Proiect SCIA

-Amplificator neinversor
-Filtru KHN Low-Pass
-PGA neinversor RF paralel
-Redresor bialternanta

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Realizat de:

Melnic Anastasia

Grupa 2133

Specificatii proiect

Etajul 1					
Sursa Semnal	Amplitudine minima (pt castig maxim PGA)	Amplitudine maxima (pt castig minim PGA)	unitate masura	Tip Etaj1	|Castig| (liniar)
1	40mV	159mV	V (single ended)	1	10

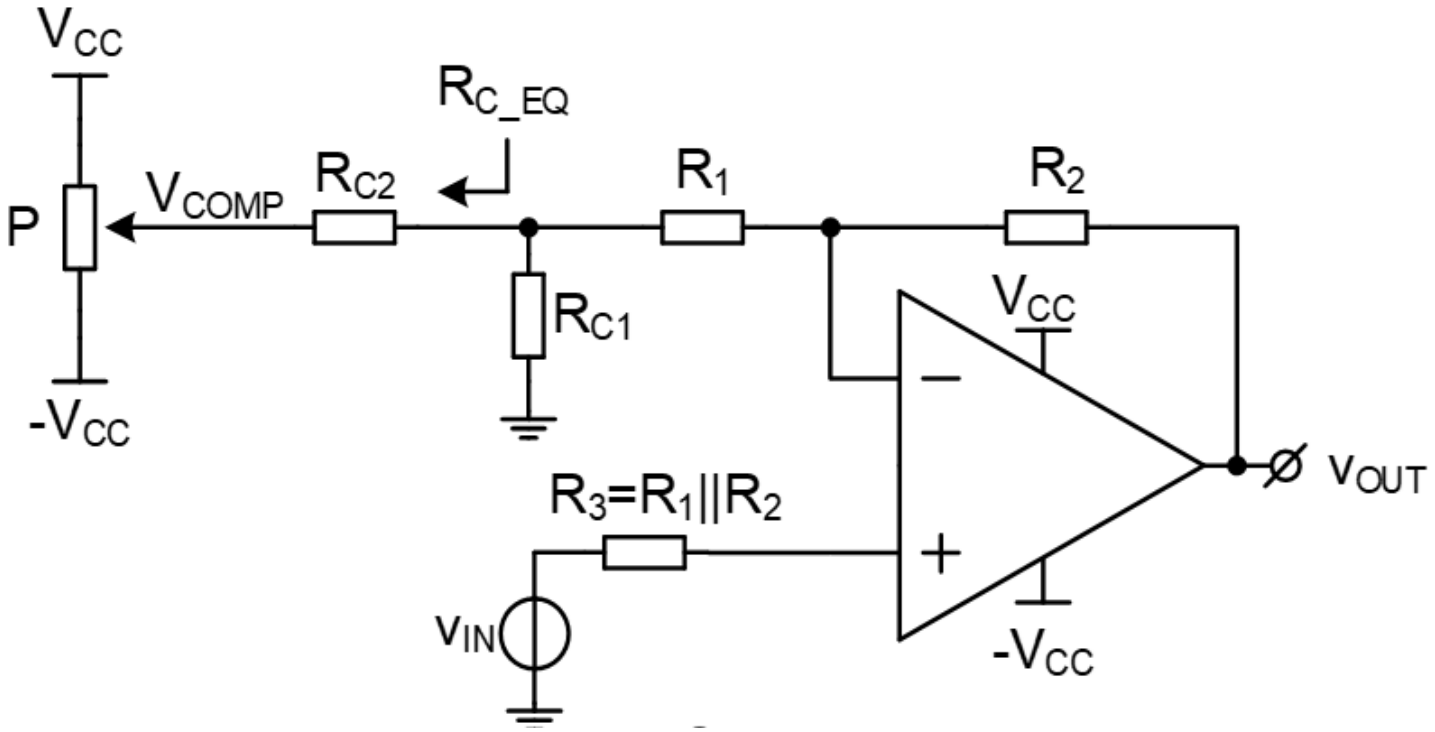
Etajul 2				
Tip etaj 2	|H0| castig liniar in banda de trecere	Rintrare minim	Banda	Q
5	1	2kOhm	1kHz	0.707

Etajul 3					
Tip etaj 3	Castig minim [dB]	Rezolutie [dB]	Nr pasi	Castig maxim [dB]	Rintrare minim
4	8	3	5	20	

Etajul 4		AO
tip Etaj 4	|Castig| (liniar)	Tip AO
4	1	LT6234

Etaj1: Amplificator neinversor V-V

Schema Circuitului



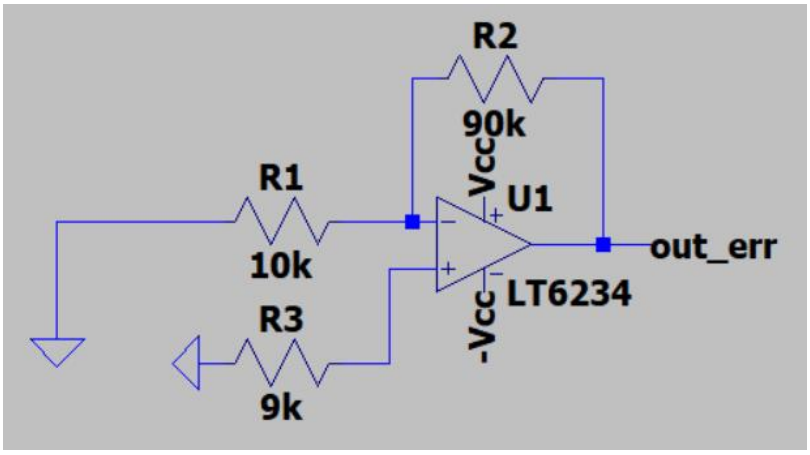
Dimensionare

$$A = 1 + \frac{R2}{R1}$$

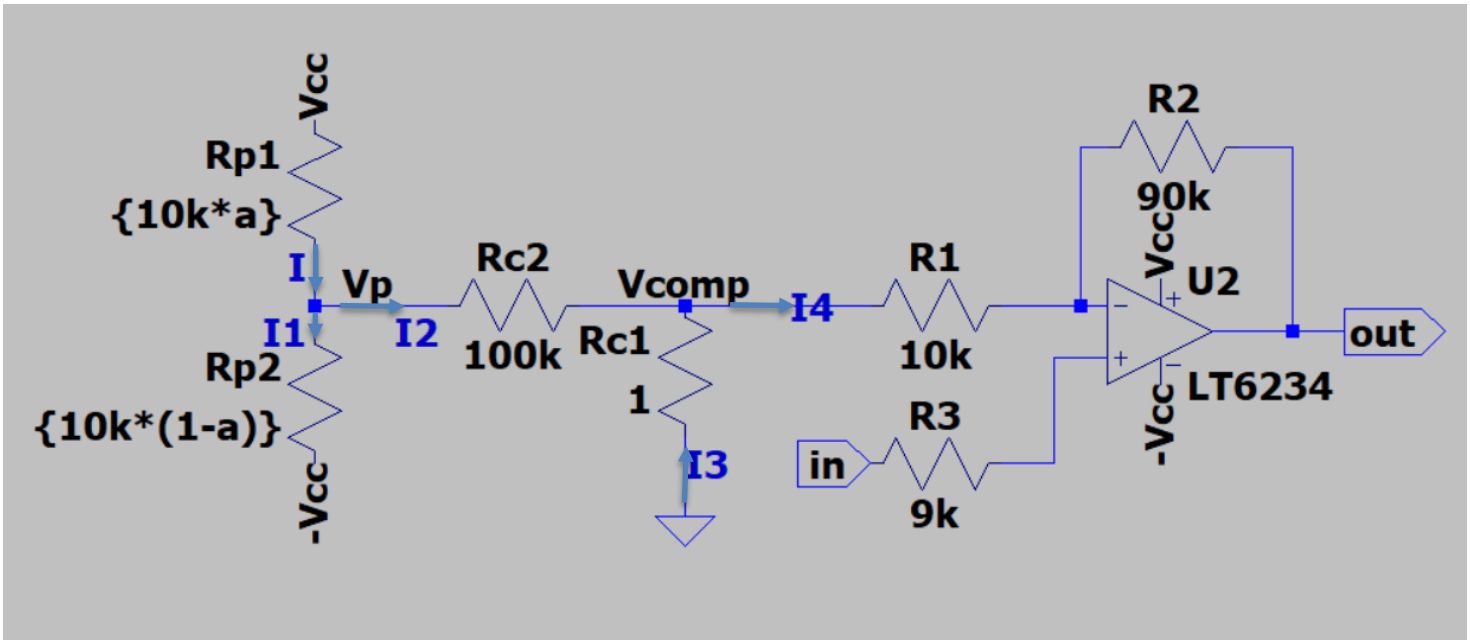
Avand in vedere ca A=10, raportul R2/R1=9. Aleg R1=10k**Ω** si R2=90k**Ω**. Pentru compensarea curentilor de polarizare, voi alege R3=R1||R2=9k**Ω**.

