Introduction

Developing an amplifier model is a tricky process that requires attention and technical choices. To illustrate it, I have chosen modelling the rather simple SPARTANO amplifier, recently described in the Italian audio magazine COSTRUIRE. This paper shows the required preliminary steps needed achieving this task, then the development of the model and the results we can get from it, regarding the amplifier behaviour and performances.

Triode valve model

Triodes valves are modelled using current sources. The complete model take care of inter-electrodes capacitances, as shown on the figure n° 1

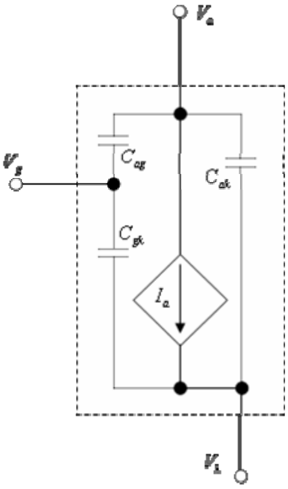


Figure n° 1 Triode valve model

The current source is described using the following Norman L Koreen (1) analytic formula, for $V_{gk} \leq 0$

$$E_1 = \frac{V_{ak}}{t_1} Log\left[1 + Exp\left[t_1\left[\frac{1}{t_2} + \frac{V_{gk}}{(t_3 + V_{ak}^2)^{0,5}}\right]\right]\right]$$

If $E_1 > 0$ then $I_a = \frac{E_1^{t_4}}{t_5}$ else $I_a = 0$

Where t_i, $\forall i = 1, \cdots, 5$ are the parameters to be adjusted for each specific triode type (2), (3).

Two types of triodes are used in the SPARTANO amplifier. The triode type ECC82 pour the two driver stages and the triode type 6080 for the power stage. The adjustable parameters and the inter-electrode capacitances needed for the model are given in the table n° 1

Triode type	t_1	t_2	t_3	t_4	t_5	c_{ag}	c_{gk}	c_{ak}
ECC82	83,6	20,4	957	1,27	645	1,5p	1,8p	0,37p
6080	9,29	2,78	620	1,31	218	8,6p	5,7p	2,5p

Table n° 1 data on triode valves

OPT model

The OPT model is shown on the figure n° 2. It is of the Self Compensated DC magnetic flux type SC-OPT (4), very appropriate to Single Ended amplifiers, as the SPARTANO. The magnetic core is made of laminated GOSS material, the relative permeability of which being given by the modified Paul Langevin analytic formula.

$$\mu_{cr} = 1 + \frac{b}{H_c}\left[coth(aH_c) - \frac{1}{(aH_c)}\right]$$

With

$$a = a_{\min} + (a_{\max} - a_{\min})th(c\left|H_c\right|)$$

Adjustable parameters $a_{\min}$, $a_{\max}$, b and c having the following values:

$$a_{\min} = 1,20E-2,\ a_{\max} = 8,90E-2,\ b = 1,67E6 \text{ et } c = 6,20E-2$$

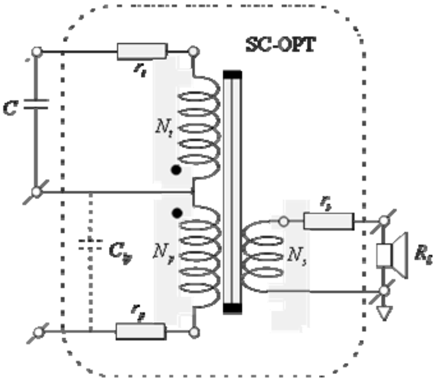


Figure n° 2 OPT type SC-OPT

The magnetic circuit schematic diagram of the SC-OPT is given on the figure n° 3

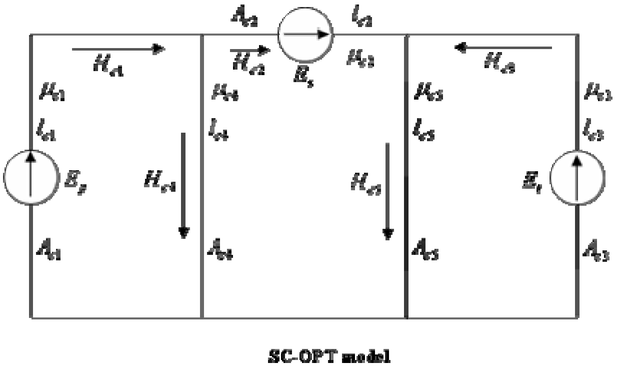


Figure n° 3 Magnetic circuit schematic diagram of the SC-OPT

With the following notations:

N_p	Primary winding number of turns
N_t	Secondary winding number of turns
N_s	Tertiary winding number of turns
I_{a0}	Idle DC anode current
i_p	Primary AC current
i_t	Tertiary AC current
i_s	Secondary AC current
$E_p = N_p(I_{a0} + i_p)$	Primary magnetomotive force
$E_t = N_t(I_{a0} + i_t)$	Tertiary magnetomotive force

$E_s = N_s i_s$	Secondary magnetomotive force
$l_{ci} \forall i = 1, \cdots, 5$	Leg $n°i$ magnetic path length
$A_{ci} \forall i = 1, \cdots, 5$	Leg $n°i$ section area
$H_{ci} \forall i = 1, \cdots, 5$	Leg $n°i$ magnetic field intensity
$\mu_{ci} \forall i = 1, \cdots, 5$	Leg $n°i$ magnetic permeability
l_c	Core magnetic path length
A_c	Core section area

Magnetomotive forces of the primary and the tertiary are opposed to cancel the DC magnetic flux resulting from the anode idle DC current of the power output triode valve.
The leg n° 5 simulates the magnetic flux leakage required to a proper behaviour of the SC-OPT (4)
The Leg n° 4 simulates the magnetic flux leakage between the primary and secondary windings.
Equations resulting from the magnetic circuit schematic diagram are :

$$H_{c1} l_{c1} + H_{c4} l_{c4} = E_p$$

$$H_{c2} l_{c2} + H_{c5} l_{c5} - H_{c4} l_{c4} = E_s$$

$$H_{c3} l_{c3} + H_{c5} l_{c5} = E_p$$

$$A_{c1} H_{c1} \mu_{c1} - A_{c4} H_{c4} \mu_{c4} - A_{c2} H_{c2} \mu_{c2} = 0$$

$$A_{c2} H_{c2} \mu_{c2} - A_{c5} H_{c5} \mu_{c5} + A_{c3} H_{c3} \mu_{c3} = 0$$

To which we add the following arbitrary but realistic relationships to allow solving them.

