

Verstärkertechniken im Vergleich: class a/b < = > class d

Dipl. Ing. Hubert Reith - HiFiAkademie

World-challenging

SINCLAIR X-10

INTEGRATED 10 WATT AMPLIFIER AND PRE-AMP

SIZE 6" x 3"

AVAILABLE FOR BUILDING OR READY 8" x 1"

THE ONLY DESIGN IN THE WORLD TO GIVE YOU ALL THESE EXCITING FEATURES

- ★ Pulse width modulated amplification.
- ★ Eleven transistor circuitry.
- ★ Unique four transistor output stage.
- ★ Input sensitivity of 1mV into 1K ohms.
- ★ 10 watts peak output into 15 ohms.
- ★ Total harmonic distortion less than 0.1%.
- ★ Choice of tone control system for mono or stereo to match pick-up, micro and radio inputs.
- ★ Power requirements—12 to 15 volts, D.C.
- ★ Very easy assembly.

By using pulse width modulation, the Sinclair X-10 integrated amplifier and pre-amp offers the constructor entirely new concepts of amplifier design and performance. Everything, except the tone and volume controls, is contained on the printed circuit board which measures only 6 x 3in. and since no heat sink is necessary, the saving in space is enormous. This gives the constructor the opportunity to build a modern sleek hi-fi installation. In performance, the X-10 is a revelation in quality and power. There is no falling off at higher frequencies up to 20Kc/s, transient response is superb and current consumption for the power output obtained is appreciably less than in comparably rated conventional amplifiers. In fact the X-10 will operate perfectly well from two 6-volt lantern batteries. The Sinclair X-10 Manual included with every X-10 Amplifier explains how it functions and gives tone control and stereo matching circuits none of which costs more than a few shillings.

THE ONLY CONSTRUCTIONAL AMPLIFIER IN THE WORLD USING PULSE WIDTH MODULATION

Hi-fi quality for very low cost

BLOCK DIAGRAM
shows in simplified form the stages of function of this remarkable amplifier. Such design with its very much better standards of performance is made possible by use of the very latest transistors and high quality components.

All parts for building, including 11 transistors, with X-10 Manual and instructions come to

£5.19.6
Ready built and tested with X-10 Manual

£6.19.6
X-10 Power Supply Unit (ready built) for A.C. Mains.

£2.14.0

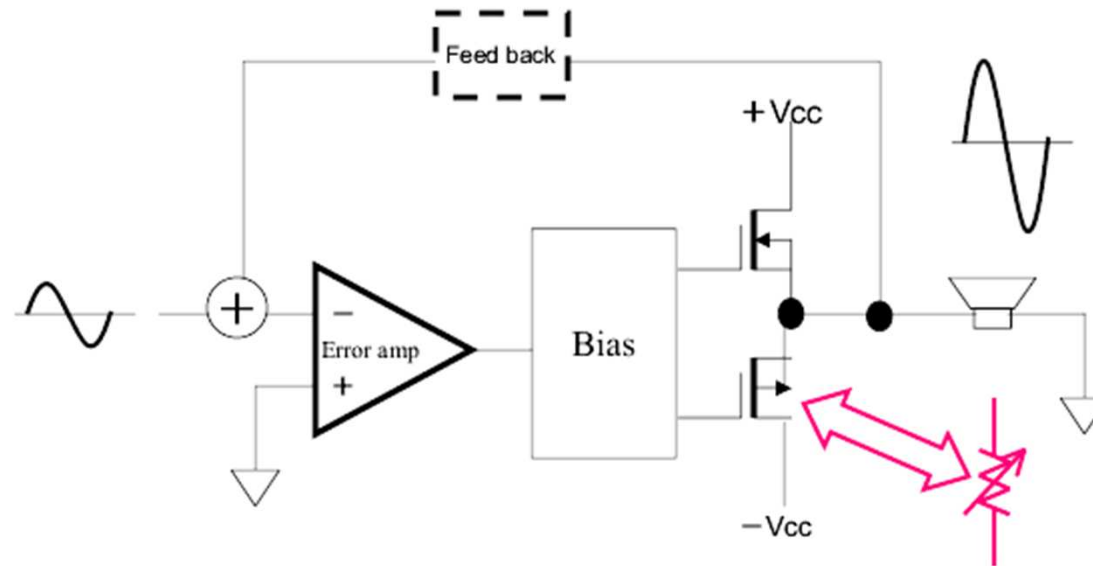
★ FULL SERVICE FACILITIES ALWAYS AVAILABLE TO SINCLAIR CUSTOMERS

sinclair **SINCLAIR RADIONICS LTD.**
COMBERTON Cambridge Telephone COMBERTON 682

Class d:

Erste Patente aus 1946
Erster Bausatz aus 1964

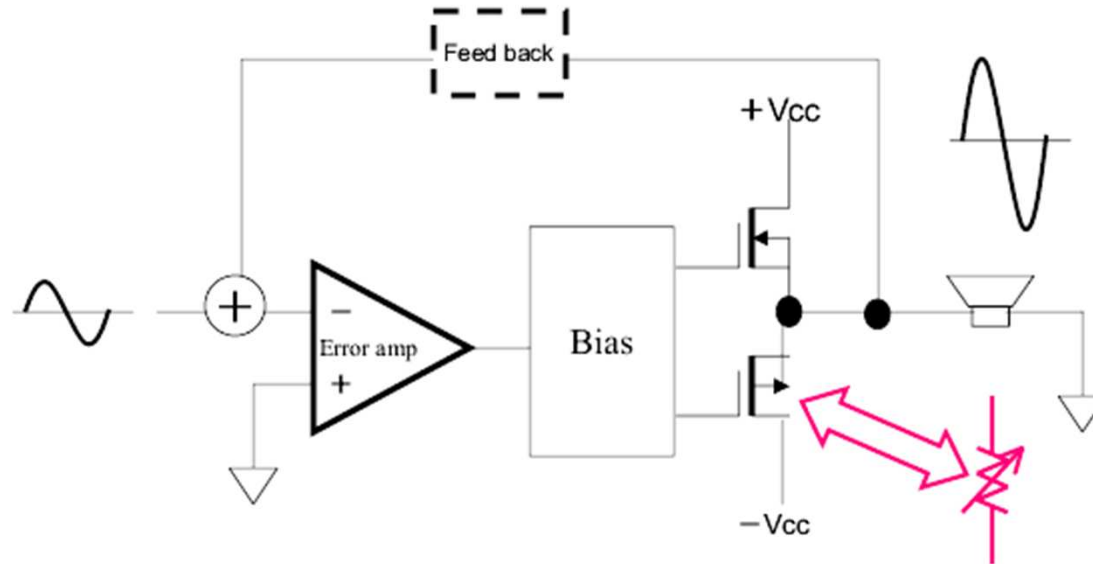
Mark Levinson spricht von
ersten PWM-Verstärkern aus
1932



Klassischer Verstärker:

Ausgangsstufe mit bipolaren Transistoren, FET, Röhre.

