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Laboratoire IM2NP

Réalisation d'un amplificateur audio sur circuit imprimé

PPR

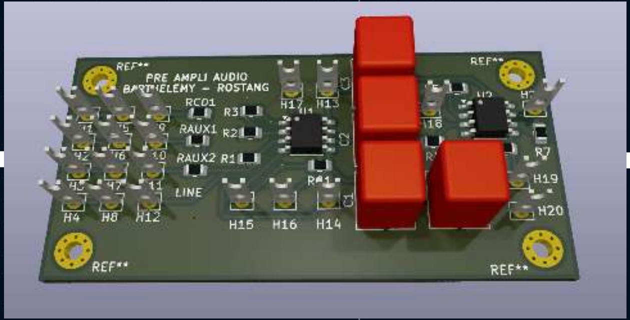
Année 2024-5

L2 SI

Sommaire

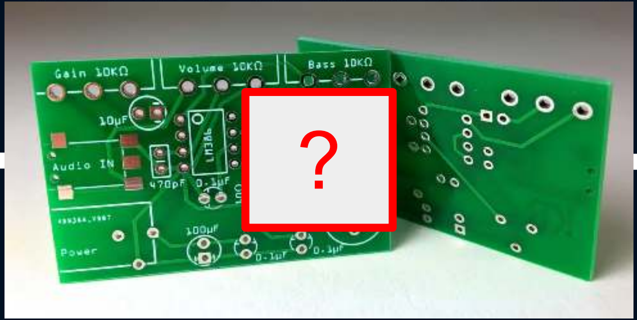
- ➢ Introduction
- ➢ Ressources
- ➢ Etude du circuit
- ➢ Méthodologie
- ➢ Quelques détails
- ➢ Conclusion

Introduction


PRE AMPLI AUDIO
BARTHELEMY - ROSTANG
RCD1
RAUX1
RAUX2
LINE
REF**

Préamplificateur

Réduire l'influence du bruit ajouté au signal source lors de la transmission

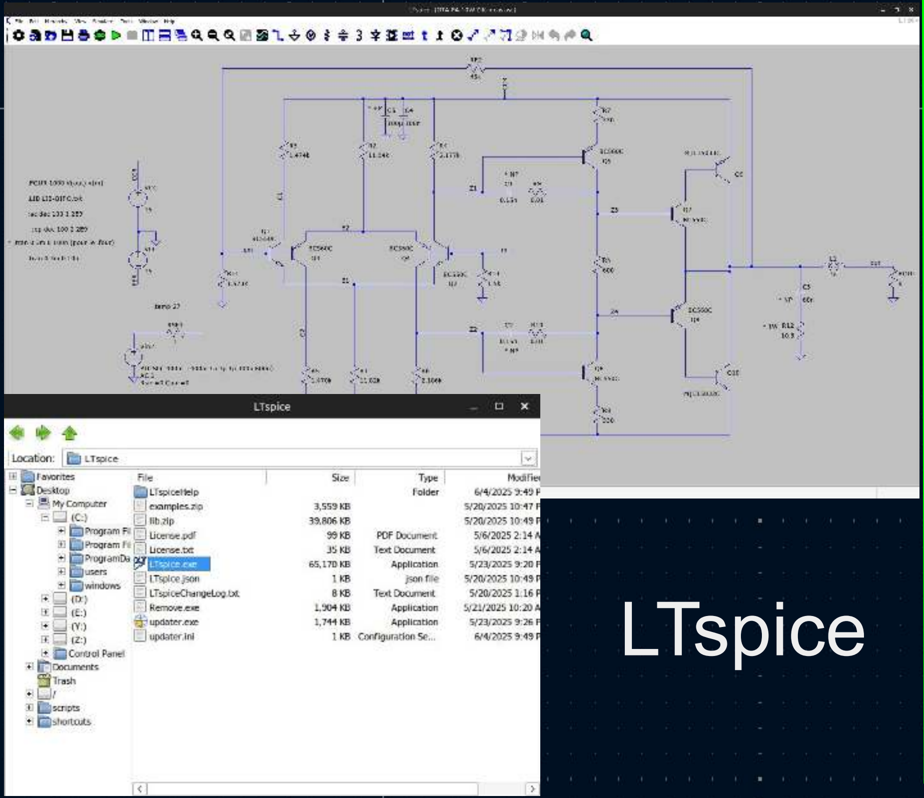

Gain 10KΩ
Volume 10KΩ
Bass 10KΩ
Audio IN
Power
?

Amplificateur de tension

Délivrer un courant suffisant pour alimenter la sortie

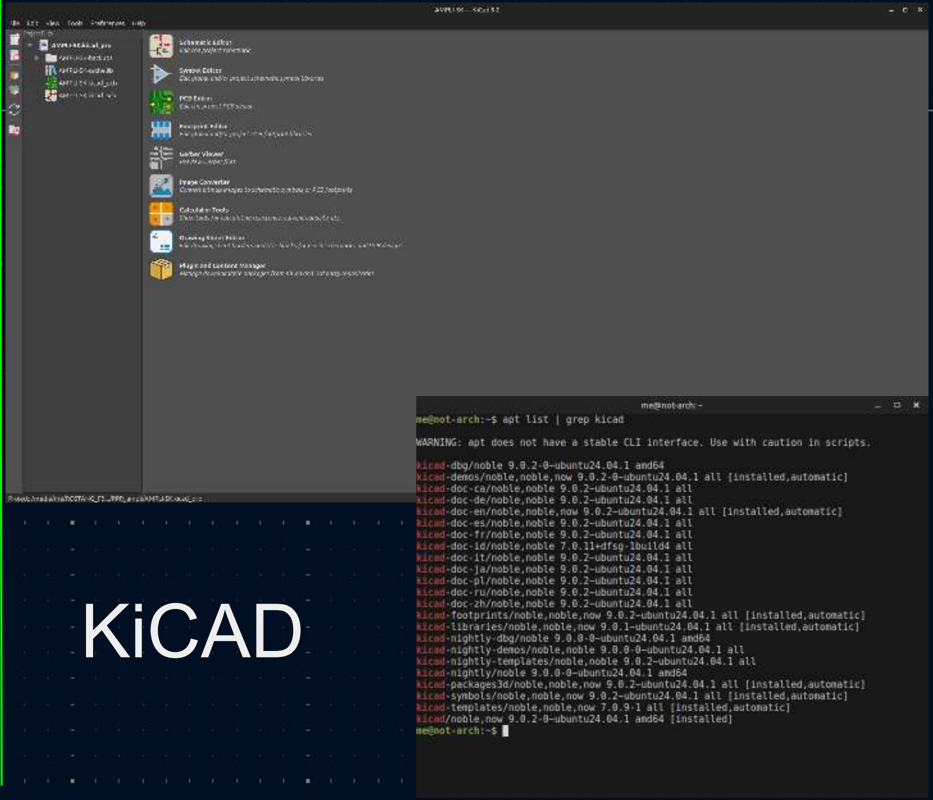
Sortie audio

Ressources - Logiciels


LTspice
Location: LTspice
Favorites
Desktop
My Computer
(C:)
Program Fi
Program Fi
ProgramDa
users
windows
(D:)
(E:)
(Y:)
(Z:)
Control Panel
Documents
Trash
/
scripts
shortcuts

File	Size	Type	Modifie
LTspiceHelp		Folder	6/4/2025 9:49 P
examples.zip	3,559 KB		5/20/2025 10:47 P
lib.zip	39,806 KB		5/20/2025 10:49 P
License.pdf	99 KB	PDF Document	5/6/2025 2:14 A
License.txt	35 KB	Text Document	5/6/2025 2:14 A
LTspice.exe	65,170 KB	Application	5/23/2025 9:20 P
LTspice.json	1 KB	json file	5/20/2025 10:49 P
LTspiceChangeLog.txt	8 KB	Text Document	5/20/2025 1:16 P
Remove.exe	1,904 KB	Application	5/21/2025 10:20 A
updater.exe	1,744 KB	Application	5/23/2025 9:26 P
updater.ini	1 KB	Configuration Se...	6/4/2025 9:49 P

LTspice


Schematic Editor
Symbol Editor
PCB Editor
Footprint Editor
Gerber Viewer
Image Converter
Calculator Tools
Drawing Sheet Editor
Plugin and Content Manager
me@not-arch: ~

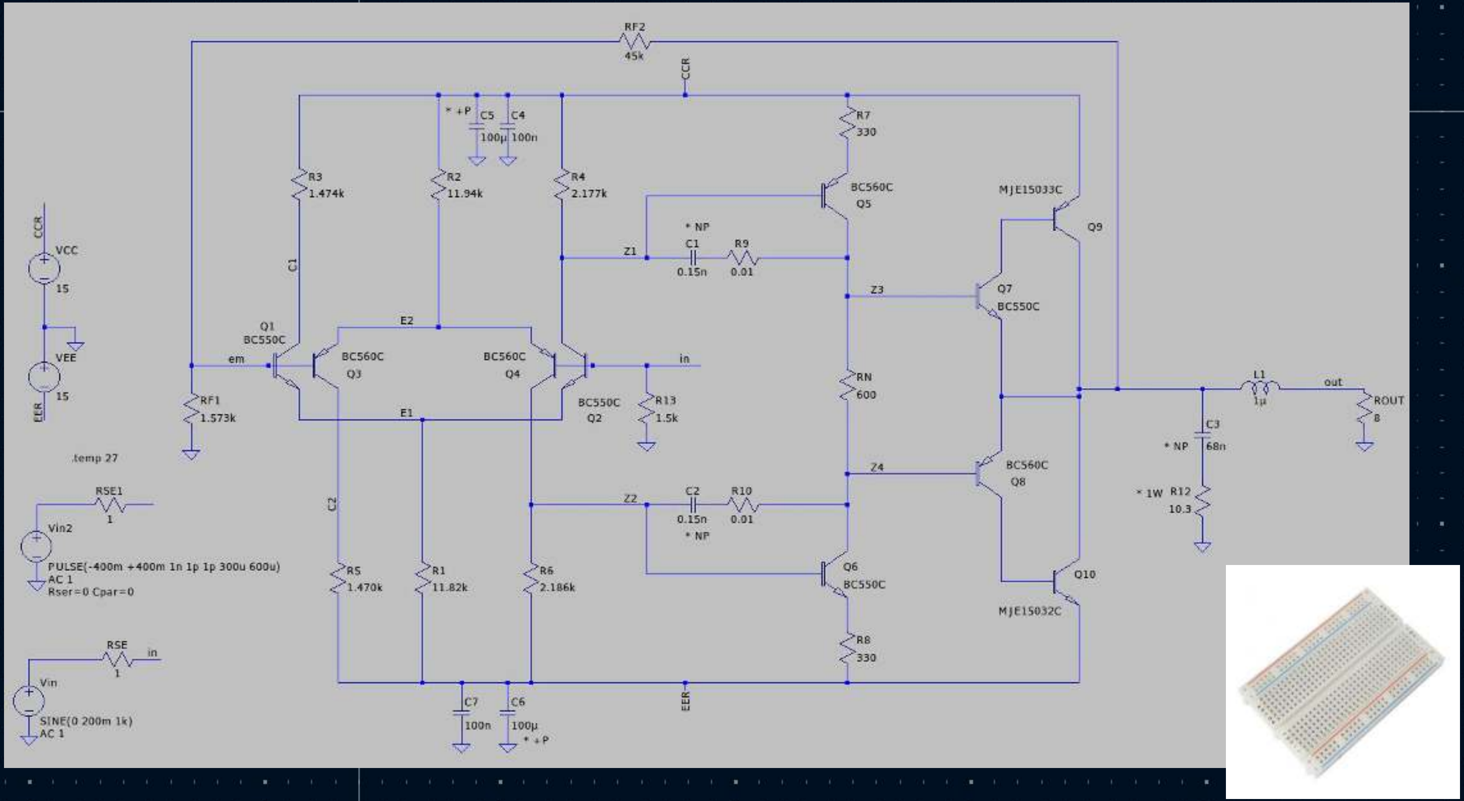
```
me@not-arch:~$ apt list | grep kicad

WARNING: apt does not have a stable CLI interface. Use with caution in scripts.

kicad-dbg/noble 9.0.2-0~ubuntu24.04.1 amd64
kicad-demos/noble,noble,now 9.0.2-0~ubuntu24.04.1 all [installed,automatic]
kicad-doc-ca/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-de/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-en/noble,noble,now 9.0.2-ubuntu24.04.1 all [installed,automatic]
kicad-doc-es/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-fr/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-id/noble,noble 7.0.11+dfsg-1build4 all
kicad-doc-it/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-ja/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-pl/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-ru/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-doc-zh/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-footprints/noble,noble,now 9.0.2-ubuntu24.04.1 all [installed,automatic]
kicad-libraries/noble,noble,now 9.0.1-ubuntu24.04.1 all [installed,automatic]
kicad-nightly-dbg/noble 9.0.0-0~ubuntu24.04.1 amd64
kicad-nightly-demos/noble,noble 9.0.0-0~ubuntu24.04.1 all
kicad-nightly-templates/noble,noble 9.0.2-ubuntu24.04.1 all
kicad-nightly/noble 9.0.0-0~ubuntu24.04.1 amd64
kicad-packages3d/noble,noble,now 9.0.2-ubuntu24.04.1 all [installed,automatic]
kicad-symbols/noble,noble,now 9.0.2-ubuntu24.04.1 all [installed,automatic]
kicad-templates/noble,noble,now 7.0.9-1 all [installed,automatic]
kicad/noble,now 9.0.2-0~ubuntu24.04.1 amd64 [installed]
me@not-arch:~$ 
```

