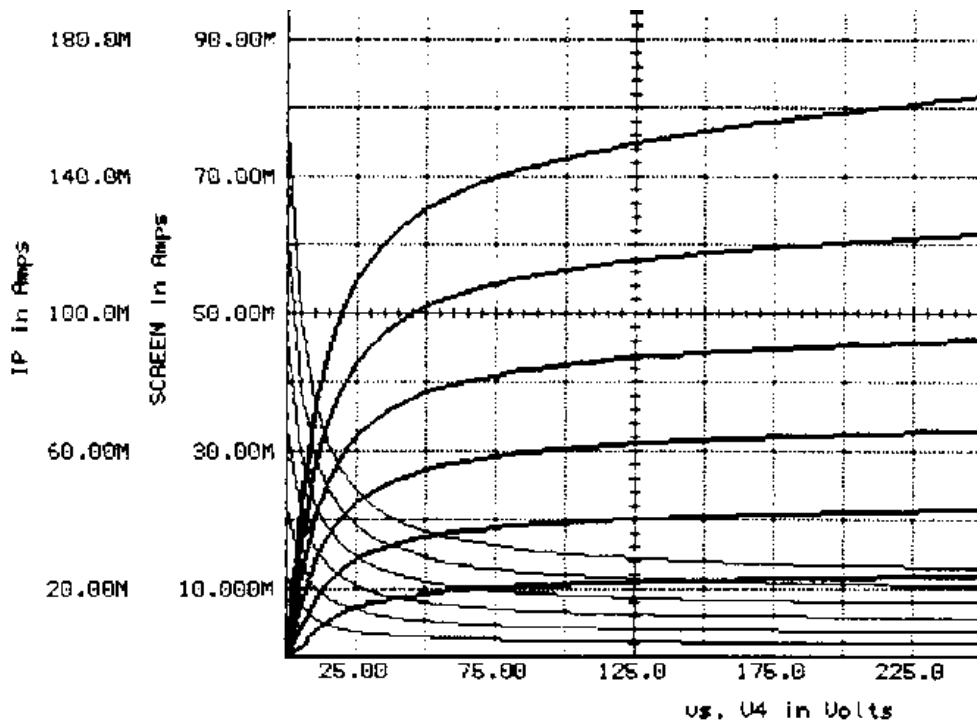


Vacuum Tube Modeling Package Vol. 1

Examples (Electronic edition)

EXCEM



Characteristics of our EL34 pentode model

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Examples
(electronic edition)

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1. Introduction

The present document shows examples of software simulation of electronic circuits with vacuum tubes. It illustrates the capabilities of simulation of real circuits.

The circuits for these examples are described in the various files contained in the

tubes_13\circuits

subdirectory created by the tube_13.zip file, using the models contained in the Lampe.lib library stored in the

tubes_13\models

subdirectory. The simulation itself was performed with an ICAP/4 Windows SPICE simulator. We have tested the library on several versions of this simulator up to version 7.6.

Please refer to the *Vacuum Tube Modeling Package Vol. 1 — User's guide* contained in the usergui5.pdf file for more information on SPICE tube models and SPICE electronic simulation. The

2. Description of the sample circuits and test circuits

2.1 Presentation of the five sample circuits

The present electronic edition of the *Vacuum Tube Modeling Package Vol. 1* contains five sample circuits. The first three circuits are Mr. Rydel's own brew : ALIM.CIR is an hydride (bipolar transistor/vacuum tube regulated power supply, RIAA.CIR is an RIAA preamplifier with direct coupling and without global feed-back, SERIAL.CIR is a power audio amplifier with serial output stage using Russian 6C33-B power triodes.

The fourth sample circuit, WILLIAMSON.CIR, is the well known Williamson amplifier, in its second embodiment as published in *Wireless World* in 1949 [13].

The fifth and last circuit, OSCBF.CIR is an amplitude stabilized low frequency oscillator used in a Philips millivoltmeter.

2.2 The ALIM.CIR sample circuit

This power supply (see schematic on page 7) is based on a triode mounted EL34 pentode, implemented as a series regulator ballast. The ECC83 is a differential amplifier comparing the voltage across the D1 zener diode, and the shifted and divided output voltage. The original part of the circuit is a cascode mounted NPN transistor, substantially increasing the open-loop gain of the regulator. As the simulation demonstrates (not shown), the regulated output is pretty clean : the input ripple of about 18 V peak to peak is reduced to an output voltage of about 50 mV peak to peak. The ripple attenuation is about 51 dB.

2.3 The RIAA.CIR sample circuit

The RIAA preamplifier schematic is shown on page 8, with an anti-RIAA circuit R17-R18-C13-C14 connected at its input. This configuration allows the control of the accuracy of the RIAA fitting (though a more rigorous approach would necessitate the addition of a unity gain voltage controlled voltage source). The figure on page 9 shows that RIAA compliance is better than 1 dB between 20 Hz and 70 kHz. The pentode in the preamplifier front-end is intentionally biased with a low anode voltage. It provides enough gain to compensate the noise produced by the R9-R10-C3-C11 RIAA circuit. The double triode output stage has a direct link to the anode of the front stage pentode, and a feed-back circuit R11-R16 that provides a low output impedance.