Transistoren/Röhren wirken als steuerbarer Widerstand nach +-Versorgung.



Beispiel:

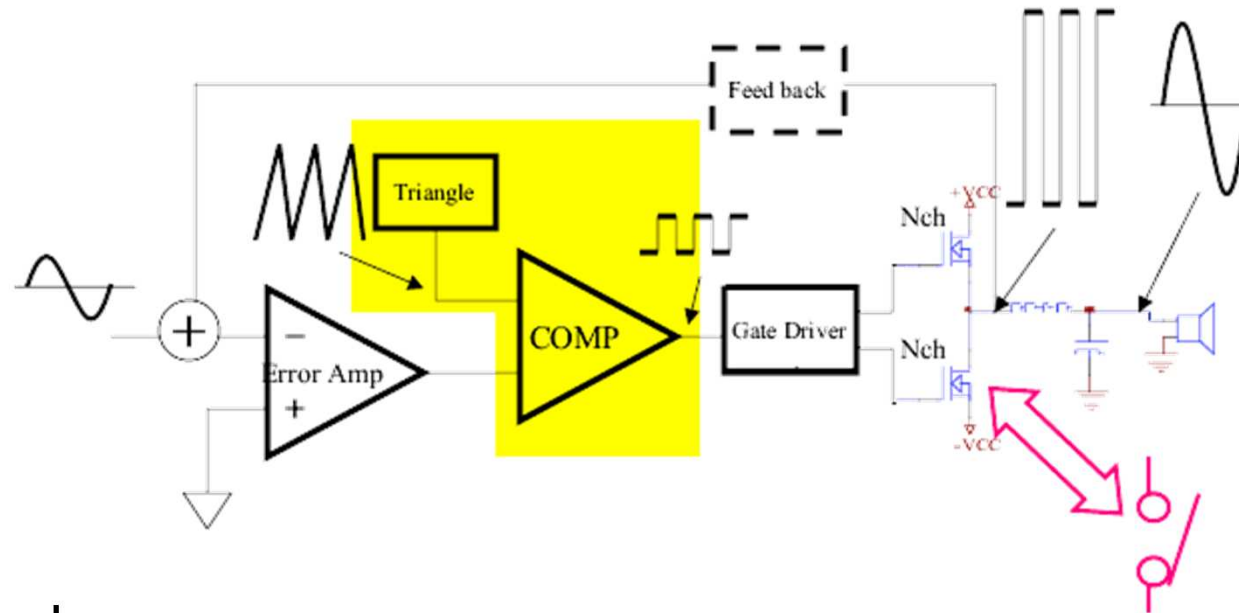
$$V_{cc} = \pm 55V ; R_l = 50\Omega$$

$$U_l = 5V ; I = 1A$$

$$P_l = 5V * 1A = 5W$$

$$P_v = 50V * 1A = 50W$$

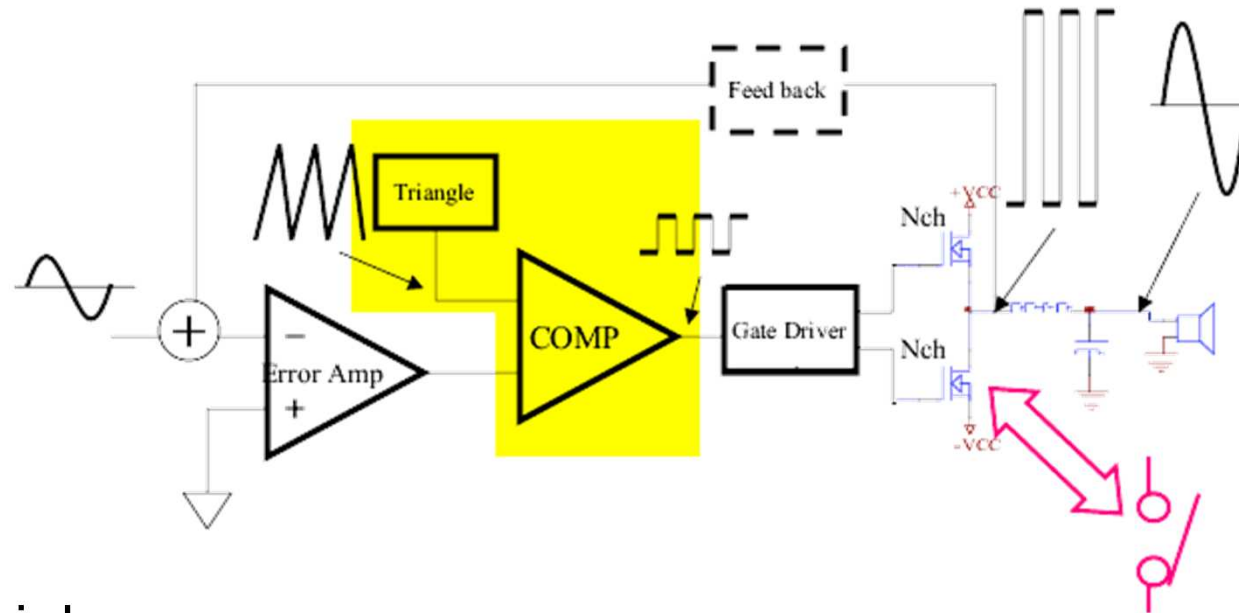
$$P_z = 55W$$



Class d:

Ausgangsstufe mit FET.

Transistoren wirken als Schalter nach +-Versorgung.