$$l_{c3} = \frac{l_c}{2}$$

$$l_{c1} = l_{c2} = \frac{l_c}{4}$$

$$A_{ci} = A_c \,,\ \forall = 1, \cdots, 5$$

The electrical circuit schematic diagram is given on the figure n° 4

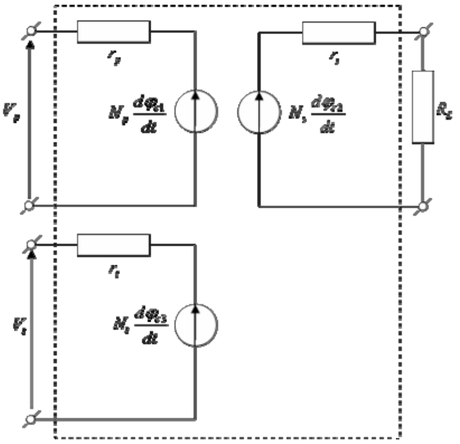


Figure n° 4 Electrical circuit schematic diagram

Resulting equations are:

$$V_p - N_p \frac{d\varphi_{c1}}{dt} = r_p (I_{a0} + i_p)$$

$$V_t - N_t \frac{d\varphi_{c3}}{dt} = r_t (I_{a0} + i_t)$$

$$-N_s \frac{d\varphi_{c2}}{dt} = (r_s + R_L) i_s$$

With the following notations:

V_p	Voltage across the primary
r_p	Primary winding resistance
V_t	Voltage across the tertiary
r_p	Tertiary winding resistance
r_s	Secondary winding resistance
R_L	Secondary loading resistance

The proposed OPT model could be modified to take into account for the hysteretic phenomena (2) in the magnetic material. But this refinement was not found pertinent, according to the objective of this paper.
The main data of the SC-OPT used for the SPARTANO amplifier are given in the table n° 2

N_p	1200	Primary number of turns
r_p	45 Ohm	Primary resistance
N_t	1200	Tertiary number of turns
r_t	45 Ohm	Tertiary resistance
N_s	94	Secondary number of turns
r_s	0,36 Ohm	Secondary resistance
A_c	6,24 cm2	Core section area
l_c	29 cm	Core magnetic path length
$l_{c3} = \frac{l_c}{2}$	14,5 cm	Leg n°3 magnetic path length
$l_{c1} = l_{c2} = \frac{l_c}{4}$	7,25 cm	Leg n° 1 and 2 magnetic path length
l_{c4}	0,30 m	Leg n° 4 magnetic path length
l_{c5}	1,20E-5 m	Leg n° 5 magnetic path length
C_{ip}	150 pF	Parasitic stray capacitance across the primary
C_1	100 µF	Shunt capacity across the tertiary
R_L	8 Ohm	Loading resistance across the secondary

Tableau n° 2 SC-OPT data

Working point and load line for the output power triode valve

For the power triode valve type 6080, the following operating parameters have been chosen:
Working point

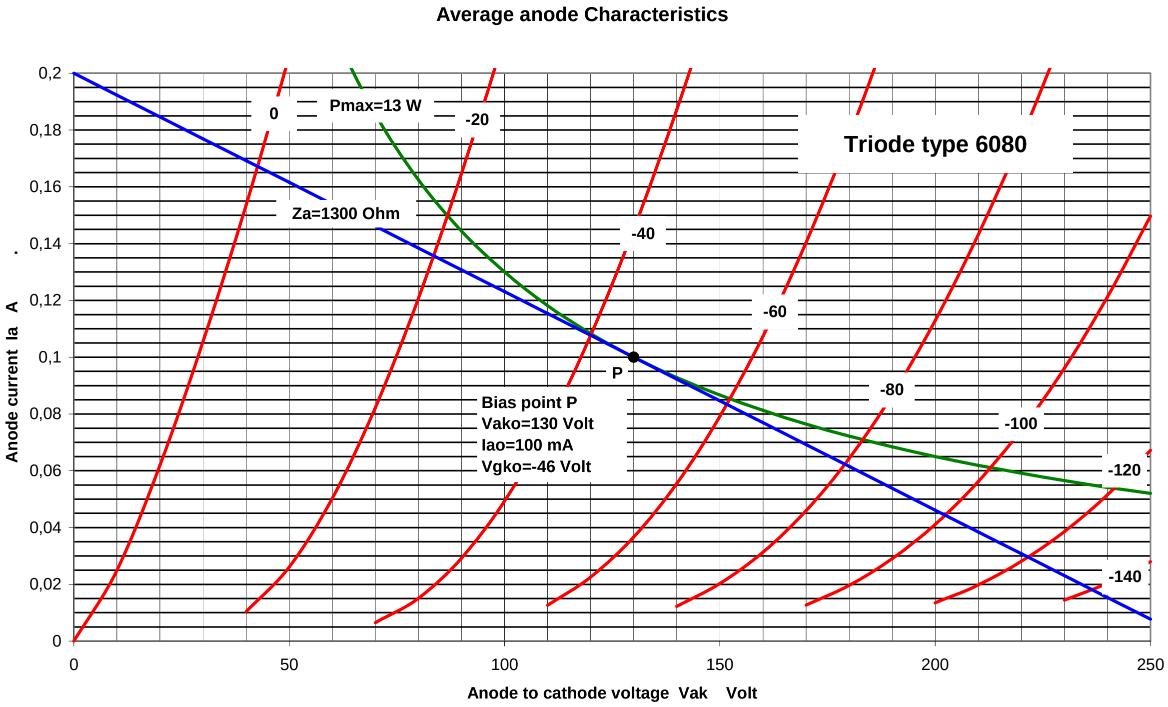
$V_{ak0} = 130$ Volt

$I_{a0} = 0{,}100$ A

Load resistance

$$R_a = 1300 \text{ Ohm}$$

These choices are shown on the graph n° 1 of the power triode valve type 6080 anode characteristics.
In particular, we can see that $V_{gk0} = -46$ Volt



Graph n° 1 Working point and Load line for the power triode valve type 6080

Working point and loading resistance of the triode valve of the first stage of the driver

Two points were considered for this stage. They lead to values for the load resistance and the cathode resistance, different from those proposed on the original schematic diagram of the SPARTANO amplifier.
These two points are

1. Grid bias set to -2 volt to improve the input dynamic of the driver
2. Load resistance set to a reasonable value to avoid problems with the high anode characteristic curvature.

