



# PROIECT SCIA

STUDENT: FETTI OANA-MARIA

GRUPA 2131

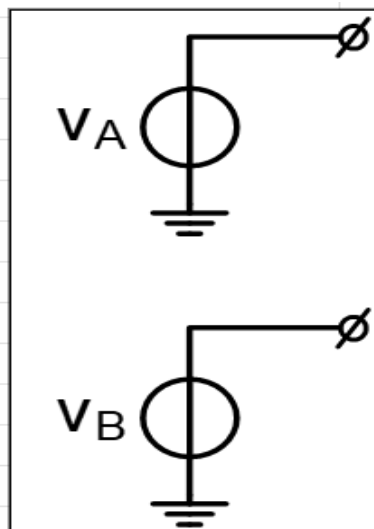
PROFESOR: VLADU GHEORGHE EDUARD

## Contents

|     |                           |    |
|-----|---------------------------|----|
| 1   | TEMATICA PROIECTULUI..... | 2  |
| 1.1 | Sursă de semnal.....      | 2  |
| 1.2 | Etajul 1 .....            | 2  |
| 1.3 | Etajul 2 Filtru .....     | 3  |
| 1.4 | Etajul 3 PGA.....         | 3  |
| 1.5 | Etajul 4.....             | 4  |
| 2   | Dimensionare .....        | 5  |
| 2.1 | Etajul 1 .....            | 5  |
| 2.2 | Etajul 2 .....            | 6  |
| 2.3 | Etajul 3 .....            | 8  |
| 2.4 | Etajul 4.....             | 10 |
| 3   | CARACTERIZARE .....       | 11 |
| 3.1 | ETAJUL 1 .....            | 11 |
| 3.2 | ETAJUL 2.....             | 14 |
| 3.3 | ETAJUL 3.....             | 16 |
| 3.4 | ETAJUL 4.....             | 22 |

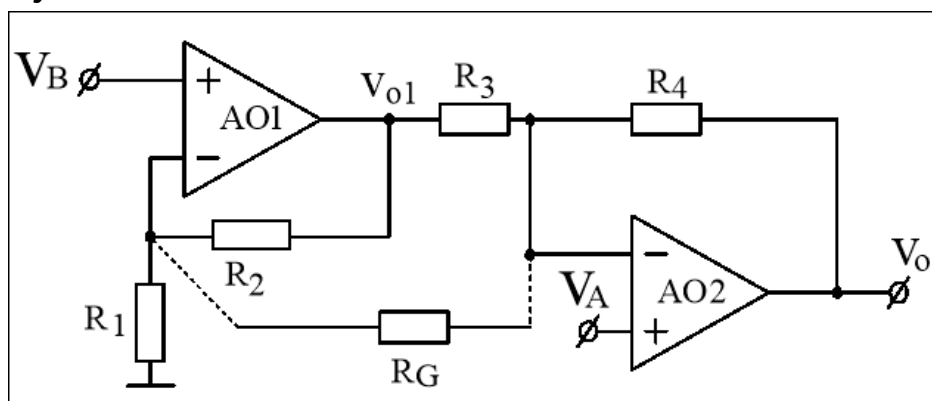
# 1 TEMATICA PROIECTULUI

## 1.1 Sursă de semnal



Figură 1: Sursa de semnal

## 1.2 Etajul 1



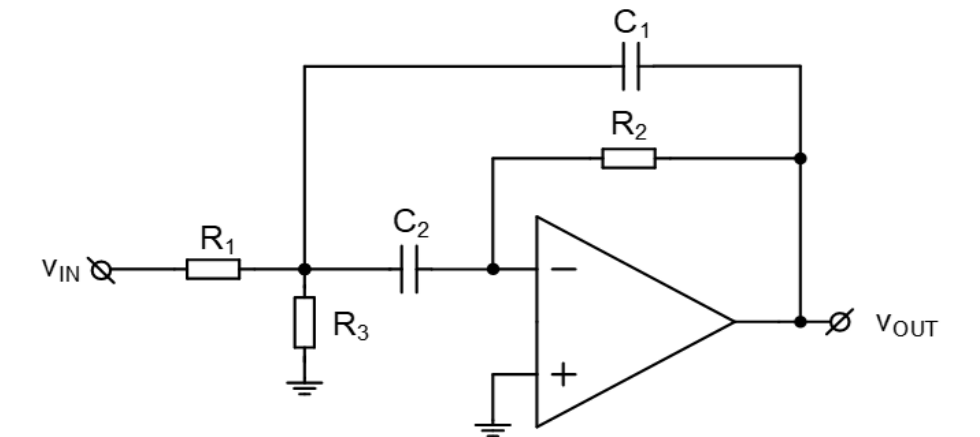
Figură 2: Etajul 1

Amplitudine maximă: 1.25E-01

Amplitudine minimă: 4.45E-02

Câștig: 10

### 1.3 Etajul 2 Filtru



Figură 3: Etaj 2-Filtru

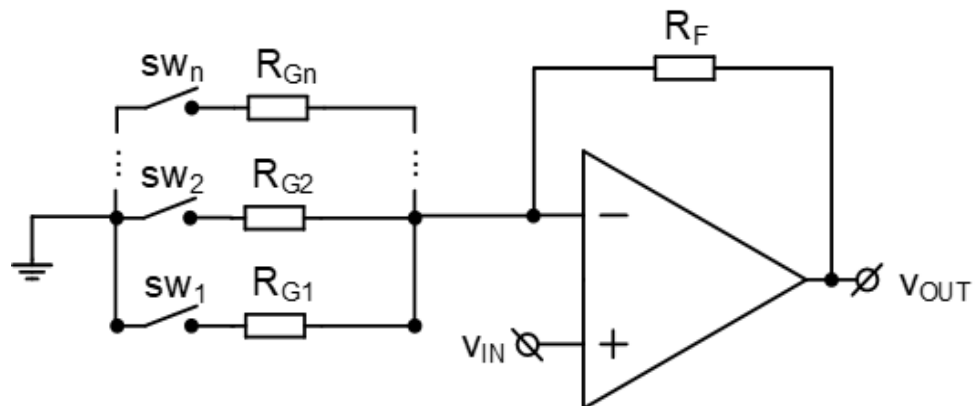
Câștig liniar in banda de trecere: 1,00E+00

Rintrare minim: 1.00E+03

Factorul de calitate(Q): 1.73

Banda: 7000

### 1.4 Etajul 3 PGA



Figură 4 Etajul 3 PGA

Câștig minim[dB]: 6

Câștig maxim[dB]: 1.50E+01

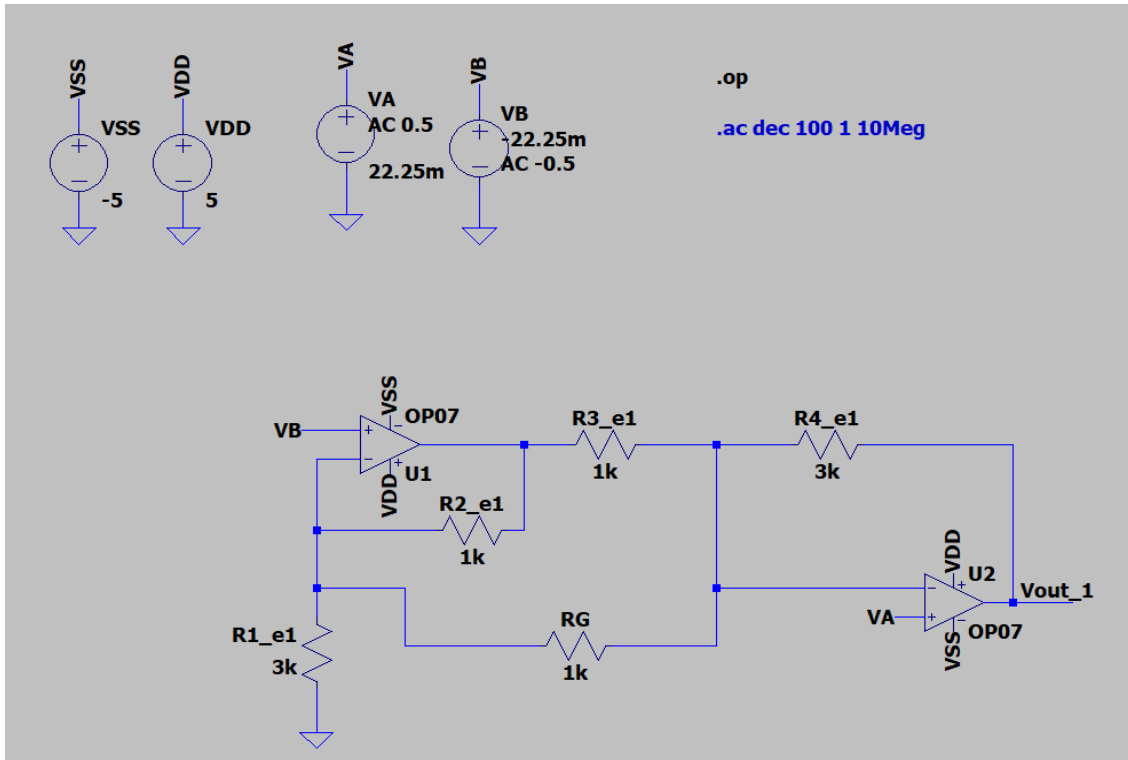
Rezoluție(pas minim): 3

Număr pași:4



## 2 Dimensionare

### 2.1 Etajul 1



Figură 6 Etajul 1 dimensionat

Pentru dimensionare optimă, aleg  $R1=R4$  și  $R2=R3$

$$v1^+ = v1^- = VB$$

$$v2^+ = v2^- = VA$$

Aplicând Millman în nodurile  $v1^-$  și  $v2^-$ , obțin:

$$v1^- = \frac{\frac{V_{O1}}{R2} + \frac{0}{R1} + \frac{VA}{RG}}{\frac{1}{R2} + \frac{1}{R1} + \frac{1}{RG}} = VB$$

$$v2^- = \frac{\frac{V_{O1}}{R3} + \frac{VB}{RG} + \frac{Vo}{R4}}{\frac{1}{R3} + \frac{1}{RG} + \frac{1}{R4}} = VA$$