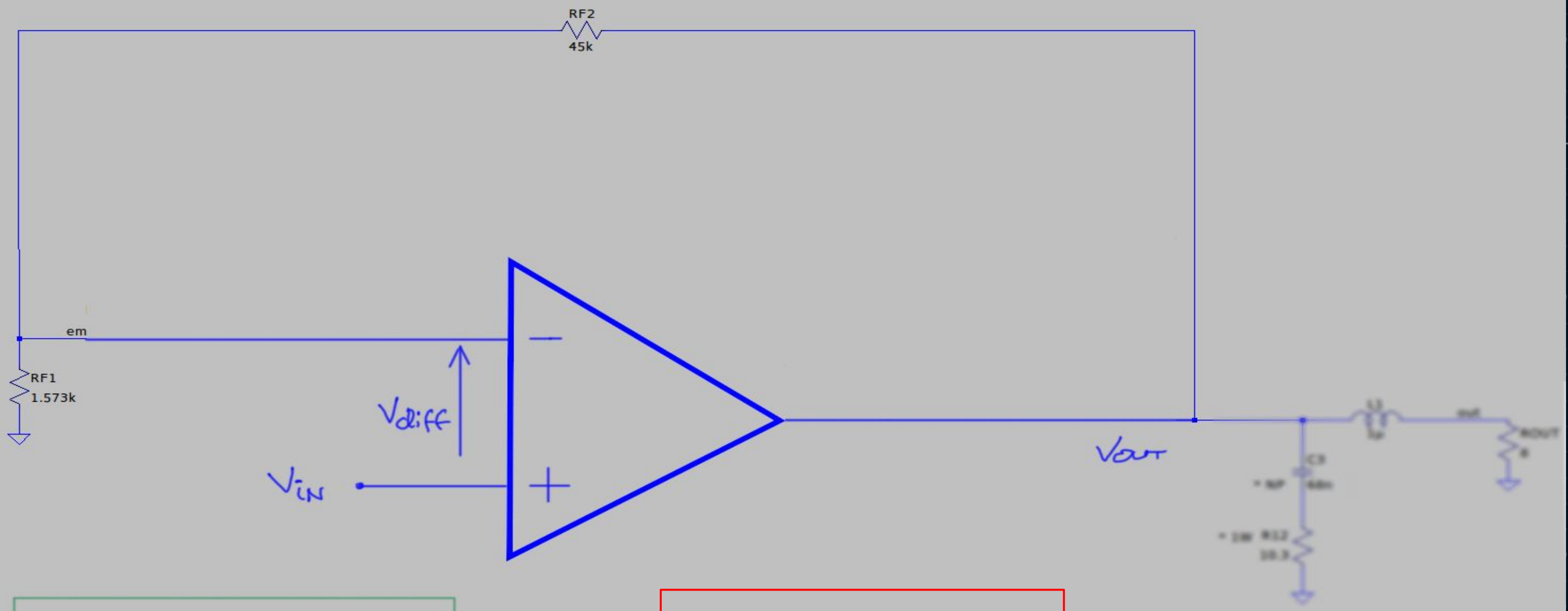
KiCAD

Ressources - Circuit prototype


RF2
45k
CCR
* +P
C5
100µ
C4
100n
R7
330
R3
1.474k
R2
11.94k
R4
2.177k
BC560C
Q5
MJE15033C
Q9
* NP
C1
0.15n
R9
0.01
Z1
Z3
Q7
BC550C
CCR
VCC
15
C1
Q1
BC550C
E2
em
BC560C
Q3
BC560C
Q4
in
VEE
15
EER
RF1
1.573k
E1
BC550C
Q2
R13
1.5k
RN
600
L1
1µ
out
ROUT
8
C3
* NP
68n
.temp 27
Z4
BC560C
Q8
* 1W
R12
10.3
RSE1
1
Vin2
PULSE(-400m +400m 1n 1p 1p 300u 600u)
AC 1
Rser=0 Cpar=0
C2
Z2
C2
0.15n
* NP
R10
0.01
R5
1.470k
R1
11.82k
R6
2.186k
Q6
BC550C
Q10
MJE15032C
R8
330
RSE
1
in
Vin
SINE(0 200m 1k)
AC 1
C7
100n
C6
100µ
* +P
EER

Hervé
BARTHELEMY

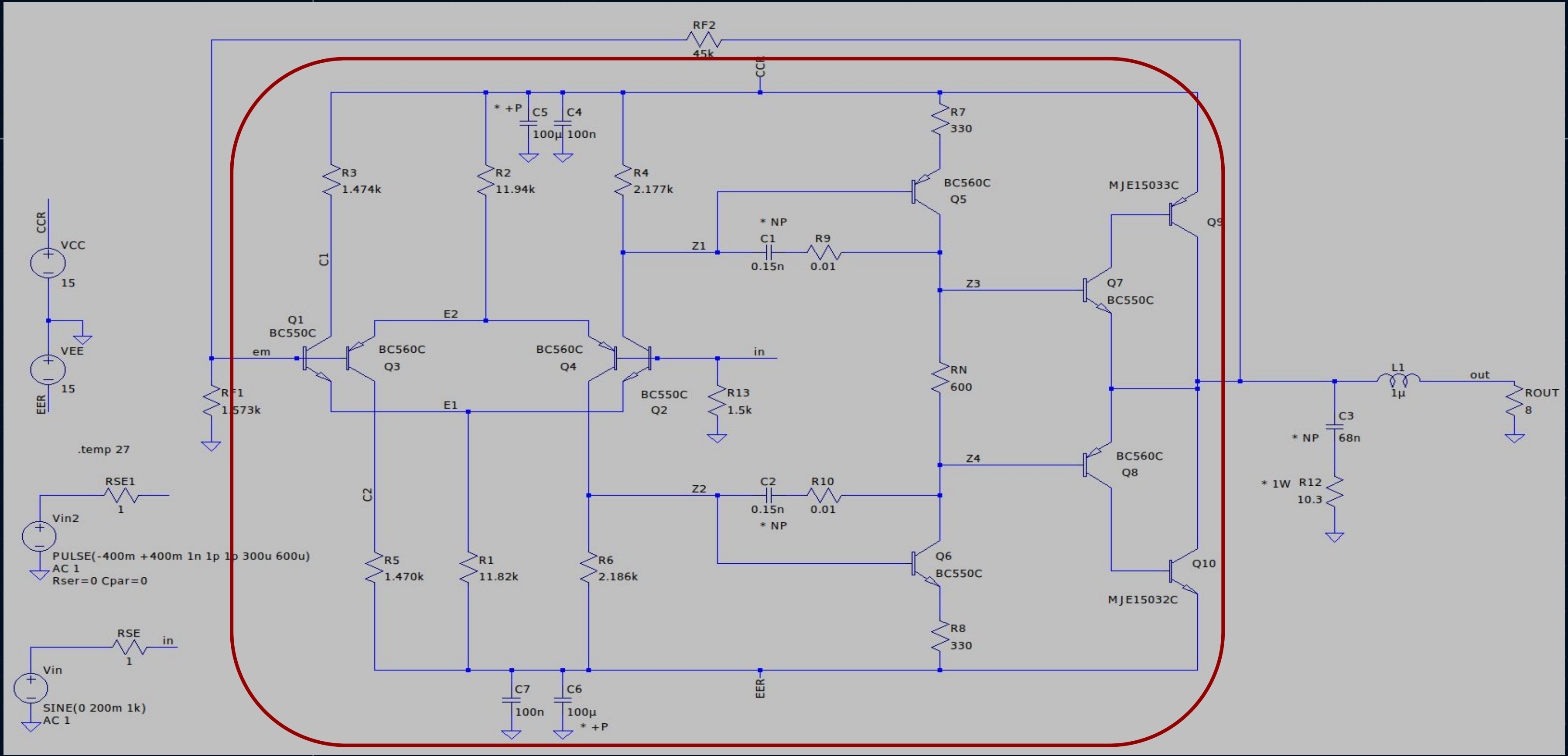
Etude du circuit - Schéma de principe


RF2
45k
em
RF1
1.573k
Vdiff
Vin
Vout

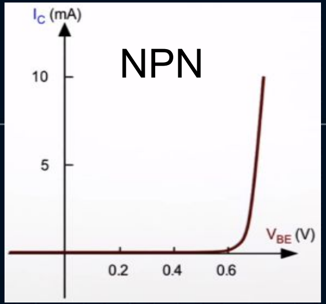
$$\frac{V_{out}}{V_{in}} = 1 + \frac{R_{F2}}{R_{F1}}$$

Montage AOP
amplificateur
non-inverseur

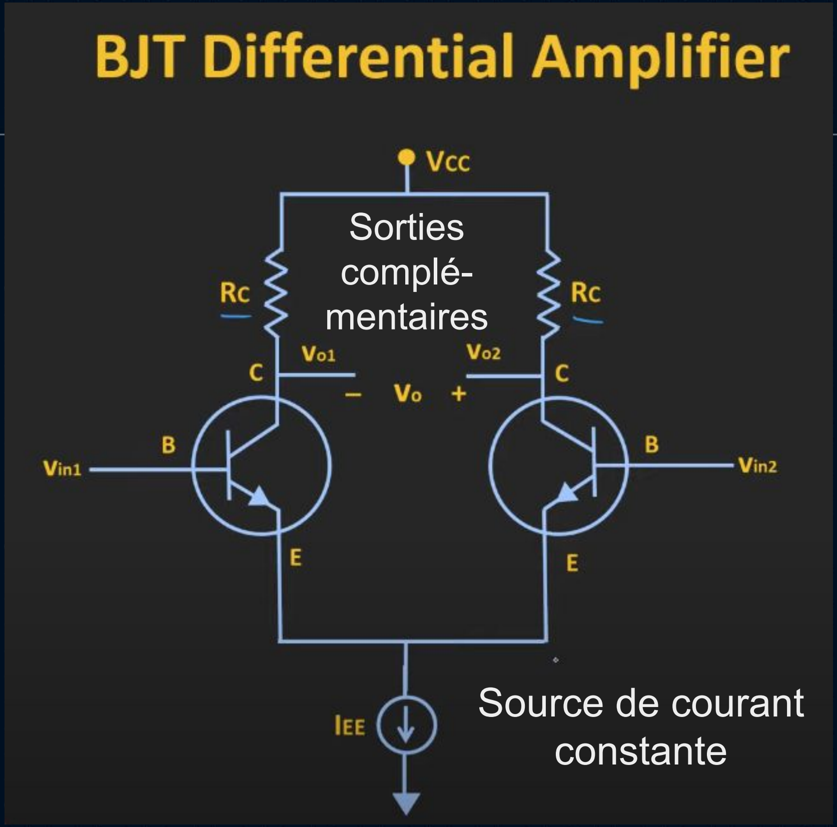
Etude du circuit - Schéma de principe


RF2
45k
CCR
R3
1.474k
R2
11.94k
* +P
C5
100µ
C4
100n
R4
2.177k
R7
330
BC560C
Q5
MJE15033C
Q9
* NP
C1
0.15n
R9
0.01
Z1
C1
Z3
Q7
BC550C
CCR
VCC
15
VEE
15
EER
Q1
BC550C
em
E2
BC560C
Q3
BC560C
Q4
in
RF1
1.573k
E1
BC550C
Q2
R13
1.5k
RN
600
L1
1µ
out
ROUT
8
C3
68n
* NP
.temp 27
BC560C
Q8
Z4
Z2
C2
0.15n
R10
0.01
* NP
C2
* 1W
R12
10.3
RSE1
1
Vin2
PULSE(-400m +400m 1n 1p 1p 300u 600u)
AC 1
Rser=0 Cpar=0
R5
1.470k
R1
11.82k
R6
2.186k
Q6
BC550C
Q10
MJE15032C
R8
330
RSE
1
in
Vin
SINE(0 200m 1k)
AC 1
C7
100n
C6
100µ
* +P
EER