They lead to choose a load resistance $R_a = 220$ kOhm and a cathode resistance $R_k = 2$ kOhm

For the triode valve type ECC82 which shows an amplification factor $\mu = 17$ and an internal resistance $\rho = 7,7$ kOhm, the voltage gain of this stage, in these conditions, is given using the formula

$$G = \frac{\mu R_a}{\rho + R_a + R_k(\mu + 1)} = 14,2$$

Working point and loading resistance of the triode valve of the second stage of the driver

The second stage of the driver is the trickiest of the SPARTANO amplifier, because it must be compliant with the following functional constraints:

1. The cathode voltage of the second stage of the driver must be equal to the anode voltage of the first stage of the driver, incremented with the absolute value of the chosen grid voltage bias of the second stage of the driver.
2. The voltage drop across the anode load resistance of the second stage of the driver must be equal to the voltage grid bias of the power triode valve.

These constraints have an incidence on the determination of anode and cathode resistances for the second stage of the driver. The method to determine these resistances is the following

Let

$R = R_a + R_k$	Global resistance of anode and cathode resistances of the second stage of the driver
R_a	Anode resistance of the second stage of the driver
R_k	Cathode resistance of the second stage of the driver
V_{g0}	Grid to ground bias voltage of the second stage of the driver
V_{k0}	Cathode to ground bias voltage of the second stage of the driver
V_{gk0}	Grid to cathode bias voltage of the second stage of the driver
V_{ba0}	Voltage drop across the loading resistance of the second stage of the driver
I_{a0}	Idle anode current of the second stage of the driver.

We can write:

$$V_{k0} = V_{g0} + \left|V_{gk0}\right|$$

$$R_a I_{a0} = V_{ba0}$$

$$R_k I_{a0} = V_{k0}$$

Which gives:

$$R_a = \frac{R}{(1+\lambda)} \text{ et } R_k = \frac{\lambda R}{(1+\lambda)} \text{ avec } \lambda = \frac{R_k}{R_a} = \frac{V_{k0}}{V_{ba0}}$$

Suppose a value for R. With this value, one can determine values of R_a and R_k as the value for λ is known. Suppose a value for I_a. With this value, one can determine V_{ak0} and as V_{gk0} is imposed, calculate the anode current I_a using the Norman L. Koren analytical formula. The last value is in general different of the previous one used to initiate the calculation and an iterative process is required determining the right value for the anode current. With this anode current value, one calculate $V_k = R_k I_a$ and $V_{ba} = R_a I_a$.

This calculation is repeated for different values of the global resistance R which allows to map on a graph V_k and V_{ba} versus R. The right value for R is the one which gives V_{k0} and V_{ba0}.

Above calculations were made with the following values:

$V_{g0} = 49,2$ Volt

$\left|V_{gk0}\right| = 6$ Volt

$V_{ba0} = 46$ Volt

They are given on the graph n° 2 and lead to the following solution :

$R = 14$ kOhm

$R_a = 6,36$ kOhm

$R_k = 7,64$ kOhm

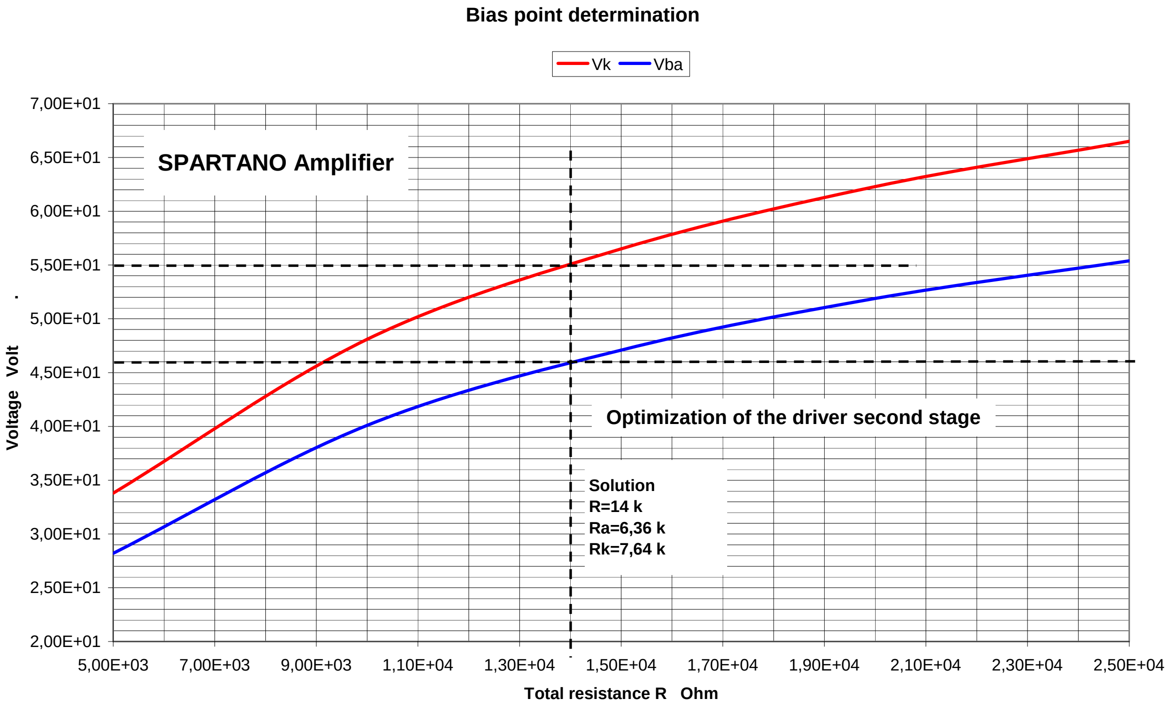
A so low resistance value for R_a is not welcome from the distortion point of view and it is necessary to apply on this stage a negative feedback to improve the situation. This negative feedback is obtained using a partial decoupling of the cathode resistance. The chosen non decoupled value is $R_k = 2$ kOhm.