Compensare VoutEroare

Din cauza curentului de offset si a tensiunii de offset, la iesire apare o tensiune de eroare. Pentru a o masura, am conectat intrarea AO-ului la masa si am facut o simulare DCOP. Am obtinut V(out-err)=-11.2uV. Deci Vout-compensare ar trebui sa fie 11,12uV.



V(out_err): -1.11227e-05 voltage



Rc1<<R1 si Rc2>>Rc1, aleg Rc1=1Ω si Rc2=100kΩ.

$$Voutcomp = -Vcomp * \frac{R2}{R1}$$

$$Vcomp = -Voutcomp * \frac{R1}{R2}$$

In urma calculului, am obtinut Vcomp=-1.236uV.

Din LTSpice, v-=v+=-13.5mV.

$$I3 = -\frac{Vcomp}{Rc1}$$

$$I4 = \frac{Vcomp - v^-}{R1}$$

$$I2 = I4 - I3$$

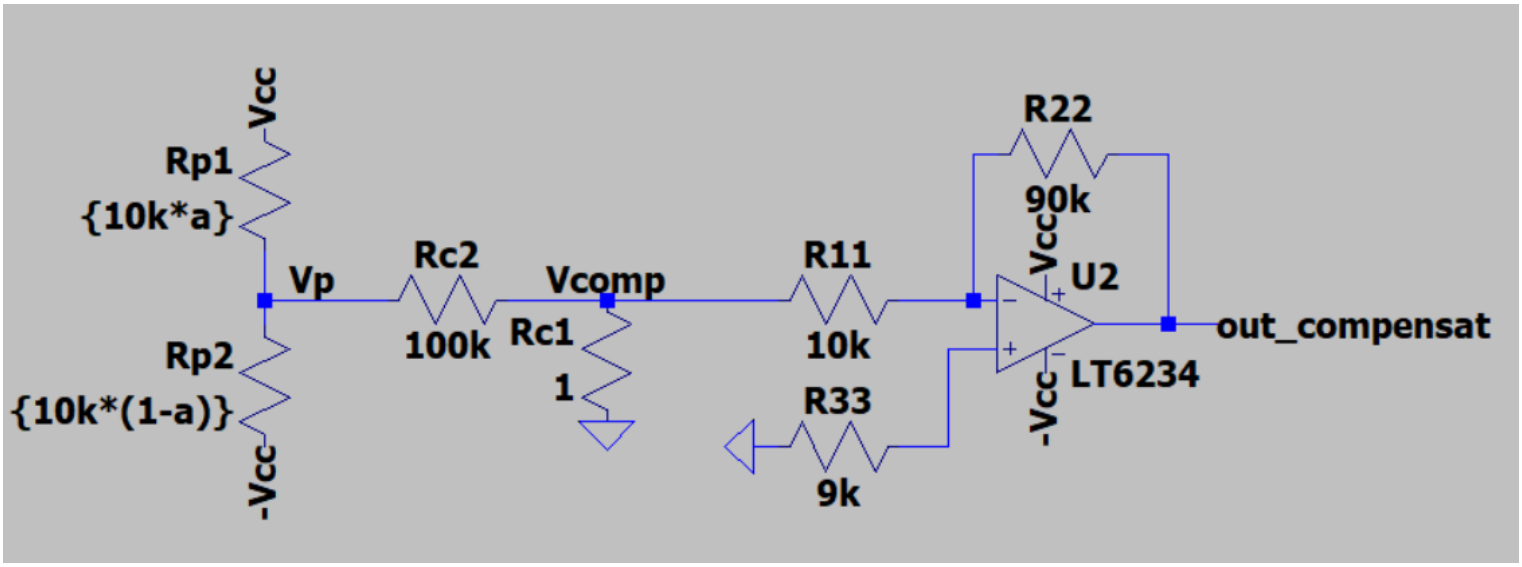
$$I2 = \frac{Vcomp - v^-}{R1} + \frac{Vcomp}{Rc1} = 114nA$$

$$Vp = Vcomp + I2 * Rc2 = 11.4mV$$

$$a = \frac{Vcc - Vp}{2Vcc} = 0.49886$$

Daca mai ajustez a=0.49883, obtin la iesire Vout_compensat=-5.34nV.

V(out_compensat): -5.33691e-09 voltage



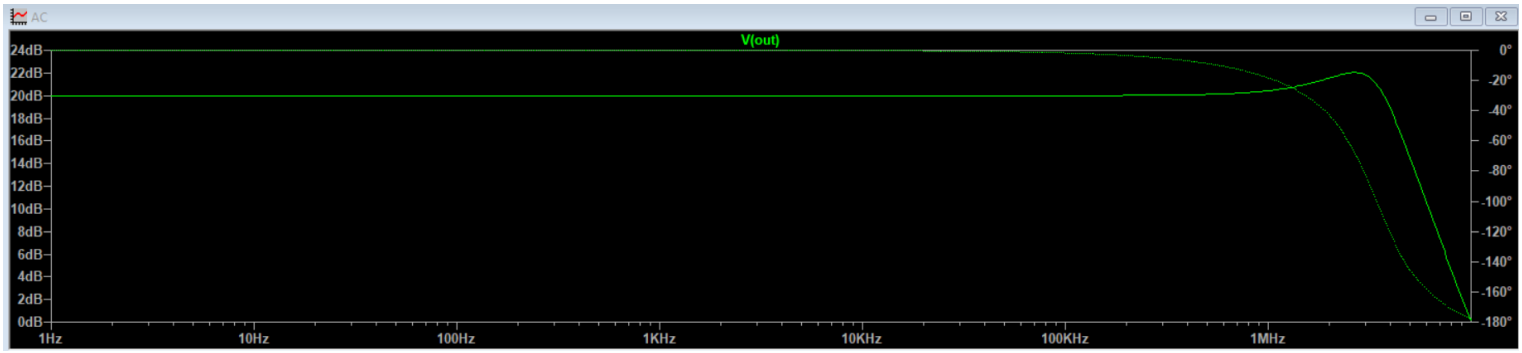
DCOP: Punct static de functionare

* C:\Users\EMELNIAP8\AppData\Local\LTspice\AC.asc

--- Operating Point ---

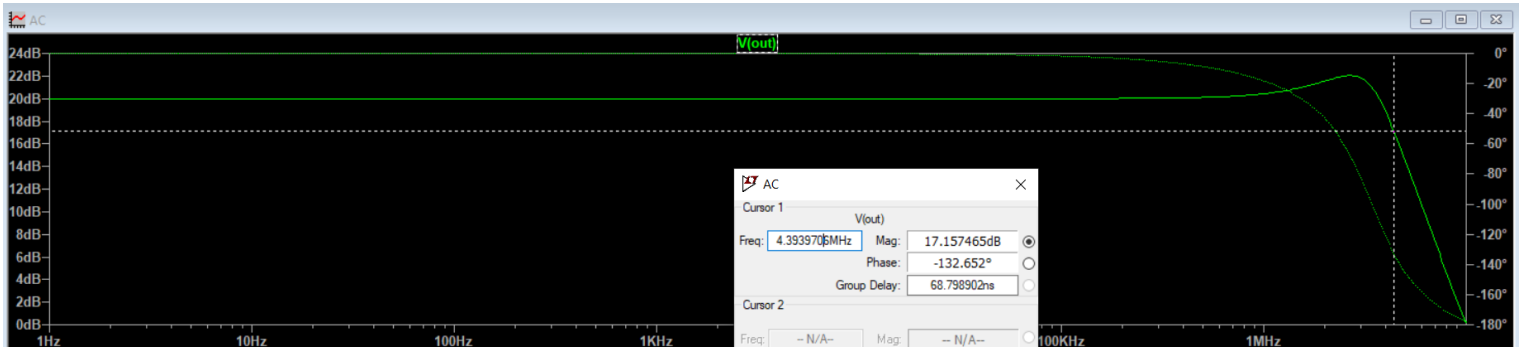
V(vcc):	5	voltage
V(-vcc):	-5	voltage
V(out):	-5.33691e-09	voltage
V(n002):	-0.0134948	voltage
V(n001):	-0.0134955	voltage
V(vcomp):	-1.23527e-06	voltage
V(in):	0	voltage
V(vp):	0.0114146	voltage
I(R1):	-1.34942e-06	device_current
I(R2):	1.4995e-07	device_current
I(R3):	-1.49943e-06	device_current
I(Rc1):	1.23527e-06	device_current
I(Rc2):	-1.14158e-07	device_current
I(Rp1):	-0.00100006	device_current
I(Rp2):	-0.000999943	device_current
I(Vcc):	-0.00204048	device_current
I(-vcc):	-0.00204321	device_current
I(V1):	-1.49943e-06	device_current
Ix(u2:1):	1.49943e-06	subckt_current
Ix(u2:2):	1.49937e-06	subckt_current
Ix(u2:3):	-1.49949e-07	subckt_current
Ix(u2:4):	0.00104042	subckt_current
Ix(u2:5):	-0.00104327	subckt_current

