Facultatea de Electronică,
Telecomunicaţii şi
Tehnologia Informaţiei

PROIECT- Sisteme cu circuite integrate analogice

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Specializarea: Electronica Aplicata

Grupa 2131/2

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Tehnologia Informației

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1.Tematica proiectului

1.1 Amplificator instrumentatie cu 3 AO V-V

-Amplitudine minima (pt castig maxim PGA): 3.96E-02

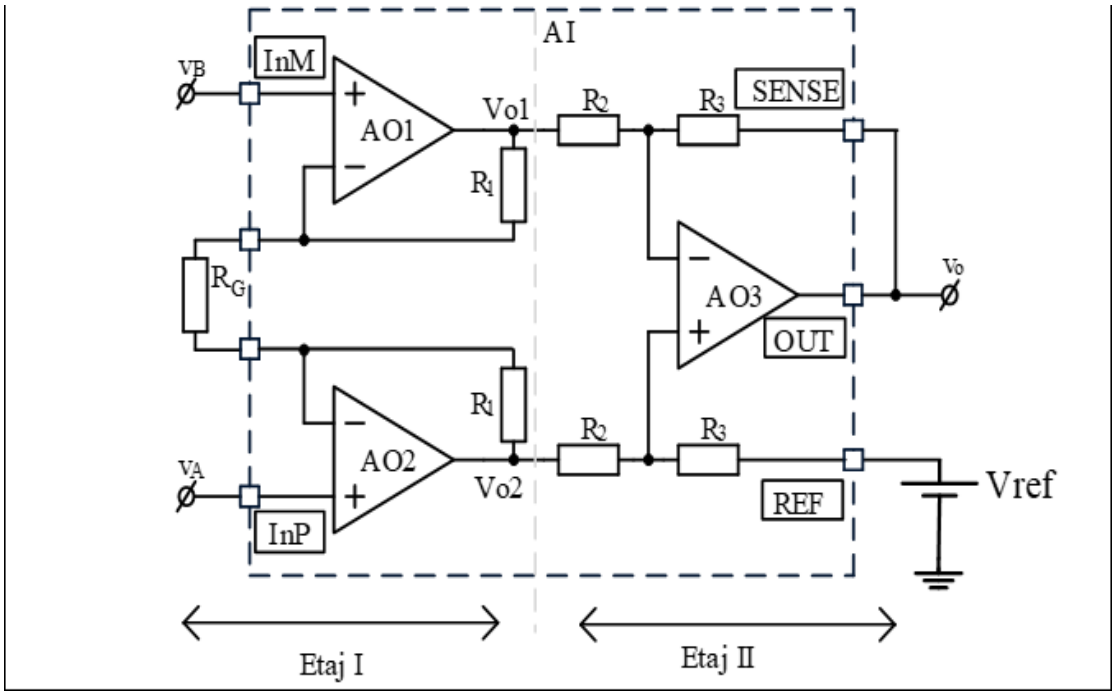
-Amplitudine maxima (pt castig minim PGA): 9.95E-02

-|Castig| etaj 1 in linear: 16

-Unitate masura: V (differential)

-Semnal intrare: tensiune

-Semnal iesire: tensiune



1.2 Band pass 2 AO V-V Tow Thomas

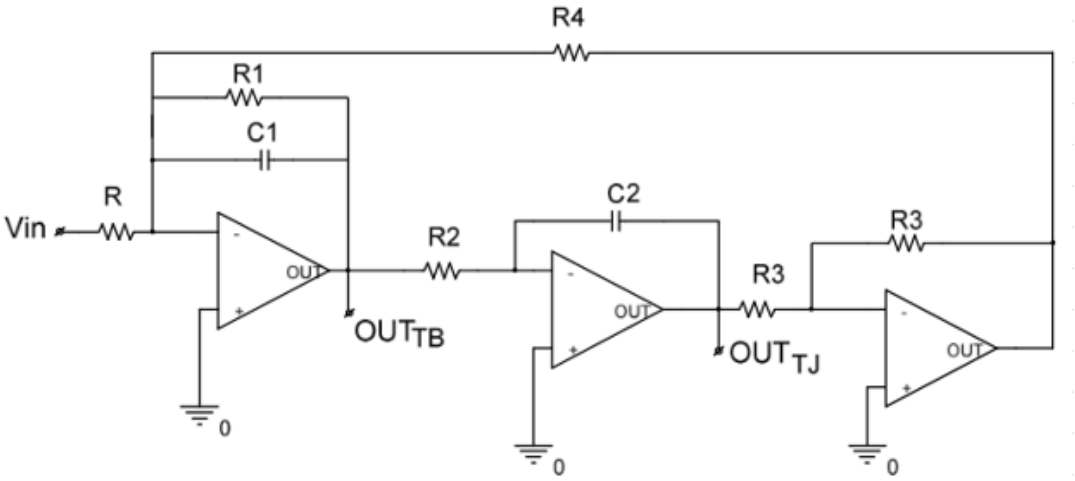
-|Ho| castig linear in banda de trecere: 1