Astfel, rezultă o tensiune de ieșire egală cu:

$$V_{out} = \left(1 + \frac{2R_4}{R_G} + \frac{R_4}{R_3}\right) \times (V_A - V_B), \text{ de unde } \rightarrow A_d = 1 + \frac{R_4}{R_3} \left(1 + \frac{R_2 + R_3}{R_G}\right)$$

Știind din specificațiile de proiectare că  $A_d = 10$ , înseamnă că

$$\frac{R_4}{R_3} \left(1 + \frac{R_2 + R_3}{R_G}\right) = 9$$

$$\text{Aleg } R_G = 1k\Omega \Rightarrow \frac{R_4}{R_3} + \frac{2R_4}{1k} = 9$$

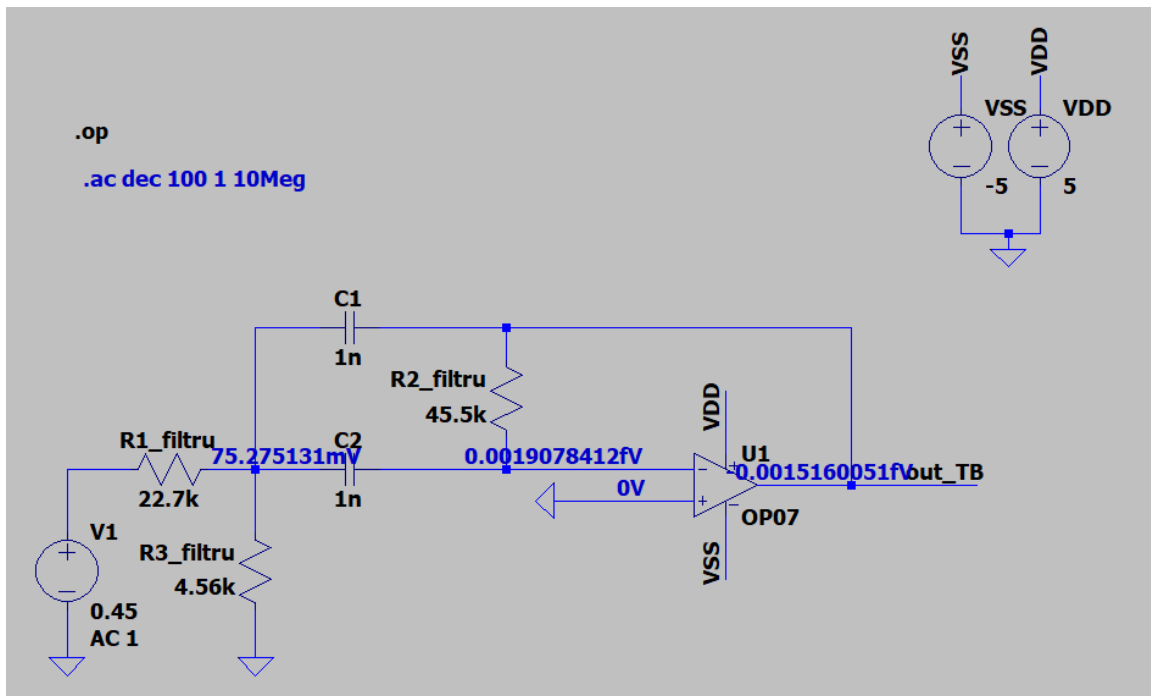
$$\text{Aleg } R_2 = 1k\Omega \Rightarrow \frac{R_4 + 2R_4}{1k} = 9 \Rightarrow \frac{3R_4}{1k} = 9 \Rightarrow R_4 = 3k$$

$$R_G = 1k\Omega$$

$$R_1 = R_4 = 3k\Omega$$

$$R_2 = R_3 = 1k\Omega$$

## 2.2 Etajul 2



Figură 7 Etajul 2 dimensionat

Pentru a dimensiona filtrul Deliyannis trece bandă, am utilizat tabelul de dimensionare:

| <b>f0 [Hz]</b> | <b>w0 [rad/sec]</b>        | <b>Q</b>  | <b> H0  [V/V]</b> | <b>H0 [dB]</b> |
|----------------|----------------------------|-----------|-------------------|----------------|
| 1.21E+04       | 7.61E+04                   | 1.73E+00  | 1.00E+00          | 0.00E+00       |
|                |                            |           |                   |                |
|                | <b>set C1=C2=C<br/>[F]</b> | <b>R1</b> | <b>R2</b>         | <b>R3</b>      |
|                | 1.00E-09                   | 2.27E+04  | 4.55E+04          | 4.56E+03       |

*Figură 8 Dimensionare filtru*

Astfel, am obținut următoarele valori:

$C1=C2=1\text{nF}$

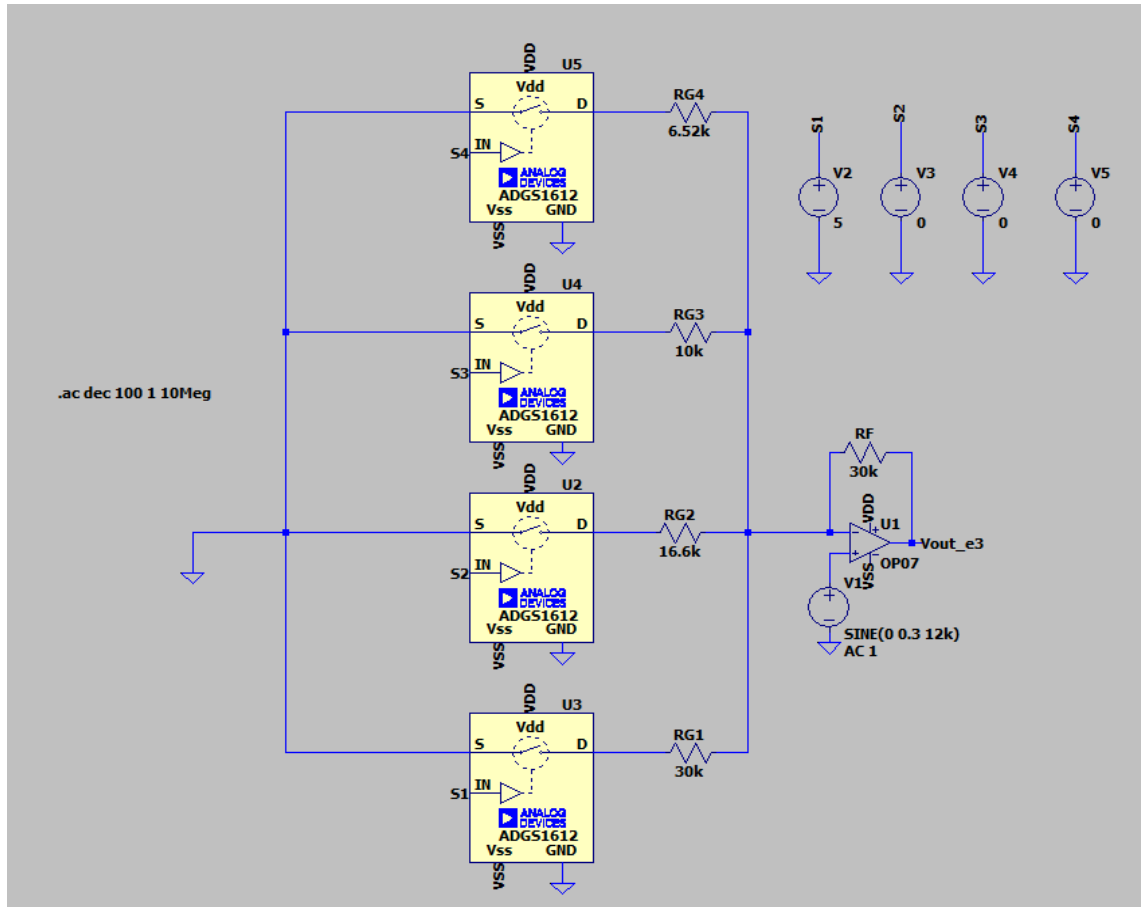
$R1=22.7\text{k}\Omega$

$R2=45.5\text{k}\Omega$

$R3=4.56\text{k}\Omega$



## 2.3 Etajul 3



Figură 9 Etajul 3 dimensionat

Având în vedere câștigul maxim de 15dB, câștigul minim de 6dB, cu un pas de 3 și număr minim de pași egal cu 4, domeniul câștigului va fi:

$$AdB = [6dB, 9dB, 12dB, 15dB]$$

Am transformat aceste valori în liniar cu ajutorul formulei  $A_{liniar} = 10^{\frac{AdB}{20}}$ . Așadar am obținut  $A_{liniar} = \left[ 2 \frac{V}{V}, 2.8 \frac{V}{V}, 4 \frac{V}{V}, 5.6 \frac{V}{V} \right]$