Castig la joasa frecventa



Din simularea de mai sus se observa ca castigul la joasa frecventa este de 20dB=10V/V, conform specificatiilor.

Banda



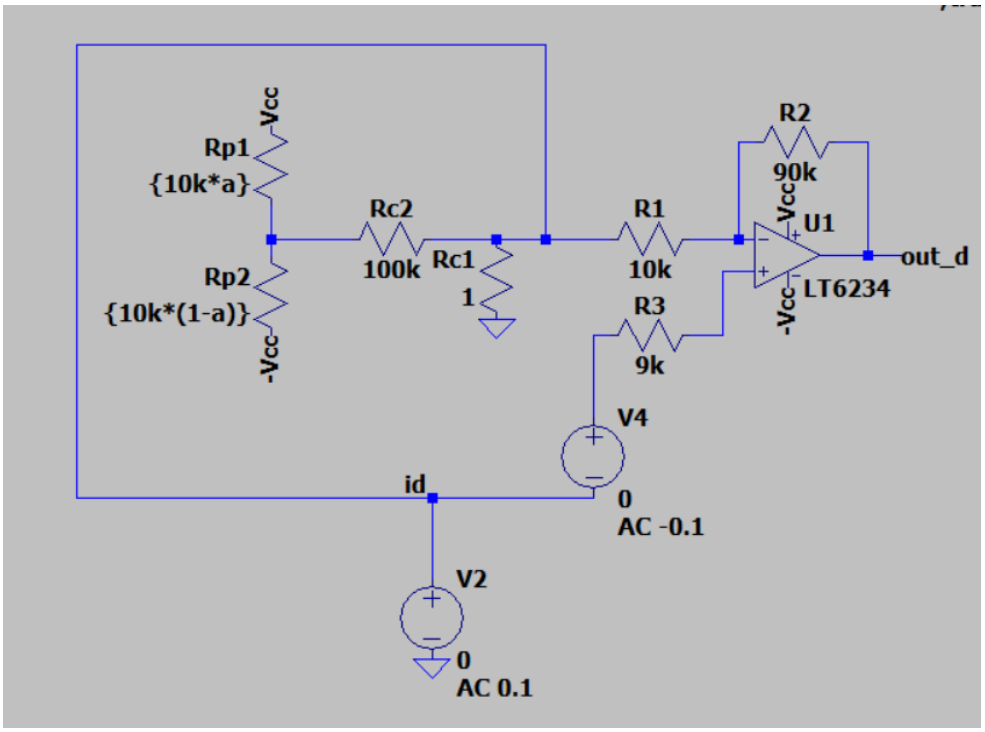
BW=4.4MHz>1kHz(banda filtrului).

CMRR

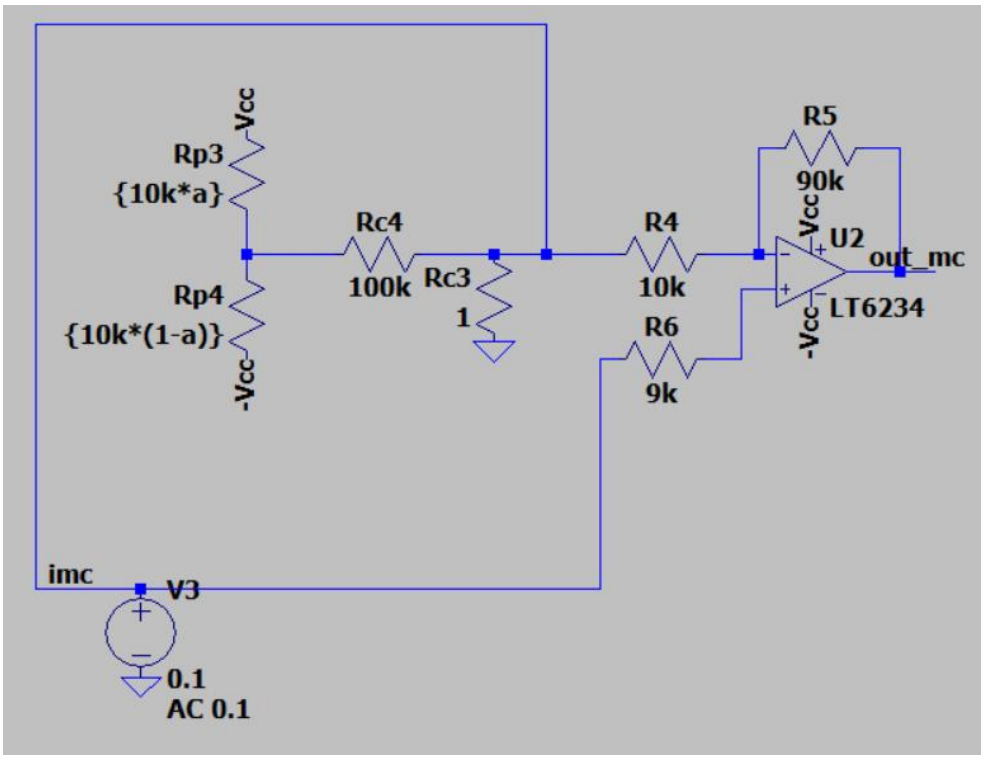
CMRR-ul (factorul de rejectie a modului comun) este variatia tensiunii de dezechilibru datorita modificarii tensiunii de intrare de mod comun.

$$CMRR[dB] = 20lg\frac{a_{dif}}{a_{mc}} = 20lg\frac{\frac{Voutdif}{Vid}}{\frac{Voutmc}{Vimc}}$$

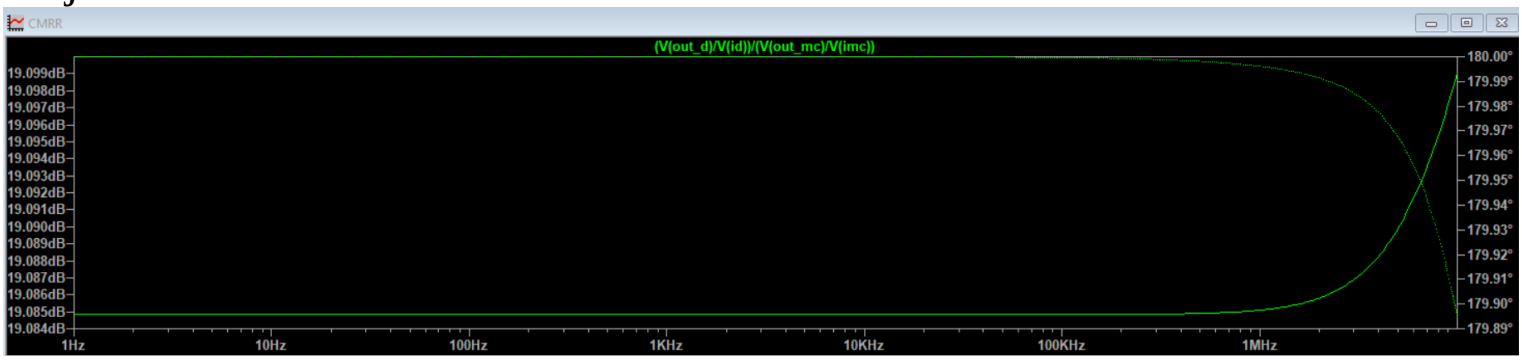
Pentru a determina CMRR-ul am facut 2 circuite, unul in care am doar tensiune de intrare diferentiala:



si altul in care am doar tensiune intrare de mod comun:



La joasa frecventa am obtinut CMRR=19dB:

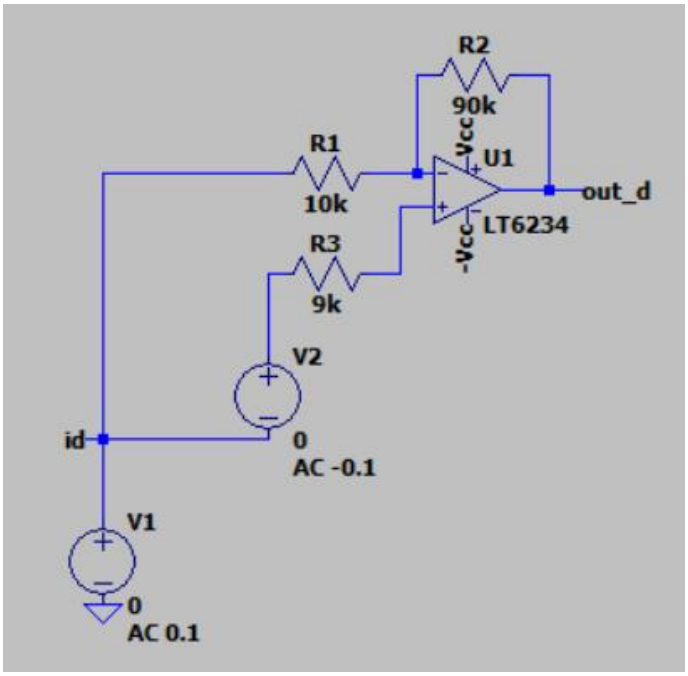


PSRR

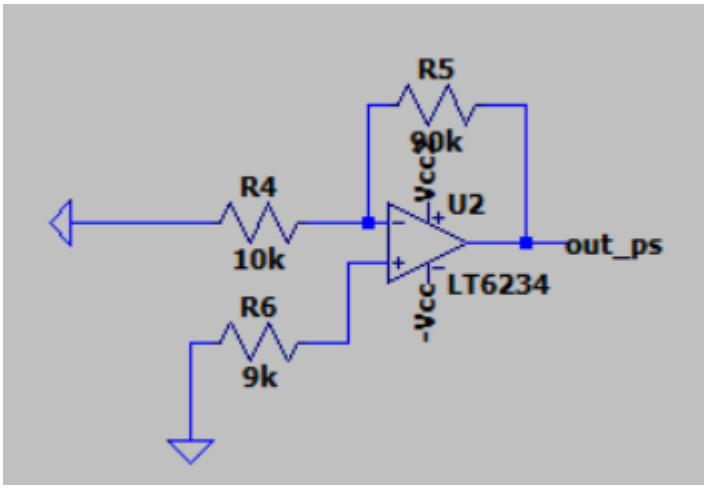
PSRR (factorul de rejectie a variatiilor tensiunii de alimentare) este variatia tensiunii de dezechilibru datorita modificarii tensiunii de alimentare.

$$PSRR[dB] = 20lg\frac{a_{dif}}{a_{ps}}$$

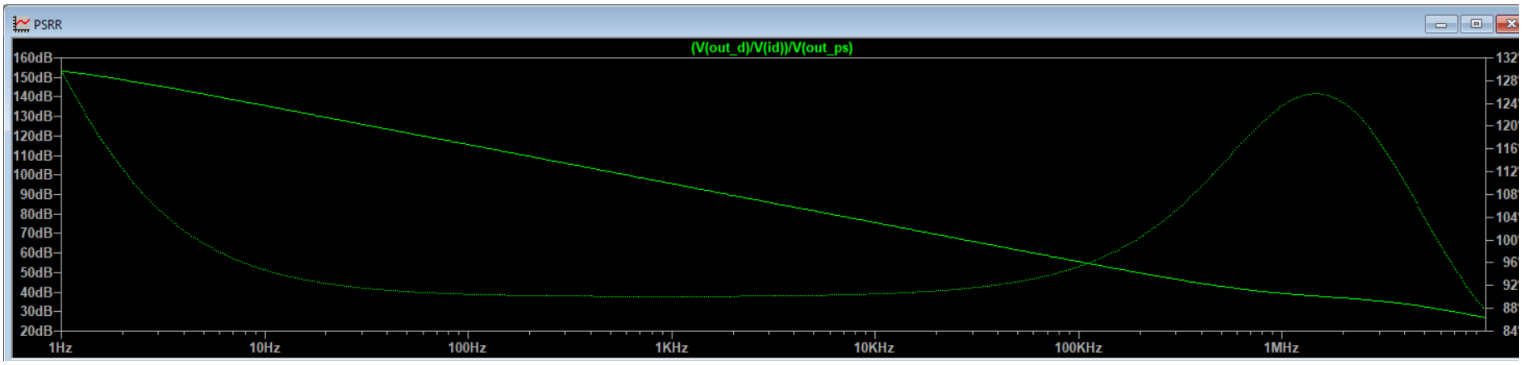
Am utilizat 2 circuite, unul pentru a calcula a_{dif}:



si altul pentru a_{ps}:



In acest circuit am setat AC 1 pentru alimentarea pozitiva.



Am obtinut PSRR=153 dB la 1Hz.

THD

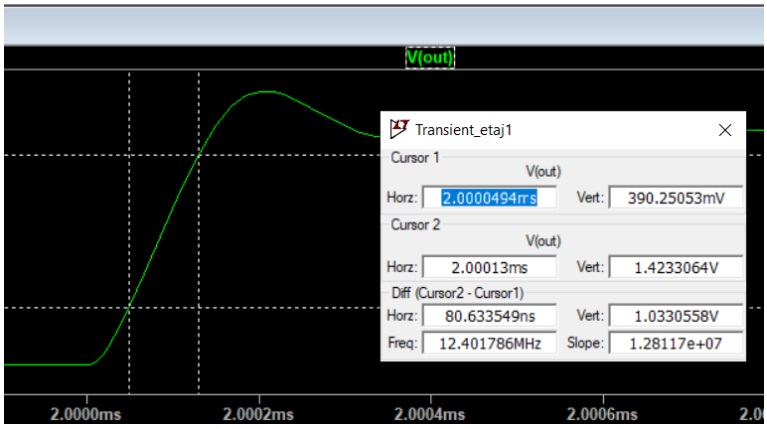
Pentru a determina liniaritatea circuitului, am realizat o analiza transient si apoi am deschis Spice Error Log.

```
Partial Harmonic Distortion: 0.100353%
Total Harmonic Distortion:   0.112898%
```

THD=0.11%<1% pentru amplitudinea semnalului de intrare=amplitudine_max*castig=159mV*10=1.59V.

Slew-Rate

Slew-Rate-ul este viteza maxima de variatie a semnalului de iesire.
Pentru a-l masura, am pus la intrare o sursa de tensiune de tip PULSE si am facut o analiza transient.