-Rintrare minim: 2.00E+03

-Banda: 8.00E+03

-Q: 1.41

-Tip functie de transfer: trece-banda BPF



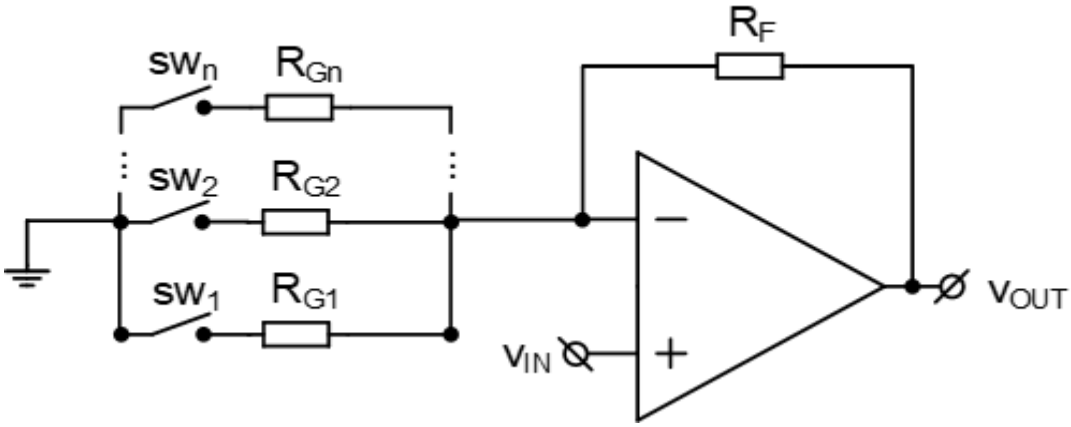
1.3 PGA, Rg paralel

-Castig minim [dB]: 8

-Rezolutie [dB]: 2

-Castig maxim [dB]: 16

-Nr pasi: 5

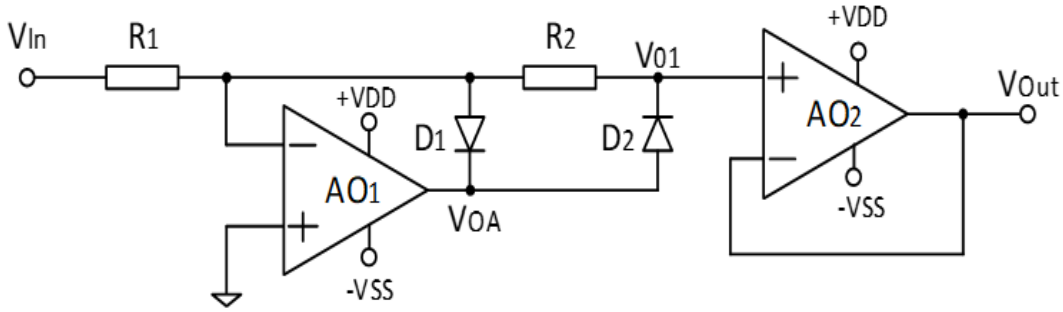


1.4 Redresor dubla alternanta FWR v11

-|Castig| (liniar): 1

-Tip AO: AD8065

-Tensiuni de alimentare: +/- 5V



2. Dimensionarea etajelor

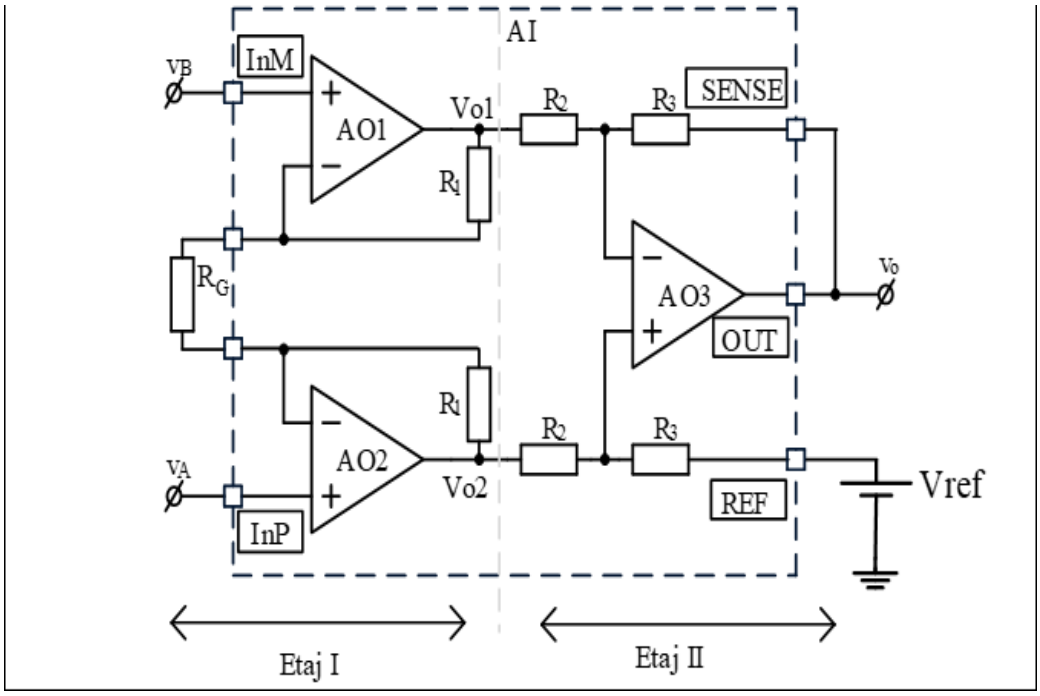
2.1 Dimensionare amplificator de instrumentatie cu 3 AO V-V

Analiza circuit:

Se poate observa ca circuitul este impartit in 2 etaje de amplificare:

-Etaj 1: amplificator cu intrare si iesire diferentiala

-Etaj 2: amplificator cu intrare diferentiala si iesire asimetrica



Etaj 1: Se aplica teorema lui Kirchhoff

-Vo2 + R1Irg + RgIrg + R1Irg + Vo1 = 0
Vo1 – Vo2 = -(2R1 + Rg)Irg
Vo2 – Vo1 = (2R1 + Rg)Irg

$$Irg = \frac{Va-Vb}{Rg}$$

⇨ Vo2 – Vo1 = $\frac{Rg+2R1}{Rg}$(Va – Vb) => expresia amplificarii etajului 1

Etaj 2:

Vo = Vo(Vo2) + Vo(Vo1) + Vo(Vref)

Efect Vo(Vo2) => amplificator neinversor cu reactie negativa

⇨ Vin = $\frac{R3}{R3+R2}$Vo2
⇨ Vo(Vo2) = (1+$\frac{R3}{R2}$)($\frac{R3}{R3+R2}$)Vo2

Efect Vo(Vref) => amplificator neinversor cu reactie negativa

⇨ Vin = $\frac{R2}{R3+R2}$Vref

⇨ Vo(Vref) = $(1+\frac{R3}{R2})(\frac{R2}{R3+R2})$Vref

Efect Vo(Vo1) => amplificator inversor cu reactie negativa

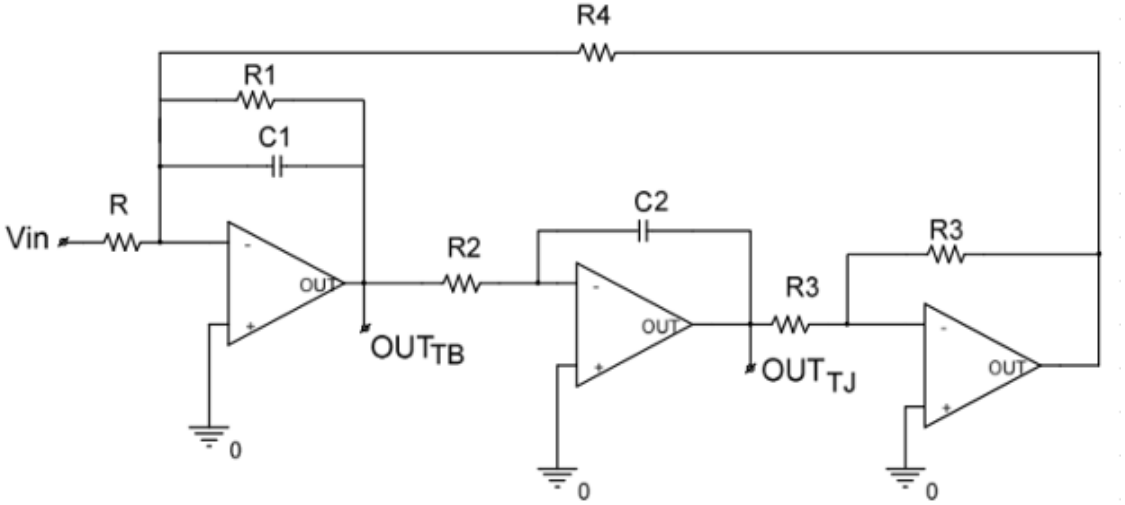
⇨ Vin = $Vo1$
⇨ Vo(Vo1) = $-\frac{R3}{R2}$Vo1
⇨ Daca A(Vo2) = A(Vo1) => Vo = $\frac{R3}{R2}$(Vo1 – Vo2) + Vref

Dimensionarea circuitului

Se cere un castig de 16 => H0 = 16, din analiza stim ca A(etaj1) + A(etaj2) = H0 = $\frac{Rg+2R1}{Rg}\frac{R3}{R2}$
Voi alege A(etaj1) = 2 iar A(etaj2) = 8, avand ecuatia de mai sus putem presupune A(etaj1) si A(etaj2)

Daca A(etaj1) = 2 => $\frac{Rg+2R1}{Rg}$ = 2, => R1 = 200 si Rg = 400
Daca A(etaj2) = 8 => $\frac{R3}{R2}$ = 8, => R3 = 16k si R2 = 2k

2.2 Dimensionare Band pass 2 AO V-V Tow Thomas



$H0 = \frac{R4}{R}$ => 1 = $\frac{R4}{R}$ => R4 = R
C1 = C2 = C => $\omega 0 = \frac{1}{\sqrt{R1*R4*C1*C2}}$ => $\omega 0 = \frac{1}{R2C}$

$Q = R1\sqrt{\frac{C1}{C2} * \frac{1}{R2R4}} => Q = \frac{R1}{R2} => 1.41 = \frac{R1}{R2} => R1 = 1.41 * R2$

Aleg C = 2.2nF

⇨ $\omega 0 = 2\pi f 0 = 50.24$ KHz

⇨ $R2 = \frac{1}{\omega 0\, C} = 9.04k$ => R2 = R4 = R = 9.04k

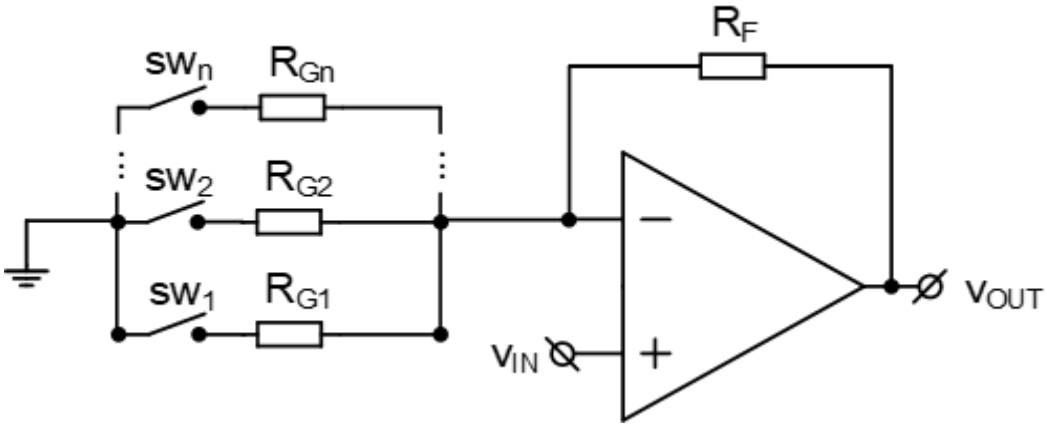
⇨ R1 = 1.41 * 9.04k = 12.74k

Deoarece in programul Ltspice valorile erau putin decalate am ales niste valori orientative care sa respecte cerintele noastre!!