Etude - Paires différentielles



Signal >


BJT Differential Amplifier
Vcc
Rc
Rc
Vo1
Vo2
C
C
– Vo +
B
B
Vin1
Vin2
E
E
IEE

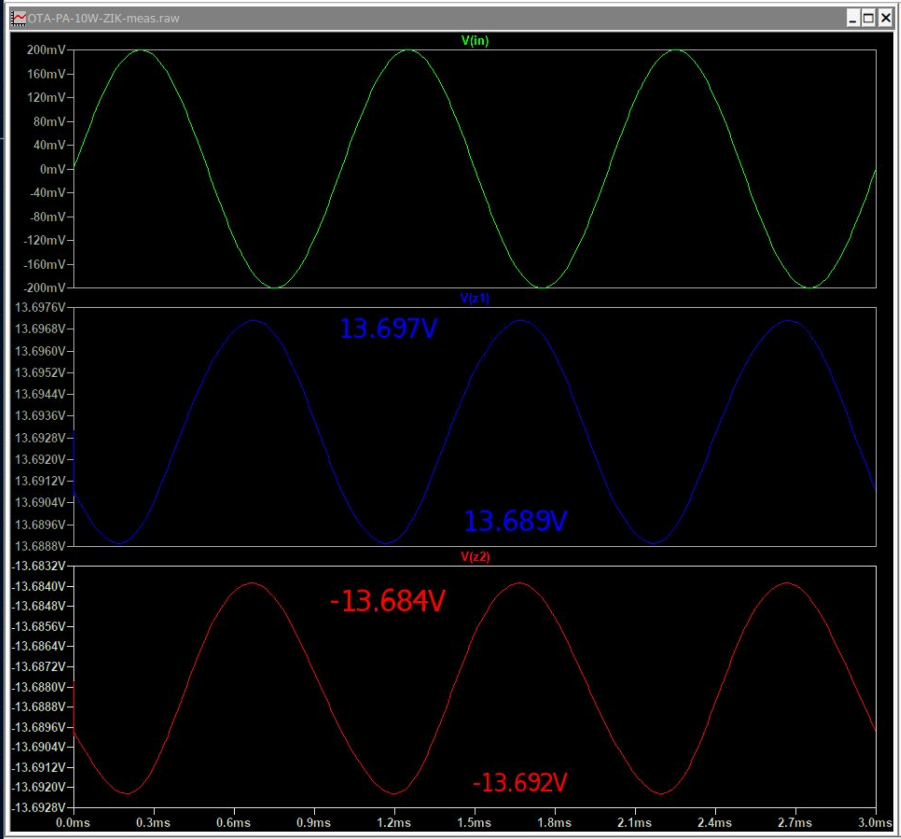
Sorties complé-mentaires

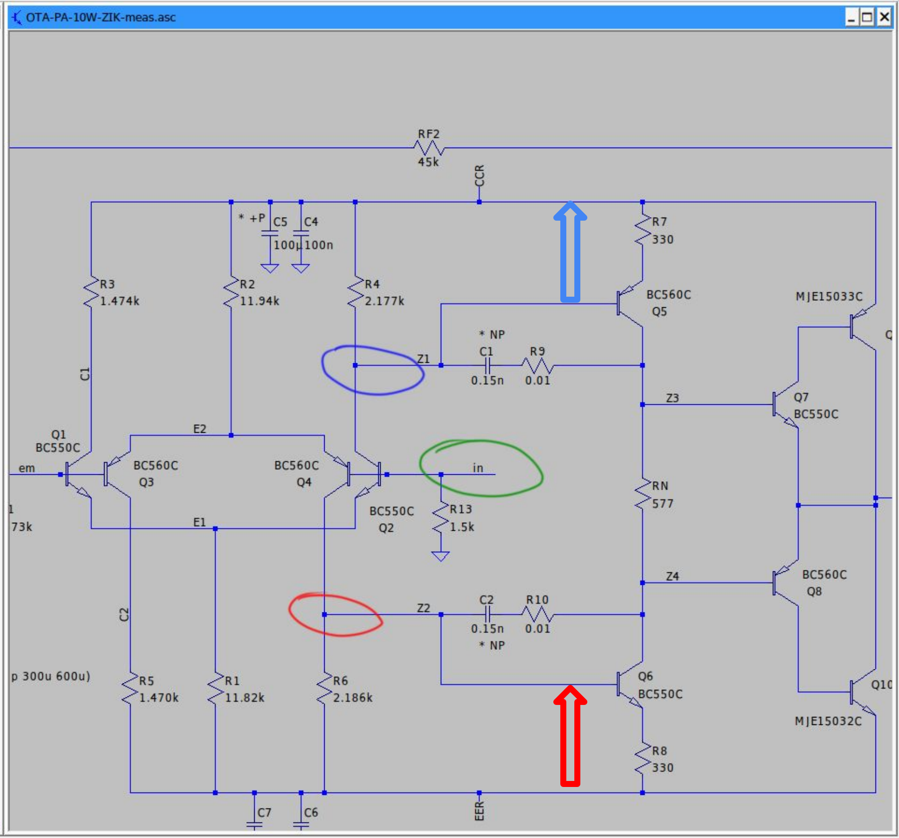
Source de courant constante

< Feedback

Paire différentielle positive

Etude - Paires différentielles

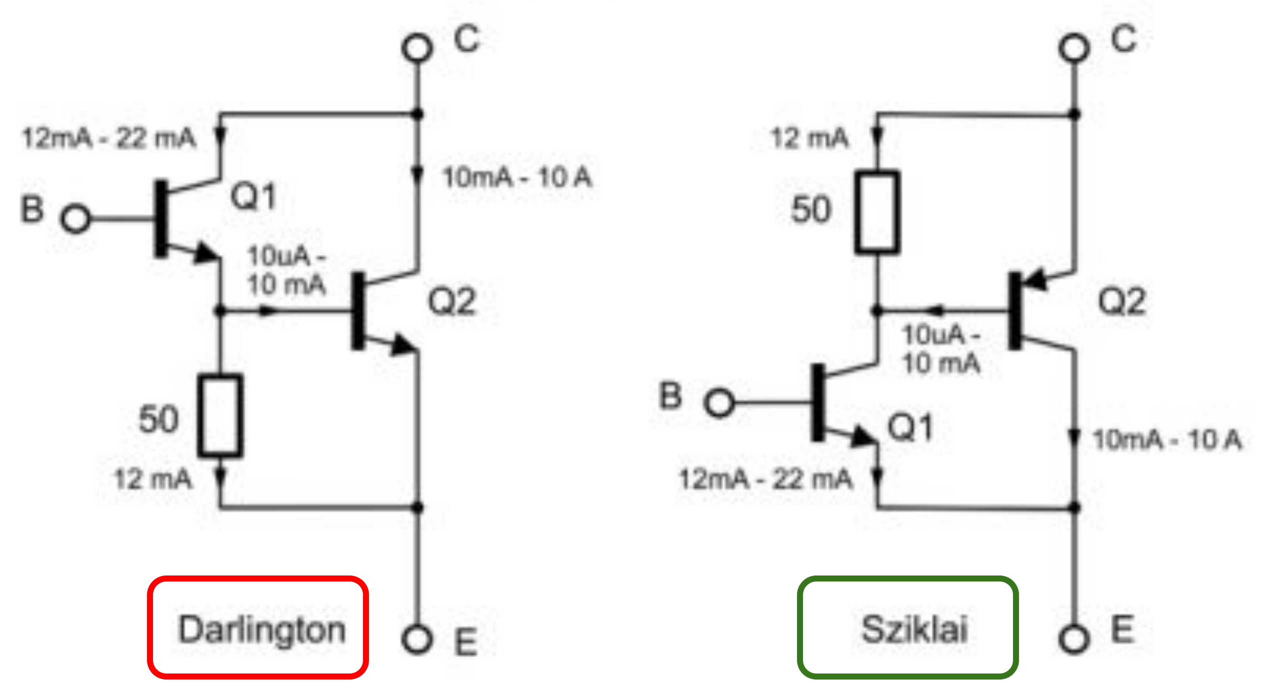



OTA-PA-10W-ZIK-meas.asc
RF2
45k
CCR
* +P
C5
100µ
C4
100n
R7
330
R3
1.474k
R2
11.94k
R4
2.177k
BC560C
Q5
MJE15033C
* NP
C1
0.15n
R9
0.01
Z1
C1
Z3
Q7
BC550C
Q1
BC550C
em
E2
BC560C
Q3
BC560C
Q4
in
RN
577
73k
E1
BC550C
Q2
R13
1.5k
Z4
BC560C
Q8
C2
Z2
C2
0.15n
R10
0.01
* NP
p 300u 600u)
R5
1.470k
R1
11.82k
R6
2.186k
Q6
BC550C
MJE15032C
R8
330
C7
C6
EER