2.4 The SERIAL.CIR sample circuit

The serial amplifier shown on page 10 does not use any output transformer. It looks more like the kind of circuit that are implemented with two NPN output transistors. This low-cost version provides 24 W to a 32 Ω loudspeaker system. If eight output tubes had been used, a power of 100 W would be available, with a reduced bandwidth. The high voltage section of the driver stage is bootstrapped (C3,

1 μF) for increased linearity.

The plot on the top of page 11 shows the harmonic distortion for an output power of 24 W at 1 kHz. H2 is at -44 dB and H3 at -42 dB. The C9 capacitor in the feed-back circuit provides a 7.8 μs rise time as shown on the bottom plot of page 11.

2.5 The WILLIAMS.CIR sample circuit

Williamson designed the first truly High Fidelity audio amplifier. Most of all, he clearly understood the causes of the lack of performance of previous designs. It is very interesting to simulate this amplifier and compare simulation results with Williamson's values. The simulated circuit appears on page 12.

Let us note that the output transformer was modeled with Williamson's data for the leakage inductance and the resistance of the windings. We used a 6.9 Ω load. The output power does not exceed 14 W without clamping. We used a 4 μF decoupling capacitors instead of the 8 μF in Williamson's circuit, without significant effect. The plots on page 13 show : the amplifier frequency response without input capacitor (curve 1), with a 50 nF C6 input capacitor (curve 2) and the open loop gain (curve 3). The feed-back ratio appears to be 17 dB. Curves 2 is in agreement with Williamson's results, even though his schematic does not include an input capacitor. Did he used that capacitor ?

The harmonic distortion analysis of the Williamson amplifier is shown on page 14.

2.6 The OSCBF.CIR sample circuit

This circuit shown at top of page 15 comes from the schematic of the Philips GM6012 millivoltmeter. This oscillator deserves interest for its amplitude regulation circuitry. The transient analysis of the starting of oscillation can be studied if one simulates this circuit (not shown).