⇨ R2 = R4 = R = 12k

⇨ R1 = 16.2k

2.3 Dimensionare PGA, Rg parallel



Av = {8dB, 10dB, 12dB, 14dB, 16dB} = {2.51, 3.16, 3.98, 5.01, 6.31}

s5	s4	s3	s2	s1	=> switch-uri
{0	0	0	0	0}	

00001 => $Av = 1 + \frac{RF}{R1}$ => RF = 10k si R1 = 6.61k

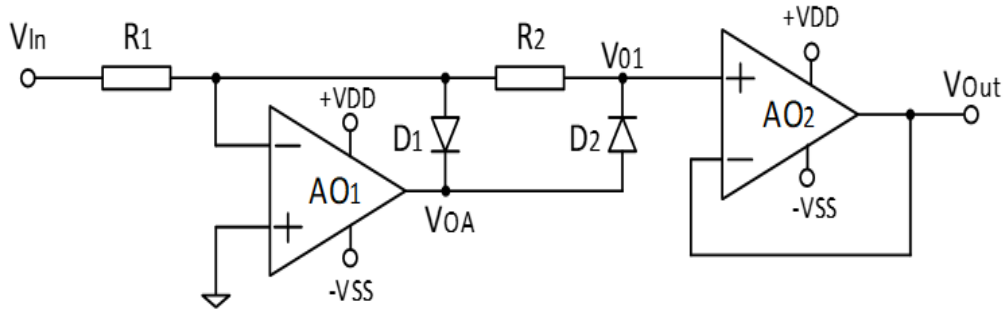
00011 => $1 + \frac{RF}{\frac{R1*R2}{R1+R2}}$ => R2 = 15.45k

$$00111 \Rightarrow 1 + \frac{RF}{\frac{R1*R2*R3}{R1*R2+R2*R3+R1*R3}} \Rightarrow R3 = 12.2k$$

$$01111 \Rightarrow 1 + \frac{RF}{\frac{R1*R2*R3*R4}{R2*R3*R4+R1*R3*R4+R1*R2*R4+R1*R2*R3*R4}} \Rightarrow R4 = 9.7k$$

$$11111 \Rightarrow 1 + \frac{RF}{\frac{R1*R2*R3*R4*R5}{R2*R3*R4*R5+R1*R3*R4*R5+R1*R2*R4*R5+R1*R2*R3*R5+R1*R2*R3*R4}} \Rightarrow R4 = 7.7k$$

2.4 Dimensionare Redresor dubla alternanta FWR v11



Vin > 0

Vin ↑ VDD => Voa ≈ $-VSS$ => D1 conduce, D2 blocata => Vout = 0V

Vin < 0

Vin ↓ -VSS => Voa = VDD => D2 conduce, D1 blocata => Vout = $-\frac{R2}{R1}$ * Vin

Castigul etajului este 1 => R2 = R1 = 10k (valoare nominala)

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3.Caracterizarea etajelor

3.1 Caracterizare amplificator de instrumentatie cu 3 AO V-V

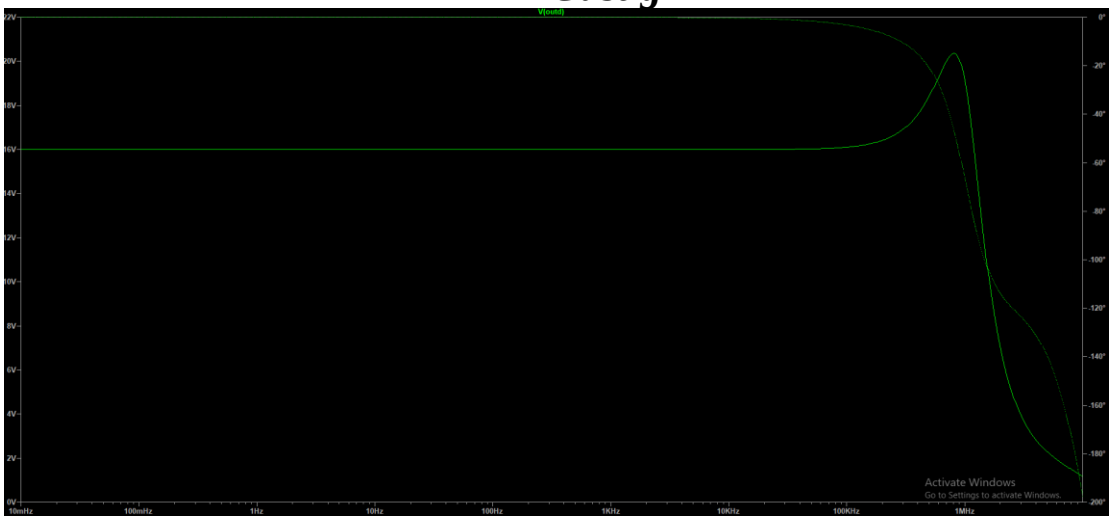
PSF

* C:\Users\andy_\OneDrive - Technical University of Cluj-Napoca\Desktop\SCIA Proiect\sr-etaj1.asc

```
        --- Operating Point ---

V(n003):        -0.000104039   voltage
V(n006):        -0.000106284   voltage
V(+v):          5              voltage
V(-v):          -5             voltage
V(outd):        2.02041e-05    voltage
V(n002):        -0.000119506   voltage
V(n009):        -0.000119506   voltage
V(n001):        1.13358e-09    voltage
V(n008):        1.13358e-09    voltage
V(n004):        0              voltage
V(n010):        0              voltage
V(n005):        0              voltage
V(n007):        0              voltage
V(n013):        -0.000104039   voltage
V(n016):        -0.000106284   voltage
V(outcm):       2.02041e-05    voltage
V(n012):        -0.000119506   voltage
V(n019):        -0.000119506   voltage
V(n011):        1.13358e-09    voltage
V(n018):        1.13358e-09    voltage
V(n014):        0              voltage
V(n020):        0              voltage
V(n015):        0              voltage
V(n017):        0              voltage
V(n021):        -0.000104039   voltage
V(n026):        -0.000106284   voltage
V(+v_ps):       5              voltage
V(outps):       2.02041e-05    voltage
V(n023):        -0.000119506   voltage
```