SR=12.8V/us

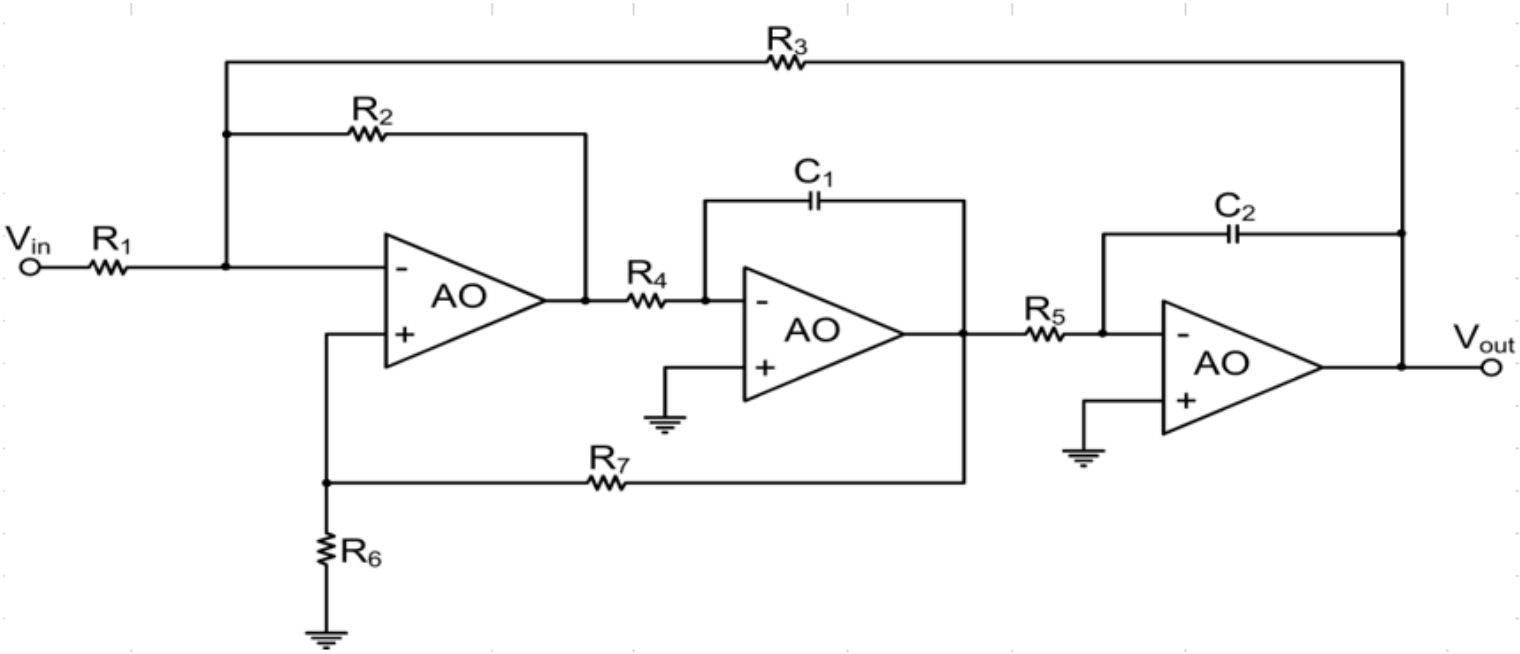
Specificatii vs Masuratori

Castig		Banda		THD	
Specificatii	Masuratori	Specificatii	Masuratori	Specificatii	Masuratori
20 dB	20dB	>1kHz	4.4MHz	<1%	0.11%

Din tabelul de mai sus se poate observa ca circuitul satisface toate cerintele.

Etaj 2:Filtru KHN V-V Low-Pass

Schema circuitului



Dimensionare

Set R1=R2=R3=…=R7=R $\Rightarrow H_0 = 1;\ \omega_0 = \frac{1}{R\sqrt{C_1 C_2}};\ Q = \frac{2}{3}\sqrt{\frac{C_1}{C_2}}$

$$C_1 = \frac{3Q}{2\omega_0 R}; C_2 = \frac{4C_1}{9Q^2} = \frac{2}{3Q\omega_0 R}.$$

$$\omega 0 = 2 * \pi * f0 = 6280\, rad/s$$

Aleg R=12kΩ, iar sin formulele de mai sus rezulta:

$$C1 = \frac{3Q}{2\omega 0 * R} = 14nF$$

$$C2 = \frac{2}{3Q * \omega 0 * R} = 12.5nF$$

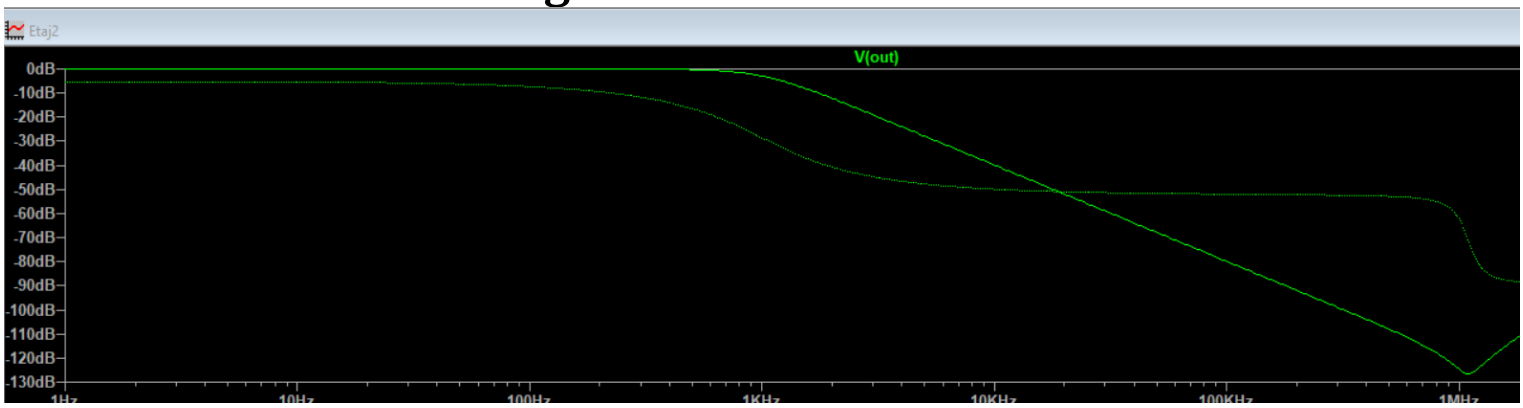
Punct static de functionare

* C:\Users\EMELNIAP8\AppData\Local\LTspice\Etaj2.asc

--- Operating Point ---

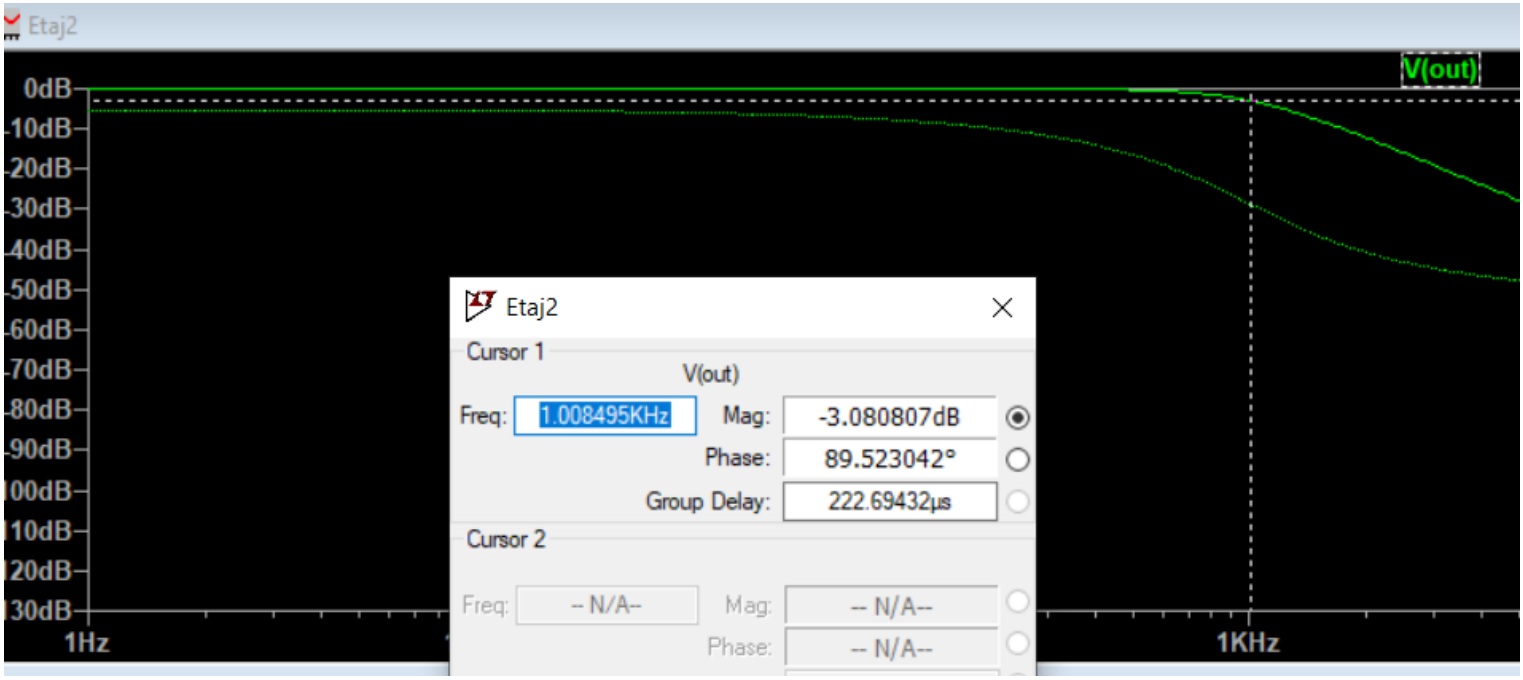
V(out):	-3.22478e-06	voltage
V(-vcc):	-5	voltage
V(vcc):	5	voltage
V(n004):	-6.38984e-07	voltage
V(n003):	0.0179999	voltage
V(n002):	-6.55349e-07	voltage
V(n005):	0.0179999	voltage
V(n006):	-6.37899e-07	voltage
V(n001):	-1.29325e-06	voltage
V(in):	0	voltage
I(C1):	2.52008e-22	device_current
I(C2):	-3.23225e-26	device_current
I(R4):	-1.50005e-06	device_current
I(R5):	-1.50005e-06	device_current
I(R7):	1.50005e-06	device_current
I(R1):	-1.07771e-10	device_current
I(R3):	-1.60961e-10	device_current
I(R6):	-5.31582e-11	device_current
I(R2):	1.5001e-06	device_current
I(V1):	-1.07771e-10	device_current
I(V2):	-0.00312404	device_current
I(V3):	0.00312704	device_current
Ix(u1:1):	1.5001e-06	subckt_current
Ix(u1:2):	1.50005e-06	subckt_current
Ix(u1:3):	1.60961e-10	subckt_current
Ix(u1:4):	0.00104035	subckt_current
Ix(u1:5):	-0.00104335	subckt_current
Ix(u2:1):	1.5001e-06	subckt_current