Etude - Paire Sziklai

Zone active
pour
Vbe > 1.2V

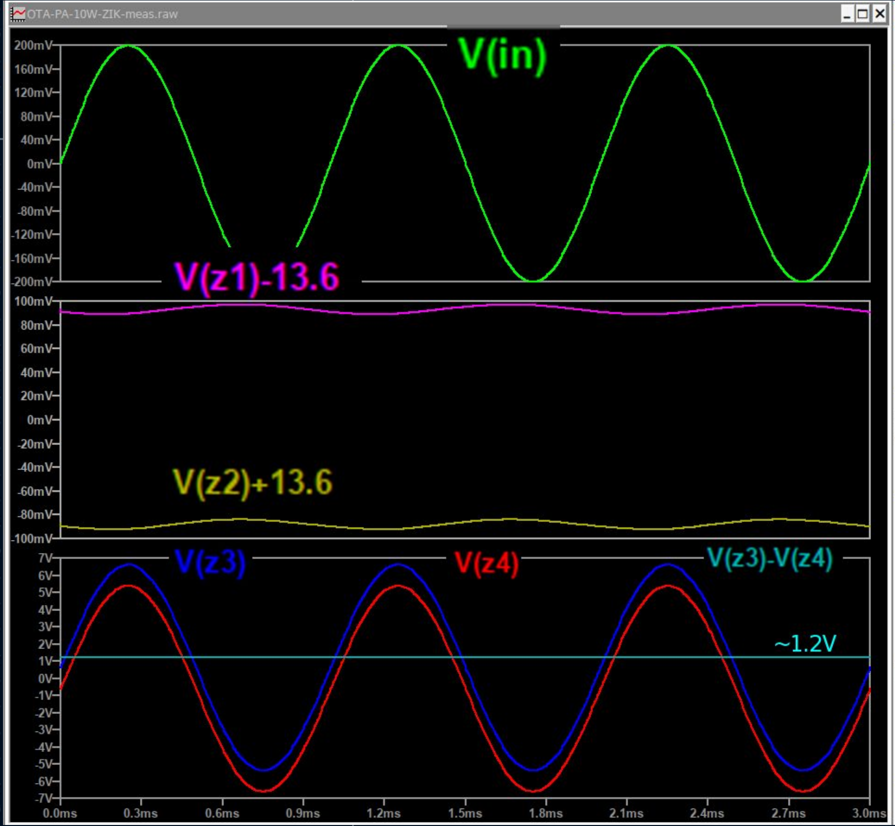
$$\beta = \beta_1 * \beta_2$$

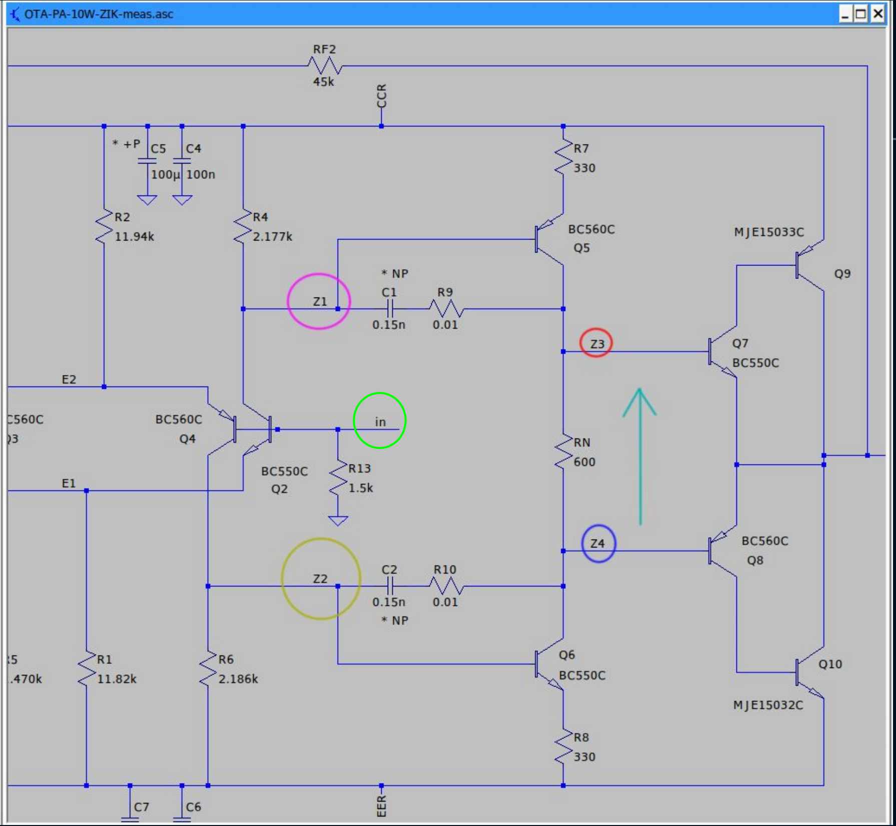

C
12mA - 22 mA
10mA - 10 A
B
Q1
10uA -
10 mA
Q2
50
12 mA
E
Darlington
C
12 mA
50
Q2
10uA -
10 mA
B
Q1
10mA - 10 A
12mA - 22 mA
E
Sziklai

Vbe > 0.6V

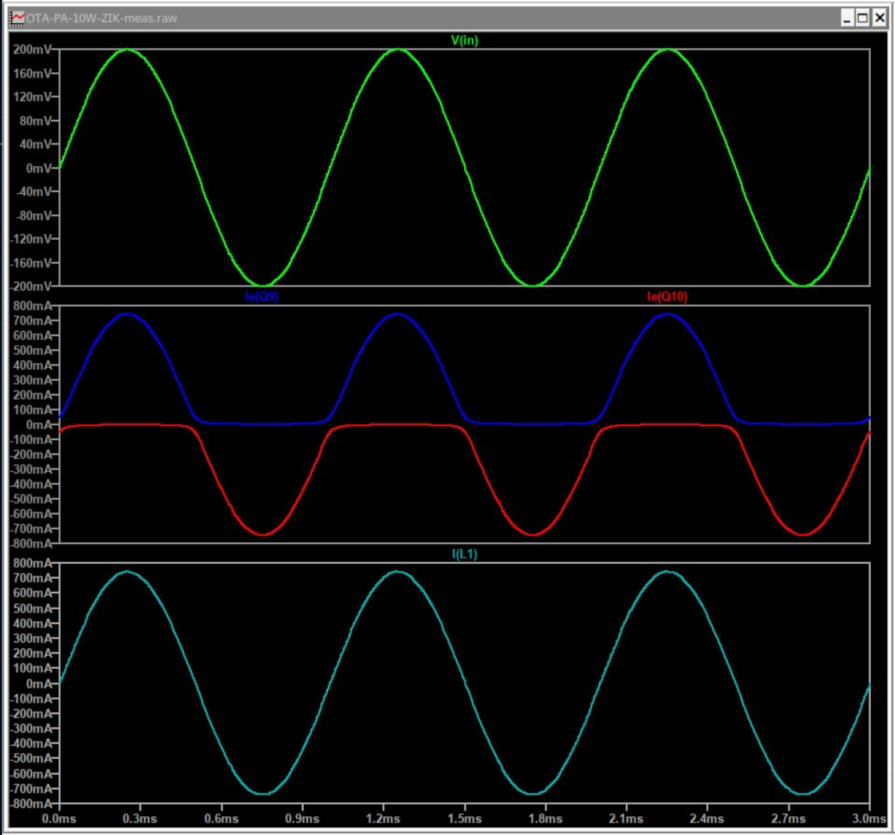
Polarisation
+ stable en
fonction de
la charge

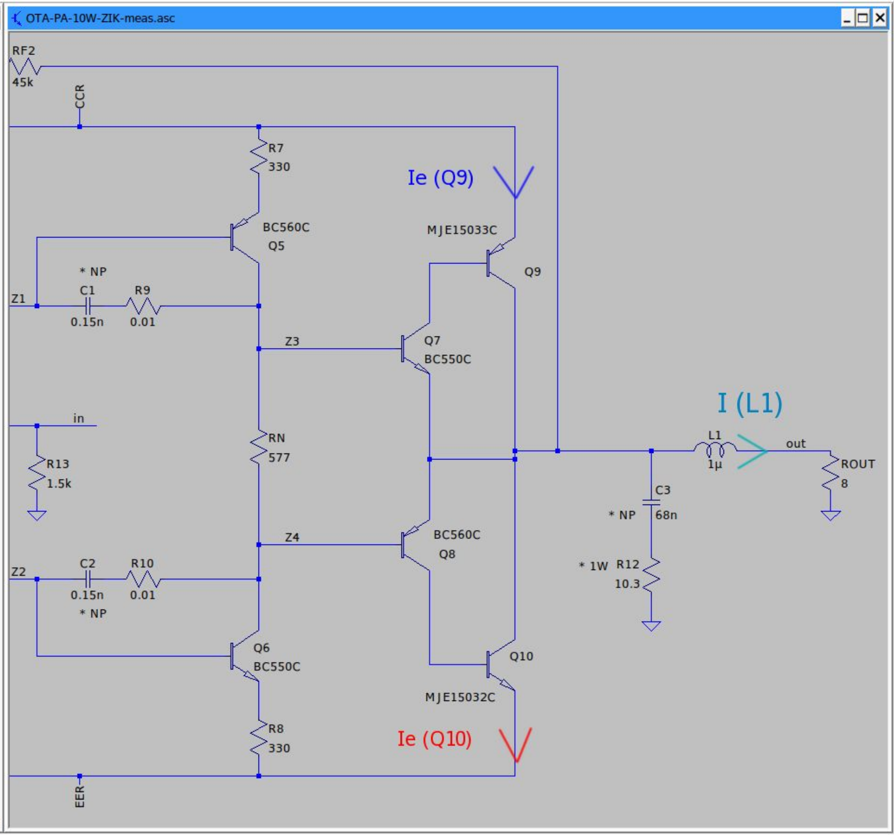
Etude - Paire Sziklai


OTA-PA-10W-ZIK-meas.raw


OTA-PA-10W-ZIK-meas.asc
RF2
45k
CCR
* +P
C5
100µ
C4
100n
R7
330
R2
11.94k
R4
2.177k
BC560C
Q5
MJE15033C
Q9
* NP
C1
0.15n
R9
0.01
Z1
Z3
Q7
BC550C
E2
C560C
Q3
BC560C
Q4
in
BC550C
Q2
R13
1.5k
RN
600
E1
Z4
BC560C
Q8
Z2
C2
0.15n
R10
0.01
* NP
Q6
BC550C
Q10
MJE15032C
R5
.470k
R1
11.82k
R6
2.186k
R8
330
C7
C6
EER

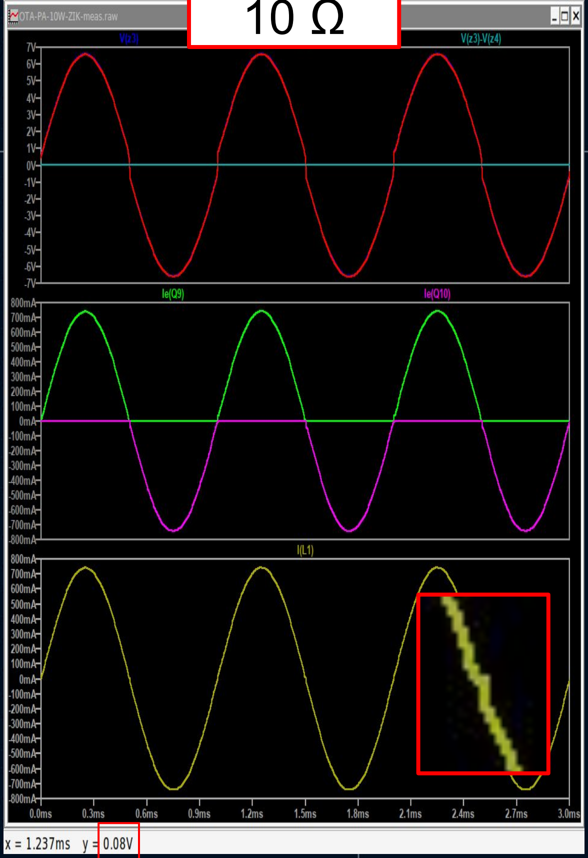
Etude - Amplification en courant




OTA-PA-10W-ZIK-meas.asc
RF2
45k
CCR
R7
330
Ie (Q9)
BC560C
Q5
MJE15033C
Q9
* NP
C1
0.15n
R9
0.01
Z1
Z3
Q7
BC550C
I (L1)
in
RN
577
R13
1.5k
L1
1µ
out
ROUT
8
C3
* NP
68n
Z4
BC560C
Q8
* 1W
R12
10.3
Z2
C2
0.15n
* NP
R10
0.01
Q6
BC550C
Q10
MJE15032C
R8
330
Ie (Q10)
EER

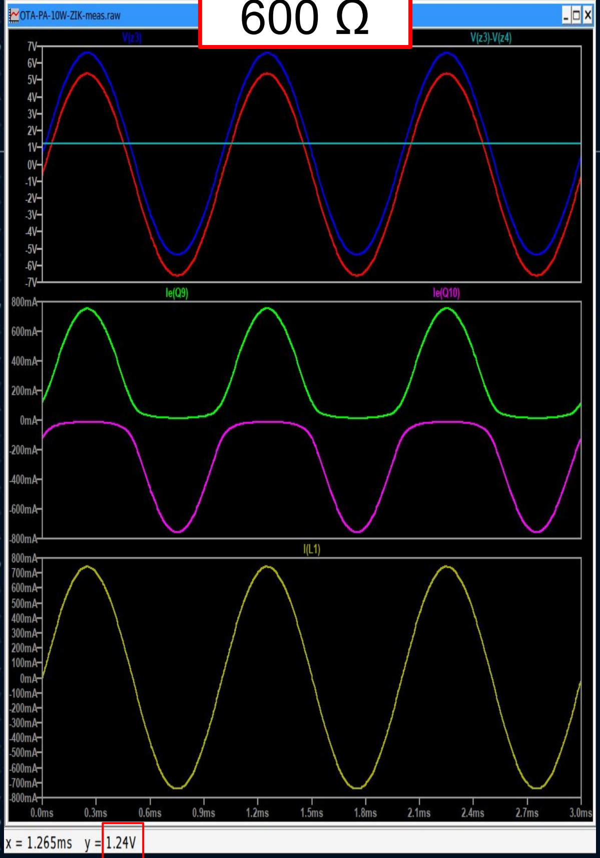
Etude - Influence de la résistance RN

10 Ω


OTA-PA-10W-ZIK-meas.raw
V(z3)
V(z3)-V(z4)
7V
0V
-7V
Ie(Q9)
Ie(Q10)
800mA
0mA
-800mA
I(L1)
800mA
0mA
-800mA
0.0ms
0.3ms
0.6ms
0.9ms
1.2ms
1.5ms
1.8ms
2.1ms
2.4ms
2.7ms
3.0ms