Castig



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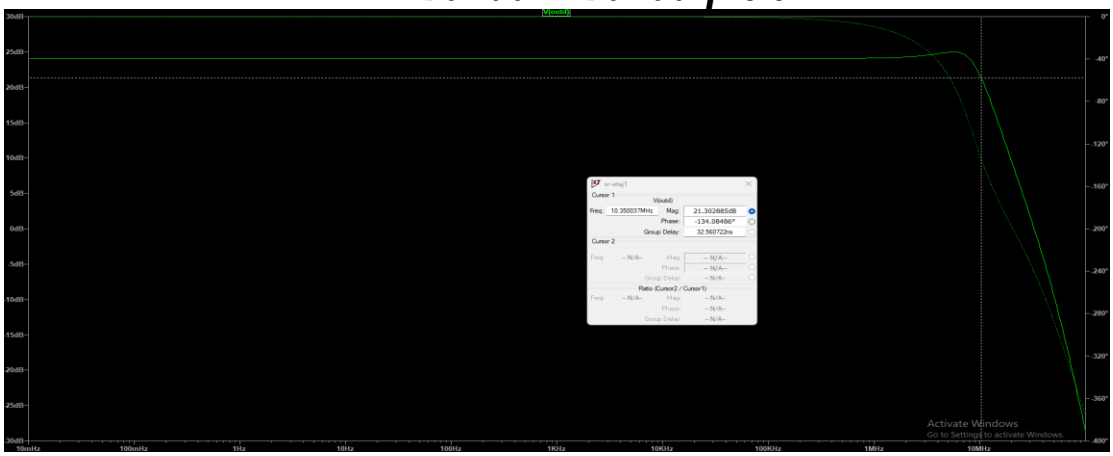
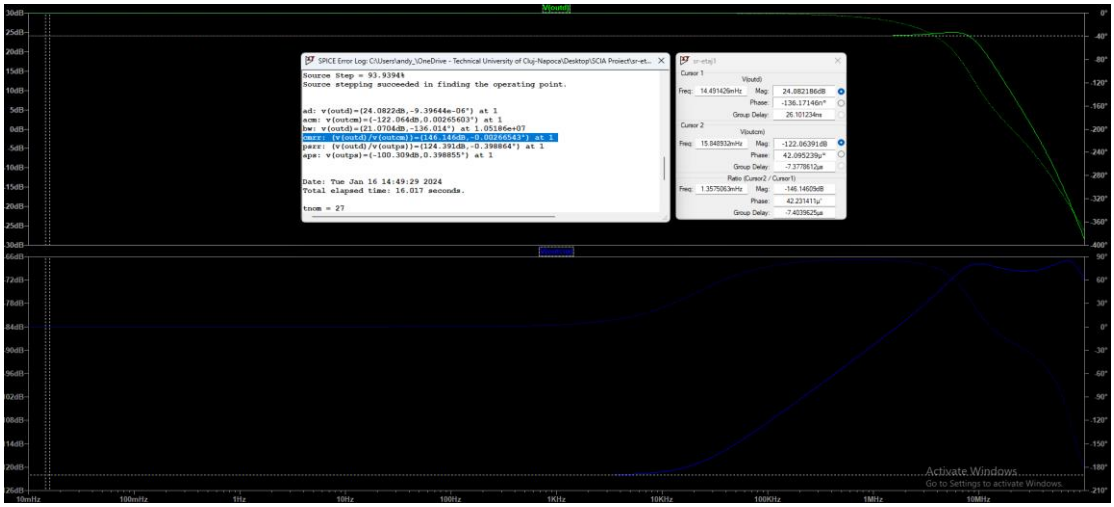
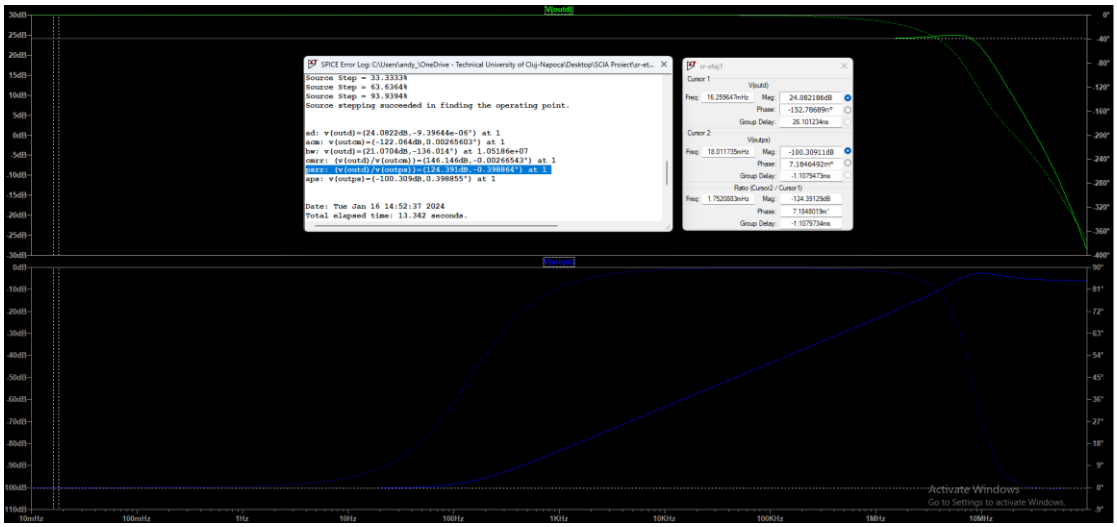
Banda > Banda filtru



