures the tube's behaviour with high fidelity. This concludes the demonstration of both oscillator modes.

ECH84 Heptode AM Modulator Circuit

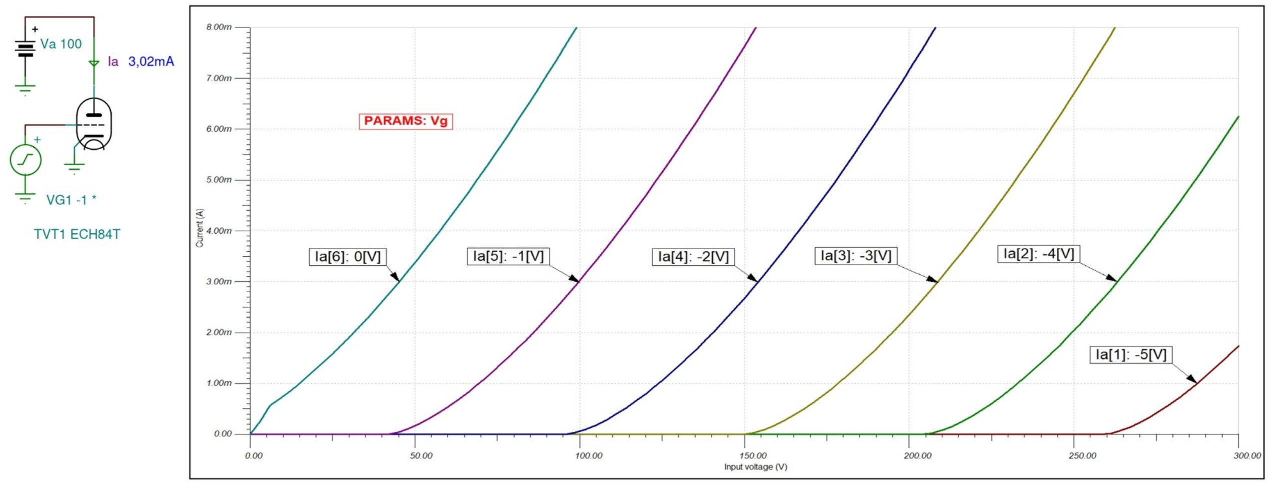


The heptode has a straight characteristic that makes it suited as AM modulator. Because both g1 and g3 exhibit very steep cutoff characteristics, the modulator operates reliably with much smaller signal amplitudes than usual.

Although these characteristic curves resemble those of a real heptode, they are not produced by a traditional vacuum-tube model. Instead, the underlying SPICE macro-model combines MOSFETs, bipolar transistors, and a pair of diodes to ensure physically reasonable behaviour even at negative electrode voltages. This hybrid structure allows the model to reproduce practical operating curves that are not provided in datasheets, yet are highly relevant for circuit design and analysis.
This is not a hidden detail: the accompanying ZIP archive includes both the full SPICE model and a ready-to-use TINA macro, complete with the schematic symbol.

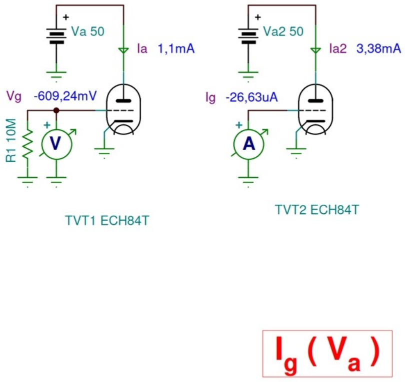
The triode section requires no special modelling techniques: its behaviour is well described by the conventional equations, and the resulting curves closely follow the expected textbook characteristics.