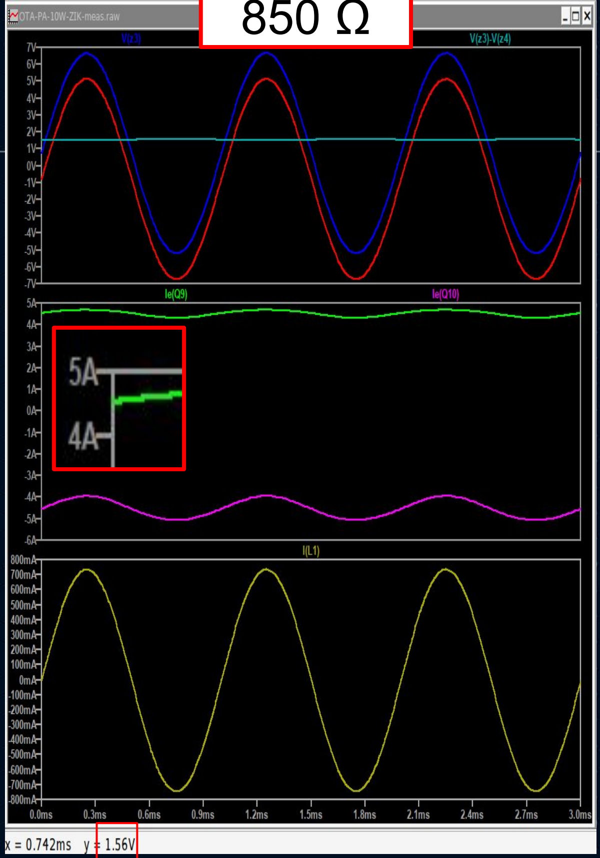
x = 1.237ms y = 0.08V

600 Ω


OTA-PA-10W-ZIK-meas.raw
V(z3)
V(z3)-V(z4)
7V
0V
-7V
Ie(Q9)
Ie(Q10)
800mA
0mA
-800mA
I(L1)
800mA
0mA
-800mA
0.0ms
0.3ms
0.6ms
0.9ms
1.2ms
1.5ms
1.8ms
2.1ms
2.4ms
2.7ms
3.0ms

x = 1.265ms y = 1.24V

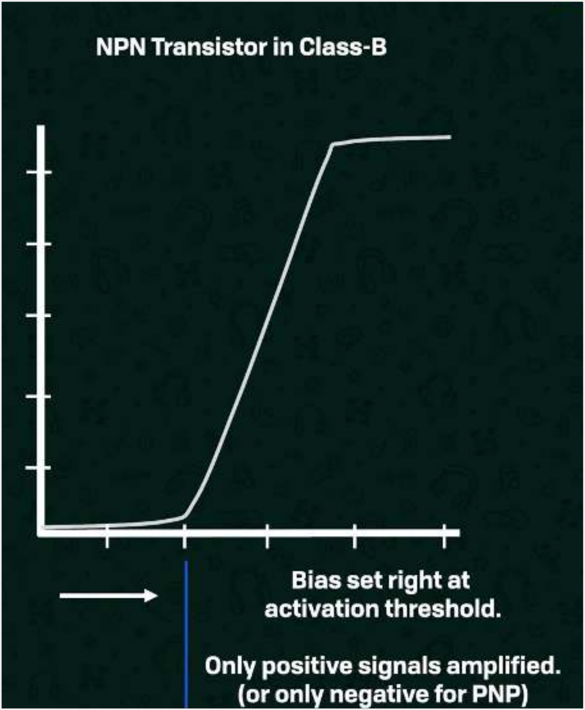
850 Ω


OTA-PA-10W-ZIK-meas.raw
V(z3)
V(z3)-V(z4)
7V
0V
-7V
Ie(Q9)
Ie(Q10)
5A
0A
-6A
5A
4A
I(L1)
800mA
0mA
-800mA
0.0ms
0.3ms
0.6ms
0.9ms
1.2ms
1.5ms
1.8ms
2.1ms
2.4ms
2.7ms
3.0ms

x = 0.742ms y = 1.56V

Etude - Influence de la résistance R_N

10 Ω

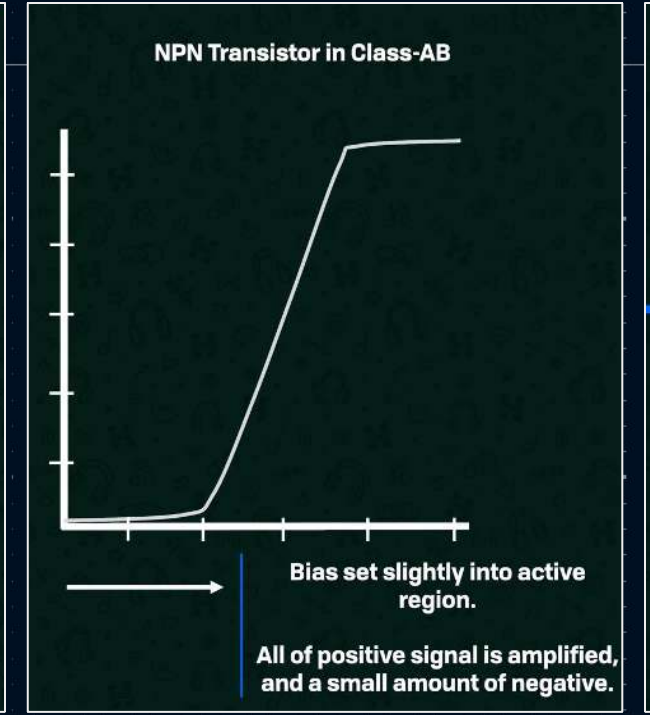


NPN Transistor in Class-B

Bias set right at activation threshold.

Only positive signals amplified. (or only negative for PNP)

600 Ω

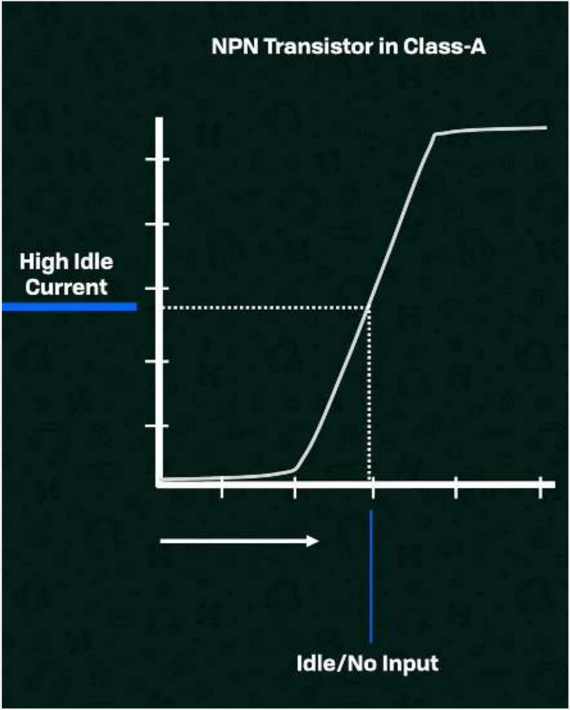


NPN Transistor in Class-AB

Bias set slightly into active region.

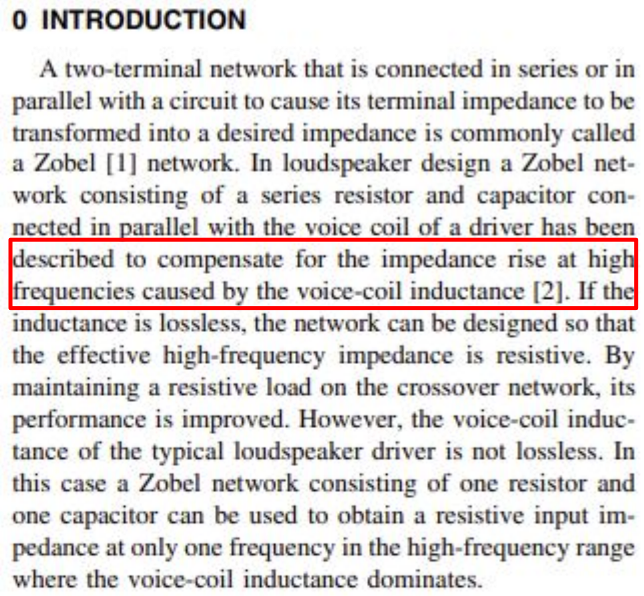
All of positive signal is amplified, and a small amount of negative.

850 Ω



NPN Transistor in Class-A

Etude - Réseau Zobel / cellule de Boucherot



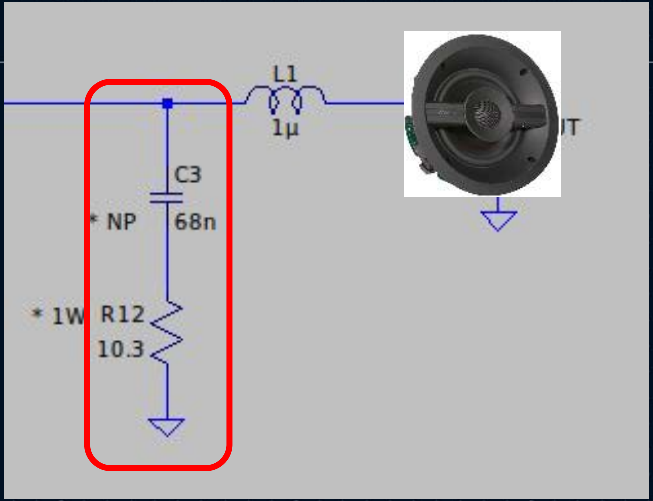
0 INTRODUCTION

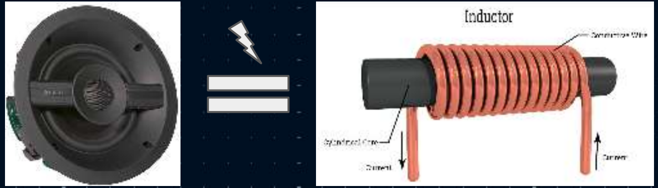
A two-terminal network that is connected in series or in parallel with a circuit to cause its terminal impedance to be transformed into a desired impedance is commonly called a Zobel [1] network. In loudspeaker design a Zobel network consisting of a series resistor and capacitor connected in parallel with the voice coil of a driver has been described to compensate for the impedance rise at high frequencies caused by the voice-coil inductance [2]. If the inductance is lossless, the network can be designed so that the effective high-frequency impedance is resistive. By maintaining a resistive load on the crossover network, its performance is improved. However, the voice-coil inductance of the typical loudspeaker driver is not lossless. In this case a Zobel network consisting of one resistor and one capacitor can be used to obtain a resistive input impedance at only one frequency in the high-frequency range where the voice-coil inductance dominates.

Extrait d'un article de
W. MARSHALL LEACH, JR.

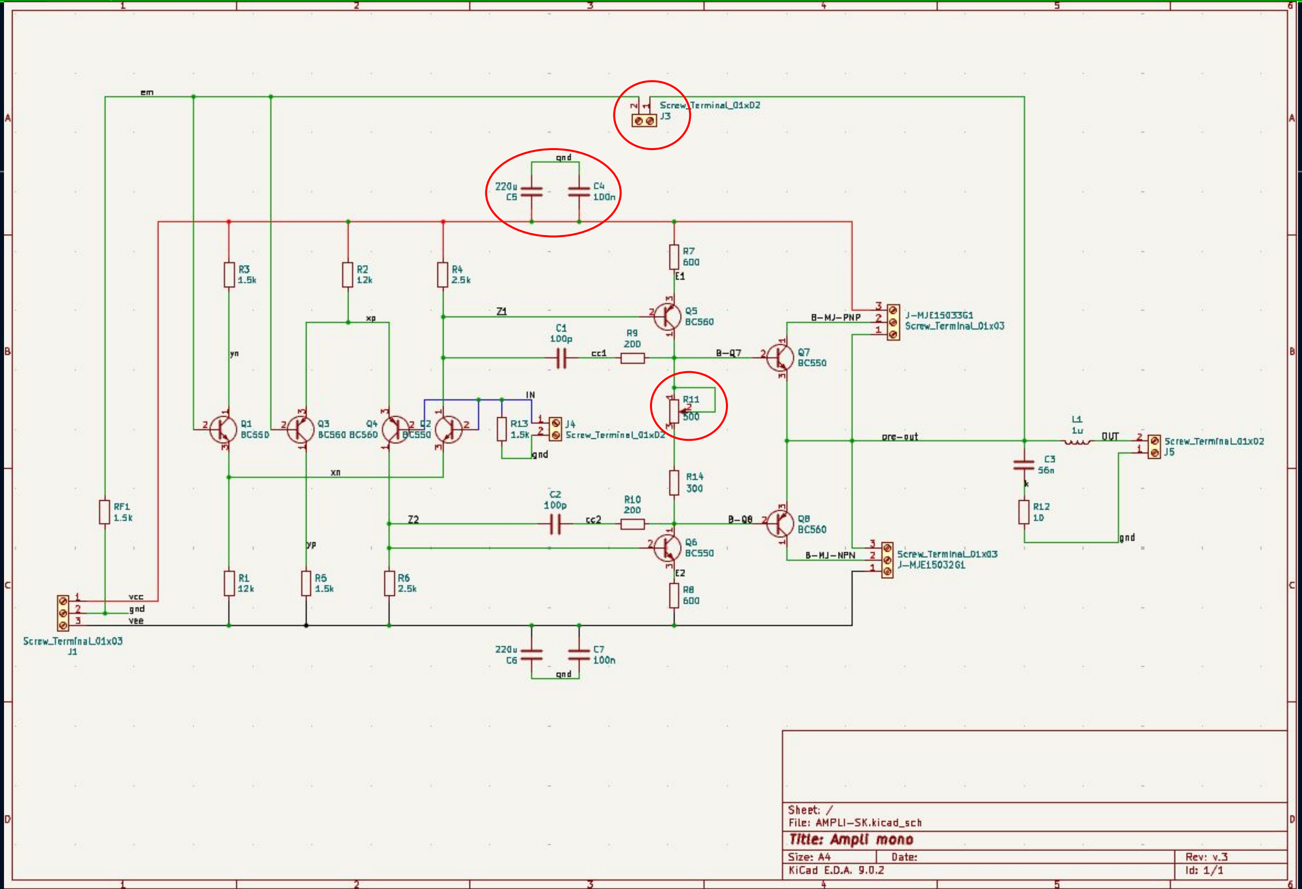
Compenser la hausse de la réactance du haut-parleur en fréquence