Expresia generală a câștigului, pentru acest circuit, este:  $A = 1 + \frac{RF}{RG}$

Astfel, pentru toate câștigurile:

$$\Rightarrow A1 = 1 + \frac{RF}{RG1} = 2$$

$$\Rightarrow A2 = 1 + \frac{RF}{RG2} = 2.8$$

$$\Rightarrow A3 = 1 + \frac{RF}{RG3} = 4$$

$$\Rightarrow A4 = 1 + \frac{RF}{RG4} = 5.6$$

Aleg  $RF = 30k\Omega$

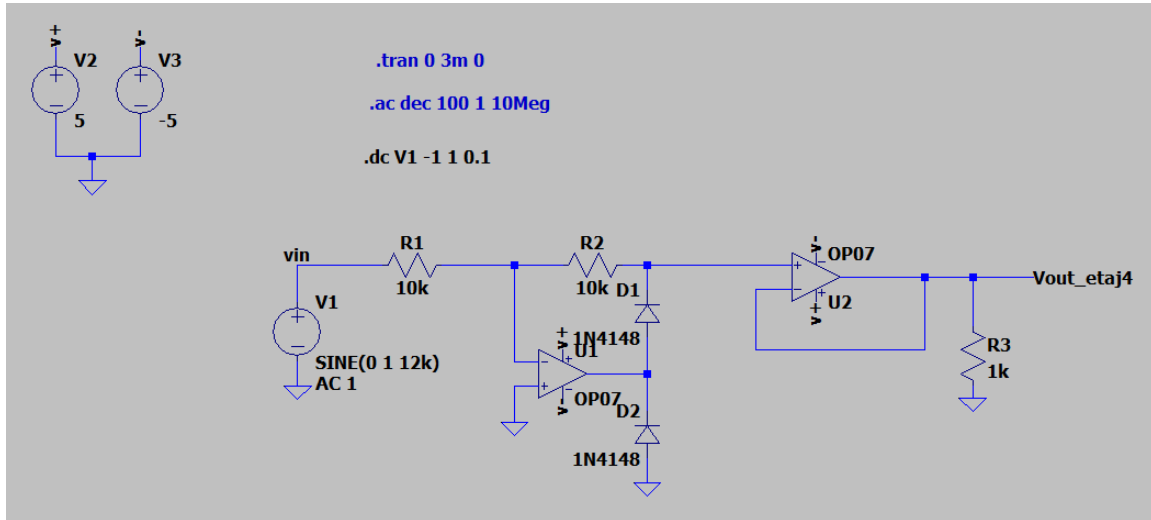
$$\Rightarrow RG1 = \frac{RF}{(A1-1)} = 30k\Omega$$

$$\Rightarrow RG2 = \frac{RF}{(A2-1)} = 16.6k\Omega$$

$$\Rightarrow RG3 = \frac{RF}{(A3-1)} = 10k\Omega$$

$$\Rightarrow RG4 = \frac{RF}{(A4-1)} = 6.52k\Omega$$

## 2.4 Etajul 4



Figură 10 Etajul 4 Dimensionat

Presupunând că ambele diode sunt blocate și că avem o tensiune de intrare pozitivă, obținem, în acest caz,  $V_{out}=V_{in}$ , pentru D1 blocată și D2 în conducție.

Pentru o tensiune de intrare negativă, prima diodă va conduce, iar D2 va fi blocată. Astfel, primul amplificator va fi inversor cu reacție negativă și vom avea  $V_{out}=-\frac{R_2}{R_1}V_{in}$  în acest caz, expresia tensiunii de ieșire este:

$$V_{out}=\begin{cases} V_{in}, & V_{in} > 0 \\ -\frac{R_2}{R_1}V_{in}, & V_{in} < 0 \end{cases}$$

Având un câștig liniar egal cu 1, aleg  $R_2=R_1=10k\Omega$

## 3 CARACTERIZARE

### 3.1 ETAJUL 1

#### DCOP

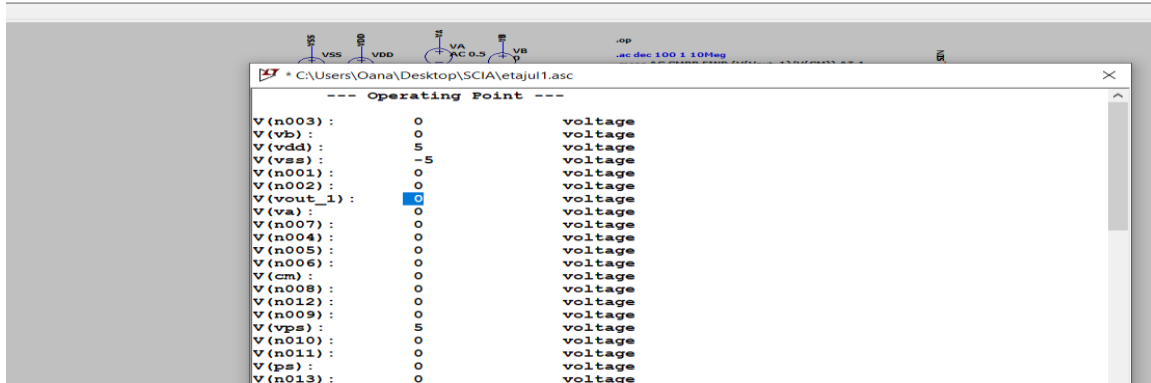
```
* C:\Users\Oana\Desktop\etj1.asc
--- Operating Point ---

V(n003):      -0.0222499    voltage
V(vb):        -0.02225     voltage
V(vdd):        5           voltage
V(vss):       -5           voltage
V(n001):      -0.0741658    voltage
V(n002):       0.0222494    voltage
V(vout_1):    0.444993     voltage
V(va):        0.02225     voltage
I(R2_e1):     -5.19159e-05  device_current
I(R3_e1):      9.64152e-05  device_current
I(R4_e1):      0.000140915  device_current
I(R1_e1):      7.41663e-06  device_current
I(Rg):        4.44993e-05  device_current
I(Vss):       0.00450487    device_current
I(Vdd):      -0.00449746    device_current
I(Va):       -4.78666e-14   device_current
I(Vb):       4.11635e-14   device_current
Ix(u1:1):    -4.11635e-14   subckt_current
Ix(u1:2):    -3.83005e-14   subckt_current
Ix(u1:3):     0.00217645    subckt_current
Ix(u1:4):    -0.00232478    subckt_current
Ix(u1:5):     0.000148331    subckt_current
Ix(u2:1):    4.78666e-14    subckt_current
Ix(u2:2):    3.15966e-14    subckt_current
Ix(u2:3):     0.00232101    subckt_current
Ix(u2:4):    -0.00218009    subckt_current
Ix(u2:5):    -0.000140915    subckt_current
```

Figură 11 .op etajul 1

Pentru DC OP, se poate observa punctul static de functionare corect.

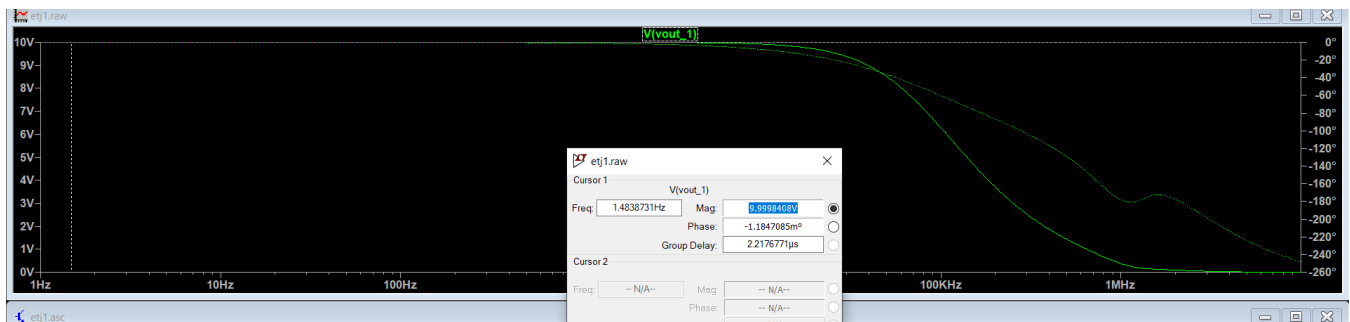
Pentru a vedea daca e nevoie de compensare de offset, am pus 0 la ambele surse de intrare si am obtinut o tensiune de iesire nula. Asadar, nu este nevoie sa compensez.