For the triode valve type ECC82 which shows an amplification factor $\mu = 17$ and an internal resistance $\rho = 7,7$ kOhm, the voltage gain of this stage, in these conditions, is given using the formula

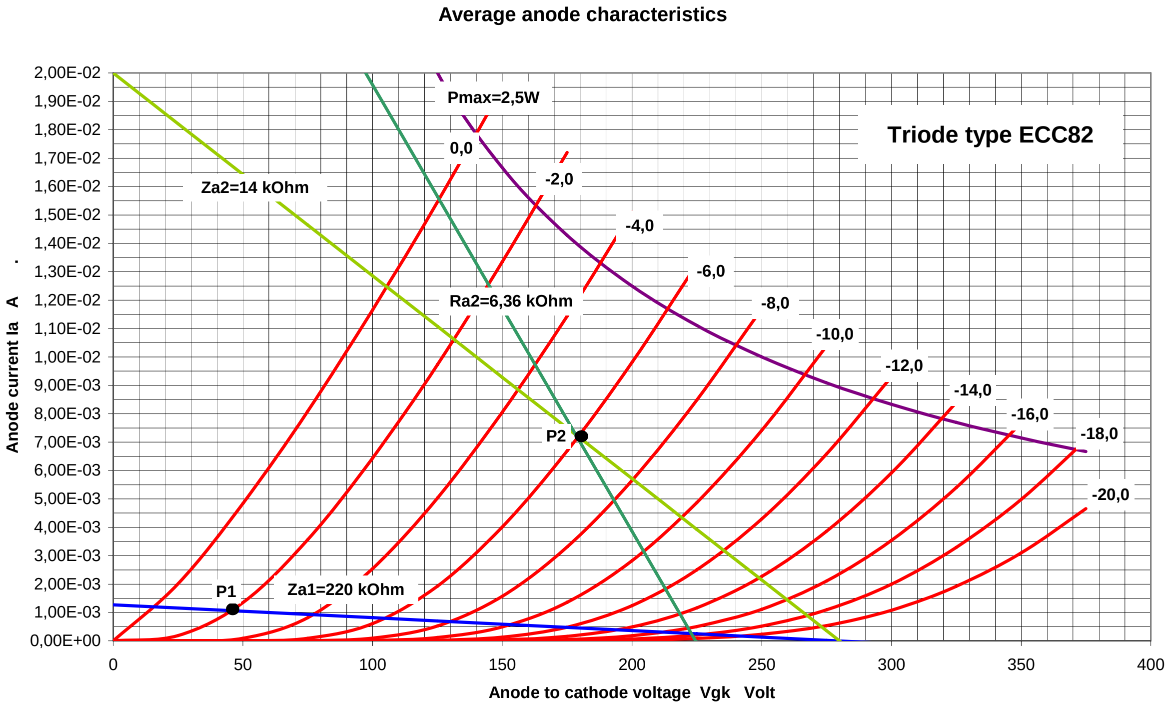
$$G = \frac{\mu R_a}{\rho + R_a + R_k(\mu + 1)} = 2,16$$

The graph n° 3 gathers the different load lines and working points for each stages of the driver. It shows that:

1. The anode resistance of 220 kOhm, for the first stage of the driver, allows to be away enough from the high anode characteristics curvature.
2. The low anode resistance of the second stage of the driver is effectively responsible of a high distortion that requires to be reduced.



Graph n° 2 Determination of R



Graph n° 3 Working points and load lines for the 2 stages of the driver

Schematic diagram and notations

The SPARTANO amplifier schematic diagram used for the model on which are defined notations and component values is given on the figure n° 5.