~ jLω

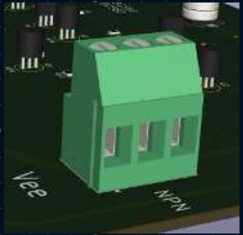




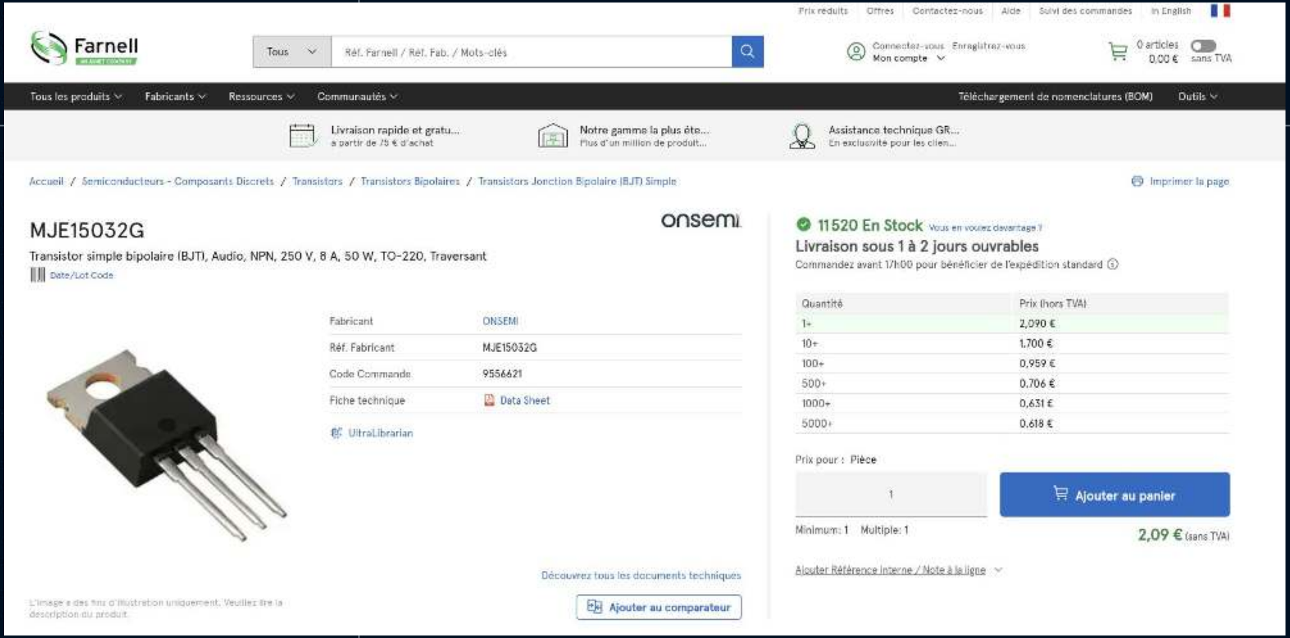
Modélisation sur KiCAD


em
Screw_Terminal_01x02
J3
gnd
220u
C5
C4
100n
R3
1.5k
R2
12k
R4
2.5k
R7
600
E1
Z1
Q5
BC560
xp
C1
100p
R9
200
cc1
B-Q7
Q7
BC550
B-MJ-PNP
J-MJE15033G1
Screw_Terminal_01x03
yn
IN
R11
500
Q1
BC550
Q3
BC560
Q4
BC560
Q2
BC550
R13
1.5k
J4
Screw_Terminal_01x02
gnd
pre-out
L1
1u
OUT
Screw_Terminal_01x02
J5
xn
R14
300
C3
56n
RF1
1.5k
Z2
C2
100p
cc2
R10
200
B-Q8
Q8
BC560
R12
10
gnd
yp
Q6
BC550
B-MJ-NPN
Screw_Terminal_01x03
J-MJE15032G1
E2
R1
12k
R5
1.5k
R6
2.5k
R8
600
vcc
gnd
vee
Screw_Terminal_01x03
J1
220u
C6
C7
100n
gnd

Sheet: /
File: AMPLI-SK.kicad_sch
Title: Ampli mono
Size: A4
Date:
Rev: v.3
KiCad E.D.A. 9.0.2
Id: 1/1



Recherche de composants


Prix réduits
Offres
Contactez-nous
Aide
Suivi des commandes
In English
Farnell
Tous
Réf. Farnell / Réf. Fab. / Mots-clés
Connectez-vous
Enregistrez-vous
Mon compte
0 articles
0,00 €
sans TVA
Tous les produits
Fabricants
Ressources
Communautés
Téléchargement de nomenclatures (BOM)
Outils
Livraison rapide et gratu...
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Accueil / Semiconducteurs - Composants Discrets / Transistors / Transistors Bipolaires / Transistors Jonction Bipolaire (BJT) Simple
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Découvrez tous les documents techniques
Ajouter au comparateur
Ajouter au panier
Ajouter Référence Interne / Note à la ligne

MJE15032G

Transistor simple bipolaire (BJT), Audio, NPN, 250 V, 8 A, 50 W, TO-220, Traversant

Fabricant	ONSEMI
Réf. Fabricant	MJE15032G
Code Commande	9556621
Fiche technique	Data Sheet

L'image a des fins d'illustration uniquement. Veuillez lire la description du produit.

11520 En Stock Vous en voulez davantage ?

Livraison sous 1 à 2 jours ouvrables

Commandez avant 17h00 pour bénéficier de l'expédition standard

Quantité	Prix (hors TVA)
1+	2,090 €
10+	1,700 €
100+	0,959 €
500+	0,706 €
1000+	0,631 €
5000+	0,618 €

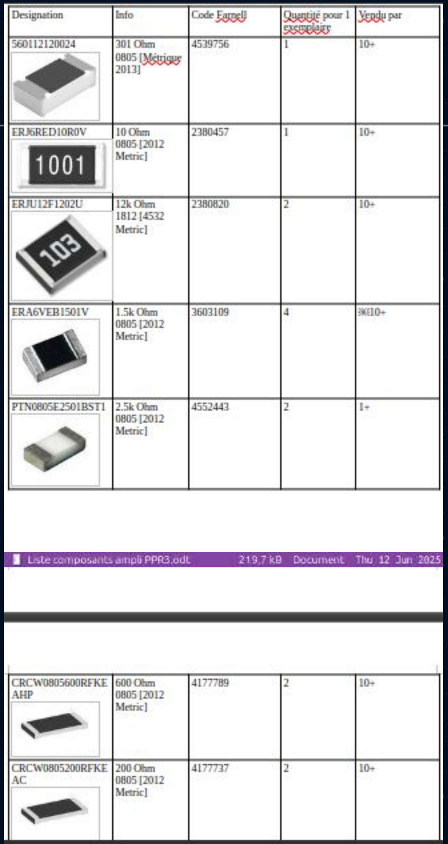
Prix pour : Pièce

1

Minimum: 1 Multiple: 1

2,09 € (sans TVA)

Site internet du fournisseur américain Farnell

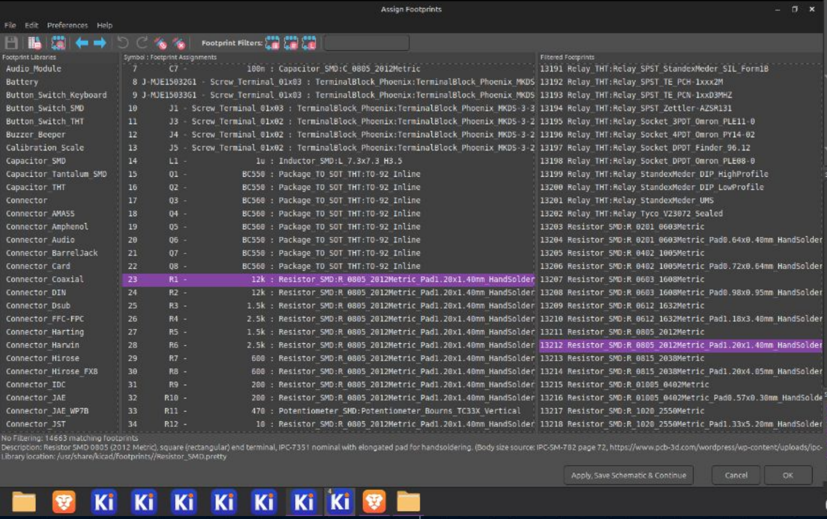


Designation	Info	Code Farnell	Quantité pour 1 exemplaire	Vendu par
560112120024	301 Ohm 0805 [Métrique 2013]	4539756	1	10+
ERJ6RED10R0V	10 Ohm 0805 [2012 Metric]	2380457	1	10+
ERJU12F1202U	12k Ohm 1812 [4532 Metric]	2380820	2	10+
ERA6VEB1501V	1.5k Ohm 0805 [2012 Metric]	3603109	4	3010+
PTN0805E2501BST1	2.5k Ohm 0805 [2012 Metric]	4552443	2	1+

Liste composants ampli PPR3.odt 219,7 kB Document Thu 12 Jun 2025

CRCW0805600RFKEAHP	600 Ohm 0805 [2012 Metric]	4177789	2	10+
CRCW0805200RFKEAC	200 Ohm 0805 [2012 Metric]	4177737	2	10+