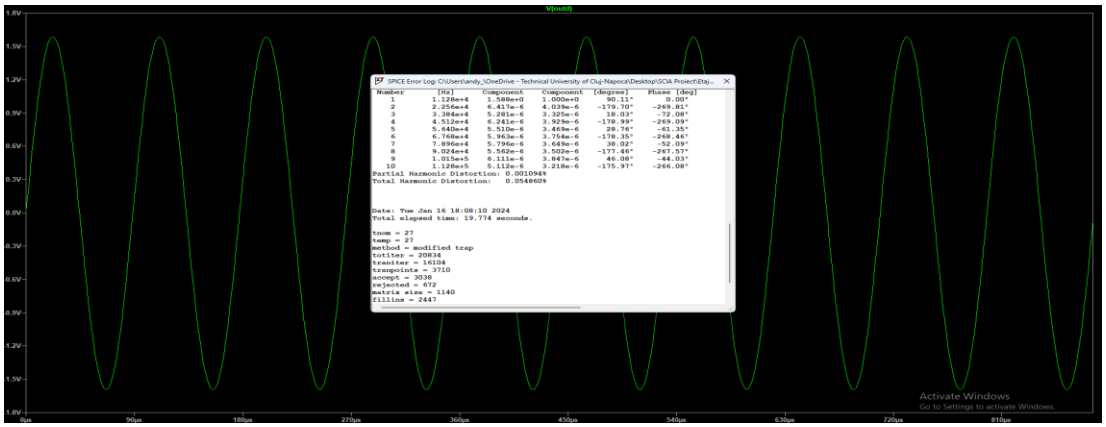
CMRR-146db



PSRR-124db

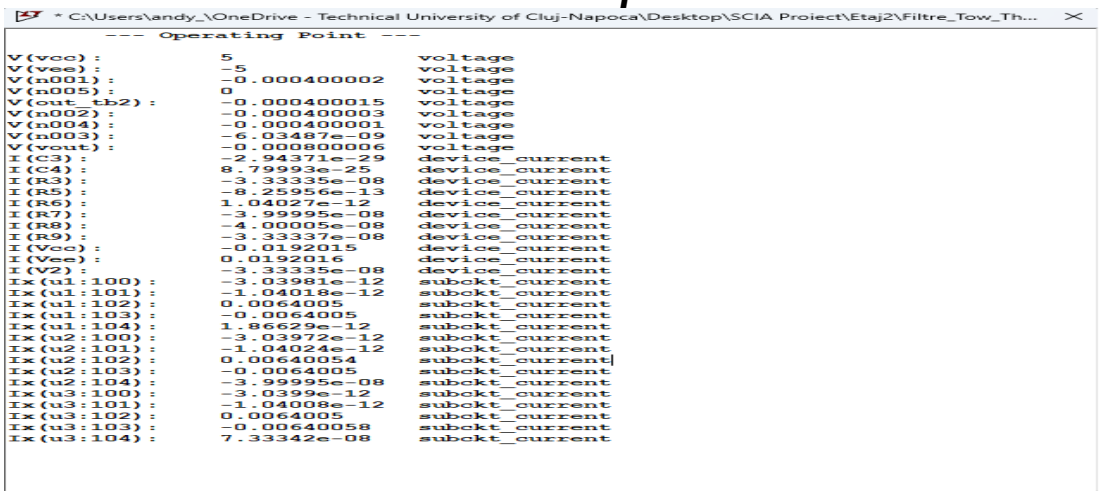


THD

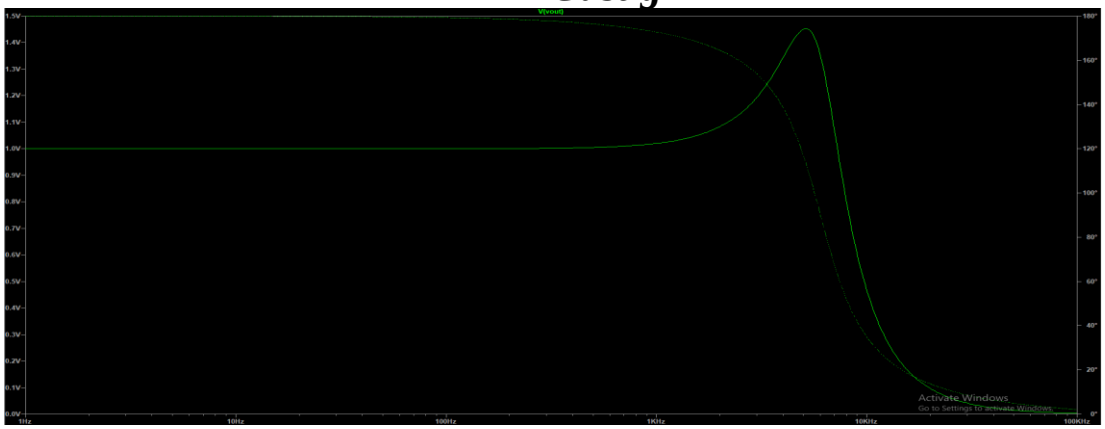


3.2 Caracterizare Band pass 2 AO V-V Tow Thomas

Psf



Castig



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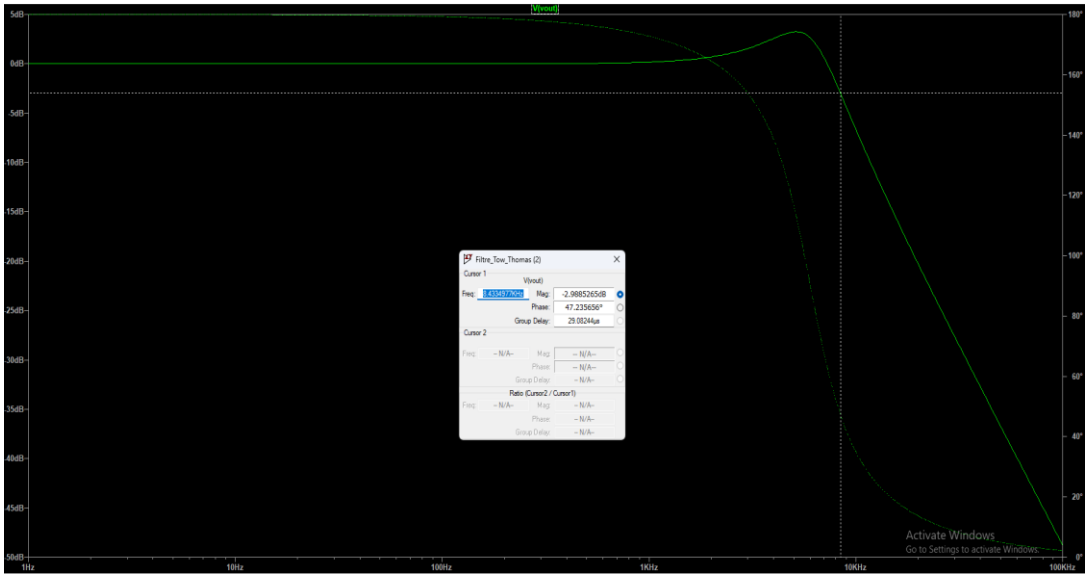
Banda-3db



Thd

SPICE Error Log: C:\Users\andy_\OneDrive - Technical University of Cluj-Napoca\Desktop\SCIA Proiect\Etaj...

```
Circuit: * C:\Users\andy_\OneDrive - Technical University of Cluj-Napoca\Desk

Direct Newton iteration for .op point succeeded.
N-Period=1
Fourier components of V(vout)
DC component:-0.000800204

Harmonic             Frequency            Fourier              Normalized
 Number                [Hz]               Component             Component
     1                8.000e+3             7.923e-4              1.000e+0
     2                1.600e+4             1.430e-6              1.805e-3
     3                2.400e+4             6.738e-7              8.505e-4
     4                3.200e+4             2.117e-6              2.672e-3
     5                4.000e+4             1.958e-6              2.471e-3
     6                4.800e+4             1.528e-6              1.929e-3
     7                5.600e+4             6.551e-8              8.269e-5
     8                6.400e+4             4.799e-7              6.057e-4
     9                7.200e+4             1.611e-6              2.033e-3
    10                8.000e+4             2.684e-7              3.387e-4
Partial Harmonic Distortion:  0.505660%
Total Harmonic Distortion:    0.544139%


Date: Mon Jan 15 21:28:00 2024
Total elapsed time: 1.876 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 39536
traniter = 39492
tranpoints = 8322
accept = 6239
rejected = 2083
matrix size = 375
fillins = 399
solver = Normal
Avg thread counts: 1.1/1.3/1.2/1.1
Matrix Compiler1: 35.49 KB object code size  14.0/9.5/[4.5]
```

3.3 Caracterizare PGA, Rg parallel

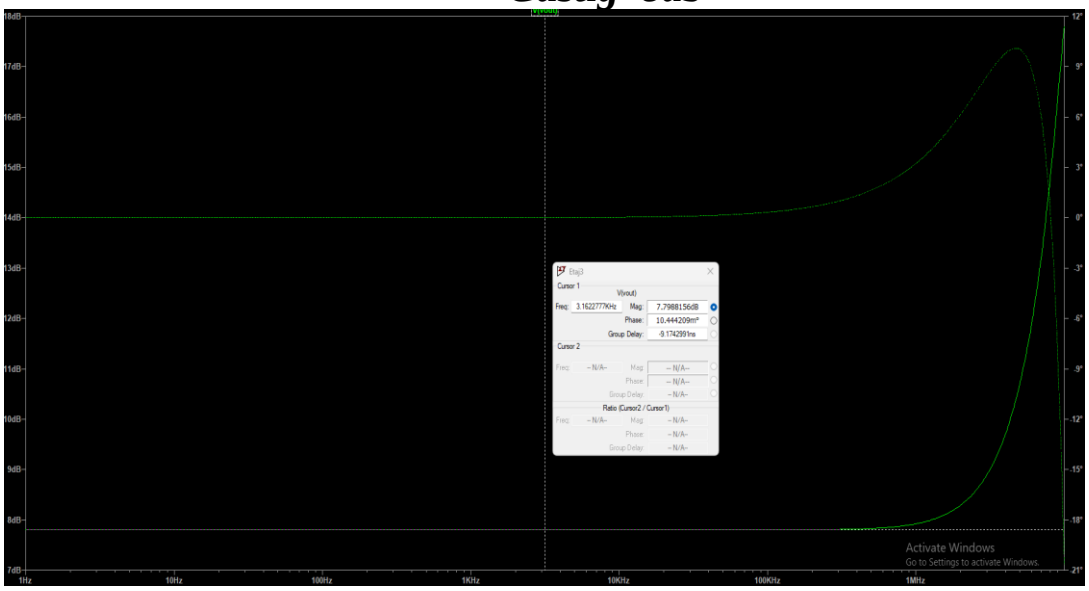
Psf

* C:\Users\andy_\OneDrive - Technical University of Cluj-Napoca\Desktop\SCIA Proiect\Etaj3\Etaj3.asc

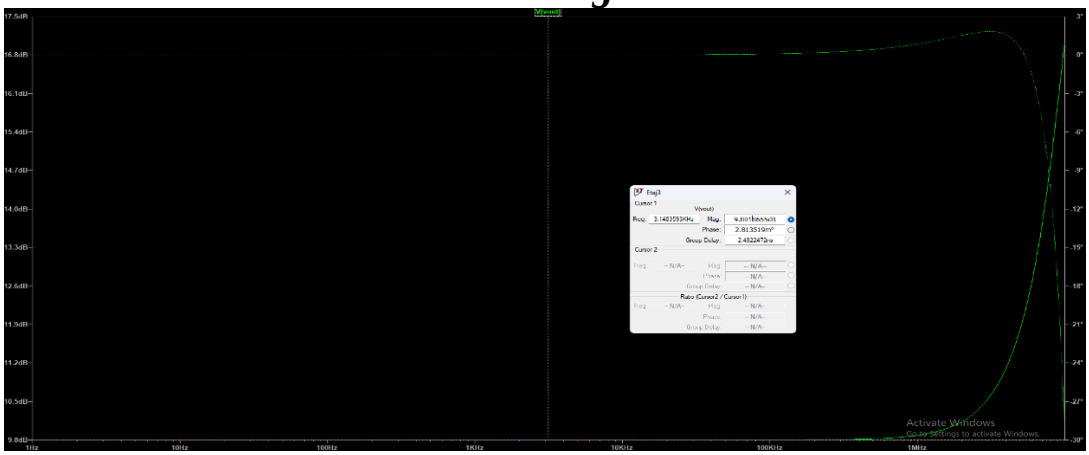
--- Operating Point ---

V(+v):	5	voltage
V(-v):	-5	voltage
V(vin):	0	voltage
V(vout):	-0.00246149	voltage
V(n002):	-0.000399997	voltage
V(n001):	-1.5016e-05	voltage
V(n003):	-6.57318e-06	voltage
V(n004):	-8.2813e-06	voltage
V(n005):	-1.03686e-05	voltage
V(n006):	-1.29744e-05	voltage
V(s1):	5	voltage
V(s2):	5	voltage
V(s3):	5	voltage
V(s5):	5	voltage
V(s4):	5	voltage
I(Rf):	-2.06149e-07	device_current
I(R1):	-5.81718e-08	device_current
I(R2):	-2.54643e-08	device_current
I(R3):	-3.20816e-08	device_current
I(R4):	-4.01679e-08	device_current
I(R5):	-5.02627e-08	device_current
I(V1):	-0.00640065	device_current
I(V2):	0.00640086	device_current
I(V3):	3.04027e-12	device_current
I(V4):	-1.25e-23	device_current
I(V5):	-1.25e-23	device_current
I(V6):	-1.25e-23	device_current
I(V8):	-1.25e-23	device_current
I(V7):	-1.25e-23	device_current
Ix(u2:1):	1.25e-23	subckt_current
Ix(u2:2):	-5.81718e-08	subckt_current
Ix(u2:3):	5.81718e-08	subckt_current
Ix(u2:4):	-3.002e-08	subckt_current
Ix(u2:5):	-1.25e-23	subckt_current
Ix(u2:6):	3.002e-08	subckt_current
Ix(u3:1):	1.25e-23	subckt_current
Ix(u3:2):	-2.54643e-08	subckt_current
Ix(u3:3):	2.54643e-08	subckt_current
Ix(u3:4):	-3.002e-08	subckt_current