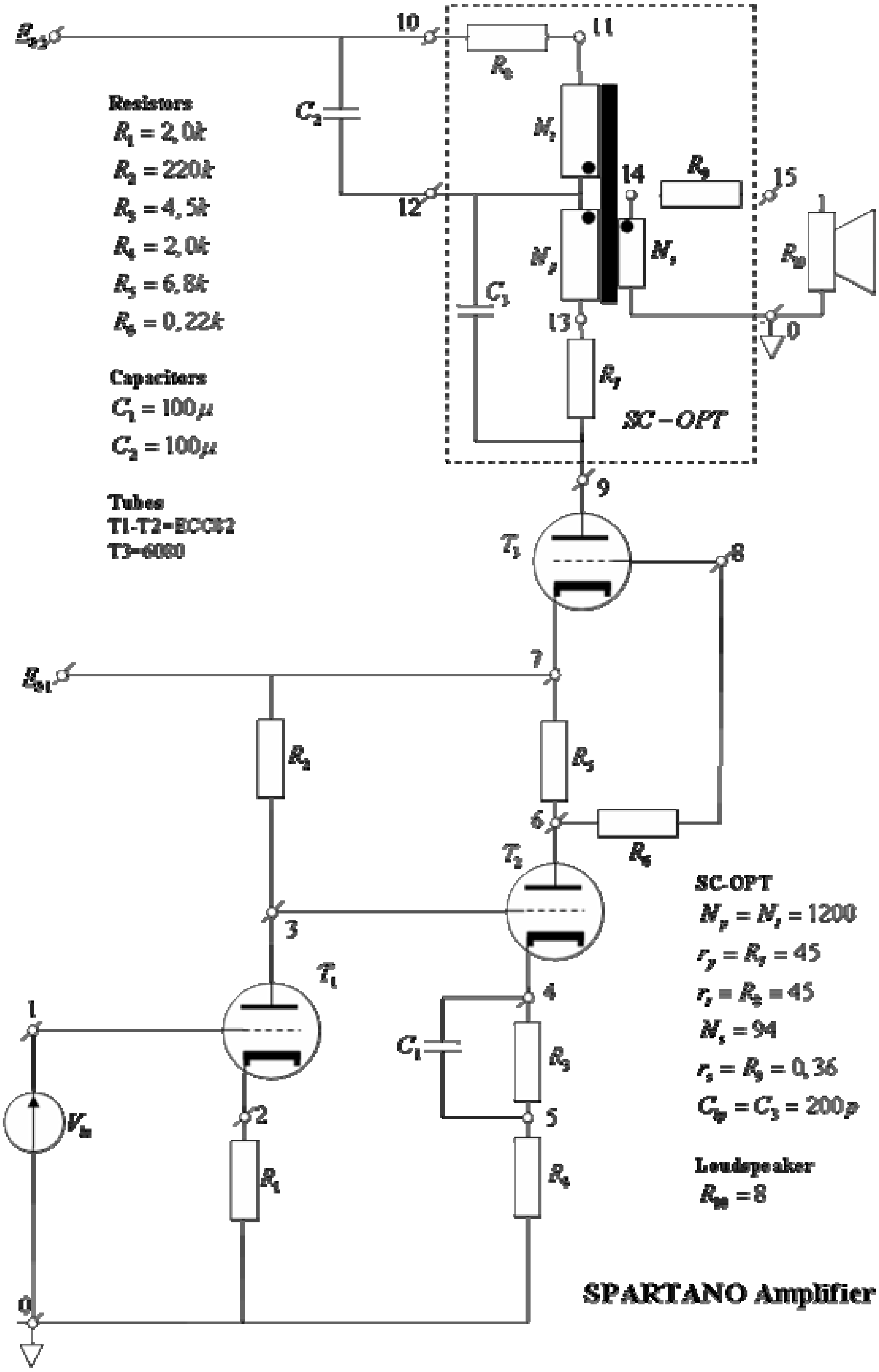


Figure n° 5 Schematic diagram of the SPARTANO amplifier

SPARTANO amplifier model

The SPARTANO amplifier has been modelled using the ESACAP software (6). ESACAP is a general network analysis software which carries out analyses on linear and non-linear systems in steady state and transient modes, or analysis in the frequency domain on linear or linearized networks. Of course, other equivalent softwares can be used. As an example, we give the complete SPARTANO amplifier model as set-up in ESACAP.

```
# THE SPARTAN0 AMPLIFIER
$$DES
$FUN: limit(x,min,max);
limit=MIN(max,MAX(min,x));
END;

$FUN: pwrs(x,y);
IF(x.GT.0) THEN
pwrs=x**y;
ELSE
   IF(x.LT.0) THEN
      pwrs=-((-x)**y);
   ELSE
      pwrs=0;
   ENDIF;
ENDIF;
END;

$CON:
# Sine input signal
A=1.414;                        # Maximum(peak) amplitude
F=1k;                           # Frequency
per=1/F;                        # Period

# Tube type ECC82
# Norman L.Koren's model
t1=83.6;                        # Tube parameter
t2=20.4;                        # Tube parameter
t3=957;                         # Tube parameter
t4=1.27;                        # Tube parameter
t5=645;                         # Tube paramater

# Tube type 6080
# Norman L.Koren's model
p1=9.29;                        # Tube parameter
p2=2.78;                        # Tube parameter
p3=620;                         # Tube parameter
p4=1.31;                        # Tube parameter
p5=218;                         # Tube parameter

# Core geometry
Ac=6.24E-4;                     # Cross section area
Lc=29E-2;                       # Average magnetic path length
Lc1=Lc/4;                       # Average magnetic path length for primary
Lc2=Lc/4;                       # Average magnetic path length for
secondary
Lc3=Lc/2;                       # Average magnetic path length for tertiary
Lc4=.3;                         # Air gap length (Flux leakage)
Lc5=1.2E-5;                     # Air gap length (SC-OPT)

# Primary winding
Np=1200;                        # winding turns
Rp= 45;                         # winding resistance
```

```
Cip=150p;                       # stray capacitance

# Secondary winding
Ns=94;                          # Winding turns
Rs=.36;                         # Winding resistance
RL=8;                           # Load resistance

# Tertiary winding
Nt=Np;                          # Winding turns
Rt=Rp;                          # Winding resistance