Empreintes

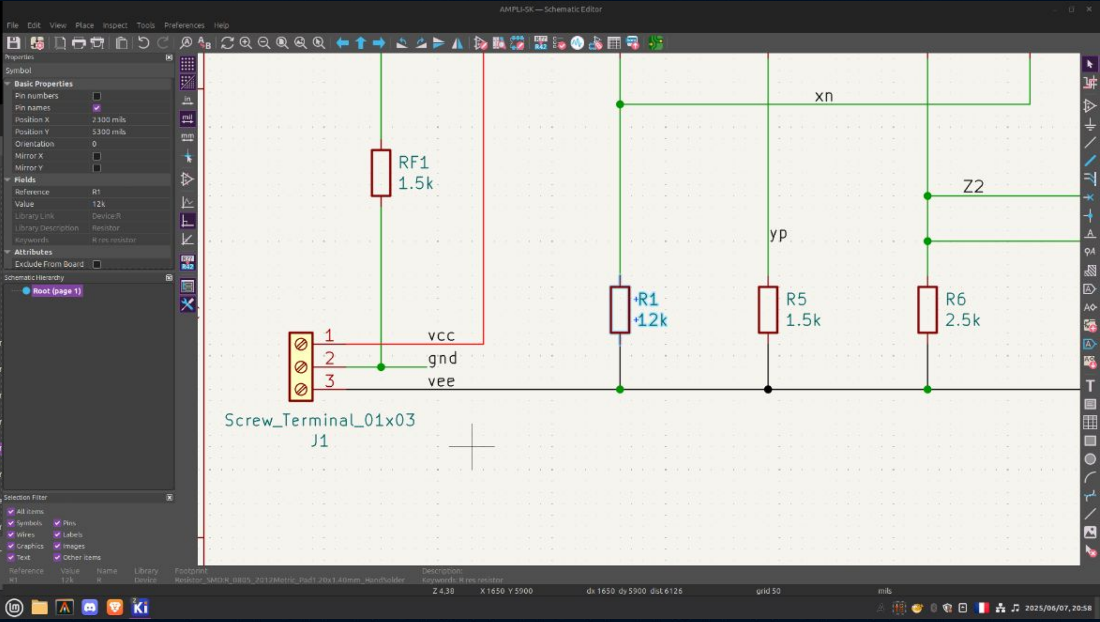


```
Audio_Module
Battery
Button_Switch_Keyboard
Button_Switch_SMD
Button_Switch_THT
Buzzer_Beeper
Calibration_Scale
Capacitor_SMD
Capacitor_Tantalum_SMD
Capacitor_THT
Connector
Connector_AMASS
Connector_Amphenol
Connector_Audio
Connector_BarrelJack
Connector_Card
Connector_Coaxial
Connector_DIN
Connector_Dsub
Connector_FFC-FPC
Connector_Harting
Connector_Harwin
Connector_Hirose
Connector_Hirose_FX8
Connector_IDC
Connector_JAE
Connector_JAE_WP7B
Connector_JST
```

```
 7         C7 -           100n : Capacitor_SMD:C_0805_2012Metric
 8 J-MJE15032G1 - Screw_Terminal_01x03 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS
 9 J-MJE15033G1 - Screw_Terminal_01x03 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS
10         J1 - Screw_Terminal_01x03 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS-3-3
11         J3 - Screw_Terminal_01x02 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS-3-2
12         J4 - Screw_Terminal_01x02 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS-3-2
13         J5 - Screw_Terminal_01x02 : TerminalBlock_Phoenix:TerminalBlock_Phoenix_MKDS-3-2
14         L1 -             1u : Inductor_SMD:L_7.3x7.3_H3.5
15         Q1 -          BC550 : Package_TO_SOT_THT:TO-92_Inline
16         Q2 -          BC550 : Package_TO_SOT_THT:TO-92_Inline
17         Q3 -          BC560 : Package_TO_SOT_THT:TO-92_Inline
18         Q4 -          BC560 : Package_TO_SOT_THT:TO-92_Inline
19         Q5 -          BC560 : Package_TO_SOT_THT:TO-92_Inline
20         Q6 -          BC550 : Package_TO_SOT_THT:TO-92_Inline
21         Q7 -          BC550 : Package_TO_SOT_THT:TO-92_Inline
22         Q8 -          BC560 : Package_TO_SOT_THT:TO-92_Inline
23         R1 -            12k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
24         R2 -            12k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
25         R3 -           1.5k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
26         R4 -           2.5k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
27         R5 -           1.5k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
28         R6 -           2.5k : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
29         R7 -            600 : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
30         R8 -            600 : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
31         R9 -            200 : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
32        R10 -            200 : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
33        R11 -            470 : Potentiometer_SMD:Potentiometer_Bourns_TC33X_Vertical
34        R12 -             10 : Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
```

```
13191 Relay_THT:Relay_SPST_StandexMeder_SIL_Form1B
13192 Relay_THT:Relay_SPST_TE_PCH-1xxx2M
13193 Relay_THT:Relay_SPST_TE_PCN-1xxD3MHZ
13194 Relay_THT:Relay_SPST_Zettler-AZSR131
13195 Relay_THT:Relay_Socket_3PDT_Omron_PLE11-0
13196 Relay_THT:Relay_Socket_4PDT_Omron_PY14-02
13197 Relay_THT:Relay_Socket_DPDT_Finder_96.12
13198 Relay_THT:Relay_Socket_DPDT_Omron_PLE08-0
13199 Relay_THT:Relay_StandexMeder_DIP_HighProfile
13200 Relay_THT:Relay_StandexMeder_DIP_LowProfile
13201 Relay_THT:Relay_StandexMeder_UMS
13202 Relay_THT:Relay_Tyco_V23072_Sealed
13203 Resistor_SMD:R_0201_0603Metric
13204 Resistor_SMD:R_0201_0603Metric_Pad0.64x0.40mm_HandSolder
13205 Resistor_SMD:R_0402_1005Metric
13206 Resistor_SMD:R_0402_1005Metric_Pad0.72x0.64mm_HandSolder
13207 Resistor_SMD:R_0603_1608Metric
13208 Resistor_SMD:R_0603_1608Metric_Pad0.98x0.95mm_HandSolder
13209 Resistor_SMD:R_0612_1632Metric
13210 Resistor_SMD:R_0612_1632Metric_Pad1.18x3.40mm_HandSolder
13211 Resistor_SMD:R_0805_2012Metric
13212 Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder
13213 Resistor_SMD:R_0815_2038Metric
13214 Resistor_SMD:R_0815_2038Metric_Pad1.20x4.05mm_HandSolder
13215 Resistor_SMD:R_01005_0402Metric
13216 Resistor_SMD:R_01005_0402Metric_Pad0.57x0.30mm_HandSolde
13217 Resistor_SMD:R_1020_2550Metric
13218 Resistor_SMD:R_1020_2550Metric_Pad1.33x5.20mm_HandSolder
```

No Filtering: 14663 matching footprints
Description: Resistor SMD 0805 (2012 Metric), square (rectangular) end terminal, IPC-7351 nominal with elongated pad for handsoldering. (Body size source: IPC-SM-782 page 72, https://www.pcb-3d.com/wordpress/wp-content/uploads/ipc-
Library location: /usr/share/kicad/footprints//Resistor_SMD.pretty



Symbol

Basic Properties
Pin numbers ☐
Pin names ☑
Position X 2300 mils
Position Y 5300 mils
Orientation 0
Mirror X ☐
Mirror Y ☐

Fields
Reference R1
Value 12k
Library Link Device:R
Library Description Resistor
Keywords R res resistor

Attributes
Exclude From Board ☐

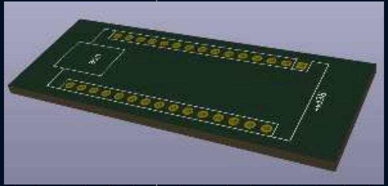
☑ All items
☑ Symbols ☑ Pins
☑ Wires ☑ Labels
☑ Graphics ☑ Images
☑ Text ☑ Other items

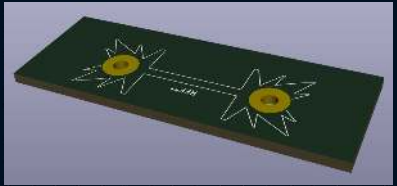
Reference	Value	Name	Library	Footprint	Description:
R1	12k	R	Device	Resistor_SMD:R_0805_2012Metric_Pad1.20x1.40mm_HandSolder	Keywords: R res resistor

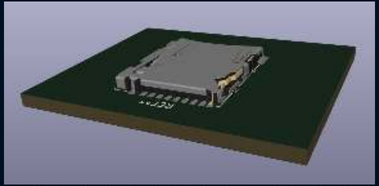
Z 4,38 X 1650 Y 5900 dx 1650 dy 5900 dist 6126 grid 50 mils

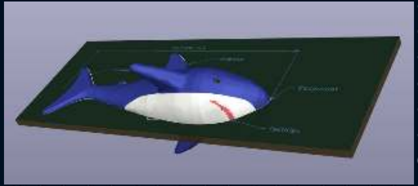
2025/06/07, 20:58

Arduino Nano
Radiateur
Lecteur SD
...Blåhaj ?