Figură 12 Compensare DC

## AC

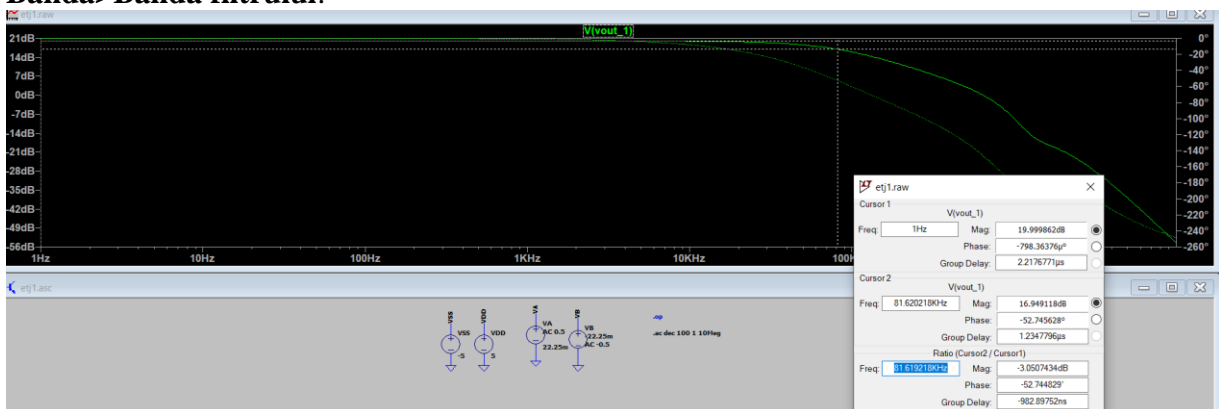
Castig la joasa frecventa:



Figură 13: Castig etaj 1

Se poate observa castigul la joasa frecveta,  $A=16$  in liniar, care respecta specificatiile de proiectare.

**Banda>Banda filtrului:**

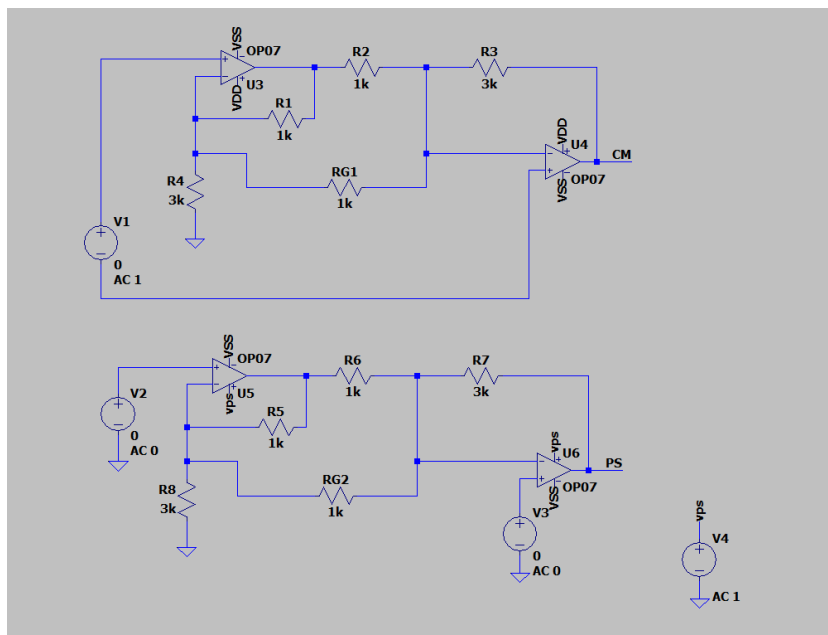


Figură 14: Banda etaj 1

Am masurat banda la diferenta de -3dB dintre cursoare. Astfel, a rezultat o banda mult mai mare decat cea a filtrului.

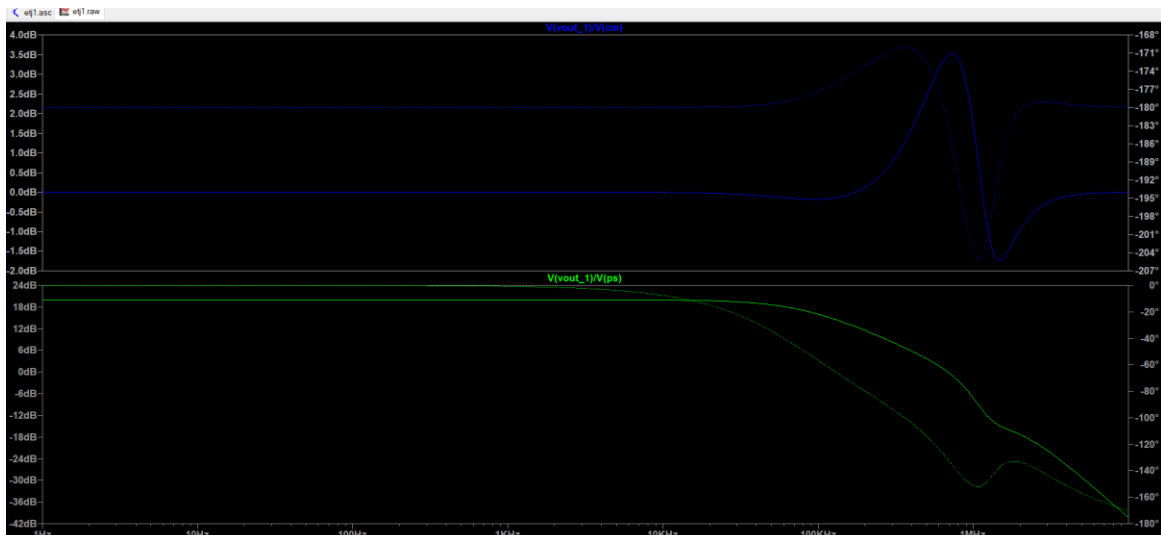
## CMRR, PSRR

Pentru CMRR si PSRR am folosit aceste doua circuite separate:



Figură 15: Circuite pentru cmrr si psrr

Am obtinut:



Figură 16: CMRR si psrr

cmrr:  $(v(vout\_1)/v(cm)) = (3.19807e-07dB, -180^\circ)$  at 1  
 psrr:  $(v(vout\_1)/v(ps)) = (20.0076dB, -0.000762956^\circ)$  at 1

## TRANSIENT

### Liniaritate:

N-Period=1  
 Fourier components of V(vout\_1)  
 DC component: 0.000115321

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|-----------------|----------------|-------------------|----------------------|----------------|------------------------|
| 1               | 1.211e+4       | 4.347e-1          | 1.000e+0             | 99.65°         | 0.00°                  |
| 2               | 2.422e+4       | 2.287e-4          | 5.261e-4             | -132.27°       | -231.92°               |
| 3               | 3.633e+4       | 1.635e-3          | 3.760e-3             | -88.36°        | -188.01°               |
| 4               | 4.844e+4       | 2.229e-4          | 5.127e-4             | 95.54°         | -4.10°                 |
| 5               | 6.055e+4       | 1.045e-3          | 2.403e-3             | 91.18°         | -8.47°                 |
| 6               | 7.266e+4       | 2.135e-4          | 4.911e-4             | -36.47°        | -136.12°               |
| 7               | 8.477e+4       | 5.657e-4          | 1.301e-3             | -103.41°       | -203.06°               |
| 8               | 9.688e+4       | 2.009e-4          | 4.621e-4             | -168.21°       | -267.85°               |
| 9               | 1.090e+5       | 3.556e-4          | 8.181e-4             | 42.20°         | -57.44°                |
| 10              | 1.211e+5       | 1.856e-4          | 4.270e-4             | 60.46°         | -39.19°                |

Partial Harmonic Distortion: 0.484302%  
 Total Harmonic Distortion: 0.537676%

Figură 17: Liniaritate etaj 1

Am realizat o analiza de tip Fourier si am obtinut rezultate pentru THD<1%.

## **3.2 ETAJUL 2**

### DCOP

#### Punct static de functionare:

```
* C:\Users\Oana\Desktop\et2.asc

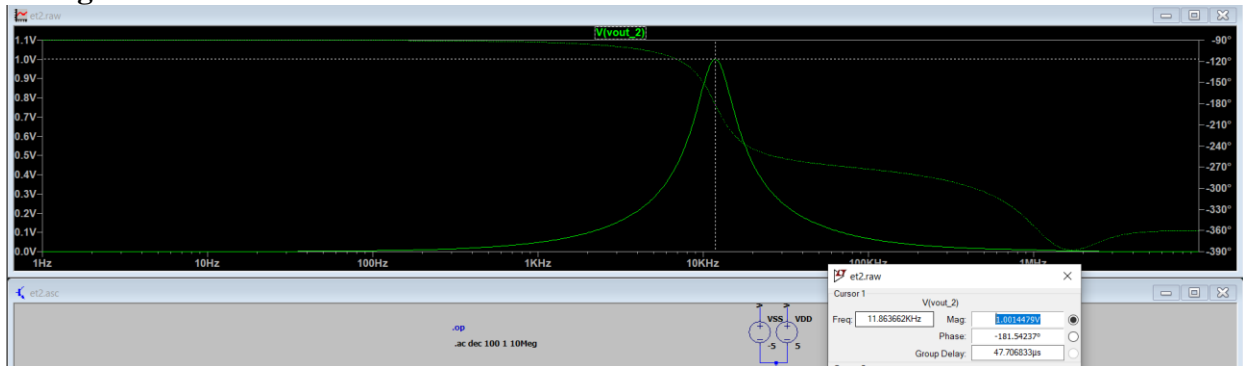
--- Operating Point ---

V(vout_2):      -1.51601e-18  voltage
V(n001):        0.0752751    voltage
V(n002):         0.45         voltage
V(n003):        1.90784e-18  voltage
V(vss):         -5           voltage
V(vdd):          5           voltage
I(C1):          -7.52751e-23  device_current
I(C2):          7.52751e-23   device_current
I(R1_filtru):   -1.65077e-05  device_current
I(R2_filtru):    7.52494e-23   device_current
I(R3_filtru):   -1.65077e-05  device_current
I(V1):          -1.65077e-05  device_current
I(Vss):         0.00225      device_current
I(Vdd):        -0.00225      device_current
Ix(u1:1):       -2.61416e-26  subckt_current
Ix(u1:2):       2.58494e-26   subckt_current
Ix(u1:3):       0.00225      subckt_current
Ix(u1:4):       -0.00225     subckt_current
Ix(u1:5):       -1e-24       subckt_current
```