# Grain oriented silicon steel
Amin=1.2E-2;                    # Fitting parameter
Amax=8.9E-2;                    # Fitting parameter
A1=6.2E-2;                      # Fitting parameter
A2=1.67E6;                      # Fitting parameter
µo=4*PI*1E-7;                   # Free space permeability
END;

$NET:
# Driver section
Ein(1,0)=A*SIN(2*PI*F*TIME);    # Sine signal input
R1(2,0)=2k;
R2(7,3)=220k;
R3(4,5)=5.6k;
R4(5,0)=2k;
R5(7,6)=6.8k;
C1(4,5)=100u;

# HT supply
E1(7,0)=280;                    # First HT DC supply

# First 1/2 ECC82
%Ut1=V(3,2)/t1*LOG(1+EXP(t1*(1/t2+V(1,2)/pwrs(pwrs(V(3,2),2)+t3,0.5))));
%Vt1=limit(%Ut1,0,1E6);
Jat1(3,2)=pwrs(%Vt1,t4)/t5;
Cagt1(3,1)=1.5p;
Cgkt1(1,2)=1.8p;
Cakt1(3,2)=0.37p;

# Second 1/2 ECC82
%Ut2=V(6,4)/t1*LOG(1+EXP(t1*(1/t2+V(3,4)/pwrs(pwrs(V(6,4),2)+t3,0.5))));
%Vt2=limit(%Ut2,0,1E6);
Jat2(6,4)=pwrs(%Vt2,t4)/t5;
Cagt2(6,3)=1.5p;
Cgkt2(3,4)=1.8p;
Cakt2(6,4)=0.37p;

# Power section
R6(6,8)=220;

# 6080
%Ut3=V(9,7)/p1*LOG(1+EXP(p1*(1/p2+V(8,7)/pwrs(pwrs(V(9,7),2)+p3,0.5))));
%Vt3=limit(%Ut3,0,1E6);
Jat3(9,7)=pwrs(%Vt3,p4)/p5;
Cagt3(9,8)=8.6p;
Cgkt3(8,7)=5.7p;
Cakt3(9,7)=2.5p;

# HT supply
E2(10,7)=140;                    # second HT DC supply
```

```
# SC-OPT magnetic core
%EP=Np*I(R7);
%ES=Ns*I(R9);
%ET=Nt*I(R8);
%Hc1=%Hc1+%Hc1*Lc1+%Hc4*Lc4-%EP;
%Hc2=%Hc2-%Hc4*Lc4+%Hc2*Lc2+%Hc5*Lc5-%ES;
%Hc3=%Hc3+%Hc5*Lc5+%Hc3*Lc3-%ET;
%Hc4=%Hc4+%Hc1*%µc1-%Hc4*%µc4-%Hc2*%µc2;
%Hc5=%Hc5+%Hc2*%µc2-%Hc5*%µc5+%Hc3*%µc3;

%AHc1=Amin+(Amax-Amin)*TANH(A1*ABS(%Hc1));
%AHc2=Amin+(Amax-Amin)*TANH(A1*ABS(%Hc2));
%AHc3=Amin+(Amax-Amin)*TANH(A1*ABS(%Hc3));
%AHc4=Amin+(Amax-Amin)*TANH(A1*ABS(%Hc4));
%AHc5=Amin+(Amax-Amin)*TANH(A1*ABS(%Hc5));

%PHIc1=%Hc1*%µc1*Ac;
%PHIc2=%Hc2*%µc2*Ac;
%PHIc3=%Hc3*%µc3*Ac;
%PHIc4=%Hc4*%µc4*Ac;
%PHIc5=%Hc5*%µc5*Ac;

IF(ABS(%Hc1).LT.0.1) THEN
%µc1=µo*(1+A2*(Amin/3+(Amax-Amin)*A1*ABS(%Hc1)/3));
ELSE
%µc1=µo*(1+A2/%Hc1*(COSH(%AHc1*%Hc1)/SINH(%AHc1*%Hc1)-1/(%AHc1*%Hc1)));
ENDIF;
IF(ABS(%Hc2).LT.0.1) THEN
%µc2=µo*(1+A2*(Amin/3+(Amax-Amin)*A1*ABS(%Hc2)/3));
ELSE
%µc2=µo*(1+A2/%Hc2*(COSH(%AHc2*%Hc2)/SINH(%AHc2*%Hc2)-1/(%AHc2*%Hc2)));
ENDIF;
IF(ABS(%Hc3).LT.0.1) THEN
%µc3=µo*(1+A2*(Amin/3+(Amax-Amin)*A1*ABS(%Hc3)/3));
ELSE
%µc3=µo*(1+A2/%Hc3*(COSH(%AHc3*%Hc3)/SINH(%AHc3*%Hc3)-1/(%AHc3*%Hc3)));
ENDIF;
%µc4=µo;
%µc5=µo;

%D1=%PHIc1';
%D2=%PHIc2';
%D3=%PHIc3';

# Primary circuit
R7(13,9)=Rp;
Ep (12,13)=Np*%D1 ;
C3(9,12)=Cip;

# Tertiary circuit
R8(10,11)=Rt;
Et(11,12)=Nt*%D3 ;
C2(10,12)=100u;

# Secondary circuit
R9(14,15)=Rs;
R10(15,0)=RL;
Es(14,0)=-Ns*%D2;
END;
```