Beispiel:

$$V_{cc} = \pm 55V ; R_l = 50\Omega$$

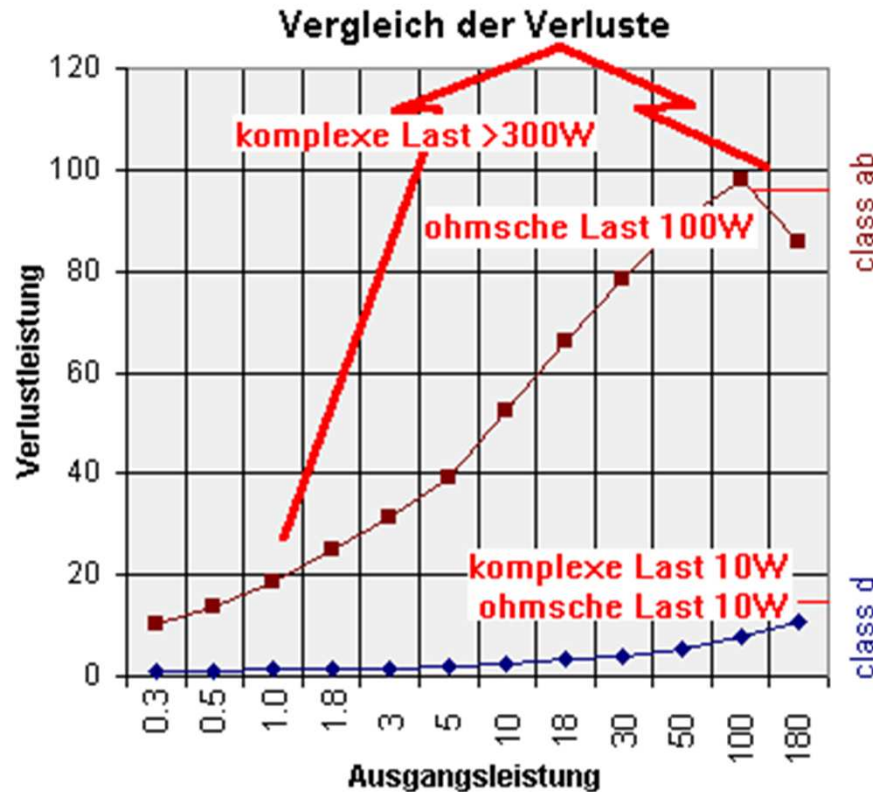
$$P_l = 5V * 1A = 5 W$$

$$U_l = 5V ; I = 1A$$

$$P_v = 1A^2 * 20m\Omega = 0,02W$$

$$R_{on} = 20m\Omega$$

$$P_z = 5,02W$$



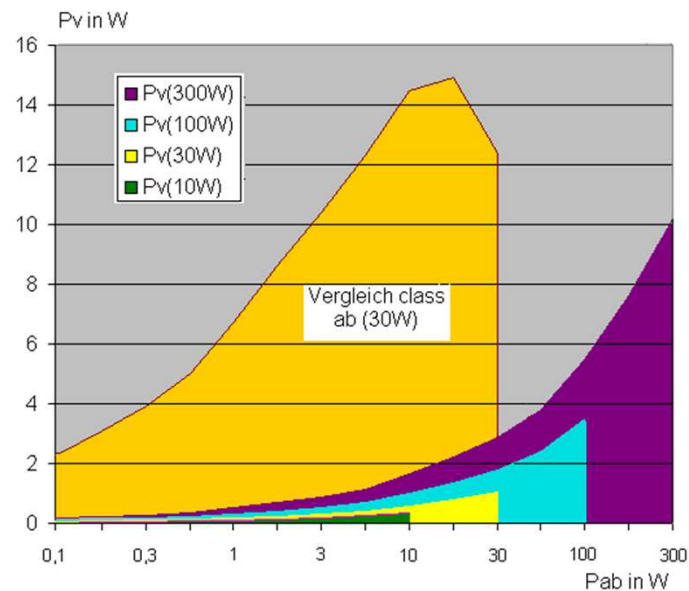
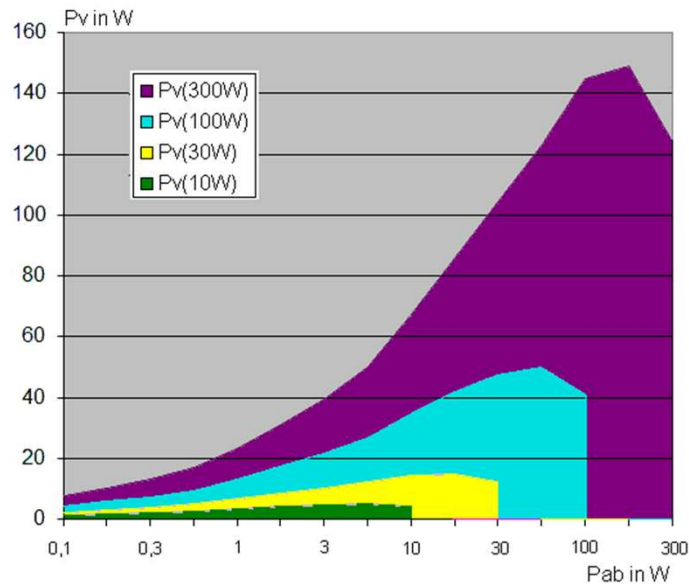
klassischer Amp =>
hohe Verluste an ohmscher Last,
extreme Verluste bei komplexer Last

class d =>
niedrige Verluste, unabhängig vom Phasenwinkel der Last.

Stabilität:

klassischer Amp =>
Schwingneigung bei komplexen Lasten, komplexe Schutzschaltung notwendig.