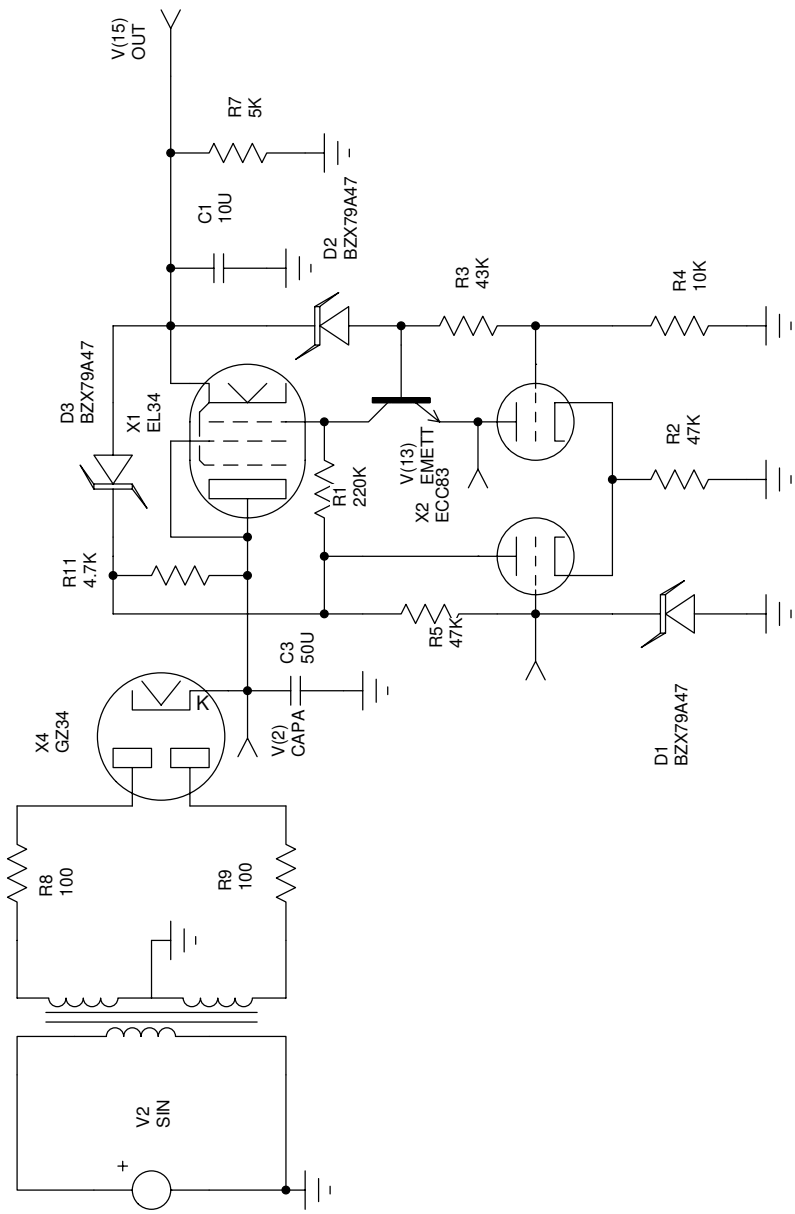
2.7 Vacuum tube test circuits

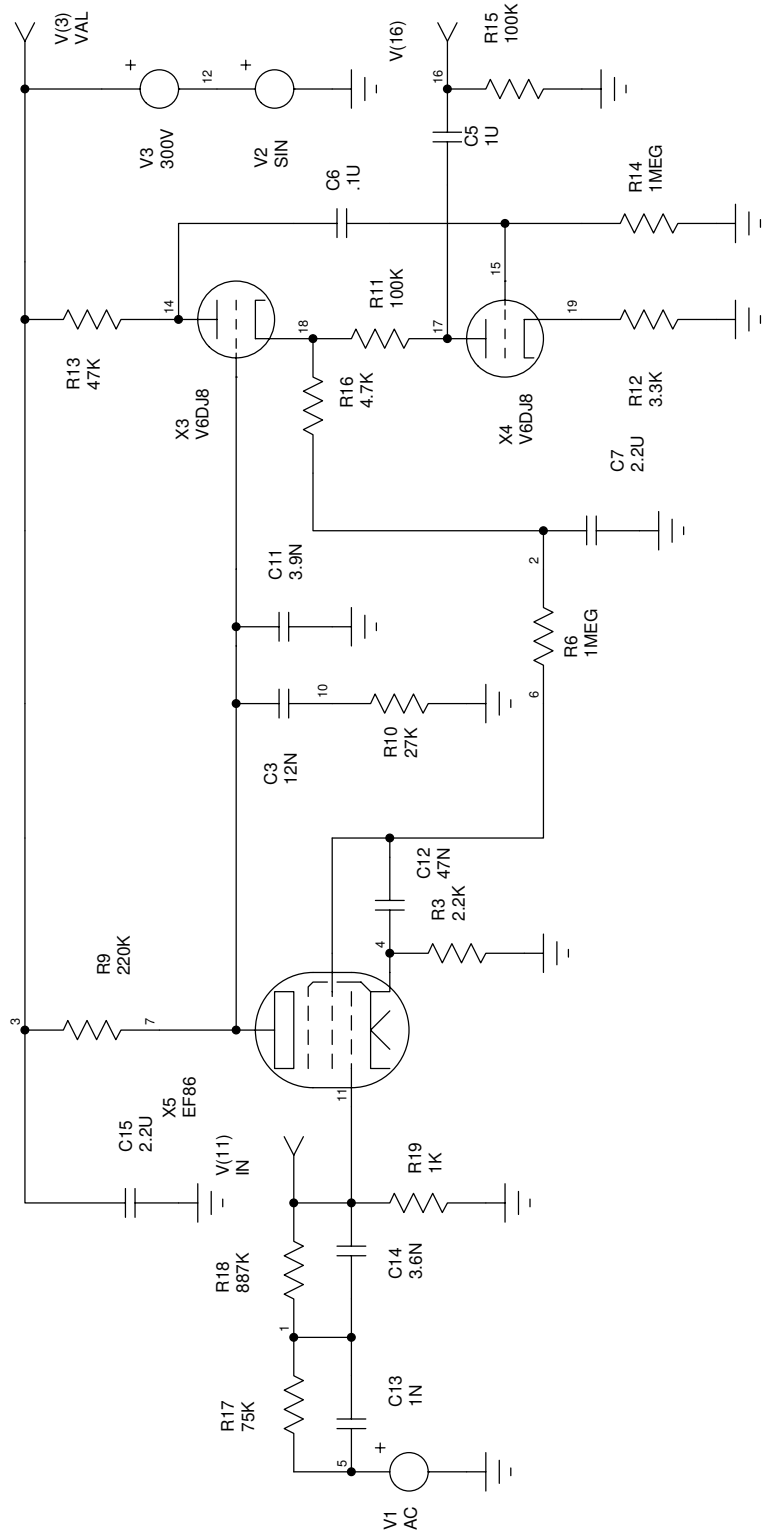
Two test circuits are provided in the Vacuum Tube Modeling Package vol. 1.