Figură 18: dcop etajul 2

## AC

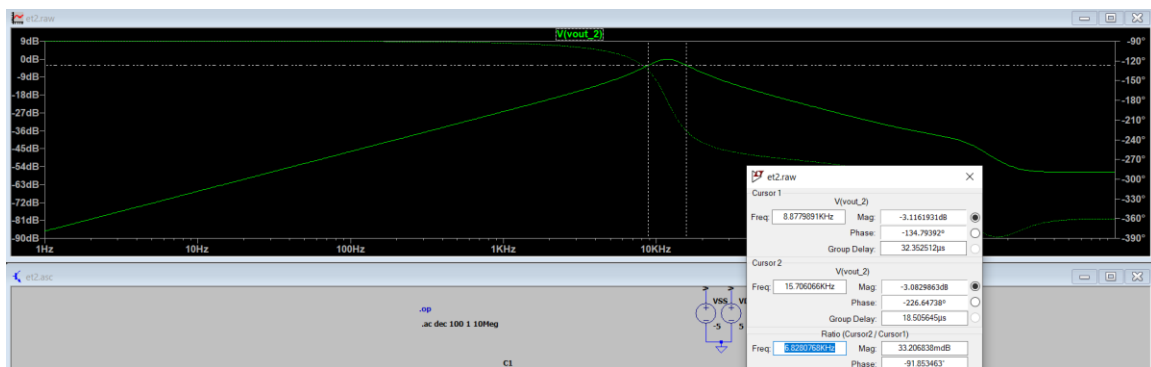
### Castig in banda de trecere:



Figură 19: Castig in banda de trecere

Castigul in banda de trecere este egal cu 1 in liniar, conform cerintei.

### Banda:



Figură 20: Banda etaj 2

Banda am masurat-o coborand din varf cu cate -3dB pe fiecare parte. Am obtinut aproximativ 7kHz, precum in cerinte.



## TRANSIENT

### Liniaritate:

N-Period=1  
Fourier components of V(vout\_2)  
DC component:-9.44882e-05

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|-----------------|----------------|-------------------|----------------------|----------------|------------------------|
| 1               | 1.210e+4       | 4.829e-1          | 1.000e+0             | -83.69°        | 0.00°                  |
| 2               | 2.420e+4       | 1.879e-4          | 3.892e-4             | 28.60°         | 112.28°                |
| 3               | 3.630e+4       | 1.870e-3          | 3.872e-3             | 89.32°         | 173.01°                |
| 4               | 4.840e+4       | 1.848e-4          | 3.827e-4             | -122.75°       | -39.06°                |
| 5               | 6.050e+4       | 1.352e-3          | 2.800e-3             | -90.95°        | -7.27°                 |
| 6               | 7.260e+4       | 1.798e-4          | 3.723e-4             | 86.03°         | 169.72°                |
| 7               | 8.470e+4       | 8.088e-4          | 1.675e-3             | 87.80°         | 171.48°                |
| 8               | 9.680e+4       | 1.729e-4          | 3.581e-4             | -65.00°        | 18.69°                 |
| 9               | 1.089e+5       | 3.336e-4          | 6.907e-4             | -97.44°        | -13.75°                |
| 10              | 1.210e+5       | 1.646e-4          | 3.408e-4             | 144.24°        | 227.93°                |

Partial Harmonic Distortion: 0.517635%  
Total Harmonic Distortion: 0.557947%

Figură 21: Liniaritate etaj 2

## 3.3 ETAJUL 3

### DCOP

#### Punct static de functionare

Am alimentat etajul cu amplitudinea maxima de 44.5mV.  
Pentru primul switch activ,  $V_{out}=A \cdot V_{in}=2 \cdot 44.5m=0.089V$ :

C:\Users\Oana\Desktop\eyj3.asc

--- Operating Point ---

|             |              |                |
|-------------|--------------|----------------|
| V(n002):    | 0.0444999    | voltage        |
| V(n005):    | 0.0445       | voltage        |
| V(vdd):     | 5            | voltage        |
| V(vss):     | -5           | voltage        |
| V(vout_e3): | 0.0890066    | voltage        |
| V(n004):    | 0.0444984    | voltage        |
| V(s2):      | 0            | voltage        |
| V(n006):    | 1.15467e-06  | voltage        |
| V(s1):      | 5            | voltage        |
| V(n003):    | 0.044499     | voltage        |
| V(s3):      | 0            | voltage        |
| V(n001):    | 0.0444993    | voltage        |
| V(s4):      | 0            | voltage        |
| I(Rg2):     | 8.91749e-11  | device_current |
| I(Rg1):     | 1.48329e-06  | device_current |
| I(Rg3):     | 8.91761e-11  | device_current |
| I(Rg4):     | 8.91768e-11  | device_current |
| I(Rf):      | 1.48356e-06  | device_current |
| I(V1):      | -8.10752e-14 | device_current |
| I(V2):      | -2e-23       | device_current |
| I(V3):      | 0            | device_current |
| I(V4):      | 0            | device_current |
| I(V5):      | 0            | device_current |
| I(Vss):     | 0.00224938   | device_current |
| I(Vdd):     | -0.00225086  | device_current |
| Ix(u1:1):   | 8.10752e-14  | subckt_current |
| Ix(u1:2):   | 7.78532e-14  | subckt_current |
| Ix(u1:3):   | 0.00225074   | subckt_current |
| Ix(u1:4):   | -0.00224926  | subckt_current |
| Ix(u1:5):   | -1.48356e-06 | subckt_current |
| Ix(u2:1):   | 0            | subckt_current |
| Ix(u2:2):   | 8.90859e-11  | subckt_current |
| Ix(u2:3):   | -8.89968e-14 | subckt_current |
| Ix(u2:4):   | -3.00643e-08 | subckt_current |
| Ix(u2:5):   | -3.91586e-24 | subckt_current |
| Ix(u3:1):   | 0.00225086   | subckt_current |

Figură 22: dcop sw1

Pentru switch 2:  $V_{out}=2.8 \cdot 44.5m=0.1246V$

--- Operating Point ---

|              |              |                |
|--------------|--------------|----------------|
| V(n002) :    | 0.0444998    | voltage        |
| V(n005) :    | 0.0445       | voltage        |
| V(vdd) :     | 5            | voltage        |
| V(vss) :     | -5           | voltage        |
| V(vout e3) : | 0.124925     | voltage        |
| V(n004) :    | 2.08671e-06  | voltage        |
| V(s2) :      | 5            | voltage        |
| V(n006) :    | 0.0444972    | voltage        |
| V(s1) :      | 0            | voltage        |
| V(n003) :    | 0.0444989    | voltage        |
| V(s3) :      | 0            | voltage        |
| V(n001) :    | 0.0444993    | voltage        |
| V(s4) :      | 0            | voltage        |
| I(Rg2) :     | 2.68059e-06  | device_current |
| I(Rg1) :     | 8.91725e-11  | device_current |
| I(Rg3) :     | 8.9176e-11   | device_current |
| I(Rg4) :     | 8.91767e-11  | device_current |
| I(Rf) :      | 2.68085e-06  | device_current |
| I(V1) :      | -8.17256e-14 | device_current |
| I(V2) :      | 0            | device_current |
| I(V3) :      | -2e-23       | device_current |
| I(V4) :      | 0            | device_current |
| I(V5) :      | 0            | device_current |

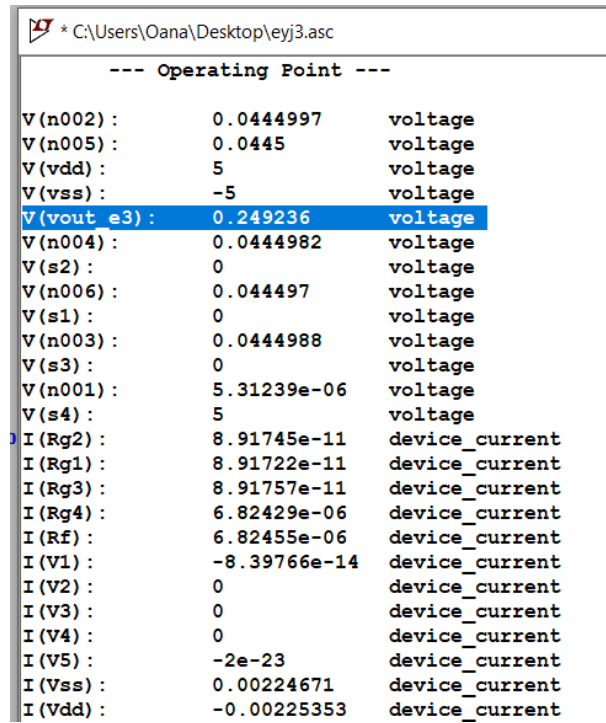
Pentru switch 3 activ:  $V_{out}=4*44.5m=0.178V$