class d =>
meist extrem unabhängig von der Last, nur Strommessung notwendig

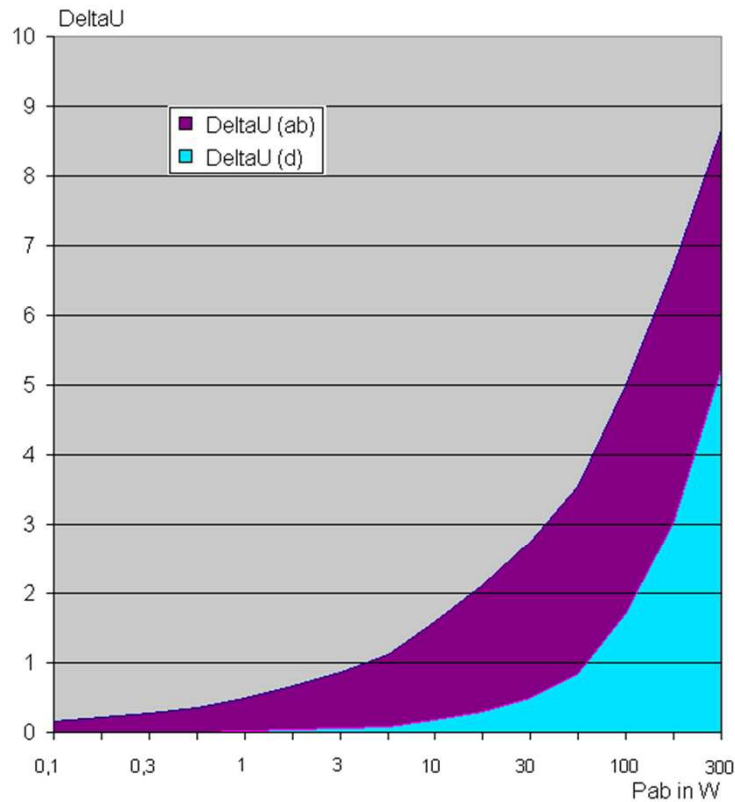


klassischer Amp =>
je höher die Maximalleistung
desto schlechter die Effizienz

auch bei kleinen
Ausgangsleistungen hohe
Verluste

class d =>
auch bei hohen
Maximalleistungen sehr gute
Effizienz

in der Praxis Begrenzung durch
endliche Schaltzeiten und
Restwiderstände



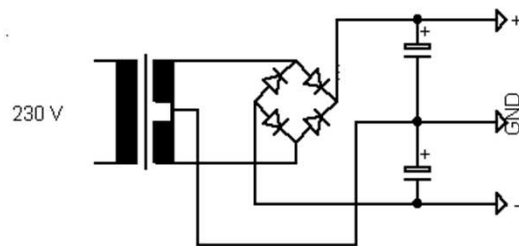
klassischer Amp =>
starke Schwankung der
Versorgung

auch bei kleinen und mittleren
Abgabeleistungen

class d =>
wesentlich geringere
Schwankung der Versorgung

bei kleinen und mittleren
Leistungen nur 1/100..1/10

kleineren Elkos, stabilere
Versorgung



Transistor-Kennlinie:

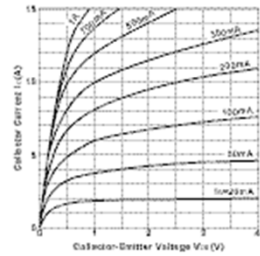
Quadrat- oder E-Funktion als Übertragungskennlinie.

Alle Parameter vom Arbeitspunkt, Temperatur.... abhängig.

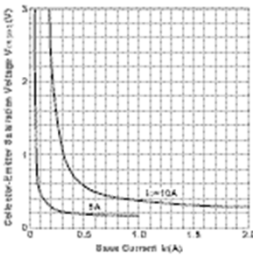
Starke Streuung.

N/P-Typen nur begrenzt vergleichbar

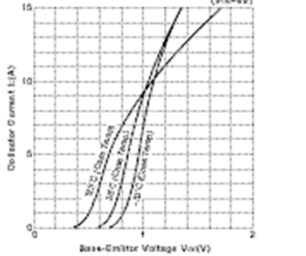
Ic-Vce Characteristics (Typical)



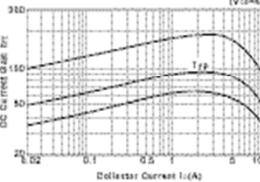
Vce(sat)-Ib Characteristics (Typical)



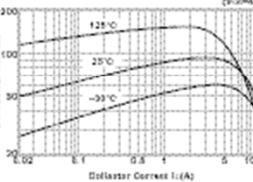
Ic-Vce Temperature Characteristics (Typical)



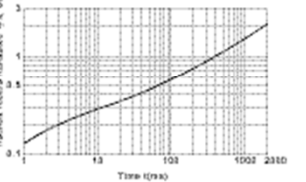
hFE-Ic Characteristics (Typical) (Vce=6V)



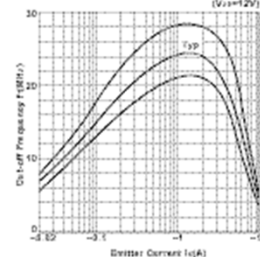
hFE-Ic Temperature Characteristics (Typical) (Vce=6V)



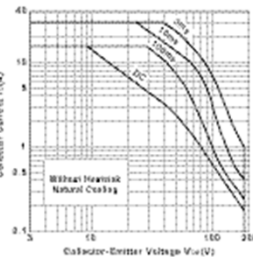
βj-x-t Characteristics



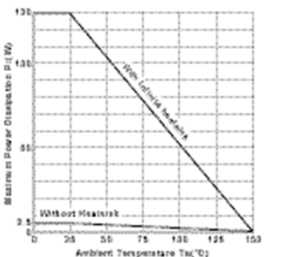
fT-Ic Characteristics (Typical) (Vce=6V)

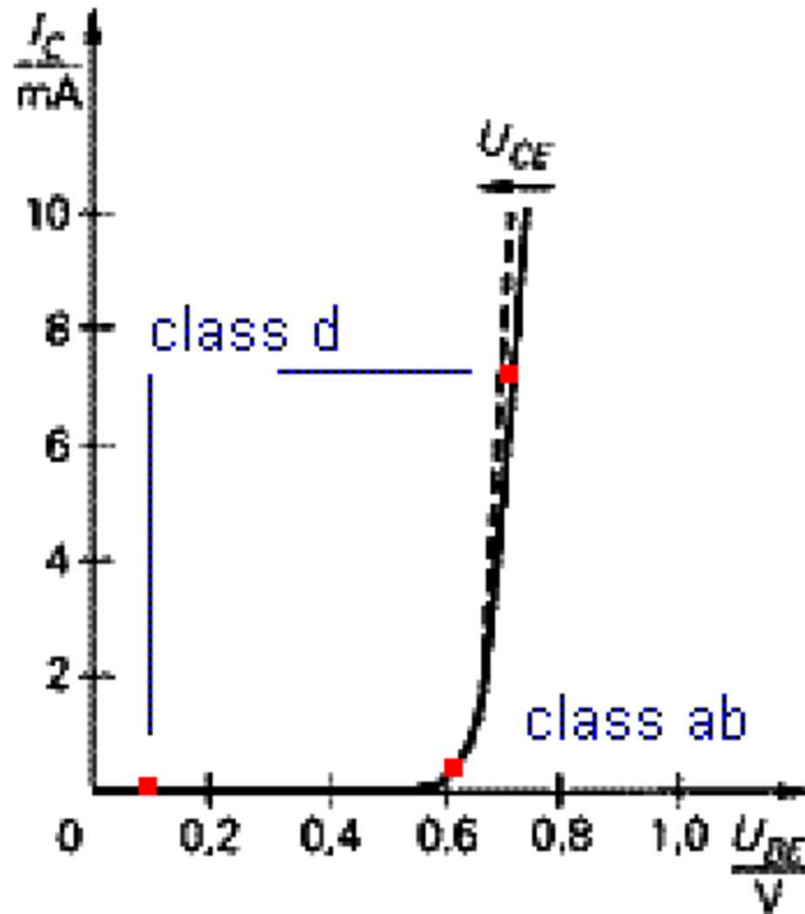


Safe Operating Area (Single Pulse)