Castig in banda de trecere



H0=0dB=1V/V (conform specificatiilor)

Banda



BW=1kHz (conform specificatiilor)

THD

THD-ul masoara distorsiunea introdusa de circuit. Pentru a-l masura, am facut o analiza transient si am deschis Spice Error Log.
In conformitate cu specificatiile generale, am masurat THD-ul la frecventa f_in_max/10, adica la 1kHz/10=100Hz si la amplit_in*castig_etaj = 159mV* *1=159mV.

```
Total Harmonic Distortion:   1.801574%
```

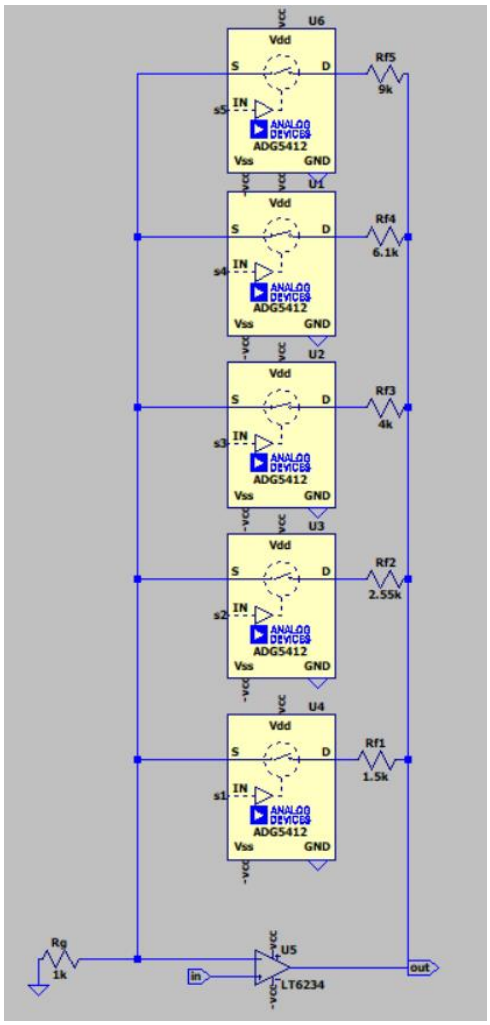
Specificatii vs Masuratori

Castig		Banda		THD	
Specificatii	Masuratori	Specificatii	Masuratori	Specificatii	Masuratori
0 dB	0dB	1kHz	1kHz	<1%	1.8%

Din tabelul de mai sus se poate observa ca circuitul satisface toate cerintele.

Etaj 3:PGA neinversor cu RF paralel

Schema circuitului



Dimensionare

Conform cerintelor, castigul minim trebuie sa fie de 8dB, iar cel maxim-20dB, cu o rezolutie de 3dB. Avem 5 pasi:
H01=8dB=2.51V/V
H02=11dB=3.55V/V
H03=14dB=5.01V/V
H04=17dB=7.08V/V
H05=20dB=10V/V

Deoarece este amplificator neinversor: $H0 = 1 + \frac{Rfi}{Rg}$

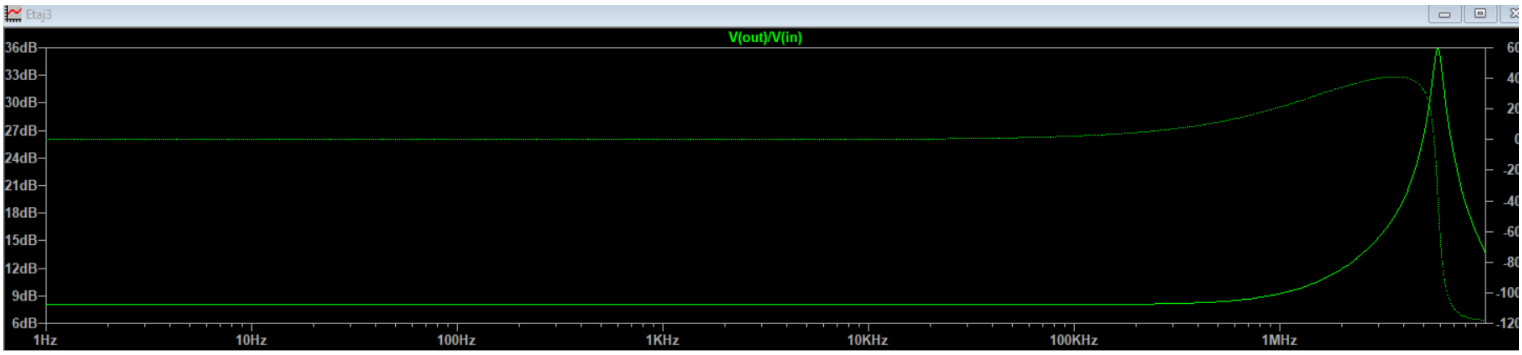
$Rfi = Rg(H0 - 1)$, cand este on doar switch-ul i, celelalte-off.
Aleg Rg=1kΩ si obtin:
Rf1=1.5kΩ
Rf2=2.55kΩ
Rf3=4kΩ
Rf4=6.1kΩ
Rf5=9kΩ
Switch-urile in LTSpice le-am implementat cu ADG5412.