--- Operating Point ---

|              |              |                |
|--------------|--------------|----------------|
| V(n002) :    | 0.0444998    | voltage        |
| V(n005) :    | 0.0445       | voltage        |
| V(vdd) :     | 5            | voltage        |
| V(vss) :     | -5           | voltage        |
| V(vout e3) : | 0.177997     | voltage        |
| V(n004) :    | 0.0444983    | voltage        |
| V(s2) :      | 0            | voltage        |
| V(n006) :    | 0.0444971    | voltage        |
| V(s1) :      | 0            | voltage        |
| V(n003) :    | 3.46383e-06  | voltage        |
| V(s3) :      | 5            | voltage        |
| V(n001) :    | 0.0444992    | voltage        |
| V(s4) :      | 0            | voltage        |
| I(Rg2) :     | 8.91747e-11  | device_current |
| I(Rg1) :     | 8.91724e-11  | device_current |
| I(Rg3) :     | 4.44963e-06  | device_current |
| I(Rg4) :     | 8.91765e-11  | device_current |
| I(Rf) :      | 4.4499e-06   | device_current |
| I(V1) :      | -8.26866e-14 | device_current |
| I(V2) :      | 0            | device_current |
| I(V3) :      | 0            | device_current |
| I(V4) :      | -2e-23       | device_current |
| I(V5) :      | 0            | device_current |

Figură 24: dcop sw3

Pentru switch-ul 4:  $V_{out}=5.6*0.0445=0.2492V$ .

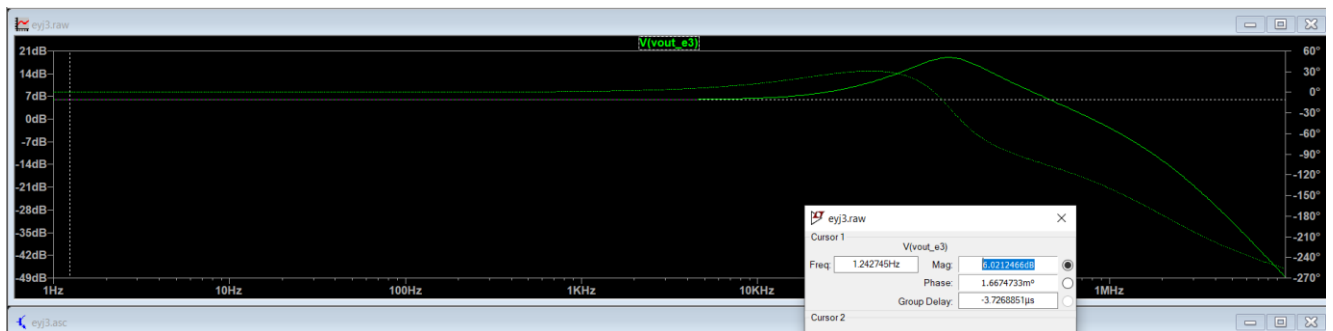


Figură 25: dcop sw4

## AC

### Trepte de castig

Pentru primul switch,  $A=6dB$ :



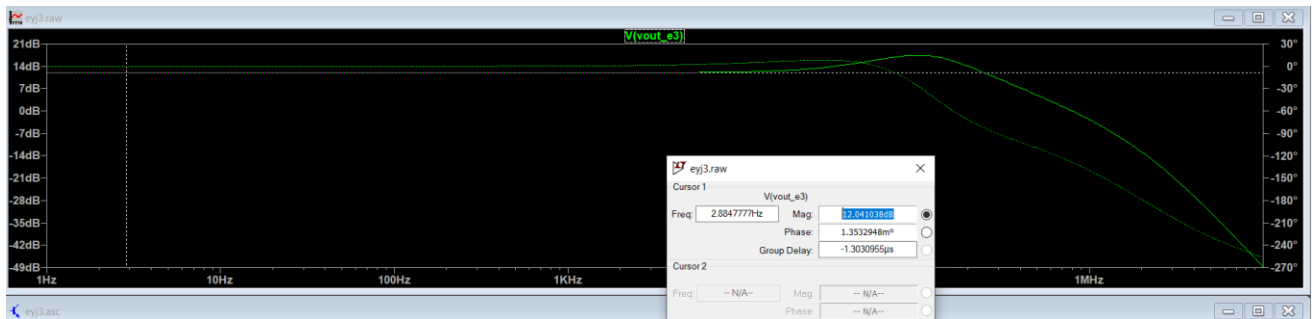
Figură 26: Castig sw1

Pentru al doilea switch:  $A=9\text{dB}$ :



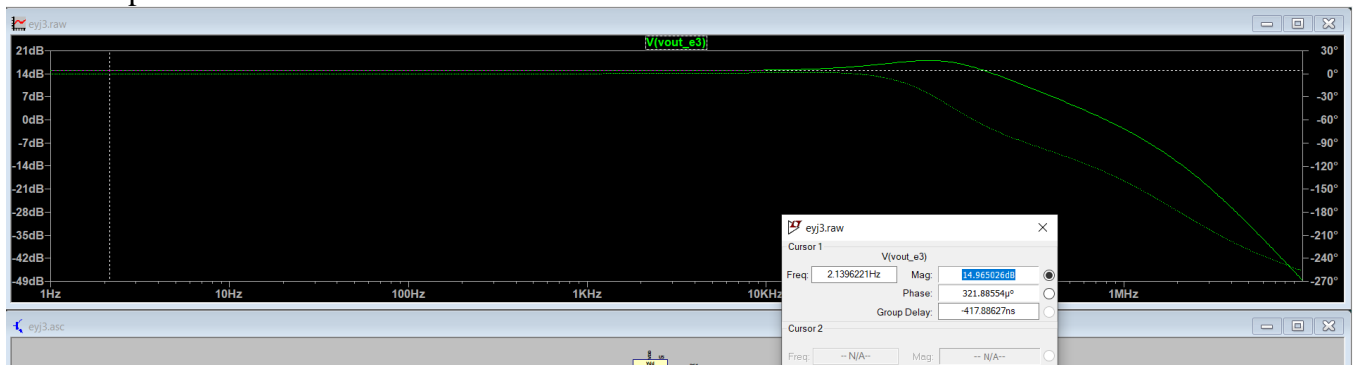
Figură 27: castig sw2

Pentru al treilea switch:  $A=12\text{dB}$ :



Figură 28: Castig sw3

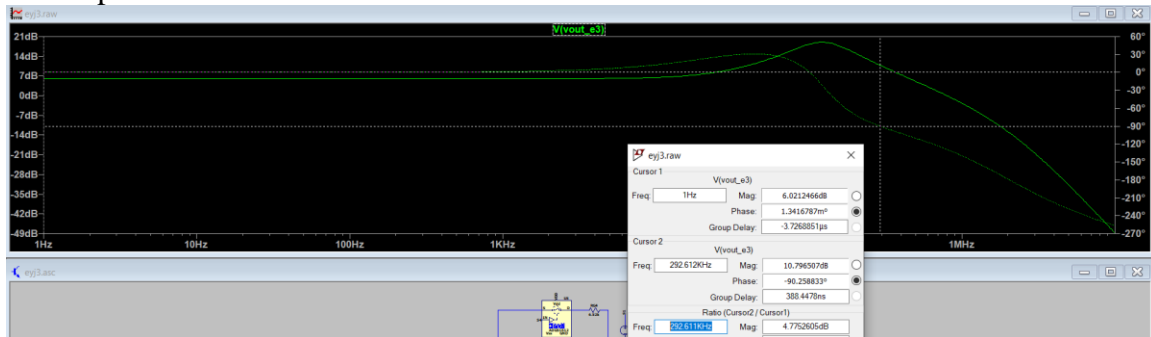
Pentru al patrulea:  $A=15\text{dB}$ :