Pc-Ta Derating





Arbeitspunkt:

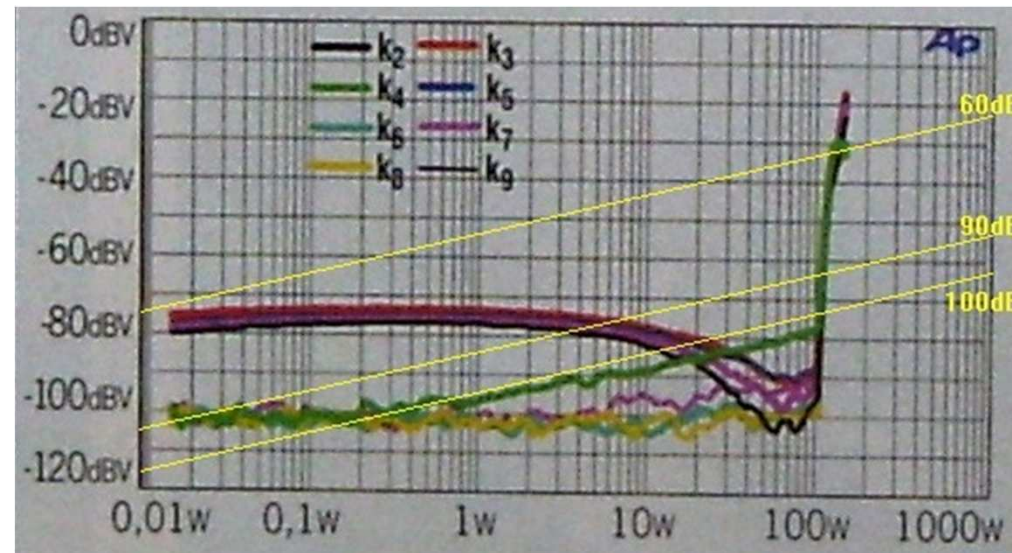
klassischer Amp =>

im Knick, relativ hoher R_i , sehr unlinear

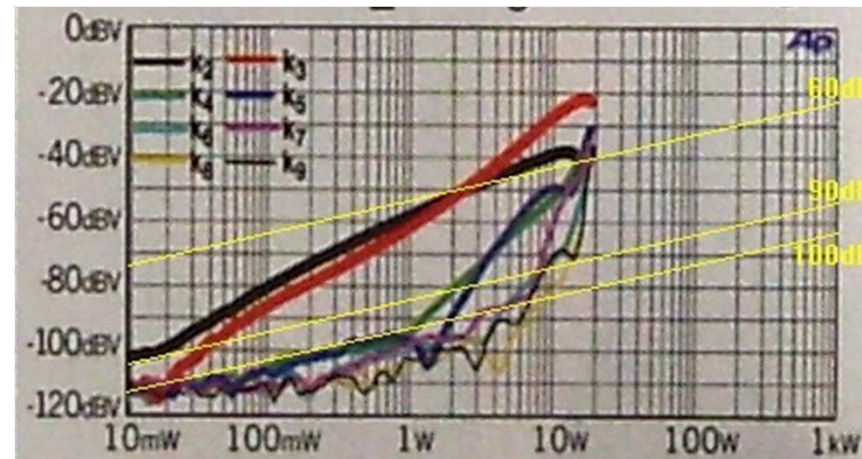
class d =>

an den Enden, relativ niederohmig, sehr linear

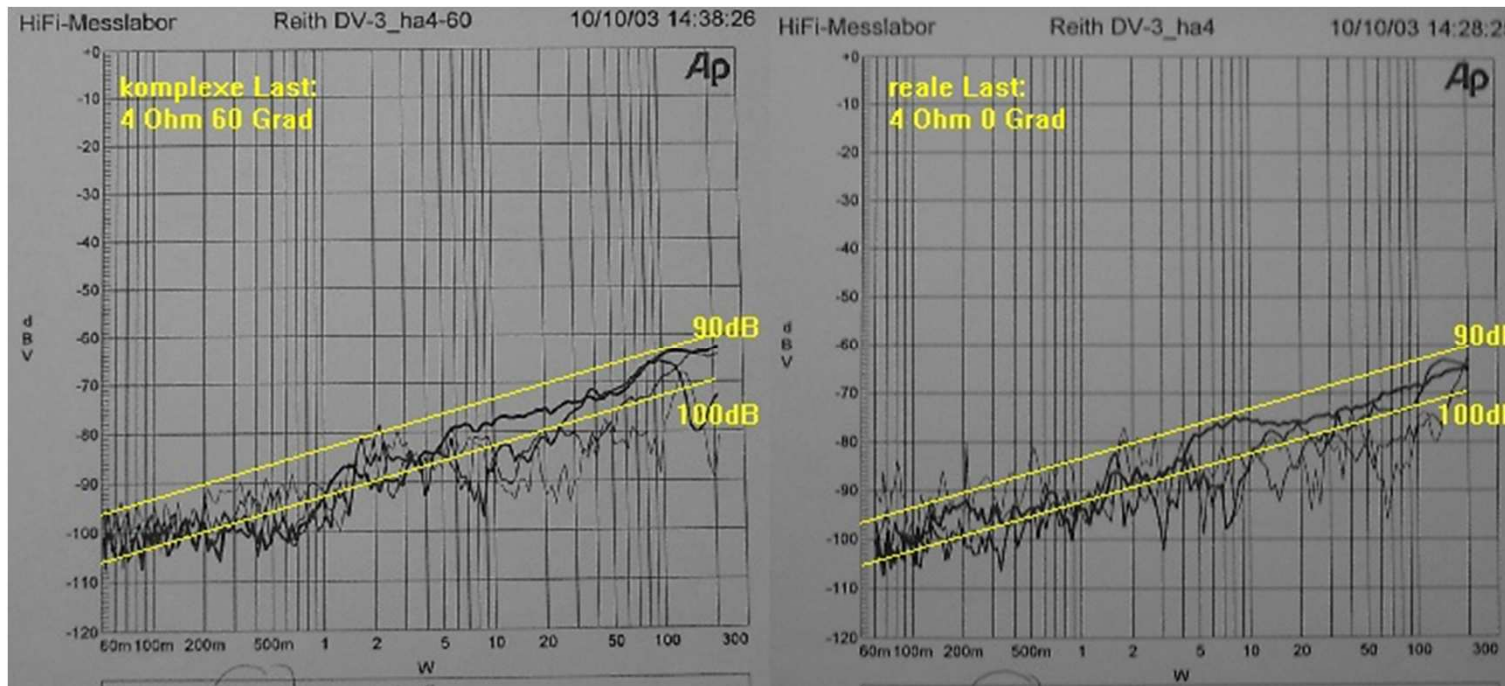
Klassischer Amp => meist zu höheren Leistungen fallend