Punct static de functionare

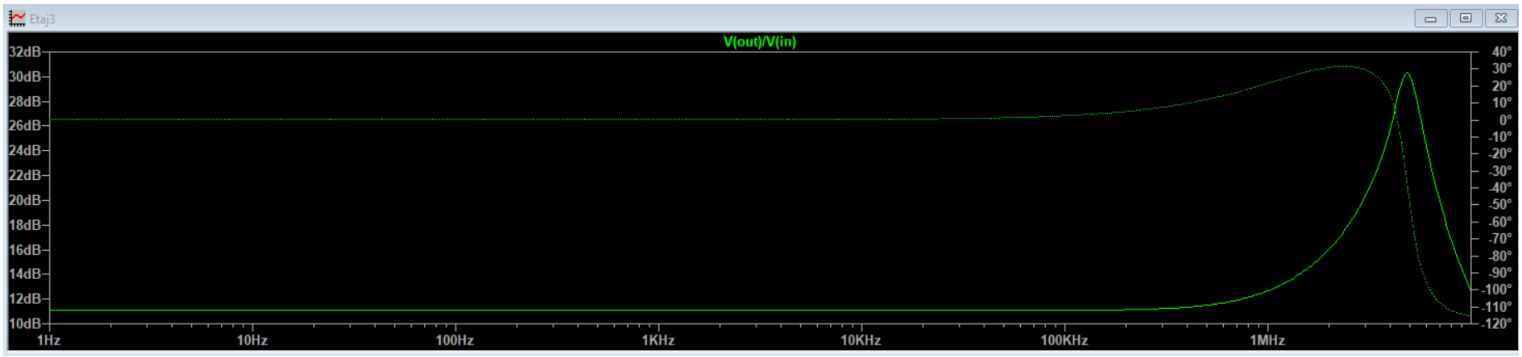
--- Operating Point ---

V(vcc):	5	voltage
V(n001):	3.3015e-07	voltage
V(n003):	0.212439	voltage
V(-vcc):	-5	voltage
V(s4):	0	voltage
V(n004):	0.200381	voltage
V(s3):	0	voltage
V(n005):	0.183232	voltage
V(s2):	0	voltage
V(n006):	3.50769e-05	voltage
V(s1):	5	voltage
V(out):	0.00228566	voltage
V(in):	0	voltage
V(n002):	0.220594	voltage
V(s5):	0	voltage
I(Rf4):	-3.44513e-05	device_current
I(Rf3):	-4.95238e-05	device_current
I(Rf2):	-7.09594e-05	device_current
I(Rf1):	1.50039e-06	device_current
I(Rf5):	-2.42565e-05	device_current
I(Rg):	3.3015e-10	device_current
I(V1):	-1.50006e-06	device_current
I(V2):	-0.000952514	device_current
I(V3):	0.00113321	device_current
I(S1):	-1.75e-23	device_current
I(S2):	0	device_current
I(S3):	0	device_current
I(S4):	0	device_current

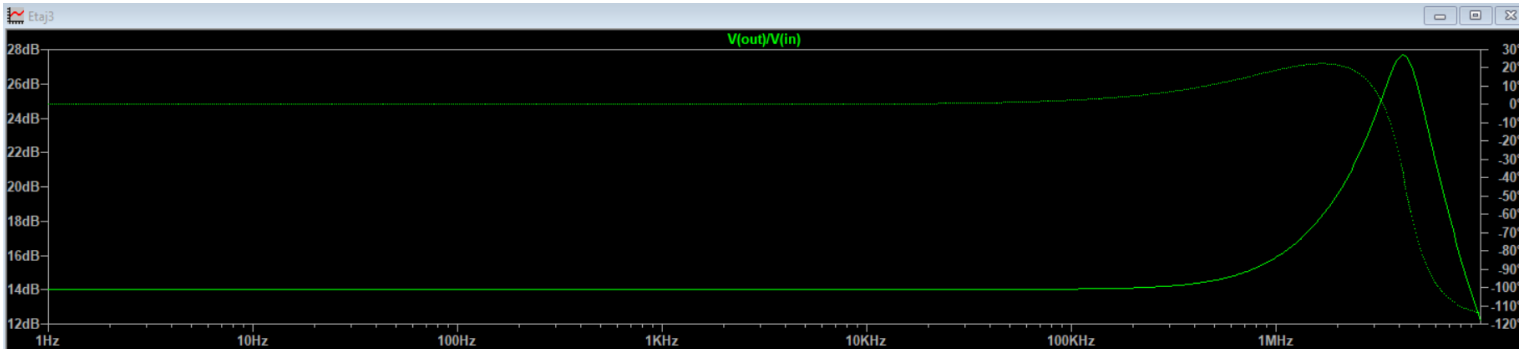
Castig si Banda



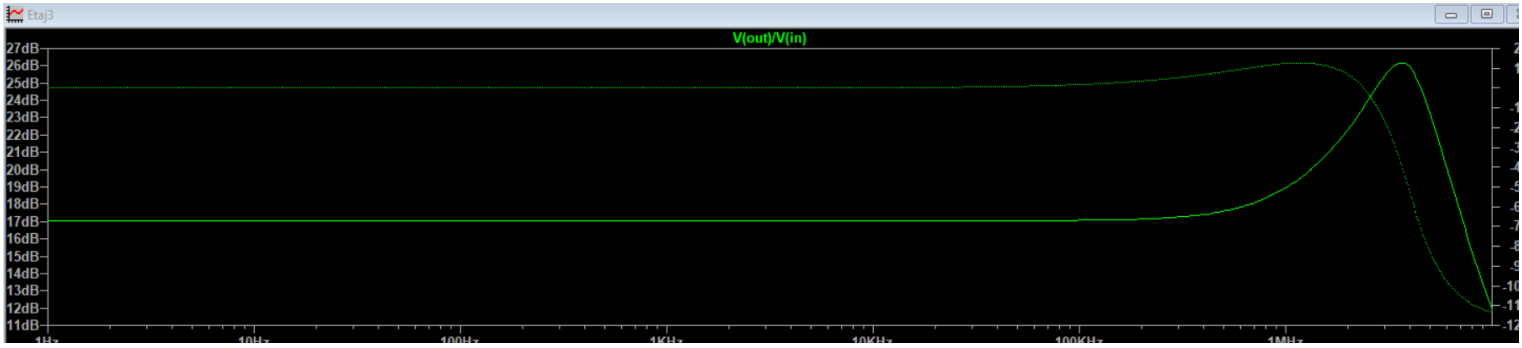
H01=8dB



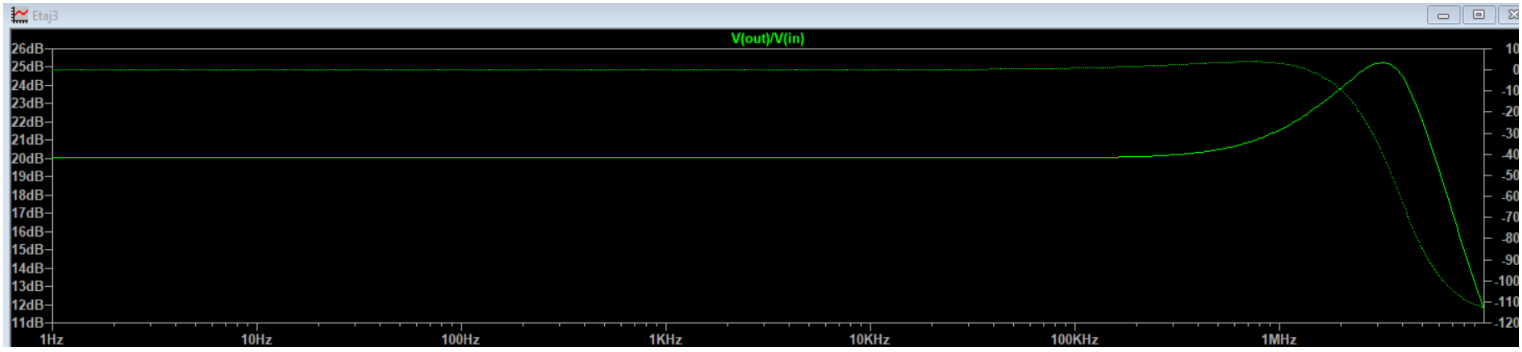
H02=11dB



H03=14dB



H04=17dB



H05=20dB

Dupa cum se poate observa in graficele de mai sus, pentru fiecare pas banda este de peste 1MHz, ceea ce satisface conditia ca banda sa fie mai mare decat banda filtrului (1kHz).

THD<1%

Conform specificatiilor, circuitul nu trebuie sa introduca distorsiuni la fin_max=1kHz pentru ampl_in_min*castig_max_PGA si pentru ampl_in_max*castig_min_PGA.
Pentru primul caz, setez semnalul de intrare ca fiind un sinus cu amplitudinea de 40mV si frecventa de 1kHz. De asemenea, las pe „on” doar switssch-ul 5 (pentru castig maxim PGA).