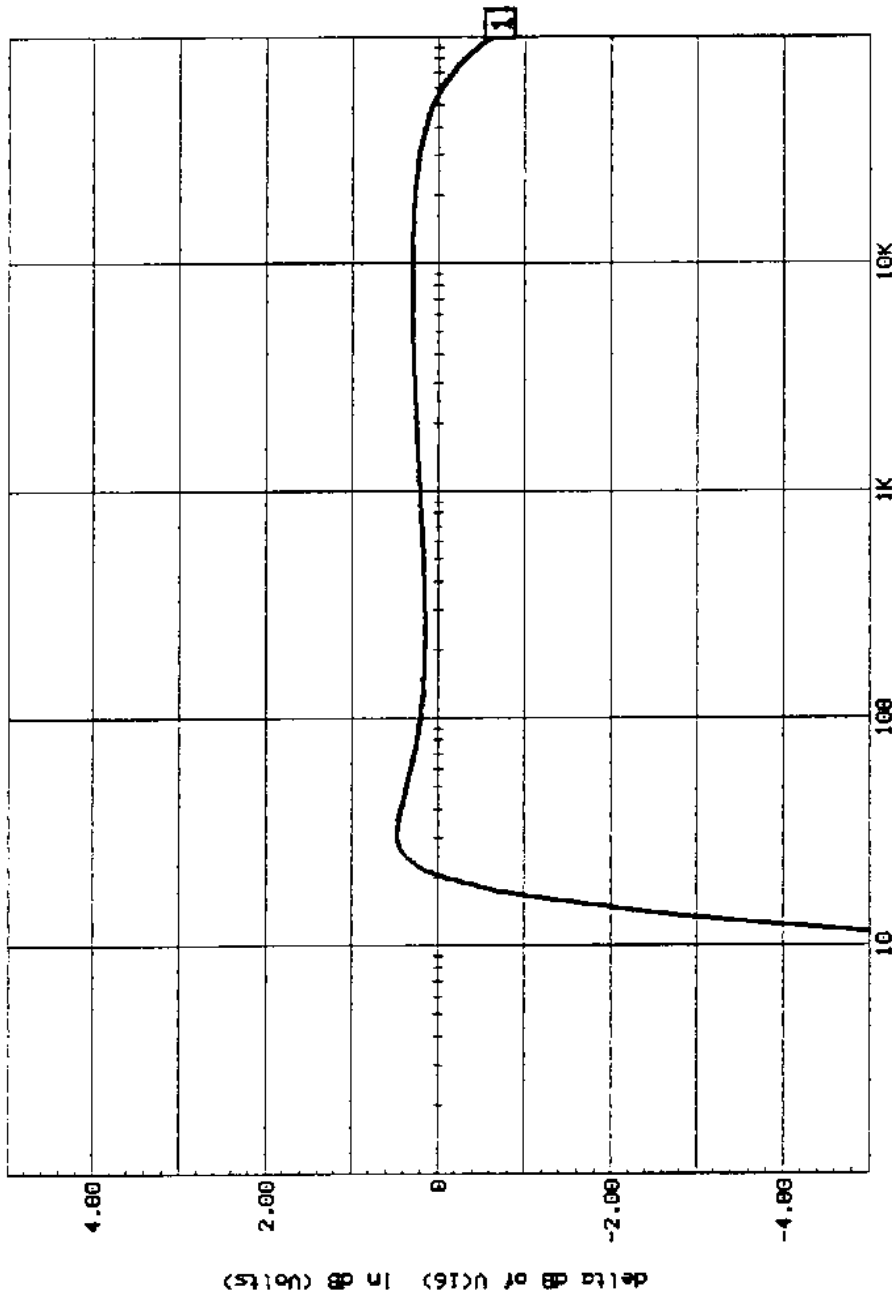
TESTRIO.CIR is intended for the testing of triodes, and TESTETRO.CIR for the testing of tetrodes and pentodes. If you want to test a tube, just insert the tube model's name, and select the appropriate grid voltage and anode voltage steps. You will obtain the tube characteristics. You will be able to check that our models are in excellent agreement with manufacturer's data.

2.8 Schematics and plots

The next pages show the schematics and plots mentioned above.