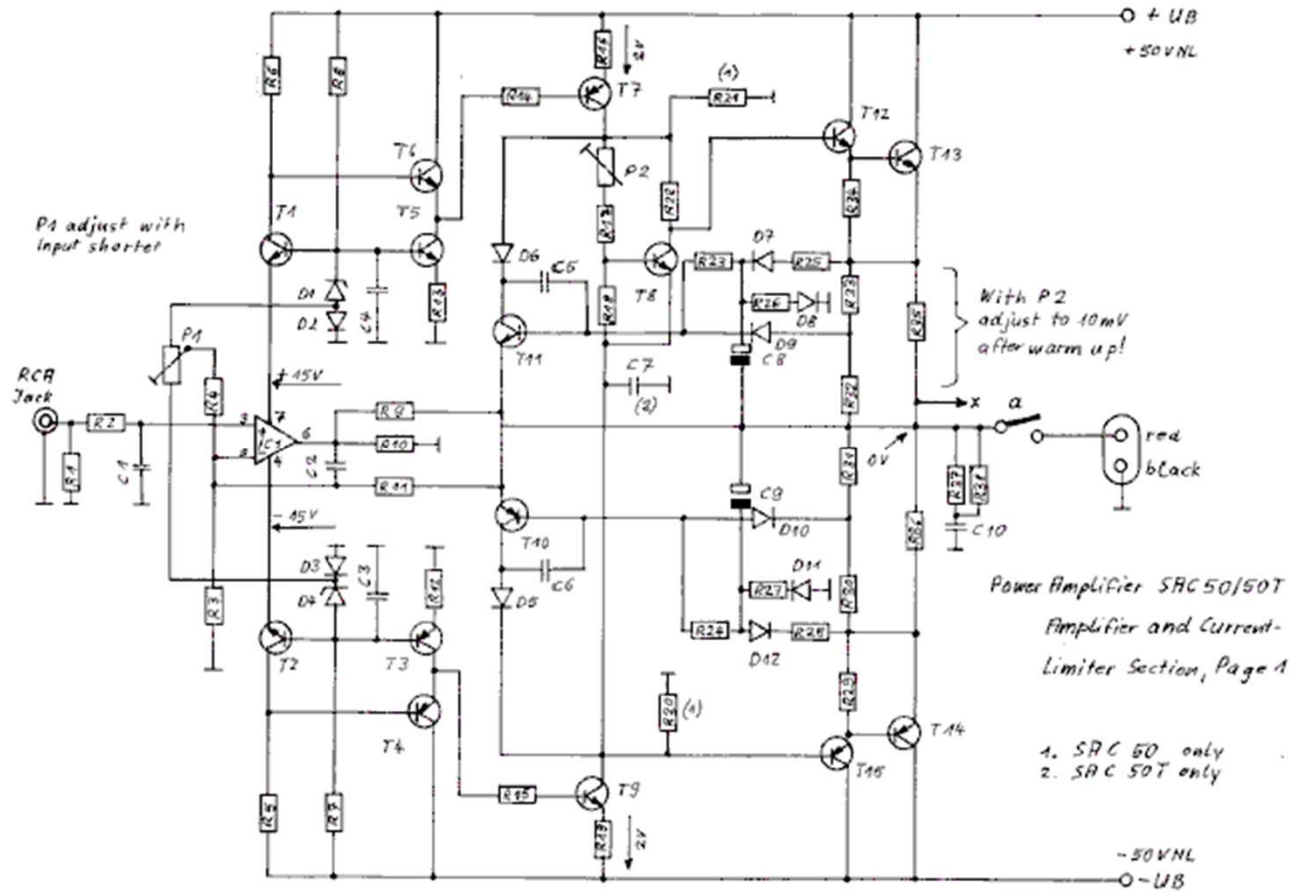


Röhre => deutlich steigend

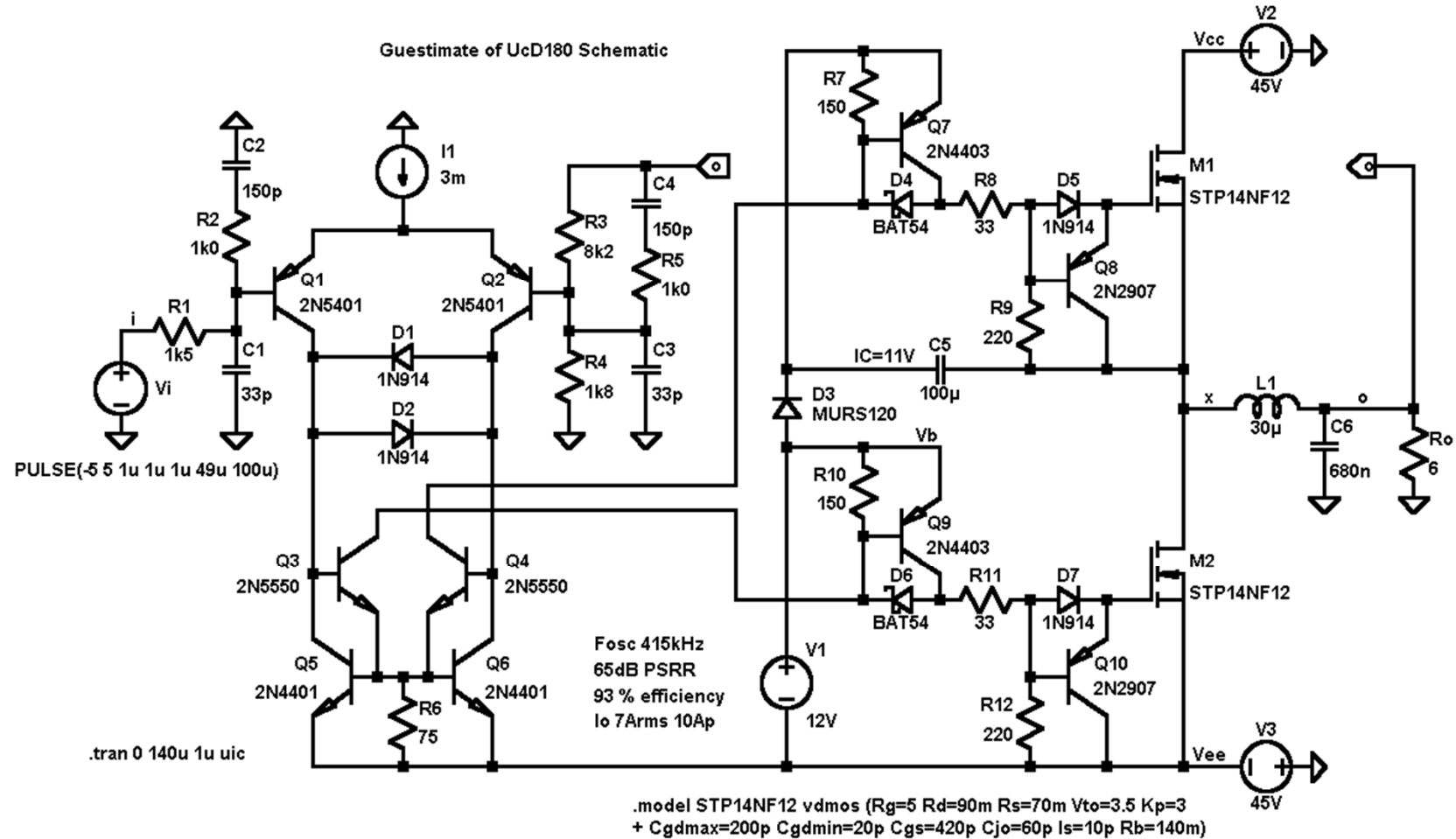


Class d => relativ unabhängig von der Aussteuerung



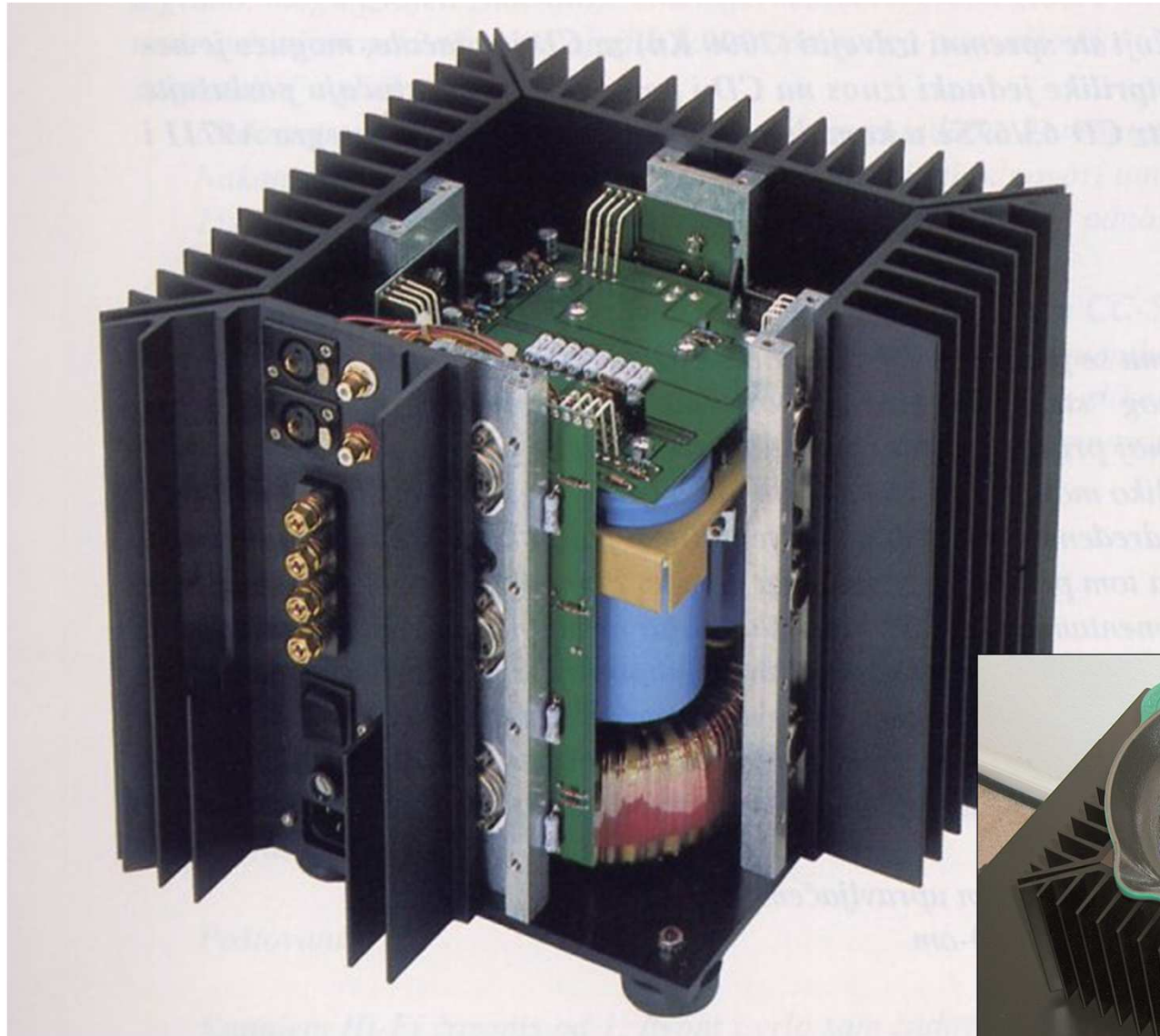


Aufbau klassischer Amp



Aufbau class d

Beispiel class a 16/20