The amplifier model is detailed in the section $$DES. The subsection $FUN: limit(x,min,max)describes the limit function. The subsection $FUN: pwrs(x,y) describes the power function. The subsection $CON gives the parameter values for the input signal, the triode valves and the transformer SC-OPT. the subsection $NET: describes the amplifier network.

Results obtained with simulations

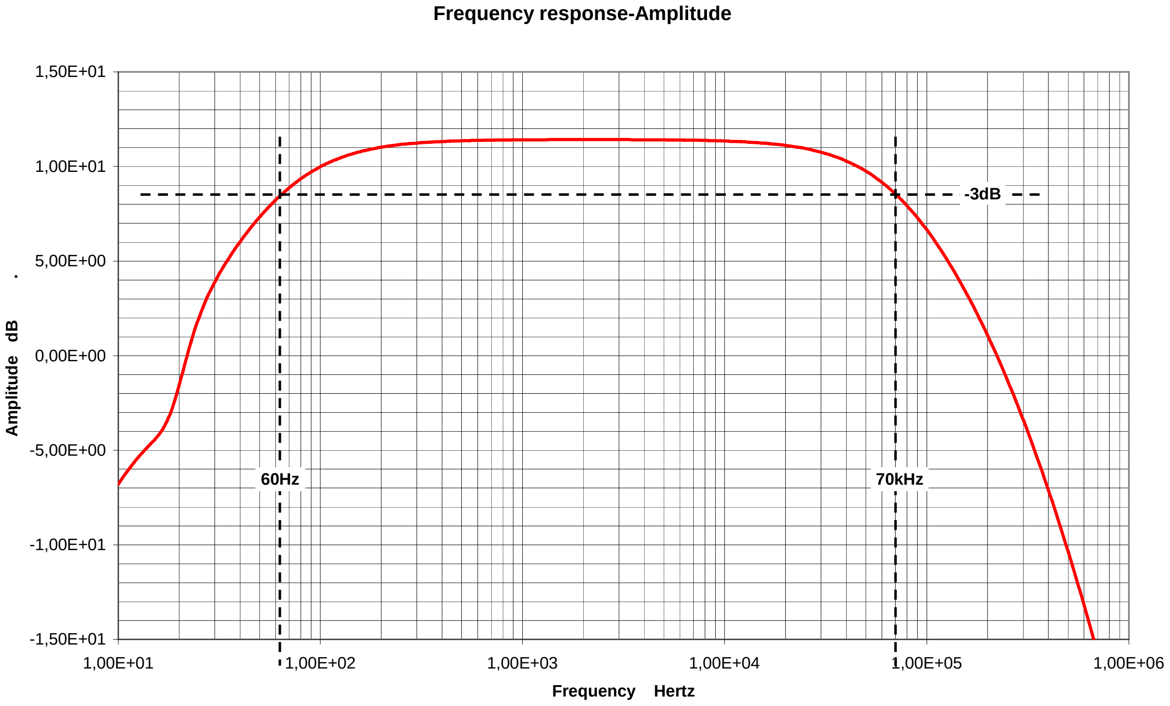
Map of the amplifier at rest

This map is given mains on, but without input signal. It gives voltage at nodes and current in branches of the network and allows verifying working points of triode valves.

```
D.C. ANALYSIS
  TIME= 0.000000E+00    V(1):                        0.000000E+00
                        I(Ein):                      0.000000E+00
                        V(2):                        2.097893E+00
                        V(7):                        2.800000E+02
                        V(3):                        4.923176E+01
                        V(4):                        5.504040E+01
                        V(5):                        1.448432E+01
                        V(6):                        2.307533E+02
                        I(E1):                      -8.291104E-03
                        V(8):                        2.307533E+02
                        V(9):                        4.121793E+02
                        V(10):                       4.200000E+02
                        I(E2):                      -8.689622E-02
                        I(R7):                       8.689622E-02
                        I(R9):                       0.000000E+00
                        I(R8):                       8.689622E-02
                        %Hc1:                        4.508426E+02
                        %Hc4:                        2.386313E+02
                        %Hc2:                        4.482997E+02
                        %Hc5:                        3.257304E+06
                        %Hc3:                        4.495712E+02
                        %µc1:                        4.540053E-03
                        %µc2:                        4.565137E-03
                        %µc3:                        4.552560E-03
                        %PHIc1:                      1.277234E-03
                        %PHIc2:                      1.277047E-03
                        %PHIc3:                      1.277141E-03
                        V(13):                       4.160897E+02
                        V(12):                       4.160897E+02
                        I(Ep):                       8.689622E-02
                        V(11):                       4.160897E+02
                       I(Et):                       8.689622E-02
                        V(14):                       0.000000E+00
                        V(15):                       0.000000E+00
                        I(Es):                       0.000000E+00
                        %Ut1:                        7.351708E-01
                        %Vt1:                        7.351708E-01
                        %Ut2:                        3.365956E+00
                        %Vt2:                        3.365956E+00
                        %Ut3:                        9.444051E+00
                        %Vt3:                        9.444051E+00
                        %EP:                         1.042755E+02
                        %ES:                         0.000000E+00
                        %ET:                         1.042755E+02
                        %µc4:                        1.256637E-06
                        %µc5:                        1.256637E-06
                        %AHc1:                       8.900000E-02
                        %AHc2:                       8.900000E-02
```

```
%AHc3:                    8.900000E-02
%AHc4:                    8.900000E-02
%AHc5:                    8.900000E-02
%PHIc4:                   1.871207E-07
%PHIc5:                   2.554187E-03
%D1:                      0.000000E+00
%D2:                      0.000000E+00
%D3:                      0.000000E+00
```

Frequency response



Graph n° 4 Frequency response of the SPARTANO amplifier

With an output transformer type SC-OPT, the frequency bandwidth at -3 dB is (60Hz-70kHz). The corner frequency, at the low frequency end, appears to be a bit high. This is due to the working principle of the SC-OPT which requires for a good response at the low frequency end, to be connected to a power triode valve having an as low as possible internal resistance. It is due also to the very accurate simulation of the magnetic core material relative permeability. This problem does not exist anymore on the original circuit because it uses an output transformer type SC-SCC-SET (5), which is an evolution of the SC-OPT, designed to solve drastically this problem in stereo amplifier applications.

The response at the high frequency end is excellent. This is due to the few number of turns, on the primary winding, which reduce the stray capacitance across the primary winding.

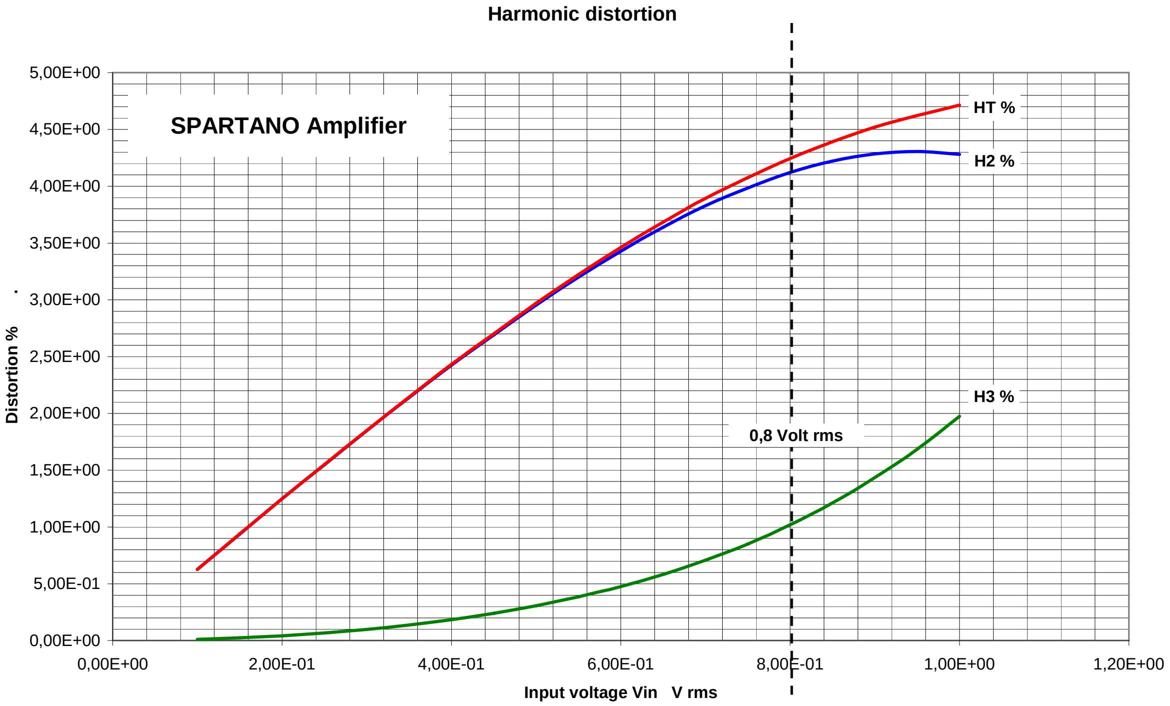
Distortion

The distortion is estimated on ESACAP using a FFT on the output harmonic signal, when a sine input signal having a predefined frequency and amplitude is applied on the amplifier.

The input signal is a sine signal of 1 kHz and amplitude varying from 0 up to 1 Volt rms.