Figură 29: Castig sw4

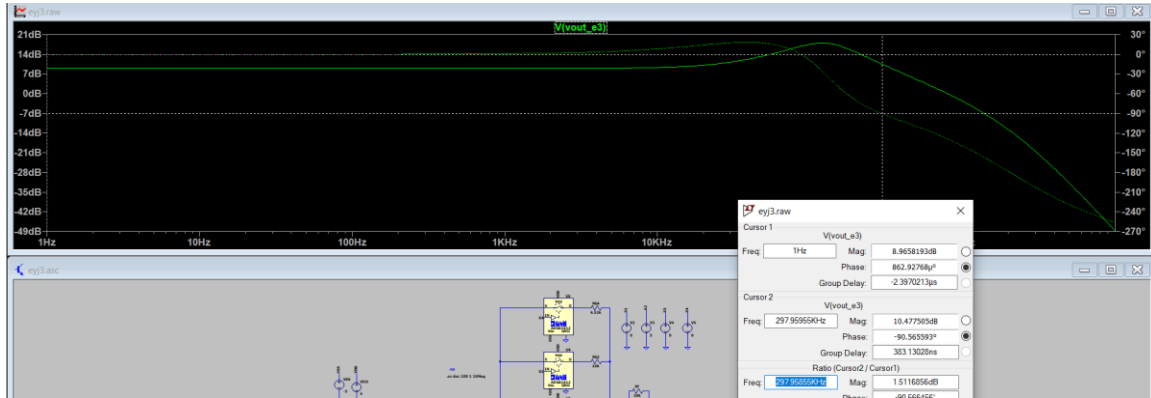
## Banda PGA>Banda filtru

Pentru primul switch:



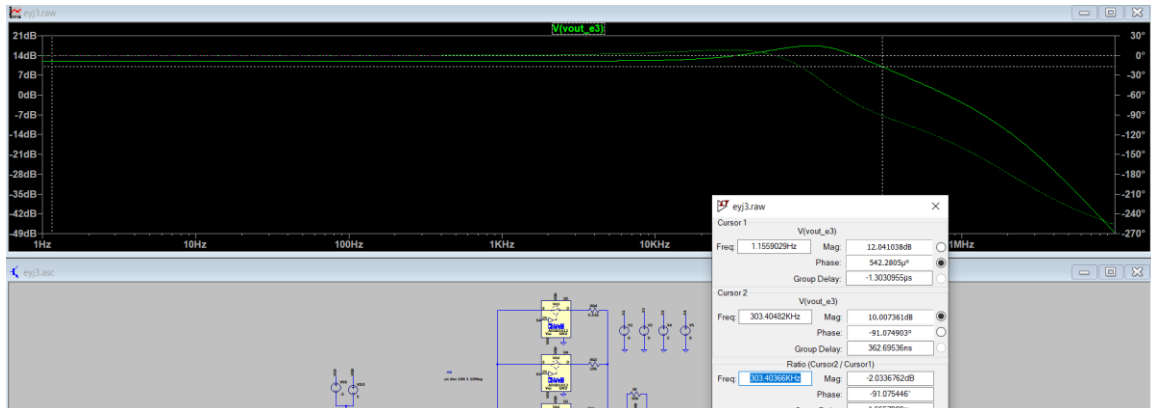
Figură 30: banda sw1

Pentru al doilea switch:



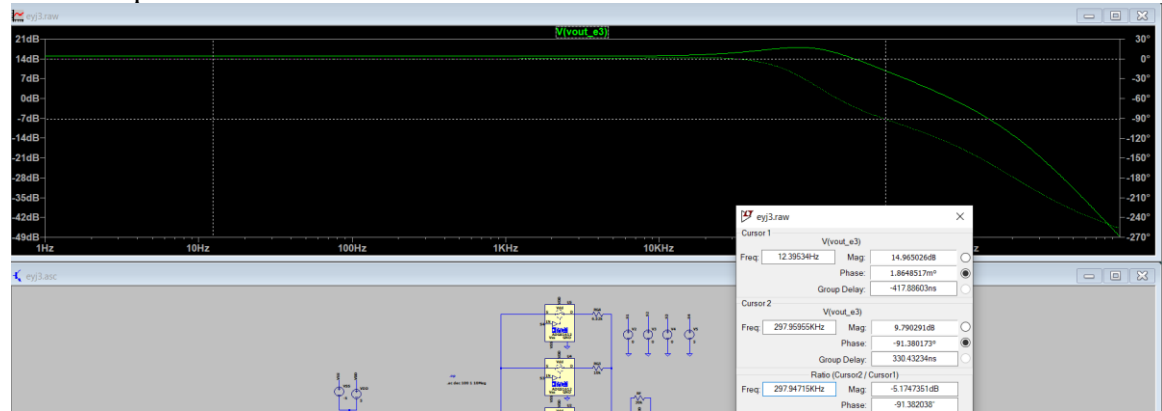
Figură 31: banda sw2

Pentru al treilea switch:



Figură 32: Banda sw3

Pentru al patrulea switch:



Figură 33: Banda sw4

## TRANSIENT

### Liniaritate

Amplitudine minima, castig maxim:

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|-----------------|----------------|-------------------|----------------------|----------------|------------------------|
| 1               | 1.210e+4       | 2.528e-1          | 1.000e+0             | 88.52°         | 0.00°                  |
| 2               | 2.420e+4       | 9.458e-5          | 3.742e-4             | -151.42°       | -239.94°               |
| 3               | 3.630e+4       | 9.435e-4          | 3.733e-3             | -92.15°        | -180.67°               |
| 4               | 4.840e+4       | 9.301e-5          | 3.680e-4             | 57.22°         | -31.30°                |
| 5               | 6.050e+4       | 7.008e-4          | 2.773e-3             | 87.20°         | -1.31°                 |
| 6               | 7.260e+4       | 9.047e-5          | 3.579e-4             | -94.02°        | -182.53°               |
| 7               | 8.470e+4       | 4.230e-4          | 1.673e-3             | -95.09°        | -183.60°               |
| 8               | 9.680e+4       | 8.702e-5          | 3.443e-4             | 114.94°        | 26.42°                 |
| 9               | 1.089e+5       | 1.777e-4          | 7.030e-4             | 77.30°         | -11.21°                |
| 10              | 1.210e+5       | 8.279e-5          | 3.275e-4             | -35.84°        | -124.35°               |

Partial Harmonic Distortion: 0.505402%  
Total Harmonic Distortion: 0.545658%

Figură 34: Liniaritate ampl max

Amplitudine maxima, castig minim:

N-Period=1  
Fourier components of V(vout\_e3)  
DC component: 4.47853e-05

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|-----------------|----------------|-------------------|----------------------|----------------|------------------------|
| 1               | 1.210e+4       | 2.665e-1          | 1.000e+0             | 74.85°         | 0.00°                  |
| 2               | 2.420e+4       | 8.907e-5          | 3.342e-4             | -151.46°       | -226.30°               |
| 3               | 3.630e+4       | 9.487e-4          | 3.560e-3             | -92.59°        | -167.43°               |
| 4               | 4.840e+4       | 8.760e-5          | 3.287e-4             | 57.15°         | -17.70°                |
| 5               | 6.050e+4       | 7.062e-4          | 2.650e-3             | 85.24°         | 10.39°                 |
| 6               | 7.260e+4       | 8.519e-5          | 3.197e-4             | -94.13°        | -168.97°               |
| 7               | 8.470e+4       | 4.251e-4          | 1.595e-3             | -99.16°        | -174.01°               |
| 8               | 9.680e+4       | 8.193e-5          | 3.074e-4             | 114.79°        | 39.94°                 |
| 9               | 1.089e+5       | 1.865e-4          | 6.999e-4             | 68.90°         | -5.94°                 |
| 10              | 1.210e+5       | 7.794e-5          | 2.924e-4             | -36.03°        | -110.87°               |

Partial Harmonic Distortion: 0.481980%  
Total Harmonic Distortion: 0.522033%

Figură 35: Liniaritate ampl minima

### 3.4 ETAJUL 4

#### DCOP

Punct static de functionare:

```
* C:\Users\Oana\Desktop\etj4.asc

--- Operating Point ---

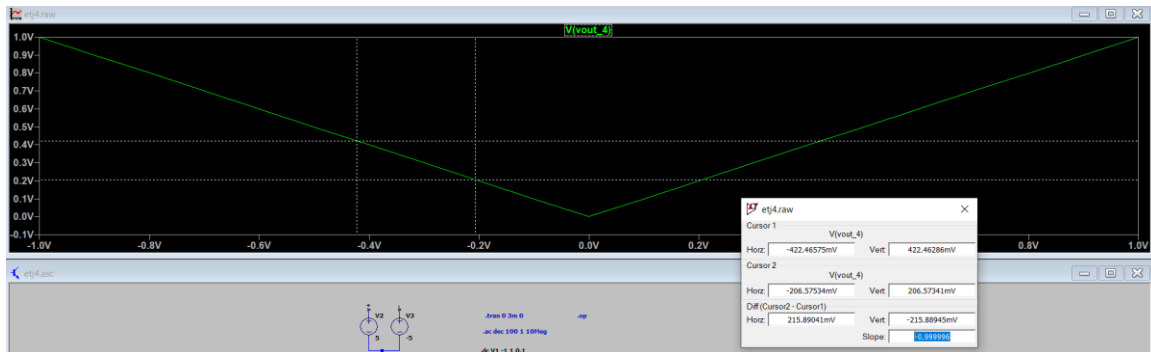
V(n001):      0.249941      voltage
V(v+):        5            voltage
V(v-):        -5           voltage
V(n003):      -0.771378     voltage
V(vout_4):    0.249915     voltage
V(n002):      0.249916     voltage
V(vin):       0.25         voltage
I(D1):        -2.52102e-09  device_current
I(D2):        0.0384467     device_current
I(R1):        -5.89612e-09  device_current
I(R2):        -2.52147e-09  device_current
I(R3):        0.000249915   device_current
I(V1):        -5.89612e-09  device_current
I(V2):        -0.00237669   device_current
I(V3):        0.0405665     device_current
Ix(u1:1):     -3.3742e-09   subckt_current
Ix(u1:2):     3.37465e-09   subckt_current
Ix(u1:3):     6.85624e-10   subckt_current
Ix(u1:4):     -0.0384397    subckt_current
Ix(u1:5):     0.0384467     subckt_current
Ix(u2:1):     4.5095e-13    subckt_current
Ix(u2:2):     4.41606e-13   subckt_current
Ix(u2:3):     0.00237669    subckt_current
Ix(u2:4):     -0.00212678   subckt_current
Ix(u2:5):     -0.000249915  subckt_current
```