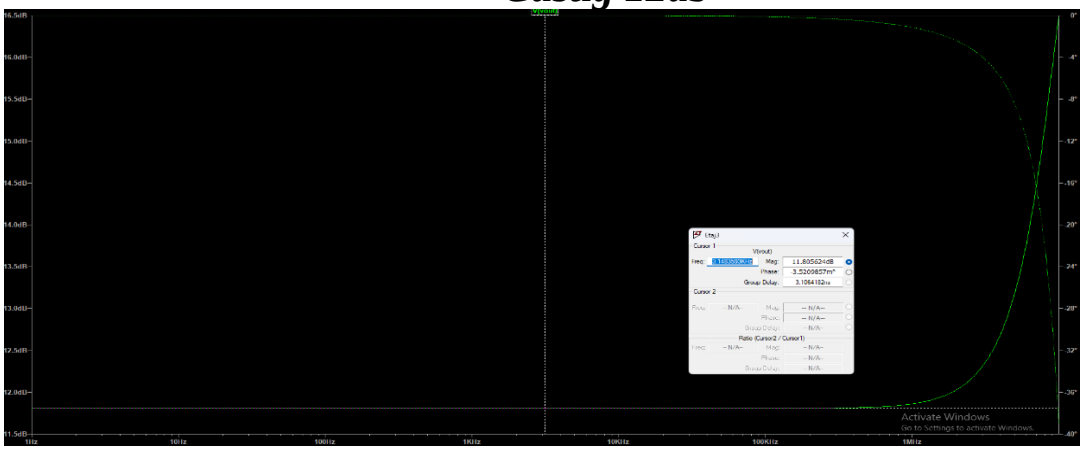
Castig 8db



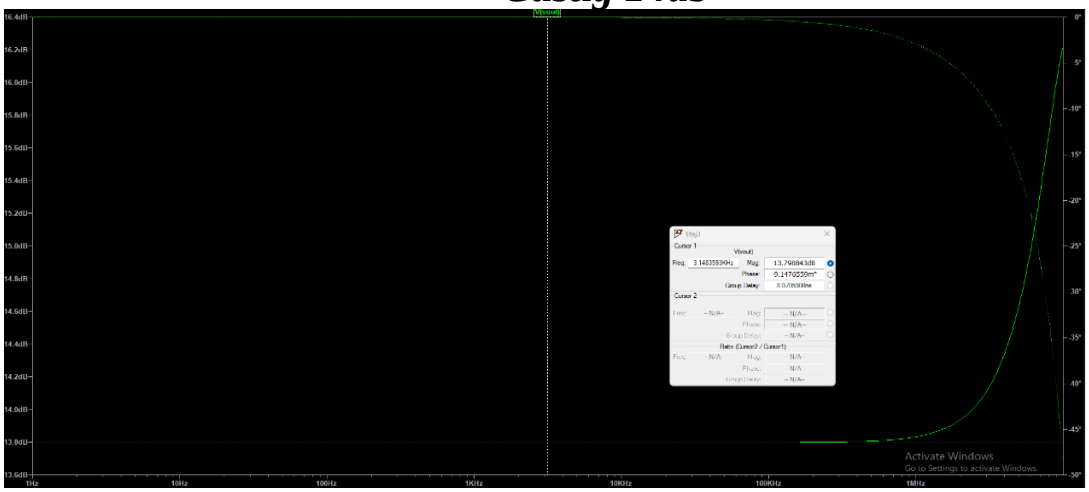
Castig 10db



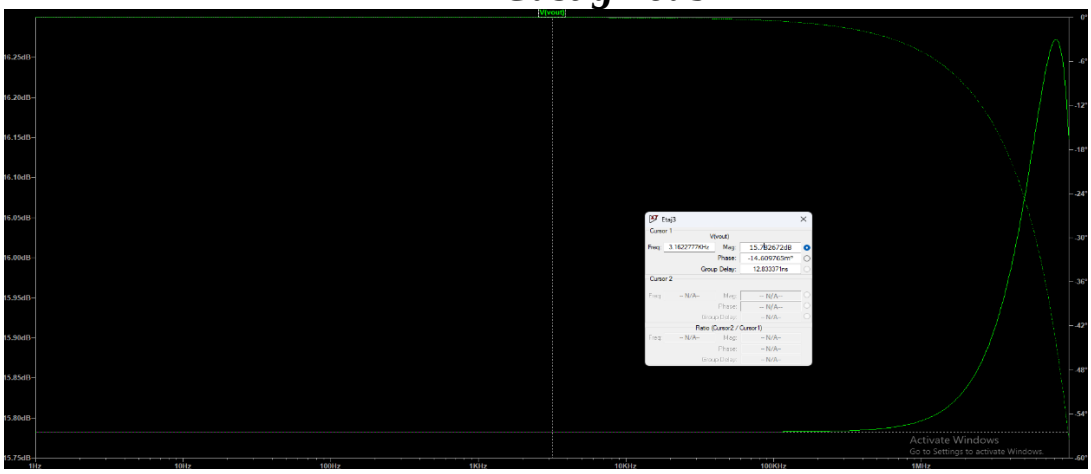
Castig 12db



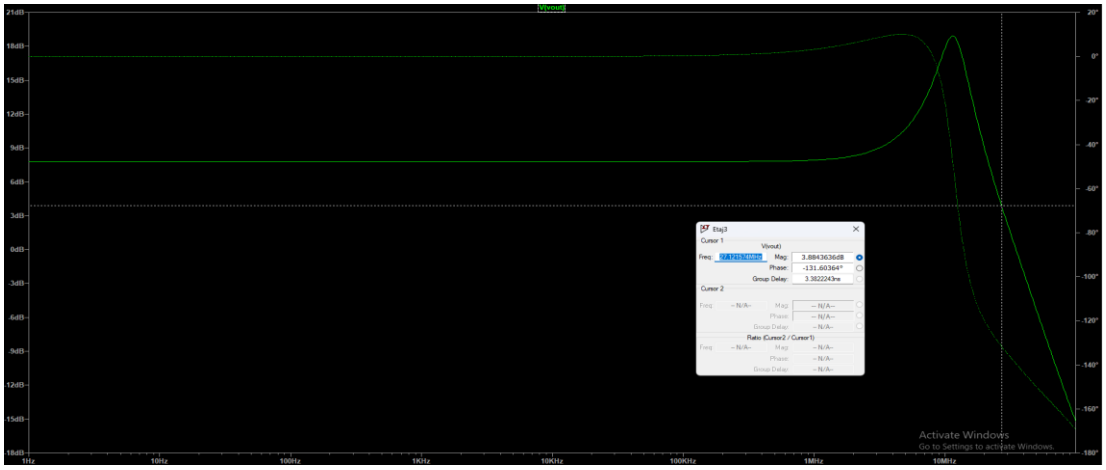
Castig 14db



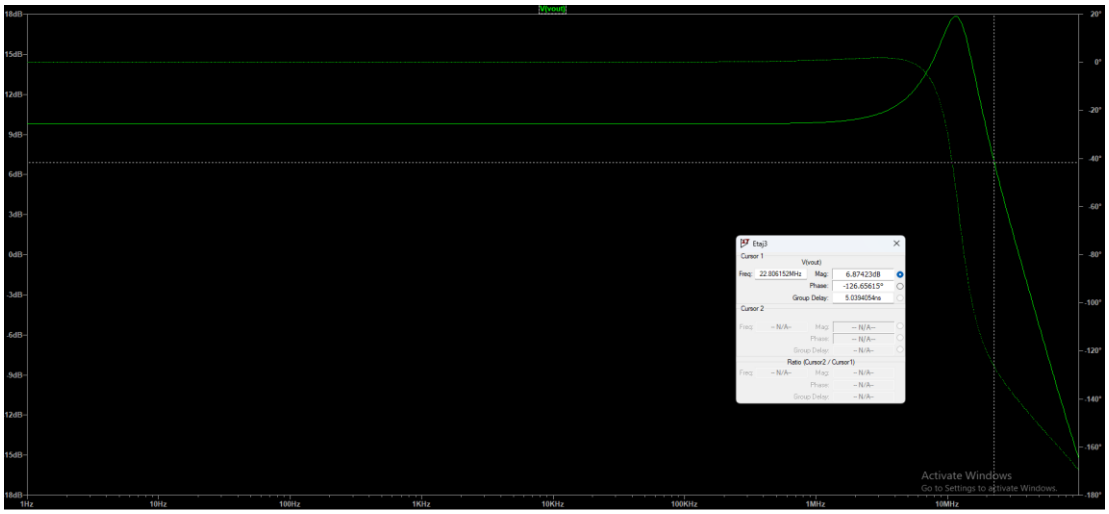
Castig 16db