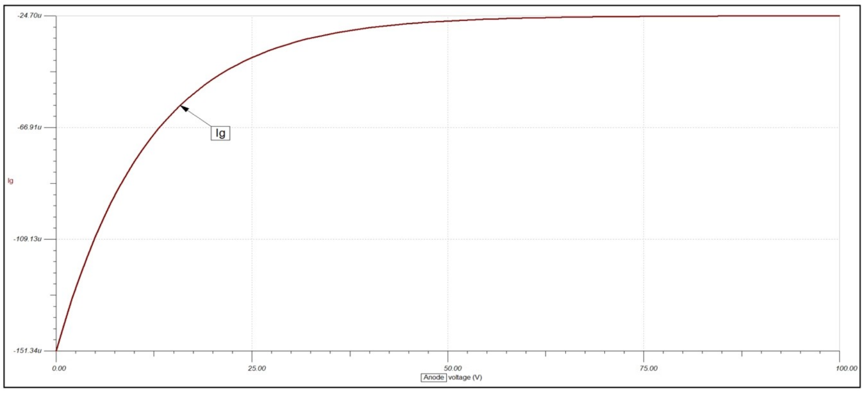
ECH84 Triode Output Characteristics



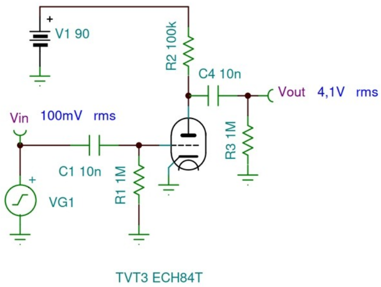
The triode exhibits a surprisingly large grid current, which therefore cannot be omitted from the model, as it has a fundamental impact on the operating point. As in the heptode section, the grid current is also a function of the anode voltage.

Triode Grid Diode Splash Current

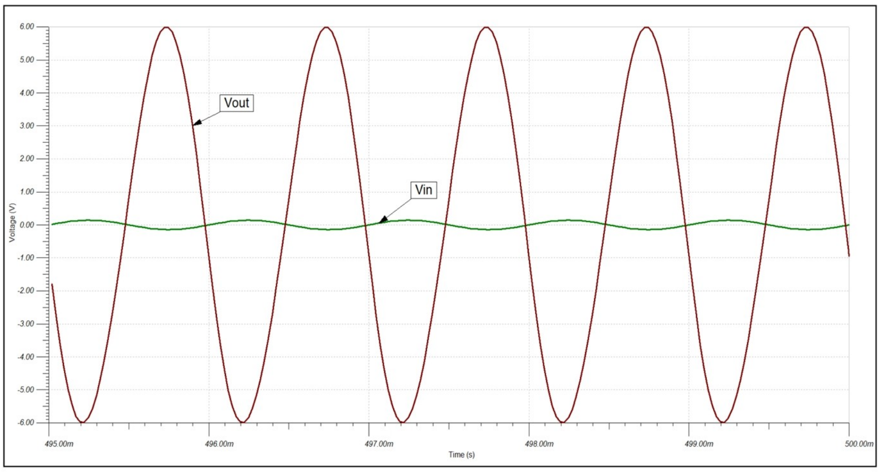


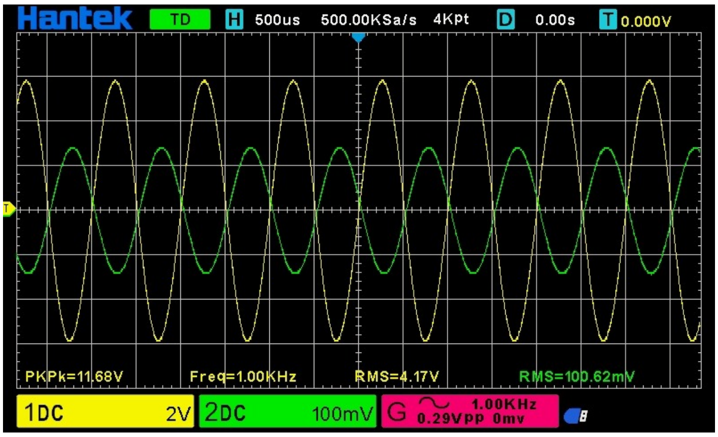


Audio Voltage Amplifier



Model Av = 41×





Real Tube Av = 41×

The model provides good accuracy for both DC operating points and AC gain.

Zabb Csaba