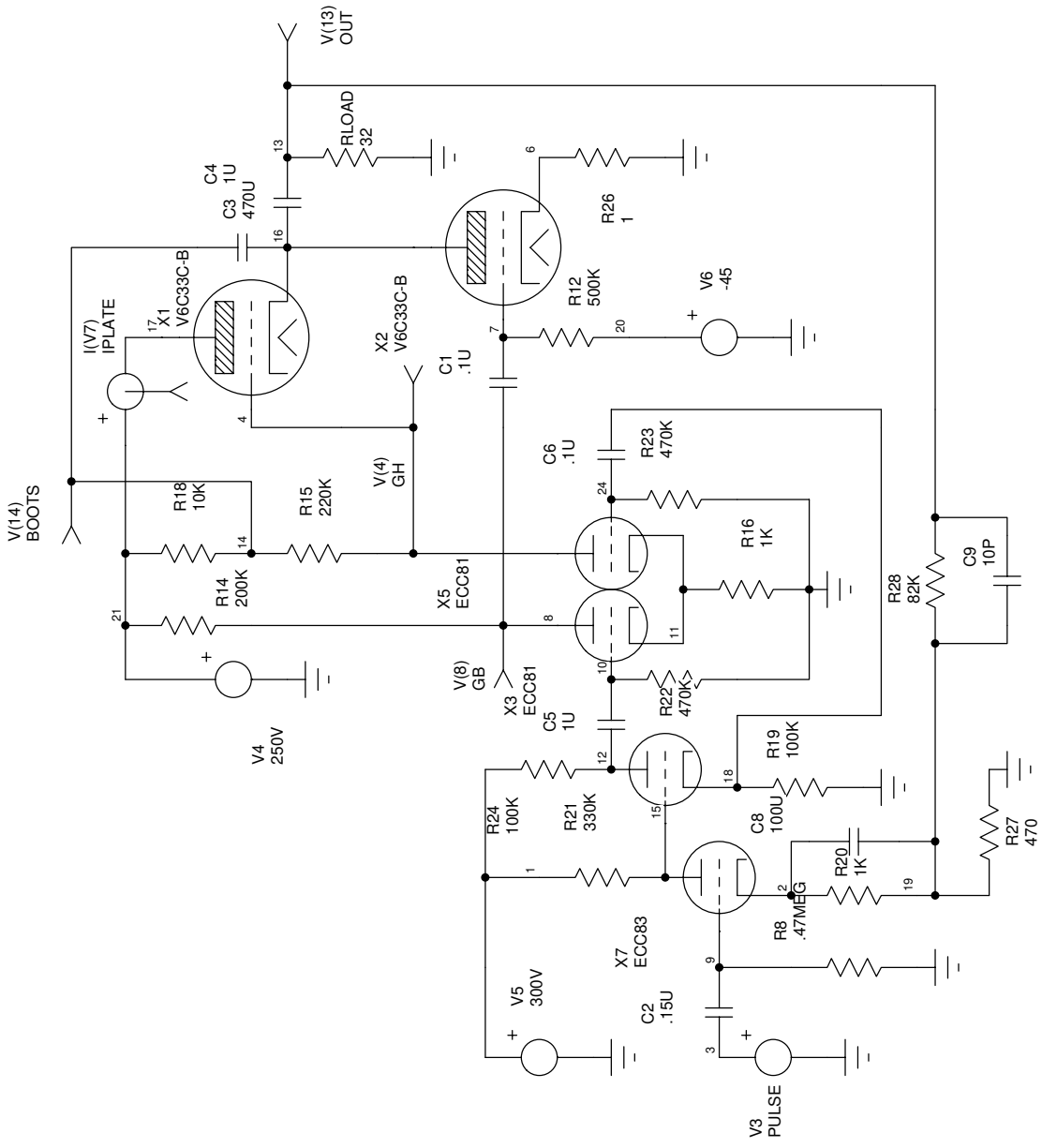


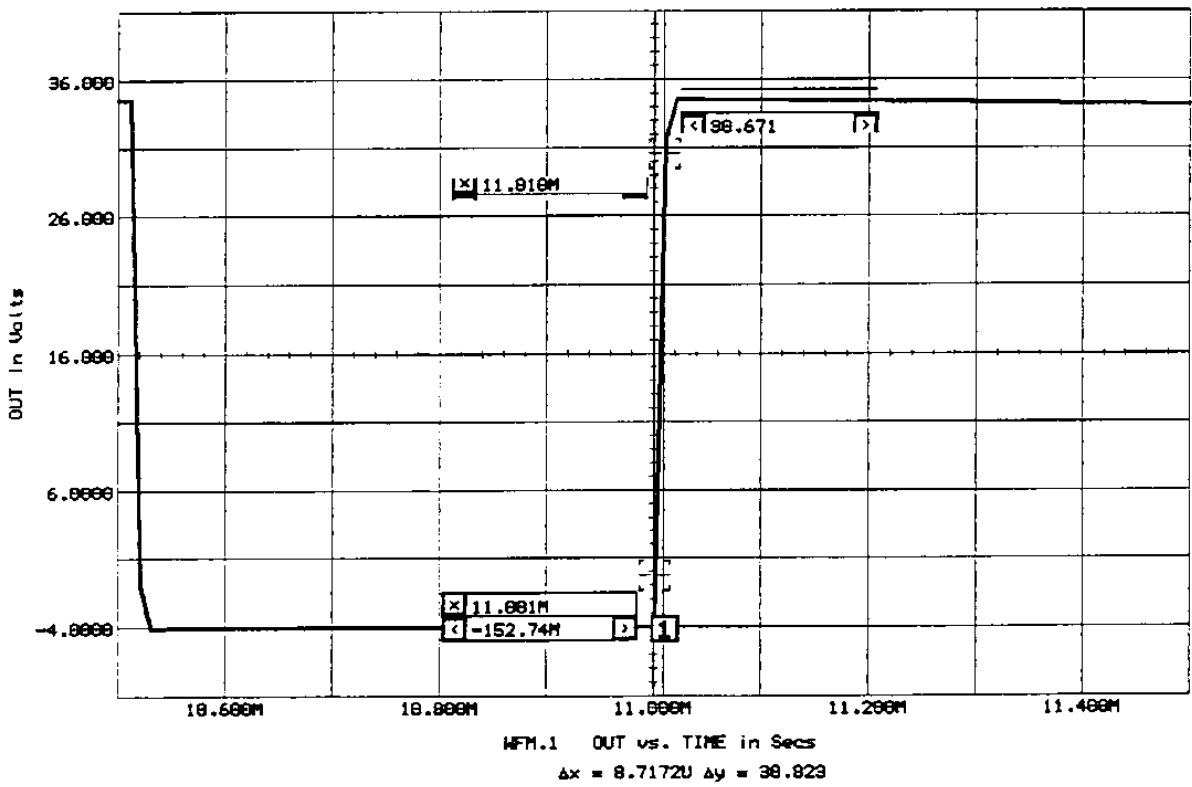