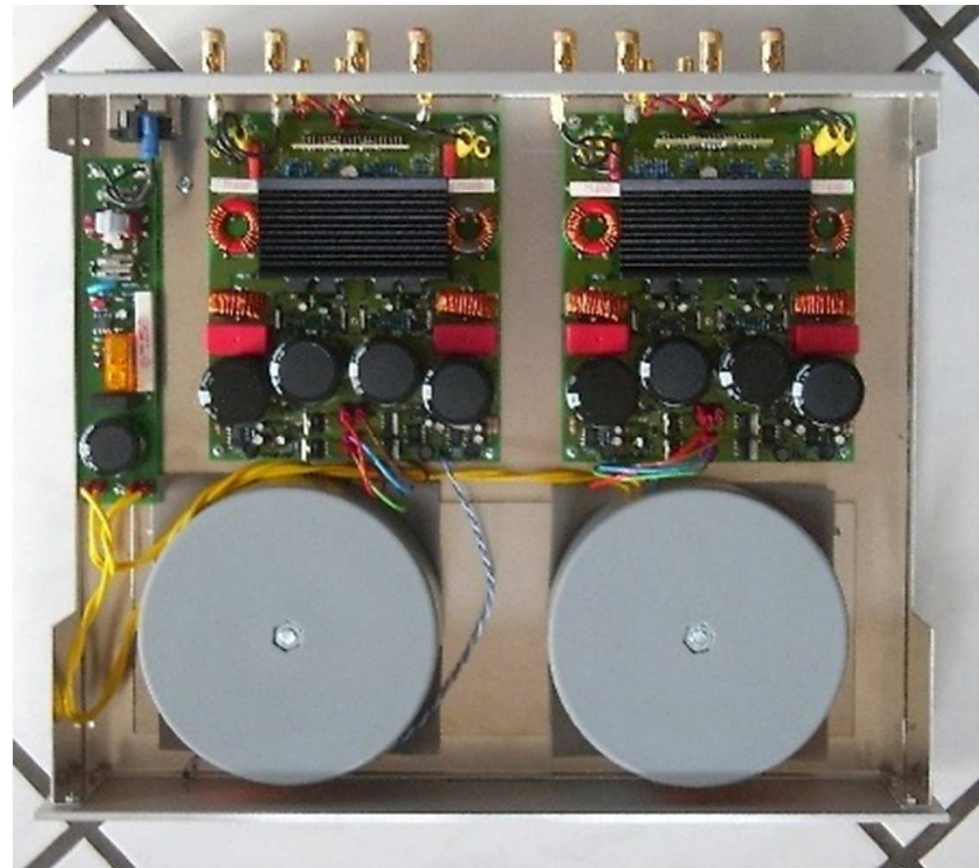
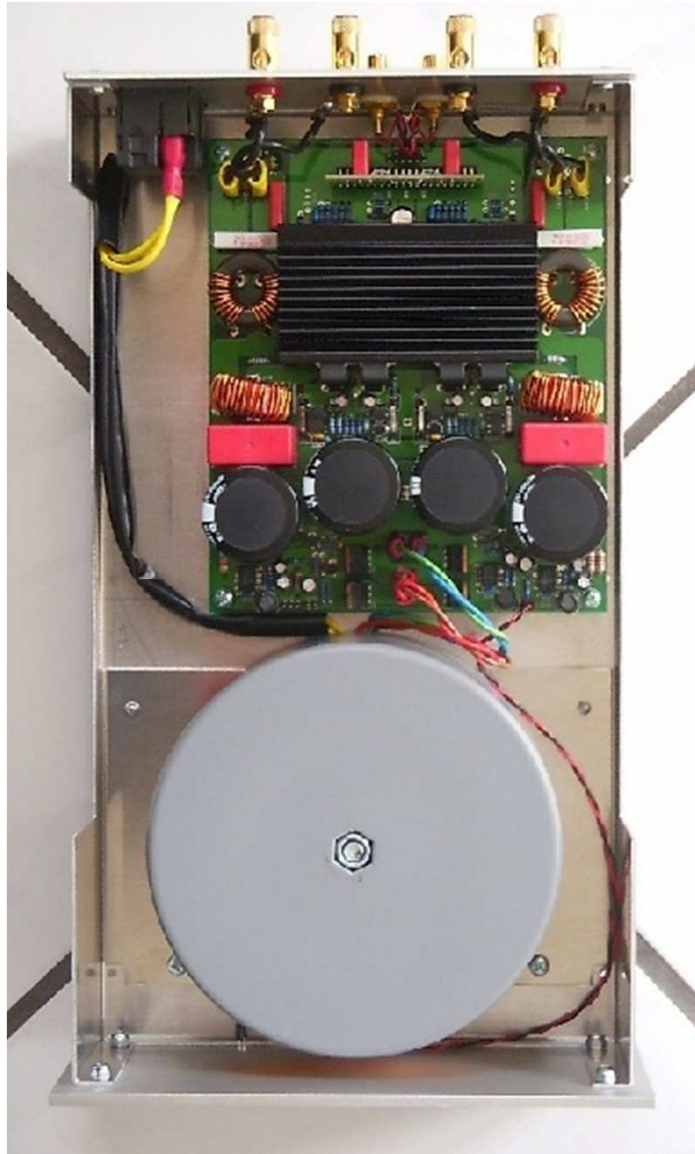
$$P_{ab} = 2 \times 60W$$

$$P_z = 250W$$



$P_{ab} = 2 \times 250W; 4 \times 250W$

$P_z = 12W \quad ; \quad 24W$

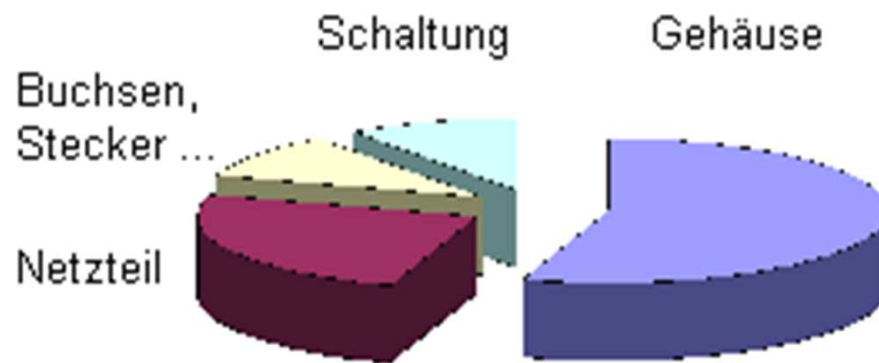


Kosten:

wichtigster Kostenfaktor ist
NICHT die Elektronik.

Verstärkerschaltungen lassen
sich für wenige 10.-EUR
aufbauen.

bei class-d kann Gehäuse und
Netzteil preiswerter ausfallen



Keine Nachteile?

Ausgangsfiter notwendig

HF-Design notwendig

EMV

kein Gewichts-HiFi

DANKE

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