Figură 36: dcop etaj 4

## DC SWEEP

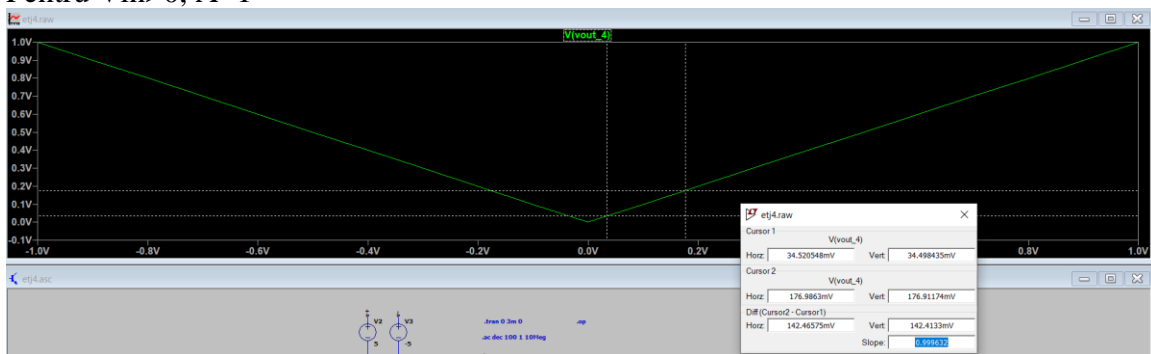
### Castig

Pentru  $V_{in} < 0$ ,  $A = -1$



Figură 37: castig etaj 4

Pentru  $V_{in} > 0$ ,  $A = 1$

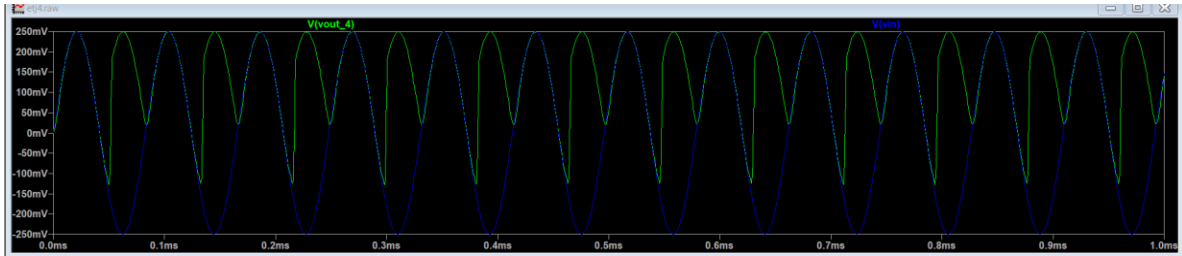


Figură 38: Castig etaj 4



## TRANSIENT

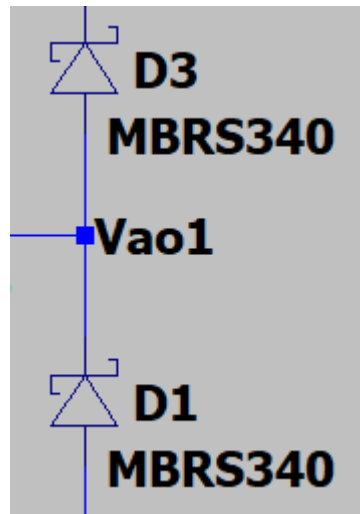
### Implementare functie de circuit



Figură 39: Implementare functie de circuit etaj 4

În alternanța pozitivă a tensiunii de intrare, primul AO devine comparator. Când se schimbă alternanța la cea negativă, el trebuie să crească înapoi la valoarea tensiunii de intrare.

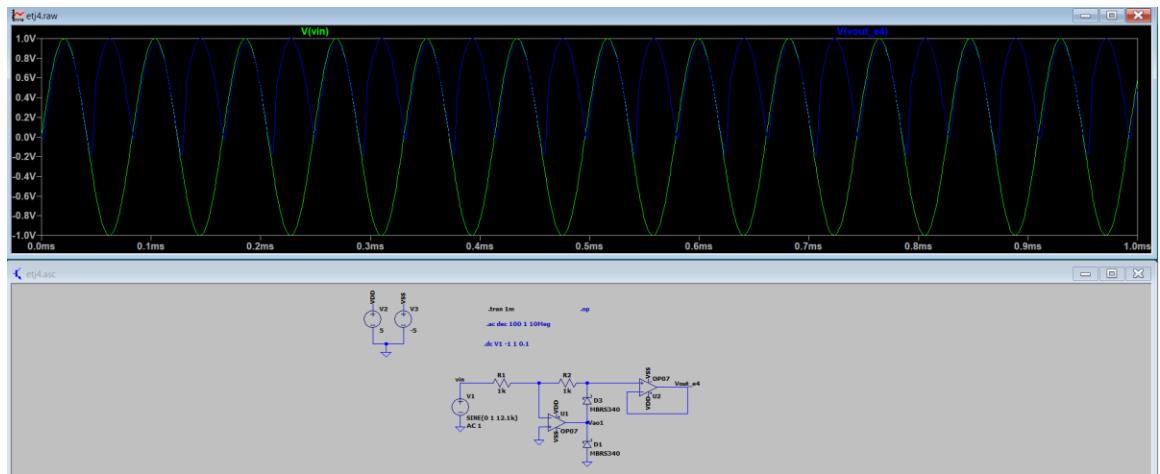
Pentru a obține o funcție de circuit mai apropiată de cea teoretică, am ales să folosesc o diodă mai rapidă, ca în Figura 39, cu un  $V_d$  mai mic, astfel amplificatorul va putea crește mai repede la  $V_{in}$ .



Figură 40: Dioda schottky

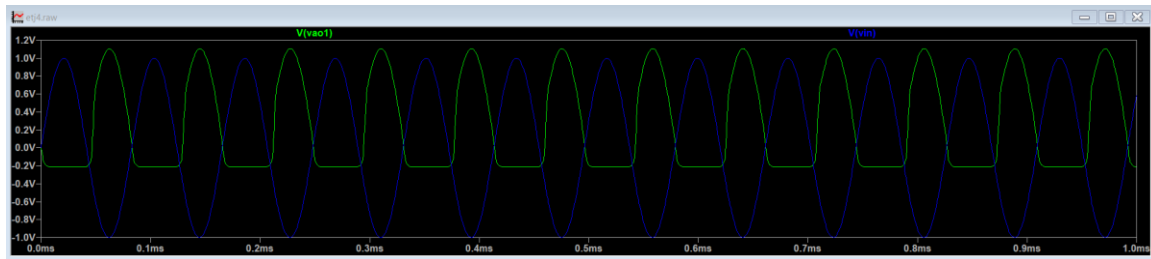
Am redimensionat circuitul la  $R_1=R_2=1k$  și am alimentat cu o sursă de amplitudine 1V.

În acest caz, funcția de circuit va arăta în felul următor:



Figură 41: Funcție de circuit

De asemenea, pentru primul amplificator, cu o tensiune de intrare pozitivă și modificările realizate, caracteristica va arăta așa:



Figură 42: Funcție de circuit pentru VAO1

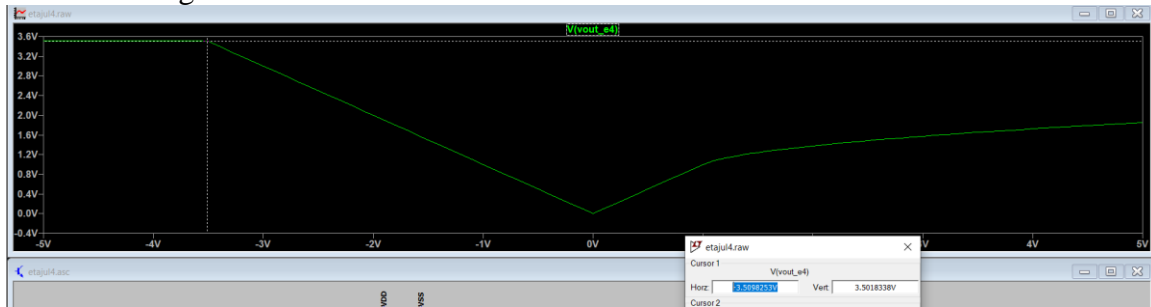
## DOMENIU DE LINIARITATE

### Alternanță pozitivă



Figură 43 Domeniu de liniaritate alternanță pozitivă

## Alternanta negativa



Figură 44 Domeniu de liniaritate alternanta negativa