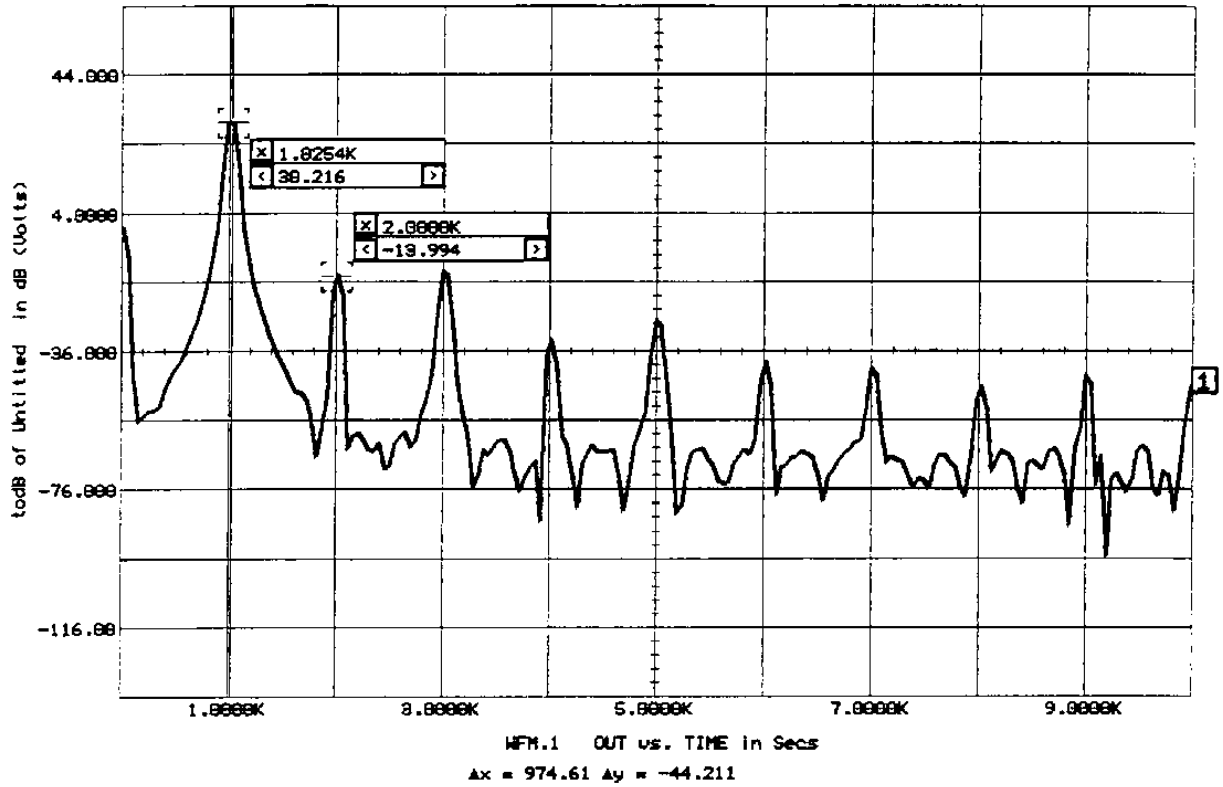