Results are available on the graph n° 5. It gives H2, H3 and THD

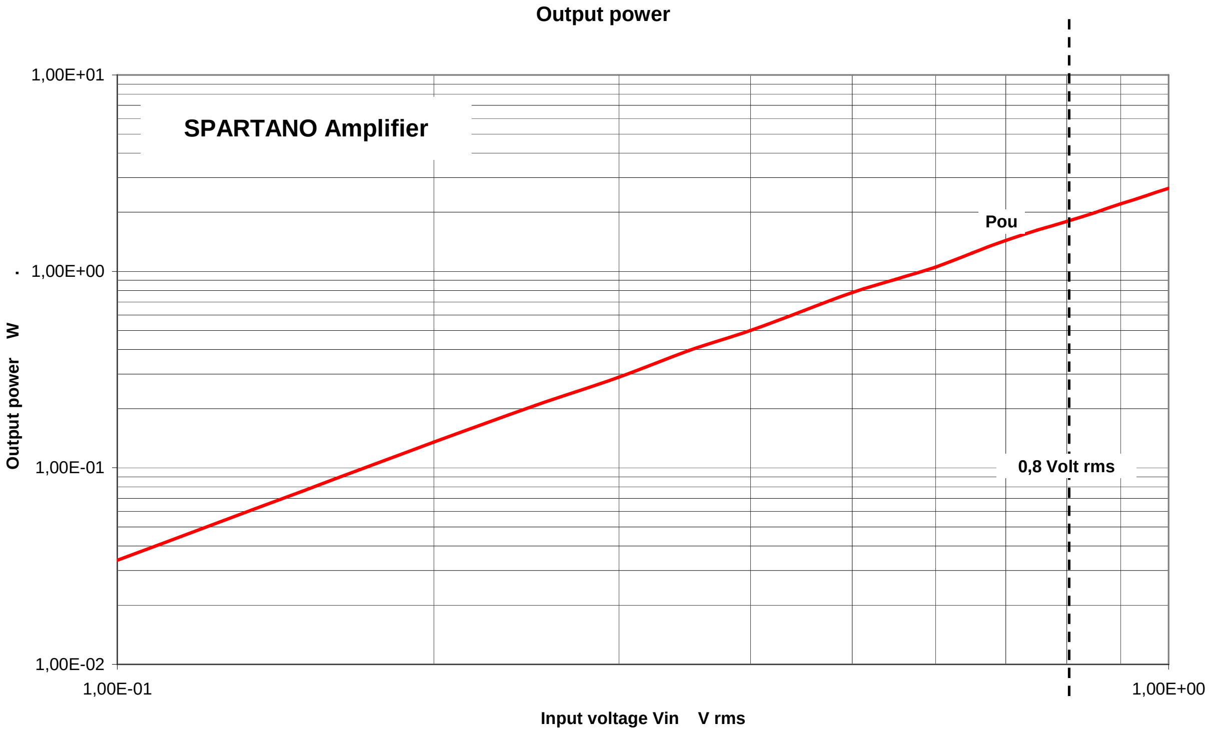
We can see on this graph, that for a sine input signal at 1 kHz and amplitude of 0,8 Volt rms, the THD is of the order of 4,3% which is a good result according to the specific power triode valve type 6080.



Graph n° 5 Harmonic distortion of the SPARTANO amplifier

Output power

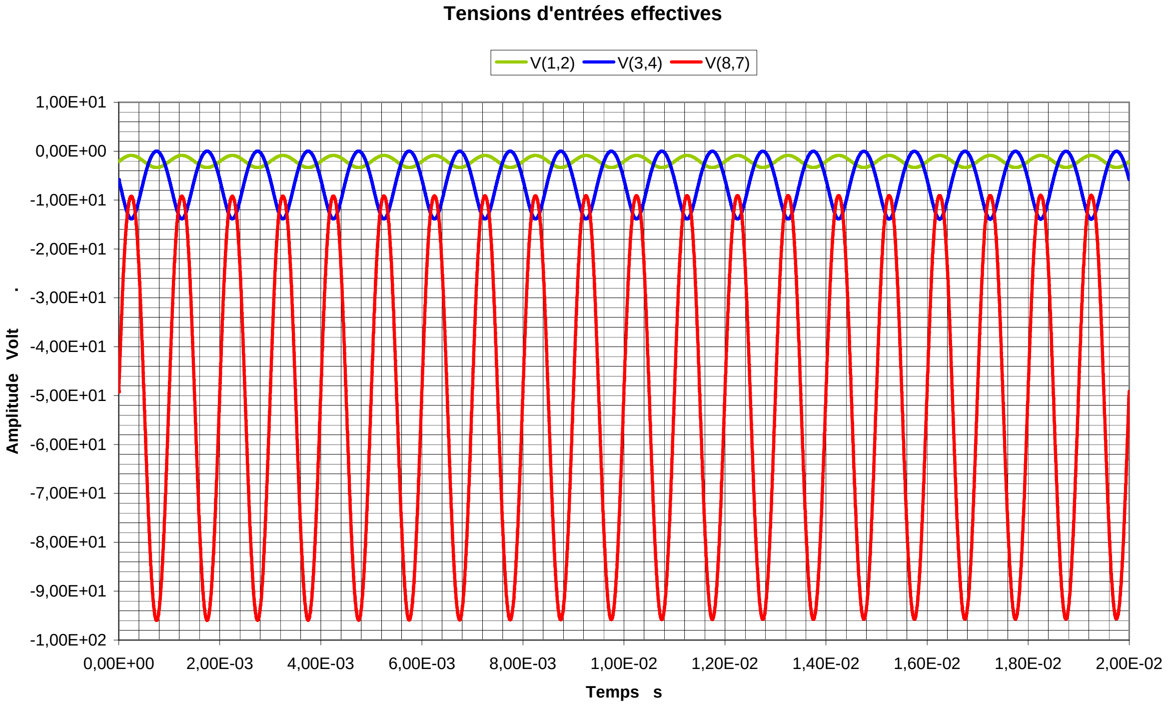
For a sine input signal at 1 kHz with amplitude varying from 0 to 1 Volt rms, the available output power on the load resistance of 8 Ohm across the SC-OPT secondary is given on the graph n° 6.
This graph shows that for an input signal of 0,8 Volt rms, we get an output power of 2W about on the load.



Graph n° 6 Output power of the SPARTANO amplifier

Limits

Effective input voltages V_{gk} for driver stages and the power stage must stay negative for a proper operation of the SPARTANO amplifier. These three effective input voltages are shown on the graph n° 7, for a sine input signal at 1 kHz and amplitude 1 Volt rms



Graph n° 7 effective input voltages in the SPARTANO amplifier

This graph shows that:

1. The effective input voltage of the first stage of the driver stays negative with a margin of 0,85 Volt.
2. The effective input voltage of the second stage of the driver stays negative but with no margin.
3. The effective input voltage of the power stage stays negative, with a margin of 8,0 Volt.

As a consequence, it is the second stage of the driver which limits the sine input signal of the SPARTANO amplifier to 1 Volt rms maximum.

Conclusion

The objective of this paper was to show that the modelization of an amplifier, despite a bit tricky, is not something inaccessible. Furthermore, the completed model has the advantage to become a powerful tool for the final design and tuning of the amplifier. We hope it will give to a number of audio amateurs, the envy to try the adventure by themselves. No doubt that they will take great profit from it.

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