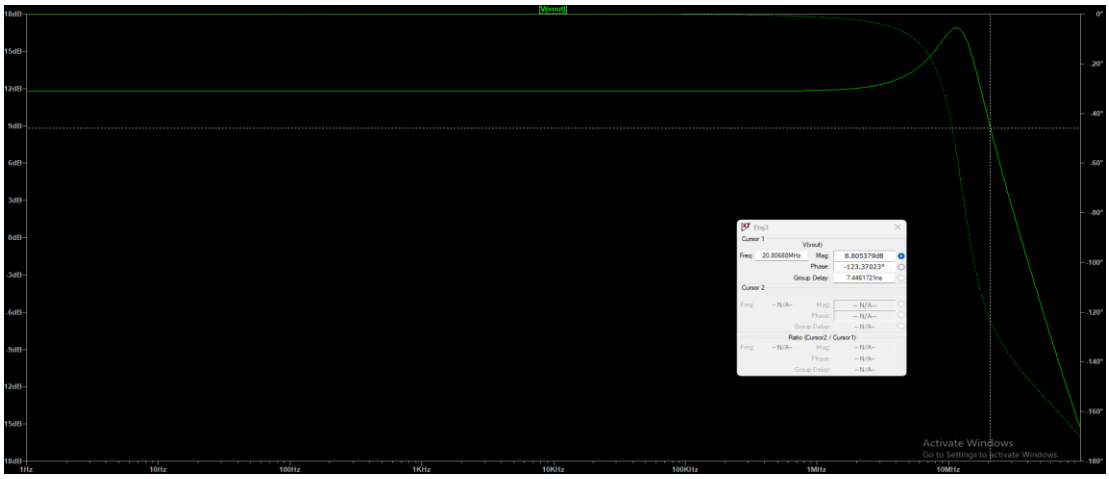
Banda 8db



Banda 10db



Banda 12db

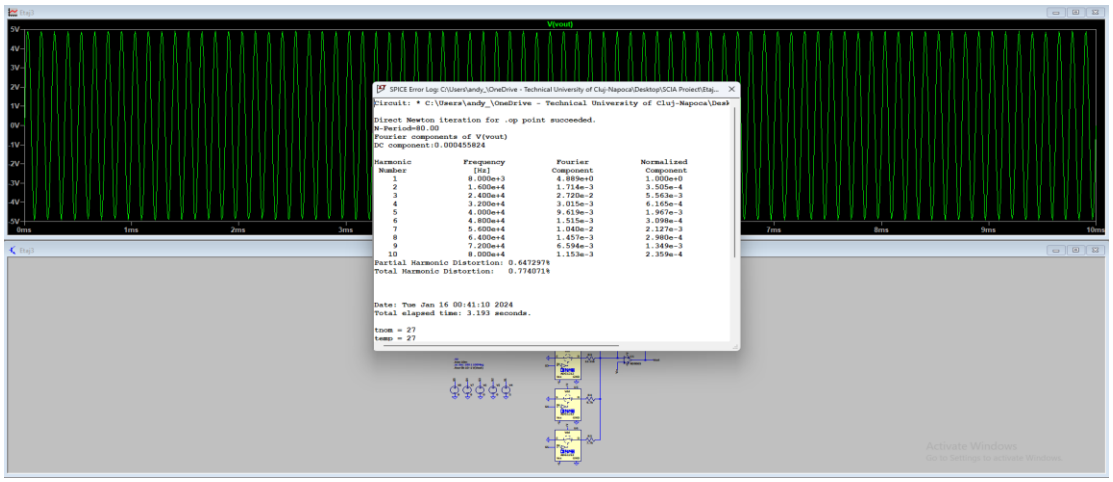


Banda 14db

Banda 16db

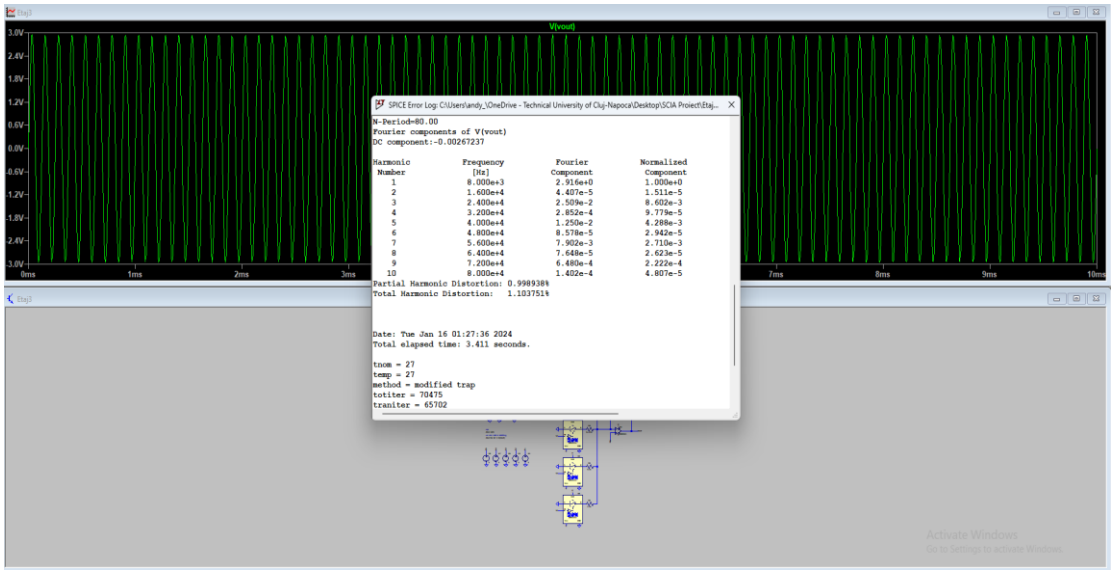
Liniaritate (castig minim, 8 db)

Valoarea gasita la 2V



Liniaritate (castig maxim, 16 db)