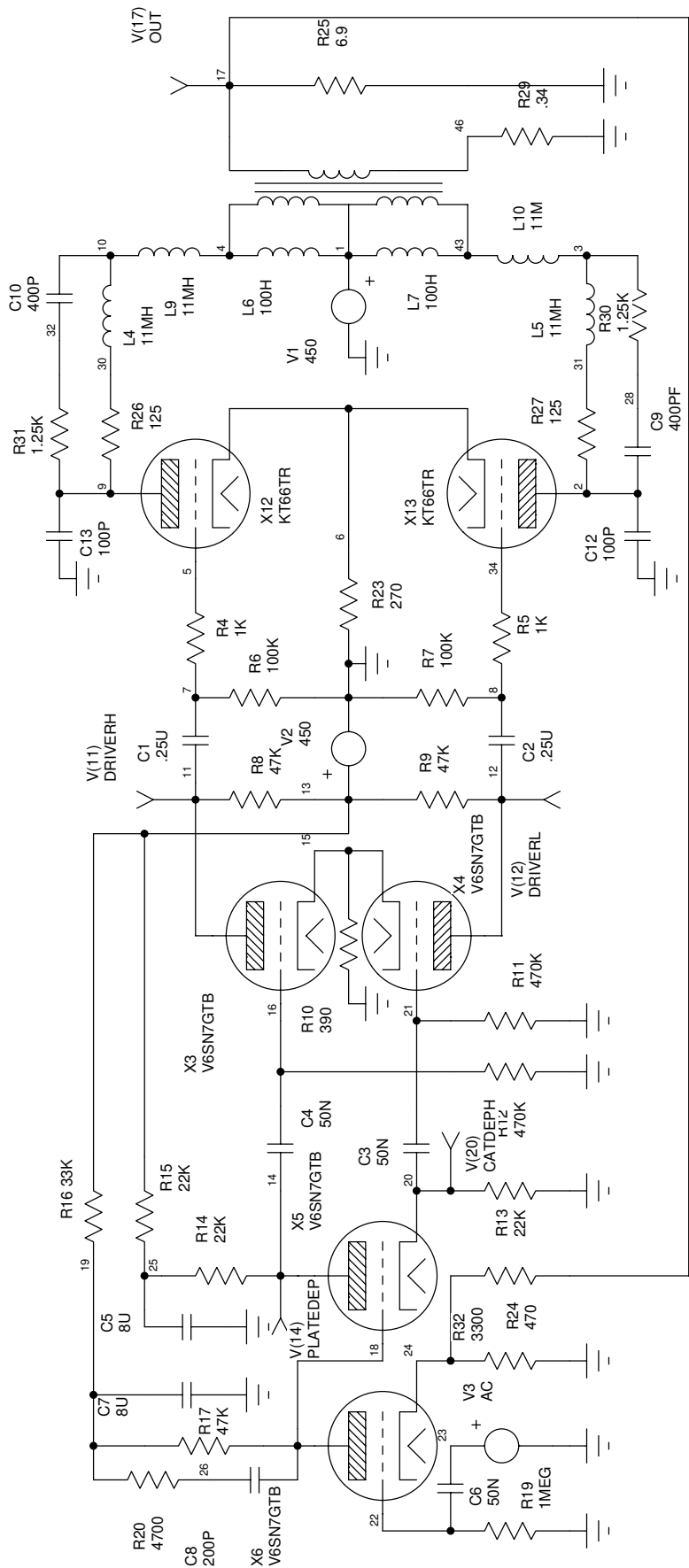


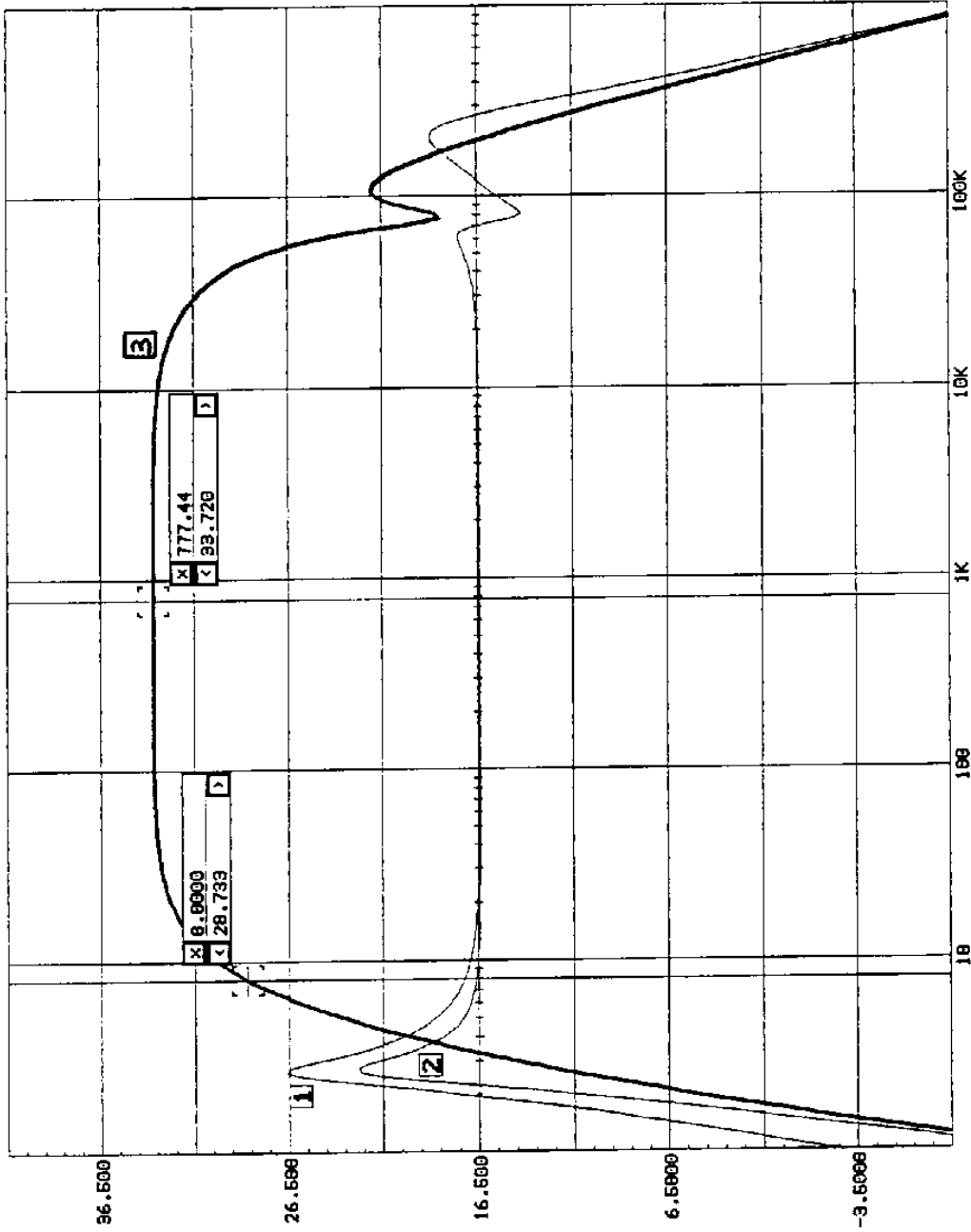
MF1.1 U(16) vs. FREQUENCY in Hz
Preamp11 RIAA