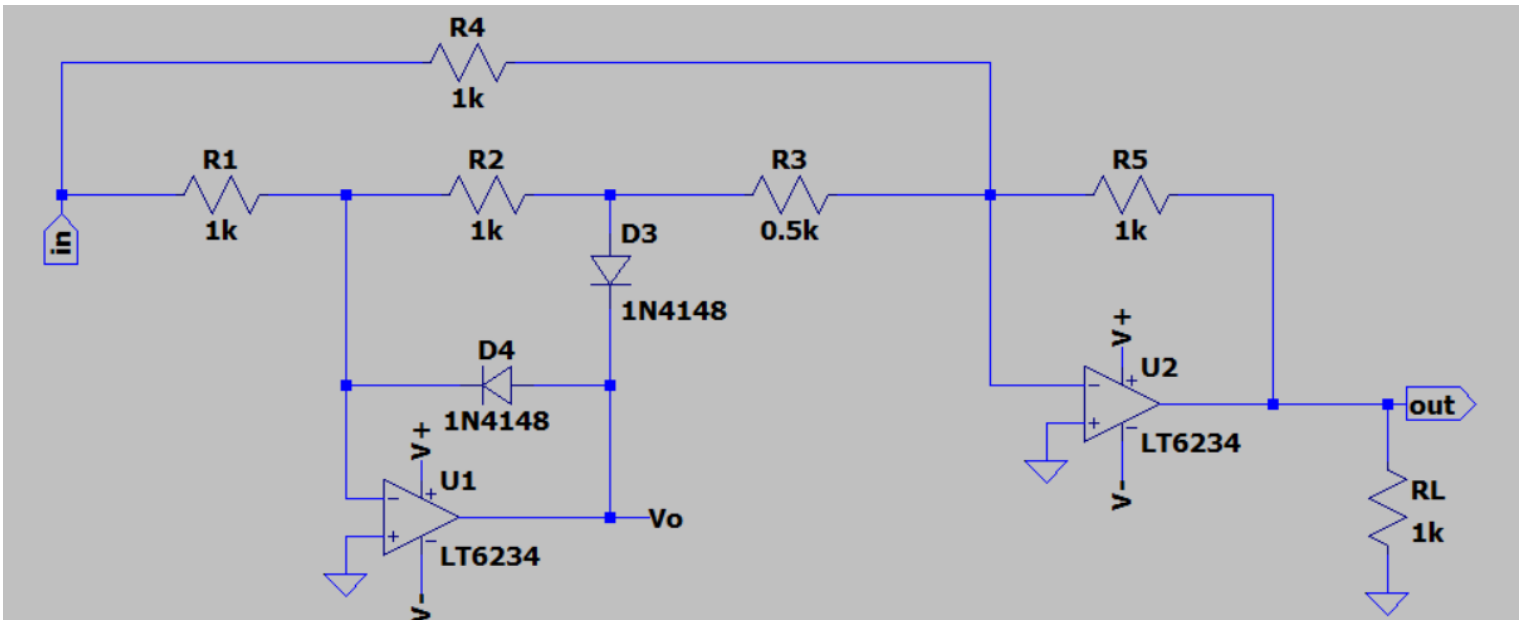
```
Total Harmonic Distortion:   0.040301%
```

Pentru al doilea caz, setez amplitudinea semnalului de intrare egala cu 159mV si las pe „on” doar switch-ul 1(pentru castig minim PGA).

```
Total Harmonic Distortion:   0.047963%
```

4.Redresor bialternanta

Schema circuitului



Dimensionare

R1=R2=R4=R5=R

R3=R/2

Aleg R=1kΩ si R3=0.5kΩ

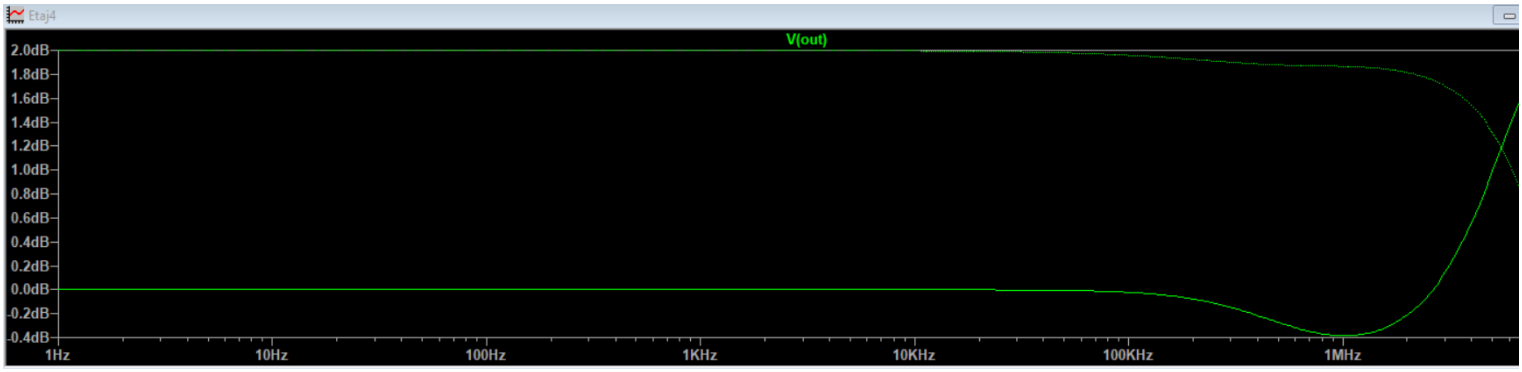
Punct static de functionare

* C:\Users\EMELNIAP8\AppData\Local\LTspice\Etaj4.asc

--- Operating Point ---

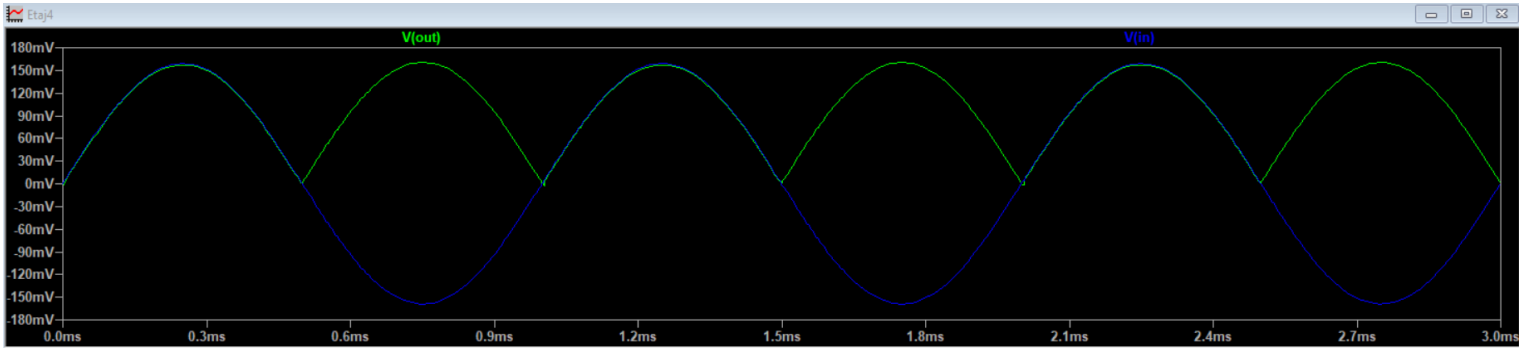
V(in):	0	voltage
V(v+):	5	voltage
V(v-):	-5	voltage
V(out):	0.00149705	voltage
V(n002):	-6.47191e-07	voltage
V(n001):	-6.5532e-07	voltage
V(n003):	1.86076e-07	voltage
V(vo):	0.289551	voltage
I(D3):	-2.51606e-09	device_current
I(D4):	1.49857e-06	device_current
I(Rl):	1.49705e-06	device_current
I(R1):	-6.47191e-10	device_current
I(R4):	-6.5532e-10	device_current
I(R3):	-1.68279e-09	device_current
I(R5):	1.49771e-06	device_current
I(R2):	8.33267e-10	device_current
I(V1):	-1.30251e-09	device_current
I(V2):	-0.00208294	device_current
I(V3):	0.00208444	device_current
Ix(u1:1):	1.5001e-06	subckt_current
Ix(u1:2):	1.50005e-06	subckt_current
Ix(u1:3):	-1.50108e-06	subckt_current
Ix(u1:4):	0.0010411	subckt_current
Ix(u1:5):	-0.0010426	subckt_current
Ix(u2:1):	1.5001e-06	subckt_current
Ix(u2:2):	1.50005e-06	subckt_current
Ix(u2:3):	-2.99476e-06	subckt_current
Ix(u2:4):	0.00104184	subckt_current

Castig



H0=0dB=1V/V(conform specificatiilor)

Implementare functie de circuit



Bibliografie

1.M.Neag, Notite de curs Sisteme cu circuite integrate analogice

2.Laboratoare SCIA