Valoarea gasita la 0.48V

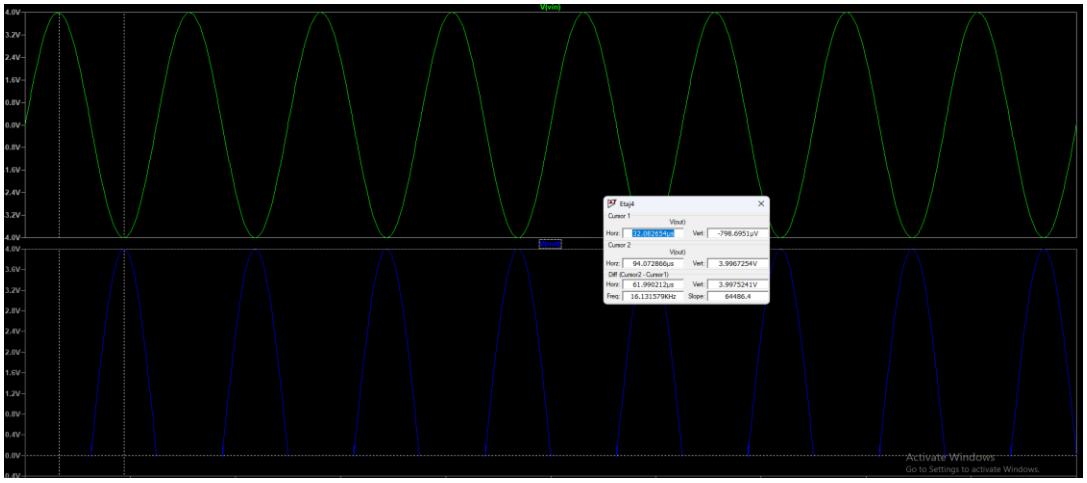


3.4 Caracterizare Redresor dubla alternanta FWR v11

PSF

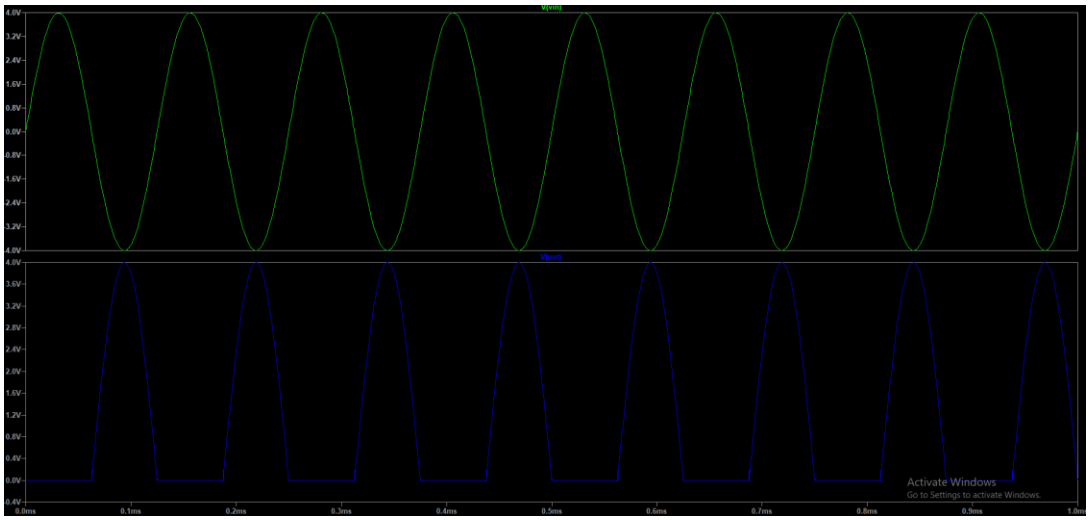
```
* C:\Users\andy_\OneDrive - Technical University of Cluj-Napoca\Desktop\SCIA Proiect\Etaj4\Etaj4.asc
        --- Operating Point ---

V(+v):          12              voltage
V(-v):          -12             voltage
V(vin):         0               voltage
V(n002):        -0.000399093    voltage
V(n001):        -0.00039912     voltage
V(n003):        -0.393538       voltage
V(out):         -0.000799095    voltage
I(D1):          3.99156e-08     device_current
I(D2):          -4.03139e-13    device_current
I(R2):          2.67668e-12     device_current
I(R1):          -3.9912e-08     device_current
I(V1):          -0.0128024      device_current
I(V2):          0.0128025       device_current
I(V3):          -3.9912e-08     device_current
Ix(u1:100):     -3.12799e-12    subckt_current
Ix(u1:101):     -9.5193e-13     subckt_current
Ix(u1:102):     0.0064012       subckt_current
Ix(u1:103):     -0.00640125     subckt_current
Ix(u1:104):     3.9916e-08      subckt_current
Ix(u2:100):     -3.07978e-12    subckt_current
Ix(u2:101):     -1.08008e-12    subckt_current
Ix(u2:102):     0.00640121      subckt_current
Ix(u2:103):     -0.00640121     subckt_current
Ix(u2:104):     1.07997e-12     subckt_current
```

Castig



Se observa faptul ca sunt egale, ceea ce releva ca avem un castig de 1

Implementare functie de circuit

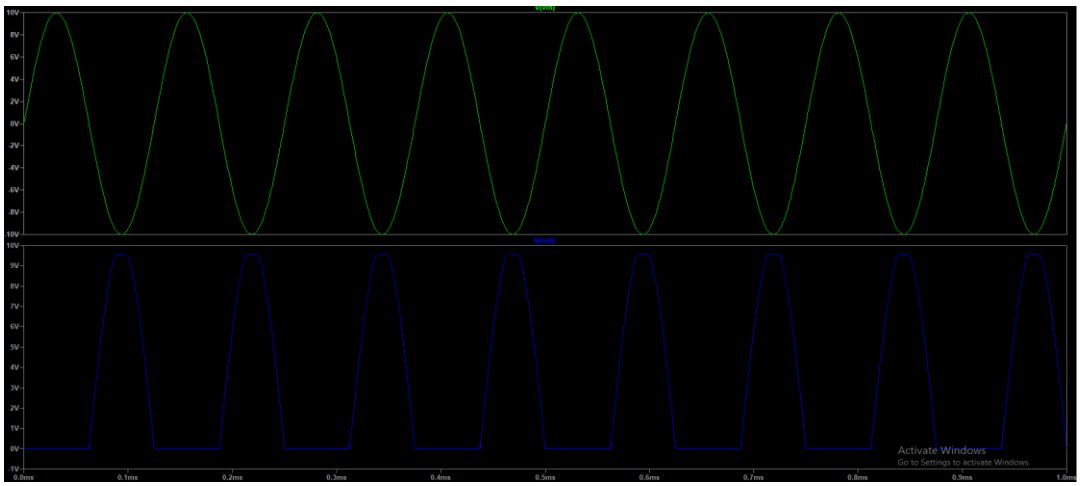


Domeniul linear > specificatii

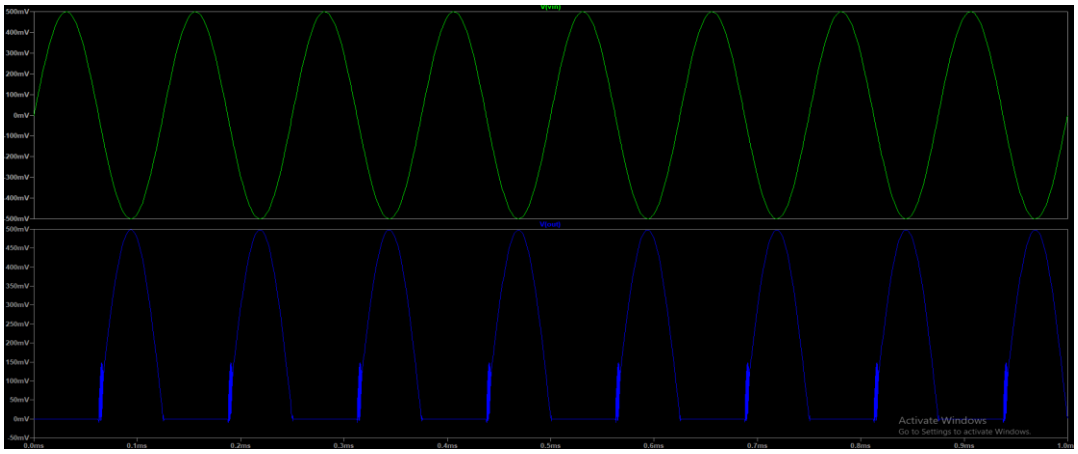
Tensiunea de intrare a etajului 4 poate varia intre 3.997, 3.998 => domeniul liniar trebuie sa fie mai mare decat domeniul tensiunii de intrare. Urmatoarele simulari releva faptul ca domeniul linear este de [500mV, 10V]

$-\frac{R2}{R1}$ * Vin + Vd2 = VOA1 => Vin = 9.4 => cam la 10V apare saturatia

Domeniul linear 10V



Domeniul linear 0.5V



Se poate observa ca apare un zgomot ce relava faptul ca mai putin de 0.5V nu se poate

4.Concluzii

	Specificatii tabel	**Masuratori**
Castig amplificator	16V	16V
Banda amplificator	8kHz	10.35MHz
Castig filtru	1V	1V
Banda filtru	8kHz	8.43kHz
Castig PGA	8dB	7.80dB
Castig PGA	10dB	9.80dB
Castig PGA	12dB	11.80dB
Castig PGA	14dB	13.80dB
Castig PGA	26dB	15.80dB
Banda(8dB)	8kHz	27.12MHz
Banda(10dB)	8kHz	22.80MHz
Banda(12dB)	8kHz	20.80MHz
Banda(14dB)	8kHz	18.01MHz
Banda(16dB)	8kHz	16.61MHz
Castig redresor	1V	1V