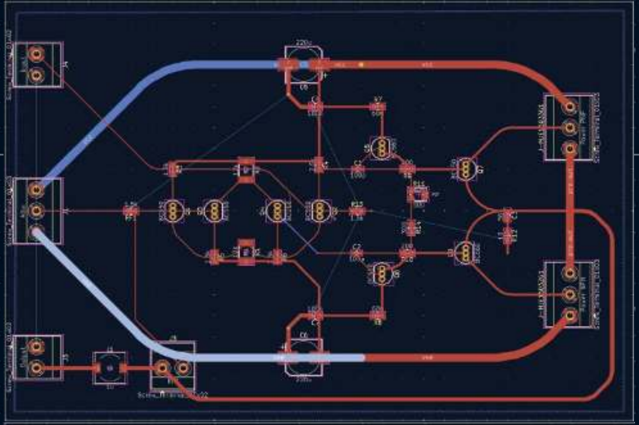


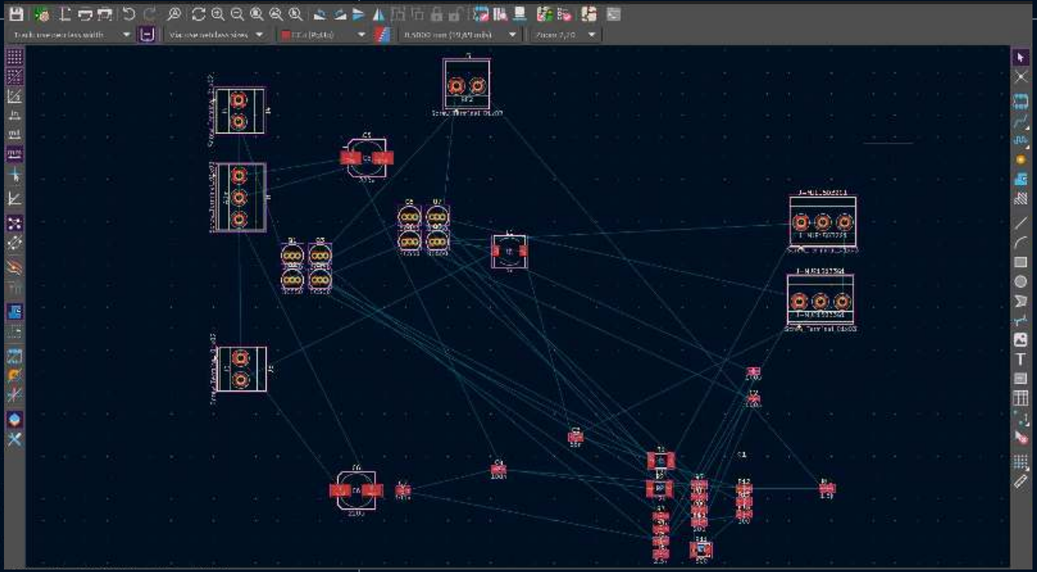




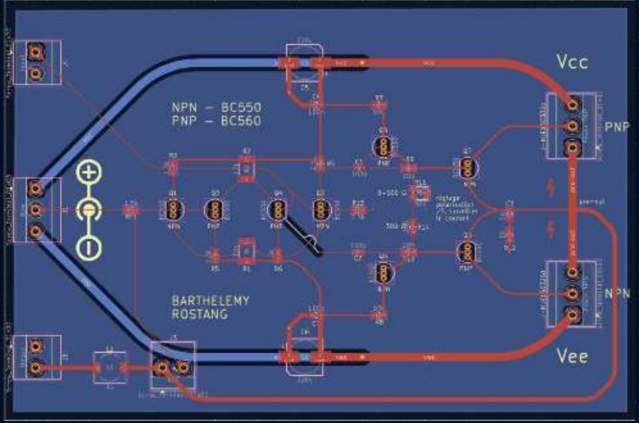
Design

Avant copper fill



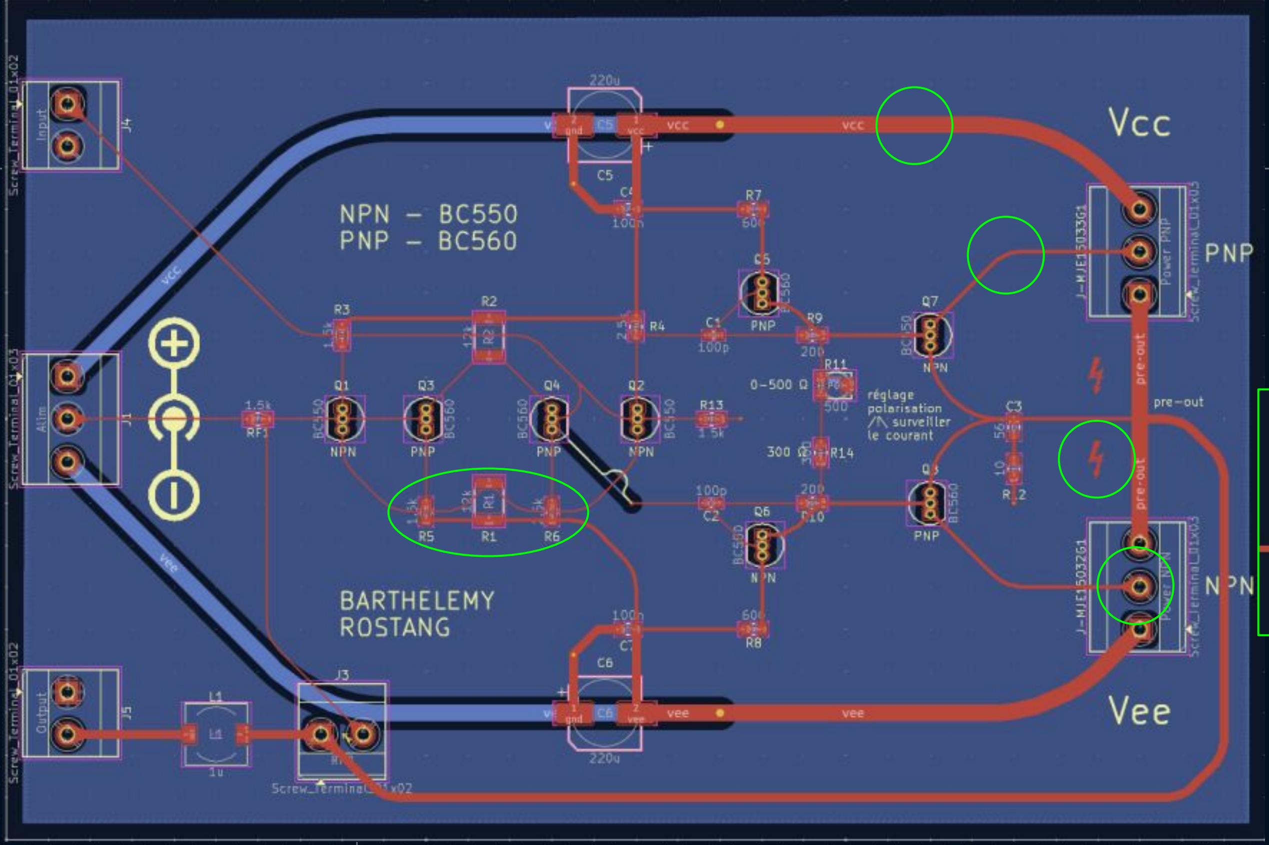


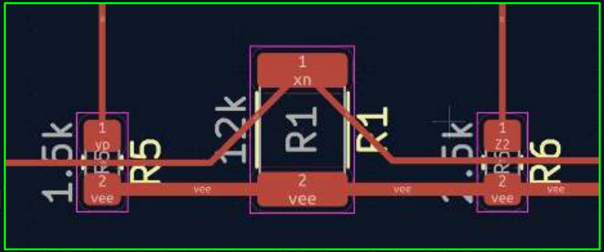
Interface de l'éditeur


Vcc
NPN – BC550
PNP – BC560
PNP
BARTHELEMY
ROSTANG
NPN
Vee

Après copper fill

Détails et ajustements


Vcc
vcc
Vee
vee
PNP
NPN
NPN – BC550
PNP – BC560
BARTHELEMY
ROSTANG
220u
C5
C6
C4
100n
R7
600
R8
C1
100p
C2
R2
12k
R3
1.5k
R4
R9
200
R10
R11
0–500 Ω
500
réglage
polarisation
/!\ surveiller
le courant
300 Ω
R14
R13
1.5k
C3
56
10
R12
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
R1
R5
R6
RF1
L1
1u
J1
J3
J4
J5
Input
Alim
Output
pre-out
Power PNP
Power NPN
Screw_Terminal_01x02
Screw_Terminal_01x03

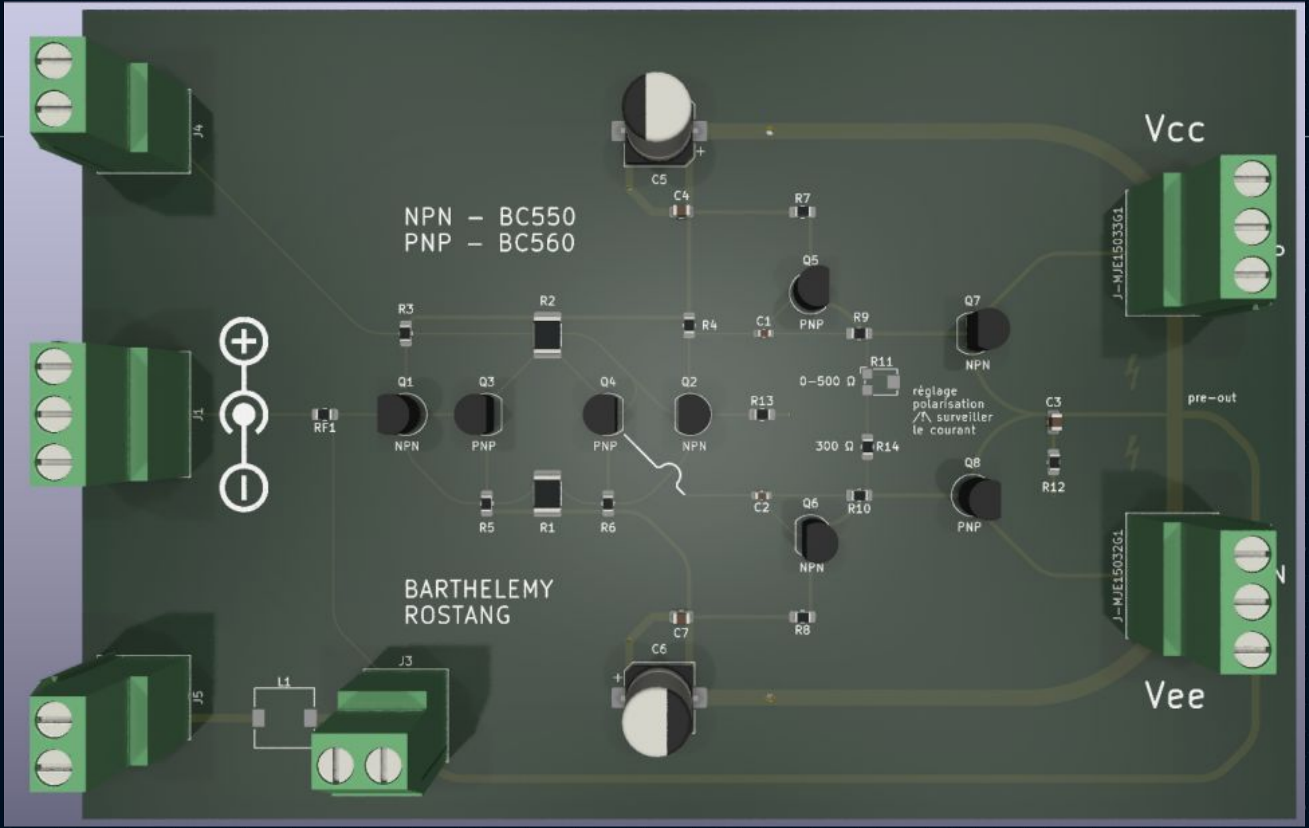

1.5k
R5
12k
R1
2.5k
R6
xn
vee

après

avant

Conclusion

- Prêt à fabriquer
- Assemblage à faire
- Radiateur
- Tests en conditions réelles
- Ampèremètre
- Préamplificateur


J4
C5
C4
R7
NPN – BC550
PNP – BC560
Vcc
J-MJE15033G1
Q5
R3
R2
R4
C1
PNP
R9
Q7
NPN
R11
0–500 Ω
réglage
polarisation
/!\ surveiller
le courant
C3
pre–out
J1
RF1
Q1
NPN
Q3
PNP
Q4
PNP
Q2
NPN
R13
300 Ω
R14
Q8
PNP
R12
R5
R1
R6
C2
Q6
R10
NPN
J-MJE15032G1
BARTHELEMY
ROSTANG
C7
R8
C6
Vee
J5
L1
J3

Credits

Articles :

https://leachlegacy.ece.gatech.edu/papers/zobel/zobel.pdf
https://leachlegacy.ece.gatech.edu/papers/tubeamp/tubeamp.pdf

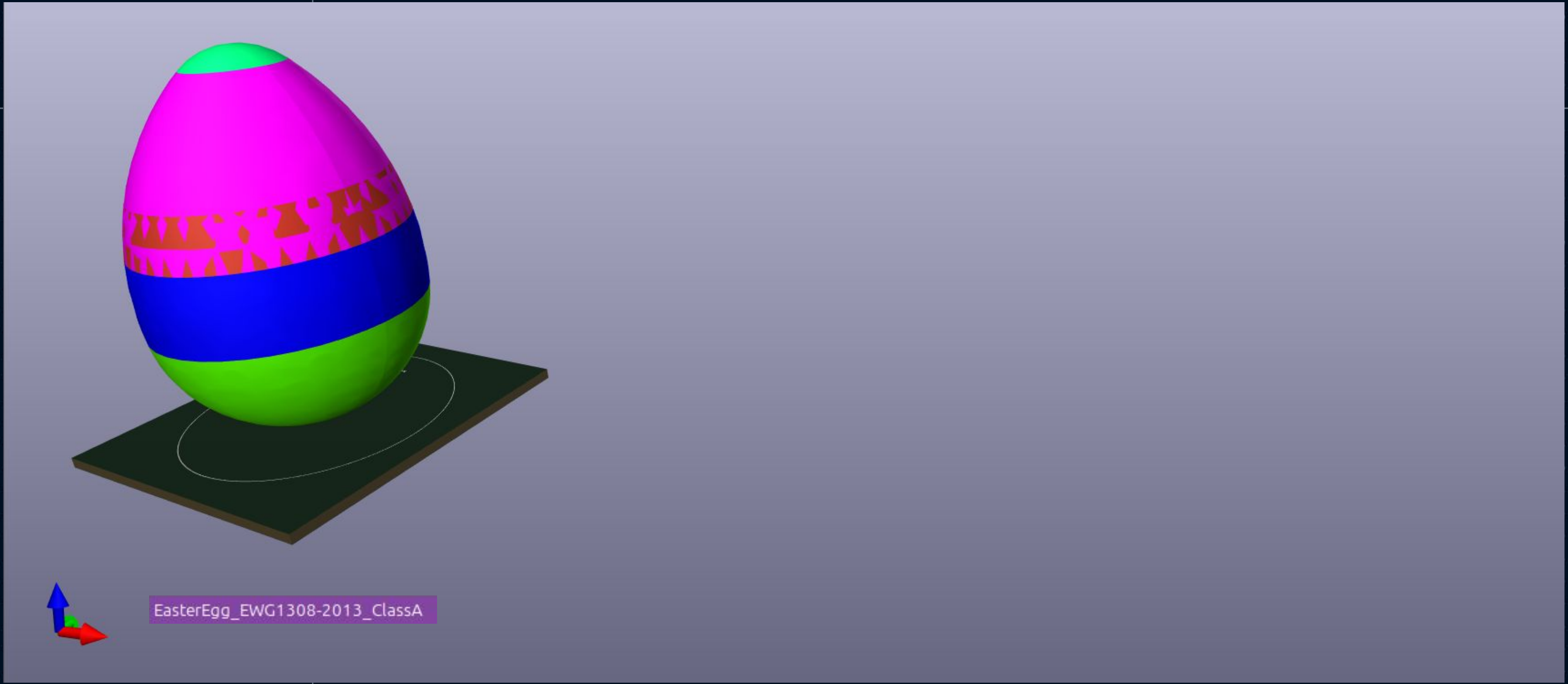
YouTube :

Robert Feranec : <https://www.youtube.com/@RobertFeranec>
Phil's Lab : <https://www.youtube.com/@PhilsLab>
The AudioPhool : <https://www.youtube.com/@TheAudioPhool>
JohnAudio Tech : <https://youtube.com/@johnaudiotech>
PCB cupid : <https://www.youtube.com/@pcbcupid>
Simply Put : <https://youtu.be/0aBtik-0ve8>
<https://youtu.be/yXJADXuWtlI>
<https://youtu.be/d8ug0NbaIds>

Images :

https://www.circuitbasics.com/make-custom-pcb
https://www.bathroomspeakers.co.uk/blogs/news/what-are-mono-ceiling-speakers
https://boutique.semageek.com/fr/61-breadboard-400-contacts-3006703346176.html
https://ieeexplore.ieee.org/author/37269236100
https://electronics.stackexchange.com/questions/330588/a-confusion-about-the-formula-for-transistor-vbe-ic-characterisitcs
https://circuitcellar.com/resources/darlington-vs-sziklai-pair
https://www.iqsdirectory.com/articles/electric-coil/inductors-and-inductor-coils.html

Questions ?


EasterEgg_EWG1308-2013_ClassA