RIAA error



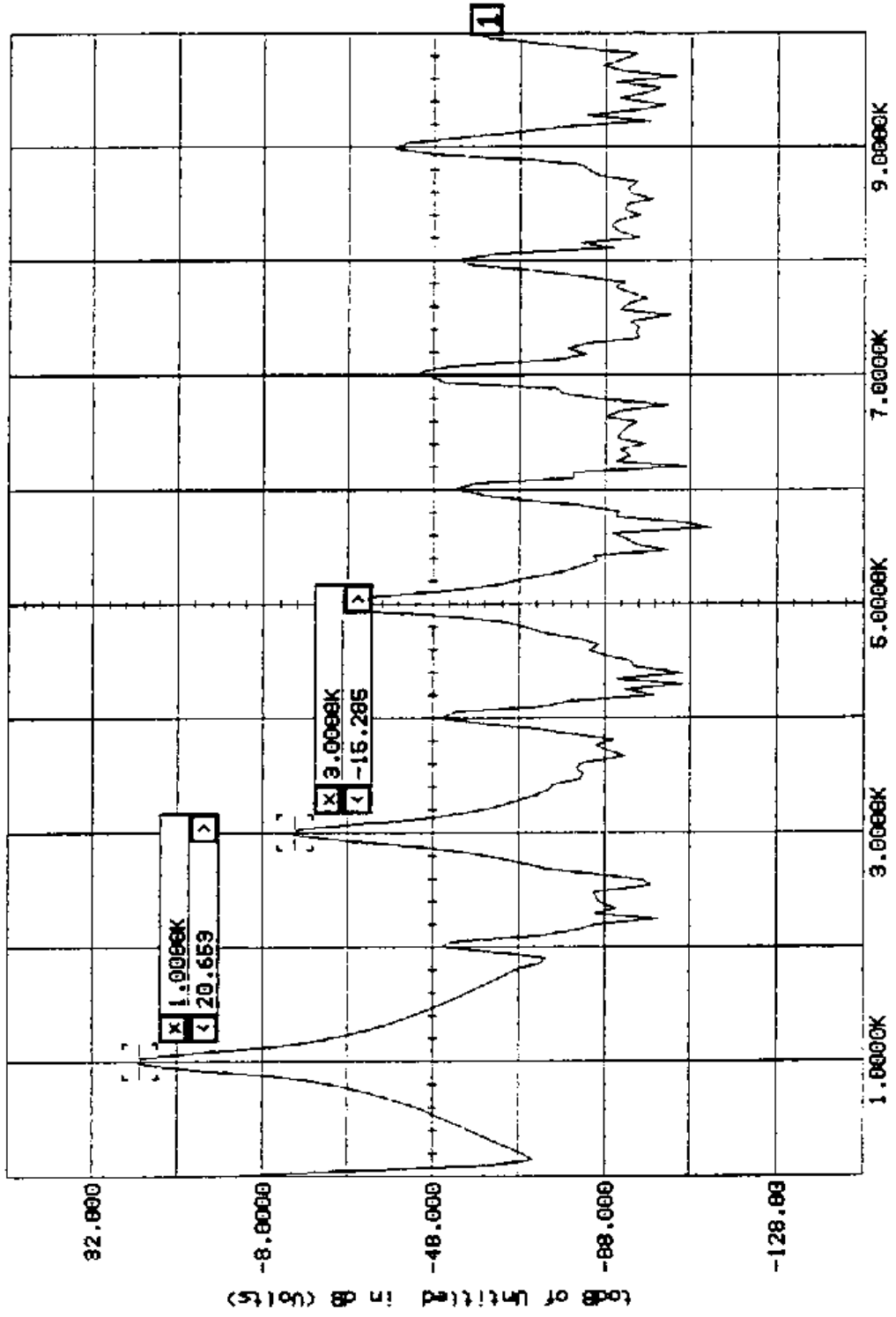






NFM.3 OUT vs. FREQUENCY In Hz $\Delta x = 769.44 \Delta y = 4.9871$
 1)ss capa In 2) avec capa In 50nf 3) boucle ouu. capa 50n

Bandwith



Ampl1 Williamson, 12U, h3=1.6%
 WFN.1 OUT vs. TIME in Secs
 AX = 2.0000K AY = -35.930

Distorsion

